

Part D1:

Steel Design Example

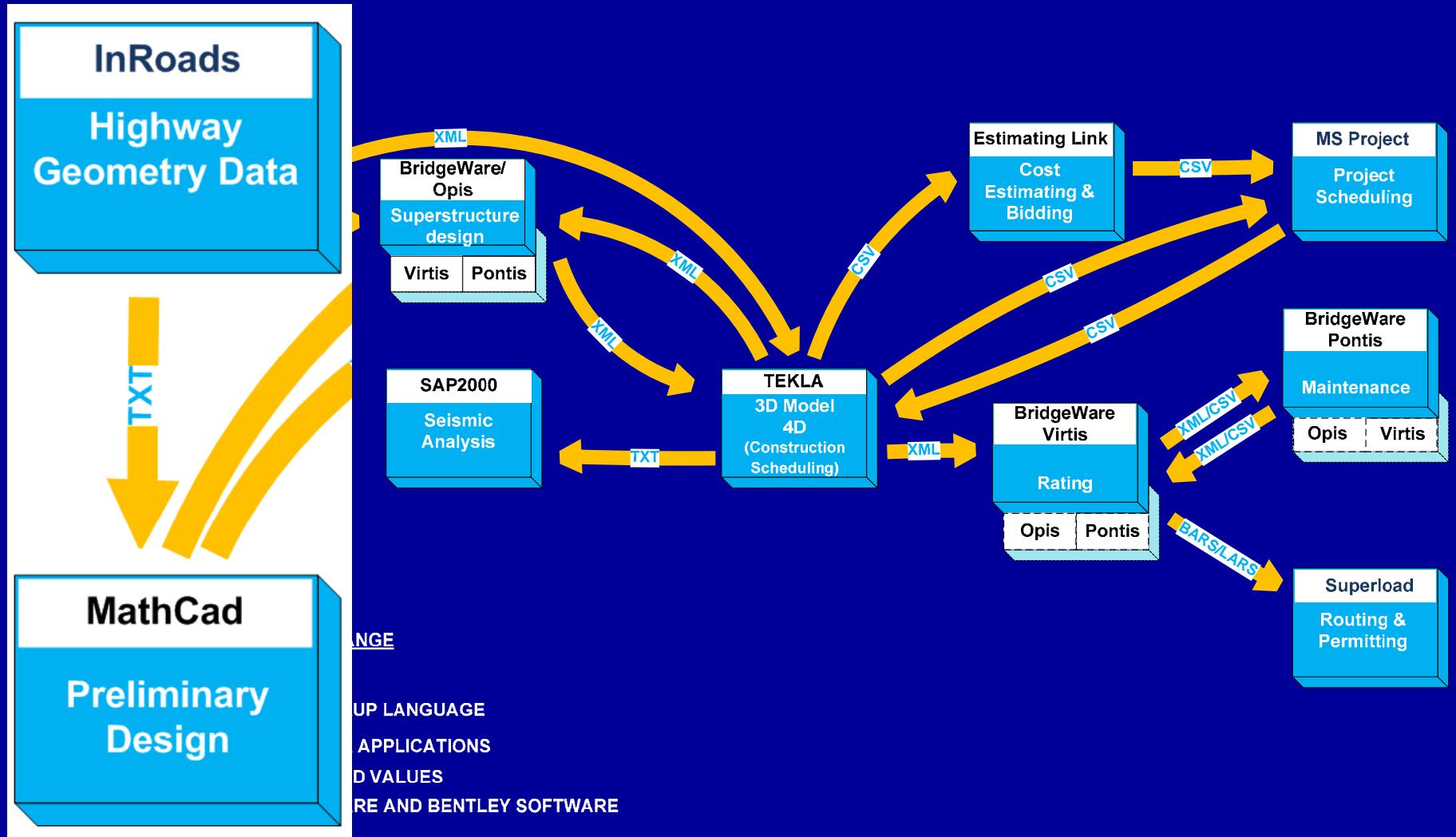


Overview (Part D1-Steel Design)

- Hwy geometry compliant bridge geometry
- To/From 3D Modeling Environment using XML
- Linking Analysis and Design Checks
- (Resulting) Steel Alternate Design
- Linking Substructure/Seismic Analysis

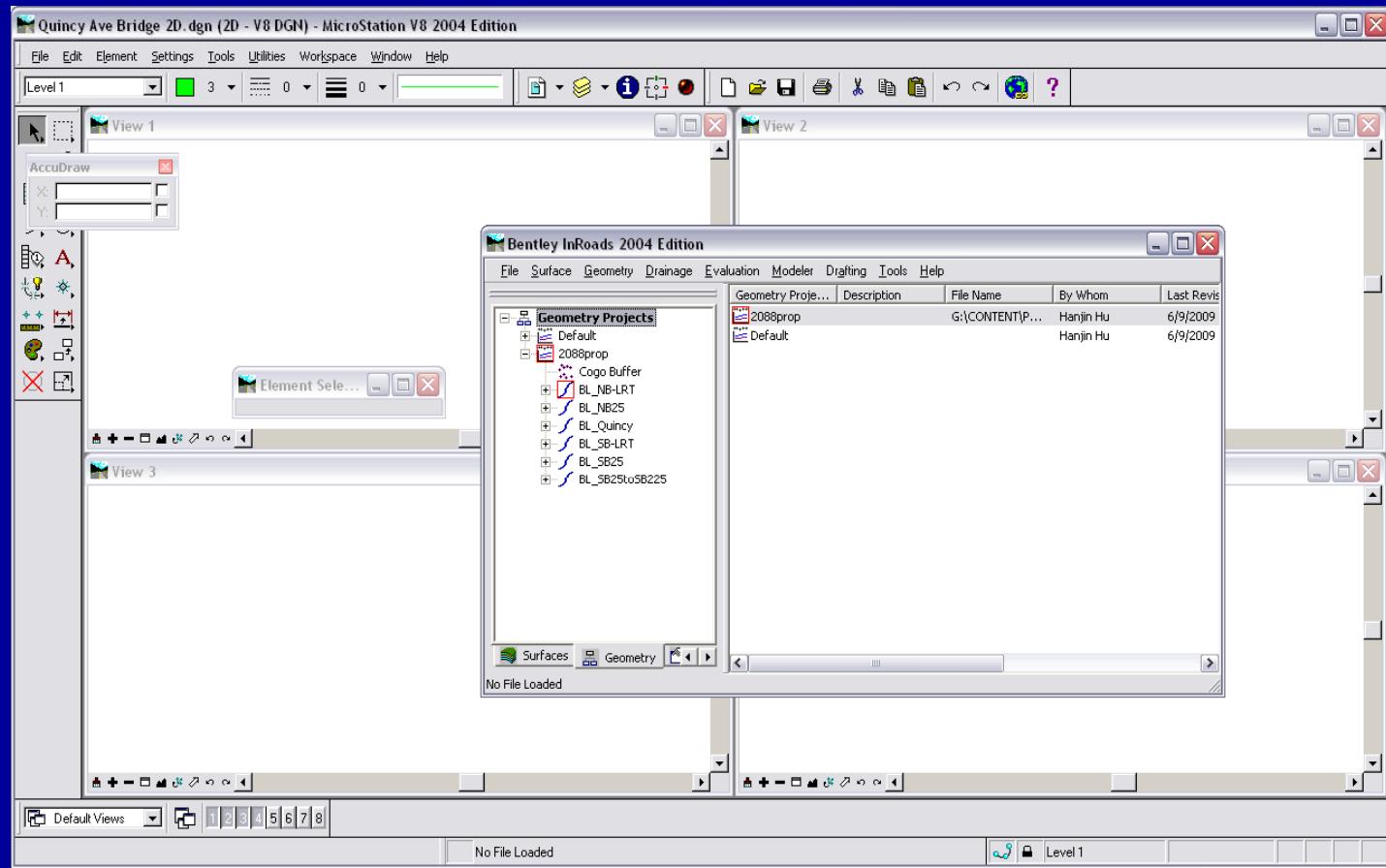


S01 InRoads to MathCAD



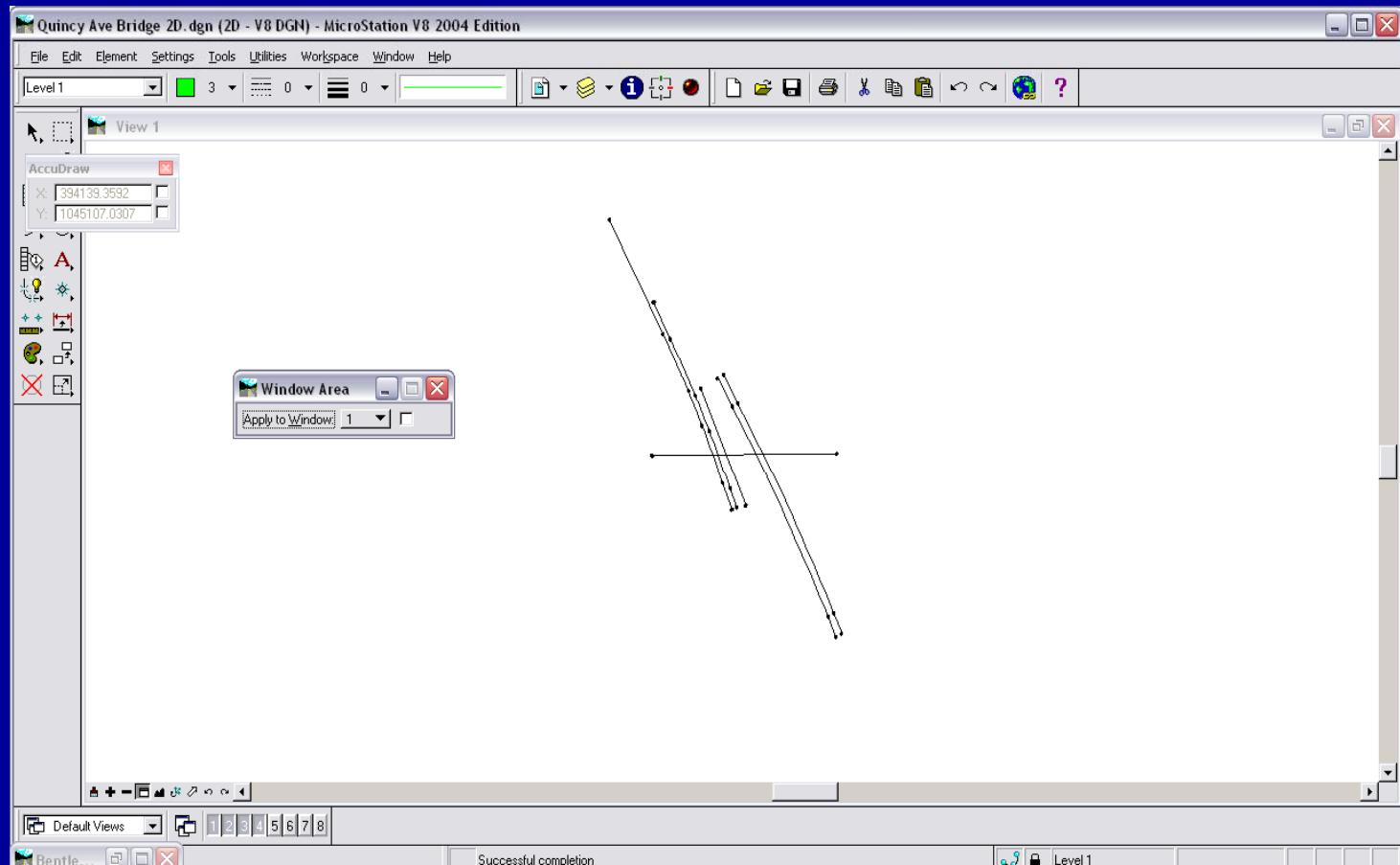
S01 InRoads to MathCAD

Loading
alg file:
6 pairs of
horizontal
and
vertical
alignments



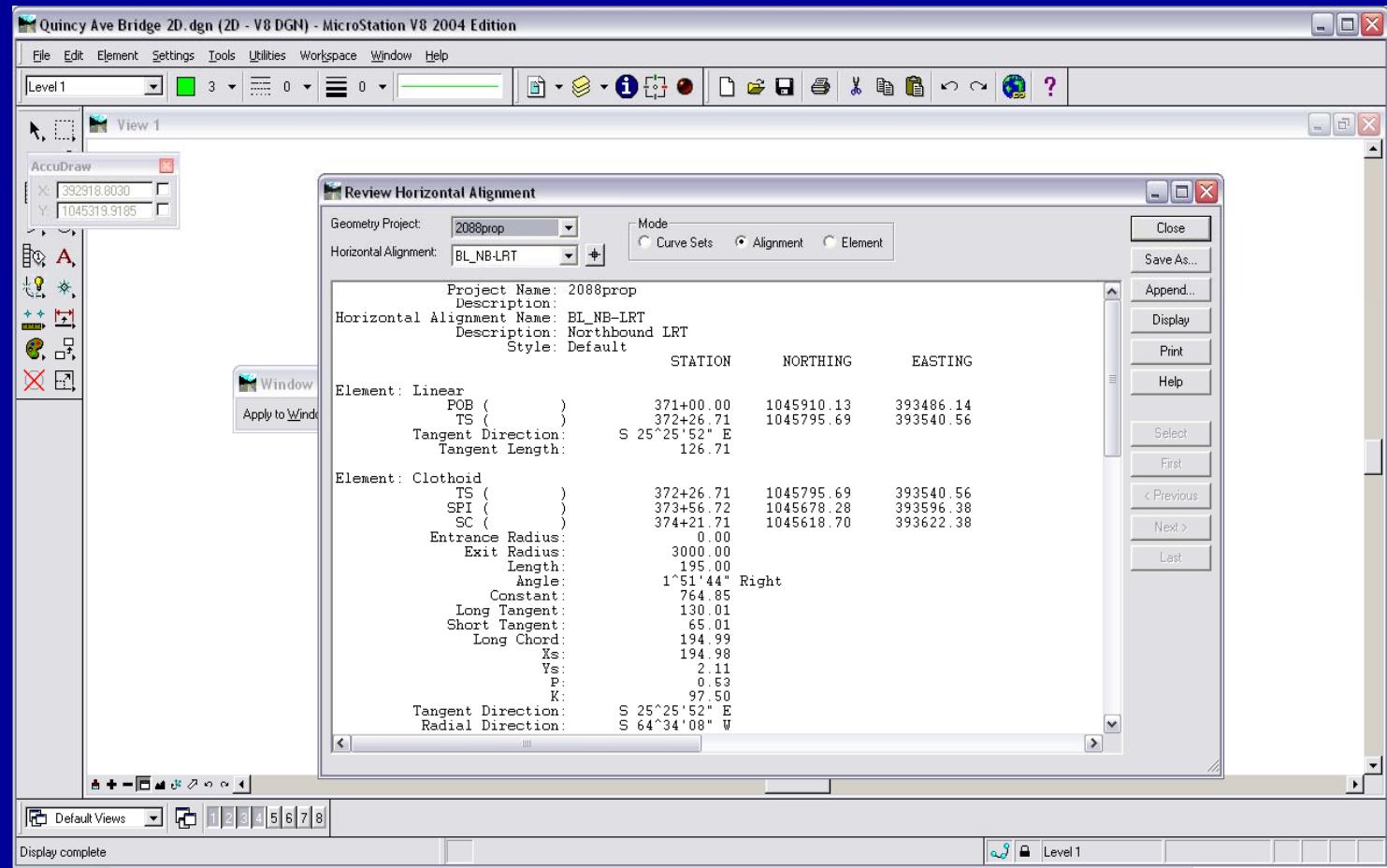
S01 InRoads to MathCAD

This picture shows 6 horizontal alignments



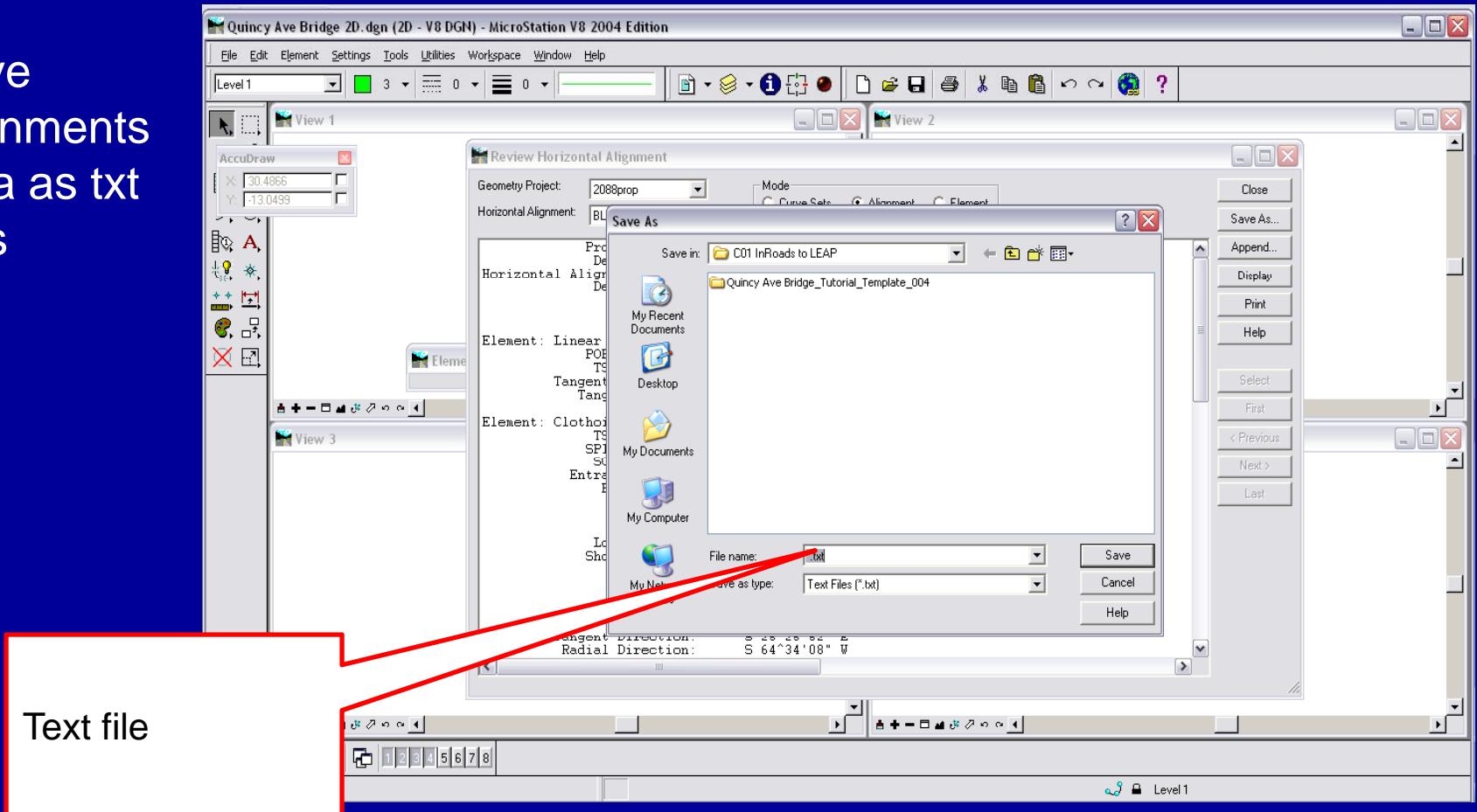
S01 InRoads to MathCAD

Details of horizontal and vertical alignments



S01 InRoads to MathCAD

Save alignments data as txt files

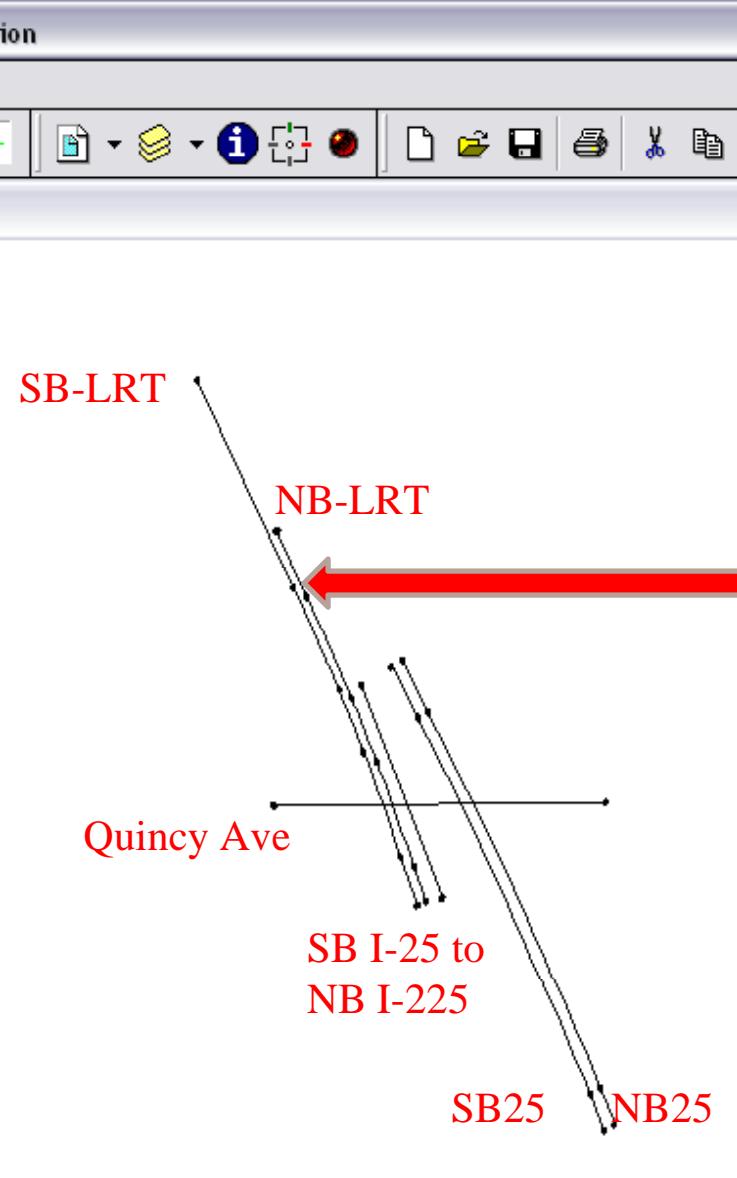


S01 InRoads to MathCAD

Sample text
file

```
BL_NB-LRT.txt - Notepad
File Edit Format View Help
Project Name: 2088prop
Description:
Horizontal Alignment Name: BL_NB-LRT
Description: Northbound LRT
Style: Default
STATION NORTHING EASTING
Element: Linear
    POB { } 371+00.00 1045910.13 393486.14
    TS { } 372+26.71 1045795.69 393540.56
    Tangent Direction: S 25A25'52" E
    Tangent Length: 126.71
Element: clothoid
    TS { } 372+26.71 1045795.69 393540.56
    SPI { } 373+56.72 1045678.28 393596.38
    SC { } 374+21.71 1045618.70 393622.38
    Entrance Radius: 0.00
    Exit Radius: 3000.00
    Length: 195.00
    Angle: 1A51'44" Right
    Constant: 764.85
    Long Tangent: 130.01
    Short Tangent: 65.01
    Long Chord: 194.99
    XS: 194.98
    YS: 2.11
    P: 0.53
    K: 97.50
    Tangent Direction: S 25A25'52" E
    Radial Direction: S 64A34'08" W
    Chord Direction: S 24A48'38" E
    Radial Direction: S 66A25'51" W
    Tangent Direction: S 23A34'09" E
Element: Circular
    SC { } 374+21.71 1045618.70 393622.38
    PI { } 374+80.93 1045564.42 393646.06
    CC { } 1044419.14 390872.64
    CS { } 375+40.13 1045509.25 393667.57
    Radius: 3000.00
    Delta: 2A15'42" Right
    Degree of Curvature(Arc): 1A54'35"
    Length: 118.42
    Tangent: 59.22
    Chord: 118.41
    Middle ordinate: 0.58
    External: 0.58
    Tangent Direction: S 23A34'09" E
    Radial Direction: S 66A25'51" W
    Chord Direction: S 22A26'18" E
    Radial Direction: S 68A41'33" W
    Tangent Direction: S 21A18'27" E
Element: Clothoid
```





BL_NB-LRT.txt - Notepad

File Edit Format View Help

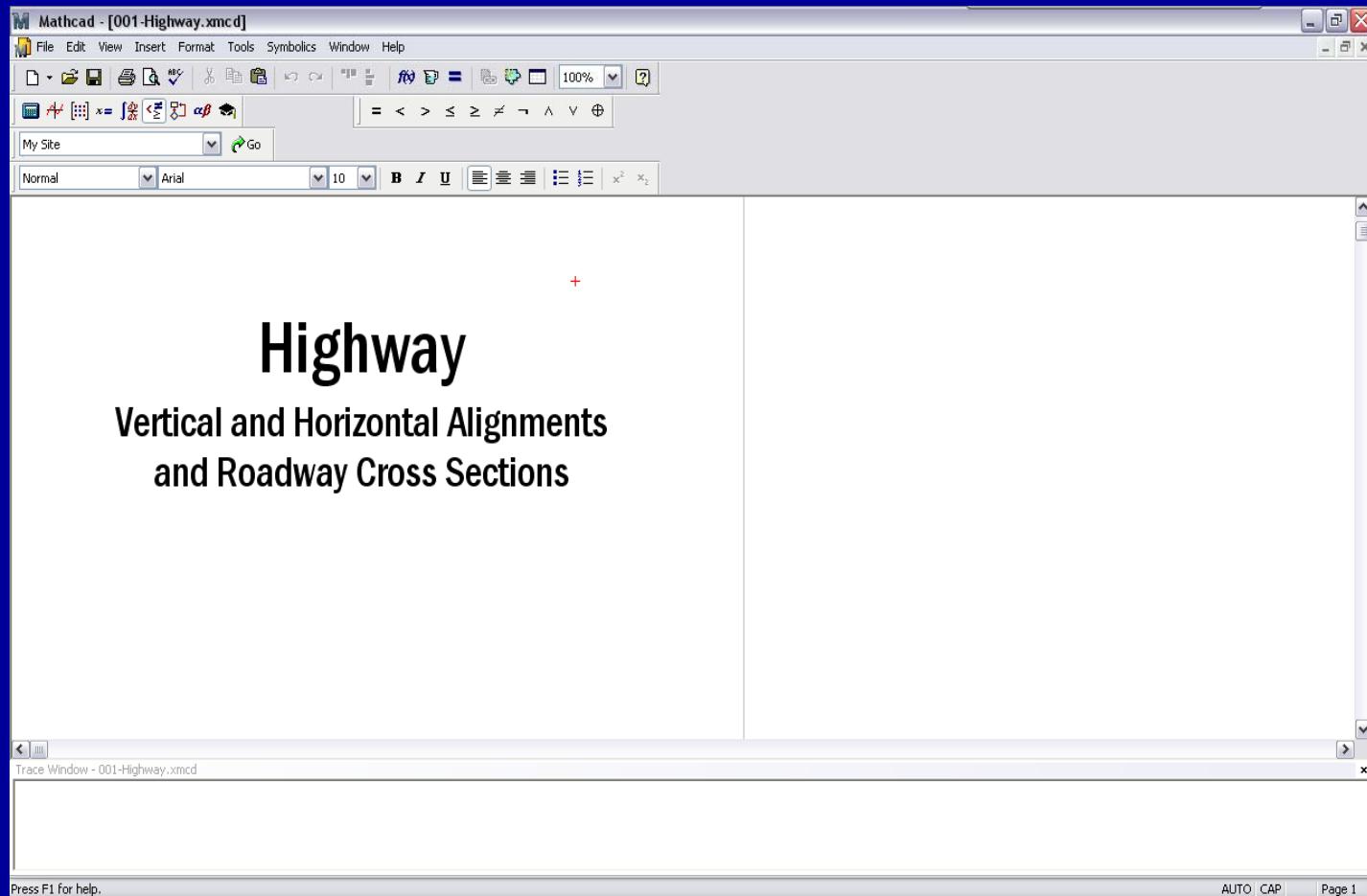
Project Name: 2088prop
Description:
Horizontal Alignment Name: BL_NB-LRT
Description: Northbound LRT
Style: Default

STATION	NORTHING
Element: Linear POB { } TS { } Tangent Direction: S 25°25'52" E Tangent Length: 126.71	371+00.00 1045910.13 372+26.71 1045795.69
Element: clothoid TS { } SPI { } Entrance Radius: 0.00 Exit Radius: 3000.00 Length: 195.00 Angle: 1°51'44" Right Constant: 764.85 Long Tangent: 130.01 Short Tangent: 65.01 Long Chord: 194.99 Xs: 194.98 Ys: 2.11	372+26.71 1045795.69 373+56.72 1045678.28 374+21.71 1045618.70



S01 InRoads to MathCAD

The
MathCAD
file used for
alignments
design



S01 InRoads to MathCAD

Highway
Inputs:
input text
files

The screenshot shows the MathCAD interface with the title bar "Mathcad - [001-Highway.xmcd]". The menu bar includes File, Edit, View, Insert, Format, Tools, Symbolics, Window, and Help. The toolbar contains various mathematical operators like +, -, *, /, and =. The ribbon bar has sections for Normal, Arial, 10pt, Bold, Italic, Underline, and various alignment and spacing tools. The main workspace displays the following text:

Highway Inputs [Back to top](#)

Define Alignment Data

```
Alglist := ("OR", "NB", "SB")
HAlist := ("350142_OR_HA.txt", "2088_NB25_HA.txt", "2088_SB25_HA.txt")
VPlist := ("350142_OR_VP.txt", "2088_NB25_VA.txt", "2088_SB25_VA.txt")
```

A callout box with a red border and a red arrow points from the text "The input text files here are all exported from InRoads." to the "VPlist" assignment. To the right of the VPlist assignment is an orange callout box containing the text: "Cross slopes that slope up to the right or down to the left are positive. Cross slopes that slope down to the right or up to the left are negative."



S01 InRoads to MathCAD

Details of
MathCAD
files

Some basic
parameter
inputs of the
project.

The screenshot shows the MathCAD interface with several code snippets and annotations:

```
Mathcad - [001-Highway.xmcd]
File Edit View Insert Format Tools Symbolics Window Help
My Site Go
Normal Arial 10 B I U
HAlist := [350142_OR_HA.txt
"2088_NB25_HA.txt"
"2088_SB25_HA.txt"]

VPlist := [350142_OR_VP.txt
"2088_NB25_VA.txt"
"2088_SB25_VA.txt"]
```

To the right or down to the left are positive. Cross slopes that slope down to the right or up to the left are negative.

Project Name and Number

Project Name	project_name := "Quincy Avenue Bridge over I-25"
Project Identification Number	project_id := "350142"

Selected Roadway Dimensions

Curb height	h_curb := 150 · mm
-------------	--------------------



S01 InRoads to MathCAD

Details of
MathCAD
files

The screenshot shows the MathCAD interface with the title bar "Mathcad - [001-Highway.xmcd]". The menu bar includes File, Edit, View, Insert, Format, Tools, Symbolics, Window, and Help. The toolbar contains various mathematical and engineering symbols. The ribbon bar includes "My Site" and "Normal" settings. The main workspace displays the following code:

```
Check Input Files

check_HA = "All Horizontal Alignment Files Read Successfully"

check_VP = "All Vertical Profiles Read Successfully"

check_SD = "All Vertical Profiles Read Successfully"

t := 0
s := 0
```

A red callout box points to the three "check" assignments, indicating they represent successful imports of alignment, vertical profiles, and survey data respectively.

From MathCAD to Tekla



Inputs Sample in Preliminary Design Sheet (MathCAD file)

Substructure Location Inputs:

Station and Skew of Substructures			
All Substructure centerline bearings stations	$\text{pts}_{\text{sub}} := \begin{pmatrix} "OR" & 6145.000 \cdot \text{m} & 0 \cdot \text{m} \\ "OR" & 6177.000 \cdot \text{m} & 0 \cdot \text{m} \\ "OR" & 6201.000 \cdot \text{m} & 0 \cdot \text{m} \end{pmatrix}$	$\alpha_{\text{skew}} := \begin{pmatrix} 20 \\ 20 \\ 20 \end{pmatrix} \cdot \text{deg}$	$n_{\text{sub,fix}} := \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

Superstructure Design Inputs:

Number of Girders	$N_{\text{girders}} := 5$
Point Functions	
Bridge Width	$W_{\text{bridge}} := W_t("OR_FG")$ $W_{\text{bridge}} = 14.234 \text{ m}$
Spacing of Girders	
Girder Spacing	$S_{\text{girder}} := 3.00 \cdot \text{m}$
Offset to centerline	$OC_{\text{CL}} := OC_{\text{CL},i}("OR_FG")$ $OC_{\text{CL}} = 0.000 \text{ m}$
	$OS_{\text{left}} := OS_i("OR_FG")_{1,1}$ $OS_{\text{left}} = -7.117 \text{ m}$
	$OS_{\text{right}} := OS_i("OR_FG")_{1,2}$ $OS_{\text{right}} = 7.117 \text{ m}$

After import the alignment data, we can input the design parameters of bridge itself.



