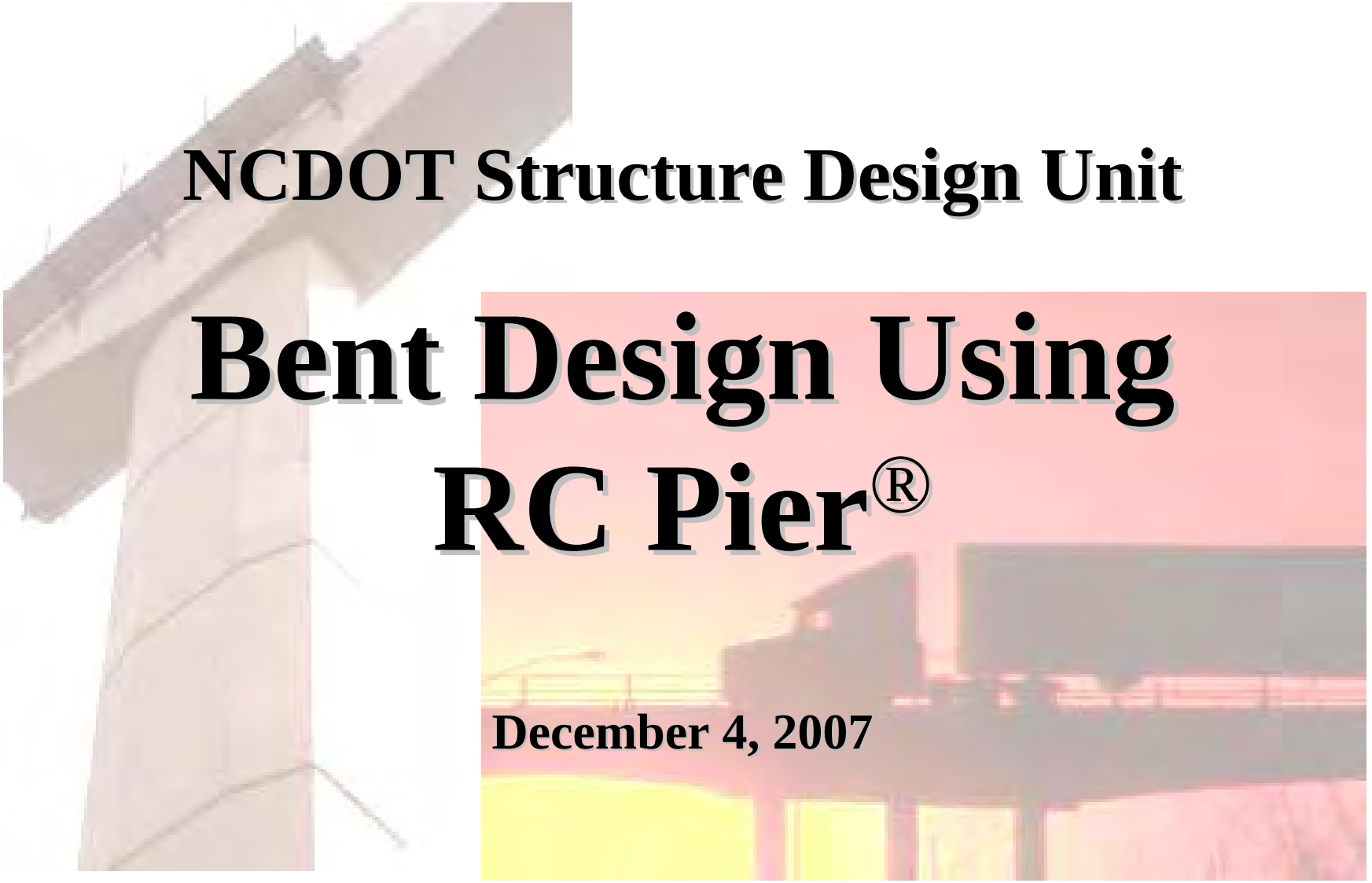


STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

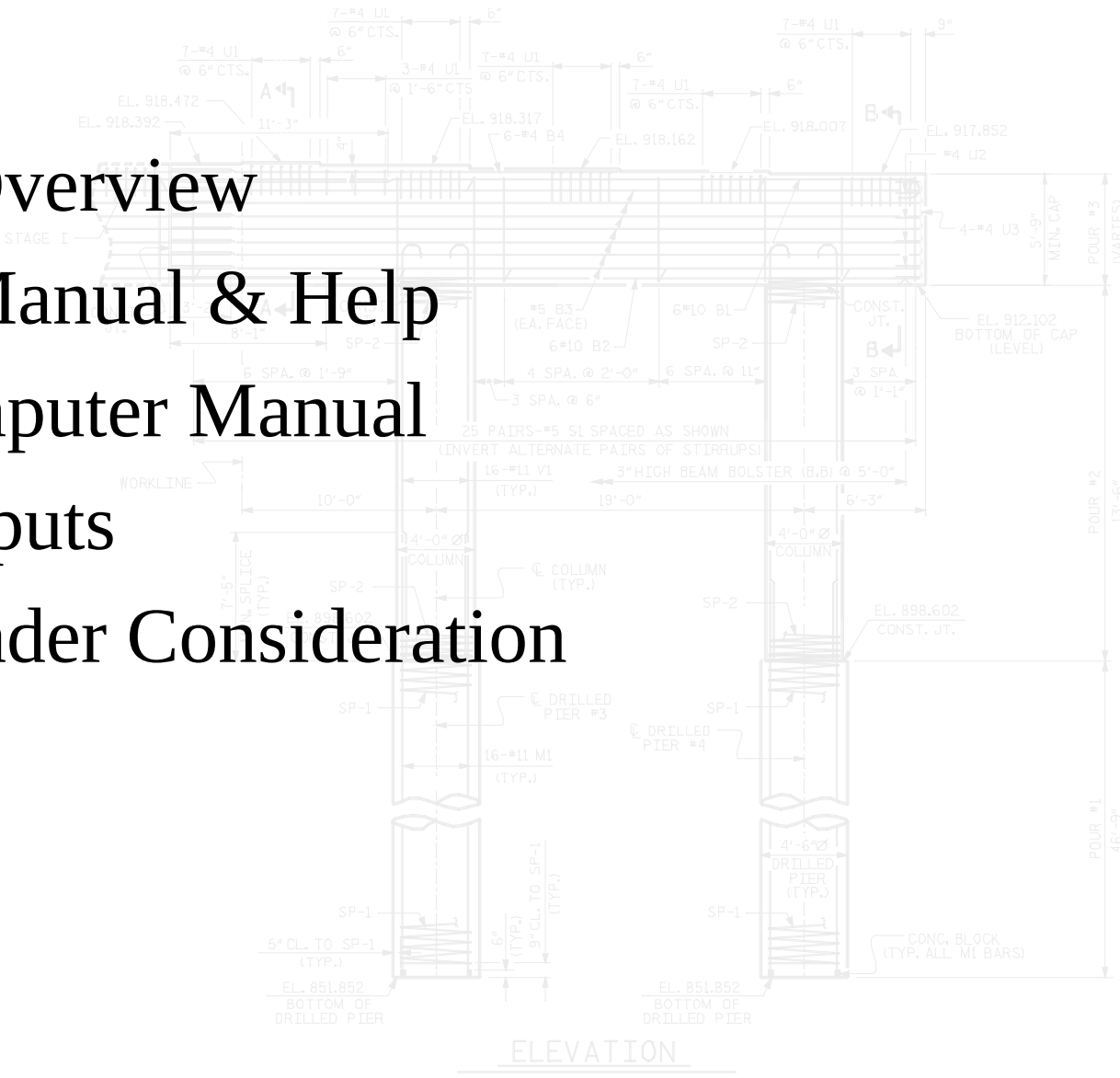
NCDOT Structure Design Unit

Bent Design Using RC Pier®

December 4, 2007

Agenda

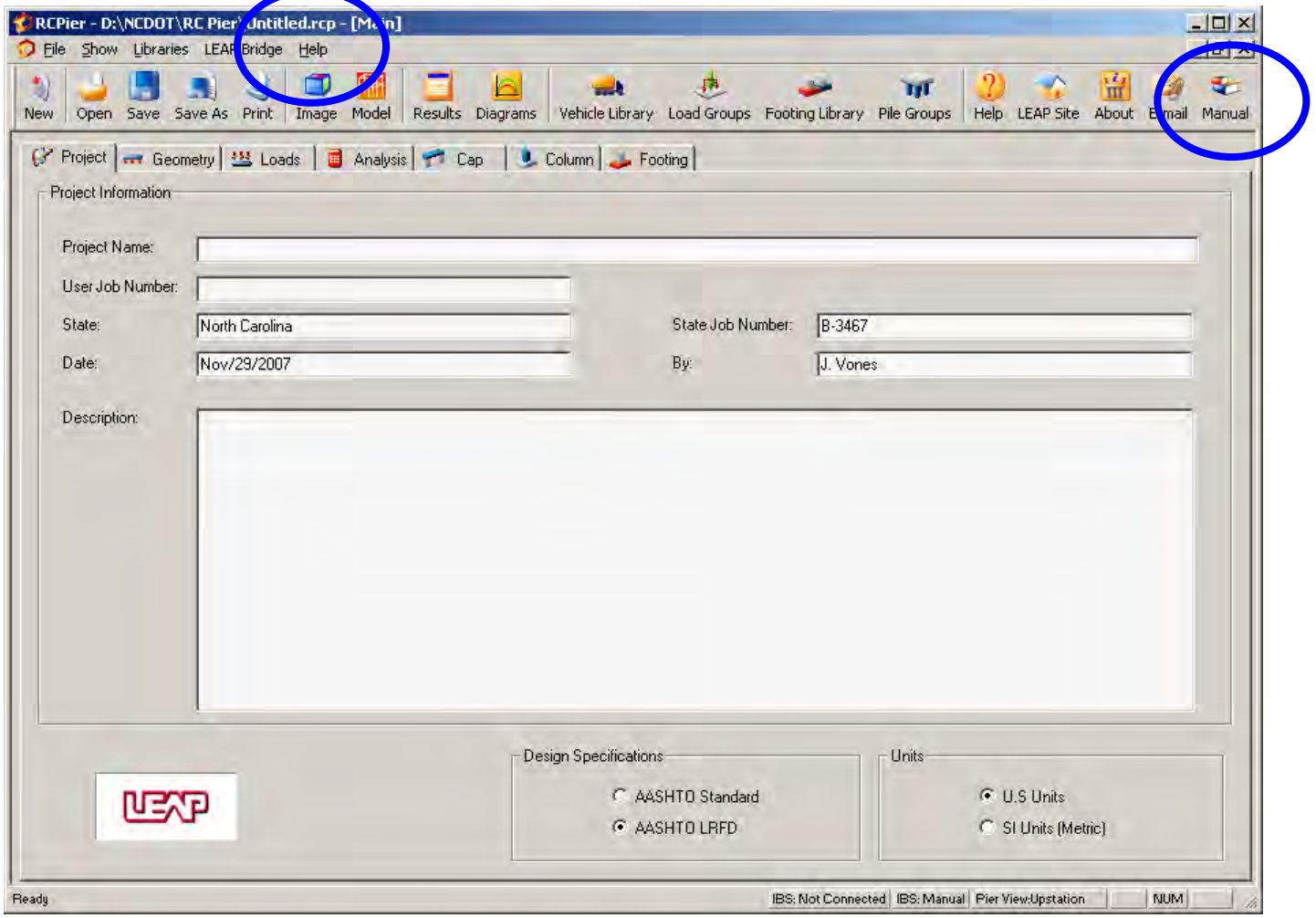
- RC Pier Overview
- RC Pier Manual & Help
- SDU Computer Manual
- Project Inputs
- Topics Under Consideration



RC Pier Overview

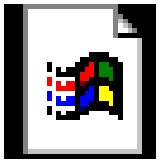
- Commercially available software
  - Pros and Cons
  - No direct interface with NCBDS
- Analysis Engine
- Design “intent” of RC Pier
- LRFD design capability
- Anticipated future capabilities

