Part D1:

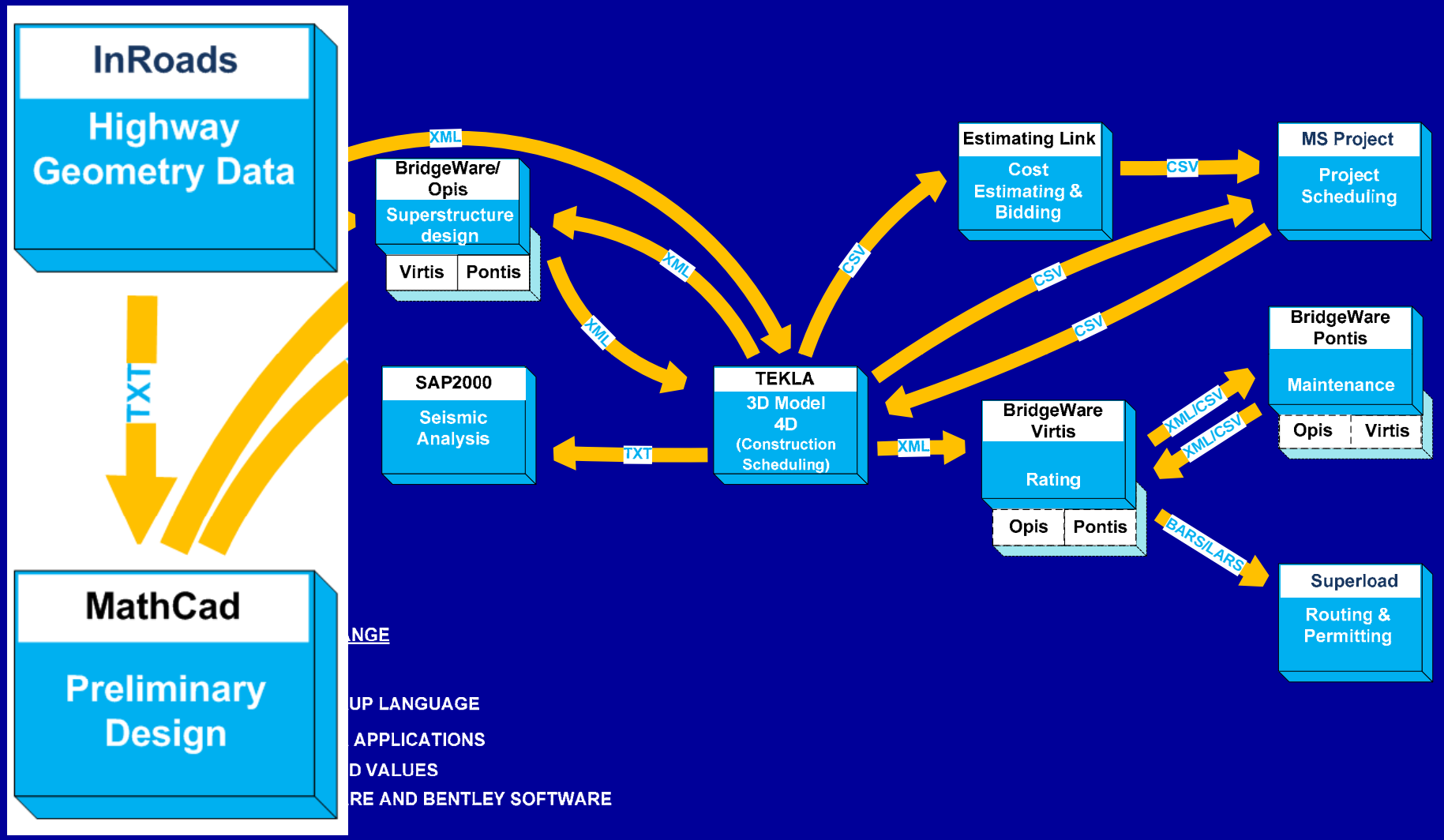
Steel Design Example

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

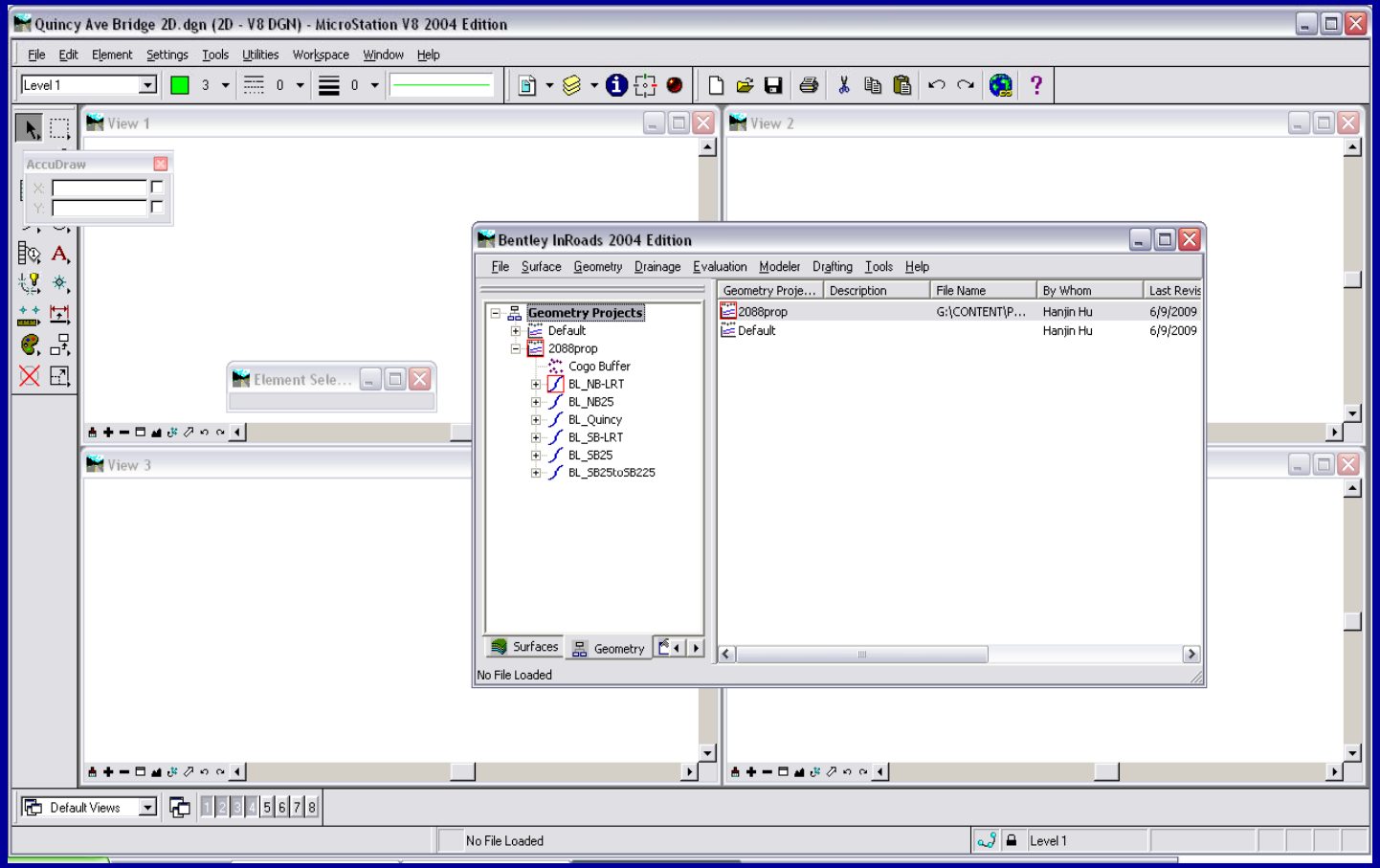
U.S. Department of Transportation
Federal Highway Administration

S01 InRoads to MathCAD



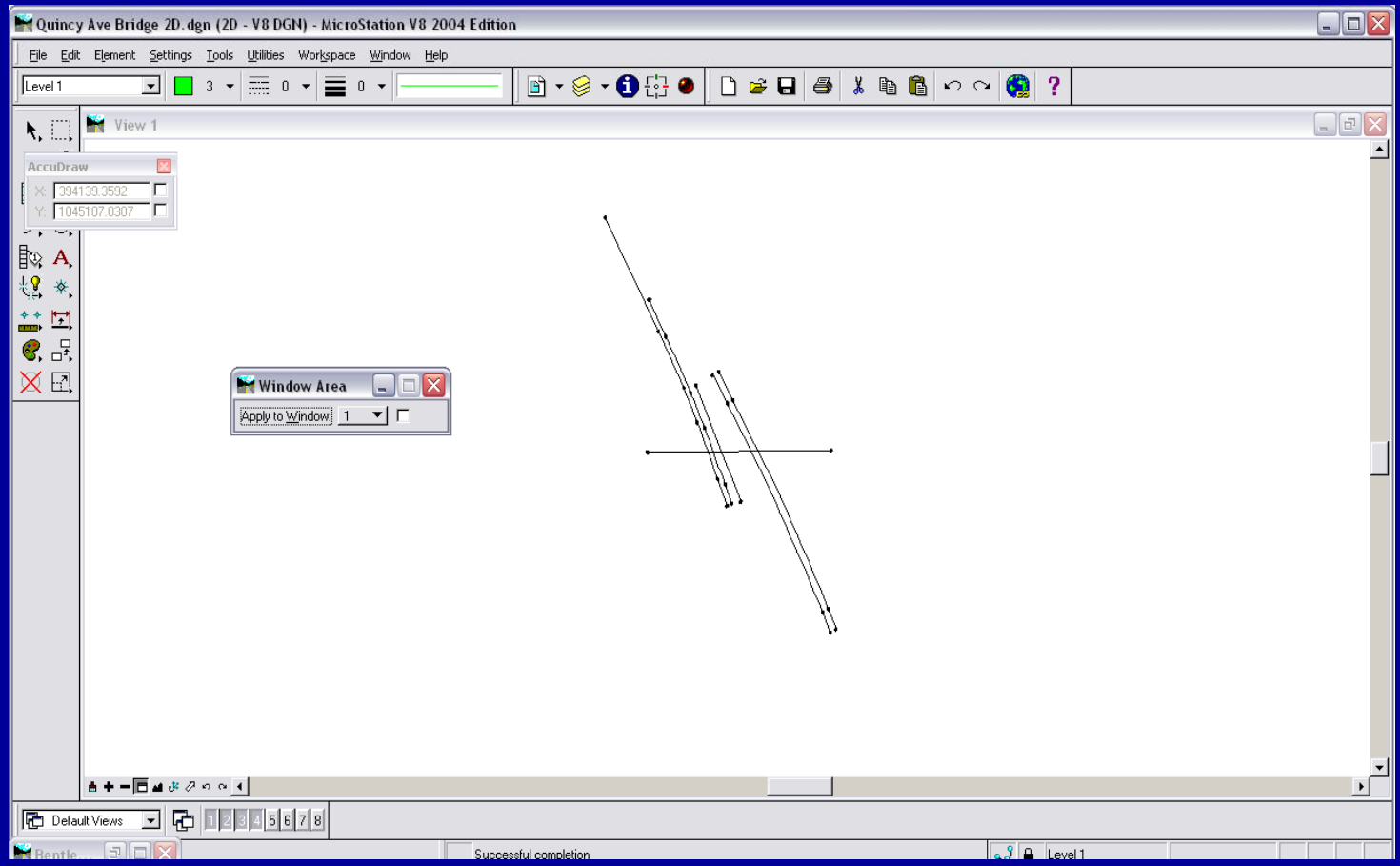
S01 InRoads to MathCAD

Loading alg file:
6 pairs of horizontal and vertical alignments



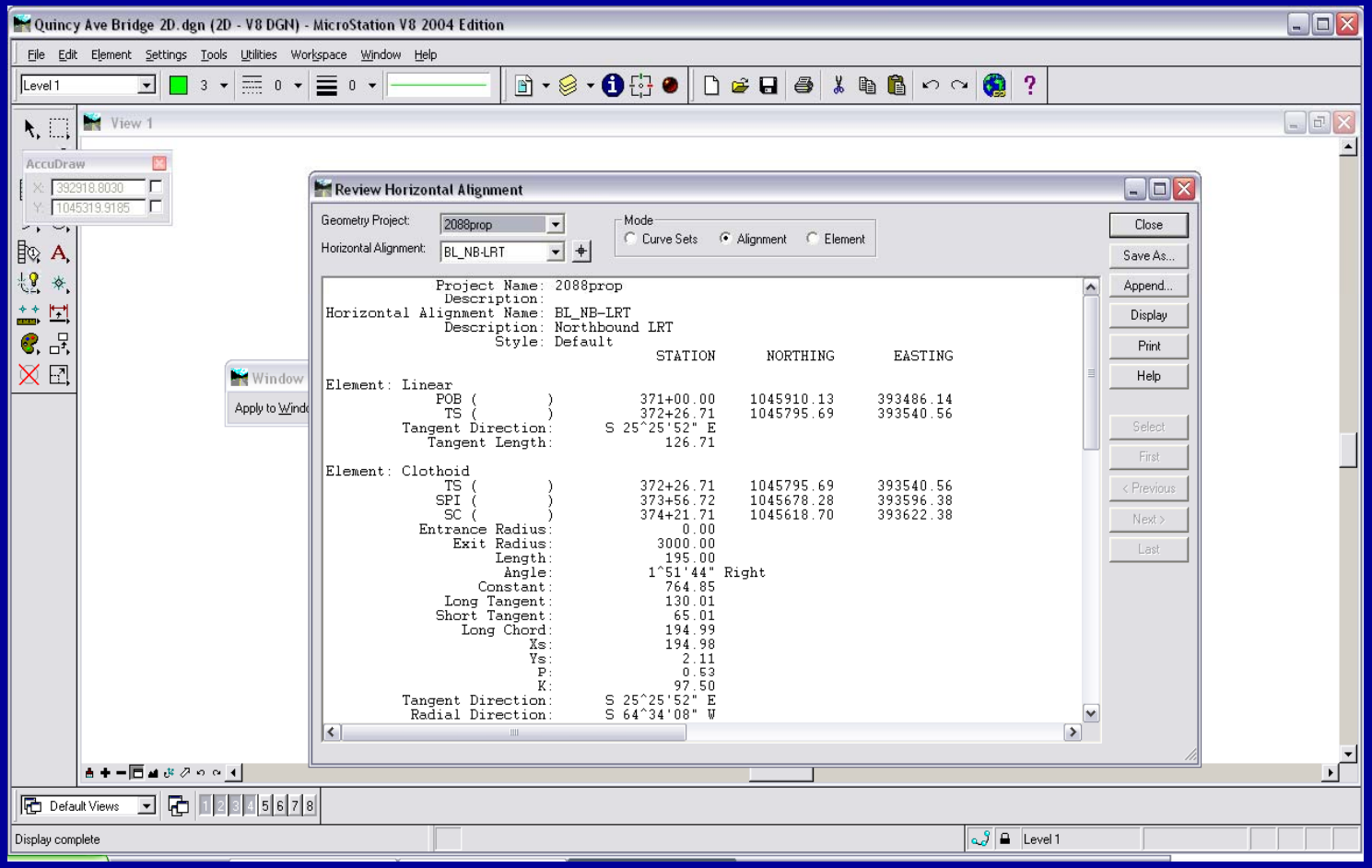
S01 InRoads to MathCAD

This picture shows 6 horizontal alignments



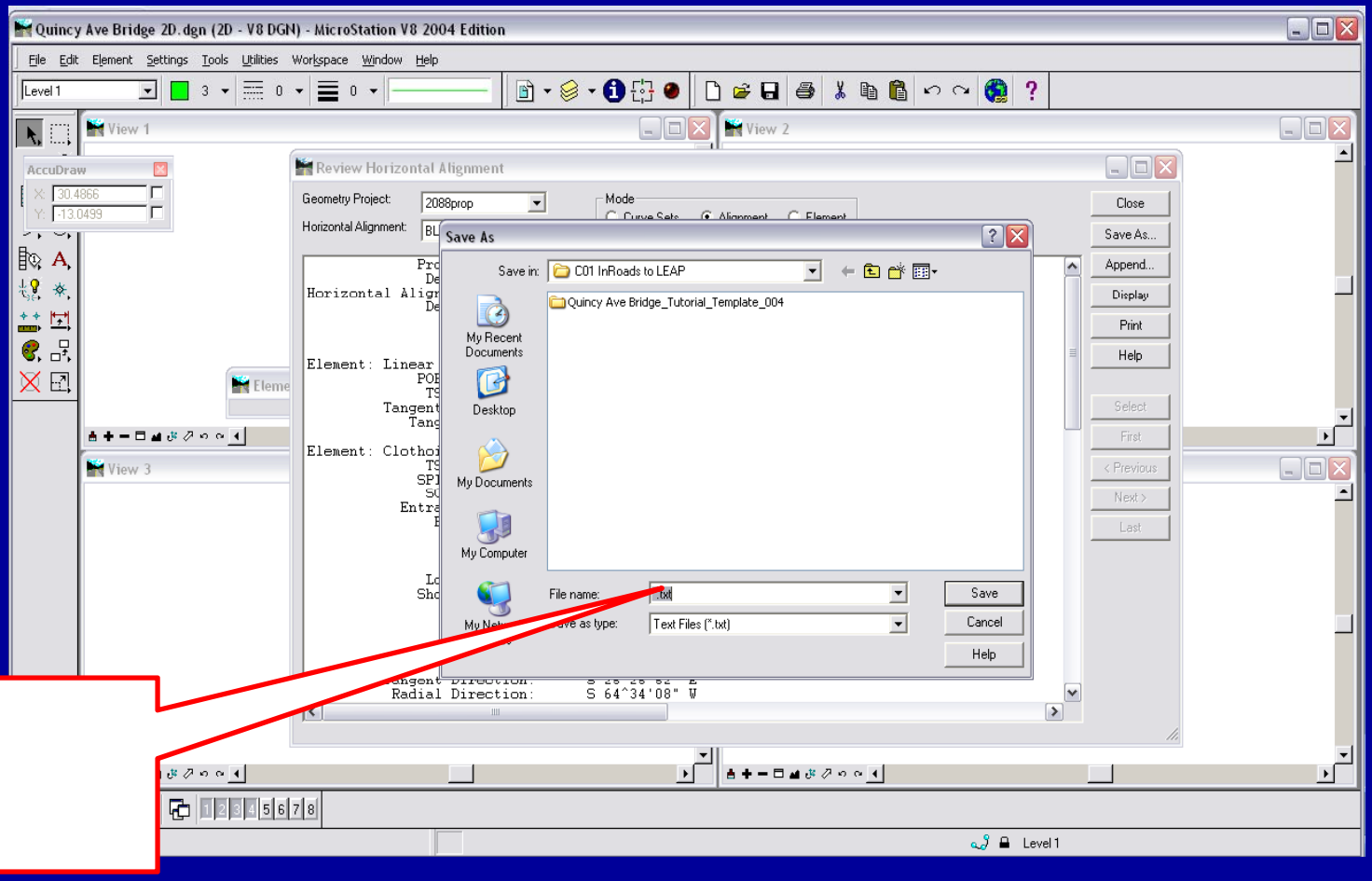
S01 InRoads to MathCAD

Details of horizontal and vertical alignments



S01 InRoads to MathCAD

Save alignments data as txt files



Text file

U.S. Department of Transportation
Federal Highway Administration

S01 InRoads to MathCAD

Sample text file

BL_NB-LRT.txt - Notepad

File Edit Format View Help

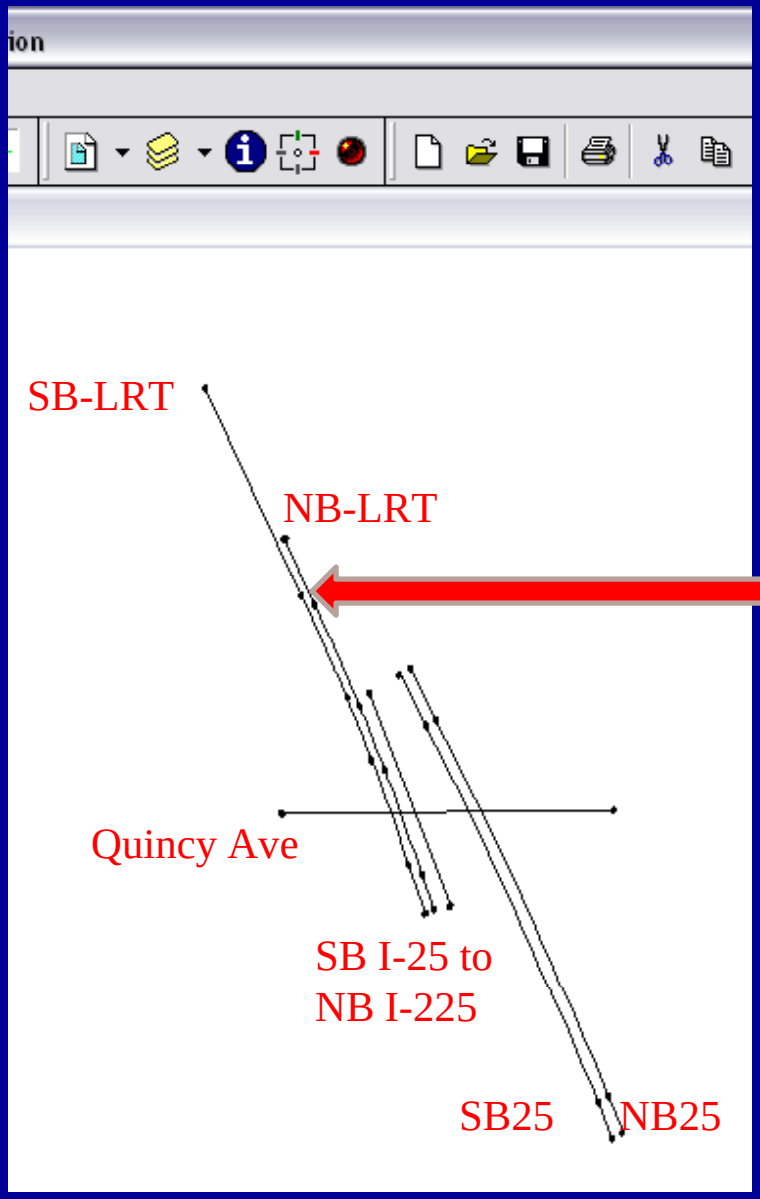
```
            Project Name: 2088prop
             Description:
Horizontal Alignment Name: BL_NB-LRT
             Description: Northbound LRT
                   Style: Default
                                        STATION      NORTHING       EASTING

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

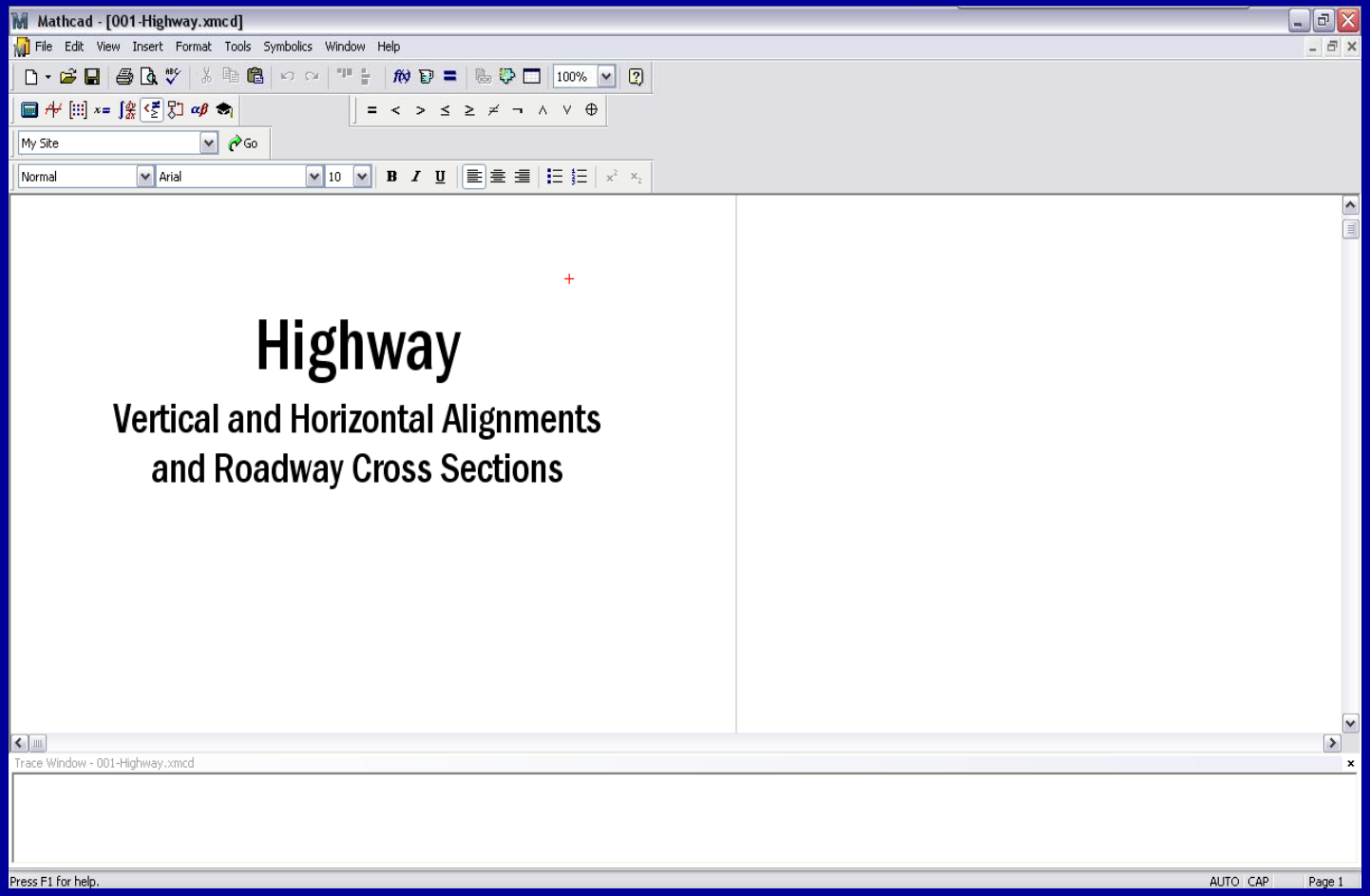
```
             Project Name: 2088prop
              Description:
Horizontal Alignment Name: BL_NB-LRT
              Description: Northbound LRT
                    Style: Default
                                                STATION       NORTHING

Element: Linear
                POB (         )              371+00.00     1045910.13
                 TS (         )              372+26.71     1045795.69
          Tangent Direction:          S 25^25'52" E
             Tangent Length:                   126.71

Element: Clothoid
                 TS (         )              372+26.71     1045795.69
                SPI (         )              373+56.72     1045678.28
                                             374+21.71     1045618.70
           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
```

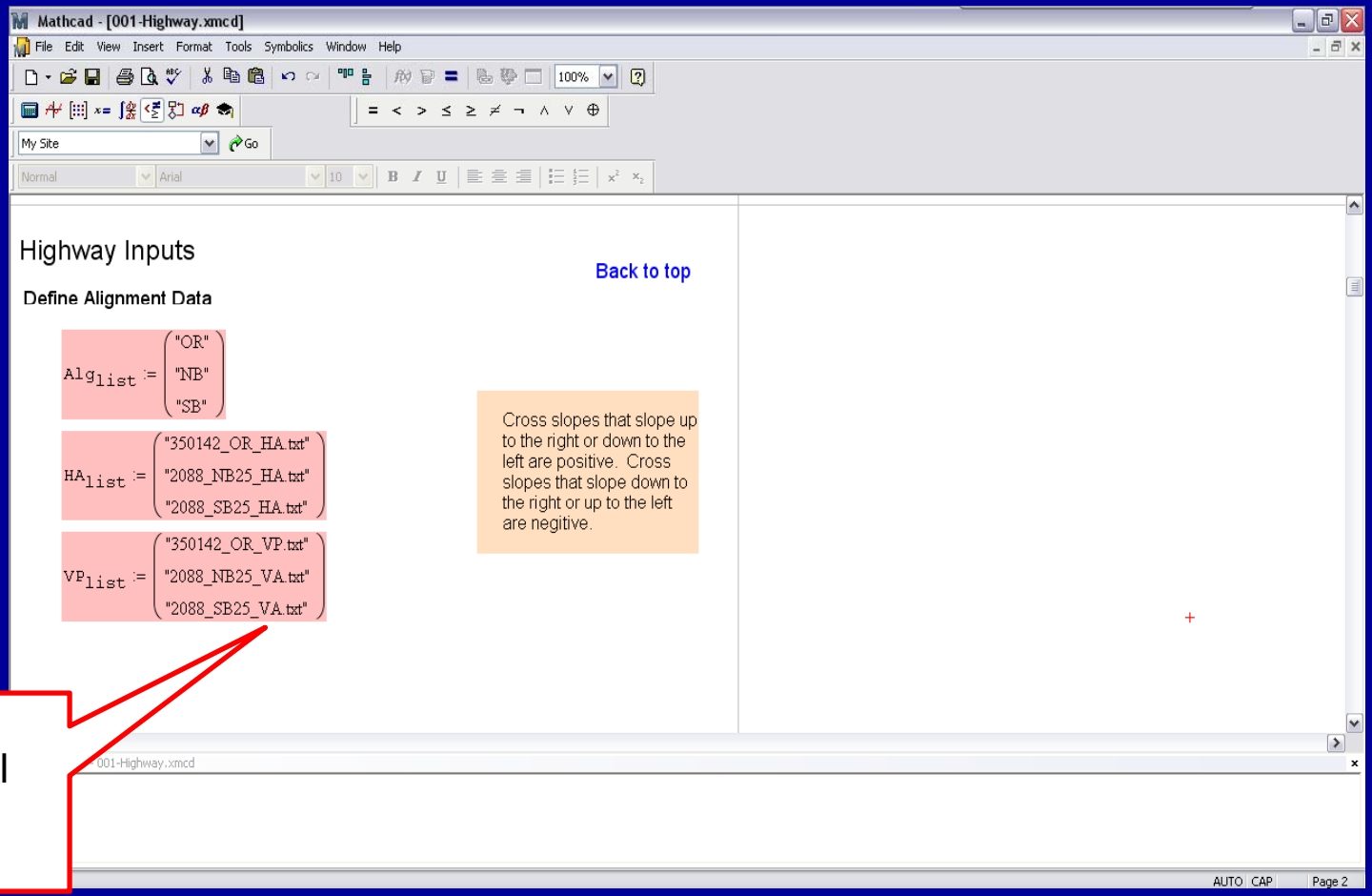
S01 InRoads to MathCAD

The MathCAD file used for alignments design



S01 InRoads to MathCAD

Highway Inputs: input text files



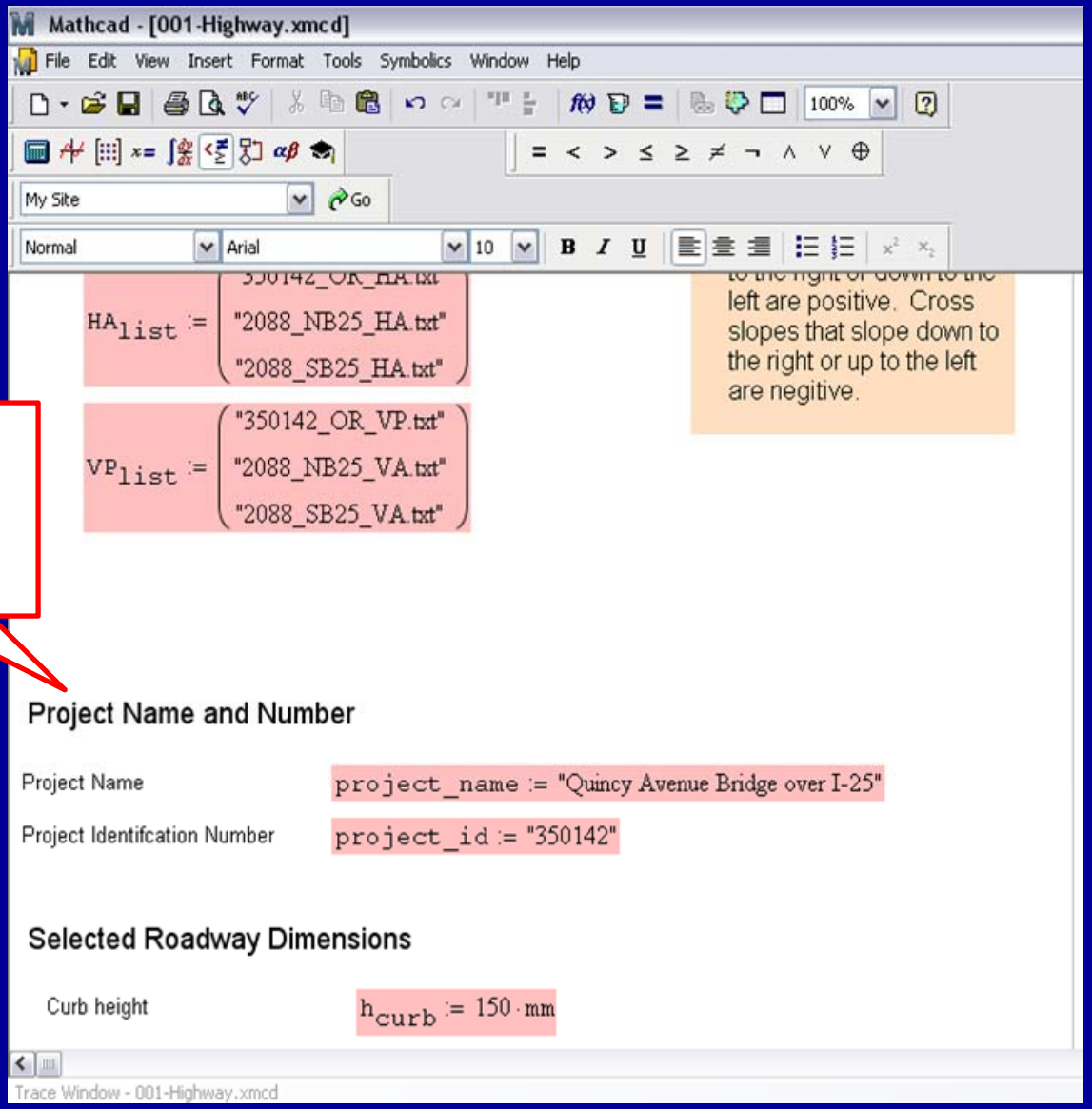
The input text files here are all exported from InRoads.

U.S. Department of Transportation
Federal Highway Administration

S01 InRoads to MathCAD

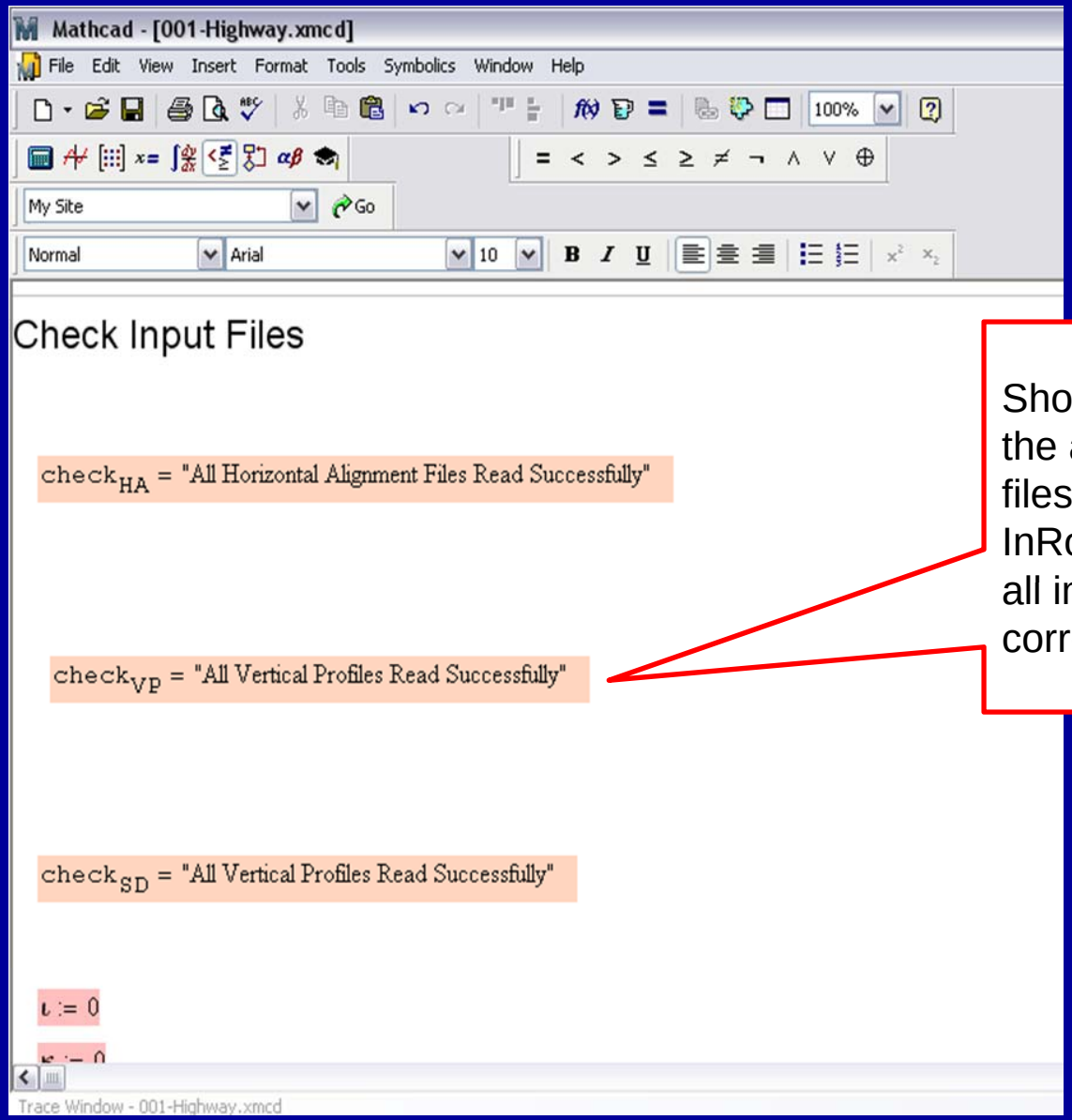
Details of MathCAD files

Some basic parameter inputs of the project.



S01 InRoads to MathCAD

Details of MathCAD files



Shows that the alignment files from InRoads are all imported correctly.

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

$$pts_{sub} := \begin{pmatrix} "OR" & 6145.000 \cdot m & 0 \cdot m \\ "OR" & 6177.000 \cdot m & 0 \cdot m \\ "OR" & 6201.000 \cdot m & 0 \cdot m \end{pmatrix} \qquad \alpha_{skew} := \begin{pmatrix} 20 \\ 20 \\ 20 \end{pmatrix} \cdot deg \qquad n_{sub.fix} := \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

Superstructure Design Inputs:

Number of Girders $N_{girders} := 5$

Point Functions

Bridge Width

$W_{bridge} := W_t("OR\_FG")$ $\quad W_{bridge} = 14.234\,m$

Spacing of Girders

Girder Spacing $S_{girder} := 3.00 \cdot m$

Offset to centerline $OC_{CL} := OC_{CL,t}("OR\_FG")$ $\quad OC_{CL} = 0.000\,m$

$OS_{left} := OS_t("OR\_FG")_{1,1}$ $\quad OS_{left} = -7.117\,m$

$OS_{right} := OS_t("OR\_FG")_{1,2}$ $\quad OS_{right} = 7.117\,m$

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 $b_{bot.o} := 500 \cdot mm$

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

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

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

Top Flange thickness

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

Bottom Flange thickness

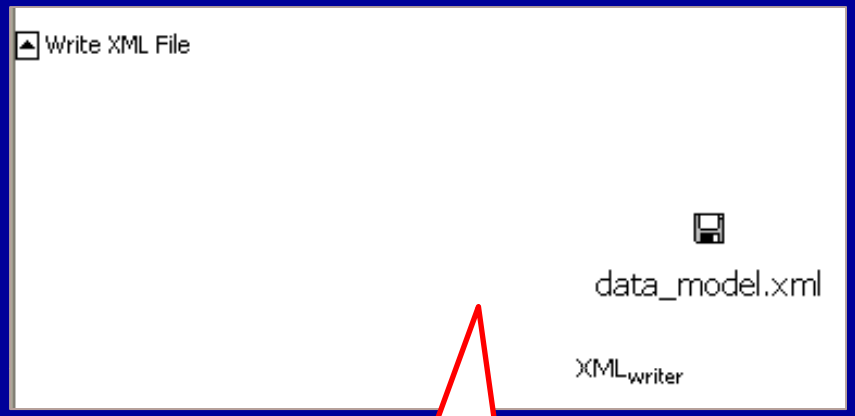
$$t_{bot.o} := \begin{pmatrix} 0.025 & 22.6 \\ 0.050 & 10.0 \\ 0.025 & 26.4 \end{pmatrix} \cdot m$$

Piece Ends

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

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

Export XML Linkage File



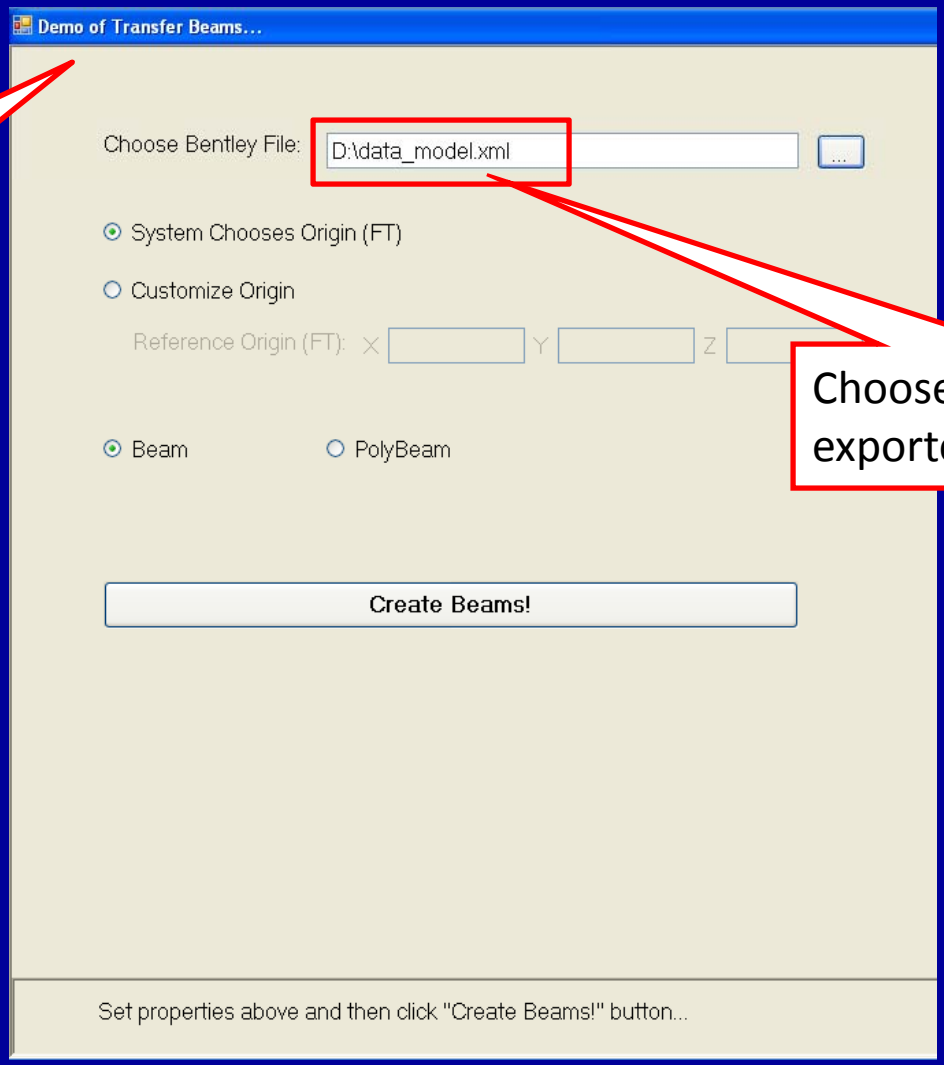
This xml exporting functionality is developed.

Export data into XML file in MathCAD …

