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Fuzzy Neural Network Models for Geotechnical Problems

by

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16. Abstract

Uncertainty, imprecision, complexity, and non-linearity are inherently associated with many problems in geotechnical engineering. The conventional modeling of the underlying systems, tend to become quite intractable and predictions from them are very difficult and unreliable. The general nature of geotechnical problems makes them ideally amenable to modeling through emerging methods of fuzzy and neural network modeling. Piles have been used as a foundation for both inland and offshore structures. The evaluation of the load carrying capacity of a pile, setup, and its drivability are important problems of pile design. In this study, Back Propagation Neural Network (BPNN) models and Adaptive Neuro Fuzzy Inference System (ANFIS) models are developed for: i) Ultimate pile capacity, ii) Pile setup, and iii) Pile drivability. A database for ultimate pile capacity and pile setup has been developed from a comprehensive literature review. Predictions for the above are made using BPNNs as well as commonly used empirical methods, and they are also compared with actual measurements. For the pile drivability analysis, a database of a number (3,283) of HP piles is developed from the data on HP piles from 57 projects in North Carolina (with both GRLWEAP data and soil profile information and without PDA and CAPWAP analyses). All of the programs are developed within MATLAB (and its toolboxes) with its Graphical User Interface (GUI). It is found that ANFIS and BPNN models for the analyses of pile response characteristics provide similar predictions, and that both are better than those from empirical methods, and can serve as a reliable and simple tool for the prediction of ultimate pile capacity and pile setup. Also, the BPNN model developed for pile drivability analysis provides good predictions. BPNN may be considered to be more efficient than ANFIS, as the BPNN model trains much faster, while both provide equally good predictions. However ANFIS models with some additional work will be more desirable for those cases in which one or more input variables may be available only in 'fuzzy' terms, and when the model is developed with a limited data range, because in ANFIS extrapolation beyond the data range is made through the membership functions .

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SUMMARY

Uncertainty, imprecision, complexity, and non-linearity are inherently associated with many problems in geotechnical engineering. The conventional modeling of the underlying systems, tend to become quite intractable and predictions from them are very difficult and unreliable. Recently an alternative approach to modeling has emerged under the rubric of 'soft computing' with 'neural network' and 'fuzzy logic' as its main constituents. These are observational models developed on the basis of available data sets. The general nature of geotechnical problems and the consequent role engineering judgments play in their treatment, make them ideally amenable to modeling through these emerging methods.

In this study, BPNN (back propagation neural network) and ANFIS (adaptive neuro fuzzy inference system) models have been developed for the analyses of important prediction problems related to pile foundation: i) Ultimate pile capacity, ii) Pile setup, and iii) Pile drivability. First theories and methodologies of artificial neural network, fuzzy logic, and adaptive neuro fuzzy inference system are introduced, and studied through various examples. Finally, BPNN and ANFIS models are developed for three important problems of pile design. Database for ultimate pile capacity and pile setup have been developed from a comprehensive literature review. The predictions by BPNN and ANFIS models are compared with those from commonly used empirical methods, as well as with actual measurements. For the pile drivability analysis, a database of a number of HP piles is developed from HP piles built at NC State using both GRLWEAP data and soil profile information (without PDA and CAPWAP analysis). Predictions obtained by BPNN model are compared to GRLWEAP calculations derived from already built piles at NC State. All of the programs are developed within MATLAB using its toolboxes and its GUI.

It is found that ANFIS and BPNN models for the analyses of pile provide similar predictions, which are better than those produced through empirical methods, and therefore they can serve as a reliable and simple tools for the prediction of ultimate pile capacity and pile setup. Also, the BPNN model developed for pile drivability analysis provides sound predictions. BPNN may be considered to be more efficient than ANFIS as BPNN model trains much faster while both provide equally good predictions. However, ANFIS models with some additional works will be more desirable for those cases in which one or more input variables may be available only in 'fuzzy' terms. It will also be more desirable in cases in which a model is developed with limited data range because in ANFIS, extrapolation beyond the data range is made through the membership functions.

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Chapter 1 Introduction

1.1 Problems of Pile Design

Piles have been used as a foundation for both onshore and offshore structures. The evaluation of the load carrying capacity of a pile, setup, and its drivability are important problems of pile design.

The best way to estimate the ultimate capacity of piles is to use a static load test. However, because of the high costs involved, static load tests cannot be done routinely. Perhaps the most frequently used method of estimating the load capacity of driven piles is the dynamic driving formulae. The driving formulae have been commonly used for estimating ultimate pile capacity because of its simplicity. This cannot, however, explain time-dependent events and cover a variety of pile driving systems. The limitations associated with such formulae have led to the development of wave equation based analysis for the evaluation of pile load capacity.

After being driven the load carrying capacity of piles increases with time, which is termed ‘setup’. An evaluation of ultimate load capacity considering pile setup may lead to more economical pile design resulting in reductions in pile lengths, pile sections, and the size of driving equipment. The commonly used relationships to estimate pile setup are highly empirical and their predictive abilities are limited by the corresponding data sets from which they are derived. These methods do not provide reliable predictions for use in practice.

In practice, driving criteria are provided to the contractor in order that the piles have a required load bearing capacity and can be driven without being overstressed. A wave equation based computer program is used to generate the pile driving criteria for every project. The pile driving criteria furnished to the contractor includes: i) hammer stroke vs. BPF(1/set) for required bearing capacity, ii) Maximum compressive stresses vs. BPF, iii) Maximum tension stress vs. BPF. This process takes up a significant amount of time and requires the usage of several programs such as PILECAP, GRLWEAP, PDA, and CAPWAP. This current practice requires significant training skills, and can be very time consuming since much effort is devoted to the analyses.

1.2 New Approaches for Modeling

The essence of modeling is prediction by mapping a set of variables in input space to a set of response variables in output space through a model as represented in Figure 1-1 below.

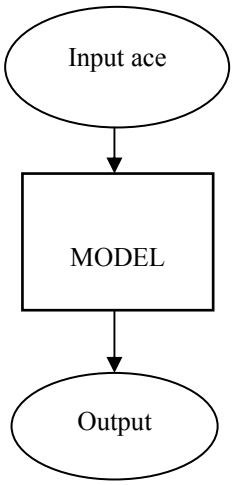


Figure 1 - 1 An input-output mapping

A mathematical model is conventionally placed in the 'model' box of the above figure. However, the conventional modeling of underlying systems, often tend to become quite intractable and difficult. Recently an alternative approach to modeling has emerged under the rubric of 'soft computing' with 'neural network' and 'fuzzy logic' as its main constituents. These are 'observational models' developed on the basis of available data sets, representing a mapping between input and output variables. The general nature of geotechnical problems and the consequent role engineering judgments play in their treatment, make them ideally amenable to this approach of modeling. The development of these models however requires a set of data. Fortunately, for many problems such data are available.

Fuzzy systems and neural networks are both model-free numerical estimators. They share the ability to improve the predictive capability of a system working in uncertain, imprecise, and noisy environments. Fuzzy logic and neural networks are complementary technologies. In order to utilize the strengths of both, fuzzy systems and neural networks may be combined into an integrated system. An integrated system has the advantages of both neural networks (e.g., learning abilities, optimization abilities, and connectionist structure)

and fuzzy systems (e.g., humanlike 'if-then' rules, and ease of incorporating expert knowledge available in linguistic terms).

1.2.1 Artificial Neural Network

A neural network model is a system of interconnected computational neurons arranged in an organized fashion that can carry out extensive computations in order to create a mathematical mapping.

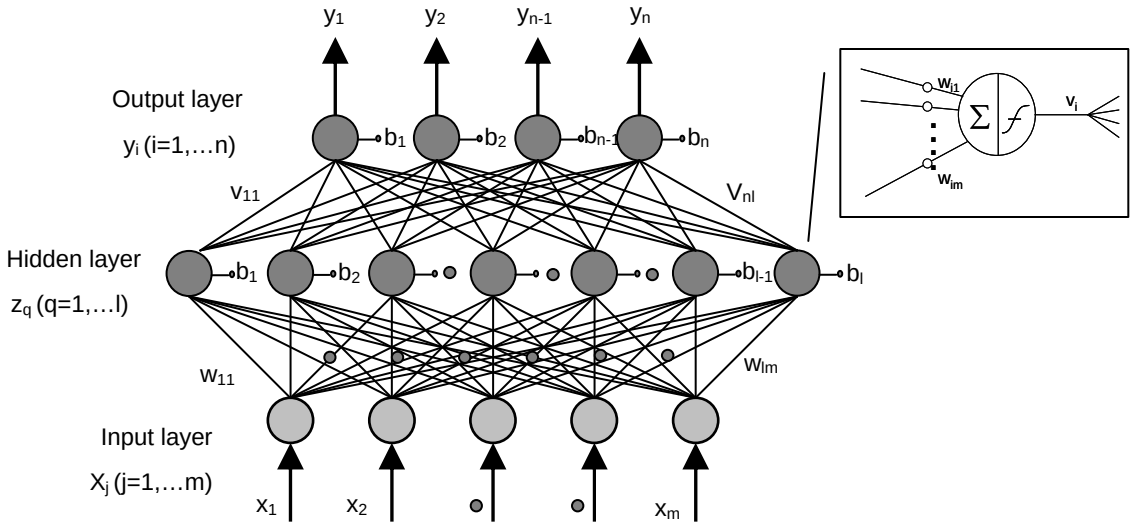


Figure 1 - 2 Typical neural network architecture

As shown in Figure 1-2, a typical neural network model consists of: (i) an input layer, where input data are presented to the network, (ii) an output layer, which comprises neurons representing target variables, and (iii) one or more hidden layers as an intermediate layer. The neural network has a parallel distributed architecture with a large number of nodes and connections with varying weights. Each node has a computation process: multiplying its weight by each input, summation of their product, and then using the non-linear transfer function it produces the actual output.

The commonly used back-propagation neural networks are trained by feeding data associated with input and target variables. The main objective of "training" the neural network is to update the connection weights to reduce the errors between the actual output values and target output values to a satisfactory level. This process is carried out through the minimization of the defined error function using update methods. Also, the determination of the number of hidden layers, number of hidden nodes, transfer functions, and normalization of data are considered to get the best performance of model. At the end of the training phase, the neural network represents a model that should be able to predict the target value given the

input pattern. After the errors are minimized, the associated trained weights of the model are tested with a separated set of "testing" data that was not used in training.

1.2.2 Fuzzy logic

Fuzzy logic is particularly useful in the development of expert systems. Expert systems are built by capturing the knowledge of humans: however, such knowledge is known to be qualitative and inexact. Experts may be only partially knowledgeable about the problem domain, or data may not be fully available, yet decisions are still expected. In these situations, educated guesses need to be made to provide solutions to problems. This is where fuzzy logic can be employed as a tool to deal with imprecision and qualitative aspects that are associated with problem solving.

A fuzzy set is a set without clear or sharp boundaries or without binary membership characteristics. Unlike a conventional set where the object either belongs or does not belong to the set, partial membership in a fuzzy set is possible. In other words, there is a 'softness' associated with the membership of elements in a fuzzy set. An example of a fuzzy set could be "the set of narrow streets in Raleigh." There are streets that clearly belong to the above narrow set, and others that cannot be considered as narrow. Since the concept of "narrow" is not precisely defined (for example, < 6.5 ft). There will be a "gray" zone in the associated set where the membership is not quite obvious. In a Venn diagram of Figure 1-3, we can see that part of the universe exists inside the circle that represents a set, while some of it exits outside that circle. If a red circle represents the set, some parts of it are pink and some parts are dark scarlet. In two-valued logic (by classical set), it's either red or it's not. Fuzzy set theory would allow areas of the Venn diagram to be darker or lighter shades of gray.

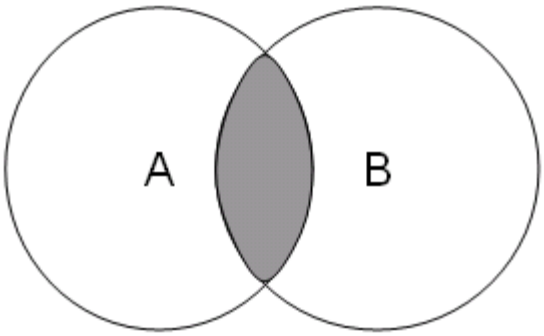


Figure 1 - 3 Venn diagram regarding to fuzzy set theory

A fuzzy set may be represented by a membership function. This function gives the grade (degree) of membership within the set. The membership function maps the elements of

the universe on to numerical values in the interval [0, 1]. For example, a fuzzy set on a numeric variable of height and temperature is represented as shown in Figure 1-4. The membership functions most commonly used in control theory are triangular, trapezoidal, Gaussian, generalized bell, sigmoidal and difference sigmoidal membership functions.

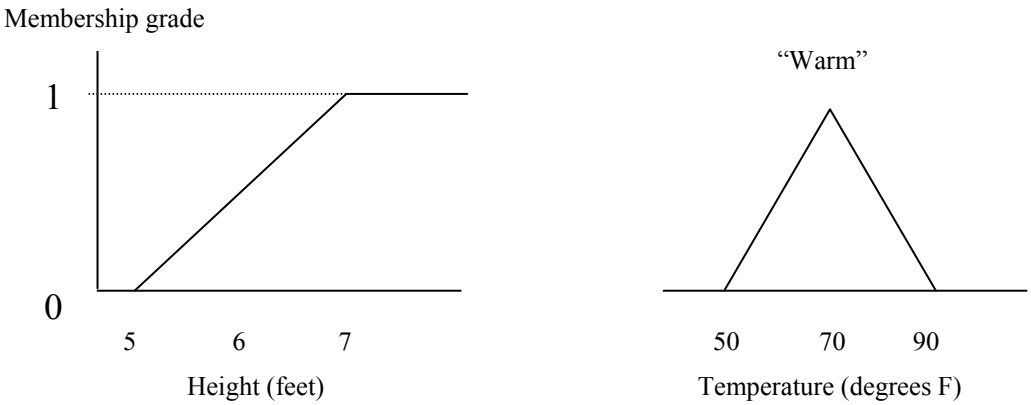


Figure 1 - 4 Fuzzy membership functions for height and temperature

One of the most interesting things about fuzzy logic is its ability to translate ordinary language into logical or numerical statements. It accomplishes this by use of the concept of the linguistic variable. For example, a label "tall" in the previous example is really a linguistic value for the numeric variable height. The very imprecision of linguistic variables makes them useful for reasoning. There are three main categories of linguistic variables: i) quantification terms-all most, many, few, and no, ii) usuality terms- always, seldom, and never, iii) likelihood terms-certain, possible, and certainly not.

1.2.3 ANFIS (Adaptive Neuro-Fuzzy Inference System)

A fuzzy system can be used to solve a problem if we have knowledge about the solution in the form of linguistic IF-THEN rules. Defining suitable fuzzy sets to represent linguistic terms used with these rules allows us to create the fuzzy system from these rules. A formal model of the problem of interest needs neither, nor training data. Fuzzy systems and neural networks are both model-free numerical estimators.

They share the ability to improve the predictive capability of a system working in uncertain, imprecise, and noisy environments. Fuzzy logic and neural networks are complementary technologies. In order to utilize the strengths of both, fuzzy systems and neural networks may be combined into an integrated system. The integrated system then has the advantages of both neural networks (e.g., learning abilities, optimization abilities, and connectionist structure) and fuzzy systems (e.g., humanlike 'if-then' rules, and ease of

incorporating expert knowledge available sometimes in linguistic terms). Because a neuron-fuzzy system is based on linguistic rules, we can easily integrate prior knowledge in to the system, and this can substantially shorten the learning process.

For the general problem of mapping of input variables $x = (x_1, x_2, .. x_n)^T$ to a single output variable y, a set of known data is first compiled. A fuzzy inference system (FIS) constitutes the basic tool for the process of mapping. FIS is then tuned with a back propagation algorithm based on a collection of input-output data resulting in an Adaptive Neuro-Fuzzy Inference System (ANFIS). A simple ANFIS architecture for two input variables and a single output is shown below.

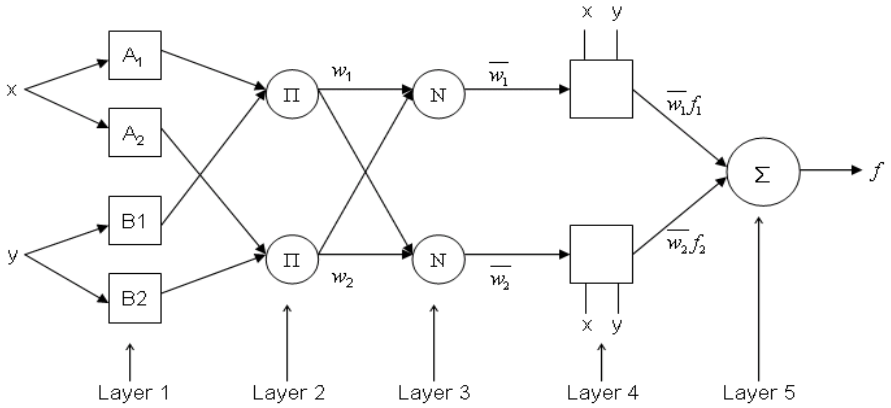


Figure 1 - 5 A simple ANFIS architecture

The input data are fed into layer 1. Layer 2 provides the value from membership function while layer 3 provides the product of incoming signals, which are normalized in layer 4. In layer 5 the values of the weighted consequents are computed. Finally the layer 6 performs the aggregation and provides the overall output, which is equated with the target value. Using a set of input-output data, and several iterations the above system is made to learn and update the membership parameters in layer 2. Thus with the final membership parameters optimized by back-propagation, the above trained model becomes available to make a prediction for a new set of input parameters.

1.3 This study

In this study, BPNN (Back Propagation Neural Network) models and ANFIS (Adaptive Neuro Fuzzy Inference System) models are developed for general pile analysis: i) Ultimate pile capacity with non-jetted and all data, ii) Pile setup, iii) Pile drivability (BPF, Maximum compressive stress, and Maximum tension stress). Databases for ultimate pile

capacity and pile setup have been developed from a variety of literature reviews. Their predictions are made using BPNNs as well as commonly used empirical methods; they are also compared with actual measurements for each application. For the pile drivability analysis, a database of a number of HP piles is developed from HP piles built at NC State using both GRLWEAP data and soil profile information (without PDA and CAPWAP analysis). All of the programs are developed within MATLAB with GUI (Graphical User Interface).

The objective of this study is to implement soft computing (BPNN and ANFIS) tools for a few important problems of pile design. This study presents that ANFIS and BPNN provide similar predictions (ANFIS being slightly better than BPNN), which are both better than those from empirical methods, and can serve as a reliable and simple tool for the prediction of ultimate pile capacity and pile setup. Also, BPNN for pile drivability analysis using five different ranges is developed which provide good predictions. BPNN may be considered to be more efficient than ANFIS as BPNN model trains much faster, while both provide equally good predictions. However ANFIS models will be more desirable for those problems in which one or more input variables may be available only in 'fuzzy' terms.

1.4 Outline

The outline of the presentation made in this report is as follows:

Chapter 1 – gives an introduction of pile problems, artificial neural network, fuzzy logic, and adaptive neuro fuzzy inference system. The objective and the outline of this study are also provided.

Chapter 2 – describes in some detail artificial neural network (especially, back-propagation neural network). This discusses typical artificial neural network architecture, processing neurons, and training procedure using optimization strategies. The elements of back-propagation neural network model and the general guidelines to find appropriate learning parameters are presented. With some simple benchmark problems the effects of sample size, hidden nodes, over fitting problem, superfluous factor, and other issues are studied. When evaluating performance of the model, correlation R^2, relative importance, and parametric study are used. The objective of this chapter is to provide some basic understanding of back-propagation neural network.

Chapter 3 – discusses ANFIS (Adaptive Neuro-Fuzzy Inference System), which is a combination of fuzzy logic and neural network. First, fundamental concepts of fuzzy sets,

fuzzy inference system, and ANFIS are presented. Four simple benchmark problems provide effects of number of membership functions, type of membership function, over fitting problem, superfluous factor, and so on. In the last section it is shown how useful ANFIS is compared to BPNN model in some cases.

Chapter 4 – deals with the application of BPNN and ANFIS for prediction of ultimate pile capacity with non-jetted data and all data including jetted data. Popular static formulae for calculating ultimate pile capacity are presented in the first section, and a database of a number (75) of field pile load tests obtained and compiled from the review of literature was developed. The detailed training and testing procedure as well as modeling results of BPNN and ANFIS were discussed. Then, pile capacity predictions were made using by BPNN and ANFIS as well as three empirical methods, and they were also compared with the actual results from measurements. These models are evaluated using correlation R^2, relative importance, and parametric study. The models are developed within MATLAB with GUI (Graphical User Interface) to combine both models for non-jetted data and for all data including some jetted data.

Chapter 5 – deals with the application of BPNN and ANFIS for prediction of pile setup. Pile setup phenomenon and empirical methods topredict them are first introduced. A database of a number (96) of field tests is developed from the available literature, and six variables are selected as input for both BPNN and ANFIS. One different input variable is roughness volume for ANFIS, and pile type for BPNN. Target variable is the increased pile capacity (ΔQ_{BOR}). The ultimate pile capacities (the sum of pile capacity at End of Drive (Q_{EOD}) and the pile capacity increase by setup at Beginning of Restrike (ΔQ_{BOR})) by BPNN and ANFIS are compared with those from four empirical relationships. ANFIS predictions are also compared with BPNN predictions.

Chapter 6 – deals with the application of BPNN for prediction of pile derivability.
Current practice for the evaluation of pile drivability and general wave propagation analysis for pile is presented first. A database of a number (4,017) of HP piles is developed from the data of HP piles from 57 projects in the State of North Carolina (with both GRLWEAP data and soil profile information, and without PDA and CAPWAP analysis). Twenty-one variables are chosen as input to predict three target variables. The database is divided into five groups with respect to ultimate pile capacity range. Stroke values are used as an input having ranges 5 to 11 ft based on an open-run database of GRLWEAP. To demonstrate the feasibility of BPNN (back-propagation neural network model) 25 cases are predicted by the

developed BPNN, and the results are compared to GRLWEAP calculations derived from the built piles in North Carolina.

Chapter 7 – includes the summary of the accomplished works, conclusions, and future works.

Chapter 2 Neural Network Model

2.1 Introduction

Neural networks are soft computing approaches to modeling. The main objective is to mimic the actions of an expert who solves complex problems. This does not attempt to model the problem by creating a mathematical model that follows some physical laws. Rather, we examine how an expert deals with the problem, and try to make use of our observations.

Let's consider how children learn to ride to a bicycle. They do not derive a lot of differential equations describing the physical dynamics of the bike, solving them every other instant to calculate the necessary actions to ride it. Instead, they probably observe someone who is already able to ride a bike, and receive some tips on how to do it from their parents. Then they just try it and learn how successfully to stay on the bike by trial and error. Finally, after some training they become skillful bicycle riders. In other words, without examining the problem in detail there are three important aspects to solve the problems: observation, instruction, and learning (Nauck.et.al, 1997).

A first interest in neural networks (or parallel distributed processing) emerged after the introduction of simplified neurons by McCulloch and Pitts in 1943. These neurons were presented as models of biological neurons and as conceptual components for circuits that could perform computational works. ANNs (Artificial Neural Network) can be most adequately characterized as 'computational models' with particular properties such as the ability to adapt or learn, to generalize, or to cluster or organize data, in which operation is based on parallel processing.

ANNs have a large number of highly interconnected processing elements (nodes or units) that usually operate in parallel and are configured in regular architectures. The collective behavior of an ANN, like a human brain, demonstrates the ability to learn, recall, and generalize from training patterns or data. ANNs are inspired by modeling networks of biological neurons in the brain. Hence, the processing elements in ANNs are also called artificial neurons.

2.2 A framework for an artificial network

An artificial network consists of a set of simple processing units (neurons) that communicate by sending signals to each other over a large number of weighted connections. A framework for artificial neural network models can be distinguished as processing units, activation functions, connections between units, external input(or bias), learning rule (Rumelhart and McCleland, 1986).

2.2.1 Processing units

Figure 2-1 shows a simple mathematical model of the artificial neuron proposed by McCulloch and Pitts (1943). In this model, the processing element computes a weighted sum of its inputs and outputs according to whether this weighted input sum is above or below a certain threshold θ_i. The computation in the *i*th neuron can be expressed as:

$$y_i(t+1) = a\left[\sum_{j=1}^{m} w_{ij} x_j(t) - \theta_i\right] \tag{2.1}$$

where, t is the time instants

m is the number of the inputs to the *i*th neuron

y_i is output from the *i*th neuron.

The transfer function *a(f)* is a binary step function:

$$a(f) = \begin{Bmatrix} 1 & if\ f \geq 0 \\ 0 & otherwise \end{Bmatrix} \tag{2.2}$$

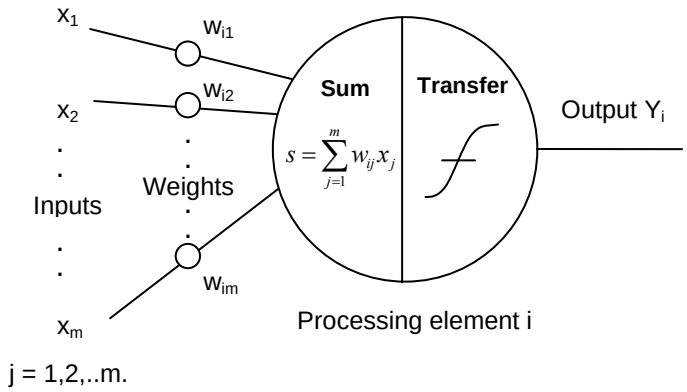


Figure 2 - 1 An artificial neuron

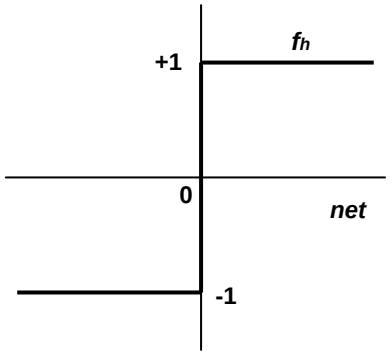
The strength of the synapses connecting input variable j to neuron i are represented as the weight w_{ij}. A positive weight corresponds to an excitatory synapse, and a negative weight corresponds to an inhibitory synapse. If $w_{ij} = 0$, then there is no connection between the two neurons.

As a summary, each unit performs a relatively simple job: receive input from neighboring neurons or external sources and use this to compute an output signal, which is propagated to other units. This is associated with the input of a PE (Processing Element), which is an integration function *f* that serves to combine information, activation. Within the neural system we can distinguish three types of units: input units that receive data from

outside the neural network, output units that send data out of the neural network, and hidden units whose input and output signals remain within the neural network. An ANN is a parallel distributed information processing structure (Fausett, 1994 and Lin & Lee, 1996).

2.2.2 Activations and output rules

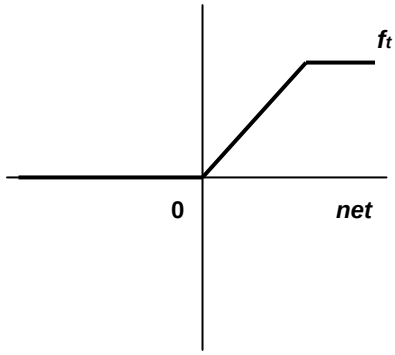
A new rule is required to give the effect of the total input on the activation of the unit. The simplest node takes the sum of the weighted inputs and passes the results through nonlinear functions as shown in Figure 2-2. The activation function defines the output of a neuron in terms of the activity level at its input. The node is characterized by an internal threshold *i* and by the type of nonlinear activation function, which include hard limiters, threshold logic elements, and sigmoidal nonlinearities (Lippmann, 1987).



$f = 1 \quad net > 0$

$f = -1 \quad net < 0$

(a) hard-limiter

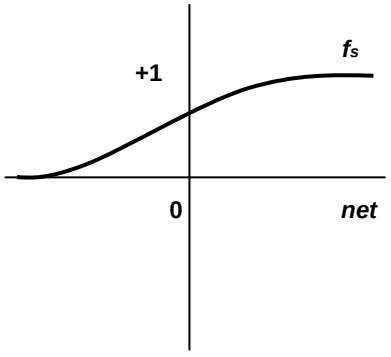


$f = 1 \quad net > 1$

$f = net \quad 0 \le net \le 1$

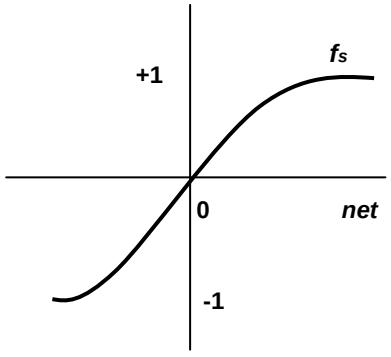
$f = 0 \quad net < 0$

(b) threshold logic



$$f = \frac{1}{1 + \exp(-\alpha net)}$$

(c) Log sigmoid



$$f = \tanh(\alpha net)$$

(d) Hyperbolic tangent sigmoid

Figure 2 - 2 Typical activation functions

2.2.3 Learning rule

Another important element in specifying a neural network is the learning rules. The definition suggested by Herbert Simon (1983) is based on the notion of change:

> *Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the same task or tasks drawn form the same population more efficiently and more effectively the next time*.

Generally speaking, learning is the process by which the neural network adapts itself to a stimulus, and after making the proper parameter adjustments to itself, it produces a desired response. During the process of learning, the network adjusts its parameters, synaptic weights, in response to an input stimulus so that its actual response converges to the desired output response. There are two categories of learning rules:

- Supervised learning: Associative learning in which the network is trained by providing it with input and correlating output patterns. These input-output pairs can be provided by an external teacher, or by the system that contains the network.

- Unsupervised learning: Self-organization in which an output unit is trained to respond to clusters of pattern within the input. In this paradigm the system is supposed to discover statistically salient features of the input population. Unlike the supervised learning paradigm, there is no feedback from the environment to indicate what the desired outputs of a network should be or whether they are correct; rather the system must develop its own representation of the input stimuli.

2.2.4 A network of one layer of neurons

The architecture for a network that consists of a layer of M perceptrons is shown in Figure 2-3. An input feature vector $x = (x_1, x_2, \cdots, x_n)$ is applied to the network via a set of *n* nodes. Each perceptron receives an input from each component of x at each neuron; the lines fan in from all of the input nodes. Each incoming line is weighted with a synaptic weight form the set $\{w_{mn}\}$, where w_{mn} weights the line from the *n*th component x_n coming into the *m*th neuron. Then, the calculated output values, $Y = (Y_1, Y_2, \cdots, Y_m)$, are compared with targets values ($T = (Ts_1, Ts_2, \cdots, Ts_m)$).

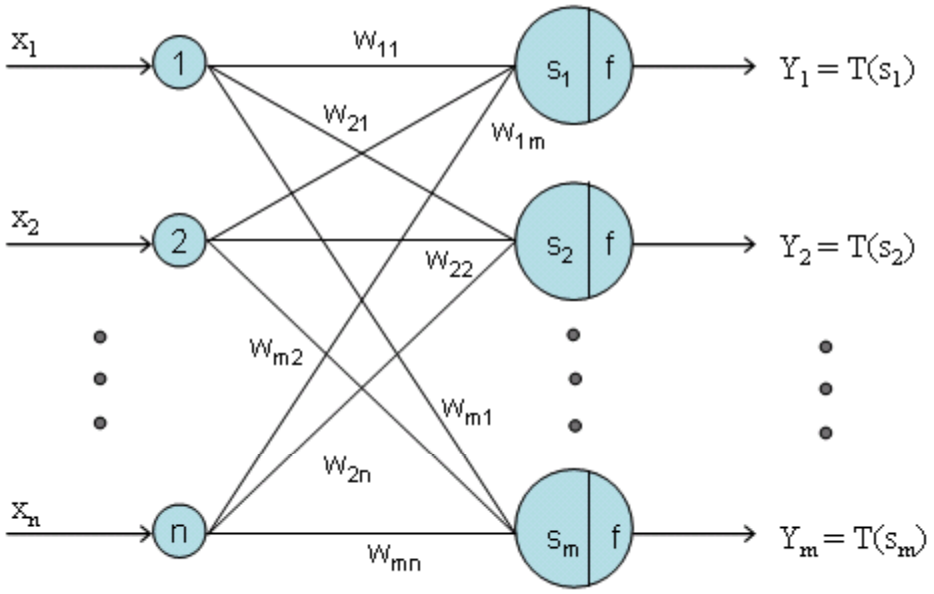


Figure 2 - 3 A network of single layer of neurons

2.3. Multilayer feedforward artificial neural network

2.3.1 Feedforward networks of layered neurons

Minsky and Papert (1969) showed that a two layer feed forward network can overcome many restrictions, but did not present a solution to the problem of how to adjust the weights from input to hidden units. An answer to this question was presented by Rumelhart, Hinton and Williams (1986). The main idea behind this solution is that the errors for the units of the hidden layer are determined by back-propagating the errors of the units of the output layer. For this reason the method is called back-propagation learning algorithm. The back-propagation algorithm has been widely used as a learning algorithm in feedforward multilayer neural networks. The BPNN is applied to feedforward neural networks with one or more hidden layers, as shown in Figure 2-4.

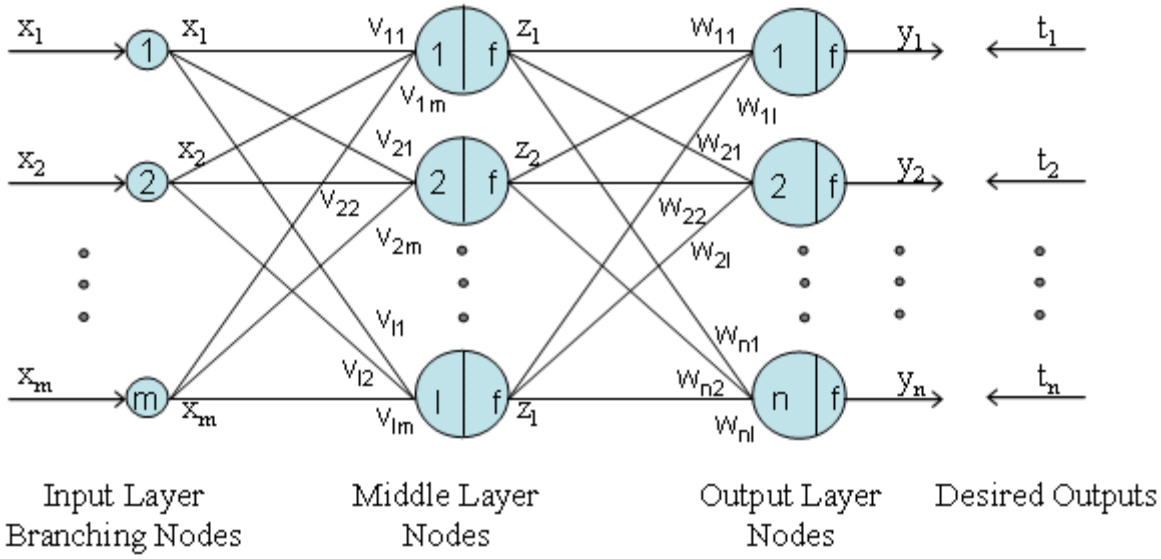


Figure 2 - 4 A typical feed-forward artificial neural network

2.3.2 Back-propagation algorithm

The back-propagation algorithm performs two steps of data flow. The first step is that the inputs are ordinarily propagated forward from input to output layer, then followed by the production of the actual output. The error from the differences between the target values and the actual values are propagated backwards from output layer to the previous layers in order to update their weights.

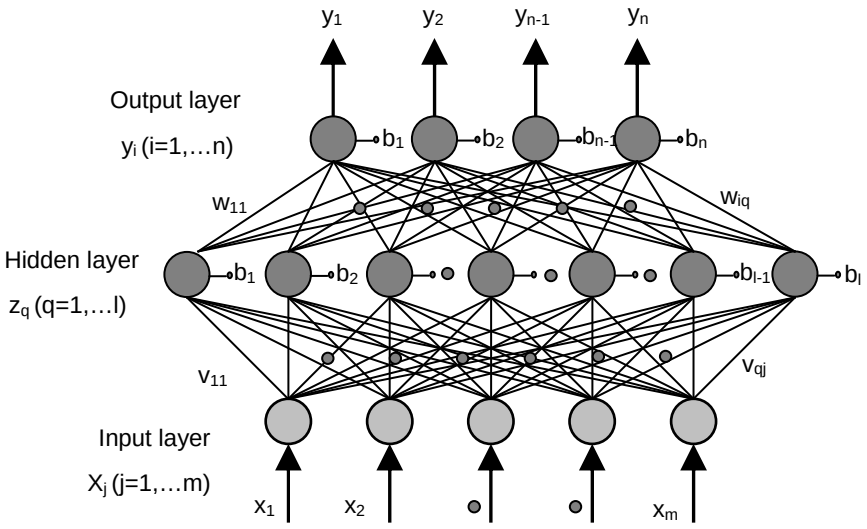


Figure 2 - 5 Three layer back-propagation neural network

Feed-forward propagation

In Figure 2-5, there are *m* nodes in the input layer, *l* nodes in the hidden layer, and *n* nodes in the output layer. Given an input pattern *x*, a node *q* in the hidden layer receives a net input of

$$net_q = \sum_{j=1}^{m} v_{qj} x_j \tag{2.3}$$

and produces an output of

$$z_q = a(net_q) = a\left(\sum_{j=1}^{m} v_{qj} x_j \right) \tag{2.4}$$

The net input for a node i in the output layer is then

$$net_i = \sum_{q=1}^{l} w_{ij} z_q = \sum_{q=1}^{l} w_{iq}\ a\left(\sum_{j=1}^{m} v_{qj} x_j \right) \tag{2.5}$$

and it produces an output of

$$y_i = a(net_i) = a\left(\sum_{q=1}^{l} w_{ij} z_q \right) = a\left(\sum_{q=1}^{l} w_{ij} a\left(\sum_{j=1}^{l} v_{ij} x_j \right) \right) \tag{2.6}$$

Back- propagation and error signals

First, define the error function as:

$$E(W) = \frac{1}{2} \sum_{i=1}^{n} (d_i - y_i)^2 = \frac{1}{2} \sum_{i=1}^{n} \left[d_i - a(net_i) \right]^2$$

$$= \frac{1}{2} \sum_{i=1}^{n} \left[d_i - a\left(\sum_{q=1}^{l} w_{ij} z_q \right) \right]^2 \tag{2.7}$$

by using gradient descent method, the weights in the hidden to output connections are updated as:

$$\Delta w_{iq} = -\eta \frac{\partial E}{\partial w_{iq}} \tag{2.8}$$

where, η is learning rate

Combining Eqs. (2.5)-(2.7) and using chain rule, we now have

$$\Delta w_{iq} = -\eta \left[\frac{\partial E}{\partial y_i}\right]\left[\frac{\partial y_i}{\partial net_i}\right]\left[\frac{\partial net_i}{\partial w_{iq}}\right] = \eta[d_i - y_i][a'(net_i)][z_q] = \eta\, \delta_{oi}\, z_q \qquad (2.9)$$

Here we define δ_{oi} as the error signal and its double signal *oi* means the *i*th node in the output layer.

$$\delta_{oi} = -\frac{\partial E}{\partial net_i} = -\left[\frac{\partial E}{\partial y_i}\right]\left[\frac{\partial y_i}{\partial net_i}\right] = [d_i - y_i][a'(net_i)] \qquad (2.10)$$

For the weight updating on the input to hidden connections, the chain rule and gradient descent method can be used to obtain the weight updating on the link connecting node *j* in the input layer to the node *q* in the hidden layer,

$$\Delta v_{qj} = -\eta\left[\frac{\partial E}{\partial v_{qj}}\right] = -\eta\left[\frac{\partial E}{\partial net_q}\right]\left[\frac{\partial net_q}{\partial v_{qj}}\right]$$

$$= -\eta\left[\frac{\partial E}{\partial z_q}\right]\left[\frac{\partial z_q}{\partial net_q}\right]\left[\frac{\partial net_q}{\partial v_{qj}}\right] \qquad (2.11)$$

From Eq.(2.7), it can be seen that each error term is a function of z_q, by evaluating the chain rule, we have

$$\Delta v_{qj} = \eta \sum_{i=1}^{n}[(d_i - y_i)a'(net_i)w_{iq}]a'(net_q)x_j \qquad (2.12)$$

By using Eq.(2.10), the above equation can be rewritten as:

$$\Delta v_{qj} = \eta \sum_{i=1}^{n}[d_{oi}w_{iq}]\, a'(net_q)\, x_j = \eta\, \delta_{hq}\, x_j \qquad (2.13)$$

where δ_{hq} is the error signal of node *l* in the hidden layer, which can be defined as:

$$\delta_{hq} = -\frac{\partial E}{\partial net_q} = -\left[\frac{\partial E}{\partial z_q}\right]\left[\frac{\partial z_q}{\partial net_q}\right] = a'(net_q)\sum_{i=1}^{n}\delta_{oi}w_{iq} \qquad (2.14)$$

where net_q is the net input to the hidden node *q* calculated by Eq.(2.3). From Eq.(2.10) and Eq.(2.14) the error signal of a node in the hidden layer is different form the error signal of a node in the output layer. Also, the error signal δ_{hq} of a hidden node *q* can be determined in terms of the error signals δ_{oi} of the node, y_i, that it feeds. In general, with an arbitrary number of layers, the back-propagation update rule is in the form:

$$\Delta w_{ij} = \eta\, \delta_i\, x_j = \eta\, \delta_{output-i}\, x_{input-j} \qquad (2.15)$$

where output i an input j refer to the two ends of the connection from node o to node i and from node i to node j, x_j is the proper input end activation from a hidden node or an external input and δ_i is the learning signal which is defined by Eq.(2.14) for all the other layers. If the hyperbolic tangent sigmoid transfer function is used as the activation function, the Eq.(2.10) and (2.14) becomes,

$$\delta_{oi} = \frac{1}{2}(1 - y_i^2)[d_i - y_i] \tag{2.16}$$

and

$$\delta_{hq} = \frac{1}{2}(1 - z_q^2)\sum_{i=1}^{n} \delta_{oi} w_{iq} \tag{2.17}$$

BPNN Learning Algorithm: Summary

Consider a network with Q feed-forward layers and let ${}^{q}net_i$ and ${}^{q}y_i$ denote the net input and output of the ith unit in the qth layer, respectively. The network has m input nodes and n output nodes. Let ${}^{q}w_{ij}$ denote the connection weight from ${}^{q-1}y_j$ to ${}^{q}y_j$,

A set of training pairs $\left\{\left(x^{(k)}, d^{(k)}\right) \middle| k = 1, 2, ..., p\right\}$ is used as basic input, where the input vectors are augmented with the last elements as -1, i.e. $x_{m+1}^{k} = -1$. the learning is achieved in following phases:

Phase 1 (initialization): choose η>0 and $E_{\max}$. Initialize the weights to small random values.
Phase 2 (training): Apply the kth input pattern to the input layer

$${}^{q}y_i = {}^{1}y_i = x_i^k \text{ for all } i. \tag{2.18}$$

Phase 3 (forward propagation): Propagate the signal forward through the network by

$$\text{using } {}^{q}y_i = a({}^{q}net_i) = a\left(\sum_j {}^{q}w_{ij}^{q-1} y_j\right) \tag{2.19}$$

Phase 4 (Error measure): compute the error value and error signals ${}^{Q}\delta_i$ for the output layer:

$$E = \frac{1}{2}\sum_{i=1}^{n}\left(d_i^k - {}^{Q}y_i\right)^2 + E \tag{2.20}$$

$${}^{Q}\delta_i = (d_i^k - {}^{Q}y_i)a'({}^{Q}net_i) \tag{2.21}$$

Phase 5 (Error back-propagation): Propagation the errors backward to update the weights and compute the error signals ${}^{q-1}\delta_i$ for the preceding layers:

$$\Delta^q w_{ij} = \eta^q \delta_i^{q-1} y_j \text{ and } {}^q w_{ij}^{new} = \Delta^q w_{ij}^{old} + \Delta^q w_{ij} \quad (2.22)$$

$${}^{q-1}\delta_i = a'({}^{q-1}net_i)\sum_j {}^q w_{ij}\,{}^q\delta_j \quad \text{for q = Q, Q-1, ……,2.} \quad (2.23)$$

Phase 6 (One epoch looping): Check whether the whole set of training data has been cycled once. If k<p, then $k = k+1$ and go to phase 1; otherwise, go to phase 6.

Phase 7 (Total error checking): Check whether the current total error is acceptable: if $E < E_{\max}$, then terminate the training process and output the final weights; otherwise, E=0, k=1, and initiate the new training epoch by going to phase 1.

2.3.3 The elements of BPNN (back-propagation neural network)

Number of hidden layers

In order to design a good neural network model, the number of hidden layers is needed as one of the first concerns. It is currently known that there is no need to have more than two hidden layers, as there is no improvement in the results with more hidden layers. A rule of thumb in the NN field is to try a single hidden layer model first. However, for some problems a small network with two hidden layers can be used where a network with one hidden layer would require an infinite number of nodes. With a very large number of hidden nodes, the training is more difficult because of the large number of local minima for which directions of local steepest descent are very different from the actual directions of the minima. In this case, it requires a large volume of computations to find a good starting weight set, or else many training runs may be required to obtain satisfactory learning. To simply matters, a second hidden layer of nodes between the first hidden layer and the output layer is utilized (Kecman, 2001, Master, 1993, and Chester, 1990).

Looney(1997) explained how extra hidden layers can be more efficient in training and modeling highly nonlinear mapping with a large number of nonlinearly separable classes. For example, if there were k=50 classes that were separable only nonlinearly, but with four subclasses of each class that were linearly separable, then we could use any number of hidden nodes (200) in the hidden layer. On the other hand, we may choose to try a number of hidden nodes (20) in the first hidden layer and 10 nodes in the second hidden layer. This reduces the total number of hidden neurons from 200 to 30, because 200 = 20*10 separations

can be made. A second hidden layer reduces the total number of weights and nodes significantly, and the use of two hidden layers of nodes often accelerates learning.

Number of hidden nodes

Both the number of input components and the number of output neurons is in general determined by the nature of the problem. The approximation capabilities of a neural network are primarily determined by the number of hidden nodes. Thus, it is extremely important to choose an appropriate number of hidden neurons in the design of a neural network model. For smooth functions only a few number of hidden nodes are needed, for wildly fluctuating functions more hidden nodes are required. Having too few hidden units, may result in high training error because the resources of the network are not optimal to solve the problem. Also, having an excessive number of hidden neurons may cause a low training error but still have high testing error due to overfitting, which may in turn increase training time. Too many hidden nodes cause training-set error to be low but high testing set error. This problem is called *overfitting*. Overfitting is dangerous since it can lead to predictions that are beyond the range of the training data with many common types of neural networks. The best way to avoid overfitting is to use a lot of training data. Typically it is a reasonable choice to use at least 10 times as many training cases as input variables (Smith, 1996, and Bailey & Thomson, 1990). Figure 2-6 illustrates that a large number of hidden nodes leads to a small error on the training set but not necessarily to a small error on the test set. Adding hidden nodes will always lead to a reduction of the error rate of training. However, adding hidden nodes will first lead to a reduction of the error rate of the test, but then lead to an increase of the error rate of test. This effect is called the peaking effect.

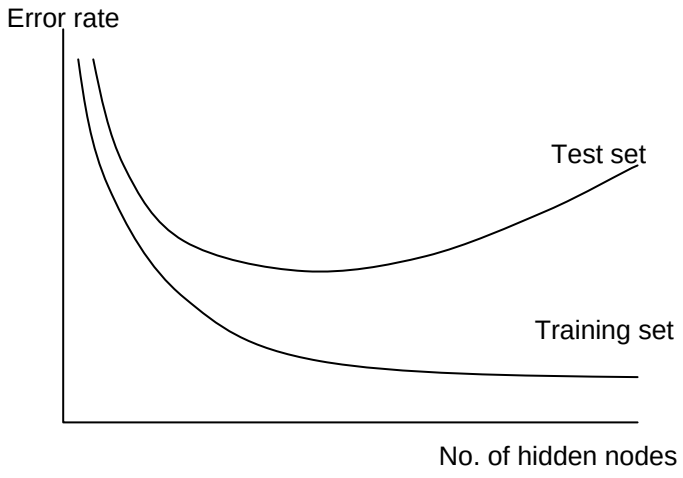


Figure 2 - 6 Average error rate as a function of number of hidden nodes (training, testing)

There are some guidelines to choose the number of hidden neurons for neural networks based on some references (Lin & Lee, 1996, and Master, 1993). A reasonable choice of the number of hidden neurons can be calculated within the range of Eqs.(2.24) and (2.25).

$$N_{H(\min)} = \sqrt{m * n} \tag{2.24}$$

$$N_{H(\max)} = m \tag{2.25}$$

where, $N_{H(\min)}$ = Minimum no. of hidden nodes

$N_{H(\max)}$ = Maximum no. of hidden nodes

m = No. of Input variables

n = No. of Output variables

Total Summed Square Error (SSE) and Mean Square Error (MSE)

Sum square error is a measure of accuracy, used in BP and some other network training procedures; it is calculated by squaring each error, then summing the squares. To lead each actual output $\mathbf{y_i}$ (i=1,…,n) toward the correct output target $\mathbf{t}_{(i)}$ we adjust the weights so as to minimize the total sum-squared error, E, between the targets and the actual outputs. The E is evaluated via the Euclidean distance

$$E = \sum \left\| t_i - z_i \right\|^2 \tag{2.26}$$

The total mean-squared error is

$$\overline{E} = E / n l \tag{2.27}$$

Considering E = E (v, w) to be the function of the weights $\mathbf{v} = (v_{11}, ..., v_{qj})$ and $\mathbf{w} = (w_{11}, ..., w_{iq})$, we have

$$E(v,w) = \sum_{q=1}^{l} \left(\sum_{i=1}^{n} \left[t_j^{(i)} - g\left(\sum_{q=1}^{l} w_{iq} h\left(\sum_{j=1}^{m} v_{qj} x_j^{(i)} \right) \right) \right]^2 \right) \tag{2.28}$$

This function is nonnegative, continuously differentiable in weight space $\{[-b,b]^{ml+ln}$; $b \geq 1\}$, which is a finite-dimensional closed bounded domain that is complete and thus compact. Therefore, E (w,u) assumes its minimizing point (w*, u*) in the weight domain. This does not mean that the sum-squared error E will be zero at the solution weight set (v*, w*), but only that it takes on its minimum value there. If the target values $\{t^{(i)}\}$ are chosen wisely to be far apart, then the maximum mapping will successfully recognize the input feature vectors by mapping them to their class identifiers.

To solve for the minimizing weight set (v*, w*), the following conditions should be fulfilled

$$\frac{\partial E}{\partial v_{qj}} = 0;\ \frac{\partial E}{\partial w_{iq}} = 0 \tag{2.29}$$

These nonlinear equations can be solved iteratively with steepest descent or using a second order optimization procedure such as the Levenberg-Marquardt method (Kecman, 2001).

Error Function Minimization Procedures

Optimization theory and its different techniques are used to find the values of a set of parameters (here called weights) that minimize or maximize some error or cost the function of interest. The name *error* or *cost function*, stands for a measure of how good the solution is for a given problem. This measure is also called *performance index* or *risk*. The problem of learning some underlying function (mapping) boils down to the estimation (identification) of the weights of neural networks. Therefore, the theory of optimization (linear or nonlinear) is of crucial importance for understanding the overall *learning process* of neural networks (or more general soft models). The optimization problem may be approached in various ways. The fact that there are many different procedures is helpful. However, as with any other tool, unless we understand its purpose and how to apply it, it will not be of much use. Only two optimization methods are presented briefly here, from among they myriad of those available.

Gradient descent method

This algorithm looks for the minimum of the error function in weight space using most commonly the first-order gradient descent. To find a local minimum w_{lc} for a nonlinear real valued function y = f (**w**), we put:

$$\frac{df(w)}{dw} = 0 \tag{2.30}$$

And solve for $w = w_{lc}$. However, in the general case of nonlinear $f(\cdot)$ we can only find an approximate solution w_{app} to w_{lc} by iterative methods. Starting from an initial point w_0, we move a step in the direction of steepest descent to $w_1 = w_0 - df(\mathbf{w})/dw$, which is opposite to the direction of steepest ascent. Note that the direction is either positive or negative along the w axis. Figure 2-7 shows the first step. For the iterative (r + 1) step we have

$$w_{(r+1)} = w_r - \eta\left(df(w_r)/dw\right) \tag{2.31}$$

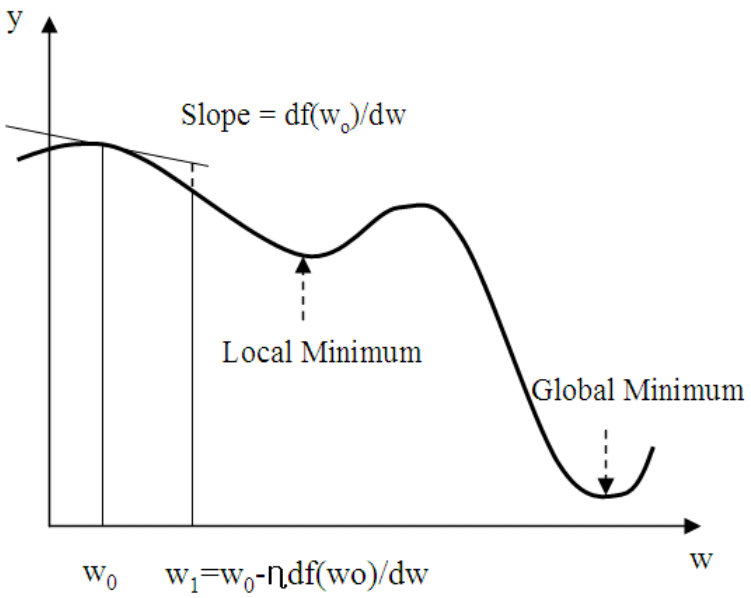


Figure 2 - 7 Search on the error surface along the gradient

The *step gain* (or *learning rate*) $\eta > 0$ amplifies or attenuates the step size. If the step were too large, then it would move past the local minimum, while if it were too small, a large number of steps might not yet reach the local minimum. In Figure 2-8, where y= f(w_1, w_2), the gradient is the vector of partial derivatives

$$\nabla f(w_1, w_2) = (\partial f(w_1, w_2)/\partial w_1, \partial f(w_1, w_2)/\partial w_2) \tag{2.32}$$

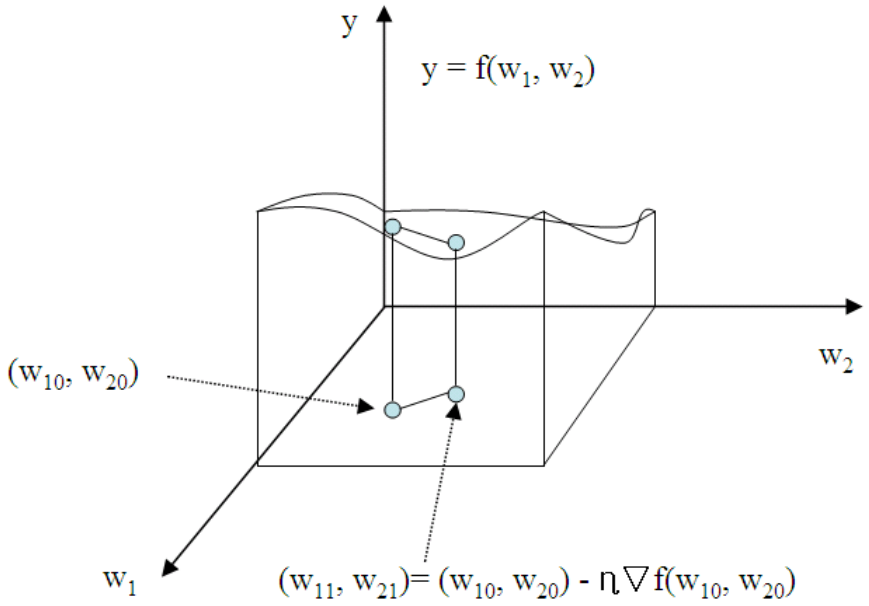


Figure 2 - 8 Two-dimensional steepest descent

A function $y = f(w_1, ..., w_p)$ of several variables can be locally minimized in an analogous manner. The iterative updates to approximate a solution in the general case are:

$$\left(w_1,...,w_p\right)_{r+1} \leftarrow \left(w_1,...,w_p\right)_r - \eta\left(\frac{\partial f\left(w_1,...,w_p\right)}{\partial w_1},...,\frac{\partial f\left(w_1,...,w_p\right)}{\partial w_p}\right) \tag{2.33}$$

In vector form

$$w_{(r+1)} = w_r - \eta\nabla f\left(w_r\right) \tag{2.34}$$

This equation is linear in **w** and provides a piecewise linear approximation for an adjustment to move w_r toward a local minimum.

Newton method

The above can be greatly improved using second order information, which uses the curvature as well as the gradient of the error surface. Using Taylor's series expansion on E(w) around the current w_o, it can be calculated.

$$E(w) = E(w_0) + (w - w_o)^T \nabla E(w_o) + \frac{1}{2}(w - w_o)^T H(w)(w - w_o) + \cdots \tag{2.35}$$

H(w) is called a Hessian matrix and is the second derivative evaluated w_o;

$$H(w) = \nabla^2 E(w) \tag{2.36}$$

Even though we need all the higher terms of the derivatives of E, normally the first term and second term of the expansion are concerned since the performance surface tends to be bowl shaped(quadratic) near the minimum. To find the minimum of E(w), we set its gradient to zero.

$$\nabla E(w) = \nabla E(w_o) + H(w)(w - w_o) + \cdots = 0. \tag{2.37}$$

$$w = w_o - H^{-1}(w)\nabla E(w_o) \tag{2.38}$$

or at *k* th step of learning,

$$w_{k+1} = w_k - H^{-1} g_k \tag{2.39}$$

This is called Newton's method of weight updating.

The most used error function is a sum of error squares function, given as

$$E(w) = e(w)^T e(w) \tag{2.40}$$

Because e(w) is usually a differentiable function of the weights w, the matrix of the first derivatives can be expressed as

$$J(w_{ij}) = \left(\frac{\partial e_i}{\partial w_j} \right) \tag{2.41}$$

which is known as the Jacobian matrix. A matrix of second derivatives is the Hessian matrix H. It is interesting to express both the gradient and the Hessian of $E(w) = e(w)^T e(w)$ in vector notation. Thus, differentiating $E(w) = e(w)^T e(w)$, one obtains

$$g = \nabla E(w) = E_w = 2J^T e \tag{2.42}$$

$$H = E_{ww} = 2J^T J + 2\frac{\partial J^T}{\partial w} e \tag{2.43}$$

Gauss-Newton method

The Gauss-Newton method usually assumes that the errors e_i are small numbers. With such an assumption the second term on the right hand side of Eq.(2.43) can be neglected, meaning that the Hessian can be approximated as

$$H_a \approx 2J^T J \tag{2.44}$$

$$w_{k+1} = w_k - H_{ak}^{-1} g_k = w_k - (2J^T J)^{-1} 2J^T e = w_k - (J^T J)^{-1} J^T e \tag{2.45}$$

It uses a matrix of first derivatives **J** to calculate a matrix of second derivatives **H**. The Gauss-Newton method can also diverge if the Jacobian **J** loses rank during the iterations, and because of possible problems a further modification is proposed.

Levenberg-Marquardt method

Very often the neglected error e_i is not small and the second-order term on the right hand side of Eq.(2.43) cannot be ignored. In this case, the Gauss-Newton method converges very slowly or diverges. Hence, it may be better to use the full Hessian matrix H. The Levenberg-Marquardt method avoids the calculation of the Hessian matrix H and uses the regularization approach when the matrix $J^T J$ is rank-deficient. Levenberg-Marquardt proposed the following iteration scheme:

$$w_{k+1} = w_k - (J^T J + \lambda_k I)^{-1} J^T e \tag{2.46}$$

where, λ_k is a scalar that may be adjusted to control the sequence of iterations, and I is an identity matrix. Note that Eq.(2.46) approaches the steepest descent as λ_k is increased because $J^T J + \lambda_k I \approx \lambda_k$ I, thus;

$$w_{k+1} = w_k - \frac{1}{\lambda_k} J^T e = w_k - \frac{1}{2\lambda_k} g_k = w_k - \eta_k g_k \tag{2.47}$$

When λ_k approaches zero, the Levenberg-Marquardt algorithm tends to the Gauss-Newton method. An example of a non-quadratic error surface is shown in Figure 2-9.

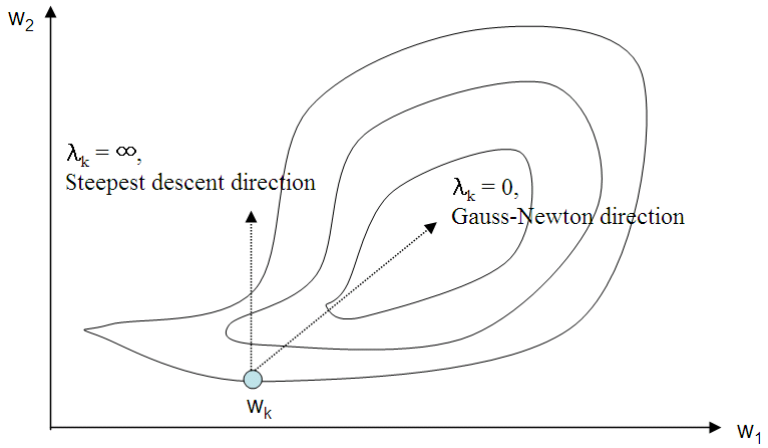


Figure 2 - 9 Levenberg-Marquardt descent directions

Therefore, Levenberg-Marquardt method involves "blending" between Gradient descent and the Gauss-Newton method.

Normalization

Neural network training can be made more efficient if certain preprocessing steps are performed on the network inputs and targets. Before training, it is often useful to scale the inputs and targets so that they always fall within a specified range. The available data for each variable are scaled to the same range (between 0 to 1), so as to remove any bias from the combination of its influence. Normalization often refers to scaling by the minimum and range of the variable such that all the variables have values between 0 and 1 as defined in Eq. (2.48).

$$V^p{}_{norm} = \frac{V^{p(i)} - V^i{}_{\min}}{V^i{}_{\max} - V^i{}_{\min}} \tag{2.48}$$

where

$V^i_{\max}$ = maximum in the data set of the input vector V^i (i^{th}),
$V^i_{\min}$ = minimum in the data set of the input vector V^i (i^{th}),
$V^{p(i)}$ = input (p^{th}) value in the vector V^i (i^{th}).

2.4 Evaluation of the Model

2.4.1 Correlation R^2

The best choice of (w, b) such that the fitted line passes the closest to all the points needs to be estimated. Least square method solves the problem of fitting a line to data by obtaining the line for which the sum of the square derivations is minimized. The fitted points in the line will be denoted by $\hat{d}_i = w\ x_i + b$ with approximated values of d_i. Mean square error, which is the average sum of square errors, is a widely used performance criterion.

$$J = \frac{1}{2N}\sum_{i=1}^{N}(d_i - \hat{d}_i)^2 \tag{2.49}$$

where N : number of the samples.

We can get the minimization of J by taking its partial derivative as in the following equations;

$$\frac{\partial J}{\partial w} = 0\,,\ \frac{\partial J}{\partial b} = 0\,. \tag{2.50}$$

In equation (50), we substitute the value of the error given by $\hat{d}_i = w\ x_i + b$ and take the derivative of equation (51), and finally we can obtain equation (52) and (53). Also slope(w) and intercept(b) of the fitted line can be estimated.

$$\frac{\partial J}{\partial b} = \frac{1}{2N}\sum_i \frac{\partial (d_i - w x_i - b)^2}{\partial b}\,.$$
$$= -\sum_i \frac{1}{N}(d_i - w x_i - b) \quad = 0 \tag{2.51}$$

$$\frac{\partial J}{\partial w} = \frac{1}{2N}\sum_i \frac{\partial (d_i - w x_i - b)^2}{\partial w}\,.$$
$$= \sum_i \frac{1}{N}(d_i - w x_i - b)x_i \quad = 0 \tag{2.52}$$

The above procedure to determine the coefficients of the line is called the least square method. We still need to find a measure of how successfully the regression line

represents the true relationship even if mean square error can be used to determine which line best fits the data. The coefficient of determination R^2 can be used to find the adequacy of a fitted line, the relationship between the approximated value (d_i), and the fitted points ($\hat{d}_i$).

$$R^2 = 1 - \frac{J}{S} = 1 - \frac{\sum_{i=1}^{N}(\hat{d}_i - d_i)^2}{\sum_{i=1}^{N}(\hat{d}_i - \overline{d_i})^2} \tag{2.53}$$

where, $\overline{d_i}$: the mean value of d_i

Correlation R^2 will have a value between 0 to 1. When it is close to 1($J = 0$), it implies that there is perfect linear correlation between x and d; when close to 0 ($J = S$), there is no correlation between x and d.

Commonly, the predictive performance of neural network model is judged by this:

$$R^2 = \frac{\sum_{i=1}^{n} d^2 - S_e - (\sum_{i=1}^{n} d)^2 / n}{\sum_{i=1}^{n} d^2 - (\sum_{i=1}^{n} d)^2 / n} \tag{2.54}$$

where, $S_e = \sum_{i=1}^{n} e^2$ (2.55)

Error term, e, is the difference the target value (d) and the predicted value by the model ($\hat{d}$), and n is sample size. There is no difference by both Eqs.(54) and (55) if the values of correlation R^2 are high.

2.4.2 Relative Importance Analysis

The relative importance of input variables can be assessed to examine the relative sizes of the input layer connection weights. The connection weights from the input layer to the hidden nodes to the output layer can be used to partition the relative share of the output prediction associated with each input variable. Simply, the process of evaluating relative importance is to partition the hidden to output connection weights of each hidden node into components associated with each input node (Garson, 1991).

In other words, the process can be illustrated as shown in Figure 2-9, where a weight connected to the output layer $W2$ (i, :) can be divided into components, each corresponding to one of the input attributes. For a hidden node q, the component of $W2$(i, :) associated with

the input node j is proportional to the weight incoming from attribute v_{qj} in relation to the sum of weights incoming from all attributes. This can be expressed as:

$$\text{Component of } W2\ (i, :) \text{ associated with input node } j = \frac{|W1(:, j)|}{\sum_{q=1}^{l} W1(q, :)} \times |W2(i, :)| \qquad (2.56)$$

where, $W1$: connection weight matrix from input to hidden nodes (number of hidden nodes, q=1, 2,…,l)

$W2$: connection weight matrix from hidden to output nodes (number of output nodes, i=1,2,…,n). In the expressions above and below, : within the paranthesis implies all the indices.

Performing this calculation for all the hidden layers and summing the shares of each input attribute results in a total share or percentage for each attribute. For a network with one hidden layer, the relative importance of each attribute can then be calculated as a percentage of the sum of the scores (Eq.(2.57)):

$$\text{Relative Importance} = \frac{\sum_{i=1}^{n} \frac{|W1(:, j)|}{\sum_{q=1}^{l} W1(q, :)} \times |W2(i, :)|}{\sum_{i=1}^{n} \sum_{j=1}^{m} \frac{|W1|}{\sum_{q=1}^{l} W1(q, :)} \times |W2(i, :)|} \qquad (2.57)$$

where, W1: connection weight matrix from input to hidden nodes

W2: connection weight matrix from hidden to output nodes.

It should be noted that the result is the percentage of all output weights attributable to the given independent variable, excluding bias weights arising from the back-propagation algorithm.

2.5 A basic study of Neural Network Model

2.5.1 Effect of the number of samples

In this section an investigation is made in to the predictive capability of BPNN through some simple examples. And the effects of various model parameters are studied.

One target function: $z = x^2 * \exp(-x^2 - y^2)$

Input variables are x, y and target variable are expressed as $z = f(x, y)$. Table 2-1 describes correlation R^2 by using BPNN corresponding no. of data. Generally, results have a high correlation R^2. As shown in Table 2-1, correlation R^2 is decreased with the decrease in number of the testing data even with similar R^2 for training data set.

Table 2 - 1 Coefficient of R^2 for one target example

Test no.	No. of Training data	No. of Testing data	Correlation R^2	
			Training	Testing
1	100	30	0.9833	0.9651
2		15		0.9307
3		5		0.9929
4	50	15	0.9865	0.9549
5		10		0.9050
6		5		0.8816

Figure 2-10 through Figure 2-13 show predicted points of training and testing data when 50 training samples are used. Figure 2-10 present results of predicted 50 points of training on desired 3D graph of z, and Figure 2-11 through Figure 2-13 presented predicted 15, 10, 5 points for 50 training samples respectively. They show that correlation R^2 decreases as the number of testing data decreases, and the predicted values are farther away from the solution surface.

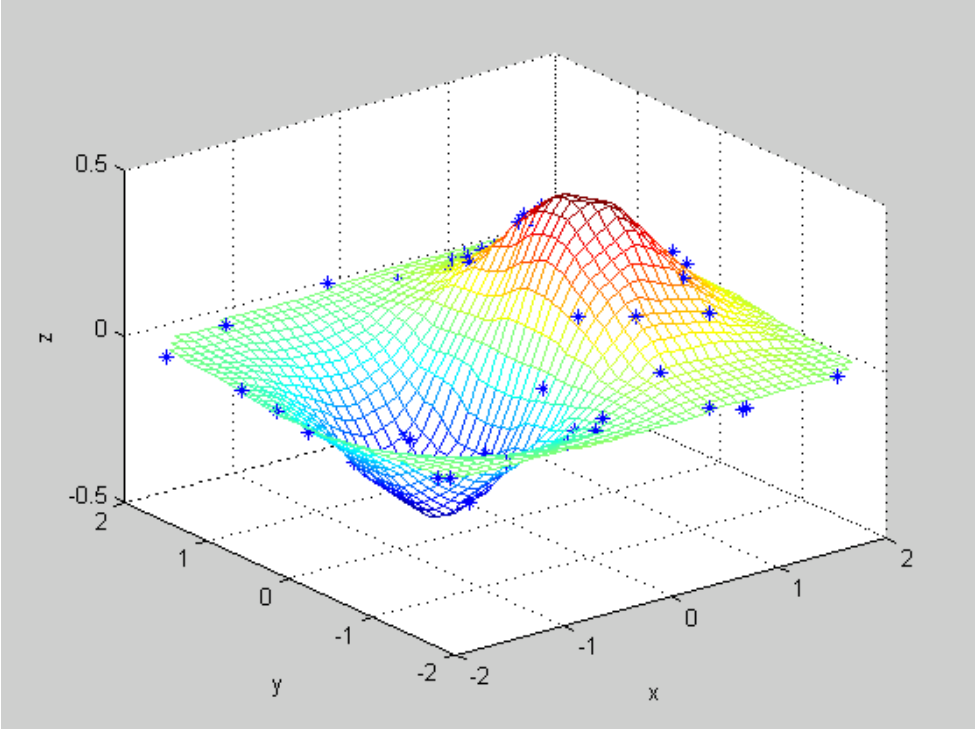


Figure 2 - 10 Predicted 50 training points to desired 3D graph

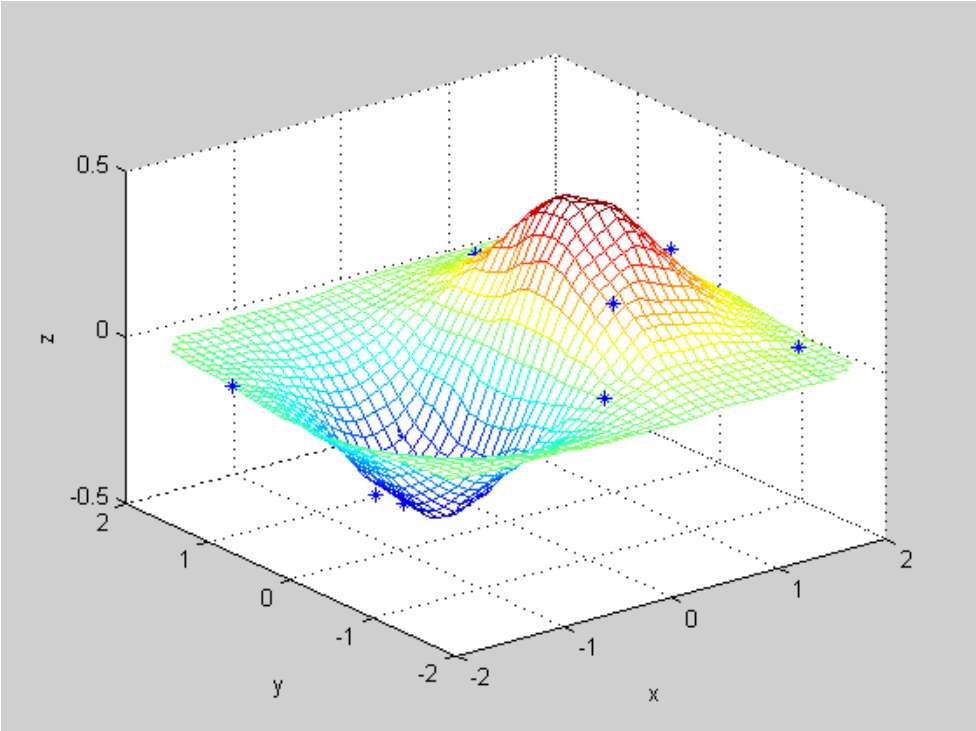


Figure 2 - 11 Predicted 15 test points to desired 3D graph for 50 training samples

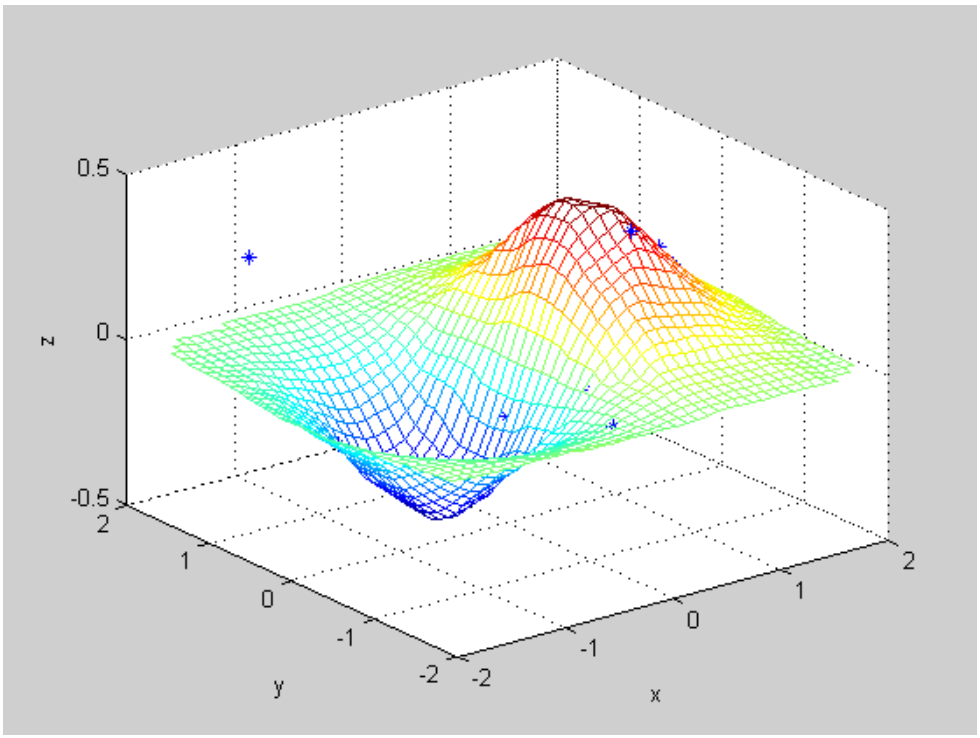


Figure 2 - 12 Predicted 10 test points to desired 3D graph for 50 training samples

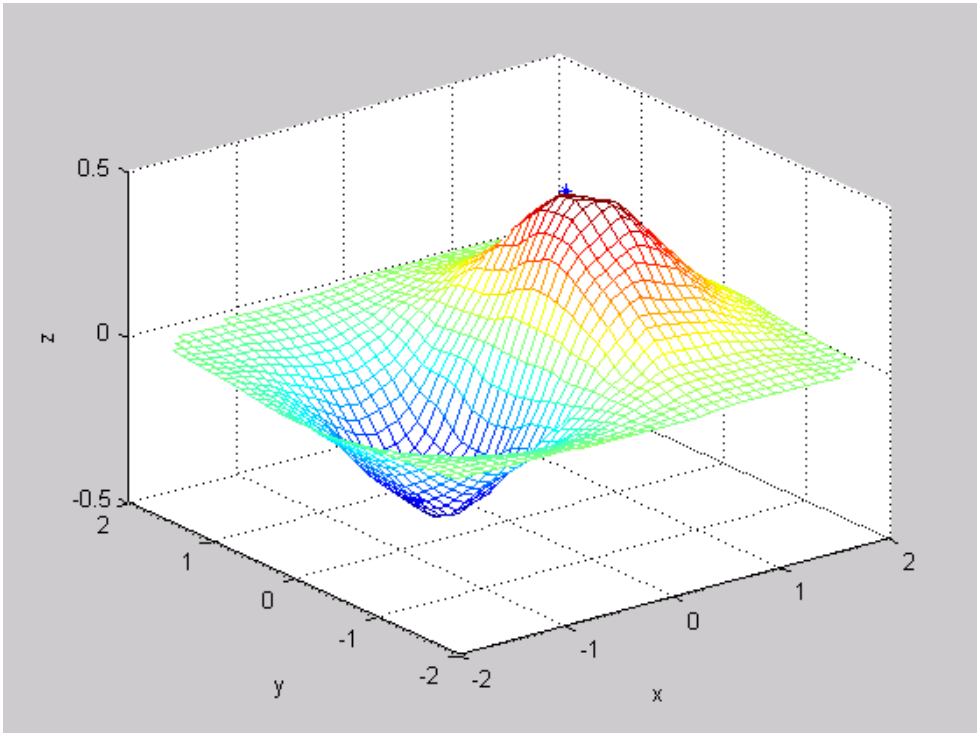


Figure 2 - 13 Predicted 5 test points to desired 3D graph for 50 training samples

***Two target functions**:* $z1 = x * \exp(-x^2 - y^2)$, $z2 = x^2 * \exp(-x^2 - y^2)$

Input variables are x, y and target variables are expressed as $[z1, z2] = f(x, y)$. Table 2-2 describes correlation R^2 that corresponds to the number of data for example with two targets. As described in Table 2-2, as a decrease in no. of training data from 100 to 50 is implemented, correlation R^2 for testing also decreases. The correlation R^2 difference between numbers of testing samples is much larger in 50 training samples than in 100 training samples. Also, it's shown that the correlation R^2 to one target function is higher than to two targets functions at the same number of samples.

Table 2 - 2 Coefficient of R^2 for two target example

Test no.	No. of Training data	No. of Testing data	Correlation R^2			
			Training		Testing	
			Z1	Z2	Z1	Z2
1	100	30	0.9701	0.9895	0.9409	0.9775
2		15			0.9351	0.9910
3		5			0.8902	0.9981
4	50	15	0.9901	0.9930	0.9383	0.9472
5		10			0.7991	0.9591
6		5			0.4973	0.9546

Figure 2-14 and 2-15 present results of each testing samples on desired 3D face of z1 and z2 for 100 training samples. For both z1 and z2, the predicted points with irrespective of no. of testing data are generally placed right on 100% agreement of 3D face. Figure 2-16 and 2-17 present results of each testing samples on desired 3D graphs of z1 and z2 for 50 training samples. For both z1 and z2, the predicted points, as the number of testing data is decreased, are placed far away on 3D face of 100% agreement. These figures indicate that visual results are well consistent with R^2 by regression analysis and that the number of training data needs to be large enough.

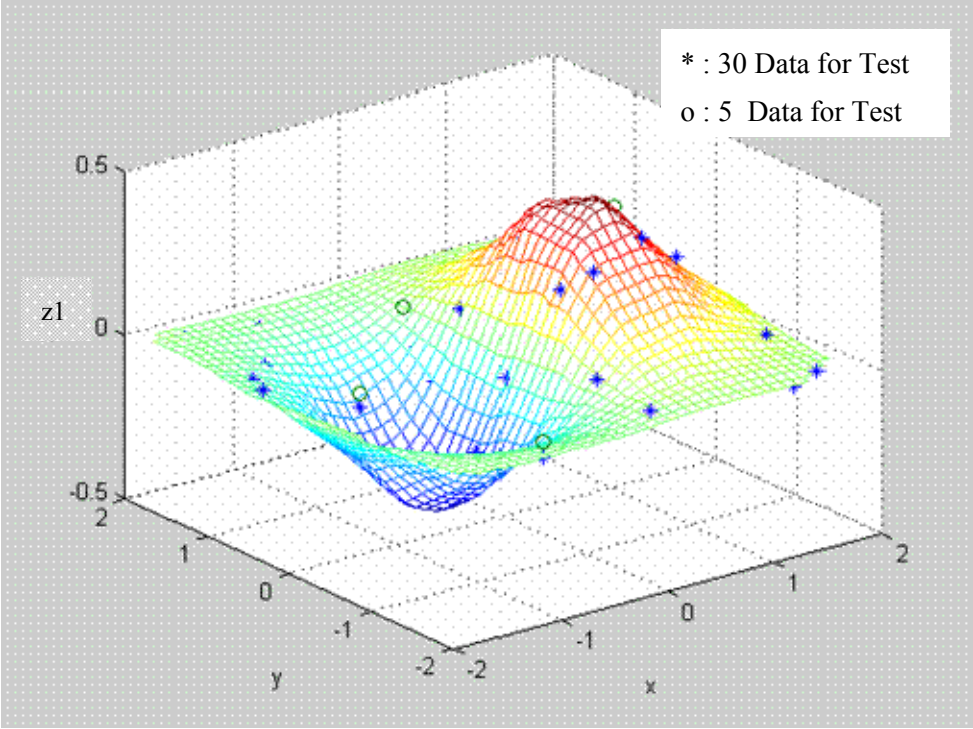


Figure 2 - 14 Predicted 30 and 5 points to desired 3D face of z1 for 100 training data

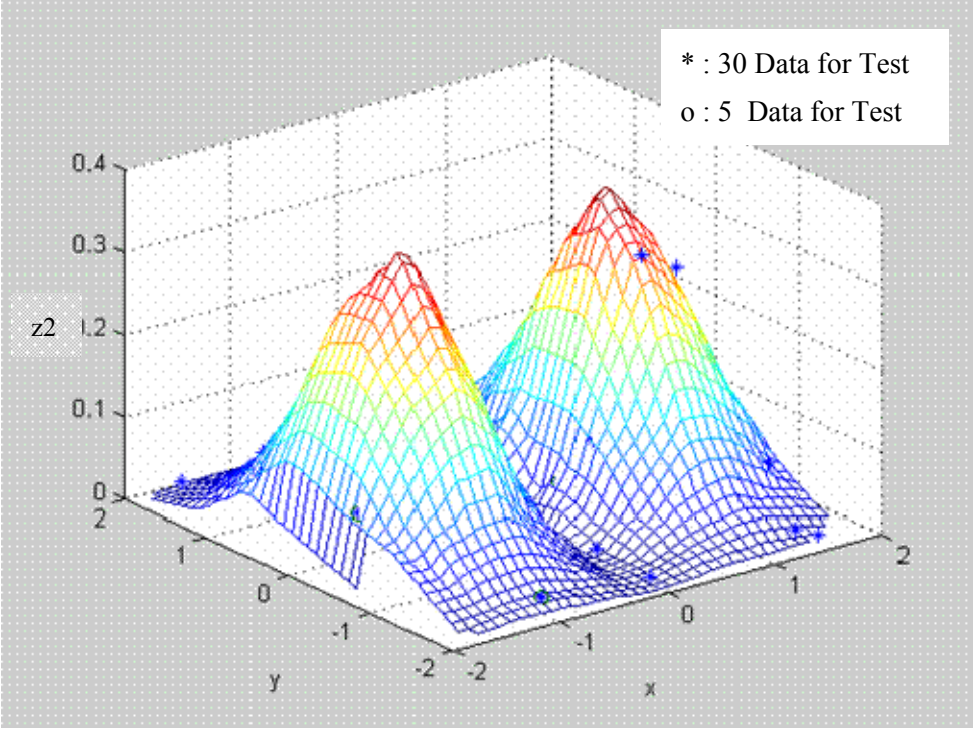


Figure 2 - 15 Predicted 30 and 5 points to desired 3D face z2 for 100 training data

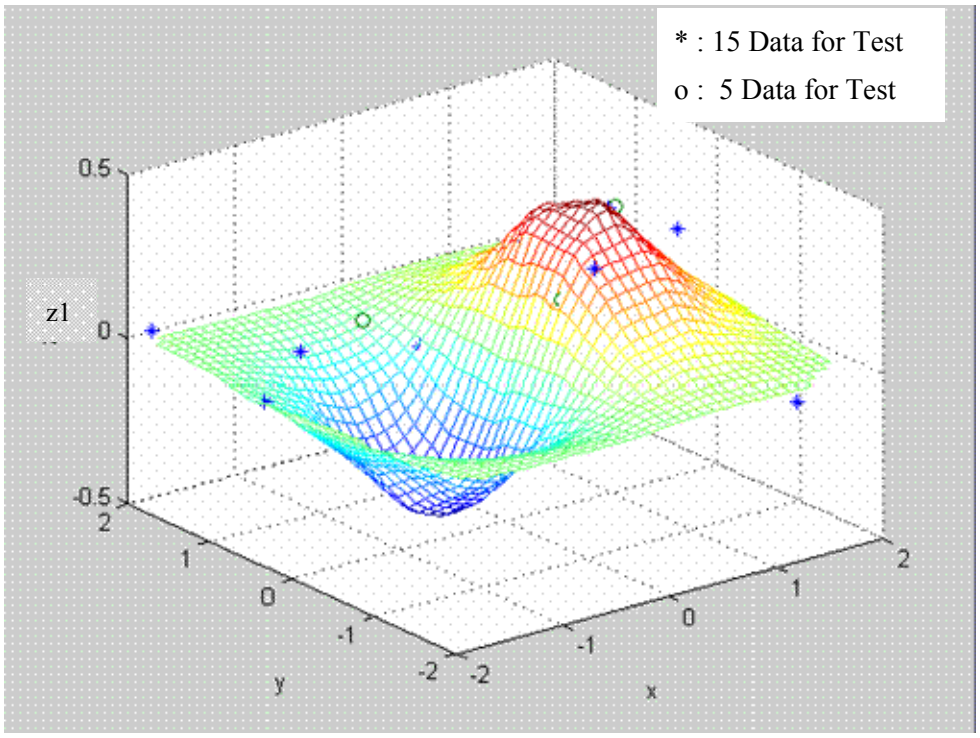


Figure 2 - 16 Predicted 15 and 5 points to desired 3D face of z1 for 50 training data

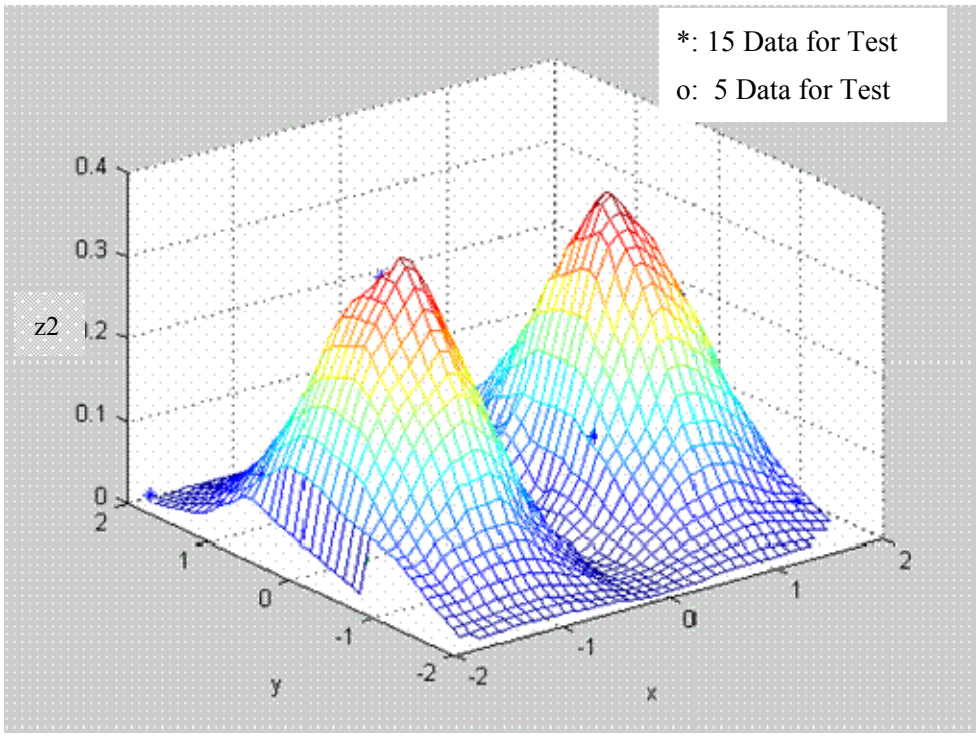


Figure 2 - 17 Predicted 15 and 5 points to desired 3D face of z2 for 50 training data

Three target functions:

$Z1 = \sin(y^2 + x) - \cos(y - x^2)$, $Z2 = \sin(x^2 + y) - \cos(x - y^2)$, $Z3 = \sin(x^2 + y^2) - \cos(y^2 - x^2)$

The above three functions are considered as $[z1, z2, z3] = f(x, y)$. As shown in Table 2-3, as no. of training data decreases from 100 to 50, correlation R^2 for testing (for the same number of testing data) also decrease. Based on this, it is shown that no. of training data needs to be large enough, as much as 100 data in this case.

Table 2 - 3 Coefficient of R^2 for three target example

Test no.	No. of Training data	No. of Testing data	Correlation R^2					
			Training			Testing		
			Z1	Z2	Z3	Z1	Z2	Z3
1	100	30	0.9963	0.9972	0.9973	0.9756	0.9872	0.9169
2		15				0.9549	0.8716	0.7388
3		5				0.6808	0.9935	0.5018
4	50	15	0.9959	0.9948	0.9969	0.6131	0.3439	0.4963
5		10				0.3946	0.2066	0.3238
6		5				0.7765	0.0005	0.3973

Figure 2-18 and 2-19 show predicted test points for 100 training samples, and Figure 2-20 and 2-21 present predicted test points for 50 training samples. While the predicted test points for 100 training data are generally placed right on the 100% agreement of the 3D face, the predicted test points for 50 training data are placed quite far away on the 3D face of the 100% agreement. These figures indicate that visual results are well consistent with correlation R^2 and the number of training data needs to be large enough and the number of testing data needs to be at least a third of the no. of training data as suggested by (Hammerstrom, 1993).

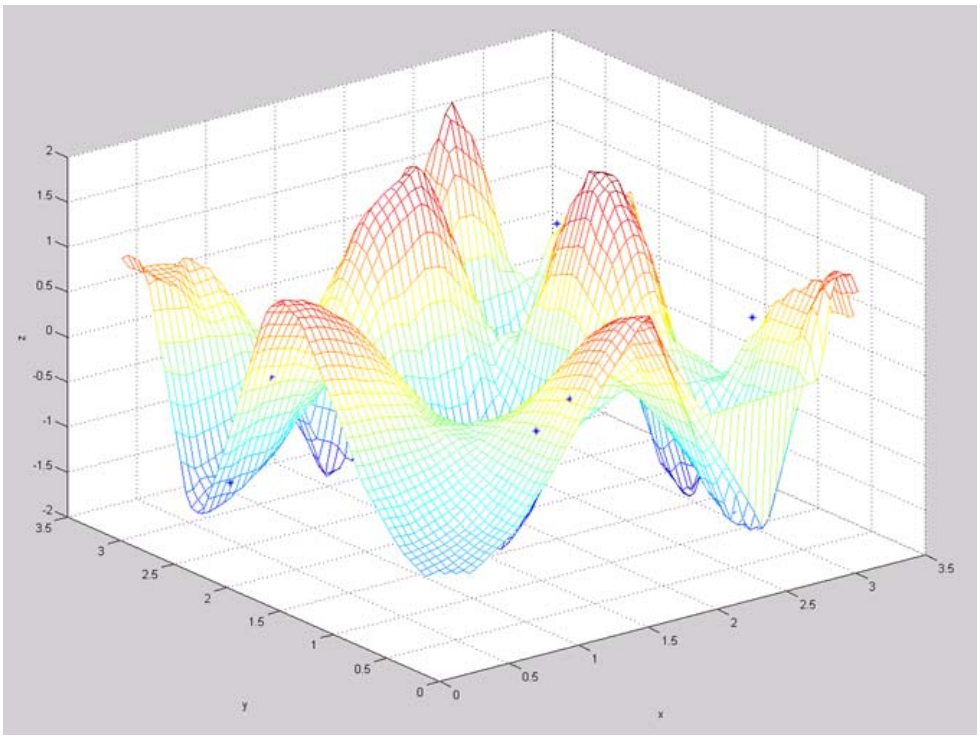


Figure 2 - 18 Predited testing 30points to desired 3D face of z3 for 100 training samples

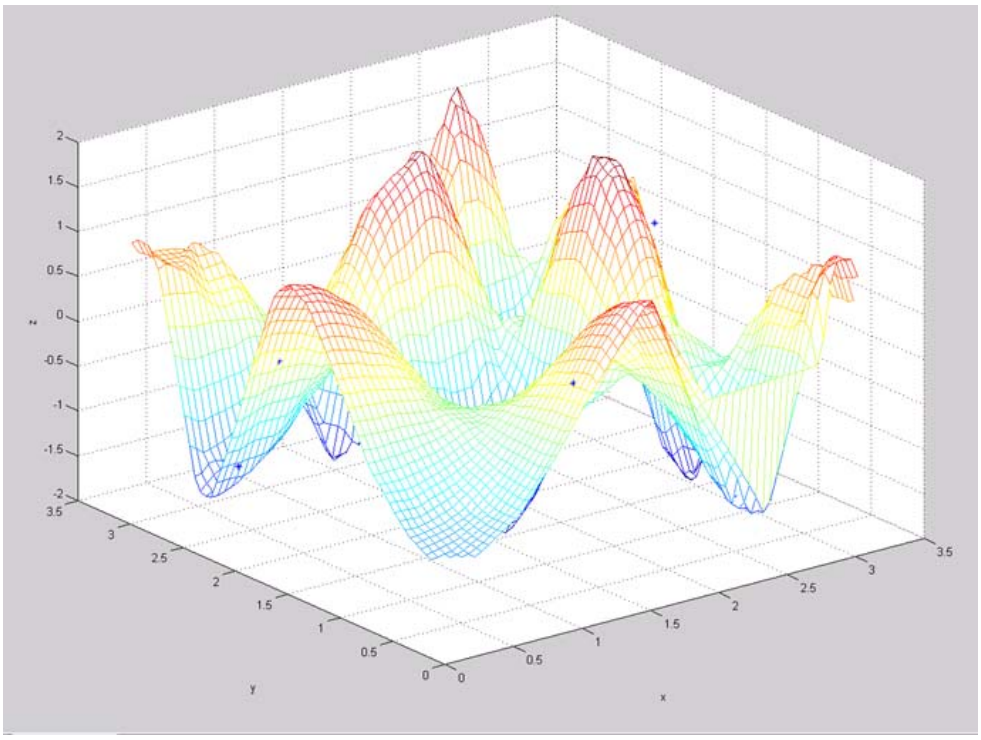


Figure 2 - 19 Predicted 15 testing points to desired 3D face of z3 for 100 training samples

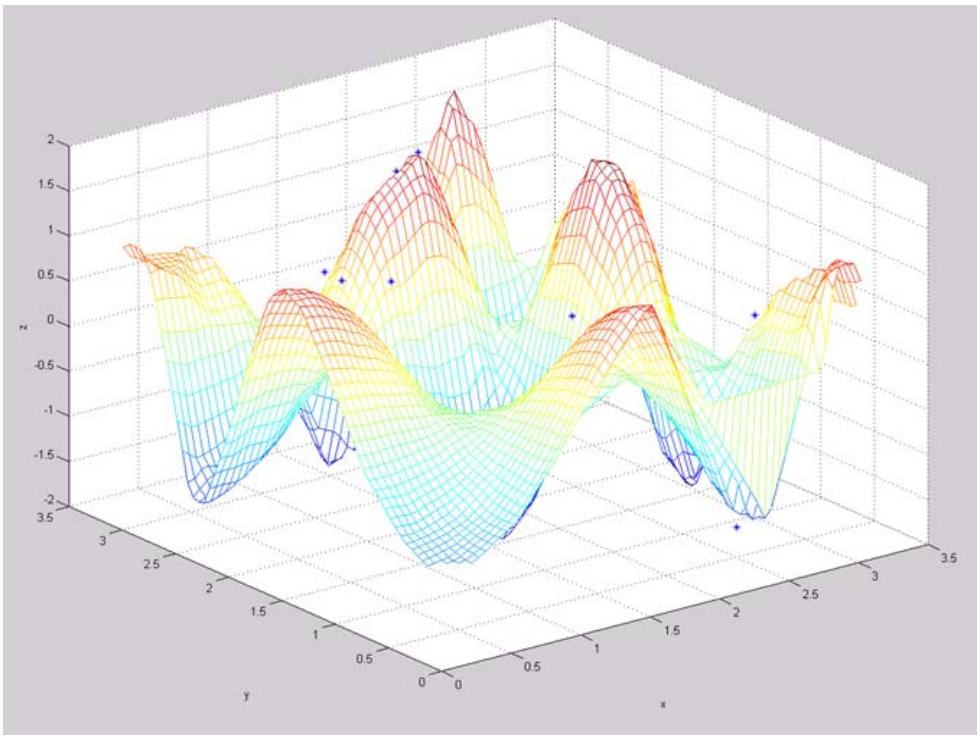


Figure 2 - 20 Predicted testing 15 points to desired 3D face of *z*3 for 50 training samples

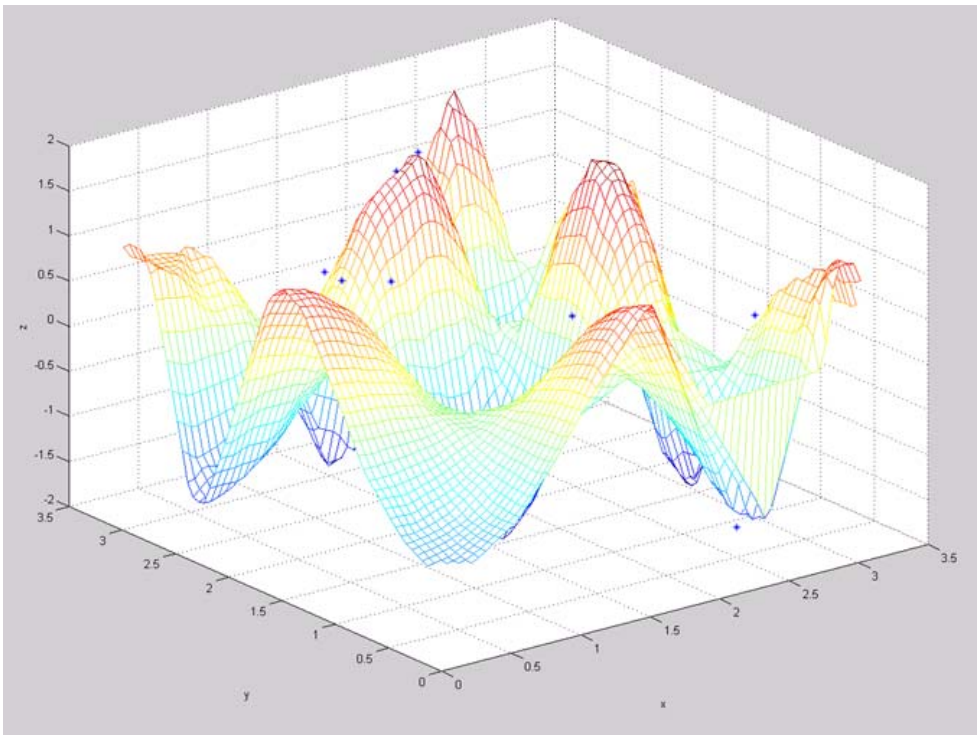


Figure 2 - 21 Predicted testing 10 points to desired 3D face of *z*3 for training 50 points

Effect of the number of samples

An example: an exponential function $y = \exp(10 * t(t-1)) * \sin(12 * \pi * t)$ has to be approximated with a back-propagation neural network. The neural network is developed with an input, 10 hidden nodes with log sigmoid activation function and one hidden layer. The exact (original) function is shown in Figure 2-22 as a dotted line. The different approximations from 100, 50, and 30 training samples are shown in Figure 2-22. The approximation improves as the number of training data increases.

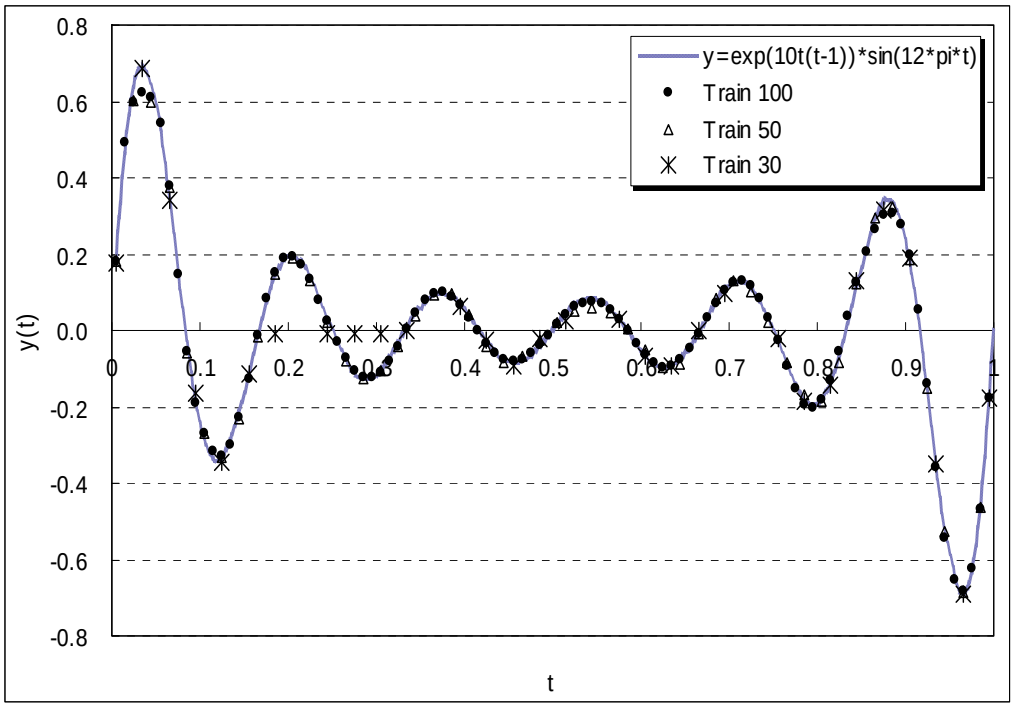


Figure 2 - 22 Effect of the training set size on the generalization

As shown in Figure 2-23, the training MSE (Mean Square Error) decreases with an increasing training set size, and the testing MSE decreases with an increasing training set size. Number of testing data is decided as much as a third of the number of training samples. It is shown that in this case there is a significant drop between 30 and 50 training samples. A network with more than 50 training samples is acceptable for a 0.002 MSE level.

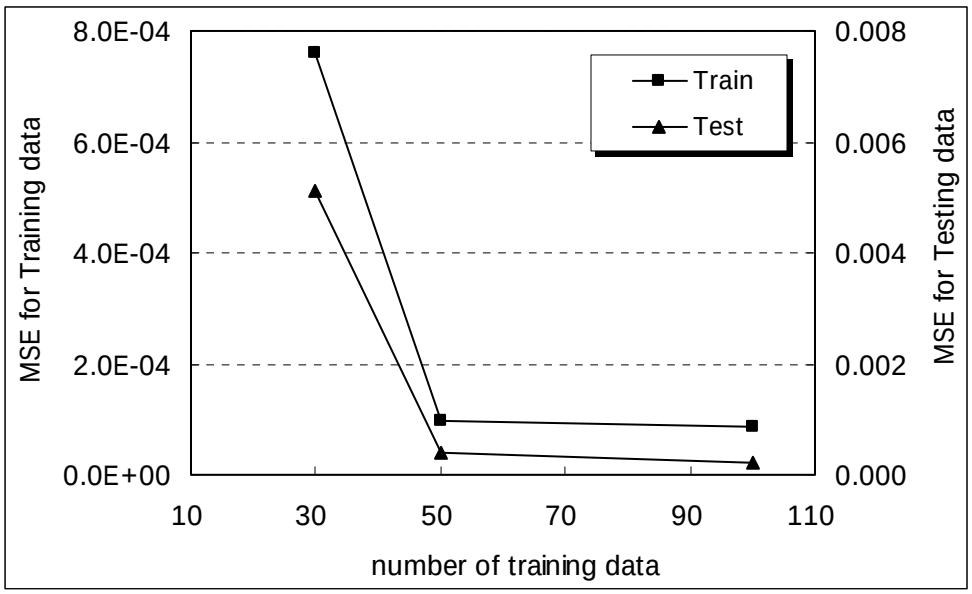


Figure 2 - 23 Mean Square Error with respect to number of training data

2.5.2 Effect of the number of hidden nodes

It is noted that both the number of nodes in input and output layers are in general determined by the nature of the problem. The generalization capacity of a neural network is primarily determined by the number of hidden nodes in the hidden layer. A simple example is used to evaluate the effect with different numbers of hidden nodes: a function $y = 0.6\sin(\pi x) + 0.3\sin(3\pi x) + 0.1\sin(5\pi x)$ (-1< x < 1) is approximated using a neural network. The neural network is developed with an input, 20 training samples and 6 testing samples with log sigmoid activation function and one hidden layer.

Figure 2-24 and 2-25 show the approximations of the network for both training and testing data sets. The thick dashed line gives the desired function, and the rectangular and star (*) denote the training samples for 6 and 15 hidden nodes respectively. As shown in Figure 2-24, the dotted line model for 6 hidden nodes fits well for both training sets, while the drawn line model for 15 hidden nodes learns irrelevant details of the individual cases without learning basic structure of the data. This example shows that a large number of hidden nodes leads to a small error on the training set but not necessarily to a small error on the test set. This problem is referred to as *over-fitting*. This is caused by the fact that the network probably has too many neurons, as previously explained.

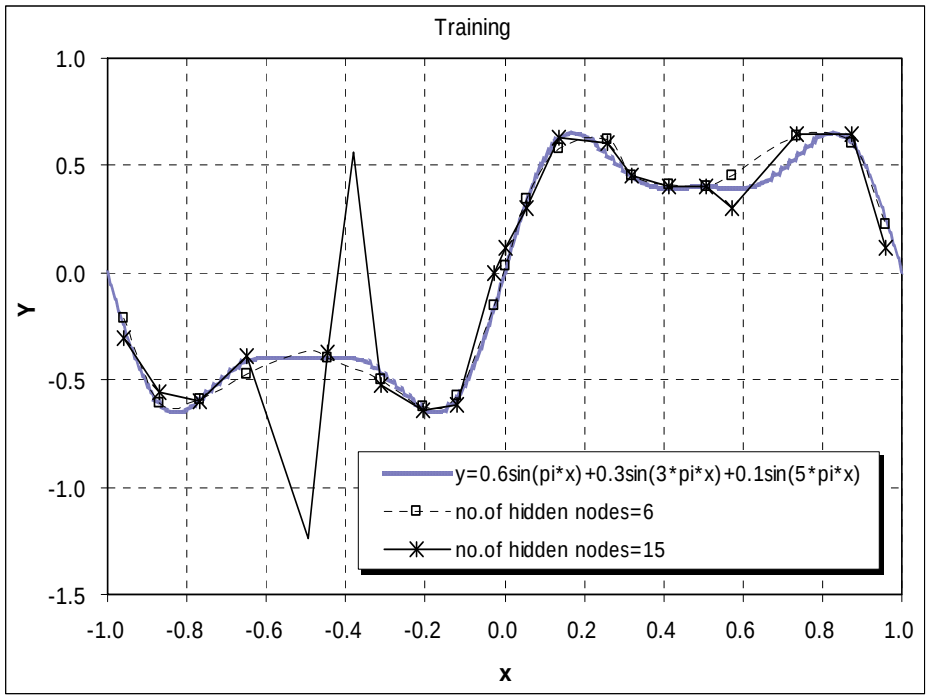


Figure 2 - 24 Effect of the number of hidden nodes on the training

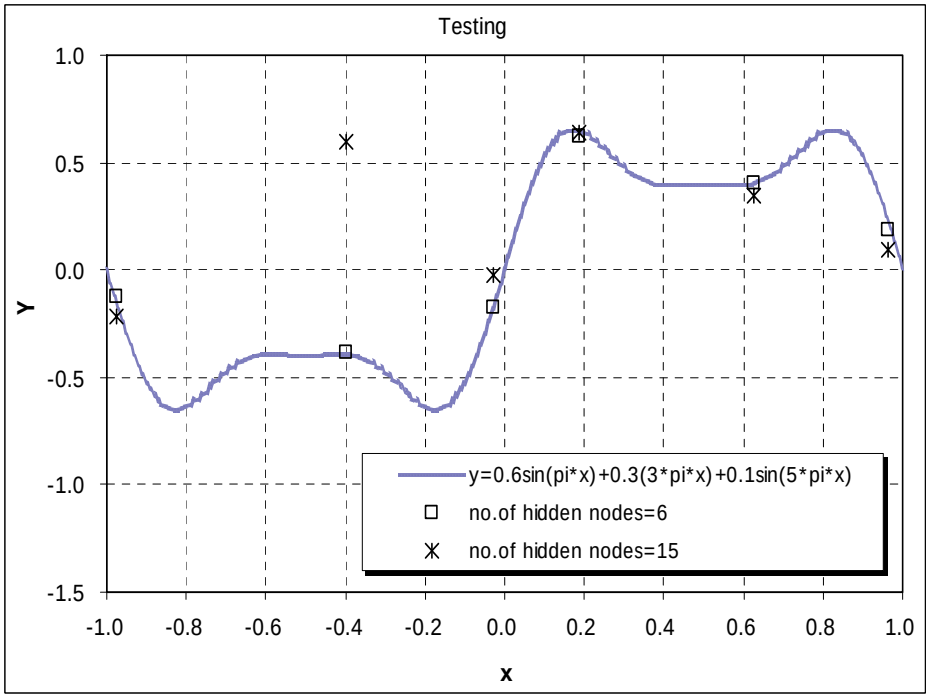


Figure 2 - 25 Effect of the number of hidden nodes on the testing

If a network is trained well, it is reasonable that the correlation R^2 to the testing set has to be similar to the training set, as in the case of 6 hidden nodes that is described in Table

2-4. For the 15 hidden nodes, however, the correlation R^2 to the testing set is too low compared to the correlation R^2 to the training set. This is a general over-fitting problem in training networks.

Table 2 - 4 Correlation R^2 with respect to number of hidden nodes

No. of Hidden Nodes	Correlation R^2	
	Training	Testing
6	0.9999	0.9929
15	0.9995	0.5096

The best way to avoid *overfitting* is to use a large number of training data. Smith (1996) suggested that at least 10 times as many training cases as the number of input variables would be appropriate. In order to avoid *overfitting*, the experiment using 60 data and 20 data are carried out for training and testing sets respectively. Figure 2-26 shows results on training and testing data set at 15 hidden nodes. The network fits exactly with both the training and testing samples, also correlation R^2 for training and testing set are high and similar to each other.

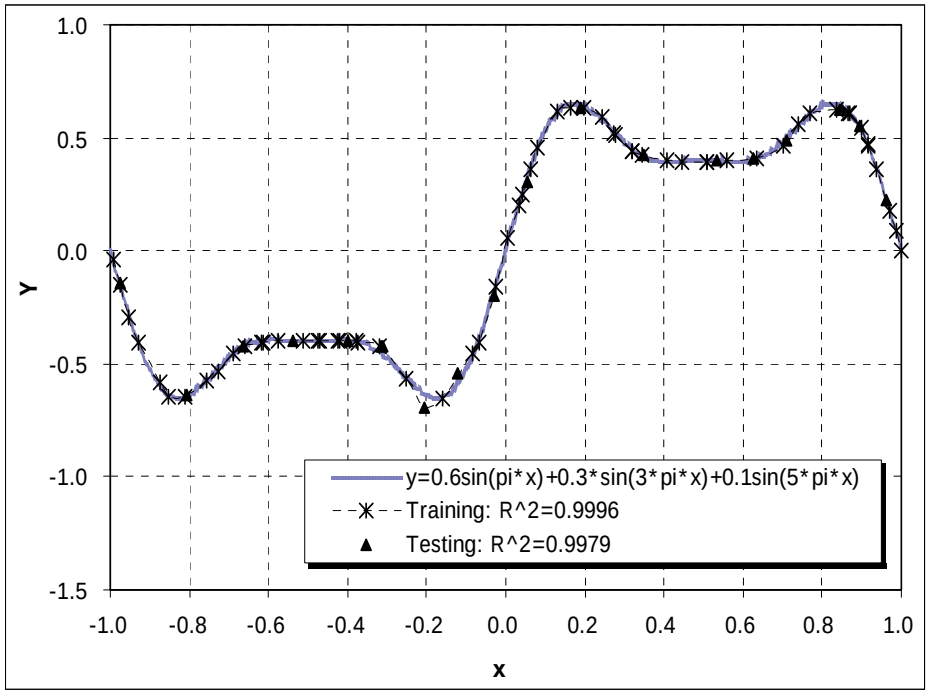


Figure 2 - 26 Effect of the *overfitting* to 60 training samples

2.5.3 Correlation R^2, Relative Importance, and Parametric study

Typically the best performance of the model is determined by the coefficient of correlation R^2. In other words, a model which gives the maximum correlation R^2 value is considered as the best model since there are lots of variations of the combination between variables and model parameters. A simple problem is used as example: A function $y = f(x_1, x_2, x_3) = x_1 + 10x_2 + x_3^3$ ($0 < x_1, x_2, x_3 < 10$) has to be approximated with a back-propagate neural network. A neural network is created with three input variables, 5 hidden nodes with log sigmoid activation function, and 1 hidden layer. Table 2-5 show correlation R^2 values corresponding to given number of data. As far as concerned with correlation R^2, a network seems to be trained fairly for up to 30 training samples (10 testing samples) since over-fitting problem occurs in the 20 training samples. In order to find more reliable models, relative importance to distribute connection weights between input and output layer can be calculated. In this case, we see that relative importance has $x_3 >> x_2 > x_1$ because of each input characteristics. As shown in Table 2-5, relative importance for the 20 and 30 training data doesn't reflect the general characteristics of each input. Therefore based on the correlation R^2 and relative importance, networks obtained from over 60 training samples are quite reasonable.

Table 2 - 5 Correlation R^2 and Relative Importance corresponding to number of data

No. of training	No. of testing	Correlation R^2		Relative Importance (%)		
		Training	Testing	x_1	x_2	x_3
90	30	0.9991	0.9992	4.1	9.8	86.1
60	20	0.9986	0.9990	9.12	12.46	78.42
30	10	0.9556	0.9644	27.28	32.99	39.72
20	6	0.9995	0.3688	39.6	34.7	25.7

Figure 2-27 shows predicted values as a function of each input parameter. For a well trained network, each parameter needs to have the exact trend($y=x_1$, $y=10x_2$, $y=x_3^3$) within the range of each input (0-10). Also, predicted y values (11.1, 99.6, and 936.7) for x_1, x_2, x_3 are supposed to be 10, 100, 1000 respectively. As shown in Figure 2-27, the three predicted values are consistent with the above results.

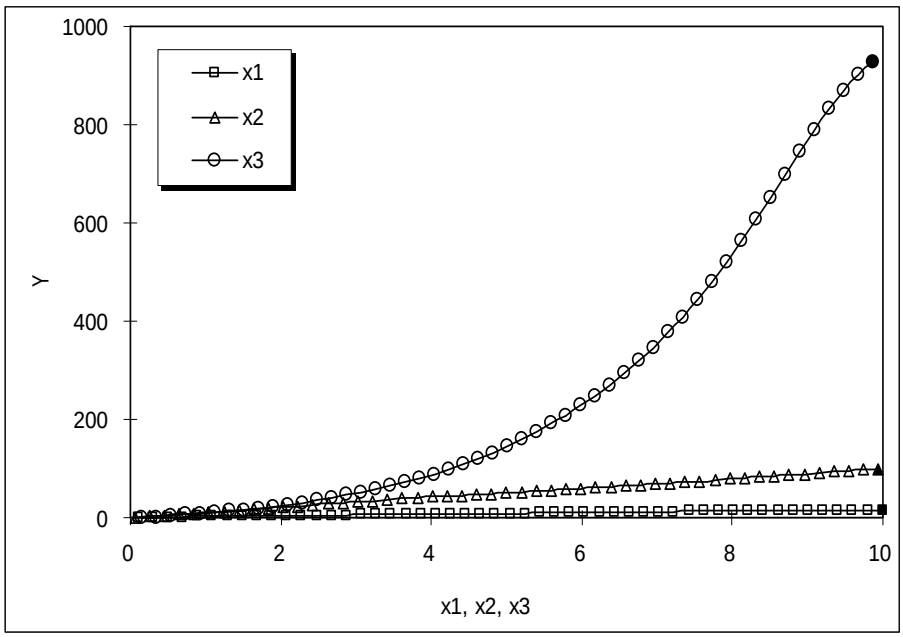


Figure 2 - 27 Parametric study (x1, x2, x3)

Effect of superfluous input variable (t_1)

When model parameters are estimated in neural network, some superfluous variables may be chosen as inputs due to the consideration of a large number of variables that affect mechanical systems. Let's consider t_1, which does not influence on y (target).

Real function: $y = f(x_1, x_2, x_3) = x_1 + 10x_2 + x_3^3$ ($0 < x_1, x_2, x_3, t_1 < 10$) (2.58)

Assumption: $y = f(x_1, x_2, x_3, t_1)$ ($0 < x_1, x_2, x_3, t_1 < 10$) (2.59)

A neural network is carried out using 60 training samples and 20 testing samples. As far as we are concerned with only correlation R^2, since a network seems to be trained fairly for all of chosen error rates as shown in Table 2-6, these network models are assumed to be good. But they are not as supposed. The best way to reduce the effect of the supposition factor is to use the minimum error rate during training model. As shown in Table 2-6, the decrease in error rate has the effect of reducing the relative importance of t_1. In order to reduce the effect by the wrongly chosen parameter it is recommended that the used error goal be small enough to ignore the supposition factor (t_1), or the parameter of the smallest value be removed.

Table 2 - 6 Effect of error rate on superfluous factor

Error rate	Correlation R^2		Relative Importance (%)			
	Training	Testing	x1	x2	x3	t1
$1/10^3$	0.9929	0.9990	15.01	6.49	68.49	10.01
$1/10^4$	0.9993	0.9998	5.23	12.86	76.82	5.09
$1/10^5$	0.9999	0.9998	1.53	3.63	93.75	1.09

The effect of each parameter on the target(y) is further investigated. Figure 2-28 through Figure 2-30 show predicted values of y as a function of each parameter in the prediction stage. Polynomial expression is given to the x_3, linear expressions are given to the x_1 and x_2. Among of them, at $1/10^5$ error rate the predicted values(y) are most consistent with desired ones: for only x3, i) $1/10^3$ error rate - (9.86, 866.5), ii) $1/10^4$ error rate - (9.86, 924.7), iii) $1/10^5$ error rate - (9.86, 939.3). Therefore, The best way to find out the reasonable performance of a network model as uncertain variables may be chosen is to use the higher error rate related to relative importance.

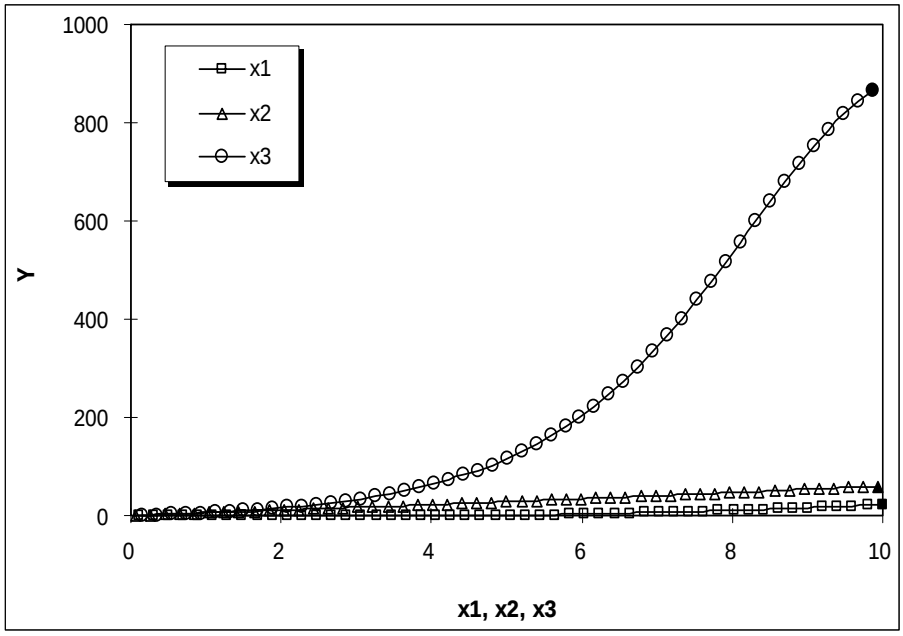


Figure 2 - 28 Parametric study at $1/10^3$ error rate

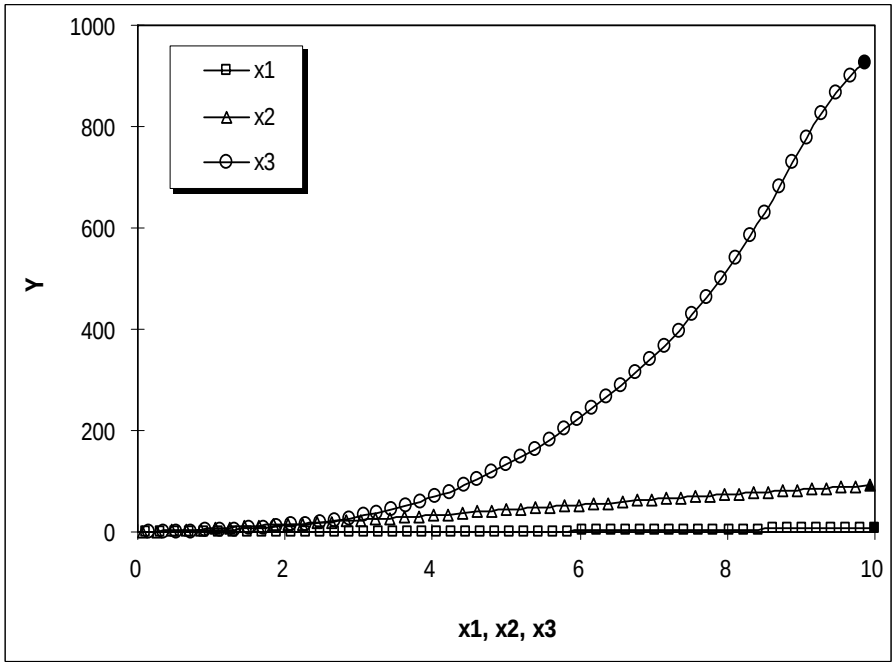


Figure 2 - 29 Parametric study at $1/10^4$ error rate

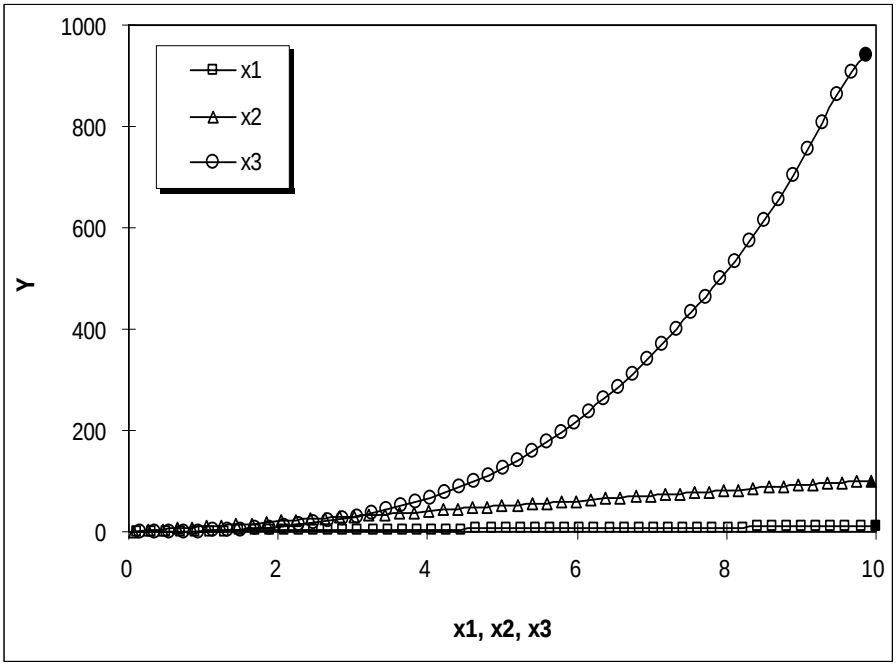


Figure 2 - 30 Parametric study at $1/10^5$ error rate

From the above we observe the following:

(a) the number of training data needs to be large enough. The number of data required for the model depends on the nature of the problems.

(b) visual results are well consistent with correlation R^2, and correlation R^2 can be generally used as a good indicator.

(c) in order to get similar correlation R^2 in both single and the multiple target problems, the larger number of data is needed. Thus as the number of target variables increases, the larger the number of data is needed for the model.

(d) inappropriately large number of hidden nodes used may lead to an *overfitting* problem. The best way to avoid *overfitting* is to use training samples as many as ten times the of number of input variables, or to use a small number of hidden nodes.

(e) as far as we are concerned only with correlation R^2, a network seems to be trained fairly even under unreasonable input characteristics. In order to find a more reliable model, relative importance and parametric studies can be used if input characteristic are known.

(f) the best way to find out the reasonable performance of a network model is to use the minimum error rate related to relative importance where some superfluous variables may be chosen as input variables.

2.6 References

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Chapter 3 Adaptive Neuro-Fuzzy Inference System

3.1 Introduction

In the previous chapter we examined the basics of neural network models. The neural network has the learning ability to generalize the 'rules' derived from those embedded in the data with which they are trained. On the other hand, the fuzzy set theory developed by Zadeh (1965) has been used to represent vagueness in linguistic description. The commonly used fuzzy inference system (FIS) is the actual process of mapping from a given input to output using fuzzy logic.

The fuzzy system and neural networks are complementary technologies. The most important reason for combining fuzzy systems with neural networks is to use the learning capability of neural networks. While the learning capability is an advantage from the view point of a fuzzy system, from the viewpoint of a neural network there are additional advantages to a combined system. Because a neuron-fuzzy system is based on linguistic rules, we can easily integrate prior knowledge in to the system, and this can substantially shorten the learning process. One of the integrated systems is an ANFIS (Adaptive Neuro-Fuzzy Inference System), which is utilizes a fuzzy inference system and back-propagation algorithm (Lin and Lee, 1996 and Jang.et.al, 1997).

In this chapter we present fundamental concepts of fuzzy sets, fuzzy inference systems, and ANFIS, followed by an illustration of the application of ANFIS on four simple benchmark problems. In later chapters ANFIS models will be developed for the prediction of ultimate pile capacity and pile setup, and their predictions will be compared with those from Neural Network Models.

3.2 Fuzzy sets

3.2.1 Fuzzy logic

A classical (crisp) set is a collection of distinct objects. It is defined in such a way as to divide the elements of a given universe of discourse into two groups: member or nonmember. Let U be a universe of discourse. The characteristic function $\mu_A(x)$ of a crisp set A in U takes its values in {0, 1} and is defined such that $\mu_A(x)$ =1 if x is a member of A (i.e., $x \in A$) and 0 otherwise (i.e., $x \notin A$). That is,

$$\mu_A(x) = \begin{cases} 1 & \text{if } x \in A \\ 0 & \text{if } x \notin A \end{cases} \tag{3.1}$$

So, the boundary of set A is sharp and rigid and performs a two-class group, and the universe of discourse U is a crisp set.

Fuzzy sets were introduced by Zadeh (1965), as a means of representing and manipulating data that was not precise, but rather fuzzy. It was especially designed to mathematically represent uncertainty and vagueness, and to provide formalized tools for dealing with the imprecision intrinsic to many problems. For example, let us consider a set A of tall people. In classical terms the set is considered crisp and may be defined as a number greater than 170 cm, which can be expressed as:

$$A = \{x \,|\, x > 170\}, \tag{3.2}$$

According to the definition, if x is greater than 170, the x will belong to set A; otherwise x does not belong to the set. However, it is unsuitable that this method in the transition zone, like the heights of 169.9 cm and 170.1 cm, will result in undesired behavior under even almost identical properties. These difficulties can be avoided by generalizing the binary view to the notion of membership in the view of fuzzy sets. We allow a degree of membership which may assume all values between 0 to 1. The value 1 stands for complete membership of the set, while 0 means that an object does not belong to the set at all. Because of the intermediate degrees of membership, a smooth transition from the property of being a member to the property of not being a member can be achieved as shown in Figure 3-1.

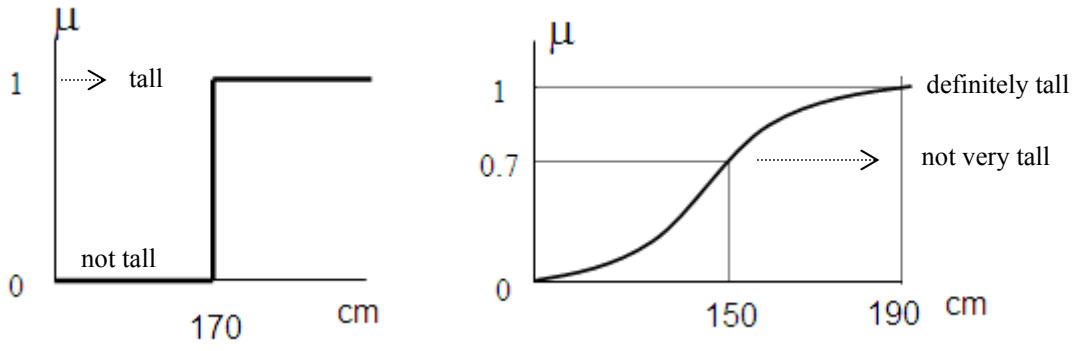

Figure 3 - 1 Crisp set A(left hand) and fuzzy set Ã(right hand)

3.2.2 Membership functions

The only condition a membership function must really satisfy is that it must vary between 0 and 1. The membership functions most commonly used in control theory are triangular, trapezoidal, Gaussian, generalized bell and sigmoidal Z- and S- functions (Nguyen. H.T.,et.al., 2003).

Triangular Membership Function

A triangular membership function is fully described by three parameters {a, b, c}, $a < b < c$;

$$\mu_{Triangle}(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ \dfrac{c-x}{c-b}, & b \le x \le c \\ 0, & c \le x \end{cases} \tag{3.3}$$

or by an alternative formula to Eq.(3.3).

$$\mu_{Triangle}(x) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-a}{c-b}\right), 0\right) \tag{3.4}$$

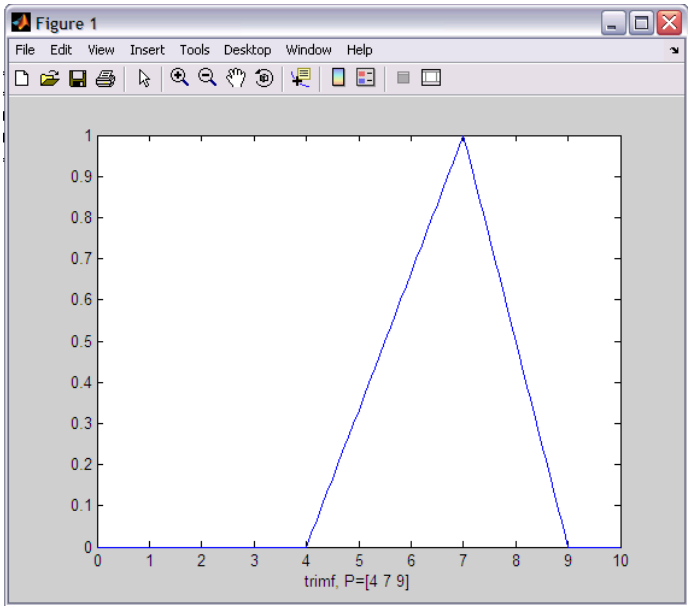

Figure 3 - 2 Triangle Membership Function (a=4, b=7, c=9)

Trapezoidal Membership Function

A trapezoidal membership function is fully described by three parameters {a, b, c, d}, $a < b < c < d$;

$$\mu_{Trap}(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 0, & d \le x \end{cases} \tag{3.5}$$

or by an alternative formula to Equation (5)

$$\mu_{Trap}(x) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right) \tag{3.6}$$

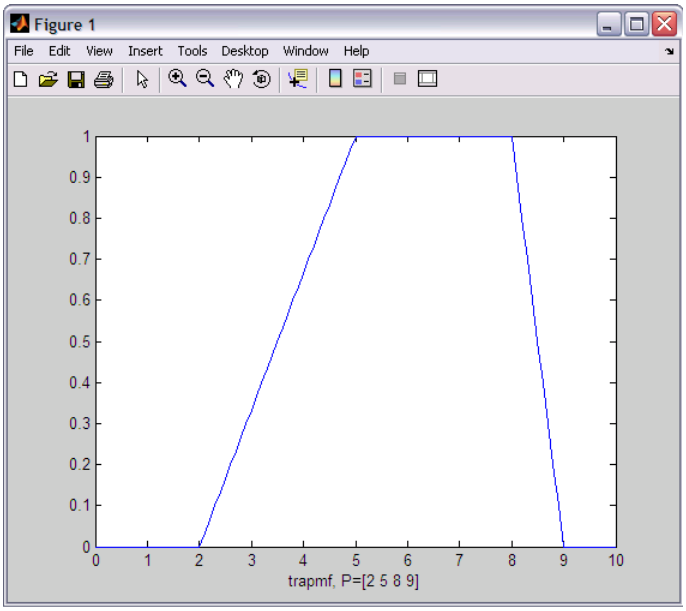

Figure 3 - 3 Trapezoidal Membership Function (a=2, b=5, c=8, d=9)

Gaussian Membership Function

A Gaussian membership function has two parameters: c - responsible for its center and σ- responsible for its width;

$$\mu_{Gauss}(x) = \exp\left[-\left(\frac{x-c}{2\sigma}\right)^2\right] \tag{3.7}$$

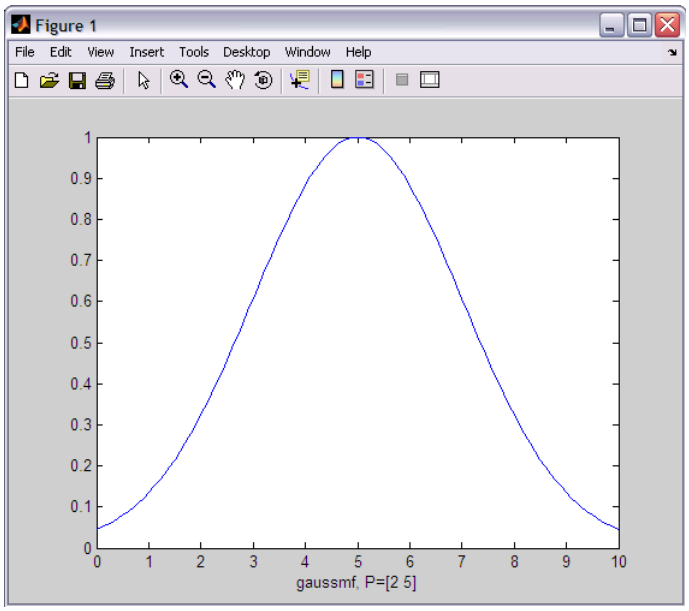

Figure 3 - 4 Gaussian Membership Function (σ=2, c=5)

Generalized Bell Membership Function

A generalized bell membership function has three parameters: a-responsible for its width, c-responsible for its center and b-responsible for its slopes;

$$\mu_{Bell}(x) = \frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}} \tag{3.8}$$

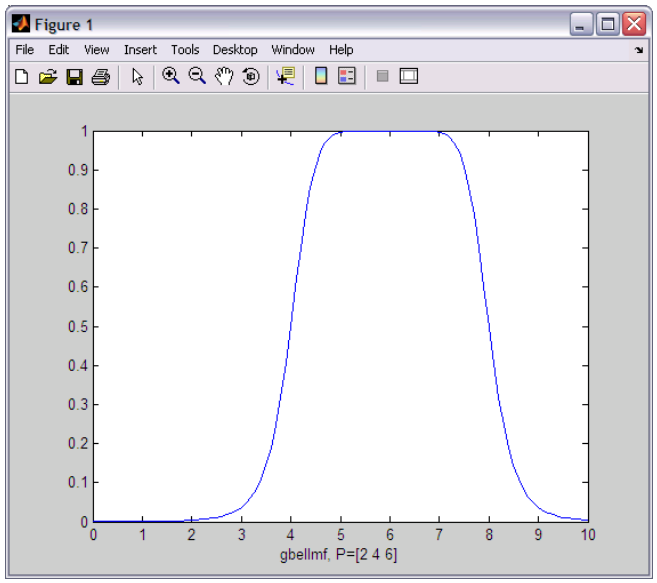

Figure 3 - 5 Generalized Bell Membership Function (a=2, b=4, c=6)

Sigmoidal Membership Function

A sigmoidal membership function has two parameters: a-responsible for its slope at the crossover point x = c;

$$\mu_{Sigm}(x) = \frac{1}{1 + \exp[-a(x - c)]} \tag{3.9}$$

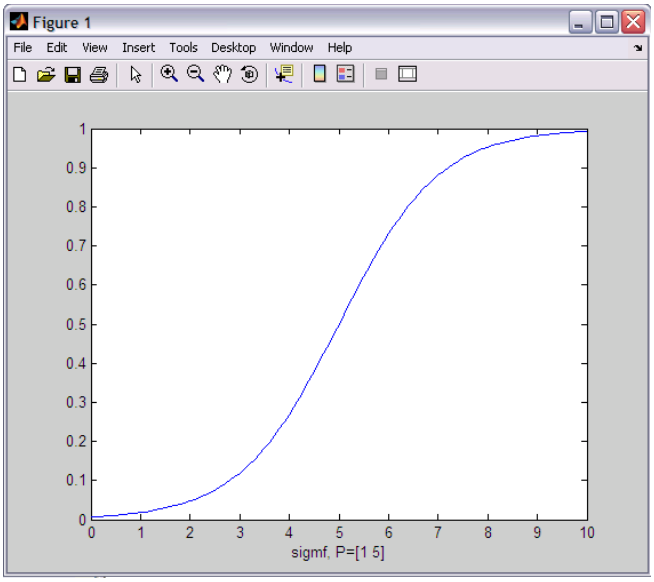

Figure 3 - 6 Sigmoidal Membership Function (a=1, c=5)

D(Difference)sigmoidal Membership Function

Dsigmoidal membership function is composed of the difference between two sigmoidal membership functions using Eq.(3.9). This membership function depends on four parameters, a1, c1, a2, and c2, and is the difference between two of these sigmoidal functions; f1(x; a1, c1) - f2(x; a2, c2).

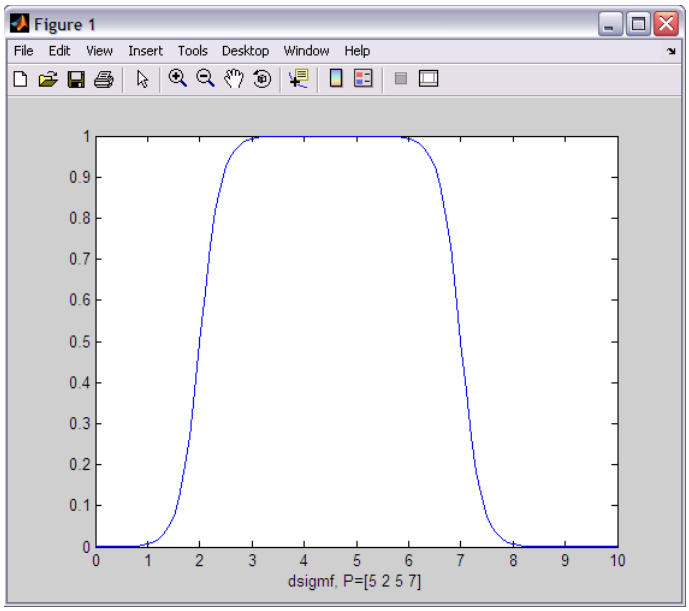

Figure 3 - 7 Difference sigmoidal Membership Function (a1=5, c1=2, a2=5, c2=7)

3.3 Fuzzy Inference System

Fuzzy inference systems usually perform crisp input-output mapping, as in control applications where the inputs correspond to system state variables, and the outputs are control signals. A fuzzy inference system implementing a real-valued function **f**(x) of **d** input variables can be represented as shown in the following:

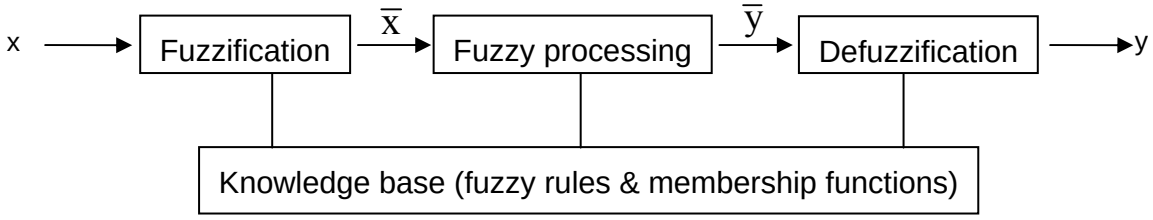

Figure 3 - 8 A fuzzy inference system diagram

here $\overline{x} = [x_1, x_2, ..., x_d]$ is a crisp multivariate input vector and y is a crisp univariate output. The knowledge base contains several fuzzy rules encoding a priori knowledge about the function f(x). Since we need to describe fuzzy systems for multivariate inputs, we need to formalize first the notion of a multivariate fuzzy set. Fuzzy membership function of a multivariate variable $x = [\overline{x}_1, \overline{x}_2, ..., \overline{x}_d]$ is usually defined as a tensor product of univariate membership functions specified for each input coordinate. That is, given univariate fuzzy

sets A(k) with a membership function $\mu_{A(K)}(x_k)$ one can define a multivariate fuzzy set A={A(1), A(2),…, A(d)} with the following fuzzy membership function

$$\mu_A(x) = \mu_{A(1)}(x_1)\mu_{A(2)}(x_2).....\mu_{A(d)}(x_d) \tag{3.10}$$

$$A= x_1 \text{ is } A(1) \text{ AND } x_2 \text{ is } A(2),\ldots, \text{ AND } (x_d \text{ is } A(d)) \tag{3.11}$$

Using the definition of a multivariate fuzzy set, we can specify an (input, output) mapping in the input and output space. A fuzzy inference system is a set of m fuzzy rules providing an interpretable representation for a multivariate function f(x):

$$\text{IF}(x \text{ is } A_i) \text{ THEN } y \text{ is } B_i \ (i = 1, 2, ..., m) \tag{3.12}$$

where x is a dimensional input and y is a scalar output. The objective of fuzzy processing is to produce a crisp output for a given input. The three elements of fuzzy inference system can be formally described as follows:

Fuzzification. For a given input, calculate rule i strength as a fuzzy membership function $\mu_{Ai}(x)$. For notational convenience, denote rule i strength as:

$$w_i = \mu_{A_i}(x) \tag{3.13}$$

Rule output evaluation. The output fuzzy sets of each rule are modified according to either the product rule:

$$\mu_i(y) = w_i \cdot \mu_{B_i}(y) \tag{3.14}$$

or the *min inference* rule:

$$\mu_i(y) = \min\{w_i \cdot \mu_{B_i}(y)\} \tag{3.15}$$

Defuzzification. The preferred approach called additive defuzzification is to defuzzify each rule output first, then combine the resulting crisp outputs, as detailed next. Perform centroid defuzzification for each output fuzzy set:

$$y_i = \frac{\int y\, \mu_i(y)\, dy}{\int \mu_i(y)\, dy} = \frac{\int y\, w_i\, \mu_{B_i}(y)\, dy}{\int w_i \mu_{B_i}(y)\, dy} = \frac{\int y\, \mu_{B_i}(y)\, dy}{\int \mu_{B_i}(y)\, dy} \tag{3.16}$$

Next calculate the system output as:

$$y = \frac{\sum w_i y_i}{w_k} \tag{3.17}$$

3.4 ANFIS (Adaptive Neuro-Fuzzy Inference Systems)

3.4.1 Combining neural network and fuzzy system

The neural networks and fuzzy systems solve the problems by performing function approximation. A fuzzy system can be used to solve a problem if we have prior knowledge about the solution in the form of linguistic if-then rules. By defining suitable fuzzy sets to represent linguistic terms used with the rules, we can create the fuzzy system from these rules. A formal model of the problem of interest does not need training data. On the other hand, we are lost without if-then rules, and to make the fuzzy system work we may need a long tuning process. For this stage there are no formal methods, so that only heuristics can be applied.

A neural network does not use a mathematical model of the problem of interest, and does not need any form of prior knowledge. The solution obtained from the learning process cannot be interpreted. This final state can not be interpreted in terms of rules, also a neural network with prior knowledge cannot be initialized. The learning process itself can take a long time. However, a well-known property attributed to neural networks is their fault tolerance regarding their inputs and changes in their structure.

As shown in Table 3-1, a suitable combination of both approaches should be able to combine the advantages and avoid the drawbacks.

Table 3 - 1 Comparing neural networks and fuzzy systems (Nauck et.al., 1997)

Neural network	Fuzzy system
advantages	
▪ No mathematical process model needed ▪ No rule-based knowledge needed ▪ Different learning algorithms available	▪ No mathematical process model needed ▪ Prior knowledge can be used ▪ Simple interpretation and implementation
disadvantages	
▪ Black box ▪ Rules cannot be extracted ▪ Determine heuristic parameters ▪ Adaptation to modified environment can be difficult and relearning may be necessary ▪ Prior knowledge cannot be used ▪ No guarantee that learning converges	▪ Rules must be available ▪ Cannot learn ▪ No formal methods for tuning ▪ Semantic problems in interpreting tuned system ▪ Adaptation to modified environment can be difficult

3.4.2 ANFIS Architecture

Fundamentally, ANFIS is a combination of a fuzzy inference system (FIS) and a back-propagation neural network algorithm based on some collection of input-output data. The most important reason for combining fuzzy systems with neural networks is to use the learning capability of neural networks. Such a combination should be able to learn linguistic rules and/or membership functions, or to optimize existing ones. To illustrate the use of neural networks for fuzzy inference, we present successful adaptive neural network fuzzy inference systems, along with training algorithms known as ANFIS. These structures, also known as adaptive neuron-fuzzy inference systems or adaptive network fuzzy inference systems, were proposed by Jang et al (1993). For simplicity we assume the fuzzy inference system that has two inputs x and y and a singleton z as its output. For a first–order Sugeno model, a common rule set with two fuzzy "If… then…" is as follows:

Rule 1: If x_1 is A_1 and y_1 is B_1 then $z = f_1 = a_0^1 + a_1^1 x + a_2^1 y$ (3.18)

Rule 2: If x_1 is A_2 and y_1 is B_2 then $z = f_2 = a_0^2 + a_1^2 x + a_2^2 y$ (3.19)

where, $a_0^1, a_1^1, a_2^1, a_0^2, a_1^2, a_2^2$ are consequent parameters (this will be explained in the end of this section). Figure 3-9 shows the reasoning mechanism for this Sugeno model. The corresponding equivalent ANFIS architecture, which we discuss now, is shown in Figure 3-10, where nodes of the same layer have similar functions. In the discussion, the term denotes the output of the ith nodes in layer *l*. The constructed adaptive network is functionally equivalent to a Sugeno fuzzy model. It is important to note that the structure of this adaptive network is not unique. For instance, Layers 3 and 4 can be combined to obtain an equivalent with only 4 layers. By the same notion, the weight normalization can be performed in the last layer.

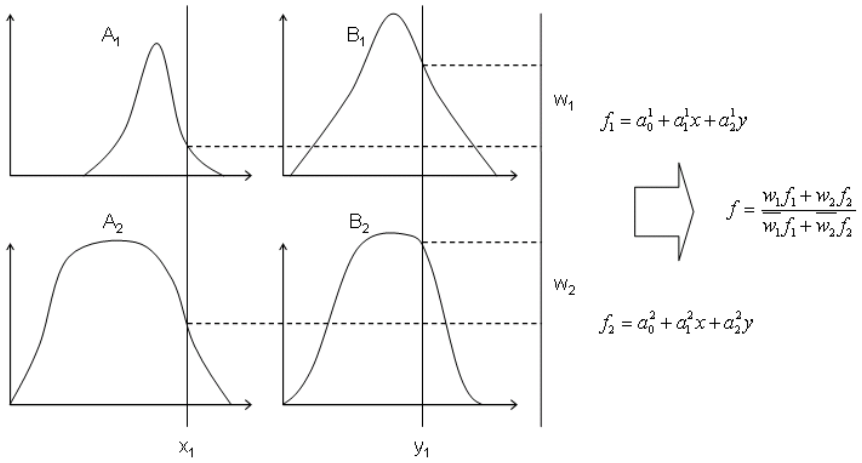

Figure 3 - 9 A two input first-order Sugeno model with two rules

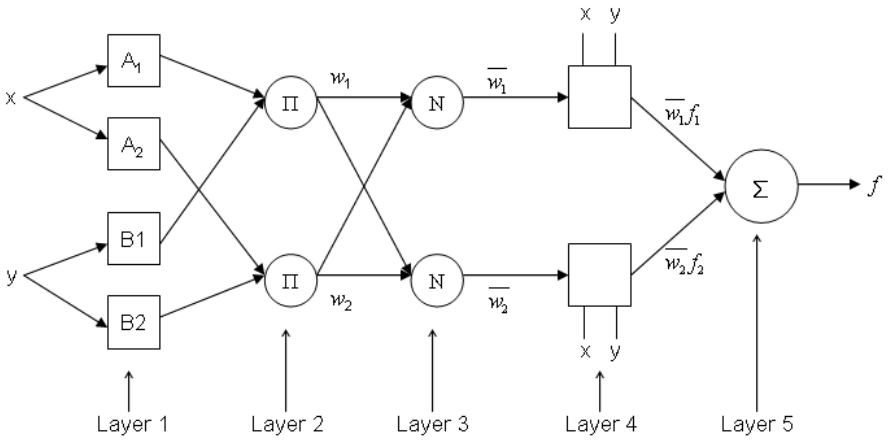

Figure 3 - 10 An equivalent ANFIS architecture

Layer 1: Every node i in this layer is an adaptive node with a node function

$$O_{1,i} = A_i(x), \text{ for } i = 1, 2 \tag{3.20}$$

$$O_{1,i} = B_{i-2}(x), \text{ for } i = 3, 4 \tag{3.21}$$

where x(or y) is the input to node i and A_i(or B_{i-2}) is a linguistic label (such as "small" or "large") associated with the node. In other words, $O_{1,i}$ is the membership grade of a fuzzy set A = (A_1, A_2, B_1, or B_2) and it specifies the degree to which the given input x (or y) satisfies a quantifier A. Here the membership function for A can be an appropriately parameterized membership function such as the generalized bell function

$$A(x) = \frac{1}{1 + \left| \frac{x - c_i}{a_i} \right|^{2b_i}} \tag{3.22}$$

where $\{a_i, b_i, c_i\}$ is the parameter set. As the values of these parameters change, the bell-shaped function varies accordingly, thus various forms of membership functions for fuzzy set A. Parameters in this layer are generally referred to as ***premise parameters***.

Layer 2: Every node in this layer is a fixed node labeled, whose output is the product of all the incoming signals:

$$O_{2,i} = w_i = A_i(x)B_i(y), \text{ for i=1, 2.} \tag{3.23}$$

Each output represents the firing strength of a rule. In general any other t-norm operator, all of which perform a fuzzy AND, can be used as the node function in this layer.

Layer 3: Every node in this layer is a fixed node labeled N. The ith node calculates the ratio of the ith rule's firing strength to the sum of all rule's firing strengths:

$$O_{3,i} = \bar{w}_i = \frac{w_i}{w_1 + w_2} \quad \text{for i=1, 2} \tag{3.24}$$

The outputs of this layer are referred to as ***normalized firing strengths***.

Layer 4: Every node i in this layer is an adaptive node with a node function

$$O_{4,i} = \bar{w}_i f_i = \bar{w}_i (a_o^i + a_1^i x + a_2^i y) \quad \text{for i=1, 2} \tag{3.25}$$

where, $\bar{w}_i$ is the normalized firing strength from layer 3 and $\{a_0^i, a_1^i, a_2^i\}$ is the parameter set of this node. Parameters in this layer are referred to as ***consequent parameters***.

Layer 5: The single node in this layer is a fixed node labeled, which computes the overall output as the summation of all incoming signals:

$$\text{Overall output} = O_5 = \sum_i \bar{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} \tag{3.26}$$

3.4.3 Hybrid-learning algorithm

Form the ANFIS architecture in Figure 3-9, we observe that when the values of the premise parameters are fixed, the overall output can be expressed as a linear combination of the consequent parameters. The output f in Figure 3-10 can be expressed as

$$\begin{aligned} f &= \frac{w_1}{w_1 + w_2} f_1 + \frac{w_2}{w_1 + w_2} f_2 \\ &= \bar{w}_1 (a_0^1 + a_1^1 x + a_2^1 y) + \bar{w}_2 (a_0^2 + a_1^2 x + a_2^2 y) \\ &= \bar{w}_1 a_0^1 + \bar{w}_1 x a_1^1 + \bar{w}_1 y a_2^1 + \bar{w}_2 a_0^2 + \bar{w}_2 x a_1^2 + \bar{w}_2 y a_2^2 \end{aligned} \tag{3.27}$$

which is linear in the consequent parameters, $a_0^1, a_1^1, a_2^1, a_0^2, a_1^2, a_2^2$.

The consequent parameters can be obtained by solving the following over constrained, simultaneous equations

$$\begin{bmatrix} \bar{w}_1^{(1)} & \bar{w}_1^{(1)}x^{(1)} & \bar{w}_1^{(1)}y^{(1)} & \bar{w}_2^{(1)} & \bar{w}_2^{(1)}x^{(1)} & \bar{w}_2^{(1)}y^{(1)} \\ \bar{w}_1^{(2)} & \bar{w}_1^{(2)}x^{(2)} & \bar{w}_1^{(2)}y^{(2)} & \bar{w}_2^{(2)} & \bar{w}_2^{(2)}x^{(2)} & \bar{w}_2^{(2)}y^{(2)} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \bar{w}_1^{(n)} & \bar{w}_1^{(n)}x^{(n)} & \bar{w}_1^{(n)}y^{(n)} & \bar{w}_2^{(n)} & \bar{w}_2^{(n)}x^{(n)} & \bar{w}_2^{(n)}y^{(n)} \end{bmatrix} \begin{Bmatrix} a_0^1 \\ a_1^1 \\ a_2^1 \\ a_0^2 \\ a_1^2 \\ a_2^2 \end{Bmatrix} = \begin{Bmatrix} d^{(1)} \\ d^{(2)} \\ \vdots \\ d^{(n)} \end{Bmatrix} \qquad (3.28)$$

where $\left[\left(x^{(k)}, y^{(k)}\right), d^{(k)}\right]$ are the k_{th} training pair k =1, 2, …. n, and $\bar{w}_1^{(k)}$ and $\bar{w}_2^{(k)}$ are the outputs of Layer 3 associated with the inputs $\left(x^{(k)}, y^{(k)}\right)$. Eq.(3.28) can be expressed in matrix-vector form as Ax = d, where $x = [a_0^1, a_1^1, a_2^1, a_0^2, a_1^2, a_2^2]^T$,$d = [d^{(1)}, d^{(2)}, ..., d^{(n)}]^T$ and A is a matrix formed by the elements, $\bar{w}_1^{(k)}$, $\bar{w}_2^{(k)}$, $x^{(k)}, y^{(k)}$. There are several approaches to solve these kinds of constrained equations that can be used to obtain the consequent parameters. One of the most concise ways to solve Ax = d (if A^TA is nonsingular) is to use the pseudo inverse technique.

$$x = (A^TA)^{-1}A^Td \qquad (3.29)$$

ANFIS model implements a Sugeno-like fuzzy system in a network structure, and applies a mixture of back-propagation and least mean squares procedure to train the system. In the forward pass of the hybrid learning algorithm, node outputs go forward until Layer 4 and the consequent parameters are identified by the least squares method outlined above. In the backward pass, the signals that propagate backwards are the error signals and the premise is updated by the gradient descent method. Table 3-2 summarizes the various activities during each of these passes (Jang et al, 1997).

Table 3 - 2 Parameters update in the hybrid learning procedure for ANFIS

Signal flow direction	Forward pass	Backward pass
Consequent parameters	Least-squares estimator	Fixed
Premise parameters	Fixed	Gradient descent method
Signals	Node outputs	Error signals

To summarize ANFIS architecture, first the membership functions for each input variable are defined. Each membership function corresponds to a linguistic term. Then degree of membership is assigned to each input value corresponding to each linguistic term. This information is first fed-forward through the network and then the error will be back-propagated through the network to update the membership functions for each input variable. The main objective is to determine the premise parameter, which is used to build the final membership for each input variable and the consequent parameters, which are the consequent results corresponding to the If-Then rule. The following examples give a detailed description of how to use ANFIS and how it performs.

3.5 A basic study of Adaptive Neuro Fuzzy Inference System

3.5.1 Effects of number of MFs and type of MFs

A total of 60 training data and 20 testing data were sampled uniformly form the input range [-1, 1]: $y = f(x) = 0.6\sin(pi * x) + 0.3\sin(3 * pi * x) + 0.1\sin(5 * pi * x)$. The training data was used for training ANFIS, while the testing data was used for verifying the identified ANFIS only. There is not a simple method to determine in advance the minimal number of membership functions needed to achieve a desired performance level. In other words, the number of membership functions is chosen empirically by trial and error (this is similar to the number of hidden units of neural networks). Generally the number of Membership Functions is decided within the range of 1 to 10 (Jang and Gulley, 1996).

The type of membership functions as well as the number of membership functions is important in building the ANFIS architecture. Table 3-3 and 3-4 show correlation R^2 with respect to type and number of MFs (membership functions) for training and testing data sets respectively. Table 3-3 and 3-4 illustrates the performance achieved in the network with different combinations of types and numbers of MFs in terms of the coefficient of correlation R^2. The best performance is achieved with a Gaussian membership function, with 6 membership functions. Also it is shown that with more number of MFs, higher correlation R^2 is achieved, as shown in Table 3-3 and 3-4.

Table 3 - 3 Correlation R^2 related to type and number of MFs for Training

Type \ Number	2	3	4	5	6
Triangle	0.7873	0.9853	0.9829	0.9855	0.9978
Gaussian	0.8695	0.8510	0.9940	0.9994	***0.9999***
Generalized Bell	0.8692	0.9083	0.9949	0.9993	0.9998
D-sigmoid	0.9118	0.8882	0.9951	0.9998	0.9993

Table 3 - 4 Correlation R^2 related to type and number of MFs for Testing

Type \ Number	2	3	4	5	6
Triangle	0.7726	0.9852	0.9843	0.9816	0.9942
Gaussian	0.8680	0.8468	0.9946	0.9994	***0.9999***
Generalized Bell	0.8674	0.9231	0.9953	0.9994	0.9998
Dsigmoid	0.9202	0.8977	0.9938	0.9998	0.9991

The ANFIS used here contains 6 (= 6^1) rules with six membership functions assigned to the input variable. And the total number of fitting parameters is 36, including 18(= 3*6) premise parameters and 18(= 6*3) consequent parameters.

Figure 3-11 and 3-12 shows initial Gaussian membership functions, and final Gaussian membership functions with six members after training. It is observed how different the circles in the figures are, even when there is not a big difference between them. Also the input variable ranges from 0 to 1 by normalization at initial MF, the variable ranges from -1 to 1 at final MF.

Figure 3-13 shows results on training and testing data set using 6 memberships with Gaussian functions. The thick dashed line gives the desired function (exact solution), and the triangular and star (*) denote the predicted training samples and testing samples respectively. The network fits exactly with both the training and testing samples. Correlation R^2 for training and testing sets are also as high and as close as 1.0.

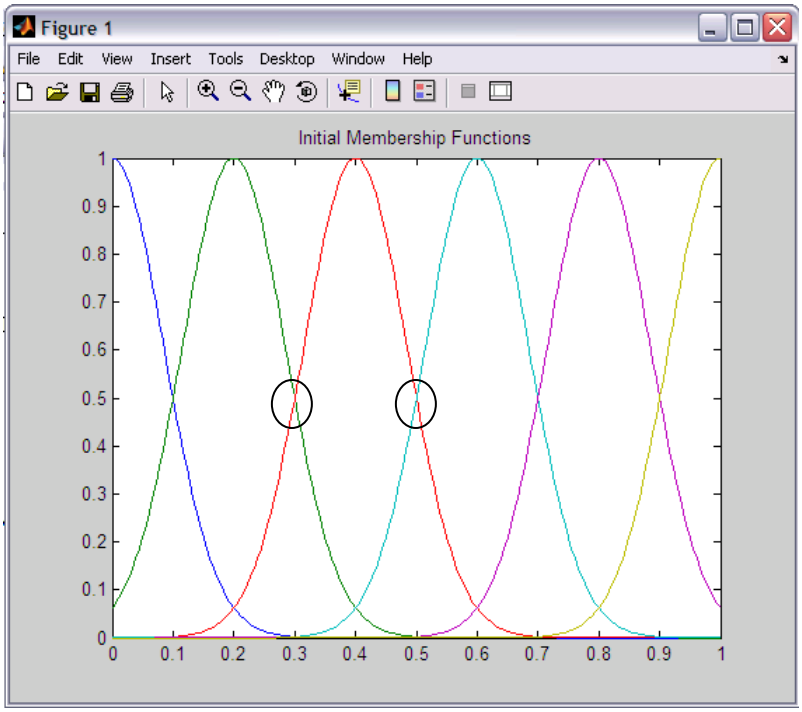

Figure 3 - 11 Initial membership function

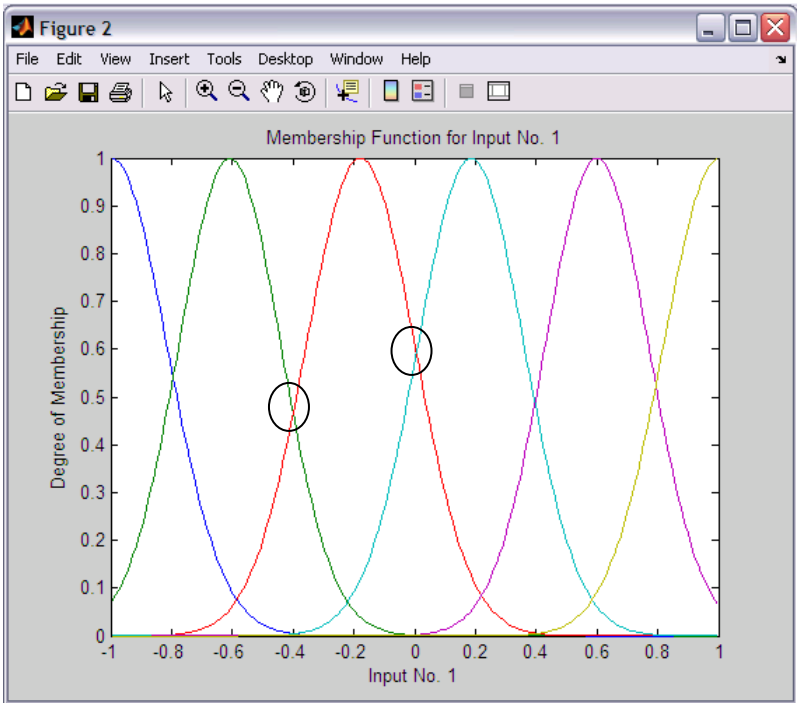

Figure 3 - 12 Final membership function

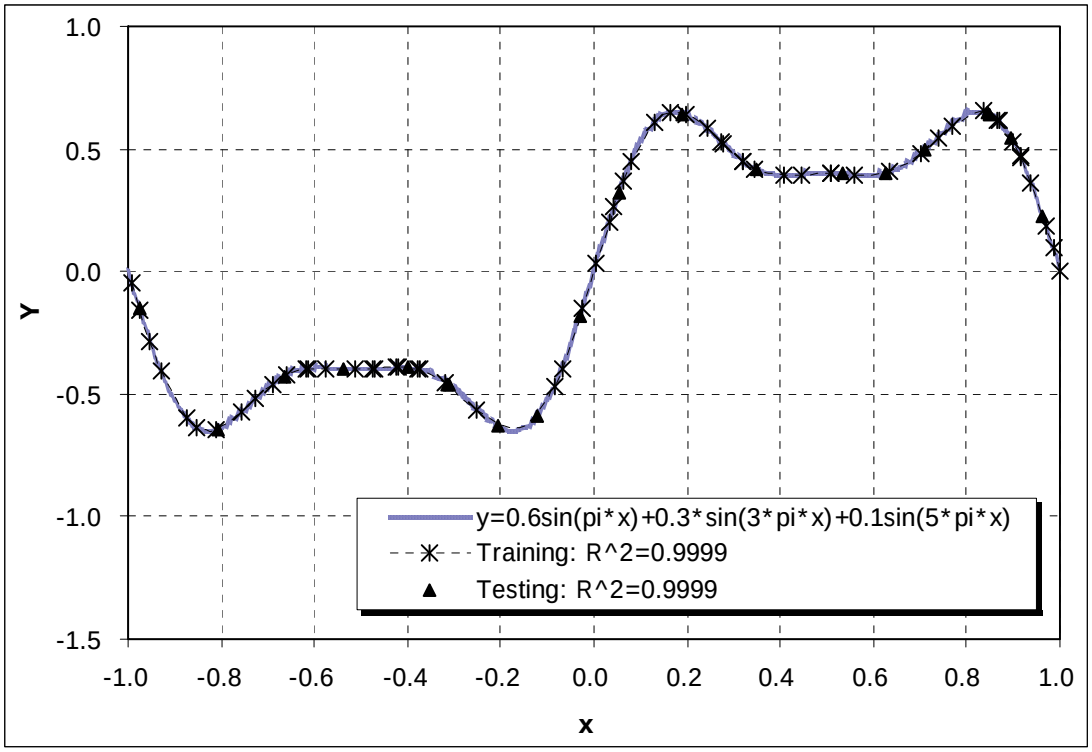

Figure 3 - 13 Training and testing results using 6 memberships with Gaussian functions

3.5.2 Effects of number of samples

In order to investigate effects of number of samples, an exponential function $y = \exp(10 * t(t-1)) * \sin(12 * \pi * t)$ is used to be approximated with an ANFIS as the same example used in the neural network model chapter. Figure 3-14 presents different approximations from 200, 100, 50, 30 training samples with 6 numbers of MFs and generalized bell shape MFs. The exact (original) function is shown in Figure 3-14 as a dotted line. The approximated lines with increasing training set size do not match suitably with the original (desired) function, in contrast to the results of back-propagation neural networks.