Inputs Sample in Preliminary Design Sheet (MathCAD file) (continued)

Girder Design Inputs:

Girder Dimensions

Width of bottom flange plate $b_{bot,o} := 500 \cdot \text{mm}$

Width of top flange plate $b_{top,o} := 450 \cdot \text{mm}$

Depth of web $d_{web,o} = 1100 \cdot \text{mm}$

Web Thickness $t_{web,o} := 14 \cdot \text{mm}$

Piece Ends

Distance Piece Ends (Splice Locations) as a fraction of total Span Length

$$\%_{ends} := \begin{pmatrix} 0.000 \\ \frac{38}{60} \\ 1.000 \end{pmatrix}$$

Top Flange thickness

$$t_{top,o} := \begin{pmatrix} 0.020 & 22.6 \\ 0.040 & 10.0 \\ 0.020 & 26.4 \end{pmatrix} \cdot \text{m}$$

Bottom Flange thickness

$$t_{bot,o} := \begin{pmatrix} 0.025 & 22.6 \\ 0.050 & 10.0 \\ 0.025 & 26.4 \end{pmatrix} \cdot \text{m}$$

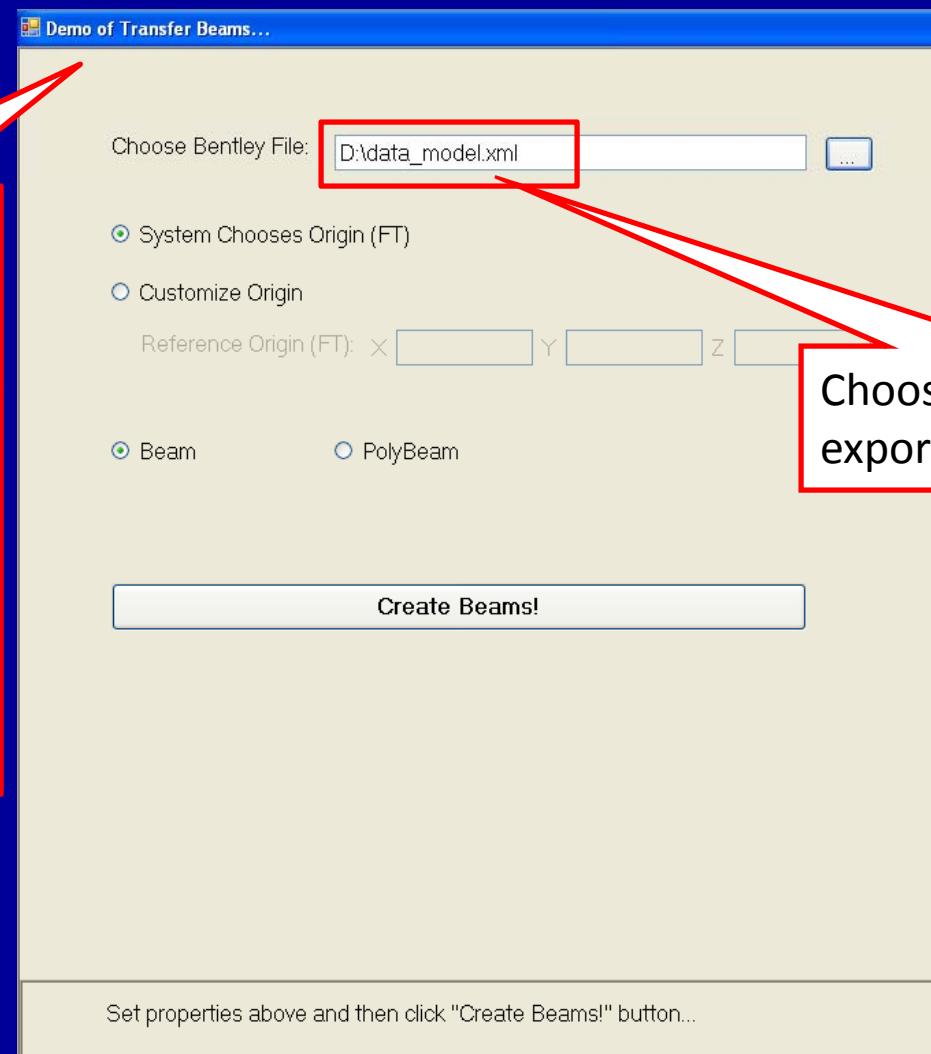


Export XML Linkage File



Import Xml File into Tekla

This program is developed by C# in Visual Studio. It reads the bridge data in xml linkage file just exported from MathCAD sheet and calls Tekla's APIs to build 3D model automatically.

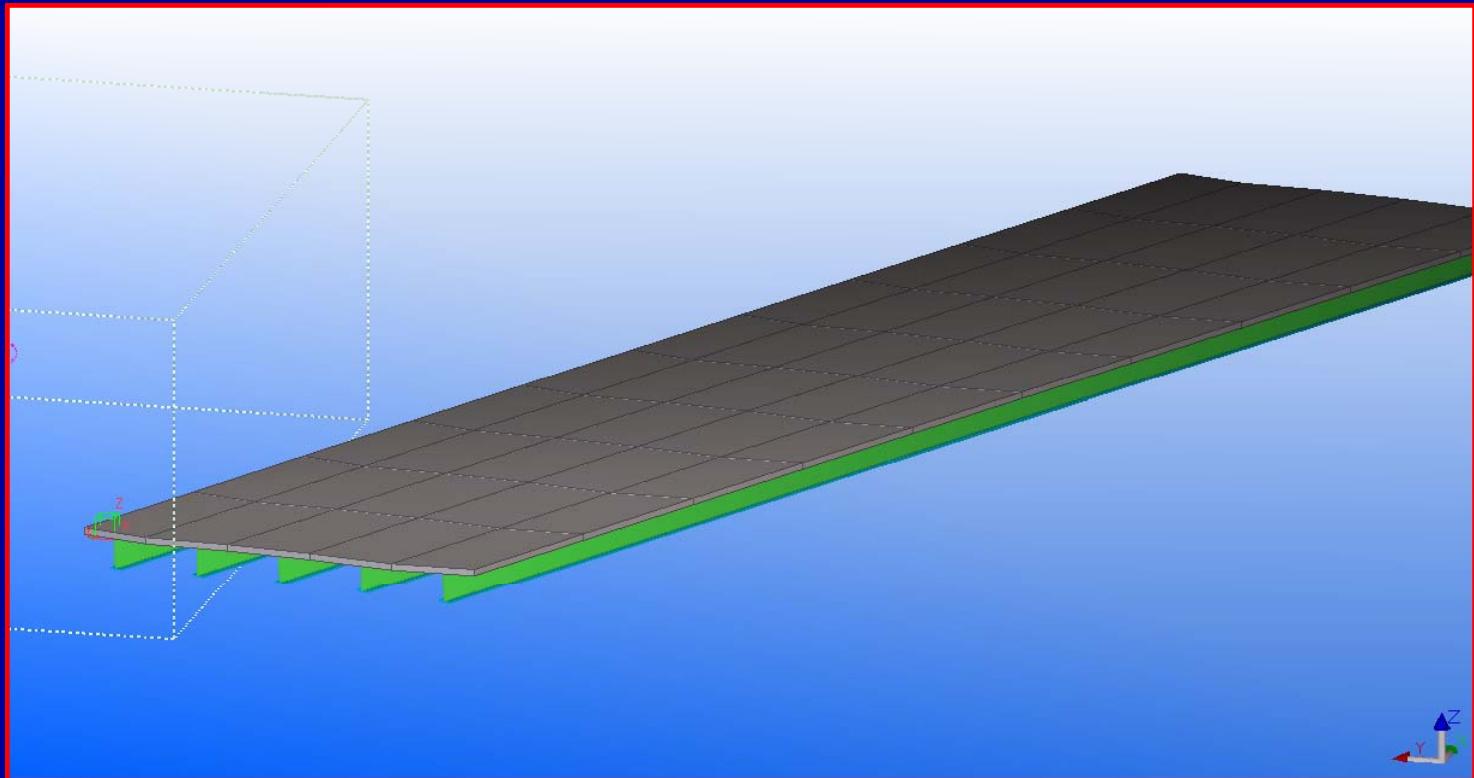


Choose the XML file just exported...



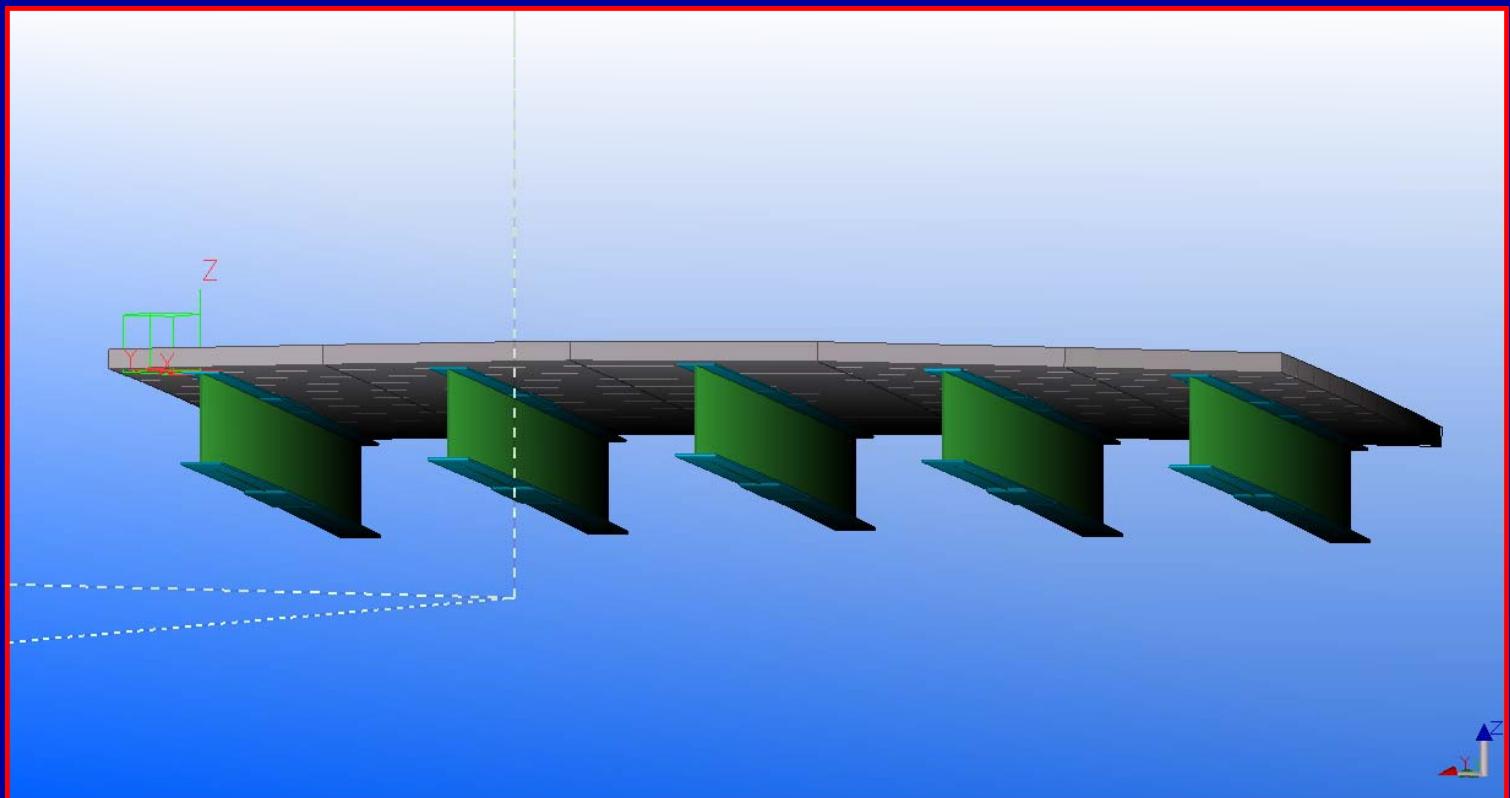
The Tekla 3D Model Automatically Generated

Output model
snapshot from
Tekla Structure:



The Tekla 3D Model Automatically Generated (cont.)

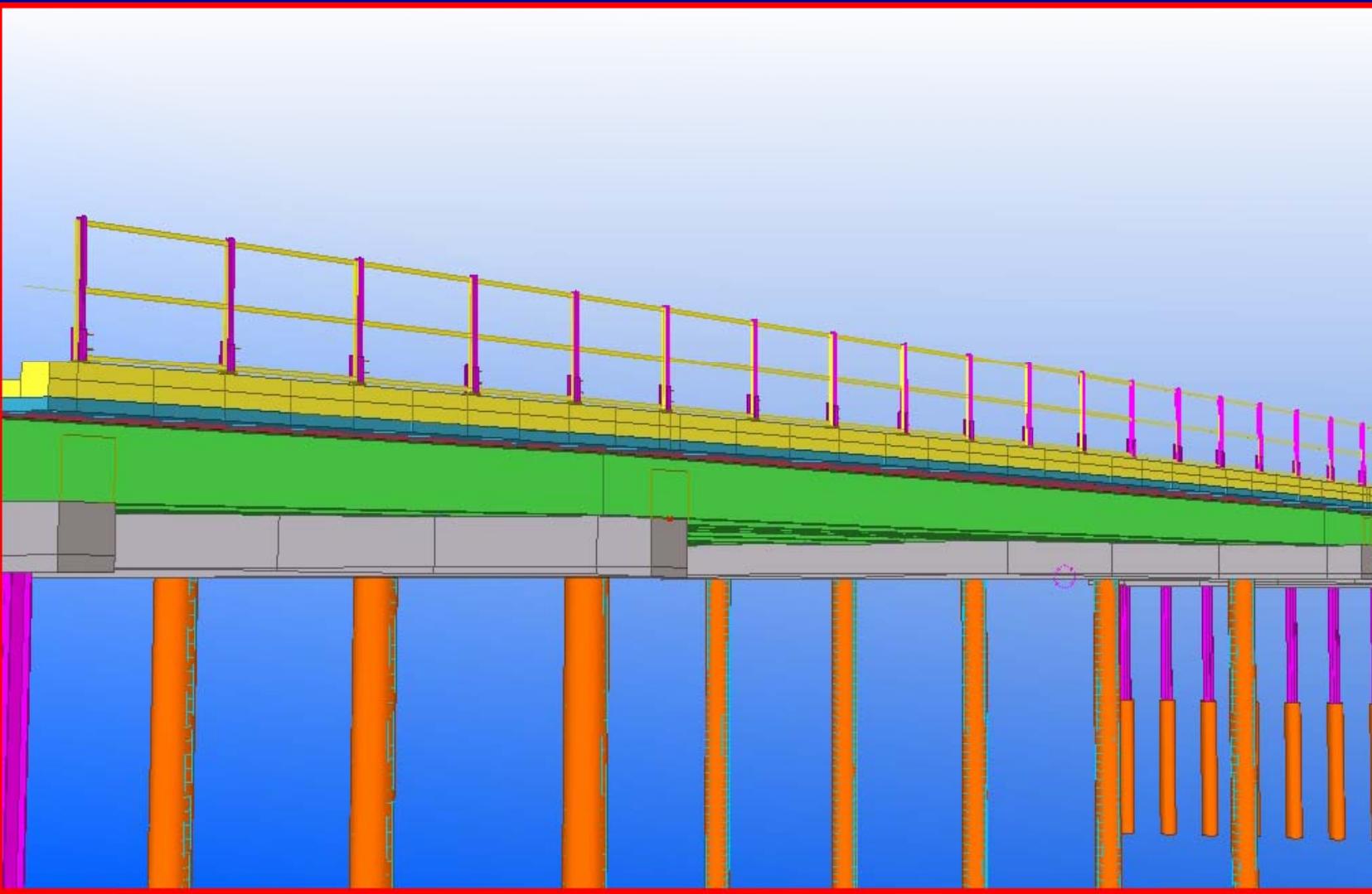
Output model
snapshot from
Tekla Structure:



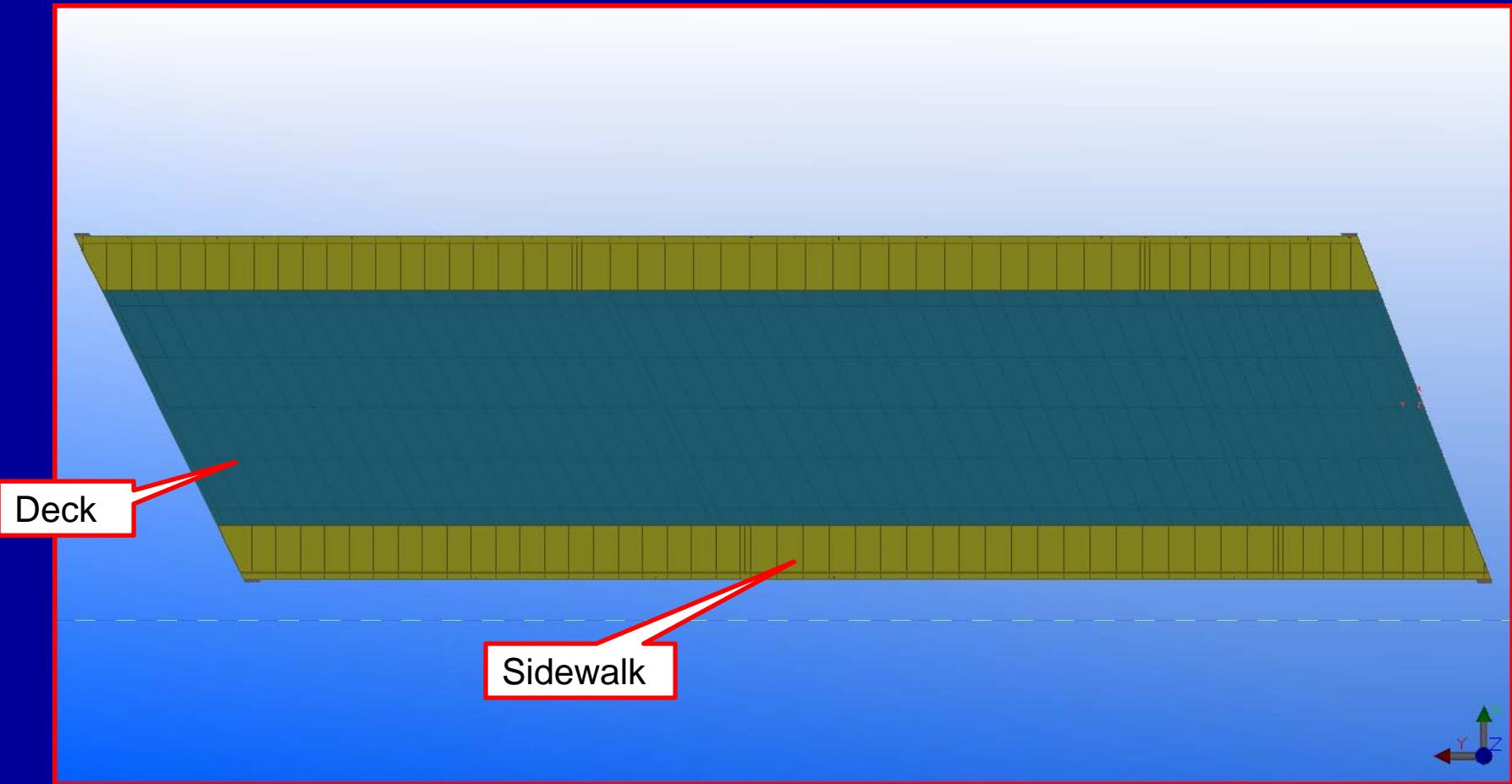
From Tekla to XML



Tekla 3D Model



Tekla 3D Model: Top View



The Code Sample and Development Environment showing Exporting

BRIDGEWareImporting - Microsoft Visual Studio

File Edit View Refactor Project Build Debug Data Tools Window Community

Object Browser Start Page Program.cs ExportingConvert.cs Program.cs Import

20 string modelName = model.GetInfo().ModelName;
21 Console.WriteLine("Model name: " + modelName);
22 //Girders...
23 ArrayList anyBeamArr = ExportingConverter.getGirderArr();
24 ArrayList girderArr = ExportingConverter.convertToGirderArr();
25 int girderNumber = ExportingConverter.getGirderNumber();
26 Console.WriteLine("the number of girder plates is: " + anyBeamArr.size());
27 Console.WriteLine("the number of girders is: " + girderArr.size());
28 ArrayList girderInfoArr = new ArrayList();
29 foreach(TeklaSteelPolyGirder girder in girderArr){
30 IPolyGirderInfo girderInfo = ExportingConverter.
31 getGirderInfo(girder);
32 girderInfoArr.Add(girderInfo);
33 }
34 XmlDocument xmlDoc = new XmlDocument();
35 xmlDoc.Load(QExportingConstants.EX_TPL_FILE);
36 ExportingConvert.insertGidersXmlNode(xmlDoc, &girderArr);
37 ExportingConvert.setBridgeNodeAttrs(xmlDoc, model);
38 //Deck...

Error List 0 Errors 0 Warnings 0 Messages

Solution Explorer - Solution 'BRIDGEWareImporting' (10 projects)

- BRIDGEWareExporting
- BRIDGEWareImporting
- ExportEstimatingLink
- QCS.Utils
- QImporting.Beans
- QImporting.Utils
- TeklaBeans
- TeklaConverter
- TeklaExporting**
- TeklaImporting

Tekla Exporting Project in Visual Studio



Export Processing

```
file:///D:/CSharpProjects/TeklaExporting/TeklaExporting/bin/Debug/TeklaExporting.EXE
Connecting to Tekla Structures process...
Connection succeeded
Model name: QC_Steel_Alt.db1
The count of plateArr: 63
the number of girder plates is:: 0
the number of girders is:: 7
The count of Deck Plate Arr: 448
The total count of Pier Columns Arr: 10
The total count of Pier Cap Arr: 2
```



Sample of Exported XML File

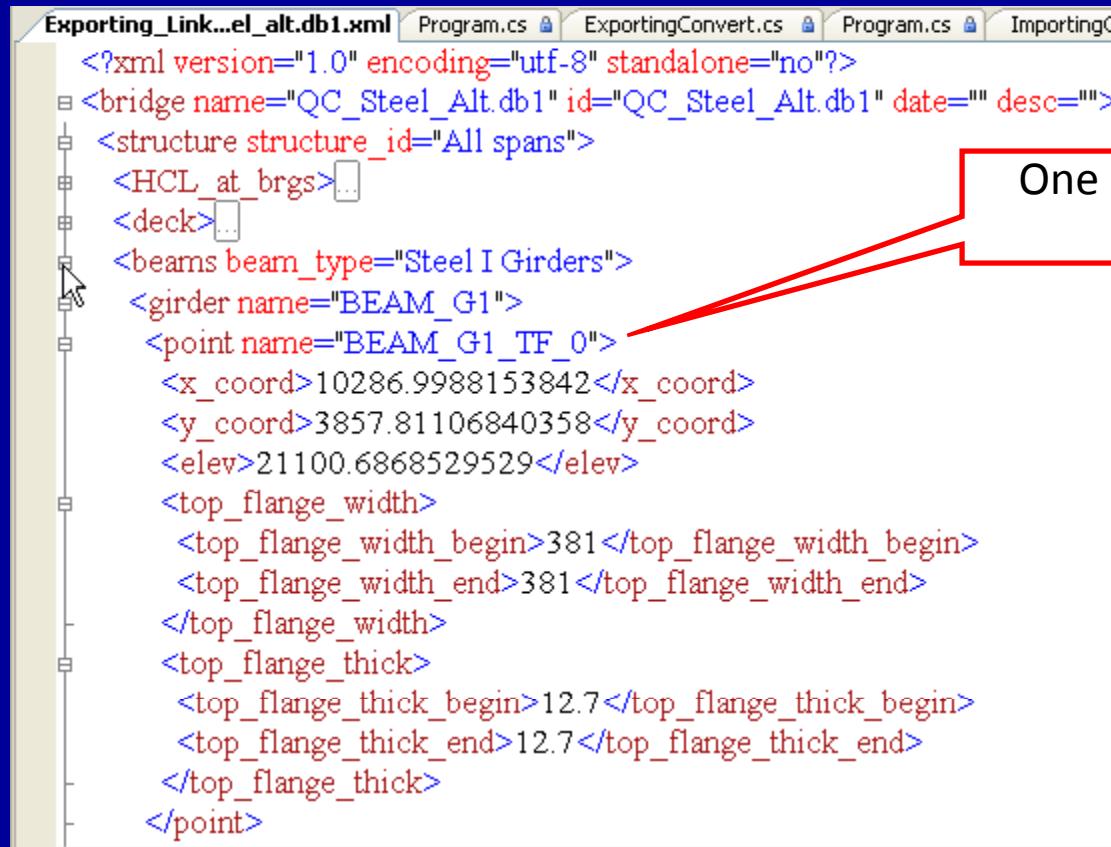
```
<?xml version="1.0" encoding="utf-8" standalone="no"?>
<bridge name="QC_Steel_Alt.db1" id="QC_Steel_Alt.db1" date="" desc="">
  <structure structure_id="All spans">
    <HCL_at_brgs>...
    <deck>...
      <beams beam_type="Steel I Girders">
        <girder name="BEAM_G1">
          <point name="BEAM_G1_TF_0">
            <x_coord>10286.9988153842</x_coord>
            <y_coord>3857.81106840358</y_coord>
            <elev>21100.6868529529</elev>
            <top_flange_width>
              <top_flange_width_begin>381</top_flange_width_begin>
              <top_flange_width_end>381</top_flange_width_end>
            </top_flange_width>
            <top_flange_thick>
              <top_flange_thick_begin>12.7</top_flange_thick_begin>
              <top_flange_thick_end>12.7</top_flange_thick_end>
            </top_flange_thick>
          </point>
        </girder>
      </beams>
    </deck>
  </structure>
</bridge>
```



XML to Opis/Virtis



Sample of XML File

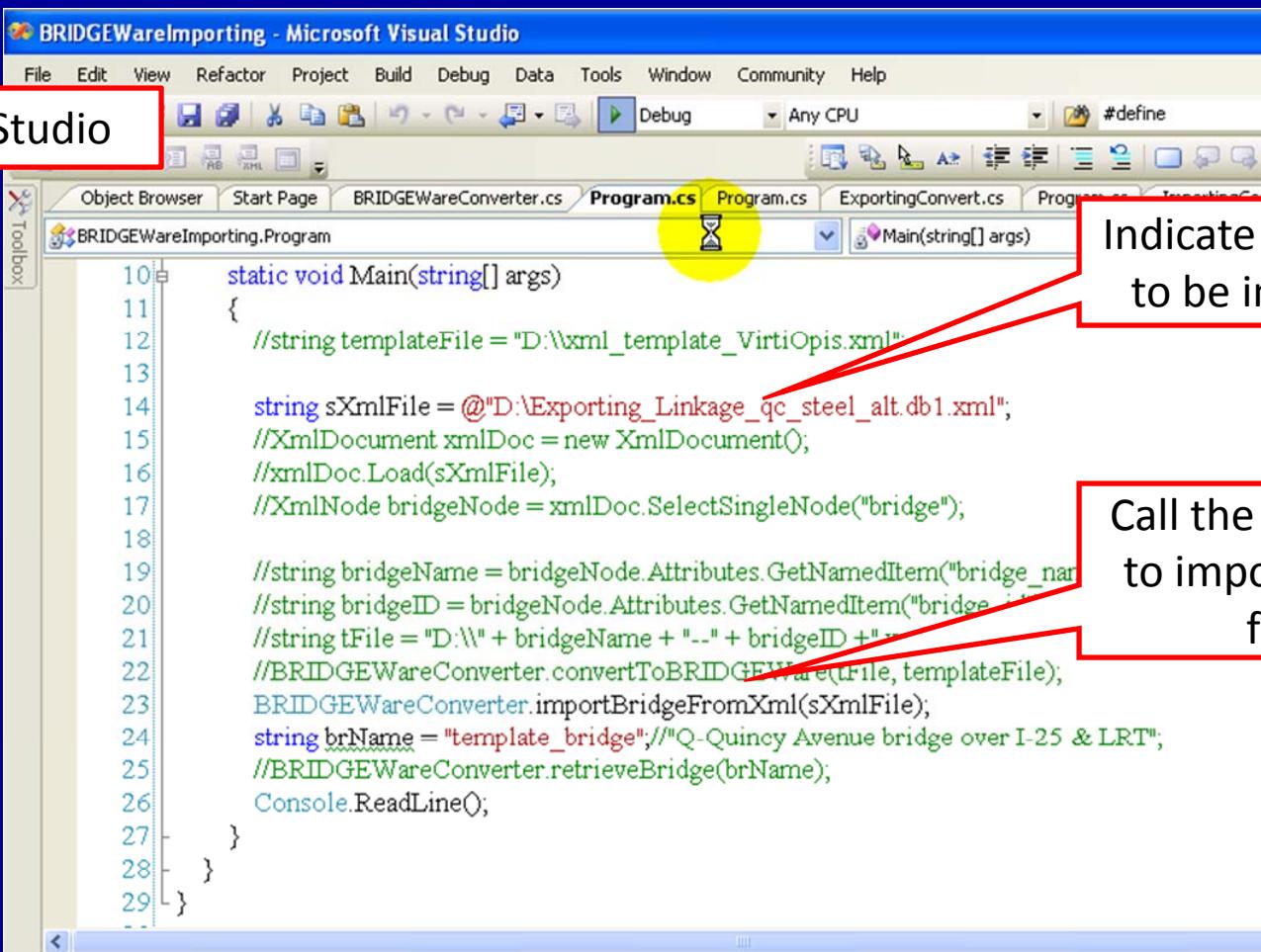


```
<?xml version="1.0" encoding="utf-8" standalone="no"?>
<bridge name="QC_Steel_Alt.db1" id="QC_Steel_Alt.db1" date="" desc="">
<structure structure_id="All spans">
<HCL_at_brgs>...
<deck>...
<beams beam_type="Steel I Girders">
<girder name="BEAM_G1">
<point name="BEAM_G1_TF_0">
<x_coord>10286.9988153842</x_coord>
<y_coord>3857.81106840358</y_coord>
<elev>21100.6868529529</elev>
<top_flange_width>
<top_flange_width_begin>381</top_flange_width_begin>
<top_flange_width_end>381</top_flange_width_end>
</top_flange_width>
<top_flange_thick>
<top_flange_thick_begin>12.7</top_flange_thick_begin>
<top_flange_thick_end>12.7</top_flange_thick_end>
</top_flange_thick>
</point>
```

One of the girder
nodes...



Code Sample and Development Environment Showing Importing



The screenshot shows the Microsoft Visual Studio interface with the title bar "BRIDGEWareImporting - Microsoft Visual Studio". The menu bar includes File, Edit, View, Refactor, Project, Build, Debug, Data, Tools, Window, Community, and Help. The toolbar has various icons for file operations like Open, Save, and Build. A status bar at the bottom shows "Any CPU" and "#define". The main window displays the code editor with the file "Program.cs" open. The code is as follows:

```
static void Main(string[] args)
{
    //string templateFile = "D:\\xml_template_VirtiOpis.xml";
    string sXmlFile = @"D:\\Exporting_Linkage_qc_steel_alt.db1.xml";
    //XmlDocument xmlDoc = new XmlDocument();
    //xmlDoc.Load(sXmlFile);
    //XmlNode bridgeNode = xmlDoc.SelectSingleNode("bridge");

    //string bridgeName = bridgeNode.Attributes.GetNamedItem("bridge_name").Value;
    //string bridgeID = bridgeNode.Attributes.GetNamedItem("bridge_id").Value;
    //string tFile = "D:\\" + bridgeName + "--" + bridgeID + ".xml";
    //BRIDGEWareConverter.convertToBRIDGEwareFile(templateFile, templateFile);
    BRIDGEWareConverter.importBridgeFromXml(sXmlFile);
    string brName = "template_bridge";//"Q-Quincy Avenue bridge over I-25 & LRT";
    //BRIDGEWareConverter.retrieveBridge(brName);
    Console.ReadLine();
}
```

Annotations highlight specific parts of the code:

- A red box labeled "Visual Studio" highlights the application window.
- A yellow circle highlights the "Main" subroutine in the code editor.
- A red box with the text "Indicate the xml file to be imported..." points to the line `string sXmlFile = @"D:\\Exporting_Linkage_qc_steel_alt.db1.xml";`.
- A red box with the text "Call the subroutine to import the xml file..." points to the line `BRIDGEWareConverter.importBridgeFromXml(sXmlFile);`.



Importing Process

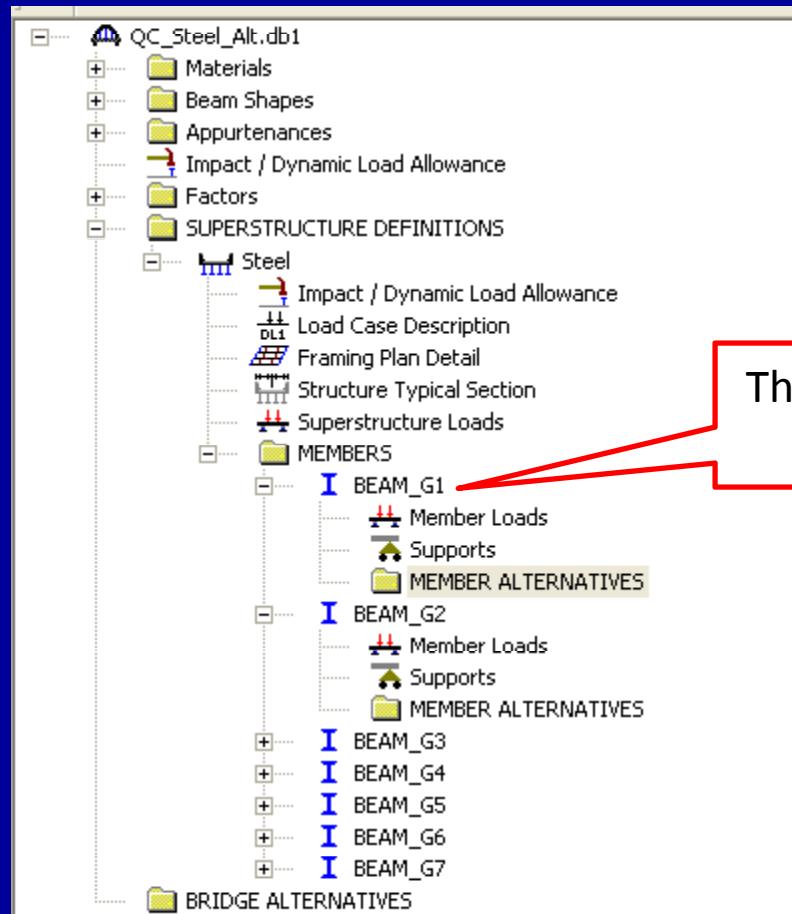
```
c:\ file:///D:/CSharpProjects/BRIDGEWareImporting/bin/Debug/BRID  
Delete Original Mbrs: True  
Delete Original Mbrs: True  
Curr Girder Number: 0  
Girder New(): System.__ComObject  
Set Girder Name:True  
GirderName: BEAM_G1  
Girder New(): System.__ComObject  
Set Girder Name:True  
GirderName: BEAM_G2  
Girder New(): System.__ComObject  
Set Girder Name:True  
GirderName: BEAM_G3  
Girder New(): System.__ComObject  
Set Girder Name:True  
GirderName: BEAM_G4
```

Indicates the girder has been created...