```
<?xml version="1.0" encoding="utf-8" standalone="no"?>
<bridge bridge_name="Rt 7 over I-87" bridge_id="1234567-89"
<structure structure_id="All spans">
<HCL_at_brgs>
<control_point control_point_id="1">
<x_coord>209809.048160415</x_coord>
<y_coord>435524.606993932</y_coord>
<elev>101.882134327649</elev>
<alignment>OR</alignment>
<station>6145</station>
<offset>0</offset>
<substructure>BA</substructure>
</control_point>
```

Import Xml File into Tekla

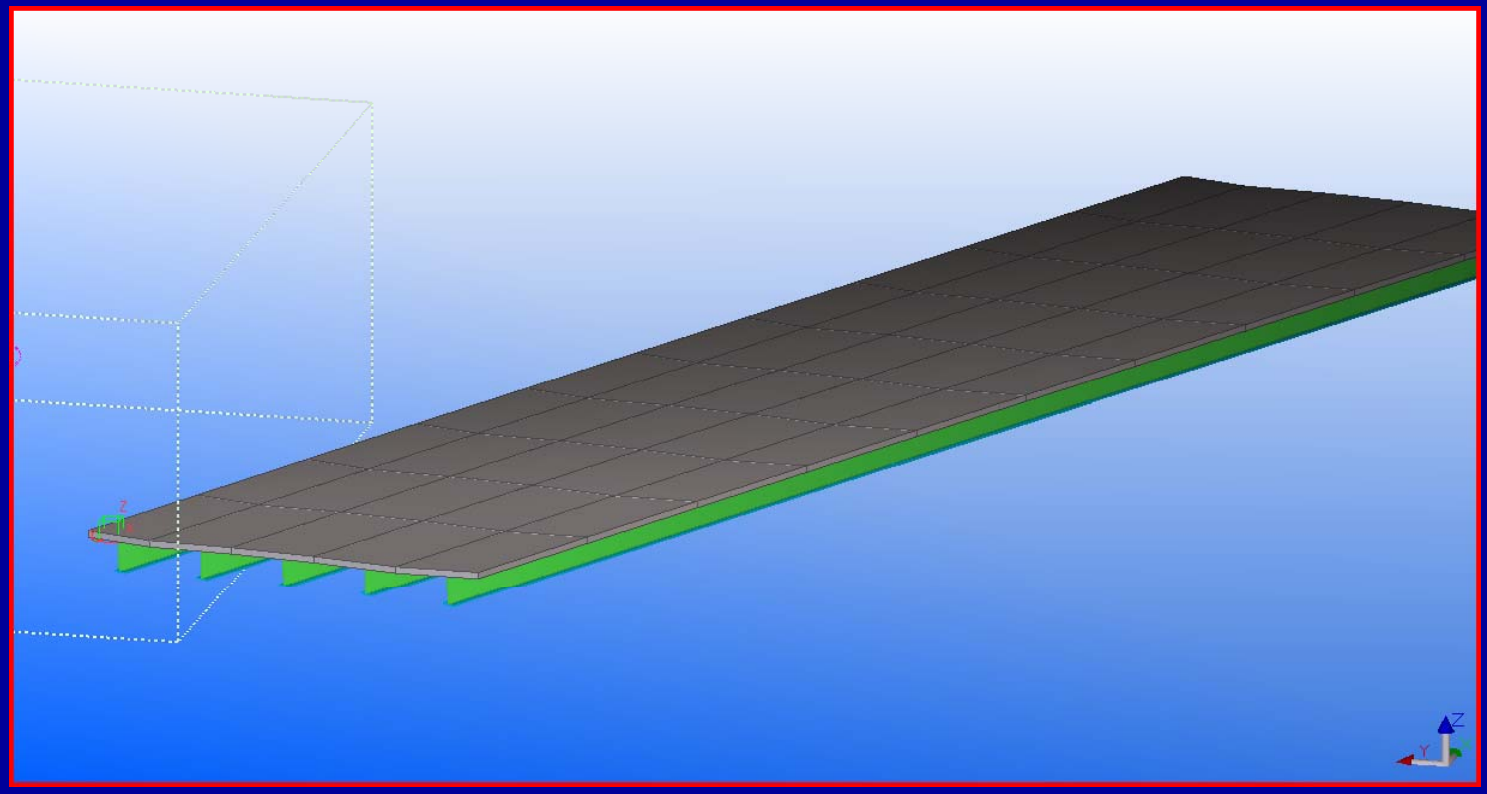
This program is developed by C# in Visual Studio. It reads the bridge data in xml linkage file just exported from MathCAD sheet and calls Tekla's APIs to build 3D model automatically.



Choose the XML file just exported…

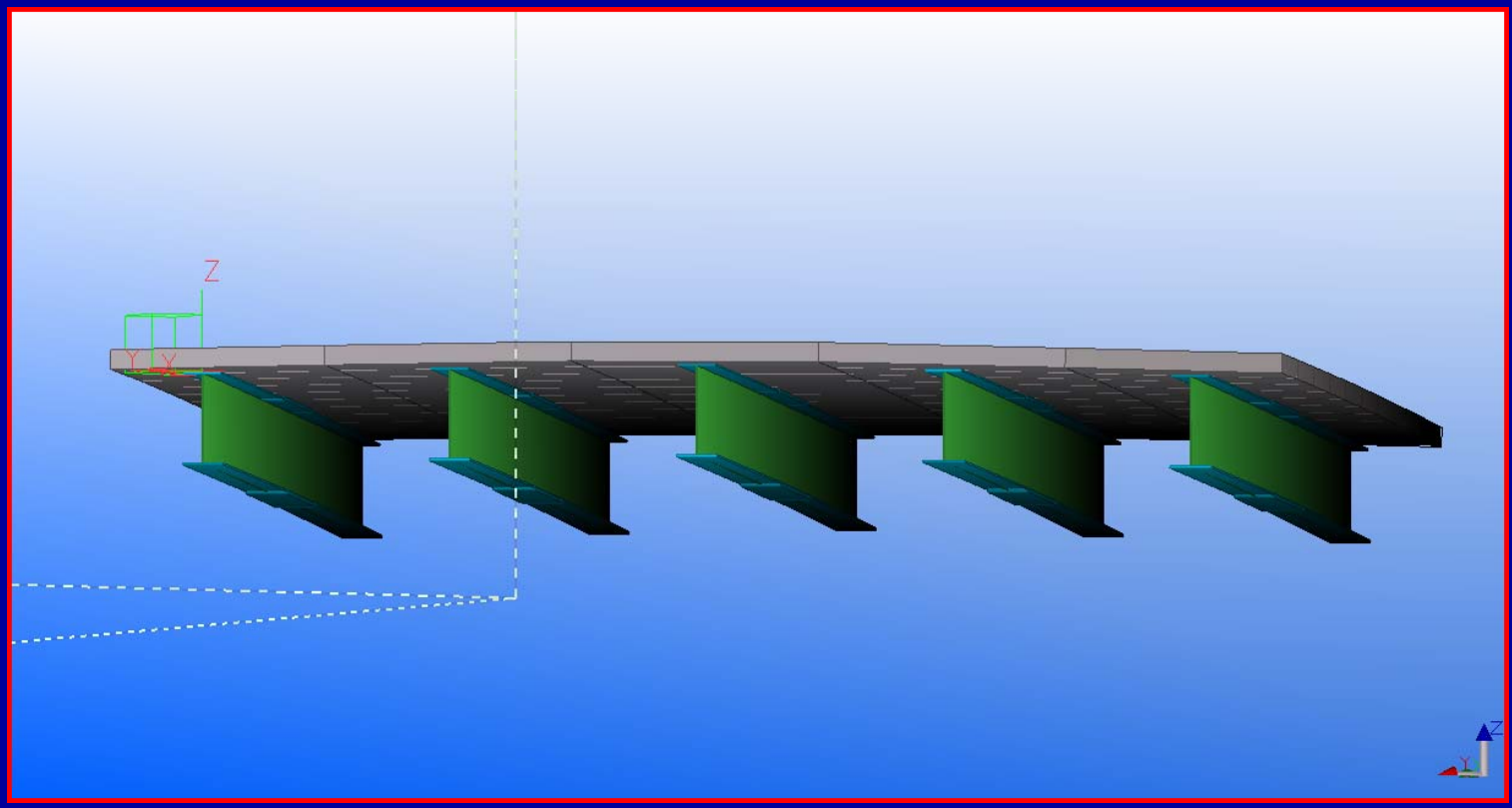
The Tekla 3D Model Automatically Generated

Output model snapshot from Tekla Structure:



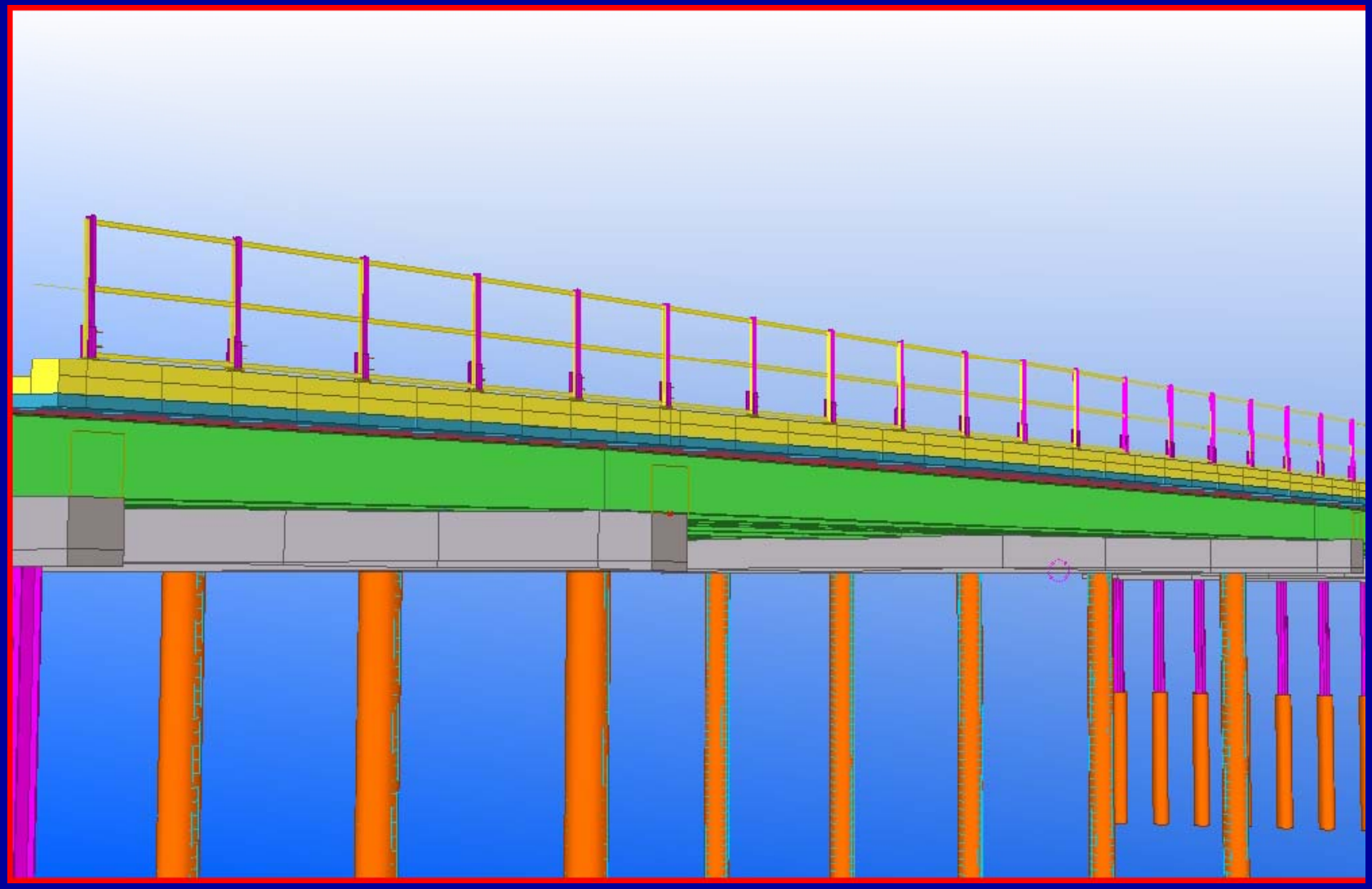
The Tekla 3D Model Automatically Generated (cont.)

Output model snapshot from Tekla Structure:

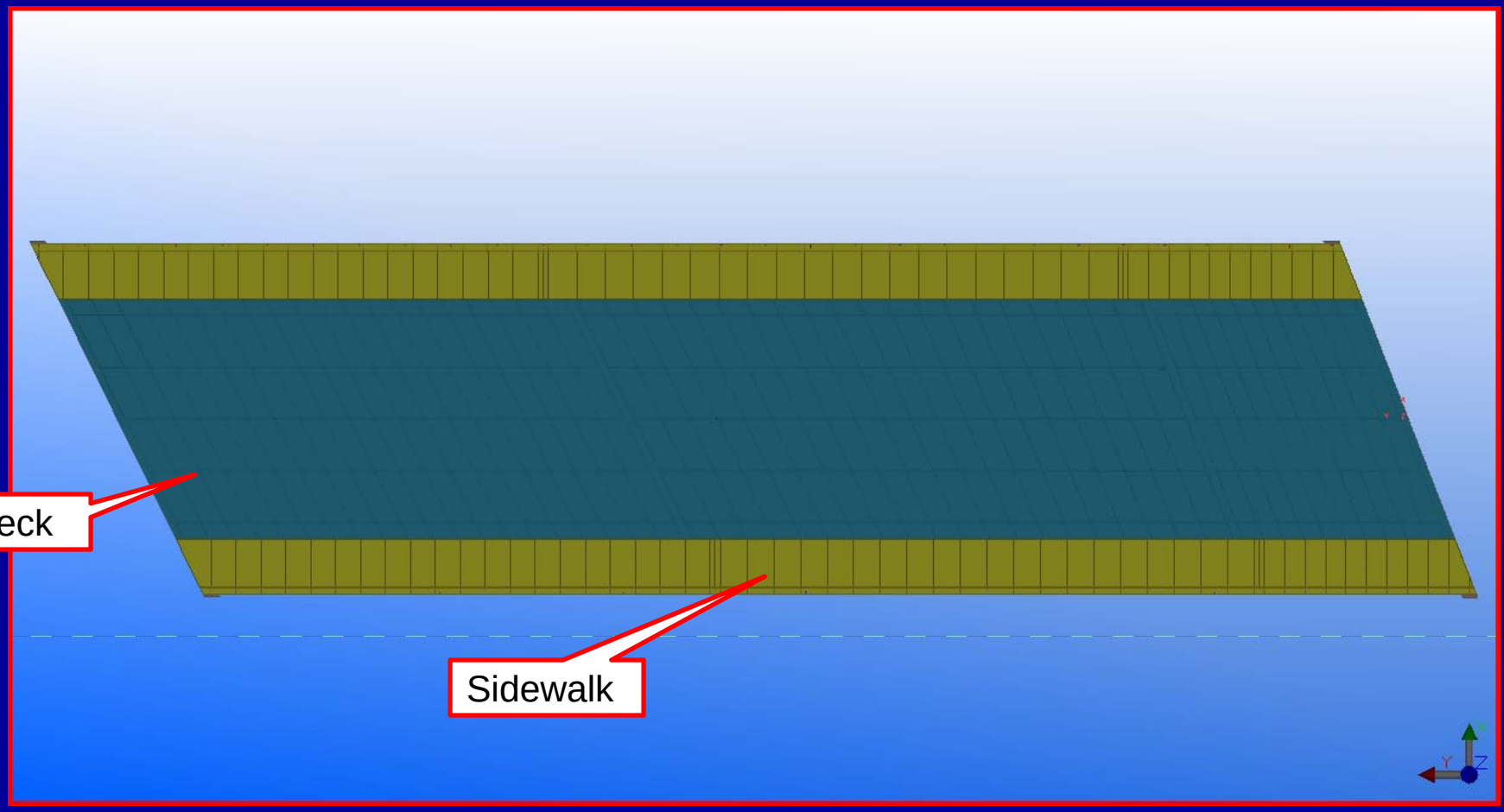


From Tekla to XML

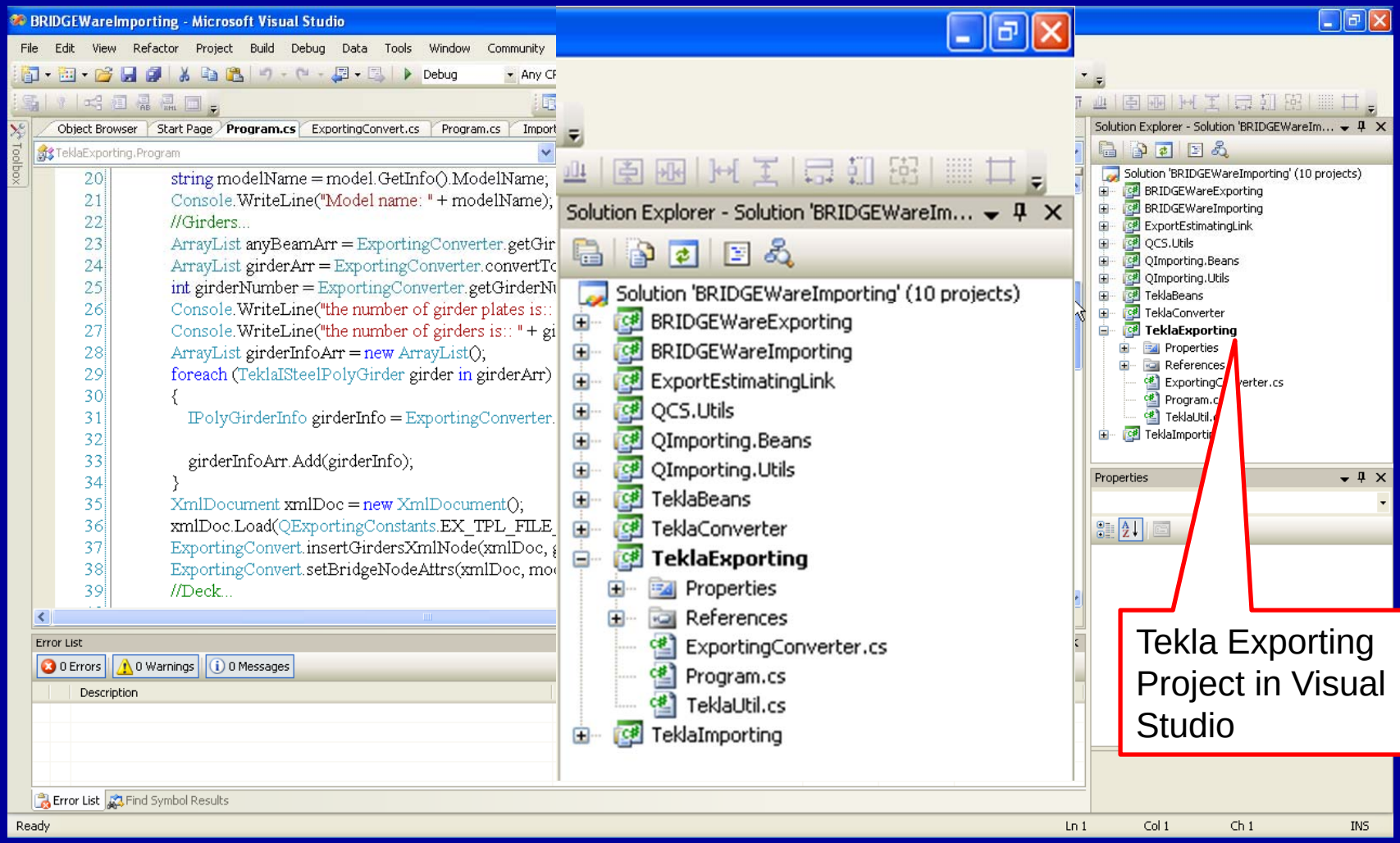
Tekla 3D Model



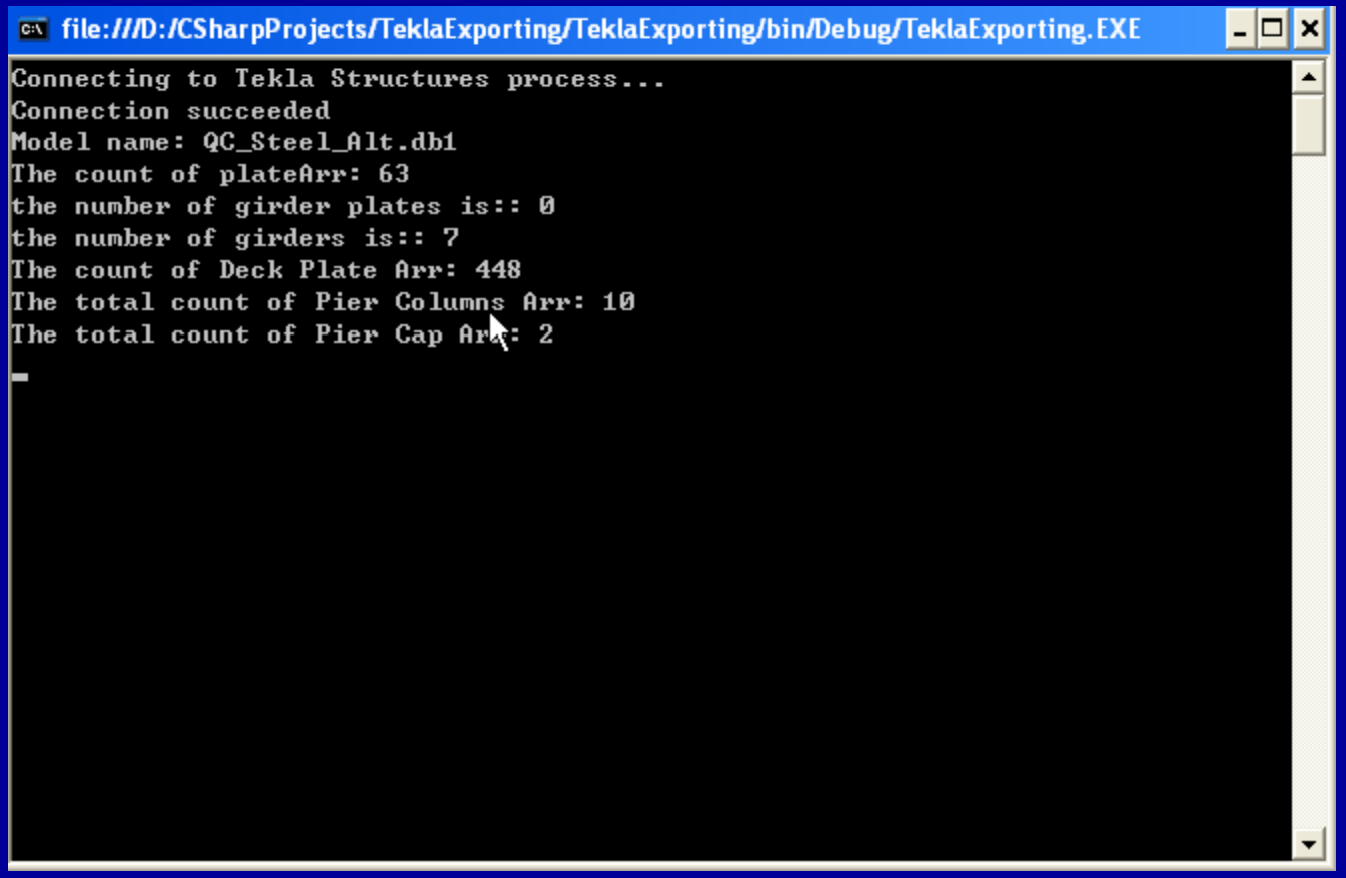
Tekla 3D Model: Top View



The Code Sample and Development Environment showing Exporting



Export Processing



Sample of Exported XML File

Deck data tag…

Girders data Tag…

Flange section data of girder…

Exporting_Link...el_alt.db1.xml | Program.cs | ExportingConvert.cs | Program.cs | ImportingC

```
<?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>
```

XML to Opis/Virtis

U.S. Department of Transportation
Federal Highway Administration

Sample of XML File

Exporting_Link...el_alt.db1.xml | Program.cs | ExportingConvert.cs | Program.cs | ImportingC

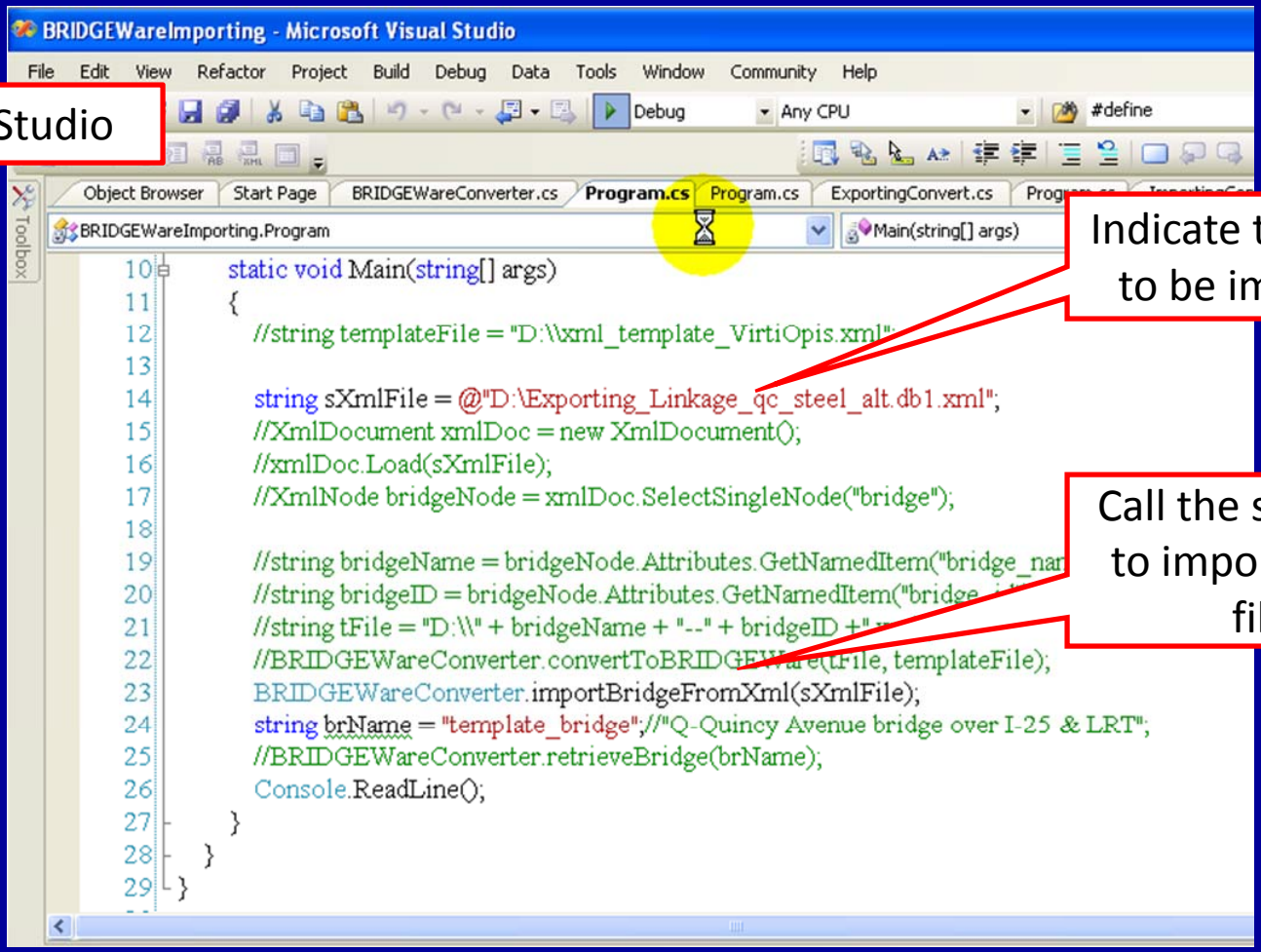
```
<?xml version="1.0" encoding="utf-8" standalone="no"?>
<bridge name="QC_Steel_Alt.db1" id="QC_Steel_Alt.db1" date="" desc="">
 <structure structure_id="All spans">
  <HCL_at_brgs>...
  <deck>...
  <beams beam_type="Steel I Girders">
   <girder name="BEAM_G1">
    <point name="BEAM_G1_TF_0">
     <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…