Figure 3-15 shows different approximations with regards to different number of MFs (6, 7, 8) with 200 training samples and generalized bell shape MFs. As shown in Figure 3-15, ANFIS with 7 or 8 numbers of MFs proves to be better than with 6 numbers of MFs. Therefore, it is shown that ANFIS is influenced greatly by the number of MFs for each input variable rather than by the number of training samples.

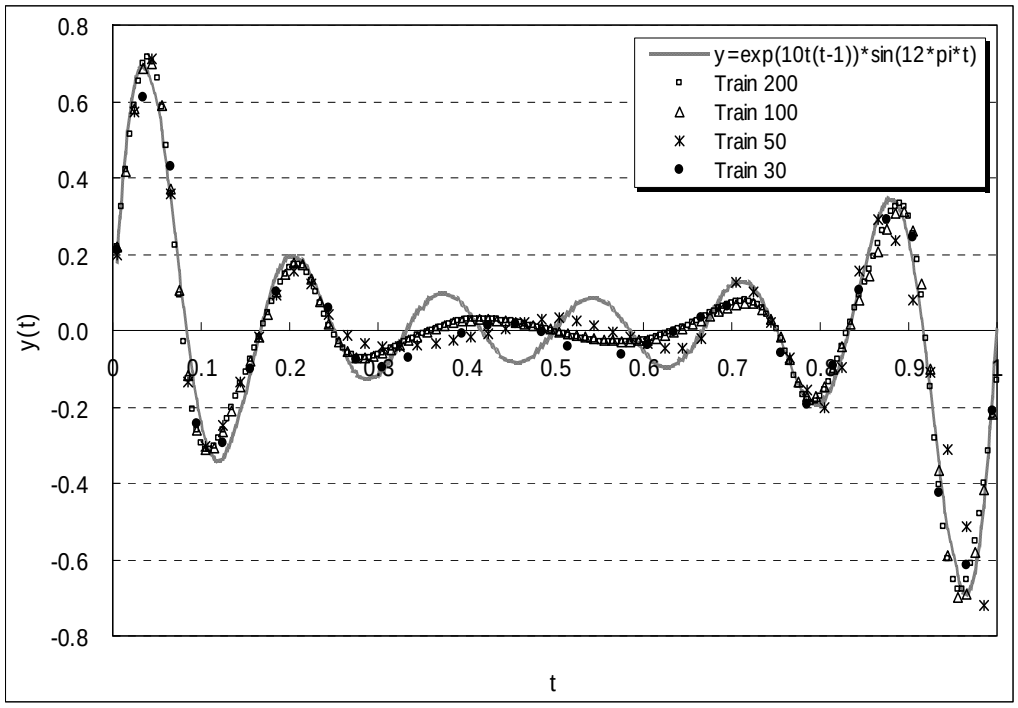

Figure 3 - 14 An example of effects of number of samples

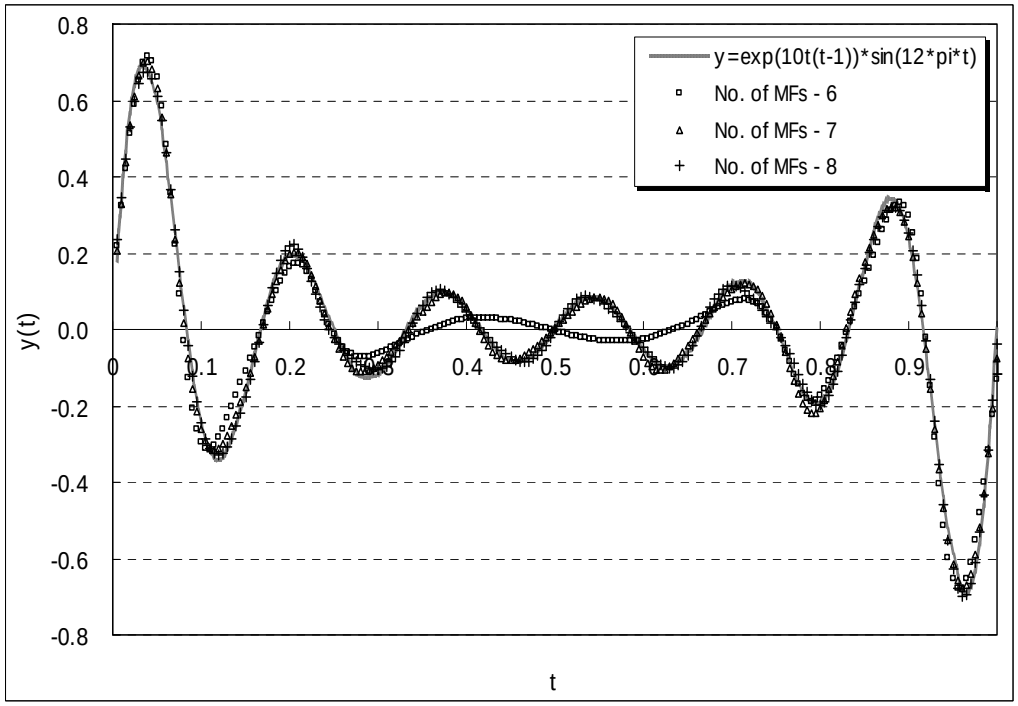

Figure 3 - 15 An example of effects of number of MFs

3.5.3 Over-fitting

For data sets with more than three inputs, visualization techniques are not very effective and usually trial and error must be relied upon. For this example, the generalization capacity of ANFIS is largely determined by the number of membership functions assigned to each input variable: $y = f(x_1, x_2, x_3) = x_1 + 10x_2 + x_3^3$ ($0 < x_1, x_2, x_3 < 10$). At this time, we should not ignore the *over-fitting* problem. Over-fitting occurs when we fit the fuzzy system to the training data so well that it no longer does a very good job of fitting the testing data. The result is a loss of generality. Table 3-5 shows that a larger number of MFs leads to a small error on the training set but does not necessarily lead to a small error on the test set. In other words, it is shown that correlation R^2 for testing is much less while high correlation R^2 for training at 6 membership functions. One of the ways to avoid *over-fitting* is to use a small number of MFs first. Table 3 -5 shows the best performance of ANFIS when two membership functions are used.

Table 3 - 5 Correlation R^2 with respect to type and number of MFs for Training

Type \ Number	Training		Testing	
	2	6	2	6
Triangle	0.9999	0.9999	0.9998	0.8055
Gaussian	0.9999	0.9999	0.9985	0.8445
Generalized Bell	0.9999	0.9999	0.9969	0.8148
Dsigmoid	0.9985	0.9999	0.9833	0.7225

Figure 3-16 presents the initial triangular membership function with two membership functions for all input variables(x_1, x_2, x_3). Figure 3-17 through 3-19 show final membership functions for each input variable after training respectively. These figures also provide each input range and express the change before and after training.

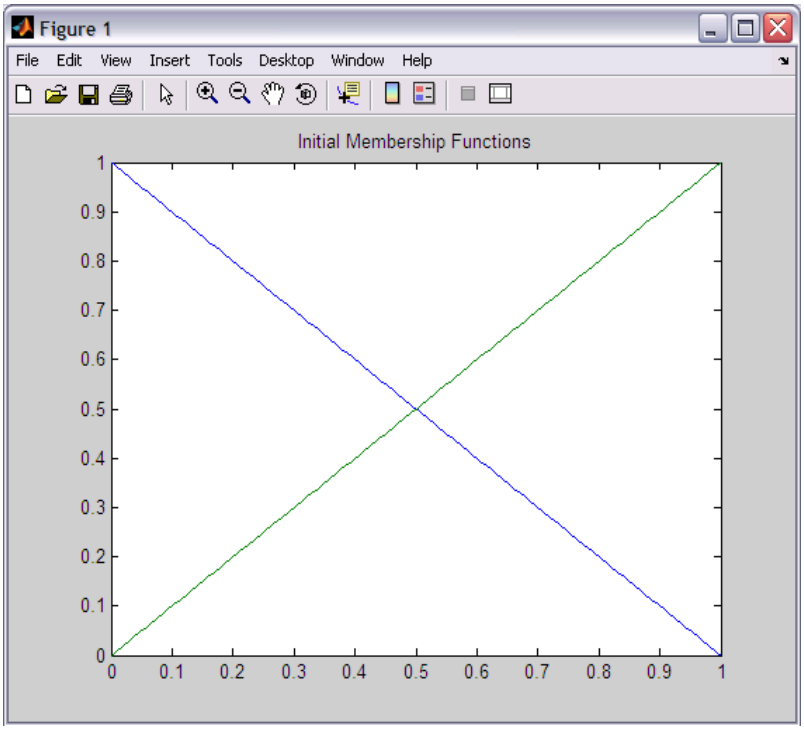

Figure 3 - 16 Initial MF (x1, x2, x3)

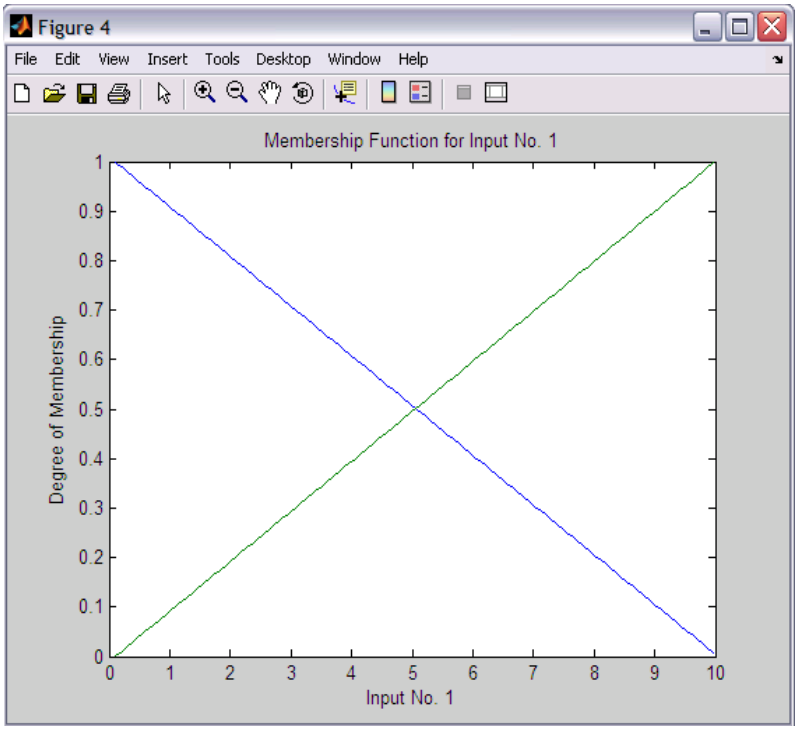

Figure 3 - 17 Final MF (x1)

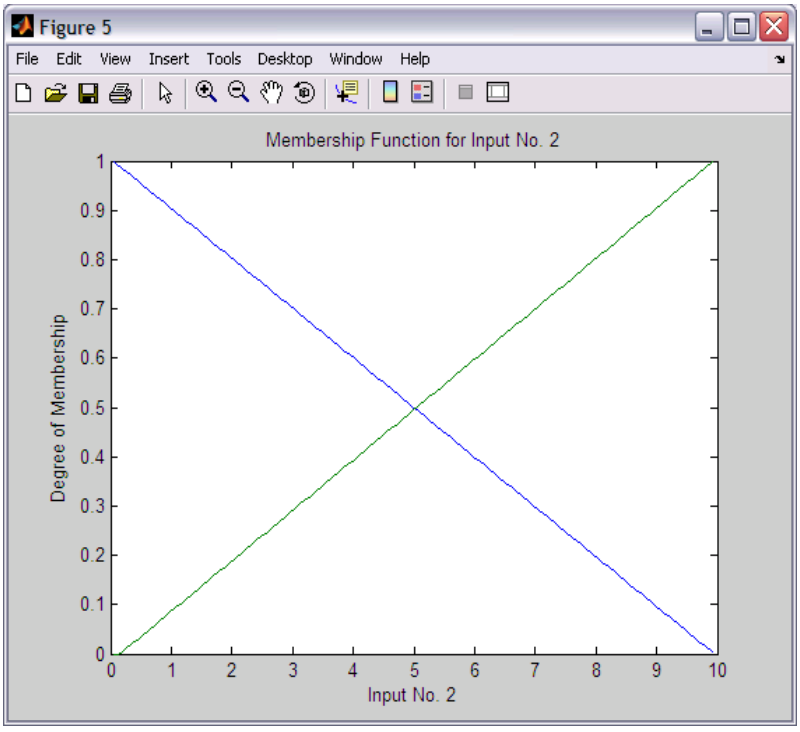

Figure 3 - 18 Final MF (x2)

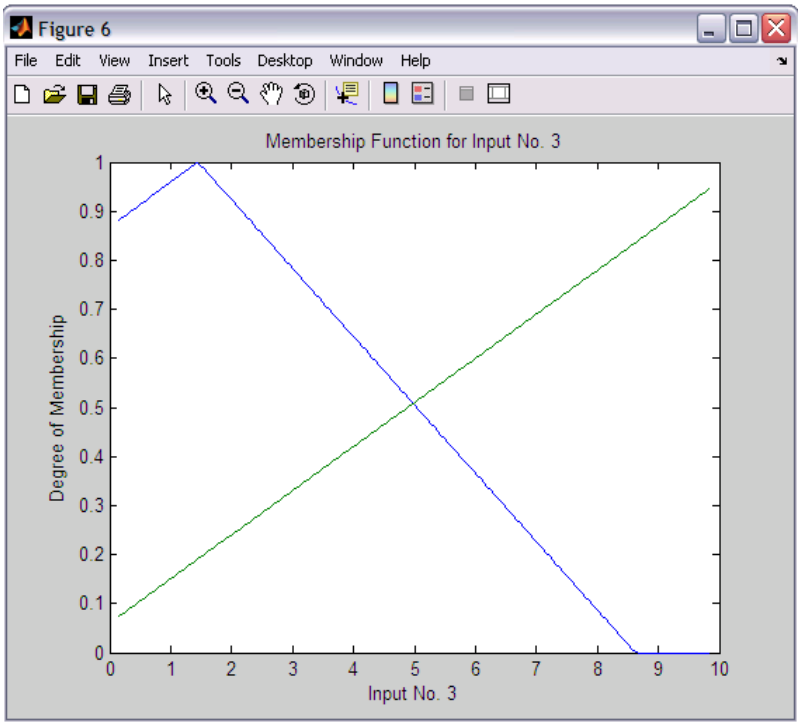

Figure 3 - 19 Final MF (x3)

3.5.4 Effects of superfluous factor (t_1)

When model parameters are estimated in neural networks, uncertain variables may be chosen as inputs when considering a large number of variables that affect mechanical systems. Let's consider t_1 as one of the input variables, which does not actually have an influence on y(target).

Real: $y = f(x_1, x_2, x_3) = x_1 + 10x_2 + x_3^3$

Assumption: $y = f(x_1, x_2, x_3, t_1)$ $(0 < x_1, x_2, x_3 < 10, 0 < t_1 < 2)$ (3.30)

An ANFIS is carried out using 60 training samples and 20 testing samples. As shown in Table 3-6 and 3-7, the performance is the best when two membership functions and triangular type of MF are used. Its correlation R^2 is 0.9999 for training and 0.9846 for testing. Also it's shown that over-fitting occurs as the number of MFs is increased.

Table 3 - 6 Correlation R^2 for training

Type \ Number	2	3	4	5
Triangle	0.9999	0.9999	0.9999	0.9999
Gaussian	0.9999	0.9999	0.9999	0.9999
Generalized Bell	0.9999	0.9999	0.9999	0.9999
D-sigmoid	0.9999	0.9999	0.9999	0.9999

Table 3 - 7 Correlation R^2 for testing

Type \ Number	2	3	4	5
Triangle	0.9846	0.9180	0.6282	0.6140
Gaussian	0.9670	0.8838	0.5218	0.4055
Generalized Bell	0.9534	0.8669	0.4748	0.3403
D-sigmoid	0.9092	0.6587	0.4353	0.2729

As far as correlation R^2 is concerned, since an ANFIS for testing seems to be trained fairly with up to three membership functions as shown in Table 3-7, these ANFIS models are assumed to be good. But they should not be expected as a good model because of superfluous factor (t_1). The best way to avoid the influence the superfluous factor (t_1) is to use the maximum epoch as convergent in the testing results. In this case, it's reasonable to use 50 epochs for the training as shown in Table 3-8.

Table 3 - 8 Effect of epochs

Epoch	Training	Testing
10	0.9999	0.9641
20	0.9999	0.9846
30	0.9999	0.9970
40	0.9999	0.9990
50	**0.9999**	***0.9993***
100	0.9999	0.9993

Figure 3-20 and 3-21 presents the initial triangular membership function with two membership functions for all input variables(x_1, x_2, x_3, t_1). Figure 3-22, 3-23, 3-24, and 3-25 show final membership functions for each input variable after training respectively. These figures also illustrate how much they were changed before (initial) and after (final) training.

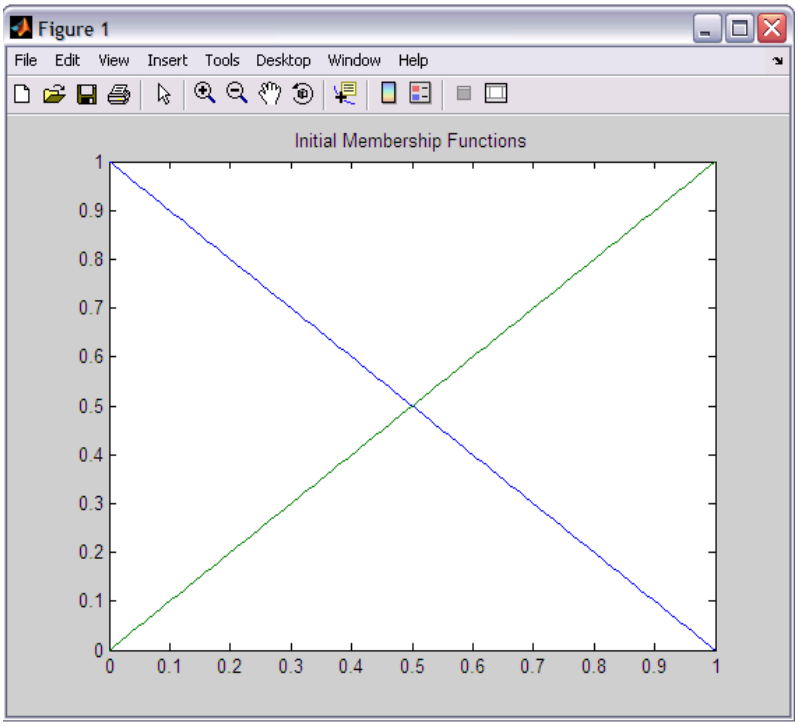

Figure 3 - 20 Initial MF (x1, x2, x3)

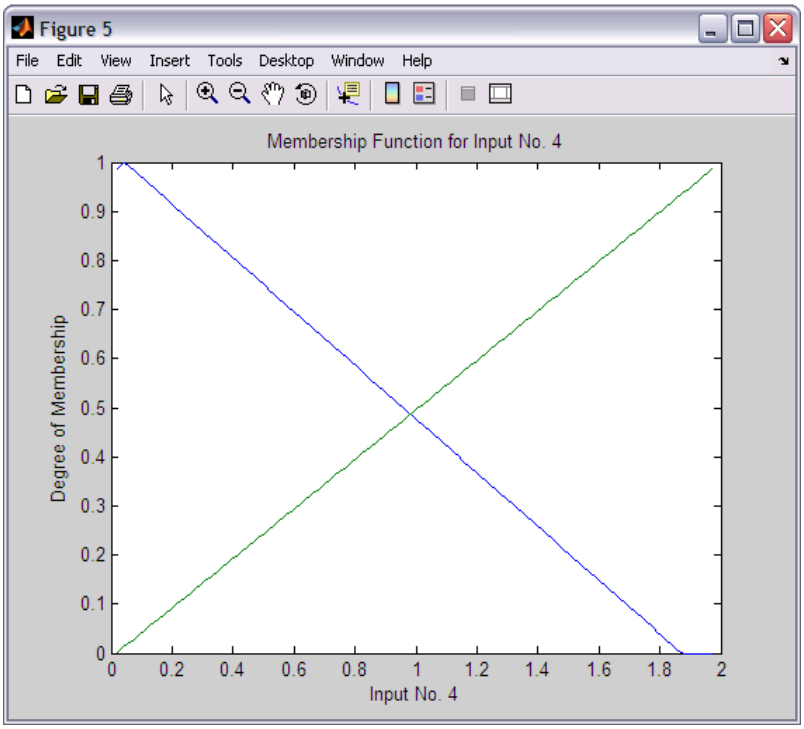

Figure 3 - 21 Initial MF (t1)

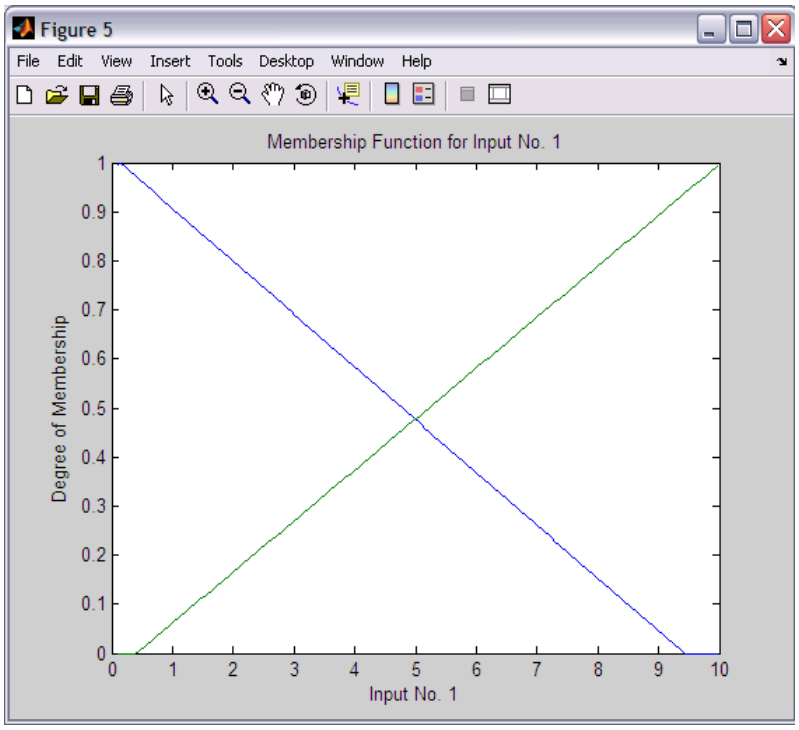

Figure 3 - 22 Final MF (x1)

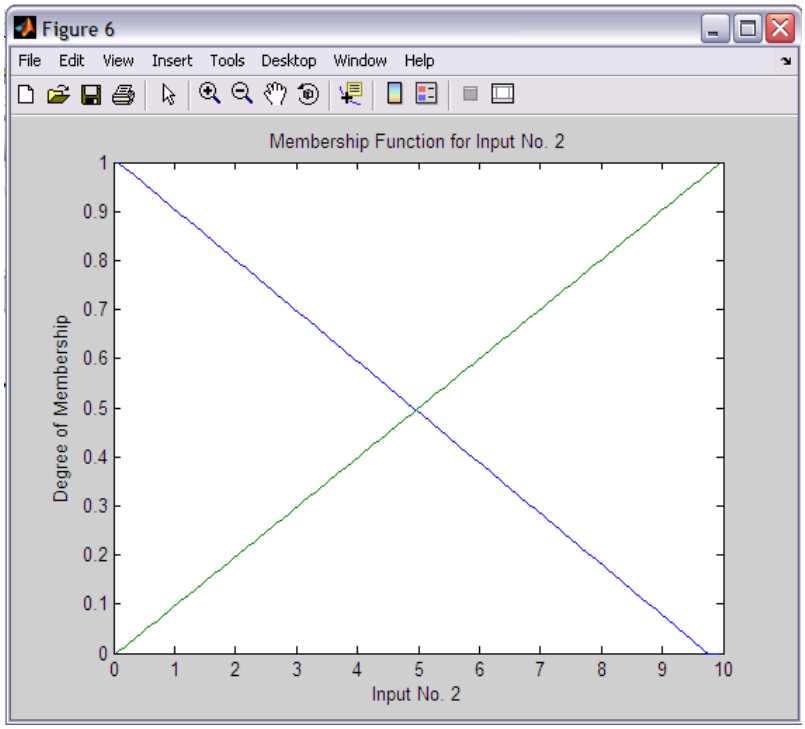

Figure 3 - 23 Final MF (x2)

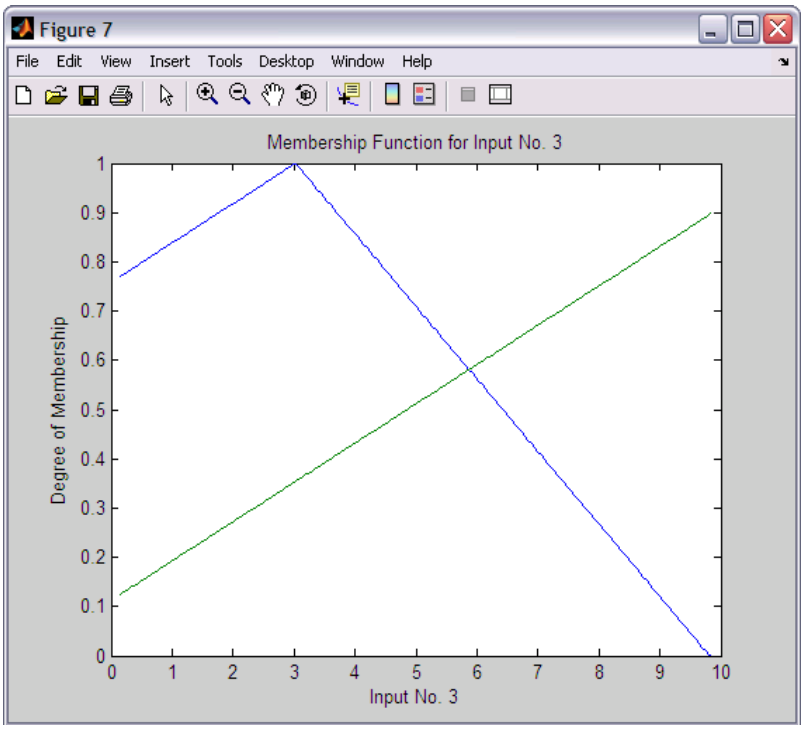

Figure 3 - 24 Final MF (x3)

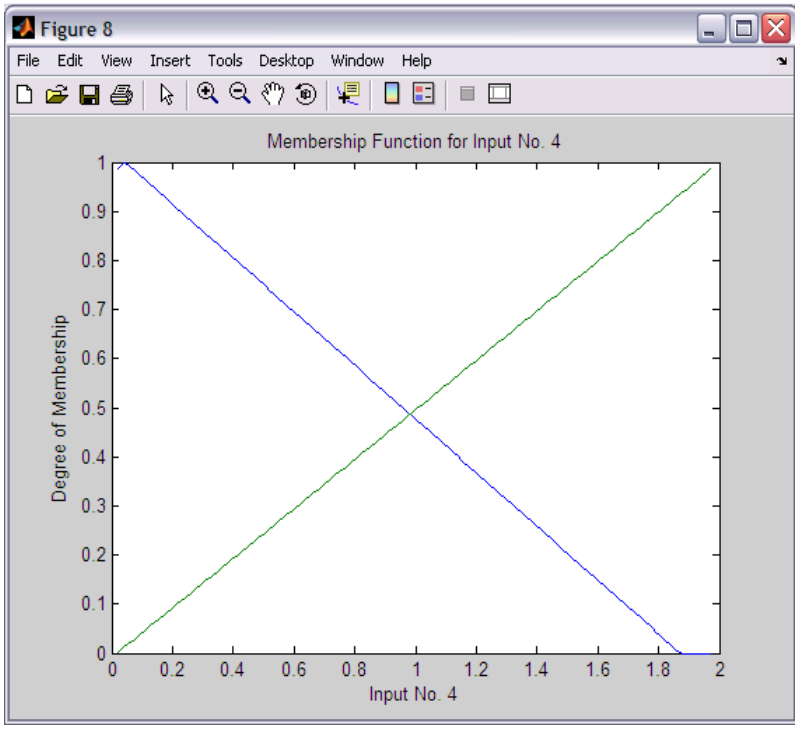

Figure 3 - 25 Final MF (t1)

3.6 ANFIS vs. BPNN

3.6.1 All of data range

In order to compare ANFIS and BPNN we use an example in Neural Network: input variables are x, y and target variable are expressed as $z = f(x, y)$, $z = x^2 * \exp(-x^2 - y^2)$, x and y range: [-2, 2]. The data used in both models development was divided by two groups: the first one - 100 training samples, the second - 30 testing samples. BPNN is developed with 1 hidden layer and 10 hidden nodes. ANFIS is developed with difference sigmoidal MFs and four MFs to all of input variables ['below medium', 'medium', 'above medium', 'very high']. Table 3-9 describes correlation R^2 by using ANFIS and BPNN. They both have high correlation R^2 results for training and testing data. Figure 3-26 and 3-27 present results of predicted 100 points of training and testing on a desired 3D graph of z. For both ANFIS and BPNN results, the predicted points to training and testing are well placed on the 3D face of 100% agreement.

Table 3 - 9 Comparison results of correlation R^2 for application to all of data range

Type	Training	Testing
ANFIS	0.9976	0.9812
BPNN	0.9989	0.9917

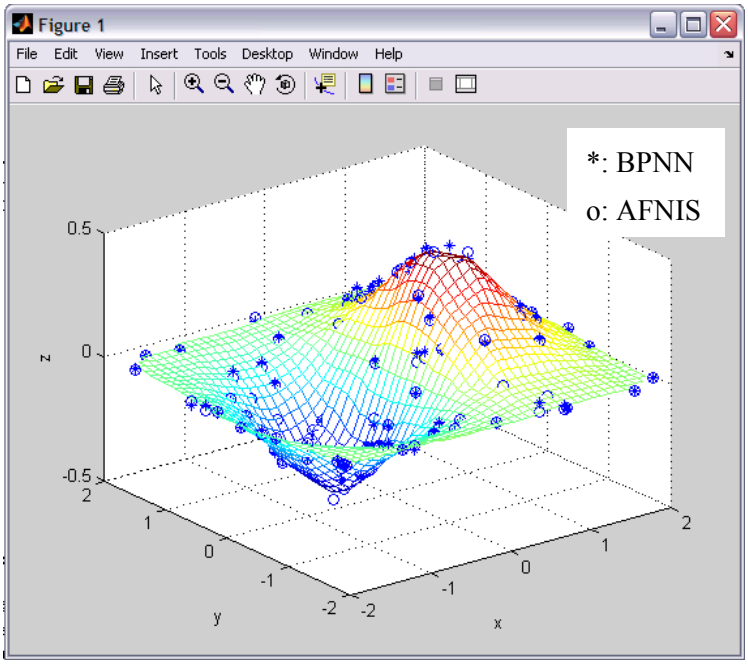

Figure 3 - 26 Comparison results for training data

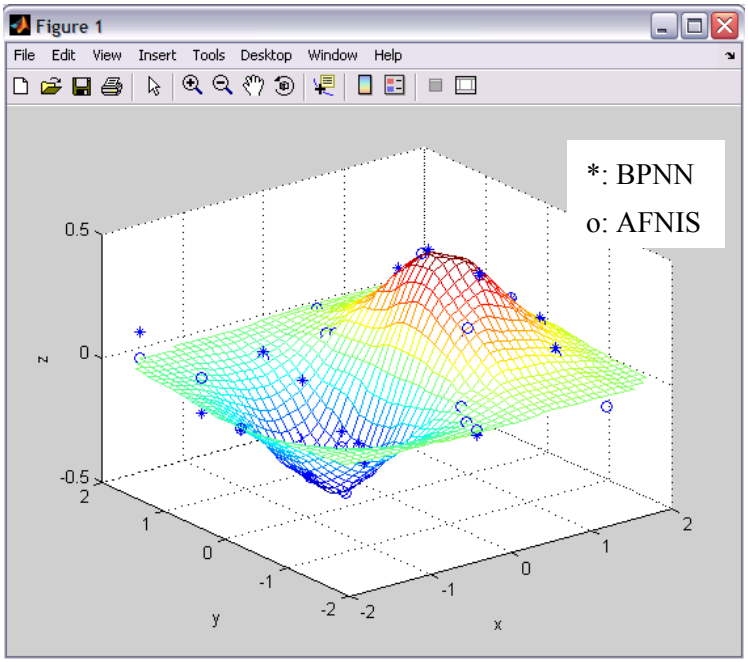

Figure 3 - 27 Comparison results for testing data

3.6.2 Limited data range

ANFIS may be more efficient than BPNN when developing models using limited data range, which is already classified. The data used in both models development was divided by two groups: the first one - 81 training samples, the second - 26 testing samples. Let's say x range: [-2, 1], y range: [-2, 2] with the same example in the previous section: $z = f(x, y)$, $z = x^2 * \exp(-x^2 - y^2)$. It is assumed that type of MFs is assigned to difference sigmoid MF, 3 numbers of MFs for x variable, and 4 for y by percentage of limited data range because x and y variables were assigned to 4 numbers of MFs in the previous section ([-2, 2]: 4, [-2, 1]: 3).

Figure 3-28 and 3-29 show initial MF and final MF to each input variable, respectively. Please note input ranges in Figure 3-30 and 3-31. Even though 'very high' to develop AFNIS was not used as a MF, ANFIS can extrapolate beyond the data range using linguistic terms like 'very high'. However, BPNN can not go beyond the range of the data used for the training.

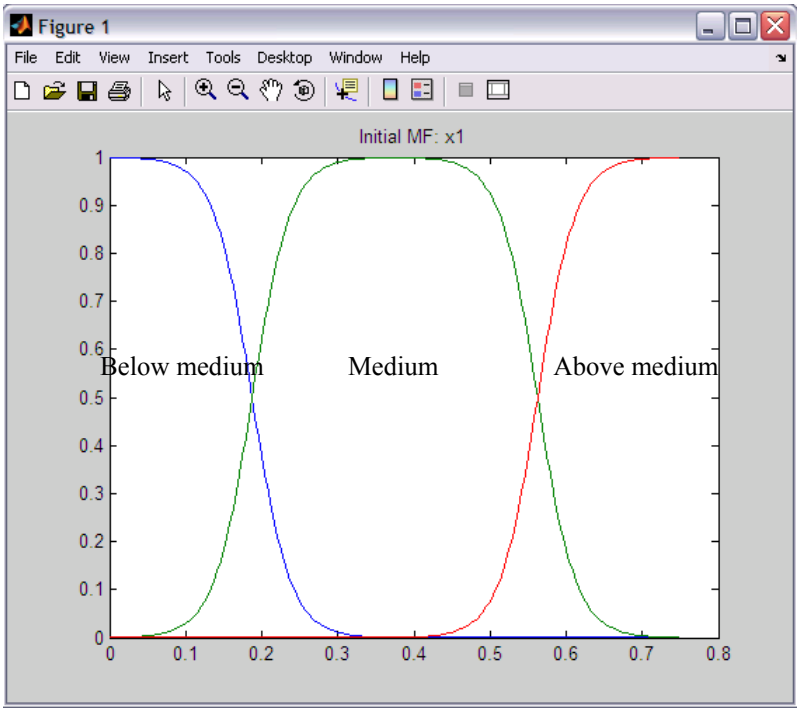

Figure 3 - 28 Initial MF: x1

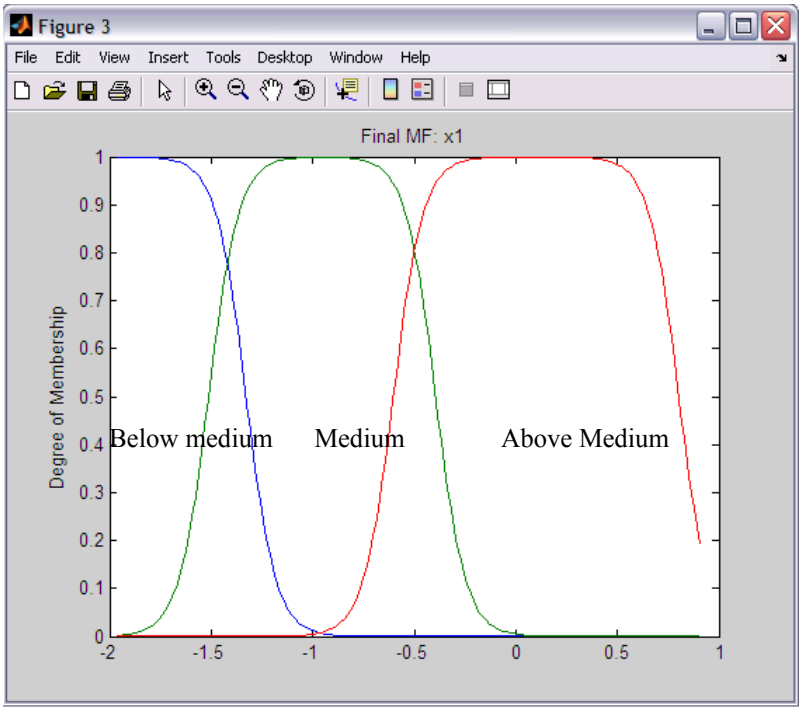

Figure 3 - 29 Final MF: x1

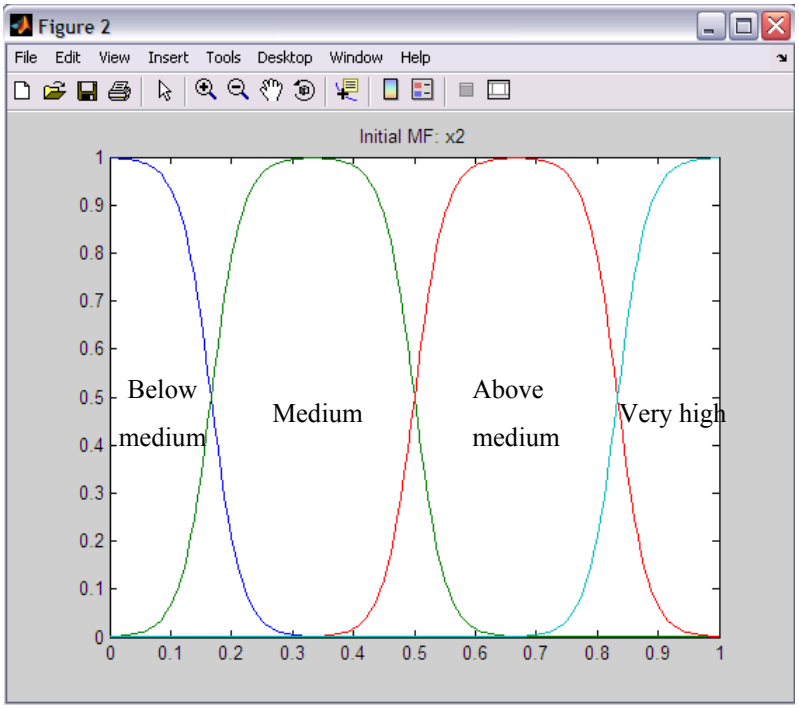

Figure 3 - 30 Initial MF: x2

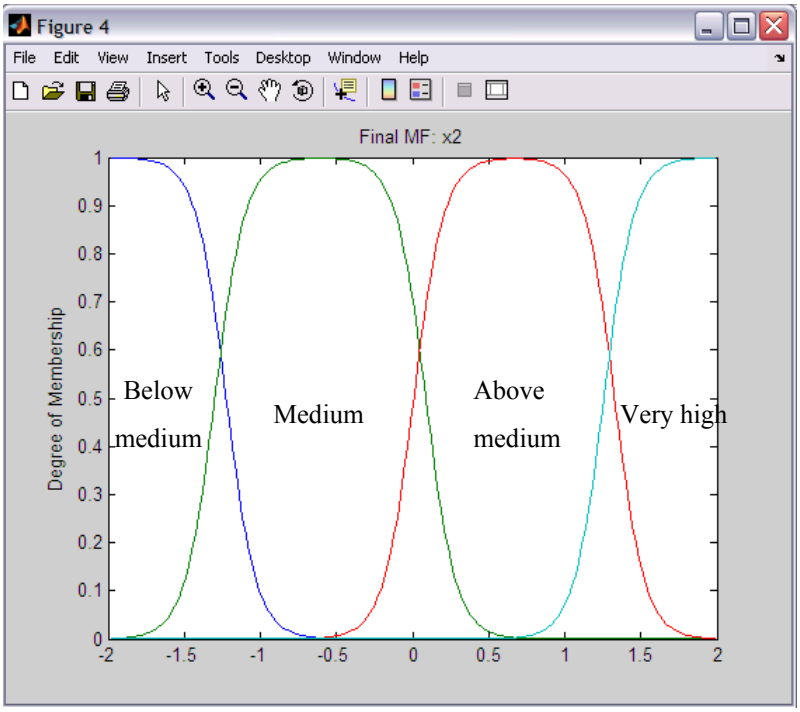

Figure 3 - 31 Final MF: x2

Table 3-10 describes comparison results of correlation R^2 by using ANFIS and BPNN within the limited data range. They both have high correlation R^2 results for training and testing data, though BPNN has slightly higher correlation R^2.

Figure 3-32 and 3-33 present predictions of training data (81) and testing (26) on the desired 3D graph of z. For both ANFIS and BPNN results, the predicted points to training and testing are well placed on the 3D face of 100% agreement.

Based on 3.7.1 and 3.7.2 sections, ANFIS may be more efficient than BPNN in the case of developing a model with limited data range because ANFIS can consider beyond the data range using membership functions.

Table 3 - 10 Comparison results of correlation R^2 for application to limited data range

	Training	Testing
ANFIS	0.9975	0.9071
BPNN	0.9807	0.9859

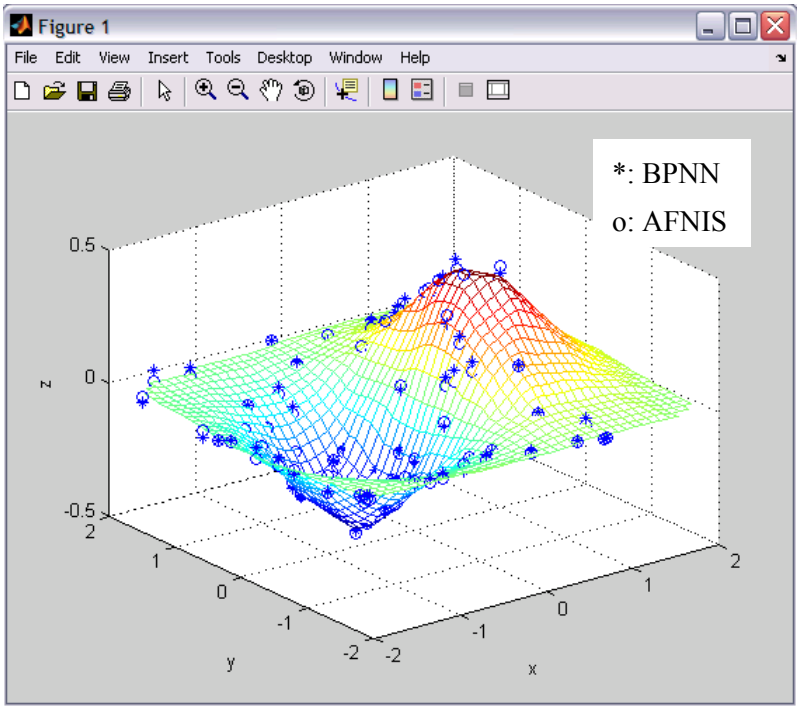

Figure 3 - 32 Comparison results for training data

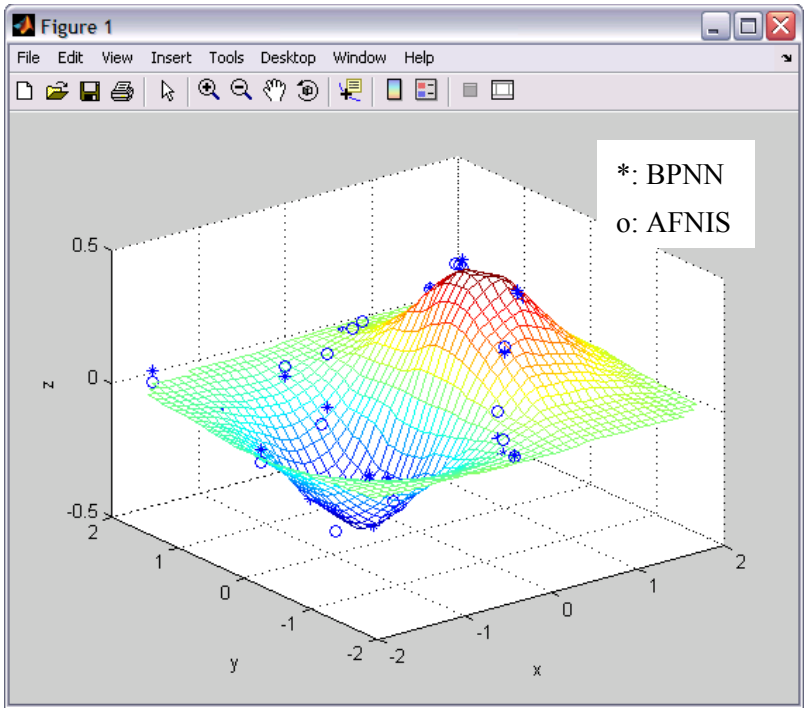

Figure 3 - 33 Comparison results for testing data

From the above we observe the following:

(a) The type of MFs and the number of MFs are important in building the ANFIS architecture. These are chosen empirically by trial and error.

(b) ANFIS is influenced greatly by the number of MFs for each input variable rather than by the number of training samples.

(c) One of the ways to avoid *over-fitting* is to use a small number of MFs first because a larger number of MFs leads to a small error on the training set but not necessarily to a small error on the test set.

(d) The best way to avoid the influence of the superfluous factor (t_1) is to use the maximum epoch as convergent in the testing results.

(e) ANFIS can consider beyond the data range using linguistic terms. However, BPNN is not available to extrapolate beyond the data range, since BPNN handles only the limited data (BPNN considers that the data covers all ranges).

3.7 References

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Chapter 4 Neural Network Models and Adaptive Neuro Fuzzy Inference System for Prediction of Ultimate Pile Capacity in Cohesion-less Soils

4.1 Introduction

The evaluation of ultimate load capacity is an important aspect of the design of pile foundations. However, the estimation of ultimate pile capacity has been a difficult task because of various factors affecting the capacity and uncertainties associated with them. Because of these restrictions, it has been commonly accepted that pile load testing is the best way to provide accurate predictions. However, pile load tests are very expensive and time-consuming, and thus cannot be done routinely.

In this section, back-propagation neural network models and adaptive neuro-fuzzy inference systems are developed to predict the ultimate load capacity of piles in cohesion-less soils. A database of a number (75) of field pile load tests obtained and compiled from the review of literature was used for the development of these models. Two separate neural network models are developed; the first one is based on the entire data set including jetting conditions as an input variable, while the second model is only for non-jetted data sets.

In the developed neural network, there is an input layer, where input data is presented to the network, and an output layer, in which one neuron represents ultimate capacity, and also two hidden layers as intermediate layers. Friction angle at shaft, friction angle around tip of the pile, effective stress at tip, pile length, pile cross-sectional area, and jetted/non-jetted conditions are chosen as input variables to evaluate the pile capacity, which is the target variable. The models are developed within MATLAB with GUI (Graphical User Interface) to combine both models for non-jetted data and for all data including some jetted data. Pile capacity predictions were made using BPNN as well as three commonly used empirical methods, and they were also compared with the actual results from measurements. These other methods are those proposed by Coyle and Castello(1981), Meyerhof(1976), and Vesic(1977). The results of this study indicate that the neural network model provides a better prediction than conventional methods, and can serve as a reliable and simple predictive tool for the prediction of the axial loading capacity of piles, and can even consider jetting methods.

In the developed ANFIS the same input variables as used in BPNN model are selected to evaluate the pile capacity, the target variable. Membership functions and numbers

to each input variable are appropriately decided when testing data set has the highest correlation R^2. Pile capacity predictions were made using ANFIS as well as commonly used empirical methods including BPNN, and they were also compared with actual measurements. The other methods are those proposed by Coyle and Castello(1981), Meyerhof(1976), and Vesic(1977). The results of this study indicate that both ANFIS and BPNN provide similar predictions (BPNN being slightly better than ANFIS) which are better than those by the empirical methods, and can serve as a reliable and simple predictive tool for the prediction of the axial loading capacity of piles. As more data become available, these models (ANFIS and BPNN) can be improved further to make more accurate capacity predictions for a wider range of load and site conditions.

4.2 Problem

4.2.1 Overview

Several methods have been proposed for the estimation of the ultimate load capacity of piles because the evaluation of ultimate load capacity is an important aspect of the design of pile foundation. Perhaps the most frequently used method of estimating the load capacity of driven piles is to use dynamic driving formulae because of their simplicity. It is obvious that the energy delivered to the pile, while driving it through soils, may serve as a basis to estimate its load carrying capacity. Simply the rated energy can be expressed as the weight of the ram multiplied by its drop. The dynamic pile driving formulae are derived by equating the delivered energy to the work done by the pile as it penetrates a distance against resistance. However, the results from these formulae show considerable scatter when compared to static load test data. They fail to cover a variety of pile driving systems by a single driving formula. Also, they can't explain a series of time-dependent events by hammer impacts. Of course the best way to estimate the ultimate capacity of pile is a static load test. However, because of the high cost involved, static load tests cannot be done routinely.

4.2.2 Ultimate Load Capacity

Generally ultimate load capacity can be expressed by the sum of the ultimate shaft and base resistance, followed by the subtraction of the weight of the pile.

$$Q_u = Q_p + Q_s - W \tag{4.1}$$

Where Q_s = ultimate shaft resistance

Q_p = ultimate base resistance

W = weight of pile

The ultimate shaft resistance (Q_s) can be evaluated by integration of the pile-soil strength over the surface area of the shaft with the Coulomb expression

$$\tau_b = c_b + \sigma_n \tan\phi_b \tag{4.2}$$

Where, τ_b = pile-soil shear strength

c_b = adhesion

σ_n = normal stress between pile and soil = $\sigma_v K_s$

K_s = coefficient of lateral pressure

ϕ_b = angle friction between pile and soil

Therefore, the ultimate shaft resistance is expressed as

$$Q_s = \int_0^L C\,\tau_b dz = \int_0^L C\,(c_a + \sigma_v K_s \tan\phi_b) dz \tag{4.3}$$

C = pile perimeter

L = length of pile shaft

Also, the ultimate base resistance Q_p can be evaluated from the general bearing capacity theory as

$$Q_p = A_p q_p = A_p (cN_c + \sigma_{vp} N_q + 0.5\gamma\, d\, N_r) \tag{4.4}$$

Where A_p = area of pile base

c = cohesion of soil

σ_{vp} = vertical stress in soil at level of pile tip

γ = unit weight of soil

d = pile diameter

N_c, N_q, N_r = bearing capacity of factors = $f(\phi)$

From combining Eqs.(5.2)-(5.4), the ultimate load capacity of a single pile can be expressed as Eqs.(5.5).

$$Q_u = Q_p + Q_s - W = A_p (cN_c + \sigma_{vp} N_q + 0.5\gamma\, d\, N_r) + \int_0^L C\,(c_a + \sigma_v K_s \tan\phi_b) dz \; - W \tag{4.5}$$

However, it is noted that the soil parameters c, ϕ_b, c_b, and γ should be appropriately used according to undrained conditions or drained conditions. If under undrained conditions, the σ_v and σ_{vp} should be total stresses, while for drained conditions the σ'_v and σ'_{vp} should be effective stresses.

4.3 Available Methods

4.3.1 Coyle and Castello's method

Coyle and Castello (1981) suggested the way to calculate ultimate pile capacity in sand

$$Q_p = q' N_q^* A_p \tag{4.6}$$

Where, q' = effective vertical stress at the pile tip

N_q^* = bearing capacity factor

Figure 4-1 shows the variation of N_q^* with embedment ratio (L/D) and soil friction angle, □.

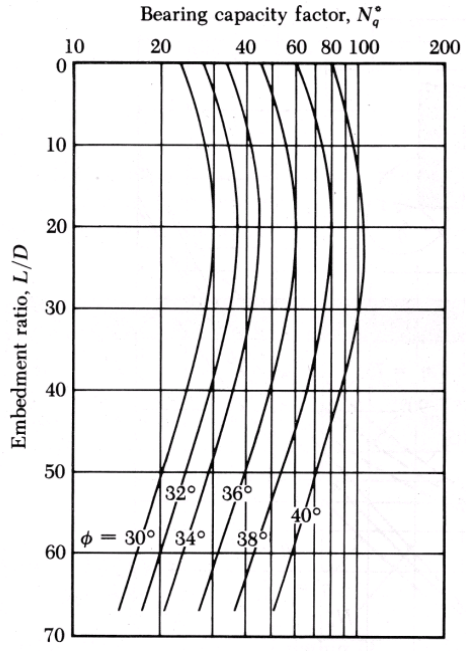

Figure 4 - 1 Variation of N^*q with L/D and ø

4.3.2 Meyerhof's method

The Meyerhof(1976) method assumes that the shaft resistance and toe resistance can be estimated separately and that these two factors do not affect each other. The ultimate load-carrying of a pile is given by a simple equation as the sum of the load carried at the pile points and the total frictional resistance as Eq.(4.7).

$$Q_u = Q_p + Q_s \tag{4.7}$$

From the Eq.(4.4), c=0 for piles in sand,

$$Q_p = A_p q_p = A_p q' N_q^* \tag{4.8}$$

$$q_p (lb/ft^2) = 800 N_{cor} \, L/D \le 8000 N_{cor} \tag{4.9}$$

N_{cor} : corrected SPT N value suggested by Peck.et.al (1974)

$$Q_s = f_s A_s \tag{4.10}$$

$$f_s = K_s \overline{p_o} \tan\phi \le f_l \tag{4.11}$$

The magnitude of the critical depth (l) may be 15 to 20 pile diameters. A conservative estimate would be

$$l \approx 15D \tag{4.12}$$

4.3.3 Vesic's method

Vesic(1977) proposed a method for estimating the pile point bearing capacity based on the theory of expansion of cavities. According to this theory, based on effective stress parameters,

$$Q_p = A_p q_p = A_p (cN_c^* + \sigma_o' N_\sigma^*) \tag{4.13}$$

σ_o' = mean normal ground effective stress at the level of the pile point

N_c^*, N_σ^* = bearing capacity factors

$$N_\sigma^* = \frac{3N_q^*}{1+2K_o} \tag{4.14}$$

where, K_o = earth pressure coefficient at rest

$$N_c^* = (N_q^* - 1)\cot\phi \tag{4.15}$$

$$N_c^* = \frac{4}{3}(\ln I_{rr} + 1) + \frac{\pi}{2} + 1 \tag{4.16}$$

$$I_{rr} = \frac{I_r}{1 + I_r \Delta} \tag{4.17}$$

where, $I_r = \dfrac{E_s}{2(1+\mu_s)(c + q'\tan\phi)}$ = rigidity index (4.18)

E_s : Modulus of elasticity of soil

μ_s : Poisson's ratio of soil

Δ: Average volumetric strain in the plastic zone below the pile point

Also, skin resistance is calculated as Eq.(4.19) using the Unit Skin Resistance (fs) related to relative density(Dr):

$$Q_s = P \times \Delta L \times f_s \tag{4.19}$$

where, $f_s = 1.5 \times 0.08\,(10)^{1.5 \times Dr^4}$ for driven Piles (4.20)

$f_s = 1.5 \times 0.025\,(10)^{1.5 \times Dr^4}$ for bored Piles (4.21)

4.4 Neural Network Models

4.4.1 Introduction

Considering the variables used in earlier methods, for the development of neural network models following five variables are used as input variables: friction angle at shaft, friction angle around tip of the pile, effective stress at tip, pile length, and pile cross-sectional area. The friction angle of the soil around the shaft and near the tip of the pile provides the information about the shear strength of surrounding and supporting soils. Effective stress at the tip of the pile also has a significant role in calculating the pile capacity. The pile length as well as cross-sectional area provides necessary information about the pile dimensions.

As a preprocess, all the inputs of the training and testing sets were scaled between 0 and 1 before being presented to the network to make the contribution of all inputs equivalent (Master, 1993 and Eberhart and Dobbins, 1990).

As shown in Figure 4-2, to predict the ultimate load capacity of piles in cohesion-less soils, two BPNN models are developed: the first model for non-jetted data (in Figure 4-2(a), and the second model for all data including jetted data (in Figure 4-2(b)). In the both models the used neural network algorithm is a back-propagation model, and the network models consist of four layers. There is an input layer, where input data is presented to the network and an output layer, which consists of one neuron representing ultimate capacity, and also two hidden layers as intermediate layers. As an activation function, a logistic sigmoid function was selected for input through the first hidden layer and for second hidden layer through output layer, and a hyperbolic tangent function was used to convert in the first hidden layer to the second hidden layer. The appropriate hidden nodes are chosen when mean square error over the entire training pattern reaches an acceptable level. Then a GUI

program combining both the models is developed to predict ultimate load capacity of piles driven with or without jetting.

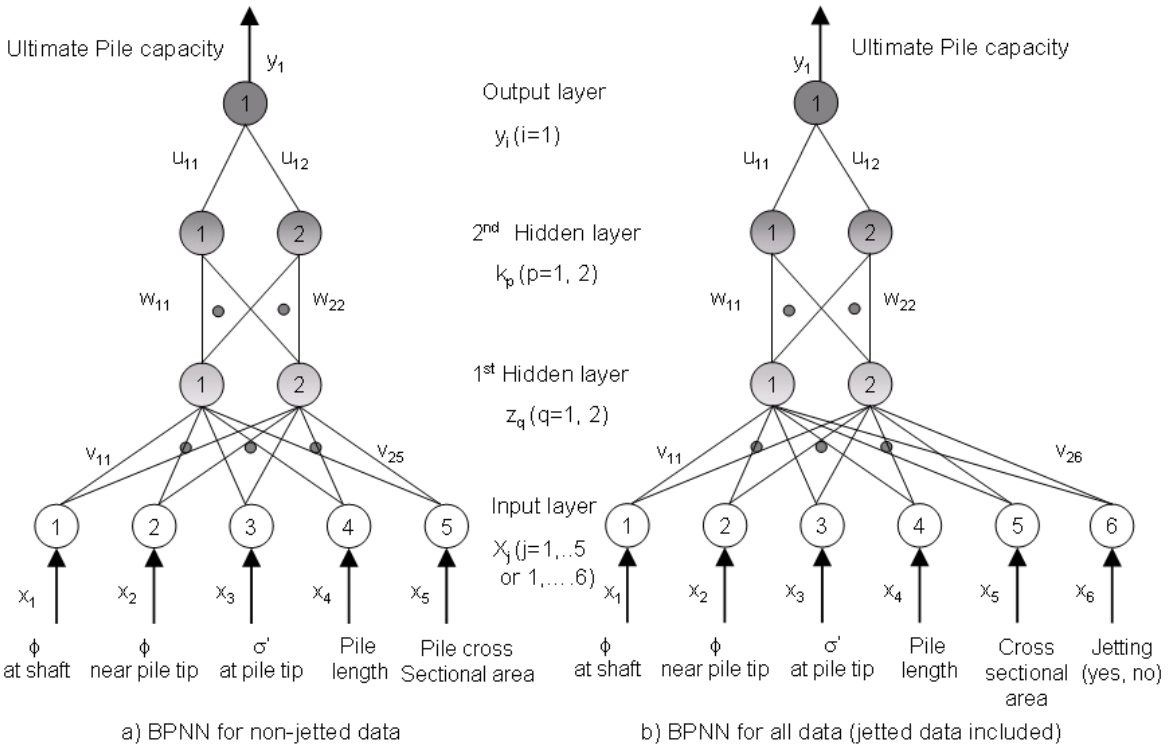

Figure 4 - 2 BPNN architectures for non-jetted data and all data (jetted data included)

4.4.2 Neural Network Model for Non-jetted data

Training and Testing

In order to develop a neural network model to estimate ultimate pile capacity using only non-jetted data the database of test data from 68 driven piles was used. As shown in Table 4-1 and 4-2, the 68 data were split at random into two groups: the first group of 51 was used as a training set, and the remaining 17 data (25 % of the data) was used for testing the robustness of the developed neural network.

Table 4 - 1 Training data set (non-jetted)

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (ft)	Pile cross-sectional area (ft^2)	Measured pile capacity (kips)	Predicted pile capacity (kips)	References
1	33.0	33.0	2318.3	40.0	0.066	16.9	80.6	Bergdahl and Wennerstrand (1976)
2	31.0	31.0	2798.7	52.5	0.660	107.9	65.6	Gregersen et al.(1973)
3	31.8	32.1	4425.2	77.0	1.778	134.9	231.8	Westinghouse(1990)
4	31.8	32.4	4943.6	86.0	0.149	146.1	126.3	Westinghouse(1990)
5	35.5	35.5	1858.8	29.9	0.860	147.3	206.7	Tavenas(1971)
6	34.0	35.0	1921.5	29.9	1.390	154.0	246.7	Thorburn and MacVicar(1970)
7	34.0	34.0	793.7	9.8	1.770	160.1	195.6	Vesic(1970)
8	34.0	35.0	2318.3	40.0	1.230	192.0	234.9	Thorburn and MacVicar(1970)
9	35.5	35.5	2485.4	40.0	0.860	201.0	229.4	Tavenas(1971)
10	35.5	35.5	3091.1	49.9	0.930	228.0	262.9	Tavenas(1971)
11	35.5	35.5	3091.1	49.9	0.860	250.2	254.0	Tavenas(1971)
12	31.8	32.4	4943.6	86.0	4.000	256.3	630.5	Westinghouse(1990)
13	35.0	37.0	5430.2	83.0	0.785	281.9	472.4	Blendy(1979)
14	35.5	35.5	3717.6	60.0	0.930	288.0	308.8	Tavenas(1971)
15	34.0	38.0	3049.3	37.1	0.340	321.3	403.9	Koizumi(1971)
16	35.0	35.0	3717.6	58.1	0.890	339.3	273.4	Goble et al.(1982)
17	32.0	35.0	5033.4	76.4	1.600	366.0	431.7	Thorburn and MacVicar(1970)
18	32.1	30.0	2020.8	92.0	4.000	390.0	409.7	Keane(1990)
19	35.0	35.0	1503.8	20.0	1.770	390.1	332.2	Vesic(1970)
20	33.0	35.5	7163.7	111.9	0.350	395.9	406.2	Kessler(1979)
21	36.5	36.5	2506.3	40.4	1.780	400.0	630.5	Hunter and Davisson (1969)
22	35.0	35.0	5054.3	79.1	0.710	400.0	377.3	Goble et al.(1982)
23	35.0	35.0	3717.6	58.1	1.000	400.0	298.3	Goble et al.(1982)
24	36.0	37.0	4365.1	67.9	0.890	420.0	468.7	Goble et al.(1982)
25	35.0	37.0	5137.8	78.1	0.785	430.1	449.5	Blendy(1979)
26	39.0	39.5	1169.6	17.1	1.075	437.9	484.9	Heins and Barends(1984)
27	39.0	39.5	1169.6	17.1	1.075	438.4	484.9	Heins and Barends(1979)
28	35.0	35.0	3467.0	54.1	0.660	472.1	232.8	Goble et al.(1982)
29	34.0	36.0	6662.5	104.0	0.350	490.1	404.0	Kessler(1979)
30	35.0	37.0	3299.9	52.8	1.770	502.0	513.9	Hunter and Davisson (1969)
31	28.2	36.0	2220.9	50.0	2.778	504.0	468.9	Keane(1990)
32	35.0	37.0	3822.1	58.1	0.785	520.0	374.8	Blendy(1979)
33	39.0	39.5	1566.4	23.0	1.075	548.3	590.5	Heins and Barends(1984)
34	31.7	38.0	1420.6	65.0	4.000	570.0	550.3	Keane(1990)
35	33.0	38.0	5325.8	80.4	1.410	587.9	680.3	Mansur and Kaufman(1958)
36	34.8	35.0	1800.8	93.0	4.000	600.0	554.2	Keane(1990)
37	31.2	29.0	3001.3	102.0	4.000	640.0	604.1	Keane(1990)
38	33.0	37.0	4302.4	65.3	1.960	642.1	584.3	Mansur and Kaufman(1958)
39	39.0	39.5	1503.8	22.0	1.075	674.5	575.6	Heins and Barends(1984)
40	33.0	37.5	4386.0	66.3	1.580	683.9	574.0	Mansur and Kaufman(1958)
41	36.0	36.0	2736.0	39.4	1.770	710.0	628.4	Vesic(1970)
42	33.0	33.0	6996.7	96.1	0.600	720.1	626.5	Wan et al.(1979)
43	33.0	34.0	7393.5	102.0	0.600	721.9	642.8	Wan et al.(1979)
44	38.0	41.0	2882.2	38.1	2.250	799.9	791.9	Furlow(1968)
45	34.0	37.5	4302.4	65.0	2.400	826.0	801.2	Mansur and Kaufman(1958)
46	36.0	36.0	3362.6	49.2	1.770	859.9	624.1	Vesic(1970)
47	38.0	40.0	4093.6	54.1	2.250	882.0	788.7	Furlow(1968)
48	37.5	39.5	5388.5	84.0	3.310	904.0	974.5	Gurtowski and Wu(1984)
49	28.0	39.0	4448.6	55.1	1.540	1049.9	1058.1	Reike and Crowser(1987)
50	33.0	35.0	3529.7	59.1	7.070	1124.1	1107.6	Mey et al.(1985)
51	34.0	38.0	9920.6	154.9	3.140	1259.9	1220.5	McCammon and Golder(1970)

Table 4 - 2 Testing data set (non-jetted)

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (ft)	Pile cross-sectional area (ft^2)	Measured pile capacity (kips)	Predicted pile capacity (kips)	References
1	31.0	31.0	2798.7	52.5	0.340	116.7	54.4	Gregersen et al(1973)
2	35.5	35.5	1858.8	29.9	0.930	147.9	212.6	Tavenas(1971)
3	35.5	35.5	2485.4	40.0	0.930	198.3	236.0	Tavenas(1971)
4	35.5	37.0	4761.9	71.9	0.710	207.3	423.3	Goble et al(1982)
5	35.5	35.5	3717.6	60.0	0.860	288.0	291.0	Tavenas(1971)
6	32.0	35.0	5033.4	76.4	1.600	366.0	431.7	Thorburn and MacVicar(1970)
7	36.0	37.0	4490.4	69.9	0.440	400.0	356.9	Goble et al(1982)
8	31.2	35.0	1200.5	30.0	3.361	408.0	393.1	Keane(1990)
9	36.0	37.0	4365.1	67.9	1.000	430.1	542.0	Goble et al(1982)
10	33.0	38.0	4657.5	70.5	1.410	486.5	617.8	Mansur and Kauffman(1958)
11	35.0	36.5	3299.9	53.1	2.270	516.0	660.8	Hunter and Davisson(1969)
12	35.0	35.0	2088.6	29.2	1.770	560.0	498.1	Vesic(1970)
13	35.5	36.0	3404.3	49.9	1.400	605.9	604.6	Vesic(1970)
14	32.0	37.0	3675.9	57.4	4.149	690.0	839.7	Milovic and Baci(1976)
15	32.0	34.0	4135.3	68.9	2.490	719.4	539.5	Carpenter et al(1984)
16	38.0	40.0	3425.2	44.9	2.250	740.1	746.9	Furbow(1968)
17	37.5	40.0	6286.5	98.1	3.310	1064.1	1126.0	Gurtowski and Wu(1984)

Table 4-3 illustrates the chosen values of learning parameters to get the best performance from the network when correlation R^2 is highest. After initial weights in the range of -3.40 to 4.33 were presented to the network, the network has trained continually through updating weights until the error goal is $6.6*10^{-3}$ and the number of hidden nodes is 2 with the two hidden layers.

Table 4 - 3 Learning factors at the highest R^2 of test data set

Initial weight	No. of Hidden nodes	Error goal	Correlation R^2	
			Training	Testing
-3.40 ~ 4.33	2	$6.6*10^{-3}$	0.8635	0.8578

The correlation R^2 and root mean-squared error (RMSE) of predicted versus measured results are summarized in Table 4-4. RMSE (Eq.(4.22)) is easily interpreted statistically since it has the same unit (kips) as the quantity of the vertical axis. As shown in Table 4-4, BPNN produced a much higher correlation R^2 and a lower root mean-squared error, when compared with other methods. It is indicated that BPNN predictions are more consistent than the three empirical methods.

$$\text{RMSE} = \sqrt{\frac{(a_i - c_i)^2}{n}} \tag{4.22}$$

where a_i is actual values (i=1,2…,n), c_i is computed values (i=1,2…,n).

Table 4 - 4 Summary of Correlation R^2 and RMSE (Root Mean Square Error)

Type	Correlation R^2		RMSE (kips)	
	Training	Testing	Training	Testing
BPNN	*0.8635*	*0.8578*	*101.0*	*101.7*
Coyle & Castello	0.5251	0.4800	484.1	940.1
Meyerhof	0.5420	0.5114	288.0	384.4
Vesic	0.6152	0.5868	249.6	303.1

In the case of non-jetted data, the predictions found using BPNN and conventional methods are plotted in Figure 4-3 for training and Figure 4-4 for testing, respectively. Figures 4-3 and 4-4 show that the predicted values from the neural networks match the measured values much better than those obtained from the three empirical methods being used in practice.

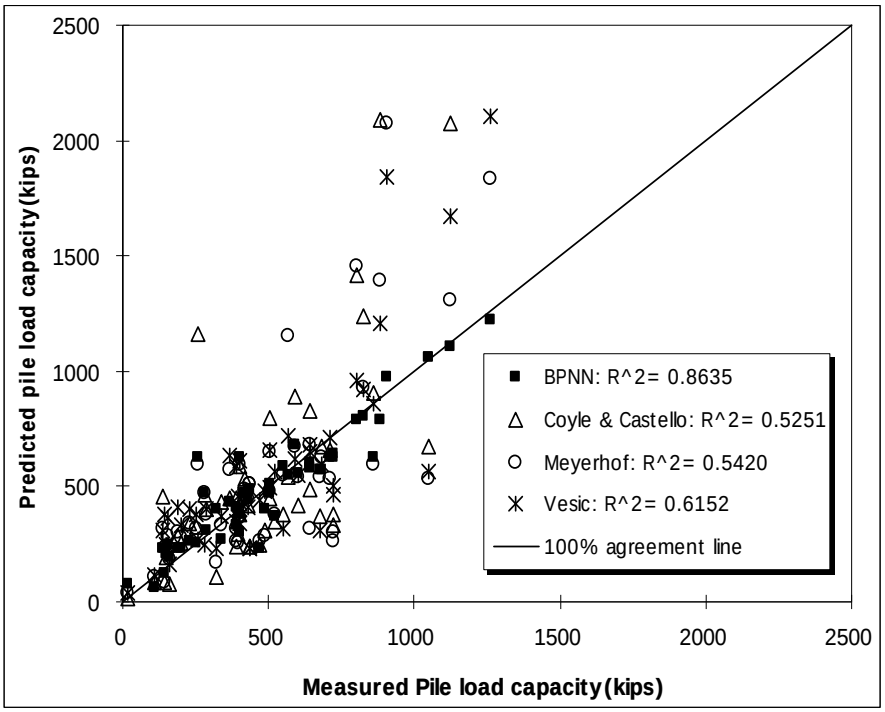

Figure 4 - 3 Comparison results of predicted and calculated for training

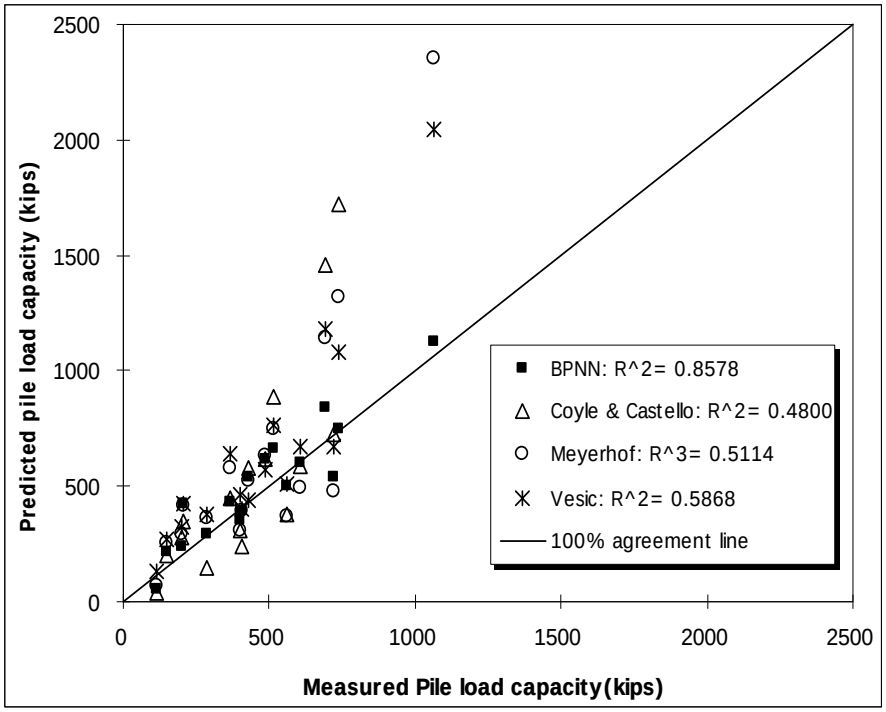

Figure 4 - 4 Comparison results of predicted and calculated for testing

Relative Importance

Table 4-5 shows the relative importance through the weights of each layer of connections. The relative importance of the various input factors can be assessed by examining input-hidden-hidden-output layer connection weights. This is carried out by partitioning the hidden-output connection weights into components connected with each input neuron. All of the selected variables have significant influence.

Table 4 - 5 Relative Importance (%) of the modeling (non-jetted)

Input Variables	ϕ_{shaft}	ϕ_{tip}	σ'_{tip}	Pile length	Cross sectional area
R.I (%)	10.34	18.38	29.6	17.32	24.36

Parametric Study

The effect of each parameter on the ultimate pile capacity was investigated. The basic idea is to predict the capacity with only one input variable while keeping the values of the remaining variables at their average value, with the same updated weights and bias matrices after being trained. Figures 4-5 through 4-9 show predicted values of ultimate pile capacity as a function of each parameter. It can be seen from these figures that the ultimate

load capacity of piles increases with an increase in the friction angle at shaft, friction angle around tip of the pile, effective stress at tip of the pile, pile length, and cross-sectional area. These results agree with the general pile characteristics.

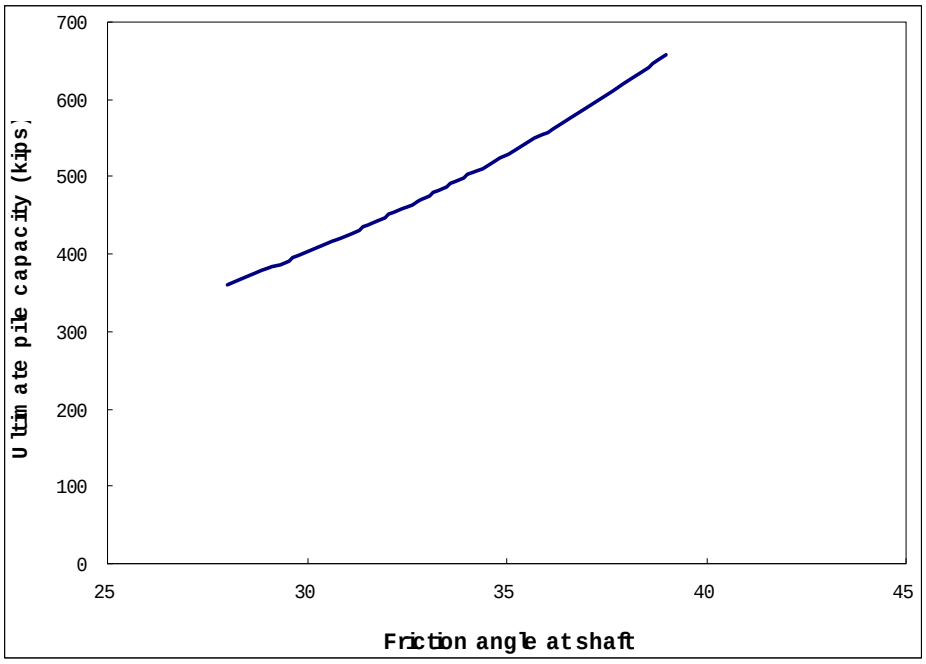

Figure 4 - 5 Parametric study: Qu vs. friction angle at shaft

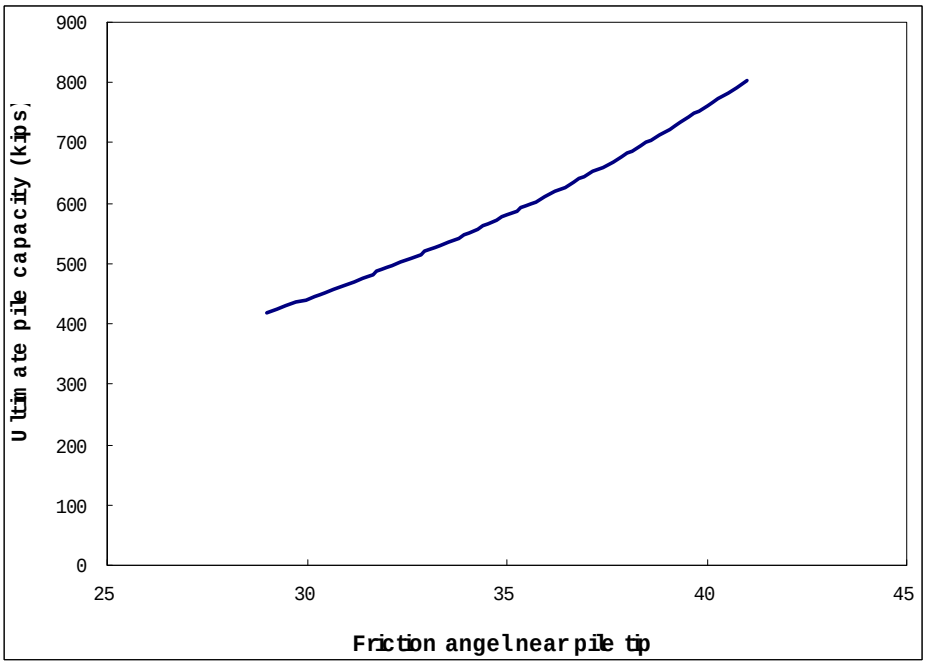

Figure 4 - 6 Parametric study: Qu vs. friction angle around pile tip

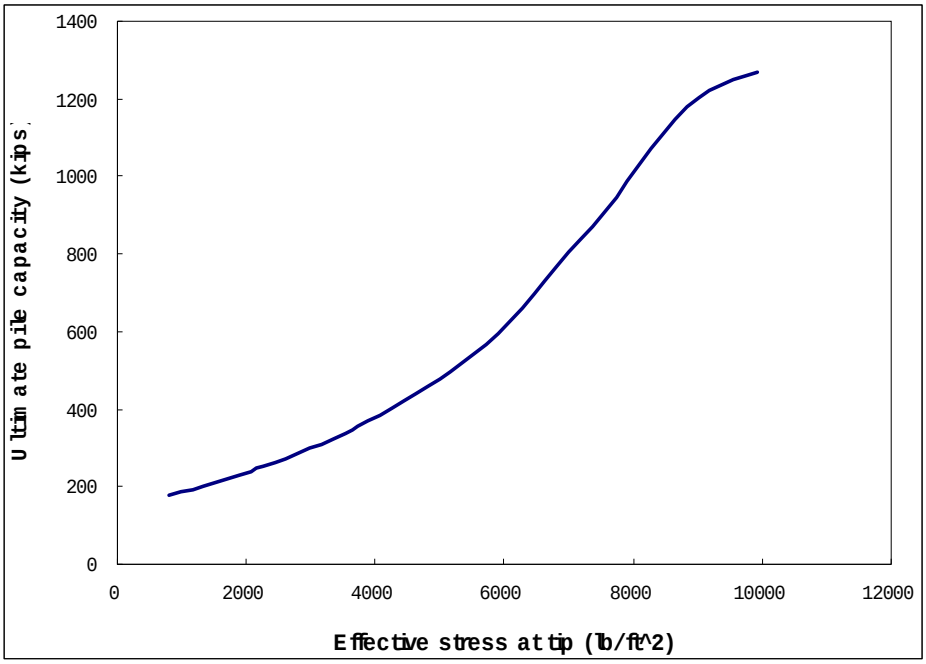

Figure 4 - 7 Parametric study: Qu vs. effective stress at pile tip

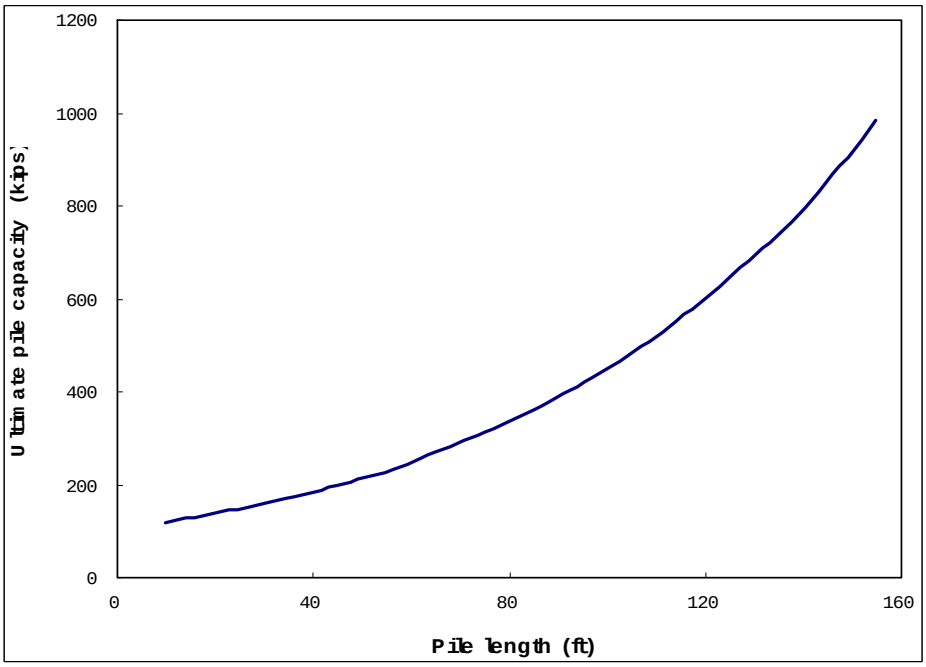

Figure 4 - 8 Parametric study: Qu vs. pile length

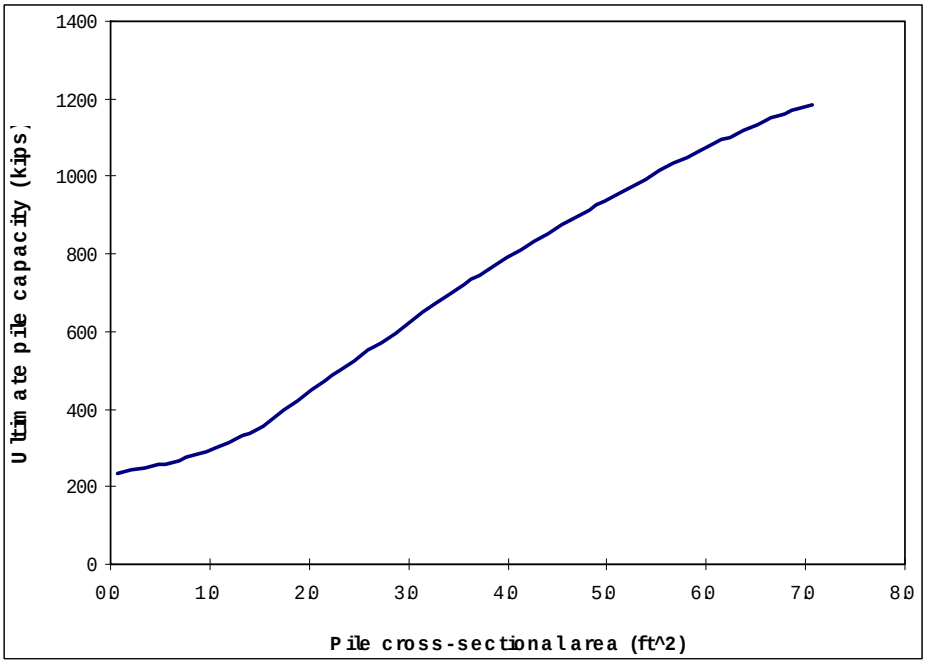

Figure 4 - 9 Parametric study: Qu vs. pile cross-sectional area

4.4.3 Neural Network Model for all data (Jetted data is included)

Training and Testing

A database derived from field pile load tests reported in the literature is compiled. As shown in Tables 4-6 and 4-7, the 75 data were split at random into two groups: the first group of 57 was used as a training set, and the remaining 18 data (24 % of the data) were used for testing the robustness of the developed neural network. Jetting was assigned a binary value of 1 for no use of jetting method and a value of 0 when using it.

Table 4 - 6 Training data set (All data with Jetted data)

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (L,ft)	Pile cross-sectional area (ft^2)	Jetting	Measured pile capacity (kips)	Predicted pile capacity (kips)	References
1	33.0	33.0	2318.3	40.0	0.066	no	16.9	79.7	Bergdahland Wennerstrand (1976)
2	31.0	31.0	2798.7	52.5	0.660	no	107.9	68.8	Gregersen et al(1973)
3	31.8	32.1	4425.2	77.0	1.778	no	134.9	167.4	Westinghouse(1990)
4	31.8	32.4	4943.6	86.0	0.149	no	146.1	81.8	Westinghouse(1990)
5	35.5	35.5	1858.8	29.9	0.860	no	147.3	159.4	Tavenas(1971)
6	34.0	35.0	1921.5	29.9	1.390	no	154.0	266.1	Thorburn and MacVicar(1970)
7	34.0	34.0	793.7	9.8	1.770	no	160.1	171.7	Vesic(1970)
8	34.0	35.0	2318.3	40.0	1.230	no	192.0	241.6	Thorburn and MacVicar(1970)
9	35.5	35.5	2485.4	40.0	0.860	no	201.0	226.5	Tavenas(1971)
10	35.5	35.5	3091.1	49.9	0.930	no	228.0	315.9	Tavenas(1971)
11	35.5	35.5	3091.1	49.9	0.860	no	250.2	297.3	Tavenas(1971)
12	31.8	32.4	4943.6	86.0	4.000	no	256.3	538.6	Westinghouse(1990)
13	35.0	37.0	5430.2	83.0	0.785	no	281.9	469.5	Blendy(1979)
14	35.5	35.5	3717.6	60.0	0.930	no	288.0	322.1	Tavenas(1971)
15	34.0	38.0	3049.3	37.1	0.340	no	321.3	242.5	Koizumi(1971)
16	35.0	35.0	3717.6	58.1	0.890	no	339.3	352.4	Goble et al(1982)
17	35.0	37.0	3299.9	53.1	1.130	no	368.0	390.6	Hunter and Davisson (1969)
18	32.7	35.0	2281.0	66.0	2.778	yes	370.0	398.7	Keane(1990)
19	32.1	30.0	2020.8	92.0	4.000	no	390.0	523.0	Keane(1990)
20	35.0	35.0	1503.8	20.0	1.770	no	390.1	371.7	Vesic(1970)
21	33.0	35.5	7163.7	111.9	0.350	no	395.9	388.9	Kessler(1979)
22	36.5	36.5	2506.3	40.4	1.780	no	400.0	494.9	Hunter and Davisson (1969)
23	35.0	35.0	5054.3	79.1	0.710	no	400.0	306.9	Goble et al(1982)
24	35.0	35.0	3717.6	58.1	1.000	no	400.0	374.2	Goble et al(1982)
25	31.2	35.0	1200.5	30.0	3.361	no	408.0	403.0	Keane(1990)
26	36.0	37.0	4365.1	67.9	0.890	no	420.0	424.0	Goble et al(1982)
27	35.0	37.0	5137.8	78.1	0.785	no	430.1	465.1	Blendy(1979)
28	39.0	39.5	1169.6	17.1	1.075	no	437.9	477.2	Heins and Barends(1984)
29	39.0	39.5	1169.6	17.1	1.075	no	438.4	477.2	Heins and Barends(1979)
30	33.3	35.0	2000.8	66.0	2.778	yes	460.0	410.2	Keane(1990)
31	35.0	35.0	3467.0	54.1	0.660	no	472.1	261.4	Goble et al(1982)
32	31.8	36.0	2761.2	64.0	2.778	yes	480.0	491.2	Keane(1990)
33	34.0	36.0	6662.5	104.0	0.350	no	490.1	353.3	Kessler(1979)
34	35.0	37.0	3299.9	52.8	1.770	no	502.0	486.0	Hunter and Davisson (1969)
35	28.2	36.0	2220.9	50.0	2.778	no	504.0	493.5	Keane(1990)
36	35.0	37.0	3822.1	58.1	0.785	no	520.0	483.7	Blendy(1979)
37	39.0	39.5	1566.4	23.0	1.075	no	548.3	586.4	Heins and Barends(1984)
38	31.7	38.0	1420.6	65.0	4.000	no	570.0	523.4	Keane(1990)
39	33.0	38.0	5325.8	80.4	1.410	no	587.9	674.0	Mansur and Kaufman(1958)
40	30.0	42.0	2000.8	70.0	2.778	yes	590.0	529.4	Keane(1990)
41	34.8	35.0	1800.8	93.0	4.000	no	600.0	523.0	Keane(1990)
42	31.2	29.0	3001.3	102.0	4.000	no	640.0	523.0	Keane(1990)
43	33.0	37.0	4302.4	65.3	1.960	no	642.1	666.5	Mansur and Kaufman(1958)
44	29.7	42.0	3361.4	65.0	2.778	yes	664.0	634.7	Keane(1990)
45	39.0	39.5	1503.8	22.0	1.075	no	674.5	570.4	Heins and Barends(1984)
46	33.0	37.5	4386.0	66.3	1.580	no	683.9	610.7	Mansur and Kaufman(1958)
47	36.0	36.0	2736.0	39.4	1.770	no	710.0	692.1	Vesic(1970)
48	33.0	33.0	6996.7	96.1	0.600	no	720.1	752.1	Wan et al(1979)
49	33.0	34.0	7393.5	102.0	0.600	no	721.9	777.5	Wan et al(1979)
50	38.0	41.0	2882.2	38.1	2.250	no	799.9	907.1	Furbow(1968)
51	34.0	37.5	4302.4	65.0	2.400	no	826.0	676.9	Mansur and Kaufman(1958)
52	36.0	36.0	3362.6	49.2	1.770	no	859.9	657.2	Vesic(1970)
53	38.0	40.0	4093.6	54.1	2.250	no	882.0	835.8	Furbow(1968)
54	37.5	39.5	5388.5	84.0	3.310	no	904.0	899.9	Gurtowskiand Wu(1984)
55	28.0	39.0	4448.6	55.1	1.540	no	1049.9	1034.5	Reike and Crowser(1987)
56	33.0	35.0	3529.7	59.1	7.070	no	1124.1	1127.6	Mey et al(1985)
57	34.0	38.0	9920.6	154.9	3.140	no	1259.9	1242.8	McCammon and Golder(1970)

Table 4 - 7 Testing data set (All data with Jetted data)

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (L,ft)	Pile cross-sectional area (ft^2)	Jetting	Measured pile capacity (kips)	Predicted pile capacity (kips)	References
1	31.0	31.0	2798.7	52.5	0.340	no	116.7	63.4	Gregersen et al.(1973)
2	35.5	35.5	1858.8	29.9	0.930	no	147.9	173.4	Tavenas(1971)
3	35.5	35.5	2485.4	40.0	0.930	no	198.3	247.5	Tavenas(1971)
4	35.5	37.0	4761.9	71.9	0.710	no	207.3	493.7	Goble et al.(1982)
5	35.5	35.5	3717.6	60.0	0.860	no	288.0	316.8	Tavenas(1971)
6	32.0	35.0	5033.4	76.4	1.600	no	366.0	500.5	Thorburn and MacVicar(1970)
7	36.0	37.0	4490.4	69.9	0.440	no	400.0	394.9	Goble et al.(1982)
8	29.3	33.0	3181.3	62.0	2.778	yes	400.0	468.0	Keane(1990)
9	36.0	37.0	4365.1	67.9	1.000	no	430.1	436.3	Goble et al.(1982)
10	33.0	38.0	4657.5	70.5	1.410	no	486.5	617.7	Mansur and Kauffman(1958)
11	35.0	36.5	3299.9	53.1	2.270	no	516.0	612.4	Hunter and Davisson(1969)
12	35.0	35.0	2088.6	29.2	1.770	no	560.0	517.9	Vesic(1970)
13	29.8	30.0	3221.3	117.0	4.000	yes	600.0	523.0	Keane(1990)
14	35.5	36.0	3404.3	49.9	1.400	no	605.9	620.0	Vesic(1970)
15	32.0	37.0	3675.9	57.4	4.149	no	690.0	581.5	Mibvic and Baci(1976)
16	32.0	34.0	4135.3	68.9	2.490	no	719.4	573.0	Carpentier et al.(1984)
17	38.0	40.0	3425.2	44.9	2.250	no	740.1	908.2	Furbow(1968)
18	37.5	40.0	6286.5	98.1	3.310	no	1064.1	1259.9	Gurtowski and Wu(1984)

Table 4-8 illustrates the chosen values of learning factors that produce the best performance from the network in terms of the highest correlation coefficient R^2. After initial weights with the range of -3.75 to 3.95 were presented to the network, the network was trained continually through updating weights until the error goal was $5*10^{-3}$ and the number of hidden nodes was 2 with the two hidden layers.

Table 4 - 8 Learning factors at the highest R^2 of test data set

Initial weight	No. of Hidden nodes	Error goal	R^2	
			Training	Testing
-3.75 ~ 3.95	2	$5*10^{-3}$	0.8935	0.8234

The correlation coefficients and root mean square errors of predicted versus measured results are summarized in Table 4-9. As shown in Table 4-9, BPNN produced the much higher correlation R^2, and the lower root mean square error, RMSE, compared with the other methods. They indicate that the BPNN predictions are more consistent than the others, produced by the three conventional methods.

Table 4 - 9 Summary of Correlation R^2 and RMSE (Root Mean Square Error)

Type	Correlation R^2		RMSE	
	Training	Testing	Training	Testing
BPNN	*0.8935*	*0.8234*	*84.0*	*116.8*
Coyle & Castello	0.5234	0.4635	324.9	645.9
Meyerhof	0.4935	0.5025	231.0	266.5
Vesic	0.6239	0.5824	166.0	208.5

Predictions for bearing capacity of piles were made using BPNN model as well as three other empirical methods. BPNN predictions in Figures 4-10 and 4-11 show smaller scatter than the predictions of the conventional methods. The results of this study indicate that the neural network model is better than the empirical methods, when they are compared to the actual measurements. It should be noted that the calculations of ultimate pile capacity with the three conventional methods are made under the condition of the equivalent one layer.

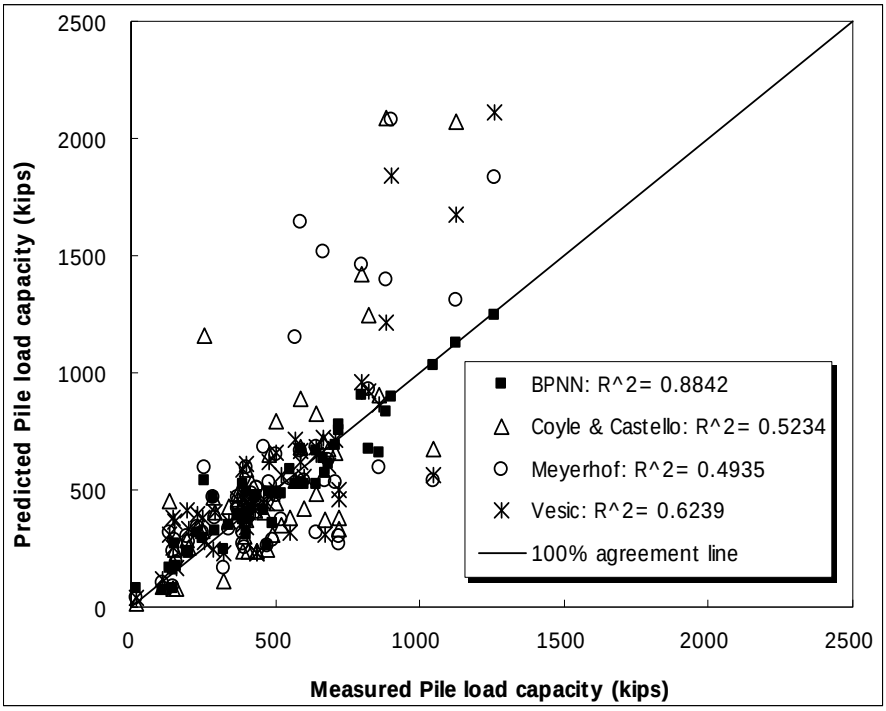

Figure 4 - 10 Comparison results of predicted and calculated for training

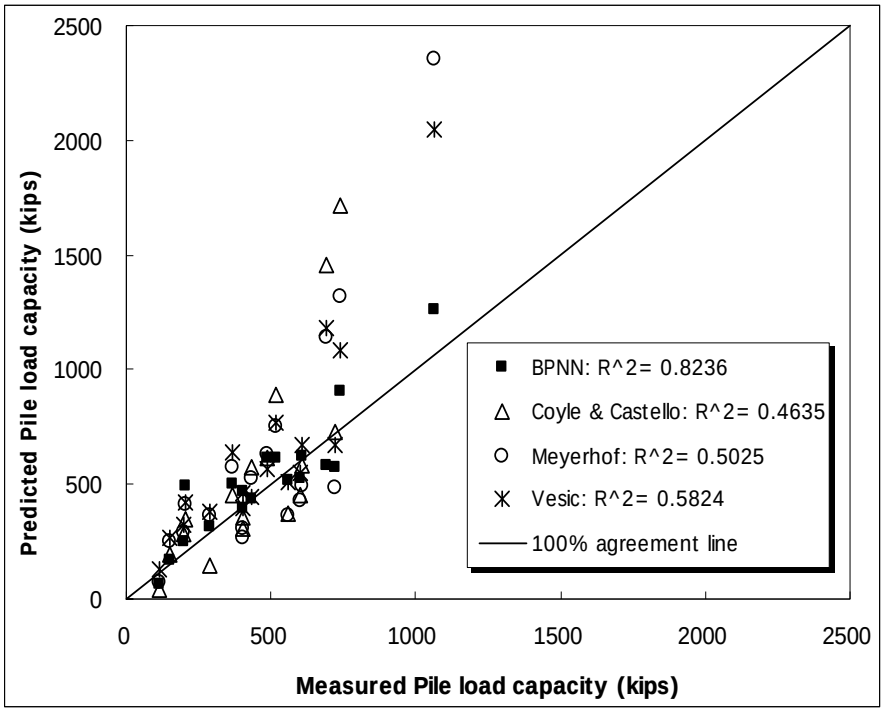

Figure 4 - 11 Comparison results of predicted and calculated for testing

Relative Importance

Table 4-10 shows the relative importance through the weights of each layer of connections. All the selected variables have significant influence, and relative importance calculated to pile length, pile cross-sectional area, and friction angle at shaft has higher than results to non-jetted data in Table 4-5. This is because effects of pile have increased while those by soils decrease. As more jetted data becomes available, this model can be clearly analyzed to make more accurate predictions of ultimate pile capacity.

Table 4 - 10 Relative Importance (%) of the modeling including jetting data

Input variables	ϕ_{shaft}	ϕ_{tip}	σ'_{tip}	Pile length	Cross sectional area	Jetting
R.I. (%)	17.6	10.6	12.5	36.7	33.7	4.8

Parametric Study

Figures 4-12 through 4-16 show predicted values of ultimate pile capacity as a function of each parameter. It shows that the ultimate load capacity of piles increases with an

increase in the friction angle at shaft, friction angle around tip of the pile, effective stress at tip of the pile, pile length, and cross-sectional area. These results are found to be reasonable.

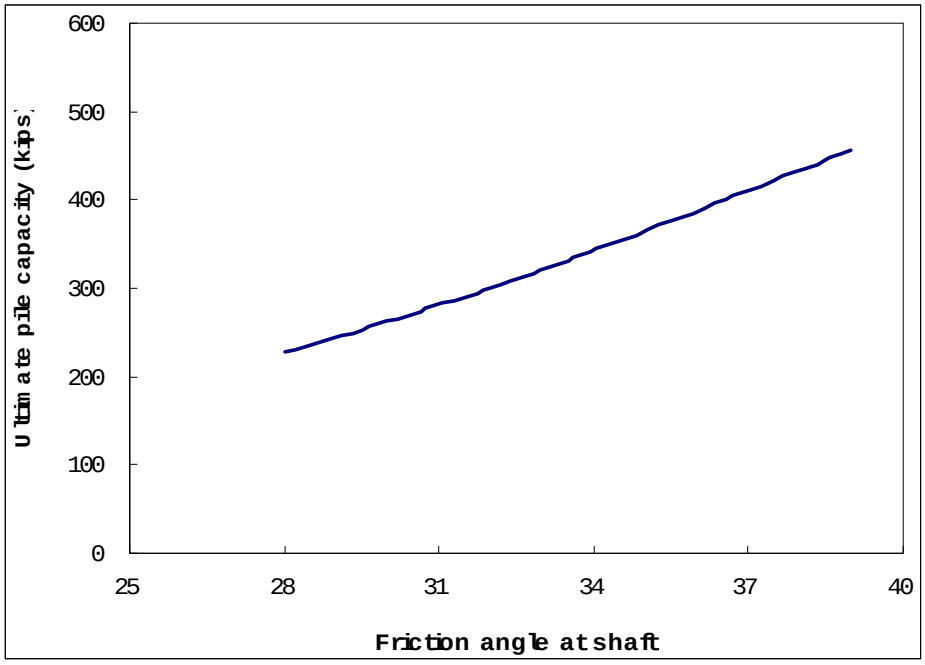

Figure 4 - 12 Parametric study: Qu vs. friction angle at shaft

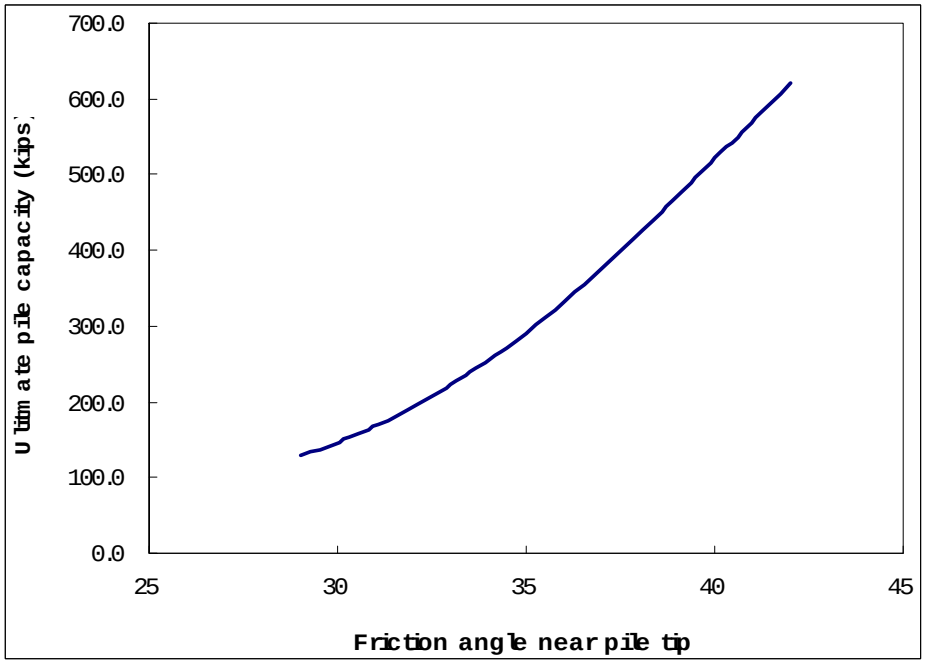

Figure 4 - 13 Parametric study: Qu vs. friction angel around pile tip

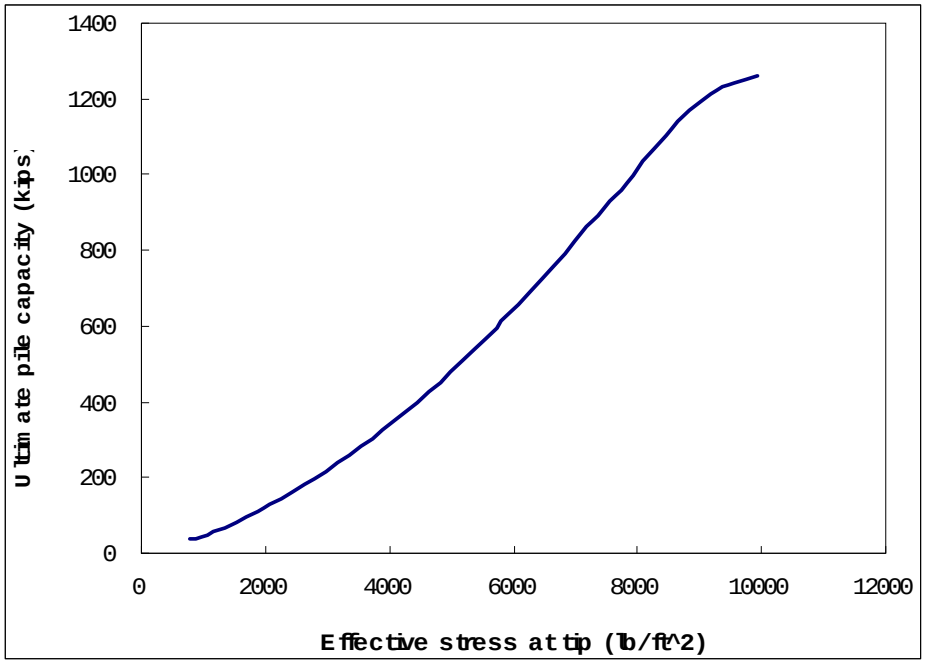

Figure 4 - 14 Parametric study: Qu vs. effective stress at the tip

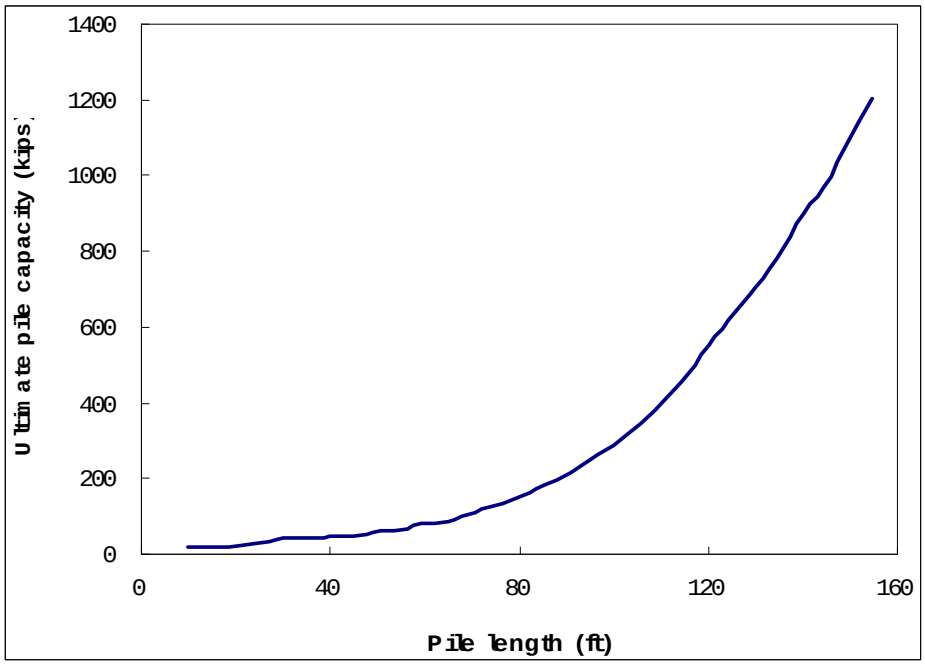

Figure 4 - 15 Parametric study: Qu vs. pile length

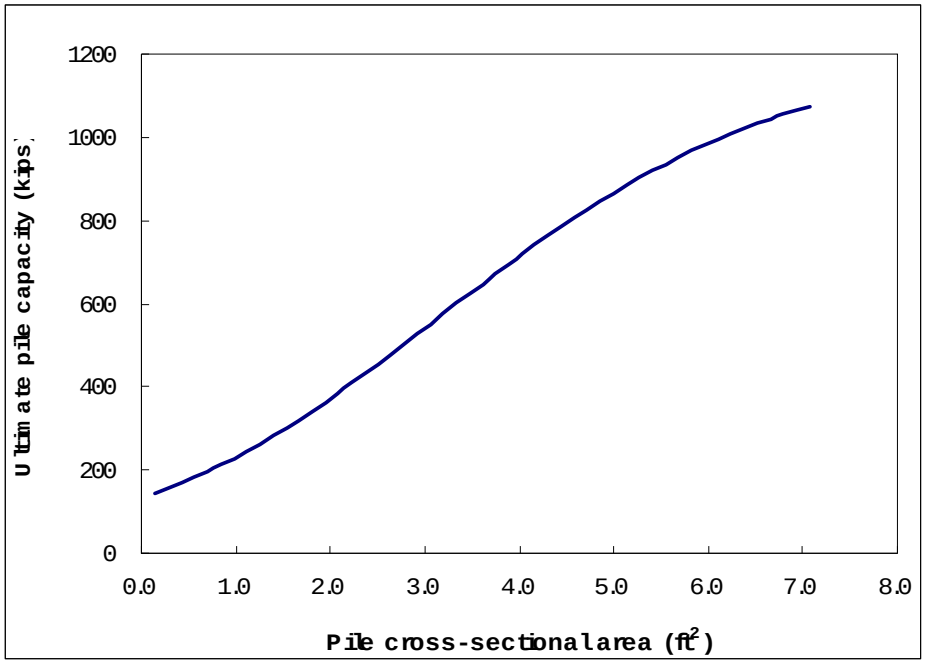

Figure 4 - 16 Parametric study: Qu vs. pile cross-sectional area

4.4.4 A flow chart of BPNN program and GUI for practicing engineers

Figure 4-17 shows a schematic flow chart of the BPNN model. The flow of this program is divided into two groups according to use of jetting. For each group, neural network factors to each model are set through the preliminary analysis: examining optimal weight matrix, and bias vector including no. of hidden nodes and MSE (Mean Square Error) value which are decided at the satisfactory level. First, a unit system (US customary or SI metric) is required to be chosen, and input information is applied to differently trained models depending on whether or not the use of jetting is done. After training the model using fixed neural network factors, testing is performed, which has never been used. Then, the chosen input information is applied to the already trained back-propagated neural network model. Finally, comparison results of measured and predicted ultimate pile capacity for both training and testing are plotted and ultimate pile capacity to given inputs is predicted.

Figure 4-18 presents a MATLAB GUI which provide input information, comparison results, and predictions. Generally there are input spaces (blanks) in the left hand side, while output information is presented on the right side.

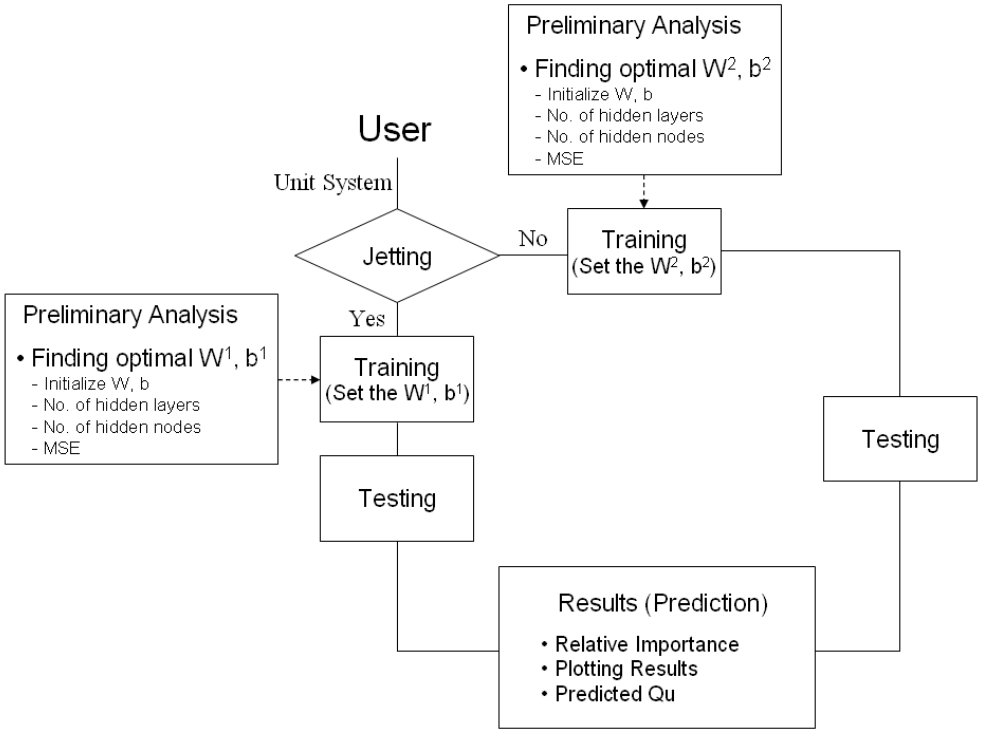

Figure 4 - 17 A schematic flow chart of the BPNN program

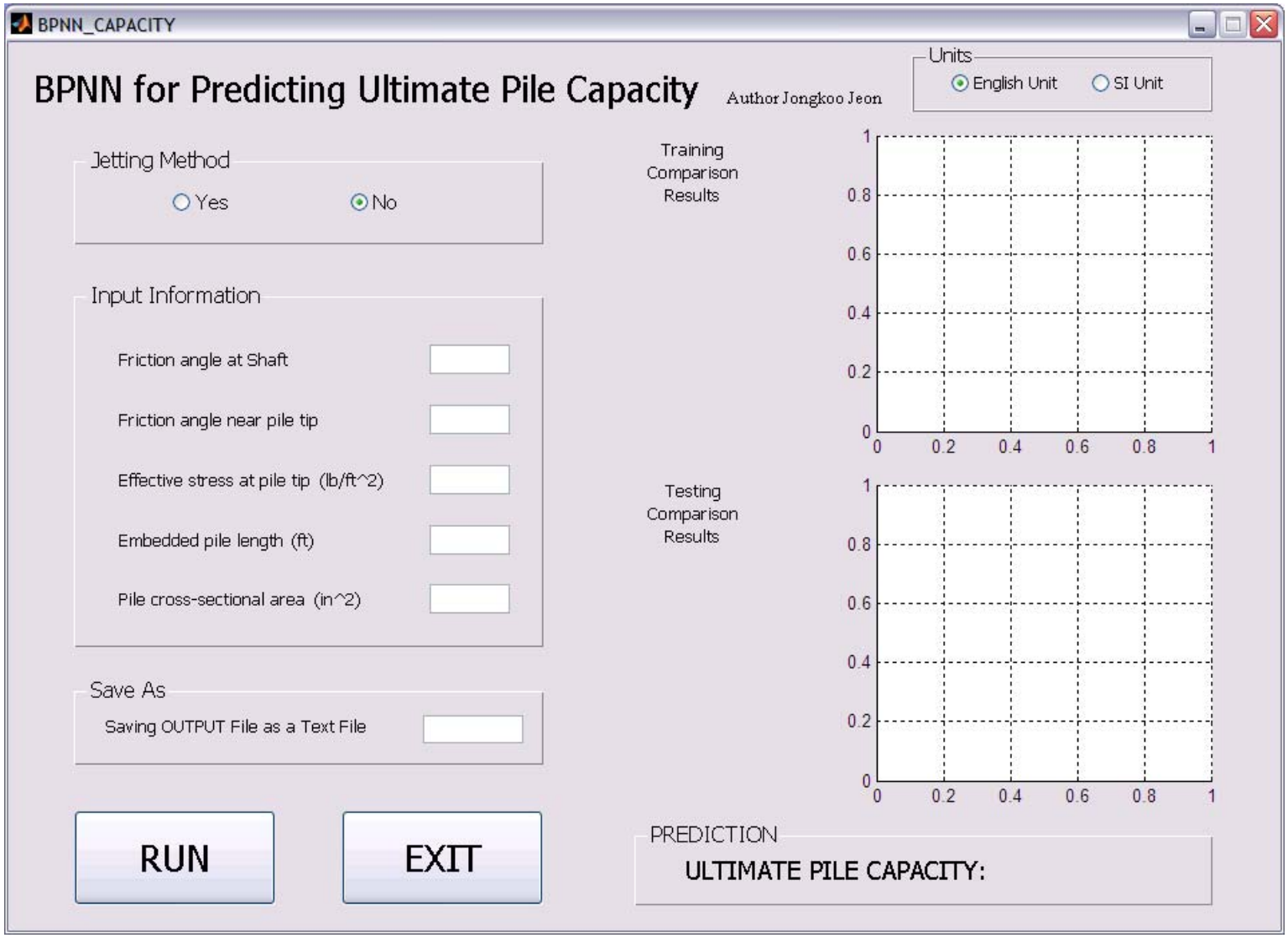

Figure 4 - 18 User friendly GUI for BPNN model to predict ultimate pile capacity

4.5 Adaptive Neural Fuzzy Inference System for Ultimate Pile Capacity

4.5.1 Introduction

An adaptive neuro-fuzzy inference system model is developed to predict the ultimate load capacity of piles in cohesion-less soils. The same database of a number (68) of non-jetted field pile load tests as the previous BPNN model was used for the development of this model, and the total 68 data were split at random into two groups (training data set, and testing data set).

In the developed ANFIS, five variables consisting of friction angle at shaft, friction angle around tip of the pile, effective stress at tip, pile length, and pile cross-sectional area are selected as input variables to evaluate the pile capacity, which is the target variable. Membership functions and numbers to each input variable are appropriately decided when testing data set has the highest correlation R^2. Pile capacity predictions were made using ANFIS as well as commonly used empirical methods, and they were also compared with actual measurements. The other methods are those proposed by Coyle and Castello (1981), Meyerhof (1976), and Vesic (1977). The results of this study indicate that ANFIS provides a better prediction than the three conventional methods, and can serve as a reliable and simple predictive tool for the prediction of axial loading capacity of piles, even considering jetting methods.

4.5.2 Database

The training and testing of the network were based on a database of 68 driven piles test data extracted from the references. As shown in Tables 4-11 and 4-12, the 68 data was split at random into two groups: the first group of 51 was used as a training set, and the remaining 17 data (25 % of the data) was used for testing the robustness of the developed adaptive neuro-fuzzy inference system.

Five variables are selected as input to the developed ANFIS. These variables are: i) friction angle at shaft, ii) friction angle near pile tip, iii) effective stress at pile tip, iv) pile length, v) pile cross-sectional area. The friction angle of the soil around the shaft and near the tip of the pile provides the information about the shear strength of the surrounding and supporting soils. Effective stress at the tip of the pile also has a significant role on calculating the pile capacity. The pile length as well as the cross-sectional area provides necessary information about pile dimensions.

Table 4 - 11 Training data set (non-jetted)

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (ft)	Pile cross-sectional area (ft^2)	Measured pile capacity (kips)	Predicted pile capacity (kips)	References
1	33.0	33.0	2318.3	40.0	0.066	16.9	16.9	Bergdahl and Wennerstrand (1976)
2	31.0	31.0	2798.7	52.5	0.660	107.9	107.9	Gregersen et al.(1973)
3	31.8	32.1	4425.2	77.0	1.778	134.9	134.9	Westinghouse(1990)
4	31.8	32.4	4943.6	86.0	0.149	146.1	146.1	Westinghouse(1990)
5	35.5	35.5	1858.8	29.9	0.860	147.3	147.3	Tavenas(1971)
6	34.0	35.0	1921.5	29.9	1.390	154.0	153.9	Thorburn and MacVicar(1970)
7	34.0	34.0	793.7	9.8	1.770	160.1	160.1	Vesic(1970)
8	34.0	35.0	2318.3	40.0	1.230	192.0	192.1	Thorburn and MacVicar(1970)
9	35.5	35.5	2485.4	40.0	0.860	201.0	201.0	Tavenas(1971)
10	35.5	35.5	3091.1	49.9	0.930	228.0	230.2	Tavenas(1971)
11	35.5	35.5	3091.1	49.9	0.860	250.2	248.0	Tavenas(1971)
12	31.8	32.4	4943.6	86.0	4.000	256.3	256.3	Westinghouse(1990)
13	35.0	37.0	5430.2	83.0	0.785	281.9	282.3	Blendy(1979)
14	35.5	35.5	3717.6	60.0	0.930	288.0	288.0	Tavenas(1971)
15	34.0	38.0	3049.3	37.1	0.340	321.3	321.3	Koizumi(1971)
16	35.0	35.0	3717.6	58.1	0.890	339.3	340.2	Goble et al.(1982)
17	32.0	35.0	5033.4	76.4	1.600	366.0	366.0	Thorburn and MacVicar(1970)
18	32.1	30.0	2020.8	92.0	4.000	390.0	390.0	Keane(1990)
19	35.0	35.0	1503.8	20.0	1.770	390.1	390.1	Vesic(1970)
20	33.0	35.5	7163.7	111.9	0.350	395.9	395.9	Kessler(1979)
21	36.5	36.5	2506.3	40.4	1.780	400.0	400.0	Hunter and Davisson (1969)
22	35.0	35.0	5054.3	79.1	0.710	400.0	400.0	Goble et al.(1982)
23	35.0	35.0	3717.6	58.1	1.000	400.0	399.2	Goble et al.(1982)
24	36.0	37.0	4365.1	67.9	0.890	420.0	420.0	Goble et al.(1982)
25	35.0	37.0	5137.8	78.1	0.785	430.1	429.7	Blendy(1979)
26	39.0	39.5	1169.6	17.1	1.075	437.9	438.3	Heins and Barends(1984)
27	39.0	39.5	1169.6	17.1	1.075	438.4	438.3	Heins and Barends(1979)
28	35.0	35.0	3467.0	54.1	0.660	472.1	471.9	Goble et al.(1982)
29	34.0	36.0	6662.5	104.0	0.350	490.1	490.1	Kessler(1979)
30	35.0	37.0	3299.9	52.8	1.770	502.0	502.0	Hunter and Davisson (1969)
31	28.2	36.0	2220.9	50.0	2.778	504.0	504.0	Keane(1990)
32	35.0	37.0	3822.1	58.1	0.785	520.0	520.1	Blendy(1979)
33	39.0	39.5	1566.4	23.0	1.075	548.3	549.9	Heins and Barends(1984)
34	31.7	38.0	1420.6	65.0	4.000	570.0	570.0	Keane(1990)
35	33.0	38.0	5325.8	80.4	1.410	587.9	587.9	Mansur and Kaufman(1958)
36	34.8	35.0	1800.8	93.0	4.000	600.0	600.0	Keane(1990)
37	31.2	29.0	3001.3	102.0	4.000	640.0	640.0	Keane(1990)
38	33.0	37.0	4302.4	65.3	1.960	642.1	642.2	Mansur and Kaufman(1958)
39	39.0	39.5	1503.8	22.0	1.075	674.5	672.7	Heins and Barends(1984)
40	33.0	37.5	4386.0	66.3	1.580	683.9	683.8	Mansur and Kaufman(1958)
41	36.0	36.0	2736.0	39.4	1.770	710.0	709.9	Vesic(1970)
42	33.0	33.0	6996.7	96.1	0.600	720.1	720.1	Wan et al.(1979)
43	33.0	34.0	7393.5	102.0	0.600	721.9	721.9	Wan et al.(1979)
44	38.0	41.0	2882.2	38.1	2.250	799.9	799.9	Furbw(1968)
45	34.0	37.5	4302.4	65.0	2.400	826.0	826.0	Mansur and Kaufman(1958)
46	36.0	36.0	3362.6	49.2	1.770	859.9	859.9	Vesic(1970)
47	38.0	40.0	4093.6	54.1	2.250	882.0	882.0	Furbw(1968)
48	37.5	39.5	5388.5	84.0	3.310	904.0	904.0	Gurtowski and Wu(1984)
49	28.0	39.0	4448.6	55.1	1.540	1049.9	1049.9	Reike and Crowser(1987)
50	33.0	35.0	3529.7	59.1	7.070	1124.1	1124.1	Mey et al.(1985)
51	34.0	38.0	9920.6	154.9	3.140	1259.9	1259.9	McCammon and Golder(1970)

Table 4 - 12 Testing data set (non-jetted data)

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (ft)	Pile cross-sectional area (ft^2)	Measured pile capacity (kips)	Predicted pile capacity (kips)	References
1	31.0	31.0	2798.7	52.5	0.340	116.7	115.1	Gregersen et al.(1973)
2	35.5	35.5	1858.8	29.9	0.930	147.9	149.8	Tavenas(1971)
3	35.5	35.5	2485.4	40.0	0.930	198.3	189.3	Tavenas(1971)
4	35.5	37.0	4761.9	71.9	0.710	207.3	342.0	Goble et al.(1982)
5	35.5	35.5	3717.6	60.0	0.860	288.0	290.0	Tavenas(1971)
6	32.0	35.0	5033.4	76.4	1.600	366.0	366.0	Thorburn and MacVicar(1970)
7	36.0	37.0	4490.4	69.9	0.440	400.0	457.4	Goble et al.(1982)
8	31.2	35.0	1200.5	30.0	3.361	408.0	288.2	Keane(1990)
9	36.0	37.0	4365.1	67.9	1.000	430.1	412.3	Goble et al.(1982)
10	33.0	38.0	4657.5	70.5	1.410	486.5	726.3	Mansur and Kauffman(1958)
11	35.0	36.5	3299.9	53.1	2.270	516.0	475.2	Hunter and Davisson(1969)
12	35.0	35.0	2088.6	29.2	1.770	560.0	512.3	Vesic(1970)
13	35.5	36.0	3404.3	49.9	1.400	605.9	529.9	Vesic(1970)
14	32.0	37.0	3675.9	57.4	4.149	690.0	450.8	Mibvic and Baci(1976)
15	32.0	34.0	4135.3	68.9	2.490	719.4	773.6	Carpentier et al.(1984)
16	38.0	40.0	3425.2	44.9	2.250	740.1	640.6	Furbow(1968)
17	37.5	40.0	6286.5	98.1	3.310	1064.1	987.7	Gurtowski and Wu(1984)

4.5.3 Modeling and Results

MFs (Membership Functions)

For ANFIS analysis, the number of types of MFs and the number of MFs assigned to each input variable is chosen by trial and error.

Figure 4-19 through 4-28 show the initial and final membership functions for all input variables: i) friction angle at shaft-generalized bell MF, ii) friction angle near pile tip-sigmoid MF, iii) effective stress at pile tip-triangular MF, iv) pile length-sigmoid MF, v) pile cross-sectional area-sigmoid MF. It is observed that a big change in the training membership functions around the initial condition is accounted for by the membership functions moving toward the origin. In other words, the initial MFs show uniformly distributed MFs between 0 and 1, while the final MFs on input variables are not symmetric due to computer truncation errors and the approximated initial conditions used for bootstrapping the recursive least-squares estimator. Most data in the database has membership grades between 0 and 1 for linguistic terms.

Friction angle at pile shaft

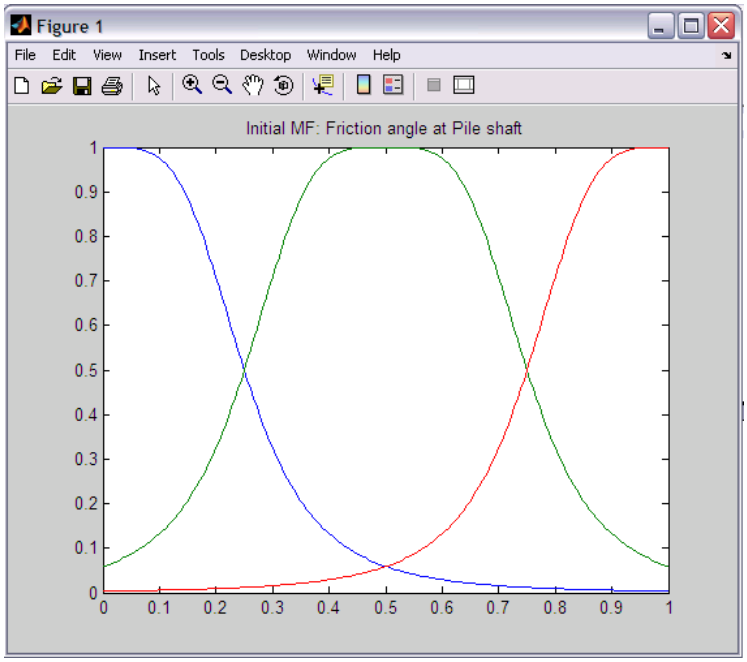

Figure 4 - 19 Initial MF: Friction angle at pile shaft

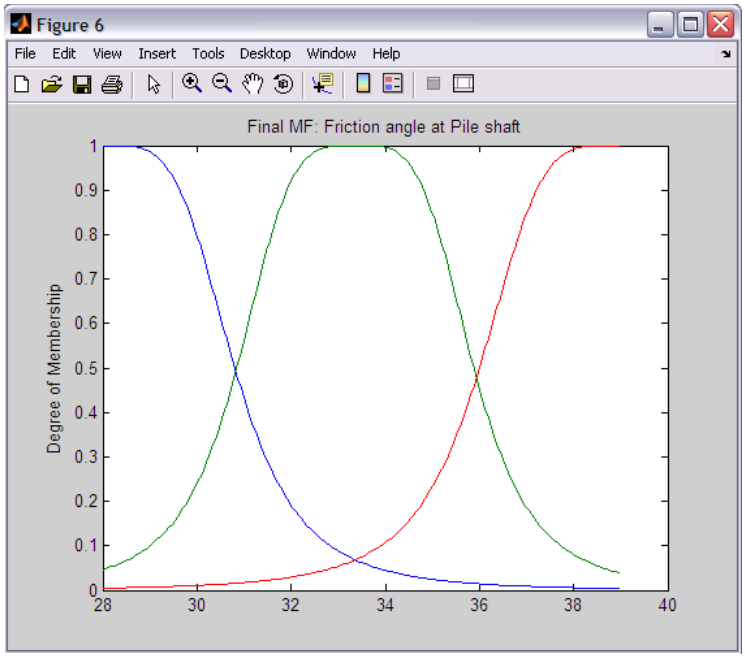

Figure 4 - 20 Final MF: Friction angle at Pile shaft

Friction angle near pile tip

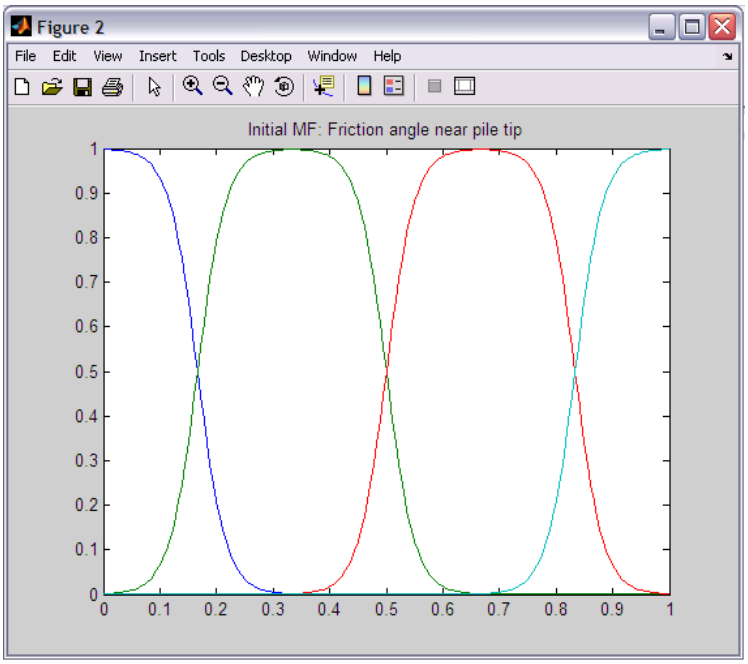

Figure 4 - 21 Initial MF: Friction angle near pile tip

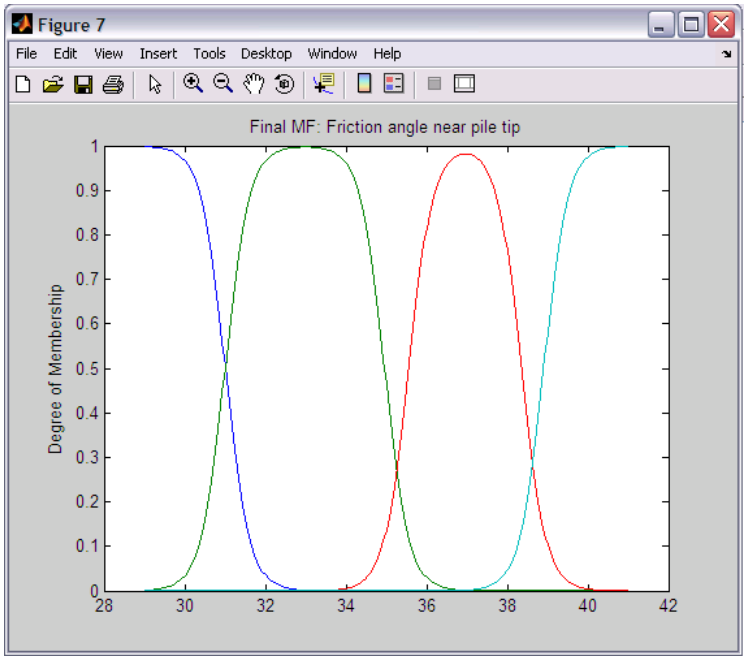

Figure 4 - 22 Final MF: Friction angle near pile tip

Effective stress at pile tip

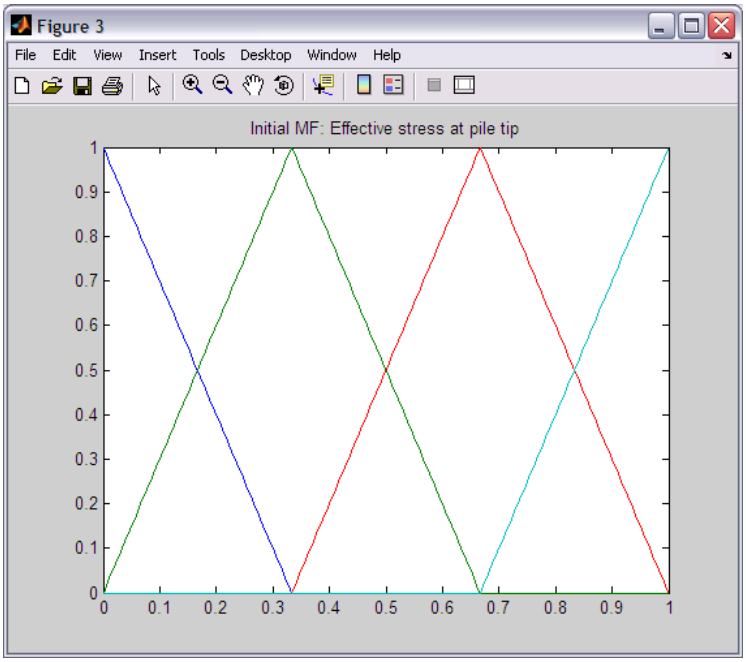

Figure 4 - 23 Initial MF: Effective stress at pile tip

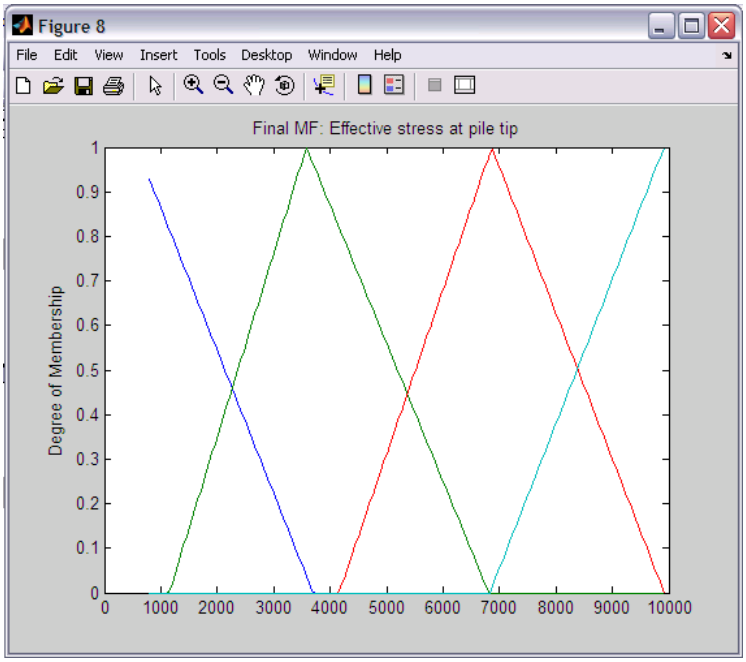

Figure 4 - 24 Final MF: Effective stress at pile tip

Pile length

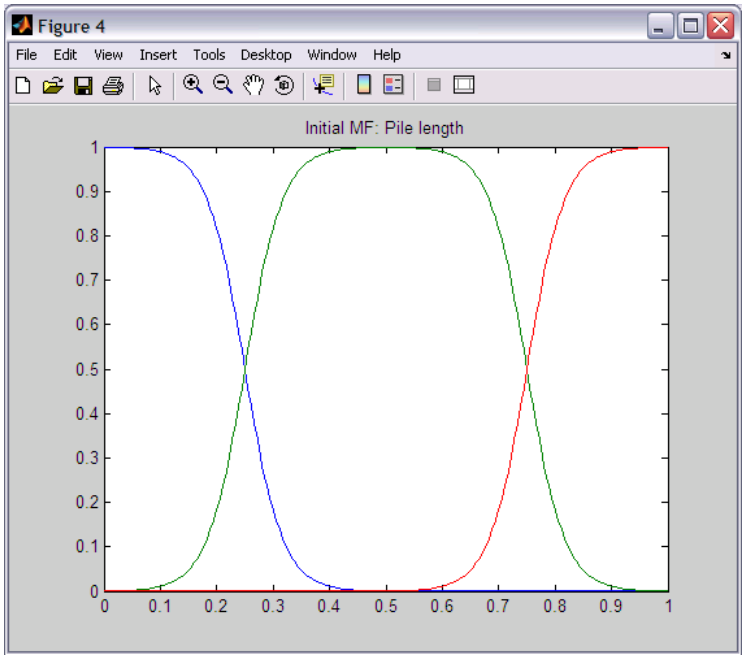

Figure 4 - 25 Initial MF: Pile length

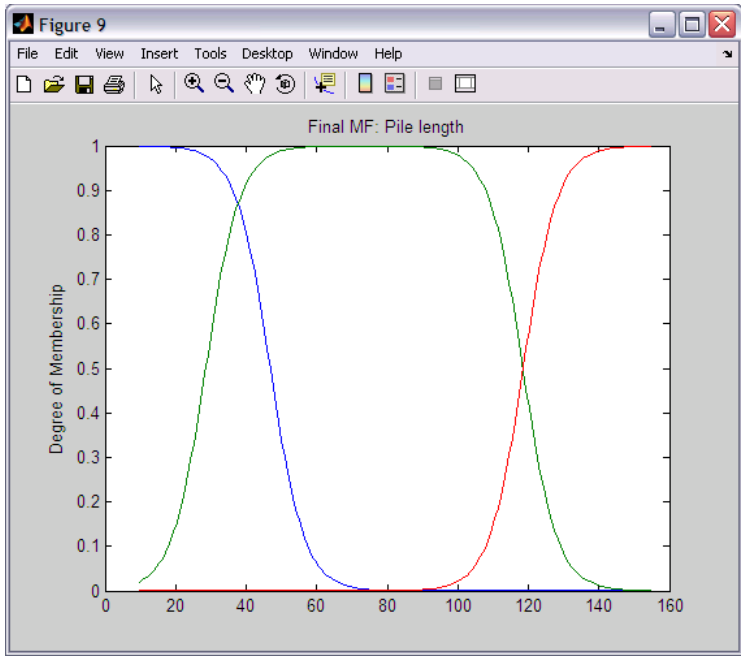

Figure 4 - 26 Final MF: Pile length

Pile cross-sectional area

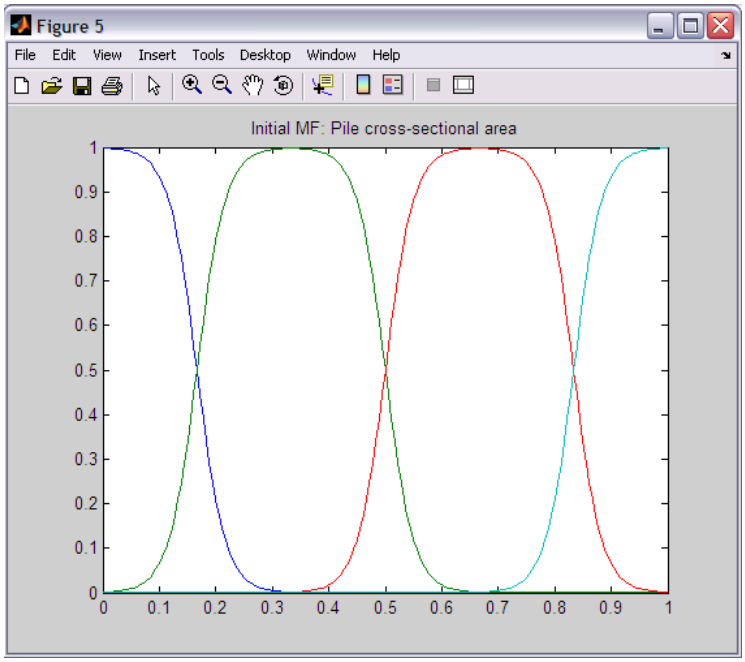

Figure 4 - 27 Initial MF: Pile cross-sectional area

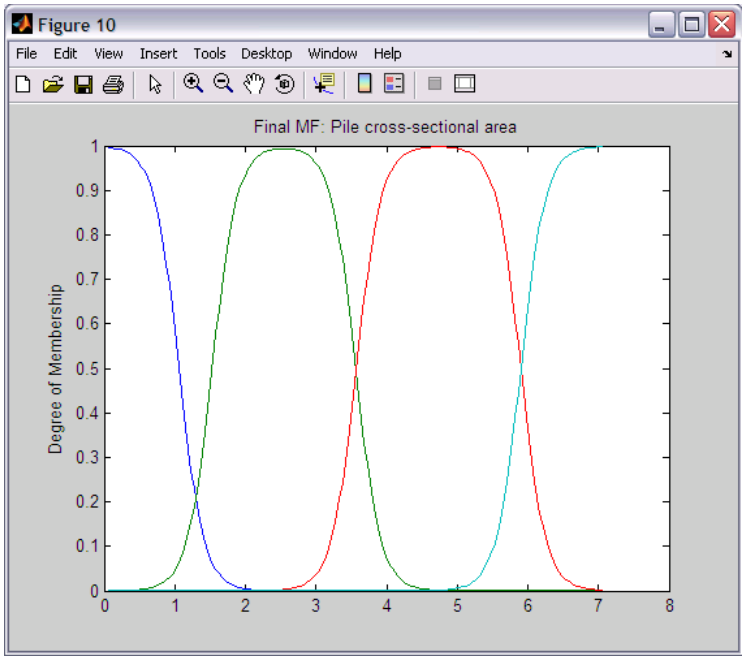

Figure 4 - 28 Final MF: Pile cross-sectional area

Types and numbers of MFs

Table 4-13 presents membership functions for each input variable when the ANFIS model reaches an acceptable satisfactory level. Different types of linguistic terms for each input variable are dependent on different numbers of MFs for each input variable.

Table 4 - 13 Type of MFs and number of MFs to each input variable

	ϕ at shaft	ϕ near pile tip	σ' at pile tip	Pile Length	Cross-sectional area
Type of MFs	General bell	Dsigmoid*	Triangle	Dsigmoid	Dsigmoid
Number of MFs	3	4	4	3	4
Linguistic terms	High Medium Low	Very high Above med. Medium Below med.	Very high Above med. Medium Below med.	Long Medium Short	Very large Above med. Medium Below med.

*: Asymmetric and closed membership functions synthesized using two sigmoid functions

The ANFIS used here contains 576 rules, with different numbers of membership functions assigned to each input variable. The total number of fitting parameters is 1783, including 55 premise (nonlinear) parameters and 1,728 consequent (linear) parameters: used rule (576 = 3*4*4*3*4), premise parameters (55 = 3*3+4*4+4*3+3*4+4*4), and consequent parameters (1,728 = 576*3).

Training and Testing Results

For the case of non-jetted data, the predictions using ANFIS as well as the conventional methods are plotted in Figure 4-29 and Figure 4-30 for training and testing respectively. The ANFIS results show less scatter in the data points in comparison to the other methods, and higher correlation R^2. It is shown that ANFIS is much better than the empirical methods when compared with actual pile load test measurements.

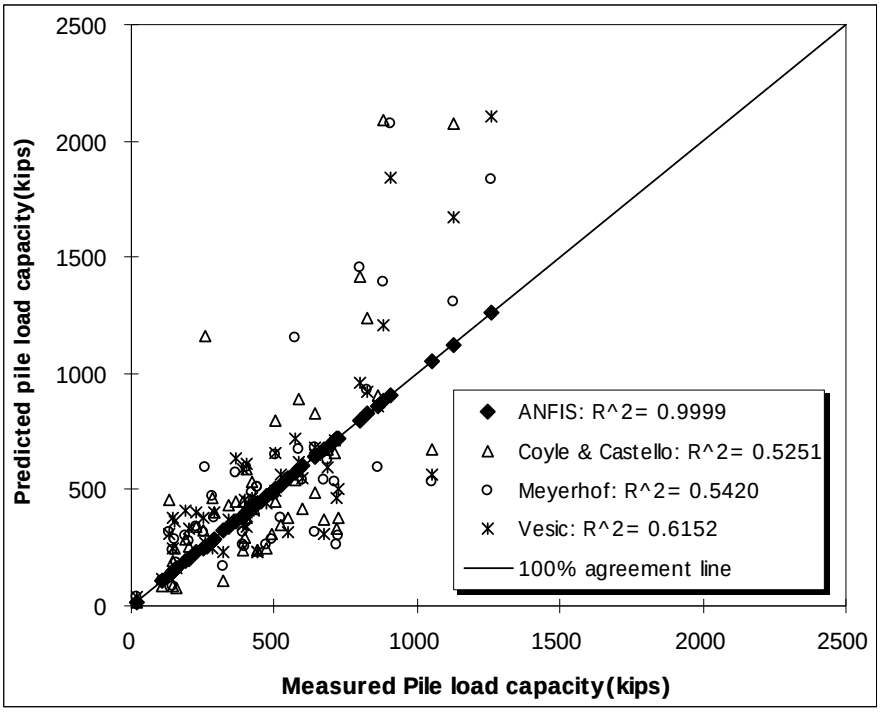

Figure 4 - 29 Comparison measured and predicted values for training

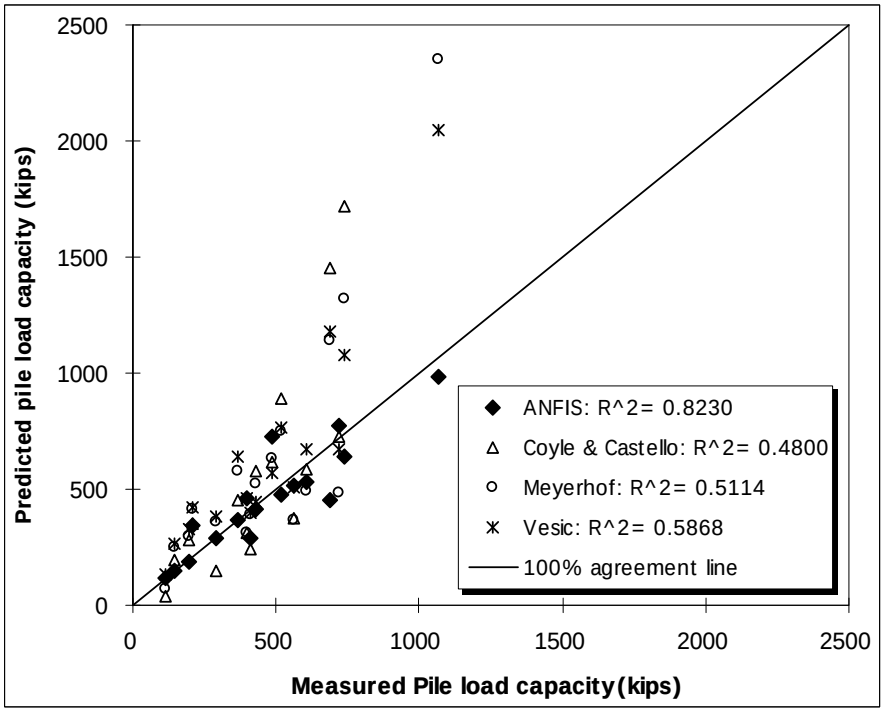

Figure 4 - 30 Comparison measured and predicted values for testing

4.6 Comparison of Results

Figure 4-31 and 4-32 show that the predicted values from ANFIS are similar to those from BPNN (BPNN being slightly better than ANFIS), and match the measured values much better than those obtained from the three empirical methods. Overall, for this study BPNN may be more useful than ANFIS since BPNN model trains much faster while providing similar predictions (BPNN-3.8s, ANFIS-6m 50.3s). However, ANFIS may be more useful than BPNN in the case where only a limited data range is available because ANFIS can extrapolate beyond the data range using membership functions.

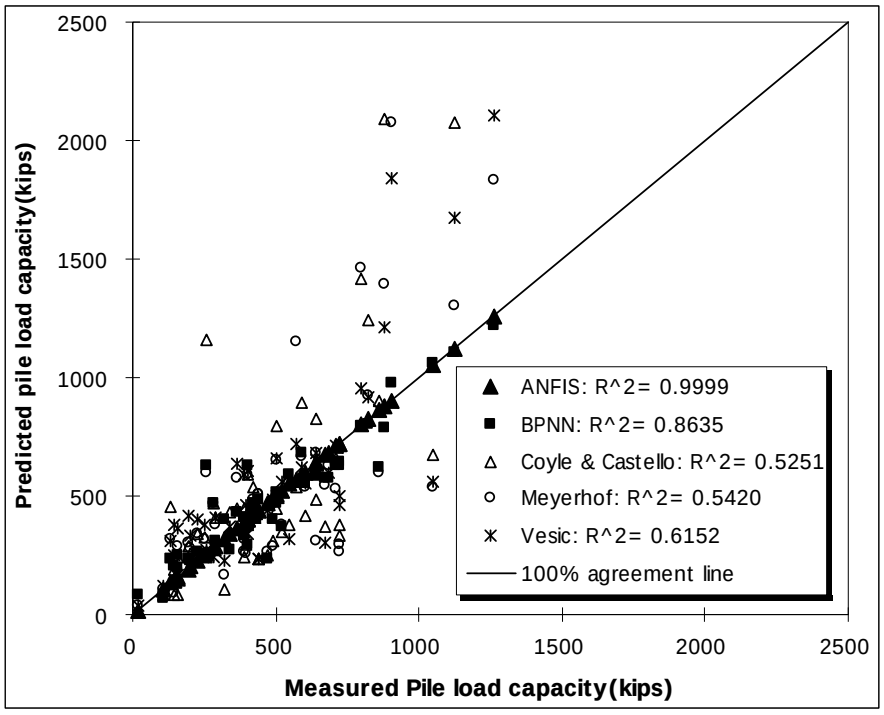

Figure 4 - 31 Comparison results of measured and predicted for training set

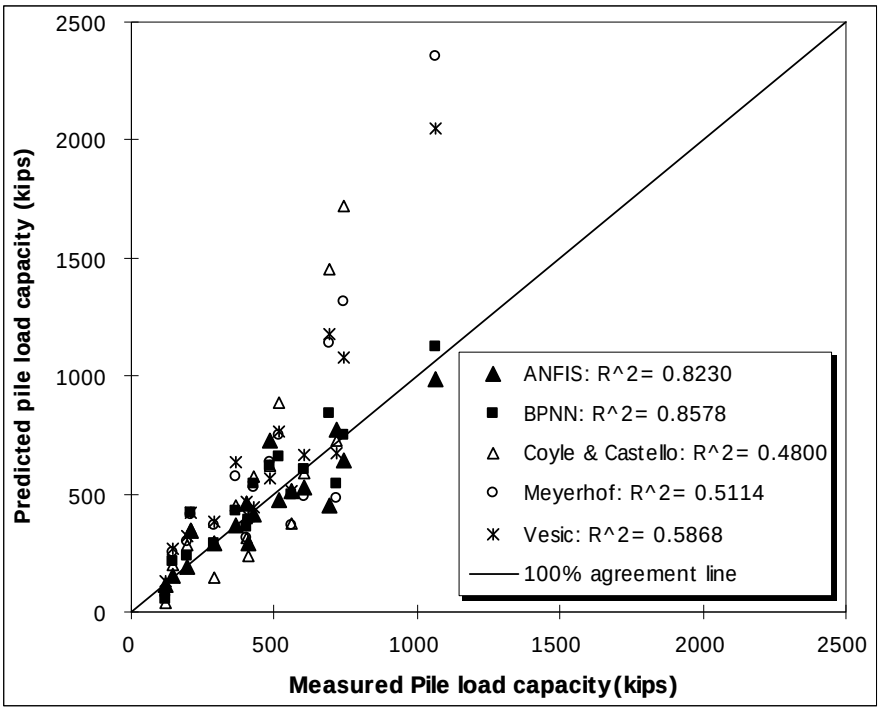

Figure 4 - 32 Comparison results of measured and predicted for testing set

The correlation R^2 and root mean-squared error (RMSE) of predicted versus measured results are summarized in Table 4-14. As shown in Table 4-14, ANFIS and BPNN produce a much higher correlation R^2 and a lower root mean-squared error, compared with the other methods. It is indicated that the ANFIS and BPNN predictions are much better than the four other empirical methods.

Table 4 - 14 Comparison results of R^2 and RMSE

Type	Correlation R^2		RMSE	
	Training	Testing	Training	Testing
ANFIS	0.9999	0.8230	1.0	102.7
BPNN	0.8635	0.8578	101.0	101.7
Coyle & Castello	0.5251	0.4800	484.1	940.1
Meyerhof	0.5420	0.5114	288.0	384.4
Vesic	0.6152	0.5868	249.6	303.1

4.7 Conclusions

In this study, the back-propagation neural network model and ANFIS are presented for predicting the pile capacities in cohesion-less soils for jetted and non-jetted conditions. A database of a number (75) of field pile load tests obtained and compiled from literature reviews was used for the development of these models.

In the developed neural network model, pile capacity predictions were made using a back-propagation neural network as well as three commonly used empirical methods, and they were also compared with actual measurements. Also for a graphical display which contains input data and the plotting results, the program was developed using MATLAB GUI (Graphical User Interface). The models for both non-jetted data and for all data including some jetted data were developed. The coefficient of correlation (R^2) and RMSE (Root Mean Square Error) are used as a qualitative measure of the prediction results with measured pile load test data. Artificial neural network predictions of the load capacity of piles are found to agree much better with the actual measured values than when compared to those from Coyle and Castello's, Meyerhof's and Vesic's methods. The results of this study indicate that the neural network models provide a better prediction and can serve as a reliable and simple tool for the prediction of axial loading capacity of piles, even for those installed with jetting. As more jetted data become available, the model itself can be improved further to make more accurate capacity predictions in a wider range of load and site conditions.

In the developed ANFIS the same input variables as used in BPNN model are selected to evaluate the pile capacity, which is the target variable. Membership functions types and numbers to each input variable are appropriately decided when the testing data set has the highest correlation R^2. Pile capacity predictions were made using ANFIS as well as commonly used empirical methods, and they were also compared with actual measurements. The other methods are those proposed by Coyle and Castello (1981), Meyerhof (1976), and Vesic (1977). The results of this study indicate that both ANFIS and BPNN provide similar predictions (BPNN being slightly better than ANFIS) which are better than those produced by the empirical methods, and can serve as a reliable and simple tool for the prediction of axial loading capacity of piles. Overall, this study shows that BPNN is little more efficient than ANFIS in that BPNN arrives at similar level of prediction much faster than ANFIS. ANFIS however, will be desirable in those situations where one or more of the input variables are available in 'fuzzy' terms when crisp information is not available.

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Chapter 5 A Neural Network Model and Adaptive Neuro Fuzzy Inference System for Prediction of Pile Setup

5.1 Introduction

The evaluation of ultimate load capacity considering pile setup may lead to more economical pile designs and thus to reductions in pile lengths, pile sections, and the size of driving equipment. The commonly used relationships that estimate pile setup are highly empirical. Also, these predictive empirical equations are limited by the corresponding data sets from which they have been derived. These methods do not provide reliable predictions for use in practice.

In this study a four layer BPNN (back-propagation neural network) model and ANFIS (Adaptive Neuro fuzzy Inference System) are developed to predict pile capacity increased by setup. A database of a number (96) of field tests is developed from the available literature for the training and testing of the model, and six variables are selected as input for both the neural network model and ANFIS.

In the developed BPNN, there is an input layer, where input data is presented to the network and an output layer, with one neuron representing the increase in pile capacity at the Beginning of Restrike by setup (ΔQ_{BOR}). Two hidden layers as intermediate layers are also included. The six variables are: soil type, pile type, pile diameter, pile length, time after pile installation, and effective stress at tip. The database was compiled from a variety of available case studies, developed from field dynamic tests; bearing capacities varying with time are calculated from CAPWAP analyses. The data set is randomly split into two groups: the first group of 73 is used for training the neural network model, and the remaining 23 data (24 % of the data) is used for testing. The predictions by the neural network model are compared with those from the four empirical relationships frequently used in practice. The results indicate that the neural network model provides a better prediction and can serve as a reliable and simple tool for the prediction of pile setup in pile design.

In the developed ANFIS, six input variables varying from roughness volume to different pile type are selected to evaluate the increased pile capacity at the beginning of restrike by setup (ΔQ_{BOR}). The total 96 data of CAPWAP were split at random into two groups (training (73), and testing data set (23)) as in the previous BPNN model. Membership functions and numbers to each input variable are appropriately decided when the testing data

set has the highest correlation R^2. Pile setup predictions are made using ANFIS as well as commonly used empirical methods, both of which were also compared with actual measurements. The four empirical methods are those proposed by Skov and Denver(1986), Svinkin(1996), Long.et.al(1999), and Svinkin and Skov(2000)). The results of this study indicate that both ANFIS and BPNN provide similar predictions (ANFIS being slightly better than BPNN) which are both better than those from empirical methods, and can serve as reliable and simple tools for the prediction of pile setup. Overall, for this prediction BPNN may be more efficient than ANFIS since BPNN model trains much faster while providing similar predictions. ANFIS, however, may be more desirable in those cases where one or more of the input variables are desirable only in 'fuzzy terms'.

5.2 Pile Setup

5.2.1 General

The increase in pile capacity with time after pile installation is referred to as pile setup or freeze. For defining this, a driven pile's long-term capacity at Beginning of Restrike (Q_{BOR}) is expressed as the sum of pile capacity at End of Drive (Q_{EOD}) and the pile capacity increase by setup at Beginning of Restrike (ΔQ_{BOR}). Setup has been demonstrated to account for capacity increases of up to 12 times the initial value.

As a pile is driven into the soil, the soil adjacent to the pile is compressed and subjected to large strains (remolded). Pile setup is predominantly associated with an increase in soil resistance acting on the side of a pile caused by the generation of pore water pressure during pile installation and its subsequent dissipation. As shown in Figure 5-1, the phenomenon may be generally described in terms of three phases:

Phase 1: Nonlinear relationship of set-up and time (log)

For some period after driving, the rate of dissipation of excess porewater pressures is not constant (non-linear) because of the highly disturbed state of the soil. During the non-constant rate of dissipation of excess pore pressures, the affected soil experiences an increase in effective and horizontal stress, gets consolidated, and gains strength in a manner which is not well understood and is difficult to model and predict. The nonlinear rate is a function of soil type, and pile properties. In clean sands, the logarithmic rate of dissipation may become linear almost immediately after driving. In cohesive soils, the logarithmic rate of dissipation may remain nonlinear for several days.

Phase 2: Linear rate relationship of set-up and time (log)

A logarithmic relationship between pile setup and time was first proposed by Skov and Denver (1988). At some time after driving, the rate of excess porewater pressure dissipation becomes constant (linear) with respect to the log of time. In fine-grained soils or mixed soils, the rate of excess porewater pressure dissipation corresponds well with the linear relationship. In cohesive soils, logarithmically linear dissipation may continue for several days, months, or even years.

Phase 3: Effects of Aging

Aging refers to a time-dependent change in soil properties at a constant effective stress. So, during the third phase of setup, setup rate is independent of effective stresses. Chow et al(1998) showed imperceptible increases in density during the aging period, so the changes in behavior must be attributable to micro-structural rearrangements of the sand grains and their contacts over time. The changes in soil properties due to aging are unlikely to be the major factor controlling setup in sand.

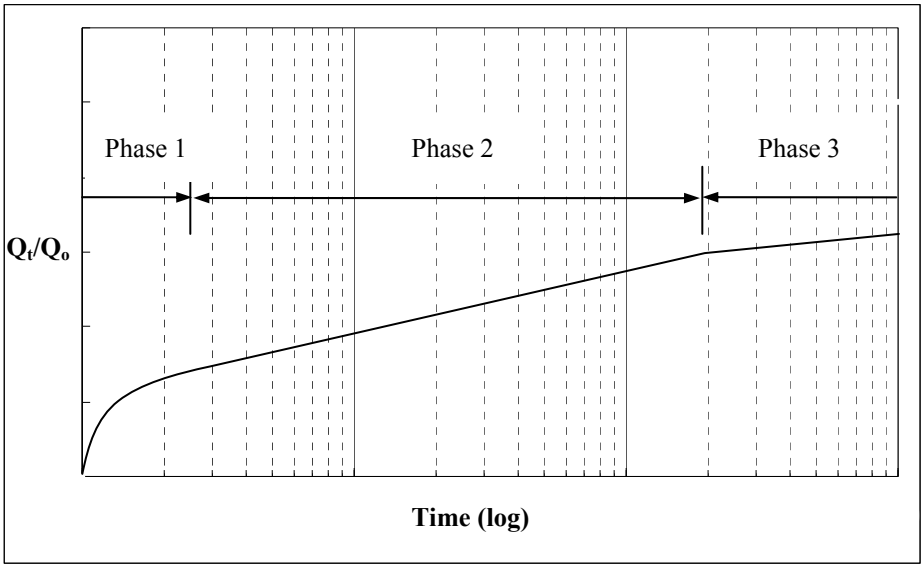

Figure 5 - 1 Idealized schematic of setup phases (after Komurka, 2003)

5.2.2 Setup by dissipation of pore water pressure

Cohesive soils

This phenomenon is generally caused by the generation of pore water pressure during pile installation in clay or fine sand. When a pile is driven into saturated clays, the soil adjacent to the pile is compressed, and pore pressure in the surrounding soil increases. This

effect temporarily reduces the effective stress and strength of the soil. As these excess pore pressures dissipate, the surrounding clay increases both in strength and in pile capacity.

Non-cohesive soils

Long et.al (1999) showed that the time-dependent increase in capacity for piles in mixed-soil profiles is similar to the increase seen for piles driven in clay, and the magnitude of increase in pile capacity in mixed soil profiles is most likely related to the proportion of clay soils in the profile. During pile driving in dense to fine sands, effective stresses temporarily increase due to the negative pore water pressures generated because of dilation, resulting in an increase in soil strength. With dissipation of excess pore pressures, the effective stresses will decrease thereafter. In the non-cohesive soils a part of the short-term setup takes place during the dissipation of excess pore pressures. Unfortunately the pile setup of non-cohesive soils is not completely explained by the effects of pore pressure.

Change in stress regimes surrounding piles

The changes in pile capacity with time are not explained completely by the effects of pore pressure. From more fundamental observations the reasons of the time-dependent strength of soils (non-cohesive) may be detailed. In loose to medium dense sand the local shear stresses acting on a pile shaft at failure, τ_f, followed the simple coulomb failure criterion:

$$\tau_f = (\sigma'_{rc} + \Delta\sigma'_r)\tan\delta_f \qquad (5.1)$$

where σ'_{rc} = radial effective stress on pile shaft after installation and equalization,

$\Delta\sigma'_r$ = increase during pile loading,

δ_f = interface angle of friction at failure.

The high degree of sand compaction at the pile tip during driving can create a thin "sleeve" of loose sand around the pile shaft. Then high hoop stresses ($\sigma'\theta$) could be sustained in the surrounding denser sand by arching, as illustrated in Figure 5-2. A reduction in the arching effect would allow horizontal stresses to increase close to the pile.

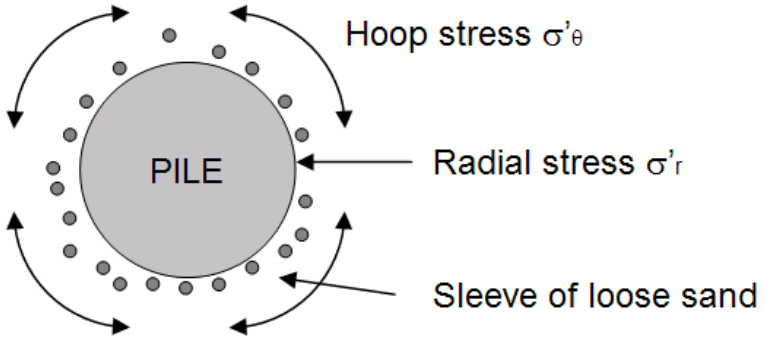

Figure 5 - 2 Plan view for arching mechanisms around pile shaft (Chow et.al, 1999)

Chow et. al (1999) presented that the best explanation for the marked setup effects on driven piles in non-cohesive soils is that sand creep rather than climatic or tide-related changes in pore pressure weakens the arching mechanisms surrounding the pile shaft. This in turn increases horizontal stresses while also producing stronger dilation effects during loading.

Axelsson (1998) showed that pile driving in sand can generate strong arching effects, even at deep depths, and then the arching deteriorates with time due to stress relaxation and leads to an increase in horizontal stress on the shaft. The increase in horizontal stress due to stress relaxation can be continued for several months and is approximately linear with the logarithm of time. The other main reason is that soil aging phenomenon with respect to piling is the reorientation of particles leading to interlocking. All these changes lead to increasing dilatancy with time. So, both the impacts of soil particles interlocking with the surface roughness and stress relaxation provide an explanation of the strong setup effects of pile in non-cohesive soils.

5.3 Estimation of Pile setup

5.3.1 Empirical relationships

Many researchers have observed the increase of pile capacity with time after installation into the ground. From their field studies, they have developed empirical relationships for predicting pile capacity with time, when pile capacity at the end of drive is given.

Skov and Denver (1988)

Skov and Denver presented a formula, which is a linear relationship with respect to the log of time, and has been commonly used so far.

$$Q_t = Q_o [A \log(t/t_o)+1] \quad (5.2)$$

where Q_t = axial capacity at time t after driving,

Q_o= axial capacity at time t_o,

A = a constant depending on soil type, and

t_o= an empirical value measured in days.

