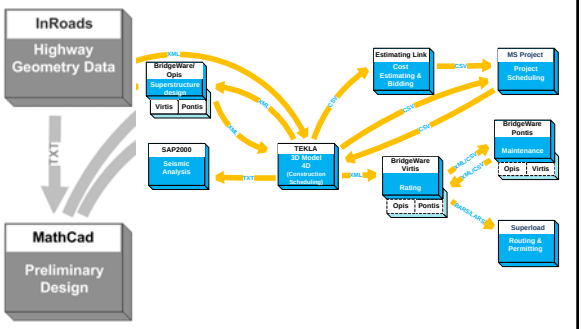
**Part D1:**

**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

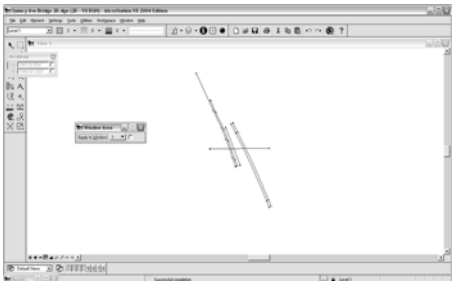


## S01 InRoads to MathCAD

Loading alg file: 6 pairs of horizontal and vertical alignments

## S01 InRoads to MathCAD

This picture shows 6 horizontal alignments

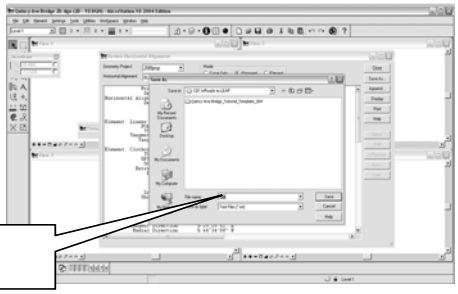


## S01 InRoads to MathCAD

Details of horizontal and vertical alignments

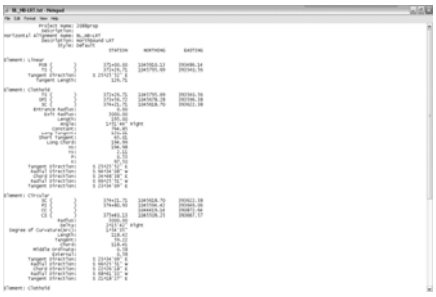
## S01 InRoads to MathCAD

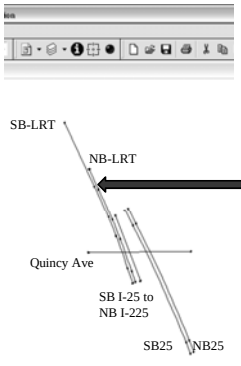
Save alignments data as txt files

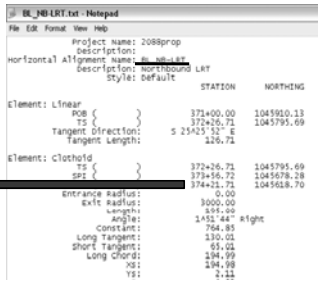



## S01 InRoads to MathCAD

Sample text file





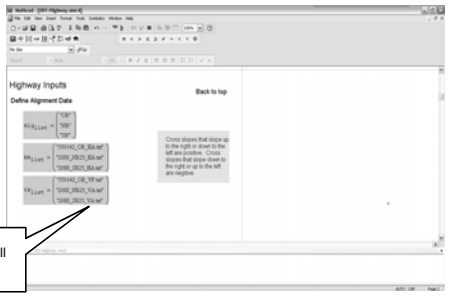



## S01 InRoads to MathCAD

The MathCAD file used for alignments design


## S01 InRoads to MathCAD

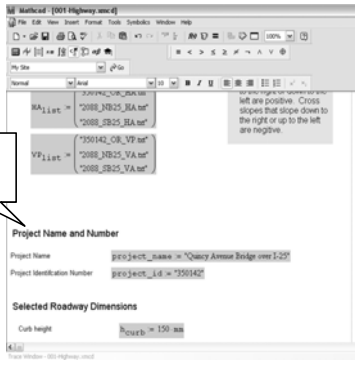
Highway Inputs: input text files




The input text files here are all exported from InRoads.