U.S. Department of Transportation
Federal Highway Administration

Code Sample and Development Environment Showing Importing

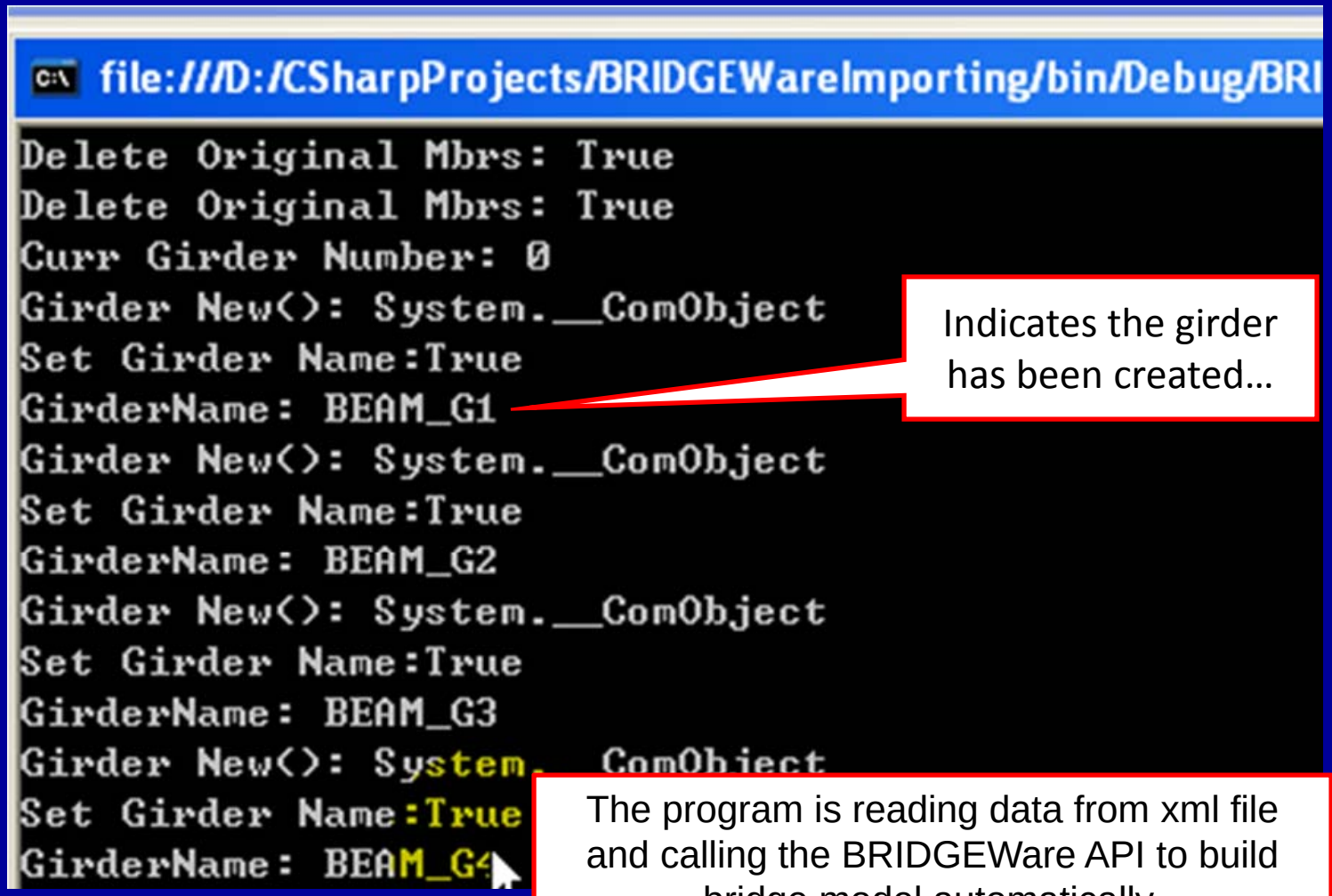
Visual Studio



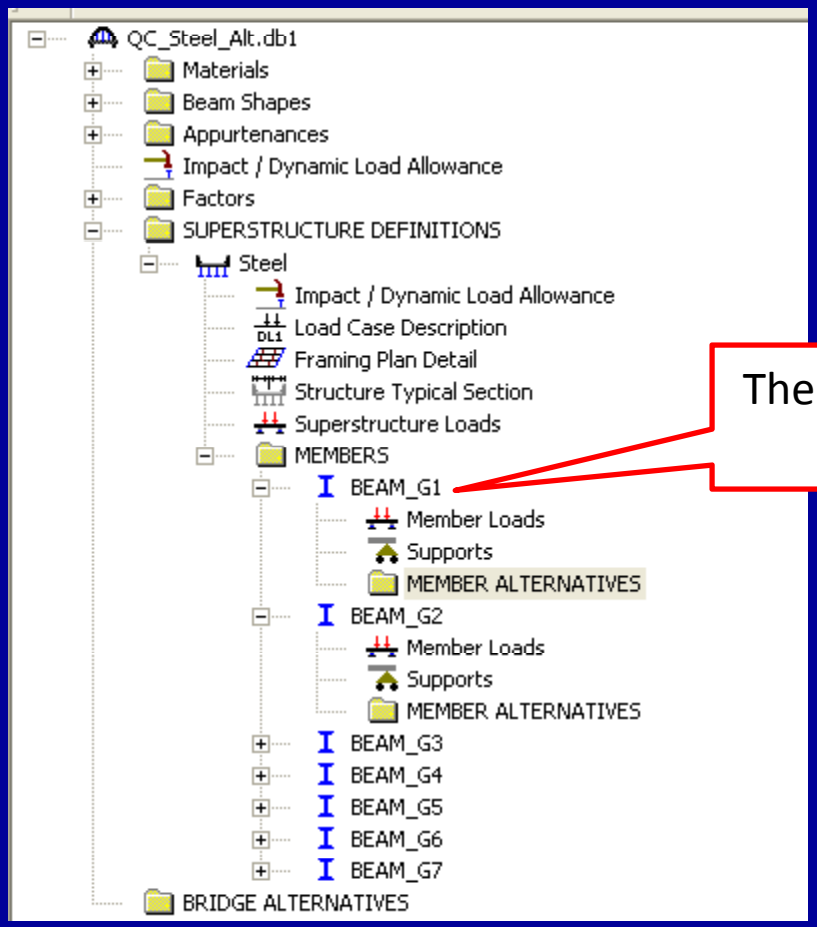
Indicate the xml file to be imported…

Call the subroutine to import the xml file…

Importing Process



BRIDGEWare Model (Steel)

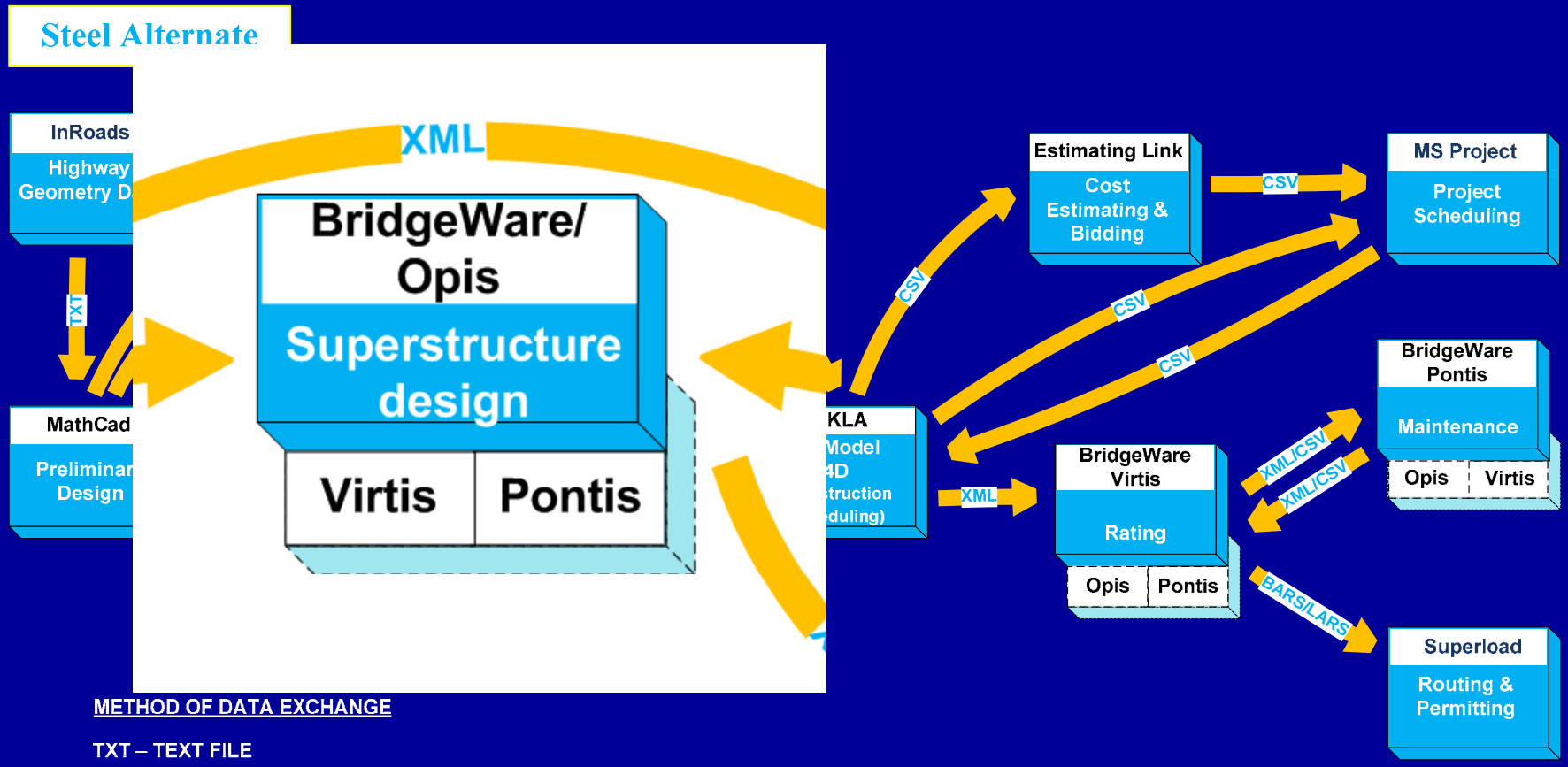


The girder has been created…

Opis Steel Design

U.S. Department of Transportation
Federal Highway Administration

S06 Opis Steel design



METHOD OF DATA EXCHANGE

TXT – TEXT FILE

XML – EXTENSIBLE MARKUP LANGUAGE

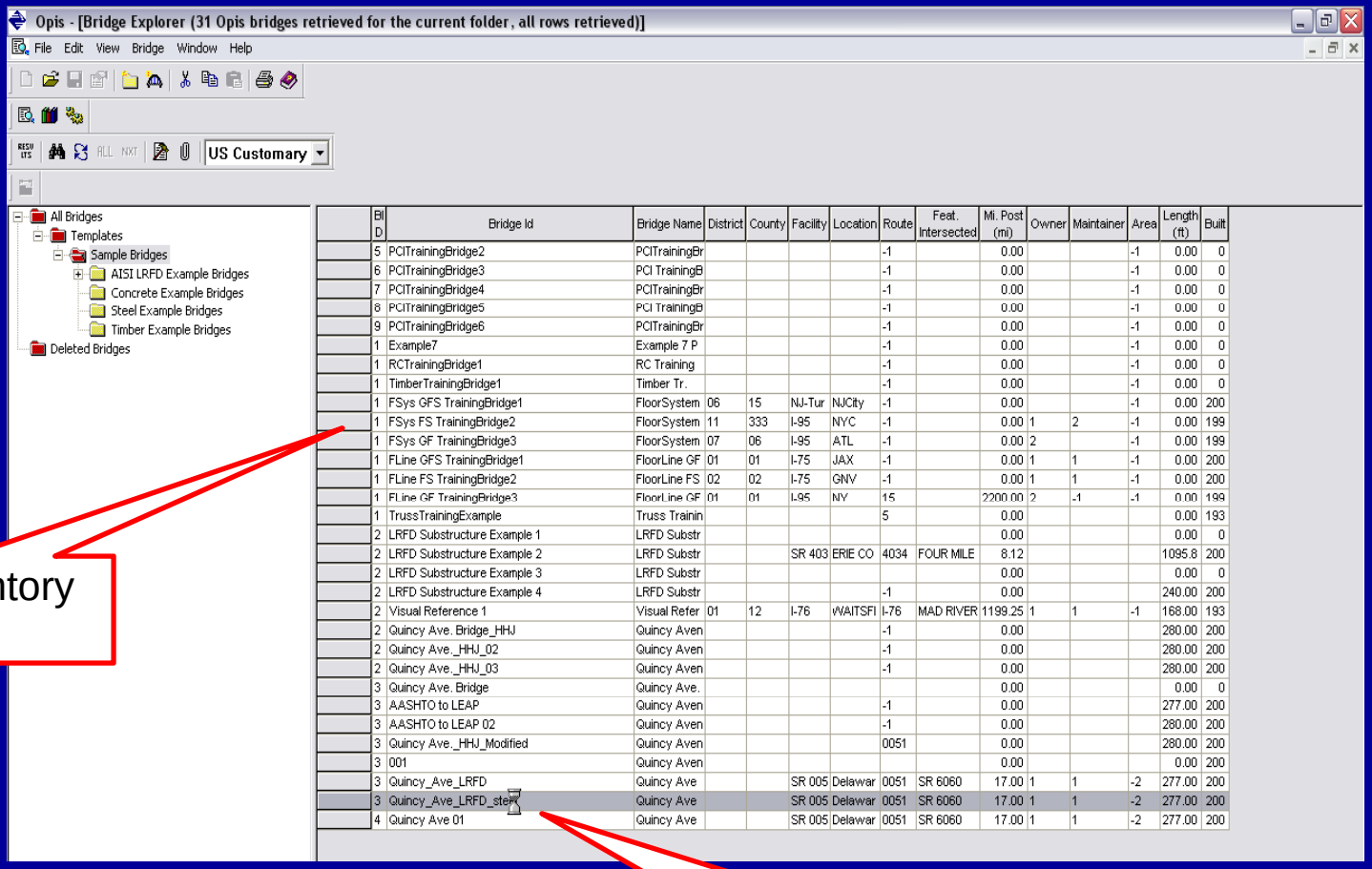
VBA – VISUAL BASIC FOR APPLICATIONS

CSV – COMMA SEPARATED VALUES

BARS/LARS – AASHTOWARE AND BENTLEY SOFTWARE

S06 Opis Steel design

In Opis: Open the XML file exported from MathCAD



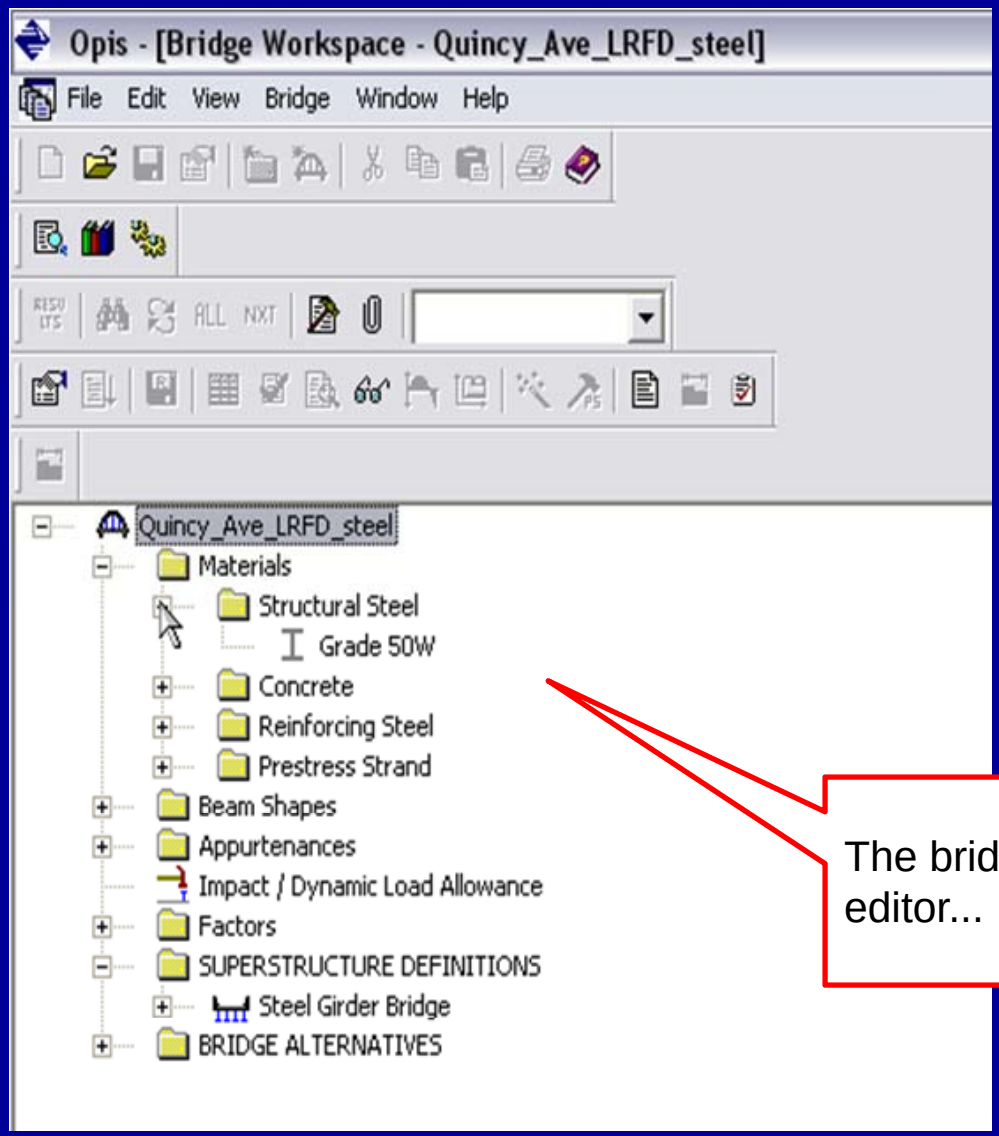
BID	Bridge Id	Bridge Name	District	County	Facility	Location	Route	Feat. Intersected	Mi. Post (mi)	Owner	Maintainer	Area	Length (ft)	Built
5	PCITrainingBridge2	PCITrainingBr					-1		0.00			-1	0.00	0
6	PCITrainingBridge3	PCI TrainingB					-1		0.00			-1	0.00	0
7	PCITrainingBridge4	PCITrainingBr					-1		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					-1		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	1	-2	277.00	200
3	Quincy_Ave_LRFD_ste	Quincy Ave			SR 005	Delawar	0051	SR 6060	17.00	1	1	-2	277.00	200
4	Quincy Ave 01	Quincy Ave			SR 005	Delawar	0051	SR 6060	17.00	1	1	-2	277.00	200

Bridge inventory in Opis.

The bridge model we just imported…

S06 Opis Steel design

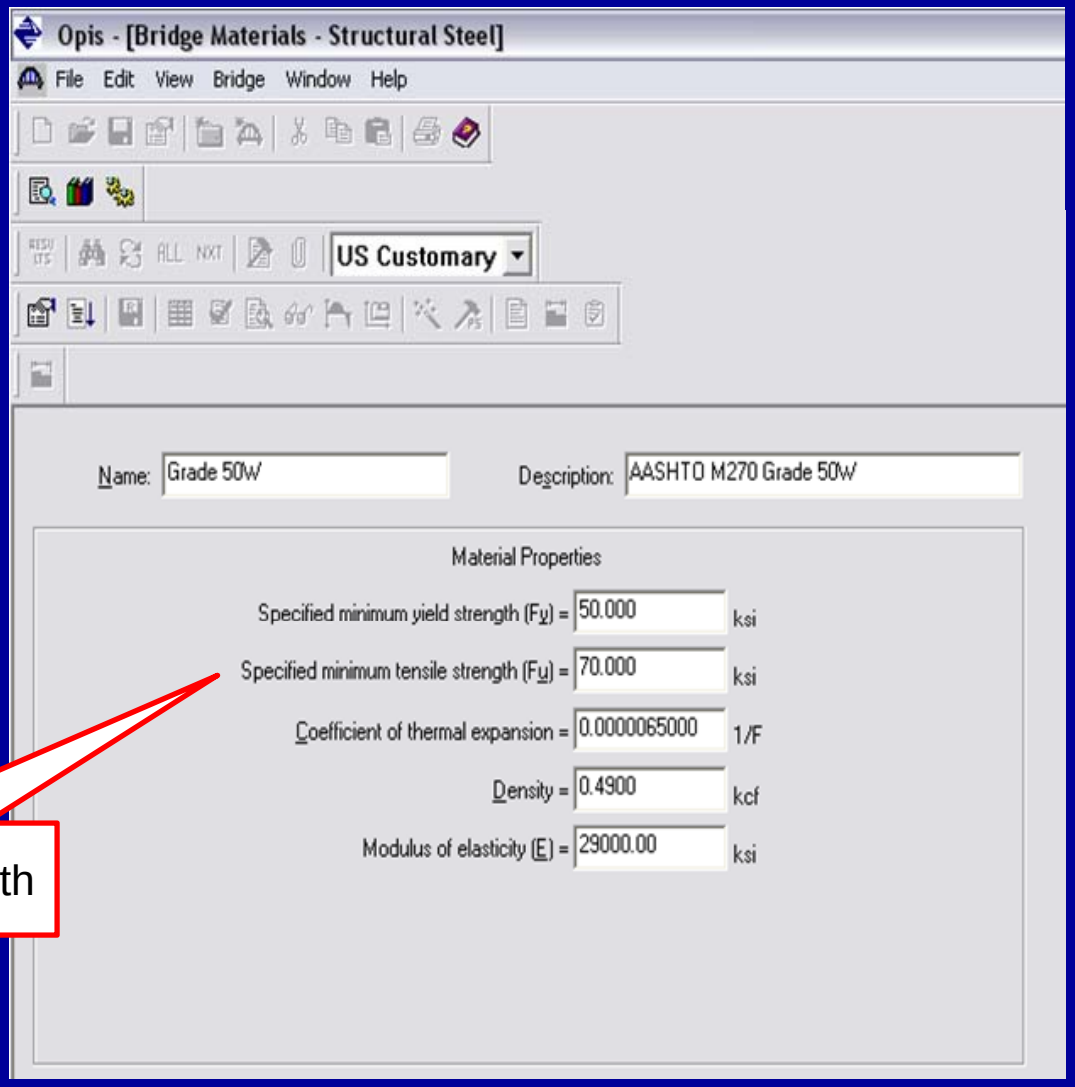
Define Material properties



The bridge model editor...

S06 Opis Steel design

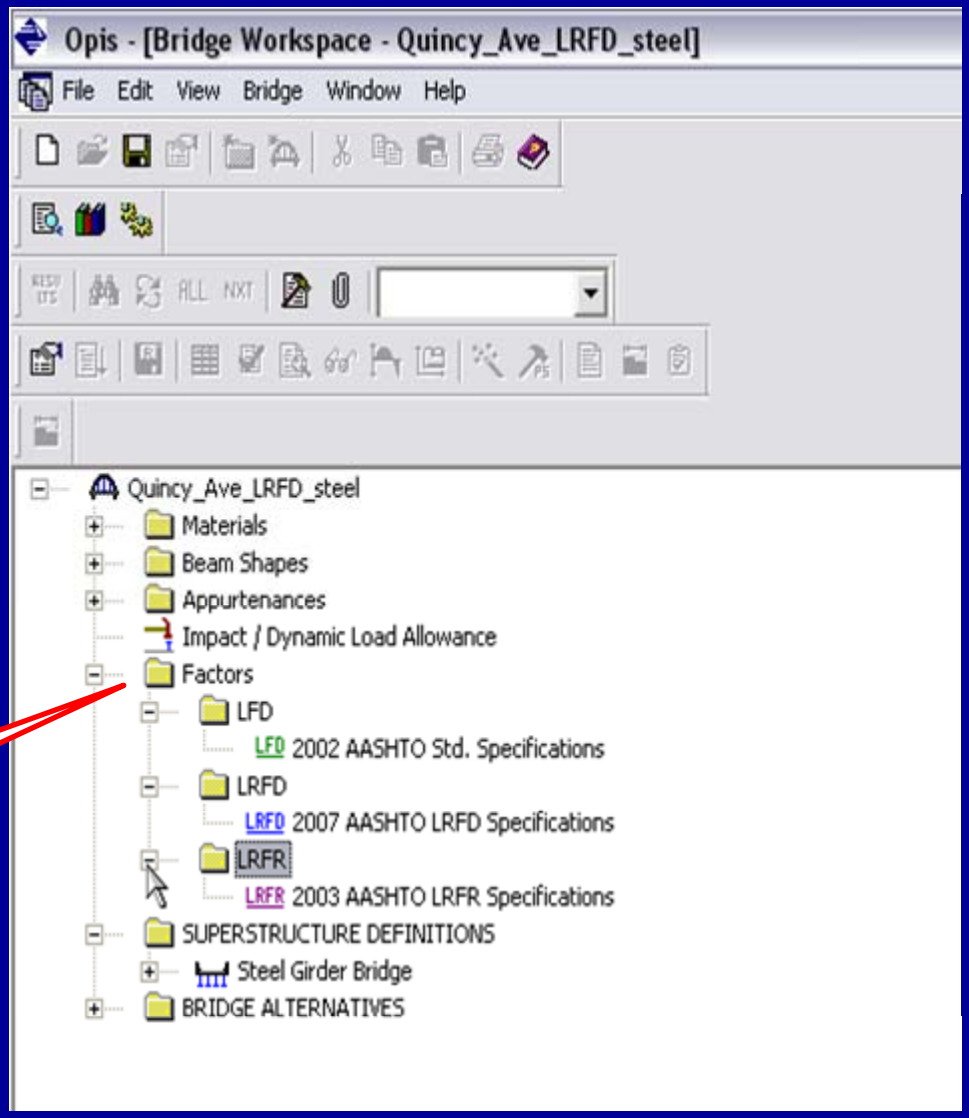
Define steel Grade 50w



Define steel strength

S06 Opis Steel design

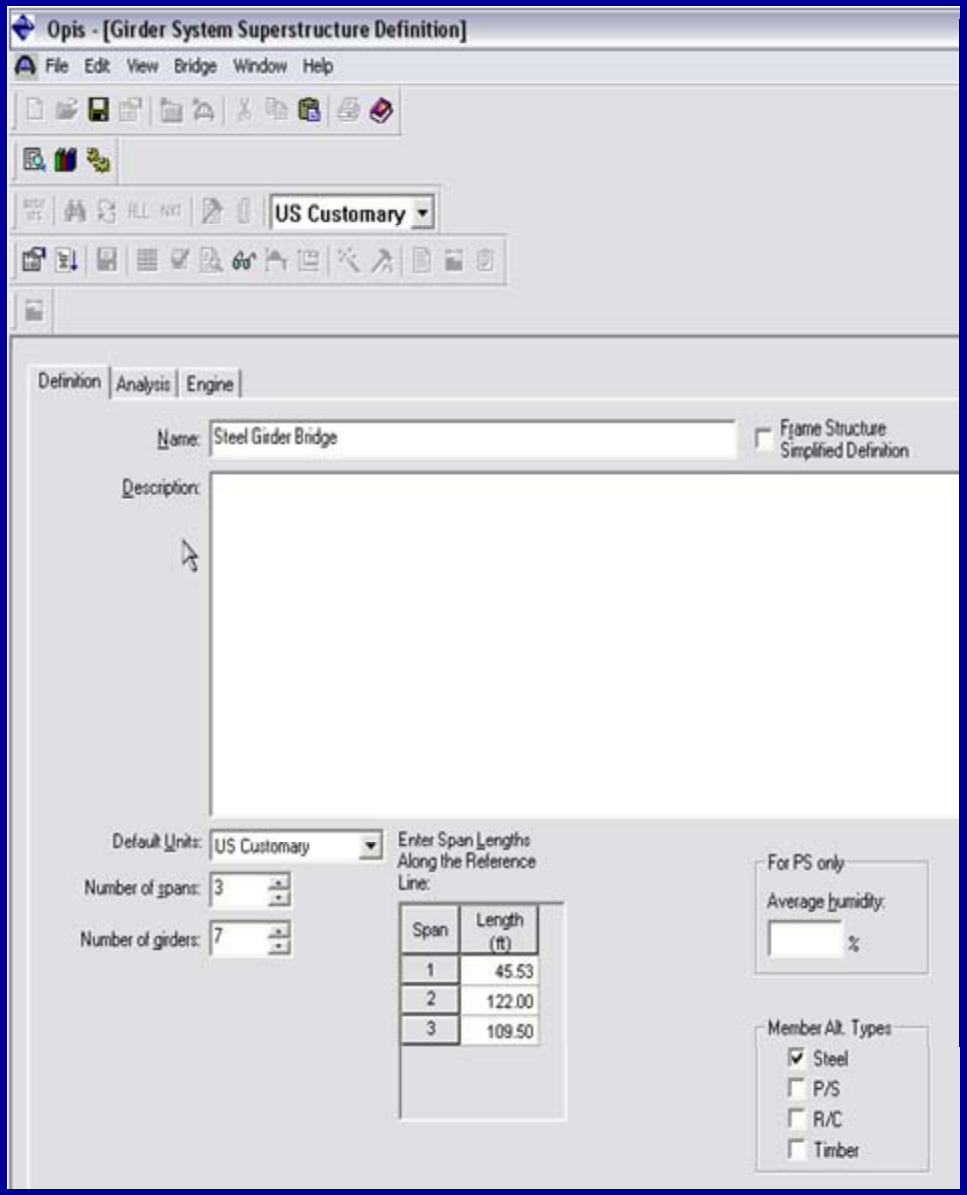
Define factors:
2007
AASHTO
LRFD
Specification