RC Pier Manual & Help



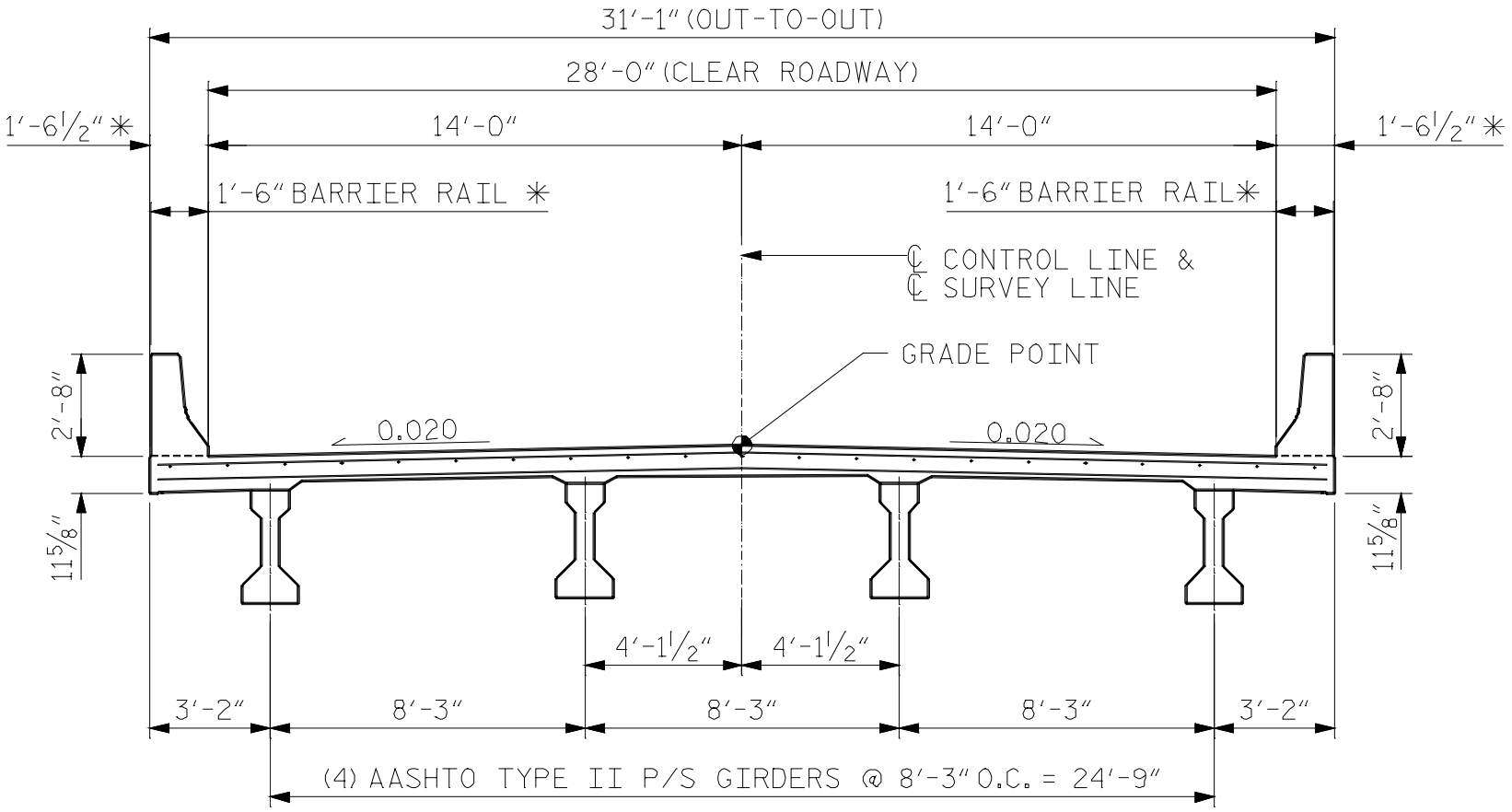
SDU Computer Manual

S:\Share\Computer Manual

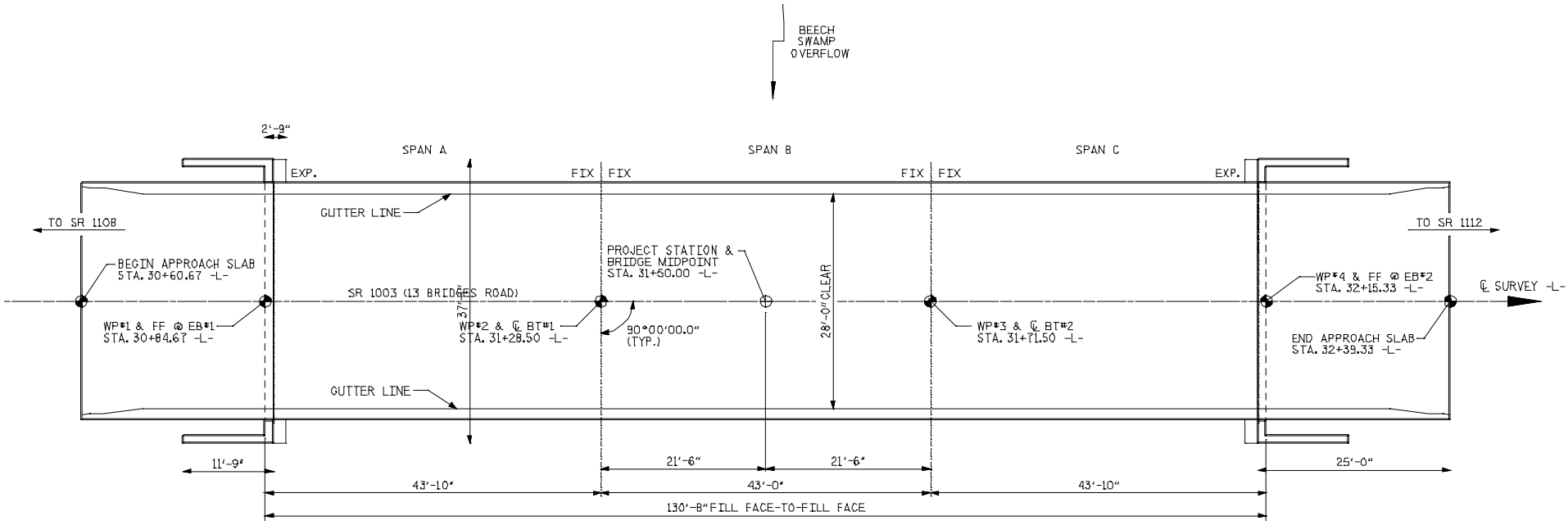


Shortcut to NCBDS Manual 14 - RC Pier.pdf.lnk

B-3467 Typical Section



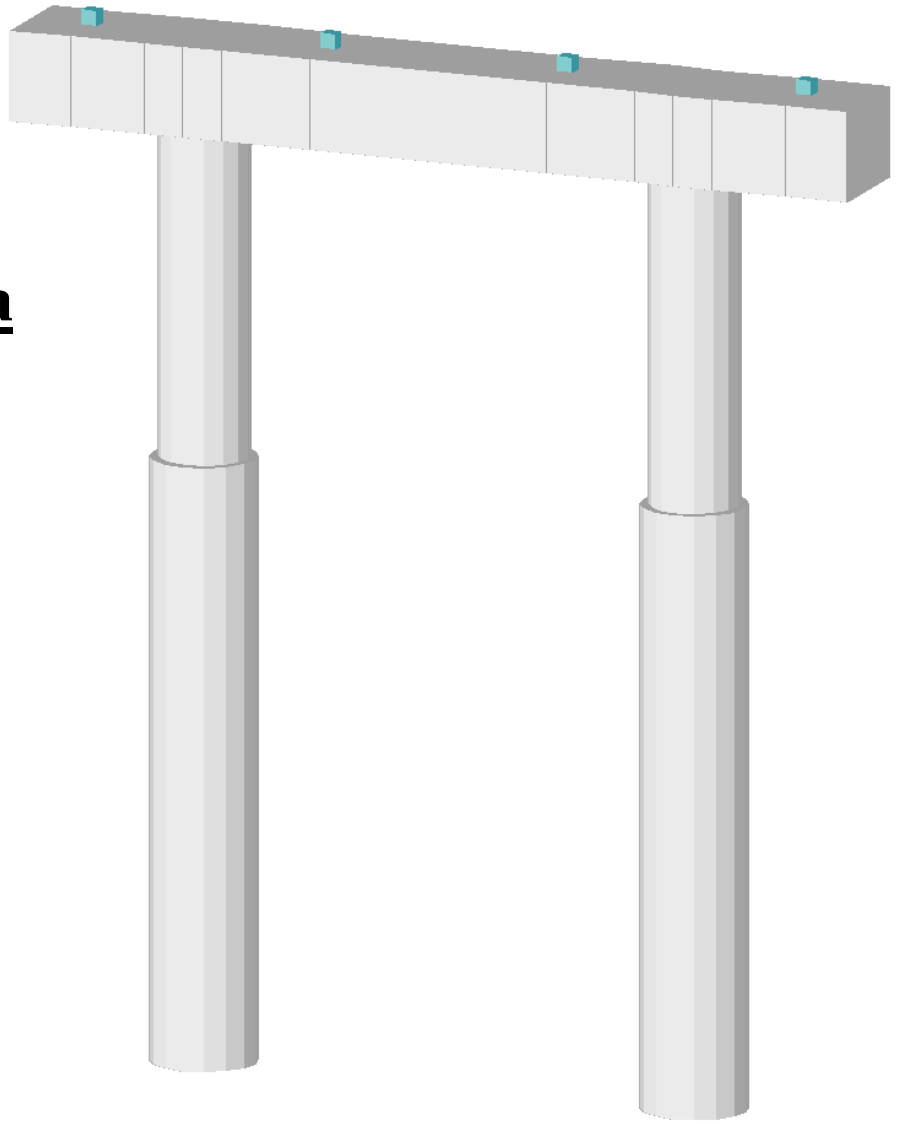
B-3467 Layout



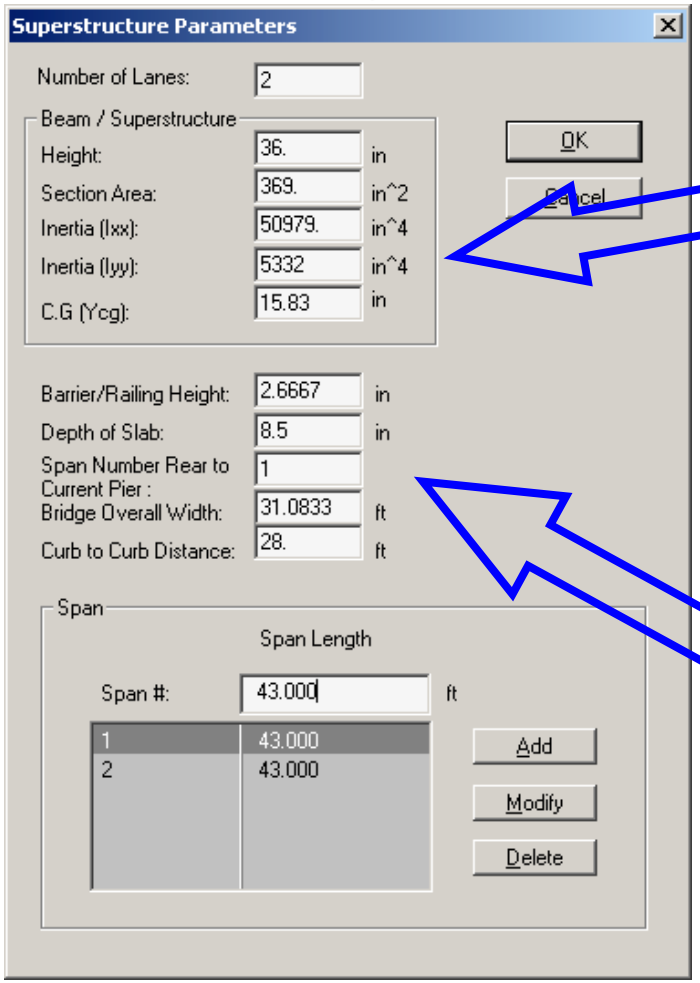
BRIDGE LAYOUT

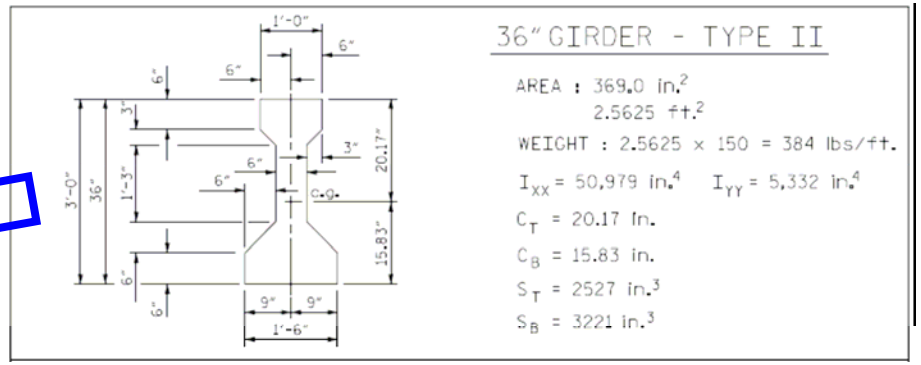
Proposed Bent Data

Cap Length: 29’-0”
Cap Width: 3’-8”
Cap Depth: 3’-0”
Column Diameter: 3’-0”
Shaft Diameter: 3’-6”
Column Spacing: 17’-0”