## S01 InRoads to MathCAD

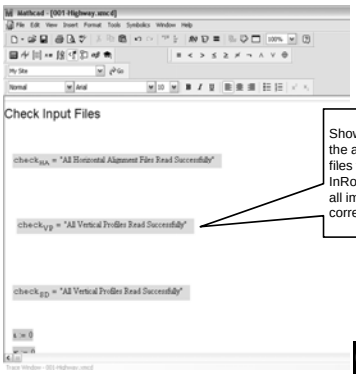
Details of MathCAD files




Some basic parameter inputs of the project.

## S01 InRoads to MathCAD

Details of MathCAD files

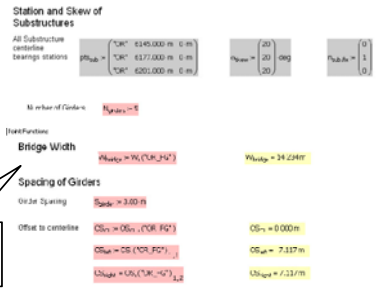



## From MathCAD to Tekla

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

**Substructure Location Inputs:**

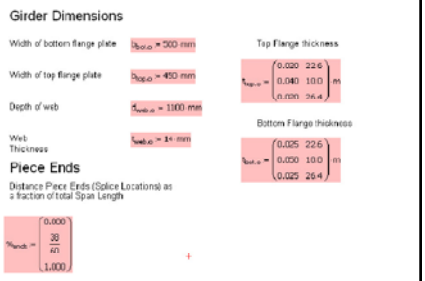
**Superstructure Design Inputs:**




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

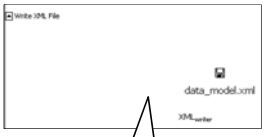
## Inputs Sample in Preliminary Design Sheet (MathCAD file) *(continued)*

Girder Design Inputs:






## Export XML Linkage File




Export data into XML file in MathCAD …

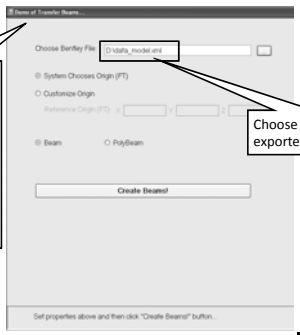
This xml exporting functionality is developed.

```
<?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

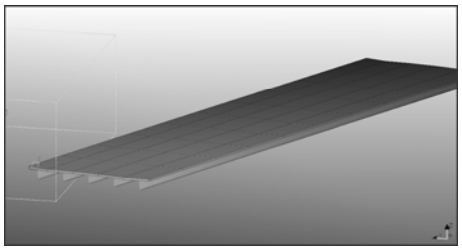
This program is developed by C# in Visual Studio. It reads the bridge data in xml linkage file just exported from MathCAD sheet and calls Tekla's APIs to build 3D model automatically.




Choose the XML file just exported…

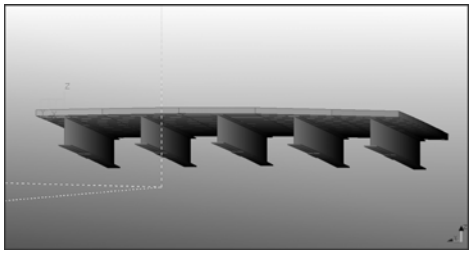
## The Tekla 3D Model Automatically Generated

Output model snapshot from Tekla Structure:



## The Tekla 3D Model Automatically Generated (cont.)

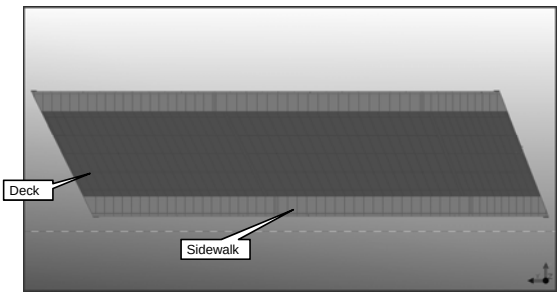
Output model snapshot from Tekla Structure:



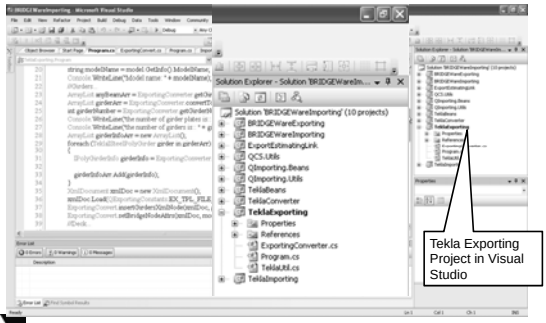
## From Tekla to XML

## Tekla 3D Model

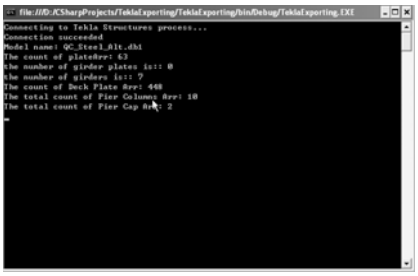
## Tekla 3D Model: Top View




## The Code Sample and Development Environment showing Exporting



## Export Processing



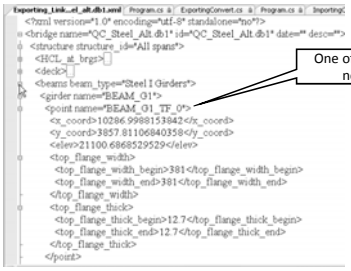



## Sample of Exported XML File

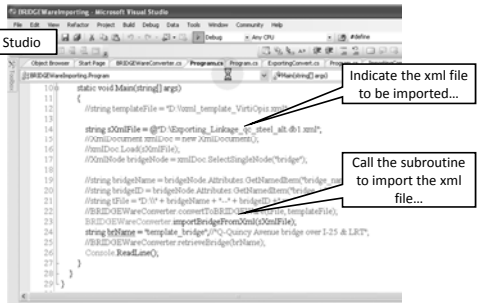



## XML to Opis/Virtis

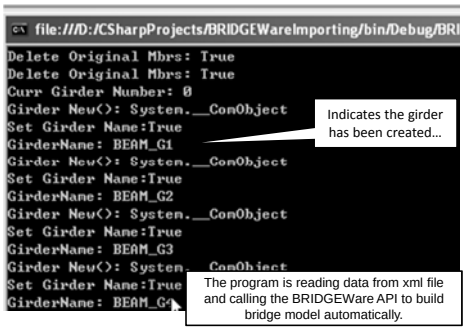
## Sample of XML File



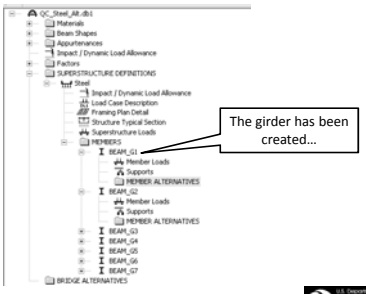