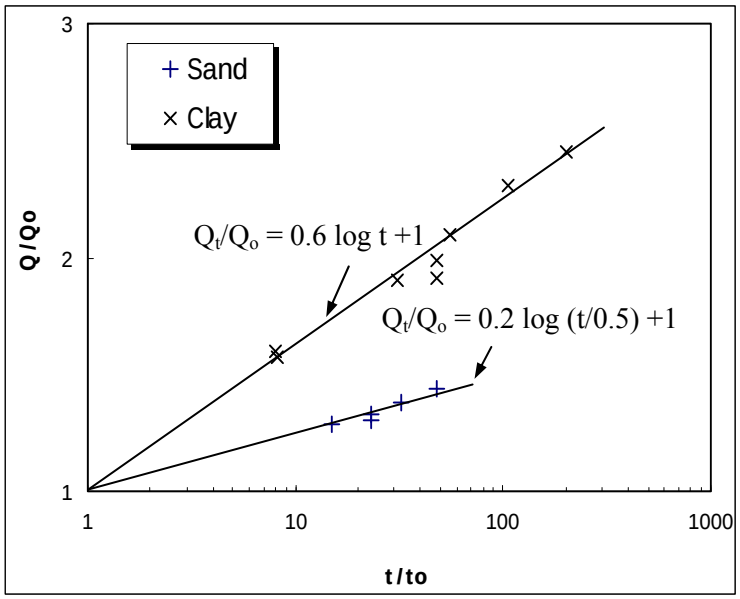

Figure 5 - 3 Time-dependent development of capacities by Skov and Denver (1988)

In this relation t_o is a function of the soil type and pile size, and is the time at which the rate of excess pore-water pressure dissipation becomes uniform (linear with respect to the log of time), as seen in Figure 5-3. The value of t_o is defined as 0.5 for sand and 1.0 for clay. And the value of parameter A is a function of soil type, pile material, type, size, and capacity. The A value is presented as 0.2 for sand and 0.6 for clay.

Huang (1988)

Huang presented a formula predicting the rate at which pile capacity is developed with time in the soft ground of Shanghai.

$$Q_t = Q_{EOD} + 0.263 (1+\log(t) (Q_{max}-Q_{EOD})) \quad (5.3)$$

where Qt = pile capacity at time t,

Q_{EOD} = pile capacity at the end of driving (EOD),

Q_{max} = the bearing capacity of pile.

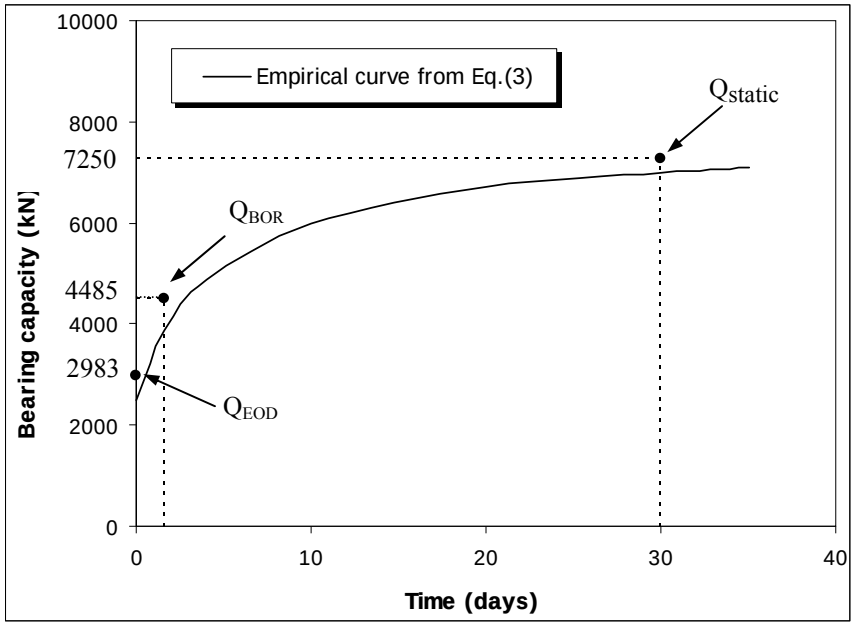

Figure 5 - 4 Variation of Bearing Capacity with Time by Huang (1988)

The results from dynamic measurements and static loading tests are presented in Figure 5-4. As shown in Figure 5-4, the bearing capacity increase agrees with the empirical curve from Eq.(5.3). Q_{EOD} and Q_{max} depend on the shear strength of the remolded sample and the undisturbed sample, respectively. It is concluded that the gain of H-pile capacity with time is similar to the empirical relationship of reinforced concrete piles in Shanghai.

Svinkin(1996)

Svinkin et.al(1996) developed a formula for setup based on load test data.

$$Q_t = 1.4\, Q_{EOD}\, t^{0.1} \quad \text{: upper bound} \tag{5.4}$$

$$Q_t = 1.025\, Q_{EOD}\, t^{0.1} \quad \text{: lower bound} \tag{5.5}$$

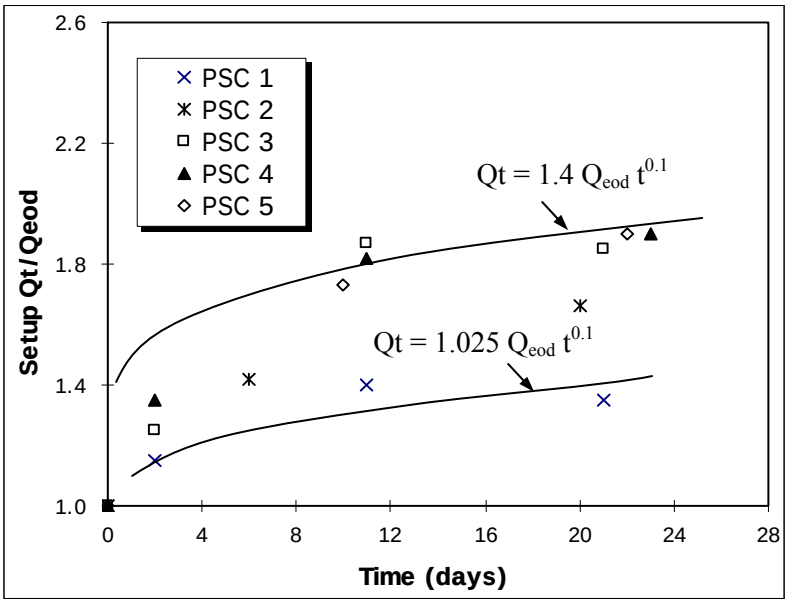

Figure 5 - 5 Pile capacity-time relationships by Svinkin(1996)

Figure 5-5 shows that the tendency of soil setup for all tested piles was the same, but the setup coefficient ranged between an upper boundary (Eq.(5.4)) and a lower boundary (Eq.(5.5)). It should be noted that these equations can be used one day after EOD (End of Driving).

Long.et.al (1999)

Long.et.al (1999) presented a formula considering to be taken 0.01 days, which is modified from Eq.(5.2).

$$Q_t = Q_O [A \log(t/0.01)+1] \quad (5.6)$$

Parameter of A is the same as the factor A in Eq.(5.2). As shown in Figures 5-6 and 5-7, time for EOD (t_o) is taken to be 0.01 days for the piles in clay and sand by monitoring the increase in capacity with time.

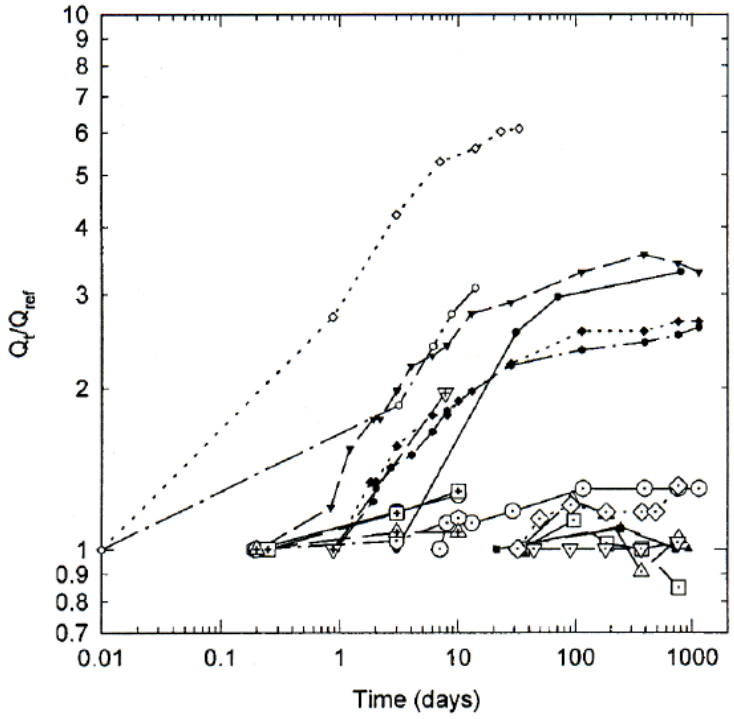

Figure 5 - 6 Normalized capacities for piles in clay by Long.et.al (1999)

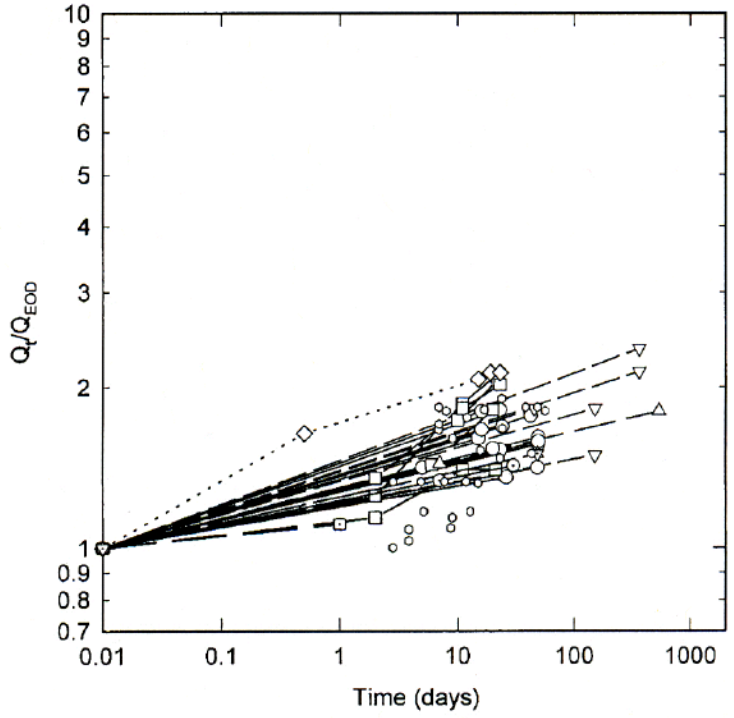

Figure 5 - 7 Normalized capacities for piles in sand by Long.et.al (1999)

Svinkin and Skov (2000)

Svinkin and Skov (2000) proposed a formula for setup based on Eq.(5.2).

$$Q_t/Q_{EOD}-1 = B\,[\log_{10}(t) + 1] \qquad (5.7)$$

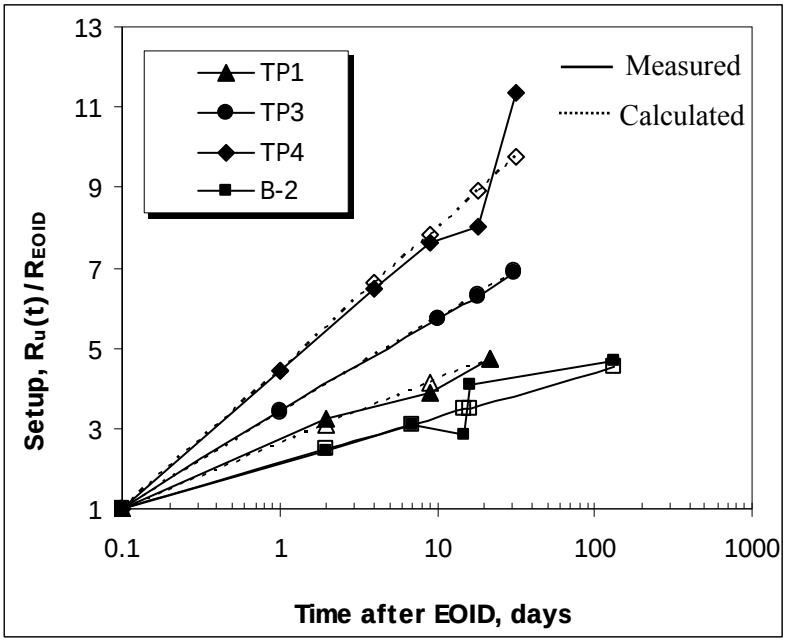

Figure 5 - 8 Pile capacity-time relationships (Svinkin and Skov, 2000)

Figure 5-8 shows that calculated values agree well with measured values of pile capacity as a function of time after EOD. Eq.(5.7) is similar to Eq.(5.2) except that the time for EOD is taken as 0.1(2.4 hours). The factor B is similar to A in Eq.(5.2). This proposed formula has some advantages: i) uses the traditional setup formulation, ii) takes into account the actual time in days passed after pile installation, iii) provides determination of the soil setup independently of the time of the first restrike. The factor B ranges from 1.6 to 3.5.

However, it should be noted that these conventional formulae are limited with respect to the field data from which they are derived. Therefore, the methods don't give reliable predictions to be used for other cases in practice. Currently, these are being used as methods for back-calculation of A and B factors.

5.3.2 Other Studies

Also, numerical studies have been made using strain path method and finite element nonlinear analysis. However, these studies have mostly been applied to clay materials, not to sandy soils. This is why it is difficult to clearly define pile setup in sandy soils compared to clay soils when considering only dissipation of excess pore water pressure. Therefore prediction by numerical methods has been difficult and limited, due to the uncertainty associated with the evaluation of model parameters.

5.4 Neural Network Model for the Prediction of Pile Setup

5.4.1 Introduction

The details of Neural Network Modeling have been presented earlier in Chapter 2. Here only the essential idea is recalled. The neural network has a parallel distributed architecture with a large number of nodes and connections of varying weights. Each node has a computation process: multiplying its weight by each input, summation of their product, and then the production of the actual output using the non-linear transfer function.

The back-propagation neural networks used for this study are trained by feeding a set of mapping data with input and target variables. The main objective of "training" the neural network is to update the connection weights and thus reduce the errors between the predicted and actual target values to a satisfactory level. This process is carried out through the minimization of the defined error function by updating the connection weights. Also, the number of hidden layers, number of hidden nodes, transfer functions, and normalization of data are chosen to gain the best performance of the model. After the errors are minimized, the model with all the parameters including the connection weights is tested with a separate set of "testing" data, not used for training. At the end of the training phase, the neural network represents a model that should be able to predict the target value given an input pattern.

Figure 5-9 shows a BPNN model developed for the prediction of pile setup. The neural network adopted in this study utilizes the back-propagation learning algorithm with two hidden layers, and nine hidden nodes as show in Figure 5-9. Also, a logistic sigmoid function is selected as an activation function to transfer the input layer to the first hidden layer and the second hidden layer to the output layer, whereas a hyperbolic tangent function is used to convert the first hidden layer to the second hidden layer by trial and error. Also, the Levenberg-Marquardt method is applied to make the convergence much faster.

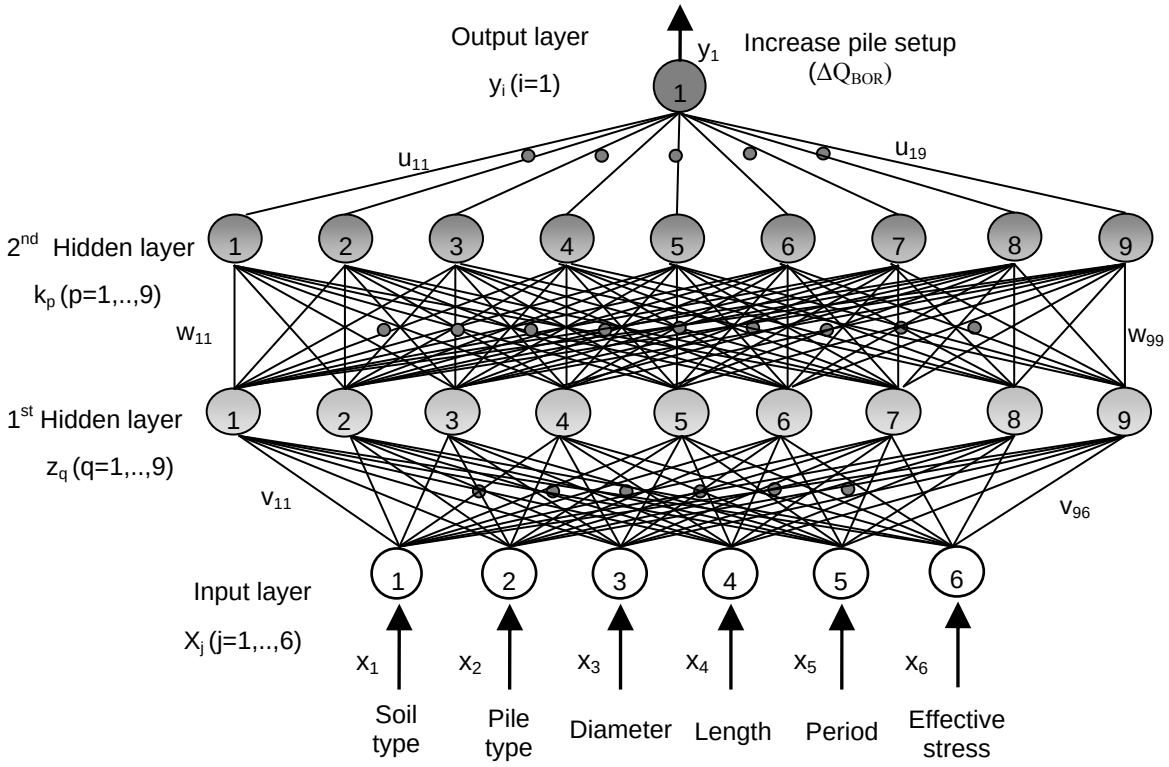

Figure 5 - 9 BPNN architecture for prediction of pile setup

5.4.2 Database

In this paper, a database is developed from the results of a number (96) of field dynamic tests, CAPWAP analyses for pile capacity. Six variables are selected as input to the developed neural network model. These variables are: soil type, pile type, pile diameter, pile length, time after EOD, and effective stress at tip. Setup is affected greatly by soil and pile type. Effective stress changes with time also has a significant role on the evaluation of pile capacity. The pile length and pile diameter affect the setup influence zone.

The variables and references are presented in Tables 5-1 and 5-2. The total 96 data were split at random into two groups: the first group of 73 data is used as a training set (Table 5-1), and the remaining 23 data (about 24 % of the data) is used for the testing set (Table 5-2). The values associated with soil type are chosen as: 1 for sand, 2 for clay, and others are calculated by considering the percentage of soil type (sand, clay) up to the pile tip.

Table 5 - 1 Training data set (BPNN)

No.	Soil Type	Pile Type	Diameter (in)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased* Q_{BOR}	*Increased* Q_{BOR} *by BPNN*	*References*
1	1.00	Pipe Pile	32.0	41.0	0.083	2.36	615.2	710.2	95.0	95.4	NCDOT(Unpublished)
2	1.61	Pipe Pile	12.8	136.4	69.0	7.02	438.0	700.0	262.0	261.8	Komurka(2004)
3	1.62	Pipe Pile	12.8	130.0	69.0	6.69	421.0	826.0	405.0	402.4	Komurka(2004)
4	1.61	Pipe Pile	12.8	131.0	69.0	6.74	352.0	677.0	325.0	331.2	Komurka(2004)
5	1.63	Pipe Pile	12.8	115.7	70.0	5.94	199.0	773.0	574.0	572.7	Komurka(2004)
6	2.00	Pipe Pile	7.6	55.8	1.33	2.65	224.8	245.1	20.2	25.3	Samson.L.and Authier.J.(1986)
7	1.33	Pipe Pile	24.0	62.6	0.67	3.44	651.0	812.0	161.0	160.7	Antorena.J.M. and McDaniel T.G.(1995)b
8	1.18	Pipe Pile	24.0	71.3	0.5	3.98	520.0	677.0	157.0	157.0	Antorena.J.M. and McDaniel T.G.(1995)b
9	1.20	Pipe Pile	24.0	67.4	16.67	3.75	295.0	487.0	192.0	192.3	Antorena.J.M. and McDaniel T.G.(1995)b
10	1.32	Pipe Pile	24.0	111.0	1.0	6.04	224.0	600.0	376.0	375.8	Holloway.D.M. and Beddard.D.L.(1995)
11	1.35	Pipe Pile	42.0	99.0	1.0	5.35	644.0	967.0	323.0	321.8	Holloway.D.M. and Beddard.D.L.(1995)
12	1.35	Pipe Pile	42.0	99.0	79.0	5.35	644.0	1750.0	1106.0	1106.7	Holloway.D.M. and Beddard.D.L.(1995)
13	1.35	Pipe Pile	42.0	100.0	1.0	5.41	488.0	671.0	183.0	184.8	Holloway.D.M. and Beddard.D.L.(1995)
14	1.62	Pipe Pile	24.0	95.1	1.0	4.88	528.3	1360.2	831.9	833.1	Dover.A.R.and Howard.Jr.R.(2002)
15	1.62	Pipe Pile	24.0	95.1	8.0	4.88	528.3	1686.2	1157.9	1139.6	Dover.A.R.and Howard.Jr.R.(2002)
16	1.64	Pipe Pile	24.0	82.0	1.0	4.21	292.3	944.2	652.0	651.2	Dover.A.R.and Howard.Jr.R.(2002)
17	1.63	Pipe Pile	24.0	88.6	1.0	4.55	314.7	764.4	449.6	449.0	Dover.A.R.and Howard.Jr.R.(2002)
18	1.64	Pipe Pile	24.0	79.1	1.0	4.06	404.7	696.9	292.3	293.7	Dover.A.R.and Howard.Jr.R.(2002)
19	1.64	Pipe Pile	24.0	79.1	8.0	4.06	404.7	1011.7	607.0	607.5	Dover.A.R.and Howard.Jr.R.(2002)
20	1.61	Pipe Pile	24.0	101.0	1.0	5.19	472.1	1101.6	629.5	629.6	Dover.A.R.and Howard.Jr.R.(2002)
21	1.63	Pipe Pile	24.0	90.9	1.0	4.67	269.8	607.0	337.2	336.9	Dover.A.R.and Howard.Jr.R.(2002)
22	1.63	Pipe Pile	24.0	90.9	8.0	4.67	269.8	876.8	607.0	607.5	Dover.A.R.and Howard.Jr.R.(2002)
23	1.20	Pipe Pile	12.7	82.0	7.0	4.56	152.9	276.5	123.7	123.5	Prelim.M.J.et.al. (1989)
24	2.00	Pipe Pile	16.0	42.0	5.0	2.21	365.8	406.0	40.2	25.5	Chambers.W.G. and Klingberg.D.J.(2000)
25	1.00	Conc' Pile	18.0	48.5	0.083	2.79	230.0	389.0	159.0	157.6	NCDOT(Unpublished)
26	1.00	Conc' Pile	16.0	55.6	0.083	3.20	290.0	361.6	71.6	66.3	NCDOT(Unpublished)
27	1.00	Conc' Pile	18.0	49.0	0.083	2.82	229.7	389.0	159.3	162.3	NCDOT(Unpublished)
28	1.00	Conc' Pile	18.0	84.0	3.0	4.84	958.0	983.0	25.0	43.1	Antorena.J.M.and McDaniel G.T.(1995)a
29	1.00	Conc' Pile	18.0	64.6	2.0	3.72	205.3	257.4	52.2	44.8	Svinkin.M.R.(1995)
30	1.00	Conc' Pile	18.0	65.6	11.0	3.78	205.3	382.6	177.4	181.8	Svinkin.M.R.(1995)
31	1.00	Conc' Pile	18.0	75.1	11.0	4.33	428.7	599.8	171.1	165.6	Svinkin.M.R.(1995)
32	1.00	Conc' Pile	24.0	64.0	10.0	3.68	340.2	587.9	247.8	249.0	Svinkin.M.R.(1995)
33	1.00	Conc' Pile	24.0	75.1	2.0	4.33	447.3	605.0	157.7	154.6	Svinkin.M.R.(1995)
34	1.00	Conc' Pile	36.0	73.2	6.0	4.21	663.0	948.2	285.2	284.5	Svinkin.M.R.(1995)
35	1.20	Conc' Pile	30.0	65.0	2.0	3.62	1090.4	1635.6	545.2	545.1	Hussein.M.H.et.al.(2002)
36	2.00	Conc' Pile	24.0	80.1	1.0	3.81	60.0	205.0	145.0	145.0	Svinkin.M.R.et.al. (1994)
37	2.00	Conc' Pile	24.0	80.1	18.0	3.81	60.0	375.9	315.9	315.3	Svinkin.M.R.et.al. (1994)
38	2.00	Conc' Pile	30.0	80.1	1.0	3.81	45.0	200.1	155.1	178.7	Svinkin.M.R.et.al. (1994)
39	2.00	Conc' Pile	30.0	80.1	4.0	3.81	45.0	292.0	247.1	228.8	Svinkin.M.R.et.al. (1994)
40	2.00	Conc' Pile	30.0	80.1	18.0	3.81	45.0	359.9	315.0	335.2	Svinkin.M.R.et.al. (1994)
41	2.00	Conc' Pile	30.0	80.1	1.0	3.81	58.9	214.0	155.1	178.7	Svinkin.M.R.et.al. (1994)
42	2.00	Conc' Pile	30.0	80.1	4.0	3.81	58.9	315.0	256.1	228.8	Svinkin.M.R.et.al. (1994)
43	2.00	Conc' Pile	30.0	80.1	20.0	3.81	58.9	393.0	334.1	320.0	Svinkin.M.R.et.al. (1994)
44	2.00	Conc' Pile	18.0	64.6	2.0	3.72	205.3	257.4	52.2	53.0	Svinkin.M.R.et.al. (1994)
45	2.00	Conc' Pile	18.0	75.1	2.0	4.33	428.7	489.2	60.5	54.0	Svinkin.M.R.et.al. (1994)
46	2.00	Conc' Pile	18.0	75.1	11.0	4.33	428.7	599.8	171.1	173.0	Svinkin.M.R.et.al. (1994)
47	2.00	Conc' Pile	24.0	75.1	2.0	4.33	446.5	605.0	158.5	158.8	Svinkin.M.R.et.al. (1994)
48	2.00	Conc' Pile	36.0	73.2	6.0	4.21	505.6	946.5	440.9	441.0	Svinkin.M.R.et.al. (1994)
49	2.00	Conc' Pile	9.3	62.3	0.04	3.59	125.9	158.0	32.1	59.3	Axelsson.G.(1998)
50	2.00	Conc' Pile	9.3	62.3	1.0	3.59	125.9	200.1	74.2	68.7	Axelsson.G.(1998)
51	2.00	Conc' Pile	9.3	62.3	6.0	3.59	125.9	280.4	154.5	146.0	Axelsson.G.(1998)
52	2.00	Conc' Pile	9.3	62.3	143.0	3.59	125.9	324.0	198.1	228.4	Axelsson.G.(1998)
53	2.00	Conc' Pile	9.3	62.3	0.028	3.59	125.9	152.4	26.5	59.1	Axelsson.G.(1998)
54	2.00	Conc' Pile	9.3	62.3	1.0	3.59	125.9	226.2	100.3	68.7	Axelsson.G.(1998)
55	2.00	Conc' Pile	9.3	62.3	37.0	3.59	125.9	377.0	251.1	250.8	Axelsson.G.(1998)
56	2.00	Conc' Pile	9.3	62.3	143.0	3.59	125.9	384.4	258.5	228.4	Axelsson.G.(1998)
57	2.00	Conc' Pile	9.3	62.3	216.0	3.59	125.9	398.8	272.9	273.1	Axelsson.G.(1998)
58	1.48	Conc' Pile	9.8	68.9	52.0	3.64	134.9	300.1	165.2	164.6	Skov.R. and Denver.H.(1988)
59	1.48	Conc' Pile	9.8	68.9	114.0	3.64	134.9	337.7	202.8	202.8	Skov.R. and Denver.H.(1988)
60	1.48	Conc' Pile	9.8	68.9	184.0	3.64	134.9	353.4	218.5	218.1	Skov.R. and Denver.H.(1988)
61	1.85	Conc' Pile	9.8	62.3	1.0	3.06	57.3	173.1	115.8	116.6	Skov.R. and Denver.H.(1988)
62	1.85	Conc' Pile	9.8	62.3	48.0	3.06	57.3	323.7	266.4	267.0	Skov.R. and Denver.H.(1988)
63	1.11	Conc' Pile	14.0	88.6	7.0	5.00	255.2	519.3	264.2	263.6	Prelim.M.J.et.al. (1989)
64	2.00	Conc' Pile	10.8	39.4	3.0	1.87	433.0	589.9	156.9	156.8	Chambers.W.G. and Klingberg.D.J.(2000)
65	1.00	H-Pile	12.0	155.0	2.0	8.93	110.0	270.0	160.0	151.8	Fellenius B.H.et.al(1989)
66	1.00	H-Pile	12.0	155.0	16.0	8.93	110.0	450.0	340.0	343.8	Fellenius B.H.et.al(1989)
67	1.00	H-Pile	12.0	155.0	1.0	8.93	146.0	272.0	126.0	140.3	Fellenius B.H.et.al(1989)
68	1.00	H-Pile	12.0	155.0	9.0	8.93	146.0	400.0	254.0	244.6	Fellenius B.H.et.al(1989)
69	1.00	H-Pile	12.0	45.9	2.0	2.65	75.3	100.0	24.7	26.2	Samson.L.and Authier.J.(1986)
70	1.53	H-Pile	12.0	50.0	21.0	2.62	240.1	515.1	275.0	277.1	Long.J.H.et.al(2002)
71	2.00	H-Pile	12.0	154.9	2.0	7.37	109.9	270.0	160.1	162.2	Svinkin.M.R.et.al. (1994)
72	2.00	H-Pile	12.0	154.9	16.0	7.37	109.9	450.1	340.2	344.4	Svinkin.M.R.et.al. (1994)
73	2.00	H-Pile	12.0	154.9	132.0	7.37	109.9	515.1	405.2	415.0	Svinkin.M.R.et.al. (1994)

Table 5 - 2 Testing data set (BPNN)

No.	Soil Type	Pile Type	Diameter (in)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased* Q_{BOR}	*Increased* Q_{BOR} *by BPNN*	*References*
1	1.61	Pipe Pile	12.8	135.1	69.0	6.96	422.0	762.0	340.0	234.7	Komurka(2004)
2	1.63	Pipe Pile	12.8	115.3	0.7	5.91	199.0	468.0	269.0	76.4	Komurka(2004)
3	1.18	Pipe Pile	24.0	71.3	15.0	3.98	520.0	700.0	180.0	131.0	Antorena.J.M. and McDaniel.T.G.(1995)b
4	1.35	Pipe Pile	42.0	99.0	7.0	5.35	644.0	1178.0	534.0	578.5	Holloway.D.M. and Beddard.D.L.(1995)
5	1.00	Pipe Pile	16.1	110.6	0.83	6.37	656.0	724.0	68.0	36.1	Dayaljee.V. and Parti.M.(2002)
6	1.64	Pipe Pile	24.0	82.0	8.0	4.21	292.3	1308.5	1016.2	1009.9	Dover.A.R. and Howard.Jr.R.(2002)
7	1.61	Pipe Pile	24.0	101.0	8.0	5.19	472.1	1304.0	831.8	1134.1	Dover.A.R. and Howard.Jr.R.(2002)
8	1.00	Conc' Pile	18.0	85.0	4.0	4.90	912.0	939.0	27.0	49.2	Antorena.J.M. and McDaniel.G.T.(1995)a
9	1.00	Conc' Pile	18.0	77.0	6.0	4.44	816.0	954.0	138.0	55.5	Antorena.J.M. and McDaniel.G.T.(1995)a
10	1.00	Conc' Pile	18.0	75.1	2.0	4.33	428.7	489.2	60.5	36.1	Svinkin.M.R.(1995)
11	1.00	Conc' Pile	24.0	75.1	11.0	4.33	447.3	813.2	365.9	255.9	Svinkin.M.R.(1995)
12	2.00	Conc' Pile	24.0	80.1	10.0	3.81	60.0	344.0	283.9	281.5	Svinkin.M.R. et.al. (1994)
13	2.00	Conc' Pile	30.0	80.1	9.0	3.81	45.0	341.1	296.1	303.2	Svinkin.M.R. et.al. (1994)
14	2.00	Conc' Pile	30.0	80.1	11.0	3.81	58.9	357.0	298.1	324.0	Svinkin.M.R. et.al. (1994)
15	2.00	Conc' Pile	18.0	64.6	11.0	3.72	205.3	382.6	177.4	102.6	Svinkin.M.R. et.al. (1994)
16	2.00	Conc' Pile	24.0	64.0	10.0	3.69	340.2	587.9	247.8	230.0	Svinkin.M.R. et.al. (1994)
17	2.00	Conc' Pile	24.0	75.1	11.0	4.33	446.5	813.2	366.7	369.6	Svinkin.M.R. et.al. (1994)
18	2.00	Conc' Pile	9.3	62.3	37.0	3.59	125.9	304.2	178.3	250.8	Axelsson.G.(1998)
19	2.00	Conc' Pile	9.3	62.3	6.0	3.59	125.9	315.2	189.3	146.0	Axelsson.G.(1998)
20	1.85	Conc' Pile	9.8	62.3	8.0	3.06	57.3	285.5	228.2	174.1	Skov.R. and Denver.H.(1988)
21	1.00	H-Pile	12.0	155.0	7.0	8.93	110.0	340.0	230.0	216.5	Fellenius B.H. et.al(1989)
22	1.53	H-Pile	12.0	50.0	7.0	2.62	240.1	284.0	43.9	33.2	Long.J.H. et.al.(2002)
23	2.00	H-Pile	12.0	154.9	7.0	7.37	109.9	339.9	230.0	221.5	Svinkin.M.R. et.al. (1994)

5.4.3 Modeling and Results

Training and Testing results

A comparison between the predictions from the neural network model and those from field tests and CAPWAP analyses is shown for both training and testing data sets in Figure 5-10.

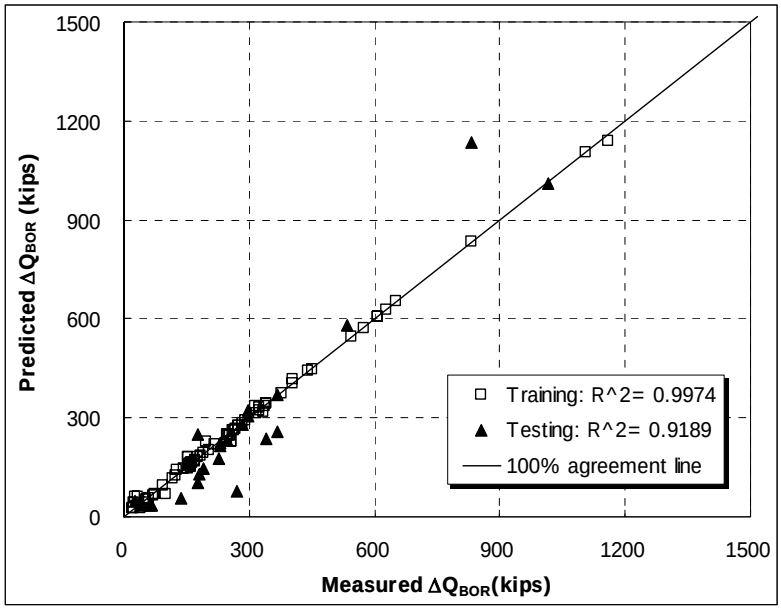

Figure 5 - 10 Predictions for Training and Testing Data Set

Table 5-3 presents the chosen values of 'learning factors' to get the best performance of the network in terms of the highest coefficient of correlation R^2. After initial weights with the range of -5.60 to 6.31 were presented to the network, the network was trained continually through the updating of weights until the error goal was 10^{-4} and the number of hidden nodes was 9 with the two hidden layers.

Table 5 - 3 Learning factors at the highest R^2 of test data set

Initial weights	No. of Hidden nodes	Error goal	Epoch	Correlation R^2	
				Training	Testing
-6.6~5.28	7	$1 / 10^6$	125	0.8231	0.8042
-6.9~5.09	8	$1 / 10^5$	12	0.8962	0.8446
-5.60~6.31	9	$1 / 10^4$	90	0.9974	0.9189
-3.99~5.63	10	$1 / 10^3$	191	0.9159	0.8579

Ultimate pile capacity (Q_{BOR}) predictions at beginning of restrike were made through the sum of pile capacity (Q_{EOD}) at end of drive and the increased pile capacity (ΔQ_{BOR}) predicted by BPNN. BPNN predictions in Figure 5-11 and Figure 5-12 show much smaller scatter as compared to those predictions produced by conventional empirical methods. The results of this study indicate that the neural network model provides better predictions than those achieved through conventional empirical methods currently used in practice.

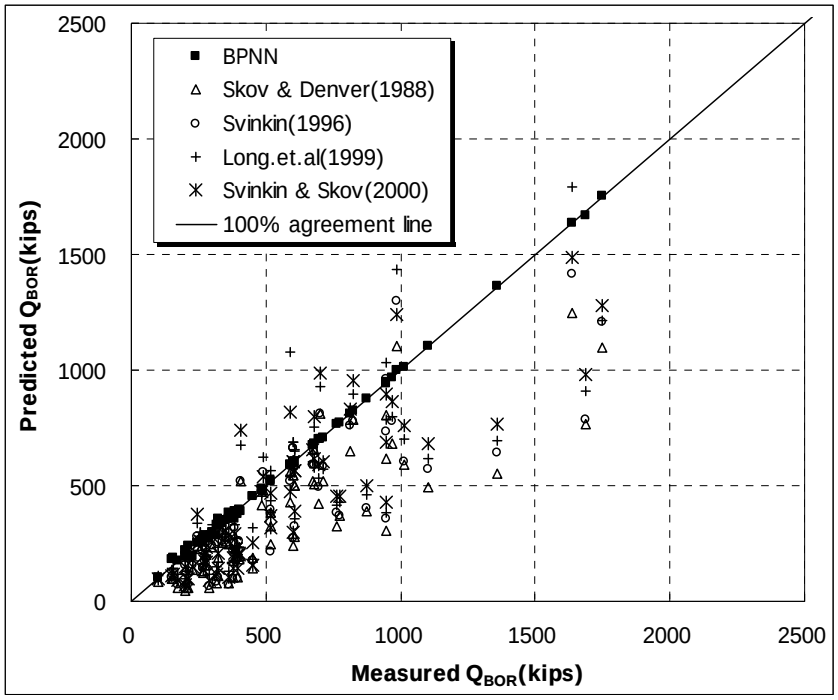

Figure 5 - 11 Comparison of predicted and measured values for Training Data Set

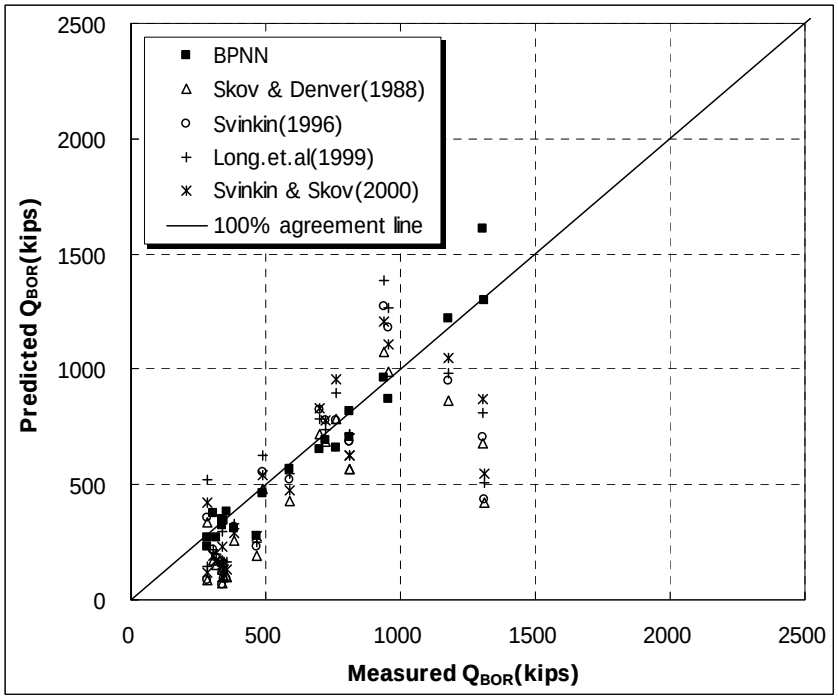

Figure 5 - 12 Comparison of predicted and measured values for Testing Data Set

The correlation coefficients and root mean square errors of predicted versus measured results are summarized in Table 5-4. As shown in Table 5-4, BPNN produced the much higher correlation R^2, and lower root mean square error, RMSE, compared with the other methods. This indicates that the BPNN predictions are more consistent than the other four empirical methods.

Table 5 - 4 Summary of Correlation R^2 and RMSE (BPNN)

Type	Correlation R^2		RMSE	
	Training	Testing	Training	Testing
BPNN	0.9994	0.9414	11.2	89.0
Skin and Denver(1988)	0.3089	0.3644	275.7	286.5
Svinkin(1996)*	0.4544	0.4490	247.7	279.5
Long.et.al(1999)	0.5497	0.4849	230.4	262.4
Svinkin and Skov(2000)	0.5993	0.5630	215.5	242.1

* Average values between upper and lower bound

Relative Importance of variables

Table 5-5 shows the relative importance, found through the weights of each layer of connections. The relative importance of the various input factors can be assessed by examining input-hidden-hidden-output layer connection weights. This is carried out by partitioning the hidden-output connection weights into components connected with each input neuron. It is shown that all the selected variables have significant influence, and time and pile diameter have relatively larger influence on the prediction.

Table 5 - 5 Relative Importance with respect to input variables

	Soil type	Pile type	Pile Diameter (in)	Pile Length (ft)	Time after EOD (days)	Effective stress at tip (ksf)
Relative Importance (%)	12.26	12.7	20.62	16.88	21.09	16.45

Parametric study

The effect of each parameter on the increased pile capacity (ΔQ_{BOR}) is investigated by varying only one input while keeping the others at their average values. The basic approach is to vary only one variable while the remaining variables are assigned to the average value of data. Figure 5-13 through Figure 5-18 show predicted values of the increased pile capacity (ΔQ_{BOR}) at beginning of restrike as a function of each parameter. Figure 5-14 shows the setup for concrete piles is larger than those in steel piles, and pipe piles are higher than H-piles. Figure 5-15 shows ΔQ_{BOR} increases as pile diameter increases. The influence of other variables also appears to be reasonable. These are consistent with the findings of other studies (York et.al(1994), Komurka et.al(2003), and Diyaljee et.al(2002)).

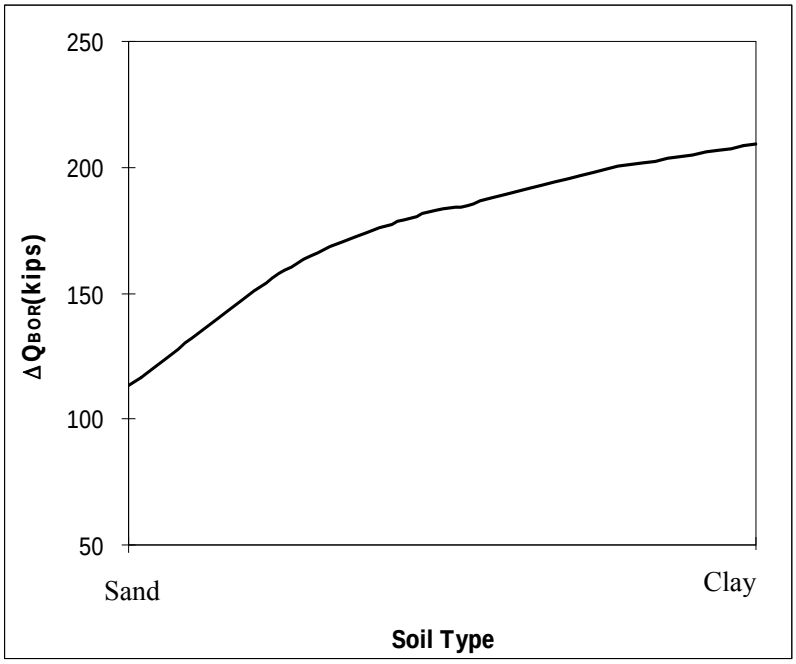

Figure 5 - 13 Parametric study: ΔQBOR vs. Soil type

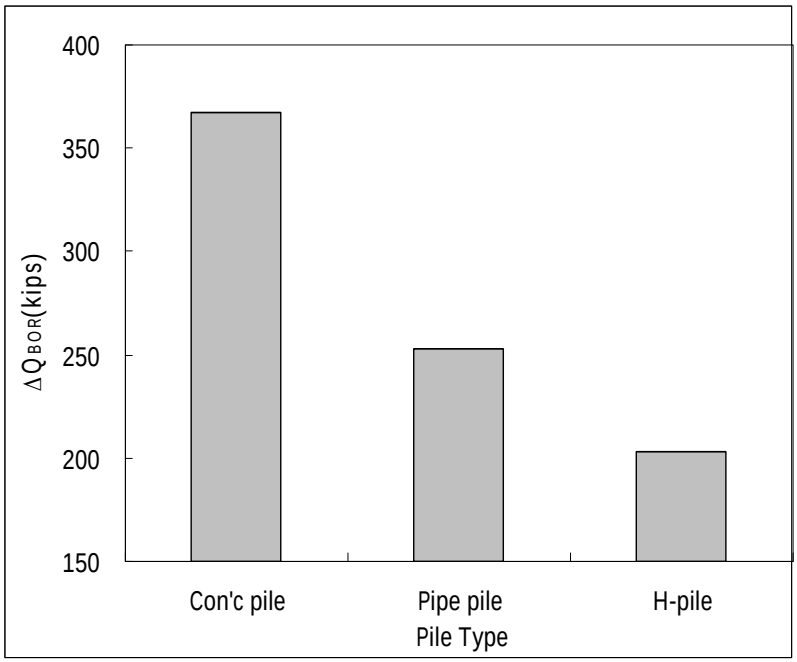

Figure 5 - 14 Parametric study: ΔQBOR vs. Pile type

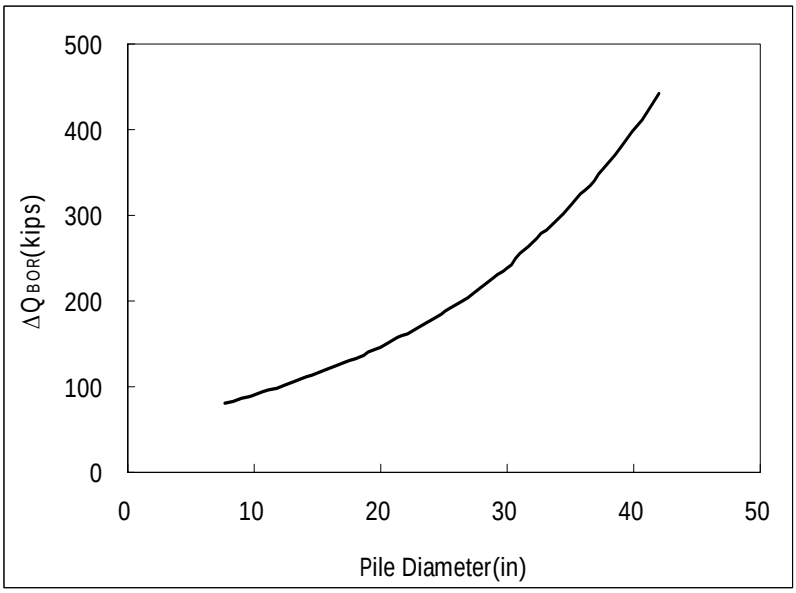

Figure 5 - 15 Parametric study: ΔQBOR vs. Pile diameter

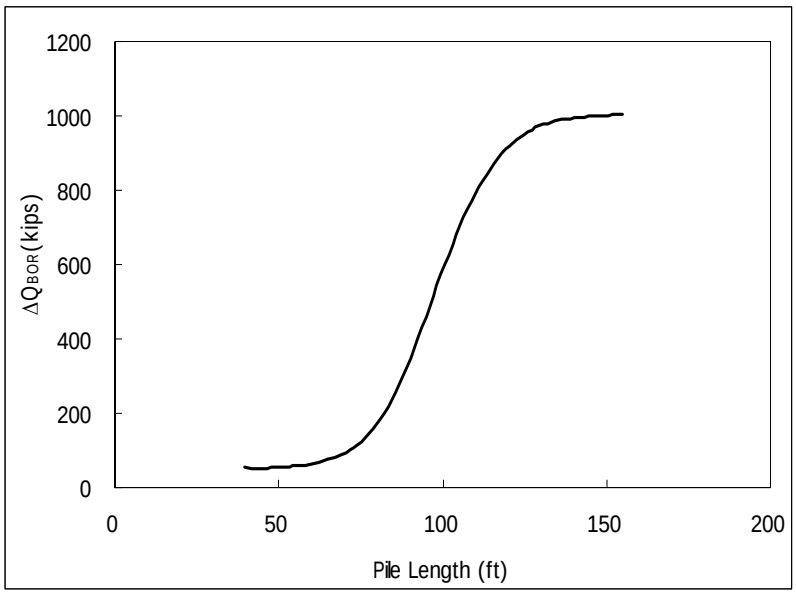

Figure 5 - 16 Parametric study: ΔQBOR vs. Pile length

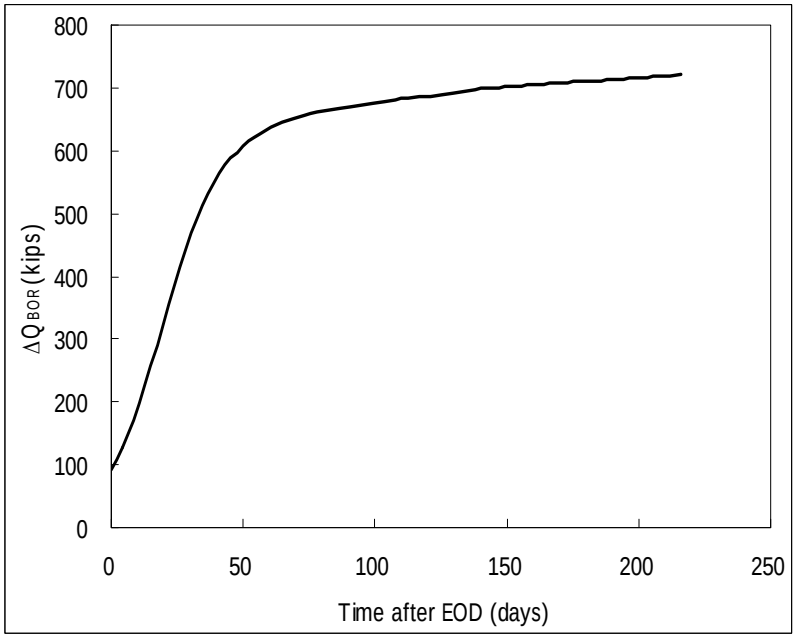

Figure 5 - 17 Parametric study: ΔQBOR vs. Time after EOD

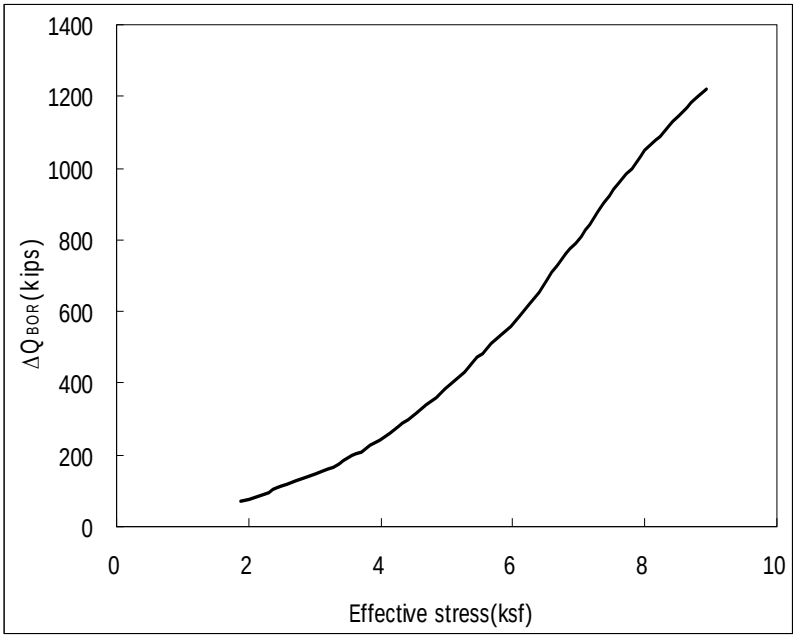

Figure 5 - 18 Parametric study: ΔQBOR vs. Effective stress at pile tip

5.4.4 A GUI of BPNN program

Figure 5-19 presents MATLAB GUI which consists of input information, comparison results, and prediction. Generally there are input spaces (blanks) in the left hand side such as project title, soil type, pile type, embedded length, pile diameter, time after EOD, and effective stress at pile tip. In the right hand side outputs are composed. First, one of two different unit systems (English and SI unit) is chosen, and then results for both training and testing are plotted and compared. Finally, pile capacity increase by setup (ΔQ_{BOR}) is predicted.

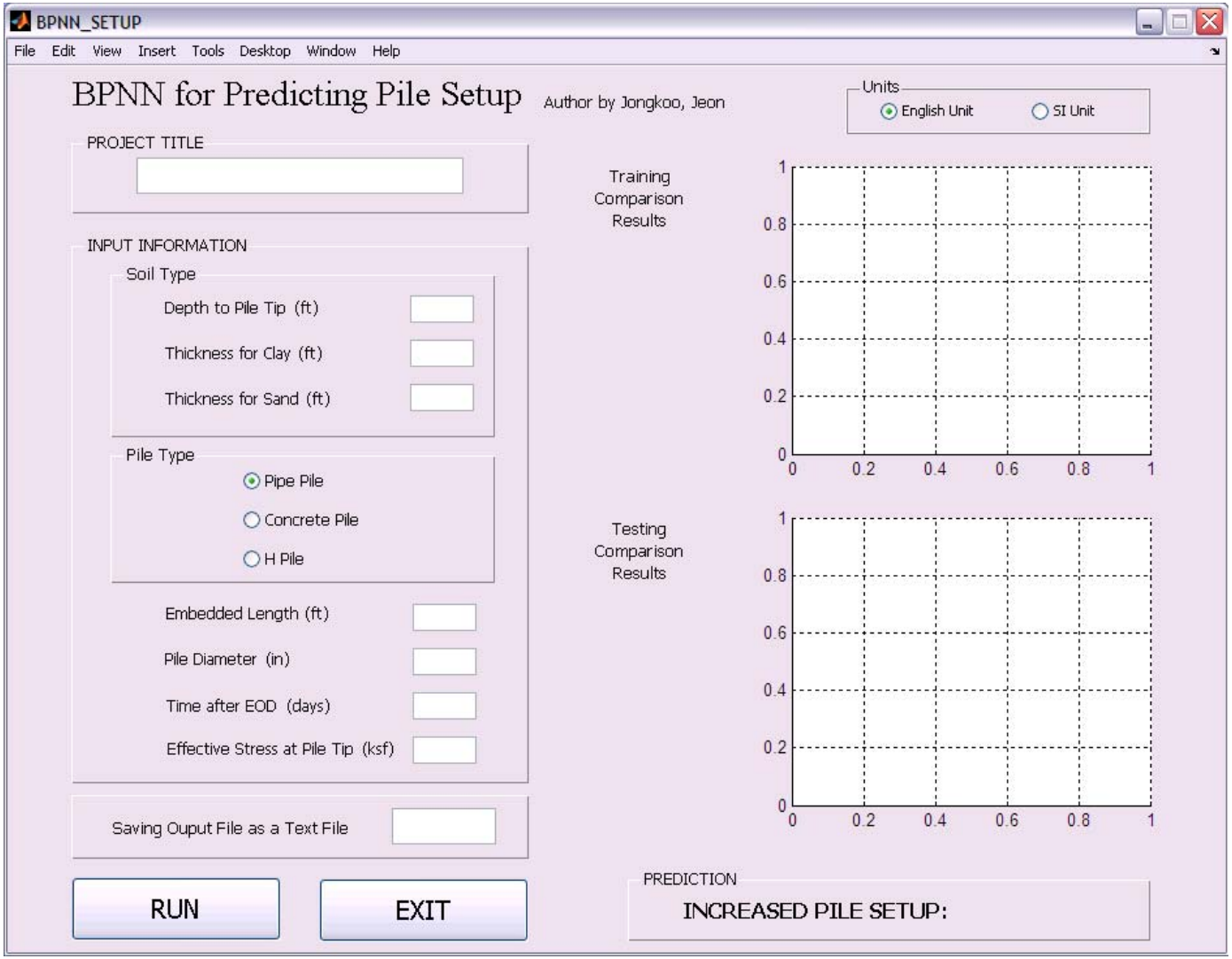

Figure 5 - 19 GUI for BPNN model: Pile Setup

5.5 ANFIS for the Prediction of Pile Setup

5.5.1 Introduction

An adaptive neuro-fuzzy inference system model is developed to predict ultimate pile capacity increase by setup. In the developed ANFIS, six variables consisting of soil type, roughness volume of pile shaft, pile diameter, embedded pile length, time after EOD, and effective stress at pile tip are selected as input variables to evaluate increase pile setup, which is the target variable. Types and numbers of MF (Membership Function) to each input variable are appropriately decided when the testing data set has the highest correlation R^2. Pile setup predictions are made using ANFIS as well as with commonly used empirical methods, and they were also compared with actual measurements. The other methods are those proposed by Skov and Denver(1986), Svkinkin(1996), Long.et.al(1999), and Svinkin and Skov(2000)). The results of this study indicate that ANFIS provides a better prediction and can serve as a reliable tool for the projection of ultimate capacity of pile by setup.

5.5.2 Database

The training and testing of the network were based on a database of 96 CAPWAP driven piles test data extracted from literature reviews. Six variables are selected as input to the developed ANFIS. These variables are: i) soil type, ii) roughness factor of pile iii) pile diameter, iv) embedded pile length, v) time after EOD, vi) effective stress at pile tip. Setup is much affected by soil type. Effective stress changing with time also has a significant role on the evaluation of pile capacity. The pile length and pile diameter affect setup influence zone. Also significance of setup by pile type is attributed to a soil/pile interface coefficient of friction. The coefficient of friction is influenced by roughness of pile material (Uesugi and Kishida, 1986).

Training and testing data set including their predictions are presented in Table 5-6 and Table 5-7 respectively. The total 96 data were split at random into two groups: the first group of 73 data is used as training set (Table 5-6), and the remaining 23 data (about 24 % of the data) are used for testing data set (Table 5-7). The values associated with soil type are chosen as: 1 for sand, 2 for clay, others are calculated by considering percentage of soil type (sand, clay) up to the pile tip. Roughness volumes are estimated by multiplying typical roughness values to pile type by pile shaft area (Pando et.al, 2006 and Iscimen, 2004).

Table 5 - 6 Training data set (ANFIS)

No.	Soil Type	Pile Type	Diameter (in)	Roughness volume of pile shaft (in^3)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased* Q_{BOR}	*Increased* Q_{BOR} *by ANFIS*	*References*
1	1.00	Pipe Pile	32.0	11.1	41.0	0.083	2.36	615.2	710.2	95.0	95.0	NC DOT(Unpublished)
2	1.61	Pipe Pile	12.8	14.7	136.4	69.0	7.02	438.0	700.0	262.0	262.0	Komurka(2004)
3	1.62	Pipe Pile	12.8	14.0	130.0	69.0	6.69	421.0	826.0	405.0	399.3	Komurka(2004)
4	1.61	Pipe Pile	12.8	14.1	131.0	69.0	6.74	352.0	677.0	325.0	330.3	Komurka(2004)
5	1.63	Pipe Pile	12.8	12.5	115.7	70.0	5.94	199.0	773.0	574.0	574.4	Komurka(2004)
6	2.00	Pipe Pile	7.6	3.6	55.8	1.33	2.65	224.8	245.1	20.2	20.2	Samson.L.and Authier.J.(1986)
7	1.33	Pipe Pile	24.0	12.7	62.6	0.67	3.44	651.0	812.0	161.0	161.0	Antorena.J.M. and McDaniel.T.G.(1995)b
8	1.18	Pipe Pile	24.0	14.5	71.3	0.5	3.98	520.0	677.0	157.0	157.1	Antorena.J.M. and McDaniel.T.G.(1995)b
9	1.20	Pipe Pile	24.0	13.7	67.4	16.67	3.75	295.0	487.0	192.0	191.9	Antorena.J.M. and McDaniel.T.G.(1995)b
10	1.32	Pipe Pile	24.0	22.5	111.0	1.0	6.04	224.0	600.0	376.0	376.0	Holloway.D.M. and Beddard.D.L.(1995)
11	1.35	Pipe Pile	42.0	35.2	99.0	1.0	5.35	644.0	967.0	323.0	322.9	Holloway.D.M. and Beddard.D.L.(1995)
12	1.35	Pipe Pile	42.0	35.2	99.0	79.0	5.35	644.0	1750.0	1106.0	1106.0	Holloway.D.M. and Beddard.D.L.(1995)
13	1.35	Pipe Pile	42.0	35.5	100.0	1.0	5.41	488.0	671.0	183.0	183.1	Holloway.D.M. and Beddard.D.L.(1995)
14	1.62	Pipe Pile	24.0	19.3	95.1	1.0	4.88	528.3	1360.2	831.9	828.3	Dover.A.R.and Howard.Jr.R.(2002)
15	1.62	Pipe Pile	24.0	19.3	95.1	8.0	4.88	528.3	1686.2	1157.9	1103.6	Dover.A.R.and Howard.Jr.R.(2002)
16	1.64	Pipe Pile	24.0	16.7	82.0	1.0	4.21	292.3	944.2	652.0	671.7	Dover.A.R.and Howard.Jr.R.(2002)
17	1.63	Pipe Pile	24.0	18.0	88.6	1.0	4.55	314.7	764.4	449.6	338.9	Dover.A.R.and Howard.Jr.R.(2002)
18	1.64	Pipe Pile	24.0	16.1	79.1	1.0	4.06	404.7	696.9	292.3	302.2	Dover.A.R.and Howard.Jr.R.(2002)
19	1.64	Pipe Pile	24.0	16.1	79.1	8.0	4.06	404.7	1011.7	607.0	590.5	Dover.A.R.and Howard.Jr.R.(2002)
20	1.61	Pipe Pile	24.0	20.5	101.0	1.0	5.19	472.1	1101.6	629.5	638.1	Dover.A.R.and Howard.Jr.R.(2002)
21	1.63	Pipe Pile	24.0	18.5	90.9	1.0	4.67	269.8	607.0	337.2	415.3	Dover.A.R.and Howard.Jr.R.(2002)
22	1.63	Pipe Pile	24.0	18.5	90.9	8.0	4.67	269.8	876.8	607.0	675.7	Dover.A.R.and Howard.Jr.R.(2002)
23	1.20	Pipe Pile	12.7	8.8	82.0	7.0	4.56	152.9	276.5	123.7	123.7	Prelim.M.J.et.al.(1989)
24	2.00	Pipe Pile	16.0	5.7	42.0	5.0	2.21	365.8	406.0	40.2	40.2	Chambers.W.G. and Klingberg.D.J.(2000)
25	1.00	Conc' Pile	18.0	46.2	48.5	0.083	2.79	230.0	389.0	159.0	160.0	NC DOT(Unpublished)
26	1.00	Conc' Pile	16.0	47.1	55.6	0.083	3.20	290.0	361.6	71.6	71.6	NC DOT(Unpublished)
27	1.00	Conc' Pile	18.0	46.7	49.0	0.083	2.82	229.7	389.0	159.3	158.1	NC DOT(Unpublished)
28	1.00	Conc' Pile	18.0	80.0	84.0	3.0	4.84	958.0	983.0	25.0	25.1	Antorena.J.M.and McDaniel.G.T.(1995)a
29	1.00	Conc' Pile	18.0	61.5	64.6	2.0	3.72	205.3	257.4	52.2	52.4	Svinkin.M.R.(1995)
30	1.00	Conc' Pile	18.0	62.5	65.6	11.0	3.78	205.3	382.6	177.4	177.5	Svinkin.M.R.(1995)
31	1.00	Conc' Pile	18.0	71.5	75.1	11.0	4.33	428.7	599.8	171.1	170.8	Svinkin.M.R.(1995)
32	1.00	Conc' Pile	24.0	81.2	64.0	10.0	3.68	340.2	587.9	247.8	247.8	Svinkin.M.R.(1995)
33	1.00	Conc' Pile	24.0	95.4	75.1	2.0	4.33	447.3	605.0	157.7	157.7	Svinkin.M.R.(1995)
34	1.00	Conc' Pile	36.0	139.4	73.2	6.0	4.21	663.0	948.2	285.2	285.2	Svinkin.M.R.(1995)
35	1.20	Conc' Pile	30.0	103.1	65.0	2.0	3.62	1090.4	1635.6	545.2	545.2	Hussein.M.H.et.al.(2002)
36	2.00	Conc' Pile	24.0	101.7	80.1	1.0	3.81	60.0	205.0	145.0	145.1	Svinkin.M.R.et.al.(1994)
37	2.00	Conc' Pile	24.0	101.7	80.1	18.0	3.81	60.0	375.9	315.9	315.8	Svinkin.M.R.et.al.(1994)
38	2.00	Conc' Pile	30.0	127.1	80.1	1.0	3.81	45.0	200.1	155.1	173.8	Svinkin.M.R.et.al.(1994)
39	2.00	Conc' Pile	30.0	127.1	80.1	4.0	3.81	45.0	292.0	247.1	227.7	Svinkin.M.R.et.al.(1994)
40	2.00	Conc' Pile	30.0	127.1	80.1	18.0	3.81	45.0	359.9	315.0	342.8	Svinkin.M.R.et.al.(1994)
41	2.00	Conc' Pile	30.0	127.1	80.1	1.0	3.81	58.9	214.0	155.1	173.8	Svinkin.M.R.et.al.(1994)
42	2.00	Conc' Pile	30.0	127.1	80.1	4.0	3.81	58.9	315.0	256.1	227.7	Svinkin.M.R.et.al.(1994)
43	2.00	Conc' Pile	30.0	127.1	80.1	20.0	3.81	58.9	393.0	334.1	316.7	Svinkin.M.R.et.al.(1994)
44	2.00	Conc' Pile	18.0	61.5	64.6	2.0	3.72	205.3	257.4	52.2	52.2	Svinkin.M.R.et.al.(1994)
45	2.00	Conc' Pile	18.0	71.5	75.1	2.0	4.33	428.7	489.2	60.5	60.5	Svinkin.M.R.et.al.(1994)
46	2.00	Conc' Pile	18.0	71.5	75.1	11.0	4.33	428.7	599.8	171.1	171.1	Svinkin.M.R.et.al.(1994)
47	2.00	Conc' Pile	24.0	95.5	75.1	2.0	4.33	446.5	605.0	158.5	158.5	Svinkin.M.R.et.al.(1994)
48	2.00	Conc' Pile	36.0	139.5	73.2	6.0	4.21	505.6	946.5	440.9	440.9	Svinkin.M.R.et.al.(1994)
49	2.00	Conc' Pile	9.3	30.5	62.3	0.04	3.59	125.9	158.0	32.1	48.9	Axelsson.G.(1998)
50	2.00	Conc' Pile	9.3	30.5	62.3	1.0	3.59	125.9	200.1	74.2	66.4	Axelsson.G.(1998)
51	2.00	Conc' Pile	9.3	30.5	62.3	6.0	3.59	125.9	280.4	154.5	156.2	Axelsson.G.(1998)
52	2.00	Conc' Pile	9.3	30.5	62.3	143.0	3.59	125.9	324.0	198.1	228.3	Axelsson.G.(1998)
53	2.00	Conc' Pile	9.3	30.5	62.3	0.028	3.59	125.9	152.4	26.5	48.7	Axelsson.G.(1998)
54	2.00	Conc' Pile	9.3	30.5	62.3	1.0	3.59	125.9	226.2	100.3	66.4	Axelsson.G.(1998)
55	2.00	Conc' Pile	9.3	30.5	62.3	37.0	3.59	125.9	377.0	251.1	252.2	Axelsson.G.(1998)
56	2.00	Conc' Pile	9.3	30.5	62.3	143.0	3.59	125.9	384.4	258.5	228.3	Axelsson.G.(1998)
57	2.00	Conc' Pile	9.3	30.5	62.3	216.0	3.59	125.9	398.8	272.9	272.9	Axelsson.G.(1998)
58	1.48	Conc' Pile	9.8	35.9	68.9	52.0	3.64	134.9	300.1	165.2	165.2	Skov.R. and Denver.H.(1988)
59	1.48	Conc' Pile	9.8	35.9	68.9	114.0	3.64	134.9	337.7	202.8	202.8	Skov.R. and Denver.H.(1988)
60	1.48	Conc' Pile	9.8	35.9	68.9	184.0	3.64	134.9	353.4	218.5	218.5	Skov.R. and Denver.H.(1988)
61	1.85	Conc' Pile	9.8	32.5	62.3	1.0	3.06	57.3	173.1	115.8	116.0	Skov.R. and Denver.H.(1988)
62	1.85	Conc' Pile	9.8	32.5	62.3	48.0	3.06	57.3	323.7	266.4	266.1	Skov.R. and Denver.H.(1988)
63	1.11	Conc' Pile	14.0	65.5	88.6	7.0	5.00	255.2	519.3	264.2	264.2	Prelim.M.J.et.al.(1989)
64	2.00	Conc' Pile	10.8	22.6	39.4	3.0	1.87	433.0	589.9	156.9	156.9	Chambers.W.G. and Klingberg.D.J.(2000)
65	1.00	H-Pile	12.0	29.1	155.0	2.0	8.93	110.0	270.0	160.0	150.7	Fellenius.B.H.et.al(1989)
66	1.00	H-Pile	12.0	29.1	155.0	16.0	8.93	110.0	450.0	340.0	342.1	Fellenius.B.H.et.al(1989)
67	1.00	H-Pile	12.0	29.1	155.0	1.0	8.93	146.0	272.0	126.0	136.0	Fellenius.B.H.et.al(1989)
68	1.00	H-Pile	12.0	29.1	155.0	9.0	8.93	146.0	400.0	254.0	251.1	Fellenius.B.H.et.al(1989)
69	1.00	H-Pile	12.0	8.6	45.9	2.0	2.65	75.3	100.0	24.7	24.7	Samson.L.and Authier.J.(1986)
70	1.53	H-Pile	12.0	9.4	50.0	21.0	2.62	240.1	515.1	275.0	275.0	Long.J.H.et.al.(2002)
71	2.00	H-Pile	12.0	29.0	154.9	2.0	7.37	109.9	270.0	160.1	160.0	Svinkin.M.R.et.al.(1994)
72	2.00	H-Pile	12.0	29.0	154.9	16.0	7.37	109.9	450.1	340.2	340.3	Svinkin.M.R.et.al.(1994)
73	2.00	H-Pile	12.0	29.0	154.9	132.0	7.37	109.9	515.1	405.2	405.2	Svinkin.M.R.et.al.(1994)

Table 5 - 7 Testing data set (ANFIS)

No.	Soil Type	Pile Type	Diameter (in)	Roughness volume of pile shaft (in^3)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased Q_{BOR}*	*Increased Q_{BOR} by ANFIS*	*References*
1	1.61	Pipe Pile	12.8	14.6	135.1	69.0	6.96	422.0	762.0	340.0	275.0	Komurka(2004)
2	1.63	Pipe Pile	12.8	12.4	115.3	0.7	5.91	199.0	468.0	269.0	274.6	Komurka(2004)
3	1.18	Pipe Pile	24.0	14.5	71.3	15.0	3.98	520.0	700.0	180.0	234.7	Antorena.J.M. and McDaniel T.G.(1995)b
4	1.35	Pipe Pile	42.0	35.2	99.0	7.0	5.35	644.0	1178.0	534.0	323.8	Holloway.D.M. and Beddard.D.L.(1995)
5	1.00	Pipe Pile	16.1	15.1	110.6	0.83	6.37	656.0	724.0	68.0	68.0	Dijaljee.V.and Parti.M.(2002)
6	1.64	Pipe Pile	24.0	16.6	82.0	8.0	4.21	292.3	1308.5	1016.2	960.6	Dover.A.R.and Howard.Jr.R.(2002)
7	1.61	Pipe Pile	24.0	20.5	101.0	8.0	5.19	472.1	1304.0	831.8	963.3	Dover.A.R.and Howard.Jr.R.(2002)
8	1.00	Conc' Pile	18.0	81.0	85.0	4.0	4.90	912.0	939.0	27.0	16.1	Antorena.J.M.and McDaniel G.T.(1995)a
9	1.00	Conc' Pile	18.0	73.3	77.0	6.0	4.44	816.0	954.0	138.0	107.2	Antorena.J.M.and McDaniel G.T.(1995)a
10	1.00	Conc' Pile	18.0	71.5	75.1	2.0	4.33	428.7	489.2	60.5	51.5	Svinkin.M.R.(1995)
11	1.00	Conc' Pile	24.0	95.4	75.1	11.0	4.33	447.3	813.2	365.9	246.7	Svinkin.M.R.(1995)
12	2.00	Conc' Pile	24.0	101.7	80.1	10.0	3.81	60.0	344.0	283.9	237.4	Svinkin.M.R.et.al.(1994)
13	2.00	Conc' Pile	30.0	127.1	80.1	9.0	3.81	45.0	341.1	296.1	303.9	Svinkin.M.R.et.al.(1994)
14	2.00	Conc' Pile	30.0	127.1	80.1	11.0	3.81	58.9	357.0	298.1	327.0	Svinkin.M.R.et.al.(1994)
15	2.00	Conc' Pile	18.0	61.5	64.6	11.0	3.72	205.3	382.6	177.4	175.7	Svinkin.M.R.et.al.(1994)
16	2.00	Conc' Pile	24.0	81.3	64.0	10.0	3.69	340.2	587.9	247.8	322.4	Svinkin.M.R.et.al.(1994)
17	2.00	Conc' Pile	24.0	95.5	75.1	11.0	4.33	446.5	813.2	366.7	251.6	Svinkin.M.R.et.al.(1994)
18	2.00	Conc' Pile	9.3	30.5	62.3	37.0	3.59	125.9	304.2	178.3	252.2	Axelsson.G.(1998)
19	2.00	Conc' Pile	9.3	30.5	62.3	6.0	3.59	125.9	315.2	189.3	156.2	Axelsson.G.(1998)
20	1.85	Conc' Pile	9.8	32.5	62.3	8.0	3.06	57.3	285.5	228.2	244.6	Skov.R. and Denver.H.(1988)
21	1.00	H-Pile	12.0	29.1	155.0	7.0	8.93	110.0	340.0	230.0	223.0	Fellenius B.H.et.al(1989)
22	1.53	H-Pile	12.0	9.4	50.0	7.0	2.62	240.1	284.0	43.9	89.7	Long.J.H.et.al.(2002)
23	2.00	H-Pile	12.0	29.0	154.9	7.0	7.37	109.9	339.9	230.0	224.7	Svinkin.M.R.et.al.(1994)

5.5.3 Modeling and Results

Membership Functions

For ANFIS analysis, types of MFs and number of MFs assigned to each input variable are decided by trial and error.

Figures 5-20 through 5-31 show the initial and final MFs (Membership Functions) for all input variables: i) soil type – sigmoidal MF, ii) pile diameter – sigmoidal MF, iii) roughness volume of pile shaft – sigmoidal MF, iv) pile length – general bell MF, v) time after EOD – sigmoidal MF, vi) effective stress at pile tip - trapezoidal MF. It is observed that a big change in the training membership functions around the initial condition is accounted for by the membership functions moving toward the origin. In other words, the initial MFs show uniformly distributed MFs between 0 and 1, while the final MFs on input variables are not symmetric due to the identification of the consequent parameters by the least squares method and the updating of the premise parameters by the gradient descent method. Most data in the database has membership grades between 0 and 1 for linguistic terms.

Soil type

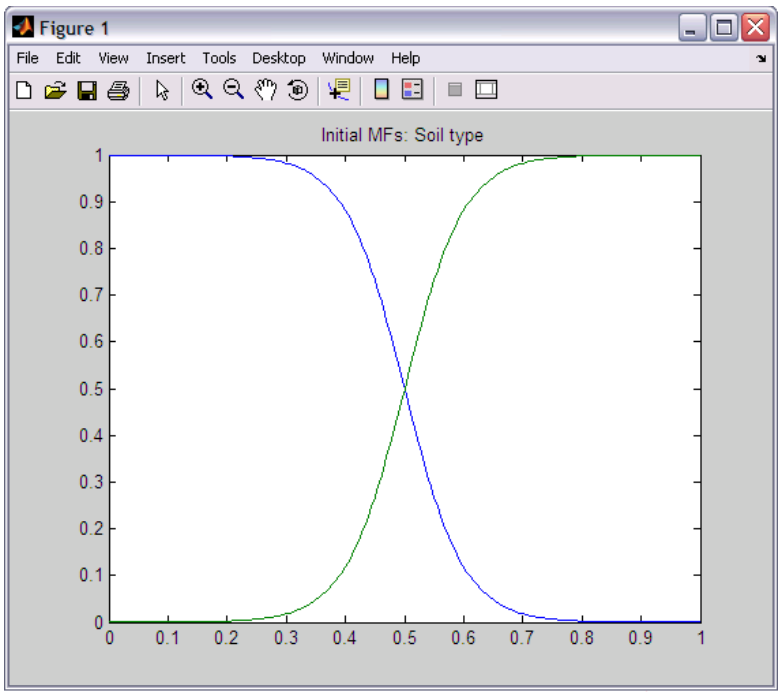

Figure 5 - 20 Initial MF: Soil type

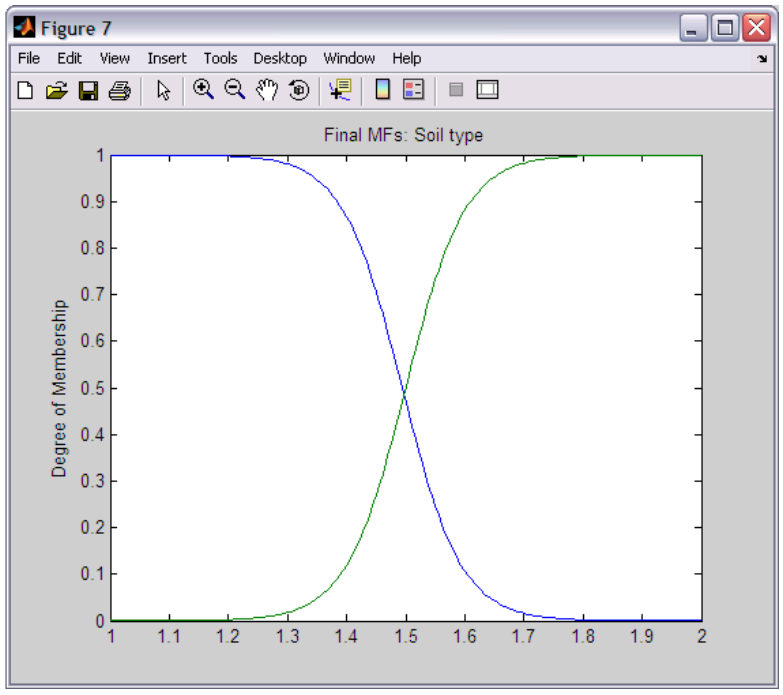

Figure 5 - 21Final MF: Soil type

Pile diameter

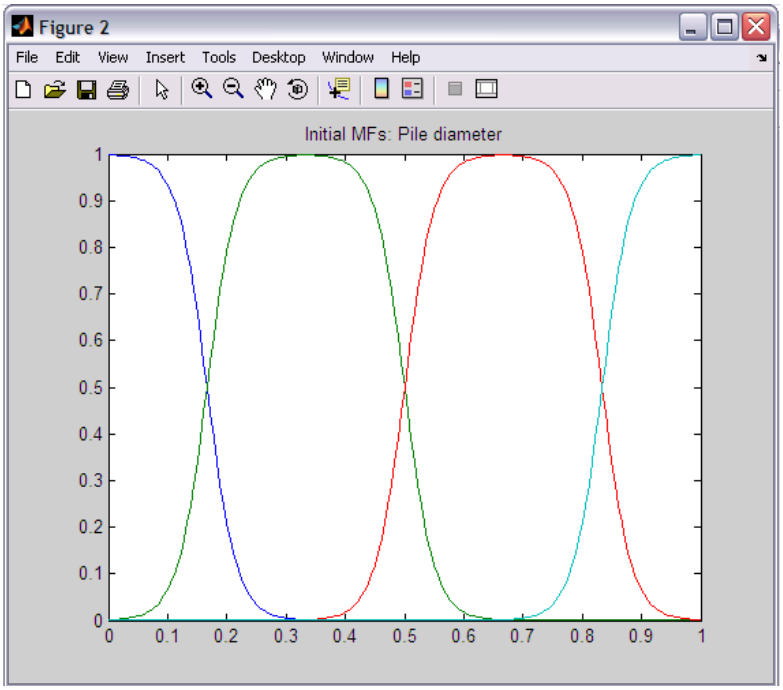

Figure 5 - 22 Initial MF: Pile diameter

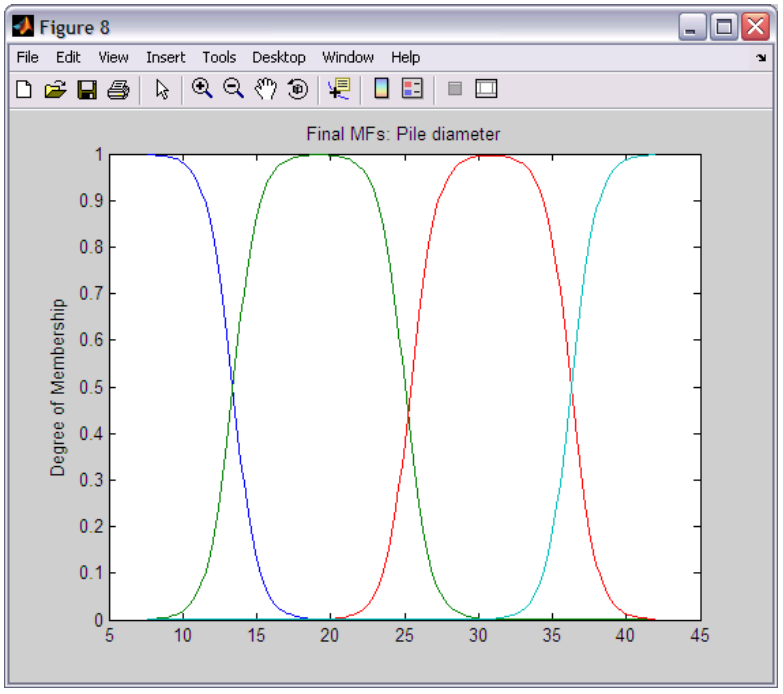

Figure 5 - 23 Final MF: Pile diameter

Roughness volume of pile shaft

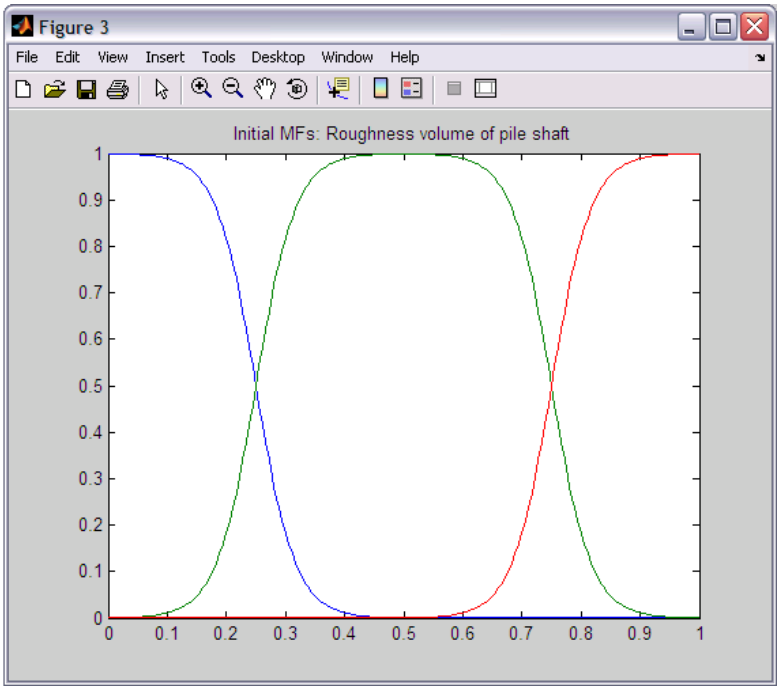

Figure 5 - 24 Initial MF: Roughness volume of pile shaft

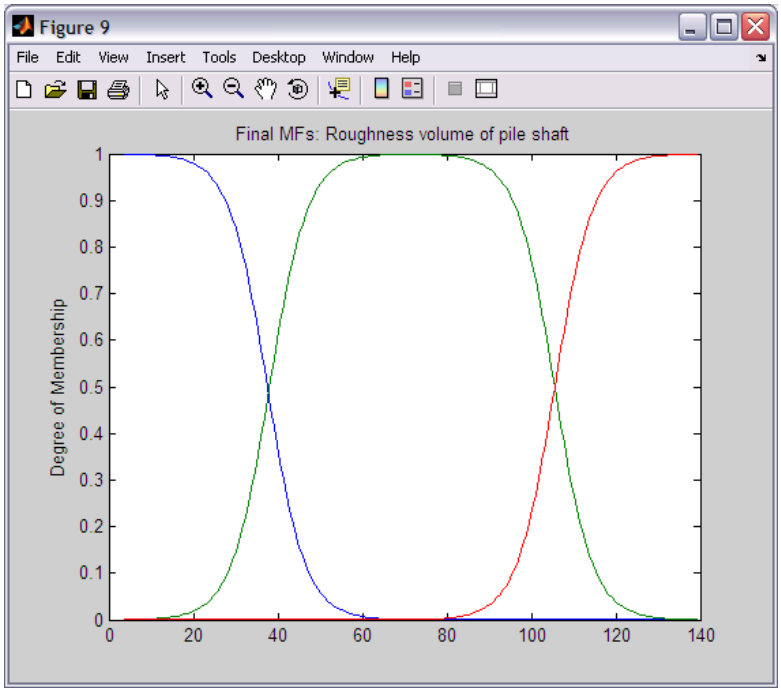

Figure 5 - 25 Final MF: Roughness volume of pile shaft

Pile length

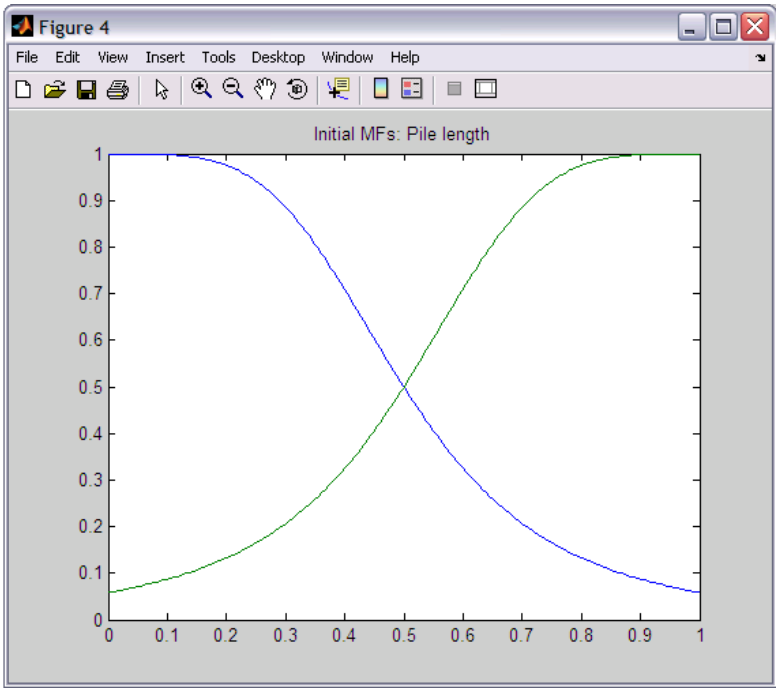

Figure 5 - 26 Initial MF: Pile length

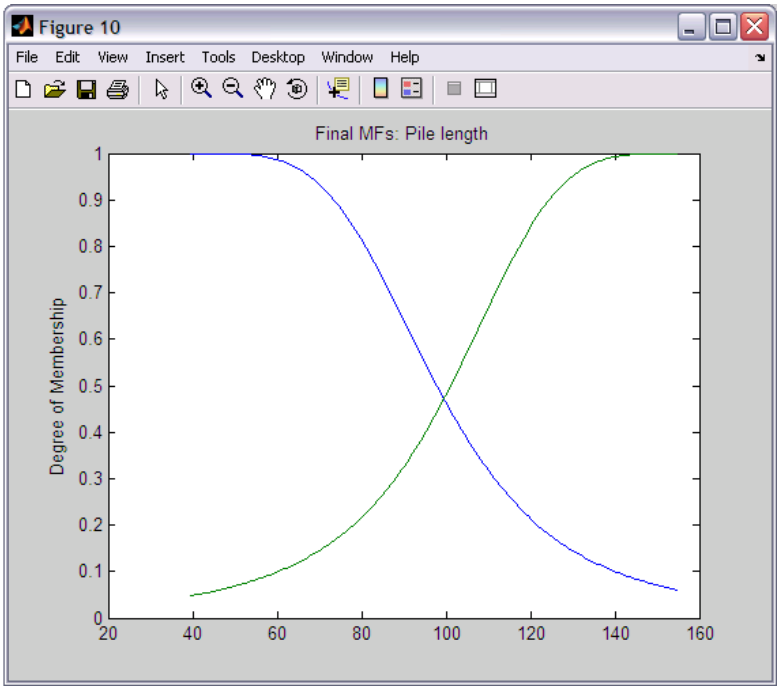

Figure 5 - 27 Final MF: Pile length

Time after EOD

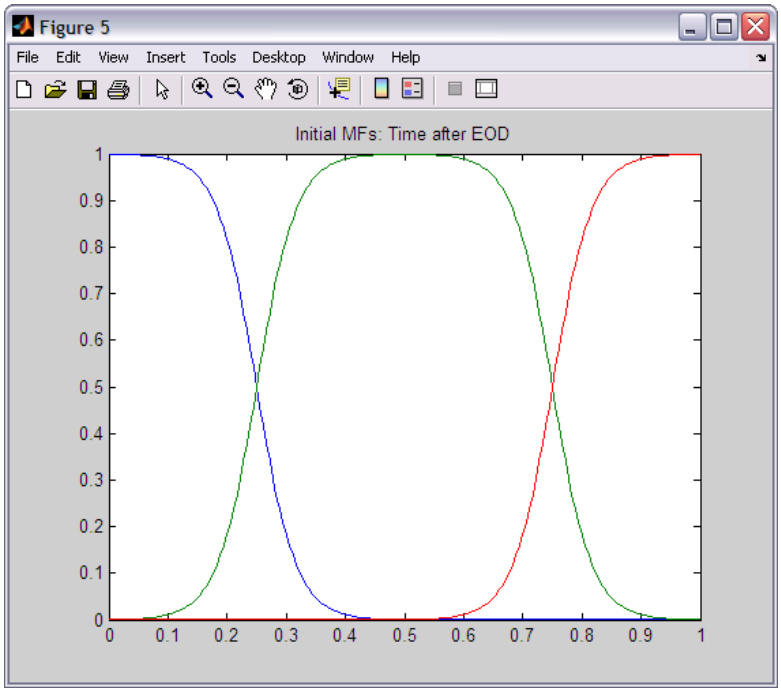

Figure 5 - 28 Initial MF: Time after EOD

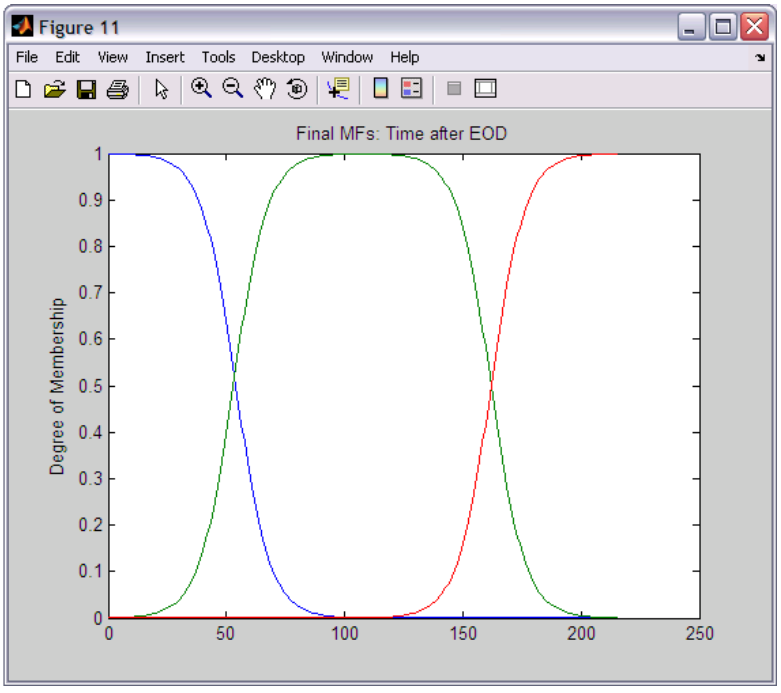

Figure 5 - 29 Final MF: Time after EOD

Effective stress at pile tip

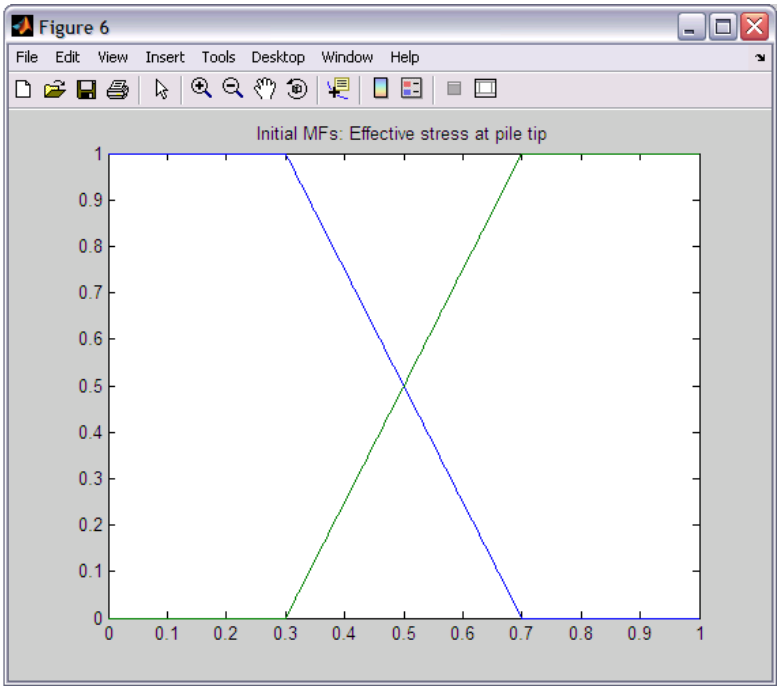

Figure 5 - 30 Initial MF: Effective stress at pile tip

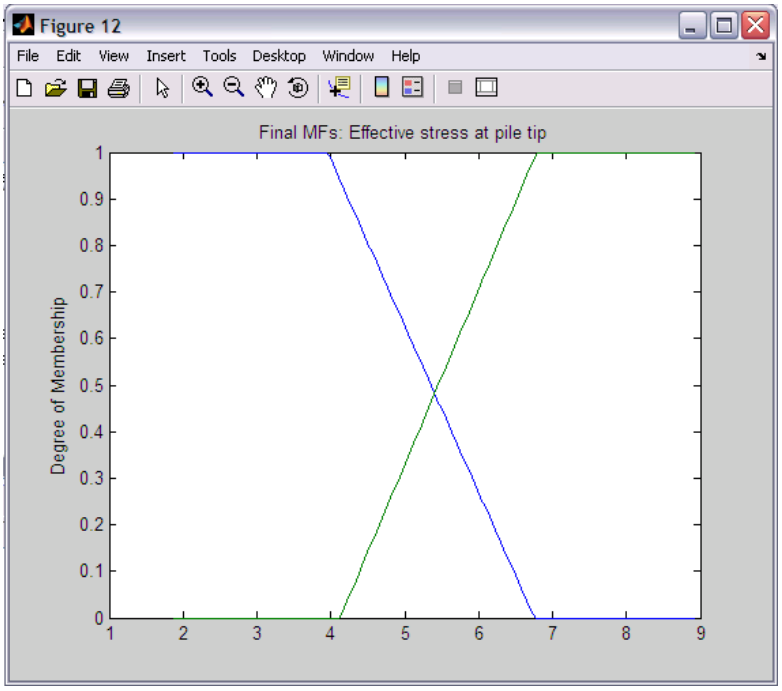

Figure 5 - 31 Final MF: Effective stress at pile tip

MFs type and number

Table 5-8 summarized membership functions for each input variable when the ANFIS model reaches an acceptable satisfactory level of error goal. Different types of linguistic terms for each input variable are dependent on different numbers of MFs to each input variable.

Table 5 - 8 Summary of MFs to each input variable

	Soil type	Pile Diameter	Roughness Volume of Pile shaft	Embedded Pile Length	Time after EOD	Effective stress
Type of MFs	Dsigmoid*	Dsigmoid	Dsigmoid	General Bell	Dsigmoid	Trapezoid
Number of MFs	2	4	3	2	3	2
Linguistic terms	High Low	Very high Fairly high Fairly low Very low	High Medium Low	High Low	High Medium Low	High Low

*Asymmetric and closed membership functions synthesized using two sigmoidal functions

The ANFIS used here contains 324 rules, with different numbers of membership functions assigned to each input variable. The total number of fitting parameters is 926, which is a summation of 62 premise (nonlinear) parameters and 864 consequent (linear) parameters: number of fuzzy rules (288 = 2*4*3*2*3*2), premise parameters (62 = 2*4 + 4*4 + 3*4+ 2*3 + 3*4 + 2*4), and consequent parameters (864 = 288*3).

Training and Testing Results

A comparison between the predictions from ANFIS and measured ones from field tests and CAPWAP analyses is shown for both training and testing data set in Figure 5-32. The results appear to be good enough to have more than 0.9 of correlation R^2 even though there is some scatter in the testing data points. The ultimate pile capacity (Q_{BOR}) predictions at beginning of restrike were made through the sum of pile capacity (Q_{EOD}) at the end of driving and the increased pile capacity (ΔQ_{BOR}) predicted by ANFIS: $Q_{BOR} = Q_{EOD} + \Delta Q_{BOR}$.

ANFIS predictions in Figure 5-33 and Figure 5-34 show smaller scatter in the data points than the predictions of the conventional methods. The results of this study indicate

that ANFIS is much better than the empirical methods when compared with actual measurements.

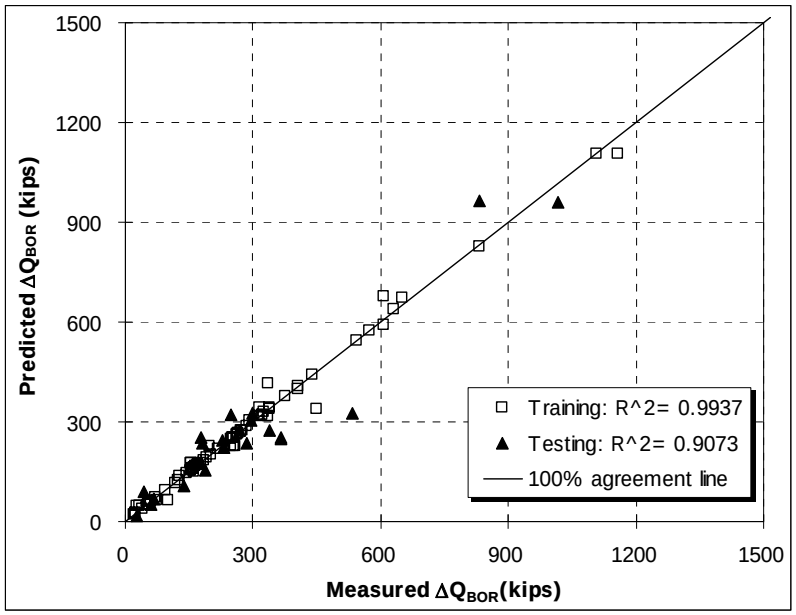

Figure 5 - 32 Predictions for Training and Testing Data Set

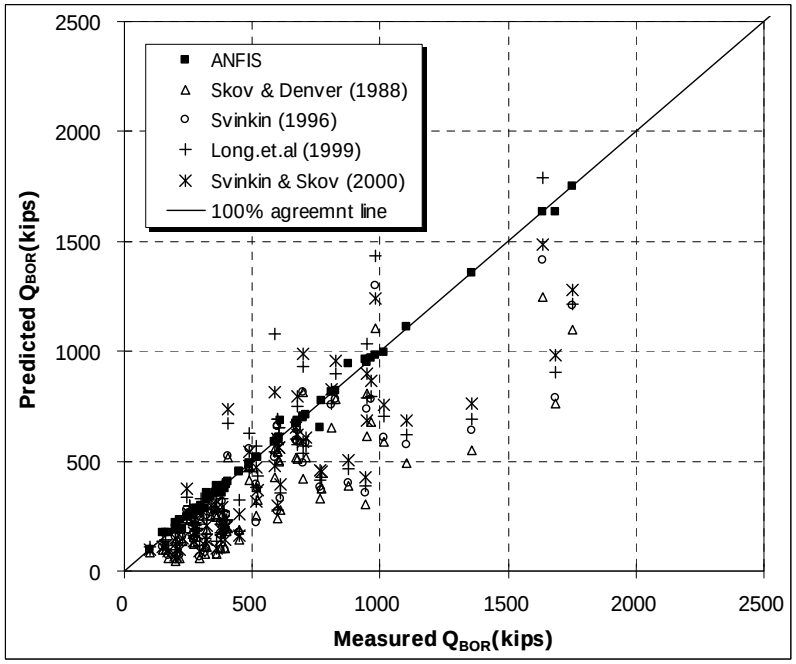

Figure 5 - 33 Comparison measured and predicted values for Training Data Set

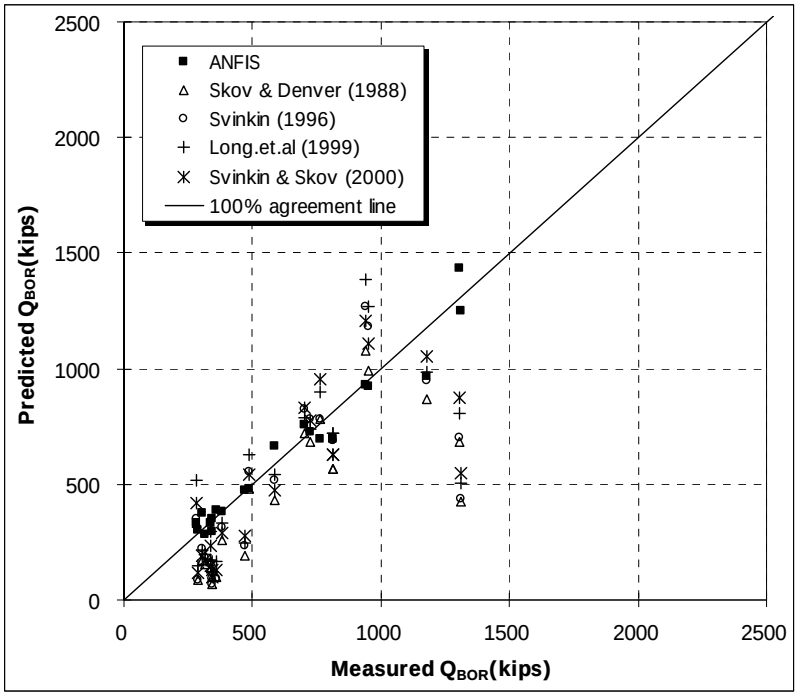

Figure 5 - 34 Comparison measured and predicted values for Testing Data Set

5.6 Comparison of Results

Figure 5-35 shows the RMSE (Root Mean Square Error) curves for both the BPNN model and the ANFIS used for this study. ANFIS' performance stayed the same after 5 epochs while BPNN seems to perform more effectively as shown in Figure 5-35. Also, the ANFIS did take much longer than BPNN since the hybrid learning rule involves more computation: ANFIS - 2min 36.33 seconds (up to 5 epochs) and BPNN - 3.37 seconds (up to 90 epochs).

Predictions by ANFIS in Figure 5-36 for training and Figure 5-37 for testing show similar results by BPNN and present smaller scatter in the data points than the predictions of the conventional methods. The results of this study indicate that ANFIS and BPNN are much better than the empirical methods when compared with actual measurements.

Overall, for this study BPNN may be more efficient and desirable than ANFIS since BPNN model trains much faster and they provide similar predictions. However, ANFIS may be more desirable than BPNN in those cases where one or more of the input variables are desirable only in 'fuzzy' terms.

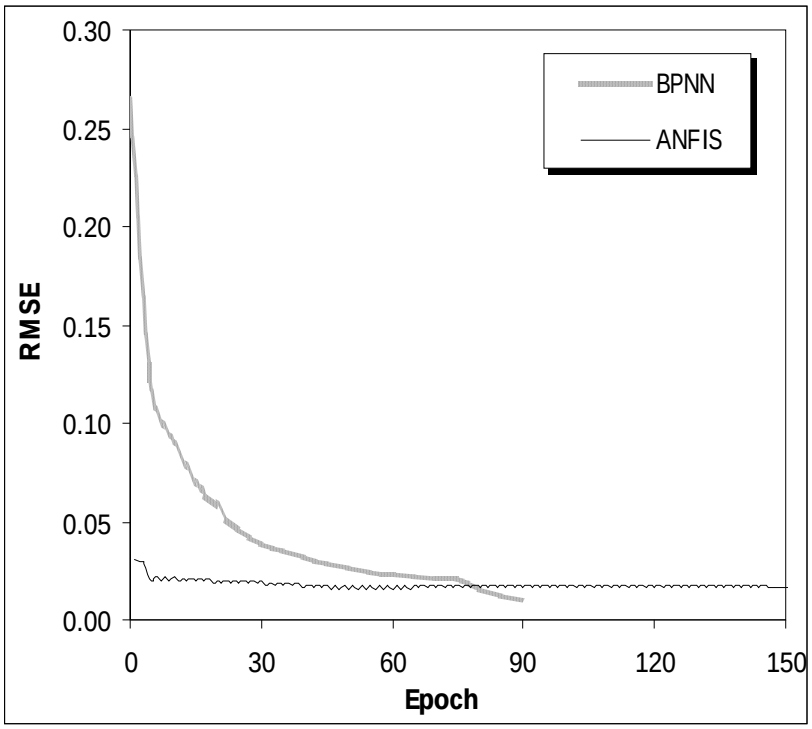

Figure 5 - 35 RMSE curves for BPNN and ANFIS

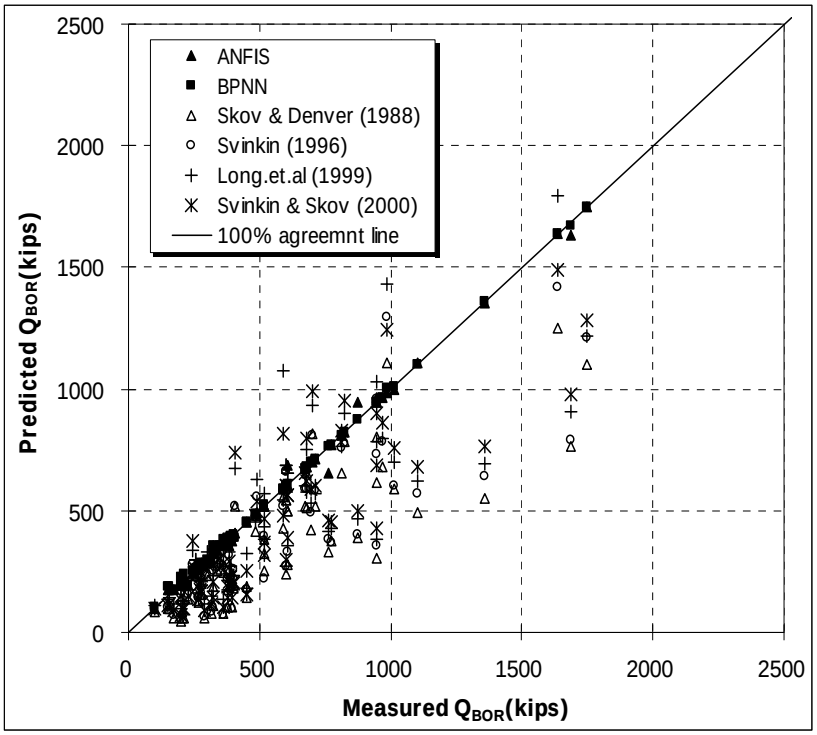

Figure 5 - 36 Comparison measured and predicted values for Training Data Set

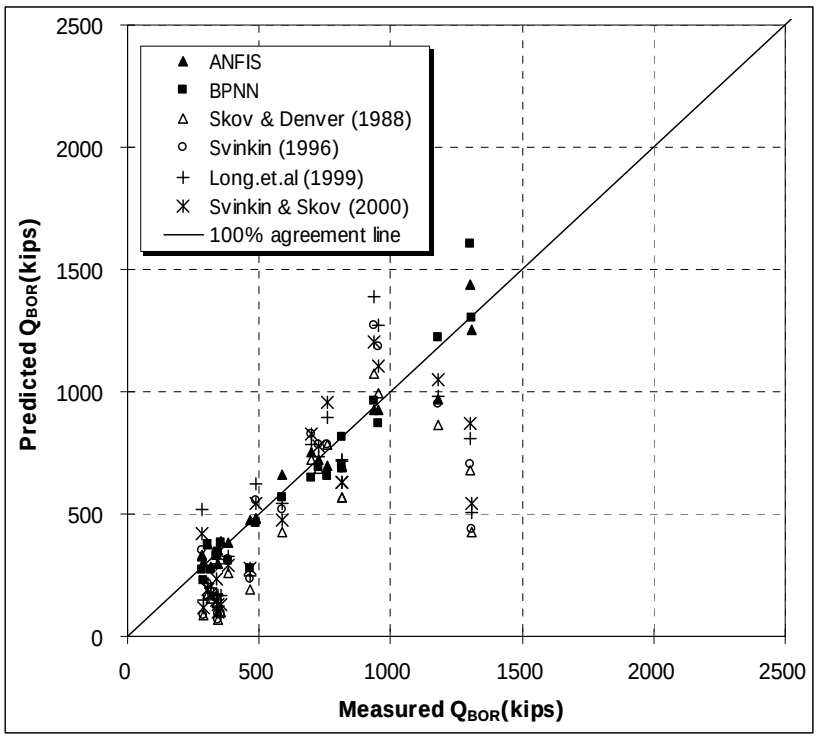

Figure 5 - 37 Comparison measured and predicted values for Testing Data Set

In Table 5-9 the correlation R^2 and root mean-squared error (RMSE) of predicted versus measured results are summarized. As shown in Table 5-9, even though ANFIS shows to be just a little better than BPNN, both ANFIS and BPNN produce a much higher correlation R^2 and a lower RMSE compared with the other methods. It is indicated that the ANFIS and BPNN predictions are more consistent than the other four empirical methods. The results of this study indicate that the ANFIS as well as BPNN provide better predictions and can serve as reliable and simple tools for the prediction of pile setup.

Table 5 - 9 Comparison Summary of Correlation R^2 and RMSE

Type	Correlation R^2		RMSE	
	Training	Testing	Training	Testing
ANFIS	0.9977	0.9539	21.5	71.6
BPNN	0.9994	0.9497	11.2	89.0
Skin and Denver(1988)	0.3089	0.3644	275.7	286.5
Svinkin(1996)*	0.4544	0.4490	247.7	279.5
Long.et.al(1999)	0.5497	0.4849	230.4	262.4
Svinkin and Skov(2000)	0.5993	0.5630	215.5	242.1

* Average values between upper and lower bound

5.7 Conclusions

In this study ANFIS (Adaptive Neuro Fuzzy Inference System) and a four layer BPNN (back-propagation neural network) model are developed to predict pile capacity increased by pile setup. A database of a number (96) of field tests is developed from the review of literature for the training and testing of model, and six variables are selected as input to both BPNN (back-propagation neural network) model and ANFIS model.

In the developed neural network model, predictions of pile capacity increased by setup were made using back-propagation neural network as well as four empirical methods, and they were also compared with actual measurements. Also MATLAB GUI which consists of input information, comparison results, and prediction (pile capacity increased by setup) was developed. The correlation R^2 and root mean square error are used as measures of the quality of prediction. The comparison of the predicted results with measured data (BPNN model for prediction of pile setup) is found to agree much better with the actual measured values as compared those from Skov and Denver(1986), Svkinkin(1996), Long.et.al(1999), and Svinkin and Skov(2000))'s methods. The results of this study indicate that BPNN model can serve as a reliable and simple tool for the prediction of pile setup, and can be expected to yield more economical pile design.

In the developed ANFIS, the same 5 input variables as used in BPNN model except roughness volume for pile type are selected to evaluate the pile capacity increased by setup. Types and numbers of membership functions to each input variable are appropriately decided

when the testing data set has the highest correlation R^2. Pile setup predictions were made using ANFIS as well as commonly used empirical methods, and they were also compared with actual measurements. The results of this study indicate that ANFIS provides slightly better prediction than BPNN with similar results, and both ANFIS and BPNN can serve as reliable and simple tools for the prediction of pile setup. Overall, for this study BPNN seems to be more useful than ANFIS since BPNN model trains much faster while providing similar predictions. However, in the case of developing a model with limited data range, ANFIS may be more useful than BPNN because ANFIS can consider beyond the data range using membership functions. Also, as more data become available, the model itself can be improved further to make more accurate capacity predictions for a wider range of load and site conditions. It can thus lead to significant savings in pile design compared to commonly used empirical methods.

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Chapter 6. A Back-propagation Neural Network Model for Analysis of HP-Pile Drivability

6.1 Introduction

In practice pile driving criteria are provided for the contractor to drive the piles to a required bearing capacity for every bridge foundation project. A wave equation based computer program is used to generate the pile driving criteria for every project. The pile driving criteria furnished to the contractor include: i) hammer stroke vs. BPF(1/set) for required bearing capacity, ii) maximum compressive stresses vs. BPF, iii) maximum tension stress vs. BPF. This work takes up a significant amount of time requiring the use of several programs such as PILECAP, GRLWEAP, PDA, and CAPWAP. Therefore there exists a need to develop an alternative model.

In this study a back-propagation neural network (BPNN) model is developed to predict pile drivability (Max com stresses, Max tensile stresses, BPF). A database of a number (4,017) of HP piles is developed from the data on HP piles from 57 projects in North Carolina (with both GRLWEAP data and soil profile information and without PDA and CAPWAP analyses). Seventeen variables are chosen as inputs to predict three target variables. The input variables consist of hammer, hammer cushion material, pile, soil parameters, ultimate pile capacities, and stroke. Stroke values are used as an input having ranges 5 to 11 ft based on an open-run database of GRLWEAP.

The database is divided into five groups with respect to ultimate pile capacity range since it is too difficult to correctly choose representative data for the training model because of the huge amount of data and the variety of the input variables. Each group is randomly split into two groups: the first group is used for training the neural network model, and the other (30% of training data set) for testing. In the developed network for each group, there is an input layer, where input data is presented to the network and an output layer, and two hidden layers as intermediate layers are also included. For the five groups, predictons with high correlation R^2 are obtained, with the exception of few scatters during both training and testing.

To demonstrate the feasibility of BPNN (back-propagation neural network model) 21 cases are predicted by the developed BPNN, and the results obtained are compared to GRLWEAP calculations derived from already built piles at NC State. The results indicate that BPNN model provides good predictions compared to GRLWEAP calculations, and can

serve as a reliable and simple predictive tool for the projection of pile drivability. The program is developed within MATLAB with a GUI for use by engineers.

6.2 Pile Drivability Analysis

The main objectives of using the wave-equation approach is to obtain a better relationship between ultimate pile load and pile set than can be obtained from a simple driving formula. The wave equation based analysis uses the propagation of the longitudinal wave caused by a hammer impact at the pile top.

When the pile driving process is viewed as shown in Figure 6-1, the ram transfers force to the pile head over a finite period of time which depends on the properties of the hammer-pile-soil system. The amplitude of the wave will decay due to system damping properties before reaching the pile tip. The force in the wave, which reaches the tip, will pull the pile tip into the soil before the wave is reflected back up the pile. Both incident and reflected force pulses will cause a pile toe motion and produce a permanent pile set in case their combined energy and force are enough to overcome the static and dynamic resistance effects of the soil.

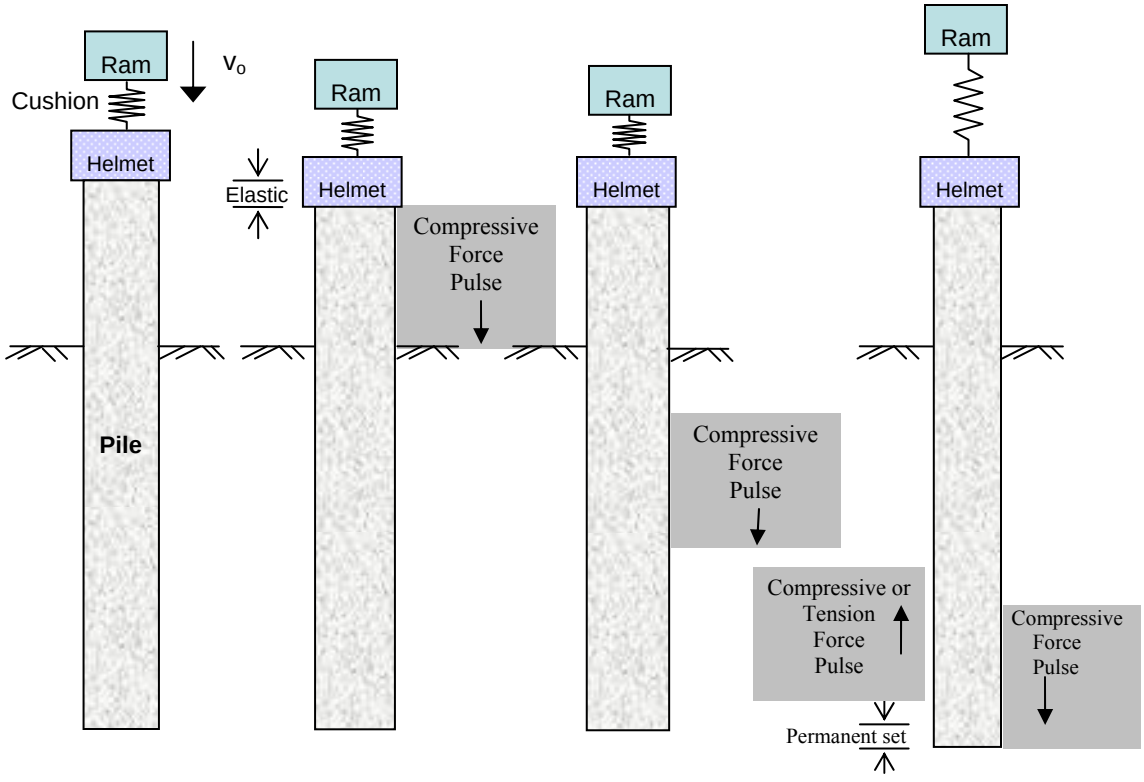

Figure 6 - 1 Wave Propagation in a pile (adapted from Cheney and Chassie, 1993)

The analysis using finite difference is carried out as follows: for a given driving equipment and pile embedment in the soil, an ultimate static capacity is specified and distributed based on engineer's experience and empirical methods, along the side of the pile and at the pile tip. An initial velocity generated by hammer impact is calculated according to hammer efficiency and stroke, then the hammer (ram) causes displacements of helmet and pile head springs, and the movement of a pile segment causes soil resistant forces. By equating all forces acting on a segment, divided by its mass, the acceleration of the segments are assessed. The product of acceleration and time gives the segment velocity. The velocity multiplied by the time yields a change of segment displacement which results in new spring forces. Also, the stress can be computed in the pile. From this process, the accelerations, velocities, displacements, forces, and stresses of each segment are computed over time. One of the most important results is a permanent set of the pile tip calculated by subtracting average shaft and tip quakes from maximum total displacement at the pile tip. Therefore, a bearing graph (plotting of ultimate pile capacities and blows per foot(1/set)) is obtained from the above successive process at various given ultimate pile capacities (Poulos, and Davis, 1980).

Figure 6-2 shows a procedure of current practice for obtaining pile driving criteria. To get reasonable pile driving criteria not only soil, pile, and driving equipment information but also several commercial programs need to be run.

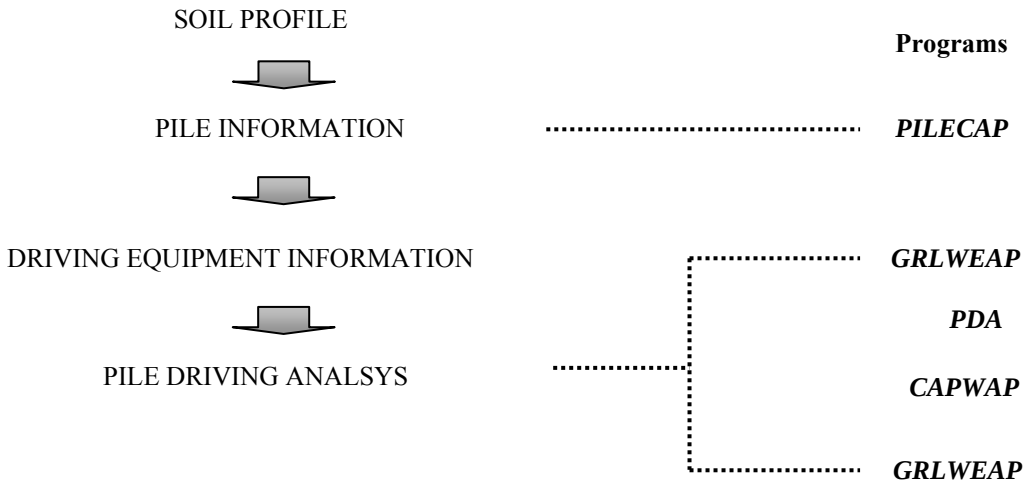

Figure 6 - 2 A Flow Chart of Current Practice for Pile Drivability

However, in order to generate the pile driving criteria, this work takes up a significant amount of time. Sometimes, the contractor needs to replace an approved hammer due to unexpected problems in the middle of pile driving, and it delays the construction

because the contractor needs to resubmit their replacement hammer data and wait for new driving criteria. PDA and several programs such as PILECAP, GRLWEAP, and CAPWAP are used during the practice. This state of current practice has provided the motivation for the development of a BPNN model in this study.

6.3 Database

In this paper a database is developed from the information on piles already installed for bridges in the State of North Carolina. Table 6-1 summarizes the collected and compiled data with respect to pile type. Only data related to HP pile of the total 67 projects are used for developing neural network model because the data available on the PCP (Pre-stressed Concrete Pile) and Pipe Pile are not large enough to develop neural network models.

Table 6 - 1 Summary of compiled database

Pile type	No. of Project	Open run	Stroke Option	Generated data	Total
HP pile	57	1,108	2,175	734	4017*
PCP	6	11	21	-	33
Pipe Pile	4	4	6	-	10

* Used for BPNN model.

The input variables used in neural network models are based on the input variables of GRLWEAP as well as soil information (SPT-N, soil types) since used piles at NC State for this study have been built by using both GRLWEAP data and soil profile information without PDA and CAPWAP analysis. Three (hammer efficiency, COR of hammer cushion, damping at toe in the soil parameters) of GRLWEAP input variables are removed since they have been used as almost constant values so that they rarely have an influence on outputs.

Table 6-2 presents an example of part of the data set for TIP no. B-2652. As described in Table 6-2, a total of seventeen variables are chosen as input to predict three target variables (max com stresses, max ten stresses, BPF). The input variables consist of hammer, hammer cushion material, pile, and soil information.

Table 6 - 2 An example of input and output variables

No	Tip No.	Hammer		Hammer cushion Material				Pile Information					Soil Information				Qu	Stroke	Output 1	Output 2	Output 3
		Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)			Com Stress	Ten Stress	BPF
1	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**200**	6.19	23.82	0.27	50.5
2	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**50**	4.41	17.09	0.09	8
3	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**100**	5.36	20.88	0	20.3
4	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**150**	5.91	22.81	0.17	35.1
5	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**250**	6.4	24.64	0.82	71.5
6	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**300**	6.66	25.67	1.22	103.4
7	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**350**	7.01	27.27	2.15	156.7
8	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**400**	7.32	28.96	1.09	264.9
9	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**450**	7.67	30.52	0.71	531.9
10	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**500**	7.95	31.71	0.53	3511.7
11	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**200**	5	20.23	0.31	69.7
12	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**50**	5	19.09	0.07	7.3
13	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**100**	5	19.73	0	21.7
14	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**150**	5	20.01	0.17	42.8
15	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**250**	5	20.45	0.86	118.4
16	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**300**	5	21.34	1.18	256.8
17	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**350**	5	22.21	1.71	1186.8
18	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**400**	5	22.9	1.95	9999
19	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**200**	6	23.28	0.28	52.5
20	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**50**	6	22.09	0.57	6.5
21	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**100**	6	22.74	0	18.4
22	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**150**	6	23.06	0.17	34.4
23	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**250**	6	23.5	0.81	80.3
24	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**300**	6	23.72	1.2	133.8
25	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**350**	6	24.95	1.97	276.5
26	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**400**	6	25.74	2.22	1095.2
27	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**450**	6	26.32	1.77	9999
28	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**200**	7	25.98	0.26	43.3
29	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**50**	7	24.77	1.29	6
30	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**100**	7	25.38	0	16.1
31	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**150**	7	25.72	0.16	29.3
32	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**250**	7	26.21	0.81	62.4
33	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**300**	7	26.46	1.22	93.8
34	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**350**	7	27.29	2.15	156.5
35	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**400**	7	28.23	1.29	322.5
36	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**450**	7	28.92	0.88	1448.5
37	B-2652	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**500**	7	29.45	0.77	9999
38	B-2652	4	43.24	415	430	2	2.128	30	30	12	15.5	30.0	0.1	0.225	0.1	37	**200**	6.19	25.29	0.07	39.4

6.4 Program procedure

6.4.1 Division of Data by Qu range

It may not be feasible to correctly choose representative data for the training model because of the huge amount of data and variety of the input variables. Still, the decrease in the number of data, which is randomly chosen as the training set, may decrease the accuracy of prediction. So, to consider the sensitivities of these data it is better to subdivide them into groups, and use all of the collected data without removing any.

The main objective of the wave propagation based approach is to find reasonable BPF and driving stresses corresponding to ultimate pile capacity. From this it may be possible to make several subdivisions that have similar behaviors by ultimate capacity, which can be a good indicator for dividing the total data to solve the complex problem. In this study we found by trial and error that five subdivisions are appropriate.

At first, the total data of 4,017 was organized by values of ultimate capacity, and then split into 5 divisions corresponding to different ranges of ultimate pile capacities. Details of the divided data for developing the model are summarized in Table 6-3. The generated data in Table 6-1 belong to Q3 and Q4 type. Total number of data for each range was split at random into two groups: the first group was used as a training set, and the remaining data (about 30% of the training data) was used for testing in the developed neural network. For the testing phase an independent data set different from the training set is also required (Hammerstrom, 1993).

Table 6 - 3 Division of data with respect to ultimate pile capacities

Type	Qu Range (kips)	Data		
		No. of Training data	No. of Testing data	Total
Q1	30-80	263	87	350
Q2	81-159	393	132	525
Q3	160-250	808	250	1058
Q4	251-399	1296	421	1717
Q5	400-700	276	91	367

6.4.2 Training and Testing Network

The neural network adopted in this study utilizes the back-propagation learning algorithm which has been widely used and studied because of its simplicity. The back-propagation neural network consists of two phases. First, the data is propagated forward from the input to output layer, it the produces an actual output. Then, in the second phase the error (the difference between target values and the computed values) is propagated backwards to update the weights and biases of the neurons and their connections in the same architecture (Figure 6-3). Many cycles of these two computational phases are performed until an error goal is achieved. The mean square error function is commonly adopted as the error function. Also, the number of hidden layers and hidden nodes, transfer functions, and normalization of data are appropriately determined to get the best performance of model. At the end of the training phase, the neural network represents a model that should be able to predict the target value given the input pattern. A logistic sigmoid function as an activation function is selected

to transfer input layer to the first hidden layer and the second hidden to the output layer, whereas a hyperbolic tangent function is used to convert first hidden layer to second hidden layer. The choices of these functions were made in order to minimize the errors. Also, Levenberg-Marquardt method is used to make the convergence much faster.

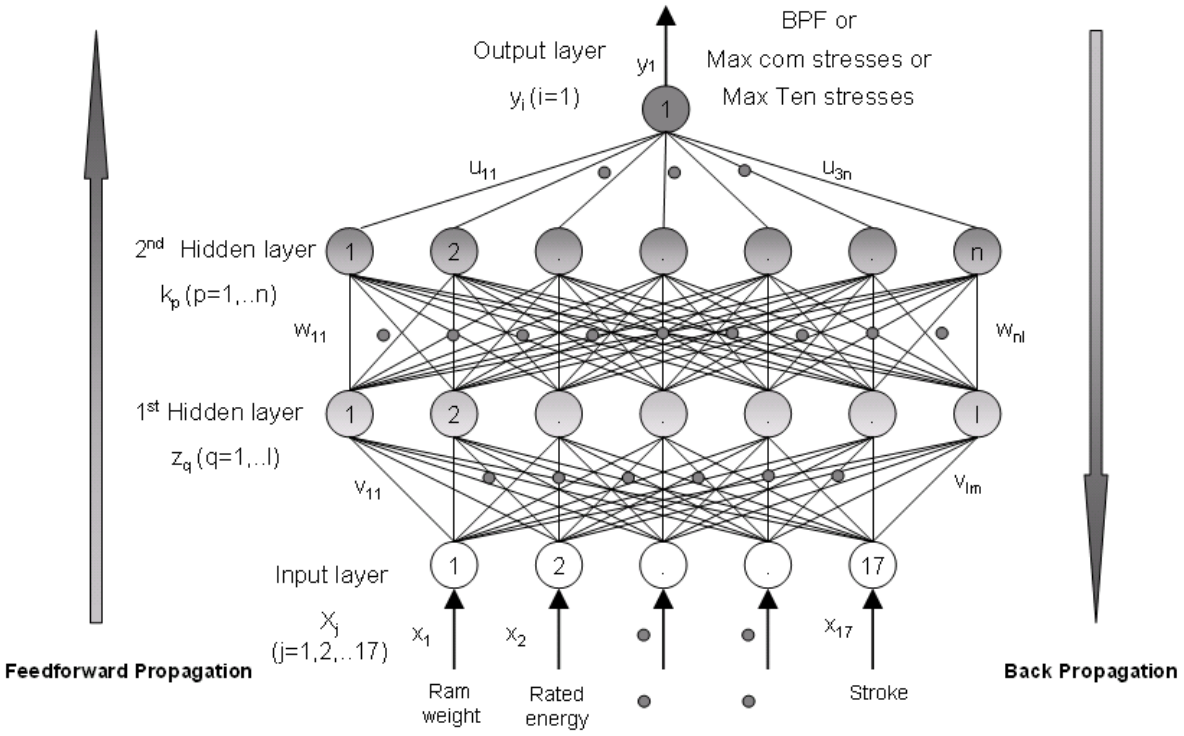

Figure 6-3 BPNN architecture to each Q type

Figure 6-4 shows training and testing network for each Q type. During training, weights and bias are updated by reducing its errors until the errors are acceptable. Then in order to assess the generalization capability of the trained neural network model with all the model parameters including the connection weights are tested with a separated set of "testing" data used in training. During testing, the finally updated weights and bias in the training phase are applied to the testing patterns and an ultimate performance of the model is evaluated by correlation R^2 values. It should also be noted that the model is trained on one data set, while the testing is done on a different set of the data.

Note that in order to reduce training time, already optimized weights matrices and bias vectors are set to the weights matrix and bias in the initial part of the program. So, the program does not spend too much running time to train the networks for each Q type.

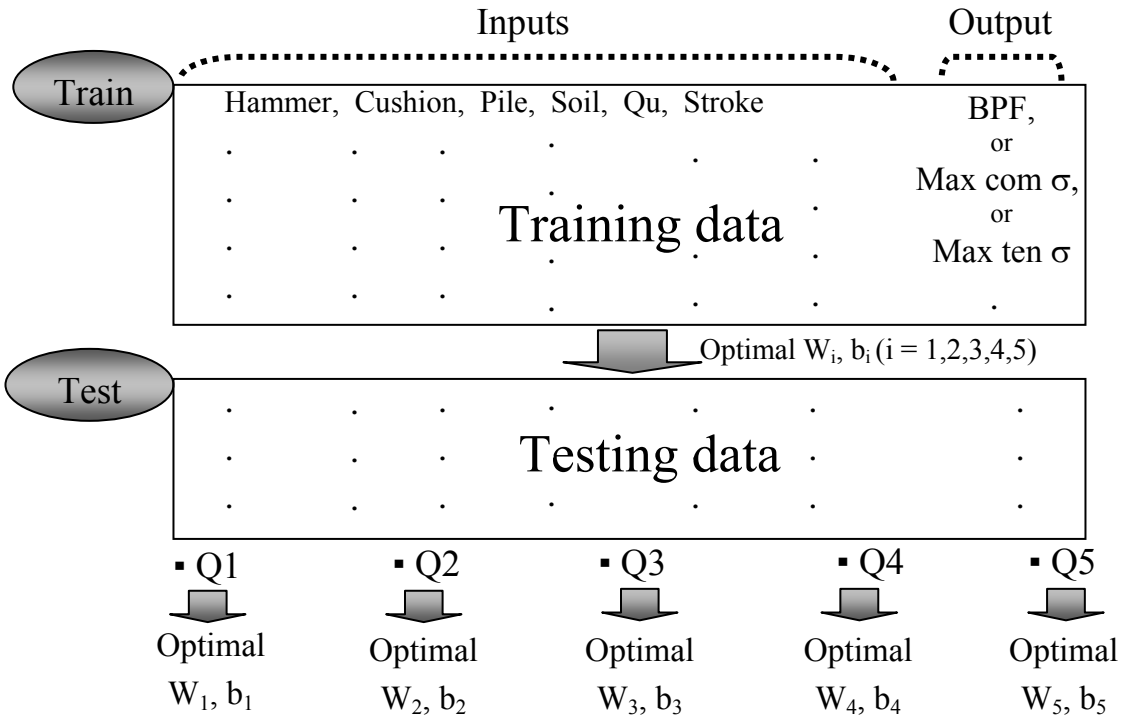

Figure 6 - 4 Training and Testing of Network

Table 6-4 illustrates the chosen values of learning factors to get the best performance from the network when correlation R^2 of test data set is highest with respect to each Q type. Some important learning factors are required to find the neural network having the best performance while training. A reasonable strategy is to find values of the learning factors for all of the cases within the reasonable range. The best appropriate values were decided through iterations of training until arriving at the best results within the reasonable range of 10^0 to 10^{-6} for error goal, 8 to 21 for number of hidden nodes, and -3.0 to 3.0 for initial weights. And then each value of the factors is set to the program for prediction.

For example, in the case of Q1, the network has learned continually through updating weights until error goal is 10^{-4} and epoch is 27 and the number of hidden nodes is 20 with initial weights in the range of -2.95 to 2.72.

Table 6 - 4 Learning factors with respect to Q type

Type	Targets	Initial Weight	No. of Hidden Nodes	Error	Training	Testing
Q1	BPF	-3.08~3.31	20	$1*10^{-4}$	0.9963	0.9688
	Max com	-3.13~3.22	17	$1*10^{-4}$	0.9975	0.9707
	Max ten	-2.85~2.99	20	$1*10^{-4}$	0.9983	0.9471
Q2	BPF	-2.86~2.92	20	$1*10^{-4}$	0.9970	0.9919
	Max com	-3.01~2.81	19	$1*10^{-4}$	0.9970	0.9841
	Max ten	-3.13~2.90	20	$1*10^{-4}$	0.9938	0.9614
Q3	BPF	-2.87~2.98	16	$1*10^{-4}$	0.9887	0.9586
	Max com	-3.55~2.85	18	$1*10^{-4}$	0.9958	0.9660
	Max ten	-2.97~2.85	19	$1*10^{-4}$	0.9922	0.8624
Q4	BPF	-3.06~2.87	10	$9*10^{-4}$	0.9747	0.9089
	Max com	-2.94~3.30	20	$1*10^{-4}$	0.9953	0.9746
	Max ten	-2.95~2.98	20	$1*10^{-4}$	0.9485	0.8763
Q5	BPF	-3.23~3.29	15	$1*10^{-4}$	0.9988	0.9285
	Max com	-2.86~2.92	20	$1*10^{-4}$	0.9980	0.9913
	Max ten	-2.90~3.25	13	$1*10^{-4}$	0.9974	0.9303

Figure 6-5 through Figure 6-18 show comparison results of maximum compressive stress, maximum tension stress, and BPF for training and testing data set with respect to Q type. For all of Q types, very high coefficients of correlation are obtained, and there are few scatters in the data points of predictions as shown in figures for both training and testing data.

Q1 type

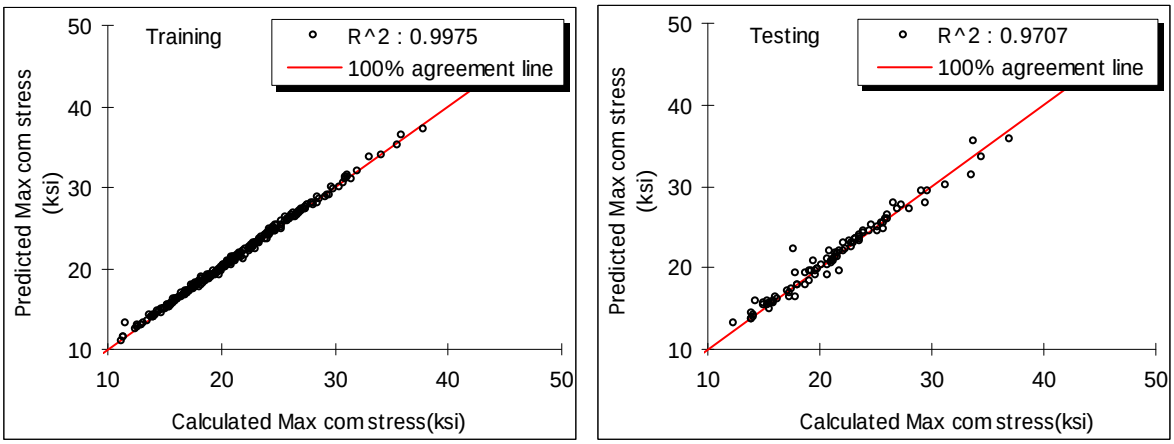

Figure 6 - 5 Comparison max com stresses by BPNN and by GRLWEAP: Q1 type

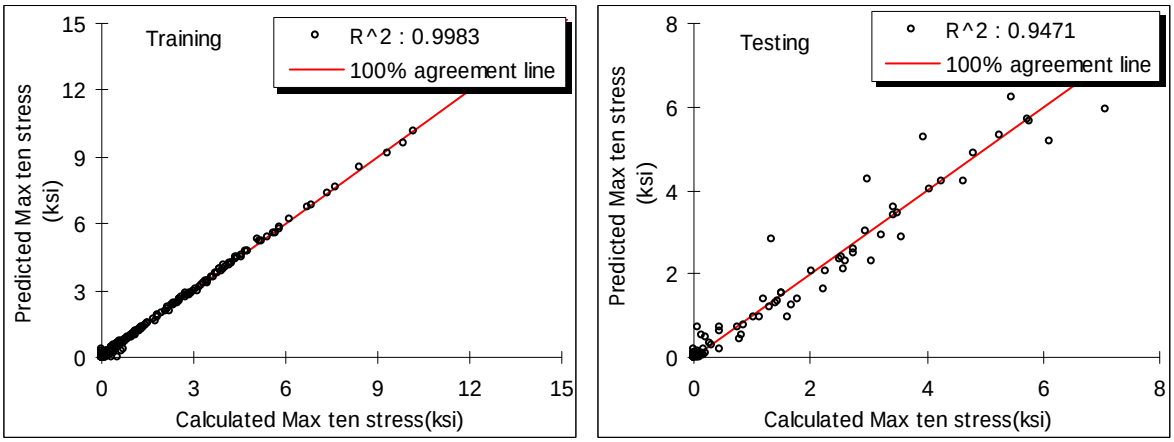

Figure 6 - 6 Comparison max ten stresses by BPNN and by GRLWEAP: Q1 type

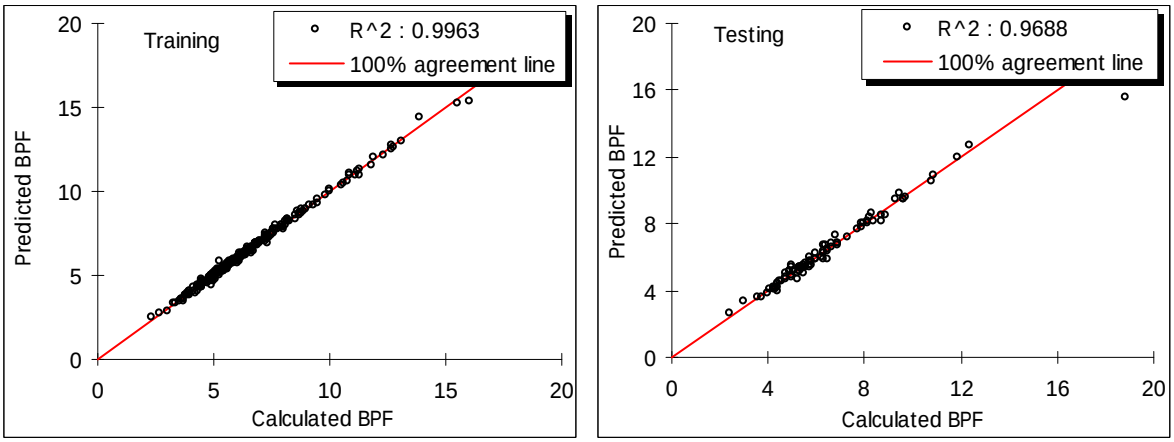

Figure 6 - 7 Comparison BPF by BPNN and by GRLWEAP: Q1 type

Q2 type

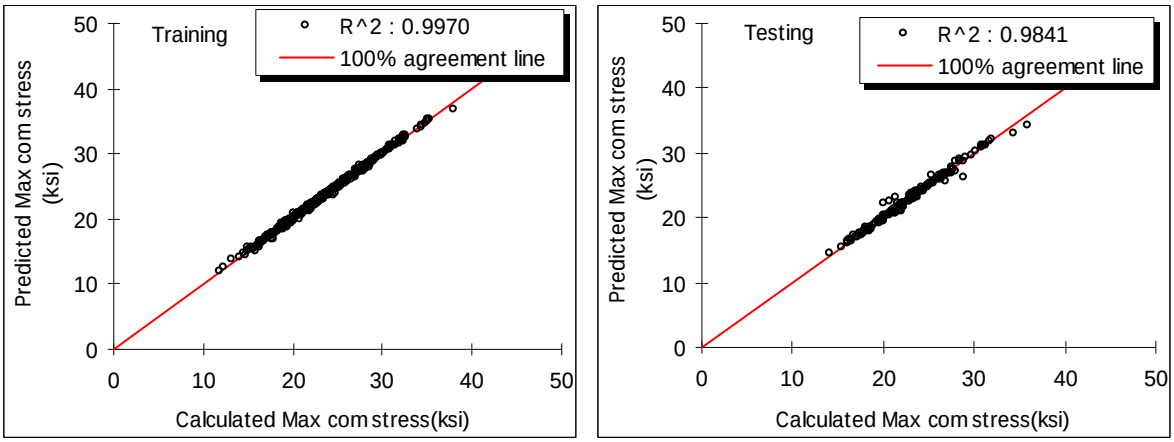

Figure 6 - 8 Comparison max com stresses by BPNN and by GRLWEAP: Q2 type

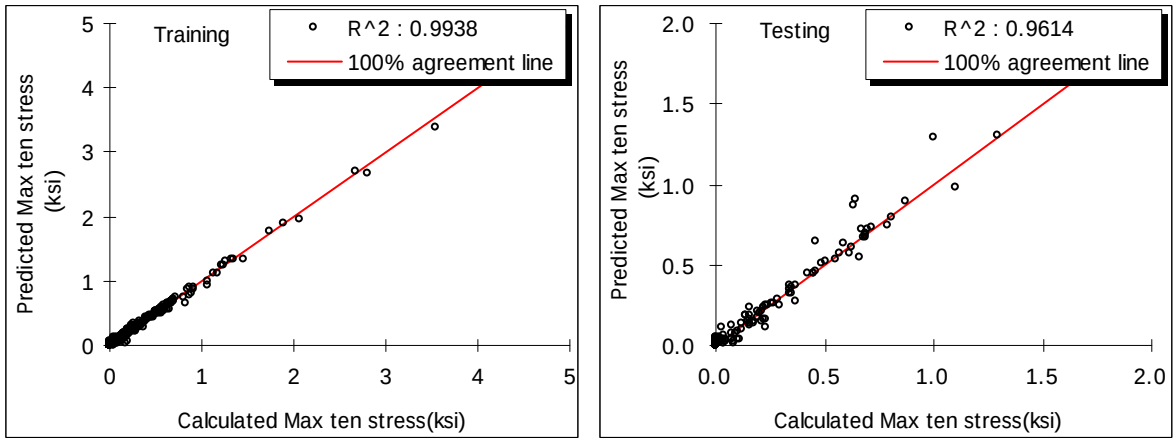

Figure 6 - 9 Comparison max ten stresses by BPNN and by GRLWEAP: Q2 type

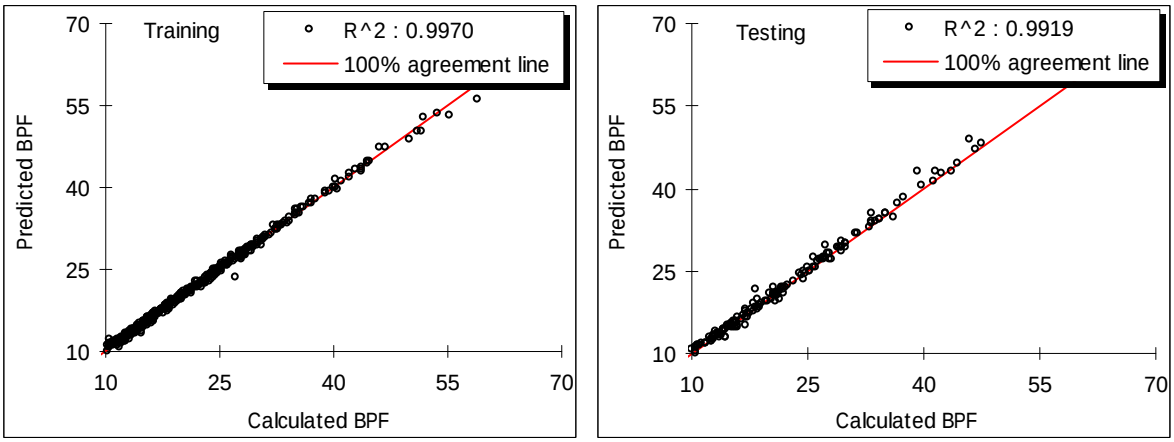

Figure 6 - 10 Comparison BPF by BPNN and by GRLWEAP: Q2 type

Q3 type

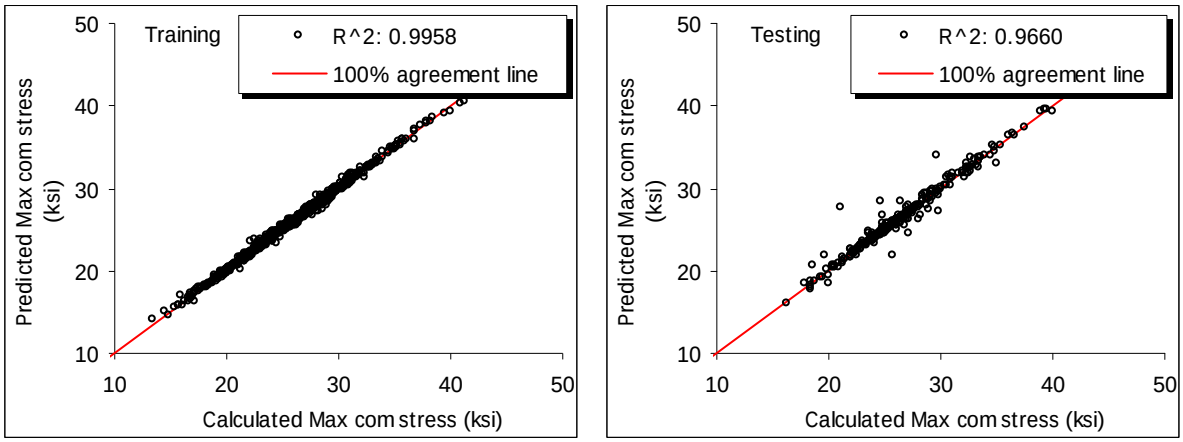

Figure 6 - 11 Comparison max com stresses by BPNN and by GRLWEAP: Q3 type

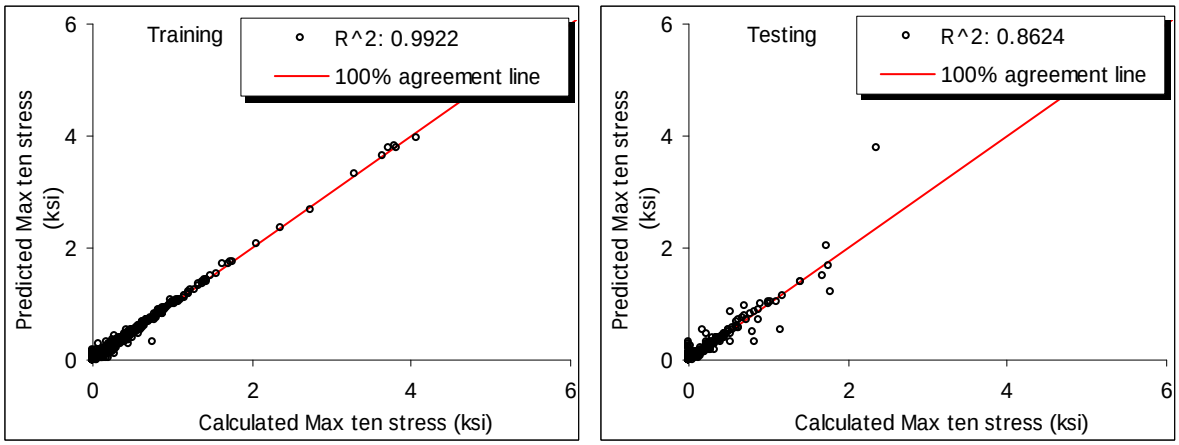

Figure 6 - 12 Comparison max ten stresses by BPNN and by GRLWEAP: Q3 type

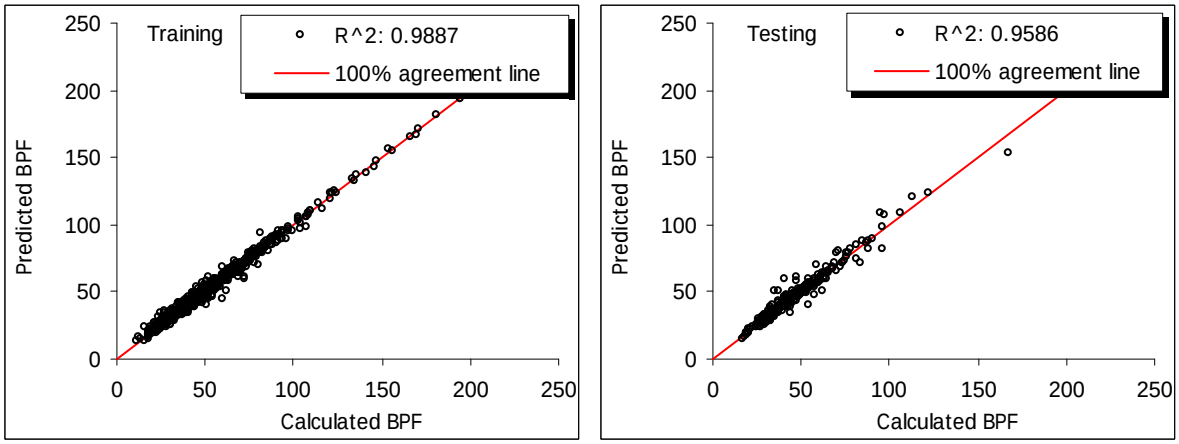

Figure 6 - 13 Comparison BPF by BPNN and by GRLWEAP: Q3 type

Q4 type

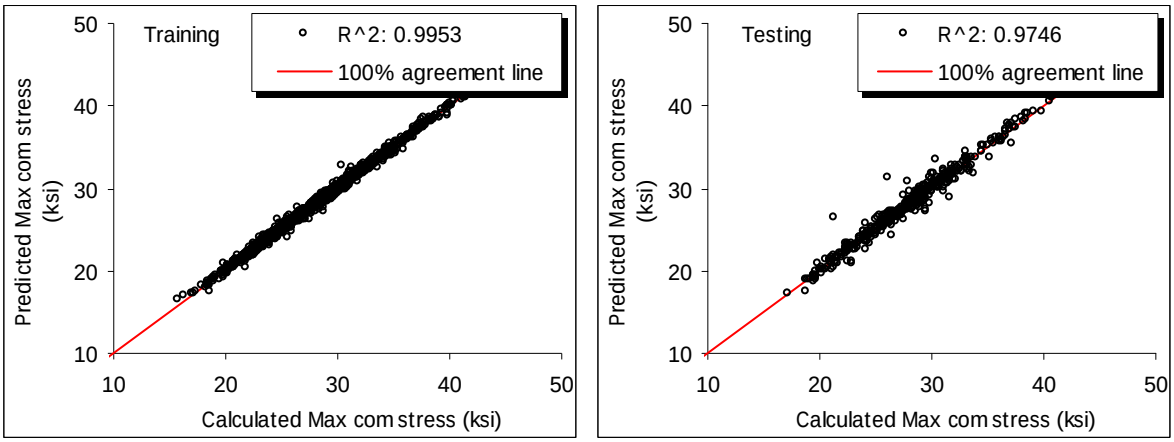

Figure 6 - 14 Comparison max com stresses by BPNN and by GRLWEAP: Q4 type

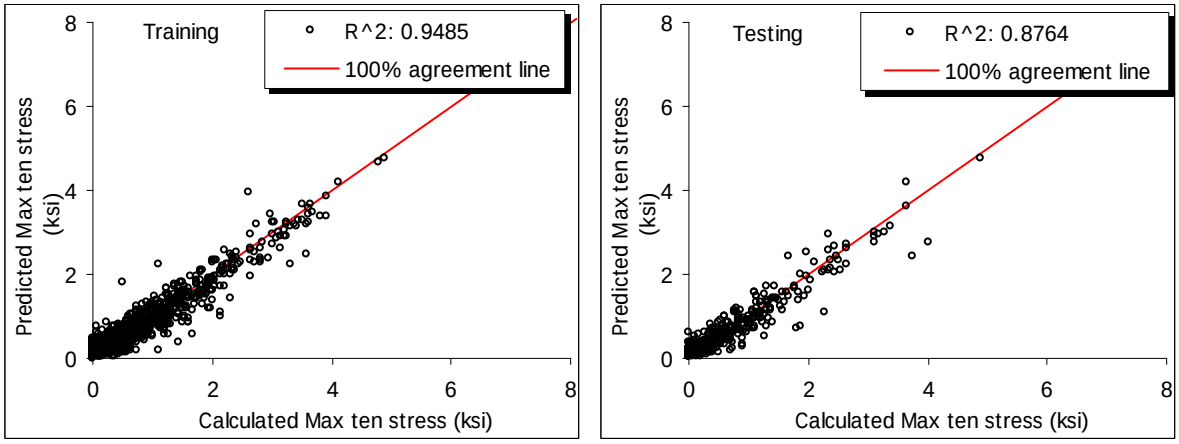

Figure 6 - 15 Comparison max ten stresses by BPNN and by GRLWEAP: Q4 type

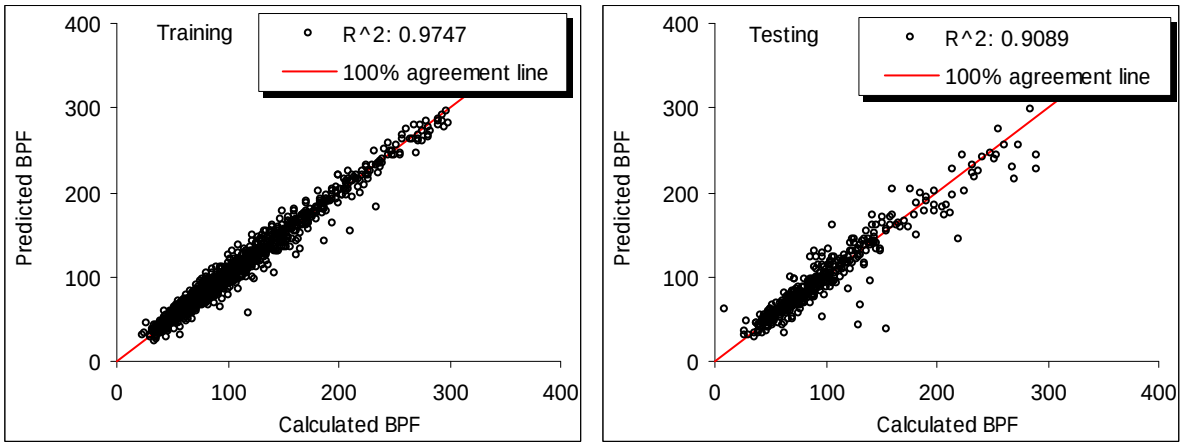

Figure 6 - 16 Comparison BPF by BPNN and by GRLWEAP: Q4 type

Q5 type

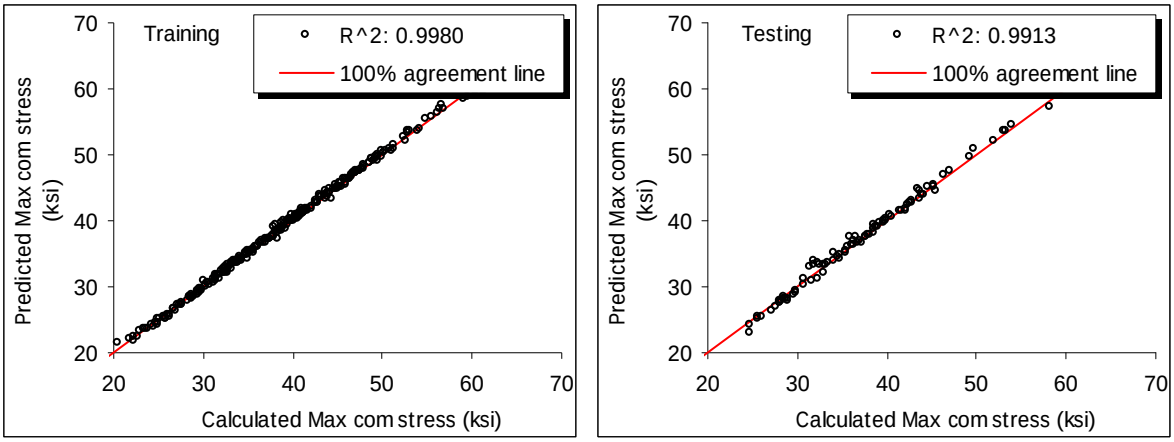

Figure 6 - 17 Comparison max com stresses by BPNN and by GRLWEAP: Q5 type

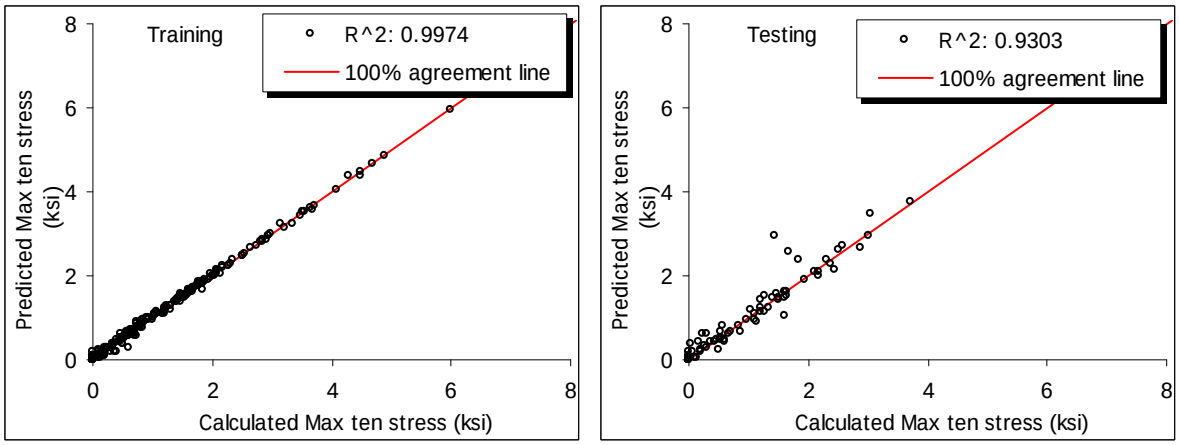

Figure 6 - 18 Comparison max ten stresses by BPNN and by GRLWEAP: Q5 type

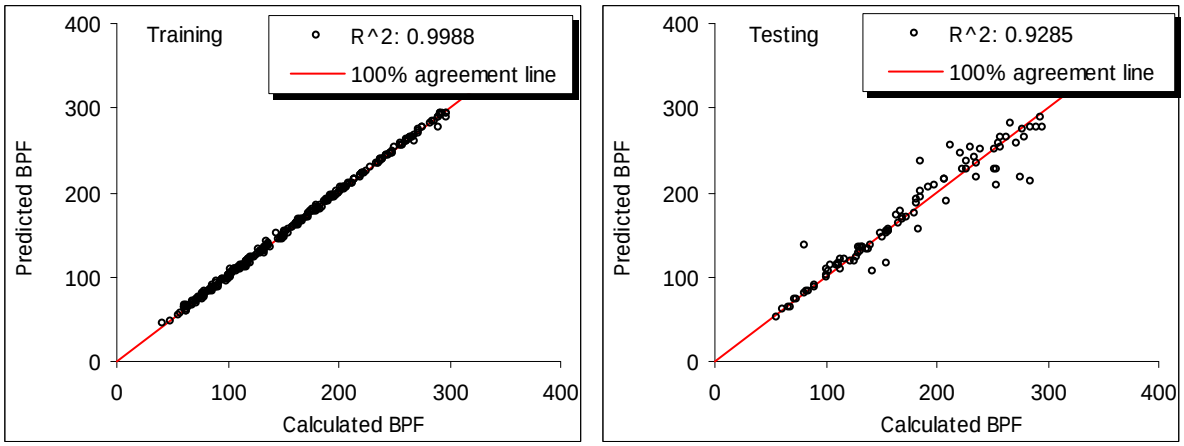

Figure 6 - 19 Comparison BPF by BPNN and by GRLWEAP: Q5 type

6.4.3 Predictions

Before making predictions for pile drivability, stroke values need to be figured out appropriately since stroke has to be used as an input variable. Stroke values are decided through open-run's database of GRLWEAP. As shown in Figure 6-20, all of the stroke values range from 5 to 11 ft. Therefore these values are used as given in the program.

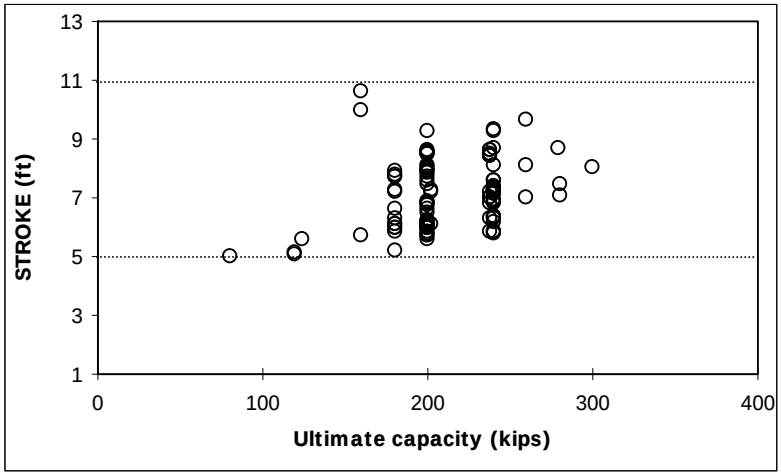

Figure 6 - 20 Collected stroke ranges at required ultimate capacity

Figure 6-21 presents a procedure to produce predictions of drivability for a specific pile. The weights matrix and bias vectors optimized in previous training phases are used for the prediction of a pile driving analysis. Then for the prediction of one pile drivability analysis, input data of pile driving (hammer, cushion, pile, soil information, ultimate pile capacities, and stroke) must to be loaded. Finally the BPNN model provides the predictions of BPF, Maximum Compression Stress, and Maximum Tension Stress with respect to the given stoke range (5-11 ft).

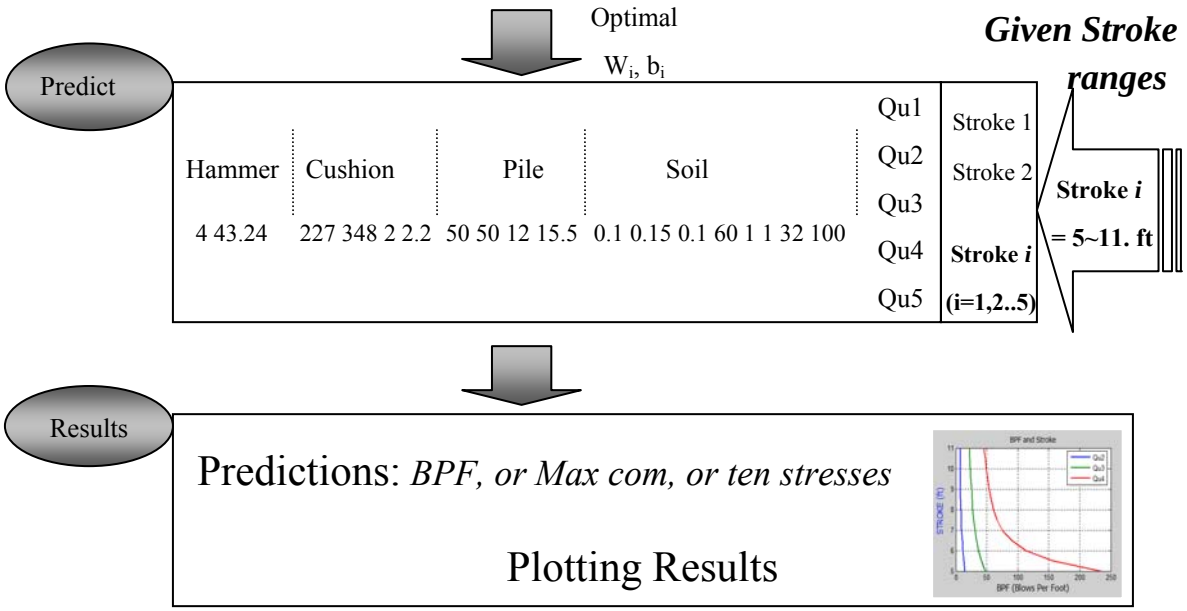

Figure 6 - 21 A procedure for predictions

6.4.4 MATLAB GUI

Figure 6-22 presents the GUI of the program developed within MATLAB, with input information, comparison results, and predictions. Generally there are two interfaces which consist of input information and plotting results. Figure 6-22 shows an example of TIP no. : B-3669. For the input interface, one of two different unit systems (English and SI unit) is chosen, and then input data (project title, hammer, cushion, pile, soil information, ultimate pile capacities, stroke) is loaded. After running the program predictions are provided. For the plot results in Figure 6-23 there is input general information in the left hand side such as project title, hammer ID, cushion, pile, soil information and in the right hand side plotting results with respect to ultimate pile capacities are composed: i) BPF vs. Stroke, ii) BPF vs. Maximum Compression Stresses, iii) BPF vs. Maximum Tension Stresses.