The program is reading data from xml file and calling the BRIDGEWare API to build bridge model automatically.



BRIDGEWare Model (Steel)



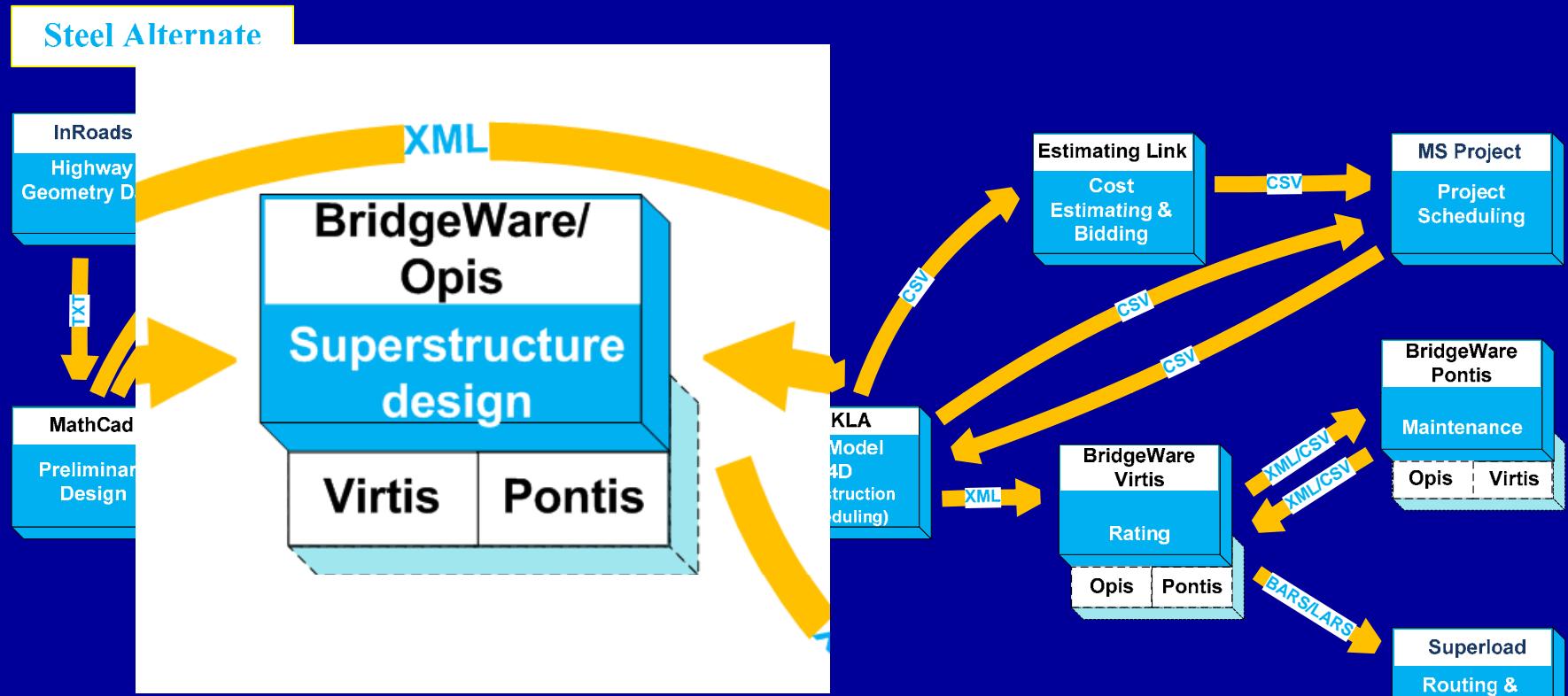
The girder has been
created...



Opis Steel Design



S06 Opis Steel design



S06 Opis Steel design

In Opis:
Open the
XML file
exported
from
MathCAD

Bridge inventory
in Opis.

The screenshot shows the Opis software interface with a title bar "Opis - [Bridge Explorer (31 Opis bridges retrieved for the current folder, all rows retrieved)]". The menu bar includes File, Edit, View, Bridge, Window, and Help. The toolbar has icons for Open, Save, Print, and Bridge Explorer. The status bar shows "RESULTS ALL NXT US Customary". The left sidebar shows a tree view of "All Bridges" with categories like Templates, Sample Bridges (AISI LRFD Example Bridges, Concrete Example Bridges, Steel Example Bridges, Timber Example Bridges), and Deleted Bridges. The main area is a table titled "Bridge Inventory" with columns: BI D, Bridge Id, Bridge Name, District, County, Facility, Location, Route, Feat. Intersected, Mi. Post (mi), Owner, Maintainer, Area, Length (ft), and Built. The table lists 31 entries, including various training and example bridges like PCITrainingBridge2, PCITrainingBridge3, PCITrainingBridge4, PCITrainingBridge5, PCITrainingBridge6, Example7, RCTrainingBridge1, TimberTrainingBridge1, FSys GFS TrainingBridge1, FSys FS TrainingBridge2, FSys GF TrainingBridge3, FLine GFS TrainingBridge1, FLine FS TrainingBridge2, FLine GF TrainingBridge3, TrussTrainingExample, LRFD Substructure Example 1, LRFD Substructure Example 2, LRFD Substructure Example 3, LRFD Substructure Example 4, Visual Reference 1, Quincy Ave_Bridge_HHJ, Quincy Ave_HHJ_02, Quincy Ave_HHJ_03, Quincy Ave_Bridge, AASHTO to LEAP, AASHTO to LEAP 02, Quincy Ave_HHJ_Modified, 001, Quincy_Ave_LRFD, Quincy_Ave_LRFD_stp, and Quincy Ave 01.

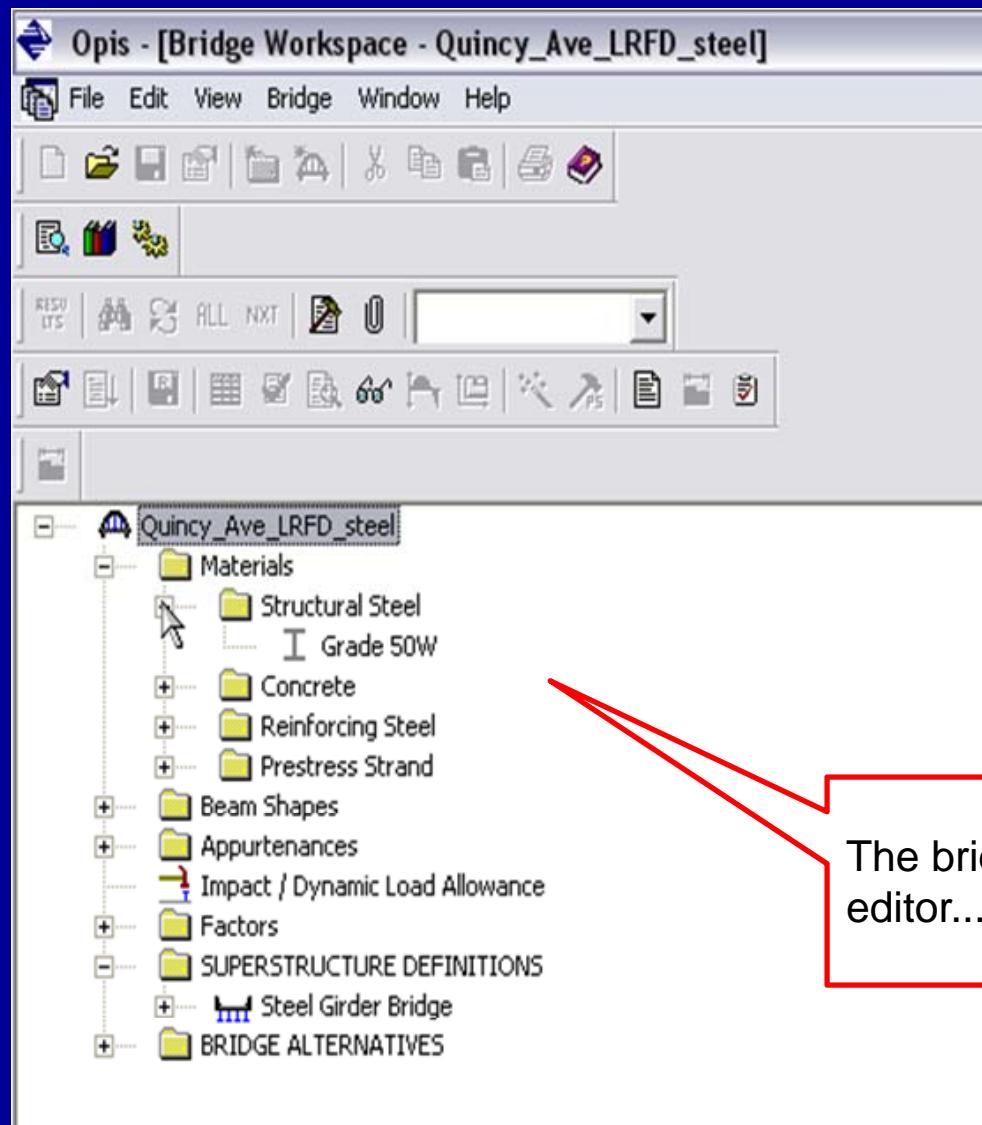
BI D	Bridge Id	Bridge Name	District	County	Facility	Location	Route	Feat. Intersected	Mi. Post (mi)	Owner	Maintainer	Area	Length (ft)	Built
5	PCITrainingBridge2	PCITrainingBr					-1		0.00			-1	0.00	0
6	PCITrainingBridge3	PCI TrainingB					-1		0.00			-1	0.00	0
7	PCITrainingBridge4	PCITrainingBr					-1		0.00			-1	0.00	0
8	PCITrainingBridge5	PCI TrainingB					-1		0.00			-1	0.00	0
9	PCITrainingBridge6	PCITrainingBr					-1		0.00			-1	0.00	0
1	Example7	Example 7 P					-1		0.00			-1	0.00	0
1	RCTrainingBridge1	RC Training					-1		0.00			-1	0.00	0
1	TimberTrainingBridge1	Timber Tr.					-1		0.00			-1	0.00	0
1	FSys GFS TrainingBridge1	FloorSystem	06	15	NJ-Tur NJCity	-1			0.00			-1	0.00	200
1	FSys FS TrainingBridge2	FloorSystem	11	333	I-95 NYC	-1			0.00	1	2	-1	0.00	199
1	FSys GF TrainingBridge3	FloorSystem	07	06	I-95 ATL	-1			0.00	2		-1	0.00	199
1	FLine GFS TrainingBridge1	FloorLine GF	01	01	I-75 JAX	-1			0.00	1	1	-1	0.00	200
1	FLine FS TrainingBridge2	FloorLine FS	02	02	I-75 GNV	-1			0.00	1	1	-1	0.00	200
1	FLine GF TrainingBridge3	FloorLine GF	01	01	I-95 NY	15			2200.00	2	-1	-1	0.00	199
1	TrussTrainingExample	Truss Trainin				5			0.00				0.00	193
2	LRFD Substructure Example 1	LRFD Substr							0.00				0.00	0
2	LRFD Substructure Example 2	LRFD Substr					SR 403 ERIE CO 4034	FOUR MILE	8.12				1095.8	200
2	LRFD Substructure Example 3	LRFD Substr							0.00				0.00	0
2	LRFD Substructure Example 4	LRFD Substr							0.00				240.00	200
2	Visual Reference 1	Visual Refer	01	12	I-76 WAITSFI	I-76	MAD RIVER	1199.25	1	1	-1	168.00	193	
2	Quincy Ave_Bridge_HHJ	Quincy Aven					-1		0.00				280.00	200
2	Quincy Ave_HHJ_02	Quincy Aven					-1		0.00				280.00	200
2	Quincy Ave_HHJ_03	Quincy Aven					-1		0.00				280.00	200
3	Quincy Ave_Bridge	Quincy Ave.							0.00				0.00	0
3	AASHTO to LEAP	Quincy Aven					-1		0.00				277.00	200
3	AASHTO to LEAP 02	Quincy Aven					-1		0.00				280.00	200
3	Quincy Ave_HHJ_Modified	Quincy Aven					0051		0.00				280.00	200
3	001	Quincy Aven							0.00				0.00	200
3	Quincy_Ave_LRFD	Quincy Ave					SR 005 Delawar	0051	SR 6060	17.00	1	-2	277.00	200
3	Quincy_Ave_LRFD_stp	Quincy Ave					SR 005 Delawar	0051	SR 6060	17.00	1	-2	277.00	200
4	Quincy Ave 01	Quincy Ave					SR 005 Delawar	0051	SR 6060	17.00	1	-2	277.00	200

The bridge model we
just imported...



S06 Opis Steel design

Define
Material
properties

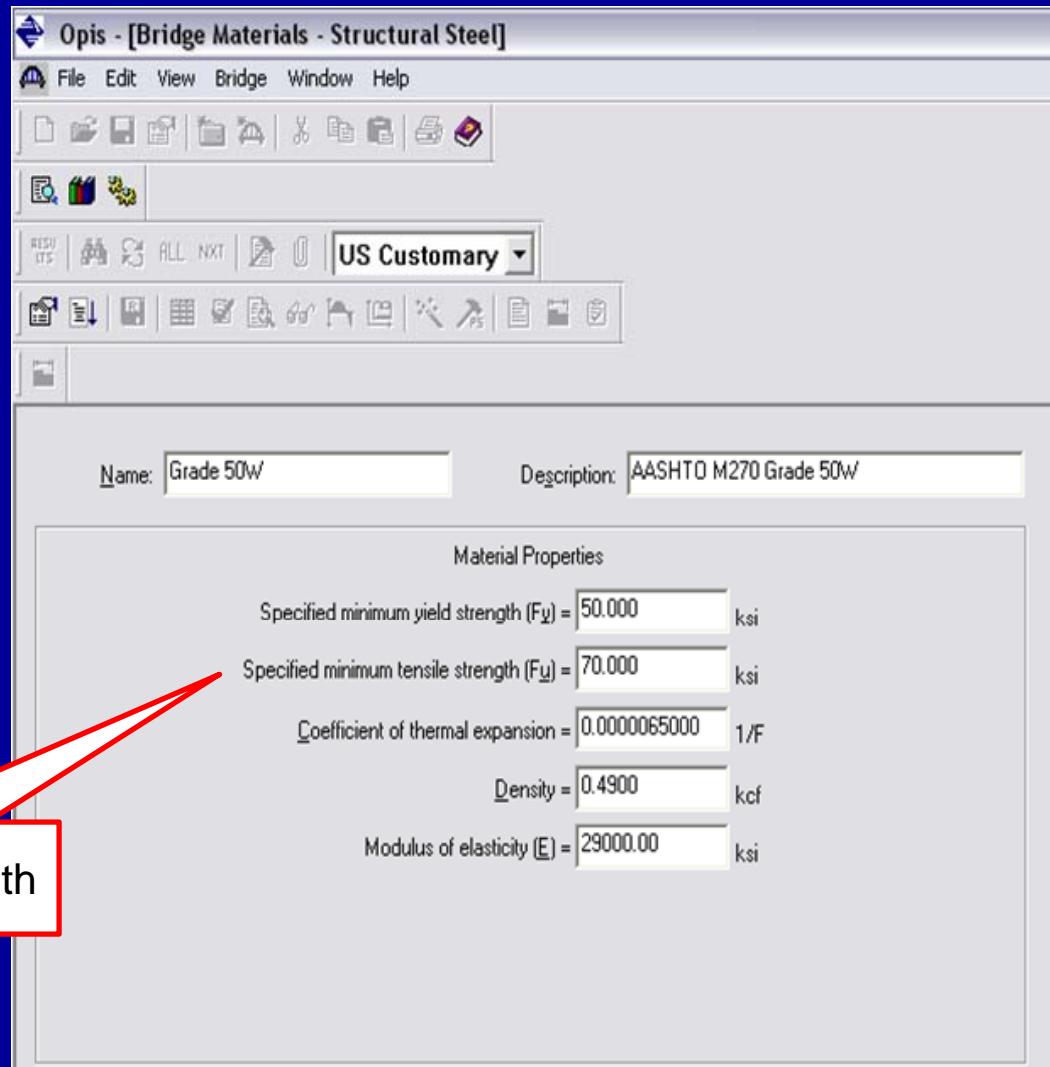


The bridge model
editor...



S06 Opis Steel design

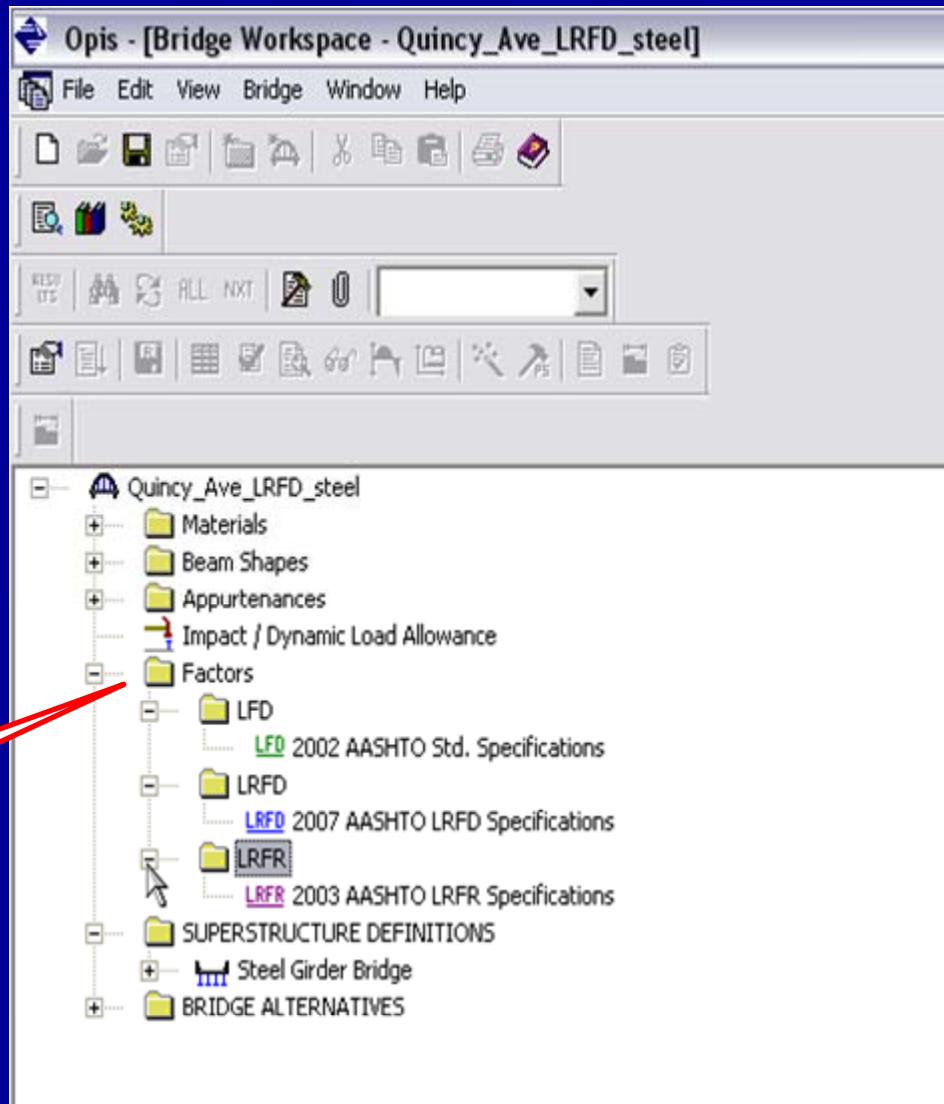
Define
steel Grade
50w



S06 Opis Steel design

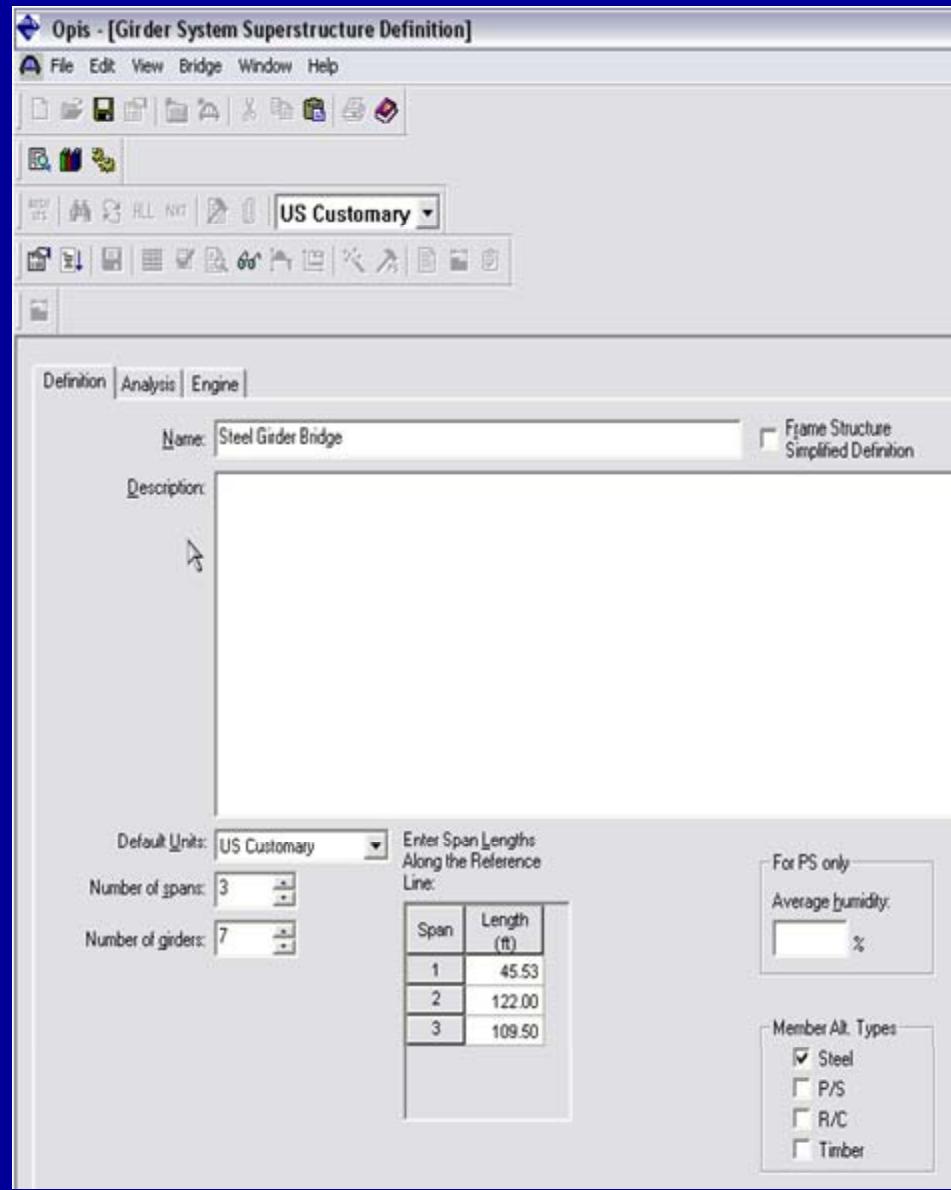
Define factors:
2007
AASHTO
LRFD
Specification

Define LRFD
factors



S06 Opis Steel design

Define bridge overall information:
Span number, girder number, etc.



S06 Opis Steel design

Load case
description

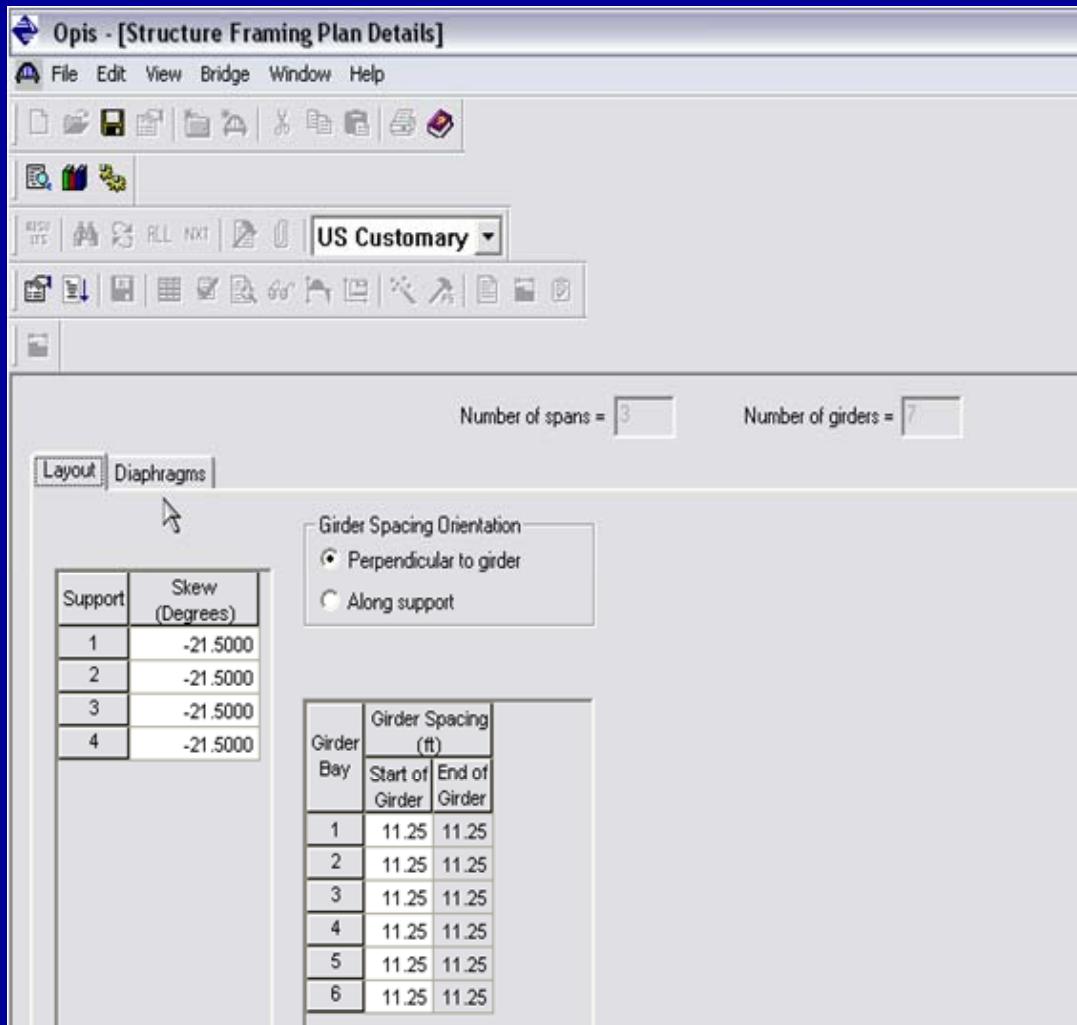
The screenshot shows the Opis software interface with the title bar "Opis - [Load Case Description]". The menu bar includes File, Edit, View, Bridge, Window, and Help. Below the menu is a toolbar with various icons. A dropdown menu shows "US Customary" selected. The main area displays a table of load cases:

Load Case Name	Description	Stage	Type	Time [*] (Days)
DC1	DC acting on no	Non-composite (Stage 1)	D,DC	
DC2	DC acting on lon	Composite (long term) (Stage 2)	D,DC	
DW	DW acting on	Composite (long term) (Stage 2)	D,DW	
SIP Forms	Weight due to st	Non-composite (Stage 1)	D,DC	



S06 Opis Steel design

Define girder spacing and skewed angle



S06 Opis Steel design

Define
diaphragm
spacing

Opis - [Structure Framing Plan Details]

File Edit View Bridge Window Help

US Customary

Number of spans = 3 Number of girders = 7

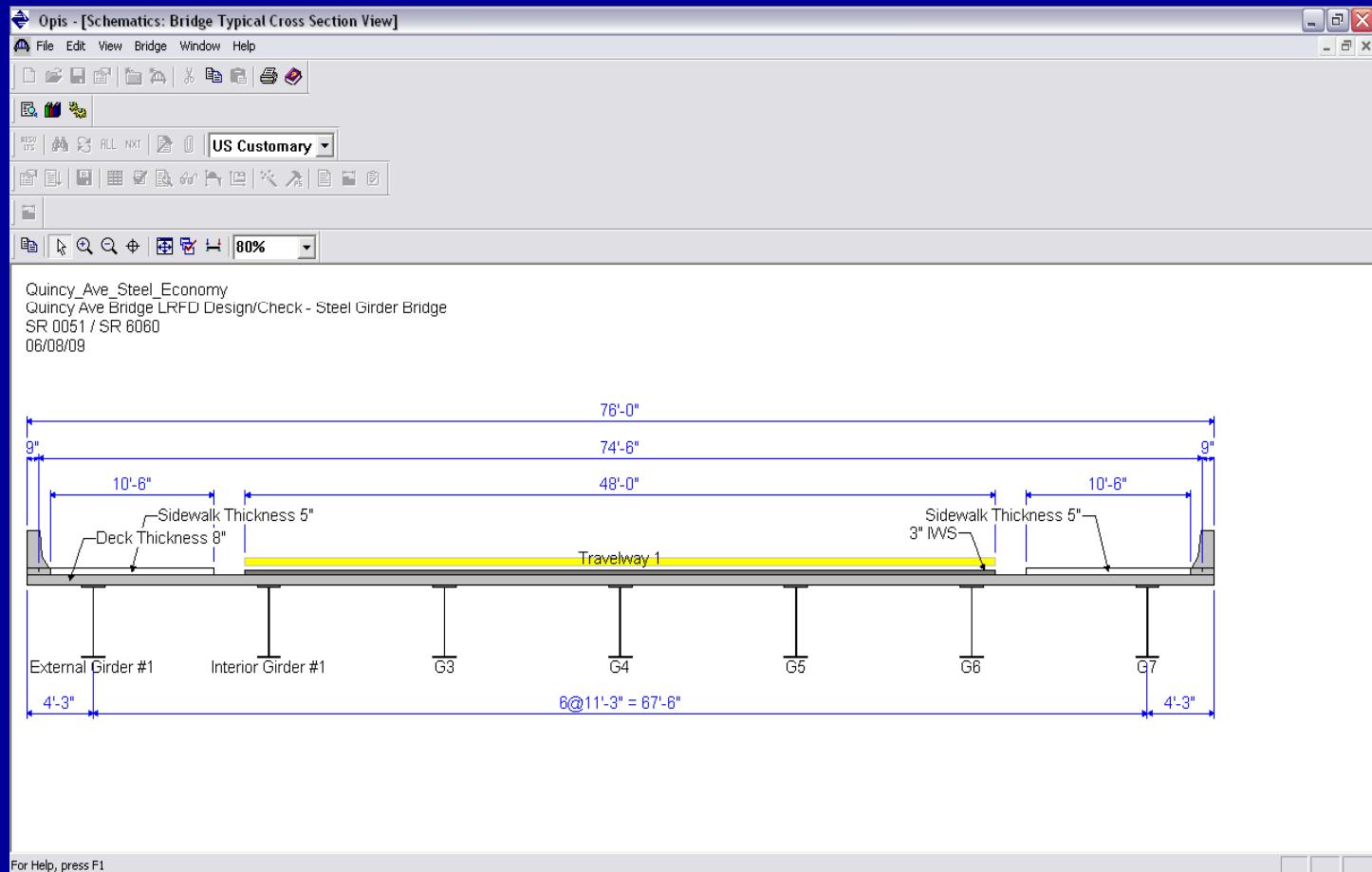
Girder Bay: 1 Copy Bay To... Diaphragm Wizard...