Define LRFD factors

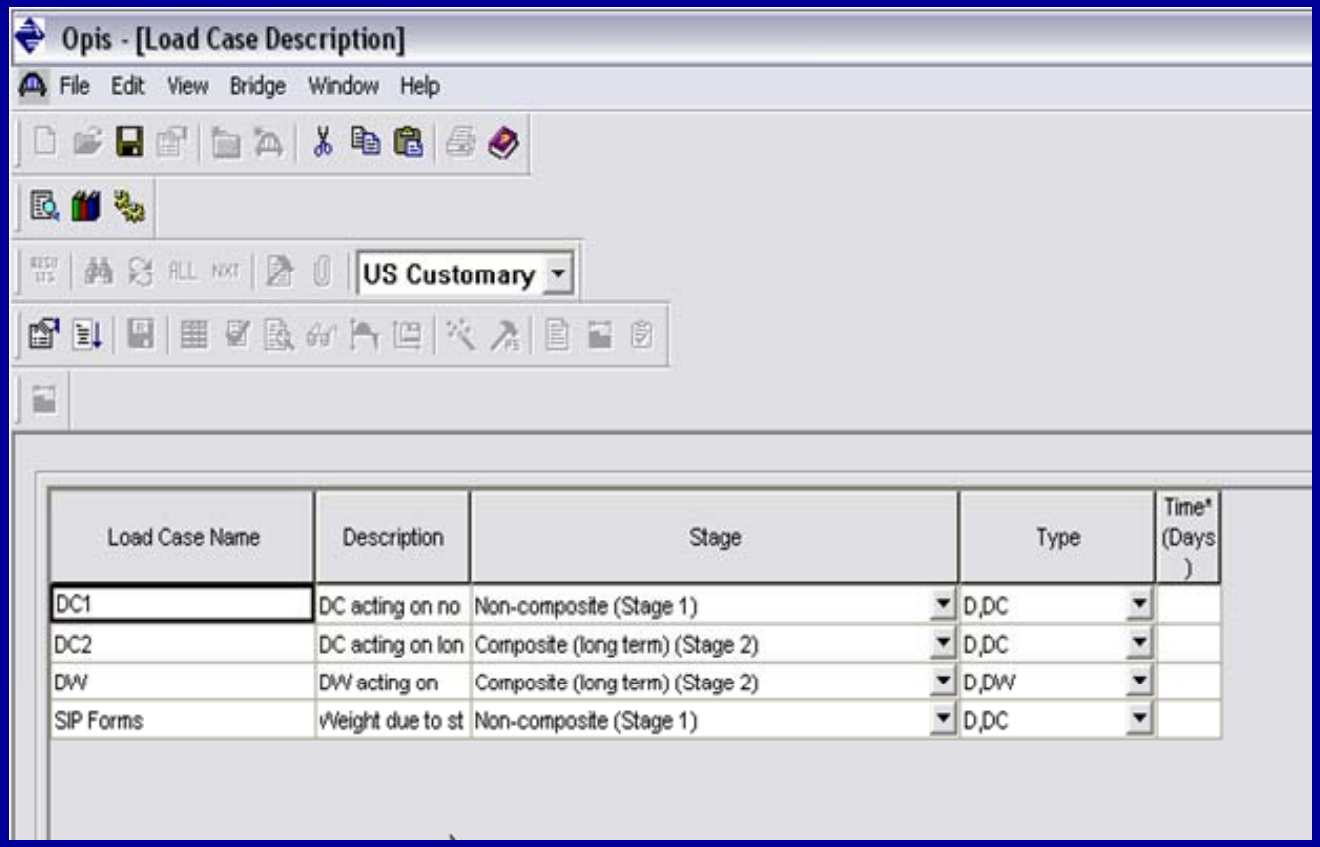
S06 Opis Steel design

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



S06 Opis Steel design

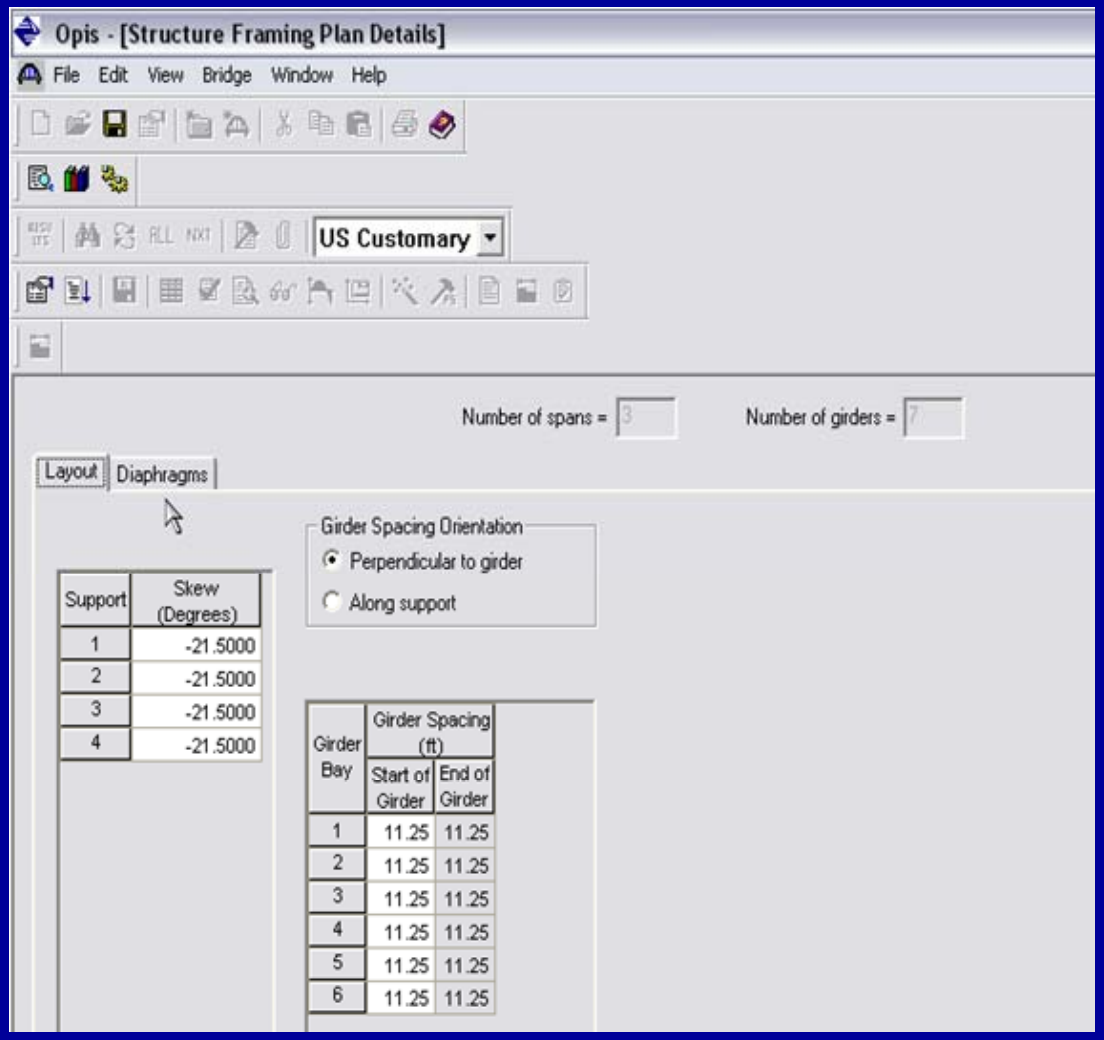
Load case description



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	

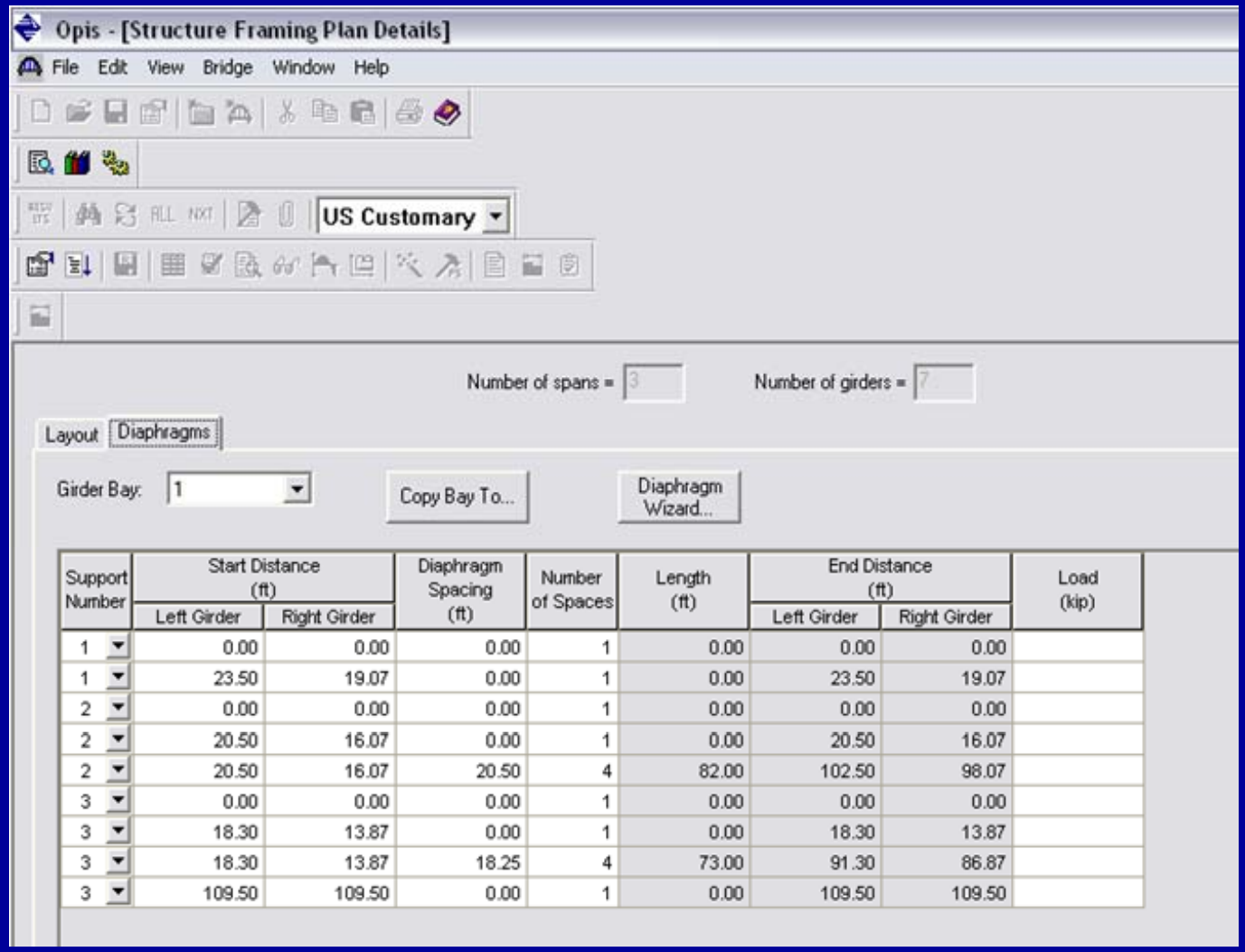
S06 Opis Steel design

Define girder spacing and skewed angle



S06 Opis Steel design

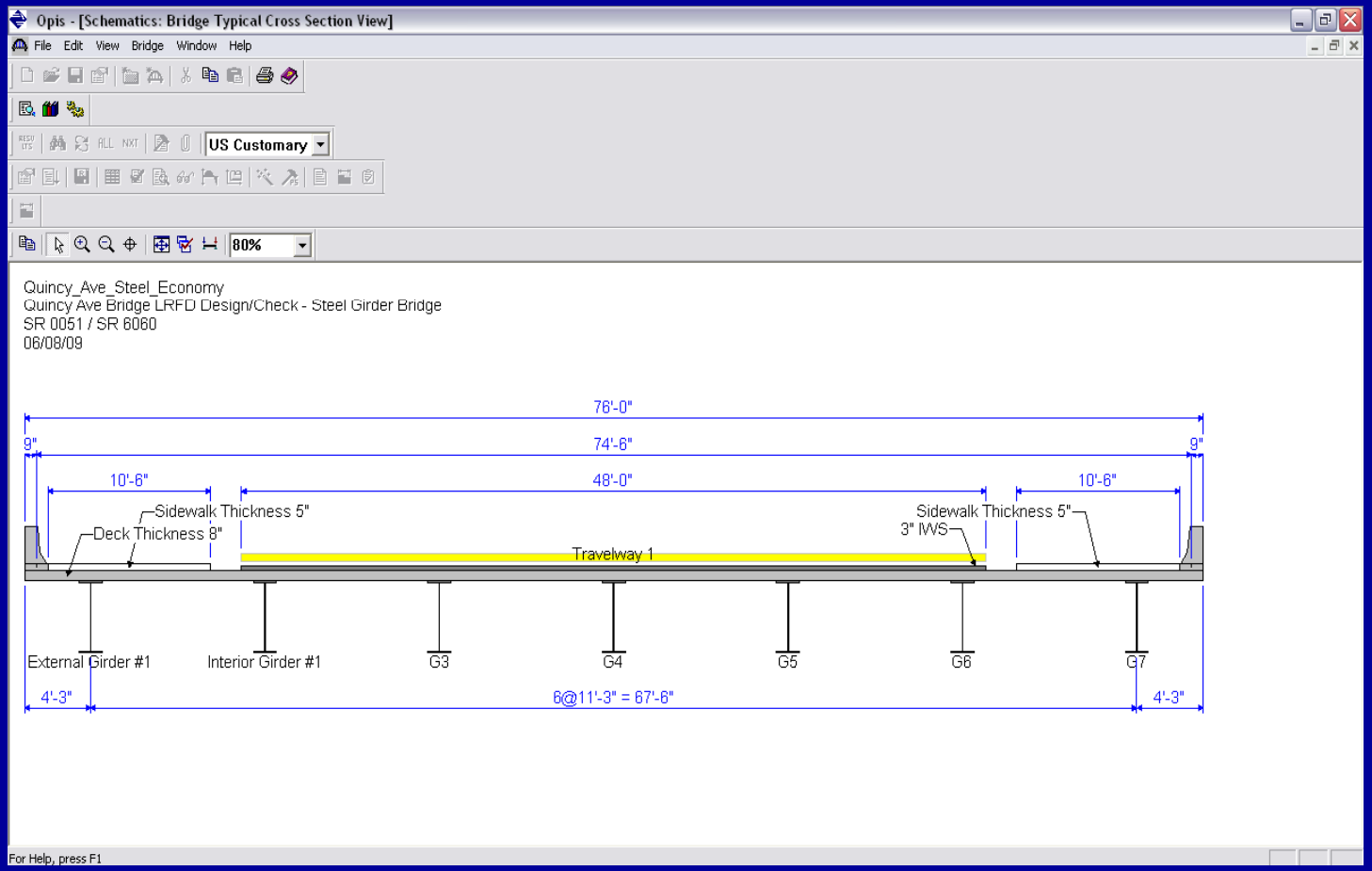
Define diaphragm spacing



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	

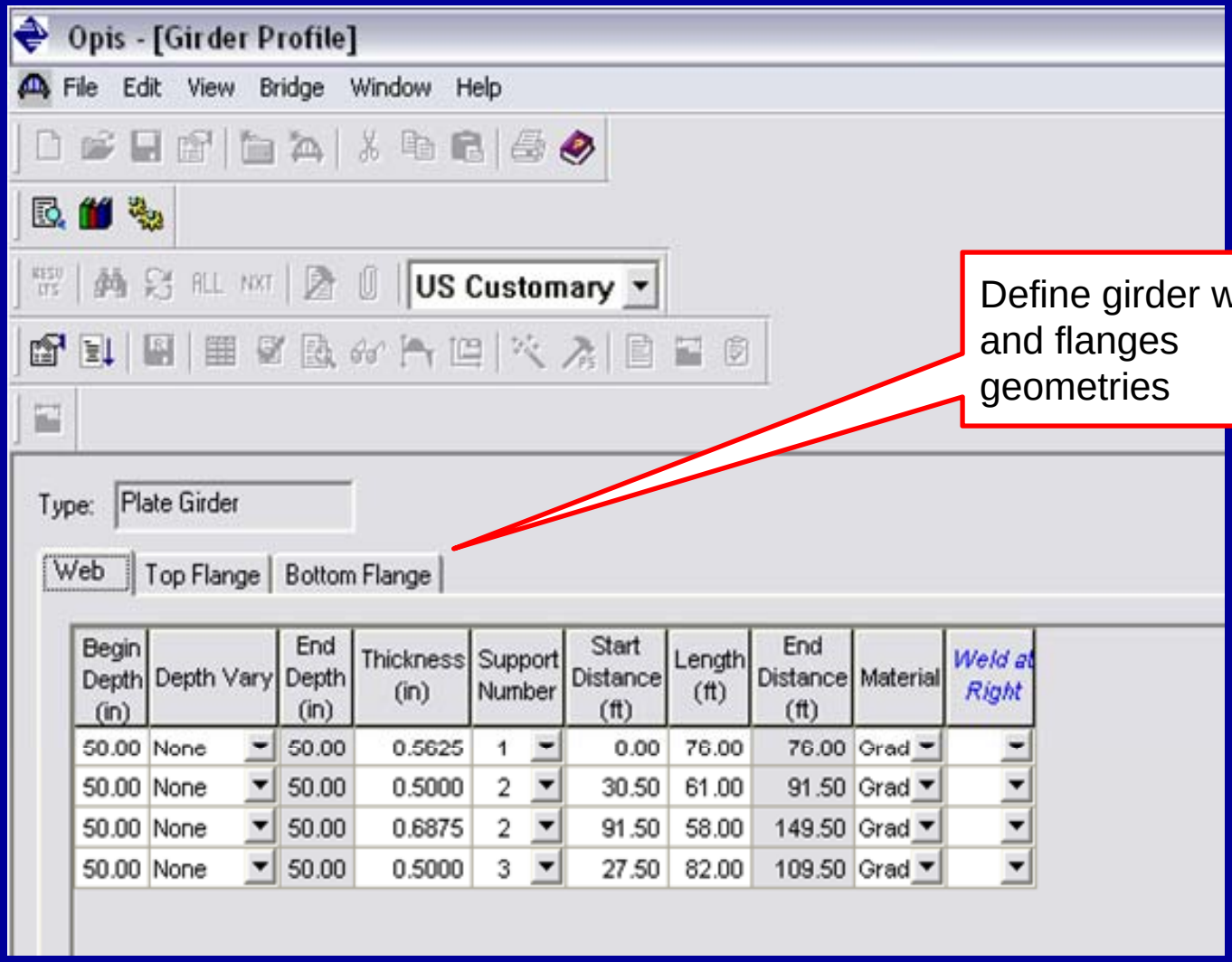
S06 Opis Steel design

Typical section view of super-structure



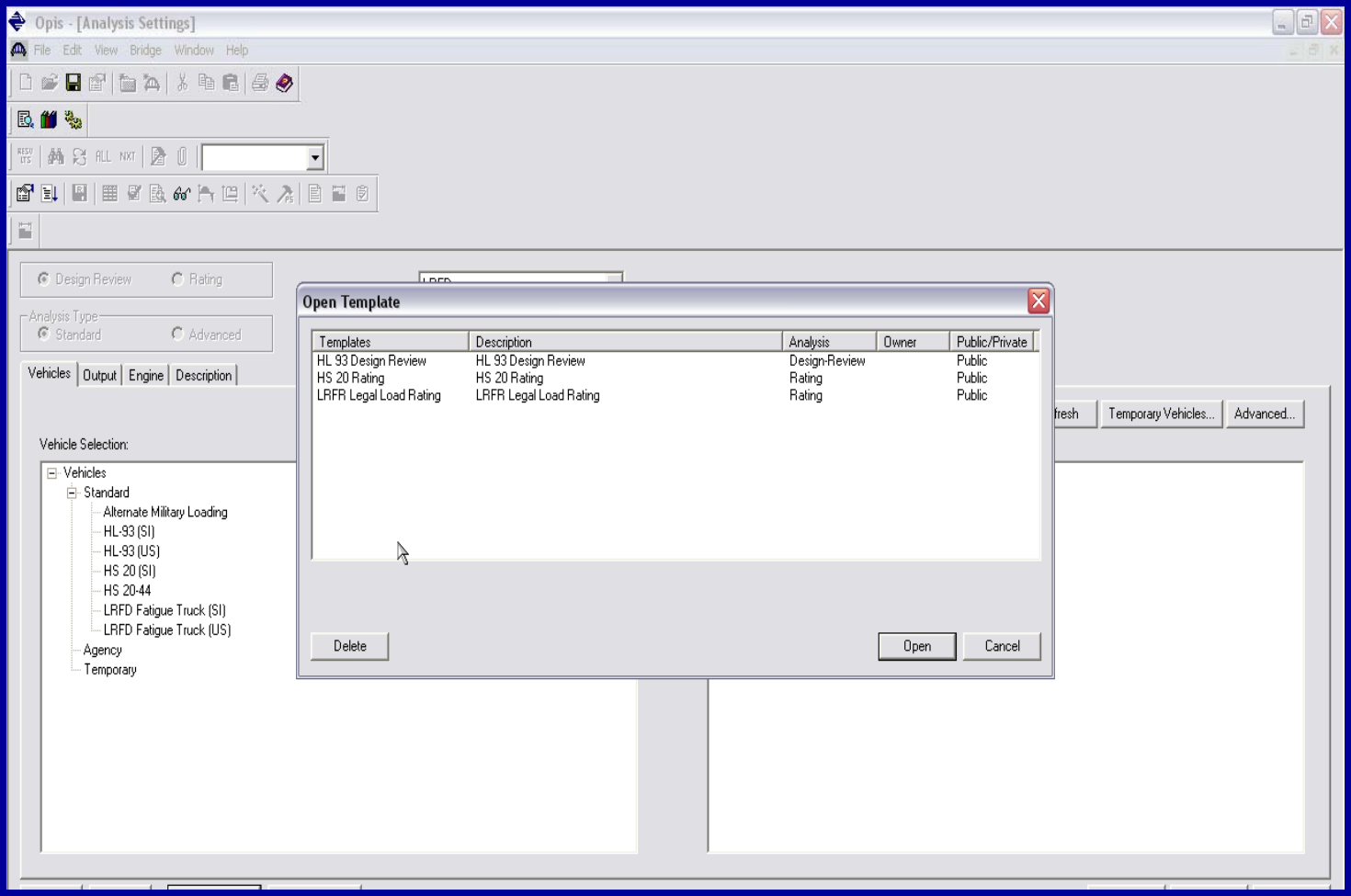
S06 Opis Steel design

Girder profile



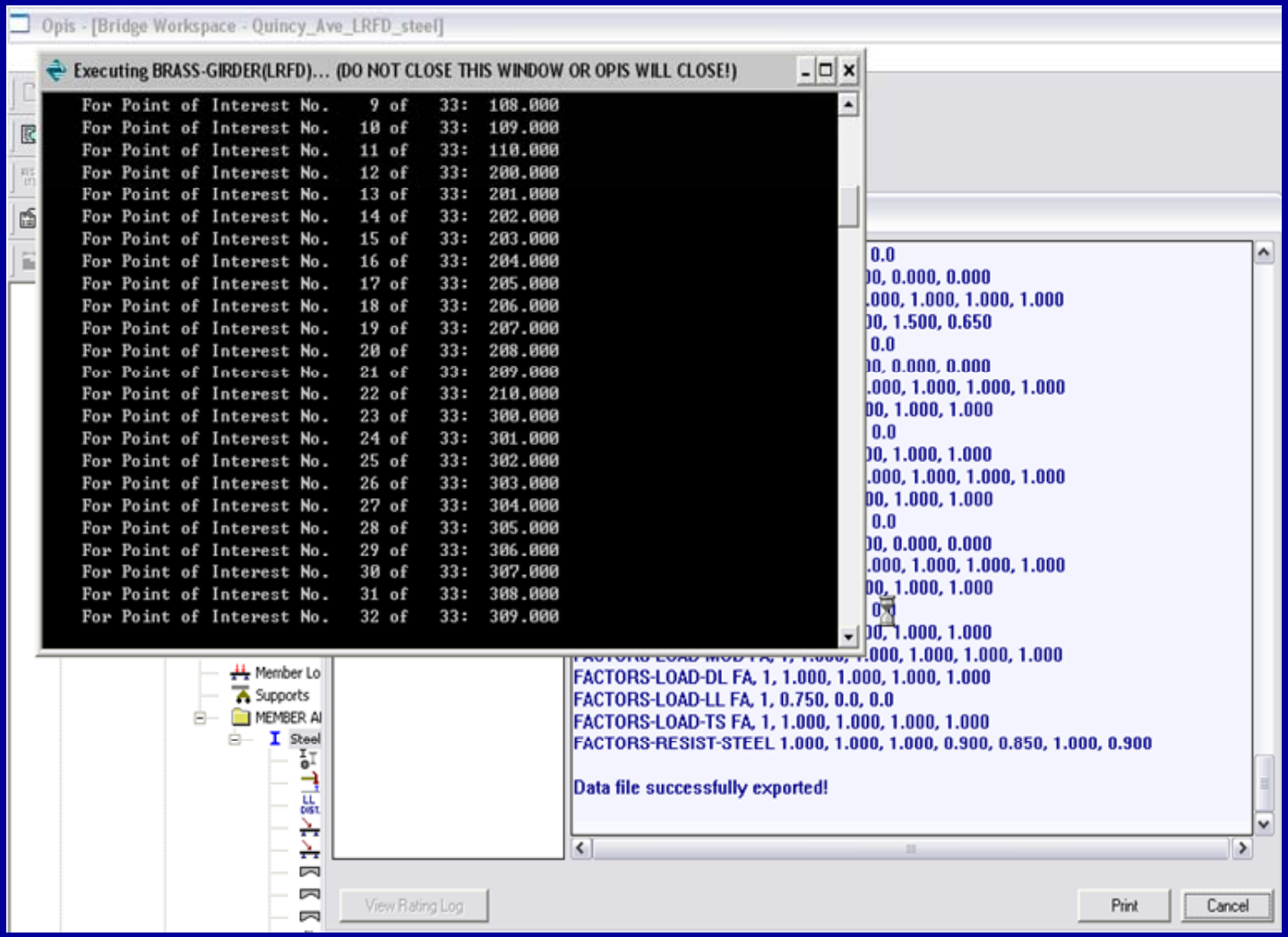
S06 Opis Steel design

Define analysis settings



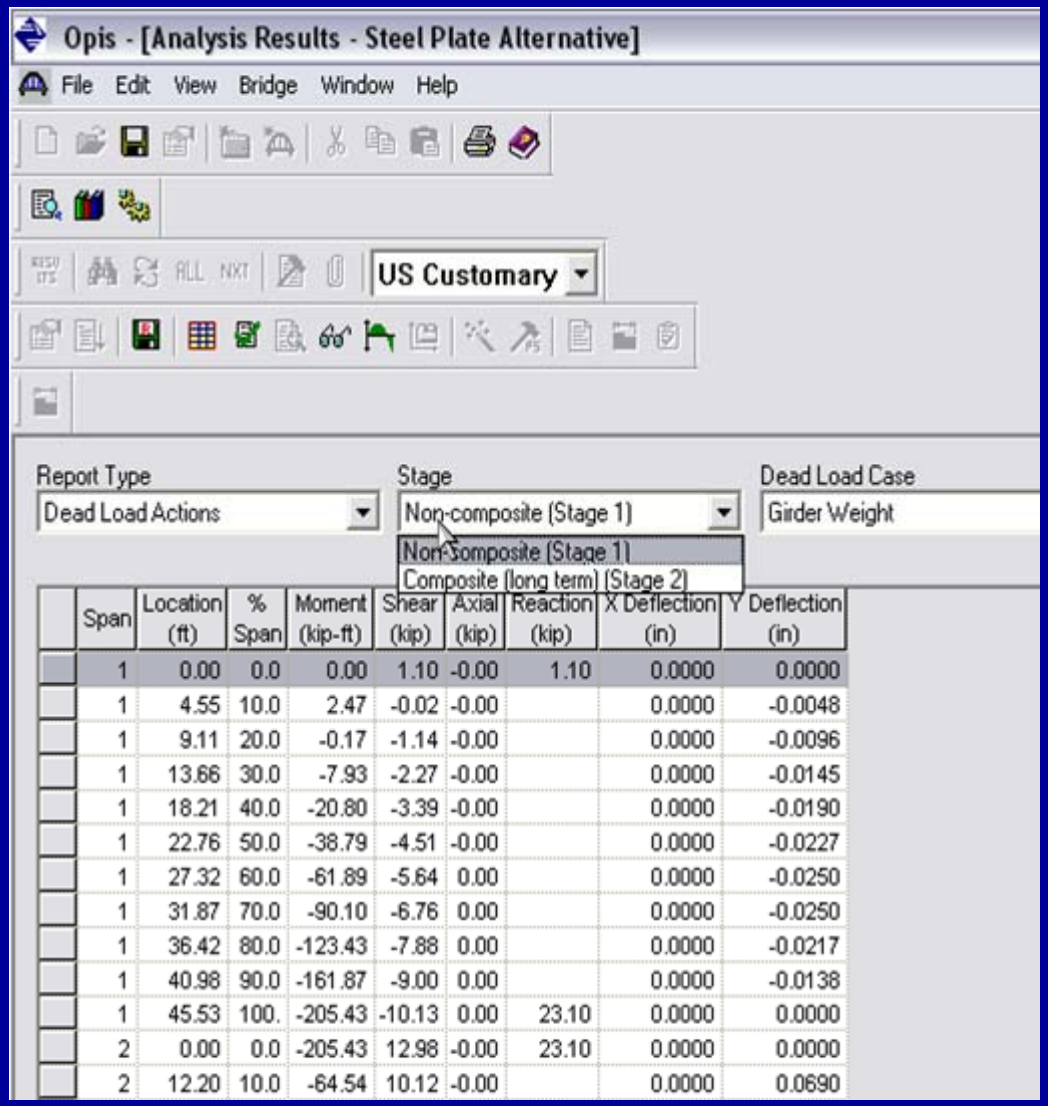
S06 Opis Steel design

Run analysis



S06 Opis Steel design

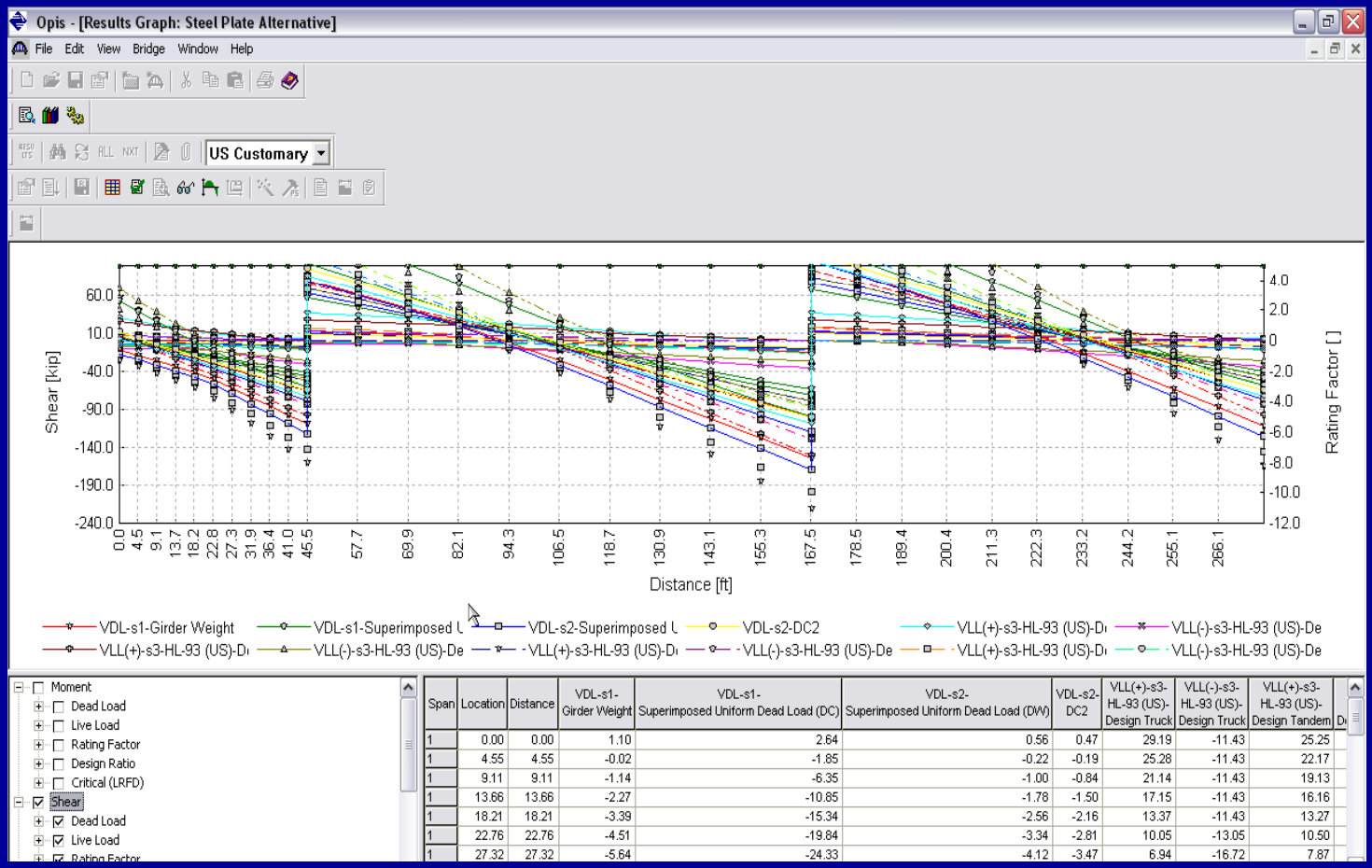
Analysis results: Moment, shear, axial force, etc.



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

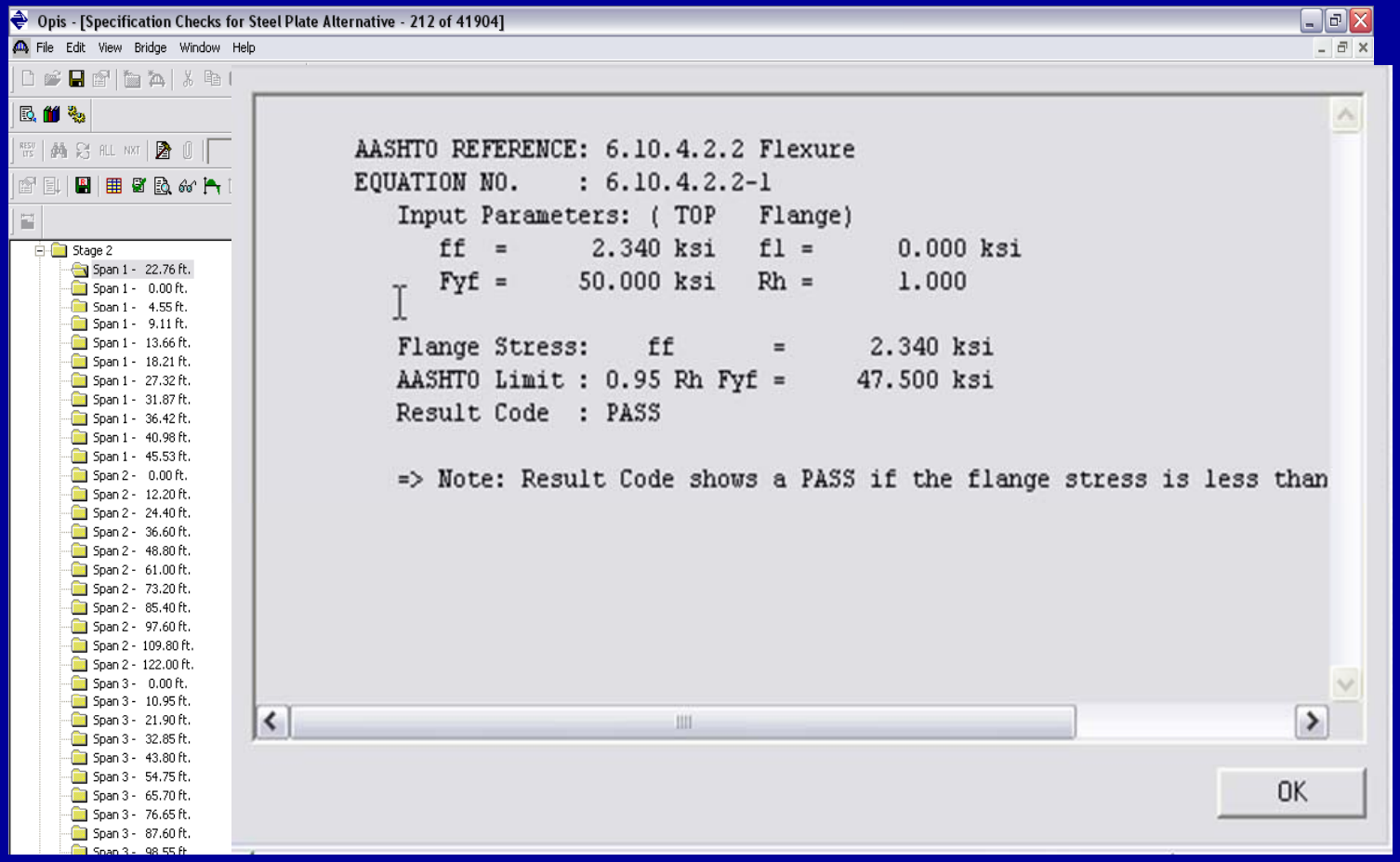
Shear diagrams and envelopes



Span	Location	Distance	VDL-s1-Girder Weight	VDL-s1-Superimposed Uniform Dead Load (DC)	VDL-s2-Superimposed Uniform Dead Load (DW)	VDL-s2-DC2	VLL(+)-s3-HL-93 (US)-Design Truck	VLL(-)-s3-HL-93 (US)-Design Truck	VLL(+)-s3-HL-93 (US)-Design Tandem
1	0.00	0.00	1.10	2.64	0.56	0.47	29.19	-11.43	25.25
1	4.55	4.55	-0.02	-1.85	-0.22	-0.19	25.28	-11.43	22.17
1	9.11	9.11	-1.14	-6.35	-1.00	-0.84	21.14	-11.43	19.13
1	13.66	13.66	-2.27	-10.85	-1.78	-1.50	17.15	-11.43	16.16
1	18.21	18.21	-3.39	-15.34	-2.56	-2.16	13.37	-11.43	13.27
1	22.76	22.76	-4.51	-19.84	-3.34	-2.81	10.05	-13.05	10.50
1	27.32	27.32	-5.64	-24.33	-4.12	-3.47	6.94	-16.72	7.87

S06 Opis Steel design

Specifi-cation checks: Service limit state: Flexural

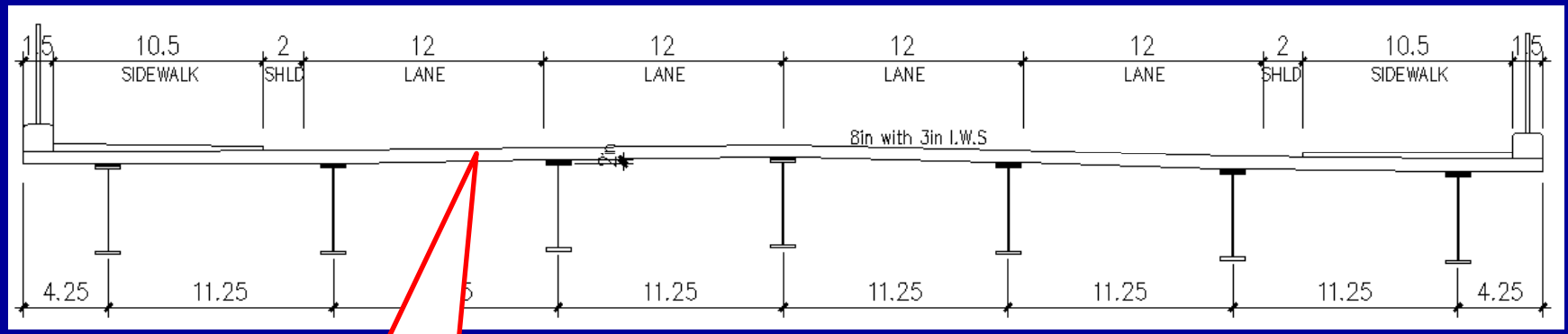


Steel Alternate Design

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

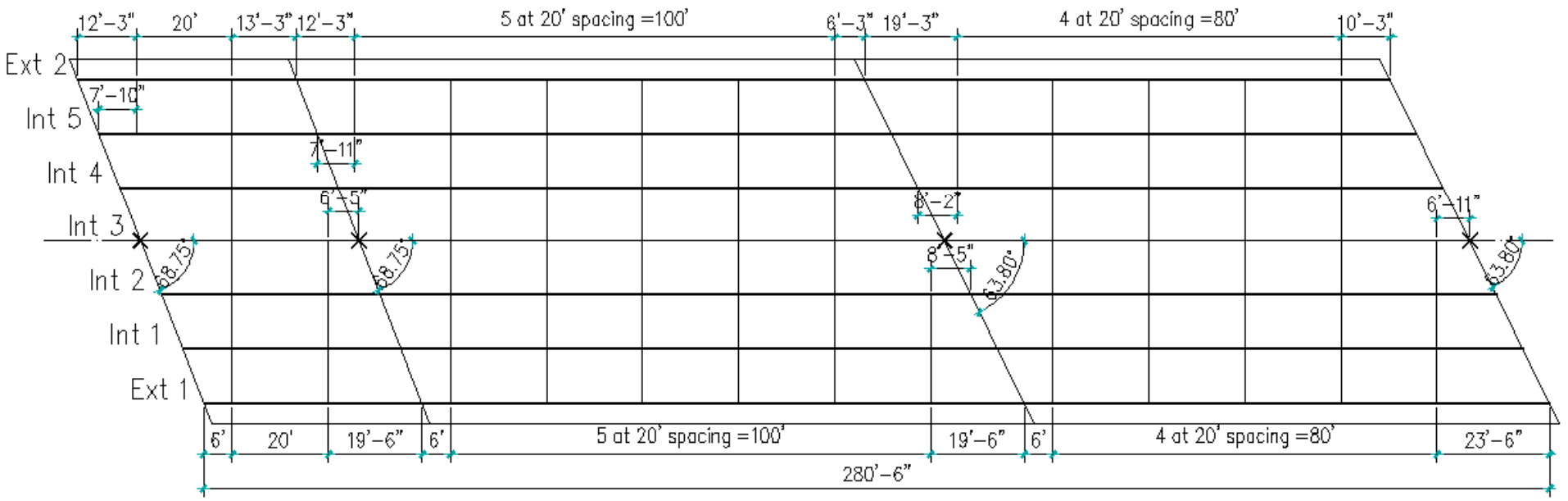


2% side slope

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.

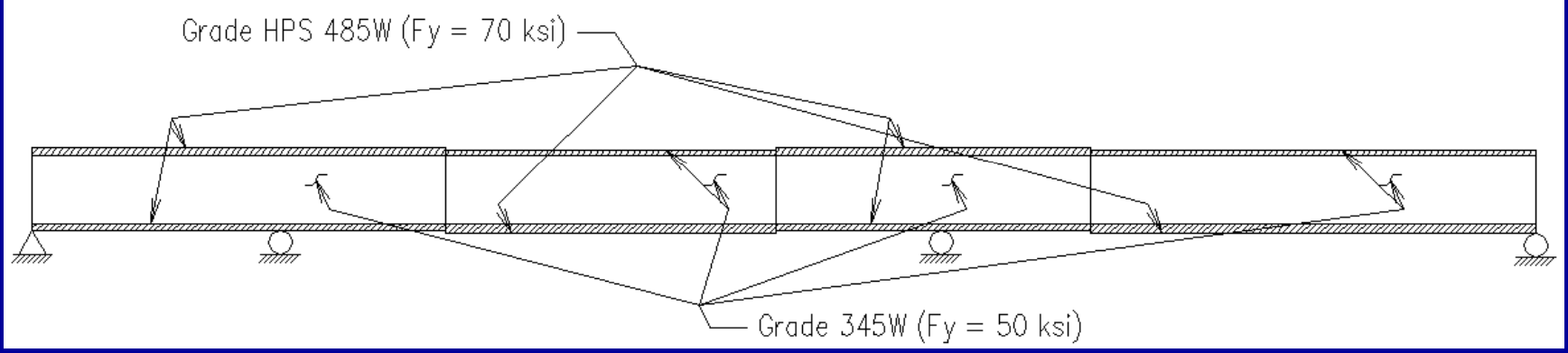


Hybrid Configuration

Material properties

This design incorporates the following structural steels:

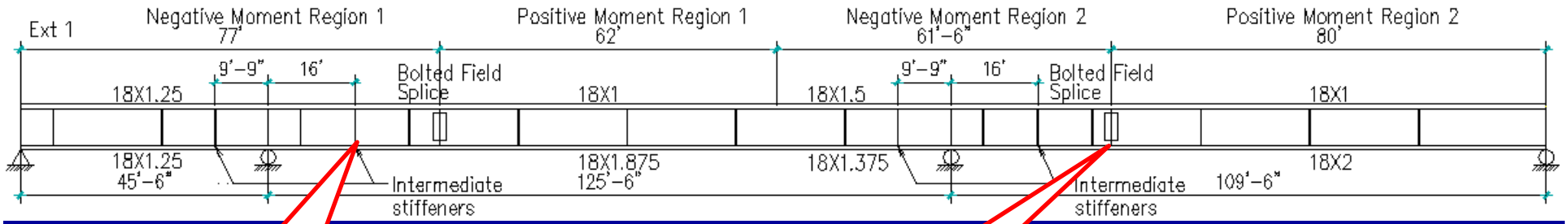
- Grade 50W: Top flange in the positive moment region and the entire web.
- Grade 70W HPS: Both flanges in the negative moment region and the bottom flange in the positive moment region.