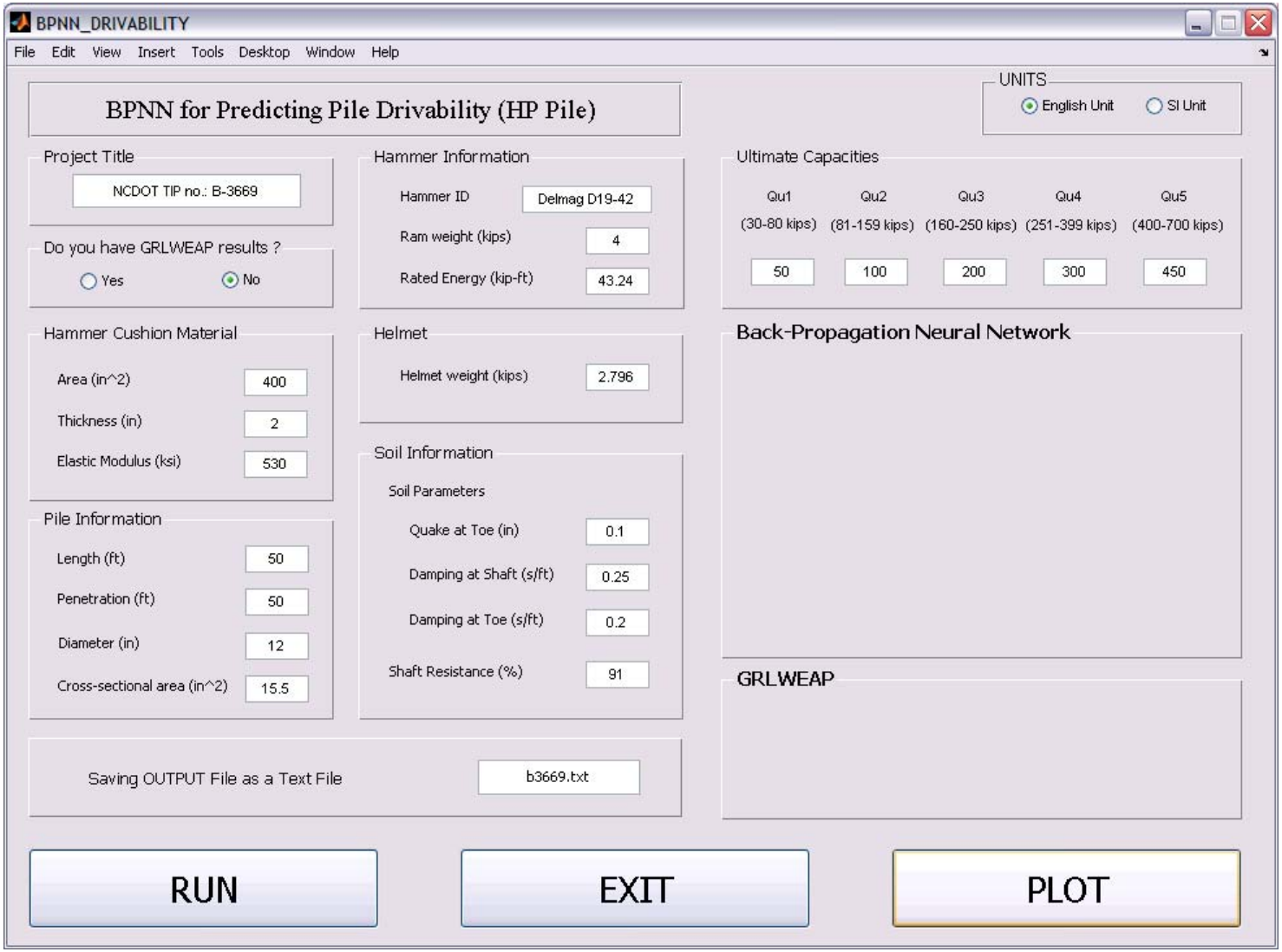

Figure 6 - 22 A MATLAB GUI for BPNN for prediction of pile drivability

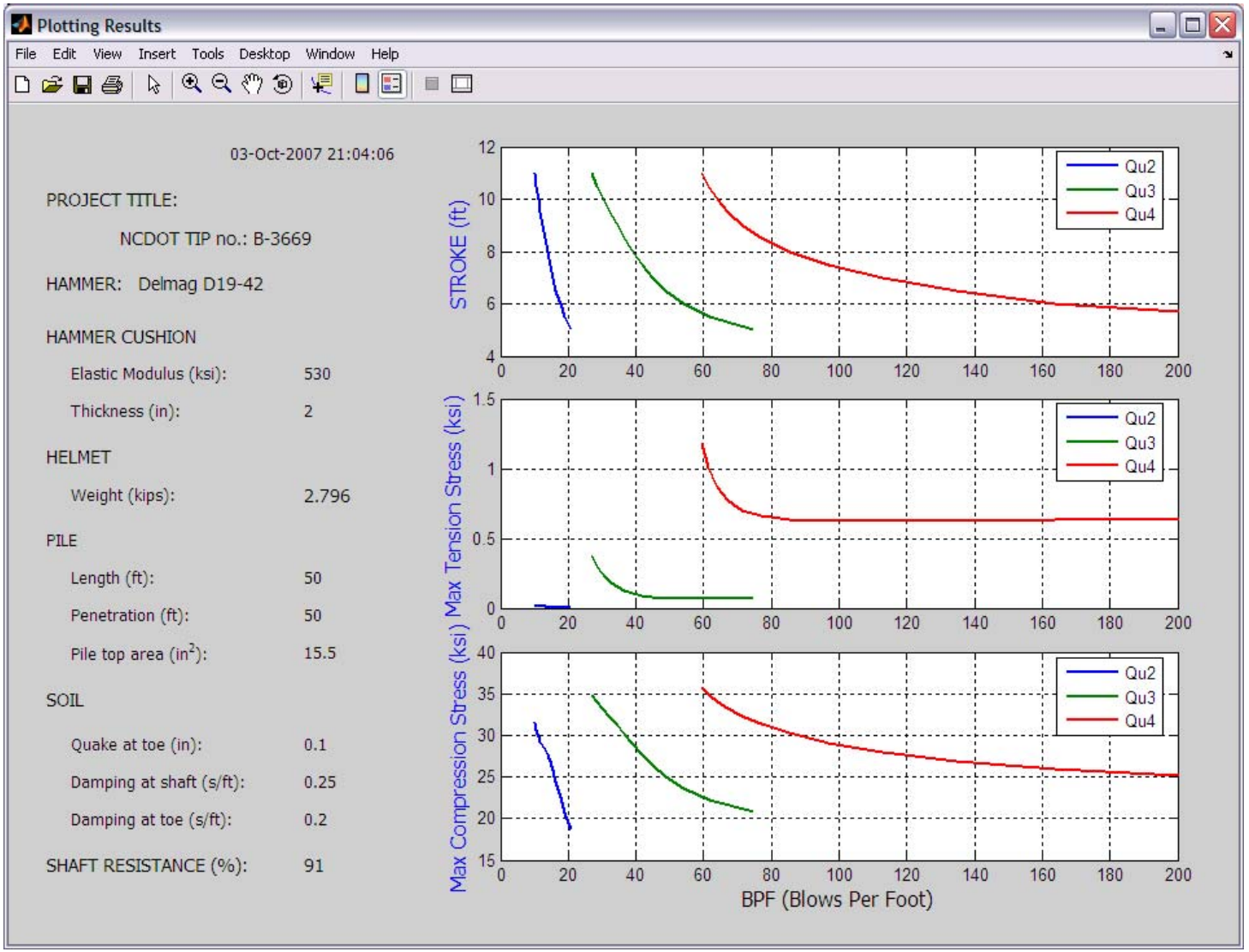

Figure 6 - 23 Plotting Results for TIP no. B-3630

6.5 Case Studies

To demonstrate the application of BPNN, 21 cases are used for BPNN, and predictions obtained by BPNN are compared to GRLWEAP calculations. Table 6-5 describes BPNN predictions and GRLWEAP calculations for given stoke values. As shown in Table 6-5, there is a good agreement between back-propagation neural network predictions and the GRLWEAP calculations for a chosen stroke.

Table 6 - 5 Comparison of Results between BPNN and GRLWEAP (case study)

No.	TIP no.	Qu (kips)	Method	Stroke (ft)	Max com stresses (ksi)	Max ten stresses (ksi)	BPF
1	U-92A	200	GRLWEAP BPNN	6.1	23.82 23.43	0.190 0.200	37.5 35.0
2	B-3630	250	GRLWEAP BPNN	8.0	27.16 26.67	0.610 0.675	48.3 51.5
3	B-3669	200	GRLWEAP BPNN	7.0	26.46 26.41	0.070 0.080	42.5 44.8
4	B-4093	200	GRLWEAP BPNN	5.7	20.60 20.33	0.201 0.190	58.4 51.7
5	B-3640	200	GRLWEAP BPNN	7.4	25.90 23.34	0.057 0.110	36.8 31.2
6	B-3636	200	GRLWEAP BPNN	6.3	24.88 23.88	0.372 0.190	64.6 53.1
7	B-3509	200	GRLWEAP BPNN	7.4	27.68 30.97	0.000 0.010	27.6 21.6
8	B-4319	300	GRLWEAP BPNN	9.0	37.40 38.40	0.060 0.070	55.0 58.3
9	B-4174	300	GRLWEAP BPNN	8.0	38.15 34.90	0.000 0.070	36.0 36.9
10	B-4224	360	GRLWEAP BPNN	7.0	30.68 32.40	0.200 0.070	54.0 54.0
11	B-3652	250	GRLWEAP BPNN	6.0	23.74 23.45	0.000 0.040	56.0 65.7
12	B-4169	200	GRLWEAP BPNN	9.0	29.54 30.09	0.000 0.020	39.0 31.2
13	B-4113	240	GRLWEAP BPNN	9.0	36.03 33.15	0.040 0.230	32.0 33.8
14	B-4110	300	GRLWEAP BPNN	7.0	32.99 37.20	0.000 0.140	43.0 40.7
15	B-4319	300	GRLWEAP BPNN	7.0	34.08 34.40	0.330 0.070	64.0 73.3
16	B-4088	270	GRLWEAP BPNN	7.5	24.70 24.10	1.700 1.130	43.0 43.6
17	B-3538(1)	120	GRLWEAP BPNN	7.1	32.47 34.75	0.000 0.000	21.1 17.3
18	B-3538(2)	120	GRLWEAP BPNN	7.4	32.80 35.40	0.000 0.001	20.1 16.1
19	B-3538(3)	120	GRLWEAP BPNN	6.0	27.74 33.30	0.000 0.000	30.6 24.0
20	B-2950	200	GRLWEAP BPNN	6.9	25.36 25.38	0.090 0.078	33.7 38.3
21	B-4127	250	GRLWEAP BPNN	7.9	31.17 31.33	0.040 0.045	38.0 46.3

Figures 6-24 through 6-26 present comparison results of BPF, maximum compressive stresses, and maximum tensile stresses, respectively. Predictions of BPF and maximum compressive stresses by BPNN agree well with those produced by GRLWEAP, while maximum tensile stresses do not appear to be close. However, this difference is small enough to be ignored, and we don't need to consider tensile stresses since this model is for HP piles.

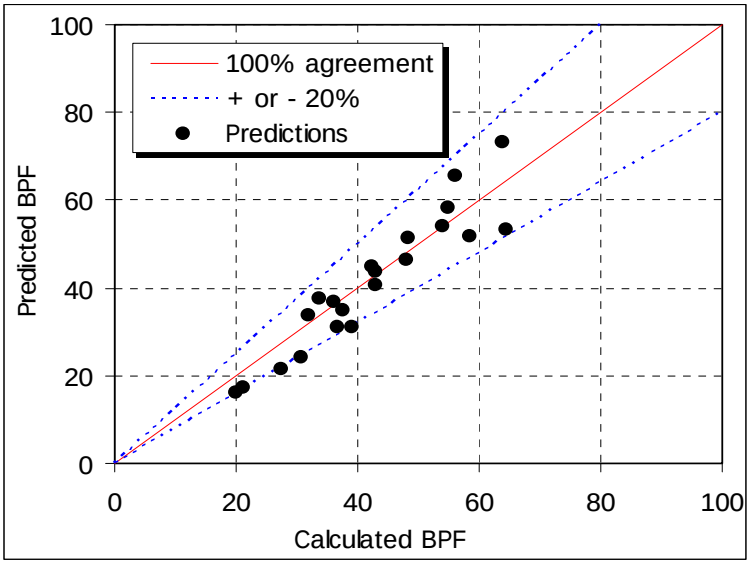

Figure 6 - 24 Comparison of BPF results: Case study

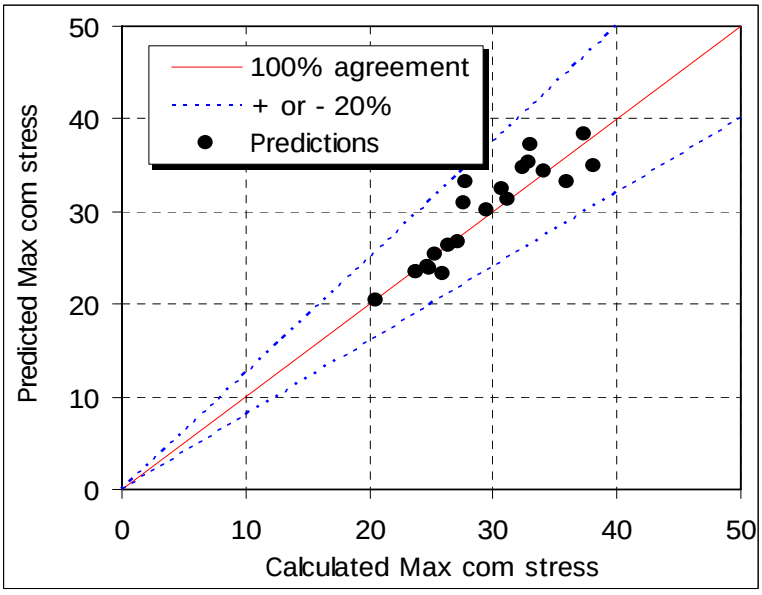

Figure 6 - 25 Comparison of Max compressive stress results: Case study

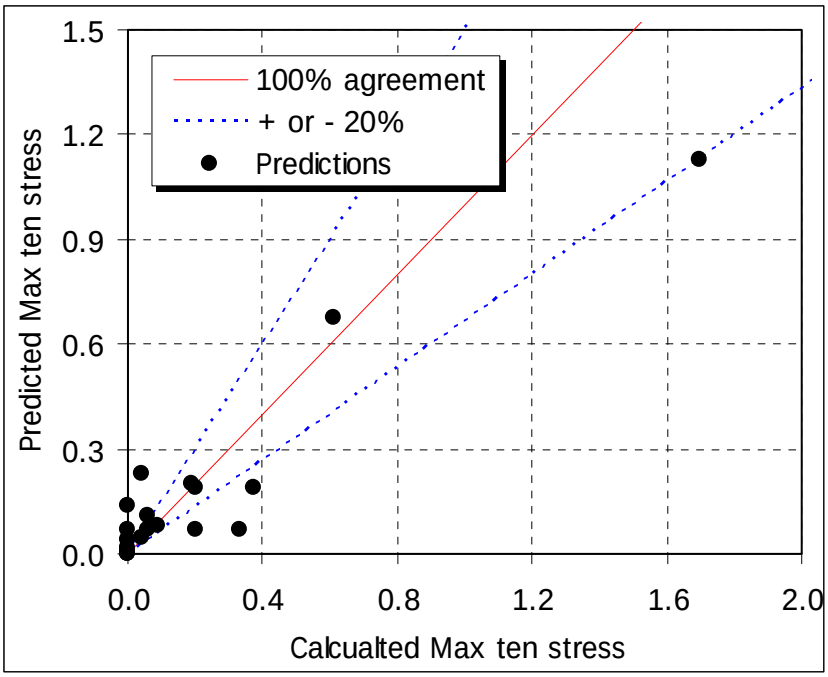

Figure 6 - 26 Comparison of Max tension stress results: Case study

6.6 Conclusions

In this study a BPNN (back-propagation neural network) model is developed to predict pile drivability (maximum compressive stresses, maximum tensile stresses, BPF) for a certain ultimate pile capacity. A database of a number (4,017) of HP piles is developed from data on HP piles from 57 projects in North Carolina with both GRLWEAP data and soil profile information (without PDA and CAPWAP analysis). Seventeen variables are chosen as inputs to predict three target variables. The input variables are for hammer, hammer cushion material, pile, soil information, ultimate pile capacities, and stroke. Stroke values are used as an input having ranges 5 to 11 ft based on open-run database of GRLWEAP.

The database is divided into five groups with respect to ultimate pile capacity range since it is too difficult to correctly choose representative data for the training model because of the huge amount of data and variety of the input variables. Each group is randomly split into two groups: the first group is used for training the neural network model, and the other (30% of training data set) for testing. In the developed network to each group, there is an input layer, where input data is presented to the network. Also included, is an output layer, and two hidden layers that serve as intermediate layers. For the results from five groups, very high correlation R^2 values are obtained (average 0.98 for training and 0.95 for testing data set) and there is little scattering in the predictions for both the training and testing sets.

To demonstrate the application of BPNN (back-propagation neural network model) 21 cases are applied to the developed BPNN. The predictions obtained by BPNN are compared to GRLWEAP calculations derived from already built piles in North Carolina. The results indicate that the BPNN model provides good predictions compared to GRLWEAP calculations, and can serve as a reliable and simple predictive tool for the ssessment of pile drivability. The program is developed within MATLAB with a GUI (Graphical User Interface) for use by engineers. It is hoped that this neural network model will be used as an alternative approach for the analyses of 'pile drivability'and will prove to be more convenient and reliable.

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Chapter 7 Closure

7.1 Summary of this study

In this study, BPNN (back propagated neural network) and ANFIS (adaptive neuro fuzzy inference system) models have been developed for a few important prediction problems related to pile foundation: i) Ultimate pile capacity, ii) Pile setup, and iii) Pile drivability. First theories and methodologies of artificial neural networks, fuzzy logic, and adaptive neuro fuzzy inference systems are introduced, and studied through some examples. Then, BPNN and ANFIS models are developed for three important problems of pile design. Databases for ultimate pile capacity and pile setup have been developed from a comprehensive review of literature. The predictions by BPNN and ANFIS models are compared with those from commonly used empirical methods, and they are also compared with actual measurements. For the pile drivability analysis, a database of a number of HP piles is developed from HP piles built at NC State using both GRLWEAP data and soil profile information (without PDA and CAPWAP analysis). Predictions obtained by BPNN model are compared to GRLWEAP calculations derived from already built piles at NC State. All of the programs are developed within MATLAB using its toolboxes and GUI.

It is found that ANFIS and BPNN models for the analyses of pile provide similar predictions, which are better than those from empirical methods. They can serve as reliable and simple tools for the prediction of ultimate pile capacity and pile setup. Also, BPNN models developed for pile drivability analysis provide good predictions. BPNN may be considered to be more efficient than ANFIS as BPNN models train much faster while both provide equally good predictions. However ANFIS models with some additional works will be more desirable for those cases in which one or more input variables may be available only in 'fuzzy' terms, and in which a model is developed with a limited data range because ANFIS can extrapolate beyond the data range using membership functions.

7.2 Conclusions

The following is a set of the conclusions from the works presented in this study:

1. For neural network modeling, a large amount of data is needed to get acceptable predictions, multiple target predictions require even larger databases.

2. For neural network modeling, inappropriate use of a large number of hidden nodes may lead to an *overfitting* problem. The best way to avoid *overfitting* is to use

training samples as much as ten times the number of input variables, or to use smaller numbers of hidden nodes for the case of enough training samples.

3. In ANFIS models, the type and number of MFs (Membership Functions) are important in building the ANFIS architecture. These are chosen empirically by trial and error.

4. ANFIS models are greatly influenced by the number of MFs for each input variable, rather than by the number of training data.

5. For ANFIS models, one of the ways to avoid *over-fitting* is to use a small number of MFs first because a larger number of MFs leads to a small error on the training set but does not necessarily lead to a small error on the test set.

6. For both neural network and ANFIS models, with respect to only correlation R^2, the models seems to be trained fairly, even with presence of some unreasonable input characteristics. In order to find a more reliable neural network model, relative importance and parametric studies can be used only if input characteristics are known. The best way to find the reasonable performance is to use the maximum error rate related to relative importance for neural network model and the maximum epoch as convergent in the testing results for ANFIS, if uncertain variables as input variables may be chosen.

7. For both neural network and ANFIS models, the number of training data must be large enough to capture the input and output mapping. The number of data required for training the model depends on the nature of the problems and the number of associated variables.

8. For both neural networks and ANFIS models, visual results are consistent with correlation R^2, which can be generally used as a good indicator.

9. For both neural networks and ANFIS models, ANFIS may be more useful than BPNN since ANFIS can extrapolate beyond the data range using linguistic terms. However, BPNN is not able to extrapolate beyond the range of the data used for its training since it assumes that the data covers all ranges.

10. For the problems of ultimate pile capacity with non-jetted and all data and pile setup, ANFIS and BPNN provide similar predictions which are better than those produced by the empirical methods. These can serve as a reliable and simple predictive tools for the prediction of ultimate pile capacity. Also, BPNN may be more efficient than ANFIS as BPNN trains much faster than ANFIS while having similar results. However, ANFIS models will be more desirable for those problems in which one or more input variables may be available only in 'fuzzy' terms.

11. For the problems of pile setup, ANFIS and BPNN provide similar predictions (BPNN being slightly better than ANFIS), which are better than those produced by the empirical methods. These can serve as a reliable and simple predictive tools for the prediction of pile setup. Overall, in this study BPNN may be more efficient than ANFIS as BPNN trains much faster than ANFIS while having similar results. However ANFIS models will be more desirable for those problems in which one or more input variables may be available only in 'fuzzy' terms.

12. For the problems of pile drivability, as far as correlation R^2 is concerned, to divide the huge amount of data (4,017) by five groups seems to be reasonable to train the model, and there is little scattering in the data points of predictions for both training and testing sets of five groups. Based on comparisons in 25 cases, it is shown that the BPNN model provides good predictions compared to GRLWEAP calculations, and can serve as a reliable and simple predictive tool for the prediction of pile drivability.

13. For these problems of pile, neural networks are available to mimic the actions of an expert who solves more complex problems than these pile problems only if large volumes of database are available and input parameters are appropriately analyzed. Also, it makes it much easier to use the developed programs using MATLAB with its GUI.

7.3 Future works

Models similar to those developed in this study can be developed for several other geotechnical problems such as evaluation of capacity of drilled shafts, prediction of settlement, etc.

These observational models can be developed for any prediction problem in geotechnical engineering for which a large number of quality data is available. For an organization like NCDOT, which over the years have acquired such data for many problems, this approach towards the development of reliable predictive models for those problems appears to have great potential.

Recently, combing the approaches of 'Genetic Algorithms', 'Fuzzy logic', and 'Neural Networks' has led to the development of an 'evolutionary fuzzy neural inference model'. Optimizing the parameters by genetic algorithm, imprecision and approximate reasoning for fuzzy logic, and learning through neural networks are integrated. This new approach may be used to develop new models for many geotechnical problems including those modelled in this study.

7.4 Implementation and Technology Transfer

The following will be provided to NCDOT for the problems of evaluating capacity, setup, and drivability of piles: (i) the data bases developed and used for the development of models, (ii) the final trained models for the predictions in form of computer programs, (iii) the computer programs for training and testing for the development of models, (iv) the documentation and guidelines for all the programs which are appended in this report.

A workshop will be presented to the Geotechnical Engineers of NCDOT to train them for: (a) the usage of the final models, (b) the enhancement of the models by additional training and testing with additional data when and if they became available, and (c) the development of new fuzzy and neural network models for other geotechnical problems.

APPENDICES

Table A: A list of programs

Type	Descriptions	Data
BPNN_CAPACITY	• Based on Neural network model (Back-propagated neural network) • Prediction of ultimate pile capacity by jetting and non-jetting method (GUI type)	Static load tests
ANFIS_CAPACITY	• Based on ANFIS (Adaptive Neuro-Fuzzy Inference System) • Prediction of ultimate pile capacity for non-jetting method	
BPNN_SETUP	• Based on Neural network model (Back-propagated neural network) • Prediction of pile setup (GUI type)	CAPWAP
ANFIS_SETUP	• Based on ANFIS (Adaptive Neuro-Fuzzy Inference System) • Prediction of pile setup	
BPNN_DRIVABILITY	Based on ANFIS (Adaptive Neuro-Fuzzy Inference System) • Prediction of pile drivability(GUI type - BPF, Maximum compressive stresses, tensile stresses)	GRLWEAP

Table B: Summary of Database for the programs

Type			Data			Page
			Training	Testing	Total	
BPNN_CAPACITY	Non-jetted		51	17	68	302-304
	All data		57	18	75	305-307
ANFIS_CAPACITY			51	17	68	302-304
BPNN_SETUP			73	23	96	308-310
ANFIS_SETUP			73	23	96	311-313
BPNN_DRIVABILITY		Q1	263	87	350	314-321
		Q2	393	132	525	322-333
		Q3	808	250	1058	334-355
		Q4	1296	421	1717	355-390
		Q5	276	91	367	391-398

Appendix I BPNN Model for Ultimate Pile Capacity

(BPNN_CAPACITY)

I.1 Introduction

In the developed neural network, there is an input layer where input data are presented to the network and an output layer with one neuron representing the ultimate capacity and also two hidden layers as intermediate layers. Five variables consisting of friction angle at shaft, friction angle around tip of the pile, effective stress at tip, pile length, pile cross-sectional area are selected as the input variables. The friction angle of the soil around the shaft and near the tip of the pile provides information about the shear strength of surrounding and supporting soil. Effective stress at the tip of the pile has also a significant role on calculating the pile capacity. The pile length as well as the cross-sectional area provide the necessary information about pile dimensions. Friction angle at shaft, friction angle around tip of the pile, effective stress at tip, pile length, pile cross-sectional area, and jetted/non-jetted conditions are chosen as input variables to evaluate the pile capacity as the target variable. In the preprocessing stage, all the inputs of the training and testing sets are scaled between 0 and 1 before being presented to the network for making equivalent contributions.

In order to predict the ultimate load capacity of piles in cohesion-less soils, two BPNN models are developed: first model for non-jetted data and a second model for all the data including the jetted ones. In both models algorithms used are that of back-propagation neural network. There is an input layer, where input data are presented to the network and an output layer consisting of one neuron representing the ultimate capacity and also two hidden layers as intermediate layers. As an activation function, a logistic sigmoid function was selected as input through the first hidden layer and for second hidden through output layer. A hyperbolic tangent function was used to convert the first hidden layer into the second layer. The appropriate hidden nodes are chosen when mean square error over the entire training pattern reaches an acceptable level. Then a GUI program combining both BPNN models is developed to predict the ultimate load capacity.

Pile capacity is predicted using BPNN and three commonly used empirical methods which are then compared with actual results from measurements. These three additional methods are proposed by Coyle and Castello (1981), Meyerhof (1976) and Vesic (1977). The results of this study indicate that the neural network model provides a better prediction than the conventional methods and can serve as a reliable and simple predictive tool for the

prediction of axial loading capacity of piles considering the jetting methods. As more data become available, BPNN models can be improved further to make more accurate capacity predictions for a wider range of load and site conditions.

I.2 Schematic Flow Chart and GUI

Figure I-1 shows a schematic flow chart of the BPNN model. The flow chart is divided into two groups according to the use of jetting. For each group, neural network factors for each model are set through the preliminary analysis. The preliminary analysis examines the optimal weight matrix and bias vector including the number of hidden nodes and MSE (Mean Square Error) value which are decided at the satisfactory level. First, unit system (US customary or SI metric) is chosen and the input data is applied to differently trained model and the decision of using the jetting is made. After training the model using fixed neural network factors, testing is performed. Then, the input data are applied to already trained back-propagated neural network model. The measured and predicted ultimate pile capacities are compared with each other and are plotted both in training and testing stages. Then the ultimate pile capacity is predicted. Figure I-2 presents a MATLAB GUI which provides the input, comparison of results and the final predictions. The input data are on the left hand side, while the output is on the right.

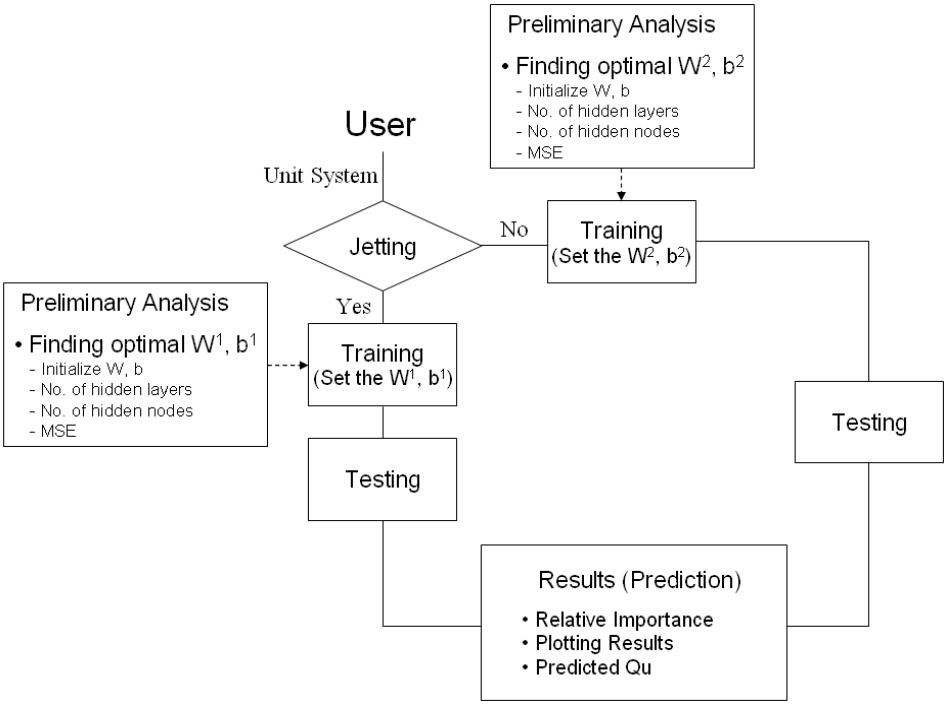


Figure I-1 A Schematic Flow Chart of the BPNN Program

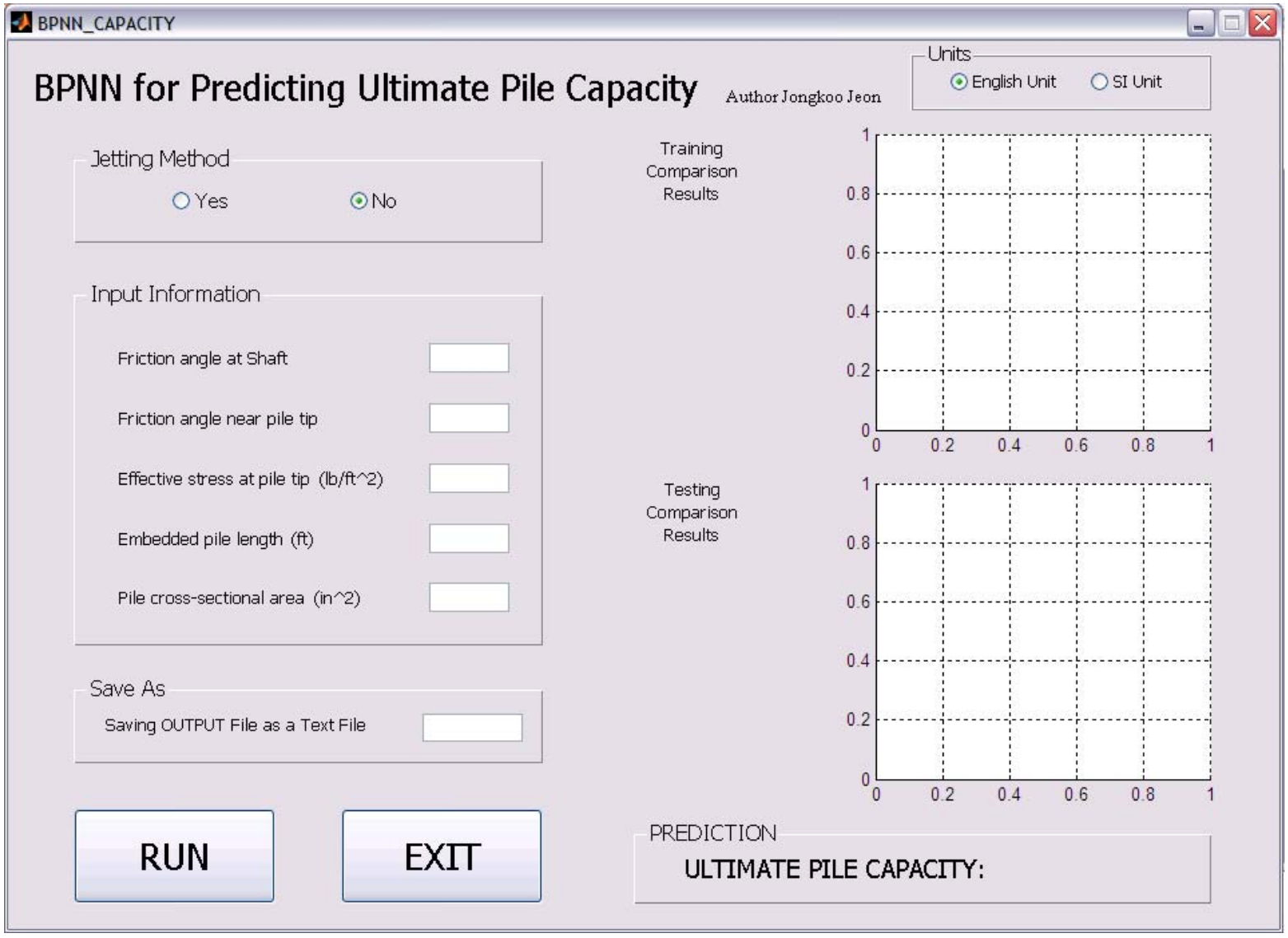


Figure I-2 A GUI of BPNN model for prediction of Ultimate Pile Capacity

I.3 Components of BPNN_CAPACITY

I.3.1 Main files in the MATLAB

- BPNN_CAPACITY.m: when you write a program in MATLAB, you save it to a file called an M-file (named after its .m file extension).
- BPNN_CAPACITY.fig: GUI figure file

I.3.2 Data files for BPNN models

Optimal weight matrices and bias vectors (w) are determined at the satisfactory level by trial and error. So, in order to reduce the running time for training the models, the followings are set in the networks:

- Training data set: train_nonjet.txt, train_all.txt
- Testing data set: test_nonjet.txt, train_all.txt
- Weight matrices: wt1, wt2, wt3, w1, w2, w3
- Bias vectors: bs1, bs2, bs3, b1, b2, b3

Figures I-3(a) and I-3(b) present the weights and bias files (*.txt) for both non-jetted and jetted data, respectively.

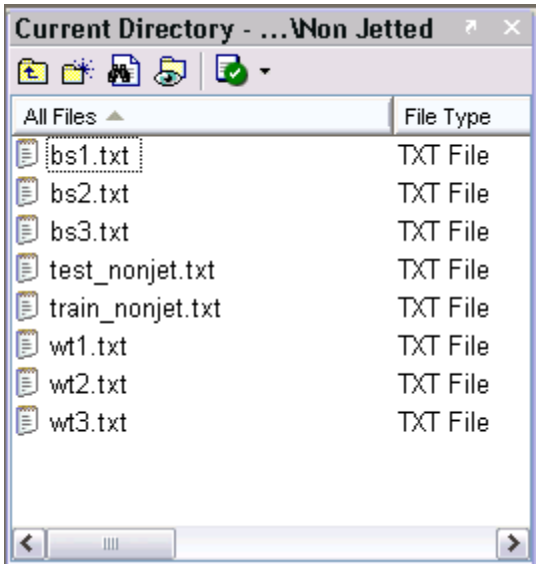


Figure I-3(a) for non-jetted

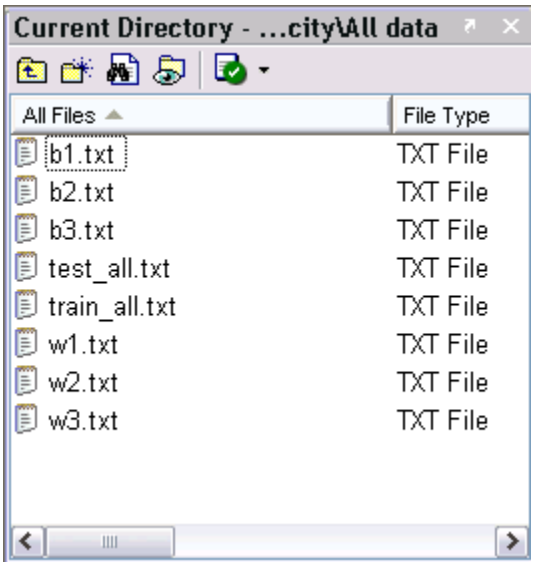


Figure I-3(b) for all data (jetted data included)

***Please do not change the order of the above files unless you modify the models.**

I.4 Training and testing

I.4.1 Training procedure

Using the program codes in section I.6.1, the initial weights (and biases), the number of hidden nodes, and the error (mean square error), which are important learning parameters affecting the results, are determined. These three parameters are chosen to get the best performance from the network (testing data set) in terms of the highest coefficient of correlation R^2 as shown in Figure I-4.

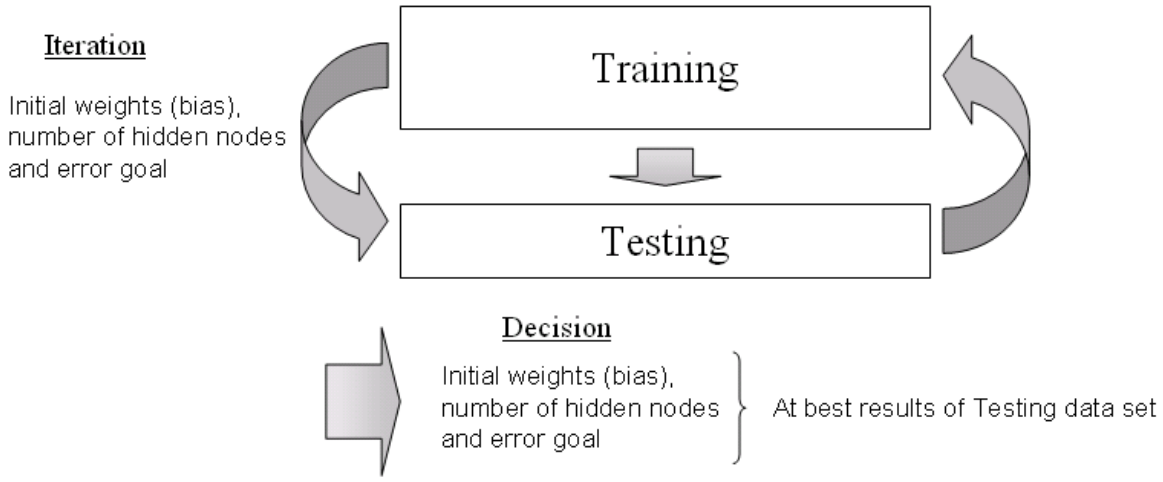


Figure I-4 Decision of learning parameters during training

I.4.2 Comparison results of Training and Testing data

The optimized learning parameters are applied to the testing data set which has not been used before. The comparison results of training and testing data sets are presented:

• Comparison Results (Training)

16.90	80.65
107.90	65.63
134.90	231.86
146.10	126.34
147.30	206.74
154.00	246.77
160.10	195.70
192.00	234.98
201.00	229.48
228.00	262.97

250.20	254.07
256.30	630.60
281.90	472.57
288.00	308.88
321.30	404.00
339.30	273.48
366.00	431.87
390.00	409.84
390.10	332.24
395.90	406.37
400.00	630.66
400.00	377.45
400.00	298.43
420.00	468.82
430.10	449.65
437.90	484.97
438.40	484.97
472.10	232.84
490.10	404.19
502.00	513.99
504.00	469.05
520.00	374.96
548.30	590.54
570.00	550.43
587.90	680.52
600.00	554.38
640.00	604.24
642.10	584.47
674.50	575.66
683.90	574.19
710.00	628.49
720.10	626.60
721.90	642.93
799.90	791.97
826.00	801.33
859.90	624.19

882.00	788.81
904.00	974.56
1049.90	1058.34
1124.10	1107.57
1259.90	1220.61

• Comparison Results (Testing)

116.70	54.46
147.90	212.65
198.30	236.13
207.30	423.45
288.00	291.07
366.00	431.87
400.00	357.04
408.00	393.22
430.10	542.11
486.50	618.01
516.00	660.91
560.00	498.19
605.90	604.76
690.00	839.79
719.40	539.65
740.10	746.98
1064.10	1126.10

I.5 An Example (Inputs & Outputs)

I.5.1 Input data

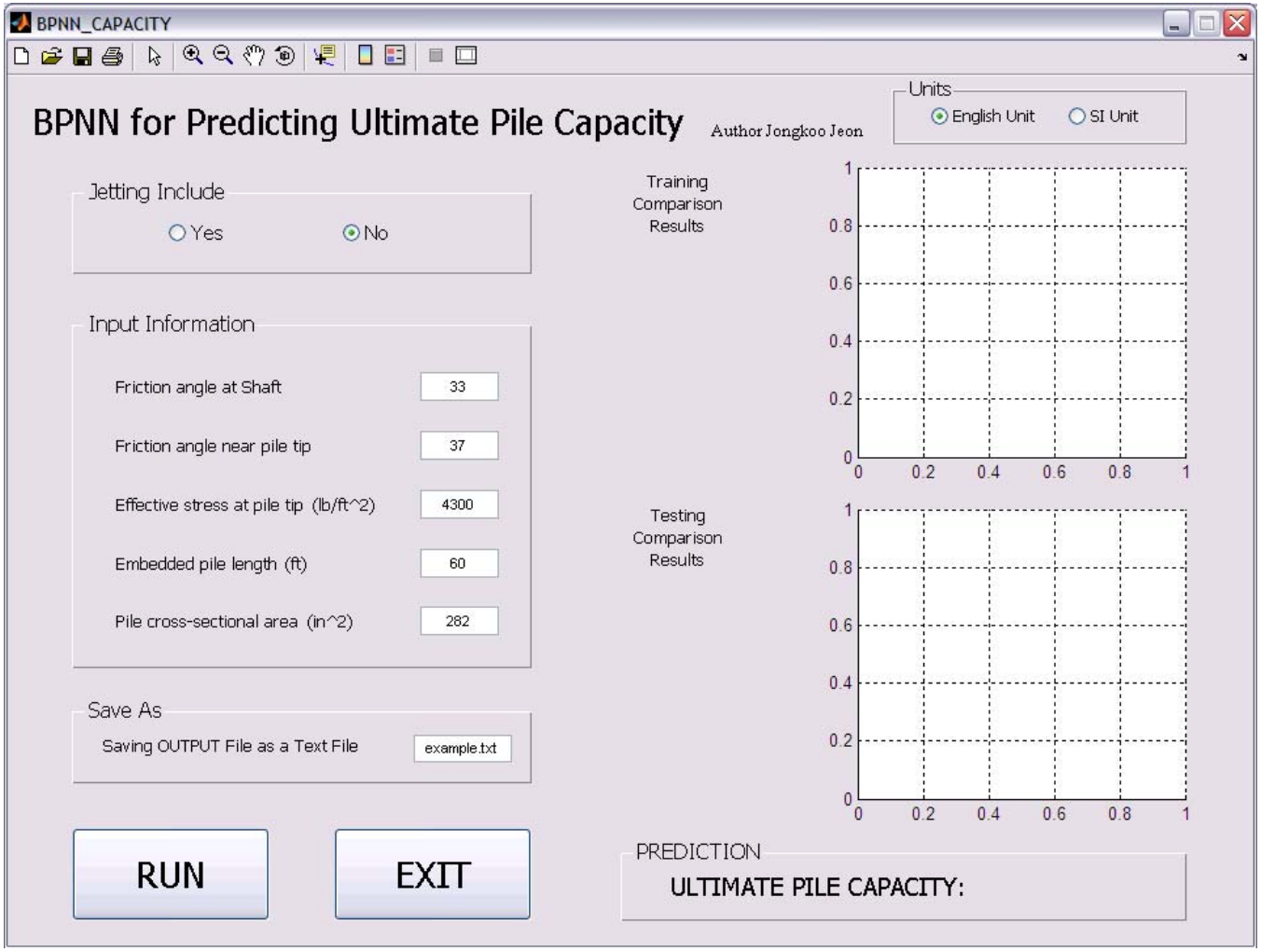


Figure I-5 An example for BPNN_CAPACITY (Input)

I.5.2 Outputs: **example.txt**

As shown in Figures I-6(a) and I-6(b), the new output file ('example.txt') was added in the directory after training.

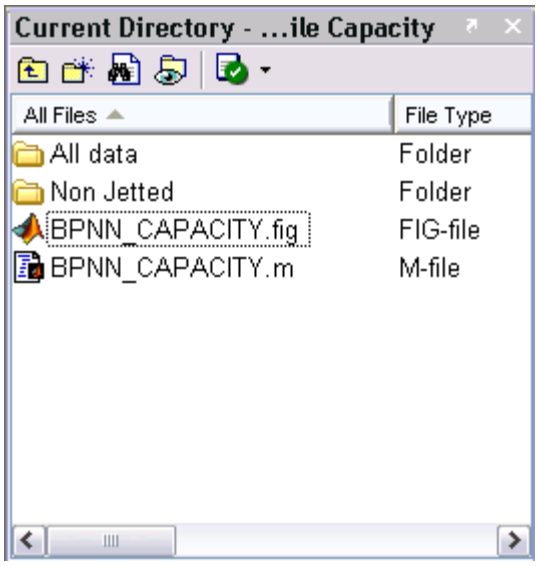
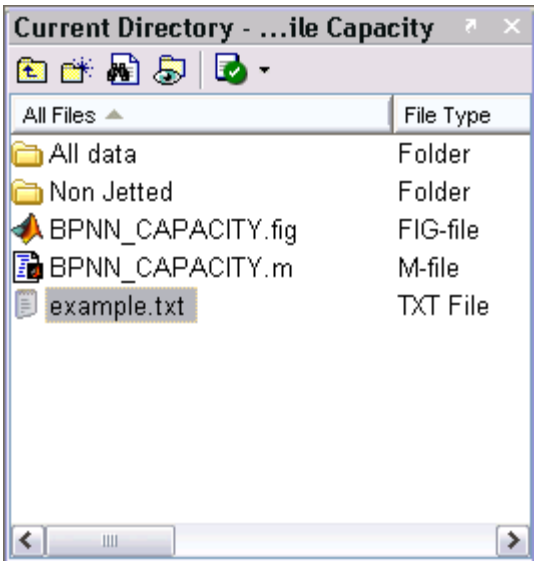


Figure I-6(a) Before training



I-6(b) After training

Outputs will be in terms of:

i) Input data
ii) Relative Importance
iii) Predicted value (Ultimate pile capacity)

========= OUTPUTS: ULTIMATE PILE CAPACITY (Non-Jetted) ========

7-Aug-2007 14:26:03

	Friction angle at shaft	Friction angle near pile tip	Effective stress at pile tip (psf)	Embedded pile length (ft)	Pile cross sectional area (ft^2)
INPUT					
	33.0	37.0	4300.0	60.0	1.958
Relative Importance					
	10.3	18.4	29.6	17.3	24.4

ULTIMATE PILE CAPACITY (kips) =

628.75

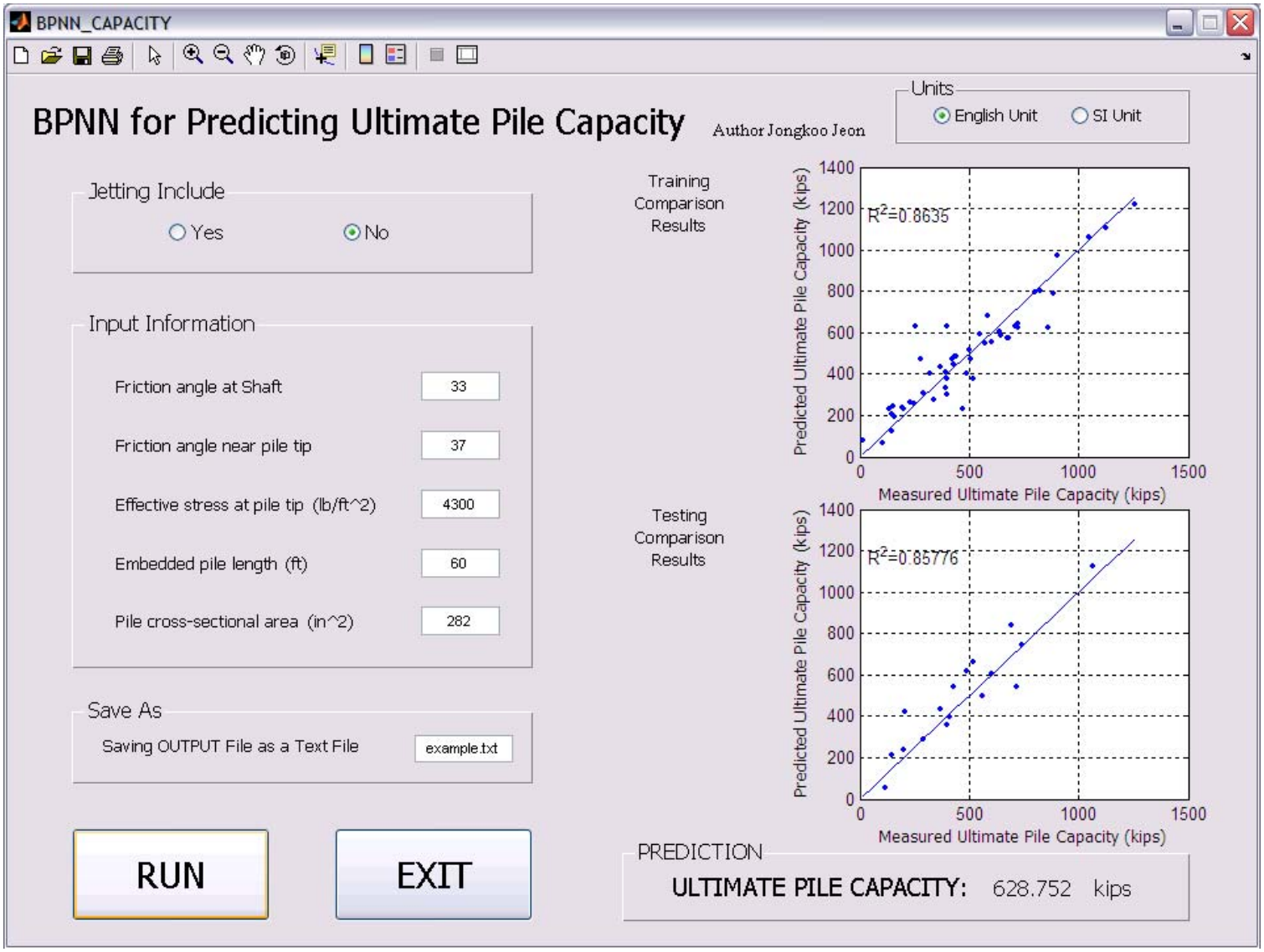


Figure I-7 An example for BPNN_CAPACITY (Outputs)

I.5 Program Requirements and Limitations

i) Need Neural Network toolbox as well as main MATLAB program.

ii) It takes some time in order to update/retrain the model.

iii) Number of data and a good quality data capturing all the 'physics' is a pre-requisite for a good model.

I.6 Program Source Codes (BPNN_CAPACITY)

I.6.1 Program Codes for Training and Testing

```
clc
clear all

% ---------------------------------------------------------
% get input information
% ---------------------------------------------------------

diary training_results.txt

train_in=input('Enter the Training Set Input Filename ==> ?
','s');
test_in=input('Enter the Testing Set Input Filename ==> ?  ','s');

% ---------------------------------------------------------
% loading the input data sets and normalized for training and
testing
% ---------------------------------------------------------

load(train_in);
load(test_in);
tr_in=eval(strtok(train_in,'.'));
te_in=eval(strtok(test_in,'.'));
[m,n]=size(tr_in);
trr=zeros(m,n);
in=zeros(n,2);
for i=1:n
  tr_max(i)=max(tr_in(:,i));
  tr_min(i)=min(tr_in(:,i));
    if tr_max(i) == tr_min(i)
      for j=1:m
        trr(j,i)=1;
      end
    else
      for j=1:m
        trr(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-tr_min(i));
      end
    end
  in(i,1)=min(trr(:,i));
  in(i,2)=max(trr(:,i));
end

% ---------------------------------------------------------
% form the neural network parameters need for the training
stage
% ---------------------------------------------------------

initt=in(1:(n-1),:);
P=trr(:,1:(n-1));
P=P';
T=trr(:,n).';
hidden_max=round(1.0*size(initt,1));
hidden_min=round(sqrt(size(initt,1)*size(T,1)));

for iw=1:10
    for hidden=hidden_min:hidden_max
        for e=1:6


net=newff(initt,[hidden,hidden,1],{'logsig','tansig','logsig'},'train
lm');% Generates Initial weights for two hidden layers

        net.IW{1}% Initial Input weights
        net.LW{2,1}
        net.LW{3,2}
        net.b{1}% Initial Bias
        net.b{2}
        net.b{3}

        net.trainParam.goal=1/10^e;
        net.trainParam.show=25;
        net.trainParam.epochs=1000;
        [net,tr]=train(net,P,T); % Train a neural network

% ---------------------------------------------------------
% training the neural network until the sum-error meets the
requirement
% ---------------------------------------------------------

      train_pred = sim(net,P);% Simulate a neural network
      train_pred=train_pred';
      train_pred1=train_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Prediction
      train_meas1=tr_in(:,n);
      train_comp=zeros(m,2);
      train_comp(:,1)=train_meas1;
      train_comp(:,2)=train_pred1;
      train_comp;

% ---------------------------------------------------------
% calculate the coefficient of determination "r^2" for the
training sets
% ---------------------------------------------------------

       r_squ_tra=corr2(train_meas1,train_pred1);
       r_squ_tr(iw,hidden,e)=r_squ_tra^2;

% ---------------------------------------------------------
% make the prediction for the test data sets
% ---------------------------------------------------------

      [m1,n1]=size(te_in);
      test_in=zeros(m1,n1-1);
```

```
    for i=1:n1-1
      for j=1:m1
        test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
      end
    end
    TE=test_in(:,1:(n1-1));
    TE=TE';
    test_pred = sim(net,TE);
    test=test_in.';
    test_pred=test_pred';
    test_pred1=test_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Maximum compressive stress
    test_meas1=te_in(:,n1);
    test_comp=zeros(m1,2);
    test_comp(:,1)=test_meas1;
    test_comp(:,2)=test_pred1;
    test_comp;

% ------------------------------------------------------------
% calculate the coefficient of determination "r^2" for the testing
sets
% ------------------------------------------------------------

    e1=test_meas1-test_pred1;
    ee1=e1.*e1;
    Se_te1=sum(ee1);
    r1=sum(test_meas1.*test_meas1)-Se_te1-
sum(test_meas1).*sum(test_meas1)./m1;
    r2=sum(test_meas1.*test_meas1)-
sum(test_meas1).*sum(test_meas1)./m1;
    r_squ_te1(iw,hidden,e)=r1./r2;

      [iw,hidden,e]
      r_squ_te1

    end
  end
end
```

I.6.2 Program Codes for prediction (with GUI)

```
function varargout = BPNN_CAPACITY(varargin)
% BPNN_CAPACITY M-file for BPNN_CAPACITY.fig
%      BPNN_CAPACITY, by itself, creates a new
BPNN_CAPACITY or raises the existing
%      singleton*.
%
%      H = BPNN_CAPACITY returns the handle to a new
BPNN_CAPACITY or the handle to
%      the existing singleton*.
%
%
BPNN_CAPACITY('CALLBACK',hObject,eventData,handles,.
..) calls the local
%      function named CALLBACK in BPNN_CAPACITY.M
with the given input arguments.
%
%      BPNN_CAPACITY('Property','Value',...) creates a new
BPNN_CAPACITY or raises the
%      existing singleton*.  Starting from the left, property value
pairs are
%      applied to the GUI before
BPNN_CAPACITY_OpeningFunction gets called.  An
%      unrecognized property name or invalid value makes
property application
%      stop.  All inputs are passed to
BPNN_CAPACITY_OpeningFcn via varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose
"GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help
BPNN_CAPACITY

% Last Modified by GUIDE v2.5 17-Jan-2007 12:11:30

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn',
@BPNN_CAPACITY_OpeningFcn, ...
                   'gui_OutputFcn',
@BPNN_CAPACITY_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State,
varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before BPNN_CAPACITY is made visible.
function BPNN_CAPACITY_OpeningFcn(hObject, eventdata,
handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)
% varargin   command line arguments to BPNN_CAPACITY
(see VARARGIN)

% Choose default command line output for BPNN_CAPACITY
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes BPNN_CAPACITY wait for user response
(see UIRESUME)
% uiwait(handles.figure1);

set(handles.chosenunit,'value',1);
set(handles.chosenyesno,'value',2);
set(handles.tx_value,'visible','off');
set(handles.tx_kips,'visible','off');
```

```
% --- Outputs from this function are returned to the command
line.
function varargout = BPNN_CAPACITY_OutputFcn(hObject,
eventdata, handles)
% varargout  cell array for returning output args (see
VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


% --------------------------------------------------------------------
function unitgroup_SelectionChangeFcn(hObject, eventdata,
handles)
% hObject    handle to unitgroup (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

if (hObject==handles.english)
   set(handles.tx_stress,'String', '(lb/ft^2)');
   set(handles.tx_length,'String', '(ft)');
   set(handles.tx_area,'String', '(ft^2)');
   set(handles.tx_kips,'String', 'kips');
   set(handles.chosenunit,'value',1);
else
   set(handles.tx_stress,'String', '(kN/m^2)');
   set(handles.tx_length,'String', '(m)');
   set(handles.tx_area,'String', '(m^2)');
   set(handles.tx_kips,'String', 'kN');
   set(handles.chosenunit,'value',2);
end


% --------------------------------------------------------------------
function yesnogroup_SelectionChangeFcn(hObject, eventdata,
handles)
% hObject    handle to yesnogroup (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

if (hObject==handles.yes)
   set(handles.chosenyesno,'Value',1);
elseif (hObject==handles.no)
   set(handles.chosenyesno,'Value',2);
end


function frict_shaft_Callback(hObject, eventdata, handles)
% hObject    handle to frict_shaft (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of frict_shaft as
text
%        str2double(get(hObject,'String')) returns contents of
frict_shaft as a double


% --- Executes during object creation, after setting all properties.
function frict_shaft_CreateFcn(hObject, eventdata, handles)
% hObject    handle to frict_shaft (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end


function frict_toe_Callback(hObject, eventdata, handles)
% hObject    handle to frict_toe (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of frict_toe as
text
%        str2double(get(hObject,'String')) returns contents of
frict_toe as a double


% --- Executes during object creation, after setting all properties.
function frict_toe_CreateFcn(hObject, eventdata, handles)
% hObject    handle to frict_toe (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end


function stress_Callback(hObject, eventdata, handles)
% hObject    handle to stress (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of stress as text
%        str2double(get(hObject,'String')) returns contents of
stress as a double


% --- Executes during object creation, after setting all properties.
function stress_CreateFcn(hObject, eventdata, handles)
% hObject    handle to stress (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
```

```
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function length_Callback(hObject, eventdata, handles)
% hObject    handle to length (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of length as text
%        str2double(get(hObject,'String')) returns contents of
length as a double


% --- Executes during object creation, after setting all properties.
function length_CreateFcn(hObject, eventdata, handles)
% hObject    handle to length (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function area_Callback(hObject, eventdata, handles)
% hObject    handle to area (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of area as text
%        str2double(get(hObject,'String')) returns contents of area
as a double


% --- Executes during object creation, after setting all properties.
function area_CreateFcn(hObject, eventdata, handles)
% hObject    handle to area (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



% --- Executes on button press in run.
function run_Callback(hObject, eventdata, handles)
% hObject    handle to run (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% ------------------------------------------------------------------
% loading the input data sets and normalized for training and
testing
% ------------------------------------------------------------------

frict_shaft=str2double(get(handles.frict_shaft,'string'));
frict_toe=str2double(get(handles.frict_toe,'string'));
effec_stress=str2double(get(handles.stress,'string'));
plength=str2double(get(handles.length,'string'));
cross_area=str2double(get(handles.area,'string'));
cross_area=cross_area/12^2;

% ----- Non-Jetted Case -----
if get(handles.chosenyesno,'value')==2. %Jetting No

  cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Capacity\Non Jetted');

    load train_nonjet.txt;
    load test_nonjet.txt;
    load wt1.txt;
    load wt2.txt;
    load wt3.txt;
    load bs1.txt;
    load bs2.txt;
    load bs3.txt;

    tr_in=train_nonjet;
    te_in=test_nonjet;
    w1=wt1;
    w2=wt2;
    w3=wt3;
    b1=bs1;
    b2=bs2;
    b3=bs3;

    [m,n]=size(tr_in);
    trr=zeros(m,n);
    in=zeros(n,2);
    for i=1:n
      tr_max(i)=max(tr_in(:,i));
      tr_min(i)=min(tr_in(:,i));
        if tr_max(i) == tr_min(i)
          for j=1:m
            trr(j,i)=1;
          end
        else
          for j=1:m
            trr(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-tr_min(i));
          end
        end
      in(i,1)=min(trr(:,i));
      in(i,2)=max(trr(:,i));
    end

% ------------------------------------------------------------------
% form the neural network parameters need for the training
stage
% ------------------------------------------------------------------

    initt=in(1:(n-1),:);
    P=trr(:,1:(n-1));
    P=P';
    T=trr(:,n).';
```

```
    net=newff(initt,[2,2,1],{'logsig','tansig','logsig'},'trainlm');

    net.IW{1}=w1;
    net.LW{2,1}=w2;
    net.LW{3,2}=w3;
    net.b{1}=b1;
    net.b{2}=b2;
    net.b{3}=b3;

    net.trainParam.epochs=1000;
    net.trainParam.goal=0.0066;
    net.trainParam.show=25;
    [net,tr]=train(net,P,T);

% ------------------------------------------------------------
% training the neural network until the sum-error meets the
requirement
% ------------------------------------------------------------

     train_pred = sim(net,P);
     train_pred=train_pred';
     train_pred1=train_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Maximum compressive stress
     train_meas1=tr_in(:,n);
     train_comp=zeros(m,2);
     train_comp(:,1)=train_meas1;
     train_comp(:,2)=train_pred1;
     train_comp;

% ------------------------------------------------------------
% calculate the coefficient of determination "r^2" for the
training sets
% ------------------------------------------------------------

     r_squ_tra=corr2(train_meas1,train_pred1);
     r_squ_tr1=r_squ_tra^2;

% ------------------------------------------------------------
% make the prediction for the test data sets
% ------------------------------------------------------------

        [m1,n1]=size(te_in);
        test_in=zeros(m1,n1-1);
        for i=1:n1-1
          for j=1:m1
            test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
          end
        end
        TE=test_in;
        TE='TE';
        test_pred = sim(net,TE);
        test_pred=test_pred';
        test_pred1=test_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Maximum compressive stress
        test_meas1=te_in(:,n1);
        test_comp=zeros(m1,2);
        test_comp(:,1)=test_meas1;
        test_comp(:,2)=test_pred1;
        test_comp;


% ------------------------------------------------------------
% calculate the coefficient of determination "r^2" for the testing
sets
% ------------------------------------------------------------

       r_squ_tea=corr2(test_meas1,test_pred1);
       r_squ_te1=r_squ_tea^2;
       max_tr_r1=r_squ_tr1;
       max_te_r1=r_squ_te1;
% ------------------------------------------------------------
% Relative weight of each input node
% ------------------------------------------------------------

    [hid,in]=size(net.IW{1});
    w_part=zeros(hid,in);
    sum1=sum(abs(net.IW{1})');
    for i=1:hid
       w_part(i,:)=abs(net.IW{1}(i,:))/sum1(i);
       modi_w2(i)=mean(abs(net.LW{2,1}(i,:)));
       w_part(i,:)=w_part(i,:)*modi_w2(i);
       w_part(i,:)=w_part(i,:)*abs(net.LW{3,2}(i));
    end
    s=sum(w_part);
    ss=sum(s');
    RI=s/ss*100; % Relative Importance;

% ------------------------------------------------------------
% Prediction Ultimate Pile Capacity for given input values
% ------------------------------------------------------------

  if get(handles.chosenunit,'value')==1.%ENGLISH UNIT


qu_test1_in=[frict_shaft,frict_toe,effec_stress,plength,cross_are
a];

    [m2,n2]=size(qu_test1_in);
      qu_te1_in=zeros(m2,n2);
       for i=1:n2
         for j=1:m2
           qu_te1_in(j,i)=(qu_test1_in(j,i)-tr_min(i))/(tr_max(i)-
tr_min(i));
         end
       end

       predic=qu_te1_in;
       predic=predic';
       te_pred = sim(net,predic);
       te_pred=te_pred';
       pred1=te_pred(:,1)*(tr_max(n)-tr_min(n))+tr_min(n);%
Ultimate Pile Capacity (kips)
       predict=pred1;

    set(handles.tx_value,'string',predict);
    set(handles.tx_value,'visible','on');
    set(handles.tx_kips,'visible','on');

% ------------------------------------------------------------
% OUTPUT: Pile Capacity Analysis
% ------------------------------------------------------------

    format bank
    E='';
    Time=datestr(now);
    cd ..

       fprintf('------------------------------------------------------------
---------------\n',E)
       fprintf('================ OUTPUTS: ULTIMATE
PILE CAPACITY(Non-Jetted)  ==================\n',E)
       fprintf('------------------------------------------------------------
---------------\n',E)
       fprintf('                                                    \n',E)
       fprintf('                                                 %s\n',
Time)
       fprintf('                                                \n',       E)
```

```
        fprintf('            Friction    Friction       Effective
Embedded     Pile cross   %s\n',E)
        fprintf('              angle     angle near      stress at        pile
sectional   %s\n',E)
        fprintf('            at shaft    pile tip     pile tip (psf)   length
(ft)   area (ft^2)  %s\n',E)
        fprintf('INPUT                                                  \n',
E)

fprintf('             %3.1f\t    %4.1f\t        %6.1f\t        %5.1f\t
  %4.3f    \n', qu_test1_in)
        fprintf('                                                  \n',       E)
        fprintf('Relative Importance                                \n',
E)

fprintf('             %3.1f\t    %4.1f\t        %6.1f\t        %5.1f\t
 %5.1f     \n', RI)
        fprintf('                                                  \n',       E)
        fprintf('ULTIMATE PILE CAPACITY (kips) =
\n', E)
        fprintf('                                %3.1f              \n',
predict')

%=== Output File Form ===

    output_file=get(handles.edit_saving,'string');
    fid=fopen(output_file,'wt');

        fprintf(fid,'-------------------------------------------------------
--------------------\n',E);
        fprintf(fid,'================ OUTPUTS: ULTIMATE
PILE CAPACITY(Non-Jetted)  ==================\n',E);
        fprintf(fid,'-------------------------------------------------------
--------------------\n',E);
        fprintf(fid,'
\n',E);
        fprintf(fid,'                                                  %s\n',
Time);
        fprintf(fid,'                                                  \n',
E);
        fprintf(fid,'            Friction    Friction       Effective
Embedded     Pile cross   %s\n',E);
        fprintf(fid,'              angle     angle near      stress at
pile       sectional   %s\n',E);
        fprintf(fid,'            at shaft    pile tip     pile tip (psf)
length (ft)   area (ft^2)  %s\n',E);
        fprintf(fid,'INPUT
\n',       E);

fprintf(fid,'             %3.1f\t    %4.1f\t  %6.1f\t   %4.1f\t       %4
.3f   \n', qu_test1_in);
        fprintf(fid,'                                                  \n',
E);
        fprintf(fid,'Relative Importance
\n', E);

fprintf(fid,'             %3.1f\t    %4.1f\t  %6.1f\t   %4.1f\t       %5.
1f     \n', RI);
        fprintf(fid,'                                                  \n',
E);
        fprintf(fid,'ULTIMATE PILE CAPACITY (kips) =
\n', E);
        fprintf(fid,'                                %3.1f              \n',
predict');


%----- plot comparison results
        axes(handles.ax_train)
        x=train_comp(:,1);
        y=train_comp(:,2);
        plot(x,y,'.')
        set(handles.ax_train,'LineWidth',1);
        xlabel('Measured Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');
        ylabel('Predicted Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/30,max(train_comp(:,1))/1.07,['R^2='
num2str(r_squ_tr1)])
        hold on
        x=linspace(tr_min(n), tr_max(n));
        y=x;
        plot(x,y)
        grid on

        axes(handles.ax_test)
        z=test_comp(:,1);
        w=test_comp(:,2);
        plot(z,w,'.')
        set(handles.ax_test,'LineWidth',1);
        xlabel('Measured Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');
        ylabel('Predicted Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/30,max(train_comp(:,1))/1.07,['R^2='
num2str(r_squ_te1)])
        hold on
        x=linspace(tr_min(n), tr_max(n));
        y=x;
        plot(x,y)
        grid on

  elseif get(handles.chosenunit,'value')==2 %SI Unit


qu_test1_in=[frict_shaft,frict_toe,effec_stress*1000/47.88,pleng
th/0.3048,cross_area/0.3048^2]; %SI--->ENG Unit
    qu_in=[frict_shaft,frict_toe,effec_stress,plength,cross_area];

    [m2,n2]=size(qu_test1_in);
      qu_te1_in=zeros(m2,n2);
       for i=1:n2
         for j=1:m2
           qu_te1_in(j,i)=(qu_test1_in(j,i)-tr_min(i))/(tr_max(i)-
tr_min(i));
          end
        end

        predic=qu_te1_in;
        predic=predic';
        te_pred = sim(net,predic);
        te_pred=te_pred';
        pred1=te_pred(:,1)*(tr_max(n)-tr_min(n))+tr_min(n);%
Ultimate Pile Capacity (kips)
        predict=pred1;

    set(handles.tx_value,'string',predict*4.448);
    set(handles.tx_value,'visible','on')
    set(handles.tx_kips,'visible','on')

% --------------------------------------------------------------
% OUTPUT: Pile Capacity Analysis
% --------------------------------------------------------------

    format bank
    E='';
    Time=datestr(now);
    cd ..
```

```
        fprintf('-------------------------------------------------------------
---------------\n',E)
        fprintf('================ OUTPUTS: ULTIMATE
PILE CAPACITY(Non-Jetted)  ==================\n',E)
        fprintf('-------------------------------------------------------------
---------------\n',E)
        fprintf('                                                    \n',E)
        fprintf('                                                 %s\n',
Time)
        fprintf('                                                \n',       E)
        fprintf('            Friction    Friction       Effective
Embedded     Pile cross   %s\n',E)
        fprintf('             angle     angle near      stress at        pile
sectional   %s\n',E)
        fprintf('            at shaft    pile tip     pile tip (kPa)   length
(m)    area (m^2)  %s\n',E)
        fprintf('INPUT                                               \n',
E)

fprintf('            %3.1f\t    %4.1f\t       %6.1f\t       %5.1f\t
  %4.3f    \n', qu_in)
        fprintf('                                                \n',       E)
        fprintf('Relative Importance                                 \n',
E)

fprintf('            %3.1f\t    %4.1f\t       %6.1f\t       %5.1f\t
 %5.1f     \n', RI)
        fprintf('                                                \n',       E)
        fprintf('ULTIMATE PILE CAPACITY (kN) =
\n', E)
        fprintf('                                %3.1f             \n',
predict'*4.448)

%=== Output File Form ===

    output_file=get(handles.edit_saving,'string');
    fid=fopen(output_file,'wt');

        fprintf(fid,'-------------------------------------------------------------
-------------------\n',E);
        fprintf(fid,'================ OUTPUTS: ULTIMATE
PILE CAPACITY(Non-Jetted)  ==================\n',E);
        fprintf(fid,'-------------------------------------------------------------
-------------------\n',E);
        fprintf(fid,'
\n',E);
        fprintf(fid,'                                                 %s\n',
Time);
        fprintf(fid,'                                                \n',
E);
        fprintf(fid,'            Friction    Friction       Effective
Embedded     Pile cross   %s\n',E);
        fprintf(fid,'             angle     angle near      stress at
pile       sectional   %s\n',E);
        fprintf(fid,'            at shaft    pile tip     pile tip (kPa)
length (m)    area (m^2)  %s\n',E);
        fprintf(fid,'INPUT
\n',       E);

fprintf(fid,'            %3.1f\t    %4.1f\t  %6.1f\t   %4.1f\t       %4
.3f   \n', qu_in);
        fprintf(fid,'                                                \n',
E);
        fprintf(fid,'Relative Importance
\n', E);

fprintf(fid,'            %3.1f\t    %4.1f\t  %6.1f\t   %4.1f\t      %5.
1f     \n', RI);
        fprintf(fid,'                                                \n',
E);
        fprintf(fid,'ULTIMATE PILE CAPACITY (kN) =
\n', E);
        fprintf(fid,'                                %3.1f             \n',
predict'*4.448);

 %----- plot comparison results
        axes(handles.ax_train)
        x=train_comp(:,1)*4.448;
        y=train_comp(:,2)*4.448;
        plot(x,y,'.')
        set(handles.ax_train,'LineWidth',1);
        xlabel('Measured Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');
        ylabel('Predicted Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))*4.448/30,max(train_comp(:,1))*4.44
8/1.07,['R^2=' num2str(r_squ_tr1)])
        hold on
        x=linspace(tr_min(n)*4.448, tr_max(n)*4.448);
        y=x;
        plot(x,y)
        grid on

        axes(handles.ax_test)
        z=test_comp(:,1)*4.448;
        w=test_comp(:,2)*4.448;
        plot(z,w,'.')
        set(handles.ax_test,'LineWidth',1);
        xlabel('Measured Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');
        ylabel('Predicted Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))*4.448/30,max(train_comp(:,1))*4.44
8/1.07,['R^2=' num2str(r_squ_tr1)])
        hold on
        x=linspace(tr_min(n)*4.448, tr_max(n)*4.448);
        y=x;
        plot(x,y)
        grid on

 end

%-----------------------------------------------------------------------
% All data Case: Including Jetted data
% In this case Neural Network Model is fixed as SI unit, so
Change to ENG
%-----------------------------------------------------------------------

elseif get(handles.chosenyesno,'value')==1. % All data Case:
Including Jetted data

    cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Capacity\All Data');

    load train_all.txt;
    load test_all.txt;
    load w1.txt;
    load w2.txt;
    load w3.txt;
    load b1.txt;
    load b2.txt;
    load b3.txt;

    tr_in=train_all;
    te_in=test_all;

    [m,n]=size(tr_in);
    trr=zeros(m,n);
```

```
in=zeros(n,2);
for i=1:n
 tr_max(i)=max(tr_in(:,i));
 tr_min(i)=min(tr_in(:,i));
  if tr_max(i) == tr_min(i)
   for j=1:m
    trr(j,i)=1;
   end
  else
   for j=1:m
    trr(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-tr_min(i));
   end
  end
 in(i,1)=min(trr(:,i));
 in(i,2)=max(trr(:,i));
end

% ---------------------------------------------------------------
% form the neural network parameters need for the training
stage
% ---------------------------------------------------------------

   initt=in(1:(n-1),:);
   P=trr(:,1:(n-1));
   P=P';
   T=trr(:,n).';

   net=newff(initt,[2,2,1],{'logsig','tansig','logsig'},'trainlm');

   net.IW{1}=w1;
   net.LW{2,1}=w2;
   net.LW{3,2}=w3;
   net.b{1}=b1;
   net.b{2}=b2;
   net.b{3}=b3;

   net.trainParam.epochs=1000;
   net.trainParam.goal=0.005;
   net.trainParam.show=25;
   [net,tr]=train(net,P,T);

% ---------------------------------------------------------------
% training the neural network until the sum-error meets the
requirement
% ---------------------------------------------------------------

    train_pred = sim(net,P);
    train_pred=train_pred';
    train_pred1=train_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Maximum compressive stress
    train_meas1=tr_in(:,n);
    train_comp=zeros(m,2);
    train_comp(:,1)=train_meas1;
    train_comp(:,2)=train_pred1;
    train_comp;

% ---------------------------------------------------------------
% calculate the coefficient of determination "r^2" for the
training sets
% ---------------------------------------------------------------

    r_squ_tra=corr2(train_meas1,train_pred1);
    r_squ_tr1=r_squ_tra^2;

% ---------------------------------------------------------------
% make the prediction for the test data sets
% ---------------------------------------------------------------

       [m1,n1]=size(te_in);
       test_in=zeros(m1,n1-1);
       for i=1:n1-1
        for j=1:m1
         test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
        end
       end
       TE=test_in;
       TE=TE';
       test_pred = sim(net,TE);
       test_pred=test_pred';
       test_pred1=test_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Maximum compressive stress
       test_meas1=te_in(:,n1);
       test_comp=zeros(m1,2);
       test_comp(:,1)=test_meas1;
       test_comp(:,2)=test_pred1;
       test_comp;


% ---------------------------------------------------------------
% calculate the coefficient of determination "r^2" for the testing
sets
% ---------------------------------------------------------------

       r_squ_tea=corr2(test_meas1,test_pred1);
       r_squ_te1=r_squ_tea^2;

       max_tr_r1=r_squ_tr1;
       max_te_r1=r_squ_te1;
% ---------------------------------------------------------------
% Relative weight of each input node
% ---------------------------------------------------------------

   [hid,in]=size(net.IW{1});
   w_part=zeros(hid,in);
   sum1=sum(abs(net.IW{1})');
   for i=1:hid
      w_part(i,:)=abs(net.IW{1}(i,:))/sum1(i);
      modi_w2(i)=mean(abs(net.LW{2,1}(i,:)));
      w_part(i,:)=w_part(i,:)*modi_w2(i);
      w_part(i,:)=w_part(i,:)*abs(net.LW{3,2}(i));
   end
   s=sum(w_part);
   ss=sum(s');
   RI=s/ss*100; % Relative Importance;

% ---------------------------------------------------------------
% Prediction Ultimate Pile Capacity for given input values
% ---------------------------------------------------------------

  if get(handles.chosenunit,'value')==1.%ENGLISH UNIT:
NEED CHANGE TO ENG unit


qu_test1_in=[frict_shaft,frict_toe,effec_stress*47.88,plength*0.
3048,cross_area*0.3048^2,0]; %ENG ----> SI Unit

qu_in=[frict_shaft,frict_toe,effec_stress,plength,cross_area]; %
Jetting = 0, Non-jetted = 1

   [m2,n2]=size(qu_test1_in);
     qu_te1_in=zeros(m2,n2);
      for i=1:n2
       for j=1:m2
        qu_te1_in(j,i)=(qu_test1_in(j,i)-tr_min(i))/(tr_max(i)-
tr_min(i));
       end
      end

       predic=qu_te1_in;
       predic=predic';
```

```
        te_pred = sim(net,predic);
        te_pred=te_pred';
        pred1=te_pred(:,1)*(tr_max(n)-tr_min(n))+tr_min(n);%
Ultimate Pile Capacity (kips)
        predict=pred1;

    set(handles.tx_value,'string',predict/4.448);
    set(handles.tx_value,'visible','on');
    set(handles.tx_kips,'visible','on');


% ------------------------------------------------------------
% OUTPUT: Pile Capacity Analysis
% ------------------------------------------------------------

    format bank
    E='';
    Time=datestr(now);
    cd ..

        fprintf('------------------------------------------------------------
----------------\n',E)
        fprintf('================ OUTPUTS: ULTIMATE
PILE CAPACITY(With Jetted) ==================\n',E)
        fprintf('------------------------------------------------------------
----------------\n',E)
        fprintf('                                                    \n',E)
        fprintf('                                                %s\n',
Time)
        fprintf('                                                \n',       E)
        fprintf('            Friction    Friction       Effective
Embbeded    Pile cross   %s\n',E)
        fprintf('             angle     angle near      stress at        pile
sectional   %s\n',E)
        fprintf('            at shaft    pile tip     pile tip (psf)    length
(ft)   area (ft^2)  %s\n',E)
        fprintf('INPUT                                                  \n',
E)

fprintf('            %3.1f\t    %4.1f\t       %6.1f\t       %5.1f\t
   %4.3f    \n', qu_in)
 %       fprintf('                                                \n',
E)
 %       fprintf('Relative Importance
\n', E)
 %
fprintf('            %3.1f\t    %4.1f\t       %6.1f\t       %5.1f\t
  %5.1f     \n', RI)
        fprintf('                                                \n',       E)
        fprintf('ULTIMATE PILE CAPACITY (kips) =
\n', E)
        fprintf('                                %3.1f             \n',
predict'/4.448)

%=== Output File Form ===

    output_file=get(handles.edit_saving,'string');
    fid=fopen(output_file,'wt');

        fprintf(fid,'------------------------------------------------------------
--------------------\n',E);
        fprintf(fid,'================ OUTPUTS: ULTIMATE
PILE CAPACITY(With Jetted) ==================\n',E);
        fprintf(fid,'------------------------------------------------------------
--------------------\n',E);
        fprintf(fid,'
\n',E);
        fprintf(fid,'                                                %s\n',
Time);
        fprintf(fid,'                                                \n',
E);
        fprintf(fid,'            Friction    Friction       Effective
Embbeded    Pile cross   %s\n',E);
        fprintf(fid,'             angle     angle near      stress at
pile       sectional   %s\n',E);
        fprintf(fid,'            at shaft    pile tip     pile tip (psf)
length (ft)   area (ft^2)  %s\n',E);
        fprintf(fid,'INPUT
\n',       E);

fprintf(fid,'            %3.1f\t    %4.1f\t  %6.1f\t   %4.1f\t       %4
.3f   \n', qu_in);
%       fprintf(fid,'                                                \n',
E);
%       fprintf(fid,'Relative Importance
\n', E);
%
fprintf(fid,'            %3.1f\t    %4.1f\t  %6.1f\t   %4.1f\t       %5.
1f     \n', RI);
        fprintf(fid,'                                                \n',
E);
        fprintf(fid,'ULTIMATE PILE CAPACITY (kips) =
\n', E);
        fprintf(fid,'                                %3.1f             \n',
predict'/4.448);


%----- plot comparison results
        axes(handles.ax_train)
        x=train_comp(:,1)/4.448;
        y=train_comp(:,2)/4.448;
        plot(x,y,'.')
        set(handles.ax_train,'LineWidth',1);
        xlabel('Measured Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');
        ylabel('Predicted Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/(4.448*30),max(train_comp(:,1))/(4.
448*1.07),['R^2=' num2str(r_squ_tr1)])
        hold on
        x=linspace(tr_min(n)/4.448, tr_max(n)/4.448);
        y=x;
        plot(x,y)
        grid on

        axes(handles.ax_test)
        z=test_comp(:,1)/4.448;
        w=test_comp(:,2)/4.448;
        plot(z,w,'.')
        set(handles.ax_test,'LineWidth',1);
        xlabel('Measured Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');
        ylabel('Predicted Ultimate Pile Capacity
(kips)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/(4.448*30),max(train_comp(:,1))/(4.
448*1.07),['R^2=' num2str(r_squ_te1)])
        hold on
        x=linspace(tr_min(n)/4.448, tr_max(n)/4.448);
        y=x;
        plot(x,y)
        grid on

  elseif get(handles.chosenunit,'value')==2 %SI Unit


qu_test1_in=[frict_shaft,frict_toe,effec_stress,plength,cross_are
a,0];
```

```
    qu_in1=[frict_shaft,frict_toe,effec_stress,plength,cross_area];

    [m2,n2]=size(qu_test1_in);
      qu_te1_in=zeros(m2,n2);
       for i=1:n2
        for j=1:m2
         qu_te1_in(j,i)=(qu_test1_in(j,i)-tr_min(i))/(tr_max(i)-
tr_min(i));
         end
       end

       predic=qu_te1_in;
       predic=predic';
       te_pred = sim(net,predic);
       te_pred=te_pred';
       pred1=te_pred(:,1)*(tr_max(n)-tr_min(n))+tr_min(n);%
Ultimate Pile Capacity (kips)
       predict=pred1;

    set(handles.tx_value,'string',predict);
    set(handles.tx_value,'visible','on')
    set(handles.tx_kips,'visible','on')

% ------------------------------------------------------------
% OUTPUT: Pile Capacity Analysis
% ------------------------------------------------------------

    format bank
    E='';
    Time=datestr(now);
    cd ..

       fprintf('------------------------------------------------------------
---------------\n',E)
       fprintf('================= OUTPUTS: ULTIMATE
PILE CAPACITY(With Jetted) ==================\n',E)
       fprintf('------------------------------------------------------------
---------------\n',E)
       fprintf('                                                  \n',E)
       fprintf('                                                %s\n',
Time)
       fprintf('                                                  \n',       E)
       fprintf('            Friction     Friction       Effective
Embbeded     Pile cross   %s\n',E)
       fprintf('             angle      angle near      stress at        pile
sectional   %s\n',E)
       fprintf('            at shaft     pile tip     pile tip (kPa)    length
(m)    area (m^2)  %s\n',E)
       fprintf('INPUT                                                \n',
E)
       fprintf('             %3.1f \t    %4.1f \t      %6.1f \t      %4.1f
\t      %4.3f      \n', qu_in1)
%       fprintf('                                                  \n',
E)
%       fprintf('Relative Importance
\n', E)
%       fprintf('             %3.1f \t      %6.1f \t        %4.1f
\t     %5.1f \t       %5.1f      \n', RI)
       fprintf('                                                  \n',       E)
       fprintf('ULTIMATE PILE CAPACITY (kN) =
\n', E)
       fprintf('                                    %3.1f              \n',
predict')

%=== Output File Form ===

    output_file=get(handles.edit_saving,'string');
    fid=fopen(output_file,'wt');
       fprintf(fid,'------------------------------------------------------------
---------------\n',E);
       fprintf(fid,'================= OUTPUTS: ULTIMATE
PILE CAPACITY(With Jetted) ==================\n',E);
       fprintf(fid,'------------------------------------------------------------
---------------\n',E);
       fprintf(fid,'
\n',E);
       fprintf(fid,'                                                %s\n',
Time);
       fprintf(fid,'                                                  \n',
E);
       fprintf(fid,'            Friction     Friction       Effective
Embbeded     Pile cross   %s\n',E);
       fprintf(fid,'             angle      angle near      stress at
pile       sectional   %s\n',E);
       fprintf(fid,'            at shaft     pile tip     pile tip (kPa)
length (m)    area (m^2)  %s\n',E);
       fprintf(fid,'INPUT
\n',       E);

fprintf(fid,'             %3.1f\t    %4.1f\t    %6.1f\t      %4.1f\t    %4
.3f      \n', qu_in1);
%       fprintf(fid,'                                                  \n',
E);
%       fprintf(fid,'Relative Importance
\n', E)
%
fprintf(fid,'             %3.1f\t    %6.1f\t        %4.1f\t     %5.1f\t
  %5.1f      \n', RI)
       fprintf(fid,'                                                  \n',
E);
       fprintf(fid,'ULTIMATE PILE CAPACITY (kN) =
\n', E);
       fprintf(fid,'                                    %3.1f              \n',
predict');


  %----- plot comparison results
       axes(handles.ax_train)
       x=train_comp(:,1);
       y=train_comp(:,2);
       plot(x,y,'.')
       set(handles.ax_train,'LineWidth',1);
       xlabel('Measured Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');
       ylabel('Predicted Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/30,max(train_comp(:,1))/1.07,['R^2='
num2str(r_squ_tr1)])
       hold on
       x=linspace(tr_min(n), tr_max(n));
       y=x;
       plot(x,y)
       grid on

       axes(handles.ax_test)
       z=test_comp(:,1);
       w=test_comp(:,2);
       plot(z,w,'.')
       set(handles.ax_test,'LineWidth',1);
       xlabel('Measured Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');
       ylabel('Predicted Ultimate Pile Capacity
(kN)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/30,max(train_comp(:,1))/1.07,['R^2='
num2str(r_squ_te1)])
       hold on
```

```
        x=linspace(tr_min(n), tr_max(n));
        y=x;
        plot(x,y)
        grid on

    end

end

disp('Comparison results (Training)')
[train_meas1, train_pred1]

disp('Comparison results (Testing)')
[test_meas1, test_pred1]

% --- Executes on button press in exit.
function exit_Callback(hObject, eventdata, handles)
% hObject    handle to exit (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)
close;



function edit_saving_Callback(hObject, eventdata, handles)
% hObject    handle to edit_saving (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of edit_saving as
text
%        str2double(get(hObject,'String')) returns contents of
edit_saving as a double


% --- Executes during object creation, after setting all properties.
function edit_saving_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit_saving (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
```

Appendix II ANFIS for Ultimate Pile Capacity

(ANFIS_CAPACITY)

II.1 Introduction

An adaptive neuro-fuzzy inference system model is developed to predict the ultimate load capacity of piles in cohesion-less soils. The same database of a number of non-jetted field pile load tests as the previous BPNN model was used for the development of this model, and a total of 68 data were split into two groups (training data set, and testing data set) randomly. The first group of 51 was used as a training set, and the remaining 17 data (25% of the data) were used for testing the robustness of the developed adaptive neuro-fuzzy inference system.

Five variables consisting of friction angle at shaft, friction angle around tip of the pile, effective stress at tip, pile length, pile cross-sectional area are selected as input variables. The friction angle of the soil around the shaft and near the tip of the pile provides information about the shear strength of surrounding and supporting soils. Effective stress at the tip of the pile has a significant role on calculating the pile capacity. The pile length as well as the cross-sectional area provide the necessary information about pile dimensions. Friction angle at shaft, friction angle around tip of the pile, effective stress at tip, pile length, pile cross-sectional area, and non-jetted condition are chosen as input variables to evaluate the pile capacity as the target variable. In the preprocessing stage, all the inputs of the training and testing sets are scaled between 0 and 1 before being presented to the network for making equivalent contributions.

Pile capacity is predicted using ANFIS and three commonly used empirical methods which are then compared with actual results from measurements. These three additional methods are proposed by Coyle and Castello (1981), Meyerhof (1976) and Vesic (1977). The results of this study indicate that the ANFIS model provides a better prediction than the conventional methods and can serve as a reliable and simple predictive tool for the prediction of axial loading capacity of piles considering the jetting methods. As more data become available, ANFIS models can be improved further to make more accurate capacity predictions for a wider range of load and site conditions.

II.2 Components of ANFIS_CAPACITY

Figures II-1 presents the main MATLAB (.m) file as well as training/testing data sets:

- ANFIS_CAPACITY.m:
- Training data set: train51.txt
- Testing data set: test17.txt

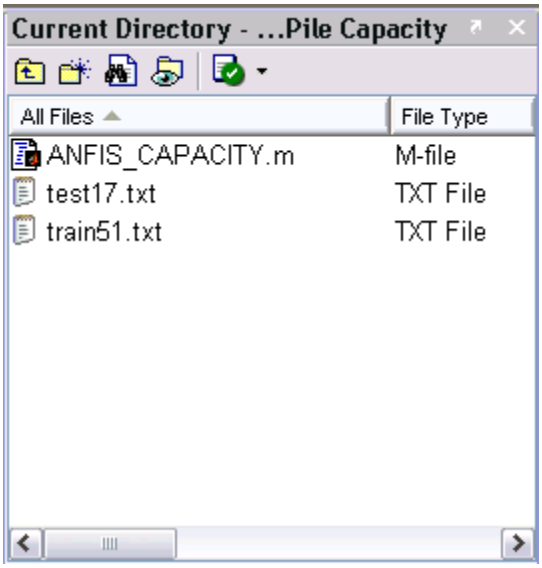


Figure II-1 components of ANFIS_SETUP

***Please do not change the order of the above files unless you modify the models.**

II.3 Training and testing

II.3.1 Training procedure

Using the program in section II.6.1, number and the types of membership functions for each input variables are determined. Usually types of membership functions for each input variables are determined first and then the number of the functions is chosen by trial and error. The two parameters are chosen to obtain the best possible performance from the network in terms of the highest coefficient of correlation R^2. Then the optimized parameters are applied to the program codes to predict the ultimate pile capacity.

II.3.2 Modeling and results

Table II-1 presents membership functions when the ANFIS model reaches an acceptable satisfactory level. Different types of linguistic terms for each input variable are dependent on different numbers of MFs for each input variable.

Table II-1 Type of MFs and number of MFs for each input variable

	ϕ at shaft	ϕ near pile tip	σ' at pile tip	Pile Length	Cross-sectional area
Type of MFs	General bell	Dsigmoid*	Triangle	Dsigmoid	Dsigmoid
Number of MFs	3	4	4	3	4
Linguistic terms	High Medium Low	Very high Above med. Medium Below med.	Very high Above med. Medium Below med.	Long Medium Short	Very large Above med. Medium Below med.

• Comparison Results (Training)

16.9 16.9
107.9 107.9
134.9 134.9
146.1 146.1
147.3 147.3
154.0 153.9
160.1 160.1
192.0 192.1
201.0 201.0
228.0 230.2
250.2 248.0
256.3 256.3
281.9 282.3
288.0 288.0
321.3 321.3
339.3 340.2

366.0	366.0
390.0	390.0
390.1	390.1
395.9	395.9
400.0	400.0
400.0	400.0
400.0	399.2
420.0	420.0
430.1	429.7
437.9	438.3
438.4	438.3
472.1	471.9
490.1	490.1
502.0	502.0
504.0	504.0
520.0	520.1
548.3	549.9
570.0	570.0
587.9	587.9
600.0	600.0
640.0	640.0
642.1	642.2
674.5	672.7
683.9	683.8
710.0	709.9
720.1	720.1
721.9	721.9
799.9	799.9
826.0	826.0
859.9	859.9
882.0	882.0
904.0	904.0
1049.9	1049.9
1124.1	1124.1
1259.9	1259.9

• Comparison Results (Testing)

116.7 115.1
147.9 149.8
198.3 189.3
207.3 342.0
288.0 290.0
366.0 366.0
400.0 457.4
408.0 288.2
430.1 412.3
486.5 726.3
516.0 475.2
560.0 512.3
605.9 529.9
690.0 450.8
719.4 773.6
740.1 640.6
1064.1 987.7

II.4 An example (Inputs and outputs)

II.4.1 Input data

• loading training and testing data set: train51.txt, test17.txt

• Input data information:

Enter the friction angle at pile shaft ==> ? 33
Enter the friction angle at pile tip ==> ? 37
Enter the effective stress at pile tip (psf) ==> ? 4300
Enter the pile length (ft) ==> ? 60
Enter the pile cross sectional area (ft^2) ==> ? 1.598

II.4.2 Outputs

• Prediction of Ultimate Pile Capacity (kips) by ANFIS

655.7264

II.5 Program Requirements and Limitations

i) Need Fuzzy toolbox as well as main MATLAB program.

ii) It takes some time to update/retrain the developed model.

iii) Number and the quality of data capturing all the 'physics' is a pre-requisite for a good model.

iv) Running time by ANFIS is much longer than by BPNN.

II.6 Program Source Code (ANFIS_CAPACITY)

II.6.1 Program codes for training and testing

• Iteration for decision on types of Memebrship Functions

```
clc
clear all

% ANFISA.m

% --------------------------------------------------------------
%   Using ANFIS for Value Prediction Problem
% --------------------------------------------------------------

diary training_results.txt

load train51.txt;
load test17.txt;
tr_in=train51;
te_in=test17;
[m,n]=size(tr_in);
tr=zeros(m,n);
in=zeros(n,2);
for i=1:n
 tr_max(i)=max(tr_in(:,i));
 tr_min(i)=min(tr_in(:,i));
  if tr_max(i) == tr_min(i)
    for j=1:m
      train_in(j,i)=1;
    end
  else
    for j=1:m
      train_in(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-tr_min(i));
    end
  end
 in(i,1)=min(tr(:,i));
 in(i,2)=max(tr(:,i));
end

[m1,n1]=size(te_in);
test_in=zeros(m1,n1);
  for i=1:n1
    for j=1:m1
      test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
    end
  end

numEpochs=20.;
numMFs=2.;
k={'dsigmf','trapmf','gbellmf' 'trimf','gaussmf'};

 for o=1:5
   for p=1:5
     for q=1:5
       for r=1:5
         for s=1:5
%    fis.input(1).mf.type=char(deblank(k(:,i)));


mftype=str2mat(char(deblank(k(:,o))),char(deblank(k(:,p))),char
(deblank(k(:,q))),char(deblank(k(:,r))),char(deblank(k(:,s))));

   fismat=genfis1(train_in,numMFs,mftype);

%Initial Membership Functions
%for i=1:n-1
%   h_figure3=figure;
%   figure(h_figure3);
%   [x,mf]=plotmf(fismat,'input',i);
%   plot(x,mf);
%   title('Initial Membership Functions')
%end

%trnOpt(2)=10.; % error goal
%[fismat1,trnErr,ss,fismat2,chkErr] = ...
 %   anfis(train_in,fismat,NaN,NaN,test_in,1);

[fismat1,trnErr,ss,fismat2,chkErr]=...
   anfis(train_in,fismat,numEpochs,NaN,test_in);%
dispOpt,chkData,optMethod)

   trnOut=evalfis(train_in(:,1:n-1),fismat1);
   tenOut=evalfis(test_in(:,1:n-1),fismat2);
   train_pred=trnOut.*(tr_max(n)-tr_min(n))+tr_min(n);
  test_pred=tenOut.*(tr_max(n)-tr_min(n))+tr_min(n);
  train_meas=tr_in(:,n);
  test_meas=te_in(:,n1);
  train_comp=zeros(m,2);
  train_comp(:,1)=train_meas;
  train_comp(:,2)=train_pred;
  train_comp;
   test_comp=zeros(m1,2);
  test_comp(:,1)=test_meas;
  test_comp(:,2)=test_pred;
```

```
  test_comp;

% ------------------------------------------------------------
% calculate the coeffient of determination "r^2" for the training
sets
% ------------------------------------------------------------

   e=train_meas-train_pred;
   ee=e.*e;
   Se_tr=sum(ee);
   r1=sum(train_meas.*train_meas)-Se_tr-
sum(train_meas).*sum(train_meas)./m;
   r2=sum(train_meas.*train_meas)-
sum(train_meas).*sum(train_meas)./m;
   r_squ_tr=r1./r2;
   trnRMSE=norm(train_pred -
train_meas)/sqrt(length(train_pred));

    r_squ_tra=corr2(train_meas,train_pred);
    r_squ_tr1=r_squ_tra^2;


% ------------------------------------------------------------
% calculate the coeffient of determination "r^2" for the testing
sets
% ------------------------------------------------------------
   e=test_meas-test_pred;
   ee=e.*e;
   Se_te=sum(ee);
   r1=sum(test_meas.*test_meas)-Se_te-
sum(test_meas).*sum(test_meas)./m1;
   r2=sum(test_meas.*test_meas)-
sum(test_meas).*sum(test_meas)./m1;
   r_squ_te=r1./r2;
  tenRMSE=norm(test_pred -
test_meas)/sqrt(length(test_pred));

     r_squ_tea=corr2(test_meas,test_pred);
     r_squ_te1=r_squ_tea^2;


   ijkmn=[o,p,q,r,s]%,n,o]

   r_squ_te=r1./r2%;,n,o)

            end
          end
        end
      end
    end
```

• Iteration for decision on number of Memebrship Functions

```
clc
clear all

% ------------------------------------------------------------
%   Using ANFIS for Value Prediction Problem
% ------------------------------------------------------------

diary training_result_nMF.txt

load train51.txt;
load test17.txt;
tr_in=train51;
te_in=test17;
[m,n]=size(tr_in);
tr=zeros(m,n);
in=zeros(n,2);
for i=1:n
 tr_max(i)=max(tr_in(:,i));
 tr_min(i)=min(tr_in(:,i));
   if tr_max(i) == tr_min(i)
     for j=1:m
       train_in(j,i)=1;
     end
   else
     for j=1:m
       train_in(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-tr_min(i));
     end
   end
 in(i,1)=min(tr(:,i));
 in(i,2)=max(tr(:,i));
end

[m1,n1]=size(te_in);
test_in=zeros(m1,n1);
  for i=1:n1
    for j=1:m1
      test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
    end
  end

numEpochs=20.;

%k={'dsigmf','trapmf','gbellmf' 'trimf','gaussmf'};

 for o=2:5
    for p=2:5
       for q=2:5
          for r=2:5
             for s=2:5

%fis.input(1).mf.type=char(deblank(k(:,i)));

%mftype=str2mat('gaussmf','dsigmf','trimf','dsigmf','gaussmf');
%5 1 4 1 5

mftype='trimf';

 numMFs=[o p q r s];

  fismat=genfis1(train_in,numMFs,mftype);

%Initial Membership Functions
%for i=1:n-1
%   h_figure3=figure;
%   figure(h_figure3);
%   [x,mf]=plotmf(fismat,'input',i);
%   plot(x,mf);
%   title('Initial Membership Functions')
%end

%trnOpt(2)=10.; % error goal
%[fismat1,trnErr,ss,fismat2,chkErr] = ...
 %   anfis(train_in,fismat,NaN,NaN,test_in,1);

[fismat1,trnErr,ss,fismat2,chkErr]=...
   anfis(train_in,fismat,numEpochs,NaN,test_in);%
dispOpt,chkData,optMethod)
```

```
   trnOut=evalfis(train_in(:,1:n-1),fismat1);
   tenOut=evalfis(test_in(:,1:n-1),fismat2);
   train_pred=trnOut.*(tr_max(n)-tr_min(n))+tr_min(n);
  test_pred=tenOut.*(tr_max(n)-tr_min(n))+tr_min(n);
  train_meas=tr_in(:,n);
  test_meas=te_in(:,n1);
  train_comp=zeros(m,2);
  train_comp(:,1)=train_meas;
  train_comp(:,2)=train_pred;
  train_comp;
   test_comp=zeros(m1,2);
  test_comp(:,1)=test_meas;
  test_comp(:,2)=test_pred;
  test_comp;

% ------------------------------------------------------------
% calculate the coeffient of determination "r^2" for the training
sets
% ------------------------------------------------------------

   e=train_meas-train_pred;
   ee=e.*e;
   Se_tr=sum(ee);
   r1=sum(train_meas.*train_meas)-Se_tr-
sum(train_meas).*sum(train_meas)./m;
   r2=sum(train_meas.*train_meas)-
sum(train_meas).*sum(train_meas)./m;
   r_squ_tr=r1./r2;
   trnRMSE=norm(train_pred -
train_meas)/sqrt(length(train_pred));

    r_squ_tra=corr2(train_meas,train_pred);
    r_squ_tr1=r_squ_tra^2;

% ------------------------------------------------------------
% calculate the coeffient of determination "r^2" for the testing
sets
% ------------------------------------------------------------

   e=test_meas-test_pred;
   ee=e.*e;
   Se_te=sum(ee);
   r1=sum(test_meas.*test_meas)-Se_te-
sum(test_meas).*sum(test_meas)./m1;
   r2=sum(test_meas.*test_meas)-
sum(test_meas).*sum(test_meas)./m1;
%   r_squ_te=r1./r2;
  tenRMSE=norm(test_pred -
test_meas)/sqrt(length(test_pred));

    r_squ_tea=corr2(test_meas,test_pred);
    r_squ_te1=r_squ_tea^2;


   opqrs=[o,p,q,r,s]%,n,o]
   r_squ_te1
   r_squ_te=r1./r2%;,n,o)

            end
          end
        end
    end
end
```

II.6.2 Program codes for prediction

```
clc
clear all

% ------------------------------------------------------------
%    get input information
% ------------------------------------------------------------

fric_shaft=input('Enter the friction angle at pile shaft ==> ?
','s');
fric_tip=input('Enter the friction angle at pile tip ==> ?  ','s');
effec=input('Enter the effective stress at pile tip (psf) ==> ?
','s');
length=input('Enter the pile length (ft) ==> ?  ','s');
area=input('Enter the pile cross sectional area (ft^2) ==> ?  ','s');

load train51.txt
load test17.txt

tr_in=train51;
te_in=test17;
[m,n]=size(tr_in);
tr=zeros(m,n);
in=zeros(n,2);
for i=1:n
  tr_max(i)=max(tr_in(:,i));
  tr_min(i)=min(tr_in(:,i));
    if tr_max(i) == tr_min(i)
      for j=1:m
        train_in(j,i)=1;
      end
    else
      for j=1:m
        train_in(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-tr_min(i));
      end
    end
  in(i,1)=min(tr(:,i));
  in(i,2)=max(tr(:,i));
end

[m1,n1]=size(te_in);
test_in=zeros(m1,n1);
  for i=1:n1
    for j=1:m1
      test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
    end
  end

  mfType = str2mat('gbellmf','dsigmf','trimf','dsigmf','dsigmf');
  numMFs = [3 4 4 3 4];
  numEpochs=6.;

  fismat=genfis1(train_in,numMFs,mfType);

%Initial Membership Functions
for i=1:n-1
  h_figure3=figure;
  figure(h_figure3);
  [x,mf]=plotmf(fismat,'input',i);
  if i==1.0
      st1='Initial MF: Friction angle at Pile shaft';
  elseif i==2.0
      st1='Initial MF: Friction angle near pile tip';
  elseif i==3.0
      st1='Initial MF: Effective stress at pile tip';
  elseif i==4.0
      st1='Initial MF: Pile length';
```

```
 elseif i==5.0
      st1='Initial MF: Pile cross-sectional area';
 end
  plot(x,mf);
  title(st1);
end

[fismat1,trnErr,ss,fismat2,chkErr]=...
   anfis(train_in,fismat,numEpochs,NaN,test_in);%
dispOpt,chkData,optMethod)

   trnOut=evalfis(train_in(:,1:n-1),fismat1);
   tenOut=evalfis(test_in(:,1:n-1),fismat2);
   train_pred=trnOut.*(tr_max(n)-tr_min(n))+tr_min(n);
  test_pred=tenOut.*(tr_max(n)-tr_min(n))+tr_min(n);
  train_meas=tr_in(:,n);
  test_meas=te_in(:,n1);
  train_comp=zeros(m,2);
  train_comp(:,1)=train_meas;
  train_comp(:,2)=train_pred;
  train_comp;
  test_comp=zeros(m1,2);
  test_comp(:,1)=test_meas;
  test_comp(:,2)=test_pred;
  test_comp;

% ------------------------------------------------------------
% calculate the coeffient of determination "r^2" for the training
sets
% ------------------------------------------------------------

   e=train_meas-train_pred;
   ee=e.*e;
   Se_tr=sum(ee);
   r1=sum(train_meas.*train_meas)-Se_tr-
sum(train_meas).*sum(train_meas)./m;
   r2=sum(train_meas.*train_meas)-
sum(train_meas).*sum(train_meas)./m;
   r_squ_tr=r1./r2;
%   trnRMSE=norm(train_pred -
train_meas)/sqrt(length(train_pred))

    r_squ_tra=corr2(train_meas,train_pred);
    r_squ_tr1=r_squ_tra^2;

% ------------------------------------------------------------
% calculate the coeffient of determination "r^2" for the testing
sets
% ------------------------------------------------------------

   e=test_meas-test_pred;
   ee=e.*e;
   Se_te=sum(ee);
   r1=sum(test_meas.*test_meas)-Se_te-
sum(test_meas).*sum(test_meas)./m1;
   r2=sum(test_meas.*test_meas)-
sum(test_meas).*sum(test_meas)./m1;
   r_squ_te=r1./r2;
%   tenRMSE=norm(test_pred -
test_meas)/sqrt(length(test_pred));

     r_squ_tea=corr2(test_meas,test_pred);
     r_squ_te2=r_squ_tea^2;

%  ------------------------------------------------------------
%   plot the membership functions for each input variable
%  ------------------------------------------------------------

member=zeros(181,3*(n-1));
for i=1:n-1
  h_figure=figure;
  figure(h_figure);
  [x,mf]=plotmf(fismat1,'input',i);
  x=x.*(tr_max(i)-tr_min(i))+tr_min(i);
  member(:,(3*i-2))=x(:,1);
  member(:,(3*i-1))=mf(:,1);
  member(:,(3*i))=mf(:,1);
  plot(x,mf);
  s2=num2str(i);

  if i==1.0
     st1='Final MF: Friction angle at Pile shaft';
  elseif i==2.0
     st1='Final MF: Friction angle near pile tip';
  elseif i==3.0
     st1='Final MF: Effective stress at pile tip';
  elseif i==4.0
     st1='Final MF: Pile length';
  elseif i==5.0
     st1='Final MF: Pile cross-sectional area';

  end

  title(st1);
  ylabel('Degree of Membership')
end

%  ------------------------------------------------------------
%   plot the error curves for training and testing data
%  ------------------------------------------------------------

h_figure1=figure;
figure(h_figure1);
epoch = 1:numEpochs;
plot(epoch,trnErr, 'o', epoch, chkErr, 'x')
hold on;
plot(epoch, [trnErr chkErr]);
hold off

%  ------------------------------------------------------------
%   Prediction for 5 input variables
%  ------------------------------------------------------------

v1=str2num(fric_shaft);
v2=str2num(fric_tip);
v3=str2num(effec);
v4=str2num(length);
v5=str2num(area);
v6=100.0;
pred_ult = [v1,v2,v3,v4,v5,v6];

[m2,n2]=size(pred_ult);
pred_in=zeros(m2,n2);
  for i=1:n2
    for j=1:m2
      pred_in(j,i)=(pred_ult(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
    end
  end

  mfType = str2mat('gbellmf','dsigmf','trimf','dsigmf','dsigmf');

  numMFs = [3 4 4 3 4];
  numEpochs=6.;
  fismat=genfis1(train_in,numMFs,mfType);

 [fismat1,trnErr,ss,fismat4,chkErr]=...
   anfis(train_in,fismat,numEpochs,NaN,pred_in);%
dispOpt,chkData,optMethod)
```

```
    predOut=evalfis(pred_in(:,1:n2-1),fismat4);
    pred=predOut.*(tr_max(n)-tr_min(n))+tr_min(n);

disp('Prediction of Ultimate Pile Capacity (kips) by ANFIS')
pred

% ------------------------------------------------------------------
% plot the final output for the training data set
% ------------------------------------------------------------------

h=axes('XLim',[0 10],'YLim',[0 10]);
subplot(221), plot(train_comp(:,1),train_comp(:,2),'.');
axis('square')
title('Trainning Data Sets')
xlabel('Measured Value   (kpa)');
ylabel('Predicted Value   (kpa)');
text(max(train_comp(:,1))/40,max(train_comp(:,1))/1.1,['R^2='
num2str(r_squ_tr)])
hold on
x=linspace(tr_min(n),tr_max(n));
x1=linspace(tr_min(n),tr_max(n)/2.);
y=x;
t1=2*x1;
t2=x./2;
plot(x,y)
hold on
plot(x1,t1,'-.')
hold on
plot(x,t2,'-.')

% ------------------------------------------------------------------
% plot the final output for the testing data set
% ------------------------------------------------------------------

subplot(222), plot(test_comp(:,1),test_comp(:,2),'.')
orient landscape
axis('square')
title('Testing Data Sets')
xlabel('Measured Value')
ylabel('Predicted Value')
text(max(test_comp(:,1))/40,max(test_comp(:,1))/1.1,['R^2='
num2str(r_squ_te)])
hold on
x=linspace(tr_min(n),tr_max(n));
y=x;
plot(x,y)
t1=2*x1;
t2=x./2;
plot(x,y)
hold on
plot(x1,t1,'-.')
hold on
plot(x,t2,'-.')
```

Appendix III BPNN Model for Pile Setup

(BPNN_SETUP)

III.1 Introduction

The evaluation of ultimate load capacity including pile setup may lead to more economical pile design yielding reductions in pile lengths, pile sections, and the size of driving equipment. The commonly used relationships to estimate pile setup are highly empirical. Also, the predictive empirical equations are limited by the corresponding data sets from which they are derived. These methods do not provide reliable predictions for use in the practice.

In the developed neural network, there is an input layer where input data are presented to the network and an output layer where exists a neuron representing the ultimate capacity and two hidden intermediate layers. A database is developed from the results of 96 field dynamic tests and CAPWAP analyses for pile capacity. Six variables are selected as input for the neural network model. These variables are: the soil type, the pile type, the pile diameter, the pile length, the time after EOD, and the effective stress at the tip. Setup is mainly affected by soil and pile type. Effective stress changing with time also has a significant role on the evaluation of the pile capacity. The pile length and diameter affect the setup influence zone.

In this study a four layer BPNN (back-propagation neural network) model is developed to predict pile capacity that is increased by setup. A database for 96 field tests is developed from the available literature for the training and testing of the model and six variables are selected as input in the model.

In the developed BPNN, there is an input layer, where input data are presented to network and an output layer, with one neuron representing the increase in pile capacity at the Beginning of Restrike by setup (ΔQ_{BOR}). Two hidden intermediate layers are also included. The variables are: soil type, pile type, pile diameter, pile length, time after pile installation, and effective stress at tip. The database from a variety of case studies available in the literature is developed from field dynamic tests; bearing capacities varying with time are calculated from CAPWAP analyses. The data set is randomly split into two groups: the first group of 73 is used for training the neural network model, and the remaining 23 data (24% of the data) are used for testing. The predictions by the neural network model are compared with those from four empirical relationships frequently used in practice. The four empirical methods are proposed by Skov and Denver(1986), Svinkin(1996), Long.et.al(1999), and

Svinkin and Skov(2000)). The results indicate that the neural network model provides a better prediction and can serve as a reliable and simple tool for the prediction of pile setup in the pile design.

III.2 BPNN Architecture and GUI

BPNN model is developed for prediction of pile setup. The neural network model adopted in this study utilizes the back-propagation learning algorithm with two hidden layers and nine hidden nodes as show in Figure III-1. Also, a logistic sigmoid function is selected as an activation function to transfer the input layer to first hidden layer and the second hidden layer to the output layer, whereas a hyperbolic tangent function is used to convert the first hidden layer into the second hidden layer by trial and error. Also, the Levenberg-Marquardt method is applied to make the convergence faster.

Figure III-2 presents the MATLAB GUI which consists of input information, comparison results, and prediction. Generally there are input spaces on the left hand side such as project title, soil type, pile type, embedded length, pile diameter, time after EOD, and effective stress at pile tip.

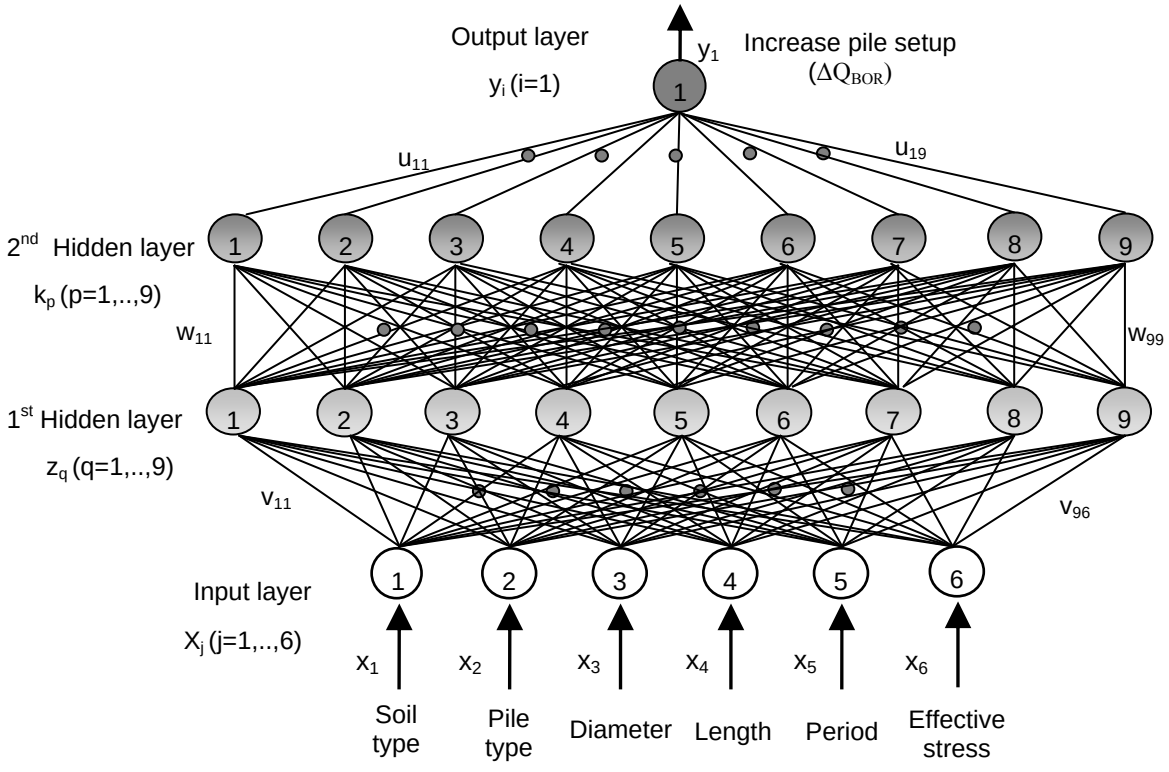


Figure III-1 BPNN architecture for prediction of pile setup

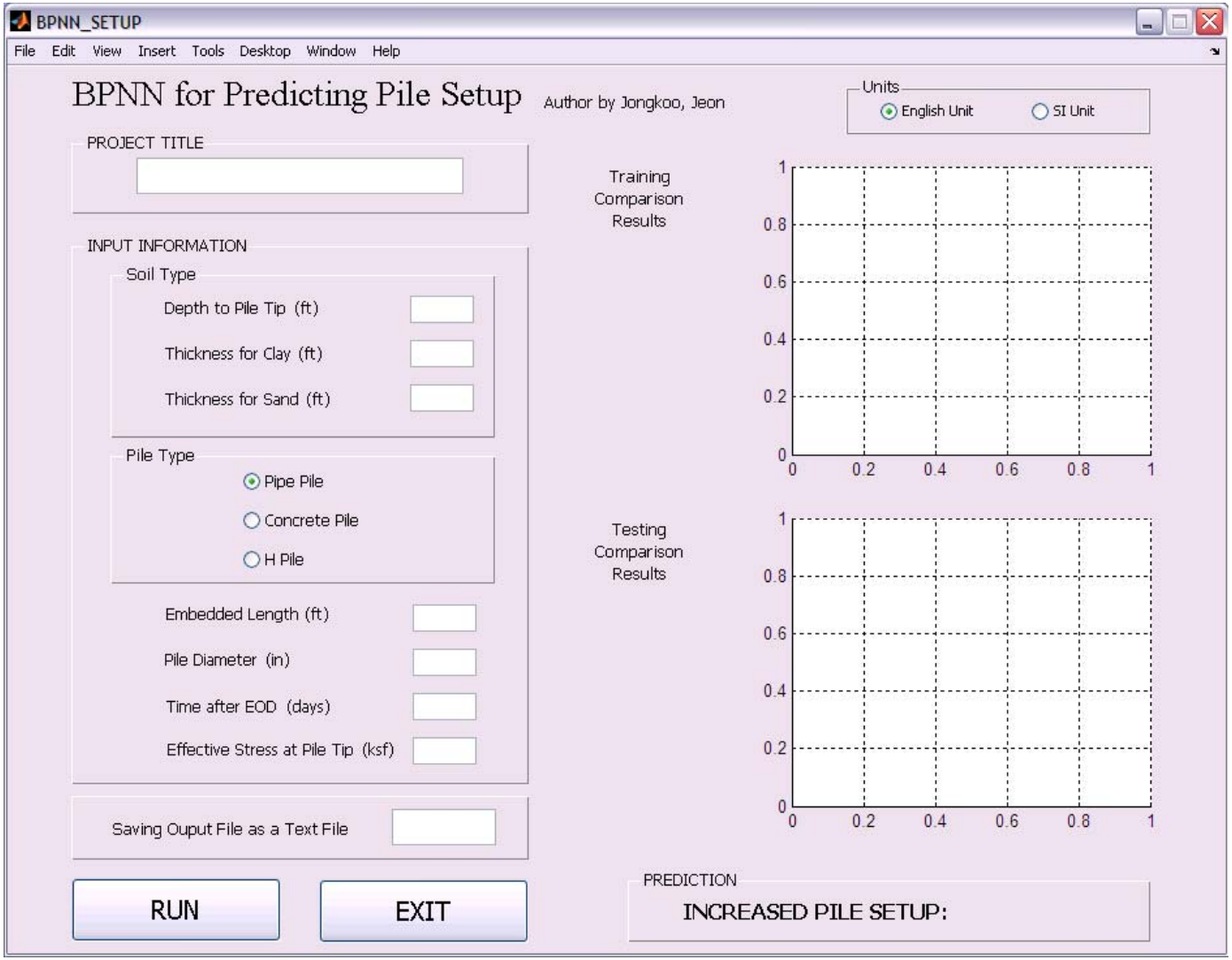


Figure III-2 A GUI of BPNN model for prediction of Ultimate Pile Capacity

III.3 Components of BPNN_SETUP

III.3.1 Main files in the MATLAB

Figure III-3(a) presents main files in the current directory for prediction of pile setup.

- BPNN_SETUP.m: when you write a program in MATLAB, you save it to a file called an M-file (named after its .m file extension).
- BPNN_SETUP.fig: GUI figure file

III.3.2 Data files for BPNN models

Optimal weight matrices and bias vectors are determined at the satisfactory level by trial and error. In order to reduce the runtime for training the models, the following are set into the networks:

- Training data set: train73.txt
- Testing data set: test23.txt
- Weight matrices: w1, w2, w3
- Bias vectors: b1, b2, b3

Figure III-3(b) presents the weights and bias files (*.txt) as well as training/testing data sets.

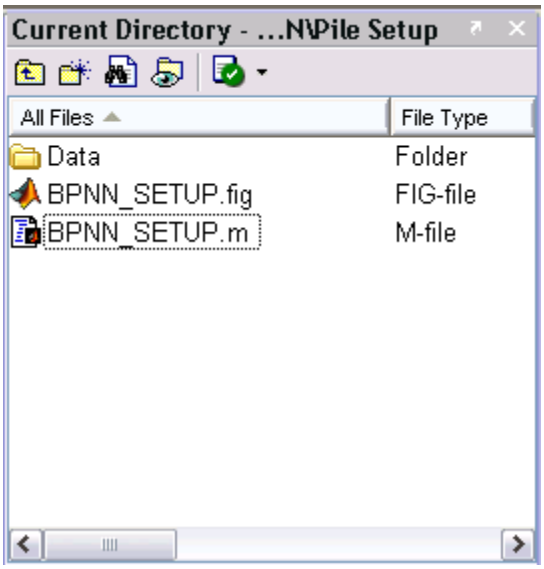


Figure III-3(a) current directory

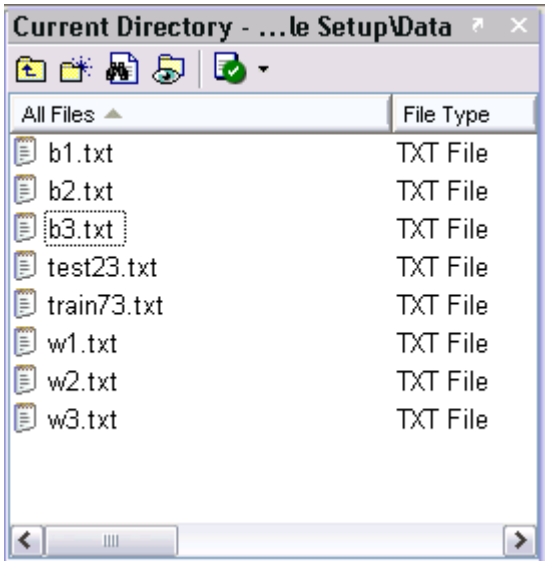


Figure III-3(b) txt files in the pile setup

***Please do not change the order of the above files unless you modify the models.**

III.4 Training and testing

III.4.1 Training procedure

Using the program codes in section I.6.1, initial weights (and biases), number of hidden nodes, and error goal (mean square error) are determined. The three parameters are chosen to obtain the best performance from the network in terms of the highest coefficient of correlation R^2 as shown in Figure III-4.

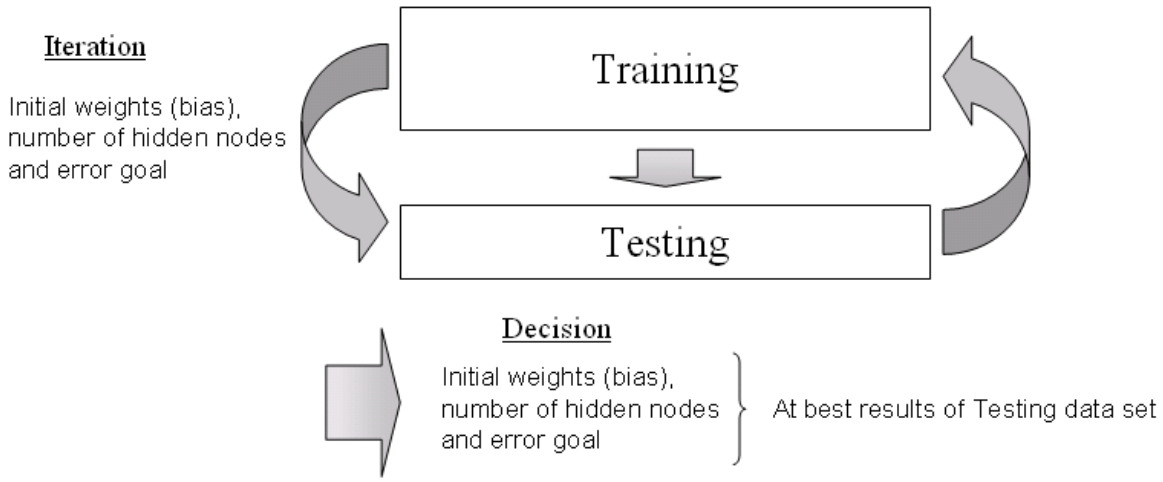


Figure III-4 Decision of learning parameters during training

III.4.2 Comparison results of Training and Testing data

The obtained optimized learning parameters are applied to testing data set. Then, comparison results of training and testing data set are presented:

• Comparison Results (Training)

95.00	95.39
262.00	261.89
405.00	402.55
325.00	331.29
574.00	572.69
20.20	25.33
161.00	160.64
157.00	157.05
192.00	192.35
376.00	375.90
323.00	322.01

1106.00	1106.75
183.00	184.87
831.90	832.80
1157.90	1139.59
652.00	650.82
449.60	448.66
292.30	293.50
607.00	607.18
629.50	629.37
337.20	336.57
607.00	607.09
123.70	123.51
40.20	25.49
159.00	157.68
71.60	66.29
159.30	162.41
25.00	43.09
52.20	44.79
177.40	181.82
171.10	165.64
247.80	249.06
157.70	154.64
285.20	284.56
545.20	545.20
145.00	145.11
315.90	315.38
155.10	178.87
247.10	228.99
315.00	335.37
155.10	178.87
256.10	228.99
334.10	320.18
52.20	52.98
60.50	54.05
171.10	173.07
158.50	158.96

440.90	441.23
32.10	59.28
74.20	68.74
154.50	146.08
198.10	228.40
26.50	59.17
100.30	68.74
251.10	250.79
258.50	228.40
272.90	273.13
165.20	164.75
202.80	202.94
218.50	218.20
115.80	116.58
266.40	266.95
264.20	263.54
156.90	156.82
160.00	151.84
340.00	343.89
126.00	140.35
254.00	244.69
24.70	26.16
275.00	277.27
160.10	162.16
340.20	344.30
405.20	415.40

• Comparison Results (Testing)

340.00	234.77
269.00	76.36
180.00	131.01
534.00	578.65
68.00	36.13
1016.20	1009.71
831.80	1134.05
27.00	49.17

138.00	55.54
60.50	36.06
365.90	255.94
283.90	281.65
296.10	303.37
298.10	324.20
177.40	102.61
247.80	230.14
366.70	369.82
178.30	250.79
189.30	146.08
228.20	174.14
230.00	216.53
43.90	33.26
230.00	221.42

III.5 An Example (Inputs & Outputs)

III.5.1 Input data

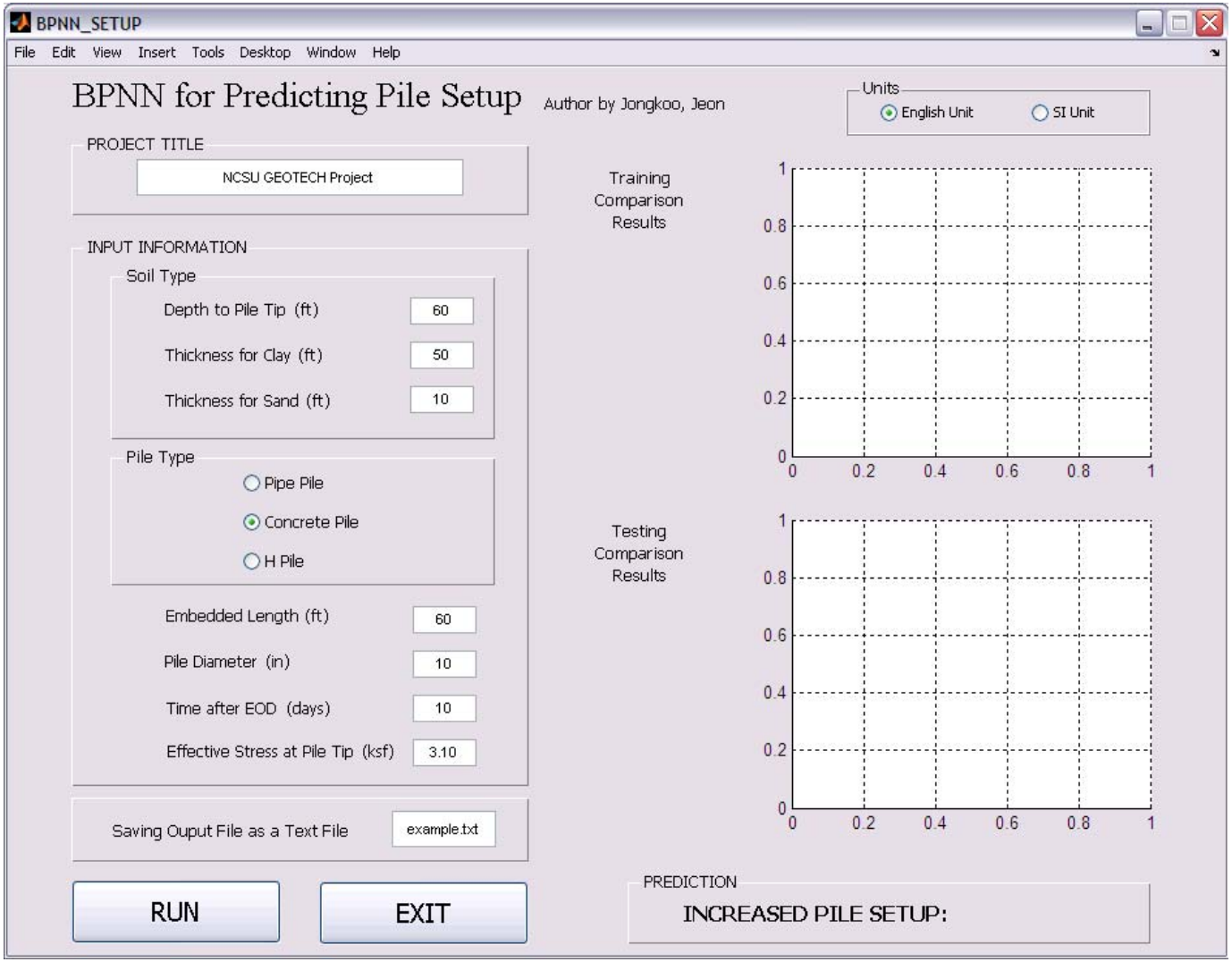


Figure III-5 An example for BPNN_SETUP (Input)

III.5.2 Outputs: **example.txt**

As shown in Figures III-6(a) and III-6(b), the new output file ('example.txt') was added in the directory after training.

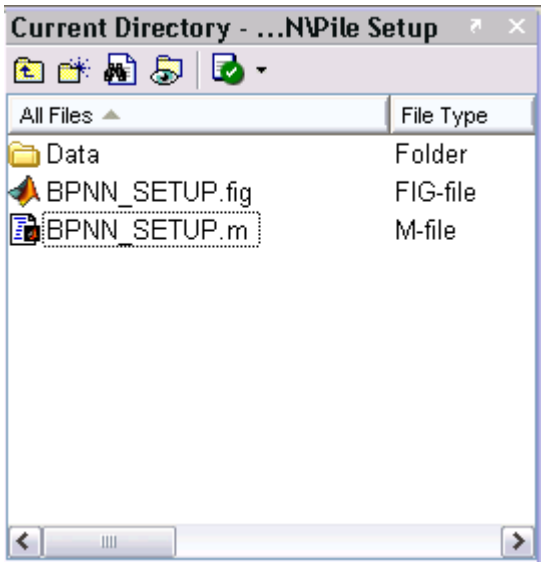


Figure III-6(a) Before training

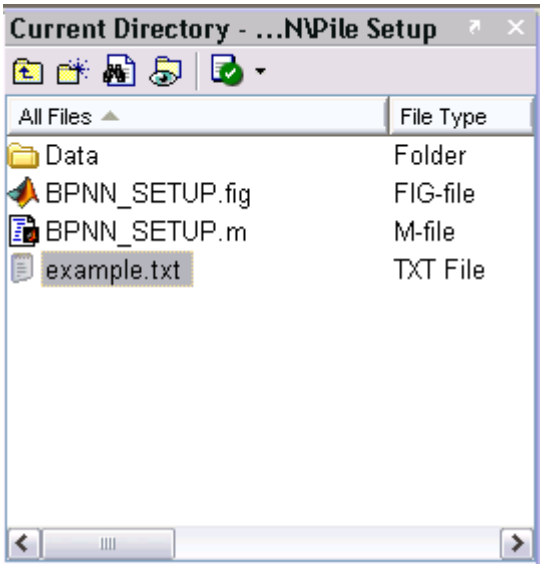


Figure III-6(b) After training

Outputs are:

iv) Input data
v) Relative Importance
vi) Predicted value (Increased Pile Setup)

========== OUTPUTS: PILE SETUP ==========

Project Title: NCSU GEOTECH Project

07-Aug-2007 08:49:47

	Soil Type	Pile Type	Pile Diameter (in)	Embbeded Pile Length (ft)	Time After EOD (days)	Effective Stress at Tip (ksf)
INPUT						
	1.8	2.0	10.0	60.0	10.0	3.100
Relative Importance						
	12.3	12.7	20.6	16.9	21.1	16.4

INCREASED PILE SETUP (kips) =

102.87

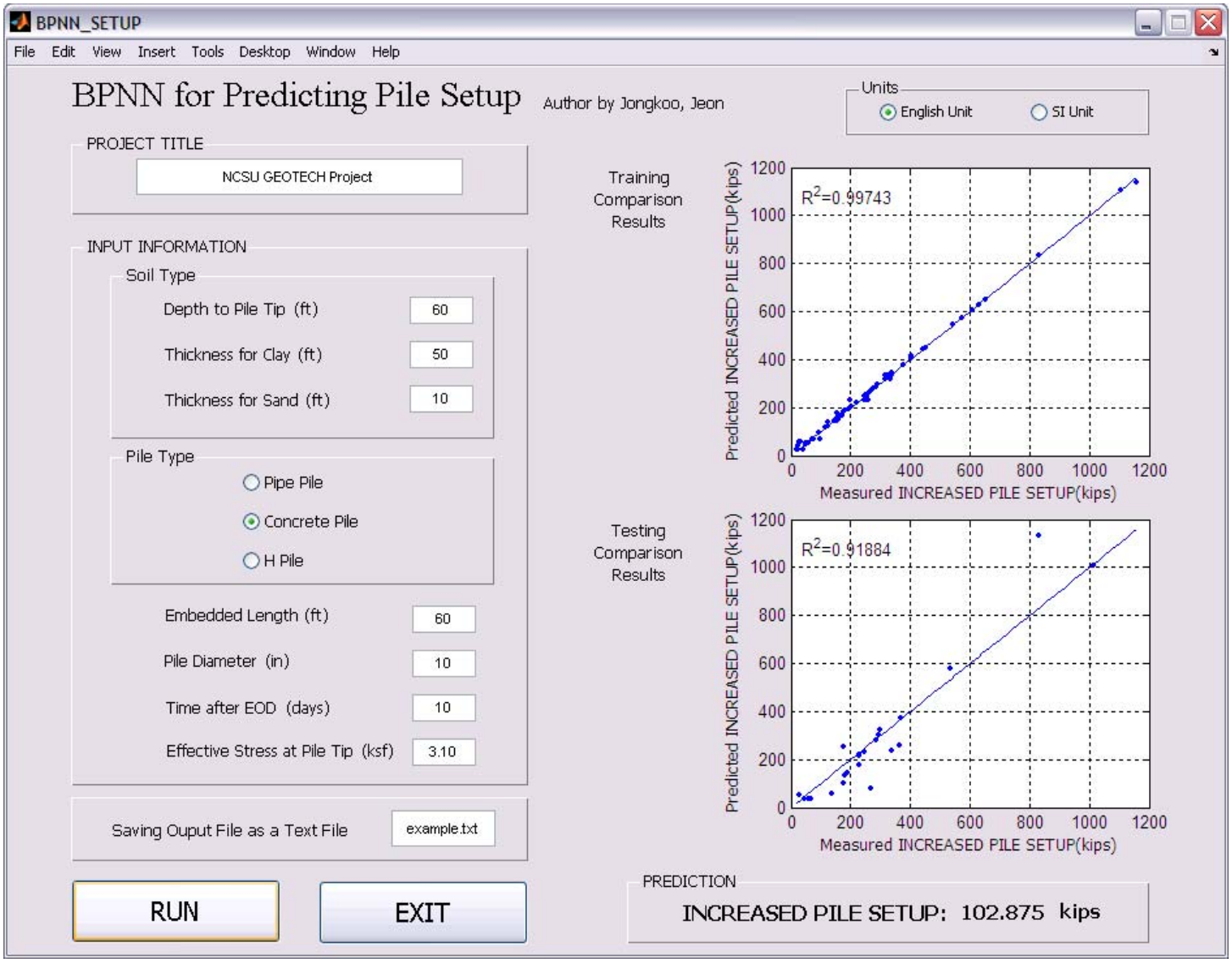


Figure III-6 An example for BPNN_SETUP (Outputs)

III.6 Program Requirements and Limitations

i) Need Neural Network toolbox as well as main MATLAB program.

ii) It takes some time to update/retrain the developed model.

iii) Number of data and a good quality data capturing all the 'physics' is a pr-requisite for a good model.

III.7 Program Source Code (BPNN_SETUP)

```
function varargout = BPNN_SETUP(varargin)
% BPNN_SETUP M-file for BPNN_SETUP.fig
%      BPNN_SETUP, by itself, creates a new BPNN_SETUP or
raises the existing
%      singleton*.
%
%      H = BPNN_SETUP returns the handle to a new
BPNN_SETUP or the handle to
%      the existing singleton*.
%
%
BPNN_SETUP('CALLBACK',hObject,eventData,handles,...)
calls the local
%      function named CALLBACK in BPNN_SETUP.M with
the given input arguments.
%
%      BPNN_SETUP('Property','Value',...) creates a new
BPNN_SETUP or raises the
%      existing singleton*.  Starting from the left, property
tx_value pairs are
%      applied to the GUI before
BPNN_SETUP_OpeningFunction gets called.  An
%      unrecognized property name or invalid tx_value makes
property application
%      stop.  All inputs are passed to
BPNN_SETUP_OpeningFcn via varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose
"GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help
BPNN_SETUP

% Last Modified by GUIDE v2.5 26-Dec-2006 12:19:40

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @BPNN_SETUP_OpeningFcn,
...
                   'gui_OutputFcn',  @BPNN_SETUP_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State,
varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before BPNN_SETUP is made visible.
function BPNN_SETUP_OpeningFcn(hObject, eventdata,
handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)
% varargin   command line arguments to BPNN_SETUP (see
VARARGIN)

% Choose default command line output for BPNN_SETUP
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes BPNN_SETUP wait for user response (see
UIRESUME)
% uiwait(handles.figure1);

set(handles.tx_chosenunit,'value',1);
set(handles.tx_chosenpile_type,'value',1);
set(handles.tx_value,'visible','off');
set(handles.tx_kips,'visible','off');

% --- Outputs from this function are returned to the command
line.
function varargout = BPNN_SETUP_OutputFcn(hObject,
eventdata, handles)
% varargout  cell array for returning output args (see
VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;
```

```
function project_title_Callback(hObject, eventdata, handles)
% hObject    handle to project_title (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of project_title as
text
%        str2double(get(hObject,'String')) returns contents of
project_title as a double


% --- Executes during object creation, after setting all
properties.
function project_title_CreateFcn(hObject, eventdata, handles)
% hObject    handle to project_title (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function soil_depth_Callback(hObject, eventdata, handles)
% hObject    handle to soil_depth (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of soil_depth as
text
%        str2double(get(hObject,'String')) returns contents of
soil_depth as a double


% --- Executes during object creation, after setting all
properties.
function soil_depth_CreateFcn(hObject, eventdata, handles)
% hObject    handle to soil_depth (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function clay_thick_Callback(hObject, eventdata, handles)
% hObject    handle to clay_thick (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of clay_thick as
text
%        str2double(get(hObject,'String')) returns contents of
clay_thick as a double


% --- Executes during object creation, after setting all
properties.
function clay_thick_CreateFcn(hObject, eventdata, handles)
% hObject    handle to clay_thick (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function sand_thick_Callback(hObject, eventdata, handles)
% hObject    handle to sand_thick (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of sand_thick as
text
%        str2double(get(hObject,'String')) returns contents of
sand_thick as a double


% --- Executes during object creation, after setting all
properties.
function sand_thick_CreateFcn(hObject, eventdata, handles)
% hObject    handle to sand_thick (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function length_Callback(hObject, eventdata, handles)
% hObject    handle to length (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of length as text
%        str2double(get(hObject,'String')) returns contents of
length as a double
```

```
% --- Executes during object creation, after setting all
properties.
function length_CreateFcn(hObject, eventdata, handles)
% hObject    handle to length (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function diameter_Callback(hObject, eventdata, handles)
% hObject    handle to diameter (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of diameter as
text
%        str2double(get(hObject,'String')) returns contents of
diameter as a double


% --- Executes during object creation, after setting all
properties.
function diameter_CreateFcn(hObject, eventdata, handles)
% hObject    handle to diameter (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function time_Callback(hObject, eventdata, handles)
% hObject    handle to time (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of time as text
%        str2double(get(hObject,'String')) returns contents of time
as a double


% --- Executes during object creation, after setting all
properties.
function time_CreateFcn(hObject, eventdata, handles)
% hObject    handle to time (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function stress_Callback(hObject, eventdata, handles)
% hObject    handle to stress (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of stress as text
%        str2double(get(hObject,'String')) returns contents of
stress as a double


% --- Executes during object creation, after setting all
properties.
function stress_CreateFcn(hObject, eventdata, handles)
% hObject    handle to stress (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function predict_Callback(hObject, eventdata, handles)
% hObject    handle to predict (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of predict as text
%        str2double(get(hObject,'String')) returns contents of
predict as a double


% --- Executes during object creation, after setting all
properties.
function predict_CreateFcn(hObject, eventdata, handles)
% hObject    handle to predict (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
```

```
    set(hObject,'BackgroundColor','white');
end


% --------------------------------------------------------------------
function unitgroup_SelectionChangeFcn(hObject, eventdata,
handles)
% hObject    handle to unitgroup (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

if (hObject==handles.english)
    set(handles.tx_soildepth,'String', '(ft)');
    set(handles.tx_claythick,'String', '(ft)');
    set(handles.tx_sandthick,'String', '(ft)');
    set(handles.tx_length,'String', '(ft)');
    set(handles.tx_diameter,'String', '(in)');
    set(handles.tx_stress,'String', '(ksf)');
    set(handles.tx_kips,'String', 'kips');
    set(handles.tx_chosenunit,'value',1);
else
    set(handles.tx_soildepth,'String', '(m)');
    set(handles.tx_claythick,'String', '(m)');
    set(handles.tx_sandthick,'String', '(m)');
    set(handles.tx_length,'String', '(m)');
    set(handles.tx_diameter,'String', '(mm)');
    set(handles.tx_stress,'String', '(kPa)');
    set(handles.tx_kips,'String', 'kN');
    set(handles.tx_chosenunit,'value',2);
end

% --------------------------------------------------------------------
function pile_type_SelectionChangeFcn(hObject, eventdata,
handles)
% hObject    handle to pile_type (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

if (hObject==handles.pipe)
    set(handles.tx_chosenpile_type,'Value',1);
elseif (hObject==handles.concrete)
    set(handles.tx_chosenpile_type,'Value',2);
elseif (hObject==handles.hpile)
    set(handles.tx_chosenpile_type,'Value',3);
end

%chosenpile_type is text box to present a value according to
pile type,
%hidden box.

% --- Executes on button press in run.
function run_Callback(hObject, eventdata, handles)
% hObject    handle to run (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)


project_title=get(handles.project_title,'string');
soil_depth=str2double(get(handles.soil_depth,'string'));
clay_thick=str2double(get(handles.clay_thick,'string'));
sand_thick=str2double(get(handles.sand_thick,'string'));
length=str2double(get(handles.length,'string'));
diameter=str2double(get(handles.diameter,'string'));
time=str2double(get(handles.time,'string'));
effect_stress=str2double(get(handles.stress,'string'));

% --------------------------------------------------------------------
% loading the input data sets and normalized for training and
testing
% --------------------------------------------------------------------

disp('                                          ')
cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Setup\Data');

load train73.txt;
load test23.txt;
load w1.txt;
load w2.txt;
load w3.txt;
load b1.txt;
load b2.txt;
load b3.txt;

% Loading the input data sets and normalization of training data
set

tr_in=train73;
te_in=test23;
in_wt1=w1;
in_wt2=w2;
in_wt3=w3;
in_bi1=b1;
in_bi2=b2;
in_bi3=b3;

[m,n]=size(tr_in);
trr=zeros(m,n);
in=zeros(n,2);
for i=1:n
  tr_max(i)=max(tr_in(:,i));
  tr_min(i)=min(tr_in(:,i));
    if tr_max(i) == tr_min(i)
      for j=1:m
        trr(j,i)=1;
      end
    else
      for j=1:m
        trr(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-tr_min(i));
      end
    end
  in(i,1)=min(trr(:,i));
  in(i,2)=max(trr(:,i));
end

% --------------------------------------------------------------------
% form the neural network parameters need for the training
stage
% --------------------------------------------------------------------

initt=in(1:(n-1),:);
P=trr(:,1:(n-1));
P=P';
T=trr(:,n).';

net=newff(initt,[9,9,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=in_wt1; % Given Initial Input Weights Matrix
net.LW{2,1}=in_wt2;
net.LW{3,2}=in_wt3;
net.b{1}=in_bi1; % Given Initial Bias Vetors
net.b{2}=in_bi2;
net.b{3}=in_bi3;
```

```
net.trainParam.epochs=1000;
net.trainParam.goal=1e-4;
net.trainParam.show=25;
[net,tr]=train(net,P,T);

% ---------------------------------------------------------------
% training the neural network until the sum-error meets the
requirement
% ---------------------------------------------------------------

    train_pred = sim(net,P);
    train_pred=train_pred';
    train_pred1=train_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Maximum compressive stress
    train_meas1=tr_in(:,n);
    train_comp=zeros(m,2);
    train_comp(:,1)=train_meas1;
    train_comp(:,2)=train_pred1;
    train_comp;

% ---------------------------------------------------------------
% calculate the coefficient of determination "r^2" for the
training sets
% ---------------------------------------------------------------

     r_squ_tra=corr2(train_meas1,train_pred1);
     r_squ_tr1=r_squ_tra^2;

% ---------------------------------------------------------------
% make the prediction for the test data sets
% ---------------------------------------------------------------

    [m1,n1]=size(te_in);
    test_in=zeros(m1,n1-1);
    for i=1:n1-1
      for j=1:m1
        test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-tr_min(i));
      end
    end
    TE=test_in;
    TE=TE';
    test_pred = sim(net,TE);
    test=test_in.';
    test_pred=test_pred';
    test_pred1=test_pred(:,1)*(tr_max(n)-
tr_min(n))+tr_min(n);% Maximum compressive stress
    test_meas1=te_in(:,n1);
    test_comp=zeros(m1,2);
    test_comp(:,1)=test_meas1;
    test_comp(:,2)=test_pred1;
    test_comp;



% ---------------------------------------------------------------
% calculate the coefficient of determination "r^2" for the testing
sets
% ---------------------------------------------------------------

     r_squ_tea=corr2(test_meas1,test_pred1);
     r_squ_te1=r_squ_tea^2;

       max_tr_r1=r_squ_tr1;
       max_te_r1=r_squ_te1;

% ---------------------------------------------------------------
% Relative weight of each input node
% ---------------------------------------------------------------

[hid,in]=size(net.IW{1});
w_part=zeros(hid,in);
sum1=sum(abs(net.IW{1})');
for i=1:hid
   w_part(i,:)=abs(net.IW{1}(i,:))/sum1(i);
   modi_w2(i)=mean(abs(net.LW{2,1}(i,:)));
   w_part(i,:)=w_part(i,:)*modi_w2(i);
   w_part(i,:)=w_part(i,:)*abs(net.LW{3,2}(i));
end
s=sum(w_part);
ss=sum(s');
RI=s/ss*100.; % Relative Importance

% ---------------------------------------------------------------
% Pile Setup Prediction for one case
% ---------------------------------------------------------------

soil_type=(clay_thick*2.0+sand_thick*1.0)/soil_depth;
pile_type=get(handles.tx_chosenpile_type,'Value');

if get(handles.tx_chosenunit,'value')==1.%ENGLISH UNIT

pile_test1_in=[soil_type,pile_type,diameter,length,time,effect_s
tress];%English unit
   [m2,n2]=size(pile_test1_in);
   pile_te1_in=zeros(m2,n2);
    for i=1:n2
      for j=1:m2
        pile_te1_in(j,i)=(pile_test1_in(j,i)-tr_min(i))/(tr_max(i)-
tr_min(i));
      end
    end

    PTE1=pile_te1_in;
    PTE1=PTE1';
    predict=sim(net,PTE1);
    predict=predict';
    pred=predict*(tr_max(n)-tr_min(n))+tr_min(n);

   set(handles.tx_value,'String',pred);
   set(handles.tx_value,'visible','on');
   set(handles.tx_kips,'visible','on');

% ---------------------------------------------------------------
% OUTPUT: Pile Setup Analysis - Increased Pile Setup
% ---------------------------------------------------------------

   format bank
   E='';
   Time=datestr(now);

   cd ..

   fprintf('-------------------------------------------------------------
-------------\n',E)
   fprintf('============================ OUTPUTS:
PILE SETUP  ============================\n',E)
   fprintf('-------------------------------------------------------------
-------------\n',E)
   fprintf('                                                  \n',E);
   fprintf('Project Title: %s\n',project_title);
   fprintf('                                                  %s\n',
Time);
   fprintf('                                                \n',       E)
   fprintf('            Soil      Pile       Pile       Embbeded       Time
Effective %s\n',E)
   fprintf('            Type      Type      Diameter   Pile Length
After EOD  Stress at Tip   %s\n',E)
   fprintf('                                  (in)       (ft)       (days)
(ksf)   %s\n',E)
```

```
    fprintf('INPUT                                                  \n',
E)
    fprintf('            %3.1f \t    %4.1f \t   %4.1f \t   %4.1f \t
%4.1f        %5.3f   \n', pile_test1_in)
    fprintf('                                                  \n',        E)
    fprintf('Relative Importance                                    \n',
E)
    fprintf('            %3.1f \t    %3.1f \t    %3.1f \t   %3.1f \t
%3.1f        %3.1f  \n', RI)
    fprintf('                                                  \n',        E)
    fprintf('INCREASED PILE SETUP (kips) =                        \n',
E)
    fprintf('                                  %3.2f              \n',  pred')


    % == Output File Form ==

    output_file=get(handles.outsaving,'string');
          fid=fopen(output_file,'wt');
    fprintf(fid,'-------------------------------------------------------------
-----------------\n',E);
    fprintf(fid,'========================== OUTPUTS:
PILE SETUP  ==============================\n',E);
    fprintf(fid,'-------------------------------------------------------------
-----------------\n',E);
    fprintf(fid,'                                                  \n',E);
    fprintf(fid,'Project Title: %s\n',project_title);
    fprintf(fid,'                                                  %s\n',
Time);
    fprintf(fid,'                                                  \n',        E);
    fprintf(fid,'            Soil      Pile       Pile       Embbeded
Time       Effective %s\n',E);
    fprintf(fid,'            Type      Type      Diameter   Pile Length
After EOD   Stress at Tip   %s\n',E);
    fprintf(fid,'                                  (in)       (ft)           (days)
(ksf)  %s\n',E);
    fprintf(fid,'INPUT                                                  \n',
E);
    fprintf(fid,'            %3.1f \t %4.1f \t   %4.1f \t  %4.1f \t
%4.1f        %5.3f   \n', pile_test1_in);
    fprintf(fid,'                                                  \n',
E);
    fprintf(fid,'Relative Importance
\n', E);
    fprintf(fid,'            %3.1f \t %3.1f \t   %3.1f \t  %3.1f \t
%3.1f        %3.1f  \n', RI);
    fprintf(fid,'                                                  \n',        E);
    fprintf(fid,'INCREASED PILE SETUP (kips) =
\n', E);
    fprintf(fid,'                                  %3.2f              \n',
pred');
    fclose(fid);

    % ---------------------------------------------------------------
    % plot the BPF output for the training data set
    % ---------------------------------------------------------------

    axes(handles.ax_train)
    x=train_comp(:,1);
    y=train_comp(:,2);
    plot(x,y,'.')
    set(handles.ax_train,'LineWidth',1);
    xlabel('Measured INCREASED PILE
SETUP(kips)','FontSize',9,'FontName','Tahoma');
    ylabel('Predicted INCREASED PILE
SETUP(kips)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/30,max(train_comp(:,1))/1.07,['R^2='
num2str(r_squ_tr1)])
    hold on
    x=linspace(tr_min(n), tr_max(n));
    y=x;
    plot(x,y)
    grid on

    % ---------------------------------------------------------------
    % plot the Maximum compressive stress output for the
testing data set
    % ---------------------------------------------------------------

    axes(handles.ax_test)
    z=test_comp(:,1);
    w=test_comp(:,2);
    plot(z,w,'.')
    set(handles.ax_test,'LineWidth',1);
    xlabel('Measured INCREASED PILE
SETUP(kips)','FontSize',9,'FontName','Tahoma');
    ylabel('Predicted INCREASED PILE
SETUP(kips)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/30,max(train_comp(:,1))/1.07,['R^2='
num2str(r_squ_te1)])
    hold on
    x=linspace(tr_min(n), tr_max(n));
    y=x;
    plot(x,y)
    grid on

elseif get(handles.tx_chosenunit,'value')==2.  %SI UNIT

pile_test1_in=[soil_type,pile_type,diameter/25.4,length/0.3048,t
ime,effect_stress/47.88];%SI--->English unit

pile_in=[soil_type,pile_type,diameter,length,time,effect_stress];
%SI unit
    [m2,n2]=size(pile_test1_in);
    pile_te1_in=zeros(m2,n2);
     for i=1:n2
       for j=1:m2
         pile_te1_in(j,i)=(pile_test1_in(j,i)-tr_min(i))/(tr_max(i)-
tr_min(i));
       end
     end

     PTE1=pile_te1_in;
     PTE1=PTE1';
     predict=sim(net,PTE1);
     predict=predict';
     pred=predict*(tr_max(n)-tr_min(n))+tr_min(n);

    set(handles.tx_value,'String',pred*4.448);%ENG ---> SI unit
    set(handles.tx_value,'visible','on');
    set(handles.tx_kips,'visible','on');

    format bank
    E='';
    Time=datestr(now);

    cd .. % Saving output to current directory

    fprintf('-------------------------------------------------------------
-------------\n',E)
    fprintf('========================== OUTPUTS:
PILE SETUP  ==============================\n',E)
    fprintf('-------------------------------------------------------------
-------------\n',E)
    fprintf('                                                  \n',E);
    fprintf('Project Title: %s\n',project_title);
    fprintf('                                                  %s\n',
Time);
```

```
    fprintf('                                                  \n',       E)
    fprintf('            Soil      Pile       Pile       Embbeded       Time
Effective %s\n',E)
    fprintf('            Type      Type      Diameter   Pile Length
After EOD  Stress at Tip   %s\n',E)
    fprintf('                                 (mm)       (m)       (days)
(Mpa)   %s\n',E)
    fprintf('INPUT                                                    \n',
E)
    fprintf('            %3.1f \t    %4.1f \t   %4.1f \t   %4.1f \t
%4.1f        %5.3f   \n', pile_in)
    fprintf('                                                  \n',       E)
    fprintf('Relative Importance                                      \n',
E)
    fprintf('            %3.1f \t    %3.1f \t    %3.1f \t   %3.1f \t
%3.1f        %3.1f  \n', RI)
    fprintf('                                                  \n',       E)
    fprintf('INCREASED PILE SETUP (kN) =                              \n',
E)
    fprintf('                                  %3.2f              \n',
pred'*4.448)


    % == Output File Form ==

    output_file=get(handles.outsaving,'string');
          fid=fopen(output_file,'wt');
    fprintf(fid,'-------------------------------------------------------------
-----------------\n',E);
    fprintf(fid,'========================== OUTPUTS:
PILE SETUP  ============================\n',E);
    fprintf(fid,'-------------------------------------------------------------
-----------------\n',E);
    fprintf(fid,'                                                  \n',E);
    fprintf(fid,'Project Title: %s\n',project_title);
    fprintf(fid,'                                                  %s\n',
Time);
    fprintf(fid,'                                                  \n',       E);
    fprintf(fid,'            Soil      Pile       Pile       Embbeded
Time       Effective %s\n',E);
    fprintf(fid,'            Type      Type      Diameter   Pile Length
After EOD   Stress at Tip   %s\n',E);
    fprintf(fid,'                                 (mm)       (m)           (days)
(Mpa)  %s\n',E);
    fprintf(fid,'INPUT                                                    \n',
E);
    fprintf(fid,'            %3.1f \t %4.1f \t   %4.1f \t  %4.1f \t
%4.1f        %5.3f   \n', pile_test1_in);
    fprintf(fid,'                                                  \n',
E);
    fprintf(fid,'Relative Importance
\n', E);
    fprintf(fid,'            %3.1f \t %3.1f \t   %3.1f \t  %3.1f \t
%3.1f        %3.1f  \n', RI);
    fprintf(fid,'                                                  \n',       E);
    fprintf(fid,'INCREASED PILE SETUP (kN) =
\n', E);
    fprintf(fid,'                                  %3.2f              \n',
pred'*4.448);
    fclose(fid);


    % ------------------------------------------------------------
    % plot the BPF output for the training data set
    % ------------------------------------------------------------

    axes(handles.ax_train)
    x=train_meas1/4.448;
    y=train_pred1/4.448;
    plot(x,y,'.')
    set(handles.ax_train,'LineWidth',1);
    xlabel('Measured INCREASED PILE
SETUP(kN)','FontSize',9,'FontName','Tahoma');
    ylabel('Predicted INCREASED PILE
SETUP(kN)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/(4.448*30),max(train_comp(:,1))/(4.
448*1.07),['R^2=' num2str(r_squ_tr1)])
    hold on
    x=linspace(tr_min(n)/4.448, tr_max(n)/4.448);
    y=x;
    plot(x,y)
    grid on

    % ------------------------------------------------------------------
    % plot the Maximum compressive stress output for the
testing data set
    % ------------------------------------------------------------------

    axes(handles.ax_test)
    z=test_meas1/4.448;
    w=test_pred1/4.448;
    plot(z,w,'.')
    set(handles.ax_test,'LineWidth',1);
    xlabel('Measured INCREASED PILE
SETUP(kN)','FontSize',9,'FontName','Tahoma');
    ylabel('Predicted INCREASED PILE
SETUP(kN)','FontSize',9,'FontName','Tahoma');

text(max(train_comp(:,1))/(4.448*30),max(train_comp(:,1))/(4.
448*1.07),['R^2=' num2str(r_squ_te1)])
    hold on
    x=linspace(tr_min(n)/4.448, tr_max(n)/4.448);
    y=x;
    plot(x,y)
    grid on

end



% --- Executes on button press in exit.
function exit_Callback(hObject, eventdata, handles)
% hObject    handle to exit (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)
close;


function outsaving_Callback(hObject, eventdata, handles)
% hObject    handle to outsaving (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of outsaving as
text
%        str2double(get(hObject,'String')) returns contents of
outsaving as a double


% --- Executes during object creation, after setting all
properties.
function outsaving_CreateFcn(hObject, eventdata, handles)
% hObject    handle to outsaving (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
```

```
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

clear all
clc
```

Appendix IV ANFIS for Pile Setup

(ANFIS_SETUP)

IV.1 Introduction

The training and testing of the network were based on a database of 96 CAPWAP driven piles test data extracted from the literature review. Six variables are selected as input to the developed ANFIS. These variables are: i) soil type, ii) roughness factor of pile iii) pile diameter, iv) embedded pile length, v) time after EOD, vi) effective stress at pile tip. Setup is mainly affected by soil type. Effective stress changing with time also has a significant role on the evaluation of pile capacity. The pile length and pile diameter affect the setup influence zone. The setup for the pile type depends on the soil/pile interface coefficient of friction. The coefficient of friction is influenced by the roughness of pile material. A total of 96 data were split randomly into two groups: the first group of 73 data is used as training set, and the remaining 23 data (about 24% of the all the data) are used for testing data set. The values associated with soil type are chosen as: 1 for sand, 2 for clay and others are calculated by considering percentage of soil type (sand, clay) up to the pile tip.

An adaptive neuro-fuzzy inference system model is developed to predict the ultimate pile capacity increase by setup. In the developed ANFIS, six variables consisting of soil type, roughness volume of pile shaft, pile diameter, embedded pile length, time after EOD, and effective stress at pile tip are selected as input variables to evaluate the increase in pile setup, which is the target variable. Types and numbers of MF (Membership Function) for each input variables are decided when testing data reach the highest correlation coefficient. Pile setup predictions are made using ANFIS as well as commonly used empirical methods, which are then compared with actual measurements. The other methods are those proposed by Skov and Denver(1986), Svkinkin(1996), Long.et.al(1999), and Svinkin and Skov(2000)). The results of this study indicate that ANFIS provides a better prediction and can serve as a reliable tool for the prediction of ultimate capacity of pile.

IV.2 Components of ANFIS_SETUP

Figures IV-1 presents used main MATALB files as well as training/testing data sets:

- ANFIS_SETUP.m:
- Training data set: train73.txt
- Testing data set: test23.txt

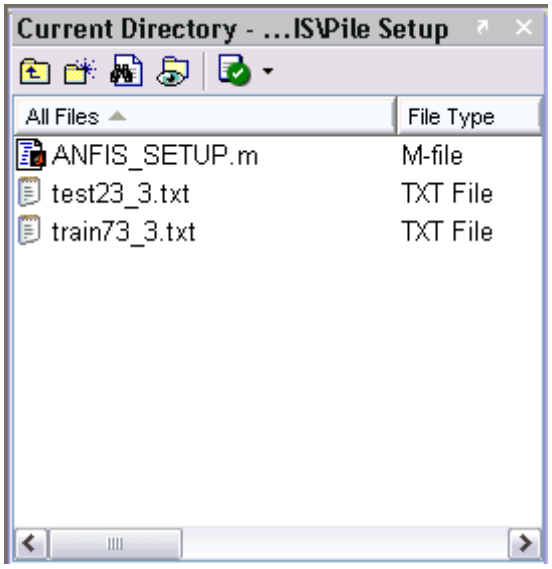


Figure IV-1 components of ANFIS_SETUP

***Please do not change the order of the above files unless you modify the models.**

IV.3 Training and testing

IV.3.1 Training procedure

Using the program codes in section II.6.1, number and the types of membership functions are determined. Usually types of membership functions for each input variable are determined first, then the number of membership functions are chosen by trial and error. The two parameters are chosen to obtain the best network (testing data set) performance in terms of the highest coefficient of correlation R^2. Then the optimized parameters are applied to the program to predict the ultimate pile capacity.

IV.3.2 Modeling and results

Table IV-1 presents membership functions for each input variable when the ANFIS model reaches an acceptable satisfactory level. Different types of linguistic terms for each input variable are dependent on different numbers of MFs.

Table IV-1Type of MFs and number of MFs to each input variable

	Soil type	Pile Diameter	Roughness Volume of Pile shaft	Embedded Pile Length	Time after EOD	Effective stress
Type of MFs	Dsigmoid*	Dsigmoid	Dsigmoid	General Bell	Dsigmoid	Trapezoid
Number of MFs	2	4	3	2	3	2
Linguistic terms	High Low	Very high Fairly high Fairly low Very low	High Medium Low	High Low	High Medium Low	High Low

• Comparison Results (Training)

95.0 95.0
262.0 262.0
405.0 399.3
325.0 330.3
574.0 574.4
20.2 20.2
161.0 161.0
157.0 157.1
192.0 191.9
376.0 376.0
323.0 322.9
1106.0 1106.0
183.0 183.1
831.9 828.3
1157.9 1103.6
652.0 671.7
449.6 338.9
292.3 302.2
607.0 590.5
629.5 638.1
337.2 415.3

607.0 675.7
123.7 123.7
40.2 40.2
159.0 160.0
71.6 71.6
159.3 158.1
25.0 25.1
52.2 52.4
177.4 177.5
171.1 170.8
247.8 247.8
157.7 157.7
285.2 285.2
545.2 545.2
145.0 145.1
315.9 315.8
155.1 173.8
247.1 227.7
315.0 342.8
155.1 173.8
256.1 227.7
334.1 316.7
52.2 52.2
60.5 60.5
171.1 171.1
158.5 158.5
440.9 440.9
32.1 48.9
74.2 66.4
154.5 156.2
198.1 228.3
26.5 48.7
100.3 66.4
251.1 252.2
258.5 228.3
272.9 272.9

165.2 165.2
202.8 202.8
218.5 218.5
115.8 116.0
266.4 266.1
264.2 264.2
156.9 156.9
160.0 150.7
340.0 342.1
126.0 136.0
254.0 251.1
24.7 24.7
275.0 275.0
160.1 160.0
340.2 340.3
405.2 405.2

• Comparison Results (Testing)
340.0 275.0
269.0 274.6
180.0 234.7
534.0 323.8
68.0 68.0
1016.2 960.6
831.8 963.3
27.0 16.1
138.0 107.2
60.5 51.5
365.9 246.7
283.9 237.4
296.1 303.9
298.1 327.0
177.4 175.7
247.8 322.4
366.7 251.6
178.3 252.2

189.3 156.2
228.2 244.6
230.0 223.0
43.9 89.7
230.0 224.7

IV.4 An example (inputs and outputs)

IV.4.1 Input data

- loading training and testing data set: train73.txt, test23.txt
- Input data information:

Enter the soil type(1.0 for sand, 2.0 for clay) ==> ? 1.2
Enter the pile diameter size (in) ==> ? 18
Enter the roughness of pile shaft (in^3) ==> ? 57.1
Enter the pile length (ft) ==> ? 60
Enter the time after EOD (days) ==> ? 10
Enter the effective stress at pile tip (psf) ==> ? 3.10

IV.4.2 Outputs

- Prediction of Pile Setup (kips) by ANFIS

208.37

IV.5 Program Requirements and Limitations

i) Need Neural Network toolbox as well as main MATLAB program.
ii) In order to update/retrain the developed model, it takes some time.
iii) Number of data and a good quality data capturing all the 'physics' is a pr-requisite for a good model.
iv) Running time by ANFIS is much longer than by BPNN.