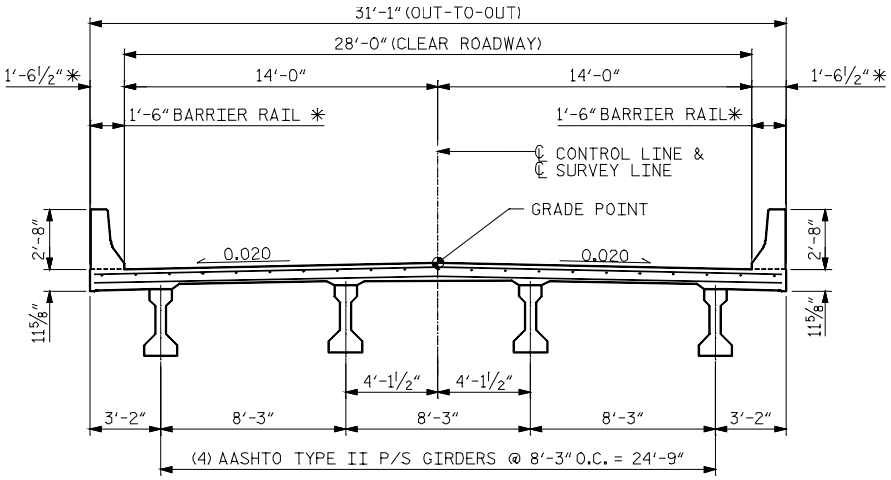
Geometry - Superstructure



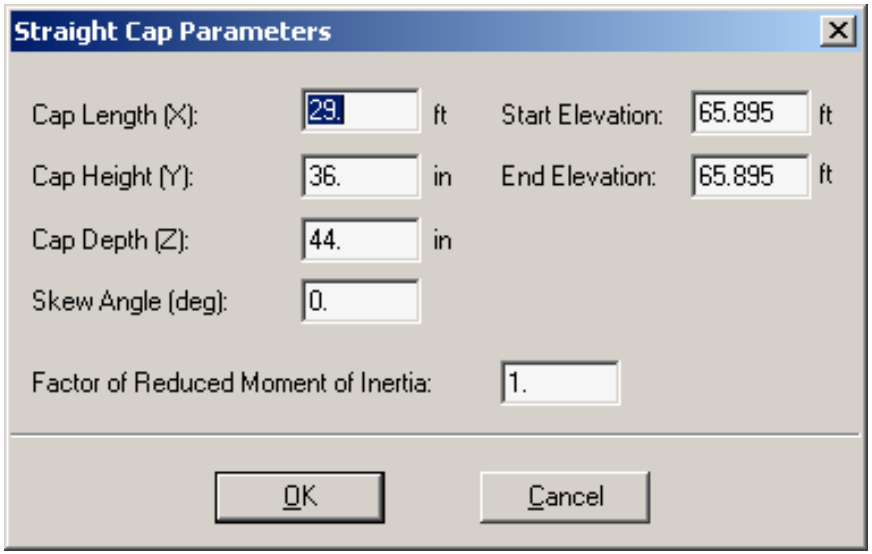


DIMENSIONS, AREA, & DESIGN DATA OF PRESTRESSED CONCRETE GIRDERS

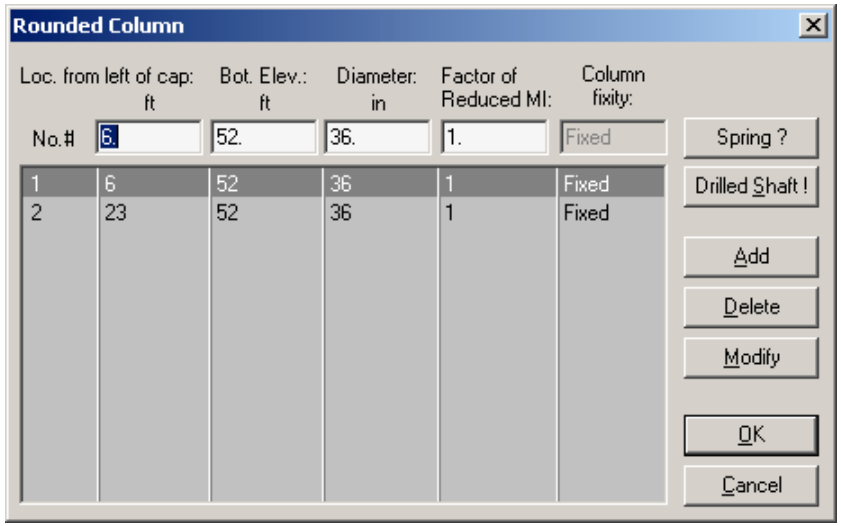
FIGURE 6 – 66

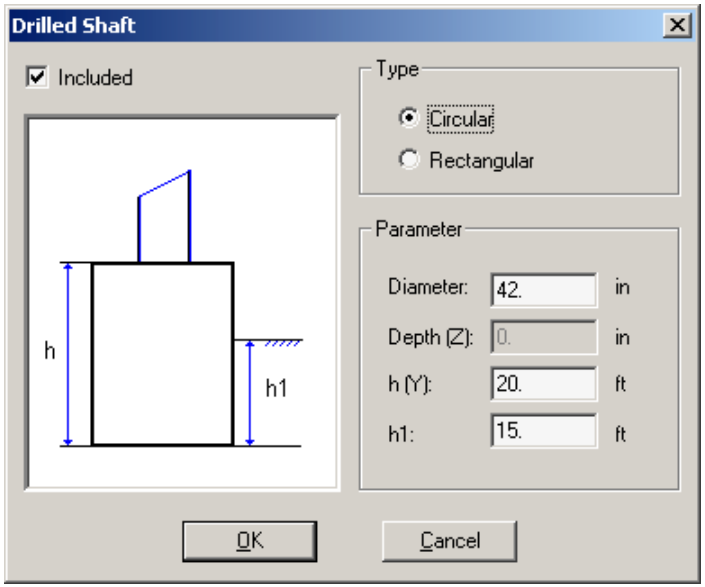


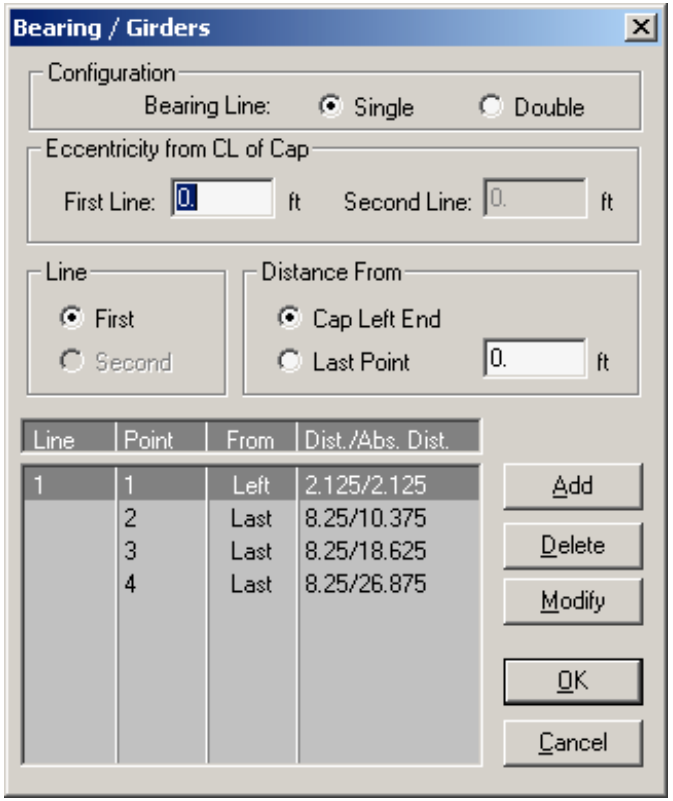
Geometry - Cap

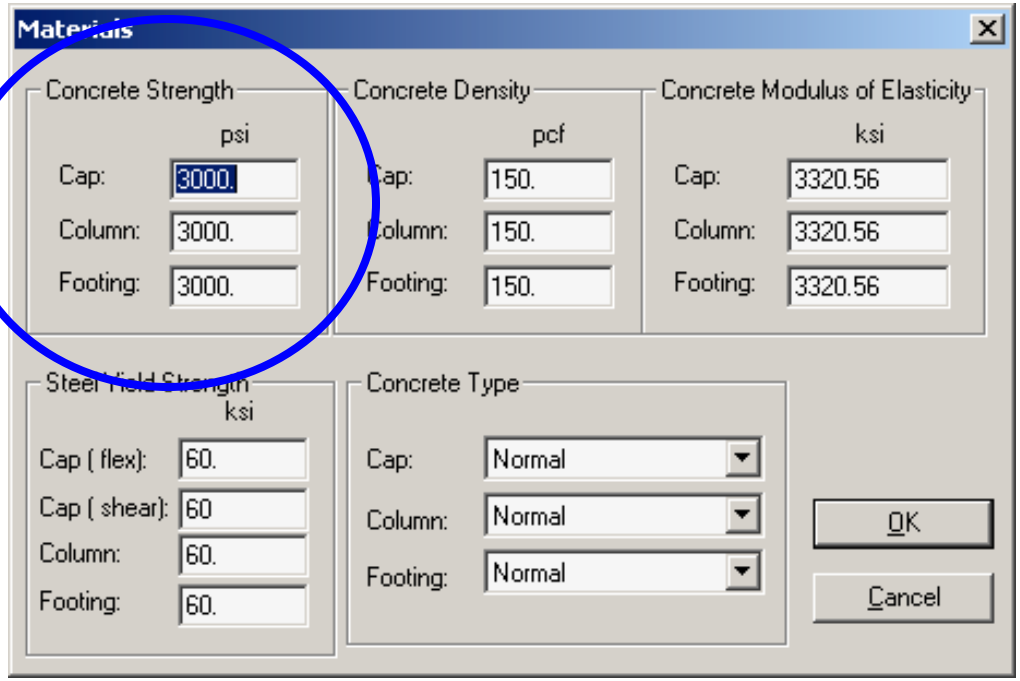


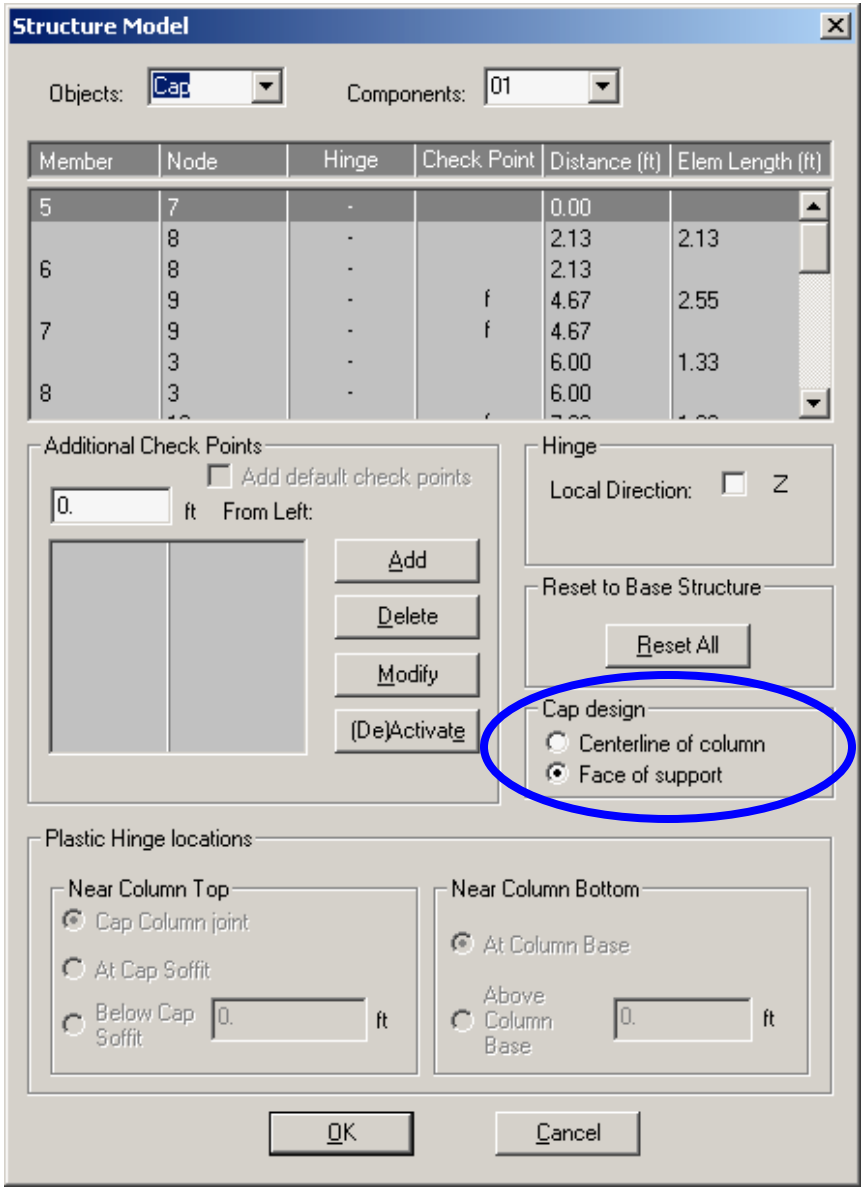
Geometry - Column

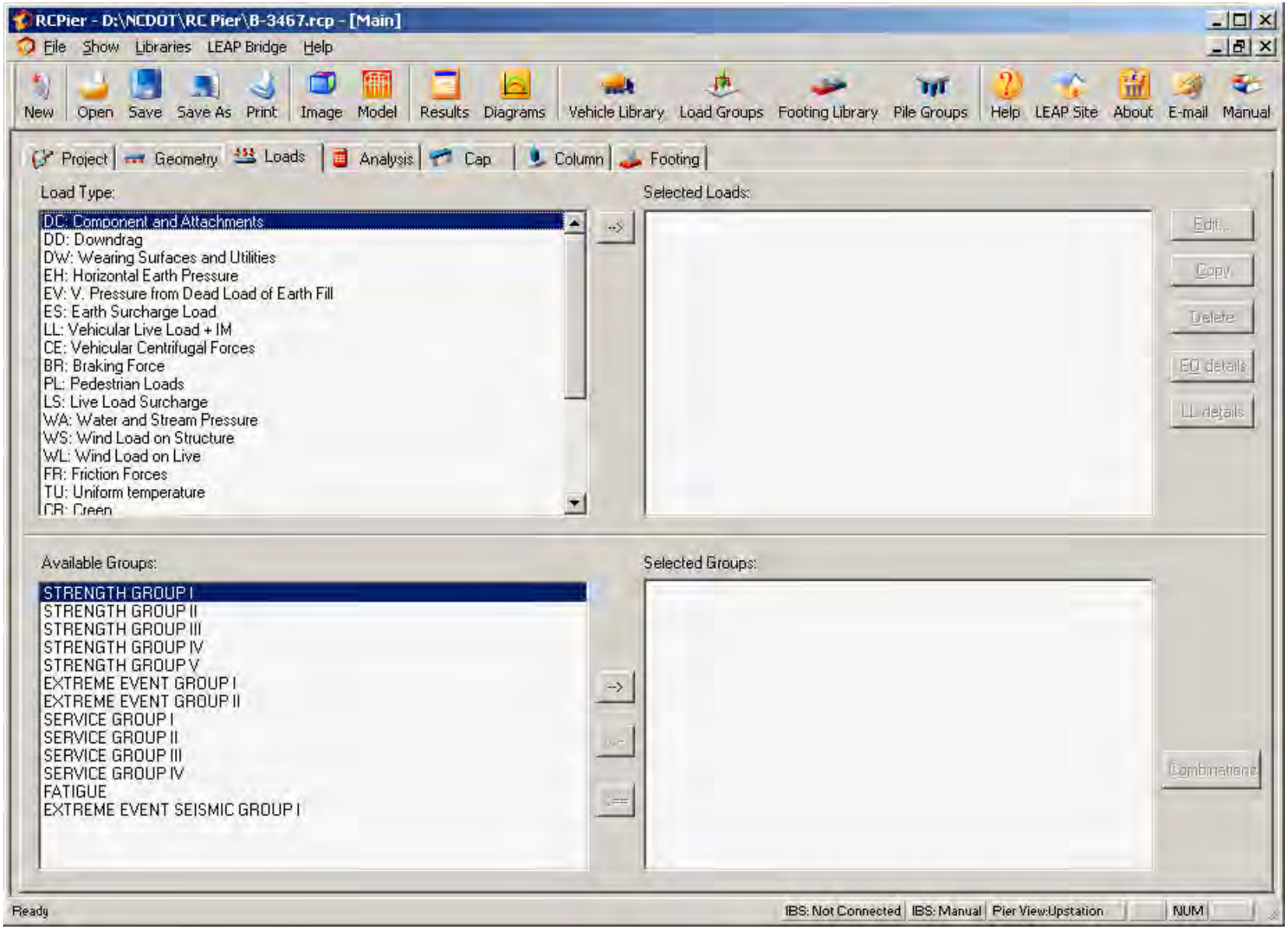


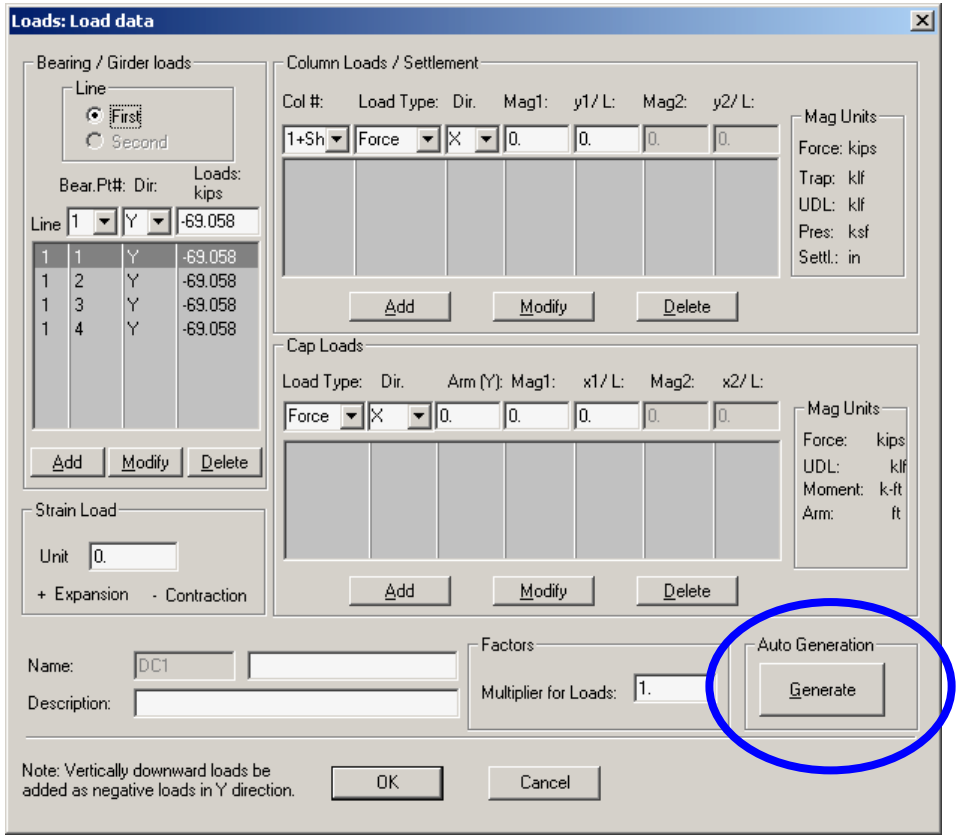


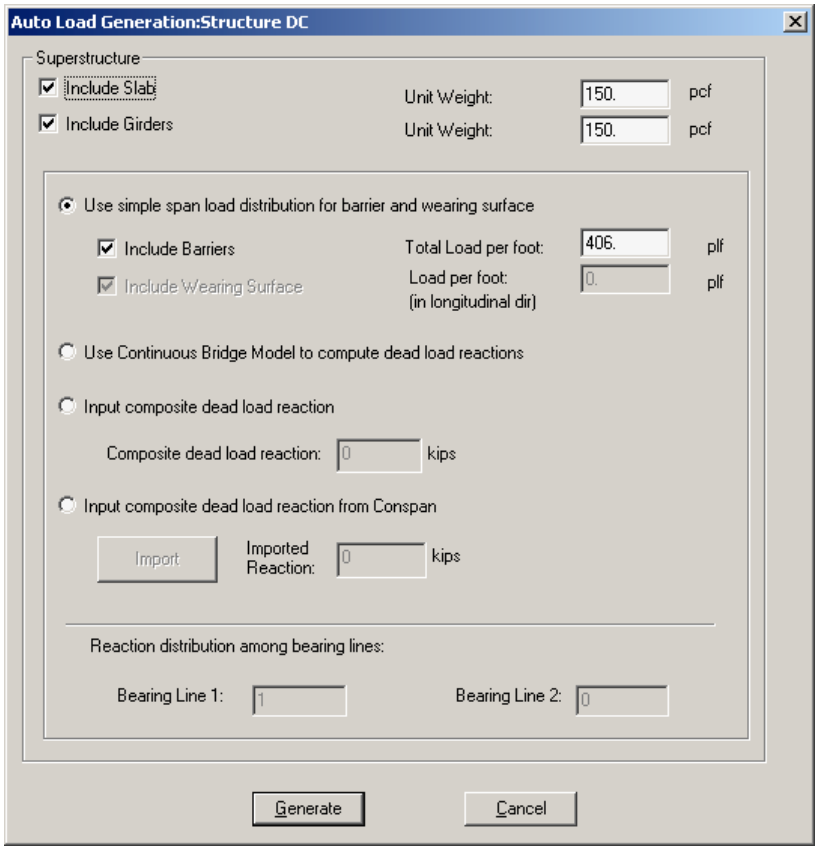

Bearing / Girders
Configuration
Bearing Line: Single Double
Eccentricity from CL of Cap