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Load (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	
1	23.50	19.07	0.00	1	0.00	23.50	19.07	
2	0.00	0.00	0.00	1	0.00	0.00	0.00	
2	20.50	16.07	0.00	1	0.00	20.50	16.07	
2	20.50	16.07	20.50	4	82.00	102.50	98.07	
3	0.00	0.00	0.00	1	0.00	0.00	0.00	
3	18.30	13.87	0.00	1	0.00	18.30	13.87	
3	18.30	13.87	18.25	4	73.00	91.30	86.87	
3	109.50	109.50	0.00	1	0.00	109.50	109.50	



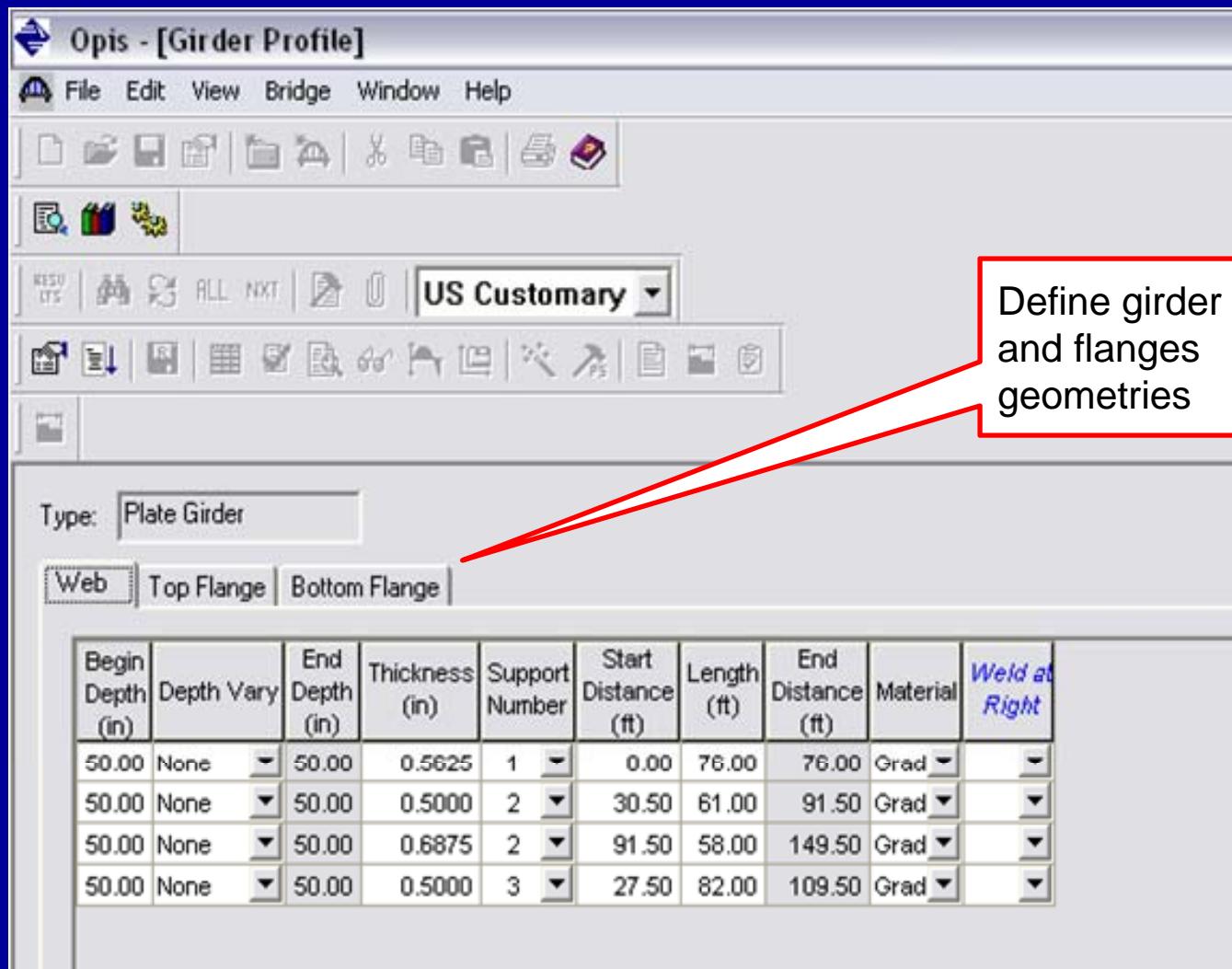
S06 Opis Steel design

Typical section view of super-structure



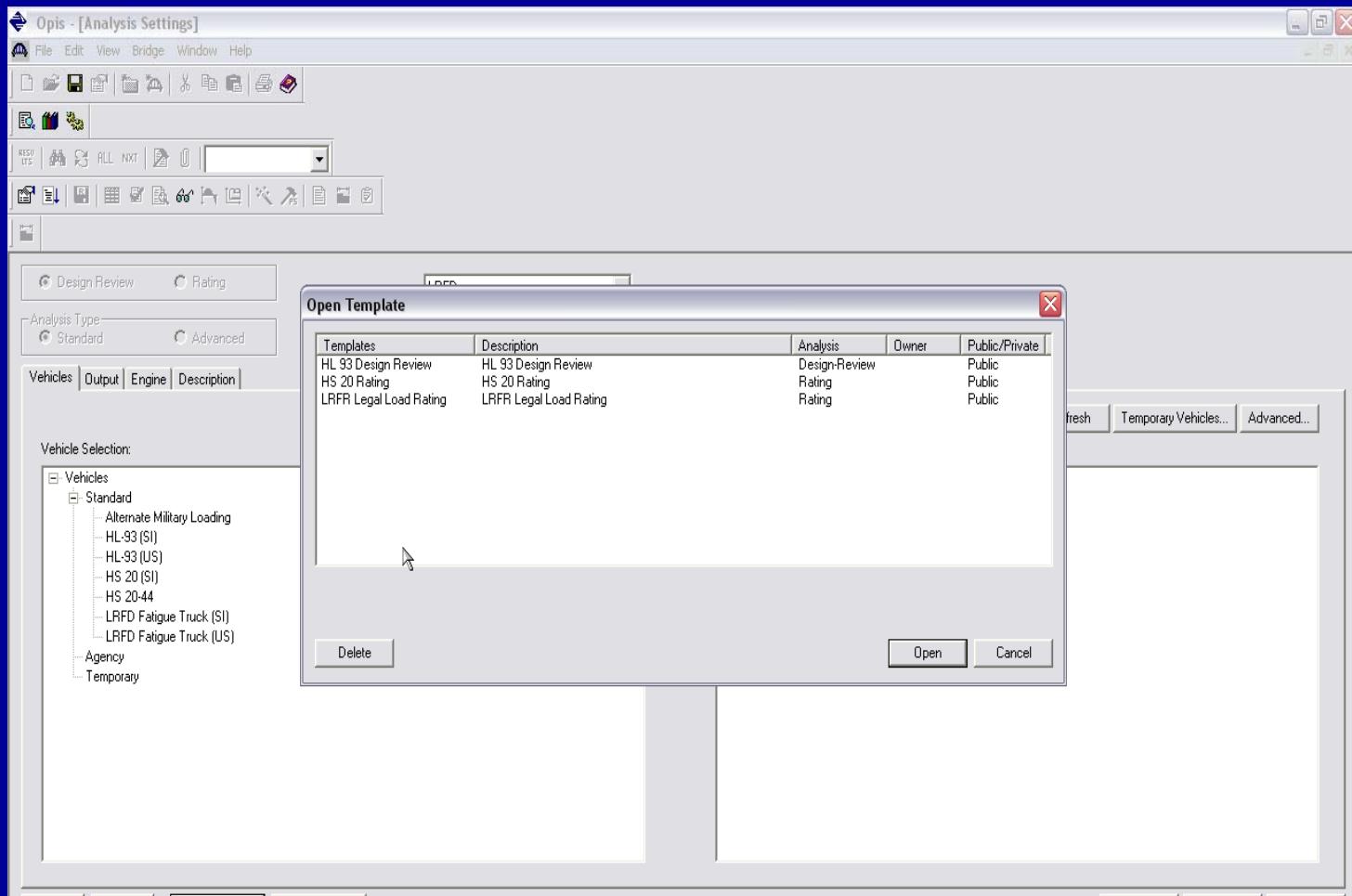
S06 Opis Steel design

Girder profile



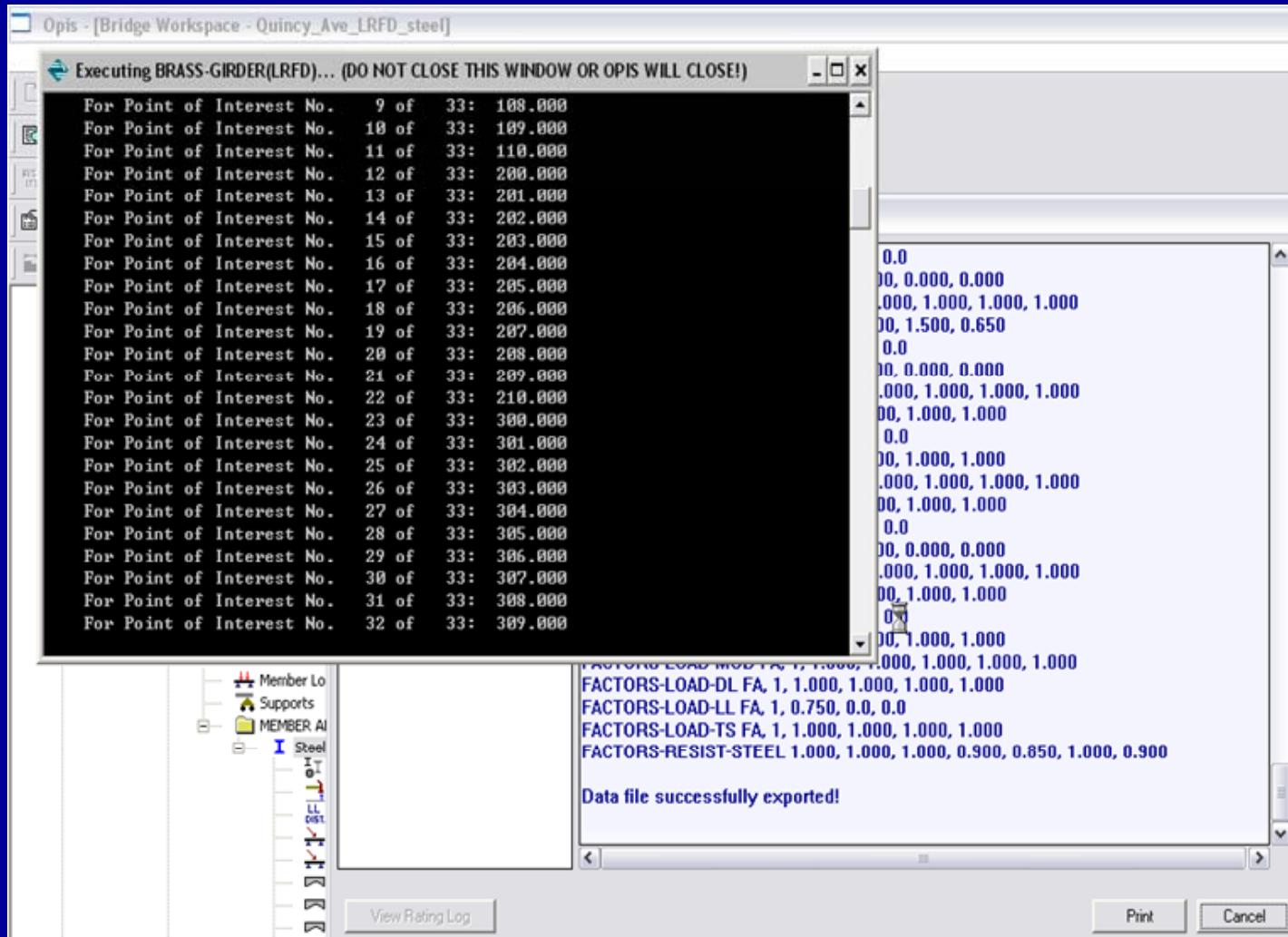
S06 Opis Steel design

Define analysis settings



S06 Opis Steel design

Run analysis



S06 Opis Steel design

Analysis
results:
Moment,
shear, axial
force, etc.

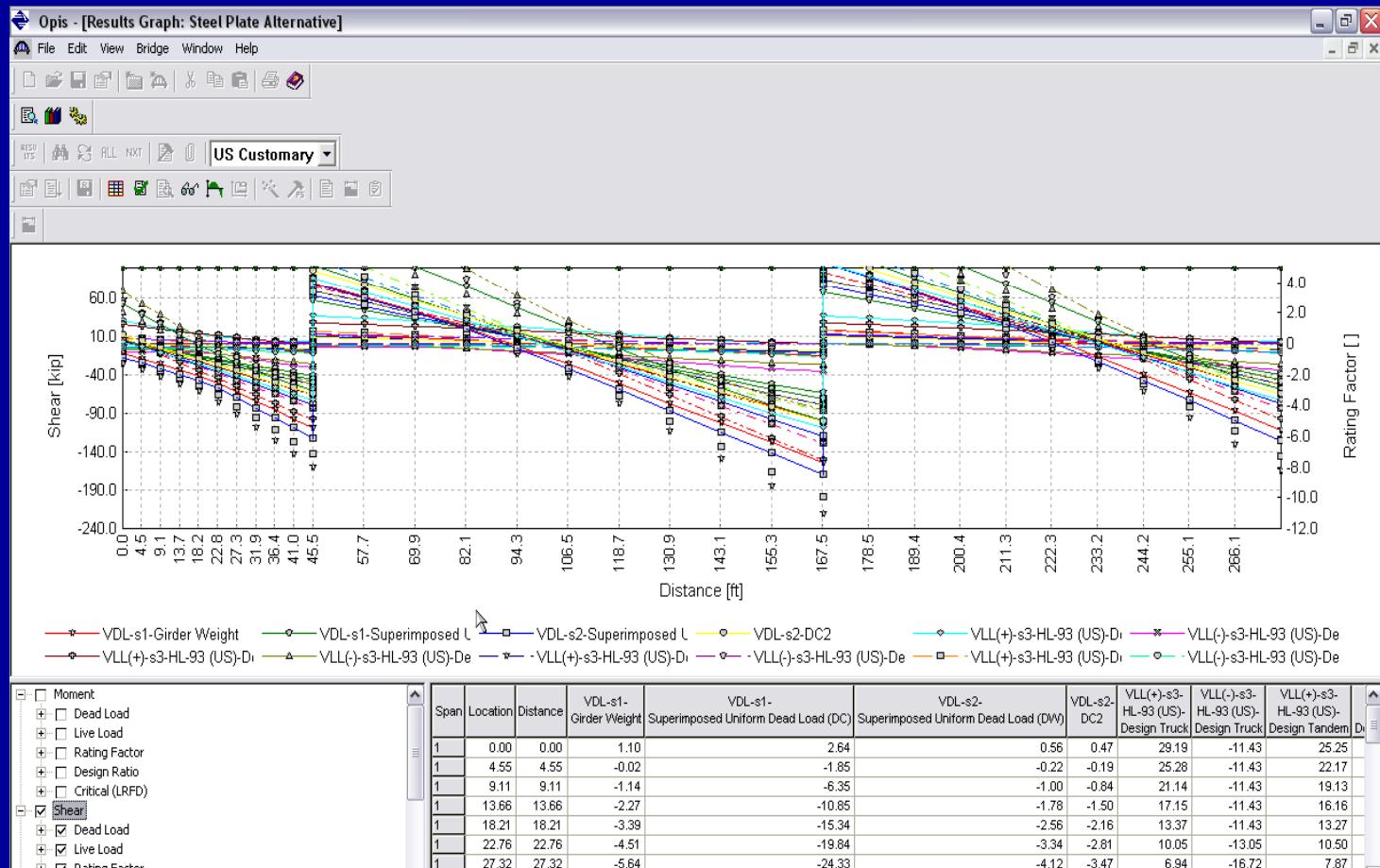
The screenshot shows the Opis software interface with the title bar "Opis - [Analysis Results - Steel Plate Alternative]". The menu bar includes File, Edit, View, Bridge, Window, and Help. The toolbar contains various icons for file operations like Open, Save, Print, and Export. A unit selection dropdown shows "US Customary". The main window displays a report table with columns for Span, Location (ft), % Span, Moment (kip-ft), Shear (kip), Axial (kip), Reaction (kip), X Deflection (in), and Y Deflection (in). The report type is set to "Dead Load Actions", the stage is "Non-composite (Stage 1)", and the dead load case is "Girder Weight". The table lists data for multiple spans, with the first few rows shown below:

Span	Location (ft)	% Span	Moment (kip-ft)	Shear (kip)	Axial (kip)	Reaction (kip)	X Deflection (in)	Y Deflection (in)
1	0.00	0.0	0.00	1.10	-0.00	1.10	0.0000	0.0000
1	4.55	10.0	2.47	-0.02	-0.00		0.0000	-0.0048
1	9.11	20.0	-0.17	-1.14	-0.00		0.0000	-0.0096
1	13.66	30.0	-7.93	-2.27	-0.00		0.0000	-0.0145
1	18.21	40.0	-20.80	-3.39	-0.00		0.0000	-0.0190
1	22.76	50.0	-38.79	-4.51	-0.00		0.0000	-0.0227
1	27.32	60.0	-61.89	-5.64	0.00		0.0000	-0.0250
1	31.87	70.0	-90.10	-6.76	0.00		0.0000	-0.0250
1	36.42	80.0	-123.43	-7.88	0.00		0.0000	-0.0217
1	40.98	90.0	-161.87	-9.00	0.00		0.0000	-0.0138
1	45.53	100.	-205.43	-10.13	0.00	23.10	0.0000	0.0000
2	0.00	0.0	-205.43	12.98	-0.00	23.10	0.0000	0.0000
2	12.20	10.0	-64.54	10.12	-0.00		0.0000	0.0690



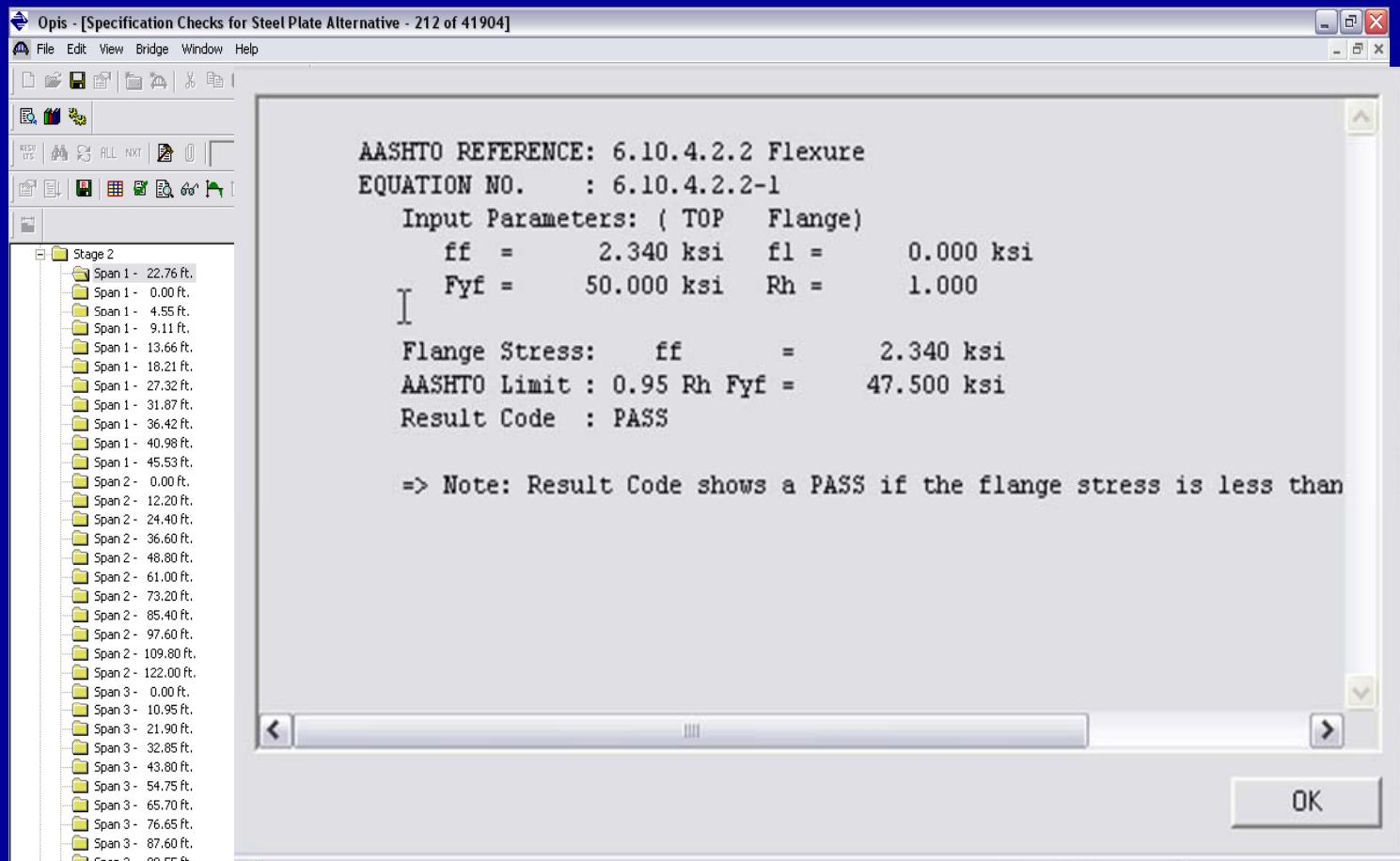
S06 Opis Steel design

Shear
diagrams
and
envelopes



S06 Opis Steel design

Specifi-
cation
checks:
Service
limit state:
Flexural



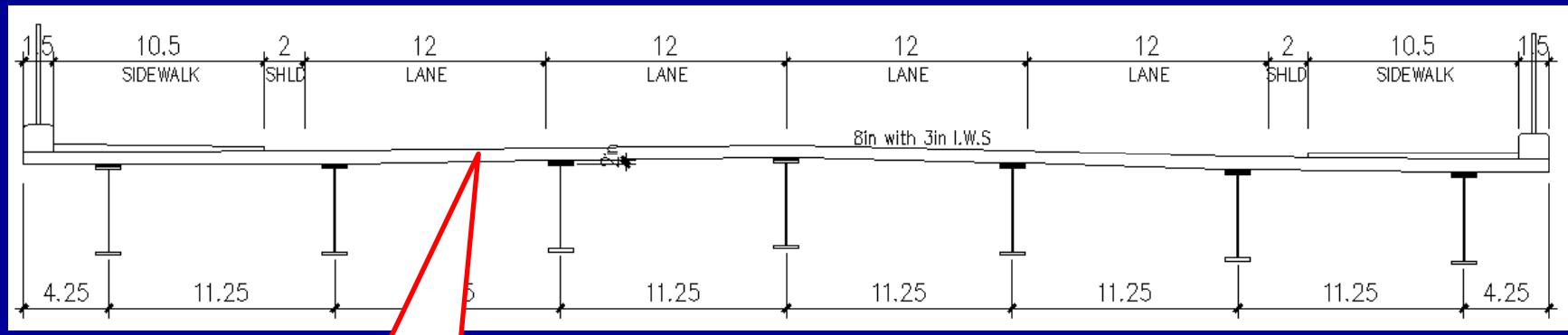
Steel Alternate Design



Typical Bridge Cross Section

Superstructure Configuration

- 7 girders spaced at 11.25 ft
- 8 inch concrete deck with integral wearing surface
- 2% cross-slope from centerline of the roadway
- 10 ft-6 in wide sidewalks and a 1 ft-6 in wide railing

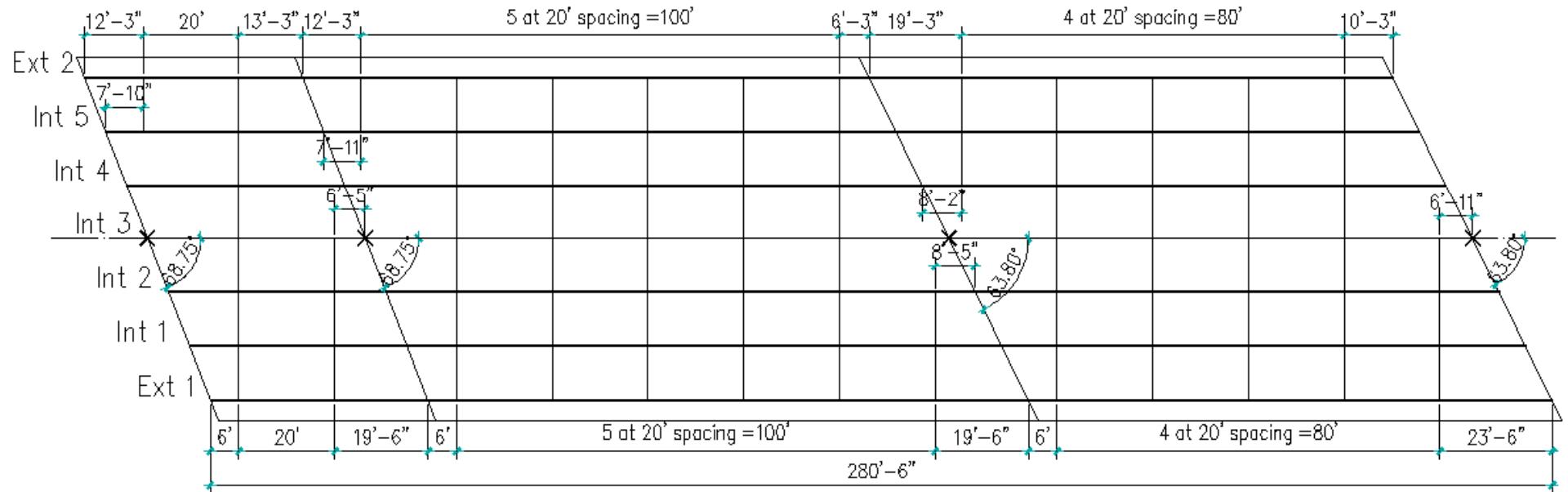


2% side slope

Bridge Framing Plan

Framing plan description:

The cross frames at the supports are positioned on the skew, others are located normal to the main members.

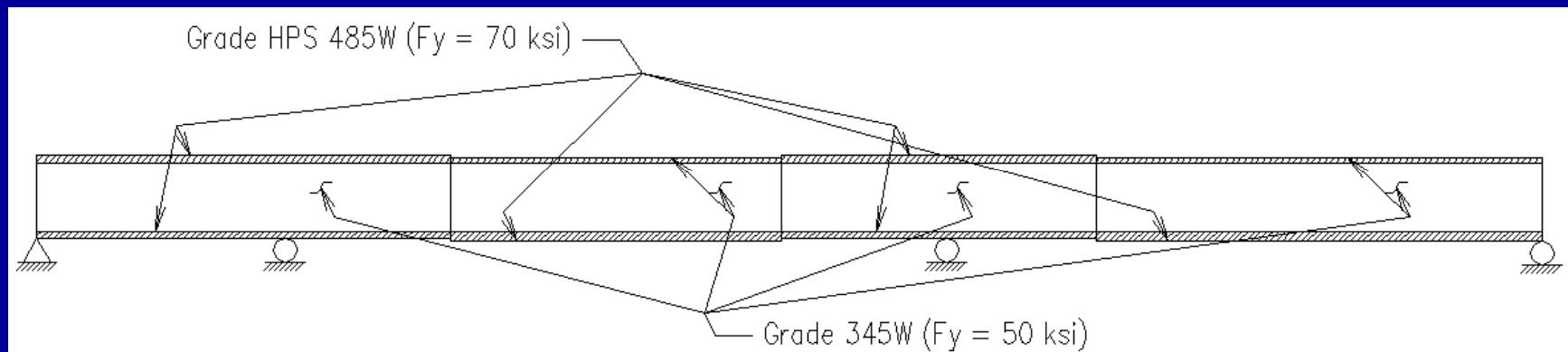


Hybrid Configuration

Material properties

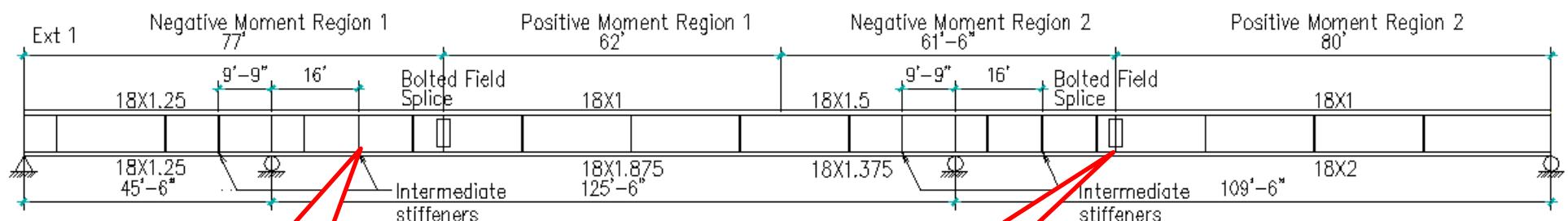
This design incorporates the following structural steels:

- Grade 50W: Top flange in the positive moment region and the entire web.
- Grade 70W HPS: Both flanges in the negative moment region and the bottom flange in the positive moment region.



Girder Elevation and Section Description

Exterior Girder No. 1 Elevation View:



Intermediate
Stiffeners

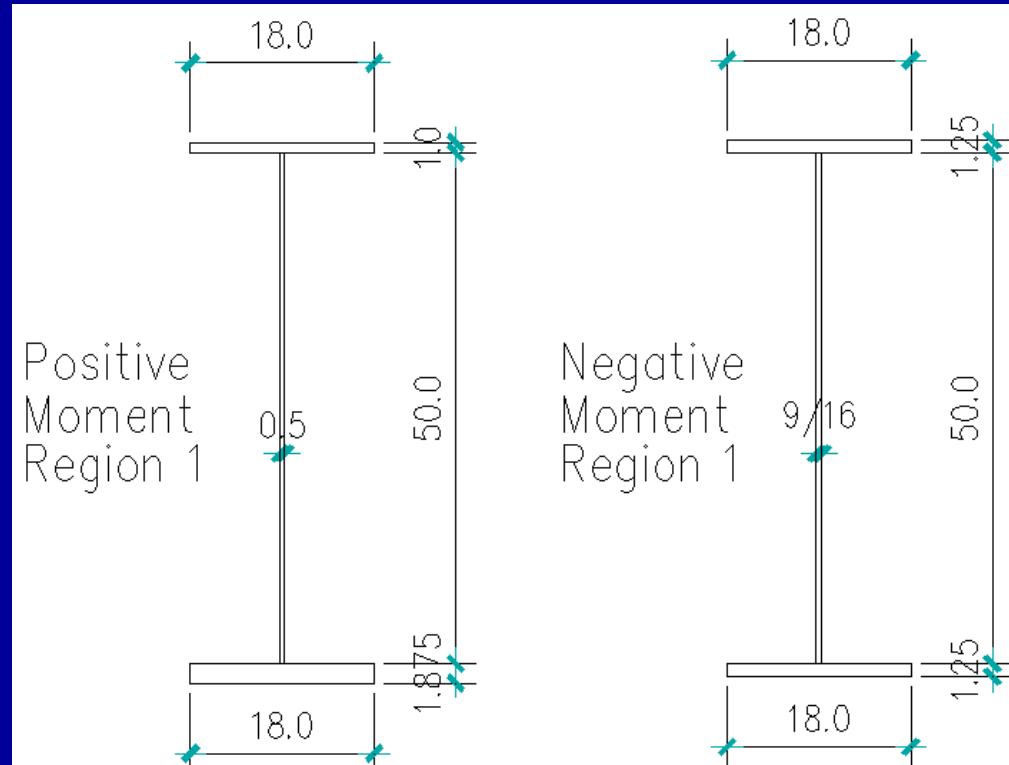
Field splices



Girder Elevation and Section Description

Exterior Girder No. 1

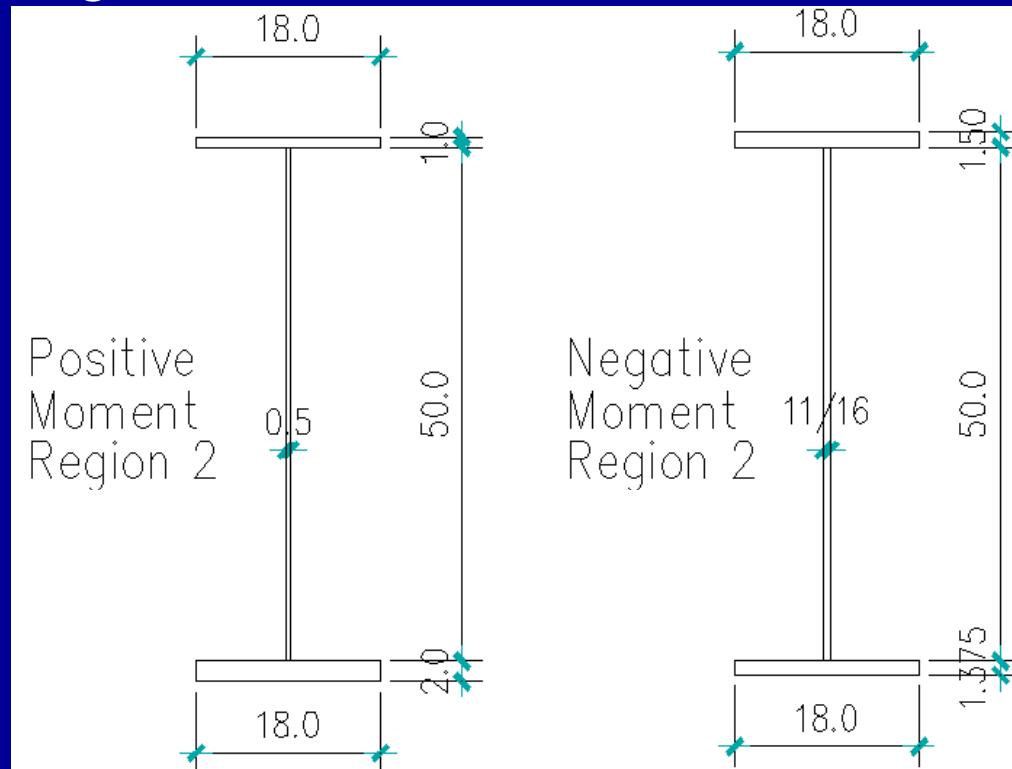
Section View: Positive Moment Region 1 and Negative Moment Region 1



Girder Elevation and Section Description

Exterior Girder No. 1

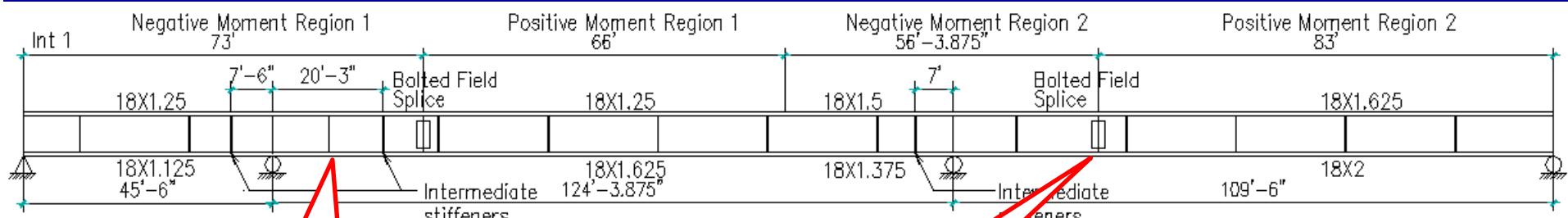
Section View: Positive Moment Region 2 and Negative Moment Region 2



