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BRIDGE MANAGEMENT SYSTEM UPDATE

by

Steven A. Duncan
Graduate Research Assistant

and

David W. Johnston, Ph.D., P.E.
Professor

Department of Civil Engineering
North Carolina State University

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16. Abstract

The objective of this project was to assist the NCDOT in updating parameters used in analysis of bridge inspection data for purposes of bridge management. Various parameters are used in OPBRIDGE, a bridge manage system decision support program for predicting optimum use of funds budgeted and for predicting performance of the bridges of the State of North Carolina in future years under various level of funding. In particular, the project examined and developed parameters for:
1. Unit costs of replacements;
2. Unit costs for rehabilitation;
3. Mentenance effort as a function of elemant condition;
4. Deterioration rate for major bridge elements;
5. ADT growth rates for the bridge functional classifications and locations;
6. Bridge-related accident unit costs; and
7. Vehicle operating costs.
In most cases, improvements over the previous parameter values was possible as documented in this report.

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EXECUTIVE SUMMARY

The OPBRIDGE program was developed at North Carolina State University (NCSU) during the 1980's to help the North Carolina Department of Transportation (NCDOT) optimize use of funding for bridge maintenance. The OPBRIDGE program uses deterioration rates of different bridge elements, costs for rehabilitation and replacement, vehicle operating costs, ADT growth rates, and accident costs stored in the COSTPARM file. The program assists the NCDOT in determining the best use of their current funding, as well as, predict future needs.

The purpose of this study was to update and determine new methods of calculating parameters used by the OPBRIDGE program. Limited data was available during the initial development of the program. Now, with 20 years of data stored in the Bridge History Files, this data was evaluated to update the parameters and compared to the parameters developed initially by Chen and Johnston in 1985. Information is presented on how these databases were used and lists of programs are provided that were used to analyze the data and to calculate the deterioration rate and rehabilitation costs and work requirements.

Since 1985, some periodic published reports containing user costs have changed or no longer exist. It was one purpose of this report to identify new sources of information that would be easily obtainable and produced on a regular basis. These new sources along with updated sources that Chen and Johnston used were compared to verify their reasonableness. To compare these costs and to update costs to the current year,

inflation indexes were needed. An accurate inflation index is needed to maintain the accuracy of the OPBRIDGE program. Several inflation indexes are provided and their uses explained so that NCDOT personnel can apply them properly in future updates.

This report provides the NCDOT personnel with the sources of information and the methods used to determine costs for rehabilitation, maintenance and replacement of bridges, deterioration rates for bridge elements, ADT growth rates, vehicle operating cost, and accident costs. Update worksheets and listings of programs used with the NCDOT databases are provided. Also, an updated COSTPARM file containing the proposed new parameters and costs current for the year 2002 is provided.

This information will allow NCDOT to regularly update the COSTPARM file that contains the parameters used by the OPBRIDGE program, and allow the OPBRIDGE program to provide more accurate results.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

1. INTRODUCTION

The OPBRIDGE program used by the North Carolina Department of Transportation (NCDOT) Bridge Maintenance Unit provides an analysis of the optimum current and future funding needs for bridge replacement, rehabilitation, and maintenance. OPBRIDGE can also predict future bridge performance under a limited budget [Al-Subhi and Johnston, 1989].

Limited data was available during the initial analysis of bridge deterioration rates, ADT growth rates, and costs affecting the performance of bridges [Chen and Johnston, 1987]. During that initial analysis, approximately 5 years of data was available from the Structure Inventory and Appraisal (SI&A) database. However, 20 years of data has now accumulated from inspections and work accomplished.

It is the purpose of this report to evaluate the 20 years of data and compare this to previous analysis performed in 1985. The data for this analysis came from the NCDOT Bridge History Files and the Bridge Maintenance Inventory File. Using these databases, the ADT growth rates, bridge deterioration rates, rehabilitation cost, maintenance effort as a function of element condition, vehicle operating cost, and accident cost are evaluated.

It was also the purpose of this report to provide instructions on the necessary steps to update the COSTPARM file, which contains the parameters used by the OPBRIDGE program. This would allow North Carolina Department of Transportation personnel to update these parameters on a regular basis, which would allow the OPBRIDGE program to provide a more accurate and current output.

2. OVERVIEW OF COST AND PARAMETER FILE

2.1. COSTPARM.DAT File

The COSTPARM.DAT file contains various parameters used by the OPBRIDGE program. This file contains ADT growth rates, deterioration rates of the different components of a bridge, maintenance unit costs, average rehabilitation unit work, and bridge related accident costs. These are some of the parameters contained in the file. It is important for the accuracy of the OPBRIDGE program results to maintain current data in this file.

The COSTPARM.DAT file was created by Al-Subhi, Johnston, and Farid [1989] from data generated by Chen and Johnston [1987]. Limited data was available in the National Bridge Inventory File and the NCDOT History File during Chen and Johnston's [1987] research, so estimations had to be made. It is the purpose of this research, now that 20 years of data is available in these files, to revaluate some of the parameters in the COSTPARM.DAT file looking at through the 20 years of data, and to create methodologies so the COSTPARM.DAT file can be updated on a more regular basis.

2.2. Updating Using Inflation Indexes

In updating the COSTPARM.DAT file, it was noted that some sources used to estimate costs presented data that was several years old. Inflation indexes were used to update these costs to present values. Also, the old data used in the COSTPARM.DAT file was updated using the inflation indexes to verify the costs presented in the latest reports. Several indexes were investigated. These inflation indexes, presented in Table 2-1, are set to a base year of 1985. The Consumer Price Index is used to update the costs of goods and services, while the ENR Construction Cost Index, Federal-Aid Highway Construction Index(Composite), and the Federal-Aid Highway Construction Index (Structures) are used to update construction related costs. The two Federal-Aid Highway Construction Indexes specifically deal with highway related construction cost.

To use these indexes, the index number for the year that the costs are to be updated to is divided by the index number for the original year of the cost. This produces a number that is multiplied by the original cost. The following example will illustrate how to updated cost.

Cost (1989) = $100
Consumer Price Index (1989) = 1.15
Consumer Price Index (2000) = 1.60
Multiplier = 1.60/1.15 = 1.39
Cost (2000) = $100 * 1.39 = $139

Table 2-1 Inflation Adjusted to 1985 Base Year

Year	Consumer Price Index Base Year 1985[1]	ENR Construction Cost Index Base Year 1985[2]	Federal-Aid Highway Construction Index (Composite) Base Year 1985[3]	Federal-Aid Highway Construction Index (Structures) Base Year 1985[3]
1980	0.77	0.77	0.95	1.02
1981	0.84	0.84	0.92	0.97
1982	0.90	0.91	0.87	0.92
1983	0.93	0.97	0.86	0.88
1984	0.97	0.99	0.91	0.90
1985	1.00	1.00	1.00	1.00
1986	1.02	1.02	0.99	1.00
1987	1.06	1.05	0.98	1.02
1988	1.10	1.08	1.05	1.13
1989	1.15	1.10	1.06	1.21
1990	1.21	1.13	1.06	1.20
1991	1.27	1.15	1.05	1.15
1992	1.30	1.19	1.03	1.10
1993	1.34	1.24	1.06	1.07
1994	1.38	1.29	1.13	1.11
1995	1.42	1.30	1.20	1.22
1996	1.46	1.34	1.18	1.24
1997	1.49	1.39	1.28	1.35
1998	1.51	1.41	1.24	1.36
1999	1.55	1.44	*1.24	*1.32
2000	1.60	1.48	*1.26	*1.34
2001	1.65	1.51	*1.28	*1.36
2002	*1.68	*1.54	*1.30	*1.38

* Indexes were extrapolated to obtain these values.

1. U.S. Department of Labor, Bureau of Labor Statistics, ftp.bls.gov/pub/special.requests/cpi/cpiai.txt, 2002
2. Engineering News-Record, www.enr.com/cost/costcci.asp, 2002
3. Federal Highway Administration, www.fhwa.dot.gov/ohim/hs97/pt1.pdf, 2002

3. VEHICLE OPERATING COST UPDATE

Bridges are sometimes posted with load capacity restrictions and under or over vertical clearance restrictions. Because of these restrictions, vehicles exceeding the limits must be detoured around these bridges. The number of vehicles detoured around the bridge is dependent on the load capacity of the bridge and the vertical clearance of the bridge, as well as, the height and weight distribution of the vehicles using the bridge [Chen and Johnston 1987].

The route detour length listed in the National Bridge Inventory (NBI) is the bypass detour distance that a vehicle will travel for a closed or detour-posted bridge. The actual detour length for a detour caused by low clearance or load capacity may be more than that listed in the NBI. This is because the load capacity or vertical clearance sign is posted at the bridge and not at the detour turnoff [Chen and Johnston 1987].

The vehicle operating cost for these detours will vary according to vehicle characteristics and operator's wage rates. OPBRIDGE uses a linear relationship between vehicle operating cost and vehicle weight, developed by Chen and Johnson [1987]. An estimate was made for the operating cost of vehicles weighing 3 tons or less and for vehicles weighing the maximum legal load limit. The variation in operating cost of vehicles weighing between these extremes was assumed to be linear and determined by interpolation.

The operating costs for passenger cars, small trucks, and other vehicles weighing up to 3 tons were assumed to be equal. The operating cost of these vehicles involves two components: vehicle cost and operator cost. The vehicle cost was taken as the Internal

Revenue Service (IRS) standard mileage rate for all business mileage for passenger cars. The operator cost was taken as the North Carolina State Government employee Vehicle Operator I minimum wage rate, assuming a 48-week work year, 40 hours per week, and a average speed of 40 mph.

The upper limit was assumed to be a truck tractor semi-trailer (TTST) vehicle weighing the legal load limit. There is limited data for the operating cost of these vehicles. Chen and Johnston used a report published by the US Department of Agriculture (USDA) to establish the operating cost of TTST type vehicles. However, the USDA report no longer provides this data. Thus, a new source was needed.

The different components for calculating the vehicle operating costs are updated at varying intervals. Most of this information can be obtained through the use of the Internet. The following paragraphs provide the websites, phone numbers, and other information necessary to obtain the updated cost.

The IRS standard mileage rate for the current year can be found at www.irs.gov. The quickest way to find the standard mileage rate may be to use the search engine and the keyword: "Standard Mileage Rate." One can refer to Tax Topic 510, Business Use of Car, and Publication 463, Travel, Entertainment, and Gift Expenses. For 2002, the standard mileage rate is $0.365 per mile [Internal Revenue Service].

The Vehicle Operator I minimum salary can be found on the North Carolina Department of Transportation website www.dot.state.nc.us. At the website, look under “employee information”, “human resources”, “salary administration”, and then “job classifications and salaries” [North Carolina Department of Transportation, 2001]. Use the minimum salary value listed for Vehicle Operator I code 7102, which is $17,821 for 2002. The following equation can be used to calculate the operator cost per mile.

Operator Cost = Vehicle Operator I (minimum salary)/(1920 hours * 40 mph)

Operator Cost = $17,821/(1920*40) = $0.23 per mile

The current operator cost is then taken as $0.23 per mile. The total cost for vehicles weighing less than 3 tons then becomes the sum of the standard mileage rate and the operator cost.

Total Vehicle Cost (under 3 tons) = Standard Mileage Rate + Operator Cost

Total Vehicle Cost (under 3 tons) = $0.365 per mile + $0.23 per mile = $0.60 per mile

The current total average operating cost for vehicles weighing less than 3 tons is then taken as $0.60 per mile for 2002.

There is very limited published data on the operating cost of tractor-trailer vehicle. The U.S. Department of Agriculture once provided a cost for owner-operator tractor-trailer operating cost in the Fruit and Vegetable Truck Cost Report. The June 1985 Fruit and Vegetable Truck Cost Report presented a cost of $1.15 per mile. This report was modified and now does not calculate the tractor-trailer operating cost. In looking for a new source for this data, a report was needed that is produced on a regular basis and provides the information in a clear and consistent format.

The U.S. Census Bureau produces a report called the Services Annual Survey [U.S. Census Bureau, 2001]. This report uses the North American Industry Classification System (NAICS) to categorize different industries. The NAICS 484 is for industries in truck transportation that provide over-the-road transportation of cargo using motor vehicles, primarily tractor-trailers. In the 1999 Service Annual Survey, the data to calculate the tractor-trailer operator cost was provided in two separate tables. Under this NAICS classification in Table 2.4 (Estimated Revenue by Size of Shipments, Commodities Handled, and Origin and Destination of Shipments for Employer Firms: 1998 and 1999), the total motor carrier revenue was given for 1999 as $152,158 million. In Table 2.6 (Estimated Number of Truck Miles Traveled by Employer Firms: 1998 and 1999), the total distance traveled in highway miles for 1999 was given as 84,729 million miles. To calculate the tractor trailer operating cost (including both vehicle and operator cost), an estimate can be made by dividing the total revenue by total miles.

Total TTST Operating Cost = motor carrier revenue/ total distance traveled in highway miles
Total TTST Operating Cost = $152,158 million / 84,729 million miles = $1.80 per mile

This produces a cost of $1.80 per mile in 1999 dollars. Adjusting this value using the Consumer Price Index ($1.80x1.68/1.55) produces a cost of $1.95 per mile in 2002 dollars. Although all these vehicle miles are not at a legal limit load which would result in a low estimate, these costs include profit and other costs which, in an approximate way, compensate.

An alternate method was used to find the vehicle operating costs as a check, using Chen and Johnston's 1985 data for vehicle operating costs and updating it with the Consumer Price Index. This method is shown below.

Consumer Price Index (1985)= 1.00
Consumer Price Index (2002)= 1.68
Multiplier = 1.68/1.00 = 1.68
Operating Cost for Vehicles Weighing 3 Tons or Less ($/mile) = 0.35*1.68 = $0.59

Operating Cost for Vehicles Weighing Max Legal Load ($/mile) = 1.15*1.68= $1.93

A comparison of the results of the two methods is shown in Table 3-1. The approach of using the Operator I wage and IRS mileage rate for the 3 Ton vehicles appear to remain valid. The approach of using the Census Bureau NAICS 484 data appears valid as a new source for the Maximum Legal Load Vehicle.

Table 3-1 Vehicle Operating Costs

	1985 Cost from IRS and NCDOT ($/mile)	1985 Cost from Fruit and Vegetable Truck Cost Report ($/mile)	1985 Cost Adjusted to 2002 Cost using CPI ($/mile)	2002 Cost from U.S. Census Bureau ($/mile)	2002 Cost from IRS, and NCDOT ($/mile)
Operating Cost for Vehicles Weighing 3 Tons or Less	0.35	--	0.59	--	0.60
Operating Cost for Vehicles Weighing the Maximum Legal Load	--	1.15	1.93	1.95	--

4. VEHICLE ACCIDENT COST UPDATE

Bridge related accidents represent only a small portion of the total number of vehicle accidents that occur. In a study of North Carolina accident data from 1984 to 1989, the number of bridge related accidents was found to be roughly 2 percent of all traffic accidents. However, the severity of bridge-related accidents is usually higher than that of other traffic accidents. The same study estimated the severity to be from 2-to-50 times that of other traffic accident [Abed-Al-Rahim and Johnston 1991].

There are three different ways of measuring motor vehicle accident cost. One approach is the comprehensive cost method, which includes all components of an accident and places a dollar value on them. There are 11 components to the comprehensive cost: property damage, lost earnings, lost household production, medical cost, emergency services, travel delay, vocational rehabilitation, workplace cost, administrative, legal, and pain and lost quality of life. Years Lost Plus Direct Cost takes the indirect cost and converts them to a non-monetary measure of lost years. The direct costs are given a monetary value in this method. The second method is the Human Capital Approach, which includes all the comprehensive cost approach components except pain and lost quality of life. The third method, the Willingness-to-Pay Cost, is the cost people are willing to pay for safety improvements. This is the same as the comprehensive cost that estimates what people pay for improvements, but the estimates are drawn from safety markets showing what people actually pay to reduce safety risk [Federal Highway Administration, 1994].

Chen and Johnston [1987] considered two methods of estimating the cost of bridge-related accidents, the Willingness-to-Pay approach and the Human Capital approach. The National Safety Council (NSC) publishes costs of traffic accidents based on the Human Capital Approach annually, and the Federal Highway Administration (FHWA) publishes costs of traffic accidents based on the Willingness-to-Pay at variable time intervals.

In 1993, the NSC revised its cost estimating procedures by adding new components, benchmarks, and inflation factors. The cost-benefit analysis on this new basis can be used for measuring the economic loss to a community from past motor-vehicle accidents, but they should not be used to compute dollar values of future benefits due to traffic safety measures. The NSC also provides a comprehensive cost, which includes a “willingness-to-pay” cost for safety improvements. This second estimate by NSC can be used in the OPBRIDGE program [National Safety Council].

The NCDOT classifies motor-vehicle accidents as fatal, injury, and property damage accidents. An A-C scale is used to describe the severity of the accident with A being the most severe. Table 4-1 shows the accident cost used currently in the Cost and Parameter Data File and Table 4-2 shows the accident cost from the most current reports.

Table 4-1 Previous Bridge Related Accident Cost from Abed-Al-Rahim and Johnston [1991]

Injury Severity	Average Number of Injuries per Accident	Human Capital Approach (1990 Dollars)		Willingness-to-Pay Approach (1988 Dollars)	
		Average Cost per Injury	Cost per Bridge-Related Accident	Average Cost per Injury	Cost per Bridge-Related Accident
Fatal	0.02	$410,000	$8,200	$1,500,000	$30,000
Injury A	0.13	$38,200	$5,000	$39,000	$5,100
Injury B	0.20	$8,900	$1,800	$12,000	$2,400
Injury C	0.34	$2,900	$900	$6,000	$2,000
Property Damage			$3,900		$3,900
Total			$19,800		$43,400

Table 4-2 Bridge Related Accident Costs Based on Recent Cost Reports

Injury Severity	Average Number of Injuries per Accident	National Safety Council Willingness-to-Pay Approach (1999 Dollars)		Federal Highway Administration Willingness-to-Pay Approach (1994 Dollars)	
		Average Cost per Injury	Cost per Bridge-Related Accident	Average Cost per Injury	Cost per Bridge-Related Accident
Fatal	0.02	$3,100,150	$62,003	$2,600,000	$52,000
Injury A	0.13	$153,453	$19,949	$180,000	$23,400
Injury B	0.20	$39,481	$7,896	$36,000	$7,200
Injury C	0.34	$18,782	$6,386	$19,000	$6,460
Property Damage		$1,787	$1,787	$2,000	$2,000
Total			$98,021		$91,060

Table 4-3 shows a comparison of the Willingness to Pay Approach, National Safety Council Willingness to Pay Approach [National Safety Council, 1999], and the Federal Highway Administration Willingness to Pay Approach [Federal Highway Administration, 1994] all updated to 2002 dollars based on the Consumer Price Index. It is recommended NSC data be used until such time as the FHWA data is updated more frequently.

Table 4-3 Bridge Related Accident Cost Updated to 2002 Dollars

Injury Severity	Average Number of Injuries per Accident	National Safety Council Willingness-to-Pay Approach (2002 Dollars)		Federal Highway Administration Willingness-to-Pay Approach (2002 Dollars)		Willingness-to-Pay Approach from 1988 (2002 Dollars)	
		Average Cost per Injury	Cost per Bridge-Related Accident	Average Cost per Injury	Cost per Bridge-Related Accident	Average Cost per Injury	Cost per Bridge-Related Accident
Fatal	0.02	$3,358,806	$67,176	$3,166,667	$63,333	$2,288,673	$45,773
Injury A	0.13	$166,256	$21,613	$219,231	$28,500	$59,505	$7,781
Injury B	0.20	$42,775	$8,555	$43,846	$8,769	$18,309	$3,662
Injury C	0.34	$20,349	$6,919	$23,141	$7,868	$9,155	$3,052
Property Damage		$1,936	$1,936	$2,436	$2,436		$5,951
Total			$106,199		$110,906		$66,219

The OPBRIDGE Program uses the total accident cost amount from the Willingness-to-Pay Approach from table 4-3 for two parameters ACOSTC and ACOSTW. They are listed in the COSTPARM file under the Coefficients to Compute Accident Costs. The Average Number of Injuries per Accident was derived by Abed-Al-Rahim and Johnston [1991] by analysis of NCDOT accident data.

The results in Table 4-3 shows that the most recent data from the National Safety Council and the Federal Highway Administration produce similar costs. The total cost from the last column was updated from Abed-Al-Rahim and Johnston [1991] accident cost data using the Consumer Price Index because the accident cost contain goods and services. It produces a result that is almost half of the most recent data. It would seem from these results that the most accurate method to update the accident cost is to use the National Safety Council's most recent data, which is published annually.

5. ADT GROWTH RATES UPDATE

Different bridge functional classifications serve different purposes. The Interstate highways were constructed to provide for long-distance interstate traffic. The arterial routes were constructed to provide services between major points within the state. The collector systems were constructed to provide transportation services within the counties. The local systems provide service to residences, farms, and other adjoining properties. Growth factors may affect the systems in different ways, so the ADT may increase at different rates for the different functional classifications [Chen and Johnston 1987].

Chen and Johnston used ADT data collected at 59 automatic traffic recording (ATR) stations located throughout the state. The data that was collected from these stations from 1974 to 1984 was used to analyze the ADT growth rate of the North Carolina Highways. The data was recorded in an unpublished report "Highway Traffic Statistics 1984" and provided by the Planning Branch of the NCDOT. Using this data and other sources, the ADT growth rate was predicted for the different functional classification highways [Chen and Johnston 1987].

In updating the ADT rate increases, the Bridge Management Inventory File (BMIF) containing the ADT for every bridge was available. Data from 1991 to 2000 from the BMIF was analyzed to determine the new ADT growth rates. If the ADT is reasonable for each bridge, this can provide a means of estimating the rate of increase for the ADT in each roadway functional classification in each county.

Chen and Johnston determined 4.06 percent as the average ADT growth rate for Interstate routes. In the analysis by Chen and Johnston [1987], it was decided that the ADT for the Interstate routes would not be significantly affected by local variations within the state. Thus, Chen and Johnston used a single number for the ADT growth rate for the Interstates. Chen and Johnston predicted the arterial ADT growth rate on a Division basis by calculating the average ADT growth rate of the ATR arterial stations in the Division and adjacent Divisions. There were no ATR station located on the local routes due to the low volume of traffic. Chen and Johnston assumed the ADT rate increase for the local routes to be equal to the county population rate increases from census data. The ADT growth rate for collectors in a county was taken as the average of the Division arterial ADT growth rate for that county and the county local roadway ADT growth rate.

Now, with the data available from the BMIF, the approach will be to calculate an ADT growth rate for each roadway functional classification in each individual county. The ADT growth rates were calculated using ADT data from the BMIF for 7 individual years from 1991 to 2000. Seven years out of the 10 years were used because the ADT for the bridges is not updated every year and because of the size of the databases. This data was imported into database software so the data could be queried by county, year, and bridge functional classification. The selected data from the files were the county, bridge number, the over/under field, features intersected, facility carried by the structure, functional classification, ADT, and location of the bridge. Descriptions of the fields are provided in the Recording and Coding Guide [U.S. Department of Transportation, 1988].

Table 5-1 Roadway Functional Classifications

Functional Classification	Code	Description
Interstate	01	Principal Arterial - Interstate
	11	Principal Arterial - Interstate
Arterial	02	Principal Arterial - Other
	06	Minor Arterial
	12	Principal Arterial – Other Freeways or Expressways
	14	Other Principal Arterial
	16	Minor Arterial
Collector	07	Major Collector
	08	Minor Collector
	17	Collector
Local	09	Local
	19	Local

Once the data was imported into the database, the bridges could be separated by county and functional classification (see Table 5-1). The average ADT for all bridges an each functional classification in each county was calculated for each year used from the BMIF. Using these averages, the ADT growth rates were determined to fit an exponential curve calculated using a regression analysis. The results are shown in Table 5-2. If bridges of one of the roadway classifications, such as interstates, did not exist in a county, then the statewide average for that classification was applied to that county in the COSTPARM.DAT file for future use. Some counties show a negative value, which could be the result of population shifts or population declines during the time period of 1990-2000.

Several problems arose in using the data. Bridges that existed in 1991 could have been taken out of service or rebuilt under a new bridge number, so the old bridge number would not exist in 2000, and new bridges were built since 1991. Also, two bridges that ran parallel to each other in 1991, with separate bridge numbers, were sometimes combined during a roadway widening under one bridge number by the year 2000. It was decided to look at the bridges that existed in 1991 and still existed in 2000. If two bridges were combined, then the ADT of the two bridges were added for the years they were labeled as separate bridges. These combined bridges, often on interstates, were found using the Bridge Location Maps. Also, the fields in the BMIF features intersected, facility carried by structure, bridge locations, and the ADT were used to determine if the bridges were combined under one bridge number between 1991 and 2000.

Table 5-2 ADT Growth Rates from Analysis of BMIF

County No.	County Name	Population Growth Rate	Area	ADT Growth Rates (% per Year)			
				Local	Collector	Arterial	Interstate
00	Alamance	1.91	2	3.82	2.32	1.68	6.81
01	Alexander	2.01	3	4.57	4.28	2.86	5.13
02	Alleghany	1.08	3	2.75	3.99	2.75	5.13
03	Anson	0.74	2	2.67	2.86	2.98	5.13
04	Ashe	0.94	3	(0.66)	3.61	2.97	5.13
05	Avery	1.45	3	3.42	6.77	(0.39)	5.13
06	Beaufort	0.62	1	1.16	5.73	2.93	5.13
07	Bertie	(0.31)	1	3.45	3.28	0.48	5.13
08	Bladen	1.19	1	4.39	1.76	2.47	5.13
09	Brunswick	3.67	1	5.96	4.56	1.71	5.13
10	Buncombe	1.67	3	0.88	1.65	2.79	5.47
11	Burke	1.64	3	2.72	3.37	3.01	5.19
12	Cabarrus	2.85	2	3.61	5.67	2.86	7.75
13	Caldwell	0.91	3	1.44	0.36	3.92	5.13
14	Camden	1.55	1	4.43	3.47	3.16	5.13
15	Carteret	1.23	1	3.50	2.59	0.89	5.13
16	Caswell	1.28	2	1.44	3.92	4.24	5.13
17	Catawba	1.81	2	3.42	2.93	2.84	4.23

18	Chatham	2.44	2	4.21	3.49	2.58	5.13
19	Cherokee	1.88	3	4.28	2.87	2.25	5.13
20	Chowan	0.73	1	0.97	1.28	2.60	5.13
21	Clay	2.06	3	2.40	2.47	5.00	5.13
22	Cleveland	1.29	3	2.59	3.15	2.79	2.96
23	Columbus	1.00	1	1.97	3.87	2.32	5.13
24	Craven	1.14	1	2.41	4.33	0.03	5.13
25	Cumberland	0.99	1	1.68	1.60	4.83	1.83
26	Currituck	2.85	1	8.50	9.93	3.15	5.13
27	Dare	2.80	1	9.06	6.96	6.17	5.13
28	Davidson	1.52	2	2.45	2.99	1.80	5.84
29	Davie	2.26	2	3.37	2.42	4.79	3.16
30	Duplin	2.06	1	4.93	4.05	(2.93)	4.02
31	Durham	2.08	2	3.39	7.33	1.48	4.67
32	Edgecombe	(0.17)	2	2.20	0.11	0.43	5.13
33	Forsyth	1.42	2	1.45	2.55	2.92	(2.27)
34	Franklin	2.64	2	3.43	2.82	1.50	5.13
35	Gaston	0.84	2	2.12	1.37	2.18	5.07
36	Gates	1.23	1	0.14	2.69	3.55	5.13
37	Graham	1.06	3	5.46	4.38	3.02	5.13
38	Granville	2.38	2	4.13	3.45	3.75	7.64
39	Greene	2.12	1	1.89	3.82	3.64	5.13
40	Guilford	1.94	2	1.14	5.74	2.52	3.55
41	Halifax	0.33	2	13.63	2.66	2.96	4.04
42	Harnett	2.99	2	4.24	4.02	4.08	5.30
43	Haywood	1.42	3	4.63	1.08	3.61	5.62
44	Henderson	2.56	3	3.20	3.11	4.01	5.01
45	Hertford	0.03	1	(3.33)	3.38	3.75	5.13
46	Hoke	3.94	2	3.52	7.57	6.17	5.13
47	Hyde	0.74	1	2.47	10.44	0.95	5.13
48	Iredell	2.81	2	3.67	4.30	3.33	3.23
49	Jackson	2.12	3	2.81	7.75	4.86	5.13
50	Johnston	4.14	2	6.68	3.21	2.33	4.24
51	Jones	0.98	1	0.78	(0.05)	1.64	5.13
52	Lee	1.71	2	4.46	5.82	3.86	5.13
53	Lenoir	0.41	1	3.06	3.38	4.11	5.13
54	Lincoln	2.40	2	2.60	3.34	0.38	5.13
55	McDowell	1.68	3	5.60	4.48	4.24	5.13
56	Macon	2.41	3	2.54	4.66	4.57	5.13
57	Madison	1.48	1	2.58	4.09	2.59	5.13
58	Martin	0.20	3	4.51	0.52	4.45	5.17
59	Mecklenburg	3.12	2	2.67	4.74	2.90	4.93
60	Mitchell	0.84	3	1.05	1.18	2.97	5.13
61	Montgomery	1.40	2	2.02	3.77	5.84	5.13
62	Moore	2.39	2	5.01	4.78	3.43	5.13
63	Nash	1.32	2	4.34	5.03	3.09	2.73
64	New Hanover	2.91	1	4.84	3.06	(1.10)	7.58

65	Northampton	0.60	2	2.17	2.05	1.35	6.83
66	Onslow	0.03	1	3.06	7.28	(1.55)	5.13
67	Orange	2.34	2	2.42	3.20	1.81	4.56
68	Pamlico	1.30	1	5.47	4.16	2.97	5.13
69	Pasquotank	1.09	1	0.52	(2.02)	4.93	5.13
70	Pender	3.60	1	6.03	5.84	2.97	10.25
71	Perquimans	0.85	1	(1.23)	1.06	4.76	5.13
72	Person	1.67	2	5.16	1.38	1.62	5.13
73	Pitt	2.17	1	5.92	1.47	3.04	5.13
74	Polk	2.43	1	5.30	3.28	13.91	4.42
75	Randolph	2.05	2	5.02	2.71	3.67	5.47
76	Richmond	0.45	2	2.63	3.20	1.85	5.13
77	Robeson	1.61	1	3.06	3.08	3.49	2.18
78	Rockingham	0.66	2	3.88	2.85	3.20	5.13
79	Rowan	1.66	2	5.17	4.51	4.63	6.91
80	Rutherford	1.00	3	4.09	2.27	1.55	5.13
81	Sampson	2.43	1	5.28	1.59	2.46	10.27
82	Scotland	0.65	2	4.09	3.50	4.19	5.13
83	Stanly	1.16	2	1.08	3.64	3.08	5.13
84	Stokes	1.85	2	4.79	3.55	4.35	5.13
85	Surry	1.44	3	6.54	5.71	4.73	3.61
86	Swain	1.42	3	(1.10)	8.38	6.90	5.13
87	Transylvania	1.40	3	(1.57)	5.82	(0.19)	5.13
88	Tyrrell	0.74	1	0.84	(0.42)	(0.06)	5.13
89	Union	3.92	2	5.05	5.88	3.68	5.13
90	Vance	1.00	2	4.11	5.11	6.30	5.82
91	Wake	4.02	2	2.22	7.09	2.30	10.71
92	Warren	1.47	2	0.76	3.15	(0.05)	7.51
93	Washington	(0.20)	1	1.44	1.54	2.21	5.13
94	Watauga	1.46	3	5.54	2.28	4.88	5.13
95	Wayne	0.80	2	2.82	4.21	2.66	5.13
96	Wilkes	1.00	3	4.07	1.24	3.36	5.13
97	Wilson	1.12	2	3.39	2.81	2.92	4.44
98	Yadkin	1.77	2	0.87	5.17	1.63	3.35
99	Yancey	1.43	3	3.77	2.65	4.35	5.13

There are many different variables that could affect changes in the ADT growth rates. The results of the analysis of the BMIF often produced similar results to that of the original data in the COSTPARM file. In some instances, however, there were drastic differences in the growth rates. In some of these cases, the difference could also be seen in the increase of the population of that county and in others there was no correlation. New roadways may provide a better route for traffic, thereby decreasing the ADT of bridges on the original route.

The results were compared to data from other sources within NCDOT, which, although having less definition by county and system, provided a basis for adjusting values that were believed to be questionable.

The ADT growth rates from Table 5-2 were reviewed by the NCDOT Traffic Forecasting Unit. They recommended modifications based upon other data available and judgment from experience. The modified ADT growth rates are marked by an asterisk in Table 5-3.

There are many complications in forecasting ADT growth:

1) Past history is not a perfect indicator of the future;

2) Certain roadways, particularly in Urban areas, may become saturated and offer no opportunity for increasing volume;

3) Reliable data on ADT is not available for many locations due to the size of the system and the limited resources available to collect data.

The potential exists to beneficially use the ADT data in the Bridge Inventory. However, necessary approximations in the ADT's recorded, which are primarily relative bridge-to-bridge comparison values, make the data only one resource for growth prediction.

Thus, the ADT growth rates presented in Table 5.3, adjusted by data from Traffic Forecasting where available, are recommended for use by OPBRIDGE.