## Code Sample and Development Environment Showing Importing




## Importing Process

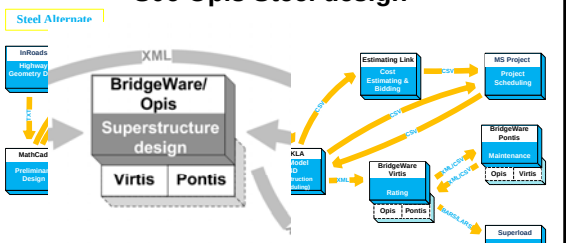


## BRIDGEWare Model (Steel)



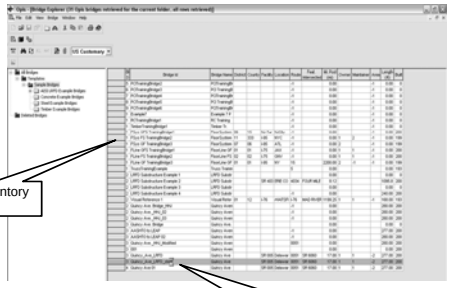

## Opis Steel Design

## S06 Opis Steel design



## S06 Opis Steel design

In Opis: Open the XML file exported from MathCAD

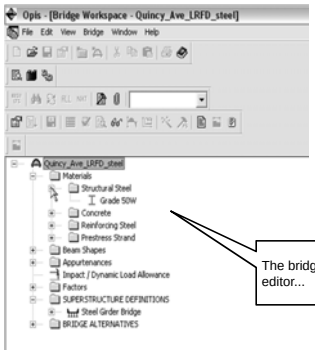


Bridge inventory in Opis.

The 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



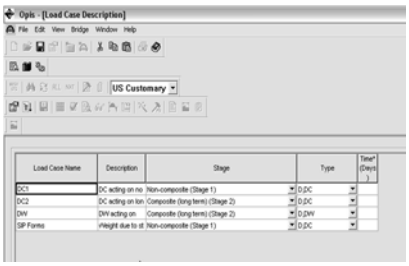
## S06 Opis Steel design

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




## S06 Opis Steel design

Load case description

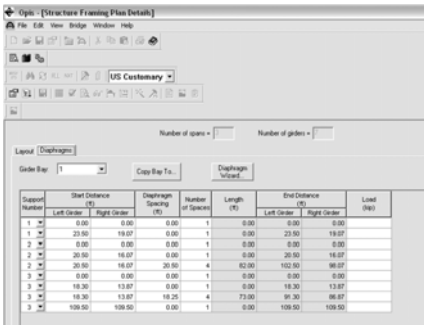


## S06 Opis Steel design

Define girder spacing and skewed angle

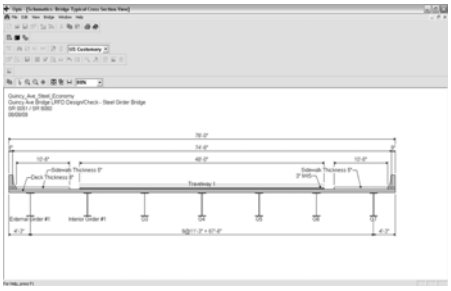
## S06 Opis Steel design

Define diaphragm spacing



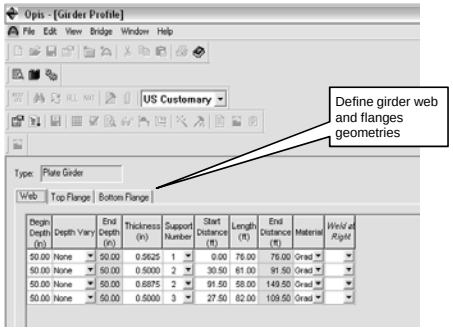
## S06 Opis Steel design

Typical section view of super-structure



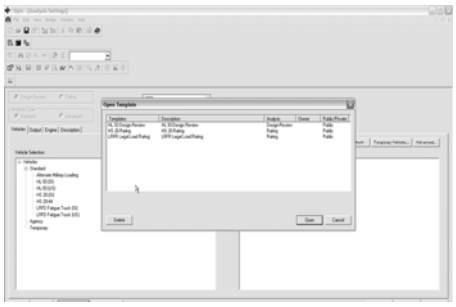
## S06 Opis Steel design

Girder profile



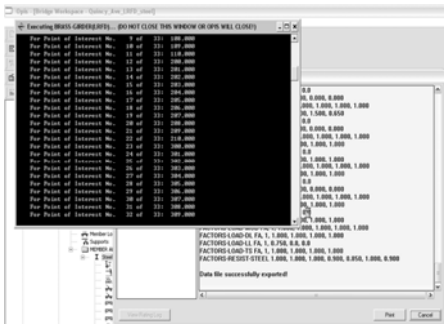

## S06 Opis Steel design

Define analysis settings



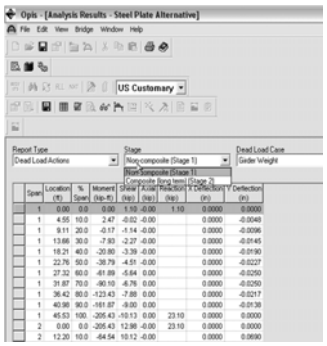
## S06 Opis Steel design

Run analysis



## S06 Opis Steel design

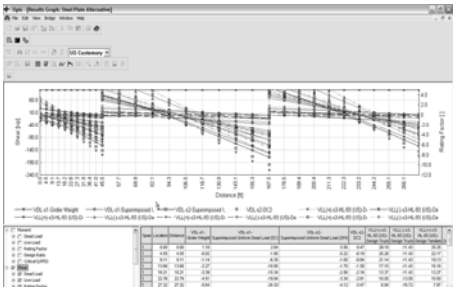