Girder Elevation and Section Description

Interior Girder No. 1

Elevation View:



Intermediate
Stiffeners

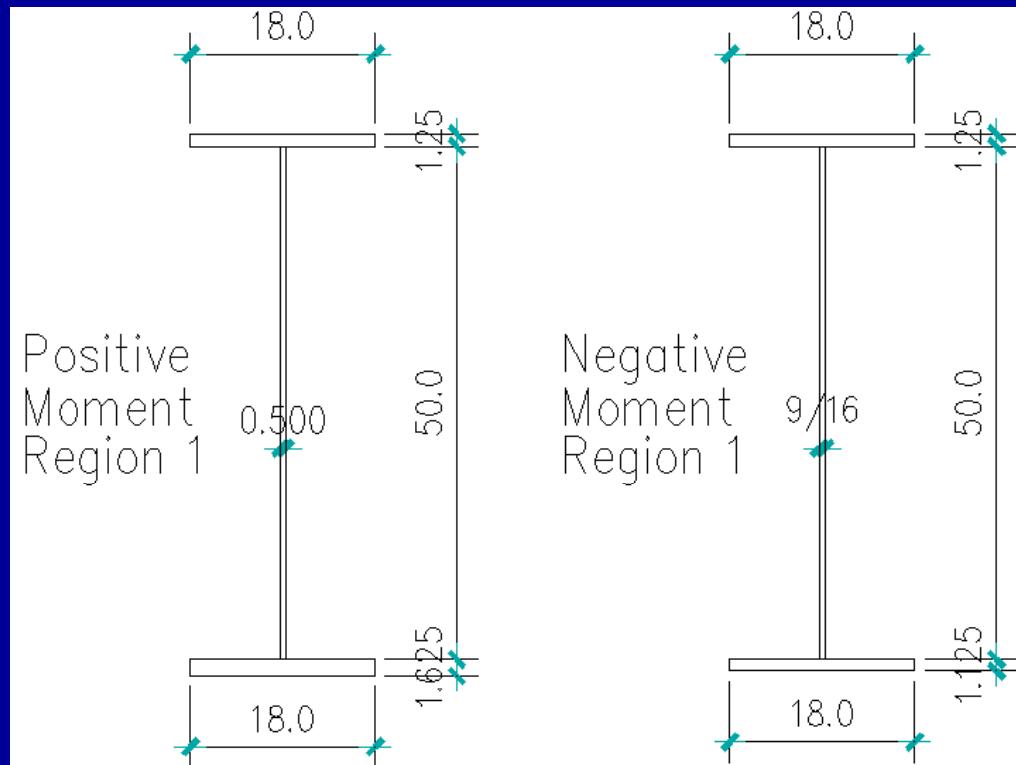
Field splices



Girder Elevation and Section Description

Interior Girder No. 1

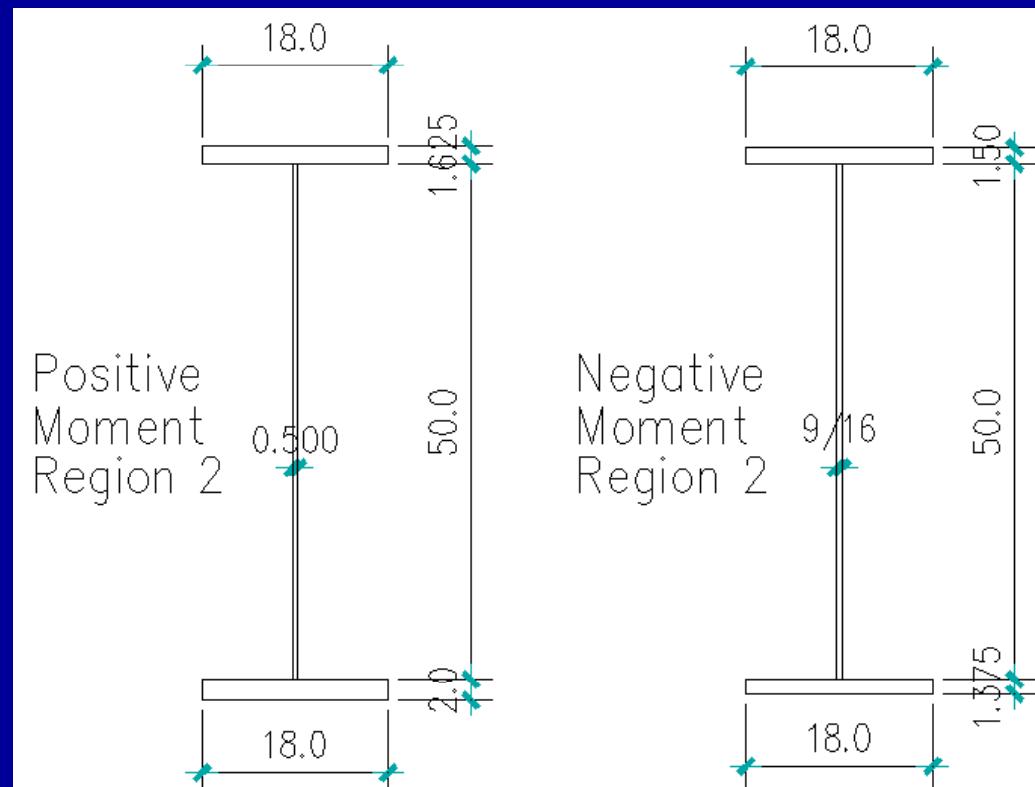
Section View: Positive Moment Region 1 and Negative Moment Region 1



Girder Elevation and Section Description

Interior Girder No. 1

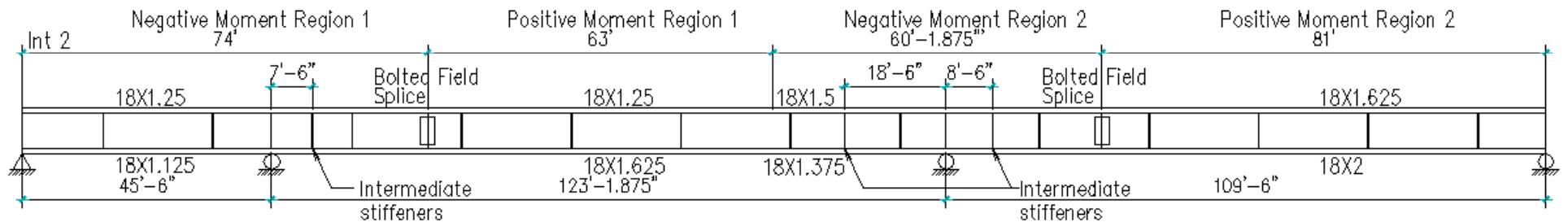
Section View: Positive Moment Region 2 and Negative Moment Region 2



Girder Elevation and Section Description

Interior Girder No. 2

Elevation View:



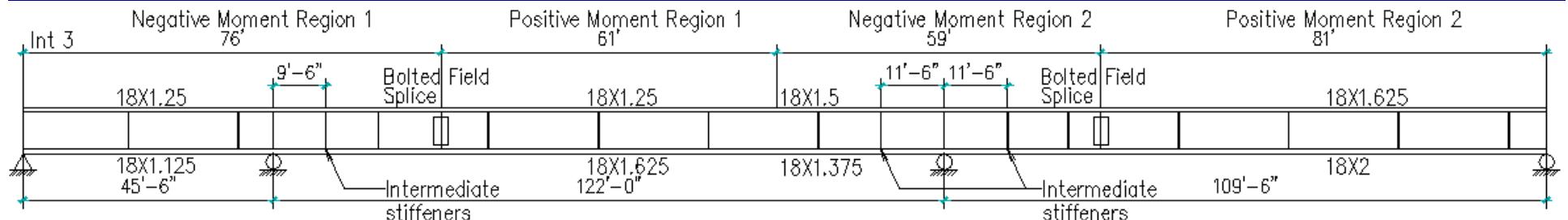
Section View: The same as interior girder No.1



Girder Elevation and Section Description

Interior Girder No. 3

Elevation View:



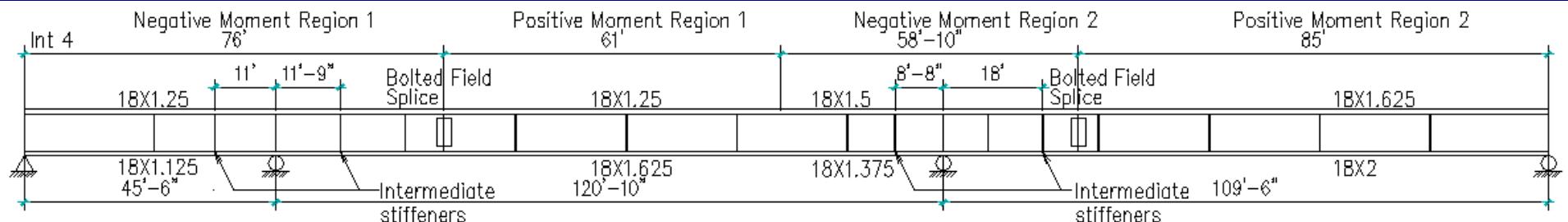
Section View: The same as interior girder No.1



Girder Elevation and Section Description

Interior Girder No. 4

Elevation View:



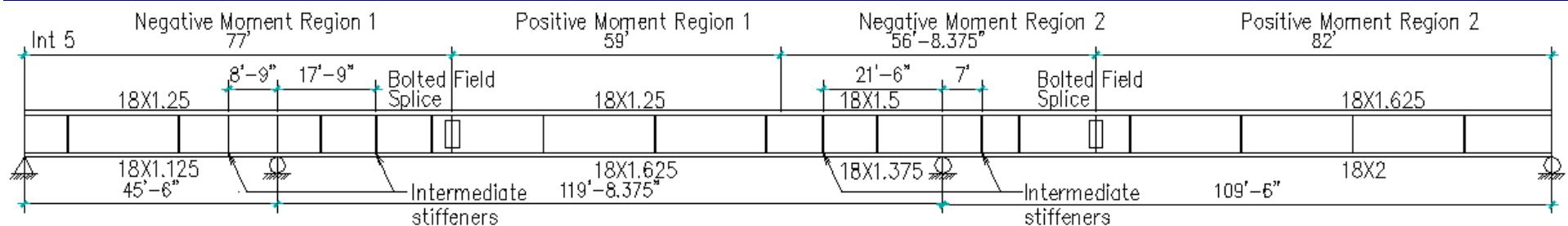
Section View: The same as interior girder No.1



Girder Elevation and Section Description

Interior Girder No. 5

Elevation View:



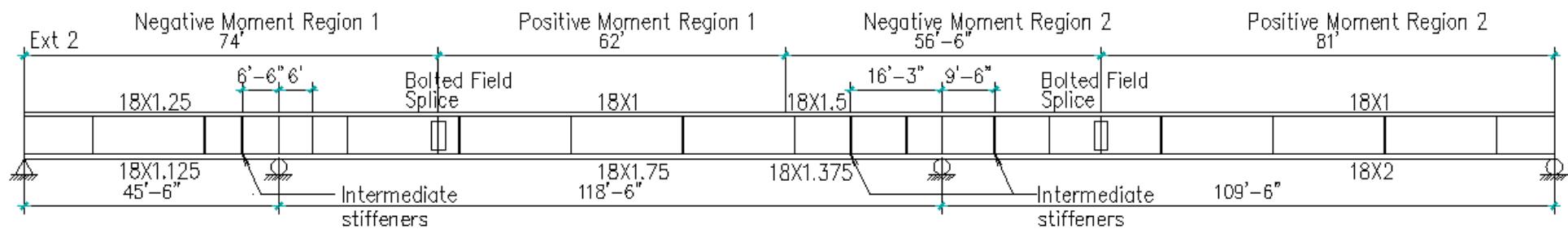
Section View: The same as interior girder No.1



Girder Elevation and Section Description

Exterior Girder No. 2

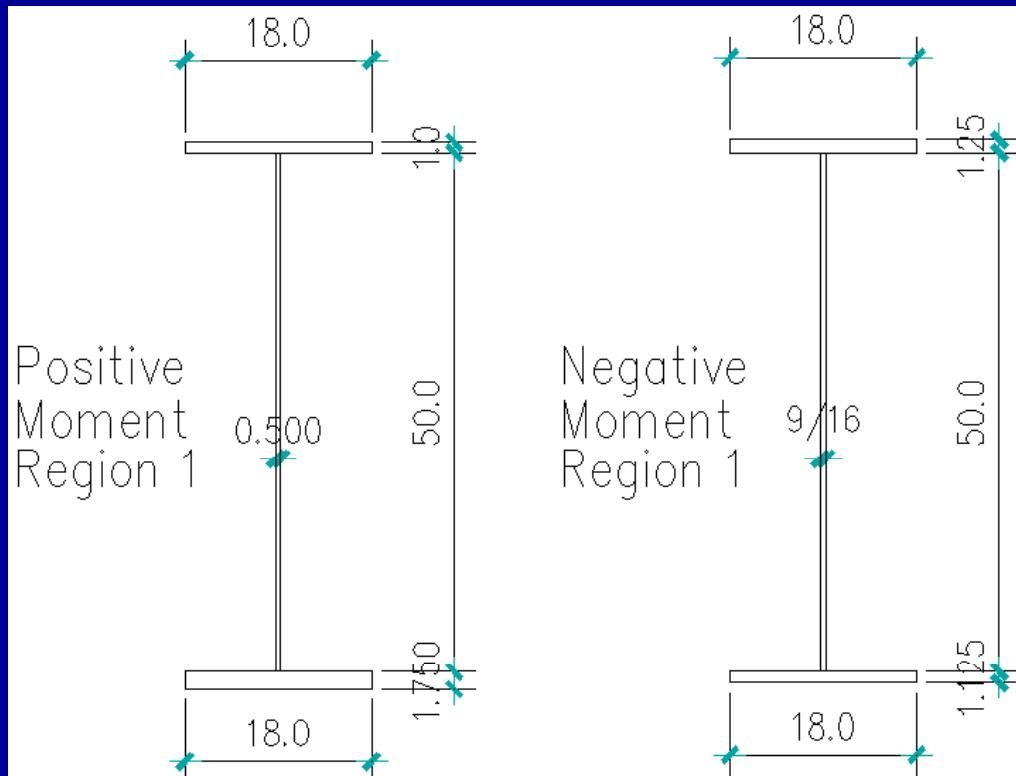
Elevation View:



Girder Elevation and Section Description

Exterior Girder No. 2

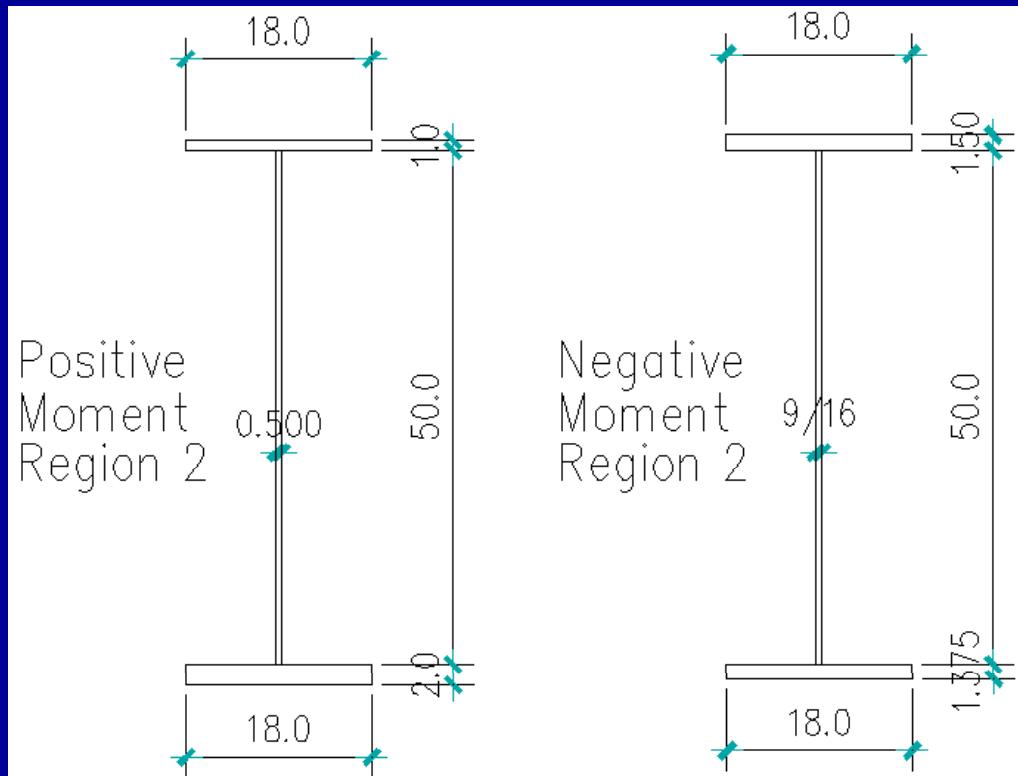
Section View: Positive Moment Region 1 and Negative Moment Region 1



Girder Elevation and Section Description

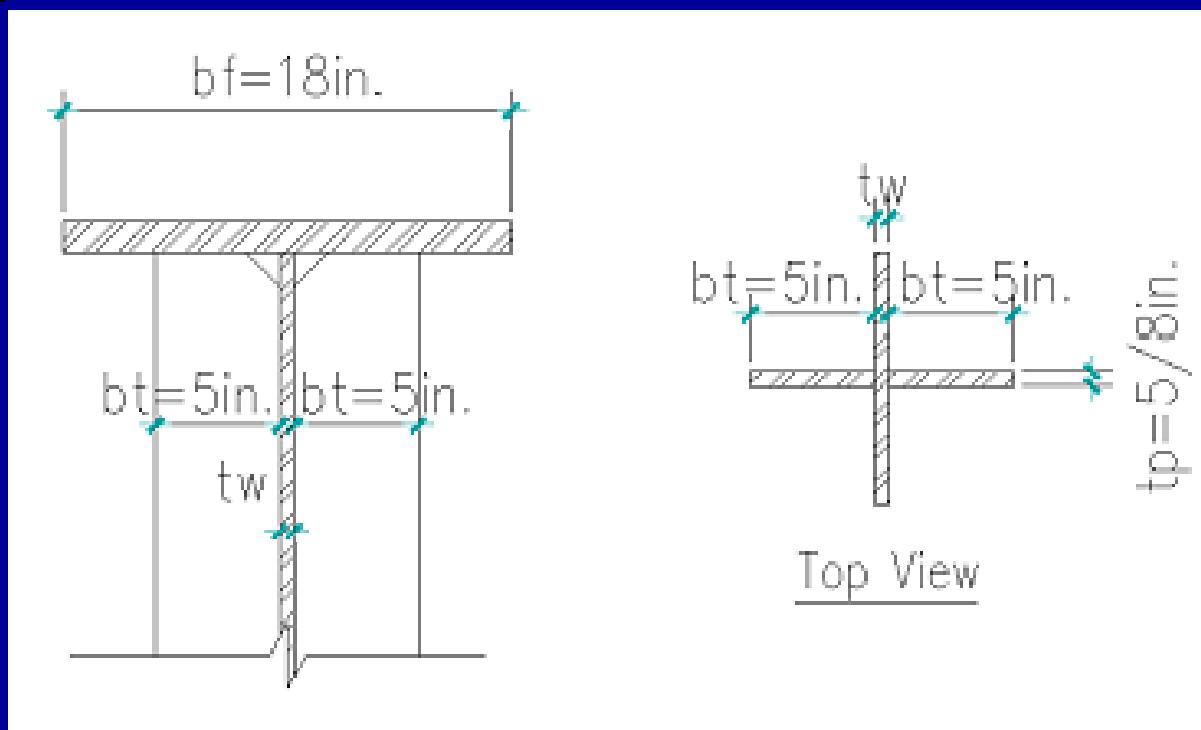
Exterior Girder No.2

Section View: Positive Moment Region 2 and Negative Moment Region 2



Stiffener Description

Section View of Intermediate Stiffener



Structure Framing Plan Details in Opis

Opis - [Structure Framing Plan Details]

File Edit View Bridge Window Help

RESU DTS ALL NXT US Customary

Number of spans = 3 Number of girders = 7

Girder Bay: 1 Copy Bay To... Diaphragm Wizard...

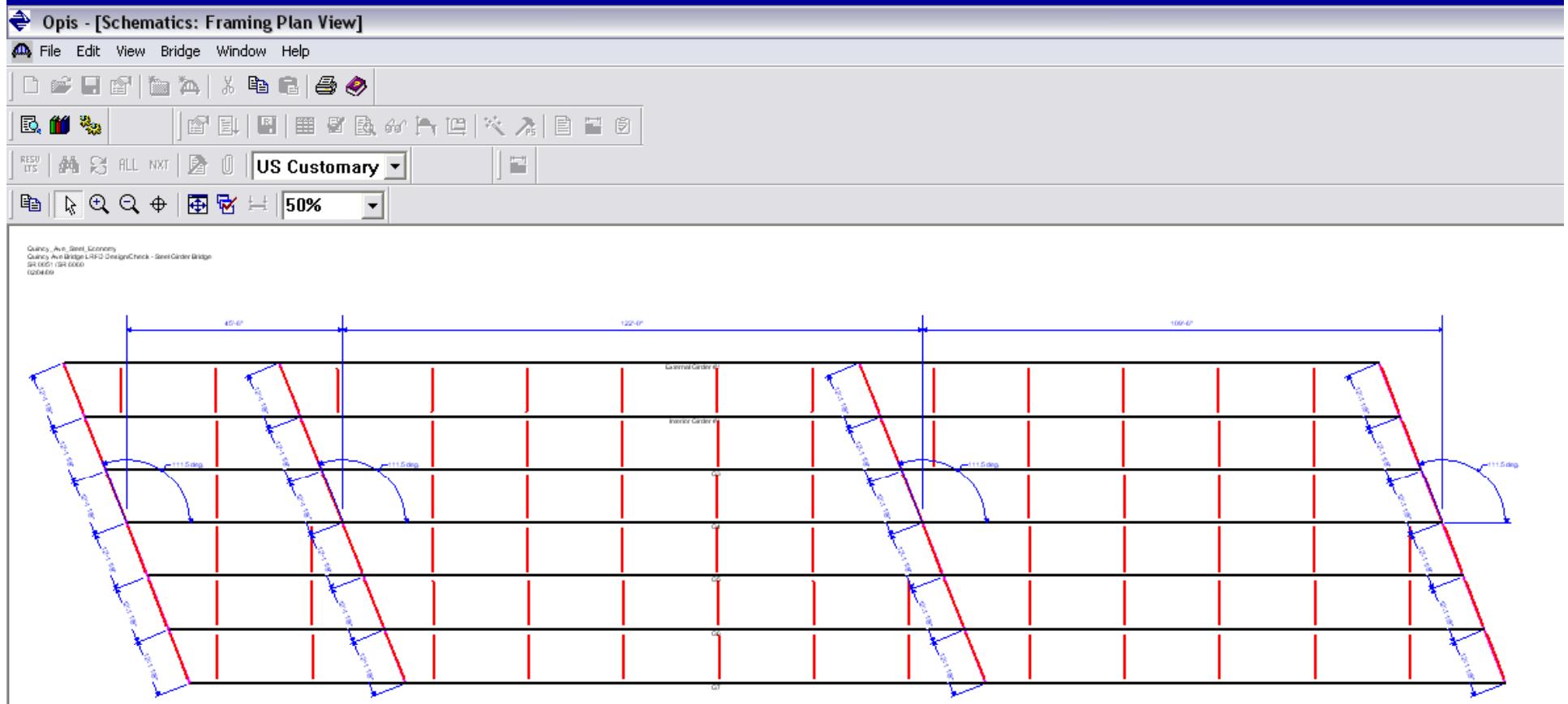
Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Load (kip)
	Left Girder	Right Girder				Left Girder	Right Girder	
1	0.00	0.00	0.00	1	0.00	0.00	0.00	
1	12.25	7.83	0.00	1	0.00	12.25	7.83	
1	12.25	7.83	20.00	1	20.00	32.25	27.83	
2	0.00	0.00	0.00	1	0.00	0.00	0.00	
2	12.25	7.87	0.00	1	0.00	12.25	7.87	
2	12.25	7.87	20.00	5	100.00	112.25	107.67	
3	0.00	0.00	0.00	1	0.00	0.00	0.00	
3	15.73	11.36	0.00	1	0.00	15.73	11.36	
3	15.73	11.36	20.00	4	80.00	95.73	91.36	
3	109.50	109.50	0.00	1	0.00	109.50	109.50	

Support No.

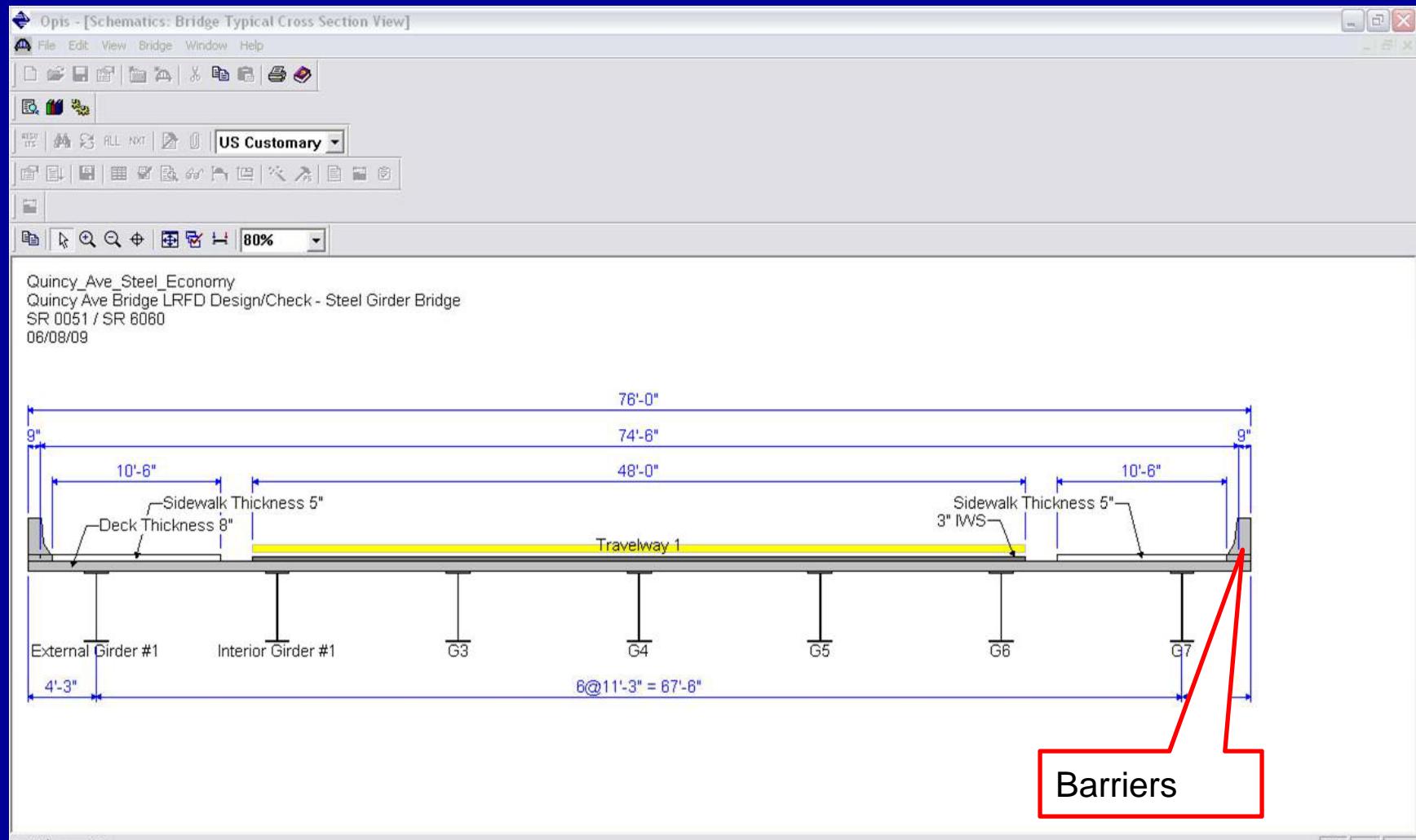
Diaphragm position
and spacing...