Table 5-3 Adjusted ADT Growth Rates from Analysis of BMIF

		Population		ADT Growth Rates (% per Year)			
County No.	County Name	Growth Rate	Area	Local	Collector	Arterial	Interstate
00	Alamance	1.91	2	3.82	3.50*	3.50*	6.81
01	Alexander	2.01	3	4.57	4.28	2.86	5.38*
02	Alleghany	1.08	3	2.75	3.99	2.75	5.38*
03	Anson	0.74	2	2.67	2.86	2.98	5.38*
04	Ashe	0.94	3	2.50*	3.61	2.97	5.38*
05	Avery	1.45	3	3.42	3.52*	3.50*	5.38*
06	Beaufort	0.62	1	2.50*	2.55*	2.93	5.38*
07	Bertie	(0.31)	1	3.45	3.28	0.48	5.38*
08	Bladen	1.19	1	4.39	2.50*	3.00*	5.38*
09	Brunswick	3.67	1	5.96	4.56	3.50*	5.38*
10	Buncombe	1.67	3	2.50*	2.55*	3.50*	5.47
11	Burke	1.64	3	2.72	3.37	3.01	5.19
12	Cabarrus	2.85	2	3.61	3.50*	2.86	7.75
13	Caldwell	0.91	3	2.50*	2.50*	3.92	5.38*
14	Camden	1.55	1	4.43	3.47	3.16	5.38*
15	Carteret	1.23	1	3.50	2.59	3.25*	5.38*
16	Caswell	1.28	2	1.44	3.92	4.24	5.38*
17	Catawba	1.81	2	3.42	2.93	2.84	5.00*
18	Chatham	2.44	2	4.21	3.49	2.58	5.38*
19	Cherokee	1.88	3	4.28	2.87	2.25	5.38*
20	Chowan	0.73	1	2.50*	2.50*	2.60	5.38*
21	Clay	2.06	3	2.40	2.47	3.50*	5.38*
22	Cleveland	1.29	3	2.59	3.15	2.79	2.96
23	Columbus	1.00	1	2.50*	3.87	2.32	5.38*
24	Craven	1.14	1	2.41	2.22*	2.50*	5.38*
25	Cumberland	0.99	1	2.50*	2.50*	3.50*	5.00*
26	Currituck	2.85	1	2.50*	2.50*	3.15	5.38*
27	Dare	2.80	1	3.50*	3.50*	4.00*	5.38*
28	Davidson	1.52	2	2.45	2.99	3.50*	5.84
29	Davie	2.26	2	3.37	3.25*	3.50*	4.50*
30	Duplin	2.06	1	2.55*	2.55*	3.50*	4.50*
31	Durham	2.08	2	3.39	3.25*	3.50*	5.00*
32	Edgecombe	(0.17)	2	2.50*	2.50*	3.50*	5.38*
33	Forsyth	1.42	2	2.50*	2.55	3.50*	3.60*

34	Franklin	2.64	2	3.43	2.82	3.50*	5.38*
35	Gaston	0.84	2	2.50*	2.50*	3.50*	5.07
36	Gates	1.23	1	2.50*	2.69	3.55	5.38*
37	Graham	1.06	3	2.50*	2.50*	3.02	5.38*
38	Granville	2.38	2	3.00*	3.45	3.75	5.00*
39	Greene	2.12	1	2.50*	3.50*	3.50*	5.38*
40	Guilford	1.94	2	2.50*	3.55*	3.50*	5.00*
41	Halifax	0.33	2	3.50*	3.00*	3.50*	4.04
42	Harnett	2.99	2	2.50*	3.50*	3.00*	5.30
43	Haywood	1.42	3	4.63	3.00*	3.61	5.62
44	Henderson	2.56	3	3.20	3.11	4.01	5.01
45	Hertford	0.03	1	2.50*	3.38	3.75	5.38*
46	Hoke	3.94	2	3.52	3.50*	3.50*	5.38*
47	Hyde	0.74	1	2.47	2.50*	3.50*	5.38*
48	Iredell	2.81	2	3.67	3.50*	3.33	4.50*
49	Jackson	2.12	3	2.81	3.00*	3.50*	5.38*
50	Johnston	4.14	2	6.68	3.21	3.50*	4.24
51	Jones	0.98	1	2.50*	2.50*	3.00*	5.38*
52	Lee	1.71	2	2.50*	3.50*	3.50*	5.38*
53	Lenoir	0.41	1	3.06	3.38	4.11	5.38*
54	Lincoln	2.40	2	2.60	3.34	3.50*	5.38*
55	McDowell	1.68	3	2.50*	3.50*	3.55*	5.38*
56	Macon	2.41	3	2.54	2.54*	3.00*	5.38*
57	Madison	1.48	1	2.58	3.00*	3.00*	5.38*
58	Martin	0.20	3	2.50*	3.20*	4.45	5.17
59	Mecklenburg	3.12	2	2.67	4.74	2.90	4.93
60	Mitchell	0.84	3	1.05	1.18	2.97	5.38*
61	Montgomery	1.40	2	2.02	3.77	5.84	6.25*
62	Moore	2.39	2	5.01	4.78	3.43	5.38*
63	Nash	1.32	2	3.00*	3.00*	3.09	4.50*
64	New Hanover	2.91	1	4.84	3.06	3.50*	6.50*
65	Northampton	0.60	2	2.17	2.05	3.50*	5.25*
66	Onslow	0.03	1	3.06	3.25*	3.50*	5.38*
67	Orange	2.34	2	2.42	3.20	3.50*	4.56
68	Pamlico	1.30	1	3.50*	4.16	3.50*	5.38*
69	Pasquotank	1.09	1	2.50*	2.50*	4.93	5.38*
70	Pender	3.60	1	3.00*	3.50*	3.50*	6.50*
71	Perquimans	0.85	1	2.50*	2.50*	3.50*	5.38*
72	Person	1.67	2	2.50*	2.75*	3.50*	5.38*
73	Pitt	2.17	1	2.55*	2.55*	3.04	5.38*
74	Polk	2.43	1	2.50*	3.28	3.50*	4.42
75	Randolph	2.05	2	3.50*	2.71	3.67	5.47
76	Richmond	0.45	2	2.63	3.20	3.50*	6.25*
77	Robeson	1.61	1	3.06	3.08	3.49	4.50*
78	Rockingham	0.66	2	3.88	2.85	3.20	6.25*
79	Rowan	1.66	2	3.00*	3.50*	4.63	6.91
80	Rutherford	1.00	3	4.09	3.25*	3.50*	5.38*

81	Sampson	2.43	1	2.50*	2.50*	3.50*	6.25*
82	Scotland	0.65	2	2.50*	3.50	3.50*	5.38*
83	Stanly	1.16	2	2.50*	3.64	3.08	5.38*
84	Stokes	1.85	2	2.50*	3.55	3.55*	5.38*
85	Surry	1.44	3	2.60*	2.60*	3.50*	6.25*
86	Swain	1.42	3	2.50*	3.50*	3.55*	5.38*
87	Transylvania	1.40	3	2.50*	2.50*	3.50*	5.38*
88	Tyrrell	0.74	1	0.84	2.50*	2.50*	5.38*
89	Union	3.92	2	3.00*	3.00*	3.50*	5.38*
90	Vance	1.00	2	3.25*	3.25*	3.50*	5.82
91	Wake	4.02	2	3.00*	5.00*	4.00*	6.5*
92	Warren	1.47	2	2.50*	3.15	3.50*	7.51
93	Washington	(0.20)	1	2.50*	2.50*	3.00*	5.38*
94	Watauga	1.46	3	2.50*	3.00*	3.50*	5.38*
95	Wayne	0.80	2	2.82	3.00*	3.50*	5.38*
96	Wilkes	1.00	3	2.50*	3.20*	3.50*	5.38*
97	Wilson	1.12	2	3.39	2.81	2.92	4.50*
98	Yadkin	1.77	2	2.50*	3.25*	3.50*	6.25*
99	Yancey	1.43	3	2.50*	2.65	4.35	5.38*

6. DETERIORATION RATES UPDATE

When Chen and Johnston [1987] first performed the analysis of bridge deterioration rates, there were only seven years of data in the bridge maintenance database. To determine the deterioration rates some analysis of data was undertaken but the final rates used were largely from experienced input of bridge inspectors and maintenance supervisors using a survey and Delphi approach [Chen and Johnston 1987]. Now, in this study, there is a desire to look at the bridge inspection database once again since there is about twenty years of data available.

The data for the deterioration analysis was found in the NCDOT history files FTR91036 and FTR91037. The needed data was imported from these files into database software as tables. The necessary information for the decks, superstructure, and substructure were extracted from the tables using a query. From this query, the data was exported as a text file.

Four SAS System programs were written to read the text files and perform a specific analysis on the data. The main program names and a description of their differences are listed in Table 6-1. In the descriptions, the “series” refers to the condition state being at a particular value.

Table 6-1 Deterioration Program Variations

Program	Description
0	The program must see the beginning of the condition series and the end of the series. The end of the series must drop to a lower rating.
1	The program must see the beginning of the condition series and the end of the series. The end of the series can increase or decrease in rating.
2	This program counts the number of years a rating appears during the recorded life of the bridge and then sums the count.
3	The program will count the years of a rating. It does not need to see the beginning or the end to count the series.

Each of these programs was run for the deck, superstructure, and substructure for each major material type. The material used in the bridge construction could change when a bridge is replaced with a new bridge of the same bridge number, and NCDOT History File lists only the material type for the new bridge. Because of the possible change in material of the bridge, the deterioration rates calculated might apply to the wrong bridge material. So, it was decided only to use the data beginning with either the year built or 1980, whichever was later, to the present. An additional analysis was done for each program. A count criterion was added to the programs. The following Table 6-2 gives a definition of each criterion. Since bridge inspections occur every two years the single occurrence of a rating was eliminated from the counting. This single occurrence of a rating could be an irregularity in the data. It was also decided to look at eliminating the occurrence of a rating for two years, because the bridge inspection takes place every two years for a single bridge. If there was an irregularity in the data it may show up for two years.

Table 6-2 Count Criteria

Count Criteria	Description
0	For ratings 9-5, the number of years counted for the series must be greater than 0 to be considered.
1	For ratings 9-5, the number of years counted for the series must be greater than 1 to be considered.
2	For ratings 9-5, the number of years counted for the series must be greater than 2 to be considered.

The following example is of a program name *decka12* and its meaning.

deck a 1 2

The name *deck* is the section of the bridge data being analyzed. The letter *a* means that the original program was modified so that only data was evaluated from the first year (usually 1980) data was available for the bridge number or from the year the bridge was built, whichever is later, to the present. The *1* shows which program was used in the analysis and the *2* specifies how many years the bridge must stay at the rating before that rating can be considered. The *2* means the deck rating must remain at the same rating for more than 2 years before the rating is considered. Table 6-3 shows how the different programs calculated their deterioration rates and Figure 6-1 shows examples of series of bridge condition ratings encountered.

Table 6-3 Program Examples

Bridge Number	Rating Series	Programs			
		0	1	2	3
1	A	No	No	Yes	Yes
	B	Yes	Yes	Yes	Yes
	C	No	No	Yes	Yes
2	D	No	No	Sum D&F	Yes
	E	No	Yes	Yes	Yes
	F	No	No	Sum D&F	Yes
3	G	No	No	Yes	Yes
4	H	No	No	Yes	Yes
	I	No	Yes	Sum I&K	Yes
	J	Yes	Yes	Yes	Yes
	K	No	No	Sum I&K	Yes

Table 12.1(a) Deck Material Types

dkmat	
1	Timber
2	Concrete
3	Steel

Table 12.1(b) Substructure Material Types

sbmat		Area	
1	Timber	1	Coastal
2	Concrete & Masonry	2	Piedimont
3	Steel	3	Mountain
4	Prestressed Concrete		

Table 12.1(c) Superstructure Material Types

spmat		State System		sptype	
1	Timber	1	U, I, P	1	Multi-Beam
2	Concrete & Masonry	2	S	2	Slab
3	Steel, Aluminum, Wrought Iron & Cast Iron			3	Tee-Beam
4	Prestressed Concrete			4	Truss
				5	Floor-Beam

Tables 12.1 Material Types for Bridge Elements

Figure 6-1 Program Examples

Program 0 looks for the first instance that a condition rating occurs in the bridge History File . It counts the number of years the bridge stayed at that rating and then it must see the rating decrease to another rating. This program looks at the entire period the bridge was at that rating and because the rating decreased it was assumed that work was not performed to increase the condition rating on that section of the bridge. The bridge was allowed to deteriorate without interference. This would result in the period of time that the bridge would stay at a specified rating. Bridge 1 series rating B and bridge 4 series rating J in Figure 6-1 show examples where the condition rating series was counted. The results of this program in terms of years that an element remained at a particular condition state were low compared to the results that Chen and Johnston found.

Program 1 is similar to program 0 in that the beginning of the condition rating must be seen, but in program 1 the end of the condition rating can increase or decrease to a different condition rating. Bridge 1 series rating B, bridge 2 series rating E, and bridge 4 series rating I and J are examples of condition rating series that program 1 would count.

Program 2 takes a different approach than the first two programs that look for one continuous series of years where the condition rating remained the same. Program 2 looks at the entire recorded life of the bridge and sums the number of years a condition rating appears. Table 6-3 shows that every condition rating series is counted for program 2. In Figure 6-1, the example of bridge 2 series condition rating D and F are discontinuous series of the same condition rating, but they are summed together. The count criteria shown in Table 6-2 affects program 2 the same way it affects the other programs. For the condition rating to be added to the total for that specified rating, that rating must appear for consecutive years specified by the count criteria.

Program 3 counts the number of years each rating appears in a series, and to be considered that series must meet the required number of years specified by the count criteria.

It was determined from the results that the most logical approach to calculating the deterioration rates was using program 1 and count criteria 1 for the three bridge sections. The results from program 2 and count criteria 1 were viewed as reasonable based on experience, but the approach to calculating the deterioration rates was viewed as less logical. The average of the two methods was adapted for the initial trials.

In some instances no data was found to calculate the deterioration rates, so the missing rate was determined from the data available for that bridge section and material. Asterisks mark these estimates of deterioration rates. The following tables show the results for each bridge section from the two methods and then the average for the two methods.

Table 6-4 Deterioration Rates for Decks from Program 11

decka11- see beginning and end goes up or down (9-5>1)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.6	4.7	4.4	4.8	3.6	20.1
1	201	2.6	5.4	4.9	4.5	3.5	20.9
1	801	2.5	4.9	4.3	4.8	3.6	20.0
1	2001	4.0	4.2	4.2	3.8	3.2	19.4
1	4001	4.0*	6.1	2.4	3.7	2.7	18.9
2	0	2.7	7.2	5.0	5.2	4.7	24.8
2	201	2.6	7.1	5.8	5.6	4.5	25.6
2	801	2.6	6.3	5.6	5.6	4.5	24.6
2	2001	2.5	5.7	5.4	5.6	5.0	24.3
2	4001	2.8	4.6	5.5	5.6	4.6	23.1
3	0	3.1	6.6	4.1	3.8	3.3	20.8
3	201	2.8	6.2	4.6	4.7	3.9	22.2
3	801	4.7	5.8	4.7	3.8	4.0	23.0
3	2001	2.0	6.3	3.9	5.1	4.3	21.6
3	4001	3.0	6.3	4.8	3.7	3.6	21.3

Table 6-5 Deterioration Rates for Decks from Program 21

decka21- total rating count for bridge (9-5>1)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.7	7.0	6.9	7.5	5.1	29.2
1	201	2.8	7.5	7.7	7.4	5.1	30.5
1	801	2.6	7.2	7.3	7.4	4.5	29.0
1	2001	3.5	8.0	8.4	6.3	5.4	31.5
1	4001	3.5*	8.7	7.6	6.5	3.9	30.2
2	0	2.9	7.7	7.6	7.9	5.9	32.0
2	201	3.0	8.0	8.9	9.0	6.9	35.7
2	801	2.8	7.7	8.6	9.7	7.3	36.2
2	2001	3.0	6.9	8.5	9.6	7.5	35.5
2	4001	3.3	6.0	8.7	9.3	7.4	34.6
3	0	3.3	11.8	7.0	5.6	3.7	31.3
3	201	2.8	11.2	7.3	6.9	4.4	32.7
3	801	3.2	10.1	7.0	6.4	5.1	31.8
3	2001	2.0	10.2	6.8	7.2	7.0	33.2
3	4001	3.0	8.1	6.2	8.3	5.9	31.5

Table 6-6 The Average of Deck Deterioration Rates

deck(average)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.6	5.9	5.6	6.2	4.3	24.7
1	201	2.7	6.5	6.3	6.0	4.3	25.7
1	801	2.6	6.0	5.8	6.1	4.0	24.5
1	2001	3.8	6.1	6.3	5.0	4.3	25.5
1	4001	3.8*	7.4	5.0	5.1	3.3	24.6
2	0	2.8	7.4	6.3	6.5	5.3	28.4
2	201	2.8	7.5	7.3	7.3	5.7	30.6
2	801	2.7	7.0	7.1	7.7	5.9	30.4
2	2001	2.8	6.3	7.0	7.6	6.3	29.9
2	4001	3.0	5.3	7.1	7.5	6.0	28.9
3	0	3.2	9.2	5.5	4.7	3.5	26.1
3	201	2.8	8.7	5.9	5.8	4.2	27.4
3	801	3.9	8.0	5.9	5.1	4.5	27.4
3	2001	2.0	8.2	5.4	6.1	5.7	27.4
3	4001	3.0	7.2	5.5	6.0	4.7	26.4

Table 6-7 Deterioration Rates for Substructures from Program 11

suba11- see beginning and end goes up or down (9-5>1)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	2.0	2.9	4.0	4.9	3.9	17.7
1	2	2.5	3.4	4.4	5.0	3.8	19.1
1	3	3.6	3.5	4.3	4.7	3.4	19.4
2	1	2.5	4.8	4.9	4.6	4.1	20.8
2	2	3.0	5.2	5.2	5.1	4.5	22.9
2	3	2.8	5.6	4.5	4.4	3.5	20.7
3	1	3.0	5.5	6.1	6.5	7.6	28.7
3	2	2.7	6.5	6.0	6.1	5.9	27.1
3	3	3.2	5.9	5.4	5.7	4.6	24.8
4	1	2.7	5.0	5.0	6.0	5.7	24.3
4	2	2.4	4.6	5.8	5.1	4.8	22.6
4	3	2.5*	4.3	5.6	3.3	4.0	19.8

Table 6-8 Deterioration Rates for Substructure from Program 21

suba21- total rating count for bridge (9-5>1)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	2.6	3.4	5.7	8.4	7.6	27.7
1	2	2.3	4.2	5.6	9.2	6.8	28.1
1	3	2.9	3.9	7.0	9.8	5.2	28.8
2	1	3.7	7.1	7.3	8.2	7.1	33.5
2	2	3.5	7.9	8.9	8.8	7.0	36.0
2	3	3.1	9.0	8.9	8.4	5.9	35.2
3	1	3.5	7.0	7.0	6.5	5.5	29.6
3	2	2.9	8.4	8.5	7.3	5.5	32.5
3	3	3.0	8.2	9.1	6.4	4.8	31.5
4	1	3.5	7.1	7.9	7.9	7.1	33.5
4	2	2.4	9.2	9.0	8.9	6.5	36.2
4	3	3.0*	8.4	9.7	6.1	4.0	31.2

Table 6-9 The Average Deterioration Rates for Substructure

substructure(average)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	2.3	3.2	4.8	6.7	5.8	22.7
1	2	2.4	3.8	5.0	7.1	5.3	23.6
1	3	3.3	3.7	5.6	7.3	4.3	24.1
2	1	3.1	6.0	6.1	6.4	5.6	27.2
2	2	3.2	6.5	7.1	6.9	5.8	29.5
2	3	2.9	7.3	6.7	6.4	4.7	28.0
3	1	3.3	6.3	6.5	6.5	6.6	29.1
3	2	2.8	7.4	7.2	6.7	5.7	29.8
3	3	3.1	7.1	7.3	6.1	4.7	28.2
4	1	3.1	6.1	6.5	6.9	6.4	28.9
4	2	2.4	6.9	7.4	7.0	5.7	29.4
4	3	2.8*	6.4	7.7	4.7	4.0	25.5

Table 6-10 Deterioration Rates for Superstructure from Program 11

supa11- see beginning and end goes up or down (9-5>1)								
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1	5.0	4.5	5.0	5.2	4.6	24.4
1	1	2	2.8	4.9	4.9	4.8	3.5	20.9
2	2	1	2.0	3.6	5.1	4.9	4.3	19.8
2	2	2	2.0	4.3	4.1	5.9	3.8	20.1
2	3	1	4.3	6.2	5.6	6.0	4.0	26.2
2	3	2	3.4	8.8	6.2	6.0	4.8	29.2
3	4	1	3.0*	2.0	4.0	4.3	3.3	16.5
3	4	2	3.0	3.0	4.5	5.6	5.8	22.0
3	5	1	3.5	5.9	4.6	4.3	3.7	22.0
3	5	2	2.8	5.9	5.0	4.4	3.6	21.6
4	1	1	3.9	6.8	5.6	5.6	4.8	26.8
4	1	2	3.1	7.3	6.3	6.1	5.1	28.0

Table 6-11 Deterioration Rates for Superstructure from Program 21

supa21- total rating count for bridge (9-5>1)								
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1	5.0	5.6	7.4	9.2	8.0	35.3
1	1	2	2.7	6.2	7.7	8.5	5.7	30.9
2	2	1	2.0	6.5	9.2	9.5	6.9	34.1
2	2	2	2.0	7.4	7.9	9.4	6.0	32.7
2	3	1	2.0*	5.8	8.6	10.1	7.1	33.6
2	3	2	2.0*	6.4	8.7	8.9	6.8	32.8
3	4	1	3.0*	2.3	14.7	8.7	5.4	34.1
3	4	2	3.0	3.9	5.5	9.5	8.1	29.9
3	5	1	3.2	10.6	8.4	7.4	6.0	35.6
3	5	2	2.6	9.1	9.8	7.5	5.1	34.1
4	1	1	3.8	9.4	7.5	6.9	5.1	32.8
4	1	2	3.1	9.5	8.7	7.3	5.4	33.9

Table 6-12 The Average Deterioration Rate for Superstructure

superstructure(average)								
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1	5.0	5.1	6.2	7.2	6.3	29.8
1	1	2	2.7	5.6	6.3	6.7	4.6	25.9
2	2	1	2.0	5.1	7.1	7.2	5.6	27.0
2	2	2	2.0	5.8	6.0	7.7	4.9	26.4
2	3	1	3.2*	6.0	7.1	8.0	5.5	29.9
2	3	2	2.7*	7.6	7.5	7.5	5.8	31.0
3	4	1	3.0*	2.2	9.3	6.5	4.3	25.3
3	4	2	3.0	3.4	5.0	7.6	6.9	25.9
3	5	1	3.3	8.3	6.5	5.8	4.8	28.8
3	5	2	2.7	7.5	7.4	5.9	4.3	27.8
4	1	1	3.9	8.1	6.5	6.2	5.0	29.8
4	1	2	3.1	8.4	7.5	6.7	5.2	30.9

7. REHABILITATION WORK UPDATE

Rehabilitation is performed on deteriorating bridges to maintain or improve the condition rating of the bridge and the level of service. Chen and Johnston [1987] looked at the relationship between the rehabilitation work and the improvement of the condition rating, using four years of data. Now that 20 years of data is available, the relationship should be re-evaluated using the actual work performed.

Chen and Johnston looked at the deck, superstructure, and substructure for timber, concrete, and steel bridges. The maintenance work was performed under a set of function codes that designated where the work was performed and the type of material. The maintenance work accomplished was evaluated where the condition rating remained the same or increased to a higher level. The maintenance work was then divided by the square footage of the deck. Chen and Johnston assumed a linear relationship between the average amount of work and the bridge element conditions before and after rehabilitation [Chen and Johnston 1987].

Based of this assumption, Chen and Johnston performed two regression analyses for each type of rehabilitation work. The first regression analysis was performed on the average amount of work where the condition rating remained the same after the work was completed. The second regression analysis was performed on the average amount of work that was needed to improve the condition rating to 8 from a lower condition rating. The result from the first regression analyses was used to set the amount of work when the condition rating remains the same. The slope of the second regression analyses was used to calculate the amount of work where the condition rating increased to a higher level after the work was performed [Chen and Johnston 1987].

The same procedure was used in the new analyses of the rehabilitation work. In 1985 a new set of function codes was introduced. Under the old codes, the superstructure work and the deck work were combined under Function Code 492. Chen and Johnston setup a table to calculate the percentage of deck work and superstructure work under Function Code 492. The new codes did not have work combined for different bridge sections under the same code, so in the new analyses only the new set of function codes was used. See Table 7-1 and Table 7-2 for the function codes that were used in the analyses.

Table 7-1 Function Codes Used by Bridge Element and Material

Material	Deck	Superstructure	Substructure
Timber	561	571, 578	580
Concrete	560	571, 578	581, 583
Steel	562, 564	571, 578	582

Table 7-2 Definitions of Function Codes Used

Code	Units	Definitions
560	SF	Maintenance and repairs to concrete bridge floors
561	Man-Hour	Repairs to timber bridge floors
562	Man-Hour	Repairs to steel plank bridge floors
564	Man-Hour	Maintenance or replacement of open grid steel floors
571	Man-Hour	Draw span maintenance
578	Man-Hour	General maintenance of bridge superstructure
580	Man-Hour	Maintenance of timber substructure
581	Man-Hour	Maintenance of concrete pile substructure
582	Man-Hour	Maintenance of steel pile substructure
583	Man-Hour	Maintenance of concrete piers and abutments

The data used for the analyses is located in four History Files. History file 91036 contains the bridge number, deck material, superstructure material, substructure material, the year the bridge was built, and the length of the bridge. History file 91037 contains the bridge number, the deck rating, superstructure rating, substructure rating, the year of the ratings, and the clear deck width. History file 91038 contains the inspectors' estimates of work needed. History file 91039 contains the bridge number, the year, the function codes, man-hours, and the quantity for work accomplished. The data from files 91036, 91037 and 91039 was imported into database software. Bridge number and the year linked the tables. The data could then be queried for information pertaining to the deck, superstructure, or substructure. The information from the query was then exported from the database as a text file. A SAS program was written to read the text file and perform the necessary calculations and produce a text file with the results. This text file was then imported back to the database software. A crosstab query was performed on the results from the SAS program to find the average work done and the number of occurrences of a function code that were used in the calculations.

Tables from the crosstab query were copied to a spreadsheet where the two regression analyses were performed. The final table for the average work done was created using the same method, as discussed above, that Chen and Johnston used. The example in Table 7-3 shows the results from the SAS program, and Table 7-4 shows the number of occurrences of the specified function codes. The regression analysis results are shown in Figures 7-1 and 7-2. The final results are shown in Table 7-5 and compared to Chen and Johnston's results shown in Table 7-6. The complete results are presented in the Appendix 10-1.

Table 7-3 Average Rehabilitation Work for Timber Decks in Man-Hours/Deck Square Feet

Rating before rehabilitation	Rating after rehabilitation						
	9	8	7	6	5	4	3
9	0.0679						
8	0.0883	0.0471					
7	0.0311	0.0285	0.0449				
6	0.0494	0.0892	0.0261	0.0434			
5	0.1034	0.0353	0.0854	0.0536	0.0524		
4	0.0450	0.0984		0.0516	0.0445	0.0527	
3	0.0848	0.0469		0.0496	0.0253	0.0272	0.0431

Table 7-4 Number of Occurrences of the Function Code for Timber Deck Bridges

Rating before rehabilitation	Rating after rehabilitation						
	9	8	7	6	5	4	3
9	16						
8	2	114					
7	4	2	126				
6	3	22	9	311			
5	6	30	7	22	287		
4	6	19		4	15	166	
3	1	6		1	1	3	18

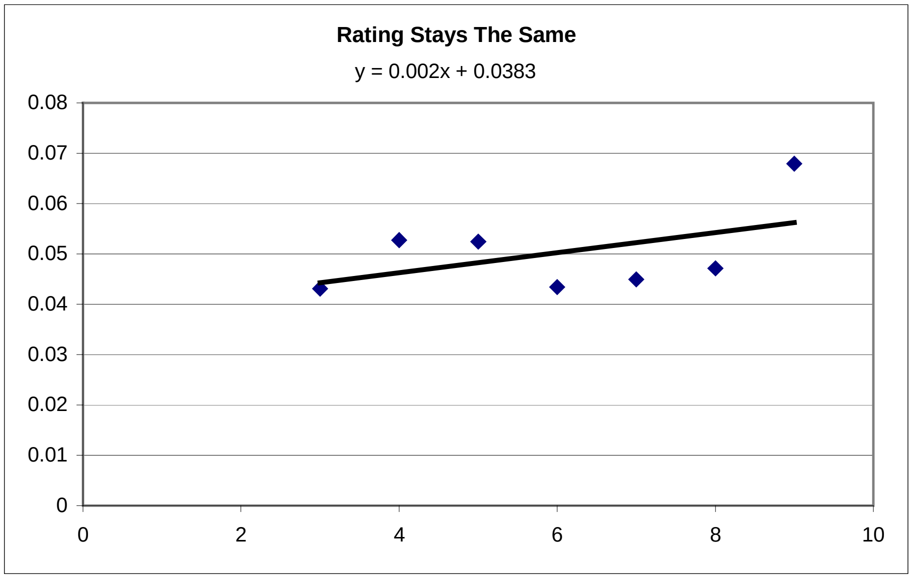

Figure 7-1 Regression Analysis of Rehabilitation Work for Timber Deck Bridges which did not Change the Condition Rating

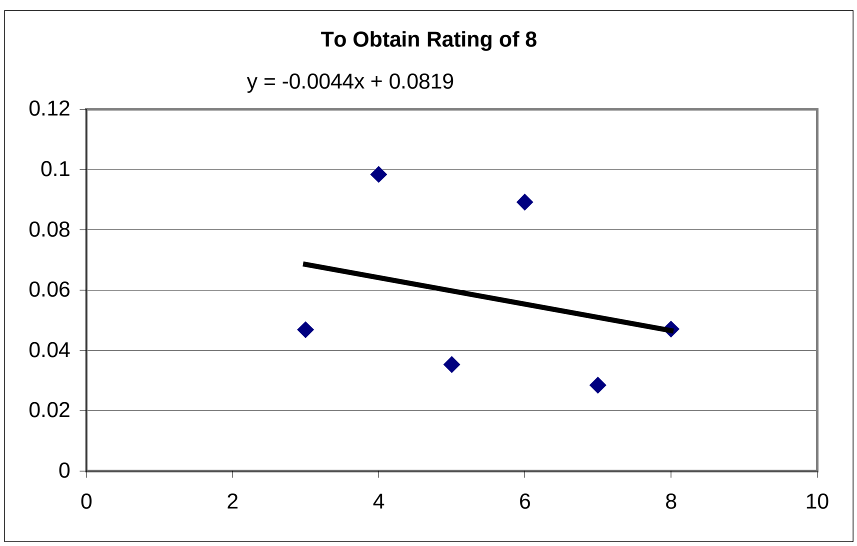

Figure 7-2 Regression Analysis of Rehabilitation Work for Timber Deck Bridges which Improved the Condition Rating to 8

Table 7-5 Final Results of Average Work Accomplished for Timber Deck Bridges after using Regression Analysis

Rating before rehabilitation	Rating after rehabilitation						
	9	8	7	6	5	4	3
9							
8		0.0543					
7		0.0587	0.0523				
6		0.0631	0.0567	0.0503			
5		0.0675	0.0611	0.0547	0.0483		
4		0.0719	0.0655	0.0591	0.0527	0.0463	
3		0.0763	0.0699	0.0635	0.0571	0.0507	0.0443

Table 7-6 Chen and Johnston [1987] Results for Average Rehabilitation Work for Timber Deck Bridges

Rating before rehabilitation	Rating after rehabilitation						
	9	8	7	6	5	4	3
9							
8		0.0738					
7		0.1143	0.0905				
6		0.1548	0.1310	0.1072			
5		0.1953	0.1715	0.1477	0.1239		
4		0.2358	0.2120	0.1882	0.1644	0.1406	
3		0.2763	0.2525	0.2287	0.2049	0.1811	0.1573

The results sometimes varied significantly from the relationships found by Chen and Johnston. In some instances, the average work required to rehabilitate to a rating of 8 from a lower condition rating decreased as the lower rating decreased. This is the opposite of the findings of Chen and Johnston found and opposite what one would normally assume. In other instances, the results showed that more work was required to maintain a rating of 8 than to maintain a rating of 3. This is also opposite of the findings of Chen and Johnston and opposite what one would normally assume.

In Table 7-4 there are a large number of occurrences of work accomplished for decks where the rating remained the same. The data was reevaluated to see if there was a delay in the rating change from when the work was accomplished or a delay in the recording of the work accomplished from when there was a rating change. No such delay was found in the data.

This apparent shift over time since the study by Chen and Johnston appears to be related to changes in Federal requirements defining how the ratings are determined. From 1978 until the early 1990's, the rating applied to the bridge major element was representative of the lowest condition found in any part of that element. As an example, if a small section of a deck were at condition rating of 4 the entire deck would then be rated at a 4 even though most of the deck might be at condition 6.

The new requirements for condition rating mandate that the rating is that which is most representative of the entire bridge major element. Using the example from the previous paragraph, the bridge deck would receive a condition rating of 6. Any work performed on the small section of the deck that was rated at a 4 would not change the overall condition rating applied to the bridge deck. Therefore, this would account for the large number of occurrences where work was performed but the condition rating remained unchanged.

Table 7-7 shows the results from the History File for Concrete Decks. This is an example that was discussed earlier. It shows more work is required to maintain the deck at a rating of 8 than increase the rating from 3 to 8. It also shows more work is required to maintain a rating of 8 than maintain a rating of 3. This is not consistent with the findings of Chen and Johnston. An example of Chen and Johnston's results are found in Table 7-8. It is believed that two factors are adversely influencing the newer data. First, there has been an increase in major maintenance by contract rather than by NCDOT crews which impacts the data. The work recorded is only for work performed by NCDOT crews and not that done by contract. Thus, some apparent increases in condition cannot be connected to a work effort. Second, Federal coding requirements for condition ratings have changed over the years. The condition ratings reflect the predominate condition state rather than the worst state. Thus, when work is done to correct a poor condition that is not predominate, no change occurs in the condition rating. Thus, there is apparent work without apparent impact on condition. Thus, the average work for rehabilitation data found by Chen and Johnston will not be changed in the COSTPARM file at this time.

Table 7-7 Average Rehabilitation Work for Concrete Decks

Rating before rehabilitation	Rating after rehabilitation						
	9	8	7	6	5	4	3
9							
8		0.0406					
7		0.0251	0.0367				
6		0.0096	0.0212	0.0328			
5		-0.0059	0.0057	0.0173	0.0289		
4		-0.0214	-0.0098	0.0018	0.0134	0.0250	
3		-0.0369	-0.0253	-0.0137	-0.0021	0.0095	0.0211

Table 7-8 Average Rehabilitation Work for Concrete Deck [Chen and Johnston 1987]

Rating before rehabilitation	Rating after rehabilitation						
	9	8	7	6	5	4	3
9							
8		0.0603					
7		0.1622	0.1109				
6		0.2641	0.2128	0.1615			
5		0.3660	0.3147	0.2634	0.2121		
4		0.4679	0.4166	0.3653	0.3140	0.2627	
3		0.5698	0.5185	0.4672	0.4159	0.3646	0.3313

The average work for rehabilitation from these tables will be multiplied by the unit cost of rehabilitation located in the COSTPARM.DAT file. The Unit Costs of Rehabilitation, Table 7-9, is created from the unit costs of related function codes in Table 7-10. The unit cost for the function codes was found in the NCDOT report Statewide Bridge Maintenance Cost by System. The report ending 30 June 2001 was used in the calculations. This report contained the year-to-date unit cost for fiscal year 2001. The unit cost for each function code was determined by adding the total cost Y-T-D for each system under that function code and dividing the total cost by the total work accomplished under that function code. The unit costs were in 2001 dollars so the Federal-Aid Highway Construction Index (Structures) was used to update the unit cost to 2002 dollars. The adjustment for one year was 1.02.

Table 7-9 Unit Costs of Rehabilitation ($/Man-Hour) in 2002 Dollars

Material Type	Deck	Superstructure	Substructure
Timber	40.59	44.42	41.11
Reinforced Concrete	40.59	44.42	40.08
Steel	38.97	44.42	34.20
Prestressed Concrete	40.59	44.42	40.08

Table 7-10 Function Codes Used to Calculate Unit Cost of Rehabilitation

Material Type	Deck	Superstructure	Substructure
Timber	561	578	580
Reinforced Concrete	561	578	581, 583
Steel	562	578	582
Prestressed Concrete	561	578	581, 583

If more than one function code is related to a specific bridge element and material type, then one of two options was taken. In the first option, the unit cost of rehabilitation was determined from a weighted average of the function codes unit cost. To calculate the weighted average, the total man-hours per year for the function codes were used to determine the weight of each function code. In the second case, if a function code was used in a special or rare case it was assumed not to have an affect on the unit cost, so it was not considered in the calculation of the unit cost of rehabilitation.

In the COSTPARM.DAT file Appendix 12.5 (Tables 9 through 12), contains the annual maintenance cost for bridge decks, handrails, superstructures and substructures. The tables were updated using the Federal-Aid Highway Construction Index (Structures), see Table 2-1. The updated tables are located in the COSTPARM.DAT file in Appendix 10.6.

8. INTERIM COST ADJUSTMENTS

Although the cost in the COSTPARM.DAT database should be periodically updated for best results, it is possible for the user of the OPBRIDGE program to make an interim adjustment within the input data file. The input file contains a "Factor to Transfer XXXX/XX Dollars to Today's Dollars," With this update of OPBRIDGE, the original,

"FACTOR TO TRANSFER 1985/86 DOLLARS TO TODAY'S DOLLARS?",

is being revised to read,

"FACTOR TO TRANSFER 2002/03 DOLLARS TO TODAY'S DOLLARS?"

The value entered to update the cost tables to current dollars should be derived from the Federal-Aid Highway Construction Index (Structures) or if this number is not available the Consumer Price Index can be used. Section 2.2 explains the use of the inflation indexes. This interim cost adjustment does not change the COSTPARM.DAT file in any permanent way. The input value should typically increase each year to reflect accumulated inflation.

9. IMPROVEMENTS TO OPBRIDGE

There was a desire to look at improvements to the OPBRIDGE program format options and analytical techniques. A couple of possible improvements to the program were noticed while updated the program. One of the improvements is to the output of the OPBRIDGE program and the other is to the actual program.

9.1. Program Output

The OPBRIDGE program has the ability to print a county-by-county output. The user can specify the counties that are to be printed. The program always begins with Alamance County and prints those counties up to and through those specified. It is desired that only those counties specified be printed.