Girder Elevation and Section Description

Exterior Girder No. 1

Elevation View:



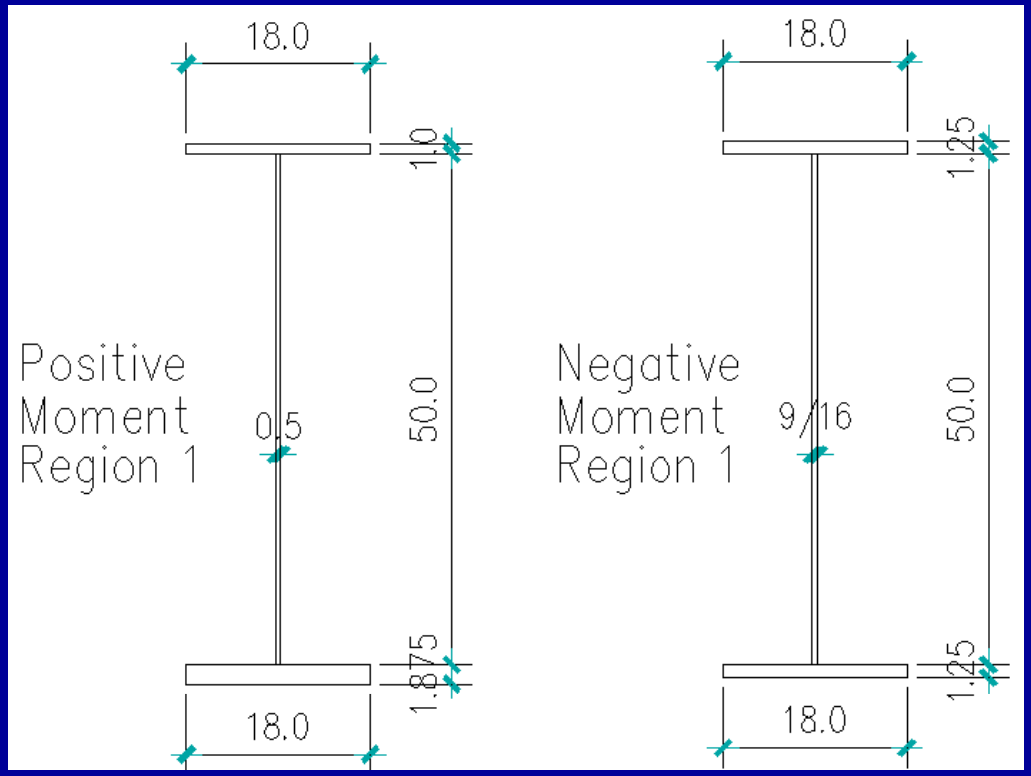
Intermediate Stiffeners

Field splices

Girder Elevation and Section Description

Exterior Girder No. 1

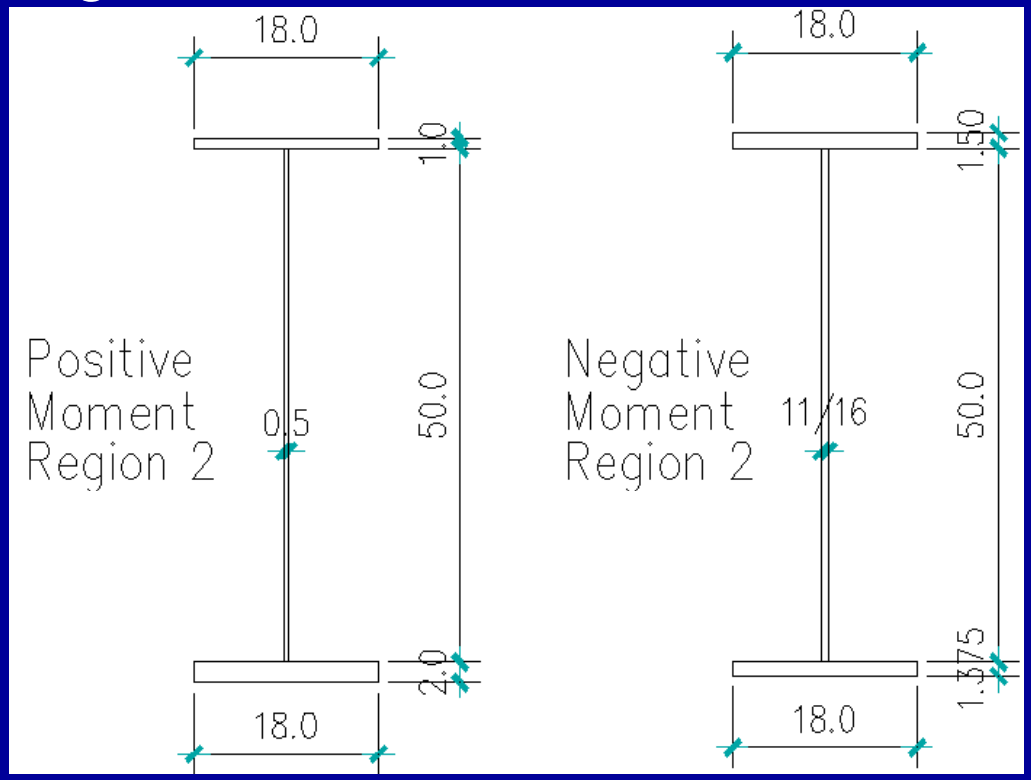
Section View: Positive Moment Region 1 and Negative Moment Region 1



Girder Elevation and Section Description

Exterior Girder No. 1

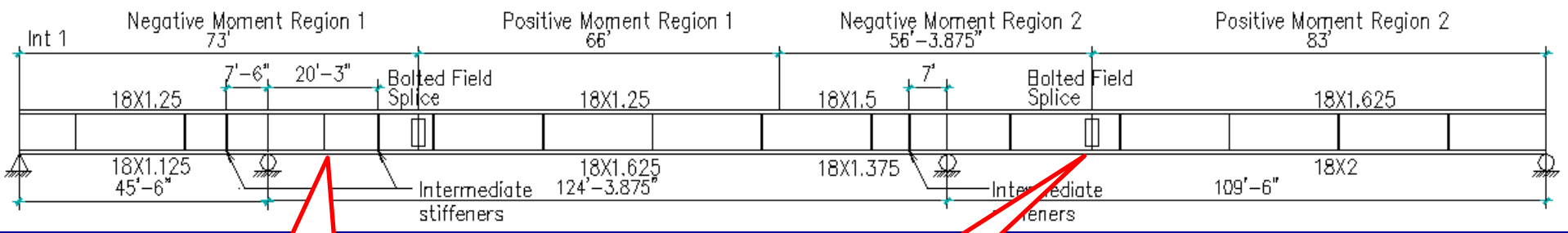
Section View: Positive Moment Region 2 and Negative Moment Region 2



Girder Elevation and Section Description

Interior Girder No. 1

Elevation View:



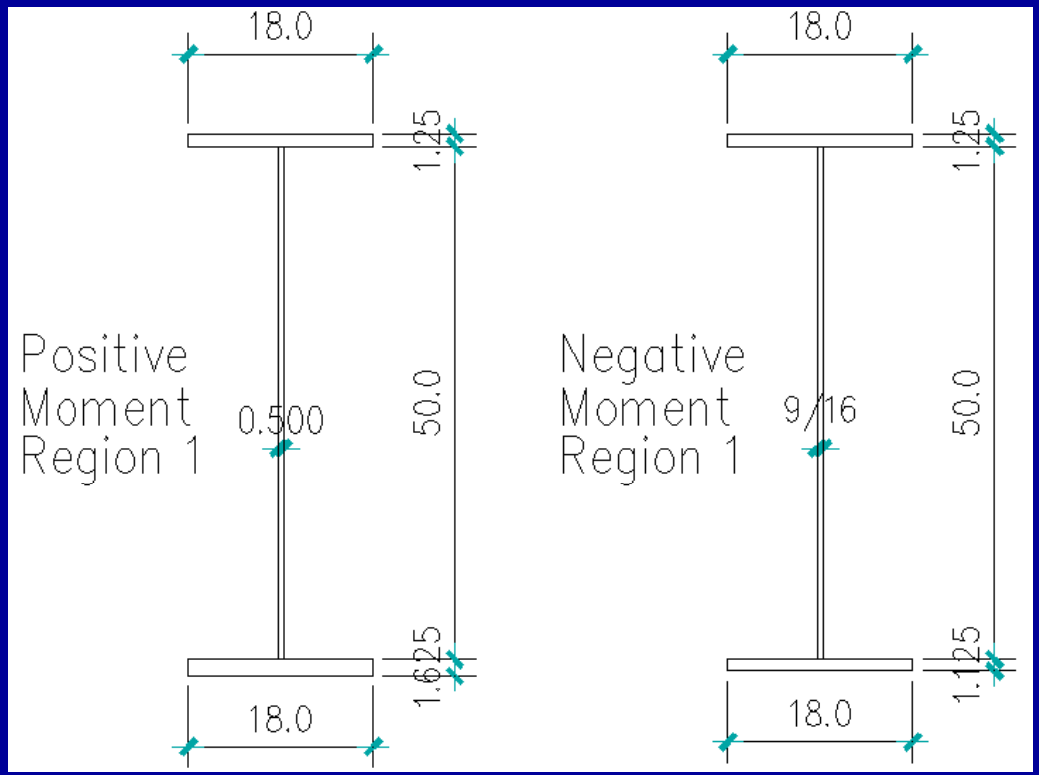
Intermediate Stiffeners

Field splices

Girder Elevation and Section Description

Interior Girder No. 1

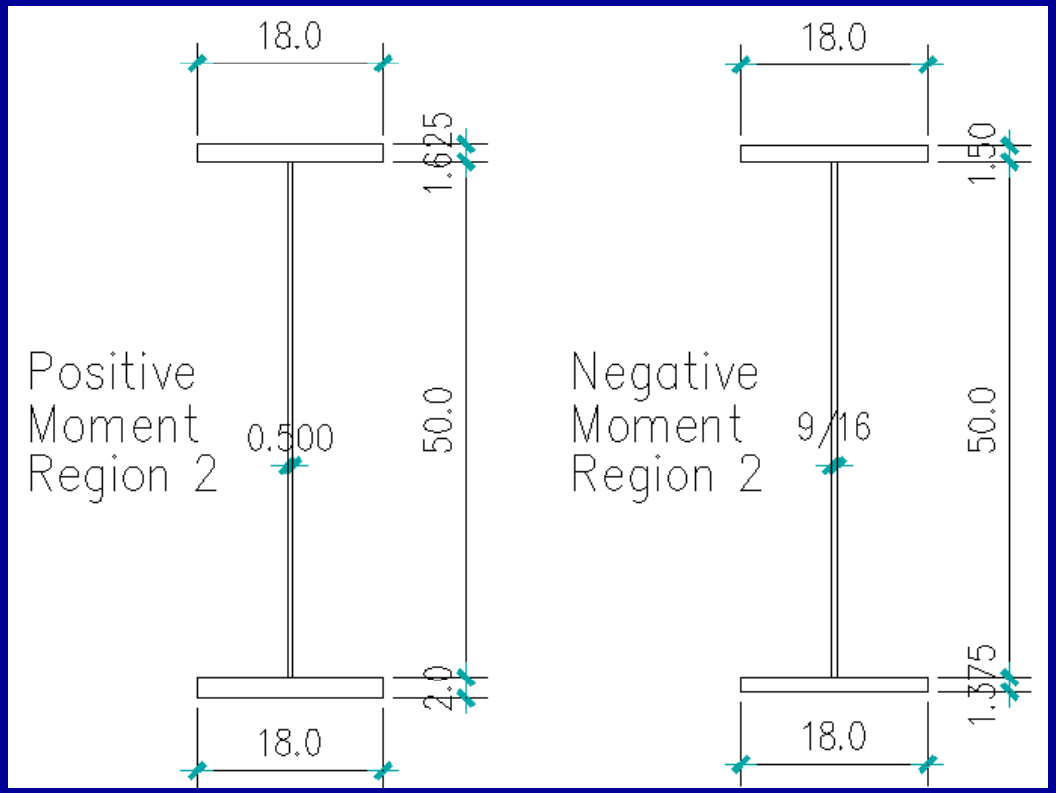
Section View: Positive Moment Region 1 and Negative Moment Region 1



Girder Elevation and Section Description

Interior Girder No. 1

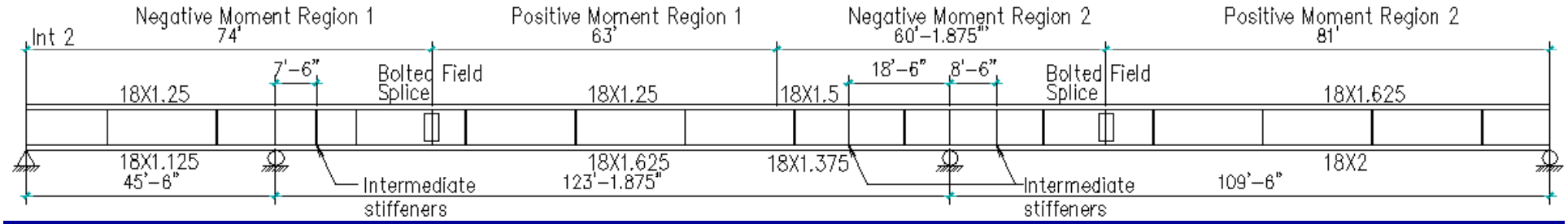
Section View: Positive Moment Region 2 and Negative Moment Region 2



Girder Elevation and Section Description

Interior Girder No. 2

Elevation View:

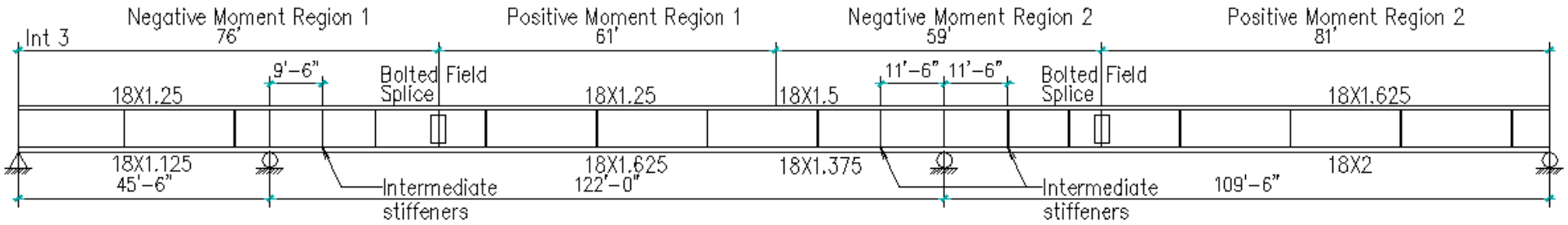


Section View: The same as interior girder No.1

Girder Elevation and Section Description

Interior Girder No. 3

Elevation View:

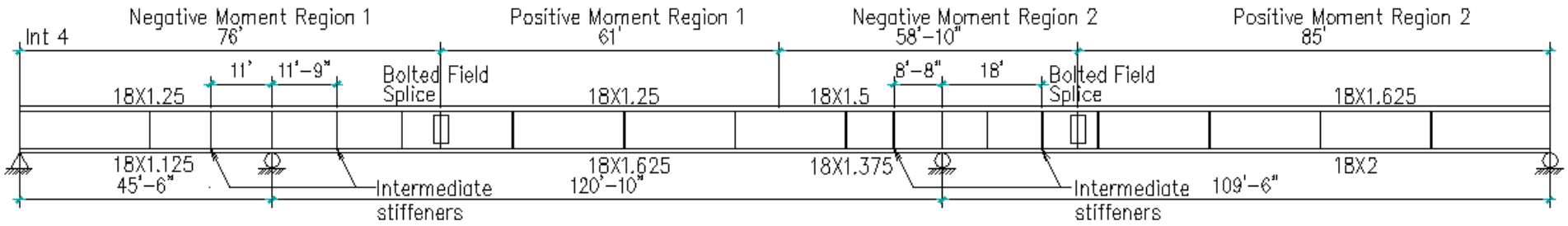


Section View: The same as interior girder No.1

Girder Elevation and Section Description

Interior Girder No. 4

Elevation View:

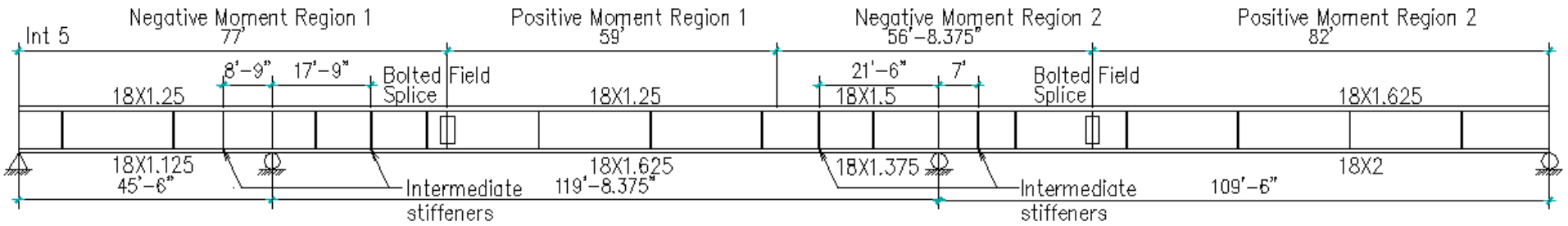


Section View: The same as interior girder No.1

Girder Elevation and Section Description

Interior Girder No. 5

Elevation View:

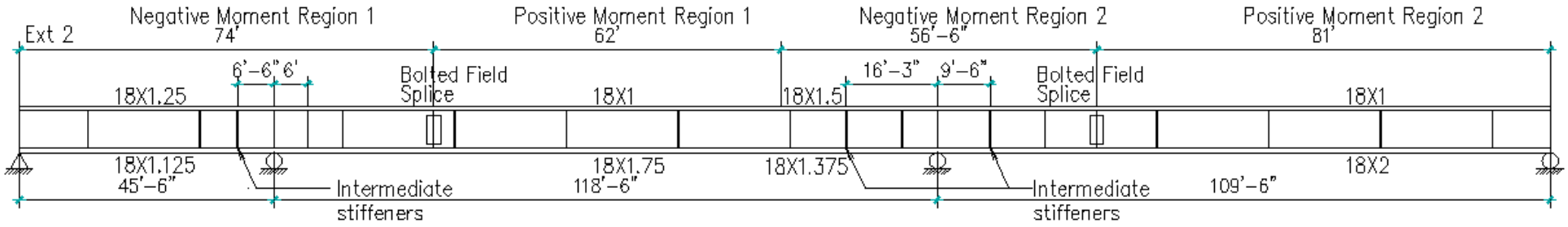


Section View: The same as interior girder No.1

Girder Elevation and Section Description

Exterior Girder No. 2

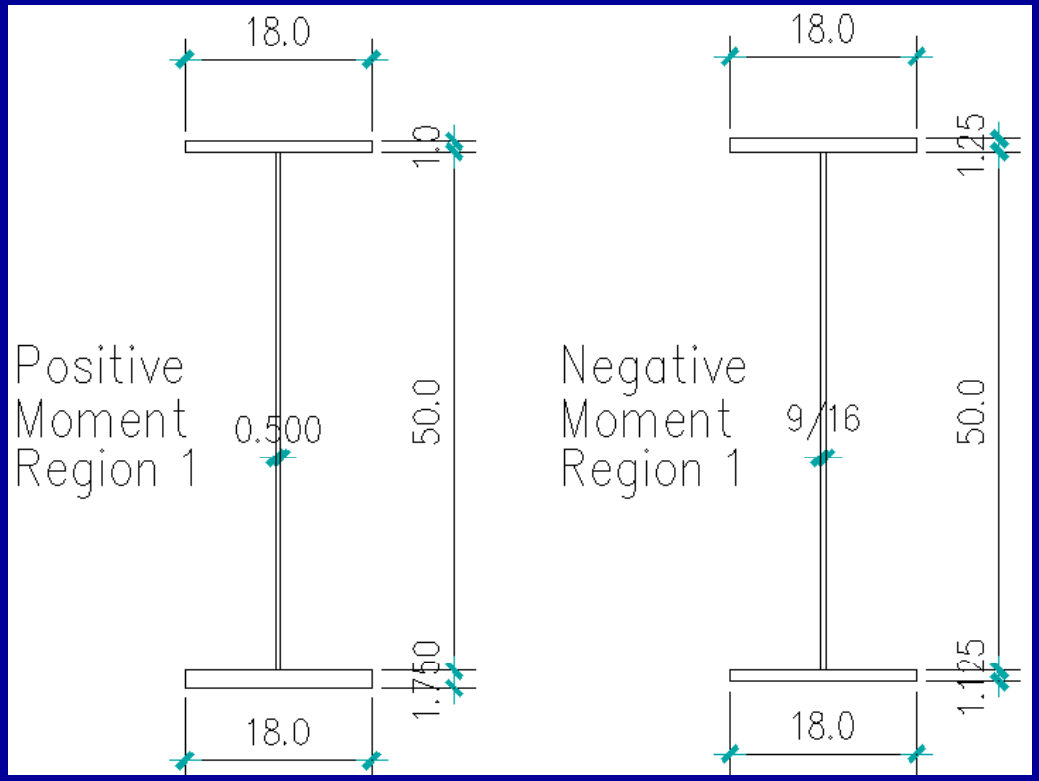
Elevation View:



Girder Elevation and Section Description

Exterior Girder No. 2

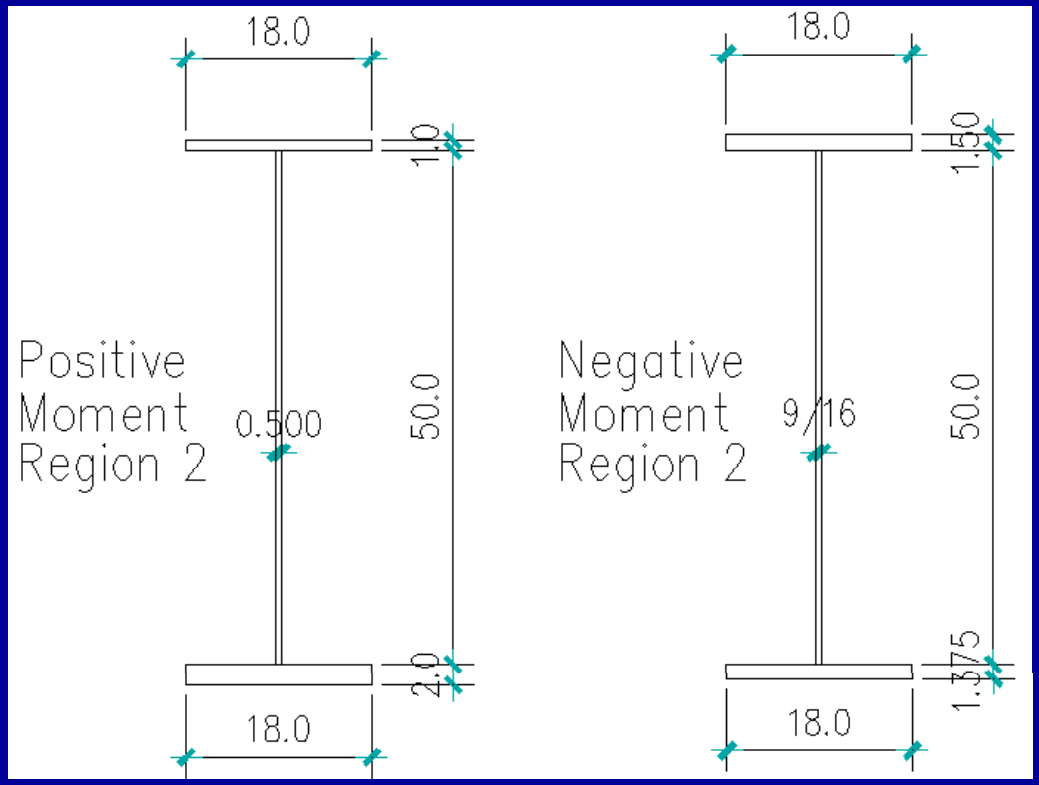
Section View: Positive Moment Region 1 and Negative Moment Region 1



Girder Elevation and Section Description

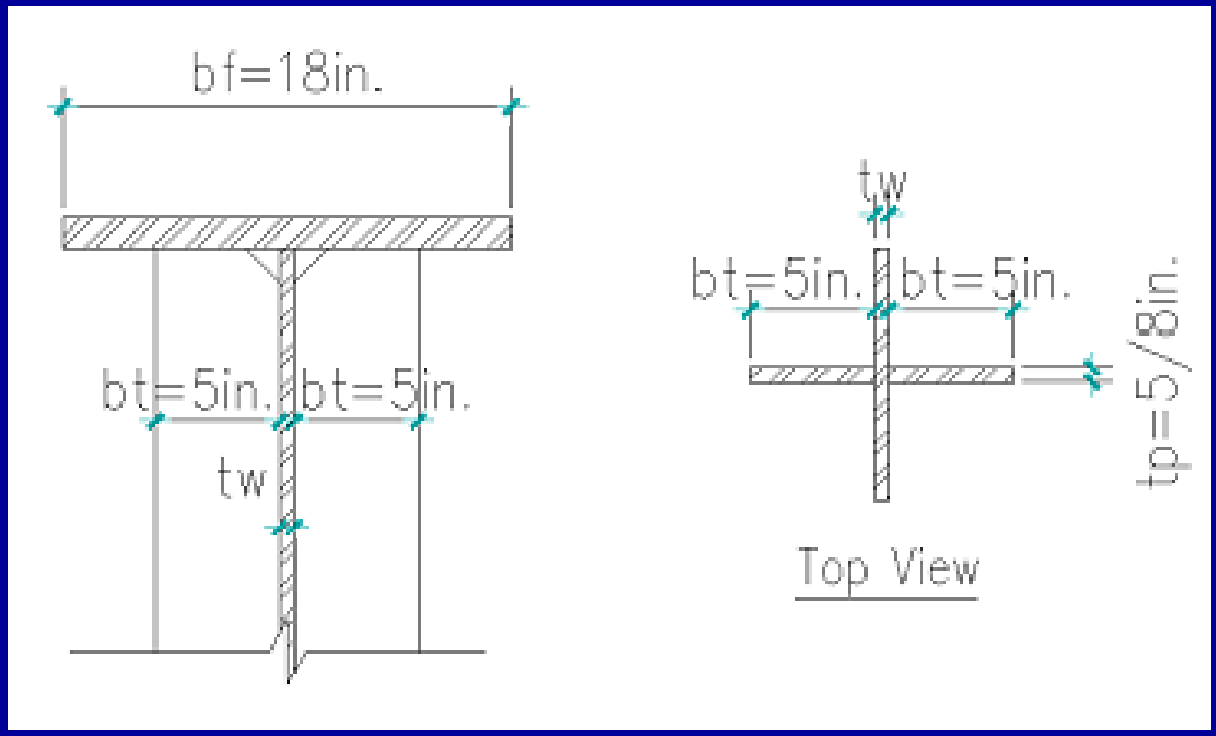
Exterior Girder No.2

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

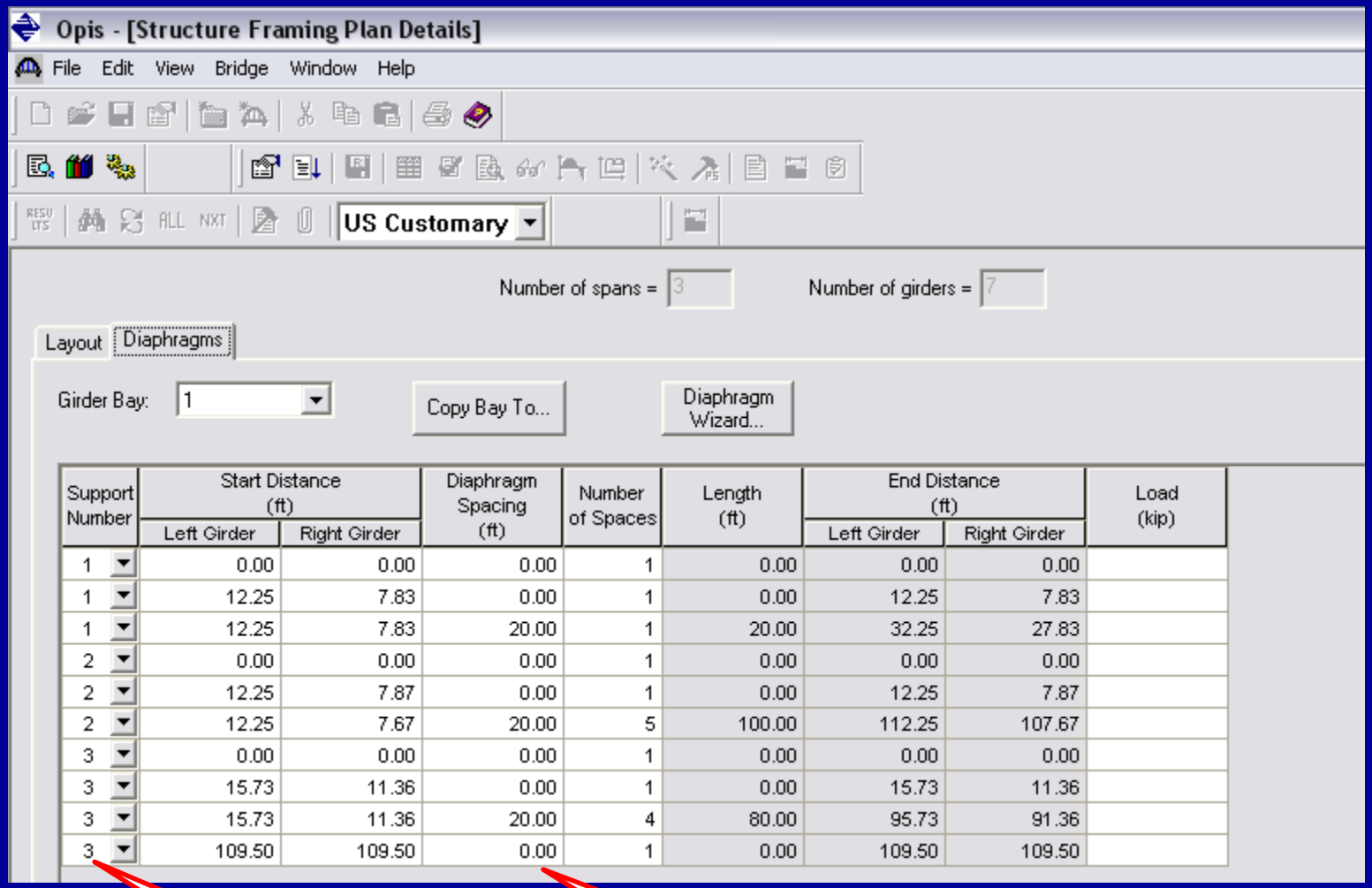


Stiffener Description

Section View of Intermediate Stiffener



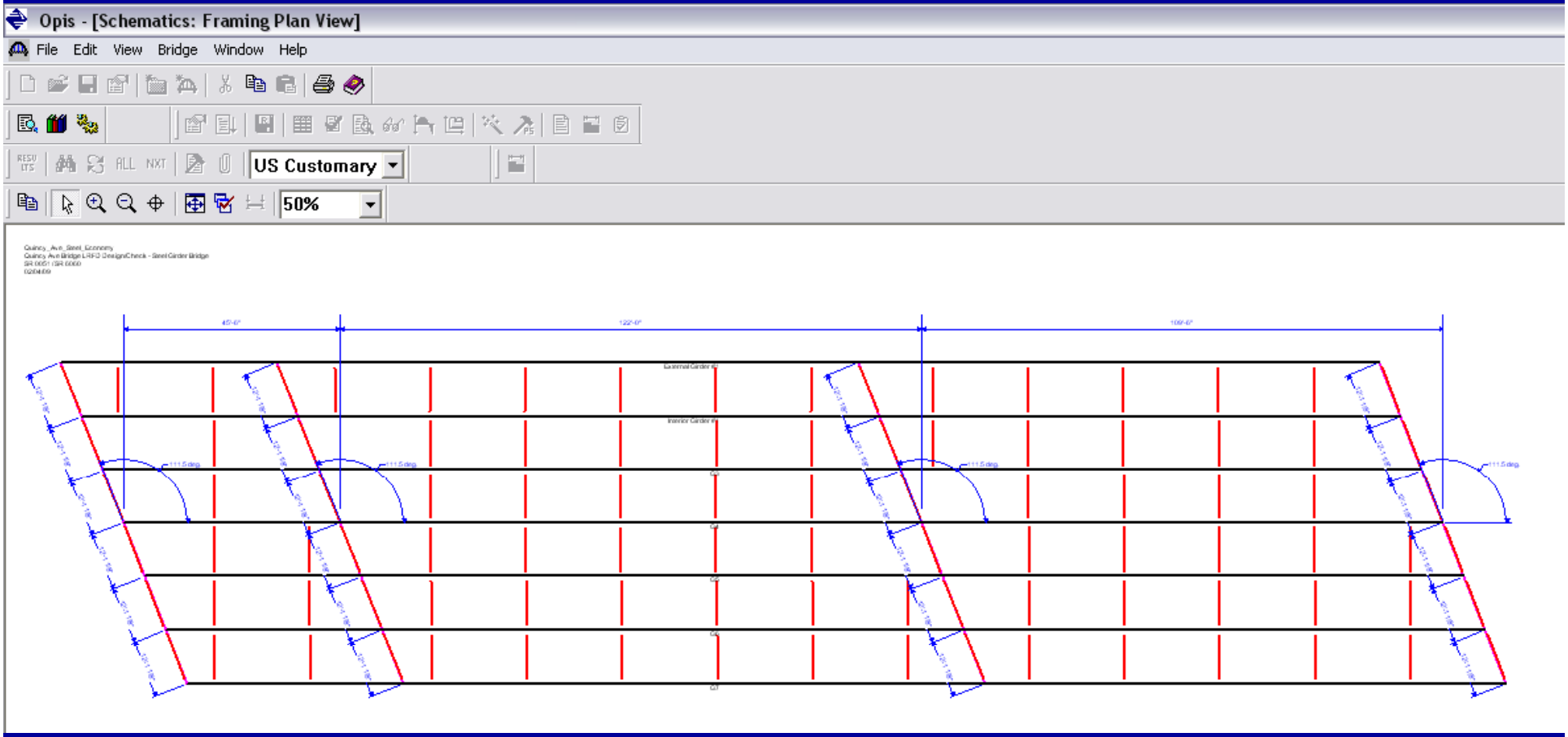
Structure Framing Plan Details in Opis



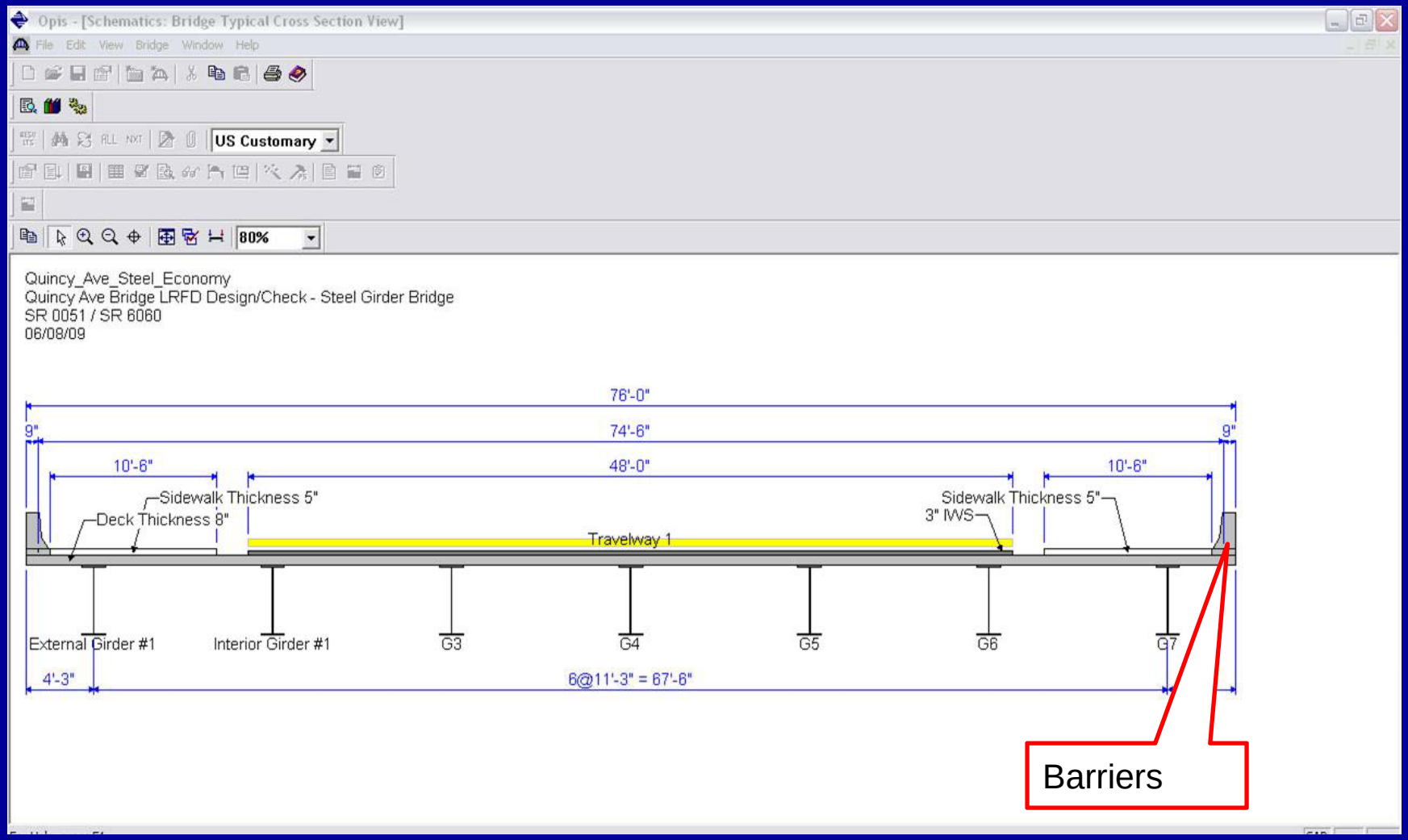
Support No.