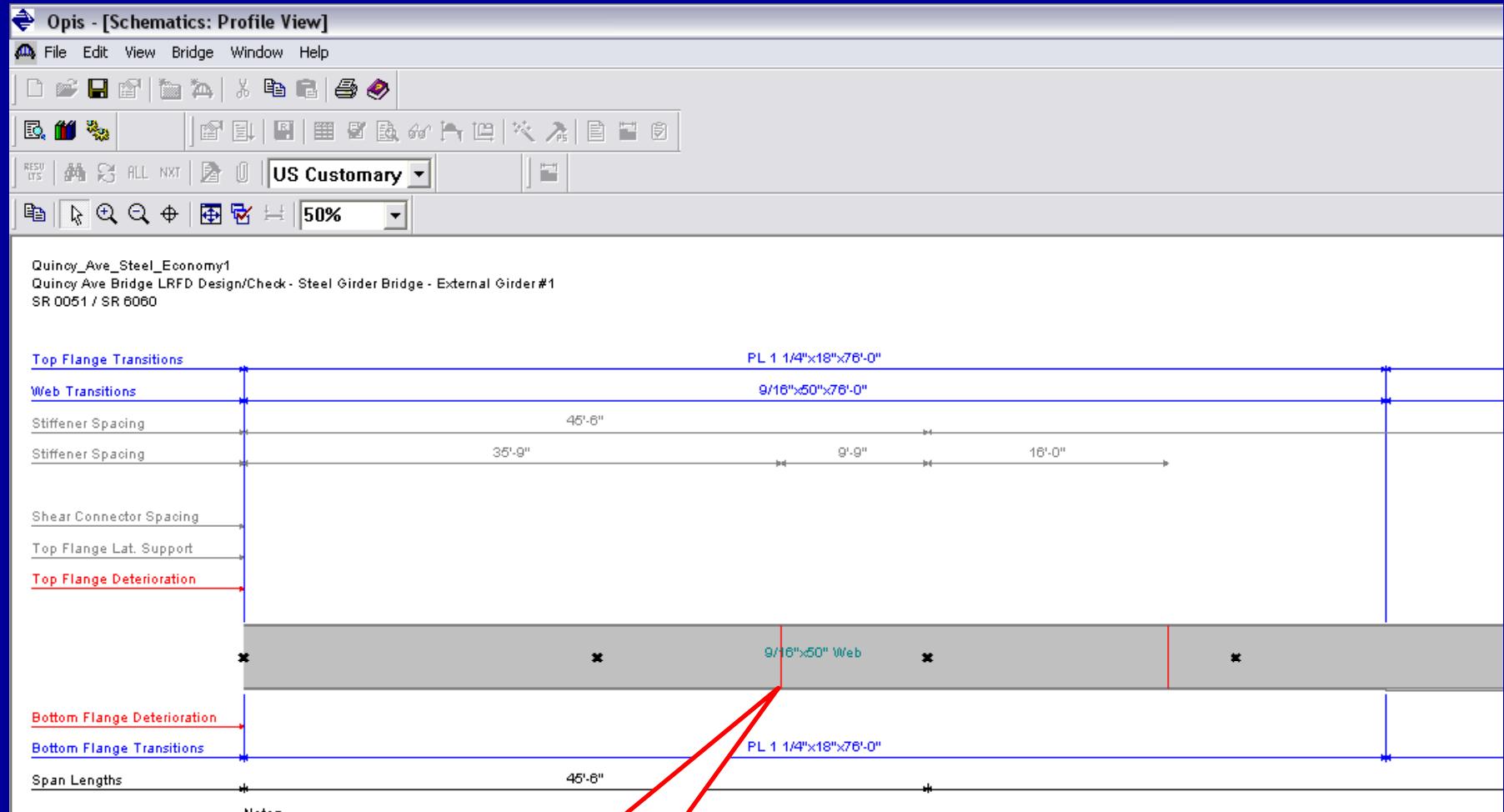
Framing Plan View in Opis



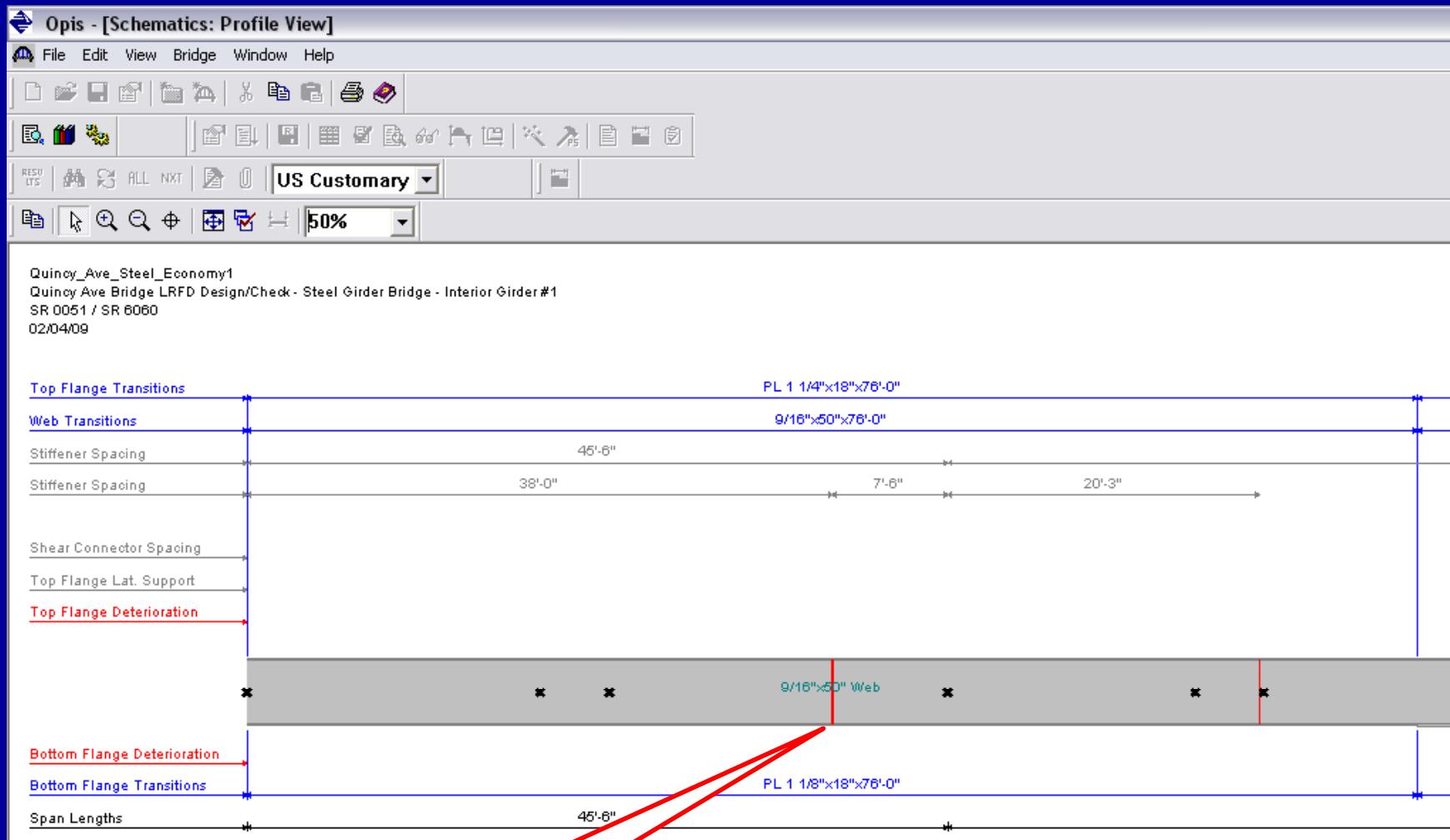
Deck Cross Section View in Opis



Exterior Girder Section View in Opis



Interior Girder Section View in Opis



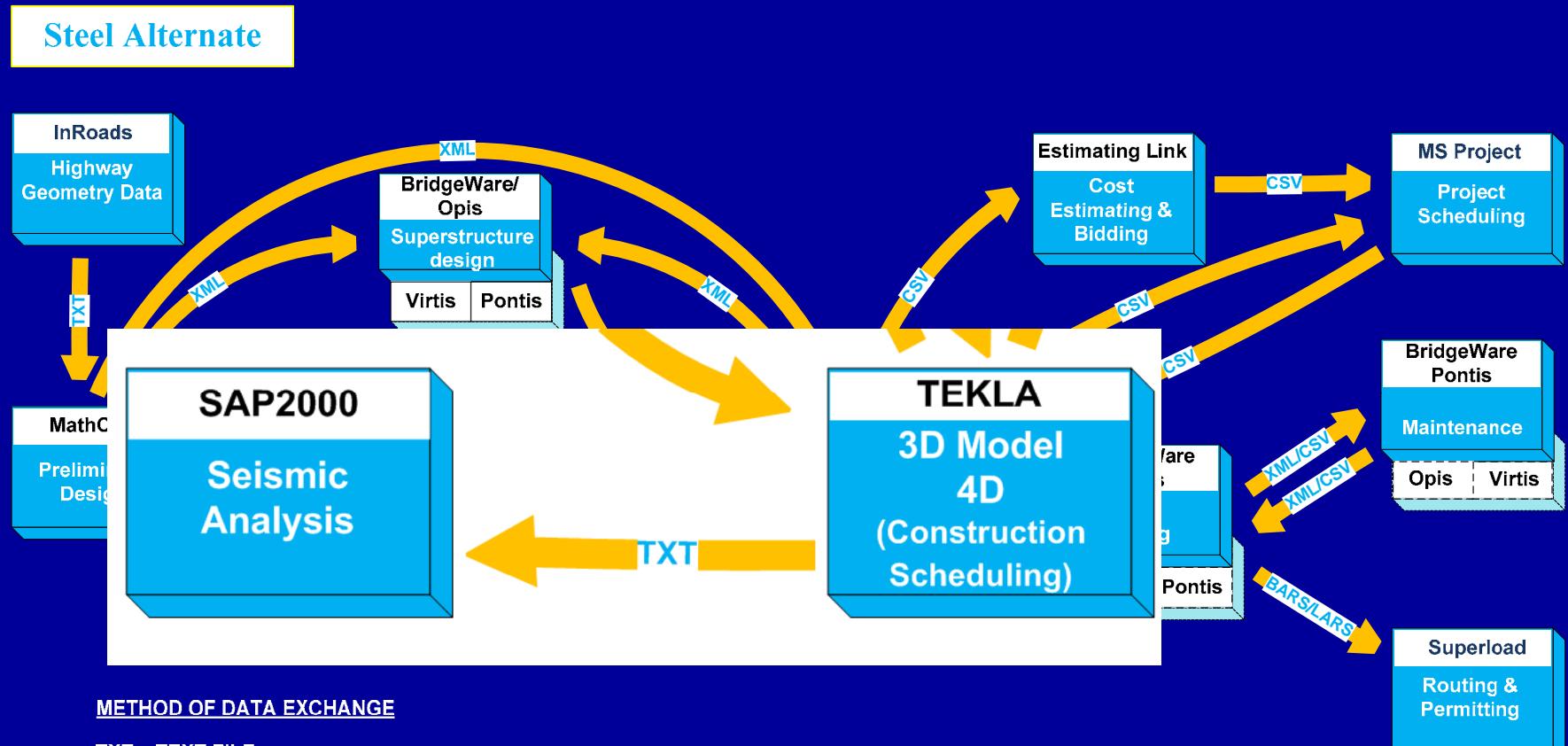
Intermediate
Stiffener



XML to SAP2000

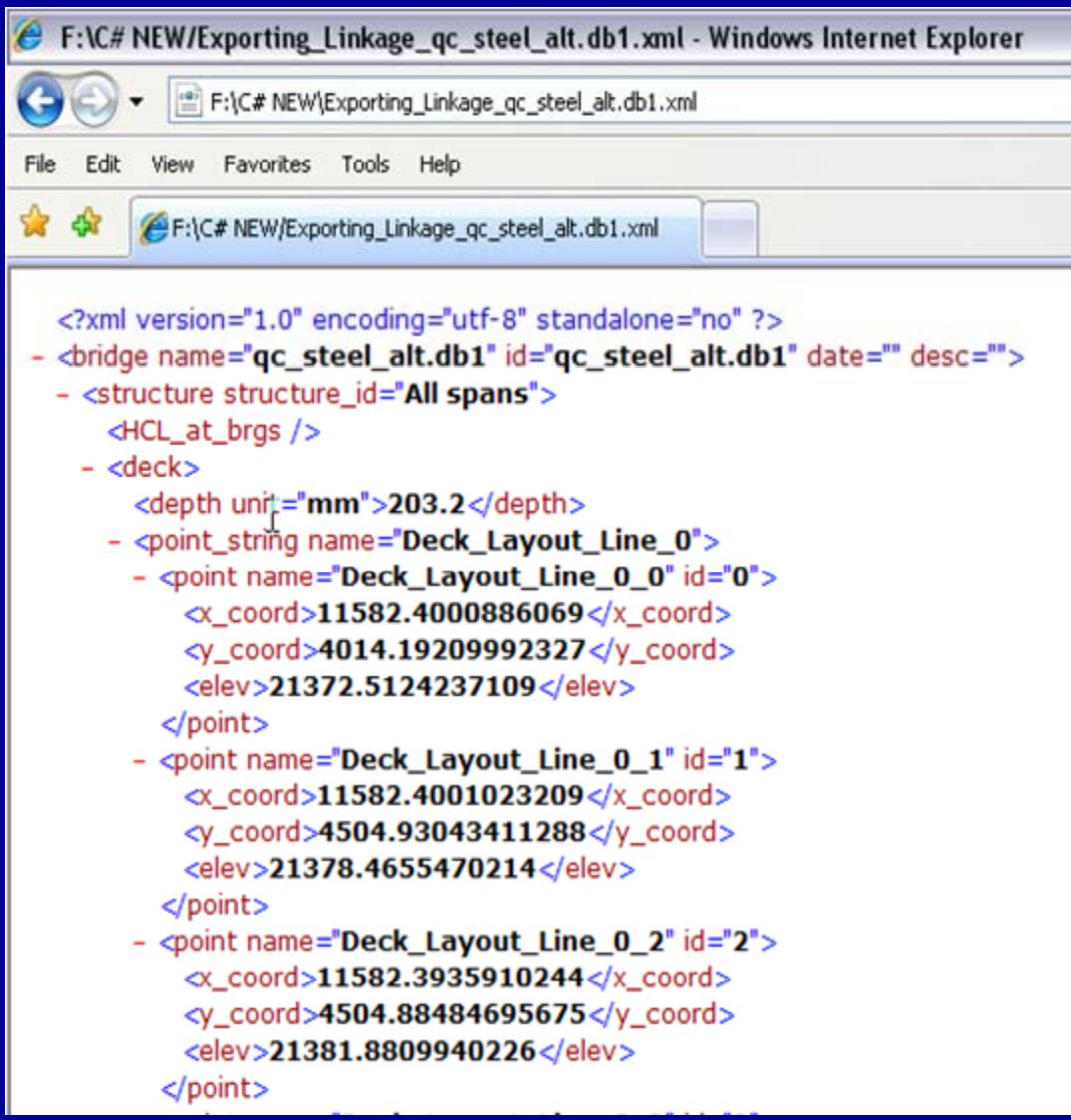


S07 XML to SAP2000



S07 XML to SAP2000

The XML
file
exported
from Tekla



F:\C# NEW\Exporting_Linkage_qc_steel_alt.db1.xml - Windows Internet Explorer

F:\C# NEW\Exporting_Linkage_qc_steel_alt.db1.xml

File Edit View Favorites Tools Help

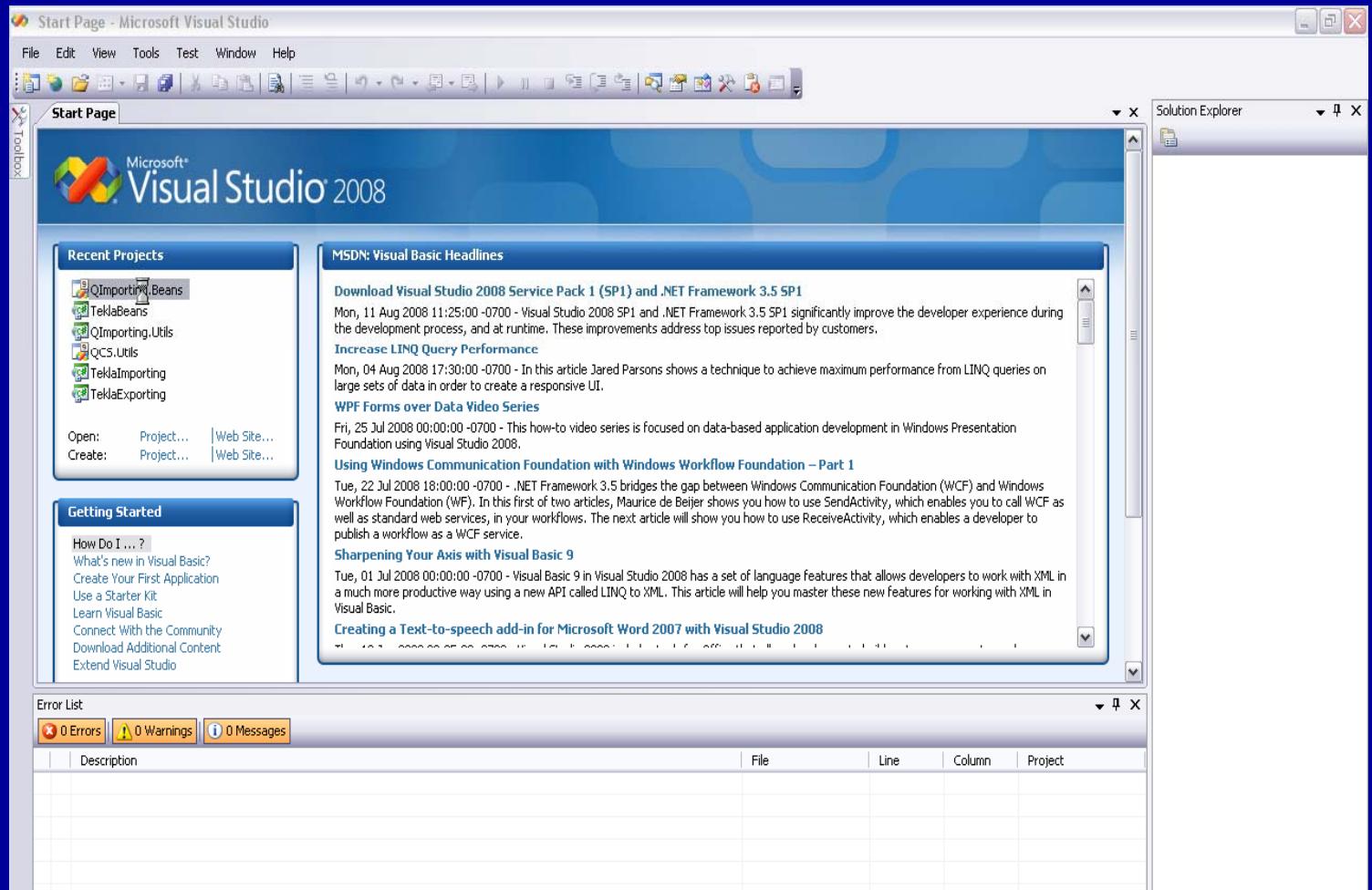
Star F:\C# NEW\Exporting_Linkage_qc_steel_alt.db1.xml

```
<?xml version="1.0" encoding="utf-8" standalone="no" ?>
- <bridge name="qc_steel_alt.db1" id="qc_steel_alt.db1" date="" desc="">
  - <structure structure_id="All spans">
    <HCL_at_brgs />
    - <deck>
      <depth unit="mm">203.2</depth>
      - <point_string name="Deck_Layout_Line_0">
        - <point name="Deck_Layout_Line_0_0" id="0">
          <x_coord>11582.4000886069</x_coord>
          <y_coord>4014.19209992327</y_coord>
          <elev>21372.5124237109</elev>
        </point>
        - <point name="Deck_Layout_Line_0_1" id="1">
          <x_coord>11582.4001023209</x_coord>
          <y_coord>4504.93043411288</y_coord>
          <elev>21378.4655470214</elev>
        </point>
        - <point name="Deck_Layout_Line_0_2" id="2">
          <x_coord>11582.3935910244</x_coord>
          <y_coord>4504.88484695675</y_coord>
          <elev>21381.8809940226</elev>
        </point>
```



S07 XML to SAP2000

Open
Visual
Studio
software
to
execute
linkage
software



S07 XML to SAP2000

C# code used to generate text input file

Read data:
Degree of Freedom

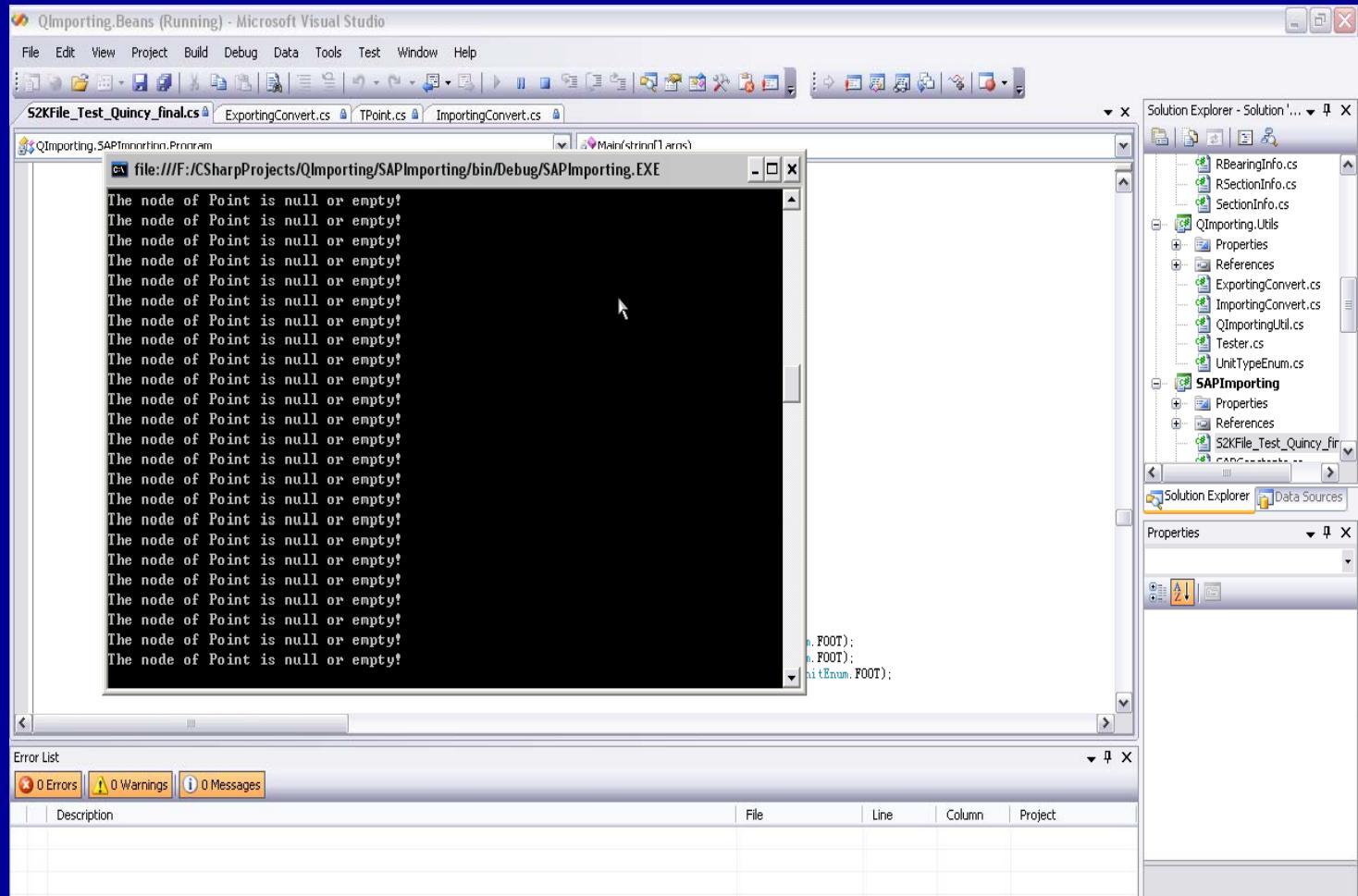
The screenshot shows the Microsoft Visual Studio interface with the following details:

- Title Bar:** QImporting.Bbeans - Microsoft Visual Studio
- Toolbox:** Standard .NET development tools.
- Code Editor:** Displays C# code for generating text input files for SAP2000. The code includes methods for "PROGRAM CONTROL", "ACTIVE DEGREES OF FREEDOM", and "ANALYSIS OPTIONS". Each method constructs a string by concatenating SAPConstants.TXT_TABLE_STR with specific section names.
- Status Bar:** Shows 0 Errors, 14 Warnings, and a link to Description.
- Warnings:** Five warnings are listed, all related to referenced components not being found: 'QCS.Utils', 'QImporting.Bbeans', and 'QImporting.Utils'.
- Solution Explorer:** Shows the project structure with several files under 'SAPImporting' and 'QImporting.Utils'.
- Properties Window:** Shows standard properties for the selected file.



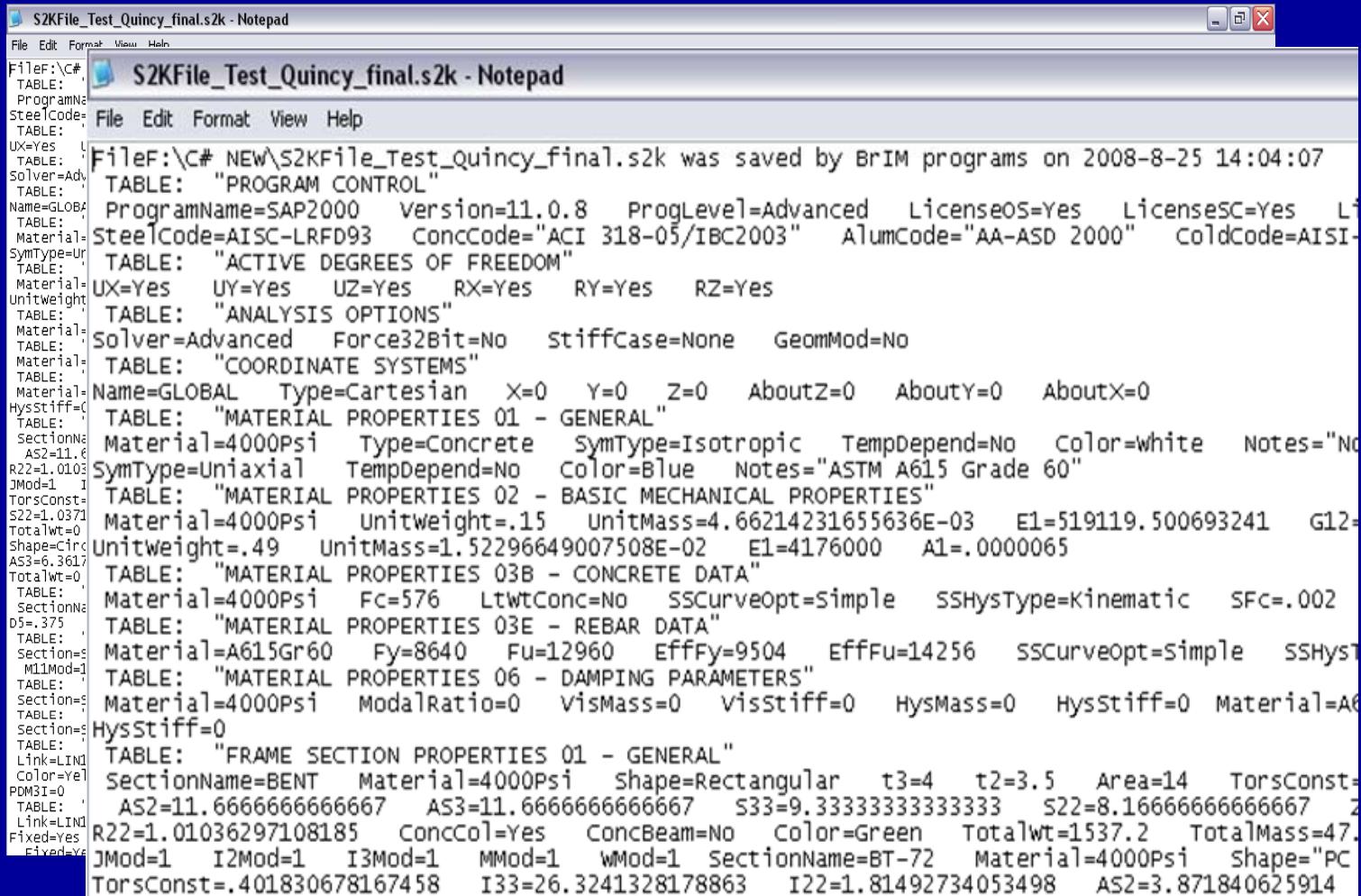
S07 XML to SAP2000

Run
C# code



S07 XML to SAP2000

Sample
SAP2000
text input
file (*.s2k
file)



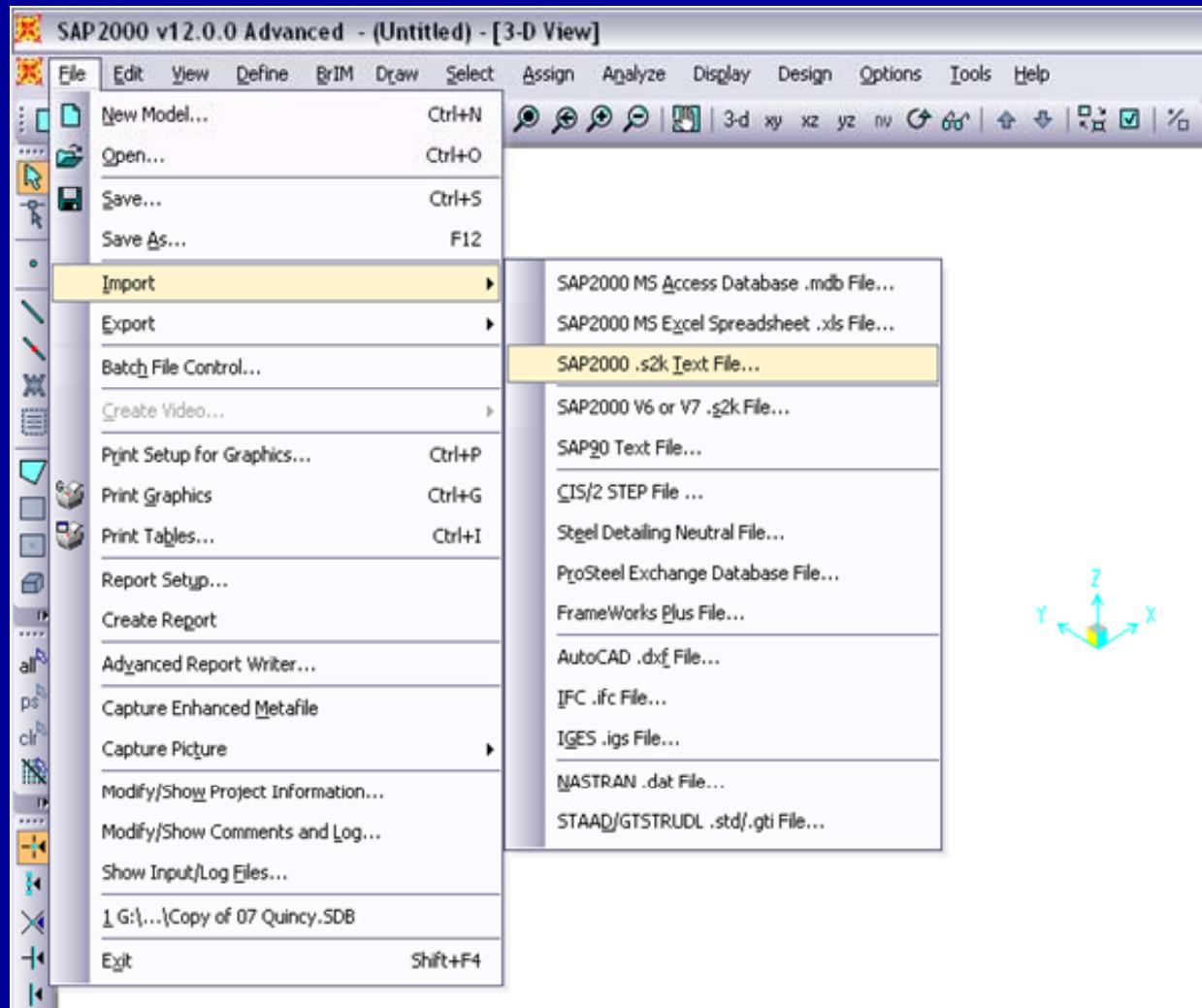
The screenshot shows a Windows Notepad window titled "S2KFile_Test_Quincy_final.s2k - Notepad". The file contains SAP2000 input code. Key sections include:

- PROGRAM CONTROL**:
ProgramName=SAP2000 Version=11.0.8 ProgLevel=Advanced LicenseOS=Yes LicenseSC=Yes LicenseP=Yes
SteelCode=AISC-LRFD93 ConcCode="ACI 318-05/IBC2003" AlumCode="AA-ASD 2000" ColdCode=AISI-2000
- ACTIVE DEGREES OF FREEDOM**: UX=Yes UY=Yes UZ=Yes RX=Yes RY=Yes RZ=Yes
- ANALYSIS OPTIONS**: Solver=Advanced Force32Bit=No StiffCase=None GeomMod=No
- COORDINATE SYSTEMS**:
Material=GLOBAL Type=Cartesian X=0 Y=0 Z=0 AboutZ=0 AboutY=0 AboutX=0
- MATERIAL PROPERTIES 01 - GENERAL**: Material=4000Psi Type=Concrete SymType=Isotropic TempDepend=No Color=White Notes="No" SymType=Uniaxial TempDepend=No Color=Blue Notes="ASTM A615 Grade 60"
- MATERIAL PROPERTIES 02 - BASIC MECHANICAL PROPERTIES**: Material=4000Psi UnitWeight=.15 UnitMass=4.66214231655636E-03 E1=519119.500693241 G12=UnitWeight=.49 UnitMass=1.52296649007508E-02 E1=4176000 A1=.0000065
- MATERIAL PROPERTIES 03B - CONCRETE DATA**: Material=4000Psi Fc=576 LtWtConc=No SSCurveOpt=Simple SSHysType=Kinematic Sfc=.002
- MATERIAL PROPERTIES 03E - REBAR DATA**: Material=A615Gr60 Fy=8640 Fu=12960 EffFy=9504 EffFu=14256 SScurveOpt=Simple SSHyst=
- MATERIAL PROPERTIES 06 - DAMPING PARAMETERS**: Material=4000Psi ModalRatio=0 VisMass=0 VisStiff=0 HysMass=0 HysStiff=0 Material=A615Gr60 HysStiff=0
- FRAME SECTION PROPERTIES 01 - GENERAL**: SectionName=BENT Material=4000Psi Shape=Rectangular t3=4 t2=3.5 Area=14 TorsConst=AS2=11.6666666666667 AS3=11.6666666666667 S33=9.3333333333333 S22=8.1666666666667 Z=R22=1.01036297108185 ConcCol=Yes ConcBeam=No Color=Green TotalWt=1537.2 TotalMass=47.3 Mod=1 I2Mod=1 I3Mod=1 MMod=1 WMod=1 SectionName=BT-72 Material=4000Psi Shape="PC" TorsConst=.401830678167458 I33=26.3241328178863 I22=1.81492734053498 AS2=3.871840625914



S07 XML to SAP2000

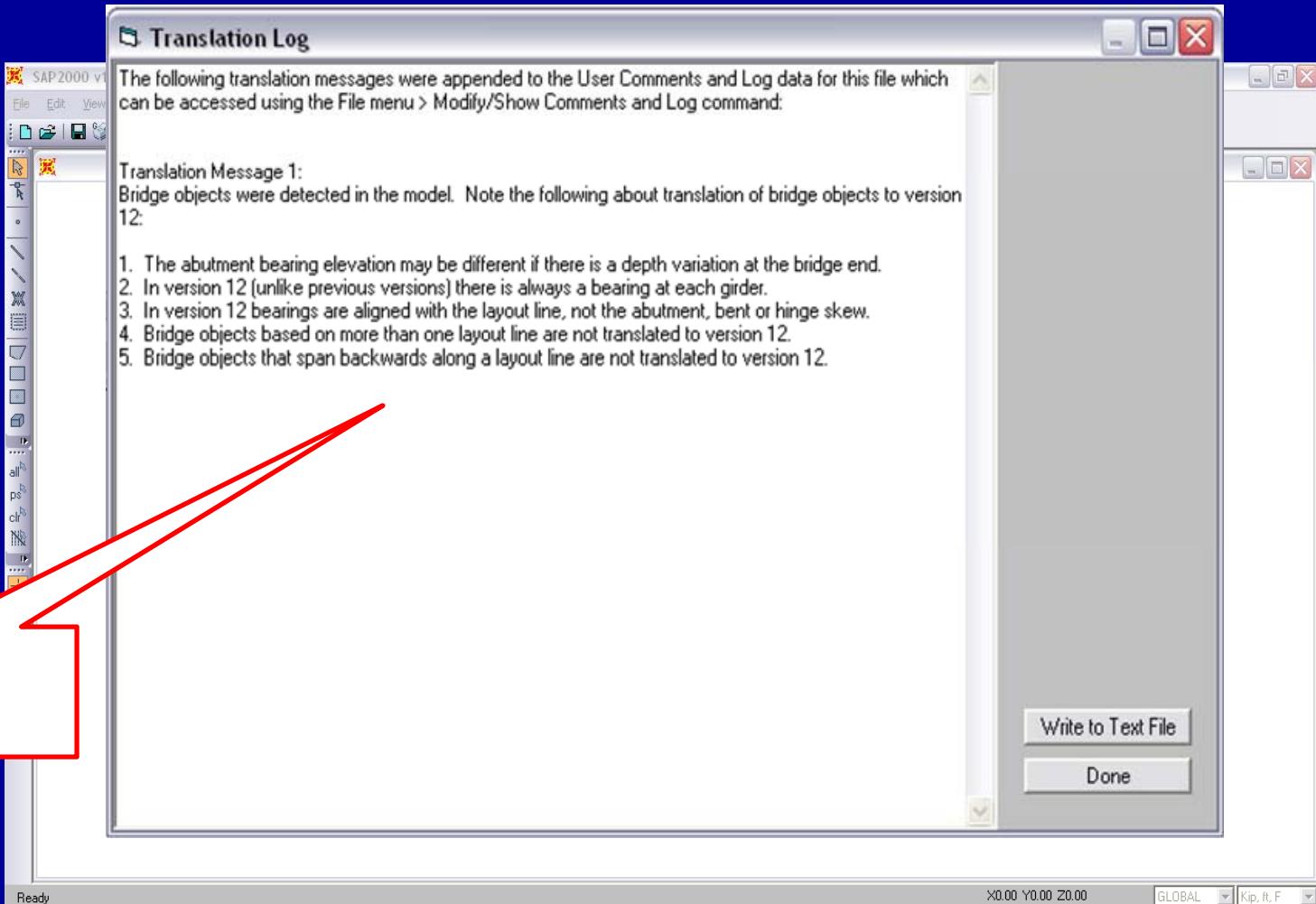
Import text
input file
(*.s2k file)