In the subroutine RDUSER, the user can specify the range of bridge numbers for analysis. The variable RANGE(1) is the starting bridge number and the variable RANGE(2) specifies the ending bridge number. The subroutine OUTPT1 actually performs the printing of the output county-by-county. The subroutine uses a loop to print through the counties. The variable ICOUN, line33, is set equal to 1, which starts the printing with Alamance County instead of the specified county.

```
33        DO 500 ICOUN=1, NCOUNT
```

To solve the problem of printing the counties before those specified, the variable ICOUN must be set equal to the county specified in the variable RANGE(1). The county can be extracted from the variable RANGE(1) by dividing by 10000.

```
33        DO 500 ICOUN=RANGE(1)/10000, NCOUNT
```

In line 27 the variable IBRD is set equal to zero, but should be set equal to the same value as ICOUN.

```
27        IBRD=RANGE(1)/10000
```

As a result of adding the use of the variable RANGE to the subroutine, it was also necessary to declare RANGE in the INTEGER statement of line 2,

```
2         INTEGER CCYEAR, …
          +  … , NALT1(15000), RANGE(2)
```

and to add an additional COMMON statement in the subroutine as follows:

```
          COMMON /OBJ3/RANGE
```

9.2. Program Improvement

The subroutine BRDAT extracts inspection data from the bridge database. On line 540, the subroutine assigns deck material. According to the Bridge Maintenance Inventory File layout and the file layout for the History file FTR91036, the deck material is assigned according to state item 86. The state item 86, as stated by the Bridge Maintenance Inventory File layout, corresponds to Federal item 107 in the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges. During review of analysis results, it was discovered that the deck material was being assigned incorrectly. Apparently during a revision in the early 1990's, the revision in materials codes that had occurred between the 1978 codes and the 1988 edition of the Recording and Coding Guide had not been implemented in the program. Deck material was being assigned as shown in Table 9-1. OPBRIDGE has now been revised in the subroutine BRDAT to assign the deck material correctly as shown in Table 9-2. For verification of revised program correctness, bridge-by-bridge output results were compared with inspection folder data.

Table 9-1 Old Deck Material Codes

Code	Description
0	Other
1	Timber
2	Reinforced Concrete
3	Steel (plank floor)
4	Steel Grid
5	Laminated Timber
6	Earth filled Spandrel
7	Cored Slab
8	Prestressed Concrete

Table 9-2 New Deck Material Codes

Code	Description
N	Not Applicable
1	Concrete Cast-In-Place
2	Concrete Precast Panels
3	Open Grating
4	Closed Grating
5	Steel Plate
6	Corrugated Steel
7	Aluminum
8	Timber
9	Other

10. SUMMARY AND CONCLUSIONS

The purpose of this report was to update data for cost, ADT growth rates, deterioration rates and rehabilitation rates in the COSTPARM.DAT file that is used by the OPBRIDGE Program. This effort included finding reports containing the necessary information that are produced on a regular basis allowing the COSTPARM.DAT file to be regularly updated; using the NCDOT History File, which now contains 20 years of data, in calculating ADT growth rates, deterioration rates and rehabilitation rates; and comparing the new rates and costs to those found by Chen and Johnston that have been previously used by OPBRIDGE.

Updating the vehicle operating cost was a relatively straightforward procedure. Cost numbers, produced on a yearly basis, were possible to find. The U.S. Department of Agriculture report used by Chen and Johnston that previously provides the tractor-trailer operating cost no longer contains that information. However, a report from the U.S. Census Bureau contained the necessary information so that the operating cost could be calculated.

The vehicle accident cost uses the "Willingness-to-Pay" Approach. This information was found presented in two reports, one by the National Safety Council (NSC) and the other by the Federal Highway Administration (FHWA). The NSC report is published every year while the FHWA report is published much less frequently. A current FHWA report should be used to update the vehicle accident cost and the NSC report can be used for years between the publishing of the FHWA report. It is suggested that these reports be used in updating the vehicle accident cost and not an inflation index such as the Consumer Price Index. The Consumer Price Index produced a cost that was almost half that found in the reports.

In calculating the ADT growth rates, ten years of bridge ADT data was used. Parts of North Carolina have seen major population growth in the past ten years. The results of this data analysis indicate roadways in some counties have had significant ADT growth while a few counties had declines on some roadway functional classifications. As the NCDOT database expands in the number of years it contains, the number of years used in the calculation of the ADT growth rates could increase. This may result in a more accurate growth rate. However, the most critical factor for an accurate calculation is having accurate ADT data for as many bridges as possible for each year.

Rehabilitation work required was determined from work-accomplished data for the bridges. The results in some instances were different from that found by Chen and Johnston and different from what was expected. A large number of occurrences of work where there was no change in the condition rating were noted. This could be from the fact that small sections of a bridge element needed repair but this did not affect the condition rating of the entire bridge element. The results are also significantly impacted by the fact the contract work is not included in the work accomplished data. If the results are to be accurate, this deficiency needs to be overcome.

As a result, it was concluded that the rehabilitation unit work values determined by Chen and Johnston could not be improved on from the information available at this time. Thus, this data remains the same in COSTPARM.DAT and is not presently recommended for change. The unit costs for rehabilitation, were updated using an NCDOT report on Statewide Bridge Maintenance Cost by System.

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12. APPENDIX

12.1 Material Types and Deterioration Rates for Bridge Elements

This section of the appendix contains tables listing the different material types for the three bridge elements. Also, this section contains the results of the deterioration rate programs for the three bridge elements.

12.2 Deterioration Rate Programs

This section list the four deterioration rate programs used by SAS for the three bridge element conditions.

12.3 Rehabilitation Rates

This section contains the results of the rehabilitation programs and those produced by Chen and Johnston 1987.

12.4 Rehabilitation Rate Programs

This section contains a listing of the rehabilitation programs used by the SAS software.

12.5 Previous Cost and Parameter Data File

This section contains the original COSTPARM.DAT file used by the OPBRIDGE Program.

12.6 Updated Cost and Parameter File

This section contains the COSTPARM.DAT file that contains new cost, ADT growth rates, deterioration rates, and rehabilitation work.

12.7 Update Worksheet

Worksheet for updating cost in the COSTPARM.DAT file.

12.1. Material Types and Deterioration Rates for Bridge Elements

Table 12.1(a) Deck Material Types

dkmat	
1	Timber
2	Concrete
3	Steel

Table 12.1(b) Substructure Material Types

sbmat		Area	
1	Timber	1	Coastal
2	Concrete & Masonry	2	Piedimont
3	Steel	3	Mountain
4	Prestressed Concrete		

Table 12.1(c) Superstructure Material Types

spmat		State System		sptype	
1	Timber	1	U, I, P	1	Multi-Beam
2	Concrete & Masonry	2	S	2	Slab
3	Steel, Aluminum, Wrought Iron & Cast Iron			3	Tee-Beam
4	Prestressed Concrete			4	Truss
				5	Floor-Beam

Tables 12.1 Material Types for Bridge Elements

Table 12.1-1(a) Decka00 Deterioration Rates

decka00- see beginning and end must drop (9-5>0)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	1.9	4.4	4.2	4.9	3.7	19.2
1	201	1.8	5.1	4.9	4.8	3.7	20.3
1	801	1.7	4.6	4.4	4.6	4.0	19.2
1	2001	2.5	3.7	4.0	3.5	2.3	16.1
1	4001	1.0	6.7	3.0	3.5	8.0	22.2
2	0	2.1	6.1	5.1	5.2	4.6	23.2
2	201	1.9	6.5	5.7	5.9	4.5	24.4
2	801	2.0	5.6	5.4	6.0	4.9	23.9
2	2001	1.9	5.0	5.3	6.0	5.6	23.8
2	4001	2.0	4.1	5.4	5.8	4.7	22.0
3	0	2.2	6.3	4.1	4.2	5.0	21.9
3	201	2.4	5.8	5.0	5.6	4.7	23.4
3	801	3.8	5.7	4.5	3.8	4.9	22.6
3	2001	1.6	5.8	3.8	5.1	4.3	20.5
3	4001	3.0	5.4	4.7	4.1	2.0	19.2

Table 12.1-1(b) Occurrences of Ratings for Decka00

decka00- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	194	792	879	989	424
1	201	88	572	481	436	170
1	801	13	144	111	94	37
1	2001	2	26	18	13	6
1	4001	2	7	2	6	1
2	0	114	274	208	137	34
2	201	158	506	521	349	78
2	801	130	322	387	287	84
2	2001	131	214	306	237	75
2	4001	316	468	854	684	282
3	0	17	70	39	13	4
3	201	16	138	88	32	9
3	801	4	47	44	28	7
3	2001	5	23	27	11	4
3	4001	2	11	24	10	2

Table 12.1-1(c) Decka01 Deterioration Rates

decka01- see beginning and end must drop (9-5>1)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.6	4.8	4.5	5.3	4.0	21.1
1	201	2.6	5.4	5.2	5.0	3.9	22.1
1	801	2.5	4.9	4.5	4.9	4.4	21.2
1	2001	4.0	4.2	4.2	4.7	3.7	20.7
1	4001		6.7	3.0	4.8	8.0	22.5
2	0	2.7	7.2	5.5	6.0	5.2	26.7
2	201	2.6	7.1	6.1	6.2	4.9	26.9
2	801	2.6	6.2	5.8	6.2	5.1	25.9
2	2001	2.5	5.7	5.6	6.2	6.0	26.0
2	4001	2.8	4.7	5.7	6.0	4.9	24.1
3	0	3.1	6.6	4.4	4.8	5.0	23.9
3	201	2.8	6.2	5.2	5.9	5.1	25.2
3	801	4.7	5.8	4.8	4.0	4.9	24.2
3	2001	2.0	6.3	3.9	5.1	4.3	21.5
3	4001	3.0	6.3	5.2	4.4	2.0	21.0

Table 12.1-1(d) Occurrences of Ratings for Decka01

decka01- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	114	710	805	908	386
1	201	46	529	451	415	154
1	801	6	134	107	87	32
1	2001	1	22	17	9	3
1	4001		7	2	4	1
2	0	74	226	190	115	29
2	201	85	456	482	325	71
2	801	87	284	356	277	79
2	2001	81	184	283	227	69
2	4001	182	395	794	656	268
3	0	10	67	36	11	4
3	201	13	126	83	30	8
3	801	3	46	40	26	7
3	2001	3	21	26	11	4
3	4001	2	9	21	9	2

Table 12.1-1(e) Decka02 Deterioration Rates

decka02- see beginning and end must drop (9-5>2)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	3.6	6.0	5.9	6.4	5.5	27.4
1	201	3.6	6.5	6.3	6.1	5.5	27.9
1	801	3.5	5.8	6.6	6.0	5.7	27.7
1	2001	4.0	5.4	5.4	6.0	4.5	25.3
1	4001		8.6	4.0	4.8	8.0	25.4
2	0	3.5	8.7	6.5	7.2	6.1	32.0
2	201	3.8	8.3	7.0	7.0	6.0	32.0
2	801	3.7	7.7	6.8	7.1	6.4	31.7
2	2001	3.5	6.9	6.5	7.1	7.0	31.1
2	4001	4.0	5.9	6.7	7.0	6.1	29.8
3	0	4.2	7.7	6.1	6.4	5.0	29.4
3	201	4.5	7.2	6.5	7.0	6.2	31.4
3	801	6.0	6.8	6.1	5.1	6.0	30.0
3	2001		7.0	5.1	6.9	6.5	25.4
3	4001	3.0	7.6	7.7	5.1		23.4

Table 12.1-1(f) Occurrences of Ratings for Decka02

decka02- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	42	499	514	668	221
1	201	18	405	336	304	84
1	801	2	100	58	62	21
1	2001	1	14	11	6	2
1	4001		5	1	4	1
2	0	35	175	148	89	23
2	201	30	371	393	274	51
2	801	29	212	283	224	56
2	2001	27	137	224	185	56
2	4001	69	270	626	520	191
3	0	5	54	21	7	4
3	201	4	102	60	23	6
3	801	2	37	27	17	5
3	2001		18	16	7	2
3	4001	2	7	12	7	

Tables 12.1-1 Deterioration Rates Calculated Using Program Decka0 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-2(a) Decka10 Deterioration Rates

decka10- see beginning and end goes up or down (9-5>0)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	1.9	4.3	4.0	4.4	3.1	17.7
1	201	1.8	5.0	4.5	4.2	3.1	18.7
1	801	1.7	4.5	4.2	4.4	3.0	17.7
1	2001	2.5	3.7	4.0	3.1	2.6	15.9
1	4001	1.0	6.1	2.4	3.3	2.4	15.3
2	0	2.1	5.9	4.4	4.1	3.1	19.6
2	201	1.9	6.3	5.3	4.8	3.5	21.7
2	801	2.0	5.5	5.2	5.1	3.8	21.7
2	2001	1.9	5.0	4.9	5.1	4.2	21.1
2	4001	2.0	4.0	5.1	5.2	4.1	20.4
3	0	2.2	6.0	3.6	3.2	2.3	17.3
3	201	2.4	5.7	4.2	4.2	2.9	19.4
3	801	3.8	5.6	4.4	3.5	3.5	20.7
3	2001	1.6	5.8	3.7	4.4	3.7	19.2
3	4001	3.0	5.4	4.3	3.6	3.1	19.3

Table 12.1-2(b) Occurrences of Ratings for Decka10

decka10- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	194	834	1130	1729	1305
1	201	88	583	616	772	564
1	801	13	147	132	166	117
1	2001	2	26	25	25	24
1	4001	2	8	5	15	12
2	0	114	299	306	301	194
2	201	158	553	691	681	359
2	801	130	343	500	518	306
2	2001	131	231	379	429	232
2	4001	316	503	1048	1207	823
3	0	17	76	91	67	27
3	201	16	141	149	108	62
3	801	4	49	67	64	33
3	2001	5	23	35	29	11
3	4001	2	11	30	20	11

Table 12.1-2(c) Decka11 Deterioration Rates

decka11- see beginning and end goes up or down (9-5>1)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.6	4.7	4.4	4.8	3.6	20.1
1	201	2.6	5.4	4.9	4.5	3.5	20.9
1	801	2.5	4.9	4.3	4.8	3.6	20.0
1	2001	4.0	4.2	4.2	3.8	3.2	19.4
1	4001		6.1	2.4	3.7	2.7	14.9
2	0	2.7	7.2	5.0	5.2	4.7	24.8
2	201	2.6	7.1	5.8	5.6	4.5	25.6
2	801	2.6	6.3	5.6	5.6	4.5	24.6
2	2001	2.5	5.7	5.4	5.6	5.0	24.3
2	4001	2.8	4.6	5.5	5.6	4.6	23.1
3	0	3.1	6.6	4.1	3.8	3.3	20.8
3	201	2.8	6.2	4.6	4.7	3.9	22.2
3	801	4.7	5.8	4.7	3.8	4.0	23.0
3	2001	2.0	6.3	3.9	5.1	4.3	21.6
3	4001	3.0	6.3	4.8	3.7	3.6	21.3

Table 12.1-2(d) Occurrences of Ratings for Decka11

decka11- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	114	735	1004	1530	1067
1	201	46	537	554	700	474
1	801	6	134	127	150	90
1	2001	1	22	23	19	17
1	4001		8	5	13	10
2	0	74	238	262	222	109
2	201	85	480	618	570	252
2	801	87	293	449	459	245
2	2001	81	193	337	385	186
2	4001	182	417	951	1100	710
3	0	10	68	79	52	15
3	201	13	126	132	93	41
3	801	3	46	61	56	28
3	2001	3	21	32	24	9
3	4001	2	9	26	19	9

Table 12.1-2(e) Decka12 Deterioration Rates

decka12- see beginning and end goes up or down (9-5>2)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	3.6	6.0	5.8	6.2	5.1	26.6
1	201	3.6	6.5	6.2	5.7	5.0	26.9
1	801	3.5	5.8	6.4	5.9	4.9	26.5
1	2001	4.0	5.4	5.6	4.8	4.6	24.5
1	4001		8.6	4.0	5.1	5.5	23.2
2	0	3.5	8.8	6.2	6.9	6.2	31.6
2	201	3.8	8.3	6.8	6.8	6.1	31.8
2	801	3.7	7.8	6.8	7.0	6.0	31.2
2	2001	3.5	7.0	6.4	6.7	6.5	30.1
2	4001	4.0	5.9	6.7	6.8	5.9	29.3
3	0	4.2	7.6	5.9	5.5	4.7	27.9
3	201	4.5	7.2	5.9	6.2	5.6	29.4
3	801	6.0	6.8	6.1	5.1	5.5	29.5
3	2001		7.0	5.4	7.3	7.3	27.0
3	4001	3.0	7.6	6.8	5.2	9.0	31.6

Table 12.1-2(f) Occurrences of Ratings for Decka12

decka12- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	42	507	620	1031	562
1	201	18	407	383	469	240
1	801	2	100	66	106	49
1	2001	1	14	14	12	8
1	4001		5	1	7	2
2	0	35	182	186	145	71
2	201	30	384	489	421	155
2	801	29	217	342	336	155
2	2001	27	143	261	294	126
2	4001	69	278	721	827	470
3	0	5	55	42	27	7
3	201	4	102	88	59	22
3	801	2	37	40	33	16
3	2001		18	18	14	4
3	4001	2	7	15	10	2

Tables 12.1-2 Deterioration Rates Calculated Using Program Decka1 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-3(a) Decka20 Deterioration Rates

decka20- total rating count for bridge (9-5>0)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.1	6.5	6.5	7.2	4.6	26.9
1	201	2.1	7.1	7.3	7.1	4.6	28.2
1	801	1.9	6.8	7.1	7.1	4.1	26.9
1	2001	2.0	7.5	8.2	5.3	4.8	27.7
1	4001	1.0	7.8	7.6	6.5	3.2	26.1
2	0	2.3	6.5	6.4	5.0	2.8	22.9
2	201	2.2	7.1	8.2	7.8	5.1	30.3
2	801	2.3	6.8	7.8	8.6	6.0	31.4
2	2001	2.3	5.8	7.6	8.5	6.5	30.8
2	4001	2.4	5.2	7.8	8.7	6.7	30.8
3	0	2.5	11.4	6.3	4.5	2.9	27.6
3	201	2.4	10.7	6.9	6.3	3.3	29.6
3	801	2.6	9.6	6.8	6.2	4.5	29.7
3	2001	1.8	10.2	6.5	6.7	7.0	32.2
3	4001	3.0	6.7	5.7	7.8	4.6	27.8

Table 12.1-3(b) Occurrences of Ratings for Decka20

decka20- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	348	1551	1855	2172	1608
1	201	174	980	1089	1163	787
1	801	33	204	245	239	167
1	2001	5	43	46	37	34
1	4001	3	17	10	13	12
2	0	143	530	512	501	328
2	201	228	1063	1420	1274	665
2	801	171	655	921	952	488
2	2001	161	478	696	711	375
2	4001	447	1158	1894	2054	1135
3	0	26	187	155	104	36
3	201	23	303	240	181	92
3	801	7	120	107	92	46
3	2001	5	48	42	39	18
3	4001	1	15	31	31	22

Table 12.1-3(c) Decka21 Deterioration Rates

decka21- total rating count for bridge (9-5>1)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.7	7.0	6.9	7.5	5.1	29.2
1	201	2.8	7.5	7.7	7.4	5.1	30.5
1	801	2.6	7.2	7.3	7.4	4.5	29.0
1	2001	3.5	8.0	8.4	6.3	5.4	31.5
1	4001		8.7	7.6	6.5	3.9	26.7
2	0	2.9	7.7	7.6	7.9	5.9	32.0
2	201	3.0	8.0	8.9	9.0	6.9	35.7
2	801	2.8	7.7	8.6	9.7	7.3	36.2
2	2001	3.0	6.9	8.5	9.6	7.5	35.5
2	4001	3.3	6.0	8.7	9.3	7.4	34.6
3	0	3.3	11.8	7.0	5.6	3.7	31.3
3	201	2.8	11.2	7.3	6.9	4.4	32.7
3	801	3.2	10.1	7.0	6.4	5.1	31.8
3	2001	2.0	10.2	6.8	7.2	7.0	33.2
3	4001	3.0	8.1	6.2	8.3	5.9	31.5

Table 12.1-3(d) Occurrences of Ratings for Decka21

decka21- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	220	1428	1740	2057	1407
1	201	108	918	1035	1096	688
1	801	18	189	239	225	147
1	2001	2	40	45	30	29
1	4001		15	10	13	9
2	0	95	434	419	291	118
2	201	134	929	1292	1078	462
2	801	116	565	817	836	382
2	2001	105	390	617	625	318
2	4001	272	975	1673	1891	1020
3	0	17	180	139	80	25
3	201	18	286	225	162	63
3	801	5	114	103	88	40
3	2001	4	48	40	36	18
3	4001	1	12	28	29	16

Table 12.1-3(e) Decka22 Deterioration Rates

decka22- total rating count for bridge (9-5>2)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	3.6	7.8	7.9	8.3	6.2	33.7
1	201	3.6	8.2	8.4	8.1	6.2	34.5
1	801	3.6	7.9	8.2	8.3	5.5	33.4
1	2001	3.5	9.0	8.7	7.3	6.3	34.8
1	4001		9.2	8.2	7.3	4.8	29.5
2	0	3.8	9.1	8.5	9.0	7.4	37.8
2	201	4.4	9.1	9.5	9.6	7.9	40.5
2	801	4.0	9.0	9.4	10.3	8.1	40.6
2	2001	4.1	8.1	9.1	9.9	8.1	39.4
2	4001	4.4	7.1	9.4	9.8	8.1	39.0
3	0	4.0	12.4	7.9	6.8	4.8	35.9
3	201	4.1	11.7	8.0	7.7	5.6	37.2
3	801	4.0	10.7	7.6	7.6	6.4	36.2
3	2001		10.7	8.0	7.6	7.3	33.7
3	4001	3.0	8.6	7.9	8.5	6.8	34.9

Table 12.1-3(f) Occurrences of Ratings for Decka22

decka22- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	98	1239	1448	1799	1039
1	201	55	811	921	973	510
1	801	7	166	204	196	105
1	2001	2	34	43	24	23
1	4001		14	9	11	6
2	0	51	347	360	243	85
2	201	55	782	1185	991	383
2	801	49	467	735	778	335
2	2001	50	313	562	597	289
2	4001	141	757	1504	1771	892
3	0	11	170	117	60	15
3	201	7	273	198	138	42
3	801	3	106	92	70	28
3	2001		45	32	33	17
3	4001	1	11	20	28	13

Tables 12.1-3 Deterioration Rates Calculated Using Program Decka2 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-4(a) Decka30 Deterioration Rates

decka30- every series counted (9-5>0)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.1	5.4	4.9	5.2	3.6	21.2
1	201	2.1	5.8	5.7	5.2	3.7	22.6
1	801	1.8	5.4	5.2	5.2	3.5	21.1
1	2001	1.7	5.5	5.0	4.2	3.6	20.0
1	4001	1.0	4.2	3.3	3.3	3.2	15.1
2	0	2.3	5.8	5.3	4.5	2.8	20.7
2	201	2.2	6.5	6.8	6.4	4.6	26.4
2	801	2.2	6.2	6.3	6.7	5.0	26.4
2	2001	2.3	5.2	6.1	6.4	5.2	25.2
2	4001	2.4	4.7	6.0	6.1	5.2	24.3
3	0	2.5	9.3	4.8	3.9	2.7	23.3
3	201	2.2	8.8	5.1	5.0	3.1	24.2
3	801	2.4	8.7	5.2	4.2	3.6	24.2
3	2001	2.0	8.6	4.1	5.1	5.3	25.1
3	4001	1.7	5.7	4.2	4.6	3.4	19.6

Table 12.1-4(b) Occurrences of Ratings for Decka30

decka30- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	347	1872	2332	2908	2029
1	201	177	1182	1407	1517	940
1	801	34	271	366	367	202
1	2001	7	65	104	90	52
1	4001	4	36	102	118	45
2	0	131	553	598	557	331
2	201	223	1126	1577	1466	716
2	801	167	728	1155	1182	582
2	2001	164	537	881	988	470
2	4001	476	1364	2592	3027	1492
3	0	24	218	197	115	38
3	201	24	359	310	225	98
3	801	7	145	149	130	56
3	2001	8	55	64	53	25
3	4001	3	30	58	64	31

Table 12.1-4(c) Decka31 Deterioration Rates

decka31- every series counted (9-5>1)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	2.7	6.0	5.4	5.7	4.1	24.0
1	201	2.8	6.4	6.2	5.7	4.3	25.4
1	801	2.7	6.1	5.5	5.7	4.1	24.1
1	2001	3.5	6.4	5.9	5.2	4.4	25.5
1	4001		5.6	4.7	4.3	3.7	18.3
2	0	2.9	7.0	6.2	6.3	5.1	27.4
2	201	3.0	7.4	7.6	7.5	6.1	31.6
2	801	2.8	7.1	7.4	7.8	6.1	31.3
2	2001	3.0	6.3	7.3	7.7	6.2	30.4
2	4001	3.2	5.6	7.2	7.4	6.0	29.5
3	0	3.3	9.9	5.3	4.8	3.5	26.8
3	201	2.7	9.6	5.8	5.7	4.2	27.9
3	801	3.0	9.3	5.7	4.9	4.1	26.9
3	2001	2.3	9.1	4.5	5.6	5.7	27.2
3	4001	3.0	7.1	5.0	5.5	4.5	25.1

Table 12.1-4(d) Occurrences of Ratings for Decka31

decka31- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	217	1652	2077	2578	1673
1	201	110	1064	1265	1360	785
1	801	16	234	342	328	162
1	2001	2	54	85	69	39
1	4001		25	64	83	37
2	0	85	441	502	370	145
2	201	129	976	1379	1206	506
2	801	112	613	969	987	454
2	2001	106	422	720	806	381
2	4001	288	1090	2066	2408	1232
3	0	16	203	174	88	26
3	201	17	325	267	191	65
3	801	5	135	136	108	46
3	2001	6	52	57	47	23
3	4001	1	23	47	52	21

Table 12.1-4(e) Decka32 Deterioration Rates

decka32- every series counted (9-5>2)							
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	0	3.6	7.1	6.7	7.1	5.5	30.0
1	201	3.6	7.4	7.3	6.9	5.7	31.0
1	801	3.6	7.2	6.9	6.8	5.2	29.7
1	2001	3.5	7.7	7.1	6.4	5.7	30.3
1	4001		7.2	6.2	5.3	4.9	23.7
2	0	3.8	8.7	7.5	7.7	6.6	34.3
2	201	4.3	8.6	8.5	8.5	7.3	37.2
2	801	4.0	8.4	8.3	8.9	7.2	36.9
2	2001	4.1	7.6	8.3	8.6	7.0	35.6
2	4001	4.4	6.9	8.2	8.3	7.2	35.0
3	0	4.0	11.0	6.5	6.2	4.7	32.4
3	201	4.0	10.6	6.9	6.8	5.6	33.9
3	801	3.7	10.2	6.6	6.1	5.5	32.2
3	2001	4.0	10.0	5.8	6.8	6.7	33.4
3	4001	3.0	10.4	6.2	6.6	6.8	33.1

Table 12.1-4(f) Occurrences of Ratings for Decka32

decka32- number of occurences						
dkmat	**adt**	**9**	**8**	**7**	**6**	**5**
1	0	95	1277	1507	1912	1009
1	201	56	860	1002	1020	487
1	801	7	186	242	253	107
1	2001	2	42	65	51	26
1	4001		17	41	58	22
2	0	45	328	383	277	96
2	201	55	796	1191	1019	392
2	801	46	488	821	833	357
2	2001	48	323	608	695	318
2	4001	148	809	1724	2061	964
3	0	10	180	126	59	15
3	201	6	288	207	145	39
3	801	3	119	108	75	28
3	2001	1	46	37	35	18
3	4001	1	14	33	39	11

Tables 12.1-4 Deterioration Rates Calculated Using Program Decka3 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-5(a) Substructurea00 Deterioration Rates

suba00- see beginning and end must drop (9-5>0)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1.8	2.7	3.6	4.7	4.0	16.8
1	2	2.5	3.1	4.2	4.9	4.0	18.7
1	3	2.4	3.0	3.9	4.5	3.6	17.3
2	1	1.8	4.5	4.7	4.4	4.1	19.5
2	2	2.2	4.7	5.2	5.4	4.7	22.2
2	3	2.1	5.2	4.4	4.4	3.3	19.4
3	1	2.5	5.0	6.0	6.5	6.6	26.7
3	2	2.3	6.0	6.3	6.5	5.1	26.1
3	3	2.1	5.6	5.7	6.5	5.3	25.1
4	1	2.0	4.8	4.7	5.6	4.3	21.4
4	2	2.4	4.1	5.7	6.1	4.4	22.7
4	3		4.3	5.7	3.5		13.5

Table 12.1-5(b) Occurrences of Ratings for Substructurea00

suba00- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1	4	57	301	759	381
1	2	2	110	439	1054	585
1	3	13	235	1208	923	246
2	1	43	93	194	130	51
2	2	405	775	1090	727	240
2	3	123	720	703	408	117
3	1	30	113	101	77	37
3	2	108	332	247	167	77
3	3	48	157	130	73	18
4	1	25	158	124	73	21
4	2	7	54	73	38	8
4	3		6	9	2	

Table 12.1-5(c) Substructurea01 Deterioration Rates

suba01- see beginning and end must drop (9-5>1)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	2.0	2.9	4.0	5.0	4.4	18.2
1	2	2.5	3.4	4.4	5.2	4.2	19.8
1	3	3.6	3.5	4.3	4.9	3.9	20.1
2	1	2.5	4.7	5.1	5.0	4.6	21.9
2	2	3.0	5.2	5.5	5.8	4.9	24.4
2	3	2.8	5.6	4.9	4.9	3.7	22.0
3	1	3.0	5.6	6.6	7.1	7.3	29.6
3	2	2.7	6.5	6.7	7.0	5.7	28.7
3	3	3.2	6.0	6.2	6.9	6.1	28.4
4	1	2.7	5.1	5.2	6.1	4.8	23.9
4	2	2.4	4.6	6.2	6.3	4.9	24.4
4	3		4.3	5.7	3.5		13.5

Table 12.1-5(d) Occurrences of Ratings for Substructurea01

suba01- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1	3	52	261	701	345
1	2	2	93	412	985	549
1	3	7	186	1062	842	215
2	1	23	87	176	110	44
2	2	248	681	1016	674	225
2	3	77	651	622	356	97
3	1	22	100	91	69	33
3	2	78	299	230	154	66
3	3	24	144	116	68	15
4	1	15	145	110	66	18
4	2	7	47	66	36	7
4	3		6	9	2	

Table 12.1-5(e) Substructurea02 Deterioration Rates

suba02- see beginning and end must drop (9-5>2)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1		4.6	5.6	6.1	5.7	22.1
1	2	3.0	5.5	5.9	6.3	5.5	26.2
1	3	3.8	5.6	5.6	6.1	5.2	26.3
2	1	3.4	6.5	6.0	6.1	6.0	27.9
2	2	4.3	6.5	6.6	6.5	5.9	29.8
2	3	3.6	6.9	6.3	6.3	5.5	28.6
3	1	3.8	6.9	7.6	7.9	7.8	34.0
3	2	3.7	7.8	7.9	7.9	6.7	33.9
3	3	4.0	7.0	7.1	7.7	7.2	33.0
4	1	5.3	5.9	6.2	7.3	5.9	30.6
4	2	3.5	6.5	7.6	7.4	5.3	30.3
4	3		6.7	5.7	3.5		15.8

Table 12.1-5(f) Occurrences of Ratings for Substructurea02

suba02- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1		17	143	508	218
1	2	1	38	258	734	342
1	3	6	75	680	592	130
2	1	8	53	138	81	28
2	2	107	491	773	558	168
2	3	36	480	420	246	48
3	1	12	73	75	60	30
3	2	34	235	182	130	53
3	3	14	114	95	59	12
4	1	3	116	84	51	13
4	2	2	27	50	29	6
4	3		3	9	2	

Tables 12.1-5 Deterioration Rates Calculated Using Program Substructurea0 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-6(a) Substructurea10 Deterioration Rates

suba10- see beginning and end goes up or down (9-5>0)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1.8	2.7	3.6	4.6	3.6	16.1
1	2	2.5	3.0	4.1	4.7	3.5	17.9
1	3	2.4	2.9	3.9	4.3	3.0	16.4
2	1	1.8	4.5	4.5	3.9	3.4	18.0
2	2	2.2	4.6	4.8	4.5	3.8	19.8
2	3	2.1	5.1	4.0	3.8	2.9	17.9
3	1	2.5	4.8	5.3	5.1	5.8	23.4
3	2	2.3	5.8	5.4	5.1	4.3	22.8
3	3	2.1	5.3	4.8	4.9	3.1	20.3
4	1	2.0	4.5	4.2	4.8	3.9	19.4
4	2	2.4	4.1	5.3	4.5	3.8	20.1
4	3		4.3	5.6	3.3	4.0	17.3

Table 12.1-6(b) Occurrences of Ratings for Substructurea10

suba10- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1	4	58	308	838	660
1	2	2	111	460	1257	1106
1	3	13	236	1280	1665	1127
2	1	43	96	218	193	111
2	2	405	821	1397	1390	718
2	3	123	737	1033	974	552
3	1	30	131	142	147	136
3	2	108	349	370	349	277
3	3	48	165	210	186	81
4	1	25	173	172	156	100
4	2	7	54	90	76	34
4	3		6	14	7	3

Table 12.1-6(c) Substructurea11 Deterioration Rates

suba11- see beginning and end goes up or down (9-5>1)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	2.0	2.9	4.0	4.9	3.9	17.7
1	2	2.5	3.4	4.4	5.0	3.8	19.1
1	3	3.6	3.5	4.3	4.7	3.4	19.4
2	1	2.5	4.8	4.9	4.6	4.1	20.8
2	2	3.0	5.2	5.2	5.1	4.5	22.9
2	3	2.8	5.6	4.5	4.4	3.5	20.7
3	1	3.0	5.5	6.1	6.5	7.6	28.7
3	2	2.7	6.5	6.0	6.1	5.9	27.1
3	3	3.2	5.9	5.4	5.7	4.6	24.8
4	1	2.7	5.0	5.0	6.0	5.7	24.3
4	2	2.4	4.6	5.8	5.1	4.8	22.6
4	3		4.3	5.6	3.3	4.0	17.3

Table 12.1-6(d) Occurrences of Ratings for Substructurea11

suba11- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1	3	52	266	762	571
1	2	2	93	427	1168	984
1	3	7	186	1118	1463	937
2	1	23	88	194	157	85
2	2	248	705	1247	1191	574
2	3	77	659	876	810	433
3	1	22	110	121	109	98
3	2	78	304	325	282	187
3	3	24	145	180	155	49
4	1	15	152	140	118	61
4	2	7	47	81	65	25
4	3		6	14	7	3

Table 12.1-6(e) Substructurea12 Deterioration Rates

suba12- see beginning and end goes up or down (9-5>2)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1		4.6	5.7	6.1	5.4	21.8
1	2	3.0	5.5	5.8	6.3	5.2	25.9
1	3	3.8	5.6	5.6	6.1	4.8	25.9
2	1	3.4	6.6	5.9	5.8	5.6	27.3
2	2	4.3	6.5	6.5	6.3	5.9	29.5
2	3	3.6	6.9	6.0	6.0	5.0	27.5
3	1	3.8	6.9	7.1	7.8	8.3	34.0
3	2	3.7	7.7	7.3	7.3	7.0	33.1
3	3	4.0	7.0	6.8	7.1	5.7	30.6
4	1	5.3	5.9	6.2	7.2	7.0	31.6
4	2	3.5	6.5	7.1	6.6	5.8	29.5
4	3		6.7	5.6	4.3	4.0	20.6

Table 12.1-6(f) Occurrences of Ratings for Substructurea12

suba12- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1		17	146	539	330
1	2	1	38	267	821	541
1	3	6	75	709	973	470
2	1	8	54	144	105	49
2	2	107	504	889	841	367
2	3	36	482	550	487	213
3	1	12	78	96	85	87
3	2	34	236	243	216	144
3	3	14	114	128	113	34
4	1	3	117	100	90	45
4	2	2	27	60	44	18
4	3		3	14	4	3

Tables 12.1-6 Deterioration Rates Calculated Using Program Substructurea1 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-7(a) Substructurea20 Deterioration Rates

suba20- total rating count for bridge (9-5>0)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	2.1	3.2	5.3	8.2	7.3	26.2
1	2	2.0	3.3	5.1	8.9	6.5	25.9
1	3	2.0	3.3	6.7	9.7	4.8	26.4
2	1	2.9	6.3	6.7	7.9	6.8	30.5
2	2	2.6	6.9	8.2	8.1	6.2	32.0
2	3	2.3	8.4	8.4	7.8	5.2	32.1
3	1	3.1	6.1	6.0	3.9	2.1	21.2
3	2	2.3	7.7	7.6	4.3	2.5	24.4
3	3	2.0	7.6	8.0	3.9	2.1	23.6
4	1	2.9	6.6	7.2	6.8	4.8	28.3
4	2	2.4	8.3	8.4	8.3	5.9	33.3
4	3		8.4	9.7	6.1	4.0	28.2