First Line: 0. ft
Second Line: 0. ft
Line
First
Second
Distance From
Cap Left End
Last Point 0. ft
Line Point From Dist./Abs. Dist.
1 1 Left 2.125/2.125
2 Last 8.25/10.375
3 Last 8.25/18.625
4 Last 8.25/26.875
Add
Delete
Modify
OK
Cancel

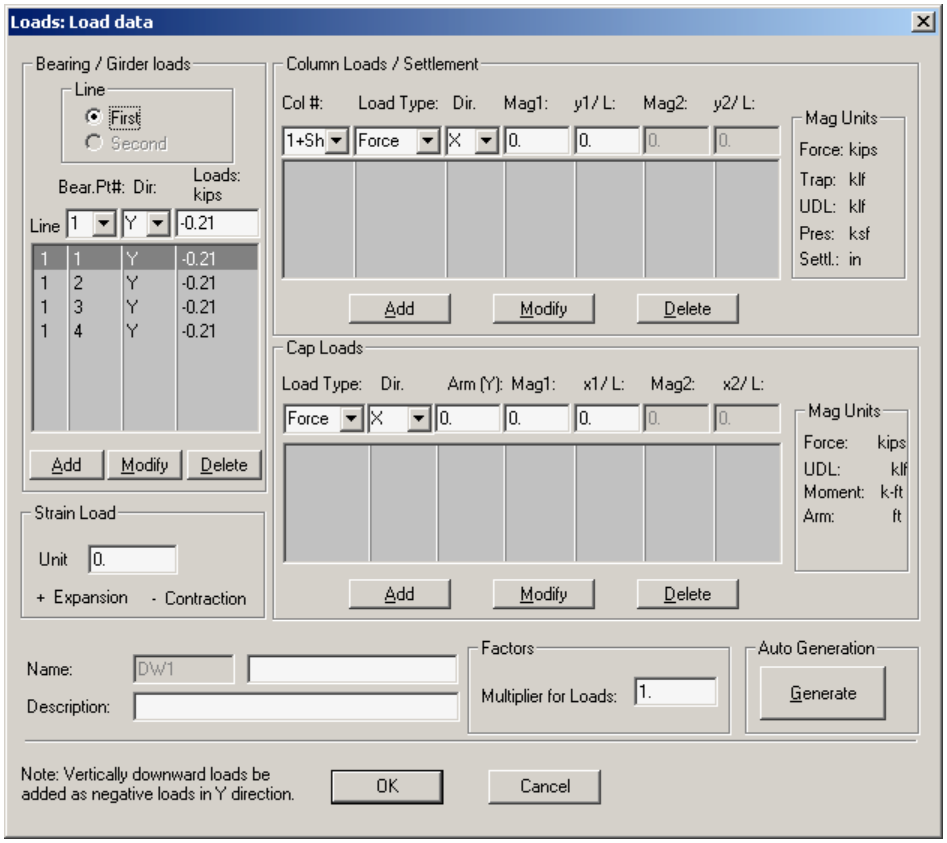

Materials
Concrete Strength
psi
Cap: 3000.
Column: 3000.
Footing: 3000.
Concrete Density
pcf
Cap: 150.
Column: 150.
Footing: 150.
Concrete Modulus of Elasticity
ksi
Cap: 3320.56
Column: 3320.56
Footing: 3320.56
Steel Yield Strength
ksi
Cap (flex): 60.
Cap (shear): 60
Column: 60.
Footing: 60.
Concrete Type
Cap: Normal
Column: Normal
Footing: Normal
OK
Cancel