S07 XML to SAP2000

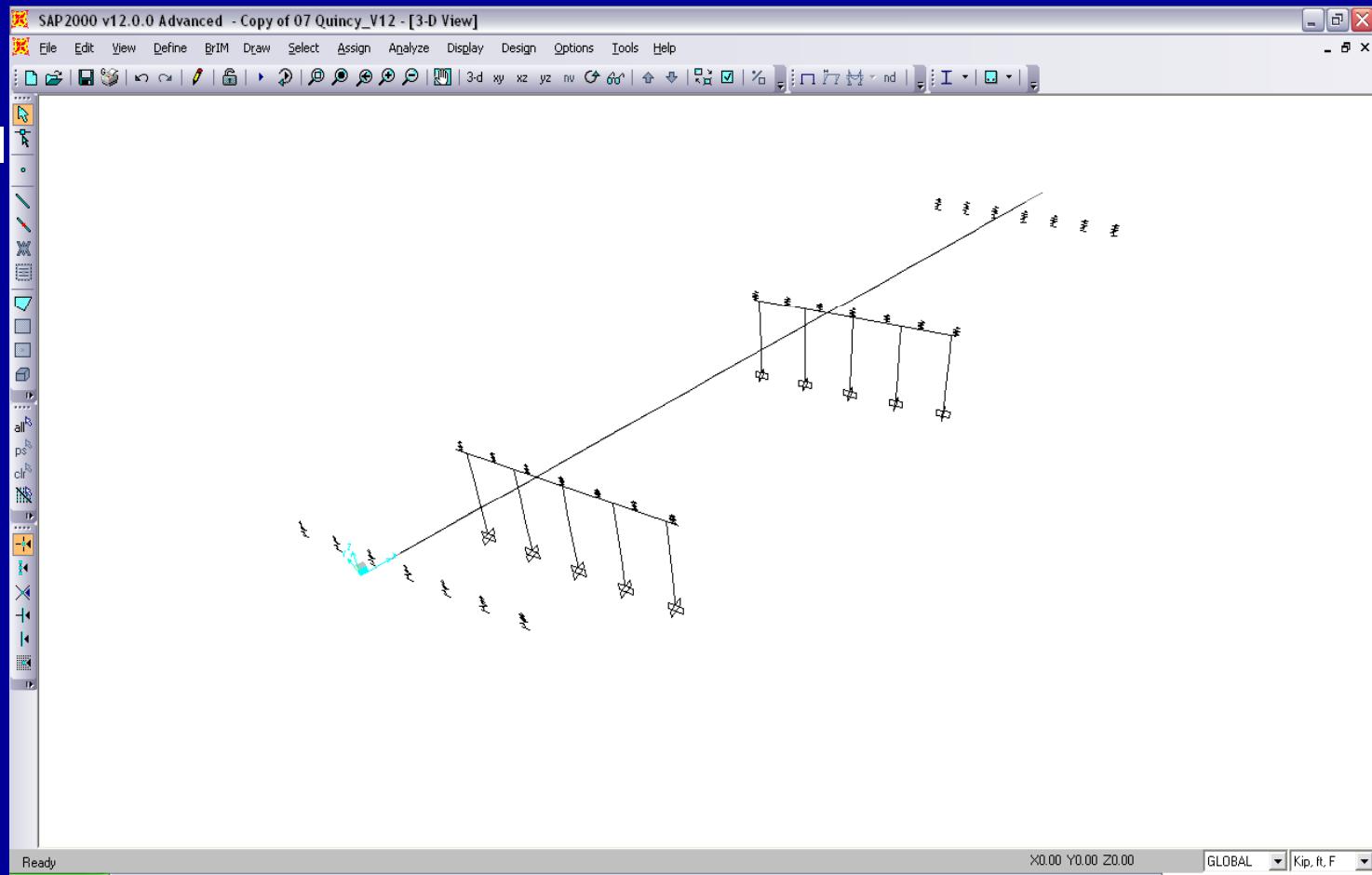
Import log:
error and
warning
information

Translate
successfully



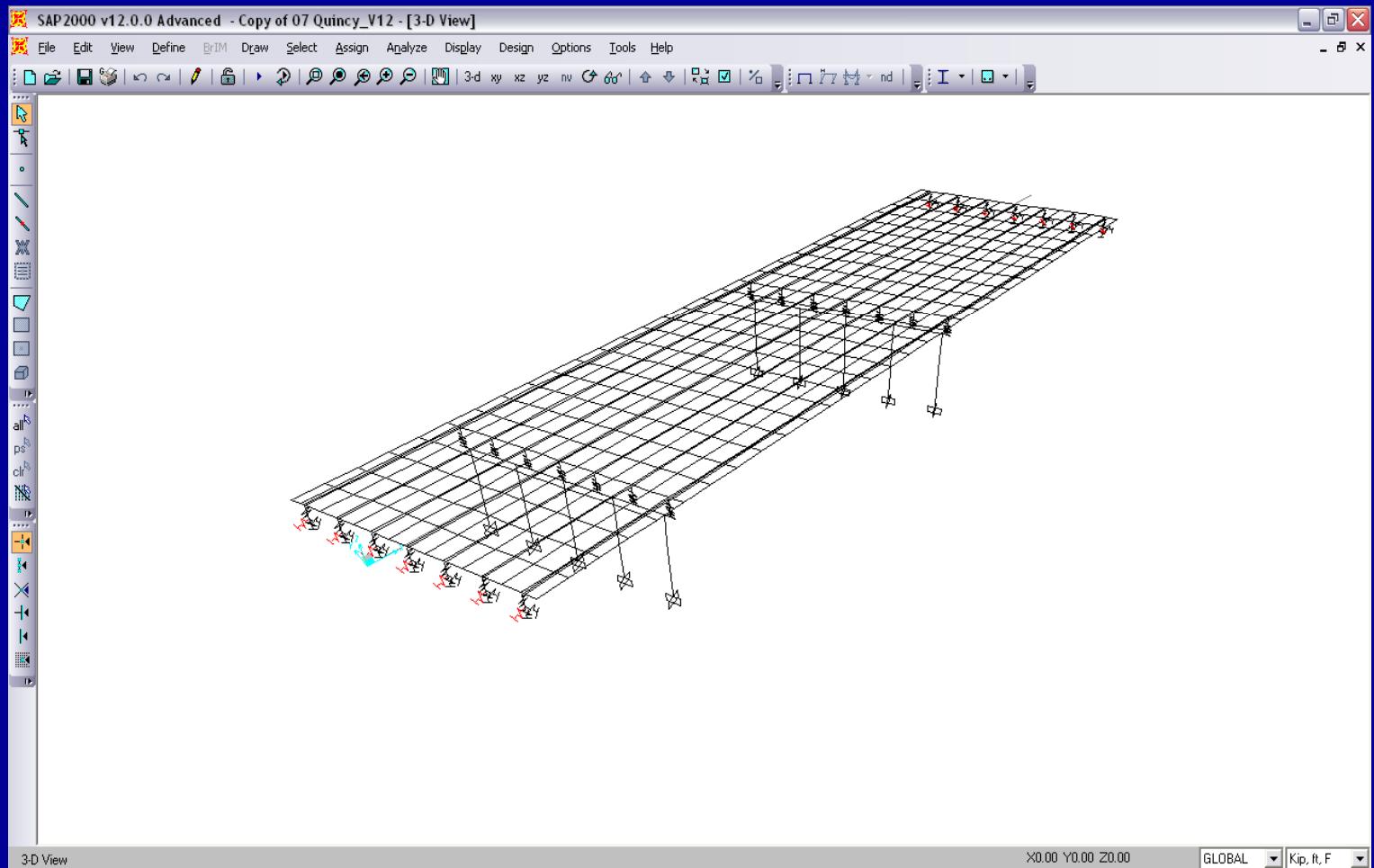
S07 XML to SAP2000

SAP2000
stick model
generated
by text
input file



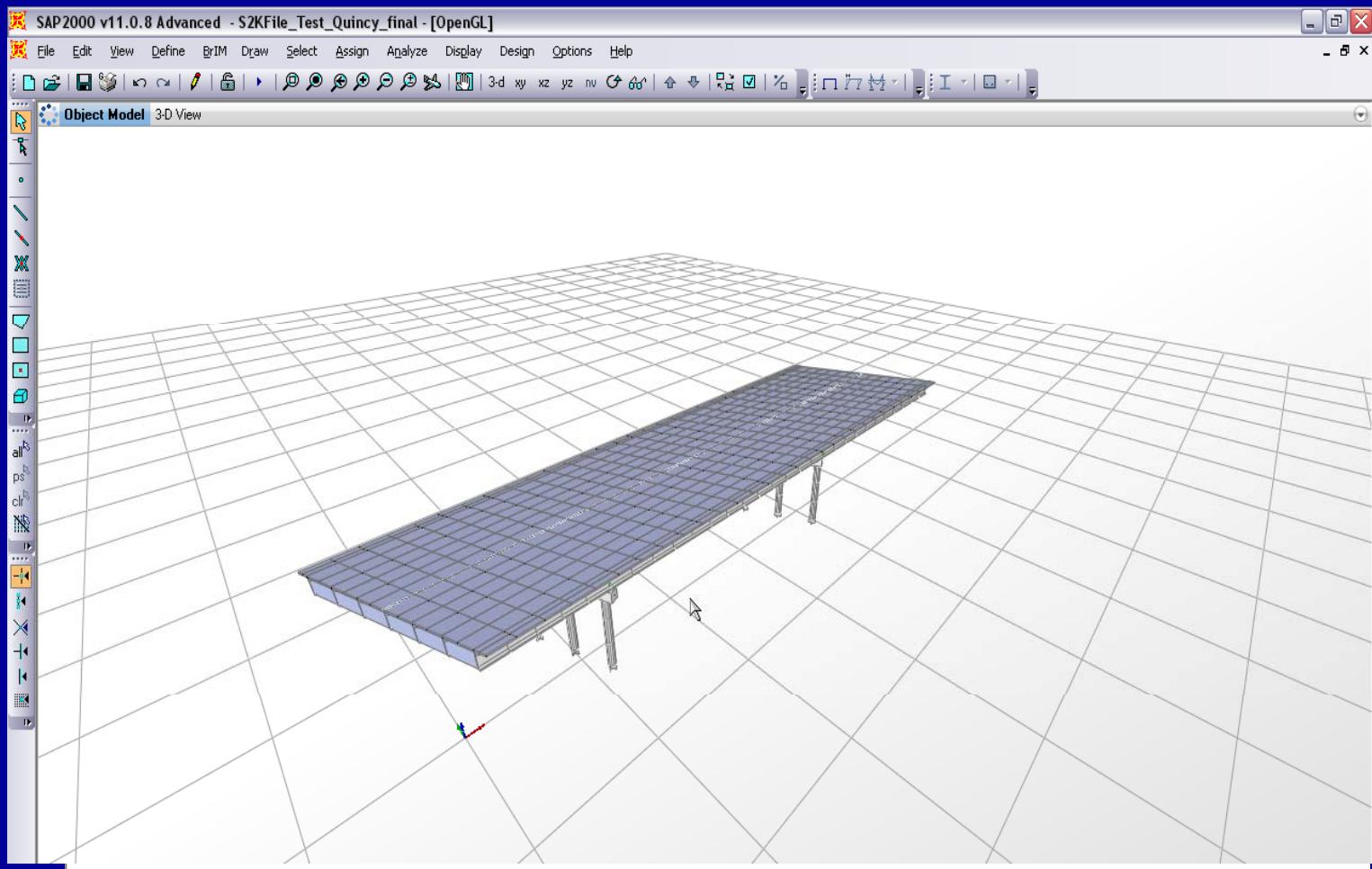
S07 XML to SAP2000

SAP2000
finite
element
model



S07 XML to SAP2000

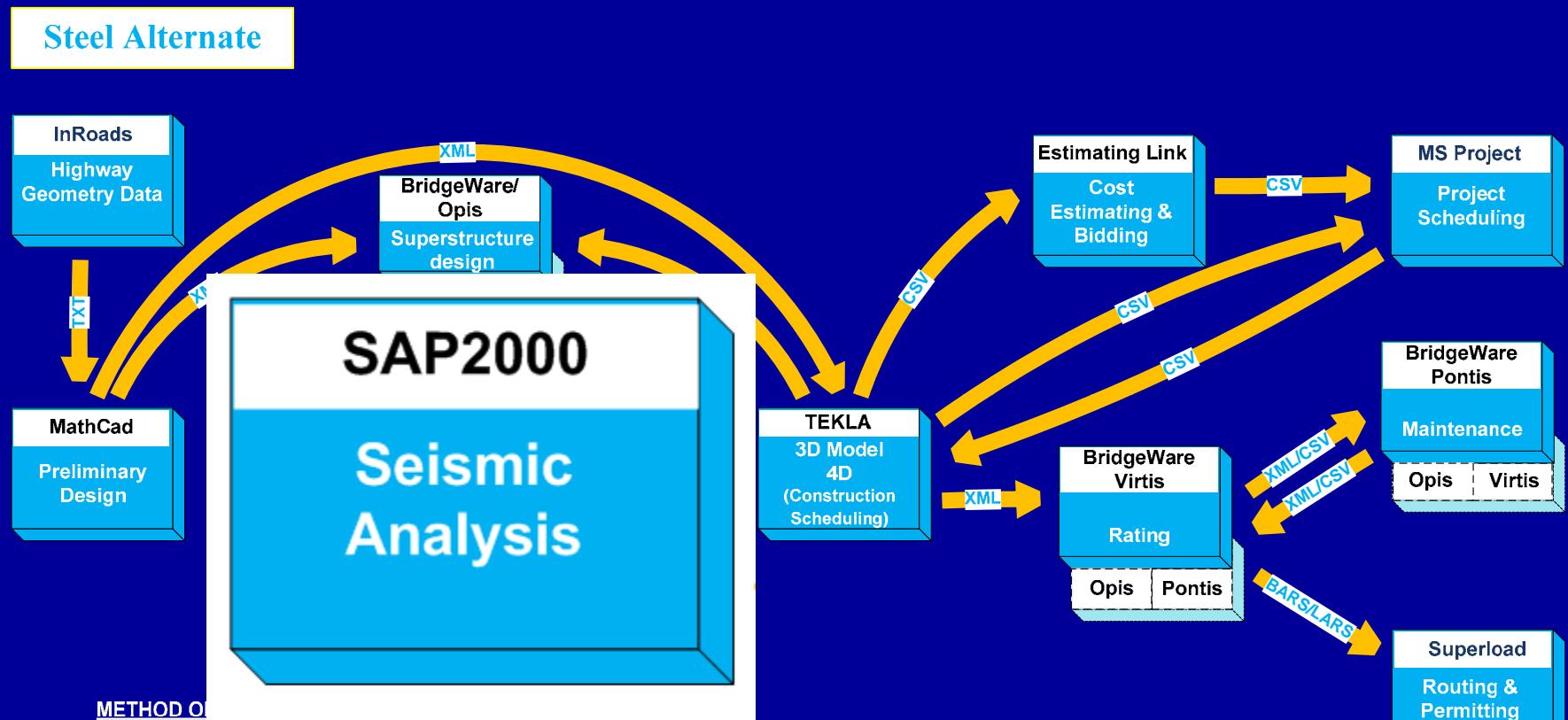
SAP2000
finite
element
model
extruded
view



Substructure Design in SAP2000

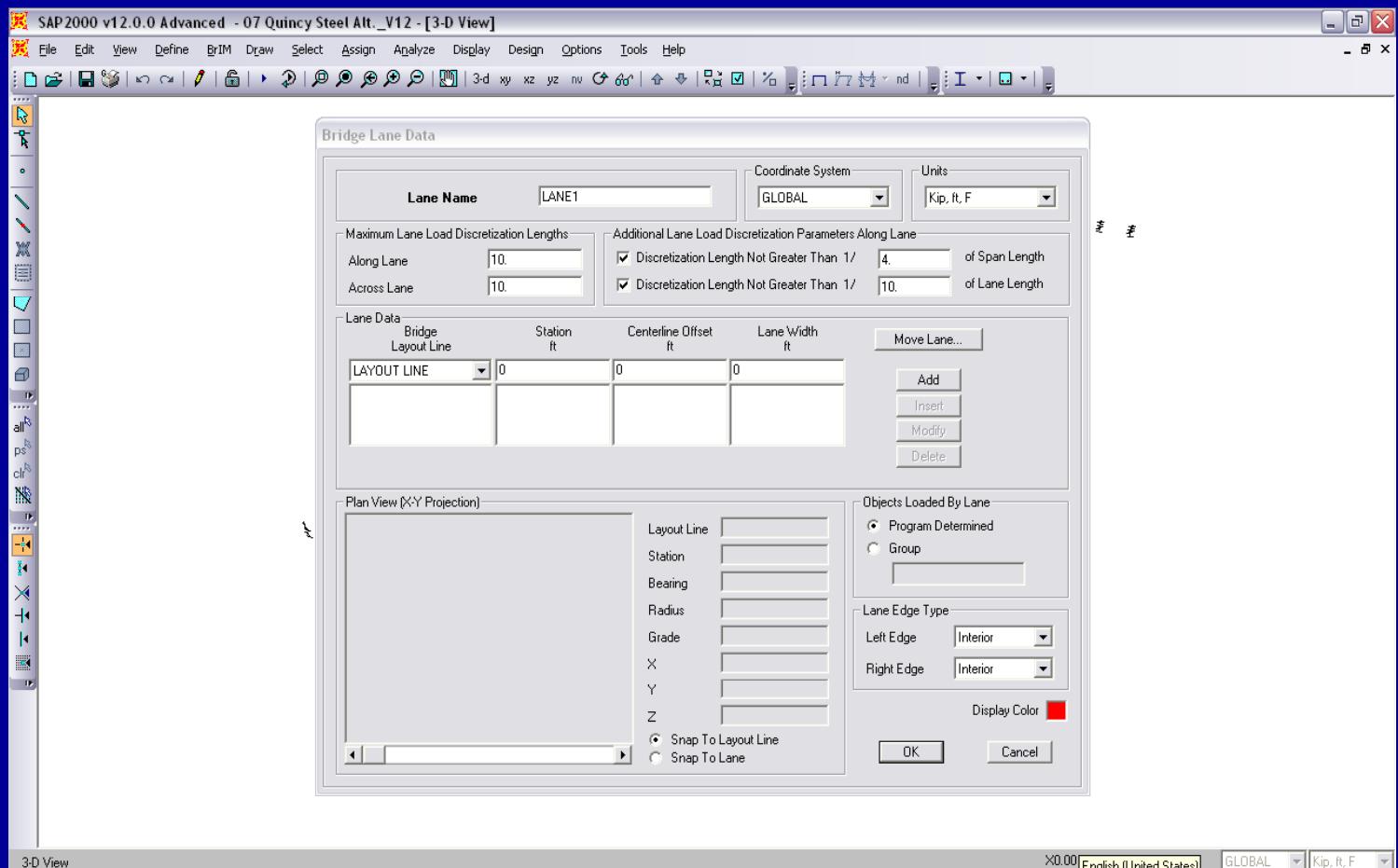


S08 SAP2000 Structure Design



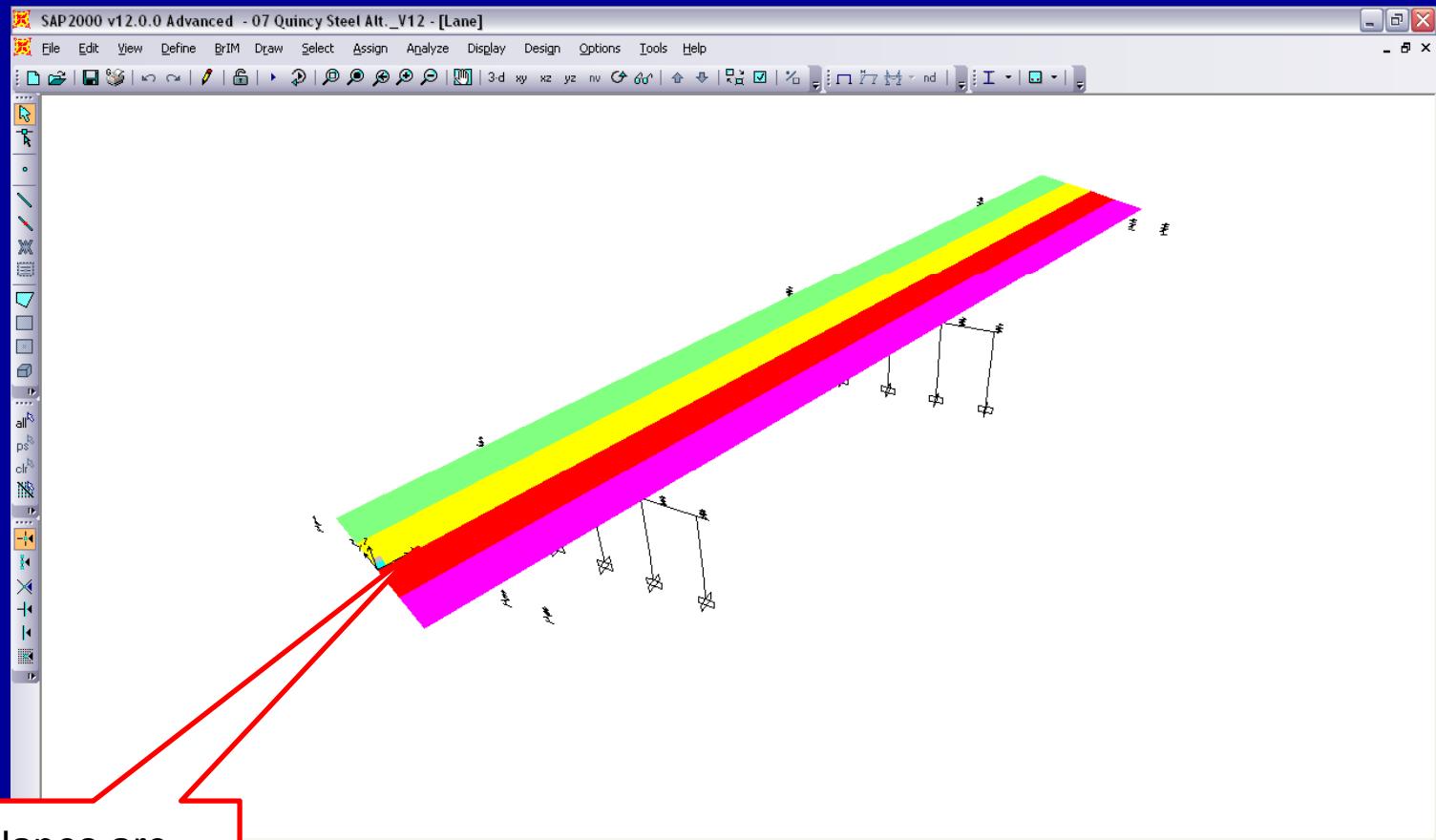
S08 SAP2000 Structure Design

Define live load: Lane number and Lane width



S08 SAP2000 Structure Design

Bridge lanes: 4 lanes defined

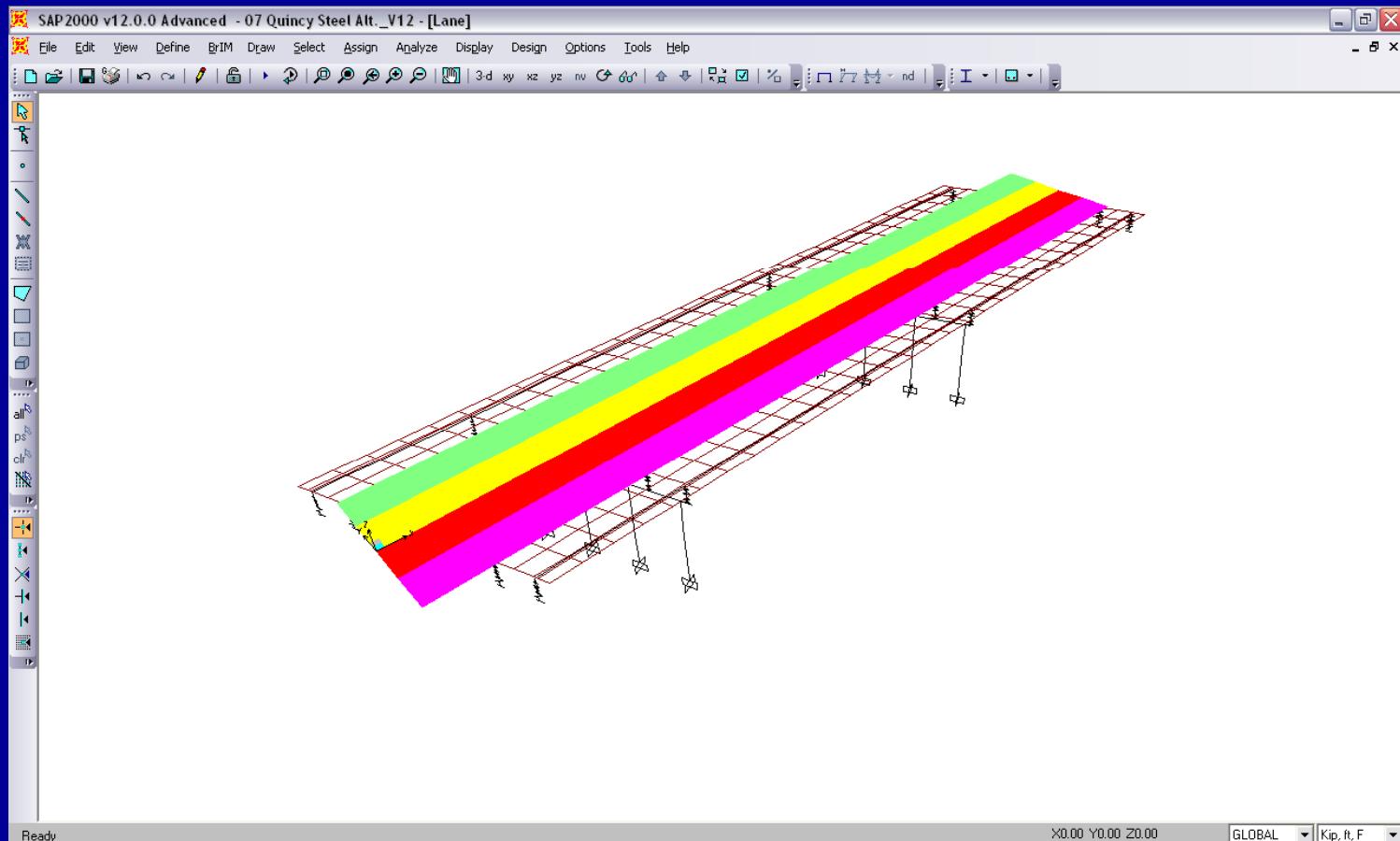


Four lanes are defined



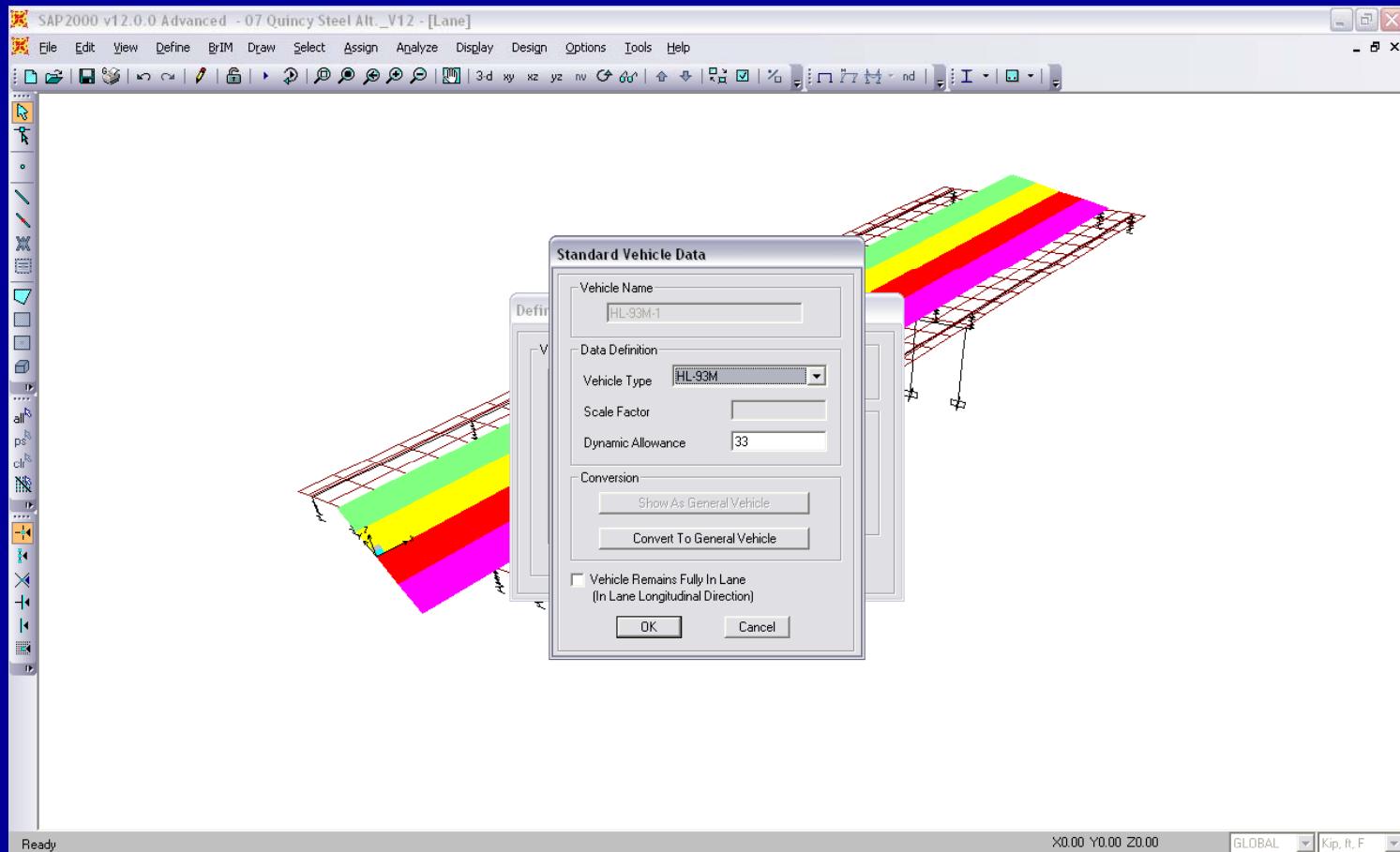
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Bridge lanes on finite element model



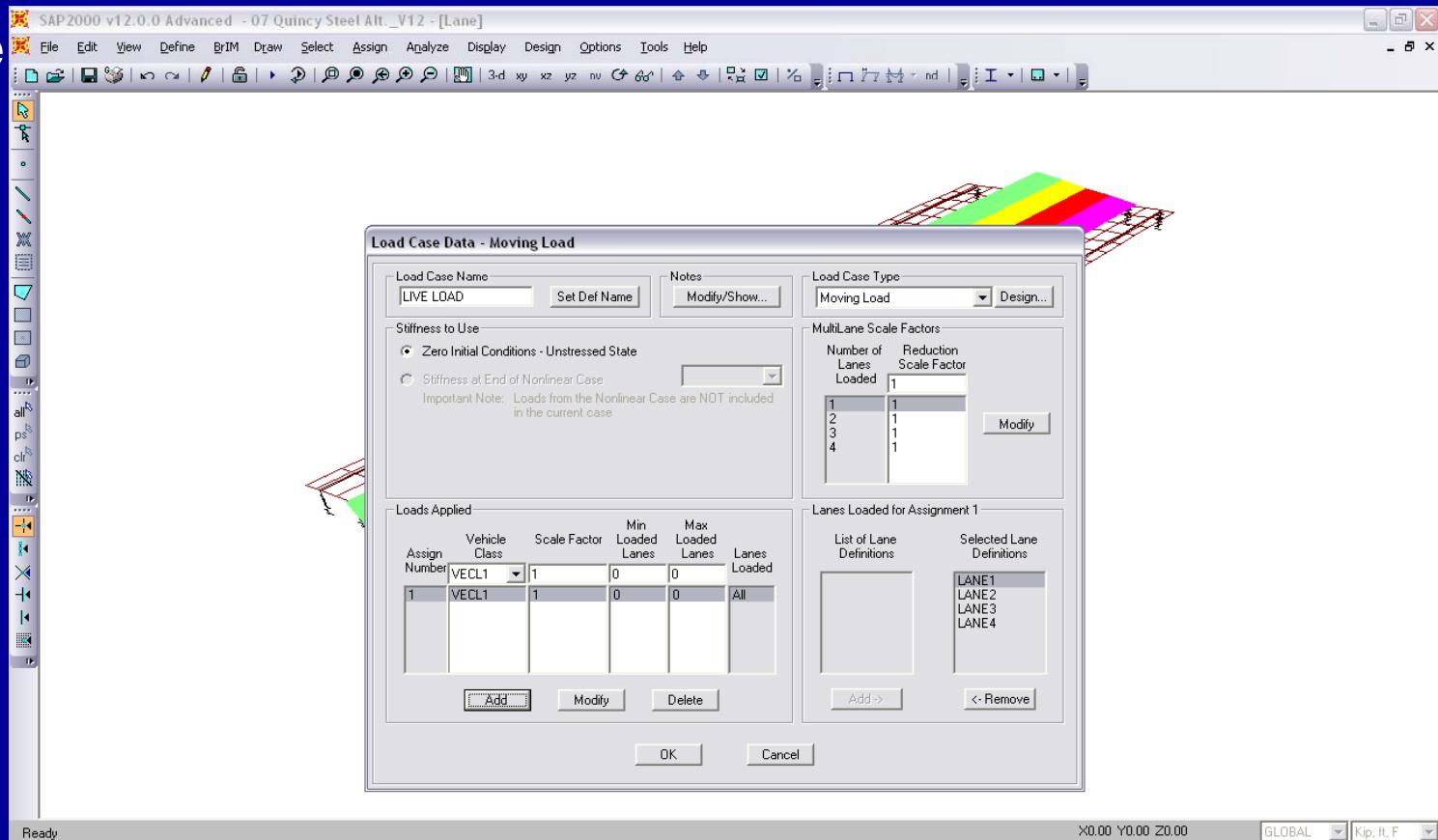
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Define standard vehicle: HL-93