IV.6 Program Source Code (ANFIS_SETUP)

```
clc
clear all

% ------------------------------------------------------------
----
%    Using ANFIS for Prediction of Pile Setup
% ------------------------------------------------------------
----

soil_type=input('Enter the soil type(1.0 for sand,
2.0 for clay) ==> ?  ','s');
diameter=input('Enter the pile diameter size (in)
==> ?  ','s');
roughness=input('Enter the roughness of pile shaft
(in^3) ==> ?  ','s');
length=input('Enter the pile length (ft) ==> ?  ','s');
period=input('Enter the time after EOD (days)
==> ?  ','s');
effec=input('Enter the effective stress at pile tip
(psf) ==> ?  ','s');

load train73.txt;
load test23.txt;
tr_in=train73;
te_in=test23;
[m,n]=size(tr_in);
tr=zeros(m,n);
in=zeros(n,2);
for i=1:n
  tr_max(i)=max(tr_in(:,i));
  tr_min(i)=min(tr_in(:,i));
    if tr_max(i) == tr_min(i)
      for j=1:m
        train_in(j,i)=1;
      end
    else
      for j=1:m
        train_in(j,i)=(tr_in(j,i)-tr_min(i))./(tr_max(i)-
tr_min(i));
      end
    end
  in(i,1)=min(tr(:,i));
  in(i,2)=max(tr(:,i));
end

[m1,n1]=size(te_in);
test_in=zeros(m1,n1);
   for i=1:n1
     for j=1:m1
       test_in(j,i)=(te_in(j,i)-tr_min(i))/(tr_max(i)-
tr_min(i));
     end
   end

   mfType =
str2mat('dsigmf','dsigmf','dsigmf','gbellmf','dsigmf',
'trapmf'); %0.9074
   numMFs = [2 4 3 2 3 2];
   numEpochs=20.;

  fismat=genfis1(train_in,numMFs,mfType);

%Initial Membership Functions
for i=1:n-1
   h_figure3=figure;
   figure(h_figure3);
   [x,mf]=plotmf(fismat,'input',i);
   if i==1.0
       st1='Initial MF: Friction angle at Pile shaft';
   elseif i==2.0
       st1='Initial MF: Friction angle near pile tip';
   elseif i==3.0
       st1='Initial MF: Effective stress at pile tip';
   elseif i==4.0
       st1='Initial MF: Pile length';
  elseif i==5.0
       st1='Initial MF: Pile cross-sectional area';
  end
   plot(x,mf);
   title(st1);
end

[fismat1,trnErr,ss,fismat2,chkErr]=...
    anfis(train_in,fismat,numEpochs,NaN,test_in);%
dispOpt,chkData,optMethod)

    trnOut=evalfis(train_in(:,1:n-1),fismat1);
    tenOut=evalfis(test_in(:,1:n-1),fismat2);
    train_pred=trnOut.*(tr_max(n)-
tr_min(n))+tr_min(n);
   test_pred=tenOut.*(tr_max(n)-
tr_min(n))+tr_min(n);
   train_meas=tr_in(:,n);
   test_meas=te_in(:,n1);
   train_comp=zeros(m,2);
   train_comp(:,1)=train_meas;
   train_comp(:,2)=train_pred;
   train_comp;
    test_comp=zeros(m1,2);
   test_comp(:,1)=test_meas;
   test_comp(:,2)=test_pred;
   test_comp;

% ------------------------------------------------------------
----
```

```
% calculate the coeffient of determination "r^2" for
the training sets
% ---------------------------------------------------------
----

   e=train_meas-train_pred;
   ee=e.*e;
   Se_tr=sum(ee);
   r1=sum(train_meas.*train_meas)-Se_tr-
sum(train_meas).*sum(train_meas)./m;
   r2=sum(train_meas.*train_meas)-
sum(train_meas).*sum(train_meas)./m;
   r_squ_tr=r1./r2;
%   trnRMSE=norm(train_pred -
train_meas)/sqrt(length(train_pred));

    r_squ_tra=corr2(train_meas,train_pred);
    r_squ_tr1=r_squ_tra^2;

% ---------------------------------------------------------
----
% calculate the coeffient of determination "r^2" for
the testing sets
% ---------------------------------------------------------
----

   e=test_meas-test_pred;
   ee=e.*e;
   Se_te=sum(ee);
   r1=sum(test_meas.*test_meas)-Se_te-
sum(test_meas).*sum(test_meas)./m1;
   r2=sum(test_meas.*test_meas)-
sum(test_meas).*sum(test_meas)./m1;
   r_squ_te=r1./r2;
%   tenRMSE=norm(test_pred -
test_meas)/sqrt(length(test_pred));

    r_squ_tea=corr2(test_meas,test_pred);
    r_squ_te1=r_squ_tea^2;

%  ---------------------------------------------------------
%   plot the membership functions for each input
variable
%  ---------------------------------------------------------

member=zeros(181,3*(n-1));

for i=1:n-1
  h_figure=figure;
  figure(h_figure);
  [x,mf]=plotmf(fismat1,'input',i);
  x=x.*(tr_max(i)-tr_min(i))+tr_min(i);
  member(:,(3*i-2))=x(:,1);
  member(:,(3*i-1))=mf(:,1);
  member(:,(3*i))=mf(:,1);
  plot(x,mf);
  s2=num2str(i);

  if i==1.0
     st1='Final MFs: Soil type';
  elseif i==2.0
     st1='Final MFs: Pile diameter';
  elseif i==3.0
     st1='Final MFs: Roughness volume of pile
shaft';
  elseif i==4.0
     st1='Final MFs: Pile length';
  elseif i==5.0
     st1='Final MFs: Time after EOD';
  elseif i==6.0
     st1='Final MFs: Effective stress at pile tip';
  end

  title(st1);
  ylabel('Degree of Membership')
end

%  ---------------------------------------------------------
%   plot the error curves for training and testing
data
%  ---------------------------------------------------------

h_figure1=figure;
figure(h_figure1);
epoch = 1:numEpochs;
plot(epoch,trnErr, 'o', epoch, chkErr, 'x')
hold on;
plot(epoch, [trnErr chkErr]);
hold off

%  ---------------------------------------------------------
%   Prediction for 6 input variables
%  ---------------------------------------------------------

v1=str2num(soil_type);
v2=str2num(diameter);
v3=str2num(roughness);
v4=str2num(length);
v5=str2num(period);
v6=str2num(effec);
o1=100.0;
pred_setup = [v1,v2,v3,v4,v5,v6,o1];

[m2,n2]=size(pred_setup);
pred_in=zeros(m2,n2);
  for i=1:n2
    for j=1:m2
```

```
      pred_in(j,i)=(pred_setup(j,i)-
tr_min(i))/(tr_max(i)-tr_min(i));
    end
  end

  mfType =
str2mat('dsigmf','dsigmf','dsigmf','gbellmf','dsigmf',
'trapmf');
  numMFs = [2 4 3 2 3 2];
  numEpochs=20.;
  fismat=genfis1(train_in,numMFs,mfType);

 [fismat1,trnErr,ss,fismat4,chkErr]=...
   anfis(train_in,fismat,numEpochs,NaN,pred_in);

   predOut=evalfis(pred_in(:,1:n2-1),fismat4);
   pred=predOut.*(tr_max(n)-
tr_min(n))+tr_min(n);

disp('Prediction of Pile Setup(kips) by ANFIS')
pred

% ------------------------------------------------------------
----
% plot the final output for the training data set
% ------------------------------------------------------------
----

h=axes('XLim',[0 10],'YLim',[0 10]);
subplot(221),
plot(train_comp(:,1),train_comp(:,2),'.');
axis('square')
title('Trainning Data Sets')
xlabel('Measured Value (kips)');
ylabel('Predicted Value (kips)');
text(max(train_comp(:,1))/40,max(train_comp(:,1))
/1.1,['R^2=' num2str(r_squ_tr)])
hold on
x=linspace(tr_min(n),tr_max(n));
x1=linspace(tr_min(n),tr_max(n)/2.);
y=x;
t1=2*x1;
t2=x./2;
plot(x,y)
hold on
plot(x1,t1,'-.')
hold on
plot(x,t2,'-.')

% ------------------------------------------------------------
-----
% plot the final output for the testing data set
% ------------------------------------------------------------
-----

subplot(222), plot(test_comp(:,1),test_comp(:,2),'.')
orient landscape
axis('square')
title('Testing Data Sets')
xlabel('Measured Value (kips)');
ylabel('Predicted Value (kips)');
text(max(test_comp(:,1))/40,max(test_comp(:,1))/1
.1,['R^2=' num2str(r_squ_te1)])
hold on
x=linspace(tr_min(n),tr_max(n));
y=x;
plot(x,y)
t1=2*x1;
t2=x./2;
plot(x,y)
hold on
plot(x1,t1,'-.')
hold on
plot(x,t2,'-.')
```

Appendix V BPNN Model for Pile Drivability

(BPNN_DRIVABILITY)

V.1 Introduction

In practice pile driving criteria are provided for the contractor to drive the piles to a required pile bearing capacity for every bridge foundation project. A wave equation based computer program is used to generate the pile driving criterion. The pile driving criterion furnished to the contractor includes: i) hammer stroke vs BPF(1/set) for required bearing capacity, ii) Maximum compressive stresses vs BPF, iii) Maximum tensile stress vs BPF. However, this work takes a significant amount of time. During this time, several programs such as PILECAP, GRLWEAP, PDA, and CAPWAP are also needed. This current practice requires significant training skills, and can be very time consuming since lots of effort is devoted to the analysis, and there exists a need to develop an alternative model.

In this study a back-propagation neural network (BPNN) model is developed to predict pile drivability (maximum compressive and tensile stresses and BPF). A database for 4,017 HP piles is developed from 57 projects in the State of North Carolina (with both GRLWEAP data and soil profile information but without PDA and CAPWAP analyses). A total of 21 variables are chosen as input to predict three target variables. The input variables are the hammer, hammer cushion material, pile, soil information, ultimate pile capacities, and stroke. Stroke values have a range of 5 -11 ft based on an open-run database of GRLWEAP.

The database is divided into five groups with respect to the ultimate pile capacity range due to the difficulty in choosing the representative data for the training model among a huge amount of data and variety of the input variables. Each group is randomly split into two groups: the first group is used for training the neural network model, and the other (30% of training data set) for testing. In the developed network of each group, there is an input layer, where input data are presented to the network and an output layer along with two hidden intermediate layers. High correlations are obtained from the results of five groups and there are few scatters in the predictions for both training and testing sets.

To demonstrate the feasibility of BPNN, 25 cases are predicted by the developed BPNN, and the results are compared to GRLWEAP calculations derived from the built-in piles in North Carolina. The results indicate that BPNN model provides good predictions compared to GRLWEAP calculations and can serve as a reliable and simple predictive tool for the prediction of pile drivability. A computer program along with a GUI was developed using MATLAB for practising engineers.

V.2 BPNN Architecture and GUI

The back-propagation neural network consists of two phases. First, the data are propagated forward from input to output layer which produces an actual output. Then, in the second phase the error (the difference between the target values and the computed values) is propagated backward to update the weights and biases of the neurons and their connections in the same architecture (Figure V-1). Many cycles of these two computational phases are performed until an error goal is achieved using program codes in section I.6.1. In other words, the number of hidden layers and hidden nodes, transfer functions, and normalized data are determined to obtain the best model performance. At the end of the training phase, the neural network represents a model that should be able to predict the target value for the given input pattern. A logistic sigmoid function is selected to transfer the input layer to the first hidden layer and the second hidden layer to the output layer, whereas a hyperbolic tangent function is used to convert first hidden layer to second one. These are performed in each Qtype (Q1,--,Q5). Also, Levenberg-Marquardt method is used to make the convergence faster. Figure V-2 shows the GUI for the MATLAB program for prediction of pile drivability.

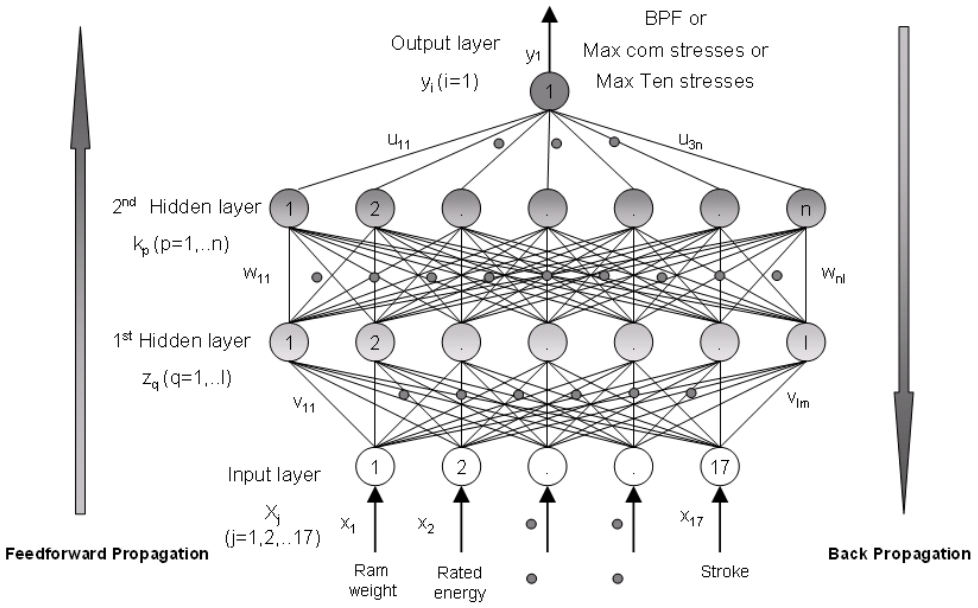


Figure V-1 BPNN architecture for prediction of pile drivability

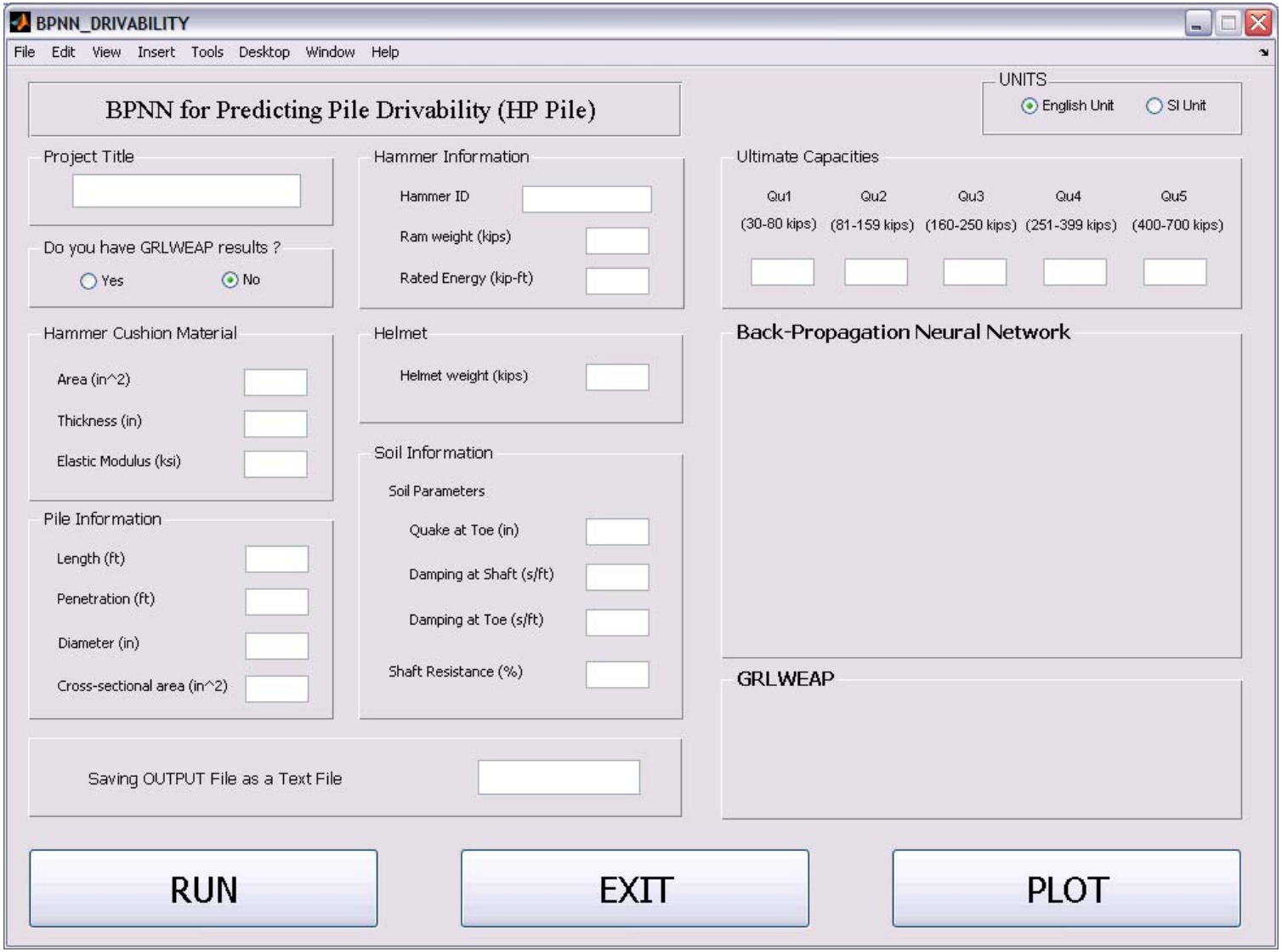


Figure V-2 A GUI of BPNN model for prediction of Ultimate Pile Capacity

V.3 Components of BPNN_DRIVABILITY

V.3.1 Main files in the MATLAB

Figure V-3(a) presents main files in the current directory for prediction of pile drivability.

- BPNN_DRIVABILITY.m:
- BPNN_DRIVABILITY.fig: GUI figure file

V.3.2 Data files for BPNN models

Optimal weight matrices and bias vectors are determined at the satisfactory level using trial and error. So, in order to reduce the running time for training the models, the followings are set in the networks:

- Training data set: trainq1.txt, trainq2.txt, trainq3.txt, trainq4.txt, and trainq5.txt
- Testing data set: testq1.txt, testq2.txt, testq3.txt, testq4.txt, and testq5.txt
- Weight matrices:
  - BPF: w1bpfqu1, w2bpfqu1, w3bpfqu1, w1bpfqu2, w2bpfqu2, w3bpfqu2, w1bpfqu3, w2bpfqu3, w3bpfqu3, w1bpfqu4, w2bpfqu4, w3bpfqu4, w1bpfqu5, w2bpfqu5, and w3bpfqu5
  - Max com: w1comqu1, w2comqu1, w3comqu1, w1comqu2, w2comqu2, w3comqu2, w1comqu3, w2comqu3, w3comqu3, w1comqu4, w2comqu4, w3comqu4, w1comqu5, w2comqu5, and w3comqu5
  - Max ten: w1tenqu1, w2tenqu1, w3tenqu1, w1tenqu2, w2tenqu2, w3tenqu2, w1tenqu3, w2tenqu3, w3tenqu3, w1tenqu4, w2tenqu4, w3tenqu4, w1tenqu5, w2tenqu5, and w3tenqu5
- Bias vectors:
  - BPF: b1bpfqu1, b2bpfqu1, b3bpfqu1, b1bpfqu2, b2bpfqu2, b3bpfqu2, b1bpfqu3, b2bpfqu3, b3bpfqu3, b1bpfqu4, b2bpfqu4, b3bpfqu4, b1bpfqu5, b2bpfqu5, and b3bpfqu5
  - Max com: b1comqu1, b2comqu1, b3comqu1, b1comqu2, b2comqu2, b3comqu2, b1comqu3, b2comqu3, b3comqu3, b1comqu4, b2comqu4, b3comqu4, b1comqu5, b2comqu5, and b3comqu5
  - Max ten: b1tenqu1, b2tenqu1, b3tenqu1, b1tenqu2, b2tenqu2, b3tenqu2, b1tenqu3, b2tenqu3, b3tenqu3, b1tenqu4, b2tenqu4, b3tenqu4, b1tenqu5, b2tenqu5, and b3tenqu5

Figure V-3(b) presents learning weights and bias files (*.txt) as well as training/testing data sets.

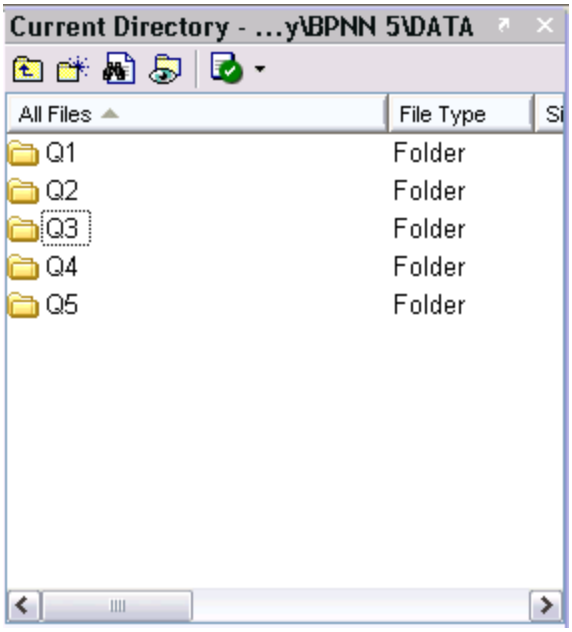


Figure V-3(a) current directory

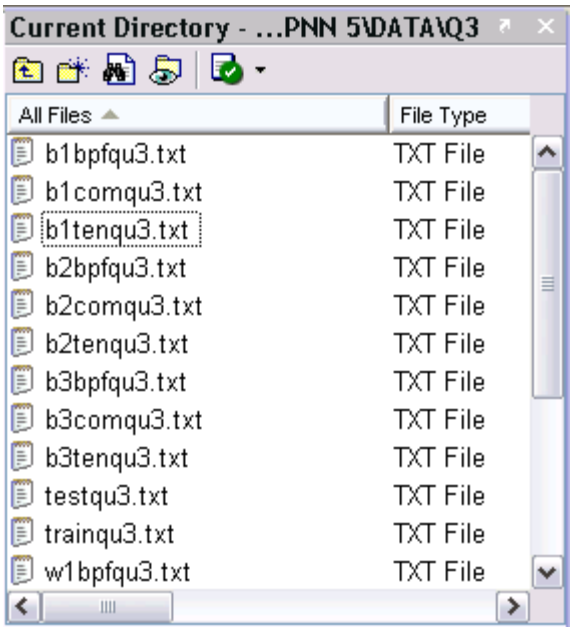


Figure V-3(b) txt files in the pile drivabiltiy

V.4. An Example (Inputs & Outputs)

V.4.1 Input data

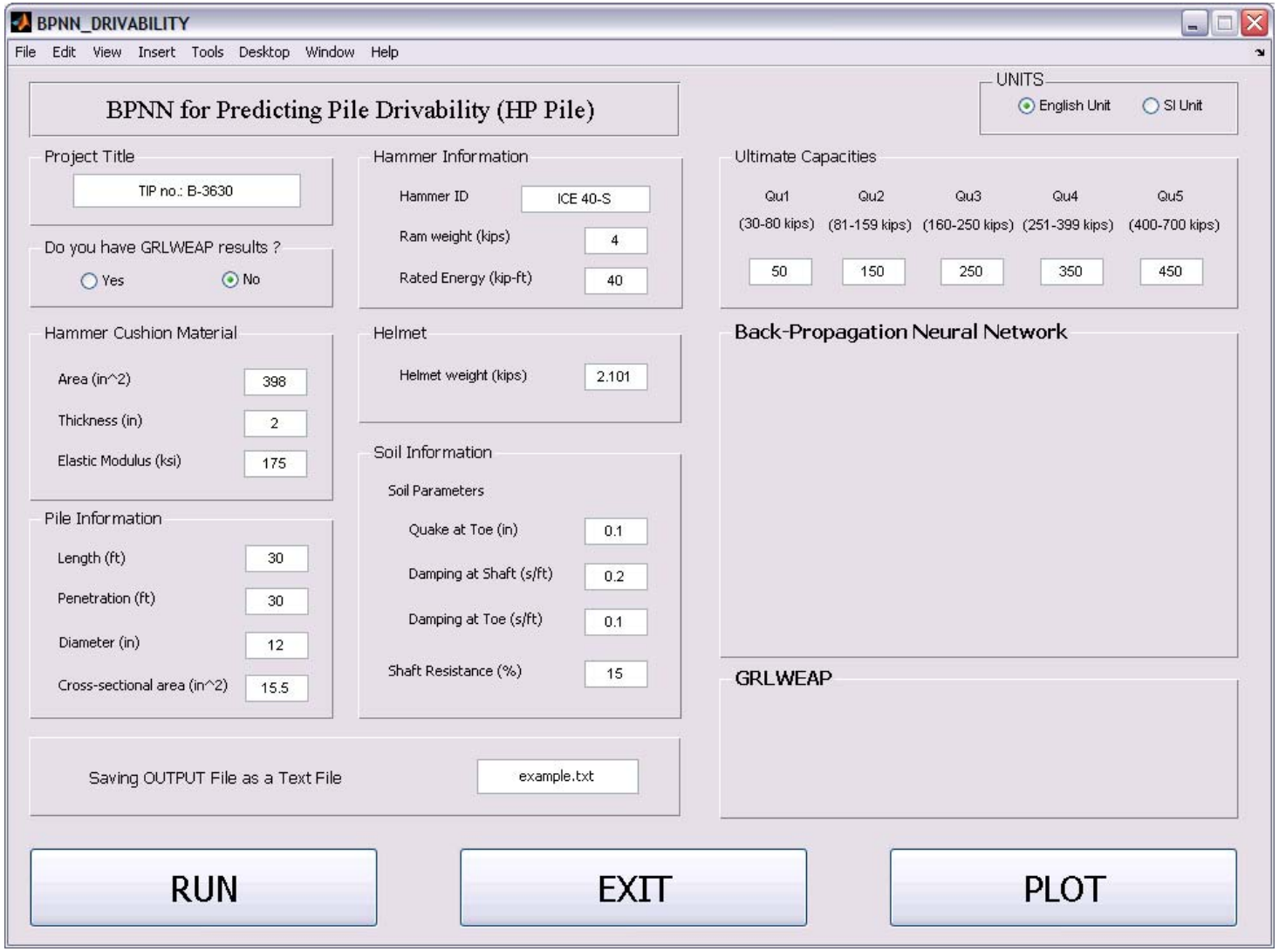


Figure V-4 An example for BPNN_CAPACITY (Input)

V.4.2 Procedure for training

---------- Qu1: 30 ~ 80 kips ----------
Training for Max Compression Stresses in Qu1,
Max Tension Stresses in Qu1,
BPF in Qu1,
Trainings for Qu1 are DONE: Performance goal met

---------- Qu2: 81 ~ 159 kips ----------
Training for Max Compression Stresses in Qu2,
Max Tension Stresses in Qu2,
BPF in Qu2,
Trainings for Qu2 are DONE: Performance goal met

---------- Qu3: 160 ~ 250 kips ----------
Training for Max Compression Stresses in Qu3,
Max Tension Stresses in Qu3,
BPF in Qu3,
Trainings for Qu3 are DONE: Performance goal met

---------- Qu4: 251 ~ 399 kips ----------
Training for Max Compression Stresses in Qu4,
Max Tension Stresses in Qu4,
BPF in Qu4,
Training for Qu4 is DONE: Performance goal met

---------- Qu5: 400 ~ 700 kips ----------
Training for Max Compression Stresses in Qu5,
Max Tension Stresses in Qu5,
BPF in Qu5,
Training for Qu5 is DONE: Performance goal met

V.4.3 Outputs: **example.txt**
As shown in Figures V-5(a) and V-5(b), the new output file (‘example.txt’) was added in the directory after training.

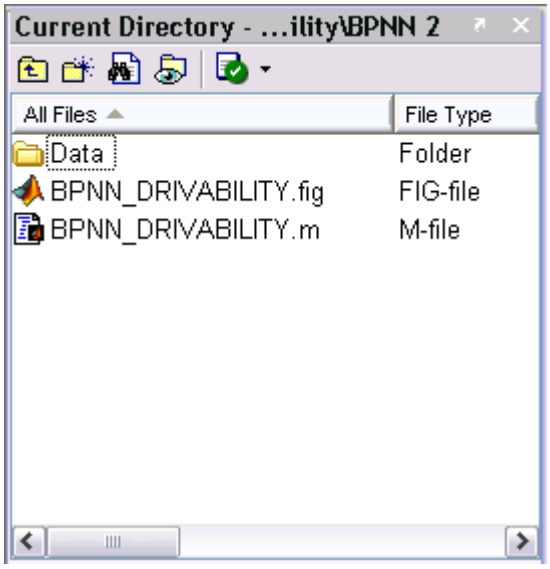


Figure V-5(a) Before training

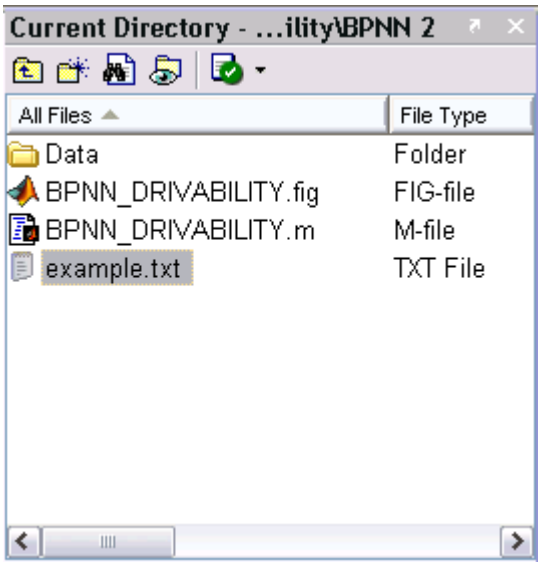


Figure V-5(b) After training

Output format are shown as follows:

vii) Input data

viii) Predicted values (BPF, Max Com Stresses, and Max Ten Stresses)

========== OUTPUT: Pile Drivability Analysis ==========

Project Title: TIP no.: B-3630

21-Oct-2007 00:23:34

Ultimate Capacity (kips)	Maximum Compression Stress (ksi)	Maximum Tension Stress (ksi)	Blow Count (bl/ct)	Stroke (ft)
50.0	9.54	0.005	4.5	5.0
50.0	10.68	0.008	4.3	5.5
50.0	12.07	0.013	4.1	6.0
50.0	13.74	0.022	4.0	6.5
50.0	15.68	0.036	3.8	7.0
50.0	17.87	0.060	3.7	7.5
50.0	20.27	0.105	3.6	8.0

50.0	22.77	0.194	3.5	8.5
50.0	25.29	0.385	3.4	9.0
50.0	27.68	0.808	3.4	9.5
50.0	29.86	1.713	3.3	10.0
50.0	31.75	3.385	3.3	10.5
50.0	33.32	5.689	3.3	11.0
150.0	17.32	0.091	31.5	5.0
150.0	18.51	0.087	29.5	5.5
150.0	19.54	0.082	27.3	6.0
150.0	20.67	0.075	25.3	6.5
150.0	22.06	0.068	23.6	7.0
150.0	23.47	0.059	22.2	7.5
150.0	24.74	0.050	21.0	8.0
150.0	25.93	0.041	19.9	8.5
150.0	27.16	0.033	18.9	9.0
150.0	28.55	0.026	17.9	9.5
150.0	30.12	0.021	17.0	10.0
150.0	31.78	0.018	16.0	10.5
150.0	33.36	0.016	15.1	11.0
250.0	22.28	0.721	91.6	5.0
250.0	22.77	0.698	77.8	5.5
250.0	23.25	0.677	69.3	6.0
250.0	23.81	0.666	63.5	6.5
250.0	24.53	0.666	59.1	7.0
250.0	25.48	0.672	55.2	7.5
250.0	26.67	0.675	51.5	8.0
250.0	28.07	0.666	47.7	8.5
250.0	29.59	0.638	43.8	9.0
250.0	31.12	0.592	40.0	9.5
250.0	32.56	0.534	36.5	10.0
250.0	33.84	0.473	33.4	10.5
250.0	34.96	0.416	30.7	11.0
350.0	23.86	1.558	244.8	5.0
350.0	24.59	1.589	213.7	5.5
350.0	25.49	1.598	206.8	6.0
350.0	26.55	1.585	197.6	6.5

350.0	27.65	1.553	181.3	7.0
350.0	28.72	1.505	157.2	7.5
350.0	29.77	1.448	130.2	8.0
350.0	30.91	1.387	106.5	8.5
350.0	32.27	1.329	88.6	9.0
350.0	33.94	1.277	75.6	9.5
350.0	35.96	1.234	66.1	10.0
350.0	38.25	1.204	58.9	10.5
350.0	40.60	1.187	53.2	11.0
450.0	25.60	2.642	297.3	5.0
450.0	26.69	2.392	297.3	5.5
450.0	27.87	2.181	297.3	6.0
450.0	29.14	2.012	296.9	6.5
450.0	30.48	1.888	291.5	7.0
450.0	31.87	1.808	270.4	7.5
450.0	33.32	1.763	234.4	8.0
450.0	34.80	1.735	195.3	8.5
450.0	36.28	1.684	160.7	9.0
450.0	37.75	1.546	132.8	9.5
450.0	39.17	1.256	111.1	10.0
450.0	40.53	0.836	94.7	10.5
450.0	41.83	0.440	82.3	11.0

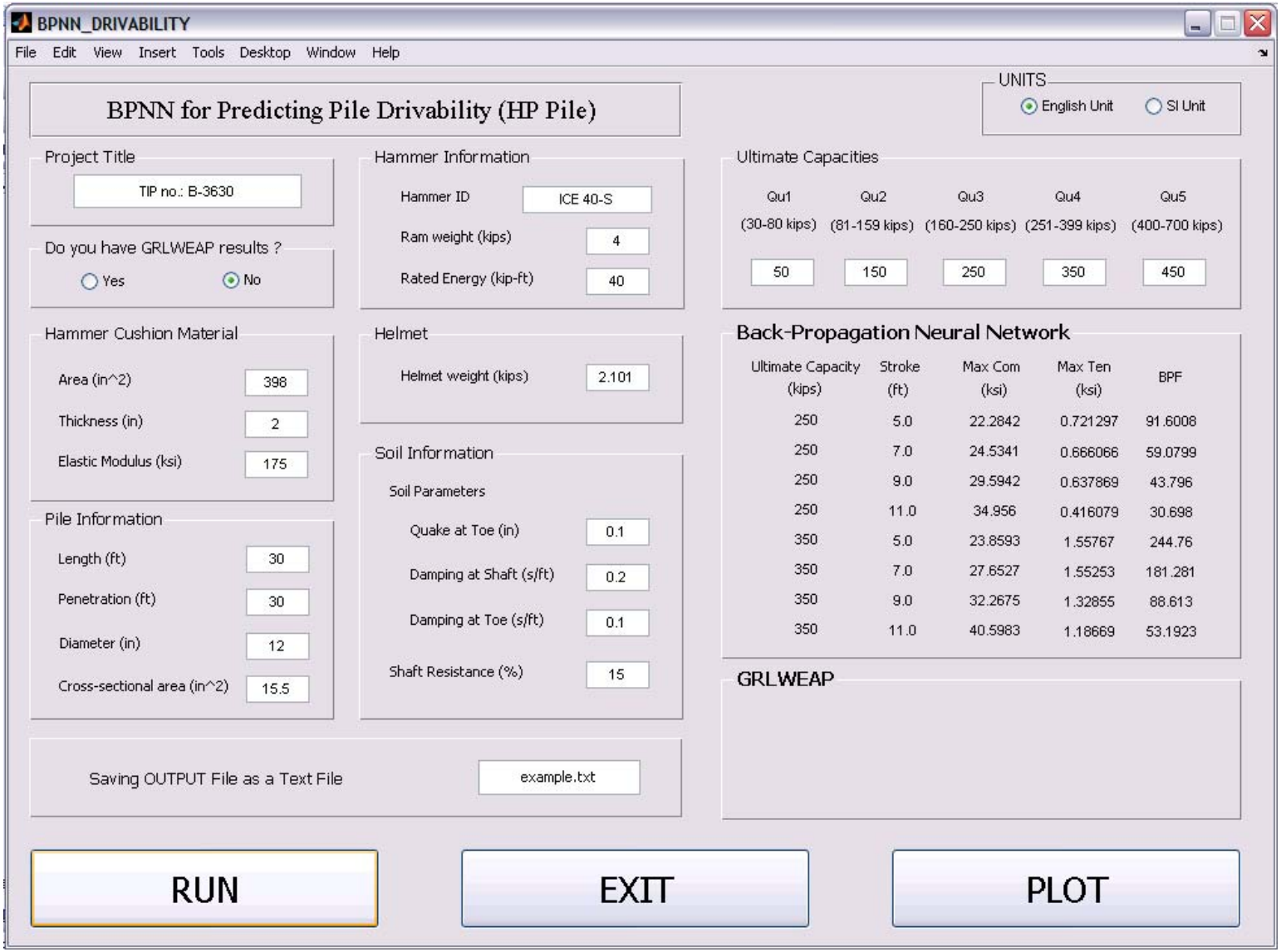


Figure V-6 An example for BPNN_DRIVABILITY (Outputs)

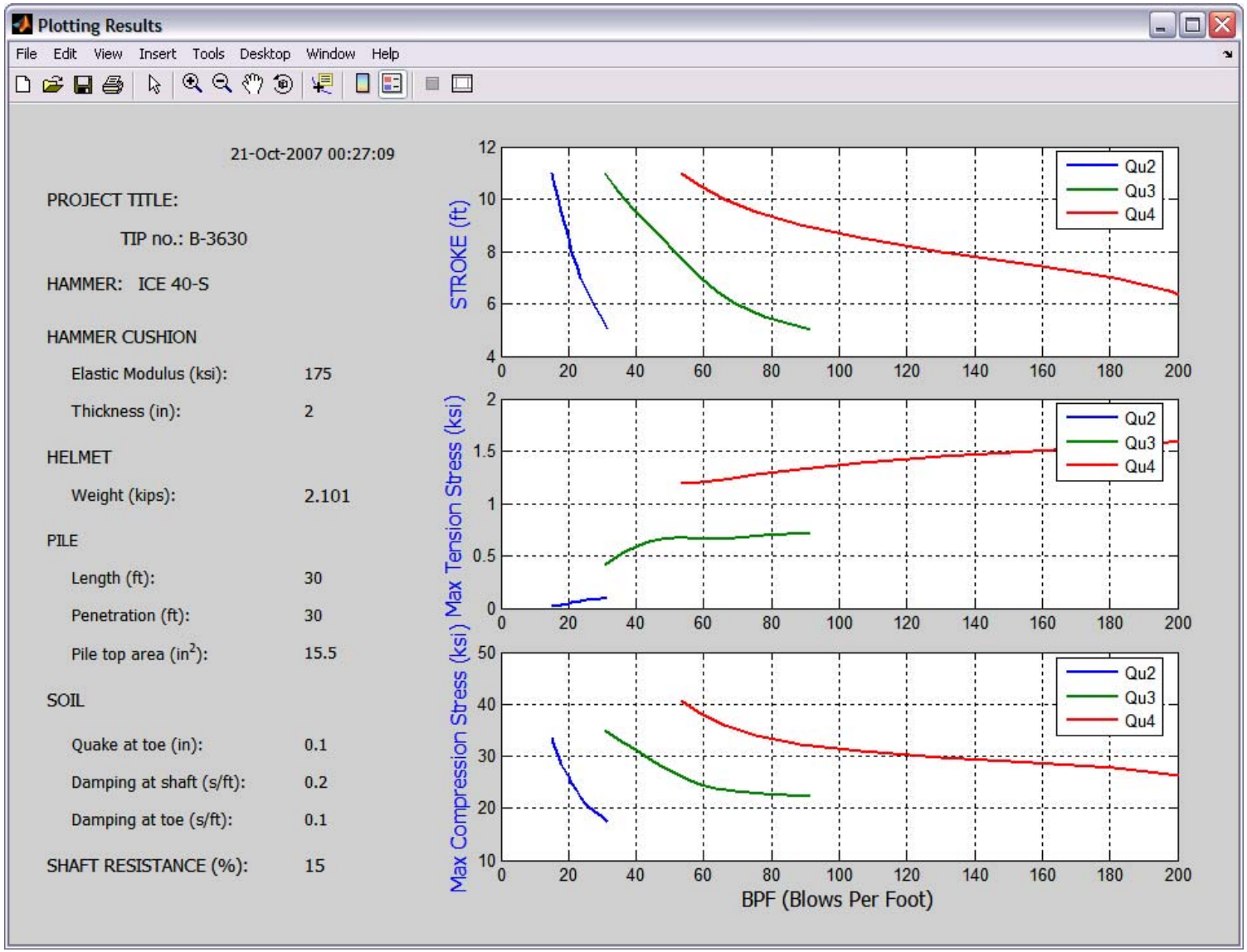


Figure V-7 Plotting results for BPNN_DRIVABILITY (Outputs)

V.5 Program Requirements and Limitations

i) Need Neural Network toolbox as well as main MATLAB program.
ii) In order to update/retrain the developed model, it takes some time.
iii) A good quality data capturing all the 'physics' is a pr-requisite for a good model.

V.6 Program Source Code (BPNN_DRIVABILITY)

```
function varargout = BPNN_DRIVABILITY(varargin)
% BPNN_DRIVABILITY M-file for
BPNN_DRIVABILITY.fig
%      BPNN_DRIVABILITY, by itself, creates a new
BPNN_DRIVABILITY or raises the existing
%      singleton*.
%
%      H = BPNN_DRIVABILITY returns the handle to a new
BPNN_DRIVABILITY or the handle to
%      the existing singleton*.
%
%
BPNN_DRIVABILITY('CALLBACK',hObject,eventData,hand
les,...) calls the local
%      function named CALLBACK in
BPNN_DRIVABILITY.M with the given input arguments.
%
%      BPNN_DRIVABILITY('Property','Value',...) creates a
new BPNN_DRIVABILITY or raises the
%      existing singleton*.  Starting from the left, property value
pairs are
%      applied to the GUI before
BPNN_DRIVABILITY_OpeningFunction gets called.  An
%      unrecognized property name or invalid value makes
property application
%      stop.  All inputs are passed to
BPNN_DRIVABILITY_OpeningFcn via varargin.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose
"GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help
BPNN_DRIVABILITY

% Last Modified by GUIDE v2.5 25-Sep-2007 12:58:12

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn',
@BPNN_DRIVABILITY_OpeningFcn, ...
                   'gui_OutputFcn',
@BPNN_DRIVABILITY_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State,
varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before BPNN_DRIVABILITY is made
visible.
function BPNN_DRIVABILITY_OpeningFcn(hObject,
eventdata, handles, varargin)
% This function has no savefile_file args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)
% varargin   command line arguments to
BPNN_DRIVABILITY (see VARARGIN)

% Choose default command line savefile_file for
BPNN_DRIVABILITY
handles.outsaving = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes BPNN_DRIVABILITY wait for user
response (see UIRESUME)
% uiwait(handles.figure1);

set(handles.chosenunit,'value',1);
set(handles.chosenyesno,'value',2);
set(handles.text24,'visible','off');
set(handles.text25,'visible','off');
set(handles.text26,'visible','off');
set(handles.text27,'visible','off');
set(handles.text28,'visible','off');
set(handles.tx_bpnnqu,'visible','off');
set(handles.tx_bpnnstroke,'visible','off');
set(handles.tx_bpnncom,'visible','off');
set(handles.tx_bpnnten,'visible','off');
set(handles.text29,'visible','off');
set(handles.text30,'visible','off');
set(handles.text31,'visible','off');
set(handles.text32,'visible','off');
set(handles.text33,'visible','off');
set(handles.text34,'visible','off');
set(handles.text35,'visible','off');
set(handles.text36,'visible','off');
set(handles.text37,'visible','off');
set(handles.text38,'visible','off');
set(handles.text39,'visible','off');
```

```
set(handles.text40,'visible','off');
set(handles.text41,'visible','off');
set(handles.text42,'visible','off');
set(handles.text43,'visible','off');
set(handles.text44,'visible','off');
set(handles.text45,'visible','off');
set(handles.text46,'visible','off');
set(handles.text47,'visible','off');
set(handles.text48,'visible','off');
set(handles.text49,'visible','off');
set(handles.text50,'visible','off');
set(handles.text51,'visible','off');
set(handles.text52,'visible','off');
set(handles.text53,'visible','off');
set(handles.text54,'visible','off');
set(handles.text55,'visible','off');
set(handles.text56,'visible','off');
set(handles.text57,'visible','off');
set(handles.text58,'visible','off');
set(handles.text59,'visible','off');
set(handles.text60,'visible','off');
set(handles.text61,'visible','off');
set(handles.text62,'visible','off');
set(handles.text63,'visible','off');
set(handles.text64,'visible','off');
set(handles.text65,'visible','off');
set(handles.text66,'visible','off');
set(handles.text67,'visible','off');
set(handles.text68,'visible','off');
set(handles.text69,'visible','off');
set(handles.text70,'visible','off');
set(handles.text71,'visible','off');
set(handles.text72,'visible','off');
set(handles.text73,'visible','off');
set(handles.tx_weapqu,'visible','off');
set(handles.tx_weapstroke,'visible','off');
set(handles.tx_weapcom,'visible','off');
set(handles.tx_weapten,'visible','off');
set(handles.weap_qu,'visible','off');
set(handles.weap_stroke,'visible','off');
set(handles.weap_com,'visible','off');
set(handles.weap_ten,'visible','off');
set(handles.weap_bpf,'visible','off');


% --- Outputs from this function are returned to the command
line.
function varargout =
BPNN_DRIVABILITY_OutputFcn(hObject, eventdata,
handles)
% varargout  cell array for returning savefile_file args (see
VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Get default command line savefile_file from handles
structure
varargout{1} = handles.outsaving;


% ------------------------------------------------------------------
function unitgroup_SelectionChangeFcn(hObject, eventdata,
handles)
% hObject    handle to unitgroup (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

if (hObject==handles.english)
    set(handles.tx_harea,'String', 'Area (in^2)');
    set(handles.tx_thick,'String', 'Thickness (in)');
    set(handles.tx_modul,'String', 'Elastic Modulus (ksi)');
    set(handles.tx_helmet,'String', 'Helmet weight (kips)');
    set(handles.tx_length,'String', 'Length (ft)');
    set(handles.tx_penetra,'String', 'Penetration (ft)');
    set(handles.tx_diam,'String', 'Diameter (in)');
    set(handles.tx_parea,'String', 'Cross-sectional area (in^2)');
    set(handles.tx_ramwt,'String', 'Ram weight (kips)');
    set(handles.tx_energy,'String', 'Rated Energy (kip-ft)');
    set(handles.tx_qtoe,'String', 'Quake at Toe (in)');
    set(handles.tx_dshaft,'String', 'Damping at Shaft (s/ft)');
    set(handles.tx_dtoe,'String', 'Damping at Toe (s/ft)');
    set(handles.tx_qu1,'String', '(30-80 kips)');
    set(handles.tx_qu2,'String', '(81-159 kips)');
    set(handles.tx_qu3,'String', '(160-250 kips)');
    set(handles.tx_qu4,'String', '(251-399 kips)');
    set(handles.tx_qu5,'String', '(400-700 kips)');
    set(handles.tx_bpnnqu,'String','(kips)');
    set(handles.tx_bpnnstroke,'string','(ft)');
    set(handles.tx_bpnncom,'string','(ksi)');
    set(handles.tx_bpnnten,'string','(ksi)');
    set(handles.text37,'string','5.0');
    set(handles.text38,'string','7.0');
    set(handles.text39,'string','9.0');
    set(handles.text40,'string','11.0');
    set(handles.text41,'string','5.0');
    set(handles.text42,'string','7.0');
    set(handles.text43,'string','9.0');
    set(handles.text44,'string','11.0');
    set(handles.tx_weapqu,'string','(kips)');
    set(handles.tx_weapstroke,'string','(ft)');
    set(handles.tx_weapcom,'string','(ksi)');
    set(handles.tx_weapten,'string','(ksi)');
    set(handles.chosenunit,'value',1);

else
    set(handles.tx_harea,'String', 'Area (cm^2)');
    set(handles.tx_thick,'String', 'Thickness (mm)');
    set(handles.tx_modul,'String', 'Elastic Modulus (Mpa)');
    set(handles.tx_helmet,'String', 'Helmet weight (kN)');
    set(handles.tx_length,'String', 'Length (m)');
    set(handles.tx_penetra,'String', 'Penetration (m)');
    set(handles.tx_diam,'String', 'Diameter (mm)');
    set(handles.tx_parea,'String', 'Cross-sectional area (cm^2)');
    set(handles.tx_ramwt,'String', 'Ram weight (kN)');
    set(handles.tx_energy,'String', 'Rated Energy (kJ)');
    set(handles.tx_qtoe,'String', 'Quake at Toe (mm)');
    set(handles.tx_dshaft,'String', 'Damping at Shaft (s/m)');
    set(handles.tx_dtoe,'String', 'Damping at Toe (s/m)');
    set(handles.tx_qu1,'String', '(133-355 kN)');
    set(handles.tx_qu2,'String', '(356-711 kN)');
    set(handles.tx_qu3,'String', '(712-1112 kN)');
    set(handles.tx_qu4,'String', '(1113-1779 kN)');
    set(handles.tx_qu5,'String', '(1780-3114 kN)');
    set(handles.tx_bpnnqu,'String','(kN)');
    set(handles.tx_bpnnstroke,'string','(m)');
    set(handles.tx_bpnncom,'string','(Mpa)');
    set(handles.tx_bpnnten,'string','(Mpa)');
    set(handles.text37,'string','1.5');
    set(handles.text38,'string','2.1');
    set(handles.text39,'string','2.7');
    set(handles.text40,'string','3.3');
    set(handles.text41,'string','1.5');
    set(handles.text42,'string','2.1');
    set(handles.text43,'string','2.7');
```

```
    set(handles.text44,'string','3.3');
    set(handles.tx_weapqu,'string','(kN)');
    set(handles.tx_weapstroke,'string','(m)');
    set(handles.tx_weapcom,'string','(Mpa)');
    set(handles.tx_weapten,'string','(Mpa)');
    set(handles.chosenunit,'value',2);
end

function project_title_Callback(hObject, eventdata, handles)
% hObject    handle to project_title (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of project_title as
text
%        str2double(get(hObject,'String')) returns contents of
project_title as a double


% --- Executes during object creation, after setting all properties.
function project_title_CreateFcn(hObject, eventdata, handles)
% hObject    handle to project_title (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end


% ---------------------------------------------------------------------
function yesnogroup_SelectionChangeFcn(hObject, eventdata,
handles)
% hObject    handle to yesnogroup (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

if (hObject==handles.no)
    set(handles.text69,'visible','off');
    set(handles.text70,'visible','off');
    set(handles.text71,'visible','off');
    set(handles.text72,'visible','off');
    set(handles.text73,'visible','off');
    set(handles.tx_weapqu,'visible','off');
    set(handles.tx_weapstroke,'visible','off');
    set(handles.tx_weapcom,'visible','off');
    set(handles.tx_weapten,'visible','off');
    set(handles.weap_qu,'visible','off');
    set(handles.weap_stroke,'visible','off');
    set(handles.weap_com,'visible','off');
    set(handles.weap_ten,'visible','off');
    set(handles.weap_bpf,'visible','off');

    set(handles.chosenyesno,'value',2); %NO

else
    set(handles.text69,'visible','on');
    set(handles.text70,'visible','on');
    set(handles.text71,'visible','on');
    set(handles.text72,'visible','on');
    set(handles.text73,'visible','on');
    set(handles.tx_weapqu,'visible','on');
    set(handles.tx_weapstroke,'visible','on');
    set(handles.tx_weapcom,'visible','on');
    set(handles.tx_weapten,'visible','on');
    set(handles.weap_qu,'visible','on');
    set(handles.weap_stroke,'visible','on');
    set(handles.weap_com,'visible','on');
    set(handles.weap_ten,'visible','on');
    set(handles.weap_bpf,'visible','on');

    set(handles.chosenyesno,'value',1); %YES
end

function hamid_Callback(hObject, eventdata, handles)
% hObject    handle to hamid (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of hamid as text
%        str2double(get(hObject,'String')) returns contents of
hamid as a double


% --- Executes during object creation, after setting all properties.
function hamid_CreateFcn(hObject, eventdata, handles)
% hObject    handle to hamid (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function ram_wt_Callback(hObject, eventdata, handles)
% hObject    handle to ram_wt (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of ram_wt as text
%        str2double(get(hObject,'String')) returns contents of
ram_wt as a double


% --- Executes during object creation, after setting all properties.
function ram_wt_CreateFcn(hObject, eventdata, handles)
% hObject    handle to ram_wt (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
```

```
end


function energy_Callback(hObject, eventdata, handles)
% hObject    handle to energy (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of energy as text
%        str2double(get(hObject,'String')) returns contents of
energy as a double


% --- Executes during object creation, after setting all properties.
function energy_CreateFcn(hObject, eventdata, handles)
% hObject    handle to energy (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function harea_Callback(hObject, eventdata, handles)
% hObject    handle to harea (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of harea as text
%        str2double(get(hObject,'String')) returns contents of
harea as a double


% --- Executes during object creation, after setting all properties.
function harea_CreateFcn(hObject, eventdata, handles)
% hObject    handle to harea (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function thick_Callback(hObject, eventdata, handles)
% hObject    handle to thick (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of thick as text
%        str2double(get(hObject,'String')) returns contents of thick
as a double


% --- Executes during object creation, after setting all properties.
function thick_CreateFcn(hObject, eventdata, handles)
% hObject    handle to thick (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function modul_Callback(hObject, eventdata, handles)
% hObject    handle to modul (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of modul as text
%        str2double(get(hObject,'String')) returns contents of
modul as a double


% --- Executes during object creation, after setting all properties.
function modul_CreateFcn(hObject, eventdata, handles)
% hObject    handle to modul (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function helmet_Callback(hObject, eventdata, handles)
% hObject    handle to helmet (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of helmet as text
%        str2double(get(hObject,'String')) returns contents of
helmet as a double


% --- Executes during object creation, after setting all properties.
function helmet_CreateFcn(hObject, eventdata, handles)
% hObject    handle to helmet (see GCBO)
```

```
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function length_Callback(hObject, eventdata, handles)
% hObject    handle to length (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of length as text
%        str2double(get(hObject,'String')) returns contents of
length as a double


% --- Executes during object creation, after setting all properties.
function length_CreateFcn(hObject, eventdata, handles)
% hObject    handle to length (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function penetra_Callback(hObject, eventdata, handles)
% hObject    handle to penetra (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of penetra as text
%        str2double(get(hObject,'String')) returns contents of
penetra as a double


% --- Executes during object creation, after setting all properties.
function penetra_CreateFcn(hObject, eventdata, handles)
% hObject    handle to penetra (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function diam_Callback(hObject, eventdata, handles)
% hObject    handle to diam (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of diam as text
%        str2double(get(hObject,'String')) returns contents of diam
as a double


% --- Executes during object creation, after setting all properties.
function diam_CreateFcn(hObject, eventdata, handles)
% hObject    handle to diam (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function parea_Callback(hObject, eventdata, handles)
% hObject    handle to parea (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of parea as text
%        str2double(get(hObject,'String')) returns contents of
parea as a double


% --- Executes during object creation, after setting all properties.
function parea_CreateFcn(hObject, eventdata, handles)
% hObject    handle to parea (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function Qtoe_Callback(hObject, eventdata, handles)
% hObject    handle to Qtoe (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
```

```
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of Qtoe as text
%        str2double(get(hObject,'String')) returns contents of Qtoe
as a double


% --- Executes during object creation, after setting all properties.
function Qtoe_CreateFcn(hObject, eventdata, handles)
% hObject    handle to Qtoe (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function Dshaft_Callback(hObject, eventdata, handles)
% hObject    handle to Dshaft (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of Dshaft as text
%        str2double(get(hObject,'String')) returns contents of
Dshaft as a double


% --- Executes during object creation, after setting all properties.
function Dshaft_CreateFcn(hObject, eventdata, handles)
% hObject    handle to Dshaft (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function Dtoe_Callback(hObject, eventdata, handles)
% hObject    handle to Dtoe (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of Dtoe as text
%        str2double(get(hObject,'String')) returns contents of Dtoe
as a double


% --- Executes during object creation, after setting all properties.
function Dtoe_CreateFcn(hObject, eventdata, handles)
% hObject    handle to Dtoe (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function shaft_resist_Callback(hObject, eventdata, handles)
% hObject    handle to shaft_resist (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of shaft_resist as
text
%        str2double(get(hObject,'String')) returns contents of
shaft_resist as a double


% --- Executes during object creation, after setting all properties.
function shaft_resist_CreateFcn(hObject, eventdata, handles)
% hObject    handle to shaft_resist (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function qu1_Callback(hObject, eventdata, handles)
% hObject    handle to qu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of qu1 as text
%        str2double(get(hObject,'String')) returns contents of qu1
as a double


% --- Executes during object creation, after setting all properties.
function qu1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to qu1 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
```

```
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function qu2_Callback(hObject, eventdata, handles)
% hObject    handle to qu2 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of qu2 as text
%        str2double(get(hObject,'String')) returns contents of qu2
as a double


% --- Executes during object creation, after setting all properties.
function qu2_CreateFcn(hObject, eventdata, handles)
% hObject    handle to qu2 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function qu3_Callback(hObject, eventdata, handles)
% hObject    handle to qu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of qu3 as text
%        str2double(get(hObject,'String')) returns contents of qu3
as a double


% --- Executes during object creation, after setting all properties.
function qu3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to qu3 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function qu4_Callback(hObject, eventdata, handles)
% hObject    handle to qu4 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of qu4 as text
%        str2double(get(hObject,'String')) returns contents of qu4
as a double


% --- Executes during object creation, after setting all properties.
function qu4_CreateFcn(hObject, eventdata, handles)
% hObject    handle to qu4 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function qu5_Callback(hObject, eventdata, handles)
% hObject    handle to qu5 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of qu5 as text
%        str2double(get(hObject,'String')) returns contents of qu5
as a double


% --- Executes during object creation, after setting all properties.
function qu5_CreateFcn(hObject, eventdata, handles)
% hObject    handle to qu5 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function weap_qu_Callback(hObject, eventdata, handles)
% hObject    handle to weap_qu (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of weap_qu as
text
%        str2double(get(hObject,'String')) returns contents of
weap_qu as a double
```

```
% --- Executes during object creation, after setting all properties.
function weap_qu_CreateFcn(hObject, eventdata, handles)
% hObject    handle to weap_qu (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end



function weap_stroke_Callback(hObject, eventdata, handles)
% hObject    handle to weap_stroke (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of weap_stroke
as text
%       str2double(get(hObject,'String')) returns contents of
weap_stroke as a double


% --- Executes during object creation, after setting all properties.
function weap_stroke_CreateFcn(hObject, eventdata, handles)
% hObject    handle to weap_stroke (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end



function weap_com_Callback(hObject, eventdata, handles)
% hObject    handle to weap_com (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of weap_com as
text
%       str2double(get(hObject,'String')) returns contents of
weap_com as a double


% --- Executes during object creation, after setting all properties.
function weap_com_CreateFcn(hObject, eventdata, handles)
% hObject    handle to weap_com (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end



function weap_ten_Callback(hObject, eventdata, handles)
% hObject    handle to weap_ten (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of weap_ten as
text
%       str2double(get(hObject,'String')) returns contents of
weap_ten as a double


% --- Executes during object creation, after setting all properties.
function weap_ten_CreateFcn(hObject, eventdata, handles)
% hObject    handle to weap_ten (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end



function weap_bpf_Callback(hObject, eventdata, handles)
% hObject    handle to weap_bpf (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of weap_bpf as
text
%       str2double(get(hObject,'String')) returns contents of
weap_bpf as a double


% --- Executes during object creation, after setting all properties.
function weap_bpf_CreateFcn(hObject, eventdata, handles)
% hObject    handle to weap_bpf (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
```

```
% --- Executes on button press in run.
function run_Callback(hObject, eventdata, handles)
% hObject    handle to run (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

project_title=get(handles.project_title,'string');
hammer_ID=get(handles.hamid,'string');
ram_wt=str2double(get(handles.ram_wt,'string'));
energy=str2double(get(handles.energy,'string'));
Harea=str2double(get(handles.harea,'string'));
Em=str2double(get(handles.modul,'string'));
Hthick=str2double(get(handles.thick,'string'));
helmet_wt=str2double(get(handles.helmet,'string'));
L=str2double(get(handles.length,'string'));
Lp=str2double(get(handles.penetra,'string'));
D=str2double(get(handles.diam,'string'));
Pa=str2double(get(handles.parea,'string'));
quake_toe=str2double(get(handles.Qtoe,'string'));
damp_shaft=str2double(get(handles.Dshaft,'string'));
damp_toe=str2double(get(handles.Dtoe,'string'));
shaft_resistance=str2double(get(handles.shaft_resist,'string'));
Qu1=str2double(get(handles.qu1,'string'));
Qu2=str2double(get(handles.qu2,'string'));
Qu3=str2double(get(handles.qu3,'string'));
Qu4=str2double(get(handles.qu4,'string'));
Qu5=str2double(get(handles.qu5,'string'));


% GRLWEAP RESULTS
weap_qu=str2double(get(handles.weap_qu,'string'));
weap_stroke=str2double(get(handles.weap_stroke,'string'));
weap_com=str2double(get(handles.weap_com,'string'));
weap_ten=str2double(get(handles.weap_ten,'string'));
weap_bpf=str2double(get(handles.weap_bpf,'string'));


%-------------------------------------------------------------------
% ------------------------------ Qu1 : 30 ~ 80 kips ----------------------
---
%-------------------------------------------------------------------

if get(handles.chosenunit,'value')==1
disp('                                                  ')
disp('---------------------- Qu1: 30 ~ 80 kips -------------------------
')
elseif get(handles.chosenunit,'value')==2
disp('                                                  ')
disp('---------------------- Qu1: 133 ~ 355 kN ------------------------
--')
end

%-------------------------------------------------------------------
% Loading the input data sets and normalization of training data
set
%-------------------------------------------------------------------

cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Drivability\BPNN 5\DATA\Q1');

load trainqu1.txt;
load testqu1.txt;
load w1comqu1.txt;
load w2comqu1.txt;
load w3comqu1.txt;
load b1comqu1.txt;
load b2comqu1.txt;
load b3comqu1.txt;
load w1tenqu1.txt;
load w2tenqu1.txt;
load w3tenqu1.txt;
load b1tenqu1.txt;
load b2tenqu1.txt;
load b3tenqu1.txt;
load w1bpfqu1.txt;
load w2bpfqu1.txt;
load w3bpfqu1.txt;
load b1bpfqu1.txt;
load b2bpfqu1.txt;
load b3bpfqu1.txt;

tr1_in=trainqu1;
te1_in=testqu1;
q1_comwt1=w1comqu1;
q1_comwt2=w2comqu1;
q1_comwt3=w3comqu1;
q1_combi1=b1comqu1;
q1_combi2=b2comqu1;
q1_combi3=b3comqu1;
q1_tenwt1=w1tenqu1;
q1_tenwt2=w2tenqu1;
q1_tenwt3=w3tenqu1;
q1_tenbi1=b1tenqu1;
q1_tenbi2=b2tenqu1;
q1_tenbi3=b3tenqu1;
q1_bpfwt1=w1bpfqu1;
q1_bpfwt2=w2bpfqu1;
q1_bpfwt3=w3bpfqu1;
q1_bpfbi1=b1bpfqu1;
q1_bpfbi2=b2bpfqu1;
q1_bpfbi3=b3bpfqu1;

[m,n]=size(tr1_in);
trr1=zeros(m,n);
in1=zeros(n,2);
for i=1:n
  tr1_max(i)=max(tr1_in(:,i));
  tr1_min(i)=min(tr1_in(:,i));
    if tr1_max(i) == tr1_min(i)
      for j=1:m
        trr1(j,i)=1;
      end
    else
      for j=1:m
        trr1(j,i)=(tr1_in(j,i)-tr1_min(i))./(tr1_max(i)-tr1_min(i));
      end
    end
  in1(i,1)=min(trr1(:,i));
  in1(i,2)=max(trr1(:,i));
end

% -------------------------------------------------------------------
% Network architecture with given learning factors & Network
Initialization
% -------------------------------------------------------------------

initt1=in1(1:(n-3),:);
P1=trr1(:,1:(n-3));
P1=P1';
T1_com=trr1(:,n-2).';
T1_ten=trr1(:,n-1).';
T1_bpf=trr1(:,n).';

%-------------------------------- Max Com Stresses for Q1 --------
-------------------
```

```
disp('Training for Max Compression Stresses in Qu1,
')

net=newff(initt1,[17,17,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q1_comwt1; % Given Input Weights Matrix
net.LW{2,1}=q1_comwt2;% Given First hidden Weights
Matrix
net.LW{3,2}=q1_comwt3;% Given Second hidden Weights
Matrix
net.b{1}=q1_combi1; % Given Input Bias Vetors
net.b{2}=q1_combi2; % Given First hidden Bias Vetors
net.b{3}=q1_combi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P1,T1_com);

% ---------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ---------------------------------------------------------------------

    train1_pred = sim(net,P1);
    train1_pred=train1_pred';
    train1_pred1=train1_pred(:,1)*(tr1_max(n-2)-tr1_min(n-
2))+tr1_min(n-2);% Maximum compressive stress
    train1_meas1=tr1_in(:,n-2);
    train1_comp1=zeros(m,2);
    train1_comp1(:,1)=train1_meas1;
    train1_comp1(:,2)=train1_pred1;
    train1_comp1;

% ---------------------------------------------------------------------
% Prediction for the test data sets
% ---------------------------------------------------------------------

    [m1,n1]=size(te1_in);
    test1_in=zeros(m1,n1-3);
    for i=1:n1-3
      for j=1:m1
        test1_in(j,i)=(te1_in(j,i)-tr1_min(i))/(tr1_max(i)-
tr1_min(i));
      end
    end
    COM1=test1_in;
    COM1=COM1';
    test1_pred = sim(net,COM1);
    test1_pred=test1_pred';
    test1_pred1=test1_pred(:,1)*(tr1_max(n-2)-tr1_min(n-
2))+tr1_min(n-2);% Maximum compressive stress
    test1_meas1=te1_in(:,n1-2);
    test1_comp1=zeros(m1,2);
    test1_comp1(:,1)=test1_meas1;
    test1_comp1(:,2)=test1_pred1;
    test1_comp1;


% ---------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ---------------------------------------------------------------------

%--------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

      str_range=5.:0.5:11;
      stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.5*j+4.5;
   end
      L_D=Lp*12./D;
   for str=1:size(str_range,2)

pile_test1_in(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_w
t,L,Lp,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resista
nce,Qu1,stroke(str)];
   end

[m2,n2]=size(pile_test1_in);
  pile_te1_in=zeros(m2,n2);
    for i=1:n2
      for j=1:m2
        pile_te1_in(j,i)=(pile_test1_in(j,i)-tr1_min(i))/(tr1_max(i)-
tr1_min(i));
      end
    end

    PCOM1=pile_te1_in;
    PCOM1=PCOM1';
    ptest1_pred=sim(net,PCOM1);
    ptest1_pred=ptest1_pred';
    pte1_pred1=ptest1_pred(:,1)*(tr1_max(n-2)-tr1_min(n-
2))+tr1_min(n-2);% Maximum compressive stress
    ptest1_com1=pte1_pred1;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

   str_range=1.5:0.1:3.4; %SI UNIT
   stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.1*j+1.4;
   end

      L_D=Lp*1000./D;
   for str=1:size(str_range,2) % SI--->ENG

pile_test1_in(str,:)=[ram_wt/4.448,energy/1.35,Harea/2.54^2,E
m/6.8947,Hthick/25.4,helmet_wt/4.448,L/0.3048,Lp/0.3048,D/2
5.4,Pa/2.54^2,L_D,quake_toe/25.4,damp_shaft*0.3048,damp_t
oe*0.3048,shaft_resistance,Qu1/4.448,stroke(str)/0.3048];

pile_in1(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_wt,L,L
p,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resistance,
Qu1,stroke(str)];
   end

[m2,n2]=size(pile_test1_in);
  pile_te1_in=zeros(m2,n2);
    for i=1:n2
      for j=1:m2
        pile_te1_in(j,i)=(pile_test1_in(j,i)-tr1_min(i))/(tr1_max(i)-
tr1_min(i));
      end
    end

    PCOM1=pile_te1_in;
    PCOM1=PCOM1';
    ptest1_pred=sim(net,PCOM1);
    ptest1_pred=ptest1_pred';
    pte1_pred1=ptest1_pred(:,1)*(tr1_max(n-2)-tr1_min(n-
2))+tr1_min(n-2);% Maximum compressive stress
    ptest1_com1=pte1_pred1;

end
```

```
%---------------------- Maximum tensile stresses for Q1 ------------
-------

disp('            Max Tension Stresses in Qu1,                    ')

net=newff(initt1,[20,20,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q1_tenwt1; % Given Input Weights Matrix
net.LW{2,1}=q1_tenwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q1_tenwt3;% Given Second hidden Weights
Matrix
net.b{1}=q1_tenbi1; % Given Input Bias Vetors
net.b{2}=q1_tenbi2; % Given First hidden Bias Vetors
net.b{3}=q1_tenbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P1,T1_ten);

% ------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------

    train1_pred = sim(net,P1);
    train1_pred=train1_pred';
    train1_pred2=train1_pred(:,1)*(tr1_max(n-1)-tr1_min(n-
1))+tr1_min(n-1);% Maximum tension stress
    train1_meas2=tr1_in(:,n-1);
    train1_comp2=zeros(m,2);
    train1_comp2(:,1)=train1_meas2;
    train1_comp2(:,2)=train1_pred2;
    train1_comp2;


% ------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------

    [m1,n1]=size(te1_in);
    test1_in=zeros(m1,n1-3);
    for i=1:n1-3
      for j=1:m1
        test1_in(j,i)=(te1_in(j,i)-tr1_min(i))/(tr1_max(i)-
tr1_min(i));
      end
    end
    TEN1=test1_in;
    TEN1=TEN1';
    test1_pred = sim(net,TEN1);
    test1_pred=test1_pred';
    test1_pred2=test1_pred(:,1)*(tr1_max(n-1)-tr1_min(n-
1))+tr1_min(n-1);% Maximum tension stress
    test1_meas2=te1_in(:,n1-1);
    test1_comp2=zeros(m1,2);
    test1_comp2(:,1)=test1_meas2;
    test1_comp2(:,2)=test1_pred2;
    test1_comp2;

% ------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ------------------------------------------------------------------

%--------------------------Decision of Stroke----------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PTE1=pile_te1_in;
    PTE1=PTE1';
    ptest1_pred=sim(net,PTE1);
    ptest1_pred=ptest1_pred';
    pte1_pred2=ptest1_pred(:,1)*(tr1_max(n-1)-tr1_min(n-
1))+tr1_min(n-1);% Maximum tension stress
    ptest1_ten1=pte1_pred2;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PTEN1=pile_te1_in;
    PTEN1=PTEN1';
    ptest1_pred=sim(net,PTEN1);
    ptest1_pred=ptest1_pred';
    pte1_pred2=ptest1_pred(:,1)*(tr1_max(n-1)-tr1_min(n-
1))+tr1_min(n-1);% Maximum tension stress
    ptest1_ten1=pte1_pred2;
end

%---------------------------------- BPF for Q1 -------------------------
---

disp('            BPF in Qu1,                                    ')

net=newff(initt1,[20,20,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q1_bpfwt1; % Given Input Weights Matrix
net.LW{2,1}=q1_bpfwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q1_bpfwt3;% Given Second hidden Weights
Matrix
net.b{1}=q1_bpfbi1; % Given Input Bias Vetors
net.b{2}=q1_bpfbi2; % Given First hidden Bias Vetors
net.b{3}=q1_bpfbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P1,T1_bpf);

% ------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------

    train1_pred = sim(net,P1);
    train1_pred=train1_pred';
    train1_pred3=train1_pred(:,1)*(tr1_max(n)-
tr1_min(n))+tr1_min(n);% BPF
    train1_meas3=tr1_in(:,n);
    train1_comp3=zeros(m,2);
    train1_comp3(:,1)=train1_meas3;
    train1_comp3(:,2)=train1_pred3;
    train1_comp3;

% ------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------

    [m1,n1]=size(te1_in);
    test1_in=zeros(m1,n1-3);
    for i=1:n1-3
      for j=1:m1
        test1_in(j,i)=(te1_in(j,i)-tr1_min(i))/(tr1_max(i)-
tr1_min(i));
      end
    end
    BPF1=test1_in;
    BPF1=BPF1';
    test1_pred = sim(net,BPF1);
```

```
    test1_pred=test1_pred';
    test1_pred3=test1_pred(:,1)*(tr1_max(n)-
tr1_min(n))+tr1_min(n);% BPF
    test1_meas3=te1_in(:,n1);
    test1_comp3=zeros(m1,2);
    test1_comp3(:,1)=test1_meas3;
    test1_comp3(:,2)=test1_pred3;
    test1_comp3;

% ------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ------------------------------------------------------------------

%--------------------------Decision of Stroke-----------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PBPF1=pile_te1_in;
    PBPF1=PBPF1';
    ptest1_pred=sim(net,PBPF1);
    ptest1_pred=ptest1_pred';
    pte1_pred3=ptest1_pred(:,1)*(tr1_max(n)-
tr1_min(n))+tr1_min(n);% BPF
    ptest1_bpf1=pte1_pred3;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PBPF1=pile_te1_in;
    PBPF1=PBPF1';
    ptest1_pred=sim(net,PBPF1);
    ptest1_pred=ptest1_pred';
    pte1_pred3=ptest1_pred(:,1)*(tr1_max(n)-
tr1_min(n))+tr1_min(n);% BPF
    ptest1_bpf1=pte1_pred3;
end


% Calculation correlation "r^2" for Max compression stresses

     r_squ1_tra=corr2(train1_meas1,train1_pred1);
     r_squ1_tr1=r_squ1_tra^2;

     r_squ1_tea=corr2(test1_meas1,test1_pred1);
     r_squ1_te1=r_squ1_tea^2;


 % Calculation correlation "r^2" for Max tension stresses

     r_squ1_trb=corr2(train1_meas2,train1_pred2);
     r_squ1_tr2=r_squ1_trb^2;

     r_squ1_teb=corr2(test1_meas2,test1_pred2);
     r_squ1_te2=r_squ1_teb^2;


% Calculation correlation "r^2" for BPF

     r_squ1_trc=corr2(train1_meas3,train1_pred3);
     r_squ1_tr3=r_squ1_trc^2;

     r_squ1_tec=corr2(test1_meas3,test1_pred3);
     r_squ1_te3=r_squ1_tec^2;

disp('Trainings for Qu1 are DONE: Performance goal met
')


%------------------------------------------------------------------
% ---------------------------- Qu2 : 81 ~ 159 kips ----------------------
---
%------------------------------------------------------------------

cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Drivability\BPNN 5\DATA\Q2');

if get(handles.chosenunit,'value')==1
disp('                                                  ')
disp('---------------------- Qu2: 81 ~ 159 kips ----------------------
-')
elseif get(handles.chosenunit,'value')==2
disp('                                                  ')
disp('---------------------- Qu2: 356 ~ 711 kN ----------------------
--')
end
%disp('Training for Qu2,                                        ')

%------------------------------------------------------------------
% Loading the input data sets and normalization of training data
set
%------------------------------------------------------------------

load trainqu2.txt;
load testqu2.txt;
load w1comqu2.txt;
load w2comqu2.txt;
load w3comqu2.txt;
load b1comqu2.txt;
load b2comqu2.txt;
load b3comqu2.txt;
load w1tenqu2.txt;
load w2tenqu2.txt;
load w3tenqu2.txt;
load b1tenqu2.txt;
load b2tenqu2.txt;
load b3tenqu2.txt;
load w1bpfqu2.txt;
load w2bpfqu2.txt;
load w3bpfqu2.txt;
load b1bpfqu2.txt;
load b2bpfqu2.txt;
load b3bpfqu2.txt;

tr2_in=trainqu2;
te2_in=testqu2;
q2_comwt1=w1comqu2;
q2_comwt2=w2comqu2;
q2_comwt3=w3comqu2;
q2_combi1=b1comqu2;
q2_combi2=b2comqu2;
q2_combi3=b3comqu2;
q2_tenwt1=w1tenqu2;
q2_tenwt2=w2tenqu2;
q2_tenwt3=w3tenqu2;
q2_tenbi1=b1tenqu2;
q2_tenbi2=b2tenqu2;
q2_tenbi3=b3tenqu2;
q2_bpfwt1=w1bpfqu2;
q2_bpfwt2=w2bpfqu2;
q2_bpfwt3=w3bpfqu2;
q2_bpfbi1=b1bpfqu2;
q2_bpfbi2=b2bpfqu2;
q2_bpfbi3=b3bpfqu2;

% Loading the input data sets and normalization of training data

[m3,n3]=size(tr2_in);
trr2=zeros(m3,n3);
in2=zeros(n3,2);
```

```
for i=1:n3
  tr2_max(i)=max(tr2_in(:,i));
  tr2_min(i)=min(tr2_in(:,i));
    if tr2_max(i) == tr2_min(i)
      for j=1:m3
        trr2(j,i)=1;
      end
    else
      for j=1:m3
        trr2(j,i)=(tr2_in(j,i)-tr2_min(i))./(tr2_max(i)-tr2_min(i));
      end
    end
  in2(i,1)=min(trr2(:,i));
  in2(i,2)=max(trr2(:,i));
end

% ------------------------------------------------------------------------
% Network architecture with given learning factors & Network
Initialization
% ------------------------------------------------------------------------

initt2=in2(1:(n3-3),:);
P2=trr2(:,1:(n3-3));
P2=P2';
T2_com=trr2(:,n3-2).';
T2_ten=trr2(:,n3-1).';
T2_bpf=trr2(:,n3).';

%--------------------------------- Max Com Stresses for Q2 ---------
--------------------
disp('Training for Max Compression Stresses in Qu2,
')

net=newff(initt2,[19,19,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q2_comwt1; % Given Input Weights Matrix
net.LW{2,1}=q2_comwt2;% Given First hidden Weights
Matrix
net.LW{3,2}=q2_comwt3;% Given Second hidden Weights
Matrix
net.b{1}=q2_combi1; % Given Input Bias Vetors
net.b{2}=q2_combi2; % Given First hidden Bias Vetors
net.b{3}=q2_combi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P2,T2_com);

% ------------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------------

    train2_pred = sim(net,P2);
    train2_pred=train2_pred';
    train2_pred1=train2_pred(:,1)*(tr2_max(n3-2)-tr2_min(n3-
2))+tr2_min(n3-2);% Maximum compressive stress
    train2_meas1=tr2_in(:,n3-2);
    train2_comp1=zeros(m3,2);
    train2_comp1(:,1)=train2_meas1;
    train2_comp1(:,2)=train2_pred1;
    train2_comp1;

% ------------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------------

    [m4,n4]=size(te2_in);
    test2_in=zeros(m4,n4-3);
    for i=1:n4-3
      for j=1:m4
        test2_in(j,i)=(te2_in(j,i)-tr2_min(i))/(tr2_max(i)-
tr2_min(i));
      end
    end
    COM2=test2_in;
    COM2=COM2';
    test2_pred = sim(net,COM2);
    test2_pred=test2_pred';
    test2_pred1=test2_pred(:,1)*(tr2_max(n3-2)-tr2_min(n3-
2))+tr2_min(n3-2);% Maximum compressive stress
    test2_meas1=te2_in(:,n4-2);
    test2_comp1=zeros(m4,2);
    test2_comp1(:,1)=test2_meas1;
    test2_comp1(:,2)=test2_pred1;
    test2_comp1;

% ------------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of 81
- 159 kips
% ------------------------------------------------------------------------

%---------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

      str_range=5.:0.5:11;
      stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.5*j+4.5;
   end
      L_D=Lp*12./D;
   for str=1:size(str_range,2)

pile_test2_in(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_w
t,L,Lp,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resista
nce,Qu2,stroke(str)];
   end

[m5,n5]=size(pile_test2_in);
  pile_te2_in=zeros(m5,n5);
    for i=1:n5
      for j=1:m5
        pile_te2_in(j,i)=(pile_test2_in(j,i)-tr2_min(i))/(tr2_max(i)-
tr2_min(i));
      end
    end

    PCOM2=pile_te2_in;
    PCOM2=PCOM2';
    ptest2_pred=sim(net,PCOM2);
    ptest2_pred=ptest2_pred';
    pte2_pred1=ptest2_pred(:,1)*(tr2_max(n3-2)-tr2_min(n3-
2))+tr2_min(n3-2);% Maximum compressive stress
    ptest2_com1=pte2_pred1;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

   str_range=1.5:0.1:3.4; %SI UNIT
   stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.1*j+1.4;
   end

      L_D=Lp*1000./D;
   for str=1:size(str_range,2) % SI--->ENG

pile_test2_in(str,:)=[ram_wt/4.448,energy/1.35,Harea/2.54^2,E
```

```
m/6.8947,Hthick/25.4,helmet_wt/4.448,L/0.3048,Lp/0.3048,D/2
5.4,Pa/2.54^2,L_D,quake_toe/25.4,damp_shaft*0.3048,damp_t
oe*0.3048,shaft_resistance,Qu2/4.448,stroke(str)/0.3048];

pile_in2(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_wt,L,L
p,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resistance,
Qu2,stroke(str)];
   end

[m5,n5]=size(pile_test2_in);
  pile_te2_in=zeros(m5,n5);
    for i=1:n5
      for j=1:m5
        pile_te2_in(j,i)=(pile_test2_in(j,i)-tr2_min(i))/(tr2_max(i)-
tr2_min(i));
      end
    end

    PCOM2=pile_te2_in;
    PCOM2=PCOM2';
    ptest2_pred=sim(net,PCOM2);
    ptest2_pred=ptest2_pred';
    pte2_pred1=ptest2_pred(:,1)*(tr2_max(n3-2)-tr2_min(n3-
2))+tr2_min(n3-2);% Maximum compressive stress
    ptest2_com1=pte2_pred1;

end

%---------------------- Maximum tensile stresses for Q2 ------------
-------

disp('            Max Tension Stresses in Qu2,                    ')

net=newff(initt2,[20,20,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q2_tenwt1; % Given Input Weights Matrix
net.LW{2,1}=q2_tenwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q2_tenwt3;% Given Second hidden Weights
Matrix
net.b{1}=q2_tenbi1; % Given Input Bias Vetors
net.b{2}=q2_tenbi2; % Given First hidden Bias Vetors
net.b{3}=q2_tenbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P2,T2_ten);

% ------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------

    train2_pred = sim(net,P2);
    train2_pred=train2_pred';
    train2_pred2=train2_pred(:,1)*(tr2_max(n3-1)-tr2_min(n3-
1))+tr2_min(n3-1);% Maximum tension stress
    train2_meas2=tr2_in(:,n3-1);
    train2_comp2=zeros(m3,2);
    train2_comp2(:,1)=train2_meas2;
    train2_comp2(:,2)=train2_pred2;
    train2_comp2;

% ------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------

    [m4,n4]=size(te2_in);
    test2_in=zeros(m4,n4-3);
    for i=1:n4-3
      for j=1:m4
        test2_in(j,i)=(te2_in(j,i)-tr2_min(i))/(tr2_max(i)-
tr2_min(i));
      end
    end
    TEN2=test2_in;
    TEN2=TEN2';
    test2_pred = sim(net,TEN2);
    test2_pred=test2_pred';
    test2_pred2=test2_pred(:,1)*(tr2_max(n3-1)-tr2_min(n3-
1))+tr2_min(n3-1);% Maximum tension stress
    test2_meas2=te2_in(:,n4-1);
    test2_comp2=zeros(m4,2);
    test2_comp2(:,1)=test2_meas2;
    test2_comp2(:,2)=test2_pred2;
    test2_comp2;

% ------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ------------------------------------------------------------------

%----------------------------Decision of Stroke-----------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PTEN2=pile_te2_in;
    PTEN2=PTEN2';
    ptest2_pred=sim(net,PTEN2);
    ptest2_pred=ptest2_pred';
    pte2_pred2=ptest2_pred(:,1)*(tr2_max(n3-1)-tr2_min(n3-
1))+tr2_min(n3-1);% Maximum tension stress
    ptest2_ten1=pte2_pred2;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PTEN2=pile_te2_in;
    PTEN2=PTEN2';
    ptest2_pred=sim(net,PTEN2);
    ptest2_pred=ptest2_pred';
    pte2_pred2=ptest2_pred(:,1)*(tr2_max(n3-1)-tr2_min(n3-
1))+tr2_min(n3-1);% Maximum tension stress
    ptest2_ten1=pte2_pred2;

end

%--------------------------------- BPF for Q2 ----------------------------
---

disp('            BPF in Qu2,                                    ')

net=newff(initt2,[20,20,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q2_bpfwt1; % Given Input Weights Matrix
net.LW{2,1}=q2_bpfwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q2_bpfwt3;% Given Second hidden Weights
Matrix
net.b{1}=q2_bpfbi1; % Given Input Bias Vetors
net.b{2}=q2_bpfbi2; % Given First hidden Bias Vetors
net.b{3}=q2_bpfbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P2,T2_bpf);

% ------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
```

```
% ------------------------------------------------------------------

    train2_pred = sim(net,P2);
    train2_pred=train2_pred';
    train2_pred3=train2_pred(:,1)*(tr2_max(n3)-
tr2_min(n3))+tr2_min(n3);% BPF
    train2_meas3=tr2_in(:,n3);
    train2_comp3=zeros(m3,2);
    train2_comp3(:,1)=train2_meas3;
    train2_comp3(:,2)=train2_pred3;
    train2_comp3;

% ------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------

    [m4,n4]=size(te2_in);
    test2_in=zeros(m4,n4-3);
    for i=1:n4-3
      for j=1:m4
        test2_in(j,i)=(te2_in(j,i)-tr2_min(i))/(tr2_max(i)-
tr2_min(i));
      end
    end
    BPF2=test2_in;
    BPF2=BPF2';
    test2_pred = sim(net,BPF2);
    test2_pred=test2_pred';
    test2_pred3=test2_pred(:,1)*(tr2_max(n3)-
tr2_min(n3))+tr2_min(n3);% BPF
    test2_meas3=te2_in(:,n4);
    test2_comp3=zeros(m4,2);
    test2_comp3(:,1)=test2_meas3;
    test2_comp3(:,2)=test2_pred3;
    test2_comp3;

% ------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ------------------------------------------------------------------

%--------------------------Decision of Stroke-----------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PBPF2=pile_te2_in;
    PBPF2=PBPF2';
    ptest2_pred=sim(net,PBPF2);
    ptest2_pred=ptest2_pred';
    pte2_pred3=ptest2_pred(:,1)*(tr2_max(n3)-
tr2_min(n3))+tr2_min(n3);% BPF
    ptest2_bpf1=pte2_pred3;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PBPF2=pile_te2_in;
    PBPF2=PBPF2';
    ptest2_pred=sim(net,PBPF2);
    ptest2_pred=ptest2_pred';
    pte2_pred3=ptest2_pred(:,1)*(tr2_max(n3)-
tr2_min(n3))+tr2_min(n3);% BPF
    ptest2_bpf1=pte2_pred3;

end


% Calculation correlation "r^2" for Max compression stresses

     r_squ2_tra=corr2(train2_meas1,train2_pred1);
     r_squ2_tr1=r_squ2_tra^2;

     r_squ2_tea=corr2(test2_meas1,test2_pred1);
     r_squ2_te1=r_squ2_tea^2;


 % Calculation correlation "r^2" for Max tension stresses

     r_squ2_trb=corr2(train2_meas2,train2_pred2);
     r_squ2_tr2=r_squ2_trb^2;

     r_squ2_teb=corr2(test2_meas2,test2_pred2);
     r_squ2_te2=r_squ2_teb^2;


% Calculation correlation "r^2" for BPF

     r_squ2_trc=corr2(train2_meas3,train2_pred3);
     r_squ2_tr3=r_squ2_trc^2;

     r_squ2_tec=corr2(test2_meas3,test2_pred3);
     r_squ2_te3=r_squ2_tec^2;

disp('Trainings for Qu2 are DONE: Performance goal met
')


%------------------------------------------------------------------
% ---------------------------- Qu3 : 160 ~ 250 kips ------------------
----
%------------------------------------------------------------------

cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Drivability\BPNN 5\DATA\Q3');

if get(handles.chosenunit,'value')==1
disp('                                                  ')
disp('----------------------- Qu3: 160 ~ 250 kips ----------------------
--')
elseif get(handles.chosenunit,'value')==2
disp('                                                  ')
disp('----------------------- Qu3: 712 ~ 1112 kN ----------------------
----')
end
%disp('Training for Qu3,                                        ')

%------------------------------------------------------------------
% Loading the input data sets and normalization of training data
set
%------------------------------------------------------------------

load trainqu3.txt;
load testqu3.txt;
load w1comqu3.txt;
load w2comqu3.txt;
load w3comqu3.txt;
load b1comqu3.txt;
load b2comqu3.txt;
load b3comqu3.txt;
load w1tenqu3.txt;
load w2tenqu3.txt;
load w3tenqu3.txt;
load b1tenqu3.txt;
load b2tenqu3.txt;
load b3tenqu3.txt;
load w1bpfqu3.txt;
load w2bpfqu3.txt;
load w3bpfqu3.txt;
load b1bpfqu3.txt;
load b2bpfqu3.txt;
```

```
load b3bpfqu3.txt;

tr3_in=trainqu3;
te3_in=testqu3;
q3_comwt1=w1comqu3;
q3_comwt2=w2comqu3;
q3_comwt3=w3comqu3;
q3_combi1=b1comqu3;
q3_combi2=b2comqu3;
q3_combi3=b3comqu3;
q3_tenwt1=w1tenqu3;
q3_tenwt2=w2tenqu3;
q3_tenwt3=w3tenqu3;
q3_tenbi1=b1tenqu3;
q3_tenbi2=b2tenqu3;
q3_tenbi3=b3tenqu3;
q3_bpfwt1=w1bpfqu3;
q3_bpfwt2=w2bpfqu3;
q3_bpfwt3=w3bpfqu3;
q3_bpfbi1=b1bpfqu3;
q3_bpfbi2=b2bpfqu3;
q3_bpfbi3=b3bpfqu3;

% Loading the input data sets and normalization of training data

[m6,n6]=size(tr3_in);
trr3=zeros(m6,n6);
in3=zeros(n6,2);
for i=1:n6
  tr3_max(i)=max(tr3_in(:,i));
  tr3_min(i)=min(tr3_in(:,i));
    if tr3_max(i) == tr3_min(i)
      for j=1:m6
        trr3(j,i)=1;
      end
    else
      for j=1:m6
        trr3(j,i)=(tr3_in(j,i)-tr3_min(i))./(tr3_max(i)-tr3_min(i));
      end
    end
  in3(i,1)=min(trr3(:,i));
  in3(i,2)=max(trr3(:,i));
end

% ---------------------------------------------------------------------
% Network architecture with given learning factors & Network
Initialization
% ---------------------------------------------------------------------

initt3=in3(1:(n6-3),:);
P3=trr3(:,1:(n6-3));
P3=P3';
T3_com=trr3(:,n6-2).';
T3_ten=trr3(:,n6-1).';
T3_bpf=trr3(:,n6).';

%------------------------ Max Com Stresses for Q3 ----------------
-------
disp('Training for Max Compression Stresses in Qu3,
')

net=newff(initt3,[18,18,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q3_comwt1; % Given Input Weights Matrix
net.LW{2,1}=q3_comwt2;% Given First hidden Weights
Matrix
net.LW{3,2}=q3_comwt3;% Given Second hidden Weights
Matrix
net.b{1}=q3_combi1; % Given Input Bias Vetors
net.b{2}=q3_combi2; % Given First hidden Bias Vetors
net.b{3}=q3_combi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P3,T3_com);

% ---------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ---------------------------------------------------------------------

    train3_pred = sim(net,P3);
    train3_pred=train3_pred';
    train3_pred1=train3_pred(:,1)*(tr3_max(n6-2)-tr3_min(n6-
2))+tr3_min(n6-2);% Maximum compressive stress
    train3_meas1=tr3_in(:,n6-2);
    train3_comp1=zeros(m6,2);
    train3_comp1(:,1)=train3_meas1;
    train3_comp1(:,2)=train3_pred1;
    train3_comp1;

% ---------------------------------------------------------------------
% Prediction for the test data sets
% ---------------------------------------------------------------------

    [m7,n7]=size(te3_in);
    test3_in=zeros(m7,n7-3);
    for i=1:n7-3
      for j=1:m7
        test3_in(j,i)=(te3_in(j,i)-tr3_min(i))/(tr3_max(i)-
tr3_min(i));
      end
    end
    COM3=test3_in;
    COM3=COM3';
    test3_pred = sim(net,COM3);
    test3_pred=test3_pred';
    test3_pred1=test3_pred(:,1)*(tr3_max(n6-2)-tr3_min(n6-
2))+tr3_min(n6-2);% Maximum compressive stress
    test3_meas1=te3_in(:,n7-2);
    test3_comp1=zeros(m7,2);
    test3_comp1(:,1)=test3_meas1;
    test3_comp1(:,2)=test3_pred1;
    test3_comp1;

% ---------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of 81
- 159 kips
% ---------------------------------------------------------------------

%---------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

      str_range=5.:0.5:11;
      stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.5*j+4.5;
   end
      L_D=Lp*12./D;
   for str=1:size(str_range,2)

pile_test3_in(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_w
t,L,Lp,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resista
nce,Qu3,stroke(str)];
   end

[m8,n8]=size(pile_test3_in);
```

```
  pile_te3_in=zeros(m8,n8);
    for i=1:n8
      for j=1:m8
        pile_te3_in(j,i)=(pile_test3_in(j,i)-tr3_min(i))/(tr3_max(i)-
tr3_min(i));
      end
    end

    PCOM3=pile_te3_in;
    PCOM3=PCOM3';
    ptest3_pred=sim(net,PCOM3);
    ptest3_pred=ptest3_pred';
    pte3_pred1=ptest3_pred(:,1)*(tr3_max(n6-2)-tr3_min(n6-
2))+tr3_min(n6-2);% Maximum compressive stress
    ptest3_com1=pte3_pred1;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

   str_range=1.5:0.1:3.4; %SI UNIT
   stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.1*j+1.4;
   end

      L_D=Lp*1000./D;
   for str=1:size(str_range,2) % SI--->ENG

pile_test3_in(str,:)=[ram_wt/4.448,energy/1.35,Harea/2.54^2,E
m/6.8947,Hthick/25.4,helmet_wt/4.448,L/0.3048,Lp/0.3048,D/2
5.4,Pa/2.54^2,L_D,quake_toe/25.4,damp_shaft*0.3048,damp_t
oe*0.3048,shaft_resistance,Qu3/4.448,stroke(str)/0.3048];

pile_in3(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_wt,L,L
p,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resistance,
Qu3,stroke(str)];
   end

[m8,n8]=size(pile_test3_in);
  pile_te3_in=zeros(m8,n8);
    for i=1:n8
      for j=1:m8
        pile_te3_in(j,i)=(pile_test3_in(j,i)-tr3_min(i))/(tr3_max(i)-
tr3_min(i));
      end
    end

    PCOM3=pile_te3_in;
    PCOM3=PCOM3';
    ptest3_pred=sim(net,PCOM3);
    ptest3_pred=ptest3_pred';
    pte3_pred1=ptest3_pred(:,1)*(tr3_max(n6-2)-tr3_min(n6-
2))+tr3_min(n6-2);% Maximum compressive stress
    ptest3_com1=pte3_pred1;

end

%---------------------- Maximum tensile stresses for Q3 ------------
-------

disp('           Max Tension Stresses in Qu3,                    ')

net=newff(initt3,[19,19,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q3_tenwt1; % Given Input Weights Matrix
net.LW{2,1}=q3_tenwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q3_tenwt3;% Given Second hidden Weights
Matrix
net.b{1}=q3_tenbi1; % Given Input Bias Vetors
net.b{2}=q3_tenbi2; % Given First hidden Bias Vetors
net.b{3}=q3_tenbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P3,T3_ten);

% ------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------

    train3_pred = sim(net,P3);
    train3_pred=train3_pred';
    train3_pred2=train3_pred(:,1)*(tr3_max(n6-1)-tr3_min(n6-
1))+tr3_min(n6-1);% Maximum tension stress
    train3_meas2=tr3_in(:,n6-1);
    train3_comp2=zeros(m6,2);
    train3_comp2(:,1)=train3_meas2;
    train3_comp2(:,2)=train3_pred2;
    train3_comp2;

% ------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------

    [m7,n7]=size(te3_in);
    test3_in=zeros(m7,n7-3);
    for i=1:n7-3
      for j=1:m7
        test3_in(j,i)=(te3_in(j,i)-tr3_min(i))/(tr3_max(i)-
tr3_min(i));
      end
    end
    TEN3=test3_in;
    TEN3=TEN3';
    test3_pred = sim(net,TEN3);
    test3_pred=test3_pred';
    test3_pred2=test3_pred(:,1)*(tr3_max(n6-1)-tr3_min(n6-
1))+tr3_min(n6-1);% Maximum tension stress
    test3_meas2=te3_in(:,n7-1);
    test3_comp2=zeros(m7,2);
    test3_comp2(:,1)=test3_meas2;
    test3_comp2(:,2)=test3_pred2;
    test3_comp2;

% ------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ------------------------------------------------------------------

%---------------------------Decision of Stroke-----------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PTEN3=pile_te3_in;
    PTEN3=PTEN3';
    ptest3_pred=sim(net,PTEN3);
    ptest3_pred=ptest3_pred';
    pte3_pred2=ptest3_pred(:,1)*(tr3_max(n6-1)-tr3_min(n6-
1))+tr3_min(n6-1);% Maximum tension stress
    ptest3_ten1=pte3_pred2;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PTEN3=pile_te3_in;
    PTEN3=PTEN3';
    ptest3_pred=sim(net,PTEN3);
    ptest3_pred=ptest3_pred';
```

```
    pte3_pred2=ptest3_pred(:,1)*(tr3_max(n6-1)-tr3_min(n6-
1))+tr3_min(n6-1);% Maximum tension stress
    ptest3_ten1=pte3_pred2;

end

%---------------------------------- BPF for Q3 ---------------------------
---

disp('            BPF in Qu3,                                    ')

net=newff(initt3,[16,16,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q3_bpfwt1; % Given Input Weights Matrix
net.LW{2,1}=q3_bpfwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q3_bpfwt3;% Given Second hidden Weights
Matrix
net.b{1}=q3_bpfbi1; % Given Input Bias Vetors
net.b{2}=q3_bpfbi2; % Given First hidden Bias Vetors
net.b{3}=q3_bpfbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P3,T3_bpf);

% ------------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------------

    train3_pred = sim(net,P3);
    train3_pred=train3_pred';
    train3_pred3=train3_pred(:,1)*(tr3_max(n6)-
tr3_min(n6))+tr3_min(n6);% BPF
    train3_meas3=tr3_in(:,n6);
    train3_comp3=zeros(m6,2);
    train3_comp3(:,1)=train3_meas3;
    train3_comp3(:,2)=train3_pred3;
    train3_comp3;

% ------------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------------

    [m7,n7]=size(te3_in);
    test3_in=zeros(m7,n7-3);
    for i=1:n7-3
      for j=1:m7
        test3_in(j,i)=(te3_in(j,i)-tr3_min(i))/(tr3_max(i)-
tr3_min(i));
      end
    end
    BPF3=test3_in;
    BPF3=BPF3';
    test3_pred = sim(net,BPF3);
    test3_pred=test3_pred';
    test3_pred3=test3_pred(:,1)*(tr3_max(n6)-
tr3_min(n6))+tr3_min(n6);% BPF
    test3_meas3=te3_in(:,n4);
    test3_comp3=zeros(m7,2);
    test3_comp3(:,1)=test3_meas3;
    test3_comp3(:,2)=test3_pred3;
    test3_comp3;

% ------------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
160-250 kips
% ------------------------------------------------------------------------

%--------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PBPF3=pile_te3_in;
    PBPF3=PBPF3';
    ptest3_pred=sim(net,PBPF3);
    ptest3_pred=ptest3_pred';
    pte3_pred3=ptest3_pred(:,1)*(tr3_max(n6)-
tr3_min(n6))+tr3_min(n6);% BPF
    ptest3_bpf1=pte3_pred3;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PBPF3=pile_te3_in;
    PBPF3=PBPF3';
    ptest3_pred=sim(net,PBPF3);
    ptest3_pred=ptest3_pred';
    pte3_pred3=ptest3_pred(:,1)*(tr3_max(n6)-
tr3_min(n6))+tr3_min(n6);% BPF
    ptest3_bpf1=pte3_pred3;

end


% Calculation correlation "r^2" for Max compression stresses

    r_squ3_tra=corr2(train3_meas1,train3_pred1);
    r_squ3_tr1=r_squ3_tra^2;

    r_squ3_tea=corr2(test3_meas1,test3_pred1);
    r_squ3_te1=r_squ3_tea^2;


 % Calculation correlation "r^2" for Max tension stresses

    r_squ3_trb=corr2(train3_meas2,train3_pred2);
    r_squ3_tr2=r_squ3_trb^2;

    r_squ3_teb=corr2(test3_meas2,test3_pred2);
    r_squ3_te2=r_squ3_teb^2;


% Calculation correlation "r^2" for BPF

    r_squ3_trc=corr2(train3_meas3,train3_pred3);
    r_squ3_tr3=r_squ3_trc^2;

    r_squ3_tec=corr2(test3_meas3,test3_pred3);
    r_squ3_te3=r_squ3_tec^2;

disp('Trainings for Qu3 are DONE: Performance goal met
')

%------------------------------------------------------------------------
% ---------------------------- Qu4 : 251 ~ 399 kips ---------------------
----
%------------------------------------------------------------------------

cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Drivability\BPNN 5\DATA\Q4');

if get(handles.chosenunit,'value')==1
disp('                                                  ')
disp('----------------------- Qu4: 251 ~ 399 kips ----------------------
--')
elseif get(handles.chosenunit,'value')==2
disp('                                                  ')
```

```
disp('---------------------- Qu4: 1113 ~ 1779 kN ----------------------')
end
%disp('Training for Qu4,                                    ')

%-------------------------------------------------------------------
% Loading the input data sets and normalization of training data set
%-------------------------------------------------------------------

load trainqu4.txt;
load testqu4.txt;
load w1comqu4.txt;
load w2comqu4.txt;
load w3comqu4.txt;
load b1comqu4.txt;
load b2comqu4.txt;
load b3comqu4.txt;
load w1tenqu4.txt;
load w2tenqu4.txt;
load w3tenqu4.txt;
load b1tenqu4.txt;
load b2tenqu4.txt;
load b3tenqu4.txt;
load w1bpfqu4.txt;
load w2bpfqu4.txt;
load w3bpfqu4.txt;
load b1bpfqu4.txt;
load b2bpfqu4.txt;
load b3bpfqu4.txt;

tr4_in=trainqu4;
te4_in=testqu4;
q4_comwt1=w1comqu4;
q4_comwt2=w2comqu4;
q4_comwt3=w3comqu4;
q4_combi1=b1comqu4;
q4_combi2=b2comqu4;
q4_combi3=b3comqu4;
q4_tenwt1=w1tenqu4;
q4_tenwt2=w2tenqu4;
q4_tenwt3=w3tenqu4;
q4_tenbi1=b1tenqu4;
q4_tenbi2=b2tenqu4;
q4_tenbi3=b3tenqu4;
q4_bpfwt1=w1bpfqu4;
q4_bpfwt2=w2bpfqu4;
q4_bpfwt3=w3bpfqu4;
q4_bpfbi1=b1bpfqu4;
q4_bpfbi2=b2bpfqu4;
q4_bpfbi3=b3bpfqu4;

% loading the input data sets and normalization of training data

[m9,n9]=size(tr4_in);
trr4=zeros(m9,n9);
in4=zeros(n9,2);
for i=1:n9
 tr4_max(i)=max(tr4_in(:,i));
 tr4_min(i)=min(tr4_in(:,i));
  if tr4_max(i) == tr4_min(i)
    for j=1:m9
      trr4(j,i)=1;
    end
  else
    for j=1:m9
      trr4(j,i)=(tr4_in(j,i)-tr4_min(i))./(tr4_max(i)-tr4_min(i));
    end
  end
 in4(i,1)=min(trr4(:,i));
 in4(i,2)=max(trr4(:,i));
end

% ---------------------------------------------------------------------
% Network architecture with given learning factors & Network Initialization
% ---------------------------------------------------------------------

initt4=in4(1:(n9-3),:);
P4=trr4(:,1:(n9-3));
P4=P4';
T4_com=trr4(:,n9-2).';
T4_ten=trr4(:,n9-1).';
T4_bpf=trr4(:,n9).';

% ---------------------------------------------------------------------
% Network architecture with given learning factors & Network Initialization
% ---------------------------------------------------------------------

%------------------------ Max Com Stresses for Q4 ----------------------
disp('Training for Max Compression Stresses in Qu4,
')

net=newff(initt4,[20,20,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q4_comwt1; % Given Input Weights Matrix
net.LW{2,1}=q4_comwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q4_comwt3;% Given Second hidden Weights Matrix
net.b{1}=q4_combi1; % Given Input Bias Vetors
net.b{2}=q4_combi2; % Given First hidden Bias Vetors
net.b{3}=q4_combi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P4,T4_com);

% ---------------------------------------------------------------------
% Training the neural network until satisfying the requirement(MSE)
% ---------------------------------------------------------------------

    train4_pred = sim(net,P4);
    train4_pred=train4_pred';
    train4_pred1=train4_pred(:,1)*(tr4_max(n9-2)-tr4_min(n9-2))+tr4_min(n9-2);% Maximum compressive stress
    train4_meas1=tr4_in(:,n9-2);
    train4_comp1=zeros(m9,2);
    train4_comp1(:,1)=train4_meas1;
    train4_comp1(:,2)=train4_pred1;
    train4_comp1;

% ---------------------------------------------------------------------
% Prediction for the test data sets
% ---------------------------------------------------------------------

    [m10,n10]=size(te4_in);
    test4_in=zeros(m10,n10-3);
    for i=1:n10-3
      for j=1:m10
        test4_in(j,i)=(te4_in(j,i)-tr4_min(i))/(tr4_max(i)-tr4_min(i));
      end
    end
    COM4=test4_in;
    COM4=COM4';
```

```
    test4_pred = sim(net,COM4);
    test4_pred=test4_pred';
    test4_pred1=test4_pred(:,1)*(tr4_max(n9-2)-tr4_min(n9-
2))+tr4_min(n9-2);% Maximum compressive stress
    test4_meas1=te4_in(:,n10-2);
    test4_comp1=zeros(m10,2);
    test4_comp1(:,1)=test4_meas1;
    test4_comp1(:,2)=test4_pred1;
    test4_comp1;

% ------------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
251-399 kips
% ------------------------------------------------------------------------

%--------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

      str_range=5.:0.5:11;
      stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.5*j+4.5;
   end
      L_D=Lp*12./D;
   for str=1:size(str_range,2)

pile_test4_in(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_w
t,L,Lp,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resista
nce,Qu4,stroke(str)];
   end

[m11,n11]=size(pile_test4_in);
  pile_te4_in=zeros(m11,n11);
    for i=1:n11
      for j=1:m11
        pile_te4_in(j,i)=(pile_test4_in(j,i)-tr4_min(i))/(tr4_max(i)-
tr4_min(i));
      end
    end

    PCOM4=pile_te4_in;
    PCOM4=PCOM4';
    ptest4_pred=sim(net,PCOM4);
    ptest4_pred=ptest4_pred';
    pte4_pred1=ptest4_pred(:,1)*(tr4_max(n9-2)-tr4_min(n9-
2))+tr4_min(n9-2);% Maximum compressive stress
    ptest4_com1=pte4_pred1;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

   str_range=1.5:0.1:3.4; %SI UNIT
   stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.1*j+1.4;
   end

      L_D=Lp*1000./D;
   for str=1:size(str_range,2) % SI--->ENG

pile_test4_in(str,:)=[ram_wt/4.448,energy/1.35,Harea/2.54^2,E
m/6.8947,Hthick/25.4,helmet_wt/4.448,L/0.3048,Lp/0.3048,D/2
5.4,Pa/2.54^2,L_D,quake_toe/25.4,damp_shaft*0.3048,damp_t
oe*0.3048,shaft_resistance,Qu4/4.448,stroke(str)/0.3048];

pile_in4(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_wt,L,L
p,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resistance,
Qu4,stroke(str)];
   end

[m11,n11]=size(pile_test4_in);
  pile_te4_in=zeros(m11,n11);
    for i=1:n11
      for j=1:m11
        pile_te4_in(j,i)=(pile_test4_in(j,i)-tr4_min(i))/(tr4_max(i)-
tr4_min(i));
      end
    end

    PCOM4=pile_te4_in;
    PCOM4=PCOM4';
    ptest4_pred=sim(net,PCOM4);
    ptest4_pred=ptest4_pred';
    pte4_pred1=ptest4_pred(:,1)*(tr4_max(n9-2)-tr4_min(n9-
2))+tr4_min(n9-2);% Maximum compressive stress
    ptest4_com1=pte4_pred1;

end

%---------------------- Maximum tensile stresses for Q4 ------------
-------

disp('           Max Tension Stresses in Qu4,                    ')

net=newff(initt4,[20,20,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q4_tenwt1; % Given Input Weights Matrix
net.LW{2,1}=q4_tenwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q4_tenwt3;% Given Second hidden Weights
Matrix
net.b{1}=q4_tenbi1; % Given Input Bias Vetors
net.b{2}=q4_tenbi2; % Given First hidden Bias Vetors
net.b{3}=q4_tenbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P4,T4_ten);

% ------------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------------

    train4_pred = sim(net,P4);
    train4_pred=train4_pred';
    train4_pred2=train4_pred(:,1)*(tr4_max(n9-1)-tr4_min(n9-
1))+tr4_min(n9-1);% Maximum tension stress
    train4_meas2=tr4_in(:,n9-1);
    train4_comp2=zeros(m9,2);
    train4_comp2(:,1)=train4_meas2;
    train4_comp2(:,2)=train4_pred2;
    train4_comp2;

% ------------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------------

    [m10,n10]=size(te4_in);
    test4_in=zeros(m10,n10-3);
    for i=1:n10-3
      for j=1:m10
        test4_in(j,i)=(te4_in(j,i)-tr4_min(i))/(tr4_max(i)-
tr4_min(i));
      end
    end
    TEN4=test4_in;
    TEN4=TEN4';
    test4_pred = sim(net,TEN4);
```

```
    test4_pred=test4_pred';
    test4_pred2=test4_pred(:,1)*(tr4_max(n9-1)-tr4_min(n9-
1))+tr4_min(n9-1);% Maximum tension stress
    test4_meas2=te4_in(:,n10-1);
    test4_comp2=zeros(m10,2);
    test4_comp2(:,1)=test4_meas2;
    test4_comp2(:,2)=test4_pred2;
    test4_comp2;

% ------------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ------------------------------------------------------------------------

%---------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PTEN4=pile_te4_in;
    PTEN4=PTEN4';
    ptest4_pred=sim(net,PTEN4);
    ptest4_pred=ptest4_pred';
    pte4_pred2=ptest4_pred(:,1)*(tr4_max(n9-1)-tr4_min(n9-
1))+tr4_min(n9-1);% Maximum tension stress
    ptest4_ten1=pte4_pred2;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PTEN4=pile_te4_in;
    PTEN4=PTEN4';
    ptest4_pred=sim(net,PTEN4);
    ptest4_pred=ptest4_pred';
    pte4_pred2=ptest4_pred(:,1)*(tr4_max(n9-1)-tr4_min(n9-
1))+tr4_min(n9-1);% Maximum tension stress
    ptest4_ten1=pte4_pred2;

end

%--------------------------------- BPF for Q4 -------------------------
---

disp('            BPF in Qu4,                                    ')

net=newff(initt4,[10,10,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q4_bpfwt1; % Given Input Weights Matrix
net.LW{2,1}=q4_bpfwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q4_bpfwt3;% Given Second hidden Weights
Matrix
net.b{1}=q4_bpfbi1; % Given Input Bias Vetors
net.b{2}=q4_bpfbi2; % Given First hidden Bias Vetors
net.b{3}=q4_bpfbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=9*1e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P4,T4_bpf);

% ------------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------------

    train4_pred = sim(net,P4);
    train4_pred=train4_pred';
    train4_pred3=train4_pred(:,1)*(tr4_max(n9)-
tr4_min(n9))+tr4_min(n9);% BPF
    train4_meas3=tr4_in(:,n9);
    train4_comp3=zeros(m9,2);
    train4_comp3(:,1)=train4_meas3;
    train4_comp3(:,2)=train4_pred3;
    train4_comp3;

% ------------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------------

    [m10,n10]=size(te4_in);
    test4_in=zeros(m10,n10-3);
    for i=1:n10-3
      for j=1:m10
        test4_in(j,i)=(te4_in(j,i)-tr4_min(i))/(tr4_max(i)-
tr4_min(i));
      end
    end
    BPF4=test4_in;
    BPF4=BPF4';
    test4_pred = sim(net,BPF4);
    test4_pred=test4_pred';
    test4_pred3=test4_pred(:,1)*(tr4_max(n9)-
tr4_min(n9))+tr4_min(n9);% BPF
    test4_meas3=te4_in(:,n10);
    test4_comp3=zeros(m10,2);
    test4_comp3(:,1)=test4_meas3;
    test4_comp3(:,2)=test4_pred3;
    test4_comp3;

% ------------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ------------------------------------------------------------------------

%---------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PBPF4=pile_te4_in;
    PBPF4=PBPF4';
    ptest4_pred=sim(net,PBPF4);
    ptest4_pred=ptest4_pred';
    pte4_pred3=ptest4_pred(:,1)*(tr4_max(n9)-
tr4_min(n9))+tr4_min(n9);% BPF
    ptest4_bpf1=pte4_pred3;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PBPF4=pile_te4_in;
    PBPF4=PBPF4';
    ptest4_pred=sim(net,PBPF4);
    ptest4_pred=ptest4_pred';
    pte4_pred3=ptest4_pred(:,1)*(tr4_max(n9)-
tr4_min(n9))+tr4_min(n9);% BPF
    ptest4_bpf1=pte4_pred3;

end


% Calculation correlation "r^2" for Max compression stresses

    r_squ4_tra=corr2(train4_meas1,train4_pred1);
    r_squ4_tr1=r_squ4_tra^2;

    r_squ4_tea=corr2(test4_meas1,test4_pred1);
    r_squ4_te1=r_squ4_tea^2;


 % Calculation correlation "r^2" for Max tension stresses
```

```
    r_squ4_trb=corr2(train4_meas2,train4_pred2);
    r_squ4_tr2=r_squ4_trb^2;

    r_squ4_teb=corr2(test4_meas2,test4_pred2);
    r_squ4_te2=r_squ4_teb^2;


% Calculation correlation "r^2" for BPF

    r_squ4_trc=corr2(train4_meas3,train4_pred3);
    r_squ4_tr3=r_squ4_trc^2;

    r_squ4_tec=corr2(test4_meas3,test4_pred3);
    r_squ4_te3=r_squ4_tec^2;


disp('Training for Qu4 is DONE: Performance goal met
')

%-------------------------------------------------------------------
% ---------------------------- Qu5 : 400 ~ 700 kips -------------------
----
%-------------------------------------------------------------------

cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Drivability\BPNN 5\DATA\Q5');

if get(handles.chosenunit,'value')==1
disp('                                                  ')
disp('----------------------- Qu5: 400 ~ 700 kips ----------------------
--')
elseif get(handles.chosenunit,'value')==2
disp('                                                  ')
disp('----------------------- Qu5: 1780 ~ 3114 kN ---------------------
-----')
end
%disp('Training for Qu5,                                          ')

%-------------------------------------------------------------------
% Loading the input data sets and normalization of training data
set
%-------------------------------------------------------------------

load trainqu5.txt;
load testqu5.txt;
load w1comqu5.txt;
load w2comqu5.txt;
load w3comqu5.txt;
load b1comqu5.txt;
load b2comqu5.txt;
load b3comqu5.txt;
load w1tenqu5.txt;
load w2tenqu5.txt;
load w3tenqu5.txt;
load b1tenqu5.txt;
load b2tenqu5.txt;
load b3tenqu5.txt;
load w1bpfqu5.txt;
load w2bpfqu5.txt;
load w3bpfqu5.txt;
load b1bpfqu5.txt;
load b2bpfqu5.txt;
load b3bpfqu5.txt;

tr5_in=trainqu5;
te5_in=testqu5;
q5_comwt1=w1comqu5;
q5_comwt2=w2comqu5;
q5_comwt3=w3comqu5;
q5_combi1=b1comqu5;
q5_combi2=b2comqu5;
q5_combi3=b3comqu5;
q5_tenwt1=w1tenqu5;
q5_tenwt2=w2tenqu5;
q5_tenwt3=w3tenqu5;
q5_tenbi1=b1tenqu5;
q5_tenbi2=b2tenqu5;
q5_tenbi3=b3tenqu5;
q5_bpfwt1=w1bpfqu5;
q5_bpfwt2=w2bpfqu5;
q5_bpfwt3=w3bpfqu5;
q5_bpfbi1=b1bpfqu5;
q5_bpfbi2=b2bpfqu5;
q5_bpfbi3=b3bpfqu5;

[m12,n12]=size(tr5_in);
trr5=zeros(m12,n12);
in5=zeros(n12,2);
for i=1:n12
  tr5_max(i)=max(tr5_in(:,i));
  tr5_min(i)=min(tr5_in(:,i));
    if tr5_max(i) == tr5_min(i)
      for j=1:m12
        trr5(j,i)=1;
      end
    else
      for j=1:m12
        trr5(j,i)=(tr5_in(j,i)-tr5_min(i))./(tr5_max(i)-tr5_min(i));
      end
    end
  in5(i,1)=min(trr5(:,i));
  in5(i,2)=max(trr5(:,i));
end

% -------------------------------------------------------------------
% Network architecture with given learning factors & Network
Initialization
% -------------------------------------------------------------------

initt5=in5(1:(n12-3),:);
P5=trr5(:,1:(n12-3));
P5=P5';
T5_com=trr5(:,n12-2).';
T5_ten=trr5(:,n12-1).';
T5_bpf=trr5(:,n12).';

% -------------------------------------------------------------------
% Network architecture with given learning factors & Network
Initialization
% -------------------------------------------------------------------

%------------------------ Max Com Stresses for Q5 -----------------
-------
disp('Training for Max Compression Stresses in Qu5,
')

net=newff(initt5,[20,20,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q5_comwt1; % Given Input Weights Matrix
net.LW{2,1}=q5_comwt2;% Given First hidden Weights
Matrix
net.LW{3,2}=q5_comwt3;% Given Second hidden Weights
Matrix
net.b{1}=q5_combi1; % Given Input Bias Vetors
net.b{2}=q5_combi2; % Given First hidden Bias Vetors
net.b{3}=q5_combi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
```

```
[net,tr]=train(net,P5,T5_com);

% ------------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ------------------------------------------------------------------------

    train5_pred = sim(net,P5);
    train5_pred=train5_pred';
    train5_pred1=train5_pred(:,1)*(tr5_max(n12-2)-
tr5_min(n12-2))+tr5_min(n12-2);% Maximum compressive
stress
    train5_meas1=tr5_in(:,n12-2);
    train5_comp1=zeros(m12,2);
    train5_comp1(:,1)=train5_meas1;
    train5_comp1(:,2)=train5_pred1;
    train5_comp1;

% ------------------------------------------------------------------------
% Prediction for the test data sets
% ------------------------------------------------------------------------

    [m13,n13]=size(te5_in);
    test5_in=zeros(m13,n13-3);
    for i=1:n13-3
      for j=1:m13
        test5_in(j,i)=(te5_in(j,i)-tr5_min(i))/(tr5_max(i)-
tr5_min(i));
      end
    end
    COM5=test5_in;
    COM5=COM5';
    test5_pred = sim(net,COM5);
    test5_pred=test5_pred';
    test5_pred1=test5_pred(:,1)*(tr5_max(n12-2)-tr5_min(n12-
2))+tr5_min(n12-2);% Maximum compressive stress
    test5_meas1=te5_in(:,n13-2);
    test5_comp1=zeros(m13,2);
    test5_comp1(:,1)=test5_meas1;
    test5_comp1(:,2)=test5_pred1;
    test5_comp1;

% ------------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of 81
- 159 kips
% ------------------------------------------------------------------------

%--------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

       str_range=5.:0.5:11;
       stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
       stroke(j)=0.5*j+4.5;
   end
       L_D=Lp*12./D;
   for str=1:size(str_range,2)

pile_test5_in(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_w
t,L,Lp,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resista
nce,Qu5,stroke(str)];
   end

[m14,n14]=size(pile_test5_in);
  pile_te5_in=zeros(m14,n14);
    for i=1:n14
      for j=1:m14
        pile_te5_in(j,i)=(pile_test5_in(j,i)-tr5_min(i))/(tr5_max(i)-
tr5_min(i));
      end
    end

    PCOM5=pile_te5_in;
    PCOM5=PCOM5';
    ptest5_pred=sim(net,PCOM5);
    ptest5_pred=ptest5_pred';
    pte5_pred1=ptest5_pred(:,1)*(tr5_max(n12-2)-tr5_min(n12-
2))+tr5_min(n12-2);% Maximum compressive stress
    ptest5_com1=pte5_pred1;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

   str_range=1.5:0.1:3.4; %SI UNIT
   stroke=zeros(1,size(str_range,2));
   for j=1:size(str_range,2)
      stroke(j)=0.1*j+1.4;
   end

      L_D=Lp*1000./D;
   for str=1:size(str_range,2) % SI--->ENG

pile_test5_in(str,:)=[ram_wt/4.448,energy/1.35,Harea/2.54^2,E
m/6.8947,Hthick/25.4,helmet_wt/4.448,L/0.3048,Lp/0.3048,D/2
5.4,Pa/2.54^2,L_D,quake_toe/25.4,damp_shaft*0.3048,damp_t
oe*0.3048,shaft_resistance,Qu5/4.448,stroke(str)/0.3048];

pile_in5(str,:)=[ram_wt,energy,Harea,Em,Hthick,helmet_wt,L,L
p,D,Pa,L_D,quake_toe,damp_shaft,damp_toe,shaft_resistance,
Qu5,stroke(str)];
   end

[m14,n14]=size(pile_test5_in);
  pile_te5_in=zeros(m14,n14);
    for i=1:n14
      for j=1:m14
        pile_te5_in(j,i)=(pile_test5_in(j,i)-tr5_min(i))/(tr5_max(i)-
tr5_min(i));
      end
    end

    PCOM5=pile_te5_in;
    PCOM5=PCOM5';
    ptest5_pred=sim(net,PCOM5);
    ptest5_pred=ptest5_pred';
    pte5_pred1=ptest5_pred(:,1)*(tr5_max(n12-2)-tr5_min(n12-
2))+tr5_min(n12-2);% Maximum compressive stress
    ptest5_com1=pte5_pred1;

end

%---------------------- Maximum tensile stresses for Q5 -----------
-------

disp('           Max Tension Stresses in Qu5,                    ')

net=newff(initt5,[13,13,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q5_tenwt1; % Given Input Weights Matrix
net.LW{2,1}=q5_tenwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q5_tenwt3;% Given Second hidden Weights
Matrix
net.b{1}=q5_tenbi1; % Given Input Bias Vetors
net.b{2}=q5_tenbi2; % Given First hidden Bias Vetors
net.b{3}=q5_tenbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
```

```
net.trainParam.show=NaN;
[net,tr]=train(net,P5,T5_ten);

% ---------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ---------------------------------------------------------------------

    train5_pred = sim(net,P5);
    train5_pred=train5_pred';
    train5_pred2=train5_pred(:,1)*(tr5_max(n12-1)-
tr5_min(n12-1))+tr5_min(n12-1);% Maximum tension stress
    train5_meas2=tr5_in(:,n12-1);
    train5_comp2=zeros(m12,2);
    train5_comp2(:,1)=train5_meas2;
    train5_comp2(:,2)=train5_pred2;
    train5_comp2;

% ---------------------------------------------------------------------
% Prediction for the test data sets
% ---------------------------------------------------------------------

    [m13,n13]=size(te5_in);
    test5_in=zeros(m13,n13-3);
    for i=1:n13-3
      for j=1:m13
        test5_in(j,i)=(te5_in(j,i)-tr5_min(i))/(tr5_max(i)-
tr5_min(i));
      end
    end
    TEN5=test5_in;
    TEN5=TEN5';
    test5_pred = sim(net,TEN5);
    test5_pred=test5_pred';
    test5_pred2=test5_pred(:,1)*(tr5_max(n12-1)-tr5_min(n12-
1))+tr5_min(n12-1);% Maximum tension stress
    test5_meas2=te5_in(:,n13-1);
    test5_comp2=zeros(m13,2);
    test5_comp2(:,1)=test5_meas2;
    test5_comp2(:,2)=test5_pred2;
    test5_comp2;

% ---------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ---------------------------------------------------------------------

%--------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English

    PTEN5=pile_te5_in;
    PTEN5=PTEN5';
    ptest5_pred=sim(net,PTEN5);
    ptest5_pred=ptest5_pred';
    pte5_pred2=ptest5_pred(:,1)*(tr5_max(n12-1)-tr5_min(n12-
1))+tr5_min(n12-1);% Maximum tension stress
    ptest5_ten1=pte5_pred2;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PTEN5=pile_te5_in;
    PTEN5=PTEN5';
    ptest5_pred=sim(net,PTEN5);
    ptest5_pred=ptest5_pred';
    pte5_pred2=ptest5_pred(:,1)*(tr5_max(n12-1)-tr5_min(n12-
1))+tr5_min(n12-1);% Maximum tension stress
    ptest5_ten1=pte5_pred2;

end

%-------------------------------- BPF for Q5 --------------------------
---

disp('          BPF in Qu5,                                    ')

net=newff(initt5,[15,15,1],{'logsig','tansig','logsig'},'trainlm');

net.IW{1}=q5_bpfwt1; % Given Input Weights Matrix
net.LW{2,1}=q5_bpfwt2;% Given First hidden Weights Matrix
net.LW{3,2}=q5_bpfwt3;% Given Second hidden Weights
Matrix
net.b{1}=q5_bpfbi1; % Given Input Bias Vetors
net.b{2}=q5_bpfbi2; % Given First hidden Bias Vetors
net.b{3}=q5_bpfbi3; % Given Second hidden Bias Vetors

net.trainParam.epochs=1000;
net.trainParam.goal=1.e-4;
net.trainParam.show=NaN;
[net,tr]=train(net,P5,T5_bpf);

% ---------------------------------------------------------------------
% Training the neural network until satisfying the
requirement(MSE)
% ---------------------------------------------------------------------

    train5_pred = sim(net,P5);
    train5_pred=train5_pred';
    train5_pred3=train5_pred(:,1)*(tr5_max(n12)-
tr5_min(n12))+tr5_min(n12);% BPF
    train5_meas3=tr5_in(:,n12);
    train5_comp3=zeros(m12,2);
    train5_comp3(:,1)=train5_meas3;
    train5_comp3(:,2)=train5_pred3;
    train5_comp3;

% ---------------------------------------------------------------------
% Prediction for the test data sets
% ---------------------------------------------------------------------

    [m13,n13]=size(te5_in);
    test5_in=zeros(m13,n13-3);
    for i=1:n13-3
      for j=1:m13
        test5_in(j,i)=(te5_in(j,i)-tr5_min(i))/(tr5_max(i)-
tr5_min(i));
      end
    end
    BPF5=test5_in;
    BPF5=BPF5';
    test5_pred = sim(net,BPF5);
    test5_pred=test5_pred';
    test5_pred3=test5_pred(:,1)*(tr5_max(n12)-
tr5_min(n12))+tr5_min(n12);% BPF
    test5_meas3=te5_in(:,n13);
    test5_comp3=zeros(m13,2);
    test5_comp3(:,1)=test5_meas3;
    test5_comp3(:,2)=test5_pred3;
    test5_comp3;

% ---------------------------------------------------------------------
% Prediction for a special pile drivability within Qu range of
30-80 kips
% ---------------------------------------------------------------------

%--------------------------Decision of Stroke-------------------------
----

if get(handles.chosenunit,'value')==1 %UNIT English
```

```
    PBPF5=pile_te5_in;
    PBPF5=PBPF5';
    ptest5_pred=sim(net,PBPF5);
    ptest5_pred=ptest5_pred';
    pte5_pred3=ptest5_pred(:,1)*(tr5_max(n12)-
tr5_min(n12))+tr5_min(n12);% BPF
    ptest5_bpf1=pte5_pred3;

elseif get(handles.chosenunit,'value')==2 %SI UNIT

    PBPF5=pile_te5_in;
    PBPF5=PBPF5';
    ptest5_pred=sim(net,PBPF5);
    ptest5_pred=ptest5_pred';
    pte5_pred3=ptest5_pred(:,1)*(tr5_max(n12)-
tr5_min(n12))+tr5_min(n12);% BPF
    ptest5_bpf1=pte5_pred3;

end


% Calculation correlation "r^2" for Max compression stresses

     r_squ5_tra=corr2(train5_meas1,train5_pred1);
     r_squ5_tr1=r_squ5_tra^2;

     r_squ5_tea=corr2(test5_meas1,test5_pred1);
     r_squ5_te1=r_squ5_tea^2;


 % Calculation correlation "r^2" for Max tension stresses

     r_squ5_trb=corr2(train5_meas2,train5_pred2);
     r_squ5_tr2=r_squ5_trb^2;

     r_squ5_teb=corr2(test4_meas2,test4_pred2);
     r_squ5_te2=r_squ5_teb^2;


% Calculation correlation "r^2" for BPF

     r_squ5_trc=corr2(train5_meas3,train5_pred3);
     r_squ5_tr3=r_squ5_trc^2;

     r_squ5_tec=corr2(test5_meas3,test5_pred3);
     r_squ5_te3=r_squ5_tec^2;


disp('Training for Qu5 is DONE: Performance goal met
')
disp('                                                  ')
disp('                                                  ')


% ------ Showing Results by Back-Propagation Neural Network
------
 set(handles.text29,'string',Qu3);
 set(handles.text30,'string',Qu3);
 set(handles.text31,'string',Qu3);
 set(handles.text32,'string',Qu3);
 set(handles.text33,'string',Qu4);
 set(handles.text34,'string',Qu4);
 set(handles.text35,'string',Qu4);
 set(handles.text36,'string',Qu4);

format bank
if get(handles.chosenunit,'value')==1 %ENG UNIT
   set(handles.text37,'string','5.0');
   set(handles.text38,'string','7.0');
   set(handles.text39,'string','9.0');
   set(handles.text40,'string','11.0');
   set(handles.text41,'string','5.0');
   set(handles.text42,'string','7.0');
   set(handles.text43,'string','9.0');
   set(handles.text44,'string','11.0');

   set(handles.text45,'string',pte3_pred1(1,:));
   set(handles.text46,'string',pte3_pred1(5,:));
   set(handles.text47,'string',pte3_pred1(9,:));
   set(handles.text48,'string',pte3_pred1(13,:));
   set(handles.text49,'string',pte4_pred1(1,:));
   set(handles.text50,'string',pte4_pred1(5,:));
   set(handles.text51,'string',pte4_pred1(9,:));
   set(handles.text52,'string',pte4_pred1(13,:));

   set(handles.text53,'string',pte3_pred2(1,:));
   set(handles.text54,'string',pte3_pred2(5,:));
   set(handles.text55,'string',pte3_pred2(9,:));
   set(handles.text56,'string',pte3_pred2(13,:));
   set(handles.text57,'string',pte4_pred2(1,:));
   set(handles.text58,'string',pte4_pred2(5,:));
   set(handles.text59,'string',pte4_pred2(9,:));
   set(handles.text60,'string',pte4_pred2(13,:));

   set(handles.text61,'string',pte3_pred3(1,:));
   set(handles.text62,'string',pte3_pred3(5,:));
   set(handles.text63,'string',pte3_pred3(9,:));
   set(handles.text64,'string',pte3_pred3(13,:));
   set(handles.text65,'string',pte4_pred3(1,:));
   set(handles.text66,'string',pte4_pred3(5,:));
   set(handles.text67,'string',pte4_pred3(9,:));
   set(handles.text68,'string',pte4_pred3(13,:));


elseif get(handles.chosenunit,'value')==2 %SI UNIT
   set(handles.text37,'string','1.5');
   set(handles.text38,'string','2.1');
   set(handles.text39,'string','2.7');
   set(handles.text40,'string','3.3');
   set(handles.text41,'string','1.5');
   set(handles.text42,'string','2.1');
   set(handles.text43,'string','2.7');
   set(handles.text44,'string','3.3');

   set(handles.text45,'string',pte3_pred1(1,:)*6.8947);
   set(handles.text46,'string',pte3_pred1(7,:)*6.8947);
   set(handles.text47,'string',pte3_pred1(13,:)*6.8947);
   set(handles.text48,'string',pte3_pred1(19,:)*6.8947);
   set(handles.text49,'string',pte4_pred1(1,:)*6.8947);
   set(handles.text50,'string',pte4_pred1(7,:)*6.8947);
   set(handles.text51,'string',pte4_pred1(13,:)*6.8947);
   set(handles.text52,'string',pte4_pred1(19,:)*6.8947);

   set(handles.text53,'string',pte3_pred2(1,:)*6.8947);
   set(handles.text54,'string',pte3_pred2(7,:)*6.8947);
   set(handles.text55,'string',pte3_pred2(13,:)*6.8947);
   set(handles.text56,'string',pte3_pred2(19,:)*6.8947);
   set(handles.text57,'string',pte4_pred2(1,:)*6.8947);
   set(handles.text58,'string',pte4_pred2(7,:)*6.8947);
   set(handles.text59,'string',pte4_pred2(13,:)*6.8947);
   set(handles.text60,'string',pte4_pred2(19,:)*6.8947);

   set(handles.text61,'string',pte3_pred3(1,:));
   set(handles.text62,'string',pte3_pred3(7,:));
   set(handles.text63,'string',pte3_pred3(13,:));
   set(handles.text64,'string',pte3_pred3(19,:));
   set(handles.text65,'string',pte4_pred3(1,:));
   set(handles.text66,'string',pte4_pred3(7,:));
   set(handles.text67,'string',pte4_pred3(13,:));
```

```
    set(handles.text68,'string',pte4_pred3(19,:));

end

set(handles.text24,'visible','on');
set(handles.text25,'visible','on');
set(handles.text26,'visible','on');
set(handles.text27,'visible','on');
set(handles.text28,'visible','on');
set(handles.tx_bpnnqu,'visible','on');
set(handles.tx_bpnnstroke,'visible','on');
set(handles.tx_bpnncom,'visible','on');
set(handles.tx_bpnnten,'visible','on');
set(handles.text29,'visible','on');
set(handles.text30,'visible','on');
set(handles.text31,'visible','on');
set(handles.text32,'visible','on');
set(handles.text33,'visible','on');
set(handles.text34,'visible','on');
set(handles.text35,'visible','on');
set(handles.text36,'visible','on');
set(handles.text37,'visible','on');
set(handles.text38,'visible','on');
set(handles.text39,'visible','on');
set(handles.text40,'visible','on');
set(handles.text41,'visible','on');
set(handles.text42,'visible','on');
set(handles.text43,'visible','on');
set(handles.text44,'visible','on');
set(handles.text45,'visible','on');
set(handles.text46,'visible','on');
set(handles.text47,'visible','on');
set(handles.text48,'visible','on');
set(handles.text49,'visible','on');
set(handles.text50,'visible','on');
set(handles.text51,'visible','on');
set(handles.text52,'visible','on');
set(handles.text53,'visible','on');
set(handles.text54,'visible','on');
set(handles.text55,'visible','on');
set(handles.text56,'visible','on');
set(handles.text57,'visible','on');
set(handles.text58,'visible','on');
set(handles.text59,'visible','on');
set(handles.text60,'visible','on');
set(handles.text61,'visible','on');
set(handles.text62,'visible','on');
set(handles.text63,'visible','on');
set(handles.text64,'visible','on');
set(handles.text65,'visible','on');
set(handles.text66,'visible','on');
set(handles.text67,'visible','on');
set(handles.text68,'visible','on');

% --------------------------------------------------------------------
% OUTPUTS: Predictions by BPNN
% --------------------------------------------------------------------

format bank
Time=datestr(now);
E='';
cd ('C:\Program Files\MATLAB704\work\BPNN\Pile
Drivability\BPNN 5');

if get(handles.chosenunit,'value')==1.%ENGLISH UNIT


pile_test_in=[pile_test1_in;pile_test2_in;pile_test3_in;pile_test4
_in;pile_test5_in];

pcom=[ptest1_com1;ptest2_com1;ptest3_com1;ptest4_com1;pt
est5_com1];

pten=[ptest1_ten1;ptest2_ten1;ptest3_ten1;ptest4_ten1;ptest5_te
n1];

pbpf=[ptest1_bpf1;ptest2_bpf1;ptest3_bpf1;ptest4_bpf1;ptest5_
bpf1];

ptest_comp=[pile_test_in(:,16),pcom,pten,pbpf,pile_test_in(:,17
)];%pile_test_in(:,16--Qu, pile_test_in(:,17)--stroke

   if get(handles.chosenyesno,'value')==2.% GRLWEAP No

      fprintf('-----------------------------------------------------------
----------\n',E);
      fprintf('================== OUTPUT: Pile
Drivability Analysis ==================\n',E);
      fprintf('-----------------------------------------------------------
----------\n',E);
      fprintf('                                                    \n',E);
      fprintf('Project Title: %s\n',project_title);
      fprintf('                                          %s\n', Time);
      fprintf('           Maximum
Maximum                    %s\n',E);
      fprintf('Ultimate    Compression    Tension
Blow              %s\n',E);
      fprintf('Capacity    Stress         Stress       Count
Stroke   %s\n',E);
      fprintf(' (kips)      (ksi)          (ksi)      (bl/ct)
(ft)    %s\n',E);
      fprintf('                                    \n',       E);
      fprintf('%6.1f\t    %6.2f\t      %7.3f\t    %6.1f\t    %6.1f
\n', ptest_comp');


      % == Output File Form ==

      out_file=get(handles.savefile,'string');
      fid=fopen(out_file,'wt');

      fprintf(fid,'-----------------------------------------------------------
----------\n',E);
      fprintf(fid,'================== OUTPUT: Pile
Drivability Analysis ==================\n',E);
      fprintf(fid,'-----------------------------------------------------------
----------\n',E);
      fprintf(fid,'                                                    \n',E);
      fprintf(fid,'Project Title: %s\n',project_title);
      fprintf(fid,'                                          %s\n', Time);
      fprintf(fid,'           Maximum
Maximum                    %s\n',E);
      fprintf(fid,'Ultimate    Compression    Tension
Blow              %s\n',E);
      fprintf(fid,'Capacity    Stress         Stress       Count
Stroke   %s\n',E);
      fprintf(fid,' (kips)      (ksi)          (ksi)      (bl/ct)
(ft)    %s\n',E);
      fprintf(fid,'                                    \n',       E);
      fprintf(fid,'%6.1f\t    %6.2f\t      %5.3f\t %6.1f\t    %6.1f
\n', ptest_comp');
      fclose(fid);

   elseif get(handles.chosenyesno,'value')==1. %GRLWEAP
Yes


weap=[weap_qu,weap_com,weap_ten,weap_bpf,weap_stroke];
```

```
        fprintf('-------------------------------------------------------------
----------\n',E);
        fprintf('==================== OUTPUT: Pile
Drivability Analysis ====================\n',E);
        fprintf('-------------------------------------------------------------
----------\n',E);
        fprintf('                                                    \n',E);
        fprintf('Project Title: %s\n',project_title);
        fprintf('                                          %s\n', Time);
        fprintf('                                        \n',       E);
        fprintf('***** Back-Propagation Neural Network
***** %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('           Maximum
Maximum                    %s\n',E);
        fprintf('Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf('Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(' (kips)      (ksi)          (ksi)      (bl/ct)
(ft)    %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('%6.1f\t    %6.2f\t      %7.3f\t    %6.1f\t    %6.1f
\n', ptest_comp');
        fprintf('                                        \n',       E);
        fprintf('***** GRLWEAP ***** %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('           Maximum
Maximum                    %s\n',E);
        fprintf('Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf('Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(' (kips)      (ksi)          (ksi)      (bl/ct)
(ft)    %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('%6.1f\t    %6.2f\t      %7.3f\t    %6.1f\t    %6.1f
\n',weap');


        % == Output File Form ==

        out_file=get(handles.savefile,'string');
        fid=fopen(out_file,'wt');

        fprintf(fid,'-------------------------------------------------------------
----------\n',E);
        fprintf(fid,'==================== OUTPUT: Pile
Drivability Analysis ====================\n',E);
        fprintf(fid,'-------------------------------------------------------------
----------\n',E);
        fprintf(fid,'                                                    \n',E);
        fprintf(fid,'Project Title: %s\n',project_title);
        fprintf(fid,'                                          %s\n', Time);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'***** Back-Propagation Neural Network
***** %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'           Maximum
Maximum                    %s\n',E);
        fprintf(fid,'Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf(fid,'Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(fid,' (kips)      (ksi)          (ksi)      (bl/ct)
(ft)    %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'%6.1f\t    %6.2f\t      %5.3f\t %6.1f\t    %6.1f
\n', ptest_comp');
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'***** GRLWEAP ***** %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'           Maximum
Maximum                    %s\n',E);
        fprintf(fid,'Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf(fid,'Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(fid,' (kips)      (ksi)          (ksi)      (bl/ct)
(ft)    %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'%6.1f\t    %6.2f\t      %5.3f\t %6.1f\t    %6.1f
\n', weap');
        fclose(fid);

    end


    % ----- 'ctb' is used for plot option: to get the vectors -----

    preout='preout'; %prelim_output = preliminary output
    fid=fopen(preout,'wt');
    fprintf(fid,'%6.1f\t    %6.2f\t      %5.3f\t %6.1f\t    %6.1f   \n',
ptest_comp');
    fclose(fid);

elseif get(handles.chosenunit,'value')==2. %SI UNIT

    pile_in=[pile_in1;pile_in2;pile_in3;pile_in4;pile_in5];

pcom=[ptest1_com1*6.8947;ptest2_com1*6.8947;ptest3_com1
*6.8947;ptest4_com1*6.8947;ptest5_com1*6.8947];

pten=[ptest1_ten1*6.8947;ptest2_ten1*6.8947;ptest3_ten1*6.89
47;ptest4_ten1*6.8947;ptest5_ten1*6.8947];

pbpf=[ptest1_bpf1;ptest2_bpf1;ptest3_bpf1;ptest4_bpf1;ptest5_
bpf1];

ptest_comp=[pile_in(:,16),pcom,pten,pbpf,pile_in(:,17)]; %pile
_in(:,16)--Qu, pile_in(:,17)--stroke

    if get(handles.chosenyesno,'value')==2.% GRLWEAP No

        fprintf('-------------------------------------------------------------
------\n',E);
        fprintf('================== OUTPUT: Pile Drivability
Analysis ==================\n',E);
        fprintf('-------------------------------------------------------------
------\n',E);
        fprintf('                                                    \n',E);
        fprintf('Project Title: %s\n',project_title);
        fprintf('                                          %s\n', Time);
        fprintf('           Maximum
Maximum                    %s\n',E);
        fprintf('Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf('Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(' (kN)        (Mpa)          (Mpa)      (bl/ct)
(m)    %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('%6.1f\t    %6.2f\t      %7.3f\t    %6.1f\t    %6.1f
\n', ptest_comp');


        % == Output File Form ==

        out_file=get(handles.savefile,'string');
        fid=fopen(out_file,'wt');
```

```
        fprintf(fid,'----------------------------------------------------------
----------\n',E);
        fprintf(fid,'================== OUTPUT: Pile
Drivability Analysis ==================\n',E);
        fprintf(fid,'----------------------------------------------------------
----------\n',E);
        fprintf(fid,'                                                    \n',E);
        fprintf(fid,'Project Title: %s\n',project_title);
        fprintf(fid,'                                          %s\n', Time);
        fprintf(fid,'           Maximum
Maximum                  %s\n',E);
        fprintf(fid,'Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf(fid,'Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(fid,' (kN)        (Mpa)          (Mpa)      (bl/ct)
(m)    %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'%6.1f\t    %6.2f\t    %6.3f\t %6.1f\t    %5.1f
\n', ptest_comp');
        fclose(fid);

    elseif get(handles.chosenyesno,'value')==1. %GRLWEAP
Yes


weap=[weap_qu,weap_com,weap_ten,weap_bpf,weap_stroke];
        fprintf('----------------------------------------------------------
------\n',E);
        fprintf('================== OUTPUT: Pile Drivability
Analysis ==================\n',E);
        fprintf('----------------------------------------------------------
------\n',E);
        fprintf('                                                \n',E);
        fprintf('Project Title: %s\n',project_title);
        fprintf('                                          %s\n', Time);
        fprintf('***** Back-Propagation Neural Network
***** %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('           Maximum
Maximum                  %s\n',E);
        fprintf('Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf('Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(' (kN)        (Mpa)          (Mpa)      (bl/ct)
(m)    %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('%6.1f\t    %6.2f\t     %7.3f\t    %6.1f\t     %6.1f
\n', ptest_comp');
        fprintf('                                        \n',       E);
        fprintf('***** GRLWEAP ***** %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('           Maximum
Maximum                  %s\n',E);
        fprintf('Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf('Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(' (kN)        (Mpa)          (Mpa)      (bl/ct)
(m)    %s\n',E);
        fprintf('                                        \n',       E);
        fprintf('%6.1f\t    %6.2f\t     %7.3f\t    %6.1f\t     %6.1f
\n', weap');


        % == Output File Form ==

        out_file=get(handles.savefile,'string');
        fid=fopen(out_file,'wt');

        fprintf(fid,'----------------------------------------------------------
----------\n',E);
        fprintf(fid,'================== OUTPUT: Pile
Drivability Analysis ==================\n',E);
        fprintf(fid,'----------------------------------------------------------
----------\n',E);
        fprintf(fid,'                                                    \n',E);
        fprintf(fid,'Project Title: %s\n',project_title);
        fprintf(fid,'                                          %s\n', Time);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'***** Back-Propagation Neural Network
***** %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'           Maximum
Maximum                  %s\n',E);
        fprintf(fid,'Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf(fid,'Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(fid,' (kN)        (Mpa)          (Mpa)      (bl/ct)
(m)    %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'%6.1f\t    %6.2f\t    %6.3f\t %6.1f\t    %5.1f
\n', ptest_comp');
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'***** GRLWEAP ***** %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'           Maximum
Maximum                  %s\n',E);
        fprintf(fid,'Ultimate    Compression    Tension
Blow              %s\n',E);
        fprintf(fid,'Capacity    Stress         Stress       Count
Stroke   %s\n',E);
        fprintf(fid,' (kN)        (Mpa)          (Mpa)      (bl/ct)
(m)    %s\n',E);
        fprintf(fid,'                                        \n',       E);
        fprintf(fid,'%6.1f\t    %6.2f\t    %6.3f\t %6.1f\t    %5.1f
\n', weap');
        fclose(fid);

    end

    preout='preout'; %preliminary outputs
    fid=fopen(preout,'wt');
    fprintf(fid,'%6.1f\t    %6.2f\t    %6.3f\t %6.1f\t    %5.1f  \n',
ptest_comp');
    fclose(fid);

end



% --- Executes on button press in plot.
function plot_Callback(hObject, eventdata, handles)
% hObject    handle to plot (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

load preout;

% ========= Axes Object Creation in Plotting Results
========

format bank
pause(0.8);
Time=datestr(now);
```

```
plot1=figure('Position',[ 40 100 950 650 ],...
          'Color',[0.8 0.8 0.8],...
          'Name', 'Plotting Results',...
          'Tag','plot',...
          'NumberTitle','off',...
          'visible','on');

   ax_text = axes(...
      'Color',[ 1 1 1 ],...
      'Position',[ 0.03 0.05 0.3 0.90 ],...
      'Units','normalized', ...
      'Xgrid','off', ...
      'Ygrid','off', ...
      'Xlim',[ 0 1 ],...
      'Ylim',[ 0 1 ],...
      'Clipping','on', ...
      'Tag','ax_text', ...
      'UserData','',...
      'Visible','off');

   ax_stroke = axes(...
      'Color',[ 1 1 1 ],...
      'Position',[ 0.4 0.7 0.55 0.25 ],...
      'Units','normalized', ...
      'Xgrid','off', ...
      'Ygrid','off', ...
      'Xlim',[ 0 1 ],...
      'Ylim',[ 0 1 ],...
      'Clipping','on', ...
      'Tag','ax_stroke', ...
      'UserData','close');

   ax_tension = axes(...
      'Color',[ 1 1 1 ],...
      'Position',[ 0.4 0.4 0.55 0.25 ],...
      'Units','normalized', ...
      'Xgrid','off', ...
      'Ygrid','off', ...
      'Xlim',[ 0 1 ],...
      'Ylim',[ 0 1 ],...
      'Clipping','on', ...
      'Tag','ax_tension', ...
      'UserData','close');

   ax_compression = axes(...
      'Color',[ 1 1 1 ],...
      'Position',[ 0.4 0.1 0.55 0.25 ],...
      'Units','normalized', ...
      'Xgrid','off', ...
      'Ygrid','off', ...
      'Xlim',[ 0 1 ],...
      'Ylim',[ 0 1 ],...
      'Clipping','on', ...
      'Tag','ax_compression', ...
      'UserData','close');


% ======== Text Object Creation in Plotting Results
========

   axes(ax_text);
   ax_time=text(0.5,0.99,0,'Time',...
     'FontName','Tahoma',...
     'FontSize',9,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');
   set(ax_time,'string',Time);

   ax_project=text(.0,.93,0,'PROJECT TITLE:',...
     'FontName','Tahoma',...
     'FontSize',11,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');

   ax_projecttitle=text(.2,.88,0,'PROJECT TITLE:',...
     'FontName','Tahoma',...
     'FontSize',11,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');
   project_title=get(handles.project_title,'string');
   set(ax_projecttitle,'string',project_title);

   ax_hammer=text(.0,.82,0,'HAMMER:',...
     'FontName','Tahoma',...
     'FontSize',11,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');

   ax_hamid=text(.25,.82,0,'HAMMER:',...
     'FontName','Tahoma',...
     'FontSize',11,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');
   hammer_id=get(handles.hamid,'string');
   set(ax_hamid,'string',hammer_id);

   ax_cush=text(.0,.75,0,'HAMMER CUSHION',...
     'FontName','Tahoma',...
     'FontSize',11,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');

   ax_cushmodulvalue=text(.7,.70,0,'Elastic Modulus (ksi):',...
     'FontName','Tahoma',...
     'FontSize',9,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');
   Em=str2double(get(handles.modul,'string'));
   set(ax_cushmodulvalue,'string',Em);

   ax_cushthickvalue=text(.7,.65,0,'Thickness (in):',...
     'FontName','Tahoma',...
     'FontSize',9,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');
   Hthick=str2double(get(handles.thick,'string'));
   set(ax_cushthickvalue,'string',Hthick);

   ax_helmet=text(.0,.59,0,'HELMET',...
     'FontName','Tahoma',...
     'FontSize',11,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');

   ax_helmetvalue=text(.7,.54,0,'Weight (kips):',...
     'FontName','Tahoma',...
     'FontSize',11,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');
   helmet_wt=str2double(get(handles.helmet,'string'));
   set(ax_helmetvalue,'string',helmet_wt);

   ax_pile=text(.0,.48,0,'PILE',...
     'FontName','Tahoma',...
     'FontSize',9,...
     'HorizontalAlignment','left',...
     'VerticalAlignment','middle');

   ax_lengthvalue=text(.7,.43,0,'Length (ft):',...
     'FontName','Tahoma',...
```

```
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');
   L=str2double(get(handles.length,'string'));
   set(ax_lengthvalue,'string',L);

   ax_penetravalue=text(.7,.38,0,'Penetration (ft):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');
   Lp=str2double(get(handles.penetra,'string'));
   set(ax_penetravalue,'string',Lp);

   ax_pileareavalue=text(.7,.33,0,'Pile top area (in^2):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');
   Pa=str2double(get(handles.parea,'string'));
   set(ax_pileareavalue,'string',Pa);


   ax_soil=text(.0,.27,0,'SOIL',...
    'FontName','Tahoma',...
    'FontSize',11,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_Qtoevalue=text(.7,.21,0,'Quake at toe (in):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');
   quake_toe=str2double(get(handles.Qtoe,'string'));
   set(ax_Qtoevalue,'string',quake_toe);

   ax_Dshaftvalue=text(.7,.16,0,'Damping at shaft (s/ft):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');
   damp_shaft=str2double(get(handles.Dshaft,'string'));
   set(ax_Dshaftvalue,'string',damp_shaft);

   ax_Dtoevalue=text(.7,.11,0,'Damping at toe (s/ft):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');
   damp_toe=str2double(get(handles.Dtoe,'string'));
   set(ax_Dtoevalue,'string',damp_toe);

   ax_shaftresist=text(.0,.05,0,'SHAFT RESISTANCE (%):',...
    'FontName','Tahoma',...
    'FontSize',11,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_shaftresistvalue=text(.7,.05,0,'SHAFT RESISTANCE
(%):',...
    'FontName','Tahoma',...
    'FontSize',11,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');
   shaft_resistance=str2double(get(handles.shaft_resist,'string'));
   set(ax_shaftresistvalue,'string',shaft_resistance);

%   ax_Quvalue=text(.7,.05,5,'ULTIMATE CAPACITY
(kips):',...
%    'FontName','Tahoma',...
%    'FontSize',11,...
%    'HorizontalAlignment','left',...
%    'VerticalAlignment','middle');
%   Qu3=str2double(get(handles.qu3,'string'));
%   set(ax_Quvalue,'string',Qu3);


if get(handles.chosenunit,'value')==1.%ENGLISH UNIT

   ax_cushmodul=text(.07,.70,0,'Elastic Modulus (ksi):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_cushthick=text(.07,.65,0,'Thickness (in):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_helmet=text(.07,.54,0,'Weight (kips):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_length=text(.07,.43,0,'Length (ft):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_penetra=text(.07,.38,0,'Penetration (ft):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_pilearea=text(.07,.33,0,'Pile top area (in^2):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_Qtoe=text(.07,.21,0,'Quake at toe (in):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_Dshaft=text(.07,.16,0,'Damping at shaft (s/ft):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_Dtoe=text(.07,.11,0,'Damping at toe (s/ft):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

%   ax_Qu=text(.0,.05,0,'ULTIMATE CAPACITY (kips):',...
%    'FontName','Tahoma',...
%    'FontSize',11,...
%    'HorizontalAlignment','left',...
%    'VerticalAlignment','middle');
```

```
elseif get(handles.chosenunit,'value')==2.%SI UNIT

   ax_cushmodul=text(.07,.70,0,'Elastic Modulus (Mpa):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_cushthick=text(.07,.65,0,'Thickness (mm):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_helmet=text(.07,.54,0,'Weight (kN):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_length=text(.07,.43,0,'Length (m):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_penetra=text(.07,.38,0,'Penetration (m):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_pilearea=text(.07,.33,0,'Pile top area (cm^2):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_Qtoe=text(.07,.21,0,'Quake at toe (mm):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_Dshaft=text(.07,.16,0,'Damping at shaft (s/m):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

   ax_Dtoe=text(.07,.11,0,'Damping at toe (s/m):',...
    'FontName','Tahoma',...
    'FontSize',9,...
    'HorizontalAlignment','left',...
    'VerticalAlignment','middle');

%   ax_Qu=text(.0,.05,0,'ULTIMATE CAPACITY (kN):',...
%    'FontName','Tahoma',...
%    'FontSize',11,...
%    'HorizontalAlignment','left',...
%    'VerticalAlignment','middle');

end

% ============= PLOTTING RESULTS ==============

% GRLWEAP RESULTS
weap_qu=str2double(get(handles.weap_qu,'string'));
weap_stroke=str2double(get(handles.weap_stroke,'string'));
weap_com=str2double(get(handles.weap_com,'string'));
weap_ten=str2double(get(handles.weap_ten,'string'));
weap_bpf=str2double(get(handles.weap_bpf,'string'));

if get(handles.chosenunit,'value')==1.%ENGLISH UNIT

   if get(handles.chosenyesno,'value')==2.% GRLWEAP NO

      % Plot 1. Relationship between BPF and STROKE

      axes(ax_stroke);
      x2=preout(14:26,4); %BPF for Qu2
      x3=preout(27:39,4); %BPF for Qu3
      x4=preout(40:52,4); %BPF for Qu4
      x=preout(1:13,5); %STROKE
      plot(x2,x,x3,x,x4,x,'LineWidth',1.5);
      legend('Qu2','Qu3','Qu4');
      %title('BPF and Stroke','FontName','Tahoma');
      %xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
      ylabel('STROKE
(ft)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
      xlim([0 200]);
      grid

      % Plot 2. Relationship between BPF and Max tension
stresses
      axes(ax_tension);
      x2=preout(14:26,4); %BPF for Qu2
      x3=preout(27:39,4); %BPF for Qu3
      x4=preout(40:52,4); %BPF for Qu4
      y2=preout(14:26,3); %Tension for Qu2
      y3=preout(27:39,3); %Tension for Qu3
      y4=preout(40:52,3); %Tension for Qu4
      plot(x2,y2,x3,y3,x4,y4,'LineWidth',1.5);
      legend('Qu2','Qu3','Qu4');
      %title('BPF and Maximum tension
stress','FontName','Tahoma');
      %xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
      ylabel('Max Tension Stress
(ksi)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
      xlim([0 200]);
      grid

      % Plot 3. Relationship between BPF and Max compression
Stresses
      axes(ax_compression);
      x2=preout(14:26,4); %BPF for Qu2
      x3=preout(27:39,4); %BPF for Qu3
      x4=preout(40:52,4); %BPF for Qu4
      z2=preout(14:26,2); %compression for Qu2
      z3=preout(27:39,2); %compression for Qu3
      z4=preout(40:52,2); %compression for Qu4
      plot(x2,z2,x3,z3,x4,z4,'LineWidth',1.5);
      legend('Qu2','Qu3','Qu4');
      %title('BPF and Maximum compression
stress','FontName','Tahoma');
      xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
      ylabel('Max Compression Stress
(ksi)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
      xlim([0 200]);
      grid

   elseif get(handles.chosenyesno,'value')==1. %GRLWEAP
YES

      % Plot 1. Relationship between BPF and STROKE
      axes(ax_stroke);
      x2=preout(14:26,4); %BPF for Qu2
```

```
        x3=preout(27:39,4); %BPF for Qu3
        x4=preout(40:52,4); %BPF for Qu4
        x=preout(1:13,5); %STROKE

plot(x2,x,x3,x,x4,x,weap_bpf,weap_stroke,'kX','LineWidth',1.5)
;
        legend('Qu2','Qu3','Qu4','GRLWEAP');
        %title('BPF and Stroke','FontName','Tahoma');
        %xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
        ylabel('STROKE
(ft)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
        grid

        % Plot 2. Relationship between BPF and Max tension
stresses
        axes(ax_tension);
        x2=preout(14:26,4); %BPF for Qu2
        x3=preout(27:39,4); %BPF for Qu3
        x4=preout(40:52,4); %BPF for Qu4
        y2=preout(14:26,3); %Tension for Qu2
        y3=preout(27:39,3); %Tension for Qu3
        y4=preout(40:52,3); %Tension for Qu4

plot(x2,y2,x3,y3,x4,y4,weap_bpf,weap_ten,'kX','LineWidth',1.5
);
        legend('Qu2','Qu3','Qu4','GRLWEAP');
        %title('BPF and Maximum tension
stress','FontName','Tahoma');
        ylabel('Max Tension Stress
(ksi)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
        grid

        % Plot 3. Relationship between BPF and Max compression
Stresses
        axes(ax_compression);
        x2=preout(14:26,4); %BPF for Qu2
        x3=preout(27:39,4); %BPF for Qu3
        x4=preout(40:52,4); %BPF for Qu4
        z2=preout(14:26,2); %compression for Qu2
        z3=preout(27:39,2); %compression for Qu3
        z4=preout(40:52,2); %compression for Qu4

plot(x2,z2,x3,z3,x4,z4,weap_bpf,weap_com,'kX','LineWidth',1.
5);
        legend('Qu2','Qu3','Qu4','GRLWEAP');
        %title('BPF and Maximum compression
stress','FontName','Tahoma');
        xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
        ylabel('Max Compression Stress
(ksi)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
        grid

    end

elseif get(handles.chosenunit,'value')==2.%SI UNIT

    if get(handles.chosenyesno,'value')==2. % GRLWEAP NO

        % Plot 1. Relationship between BPF and STROKE
        axes(ax_stroke);
        x2=preout(21:40,4); %BPF for Qu2
        x3=preout(41:60,4); %BPF for Qu3
        x4=preout(61:80,4); %BPF for Qu4
        x=preout(1:20,5); %STROKE
        plot(x2,x,x3,x,x4,x,'LineWidth',1.5);
        legend('Qu2','Qu3','Qu4');
        %title('BPF and Stroke','FontName','Tahoma');
        %xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
        ylabel('STROKE
(m)','FontSize',11,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
%       ylim([1.2 3.6]);
        grid

        % Plot 2. Relationship between BPF and Max tension
stresses
        axes(ax_tension);
        x2=preout(21:40,4); %BPF for Qu2
        x3=preout(41:60,4); %BPF for Qu3
        x4=preout(61:80,4); %BPF for Qu4
        y2=preout(21:40,3); %Tension for Qu2
        y3=preout(41:60,3); %Tension for Qu3
        y4=preout(61:80,3); %Tension for Qu4
        plot(x2,y2,x3,y3,x4,y4,'LineWidth',1.5);
        legend('Qu2','Qu3','Qu4');
        %title('BPF and Maximum tension
stress','FontName','Tahoma');
        %xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
        ylabel('Max Tension Stress
(Mpa)','FontSize',11,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
        grid

        % Plot 3. Relationship between BPF and Max compression
Stresses
        axes(ax_compression);
        x2=preout(21:40,4); %BPF for Qu2
        x3=preout(41:60,4); %BPF for Qu3
        x4=preout(61:80,4); %BPF for Qu4
        z2=preout(21:40,2); %Tension for Qu2
        z3=preout(41:60,2); %Tension for Qu3
        z4=preout(61:80,2); %Tension for Qu4
        plot(x2,z2,x3,z3,x4,z4,'LineWidth',1.5);
        legend('Qu2','Qu3','Qu4');
        %title('BPF and Maximum compression
stress','FontName','Tahoma');
        xlabel('BPF (Blows Per
Foot)','FontSize',11,'FontName','Tahoma');
        ylabel('Max Compression Stress
(Mpa)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
        grid

   elseif get(handles.chosenyesno,'value')==1. %GRLWEAP
Yes

        % Plot 1. Relationship between BPF and STROKE
        axes(ax_stroke);
        x2=preout(21:40,4); %BPF for Qu2
        x3=preout(41:60,4); %BPF for Qu3
        x4=preout(61:80,4); %BPF for Qu4
        x=preout(1:20,5); %STROKE

plot(x2,x,x3,x,x4,x,weap_bpf,weap_stroke,'kX','LineWidth',1.5)
;
        legend('Qu2','Qu3','Qu4','GRLWEAP');
        %title('BPF and Stroke','FontName','Tahoma');
        %xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
        ylabel('STROKE
(m)','FontSize',11,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
%       ylim([1.2 3.6]);
```

```
        grid

        % Plot 2. Relationship between BPF and Max tension
stresses
        axes(ax_tension);
        x2=preout(21:40,4); %BPF for Qu2
        x3=preout(41:60,4); %BPF for Qu3
        x4=preout(61:80,4); %BPF for Qu4
        y2=preout(21:40,3); %Tension for Qu2
        y3=preout(41:60,3); %Tension for Qu3
        y4=preout(61:80,3); %Tension for Qu4

plot(x2,y2,x3,y3,x4,y4,weap_bpf,weap_ten,'kX','LineWidth',1.5
);
        legend('Qu2','Qu3','Qu4','GRLWEAP');
        %title('BPF and Maximum tension
stress','FontName','Tahoma');
        %xlabel('BPF (Blows Per
Foot)','FontSize',12,'FontName','Tahoma');
        ylabel('Max Tension Stress
(Mpa)','FontSize',11,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
        grid

        % Plot 3. Relationship between BPF and Max compression
Stresses
        axes(ax_compression);
        x2=preout(21:40,4); %BPF for Qu2
        x3=preout(41:60,4); %BPF for Qu3
        x4=preout(61:80,4); %BPF for Qu4
        z2=preout(21:40,2); %Tension for Qu2
        z3=preout(41:60,2); %Tension for Qu3
        z4=preout(61:80,2); %Tension for Qu4

plot(x2,z2,x3,z3,x4,z4,weap_bpf,weap_com,'kX','LineWidth',1.
5);
        legend('Qu2','Qu3','Qu4','GRLWEAP');
        %title('BPF and Maximum compression
stress','FontName','Tahoma');
        xlabel('BPF (Blows Per
Foot)','FontSize',11,'FontName','Tahoma');
        ylabel('Max Compression Stress
(Mpa)','FontSize',12,'FontName','Tahoma','Color',[0. 0. 1.]);
        xlim([0 200]);
        grid

    end
end



function savefile_Callback(hObject, eventdata, handles)
% hObject    handle to savefile (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)

% Hints: get(hObject,'String') returns contents of savefile as text
%        str2double(get(hObject,'String')) returns contents of
savefile as a double


% --- Executes during object creation, after setting all properties.
function savefile_CreateFcn(hObject, eventdata, handles)
% hObject    handle to savefile (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    empty - handles not created until after all
CreateFcns called

% Hint: edit controls usually have a white background on
Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end


% --- Executes on button press in exit.
function exit_Callback(hObject, eventdata, handles)
% hObject    handle to exit (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see
GUIDATA)
close;
```