Table 12.1-7(b) Occurrences of Ratings for Substructurea20

suba20- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1	7	239	750	1079	905
1	2	4	211	899	1603	1321
1	3	28	671	1614	1913	1172
2	1	64	338	355	352	161
2	2	633	1844	2329	2082	1097
2	3	210	1296	1628	1284	631
3	1	39	259	168	178	150
3	2	122	570	480	523	369
3	3	65	316	318	250	132
4	1	34	296	276	213	112
4	2	7	114	141	126	58
4	3		18	21	9	3

Table 12.1-7(c) Substructurea21 Deterioration Rates

suba21- total rating count for bridge (9-5>1)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	2.6	3.4	5.7	8.4	7.6	27.7
1	2	2.3	4.2	5.6	9.2	6.8	28.1
1	3	2.9	3.9	7.0	9.8	5.2	28.8
2	1	3.7	7.1	7.3	8.2	7.1	33.5
2	2	3.5	7.9	8.9	8.8	7.0	36.0
2	3	3.1	9.0	8.9	8.4	5.9	35.2
3	1	3.5	7.0	7.0	6.5	5.5	29.6
3	2	2.9	8.4	8.5	7.3	5.5	32.5
3	3	3.0	8.2	9.1	6.4	4.8	31.5
4	1	3.5	7.1	7.9	7.9	7.1	33.5
4	2	2.4	9.2	9.0	8.9	6.5	36.2
4	3		8.4	9.7	6.1	4.0	28.2

Table 12.1-7(d) Occurrences of Ratings for Substructurea21

suba21- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1	5	220	691	1043	869
1	2	3	156	799	1563	1252
1	3	15	540	1526	1881	1055
2	1	44	294	319	337	151
2	2	425	1591	2107	1896	941
2	3	133	1206	1522	1186	536
3	1	32	220	141	94	37
3	2	85	515	422	273	126
3	3	32	290	274	132	40
4	1	25	271	248	180	70
4	2	7	101	130	116	51
4	3		18	21	9	3

Table 12.1-7(e) Substructurea22 Deterioration Rates

suba22- total rating count for bridge (9-5>2)							
sbmat	**area**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	5.0	4.1	6.5	8.8	8.1	32.6
1	2	3.0	5.9	6.7	9.7	7.5	32.9
1	3	3.8	5.1	7.7	10.1	6.3	33.0
2	1	4.6	8.5	7.9	8.4	8.0	37.4
2	2	4.6	8.8	9.7	9.3	7.9	40.3
2	3	3.9	10.0	9.6	9.2	7.0	39.8
3	1	4.3	8.4	7.9	7.4	6.9	34.8
3	2	3.8	9.1	9.2	8.0	6.8	36.9
3	3	3.8	9.5	10.4	8.5	6.8	39.0
4	1	4.7	8.0	8.5	8.6	7.9	37.5
4	2	3.5	10.9	9.7	9.4	7.3	40.8
4	3		9.7	9.7	6.6	4.0	30.0

Table 12.1-7(f) Occurrences of Ratings for Substructurea22

suba22- number of occurences						
sbmat	**area**	**9**	**8**	**7**	**6**	**5**
1	1	1	149	563	988	789
1	2	1	86	612	1454	1096
1	3	8	327	1338	1803	783
2	1	29	234	286	324	130
2	2	240	1364	1902	1750	805
2	3	76	1046	1379	1052	417
3	1	21	172	119	79	27
3	2	42	466	381	238	92
3	3	18	238	232	90	23
4	1	14	232	228	161	61
4	2	2	82	118	109	44
4	3		15	21	8	3

Tables 12.1-7 Deterioration Rates Calculated Using Program Substructurea2 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-8(a) Substructurea30 Deterioration Rates

suba30- every series counted (9-5>0)							
sbmat	area	9	8	7	6	5	Total Years
1	1	2.1	3.1	4.7	5.9	5.2	21.0
1	2	2.0	3.3	4.3	6.1	4.3	20.0
1	3	2.3	2.9	4.6	5.6	3.4	18.9
2	1	2.8	5.9	5.4	6.0	5.1	25.2
2	2	2.8	6.3	6.1	6.0	5.1	26.2
2	3	2.3	6.7	5.7	5.3	3.8	24.0
3	1	2.9	5.9	5.6	5.0	5.1	24.5
3	2	2.5	7.1	6.4	5.8	4.2	26.1
3	3	2.1	6.7	6.5	5.2	3.1	23.7
4	1	2.7	5.9	5.4	5.9	4.9	24.8
4	2	2.4	7.3	5.8	6.2	5.1	26.9
4	3		6.6	6.3	3.9	4.0	20.8

Table 12.1-8(b) Occurrences of Ratings for Substructurea30

suba30- number of occurences						
sbmat	area	9	8	7	6	5
1	1	7	251	848	1549	1342
1	2	4	222	1091	2442	2080
1	3	34	760	2382	3418	1739
2	1	68	375	441	474	224
2	2	713	2147	3349	3012	1482
2	3	231	1660	2498	2033	903
3	1	57	335	279	331	280
3	2	173	851	860	834	600
3	3	88	437	562	425	193
4	1	42	365	389	309	166
4	2	7	132	218	175	76
4	3		23	32	16	3

Table 12.1-8(c) Substructurea31 Deterioration Rates

suba31- every series counted (9-5>1)							
sbmat	area	9	8	7	6	5	Total Years
1	1	2.6	3.3	5.1	6.4	5.7	23.2
1	2	2.3	4.1	5.0	6.6	4.8	22.9
1	3	3.2	3.6	5.1	6.1	3.9	21.8
2	1	3.7	6.7	6.5	6.7	5.9	29.6
2	2	3.6	7.3	7.4	7.0	5.9	31.2
2	3	3.1	7.4	6.7	6.0	4.5	27.7
3	1	3.4	6.9	6.6	7.0	7.2	31.2
3	2	3.0	8.1	7.4	7.7	6.1	32.4
3	3	3.2	7.4	7.5	6.5	5.0	29.7
4	1	3.4	6.5	6.7	6.9	6.7	30.3
4	2	2.4	8.7	7.2	7.5	6.1	31.9
4	3		6.6	6.9	4.3	4.0	21.7

Table 12.1-8(d) Occurrences of Ratings for Substructurea31

suba31- number of occurences						
sbmat	area	9	8	7	6	5
1	1	5	230	758	1397	1185
1	2	3	162	898	2192	1824
1	3	20	579	2084	3098	1446
2	1	47	318	353	411	187
2	2	494	1800	2672	2509	1233
2	3	146	1492	2083	1752	727
3	1	45	275	231	224	183
3	2	131	733	730	604	370
3	3	43	388	475	326	103
4	1	29	321	304	255	114
4	2	7	108	168	141	62
4	3		23	29	14	3

Table 12.1-8(e) Substructurea32 Deterioration Rates

suba32- every series counted (9-5>2)							
sbmat	area	9	8	7	6	5	Total Years
1	1	5.0	4.0	6.2	7.5	6.9	29.6
1	2	3.0	6.0	6.3	7.9	6.1	29.3
1	3	3.9	4.9	6.4	7.3	5.3	27.8
2	1	4.4	8.2	7.4	7.6	7.0	34.7
2	2	4.7	8.5	8.6	8.0	7.1	36.9
2	3	3.9	8.7	8.1	7.3	6.0	34.0
3	1	4.0	8.3	7.5	7.9	8.1	35.9
3	2	3.9	9.2	8.5	8.8	7.3	37.7
3	3	4.1	8.9	8.9	7.9	6.5	36.3
4	1	4.6	7.5	7.6	7.7	7.6	35.1
4	2	3.5	10.5	8.6	8.7	6.8	38.1
4	3		8.2	7.1	5.2	4.0	24.4

Table 12.1-8(f) Occurrences of Ratings for Substructurea32

suba32- number of occurences						
sbmat	area	9	8	7	6	5
1	1	1	146	570	1122	903
1	2	1	86	628	1722	1250
1	3	12	315	1488	2405	819
2	1	32	244	296	349	145
2	2	293	1469	2175	2071	943
2	3	87	1191	1609	1319	455
3	1	32	213	193	187	158
3	2	71	622	604	509	288
3	3	25	304	381	250	68
4	1	16	263	255	220	94
4	2	2	85	134	116	52
4	3		17	28	10	3

Tables 12.1-8 Deterioration Rates Calculated Using Program Substructurea3 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-9(a) Superstructurea00 Deterioration Rates

supa00- see beginning and end must drop (9-5>0)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	3.0	4.5	4.8	5.4	6.2	23.9
1	1	2	2.1	4.6	4.7	4.9	3.5	19.8
2	2	1	2.0	3.3	5.5	5.4	5.5	21.7
2	2	2	1.3	3.8	4.3	6.6	3.5	19.6
2	3	1	4.3	5.4	5.4	6.5	4.3	26.0
2	3	2	3.0	8.3	6.1	5.6	4.3	27.3
3	4	1		2.0	4.0	4.3	3.0	13.3
3	4	2	3.0	3.0	4.4	5.0	6.6	22.1
3	5	1	2.6	5.5	4.9	5.0	4.1	22.1
3	5	2	2.1	5.2	5.1	5.2	4.0	21.6
4	1	1	3.1	6.3	6.1	6.3	4.4	26.2
4	1	2	2.5	6.7	6.5	6.4	4.1	26.2

Table 12.1-9(b) Occurrences of Ratings for Superstructurea00

supa00- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	2	17	43	65	11
1	1	2	144	295	633	689	232
2	2	1	2	30	33	28	8
2	2	2	3	32	21	22	2
2	3	1	3	114	221	173	95
2	3	2	12	66	68	54	27
3	4	1		1	2	3	2
3	4	2	1	5	17	32	19
3	5	1	395	1126	651	331	97
3	5	2	174	1672	1392	542	138
4	1	1	395	337	182	72	12
4	1	2	486	519	316	145	49

Table 12.1-9(c) Superstructurea01 Deterioration Rates

supa01- see beginning and end must drop (9-5>1)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	5.0	4.5	5.2	5.8	7.3	27.8
1	1	2	2.8	4.9	4.9	5.2	3.7	21.6
2	2	1	2.0	3.4	5.7	6.0	5.5	22.6
2	2	2	2.0	4.3	4.5	7.2	3.5	21.5
2	3	1	4.3	6.2	5.8	6.7	4.7	27.7
2	3	2	3.4	8.8	6.4	6.6	4.8	29.9
3	4	1		2.0	4.0	4.3	3.0	13.3
3	4	2	3.0	3.0	4.6	5.8	6.6	23.0
3	5	1	3.5	5.9	5.2	5.2	4.2	23.9
3	5	2	2.8	5.9	5.5	5.6	4.3	24.0
4	1	1	3.9	6.9	6.3	6.6	4.4	28.2
4	1	2	3.1	7.3	6.8	7.0	4.8	29.0

Table 12.1-9(d) Occurrences of Ratings for Superstructurea01

supa01- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	1	17	39	60	9
1	1	2	93	269	587	638	212
2	2	1	2	29	31	25	8
2	2	2	1	28	20	20	2
2	3	1	3	98	202	165	86
2	3	2	10	62	64	44	24
3	4	1		1	2	3	2
3	4	2	1	5	16	27	19
3	5	1	262	1032	605	319	93
3	5	2	102	1462	1272	497	124
4	1	1	286	304	172	68	12
4	1	2	330	469	300	130	41

Table 12.1-9(e) Superstructurea02 Deterioration Rates

supa02- see beginning and end must drop (9-5>2)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	5.0	5.9	6.8	7.1	8.0	32.8
1	1	2	3.5	6.4	6.3	6.4	5.1	27.8
2	2	1		4.7	6.3	7.5	6.0	24.5
2	2	2		5.5	5.3	7.5	3.5	21.8
2	3	1	4.3	7.5	6.9	7.5	6.4	32.6
2	3	2	4.3	10.4	7.2	7.7	6.1	35.7
3	4	1			6.0	5.5	4.0	15.5
3	4	2	3.0	4.5	5.8	7.1	7.9	28.3
3	5	1	4.6	7.1	6.4	6.4	5.7	30.2
3	5	2	3.7	7.1	6.7	6.8	5.9	30.2
4	1	1	4.7	8.1	7.3	7.6	6.8	34.6
4	1	2	4.1	8.6	7.9	8.0	5.8	34.4

Table 12.1-9(f) Occurrences of Ratings for Superstructurea02

supa02- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	1	11	26	44	8
1	1	2	46	180	404	462	118
2	2	1		15	27	18	7
2	2	2		18	15	19	2
2	3	1	3	74	157	141	53
2	3	2	6	50	54	36	16
3	4	1			1	2	1
3	4	2	1	2	11	20	15
3	5	1	150	785	440	229	56
3	5	2	47	1103	953	365	74
4	1	1	202	246	140	56	6
4	1	2	175	378	245	108	30

Tables 12.1-9 Deterioration Rates Calculated Using Program Superstructurea0 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-10(a) Superstructurea10 Deterioration Rates

supa10- see beginning and end goes up or down (9-5>0)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	3.0	4.5	4.6	4.8	4.1	20.9
1	1	2	2.1	4.5	4.6	4.4	3.1	18.7
2	2	1	2.0	3.5	4.7	4.3	4.0	18.5
2	2	2	1.3	3.8	3.9	5.0	3.1	17.1
2	3	1	4.3	5.4	5.2	5.6	3.7	24.3
2	3	2	3.0	8.3	5.8	5.1	4.1	26.3
3	4	1		2.0	4.0	4.3	3.3	13.5
3	4	2	3.0	3.0	4.3	4.9	5.6	20.9
3	5	1	2.6	5.5	4.2	3.9	3.3	19.5
3	5	2	2.1	5.2	4.5	3.9	3.1	18.8
4	1	1	3.1	6.1	5.0	4.3	3.1	21.7
4	1	2	2.5	6.4	5.4	4.4	2.9	21.5

Table 12.1-10(b) Occurrences of Ratings for Superstructurea10

supa10- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	2	17	48	83	39
1	1	2	144	305	710	1122	657
2	2	1	2	31	44	51	24
2	2	2	3	32	41	36	15
2	3	1	3	114	252	280	205
2	3	2	12	66	79	75	59
3	4	1		1	2	4	4
3	4	2	1	5	18	39	42
3	5	1	395	1151	1338	935	395
3	5	2	174	1682	2212	1908	666
4	1	1	395	386	408	283	140
4	1	2	486	599	651	520	328

Table 12.1-10(c) Superstructurea11 Deterioration Rates

supa11- see beginning and end goes up or down (9-5>1)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	5.0	4.5	5.0	5.2	4.6	24.4
1	1	2	2.8	4.9	4.9	4.8	3.5	20.9
2	2	1	2.0	3.6	5.1	4.9	4.3	19.8
2	2	2	2.0	4.3	4.1	5.9	3.8	20.1
2	3	1	4.3	6.2	5.6	6.0	4.0	26.2
2	3	2	3.4	8.8	6.2	6.0	4.8	29.2
3	4	1		2.0	4.0	4.3	3.3	13.5
3	4	2	3.0	3.0	4.5	5.6	5.8	22.0
3	5	1	3.5	5.9	4.6	4.3	3.7	22.0
3	5	2	2.8	5.9	5.0	4.4	3.6	21.6
4	1	1	3.9	6.8	5.6	5.6	4.8	26.8
4	1	2	3.1	7.3	6.3	6.1	5.1	28.0

Table 12.1-10(d) Occurrences of Ratings for Superstructurea11

supa11- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	1	17	43	74	33
1	1	2	93	271	652	999	550
2	2	1	2	30	40	43	22
2	2	2	1	28	38	29	11
2	3	1	3	98	231	255	182
2	3	2	10	62	73	62	48
3	4	1		1	2	4	4
3	4	2	1	5	17	33	40
3	5	1	262	1045	1189	827	329
3	5	2	102	1464	1942	1651	528
4	1	1	286	336	359	203	78
4	1	2	330	511	543	343	153

Table 12.1-10(e) Superstructurea12 Deterioration Rates

supa12- see beginning and end goes up or down (9-5>2)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	5.0	5.9	6.4	6.9	6.1	30.3
1	1	2	3.5	6.4	6.3	6.2	5.0	27.4
2	2	1		5.1	5.8	6.6	5.1	22.6
2	2	2		5.5	5.0	7.2	4.5	22.1
2	3	1	4.3	7.5	6.8	7.2	5.7	31.5
2	3	2	4.3	10.4	7.2	7.0	6.0	34.9
3	4	1			6.0	5.0	4.5	15.5
3	4	2	3.0	4.5	5.6	6.6	6.9	26.6
3	5	1	4.6	7.1	6.0	5.7	5.1	28.5
3	5	2	3.7	7.1	6.4	6.1	5.4	28.7
4	1	1	4.7	8.1	6.9	7.2	6.3	33.3
4	1	2	4.1	8.7	7.6	7.7	6.7	34.9

Table 12.1-10(f) Occurrences of Ratings for Superstructurea12

supa12- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	1	11	29	49	21
1	1	2	46	181	442	668	273
2	2	1		16	32	27	16
2	2	2		18	27	22	8
2	3	1	3	74	176	199	100
2	3	2	6	50	59	50	33
3	4	1			1	3	2
3	4	2	1	2	12	26	31
3	5	1	150	793	785	510	183
3	5	2	47	1105	1320	947	254
4	1	1	202	265	262	142	51
4	1	2	175	401	412	250	102

Tables 12.1-10 Deterioration Rates Calculated Using Program Superstructurea1 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-11(a) Superstructurea20 Deterioration Rates

supa20- total rating count for bridge (9-5>0)								
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1	3.0	5.1	6.6	8.8	7.5	31.1
1	1	2	2.1	5.8	7.4	8.3	5.2	28.8
2	2	1	2.0	5.9	8.4	8.6	6.4	31.4
2	2	2	1.3	6.9	7.6	8.2	4.8	28.9
2	3	1		4.7	7.6	9.1	6.4	27.8
2	3	2	1.0	5.1	6.6	6.2	4.5	23.4
3	4	1		2.3	14.7	6.8	4.7	28.4
3	4	2	3.0	3.5	5.0	8.9	7.6	28.0
3	5	1	2.4	10.0	7.7	6.6	5.2	32.0
3	5	2	2.0	8.3	9.1	6.6	3.9	30.0
4	1	1	3.0	8.5	6.7	5.2	2.9	26.3
4	1	2	2.4	8.7	7.7	5.1	2.7	26.6

Table 12.1-11(b) Occurrences of Ratings for Superstructurea20

supa20- number of occurences							
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**
1	1	1	2	30	124	125	71
1	1	2	128	691	1338	1509	962
2	2	1	2	48	85	89	48
2	2	2	3	55	71	56	30
2	3	1		149	522	610	341
2	3	2	1	51	135	192	131
3	4	1		3	3	8	6
3	4	2	1	8	24	60	51
3	5	1	361	2152	2176	1411	573
3	5	2	126	2825	3939	3172	1166
4	1	1	355	947	583	337	142
4	1	2	403	1222	892	591	308

Table 12.1-11(c) Superstructurea21 Deterioration Rates

supa21- total rating count for bridge (9-5>1)								
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1	5.0	5.6	7.4	9.2	8.0	35.3
1	1	2	2.7	6.2	7.7	8.5	5.7	30.9
2	2	1	2.0	6.5	9.2	9.5	6.9	34.1
2	2	2	2.0	7.4	7.9	9.4	6.0	32.7
2	3	1		5.8	8.6	10.1	7.1	31.6
2	3	2		6.4	8.7	8.9	6.8	30.8
3	4	1		2.3	14.7	8.7	5.4	31.1
3	4	2	3.0	3.9	5.5	9.5	8.1	29.9
3	5	1	3.2	10.6	8.4	7.4	6.0	35.6
3	5	2	2.6	9.1	9.8	7.5	5.1	34.1
4	1	1	3.8	9.4	7.5	6.9	5.1	32.8
4	1	2	3.1	9.5	8.7	7.3	5.4	33.9

Table 12.1-11(d) Occurrences of Ratings for Superstructurea21

supa21- number of occurences							
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**
1	1	1	1	27	108	119	66
1	1	2	84	631	1274	1464	857
2	2	1	2	43	77	80	44
2	2	2	1	51	68	48	23
2	3	1		115	449	546	302
2	3	2		39	98	126	79
3	4	1		3	3	6	5
3	4	2	1	7	21	56	48
3	5	1	233	2029	1976	1243	484
3	5	2	75	2555	3630	2744	841
4	1	1	249	840	515	240	66
4	1	2	264	1108	772	389	119

Table 12.1-11(e) Superstructurea22 Deterioration Rates

supa22- total rating count for bridge (9-5>2)								
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**	**Total Years**
1	1	1	5.0	6.6	8.4	10.4	8.2	38.6
1	1	2	3.5	7.4	8.4	9.2	7.0	35.5
2	2	1		8.4	9.8	10.6	7.4	36.2
2	2	2		8.0	8.3	9.9	6.6	32.8
2	3	1		7.7	10.0	10.6	8.2	36.5
2	3	2		8.1	9.7	10.0	8.1	35.8
3	4	1		3.0	14.7	8.7	6.3	32.6
3	4	2	3.0	6.3	5.9	10.0	8.6	33.9
3	5	1	4.3	11.4	9.0	8.4	7.0	40.1
3	5	2	3.6	10.1	10.4	8.6	6.6	39.4
4	1	1	4.6	10.3	8.4	7.8	6.3	37.4
4	1	2	4.2	10.4	9.4	8.4	6.5	38.9

Table 12.1-11(f) Occurrences of Ratings for Superstructurea22

supa22- number of occurences							
spmat	**sptype**	**sys**	**9**	**8**	**7**	**6**	**5**
1	1	1	1	21	92	102	64
1	1	2	41	497	1121	1332	637
2	2	1		30	71	70	40
2	2	2		46	64	45	20
2	3	1		77	375	510	248
2	3	2		28	86	110	62
3	4	1		1	3	6	4
3	4	2	1	3	19	52	44
3	5	1	121	1864	1802	1054	382
3	5	2	28	2228	3355	2291	562
4	1	1	173	751	445	201	48
4	1	2	133	990	698	321	89

Tables 12.1-11 Deterioration Rates Calculated Using Program Superstructurea2 and Number of Occurrences of Ratings Used in the Calculations

Table 12.1-12(a) Superstructurea30 Deterioration Rates

supa30- every series counted (9-5>0)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	3.0	4.5	5.7	6.3	6.0	25.5
1	1	2	2.1	4.9	5.7	5.9	4.0	22.6
2	2	1	2.0	4.9	6.2	6.8	5.3	25.1
2	2	2	1.3	5.6	6.2	6.6	4.2	23.8
2	3	1	4.0	5.1	6.2	6.7	5.1	27.0
2	3	2	2.7	7.5	6.5	5.7	4.1	26.6
3	4	1		2.3	11.0	4.9	3.5	21.7
3	4	2	3.0	3.1	4.3	6.1	5.3	21.7
3	5	1	2.5	8.1	5.2	4.9	4.2	24.8
3	5	2	2.0	7.0	6.5	5.1	3.5	24.1
4	1	1	3.0	7.7	5.6	5.1	3.5	24.9
4	1	2	2.4	8.1	6.7	5.3	3.3	25.8

Table 12.1-12(b) Occurrences of Ratings for Superstructurea30

supa30- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	2	34	144	175	89
1	1	2	132	818	1743	2142	1230
2	2	1	2	62	117	117	60
2	2	2	3	74	91	82	38
2	3	1	2	193	680	865	437
2	3	2	7	108	202	248	173
3	4	1		3	4	11	8
3	4	2	1	9	30	88	74
3	5	1	373	2747	3372	1983	730
3	5	2	150	3618	5888	4390	1424
4	1	1	370	1185	858	491	187
4	1	2	453	1577	1340	844	412

Table 12.1-12(c) Superstructurea31 Deterioration Rates

supa31- every series counted (9-5>1)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	5.0	4.9	6.5	7.4	6.6	30.4
1	1	2	2.7	5.5	6.1	6.4	4.6	25.3
2	2	1	2.0	5.5	7.4	7.8	6.1	28.9
2	2	2	2.0	6.0	6.6	7.5	5.1	27.3
2	3	1	4.0	6.3	7.5	8.0	5.8	31.5
2	3	2	3.4	8.5	7.7	7.6	5.9	33.2
3	4	1		2.3	11.0	6.4	4.3	24.0
3	4	2	3.0	3.4	5.0	7.2	6.1	24.6
3	5	1	3.3	9.0	6.2	5.7	4.9	29.2
3	5	2	2.7	7.9	7.2	5.8	4.5	28.0
4	1	1	3.8	8.8	6.5	6.4	5.1	30.6
4	1	2	3.1	9.1	7.5	6.7	5.4	31.9

Table 12.1-12(d) Occurrences of Ratings for Superstructurea31

supa31- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	1	31	122	145	79
1	1	2	83	711	1583	1953	1028
2	2	1	2	53	95	99	50
2	2	2	1	68	84	70	29
2	3	1	2	151	542	698	373
2	3	2	5	93	165	177	110
3	4	1		3	4	8	6
3	4	2	1	8	25	72	62
3	5	1	241	2429	2682	1634	603
3	5	2	87	3164	5230	3709	1038
4	1	1	261	1020	715	373	115
4	1	2	301	1385	1172	628	216

Table 12.1-12(e) Superstructurea32 Deterioration Rates

supa32- every series counted (9-5>2)								
spmat	sptype	sys	9	8	7	6	5	Total Years
1	1	1	5.0	5.7	7.5	9.3	7.6	35.0
1	1	2	3.5	6.8	7.3	7.6	6.1	31.3
2	2	1		7.3	8.4	9.0	6.7	31.5
2	2	2		7.7	7.4	8.5	6.3	29.9
2	3	1	4.0	8.1	8.9	9.0	7.2	37.1
2	3	2	4.3	10.3	9.1	8.6	7.0	39.4
3	4	1		3.0	14.0	7.0	5.5	29.5
3	4	2	3.0	5.7	5.7	8.4	7.1	29.9
3	5	1	4.5	10.2	7.3	6.8	6.1	35.0
3	5	2	3.6	9.3	8.3	7.2	6.2	34.7
4	1	1	4.7	10.0	7.5	7.5	6.5	36.1
4	1	2	4.2	10.3	8.5	7.9	6.6	37.5

Table 12.1-12(f) Occurrences of Ratings for Superstructurea32

supa32- number of occurences							
spmat	sptype	sys	9	8	7	6	5
1	1	1	1	24	100	108	66
1	1	2	39	520	1228	1516	656
2	2	1		35	80	82	44
2	2	2		48	72	59	21
2	3	1	2	106	430	600	271
2	3	2	3	73	134	149	86
3	4	1		1	3	7	4
3	4	2	1	3	20	58	50
3	5	1	129	2073	2138	1244	424
3	5	2	37	2544	4263	2710	612
4	1	1	178	861	586	300	80
4	1	2	157	1186	993	504	159

Tables 12.1-12 Deterioration Rates Calculated Using Program Substructurea3 and Number of Occurrences of Ratings Used in the Calculations

12.2. Deterioration Rate Programs

12.2-1(a) Decka0 Deterioration Rate Program

```
data test;

*decka00;

infile 'c:\My Documents\Steve Project\decka.txt' pad ;

input co $ 1-2  bridge $ 4-7  year 9-12  rating 14  mat $ 16  yearbuilt 18-21 adt 23-28 ;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\dkresulta.txt';

if mat='8' then dkmat=1;
if  mat='1' or mat='2' or mat='9' or mat='N' then dkmat=2;
if mat='3' or mat='4' or mat='5' or mat='6' or mat='7' then dkmat=3;

Z=0;
retain Z;


if yearbuilt le year then do;


H=9;
retain H;

if first.bridge then count9=0;
if first.bridge then rate9=0;
if first.bridge then avg9=0;
if first.bridge then sum9=0;

if rating=H then count9+1;
if rating=H then sum9+adt;
if rating < H and rate9=H and count9>Z then do;
        avg9=int(sum9/count9);
        if avg9<201 then avg9=0;
        if avg9>200 and avg9<801 then avg9=201;
        if avg9>800 and avg9<2001 then avg9=801;
        if avg9>2000 and avg9<4001 then avg9=2001;
        if avg9>4000 then avg9=4001;
        end;
if rating < H and rate9=H and count9>Z then put co bridge dkmat H count9 avg9;
if rating < H and rate9=H and count9>0 then count9=0;
if rating < H and rate9=H and count9>0 then avg9=0;
if rating < H and rate9=H and count9>0 then sum9=0;

rate9=rating;
retain count9 rate9 sum9;
```

```
I=8;
retain I;
if first.bridge then count8=0 and rate8=0 and avg8=0 and sum8=0;
if first.bridge and rating=I then check8=1;
if first.bridge and rating ne I then check8=0;
if rate8 ne 0 and rating ne I then check8=0;

retain check8;
if check8=0 then
        do;
if rating=I and rate8 ne I then count8+1;
if rating=I and rate8 ne I then sum8+adt;
if rating=I and rate8=I then count8+1;
if rating=I and rate8=I then sum8+adt;
if rating < I and rate8=I and count8>Z then do;
        avg8=int(sum8/count8);
        if avg8<201 then avg8=0;
        if avg8>200 and avg8<801 then avg8=201;
        if avg8>800 and avg8<2001 then avg8=801;
        if avg8>2000 and avg8<4001 then avg8=2001;
        if avg8>4000 then avg8=4001;
        end;
if rating < I and rate8=I and count8>Z then put co bridge dkmat I count8 avg8;
if rating ne I and rate8=I then count8=0;
if rating ne I and rate8=I then avg8=0;
if rating ne I and rate8=I then sum8=0;
end;
rate8=rating;
retain count8 rate8 sum8;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0 and avg7=0 and sum7=0;
if first.bridge and rating=J then check7=1;
if first.bridge and rating ne J then check7=0;
if rate7 ne 0 and rating ne J then check7=0;

retain check7;
if check7=0 then
        do;
if rating=J and rate7 ne J then count7+1;
if rating=J and rate7 ne J then sum7+adt;
if rating=J and rate7=J then count7+1;
if rating=J and rate7=J then sum7+adt;
if rating < J and rate7=J and count7>Z then do;
        avg7=int(sum7/count7);
        if avg7<201 then avg7=0;
        if avg7>200 and avg7<801 then avg7=201;
        if avg7>800 and avg7<2001 then avg7=801;
        if avg7>2000 and avg7<4001 then avg7=2001;
        if avg7>4000 then avg7=4001;
        end;
if rating < J and rate7=J and count7>Z then put co bridge dkmat J count7 avg7;
if rating ne J and rate7=J then count7=0;
```

```
if rating ne J and rate7=J then avg7=0;
if rating ne J and rate7=J then sum7=0;
end;
rate7=rating;
retain count7 rate7 sum7;

K=6;
retain K;
if first.bridge then count6=0 and rate6=0 and avg6=0 and sum6=0;
if first.bridge and rating=K then check6=1;
if first.bridge and rating ne K then check6=0;
if rate6 ne 0 and rating ne K then check6=0;

retain check6;
if check6=0 then
        do;
if rating=K and rate6 ne K then count6+1;
if rating=K and rate6 ne K then sum6+adt;
if rating=K and rate6=K then count6+1;
if rating=K and rate6=K then sum6+adt;
if rating < K and rate6=K and count6>Z then do;
        avg6=int(sum6/count6);
        if avg6<201 then avg6=0;
        if avg6>200 and avg6<801 then avg6=201;
        if avg6>800 and avg6<2001 then avg6=801;
        if avg6>2000 and avg6<4001 then avg6=2001;
        if avg6>4000 then avg6=4001;
        end;
if rating < K and rate6=K and count6>Z then put co bridge dkmat K count6 avg6;
if rating ne K and rate6=K then count6=0;
if rating ne K and rate6=K then avg6=0;
if rating ne K and rate6=K then sum6=0;
end;
rate6=rating;
retain count6 rate6 sum6;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0 and avg5=0 and sum5=0;
if first.bridge and rating=L then check5=1;
if first.bridge and rating ne L then check5=0;
if rate5 ne 0 and rating ne L then check5=0;

retain check5;
if check5=0 then
        do;
if rating=L and rate5 ne L then count5+1;
if rating=L and rate5 ne L then sum5+adt;
if rating=L and rate5=L then count5+1;
if rating=L and rate5=L then sum5+adt;
if rating < L and rate5=L and count5>Z then do;
        avg5=int(sum5/count5);
        if avg5<201 then avg5=0;
        if avg5>200 and avg5<801 then avg5=201;
        if avg5>800 and avg5<2001 then avg5=801;
```

```
        if avg5>2000 and avg5<4001 then avg5=2001;
        if avg5>4000 then avg5=4001;
        end;
if rating < L and rate5=L and count5>Z then put co bridge dkmat L count5 avg5;
if rating ne L and rate5=L then count5=0;
if rating ne L and rate5=L then avg5=0;
if rating ne L and rate5=L then sum5=0;
end;
rate5=rating;
retain count5 rate5 sum5;

end;

run;
```

12.2-1(b) Decka1 Deterioration Rate Program

```
data test;

*decka10;

infile 'c:\My Documents\Steve Project\decka.txt' pad ;

input co $ 1-2  bridge $ 4-7  year 9-12  rating 14  mat $ 16  yearbuilt 18-21 adt 23-28  ;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\dkresulta.txt';

if mat='8' then dkmat=1;
if  mat='1' or mat='2' or mat='9' or mat='N' then dkmat=2;
if mat='3' or mat='4' or mat='5' or mat='6' or mat='7' then dkmat=3;

Z=0;
retain Z;


if yearbuilt le year then do;


H=9;
retain H;

if first.bridge then count9=0;
if first.bridge then rate9=0;
if first.bridge then avg9=0;
if first.bridge then sum9=0;

if rating=H then count9+1;
if rating=H then sum9+adt;
if rating ne H and rate9=H and count9>Z then do;
          avg9=int(sum9/count9);
          if avg9<201 then avg9=0;
          if avg9>200 and avg9<801 then avg9=201;
          if avg9>800 and avg9<2001 then avg9=801;
          if avg9>2000 and avg9<4001 then avg9=2001;
          if avg9>4000 then avg9=4001;
          end;
if rating ne H and rate9=H and count9>Z then put co bridge dkmat H count9 avg9;
if rating ne H and rate9=H and count9>0 then count9=0;
if rating ne H and rate9=H and count9>0 then avg9=0;
if rating ne H and rate9=H and count9>0 then sum9=0;

rate9=rating;
retain count9 rate9 sum9;
```

```
I=8;
retain I;
if first.bridge then count8=0 and rate8=0 and avg8=0 and sum8=0;
if first.bridge and rating=I then check8=1;
if first.bridge and rating ne I then check8=0;
if rate8 ne 0 and rating ne I then check8=0;

retain check8;
if check8=0 then
        do;
if rating=I and rate8 ne I then count8+1;
if rating=I and rate8 ne I then sum8+adt;
if rating=I and rate8=I then count8+1;
if rating=I and rate8=I then sum8+adt;
if rating ne I and rate8=I and count8>Z then do;
        avg8=int(sum8/count8);
        if avg8<201 then avg8=0;
        if avg8>200 and avg8<801 then avg8=201;
        if avg8>800 and avg8<2001 then avg8=801;
        if avg8>2000 and avg8<4001 then avg8=2001;
        if avg8>4000 then avg8=4001;
        end;
if rating ne I and rate8=I and count8>Z then put co bridge dkmat I count8 avg8;
if rating ne I and rate8=I then count8=0;
if rating ne I and rate8=I then avg8=0;
if rating ne I and rate8=I then sum8=0;

end;
rate8=rating;
retain count8 rate8 sum8;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0 and avg7=0 and sum7=0;
if first.bridge and rating=J then check7=1;
if first.bridge and rating ne J then check7=0;
if rate7 ne 0 and rating ne J then check7=0;

retain check7;
if check7=0 then
        do;
if rating=J and rate7 ne J then count7+1;
if rating=J and rate7 ne J then sum7+adt;
if rating=J and rate7=J then count7+1;
if rating=J and rate7=J then sum7+adt;
if rating ne J and rate7=J and count7>Z then do;
        avg7=int(sum7/count7);
        if avg7<201 then avg7=0;
        if avg7>200 and avg7<801 then avg7=201;
        if avg7>800 and avg7<2001 then avg7=801;
        if avg7>2000 and avg7<4001 then avg7=2001;
        if avg7>4000 then avg7=4001;
        end;
if rating ne J and rate7=J and count7>Z then put co bridge dkmat J count7 avg7;
```

```
if rating ne J and rate7=J then count7=0;
if rating ne J and rate7=J then avg7=0;
if rating ne J and rate7=J then sum7=0;

end;
rate7=rating;
retain count7 rate7 sum7;

K=6;
retain K;
if first.bridge then count6=0 and rate6=0 and avg6=0 and sum6=0;
if first.bridge and rating=K then check6=1;
if first.bridge and rating ne K then check6=0;
if rate6 ne 0 and rating ne K then check6=0;

retain check6;
if check6=0 then
        do;
if rating=K and rate6 ne K then count6+1;
if rating=K and rate6 ne K then sum6+adt;
if rating=K and rate6=K then count6+1;
if rating=K and rate6=K then sum6+adt;
if rating ne K and rate6=K and count6>Z then do;
        avg6=int(sum6/count6);
        if avg6<201 then avg6=0;
        if avg6>200 and avg6<801 then avg6=201;
        if avg6>800 and avg6<2001 then avg6=801;
        if avg6>2000 and avg6<4001 then avg6=2001;
        if avg6>4000 then avg6=4001;
        end;
if rating ne K and rate6=K and count6>Z then put co bridge dkmat K count6 avg6;
if rating ne K and rate6=K then count6=0;
if rating ne K and rate6=K then avg6=0;
if rating ne K and rate6=K then sum6=0;

end;
rate6=rating;
retain count6 rate6 sum6;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0 and avg5=0 and sum5=0;
if first.bridge and rating=L then check5=1;
if first.bridge and rating ne L then check5=0;
if rate5 ne 0 and rating ne L then check5=0;

retain check5;
if check5=0 then
        do;
if rating=L and rate5 ne L then count5+1;
if rating=L and rate5 ne L then sum5+adt;
if rating=L and rate5=L then count5+1;
if rating=L and rate5=L then sum5+adt;
if rating ne L and rate5=L and count5>Z then do;
        avg5=int(sum5/count5);
```

```
        if avg5<201 then avg5=0;
        if avg5>200 and avg5<801 then avg5=201;
        if avg5>800 and avg5<2001 then avg5=801;
        if avg5>2000 and avg5<4001 then avg5=2001;
        if avg5>4000 then avg5=4001;
        end;
if rating ne L and rate5=L and count5>Z then put co bridge dkmat L count5 avg5;
if rating ne L and rate5=L then count5=0;
if rating ne L and rate5=L then avg5=0;
if rating ne L and rate5=L then sum5=0;

end;
rate5=rating;
retain count5 rate5 sum5;

end;

run;
```