Diaphragm position and spacing…

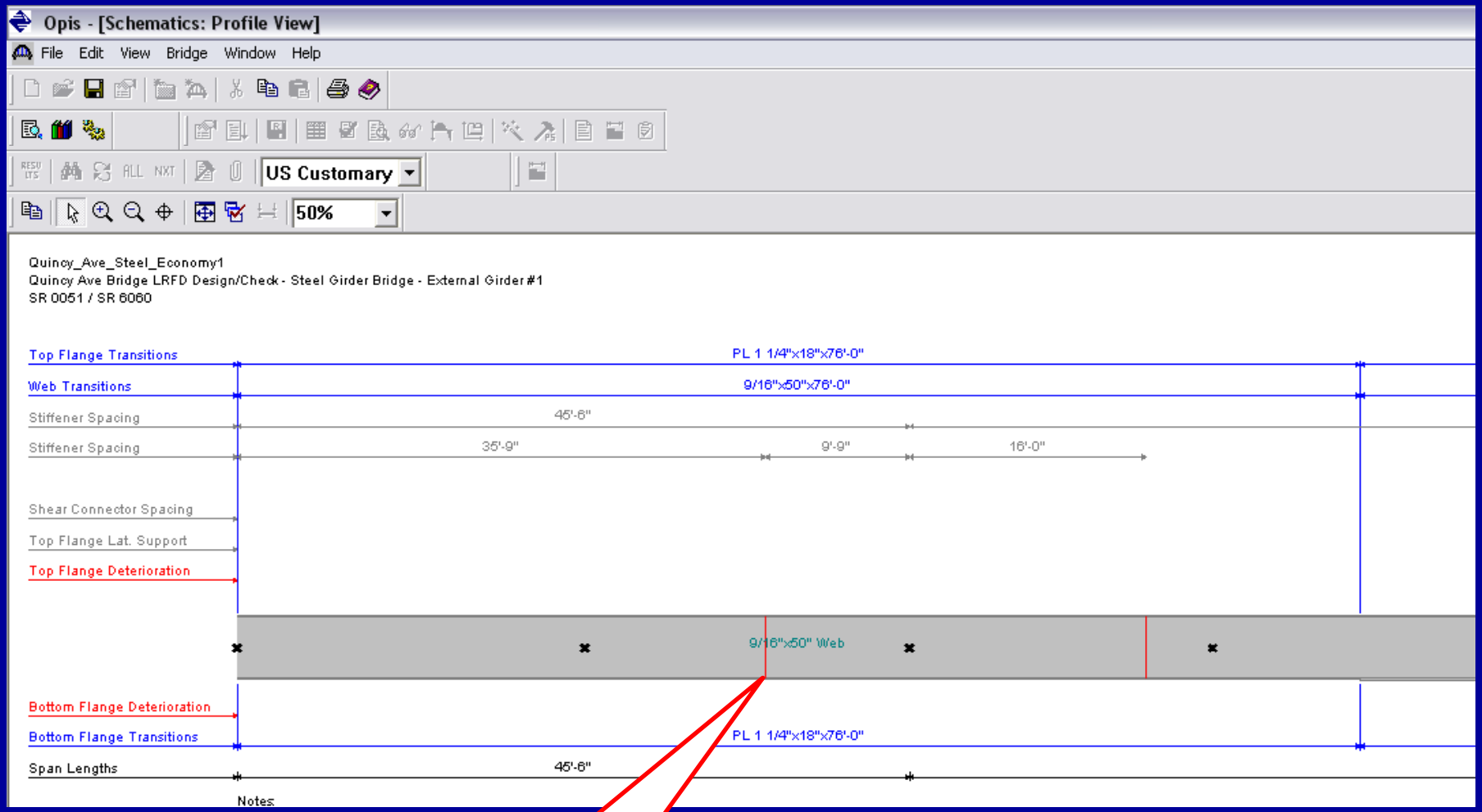
Framing Plan View in Opis



Deck Cross Section View in Opis

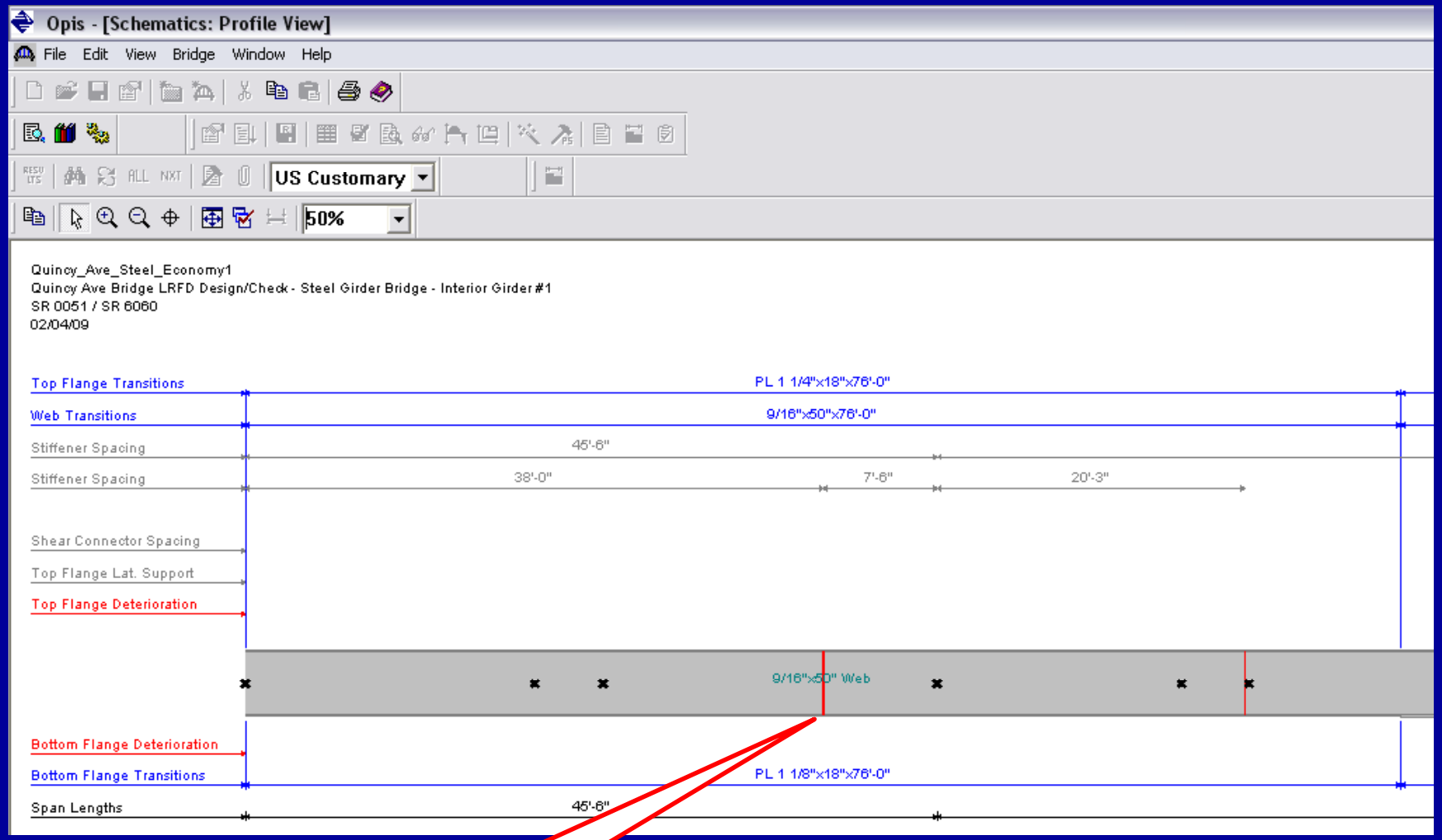


Exterior Girder Section View in Opis



Intermediate Stiffener

Interior Girder Section View in Opis

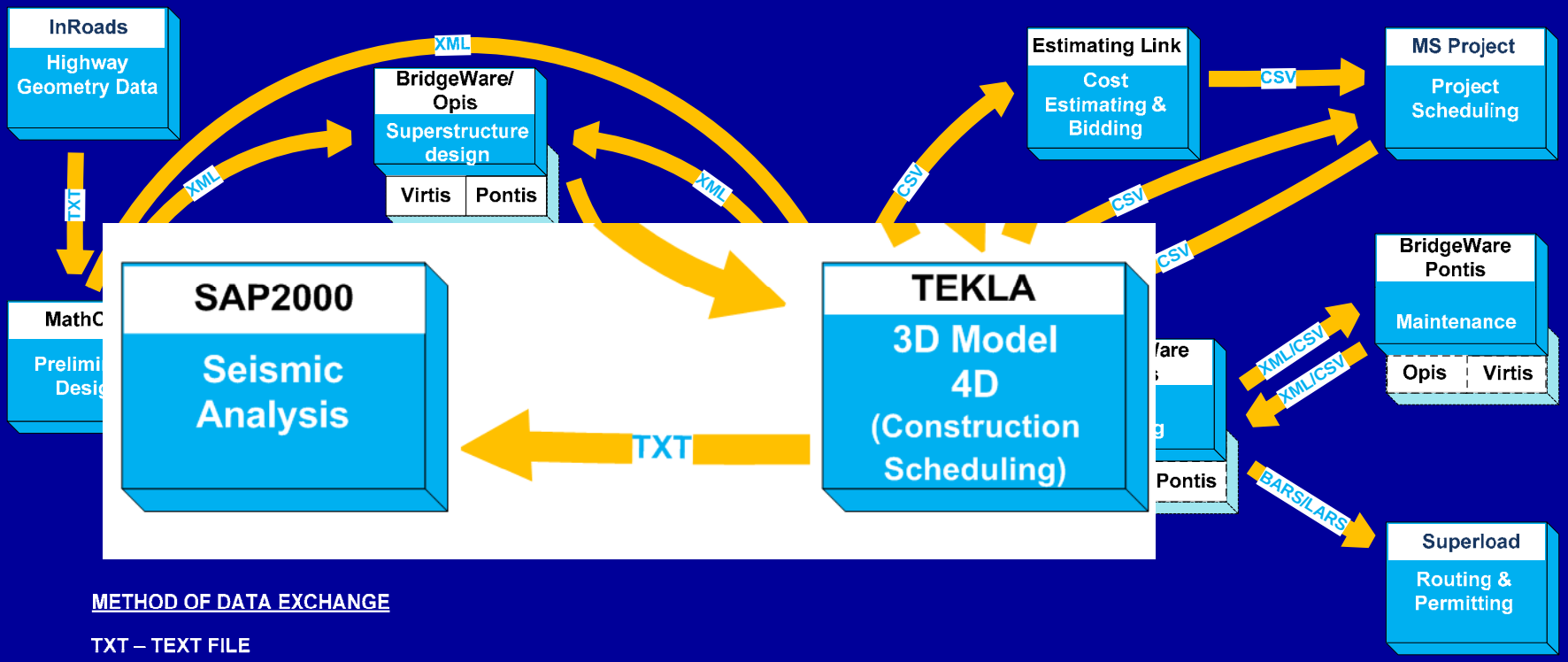


Intermediate Stiffener

XML to SAP2000

S07 XML to SAP2000

Steel Alternate



METHOD OF DATA EXCHANGE

TXT – TEXT FILE

XML – EXTENSIBLE MARKUP LANGUAGE

VBA – VISUAL BASIC FOR APPLICATIONS

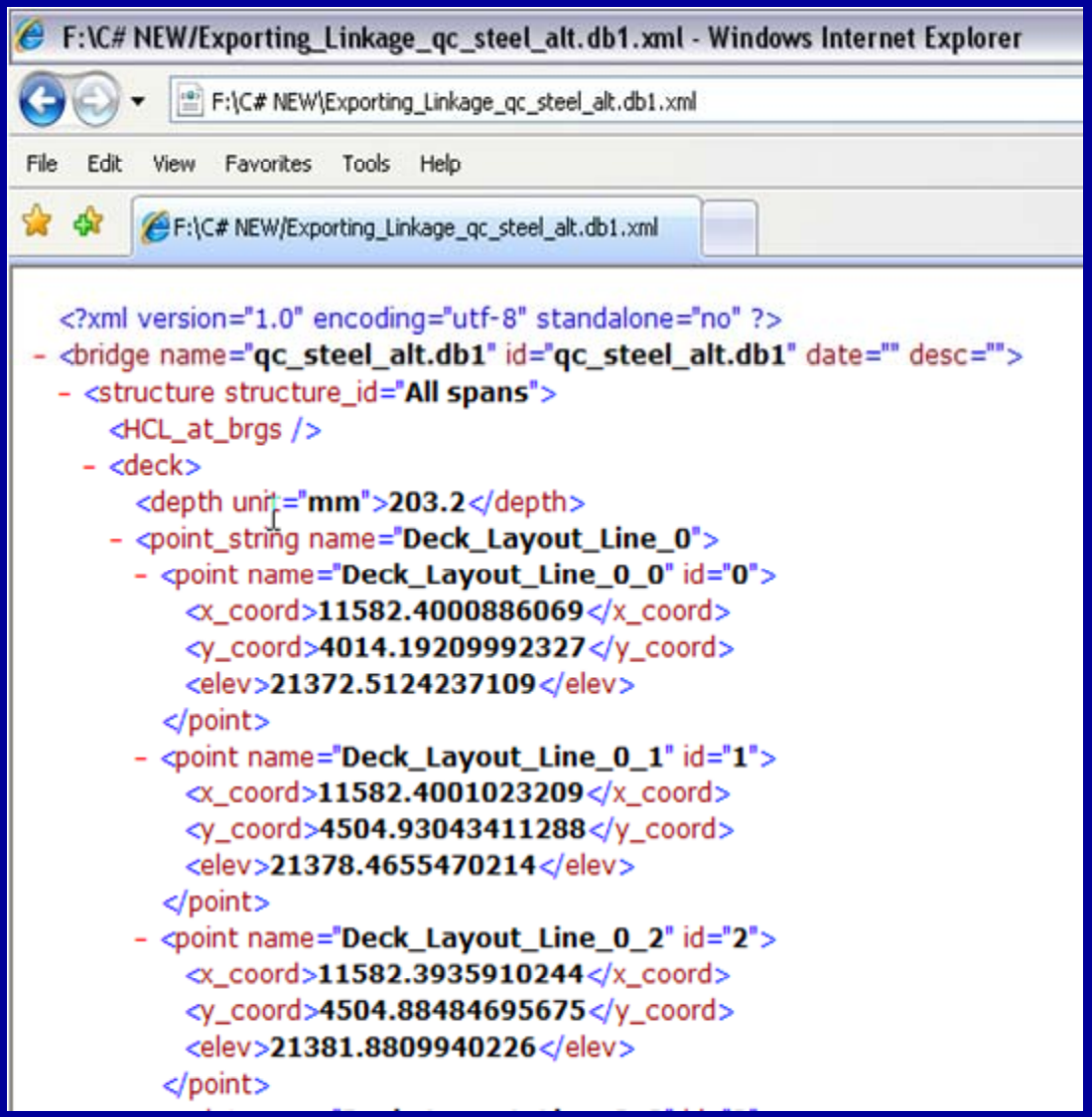
CSV – COMMA SEPARATED VALUES

BARS/LARS – AASHTOWARE AND BENTLEY SOFTWARE

U.S. Department of Transportation
Federal Highway Administration

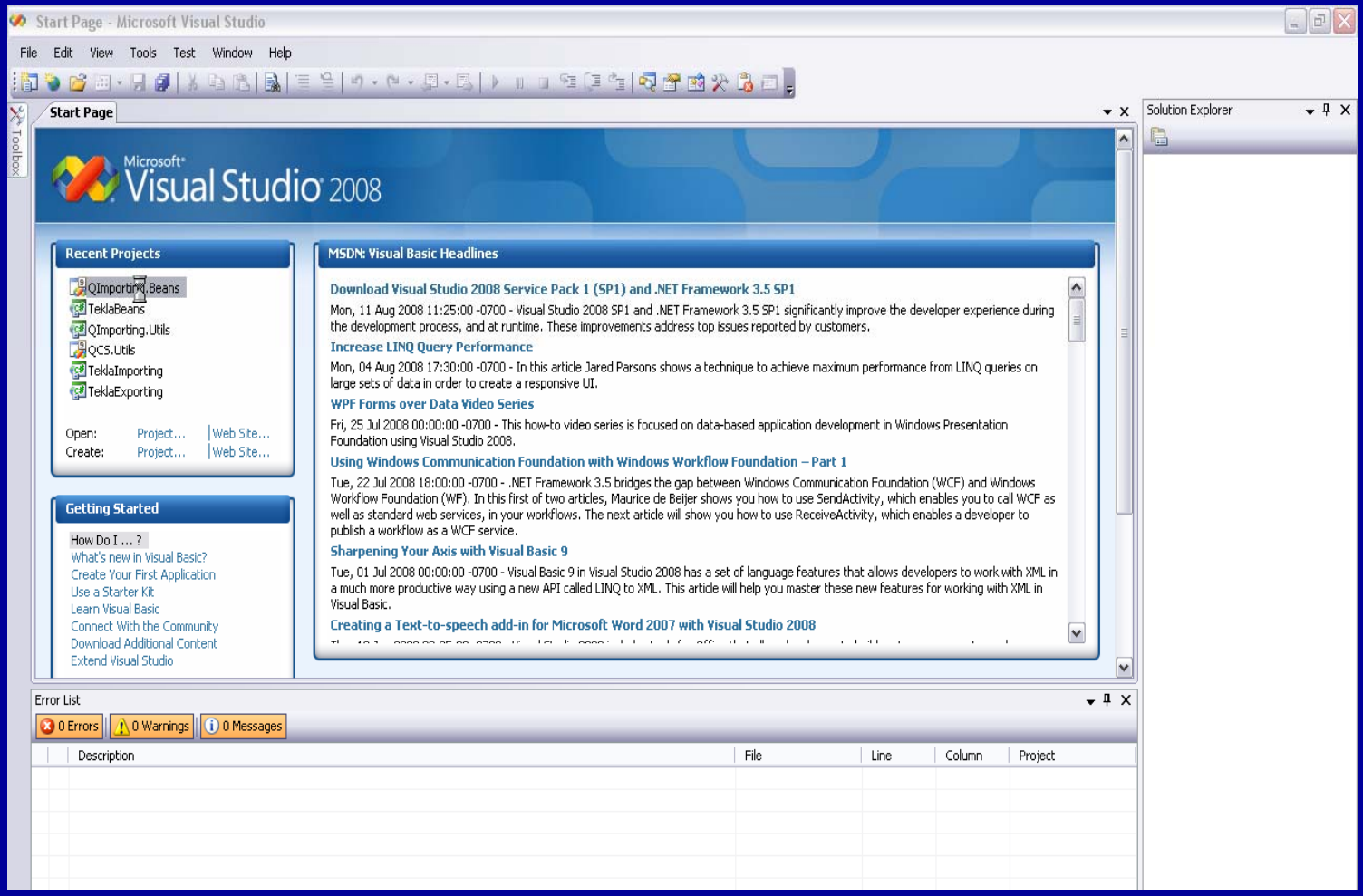
S07 XML to SAP2000

The XML file exported from Tekla



S07 XML to SAP2000

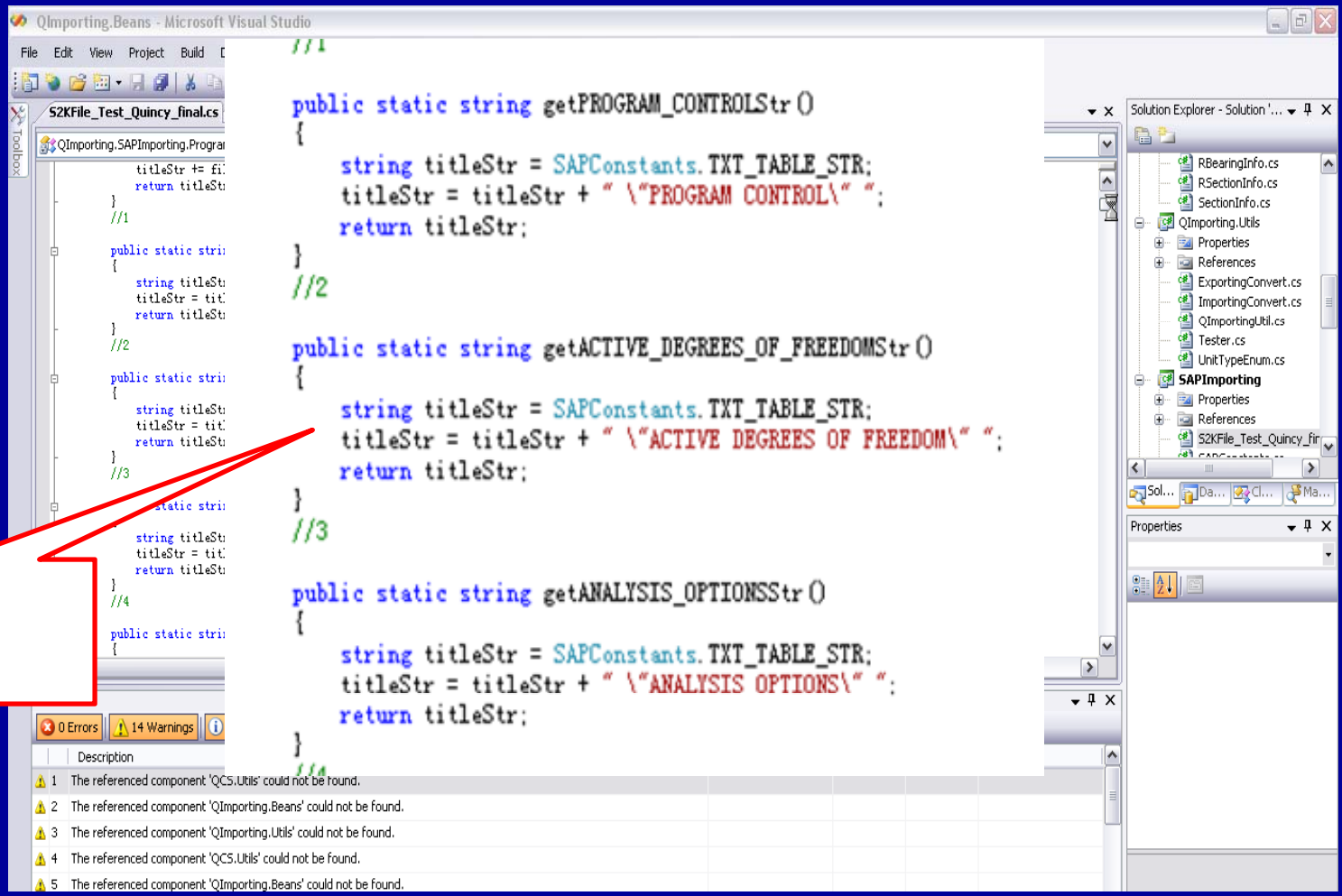
Open Visual Studio software to execute linkage software



S07 XML to SAP2000

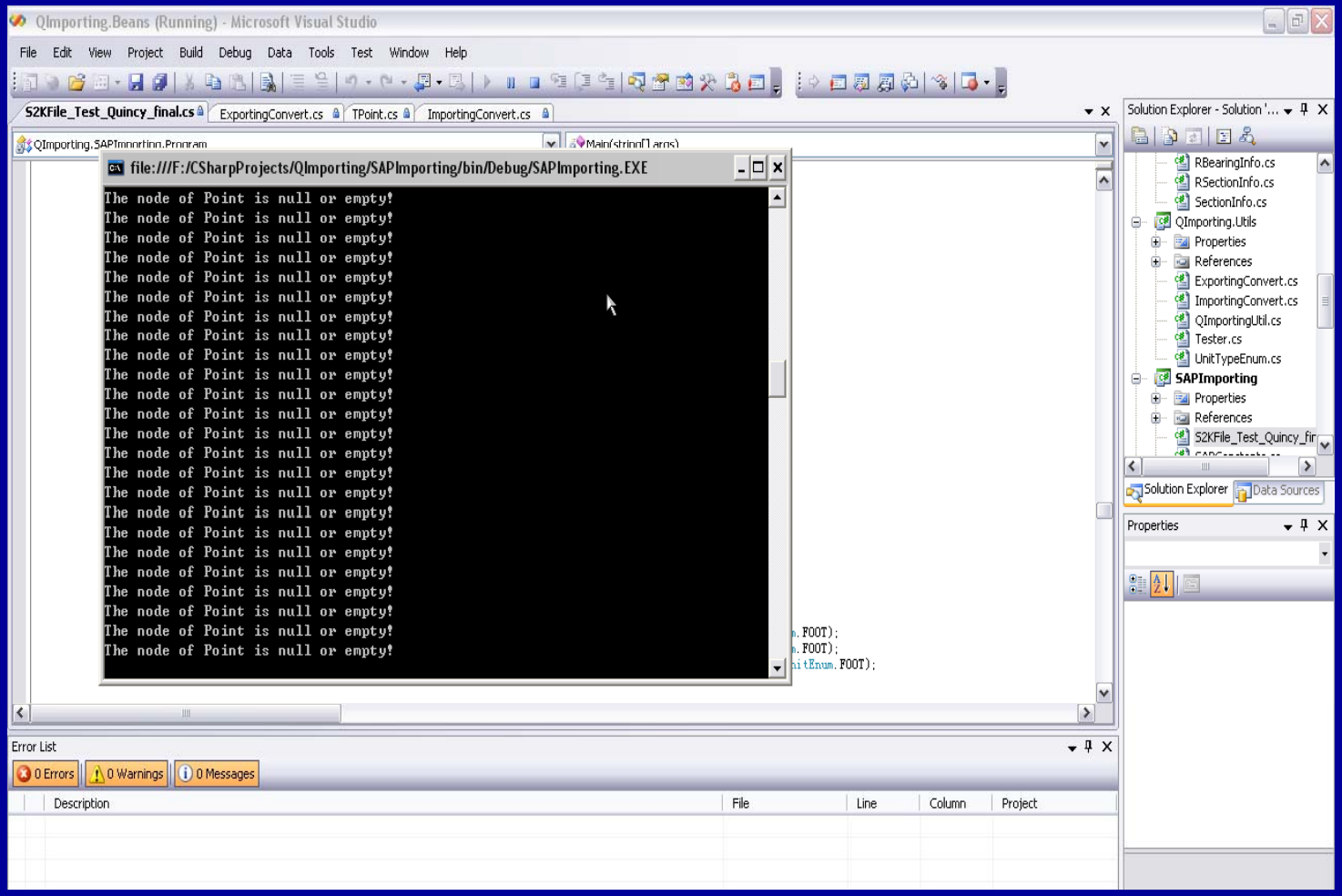
C# code used to generate text input file

Read data: Degree of Freedom



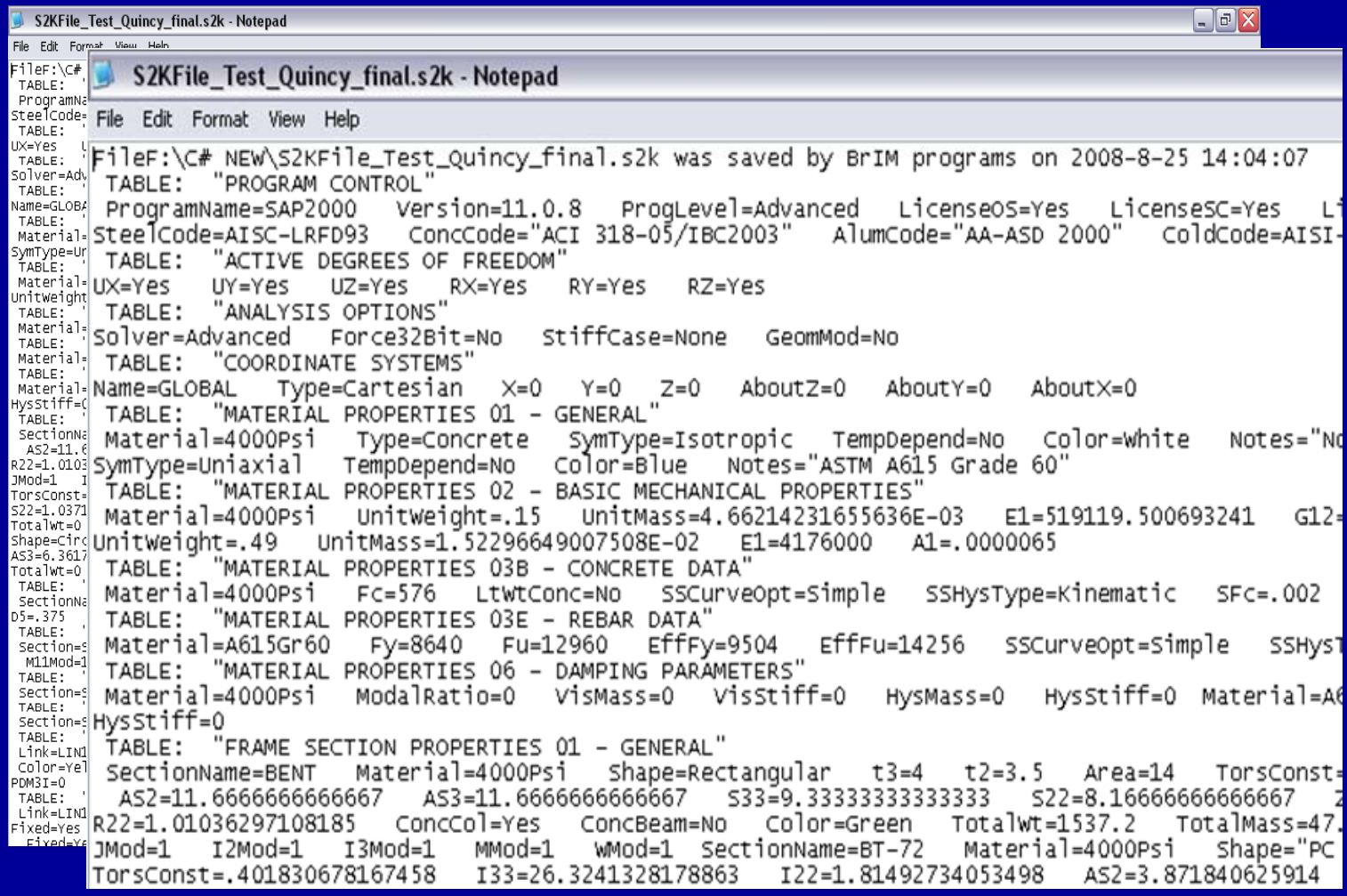
S07 XML to SAP2000

Run
C# code



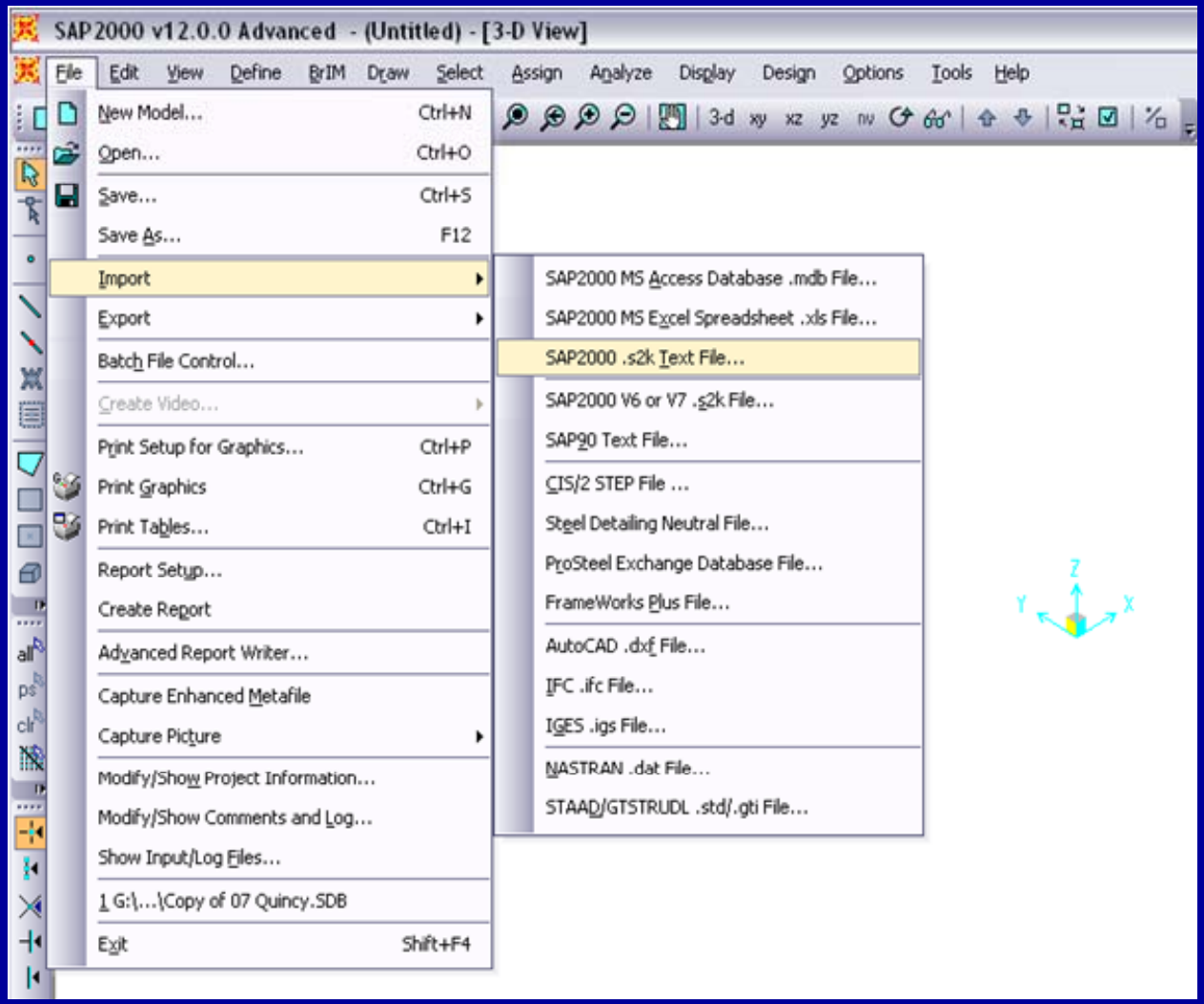
S07 XML to SAP2000

Sample SAP2000 text input file (*.$2k file)