Appendix VI Database

VI.1 Ultimate Pile Capacity

VI.1.1 Non-jetted data only

• Training data set

Table VI-1 Training data set

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (ft)	Pile cross-sectional area (ft^2)	Measured pile capacity (kips)	Predicted by BPNN (kips)	Predicted by ANFIS (kips)	References
1	33.0	33.0	2318.3	40.0	0.066	16.9	80.6	16.9	Bergdahland Wennerstrand (1976)
2	31.0	31.0	2798.7	52.5	0.660	107.9	65.6	107.9	Gregersen et al(1973)
3	31.8	32.1	4425.2	77.0	1.778	134.9	231.8	134.9	Westinghouse(1990)
4	31.8	32.4	4943.6	86.0	0.149	146.1	126.3	146.1	Westinghouse(1990)
5	35.5	35.5	1858.8	29.9	0.860	147.3	206.7	147.3	Tavenas(1971)
6	34.0	35.0	1921.5	29.9	1.390	154.0	246.7	153.9	Thorbum and MacVicar(1970)
7	34.0	34.0	793.7	9.8	1.770	160.1	195.6	160.1	Vesic(1970)
8	34.0	35.0	2318.3	40.0	1.230	192.0	234.9	192.1	Thorbum and MacVicar(1970)
9	35.5	35.5	2485.4	40.0	0.860	201.0	229.4	201.0	Tavenas(1971)
10	35.5	35.5	3091.1	49.9	0.930	228.0	262.9	230.2	Tavenas(1971)
11	35.5	35.5	3091.1	49.9	0.860	250.2	254.0	248.0	Tavenas(1971)
12	31.8	32.4	4943.6	86.0	4.000	256.3	630.5	256.3	Westinghouse(1990)
13	35.0	37.0	5430.2	83.0	0.785	281.9	472.4	282.3	Blendy(1979)
14	35.5	35.5	3717.6	60.0	0.930	288.0	308.8	288.0	Tavenas(1971)
15	34.0	38.0	3049.3	37.1	0.340	321.3	403.9	321.3	Koizumi(1971)
16	35.0	35.0	3717.6	58.1	0.890	339.3	273.4	340.2	Goble et al(1982)
17	32.0	35.0	5033.4	76.4	1.600	366.0	431.7	366.0	Thorbum and MacVicar(1970)
18	32.1	30.0	2020.8	92.0	4.000	390.0	409.7	390.0	Keane(1990)
19	35.0	35.0	1503.8	20.0	1.770	390.1	332.2	390.1	Vesic(1970)
20	33.0	35.5	7163.7	111.9	0.350	395.9	406.2	395.9	Kessler(1979)

Table VI-1 Training data set (continued)

21	36.5	36.5	2506.3	40.4	1.780	400.0	630.5	400.0	Hunter and Davisson (1969)
22	35.0	35.0	5054.3	79.1	0.710	400.0	377.3	400.0	Goble et al (1982)
23	35.0	35.0	3717.6	58.1	1.000	400.0	298.3	399.2	Goble et al (1982)
24	36.0	37.0	4365.1	67.9	0.890	420.0	468.7	420.0	Goble et al (1982)
25	35.0	37.0	5137.8	78.1	0.785	430.1	449.5	429.7	Blendy (1979)
26	39.0	39.5	1169.6	17.1	1.075	437.9	484.9	438.3	Heins and Barends (1984)
27	39.0	39.5	1169.6	17.1	1.075	438.4	484.9	438.3	Heins and Barends (1979)
28	35.0	35.0	3467.0	54.1	0.660	472.1	232.8	471.9	Goble et al (1982)
29	34.0	36.0	6662.5	104.0	0.350	490.1	404.0	490.1	Kessler (1979)
30	35.0	37.0	3299.9	52.8	1.770	502.0	513.9	502.0	Hunter and Davisson (1969)
31	28.2	36.0	2220.9	50.0	2.778	504.0	468.9	504.0	Keane (1990)
32	35.0	37.0	3822.1	58.1	0.785	520.0	374.8	520.1	Blendy (1979)
33	39.0	39.5	1566.4	23.0	1.075	548.3	590.5	549.9	Heins and Barends (1984)
34	31.7	38.0	1420.6	65.0	4.000	570.0	550.3	570.0	Keane (1990)
35	33.0	38.0	5325.8	80.4	1.410	587.9	680.3	587.9	Mansur and Kaufman (1958)
36	34.8	35.0	1800.8	93.0	4.000	600.0	554.2	600.0	Keane (1990)
37	31.2	29.0	3001.3	102.0	4.000	640.0	604.1	640.0	Keane (1990)
38	33.0	37.0	4302.4	65.3	1.960	642.1	584.3	642.2	Mansur and Kaufman (1958)
39	39.0	39.5	1503.8	22.0	1.075	674.5	575.6	672.7	Heins and Barends (1984)
40	33.0	37.5	4386.0	66.3	1.580	683.9	574.0	683.8	Mansur and Kaufman (1958)
41	36.0	36.0	2736.0	39.4	1.770	710.0	628.4	709.9	Vesic (1970)
42	33.0	33.0	6996.7	96.1	0.600	720.1	626.5	720.1	Wan et al (1979)
43	33.0	34.0	7393.5	102.0	0.600	721.9	642.8	721.9	Wan et al (1979)
44	38.0	41.0	2882.2	38.1	2.250	799.9	791.9	799.9	Furbow (1968)
45	34.0	37.5	4302.4	65.0	2.400	826.0	801.2	826.0	Mansur and Kaufman (1958)
46	36.0	36.0	3362.6	49.2	1.770	859.9	624.1	859.9	Vesic (1970)
47	38.0	40.0	4093.6	54.1	2.250	882.0	788.7	882.0	Furbow (1968)
48	37.5	39.5	5388.5	84.0	3.310	904.0	974.5	904.0	Gurtowski and Wu (1984)
49	28.0	39.0	4448.6	55.1	1.540	1049.9	1058.1	1049.9	Reike and Crowser (1987)
50	33.0	35.0	3529.7	59.1	7.070	1124.1	1107.6	1124.1	Mey et al (1985)
51	34.0	38.0	9920.6	154.9	3.140	1259.9	1220.5	1259.9	McCammon and Golder (1970)

• Testing data set

Table VI-2 Testing data set

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (ft)	Pile cross-sectional area (ft^2)	Measured pile capacity (kips)	Predicted by BPNN (kips)	Predicted by ANFIS (kips)	References
1	31.0	31.0	2798.7	52.5	0.340	116.7	54.4	115.1	Gregersen et al(1973)
2	35.5	35.5	1858.8	29.9	0.930	147.9	212.6	149.8	Tavenas(1971)
3	35.5	35.5	2485.4	40.0	0.930	198.3	236.0	189.3	Tavenas(1971)
4	35.5	37.0	4761.9	71.9	0.710	207.3	423.3	342.0	Goble et al(1982)
5	35.5	35.5	3717.6	60.0	0.860	288.0	291.0	290.0	Tavenas(1971)
6	32.0	35.0	5033.4	76.4	1.600	366.0	431.7	366.0	Thorburn and MacVicar(1970)
7	36.0	37.0	4490.4	69.9	0.440	400.0	356.9	457.4	Goble et al(1982)
8	31.2	35.0	1200.5	30.0	3.361	408.0	393.1	288.2	Keane(1990)
9	36.0	37.0	4365.1	67.9	1.000	430.1	542.0	412.3	Goble et al(1982)
10	33.0	38.0	4657.5	70.5	1.410	486.5	617.8	726.3	Mansur and Kauffman(1958)
11	35.0	36.5	3299.9	53.1	2.270	516.0	660.8	475.2	Hunter and Davisson(1969)
12	35.0	35.0	2088.6	29.2	1.770	560.0	498.1	512.3	Vesic(1970)
13	35.5	36.0	3404.3	49.9	1.400	605.9	604.6	529.9	Vesic(1970)
14	32.0	37.0	3675.9	57.4	4.149	690.0	839.7	450.8	Milovic and Baci(1976)
15	32.0	34.0	4135.3	68.9	2.490	719.4	539.5	773.6	Carpentier et al(1984)
16	38.0	40.0	3425.2	44.9	2.250	740.1	746.9	640.6	Furbow(1968)
17	37.5	40.0	6286.5	98.1	3.310	1064.1	1126.0	987.7	Gurtowski and Wu(1984)

VI.1.2 All data (jetted data included)

• Training data set

Table VI-3 Training data set

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (L,ft)	Pile cross-sectional area (ft^2)	Jetting	Measured pile capacity (kips)	Predictions by BPNN (kips)	References
1	33.0	33.0	2318.3	40.0	0.066	no	16.9	79.7	Bergdahl and Wennerstrand (1976)
2	31.0	31.0	2798.7	52.5	0.660	no	107.9	68.8	Gregersen et al.(1973)
3	31.8	32.1	4425.2	77.0	1.778	no	134.9	167.4	Westinghouse(1990)
4	31.8	32.4	4943.6	86.0	0.149	no	146.1	81.8	Westinghouse(1990)
5	35.5	35.5	1858.8	29.9	0.860	no	147.3	159.4	Tavenas(1971)
6	34.0	35.0	1921.5	29.9	1.390	no	154.0	266.1	Thorburn and MacVicar(1970)
7	34.0	34.0	793.7	9.8	1.770	no	160.1	171.7	Vesic(1970)
8	34.0	35.0	2318.3	40.0	1.230	no	192.0	241.6	Thorburn and MacVicar(1970)
9	35.5	35.5	2485.4	40.0	0.860	no	201.0	226.5	Tavenas(1971)
10	35.5	35.5	3091.1	49.9	0.930	no	228.0	315.9	Tavenas(1971)
11	35.5	35.5	3091.1	49.9	0.860	no	250.2	297.3	Tavenas(1971)
12	31.8	32.4	4943.6	86.0	4.000	no	256.3	538.6	Westinghouse(1990)
13	35.0	37.0	5430.2	83.0	0.785	no	281.9	469.5	Blendy(1979)
14	35.5	35.5	3717.6	60.0	0.930	no	288.0	322.1	Tavenas(1971)
15	34.0	38.0	3049.3	37.1	0.340	no	321.3	242.5	Koizumi(1971)
16	35.0	35.0	3717.6	58.1	0.890	no	339.3	352.4	Goble et al.(1982)
17	35.0	37.0	3299.9	53.1	1.130	no	368.0	390.6	Hunter and Davisson (1969)
18	32.7	35.0	2281.0	66.0	2.778	yes	370.0	398.7	Keane(1990)
19	32.1	30.0	2020.8	92.0	4.000	no	390.0	523.0	Keane(1990)
20	35.0	35.0	1503.8	20.0	1.770	no	390.1	371.7	Vesic(1970)
21	33.0	35.5	7163.7	111.9	0.350	no	395.9	388.9	Kessler(1979)
22	36.5	36.5	2506.3	40.4	1.780	no	400.0	494.9	Hunter and Davisson (1969)
23	35.0	35.0	5054.3	79.1	0.710	no	400.0	306.9	Goble et al.(1982)
24	35.0	35.0	3717.6	58.1	1.000	no	400.0	374.2	Goble et al.(1982)
25	31.2	35.0	1200.5	30.0	3.361	no	408.0	403.0	Keane(1990)

Table VI-3 Training data set (continued)

26	36.0	37.0	4365.1	67.9	0.890	no	420.0	424.0	Goble et al.(1982)
27	35.0	37.0	5137.8	78.1	0.785	no	430.1	465.1	Blendy(1979)
28	39.0	39.5	1169.6	17.1	1.075	no	437.9	477.2	Heins and Barends(1984)
29	39.0	39.5	1169.6	17.1	1.075	no	438.4	477.2	Heins and Barends(1979)
30	33.3	35.0	2000.8	66.0	2.778	yes	460.0	410.2	Keane(1990)
31	35.0	35.0	3467.0	54.1	0.660	no	472.1	261.4	Goble et al.(1982)
32	31.8	36.0	2761.2	64.0	2.778	yes	480.0	491.2	Keane(1990)
33	34.0	36.0	6662.5	104.0	0.350	no	490.1	353.3	Kessler(1979)
34	35.0	37.0	3299.9	52.8	1.770	no	502.0	486.0	Hunter and Davisson (1969)
35	28.2	36.0	2220.9	50.0	2.778	no	504.0	493.5	Keane(1990)
36	35.0	37.0	3822.1	58.1	0.785	no	520.0	483.7	Blendy(1979)
37	39.0	39.5	1566.4	23.0	1.075	no	548.3	586.4	Heins and Barends(1984)
38	31.7	38.0	1420.6	65.0	4.000	no	570.0	523.4	Keane(1990)
39	33.0	38.0	5325.8	80.4	1.410	no	587.9	674.0	Mansur and Kaufman(1958)
40	30.0	42.0	2000.8	70.0	2.778	yes	590.0	529.4	Keane(1990)
41	34.8	35.0	1800.8	93.0	4.000	no	600.0	523.0	Keane(1990)
42	31.2	29.0	3001.3	102.0	4.000	no	640.0	523.0	Keane(1990)
43	33.0	37.0	4302.4	65.3	1.960	no	642.1	666.5	Mansur and Kaufman(1958)
44	29.7	42.0	3361.4	65.0	2.778	yes	664.0	634.7	Keane(1990)
45	39.0	39.5	1503.8	22.0	1.075	no	674.5	570.4	Heins and Barends(1984)
46	33.0	37.5	4386.0	66.3	1.580	no	683.9	610.7	Mansur and Kaufman(1958)
47	36.0	36.0	2736.0	39.4	1.770	no	710.0	692.1	Vesic(1970)
48	33.0	33.0	6996.7	96.1	0.600	no	720.1	752.1	Wan et al.(1979)
49	33.0	34.0	7393.5	102.0	0.600	no	721.9	777.5	Wan et al.(1979)
50	38.0	41.0	2882.2	38.1	2.250	no	799.9	907.1	Furbow(1968)
51	34.0	37.5	4302.4	65.0	2.400	no	826.0	676.9	Mansur and Kaufman(1958)
52	36.0	36.0	3362.6	49.2	1.770	no	859.9	657.2	Vesic(1970)
53	38.0	40.0	4093.6	54.1	2.250	no	882.0	835.8	Furbow(1968)
54	37.5	39.5	5388.5	84.0	3.310	no	904.0	899.9	Gurtowski and Wu(1984)
55	28.0	39.0	4448.6	55.1	1.540	no	1049.9	1034.5	Reike and Crowser(1987)
56	33.0	35.0	3529.7	59.1	7.070	no	1124.1	1127.6	Mey et al.(1985)
57	34.0	38.0	9920.6	154.9	3.140	no	1259.9	1242.8	McCammon and Golder(1970)

• Testing data set

Table VI-4 Testing data set (continuted)

No	Friction angel at shaft	Friction angle near pile tip	Effective stress at tip (lb/ft^2)	Pile length (L,ft)	Pile cross-sectional area (ft^2)	Jetting	Measured pile capacity (kips)	Predictions by BPNN (kips)	References
1	31.0	31.0	2798.7	52.5	0.340	no	116.7	63.4	Gregersen et al.(1973)
2	35.5	35.5	1858.8	29.9	0.930	no	147.9	173.4	Tavenas(1971)
3	35.5	35.5	2485.4	40.0	0.930	no	198.3	247.5	Tavenas(1971)
4	35.5	37.0	4761.9	71.9	0.710	no	207.3	493.7	Goble et al.(1982)
5	35.5	35.5	3717.6	60.0	0.860	no	288.0	316.8	Tavenas(1971)
6	32.0	35.0	5033.4	76.4	1.600	no	366.0	500.5	Thorburn and MacVicar(1970)
7	36.0	37.0	4490.4	69.9	0.440	no	400.0	394.9	Goble et al.(1982)
8	29.3	33.0	3181.3	62.0	2.778	yes	400.0	468.0	Keane(1990)
9	36.0	37.0	4365.1	67.9	1.000	no	430.1	436.3	Goble et al.(1982)
10	33.0	38.0	4657.5	70.5	1.410	no	486.5	617.7	Mansur and Kauffman(1958)
11	35.0	36.5	3299.9	53.1	2.270	no	516.0	612.4	Hunter and Davisson(1969)
12	35.0	35.0	2088.6	29.2	1.770	no	560.0	517.9	Vesic(1970)
13	29.8	30.0	3221.3	117.0	4.000	yes	600.0	523.0	Keane(1990)
14	35.5	36.0	3404.3	49.9	1.400	no	605.9	620.0	Vesic(1970)
15	32.0	37.0	3675.9	57.4	4.149	no	690.0	581.5	Mibvic and Baci(1976)
16	32.0	34.0	4135.3	68.9	2.490	no	719.4	573.0	Carpentier et al.(1984)
17	38.0	40.0	3425.2	44.9	2.250	no	740.1	908.2	Furbow(1968)
18	37.5	40.0	6286.5	98.1	3.310	no	1064.1	1259.9	Gurtowski and Wu(1984)

V.2 Pile Setup

V.2.1 BPNN

Table VI-5 Training data set

No.	Soil Type	Pile Type	Diameter (in)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased* Q_{BOR}	*Increased* Q_{BOR} *by BPNN*	*References*
1	1.00	Pipe Pile	32.0	41.0	0.083	2.36	615.2	710.2	95.0	95.4	NC DOT(Unpublished)
2	1.61	Pipe Pile	12.8	136.4	69.0	7.02	438.0	700.0	262.0	261.8	Komurka(2004)
3	1.62	Pipe Pile	12.8	130.0	69.0	6.69	421.0	826.0	405.0	402.4	Komurka(2004)
4	1.61	Pipe Pile	12.8	131.0	69.0	6.74	352.0	677.0	325.0	331.2	Komurka(2004)
5	1.63	Pipe Pile	12.8	115.7	70.0	5.94	199.0	773.0	574.0	572.7	Komurka(2004)
6	2.00	Pipe Pile	7.6	55.8	1.33	2.65	224.8	245.1	20.2	25.3	Samson.L.and Authier.J.(1986)
7	1.33	Pipe Pile	24.0	62.6	0.67	3.44	651.0	812.0	161.0	160.7	Antorena.J.M. and McDaniel.T.G (1995)b
8	1.18	Pipe Pile	24.0	71.3	0.5	3.98	520.0	677.0	157.0	157.0	Antorena.J.M. and McDaniel.T.G (1995)b
9	1.20	Pipe Pile	24.0	67.4	16.67	3.75	295.0	487.0	192.0	192.3	Antorena.J.M. and McDaniel.T.G (1995)b
10	1.32	Pipe Pile	24.0	111.0	1.0	6.04	224.0	600.0	376.0	375.8	Holloway.D.M. and Beddard.D.L.(1995)
11	1.35	Pipe Pile	42.0	99.0	1.0	5.35	644.0	967.0	323.0	321.8	Holloway.D.M. and Beddard.D.L.(1995)
12	1.35	Pipe Pile	42.0	99.0	79.0	5.35	644.0	1750.0	1106.0	1106.7	Holloway.D.M. and Beddard.D.L.(1995)
13	1.35	Pipe Pile	42.0	100.0	1.0	5.41	488.0	671.0	183.0	184.8	Holloway.D.M. and Beddard.D.L.(1995)
14	1.62	Pipe Pile	24.0	95.1	1.0	4.88	528.3	1360.2	831.9	833.1	Dover.A.R.and Howard.Jr.R.(2002)
15	1.62	Pipe Pile	24.0	95.1	8.0	4.88	528.3	1686.2	1157.9	1139.6	Dover.A.R.and Howard.Jr.R.(2002)
16	1.64	Pipe Pile	24.0	82.0	1.0	4.21	292.3	944.2	652.0	651.2	Dover.A.R.and Howard.Jr.R.(2002)
17	1.63	Pipe Pile	24.0	88.6	1.0	4.55	314.7	764.4	449.6	449.0	Dover.A.R.and Howard.Jr.R.(2002)
18	1.64	Pipe Pile	24.0	79.1	1.0	4.06	404.7	696.9	292.3	293.7	Dover.A.R.and Howard.Jr.R.(2002)
19	1.64	Pipe Pile	24.0	79.1	8.0	4.06	404.7	1011.7	607.0	607.5	Dover.A.R.and Howard.Jr.R.(2002)
20	1.61	Pipe Pile	24.0	101.0	1.0	5.19	472.1	1101.6	629.5	629.6	Dover.A.R.and Howard.Jr.R.(2002)
21	1.63	Pipe Pile	24.0	90.9	1.0	4.67	269.8	607.0	337.2	336.9	Dover.A.R.and Howard.Jr.R.(2002)
22	1.63	Pipe Pile	24.0	90.9	8.0	4.67	269.8	876.8	607.0	607.5	Dover.A.R.and Howard.Jr.R.(2002)
23	1.20	Pipe Pile	12.7	82.0	7.0	4.56	152.9	276.5	123.7	123.5	Prelim.M.J.et.al. (1989)
24	2.00	Pipe Pile	16.0	42.0	5.0	2.21	365.8	406.0	40.2	25.5	Chambers.W.G. and Klingberg.D.J.(2000)
25	1.00	Conc' Pile	18.0	48.5	0.083	2.79	230.0	389.0	159.0	157.6	NC DOT(Unpublished)
26	1.00	Conc' Pile	16.0	55.6	0.083	3.20	290.0	361.6	71.6	66.3	NC DOT(Unpublished)
27	1.00	Conc' Pile	18.0	49.0	0.083	2.82	229.7	389.0	159.3	162.3	NC DOT(Unpublished)
28	1.00	Conc' Pile	18.0	84.0	3.0	4.84	958.0	983.0	25.0	43.1	Antorena.J.M.and McDaniel.G.T.(1995)a
29	1.00	Conc' Pile	18.0	64.6	2.0	3.72	205.3	257.4	52.2	44.8	Svinkin.M.R.(1995)
30	1.00	Conc' Pile	18.0	65.6	11.0	3.78	205.3	382.6	177.4	181.8	Svinkin.M.R.(1995)
31	1.00	Conc' Pile	18.0	75.1	11.0	4.33	428.7	599.8	171.1	165.6	Svinkin.M.R.(1995)
32	1.00	Conc' Pile	24.0	64.0	10.0	3.68	340.2	587.9	247.8	249.0	Svinkin.M.R.(1995)
33	1.00	Conc' Pile	24.0	75.1	2.0	4.33	447.3	605.0	157.7	154.6	Svinkin.M.R.(1995)
34	1.00	Conc' Pile	36.0	73.2	6.0	4.21	663.0	948.2	285.2	284.5	Svinkin.M.R.(1995)
35	1.20	Conc' Pile	30.0	65.0	2.0	3.62	1090.4	1635.6	545.2	545.1	Hussein.M.H.et.al.(2002)

Table VI-5 Training data set (continued)

36	2.00	Conc' Pile	24.0	80.1	1.0	3.81	60.0	205.0	145.0	145.0	Svinkin.M.R.et.al.(1994)
37	2.00	Conc' Pile	24.0	80.1	18.0	3.81	60.0	375.9	315.9	315.3	Svinkin.M.R.et.al.(1994)
38	2.00	Conc' Pile	30.0	80.1	1.0	3.81	45.0	200.1	155.1	178.7	Svinkin.M.R.et.al.(1994)
39	2.00	Conc' Pile	30.0	80.1	4.0	3.81	45.0	292.0	247.1	228.8	Svinkin.M.R.et.al.(1994)
40	2.00	Conc' Pile	30.0	80.1	18.0	3.81	45.0	359.9	315.0	335.2	Svinkin.M.R.et.al.(1994)
41	2.00	Conc' Pile	30.0	80.1	1.0	3.81	58.9	214.0	155.1	178.7	Svinkin.M.R.et.al.(1994)
42	2.00	Conc' Pile	30.0	80.1	4.0	3.81	58.9	315.0	256.1	228.8	Svinkin.M.R.et.al.(1994)
43	2.00	Conc' Pile	30.0	80.1	20.0	3.81	58.9	393.0	334.1	320.0	Svinkin.M.R.et.al.(1994)
44	2.00	Conc' Pile	18.0	64.6	2.0	3.72	205.3	257.4	52.2	53.0	Svinkin.M.R.et.al.(1994)
45	2.00	Conc' Pile	18.0	75.1	2.0	4.33	428.7	489.2	60.5	54.0	Svinkin.M.R.et.al.(1994)
46	2.00	Conc' Pile	18.0	75.1	11.0	4.33	428.7	599.8	171.1	173.0	Svinkin.M.R.et.al.(1994)
47	2.00	Conc' Pile	24.0	75.1	2.0	4.33	446.5	605.0	158.5	158.8	Svinkin.M.R.et.al.(1994)
48	2.00	Conc' Pile	36.0	73.2	6.0	4.21	505.6	946.5	440.9	441.0	Svinkin.M.R.et.al.(1994)
49	2.00	Conc' Pile	9.3	62.3	0.04	3.59	125.9	158.0	32.1	59.3	Axelsson.G.(1998)
50	2.00	Conc' Pile	9.3	62.3	1.0	3.59	125.9	200.1	74.2	68.7	Axelsson.G.(1998)
51	2.00	Conc' Pile	9.3	62.3	6.0	3.59	125.9	280.4	154.5	146.0	Axelsson.G.(1998)
52	2.00	Conc' Pile	9.3	62.3	143.0	3.59	125.9	324.0	198.1	228.4	Axelsson.G.(1998)
53	2.00	Conc' Pile	9.3	62.3	0.028	3.59	125.9	152.4	26.5	59.1	Axelsson.G.(1998)
54	2.00	Conc' Pile	9.3	62.3	1.0	3.59	125.9	226.2	100.3	68.7	Axelsson.G.(1998)
55	2.00	Conc' Pile	9.3	62.3	37.0	3.59	125.9	377.0	251.1	250.8	Axelsson.G.(1998)
56	2.00	Conc' Pile	9.3	62.3	143.0	3.59	125.9	384.4	258.5	228.4	Axelsson.G.(1998)
57	2.00	Conc' Pile	9.3	62.3	216.0	3.59	125.9	398.8	272.9	273.1	Axelsson.G.(1998)
58	1.48	Conc' Pile	9.8	68.9	52.0	3.64	134.9	300.1	165.2	164.6	Skov.R. and Denver.H.(1988)
59	1.48	Conc' Pile	9.8	68.9	114.0	3.64	134.9	337.7	202.8	202.8	Skov.R. and Denver.H.(1988)
60	1.48	Conc' Pile	9.8	68.9	184.0	3.64	134.9	353.4	218.5	218.1	Skov.R. and Denver.H.(1988)
61	1.85	Conc' Pile	9.8	62.3	1.0	3.06	57.3	173.1	115.8	116.6	Skov.R. and Denver.H.(1988)
62	1.85	Conc' Pile	9.8	62.3	48.0	3.06	57.3	323.7	266.4	267.0	Skov.R. and Denver.H.(1988)
63	1.11	Conc' Pile	14.0	88.6	7.0	5.00	255.2	519.3	264.2	263.6	Prelim.M.J.et.al.(1989)
64	2.00	Conc' Pile	10.8	39.4	3.0	1.87	433.0	589.9	156.9	156.8	Chambers.W.G. and Klingberg.D.J.(2000)
65	1.00	H-Pile	12.0	155.0	2.0	8.93	110.0	270.0	160.0	151.8	Fellenius B.H.et.al(1989)
66	1.00	H-Pile	12.0	155.0	16.0	8.93	110.0	450.0	340.0	343.8	Fellenius B.H.et.al(1989)
67	1.00	H-Pile	12.0	155.0	1.0	8.93	146.0	272.0	126.0	140.3	Fellenius B.H.et.al(1989)
68	1.00	H-Pile	12.0	155.0	9.0	8.93	146.0	400.0	254.0	244.6	Fellenius B.H.et.al(1989)
69	1.00	H-Pile	12.0	45.9	2.0	2.65	75.3	100.0	24.7	26.2	Samson.L.and Authier.J.(1986)
70	1.53	H-Pile	12.0	50.0	21.0	2.62	240.1	515.1	275.0	277.1	Long.J.H.et.al(2002)
71	2.00	H-Pile	12.0	154.9	2.0	7.37	109.9	270.0	160.1	162.2	Svinkin.M.R.et.al.(1994)
72	2.00	H-Pile	12.0	154.9	16.0	7.37	109.9	450.1	340.2	344.4	Svinkin.M.R.et.al.(1994)
73	2.00	H-Pile	12.0	154.9	132.0	7.37	109.9	515.1	405.2	415.0	Svinkin.M.R.et.al.(1994)

Table VI-6 Testing data set

No.	Soil Type	Pile Type	Diameter (in)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased* Q_{BOR}	*Increased* Q_{BOR} *by BPNN*	*References*
1	1.61	Pipe Pile	12.8	135.1	69.0	6.96	422.0	762.0	340.0	234.7	Komurka(2004)
2	1.63	Pipe Pile	12.8	115.3	0.7	5.91	199.0	468.0	269.0	76.4	Komurka(2004)
3	1.18	Pipe Pile	24.0	71.3	15.0	3.98	520.0	700.0	180.0	131.0	Antorena J.M. and McDaniel T.G (1995)b
4	1.35	Pipe Pile	42.0	99.0	7.0	5.35	644.0	1178.0	534.0	578.5	Holloway D.M. and Beddard D.L.(1995)
5	1.00	Pipe Pile	16.1	110.6	0.83	6.37	656.0	724.0	68.0	36.1	Diyaljee V. and Parti M.(2002)
6	1.64	Pipe Pile	24.0	82.0	8.0	4.21	292.3	1308.5	1016.2	1009.9	Dover A.R. and Howard Jr. R.(2002)
7	1.61	Pipe Pile	24.0	101.0	8.0	5.19	472.1	1304.0	831.8	1134.1	Dover A.R. and Howard Jr. R.(2002)
8	1.00	Conc' Pile	18.0	85.0	4.0	4.90	912.0	939.0	27.0	49.2	Antorena J.M. and McDaniel G.T.(1995)a
9	1.00	Conc' Pile	18.0	77.0	6.0	4.44	816.0	954.0	138.0	55.5	Antorena J.M. and McDaniel G.T.(1995)a
10	1.00	Conc' Pile	18.0	75.1	2.0	4.33	428.7	489.2	60.5	36.1	Svinkin M.R.(1995)
11	1.00	Conc' Pile	24.0	75.1	11.0	4.33	447.3	813.2	365.9	255.9	Svinkin M.R.(1995)
12	2.00	Conc' Pile	24.0	80.1	10.0	3.81	60.0	344.0	283.9	281.5	Svinkin M.R. et al. (1994)
13	2.00	Conc' Pile	30.0	80.1	9.0	3.81	45.0	341.1	296.1	303.2	Svinkin M.R. et al. (1994)
14	2.00	Conc' Pile	30.0	80.1	11.0	3.81	58.9	357.0	298.1	324.0	Svinkin M.R. et al. (1994)
15	2.00	Conc' Pile	18.0	64.6	11.0	3.72	205.3	382.6	177.4	102.6	Svinkin M.R. et al. (1994)
16	2.00	Conc' Pile	24.0	64.0	10.0	3.69	340.2	587.9	247.8	230.0	Svinkin M.R. et al. (1994)
17	2.00	Conc' Pile	24.0	75.1	11.0	4.33	446.5	813.2	366.7	369.6	Svinkin M.R. et al. (1994)
18	2.00	Conc' Pile	9.3	62.3	37.0	3.59	125.9	304.2	178.3	250.8	Axelsson G.(1998)
19	2.00	Conc' Pile	9.3	62.3	6.0	3.59	125.9	315.2	189.3	146.0	Axelsson G.(1998)
20	1.85	Conc' Pile	9.8	62.3	8.0	3.06	57.3	285.5	228.2	174.1	Skov R. and Denver H.(1988)
21	1.00	H-Pile	12.0	155.0	7.0	8.93	110.0	340.0	230.0	216.5	Fellenius B.H. et al(1989)
22	1.53	H-Pile	12.0	50.0	7.0	2.62	240.1	284.0	43.9	33.2	Long J.H. et al.(2002)
23	2.00	H-Pile	12.0	154.9	7.0	7.37	109.9	339.9	230.0	221.5	Svinkin M.R. et al. (1994)

V.2.2 ANFIS

Table VI-7 Training data set

No.	Soil Type	Pile Type	Diameter (in)	Roughness volume of pile shaft (in^3)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased* Q_{BOR}	*Increased* Q_{BOR} *by ANFIS*	*References*
1	1.00	Pipe Pile	32.0	11.1	41.0	0.083	2.36	615.2	710.2	95.0	95.0	NC DOT(Unpublished)
2	1.61	Pipe Pile	12.8	14.7	136.4	69.0	7.02	438.0	700.0	262.0	262.0	Komurka(2004)
3	1.62	Pipe Pile	12.8	14.0	130.0	69.0	6.69	421.0	826.0	405.0	399.3	Komurka(2004)
4	1.61	Pipe Pile	12.8	14.1	131.0	69.0	6.74	352.0	677.0	325.0	330.3	Komurka(2004)
5	1.63	Pipe Pile	12.8	12.5	115.7	70.0	5.94	199.0	773.0	574.0	574.4	Komurka(2004)
6	2.00	Pipe Pile	7.6	3.6	55.8	1.33	2.65	224.8	245.1	20.2	20.2	Samson.L.and Authier.J.(1986)
7	1.33	Pipe Pile	24.0	12.7	62.6	0.67	3.44	651.0	812.0	161.0	161.0	Antorena.J.M. and McDaniel.T.G(1995)b
8	1.18	Pipe Pile	24.0	14.5	71.3	0.5	3.98	520.0	677.0	157.0	157.1	Antorena.J.M. and McDaniel.T.G(1995)b
9	1.20	Pipe Pile	24.0	13.7	67.4	16.67	3.75	295.0	487.0	192.0	191.9	Antorena.J.M. and McDaniel.T.G(1995)b
10	1.32	Pipe Pile	24.0	22.5	111.0	1.0	6.04	224.0	600.0	376.0	376.0	Holloway.D.M. and Beddard.D.L.(1995)
11	1.35	Pipe Pile	42.0	35.2	99.0	1.0	5.35	644.0	967.0	323.0	322.9	Holloway.D.M. and Beddard.D.L.(1995)
12	1.35	Pipe Pile	42.0	35.2	99.0	79.0	5.35	644.0	1750.0	1106.0	1106.0	Holloway.D.M. and Beddard.D.L.(1995)
13	1.35	Pipe Pile	42.0	35.5	100.0	1.0	5.41	488.0	671.0	183.0	183.1	Holloway.D.M. and Beddard.D.L.(1995)
14	1.62	Pipe Pile	24.0	19.3	95.1	1.0	4.88	528.3	1360.2	831.9	828.3	Dover.A.R.and Howard.Jr.R.(2002)
15	1.62	Pipe Pile	24.0	19.3	95.1	8.0	4.88	528.3	1686.2	1157.9	1103.6	Dover.A.R.and Howard.Jr.R.(2002)
16	1.64	Pipe Pile	24.0	16.7	82.0	1.0	4.21	292.3	944.2	652.0	671.7	Dover.A.R.and Howard.Jr.R.(2002)
17	1.63	Pipe Pile	24.0	18.0	88.6	1.0	4.55	314.7	764.4	449.6	338.9	Dover.A.R.and Howard.Jr.R.(2002)
18	1.64	Pipe Pile	24.0	16.1	79.1	1.0	4.06	404.7	696.9	292.3	302.2	Dover.A.R.and Howard.Jr.R.(2002)
19	1.64	Pipe Pile	24.0	16.1	79.1	8.0	4.06	404.7	1011.7	607.0	590.5	Dover.A.R.and Howard.Jr.R.(2002)
20	1.61	Pipe Pile	24.0	20.5	101.0	1.0	5.19	472.1	1101.6	629.5	638.1	Dover.A.R.and Howard.Jr.R.(2002)
21	1.63	Pipe Pile	24.0	18.5	90.9	1.0	4.67	269.8	607.0	337.2	415.3	Dover.A.R.and Howard.Jr.R.(2002)
22	1.63	Pipe Pile	24.0	18.5	90.9	8.0	4.67	269.8	876.8	607.0	675.7	Dover.A.R.and Howard.Jr.R.(2002)
23	1.20	Pipe Pile	12.7	8.8	82.0	7.0	4.56	152.9	276.5	123.7	123.7	Prelim.M.J.et.al.(1989)
24	2.00	Pipe Pile	16.0	5.7	42.0	5.0	2.21	365.8	406.0	40.2	40.2	Chambers.W.G. and Klingberg.D.J.(2000)
25	1.00	Conc' Pile	18.0	46.2	48.5	0.083	2.79	230.0	389.0	159.0	160.0	NC DOT(Unpublished)
26	1.00	Conc' Pile	16.0	47.1	55.6	0.083	3.20	290.0	361.6	71.6	71.6	NC DOT(Unpublished)
27	1.00	Conc' Pile	18.0	46.7	49.0	0.083	2.82	229.7	389.0	159.3	158.1	NC DOT(Unpublished)
28	1.00	Conc' Pile	18.0	80.0	84.0	3.0	4.84	958.0	983.0	25.0	25.1	Antorena.J.M.and McDaniel.G.T.(1995)a
29	1.00	Conc' Pile	18.0	61.5	64.6	2.0	3.72	205.3	257.4	52.2	52.4	Svinkin.M.R.(1995)
30	1.00	Conc' Pile	18.0	62.5	65.6	11.0	3.78	205.3	382.6	177.4	177.5	Svinkin.M.R.(1995)
31	1.00	Conc' Pile	18.0	71.5	75.1	11.0	4.33	428.7	599.8	171.1	170.8	Svinkin.M.R.(1995)
32	1.00	Conc' Pile	24.0	81.2	64.0	10.0	3.68	340.2	587.9	247.8	247.8	Svinkin.M.R.(1995)
33	1.00	Conc' Pile	24.0	95.4	75.1	2.0	4.33	447.3	605.0	157.7	157.7	Svinkin.M.R.(1995)
34	1.00	Conc' Pile	36.0	139.4	73.2	6.0	4.21	663.0	948.2	285.2	285.2	Svinkin.M.R.(1995)
35	1.20	Conc' Pile	30.0	103.1	65.0	2.0	3.62	1090.4	1635.6	545.2	545.2	Hussein.M.H.et.al.(2002)

Table VI-7 Training data set (continued)

36	2.00	Conc' Pile	24.0	101.7	80.1	1.0	3.81	60.0	205.0	145.0	145.1	Svinkin.M.R.et.al. (1994)
37	2.00	Conc' Pile	24.0	101.7	80.1	18.0	3.81	60.0	375.9	315.9	315.8	Svinkin.M.R.et.al. (1994)
38	2.00	Conc' Pile	30.0	127.1	80.1	1.0	3.81	45.0	200.1	155.1	173.8	Svinkin.M.R.et.al. (1994)
39	2.00	Conc' Pile	30.0	127.1	80.1	4.0	3.81	45.0	292.0	247.1	227.7	Svinkin.M.R.et.al. (1994)
40	2.00	Conc' Pile	30.0	127.1	80.1	18.0	3.81	45.0	359.9	315.0	342.8	Svinkin.M.R.et.al. (1994)
41	2.00	Conc' Pile	30.0	127.1	80.1	1.0	3.81	58.9	214.0	155.1	173.8	Svinkin.M.R.et.al. (1994)
42	2.00	Conc' Pile	30.0	127.1	80.1	4.0	3.81	58.9	315.0	256.1	227.7	Svinkin.M.R.et.al. (1994)
43	2.00	Conc' Pile	30.0	127.1	80.1	20.0	3.81	58.9	393.0	334.1	316.7	Svinkin.M.R.et.al. (1994)
44	2.00	Conc' Pile	18.0	61.5	64.6	2.0	3.72	205.3	257.4	52.2	52.2	Svinkin.M.R.et.al. (1994)
45	2.00	Conc' Pile	18.0	71.5	75.1	2.0	4.33	428.7	489.2	60.5	60.5	Svinkin.M.R.et.al. (1994)
46	2.00	Conc' Pile	18.0	71.5	75.1	11.0	4.33	428.7	599.8	171.1	171.1	Svinkin.M.R.et.al. (1994)
47	2.00	Conc' Pile	24.0	95.5	75.1	2.0	4.33	446.5	605.0	158.5	158.5	Svinkin.M.R.et.al. (1994)
48	2.00	Conc' Pile	36.0	139.5	73.2	6.0	4.21	505.6	946.5	440.9	440.9	Svinkin.M.R.et.al. (1994)
49	2.00	Conc' Pile	9.3	30.5	62.3	0.04	3.59	125.9	158.0	32.1	48.9	Axelsson.G.(1998)
50	2.00	Conc' Pile	9.3	30.5	62.3	1.0	3.59	125.9	200.1	74.2	66.4	Axelsson.G.(1998)
51	2.00	Conc' Pile	9.3	30.5	62.3	6.0	3.59	125.9	280.4	154.5	156.2	Axelsson.G.(1998)
52	2.00	Conc' Pile	9.3	30.5	62.3	143.0	3.59	125.9	324.0	198.1	228.3	Axelsson.G.(1998)
53	2.00	Conc' Pile	9.3	30.5	62.3	0.028	3.59	125.9	152.4	26.5	48.7	Axelsson.G.(1998)
54	2.00	Conc' Pile	9.3	30.5	62.3	1.0	3.59	125.9	226.2	100.3	66.4	Axelsson.G.(1998)
55	2.00	Conc' Pile	9.3	30.5	62.3	37.0	3.59	125.9	377.0	251.1	252.2	Axelsson.G.(1998)
56	2.00	Conc' Pile	9.3	30.5	62.3	143.0	3.59	125.9	384.4	258.5	228.3	Axelsson.G.(1998)
57	2.00	Conc' Pile	9.3	30.5	62.3	216.0	3.59	125.9	398.8	272.9	272.9	Axelsson.G.(1998)
58	1.48	Conc' Pile	9.8	35.9	68.9	52.0	3.64	134.9	300.1	165.2	165.2	Skov.R. and Denver.H.(1988)
59	1.48	Conc' Pile	9.8	35.9	68.9	114.0	3.64	134.9	337.7	202.8	202.8	Skov.R. and Denver.H.(1988)
60	1.48	Conc' Pile	9.8	35.9	68.9	184.0	3.64	134.9	353.4	218.5	218.5	Skov.R. and Denver.H.(1988)
61	1.85	Conc' Pile	9.8	32.5	62.3	1.0	3.06	57.3	173.1	115.8	116.0	Skov.R. and Denver.H.(1988)
62	1.85	Conc' Pile	9.8	32.5	62.3	48.0	3.06	57.3	323.7	266.4	266.1	Skov.R. and Denver.H.(1988)
63	1.11	Conc' Pile	14.0	65.5	88.6	7.0	5.00	255.2	519.3	264.2	264.2	Prelim.M.J.et.al. (1989)
64	2.00	Conc' Pile	10.8	22.6	39.4	3.0	1.87	433.0	589.9	156.9	156.9	Chambers.W.G. and Klingberg.D.J.(2000)
65	1.00	H-Pile	12.0	29.1	155.0	2.0	8.93	110.0	270.0	160.0	150.7	Fellenius B.H.et.al(1989)
66	1.00	H-Pile	12.0	29.1	155.0	16.0	8.93	110.0	450.0	340.0	342.1	Fellenius B.H.et.al(1989)
67	1.00	H-Pile	12.0	29.1	155.0	1.0	8.93	146.0	272.0	126.0	136.0	Fellenius B.H.et.al(1989)
68	1.00	H-Pile	12.0	29.1	155.0	9.0	8.93	146.0	400.0	254.0	251.1	Fellenius B.H.et.al(1989)
69	1.00	H-Pile	12.0	8.6	45.9	2.0	2.65	75.3	100.0	24.7	24.7	Samson.L.and Authier.J.(1986)
70	1.53	H-Pile	12.0	9.4	50.0	21.0	2.62	240.1	515.1	275.0	275.0	Long.J.H.et.al.(2002)
71	2.00	H-Pile	12.0	29.0	154.9	2.0	7.37	109.9	270.0	160.1	160.0	Svinkin.M.R.et.al. (1994)
72	2.00	H-Pile	12.0	29.0	154.9	16.0	7.37	109.9	450.1	340.2	340.3	Svinkin.M.R.et.al. (1994)
73	2.00	H-Pile	12.0	29.0	154.9	132.0	7.37	109.9	515.1	405.2	405.2	Svinkin.M.R.et.al. (1994)

Table VI-8 Testing data set

No.	Soil Type	Pile Type	Diameter (in)	Roughness volume of pile shaft (in^3)	Length (ft)	Period (days)	Effective stress (ksf)	Q_{EOD} (kips)	Q_{BOR} (kips)	*Increased* Q_{BOR}	*Increased* Q_{BOR} *by ANFIS*	*References*
1	1.61	Pipe Pile	12.8	14.6	135.1	69.0	6.96	422.0	762.0	340.0	275.0	Komurka(2004)
2	1.63	Pipe Pile	12.8	12.4	115.3	0.7	5.91	199.0	468.0	269.0	274.6	Komurka(2004)
3	1.18	Pipe Pile	24.0	14.5	71.3	15.0	3.98	520.0	700.0	180.0	234.7	Antorena,J.M. and McDaniel,T.G.(1995)b
4	1.35	Pipe Pile	42.0	35.2	99.0	7.0	5.35	644.0	1178.0	534.0	323.8	Holbway,D.M. and Beddard,D.L.(1995)
5	1.00	Pipe Pile	16.1	15.1	110.6	0.83	6.37	656.0	724.0	68.0	68.0	Diyaljee,V.and Parti,M.(2002)
6	1.64	Pipe Pile	24.0	16.6	82.0	8.0	4.21	292.3	1308.5	1016.2	960.6	Dover,A.R.and Howard,Jr,R.(2002)
7	1.61	Pipe Pile	24.0	20.5	101.0	8.0	5.19	472.1	1304.0	831.8	963.3	Dover,A.R.and Howard,Jr,R.(2002)
8	1.00	Conc' Pile	18.0	81.0	85.0	4.0	4.90	912.0	939.0	27.0	16.1	Antorena,J.M.and McDaniel,G.T.(1995)a
9	1.00	Conc' Pile	18.0	73.3	77.0	6.0	4.44	816.0	954.0	138.0	107.2	Antorena,J.M.and McDaniel,G.T.(1995)a
10	1.00	Conc' Pile	18.0	71.5	75.1	2.0	4.33	428.7	489.2	60.5	51.5	Svinkin,M.R.(1995)
11	1.00	Conc' Pile	24.0	95.4	75.1	11.0	4.33	447.3	813.2	365.9	246.7	Svinkin,M.R.(1995)
12	2.00	Conc' Pile	24.0	101.7	80.1	10.0	3.81	60.0	344.0	283.9	237.4	Svinkin,M.R.et.al.(1994)
13	2.00	Conc' Pile	30.0	127.1	80.1	9.0	3.81	45.0	341.1	296.1	303.9	Svinkin,M.R.et.al.(1994)
14	2.00	Conc' Pile	30.0	127.1	80.1	11.0	3.81	58.9	357.0	298.1	327.0	Svinkin,M.R.et.al.(1994)
15	2.00	Conc' Pile	18.0	61.5	64.6	11.0	3.72	205.3	382.6	177.4	175.7	Svinkin,M.R.et.al.(1994)
16	2.00	Conc' Pile	24.0	81.3	64.0	10.0	3.69	340.2	587.9	247.8	322.4	Svinkin,M.R.et.al.(1994)
17	2.00	Conc' Pile	24.0	95.5	75.1	11.0	4.33	446.5	813.2	366.7	251.6	Svinkin,M.R.et.al.(1994)
18	2.00	Conc' Pile	9.3	30.5	62.3	37.0	3.59	125.9	304.2	178.3	252.2	Axelsson,G.(1998)
19	2.00	Conc' Pile	9.3	30.5	62.3	6.0	3.59	125.9	315.2	189.3	156.2	Axelsson,G.(1998)
20	1.85	Conc' Pile	9.8	32.5	62.3	8.0	3.06	57.3	285.5	228.2	244.6	Skov,R. and Denver,H.(1988)
21	1.00	H-Pile	12.0	29.1	155.0	7.0	8.93	110.0	340.0	230.0	223.0	Fellenius B.H.et.al(1989)
22	1.53	H-Pile	12.0	9.4	50.0	7.0	2.62	240.1	284.0	43.9	89.7	Long,J.H.et.al.(2002)
23	2.00	H-Pile	12.0	29.0	154.9	7.0	7.37	109.9	339.9	230.0	224.7	Svinkin,M.R.et.al.(1994)

V.3 Pile Drivability

V.3.1 Q1 type (30-80 kips)

Table VI-9 Training data set for Q1

No	Hammer		Hammer cushion Material				Pile Information					Soil Information					Stroke	out1	out2	out3	BPNN		
	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	*Qu*		Com Stress	Ten Stress	BPF	Com Stress	Ten Stress	BPF
1	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**31**	4.12	11.42	1.7	5.5	11.465	1.7106	5.4315
2	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**31**	5	14.67	2.73	4.9	14.338	2.839	5.0101
3	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**31**	6	17.71	4.34	4.5	17.715	4.4498	4.6619
4	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**40**	3.87	12.94	0.88	5.3	12.893	0.8984	5.2591
5	2.87	25.428	272.25	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**40**	4.25	13.86	0.91	7.7	13.837	0.8759	7.9728
6	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**40**	3.89	16.61	1.78	6.3	16.694	1.6451	6.3346
7	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**40**	6.5	25.36	5.83	4.9	25.167	5.7778	4.9127
8	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**40**	4.5	19.04	2.52	5.9	18.879	2.5776	5.748
9	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**45**	3.83	17.91	0.33	6.4	18.007	0.2916	6.3334
10	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**45**	6.5	28.19	3.75	4.9	27.999	3.8014	4.8729
11	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**45**	7.5	31.21	5.2	4.5	31.419	5.2214	4.5544
12	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**45**	3.72	15.29	2.75	5.3	15.396	2.7612	4.9735
13	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**45**	7	27.29	10.18	3.7	27.227	10.111	3.5014
14	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**45**	4.41	14.05	0.53	8.6	14.002	0.513	8.7801
15	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**45**	7	21.22	0.42	6.6	21.272	0.4388	6.4647
16	1.76	20.099	314	175	2	2.79	60	60	12	15.5	60.00	0.1	0.18	0.18	92	**45**	6.39	14.82	1.27	11.1	14.992	1.2778	10.994
17	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**45**	7	15.99	1.49	10.5	16.289	1.4865	10.412
18	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**45**	9	18.97	3	9	19.026	2.9975	8.8915
19	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**45**	5.87	13.76	0.14	5.7	14.164	0.2019	5.5361
20	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**45**	7	15.3	0.37	5.2	15.404	0.2702	5.1262
21	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**45**	5.98	12.67	0.35	5.4	12.621	0.4018	5.3652
22	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**45**	5	11.17	0.37	6	11.054	0.2961	5.9002
23	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**45**	6	12.69	0.35	5.4	12.65	0.4042	5.3547
24	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**45**	7	14.05	0.57	4.9	13.935	0.5045	4.8676
25	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**45**	4.84	17.94	0.64	5.8	18.263	0.5858	5.7515
26	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**45**	6.5	23.23	1.82	5	23.198	1.8641	4.8756
27	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**45**	7.5	25.92	2.92	4.6	26.154	2.9031	4.4963
28	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**45**	3.36	13.56	0	6.6	13.446	0.0037	6.5018
29	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**45**	5	20.39	0	5.2	20.266	0.0314	5.3375
30	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**45**	3.66	15.66	0.04	7.2	15.444	0.0016	7.4466
31	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**45**	5	20.76	0.04	6	20.546	0.009	6.0911
32	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**45**	7	26.72	0	5.1	26.602	0.0422	5.2396
33	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**45**	3.55	14.85	0.05	6.6	14.845	0.0013	6.5153
34	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**45**	5	20.46	0.05	5.4	20.126	0.0032	5.4782
35	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**45**	4.5	20.55	0.45	5.9	20.506	0.3891	5.8186
36	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**45**	7	29.51	3.09	4.7	29.113	3.0453	4.5933
37	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**45**	6	26.44	3.44	5.2	26.668	3.3479	5.2002
38	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**45**	7	29.79	4.44	4.8	30.063	4.4694	4.8246
39	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**50**	4.41	17.09	0.09	8	16.905	0.0653	7.7364
40	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**50**	6	22.09	0.57	6.5	21.549	0.5339	6.3942
41	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**50**	7	24.77	1.29	6	25.24	1.3212	5.7242
42	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**50**	4.15	16.01	0	6.2	16.224	0.0404	6.1423
43	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**50**	5	19.42	0	5.6	19.549	0.0915	5.7388
44	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**50**	5.83	20.66	0	4.7	20.927	0.0118	4.5825
45	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**50**	6	21.2	0	4.6	21.447	0.0137	4.4983

Table VI-9 Training data set for Q1 (continued)

46	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**50**	6	20.91	0	4.6	21.31	0.0041	4.5906
47	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**50**	4.3	13.22	0.2	8.2	13.297	0.2702	8.1677
48	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**50**	5	15.38	0.55	7.3	15.22	0.4137	7.3424
49	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**50**	7	20.41	0.57	6	20.482	0.6762	5.8677
50	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**50**	4.48	12.48	0.33	8.7	12.516	0.2638	8.7272
51	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**50**	6	16.7	1.21	7.2	16.739	1.3022	7.1109
52	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**50**	7	19.09	2.4	6.6	19.12	2.4363	6.5919
53	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**50**	5	17.42	0.11	7.6	17.461	0.1089	7.5299
54	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**50**	6	20.13	0.11	6.8	20.151	0.1646	6.866
55	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**50**	4.19	12.91	0.1	8.2	13.074	0.0011	8.1725
56	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**50**	5	15.41	0.1	7.2	15.067	0.0017	7.3743
57	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**50**	4.08	15.01	0.07	10.6	14.98	0.1073	10.48
58	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**50**	7	23	0.08	7.7	23.115	0.059	7.743
59	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**50**	5	15.99	0.1	8.8	15.811	0.0424	8.7124
60	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**50**	7	21.15	0.1	7.2	21.2	0.044	7.0732
61	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**50**	4.53	15.14	0.33	6.5	15.054	0.3299	6.4862
62	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**50**	6.16	14.45	0.16	11.8	14.74	0.0634	11.542
63	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**50**	8	17.44	0.17	10	17.307	0.1327	10.038
64	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**50**	9	18.86	0.18	9.3	19.06	0.275	9.1716
65	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**50**	4.57	20.78	0	6.5	20.615	0.0622	6.6092
66	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**50**	7.5	3.18	0.26	5	4.013	0.3064	5.073
67	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**50**	5	17.7	0	5.9	18.224	0.007	5.7867
68	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**50**	6	21.32	0	5.3	21.179	0.0224	5.1676
69	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**50**	7	24.32	0	4.8	24.623	0.0576	4.6896
70	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**50**	4.82	21.98	2.54	6.6	22.099	2.5701	6.6666
71	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**50**	7.5	31.44	5.68	5.2	30.999	5.6092	5.2584
72	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**50**	5	16.04	0	5.2	16.01	0.021	5.2617
73	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**50**	6	18.47	0	4.47	18.146	0.0314	4.6881
74	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**50**	7	20.65	0	4.3	20.547	0.0639	4.3254
75	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	4.88	15.74	0	5.5	16.067	0.0225	5.4126
76	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	6	18.49	0	4.8	18.505	0.0345	4.7515
77	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	7	20.68	0	4.4	20.832	0.0694	4.3894
78	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	6.33	11.61	0	4.3	13.141	0.0187	4.0234
79	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	8	20.58	0.07	3.6	20.266	0.1047	3.5911
80	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	5.58	12.69	0	6.6	12.924	0.0369	6.3498
81	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	8	22.04	0.96	5	22.015	0.9429	4.8993
82	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**50**	5.77	20.42	0	4.4	20.011	0.0055	4.3394
83	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**50**	7	24.12	0.52	4	24.198	0.0171	3.9274
84	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**50**	5	17.62	0	4.9	17.549	0.003	4.7024
85	3.3	27.093	240.25	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**50**	3.73	16.48	0.07	7.5	16.302	0.0013	7.5344
86	3.3	27.093	240.25	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**50**	6	24.22	0.07	5.7	24.3	0.0063	5.8637
87	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**50**	5	22.55	0.8	6.2	22.408	0.8005	6.1269
88	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**50**	6	26.25	1.85	5.6	26.519	1.8574	5.4951
89	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**50**	6	14.04	0.13	10.8	14.224	0.0629	10.581
90	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**50**	7	15.74	0.13	9.8	15.583	0.0718	9.8212
91	4.2	42	283.34	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**50**	3.77	19.74	0	5.7	19.559	0.0471	5.7069
92	4.2	42	283.34	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**50**	7.5	33.08	2.17	4.1	33.668	2.1478	4.2638
93	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**50**	3.43	16.1	0	7.3	16.054	0.0692	7.1737
94	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**50**	6.5	28.64	1.03	5	28.529	1.0184	4.6777
95	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**50**	3.9	17.91	0.04	7.9	17.805	0.0442	7.9865

Table VI-9 Training data set for Q1 (continued)

96	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**50**	5.5	23.97	0.73	6.5	24.131	0.7236	6.5212
97	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**50**	5.74	20.2	0	4.5	20.184	0.0029	4.4462
98	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**50**	7.5	25.35	0.33	3.8	25.776	0.0145	3.8424
99	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**50**	6.5	22.92	0	4.5	22.72	0.12	4.2936
100	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**50**	7.5	25.73	0.26	4.2	26.262	0.2465	3.9031
101	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**50**	5	18.8	0.67	7.2	18.6	0.3078	7.2268
102	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**50**	7	24.86	0.51	6.1	24.632	0.6525	6.0437
103	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**50**	8	27.4	1.01	5.7	27.259	1.0026	5.6349
104	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**50**	4.45	14.95	0.84	9.5	14.826	0.7825	9.2966
105	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**50**	7	22.53	2.29	5.3	22.5	2.3263	5.8912
106	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**50**	4.29	16.26	0	6.8	16.309	0.3318	6.8303
107	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**50**	5	18.93	0.69	6.2	18.964	0.3662	6.1661
108	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**50**	7	25.03	0.66	5.1	25.188	0.6688	5.1438
109	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**50**	5	18.72	0.07	7.3	18.705	0.0298	6.9013
110	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**50**	6	21.82	0.07	6.4	21.874	0.1589	6.1453
111	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**50**	5	16.5	0	4.9	16.801	0.0018	4.4577
112	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**50**	4.56	20.52	0.35	5.9	20.494	0.2316	5.7856
113	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**50**	7.5	30.75	3.27	4.5	30.591	3.2149	4.3002
114	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**50**	3.61	17.06	0.18	8	17.19	0.2127	7.8401
115	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**50**	6	26.81	2.52	5.8	26.731	2.5025	5.6985
116	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**50**	7	29.98	3.84	5.4	29.725	3.918	5.248
117	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**50**	5	16.88	1.12	8.8	17.116	0.9746	8.9091
118	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**50**	6	19.85	1.17	7.9	19.748	1.1817	7.8247
119	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**50**	7	22.51	1.12	7.2	22.226	1.195	7.1761
120	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**50**	3.94	16.97	0.63	6.9	16.918	0.6749	6.9162
121	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**50**	6	24.19	4.24	5.4	24.025	4.1778	5.2811
122	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**50**	7	27	5.81	4.9	26.987	5.8057	5.0586
123	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**50**	5.76	20.23	0	4.5	20.096	0.0026	4.4318
124	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**50**	5	17.43	0	5	17.787	0.0013	4.7584
125	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**50**	7	23.99	0	4	24.195	0.0093	4.0158
126	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**50**	5.07	17.27	2.79	6.5	17.099	2.8087	6.4327
127	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**50**	5.5	18.69	3.59	6.2	18.374	3.5724	6.1496
128	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**50**	7.5	24.15	6.84	5.2	24.035	6.8502	5.2301
129	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**50**	4.86	18.322	0.369	4.5	18.921	0.1748	4.7382
130	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**50**	5.5	21.969	0.218	4.46	21.101	0.2309	4.3183
131	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**50.6**	4.27	14.93	0	6.2	14.884	0.0029	6.0184
132	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**50.6**	5	17.3	0	5.6	17.202	0.0036	5.4101
133	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**50.6**	6	20.19	0	5.1	20.273	0.0063	4.783
134	2.8	23.8	315.66	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**50.6**	6	13.98	0	5.6	14.029	0.0657	5.5234
135	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**50.6**	4	8.8	0	3	8.5722	0.005	2.9031
136	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**50.6**	5	11.47	0	2.7	11.565	0.0064	2.7108
137	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**50.6**	7	24.01	0.08	2.3	23.562	0.0959	2.4849
138	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.2012	0.101	87	**59.6**	4.04	20.11	0	5.1	19.739	0.0863	5.1608
139	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.2012	0.101	87	**59.6**	7	35.91	3.1	3.9	36.518	2.9641	3.8937
140	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.2012	0.101	87	**59.6**	7.5	37.91	3.43	3.8	37.139	3.437	3.7729
141	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.2012	0.101	60	**59.6**	3.84	18.05	0	4.8	17.555	0.0139	4.7823
142	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.2012	0.101	60	**59.6**	6	30.93	0	3.9	31.04	0.1685	3.8423
143	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.2012	0.101	60	**59.6**	7	35.5	0.86	3.6	35.142	0.8152	3.6068
144	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**59.6**	5.09	19.06	0.4	7.4	18.879	0.4467	7.2051
145	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**59.6**	6	21.89	1.03	6.7	21.854	1.0327	6.4866

Table VI-9 Training data set for Q1 (continued)

146	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**59.6**	7	24.7	2.07	6.1	24.865	2.052	5.8897
147	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**59.6**	4.59	17.58	0	8.5	17.803	0.1244	8.3858
148	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**59.6**	6.5	23.6	0.34	6.8	23.84	0.4265	6.8294
149	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**59.6**	7.5	26.27	1	6.3	26.375	0.9517	6.1848
150	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**59.6**	6.59	20.92	0.32	6.9	21.197	0.1359	6.9025
151	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**59.6**	8.5	25.37	0.51	5.9	24.936	0.5397	5.7839
152	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**59.6**	9.5	27.43	0.97	5.5	27.55	0.9808	5.4147
153	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**59.6**	5.97	17.05	0	5	16.905	0.0017	4.9494
154	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**59.6**	8.5	22.82	0	4	22.984	0.0072	3.8013
155	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**59.6**	6.4	21.02	0	6.6	21.457	0.0044	6.5169
156	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**59.6**	7.5	23.84	0	6	23.468	0.0078	5.8638
157	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**59.6**	6	17.1	0	5.1	17.115	0.0065	5.0239
158	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**59.6**	8.5	22.74	0	4.1	22.738	0.0346	4.0537
159	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**59.6**	6.1	19.42	0	5.1	19.231	0.0962	5.0125
160	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**59.6**	7.5	23.09	0	4.7	23.174	0.0053	4.6559
161	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**59.6**	4.99	20.53	1.02	6	20.481	1.0306	5.981
162	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**59.6**	7	26.47	4.22	5.1	26.383	4.2159	4.9497
163	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**59.6**	8	29.12	5.61	4.7	28.716	5.6075	4.5867
164	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**59.6**	5.5	21.74	0.05	6.5	21.302	0.0615	6.5929
165	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**59.6**	6	23.35	0.05	6.1	23.294	0.1112	6.2992
166	4	43.24	228	408	2	1.9	21.33	21.33	12	15.5	21.33	0.1	0.122	0.101	90	**59.6**	3.9	15.51	0.07	8.3	15.402	0.0117	8.2068
167	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**59.6**	4.13	16.16	0.21	9.1	16.145	0.2345	9.2042
168	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**59.6**	5.5	21.22	0.95	7.3	20.86	0.9427	7.3167
169	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**59.6**	6.5	24.32	1.97	6.6	24.015	1.9871	6.5642
170	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**59.6**	4	15.38	0.16	8.2	15.449	0.0825	8.2974
171	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**59.6**	5.5	21	0.48	6.4	20.874	0.5012	6.2204
172	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**59.6**	4.89	18.27	0.09	7	17.903	0.0254	7.0659
173	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**59.6**	6	21.69	0.08	6.2	21.748	0.1068	6.3037
174	4.015	43.242	225	408	2.5	2.286	45.93	45.93	12	15.5	45.93	0.1	0.152	0.1	90	**59.6**	4.95	18.27	0.17	7	18.559	0.2145	6.9419
175	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**59.6**	5.12	18.62	1.1	7.6	18.375	1.1232	7.5521
176	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**59.6**	7	24.07	4.04	6.2	23.956	4.009	6.1683
177	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**59.6**	8	26.64	5.39	5.8	26.353	5.3856	5.7793
178	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**59.6**	5.02	19.47	1.32	10.9	19.284	1.3051	11.064
179	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**59.6**	5.05	19.52	1.31	11.3	19.2	1.2799	11.254
180	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**59.6**	8	27.62	5.18	8.7	27.796	5.1954	8.5902
181	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**59.6**	4.99	18.16	0.49	11.3	18.384	0.5937	10.949
182	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**59.6**	7.5	26.08	1.36	7.2	26.063	1.3295	7.2315
183	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**60**	4.32	16.2	0.11	9	16.102	0.1753	8.9605
184	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**60**	8	22.75	1.47	5.4	22.585	1.4931	5.197
185	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**60**	9	26.07	2.84	4.9	26.067	2.8239	4.9375
186	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**60**	6.55	14.16	0	5.7	14.305	0.0046	5.5405
187	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**60**	8	20.86	0	4.8	20.279	0.0168	4.6842
188	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**60**	9	24.63	0	4.4	25.047	0.0681	4.2704
189	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	4.35	20.11	1.52	10.9	19.789	1.5613	10.999
190	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	6	26.06	2.88	8.9	26.106	2.8352	8.7748
191	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	8	31.96	3.97	7.6	31.87	3.9571	7.7479
192	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	4.85	23.47	1.41	6.8	23.49	1.4308	6.9354
193	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	7	31.04	3.21	5.6	31.216	3.1801	5.5447
194	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	8	34.15	3.71	5.3	33.841	3.7415	5.3678
195	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**60**	5.03	21.17	0.05	6.8	21.284	0.0254	6.8857

Table VI-9 Training data set for Q1 (continued)

196	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**60**	7.5	28.57	0.05	5.6	28.646	0.0635	5.4795
197	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**60**	8.5	31.07	0.05	5.3	31.122	0.0955	5.2258
198	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**60**	4.88	18.04	1.07	5.5	18.163	1.0264	5.5515
199	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**60**	7	24.35	3.96	4.6	24.448	4.0897	4.6092
200	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**60**	8	26.82	5.09	4.3	26.852	5.2807	4.3984
201	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**60**	6.5	19.05	2.45	5.9	18.751	2.4252	5.896
202	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**60**	7.5	21.31	3.65	5.5	21.06	3.6032	5.4025
203	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**60**	8.5	23.39	4.77	5.1	23.065	4.7673	4.9663
204	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**60**	6.1	21.67	0	5.4	21.519	0.0068	5.4422
205	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**60**	6	21.35	0	5.5	21.165	0.0062	5.4976
206	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**60**	7	24.28	0.05	4.9	24.725	0.0189	5.0101
207	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**60**	4.4	14.22	1.04	5.8	14.173	1.074	5.806
208	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**60**	6	21.34	3.43	4	21.183	3.4555	4.0243
209	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**60**	7	24.76	4.56	3.4	24.679	4.6079	3.355
210	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**60**	4.6	19.52	4.16	7.5	19.288	4.1012	7.4284
211	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**60**	6	24.59	6.7	6.4	24.5	6.7166	6.4178
212	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**60**	7	27.66	8.4	5.9	27.817	8.5138	5.8713
213	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**60**	8	30.38	9.88	5.5	30.087	9.6133	5.3179
214	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**60**	4.72	14.57	1.25	11.9	14.608	1.2632	11.979
215	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**60**	7.5	22.24	4.34	8.7	22.231	4.4239	8.6321
216	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**60**	5.16	20.25	0.99	6.8	20.076	1.0077	6.847
217	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**60**	6	22.83	2.21	6.3	22.683	2.0557	6.2152
218	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**60**	8	28.11	4.69	5.5	27.898	4.7208	5.4099
219	2.87	25.428	272.25	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**60**	4.7	16.19	0.16	12.8	16.263	0.2417	12.668
220	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**60**	5.07	18.99	3.84	5.9	19.101	3.9299	5.8791
221	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**60**	7	24.54	7.63	5	24.612	7.6372	4.9016
222	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**60**	8	27.07	9.32	4.6	27.1	9.1587	4.5871
223	3.3	27.093	240.25	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**60**	4.22	18.34	0.24	10	18.658	0.086	10.111
224	3.3	27.093	240.25	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**60**	7.5	28.42	2.75	7.1	28.125	2.7342	7.0809
225	3.3	27.093	240.25	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**60**	5.5	22.77	0.49	8.5	22.462	0.5147	8.5302
226	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.1829	0.152	91	**60**	6	19.95	0	3.5	19.138	0.0329	3.4506
227	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.1829	0.152	91	**60**	6.5	23.03	0	3.3	22.332	0.0459	3.3487
228	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**60**	4.98	19.89	0.39	6.6	19.687	0.4867	6.6485
229	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**60**	6.5	24.42	1.83	5.8	24.542	1.8127	5.7667
230	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**60**	8.5	29.43	4.19	5.1	29.117	4.1906	5.1013
231	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**60**	5.5	21.67	0	6.3	21.237	0.2359	6.2851
232	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**60**	6.5	24.55	0.57	5.8	24.553	0.5208	5.8093
233	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**60**	7.5	27.17	1.22	5.4	27.351	1.1748	5.51
234	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**60**	6.5	24.32	2.64	6.5	24.252	2.6694	6.3844
235	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**60**	7.5	26.93	3.89	6	26.741	3.8989	5.9865
236	4	43.24	379.91	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**60**	6	20.25	4.58	3.7	20.315	4.5026	3.5632
237	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**60**	4.3	17.17	0.18	7	17.122	0.1625	6.9964
238	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**60**	6	23.31	1.46	5.6	23.313	1.4103	5.5024
239	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**60**	6.5	24.84	2.17	5.3	24.911	2.2214	5.2141
240	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**60**	5	16.7	2.35	7.8	16.705	2.3835	7.7199
241	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**60**	6	19.75	3.45	6.9	19.482	3.3788	6.8767
242	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**60**	7	22.45	4.77	6.3	22.086	4.7256	6.2425
243	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**60**	6	20.93	4.23	5.9	20.557	4.1778	5.8631
244	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**60**	8	25.91	7.35	5.1	25.838	7.3473	5.0224
245	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**62**	4.78	14.87	0.58	13.1	14.854	0.5577	13.01

Table VI-9 Training data set for Q1 (continued)

246	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**62**	5	15.56	0.72	12.7	15.569	0.6736	12.694
247	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**62**	6	18.47	1.28	11.2	18.49	1.2825	11.19
248	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**65**	4.73	19.79	0.13	7.9	19.931	0.1049	7.9638
249	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**65**	6.5	25.39	0.75	6.5	25.409	0.7442	6.3968
250	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**65**	6.5	22.67	0.21	7.2	22.641	0.1688	7.2728
251	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**65**	6.76	13.79	0	5.9	13.944	0.0011	5.8336
252	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**65**	7.5	16.82	0	5.4	16.566	0.0021	5.4024
253	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**65**	8.5	20.66	0	4.8	20.724	0.0068	4.9208
254	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**69.7**	6.5	19.12	0	6.9	19.005	0.0896	6.7951
255	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**69.7**	7.5	21.46	0.32	6.2	21.726	0.2342	6.1861
256	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**69.7**	8.5	23.63	0.8	5.7	23.587	0.7953	5.725
257	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**70**	5.12	17.92	0.42	8.1	17.889	0.4033	8.2146
258	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**70**	5	17.51	0.39	8.2	17.451	0.3547	8.345
259	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**70**	6	20.58	0.91	7.3	20.739	0.9224	7.3713
260	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**70**	5.21	18.98	1.34	7.5	18.931	1.3527	7.5563
261	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**70**	6.5	22.63	3.38	6.6	22.661	3.3863	6.5586
262	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**70**	8.5	27.43	6.11	5.7	27.373	6.237	5.5814
263	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**75**	6.04	20.63	0.99	9.5	20.697	0.9926	9.4681
264	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**75**	8	25.66	2.32	8.1	25.68	2.3229	7.9893
265	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**75**	9	27.89	3.33	7.6	27.927	3.3406	7.7142
266	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**80**	4.63	17.68	0.44	12.7	17.646	0.3544	12.464
267	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**80**	4.5	18.74	0.18	12.3	18.69	0.1486	12.191
268	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**80**	4.71	20.46	0.41	15.5	20.372	0.3469	15.26
269	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**80**	5.5	22.99	0.42	13.9	23.067	0.499	14.352
270	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**80**	4.5	19.64	0.39	16	19.691	0.3063	15.412

Table VI-10 Testing data set for Q1

No	Hammer		Hammer cushion Material				Pile Information					Soil Information					Stroke	out1	out2	out3	BPNN		
	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	*Qu*		Com Stress	Ten Stress	BPF	Com Stress	Ten Stress	BPF
1	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**31**	5.5	16.26	3.45	4.7	16.037	3.60	4.8
2	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**40**	5.5	22.41	4.27	5.3	22.34	4.23	5.2
3	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**45**	5	20.72	6.14	4.4	19.011	8.03	4.2
4	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**45**	5	15.97	0.83	8	15.707	0.52	8.0
5	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**45**	8	17.54	2.27	9.7	17.299	2.08	9.6
6	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**45**	5	12.39	0	6.3	13.284	0.17	5.9
7	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**45**	6	13.93	0.16	5.7	14.301	0.21	5.5
8	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**45**	5.5	20.21	1.15	5.4	20.325	0.97	5.4
9	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**45**	6	23.54	0	4.7	24.101	0.07	5.1
10	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**45**	6	23.58	0.04	4.9	23.822	0.01	5.2
11	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**45**	4.58	20.93	1.62	6	21.955	0.96	6.2
12	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**45**	5	22.71	2.22	5.7	23.347	1.64	5.8
13	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**50**	5	19.09	0.07	7.3	18.457	0.16	7.2
14	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**50**	6	22.82	0.45	5	22.9	0.19	5.5
15	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**50**	7	23.98	0	4.2	24.262	0.01	4.2
16	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**50**	6	18.04	0.44	6.5	17.94	0.63	6.5
17	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**50**	5	14.05	0.22	8.1	13.879	0.47	8.0
18	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**50**	3.89	13.92	0.12	8.9	13.741	0.06	8.6
19	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**50**	6	18.03	0.1	6.4	17.773	0.00	6.7
20	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**50**	5	17.88	0.07	9.3	19.415	0.08	9.4
21	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**50**	4.35	13.96	0.09	9.6	13.656	0.03	9.5
22	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**50**	6	18.74	0.1	7.9	19.222	0.05	7.8
23	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**50**	7	21.77	1.29	5	19.677	1.19	4.8
24	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**50**	7	15.89	0.14	10.9	15.787	0.08	10.9
25	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**50**	4.86	22.17	1.19	6.9	23.09	1.39	6.8
26	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**50**	7.5	31.28	3.58	5.5	30	2.86	5.5
27	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**50**	6.01	21.37	0	5.3	21.211	0.02	5.2
28	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**50**	8.5	34.39	7.09	4.9	33.597	5.94	5.1
29	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**50**	4.82	15.6	0	5.3	15.626	0.02	5.4
30	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	5	16.06	0	5.4	16.331	0.02	5.3
31	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	7	15.78	0	4	15.679	0.04	3.8
32	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**50**	7	18.83	0.32	5.5	17.805	0.28	5.4
33	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**50**	6	21.17	0	4.3	20.775	0.01	4.2
34	3.3	27.093	240.25	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**50**	5	21.11	0.07	6.3	20.834	0.00	6.4
35	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**50**	7	29.61	2.74	5.2	29.413	2.60	5.0
36	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**50**	6.02	14.08	0.13	10.8	14.256	0.06	10.6
37	4.2	42	283.34	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**50**	5.5	26.68	0.15	4.7	27.956	0.54	4.7
38	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**50**	5.5	25.21	0.43	5.5	24.575	0.74	5.0
39	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**50**	5.5	19.33	0	4.6	19.471	0.00	4.6
40	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**50**	6	22.06	0.8	6.6	21.981	0.42	6.6
41	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**50**	6	19.87	1.79	6.3	19.7	1.39	6.7
42	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**50**	7	24.61	0.07	5.8	25.221	0.74	5.5
43	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**50**	6	19.19	0	4.4	19.632	0.00	4.0

Table VI-10 Testing data set for Q1 (continued)

44	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**50**	8.5	33.64	3.96	4.2	31.317	5.27	4.1
45	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**50**	5	23.23	1.4	6.5	23.409	1.28	6.3
46	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**50**	4.44	14.96	0.77	9.5	15.668	0.70	9.8
47	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**50**	5	21	2.5	6	20.609	2.34	5.9
48	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**50**	6.5	21.59	5.26	5.6	21.297	5.30	5.6
49	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**50**	3.88	14.99	0	6.5	15.282	0.11	5.8
50	2.8	23.8	315.66	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**50.6**	7	15.35	0	5.1	15.318	0.08	5.1
51	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**50.6**	6	17.87	0	2.4	16.479	0.02	2.6
52	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.2012	0.101	87	**59.6**	6.5	33.73	2.62	4.1	35.449	2.30	4.0
53	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**59.6**	8	27.25	3.22	5.7	27.734	2.92	5.4
54	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**59.6**	6.1	19.61	0	5.2	19.019	0.01	4.7
55	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**59.6**	7.5	20.68	0	4.3	20.255	0.00	4.1
56	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**59.6**	8.5	26.15	0	5.6	25.838	0.01	5.4
57	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**59.6**	7.5	20.63	0	4.4	21.162	0.02	4.4
58	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**59.6**	6.1	19.48	0	5.3	20.678	0.00	5.4
59	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**59.6**	6	23.65	2.75	5.5	23.607	2.50	5.4
60	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**59.6**	3.87	15.51	0.05	8.4	14.983	0.01	8.1
61	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**59.6**	6	22.82	1.44	6.9	22.498	1.36	6.9
62	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**59.6**	7	24.49	0.29	5.7	24.58	0.35	5.9
63	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**59.6**	6	21.26	2.55	6.9	21.063	2.39	6.8
64	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**59.6**	7.5	28.02	5.46	8.2	27.235	6.22	8.4
65	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**59.6**	8	29.45	6.12	8.3	27.796	5.20	8.6
66	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**60**	4.19	17.36	0.06	8.7	16.441	0.04	8.1
67	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	7	29.13	3.45	8.1	29.351	3.42	8.1
68	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**60**	9	36.93	4.64	5	35.704	4.21	5.3
69	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**60**	6.5	25.82	0.04	6	25.964	0.04	5.9
70	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**60**	6	21.58	2.59	5	21.726	2.10	4.9
71	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**60**	5.77	17.24	1.5	6.3	16.78	1.55	6.3
72	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**60**	6.5	23.11	4.06	3.7	23.065	4.03	3.6
73	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**60**	6.5	19.72	3.06	9.6	19.474	2.28	9.4
74	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**60**	7	25.57	3.51	5.8	25.553	3.46	5.7
75	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**60**	6	21.82	5.74	5.4	22.063	5.72	5.3
76	3.3	27.093	240.25	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**60**	6.5	25.75	1.69	7.7	25.43	1.23	7.7
77	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.1829	0.152	91	**60**	5.5	15.31	0	3.6	15.909	0.02	3.6
78	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**60**	7.5	27.03	2.94	5.4	27.114	3.01	5.4
79	4	43.24	379.91	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**60**	6.5	21.35	2.99	3	21.786	4.24	3.4
80	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**60**	4.22	14.36	0.07	6.8	15.949	0.00	7.3
81	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**60**	7	23.52	5.78	5.4	23.213	5.63	5.4
82	2.9	25.428	272.25	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**62**	5.5	17.1	1.03	11.9	17.09	0.98	11.9
83	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**65**	5.42	19.81	0.2	7.9	19.813	0.11	8.0
84	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**65**	9.5	23.88	0	4.5	24.557	0.03	4.6
85	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**69.7**	9.5	25.64	1.35	5.3	24.774	2.84	5.4
86	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**70**	7	23.29	2.02	6.6	23.614	2.07	6.8
87	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**70**	7.5	25.12	4.81	6.2	24.878	4.87	6.0
88	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**75**	7	23.25	1.51	8.7	23.452	1.55	8.5
89	2.87	25.428	272.25	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**80**	5	17.61	0.16	18.8	22.258	0.04	15.5
90	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**80**	6.5	26.05	0.85	12.4	26.522	0.75	12.7

V.3.2 Q2 type (81-159 kips)

Table VI-11 Training data set for Q2

No	*Hammer*		*Hammer cushion Material*				*Pile Information*					*Soil Information*						**out1**	**out2**	**out3**	***BPNN***		
	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***	Stroke	**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**90**	5.5	25.72	0	14.3	25.999	0.0061	13.911
2	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**90**	7.5	32	0	11.6	31.702	0.0036	11.51
3	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**90**	5	21.7	1.13	12.1	21.58	1.1185	11.942
4	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**90**	5.17	17.35	0.34	21.1	17.337	0.3288	21.128
5	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**90**	7	22.02	0.34	16.6	22.186	0.3361	16.689
6	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**90**	4.73	18.32	0.13	15.4	18.048	0.0855	16.011
7	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**90**	7	16.29	0.62	27.8	16.317	0.6332	27.365
8	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**90**	8	17.83	0.65	25.1	17.557	0.6486	25.445
9	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**90**	9	19.24	0.66	22.8	19.424	0.6645	22.568
10	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**90**	5.15	16.48	0.06	21	16.433	0.0649	21.255
11	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**90**	6	18.79	0.06	18.3	18.865	0.0658	18.039
12	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**90**	5	14	0.14	16.6	14.006	0.1603	16.406
13	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**90**	6	15.39	0.15	14.3	15.397	0.1496	14.346
14	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**90**	7	16.65	0.15	12.8	16.561	0.1559	12.995
15	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**90**	5	11.75	0.22	15.9	11.818	0.2078	15.902
16	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**90**	6	13.26	0.17	13.7	13.83	0.1941	13.719
17	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**90**	7	14.59	0.16	12.3	14.845	0.1765	11.916
18	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**90**	5.66	21.48	0.56	13.8	21.454	0.5647	13.965
19	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**90**	6.5	23.95	0.92	12.6	23.805	0.8615	12.485
20	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**90**	7.5	26.6	1.24	11.5	26.602	1.2386	11.234
21	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**90**	4.27	19.13	0	16.3	18.913	0.0109	15.801
22	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**90**	5	21.8	0	14.2	21.505	0.0099	14.406
23	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**90**	4.76	21.23	0.01	17.1	21.04	0.0154	16.871
24	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**90**	6	25.22	0.01	14.4	25.146	0.0107	15.276
25	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**90**	4.62	20.35	0.04	15.5	20.401	0.0317	15.038
26	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**90**	6	24.68	0.04	12.7	23.99	0.0298	13.104
27	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**90**	7	27.52	0.04	11.5	28.099	0.0307	11.842
28	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**90**	6.01	27.32	0	14	27.216	0.0122	14.104
29	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**90**	5	23.65	0.03	16.5	24.002	0.019	16.394
30	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**90**	6	27.39	0.01	14.4	27.516	0.0145	14.423
31	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**90**	5	22.07	0.01	16.4	21.785	0.0143	16.551
32	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**90**	5	21.65	0.04	14.5	21.591	0.0308	14.475
33	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**90**	7	30.58	0	12.6	30.591	0.0093	12.843
34	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**93**	5	15.97	0.29	23.5	16.049	0.2873	23.24
35	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**93**	6	18.89	0.28	20.1	19.029	0.2903	20.579
36	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	5.36	20.88	0	20.3	20.523	0.044	20.331
37	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	5	19.73	0	21.7	19.487	0.0442	21.837
38	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	7	25.38	0	16.1	25.438	0.0411	16.316
39	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	5.11	20.88	0.02	15.3	20.794	0.034	15.074
40	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	5	20.47	0.02	15.6	20.448	0.034	15.258
41	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	7	26.75	0	11.9	26.798	0.0294	12.346
42	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**100**	7	25.33	0	11.8	25.358	0.0062	12.044
43	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**100**	6	22.07	0	13.5	22.051	0.0129	13.382
44	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**100**	7	25.16	0	11.6	24.954	0.0068	11.864
45	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**100**	5.05	16.31	0.46	20.1	15.518	0.4629	19.525

Table VI-11 Training data set for Q2 (continued)

46	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**100**	6	17.9	0.52	17.2	16.9	0.4934	17.383
47	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**100**	7	21.12	0.55	15.2	20.785	0.5532	15.375
48	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**100**	5	14.99	0.88	22.6	14.927	0.9065	22.633
49	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**100**	6	17.66	0.84	19.2	17.639	0.856	19.183
50	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	4.81	17.69	0.12	21.7	17.509	0.0976	21.602
51	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	6	20.94	0.12	17.8	20.954	0.1241	18.094
52	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	7	23.36	0.12	15.7	23.157	0.146	15.664
53	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	5	16.36	0.16	19.8	16.428	0.1406	19.487
54	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	6	18.98	0.17	16.6	18.555	0.1567	16.828
55	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**100**	5	18.88	0.07	26.3	18.634	0.0369	26.139
56	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**100**	7	24.13	0.07	19.9	24.252	0.0226	19.636
57	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**100**	5.19	17.62	0.12	23.6	17.492	0.1293	22.823
58	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**100**	7	22.18	0.13	18.3	22.367	0.1238	18.734
59	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**100**	5	17.35	0.33	16.3	17.241	0.3452	16.337
60	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**100**	7	22.45	0.5	12.4	22.456	0.494	11.954
61	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**100**	7.06	16.52	0.57	27.5	16.609	0.5704	27.944
62	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**100**	8	17.94	0.58	24.8	17.664	0.58	25.133
63	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**100**	9	19.34	0.57	22.6	19.423	0.5539	22.281
64	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**100**	6.18	28	0	15.5	27.593	0.0081	15.481
65	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**100**	7.5	32.32	0	13.5	32.076	0.0061	13.166
66	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**100**	7.56	27.18	0	12.8	27.064	0.0022	12.402
67	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**100**	5	18.84	0	19.4	18.996	0.0062	19.504
68	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**100**	6	22.52	0	15.8	22.249	0.0047	15.828
69	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**100**	6.26	28.2	0	16.1	27.915	0.0353	16.482
70	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**100**	7.5	32.14	0	14.1	32.335	0.015	13.831
71	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**100**	8.5	35.07	0	12.9	34.938	0.0066	12.738
72	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**100**	5	16.66	0.2	13.9	16.421	0.2083	13.566
73	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**100**	6	19.06	0.22	12	18.976	0.2173	12.051
74	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**100**	7	21.25	0.23	10.7	21.355	0.2095	11.196
75	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	5	16.62	0.23	14.3	16.587	0.2445	13.545
76	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	6	19.05	0.23	12.3	19.132	0.2517	11.812
77	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	7	21.25	0.24	11	21.297	0.2411	10.947
78	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	7	20.16	0	12.2	20.719	0.0359	11.742
79	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	8	23.77	0	10.3	23.564	0.0265	10.974
80	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	6.73	19.23	0.15	16	19.576	0.1322	15.098
81	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	8	22.9	0.16	13.2	22.863	0.1302	13.371
82	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**100**	7.17	25.43	0	10.8	25.315	0.0146	11.388
83	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**100**	6	22.01	0	12.7	21.737	0.0247	12.783
84	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**100**	5	18.47	0	15.6	18.769	0.0349	14.933
85	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**100**	4.82	21.51	0.07	18	21.582	0.0379	17.819
86	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**100**	6	25.2	0.06	15.1	24.972	0.0358	15.391
87	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**100**	5	23.42	0.04	18.4	23.347	0.0164	18.307
88	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**100**	7	30.45	0.03	14.2	30.41	0.012	13.556
89	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**100**	7	16.39	0.28	25.3	16.268	0.2912	24.704
90	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**100**	6	14.7	0.26	29.2	14.499	0.2432	29.329
91	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**100**	5.11	26.09	0	13.6	25.891	0.0159	14.038
92	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**100**	6.5	30.91	0	11.5	31.229	0.0136	12.046
93	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**100**	7.5	33.89	0	10.5	33.647	0.0098	11.436
94	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**100**	4.64	23.2	0	18.3	23.134	0.0093	18.635
95	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**100**	5.5	26.59	0	15.7	26.134	0.0068	15.544

Table VI-11 Training data set for Q2 (continued)

96	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**100**	6.5	29.97	0	13.6	29.917	0.0041	13.283
97	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**100**	5.16	23.88	0.03	19.7	23.903	0.0406	19.676
98	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**100**	5.5	25.04	0.03	18.7	24.71	0.0409	18.973
99	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**100**	7.18	25.41	0	10.8	25.368	0.0121	11.354
100	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**100**	5.5	20.22	0	14	20.184	0.0271	13.815
101	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**100**	6.5	23.46	0	11.8	23.389	0.0175	12.086
102	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**100**	5.5	20.9	0	15.4	20.942	0.0045	15.44
103	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**100**	6.5	24.28	0	13	24.288	0.0019	12.939
104	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**100**	7.5	27.21	0	11.4	27.347	0.0011	11.426
105	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**100**	5.92	22.61	0	17.6	22.273	0.0073	17.757
106	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**100**	7	25.66	0	15.6	25.798	0.0088	15.515
107	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**100**	8	28.17	0	14.3	27.714	0.0095	13.975
108	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**100**	5.27	18.51	0.29	23.6	18.563	0.2046	23.618
109	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**100**	6	20.65	0.27	19.1	20.618	0.3314	19.021
110	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**100**	7	23.29	0.56	15.4	23.549	0.566	15.41
111	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**100**	5.18	20.76	0.03	16.6	20.497	0.0444	16.952
112	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**100**	7	26.19	0.02	13.1	26.303	0.06	12.916
113	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**100**	5	19.45	0.09	21.3	19.336	0.0959	21.316
114	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**100**	6	22.59	0.1	17.8	22.68	0.0928	17.865
115	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**100**	5	17.45	0.12	13.3	17.444	0.1201	12.979
116	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**100**	6	20.12	0.13	11.2	19.619	0.1004	11.662
117	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**100**	6.5	28.47	0.07	13.3	28.122	0.0334	13.535
118	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**100**	7.5	31.55	0.06	12	31.83	0.0235	12.575
119	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**100**	8.5	34.4	0.04	11	34.306	0.0142	11.899
120	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**100**	4.68	22.97	0	20.3	22.57	0.0028	20.209
121	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**100**	7	30.92	0	14.5	31.205	0.0014	14.051
122	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**100**	5.23	18.55	0.19	23.6	18.84	0.1838	24.084
123	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**100**	6	20.81	0.16	20.8	20.878	0.1509	20.989
124	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**100**	7	23.41	0.12	18.5	23.335	0.1179	17.62
125	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**100**	4.73	20.56	0.25	16.7	20.717	0.2673	17.145
126	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**100**	6	24.72	0.29	13.9	24.828	0.2716	13.587
127	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**100**	7	27.57	0.31	12.4	27.498	0.3171	12.273
128	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**100**	5	18.32	0	15.8	18.395	0.0147	15.715
129	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**100**	6	21.88	0	12.9	21.671	0.0122	13.08
130	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**100**	7	24.87	0	11.2	24.783	0.0091	11.672
131	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**100**	5.5	19.22	0.49	16.3	19.416	0.5375	16.946
132	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**100**	6.5	22.1	0.92	14.4	21.953	0.9004	14.31
133	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**100**	7.5	24.63	1.34	13.1	24.788	1.3467	12.196
134	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**100**	5.3	18.81	0.16	25.1	18.504	0.1334	25.137
135	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**100**	6.14	23.045	0.563	10.4	23.132	0.5889	12.236
136	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**100**	5.21	20.675	0.621	13.7	19.866	0.5592	13.88
137	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**100**	4.65	18.814	0.506	16.2	19.252	0.5251	15.32
138	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**100**	7.27	25.9	0	11.3	25.71	0.0055	11.567
139	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**100**	5.03	18.98	0.07	26.1	18.695	0.0366	26.007
140	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**100**	6	19.78	0.13	20.7	19.282	0.1207	20.843
141	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**100**	7.5	32	0	15.1	31.965	0.0106	14.526
142	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**100**	5.72	18.32	0.34	12.5	18.041	0.3212	13.257
143	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**100**	6	27.76	0	16.4	27.942	0.0017	16.357
144	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**100**	5	21.5	0.25	16	21.27	0.2647	16.057
145	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**101.2**	5	18.53	0.14	15.4	18.668	0.077	15.117

Table VI-11 Training data set for Q2 (continued)

146	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**101.2**	6	21.37	0.14	13.2	21.236	0.0573	13.52
147	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**101.2**	6.46	15.67	0.19	13.6	15.37	0.2021	13.524
148	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**101.2**	7	16.32	0.2	12.7	16.056	0.2049	12.953
149	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**101.2**	5.12	18.98	0.14	15.1	18.953	0.0753	14.898
150	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**119.1**	5.41	31.28	0	11.9	31.31	0.0004	10.732
151	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**119.1**	5.28	30.87	0	11	30.627	0.0004	11.304
152	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**119.1**	5.94	22.35	0.51	19	22.143	0.482	19.007
153	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**119.1**	6	22.42	0.51	18.8	22.321	0.4852	18.855
154	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**119.1**	7	25.22	0.52	16.6	25.329	0.5039	16.59
155	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**119.1**	8	27.74	0.48	14.9	27.723	0.4577	14.712
156	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**119.1**	5.5	21.33	0.07	21.1	21.362	0.0706	20.994
157	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**119.1**	6.5	24.29	0.04	18.1	24.149	0.0585	18.672
158	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**119.1**	7.5	26.96	0.05	16.2	26.836	0.0389	15.646
159	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**119.1**	7.28	23.47	0.15	12.5	23.242	0.0796	12.934
160	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**119.1**	7.5	23.75	0	17.2	23.859	0.0521	17.074
161	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**119.1**	8.5	26	0	15.4	25.717	0.0319	15.677
162	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**119.1**	7.25	21.52	0.02	12	21.476	0.0491	11.564
163	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**119.1**	7.5	21.96	0.02	11.6	22.119	0.0402	11.265
164	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**119.1**	8.5	27.7	0	14.7	27.365	0.0016	14.292
165	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**119.1**	7.5	25.34	0	16.4	25.371	0.0038	16.747
166	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**119.1**	7.28	21.38	0.02	12.2	21.169	0.0216	12.004
167	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**119.1**	8.5	23.94	0.03	10.6	23.669	0.0246	11.176
168	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**119.1**	7.25	23.04	0.19	12.1	23.017	0.176	12.001
169	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**119.1**	7.5	24.12	0.03	12.6	24.291	0.0314	12.264
170	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**119.1**	6	24.09	0.28	14.9	24.194	0.2616	15.305
171	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**119.1**	7	26.9	0.24	13.4	26.69	0.2461	13.358
172	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**119.1**	8	29.47	0.19	12.2	29.809	0.2021	12.165
173	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**119.1**	5.5	23.47	0	18.9	23.557	0.0018	18.569
174	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**119.1**	6	25.13	0	17.4	25.045	0.0014	17.678
175	4	43.24	228	408	2	1.9	21.33	21.33	12	15.5	21.33	0.1	0.122	0.101	90	**119.1**	4.92	20.95	0.05	21.3	20.654	0.0045	20.729
176	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**119.1**	6	23.64	0	19.4	23.542	0.0317	19.282
177	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**119.1**	6.5	25.13	0	18	24.712	0.0307	17.663
178	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**119.1**	4.89	19.69	0.08	20.8	19.643	0.1155	20.744
179	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**119.1**	5.5	21.73	0.05	18.4	21.701	0.1167	18.149
180	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**119.1**	6	22.69	0	17.4	22.529	0.0119	17.606
181	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**119.1**	7	25.52	0	15.4	25.587	0.0099	15.351
182	4.015	43.242	225	408	2.5	2.286	34.45	34.45	12	15.5	34.45	0.1	0.18	0.1	39	**119.1**	5.84	21.88	0.08	16.3	21.126	0.0522	16.282
183	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**119.1**	6.04	21.98	0.57	19.7	21.887	0.5299	19.372
184	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**119.1**	7	24.56	0.54	17.2	24.42	0.5154	17.307
185	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**119.1**	8	27.07	0.47	15.4	27.226	0.4251	15.583
186	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**119.1**	6.14	24.36	0.23	28.3	24.179	0.2022	28.757
187	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**119.1**	7.5	28.59	0.19	23.1	28.023	0.1808	23.427
188	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**119.1**	6.17	24.29	0.56	29.6	24.097	0.5468	29.367
189	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**119.1**	8	29.97	0.55	22.8	30.01	0.4967	22.381
190	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**119.1**	7.5	27	0.07	24.2	27.657	0.0307	23.536
191	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**119.1**	5.97	22.6	0.2	25.9	22.598	0.0493	25.976
192	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**119.1**	7.5	27	0.17	20.6	26.689	0.0414	20.237
193	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**119.1**	7.74	26.15	0	15.9	25.954	0.0032	16.11
194	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**119.1**	5.94	22.66	0	17.5	22.347	0.012	17.761
195	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**120**	5.09	19.91	0.08	22.6	19.919	0.0757	22.506

Table VI-11 Training data set for Q2 (continued)

196	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**120**	5.05	19.78	0.26	21.9	19.675	0.2306	21.853
197	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**120**	8.29	25.07	0	15.6	25.092	0.0319	15.869
198	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**120**	8	24.07	0	16.4	24.2	0.0386	16.364
199	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**120**	9	27.28	0	14.2	27.476	0.0223	14.533
200	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**120**	8	25.05	0	14.8	24.697	0.0375	13.114
201	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**120**	9	27.93	0	12.7	28.199	0.0227	11.697
202	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	5.62	25.54	0.01	28.9	25.247	0.0611	28.998
203	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	7	29.81	0.01	23.9	29.639	0.024	24.218
204	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	8	32.62	0	21.5	32.53	0.0112	21.611
205	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	7	31.97	0	15.2	32.178	0.001	15.383
206	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	8	35.11	0	13.7	35.209	0.0008	13.571
207	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	9	37.86	0	12.6	36.855	0.001	12.755
208	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**120**	6.5	27.19	0	16.3	27.176	0.01	16.134
209	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**120**	7.5	29.95	0	14.7	29.884	0.0104	14.912
210	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**120**	8.5	32.48	0	13.5	32.529	0.0095	13.991
211	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**120**	6	22.18	0.19	13.5	22.135	0.2068	12.864
212	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**120**	7	24.93	0.22	12.1	25.046	0.2304	12.171
213	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**120**	8	27.39	0.21	11	27.249	0.2497	11.425
214	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**120**	6.63	19.84	0.8	14.9	19.986	0.754	15.099
215	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**120**	7.5	21.79	0.86	13.6	21.47	0.7802	13.229
216	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**120**	8.5	23.85	0.9	12.5	23.981	0.808	12.855
217	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**120**	6	22.03	0	16.9	21.619	0.0326	17.108
218	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**120**	7	24.97	0	14.3	24.843	0.0241	14.596
219	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**120**	5.32	20.14	0.55	14.1	20.145	0.5606	13.883
220	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**120**	5.95	25.05	1.06	18.8	25.033	0.9346	18.692
221	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**120**	7	28.25	2.06	16.2	28.444	1.9538	16.564
222	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**120**	8	31	2.81	14.5	31.096	2.6777	14.17
223	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**120**	5.52	17.63	0.63	29.6	17.872	0.6596	29.511
224	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**120**	7.5	22.76	0.69	22.3	22.95	0.7284	22.104
225	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**120**	6.19	23.79	0.65	17.3	23.889	0.5546	17.588
226	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**120**	8	28.47	0.58	14.4	28.509	0.5266	14.098
227	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**120**	5.54	19.77	0.13	32.5	19.617	0.1146	32.174
228	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**120**	6.16	22.74	1.9	14.1	22.868	1.8965	14.075
229	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**120**	6	22.29	1.73	14.4	22.391	1.7701	14.27
230	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**120**	7	25	2.67	12.9	25.153	2.6936	13.02
231	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**120**	8	27.46	3.55	11.8	27.557	3.3901	11.581
232	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**120**	5.34	22.88	0.17	27.7	22.641	0.1259	28.281
233	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**120**	6.5	26.26	0.06	23.2	26.586	0.135	22.277
234	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**120**	5.24	22.5	0.12	24.9	22.472	0.1043	24.987
235	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**120**	6.5	26.19	0.09	20.7	26.096	0.0743	20.578
236	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**120**	7.5	28.97	0.03	18.6	28.969	0.0707	19.185
237	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**120**	7.5	22.39	0	20.6	22.408	0.039	20.661
238	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**120**	8.5	25.84	0	17.2	25.795	0.0251	16.905
239	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**120**	5.5	19.56	0	10.2	19.487	0.0152	10.14
240	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**120**	6.16	24.09	0	15.9	23.881	0.037	15.694
241	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**120**	7.5	27.65	0.05	13.9	27.657	0.0581	13.862
242	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**120**	8.5	30.03	0.09	12.8	30.208	0.0783	13.052
243	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**120**	5.5	22.47	0	17.8	22.527	0.0141	18.278
244	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**120**	6.5	25.35	0	15.8	25.18	0.0147	15.567
245	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**120**	7.5	27.95	0	14.2	27.741	0.0166	13.858

Table VI-11 Training data set for Q2 (continued)

246	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**120**	6.5	24.86	0.29	18.1	24.859	0.2826	17.876
247	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**120**	7.5	27.44	0.57	16.2	27.442	0.5092	16.131
248	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**120**	6	24.28	0.18	16.1	24.547	0.1822	16.054
249	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**120**	6.5	25.82	0.22	15	25.609	0.1751	15.023
250	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**120**	5.21	19.3	0.02	16.5	19.039	0.0244	16.668
251	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**120**	5	17.26	1.07	21.8	17.189	1.0035	21.956
252	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**120**	6	20.25	1.17	18.2	20.172	1.1069	17.454
253	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**120**	6	21.41	0.23	15.4	21.455	0.3148	16.114
254	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**120**	7	24.02	0.83	13.9	24.083	0.6482	14.112
255	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**120**	8	26.37	1.45	12.7	26.383	1.3449	12.562
256	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**120**	6.5	24.35	0.72	10.4	24.489	0.746	10.89
257	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**120**	7	25.97	0.61	15.9	25.761	0.5659	15.81
258	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**120**	5.5	23.3	0.12	23.8	23.216	0.0947	23.675
259	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**120**	6	22.78	0	9.4	22.646	0.0112	9.9374
260	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**124**	5	16.25	0.5	37.6	16.269	0.5199	37.944
261	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**124**	6	19.13	0.49	30.9	19.354	0.5025	30.497
262	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**124**	5.5	17.73	0.51	33.7	17.768	0.5198	33.695
263	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**130**	5.97	24.77	0	19.8	24.636	0.0114	20.079
264	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**130**	6.79	23.98	0	19.5	23.71	0.0016	19.437
265	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**130**	9.5	28.87	0	12.5	28.952	0.0125	11.682
266	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**130**	6.5	23.29	0	20.2	23.42	0.0017	20.349
267	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**135**	5.8	27.15	0	28.4	27.206	0.0025	28.432
268	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**135**	6.5	29.47	0	25.6	29.515	0.0016	25.6
269	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**135**	7.5	32.46	0	22.6	31.96	0.0008	22.681
270	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**135**	5.47	23.82	0.11	22.8	23.766	0.1156	22.79
271	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**135**	5	22.12	0.04	24.8	21.863	0.0891	24.693
272	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**135**	7	28.66	0.27	18.3	28.627	0.2604	18.478
273	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**135**	5.76	19.4	0.32	37.1	18.855	0.317	37.642
274	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**135**	7	22.46	0.33	30.5	22.049	0.2946	29.527
275	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**135**	7	16.48	0.69	44.7	16.646	0.694	44.804
276	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**135**	5.69	18.66	0.07	36.1	18.589	0.0903	36.499
277	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**135**	6	19.46	0.07	34	19.317	0.0892	33.522
278	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**135**	5	15.92	0.16	30.4	15.615	0.167	30.102
279	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**135**	6	17.51	0.16	25.3	17.602	0.1592	25.861
280	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**135**	7	18.96	0.16	22	18.788	0.158	21.625
281	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**135**	5	12.23	0.25	29.2	12.486	0.2892	29.525
282	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**135**	6	15.95	0.28	51.6	15.175	0.2315	50.199
283	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**135**	6.3	23.77	0.28	24.5	23.761	0.2454	24.874
284	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**135**	5.5	21.36	0.21	27.7	21.245	0.215	27.257
285	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**135**	5	22.6	0	28.7	22.55	0.0062	28.77
286	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**135**	6	25.9	0	23.9	25.753	0.0058	24.118
287	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**135**	5	22.78	0	33	22.862	0.0113	33.076
288	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**135**	6	25.94	0	27.7	25.66	0.0092	27.651
289	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**135**	7	28.86	0	24.2	28.818	0.0075	23.917
290	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**135**	5	22.2	0	28.8	21.934	0.0294	29.123
291	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**135**	6	25.28	0	24.3	25.089	0.0291	24.087
292	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**135**	7	28.12	0	21.2	28.127	0.0315	20.84
293	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**135**	7	31.04	0	25.2	31.161	0.0057	25.001
294	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**135**	7.01	31.2	0	26	31.322	0.005	25.56
295	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**135**	5	24.08	0	35.9	23.597	0.0135	36.176

Table VI-11 Training data set for Q2 (continued)

296	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**135**	6	27.79	0	30	27.306	0.0092	30.029
297	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**135**	5	17.29	0.31	43.6	17.45	0.3053	43.618
298	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**135**	6.96	14.95	0.18	21.2	15.565	0.1744	21.825
299	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**139.4**	7.5	22.2	0.07	17.5	22.297	0.0675	17.082
300	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**139.4**	8.5	24.39	0.08	15.5	24.338	0.0831	16.149
301	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**139.4**	9.5	26.39	0.09	14	26.48	0.1004	13.463
302	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**139.4**	7.81	23	0.07	16.9	22.916	0.0719	16.89
303	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**140**	5	18.32	0.28	24.5	18.427	0.2996	24.444
304	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**140**	7	24.11	0.4	17.9	24.175	0.4327	18.188
305	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**140**	5.8	20.65	0.1	40.2	20.736	0.1218	40.179
306	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**140**	7.5	25.57	0.13	16.2	25.613	0.1384	16.956
307	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**140**	8.5	27.89	0.16	14.8	28.058	0.1825	13.825
308	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**150**	5	20.01	0.17	42.8	19.877	0.13	43.406
309	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**150**	7	25.72	0.16	29.3	26.146	0.1341	28.16
310	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**150**	5	20.97	0.08	31.5	21.045	0.0226	31.127
311	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**150**	6	24.35	0.08	25.8	24.181	0.0253	26.475
312	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**150**	5.37	22.1	0.05	30.5	22.006	0.0951	30.428
313	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**150**	5.47	23.23	0.02	30	23.048	0.0175	29.802
314	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**150**	8.19	29.29	0	20	29.182	0.0048	20.626
315	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**150**	6	22.93	0	28.9	22.779	0.015	28.43
316	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**150**	8.17	29.07	0	19.6	28.874	0.0049	19.951
317	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**150**	6	22.72	0	28.5	22.717	0.0127	28.066
318	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**150**	7	25.86	0	23.3	25.715	0.0088	23.031
319	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**150**	5	16.53	0.59	40.4	16.238	0.6078	39.641
320	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**150**	6	19.13	0.62	32.1	19.734	0.6302	32.898
321	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**150**	5	15.47	1.32	43.7	15.602	1.3293	43.242
322	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**150**	6	18.15	1.27	35.2	17.751	1.2927	36.091
323	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**150**	7	20.53	1.22	30	20.782	1.2354	29.542
324	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	5	18.63	0.2	41.1	18.629	0.1484	41.084
325	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	7	23.74	0.22	28.5	23.631	0.1828	28.19
326	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	5	16.84	0.24	38.9	16.456	0.264	39.054
327	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	6	19.43	0.24	31	19.239	0.2371	30.787
328	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	7	21.75	0.25	26.3	21.9	0.25	26.477
329	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**150**	5	19.49	0.04	53.7	19.417	0.0796	53.575
330	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**150**	7	24.77	0.04	36.8	24.528	0.0397	37.182
331	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**150**	6	20.3	0.15	39	20.176	0.1683	39.094
332	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**150**	7	22.7	0.16	33.2	22.543	0.1217	33.025
333	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**150**	5	17.79	0.23	31.1	17.738	0.2139	31.153
334	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**150**	7	22.82	0.25	22.4	22.708	0.2431	22.201
335	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**150**	7	16.78	0.69	51	16.635	0.6918	50.355
336	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**150**	8	18.3	0.68	44.4	18.199	0.6835	44.9
337	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**150**	9	19.68	0.68	39.6	19.695	0.6718	39.18
338	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**150**	7.25	31.97	0	28	32.009	0.0041	28.44
339	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**150**	7.5	32.67	0	27.1	32.731	0.0039	26.704
340	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**150**	7.5	32.46	0	30.7	32.369	0.0102	30.863
341	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**150**	8.33	30.13	0	22.7	29.998	0.0011	21.848
342	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**150**	5	19.53	0	44.5	19.441	0.0042	44.351
343	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**150**	7	26.44	0	27.5	26.297	0.0024	27.964
344	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**150**	6.5	29.31	0	32.5	29.331	0.0305	32.318
345	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**150**	7.5	32.39	0	28.3	32.796	0.0154	28.186

Table VI-11 Training data set for Q2 (continued)

346	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**150**	8.5	35.31	0	25.3	35.214	0.0075	26.107
347	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**150**	5	16.95	0.32	26.1	16.878	0.3173	25.667
348	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**150**	6	19.37	0.34	21.6	19.114	0.3512	21.768
349	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**150**	7	21.52	0.36	18.8	21.504	0.3531	19.202
350	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	5	16.92	0.42	26.6	16.828	0.4143	27.166
351	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	6	19.31	0.44	22.1	19.04	0.4444	21.957
352	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	7	21.49	0.46	19.3	21.309	0.4348	18.657
353	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	7	21.74	0.03	27.2	22.062	0.0679	23.642
354	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	8	25	0.08	20.9	24.736	0.0504	21.006
355	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	7	20.9	0.33	29.3	20.813	0.3695	28.989
356	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	8	23.51	0.34	24.1	23.256	0.3148	25.106
357	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**150**	7	25.41	0.05	21.8	25.524	0.0235	22.735
358	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**150**	6	22.42	0.01	26.5	22.251	0.0317	27.412
359	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**150**	5	18.87	0	35.4	18.678	0.0381	35.145
360	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**150**	5	22.59	0.05	35.2	22.573	0.0428	35.424
361	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**150**	6	25.75	0.04	29.2	25.363	0.0428	28.85
362	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**150**	6	27.46	0	33.1	27.162	0.0135	33.152
363	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**150**	7	30.89	0	28.5	30.641	0.0118	27.597
364	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**150**	6	15.09	0.4	55.3	15.235	0.3867	53.185
365	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**150**	7	16.81	0.41	46.1	16.691	0.425	47.403
366	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**150**	5.5	27.87	0	26.9	27.446	0.009	27.064
367	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**150**	6.5	31.2	0	23.1	31.361	0.0084	22.652
368	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**150**	7.5	34.31	0	20.4	34.021	0.0068	20.557
369	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**150**	5.5	27.1	0	35	26.916	0.0045	35.214
370	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**150**	6.5	30.55	0	27.9	30.66	0.0027	27.412
371	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**150**	5.94	26.98	0	37.1	26.979	0.0247	37.127
372	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**150**	5.5	25.52	0	40.2	25.3	0.0274	40.024
373	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**150**	8.11	28.38	0.01	18.6	28.508	0.0118	19.407
374	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**150**	6.5	23.98	0	24	23.859	0.0227	24.233
375	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**150**	8.21	30.22	0	20.6	30.052	0.0022	20.674
376	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**150**	5.5	21.74	0	34.2	21.761	0.0035	34.659
377	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**150**	6.5	25.23	0	26.9	25.199	0.0021	26.642
378	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**150**	7.5	28.25	0	22.7	28.15	0.0018	22.285
379	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**150**	6	23.33	0	32.3	23.093	0.0059	32.413
380	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**150**	7	26.12	0	28.2	26.14	0.0058	27.549
381	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**150**	8	28.65	0	25.3	28.263	0.0058	25.81
382	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**150**	7	23.78	0.67	24.7	23.762	0.6629	24.317
383	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**150**	8	26.19	0.68	22	26.329	0.698	22.703
384	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**150**	9	28.4	0.68	20.1	28.477	0.6538	20.147
385	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**150**	6	21.06	0.2	42.2	21.055	0.249	42.395
386	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**150**	7	23.71	0.46	32.3	23.842	0.4398	32.163
387	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**150**	6	24.06	0.05	27.9	24.321	0.0298	28.436
388	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**150**	7	26.9	0.05	23.9	26.417	0.035	23.238
389	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**150**	5	19.74	0.14	42	19.899	0.1632	41.932
390	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**150**	7	25.72	0.16	28.2	25.731	0.1628	28.199
391	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**150**	5	17.93	0.18	25.1	17.777	0.1544	24.865
392	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**150**	6	20.64	0.2	20.3	20.44	0.1423	21.008
393	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**150**	6.5	28.8	0.01	26.6	28.5	0.042	26.8
394	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**150**	7.5	31.92	0	23.3	32.217	0.034	23.918
395	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**150**	8.5	34.75	0	20.9	34.762	0.0227	21.2

Table VI-11 Training data set for Q2 (continued)

396	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**150**	5	24.66	0	43.6	24.477	0.0015	43.105
397	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**150**	6	28.27	0	35	28.329	0.0007	35.83
398	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**150**	5	18.34	0.17	50	18.197	0.1735	48.857
399	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**150**	6	21.25	0.16	40.2	21.014	0.1407	41.498
400	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**150**	7	23.85	0.16	34.2	23.697	0.1069	33.805
401	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**150**	5	21.64	0.44	31.8	21.42	0.4626	31.668
402	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**150**	6	24.88	0.44	26.5	24.441	0.444	27.09
403	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**150**	7	27.65	0.5	23.1	28.025	0.5013	22.319
404	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**150**	8.13	28.36	0.01	18.8	28.457	0.006	18.989
405	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**150**	7	25.37	0	22.1	25.191	0.0085	22.085
406	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**150**	5.5	19.51	0.31	32.5	19.546	0.2917	32.94
407	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**150**	6.5	22.36	0.37	27.8	22.316	0.3793	27
408	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**150**	7.5	24.9	0.41	24.7	24.884	0.436	24.672
409	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**150**	6.78	25.231	0.187	17.8	25.001	0.2418	18.373
410	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**150**	5.78	22.808	0.243	24.5	22.476	0.2652	24.898
411	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**150**	5.5	21.943	0.359	28	21.865	0.2684	27.22
412	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**150**	5.91	22.81	0.17	35.1	22.609	0.1379	35.032
413	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**150**	7	26.05	0	23.7	25.916	0.009	23.666
414	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**150**	6.33	20.01	0.53	20.4	19.975	0.5184	20.162
415	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**150**	5	23.85	0	40.1	23.971	0.0136	39.995
416	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**150**	5.5	20.7	0	30.4	20.645	0.0287	30.621
417	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**150**	6	22.9	0.15	33.4	22.692	0.173	33.405
418	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**150**	7	31.43	0	29.5	31.265	0.0004	29.053
419	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**151.7**	5	19.25	0.07	29.9	19.04	0.0915	30.454
420	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**151.7**	6	17.63	0.25	25.8	16.88	0.2665	25.765
421	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**151.7**	7	18.37	0.26	22.1	18.027	0.2652	22.008
422	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**151.7**	5	16.86	0	15.9	17.266	0.0047	15.895
423	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**151.7**	6	24.47	0	12.1	23.496	0.0032	12.247
424	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**151.7**	7	28.69	0	10.4	29.214	0.002	10.679
425	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**151.7**	6	22.09	0.07	24.5	21.861	0.0723	23.952
426	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**155**	5	16.42	0.63	59	16.528	0.6437	56.082
427	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**155**	5.5	17.91	0.67	51.9	17.836	0.6959	52.679
428	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**155**	6	19.33	0.7	46.8	19.431	0.7174	47.418

Table VI-12 Testing data set for Q2

No	*Hammer*		*Hammer cushion Material*				*Pile Information*					*Soil Information*					Stroke	**out1**	**out2**	**out3**	***BPNN***		
	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***		**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**90**	4.98	23.8	0	15.4	24.025	0.0069	14.903
2	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**90**	6.5	29	0	12.7	29.209	0.0046	12.498
3	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**90**	5	16.85	0.34	21.8	17.181	0.3283	21.667
4	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**90**	7.01	16.45	0.59	25.8	16.328	0.6334	27.356
5	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**90**	6.5	16.02	0.15	13.5	15.926	0.1503	13.594
6	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**90**	6.55	14.02	0.16	12.9	14.375	0.1849	12.761
7	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**90**	5.5	20.97	0.49	14.1	21.033	0.5152	14.315
8	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**90**	6	24.99	0	12.4	25.084	0.0092	12.753
9	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**90**	7	28.01	0	13	28.559	0.0078	13.944
10	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**90**	6.05	27.61	0.01	14.3	27.707	0.0142	14.344
11	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**90**	7	30.74	0	12.9	31.244	0.0086	13.151
12	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**90**	4.7	20.58	0.64	12.7	20.297	0.9043	12.352
13	1.76	20.099	314	175	2	2.79	60	60	12	15.5	60.00	0.1	0.18	0.18	92	**90**	7.03	16.19	0.63	27.8	16.573	0.8741	28.257
14	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**93**	5.5	17.49	0.28	21.6	17.573	0.2899	21.821
15	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	6	22.74	0	18.4	22.636	0.0433	18.346
16	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**100**	6	23.84	0.02	13.4	23.152	0.0327	13.703
17	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**100**	7.29	26.13	0	11.4	26.184	0.0048	11.69
18	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**100**	5	16.16	0.46	20.3	16.268	0.4621	19.651
19	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**100**	7	20.01	0.81	17	22.141	0.7987	15.029
20	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	5	18.25	0.12	20.9	17.973	0.1014	20.979
21	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	7	21.31	0.19	14.7	23.276	0.1789	14.707
22	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**100**	5	17.06	0.12	24.4	17.031	0.1333	23.341
23	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**100**	5.2	17.91	0.34	15.7	17.728	0.3679	15.497
24	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**100**	7	16.43	0.57	27.7	16.552	0.5694	28.125
25	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**100**	6.35	28.43	0	17	28.871	0.014	17.831
26	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**100**	7	25.61	0	13.6	25.517	0.003	13.367
27	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**100**	6.5	28.95	0	15.6	28.851	0.031	15.819
28	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**100**	5.72	18.42	0.21	12.5	18.213	0.2162	12.403
29	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	5.75	18.48	0.23	12.7	18.494	0.2513	12.15
30	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	7.83	23.22	0	10.6	23.053	0.0281	11.09
31	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**100**	7	20.01	0.16	15.2	20.275	0.1327	14.681
32	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**100**	7	24.97	0	11	24.887	0.0159	11.547
33	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**100**	5	22.14	0.07	17.5	22.101	0.0373	17.39
34	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**100**	6	27.21	0.04	15.9	26.837	0.0152	15.192
35	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**100**	5.5	27.52	0	13	27.604	0.0157	13.271
36	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**100**	7.5	26.27	0	10.4	26.198	0.01	11.081
37	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**100**	7.32	26.72	0	11.7	26.816	0.0012	11.65
38	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**100**	6	22.85	0	17	22.57	0.0074	17.554
39	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**100**	5	20.15	0.04	17.2	20.063	0.043	17.387
40	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**100**	7	25.33	0.1	15.6	26.4	0.0856	15.853
41	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**100**	6.01	26.8	0.07	14.1	25.55	0.0378	14.192
42	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**100**	5	24.21	0	19.1	23.995	0.0025	19.173
43	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**100**	5	17.85	0.2	24.6	18.053	0.1946	25.087
44	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**100**	7.2	25.43	0	10.9	25.298	0.0084	11.471
45	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**100**	5.9	20.42	0.69	15.5	20.382	0.669	15.841

Table VI-12 Testing data set for Q2 (continued)

46	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**100**	5.5	21.403	0.618	13.9	20.758	0.5729	13.269
47	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**100**	5.19	15.52	0.87	21.8	15.339	0.8986	22.006
48	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**100**	5.06	16.53	0.16	19.5	16.535	0.1414	19.311
49	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**100**	6.17	27.72	0.04	15.6	27.482	0.0148	14.832
50	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**100**	6	23.37	0.02	14.7	22.799	0.0517	15.076
51	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**119.1**	6.5	36	0	10.4	34.253	0.0005	10.033
52	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**119.1**	6	34.27	0	10	33.115	0.0004	10.58
53	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**119.1**	5.41	21.15	0.09	21.4	21.081	0.071	21.16
54	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**119.1**	7.71	24.38	0	16.7	24.337	0.0476	16.786
55	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**119.1**	9.5	28.06	0	14.1	27.112	0.0165	14.165
56	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**119.1**	8.5	24.15	0.03	10.4	24.767	0.0211	10.306
57	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**119.1**	7.5	21.78	0.03	11.9	21.623	0.0222	11.832
58	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**119.1**	7.35	23.86	0.03	12.8	23.941	0.0347	12.465
59	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**119.1**	4.92	21.52	0	21.3	22.181	0.0025	19.697
60	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**119.1**	5.02	20.55	0	23.3	20.409	0.0341	22.94
61	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**119.1**	5.5	22.06	0	21.1	22.095	0.0328	21.089
62	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**119.1**	6	23.3	0.03	16.9	23.666	0.1167	16.6
63	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**119.1**	5	19.48	0	20.6	19.553	0.0144	20.473
64	4.015	43.242	225	408	2.5	2.286	45.93	45.93	12	15.5	45.93	0.1	0.152	0.1	90	**119.1**	5.94	22.18	0	17.2	21.87	0.0493	16.493
65	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**119.1**	6	21.79	0.55	19.7	21.778	0.5284	19.466
66	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**119.1**	6.17	23.17	0.1	29.5	23.74	0.0383	28.398
67	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**119.1**	6.07	24.44	0.27	14.8	24.38	0.2617	15.147
68	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**120**	5.09	21.23	0	21.1	20.61	0.0057	21.008
69	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**120**	8.2	25.65	0	14.3	25.384	0.0335	12.792
70	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	6	26.77	0.01	27.2	26.517	0.0488	27.588
71	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**120**	6.63	30.89	0	15.9	30.764	0.0011	16.45
72	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**120**	6.4	26.89	0	16.5	26.905	0.0099	16.297
73	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**120**	6.01	22.21	0.19	13.5	22.17	0.2071	12.857
74	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**120**	6.5	19.54	0.79	15.1	19.811	0.7486	15.625
75	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**120**	7.54	26.42	0	13.3	26.054	0.0197	13.599
76	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**120**	6	22.64	0.46	11.7	22.576	0.6428	11.664
77	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**120**	6	25.22	1.1	18.7	25.212	0.9793	18.572
78	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**120**	6.5	20.28	0.69	25.2	20.451	0.6931	24.94
79	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**120**	6	23.24	0.66	17.7	23.491	0.5426	18.054
80	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**120**	5.5	23.37	0.16	27	23.178	0.1276	27.343
81	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**120**	8	24.19	0	18.7	24.085	0.0316	18.528
82	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**120**	6.5	25.03	0	15.3	24.896	0.0417	15.114
83	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**120**	5.5	21.97	0.23	20.8	21.341	0.1622	19.564
84	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**120**	5.33	22.09	0.14	17.9	21.095	0.1842	17.807
85	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**120**	7	22.95	1	15.9	22.449	1.2919	14.759
86	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**120**	5.13	21.75	0	22	20.899	0.018	20.859
87	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**120**	4.5	20.02	0.23	33.2	19.911	0.1166	34.011
88	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**124**	5.6	18.02	0.5	33.1	18.088	0.5177	32.979
89	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**130**	6.5	26.32	0	18.5	26.496	0.0109	18.099
90	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**130**	8.48	26.11	0	14.4	25.928	0.0189	12.994
91	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**135**	5.5	26.14	0	29.9	26.109	0.0029	29.946
92	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**135**	7.49	17.52	0.67	44.4	17.322	0.7217	44.646
93	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**135**	8	18.02	0.72	39.2	17.99	0.7353	43.036
94	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**135**	6.92	18.84	0.16	22.2	18.731	0.1576	21.818
95	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**135**	6.5	24.33	0.29	23.9	24.325	0.2506	24.427

Table VI-12 Testing data set for Q2 (continued)

96	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**135**	4.91	22.31	0	29.2	22.283	0.0063	29.253
97	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**135**	5.51	24.46	0	30	24.258	0.0101	30.058
98	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**135**	5.39	23.48	0	26.8	23.138	0.029	26.966
99	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**135**	6.99	31.07	0	25.2	31.128	0.0057	25.046
100	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**135**	7	31.17	0	26	31.284	0.0051	25.595
101	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**140**	6	21.43	0.35	20.5	20.848	0.3203	21.951
102	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**140**	6.39	22.82	0.07	18.2	23.566	0.1292	21.659
103	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**150**	6	23.06	0.17	34.4	22.886	0.1383	34.279
104	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**150**	5.83	23.82	0.08	26.5	23.663	0.0247	27.081
105	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**150**	5.56	18.03	0.62	35.1	18.502	0.6108	35.368
106	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**150**	5.66	17.26	1.29	37.5	16.963	1.308	38.51
107	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	5.48	19.97	0.21	36.7	19.569	0.1544	37.421
108	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	5.58	18.37	0.24	33.7	18.145	0.2436	33.835
109	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**150**	5.66	21.36	0.04	46	20.987	0.0653	48.825
110	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**150**	5.74	19.62	0.14	41.2	19.585	0.1842	41.113
111	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**150**	5.65	19.53	0.22	27.4	19.097	0.2397	29.619
112	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**150**	7.61	17.72	0.69	46.7	17.644	0.6858	47.158
113	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**150**	7.36	32.01	0	31.2	32.036	0.0108	31.644
114	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**150**	6	23.27	0	33.4	23.014	0.0034	35.498
115	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**150**	7.2	31.62	0	29.4	31.854	0.0192	29.182
116	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**150**	6.33	20.11	0.35	20.5	19.868	0.3567	20.77
117	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	6.34	20.07	0.45	21	19.802	0.4472	20.587
118	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	8.84	27.43	0.11	18	26.754	0.0357	19.228
119	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**150**	7.48	22.2	0.34	26.4	22.084	0.3481	26.827
120	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**150**	8.1	28.32	0.08	18.5	28.724	0.0146	19.762
121	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**150**	5.55	24.41	0.05	31.5	24.087	0.0422	31.974
122	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**150**	7.12	31.26	0	28.1	31.039	0.0115	27.061
123	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**150**	7.61	17.75	0.42	42.2	17.697	0.4428	42.588
124	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**150**	6.01	29.63	0	24.8	29.585	0.0088	24.373
125	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**150**	5.49	27.12	0	35.2	26.875	0.0045	35.299
126	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**150**	7.5	26.8	0	20.2	26.866	0.0157	20.816
127	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**150**	6.53	24.84	0	29.9	24.83	0.0059	29.416
128	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**150**	7.13	24.11	0.68	24.3	24.132	0.6736	24.078
129	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**150**	5.89	20.75	0.16	43.5	20.788	0.2338	43.188
130	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**150**	5.82	23.51	0.05	28.8	24.004	0.0285	29.448
131	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**150**	6.93	30.18	0.01	25	30.226	0.0393	25.634
132	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**150**	5.36	25.99	0	39.8	26.007	0.0011	40.681
133	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**150**	5.82	20.78	0.17	41.5	20.497	0.1466	42.966
134	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**150**	5.38	22.97	0.45	29.5	22.765	0.4468	30.396
135	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**150**	6	22.34	0	27	21.703	0.0102	27.138
136	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**150**	6.47	22.26	0.37	27.9	22.235	0.377	27.113
137	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**150**	5.27	21.138	0.367	29.3	21.315	0.2703	29.219
138	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**150**	6	21.36	0.22	33.3	20.69	0.1635	33.585
139	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**150**	5	20.79	0.05	34.2	22.493	0.0227	34.343
140	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**150**	5	18.76	0	36.1	18.277	0.0109	34.793
141	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**151.7**	5.68	21.37	0.07	25.8	21.035	0.0798	25.477
142	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**151.7**	6.92	18.42	0.26	22.3	17.933	0.2652	22.441
143	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**151.7**	6.43	28.95	0	10.7	26.193	0.0027	11.372
144	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**155**	5.93	19.12	0.7	47.5	19.197	0.7165	48.238

V.3.3 Q3 type (160 - 250 kips)

Table VI-13 Training data set for Q3

	Hammer		*Hammer cushion Material*				*Pile Information*					*Soil Information*						**out1**	**out2**	**out3**	***BPNN***		
No	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***	Stroke	**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	1.76	20.099	314	175	2	2.79	60	60	12	15.5	60.00	0.1	0.18	0.18	92	**180**	7.79	17.69	0.68	66.3	17.855	0.684	64.925
2	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**180**	7	16.65	0.73	78.1	16.322	0.7188	81.802
3	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**180**	8	18.17	0.72	64.5	18.012	0.7084	66.809
4	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**180**	9	19.54	0.71	55.3	19.824	0.7312	57.915
5	1.76	20.099	314	175	2	1.69	40	40	12	15.5	40.00	0.1	0.18	0.12	45	**180**	8	20.54	1.024	65.9	20.706	1.017	65.287
6	1.76	20.099	314	175	2	2.79	40	40	14	21.4	34.29	0.1	0.18	0.12	45	**180**	8	16.212	0.906	62.3	16.329	0.9206	62.78
7	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**200**	7	17.07	0.84	86	17.593	0.886	80.858
8	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**200**	8	18.58	0.86	70.4	18.584	0.8867	71.388
9	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**200**	9	19.98	0.88	60.5	19.647	0.8797	62.063
10	1.76	17.6	314	175	2	1.69	30	30	12	15.5	30.00	0.1	0.2	0.1	90	**200**	8	21.507	0.605	88.7	21.682	0.5338	84.379
11	1.76	17.6	314	175	2	2.79	30	30	14	21.4	25.71	0.1	0.2	0.1	90	**200**	8	16.897	0.604	81.6	16.731	0.603	82.788
12	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**200**	8.02	20.27	0.66	61.5	20.48	0.621	61.136
13	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**200**	6	18.64	0.63	94.4	18.478	0.6711	95.715
14	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**200**	7	19.58	0.64	73.8	19.421	0.6392	74.069
15	1.76	20.099	314	175	2	1.66	20	20	12	15.5	20.00	0.1	0.23	0.1	50	**200**	7	19.904	0.267	107.9	19.691	0.282	106.11
16	1.76	20.099	314	175	2	2.79	20	20	14	21.4	17.14	0.1	0.23	0.1	50	**200**	7	15.426	0.399	97.3	15.562	0.407	96.041
17	1.76	20.099	314	175	2	2.79	60	60	12	15.5	60.00	0.1	0.18	0.18	92	**225**	8.16	18.36	1.21	114.2	18.181	1.2164	116.75
18	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**225**	7	16.78	1.15	171.2	16.947	1.1266	170.67
19	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**225**	8	18.31	1.2	121.4	18.146	1.1813	118.43
20	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**225**	9	19.67	1.23	96.4	19.581	1.2508	88.934
21	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**250**	7	19.07	1.42	169.6	19.172	1.4156	166.72
22	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**250**	8	20.26	1.42	121.9	20.247	1.4064	123.89
23	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**250**	9	21.18	1.4	97.6	21.318	1.3942	97.633
24	1.76	17.6	314	175	2	1.69	30	30	12	15.5	30.00	0.1	0.2	0.1	90	**250**	8	21.828	0.786	153.6	21.708	0.8053	156.87
25	1.76	17.6	314	175	2	1.69	30	30	14	21.4	25.71	0.1	0.2	0.1	90	**250**	8	19.374	0.628	134.1	19.364	0.6398	133.12
26	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**250**	8.51	24.58	1.05	86.6	24.801	1.052	84.931
27	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**250**	6	21.24	1.09	180.7	21.179	1.0735	180.94
28	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**250**	7	22.82	1.07	123.6	22.815	1.0561	125.3
29	1.76	20.099	314	175	2	2.37	40	40	12	15.5	40.00	0.1	0.23	0.1	55	**250**	7	17.461	1.735	291.9	17.423	1.7371	281.99
30	1.76	20.099	314	175	2	2.37	40	40	14	21.4	34.29	0.1	0.23	0.1	55	**250**	7	15.74	1.481	194.9	15.775	1.4902	192.88
31	2.75	22.605	225	280	1	1.66	20	20	12	15.5	20.00	0.1	0.2	0.1	10	**180**	4.5	18.46	0.12	73.1	18.486	0.1352	74.466
32	2.75	22.605	225	280	1	1.66	20	20	12	15.5	20.00	0.1	0.2	0.1	10	**180**	5.5	21.57	0.13	54.7	21.114	0.1207	53.073
33	2.75	22.605	225	280	1	1.66	20	20	12	15.5	20.00	0.1	0.2	0.1	10	**180**	6.5	24.31	0.13	45	24.674	0.1184	41.767
34	2.75	22.605	225	280	2	2.37	30	25	12	15.5	25.00	0.1	0.2	0.1	30	**180**	5	17.224	0.896	52.9	17.335	0.9048	51.613
35	2.75	22.605	225	280	2	2.37	30	25	14	21.4	21.43	0.1	0.2	0.1	30	**180**	5	15.679	0.537	55.7	15.714	0.5501	55.724
36	2.75	22.605	314	175	2	3.2	50	50	12	15.5	50.00	0.1	0.18	0.1	75	**180**	5.5	16.71	0.42	50.5	16.656	0.4698	49.708
37	2.75	22.605	314	175	2	3.2	50	50	12	15.5	50.00	0.1	0.18	0.1	75	**180**	6.5	18.49	0.36	41.3	18.546	0.3845	43.072
38	2.75	22.605	314	175	2	2.126	50	50	12	15.5	50.00	0.1	0.18	0.1	75	**180**	6	20.098	0.391	50.6	19.845	0.3319	52.125
39	2.75	22.605	314	175	2	2.126	50	50	14	21.4	42.86	0.1	0.18	0.1	55	**180**	6	18.443	0.877	48.7	18.311	0.8885	48.621
40	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	5	18.91	0.26	69.3	19.506	0.2267	68.576
41	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	6	21.61	0.27	52.6	21.241	0.2586	53.995
42	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	7	24.02	0.28	43.9	23.655	0.2601	45.953
43	2.75	22.605	225	175	3	2.126	20	20	12	15.5	20.00	0.1	0.22	0.1	45	**200**	7	22.493	0.176	49.2	22.572	0.2006	47.184
44	2.75	22.605	225	175	3	1.66	30	20	14	21.4	17.14	0.1	0.22	0.1	45	**200**	7	21.723	0.634	53.3	21.692	0.645	52.483
45	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	5	19.26	0.33	65.2	18.88	0.3597	63.451

Table VI-13 Training data set for Q3 (continued)

46	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	6	20.52	0.36	48.9	20.644	0.3486	50.482
47	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	7	22.05	0.37	40.5	22.092	0.356	42.998
48	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	45	**200**	6	21.206	0.22	57.4	21.706	0.1752	53.893
49	2.75	22.605	272	408	4	1.66	40	40	14	21.4	34.29	0.1	0.22	0.1	45	**200**	6	20.331	0.616	67.8	19.879	0.6237	68.259
50	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**200**	5	20.81	0.01	89.8	20.681	0.0233	91.177
51	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**200**	7	25.25	0.01	56.6	25.363	0.0242	54.892
52	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	6	24.04	0.37	79.3	23.67	0.3897	80.578
53	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	7	25.45	0.36	62.6	25.981	0.4048	62.565
54	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	5	22.63	0.6	107.4	22.509	0.5645	106.33
55	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	6	24.57	0.59	73	24.649	0.5623	71.051
56	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	7	26.19	0.59	57.2	26.042	0.6198	57.996
57	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	45	**250**	7	26.458	0.484	69.4	26.099	0.496	64.095
58	2.75	22.605	272	408	3.5	2.37	20	20	14	21.4	17.14	0.1	0.22	0.1	45	**250**	7	20.65	0.389	70	20.697	0.3714	68.323
59	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**202**	7.28	23.92	0.32	32.1	23.868	0.3426	29.872
60	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**202**	6	22.32	0.31	40	22.345	0.2954	41.521
61	2.8	23.8	315.7	175	2	2.37	30	30	12	15.5	30.00	0.1	0.204	0.101	50	**200**	6	21.237	0.399	46.6	20.242	0.3281	49.392
62	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**180**	6.09	22.79	0.09	52.4	22.741	0.0695	51.234
63	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**180**	6	22.58	0.08	53.4	22.444	0.0702	52.944
64	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**225**	6.31	27.24	0.11	70.1	27.284	0.1128	70.988
65	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**225**	6	26.4	0.11	75.6	26.629	0.1237	78.604
66	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**240**	7	30.277	0.121	69.3	30.09	0.0939	64.257
67	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**160**	5.94	21.2	0.13	47.8	21.461	0.1167	49.036
68	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**180**	5	18.01	0.14	73.6	17.952	0.1558	71.156
69	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**180**	7	22.75	0.17	45.3	22.666	0.1871	46.633
70	2.87	25.428	272	243	4	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	35	**180**	7	21.587	0.637	39.6	21.352	0.6454	40.251
71	2.87	25.428	272	243	4	2.106	40	35	14	21.4	30.00	0.1	0.22	0.1	35	**180**	7	19.813	1.065	41.8	19.902	1.0613	39.98
72	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**180**	6.03	19.33	0.4	53	19.138	0.4046	52.11
73	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**180**	6.5	20.58	0.43	48.5	20.472	0.4003	47.75
74	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**180**	7.5	23.01	0.47	41.7	23.115	0.4698	41.421
75	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**180**	6.06	22.13	0.09	55.8	22.166	0.0817	56.966
76	2.87	25.428	272.3	486	4	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	45	**180**	7	22.921	0.313	44.1	22.527	0.3547	43.833
77	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**200**	5	16.79	0.42	68.8	17.252	0.5182	65.62
78	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**200**	6	19.37	0.51	51.2	19.162	0.4919	48.22
79	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**200**	7	21.68	0.6	41.9	21.375	0.5209	39.788
80	2.87	25.428	272	380	3.5	2.37	45	45	14	21.4	38.57	0.1	0.15	0.1	90	**200**	6	17.666	1.328	56.5	17.754	1.3253	59.024
81	2.87	25.428	272	380	3.5	1.69	45	40	14	21.4	34.29	0.1	0.15	0.1	90	**200**	7	22.723	0.925	51.3	22.717	0.9228	50.911
82	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**200**	5	15.82	1.76	72.9	17.11	1.7625	73.118
83	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**200**	7	20.88	1.71	45.9	20.772	1.7114	48.207
84	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**200**	5	21.1	0.12	82.9	20.6	0.0959	81.052
85	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**200**	6	21.85	0.13	62	22.211	0.0838	61.665
86	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**200**	7	23.35	0.13	51	23.596	0.08	50.394
87	2.87	25.43	272	380	4	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	90	**200**	7	25.709	0	64.7	25.689	0.043	61.976
88	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**200**	6	21.31	0.05	75.3	21.153	0.1562	73.053
89	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**200**	7	23.93	0.07	53.4	23.757	0.1543	54.625
90	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**200**	5	19.98	0.18	84.9	19.717	0.1605	88.36
91	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**200**	6	22.32	0.18	62.6	22.363	0.1587	62.102
92	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**200**	7	24.44	0.17	51.1	24.351	0.1766	48.686
93	2.87	25.428	272.3	486	3.5	1.69	30	30	12	15.5	30.00	0.1	0.18	0.12	50	**200**	7	25.131	0.213	52.6	25.207	0.2261	48.963
94	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.2	0.15	95	**200**	6.18	23.16	0.11	64.9	23.033	0.1361	66.418
95	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**225**	5	19.18	0.41	136.3	18.668	0.4322	136.88

Table VI-13 Training data set for Q3 (continued)

96	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**225**	7	23.54	0.45	67.5	23.8	0.4243	71.342
97	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	45	**225**	7	22.09	0.789	61.6	22.216	0.7563	59.038
98	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**240**	6.5	20.76	0.29	77.2	20.844	0.3071	80.257
99	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**240**	7.5	23.17	0.26	63	23.144	0.2458	58.392
100	2.87	25.428	272.3	486	3.5	2.106	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**240**	7.5	24.553	0.909	71	24.814	0.9066	66.881
101	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**250**	5	18.72	1.05	133.7	18.424	1.0208	134.53
102	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**250**	6	19.87	1.01	83.3	20.054	0.9962	81.991
103	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**250**	7	21.87	0.97	62.8	21.86	1.0537	62.098
104	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**250**	7	21.868	1.098	64.8	21.86	1.0537	62.098
105	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**250**	5	19.961	3.643	141.9	19.74	3.6301	138.7
106	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**250**	6	21.836	3.725	88.6	21.309	3.7682	88.305
107	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**250**	7	23.54	3.799	66.8	23.2	3.8211	69.195
108	2.87	25.428	272	380	4	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	75	**250**	7	23.676	4.061	68.5	23.993	3.9562	70.428
109	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**250**	5	22.49	0.25	146.9	22.826	0.2804	146.95
110	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**250**	7	27.08	0.26	74.7	26.942	0.2428	76.575
111	2.87	25.43	272	380	2	2.37	35	35	12	15.5	35.00	0.1	0.25	0.1	90	**250**	7	25.539	0.469	107	25.424	0.4956	105.82
112	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**250**	6.57	23.07	0.43	109.2	23.214	0.3869	109.72
113	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**250**	6	21.5	0.38	145.4	21.757	0.3444	143.18
114	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**250**	7	24.14	0.41	93	24.25	0.4301	92.804
115	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**250**	5	21.15	0.44	166.5	21.033	0.4504	164.79
116	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**250**	6	23.8	0.47	102.8	23.927	0.4454	102.9
117	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**250**	7	26.09	0.51	77.3	26.101	0.5139	75.493
118	2.87	25.428	272.3	486	4	1.69	30	30	12	15.5	30.00	0.1	0.18	0.12	45	**240**	7	25.08	0.406	73.3	25.134	0.4491	67.72
119	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**186**	5	16.58	0.23	80	16.851	0.2421	78.311
120	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**186**	5.5	18.08	0.25	69.6	18.152	0.2412	67.5
121	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**186**	6	19.46	0.26	61.4	19.614	0.2495	59.467
122	2.87	25.428	272.3	486	4	2.106	35	32	12	15.5	32.00	0.12	0.2	0.1	50	**200**	6	20.463	0.771	61.1	20.345	0.7048	61.986
123	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**217**	5	16.72	0.58	110	16.881	0.5594	110.34
124	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**217**	5.5	18.21	0.59	91.3	18.126	0.571	92.227
125	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**217**	6	19.57	0.59	78.6	19.537	0.596	78.695
126	2.87	25.428	272.3	486	3.5	2.106	35	32	12	15.5	32.00	0.12	0.2	0.1	50	**220**	6	20.663	0.833	75.1	20.73	0.9026	78.595
127	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**248**	5	16.82	0.5	156.6	16.847	0.5252	154.35
128	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**248**	6	19.67	0.41	102.8	19.234	0.3972	105.53
129	2.87	25.428	272.3	486	4	2.106	35	32	12	15.5	32.00	0.12	0.2	0.1	45	**240**	7	23.071	1.147	68.6	23.055	1.1209	67.101
130	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**200**	5	20.61	0.25	67.4	20.749	0.267	67.571
131	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**200**	6	23.12	0.26	51.3	23.001	0.2012	51.848
132	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**200**	7	25.91	0.27	42.3	25.689	0.1708	41.226
133	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**200**	7	25.338	0.168	38	25.689	0.1708	41.226
134	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**250**	5	24.56	0.24	103.3	24.556	0.2332	103.65
135	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**250**	6	26.45	0.22	73.5	25.873	0.2326	71.358
136	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**250**	7	27.87	0.21	58.9	27.869	0.2733	56.965
137	2.97	25.245	415.5	175	2	1.75	25	20	12	15.5	20.00	0.1	0.2	0.1	18	**250**	7	25.452	0.912	51.4	26.122	0.9076	57.867
138	3	26.01	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	7.89	23.81	0.6	37.7	24.025	0.591	37.33
139	3	26.01	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	7	21.65	0.58	46.3	21.542	0.6226	44.995
140	3	26.01	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	8	24.08	0.6	36.9	24.352	0.5871	36.407
141	3	26.01	398	175	4	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	45	**200**	8	23.924	0.081	48.8	24.009	0.0596	50.771
142	3	26.01	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	8.18	26.53	1.07	49.7	26.313	1.0375	50.456
143	3	26.01	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	7	23.45	1.02	69	23.365	1.0205	60.886
144	3	26.01	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	8	26.11	1.06	51.7	25.776	1.0428	51.884
145	3	26.01	398	175	2	2.126	45	45	12	15.5	45.00	0.1	0.2	0.1	45	**250**	8	22.717	0.348	78.1	22.66	0.3449	77.525

Table VI-13 Training data set for Q3 (continued)

146	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**160**	5.5	23.59	0.06	42.8	23.583	0.0844	41.479
147	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**160**	6.5	26.51	0.05	36.4	26.31	0.0781	32.842
148	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**160**	4.5	20.18	0.09	53.8	20.347	0.0838	56.224
149	3.3	27.093	240.2	408	4	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	45	**160**	6	24.999	0.153	35	25.224	0.0812	34.636
150	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	7	30.13	0	51.7	30.583	0.0441	46.052
151	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	8	32.99	0	44.6	32.868	0.0469	46.637
152	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	50	**180**	7	29.649	0.044	37.8	29.789	0.0784	41.139
153	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**180**	5	18.2	0.16	47.6	18.199	0.1851	48.677
154	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**180**	6	19.64	0.17	38.2	19.741	0.1658	38.538
155	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**180**	7	21.06	0.18	32.4	20.987	0.1498	31.042
156	3.3	33	314	175	2	2.126	40	40	12	15.5	40.00	0.1	0.2	0.2	45	**180**	6	22.009	0.202	43.8	21.85	0.2099	44.031
157	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**180**	5	13.36	0.26	46.4	14.038	0.2662	43.93
158	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**180**	6	14.75	0.24	37.4	14.704	0.2594	36.733
159	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**180**	7	16	0.24	31.9	15.775	0.2385	32.571
160	3.3	33	314	175	2	2.126	40	40	14	21.4	34.29	0.12	0.18	0.2	45	**180**	7	22.069	0.133	40.4	22.039	0.1121	38.61
161	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**180**	5	23.31	0	56	23.177	0.0074	54.752
162	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**180**	6	26.54	0	45.2	26.435	0.0081	45.475
163	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**180**	7	29.4	0	38.4	29.618	0.0098	39.276
164	3.3	27.093	240.3	408	4	1.31	20	20	12	15.5	20.00	0.1	0.16	0.1	75	**180**	7	28.942	0	38.1	29.119	0.0307	38.302
165	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**180**	5	22.63	0	48.4	22.638	0.0131	47.987
166	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**180**	6	25.74	0	39.1	25.62	0.014	39.616
167	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**180**	7	28.69	0	33.4	28.72	0.0155	34.508
168	3.3	27.093	240.3	408	4	1.31	20	20	12	15.5	20.00	0.1	0.16	0.1	45	**180**	7	28.514	0.021	34.2	28.667	0.0336	34.309
169	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**180**	7.68	33.47	0	38.5	33.668	0.0062	38.557
170	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**180**	7	31.28	0	42.4	31.659	0.0076	41.406
171	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.23	0.1	30	**180**	7	30.396	0	42	31.245	0.0328	42.803
172	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**180**	5	24.31	0	64.9	24.245	0.0166	64.094
173	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**180**	7	31.43	0	44	31.317	0.0181	43.738
174	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**180**	7	30.841	0	44.6	31.317	0.0181	43.738
175	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**180**	6.5	26.54	0.11	41.1	26.573	0.0981	41.866
176	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**180**	7.5	29.2	0.11	35.9	29.009	0.1055	36.138
177	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**180**	5.5	23.61	0.13	49	23.78	0.0818	50.002
178	3.3	33	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	55	**200**	6	24.741	0.057	60.2	24.927	0.0577	62.655
179	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**200**	7.94	34.41	0	42	34.251	0.0063	40.178
180	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**200**	7.5	33.11	0	44.5	33.084	0.0078	42.16
181	3.3	33	283.4	175	2	1.31	20	15	12	15.5	15.00	0.1	0.25	0.1	45	**200**	7.5	30.479	0.059	45.7	30.126	0.0586	46.034
182	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**200**	7.9	33.87	0	47.9	33.77	0.0185	48.3
183	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**200**	6.5	29.56	0	57	29.279	0.0488	53.699
184	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**200**	7.5	32.73	0	48.5	32.628	0.0449	46.716
185	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**200**	8.5	35.61	0	42.7	35.338	0.0442	44.155
186	3.3	33	283.4	175	2	1.31	45	35	12	15.5	35.00	0.1	0.18	0.1	65	**200**	8	30.78	0.294	39.1	30.76	0.3431	34.281
187	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**200**	5	19.64	0.52	41	19.843	0.5448	39.378
188	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**200**	6	21.11	0.54	32.9	20.954	0.5635	32.491
189	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**200**	7	22.84	0.55	28	22.67	0.5753	27.758
190	3.3	33	283.4	175	2	2.126	25	25	12	15.5	25.00	0.1	0.2	0.1	35	**200**	7	24.145	0.146	36.1	24.827	0.1531	37.744
191	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	5	18.9	0.68	41.6	19.032	0.6744	40.149
192	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	6	20.09	0.7	33.4	20.257	0.7189	33.287
193	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	7	21.67	0.72	28.6	22.07	0.7102	28.853
194	3.3	33	283.4	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	45	**200**	6	21.649	0.191	44.5	21.73	0.1413	45.838
195	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**200**	5	22.9	0.04	58.5	22.587	0.0342	57.12

Table VI-13 Training data set for Q3 (continued)

196	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**200**	6	26.11	0.03	46.7	25.571	0.0377	46.345
197	3.3	27.093	240.3	408	4	1.31	25	25	12	15.5	25.00	0.1	0.18	0.1	30	**200**	6	25.595	0.14	45.4	25.524	0.1257	45.958
198	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**200**	5	24.02	0.01	70.1	24.255	0.038	70.635
199	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**200**	6	27.78	0	54.8	27.373	0.0353	55.915
200	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**200**	7	31.11	0	46.2	30.672	0.0303	47.172
201	3.3	33	314	175	2	1.31	20	20	14	21.4	17.14	0.1	0.23	0.1	25	**200**	7	25.847	0.001	42.7	25.881	0.0504	42.769
202	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**200**	6.51	29.07	0	55.6	29.124	0.0189	53.022
203	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**200**	5.5	25.8	0	69.7	25.535	0.0228	64.395
204	3.3	27.093	225	280	2	1.113	25	20	12	15.5	20.00	0.1	0.18	0.1	45	**200**	6	27.021	0.18	49.1	26.53	0.1967	56.534
205	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**200**	6.5	29.02	0.11	42.8	28.458	0.0783	45.258
206	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**200**	7.5	32.16	0.1	36.8	31.928	0.0613	37.906
207	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**200**	8.5	34.94	0.08	32.7	34.709	0.0495	32.953
208	3.3	33	314	175	2	1.31	20	20	12	15.5	20.00	0.1	0.2	0.1	50	**200**	8	31.229	0	40.9	30.979	0.037	42.29
209	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**200**	5	21.93	0.82	53.9	21.752	0.8351	54.526
210	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**200**	6	25.09	0.81	42.8	24.86	0.8109	42.474
211	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**200**	7	27.9	0.81	36.2	27.786	0.8208	35.624
212	3.3	27.093	240.3	530	4	1.31	50	45	12	15.5	45.00	0.1	0.18	0.1	60	**200**	7	28.387	0.368	41.4	28.393	0.3254	41.47
213	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**200**	5.5	23.72	0.05	64	23.578	0.0508	63.499
214	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**200**	6.5	26.67	0.01	51.9	26.597	0.0529	48.663
215	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**200**	4.5	20.3	0.08	87.8	20.27	0.0486	91.487
216	3.3	27.093	240.2	408	4	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	50	**200**	6	25.159	0.188	52.1	25.61	0.1308	52.04
217	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**225**	5	20.74	0.19	75	20.628	0.206	72.638
218	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**225**	6	22.5	0.2	55.9	22.523	0.1875	56.748
219	3.3	33	314	175	2	2.126	40	40	12	15.5	40.00	0.1	0.2	0.2	50	**225**	6	21.635	0.519	68.2	21.858	0.5149	66.697
220	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**225**	5	14.44	0.25	66.8	15.036	0.3276	73.159
221	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**225**	6	17.18	0.45	72.6	16.295	0.3428	60.879
222	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**225**	7	17.26	0.3	42.9	17.697	0.369	48.374
223	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**225**	5	23.82	0	82.3	24.022	0.0093	82.702
224	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**225**	6	27.07	0	64.7	27.047	0.0117	64.749
225	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**225**	7	30.11	0	54.2	30.038	0.0153	55.439
226	3.3	27.093	240.3	408	4.5	1.31	25	25	12	15.5	25.00	0.1	0.16	0.1	75	**240**	7	28.793	0.093	60.8	28.218	0.0866	60.363
227	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**225**	5	22.93	0	71.9	23.667	0.0278	70.472
228	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**225**	6	26.18	0	56.6	26.315	0.0311	55.053
229	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**225**	7	29.05	0	47.7	28.968	0.0365	46.222
230	3.3	27.093	240.3	408	4	1.31	25	25	12	15.5	25.00	0.1	0.16	0.1	35	**240**	7	28.489	0.209	51.5	28.853	0.1764	51.794
231	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**225**	8.07	34.79	0	51.8	34.974	0.0195	50.294
232	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**225**	7	31.63	0	61	31.661	0.024	58.863
233	3.3	33	283.4	175	2	0.895	25	20	12	15.5	20.00	0.1	0.23	0.1	30	**240**	7	30.808	0.342	67.4	31.559	0.3372	65.764
234	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**225**	5	24.43	0	108.9	24.708	0.0306	108.27
235	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**225**	6	28.28	0	79.7	27.919	0.0281	79.691
236	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**225**	7	31.62	0	65	31.476	0.0278	64.068
237	3.3	33	283.4	175	2	1.31	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**240**	7	28.607	0.033	62.6	28.745	0.0541	63.614
238	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	6	27.36	0	107.9	27.353	0.0815	98.124
239	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	7	30.44	0	83	30.257	0.0747	78.432
240	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	8	33.21	0	68.3	33.004	0.0799	67.929
241	3.3	27.093	225	280	2	1.113	40	40	12	15.5	40.00	0.1	0.18	0.1	50	**240**	7	29.511	0.201	59.5	29.537	0.2128	68.726
242	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**240**	5.5	23.83	0.12	103.6	23.717	0.0996	96.909
243	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**240**	6.5	26.8	0.1	77.5	26.912	0.1114	71.223
244	3.3	27.093	240.2	408	4	1.31	50	45	12	15.5	45.00	0.1	0.18	0.12	45	**240**	7	29.535	0.505	61.1	28.908	0.5397	61.184
245	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**240**	6.5	26.74	0.29	69.8	26.998	0.3086	68.735

Table VI-13 Training data set for Q3 (continued)

246	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**240**	7.5	29.34	0.27	57.6	29.439	0.3018	58.581
247	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**240**	5.5	23.84	0.3	92	23.792	0.313	87.1
248	3.3	27.093	240.3	408	4	1.31	40	35	14	21.4	30.00	0.1	0.215	0.1	65	**240**	7	27.113	0.073	68.4	27.335	0.0696	68.154
249	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**250**	8.09	35.12	0.04	55.4	34.905	0.042	53.323
250	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**250**	7.5	33.41	0.02	61.5	33.128	0.0495	58.633
251	3.3	33	283.4	175	2	1.31	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**250**	8	31.564	0	65.6	31.701	0.0503	66.677
252	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**250**	8.33	35.25	0.03	66.4	35.312	0.0331	64.488
253	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**250**	7.5	32.84	0	76	32.842	0.0417	76.778
254	3.3	33	283.4	175	2	1.31	25	25	12	15.5	25.00	0.1	0.25	0.1	65	**250**	8	31.245	0.01	73.9	31.372	0.0641	74.046
255	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**250**	6.5	29.67	0.01	90	29.4	0.0707	86.865
256	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**250**	8.5	35.82	0	61.6	35.579	0.0446	57.755
257	3.3	33	283.4	175	2	2.126	30	30	12	15.5	30.00	0.1	0.18	0.1	60	**250**	7.5	25.593	0.259	51.2	25.754	0.1597	51.156
258	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**250**	7.14	27.54	1.33	36.7	27.423	1.3525	33.857
259	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**250**	5	23.77	0.87	60.1	24.011	0.878	59.276
260	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**250**	6	25.39	0.89	46	25.071	0.9292	45.375
261	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	45	**250**	7	27.217	0.387	48.5	26.736	0.3711	49.249
262	3.3	33	283.4	175	2	2.126	25	25	14	21.4	21.43	0.1	0.2	0.1	45	**250**	7	22.335	0.289	55.6	22.292	0.2935	59.524
263	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	5	22.83	1.03	63	23.108	1.053	63.238
264	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	6	24.23	1.03	47.6	24.144	1.0523	47.592
265	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	7	25.32	1.03	39.3	25.142	1.0374	41.256
266	3.3	33	283.4	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	50	**240**	7	24.323	0.262	51.9	24.717	0.1769	54.858
267	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**250**	6.33	27.39	0.1	62.8	27.57	0.1054	62.838
268	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**250**	5	24.89	0.13	88.2	24.013	0.0971	88.878
269	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**250**	6	26.45	0.11	67.2	26.68	0.1025	67.393
270	3.3	27.093	240.3	408	4	2.126	25	25	12	15.5	25.00	0.1	0.18	0.1	50	**240**	7	25.013	0.205	48.3	25.469	0.2234	50.051
271	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**250**	5	24.16	0.16	120.9	24.711	0.1349	122.86
272	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**250**	6	27.97	0.14	85.1	27.703	0.1349	84.846
273	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**250**	7	31.24	0.01	68.1	30.948	0.1261	66.095
274	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	50	**240**	7	30.898	0	79.1	30.274	0.0457	75.705
275	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**250**	6.78	30.12	0	76.4	30.096	0.0318	78.763
276	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**250**	5.5	26.03	0	108.9	26.355	0.04	106.52
277	3.3	27.093	225	280	2	1.113	35	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	6	27.074	0.44	81.4	27.348	0.3017	93.55
278	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**250**	6.5	29.11	0.24	62.8	29.531	0.2332	62.931
279	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**250**	8.5	35.09	0.26	45.1	35.245	0.1713	45.422
280	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**250**	5	22.07	1.38	93.8	22.036	1.3737	94.287
281	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**250**	6	25.26	1.21	67.1	25.218	1.1716	67.049
282	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**250**	7	28.07	1.01	53.6	28.144	1.0245	53.578
283	3.3	27.093	240.3	530	4	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	45	**250**	7	28.237	0.278	61.1	28.457	0.3077	60.829
284	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	5	20.23	0.31	69.7	20.167	0.3152	65.7
285	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	6	23.28	0.28	52.5	22.997	0.293	51.012
286	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	7	25.98	0.26	43.3	25.933	0.2574	45.514
287	3.31	28.14	415.5	175	4	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	60	**200**	7	25.156	0	46.1	25.032	0.0334	51.753
288	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**250**	6	23.5	0.81	80.3	23.668	0.7632	80.601
289	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**250**	7	26.21	0.81	62.4	26.06	0.8164	64.478
290	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	75	**240**	7	26.83	0.101	64.3	26.919	0.1069	64.041
291	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	4.5	19.68	0.43	40.5	19.802	0.4186	34.042
292	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	5.72	23.09	0.45	30.1	23.104	0.455	28.721
293	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	6.94	25.92	0.46	24.7	26.008	0.4846	24.894
294	4	32	397	175	2	2.819	40	40	12	15.5	40.00	0.1	0.18	0.15	45	**160**	6.5	23.132	0.338	21.8	23.016	0.3352	26.86
295	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	7.56	27.2	0.46	22.9	27.238	0.4884	23.173

Table VI-13 Training data set for Q3 (continued)

296	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	8.78	29.82	0.46	20.1	29.648	0.4658	20.154
297	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	9.39	31.15	0.46	19.1	31.031	0.4436	18.854
298	4	32	397	175	2	2.819	40	40	12	15.5	40.00	0.1	0.18	0.15	45	**160**	8	26.781	0.384	18.5	26.861	0.3686	20.216
299	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	10	32.44	0.46	18.2	32.492	0.4204	17.776
300	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**178.7**	6	22.72	0.24	33	22.597	0.2518	34.295
301	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**178.7**	7	25.51	0.14	28	25.466	0.0966	29.338
302	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**178.7**	8	28.02	0	24.8	28.234	0.0496	26.409
303	4	43.24	416	530	2	2.794	75.00	75.00	12	15.5	75.00	0.1	0.2	0.101	50	**180**	7	25.345	0.395	26.3	25.339	0.434	26.247
304	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**178.7**	5.5	21.74	0.12	40.3	21.775	0.0866	38.929
305	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**178.7**	6.5	24.72	0.11	33.2	24.616	0.094	33.174
306	4	43.24	416	530	2	1.31	50.00	50.00	12	15.5	50.00	0.1	0.2	0.101	50	**180**	7	28.589	0.042	34.1	28.679	0.0305	32.924
307	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**178.7**	8.04	25.73	0.25	20.5	25.801	0.1931	19.527
308	4	47.2	399	175	2	1.9	30.00	30.00	12	15.5	30.00	0.1	0.15	0.101	60	**180**	8	29.489	0	21.8	29.881	0.0127	26.17
309	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**178.7**	7.5	24.16	0	30.8	24.299	0.0348	31.27
310	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**178.7**	8.5	26.4	0	26.9	26.31	0.0352	27.132
311	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**178.7**	9.5	28.48	0	24	28.517	0.0351	22.301
312	4	47.2	399	175	2	1.9	60.00	55.00	12	15.5	55.00	0.1	0.2	0.101	45	**180**	9	31.116	0	20.2	30.84	0.006	19.887
313	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**178.7**	7.5	23.99	0.06	21.7	24.044	0.0715	22.127
314	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**178.7**	8.5	25.93	0.06	18.8	25.871	0.0679	17.957
315	4	47.2	399	175	2	2.1	15.00	10.00	12	15.5	10.00	0.1	0.122	0.101	65	**180**	8	29.041	0	19.2	29.136	0.0403	23.319
316	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**178.7**	8.5	29.12	0	26.5	29.295	0.0356	25.661
317	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**178.7**	7.5	26.59	0	30.3	26.454	0.0376	31.804
318	4	47.2	399	175	2	2.126	20	18	12	15.5	18.00	0.1	0.25	0.101	50	**180**	8	30.981	0	26.8	30.735	0.0573	28.117
319	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**178.7**	7.5	24.48	0.05	22.2	24.807	0.0108	20.541
320	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**178.7**	8.5	26.45	0.05	19.2	26.273	0.0165	19.873
321	4	47.2	399	175	2	3.423	10	10	14	21.4	8.57	0.1	0.2	0.101	60	**180**	8	24.024	0	22.1	23.901	0.0049	22.786
322	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**178.7**	8.01	25.08	0.53	19.7	25.048	0.5404	21.634
323	4	47.2	399	175	2	2.126	35	32	14	21.4	27.43	0.1	0.12	0.101	65	**180**	7	23.514	0.19	21.6	23.701	0.1404	25.718
324	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**178.7**	8.1	26.33	0.11	21.3	26.165	0.1073	20.591
325	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**178.7**	7.5	24.74	0.11	23.3	24.816	0.1156	22.489
326	4	47.2	399	175	2	2.819	20	20	12	15.5	20.00	0.1	0.18	0.101	65	**180**	8	29.95	0	22.1	30.017	0.0559	22.18
327	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**178.7**	5.5	24.66	0	39	24.688	0.0107	39.119
328	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**178.7**	6	26.44	0	34.9	26.139	0.0105	35.21
329	4	43.24	228	408	2	1.9	15	15	12	15.5	15.00	0.1	0.122	0.101	50	**180**	6	25.068	0	31	24.952	0.0125	33.142
330	4	43.24	228	408	2	1.9	21.33	21.33	12	15.5	21.33	0.1	0.122	0.101	90	**178.7**	5.54	24.02	0	38.6	24.079	0.018	37.449
331	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**178.7**	5.5	22.47	0.05	43.9	22.452	0.0815	38.538
332	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**178.7**	6.5	25.54	0.05	35.6	25.401	0.0774	33.774
333	4	43.24	228	408	2	1.9	45	45	12	15.5	45.00	0.1	0.15	0.101	50	**180**	6.5	25.134	0.183	30.3	25.525	0.1893	29.484
334	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**178.7**	5.5	22.02	0.32	37.2	22.081	0.3305	36.813
335	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**178.7**	6	23.63	0.32	33.3	23.942	0.342	33.261
336	4	43.24	228	408	2	2.126	40	40	12	15.5	40.00	0.1	0.18	0.101	70	**180**	6	23.617	0.06	37.6	23.24	0.0443	34.616
337	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**180**	5.6	24.09	0.05	38.4	24.419	0.0283	38.037
338	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**180**	8	24.82	0	36.6	24.72	0.0124	35.138
339	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**180**	9	27.95	0	28	27.991	0.0106	30.4
340	4	40	398	175	2	1.31	50	45	12	15.5	45.00	0.1	0.15	0.1	45	**180**	8	21.521	0	41.2	21.604	0.0096	35.648
341	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**180**	8	26.42	0	30.6	26.609	0.0414	29.564
342	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**180**	9	29.31	0	24.9	28.667	0.0372	23.698
343	4	40	398	175	2	1.31	20	20	12	15.5	20.00	0.1	0.15	0.1	65	**180**	9	30.112	0	35.8	30.194	0.0029	34.455
344	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**180**	6.5	28.1	0	32.1	28.233	0.0094	34.053
345	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**180**	7.5	30.95	0	28.2	30.897	0.0089	28.774

Table VI-13 Training data set for Q3 (continued)