12.2-1(c) Decka2 Deterioration Rate Program

```
data test;

*decka20;

infile 'c:\My Documents\Steve Project\decka.txt' pad ;

input co $ 1-2  bridge $ 4-7  year 9-12  rating 14  mat $ 16  yearbuilt 18-21 adt 23-28  ;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\dkresulta.txt';

if mat='8' then dkmat=1;
if  mat='1' or mat='2' or mat='9' or mat='N' then dkmat=2;
if mat='3' or mat='4' or mat='5' or mat='6' or mat='7' then dkmat=3;

Z=0;
retain Z;


if yearbuilt le year then do;


H=9;
retain H;

if first.bridge then count9=0;
if first.bridge then rate9=0;
if first.bridge then avg9=0;
if first.bridge then sum9=0;

if rating=H then count9+1;
if rating=H then sum9+adt;

if last.bridge and count9>Z then do;
        avg9=int(sum9/count9);
        if avg9<201 then avg9=0;
        if avg9>200 and avg9<801 then avg9=201;
        if avg9>800 and avg9<2001 then avg9=801;
        if avg9>2000 and avg9<4001 then avg9=2001;
        if avg9>4000 then avg9=4001;
        end;
if last.bridge and count9>Z then put co bridge dkmat H count9 avg9;
if last.bridge  then count9=0;
if last.bridge  then avg9=0;
if last.bridge  then sum9=0;

rate9=rating;
retain count9 rate9 sum9;
```

```
I=8;
retain I;
if first.bridge then count8=0 and rate8=0 and avg8=0 and sum8=0;

if rating=I  then count8+1;
if rating=I  then sum8+adt;

if last.bridge and count8>Z then do;
        avg8=int(sum8/count8);
        if avg8<201 then avg8=0;
        if avg8>200 and avg8<801 then avg8=201;
        if avg8>800 and avg8<2001 then avg8=801;
        if avg8>2000 and avg8<4001 then avg8=2001;
        if avg8>4000 then avg8=4001;
        end;
if last.bridge and count8>Z then put co bridge dkmat I count8 avg8;
if last.bridge then count8=0;
if last.bridge then avg8=0;
if last.bridge then sum8=0;

rate8=rating;
retain count8 rate8 sum8;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0 and avg7=0 and sum7=0;

if rating=J then count7+1;
if rating=J  then sum7+adt;

if last.bridge and count7>Z then do;
        avg7=int(sum7/count7);
        if avg7<201 then avg7=0;
        if avg7>200 and avg7<801 then avg7=201;
        if avg7>800 and avg7<2001 then avg7=801;
        if avg7>2000 and avg7<4001 then avg7=2001;
        if avg7>4000 then avg7=4001;
        end;
if last.bridge and count7>Z then put co bridge dkmat J count7 avg7;
if last.bridge then count7=0;
if last.bridge then avg7=0;
if last.bridge then sum7=0;

rate7=rating;
retain count7 rate7 sum7;

K=6;
retain K;
if first.bridge then count6=0 and rate6=0 and avg6=0 and sum6=0;

if rating=K then count6+1;
if rating=K then sum6+adt;
```

```
if last.bridge and count6>Z then do;
          avg6=int(sum6/count6);
          if avg6<201 then avg6=0;
          if avg6>200 and avg6<801 then avg6=201;
          if avg6>800 and avg6<2001 then avg6=801;
          if avg6>2000 and avg6<4001 then avg6=2001;
          if avg6>4000 then avg6=4001;
          end;
if last.bridge and count6>Z then put co bridge dkmat K count6 avg6;
if last.bridge then count6=0;
if last.bridge then avg6=0;
if last.bridge then sum6=0;

rate6=rating;
retain count6 rate6 sum6;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0 and avg5=0 and sum5=0;

if rating=L then count5+1;
if rating=L then sum5+adt;

if last.bridge and count5>Z then do;
          avg5=int(sum5/count5);
          if avg5<201 then avg5=0;
          if avg5>200 and avg5<801 then avg5=201;
          if avg5>800 and avg5<2001 then avg5=801;
          if avg5>2000 and avg5<4001 then avg5=2001;
          if avg5>4000 then avg5=4001;
          end;
if last.bridge and count5>Z then put co bridge dkmat L count5 avg5;
if last.bridge then count5=0;
if last.bridge then avg5=0;
if last.bridge then sum5=0;

rate5=rating;
retain count5 rate5 sum5;

end;

run;
```

12.2-1(d) Decka3 Deterioration Rate Program

```
data test;

*decka30;

infile 'c:\My Documents\Steve Project\decka.txt' pad ;

input co $ 1-2  bridge $ 4-7  year 9-12  rating 14  mat $ 16  yearbuilt 18-21 adt 23-28   ;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\dkresulta.txt';

if mat='8' then dkmat=1;
if  mat='1' or mat='2' or mat='9' or mat='N' then dkmat=2;
if mat='3' or mat='4' or mat='5' or mat='6' or mat='7' then dkmat=3;

Z=0;
retain Z;


if yearbuilt le year then do;


H=9;
retain H;

if first.bridge then count9=0;
if first.bridge then rate9=0;
if first.bridge then avg9=0;
if first.bridge then sum9=0;

if rating=H then count9+1;
if rating=H then sum9+adt;
if rating ne H and rate9=H and count9>Z then do;
        avg9=int(sum9/count9);
        if avg9<201 then avg9=0;
        if avg9>200 and avg9<801 then avg9=201;
        if avg9>800 and avg9<2001 then avg9=801;
        if avg9>2000 and avg9<4001 then avg9=2001;
        if avg9>4000 then avg9=4001;
        end;
if rating ne H and rate9=H and count9>Z then put co bridge dkmat H count9 avg9;
if rating ne H and rate9=H and count9>0 then count9=0;
if rating ne H and rate9=H and count9>0 then avg9=0;
if rating ne H and rate9=H and count9>0 then sum9=0;
if last.bridge and count9>Z then do;
        avg9=int(sum9/count9);
        if avg9<201 then avg9=0;
        if avg9>200 and avg9<801 then avg9=201;
```

```
            if avg9>800 and avg9<2001 then avg9=801;
            if avg9>2000 and avg9<4001 then avg9=2001;
            if avg9>4000 then avg9=4001;
            end;
if last.bridge and count9>Z then put co bridge dkmat H count9 avg9;
if last.bridge and count9>0 then count9=0;
if last.bridge and count9>0 then avg9=0;
if last.bridge and count9>0 then sum9=0;

rate9=rating;
retain count9 rate9 sum9;


I=8;
retain I;
if first.bridge then count8=0 and rate8=0 and avg8=0 and sum8=0;

if rating=I  then count8+1;
if rating=I  then sum8+adt;

if rating ne I and rate8=I and count8>Z then do;
            avg8=int(sum8/count8);
            if avg8<201 then avg8=0;
            if avg8>200 and avg8<801 then avg8=201;
            if avg8>800 and avg8<2001 then avg8=801;
            if avg8>2000 and avg8<4001 then avg8=2001;
            if avg8>4000 then avg8=4001;
            end;
if rating ne I and rate8=I and count8>Z then put co bridge dkmat I count8 avg8;
if rating ne I and rate8=I then count8=0;
if rating ne I and rate8=I then avg8=0;
if rating ne I and rate8=I then sum8=0;
if last.bridge and count8>Z then do;
            avg8=int(sum8/count8);
            if avg8<201 then avg8=0;
            if avg8>200 and avg8<801 then avg8=201;
            if avg8>800 and avg8<2001 then avg8=801;
            if avg8>2000 and avg8<4001 then avg8=2001;
            if avg8>4000 then avg8=4001;
            end;
if last.bridge and count8>Z then put co bridge dkmat I count8 avg8;
if last.bridge and count8>0 then count8=0;
if last.bridge and count8>0 then avg8=0;
if last.bridge and count8>0 then sum8=0;
rate8=rating;
retain count8 rate8 sum8;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0 and avg7=0 and sum7=0;

if rating=J then count7+1;
if rating=J  then sum7+adt;

if rating ne J and rate7=J and count7>Z then do;
```

```
            avg7=int(sum7/count7);
            if avg7<201 then avg7=0;
            if avg7>200 and avg7<801 then avg7=201;
            if avg7>800 and avg7<2001 then avg7=801;
            if avg7>2000 and avg7<4001 then avg7=2001;
            if avg7>4000 then avg7=4001;
            end;
if rating ne J and rate7=J and count7>Z then put co bridge dkmat J count7 avg7;
if rating ne J and rate7=J then count7=0;
if rating ne J and rate7=J then avg7=0;
if rating ne J and rate7=J then sum7=0;
if last.bridge and count7>Z then do;
            avg7=int(sum7/count7);
            if avg7<201 then avg7=0;
            if avg7>200 and avg7<801 then avg7=201;
            if avg7>800 and avg7<2001 then avg7=801;
            if avg7>2000 and avg7<4001 then avg7=2001;
            if avg7>4000 then avg7=4001;
            end;
if last.bridge and count7>Z then put co bridge dkmat J count7 avg7;
if last.bridge and count7>0 then count7=0;
if last.bridge and count7>0 then avg7=0;
if last.bridge and count7>0 then sum7=0;
rate7=rating;
retain count7 rate7 sum7;

K=6;
retain K;
if first.bridge then count6=0 and rate6=0 and avg6=0 and sum6=0;

if rating=K then count6+1;
if rating=K then sum6+adt;

if rating ne K and rate6=K and count6>Z then do;
            avg6=int(sum6/count6);
            if avg6<201 then avg6=0;
            if avg6>200 and avg6<801 then avg6=201;
            if avg6>800 and avg6<2001 then avg6=801;
            if avg6>2000 and avg6<4001 then avg6=2001;
            if avg6>4000 then avg6=4001;
            end;
if rating ne K and rate6=K and count6>Z then put co bridge dkmat K count6 avg6;
if rating ne K and rate6=K then count6=0;
if rating ne K and rate6=K then avg6=0;
if rating ne K and rate6=K then sum6=0;
if last.bridge and count6>Z then do;
            avg6=int(sum6/count6);
            if avg6<201 then avg6=0;
            if avg6>200 and avg6<801 then avg6=201;
            if avg6>800 and avg6<2001 then avg6=801;
            if avg6>2000 and avg6<4001 then avg6=2001;
            if avg6>4000 then avg6=4001;
            end;
if last.bridge and count6>Z then put co bridge dkmat K count6 avg6;
if last.bridge and count6>0 then count6=0;
if last.bridge and count6>0 then avg6=0;
```

```
if last.bridge and count6>0 then sum6=0;
rate6=rating;
retain count6 rate6 sum6;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0 and avg5=0 and sum5=0;

if rating=L then count5+1;
if rating=L then sum5+adt;

if rating ne L and rate5=L and count5>Z then do;
        avg5=int(sum5/count5);
        if avg5<201 then avg5=0;
        if avg5>200 and avg5<801 then avg5=201;
        if avg5>800 and avg5<2001 then avg5=801;
        if avg5>2000 and avg5<4001 then avg5=2001;
        if avg5>4000 then avg5=4001;
        end;
if rating ne L and rate5=L and count5>Z then put co bridge dkmat L count5 avg5;
if rating ne L and rate5=L then count5=0;
if rating ne L and rate5=L then avg5=0;
if rating ne L and rate5=L then sum5=0;
if last.bridge and count5>Z then do;
        avg5=int(sum5/count5);
        if avg5<201 then avg5=0;
        if avg5>200 and avg5<801 then avg5=201;
        if avg5>800 and avg5<2001 then avg5=801;
        if avg5>2000 and avg5<4001 then avg5=2001;
        if avg5>4000 then avg5=4001;
        end;
if last.bridge and count5>Z then put co bridge dkmat L count5 avg5;
if last.bridge and count5>0 then count5=0;
if last.bridge and count5>0 then avg5=0;
if last.bridge and count5>0 then sum5=0;
rate5=rating;
retain count5 rate5 sum5;

end;

run;
```

12.2-2(a) Superstructurea0 Deterioration Rate Program

```
data test;

*supa00;

infile 'c:\My Documents\Steve Project\superstructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 system $ 9 supmat 11  rating 13 year 15-18 yearbuilt 20-23 type 25-26;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\supresulta.txt';

if supmat=7 then spmat=1;
if supmat=1 or supmat=2 or supmat=8 then spmat=2;
if supmat=3 or supmat=4 or supmat=9 or supmat=0 then spmat=3;
if supmat=5 or supmat=6 then spmat=4;

if system='U' or system='I' or system='P' then sys=1;
if system='S' then sys=2;

if type=1 or type=2 then sptype=2;
if type=3 or type=5 or type=6 or type=7 then sptype=5;
if type=4 then sptype=3;
if type=8 or type=14 then sptype=1;
if type=9 or type=10 then sptype=4;

if spmat=1 then sptype=1;
if spmat=2 and type ne 1 then sptype=3;
if spmat=3 and type ne 9 and type ne 10 then sptype=5;
if spmat=4 then sptype=1;

Z=0;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;
if rating=H then count9+1;
if rating ne H and rate9=H and count9>Z then put spmat sptype sys H count9;
if last.bridge and count9>Z then put spmat sptype sys H count9;
if rating ne H then count9=0;
rate9=rating;
retain count9 rate9;


I=8;
```

```
retain I;
if first.bridge then count8=0 and rate8=0;
if first.bridge and rating=I then check8=1;
if first.bridge and rating ne I then check8=0;
if rate8 ne 0 and rating ne I then check8=0;

retain check8;
if check8=0 then
        do;
if rating=I and rate8 ne I then count8+1;
if rating=I and rate8=I then count8+1;
if rating < I and rate8=I and count8>Z then put spmat sptype sys I count8;
if rating < I and rate8=I then count8=0;
if rating > I and rate8=I then count8=0;

end;

rate8=rating;
retain count8 rate8 ;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0;
if first.bridge and rating=J then check7=1;
if first.bridge and rating ne J then check7=0;
if rate7 ne 0 and rating ne J then check7=0;

retain check7;
if check7=0 then
        do;
if rating=J and rate7 ne J then count7+1;
if rating=J and rate7=J then count7+1;
if rating < J and rate7=J and count7>Z then put spmat sptype sys J count7;
if rating < J and rate7=J then count7=0;
if rating > J and rate7=J then count7=0;

end;

rate7=rating;
retain count7 rate7 ;


K=6;
retain K;
if first.bridge then count6=0 and rate6=0;
if first.bridge and rating=K then check6=1;
if first.bridge and rating ne K then check6=0;
if rate6 ne 0 and rating ne K then check6=0;

retain check6;
if check6=0 then
        do;
if rating=K and rate6 ne K then count6+1;
if rating=K and rate6=K then count6+1;
if rating < K and rate6=K and count6>Z then put spmat sptype sys K count6;
```

```
if rating < K and rate6=K then count6=0;
if rating > K and rate6=K then count6=0;

end;

rate6=rating;
retain count6 rate6 ;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0;
if first.bridge and rating=L then check5=1;
if first.bridge and rating ne L then check5=0;
if rate5 ne 0 and rating ne L then check5=0;

retain check5;
if check5=0 then
        do;
if rating=L and rate5 ne L then count5+1;
if rating=L and rate5=L then count5+1;
if rating < L and rate5=L and count5>Z then put spmat sptype sys L count5;
if rating < L and rate5=L then count5=0;
if rating > L and rate5=L then count5=0;

end;

rate5=rating;
retain count5 rate5 ;

end;

run;
```

12.2-2(b) Superstructurea1 Deterioration Rate Program

```
data test;

*supa10;

infile 'c:\My Documents\Steve Project\superstructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 system $ 9 supmat 11 rating 13 year 15-18 yearbuilt 20-23 type 25-26 ;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\supresulta.txt';

if supmat=7 then spmat=1;
if supmat=1 or supmat=2 or supmat=8 then spmat=2;
if supmat=3 or supmat=4 or supmat=9 or supmat=0 then spmat=3;
if supmat=5 or supmat=6 then spmat=4;

if system='U' or system='I' or system='P' then sys=1;
if system='S' then sys=2;

if type=1 or type=2 then sptype=2;
if type=3 or type=5 or type=6 or type=7 then sptype=5;
if type=4 then sptype=3;
if type=8 or type=14 then sptype=1;
if type=9 or type=10 then sptype=4;

if spmat=1 then sptype=1;
if spmat=2 and type ne 1 then sptype=3;
if spmat=3 and type ne 9 and type ne 10 then sptype=5;
if spmat=4 then sptype=1;

Z=0;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;
if rating=H then count9+1;
if rating ne H and rate9=H and count9>Z then put spmat sptype sys H count9;
if last.bridge and count9>Z then put spmat sptype sys H count9;
if rating ne H then count9=0;
rate9=rating;
retain count9 rate9;


I=8;
```

```
retain I;
if first.bridge then count8=0 and rate8=0;
if first.bridge and rating=I then check8=1;
if first.bridge and rating ne I then check8=0;
if rate8 ne 0 and rating ne I then check8=0;

retain check8;
if check8=0 then
        do;
if rating=I and rate8 ne I then count8+1;
if rating=I and rate8=I then count8+1;
if rating ne I and rate8=I and count8>Z then put spmat sptype sys I count8;
if rating ne I and rate8=I then count8=0;


end;

rate8=rating;
retain count8 rate8 ;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0;
if first.bridge and rating=J then check7=1;
if first.bridge and rating ne J then check7=0;
if rate7 ne 0 and rating ne J then check7=0;

retain check7;
if check7=0 then
        do;
if rating=J and rate7 ne J then count7+1;
if rating=J and rate7=J then count7+1;
if rating ne J and rate7=J and count7>Z then put spmat sptype sys J count7;
if rating ne J and rate7=J then count7=0;


end;

rate7=rating;
retain count7 rate7 ;


K=6;
retain K;
if first.bridge then count6=0 and rate6=0;
if first.bridge and rating=K then check6=1;
if first.bridge and rating ne K then check6=0;
if rate6 ne 0 and rating ne K then check6=0;

retain check6;
if check6=0 then
        do;
if rating=K and rate6 ne K then count6+1;
if rating=K and rate6=K then count6+1;
if rating ne K and rate6=K and count6>Z then put spmat sptype sys K count6;
```

```
if rating ne K and rate6=K then count6=0;


end;

rate6=rating;
retain count6 rate6 ;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0;
if first.bridge and rating=L then check5=1;
if first.bridge and rating ne L then check5=0;
if rate5 ne 0 and rating ne L then check5=0;

retain check5;
if check5=0 then
        do;
if rating=L and rate5 ne L then count5+1;
if rating=L and rate5=L then count5+1;
if rating ne L and rate5=L and count5>Z then put spmat sptype sys L count5;
if rating ne L and rate5=L then count5=0;


end;

rate5=rating;
retain count5 rate5 ;

end;

run;
```

12.2-2(c) Superstucturea2 Deterioration Rate Program

```
data test;

*supa20;

infile 'c:\My Documents\Steve Project\superstructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 system $ 9 supmat 11  rating 13 year 15-18 yearbuilt 20-23 type 25-26;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\supresulta.txt';

if supmat=7 then spmat=1;
if supmat=1 or supmat=2 or supmat=8 then spmat=2;
if supmat=3 or supmat=4 or supmat=9 or supmat=0 then spmat=3;
if supmat=5 or supmat=6 then spmat=4;

if system='U' or system='I' or system='P' then sys=1;
if system='S' then sys=2;

if type=1 or type=2 then sptype=2;
if type=3 or type=5 or type=6 or type=7 then sptype=5;
if type=4 then sptype=3;
if type=8 or type=14 then sptype=1;
if type=9 or type=10 then sptype=4;

if spmat=1 then sptype=1;
if spmat=2 and type ne 1 then sptype=3;
if spmat=3 and type ne 9 and type ne 10 then sptype=5;
if spmat=4 then sptype=1;

Z=0;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;
if rating=H then count9+1;


if last.bridge and count9>Z then put spmat sptype sys H count9;
if last.bridge then count9=0;

retain count9 ;

I=8;
```

```
retain I;
if first.bridge then count8=0;
if first.bridge then rate8=0;
if rating=I then count8+1;

if last.bridge and count8>Z then put spmat sptype sys I count8;
if last.bridge then count8=0;

retain count8 ;

J=7;
retain J;
if first.bridge then count7=0;
if first.bridge then rate7=0;
if rating=J then count7+1;

if last.bridge and count7>Z then put spmat sptype sys J count7;
if last.bridge then count7=0;

retain count7 ;

K=6;
retain K;
if first.bridge then count6=0;
if first.bridge then rate6=0;
if rating=K then count6+1;

if last.bridge and count6>Z then put spmat sptype sys K count6;
if last.bridge then count6=0;

retain count6 ;

L=5;
retain L;
if first.bridge then count5=0;
if first.bridge then rate5=0;
if rating=L then count5+1;

if last.bridge and count5>Z then put spmat sptype sys L count5;
if last.bridge then count5=0;

retain count5 ;

end;

run;
```

12.2-2(d) Superstucturea3 Deterioration Rate Program

```
data test;

*supa30;

infile 'c:\My Documents\Steve Project\superstructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 system $ 9 supmat 11  rating 13 year 15-18 yearbuilt 20-23 type 25-26;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\supresulta.txt';

if supmat=7 then spmat=1;
if supmat=1 or supmat=2 or supmat=8 then spmat=2;
if supmat=3 or supmat=4 or supmat=9 or supmat=0 then spmat=3;
if supmat=5 or supmat=6 then spmat=4;

if system='U' or system='I' or system='P' then sys=1;
if system='S' then sys=2;

if type=1 or type=2 then sptype=2;
if type=3 or type=5 or type=6 or type=7 then sptype=5;
if type=4 then sptype=3;
if type=8 or type=14 then sptype=1;
if type=9 or type=10 then sptype=4;

if spmat=1 then sptype=1;
if spmat=2 and type ne 1 then sptype=3;
if spmat=3 and type ne 9 and type ne 10 then sptype=5;
if spmat=4 then sptype=1;

Z=0;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;
if rating=H then count9+1;
if rating ne H and rate9=H and count9>Z then put spmat sptype sys H count9;
if rating ne H and rate9=H and count9>0 then count9=0;
if last.bridge and count9>Z then put spmat sptype sys H count9;
if rating ne H then count9=0;
rate9=rating;
retain count9 rate9;

I=8;
```

```
retain I;
if first.bridge then count8=0;
if first.bridge then rate8=0;
if rating=I then count8+1;
if rating ne I and rate8=I and count8>Z then put spmat sptype sys I count8;
if rating ne I and rate8=I and count8>0 then count8=0;
if last.bridge and count8>Z then put spmat sptype sys I count8;
if rating ne I then count8=0;
rate8=rating;
retain count8 rate8;

J=7;
retain J;
if first.bridge then count7=0;
if first.bridge then rate7=0;
if rating=J then count7+1;
if rating ne J and rate7=J and count7>Z then put spmat sptype sys J count7;
if rating ne J and rate7=J and count7>0 then count7=0;
if last.bridge and count7>Z then put spmat sptype sys J count7;
if rating ne J then count7=0;
rate7=rating;
retain count7 rate7;

K=6;
retain K;
if first.bridge then count6=0;
if first.bridge then rate6=0;
if rating=K then count6+1;
if rating ne K and rate6=K and count6>Z then put spmat sptype sys K count6;
if rating ne K and rate6=K and count6>0 then count6=0;
if last.bridge and count6>Z then put spmat sptype sys K count6;
if rating ne K then count6=0;
rate6=rating;
retain count6 rate6;

L=5;
retain L;
if first.bridge then count5=0;
if first.bridge then rate5=0;
if rating=L then count5+1;
if rating ne L and rate5=L and count5>Z then put spmat sptype sys L count5;
if rating ne L and rate5=L and count5>0 then count5=0;
if last.bridge and count5>Z then put spmat sptype sys L count5;
if rating ne L then count5=0;
rate5=rating;
retain count5 rate5;

end;

run;
```

12.2-3(a) Substructurea0 Deterioration Rate Program

```
data test;

*suba00;

infile 'c:\My Documents\Steve Project\substructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 area 9 sbmat 11 rating 13 year 15-18 yearbuilt 20-23;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\subresulta.txt';

if sbmat=7 then submat=1;
if sbmat=1 or sbmat=2 or sbmat=8 then submat=2;
if sbmat=3 or sbmat=4 or sbmat=9 or sbmat=0 then submat=3;
if sbmat=5 or sbmat=6 then submat=4;

Z=0;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;
if rating=H then count9+1;
if rating < H and rate9=H and count9>Z then put submat area H count9;
if rating ne H then count9=0;
rate9=rating;
retain count9 rate9;


I=8;
retain I;
if first.bridge then count8=0 and rate8=0;
if first.bridge and rating=I then check8=1;
if first.bridge and rating ne I then check8=0;
if rate8 ne 0 and rating ne I then check8=0;

retain check8;
if check8=0 then
        do;
if rating=I and rate8 ne I then count8+1;
if rating=I and rate8=I then count8+1;
if rating < I and rate8=I and count8>Z then put submat area I count8;
if rating ne I and rate8=I then count8=0;
```

```
end;

rate8=rating;
retain count8 rate8 ;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0;
if first.bridge and rating=J then check7=1;
if first.bridge and rating ne J then check7=0;
if rate7 ne 0 and rating ne J then check7=0;

retain check7;
if check7=0 then
        do;
if rating=J and rate7 ne J then count7+1;
if rating=J and rate7=J then count7+1;
if rating < J and rate7=J and count7>Z then put submat area J count7;
if rating ne J and rate7=J then count7=0;

end;

rate7=rating;
retain count7 rate7 ;


K=6;
retain K;
if first.bridge then count6=0 and rate6=0;
if first.bridge and rating=K then check6=1;
if first.bridge and rating ne K then check6=0;
if rate6 ne 0 and rating ne K then check6=0;

retain check6;
if check6=0 then
        do;
if rating=K and rate6 ne K then count6+1;
if rating=K and rate6=K then count6+1;
if rating < K and rate6=K and count6>Z then put submat area K count6;
if rating ne K and rate6=K then count6=0;

end;

rate6=rating;
retain count6 rate6 ;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0;
if first.bridge and rating=L then check5=1;
if first.bridge and rating ne L then check5=0;
if rate5 ne 0 and rating ne L then check5=0;

retain check5;
```

```
if check5=0 then
        do;
if rating=L and rate5 ne L then count5+1;
if rating=L and rate5=L then count5+1;
if rating < L and rate5=L and count5>Z then put submat area L count5;
if rating ne L and rate5=L then count5=0;

end;

rate5=rating;
retain count5 rate5 ;

end;

run;
```

12.2-3(b) Substructurea1 Deterioration Rate Program

```
data test;

*suba10;

infile 'c:\My Documents\Steve Project\substructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 area 9 sbmat 11 rating 13 year 15-18 yearbuilt 20-23;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\subresulta.txt';

if sbmat=7 then submat=1;
if sbmat=1 or sbmat=2 or sbmat=8 then submat=2;
if sbmat=3 or sbmat=4 or sbmat=9 or sbmat=0 then submat=3;
if sbmat=5 or sbmat=6 then submat=4;

Z=2;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;

if rating=H then count9+1;
if rating ne H and rate9=H and count9>Z then put submat area H count9 ;
if rating ne H  then count9=0;
rate9=rating;
retain count9 rate9;


I=8;
retain I;
if first.bridge then count8=0 and rate8=0;
if first.bridge and rating=I then check8=1;
if first.bridge and rating ne I then check8=0;
if rate8 ne 0 and rating ne I then check8=0;

retain check8;
if check8=0 then
      do;
if rating=I and rate8 ne I then count8+1;
if rating=I and rate8=I then count8+1;
if rating ne I and rate8=I and count8>Z then put submat area I count8;
if rating ne I then count8=0;
```

```
end;

rate8=rating;
retain count8 rate8 ;


J=7;
retain J;
if first.bridge then count7=0 and rate7=0;
if first.bridge and rating=J then check7=1;
if first.bridge and rating ne J then check7=0;
if rate7 ne 0 and rating ne J then check7=0;

retain check7;
if check7=0 then
        do;
if rating=J and rate7 ne J then count7+1;
if rating=J and rate7=J then count7+1;
if rating ne J and rate7=J and count7>Z then put submat area J count7;
if rating ne J then count7=0;

end;

rate7=rating;
retain count7 rate7 ;


K=6;
retain K;
if first.bridge then count6=0 and rate6=0;
if first.bridge and rating=K then check6=1;
if first.bridge and rating ne K then check6=0;
if rate6 ne 0 and rating ne K then check6=0;

retain check6;
if check6=0 then
        do;
if rating=K and rate6 ne K then count6+1;
if rating=K and rate6=K then count6+1;
if rating ne K and rate6=K and count6>Z then put submat area K count6;
if rating ne K then count6=0;


end;

rate6=rating;
retain count6 rate6 ;


L=5;
retain L;
if first.bridge then count5=0 and rate5=0;
if first.bridge and rating=L then check5=1;
if first.bridge and rating ne L then check5=0;
if rate5 ne 0 and rating ne L then check5=0;
```

```
retain check5;
if check5=0 then
        do;
if rating=L and rate5 ne L then count5+1;
if rating=L and rate5=L then count5+1;
if rating ne L and rate5=L and count5>Z then put submat area L count5;
if rating ne L then count5=0;

end;

rate5=rating;
retain count5 rate5 ;

end;

run;
```

12.2-3(c) Substructurea2 Deterioration Rate Program

```
data test;

*suba20;

infile 'c:\My Documents\Steve Project\substructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 area 9 sbmat 11 rating 13 year 15-18 yearbuilt 20-23;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\subresulta.txt';

if sbmat=7 then submat=1;
if sbmat=1 or sbmat=2 or sbmat=8 then submat=2;
if sbmat=3 or sbmat=4 or sbmat=9 or sbmat=0 then submat=3;
if sbmat=5 or sbmat=6 then submat=4;

Z=0;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;
if rating=H then count9+1;


if last.bridge and count9>Z then put  submat area H count9;
if last.bridge then count9=0;

retain count9 ;

I=8;
retain I;
if first.bridge then count8=0;
if first.bridge then rate8=0;
if rating=I then count8+1;

if last.bridge and count8>Z then put  submat area I count8;
if last.bridge then count8=0;

retain count8 ;

J=7;
retain J;
if first.bridge then count7=0;
if first.bridge then rate7=0;
```

```
if rating=J then count7+1;

if last.bridge and count7>Z then put  submat area J count7;
if last.bridge then count7=0;

retain count7 ;

K=6;
retain K;
if first.bridge then count6=0;
if first.bridge then rate6=0;
if rating=K then count6+1;

if last.bridge and count6>Z then put  submat area K count6;
if last.bridge then count6=0;

retain count6 ;

L=5;
retain L;
if first.bridge then count5=0;
if first.bridge then rate5=0;
if rating=L then count5+1;

if last.bridge and count5>Z then put  submat area L count5;
if last.bridge then count5=0;

retain count5 ;

end;

run;
```

12.2-3(d) Substructurea3 Deterioration Rate Program

```
data test;

*suba30;

infile 'c:\My Documents\Steve Project\substructurea.txt' pad ;

input co $ 1-2  bridge $ 4-7 area 9 sbmat 11 rating 13 year 15-18 yearbuilt 20-23;
run;
Proc Sort Data=test;
By co bridge;
run;

Data results;
Set test;
By co bridge;
file 'c:\My Documents\Steve Project\subresulta.txt';

if sbmat=7 then submat=1;
if sbmat=1 or sbmat=2 or sbmat=8 then submat=2;
if sbmat=3 or sbmat=4 or sbmat=9 or sbmat=0 then submat=3;
if sbmat=5 or sbmat=6 then submat=4;

Z=0;
retain Z;

if yearbuilt le year then do;

H=9;
retain H;
if first.bridge then count9=0;
if first.bridge then rate9=0;
if rating=H then count9+1;
if rating ne H and rate9=H and count9>Z then put submat area H count9;
if last.bridge and count9>Z then put  submat area H count9;
if rating ne H then count9=0;
rate9=rating;
retain count9 rate9;

I=8;
retain I;
if first.bridge then count8=0;
if first.bridge then rate8=0;
if rating=I then count8+1;
if rating ne I and rate8=I and count8>Z then put  submat area I count8;
if last.bridge and count8>Z then put  submat area I count8;
if rating ne I then count8=0;
rate8=rating;
retain count8 rate8;

J=7;
retain J;
if first.bridge then count7=0;
if first.bridge then rate7=0;
if rating=J then count7+1;
```

```
if rating ne J and rate7=J and count7>Z then put  submat area J count7;
if last.bridge and count7>Z then put  submat area J count7;
if rating ne J then count7=0;
rate7=rating;
retain count7 rate7;

K=6;
retain K;
if first.bridge then count6=0;
if first.bridge then rate6=0;
if rating=K then count6+1;
if rating ne K and rate6=K and count6>Z then put submat area K count6;
if last.bridge and count6>Z then put submat area K count6;
if rating ne K then count6=0;
rate6=rating;
retain count6 rate6;

L=5;
retain L;
if first.bridge then count5=0;
if first.bridge then rate5=0;
if rating=L then count5+1;
if rating ne L and rate5=L and count5>Z then put submat area L count5;
if last.bridge and count5>Z then put submat area L count5;
if rating ne L then count5=0;
rate5=rating;
retain count5 rate5;

end;

run;
```

12.3. Rehabilitation Rates

Table 12.3-1(a) Average Rehabilitation Work for Concrete Decks (man-hours/square foot)