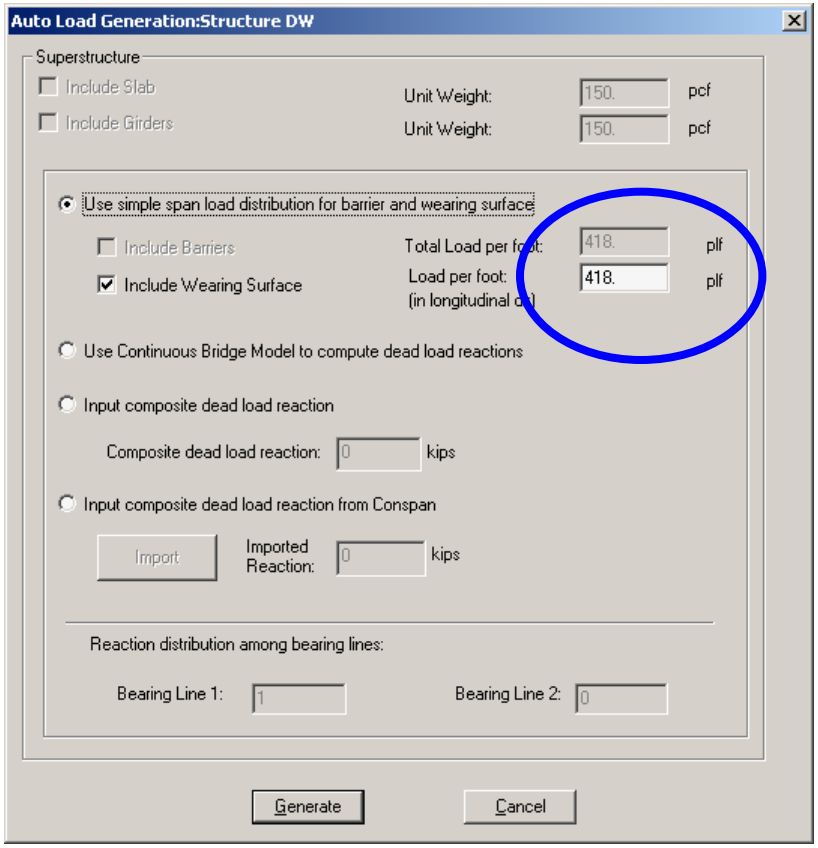

Structure Model
Objects: Cap
Components: 01
Member
Node
Hinge
Check Point
Distance (ft)
Elem Length (ft)
5 7 - 0.00
8 - 2.13 2.13
6 8 - 2.13
9 - f 4.67 2.55
7 9 - f 4.67
3 - 6.00 1.33
8 3 - 6.00
Additional Check Points
Add default check points
0. ft From Left:
Add
Delete
Modify
(De)Activate
Hinge
Local Direction: Z
Reset to Base Structure
Reset All
Cap design
Centerline of column
Face of support
Plastic Hinge locations
Near Column Top
Cap Column joint
At Cap Soffit
Below Cap Soffit 0. ft
Near Column Bottom
At Column Base
Above Column Base 0. ft
OK
Cancel

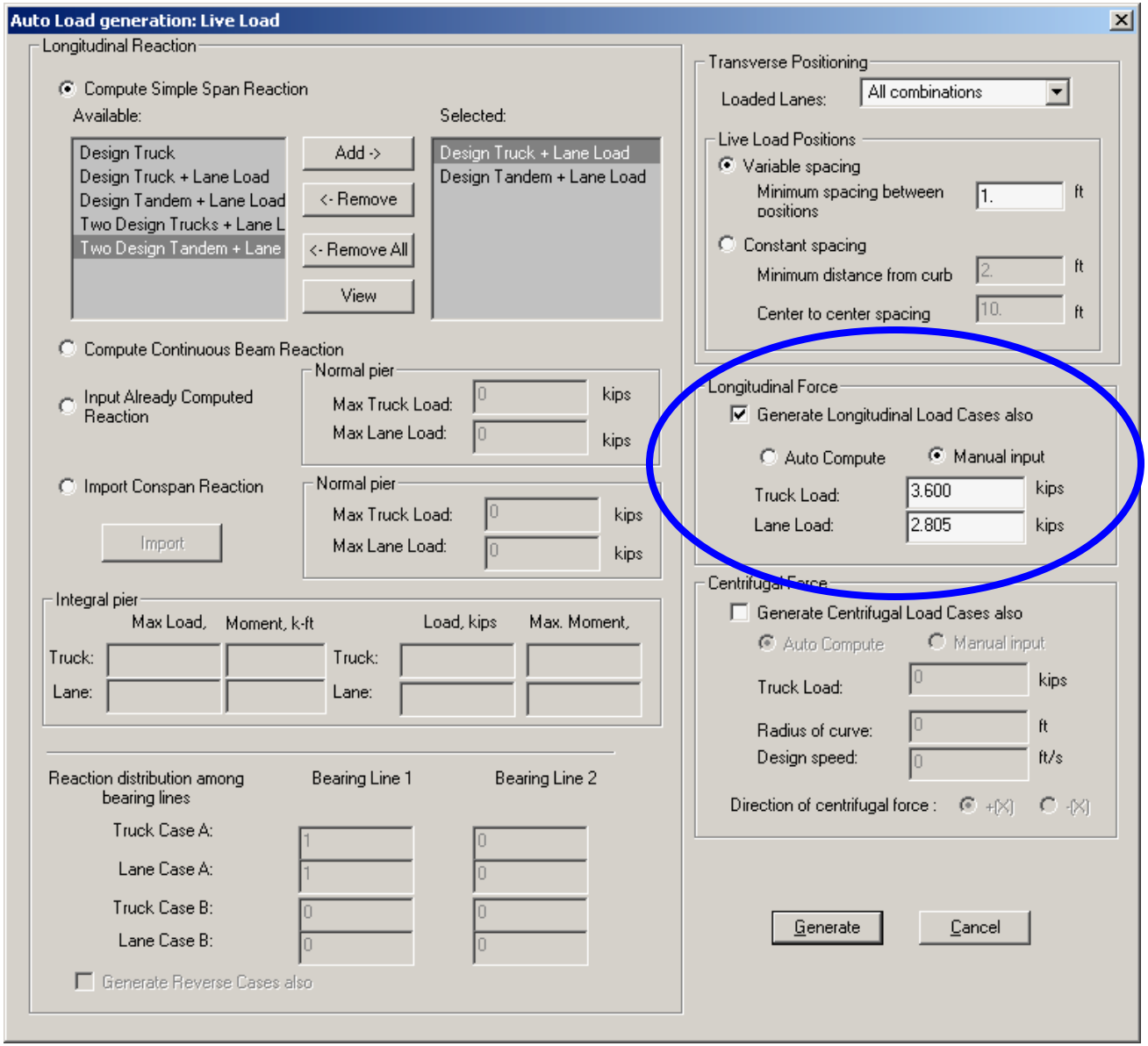

RCPier - D:\NCDOT\RC Pier\B-3467.rcp - [Main]
File Show Libraries LEAP Bridge Help
New Open Save Save As Print Image Model Results Diagrams Vehicle Library Load Groups Footing Library Pile Groups Help LEAP Site About E-mail Manual
Project Geometry Loads Analysis Cap Column Footing
Load Type:
DC: Component and Attachments
DD: Downdrag
DW: Wearing Surfaces and Utilities
EH: Horizontal Earth Pressure
EV: V. Pressure from Dead Load of Earth Fill
ES: Earth Surcharge Load
LL: Vehicular Live Load + IM
CE: Vehicular Centrifugal Forces
BR: Braking Force
PL: Pedestrian Loads
LS: Live Load Surcharge
WA: Water and Stream Pressure
WS: Wind Load on Structure
WL: Wind Load on Live
FR: Friction Forces
TU: Uniform temperature
CR: Creep
Selected Loads:
Edit...
Copy
Delete
EQ details
LL details
Available Groups:
STRENGTH GROUP I
STRENGTH GROUP II
STRENGTH GROUP III
STRENGTH GROUP IV
STRENGTH GROUP V
EXTREME EVENT GROUP I
EXTREME EVENT GROUP II
SERVICE GROUP I
SERVICE GROUP II
SERVICE GROUP III
SERVICE GROUP IV
FATIGUE
EXTREME EVENT SEISMIC GROUP I
Selected Groups:
Combinations
Ready
IBS: Not Connected
IBS: Manual
Pier View:Upstation
NUM

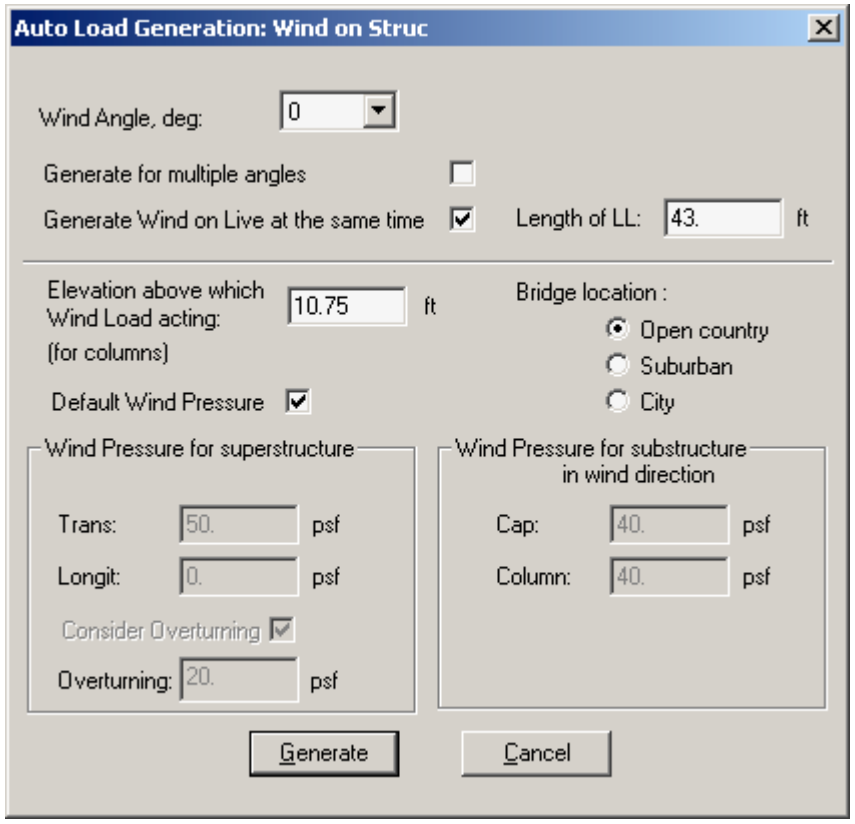

Loads: Load data
Bearing / Girder loads
Line
First
Second
Bear.Pt#: Dir: Loads: kips
Line 1 Y -69.058
1 1 Y -69.058
1 2 Y -69.058
1 3 Y -69.058
1 4 Y -69.058
Add Modify Delete
Strain Load
Unit 0.
+ Expansion - Contraction
Column Loads / Settlement
Col #: Load Type: Dir. Mag1: y1/ L: Mag2: y2/ L:
1+Sh Force X 0. 0. 0. 0.
Add Modify Delete
Mag Units
Force: kips
Trap: klf
UDL: klf
Pres: ksf
Settl.: in
Cap Loads
Load Type: Dir. Arm (Y): Mag1: x1/ L: Mag2: x2/ L:
Force X 0. 0. 0. 0. 0.
Add Modify Delete
Mag Units
Force: kips
UDL: klf
Moment: k-ft
Arm: ft
Name: DC1
Description:
Factors
Multiplier for Loads: 1.
Auto Generation
Generate
Note: Vertically downward loads be added as negative loads in Y direction.
OK
Cancel