346	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**180**	8.5	33.52	0	25.2	33.518	0.0124	24.631
347	4	42.4	415	430	2	2.126	24	20	12	15.5	20.00	0.1	0.19	0.1	40	**180**	7	28.628	0.18	24.7	28.462	0.1959	23.208
348	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**180**	6	22.53	0.28	26.2	22.585	0.3038	25.258
349	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**180**	7	25.23	0.28	22.7	25.12	0.2447	23.491
350	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	65	**180**	7	25.851	0.046	29	25.934	0.0572	31.06
351	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**180**	6.5	19.81	0.49	28.4	19.491	0.5384	29.98
352	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**180**	7.5	22.05	0.5	25.1	22.027	0.5396	25.2
353	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**180**	8.5	24.12	0.52	22.6	24.35	0.5445	22.034
354	4	43.24	380	175	2	2.126	60	57	14	21.4	48.86	0.12	0.18	0.18	45	**180**	7	23.333	0.12	34.6	23.316	0.1273	34.369
355	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**180**	8.36	28.79	0.19	22.5	28.86	0.094	19.792
356	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**180**	6	22.36	0.11	34.3	22.26	0.1703	33.473
357	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**180**	7	25.31	0.15	27.8	25.594	0.1383	26.402
358	4	47.2	397	175	2	1.31	30	30	12	15.5	30.00	0.1	0.2	0.1	45	**200**	7	28.066	0	37.6	29.044	0.0472	38.383
359	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**180**	5.5	21.65	0.07	41.8	21.543	0.0738	41.373
360	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**180**	7.5	27.25	0.04	29.9	27.307	0.0882	33.542
361	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**180**	6	21.2	3.82	18.5	21.154	3.7854	17.21
362	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**180**	6.5	22.36	1.63	13.7	22.385	1.7164	15.605
363	4	43.24	379.9	175	2	2.126	75	56	12	15.5	56.00	0.33	0.05	0.06	40	**200**	6.5	23.799	3.279	26	23.76	3.3218	27.371
364	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**180**	6	24.8	0.13	33	24.531	0.033	30.16
365	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**180**	6.5	26.35	0.12	29.8	26.542	0.0339	27.182
366	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**180**	5.77	22.13	0.01	28.7	21.986	0.005	25.777
367	4	43.24	314	408	2	2.126	20	20	12	15.5	20.00	0.1	0.12	0.1	65	**180**	6	25.189	0.037	30.1	25.449	0.0173	31.368
368	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**180**	5	17.55	0.58	41.2	17.973	0.6103	36.639
369	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**180**	6	20.54	0.78	32.8	20.375	0.7487	31.045
370	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**180**	7	23.19	0.9	28	22.917	0.9226	27.457
371	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	50	**200**	6	19.941	0.873	31.9	20.067	0.8727	35.568
372	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**195**	6.64	27.32	0	36.3	27.449	0.0073	37.997
373	4	42.4	227	530	3	1.31	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**200**	7	29.769	0	39.4	29.642	0.0097	41.475
374	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**195**	7.62	26.23	0	34.5	26.301	0.0128	35.25
375	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**195**	6.5	23.64	0	39.9	24.207	0.0046	41.391
376	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**200**	7	26.034	0	39.3	25.43	0.0076	39.351
377	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	5	21.33	0.07	53	21.437	0.0652	51.913
378	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	6	24.73	0.07	40.9	24.743	0.058	40.589
379	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	7	27.7	0.07	34.4	27.729	0.0583	32.935
380	4	43.24	415	430	2	2.15	45	45	12	15.5	45.00	0.1	0.225	0.1	70	**200**	6	24.482	0.04	48.9	24.467	0.0539	53.286
381	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**200**	8.02	29.5	0.08	31	29.803	0.051	28.456
382	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**200**	6	23.46	0.09	45.9	23.631	0.0821	44.459
383	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**200**	7	26.64	0.08	36.7	26.754	0.0596	35.28
384	4	47.2	397	175	2	2.15	35	35	12	15.5	35.00	0.1	0.18	0.1	80	**200**	7	26.834	0	34.5	26.445	0.0216	34.414
385	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**200**	6	23.26	0.1	45.3	23.381	0.1265	45.459
386	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**200**	7	26.43	0.09	36.1	26.695	0.096	35.549
387	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	60	**200**	7	27.621	0	34.2	27.202	0.0356	33.676
388	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**200**	5	18.98	0.55	50.6	19.129	0.5457	49.984
389	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**200**	5.99	21.03	0.56	38.8	21.246	0.5458	36.403
390	4	43.24	380	175	2	2.126	60	60	12	15.5	60.00	0.1	0.18	0.12	45	**200**	6.5	23.962	0.265	38	24.062	0.2434	42.713
391	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**200**	7	23.1	0.56	32.2	22.641	0.5281	33.158
392	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**200**	5	20.1	0.09	72.9	20.147	0.0724	70.423
393	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**200**	6	23.91	0.08	51.8	24.068	0.0805	50.289
394	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**200**	7	27.18	0.08	41.5	27.448	0.0787	39.136
395	4	47.2	397	175	4	2.15	35	35	12	15.5	35.00	0.1	0.25	0.1	80	**200**	7	26.712	0	44.9	26.538	0.0026	47.601

Table VI-13 Training data set for Q3 (continued)

396	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	9.28	29.34	0.11	26.7	29.053	0.0931	25.829
397	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	7	22.58	0	47.4	23.721	0.1455	42.685
398	4	40	398	175	4	2.101	30	25	12	15.5	25.00	0.1	0.2	0.1	50	**200**	9	28.138	0	40.6	28.513	0.0068	38.787
399	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**200**	7	25.7	0.18	33.5	25.365	0.1629	33.058
400	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**200**	6	22.69	0.19	41.8	22.349	0.1854	41.735
401	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**200**	5	19.13	0.21	58.9	19.242	0.2134	57.939
402	4	47.2	397	175	3	2.15	30	25	12	15.5	25.00	0.1	0.2	0.1	20	**240**	6	23.069	0.18	45.8	23.751	0.2267	46.277
403	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**200**	8.5	29.77	0.16	26.7	29.99	0.1318	24.758
404	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**200**	5.5	21.04	0.18	49	20.83	0.1911	50.171
405	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**200**	6.5	24.33	0.17	37.5	23.967	0.1551	38.218
406	4	47.2	397.4	175	2	2.15	40	40	14	21.4	34.29	0.1	0.2	0.1	60	**200**	7	23.513	0.039	35.9	23.487	0.0493	36.59
407	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**200**	7.5	27.2	0.17	30.9	26.969	0.1346	30.693
408	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**200**	8.6	32.29	0.01	29.8	31.932	0.0203	28.862
409	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**200**	5.5	22.49	0.03	55.6	22.247	0.0327	51.186
410	4	47.2	397.4	175	3	3.1	35	35	12	15.5	35.00	0.1	0.15	0.1	45	**200**	6.5	22.553	0.117	27.6	22.564	0.0455	33.53
411	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**200**	7.5	29.23	0.01	35	29.014	0.0194	33.82
412	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**200**	6	23.65	0.07	51.2	23.624	0.0714	54.004
413	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**200**	8	28.99	0.08	37	28.971	0.103	39.082
414	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**200**	5	22.54	0.01	55.9	22.547	0.0276	53.668
415	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**200**	6	25.33	0.01	43.3	25.287	0.0265	41.502
416	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**200**	7	27.73	0.02	36.2	27.787	0.031	34.861
417	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**200**	5	20.09	0.3	40.2	20.432	0.3375	41.026
418	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**200**	6	22.23	0.32	31.1	21.568	0.2822	32.725
419	4	43.24	380	175	2	2.126	30	25	14	21.4	21.43	0.1	0.2	0.1	60	**200**	6	21.447	0.207	46.3	21.343	0.0342	43.843
420	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**200**	6	22.68	0.19	42.6	22.515	0.1651	44.101
421	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**200**	7	25.72	0.18	34.1	25.515	0.1829	33.864
422	4	47.2	397.4	175	2	2.15	30	25	14	21.4	21.43	0.1	0.25	0.1	65	**200**	7	24.255	0	40.8	24.329	0.0065	42.62
423	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**200**	5.5	19.72	0.18	49.4	19.773	0.1653	49.822
424	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**200**	6.5	22.56	0.08	40.4	22.594	0.1211	40.864
425	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**200**	7.5	25.08	0	34.8	24.973	0.0936	35.677
426	4	43.24	400	530	2	1.31	65	60	14	21.4	51.43	0.12	0.22	0.15	45	**200**	7	26.459	0.276	46.4	26.301	0.1028	45.324
427	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**200**	7.48	27.23	0.226	26.3	27.515	0.1686	29.234
428	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**200**	6.06	23.816	0.19	37.5	23.609	0.199	34.596
429	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**200**	5.5	21.969	0.219	44.6	21.876	0.2092	38.966
430	4	43.24	227	348	3	1.31	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**200**	6	25.324	0.055	47.8	25.509	0.0855	48.768
431	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**202.3**	5	21.02	0.05	48.5	20.878	0.0994	46.719
432	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**202.3**	6	22.7	0.05	37.9	23.093	0.1001	36.936
433	4	43.24	381.1	175	2	2.2	25	25	12	15.5	25.00	0.1	0.2	0.101	90	**200**	7	27.873	0	43	28.248	0.0144	41.14
434	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**209.1**	7.5	22.65	0.09	32.7	22.625	0.1168	33.363
435	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**209.1**	8.5	24.85	0.1	28.2	24.734	0.1089	26.865
436	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**209.1**	9.5	26.88	0.12	25	27.109	0.1204	22.244
437	4	47.2	399	175	2	2.126	30.00	25.00	14	21.4	21.43	0.119	0.18	0.101	50	**220**	9	28.913	0	28	28.813	0.0798	27.78
438	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**210**	5.75	25.72	0.04	46.6	25.579	0.0216	45.68
439	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**210**	5	18.78	0.46	51.4	18.754	0.4843	51.781
440	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**210**	6	21.9	0.48	40.6	21.795	0.4586	39.834
441	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**210**	7	24.62	0.51	34.3	24.674	0.5496	32.83
442	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**225**	7	24.12	0.23	43.1	24.408	0.2508	44.735
443	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**225**	8	26.51	0.18	37.4	26.668	0.1717	38.629
444	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**225**	9	28.72	0.12	33.6	28.434	0.1261	34.909
445	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	45	**240**	9	28.376	0.37	36.3	28.502	0.3962	34.418

Table VI-13 Training data set for Q3 (continued)

446	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**225**	5.5	21.87	0.18	66.4	21.713	0.1458	70.442
447	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**225**	6.5	24.85	0.16	51.5	24.688	0.138	50.348
448	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**225**	7.5	27.48	0.17	42.7	27.741	0.1725	43.989
449	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	50	**240**	7	23.794	0.302	44.1	23.826	0.2863	44.918
450	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**238.3**	6	22.93	1.01	63.4	23.06	1.0347	64.039
451	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**238.3**	7	25.71	0.99	49.4	25.671	1.0162	47.243
452	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**238.3**	8	28.22	0.98	41.3	27.837	1.0123	39.566
453	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**238.3**	5.5	22.02	0.42	73.2	22.15	0.4199	70.788
454	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**238.3**	6.5	25.02	0.41	54	25.16	0.4028	50.144
455	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**238.3**	7.5	27.64	0.48	44.8	27.679	0.5062	41.96
456	4	43.24	416	530	4	2.794	50.00	50.00	12	15.5	50.00	0.1	0.2	0.101	55	**240**	7	25.228	0.402	45.7	25.227	0.3921	44.676
457	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**238.3**	8.43	27.22	0.56	28.8	27.017	0.513	28.374
458	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**238.3**	7.5	24.46	0.39	50.4	24.439	0.4457	50.836
459	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**238.3**	9.5	28.8	0.44	36.1	28.774	0.3666	38.182
460	4	47.2	399	175	4	3.423	55.00	55.00	12	15.5	55.00	0.1	0.2	0.101	75	**240**	9	27.652	0.22	31	27.875	0.2346	25.213
461	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**238.3**	7.5	30.56	0.1	33.4	30.387	0.1037	32.61
462	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**238.3**	8.5	32.59	0.1	28.4	32.854	0.1318	26.401
463	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**238.3**	8.63	33.05	0.09	38.2	32.828	0.0716	39.185
464	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**238.3**	8.5	32.55	0.05	38.8	32.573	0.0705	39.751
465	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**238.3**	7.5	30.47	0.05	45.4	30.512	0.0679	44.433
466	4	47.2	399	175	3	2.126	20	20	12	15.5	20.00	0.1	0.25	0.101	90	**240**	8	36.091	0	52.8	36.018	0.0118	55.386
467	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**238.3**	8.5	33.34	0.12	29	33.243	0.0861	30.144
468	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**238.3**	8.4	28.79	0.45	27.5	28.777	0.4726	26.531
469	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**238.3**	8.5	29.46	0.14	30.3	29.489	0.1884	30.304
470	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**238.3**	7.5	27.55	0.14	35.4	27.293	0.1899	34.226
471	4	47.2	399	175	4	2.126	20	20	12	15.5	20.00	0.1	0.18	0.101	65	**240**	8	31.591	0	39.8	31.492	0.0065	43.085
472	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**238.3**	5.5	25.78	0	64.7	26.176	0.0076	65.847
473	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**238.3**	6	27.7	0	56.4	27.349	0.0081	57.503
474	4	43.24	228	408	3	2.126	15	15	12	15.5	15.00	0.1	0.12	0.101	40	**240**	6	24.301	0.039	48.9	24.279	0.0716	47.351
475	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**240**	5.86	26.24	1.06	54	26.263	1.0437	47.96
476	4	32	397	175	4	2.819	40	35	12	15.5	35.00	0.1	0.18	0.15	45	**240**	6	25.383	0.807	44.8	25.378	0.7799	54.212
477	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**240**	8	25.4	0.19	56.6	25.5	0.1257	54.639
478	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**240**	9	28.48	0.16	43.4	28.588	0.1402	47.589
479	4	40	398	175	2	2.819	50	50	12	15.5	50.00	0.1	0.15	0.1	35	**240**	9	23.946	0.254	39.4	24.002	0.3248	39.736
480	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**240**	9.31	31.11	0.32	35.9	31.199	0.3344	35.111
481	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**240**	8	27.47	0.34	48.3	27.438	0.2925	45.464
482	4	40	398	175	4	3.13	20	20	12	15.5	20.00	0.1	0.15	0.1	65	**240**	8	25.768	0	62.1	25.884	0.0177	51.172
483	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**240**	6.5	28.88	0	50.8	28.893	0.0154	53.515
484	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**240**	7.5	31.78	0	43	31.716	0.0215	45.499
485	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**240**	8.5	34.42	0	38	34.401	0.0396	39.715
486	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	40	**240**	8	31.699	0.014	34	31.533	0.0913	33.893
487	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**240**	6	22.73	0.34	43.8	22.706	0.3602	42.534
488	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**240**	8	27.91	0.33	32.1	27.931	0.2949	32.746
489	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	70	**240**	7	28.767	0	43.4	28.629	0.0904	45.607
490	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**240**	6.5	20.01	0.56	42	20.159	0.5658	44.563
491	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**240**	7.5	22.25	0.46	35.8	22.354	0.4516	35.411
492	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**240**	8.5	24.31	0.38	31.5	24.078	0.3971	30.442
493	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**240**	8.7	30.77	0.84	31.2	30.966	0.843	31.133
494	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**240**	6	24.14	0.88	54.2	23.974	0.8356	53.951
495	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**240**	7	26.85	0.88	41.8	26.427	0.8139	42.403

Table VI-13 Training data set for Q3 (continued)

496	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	55	**240**	7	27.182	0	43.4	27.117	0.1768	44.115
497	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**240**	6	21.41	2.37	27.6	21.368	2.3596	27
498	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**240**	6.5	22.6	1.39	23.5	22.665	1.3796	22.225
499	4	43.24	228	408	2	1.9	21.33	21.33	12	15.5	21.33	0.1	0.122	0.101	90	**240**	5.87	25.9	0	59.1	25.917	0.0246	58.621
500	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**240**	5.5	22.77	0.09	76.1	22.79	0.0918	72.371
501	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**240**	6.5	25.86	0.06	56.5	25.547	0.0822	58.71
502	4	43.24	228	408	2	2.126	45	45	12	15.5	45.00	0.1	0.15	0.101	45	**240**	7	26.198	0.27	42.5	25.804	0.3367	40.188
503	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**240**	5.5	22.21	0.57	65	22.017	0.5911	63.631
504	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**240**	6	23.8	0.54	55.6	23.474	0.5253	55.455
505	4	43.24	228	408	2	1.9	45	40	12	15.5	40.00	0.1	0.18	0.101	70	**240**	6	24.867	0.349	55.1	24.726	0.3422	59.616
506	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**240**	6	25.2	0.09	52.5	25.135	0.1066	52.779
507	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**240**	6.5	26.74	0.08	46.7	26.83	0.1001	46.094
508	4	43.24	314	408	2	2.126	36	36	12	15.5	36.00	0.1	0.12	0.1	45	**240**	7	26.936	0.297	38.5	27.145	0.2499	41.941
509	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**240**	6.19	27.76	0	41.9	27.936	0.0082	44.628
510	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**240**	5	17.71	0.42	70.1	18.055	0.4186	63.358
511	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**240**	6	20.67	0.48	51	20.613	0.5307	51.329
512	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**240**	7	23.32	0.54	41.3	23.11	0.5526	44.259
513	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	45	**240**	7	21.141	0.858	35.6	21.156	0.8454	42.029
514	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**250**	5	21.61	0.19	84.8	21.485	0.1912	84.695
515	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**250**	6	25.03	0.18	60.7	24.896	0.1699	62.077
516	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**250**	7	28.03	0.18	48.3	28.097	0.1814	50.696
517	4	43.24	415	430	3.5	2.128	30	30	12	15.5	30.00	0.1	0.2	0.1	65	**250**	7	27.826	0.053	54.9	27.706	0.0639	54.945
518	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**250**	8.8	31.94	0.45	37.7	32.538	0.3407	37.478
519	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**250**	6	24.8	0.42	65.2	25.307	0.3955	62.959
520	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**250**	7	27.2	0.43	50.3	27.767	0.3591	49.835
521	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**250**	6	26.18	0.36	62.8	25.459	0.3893	63.494
522	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**250**	7	28.84	0.36	49.1	27.954	0.3614	50.149
523	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	65	**250**	7	30.469	0	49.7	30.549	0.1523	50.662
524	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**250**	5	20.03	0.66	90.4	19.814	0.6704	91.512
525	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**250**	6.26	22.73	0.71	56.9	22.971	0.7225	54.156
526	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**250**	7	24.1	0.73	48	24.239	0.7421	48.25
527	4	43.24	380	175	2	2.15	60	55	12	15.5	55.00	0.1	0.18	0.12	45	**250**	7	25.491	0.735	53.2	25.205	0.7195	55.778
528	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**250**	5	22.91	0.36	116.2	22.826	0.3317	112.31
529	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**250**	6	25.94	0.37	74.5	26.287	0.3371	71.735
530	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**250**	7	28.38	0.38	57.1	29.253	0.3305	54.43
531	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	9.61	31.49	0.56	33.8	31.449	0.5797	39.202
532	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	7	23.86	0.64	72	24.534	0.6661	59.08
533	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**250**	7	26.49	0.69	46.5	26.223	0.7086	46.192
534	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**250**	6	23.67	0.68	60.7	23.924	0.7226	58.735
535	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**250**	5	21.06	0.68	94	21.714	0.7175	88.788
536	4	47.2	397	175	2	2.15	30	25	12	15.5	25.00	0.1	0.2	0.1	65	**250**	6	25.902	0.353	61.7	25.452	0.3647	59.829
537	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**250**	8.63	31.5	0.64	35.2	31.281	0.6186	35.583
538	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**250**	5.5	23.64	0.63	71.6	23.242	0.5732	71.224
539	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**250**	8.73	33.69	0.27	39.1	33.381	0.191	40.687
540	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**250**	5.5	23.29	0.26	80.9	23.416	0.2137	78.545
541	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**250**	7.5	30.19	0.26	47.3	30.495	0.179	46.576
542	4	47.2	397.4	175	2	2.15	30	25	12	15.5	25.00	0.1	0.15	0.1	35	**250**	8	29.145	0.281	31.1	28.475	0.4302	35.706
543	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**250**	6	24.45	0.33	85.7	24.335	0.3784	86.011
544	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**250**	7	26.75	0.36	66.1	26.856	0.3686	62.098
545	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**250**	8	29.28	0.39	55.2	29.24	0.3795	51.857

Table VI-13 Training data set for Q3 (continued)

546	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	50	**250**	8	29.134	0.744	46.9	29.237	0.7635	47.688
547	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**250**	5	24.06	0.07	88.6	24.185	0.0334	88.365
548	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**250**	7	29.74	0.07	50.4	29.518	0.0434	47.89
549	4	43.24	400	530	3.5	2.126	30	25	12	15.5	25.00	0.1	0.18	0.12	50	**250**	7	27.78	0.506	48.4	27.903	0.4846	47.51
550	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**250**	5	24.54	0.47	58.6	23.351	0.4719	58.424
551	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**250**	6	22.23	0.5	43.5	23.659	0.4702	43.318
552	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**250**	5	22.63	0.66	91.6	22.383	0.6609	94.521
553	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**250**	6	25.04	0.67	60.4	25.278	0.6848	61.98
554	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**250**	7	28.05	0.67	46.8	27.936	0.6973	47.86
555	4	47.2	397.4	175	3.5	2.15	25	25	12	15.5	25.00	0.1	0.25	0.1	45	**250**	7	28.168	0.108	52.2	27.776	0.1057	47.786
556	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**250**	5.5	19.87	0.38	79	19.896	0.4104	77.672
557	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**250**	6.5	22.73	0.26	60.5	22.629	0.2693	58.144
558	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**250**	7.5	25.26	0.24	50	25.268	0.1855	47.739
559	4	43.24	400	530	2	3.622	65	60	14	21.4	51.43	0.12	0.22	0.15	45	**250**	7	22.683	1.407	42.7	22.638	1.4267	44.064
560	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**250**	6	21.44	2.73	29.8	21.392	2.6949	30.286
561	4	43.24	379.9	175	2	2.126	75	56	12	15.5	56.00	0.33	0.05	0.06	40	**250**	6	22.501	2.06	49.7	22.518	2.0562	48.541
562	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**250**	7.82	28.309	0.226	36.3	28.381	0.2725	42.308
563	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**250**	5.86	23.243	0.423	63.8	23.427	0.4102	58.837
564	4	43.24	227	348	3	1.31	50	50	12	15.5	50.00	0.1	0.15	0.1	45	**250**	6.5	26.957	0.133	66.2	27.256	0.1463	65.641
565	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**178.7**	5	20.39	0.06	43	20.299	0.0559	39.172
566	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**178.7**	6	23.27	0.07	34.5	23.248	0.0622	31.899
567	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**178.7**	7	26.12	0.07	29.3	25.935	0.0663	28.092
568	4.015	43.242	225	408	2.5	1.31	35	32	12	15.5	32.00	0.1	0.152	0.101	45	**180**	7	28.872	0.137	24.8	28.441	0.1339	34.959
569	4.015	43.242	225	408	2.5	2.286	45.93	45.93	12	15.5	45.93	0.1	0.152	0.1	90	**178.7**	6.56	24.46	0.12	30.6	24.831	0.1138	28.685
570	4.015	43.242	225	408	2.5	2.286	34.45	34.45	12	15.5	34.45	0.1	0.18	0.1	39	**178.7**	6.53	24.27	0.18	27.9	24.128	0.1229	28.936
571	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**178.7**	6	22.06	0	34.7	22.272	0.0152	34.389
572	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**178.7**	7	24.84	0	29.4	24.838	0.0102	29.134
573	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**178.7**	8	27.34	0	25.8	27.295	0.0062	26.081
574	4.015	43.242	225	408	2.5	2.07	80	80	12	15.5	80.00	0.1	0.18	0.152	45	**180**	8	27.866	0	22.8	27.977	0.0103	24.253
575	4.015	43.242	225	408	2.5	2.286	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	39	**240**	5	19.44	0.57	74.7	19.683	0.5637	72.236
576	4.015	43.242	225	408	2.5	2.286	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	39	**240**	6	22.61	0.51	53	22.702	0.5088	50.971
577	4.015	43.242	225	408	2.5	2.286	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	39	**240**	7	25.43	0.49	42.4	25.49	0.3885	41.435
578	4.015	43.242	225	408	2	2.126	40	40	12	15.5	40.00	0.1	0.18	0.101	80	**240**	7	27.325	0.08	42.8	27.279	0.0897	48.785
579	4.015	43.242	225	408	2.5	2.286	26.25	26.25	12	15.5	26.25	0.1	0.18	0.101	28	**240**	5	21.07	0.22	66	20.985	0.2055	68.566
580	4.015	43.242	225	408	2.5	2.286	26.25	26.25	12	15.5	26.25	0.1	0.18	0.101	28	**240**	6	23.1	0.23	48.5	23.518	0.2544	49.59
581	4.015	43.242	225	408	2.5	2.286	26.25	26.25	12	15.5	26.25	0.1	0.18	0.101	28	**240**	7	25.91	0.24	39.5	25.98	0.2514	40.743
582	4.015	43.242	225	408	2.5	2.286	30	25	12	15.5	25.00	0.1	0.18	0.101	75	**240**	7	28.921	0.324	40.6	29.266	0.3526	46.405
583	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**240**	5	22.09	0.09	73.1	21.928	0.105	72.628
584	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**240**	6	24.9	0.08	53.7	24.898	0.1023	52.136
585	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**240**	7	27.35	0.07	43.8	27.317	0.0998	42.645
586	4.015	43.242	225	408	2.5	2.286	45.93	45.93	12	15.5	45.93	0.1	0.152	0.1	90	**240**	6.89	25.69	0.16	44	25.832	0.1364	43.495
587	4.015	43.242	225	408	2.5	2.286	34.45	34.45	12	15.5	34.45	0.1	0.18	0.1	39	**240**	6.89	25.56	0.29	40.3	25.577	0.2796	42.736
588	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**240**	6	22.26	0.37	67.2	21.99	0.3843	68.295
589	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**240**	7	25.02	0.35	52.2	25.094	0.3672	50.409
590	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**240**	8	27.55	0.34	43.4	27.737	0.317	41.517
591	4.015	43.242	225	408	2	2.286	85	82	14	21.4	70.29	0.1	0.18	0.152	45	**240**	8	25.682	0.574	35.1	25.727	0.5435	36.354
592	4.09	42	380	280	2.5	2.07	62.34	62.34	12	15.5	62.34	0.1	0.18	0.101	80	**240**	8	25.57	0.12	61.7	25.361	0.1265	61.476
593	4.09	42	380	280	2.5	2.07	62.34	62.34	12	15.5	62.34	0.1	0.18	0.101	80	**240**	9	28.63	0.11	47	28.049	0.1728	48.381
594	4.09	42	380	280	2.5	2.07	62.34	62.34	12	15.5	62.34	0.1	0.18	0.101	80	**240**	10	31.33	0.14	38.8	31.738	0.2244	38.785
595	4.09	42	380	280	2.5	2.07	60	60	12	15.5	60.00	0.1	0.18	0.101	45	**240**	9	26.453	0.237	47	26.232	0.2893	45.103

Table VI-13 Training data set for Q3 (continued)

596	4.09	42	380	280	2.5	2.07	16.4	16.4	12	15.5	16.40	0.1	0.25	0.101	39	**240**	9.71	36.71	0.07	40	35.979	0.0938	38.513
597	4.09	42	380	280	2.5	2.07	20	15	12	15.5	15.00	0.1	0.25	0.101	50	**240**	9	33.901	0.257	52.5	34.577	0.2086	45.31
598	4.09	42	380	280	2.5	2.07	49.21	49.21	12	15.5	49.21	0.1	0.15	0.101	85	**240**	9.58	31.31	0.06	36.5	31.548	0.1769	39.169
599	4.09	42	380	280	2	2.07	50	50	12	15.5	50.00	0.1	0.15	0.101	45	**240**	9	26.978	0.173	42.2	27.344	0.3218	42.089
600	4.09	42	380	280	2.5	2.07	37.73	37.73	12	15.5	37.73	0.1	0.25	0.101	33	**240**	9.65	31.15	0.26	37.4	31.861	0.2855	39.083
601	4.09	42	380	280	2.5	2.07	52.49	52.49	12	15.5	52.49	0.1	0.18	0.101	18	**240**	9.51	29.24	0.58	31.6	28.929	0.481	35.498
602	4.09	42	380	280	2.5	2.07	55	45	12	15.5	45.00	0.1	0.18	0.101	65	**240**	9	27.53	0.891	48.7	27.976	0.8257	41.957
603	4.09	42	380	280	2.5	2.07	72.18	72.18	12	15.5	72.18	0.1	0.15	0.101	89	**240**	9.51	30.02	0.18	38.1	30.049	0.1945	43.187
604	4.09	42	380	280	2.5	2.07	49.21	49.21	12	15.5	49.21	0.1	0.15	0.101	65	**240**	9.51	30.69	0.08	35.6	30.601	0.2699	41.28
605	4.09	42	380	280	3	2.07	50	45	12	15.5	45.00	0.1	0.15	0.101	55	**240**	9	27.33	0.47	43.9	27.515	0.4583	44.451
606	4.09	42	380	280	2.5	2.07	65.62	65.62	12	15.5	65.62	0.1	0.18	0.101	50	**240**	8	24.91	0.24	55.1	25.41	0.2506	57.051
607	4.09	42	380	280	2.5	2.07	55.77	55.77	12	15.5	55.77	0.1	0.15	0.101	85	**240**	9.55	30.79	0.06	36.9	30.987	0.1892	39.54
608	4.09	42	380	280	2.5	2.07	45.93	45.93	12	15.5	45.93	0.1	0.25	0.101	90	**240**	8	27.56	0.19	79.8	27.635	0.1361	70.578
609	4.09	42	380	280	2.5	2.07	45.93	45.93	12	15.5	45.93	0.1	0.25	0.101	90	**240**	9	30.76	0.24	60.8	30.398	0.202	58.585
610	4.09	42	380	280	2.5	2.07	45.93	45.93	12	15.5	45.93	0.1	0.25	0.101	90	**240**	10	33.5	0.25	50.3	33.597	0.2936	50.43
611	4.09	42	380	280	3	2.07	50	45	12	15.5	45.00	0.1	0.25	0.101	45	**240**	10	30.353	0.807	42.3	29.866	0.7888	42.109
612	4.09	42	380	280	2.5	2.07	55.77	55.77	12	15.5	55.77	0.1	0.25	0.101	92	**240**	8	26.84	0.22	84.1	27	0.2191	85.582
613	4.09	42	380	280	2.5	2.07	55.77	55.77	12	15.5	55.77	0.1	0.25	0.101	92	**240**	9	29.92	0.24	63.1	30.111	0.2368	66.366
614	4.09	42	380	280	2.5	2.07	55.77	55.77	12	15.5	55.77	0.1	0.15	0.101	65	**240**	9.81	32.4	0.76	50.4	31.43	0.3319	39.997
615	4.09	42	380	280	2.5	2.07	54.13	54.13	12	15.5	54.13	0.1	0.18	0.101	65	**240**	9	28.05	0.29	38.3	27.318	0.2238	43.653
616	4.09	42	380	280	2.5	2.07	54.13	54.13	12	15.5	54.13	0.1	0.18	0.101	65	**240**	10	30.84	0.27	32.1	30.955	0.3111	37.398
617	4.09	42	380	280	4	2.544	65	60	12	15.5	60.00	0.1	0.18	0.101	65	**240**	9	26.002	0.534	47.1	25.916	0.5397	47.092
618	4.09	42	380	280	2.5	2.07	50.85	50.85	12	15.5	50.85	0.1	0.198	0.101	20	**240**	9.55	29.51	0.47	32.5	29.623	0.5068	36.215
619	4.09	42	380	280	3	2.07	50	50	14	21.4	42.86	0.1	0.2	0.101	60	**240**	9	24.238	0	49.7	24.391	0.0586	45.042
620	4.09	42	380	280	2.5	2.07	100.06	100.1	12	15.5	100.1	0.1	0.18	0.101	77	**240**	8	24.35	0.17	66.4	24.496	0.1988	63.42
621	4.09	42	380	280	2.5	2.07	100.06	100.1	12	15.5	100.1	0.1	0.18	0.101	77	**240**	9	27.55	0.2	49.3	27.285	0.1913	50.811
622	4.09	42	380	280	2.5	2.07	100.06	100.1	12	15.5	100.1	0.1	0.18	0.101	77	**240**	10	30.31	0.23	40.2	30.341	0.2138	42.196
623	4.09	42	380	280	2.5	2.07	100	100	14	21.4	85.71	0.1	0.18	0.101	45	**240**	9.5	24.189	0.454	40.3	24.221	0.4294	36.795
624	4.09	42	380	280	2.5	2.07	73.82	73.82	12	15.5	73.82	0.1	0.18	0.101	50	**240**	9.81	27.45	0.32	60.1	27.986	0.35	45.057
625	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**180**	7.5	23.07	0	42.3	22.983	0.032	39.008
626	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**180**	8	24.86	0	37	24.68	0.0324	34.94
627	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**180**	8.5	26.48	0	33.2	26.703	0.0335	31.603
628	4.092	42	400	175	2.5	2.07	70.00	70.00	12	15.5	70.00	0.1	0.18	0.152	50	**180**	9	25.445	0	31.3	25.451	0.0627	30.753
629	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**195**	7.5	26.26	0	26.6	26.347	0.0596	35.373
630	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**195**	8.5	29.22	0	28.8	29.257	0.0518	29.327
631	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**195**	9.5	31.88	0	24.2	32.045	0.0545	23.749
632	4.092	42	399	175	3	2.126	25	25	12	15.5	25.00	0.1	0.18	0.1	55	**200**	9	30.669	0	37.7	30.591	0.0047	34.958
633	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**239.2**	7.5	23.59	0.12	83.9	23.812	0.12	83.116
634	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**239.2**	8.5	26.93	0.12	58.2	26.855	0.0968	57.345
635	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**240**	7.5	23.6	0.12	84.9	23.824	0.1225	83.992
636	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**240**	8	25.33	0.12	68.9	25.153	0.108	69.335
637	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**240**	8.5	26.94	0.13	58.7	26.889	0.0982	57.844
638	4.092	42	400	175	3	2	75.00	72.00	12	15.5	72.00	0.1	0.18	0.152	55	**240**	8.5	24.035	0.268	70.3	23.989	0.2942	64.217
639	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	4.5	19.64	0.23	38.9	19.661	0.1903	41.849
640	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	5.86	23.98	0.24	29.6	23.802	0.1868	31.082
641	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	6.53	25.88	0.24	26.9	25.792	0.1931	27.966
642	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	7.89	29.32	0.25	23.1	29.329	0.2164	23.26
643	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	8.57	30.9	0.24	21.7	31.015	0.2282	21.417
644	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	10.6	35.24	0.23	18.5	35.285	0.2358	18.183
645	4.19	42.822	398	175	3	2.544	35	30	12	15.5	30.00	0.1	0.18	0.15	45	**160**	9	30.05	0.209	20.4	30.045	0.2218	19.372

Table VI-13 Training data set for Q3 (continued)

646	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**178.7**	6	24.3	0	29	24.206	0.0388	31.413
647	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**178.7**	7	27.09	0	25.3	27.075	0.0357	28.346
648	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**178.7**	8	29.67	0	22.9	29.592	0.0377	25.393
649	4.19	42.822	270.9	470	2.5	2.126	80	75	12	15.5	75.00	0.1	0.18	0.1	35	**180**	8	29.471	0.621	22.7	29.149	0.6336	22.636
650	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**178.7**	6.82	26.86	0.11	53.7	26.829	0.0548	53.794
651	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**178.7**	7.5	28.8	0.13	47.9	28.155	0.0486	49.365
652	4.19	42.822	228	285	2	2.2	55	52	14	21.4	44.57	0.1	0.18	0.1	70	**180**	7.5	25.685	0.174	29.4	25.692	0.1757	26.437
653	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**178.7**	6.82	26.75	0.14	56.2	26.79	0.0251	57.699
654	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**178.7**	8	28.39	0.1	50.9	28.974	0.0275	47.575
655	4.19	42.822	228	285	2	2.2	60	60	12	15.5	60.00	0.1	0.2	0.1	45	**180**	8	28.769	0	25.6	28.21	0.056	28.695
656	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**178.7**	6.89	25.71	0.07	58.6	26.263	0.0572	54.308
657	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**178.7**	7.5	27.35	0.05	52.7	27.35	0.0504	53.473
658	4.19	42.822	228	285	2	2.126	45	45	12	15.5	45.00	0.1	0.18	0.1	45	**180**	7.5	27.998	0.154	27.1	27.607	0.2094	26.391
659	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**178.7**	6.73	25.37	0.15	47.2	24.922	0.1374	44.373
660	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**178.7**	7.5	27.47	0.12	41.4	27.959	0.0973	42.126
661	4.19	42.822	228	285	3	2.126	25	25	14	21.4	21.43	0.1	0.18	0.1	55	**180**	7.5	25.599	0.013	28	25.544	0.0538	27.929
662	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**180**	5.5	26.43	0	56.1	26.472	0.0134	53.011
663	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**180**	6.5	29.72	0	45.9	30.108	0.0144	41.192
664	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**180**	7.5	32.74	0	37.2	32.599	0.0127	34.376
665	4.19	42.82	398	175	2	2.2	35	30	12	15.5	30.00	0.1	0.22	0.1	45	**180**	7.5	28.527	0.167	28.4	27.372	0.1049	27.507
666	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**180**	6	25.89	0.34	35.7	25.759	0.328	36.627
667	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**180**	5	22.42	0.3	44.3	22.444	0.3024	45.389
668	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**180**	7	28.98	0.35	29.7	28.894	0.4047	30.835
669	4.19	42.82	398	175	2	2.126	40	35	14	21.4	30.00	0.12	0.15	0.1	50	**180**	7	24.859	0.267	27.5	24.758	0.2758	25.932
670	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**180**	5.68	24.25	0	38.4	24.211	0.0221	39.642
671	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	8	35.53	0	27	35.328	0.021	31.153
672	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	9	38.26	0	24	38.175	0.0324	26.247
673	4.19	42.822	255	175	3	1.96	45	40	12	15.5	40.00	0.1	0.18	0.1	55	**180**	9	27.945	0.393	24	28.178	0.3604	20.948
674	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**180**	6	25.46	0	38.2	25.44	0.0064	38.052
675	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**180**	7	28.48	0	31	28.64	0.0029	31.552
676	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**180**	8	31.27	0	26.6	31.21	0.0013	26.906
677	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	55	**180**	8	30.853	0	27.5	30.778	0.0213	27.138
678	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**180**	6	23.49	0	31.6	23.574	0.0023	30.826
679	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**180**	7	26.2	0	27.7	26.168	0.0016	29.81
680	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**180**	8	28.69	0	24.8	28.478	0.0012	27.933
681	4.19	42.822	272	470	3.5	2.2	90	85	12	15.5	85.00	0.1	0.2	0.15	50	**180**	8	28.804	0	27.5	28.938	0.0214	26.231
682	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**180**	5	23.22	0	47.6	23.115	0.0037	44.139
683	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**180**	6	26.68	0	38.6	26.317	0.0035	36.653
684	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**180**	6	22.5	1.28	29.7	22.391	1.2575	30.291
685	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**180**	7	25.19	1.42	25.7	25.236	1.4203	25.951
686	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**180**	8	27.67	1.56	22.8	27.745	1.5471	23.806
687	4.19	42.822	272	470	3	2.22	65	60	14	21.4	51.43	0.12	0.15	0.15	50	**180**	8	27.14	1.048	27.1	27.095	1.045	31.942
688	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**180**	6.5	25.39	0	29.6	25.321	0.0242	31.439
689	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**180**	7.5	27.99	0	26.1	27.899	0.0205	26.934
690	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**180**	8.5	30.4	0	23.7	30.422	0.0196	24.172
691	4.19	42.822	272	470	3	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	50	**180**	8	29.209	0	24.4	29.482	0.0755	22.607
692	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**180**	5.5	22.92	0.05	36.2	23.025	0.0208	37.637
693	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**180**	6.5	25.84	0.05	30.7	26.05	0.0213	31.285
694	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**180**	7.5	28.46	0.05	27.2	28.66	0.0216	27.078
695	4.19	42.822	272	470	3	1.31	40	40	12	15.5	40.00	0.1	0.18	0.1	55	**180**	7.5	31.537	0	32.8	31.266	0.0063	28.717

Table VI-13 Training data set for Q3 (continued)

696	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**180**	5.5	22.3	0	37.6	22.447	0.0162	32.969
697	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**180**	7.5	27.75	0	28	27.611	0.0144	29.624
698	4.19	42.822	272	470	3	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	55	**180**	7.5	27.835	0	27.3	28.028	0.0447	26.732
699	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**180**	6	21.66	0.14	31	21.535	0.1682	30.381
700	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**180**	7	24.25	0.18	27.2	24.232	0.1739	26.47
701	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**180**	8	26.62	0.23	24.5	26.783	0.18	23.018
702	4.19	42.822	397	175	2	2.544	60	55	14	21.4	47.14	0.12	0.18	0.1	55	**180**	8	26.12	0.826	25.6	26.142	0.8301	23.935
703	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**200**	5.74	23.99	0.26	41.4	24.164	0.3455	43.858
704	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**200**	5.5	27.53	0	50.5	27.297	0.0048	47.809
705	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**200**	6.5	30.97	0	39.5	31.337	0.0036	45.295
706	4.19	42.822	255	175	2	1.31	25	25	12	15.5	25.00	0.1	0.18	0.1	45	**200**	7	29.824	0	40.1	29.52	0.0169	33.676
707	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**200**	5	24.97	0	76.3	25.137	0.0033	75.356
708	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**200**	6	28.56	0	56	28.595	0.0024	55.934
709	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**200**	7	31.74	0	43.7	31.511	0.002	45.146
710	4.19	42.822	398	175	2	1.166	40	40	12	15.5	40.00	0.1	0.18	0.1	45	**200**	6	27.569	0	50.2	26.975	0.038	54.465
711	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**210**	5.83	25.09	0	47.1	25.26	0.0173	49.538
712	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**210**	6.5	23.38	0.09	37.5	23.481	0.1123	39.27
713	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**210**	7.5	25.83	0.1	32.9	25.756	0.1043	31.66
714	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**210**	8.5	28.13	0.12	29.4	28.044	0.1162	27.513
715	4.19	42.822	272	470	3	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	55	**210**	8	27.245	0.265	32.7	27.222	0.2648	30.415
716	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**225**	5.5	26.62	0	86.7	26.497	0.0252	89.342
717	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**225**	6.5	29.88	0	65.8	30.141	0.0258	63.925
718	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**225**	7.5	32.93	0	50.9	32.755	0.0269	50.59
719	4.19	42.82	398	175	2	1.96	35	35	12	15.5	35.00	0.1	0.22	0.1	55	**240**	7	28.17	0.121	52.8	27.32	0.1801	51.576
720	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**225**	6.4	27.37	0.28	52	27.441	0.3054	49.649
721	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**225**	5	22.64	0.3	73.3	22.525	0.3087	70.694
722	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**225**	7	29.18	0.31	44.5	29.198	0.3184	44.362
723	4.19	42.82	398	175	2	2.126	40	21	14	21.4	18.00	0.12	0.15	0.1	55	**220**	7	25.782	1.148	38	25.885	1.1557	35.859
724	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**225**	5	23.99	0	70.2	24.23	0.0034	64.446
725	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**225**	6	27.45	0	54.6	27.436	0.0041	52.027
726	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**238.3**	6	24.48	0.25	52.3	24.303	0.2185	55.651
727	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**238.3**	7	27.25	0.13	42.7	27.487	0.1596	44.582
728	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**238.3**	8	29.83	0.11	36.7	30.164	0.1568	37.651
729	4.19	42.822	270.9	470	3	1.96	75	75	12	15.5	75.00	0.1	0.18	0.1	50	**240**	8	29.792	0.281	41	29.616	0.2265	36.754
730	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**240**	5.95	25.64	0.56	54.1	25.26	0.5379	58.747
731	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	7	32.78	0	51.8	32.503	0.0122	50.826
732	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	8	35.74	0	42.6	36.026	0.01	41.904
733	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	9	38.43	0	36.5	38.559	0.0112	35.382
734	4.19	42.822	255	175	3	1.31	30	30	12	15.5	30.00	0.1	0.18	0.1	55	**240**	8	31.896	0.106	44.1	32.076	0.0235	40.54
735	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**240**	6	25.66	0	71	25.865	0.0026	69.042
736	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**240**	8	31.47	0	43.2	31.258	0.001	43.967
737	4.19	42.822	398	175	3	2.2	40	39	14	21.4	33.43	0.12	0.18	0.13	55	**240**	8	26.508	0.107	42.1	26.465	0.0378	39.311
738	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**240**	6	23.66	0.29	61.8	23.554	0.2621	62.324
739	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**240**	7	26.39	0.27	49.8	26.43	0.2695	49.833
740	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**240**	8	28.87	0.25	42.8	28.836	0.2899	44.513
741	4.19	42.822	272	470	2.5	2.2	90	85	12	15.5	85.00	0.1	0.2	0.15	50	**240**	7	26.82	0.955	56.8	26.718	0.9783	52.014
742	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**240**	7	25.33	0.38	40.1	25.48	0.3714	43.605
743	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**240**	8	27.82	0.37	35.1	27.711	0.3892	35.132
744	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**240**	6.5	25.65	0.09	48.1	25.659	0.1047	52.258
745	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**240**	7.5	28.26	0.07	40.9	28.35	0.0677	40.618

Table VI-13 Training data set for Q3 (continued)

746	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**240**	8.5	30.66	0.05	36.1	30.622	0.0609	33.739
747	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**240**	5.5	23.26	0.09	61.2	23.158	0.0585	63.762
748	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**240**	6.5	26.21	0.07	48.7	26.156	0.0534	49.875
749	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**240**	7.5	28.85	0.04	41.4	28.644	0.0501	41.566
750	4.19	42.822	272	470	3	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	40	**240**	7	25.032	0.298	43.4	25.053	0.2883	45.228
751	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**240**	5.5	22.5	0.22	75.2	22.506	0.2437	75.306
752	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**240**	6.5	25.36	0.19	57.7	25.392	0.1391	54.497
753	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**240**	7.5	27.96	0.17	48	27.697	0.1109	45.431
754	4.19	42.822	272	470	3	2.22	75	70	12	15.5	70.00	0.1	0.2	0.1	50	**240**	7	26.681	0.659	49.2	26.824	0.686	46.209
755	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**240**	7.28	28.57	0.07	94.2	28.355	0.0647	95.793
756	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**240**	7.5	28.99	0.08	90.4	28.737	0.0622	92.546
757	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**240**	7.28	28.38	0.07	104.2	28.674	0.0616	101.66
758	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**240**	8	30.29	0.05	87.9	30.02	0.055	87.251
759	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**240**	7.35	27.29	0.04	99.5	27.676	0.0415	95.617
760	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**240**	7.5	27.61	0.03	96.9	27.901	0.0402	95.272
761	4.19	42.822	228	285	3	2.1	40	40	12	15.5	40.00	0.1	0.18	0.1	50	**240**	7	27.764	0.224	45	26.731	0.2461	40.94
762	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**240**	7.32	27.31	0.34	71.7	27.231	0.3719	67.416
763	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**240**	7.5	27.66	0.34	68.7	27.724	0.3258	68.657
764	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**240**	6	22.2	0.04	47.4	21.986	0.0531	51.003
765	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**240**	7	24.44	0.03	39.8	24.672	0.0496	42.26
766	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**240**	8	26.81	0.04	35.1	26.823	0.0383	36.638
767	4.19	42.822	397	175	3.5	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	55	**240**	8	24.959	0.216	37	24.813	0.1855	38.565
768	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**250**	5.5	27.87	0.01	70.1	27.833	0.0194	67.574
769	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**250**	6.5	31.36	0	52.4	31.351	0.0148	60.828
770	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**250**	5	25.18	0	124.8	25.146	0.0127	123.51
771	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**250**	6	28.76	0	82.3	29.066	0.0115	82.471
772	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**250**	7	31.96	0	60.6	31.947	0.0121	62.356
773	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**200**	5.5	28.14	0	44.7	28.036	0.0174	46.022
774	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**200**	6.5	31.52	0	37.5	31.6	0.016	38.814
775	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**200**	7.5	34.58	0	32.8	34.924	0.0118	34.837
776	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**250**	5.5	28.3	0	65.7	28.07	0.0606	64.87
777	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**250**	6.5	31.69	0.11	52.7	31.471	0.0629	53.784
778	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**250**	7.5	34.74	0.17	43	34.825	0.0528	46.953
779	4.2	42	283.3	175	2.5	2.126	25	25	12	15.5	25.00	0.1	0.25	0.1	60	**250**	7.5	30.202	0.088	54	29.83	0.0324	46.476
780	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**180**	6	23.18	0.46	23.8	23.332	0.4432	23.564
781	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**180**	6.5	24.92	0.61	20.6	24.878	0.5518	22.298
782	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**180**	7	26.5	0.71	18.4	26.458	0.6776	21.182
783	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**240**	6	23.63	0.33	41.2	23.441	0.3212	36.487
784	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**240**	6.5	25.25	0.47	35.3	25.206	0.42	32.853
785	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**240**	7	26.84	0.57	31.1	26.997	0.5438	30.201
786	5.51	51.52	272	350	2	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	50	**240**	7	28.113	0.425	23.9	28.049	0.4178	31.363
787	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**178.7**	6.5	36.87	0	21.1	36.827	0.001	21.87
788	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**178.7**	7.5	40.82	0	18.4	40.402	0.0008	15.897
789	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**178.7**	6	35.23	0	20.4	35.119	0.0007	22.806
790	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**178.7**	7	39.47	0	17.6	39.016	0.0005	15.239
791	6.603	75.438	415.5	280	2	1.31	25.0	25.0	12	15.5	25.00	0.1	0.2	0.101	50	**180**	7	36.749	0	11.7	37.049	0.0028	13.401
792	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**238.3**	6.5	37.3	0	37.6	37.756	0.0036	36.506
793	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**238.3**	7.5	41.3	0	28.8	40.544	0.0034	24.319
794	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**238.3**	6	35.77	0	40	35.834	0.0019	40.866
795	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**238.3**	6.5	37.89	0	34.7	37.887	0.002	32.648

Table VI-13 Training data set for Q3 (continued)

796	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**238.3**	7	40.02	0	30.1	39.349	0.0022	25.749
797	6.603	75.438	415.5	280	2	1.31	20.0	20.0	12	15.5	20.00	0.1	0.201	0.101	45	**240**	7	37.775	0	19	38.228	0.0045	19.738
798	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**180**	5.5	21.22	0	23.1	21.581	0.0019	23.626
799	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**180**	6	24.06	0	20.2	23.662	0.0014	21.255
800	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**180**	6.5	26.36	0	18.2	26.544	0.0011	19.538
801	7	59.99	400	175	2.5	2.126	72.00	72.00	12	15.5	72.00	0.1	0.18	0.15	60	**180**	7	24.698	0	12.4	24.634	0.001	15.757
802	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**202.3**	7.22	35.35	0	15.9	35.649	0.0003	13.843
803	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**202.3**	5	19.58	0	34.2	19.754	0.0005	30.693
804	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**202.3**	6	25.61	0	21.7	25.192	0.0004	20.002
805	7	59.99	398	175	3	2.14	20	20	12	15.5	20.00	0.1	0.152	0.101	80	**200**	6	25.176	0	15.5	25.217	0.0009	23.466
806	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**240**	5.5	22.27	0	46.7	22.176	0.0042	44.853
807	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**240**	6.5	27.12	0	31	27.197	0.0014	29.27
808	7	59.99	400	175	1.5	2	72.00	72.00	12	15.5	72.00	0.1	0.2	0.152	65	**240**	7	27.602	0	22.4	27.474	0.0013	26.003

Table VI-14 Testing data set for Q3

No	*Hammer*		*Hammer cushion Material*				*Pile Information*					*Soil Information*					Stroke	**out1**	**out2**	**out3**	***BPNN***		
	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***		**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	5.38	22.19	0.44	32.2	22.186	0.4445	29.968
2	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	6.33	24.57	0.46	27	24.647	0.4724	26.716
3	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	8.17	28.43	0.46	21.4	28.404	0.4819	21.601
4	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	5.18	21.92	0.23	33.5	21.678	0.1859	35.349
5	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	7.21	27.64	0.25	24.8	27.622	0.2037	25.412
6	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	9.24	32.42	0.24	20.5	32.641	0.2359	19.87
7	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	85	**160**	8.5	30.828	0.021	18.7	31.179	0.2354	19.84
8	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**160**	5.7	24.16	0.06	41.3	24.184	0.0834	39.388
9	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**178.7**	6.43	36.54	0	21.2	36.356	0.001	22.476
10	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**178.7**	6.3	36.5	0	19.4	36.581	0.0006	19.729
11	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**178.7**	6.43	24.09	0.19	30.6	23.85	0.1622	31.783
12	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**178.7**	5.94	23.22	0.12	36.6	23.049	0.0868	35.975
13	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**178.7**	8.27	26	0	27.7	25.836	0.0353	28.153
14	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**178.7**	8.04	25.26	0.06	19.9	24.891	0.0684	19.687
15	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**178.7**	8.3	29.01	0.01	27.1	28.742	0.0356	26.848
16	4	47.2	399	175	2	2.2	20	20	12	15.5	20.00	0.1	0.25	0.101	80	**180**	8.5	35.038	0	33.2	33.138	0.0171	36.881
17	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**178.7**	6.76	26.54	0	26.2	26.419	0.0359	29.087
18	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**178.7**	5.58	25.05	0	38.4	24.92	0.0106	38.41
19	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**178.7**	5.58	22.82	0.05	42.9	22.691	0.0815	38.004
20	4	43.24	228	408	2	1.9	45	45	12	15.5	45.00	0.1	0.152	0.101	55	**180**	6	23.721	0.166	29.7	23.946	0.14	32.535
21	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**178.7**	5.48	22.06	0.33	37.2	22.008	0.3297	36.977
22	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**178.7**	6.63	25.22	0.07	31	24.969	0.065	29.232
23	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**178.7**	6.53	23.66	0	31.8	23.639	0.0126	31.305
24	4.015	43.242	225	408	3	1.31	80	75	12	15.5	75.00	0.1	0.18	0.152	55	**180**	7	28.226	0	30.6	26.706	0.0072	32.684
25	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**180**	6.32	29.15	0	47.7	29.53	0.0144	42.827

Table VI-14 Testing data set for Q3 (continued)

26	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**180**	8.93	27.76	0	28.3	27.76	0.0107	30.679
27	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**180**	8.92	29.11	0	25.2	28.502	0.0372	24.151
28	4	40	398	175	3	2.1	45	40	12	15.5	40.00	0.1	0.15	0.1	45	**180**	8.5	24.871	0	32.3	25.231	0.011	27.886
29	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**180**	7.9	18.42	0.89	64.4	17.832	0.7079	67.907
30	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	6.42	28.48	0	57.2	29.062	0.0454	47.955
31	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	7.62	34.39	0	29.4	34.036	0.0189	33.087
32	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**180**	7.15	30.01	0	29.3	29.97	0.0087	30.473
33	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**180**	6.87	24.91	0.28	23.1	24.8	0.2512	23.652
34	4	42.4	415	430	2	2.126	35	30	14	21.4	25.71	0.12	0.2	0.1	60	**180**	7	25.584	0.288	35.1	25.372	0.1623	30.982
35	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**180**	7.23	21.47	0.49	25.9	21.352	0.5375	26.339
36	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**180**	5.89	22.82	0.43	24.6	22.997	0.4218	23.873
37	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**180**	7.22	21.33	0.18	31.4	21.185	0.1464	29.54
38	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**180**	7.27	16.31	0.24	30.7	16.119	0.232	32.011
39	3.3	33	314	175	2	2.5	40	40	14	21.4	34.29	0.12	0.18	0.2	45	**180**	7.5	21.96	0.171	36.1	22.576	0.1492	37.713
40	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**180**	6.69	27.61	0	32.8	27.722	0.0037	33.396
41	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**180**	6.73	25.47	0	28.6	25.5	0.0017	30.069
42	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**180**	6.63	24.96	0.06	33.8	24.649	0.0788	34.853
43	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**180**	5.22	24.09	0	45.3	23.857	0.0037	42.194
44	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**180**	6.86	24.85	1.4	26.1	24.853	1.4011	26.394
45	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**180**	5.94	26.38	0	45.6	26.238	0.008	45.915
46	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**180**	5.85	25.3	0	40.2	25.167	0.0139	40.602
47	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**180**	7.7	33.54	0	40.1	33.664	0.021	41.277
48	3.3	33	283.4	175	2	1.31	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**180**	7.5	29.729	0	36.7	29.767	0.0347	36.691
49	2.75	22.605	225	280	1	1.66	20	20	12	15.5	20.00	0.1	0.2	0.1	10	**180**	5.66	22.04	0.13	52.7	21.63	0.1195	50.811
50	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**180**	5.83	24.62	0.13	45.9	24.744	0.0877	46.973
51	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**180**	6.86	26.34	0	28	26.27	0.0226	29.582
52	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**180**	6.05	24.97	0.13	32.5	24.734	0.0331	29.829
53	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**186**	6.12	19.76	0.26	59.9	20.11	0.2584	56.92
54	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**195**	9.21	31.15	0	25.4	31.311	0.0526	25.352
55	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	6.19	23.82	0.27	50.5	23.549	0.287	49.511
56	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**200**	6.19	25.29	0.07	39.4	25.345	0.0573	38.958
57	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**200**	8.57	30.94	0.08	28.7	31.326	0.0517	25.356
58	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**200**	8.57	30.75	0.08	28.3	31.566	0.0776	25.133
59	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	60	**200**	8.5	32.099	0	30.2	31.383	0.0349	26.995
60	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**200**	5.98	19.32	0.51	51.3	19.12	0.4918	48.449
61	2.87	25.428	272	380	3.5	2.37	35	15	12	21.4	15.00	0.12	0.18	0.1	66	**200**	6.06	18.63	1.73	54.7	20.609	2.0283	40.804
62	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	5.86	21.22	0.27	54.6	20.963	0.2559	55.492
63	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**200**	5.97	20.45	0.35	49.4	20.596	0.3487	50.758
64	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**200**	6.02	22.86	0.01	68.3	23.029	0.024	67.206
65	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**200**	6.12	22.08	0.13	60.1	22.38	0.0828	60.01
66	2.87	25.43	272	380	2	2.37	35	35	12	15.5	35.00	0.1	0.25	0.1	85	**200**	6	22.599	0.326	69.6	22.656	0.1695	78.649
67	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**200**	8.08	18.69	0.87	69.5	18.665	0.8864	70.763
68	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**200**	8.58	31.63	0.08	32.6	31.862	0.0677	28.358
69	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**200**	7.84	33.64	0	46.5	33.642	0.0443	45.4
70	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**200**	6.8	22.48	0.55	28.8	22.265	0.5733	28.615
71	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	6.79	21.32	0.72	29.4	21.628	0.7164	29.678
72	3.3	33	283.4	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	55	**200**	7	24.143	0.131	39.8	23.451	0.1099	40.103
73	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**200**	8.5	29.62	0.19	26.6	29.643	0.1546	24.102
74	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**200**	7.72	33.18	0	41.7	32.818	0.0269	42.701
75	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**200**	6.62	31.89	0	36.9	32.024	0.0156	38.158

Table VI-14 Testing data set for Q3 (continued)

76	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**200**	5.68	28.14	0	47.9	28.005	0.0046	46.978
77	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**200**	6.86	26.09	0.07	43.4	26.028	0.0782	45.774
78	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**200**	6.25	22.01	0.07	68.3	21.839	0.1542	67.189
79	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**200**	6.13	25.68	0.01	42.2	25.623	0.0268	40.435
80	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**200**	7.59	32.35	0.09	36.5	32.216	0.06	37.372
81	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**200**	5.72	27.61	0	61	27.674	0.0026	60.159
82	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**200**	6.14	22.56	0.18	60.9	22.687	0.1599	59.732
83	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**200**	5.79	24.45	0.79	44.6	24.216	0.8118	44.402
84	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	60	**200**	6	25.413	0.046	45.8	25.752	0.1547	50.976
85	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**200**	8.51	29.67	0.18	27	29.475	0.1635	24.263
86	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**200**	6.76	23.26	0.06	38.7	23.276	0.1124	39.239
87	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**200**	6.01	25.31	0.01	56.8	25.184	0.0517	55.003
88	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**200**	5.58	22.236	0.215	43.8	22.127	0.2079	38.219
89	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**202.3**	6.1	23.07	0.05	37.3	23.273	0.1005	36.317
90	4	43.24	381.1	175	2	2.126	35	30	12	15.5	30.00	0.1	0.204	0.101	90	**200**	6	24.174	0	46.1	24.347	0.0436	48.464
91	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**202.3**	7	29.6	0	17.4	33.944	0.0004	14.535
92	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**209.1**	8.37	24.69	0.1	28.7	24.451	0.109	27.594
93	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**210**	6.76	23.97	0.5	35.5	24.016	0.5194	34.194
94	4	43.24	400	530	2	2.5	35	28	14	21.4	24.00	0.12	0.15	0.1	55	**220**	7	24.776	0.624	33	25.827	0.6967	29.408
95	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**210**	7.12	24.93	0.1	34.5	24.897	0.1051	34.013
96	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**217**	6.27	20.3	0.59	73.4	20.445	0.6082	71.426
97	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**225**	6.51	29.97	0	65.6	30.173	0.0258	63.749
98	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	45	**225**	7	30.814	0	46.8	30.317	0.0619	48.85
99	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**225**	8.33	20.07	1.79	96.9	18.597	1.2039	106.55
100	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**225**	7.65	25.69	0.2	39.2	25.93	0.1939	40.42
101	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**225**	7.5	24.67	0.22	41.9	24.419	0.1643	41.599
102	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**225**	7.5	17.91	0.31	39.8	18.379	0.391	43.168
103	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**225**	6.89	25.9	0.16	47.5	25.869	0.1459	46.872
104	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**225**	5.48	25.72	0	61.5	25.842	0.0038	57.646
105	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**225**	6.29	28.07	0	61.6	27.932	0.0125	61.502
106	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**225**	6.19	26.74	0	54.7	26.822	0.032	53.018
107	3.3	27.093	240.3	408	4	1.31	25	25	12	15.5	25.00	0.1	0.16	0.1	65	**240**	6.5	27.541	0	70.3	27.24	0.0735	65.118
108	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**225**	8.1	34.88	0	54.4	34.97	0.0315	54.61
109	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**238.3**	7.02	39.37	0	32	39.689	0.0035	29.47
110	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**238.3**	7.02	39.94	0	29.9	39.395	0.0022	25.507
111	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**238.3**	6.79	25.31	1	51.3	25.158	1.0202	49.704
112	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**238.3**	6.27	24.46	0.43	57.9	24.505	0.3969	53.169
113	4	43.24	416	530	2	2.794	50.00	50.00	12	15.5	50.00	0.1	0.2	0.101	62	**240**	6.5	24.895	0.449	45.9	26.658	0.4586	48.27
114	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**238.3**	8.6	27.08	0.36	40.9	26.342	0.4051	45.898
115	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**238.3**	8.43	32.74	0.1	28.7	32.636	0.1295	26.76
116	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**238.3**	8.46	33.44	0.12	29.2	33.196	0.085	30.232
117	4.19	42.822	270.9	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**238.3**	7.18	27.88	0.13	41.6	28.007	0.1557	43.162
118	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**238.3**	5.87	27.43	0	58.1	27.048	0.0079	59.411
119	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**240**	9.28	29.26	0.16	41	29.554	0.1436	46.008
120	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	6.79	29.77	0	87.8	29.664	0.0752	81.682
121	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**240**	8.1	36.12	0	41.8	36.334	0.01	41.164
122	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**240**	7.58	32.02	0	42.6	31.934	0.0224	44.971
123	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**240**	7.39	26.45	0.33	34.8	26.327	0.2952	34.835
124	4	42.4	415	430	4	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	65	**240**	7.5	26.4	0	45.9	28.358	0.1329	42.661
125	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**240**	7.55	22.35	0.46	35.5	22.452	0.4472	35.098

Table VI-14 Testing data set for Q3 (continued)

126	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**240**	6.36	24.8	0.44	36.8	24.708	0.3894	33.748
127	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**240**	7.15	29.11	0	51.3	29.15	0.0015	52.463
128	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**240**	6.34	20.34	0.28	80.9	20.434	0.3146	84.85
129	2.87	25.428	272.3	486	4	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	65	**240**	6.5	19.97	0.709	76.5	19.552	0.979	78.438
130	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**240**	7.16	26.79	0.26	48.8	26.844	0.2714	48.851
131	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**240**	7.29	26.08	0.34	38.5	26.185	0.386	40.527
132	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**240**	6.3	26.1	0.1	81.5	26.304	0.1084	75.085
133	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**240**	6.28	26.11	0.29	73.6	26.352	0.31	71.726
134	3.3	27.093	240.3	408	4	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	80	**240**	7	28.733	0	84.1	29.44	0.1125	71.839
135	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**240**	6.86	28.59	0	28.3	29.422	0.001	26.406
136	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**240**	7.25	27.62	0.08	42.4	27.724	0.0731	42.996
137	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**240**	5.81	23.89	0.09	68.4	23.684	0.0884	66.881
138	4.015	43.242	225	408	2.5	2.286	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	39	**240**	6.23	23.45	0.52	49.7	23.383	0.4811	48.114
139	4.015	43.242	225	408	2.5	2.286	26.25	26.25	12	15.5	26.25	0.1	0.18	0.101	28	**240**	6.24	23.81	0.23	45.9	24.122	0.2574	46.85
140	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**240**	6.92	27.34	0.07	44.3	27.142	0.0997	43.167
141	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**240**	6.86	24.8	0.35	53.8	24.678	0.3728	52.23
142	4.015	43.242	225	408	2.5	2.286	80	80	12	15.5	80.00	0.1	0.18	0.152	65	**240**	7	25.213	0.818	43.2	25.776	0.3349	45.607
143	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**240**	6.38	26.38	0.09	48.2	26.432	0.1004	47.508
144	4.09	42	380	280	2.5	2.07	62.34	62.34	12	15.5	62.34	0.1	0.18	0.101	80	**240**	9.61	30.49	0.14	41.2	30.275	0.2047	42.106
145	4.09	42	380	280	2.5	2.07	65.62	65.62	12	15.5	65.62	0.1	0.18	0.101	50	**240**	9.55	29.75	0.23	37.7	27.252	0.2961	43.68
146	4.09	42	380	280	2.5	2.07	45.93	45.93	12	15.5	45.93	0.1	0.25	0.101	90	**240**	9.88	33.35	0.25	51.1	33.216	0.2819	51.263
147	4.09	42	380	280	2.5	2.07	55.77	55.77	12	15.5	55.77	0.1	0.25	0.101	92	**240**	9.81	32.27	0.26	53.3	33.011	0.2508	55.259
148	4.09	42	380	280	2.5	2.07	54.13	54.13	12	15.5	54.13	0.1	0.18	0.101	65	**240**	9.55	29.75	0.28	34.4	29.164	0.272	39.979
149	4.09	42	380	280	2.5	2.07	100.06	100.1	12	15.5	100.1	0.1	0.18	0.101	77	**240**	9.55	29.3	0.22	43.5	29.022	0.1999	45.668
150	4.09	42	380	280	2.5	2.07	100.06	100.1	12	15.5	100.1	0.1	0.18	0.101	55	**240**	9	21.155	0	48.9	27.685	0.3262	46.019
151	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**248**	6.44	20.83	0.39	90.2	20.473	0.3338	89.14
152	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**250**	6.46	26.45	0.18	54.1	26.439	0.1703	56.154
153	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**250**	6.32	20.31	1	75.2	20.618	1.0051	73.594
154	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**250**	6.36	19.66	2.37	75.3	21.963	3.7971	79.315
155	2.87	25.428	272	380	2.5	2.37	35	35	12	15.5	35.00	0.12	0.18	0.1	75	**250**	7	23.647	0.526	71.7	24.716	0.8642	80.019
156	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	6.19	24.32	0.36	75.4	24.063	0.3925	76.085
157	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	6.36	25.21	0.59	66.1	25.248	0.576	64.983
158	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**250**	6.31	27.1	0.06	94.9	24.5	0.067	108.56
159	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**250**	6.43	25.95	0.25	85.4	26.101	0.2398	87.197
160	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**250**	8.55	20.81	1.41	106.8	20.832	1.4014	108.31
161	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**250**	8.8	33.06	0.39	42.1	33.476	0.3644	38.904
162	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**250**	8.31	35.28	0	63.7	35.119	0.0452	59.289
163	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**250**	7.12	26.91	0.91	37.5	26.245	0.9932	38.843
164	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	7.13	25.46	1.03	38.5	25.299	1.0344	40.683
165	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	7	26.058	1.093	37.2	25.142	1.0374	41.256
166	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**250**	8.73	30.57	0.7	34.4	31.228	0.7773	34.344
167	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**250**	8.19	34.87	0	55.2	34.548	0.1109	54.273
168	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**250**	6.8	32.59	0.14	49.8	32.51	0.0612	51.378
169	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**250**	5.84	29.09	0	62.7	28.988	0.018	64.604
170	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**250**	7.5	28.68	0.64	42.1	27.925	0.5609	43.205
171	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**250**	6.5	26.98	0.26	58.6	27.081	0.1931	55.982
172	4	47.2	397.4	175	2	2.15	30	30	12	15.5	30.00	0.1	0.15	0.1	55	**250**	7	26.597	0	37.3	26.275	0.2717	50.814
173	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**250**	7.15	27.15	0.36	64.2	27.226	0.3695	60.072
174	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**250**	6.36	28.1	0.07	57.6	27.91	0.0355	54.802
175	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**250**	7.93	33.52	0.28	48.7	33.822	0.1864	48.75

Table VI-14 Testing data set for Q3 (continued)

176	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**250**	5.87	28.34	0	87	28.6	0.0116	86.247
177	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**250**	6.46	24.88	0.48	88.8	25.043	0.4675	87.593
178	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**250**	6.2	25.82	1.17	63.9	25.835	1.1387	63.632
179	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**250**	8.64	32.27	0.67	35.4	31.873	0.7389	35.336
180	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**250**	7	24.03	0.23	54.6	23.988	0.2243	52.163
181	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**160**	5.11	21.47	0.44	34.2	21.445	0.4361	31.059
182	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	5.5	22.91	0.24	31.5	22.679	0.1856	33.152
183	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**160**	9.92	33.88	0.24	19.5	34.11	0.2382	18.677
184	4.19	42.822	398	175	2	2.129	30	30	12	15.5	30.00	0.1	0.18	0.15	55	**160**	10	34.572	0	17.6	35.271	0.2117	15.734
185	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**178.7**	7	38.87	0	19.7	39.242	0.0009	18.331
186	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**178.7**	6.5	37.49	0	18.9	37.415	0.0006	18.103
187	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**178.7**	7.5	27.34	0.11	28.7	27.364	0.1259	29.267
188	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**178.7**	8.07	25.8	0.05	20.3	25.676	0.0135	20.085
189	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**178.7**	6	24.05	0.06	39.1	23.936	0.0806	35.687
190	4	43.24	228	408	2	1.9	45	45	12	15.5	45.00	0.1	0.15	0.101	65	**180**	7	26.654	0.144	26.4	26.73	0.1044	28.592
191	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**180**	6.08	20.51	0.14	54.2	20.419	0.1733	54.318
192	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	6	27.11	0	62.4	27.838	0.0472	50.662
193	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**180**	7	32.5	0	31.4	31.881	0.017	36.274
194	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**180**	8	27.69	0.28	20.3	27.397	0.2066	22.765
195	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**180**	6.5	24.62	0.06	34.5	24.276	0.078	35.246
196	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**180**	6	28.03	0	51.7	27.643	0.0165	51.094
197	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**180**	6.5	25.14	0	32	25.201	0.0147	31.387
198	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**195**	6.5	26.89	0	37.2	27.187	0.0071	39.078
199	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**200**	8.02	29.32	0.08	30.5	29.929	0.0801	28.37
200	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	65	**200**	8	32.6	0	28	32.181	0.0247	31.354
201	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**200**	6	18.47	1.75	55.1	18.795	1.6799	56.478
202	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**200**	7.5	32.72	0	50.4	32.644	0.0199	50.829
203	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**200**	8	25.8	0.03	34.4	25.886	0.1207	34.845
204	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**200**	5.97	26.06	0.03	46.8	25.483	0.0376	46.586
205	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**200**	6.5	26.08	0.02	42.4	25.746	0.0233	39.789
206	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**200**	5	19.48	0.2	59.6	19.189	0.1304	62.222
207	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	65	**200**	6	26.178	0	54.6	26.737	0.0338	59.619
208	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**202**	7	23.49	0.32	33.5	23.565	0.3278	31.774
209	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**225**	6.39	22.28	0.42	78.6	22.077	0.4268	82.262
210	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**225**	7	23.98	0.21	45.6	24.052	0.1718	45.741
211	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**238.3**	7	39.38	0	32.3	39.638	0.0035	29.711
212	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**238.3**	8.5	26.71	0.38	41.7	26.132	0.4094	46.581
213	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**238.3**	7.5	31.14	0.13	34	31.883	0.0658	32.57
214	4	47.2	399	175	4	2.37	10	10	14	21.4	8.57	0.1	0.2	0.101	65	**240**	8	26.905	0.005	44.3	27.811	0.0028	34.004
215	4.092	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**239.2**	8	25.32	0.12	68.2	25.13	0.1062	68.666
216	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**240**	9	30.36	0.32	38.1	30.303	0.3221	37.444
217	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**240**	7	25.48	0.33	36.8	25.318	0.3033	36.493
218	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**240**	7	28.68	0	52.9	28.747	0.0016	54.181
219	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**240**	6	22.68	0.52	47.2	22.76	0.305	60.816
220	4.19	42.822	272	470	2.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	65	**240**	6	23.012	0.36	47.6	23.651	0.3645	58.399
221	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**240**	4.5	20.47	0.14	167.6	20.435	0.0939	152.94
222	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.183	0.152	91	**240**	6	24.95	0	36.5	24.451	0.0024	35.142
223	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**240**	6	24.36	0.07	64.9	24.215	0.0864	64.144
224	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**240**	5.84	23.4	0.54	58.2	23.011	0.5488	57.751
225	4.09	42	380	280	2.5	2.07	65.62	65.62	12	15.5	65.62	0.1	0.18	0.101	50	**240**	9	28.05	0.24	42.2	26.135	0.2728	48.308

Table VI-14 Testing data set for Q3 (continued)

226	4.09	42	380	280	2.5	2.07	55.77	55.77	12	15.5	55.77	0.1	0.25	0.101	92	**240**	10	32.61	0.26	51.8	33.68	0.2544	53.11
227	4.09	42	380	280	2.5	2.07	60	60	12	15.5	60.00	0.1	0.25	0.101	65	**240**	9.5	29.104	0.279	56.5	29.149	0.29	56.529
228	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**250**	8.71	33.35	0.35	37.1	32.618	0.3758	37.357
229	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**250**	5	22.45	0.37	113.3	21.803	0.3706	120.52
230	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**250**	6	25.01	0.25	96.7	25.314	0.2457	98.534
231	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**250**	7.5	32.91	0	72.6	32.785	0.0518	68.125
232	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**250**	6.5	26	0.64	52.1	25.432	0.5579	52.75
233	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**250**	6	27.12	0.07	63.1	26.97	0.0333	60.274
234	4	43.24	400	530	2	2.126	45	45	12	15.5	45.00	0.1	0.18	0.12	55	**250**	6	24.678	0.237	58.4	28.488	0.3089	69.319
235	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**250**	7.5	32.31	0.27	52	32.586	0.1997	51.991
236	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**250**	6.48	25.147	0.364	51.9	25.166	0.3506	50.227
237	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**200**	6.8	23.88	0.83	28.4	24.521	0.8595	25.83
238	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**200**	7	26.46	0.07	42.5	26.41	0.0802	44.786
239	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**248**	5.5	18.31	0.46	122.2	18.046	0.4519	124.2
240	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**250**	8	27.16	0.61	48.3	26.675	0.6752	51.458
241	4	43.2	255	175	2	1.31	30	25	12	15.5	25	0.1	0.25	0.1	50	250	6	26.453	0	96.2	25.72	0.238	81.453
242	4	47.2	397	218	2.5	2.126	40	35	14	21.4	30	0.12	0.2	0.1	60	200	9	28.865	0	29.8	27.459	0.2227	26.427
243	4	47.2	397	218	2.5	1.5	25	25	12	15.5	25	0.1	0.2	0.1	25	240	9	33.376	0.25	33.3	33.744	0.2379	38.904
244	6.6	75.4	398	220	2.5	2.3	62	62	12	15.5	62	0.1	0.18	0.25	35	240	6	27.648	0.226	35.1	27.625	0.4703	51.018
245	2.75	22.6	324	280	3	2.825	40	30	12	15.5	30	0.1	0.15	0.12	50	200	6	18.364	1.693	53	18.324	1.4967	49.848
246	4.2	42.8	398	175	2	2.7	55	55	12	15.5	55	0.1	0.22	0.25	55	200	7	25.663	0.174	35.6	21.799	0.5219	33.792
247	2.8	31.3	397	175	3	2	50	50	12	15.5	50	0.1	0.18	0.12	45	200	8	23.569	1.143	40.8	24.652	0.5313	59.712
248	2.87	25.4	272	486	3.5	2	50	50	12	15.5	50	0.1	0.18	0.12	45	200	6.5	21.926	0.793	48.6	22.493	0.5108	48.493
249	4.2	42.8	255	175	2.5	2.3	25	20	12	15.5	20	0.1	0.2	0.1	50	200	7	26.824	0.143	29.3	25.539	0.1227	26.143

V.3.4 Q4 type (251-399 kips)

Table VI-15 Training data set for Q4

	Hammer		*Hammer cushion Material*				*Pile Information*					*Soil Information*						**out1**	**out2**	**out3**	***BPNN***		
No	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***	Stroke	**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**300**	8	21.74	1.28	275.1	21.9075	1.4829	271.97
2	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**300**	9	22.93	1.28	183.5	23.0524	1.5253	190.883
3	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**300**	10	24.44	1.552	133.9	24.3042	1.593	128.605
4	1.76	20.099	314	175	2	2.79	60	60	12	15.5	60.00	0.1	0.18	0.18	92	**270**	8.55	19.00	1.24	245.5	19.0784	1.5139	244.038
5	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**270**	8.65	21.77	2.02	159.6	20.5217	1.6094	179.412
6	1.76	20.099	314	175	2	2.79	40	35	12	15.5	35.00	0.1	0.18	0.12	95	**270**	9	19.80	1.25	220.6	20.911	1.6814	198.566
7	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**300**	9.02	27.82	1.14	120.5	28.0172	1.3479	125.56
8	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**300**	7	24.87	1.1	233.9	24.7975	1.2733	232.173
9	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**350**	9.53	30.34	1.73	174.6	30.2899	1.8416	175.304
10	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	6	26.96	0.84	123.5	26.952	0.8529	119.164

Table VI-15 Training data set for Q4 (continued)

11	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	7	28.89	0.83	90.3	28.9896	0.831	91.7264
12	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	8	30.32	0.638	78.3	30.5078	0.8322	84.4323
13	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	5	24.71	0.99	205.5	24.5931	0.8953	204.725
14	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	6	27.29	1.03	114.7	27.4329	0.8803	119.53
15	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	7	29.51	1.06	82.5	29.4191	0.8963	84.08
16	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	6	28.71	1.5	216.7	28.8351	1.2849	215.794
17	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	7	31.18	1.55	137.6	31.1814	1.2268	132.068
18	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	8	32.89	1.521	113.7	32.592	1.1808	99.0032
19	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	6	29.10	1.23	203	28.964	1.0238	196.783
20	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	7	31.60	1.28	126	31.8466	1.0596	140.516
21	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	8	33.82	1.45	97.2	33.7112	1.108	97.7284
22	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**252.9**	7.58	28.09	0.29	42.6	28.5347	0.3345	34.4651
23	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**252.9**	6	25.40	0.17	58.8	25.6494	0.244	60.3917
24	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**252.9**	7	27.08	0.28	47.4	26.2639	0.2983	38.6064
25	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**303.5**	7.91	31.16	0.45	56.1	30.6119	0.3693	70.3295
26	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**303.5**	6	27.47	0.44	89.3	26.2325	0.2355	110.682
27	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**300**	6.5	24.66	0.484	143	26.1319	0.2584	105.209
28	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**354.1**	8.17	33.76	0.57	75	33.757	0.5562	94.3
29	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**354.1**	6	28.70	0.54	150.9	28.8967	0.3632	148.033
30	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**350**	9	30.66	0.506	110	30.7171	0.6429	96.2351
31	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**270**	6.53	30.83	0.1	90.2	30.7155	0.3353	96.0533
32	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**270**	6	29.31	0.1	105.2	29.5354	0.3298	103.025
33	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**270**	8	34.74	0.136	70.6	34.8219	0.3496	82.5295
34	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**360**	6.98	36.93	0.41	144.5	37.1046	0.5917	133.207
35	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**360**	6	33.78	0.41	216.3	33.4522	0.6096	219.499
36	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**360**	8	38.78	0.393	117.1	38.8664	0.5576	130.707
37	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**270**	7	24.72	0.58	107.3	24.7169	0.5132	119.345
38	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**270**	6.67	24.00	0.56	120.2	24.1049	0.5229	134.759
39	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**270**	8.5	26.81	0.679	85.8	27.1736	0.4968	85.0085
40	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**300**	6	21.97	1.2	159.7	22.037	0.8697	162.712
41	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**300**	7	23.18	1.26	103	23.1338	0.8286	110.91
42	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**300**	8	23.93	1.228	84.4	24.0695	0.8284	85.7848
43	2.87	25.428	272	380	3.5	2.37	35	15	14	21.4	12.86	0.12	0.18	0.1	66	**300**	5	16.30	3.625	257.2	16.9278	3.4505	262.611
44	2.87	25.428	272	380	3.5	2.37	35	15	14	21.4	12.86	0.12	0.18	0.1	66	**300**	6	18.98	3.631	133.7	18.8277	3.5593	132.896
45	2.87	25.428	272	380	3.5	2.37	35	15	14	21.4	12.86	0.12	0.18	0.1	66	**300**	7	21.39	3.66	94.3	20.9737	3.6612	92.3827
46	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**300**	7	27.48	0.41	126.6	27.5834	0.425	118.15
47	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	6.5	20.90	1	134.9	21.3831	0.8225	127.577
48	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	7.5	23.30	1.01	100.6	23.2139	0.8328	95.9214
49	2.87	25.428	272	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	8.5	24.27	0.947	92.3	24.6666	0.9159	77.1995
50	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	6.93	25.65	0.73	204	25.6497	0.7776	196.993
51	2.87	25.428	272	243	3.5	2.106	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	7	25.76	0.73	197.8	25.774	0.7761	191.314
52	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**350**	7	24.79	1.29	209.5	24.7286	1.1334	224.735
53	2.87	25.428	272	380	3.5	2.37	35	15	14	21.4	12.86	0.12	0.18	0.1	66	**350**	6	19.18	4.797	271.3	19.5644	4.6598	260.507
54	2.87	25.428	272	380	3.5	2.37	35	15	14	21.4	12.86	0.12	0.18	0.1	66	**350**	7	21.62	4.894	152.9	21.7709	4.7446	152.134
55	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**350**	7	28.76	0.53	248.8	28.9619	0.5041	243.065
56	2.87	25.428	272	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**350**	8	29.98	0.548	198.9	29.7285	0.5087	201.417
57	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	6.5	21.02	0.74	290.3	21.0737	1.1017	283.209
58	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	7.5	23.44	0.78	179.6	22.8313	1.0181	175.402
59	2.87	25.428	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**300**	6	26.92	0.59	163.4	27.12	0.7358	164.181
60	2.87	25.428	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	7	24.28	0.49	183.6	24.4957	0.5839	188.105

Table VI-15 Training data set for Q4 (continued)

61	2.87	25.428	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	50	**300**	8	26.66	1.6	128.8	26.2906	0.9743	124.257
62	2.87	25.428	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**350**	7	31.01	0.6	189.2	31.096	0.9957	177.904
63	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**279**	5	16.91	0.73	242.1	17.2317	0.8064	250.997
64	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**279**	5.5	18.40	0.75	173	18.2443	0.7866	174.763
65	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**279**	6	19.76	0.75	138.8	19.3172	0.7803	132.544
66	2.87	25.428	272	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**280**	7	20.85	0.76	116.3	21.043	0.8183	99.7681
67	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**310**	5.5	18.47	1.07	267	18.4995	1.2264	261.545
68	2.87	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**310**	6	19.84	1.12	197.8	19.4869	1.1797	206.559
69	2.87	25.428	272	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	50	**310**	7	20.95	1.827	137.4	20.9421	1.5088	113.028
70	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**300**	5	27.44	0.72	167.4	27.6404	0.6892	172.981
71	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**300**	6	30.13	0.73	105.7	29.6714	0.6383	109.33
72	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**300**	7	32.21	0.73	80	32.2845	0.5928	81.5231
73	2.97	25.245	415.5	175	2	2.1	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**300**	7	32.32	0.53	73.8	32.463	0.7111	74.8576
74	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**350**	7	35.17	1.21	111.6	34.927	0.8555	117.983
75	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	50	**350**	6	31.93	0.524	212.6	32.1244	0.5265	214.055
76	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	8.67	29.43	1.52	62.5	29.6044	1.8131	61.5958
77	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	7	25.09	1.36	111	25.0195	1.7806	100.338
78	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	8	27.82	1.46	74.6	27.766	1.7951	80.4726
79	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	8.5	29.98	2.699	104.8	30.3854	2.3093	98.1935
80	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	9.03	31.95	2.8	82.1	31.6029	2.2721	87.9392
81	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	8	29.27	2.65	116.9	29.2764	2.3459	107.495
82	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**270**	5	26.31	0	116.9	26.0208	0.1275	109.234
83	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**270**	7	31.21	0	71	31.3108	0.0995	70.5921
84	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**270**	8	33.62	0	69.7	33.5347	0.1011	62.669
85	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**270**	5	25.93	0.03	99.8	25.7265	0.1941	102.157
86	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**270**	6	28.07	0	75.4	28.2667	0.1766	79.1225
87	3.3	27.093	240.3	408	4.5	2.126	10	10	12	15.5	10.00	0.1	0.16	0.1	50	**270**	7	32.19	0	60.7	32.728	0.1762	55.9516
88	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**280**	6.5	26.89	0.17	126.5	26.9166	0.2668	127.588
89	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**280**	5.5	23.91	0.19	194.6	23.4046	0.3318	204.657
90	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	45	**280**	7	28.11	0.267	121.5	28.2103	0.5068	116.108
91	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	6	27.52	0	226.8	27.5318	0.2136	215.812
92	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	7	30.62	0.01	148	31.0009	0.2108	151.204
93	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	8	33.40	0.05	112.6	33.4406	0.2233	110.997
94	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**300**	5	28.05	0.28	135.1	28.0439	0.2773	137.029
95	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**300**	6	30.12	0.27	95.1	29.8934	0.2469	93.372
96	3.3	27.093	240.3	408	4.5	2.37	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**300**	7	32.49	0.297	66.3	32.3457	0.3933	63.7176
97	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**300**	6.98	30.92	0.05	103	30.2053	0.1738	100.202
98	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**300**	5.5	26.22	0	173.5	26.4418	0.1763	163.057
99	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	90	**300**	7	31.98	0	126.2	32.0428	0.1532	137.082
100	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**300**	5	22.23	1.95	189.2	22.3224	1.6923	191.243
101	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**300**	6	25.40	1.78	116.8	25.5243	1.5483	111.2
102	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**300**	7	28.25	1.6	84.7	28.3634	1.4467	77.2106
103	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**300**	6.5	26.99	0.37	134.2	26.6079	0.4538	139.061
104	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**300**	7.5	29.61	0.37	100.3	29.9994	0.4133	103.349
105	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**300**	5.5	24.01	0.57	212.4	23.9583	0.5417	213.326
106	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**315**	5	28.60	0	171.9	28.7415	0.0834	173.307
107	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**315**	6	31.57	0	118.3	31.6366	0.0683	114.28
108	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**315**	7	34.29	0	92.4	34.2903	0.0617	90.8007
109	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**315**	5	28.53	0.09	142	28.9515	0.1249	143.332
110	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**315**	7	33.71	0	79.3	33.6559	0.122	83.4323

Table VI-15 Training data set for Q4 (continued)

111	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**315**	6	31.29	0	100.2	30.8308	0.1161	107.038
112	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**320**	6.65	27.30	0.35	219.5	27.5655	0.2538	211.911
113	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**350**	8	34.22	0.094	100.5	34.804	0.2753	84.4417
114	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**350**	6.9	34.92	0	105.4	34.4655	0.2202	108.794
115	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**350**	5	29.94	0.27	229.1	30.0023	0.2187	223.922
116	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**350**	6	32.77	0.11	139.6	32.8672	0.2055	137.5
117	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**350**	6	25.50	2.29	222.5	25.5242	2.2416	219.8
118	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**350**	7	28.38	2.22	142.2	28.2492	2.0105	134.451
119	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**350**	7.23	32.29	0.09	138.4	32.5611	0.1766	151.532
120	3.3	27.093	225	280	2	2.126	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**360**	8	37.07	0.518	89.3	37.0064	0.3514	91.5362
121	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	8	33.53	0.11	212.6	33.2487	0.2875	194.114
122	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**360**	5	30.25	0	273.6	30.1407	0.0919	280.276
123	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**360**	6	33.59	0	164.9	33.6667	0.0749	152.464
124	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**360**	7	36.71	0	121.6	36.971	0.065	117.702
125	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**360**	5	30.43	0	213.3	30.4956	0.1186	219.478
126	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**360**	6	33.62	0	135.4	33.5613	0.1153	125.408
127	3.3	27.093	240.3	408	4.5	2.126	10	10	12	15.5	10.00	0.1	0.16	0.1	70	**360**	8	41.18	0	87.4	40.9195	0.1004	96.1139
128	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**360**	7.5	29.81	0.7	209.1	29.8105	0.5343	215.34
129	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**270**	5	22.38	0.38	131.9	22.6228	0.2554	128.339
130	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**270**	6	24.51	0.4	86.3	24.3329	0.3171	88.2134
131	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**270**	7	26.30	0.4	66	26.438	0.4129	73.2202
132	3.3	33	314	175	2	2.126	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**270**	7	26.34	0.653	86.1	26.5744	0.3693	107.843
133	3.3	33	314	175	2	2.126	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**270**	5	21.96	0.586	179.1	21.8741	0.4464	177.665
134	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**270**	5	15.71	0.44	102.4	16.5231	0.4382	121.867
135	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**270**	6	18.54	0.45	109.3	17.5383	0.5271	86.2693
136	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**270**	7	18.46	0.44	57.7	18.6965	0.6356	68.3178
137	3.3	33	314	175	2	1.31	40	40	14	21.4	34.29	0.12	0.18	0.2	55	**270**	7	19.78	0.126	201.7	20.0094	0.0902	204.248
138	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**270**	8.26	35.62	0.06	65	35.5182	0.1504	62.382
139	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**270**	7	31.88	0.02	84.1	31.9331	0.1586	79.772
140	3.3	33	283	175	2	1.31	15	15	12	15.5	15.00	0.1	0.23	0.1	60	**270**	6.5	29.89	0	101.3	29.8981	0.1521	100.102
141	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**270**	5	24.61	0.02	180	24.573	0.1533	183.017
142	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**270**	6	28.45	0	118.6	28.5956	0.1379	117.033
143	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**270**	7	31.76	0	91.3	32.1764	0.1298	87.6246
144	3.3	33	283.4	175	2	1.31	20	20	12	15.5	20.00	0.1	0.19	0.1	85	**270**	7	29.16	0	92.2	29.1478	0.137	81.2793
145	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**300**	8.33	37.28	0.14	69.3	37.2236	0.1694	66.8134
146	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**300**	8.63	36.32	0.23	91.8	36.4112	0.1524	86.6537
147	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**300**	7.5	33.06	0.12	117.1	32.6545	0.1702	119.867
148	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**300**	6.5	29.74	0	150.2	29.6823	0.1875	161.951
149	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**300**	7.5	33.02	0.05	111.2	32.997	0.1707	109.301
150	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**300**	8.5	35.91	0.16	89.7	35.4547	0.1635	84.1053
151	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**300**	7.53	32.43	1.91	45.9	32.2387	1.7324	47.3701
152	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**300**	5	26.57	1.45	91.8	26.5854	1.3265	88.6137
153	3.3	33	283.4	175	2	2.106	25	25	12	15.5	25.00	0.1	0.2	0.1	35	**300**	7	28.21	0.844	73.8	28.1607	0.5435	70.4429
154	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**300**	6	28.83	1.45	65.1	28.7231	1.3724	57.1225
155	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**300**	7	30.77	1.46	51.6	30.8044	1.397	48.1468
156	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	5	25.40	1.71	100.8	25.4121	1.4375	100.816
157	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	6	27.48	1.76	69.3	27.3742	1.5057	70.2125
158	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	7	29.11	1.81	54.2	29.265	1.5466	59.244
159	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**300**	8.52	35.97	0.11	73.1	35.7353	0.1874	72.8804
160	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**300**	5	24.37	0.26	221.3	24.476	0.3153	225.28

Table VI-15 Training data set for Q4 (continued)

161	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**300**	6	28.11	0	133	27.6802	0.2669	147.697
162	3.3	33	314	175	2	1.31	20	20	12	15.5	20.00	0.1	0.23	0.1	45	**300**	7	28.97	0.025	104.6	29.0044	0.1964	106.937
163	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	6.5	30.98	0.28	93	31.5256	0.4073	108.984
164	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	7.5	34.20	0.03	73.1	34.9692	0.3637	75.7885
165	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**315**	6	25.94	0.35	151.9	25.6594	0.4425	134.024
166	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**315**	7	27.93	0.35	102	28.1027	0.5345	91.8744
167	3.3	33	314	175	2	2.126	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**320**	7	27.52	0.473	154.7	27.2626	0.5675	165.211
168	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**315**	5	17.14	0.45	181.1	17.2552	0.3786	200.103
169	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**315**	6	19.80	0.42	187.9	19.7993	0.415	141.294
170	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**315**	7	19.92	0.45	80.6	19.6625	0.5009	98.2629
171	3.3	33	314	175	2	2.126	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**320**	7	22.54	0.564	107.6	22.4555	0.2149	107.562
172	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**315**	8.55	36.75	0.23	80.8	36.8174	0.1424	76.3981
173	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**315**	7	32.13	0.08	115.5	32.169	0.1684	116.647
174	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**315**	6	28.56	0	191.3	28.5637	0.1556	189.207
175	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**350**	8.59	40.19	0.27	83.7	40.0971	0.1842	80.8017
176	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**350**	7.5	36.77	0.23	110	37.0643	0.2155	96.7669
177	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**350**	8.92	37.37	0.35	129.8	37.201	0.1685	125.441
178	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**350**	7.5	33.17	0.23	200.4	33.0037	0.2224	220.663
179	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**350**	8.77	36.77	0.23	129.5	36.8541	0.1843	129.419
180	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**350**	7.91	36.53	2.32	57.1	36.6089	2.4822	65.1223
181	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**350**	5	28.57	1.96	155.1	28.4922	1.8848	164.53
182	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**350**	6	31.15	2	95.4	31.3452	1.9236	98.3154
183	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**350**	7	33.57	2.01	71.2	33.5702	1.9055	62.4503
184	3.3	33	283.4	175	2	3	30	30	14	21.4	25.71	0.1	0.2	0.1	50	**350**	7	20.74	1.298	99.3	20.5203	1.117	101.878
185	3.3	33	283.4	175	2	2.106	30	30	14	21.4	25.71	0.1	0.2	0.1	50	**350**	7	22.54	0.951	118.5	22.9308	0.6812	123.569
186	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	5	27.20	2.19	194.7	27.177	2.0361	192.489
187	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	7	31.64	2.36	78.2	31.7195	2.0927	73.2887
188	3.3	33	283.4	175	2	2.106	30	30	12	15.5	30.00	0.1	0.2	0.1	50	**350**	7	28.39	1.12	140.3	27.8931	0.8634	149.301
189	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**350**	6	28.32	0	235.4	28.5289	0.4	221.86
190	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**350**	7	31.59	0.1	150.4	31.4127	0.3161	149.111
191	3.3	33	314	175	2	1.31	45	45	12	15.5	45.00	0.1	0.23	0.1	45	**350**	8	30.75	0.509	210.9	30.9707	0.5236	213.236
192	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**350**	6.5	32.44	0.08	139.3	32.1769	0.6084	145.895
193	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**350**	7.5	35.97	0.12	102.3	35.6023	0.5161	103.649
194	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**350**	8.5	39.09	0.25	82.3	38.6879	0.4597	73.8039
195	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**360**	8.3	31.64	0.43	115.3	31.6185	0.5987	116.722
196	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**360**	7	21.23	0.47	120.3	21.4002	0.5487	122.235
197	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**360**	8.82	37.70	0.41	102.6	38.5711	0.1504	96.072
198	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**360**	7	33.43	0.23	167.4	33.2167	0.2016	173.265
199	3.3	33	283.4	175	2	1.31	20	20	12	15.5	20.00	0.1	0.23	0.1	60	**360**	7	31.49	0	218.7	31.5695	0.2563	205.697
200	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**360**	7	32.12	0.17	207.5	32.0226	0.1567	210.175
201	3.3	33	283.4	175	2	0.895	20	20	14	21.4	17.14	0.1	0.19	0.1	50	**360**	7	28.24	0.306	182.3	28.0226	0.2546	181.204
202	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**360**	7	29.22	0.4	186.5	29.2007	0.4812	180.632
203	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	6	23.72	1.2	133.8	24.2372	0.7332	131.199
204	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	7	26.46	1.22	93.8	26.2115	0.7042	93.0109
205	3.31	28.14	415.5	175	2	2.126	30	30	14	21.4	25.71	0.1	0.225	0.1	70	**300**	7	23.33	0.19	92.1	23.13	0.4178	82.8979
206	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**350**	6	24.95	1.97	276.5	25.1317	1.209	261.495
207	3.31	28.14	415.5	175	2	1.75	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**350**	7	27.29	2.15	156.5	27.0902	1.1159	163.924
208	3.31	28.14	415.5	175	2	1.75	30	30	14	21.4	25.71	0.1	0.225	0.1	70	**350**	7	23.77	0.149	97	23.8808	0.4223	99.6876
209	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**270**	6.04	28.72	0.34	69.2	29.1422	0.3019	80.1152
210	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**280**	6.08	28.02	1.6	71.3	28.1946	0.859	72.3799

Table VI-15 Training data set for Q4 (continued)

211	4	32	397	175	2	2.819	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**300**	6.19	30.18	0.31	85	29.6984	0.5503	83.7451
212	4	32	397	175	2	1.31	30	30	12	15.5	30.00	0.1	0.2	0.1	45	**300**	7	32.17	0.118	75.1	31.9451	0.2244	69.1822
213	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	5	17.85	0.78	144.5	18.1623	0.9727	142.312
214	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	6	20.80	0.85	86.4	21.1798	0.827	88.3505
215	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	7	23.44	0.93	64.1	23.5841	0.7571	60.4188
216	4	32	397	175	2	2.819	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	7	26.86	0.909	69.5	26.7905	0.7484	68.5525
217	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**320**	6.29	29.69	1.43	97.5	29.3586	1.4841	85.5386
218	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**360**	6.45	31.14	1.94	144.7	30.9677	1.8057	151.848
219	4	32	397	175	2	2.819	40	34	14	21.4	29.14	0.1	0.18	0.15	50	**360**	7	23.30	2.139	85	23.1783	2.0187	87.7583
220	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	7	23.55	1.51	111	23.2967	0.8412	114.776
221	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**360**	10	31.95	0.68	96.7	31.5876	0.6512	106.319
222	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**360**	8	26.28	0.88	265.6	26.2375	0.8027	263.489
223	4	40	398	175	2	2.1	50	50	14	21.4	42.86	0.1	0.15	0.1	35	**360**	9	22.80	0.792	105.9	22.8369	1.1574	110.234
224	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**360**	10	38.13	0	58	38.5515	0.4916	65.4023
225	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**360**	9	35.23	0.04	72.9	34.7348	0.4994	89.4595
226	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**300**	8	30.01	0.75	69.3	29.898	0.374	56.9424
227	4	40	398	175	2	2.1	50	40	12	15.5	40.00	0.1	0.15	0.1	65	**300**	8	24.53	1.247	150.6	25.3754	1.2947	139.187
228	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	9.9	34.52	1.4	42.3	34.5077	0.9493	43.8381
229	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	7	25.45	1.27	117.8	26.495	1.1038	104.213
230	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	8	29.12	1.3	69	28.7121	1.0312	71.1675
231	4	40	398	175	2	2.101	30	30	14	21.4	25.71	0.1	0.2	0.1	65	**300**	8	23.05	0.187	119.1	24.0934	0.1302	56.7207
232	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	10.27	37.28	0.74	52.2	37.1763	1.2166	61.9734
233	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	7	26.50	1.6	235.1	27.6527	1.5525	181.281
234	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	8	30.47	1.17	104.7	29.7687	1.448	130.181
235	4	40	398	175	2	2.101	50	50	14	21.4	42.86	0.1	0.2	0.1	65	**350**	9	23.43	0.433	140.1	24.3912	0.3468	131.959
236	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**278.8**	7.5	23.00	0.15	50.3	23.0899	0.3029	51.2364
237	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**278.8**	8.5	25.22	0.18	42.3	25.2637	0.2911	44.5953
238	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**278.8**	9.5	27.26	0.22	36.8	27.0856	0.2959	38.8984
239	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**297.9**	8.79	33.42	0.77	37.8	33.1415	1.0649	34.3744
240	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**297.9**	7.5	25.27	0.99	93.9	25.2325	0.8288	64.6168
241	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**297.9**	9.5	29.07	1.13	57.7	29.0184	1.012	41.2402
242	4	47.2	399	175	2	2.126	56.00	56.00	12	15.5	56.00	0.1	0.223	0.101	75	**300**	10	33.96	0.525	51.1	33.8404	0.2664	46.7169
243	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**297.9**	8.69	39.23	0.18	37.8	39.5179	0.2262	32.2332
244	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**297.9**	7.5	35.87	0.16	46	35.7027	0.2245	36.3067
245	4	47.2	399	175	2	2.37	20.00	20.00	12	15.5	20.00	0.1	0.122	0.101	75	**300**	8	33.34	0.116	42.8	32.9765	0.1121	38.9523
246	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**297.9**	8.76	37.68	0.22	51	37.4353	0.4387	54.9838
247	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**297.9**	8.5	36.91	0.17	53.2	36.8763	0.4493	56.1728
248	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**297.9**	7.5	34.51	0.17	63.9	34.2427	0.483	62.2985
249	4	47.2	399	175	2	2.37	35	35	12	15.5	35.00	0.1	0.253	0.101	50	**300**	8	31.03	0.466	58.7	30.4268	0.4036	69.8753
250	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**297.9**	8.69	39.92	0.26	38.2	40.0239	0.2261	35.637
251	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**297.9**	7.5	36.40	0.25	46.7	36.3951	0.2294	43.4288
252	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**297.9**	8.79	32.50	1.09	35.9	32.4974	0.9954	31.2736
253	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**297.9**	8.76	35.52	0.46	39.6	35.7254	0.4785	41.3951
254	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**297.9**	7.5	32.53	0.45	49.2	32.1603	0.5216	47.5594
255	4	47.2	399	175	2	2.79	20	20	12	15.5	20.00	0.1	0.18	0.101	65	**300**	8	36.78	0.068	48.4	36.2911	0.2125	53.7054
256	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**300**	8.97	34.66	0.44	46.5	35.5303	0.1452	48.6967
257	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**300**	6	28.04	0.62	93.6	27.2247	0.2365	86.6492
258	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**300**	7	30.63	0.63	67.9	30.3567	0.1958	66.3421
259	4	47.2	397	175	2	2.15	45	45	12	15.5	45.00	0.1	0.18	0.1	65	**300**	7	26.45	0.376	72.4	26.2349	0.3402	74.0611
260	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**300**	6	29.46	0.61	86.7	29.2603	0.2335	83.7622

Table VI-15 Training data set for Q4 (continued)

261	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**300**	7	32.27	0.56	64.4	32.3917	0.1921	64.7697
262	4	47.2	397	175	2	2.15	15	15	14	21.4	12.86	0.1	0.2	0.1	55	**300**	7	25.89	0.171	63.7	26.1327	0.0694	72.6063
263	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**300**	8.93	34.22	2.13	41.8	33.8843	0.9939	40.9118
264	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**300**	6	26.36	1.84	89.1	26.2035	1.2819	77.1729
265	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**300**	7	29.36	1.95	62.5	28.773	1.2028	56.7215
266	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**300**	5	24.69	0.64	206.9	25.1487	0.309	201.33
267	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**300**	6	28.51	0.65	110.2	28.4696	0.2936	112.369
268	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**300**	7	31.53	0.35	78.8	31.5877	0.2594	79.3576
269	4	47.2	397	175	2	2.15	50	50	12	15.5	50.00	0.1	0.25	0.1	41	**300**	7	25.90	0.448	80.7	26.3527	0.6256	98.1267
270	4	47.2	397	175	2	2.15	50	50	12	15.5	50.00	0.1	0.25	0.1	90	**300**	7	27.45	0.329	118.6	27.4533	0.1604	128.438
271	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**300**	7	29.10	1.2	63.7	29.6412	0.6786	61.4676
272	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**300**	6	26.67	1.17	88.9	27.0922	0.7545	82.2314
273	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**300**	5	23.52	1.15	165.1	24.3101	0.7816	131.814
274	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**300**	5.5	26.83	0.82	106.4	26.8249	0.546	99.8406
275	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**300**	6.5	29.60	0.85	71.2	29.7335	0.4848	69.243
276	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**300**	7.5	31.82	0.88	55.2	32.2897	0.4128	55.9141
277	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**300**	5.5	25.97	0.48	122.5	25.9993	0.1651	99.0389
278	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**300**	6.5	28.69	0.5	80.9	28.9009	0.1332	67.5203
279	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**300**	7.5	31.22	0.44	62.3	31.6711	0.1115	53.1553
280	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**300**	8.9	35.37	1	43.6	35.8172	0.5072	44.1225
281	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**300**	5	25.34	0.87	149.4	25.1912	0.7296	139.504
282	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**300**	6	28.56	0.92	85.3	28.4235	0.7286	81.9975
283	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**348.4**	7.5	23.31	0.53	73.4	23.5258	0.6895	75.4212
284	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**348.4**	8.5	25.54	0.53	59.3	25.4442	0.6361	60.58
285	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**348.4**	9.5	27.59	0.54	50.3	27.692	0.5871	53.0746
286	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**350**	9.36	39.03	0.06	55.9	38.727	0.1954	61.7681
287	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**350**	7	33.25	0.4	94	32.6863	0.3258	95.1053
288	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**350**	9.26	41.15	0	53.9	40.8112	0.1994	58.4511
289	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**350**	6	31.70	0.18	123.9	31.871	0.3865	121.565
290	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**350**	7	35.03	0.1	85.6	34.8987	0.3136	85.1588
291	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**350**	9.48	40.34	0	64.1	40.7287	0.2636	66.0423
292	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**350**	7	33.53	0.08	112.5	33.8501	0.4762	121.517
293	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**350**	7	31.89	1.45	89.8	31.8142	1.0576	91.4189
294	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**350**	6	28.82	1.67	140.3	29.0141	1.1433	141.593
295	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**350**	9.32	39.26	0.49	51.3	39.1477	0.4966	54.9228
296	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**350**	5.5	28.91	1.03	172.6	28.9773	0.8482	164.955
297	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**350**	7.5	35.14	0.65	73.2	34.9126	0.6674	73.6613
298	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**350**	9.28	37.99	0	58.5	38.1412	0.1278	58.9396
299	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**350**	5.5	27.91	0.36	208.1	27.9427	0.3242	212.345
300	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**350**	7.5	34.02	0	83.9	33.6155	0.1922	83.6907
301	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**350**	9.35	39.82	0.53	51.5	39.5315	0.7918	51.3925
302	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**350**	5	27.07	1.3	293.2	27.1598	1.1872	285.111
303	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**350**	7	34.14	0.75	84.9	33.3525	1.1306	89.4484
304	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**357.4**	9.12	38.26	1.27	49.3	38.3463	1.3813	52.1897
305	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**357.4**	7.5	26.45	0.9	253	26.514	1.3466	255.919
306	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**357.4**	8.5	28.46	1.03	147.1	28.2785	1.4904	143.108
307	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**357.4**	8.86	44.37	0.27	46.6	44.0158	0.3394	38.6782
308	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**357.4**	7.5	39.83	0.29	59.7	40.0943	0.3481	70.3603
309	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**357.4**	9.09	41.50	0.87	65.7	41.0325	0.7517	66.8823
310	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**357.4**	8.5	39.90	0.89	73.2	40.1283	0.8312	72.2243

Table VI-15 Training data set for Q4 (continued)

311	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**357.4**	7.5	37.39	0.82	91.9	37.8011	0.9403	88.9151
312	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**357.4**	8.89	44.96	0.41	47	44.8381	0.5238	47.0543
313	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**357.4**	7.5	40.23	0.41	60.5	40.1501	0.4735	63.8884
314	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**357.4**	9.25	36.63	2.81	46.4	36.5409	2.3933	41.3056
315	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**357.4**	9.06	40.23	0.64	49.3	40.0355	0.7284	51.2485
316	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**357.4**	7.5	36.04	0.65	66.5	36.2636	0.8081	64.5649
317	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**357.4**	8.5	43.50	0.4	50.2	43.5889	0.5145	51.5292
318	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**360**	9.45	37.58	2.02	53.4	38.3335	1.3805	54.9977
319	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**360**	6	27.75	2.13	170.5	28.2302	1.726	161.511
320	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**360**	7	31.11	2.22	99.2	31.037	1.7119	100.886
321	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**297.9**	5	23.60	0.27	141.9	23.6666	0.3115	130.303
322	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**297.9**	6	26.65	0.21	88	26.5215	0.2476	83.7442
323	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**297.9**	7	29.32	0.22	66.3	29.0239	0.2143	66.3096
324	4.015	43.242	225	408	2.5	2.286	40	40	12	15.5	40.00	0.1	0.152	0.101	45	**300**	7	25.73	0.877	60.4	26.7355	0.7071	60.5058
325	4.015	43.242	225	408	2.5	2.286	45.93	45.93	12	15.5	45.93	0.1	0.152	0.1	90	**297.9**	7.22	26.90	0.56	65.9	27.0122	0.3326	66.6998
326	4.015	43.242	225	408	2.5	2.286	34.45	34.45	12	15.5	34.45	0.1	0.18	0.1	39	**297.9**	7.22	27.47	0.68	57.1	27.2842	0.6613	59.8801
327	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**297.9**	6	22.41	0.82	173.2	22.2142	0.6047	155.491
328	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**297.9**	7	25.20	0.82	108.3	25.1147	0.7	106.101
329	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**297.9**	8	27.70	0.83	80.6	27.7427	0.824	82.8281
330	4.015	43.242	225	408	2.5	2.286	80	80	12	15.5	80.00	0.1	0.18	0.152	45	**300**	8	24.84	1.623	100.4	24.9068	1.4894	78.9633
331	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**357.4**	6	28.17	0.45	171.5	27.9874	0.4267	188.462
332	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**357.4**	7	31.02	0.45	109.3	30.9081	0.3525	117.333
333	4.015	43.242	225	408	2.5	2.286	45.93	45.93	12	15.5	45.93	0.1	0.152	0.1	90	**357.4**	7.48	28.73	0.94	108.8	28.2122	0.565	105.215
334	4.015	43.242	225	408	2.5	2.286	34.45	34.45	12	15.5	34.45	0.1	0.18	0.1	39	**357.4**	7.58	30.37	1.53	83.4	30.4662	0.9656	97.372
335	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**357.4**	8	27.85	0.89	208.4	28.0383	0.9046	208.113
336	4.015	43.242	225	408	2.5	2.286	80	80	14	21.4	68.57	0.1	0.18	0.152	50	**360**	8	25.46	1.122	106	25.0413	1.1753	100.123
337	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**260**	7.5	30.60	0.16	57.7	30.8107	0.1686	30.7333
338	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**260**	8.5	33.96	0.17	44.2	33.6793	0.1718	29.5593
339	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**260**	9.5	36.84	0.17	36.8	36.7219	0.1843	28.7052
340	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	50	**260**	9	37.01	0	52.5	36.9893	0.0819	37.0919
341	4.09	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**300**	7.5	24.01	0.41	238.3	24.0882	0.2522	229.479
342	4.09	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**300**	8	25.74	0.48	161.1	25.7778	0.2478	165.613
343	4.09	42	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**300**	8.5	27.34	0.54	121	27.5056	0.2401	129.058
344	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**325**	9.97	43.25	0	45.3	43.5925	0.2294	37.616
345	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**325**	7.5	34.36	0.14	82.9	34.7368	0.2507	67.1853
346	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**325**	8.5	38.37	0.09	60.5	38.1695	0.232	49.0806
347	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**390**	10.27	48.70	0	55.4	47.7878	0.3771	52.8819
348	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**390**	7.5	37.64	0.01	119.8	37.6528	0.4048	120.183
349	4.09	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**390**	9.5	46.02	0	63.8	46.145	0.3696	70.4881
350	4.09	42	399	175	2	2.126	45	45	12	15.5	45.00	0.1	0.18	0.1	50	**390**	9	28.72	1.1	272	29.1417	1.1042	267.962
351	4.09	42	399	175	2	2.126	45	45	14	21.4	38.57	0.1	0.18	0.1	50	**390**	9	24.56	0.741	144.9	23.96	0.7527	130.083
352	4.09	42	399	175	2	2.126	45	35	14	21.4	30.00	0.1	0.18	0.1	50	**390**	9	25.41	2.356	138.6	25.6268	2.0735	136.138
353	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**300**	5.5	28.44	0.14	95.7	28.6276	0.1768	102.453
354	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**300**	6.5	31.82	0.29	70.8	31.2167	0.1461	77.601
355	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**300**	7.5	34.85	0.34	54.9	34.1049	0.122	66.7399
356	4.2	42	283	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**300**	7	31.34	0.173	68	32.5215	0.1331	71.1696
357	4.2	42	283	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	60	**300**	7	32.06	0	89	31.9755	0.0596	91.6423
358	4.2	42	283	175	2	2.126	20	20	12	15.5	20.00	0.1	0.25	0.1	60	**300**	7	35.31	0.057	73.3	34.6754	0.1988	75.4214
359	4.2	42	283	175	2	2.126	40	40	12	15.5	40.00	0.1	0.25	0.1	60	**300**	7	27.67	0.422	84.9	28.0877	0.246	85.7187
360	4.2	42	283	175	2	2.126	40	40	14	21.4	34.29	0.1	0.25	0.1	60	**300**	7	24.74	0.185	75.6	24.711	0.1229	71.7641

Table VI-15 Training data set for Q4 (continued)

361	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**350**	5.5	30.11	0.32	145.9	30.1916	0.3086	156.353
362	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**350**	6.5	32.32	0.57	98.9	32.2258	0.2414	99.3847
363	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**350**	7.5	34.96	0.73	73.1	35.1818	0.185	77.2659
364	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	60	**350**	7	32.85	0.088	131.9	32.8779	0.0917	113.569
365	4.2	42	283.3	175	2	2.126	20	20	12	15.5	20.00	0.1	0.25	0.1	60	**350**	7	37.20	0	103.1	37.3368	0.3627	100.854
366	4.2	42	283.3	175	2	2.126	40	40	12	15.5	40.00	0.1	0.25	0.1	60	**350**	7	28.79	0.617	151.2	29.1687	0.4248	151.3
367	4.2	42	283.3	175	2	2.126	40	40	12	15.5	40.00	0.1	0.25	0.1	60	**350**	8	30.96	0.636	109.8	30.6915	0.3713	105.578
368	4.2	42	283.3	175	2	2.126	40	40	14	21.4	34.29	0.1	0.25	0.1	60	**350**	7	24.88	0.288	111.1	24.6857	0.1628	100.405
369	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**297.9**	6.5	37.71	0	52.2	37.6988	0.043	52.2288
370	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**297.9**	7	39.73	0	45.4	39.8147	0.0381	47.8428
371	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**297.9**	7.5	41.59	0	40.6	41.4385	0.0339	44.5426
372	6.603	75.438	415	280	2	1.31	28.0	28.0	14	21.4	24.00	0.1	0.2	0.1	45	**300**	7	37.49	0	36.3	37.5491	0.0166	37.3219
373	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**297.9**	6	36.05	0	53.3	35.8302	0.0489	53.8691
374	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**297.9**	7	40.28	0	39.7	40.5915	0.0366	46.7905
375	6.603	75.438	415.5	280	2	1.31	18.0	18.0	14	21.4	15.43	0.1	0.2	0.1	60	**300**	7	34.96	0	42	34.8915	0.016	43.2818
376	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**357.4**	7	40.04	0	65.4	40.2504	0.0801	68.1689
377	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**357.4**	7.5	41.98	0	56.5	41.89	0.0762	57.3959
378	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**357.4**	6	38.13	0	74.4	38.2184	0.0847	72.108
379	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**357.4**	6.5	40.04	0	60.8	39.9563	0.0785	65.3288
380	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**357.4**	7	41.79	0	52.1	41.6091	0.073	43.966
381	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**252.9**	7.81	39.91	0	22.7	39.165	0.043	31.7082
382	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**252.9**	5	21.23	0	77.4	21.4192	0.0673	68.0605
383	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**252.9**	6	26.49	0	36.7	26.7168	0.0545	43.3644
384	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**300**	5.5	23.09	0	108.8	23.2595	0.1187	105.599
385	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**300**	6	25.63	0	69.9	25.4051	0.1227	79.4639
386	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**300**	6.5	27.71	0	53.9	27.7954	0.1254	44.7413
387	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**303.5**	5	22.40	0	186.9	22.592	0.1103	185.818
388	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**303.5**	6	27.70	0	56	27.1679	0.0919	61.3403
389	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**303.5**	7	31.00	0	38	32.1213	0.0764	43.6706
390	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**354.1**	8.46	47.57	0	34.7	46.8708	0.1296	22.7
391	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**354.1**	6	28.68	0	94.2	27.7618	0.1962	93.1411
392	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**354.1**	7	32.19	0.14	55.2	32.6429	0.1669	56.7551
393	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**360**	6	26.18	0	184.3	25.881	0.1856	185.058
394	7	59.99	400	175	1.5	2	72.18	72.18	12	15.5	72.18	0.1	0.18288	0.1524	91	**360**	6.5	28.22	0	112.5	28.403	0.1939	113.314
395	7	70	397	175	2	1.5	65.00	65.00	12	15.5	65.00	0.1	0.18	0.1	65	**300**	6	31.22	0	52.5	31.0512	0.0404	51.4947
396	7	70	397	175	2	1.5	65.00	65.00	12	15.5	65.00	0.1	0.18	0.1	65	**300**	7	34.97	0	41.4	34.8614	0.0425	42.7525
397	7	70	397	175	2	1.5	65.00	65.00	12	15.5	65.00	0.1	0.18	0.1	65	**300**	8	38.42	0	34.5	38.4415	0.0431	33.1655
398	7	70	397	175	2	2.126	65.00	65.00	12	15.5	65.00	0.1	0.18	0.1	65	**300**	7	35.69	0.055	30.8	35.7242	0.0747	30.0726
399	7	70	397	175	2	2.126	50.00	45.00	12	15.5	45.00	0.1	0.18	0.1	70	**300**	7	33.26	0.253	35.8	33.5794	0.1399	27.3003
400	7	70	397	175	2	2.126	30.00	30.00	12	15.5	30.00	0.1	0.18	0.1	65	**300**	7	36.43	0	35.9	36.2002	0.0921	27.1818
401	7	70	397	175	2	2.4	65.00	65.00	14	21.4	55.71	0.1	0.18	0.1	50	**300**	7	29.06	0	32.3	29.0314	0.0424	36.7968
402	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	6.5	31.11	0	76.3	31.0289	0.088	74.3726
403	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	7.5	33.57	0	62.3	34.1532	0.0782	60.4707
404	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	8.5	35.66	0	53.4	36.215	0.0768	53.6057
405	4	42.4	415	430	2	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	7.5	28.70	0.003	64	29.2331	0.0862	60.778
406	4	42.4	415	430	2	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	8.5	31.19	0	54.8	31.2086	0.0803	55.0006
407	4	42.4	415	430	2	0.9	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	6.5	30.76	0	107.6	30.6562	0.0357	99.8589
408	4	42.4	415	430	2	0.9	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	8.5	36.75	0	61.2	37.3919	0.0293	64.0407
409	4	42.4	415	430	2	0.9	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	6.5	27.82	0	90.8	27.5651	0.034	86.6531
410	4	42.4	415	430	2	0.9	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	7.5	30.74	0	69.2	29.8942	0.0334	68.3886

Table VI-15 Training data set for Q4 (continued)

411	4	42.4	415	430	3.5	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	6.5	30.29	0	80.7	30.3875	0.086	82.8108
412	4	42.4	415	430	3.5	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	7.5	34.07	0.344	62.6	33.6605	0.0669	69.0606
413	4	42.4	415	430	3.5	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	8.5	36.32	0.372	53.3	35.9955	0.0587	61.6477
414	4	42.4	415	430	3.5	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	7.5	27.77	0	65.5	27.5438	0.0692	62.4887
415	4	42.4	415	430	3.5	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	8.5	30.23	0	56.3	30.1408	0.0702	57.6472
416	4	42.4	415	430	2	2.126	50	50	12	15.5	50.00	0.1	0.19	0.1	77	**300**	6.5	26.89	0.235	91.2	26.7091	0.2629	97.1587
417	4	42.4	415	430	2	2.126	50	50	12	15.5	50.00	0.1	0.19	0.1	77	**300**	8.5	32.09	0.227	58	32.5286	0.2326	63.0135
418	4	42.4	415	430	2	2.126	50	50	14	21.4	42.86	0.1	0.19	0.1	77	**300**	6.5	24.43	0.136	77.9	24.0279	0.1679	91.7912
419	4	42.4	415	430	2	2.126	50	50	14	21.4	42.86	0.1	0.19	0.1	77	**300**	7.5	27.01	0.118	63.1	27.1527	0.1639	66.731
420	4	42.4	415	430	2	2.126	24	20	12	15.5	20.00	0.1	0.19	0.1	55	**300**	6.5	31.15	0.459	66.7	31.0628	0.155	60.4921
421	4	42.4	415	430	2	2.126	24	20	12	15.5	20.00	0.1	0.19	0.1	55	**300**	7.5	33.43	0.474	54.3	33.604	0.1386	52.4073
422	4	42.4	415	430	2	2.126	24	20	12	15.5	20.00	0.1	0.19	0.1	55	**300**	8.5	35.42	0.477	46.9	35.2927	0.1369	48.3493
423	4	42.4	415	430	2	2.126	24	20	14	21.4	17.14	0.1	0.19	0.1	55	**300**	7.5	28.27	0.272	55.7	28.8588	0.2076	53.6518
424	4	42.4	415	430	2	2.126	24	20	14	21.4	17.14	0.1	0.19	0.1	55	**300**	8.5	30.69	0.318	48	30.1477	0.1782	50.921
425	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	7	25.64	0.42	54.3	25.4403	0.4052	59.826
426	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**300**	7	29.02	0.528	52.8	28.9133	0.7232	58.8042
427	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**300**	8	31.01	0.515	44	31.0285	0.7151	47.1562
428	4	42.4	415	430	2	0.9	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	7	24.85	0.05	76.4	25.8384	0.1083	67.4222
429	4	42.4	415	430	2	0.9	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**300**	7	31.57	0	79.9	31.2375	0.1608	72.5644
430	4	42.4	415	430	2	0.9	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**300**	8	34.50	0.053	65.6	34.2778	0.153	55.4805
431	4	42.4	415	430	3.5	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	7	24.86	0.39	55	24.8348	0.3124	60.5573
432	4	42.4	415	430	3.5	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**300**	7	27.93	0.455	53.8	28.366	0.5942	61.2236
433	4	42.4	415	430	3.5	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**300**	8	30.32	0.425	45.4	30.3638	0.518	50.2204
434	4	42.4	415	430	2	2.126	30	20	14	21.4	17.14	0.12	0.2	0.1	20	**300**	7	25.91	1.08	51.8	25.3504	1.0036	52.7526
435	4	42.4	415	430	2	2.126	30	20	12	15.5	20.00	0.12	0.2	0.1	20	**300**	7	29.96	1.45	50.7	30.1652	1.3095	50.7486
436	4	42.4	415	430	2	2.126	30	20	12	15.5	20.00	0.12	0.2	0.1	20	**300**	8	32.14	1.44	42.5	32.2176	1.3374	43.7296
437	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	70	**300**	7	26.58	0.011	72.2	26.7624	0.1323	72.2346
438	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	70	**300**	7	30.27	0.116	72	30.5311	0.1515	77.705
439	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	70	**300**	8	32.56	0.124	59.9	32.3775	0.1381	61.5306
440	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	8.2	32.73	0.176	65.2	32.573	0.2422	60.9226
441	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	7.5	31.16	0.165	75.4	30.7819	0.2334	69.5632
442	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	8.5	33.35	0.18	62	33.1807	0.2493	58.2839
443	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	6.5	24.78	0.03	86.8	24.7781	0.2131	82.8879
444	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	8.5	29.77	0	58.8	29.7235	0.1547	59.1331
445	4	42.4	227	530	2	0.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	6.5	30.69	0	154.8	30.5583	0.0908	143.294
446	4	42.4	227	530	2	0.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	7.5	33.81	0.043	99	33.9542	0.0834	109.176
447	4	42.4	227	530	2	0.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	6.5	27.81	0.036	109.6	28.2281	0.0763	119.284
448	4	42.4	227	530	2	0.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	7.5	30.79	0.033	79.2	30.9264	0.0617	93.5026
449	4	42.4	227	530	2	0.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	8.5	33.54	0.028	63.1	32.65	0.0543	78.0672
450	4	42.4	227	530	3.5	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	7.5	30.32	0.139	80.6	30.4242	0.1531	75.5408
451	4	42.4	227	530	3.5	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	8.5	32.38	0.139	66	32.592	0.1584	63.3623
452	4	42.4	227	530	3.5	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	6.5	24.10	0.004	89.2	24.6358	0.1477	84.394
453	4	42.4	227	530	3.5	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	8.5	29.01	0	61	29.0211	0.1133	63.0914
454	4	42.4	227	530	2	1.9	35	32	12	15.5	32.00	0.1	0.15	0.15	65	**325**	6.5	27.59	0.645	94	27.1408	0.4011	86.5013
455	4	42.4	227	530	2	1.9	35	32	12	15.5	32.00	0.1	0.15	0.15	65	**325**	7.5	29.98	0.652	72.7	30.1481	0.3988	69.0816
456	4	42.4	227	530	2	1.9	35	32	14	21.4	27.43	0.1	0.15	0.15	65	**325**	6.5	24.54	0.383	88.5	24.4553	0.3725	79.9988
457	4	42.4	227	530	2	1.9	35	32	14	21.4	27.43	0.1	0.15	0.15	65	**325**	7.5	27.12	0.351	70.7	27.4822	0.3323	67.7642
458	4	42.4	227	530	2	1.9	35	32	14	21.4	27.43	0.1	0.15	0.15	65	**325**	8.5	29.45	0.324	59.4	29.7766	0.2696	59.2343
459	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**325**	7.5	27.72	0.153	121.3	27.9249	0.1882	126.633
460	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**325**	8.5	30.00	0.152	95.4	29.5321	0.144	94.1787

Table VI-15 Training data set for Q4 (continued)

461	4	42.4	227	530	3.5	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**325**	6.5	26.22	0.166	171.5	26.2839	0.228	163.75
462	4	42.4	227	530	3.5	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**325**	8.5	31.30	0.171	93.1	31.2859	0.1741	88.3631
463	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	7.5	36.28	0.13	93.9	36.501	0.119	86.1041
464	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	8.5	38.63	0.15	76.8	38.4981	0.1083	75.2762
465	4	42.4	415	430	2	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**360**	8.5	31.65	0.11	74.1	31.767	0.1694	68.4063
466	4	42.4	415	430	2	1.3	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	7.5	34.48	0	124.6	34.008	0.062	98.0205
467	4	42.4	415	430	2	1.3	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	8.5	37.42	0	99.2	37.3303	0.0547	103.836
468	4	42.4	415	430	2	1.3	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**360**	8.5	31.78	0.023	89.8	31.8953	0.072	79.5926
469	4	42.4	415	430	3.5	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	7.5	35.50	0.084	99.5	35.6924	0.0987	94.8708
470	4	42.4	415	430	3.5	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	8.5	37.80	0.1	81.3	38.0728	0.0824	87.3269
471	4	42.4	415	430	3.5	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**360**	8.5	30.69	0.08	75.9	30.6416	0.145	78.7915
472	4	42.4	415	430	2	2.126	24	22	12	15.5	22.00	0.1	0.19	0.1	77	**360**	7.5	37.20	0.534	91.2	36.8696	0.1554	82.267
473	4	42.4	415	430	2	2.126	24	22	12	15.5	22.00	0.1	0.19	0.1	77	**360**	8.5	39.80	0.555	74.2	38.7799	0.1408	74.2152
474	4	42.4	415	430	2	2.126	24	22	14	21.4	18.86	0.1	0.19	0.1	77	**360**	8.5	31.66	0.363	72.5	31.6179	0.2084	66.4002
475	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	45	**360**	7.5	34.59	0.285	77.7	34.9931	0.1547	75.5337
476	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	45	**360**	8.5	36.76	0.289	64.3	36.6838	0.1467	63.8516
477	4	42.4	415	430	2	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	45	**360**	8.5	30.57	0.208	63.2	30.3721	0.2976	62.6904
478	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	6	23.03	0.84	105	22.6992	0.7301	110.275
479	4	42.4	415	430	2	2.126	50	50	14	21.4	42.86	0.12	0.2	0.1	20	**360**	6	22.53	1.573	123.9	23.045	1.4756	122.628
480	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**360**	6	30.54	1.15	115.8	30.1798	1.1705	132.908
481	4	42.4	415	430	2	2.126	50	50	12	15.5	50.00	0.12	0.2	0.1	20	**360**	6	25.59	2.311	177.7	25.6103	2.0083	178.024
482	4	42.4	415	430	2	2.126	70	70	12	15.5	70.00	0.12	0.2	0.1	20	**360**	6	24.25	2.8	231	24.3844	2.602	232.244
483	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	8	28.23	0.72	63.2	28.4657	0.608	62.6104
484	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**360**	7	32.52	1.123	81.7	32.3599	1.1301	85.193
485	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**360**	8	34.17	1.112	64.1	34.0866	1.092	64.6919
486	4	42.4	415	430	2	1.3	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	8	29.96	0.091	82	29.352	0.2266	70.407
487	4	42.4	415	430	2	1.3	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**360**	7	30.52	0.587	106.8	30.6342	0.5685	100.502
488	4	42.4	415	430	2	1.3	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**360**	8	33.25	0.131	81	33.2957	0.5063	78.8703
489	4	42.4	415	430	2.5	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	8	27.90	0.73	63.9	28.2141	0.6	63.6695
490	4	42.4	415	430	2.5	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**360**	7	31.86	1.106	82.4	31.839	1.0825	86.1056
491	4	42.4	415	430	2.5	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	20	**360**	8	33.30	1.064	64.8	33.7046	1.0248	65.7999
492	4	42.4	415	430	2	2.126	30	25	14	21.4	21.43	0.12	0.2	0.1	20	**360**	8	28.25	1.207	61.8	28.3253	0.9528	58.818
493	4	42.4	415	430	2	2.126	30	25	12	15.5	25.00	0.12	0.2	0.1	20	**360**	7	33.03	1.687	78.9	32.6818	1.4809	75.2824
494	4	42.4	415	430	2	2.126	30	25	12	15.5	25.00	0.12	0.2	0.1	20	**360**	8	34.73	1.693	62.3	34.5782	1.4438	62.9766
495	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	50	**360**	8	28.94	0.225	78.1	29.354	0.3267	76.9722
496	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	50	**360**	7	30.77	0.359	108.6	31.1379	0.3672	101.825
497	4	42.4	415	430	2	2.126	30	30	12	15.5	30.00	0.12	0.2	0.1	50	**360**	8	33.10	0.376	82.7	33.0245	0.3206	78.0564
498	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	6.5	30.30	0.272	210.8	32.8948	0.4612	154.74
499	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	7.5	35.19	0.327	101	34.4546	0.4467	124.636
500	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	8.5	35.13	0.325	101.7	34.2894	0.4411	108.106
501	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	7.5	29.81	0.199	86.6	29.2185	0.2198	92.561
502	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	8.5	29.82	0.199	86.1	29.9279	0.1998	81.9972
503	4	42.4	227	530	2	0.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	6.5	38.51	0.198	105	38.2572	0.2227	111.078
504	4	42.4	227	530	2	0.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	8.5	38.55	0.197	105.5	38.3279	0.2062	97.1932
505	4	42.4	227	530	2	0.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	6.5	34.46	0.155	87.8	34.2696	0.1289	93.6072
506	4	42.4	227	530	2	0.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	7.5	34.49	0.156	87.4	34.5764	0.1025	74.667
507	4	42.4	227	530	3.5	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	6.5	34.56	0.202	105	34.0927	0.31	114.856
508	4	42.4	227	530	3.5	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	7.5	34.42	0.203	106.5	35.0073	0.2849	97.7867
509	4	42.4	227	530	3.5	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	8.5	34.58	0.205	104.8	34.4214	0.2851	96.0785
510	4	42.4	227	530	3.5	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	7.5	29.20	0.102	88.4	28.9219	0.221	94.0607

Table VI-15 Training data set for Q4 (continued)

511	4	42.4	227	530	3.5	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	8.5	29.21	0.065	89.1	29.4069	0.2034	82.655
512	4	42.4	227	530	2	1.9	35	30	12	15.5	30.00	0.1	0.15	0.15	95	**390**	6.5	35.97	1.293	94.9	34.6745	0.791	111.333
513	4	42.4	227	530	2	1.9	35	30	12	15.5	30.00	0.1	0.15	0.15	95	**390**	8.5	35.13	0.325	101.7	35.8147	0.7439	101.168
514	4	42.4	227	530	2	1.9	35	30	14	21.4	25.71	0.1	0.15	0.15	95	**390**	6.5	29.47	0.643	86	29.6992	0.325	103.147
515	4	42.4	227	530	2	1.9	35	30	14	21.4	25.71	0.1	0.15	0.15	95	**390**	7.5	29.98	0.599	83.8	30.3972	0.3318	84.718
516	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	65	**390**	6.5	34.36	1.454	100	34.04	0.3593	116.855
517	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	65	**390**	7.5	32.88	0.54	102.6	32.6507	0.3456	103.698
518	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	65	**390**	8.5	29.61	0.218	88.3	30.7133	0.3449	99.1385
519	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	65	**390**	7.5	29.44	0.218	89.7	28.7698	0.2807	87.7459
520	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	65	**390**	8.5	29.61	0.218	88.3	29.9578	0.2639	80.6661
521	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**390**	8.85	29.76	0.3	189.2	30.0537	0.3756	189.091
522	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**252.9**	5	24.77	0.054	68.1	24.7531	0.3156	73.8502
523	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**252.9**	6	26.89	0.06	51.5	26.1994	0.3207	57.1052
524	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**252.9**	7	28.71	0.064	42.3	28.8182	0.3185	47.3078
525	4	43.24	381.1	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**252.9**	6	19.96	0.129	52.2	19.7992	0.2177	57.1194
526	4	43.24	381.1	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**252.9**	7	22.43	0.133	43.2	22.6096	0.202	48.3683
527	4	43.24	381.1	175	2	3.2	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	50	**252.9**	5	24.93	0.189	67.6	25.0432	0.3658	71.8671
528	4	43.24	381.1	175	2	3.2	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	50	**252.9**	7	29.01	0.202	41.7	29.5166	0.3673	45.8664
529	4	43.24	381.1	175	2	3.2	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	50	**252.9**	5	17.34	0.262	67.1	17.5217	0.3008	73.2878
530	4	43.24	381.1	175	2	3.2	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	50	**252.9**	6	20.08	0.256	51.5	20.2878	0.2676	55.1822
531	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**270**	5.5	22.69	0.438	111.3	22.3362	0.4114	114.509
532	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**270**	6.5	25.07	0.471	77.6	24.9144	0.4071	86.4375
533	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**270**	7.5	27.71	0.5	61.4	27.8314	0.4048	62.1214
534	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**270**	6.5	22.89	0.114	69.2	22.7777	0.2877	70.2178
535	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**270**	7.5	25.45	0.084	56.4	25.2348	0.3402	59.6505
536	4	43.24	400	530	2	2.796	60	40	12	15.5	40.00	0.1	0.22	0.1	95	**270**	5.5	24.07	3.123	95.6	23.7409	2.9841	91.4131
537	4	43.24	400	530	2	2.796	60	40	12	15.5	40.00	0.1	0.22	0.1	95	**270**	7.5	28.11	3.237	55.4	28.5561	2.9222	52.7877
538	4	43.24	400	530	2	2.796	60	40	14	21.4	34.29	0.1	0.22	0.1	95	**270**	5.5	20.27	1.949	82.1	20.5035	1.8547	85.3077
539	4	43.24	400	530	2	2.796	60	40	14	21.4	34.29	0.1	0.22	0.1	95	**270**	6.5	23.14	1.812	62.3	23.015	2.0752	64.8722
540	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	45	**270**	5.5	21.52	1.318	85	21.7361	0.9985	84.5205
541	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	45	**270**	6.5	24.46	1.302	60.3	24.6488	1.0318	68.4829
542	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	45	**270**	7.5	27.09	1.279	48.2	27.3388	1.0649	53.511
543	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	45	**270**	6.5	22.51	0.75	54.7	21.8157	0.6586	63.3782
544	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	45	**270**	7.5	25.06	0.643	45.1	24.5722	0.7054	54.7928
545	4	43.24	400	530	2	2.796	60	40	12	15.5	40.00	0.1	0.22	0.1	45	**270**	5.5	22.76	3.222	71.8	22.7898	2.9077	74.614
546	4	43.24	400	530	2	2.796	60	40	12	15.5	40.00	0.1	0.22	0.1	45	**270**	7.5	27.32	3.325	43.2	27.1045	3.1338	47.7587
547	4	43.24	400	530	2	2.796	60	40	14	21.4	34.29	0.1	0.22	0.1	45	**270**	5.5	19.81	2.19	66.5	20.0146	2.2104	70.6041
548	4	43.24	400	530	2	2.796	60	40	14	21.4	34.29	0.1	0.22	0.1	45	**270**	6.5	22.67	2.072	51	22.6273	2.3468	58.1178
549	4	43.24	400	530	2	1.66	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**270**	5.5	23.73	0.081	150.6	23.7333	0.1544	145.474
550	4	43.24	400	530	2	1.66	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**270**	6.5	26.97	0.077	101.2	27.0949	0.1314	100.78
551	4	43.24	400	530	2	1.66	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**270**	7.5	29.85	0.073	78.2	30.0215	0.1128	68.2637
552	4	43.24	400	530	2	1.66	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**270**	6.5	24.31	0	88.5	24.6212	0.1015	69.5348
553	4	43.24	400	530	2	1.66	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**270**	7.5	26.99	0	71.2	27.4255	0.1147	58.3374
554	4	43.24	400	530	2	1.66	60	40	12	15.5	40.00	0.1	0.22	0.1	95	**270**	5.5	24.27	1.796	118	24.5068	1.8809	113.678
555	4	43.24	400	530	2	1.66	60	40	12	15.5	40.00	0.1	0.22	0.1	95	**270**	7.5	30.59	1.789	66.5	30.0027	1.53	57.5589
556	4	43.24	400	530	2	1.66	60	40	14	21.4	34.29	0.1	0.22	0.1	95	**270**	5.5	21.98	0.907	104.2	22.2662	0.6945	94.5874
557	4	43.24	400	530	2	1.66	60	40	14	21.4	34.29	0.1	0.22	0.1	95	**270**	6.5	25.21	0.77	78.2	25.0262	0.7456	71.1924
558	4	43.24	400	530	2	1.66	60	60	12	15.5	60.00	0.1	0.22	0.1	45	**270**	5.5	23.13	0.24	104.7	23.1993	0.4495	99.9771
559	4	43.24	400	530	2	1.66	60	60	12	15.5	60.00	0.1	0.22	0.1	45	**270**	6.5	26.35	0.209	73	26.5676	0.3874	76.0657
560	4	43.24	400	530	2	1.66	60	60	12	15.5	60.00	0.1	0.22	0.1	45	**270**	7.5	29.15	0.193	57.9	29.3197	0.3396	57.8452

Table VI-15 Training data set for Q4 (continued)

561	4	43.24	400	530	2	1.66	60	60	14	21.4	51.43	0.1	0.22	0.1	45	**270**	6.5	24.06	0.226	67.3	24.0476	0.2356	63.6593
562	4	43.24	400	530	2	1.66	60	60	14	21.4	51.43	0.1	0.22	0.1	45	**270**	7.5	26.78	0.162	55	27.1487	0.246	54.6659
563	4	43.24	400	530	2	1.66	60	40	12	15.5	40.00	0.1	0.22	0.1	45	**270**	5.5	23.76	1.81	89.5	23.4439	2.0459	96.5532
564	4	43.24	400	530	2	1.66	60	40	12	15.5	40.00	0.1	0.22	0.1	45	**270**	7.5	30.04	2.042	52.3	30.4311	1.8685	54.4016
565	4	43.24	400	530	2	1.66	60	40	14	21.4	34.29	0.1	0.22	0.1	45	**270**	5.5	21.66	1.157	80.3	21.9561	1.1557	81.2775
566	4	43.24	400	530	2	1.66	60	40	14	21.4	34.29	0.1	0.22	0.1	45	**270**	6.5	24.87	1.149	61.6	24.8823	1.0985	64.7433
567	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**280**	5	19.12	0.75	91.5	19.1674	0.7828	93.5891
568	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**280**	6	22.26	0.77	64.8	22.2098	0.7904	68.41
569	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**280**	7	25.00	0.75	52	25.1434	0.8204	55.2145
570	4	43.24	400	530	2	2.796	35	28	12	15.5	28.00	0.12	0.15	0.1	92	**280**	6	26.70	0.935	61.7	26.5586	0.6052	65.5443
571	4	43.24	400	530	2	2.796	35	28	12	15.5	28.00	0.12	0.15	0.1	92	**280**	7	29.21	0.915	48.9	29.4069	0.547	52.6663
572	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**285**	6	20.08	3.047	40.2	20.0663	3.2241	33.4519
573	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**285**	8	24.55	3.152	26	24.5542	2.604	34.0293
574	4	43.24	379.9	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**285**	6	18.35	2.937	39.2	18.2624	2.3751	39.6136
575	4	43.24	379.9	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**285**	7	20.66	2.65	31.3	20.8405	1.9406	30.79
576	4	43.24	379.9	175	2	2	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**285**	6	23.32	3.214	48.3	23.2946	3.0561	50.4645
577	4	43.24	379.9	175	2	2	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**285**	7	26.19	3.024	37.3	26.1799	2.9429	37.9547
578	4	43.24	379.9	175	2	2	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**285**	8	28.83	2.63	30.9	28.7648	2.9606	28.2025
579	4	43.24	379.9	175	2	2	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**285**	7	24.17	3.925	38.7	24.1746	3.3732	32.0779
580	4	43.24	379.9	175	2	2	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**285**	8	26.70	4.129	32.7	26.7157	4.1733	34.9362
581	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**297.9**	6	23.10	0.93	168.6	23.0818	0.8206	172.528
582	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**297.9**	8	28.39	1.03	77.4	28.167	0.9819	76.1931
583	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**297.9**	5.5	22.24	0.79	174.6	22.6104	0.6705	172.55
584	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**297.9**	6.5	25.26	0.87	104.4	24.8487	0.6504	99.7334
585	4	43.24	416	530	2	2	75.46	75.46	14	21.4	64.68	0.1	0.232	0.101	63	**297.9**	6	22.27	0.346	119.8	22.13	0.4179	116.474
586	4	43.24	416	530	2	2	75.46	75.46	14	21.4	64.68	0.1	0.232	0.101	63	**297.9**	7	25.12	0.291	86.3	24.9466	0.3706	78.2676
587	4	43.24	416	530	2	2	75.46	75.46	14	21.4	64.68	0.1	0.232	0.101	63	**297.9**	8	27.66	0.223	69.5	27.7798	0.3552	62.4593
588	4	43.24	416	530	2	2.794	49.21	49.21	14	21.4	42.18	0.1	0.232	0.101	62	**297.9**	6.5	23.03	0.548	77.6	23.1313	0.5114	74.0862
589	4	43.24	416	530	2	2.794	49.21	49.21	14	21.4	42.18	0.1	0.232	0.101	62	**297.9**	7.5	25.61	0.456	62.1	25.9115	0.4589	61.0648
590	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**297.9**	5.5	27.74	0	96.6	28.0579	0.0846	84.0603
591	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**297.9**	6.14	29.78	0	77.6	29.8678	0.0804	70.6699
592	4	43.24	228	408	2	1.9	21.33	21.33	12	15.5	21.33	0.1	0.122	0.101	90	**297.9**	6.1	27.62	0.16	82.3	26.9886	0.1115	73.4
593	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**297.9**	5.5	23.02	0.114	126.2	23.1792	0.266	129.229
594	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**297.9**	6.5	26.11	0.104	84.5	25.9597	0.2207	86.839
595	4	43.24	228	408	2	1.9	44.29	44.29	14	21.4	37.96	0.1	0.152	0.101	95	**297.9**	5.5	20.65	0.053	107.3	20.5703	0.2056	105.962
596	4	43.24	228	408	2	1.9	44.29	44.29	14	21.4	37.96	0.1	0.152	0.101	95	**297.9**	6	22.17	0.031	90.3	22.2817	0.1915	88.0474
597	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	45	**297.9**	5.5	22.48	0.524	108.3	22.4206	0.6856	106.78
598	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	45	**297.9**	6	24.06	0.493	88	24.0135	0.6638	85.869
599	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	45	**297.9**	6.5	25.54	0.466	74.6	25.6357	0.6488	72.9976
600	4	43.24	228	408	2	1.9	44.29	44.29	14	21.4	37.96	0.1	0.152	0.101	45	**297.9**	6	21.87	0.236	79.6	21.7492	0.3332	76.5877
601	4	43.24	228	408	2	1.9	44.29	44.29	14	21.4	37.96	0.1	0.152	0.101	45	**297.9**	6.5	23.32	0.225	69.3	23.2385	0.3126	66.4209
602	4	43.24	228	408	2	1.9	44.29	29.5	12	15.5	29.53	0.1	0.152	0.101	45	**297.9**	5.5	23.18	2.455	93.9	23.525	2.2181	90.1381
603	4	43.24	228	408	2	1.9	44.29	29.5	12	15.5	29.53	0.1	0.152	0.101	45	**297.9**	6.5	26.24	2.205	66.3	26.4669	2.0718	65.9263
604	4	43.24	228	408	2	1.9	44.29	29.5	14	21.4	25.31	0.1	0.152	0.101	45	**297.9**	5.5	20.85	1.514	88.5	20.7796	1.5752	76.5586
605	4	43.24	228	408	2	1.9	44.29	29.5	14	21.4	25.31	0.1	0.152	0.101	45	**297.9**	6	22.43	1.488	74.4	22.5813	1.5031	65.8911
606	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**297.9**	6.17	24.54	1.23	94.4	24.1198	0.9662	86.3814
607	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**297.9**	5.5	22.37	1.31	134.4	22.5832	0.9881	118.436
608	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	5	24.70	0.237	130.3	24.492	0.4152	135.325
609	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	7	29.02	0.222	64.2	28.723	0.3024	69.7457
610	4	43.24	415	430	2	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	5	19.39	0.218	119.8	19.0592	0.2946	110.467

Table VI-15 Training data set for Q4 (continued)

611	4	43.24	415	430	2	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	6	22.54	0.205	80.1	22.6013	0.2348	80.0619
612	4	43.24	415	430	2.5	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	5	24.39	0.229	131.3	24.1309	0.427	137.901
613	4	43.24	415	430	2.5	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	6	26.71	0.231	83	26.6882	0.3539	93.8176
614	4	43.24	415	430	2.5	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	7	28.90	0.213	64.4	28.8881	0.2892	71.4436
615	4	43.24	415	430	2.5	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	6	22.26	0.198	80.2	22.4363	0.2111	81.0638
616	4	43.24	415	430	2.5	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	7	25.16	0.153	64.6	25.1757	0.1702	65.2722
617	4	43.24	415	430	2	1.31	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	5	22.72	0.116	184.8	22.8624	0.2016	178.812
618	4	43.24	415	430	2	1.31	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	7	29.26	0.094	79.7	29.4613	0.1141	80.7929
619	4	43.24	415	430	2	1.31	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	5	20.38	0.032	164.4	20.1628	0.1122	143.572
620	4	43.24	415	430	2	1.31	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	6	23.75	0.022	105.5	23.2834	0.0916	93.8083
621	4	43.24	415	430	2	2.128	50	50	12	15.5	50.00	0.1	0.225	0.1	37	**300**	5	21.07	1.111	180.8	21.7609	0.7603	174.964
622	4	43.24	415	430	2	2.128	50	50	12	15.5	50.00	0.1	0.225	0.1	37	**300**	6	24.23	0.946	100.8	24.2734	0.7673	104.178
623	4	43.24	415	430	2	2.128	50	50	12	15.5	50.00	0.1	0.225	0.1	37	**300**	7	27.18	0.815	72.8	26.609	0.7588	76.6954
624	4	43.24	415	430	2	2.128	50	50	14	21.4	42.86	0.1	0.225	0.1	37	**300**	6	22.00	0.35	86.4	21.8555	0.4418	87.0619
625	4	43.24	415	430	2	2.128	50	50	14	21.4	42.86	0.1	0.225	0.1	37	**300**	7	24.83	0.335	65.8	24.628	0.3739	66.2589
626	4	43.24	415	430	2	2.128	50	40	12	15.5	40.00	0.1	0.225	0.1	37	**300**	5	22.50	2.311	151.3	21.9378	1.4405	147.363
627	4	43.24	415	430	2	2.128	50	40	12	15.5	40.00	0.1	0.225	0.1	37	**300**	7	27.21	1.858	66.8	27.2768	1.5054	74.8253
628	4	43.24	415	430	2	2.128	50	40	14	21.4	34.29	0.1	0.225	0.1	37	**300**	5	18.82	1.276	121.5	19.0761	1.3581	127.61
629	4	43.24	415	430	2	2.128	50	40	14	21.4	34.29	0.1	0.225	0.1	37	**300**	6	22.13	0.933	82.2	21.7788	1.1754	86.1255
630	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	70	**300**	5	24.60	0.097	173.6	24.9946	0.2306	162.715
631	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	70	**300**	6	27.74	1.102	109.2	27.5461	0.1772	117.001
632	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	70	**300**	7	30.50	0.112	81.8	30.2428	0.1382	87.0969
633	4	43.24	415	430	2	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	70	**300**	6	23.23	0.019	103.8	23.7224	0.1042	97.9981
634	4	43.24	415	430	2	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	70	**300**	7	26.13	0	78.9	25.8701	0.0882	74.5413
635	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	5	20.94	0.59	226.5	21.3975	0.7135	221.039
636	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	7	25.22	0.67	77.1	25.1863	0.8898	71.6752
637	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	6.5	20.17	0.8	65.3	20.1974	0.743	65.8889
638	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	7.5	22.41	0.8	52.5	22.2922	0.6844	59.4692
639	4	43.24	380	175	2.5	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	6.5	24.71	0.676	83.4	24.0774	0.7952	82.4492
640	4	43.24	380	175	2.5	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	7.5	26.44	0.699	63.8	25.9326	0.8651	57.0859
641	4	43.24	380	175	2.5	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	8.5	28.03	0.719	52.6	28.0427	0.9043	47.6589
642	4	43.24	380	175	2.5	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	7.5	21.73	0.892	55.4	22.0243	0.7168	54.6307
643	4	43.24	380	175	2.5	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	8.5	23.71	0.887	46.7	23.9053	0.7186	50.5438
644	4	43.24	380	175	2	2	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	6.5	25.03	0.159	116.6	25.27	0.1909	115.856
645	4	43.24	380	175	2	2	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	8.5	30.14	0.16	68.8	30.0889	0.1921	63.0055
646	4	43.24	380	175	2	2	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	6.5	22.83	0.17	94.3	22.9987	0.1274	86.9559
647	4	43.24	380	175	2	2	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	7.5	26.42	0.143	74.2	25.9934	0.1166	68.3618
648	4	43.24	380	175	2	2	60	57	12	15.5	57.00	0.1	0.18	0.12	50	**300**	6.5	24.71	0.888	98.3	24.7478	0.8221	104.859
649	4	43.24	380	175	2	2	60	57	12	15.5	57.00	0.1	0.18	0.12	50	**300**	7.5	27.38	0.66	74.1	27.2487	0.873	79.8439
650	4	43.24	380	175	2	2	60	57	12	15.5	57.00	0.1	0.18	0.12	50	**300**	8.5	29.83	0.577	60	29.8929	0.896	69.6235
651	4	43.24	380	175	2	2	60	60	14	21.4	51.43	0.12	0.18	0.18	50	**300**	7.5	25.13	0.281	77.4	25.1159	0.2098	66.918
652	4	43.24	380	175	2	2	60	60	14	21.4	51.43	0.12	0.18	0.18	50	**300**	8.5	27.49	0.224	64.6	27.2888	0.1886	58.7822
653	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**300**	6	25.42	0.36	172.1	25.8675	0.6356	163.711
654	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**300**	8	30.18	0.43	88.4	30.2334	0.6337	85.4801
655	4	43.24	400	530	2	2.796	50	50	14	21.4	42.86	0.1	0.25	0.2	91	**300**	6	21.84	0.14	121	21.6086	0.334	124.945
656	4	43.24	400	530	2	2.796	50	50	14	21.4	42.86	0.1	0.25	0.2	91	**300**	7	24.59	0.141	89.7	24.5419	0.3327	96.9095
657	4	43.24	400	530	2	1.66	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**300**	6	26.00	0.076	235.3	26.2235	0.2604	235.007
658	4	43.24	400	530	2	1.66	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**300**	7	29.11	0.088	148.8	29.2037	0.237	149.096
659	4	43.24	400	530	2	1.66	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**300**	8	31.91	0.107	111.3	32.2504	0.2306	108.826
660	4	43.24	400	530	2	1.66	50	50	14	21.4	42.86	0.1	0.25	0.2	91	**300**	7	26.06	0	118.4	26.0695	0.1049	116.494

Table VI-15 Training data set for Q4 (continued)

661	4	43.24	400	530	2	1.66	50	50	14	21.4	42.86	0.1	0.25	0.2	91	**300**	8	28.64	0	93.7	28.7652	0.0999	95.5792
662	4	43.24	400	530	2	2.796	70	70	12	15.5	70.00	0.1	0.25	0.2	91	**300**	6	23.47	0.595	214	23.7794	0.6666	218.354
663	4	43.24	400	530	2	2.796	70	70	12	15.5	70.00	0.1	0.25	0.2	91	**300**	8	28.77	0.6	97.2	28.3061	0.7437	94.9475
664	4	43.24	400	530	2	2.796	70	70	14	21.4	60.00	0.1	0.25	0.2	91	**300**	6	21.41	0.403	136.6	21.2876	0.4974	140.734
665	4	43.24	400	530	2	2.796	70	70	14	21.4	60.00	0.1	0.25	0.2	91	**300**	7	24.13	0.327	97.6	24.0182	0.5272	103.366
666	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	45	**300**	6	24.26	0.967	132.9	24.299	0.8821	153.274
667	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	45	**300**	7	26.26	0.979	93	26.6348	0.9383	108.069
668	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	45	**300**	8	28.77	0.984	73.2	28.8361	1.0027	85.1733
669	4	43.24	400	530	2	2.796	50	50	14	21.4	42.86	0.1	0.25	0.2	45	**300**	7	24.13	0.867	82.5	24.1282	0.6966	94.0461
670	4	43.24	400	530	2	2.796	50	50	14	21.4	42.86	0.1	0.25	0.2	45	**300**	8	26.53	0.889	66.8	26.6561	0.6971	82.2155
671	4	43.24	400	530	2	2.796	50	33.333	12	15.5	33.33	0.1	0.25	0.2	91	**300**	6	28.31	3.023	126.2	27.4987	2.733	130.593
672	4	43.24	400	530	2	2.796	50	33.333	12	15.5	33.33	0.1	0.25	0.2	91	**300**	8	32.42	3.241	72.4	32.6151	3.1831	77.986
673	4	43.24	400	530	2	2.796	50	33.333	14	21.4	28.57	0.1	0.25	0.2	91	**300**	6	22.29	2.161	105.8	21.9814	2.1509	113.628
674	4	43.24	400	530	2	2.796	50	33.333	14	21.4	28.57	0.1	0.25	0.2	91	**300**	7	25.03	2.224	80.2	24.8185	2.5571	88.3742
675	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	7	24.36	0.71	76.3	24.3905	0.7253	85.645
676	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	8	26.76	0.64	62.3	26.711	0.7205	69.1944
677	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	9	28.97	0.6	53.4	28.4902	0.7678	60.7259
678	4	43.24	400	530	2	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	8	29.18	1.14	71.3	29.5773	1.0369	72.883
679	4	43.24	400	530	2	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	9	31.47	1.174	59.6	31.7568	1.1043	60.1025
680	4	43.24	400	530	3	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	7	23.81	0.581	78.4	24.0025	0.5543	83.2422
681	4	43.24	400	530	3	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	9	28.38	0.555	54.8	28.1605	0.6365	60.8738
682	4	43.24	400	530	3	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	7	27.12	1.158	92.9	26.7995	0.9563	91.2204
683	4	43.24	400	530	3	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	8	29.09	1.157	72.8	29.0776	0.9358	71.1725
684	4	43.24	400	530	2	1.66	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	7	25.92	0.141	99.5	26.1298	0.1662	97.7189
685	4	43.24	400	530	2	1.66	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	8	28.48	0.074	80.5	28.6656	0.1653	77.0793
686	4	43.24	400	530	2	1.66	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	9	30.88	0.019	68.2	30.5893	0.1881	65.4777
687	4	43.24	400	530	2	1.66	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	8	31.27	0.474	90.5	31.2676	0.3033	83.5873
688	4	43.24	400	530	2	1.66	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	9	33.70	0.508	74.5	33.944	0.3044	67.4065
689	4	43.24	400	530	2	1.66	55	50	14	21.4	42.86	0.12	0.22	0.15	45	**300**	7	25.69	0.294	89.8	25.8575	0.5117	93.6581
690	4	43.24	400	530	2	1.66	55	50	14	21.4	42.86	0.12	0.22	0.15	45	**300**	9	30.69	0.241	61.3	30.7443	0.3861	66.2567
691	4	43.24	400	530	2	1.66	55	50	12	15.5	50.00	0.12	0.22	0.15	45	**300**	7	27.91	0.676	101.8	27.5627	0.695	108.76
692	4	43.24	400	530	2	1.66	55	50	12	15.5	50.00	0.12	0.22	0.15	45	**300**	8	30.58	0.617	79.6	30.5332	0.7102	80.1811
693	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**300**	5	25.47	0.32	153.8	25.5558	0.2644	143.006
694	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**300**	6	28.65	0.33	95.3	29.0315	0.2094	91.4951
695	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**300**	7	32.08	0.096	66.9	31.9754	0.1819	70.4124
696	4	43.24	400	530	2	2.796	30	30	14	21.4	25.71	0.1	0.18	0.12	92	**300**	6	22.62	0.078	83.6	22.4651	0.2109	86.0332
697	4	43.24	400	530	2	2.796	30	30	14	21.4	25.71	0.1	0.18	0.12	92	**300**	7	25.43	0.072	65.4	25.2854	0.1924	66.7274
698	4	43.24	400	530	2	2.2	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**300**	5	25.60	0.054	153.5	25.2509	0.1792	156.626
699	4	43.24	400	530	2	2.2	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**300**	7	31.78	0.06	73.9	30.9245	0.1178	72.8129
700	4	43.24	400	530	2	2.2	30	30	14	21.4	25.71	0.1	0.18	0.12	92	**300**	5	20.15	0.028	141.6	20.563	0.1251	143.722
701	4	43.24	400	530	2	2.2	30	30	14	21.4	25.71	0.1	0.18	0.12	92	**300**	6	23.56	0	94.2	23.5218	0.107	88.7676
702	4	43.24	380	175	2	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	5	28.04	0.442	92.5	27.7834	0.7604	100.005
703	4	43.24	380	175	2	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	6	30.62	0.435	65.1	30.138	0.718	69.8215
704	4	43.24	380	175	2	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	7	32.82	0.425	51.6	32.7012	0.6438	53.3819
705	4	43.24	380	175	2	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**300**	6	22.53	0.278	65	22.6311	0.2389	56.5079
706	4	43.24	380	175	2	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**300**	7	24.89	0.272	52.2	24.7819	0.2075	46.1826
707	4	43.24	380	175	2	2.2	40	40	12	15.5	40.00	0.1	0.2	0.1	12	**300**	5	24.64	1.222	98.2	24.4092	1.6841	112.123
708	4	43.24	380	175	2	2.2	40	40	12	15.5	40.00	0.1	0.2	0.1	12	**300**	7	29.57	1.367	51.5	29.5786	1.7081	52.941
709	4	43.24	380	175	2	2.2	40	40	14	21.4	34.29	0.1	0.2	0.1	12	**300**	5	18.93	0.973	92.6	19.134	0.6911	88.2086
710	4	43.24	380	175	2	2.2	40	40	14	21.4	34.29	0.1	0.2	0.1	12	**300**	6	21.73	0.92	65	21.7113	0.5616	54.5752

Table VI-15 Training data set for Q4 (continued)

711	4	43.24	380	175	2.5	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	5	27.84	0.432	91.9	27.7161	0.8163	98.3812
712	4	43.24	380	175	2.5	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	6	30.34	0.426	64.9	30.326	0.7781	68.3766
713	4	43.24	380	175	2.5	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	7	32.38	0.42	51.8	32.9973	0.7007	53.1785
714	4	43.24	380	175	2.5	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**300**	6	22.18	0.28	64.6	22.2729	0.2553	58.4807
715	4	43.24	380	175	2.5	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**300**	7	24.67	0.268	52.1	24.5119	0.2216	47.9906
716	4	43.24	380	175	2.5	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	40	**300**	5	27.14	0.064	117.6	26.7267	0.3055	127.336
717	4	43.24	380	175	2.5	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	40	**300**	7	32.20	0.05	63.3	32.1483	0.2341	67.7207
718	4	43.24	380	175	2.5	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	40	**300**	5	18.46	0.074	110.5	18.565	0.1931	113.062
719	4	43.24	380	175	2.5	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	40	**300**	6	21.57	0.059	78.9	21.6409	0.164	79.1151
720	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	7.24	24.75	0.85	79.2	24.7942	0.8349	82.1024
721	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	5.5	19.98	0.85	143.5	20.1511	0.8762	132.44
722	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	6.5	22.85	0.85	97.1	22.8813	0.8403	101.446
723	4	43.24	400	530	2	2.796	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	5.5	23.23	0.989	191.5	23.0699	0.9828	189.849
724	4	43.24	400	530	2	2.796	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	6.5	25.11	1.033	115.4	25.2399	1.034	121.206
725	4	43.24	400	530	2	2.796	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	7.5	27.63	1.132	84.1	27.5968	1.0838	88.0883
726	4	43.24	400	530	2	2	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	6.5	23.98	0.377	108.8	24.1276	0.2906	113.498
727	4	43.24	400	530	2	2	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	7.5	26.63	0.362	84.1	26.7303	0.2764	84.382
728	4	43.24	400	530	2	2	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	5.5	23.28	0.665	247.3	23.3869	0.5459	247.479
729	4	43.24	400	530	2	2	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	7.5	29.24	0.731	100.3	28.7683	0.5172	100.526
730	4	43.24	400	530	2.5	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	5.5	19.71	0.816	134.7	20.0146	0.7652	128.835
731	4	43.24	400	530	2.5	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	6.5	22.57	0.808	92.8	22.6965	0.7322	99.9756
732	4	43.24	400	530	2.5	2.796	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	5.5	23.17	0.998	197.7	22.92	0.9467	197.641
733	4	43.24	400	530	2.5	2.796	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	6.5	25.05	1.026	117.1	25.0349	0.987	119.348
734	4	43.24	400	530	2.5	2.796	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	7.5	27.31	1.054	85.3	27.354	1.0259	87.9318
735	4	43.24	380	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**300**	6.5	21.30	3.154	40	21.3639	2.9178	32.5208
736	4	43.24	380	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**300**	7	22.43	3.086	35.2	22.6109	2.8479	33.377
737	4	43.24	380	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**300**	6	18.38	31.77	43.9	18.2451	23.4615	35.9707
738	4	43.24	380	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**300**	7	20.69	3.429	34.4	20.8278	3.1618	35.8446
739	4	43.24	380	175	2	2.2	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**300**	6	22.80	3.025	54.6	22.9915	3.2185	49.4327
740	4	43.24	380	175	2	2.2	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**300**	6.5	24.25	3.377	47	24.3724	3.1673	50.2834
741	4	43.24	380	175	2	2.2	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**300**	6	20.88	3.618	52.5	21.1091	3.2451	52.1884
742	4	43.24	380	175	2	2.2	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**300**	6.5	22.29	3.801	46.1	22.3212	3.4043	52.8927
743	4	43.24	380	175	2	2.2	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**300**	7	23.61	3.919	41.2	23.6071	3.8761	41.4804
744	4	43.24	380	175	2	3.622	60	60	12	15.5	60.00	0.33	0.05	0.06	76	**300**	6.5	21.38	1.428	40.4	21.2771	1.7018	40.7805
745	4	43.24	380	175	2	3.622	60	60	12	15.5	60.00	0.33	0.05	0.06	76	**300**	7	22.51	1.379	36	22.4862	1.709	32.9656
746	4	43.24	380	175	2	3.622	60	60	14	21.4	51.43	0.33	0.05	0.06	76	**300**	6	18.40	1.3	44	18.2393	1.4038	42.9808
747	4	43.24	380	175	2	3.622	60	60	14	21.4	51.43	0.33	0.05	0.06	76	**300**	7	20.70	1.87	34.7	20.6581	1.4239	42.3296
748	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**300**	6	25.53	0.27	86.1	25.6982	0.4001	76.8803
749	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**300**	6.5	27.07	0.28	72.9	27.1569	0.385	68.1478
750	4	43.24	314	408	2	3.2	36	36	14	21.4	30.86	0.1	0.12	0.1	85	**300**	6	20.70	0.395	62.7	20.4179	0.4867	68.854
751	4	43.24	314	408	2	3.2	36	36	14	21.4	30.86	0.1	0.12	0.1	85	**300**	6.5	22.00	0.381	55.4	21.8944	0.5013	60.8104
752	4	43.24	314	408	2	3.2	36	36	14	21.4	30.86	0.1	0.12	0.1	85	**300**	7	23.26	0.373	49.8	23.3976	0.5163	55.2664
753	4	43.24	314	408	2	2.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**300**	6.5	26.52	0.207	64.5	26.9407	0.1739	73.0903
754	4	43.24	314	408	2	2.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**300**	7	27.74	0.201	57	28.1467	0.17	63.5914
755	4	43.24	314	408	2	2.2	36	36	14	21.4	30.86	0.1	0.12	0.1	85	**300**	6	22.19	0.146	71	21.96	0.2792	80.9204
756	4	43.24	314	408	2	2.2	36	36	14	21.4	30.86	0.1	0.12	0.1	85	**300**	7	24.96	0.149	56.3	25.1352	0.2681	61.8236
757	4	43.24	314	408	2	3.2	50	38.46	12	15.5	38.46	0.1	0.12	0.1	85	**300**	6	25.24	2.344	63.9	24.622	2.4117	72.1429
758	4	43.24	314	408	2	3.2	50	38.46	12	15.5	38.46	0.1	0.12	0.1	85	**300**	6.5	25.83	2.354	55.2	25.8961	2.3777	65.3963
759	4	43.24	314	408	2	3.2	50	38.46	14	21.4	32.97	0.1	0.12	0.1	85	**300**	6	20.45	2.033	58.9	20.3381	1.7335	57.2664
760	4	43.24	314	408	2	3.2	50	38.46	14	21.4	32.97	0.1	0.12	0.1	85	**300**	6.5	21.77	1.991	51.9	21.6473	1.7905	52.8268

Table VI-15 Training data set for Q4 (continued)