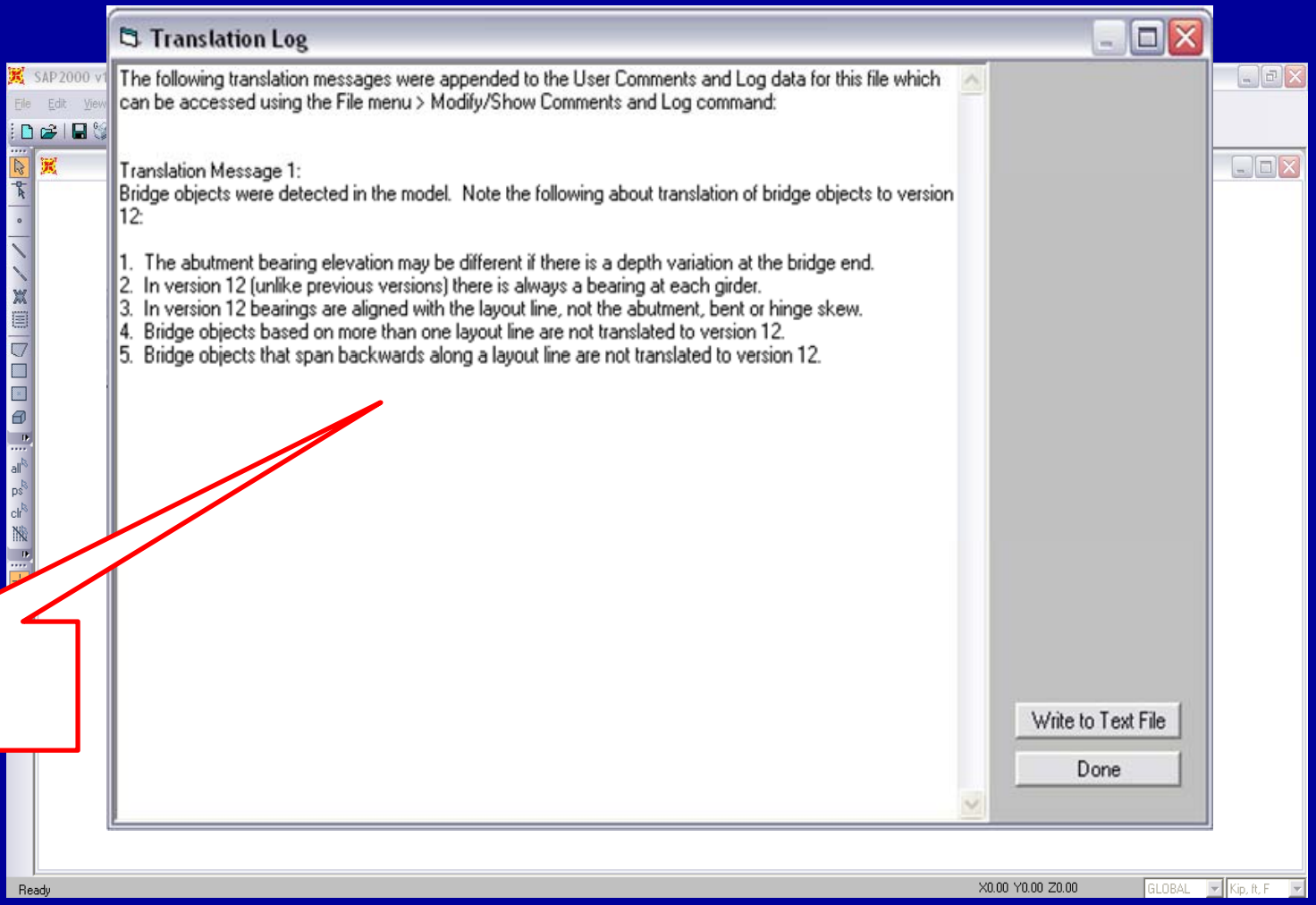
S07 XML to SAP2000

Import text input file (*.s2k file)



S07 XML to SAP2000

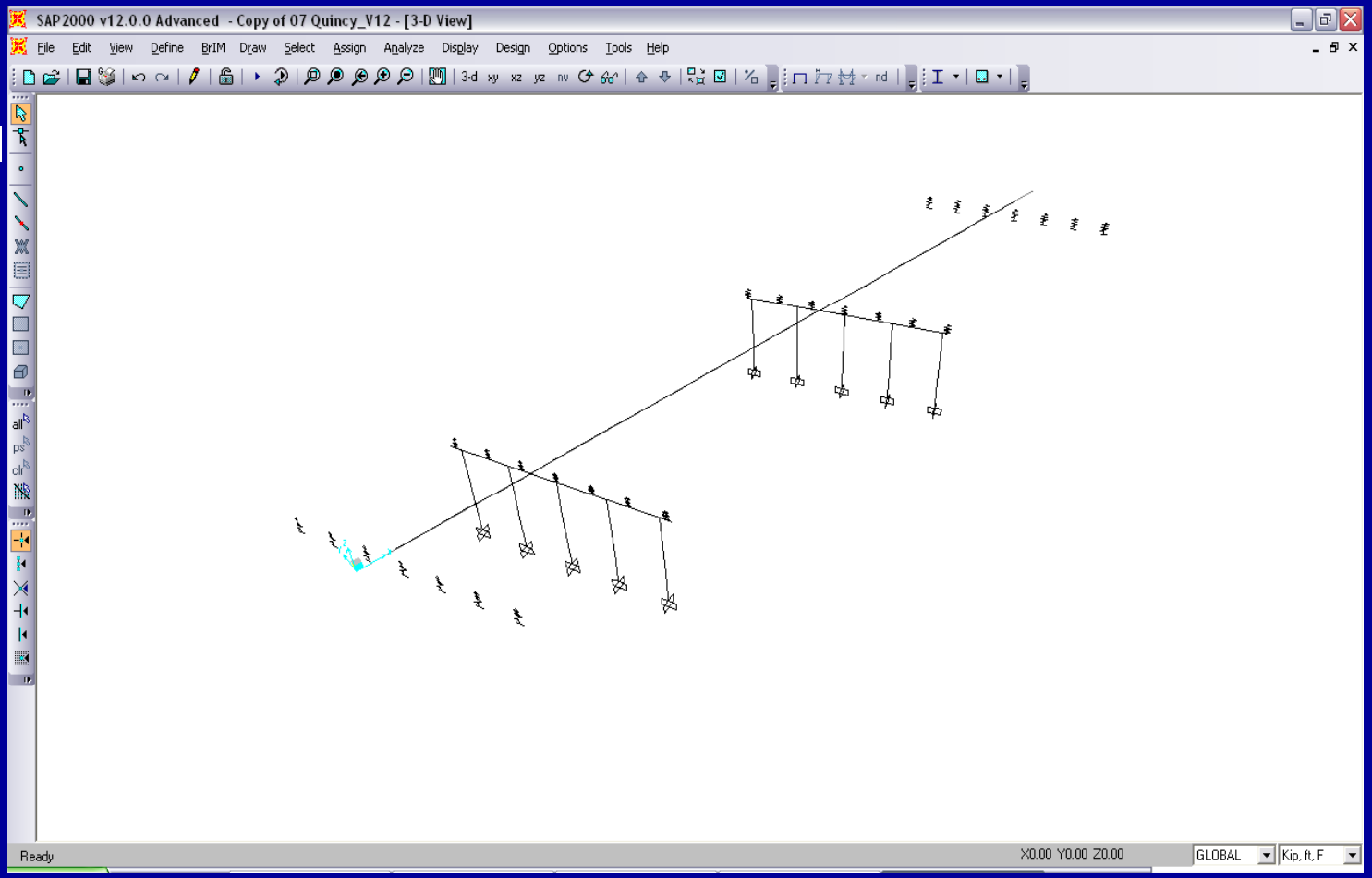
Import log: error and warning information