Concrete Deck							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	0.00878818						
8		0.09363641					
7		0.08197877	0.03338764				
6		0.05352967	0.07362404	0.0241725			
5	0.01897983	0.04345656	0.00285714	0.0239375	0.02273396		
4		0.03531807	0.04773893	0.09905386	0.02669795	0.02243699	
3				0.00572843	0.02033599	0.04793325	0.02354673

Table 12.3-1(b) Average Rehabilitation Work for Concrete Decks [Chen and Johnston 1987] (square foot/square foot)

Concrete Deck [Chen and Johnston 1987] (sf/sf)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.005					
7		0.0001	0.345				
6		0.473	0.47	0.311			
5			0.037	0.019	0.03		
4		0.0003	0.002	0.227	0.023	0.179	
3							

Table 12.3-1(c) Occurrences of Function Codes for Work on Concrete Decks

Concrete Deck- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	6						
8		56					
7		9	223				
6		11	24	570			
5	1	4	1	33	565		
4		2	5	12	21	371	
3				1	1	8	86

Table 12.3-1(d) Occurrences of Function Codes for Work on Concrete Decks [Chen and Johnston 1987]

Concrete Deck (Chen) (sf/sf)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		3					
7		1	7				
6		2	4	21			
5			4	5	10		
4		1	2	1	73	6	
3							

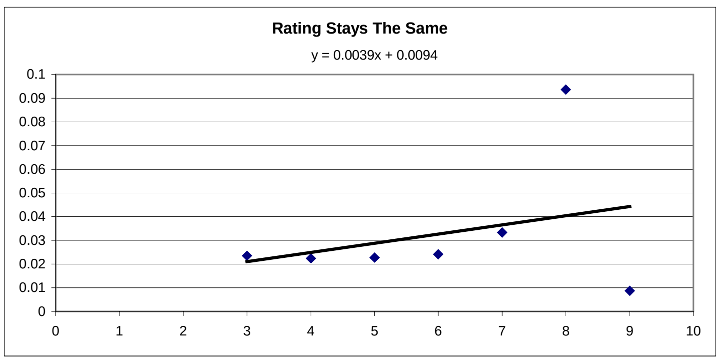

Figure 12.3-1(a) Regression Analysis for Rehabilitation Work for Concrete Decks Which Did not Change the Condition Rating

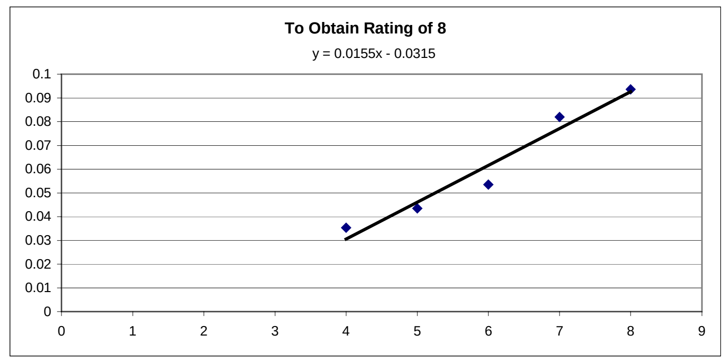

Figure 12.3-1(b) Regression Analysis for Rehabilitation Work for Concrete Decks Which Changed the Condition Rating to 8

Table 12.3-1(e) Average Rehabilitation Work After Regression Analysis for Concrete Decks (man-hours/square foot)

Concrete Deck- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0406					
7		0.0251	0.0367				
6		0.0096	0.0212	0.0328			
5		-0.0059	0.0057	0.0173	0.0289		
4		-0.0214	-0.0098	0.0018	0.0134	0.0250	
3		-0.0369	-0.0253	-0.0137	-0.0021	0.0095	0.0211

Table 12.3-1(f) Average Rehabilitation Work After Regression Analysis for Concrete Decks [Chen and Johnston 1987] (square foot/square foot)

Concrete Deck (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0603					
7		0.1622	0.1109				
6		0.2641	0.2128	0.1615			
5		0.3660	0.3147	0.2634	0.2121		
4		0.4679	0.4166	0.3653	0.3140	0.2627	
3		0.5698	0.5185	0.4672	0.4159	0.3646	0.3313

Tables 12.3-1 and Figures 12.3-1 Rehabilitation Work for Concrete Decks

Table 12.3-2(a) Average Rehabilitation Work for Timber Decks (man-hours/square foot)

Timber Deck							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	0.0679187						
8	0.08828205	0.04712673					
7	0.03114291	0.02851431	0.04493717				
6	0.04939151	0.08916209	0.02614446	0.04344165			
5	0.10338958	0.03531499	0.08541772	0.053579	0.05243066		
4	0.04496933	0.09838803		0.05163549	0.04449924	0.05273191	
3	0.08484848	0.04690002		0.04960317	0.0252809	0.02721629	0.04310158

Table 12.3-2(b) Average Rehabilitation Work for Timber Decks [Chen and Johnston 1987] (man-hours/square foot)

Timber Deck (Chen)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.05					
7		0.263	0.079				
6	0.253	0.284	0.176	0.116			
5	1.342	0.276	0.101	0.115	0.145		
4		0.303	0.183	0.056	0.161	0.242	
3		0.311	0.088	0.056			0.063

Table 12.3-2(c) Occurrences of Function Codes for Work on Timber Decks

Timber Deck- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	16						
8	2	114					
7	4	2	126				
6	3	22	9	311			
5	6	30	7	22	287		
4	6	19		4	15	166	
3	1	6		1	1	3	18

Table 12.3-2(d) Occurrences of Function Codes for Work on Timber Decks [Chen and Johnston 1987]

Timber Deck (Chen)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		35					
7		37	102				
6	2	92	17	268			
5	1	97	10	43	181		
4		41	3	5	17	60	
3		8	2	6			4

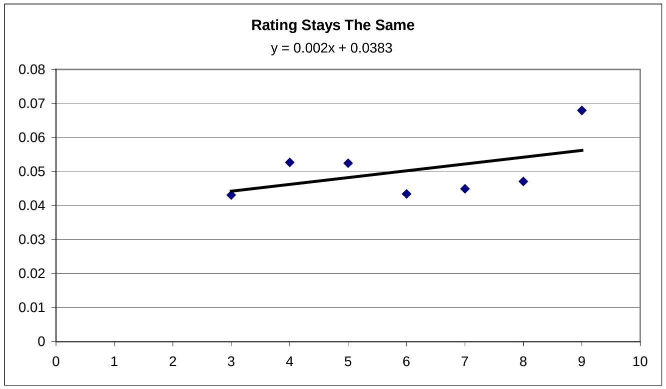

Figure 12.3-2(a) Regression Analysis for Rehabilitation Work for Timber Decks Which Did not Change the Condition Rating

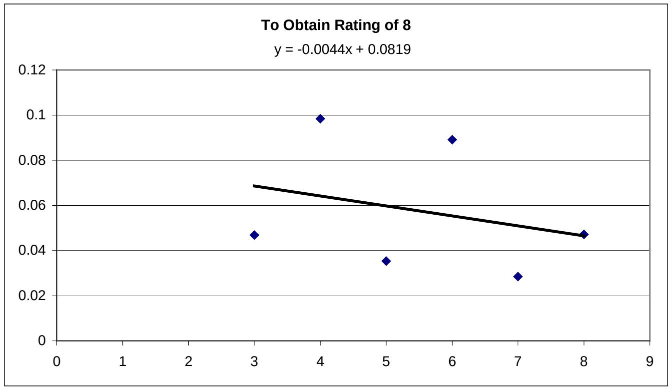

Figure 12.3-2(b) Regression Analysis for Rehabilitation Work for Timber Decks Which Changed the Condition Rating to 8

Table 12.3-2(e) Average Rehabilitation Work After Regression Analysis for Timber Decks (man-hours/square foot)

Timber Deck- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0543					
7		0.0587	0.0523				
6		0.0631	0.0567	0.0503			
5		0.0675	0.0611	0.0547	0.0483		
4		0.0719	0.0655	0.0591	0.0527	0.0463	
3		0.0763	0.0699	0.0635	0.0571	0.0507	0.0443

Table 12.3-2(f) Average Rehabilitation Work After Regression Analysis for Timber Decks [Chen and Johnston 1987] (man-hours/square foot)

Timber Deck (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0738					
7		0.1143	0.0905				
6		0.1548	0.1310	0.1072			
5		0.1953	0.1715	0.1477	0.1239		
4		0.2358	0.2120	0.1882	0.1644	0.1406	
3		0.2763	0.2525	0.2287	0.2049	0.1811	0.1573

Tables 12.3-2 and Figures 12.3-2 Rehabilitation Work for Timber Decks

Table 12.3-3(a) Average Rehabilitation Work for Steel Decks (man-hours/square foot)

Steel Decks							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	0.03604578						
8		0.02153159					
7		0.0257469	0.02441798				
6	0.02490942	0.03526347	0.05964108	0.03349455			
5		0.04003307	0.2265075	0.05255318	0.05091816		
4	0.1361944		0.0314325	0.00933239	0.02534432	0.06238136	
3						0.01132428	0.00398395

Table 12.3-3(b) Average Rehabilitation Work for Steel Decks [Chen and Johnston 1987] (man-hours/square foot)

Steel Decks (Chen)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.018					
7		0.273	0.278				
6		0.349	0.234	0.321			
5		0.294		0.016	0.346		
4		0.48				0.758	
3		0.524					

Table 12.3-3(c) Occurrences of Function Codes for Work on Steel Decks

Steel Decks- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	1						
8		51					
7		3	72				
6	1	3	11	178			
5		3	1	4	66		
4	1		2	3	2	30	
3						2	1

Table 12.3-3(d) Occurrences of Function Codes for Work on Steel Decks [Chen and Johnston 1987]

Steel Decks (Chen)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		2					
7		7	7				
6		17	1	12			
5		7		1	9		
4		6				3	
3		1					

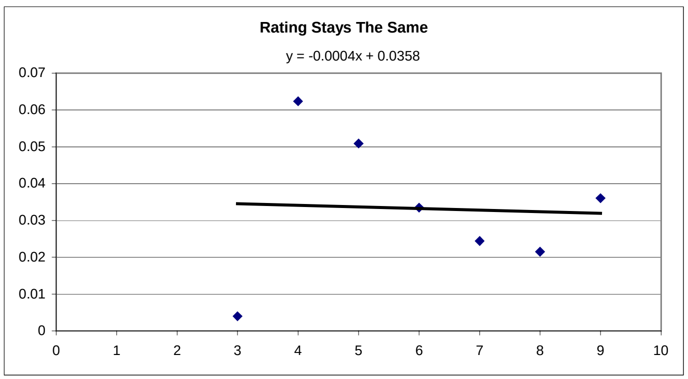

Figure 12.3-3(a) Regression Analysis for Rehabilitation Work for Steel Decks Which Did not Change the Condition Rating

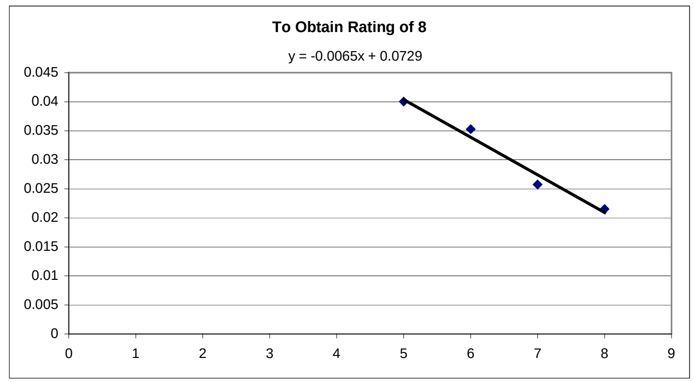

Figure 12.3-3(b) Regression Analysis for Rehabilitation Work for Steel Decks Which Changed the Condition Rating to 8

Table 12.3-3(e) Average Rehabilitation Work After Regression Analysis for Steel Decks (man-hours/square foot)

Steel Decks- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0326					
7		0.0391	0.0330				
6		0.0456	0.0395	0.0334			
5		0.0521	0.0460	0.0399	0.0338		
4		0.0586	0.0525	0.0464	0.0403	0.0342	
3		0.0651	0.0590	0.0529	0.0468	0.0407	0.0346

Table 12.3-3(f) Average Rehabilitation Work After Regression Analysis for Steel Decks [Chen and Johnston 1987] (man-hours/square foot)

Steel Decks (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0603					
7		0.1622	0.1109				
6		0.2641	0.2128	0.1615			
5		0.3660	0.3147	0.2634	0.2121		
4		0.4679	0.4166	0.3653	0.3140	0.2627	
3		0.5698	0.5185	0.4672	0.4159	0.3646	0.3313

Tables 12.3-3 and Figures 12.3-3 Rehabilitation Work for Steel Decks

Table 12.3-4(a) Average Rehabilitation Work for Timber Superstructures (man-hours/square foot)

Timber Superstructure							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	0.38030395						
8		0.24203565					
7	0.07838746		0.07794044				
6	0.34486764	0.15745125	0.11325568	0.10077821			
5	0.34432993	0.06671587	0.11446728	0.0727016	0.09680857		
4	0.29963164	0.08834199	0.05410158	0.16803265	0.08752651	0.0773235	
3		0.01941748	0.03436548		0.10465794	0.10665061	0.08021365

Table 12.3-4(b) Average Rehabilitation Work for Timber Superstructures [Chen and Johnston 1987] (man-hours/square foot)

Timber Superstructure (Chen)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.066					
7		0.191	0.054				
6		0.209	0.045	0.058			
5	0.205	0.269	0.214	0.048	0.072		
4	0.487	0.054	0.056	0.132	0.055		
3	0.227				0.17	0.171	0.154

Table 12.3-4(c) Occurrences of Function Codes for Work on Timber Superstructures

Timber Superstructure- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	42						
8		88					
7	1		91				
6	2	6	9	215			
5	2	3	11	28	264		
4	4	2	1	8	17	122	
3		1	3		7	3	80

Table 12.3-4(d) Occurrences of Function Codes for Work on Timber Superstructures [Chen and Johnston 1987]

Timber Superstructure (Chen)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		15					
7		10	59				
6		19	2	131			
5	1	20	3	17	53		
4	7	1	5	4	28		
3					4	3	6

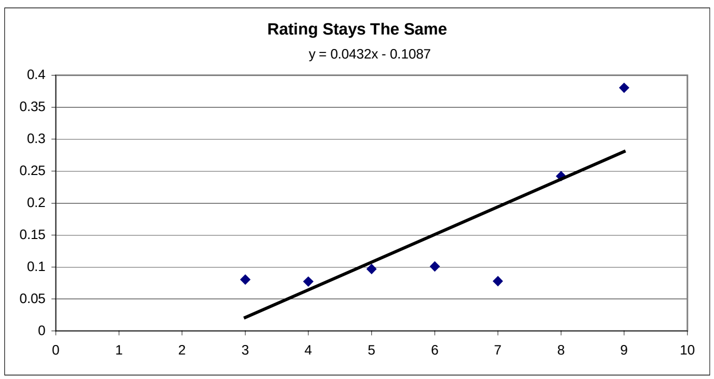

Figure 12.3-4(a) Regression Analysis for Rehabilitation Work for Timber Superstructures Which Did not Change the Condition Rating

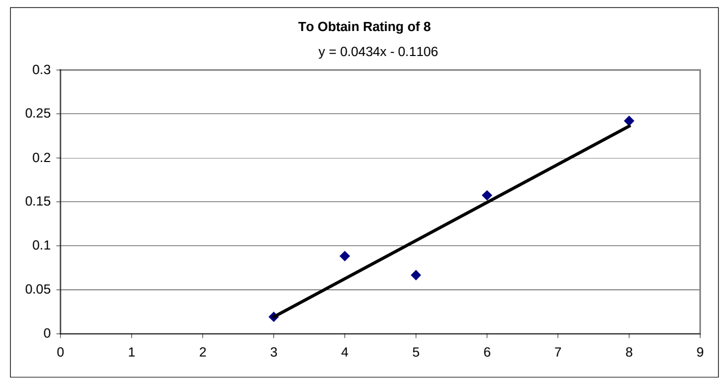

Figure 12.3-4(b) Regression Analysis for Rehabilitation Work forTimber Superstructures Which Changed the Condition Rating to 8

Table 12.3-4(e) Average Rehabilitation Work After Regression Analysis forTimber Superstructures (man-hours/square foot)

Timber Superstructure- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.2369					
7		0.1935	0.1937				
6		0.1501	0.1503	0.1505			
5		0.1067	0.1069	0.1071	0.1073		
4		0.0633	0.0635	0.0637	0.0639	0.0641	
3		0.0199	0.0201	0.0203	0.0205	0.0207	0.0209

Table 12.3-4(f) Average Rehabilitation Work After Regression Analysis for Timber Superstructures [Chen and Johnston 1987] (man-hours/square foot)

Timber Superstructure (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0407					
7		0.1034	0.0588				
6		0.1661	0.1215	0.0769			
5		0.2288	0.1842	0.1396	0.0950		
4		0.2915	0.2469	0.2023	0.1577	0.1131	
3		0.3542	0.3096	0.2650	0.2204	0.1758	0.1312

Tables 12.3-4 and Figures 12.3-4 Rehabilitation Work for Timber Superstructures

Table 12.3-5(a) Average Rehabilitation Work for Concrete Superstructures (man-hours/square foot)

Concrete Superstructure							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	0.00408771						
8	0.04298996	0.01174278					
7		0.00403551	0.02702228				
6			0.00341297	0.02885825			
5		0.02142857		0.03477956	0.02739631		
4		0.01036269		0.09917033	0.05236589	0.04565165	
3				0.15032912	0.08840953		0.10085126

Table 12.3-5(b) Average Rehabilitation Work for Concrete Superstructures [Chen and Johnston 1987] (man-hours/square foot)

Concrete Superstructure (Chen)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8							
7		0.677					
6				0.018			
5				0.098	0.034		
4					0.177	0.07	
3							

Table 12.3-5(c) Occurrences of Function Codes for Work on Concrete Superstructures

Concrete Superstructure- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	3						
8	2	32					
7		1	43				
6			1	88			
5		1		6	57		
4		1		3	3	53	
3				1	1		6

Table 12.3-5(d) Occurrences of Function Codes for Work on Concrete Superstructures [Chen and Johnston 1987]

Concrete Superstructure (Chen)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8							
7		1					
6				4			
5				4	4		
4					1	2	
3							

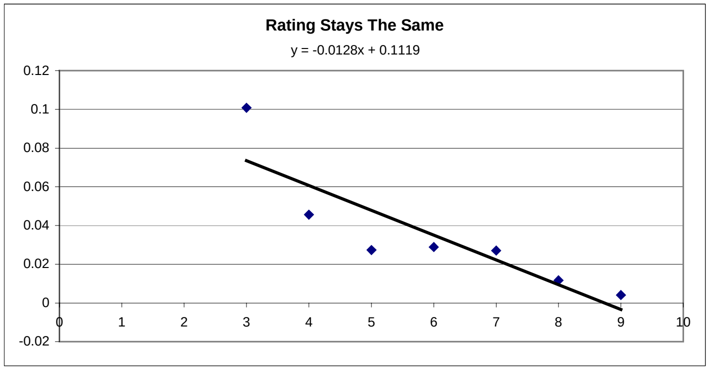

Figure 12.3-5(a) Regression Analysis for Rehabilitation Work for Concrete Superstructures Which Did not Change the Condition Rating

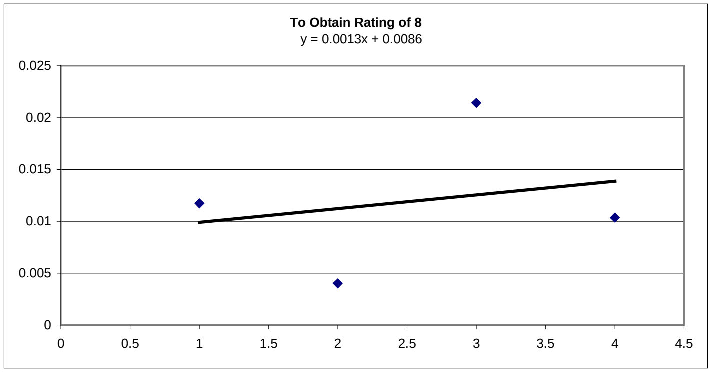

Figure 12.3-5(b) Regression Analysis for Rehabilitation Work for Concrete Superstructures Which Changed the Condition Rating to 8

Table 12.3-5(e) Average Rehabilitation Work After Regression Analysis for Concrete Superstructures (man-hours/square foot)

Concrete Superstructure- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0111					
7		0.0126	0.0237				
6		0.0141	0.0252	0.0363			
5		0.0156	0.0267	0.0378	0.0489		
4		0.0171	0.0282	0.0393	0.0504	0.0615	
3		0.0186	0.0297	0.0408	0.0519	0.0630	0.0741

Table 12.3-5(f) Average Rehabilitation Work After Regression Analysis for Concrete Superstructures [Chen and Johnston 1987] (man-hours/square foot)

Concrete Superstructure (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.2470					
7		0.3355	0.2810				
6		0.4240	0.3695	0.3150			
5		0.5125	0.4580	0.4035	0.3490		
4		0.6010	0.5465	0.4920	0.4375	0.3830	
3		0.6895	0.6350	0.5805	0.5260	0.4715	0.4170

Tables 12.3-5 and Figures 12.3-5 Rehabilitation Work for Concrete Superstructures

Table 12.3-6(a) Average Rehabilitation Work for Steel Superstructures (man-hours/square foot)

Steel Superstructure							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	0.42661941						
8	0.00623053	0.18108215					
7		0.33985918	0.14368302				
6	0.22821281	0.3641772	0.2193245	0.08836221			
5	0.23919753	0.26895488	0.17064929	0.09340629	0.10693561		
4		0.10443702	0.0400841	0.04211417	0.03900413	0.06897671	
3			0.26991304	0.12066692		0.06313716	0.09329441

Table 12.3-6(b) Average Rehabilitation Work for Steel Superstructures [Chen and Johnston 1987] (man-hours/square foot)

Steel Superstructure (Chen)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8							
7							
6			Not Available				
5							
4							
3							

Table 12.3-6(c) Occurrences of Function Codes for Work on Steel Superstructures

Steel Superstructure- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9	5						
8	1	165					
7		28	334				
6	1	17	30	346			
5	1	8	10	11	185		
4		2	3	5	12	136	
3			1	3		2	27

Table 12.3-6(d) Occurrences of Function Codes for Work on Steel Superstructures [Chen and Johnston 1987]

Steel Superstructure (Chen)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8							
7							
6			Not Available				
5							
4							
3							

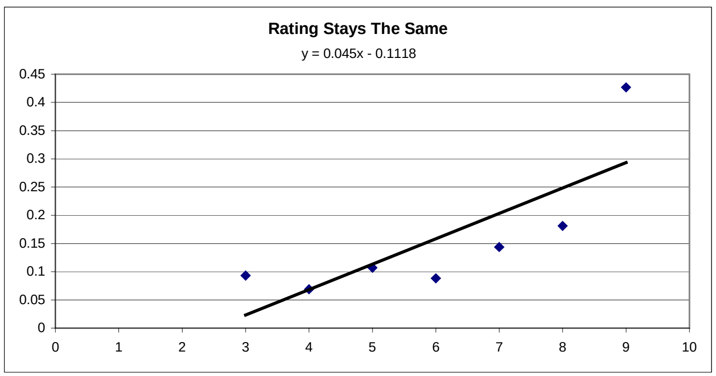

Figure 12.3-6(a) Regression Analysis for Rehabilitation Work for Steel Superstructures Which Did not Change the Condition Rating

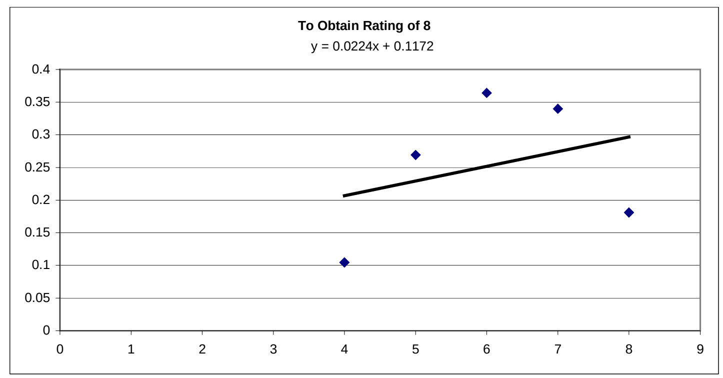

Figure 12.3-6(b) Regression Analysis for Rehabilitation Work for Steel Superstructures Which Changed the Condition Rating to 8

Table 12.3-6(e) Average Rehabilitation Work After Regression Analysis for Steel Superstructures (man-hours/square foot)

Steel Superstructure- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.2482					
7		0.2258	0.2032				
6		0.2034	0.1808	0.1582			
5		0.1810	0.1584	0.1358	0.1132		
4		0.1586	0.1360	0.1134	0.0908	0.0682	
3		0.1362	0.1136	0.0910	0.0684	0.0458	0.0232

Table 12.3-6(f) Average Rehabilitation Work After Regression Analysis for Steel Superstructures [Chen and Johnston 1987] (man-hours/square foot)

Steel Superstructure (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.2470					
7		0.3355	0.2810				
6		0.4240	0.3695	0.3150			
5		0.5125	0.4580	0.4035	0.3490		
4		0.6010	0.5465	0.4920	0.4375	0.3830	
3		0.6895	0.6350	0.5805	0.5260	0.4715	0.4170

Tables 12.3-6 and Figures 12.3-6 Rehabilitation Work for Steel Superstructures

Table 12.3-7(a) Average Rehabilitation Work for Concrete Substructures (man-hours/square foot)

Concrete Substructure								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9	0.02066193							
8		0.14404104						
7		0.16256291	0.14392382					
6		0.34589966	0.11290721	0.11938998				
5		0.25430622	0.22525567	0.08403138	0.08679933			
4		0.0729927	0.6502557	0.16511307	0.13074648	0.08151965		
3		0.00611451		0.07427536	0.0924339	0.05089552	0.08311907	
2		0.202855						0.12591987
1			0.42487267					

Table 12.3-7(b) Average Rehabilitation Work for Concrete Substructures [Chen and Johnston 1987] (man-hours/square foot)

Concrete Substructure (Chen)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.057					
7		0.007	0.056				
6			0.036	0.069			
5			0.008	0.447	0.058		
4		0.217		0.326	0.007	0.117	
3				0.082			0.103

Table 12.3-7(c) Occurrences of Function Codes for Work on Concrete Substructures

Concrete Substructure- number of occurences								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9	3							
8		54						
7		3	130					
6		5	16	330				
5		4	8	39	264			
4		1	3	15	25	153		
3		1		1	4	7	23	
2		1						3
1			1					

Table 12.3-7(d) Occurrences of Function Codes for Work on Concrete Substructures [Chen and Johnston 1987]

Concrete Substructure (Chen)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		2					
7		1	8				
6			2	8			
5			2	1	7		
4		1		2	2	82	
3				9			2

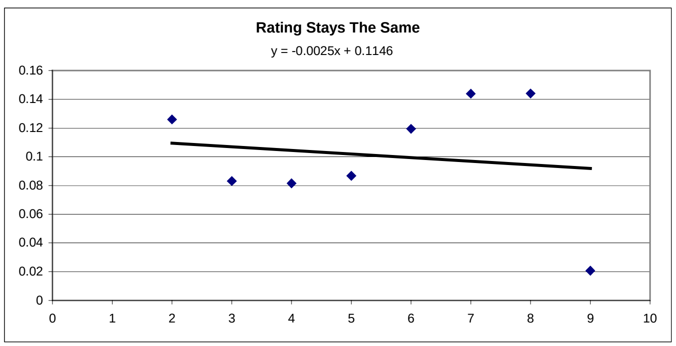

Figure 12.3-7(a) Regression Analysis for Rehabilitation Work for Concrete Substructures Which Did not Change the Condition Rating

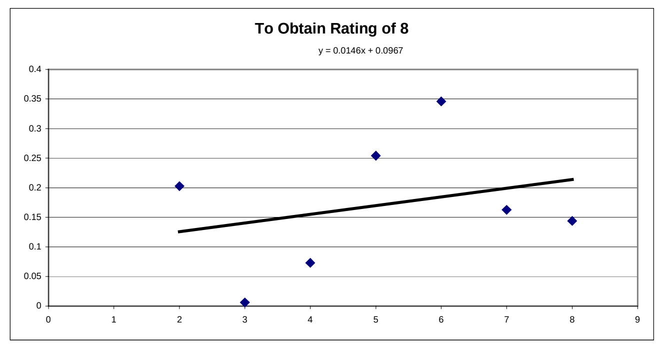

Figure 12.3-7(b) Regression Analysis for Rehabilitation Work for Concrete Substructures Which Changed the Condition Rating to 8

Table 12.3-7(e) Average Rehabilitation Work After Regression Analysis for Concrete Substructures (man-hours/square foot)

Concrete Substructure- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0946					
7		0.0800	0.0971				
6		0.0654	0.0825	0.0996			
5		0.0508	0.0679	0.0850	0.1021		
4		0.0362	0.0533	0.0704	0.0875	0.1046	
3		0.0216	0.0387	0.0558	0.0729	0.0900	0.1071

Table 12.3-7(f) Average Rehabilitation Work After Regression Analysis for Concrete Substructures [Chen and Johnston 1987] (man-hours/square foot)

Concrete Substructure (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0413					
7		0.1418	0.0651				
6		0.2423	0.1656	0.0889			
5		0.3428	0.2661	0.1894	0.1127		
4		0.4433	0.3666	0.2899	0.2132	0.1365	
3		0.5438	0.4671	0.3904	0.3137	0.2370	0.1603

Tables 12.3-7 and Figures 12.3-7 Rehabilitation Work for Concrete Substructures

Table 12.3-8(a) Average Rehabilitation Work for Timber Substructures (man-hours/square foot)

Timber Substructure								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9	0.86561821							
8	0.53192957	0.27288681						
7		0.15585277	0.1409924					
6		0.36660257	0.15493988	0.10338211				
5	0.31874484	0.33366988	0.16809037	0.12539027	0.08422336			
4	0.03763275	0.83747016	0.30997131	0.13448249	0.08851998	0.09315218		
3			0.32239407	0.12001334	0.10935774	0.12458672	0.08711843	
2					0.09879592	0.19265205		0.19208761

Table 12.3-8(b) Average Rehabilitation Work for Timber Substructures [Chen and Johnston 1987] (man-hours/square foot)

Timber Substructure (Chen)								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9								
8		0.123						
7	0.036	0.273	0.102					
6		0.344	0.188	0.09				
5		0.322	0.197	0.105	0.11			
4		0.475	0.172	0.102	0.093	0.117		
3		0.71	0.036	0.082	0.052	0.085	0.138	
2							0.035	0.143

Table 12.3-8(c) Occurrences of Function Codes for Work on Timber Substructures

Timber Substructure- number of occurences								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9	11							
8	2	110						
7		5	389					
6		13	86	1567				
5	3	11	38	175	1278			
4	1	2	13	65	99	782		
3			2	16	17	18	237	
2					1	1		5

Table 12.3-8(d) Occurrences of Function Codes for Work on Timber Substructures [Chen and Johnston 1987]

Timber Substructure (Chen)- number of occurences								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9								
8		32						
7	1	8	102					
6		9	38	416				
5		10	22	77	267			
4		4	17	30	33	82		
3		4	1	9	20	20	36	
2							3	1

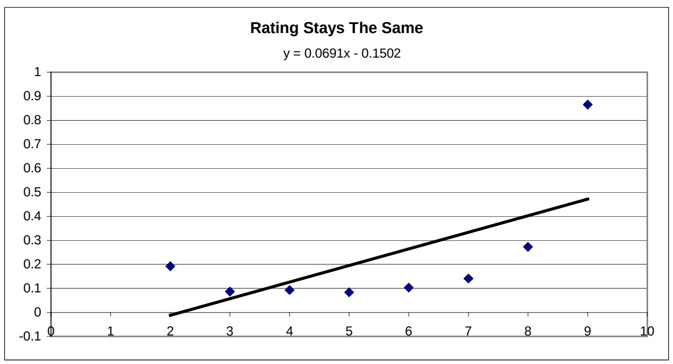

Figure 12.3-8(a) Regression Analysis for Rehabilitation Work for Timber Substructures Which Did not Change the Condition Rating

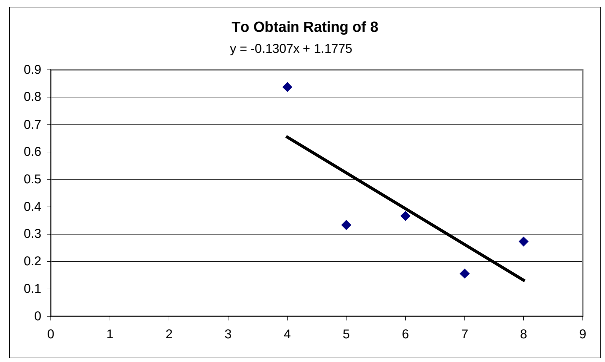

Figure 12.3-7(b) Regression Analysis for Rehabilitation Work for Timber Substructures Which Changed the Condition Rating to 8

Table 12.3-7(e) Average Rehabilitation Work After Regression Analysis forTimber Substructures (man-hours/square foot)

Timber Substructure- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.4026					
7		0.5333	0.3335				
6		0.6640	0.4642	0.2644			
5		0.7947	0.5949	0.3951	0.1953		
4		0.9254	0.7256	0.5258	0.3260	0.1262	
3		1.0561	0.8563	0.6565	0.4567	0.2569	0.0571

Table 12.3-8(f) Average Rehabilitation Work After Regression Analysis for Timber Substructures [Chen and Johnston 1987] (man-hours/square

Timber Substructure (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.1033					
7		0.2038	0.1073				
6		0.3043	0.2078	0.1113			
5		0.4048	0.3083	0.2118	0.1153		
4		0.5053	0.4088	0.3123	0.2158	0.1193	
3		0.6058	0.5093	0.4128	0.3163	0.2198	0.1233

Tables 12.3-8 and Figures 12.3-8 Rehabilitation Work for Timber Substructures

Table 12.3-9(a) Average Rehabilitation Work for Steel Substructures (man-hours/square foot)

Steel Substructure								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9								
8		0.05347782						
7			0.05261507					
6		0.024785	0.02958361	0.05492913				
5				0.210433	0.15408053			
4			0.23939542			0.0567356		
3					0.07407407	0.02432825	0.05806887	
2							0.09578544	0.06595376

Table 12.3-9(b) Average Rehabilitation Work for Steel Substructures [Chen and Johnston 1987] (man-hours/square foot)

Steel Substructure (Chen)							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8							
7							
6			Not Available				
5							
4							
3							

Table 12.3-9(c) Occurrences of Function Codes for Work on Steel Substructures

Steel Substructure- number of occurences								
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
9								
8		23						
7			25					
6		2	4	15				
5				4	19			
4			1			12		
3					1	1	5	
2							1	1

Table 12.3-9(d) Occurrences of Function Codes for Work on Steel Substructures [Chen and Johnston 1987]

Steel Substructure (Chen)- number of occurences							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8							
7							
6			Not Available				
5							
4							
3							

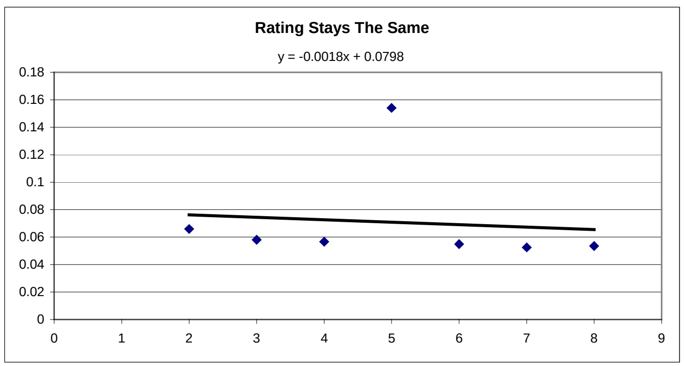

Figure 12.3-9(a) Regression Analysis for Rehabilitation Work for Steel Substructures Which Did not Change the Condition Rating