761	4	43.24	314	408	2	3.2	50	38.46	14	21.4	32.97	0.1	0.12	0.1	85	**300**	7	22.99	1.951	46.6	22.9893	1.8543	49.8502
762	4	43.24	314	408	2	3.2	50	38.46	12	15.5	38.46	0.1	0.12	0.1	40	**300**	6.5	24.71	2.657	51	24.0725	2.6271	55.1147
763	4	43.24	314	408	2	3.2	50	38.46	12	15.5	38.46	0.1	0.12	0.1	40	**300**	7	25.17	2.64	45.5	25.6987	2.5831	50.1239
764	4	43.24	314	408	2	3.2	50	38.46	14	21.4	32.97	0.1	0.12	0.1	40	**300**	6	20.10	1.925	57.4	19.8578	1.911	51.1841
765	4	43.24	314	408	2	3.2	50	38.46	14	21.4	32.97	0.1	0.12	0.1	40	**300**	7	22.62	1.833	45.5	22.4743	2.1056	45.7049
766	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**300**	8.24	29.48	0.375	48.9	29.6394	0.6402	59.7273
767	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**300**	6.68	25.86	0.538	78.6	25.164	0.6713	76.9809
768	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**300**	6.5	24.68	0.562	78.8	24.6688	0.6788	80.9334
769	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**300**	7.5	27.36	0.442	60.3	27.4891	0.6453	65.2755
770	4	43.24	227	348	2	2.2	50	50	14	21.4	42.86	0.1	0.15	0.1	60	**300**	5.5	19.61	0.252	95.5	19.8458	0.4563	97.869
771	4	43.24	227	348	2	2.2	50	50	14	21.4	42.86	0.1	0.15	0.1	60	**300**	7.5	25.02	0.199	55.3	24.7535	0.3605	55.8775
772	4	43.24	227	348	2	1.66	50	38.46	12	15.5	38.46	0.1	0.15	0.1	60	**300**	5.5	23.37	1.49	122.9	23.288	1.4659	150.109
773	4	43.24	227	348	2	1.66	50	38.46	12	15.5	38.46	0.1	0.15	0.1	60	**300**	6.5	26.62	1.452	81.4	26.1602	1.3076	103.311
774	4	43.24	227	348	2	1.66	50	38.46	14	21.4	32.97	0.1	0.15	0.1	60	**300**	5.5	21.17	0.783	103.7	21.1634	0.9747	110.652
775	4	43.24	227	348	2	1.66	50	38.46	14	21.4	32.97	0.1	0.15	0.1	60	**300**	6.5	24.27	0.745	74.2	24.5417	0.8113	77.669
776	4	43.24	227	348	2	1.66	50	38.46	14	21.4	32.97	0.1	0.15	0.1	60	**300**	7.5	27.06	0.688	59.5	27.4968	0.6844	60.9509
777	4	43.24	380	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**303.5**	5	26.34	0.47	125.1	26.7453	0.6283	123.741
778	4	43.24	380	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**303.5**	6	29.01	0.51	81.1	28.8727	0.6628	84.1054
779	4	43.24	380	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**303.5**	7	31.63	0.153	59.1	31.7984	0.6505	66.1989
780	4	43.24	380	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**303.5**	6	20.22	0.208	72.9	19.9377	0.3395	78.3685
781	4	43.24	380	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**303.5**	7	22.68	0.194	58.2	22.1374	0.3106	60.1253
782	4	43.24	380	175	2	2.79	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	50	**303.5**	5	26.73	0.271	118.6	26.7332	0.6317	126.919
783	4	43.24	380	175	2	2.79	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	50	**303.5**	7	31.36	0.295	61.5	31.9665	0.5919	68.1316
784	4	43.24	380	175	2	2.79	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	50	**303.5**	5	18.27	0.364	109.6	18.1037	0.373	121.496
785	4	43.24	380	175	2	2.79	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	50	**303.5**	6	20.89	0.331	77.1	20.8851	0.3266	80.3355
786	4	43.24	380	175	2	2.79	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	85	**303.5**	5	27.31	0.289	145.9	27.2958	0.6581	131.316
787	4	43.24	380	175	2	2.79	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	85	**303.5**	6	30.21	0.315	96.2	29.9899	0.6235	87.6926
788	4	43.24	380	175	2	2.79	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	85	**303.5**	7	32.92	0.33	73.6	33.3692	0.551	69.6892
789	4	43.24	380	175	2	2.79	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	85	**303.5**	6	21.74	0.216	90.7	21.2421	0.18	91.339
790	4	43.24	380	175	2	2.79	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	85	**303.5**	7	24.36	0.209	71.9	23.9842	0.1594	69.7894
791	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**315**	6.5	25.21	0.4	154.5	25.5798	0.5417	146.417
792	4	43.24	400	530	2	2	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**315**	6.5	26.75	0.254	179.7	26.5305	0.2289	177.22
793	4	43.24	400	530	2	2	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**315**	7.5	29.62	0.291	121.2	29.123	0.2061	115.857
794	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**315**	6.5	23.02	0.385	106.5	22.9932	0.3411	98.5353
795	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	50	**315**	6.5	22.66	1.106	84.6	22.9143	1.0939	88.9304
796	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	50	**315**	7.5	25.20	1.028	65.4	25.7924	0.9742	69.568
797	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**350**	6	27.35	0.69	161.6	27.4351	0.5334	125.059
798	4	43.24	415	430	2	1.66	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**350**	6	25.93	0.219	110.1	26.0583	0.3611	136.557
799	4	43.24	415	430	2	1.66	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**350**	7	28.99	0.221	79.8	29.0172	0.3005	95.4724
800	4	43.24	415	430	2	1.66	30	30	12	15.5	30.00	0.1	0.225	0.1	70	**350**	6	27.14	0.069	150.4	27.2471	0.1787	178.422
801	4	43.24	415	430	2	1.66	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**350**	6	23.10	0.141	105.5	23.5424	0.2373	121.666
802	4	43.24	415	430	2	1.66	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**350**	7	25.91	0.102	79.6	25.9681	0.1941	87.8821
803	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**350**	7	26.20	0.83	249.3	26.3033	1.2694	249.162
804	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**350**	8	31.36	0.56	160.2	31.2949	0.8623	153.716
805	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**350**	6	30.09	0.39	159.1	29.8254	0.2543	164.373
806	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**350**	7	32.97	0.46	106.4	33.4474	0.229	106.385
807	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**350**	6	33.18	1.23	82.9	33.2947	1.2951	79.6995
808	4	43.24	380	175	2	3.624	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**350**	5	22.86	0.538	103.5	22.7519	0.7258	96.3603
809	4	43.24	380	175	2	3.624	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**350**	6	24.55	0.541	71.3	24.6691	0.7866	62.1258
810	4	43.24	380	175	2	3	40	40	12	15.5	40.00	0.1	0.2	0.1	12	**350**	6	29.67	2.408	94.2	28.9979	2.3788	90.9683

Table VI-15 Training data set for Q4 (continued)

811	4	43.24	380	175	2	3	40	40	14	21.4	34.29	0.1	0.2	0.1	12	**350**	5	19.66	2	131.5	19.9741	1.8981	143.782
812	4	43.24	380	175	2	3	40	40	14	21.4	34.29	0.1	0.2	0.1	12	**350**	6	22.28	1.923	82.5	22.1057	1.6756	86.8197
813	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**350**	7.05	26.98	1.262	125.2	27.1266	0.9069	125.037
814	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**350**	6.27	24.60	1.556	200.6	24.8279	0.9786	186.705
815	4	43.24	380	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**354.1**	6.89	33.42	0.68	92.8	33.4794	1.0589	103.877
816	4	43.24	380	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**354.1**	6	30.85	0.65	129.9	30.7374	1.0704	144.957
817	4	43.24	380	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**354.1**	5	27.63	0.6	255.9	27.7055	0.6266	244.648
818	4	43.24	380	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**354.1**	6	30.85	0.65	129.9	30.5203	0.6119	118.96
819	4	43.24	380	175	2	3.2	26.25	21.88	12	15.5	21.88	0.1	0.204	0.101	50	**350**	6	32.02	1.41	109.2	31.8942	1.4199	127.706
820	4	43.24	380	175	2	3.2	26.25	21.88	14	21.4	18.75	0.1	0.204	0.101	50	**350**	5	20.80	1.005	155.4	20.4567	0.8095	169.869
821	4	43.24	380	175	2	3.2	26.25	21.88	14	21.4	18.75	0.1	0.204	0.101	50	**350**	6	22.45	0.978	97.7	23.3903	0.7991	95.9666
822	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**357.4**	6.5	25.46	1	281.8	25.5704	0.8959	277.16
823	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**357.4**	7.5	28.14	1.04	158.5	27.9868	0.8586	163.754
824	4	43.24	416	530	2	2.794	49.21	49.21	14	21.4	42.18	0.1	0.232	0.101	62	**357.4**	6.5	25.46	1	281.8	24.0498	0.8516	264.453
825	4	43.24	416	530	2	3.622	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**357.4**	6.5	26.98	0.976	185.6	26.8661	1.2182	174.76
826	4	43.24	416	530	2	3.622	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**357.4**	7.5	29.04	1.047	117.4	29.1847	1.2206	108.204
827	4	43.24	416	530	2	3.622	49.21	49.21	14	21.4	42.18	0.1	0.232	0.101	62	**357.4**	6.5	21.64	1.061	122.4	21.9847	1.397	142.103
828	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**357.4**	6.36	33.90	0	104.2	33.8898	0.1031	113.817
829	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**357.4**	5.5	31.24	0	148	30.8856	0.1125	167.075
830	4	43.24	228	408	2	1.9	21.33	21.33	12	15.5	21.33	0.1	0.122	0.101	90	**357.4**	6.43	29.62	0	113.7	30.1014	0.1391	124.425
831	4	43.24	228	408	2	1.9	41.01	41.01	12	15.5	41.01	0.1	0.18	0.101	26	**357.4**	6.53	25.73	1.91	169.4	25.688	1.5132	174.787
832	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**360**	6.5	20.30	0.89	114.1	20.4093	0.9679	102.07
833	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**360**	7.5	22.56	0.93	82.9	22.3409	0.9283	79.9489
834	4	43.24	380	175	2	3.624	60	57	12	15.5	57.00	0.12	0.18	0.18	94	**360**	6.5	26.00	1.249	209.2	26.0705	1.2119	204.557
835	4	43.24	380	175	2	3.624	60	57	12	15.5	57.00	0.12	0.18	0.18	94	**360**	7.5	27.82	1.3	128.8	28.0081	1.4163	146.11
836	4	43.24	380	175	2	3.624	60	57	12	15.5	57.00	0.12	0.18	0.18	94	**360**	8.5	29.63	1.372	93.7	29.5651	1.5366	94.8786
837	4	43.24	380	175	2	1.8	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**360**	7.5	26.14	0.303	139.2	26.4974	0.2153	141.94
838	4	43.24	380	175	2	1.8	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**360**	8.5	28.57	0.296	106.2	29.0598	0.1997	111.839
839	4	43.24	380	175	2	1.8	60	57	12	15.5	57.00	0.12	0.18	0.18	94	**360**	7.5	28.57	0.584	224.4	28.4114	0.5923	220.189
840	4	43.24	380	175	2	1.8	60	57	14	21.4	48.86	0.12	0.18	0.18	50	**360**	6.5	23.27	0.58	218.8	22.9466	0.6211	216.119
841	4	43.24	380	175	2	1.8	60	57	14	21.4	48.86	0.12	0.18	0.18	50	**360**	8	27.20	0.499	128.2	27.3875	0.49	139.563
842	4	43.24	380	175	2	1.8	60	57	14	21.4	48.86	0.12	0.18	0.18	50	**360**	9	29.51	0.445	101.4	29.5563	0.4336	106.149
843	4	43.24	380	175	2	4.472	60	57	12	15.5	57.00	0.12	0.18	0.18	50	**360**	7.5	26.81	1.931	125.2	26.7589	1.8484	120.483
844	4	43.24	380	175	2	4.472	60	57	12	15.5	57.00	0.12	0.18	0.18	50	**360**	8.5	28.39	2.014	89.9	28.2529	2.3503	84.7468
845	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**360**	7.5	28.05	0.769	199.9	28.1078	0.7761	220.43
846	4	43.24	380	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**360**	6	21.69	3.31	84	21.8827	2.2535	85.7153
847	4	43.24	380	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**360**	6.5	23.68	1.1	50.3	23.4089	2.2285	54.228
848	4	43.24	380	175	2	3.622	75	75	12	15.5	75.00	0.33	0.05	0.06	76	**360**	6	20.04	0.964	88.5	20.1823	1.1425	88.2787
849	4	43.24	380	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**360**	6	18.49	2.618	70.2	18.2725	3.97	73.1911
850	4	43.24	380	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**360**	7	20.78	2.838	51.9	21.0798	2.7665	49.4654
851	4	43.24	380	175	2	3.622	75	75	14	21.4	64.29	0.33	0.05	0.06	76	**360**	6	18.32	2.404	70.7	18.2318	2.5452	72.4397
852	4	43.24	380	175	2	2.3	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**360**	6	20.75	3.235	83.3	20.5474	3.2426	84.9744
853	4	43.24	380	175	2	2.3	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**360**	7	23.44	3.672	62	23.4458	3.4968	56.2061
854	4	43.24	380	175	2	2.3	75	75	14	21.4	64.29	0.33	0.05	0.06	76	**360**	6	20.42	3.579	81.8	20.2843	2.4845	79.0831
855	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**360**	6.9	28.59	0.38	108.8	29.1933	0.5469	101.21
856	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**360**	6	25.83	0.35	167.9	26.2951	0.5709	162.121
857	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**360**	7	29.97	0.543	77.4	29.5307	0.5448	96.7119
858	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**360**	6.62	37.80	0	74.1	37.6369	0.1062	68.0973
859	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**375**	7	24.56	1.04	160.3	24.8599	0.8806	177.203
860	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**375**	8	26.98	1.1	115.3	27.0386	0.9773	117.938

Table VI-15 Training data set for Q4 (continued)

861	4	43.24	400	530	2	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**375**	7	28.73	1.426	289.2	28.8602	1.5046	279.727
862	4	43.24	400	530	2	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**375**	8	30.71	1.6	175.8	30.9063	1.4854	170.096
863	4	43.24	400	530	2	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**375**	9	32.91	1.742	126.7	32.8243	1.4252	110.917
864	4	43.24	400	530	2.5	3.2	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**375**	8	25.85	1.271	109.8	25.8356	1.2363	111.448
865	4	43.24	400	530	2.5	3.2	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**375**	9	27.94	1.312	87.7	27.8231	1.4369	87.7079
866	4	43.24	400	530	2.5	3.2	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**375**	7	28.88	1.618	271.5	28.8734	1.686	262.835
867	4	43.24	400	530	2.5	3.2	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**375**	9	33.15	1.828	119.5	33.0668	1.7056	107.929
868	4	43.24	400	530	2	2.796	55	55	14	21.4	47.14	0.12	0.22	0.15	90	**375**	7	24.54	0.562	172	24.814	0.5358	176.823
869	4	43.24	400	530	2	2.796	55	55	14	21.4	47.14	0.12	0.22	0.15	90	**375**	8	27.02	0.609	121.7	26.9791	0.5867	117.987
870	4	43.24	400	530	2	3.2	55	55	12	15.5	55.00	0.12	0.22	0.15	90	**375**	7	28.52	0.749	294.3	28.4739	1.1102	291.401
871	4	43.24	400	530	2	3.2	55	55	12	15.5	55.00	0.12	0.22	0.15	90	**375**	8	30.43	0.82	173.9	30.5262	1.1223	180.94
872	4	43.24	400	530	2	3.2	55	55	12	15.5	55.00	0.12	0.22	0.15	90	**375**	9	32.56	0.826	126.6	32.4646	1.0957	118.738
873	4	43.24	400	530	2	2.796	55	55	14	21.4	47.14	0.12	0.22	0.15	45	**375**	8	26.52	1.405	108.8	26.7911	1.3035	113.763
874	4	43.24	400	530	2	2.796	55	55	14	21.4	47.14	0.12	0.22	0.15	45	**375**	9	28.75	1.452	86.4	28.7578	1.4284	90.3344
875	4	43.24	400	530	2	2.796	55	55	12	15.5	55.00	0.12	0.22	0.15	45	**375**	7	26.22	1.244	280.3	26.5526	1.2749	267.614
876	4	43.24	400	530	2	2.796	55	55	12	15.5	55.00	0.12	0.22	0.15	45	**375**	9	31.02	1.366	118.1	31.0581	1.4194	110.747
877	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**270**	5.5	26.76	0	145.9	26.2323	0.0534	149.027
878	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**270**	6.5	30.07	0.04	97.6	30.2081	0.0523	100.158
879	4.19	42.82	398	175	2	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**270**	5.5	23.77	0	119.9	24.195	0.0424	115.906
880	4.19	42.82	398	175	2	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**270**	6.5	26.88	0	80.7	26.9807	0.0419	81.1129
881	4.19	42.82	398	175	2	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**270**	7.5	29.67	0	61.5	29.5046	0.0427	64.5878
882	4.19	42.82	398	175	3.5	1.166	35	30	12	15.5	30.00	0.1	0.22	0.1	40	**270**	6.5	29.02	0	74.2	29.0941	0.1478	83.5314
883	4.19	42.82	398	175	3.5	1.166	35	30	12	15.5	30.00	0.1	0.22	0.1	40	**270**	7.5	31.95	0	60.5	31.8356	0.134	68.8751
884	4.19	42.82	398	175	3.5	1.166	35	30	14	21.4	25.71	0.1	0.22	0.1	40	**270**	5.5	23.12	0	92.2	22.8336	0.0951	98.3614
885	4.19	42.82	398	175	3.5	1.166	35	30	14	21.4	25.71	0.1	0.22	0.1	40	**270**	7.5	28.94	0	54	29.1188	0.0947	59.0868
886	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**270**	6.6	28.18	0.82	68.3	28.1955	0.6377	49.1268
887	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**270**	5	22.64	0.465	96.7	23.0728	0.7256	89.818
888	4.19	42.82	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**270**	5	25.39	0.86	97.8	25.1616	0.9051	93.5137
889	4.19	42.82	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**270**	7	32.36	0.08	56.5	32.7669	0.7418	44.2913
890	4.19	42.82	398	175	2	2	40	21	14	21.4	18.00	0.12	0.15	0.1	40	**270**	5	20.22	1.437	65.5	20.4529	1.5125	50.6744
891	4.19	42.82	398	175	2	2	40	21	12	15.5	21.00	0.12	0.15	0.1	40	**270**	5	22.67	2.007	65	23.1411	1.6379	67.2945
892	4.19	42.82	398	175	2	2	40	21	12	15.5	21.00	0.12	0.15	0.1	40	**270**	7	28.68	1.7	40.8	27.1175	1.5433	36.4917
893	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**270**	6.07	27.64	0.11	70.6	27.7401	0.1848	70.5425
894	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**270**	6	28.23	0	73.5	28.3405	0.1126	70.0128
895	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**270**	5	21.06	0	89.2	21.3423	0.0814	85.3948
896	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**270**	6	24.30	0	68.3	24.6813	0.0738	68.6954
897	4.19	42.822	272	470	2	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**270**	6	28.48	0	63.9	28.4324	0.1113	69.2637
898	4.19	42.822	272	470	2	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**270**	5	21.87	0	86.4	21.4969	0.1325	83.7447
899	4.19	42.822	272	470	2	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**270**	6	25.22	0	66.5	25.1244	0.1146	67.4823
900	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	35	**270**	6	28.67	0	55.5	28.2693	0.1903	60.4074
901	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	35	**270**	5	20.34	0.067	72.6	20.3612	0.1532	72.0714
902	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	35	**270**	6	23.41	0.046	56	23.2619	0.1341	60.6538
903	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**280**	6.5	23.56	0.07	61.2	23.5265	0.1591	69.7826
904	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**280**	7.5	26.03	0.07	51.1	26.0112	0.1679	59.2569
905	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**280**	8.5	28.34	0.06	44.1	28.0294	0.1946	52.4467
906	4.19	42.822	272	470	3.5	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**280**	7.5	28.68	0.146	54.2	28.5536	0.2684	57.7564
907	4.19	42.822	272	470	3.5	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**280**	8.5	31.10	0.143	46.6	30.5257	0.2681	49.4546
908	4.19	42.822	272	470	2	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**280**	6.5	23.68	0.07	60.9	23.9917	0.2601	67.9101
909	4.19	42.822	272	470	2	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**280**	8.5	28.49	0.054	44.1	28.7214	0.2809	48.8843
910	4.19	42.822	272	470	2	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**280**	6.5	26.95	0.149	65.6	26.6085	0.3775	69.737

Table VI-15 Training data set for Q4 (continued)

911	4.19	42.822	272	470	2	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**280**	7.5	29.64	0.149	52.9	29.0592	0.3586	53.9985
912	4.19	42.822	271	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**297.9**	6	24.62	0.38	116.6	24.4397	0.374	116.521
913	4.19	42.822	271	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**297.9**	7	27.40	0.34	82.2	27.1312	0.3675	78.8096
914	4.19	42.822	271	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**297.9**	8	29.93	0.3	65	29.8683	0.3908	64.0155
915	4.19	42.822	271	470	3.5	1.96	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**297.9**	7	25.19	0.305	67.8	25.0771	0.2542	67.1975
916	4.19	42.822	271	470	3.5	1.96	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**297.9**	8	27.64	0.251	56	27.4807	0.2598	56.2332
917	4.19	42.822	271	470	2	0.9	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**297.9**	6	28.66	0	195.2	28.2857	0.1206	201.602
918	4.19	42.822	271	470	2	0.9	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**297.9**	8	34.85	0	94.8	34.7981	0.136	93.3567
919	4.19	42.822	271	470	2	0.9	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**297.9**	6	26.11	0.09	130.9	26.1908	0.1479	127.771
920	4.19	42.822	271	470	2	0.9	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**297.9**	7	29.22	0	88.5	29.0584	0.1418	88.5325
921	4.19	42.822	228	285	2	1.099	52.49	52.49	12	15.5	52.49	0.1	0.18	0.1	70	**297.9**	7.68	29.85	0.14	187.8	29.4714	0.0964	186.639
922	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**297.9**	7.64	29.57	0.14	233.4	29.8602	0.114	232.322
923	4.19	42.822	228	285	2	1.099	59.05	59.05	12	15.5	59.05	0.1	0.198	0.1	67	**297.9**	8	30.44	0.13	205.3	30.6769	0.1144	214.246
924	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**297.9**	7.78	29.15	0.41	107.2	29.2533	0.2822	108.524
925	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**297.9**	7.5	28.13	0.54	115.8	28.4465	0.28	116.46
926	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**297.9**	7.71	28.55	0.14	194.1	28.7585	0.0796	164.257
927	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	7	32.98	0	81.2	32.9262	0.0525	83.3933
928	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	8	35.92	0	63.2	35.9059	0.0477	64.6889
929	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	9	38.73	0	52.5	38.7637	0.0466	63.384
930	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**300**	8	32.12	0	58	32.7821	0.0569	63.5011
931	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**300**	9	34.82	0	49.2	34.9272	0.0531	57.9606
932	4.19	42.822	255	175	2	1.8	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	7	29.01	0	77.8	29.203	0.1513	69.3698
933	4.19	42.822	255	175	2	1.8	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	9	34.09	0	55.8	33.7283	0.1254	50.2573
934	4.19	42.822	255	175	2	1.8	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**300**	7	25.87	0	72.8	26.0739	0.0992	71.9249
935	4.19	42.822	255	175	2	1.8	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**300**	8	28.34	0	61.7	28.0157	0.0887	58.904
936	4.19	42.822	255	175	2	1.8	30	24	12	15.5	24.00	0.1	0.18	0.1	85	**300**	7	30.63	0.497	73	30.4752	0.3301	69.9886
937	4.19	42.822	255	175	2	1.8	30	24	12	15.5	24.00	0.1	0.18	0.1	85	**300**	8	32.72	0.502	60.8	32.5612	0.2839	59.523
938	4.19	42.822	255	175	2	1.8	30	24	12	15.5	24.00	0.1	0.18	0.1	85	**300**	9	34.62	0.322	53	34.9847	0.256	55.5193
939	4.19	42.822	255	175	2	1.8	30	24	14	21.4	20.57	0.1	0.18	0.1	85	**300**	8	28.81	0.129	59.5	28.8664	0.1487	57.7181
940	4.19	42.822	255	175	2	1.8	30	24	14	21.4	20.57	0.1	0.18	0.1	85	**300**	9	31.14	0	52.2	30.7814	0.1327	52.9652
941	4.19	42.822	255	175	2	1.8	30	30	12	15.5	30.00	0.1	0.18	0.1	40	**300**	7	28.04	0.112	61.1	27.7793	0.2358	57.1086
942	4.19	42.822	255	175	2	1.8	30	30	12	15.5	30.00	0.1	0.18	0.1	40	**300**	9	32.91	0.072	45.1	32.8451	0.2089	44.041
943	4.19	42.822	255	175	2	1.8	30	30	14	21.4	25.71	0.1	0.18	0.1	40	**300**	7	25.42	0.047	60.4	25.3842	0.1441	62.162
944	4.19	42.822	255	175	2	1.8	30	30	14	21.4	25.71	0.1	0.18	0.1	40	**300**	8	27.86	0.008	51.7	27.644	0.1209	51.4374
945	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**300**	5.5	28.12	0.04	100.1	27.8691	0.0766	99.7745
946	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**300**	6.5	31.63	0	69.6	31.5977	0.066	82.1719
947	4.19	42.822	255	175	2	0.9	15	15	14	21.4	12.86	0.1	0.18	0.1	45	**300**	5.5	24.77	0	97.9	24.4389	0.0706	88.2639
948	4.19	42.822	255	175	2	1.8	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**300**	5.5	29.83	0	87.7	30.2174	0.1461	91.6214
949	4.19	42.822	255	175	2	1.8	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**300**	6.5	32.22	0	67.7	31.8562	0.1264	72.0787
950	4.19	42.822	255	175	2	1.8	15	15	14	21.4	12.86	0.1	0.18	0.1	45	**300**	5.5	22.06	0	85	22.7594	0.1087	88.7491
951	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	45	**300**	5.5	27.29	0	162.3	27.1716	0.0998	142.204
952	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	45	**300**	6.5	30.76	0.004	92.3	31.1293	0.0855	98.3135
953	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	45	**300**	5.5	24.38	0	112.4	23.9455	0.0981	109.94
954	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**300**	5	25.02	0	225.8	25.4277	0.0662	228.853
955	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**300**	6	28.57	0	133.2	28.3136	0.0591	122.771
956	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**300**	7	31.70	0	92.5	31.9065	0.0529	86.9186
957	4.19	42.822	398	175	2	1.166	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**300**	6	25.71	0	105.9	25.8939	0.0591	110.36
958	4.19	42.822	398	175	2	1.166	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**300**	7	28.68	0	76.1	28.7533	0.0557	78.5446
959	4.19	42.822	398	175	2	2.3	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**300**	5	26.14	0.036	123	26.1451	0.2519	130.626
960	4.19	42.822	398	175	2	2.3	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**300**	7	31.74	0.04	68.1	31.6977	0.2007	68.8392

Table VI-15 Training data set for Q4 (continued)

961	4.19	42.822	398	175	2	2.3	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**300**	5	20.11	0.006	114.3	20.5198	0.1339	116.035
962	4.19	42.822	398	175	2	2.3	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**300**	6	23.16	0	82.6	23.579	0.1194	83.418
963	4.19	42.822	398	175	2	1.166	50	50	12	15.5	50.00	0.1	0.18	0.1	93	**300**	5	24.39	0	299.8	23.8588	0.0539	282.666
964	4.19	42.822	398	175	2	1.166	50	50	12	15.5	50.00	0.1	0.18	0.1	93	**300**	6	27.92	0	153.7	27.9088	0.0577	156.578
965	4.19	42.822	398	175	2	1.166	50	50	12	15.5	50.00	0.1	0.18	0.1	93	**300**	7	31.00	0	108.1	30.9932	0.0595	96.9609
966	4.19	42.822	398	175	2	1.166	50	50	14	21.4	42.86	0.1	0.18	0.1	93	**300**	6	25.33	0	128.4	25.2719	0.0621	133.371
967	4.19	42.822	398	175	2	1.166	50	50	14	21.4	42.86	0.1	0.18	0.1	93	**300**	7	28.27	0	89.5	27.7586	0.0617	82.5363
968	4.19	42.822	398	175	2	1.166	50	33.33	12	15.5	33.33	0.1	0.18	0.1	45	**300**	5	24.65	1.754	159.3	24.6077	1.4137	157.77
969	4.19	42.822	398	175	2	1.166	50	33.33	12	15.5	33.33	0.1	0.18	0.1	45	**300**	7	31.50	1.22	74.2	31.4952	1.2844	81.0913
970	4.19	42.822	398	175	2	1.166	50	33.33	14	21.4	28.57	0.1	0.18	0.1	45	**300**	5	22.18	1.186	131.2	22.0793	0.9605	149.078
971	4.19	42.822	398	175	2	1.166	50	33.33	14	21.4	28.57	0.1	0.18	0.1	45	**300**	6	25.59	0.977	91.1	25.1865	0.7462	90.1363
972	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	6	25.80	0.1	121	25.282	0.049	122.551
973	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	7	28.84	0.11	84.1	28.8287	0.0469	83.7565
974	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	8	31.60	0.11	64.9	31.3512	0.0458	64.7563
975	4.19	42.822	398	175	2	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**300**	7	31.31	0	102.8	31.2806	0.0739	106.492
976	4.19	42.822	398	175	2	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**300**	8	34.18	0.013	80.7	33.906	0.0671	79.1759
977	4.19	42.822	398	175	2	2	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	6	23.05	0	89.3	22.9642	0.0885	98.0712
978	4.19	42.822	398	175	2	2	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	8	28.21	0	59.6	28.3609	0.0779	58.1265
979	4.19	42.822	398	175	2	2	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**300**	6	27.01	0.177	101.1	27.294	0.2213	110.703
980	4.19	42.822	398	175	2	2	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**300**	7	29.25	0.173	77.5	29.3528	0.2029	80.4665
981	4.19	42.822	398	175	2.5	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	50	**300**	6	25.09	0	117.4	24.9204	0.0885	104.969
982	4.19	42.822	398	175	2.5	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	50	**300**	7	28.11	0	84.9	28.189	0.0773	76.5062
983	4.19	42.822	398	175	2.5	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	50	**300**	8	30.82	0	65.1	30.4386	0.0709	62.8106
984	4.19	42.822	398	175	2.5	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	50	**300**	7	30.85	0	97.7	30.9124	0.1333	101.407
985	4.19	42.822	398	175	2.5	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	50	**300**	8	33.72	0	77.7	33.4122	0.121	81.4805
986	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**300**	6	23.82	0.57	168.8	23.9047	0.4022	173.465
987	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**300**	8	29.02	0.49	83.7	29.1995	0.4742	78.0643
988	4.19	42.822	272	470	3.5	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	83	**300**	6	21.96	0.639	104.7	22.209	0.4457	103.547
989	4.19	42.822	272	470	3.5	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	83	**300**	7	24.60	0.519	80.3	24.9096	0.3926	79.7488
990	4.19	42.822	272	470	2	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**300**	6	24.75	0.519	161.7	24.7452	0.5661	167.855
991	4.19	42.822	272	470	2	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**300**	7	27.56	0.501	106	27.4965	0.6551	109.163
992	4.19	42.822	272	470	2	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**300**	8	30.14	0.485	80.9	30.0702	0.7705	82.1271
993	4.19	42.822	272	470	2	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	83	**300**	7	25.37	0.573	78	25.9614	0.5436	81.3272
994	4.19	42.822	272	470	2	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	83	**300**	8	27.80	0.554	64.3	28.0189	0.5112	65.1021
995	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	50	**300**	6	23.65	1.136	141	23.4875	1.0834	158.739
996	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	50	**300**	8	28.88	0.968	75.5	28.8203	1.1642	74.9498
997	4.19	42.822	272	470	3.5	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	50	**300**	6	21.82	0.813	95.3	21.5656	0.8811	102.258
998	4.19	42.822	272	470	3.5	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	50	**300**	7	24.46	0.658	73.2	24.2679	0.8234	80.13
999	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	6	22.78	0.43	77.9	22.4149	0.3159	79.9881
1000	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	7	25.47	0.31	61.9	25.5127	0.297	62.3086
1001	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	8	27.95	0.3	51.8	27.9247	0.3188	53.2509
1002	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	7	27.85	0.75	68.3	27.7319	0.6469	71.3538
1003	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	8	30.42	0.684	55.9	30.6135	0.6043	57.3075
1004	4.19	42.822	272	470	3.5	2.5	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	6	21.78	0.831	68.2	21.6786	0.5876	69.5334
1005	4.19	42.822	272	470	3.5	2.5	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	8	26.71	0.528	46.1	26.9201	0.5762	49.8653
1006	4.19	42.822	272	470	3.5	2.5	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	6	23.87	1.557	80.3	24.2544	1.261	82.67
1007	4.19	42.822	272	470	3.5	2.5	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	7	26.55	1.57	61	27.1511	1.1824	63.6897
1008	4.19	42.822	272	470	2	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	6	23.44	0.418	76.1	23.3357	0.5346	74.5936
1009	4.19	42.822	272	470	2	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	7	26.19	0.322	59.9	26.3488	0.4644	58.4891
1010	4.19	42.822	272	470	2	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	8	28.68	0.295	50.5	28.6306	0.4504	51.0865

Table VI-15 Training data set for Q4 (continued)

1011	4.19	42.822	272	470	2	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	7	28.43	0.808	65.5	28.2037	0.8736	70.903
1012	4.19	42.822	272	470	2	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	8	30.99	0.794	53.6	31.0355	0.8287	56.106
1013	4.19	42.822	272	470	2	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	50	**300**	6	23.24	0.956	79.2	23.2994	1.2792	74.739
1014	4.19	42.822	272	470	2	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	50	**300**	8	28.48	0.755	52.1	28.1551	0.9375	51.7014
1015	4.19	42.822	272	470	2	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	50	**300**	6	25.22	1.43	92.4	25.1866	1.5277	87.9173
1016	4.19	42.822	272	470	2	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	50	**300**	7	28.05	1.241	68.5	28.3386	1.5084	64.0232
1017	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	6.5	25.87	0.19	88.5	26.1913	0.2497	86.8632
1018	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	7.5	28.48	0.16	69.5	28.7039	0.2219	66.6834
1019	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	8.5	30.89	0.17	57.9	31.0957	0.2148	58.7773
1020	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	7.5	26.17	0.054	61.8	26.4481	0.1251	63.3298
1021	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	8.5	28.45	0.043	52.6	28.6696	0.1401	55.4114
1022	4.19	42.822	272	470	2	1.3	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	6.5	28.86	0	117.7	28.4135	0.0916	124.914
1023	4.19	42.822	272	470	2	1.3	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	8.5	34.40	0	72.2	34.3723	0.0794	69.5159
1024	4.19	42.822	272	470	2	1.3	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	6.5	26.65	0	98.5	26.4418	0.0811	94.9774
1025	4.19	42.822	272	470	2	1.3	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	7.5	29.28	0	78.8	29.2383	0.0823	72.6905
1026	4.19	42.822	272	470	2.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	6.5	26.53	0.215	88.2	26.4504	0.2917	86.5318
1027	4.19	42.822	272	470	2.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	7.5	29.20	0.191	68.4	29.0778	0.2707	67.3669
1028	4.19	42.822	272	470	2.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	8.5	31.67	0.167	56.6	31.4826	0.2716	59.1426
1029	4.19	42.822	272	470	2.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	7.5	26.71	0.07	61.1	26.8799	0.1622	61.142
1030	4.19	42.822	272	470	2.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	8.5	29.02	0.066	52.1	29.0874	0.1787	53.0542
1031	4.19	42.822	272	470	3.5	1.3	60	60	12	15.5	60.00	0.1	0.18	0.1	50	**300**	6.5	28.49	0.113	100.3	27.9775	0.198	106.781
1032	4.19	42.822	272	470	3.5	1.3	60	60	12	15.5	60.00	0.1	0.18	0.1	50	**300**	8.5	34.09	0	61.2	34.1808	0.2036	60.2813
1033	4.19	42.822	272	470	3.5	1.3	60	60	14	21.4	51.43	0.1	0.18	0.1	50	**300**	6.5	26.12	0.162	86.3	25.7703	0.1122	84.4427
1034	4.19	42.822	272	470	3.5	1.3	60	60	14	21.4	51.43	0.1	0.18	0.1	50	**300**	7.5	28.93	0.113	68.1	28.693	0.1098	68.3117
1035	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**300**	5.5	24.32	0.22	113.9	24.8232	0.3255	110.814
1036	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**300**	6.5	26.55	0.22	81.3	27.1384	0.243	76.1517
1037	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**300**	7.5	29.16	0.23	64.4	29.1074	0.1948	63.6302
1038	4.19	42.822	272	470	3.5	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**300**	6.5	24.00	0.079	70.6	24.1692	0.1206	74.1836
1039	4.19	42.822	272	470	3.5	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**300**	7.5	26.54	0.044	58.5	26.7235	0.1126	63.5252
1040	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**300**	5.5	22.75	0.345	184.7	23.1721	0.2624	186.321
1041	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**300**	7.5	28.27	0.317	85.5	28.3908	0.2344	75.9698
1042	4.19	42.822	272	470	3.5	2.22	75	75	14	21.4	64.29	0.1	0.2	0.1	95	**300**	5.5	20.69	0.172	120	20.9371	0.2577	114.652
1043	4.19	42.822	272	470	3.5	2.22	75	75	14	21.4	64.29	0.1	0.2	0.1	95	**300**	6.5	23.46	0.172	85.3	23.4867	0.2124	82.8194
1044	4.19	42.822	272	470	2	2.22	75	60	12	15.5	60.00	0.1	0.2	0.1	95	**300**	5.5	23.62	1.921	145.3	23.8068	1.709	129.019
1045	4.19	42.822	272	470	2	2.22	75	60	12	15.5	60.00	0.1	0.2	0.1	95	**300**	6.5	26.59	1.933	95.3	26.7454	1.6999	90.6028
1046	4.19	42.822	272	470	2	2.22	75	60	12	15.5	60.00	0.1	0.2	0.1	95	**300**	7.5	29.27	1.853	73.6	29.6822	1.7218	72.7681
1047	4.19	42.822	272	470	2	2.22	75	60	14	21.4	51.43	0.1	0.2	0.1	95	**300**	6.5	24.46	1.005	79.4	24.5272	1.1386	68.8065
1048	4.19	42.822	272	470	2	2.22	75	60	14	21.4	51.43	0.1	0.2	0.1	95	**300**	7.5	27.02	0.883	64.6	27.3492	1.0749	56.3289
1049	4.19	42.822	272	470	2	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	55	**300**	5.5	23.38	1.154	148	23.5998	0.706	138.67
1050	4.19	42.822	272	470	2	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	55	**300**	7.5	29.04	0.93	70	29.3816	0.7493	63.059
1051	4.19	42.822	272	470	2	2.22	75	75	14	21.4	64.29	0.1	0.2	0.1	55	**300**	5.5	21.18	0.652	97.3	21.2617	0.7932	96.3065
1052	4.19	42.822	272	470	2	2.22	75	75	14	21.4	64.29	0.1	0.2	0.1	55	**300**	6.5	24.02	0.506	71.3	24.0088	0.6822	68.15
1053	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	6	21.99	0.08	77.5	21.562	0.328	85.1882
1054	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	7	24.59	0.07	60.7	23.9859	0.2847	72.513
1055	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	8	26.94	0.06	51.5	26.3229	0.2716	57.9648
1056	4.19	42.822	397	175	2	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	7	26.58	0.338	73	26.4736	0.3831	87.4473
1057	4.19	42.822	397	175	2	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	8	29.02	0.307	59.1	28.6133	0.4067	64.8613
1058	4.19	42.822	397	175	2	1.6	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	6	23.69	0	107.5	24.0487	0.1269	108.69
1059	4.19	42.822	397	175	2	1.6	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	8	29.02	0	67.7	29.5414	0.1135	59.8231
1060	4.19	42.822	397	175	2	1.6	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	6	26.00	0.089	134.8	26.2391	0.1217	154.253

Table VI-15 Training data set for Q4 (continued)

1061	4.19	42.822	397	175	2	1.6	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	7	28.88	0.08	94.5	28.7441	0.1365	101.75
1062	4.19	42.822	397	175	3.5	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	6	20.66	0.094	79	20.7968	0.2681	81.2889
1063	4.19	42.822	397	175	3.5	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	7	23.12	0.084	62.8	23.1719	0.2295	69.1366
1064	4.19	42.822	397	175	3.5	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	8	25.33	0.071	52.5	25.6803	0.2154	58.6618
1065	4.19	42.822	397	175	3.5	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	7	25.71	0.356	71.6	26.1277	0.2815	76.5795
1066	4.19	42.822	397	175	3.5	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	8	27.74	0.299	58.7	28.0361	0.3137	57.9253
1067	4.19	42.822	397	175	3.5	2.544	60	45	14	21.4	38.57	0.12	0.18	0.1	50	**300**	6	20.68	1.751	65.5	20.8973	1.8183	68.0453
1068	4.19	42.822	397	175	3.5	2.544	60	45	14	21.4	38.57	0.12	0.18	0.1	50	**300**	8	25.38	1.409	44.3	25.2791	1.4498	44.7213
1069	4.19	42.822	397	175	3.5	2.544	60	45	12	15.5	45.00	0.12	0.18	0.1	50	**300**	6	23.33	2.805	75.9	23.8667	2.3434	81.2012
1070	4.19	42.822	397	175	3.5	2.544	60	45	12	15.5	45.00	0.12	0.18	0.1	50	**300**	7	25.23	2.719	57.7	24.9309	2.5436	62.6317
1071	4.19	42.822	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	5.5	26.87	0.03	294.9	26.9976	0.0806	277.394
1072	4.19	42.822	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	6.5	30.23	0.12	162.1	30.2486	0.0766	154.813
1073	4.19	42.822	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	7.5	33.20	0.14	105.5	33.3101	0.0694	109.846
1074	4.19	42.822	398	175	2	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**315**	6.5	26.98	0	119	27.3605	0.0452	121.148
1075	4.19	42.822	398	175	2	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**315**	7.5	29.82	0	85.6	29.8627	0.043	83.6681
1076	4.19	42.822	398	175	2	2.5	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	5.5	27.15	0.18	131.5	27.0937	0.3902	135.597
1077	4.19	42.822	398	175	2	2.5	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	7.5	32.17	0.19	74.1	32.0954	0.3709	82.8504
1078	4.19	42.822	398	175	2	2.5	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**315**	5.5	21.05	0.114	115.1	20.8497	0.1708	106.215
1079	4.19	42.822	398	175	2	2.5	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**315**	6.5	23.85	0.108	85.9	22.9756	0.1427	81.5837
1080	4.19	42.822	398	175	3.5	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	30	**315**	5.5	25.54	0.083	170.8	25.403	0.1965	186.088
1081	4.19	42.822	398	175	3.5	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	30	**315**	6.5	28.74	0	112.2	28.6863	0.1822	114.636
1082	4.19	42.822	398	175	3.5	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	30	**315**	7.5	31.68	0	84.8	31.6907	0.1657	85.5446
1083	4.19	42.822	398	175	3.5	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	30	**315**	6.5	26.04	0.043	93.8	26.1499	0.0751	93.9946
1084	4.19	42.822	398	175	3.5	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	30	**315**	7.5	28.79	0.039	70.3	28.3802	0.0668	68.6796
1085	4.19	42.822	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**315**	5	22.90	1.22	180.7	22.7573	0.9462	167.707
1086	4.19	42.822	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**315**	5	25.59	1.93	187.4	25.3984	1.7653	183.328
1087	4.19	42.822	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**315**	7	32.60	1.436	80.6	32.414	1.2849	72.3858
1088	4.19	42.822	398	175	2	1.166	40	40	14	21.4	34.29	0.12	0.15	0.1	80	**315**	5	22.06	0	190.2	21.5841	0.1348	188.656
1089	4.19	42.822	398	175	2	1.166	40	40	12	15.5	40.00	0.12	0.15	0.1	80	**315**	5	24.53	0	261.1	24.6583	0.1127	274.824
1090	4.19	42.822	398	175	2	1.166	40	40	12	15.5	40.00	0.12	0.15	0.1	80	**315**	7	31.17	0	97.2	31.2499	0.1062	93.4298
1091	4.19	42.822	398	175	2	2.5	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**315**	5	20.15	2.149	94.4	19.744	2.0777	95.1624
1092	4.19	42.822	398	175	2	2.5	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**315**	5	25.94	2.978	103.2	25.1689	3.4151	97.019
1093	4.19	42.822	398	175	2	2.5	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**315**	7	29.75	2.739	56.9	30.3581	3.2002	57.1082
1094	4.19	42.822	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	45	**315**	5	22.47	1.427	149.9	22.5633	1.6847	154.458
1095	4.19	42.822	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	45	**315**	5	25.10	2.042	165.1	25.577	2.3134	165.677
1096	4.19	42.822	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	45	**315**	7	32.06	1.553	73.2	32.7699	1.7226	76.2267
1097	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**315**	5	27.44	0	153.6	27.8789	0.1448	134.719
1098	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**315**	5	21.35	0	125.8	21.0309	0.1248	118.983
1099	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**315**	6	24.63	0	89.8	24.382	0.1104	90.2013
1100	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**320**	6.44	29.46	1.68	95.1	29.617	0.5507	92.3155
1101	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**350**	6	28.71	0	256	28.8928	0.1389	245.071
1102	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**350**	7	31.88	0	149.4	32.0348	0.1105	141.274
1103	4.19	42.822	398	175	2	1.166	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**350**	6	25.79	0	170.5	25.507	0.0916	175.649
1104	4.19	42.822	398	175	2	2.3	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**350**	6	30.37	0.095	143.8	30.5582	0.5496	149.194
1105	4.19	42.822	398	175	2	2.3	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**350**	7	33.26	0.108	102	33.0496	0.4524	109.204
1106	4.19	42.822	398	175	2	2.3	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**350**	6	23.41	0.055	118.1	23.6742	0.1979	124.593
1107	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	45	**350**	6	28.22	0	188.8	28.0427	0.2607	191.122
1108	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	45	**350**	7	31.35	0.02	123.3	31.0101	0.2083	130.964
1109	4.19	42.822	398	175	2	1.166	30	30	14	21.4	25.71	0.1	0.18	0.1	45	**350**	6	25.52	0.055	152.2	25.6544	0.1764	155.716
1110	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**350**	6.5	23.71	0.21	112.7	23.5862	0.2647	117.191

Table VI-15 Training data set for Q4 (continued)

1111	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**350**	7.5	26.21	0.18	86	26.0838	0.227	87.5769
1112	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**350**	8.5	28.51	0.16	69.8	28.2578	0.2047	71.3975
1113	4.19	42.822	272	470	3.5	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**350**	7.5	28.96	0.347	108	29.0542	0.3193	103.363
1114	4.19	42.822	272	470	3.5	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**350**	8.5	31.40	0.35	84.6	31.0251	0.3171	73.3366
1115	4.19	42.822	272	470	2	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	35	**350**	6.5	24.29	0.575	90.1	24.1214	0.7985	95.8581
1116	4.19	42.822	272	470	2	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	35	**350**	8.5	29.18	0.412	57.9	28.9087	0.6417	58.2548
1117	4.19	42.822	272	470	2	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	35	**350**	6.5	26.53	1.016	117.5	26.0429	1.2756	130.35
1118	4.19	42.822	272	470	2	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	35	**350**	7.5	29.21	0.945	82.4	29.0584	1.1815	79.2318
1119	4.19	42.822	272	470	3.5	2.22	50	30	14	21.4	25.71	0.12	0.18	0.1	75	**350**	6.5	24.69	2.022	96	24.8031	2.2644	102.638
1120	4.19	42.822	272	470	3.5	2.22	50	30	14	21.4	25.71	0.12	0.18	0.1	75	**350**	7.5	27.31	1.745	75.3	27.296	1.9445	79.595
1121	4.19	42.822	272	470	3.5	2.22	50	30	14	21.4	25.71	0.12	0.18	0.1	75	**350**	8.5	29.71	1.803	62.5	29.5356	1.6342	67.3599
1122	4.19	42.822	272	470	3.5	2.22	50	30	12	15.5	30.00	0.12	0.18	0.1	75	**350**	7.5	29.99	3.531	89.2	30.779	3.6893	85.4561
1123	4.19	42.822	272	470	3.5	2.22	50	30	12	15.5	30.00	0.12	0.18	0.1	75	**350**	8.5	32.52	3.517	71	32.2992	3.3079	70.2456
1124	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**350**	5.5	28.41	0.06	156.1	28.1912	0.0925	157.328
1125	4.19	42.822	272	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**357.4**	8	29.95	0.441	143.9	29.6895	0.4898	143.611
1126	4.19	42.822	272	470	3.5	1.96	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**357.4**	7	25.27	0.334	122.3	25.4013	0.2744	112.964
1127	4.19	42.822	272	470	3.5	1.96	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**357.4**	8	27.69	0.307	93.1	27.8604	0.2513	86.6293
1128	4.19	42.822	272	470	2	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	40	**357.4**	8	30.41	0.997	100.6	30.8387	1.0494	92.5977
1129	4.19	42.822	272	470	2	1.96	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	40	**357.4**	7	25.70	0.769	93.5	25.7635	0.942	88.7238
1130	4.19	42.822	272	470	2	1.96	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	40	**357.4**	8	28.16	0.693	73.7	28.179	0.8969	68.5339
1131	4.19	42.822	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**360**	7.5	33.34	0.24	177.3	33.4541	0.1354	172.96
1132	4.19	42.822	398	175	2	2.1	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**360**	6.5	30.16	0.19	183.5	29.9833	0.5097	188.864
1133	4.19	42.822	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**360**	5	23.02	1	296.4	22.9508	1.3246	295.077
1134	4.19	42.822	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**360**	6	29.47	2.329	206.4	29.2162	2.1447	204.57
1135	4.19	42.822	398	175	2	1.166	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**360**	7	32.81	0.487	126.6	32.2538	1.8294	118.513
1136	4.19	42.822	398	175	2	1.166	40	35	14	21.4	30.00	0.12	0.15	0.1	40	**360**	6	25.43	0.394	163.6	25.7485	0.6267	159.093
1137	4.19	42.822	398	175	2	1.166	40	35	12	15.5	35.00	0.12	0.15	0.1	40	**360**	6	28.01	0.781	227.9	27.8247	0.9527	224.987
1138	4.19	42.822	398	175	2	1.166	40	35	12	15.5	35.00	0.12	0.15	0.1	40	**360**	7	31.24	0.226	133.5	31.1873	0.8595	131.58
1139	4.19	42.822	398	175	2	2.1	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**360**	6	24.03	2.478	108.5	24.0424	2.2829	118.514
1140	4.19	42.822	398	175	2	2.1	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**360**	6	28.75	3.449	123.9	28.933	3.2776	124.745
1141	4.19	42.822	398	175	2	2.1	40	21	12	15.5	21.00	0.12	0.15	0.1	80	**360**	7	30.68	3.568	88.5	31.0851	3.201	89.2175
1142	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**360**	6.62	31.02	1.59	137.6	31.7397	0.8603	144.47
1143	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	8	36.06	0	99.3	35.8933	0.0724	107.081
1144	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	9	38.94	0	77.4	38.8618	0.06	90.782
1145	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**360**	7	29.47	0	112.5	29.3705	0.0797	117.618
1146	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**360**	9	34.98	0	68.1	34.9822	0.0597	77.3539
1147	4.19	42.822	255	175	2	1.5	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	7	30.12	0	158.1	30.3242	0.2048	145.22
1148	4.19	42.822	255	175	2	1.5	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	8	32.81	0	116.1	33.1499	0.1567	110.276
1149	4.19	42.822	255	175	2	1.5	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**360**	7	26.94	0	122.6	27.1962	0.1232	115.831
1150	4.19	42.822	255	175	2	1.5	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**360**	8	29.49	0.035	97.5	29.1062	0.103	94.5475
1151	4.19	42.822	255	175	2	1.5	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**360**	9	31.86	0.058	77.4	32.0246	0.0884	81.4016
1152	4.19	42.822	255	175	3.5	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	35	**360**	8	33.97	0.218	92.6	33.7117	0.1114	79.5826
1153	4.19	42.822	255	175	3.5	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	35	**360**	9	36.57	0.216	70.2	36.2626	0.1042	70.8163
1154	4.19	42.822	255	175	3.5	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	35	**360**	7	27.87	0.09	100.5	27.9879	0.115	91.449
1155	4.19	42.822	255	175	3.5	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	35	**360**	9	32.91	0.13	61.8	33.127	0.0714	67.8466
1156	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	6	25.62	0.104	245.8	25.945	0.0912	257.336
1157	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	7	28.59	0.115	145.2	29.3901	0.0868	151.661
1158	4.19	42.822	398	175	2	2.4	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	6	22.59	0.19	132.7	22.8112	0.2357	128.817
1159	4.19	42.822	398	175	2	2.4	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	7	25.28	0.196	98.3	25.3207	0.2156	93.0059
1160	4.19	42.822	398	175	2	2.4	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	8	27.69	0.205	79.4	27.5534	0.2014	75.3151

Table VI-15 Training data set for Q4 (continued)

1161	4.19	42.822	398	175	2	2.4	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**360**	7	31.83	0.381	123.4	31.3959	0.7681	111.85
1162	4.19	42.822	398	175	2	2.4	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**360**	8	34.08	0.398	94.1	33.9908	0.6485	97.9741
1163	4.19	42.822	398	175	3.5	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	6	24.97	0.111	251.3	24.7717	0.0693	243.731
1164	4.19	42.822	398	175	3.5	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	8	30.56	0.13	100.7	30.4755	0.0695	100.643
1165	4.19	42.822	398	175	3.5	2.3	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**360**	6	28.64	0.352	193.7	28.0895	0.5078	197.33
1166	4.19	42.822	398	175	3.5	2.3	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**360**	7	30.91	0.365	128.5	30.6258	0.5033	127.753
1167	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	45	**360**	6	25.33	0.079	224.3	25.4254	0.2379	208.674
1168	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	45	**360**	7	28.35	0.104	144.8	28.7352	0.2018	141.365
1169	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	45	**360**	8	31.08	0.143	106.4	30.7307	0.1778	93.9041
1170	4.19	42.822	398	175	2	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	45	**360**	7	31.04	0	191.9	31.3503	0.3763	188.644
1171	4.19	42.822	398	175	2	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	45	**360**	8	33.92	0	133.6	34.3132	0.3163	130.524
1172	4.19	42.822	272	470	2	3.6	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**360**	7	24.74	1.191	289.3	24.6655	1.1975	285.823
1173	4.19	42.822	272	470	2.5	0.9	90	85	14	21.4	72.86	0.1	0.2	0.15	83	**360**	7	29.48	0.257	238.8	29.3703	0.18	238.962
1174	4.19	42.822	272	470	2.5	0.9	90	85	14	21.4	72.86	0.1	0.2	0.15	83	**360**	8	32.34	0.203	171.9	31.7994	0.159	171.128
1175	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**360**	5	30.10	0	225.3	29.8964	0.1757	232.237
1176	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**360**	5	21.64	0	187.1	21.3921	0.1822	187.248
1177	4.19	42.822	272	470	3.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**360**	7	27.94	0	92.5	27.876	0.166	91.6109
1178	4.19	42.822	272	470	3.5	0.9	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**360**	5.5	28.56	0	257.6	29.1076	0.0628	267.52
1179	4.19	42.822	272	470	3.5	0.9	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**360**	5	23.57	0	282.9	23.6174	0.0678	271.851
1180	4.19	42.822	272	470	3.5	0.9	20	20	14	21.4	17.14	0.1	0.18	0.1	72	**360**	7	30.29	0	93.4	29.8887	0.0419	111.057
1181	4.19	42.822	272	470	2.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	35	**360**	5	30.95	0.255	161.9	30.8468	0.2232	165.287
1182	4.19	42.822	272	470	2.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	35	**360**	5	21.45	0.189	142	21.5529	0.2444	134.229
1183	4.19	42.822	272	470	2.5	1.96	20	20	14	21.4	17.14	0.1	0.18	0.1	35	**360**	7	27.04	0.158	76.1	27.463	0.2588	75.0766
1184	4.19	42.822	272	470	2.5	1.96	30	20	12	15.5	20.00	0.1	0.18	0.1	72	**360**	5	29.21	1.709	238.8	29.0743	1.3087	234.701
1185	4.19	42.822	272	470	2.5	1.96	30	20	14	21.4	17.14	0.1	0.18	0.1	72	**360**	5	21.71	1.269	189.2	21.8848	0.5655	195.472
1186	4.19	42.822	272	470	2.5	1.96	30	20	14	21.4	17.14	0.1	0.18	0.1	72	**360**	7	27.83	1.192	88.5	27.9713	0.5587	90.7763
1187	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	6	22.88	0.74	147.5	22.7609	0.5399	150.252
1188	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	8	28.06	0.59	81.2	27.8071	0.4211	80.4484
1189	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	6	25.19	1.301	270.7	25.5039	1.2026	247.238
1190	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	7	27.99	1.336	145.7	28.4605	1.0846	159.411
1191	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	35	**360**	6	22.69	1.543	155.9	23.0501	1.51	134.823
1192	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	35	**360**	7	25.40	1.45	107.3	25.6517	1.4206	97.0323
1193	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	35	**360**	8	27.88	1.339	82.9	27.6811	1.362	79.207
1194	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	35	**360**	7	27.47	2.028	150	27.7301	1.959	136.026
1195	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	35	**360**	8	30.06	1.901	107.3	29.9629	1.7033	92.5611
1196	4.19	42.822	272	470	3.5	3.6	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	6	20.19	1.495	99.4	20.6186	1.4322	99.7021
1197	4.19	42.822	272	470	3.5	3.6	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	8	24.63	1.75	58.3	24.2691	1.7443	62.1688
1198	4.19	42.822	272	470	3.5	3.6	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	6	25.92	2.257	154.7	24.8115	2.238	155.593
1199	4.19	42.822	272	470	3.5	3.6	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	7	27.63	2.368	99	27.0584	2.3128	91.052
1200	4.19	42.822	272	470	2.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	6	23.33	0.728	145.5	23.2224	0.7476	154.204
1201	4.19	42.822	272	470	2.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	7	26.08	0.633	99.9	25.9841	0.6445	104.469
1202	4.19	42.822	272	470	2.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	8	28.57	0.595	78.6	28.1818	0.5641	79.5436
1203	4.19	42.822	272	470	2.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	7	28.37	1.359	138.6	28.7309	1.2871	153.081
1204	4.19	42.822	272	470	2.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	8	30.94	1.383	99.3	31.1707	1.1719	99.2869
1205	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**360**	6.5	26.18	0.389	237.6	26.2114	0.3662	233.923
1206	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**360**	6.5	23.78	0.187	137.4	23.9423	0.1874	134.597
1207	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**360**	7.5	26.29	0.165	102.5	26.293	0.1668	95.689
1208	4.19	42.822	272	470	2.5	2.22	60	55	12	15.5	55.00	0.1	0.18	0.1	95	**360**	6.5	26.71	0.897	205.3	26.934	1.0333	203.07
1209	4.19	42.822	272	470	2.5	2.22	60	55	14	21.4	47.14	0.1	0.18	0.1	95	**360**	6.5	24.31	0.704	129.5	24.6043	0.4227	128.598
1210	4.19	42.822	272	470	2.5	2.22	60	55	14	21.4	47.14	0.1	0.18	0.1	95	**360**	7.5	26.84	0.683	96.6	27.0598	0.3681	93.2913

Table VI-15 Training data set for Q4 (continued)

1211	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	40	**360**	6.5	25.48	1.473	161.2	25.4959	1.3757	173.666
1212	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	40	**360**	6.5	23.39	0.993	104.6	23.5115	0.5689	97.7675
1213	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	40	**360**	7.5	25.88	0.806	79.6	26.1053	0.5086	75.251
1214	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**360**	6.5	27.89	0.37	165.1	28.0234	0.3807	161.342
1215	4.19	42.822	272	470	3.5	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**360**	6.5	24.15	0.124	112.1	24.3454	0.2661	116.652
1216	4.19	42.822	272	470	3.5	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**360**	7.5	26.72	0.119	86.9	26.7787	0.2248	89.9932
1217	4.19	42.822	272	470	3.5	1.5	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**360**	6.5	28.40	0.133	207.5	28.2561	0.1324	195.616
1218	4.19	42.822	272	470	3.5	1.5	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**360**	6.5	25.79	0	144.9	25.8263	0.1068	130.6
1219	4.19	42.822	272	470	3.5	1.5	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**360**	7.5	28.49	0	107.8	28.6295	0.0878	100.004
1220	4.19	42.822	272	470	2	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**360**	6.5	29.08	0.328	139.8	28.408	0.5	161.885
1221	4.19	42.822	272	470	2	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**360**	8.5	33.40	0.366	78.1	33.2154	0.3847	76.0092
1222	4.19	42.822	272	470	2	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**360**	6.5	25.04	0.157	109.8	24.7571	0.3382	119.594
1223	4.19	42.822	272	470	2	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**360**	7.5	27.66	0.152	83.9	27.3905	0.2858	88.8755
1224	4.19	42.822	272	470	3.5	2.22	40	38	12	15.5	38.00	0.1	0.18	0.1	55	**360**	7.5	29.77	0.789	90.9	29.8323	0.5784	102.319
1225	4.19	42.822	272	470	3.5	2.22	40	38	14	21.4	32.57	0.1	0.18	0.1	55	**360**	6.5	23.97	0.43	101.8	23.7174	0.4578	106.44
1226	4.19	42.822	272	470	3.5	2.22	40	38	14	21.4	32.57	0.1	0.18	0.1	55	**360**	7.5	26.50	0.437	79.5	26.5092	0.4015	84.5099
1227	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	6	21.81	0.33	155.1	21.7618	0.3804	159.361
1228	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	7	24.40	0.314	106.5	24.0211	0.3626	106.415
1229	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	8	26.75	0.282	83.4	26.3783	0.3687	95.9838
1230	4.19	42.822	397	175	2	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	7	26.93	0.507	159.1	27.2857	0.6549	156.001
1231	4.19	42.822	397	175	2	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	8	29.24	0.559	110.6	29.4755	0.6846	113.04
1232	4.19	42.822	397	175	2	1.5	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	6	24.10	0.055	237.3	24.2351	0.1597	235.94
1233	4.19	42.822	397	175	2	1.5	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	8	29.55	0	113	29.7467	0.1677	106.714
1234	4.19	42.822	397	175	2	1.5	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	7	29.41	0.132	267.9	29.1643	0.2006	278.431
1235	4.19	42.822	397	175	2	1.5	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	8	32.10	0.139	167	31.9509	0.2036	163.183
1236	4.19	42.822	397	175	4	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	7	22.92	0.303	103.7	22.9772	0.1983	101.908
1237	4.19	42.822	397	175	4	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	8	25.07	0.3	81.1	25.4921	0.2115	85.3986
1238	4.19	42.822	397	175	4	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	6	25.14	0.461	280.1	24.8828	0.4414	283.047
1239	4.19	42.822	397	175	4	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	8	28.44	0.42	110	28.794	0.4734	109.903
1240	4.19	42.822	397	175	2	2.544	60	55	14	21.4	47.14	0.12	0.18	0.1	55	**360**	6	21.57	1.628	131.7	21.6303	1.9383	132.283
1241	4.19	42.822	397	175	2	2.544	60	55	14	21.4	47.14	0.12	0.18	0.1	55	**360**	7	24.14	1.529	91.7	23.8124	1.6113	98.928
1242	4.19	42.822	397	175	2	2.544	60	55	12	15.5	55.00	0.12	0.18	0.1	55	**360**	6	23.84	1.985	232.6	24.4645	1.61	249.543
1243	4.19	42.822	397	175	2	2.544	60	55	12	15.5	55.00	0.12	0.18	0.1	55	**360**	7	26.28	2.027	132.5	26.3674	1.734	109.423
1244	4.19	42.822	397	175	2	2.544	60	55	12	15.5	55.00	0.12	0.18	0.1	55	**360**	8	28.71	2.022	95.3	28.4146	1.8652	73.4823
1245	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	55	**360**	9.5	32.98	0.659	72.9	32.7206	0.6446	67.3303
1246	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	55	**360**	8.5	28.31	0.405	70.5	28.343	0.3546	71.5152
1247	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	55	**360**	9.5	30.43	0.351	60	30.8236	0.3629	64.1335
1248	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	6	25.88	0.273	45.5	26.0051	0.1278	42.661
1249	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	7	28.98	0.243	38.3	29.0441	0.1066	34.663
1250	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	5	28.98	0.551	60.7	28.8097	0.4113	58.1403
1251	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	7	34.48	0.43	38.2	34.5143	0.3152	41.714
1252	5.51	51.52	272	350	2.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	5	22.51	0.291	59.6	21.8698	0.1137	60.72
1253	5.51	51.52	272	350	2.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	6	25.56	0.268	26.6	25.7201	0.0924	45.6258
1254	5.51	51.52	272	350	2.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	5	29.39	0.553	62.6	29.1166	0.3261	59.6702
1255	5.51	51.52	272	350	2.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	6	32.50	0.466	47.8	32.5767	0.2776	46.8442
1256	5.51	51.52	272	350	2.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	7	35.02	0.404	39.6	34.9216	0.2285	40.8294
1257	5.51	51.52	272	350	1.5	1.5	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	6	28.18	0.147	51.6	27.8982	0.0617	51.4376
1258	5.51	51.52	272	350	1.5	1.5	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	7	31.68	0.109	43.2	31.405	0.0564	40.873
1259	5.51	51.52	272	350	1.5	1.5	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	5	27.76	0.33	70.6	28.1815	0.1525	75.9219
1260	5.51	51.52	272	350	1.5	1.5	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	7	34.71	0.116	43.4	34.3272	0.0945	59.0312

Table VI-15 Training data set for Q4 (continued)

1261	5.51	51.52	272	350	1.5	2.37	45	45	14	21.4	38.57	0.12	0.18	0.1	85	**300**	5	22.18	0.069	60.5	22.239	0.0824	62.0749
1262	5.51	51.52	272	350	1.5	2.37	45	45	14	21.4	38.57	0.12	0.18	0.1	85	**300**	6	25.70	0.052	47.1	25.9865	0.0687	45.9139
1263	5.51	51.52	272	350	1.5	2.37	45	45	12	15.5	45.00	0.12	0.18	0.1	85	**300**	5	28.02	0.141	63.4	28.1615	0.1962	60.1759
1264	5.51	51.52	272	350	1.5	2.37	45	45	12	15.5	45.00	0.12	0.18	0.1	85	**300**	6	30.99	0.102	48.1	31.381	0.1742	46.3357
1265	5.51	51.52	272	350	1.5	2.37	45	45	12	15.5	45.00	0.12	0.18	0.1	85	**300**	7	33.68	0.093	39.4	33.712	0.151	40.1998
1266	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	55	**300**	6	25.48	0.39	40.3	25.506	0.2489	43.4188
1267	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	55	**300**	7	28.60	0.371	34.1	28.8511	0.1955	37.6441
1268	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	55	**300**	5	27.90	0.818	53.9	27.625	0.4589	47.9129
1269	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	55	**300**	7	31.50	0.612	34.3	31.785	0.3895	37.0833
1270	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	5	22.80	0.38	99.4	23.0291	0.2388	94.3379
1271	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	6	26.08	0.408	69.4	26.1069	0.2116	65.7592
1272	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	5	30.72	1.089	117.6	30.43	0.8161	124.862
1273	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	6	33.18	0.886	77.5	33.3569	0.8101	75.9692
1274	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	7	35.93	0.758	58.7	36.0198	0.7285	65.248
1275	5.51	51.52	272	350	1.5	1.5	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	6	28.38	0.207	80.3	28.3197	0.0906	71.2396
1276	5.51	51.52	272	350	1.5	1.5	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	7	31.88	0.055	62.8	31.474	0.0794	47.0015
1277	5.51	51.52	272	350	1.5	1.5	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	5	29.48	0.48	146.6	29.7823	0.348	144.39
1278	5.51	51.52	272	350	1.5	1.5	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	7	35.00	0.364	69.2	35.2862	0.2271	76.4689
1279	5.51	51.52	272	350	2.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	5	23.41	0.436	100.3	23.1042	0.1883	105.216
1280	5.51	51.52	272	350	2.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	6	25.82	0.41	70.3	25.6333	0.1669	73.4436
1281	5.51	51.52	272	350	2.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	5	30.54	0.946	124.3	30.7619	0.6155	124.069
1282	5.51	51.52	272	350	2.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	6	33.84	0.803	81.6	33.7184	0.589	76.8299
1283	5.51	51.52	272	350	2.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	7	36.53	0.658	62.4	36.4284	0.5201	62.0226
1284	5.51	51.52	272	350	1.5	2.37	45	45	14	21.4	38.57	0.12	0.18	0.1	85	**360**	6	25.95	0.097	72	26.0228	0.1212	77.0753
1285	5.51	51.52	272	350	1.5	2.37	45	45	14	21.4	38.57	0.12	0.18	0.1	85	**360**	7	29.01	0.093	56.1	28.8013	0.106	58.964
1286	5.51	51.52	272	350	1.5	2.37	45	45	12	15.5	45.00	0.12	0.18	0.1	85	**360**	5	29.35	0.305	128.4	29.5547	0.4181	120.369
1287	5.51	51.52	272	350	1.5	2.37	45	45	12	15.5	45.00	0.12	0.18	0.1	85	**360**	7	35.08	0.206	61.6	35.0987	0.3535	59.8346
1288	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	55	**360**	5	22.14	0.751	85.2	22.2673	0.4541	78.3737
1289	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	55	**360**	6	25.73	0.152	60.7	25.9062	0.4076	56.7879
1290	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	55	**360**	5	29.64	1.174	99.3	29.4047	0.8837	104.973
1291	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	55	**360**	6	32.06	0.976	67.1	31.7483	0.8533	64.5185
1292	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	55	**360**	7	34.00	0.953	52	33.9801	0.7696	49.6503
1293	5.51	51.52	272	540	2	2.37	35	35	12	15.5	35.00	0.12	0.15	0.1	85	**360**	6	34.23	0.092	64.4	33.8701	0.2411	69.6151
1294	5.51	51.52	272	540	2	2.37	35	35	12	15.5	35.00	0.12	0.15	0.1	85	**360**	7	37.17	0.076	50.4	37.5541	0.1975	55.731
1295	5.51	51.52	272	540	2	1.5	35	35	14	21.4	30.00	0.12	0.15	0.1	85	**360**	5	24.68	0	102.4	24.893	0.0549	87.4826
1296	5.51	51.52	272	540	2	1.5	35	35	14	21.4	30.00	0.12	0.15	0.1	85	**360**	7	32.18	0	56.5	32.1834	0.0401	56.3746

Table VI-16 Testing data set for Q4

No	*Hammer*		*Hammer cushion Material*				*Pile Information*					*Soil Information*					Stroke	**out1**	**out2**	**out3**	**BPNN**		
	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***		**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	1.76	17.6	314	175	2	2.79	30	30	12	15.5	30.00	0.1	0.2	0.1	54	**300**	9.03	22.96	1.28	182	23.0897	1.5268	187.923
2	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	6.56	28.11	0.84	101.7	28.2051	0.8386	99.731
3	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	6.68	28.84	1.05	90.2	28.8117	0.8879	95.0853
4	2.75	23.59	227	175	3	1.66	15	15	12	15.5	15.00	0.1	0.25	0.1	50	**300**	6.54	30.06	0.09	134.4	31.8297	0.438	144.884
5	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**300**	5	24.55	0.84	215.2	23.34	0.8814	196.093
6	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	6.87	30.83	1.54	145	30.9553	1.2341	140.151
7	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**350**	7.01	31.64	1.28	125.3	31.8702	1.0601	140.071
8	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**303.5**	7	29.50	0.45	67.7	27.4068	0.3	100.531
9	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**354.1**	7	31.12	0.55	101.9	32.2607	0.445	97.5405
10	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**300**	6.64	22.68	1.25	117.1	22.8079	0.8389	124.534
11	2.87	25.428	272	380	3.5	2.37	35	15	14	21.4	12.86	0.12	0.18	0.1	66	**300**	6.65	20.59	3.65	104.5	20.2438	3.6259	103.339
12	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**300**	6.73	28.77	0.62	123.4	29.6127	0.7112	130.502
13	2.87	25.43	272	350	3.5	1.69	40	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	6.87	23.95	0.51	198	24.2661	0.5877	201.03
14	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**300**	6.76	26.94	0.41	137.8	27.2093	0.4282	129.364
15	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	6.6	21.16	1.01	130.1	21.5874	0.8209	123.814
16	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**300**	7	29.42	0.63	113.7	30.3637	0.704	120.083
17	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**300**	6	25.05	0.39	197.7	25.3936	0.4568	177.805
18	2.87	25.428	272	380	3.5	2.37	35	35	12	15.5	35.00	0.1	0.15	0.1	55	**350**	6.97	24.73	1.29	214.8	24.6964	1.1351	226.658
19	2.87	25.428	272	380	3.5	2.37	35	15	14	21.4	12.86	0.12	0.18	0.1	66	**350**	6.97	21.54	4.885	155.1	21.7089	4.7434	153.799
20	2.87	25.43	272	380	2	2.37	20	20	12	15.5	20.00	0.1	0.25	0.1	50	**350**	6.99	31.03	0.61	188.9	31.0711	0.9962	178.627
21	2.87	25.428	272.3	486	3.5	2.106	30	30	12	15.5	30.00	0.1	0.18	0.12	93	**350**	6.98	28.64	0.53	254.4	28.9405	0.5046	244.337
22	2.87	25.428	272.3	486	3.5	2.106	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	6.88	21.96	0.76	232.3	21.794	1.0719	232.075
23	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**279**	6.57	21.24	0.79	113.4	20.4805	0.7719	110.645
24	2.9	25.428	272.3	486	3.5	2.106	35	32	14	21.4	27.43	0.12	0.2	0.1	95	**310**	6.71	21.69	1.19	145.8	20.8023	1.1017	133.201
25	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**350**	6	32.59	1.2	159.5	31.9602	0.9714	203.833
26	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	7	26.15	2.48	219.9	27.0456	2.4072	144.679
27	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**270**	7.79	27.57	0.4	56.2	29.2275	0.5289	68.2363
28	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**270**	7.72	19.42	0.44	50.7	19.5492	0.7201	60.8457
29	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**270**	6.46	29.94	0	78.7	29.6737	0.1023	76.9013
30	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**270**	6.43	29.02	0	68.5	29.8361	0.1748	69.4513
31	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**270**	8.31	35.64	0.03	70	36.0694	0.1309	69.9882
32	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**270**	6	28.85	0	87.2	28.2422	0.1072	83.9249
33	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**270**	7	30.16	0	61.7	31.7283	0.1765	61.071
34	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**280**	6.46	26.75	0.17	128.4	26.7886	0.2689	129.704
35	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	7.09	30.87	0.02	143.4	31.2605	0.2114	146.516
36	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**300**	8.61	36.27	0.17	87.7	35.6957	0.1634	82.1549
37	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**300**	7.49	31.56	1.47	47.2	31.8759	1.4094	46.9228
38	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**300**	7.5	29.83	1.84	49.3	30.1377	1.565	56.368
39	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**300**	7	31.45	0.01	99.2	30.6791	0.2246	102.733
40	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	8.4	36.92	0.05	61.9	37.701	0.3443	60.1012
41	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**300**	6.57	27.03	1.68	95.9	27.2115	1.4868	88.1589
42	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**300**	6.61	27.31	0.37	129.2	26.9355	0.4468	133.363
43	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**300**	7.5	35.00	0.1	81.8	35.1238	0.1823	80.1529
44	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**300**	6.64	31.44	0.2	80.9	31.3071	0.2459	78.283
45	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**300**	8.5	37.22	0.06	60.8	37.975	0.3433	58.7445

Table VI-16 Testing data set for Q4 (continued)

46	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**315**	8.06	29.82	0.36	78	31.2611	0.6553	73.6648
47	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**315**	7.97	21.14	0.45	65.3	20.0774	0.6455	76.3437
48	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**315**	6.74	33.64	0	98	33.6911	0.0628	95.8385
49	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**315**	6.69	33.02	0	84.5	32.845	0.1187	89.907
50	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**315**	8.58	36.57	0.25	88.2	37.1077	0.1231	87.3322
51	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**315**	7	31.90	0.04	131	32.0051	0.1364	125.926
52	3.3	27.093	240.2	408	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.12	85	**320**	6.5	26.97	0.34	238.1	27.0882	0.2601	224.53
53	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**350**	8.5	36.02	0.22	139.7	36.2262	0.19	138.364
54	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**350**	7.86	35.37	2.03	59.3	35.7173	1.86	52.0188
55	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	7.9	33.28	2.43	63.5	33.3884	2.0475	64.7417
56	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**350**	8.8	36.97	0.34	95.6	37.1145	0.2219	82.8497
57	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**350**	8.73	39.81	0.3	78.9	39.3581	0.4517	69.547
58	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**350**	6.93	28.19	2.23	145.7	28.0747	2.0263	138.758
59	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**350**	7.5	33.11	0.17	190.2	33.5737	0.222	193.121
60	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**350**	6	29.54	2.27	108.9	29.7919	2.0975	103.189
61	3.3	27.093	225	280	2	1.113	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	7.32	31.67	0.09	289.7	30.7338	0.2978	227.845
62	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**360**	8.19	22.83	0.51	86.5	20.8191	0.7301	89.1319
63	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**360**	6.95	36.56	0	123.1	36.8264	0.0654	118.86
64	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**360**	6.89	36.18	0	105	35.9541	0.1219	115.323
65	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**360**	8.84	37.49	0.49	116.1	38.4049	0.1223	117.959
66	3.3	27.093	240.3	408	4.5	1.31	40	40	12	15.5	40.00	0.1	0.215	0.1	43	**360**	6.93	28.34	0.83	273.6	28.8689	0.5608	255.77
67	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**360**	7	36.44	0	102.2	36.2056	0.1234	114.002
68	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**297.9**	7.22	30.06	0.22	62.7	29.5466	0.2109	64.1541
69	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**297.9**	7.15	25.71	0.82	102.5	25.5289	0.7171	101.363
70	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**357.4**	7.48	32.43	0.45	94	32.2995	0.3334	96.9868
71	4.015	43.242	225	408	2.5	2.286	82.02	82.02	12	15.5	82.02	0.1	0.18	0.152	89	**357.4**	7.45	26.61	0.89	290.8	27.0589	0.9018	244.964
72	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**260**	9.66	37.31	0.17	35.8	37.2803	0.187	28.3277
73	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**325**	9.5	41.80	0.01	49.1	41.8203	0.2271	39.334
74	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**390**	8.5	41.02	0	81.4	42.5233	0.3774	97.38
75	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**300**	7	33.38	0.32	61.6	32.5225	0.133	71.1857
76	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**350**	7.28	34.40	0.69	77.4	34.4642	0.196	80.6338
77	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**297.9**	7.18	40.49	0	43.2	40.4423	0.0365	46.1523
78	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**297.9**	7.12	40.77	0	38.4	41.0847	0.0355	44.7125
79	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**297.9**	6.5	38.34	0	45.3	38.3509	0.0421	53.3793
80	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**357.4**	7.51	41.96	0	56	41.925	0.0761	56.8197
81	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.20117	0.1006	60	**357.4**	7.38	42.99	0	47.5	43.0508	0.0692	34.607
82	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.20117	0.1006	87	**357.4**	6.5	37.95	0	78.3	38.7085	0.0836	61.9664
83	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**252.9**	7	30.32	0	27.3	33.449	0.0464	34.622
84	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**303.5**	8.2	43.85	0	28.9	43.1911	0.0628	46.6194
85	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**278.8**	8.66	25.71	0.17	41.1	25.5688	0.2906	43.6783
86	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**297.9**	8.92	28.09	1.09	63.9	27.6821	0.9679	45.944
87	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**297.9**	8.5	38.58	0.17	38.9	39.0145	0.2249	33.9144
88	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**297.9**	8.5	39.18	0.26	39.5	39.3777	0.2272	36.1814
89	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**297.9**	8.5	27.18	1.06	70.8	26.8089	0.931	50.1768
90	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**300**	9.2	36.80	0.17	51.5	37.7591	0.1765	56.2857
91	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**300**	8.9	33.26	1.27	43.7	33.81	0.5241	44.8348
92	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**300**	8.87	34.47	0.92	43.4	35.2922	0.3393	45.6537
93	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**300**	8.98	35.54	0.21	47.9	35.487	0.0947	40.46
94	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**300**	7	31.12	0.94	62.5	31.3726	0.6704	58.9158
95	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**300**	8.96	36.91	0.41	45.1	37.5534	0.1428	48.9343

Table VI-16 Testing data set for Q4 (continued)

96	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**348.4**	8.96	26.60	0.51	54.8	26.5197	0.6122	56.6042
97	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**350**	6	30.00	0.18	176.8	31.0164	0.5478	202.547
98	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**350**	9.37	37.44	1.09	52.3	37.4816	0.7529	55.197
99	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**350**	6.5	32.37	0.69	100.1	31.9749	0.7781	103.463
100	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**350**	6.5	31.25	0.02	116.3	31.0202	0.2525	117.21
101	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**350**	6	30.99	0.81	126.9	30.1218	1.2021	144.227
102	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**350**	6	30.08	0.52	143.1	29.5209	0.4043	141.801
103	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**357.4**	9.28	30.07	1.1	111	30.2399	1.5701	109.435
104	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**357.4**	8.5	42.97	0.28	49.5	43.0695	0.3398	44.0138
105	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**357.4**	9.5	30.29	1.11	105.4	30.8421	1.5868	102.809
106	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	6	20.88	1.41	180.7	21.3235	0.8685	173.127
107	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**300**	9	28.92	0.6	72.7	27.6712	0.438	97.0615
108	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**300**	9	33.20	0.73	52.7	32.2536	0.3608	44.7753
109	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**360**	9	29.32	1.09	138.9	28.3957	0.7216	140.389
110	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**360**	8	31.72	0.1	102.8	32.0676	0.5366	131.968
111	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	7.96	34.63	0	57.6	35.2383	0.0767	56.9761
112	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	7.69	27.35	0.42	48	27.3691	0.3602	53.3663
113	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	6	22.90	0.46	67	21.085	0.4809	76.9962
114	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**325**	8.49	28.55	0.16	92.2	29.5175	0.1443	94.4722
115	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	8.34	38.24	0.14	79.2	38.2278	0.1096	75.7563
116	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	8.04	28.35	0.73	62.4	28.508	0.6045	62.2169
117	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**360**	6.5	33.51	0.1	124.6	32.8848	0.1383	116.034
118	4	42.4	415	430	2	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	6.5	25.95	0.004	77.6	26.2354	0.0979	72.6175
119	4	42.4	415	430	2	0.9	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**300**	7.5	33.88	0	77.3	33.7993	0.0311	75.8211
120	4	42.4	415	430	2	0.9	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	8.5	33.45	0	57.1	32.0271	0.0335	60.4636
121	4	42.4	415	430	3.5	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**300**	6.5	25.08	0	79.5	24.807	0.0735	73.9451
122	4	42.4	415	430	2	2.126	50	50	12	15.5	50.00	0.1	0.19	0.1	77	**300**	7.5	29.60	0.229	70.5	29.5925	0.2419	82.5474
123	4	42.4	415	430	2	2.126	50	50	14	21.4	42.86	0.1	0.19	0.1	77	**300**	8.5	29.38	0.08	53.8	29.3726	0.176	54.6195
124	4	42.4	415	430	2	2.126	24	20	14	21.4	17.14	0.1	0.19	0.1	55	**300**	6.5	25.59	0.241	67	25.9281	0.2499	64.3312
125	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	8	28.09	0.41	45.8	27.9538	0.3426	51.1171
126	4	42.4	415	430	2	0.9	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	8	31.65	0.049	59.5	28.9047	0.0963	54.5225
127	4	42.4	415	430	3.5	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**300**	8	27.28	0.358	46.5	27.1081	0.2792	51.7536
128	4	42.4	415	430	2	2.126	30	20	14	21.4	17.14	0.12	0.2	0.1	20	**300**	8	28.37	1.044	44.3	27.7588	0.8368	48.3056
129	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	70	**300**	8	29.11	0	60.1	29.2166	0.1227	61.1343
130	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	6.5	28.80	0.155	98.4	27.8395	0.24	91.4321
131	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	7.5	27.40	0	69.6	27.5941	0.18	68.4128
132	4	42.4	227	530	2	0.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	8.5	36.58	0.075	73.5	36.3907	0.0858	85.173
133	4	42.4	227	530	3.5	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**325**	6.5	28.10	0.14	105.4	28.0021	0.1702	96.1978
134	4	42.4	227	530	3.5	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**325**	7.5	26.68	0	71.6	27.1304	0.1256	71.0618
135	4	42.4	227	530	2	1.9	35	32	12	15.5	32.00	0.1	0.15	0.15	65	**325**	8.5	32.49	0.672	60	32.7845	0.4137	59.0059
136	4	42.4	227	530	7	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**325**	6.5	25.16	0.168	171.6	26.4128	0.2767	165.862
137	4	42.4	227	530	3.5	1.9	50	50	12	15.5	50.00	0.1	0.2	0.15	88	**325**	7.5	28.88	0.164	119.6	28.991	0.1819	115.215
138	4	42.4	415	430	2	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**360**	7.5	29.11	0.106	89.8	29.1241	0.1917	78.0306
139	4	42.4	415	430	2	1.3	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**360**	7.5	29.28	0	110.2	29.2369	0.0812	91.9712
140	4	42.4	415	430	3.5	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	77	**360**	7.5	28.19	0.079	91.6	27.3897	0.1651	85.6355
141	4	42.4	415	430	2	2.126	24	22	14	21.4	18.86	0.1	0.19	0.1	77	**360**	7.5	29.14	0.356	87.7	28.9027	0.2342	75.7199
142	4	42.4	415	430	2	2.126	24	24	14	21.4	20.57	0.1	0.19	0.1	45	**360**	7.5	28.11	0.214	76	28.7863	0.3384	78.5147
143	4	42.4	415	430	2	2.126	70	70	14	21.4	60.00	0.12	0.2	0.1	20	**360**	6	22.27	2.357	130.5	22.756	2.5834	43.5058
144	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	7	25.78	0.77	78.5	26.6593	0.6869	78.5942
145	4	42.4	415	430	2	1.3	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	7	27.35	0.371	102.4	27.5697	0.276	96.3197

Table VI-16 Testing data set for Q4 (continued)

146	4	42.4	415	430	2.5	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**360**	7	25.46	0.782	78.4	26.3478	0.6783	80.8402
147	4	42.4	415	430	2	2.126	30	25	14	21.4	21.43	0.12	0.2	0.1	20	**360**	7	25.82	1.275	75.6	26.492	1.049	71.9474
148	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	50	**360**	7	26.43	0.224	99.2	26.973	0.384	105.229
149	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	7.74	33.06	0.31	128.8	34.5986	0.4449	120.069
150	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	6.5	29.77	0.199	86.4	28.1523	0.2251	121.985
151	4	42.4	227	530	2	0.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**390**	7.5	38.40	0.197	106.3	39.1494	0.2087	92.4317
152	4	42.4	227	530	2	0.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	8.5	34.51	0.155	87.3	34.5095	0.0785	68.7958
153	4	42.4	227	530	3.5	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	95	**390**	6.5	29.16	0.087	89.3	28.2178	0.2244	130.781
154	4	42.4	227	530	2	1.9	35	30	12	15.5	30.00	0.1	0.15	0.15	95	**390**	7.5	36.00	1.292	94.6	36.1192	0.7686	105.032
155	4	42.4	227	530	2	1.9	35	30	14	21.4	25.71	0.1	0.15	0.15	95	**390**	8.5	30.13	0.602	82.4	30.7777	0.3166	81.1678
156	4	42.4	227	530	2	1.9	35	35	14	21.4	30.00	0.1	0.15	0.15	65	**390**	6.5	29.39	0.217	90	27.2795	0.2769	111.173
157	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**252.9**	6.33	27.36	0.17	50.4	26.9461	0.3205	53.4972
158	4	43.24	381.1	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**252.9**	5	17.23	0.127	68.2	17.3455	0.2453	77.2438
159	4	43.24	381.1	175	2	3.2	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	50	**252.9**	6	27.14	0.196	50.8	26.7431	0.3704	55.6724
160	4	43.24	381.1	175	2	3.2	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	50	**252.9**	7	22.56	0.255	42.6	23.2754	0.2478	47.1332
161	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**270**	5.5	20.00	0.147	92.6	20.0894	0.2729	85.2286
162	4	43.24	400	530	2	2.796	60	40	12	15.5	40.00	0.1	0.22	0.1	95	**270**	6.5	25.99	3.188	68.9	26.3335	2.933	64.2362
163	4	43.24	400	530	2	2.796	60	40	14	21.4	34.29	0.1	0.22	0.1	95	**270**	7.5	25.68	1.683	51.4	25.5318	2.4346	54.1685
164	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	45	**270**	5.5	19.64	0.878	72.5	18.986	0.6565	78.1186
165	4	43.24	400	530	2	2.796	60	40	12	15.5	40.00	0.1	0.22	0.1	45	**270**	6.5	24.72	3.27	52.9	25.2622	2.982	56.4559
166	4	43.24	400	530	2	2.796	60	40	14	21.4	34.29	0.1	0.22	0.1	45	**270**	7.5	25.20	1.961	42.4	25.1749	2.5429	50.4283
167	4	43.24	400	530	2	1.66	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**270**	5.5	21.29	0	121.4	21.8749	0.0997	84.4892
168	4	43.24	400	530	2	1.66	60	40	12	15.5	40.00	0.1	0.22	0.1	95	**270**	6.5	27.63	1.762	84.3	27.6432	1.6876	74.8719
169	4	43.24	400	530	2	1.66	60	40	14	21.4	34.29	0.1	0.22	0.1	95	**270**	7.5	28.07	0.651	63.4	28.098	0.8776	58.7123
170	4	43.24	400	530	2	1.66	60	60	14	21.4	51.43	0.1	0.22	0.1	45	**270**	5.5	20.99	0.315	90.8	21.0293	0.2431	77.3288
171	4	43.24	400	530	2	1.66	60	40	12	15.5	40.00	0.1	0.22	0.1	45	**270**	6.5	27.09	1.976	64.7	27.4003	1.9329	68.4134
172	4	43.24	400	530	2	1.66	60	40	14	21.4	34.29	0.1	0.22	0.1	45	**270**	7.5	27.70	1.077	50.8	27.9224	1.0998	55.7898
173	4	43.24	400	530	2	2.796	35	28	12	15.5	28.00	0.12	0.15	0.1	92	**280**	5	24.02	0.973	88	23.593	0.7119	88.5246
174	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**285**	7	22.40	3.102	31.3	22.2111	2.7629	30.6728
175	4	43.24	379.9	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**285**	8	22.77	2.44	26.4	23.3999	2.6434	31.33
176	4	43.24	379.9	175	2	2	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**285**	6	21.36	3.743	48.6	21.6976	2.4242	40.9121
177	4	43.24	416	530	2	2.794	75.46	75.46	12	15.5	75.46	0.1	0.232	0.101	63	**297.9**	7	25.86	0.99	104.1	25.7141	0.8969	109.296
178	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**297.9**	7.5	27.91	0.96	76.8	27.3868	0.6232	67.4315
179	4	43.24	416	530	2	2.794	49.21	49.21	14	21.4	42.18	0.1	0.232	0.101	62	**297.9**	5.5	20.11	0.606	109	19.7009	0.5965	99.1244
180	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**297.9**	6	29.10	0	81.3	29.4414	0.0811	73.1656
181	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**297.9**	6	24.63	0.109	100.2	24.5995	0.2402	103.387
182	4	43.24	228	408	2	1.9	44.29	44.29	14	21.4	37.96	0.1	0.152	0.101	95	**297.9**	6.5	23.59	0.01	78.1	24.1306	0.1797	75.3557
183	4	43.24	228	408	2	1.9	44.29	44.29	14	21.4	37.96	0.1	0.152	0.101	45	**297.9**	5.5	20.36	0.256	95.8	20.1954	0.3552	90.6392
184	4	43.24	228	408	2	1.9	44.29	29.5	12	15.5	29.53	0.1	0.152	0.101	45	**297.9**	6	24.68	2.365	76.9	25.0324	2.1426	76.4636
185	4	43.24	228	408	2	1.9	44.29	29.5	14	21.4	25.31	0.1	0.152	0.101	45	**297.9**	6.5	23.92	1.437	65.1	24.3408	1.4176	58.3774
186	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	6	26.65	0.224	84.4	26.8176	0.3549	92.0599
187	4	43.24	415	430	2	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	7	25.49	0.166	63.5	25.4252	0.1869	65.175
188	4	43.24	415	430	2.5	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	5	19.14	0.224	120.9	19.0261	0.2663	114.821
189	4	43.24	415	430	2	1.31	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**300**	6	26.25	0.098	109	25.9309	0.1483	113.433
190	4	43.24	415	430	2	1.31	30	30	14	21.4	25.71	0.1	0.225	0.1	37	**300**	7	26.75	0.01	80.7	26.0646	0.0776	70.6735
191	4	43.24	415	430	2	2.128	50	50	14	21.4	42.86	0.1	0.225	0.1	37	**300**	5	18.72	0.555	130.1	18.8601	0.5413	133.362
192	4	43.24	415	430	2	2.128	50	40	12	15.5	40.00	0.1	0.225	0.1	37	**300**	6	24.31	1.929	91.6	24.8489	1.4764	108.974
193	4	43.24	415	430	2	2.128	50	40	14	21.4	34.29	0.1	0.225	0.1	37	**300**	7	24.95	1.02	63.2	24.3061	0.9926	66.8196
194	4	43.24	415	430	2	2.128	30	30	14	21.4	25.71	0.1	0.225	0.1	70	**300**	5	19.79	0.059	155.3	20.8971	0.1299	156.278
195	4	43.24	380	175	2	3.624	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	6.52	24.24	0.66	90.7	24.2566	0.8571	88.7579

Table VI-16 Testing data set for Q4 (continued)

196	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	8.5	24.48	0.79	44.8	24.228	0.6991	54.5936
197	4	43.24	380	175	2.5	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	6.5	19.59	0.9	69.1	20.0307	0.796	59.8581
198	4	43.24	380	175	2	2	60	60	12	15.5	60.00	0.1	0.18	0.12	94	**300**	7.5	27.71	0.161	85	27.4163	0.1978	76.9768
199	4	43.24	380	175	2	2	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**300**	8.5	27.81	0.12	61.6	28.3181	0.1148	56.6436
200	4	43.24	380	175	2	2	60	60	14	21.4	51.43	0.12	0.18	0.18	50	**300**	6.5	22.55	0.337	98.8	22.3998	0.2549	77.1425
201	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**300**	7	27.86	0.39	114.3	27.9213	0.6222	112.97
202	4	43.24	400	530	2	2.796	50	50	14	21.4	42.86	0.1	0.25	0.2	91	**300**	8	27.04	0.144	72.6	26.9707	0.3331	82.2523
203	4	43.24	400	530	2	1.66	50	50	14	21.4	42.86	0.1	0.25	0.2	91	**300**	6	23.19	0	166.7	22.6575	0.1148	157.868
204	4	43.24	400	530	2	2.796	70	70	12	15.5	70.00	0.1	0.25	0.2	91	**300**	7	26.26	0.609	131.3	25.8532	0.7023	137.849
205	4	43.24	400	530	2	2.796	70	70	14	21.4	60.00	0.1	0.25	0.2	91	**300**	8	26.53	0.329	77.4	26.4077	0.5657	83.587
206	4	43.24	400	530	2	2.796	50	50	14	21.4	42.86	0.1	0.25	0.2	45	**300**	6	21.40	0.86	111	20.9686	0.6786	117.575
207	4	43.24	400	530	2	2.796	50	33.333	12	15.5	33.33	0.1	0.25	0.2	91	**300**	7	30.49	3.128	90.7	30.2766	2.8911	94.3022
208	4	43.24	400	530	2	2.796	50	33.333	14	21.4	28.57	0.1	0.25	0.2	91	**300**	8	27.47	2.327	65.8	27.2792	2.9706	74.2908
209	4	43.24	400	530	2	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	7	27.14	1.098	90.7	27.2558	1.0283	96.2672
210	4	43.24	400	530	3	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**300**	8	26.19	0.561	64	26.3209	0.5683	69.0152
211	4	43.24	400	530	3	2.796	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	9	31.00	1.201	60.7	31.2958	0.9625	60.5966
212	4	43.24	400	530	2	1.66	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**300**	7	28.59	0.446	118.5	28.5226	0.3324	116.408
213	4	43.24	400	530	2	1.66	55	50	14	21.4	42.86	0.12	0.22	0.15	45	**300**	8	28.29	0.263	72.3	28.622	0.4243	76.6921
214	4	43.24	400	530	2	1.66	55	50	12	15.5	50.00	0.12	0.22	0.15	45	**300**	9	33.03	0.58	65.9	33.8624	0.7597	66.7167
215	4	43.24	400	530	2	2.796	30	30	14	21.4	25.71	0.1	0.18	0.12	92	**300**	5	19.39	0.086	122.4	19.4052	0.2302	140.007
216	4	43.24	400	530	2	2.2	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**300**	6	28.95	0.055	98.1	28.3199	0.1377	96.6962
217	4	43.24	400	530	2	2.2	30	30	14	21.4	25.71	0.1	0.18	0.12	92	**300**	7	26.48	0	72.9	26.097	0.0961	68.5042
218	4	43.24	380	175	2	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**300**	5	19.70	0.296	89.3	19.156	0.2677	75.392
219	4	43.24	380	175	2	2.2	40	40	12	15.5	40.00	0.1	0.2	0.1	12	**300**	6	26.65	1.309	66.1	26.9848	1.7295	69.0992
220	4	43.24	380	175	2	2.2	40	40	14	21.4	34.29	0.1	0.2	0.1	12	**300**	7	24.22	0.918	52.2	23.5735	0.4811	43.6237
221	4	43.24	380	175	2.5	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	12	**300**	5	19.46	0.298	88.5	18.8413	0.2871	78.3599
222	4	43.24	380	175	2.5	2.2	20	20	12	15.5	20.00	0.1	0.2	0.1	40	**300**	6	29.90	0.057	80.5	29.216	0.2743	86.3947
223	4	43.24	380	175	2.5	2.2	20	20	14	21.4	17.14	0.1	0.2	0.1	40	**300**	7	24.29	0.059	62.9	24.0395	0.1383	61.5513
224	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	7.5	25.38	0.84	75	25.4069	0.84	77.0828
225	4	43.24	400	530	2	2	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	5.5	20.98	0.41	160.6	21.247	0.3368	172.061
226	4	43.24	400	530	2	2	65	60	12	15.5	60.00	0.12	0.22	0.15	95	**300**	6.5	26.45	0.689	140.3	25.9702	0.5325	139.994
227	4	43.24	400	530	2.5	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**300**	7.5	25.06	0.753	72.7	25.2111	0.7396	76.8244
228	4	43.24	380	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**300**	6	20.11	3.11	46.3	20.3065	3.0197	39.9315
229	4	43.24	380	175	2	3.622	75	56	14	21.4	48.00	0.33	0.05	0.06	76	**300**	6.5	19.57	3.327	38.2	19.4684	6.3299	44.7037
230	4	43.24	380	175	2	2.2	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**300**	7	25.60	3.366	41.2	25.8789	3.1409	54.1306
231	4	43.24	380	175	2	3.622	60	60	12	15.5	60.00	0.33	0.05	0.06	76	**300**	6	20.20	1.448	46.9	20.2146	1.7062	49.2588
232	4	43.24	380	175	2	3.622	60	60	14	21.4	51.43	0.33	0.05	0.06	76	**300**	6.5	19.57	1.598	38.8	19.3238	1.3342	43.2321
233	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**300**	7	28.31	0.341	49.7	28.5851	0.3787	61.5947
234	4	43.24	314	408	2	2.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**300**	6	25.32	0.214	74.8	25.5422	0.1827	86.6562
235	4	43.24	314	408	2	2.2	36	36	14	21.4	30.86	0.1	0.12	0.1	85	**300**	6.5	23.60	0.149	62.3	23.5254	0.2734	69.7635
236	4	43.24	314	408	2	3.2	50	38.46	12	15.5	38.46	0.1	0.12	0.1	85	**300**	7	26.38	2.371	48.7	27.2067	2.3403	59.7929
237	4	43.24	314	408	2	3.2	50	38.46	12	15.5	38.46	0.1	0.12	0.1	40	**300**	6	24.07	2.639	59.3	22.5112	2.6409	60.9773
238	4	43.24	314	408	2	3.2	50	38.46	14	21.4	32.97	0.1	0.12	0.1	40	**300**	6.5	21.39	1.878	50.7	21.1535	2.0071	47.9778
239	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**300**	5.5	21.71	0.71	116.3	22.0175	0.7221	120.542
240	4	43.24	227	348	2	2.2	50	50	14	21.4	42.86	0.1	0.15	0.1	60	**300**	6.5	22.46	0.219	68.9	22.4006	0.3988	70.1978
241	4	43.24	227	348	2	1.66	50	38.46	12	15.5	38.46	0.1	0.15	0.1	60	**300**	7.5	29.51	1.361	62.8	28.9425	1.1892	81.2031
242	4	43.24	380	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**303.5**	6.59	30.70	0.54	67.9	30.5641	0.6608	71.9924
243	4	43.24	380	175	2	3.2	26.25	26.25	14	21.4	22.50	0.1	0.204	0.101	50	**303.5**	5	18.67	0.224	104.4	17.5814	0.3711	118.01
244	4	43.24	380	175	2	2.79	26.25	23.86	12	15.5	23.86	0.1	0.204	0.101	50	**303.5**	6	29.20	0.274	79.3	29.2131	0.6325	86.5189
245	4	43.24	380	175	2	2.79	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	50	**303.5**	7	23.48	0.313	60.9	22.9543	0.2857	61.368

Table VI-16 Testing data set for Q4 (continued)

246	4	43.24	380	175	2	2.79	26.25	23.86	14	21.4	20.45	0.1	0.204	0.101	85	**303.5**	5	18.91	0.221	132.6	18.9093	0.2073	141.757
247	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**315**	7.5	27.86	0.55	105.8	28.3891	0.5312	95.1825
248	4	43.24	400	530	2	2.796	60	60	14	21.4	51.43	0.1	0.22	0.1	95	**315**	7.5	25.58	0.322	81.4	25.362	0.3075	74.7569
249	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**350**	7	30.22	0.71	104.3	30.1887	0.4682	87.8919
250	4	43.24	415	430	2	1.66	30	30	12	15.5	30.00	0.1	0.225	0.1	70	**350**	7	30.24	0.085	105.7	30.6486	0.1341	123.97
251	4	43.24	400	530	2	2.796	50	50	12	15.5	50.00	0.1	0.25	0.2	91	**350**	7	28.86	0.52	248.4	29.7578	0.8993	245.229
252	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**350**	5	29.97	1.18	135	30.1172	1.023	116.247
253	4	43.24	380	175	2	3	40	40	12	15.5	40.00	0.1	0.2	0.1	12	**350**	5	27.32	2.347	173.9	26.6775	2.0737	158.107
254	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**350**	7.5	25.50	1.16	119.6	25.8657	1.0482	115.056
255	4	43.24	380	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**354.1**	5	27.63	0.6	255.9	27.4027	0.9762	273.808
256	4	43.24	380	175	2	3.2	26.25	21.88	12	15.5	21.88	0.1	0.204	0.101	50	**350**	5	29.02	1.327	186	28.6574	1.3128	198.312
257	4	43.24	416	530	2	2.794	49.21	49.21	12	15.5	49.21	0.1	0.232	0.101	62	**357.4**	6.82	26.47	1.01	224.2	26.3115	0.8847	244.363
258	4	43.24	416	530	2	2.794	49.21	49.21	14	21.4	42.18	0.1	0.232	0.101	62	**357.4**	7.5	28.14	1.04	158.5	27.3362	0.81	161.278
259	4	43.24	416	530	2	3.622	49.21	49.21	14	21.4	42.18	0.1	0.232	0.101	62	**357.4**	7.5	24.02	1.136	88.8	25.8101	1.4826	98.0674
260	4	43.24	228	408	2	1.9	44.29	44.29	12	15.5	44.29	0.1	0.152	0.101	95	**357.4**	6.5	26.35	0.47	225.9	26.6691	0.4131	200.84
261	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**360**	8.5	24.61	0.97	66.8	24.1489	0.9197	73.0631
262	4	43.24	380	175	2	1.8	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**360**	6.5	23.48	0.327	205.4	23.2624	0.2371	182.213
263	4	43.24	380	175	2	1.8	60	57	12	15.5	57.00	0.12	0.18	0.18	94	**360**	8.5	31.07	0.585	148.7	31.9475	0.4944	131.296
264	4	43.24	380	175	2	4.472	60	57	12	15.5	57.00	0.12	0.18	0.18	50	**360**	6.5	25.12	1.828	207.8	24.6981	1.3658	173.744
265	4	43.24	400	530	2	2.796	60	60	12	15.5	60.00	0.1	0.22	0.1	95	**360**	8.5	30.45	0.844	135.7	31.3648	0.7489	112.576
266	4	43.24	380	175	2	3.622	75	75	12	15.5	75.00	0.33	0.05	0.06	76	**360**	7	22.39	0.863	62.2	22.5569	1.1351	32.1136
267	4	43.24	380	175	2	3.622	75	75	14	21.4	64.29	0.33	0.05	0.06	76	**360**	7	20.63	2.644	51.6	20.4827	2.2539	47.2309
268	4	43.24	380	175	2	2.3	75	75	14	21.4	64.29	0.33	0.05	0.06	76	**360**	7	23.06	4.024	61.8	22.5267	2.7442	43.5135
269	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**360**	8	32.11	0.511	60.2	32.8742	0.5354	69.3426
270	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**375**	9	29.18	1.17	91.6	28.91	1.0784	90.8711
271	4	43.24	400	530	2.5	3.2	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**375**	7	23.52	1.211	151.3	23.726	1.0595	164.123
272	4	43.24	400	530	2.5	3.2	55	50	12	15.5	50.00	0.12	0.22	0.15	90	**375**	8	30.90	1.758	163.4	31.0513	1.7313	160.584
273	4	43.24	400	530	2	2.796	55	55	14	21.4	47.14	0.12	0.22	0.15	90	**375**	9	29.23	0.652	96	28.8011	0.6375	91.3968
274	4	43.24	400	530	2	2.796	55	55	14	21.4	47.14	0.12	0.22	0.15	45	**375**	7	24.10	1.356	151.8	24.2799	1.1889	169.521
275	4	43.24	400	530	2	2.796	55	55	12	15.5	55.00	0.12	0.22	0.15	45	**375**	8	28.72	1.302	165.7	28.8235	1.356	163.154
276	4.19	42.82	398	175	2	1.166	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**270**	7.5	33.07	0.07	71.1	33.6465	0.0506	79.05
277	4.19	42.82	398	175	3.5	1.166	35	30	12	15.5	30.00	0.1	0.22	0.1	40	**270**	5.5	25.77	0.06	96.9	25.298	0.1615	112.488
278	4.19	42.82	398	175	3.5	1.166	35	30	14	21.4	25.71	0.1	0.22	0.1	40	**270**	6.5	26.18	0	69.4	26.291	0.0925	71.2006
279	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**270**	7	29.20	0	58.3	29.3787	0.6219	44.1883
280	4.19	42.82	398	175	2	2	40	21	14	21.4	18.00	0.12	0.15	0.1	40	**270**	7	26.15	1.254	42.7	26.1768	1.2268	33.6455
281	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**270**	5	25.32	0	101.4	26.7802	0.1569	88.0018
282	4.19	42.822	272	470	2	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**270**	5	26.90	0	85.4	26.4849	0.1351	87.9171
283	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	35	**270**	5	26.62	0	72.8	26.3935	0.2361	71.5472
284	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**280**	6.15	27.47	0.9	71.7	27.1218	0.2856	73.7145
285	4.19	42.822	272	470	3.5	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**280**	6.5	26.04	0.147	67.1	26.2272	0.3009	74.2645
286	4.19	42.822	272	470	2	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**280**	7.5	26.19	0.07	51	26.6268	0.2611	55.7845
287	4.19	42.822	272	470	2	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**280**	8.5	32.13	0.144	44.9	31.0659	0.3717	47.3226
288	4.19	42.822	271	470	3.5	1.96	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**297.9**	6	22.52	0.35	86.5	22.4917	0.2833	86.3078
289	4.19	42.822	271	470	2	0.9	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**297.9**	7	31.97	0	124.6	31.8174	0.1228	130.916
290	4.19	42.822	271	470	2	0.9	75.5	75.5	14	21.4	64.71	0.1	0.18	0.1	69	**297.9**	8	26.11	0.09	130.9	31.3754	0.148	67.2851
291	4.19	42.822	228	285	2	1.099	39.37	39.37	12	15.5	39.37	0.1	0.18	0.1	65	**297.9**	7.5	27.77	0.15	213	28.38	0.0804	173.999
292	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.2	0.1	86	**300**	6.25	29.39	0.19	85.9	29.5069	0.3035	85.285
293	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**300**	7	29.34	0	72	30.438	0.0622	73.9917
294	4.19	42.822	255	175	2	1.8	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**300**	8	31.65	0	64.4	31.3428	0.1341	56.4325
295	4.19	42.822	255	175	2	1.8	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**300**	9	30.60	0	54	30.1793	0.0814	51.7912

Table VI-16 Testing data set for Q4 (continued)

296	4.19	42.822	255	175	2	1.8	30	24	14	21.4	20.57	0.1	0.18	0.1	85	**300**	7	26.27	0.163	69.9	27.115	0.1707	68.3963
297	4.19	42.822	255	175	2	1.8	30	30	12	15.5	30.00	0.1	0.18	0.1	40	**300**	8	30.59	0.086	51.7	30.0807	0.2152	47.4961
298	4.19	42.822	255	175	2	1.8	30	30	14	21.4	25.71	0.1	0.18	0.1	40	**300**	9	30.11	0	45.6	30.3441	0.1039	45.7759
299	4.19	42.822	255	175	2	0.9	15	15	14	21.4	12.86	0.1	0.18	0.1	45	**300**	6.5	28.03	0	69.4	29.7033	0.0561	75.6758
300	4.19	42.822	255	175	2	1.8	15	15	14	21.4	12.86	0.1	0.18	0.1	45	**300**	6.5	25.03	0	67.1	26.2958	0.0956	74.199
301	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	45	**300**	6.5	27.66	0	75.6	27.9944	0.0795	83.7301
302	4.19	42.822	398	175	2	1.166	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**300**	5	22.35	0	181.5	23.2351	0.0633	150.055
303	4.19	42.822	398	175	2	2.3	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**300**	6	28.99	0.031	87	29.0271	0.2302	87.7263
304	4.19	42.822	398	175	2	2.3	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**300**	7	25.88	0	66.8	26.6631	0.1089	65.9398
305	4.19	42.822	398	175	2	1.166	50	50	14	21.4	42.86	0.1	0.18	0.1	93	**300**	5	21.96	0	208.8	22.1213	0.0655	184.907
306	4.19	42.822	398	175	2	1.166	50	33.33	12	15.5	33.33	0.1	0.18	0.1	45	**300**	6	28.27	1.509	98.5	28.5578	1.3755	94.2915
307	4.19	42.822	398	175	2	1.166	50	33.33	14	21.4	28.57	0.1	0.18	0.1	45	**300**	7	28.67	0.723	70.3	27.8932	0.6153	63.548
308	4.19	42.822	398	175	2	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**300**	6	28.21	0	141.6	28.1943	0.0803	172.96
309	4.19	42.822	398	175	2	2	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**300**	7	25.75	0	70.5	26.0734	0.0815	71.1161
310	4.19	42.822	398	175	2	2	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**300**	8	31.51	0.175	63	31.3818	0.1779	65.3924
311	4.19	42.822	398	175	2.5	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	50	**300**	6	27.69	0.051	138.9	28.269	0.141	145.201
312	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**300**	7	26.52	0.5	110	26.5067	0.4253	106.333
313	4.19	42.822	272	470	3.5	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	83	**300**	8	27.00	0.485	65.4	27.1969	0.3783	66.9541
314	4.19	42.822	272	470	2	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	83	**300**	6	22.68	0.608	102.9	23.1874	0.6368	112.793
315	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	50	**300**	7	26.40	1.072	98.3	26.1191	1.1441	99.0925
316	4.19	42.822	272	470	3.5	2.2	90	90	14	21.4	77.14	0.1	0.2	0.15	50	**300**	8	26.88	0.511	60.8	26.7095	0.8384	68.316
317	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	6	25.04	0.818	91.4	24.4836	0.7362	98.4827
318	4.19	42.822	272	470	3.5	2.5	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**300**	7	24.37	0.677	54.3	24.5661	0.5432	56.4122
319	4.19	42.822	272	470	3.5	2.5	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	8	28.99	1.587	50.4	29.7979	1.1413	53.9341
320	4.19	42.822	272	470	2	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**300**	6	25.60	0.848	86.4	24.9028	0.966	98.1325
321	4.19	42.822	272	470	2	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	50	**300**	7	25.98	0.843	62.1	26.1629	1.0606	59.3304
322	4.19	42.822	272	470	2	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	50	**300**	8	30.66	1.152	55.9	31.0967	1.489	53.5765
323	4.19	42.822	272	470	3.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	6.5	23.65	0.065	75.4	23.9839	0.1259	76.3255
324	4.19	42.822	272	470	2	1.3	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**300**	7.5	31.77	0	87.7	31.585	0.0809	86.4149
325	4.19	42.822	272	470	2	1.3	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	8.5	31.84	0	65.8	31.5907	0.089	60.13
326	4.19	42.822	272	470	2.5	2.22	60	60	14	21.4	51.43	0.1	0.18	0.1	95	**300**	6.5	24.16	0.087	74.7	24.3448	0.1631	75.2995
327	4.19	42.822	272	470	3.5	1.3	60	60	12	15.5	60.00	0.1	0.18	0.1	50	**300**	7.5	31.41	0.02	75.3	31.2526	0.1865	75.2615
328	4.19	42.822	272	470	3.5	1.3	60	60	14	21.4	51.43	0.1	0.18	0.1	50	**300**	8.5	31.53	0.054	57.8	31.186	0.1185	58.6196
329	4.19	42.822	272	470	3.5	2.22	40	40	14	21.4	34.29	0.1	0.18	0.1	76	**300**	5.5	21.18	0.094	92	21.2963	0.1401	95.9575
330	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**300**	6.5	25.64	0.322	114.8	25.7251	0.2396	109.735
331	4.19	42.822	272	470	3.5	2.22	75	75	14	21.4	64.29	0.1	0.2	0.1	95	**300**	7.5	25.95	0.177	69.6	25.9779	0.1932	67.3007
332	4.19	42.822	272	470	2	2.22	75	60	14	21.4	51.43	0.1	0.2	0.1	95	**300**	5.5	21.59	1.122	108.8	21.6269	1.3143	95.629
333	4.19	42.822	272	470	2	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	55	**300**	6.5	26.35	1.076	92.5	26.4797	0.7209	84.2977
334	4.19	42.822	272	470	2	2.22	75	75	14	21.4	64.29	0.1	0.2	0.1	55	**300**	7.5	21.18	0.652	97.3	26.533	0.6437	53.2451
335	4.19	42.822	397	175	2	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	6	23.96	0.451	96.5	24.7858	0.3428	127.491
336	4.19	42.822	397	175	2	1.6	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**300**	7	26.52	0	81.9	26.8472	0.1153	78.338
337	4.19	42.822	397	175	2	1.6	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	8	31.15	0.069	74.9	31.293	0.1437	73.8841
338	4.19	42.822	397	175	3.5	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**300**	6	23.98	0.474	95.9	24.7087	0.2457	103.659
339	4.19	42.822	397	175	3.5	2.544	60	45	14	21.4	38.57	0.12	0.18	0.1	50	**300**	7	23.13	1.577	52.2	23.1394	1.5825	52.9967
340	4.19	42.822	397	175	3.5	2.544	60	45	12	15.5	45.00	0.12	0.18	0.1	50	**300**	8	27.57	2.654	47.4	26.3277	2.7317	51.1947
341	4.19	42.822	398	175	2	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**315**	5.5	23.85	0	199	24.0448	0.0492	184.074
342	4.19	42.822	398	175	2	2.5	35	35	12	15.5	35.00	0.1	0.22	0.1	75	**315**	6.5	29.82	0.185	93.3	29.7993	0.3948	97.7387
343	4.19	42.822	398	175	2	2.5	35	35	14	21.4	30.00	0.1	0.22	0.1	75	**315**	7.5	26.39	0.106	69.3	24.3363	0.1263	67.1185
344	4.19	42.822	398	175	3.5	1.166	35	35	14	21.4	30.00	0.1	0.22	0.1	30	**315**	5.5	22.98	0.047	136.8	22.7204	0.0909	153.38
345	4.19	42.822	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**315**	7	29.52	1.81	9.5	29.9966	0.7096	61.6934

Table VI-16 Testing data set for Q4 (continued)

346	4.19	42.822	398	175	2	1.166	40	40	14	21.4	34.29	0.12	0.15	0.1	80	**315**	7	28.35	0.083	84.6	28.7756	0.1204	84.119
347	4.19	42.822	398	175	2	2.5	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**315**	7	25.92	2.006	54.7	25.9758	1.6019	48.2395
348	4.19	42.822	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	45	**315**	7	29.00	0.758	75.4	30.0864	1.1308	56.5212
349	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**315**	6	30.23	0	102.3	30.4308	0.0995	99.1123
350	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**350**	6.5	31.96	0	95.8	31.1915	0.0749	98.7297
351	4.19	42.822	398	175	2	1.166	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**350**	7	28.81	0	107.9	28.0718	0.0862	122.484
352	4.19	42.822	398	175	2	2.3	30	30	14	21.4	25.71	0.1	0.18	0.1	93	**350**	7	26.15	0.041	90.3	25.7914	0.179	85.8607
353	4.19	42.822	398	175	2	1.166	30	30	14	21.4	25.71	0.1	0.18	0.1	45	**350**	7	28.49	0.111	100.6	27.1442	0.1507	99.3474
354	4.19	42.822	272	470	3.5	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	75	**350**	6.5	26.31	0.328	158.4	26.4786	0.3607	170.417
355	4.19	42.822	272	470	2	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	35	**350**	7.5	26.84	0.403	70.2	26.6893	0.7098	70.8416
356	4.19	42.822	272	470	2	2.22	50	50	12	15.5	50.00	0.12	0.18	0.1	35	**350**	8.5	31.67	0.799	65.3	31.8797	1.104	59.4012
357	4.19	42.822	272	470	3.5	2.22	50	30	12	15.5	30.00	0.12	0.18	0.1	75	**350**	6.5	28.31	3.638	120.9	28.7312	4.1738	122.363
358	4.19	42.822	272	470	3.5	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	69	**357.4**	7	27.42	0.479	231.8	27.3815	0.5009	221.46
359	4.19	42.822	272	470	2	1.96	75.5	75.5	12	15.5	75.50	0.1	0.18	0.1	40	**357.4**	7	27.81	1.143	142.5	28.2719	1.188	161.391
360	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**357.4**	7.5	29.39	0.45	233.7	28.6012	0.4029	218.531
361	4.19	42.822	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**360**	7	29.65	2.29	122.7	30.1344	1.1019	108.943
362	4.19	42.822	398	175	2	1.166	40	35	14	21.4	30.00	0.12	0.15	0.1	40	**360**	7	28.49	0.357	113.1	28.296	0.5687	99.1802
363	4.19	42.822	398	175	2	2.1	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**360**	7	26.90	2.551	80.3	26.9619	2.0866	75.9578
364	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	7	33.17	0	143.8	32.6781	0.0927	142.361
365	4.19	42.822	255	175	2	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	85	**360**	8	32.24	0	83.9	32.0921	0.0681	93.6999
366	4.19	42.822	255	175	2	1.5	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**360**	9	35.28	0.037	93.8	35.9177	0.1252	89.334
367	4.19	42.822	255	175	3.5	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	35	**360**	7	31.18	0.22	140.9	31.0013	0.1308	94.3831
368	4.19	42.822	255	175	3.5	0.9	30	30	14	21.4	25.71	0.1	0.18	0.1	35	**360**	8	30.49	0.109	76	30.3634	0.0889	75.8292
369	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	8	31.28	0.119	101.9	31.7105	0.0837	100.473
370	4.19	42.822	398	175	2	2.4	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**360**	6	29.24	0.354	191.3	28.8391	0.8154	188.418
371	4.19	42.822	398	175	3.5	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**360**	7	27.91	0.12	142.2	27.9016	0.069	142.516
372	4.19	42.822	398	175	3.5	2.3	40	39	12	15.5	39.00	0.12	0.18	0.13	94	**360**	8	33.15	0.384	96.6	33.2272	0.4495	122.267
373	4.19	42.822	398	175	2	1.166	40	39	12	15.5	39.00	0.12	0.18	0.13	45	**360**	6.5	29.53	0.017	252	29.6949	0.4017	239.668
374	4.19	42.822	272	470	3.5	2.2	90	90	12	15.5	90.00	0.1	0.2	0.15	83	**360**	8	29.31	0.556	262.1	29.9843	0.6853	256.271
375	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**360**	7	36.00	0	99.5	35.7434	0.0976	111.401
376	4.19	42.822	272	470	3.5	0.9	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**360**	7	33.78	0	106.4	31.8437	0.0399	161.271
377	4.19	42.822	272	470	2.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	35	**360**	7	37.15	0.281	77.6	35.5377	0.2043	82.7563
378	4.19	42.822	272	470	2.5	1.96	30	20	12	15.5	20.00	0.1	0.18	0.1	72	**360**	7	35.25	1.859	93.6	33.7404	0.7801	112.718
379	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	7	25.57	0.65	104.6	25.5299	0.4696	102.966
380	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	8	30.57	1.341	103.4	30.849	0.9746	101.479
381	4.19	42.822	272	470	3.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	35	**360**	6	24.66	2.106	269.6	25.2385	2.2874	214.889
382	4.19	42.822	272	470	3.5	3.6	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**360**	7	22.50	1.637	72.3	22.4319	1.5806	75.0776
383	4.19	42.822	272	470	3.5	3.6	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	8	29.29	2.496	73.1	28.4793	2.3108	67.4102
384	4.19	42.822	272	470	2.5	1.96	65	57	12	15.5	57.00	0.12	0.15	0.15	95	**360**	6	25.55	1.319	241.8	25.628	1.3975	240.852
385	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**360**	7.5	28.81	0.411	143.6	28.5369	0.3316	151.708
386	4.19	42.822	272	470	2.5	2.22	60	55	12	15.5	55.00	0.1	0.18	0.1	95	**360**	7.5	29.36	0.945	129.6	29.4657	0.9299	125.236
387	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	40	**360**	7.5	28.09	1.356	107.9	27.8881	1.1523	110.611
388	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**360**	7.5	30.08	0.4	113.1	30.4372	0.3048	110.303
389	4.19	42.822	272	470	3.5	1.5	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**360**	7.5	31.20	0	134.3	30.689	0.1008	138.447
390	4.19	42.822	272	470	2	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**360**	7.5	31.33	0.34	99.8	31.2168	0.4218	103.952
391	4.19	42.822	272	470	3.5	2.22	40	38	12	15.5	38.00	0.1	0.18	0.1	55	**360**	6.5	27.80	0.79	125	27.3842	0.657	143.745
392	4.19	42.822	272	470	3.5	2.22	75	75	12	15.5	75.00	0.1	0.2	0.1	95	**360**	7.5	28.31	0.53	269.1	28.4164	0.3189	229.597
393	4.19	42.822	397	175	2	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	6	24.95	0.47	285	25.2741	0.6046	299.149
394	4.19	42.822	397	175	2	1.5	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	7	26.94	0	150	27.0946	0.1606	133.322
395	4.19	42.822	397	175	4	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**360**	6	20.51	0.329	146.1	21.514	0.201	161.966

Table VI-16 Testing data set for Q4 (continued)

396	4.19	42.822	397	175	4	2.544	60	60	12	15.5	60.00	0.12	0.18	0.1	95	**360**	7	26.90	0.438	154.4	26.6858	0.4492	38.2072
397	4.19	42.822	397	175	2	2.544	60	55	14	21.4	47.14	0.12	0.18	0.1	55	**360**	8	26.47	1.412	72.3	25.577	1.449	96.7075
398	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	55	**360**	8.5	30.72	0.759	91	30.1341	0.6814	86.5924
399	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	5	22.28	0.301	58.2	22.1742	0.1592	58.8096
400	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	6	31.70	0.474	46.4	32.1926	0.3665	46.7115
401	5.51	51.52	272	350	2.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	7	28.62	0.244	39.3	29.0112	0.0802	35.1647
402	5.51	51.52	272	350	1.5	1.5	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**300**	5	24.14	0.212	66.5	23.5556	0.0697	49.6201
403	5.51	51.52	272	350	1.5	1.5	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**300**	6	31.14	0.229	52.6	32.1116	0.1195	67.1826
404	5.51	51.52	272	350	1.5	2.37	45	45	14	21.4	38.57	0.12	0.18	0.1	85	**300**	7	28.78	0.047	39.5	28.8424	0.0598	36.1954
405	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	55	**300**	5	21.97	0.415	51	21.63	0.3199	55.2839
406	5.51	51.52	272	350	1.5	2.37	45	40	12	15.5	40.00	0.12	0.18	0.1	55	**300**	6	29.87	0.714	41.1	30.1269	0.4307	40.0405
407	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	7	29.18	0.384	55	29.0832	0.1816	55.7059
408	5.51	51.52	272	350	1.5	1.5	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	5	24.38	0.293	118	24.2575	0.1037	104.871
409	5.51	51.52	272	350	1.5	1.5	45	40	12	15.5	40.00	0.12	0.18	0.1	85	**360**	6	31.78	0.413	92.3	32.8545	0.2916	122.748
410	5.51	51.52	272	350	2.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**360**	7	28.84	0.37	56	28.6057	0.1453	58.2862
411	5.51	51.52	272	350	1.5	2.37	45	45	14	21.4	38.57	0.12	0.18	0.1	85	**360**	5	22.42	0.107	104.4	23.0971	0.1362	113.405
412	5.51	51.52	272	350	1.5	2.37	45	45	12	15.5	45.00	0.12	0.18	0.1	85	**360**	6	32.38	0.207	81	32.4486	0.4016	69.2801
413	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	55	**360**	7	28.83	0.551	48.5	29.3465	0.3441	51.3068
414	5.51	51.52	272	540	2	2.37	35	35	12	15.5	35.00	0.12	0.15	0.1	85	**360**	5	31.09	0.133	94	29.7456	0.3136	100.125
415	5.51	51.52	272	540	2	1.5	35	35	14	21.4	30.00	0.12	0.15	0.1	85	**360**	6	28.67	0	71.4	29.0584	0.0467	66.0111
416	4	43.2	283	175	2	1.166	30	30	12	15.5	30	0.1	0.18	0.1	50	300	8	32.78	0	76.1	33.2999	0.0954	66.1861
417	7	70	397	175	2	2.1	70	65	12	15.5	65	0.1	0.18	0.1	65	300	7	32.73	0.374	36.2	32.0277	0.1275	32.1413
418	5.5	51.5	272	540	2.5	2.22	45	45	14	21.4	38.57	0.1	0.15	0.1	90	360	6.5	27.93	0.098	69.4	30.9235	0.0892	53.1877
419	4.85	45.3	272	200	3.2	1.166	15	12	12	15.5	12	0.1	0.18	0.1	35	300	6.5	33.28	0	61.2	33.4319	0.0544	56.2668
420	4.2	42	283	175	2	1.5	30	25	12	15.5	25	0.1	0.2	0.1	55	300	6.5	29.59	0.743	71.3	30.6394	0.2318	82.5189
421	4	42	380	175	2	4.47	40	30	14	21.4	25.71	0.1	0.2	0.1	80	270	7	22.53	1.191	39.8	21.1703	1.3569	43.6046

V.3.5 Q5 type (400-700 kips)

Table VI-17 Training data set for Q5

	Hammer		*Hammer cushion Material*				*Pile Information*					*Soil Information*						**out1**	**out2**	**out3**	***BPNN***		
No	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***	Stroke	**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**400**	7	31.28	1.16	181.0	31.329	1.1116	182.2
2	4	32	397	175	2	2.819	40	34	12	15.5	34.00	0.1	0.18	0.15	95	**400**	6.73	32.79	2.3	222.9	32.176	2.2807	223.63
3	4.19	42.822	398	175	2	2.544	30	30	12	15.5	30.00	0.1	0.18	0.15	95	**400**	6.85	32.63	1.96	211.8	32.36	1.9655	210.7
4	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**400**	6	31.46	0.15	251.1	31.806	0.1255	253.72
5	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**400**	7	34.95	0.06	137.3	34.729	0.1093	138.67
6	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**400**	9.57	44.56	0	64.0	44.808	0.0242	63.051
7	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**400**	6	33.35	0	189.8	33.586	0.0637	190.01
8	2.87	25.428	272	380	3.5	2.37	35	15	12	15.5	15.00	0.12	0.18	0.1	66	**400**	7.22	22.33	5.98	276.0	22.466	5.9375	276.1
9	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**400**	7	32.42	2.09	237.8	32.692	2.0989	237.13
10	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**400**	7.26	33.84	1.46	189.6	33.689	1.4795	191.23

Table VI-17 Training data set for Q5 (continued)

11	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**400**	7	33.19	1.45	214.7	33.518	1.4544	214.24
12	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**400**	7.5	38	0.2	151.8	38.352	0.0939	148
13	3.3	33	283.4	175	2	0.895	25	25	12	15.5	25.00	0.1	0.25	0.1	37	**400**	9.18	38.28	1.04	199.6	37.184	1.0618	198.38
14	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**400**	9.81	43.12	0	79.5	43.61	0.0774	80.909
15	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**400**	7	34.79	0	172.9	35.296	0.1965	169.78
16	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**400**	9.13	37.95	0.34	198.6	37.679	0.3527	200.57
17	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**400**	8.29	39.87	2.98	71.6	40.034	2.9821	74.224
18	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**400**	7	35.55	2.51	103.3	35.43	2.455	98.684
19	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**400**	6	31.13	2.65	201.3	30.653	2.6718	202.33
20	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**400**	7	33.4	2.76	122.3	33.903	2.7352	123.48
21	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**400**	10.42	39.09	0.5	68.4	38.9	0.3778	72.002
22	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**400**	9.42	34.16	3.72	110.8	34.109	3.6694	109.93
23	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**400**	8	30.13	3.54	219.9	30.898	3.5434	220.01
24	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**400**	9.75	40.96	0.59	63.7	41.873	0.3065	62.358
25	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**400**	7	33.64	0.75	135.2	33.486	0.5706	142.53
26	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**400**	6	30.47	0.6	267.6	30.601	0.6741	259.96
27	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**400**	7.23	37.77	0	137.4	37.784	0.0043	136.95
28	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**400**	9.05	37.77	0.84	129.5	39.006	0.9552	130.98
29	1.76	20.099	314	175	2	2.79	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**400**	9.93	32.28	2.17	290.6	32.693	2.1702	289.49
30	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**400**	5.5	31.48	0.61	256.5	31.5	0.6574	258.91
31	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**400**	6.5	34.27	1.19	150.1	33.985	1.0948	144.99
32	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**400**	7.5	36.55	1.48	102.1	36.598	1.5535	109.83
33	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**400**	5.5	29.58	0.02	296.8	29.777	0.0304	289.48
34	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**400**	7.49	34.75	0.49	193.2	34.948	0.3746	197.56
35	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**400**	9.64	43.04	0.06	61.7	43.753	0.0946	62.935
36	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**400**	7.5	37.44	0.3	100.0	37.136	0.2023	100.39
37	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**400**	9.58	41.51	0	71.6	41.862	0.0179	68.574
38	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**400**	7.5	36.15	0	117.7	36.076	0.0586	117.31
39	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**400**	7	34.38	0.54	176.4	34.349	0.5325	176.57
40	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**400**	7	37.16	1.56	163.7	37.181	1.5425	163.23
41	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**400**	5	31.38	1.42	239.6	31.364	1.3577	239.58
42	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**400**	6	35.11	1.48	121.2	35.29	1.5312	122.75
43	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**400**	9.01	42.07	0.69	101.6	42.182	0.5487	97.85
44	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**400**	6.5	33.13	0.1	237.1	33.463	0.1939	237.99
45	4.19	42.822	398	175	2	1.166	30	30	12	15.5	30.00	0.1	0.18	0.1	93	**400**	7	32.46	0.6	283.5	32.718	0.6004	282.09
46	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**400**	7.11	28.73	2.53	260.8	28.769	2.5463	260.06
47	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**400**	9.68	43.57	0.09	61.9	44.439	0.2155	63.767
48	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**400**	7	36.15	0.37	120.8	36.18	0.3783	115.09
49	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**400**	7.66	25.99	1.08	208.7	25.739	1.0736	209.97
50	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**400**	8.87	31.219	0.995	107.9	31.193	0.9961	109.47
51	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**400**	7.23	27.593	1.51	262.3	27.555	1.5179	261.88
52	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**400**	7	36.89	0	117.0	36.643	0.053	110.87
53	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**400**	8.85	42.46	0.23	102.4	42.592	0.2755	103.85
54	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**400**	8	31.52	0.87	183.0	31.68	0.8891	180.41
55	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**400**	6	34.39	0	222.3	34.387	0.0015	222.65
56	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**400**	6	34.02	1.57	272.0	34.215	1.5855	273.81
57	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**404.6**	7.12	35.57	0.79	133.3	35.665	0.7859	130.97
58	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**404.6**	8.46	35.7	0.59	103.7	35.219	0.6063	104.52
59	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**404.6**	7	32.24	0.58	173.3	32.087	0.5827	174.3
60	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**404.6**	8.66	51.06	0	40.8	50.458	0.0531	45.156

Table VI-17 Training data set for Q5 (continued)

61	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**404.6**	6	29.51	0.21	195.9	28.96	0.2912	194.93
62	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**404.6**	6	32.01	0.7	246.5	32.304	0.6269	245.78
63	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**404.6**	7	33.25	0.4	86.2	33.757	0.1857	84.342
64	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**405**	7.32	30.72	2.5	153.0	30.26	2.4645	153.18
65	3.3	33	314	175	2	7.749	40	40	12	15.5	40.00	0.1	0.2	0.2	95	**405**	8.53	33.25	0.54	191.0	32.6	0.5353	191.39
66	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**405**	8.45	24.37	0.62	119.1	23.936	0.6373	120.9
67	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**405**	7	22.34	0.59	205.0	21.956	0.5816	205.27
68	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**405**	6	35	0	243.6	35.513	0.0033	243.18
69	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**405**	7.1	38.78	0	130.6	39.127	0.0006	130.31
70	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**405**	6	35.21	0	191.5	35.392	0.0002	190.98
71	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**405**	9.02	39.6	0.72	131.0	39.98	0.8365	129.68
72	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**405**	7	34.68	0.34	265.4	34.719	0.3668	264.01
73	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**405**	9.1	38.48	0.84	162.1	38.936	0.7637	162.88
74	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**405**	6.26	34.14	0	205.3	34.15	0.0002	204.61
75	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**405**	7	38.41	0	165.0	38.5	0.0116	166.17
76	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**417**	7.68	43.07	0	77.0	43.539	0.0012	76.802
77	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**417**	6.5	39.14	0	127.9	39.551	0.0034	128.81
78	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**417**	7.51	45.98	0	61.6	45.829	0.0152	63.511
79	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**417**	6	40.06	0	107.9	40.092	0.0242	107.19
80	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**417**	7	44.22	0	71.2	43.484	0.0186	71.732
81	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**417**	9.51	42.09	1.67	63.8	41.941	1.7029	65.412
82	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**417**	9.15	48.67	0.46	55.7	48.882	0.472	54.688
83	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**417**	7.5	42.81	0.48	77.3	42.703	0.5138	79.259
84	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**417**	9.38	44.97	0.82	85.7	45.299	0.7907	90.128
85	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**417**	8.5	42.49	0.82	104.0	42.675	0.9001	106.18
86	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**417**	7.5	39.45	0.81	139.6	39.52	0.745	135.62
87	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**417**	7.5	43.07	0.52	78.4	43.826	0.562	78.518
88	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**417**	8.5	46.69	0.52	63.3	47.197	0.5008	59.65
89	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**417**	9.61	40.64	3.69	62.0	41.038	3.5904	65.55
90	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**417**	7.5	38.8	1.48	92.5	39.727	1.4022	89.471
91	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**417**	6.66	37.82	0	137.4	37.469	0.0015	136.16
92	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**417**	5.5	33.59	0	257.2	33.88	0.0005	256.5
93	4	43.24	228	408	2	1.9	21.33	21.33	12	15.5	21.33	0.1	0.122	0.101	90	**417**	6.69	32.73	0	170.5	33.362	0.0044	171.33
94	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**417**	7.84	34.93	0.71	148.8	34.329	0.6869	149.67
95	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**417**	7	32.5	0.62	220.3	32.885	0.6589	220.83
96	4.015	43.242	225	408	2.5	2.286	34.45	34.45	12	15.5	34.45	0.1	0.18	0.1	39	**417**	7.94	32.52	1.78	133.9	32.41	1.8061	133.26
97	4.19	42.822	228	285	2	1.099	22.97	22.97	12	15.5	22.97	0.1	0.18	0.1	16	**417**	8.6	33.71	0.65	297.1	33.903	0.6509	292.68
98	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**417**	7	40.84	0	99.5	41.052	0.0021	97.358
99	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**417**	8.5	46.32	0.46	62.4	46.335	0.505	59.712
100	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**418.1**	7.5	24.9	1.72	114.1	25.097	1.7197	113.97
101	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**418.1**	9.5	28.45	1.94	69.4	28.392	1.9031	71.044
102	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**418.1**	8.5	26.76	1.83	85.5	26.711	1.8246	85.532
103	4	40	398	175	2	2.1	50	50	12	15.5	50.00	0.1	0.15	0.1	70	**420**	10.17	32.81	0.13	182.2	32.571	0.1554	182.69
104	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**420**	10.17	41.33	0	75.8	41.602	0.0252	76.133
105	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**420**	8	34	0.16	168.2	34.496	0.0913	167.09
106	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**420**	9.23	39.71	0	116.8	40.136	0.0312	112.87
107	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**420**	6.5	35.34	0.22	242.8	35.457	0.2352	244.35
108	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**420**	7.5	38.32	0.36	155.7	38.188	0.2125	152.34
109	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**420**	8.5	40.85	0.19	117.2	41.18	0.2026	119.01
110	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**420**	8.39	29.54	1.2	82.1	29.247	1.1444	81.847

Table VI-17 Training data set for Q5 (continued)

111	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**420**	6	23.45	1.19	188.4	23.662	1.1425	188.87
112	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**420**	6.5	20.44	1.53	261.6	21.443	1.4874	262.57
113	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**420**	8.5	24.74	1.64	109.5	24.432	1.6112	111.28
114	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**420**	10	40.48	1.81	68.3	40.26	1.8518	69.23
115	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**420**	7.24	28.16	0.81	108.3	27.824	0.8324	107.89
116	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**420**	6	24.28	1.54	256.0	24.14	1.523	256.11
117	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**420**	7.75	27.5	2.26	102.2	27.218	2.2619	102.07
118	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**420**	6	22.82	2	215.2	23.36	2.0171	216.05
119	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**420**	8	31.79	0.43	170.8	31.208	0.4325	171.21
120	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**420**	8.27	28.76	1.21	126.5	28.171	1.2063	125.85
121	4.19	42.822	272	470	3.5	2.22	60	60	12	15.5	60.00	0.1	0.18	0.1	95	**420**	8.5	31.3	0.59	289.8	31.097	0.5641	289.48
122	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**420**	6.5	23.85	0.32	264.2	23.712	0.3128	264.06
123	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**420**	8.5	28.66	0.29	120.8	28.453	0.2849	120.67
124	4.19	42.822	272	470	3.5	2.22	40	40	12	15.5	40.00	0.1	0.18	0.1	76	**420**	7.5	31.36	0.56	256.1	31.296	0.5702	256
125	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**420**	6	21.82	3.47	202.0	22.171	3.4295	204.86
126	4	43.24	314	408	2	3.2	36	36	12	15.5	36.00	0.1	0.12	0.1	85	**420**	7.19	29.71	1.24	189.7	29.538	1.2377	189.44
127	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**420**	6.81	41.36	0	93.6	41.436	0.0108	94.446
128	4	32	397	175	2	2.819	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**420**	7	23.6	1.31	239.0	23.507	1.3076	240.09
129	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**420**	8	27.21	0.54	137.0	27.208	0.5277	138.12
130	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**420**	7	25.66	1.23	194.3	25.564	1.2236	194.11
131	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**420**	7.5	26.35	0.31	161.3	25.867	0.3074	160.44
132	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**420**	7	26.27	1.2	119.5	25.536	1.1713	121.16
133	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**420**	7.5	22.67	1.59	152.0	22.429	1.6582	153.68
134	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**420**	7	24.85	0.64	194.4	24.161	0.6387	196.58
135	4	43.24	415	430	2	2.128	30	30	12	15.5	30.00	0.1	0.225	0.1	37	**450**	7.56	33.57	1.41	276.2	33.785	1.361	276.44
136	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**450**	7.53	31.48	3.36	200.1	31.405	3.2495	199.68
137	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**450**	7	29.89	2.9	246.0	29.605	2.8685	245.93
138	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**450**	9.96	44.91	0	84.4	44.895	0.0251	82.748
139	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**450**	9.79	47.09	0	77.3	47.184	0.0269	74.894
140	2.75	22.605	272	408	3.5	2.37	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**450**	7.63	35.79	1.77	294.0	35.959	1.801	292.98
141	2.82	31.33	415	175	2	2.79	10	10	12	15.5	10.00	0.1	0.25	0.15	20	**450**	7.36	41.64	0.44	244.6	41.909	0.4398	243.74
142	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**450**	9.08	44.8	0.33	129.2	44.933	0.3978	128.27
143	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**450**	7.5	39.63	0.21	221.5	39.907	0.1062	223.11
144	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**450**	10.03	45.06	0	101.9	45.234	0.0366	100.4
145	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**450**	8.64	41.09	3.13	96.4	41.353	3.223	98.055
146	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**450**	8.67	38.17	3.21	114.6	39.432	3.1521	111.16
147	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**450**	10.42	40.1	0.72	96.2	40.314	0.9068	96.994
148	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**450**	9.74	35.77	4.29	162.9	36.117	4.368	162.7
149	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**450**	10.13	43.84	0.22	78.2	44.328	0.2697	73.094
150	3.3	27.093	240.3	408	4.5	1.31	15	15	12	15.5	15.00	0.1	0.18	0.1	30	**450**	7.48	39.8	0	188.5	40.133	0.0048	189.2
151	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**450**	9.36	38.87	1.83	180.0	39.921	1.664	185.18
152	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**450**	7.83	38.79	1.62	136.2	38.76	1.6309	136.7
153	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**450**	6.69	35.24	0	210.4	35.173	0.0696	211.51
154	3.3	27.093	225	280	2	1.113	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**450**	7.71	36.68	0.41	289.6	36.8	0.496	277.49
155	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**450**	9.96	46.05	0.04	74.5	46.255	0.0669	72.804
156	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**450**	9.78	44.07	0	90.5	44.146	0.015	91.996
157	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**450**	7.5	37.7	0	177.4	37.661	0.0519	176.99
158	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**450**	9	29.38	1.5	190.2	29.056	1.4953	190.11
159	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**450**	7.36	36.59	0.54	292.7	36.87	0.5086	292.39
160	3.3	33	314	175	2	7.749	40	40	14	21.4	34.29	0.12	0.18	0.2	95	**450**	8.65	25.7	0.63	177.8	25.266	0.6256	178.52

Table VI-17 Training data set for Q5 (continued)

161	2.97	25.245	415.5	175	2	1.75	15	15	12	15.5	15.00	0.1	0.2	0.1	18	**450**	7	38.48	1.37	263.7	38.444	1.3636	262.17
162	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**450**	9.34	43.95	1.06	133.0	43.766	1.1237	128.88
163	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**450**	8.5	41.14	0.91	167.9	41.143	0.9806	167.57
164	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**450**	10.01	46.61	0.12	74.7	46.652	0.1496	76.114
165	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**450**	7.34	41	0	205.5	40.975	0.009	205.62
166	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**450**	7.33	40.99	0	163.3	41.411	0.0006	163.5
167	3.3	33	283.4	175	2	0.895	15	15	12	15.5	15.00	0.1	0.23	0.1	30	**450**	9.31	41.6	1.18	167.7	41.578	1.104	166.78
168	3.3	33	283.4	175	2	0.895	20	20	12	15.5	20.00	0.1	0.19	0.1	50	**450**	9.38	39.42	0.64	236.6	39.91	0.7138	235.48
169	4	43.24	227	348	2	2.2	50	50	12	15.5	50.00	0.1	0.15	0.1	60	**450**	9.08	31.872	1.425	197.3	31.874	1.4089	196.66
170	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**450**	7	35.17	1.01	235.9	35.294	0.9714	234.8
171	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**450**	7.5	38.91	0.09	144.2	39.02	0.2059	150.72
172	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**450**	6	36.26	0	292.0	36.667	0.0001	290.59
173	4	42.4	227	530	2	1.9	35	35	12	15.5	35.00	0.1	0.15	0.15	95	**455**	8.11	35.41	0	239.7	35.395	0.0163	239.46
174	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**455**	10.42	52.76	0.12	68.3	53.488	0.0378	66.762
175	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**455**	7.5	40.25	0	181.8	40.603	0.0231	180.83
176	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**455**	9.5	49.39	0	82.9	49.01	0.0334	81.681
177	4	43.24	381.1	175	2	3.2	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**455.2**	7.38	37.38	0.95	206.2	37.313	1.0144	206.08
178	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**455.2**	8.73	37.31	0.61	154.3	37.283	0.6157	155.44
179	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**455.2**	8.83	54.11	0	48.2	53.791	0.0588	47.468
180	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**476.6**	7.94	45.5	0	107.2	45.864	0.0034	108.56
181	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**476.6**	6.5	40.31	0	248.4	40.371	0.0044	246.89
182	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**476.6**	7.78	48.83	0	78.5	49.468	0.0115	78.806
183	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**476.6**	6	41.54	0	176.5	41.642	0.0153	179.85
184	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**476.6**	7	45.92	0	102.2	45.369	0.0132	100.89
185	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**476.6**	9.78	44.75	2.5	86.2	44.857	2.4724	83.213
186	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**476.6**	6.82	40.65	0	199.2	41.024	0.0024	199.43
187	4.015	43.242	225	408	2.5	2.286	32.81	32.81	12	15.5	32.81	0.1	0.152	0.101	90	**476.6**	8.1	37	0.66	284.4	37.136	0.6591	283.5
188	4.015	43.242	225	408	2.5	2.286	34.45	34.45	12	15.5	34.45	0.1	0.18	0.1	39	**476.6**	8.3	34.23	1.85	262.3	34.179	1.8753	263.11
189	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**477**	9.42	52.37	0.7	65.9	52.657	0.6476	65.838
190	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**477**	8.5	48.92	0.69	78.9	49.025	0.6695	76.86
191	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**477**	9.78	48	0.64	112.0	48.01	0.6567	110.85
192	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**477**	7.5	40.72	0.58	238.0	40.685	0.6483	238.2
193	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**477**	7.5	45.72	0.83	102.4	46.269	0.8712	104.84
194	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**477**	8.5	49.32	0.85	79.9	49.791	0.8721	79.964
195	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**477**	10.1	44.18	4.07	82.6	44.851	4.0582	81.698
196	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**477**	9.65	47.11	1.86	75.7	47.223	1.8446	75.414
197	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**477**	7.5	41.27	1.74	135.8	41.416	1.7753	135.43
198	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**480**	10.17	43.68	0.1	106.0	44.013	0.029	108.74
199	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**480**	9	39.63	0.11	163.8	40.3	0.0561	163.1
200	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**480**	9.55	41.19	0	195.2	41.326	0.0089	196.57
201	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**480**	9.04	44.18	0	166.5	44.101	0.0745	168.22
202	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**480**	8.73	31.29	1.62	113.3	30.846	1.6864	112.62
203	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**480**	8.7	25.24	1.66	203.2	25.166	1.6426	206.2
204	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**480**	8.5	24.86	1.66	222.1	24.562	1.6865	221.97
205	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**480**	10.36	42.5	2.13	92.4	42.895	2.05	90.738
206	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**480**	7.57	29.28	1.69	175.2	29.346	1.6602	176.77
207	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**480**	8.5	29.31	1.41	225.6	28.838	1.4193	223.95
208	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**480**	6.5	25.84	1.51	163.5	25.257	1.5241	166.91
209	4.19	42.822	397	175	2	2.544	60	60	14	21.4	51.43	0.12	0.18	0.1	95	**480**	8	27.33	0.78	297.3	27.334	0.8054	294.51
210	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**480**	7	26.86	1.59	214.2	26.359	1.5597	214.54

Table VI-17 Training data set for Q5 (continued)

211	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**480**	7	27.65	1.78	265.8	27.122	1.8018	266.08
212	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**487.8**	7.5	26.74	2.03	206.5	26.808	2.0006	206.56
213	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**487.8**	9.5	30.59	2.33	100.9	30.472	2.3865	99.174
214	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**487.8**	8.5	28.75	2.19	133.8	28.608	2.2291	135.41
215	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**490**	8.06	28.54	2.93	158.6	28.603	2.9306	157.78
216	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**490**	8.5	28.82	0.46	261.1	28.405	0.4511	260.81
217	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**490**	7	25.9	2.81	266.4	25.491	2.8306	264.11
218	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**500**	10.19	46.79	0	107.2	47.158	0.0224	109.52
219	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**500**	10.16	50.11	0	91.5	50.443	0.047	87.8
220	3.3	33	283.4	175	2	0.895	10	10	12	15.5	10.00	0.1	0.25	0.1	18	**500**	9.41	47.36	0.6	161.2	47.7	0.5848	160.73
221	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	41	**500**	10.21	46.59	0	135.7	47.121	0.0222	135.06
222	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**500**	9.25	45.87	4.5	111.9	46.292	4.4978	109.11
223	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**500**	9.05	43.62	3.66	127.4	43.262	3.6427	132.34
224	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**500**	9.13	40.32	3.5	163.1	40.896	3.5402	160.61
225	4	40	398	175	2	2.101	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**500**	10.42	41.11	1.3	146.4	41.15	1.195	144.3
226	3	26	398	175	2	2.126	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**500**	10.15	37.29	4.7	257.2	37.239	4.6734	255.32
227	4	47.2	397	175	2	2.15	25	25	12	15.5	25.00	0.1	0.2	0.1	20	**500**	10.4	45.84	0.2	99.8	46.309	0.1332	93.713
228	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**500**	9.67	39.77	1.77	272.2	40.771	1.8456	269.22
229	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**500**	8.21	40.7	1.29	185.2	40.905	1.2792	181.74
230	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**500**	10.32	48.6	0	90.4	48.938	0.04	86.968
231	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**500**	9.66	45.45	1.63	180.6	45.093	1.6021	178.36
232	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**500**	10.37	49.14	0	90.4	49.275	0.0529	93.99
233	2.8	23.8	315.7	175	2	7.74	26.25	26.25	12	15.5	26.25	0.1	0.204	0.101	50	**505.8**	8.96	38.73	0.61	261.6	38.576	0.6188	261.34
234	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**505.8**	9.02	56.85	0	56.8	56.884	0.0583	57.062
235	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**520**	10.42	56.15	0.14	87.1	56.316	0.1371	86.831
236	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**520**	9.5	52.48	0.1	109.5	52.238	0.0813	108.66
237	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**536.1**	8.17	48.86	0	165.1	49.253	0.0103	164.57
238	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**536.1**	7.5	45.12	0	248.6	45.614	0.0094	248.61
239	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**536.1**	8.04	54.03	0	101.8	53.683	0.0099	102.69
240	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**536.1**	7	47.64	0	159.3	47.898	0.0093	159.52
241	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**536.1**	10.17	47.5	2.84	118.2	47.514	2.8272	116.37
242	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**536.1**	9.61	55.58	0.68	78.9	55.688	0.7052	82.969
243	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**536.1**	7.5	47.34	0.7	135.6	47.666	0.6991	133.93
244	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**536.1**	8.5	51.17	0.69	100.8	51.589	0.7073	102.64
245	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**536.1**	10.14	50.41	0.56	151.2	50.579	0.5914	147.58
246	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**536.1**	8.5	45.23	0.45	268.1	45.23	0.4293	267.3
247	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**536.1**	9.74	56.46	1.06	78.2	56.924	1.1177	80.535
248	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**536.1**	7.5	47.96	1.05	137.4	48.483	1.0884	136.16
249	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**536.1**	10.47	46.99	4.48	119.5	47.62	4.3954	118.6
250	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**536.1**	9.94	49.99	1.89	95.0	49.83	1.9019	97.064
251	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**536.1**	7.5	42.85	1.79	220.3	42.875	1.7469	218.53
252	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**540**	9.35	46.36	0	286.0	46.452	0.0065	284.33
253	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**540**	9.04	32.49	2.28	164.5	32.05	2.2404	165.41
254	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**540**	10.94	44.87	0.48	124.1	45.471	0.6357	123.1
255	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**540**	7.23	47.96	0	151.8	48.061	0.0061	151.83
256	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**557.5**	9.78	32.84	2.06	147.9	32.902	2.069	145.51
257	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**557.5**	9.5	32.24	2.07	161.9	32.231	2.126	162.97
258	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**557.5**	8.5	30.17	1.96	248.9	30.056	2.0343	246.55
259	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**560**	8.47	30.16	2.86	271.2	30.245	2.8676	272.63
260	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**585**	10.42	59.1	0.35	112.2	58.5	0.3059	113.24

Table VI-17 Training data set for Q5 (continued)

261	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**585**	9.5	54.83	0.14	149.0	55.304	0.1529	147.23
262	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**595.7**	7	50.77	0	292.5	51.046	0.0099	292.81
263	4	47.2	399	175	2	3.423	26.25	26.25	12	15.5	26.25	0.1	0.152	0.101	25	**595.7**	10.53	49.52	2.95	173.2	49.704	2.9404	171.89
264	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**595.7**	10.1	59.59	0.66	89.6	58.637	0.6305	87.243
265	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**595.7**	7.5	49.41	0.68	190.5	49.736	0.6499	191.17
266	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**595.7**	10.6	52.89	0.61	207.1	53.218	0.6367	205.67
267	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**595.7**	10.24	60.51	1.23	89.0	59.686	1.307	87.79
268	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**595.7**	7.5	49.92	1.2	192.9	50.547	1.2347	195.2
269	4	47.2	399	175	2	3.423	32.81	32.81	14	21.4	28.12	0.1	0.108	0.101	10	**595.7**	10.89	49.57	4.88	183.8	50.061	4.8365	184.73
270	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**595.7**	10.5	53.12	1.79	115.3	53.605	1.7585	113.27
271	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**600**	9.54	33.9	1.07	233.9	33.589	1.14	234.17
272	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**600**	11.35	46.93	0.95	187.9	47.347	0.9439	189.12
273	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**600**	7.49	51.14	0	195.3	50.801	0.0033	194.84
274	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**627.2**	10.14	34.7	1.63	229.5	34.917	1.609	230.72
275	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**650**	10.42	61.23	0.64	149.1	59.82	0.64	147.4
276	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**650**	9.5	56.5	0.34	212.5	57.626	0.3507	210.25

Table VI-17 Testing data set for Q5

No	*Hammer*		*Hammer cushion Material*				*Pile Information*					*Soil Information*					Stroke	**out1**	**out2**	**out3**	***BPNN***		
	Ram wt	Energy	area	Elastic Modulus	Thick	Helmet wt	Length	Penetr	Diam	Section area	L/D	Quake at toe	Damp at shaft	Damp at toe	Shaft resist (%)	***Qu***		**Com Stress**	**Ten Stress**	**BPF**	**Com Stress**	**Ten Stress**	**BPF**
1	2.75	22.605	225	175	3	1.66	20	20	12	15.5	20.00	0.1	0.22	0.1	20	**400**	7.27	33.11	2.12	207.9	33.227	2.0876	216.56
2	3.3	33	283.4	175	2	0.895	30	30	12	15.5	30.00	0.1	0.18	0.1	53	**400**	8.5	36.15	0.29	252.1	36.376	0.6367	228.14
3	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**400**	8.27	38.5	2.57	74.6	39.246	2.7089	72.195
4	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**400**	8.29	35.94	2.88	83.6	37.595	2.6458	82.132
5	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**400**	7.56	36.67	1.48	100.3	36.761	1.5759	108.46
6	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**400**	6.5	34.15	0.49	150.4	34.002	0.2412	152.46
7	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**400**	6.5	33	0	182.1	33.37	0.0597	190.69
8	4	43.24	400	530	2	2.796	30	30	12	15.5	30.00	0.1	0.18	0.12	92	**400**	7.05	34.47	0.54	173.4	34.487	0.521	170.96
9	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**400**	8.5	40.44	0.6	114.4	40.571	0.4902	109.89
10	3.3	27.093	240.3	530	4.5	1.31	50	50	12	15.5	50.00	0.1	0.18	0.1	20	**400**	7	28.47	2.52	278.4	28.569	2.6285	265.96
11	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**400**	6	32.53	0.59	209.1	33.335	0.448	189.57
12	4	43.24	400	530	2	2.796	65	60	14	21.4	51.43	0.12	0.22	0.15	95	**400**	7.5	25.61	1.09	226.9	25.369	1.0779	236.24
13	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**400**	9.64	42.28	0	68.7	42.536	0.0409	64.424
14	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**400**	6	33.01	2.45	154.5	31.992	2.1486	150.84
15	3.3	33	314	175	2	0.95	20	20	12	15.5	20.00	0.1	0.23	0.1	25	**400**	7	31.77	0.25	263.9	33.946	0.616	263.98

Table VI-17 Testing data set for Q5 (continued)

16	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**400**	6.5	32.2	0	141.8	33.526	0.0647	106.86
17	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**400**	7.5	37.02	0.28	151.5	37.059	0.32	147.13
18	4.19	42.82	398	175	2	1.166	40	21	14	21.4	18.00	0.12	0.15	0.1	80	**405**	7	29.77	2.39	169.7	29.169	2.2999	170.82
19	4.19	42.822	272	470	3.5	1.96	20	20	12	15.5	20.00	0.1	0.18	0.1	72	**405**	6	33.36	0	236.1	33.534	0.0002	234.23
20	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**405**	7.16	38.97	0	157.1	38.944	0.0139	155.77
21	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**405**	7	38.51	0	134.1	38.797	0.0005	134.63
22	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**417**	7.5	42.61	0	81.8	42.818	0.0013	80.751
23	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**417**	6.5	42.15	0	85.1	41.619	0.0216	83.933
24	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**417**	9.5	31.47	1.12	276.2	33.132	0.9611	216.73
25	4	47.2	399	175	2	3.423	16.4	16.4	12	15.5	16.40	0.1	0.18	0.101	25	**417**	9.28	43.71	1.61	61.5	44.654	1.475	60.582
26	4	47.2	399	175	2	3.423	55.77	55.77	12	15.5	55.77	0.1	0.223	0.101	75	**417**	9.61	31.88	1.13	254.5	33.481	0.8866	208.11
27	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**417**	9.19	49.22	0.52	56.1	49.724	0.4836	52.708
28	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**417**	6	35.4	0	185.4	35.376	0.0008	200.84
29	4.015	43.242	225	408	2.5	2.286	45.93	45.93	12	15.5	45.93	0.1	0.152	0.1	90	**417**	7.81	30.63	0.87	212.4	31.197	0.6552	256.56
30	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**418.1**	9.25	28.14	1.93	72.7	27.96	1.8911	74.08
31	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**420**	9	39.09	0.01	125.3	39.571	0.0603	119.02
32	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**420**	8.64	41.33	0.2	112.5	41.596	0.2009	115.74
33	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**420**	8	28.72	1.19	90.4	28.064	1.1524	90.348
34	4	43.24	380	175	2	3.624	60	57	14	21.4	48.86	0.12	0.18	0.18	94	**420**	8.44	24.6	1.64	110.8	24.272	1.6193	112.46
35	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**420**	7	27.48	0.98	122.3	26.968	0.9546	118.82
36	4	43.24	400	530	2	2.796	35	28	14	21.4	24.00	0.12	0.15	0.1	92	**420**	7	25.61	2.16	130.0	25.141	2.0993	135.38
37	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**420**	7.89	31.51	0.42	179.3	30.835	0.4255	174.62
38	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**420**	8	28.14	1.21	137.0	27.583	1.2269	132.48
39	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**420**	8.2	27.99	0.3	131.4	27.648	0.2944	130.38
40	4	40	398	175	2	2.1	20	20	12	15.5	20.00	0.1	0.15	0.1	20	**420**	9	37.76	0.11	104.8	37.805	0.0609	112.98
41	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**420**	8	36.25	0.02	183.4	37.074	0.3572	156.1
42	4	47.2	397	175	2	2.15	30	30	12	15.5	30.00	0.1	0.2	0.1	14	**420**	7	32.21	1.69	186.4	31.117	2.5941	236.14
43	5.51	51.52	272	350	1.5	2.37	45	40	14	21.4	34.29	0.12	0.18	0.1	85	**420**	6.5	25.97	1.34	165.5	25.405	1.23	162.87
44	4.19	42.822	398	175	2	1.166	40	39	14	21.4	33.43	0.12	0.18	0.13	94	**420**	7	29.04	0.36	284.8	27.972	0.4166	212.62
45	4	43.24	379.9	175	2	3.622	75	56	12	15.5	56.00	0.33	0.05	0.06	76	**420**	6.5	24.75	1.43	81.8	22.928	2.9714	137.2
46	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**450**	7	38.6	0	168.4	38.229	0.036	177.68
47	3.3	33	283.4	175	2	3	25	25	12	15.5	25.00	0.1	0.2	0.1	10	**450**	7	37.13	3	164.1	36.516	2.9594	171.99
48	3.3	33	283.4	175	2	3	30	30	12	15.5	30.00	0.1	0.2	0.1	15	**450**	7	34.63	3.03	227.4	34.812	3.461	226.39
49	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**450**	7.5	38.01	1.64	155.6	37.878	1.5203	152.91
50	4.19	42.822	255	175	2	0.9	15	15	12	15.5	15.00	0.1	0.18	0.1	45	**450**	6.5	34.66	0	240.1	34.383	0.0586	252.03
51	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**450**	6.5	35.58	0.19	257.6	35.941	0.2591	264.78
52	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**450**	8.76	28.87	1.5	207.2	28.309	1.4883	215.78
53	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**450**	7.5	37.54	0.53	256.1	37.659	0.648	257.86
54	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	75	**450**	7	39.81	0	234.1	39.933	0.006	240.32
55	3.3	27.093	240.3	408	4.5	1.31	10	10	12	15.5	10.00	0.1	0.16	0.1	35	**450**	7	39.86	0	182.8	40.27	0.0004	187.88
56	4	47.2	397	175	2	2.15	20	20	12	15.5	20.00	0.1	0.18	0.1	41	**450**	7	36.23	0	223.3	36.287	0.0946	226.87
57	3.3	33	238.4	175	2	3	25	10	12	15.5	10.00	0.1	0.2	0.1	10	**450**	8.75	42.81	3.72	89.2	43.078	3.7811	86.938
58	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**450**	6.5	35.34	1.62	258.0	35.269	1.0698	253.2
59	4	43.24	400	530	2	2.796	55	50	14	21.4	42.86	0.12	0.22	0.15	90	**450**	8	27.16	1.49	293.5	26.245	1.4151	289.17
60	4	43.24	380	175	2	3.624	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**450**	6	36.49	1.85	193.4	37.571	2.3666	206.44
61	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.25	0.1	15	**450**	7	37.58	0.16	185.6	37.495	0.4483	193.22
62	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**455**	8.5	45.34	0	111.1	44.475	0.0279	114.35
63	7	59.99	398	175	2	2.14	18.04	18.04	12	15.5	18.04	0.1	0.152	0.101	57	**455.2**	7	34.15	0.07	155.5	35.128	0.1889	115.36
64	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**476.6**	7.5	43.94	0	129.5	43.833	0.0036	127.41
65	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**476.6**	6.5	43.77	0	128.7	43.303	0.0143	123.35

Table VI-17 Testing data set for Q5 (continued)

66	6.603	75.438	415.5	280	2	0.899	27.9	27.9	12	15.5	27.88	0.1	0.201	0.101	87	**476.6**	7	42.09	0	169.6	41.931	0.0039	167.45
67	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**477**	7.5	45.18	0.7	101.2	45.233	0.647	102.79
68	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**477**	9.48	52.93	0.85	66.1	53.605	0.8172	63.867
69	4	47.2	399	175	2	3.423	18.04	18.04	12	15.5	18.04	0.1	0.253	0.101	50	**477**	8.5	44.12	0.56	157.5	44.01	0.7864	155.02
70	4.19	42.822	255	175	2	0.9	30	30	12	15.5	30.00	0.1	0.18	0.1	85	**480**	9	39.72	0	253.7	39.619	0.05	226.37
71	4	42.4	415	430	2	2.126	24	24	12	15.5	24.00	0.1	0.19	0.1	77	**480**	8.5	42.81	0	198.2	42.826	0.0689	207.19
72	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**480**	8	29.52	1.61	140.9	28.766	1.5991	136.71
73	4.19	42.822	272	470	3.5	1.96	65	57	14	21.4	48.86	0.12	0.15	0.15	95	**480**	8	28.19	1.4	290.8	27.737	1.47	276.09
74	4	43.24	314	408	2	3.2	10	10	12	15.5	10.00	0.1	0.12	0.1	65	**480**	7.06	44.65	0	116.8	45.126	0.012	121.26
75	4	47.2	399	175	2	3.423	26.25	26.25	14	21.4	22.50	0.119	0.18	0.101	42	**487.8**	9.48	30.66	2.31	101.1	30.433	2.3855	99.759
76	4.19	42.822	272	470	3.5	2.22	50	50	14	21.4	42.86	0.12	0.18	0.1	75	**490**	8.38	28.56	0.46	277.3	28.08	0.4576	273.78
77	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.15	0.1	74	**500**	10.09	46.38	0	114.1	47.073	0.0252	121.19
78	3.3	33	314	175	2	1	20	20	12	15.5	20.00	0.1	0.2	0.1	12	**500**	8.5	41.55	1.26	285.0	41.451	1.5326	277.02
79	4	47.2	397	175	2	2.15	15	15	12	15.5	15.00	0.1	0.2	0.1	30	**500**	7	39.68	0	265.8	39.85	0.0271	282.71
80	4.2	42	283.3	175	2	1.045	20	20	12	15.5	20.00	0.1	0.25	0.1	20	**500**	7.5	38.82	1.27	272.0	38.996	1.1202	258.44
81	4	47.2	397.4	175	2	2.15	20	20	12	15.5	20.00	0.1	0.2	0.1	20	**500**	7.5	40.31	0.01	230.7	40.807	0.2118	254.33
82	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**520**	8.5	47.01	0.04	156.7	47.52	0.0455	153.53
83	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**536.1**	6.5	45.26	0	222.2	45.584	0.0091	246.86
84	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**536.1**	8.5	51.84	1.05	102.2	52.219	1.1902	107.21
85	4	43.24	228	408	2	1.9	13.12	13.12	12	15.5	13.12	0.1	0.122	0.101	90	**536.1**	7.02	43.49	0	295.4	44.926	0.0033	276.05
86	4	42.4	415	430	2	2.126	30	30	14	21.4	25.71	0.12	0.2	0.1	20	**540**	8	29.85	2.19	252.5	29.373	1.9946	251.28
87	4.092	42	399	175	2	2.126	10	10	12	15.5	10.00	0.1	0.18	0.1	10	**585**	8.5	49.7	0.12	235.7	50.776	0.0684	217.85
88	6.603	75.438	415.5	280	2	0.899	18.0	18.0	12	15.5	18.00	0.1	0.201	0.101	60	**595.7**	8.23	58.14	0	138.9	57.186	0.0123	132.75
89	4	47.2	399	175	2	3.423	9.84	9.84	12	15.5	9.84	0.1	0.122	0.101	25	**595.7**	8.5	53.26	0.66	131.8	53.734	0.6121	134.05
90	4	47.2	399	175	2	3.423	9.84	9.84	14	21.4	8.43	0.1	0.201	0.101	10	**595.7**	8.5	53.95	1.2	133.5	54.429	1.4235	135.94