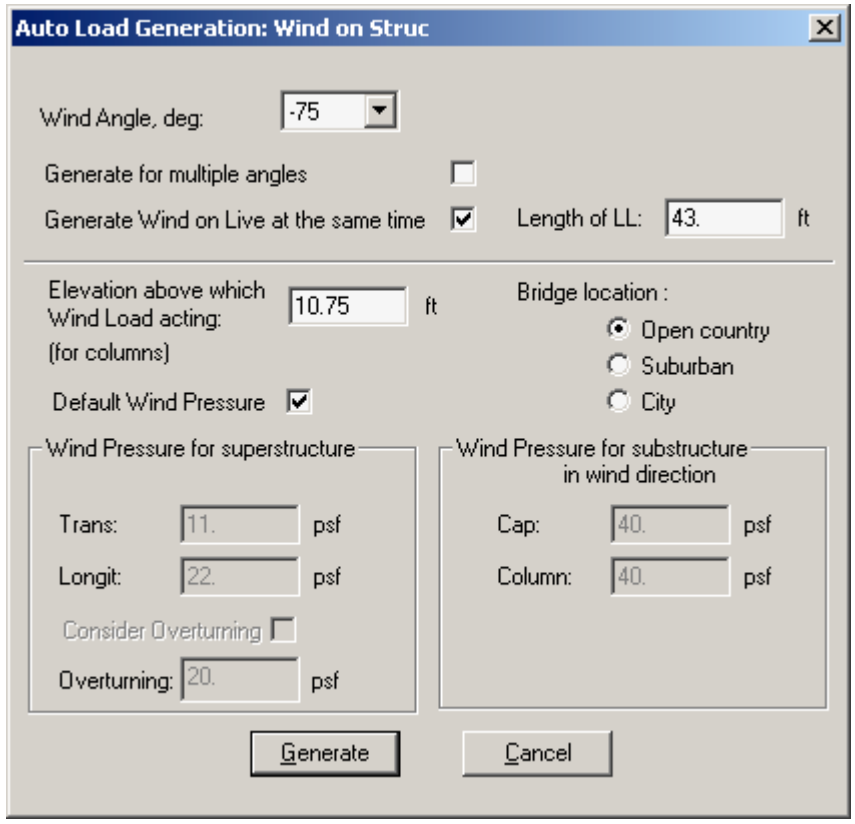

Auto Load Generation:Structure DC
Superstructure
Include Slab
Unit Weight: 150. pcf
Include Girders
Unit Weight: 150. pcf
Use simple span load distribution for barrier and wearing surface
Include Barriers
Total Load per foot: 406. plf
Include Wearing Surface
Load per foot: (in longitudinal dir) 0. plf
Use Continuous Bridge Model to compute dead load reactions
Input composite dead load reaction
Composite dead load reaction: 0 kips
Input composite dead load reaction from Conspan
Import
Imported Reaction: 0 kips
Reaction distribution among bearing lines:
Bearing Line 1: 1
Bearing Line 2: 0
Generate
Cancel

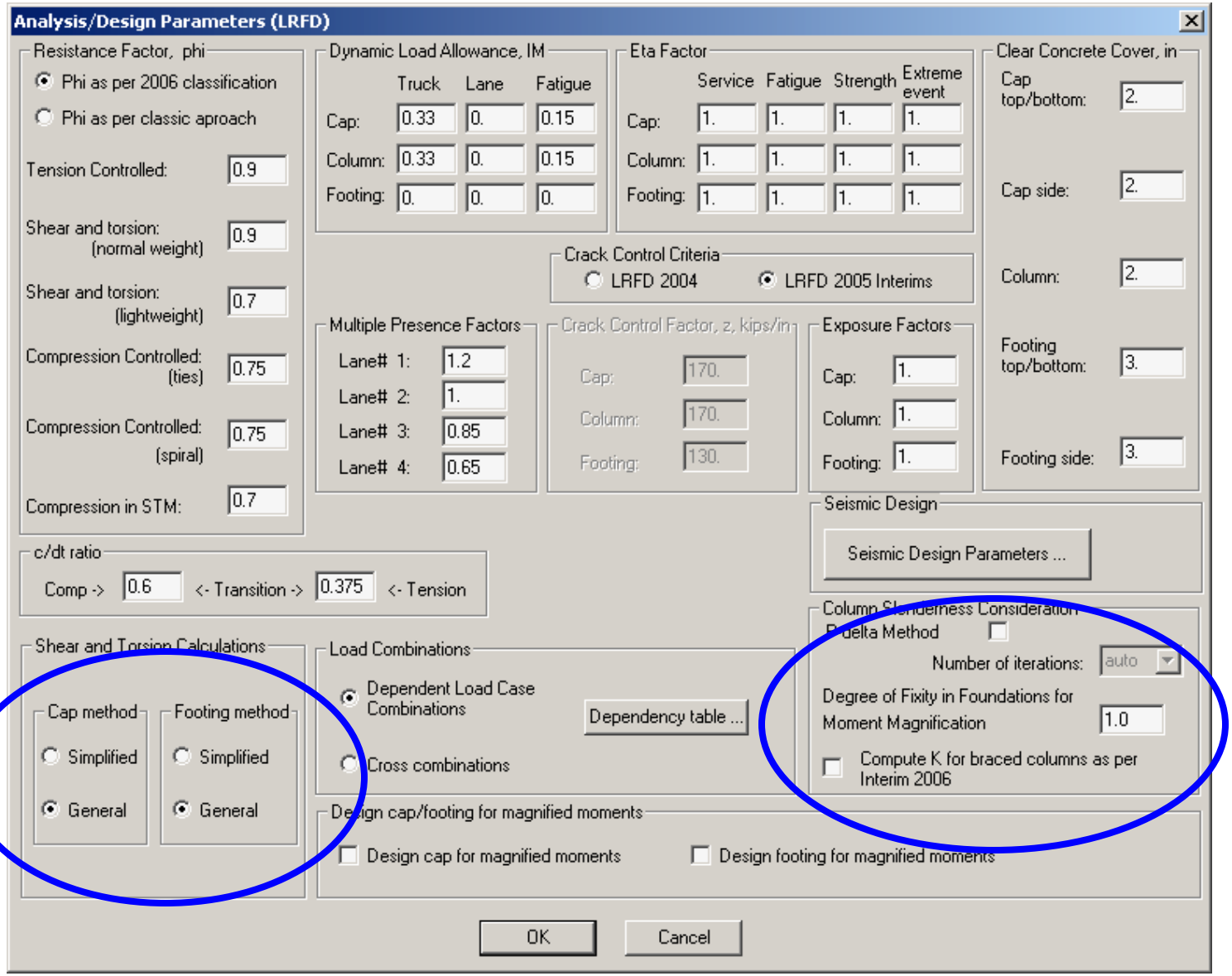

Loads: Load data
Bearing / Girder loads
Line
First
Second
Bear.Pt#: Dir: Loads: kips
Line 1 Y -0.21
1 1 Y -0.21
1 2 Y -0.21
1 3 Y -0.21
1 4 Y -0.21
Add Modify Delete
Strain Load
Unit 0.
+ Expansion - Contraction
Column Loads / Settlement
Col #: Load Type: Dir. Mag1: y1/L: Mag2: y2/L:
1+Sh Force X 0. 0. 0. 0.
Add Modify Delete
Mag Units
Force: kips
Trap: klf
UDL: klf
Pres: ksf
Settl.: in
Cap Loads
Load Type: Dir. Arm (Y): Mag1: x1/L: Mag2: x2/L:
Force X 0. 0. 0. 0. 0.
Add Modify Delete
Mag Units
Force: kips
UDL: klf
Moment: k-ft
Arm: ft
Name: DW1
Description:
Factors
Multiplier for Loads: 1.
Auto Generation
Generate
Note: Vertically downward loads be added as negative loads in Y direction.
OK
Cancel

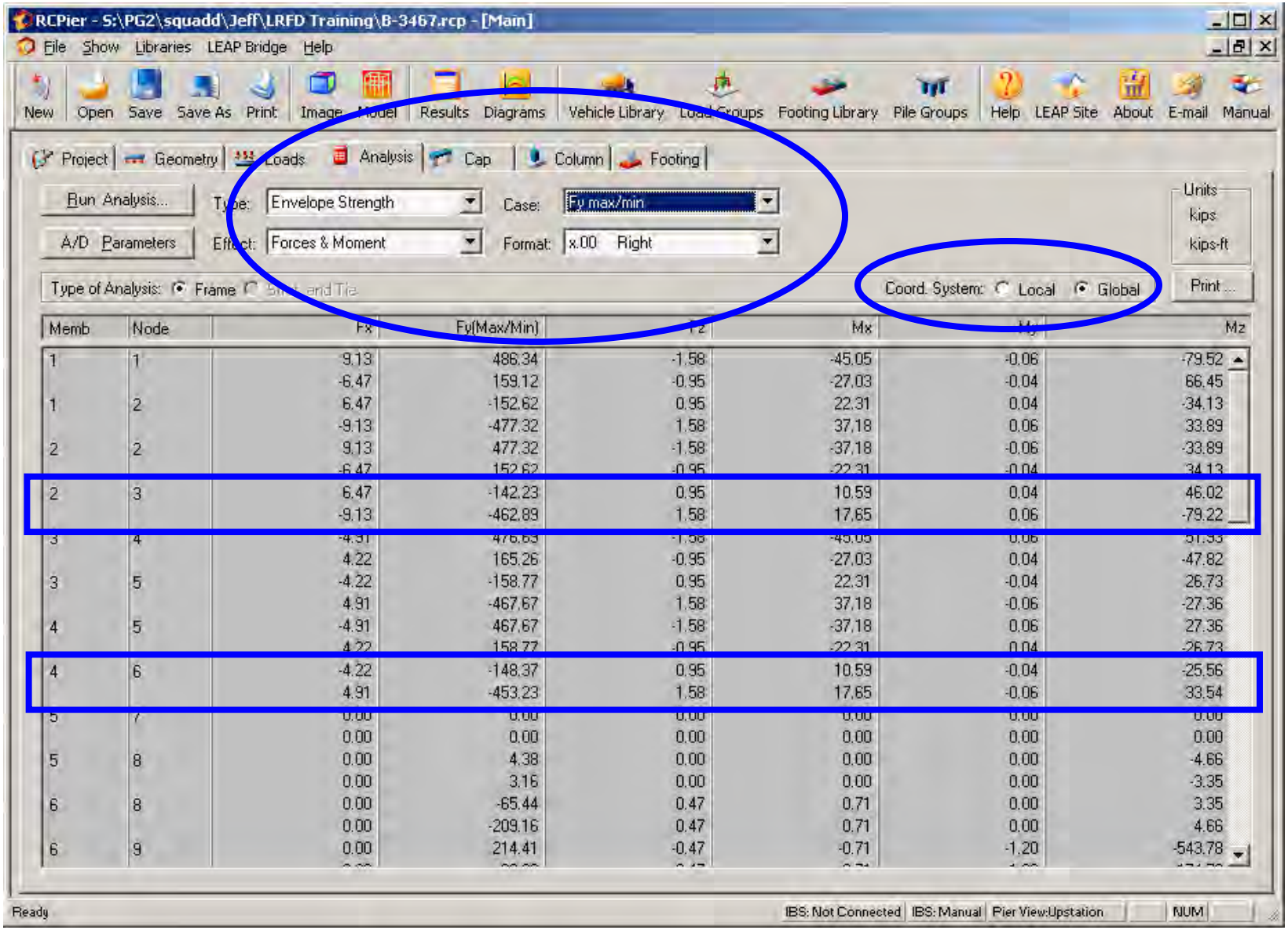

Auto Load Generation:Structure DW
Superstructure
Include Slab
Unit Weight: 150. pcf
Include Girders
Unit Weight: 150. pcf
Use simple span load distribution for barrier and wearing surface
Include Barriers
Total Load per foot: 418. plf
Include Wearing Surface
Load per foot: 418. plf
(in longitudinal dir.)
Use Continuous Bridge Model to compute dead load reactions
Input composite dead load reaction
Composite dead load reaction: 0 kips
Input composite dead load reaction from Conspan
Import
Imported Reaction: 0 kips
Reaction distribution among bearing lines:
Bearing Line 1: 1
Bearing Line 2: 0
Generate
Cancel