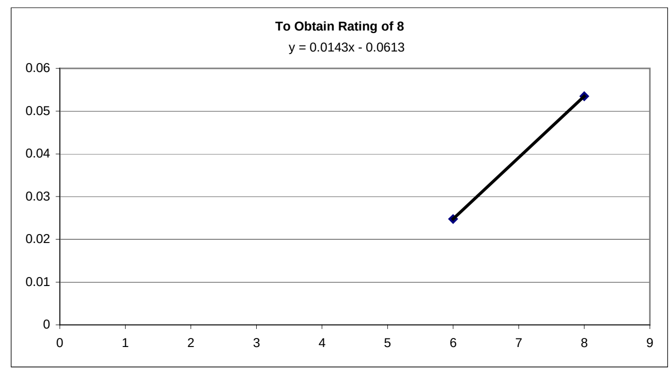

Figure 12.3-9(b) Regression Analysis for Rehabilitation Work for Steel Substructures Which Changed the Condition Rating to 8

Table 12.3-9(e) Average Rehabilitation Work After Regression Analysis for Steel Substructures (man-hours/square foot)

Steel Substructure- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0654					
7		0.0511	0.0672				
6		0.0368	0.0529	0.069			
5		0.0225	0.0386	0.0547	0.0708		
4		0.0082	0.0243	0.0404	0.0565	0.0726	
3		-0.0061	0.01	0.0261	0.0422	0.0583	0.0744

Table 12.3-9(f) Average Rehabilitation Work After Regression Analysis for Steel Substructures [Chen and Johnston 1987] (man-hours/square foot)

Steel Substructure (Chen)- final results							
before/after	**9**	**8**	**7**	**6**	**5**	**4**	**3**
9							
8		0.0413					
7		0.1418	0.0651				
6		0.2423	0.1656	0.0889			
5		0.3428	0.2661	0.1894	0.1127		
4		0.4433	0.3666	0.2899	0.2132	0.1365	
3		0.5438	0.4671	0.3904	0.3137	0.2370	0.1603

Tables 12.3-9 and Figures 12.3-9 Rehabilitation Work for Steel Substructures

12.4. Rehabilitation Rate Programs

12.4-1 Deck Rehabilitation Program

```
data test2;

*deckrehab;

infile 'c:\My Documents\Steve Project\deckrehab.txt' pad;

input co $ 1-2 bridge $ 3-6 dkmat 7 yearbuilt 8-18 length 19-29 year 30-40 dkrat 41 cdw 42-52 fun1 $ 53-55
man1 56-65 quant1 66-75 fun2 $ 76-78 man2 79-88 quant2 89-98 fun3 $ 99-101 man3 102-111 quant3 112-121
fun4 $ 122-124 man4 125-134 quant4 135-144 fun5 $ 145-147 man5 148-157 quant5 158-167 fun6 $ 168-170
man6 171-180 quant6 181-190 fun7 $ 191-193 man7 194-203 quant7 204-213;
run;

Proc Sort Data=test2;
By co bridge;
run;

Data rehabresults;
Set test2;
By co bridge;
file 'c:\My Documents\Steve Project\dkrehresults.txt';

length code $3;

if first.bridge then rehab=0 and quantity=0 and rating=0 and code='0';
if dkrat ge rating and rehab gt 0 then put co bridge year rating dkrat code rehab ;
rehab=0;
quantity=0;
rating=0;
code='0';


if year gt yearbuilt then do;
        if fun1 in ('560','561','562','564') then do;
                quantity+man1;
                code=fun1;
        end;

        if fun2 in ('560','561','562','564') then do;
                quantity+man2;
                code=fun2;
        end;

        if fun3 in ('560','561','562','564') then do;
                quantity+man3;
                code=fun3;
        end;

        if fun4 in ('560','561','562','564') then do;
                quantity+man4;
                code=fun4;
        end;

        if fun5 in ('560','561','562','564') then do;
                quantity+man5;
```

```
                code=fun5;
        end;

        if fun6 in ('560','561','562','564') then do;
                quantity+man6;
                code=fun6;
        end;

        if fun7 in ('560','561','562','564') then do;
                quantity+man7;
                code=fun7;
        end;

end;

if quantity gt 0 then do;
        rehab=quantity/(length*(cdw/10));
        rating=dkrat;
        retain rehab rating code;
end;

run;
```

12.4-2 Superstructure Rehabilitation Program

```
data test2;

*suprehab;

infile 'c:\My Documents\Steve Project\suprehab.txt' pad;

input co $ 1-2 bridge $ 3-6 supmat 7 yearbuilt 8-18 length 19-29 year 30-40 suprat 41 cdw 42-52 fun1 $ 53-55 man1
56-65 quant1 66-75 fun2 $ 76-78 man2 79-88 quant2 89-98 fun3 $ 99-101 man3 102-111 quant3 112-121 fun4 $ 122-
124 man4 125-134 quant4 135-144 fun5 $ 145-147 man5 148-157 quant5 158-167 fun6 $ 168-170 man6 171-180
quant6 181-190 fun7 $ 191-193 man7 194-203 quant7 204-213;
run;

Proc Sort Data=test2;
By co bridge;
run;

Data rehabresults;
Set test2;
By co bridge;
file 'c:\My Documents\Steve Project\suprehresults.txt';

length code $3;

if supmat=7 then spmat=1;
if supmat=1 or supmat=2 or supmat=8 then spmat=2;
if supmat=3 or supmat=4 or supmat=9 or supmat=0 then spmat=3;
if supmat=5 or supmat=6 then spmat=2;

if first.bridge then rehab=0 and quantity=0 and rating=0 and code='0';
if suprat ge rating and rehab gt 0 then put co bridge year rating suprat code spmat rehab ;
rehab=0;
quantity=0;
rating=0;
code='0';


if year gt yearbuilt then do;
	if fun1 in ('571','578') then do;
		quantity+man1;
		code=fun1;
	end;

	if fun2 in ('571','578') then do;
		quantity+man2;
		code=fun2;
	end;

	if fun3 in ('571','578') then do;
		quantity+man3;
		code=fun3;
	end;

	if fun4 in ('571','578') then do;
		quantity+man4;
```

```
		code=fun4;
	end;

	if fun5 in ('571','578') then do;
		quantity+man5;
		code=fun5;
	end;

	if fun6 in ('571','578') then do;
		quantity+man6;
		code=fun6;
	end;

	if fun7 in ('571','578') then do;
		quantity+man7;
		code=fun7;
	end;

end;

if quantity gt 0 then do;
	rehab=quantity/(length*(cdw/10));
	rating=suprat;
	retain rehab rating code;
end;

run;
```

12.4-3 Substructure Rehabilitation Program

```
data test2;

*subrehab;

infile 'c:\My Documents\Steve Project\subrehab.txt' pad;

input co $ 1-2 bridge $ 3-6 submat 7 yearbuilt 8-18 length 19-29 year 30-40 subrat 41 cdw 42-52 fun1 $ 53-55
man1 56-65 quant1 66-75 fun2 $ 76-78 man2 79-88 quant2 89-98 fun3 $ 99-101 man3 102-111 quant3 112-121
fun4 $ 122-124 man4 125-134 quant4 135-144 fun5 $ 145-147 man5 148-157 quant5 158-167 fun6 $ 168-170
man6 171-180 quant6 181-190 fun7 $ 191-193 man7 194-203 quant7 204-213;
run;

Proc Sort Data=test2;
By co bridge;
run;

Data rehabresults;
Set test2;
By co bridge;
file 'c:\My Documents\Steve Project\subrehresults.txt';

length code $3;

if first.bridge then rehab=0 and quantity=0 and rating=0 and code='0';
if subrat ge rating and rehab gt 0 then put co bridge year rating subrat code rehab ;
rehab=0;
quantity=0;
rating=0;
code='0';


if year gt yearbuilt then do;
        if fun1 in ('580','581','582','583') then do;
                quantity+man1;
                code=fun1;
        end;

        if fun2 in ('580','581','582','583') then do;
                quantity+man2;
                code=fun2;
        end;

        if fun3 in ('580','581','582','583') then do;
                quantity+man3;
                code=fun3;
        end;

        if fun4 in ('580','581','582','583') then do;
                quantity+man4;
                code=fun4;
        end;

        if fun5 in ('580','581','582','583') then do;
                quantity+man5;
```

```
                code=fun5;
        end;

        if fun6 in ('580','581','582','583') then do;
                quantity+man6;
                code=fun6;
        end;

        if fun7 in ('560','561','562','564') then do;
                quantity+man7;
                code=fun7;
        end;

end;

if quantity gt 0 then do;
        rehab=quantity/(length*(cdw/10));
        rating=subrat;
        retain rehab rating code;
end;

run;
```

12.5. Previous Cost and Parameter Data File

TABLES OF COST AND DETERIORATION PARAMETERS
FILE: HWY.LIBR(COSTPARM)

****

TABLE 1 GEOGRAPHIC AREA (1=COASTAL, 2=PIEDIMONT, 3=MOUNTAIN)

****

TABLE 2 YEARLY ADT GROWTH RATES FOR BRIDGES OF VARIOUS FUNCTIONAL CLASSIFICATIONS (%).

****

CO #	COUNTY NAME	AREA	LOCAL	COLLECTOR	ARTERIAL	INTERSTATE
00	ALAMANCE	2	0.18	2.35	5.74	4.06
01	ALEXANDER	3	1.29	1.62	1.94	4.06
02	ALLEGHANY	3	0.83	1.38	1.94	4.06
03	ANSON	2	0.53	1.55	2.62	4.06
04	ASHE	3	0.83	1.38	1.94	4.06
05	AVERY	3	0.75	1.34	1.94	4.06
06	BEAUFORT	1	0.93	2.21	3.50	4.06
07	BERTIE	1	0.21	1.97	3.92	4.06
08	BLADEN	1	0.30	1.97	3.64	4.06
09	BRUNSWICK	1	2.75	2.75	2.75	4.06
10	BUNCOMBE	3	0.59	1.30	2.01	4.06
11	BURKE	3	0.73	1.37	2.01	4.06
12	CABARRUS	2	1.14	1.86	2.62	4.06
13	CALDWELL	3	0.36	1.15	1.94	4.06
14	CAMDEN	1	0.29	1.94	3.92	4.06
15	CARTERET	1	2.07	2.78	3.50	4.06
16	CASWELL	2	0.95	2.74	5.74	4.06
17	CATAWBA	2	0.92	1.43	1.94	4.06
18	CHATHAM	2	0.80	2.52	5.31	4.06
19	CHEROKEE	3	0.93	1.15	1.36	4.06
20	CHOWAN	1	0.53	2.19	3.92	4.06
21	CLAY	3	1.26	1.31	1.36	4.06
22	CLEVELAND	3	0.30	1.12	1.94	4.06
23	COLUMBUS	1	0.24	1.94	3.64	4.06
24	CRAVEN	1	1.07	2.29	3.50	4.06
25	CUMBERLAND	1	0.73	2.19	3.64	4.06
26	CURRITUCK	1	2.81	2.31	3.92	4.06
27	DARE	1	2.97	2.25	3.92	4.06
28	DAVIDSON	2	0.77	1.62	2.49	4.06
29	DAVIE	2	1.88	2.19	2.49	4.06
30	DUPLIN	1	0.12	1.43	2.75	4.06
31	DURHAM	2	0.74	2.31	3.88	4.06
32	EDGECOMBE	2	0.47	2.29	4.11	4.06
33	FORSYTH	2	0.76	1.63	2.49	4.06
34	FRANKLIN	2	0.86	2.37	3.88	4.06
35	GASTON	2	0.62	2.78	1.94	4.06
36	GATES	1	0.32	2.31	3.88	4.06
37	GRAHAM	3	0.00	1.60	1.36	4.06
38	GRANVILLE	2	0.82	2.35	3.88	4.06
39	GREENE	1	0.41	1.95	3.50	4.06
40	GUILFORD	2	0.33	2.43	5.74	4.06
41	HALIFAX	2	0.03	2.07	4.11	4.06
42	HARNETT	2	0.98	2.31	3.64	4.06
43	HAYWOOD	3	0.32	0.84	1.36	4.06
44	HENDERSON	3	1.80	1.58	1.36	4.06
45	HERTFORD	1	0.00	1.91	3.92	4.06

46	HOKE	2	1.64	2.94	5.31	4.06
47	HYDE	1	0.46	2.30	3.92	4.06
48	IREDELL	2	0.74	1.34	1.94	4.06
49	JACKSON	3	0.97	1.17	1.36	4.06
50	JOHNSTON	2	0.86	2.48	4.11	4.06
51	JONES	1	0.00	1.75	3.50	4.06
52	LEE	2	1.19	2.72	5.31	4.06
53	LENOIR	1	0.20	1.85	3.50	4.06
54	LINCOLN	2	1.13	1.53	1.94	4.06
55	MACON	3	1.95	1.66	1.36	4.06
56	MADISON	3	0.26	1.14	2.01	4.06
57	MARTIN	1	0.18	1.99	3.92	4.06
58	MCDOWELL	3	0.77	1.39	2.01	4.06
59	MECKLENBURG	2	1.05	1.81	2.62	4.06
60	MITCHELL	3	0.00	0.95	2.01	4.06
61	MONTGOMERY	2	0.90	2.58	5.31	4.06
62	MOORE	2	1.22	2.74	5.31	4.06
63	NASH	2	0.79	2.45	4.11	4.06
64	NEW HANOVER	1	1.32	2.04	2.75	4.06
65	NORTHAMPTON	2	0.00	2.34	3.92	4.06
66	ONSLOW	1	1.04	1.89	2.75	4.06
67	ORANGE	2	2.78	1.04	5.74	4.06
68	PAMLICO	1	0.53	2.02	3.50	4.06
69	PASQUOTANK	1	0.14	2.11	3.92	4.06
70	PENDER	1	1.25	2.00	2.75	4.06
71	PERQUIMANS	1	0.68	1.82	3.92	4.06
72	PERSON	2	0.60	2.24	3.88	4.06
73	PITT	1	1.10	2.30	3.50	4.06
74	POLK	1	1.45	1.41	1.36	4.06
75	RANDOLPH	2	1.04	2.65	5.31	4.06
76	RICHMOND	2	0.07	2.16	5.31	4.06
77	ROBESON	1	0.85	2.24	3.64	4.06
78	ROCKINGHAM	2	0.58	2.55	5.74	4.06
79	ROWAN	2	0.49	1.49	2.49	4.06
80	RUTHERFORD	3	0.89	1.45	2.01	4.06
81	SAMPSON	1	0.26	1.50	2.75	4.06
82	SCOTLAND	2	0.90	2.57	5.31	4.06
83	STANLY	2	0.37	1.47	2.62	4.06
84	STOKES	2	1.53	2.01	2.49	4.06
85	SURRY	3	0.37	1.15	1.94	4.06
86	SWAIN	3	0.98	1.17	1.36	4.06
87	TRANSYLVANIA	3	0.99	1.17	1.36	4.06
88	TYRRELL	1	0.82	2.22	3.92	4.06
89	UNION	2	1.68	2.13	2.62	4.06
90	VANCE	2	0.54	2.21	3.88	4.06
91	WAKE	2	1.74	2.81	3.88	4.06
92	WARREN	2	0.00	1.89	3.88	4.06
93	WASHINGTON	1	0.00	2.64	3.92	4.06
94	WATAUGA	3	1.39	1.67	1.94	4.06
95	WAYNE	2	0.33	2.22	4.11	4.06
96	WILKES	3	0.73	1.34	1.94	4.06
97	WILSON	2	0.46	2.28	4.11	4.06
98	YADKIN	2	0.73	1.33	1.94	4.06
99	YANCE	3	0.78	1.39	2.01	4.06

****
TABLE 3 PERCENTAGE OF VEHICLES DETOURED VERSUS BRIDGE POSTING.
****

BRID POST	INTERSTATE		PRINCIPLE ARTERIAL		MINOR ARTERIAL		MOJOR COLLECTOR		MINOR COLLECTOR		LOCAL	
	SV	TTST	SV	TTST	SV	TTST	SV	TTST	SV	TTST	SV	TTST
3.0	4.40	12.50	6.00	6.60	4.60	3.30	2.60	1.10	2.60	0.80	2.40	0.60
4.0	3.87	12.45	5.21	6.57	4.11	3.29	2.32	1.09	2.32	0.80	2.14	0.60
5.0	3.35	12.40	4.41	6.54	3.61	3.28	2.04	1.09	2.04	0.79	1.88	0.60
6.0	2.82	12.36	3.62	6.50	3.12	3.26	1.76	1.08	1.76	0.79	1.63	0.59
7.0	2.30	12.31	2.82	6.47	2.62	3.25	1.48	1.08	1.48	0.78	1.37	0.59
8.0	1.77	12.26	2.03	6.44	2.13	3.24	1.20	1.07	1.20	0.78	1.11	0.59
9.0	1.52	12.24	1.70	6.33	1.78	3.19	1.00	1.05	1.00	0.77	0.92	0.58
10.0	1.26	12.02	1.36	6.23	1.43	3.14	0.80	1.04	0.80	0.76	0.74	0.57
11.0	1.10	11.65	1.22	5.97	1.28	3.01	0.72	0.99	0.72	0.73	0.67	0.54
12.0	0.95	11.28	1.08	5.70	1.13	2.87	0.64	0.95	0.64	0.69	0.59	0.52
13.0	0.82	10.74	0.97	5.39	1.02	2.71	0.57	0.90	0.57	0.66	0.53	0.49
14.0	0.71	10.04	0.90	5.02	0.94	2.53	0.53	0.84	0.53	0.61	0.49	0.46
15.0	0.60	9.34	0.82	4.66	0.86	2.35	0.48	0.78	0.48	0.57	0.45	0.42
16.0	0.51	8.89	0.76	4.41	0.79	2.22	0.45	0.73	0.45	0.54	0.41	0.40
17.0	0.42	8.35	0.69	4.16	0.73	2.09	0.41	0.69	0.41	0.51	0.38	0.38
18.0	0.35	8.04	0.63	3.95	0.66	1.99	0.37	0.66	0.37	0.48	0.34	0.36
19.0	0.30	7.71	0.58	3.78	0.60	1.90	0.34	0.63	0.34	0.46	0.31	0.34
20.0	0.24	7.37	0.52	3.61	0.55	1.82	0.31	0.60	0.31	0.44	0.28	0.33
21.0	0.21	7.06	0.44	3.50	0.47	1.76	0.26	0.58	0.26	0.43	0.24	0.32
22.0	0.18	6.75	0.37	3.39	0.39	1.71	0.22	0.56	0.22	0.41	0.20	0.31
23.0	0.16	6.46	0.30	3.28	0.32	1.65	0.18	0.55	0.18	0.40	0.17	0.30
24.0	0.15	6.17	0.25	3.17	0.26	1.60	0.15	0.53	0.15	0.39	0.14	0.29
25.0	0.13	5.89	0.20	3.06	0.21	1.54	0.12	0.51	0.12	0.37	0.11	0.28
26.0	0.11	5.61	0.16	2.96	0.17	1.49	0.10	0.49	0.10	0.36	0.09	0.27
27.0	0.09	5.32	0.13	2.86	0.13	1.44	0.08	0.48	0.08	0.35	0.07	0.26
28.0	0.08	5.01	0.10	2.75	0.10	1.39	0.06	0.46	0.06	0.33	0.05	0.25
29.0	0.07	4.68	0.07	2.64	0.08	1.33	0.04	0.44	0.04	0.32	0.04	0.24
30.0	0.06	4.35	0.05	2.52	0.05	1.27	0.05	0.42	0.03	0.31	0.03	0.23
31.0	0.05	3.95	0.03	2.38	0.04	1.20	0.02	0.40	0.02	0.29	0.02	0.22
32.0	0.04	3.56	0.02	2.25	0.02	1.13	0.01	0.37	0.01	0.27	0.01	0.20
33.0	0.04	3.11	0.01	2.09	0.01	1.05	0.00	0.35	0.00	0.25	0.00	0.19
33.6	0.00	2.81	0.00	1.98	0.00	1.00	0.00	0.33	0.00	0.24	0.00	0.18
34.0	0.00	2.60	0.00	1.91	0.00	0.96	0.00	0.29	0.00	0.23	0.00	0.16
36.0	0.00	1.74	0.00	1.56	0.00	0.78	0.00	0.24	0.00	0.19	0.00	0.14
36.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 4 PERCENTAGE OF VEHICLES DETOURED DUE TO VERTICAL CLEARANCE DEFICIENCY.

(A) DUALS

CLEARANCE POSTINGS (FT)	% OF THE TOTAL VEHICLES DETOURED					
	INTER-STATE	PRIMARY ARTERIAL	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR	LOCAL
8.0	4.40	6.00	4.60	2.60	2.60	2.40
8.5	4.00	5.45	4.18	2.36	2.36	2.18
9.0	3.60	4.91	3.76	2.13	2.13	1.96
9.5	3.20	4.36	3.35	1.89	1.89	1.75
10.0	2.80	3.82	2.93	1.66	1.66	1.53
10.5	2.40	3.27	2.51	1.42	1.42	1.31
11.0	2.00	2.73	2.09	1.18	1.18	1.09
11.5	1.60	2.18	1.67	0.95	0.95	0.87
12.0	1.20	1.64	1.26	0.71	0.71	0.66
12.5	0.80	1.09	0.84	0.47	0.47	0.44
13.0	0.40	0.55	0.42	0.24	0.24	0.22
13.5	0.00	0.00	0.00	0.00	0.00	0.00
14.0	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00

(B) TRUCK-TRACTOR-SEMITRAILERS (TTST)

CLEARANCE POSTINGS (FT)	% OF THE TOTAL VEHICLES DETOURED					
	INTER-STATE	PRIMARY ARTERIAL	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR	LOCAL
10.0	12.50	6.60	3.30	1.10	0.80	0.60
10.5	10.72	5.66	2.83	0.94	0.69	0.51
11.0	8.94	4.72	2.36	0.79	0.57	0.43
11.5	7.17	3.78	1.89	0.63	0.46	0.34
12.0	5.39	2.85	1.42	0.47	0.34	0.26
12.5	3.61	1.91	0.95	0.32	0.23	0.17
13.0	1.83	0.97	0.48	0.16	0.12	0.09
13.5	0.06	0.03	0.01	0.00	0.00	0.00
14.0	0.01	0.01	0.00	0.00	0.00	0.00
14.5	0.01	0.00	0.00	0.00	0.00	0.00

****

TABLE 5 LEVEL OF SERVICE GOALS

****

FIRST: BRIDGE CAPACITY GOALS (TONS)

FUNC	ACCEPTABLE=1	DESIRABLE=2
1	33.6	33.6
2	33.6	33.6
3	33.6	33.6
4	25.0	33.6
5	16.0	33.6
6	16.0	33.6

SECOND: BRIDGE VERTICAL CLEARANCE GOALS (FEET)

FUNC	ACCEPTABLE=1	DESIRABLE=2
1	14.0	16.5
2	14.0	16.5
3	14.0	16.5
4	14.0	15.0
5	14.0	15.0
6	14.0	15.0

THIRD: BRIDGE CLEAR DECK WIDTH GOALS (FEET)

FUNC	ADT	ACCEPTABLE=1		DESIRABLE=2	
		LANE	SHOULDER	LANE	SHOULDER
1	0	10.0	1.0	12.0	4.0
1	801	10.0	2.0	12.0	6.0
1	2001	11.0	2.0	12.0	8.0
1	4001	11.0	3.0	12.0	8.0
2	0	10.0	1.0	12.0	4.0
2	801	10.0	2.0	12.0	6.0
2	2001	11.0	2.0	12.0	8.0
2	4001	11.0	3.0	12.0	8.0
3	0	10.0	1.0	12.0	4.0
3	801	10.0	2.0	12.0	6.0
3	2001	11.0	2.0	12.0	8.0
3	4001	11.0	3.0	12.0	8.0
4	0	9.0	1.0	10.0	2.0
4	801	9.0	2.0	11.0	3.0
4	2001	10.0	2.0	12.0	3.0
4	4001	10.0	3.0	12.0	3.0
5	0	9.0	1.0	10.0	2.0
5	801	9.0	2.0	11.0	3.0
5	2001	10.0	2.0	12.0	3.0
5	4001	10.0	3.0	12.0	3.0

6	0	9.0	1.0	10.0	2.0
6	801	9.0	2.0	11.0	3.0
6	2001	10.0	2.0	12.0	3.0
6	4001	10.0	3.0	12.0	3.0

****
TABLE 6 DECK DETERIORATION RATES (YEARS/POINT).
****

DKMAT	ADT	9.0	8.0	7.0	6.0	5.0
1	0	5.0	5.7	5.7	5.7	3.6
1	201	5.0	4.9	4.9	4.9	3.6
1	801	5.0	3.9	3.9	3.9	3.2
1	2001	5.0	3.0	3.0	3.0	3.0
1	4001	5.0	2.6	2.6	2.6	2.6
2	0	5.0	9.7	9.7	9.7	6.5
2	201	5.0	9.0	9.0	9.0	6.3
2	801	5.0	8.0	8.0	8.0	5.6
2	2001	5.0	7.4	7.4	7.4	5.5
2	4001	5.0	6.4	6.4	6.4	5.2
3	0	5.0	7.8	7.8	7.8	4.9
3	201	5.0	7.2	7.2	7.2	4.9
3	801	5.0	6.3	6.3	6.3	4.9
3	2001	5.0	5.6	5.6	5.6	4.7
3	4001	5.0	5.1	5.1	5.1	4.1

****
TABLE 7 SUPERSTRUCTURE DETERIORATION RATES (YEARS/POINT).
****

SPMAT	SPTYPE	SYS	9.0	8.0	7.0	6.0	5.0
1	1	1	5.0	5.3	5.3	5.3	3.7
1	1	2	5.0	6.0	6.0	6.0	3.9
2	2	1	5.0	8.7	8.7	8.7	6.0
2	2	2	5.0	10.6	10.6	10.6	6.7
2	3	1	5.0	9.2	9.2	9.2	4.9
2	3	2	5.0	9.5	9.5	9.5	6.1
3	4	1	5.0	6.8	6.8	6.8	5.8
3	4	2	5.0	8.8	8.8	8.8	5.8
3	1	1	5.0	7.5	7.5	7.5	5.6
3	1	2	5.0	9.4	9.4	9.4	6.1
3	5	1	5.0	7.5	7.5	7.5	5.6
3	5	2	5.0	9.4	9.4	9.4	6.1
4	1	1	5.0	7.9	7.9	7.9	5.1
4	1	2	5.0	8.5	8.5	8.5	5.1

****

TABLE 8 SUBSTRUCTURE DETERIORATION RATES (YEARS/POINT)

****

SBMAT	AREA	9.0	8.0	7.0	6.0	5.0
1	1	5.0	5.1	5.1	5.1	3.2
1	2	5.0	5.9	5.9	5.9	4.2
1	3	5.0	5.5	5.5	5.5	3.5
2	1	5.0	7.8	7.8	7.8	4.9
2	2	5.0	11.3	11.3	11.3	6.9
2	3	5.0	8.8	8.8	8.8	6.7
3	1	5.0	6.3	6.3	6.3	4.6
3	2	5.0	9.6	9.6	9.6	5.6
3	3	5.0	7.1	7.1	7.1	5.8
4	1	5.0	7.5	7.5	7.5	5.6
4	2	5.0	11.7	11.7	11.7	7.0
4	3	5.0	8.2	8.2	8.2	4.9

****

TABLE 9 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE DECKS AT VARIOUS CONDITION RATINGS ($/SF OF DECK AREA)

****

DKMAT	ADT	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	0	0.000	0.035	0.065	0.093	0.246	0.464	0.860
1	201	0.000	0.040	0.076	0.108	0.246	0.464	0.860
1	801	0.000	0.051	0.095	0.135	0.277	0.522	0.967
1	2001	0.000	0.066	0.124	0.176	0.296	0.557	1.032
1	4001	0.000	0.076	0.143	0.203	0.341	0.642	1.191
2	0	0.000	0.008	0.011	0.015	0.040	0.133	0.319
2	201	0.000	0.009	0.012	0.016	0.041	0.137	0.329
2	801	0.000	0.010	0.014	0.018	0.046	0.155	0.370
2	2001	0.000	0.011	0.015	0.019	0.047	0.157	0.376
2	4001	0.000	0.013	0.017	0.022	0.050	0.166	0.398
3	0	0.000	0.094	0.111	0.128	0.231	0.258	0.286
3	201	0.000	0.102	0.121	0.140	0.231	0.258	0.286
3	801	0.000	0.117	0.138	0.159	0.231	0.258	0.286
3	2001	0.000	0.131	0.155	0.179	0.241	0.269	0.300
3	4001	0.000	0.144	0.170	0.196	0.276	0.309	0.341

****

TABLE 10 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE HANDRAILS AT VARIOUS CONDITION RATINGS ($/LF OF BRIDGE LENGTH)

****

HRMAT	ADT	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	0	0.000	0.032	0.032	0.032	0.051	0.051	0.051
1	201	0.000	0.037	0.037	0.037	0.051	0.051	0.051
1	801	0.000	0.047	0.047	0.047	0.057	0.057	0.057
1	2001	0.000	0.061	0.061	0.061	0.061	0.061	0.061
1	4001	0.000	0.070	0.070	0.070	0.070	0.070	0.070
2	0	0.000	0.085	0.085	0.085	0.127	0.127	0.127
2	201	0.000	0.092	0.092	0.092	0.131	0.131	0.131
2	801	0.000	0.103	0.103	0.103	0.147	0.147	0.147
2	2001	0.000	0.111	0.111	0.111	0.150	0.150	0.150
2	4001	0.000	0.129	0.129	0.129	0.159	0.159	0.159
3	0	0.000	0.043	0.043	0.043	0.068	0.068	0.068
3	201	0.000	0.046	0.046	0.046	0.068	0.068	0.068
3	801	0.000	0.053	0.053	0.053	0.068	0.068	0.068
3	2001	0.000	0.060	0.060	0.060	0.071	0.071	0.071
3	4001	0.000	0.065	0.065	0.065	0.081	0.081	0.081

****

TABLE 11 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE SUPERSTRUCTURE AT VARIOUS CONDITION RATINGS ($/SF OF DECK AREA)

****

SPMAT	SPTYPE	SYS	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	1	1	0.000	0.033	0.052	0.071	0.128	0.155	0.181
1	1	2	0.000	0.029	0.046	0.062	0.121	0.147	0.172
2	2	1	0.000	0.000	0.009	0.057	0.132	0.183	0.232
2	2	2	0.000	0.000	0.007	0.046	0.119	0.164	0.209
2	3	1	0.000	0.000	0.008	0.054	0.162	0.224	0.286
2	3	2	0.000	0.000	0.008	0.052	0.130	0.180	0.230
3	4	1	0.000	0.007	0.038	0.068	0.116	0.152	0.188
3	4	2	0.000	0.005	0.029	0.053	0.116	0.152	0.188
3	1	1	0.000	0.006	0.034	0.062	0.120	0.158	0.195
3	1	2	0.000	0.005	0.027	0.049	0.111	0.145	0.179
3	5	1	0.000	0.006	0.034	0.062	0.120	0.158	0.195
3	5	2	0.000	0.005	0.027	0.049	0.111	0.145	0.179
4	1	1	0.000	0.000	0.003	0.016	0.025	0.040	0.056
4	1	2	0.000	0.000	0.003	0.015	0.025	0.040	0.056

****
TABLE 12 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE SUBSTRUCTURES AT VARIOUS CONDITION RATINGS ($/SF OF DECK AREA).
****

SBMAT	IAREA	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	1	0.000	0.121	0.123	0.126	0.205	0.209	0.214
1	2	0.000	0.104	0.107	0.109	0.156	0.159	0.163
1	3	0.000	0.112	0.114	0.117	0.187	0.191	0.195
2	1	0.000	0.000	0.022	0.066	0.174	0.244	0.314
2	2	0.000	0.000	0.015	0.045	0.124	0.174	0.223
2	3	0.000	0.000	0.019	0.058	0.128	0.179	0.230
3	1	0.000	0.000	0.024	0.058	0.125	0.171	0.217
3	2	0.000	0.000	0.016	0.038	0.103	0.141	0.178
3	3	0.000	0.000	0.021	0.051	0.099	0.136	0.172
4	1	0.000	0.000	0.006	0.024	0.057	0.081	0.105
4	2	0.000	0.000	0.004	0.016	0.046	0.065	0.084
4	3	0.000	0.000	0.006	0.022	0.065	0.093	0.147

****
TABLE 13 AVERAGE REHABILITATION WORK (MAN-HOURS/SF OF DECK AREA)
****

1. TIMBER DECK

0.0738					
0.1143	0.0905				
0.1548	0.1310	0.1072			
0.1953	0.1715	0.1477	0.1239		
0.2358	0.2120	0.1882	0.1644	0.1406	
0.2763	0.2525	0.2287	0.2049	0.1811	0.1573

2. TIMBER SUPERSTRUCTURE

0.0407					
0.1034	0.0588				
0.1661	0.1215	0.0769			
0.2288	0.1842	0.1396	0.0950		
0.2915	0.2469	0.2023	0.1577	0.1131	
0.3542	0.3096	0.2650	0.2204	0.1758	0.1312

3. TIMBER SUBSTRUCTURE

0.1033					
0.2038	0.1073				
0.3043	0.2078	0.1113			
0.4048	0.3083	0.2118	0.1153		
0.5053	0.4088	0.3123	0.2158	0.1193	
0.6058	0.5093	0.4128	0.3163	0.2198	0.1233

```
4. REINFORCED CONCRETE DECK
   ------------------------
  0.0603
  0.1622 0.1109
  0.2641 0.2128 0.1615
  0.3660 0.3147 0.2634 0.2121
  0.4679 0.4166 0.3653 0.3140 0.2627
  0.5698 0.5185 0.4672 0.4159 0.3646 0.3313

5. REINFORCED CONCRETE SUPERSTRUCTURE
   ----------------------------------
  0.2470
  0.3355 0.2810
  0.4240 0.3695 0.3150
  0.5125 0.4580 0.4035 0.3490
  0.6010 0.5465 0.4920 0.4375 0.3830
  0.6895 0.6350 0.5805 0.5260 0.4715 0.4170

6. REINFORCED CONCRETE SUBSTRUCTURE
   --------------------------------
  0.0413
  0.1418 0.0651
  0.2423 0.1656 0.0889
  0.3428 0.2661 0.1894 0.1127
  0.4433 0.3666 0.2899 0.2132 0.1365
  0.5438 0.4671 0.3904 0.3137 0.2370 0.1603

7. STEEL DECK
   ----------
  0.0603
  0.1622 0.1109
  0.2641 0.2128 0.1615
  0.3660 0.3147 0.2623 0.2121
  0.4679 0.4166 0.3653 0.3140 0.2627
  0.5698 0.5185 0.4672 0.4159 0.3646 0.3133

8. STEEL SUPERSTRUCTURE
   --------------------
  0.2470
  0.3355 0.2810
  0.4240 0.3695 0.3150
  0.5125 0.4580 0.4035 0.3490
  0.6010 0.5465 0.4920 0.4375 0.3830
  0.6895 0.6350 0.5805 0.5260 0.4715 0.4170

9. STEEL SUBSTRUCTURE
   ------------------
  0.0413
  0.1418 0.0651
  0.2423 0.1656 0.0889
  0.3428 0.2661 0.1894 0.1127
  0.4433 0.3666 0.2899 0.2132 0.1365
  0.5438 0.4671 0.3904 0.3137 0.2370 0.1603
```

****
TABLE 14 LOAD CAPACITY DETERIORATION (TONS/YEAR).
****

CR	TIMBER=1	CONCRETE=2	STEEL=3
1	1.00	0.50	0.50
2	1.00	0.50	0.50
3	1.00	0.50	0.50
4	0.50	0.30	0.30
5	0.30	0.20	0.20
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00

****
TABLE 15 LOAD CAPACITY RECOVERY DUE TO REHABILITATION (TONS).
****

CR	TIMBER=1	CONCRETE=2	STEEL=3
1	5.00	5.00	5.00
2	5.00	5.00	5.00
3	5.00	5.00	5.00
4	3.00	2.00	2.00
5	1.00	1.00	1.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00

****
TABLE 16 GOALS FOR NUMBER OF LANES
****

FIRST: ONE-WAY BRIDGE TRAFFIC

AVERAGE DAILY TRAFFIC (ADT) ON THE BRIDGE (VEHICLES/DAY)	ACCEPTABLE	DESIRABLE
0 - 3000	1	1
3001 - 5000	1	2
5001 - 15000	2	2
15001 - 22500	2	3
22501 - 27500	3	3
27501 - 35000	3	4
OVER 35000	4	4

SECOND: TWO-WAY BRIDGE TRAFFIC

AVERAGE DAILY TRAFFIC (ADT) ON THE BRIDGE (VEHICLES/DAY)	ACCEPTABLE	DESIRABLE
0 - 6000	2 OR 3	2 OR 3
6001 - 10000	2 OR 3	4 OR 5
10001 - 30000	4 OR 5	4 OR 5
30001 - 45000	4 OR 5	6 OR 7

45001 - 55000	6 OR 7	6 OR 7
55001 - 70000	6 OR 7	8
OVER 70000	8	8

EXAMPLE: AN EXISTING BRIDGE WITH TWO-WAY TRAFFIC AND ADT EXPECTED TO BE 31,000 IN 20 YEARS IS REPLACED WITH: (1) A 6-LANE BRIDGE IF THE CURRENT NUMBER OF LANES IS EVEN, OR (2) A 7-LANE BRIDGE IF THE CURRENT NUMBER OF LANES IS ODD. IN ALL CASES, THE NEW BRIDGE SHOULD HAVE NO LESS THAN THE CURRENT NUMBER OF LANES.