Translate successfully

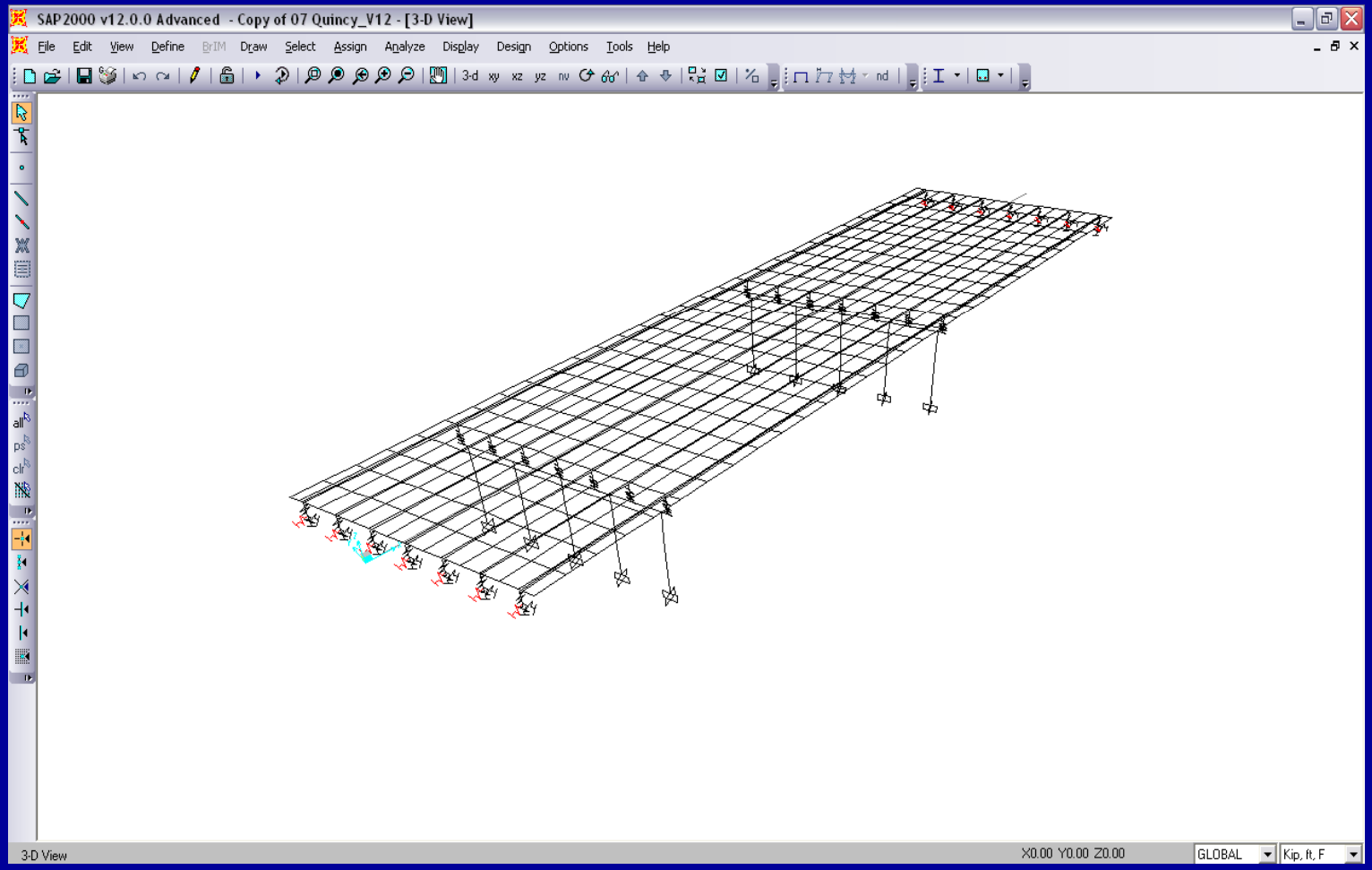
S07 XML to SAP2000

SAP2000 stick model generated by text input file



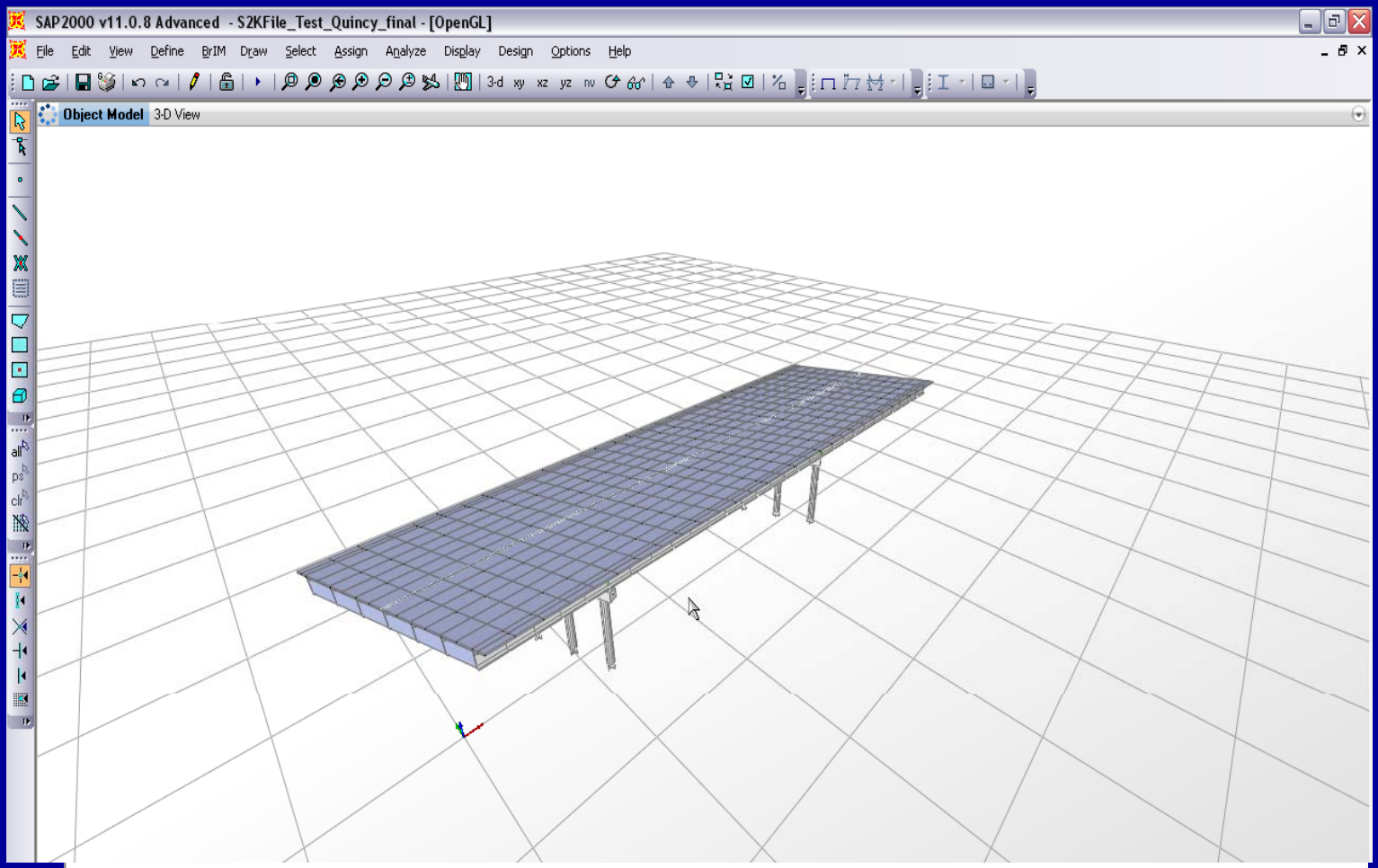
S07 XML to SAP2000

SAP2000 finite element model



S07 XML to SAP2000

SAP2000 finite element model extruded view

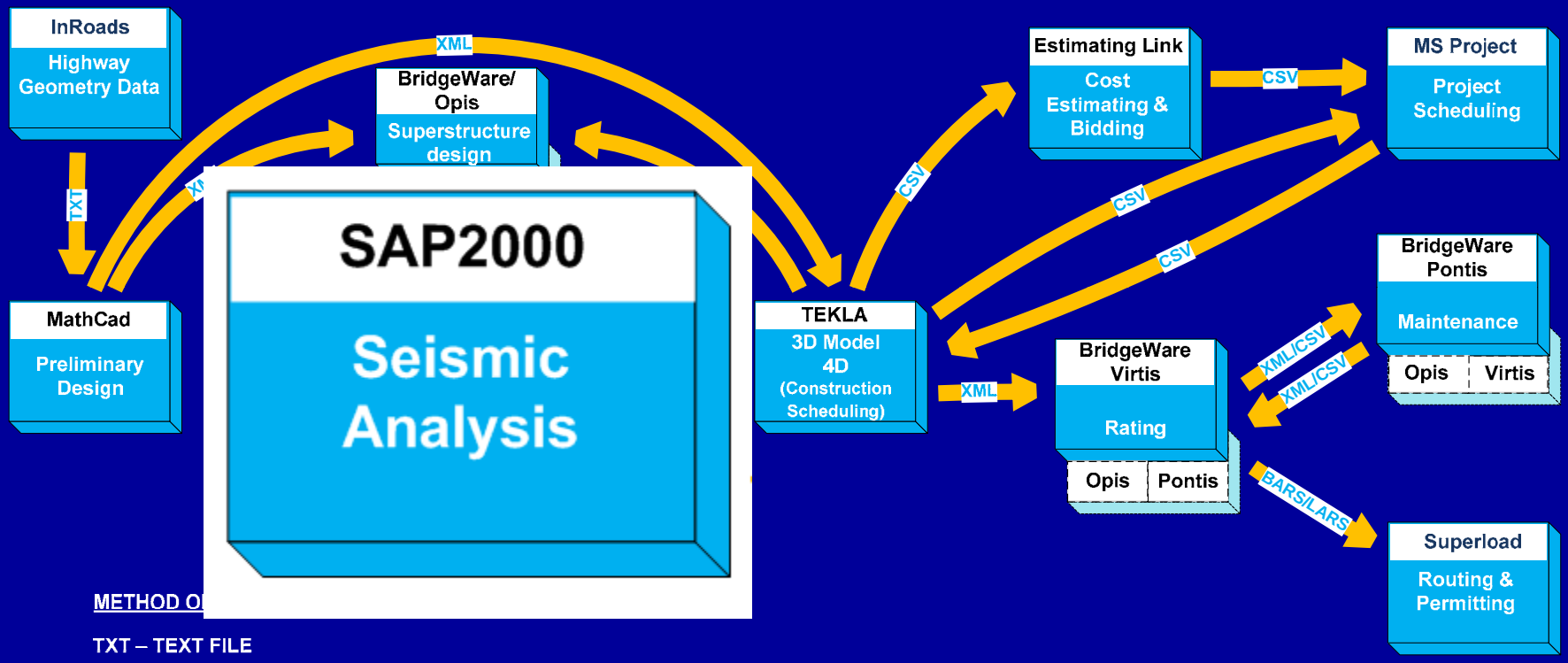


Substructure Design in SAP2000

U.S. Department of Transportation
Federal Highway Administration

S08 SAP2000 Structure Design

Steel Alternate



METHOD O

TXT – TEXT FILE

XML – EXTENSIBLE MARKUP LANGUAGE

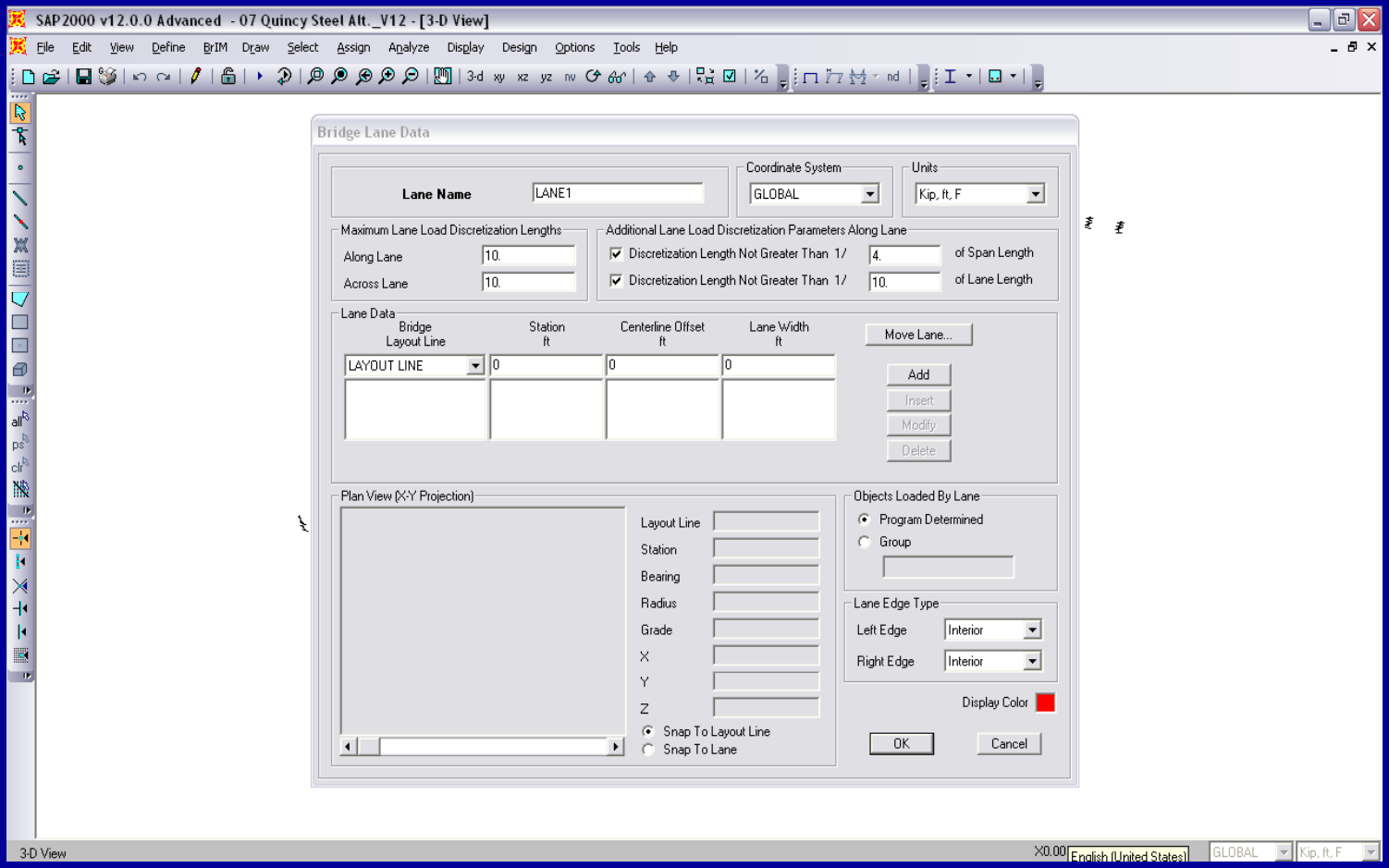
VBA – VISUAL BASIC FOR APPLICATIONS

CSV – COMMA SEPARATED VALUES

BARS/LARS – AASHTOWARE AND BENTLEY SOFTWARE

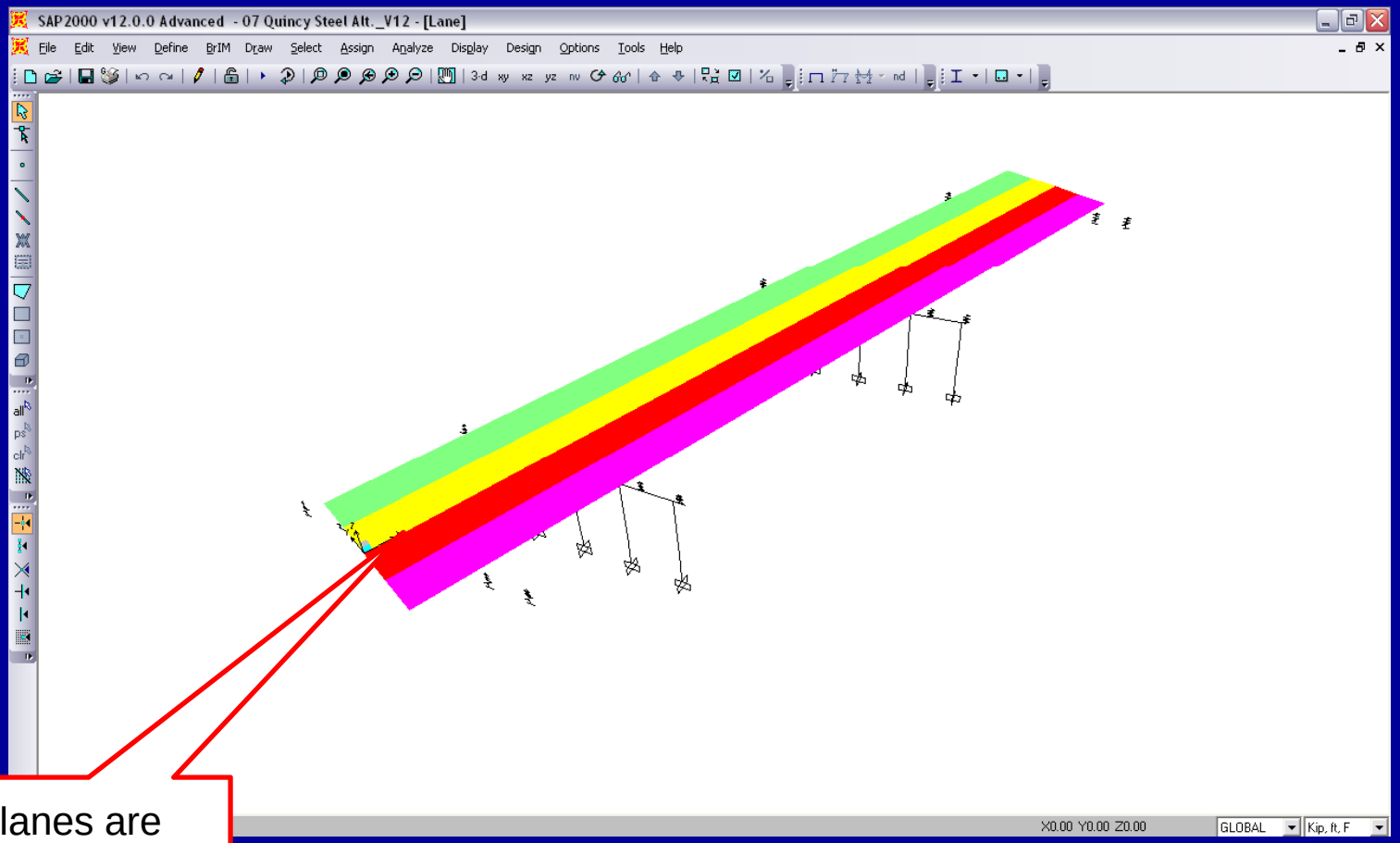
S08 SAP2000 Structure Design

Define live load: Lane number and Lane width



S08 SAP2000 Structure Design

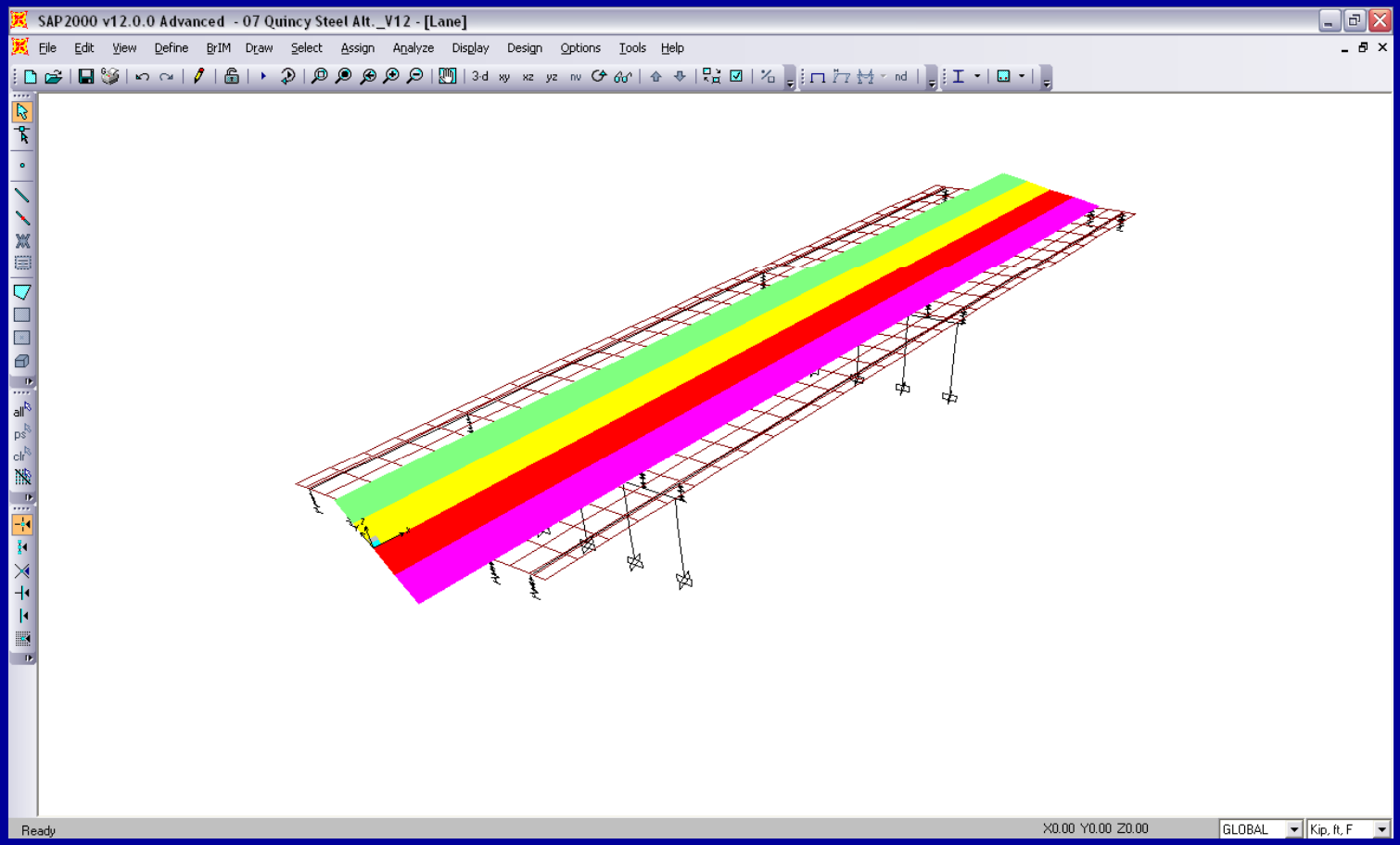
Bridge lanes: 4 lanes defined



Four lanes are defined

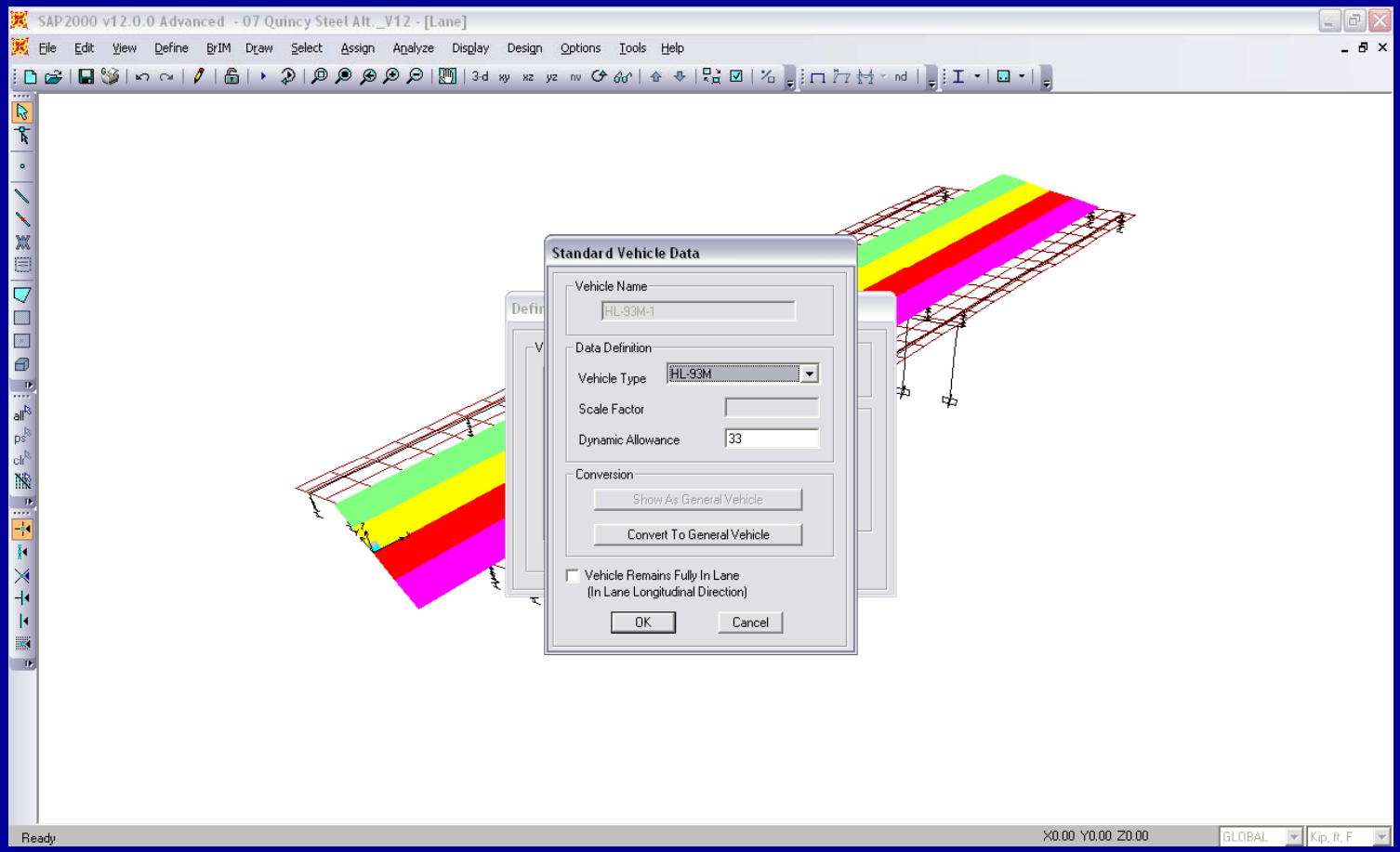
S08 SAP2000 Structure Design

Bridge lanes on finite element model



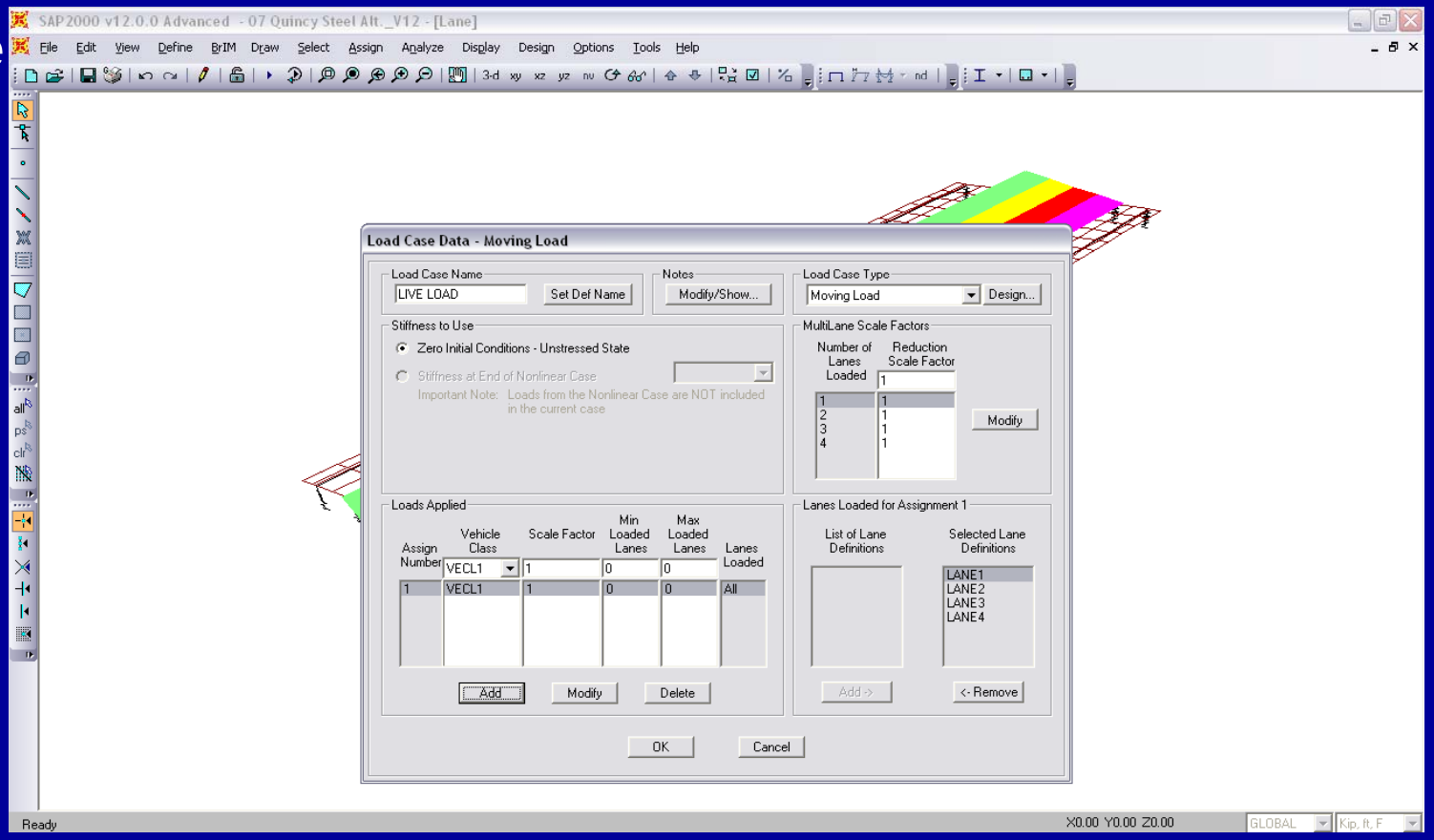
S08 SAP2000 Structure Design

Define standard vehicle: HL-93



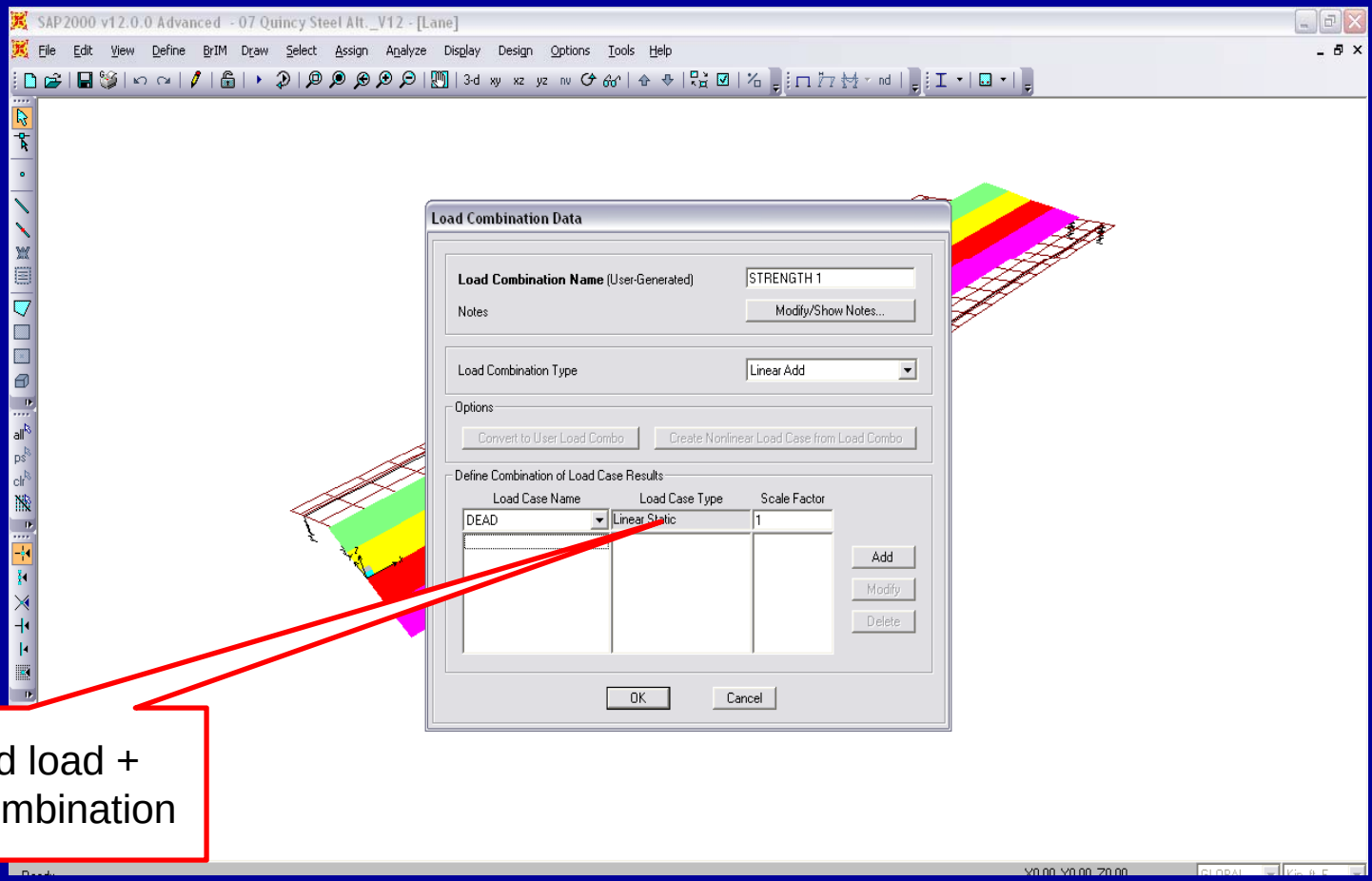
S08 SAP2000 Structure Design

Define live load case



S08 SAP2000 Structure Design

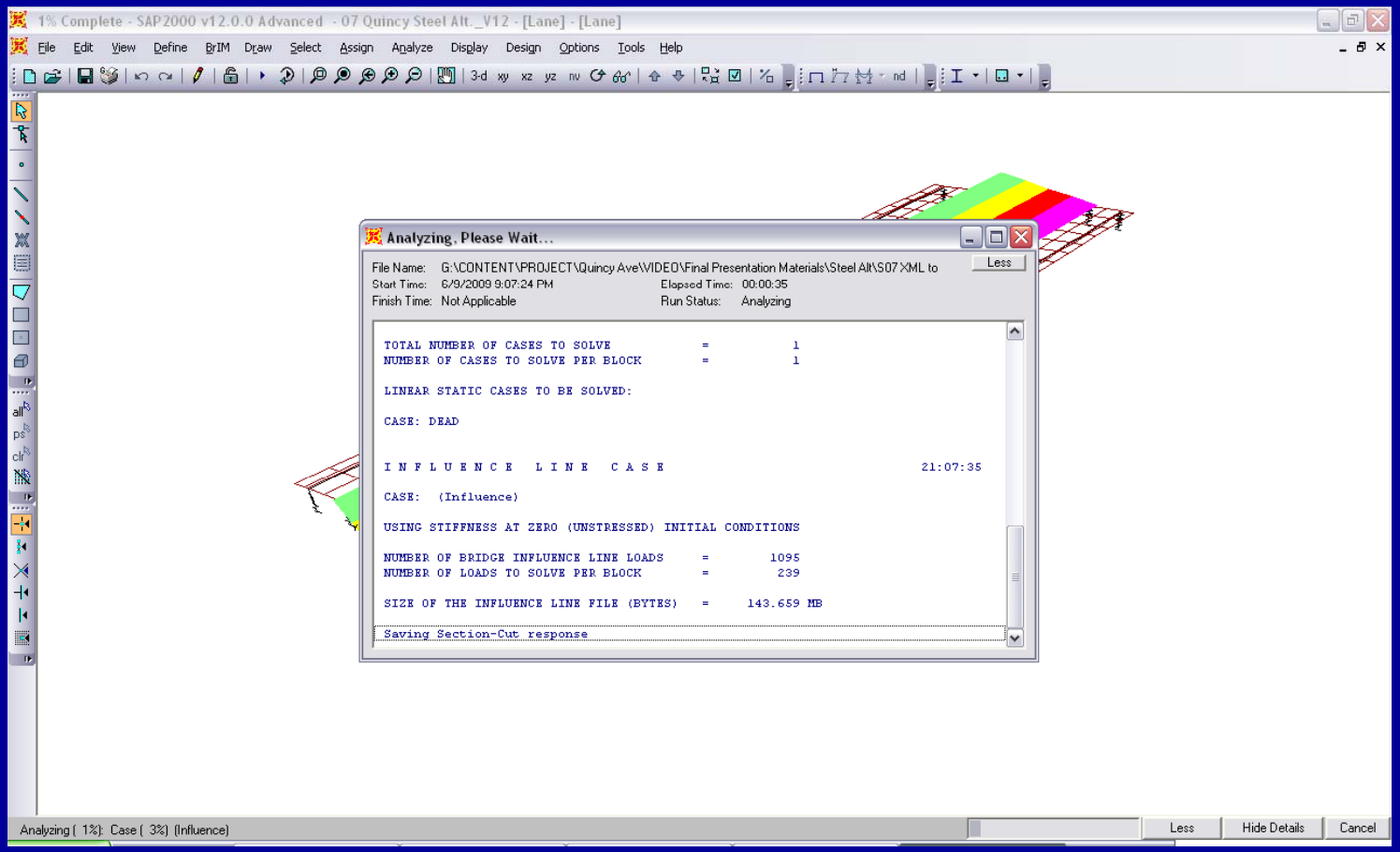
Define load combination: Strength 1



Define dead load + live load combination

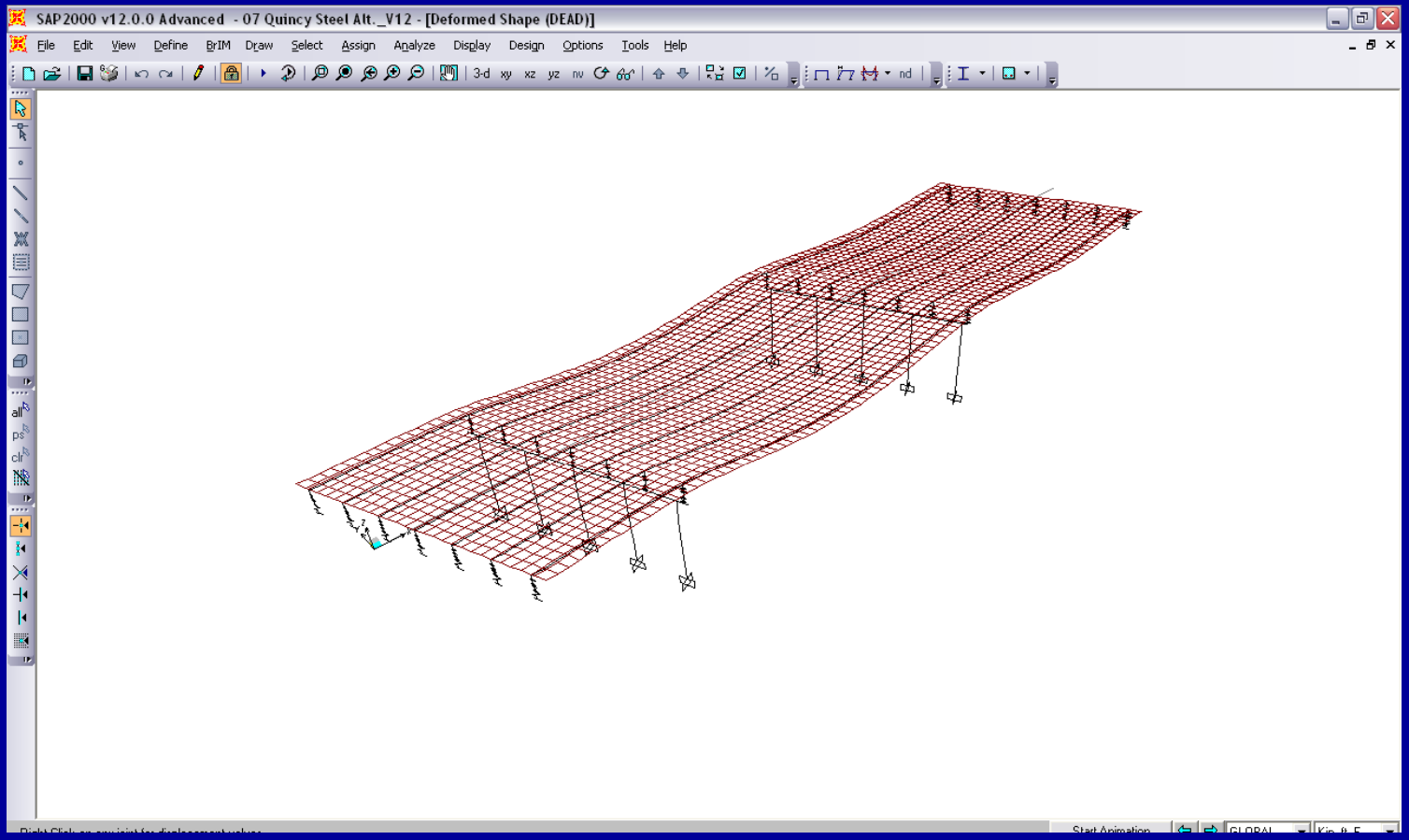
S08 SAP2000 Structure Design

Run analysis: Dead load and live load cases



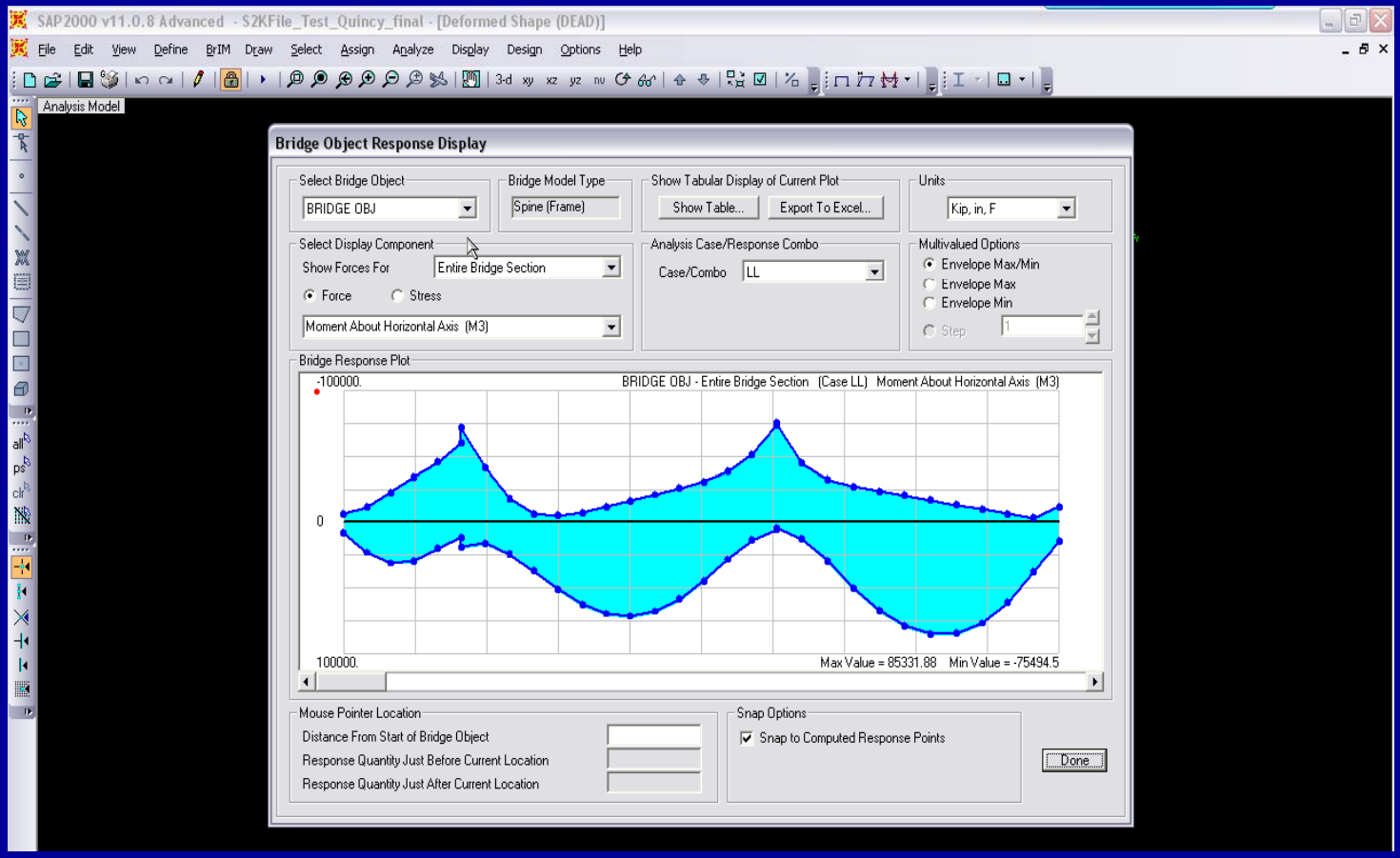
S08 SAP2000 Structure Design

Deformed shape under dead load



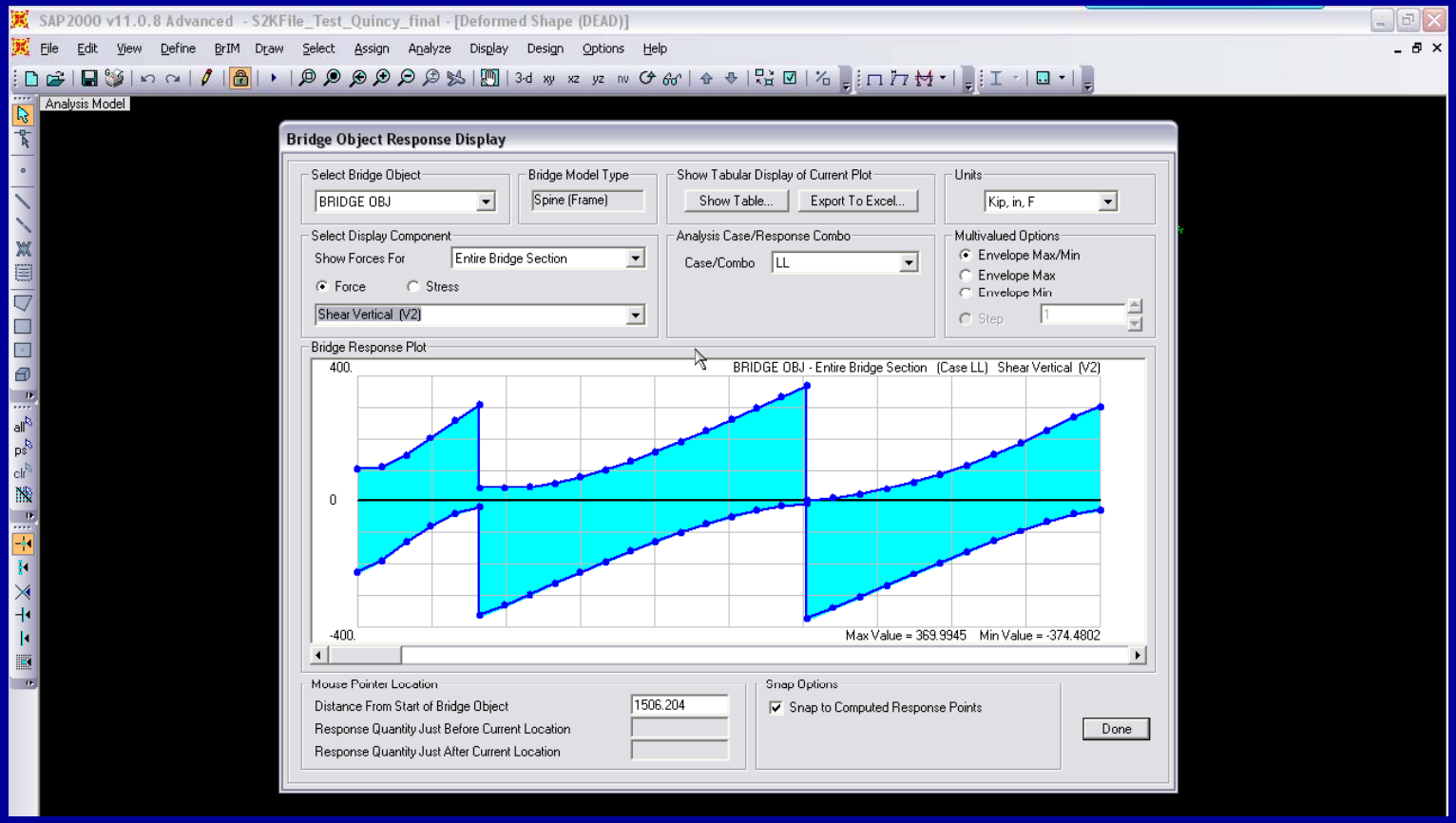
S08 SAP2000 Structure Design

Moment envelope



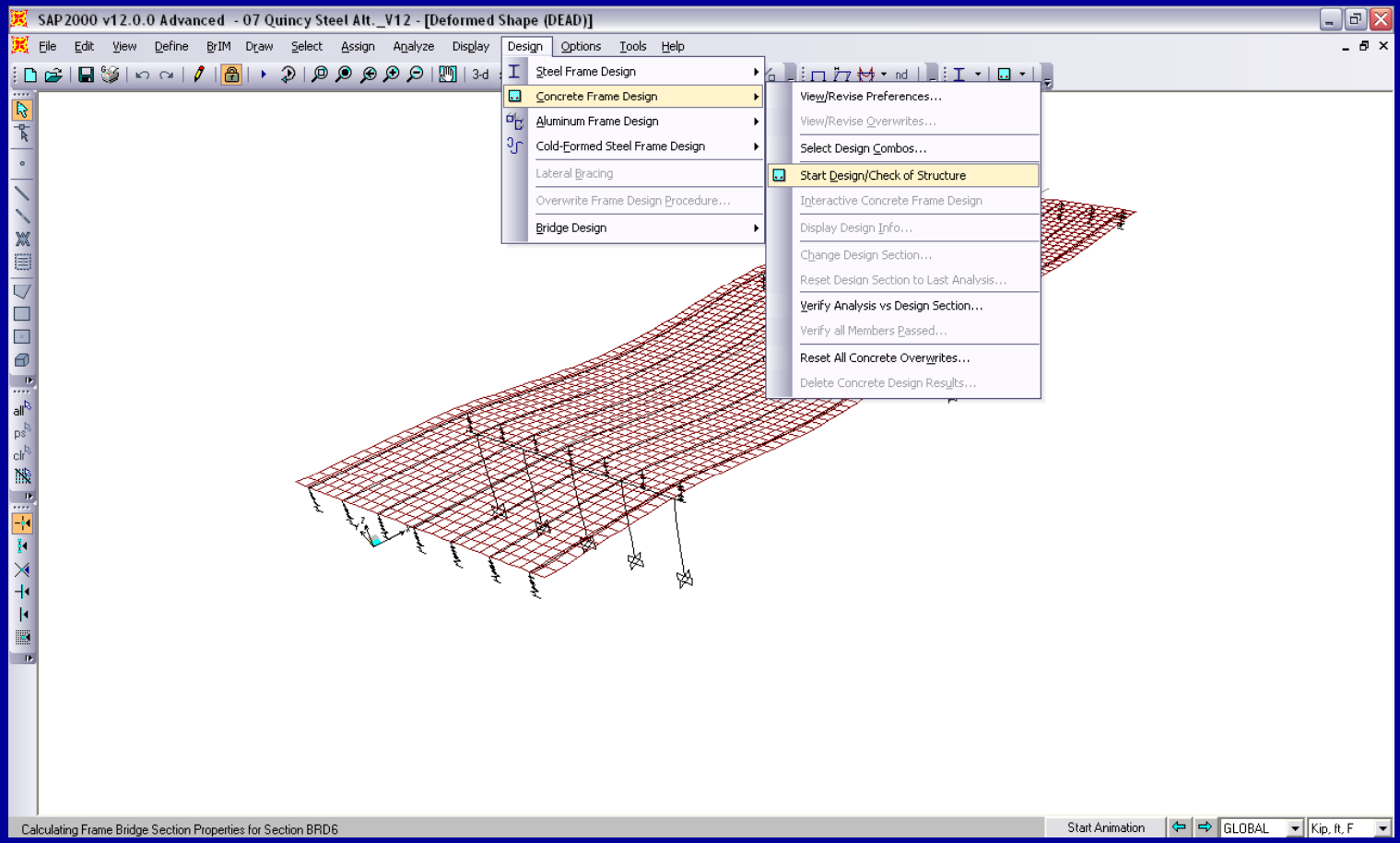
S08 SAP2000 Structure Design

Shear force envelope



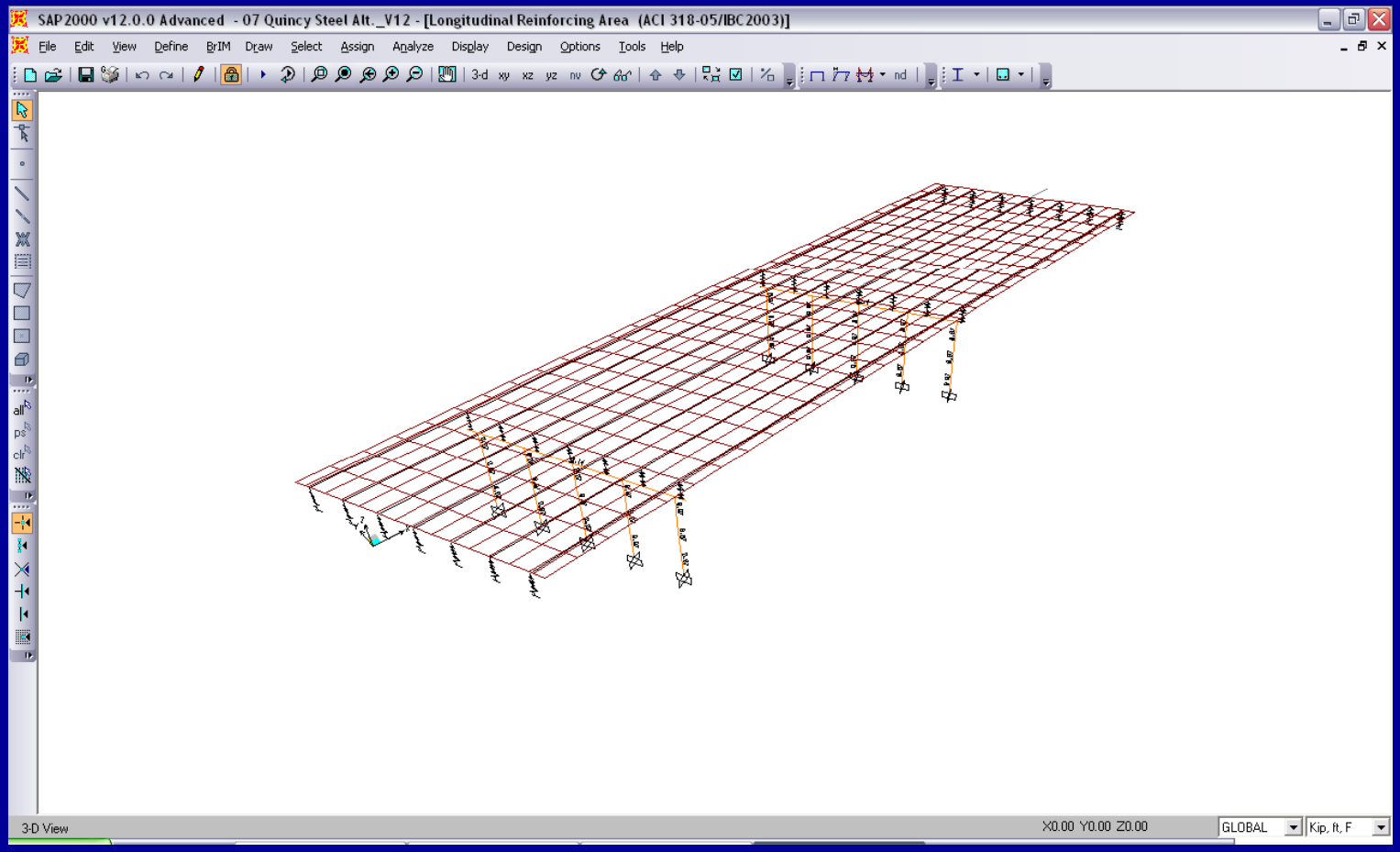
S08 SAP2000 Structure Design

Start design and check of whole structure



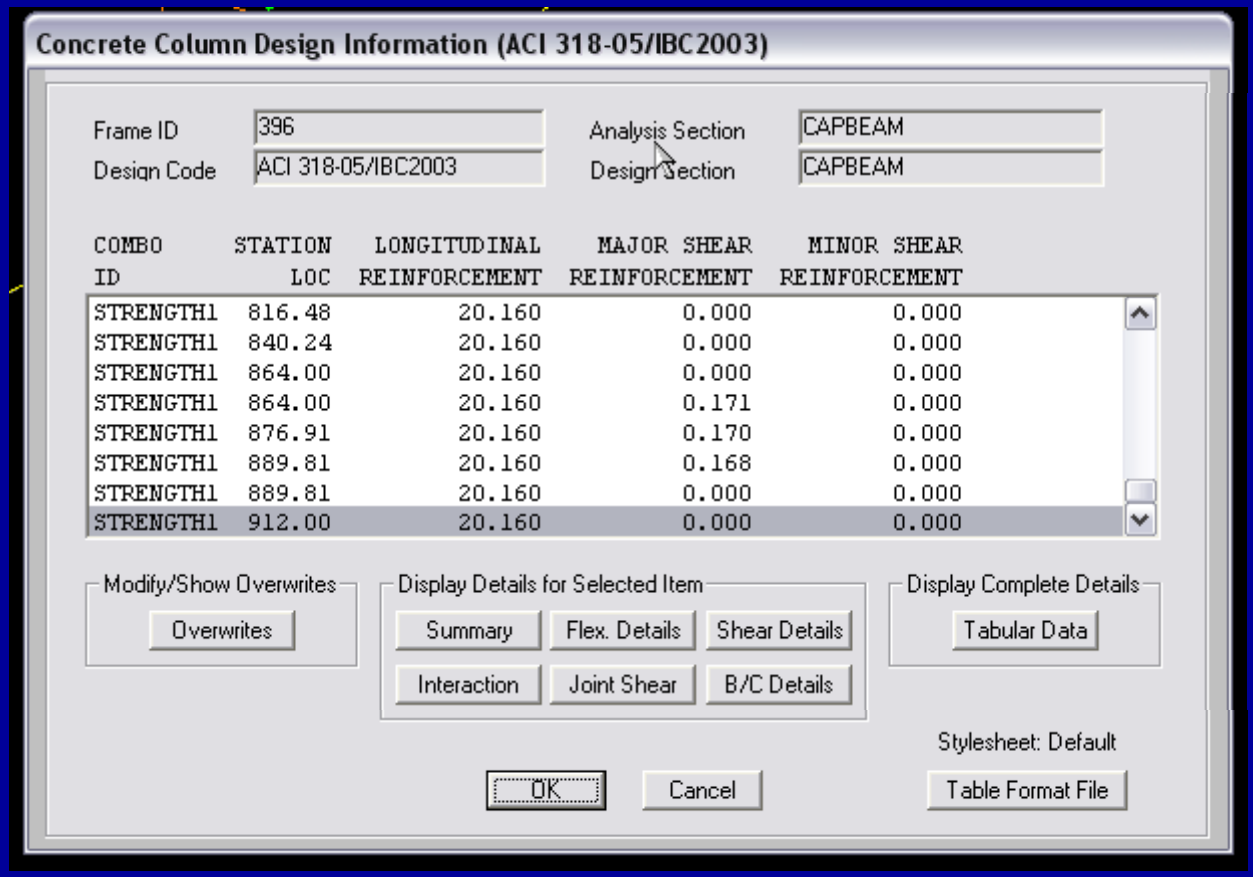
S08 SAP2000 Structure Design

Sub-structure Design result



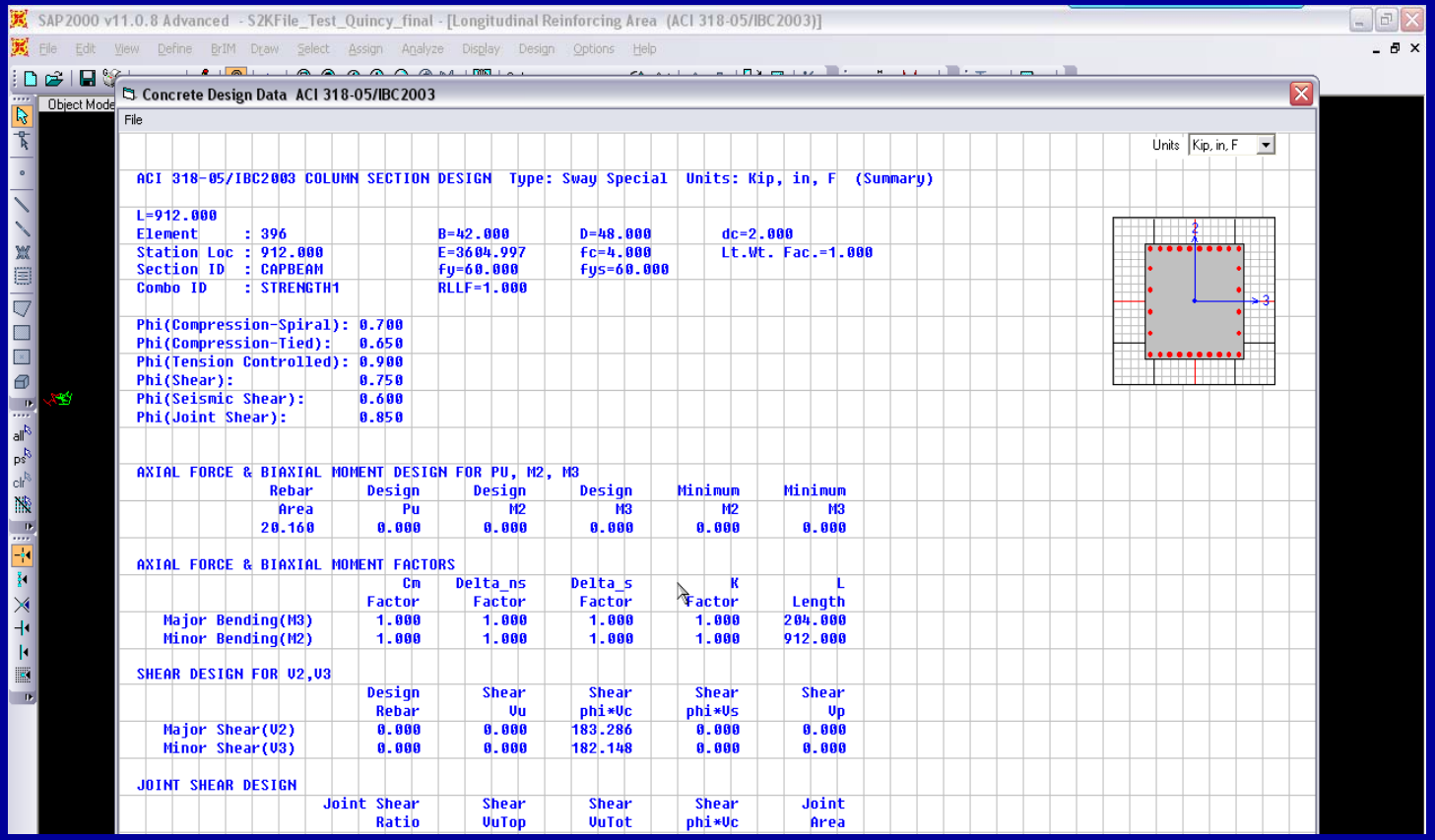
S08 SAP2000 Structure Design

Substructure design result



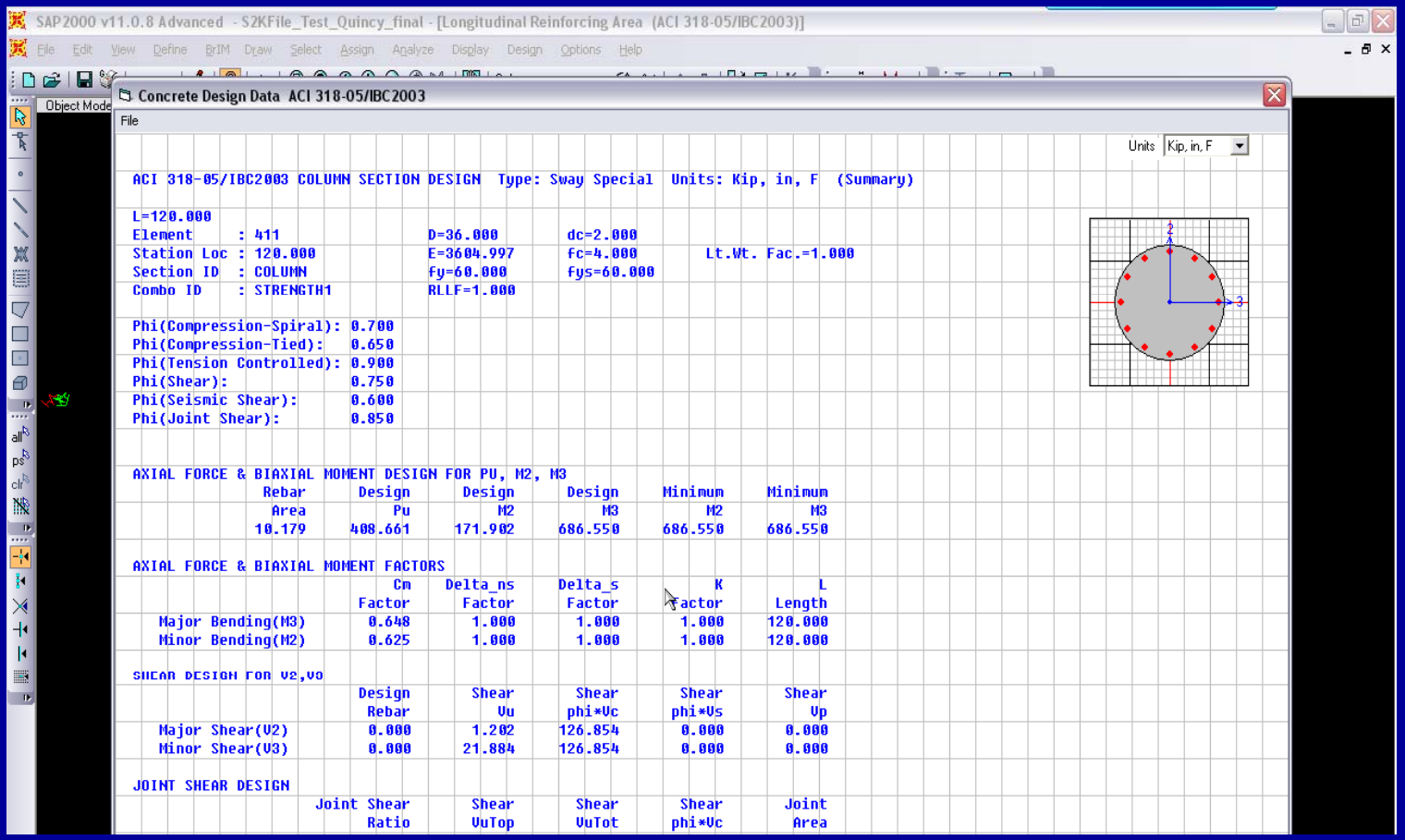
S08 SAP2000 Structure Design

Design result: concrete cap beam design data



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…)

U.S. Department of Transportation
Federal Highway Administration