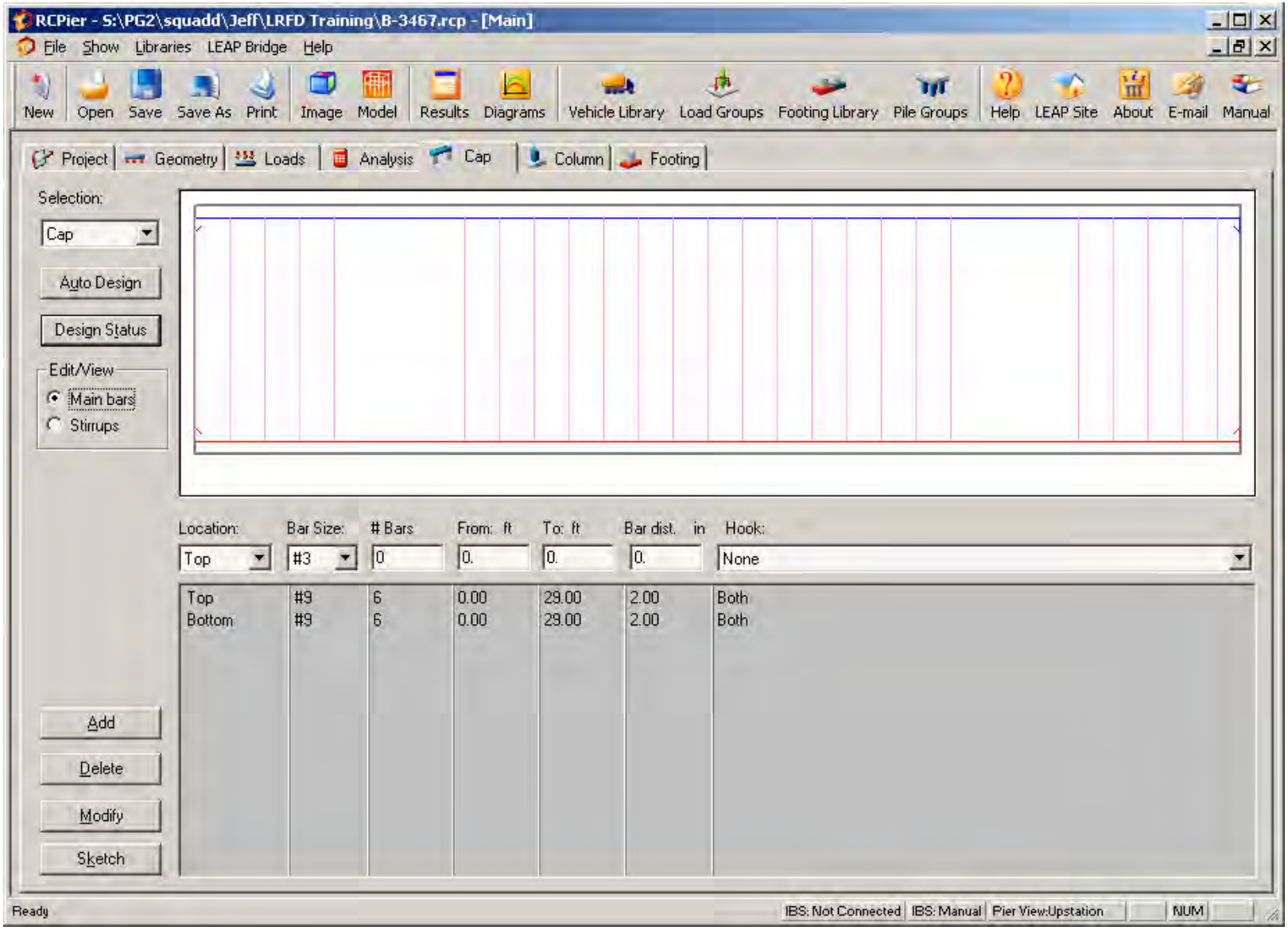

Auto Load generation: Live Load
Longitudinal Reaction
Compute Simple Span Reaction
Available:
Design Truck
Design Truck + Lane Load
Design Tandem + Lane Load
Two Design Trucks + Lane L
Two Design Tandem + Lane
Add ->
<- Remove
<- Remove All
View
Selected:
Design Truck + Lane Load
Design Tandem + Lane Load
Compute Continuous Beam Reaction
Input Already Computed Reaction
Normal pier
Max Truck Load: 0 kips
Max Lane Load: 0 kips
Import Conspan Reaction
Import
Normal pier
Max Truck Load: 0 kips
Max Lane Load: 0 kips
Integral pier
Max Load, Moment, k-ft
Load, kips Max. Moment,
Truck:
Lane:
Truck:
Lane:
Reaction distribution among bearing lines
Bearing Line 1
Bearing Line 2
Truck Case A: 1 0
Lane Case A: 1 0
Truck Case B: 0 0
Lane Case B: 0 0
Generate Reverse Cases also
Transverse Positioning
Loaded Lanes: All combinations
Live Load Positions
Variable spacing
Minimum spacing between positions 1. ft
Constant spacing
Minimum distance from curb 2. ft
Center to center spacing 10. ft
Longitudinal Force
Generate Longitudinal Load Cases also
Auto Compute
Manual input
Truck Load: 3.600 kips
Lane Load: 2.805 kips
Centrifugal Force
Generate Centrifugal Load Cases also
Auto Compute
Manual input
Truck Load: 0 kips
Radius of curve: 0 ft
Design speed: 0 ft/s
Direction of centrifugal force : +(X) -(X)
Generate
Cancel

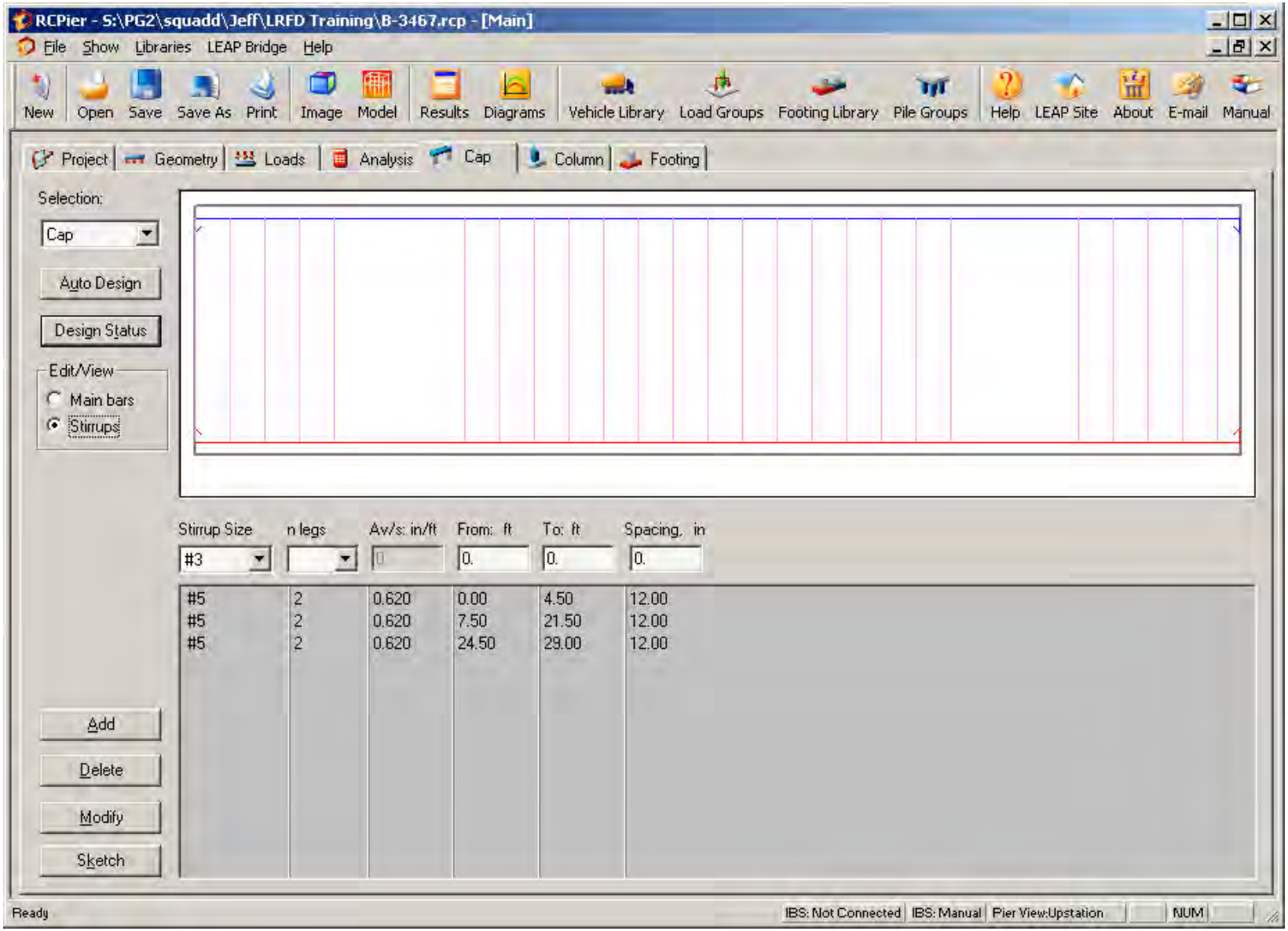

Auto Load Generation: Wind on Struc
Wind Angle, deg: 0
Generate for multiple angles
Generate Wind on Live at the same time
Length of LL: 43. ft
Elevation above which Wind Load acting: 10.75 ft
(for columns)
Bridge location :
Open country
Suburban
City
Default Wind Pressure
Wind Pressure for superstructure
Trans: 50. psf
Longit: 0. psf
Consider Overturning
Overturning: 20. psf
Wind Pressure for substructure in wind direction
Cap: 40. psf
Column: 40. psf
Generate
Cancel

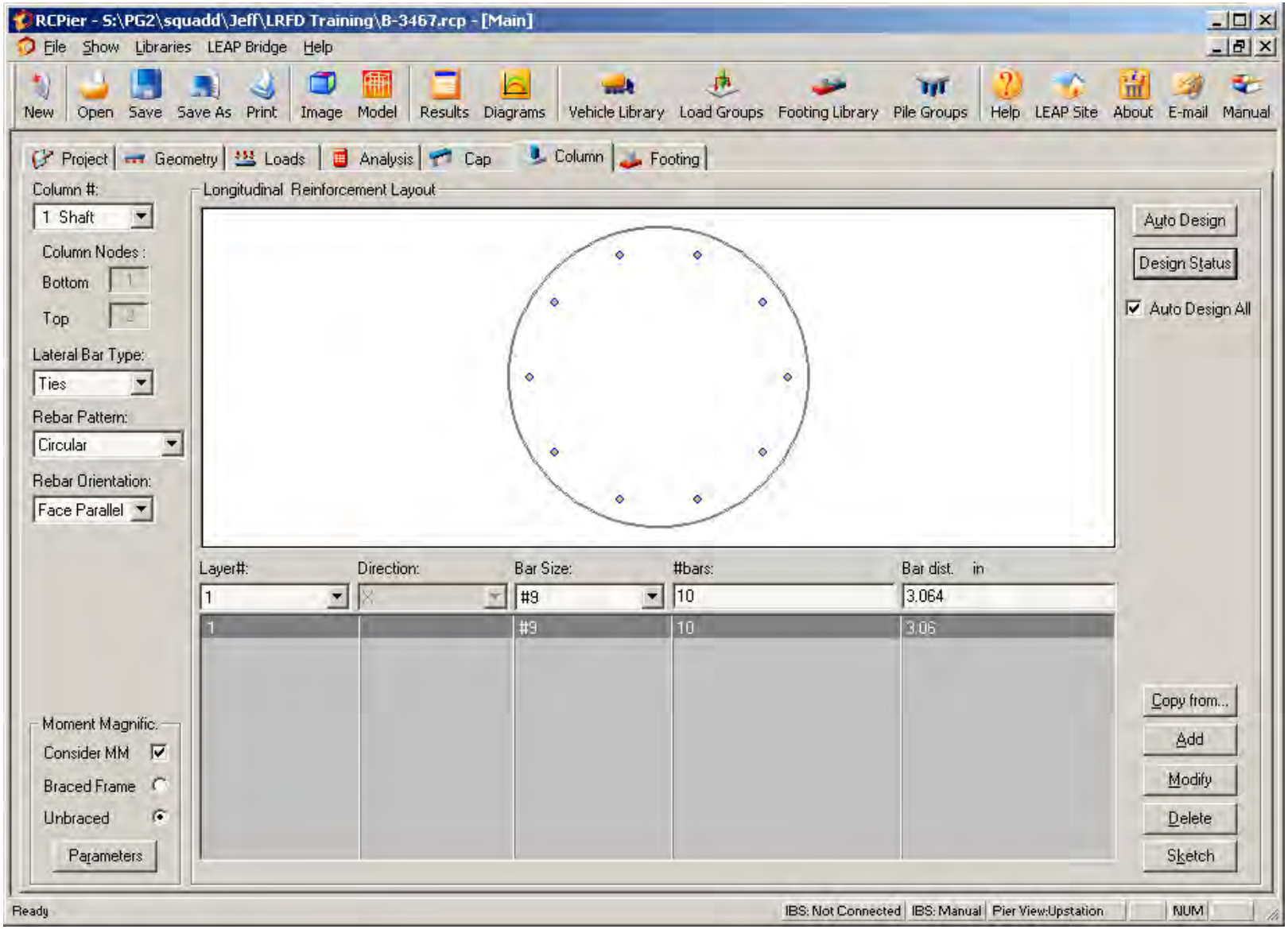

Auto Load Generation: Wind on Struc
Wind Angle, deg: -75
Generate for multiple angles
Generate Wind on Live at the same time
Length of LL: 43. ft
Elevation above which Wind Load acting: 10.75 ft
(for columns)
Bridge location :
Open country
Suburban
City
Default Wind Pressure
Wind Pressure for superstructure
Trans: 11. psf
Longit: 22. psf
Consider Overturning
Overturning: 20. psf
Wind Pressure for substructure in wind direction
Cap: 40. psf
Column: 40. psf
Generate
Cancel