****

OTHER PARAMETERS

****

	UNIT COSTS OF REHABILITATION ($/MAN-HOUR)		
MATERIAL TYPE	DECK	SUPERSTRUCTURE	SUBSTRUCTURE
TIMBER	22.19	22.19	19.53
REINFORCED CONCRETE	22.19	22.19	17.95
STEEL	22.19	22.19	19.81
PRESTRESSED CONCRETE	22.19	22.19	15.41

OPERATING COST FOR VEHICLE WEIGHING 3 TONS OR LESS
UD3 = $ 0.35 / MILE

OPERATING COST FOR VEHICLE WEIGHING THE MAXIMUM LEGAL LOAD
UDNB = $ 1.15 / MILE

MAXIMUM LEGAL LOAD OR NON-POSTED SINGLE-VEHICLE CAPACITY,
NP = 33.60 TONS

NON-POSTED TRUCK-TRACTOR-SEMITRAILER CAPACITY,
NPTT = 36.75 TONS

COEFFICIENTS TO COMPUTE ACCIDENT COSTS,
ACCA = 63.
ACCB = 6.5
ACOSTC = 31919.
ACOSTW = 31919.
ACCU(1) = 7000000.
ACCU(2) = 37000000.
ACCU(3) = 37000000.
ACCU(4) = 8000000.
ACCU(5) = 8000000.
ACCU(6) = 1000000.

ADDITIONAL FACTOR FOR DROP IN CONDITION RATINGS AND LOAD CAPACITY FOR NO ROUTINE MAINTENANCE VERSUS COMPLETE ROUTINE MAINTENANCE,
DROPMN = 0.2

12.6. Updated Cost and Parameter File

TABLES OF COST AND DETERIORATION PARAMETERS
FILE: HWY.LIBR(COSTPARM)

****

TABLE 1 GEOGRAPHIC AREA (1=COASTAL, 2=PIEDIMONT, 3=MOUNTAIN)

****

TABLE 2 YEARLY ADT GROWTH RATES FOR BRIDGES OF VARIOUS FUNCTIONAL CLASSIFICATIONS (%).

****

CO #	COUNTY NAME	AREA	LOCAL	COLLECTOR	ARTERIAL	INTERSTATE
00	ALAMANCE	2	3.82	3.50	3.50	6.81
01	ALEXANDER	3	4.57	4.28	2.86	5.38
02	ALLEGHANY	3	2.75	3.99	2.75	5.38
03	ANSON	2	2.67	2.86	2.98	5.38
04	ASHE	3	2.50	3.61	2.97	5.38
05	AVERY	3	3.42	3.52	3.50	5.38
06	BEAUFORT	1	2.50	2.55	2.93	5.38
07	BERTIE	1	3.45	3.28	0.48	5.38
08	BLADEN	1	4.93	2.50	3.00	5.38
09	BRUNSWICK	1	5.96	4.56	3.50	5.38
10	BUNCOMBE	3	2.50	2.55	3.50	5.47
11	BURKE	3	2.72	3.37	3.01	5.19
12	CABARRUS	2	3.61	3.50	2.86	7.75
13	CALDWELL	3	2.50	2.50	3.92	5.38
14	CAMDEN	1	4.43	3.47	3.16	5.38
15	CARTERET	1	3.50	2.59	3.25	5.38
16	CASWELL	2	1.44	3.92	4.24	5.38
17	CATAWBA	2	3.42	2.93	2.84	5.00
18	CHATHAM	2	4.21	3.49	2.58	5.38
19	CHEROKEE	3	4.28	2.87	2.25	5.38
20	CHOWAN	1	2.50	2.50	2.60	5.38
21	CLAY	3	2.40	2.47	3.50	5.38
22	CLEVELAND	3	2.59	3.15	2.79	2.96
23	COLUMBUS	1	2.50	3.87	2.32	5.38
24	CRAVEN	1	2.41	2.22	2.50	5.38
25	CUMBERLAND	1	2.50	2.50	3.50	5.00
26	CURRITUCK	1	2.50	2.50	3.15	5.38
27	DARE	1	3.50	3.50	4.00	5.38
28	DAVIDSON	2	2.45	2.99	3.50	5.84
29	DAVIE	2	3.37	3.25	3.50	4.50
30	DUPLIN	1	2.55	2.55	3.50	4.50
31	DURHAM	2	3.39	3.25	3.50	5.00
32	EDGECOMBE	2	2.50	2.50	3.50	5.38
33	FORSYTH	2	2.50	2.55	3.50	3.60
34	FRANKLIN	2	3.43	2.82	3.50	5.38
35	GASTON	2	2.50	2.50	3.50	5.07
36	GATES	1	2.50	2.69	3.55	5.38
37	GRAHAM	3	2.50	2.50	3.02	5.38
38	GRANVILLE	2	3.00	3.45	3.75	5.00
39	GREENE	1	2.50	3.50	3.50	5.38
40	GUILFORD	2	2.50	3.55	3.50	5.00
41	HALIFAX	2	3.50	3.00	3.50	4.04
42	HARNETT	2	2.50	3.50	3.00	5.03
43	HAYWOOD	3	4.63	3.00	3.61	5.62
44	HENDERSON	3	3.20	3.11	4.01	5.01
45	HERTFORD	1	2.50	3.38	3.75	5.38

46	HOKE	2	3.52	2.50	3.50	5.38
47	HYDE	1	2.47	2.50	3.50	5.38
48	IREDELL	2	3.67	3.50	3.33	4.50
49	JACKSON	3	2.81	3.00	3.50	5.38
50	JOHNSTON	2	6.68	3.21	3.50	4.24
51	JONES	1	2.50	2.50	3.00	5.38
52	LEE	2	2.50	3.50	3.50	5.38
53	LENOIR	1	3.06	3.38	4.11	5.38
54	LINCOLN	2	2.60	3.34	3.50	5.38
55	MACON	3	2.54	2.54	3.00	5.38
56	MADISON	3	2.58	3.00	3.00	5.38
57	MARTIN	1	2.50	3.20	2.59	5.38
58	MCDOWELL	3	2.50	3.50	3.55	5.17
59	MECKLENBURG	2	2.67	4.74	2.90	4.93
60	MITCHELL	3	1.05	1.18	2.97	5.38
61	MONTGOMERY	2	2.02	3.77	5.84	6.25
62	MOORE	2	5.01	4.78	3.43	5.38
63	NASH	2	3.00	3.00	3.09	4.50
64	NEW HANOVER	1	4.84	3.06	3.50	6.50
65	NORTHAMPTON	2	2.17	2.05	3.50	5.25
66	ONSLOW	1	3.06	3.25	3.50	5.38
67	ORANGE	2	2.42	3.20	3.50	4.56
68	PAMLICO	1	3.50	4.16	3.50	5.38
69	PASQUOTANK	1	2.50	2.50	4.93	5.38
70	PENDER	1	3.00	3.50	3.50	6.50
71	PERQUIMANS	1	2.50	2.50	3.50	5.38
72	PERSON	2	2.50	2.75	3.50	5.38
73	PITT	1	2.55	2.55	3.04	5.38
74	POLK	1	2.50	3.28	3.50	4.42
75	RANDOLPH	2	3.50	2.71	3.67	5.47
76	RICHMOND	2	2.63	3.20	3.50	6.25
77	ROBESON	1	3.06	3.08	3.49	4.50
78	ROCKINGHAM	2	3.88	2.85	3.20	6.25
79	ROWAN	2	3.00	3.50	4.63	6.91
80	RUTHERFORD	3	4.09	3.25	3.50	5.38
81	SAMPSON	1	2.50	2.50	3.50	6.25
82	SCOTLAND	2	2.50	3.50	3.50	5.38
83	STANLY	2	2.50	3.64	3.08	5.38
84	STOKES	2	2.50	3.55	3.55	5.38
85	SURRY	3	2.60	2.60	3.50	6.25
86	SWAIN	3	2.50	3.50	3.55	5.38
87	TRANSYLVANIA	3	2.50	2.50	3.50	5.38
88	TYRRELL	1	0.84	2.50	2.50	5.38
89	UNION	2	3.00	3.00	3.50	5.38
90	VANCE	2	3.25	3.25	3.50	5.82
91	WAKE	2	3.00	5.00	4.00	6.50
92	WARREN	2	2.50	3.15	3.50	7.51
93	WASHINGTON	1	2.50	2.50	3.00	5.38
94	WATAUGA	3	2.50	3.00	3.50	5.38
95	WAYNE	2	2.82	3.00	3.50	5.38
96	WILKES	3	2.50	3.20	3.50	5.38
97	WILSON	2	3.39	2.81	2.92	4.50
98	YADKIN	2	2.50	3.25	3.50	6.25
99	YANCE	3	2.50	2.65	4.35	5.38

****
TABLE 3 PERCENTAGE OF VEHICLES DETOURED VERSUS BRIDGE POSTING.
****

BRID POST	INTERSTATE		PRINCIPLE ARTERIAL		MINOR ARTERIAL		MOJOR COLLECTOR		MINOR COLLECTOR		LOCAL	
	SV	TTST	SV	TTST	SV	TTST	SV	TTST	SV	TTST	SV	TTST
3.0	4.40	12.50	6.00	6.60	4.60	3.30	2.60	1.10	2.60	0.80	2.40	0.60
4.0	3.87	12.45	5.21	6.57	4.11	3.29	2.32	1.09	2.32	0.80	2.14	0.60
5.0	3.35	12.40	4.41	6.54	3.61	3.28	2.04	1.09	2.04	0.79	1.88	0.60
6.0	2.82	12.36	3.62	6.50	3.12	3.26	1.76	1.08	1.76	0.79	1.63	0.59
7.0	2.30	12.31	2.82	6.47	2.62	3.25	1.48	1.08	1.48	0.78	1.37	0.59
8.0	1.77	12.26	2.03	6.44	2.13	3.24	1.20	1.07	1.20	0.78	1.11	0.59
9.0	1.52	12.24	1.70	6.33	1.78	3.19	1.00	1.05	1.00	0.77	0.92	0.58
10.0	1.26	12.02	1.36	6.23	1.43	3.14	0.80	1.04	0.80	0.76	0.74	0.57
11.0	1.10	11.65	1.22	5.97	1.28	3.01	0.72	0.99	0.72	0.73	0.67	0.54
12.0	0.95	11.28	1.08	5.70	1.13	2.87	0.64	0.95	0.64	0.69	0.59	0.52
13.0	0.82	10.74	0.97	5.39	1.02	2.71	0.57	0.90	0.57	0.66	0.53	0.49
14.0	0.71	10.04	0.90	5.02	0.94	2.53	0.53	0.84	0.53	0.61	0.49	0.46
15.0	0.60	9.34	0.82	4.66	0.86	2.35	0.48	0.78	0.48	0.57	0.45	0.42
16.0	0.51	8.89	0.76	4.41	0.79	2.22	0.45	0.73	0.45	0.54	0.41	0.40
17.0	0.42	8.35	0.69	4.16	0.73	2.09	0.41	0.69	0.41	0.51	0.38	0.38
18.0	0.35	8.04	0.63	3.95	0.66	1.99	0.37	0.66	0.37	0.48	0.34	0.36
19.0	0.30	7.71	0.58	3.78	0.60	1.90	0.34	0.63	0.34	0.46	0.31	0.34
20.0	0.24	7.37	0.52	3.61	0.55	1.82	0.31	0.60	0.31	0.44	0.28	0.33
21.0	0.21	7.06	0.44	3.50	0.47	1.76	0.26	0.58	0.26	0.43	0.24	0.32
22.0	0.18	6.75	0.37	3.39	0.39	1.71	0.22	0.56	0.22	0.41	0.20	0.31
23.0	0.16	6.46	0.30	3.28	0.32	1.65	0.18	0.55	0.18	0.40	0.17	0.30
24.0	0.15	6.17	0.25	3.17	0.26	1.60	0.15	0.53	0.15	0.39	0.14	0.29
25.0	0.13	5.89	0.20	3.06	0.21	1.54	0.12	0.51	0.12	0.37	0.11	0.28
26.0	0.11	5.61	0.16	2.96	0.17	1.49	0.10	0.49	0.10	0.36	0.09	0.27
27.0	0.09	5.32	0.13	2.86	0.13	1.44	0.08	0.48	0.08	0.35	0.07	0.26
28.0	0.08	5.01	0.10	2.75	0.10	1.39	0.06	0.46	0.06	0.33	0.05	0.25
29.0	0.07	4.68	0.07	2.64	0.08	1.33	0.04	0.44	0.04	0.32	0.04	0.24
30.0	0.06	4.35	0.05	2.52	0.05	1.27	0.05	0.42	0.03	0.31	0.03	0.23
31.0	0.05	3.95	0.03	2.38	0.04	1.20	0.02	0.40	0.02	0.29	0.02	0.22
32.0	0.04	3.56	0.02	2.25	0.02	1.13	0.01	0.37	0.01	0.27	0.01	0.20
33.0	0.04	3.11	0.01	2.09	0.01	1.05	0.00	0.35	0.00	0.25	0.00	0.19
33.6	0.00	2.81	0.00	1.98	0.00	1.00	0.00	0.33	0.00	0.24	0.00	0.18
34.0	0.00	2.60	0.00	1.91	0.00	0.96	0.00	0.29	0.00	0.23	0.00	0.16
36.0	0.00	1.74	0.00	1.56	0.00	0.78	0.00	0.24	0.00	0.19	0.00	0.14
36.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 4 PERCENTAGE OF VEHICLES DETOURED DUE TO VERTICAL CLEARANCE DEFICIENCY.

(A) DUALS

CLEARANCE POSTINGS (FT)	% OF THE TOTAL VEHICLES DETOURED					
	INTER-STATE	PRIMARY ARTERIAL	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR	LOCAL
8.0	4.40	6.00	4.60	2.60	2.60	2.40
8.5	4.00	5.45	4.18	2.36	2.36	2.18
9.0	3.60	4.91	3.76	2.13	2.13	1.96
9.5	3.20	4.36	3.35	1.89	1.89	1.75
10.0	2.80	3.82	2.93	1.66	1.66	1.53
10.5	2.40	3.27	2.51	1.42	1.42	1.31
11.0	2.00	2.73	2.09	1.18	1.18	1.09
11.5	1.60	2.18	1.67	0.95	0.95	0.87
12.0	1.20	1.64	1.26	0.71	0.71	0.66
12.5	0.80	1.09	0.84	0.47	0.47	0.44
13.0	0.40	0.55	0.42	0.24	0.24	0.22
13.5	0.00	0.00	0.00	0.00	0.00	0.00
14.0	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00

(B) TRUCK-TRACTOR-SEMITRAILERS (TTST)

CLEARANCE POSTINGS (FT)	% OF THE TOTAL VEHICLES DETOURED					
	INTER-STATE	PRIMARY ARTERIAL	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR	LOCAL
10.0	12.50	6.60	3.30	1.10	0.80	0.60
10.5	10.72	5.66	2.83	0.94	0.69	0.51
11.0	8.94	4.72	2.36	0.79	0.57	0.43
11.5	7.17	3.78	1.89	0.63	0.46	0.34
12.0	5.39	2.85	1.42	0.47	0.34	0.26
12.5	3.61	1.91	0.95	0.32	0.23	0.17
13.0	1.83	0.97	0.48	0.16	0.12	0.09
13.5	0.06	0.03	0.01	0.00	0.00	0.00
14.0	0.01	0.01	0.00	0.00	0.00	0.00
14.5	0.01	0.00	0.00	0.00	0.00	0.00

****

TABLE 5 LEVEL OF SERVICE GOALS

****

FIRST: BRIDGE CAPACITY GOALS (TONS)

FUNC	ACCEPTABLE=1	DESIRABLE=2
1	33.6	33.6
2	33.6	33.6
3	33.6	33.6
4	25.0	33.6
5	16.0	33.6
6	16.0	33.6

SECOND: BRIDGE VERTICAL CLEARANCE GOALS (FEET)

FUNC	ACCEPTABLE=1	DESIRABLE=2
1	14.0	16.5
2	14.0	16.5
3	14.0	16.5
4	14.0	15.0
5	14.0	15.0
6	14.0	15.0

THIRD: BRIDGE CLEAR DECK WIDTH GOALS (FEET)

FUNC	ADT	ACCEPTABLE=1		DESIRABLE=2	
		LANE	SHOULDER	LANE	SHOULDER
1	0	10.0	1.0	12.0	4.0
1	801	10.0	2.0	12.0	6.0
1	2001	11.0	2.0	12.0	8.0
1	4001	11.0	3.0	12.0	8.0
2	0	10.0	1.0	12.0	4.0
2	801	10.0	2.0	12.0	6.0
2	2001	11.0	2.0	12.0	8.0
2	4001	11.0	3.0	12.0	8.0
3	0	10.0	1.0	12.0	4.0
3	801	10.0	2.0	12.0	6.0
3	2001	11.0	2.0	12.0	8.0
3	4001	11.0	3.0	12.0	8.0
4	0	9.0	1.0	10.0	2.0
4	801	9.0	2.0	11.0	3.0
4	2001	10.0	2.0	12.0	3.0
4	4001	10.0	3.0	12.0	3.0
5	0	9.0	1.0	10.0	2.0
5	801	9.0	2.0	11.0	3.0
5	2001	10.0	2.0	12.0	3.0
5	4001	10.0	3.0	12.0	3.0

6	0	9.0	1.0	10.0	2.0
6	801	9.0	2.0	11.0	3.0
6	2001	10.0	2.0	12.0	3.0
6	4001	10.0	3.0	12.0	3.0

****
TABLE 6 DECK DETERIORATION RATES (YEARS/POINT).
****

DKMAT	ADT	9.0	8.0	7.0	6.0	5.0
1	0	2.6	5.9	5.6	6.2	4.3
1	201	2.7	6.5	6.3	6.0	4.3
1	801	2.6	6.0	5.8	6.1	4.0
1	2001	3.8	6.1	6.3	5.0	4.3
1	4001	3.8	7.4	5.0	5.1	3.3
2	0	2.8	7.4	6.3	6.5	5.3
2	201	2.8	7.5	7.3	7.3	5.7
2	801	2.7	7.0	7.1	7.7	5.9
2	2001	2.8	6.3	7.0	7.6	6.3
2	4001	3.0	5.3	7.1	7.5	6.0
3	0	3.2	9.2	5.5	4.7	3.5
3	201	2.8	8.7	5.9	5.8	4.2
3	801	3.9	8.0	5.9	5.1	4.5
3	2001	2.0	8.2	5.4	6.1	4.7
3	4001	3.0	7.2	5.5	6.0	4.7

****
TABLE 7 SUPERSTRUCTURE DETERIORATION RATES (YEARS/POINT).
****

SPMAT	SPTYPE	SYS	9.0	8.0	7.0	6.0	5.0
1	1	1	5.0	5.1	6.2	7.2	6.3
1	1	2	2.7	5.6	6.3	6.7	4.6
2	2	1	2.0	5.1	7.1	7.2	5.6
2	2	2	2.0	5.8	6.0	7.7	4.9
2	3	1	3.2	6.0	7.1	8.0	5.5
2	3	2	2.7	7.6	7.5	7.5	5.8
3	4	1	3.0	2.2	9.3	6.5	4.3
3	4	2	3.0	3.4	5.0	7.6	6.9
3	1	1	3.3	8.3	6.5	5.8	4.8
3	1	2	2.7	7.5	7.4	5.9	4.3
3	5	1	3.3	8.3	6.5	5.8	4.8
3	5	2	2.7	7.5	7.4	5.9	4.3
4	1	1	3.9	8.1	6.5	6.2	5.0
4	1	2	3.1	8.4	7.5	6.7	5.2

****
TABLE 8 SUBSTRUCTURE DETERIORATION RATES (YEARS/POINT)
****

SBMAT	AREA	9.0	8.0	7.0	6.0	5.0
1	1	2.3	3.2	4.8	6.7	5.8
1	2	2.4	3.8	5.0	7.1	5.3
1	3	3.3	3.7	5.6	7.3	4.3
2	1	3.1	6.0	6.1	6.4	5.6
2	2	3.2	6.5	7.1	6.9	5.8
2	3	2.9	7.3	6.7	6.4	4.7
3	1	3.3	6.3	6.5	6.5	6.6
3	2	2.8	7.4	7.2	6.7	5.7
3	3	3.1	7.1	7.3	6.1	4.7
4	1	3.1	6.1	6.5	6.9	6.4
4	2	2.4	6.9	7.4	7.0	5.7
4	3	2.8	6.4	7.7	4.7	4.0

****
TABLE 9 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE DECKS AT VARIOUS CONDITION RATINGS ($/SF OF DECK AREA)
****

DKMAT	ADT	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	0	0.000	0.048	0.090	0.128	0.339	0.640	1.187
1	201	0.000	0.055	0.105	0.149	0.339	0.640	1.187
1	801	0.000	0.070	0.131	0.186	0.382	0.720	1.334
1	2001	0.000	0.091	0.171	0.243	0.408	0.769	1.424
1	4001	0.000	0.105	0.197	0.280	0.471	0.886	1.644
2	0	0.000	0.011	0.015	0.021	0.055	0.184	0.440
2	201	0.000	0.012	0.017	0.022	0.057	0.189	0.454
2	801	0.000	0.014	0.019	0.025	0.063	0.214	0.511
2	2001	0.000	0.015	0.021	0.026	0.065	0.217	0.519
2	4001	0.000	0.018	0.023	0.030	0.069	0.229	0.549
3	0	0.000	0.130	0.153	0.177	0.319	0.356	0.395
3	201	0.000	0.141	0.167	0.193	0.319	0.356	0.395
3	801	0.000	0.161	0.190	0.219	0.319	0.356	0.395
3	2001	0.000	0.181	0.214	0.247	0.333	0.371	0.414
3	4001	0.000	0.199	0.235	0.270	0.381	0.426	0.471

****

TABLE 10 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE HANDRAILS AT VARIOUS CONDITION RATINGS ($/LF OF BRIDGE LENGTH)

****

HRMAT	ADT	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	0	0.000	0.044	0.044	0.044	0.070	0.070	0.070
1	201	0.000	0.051	0.051	0.051	0.070	0.070	0.070
1	801	0.000	0.065	0.065	0.065	0.079	0.079	0.079
1	2001	0.000	0.084	0.084	0.084	0.084	0.084	0.084
1	4001	0.000	0.097	0.097	0.097	0.097	0.097	0.097
2	0	0.000	0.117	0.117	0.117	0.175	0.175	0.175
2	201	0.000	0.127	0.127	0.127	0.181	0.181	0.181
2	801	0.000	0.142	0.142	0.142	0.203	0.203	0.203
2	2001	0.000	0.153	0.153	0.153	0.207	0.207	0.207
2	4001	0.000	0.178	0.178	0.178	0.219	0.219	0.219
3	0	0.000	0.059	0.059	0.059	0.094	0.094	0.094
3	201	0.000	0.063	0.063	0.063	0.094	0.094	0.094
3	801	0.000	0.073	0.073	0.073	0.094	0.094	0.094
3	2001	0.000	0.083	0.083	0.083	0.098	0.098	0.098
3	4001	0.000	0.090	0.090	0.090	0.112	0.112	0.112

****

TABLE 11 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE SUPERSTRUCTURE AT VARIOUS CONDITION RATINGS ($/SF OF DECK AREA)

****

SPMAT	SPTYPE	SYS	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	1	1	0.000	0.046	0.072	0.098	0.177	0.214	0.250
1	1	2	0.000	0.040	0.063	0.086	0.167	0.203	0.237
2	2	1	0.000	0.000	0.012	0.079	0.182	0.253	0.320
2	2	2	0.000	0.000	0.010	0.063	0.164	0.226	0.288
2	3	1	0.000	0.000	0.011	0.075	0.224	0.309	0.395
2	3	2	0.000	0.000	0.011	0.072	0.179	0.248	0.317
3	4	1	0.000	0.010	0.052	0.094	0.160	0.210	0.259
3	4	2	0.000	0.007	0.040	0.073	0.160	0.210	0.259
3	1	1	0.000	0.008	0.047	0.086	0.166	0.218	0.269
3	1	2	0.000	0.007	0.037	0.068	0.153	0.200	0.247
3	5	1	0.000	0.008	0.047	0.086	0.166	0.218	0.269
3	5	2	0.000	0.007	0.037	0.068	0.153	0.200	0.247
4	1	1	0.000	0.000	0.004	0.022	0.035	0.055	0.077
4	1	2	0.000	0.000	0.004	0.021	0.035	0.055	0.077

****
TABLE 12 ANNUAL MAINTENANCE UNIT COSTS FOR BRIDGE SUBSTRUCTURES AT VARIOUS CONDITION RATINGS ($/SF OF DECK AREA).
****

SBMAT	IAREA	9.0	8.0	7.0	6.0	5.0	4.0	3.0
1	1	0.000	0.167	0.170	0.174	0.283	0.288	0.295
1	2	0.000	0.144	0.148	0.150	0.215	0.219	0.225
1	3	0.000	0.155	0.157	0.161	0.258	0.264	0.269
2	1	0.000	0.000	0.030	0.091	0.240	0.337	0.433
2	2	0.000	0.000	0.021	0.062	0.171	0.240	0.308
2	3	0.000	0.000	0.026	0.080	0.177	0.247	0.317
3	1	0.000	0.000	0.033	0.080	0.173	0.236	0.299
3	2	0.000	0.000	0.022	0.052	0.142	0.195	0.246
3	3	0.000	0.000	0.029	0.070	0.137	0.188	0.237
4	1	0.000	0.000	0.008	0.033	0.079	0.112	0.145
4	2	0.000	0.000	0.006	0.022	0.063	0.090	0.116
4	3	0.000	0.000	0.008	0.030	0.090	0.128	0.203

****
TABLE 13 AVERAGE REHABILITATION WORK (MAN-HOURS/SF OF DECK AREA)
****

1. TIMBER DECK

0.0738					
0.1143	0.0905				
0.1548	0.1310	0.1072			
0.1953	0.1715	0.1477	0.1239		
0.2358	0.2120	0.1882	0.1644	0.1406	
0.2763	0.2525	0.2287	0.2049	0.1811	0.1573

2. TIMBER SUPERSTRUCTURE

0.0407					
0.1034	0.0588				
0.1661	0.1215	0.0769			
0.2288	0.1842	0.1396	0.0950		
0.2915	0.2469	0.2023	0.1577	0.1131	
0.3542	0.3096	0.2650	0.2204	0.1758	0.1312

3. TIMBER SUBSTRUCTURE

0.1033					
0.2038	0.1073				
0.3043	0.2078	0.1113			
0.4048	0.3083	0.2118	0.1153		
0.5053	0.4088	0.3123	0.2158	0.1193	
0.6058	0.5093	0.4128	0.3163	0.2198	0.1233

```
4. REINFORCED CONCRETE DECK
   ------------------------
  0.0603
  0.1622 0.1109
  0.2641 0.2128 0.1615
  0.3660 0.3147 0.2634 0.2121
  0.4679 0.4166 0.3653 0.3140 0.2627
  0.5698 0.5185 0.4672 0.4159 0.3646 0.3313

5. REINFORCED CONCRETE SUPERSTRUCTURE
   ----------------------------------
  0.2470
  0.3355 0.2810
  0.4240 0.3695 0.3150
  0.5125 0.4580 0.4035 0.3490
  0.6010 0.5465 0.4920 0.4375 0.3830
  0.6895 0.6350 0.5805 0.5260 0.4715 0.4170

6. REINFORCED CONCRETE SUBSTRUCTURE
   --------------------------------
  0.0413
  0.1418 0.0651
  0.2423 0.1656 0.0889
  0.3428 0.2661 0.1894 0.1127
  0.4433 0.3666 0.2899 0.2132 0.1365
  0.5438 0.4671 0.3904 0.3137 0.2370 0.1603

7. STEEL DECK
   ----------
  0.0603
  0.1622 0.1109
  0.2641 0.2128 0.1615
  0.3660 0.3147 0.2623 0.2121
  0.4679 0.4166 0.3653 0.3140 0.2627
  0.5698 0.5185 0.4672 0.4159 0.3646 0.3133

8. STEEL SUPERSTRUCTURE
   --------------------
  0.2470
  0.3355 0.2810
  0.4240 0.3695 0.3150
  0.5125 0.4580 0.4035 0.3490
  0.6010 0.5465 0.4920 0.4375 0.3830
  0.6895 0.6350 0.5805 0.5260 0.4715 0.4170

9. STEEL SUBSTRUCTURE
   ------------------
  0.0413
  0.1418 0.0651
  0.2423 0.1656 0.0889
  0.3428 0.2661 0.1894 0.1127
  0.4433 0.3666 0.2899 0.2132 0.1365
  0.5438 0.4671 0.3904 0.3137 0.2370 0.1603
```

****

TABLE 14 LOAD CAPACITY DETERIORATION (TONS/YEAR).

****

CR	TIMBER=1	CONCRETE=2	STEEL=3
1	1.00	0.50	0.50
2	1.00	0.50	0.50
3	1.00	0.50	0.50
4	0.50	0.30	0.30
5	0.30	0.20	0.20
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00

****

TABLE 15 LOAD CAPACITY RECOVERY DUE TO REHABILITATION (TONS).

****

CR	TIMBER=1	CONCRETE=2	STEEL=3
1	5.00	5.00	5.00
2	5.00	5.00	5.00
3	5.00	5.00	5.00
4	3.00	2.00	2.00
5	1.00	1.00	1.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00

****

TABLE 16 GOALS FOR NUMBER OF LANES

****

FIRST: ONE-WAY BRIDGE TRAFFIC

AVERAGE DAILY TRAFFIC (ADT) ON THE BRIDGE (VEHICLES/DAY)	ACCEPTABLE	DESIRABLE
0 - 3000	1	1
3001 - 5000	1	2
5001 - 15000	2	2
15001 - 22500	2	3
22501 - 27500	3	3
27501 - 35000	3	4
OVER 35000	4	4

SECOND: TWO-WAY BRIDGE TRAFFIC

AVERAGE DAILY TRAFFIC (ADT) ON THE BRIDGE (VEHICLES/DAY)	ACCEPTABLE	DESIRABLE
0 - 6000	2 OR 3	2 OR 3
6001 - 10000	2 OR 3	4 OR 5
10001 - 30000	4 OR 5	4 OR 5
30001 - 45000	4 OR 5	6 OR 7

45001 - 55000	6 OR 7	6 OR 7
55001 - 70000	6 OR 7	8
OVER 70000	8	8

EXAMPLE: AN EXISTING BRIDGE WITH TWO-WAY TRAFFIC AND ADT EXPECTED TO BE 31,000 IN 20 YEARS IS REPLACED WITH: (1) A 6-LANE BRIDGE IF THE CURRENT NUMBER OF LANES IS EVEN, OR (2) A 7-LANE BRIDGE IF THE CURRENT NUMBER OF LANES IS ODD. IN ALL CASES, THE NEW BRIDGE SHOULD HAVE NO LESS THAN THE CURRENT NUMBER OF LANES.

****
OTHER PARAMETERS
****

	UNIT COSTS OF REHABILITATION ($/MAN-HOUR)		
MATERIAL TYPE	DECK	SUPERSTRUCTURE	SUBSTRUCTURE
TIMBER	40.59	44.42	41.11
REINFORCED CONCRETE	40.59	44.42	40.08
STEEL	38.97	44.42	34.20
PRESTRESSED CONCRETE	40.59	44.42	40.08

OPERATING COST FOR VEHICLE WEIGHING 3 TONS OR LESS
UD3 = $ 0.60 / MILE

OPERATING COST FOR VEHICLE WEIGHING THE MAXIMUM LEGAL LOAD
UDNB = $ 1.95 / MILE

MAXIMUM LEGAL LOAD OR NON-POSTED SINGLE-VEHICLE CAPACITY,
NP = 33.60 TONS

NON-POSTED TRUCK-TRACTOR-SEMITRAILER CAPACITY,
NPTT = 36.75 TONS

COEFFICIENTS TO COMPUTE ACCIDENT COSTS,
ACCA = 63.
ACCB = 6.5
ACOSTC = 110906.
ACOSTW = 110906.
ACCU(1) = 7000000.
ACCU(2) = 37000000.
ACCU(3) = 37000000.
ACCU(4) = 8000000.
ACCU(5) = 8000000.
ACCU(6) = 1000000.

ADDITIONAL FACTOR FOR DROP IN CONDITION RATINGS AND LOAD CAPACITY FOR NO ROUTINE MAINTENANCE VERSUS COMPLETE ROUTINE MAINTENANCE,
DROPMN = 0.2

12.7. Update Worksheets

12.7-1 Vehicle Operating Cost Update Worksheet

Vehicle Operating Cost	
Under 3 Tons	IRS Standard Mileage Rate= ______ www.irs.gov NCDOT Vehicle Operator I (7102) + minimum salary= ______ /(1920hours*40 mph)= ______ www.ncdot.org Under 3 Ton Vehicle Operating Cost= COSTPARM.DAT variable UD3= [ ]
Tractor-Trailer	U.S. Census Bureau Service Annual Survey (NAICS classification 484) www.census.gov Estimated Revenue by Size of Shipments, Commodities Handled, and Origin and Destination of Shipments for Employer Firms= ______ Estimated Number of Truck Miles Traveled by Employer Firms= ÷ ______ Tractor-Trailer Operating Cost= COSTPARM.DAT variable UDNB= [ ]

12.7-2 Vehicle Accident Costs Update Worksheet

Vehicle Accident Cost	Federal Highway Aministration or National Safety Council "Willingness-to-Pay" Approach			
	www.fhwa.dot.gov	or	www.nsc.org	
	Fatal	________	* 0.02=	________
	Injury A	________	* 0.13=	________
	Injury B	________	* 0.20=	________
	Injury C	________	* 0.34=	________
	Property Damage			________
	Total	COSTPARM.DAT variable ACOSTA and ACOSTW=		[ ]

12.7-3 Rehabilitation Costs Update Worksheet

Unit Cost	Report (NCDOT): Statewide Bridge Maintenance Cost by System Fiscal Y-T-D thru 06-30-___						
Function Codes			Secondary				
		Primary	Paved	Unpaved	Urban	Total	
561	Total YTD Cost						
	Units Accomplished						
	Total YTD Cost/Units Accomplished=						
			Secondary				
		Primary	Paved	Unpaved	Urban	Total	
562	Total YTD Cost						
	Units Accomplished						
	Total YTD Cost/Units Accomplished=						
			Secondary				
		Primary	Paved	Unpaved	Urban	Total	
578	Total YTD Cost						
	Units Accomplished						
	Total YTD Cost/Units Accomplished=						
			Secondary				
		Primary	Paved	Unpaved	Urban	Total	
580	Total YTD Cost						
	Units Accomplished						
	Total YTD Cost/Units Accomplished=						
			Secondary				
		Primary	Paved	Unpaved	Urban	Total	
582	Total YTD Cost						
	Units Accomplished						
	Total YTD Cost/Units Accomplished=						
			Secondary				
		Primary	Paved	Unpaved	Urban	Total	
581	Total YTD Cost						
	Units Accomplished						
	Function Code 581 & 583 are combined						
			Secondary				
		Primary	Paved	Unpaved	Urban	Total	Total for 581 & 583
583	Total YTD Cost						
	Units Accomplished						
	Total YTD Cost/Units Accomplished=						