Analysis results: Moment, shear, axial force, etc.





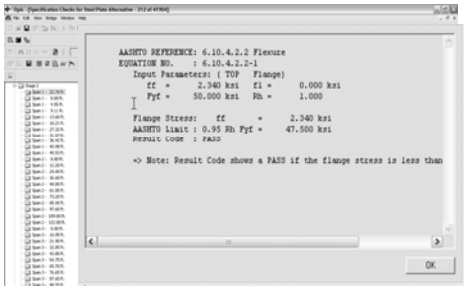
## S06 Opis Steel design

Shear diagrams and envelopes




## S06 Opis Steel design

Specifi-cation checks: Service limit state: Flexural




# Steel Alternate Design

## Typical Bridge Cross Section

Superstructure Configuration

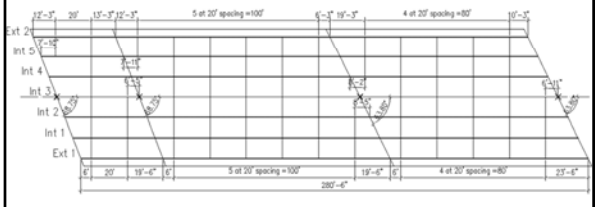
- 7 girders spaced at 11.25 ft
- 8 inch concrete deck with integral wearing surface
- 2% cross-slope from centerline of the roadway
- 10 ft-6 in wide sidewalks and a 1 ft-6 in wide railing


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.

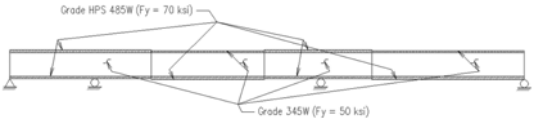


## Hybrid Configuration

Material properties

This design incorporates the following structural steels:

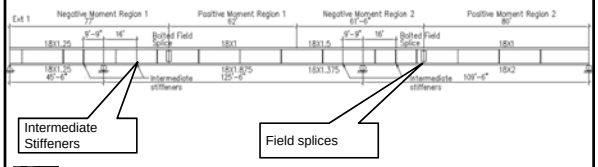
- Grade 50W: Top flange in the positive moment region and the entire web.
- Grade 70W HPS: Both flanges in the negative moment region and the bottom flange in the positive moment region.




## Girder Elevation and Section Description

Exterior Girder No. 1

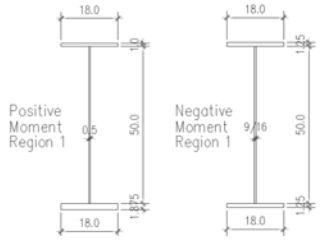
Elevation View:




## Girder Elevation and Section Description

Exterior Girder No. 1

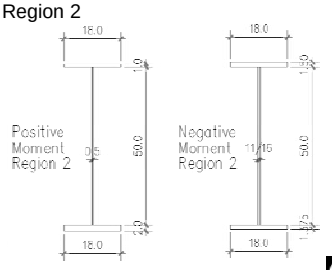
Section View: Positive Moment Region 1 and Negative Moment Region 1