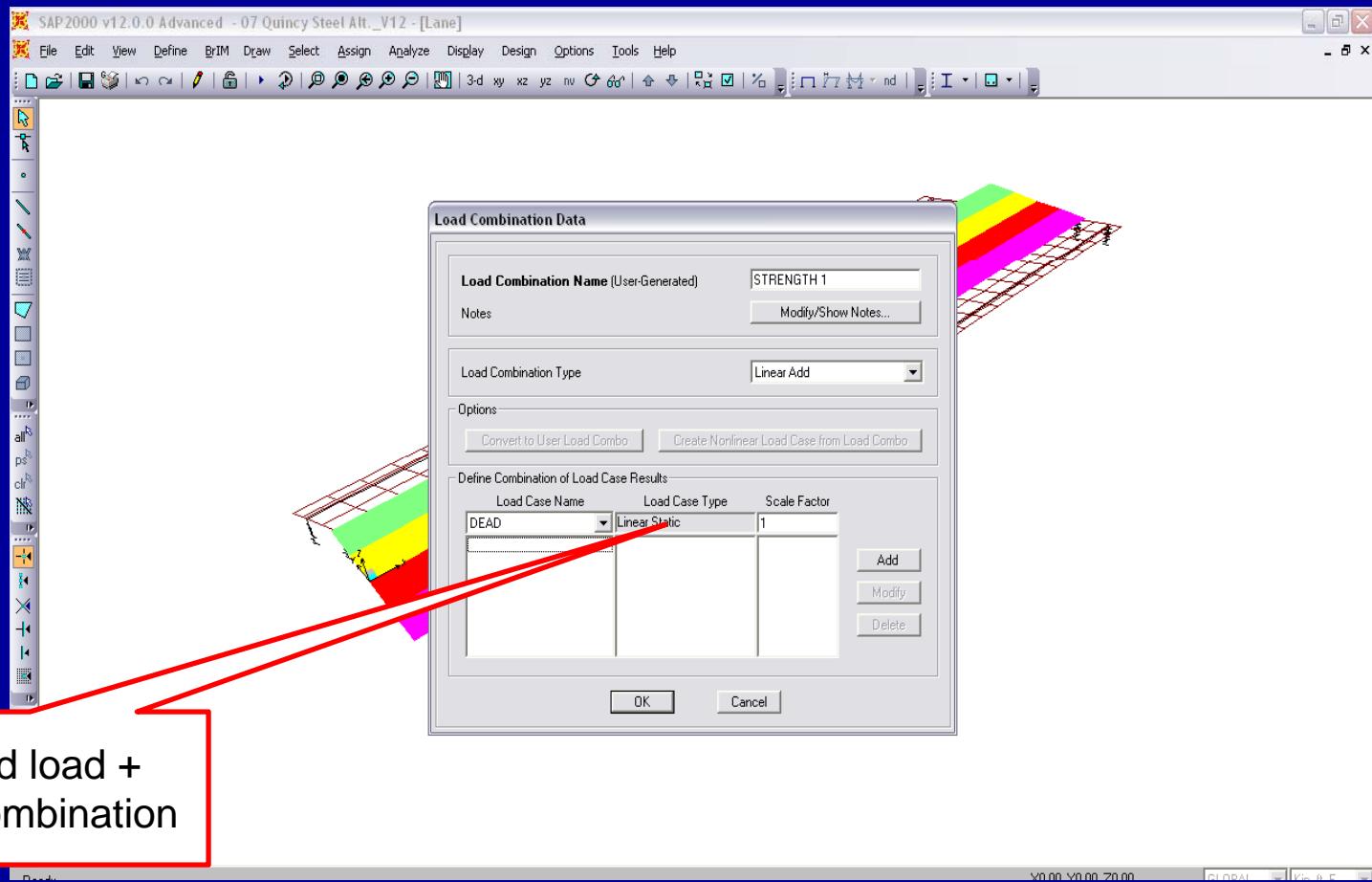
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Define live load case



S08 SAP2000 Structure Design

Define load combination:
Strength 1

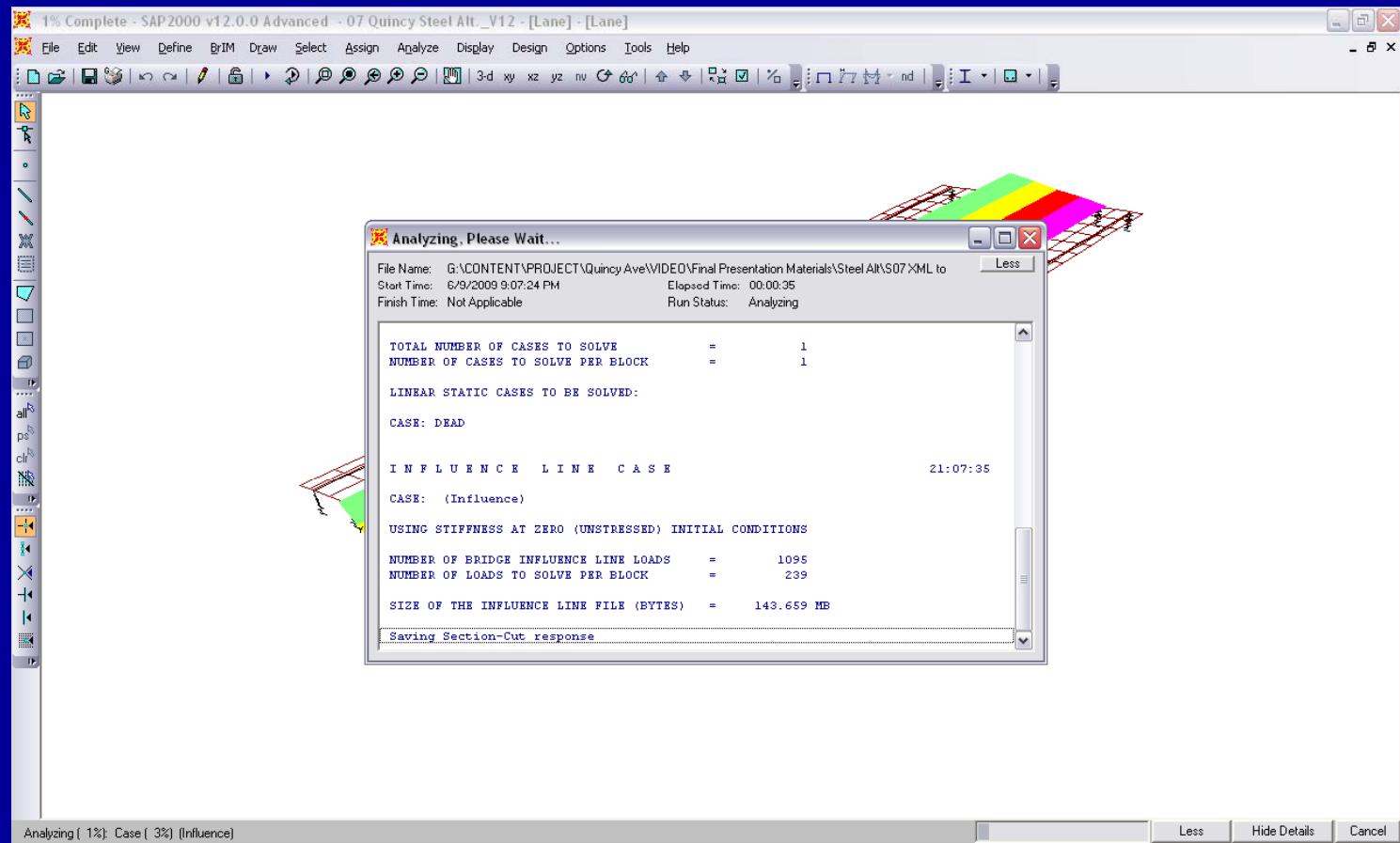


Define dead load +
live load combination



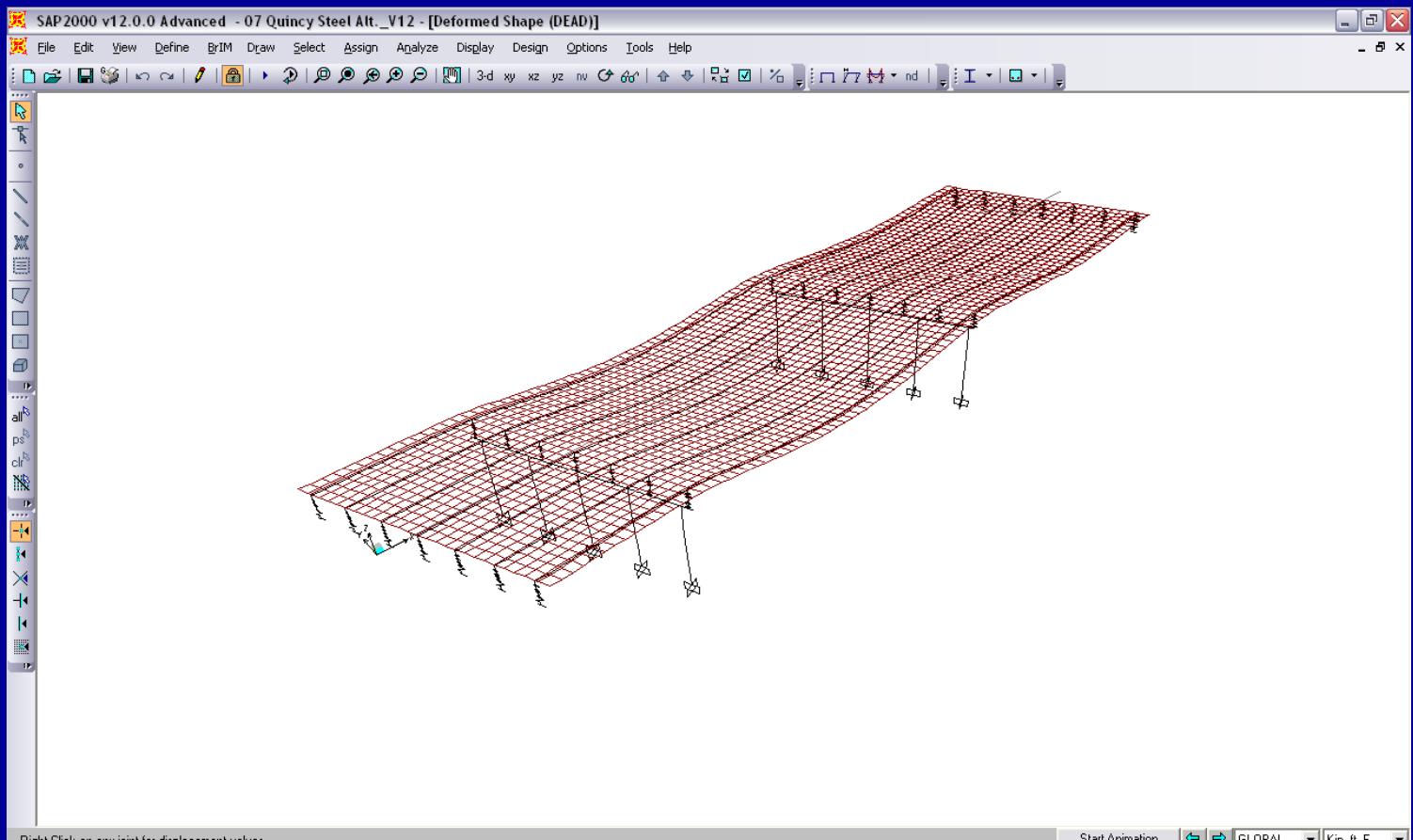
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Run analysis:
Dead load
and live
load cases



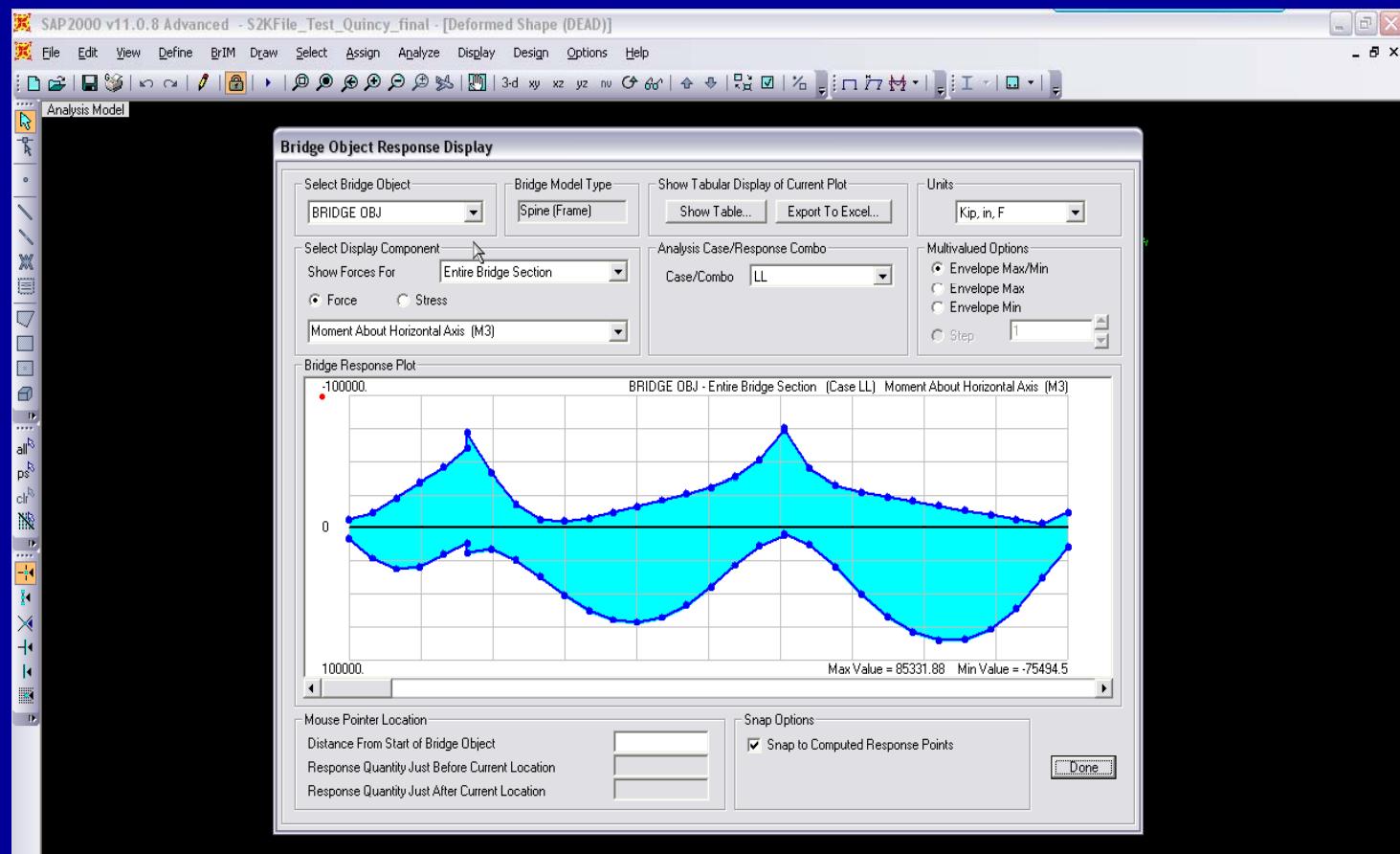
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Deformed
shape
under dead
load



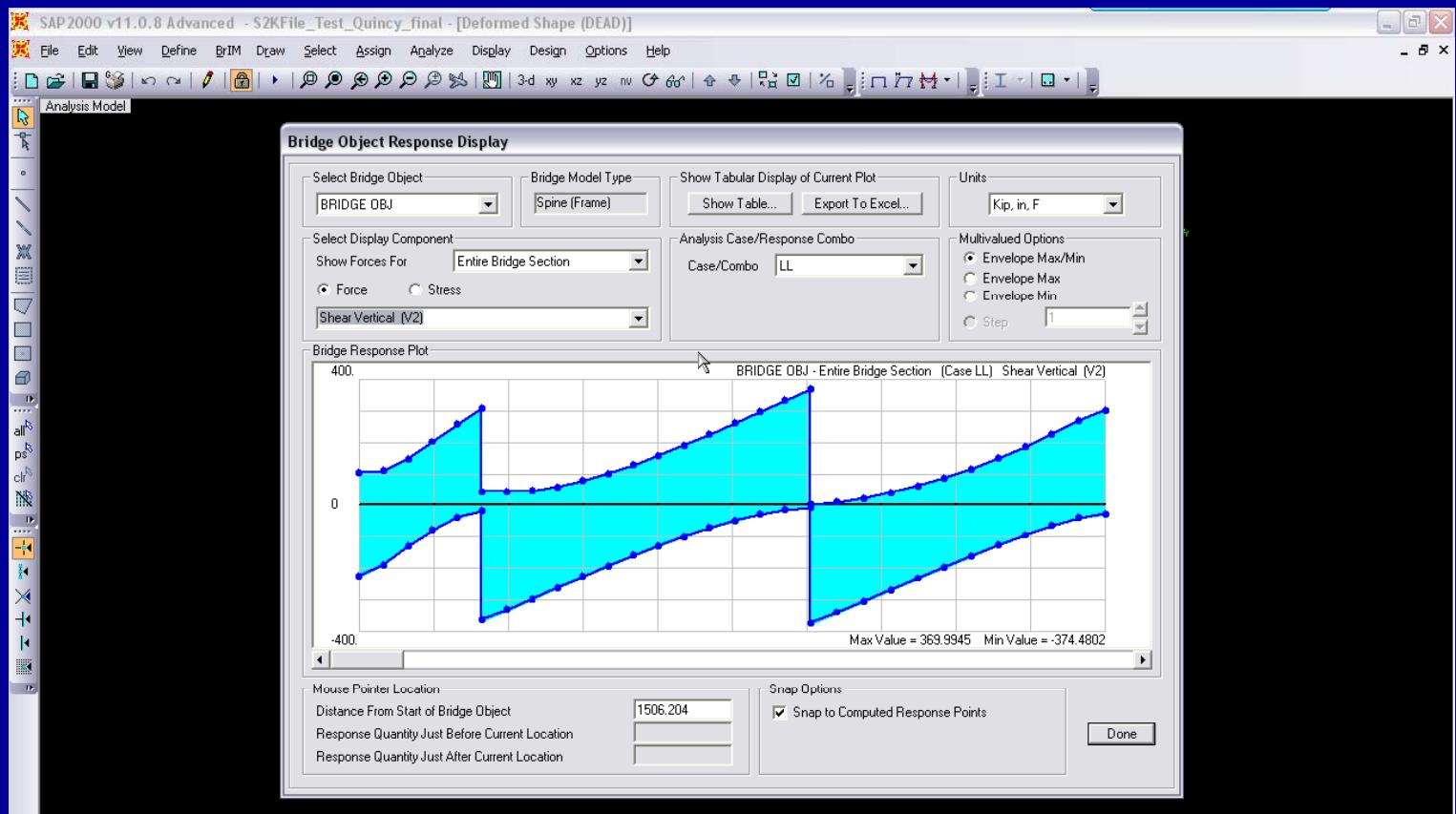
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Moment envelope



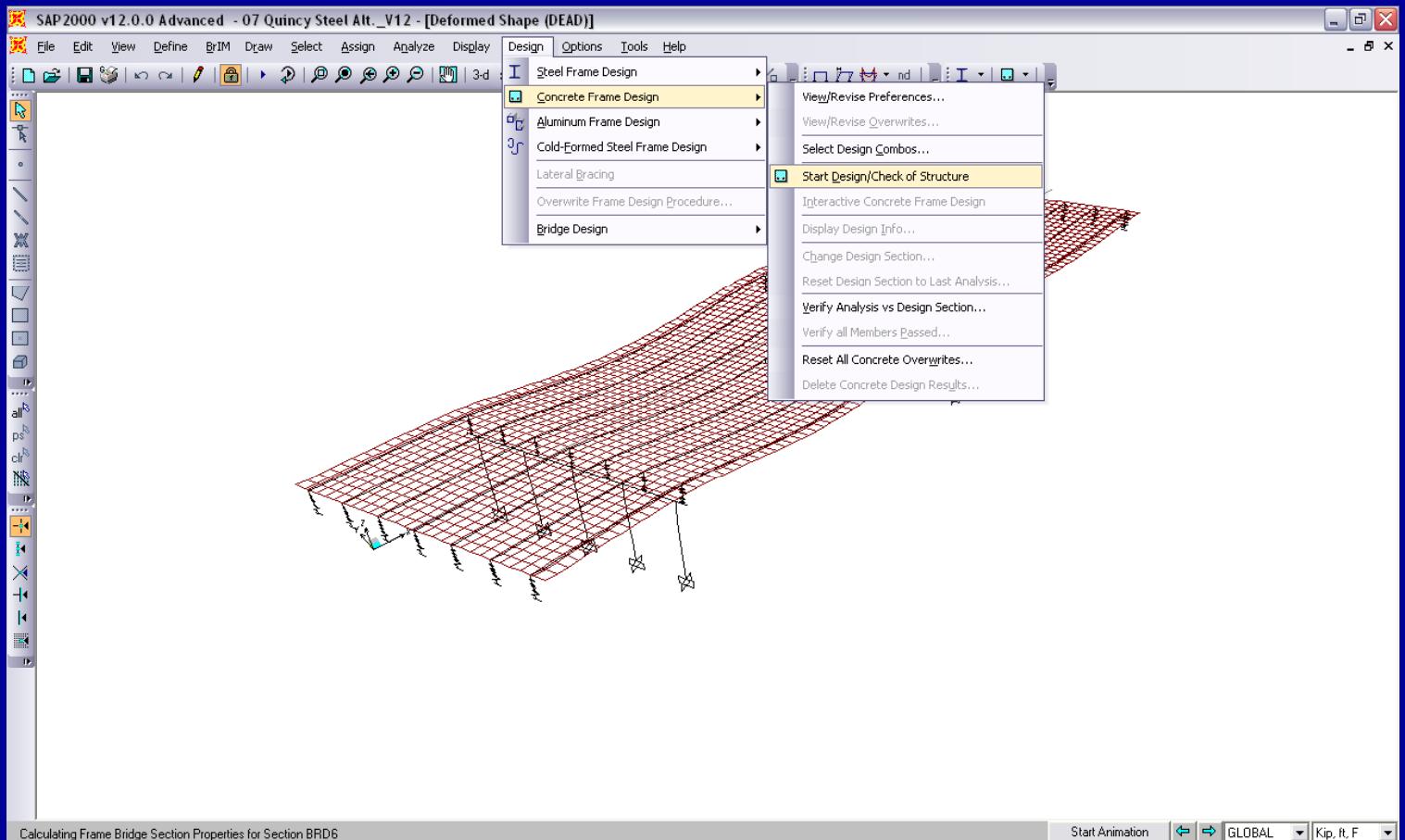
S08 SAP2000 Structure Design

Shear
force
envelope



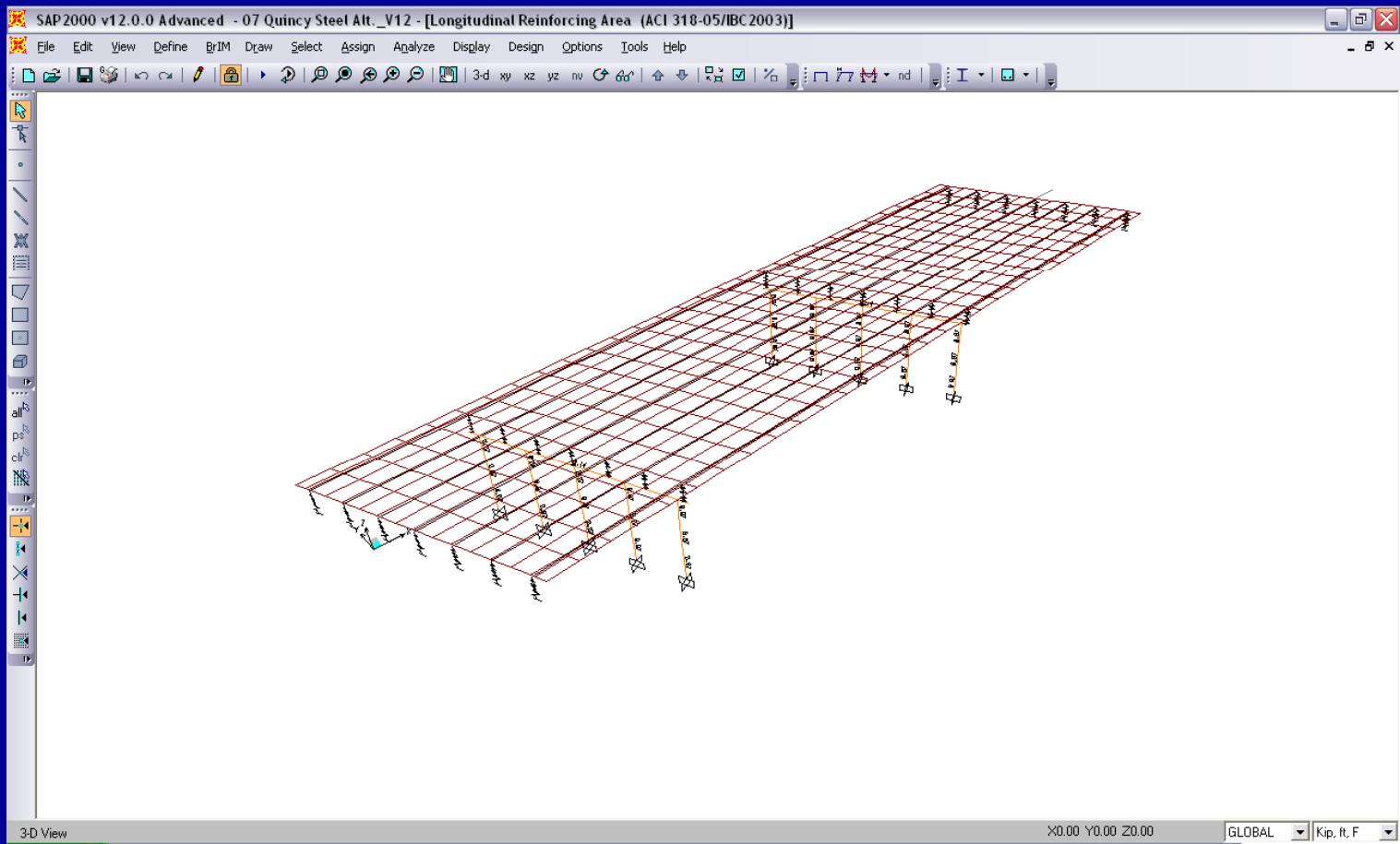
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Start design and check of whole structure



S08 SAP2000 Structure Design

Sub-
structure
Design
result



S08 SAP2000 Structure Design

Substructure
design result

Concrete Column Design Information (ACI 318-05/IBC2003)

COMBO ID	STATION LOC	LONGITUDINAL REINFORCEMENT	MAJOR SHEAR REINFORCEMENT	MINOR SHEAR REINFORCEMENT
STRENGTH1	816.48	20.160	0.000	0.000
STRENGTH1	840.24	20.160	0.000	0.000
STRENGTH1	864.00	20.160	0.000	0.000
STRENGTH1	864.00	20.160	0.171	0.000
STRENGTH1	876.91	20.160	0.170	0.000
STRENGTH1	889.81	20.160	0.168	0.000
STRENGTH1	889.81	20.160	0.000	0.000
STRENGTH1	912.00	20.160	0.000	0.000

Modify/Show Overwrites Display Details for Selected Item Display Complete Details

Overwrites Summary Flex. Details Shear Details

Interaction Joint Shear B/C Details

Tabular Data

Stylesheet: Default Table Format File

OK Cancel



S08 SAP2000 Structure Design

Design
result:
concrete
cap beam
design data

SAP2000 v11.0.8 Advanced - S2KFile_Test_Quincy_final - [Longitudinal Reinforcing Area (ACI 318-05/IBC2003)]

File Edit View Define BrIM Draw Select Assign Analyze Display Design Options Help

Concrete Design Data ACI 318-05/IBC2003

ACI 318-05/IBC2003 COLUMN SECTION DESIGN Type: Sway Special Units: Kip, in, F (Summary)

L=912.000	B=42.000	D=48.000	dc=2.000
Element : 396	E=3604.997	Fc=4.000	Lt.Mt. Fac.=1.000
Station Loc : 912.000	Fy=60.000	Fys=60.000	
Section ID : CAPBEAM	RLLF=1.000		
Combo ID : STRENGTH1			

Phi(Compression-Spiral): 0.700
Phi(Compression-Tied): 0.650
Phi(Tension Controlled): 0.900
Phi(Shear): 0.750
Phi(Seismic Shear): 0.600
Phi(Joint Shear): 0.850

AXIAL FORCE & BIAXIAL MOMENT DESIGN FOR PU, M2, M3

Rebar Area	Design Pu	Design M2	Design M3	Minimum M2	Minimum M3
20.160	0.000	0.000	0.000	0.000	0.000

AXIAL FORCE & BIAXIAL MOMENT FACTORS

	Cm Factor	Delta_ns Factor	Delta_s Factor	K Factor	L Length
Major Bending(M3)	1.000	1.000	1.000	1.000	204.000
Minor Bending(M2)	1.000	1.000	1.000	1.000	912.000

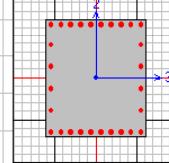
SHEAR DESIGN FOR U2,U3

	Design Rebar	Shear Vu	Shear phi*Uc	Shear phi*Us	Shear Up
Major Shear(U2)	0.000	0.000	183.286	0.000	0.000
Minor Shear(U3)	0.000	0.000	182.148	0.000	0.000

JOINT SHEAR DESIGN

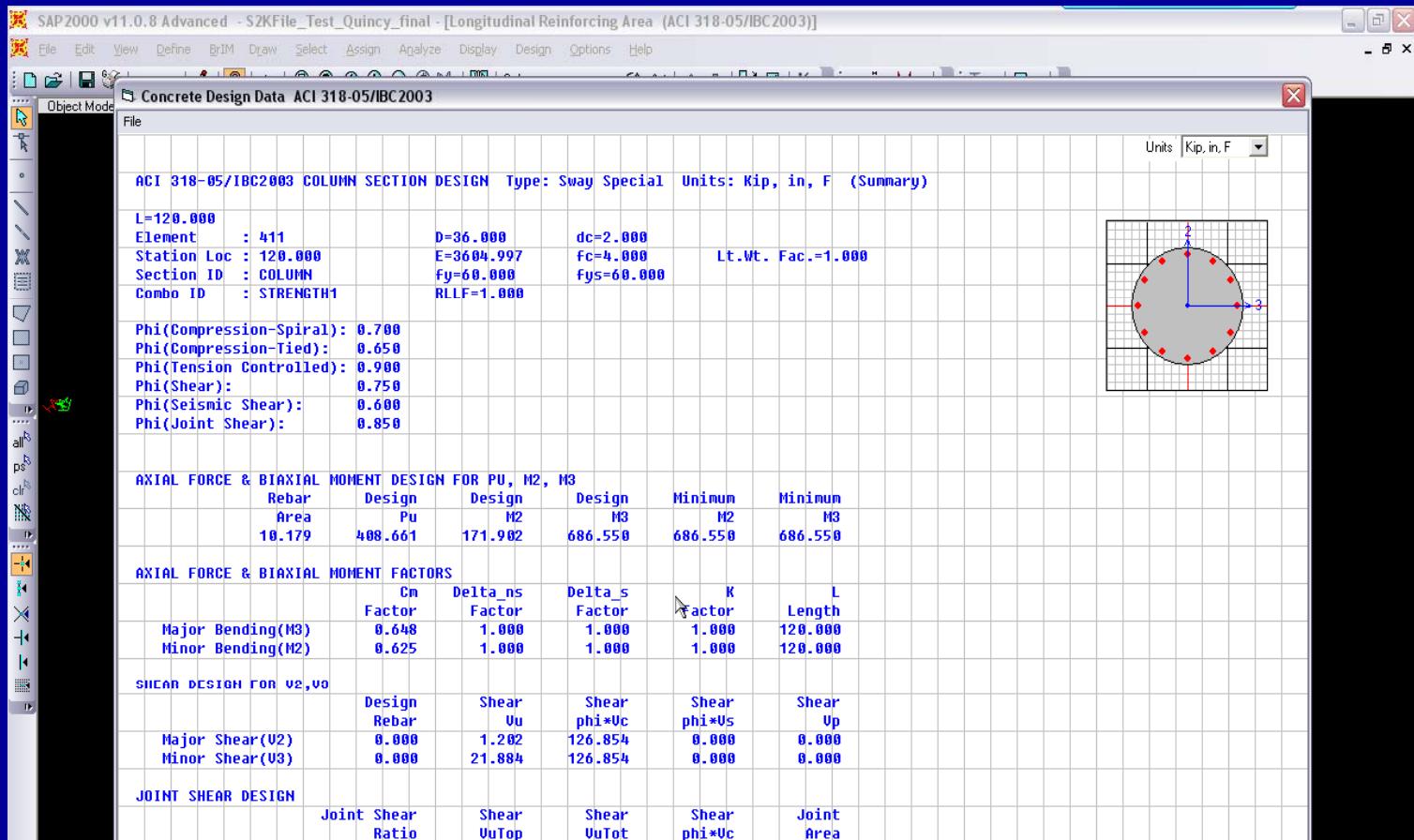
	Joint Shear Ratio	Shear VuTop	Shear VuTot	Shear phi*Uc	Joint Area

Units: Kip, in, F



S08 SAP2000 Structure Design

Design result:
concrete
column
design
data



Summary (Part D1-Steel Design)

- Workflow demonstrated for steel alternate of Case Study bridge
- One of several possible such workflows
- Encompassing analysis & design, superstructure & substructure, 3D modeling environment (used subsequently for detailing/shop/ and further downstream...)