Analysis/Design Parameters (LRFD)
Resistance Factor, phi
Phi as per 2006 classification
Phi as per classic aproach
Tension Controlled: 0.9
Shear and torsion: (normal weight) 0.9
Shear and torsion: (lightweight) 0.7
Compression Controlled: (ties) 0.75
Compression Controlled: (spiral) 0.75
Compression in STM: 0.7
Dynamic Load Allowance, IM
Truck Lane Fatigue
Cap: 0.33 0. 0.15
Column: 0.33 0. 0.15
Footing: 0. 0. 0.
Eta Factor
Service Fatigue Strength Extreme event
Cap: 1. 1. 1. 1.
Column: 1. 1. 1. 1.
Footing: 1. 1. 1. 1.
Clear Concrete Cover, in
Cap top/bottom: 2.
Cap side: 2.
Column: 2.
Footing top/bottom: 3.
Footing side: 3.
Crack Control Criteria
LRFD 2004
LRFD 2005 Interims
Multiple Presence Factors
Lane# 1: 1.2
Lane# 2: 1.
Lane# 3: 0.85
Lane# 4: 0.65
Crack Control Factor, z, kips/in
Cap: 170.
Column: 170.
Footing: 130.
Exposure Factors
Cap: 1.
Column: 1.
Footing: 1.
Seismic Design
Seismic Design Parameters ...
c/dt ratio
Comp -> 0.6 <- Transition -> 0.375 <- Tension
Shear and Torsion Calculations
Cap method
Simplified
General
Footing method
Simplified
General
Load Combinations
Dependent Load Case Combinations
Dependency table ...
Cross combinations
Column Slenderness Consideration
Pdelta Method
Number of iterations: auto
Degree of Fixity in Foundations for Moment Magnification 1.0
Compute K for braced columns as per Interim 2006
Design cap/footing for magnified moments
Design cap for magnified moments
Design footing for magnified moments
OK
Cancel


RCPier - S:\PG2\squadd\Jeff\LRFD Training\B-3467.rcp - [Main]
File Show Libraries LEAP Bridge Help
New Open Save Save As Print Image Model Results Diagrams Vehicle Library Load Groups Footing Library Pile Groups Help LEAP Site About E-mail Manual
Project Geometry Loads Analysis Cap Column Footing
Run Analysis...
Type: Envelope Strength
Case: Fy max/min
A/D Parameters
Effect: Forces & Moment
Format: x.00 Right
Units
kips
kips-ft
Type of Analysis: Frame
Coord. System: Local Global
Print...
Memb Node Fx Fy(Max/Min) Fz Mx My Mz
1 1 9.13 486.34 -1.58 -45.05 -0.06 -79.52
-6.47 159.12 -0.95 -27.03 -0.04 66.45
1 2 6.47 -152.62 0.95 22.31 0.04 -34.13
-9.13 -477.32 1.58 37.18 0.06 33.89
2 2 9.13 477.32 -1.58 -37.18 -0.06 -33.89
2 3 6.47 -142.23 0.95 10.59 0.04 46.02
-9.13 -462.89 1.58 17.65 0.06 -79.22
4.22 165.26 -0.95 -27.03 0.04 -47.82
3 5 -4.22 -158.77 0.95 22.31 -0.04 26.73
4.91 -467.67 1.58 37.18 -0.06 -27.36
4 5 -4.91 467.67 -1.58 -37.18 0.06 27.36
4 6 -4.22 -148.37 0.95 10.59 -0.04 -25.56
4.91 -453.23 1.58 17.65 -0.06 33.54
0.00 0.00 0.00 0.00 0.00 0.00
5 8 0.00 4.38 0.00 0.00 0.00 -4.66
0.00 3.16 0.00 0.00 0.00 -3.35
6 8 0.00 -65.44 0.47 0.71 0.00 3.35
0.00 -209.16 0.47 0.71 0.00 4.66
6 9 0.00 214.41 -0.47 -0.71 -1.20 -543.78
Ready
IBS: Not Connected
IBS: Manual
Pier View:Upstation
NUM


RCPier - S:\PG2\squadd\Jeff\LRFD Training\B-3467.rcp - [Main]
File Show Libraries LEAP Bridge Help
New Open Save Save As Print Image Model Results Diagrams Vehicle Library Load Groups Footing Library Pile Groups Help LEAP Site About E-mail Manual
Project Geometry Loads Analysis Cap Column Footing
Selection:
Cap
Auto Design
Design Status
Edit/View
Main bars
Stirrups
Location: Bar Size: # Bars From: ft To: ft Bar dist. in Hook:
Top #3 0 0. 0. 0. None
Top #9 6 0.00 29.00 2.00 Both
Bottom #9 6 0.00 29.00 2.00 Both
Add
Delete
Modify
Sketch
Ready
IBS: Not Connected
IBS: Manual
Pier View:Upstation
NUM

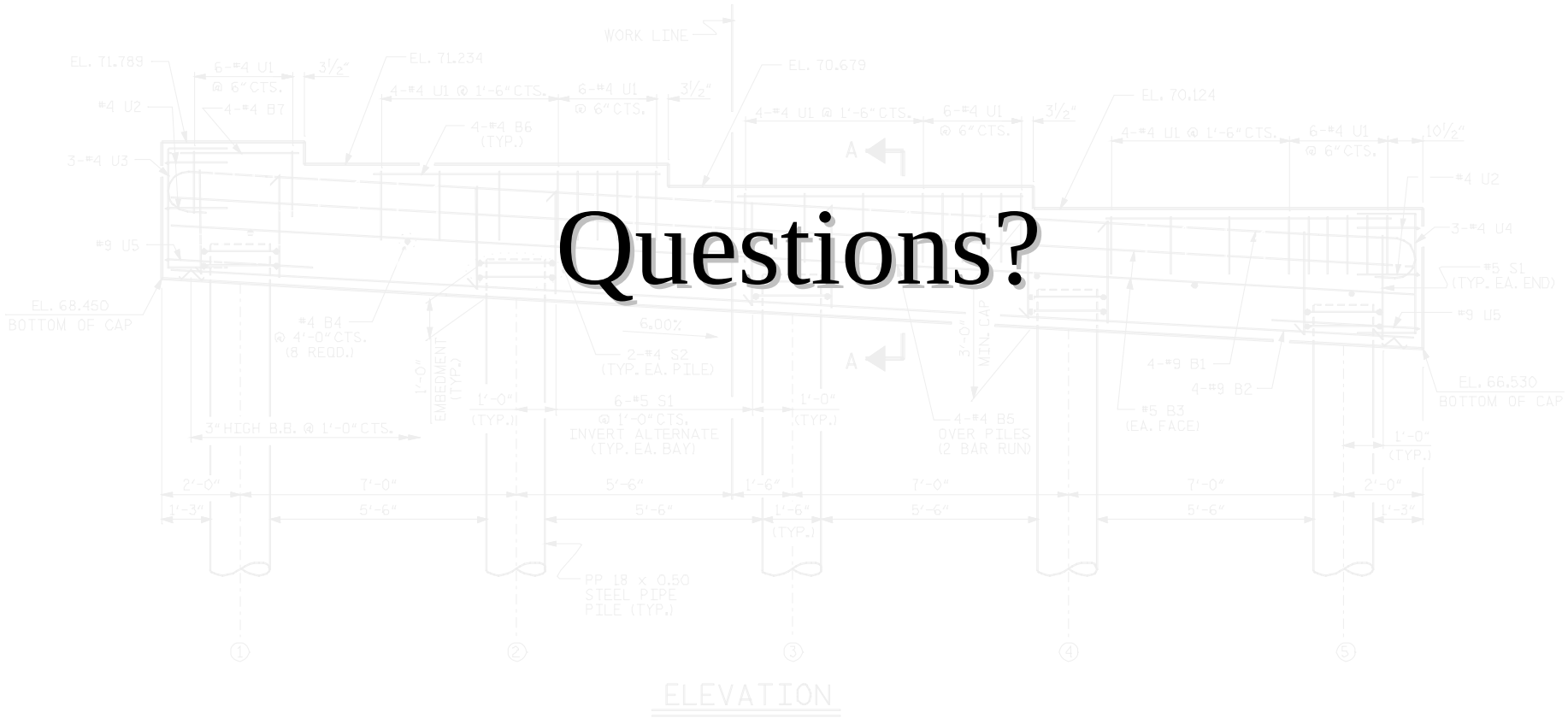

RCPier - S:\PG2\squadd\Jeff\LRFD Training\B-3467.rcp - [Main]
File Show Libraries LEAP Bridge Help
New Open Save Save As Print Image Model Results Diagrams Vehicle Library Load Groups Footing Library Pile Groups Help LEAP Site About E-mail Manual
Project Geometry Loads Analysis Cap Column Footing
Selection:
Cap
Auto Design
Design Status
Edit/View
Main bars
Stirrups
Stirrup Size
n legs
Av/s: in/ft
From: ft
To: ft
Spacing, in
#3
0.
0.
0.
#5 2 0.620 0.00 4.50 12.00
#5 2 0.620 7.50 21.50 12.00
#5 2 0.620 24.50 29.00 12.00
Add
Delete
Modify
Sketch
Ready
IBS: Not Connected
IBS: Manual
Pier View:Upstation
NUM


RCPier - S:\PG2\squadd\Jeff\LRFD Training\B-3467.rcp - [Main]
File Show Libraries LEAP Bridge Help
New Open Save Save As Print Image Model Results Diagrams Vehicle Library Load Groups Footing Library Pile Groups Help LEAP Site About E-mail Manual
Project Geometry Loads Analysis Cap Column Footing
Column #:
1 Shaft
Column Nodes :
Bottom 1
Top 2
Lateral Bar Type:
Ties
Rebar Pattern:
Circular
Rebar Orientation:
Face Parallel
Longitudinal Reinforcement Layout
Auto Design
Design Status
Auto Design All
Layer#: Direction: Bar Size: #bars: Bar dist. in
1 #9 10 3.064
1 #9 10 3.06
Copy from...
Add
Modify
Delete
Sketch
Moment Magnific.
Consider MM
Braced Frame
Unbraced
Parameters
Ready
IBS: Not Connected
IBS: Manual
Pier View:Upstation
NUM

Topics Under Consideration

- Steel H-Pile Design
- Seismic Design
- Strain Loads

Questions?


WORK LINE
EL. 71.789
EL. 71.234
EL. 70.679
EL. 70.124
EL. 68.450
BOTTOM OF CAP
EL. 66.530
BOTTOM OF CAP
6.00%
2-#4 S2
(TYP. EA. PILE)
6-#5 S1
@ 1'-0" CTS.
INVERT ALTERNATE
(TYP. EA. BAY)
4-#4 B5
OVER PILES
(2 BAR RUN)
4-#9 B1
4-#9 B2
#5 B3
(EA. FACE)
#4 B4
@ 4'-0" CTS.
(8 REQD.)
3"HIGH B.B. @ 1'-0" CTS.
PP 18 x 0.50
STEEL PIPE
PILE (TYP.)
ELEVATION