## Girder Elevation and Section Description

Exterior Girder No. 1

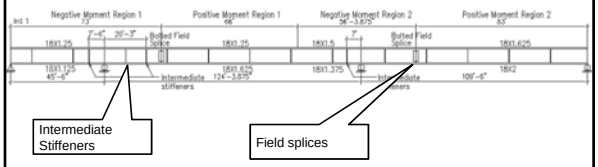
Section View: Positive Moment Region 2 and Negative Moment Region 2




## Girder Elevation and Section Description

Interior Girder No. 1

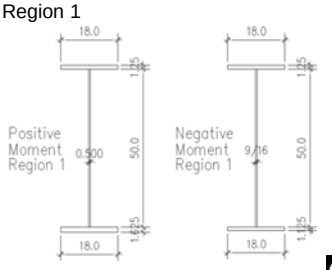
Elevation View:




## Girder Elevation and Section Description

Interior Girder No. 1

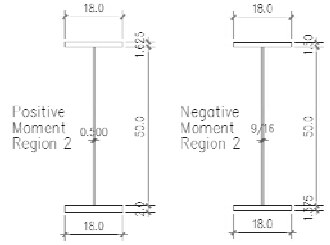
Section View: Positive Moment Region 1 and Negative Moment Region 1



## Girder Elevation and Section Description

Interior Girder No. 1

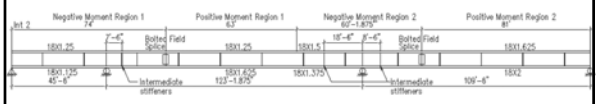
Section View: Positive Moment Region 2 and Negative Moment Region 2




## Girder Elevation and Section Description

Interior Girder No. 2

Elevation View:

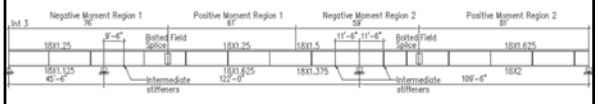



Section View: The same as interior girder No.1

## Girder Elevation and Section Description

Interior Girder No. 3

Elevation View:

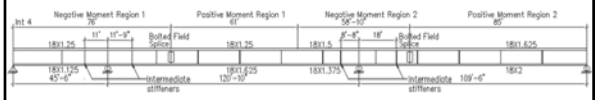



Section View: The same as interior girder No.1

## Girder Elevation and Section Description

Interior Girder No. 4

Elevation View:



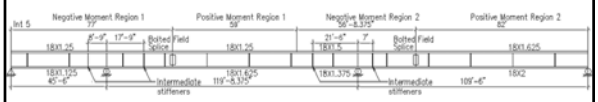

Section View: The same as interior girder No.1



## Girder Elevation and Section Description

Interior Girder No. 5

Elevation View:



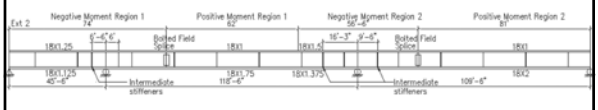

Section View: The same as interior girder No.1



## Girder Elevation and Section Description

Exterior Girder No. 2

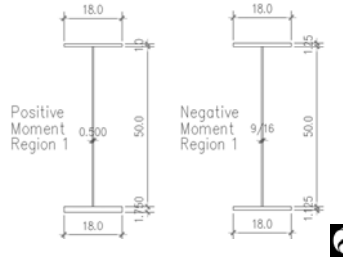
Elevation View:



## Girder Elevation and Section Description

Exterior Girder No. 2

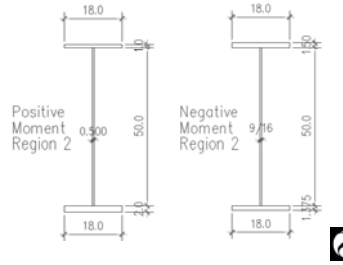
Section View: Positive Moment Region 1 and Negative Moment Region 1




## Girder Elevation and Section Description

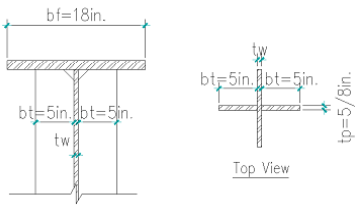
Exterior Girder No.2

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

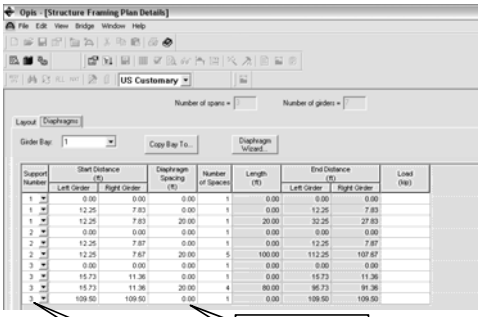



## Stiffener Description

Section View of Intermediate Stiffener

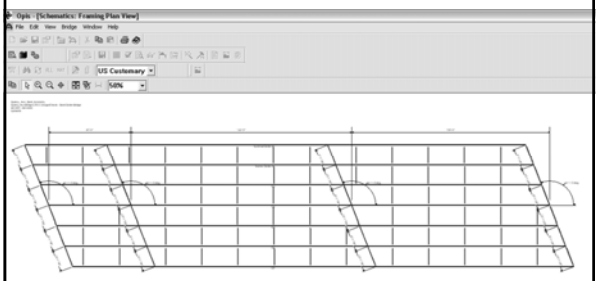


## Structure Framing Plan Details in Opis



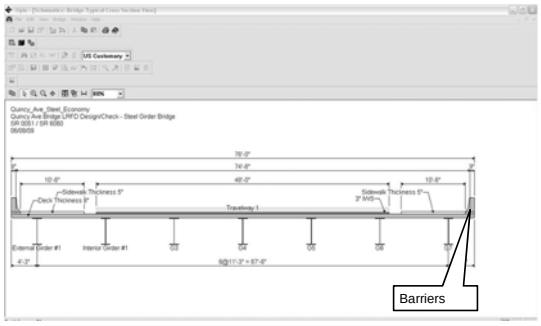



## Framing Plan View in Opis

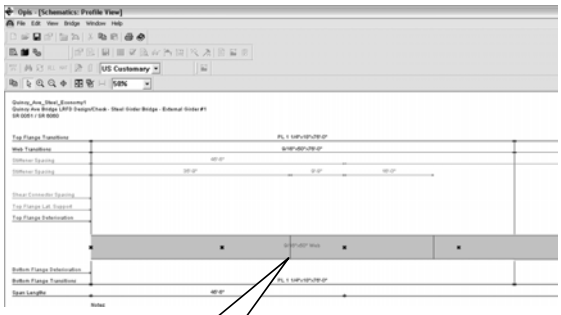




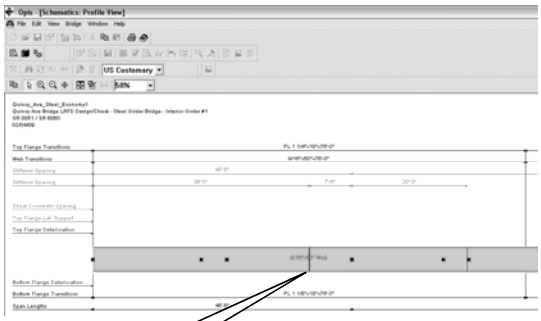

## Deck Cross Section View in Opis



## Exterior Girder Section View in Opis

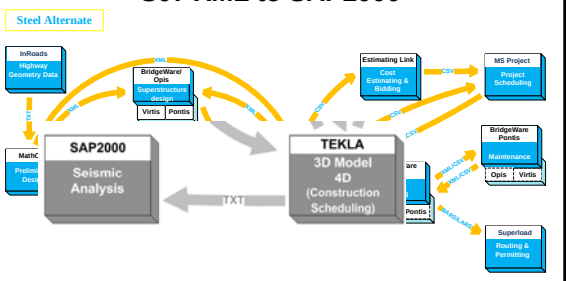



## Interior Girder Section View in Opis




## XML to SAP2000

## S07 XML to SAP2000




## S07 XML to SAP2000

The XML file exported from Tekla


## S07 XML to SAP2000

Open Visual Studio software to execute linkage software

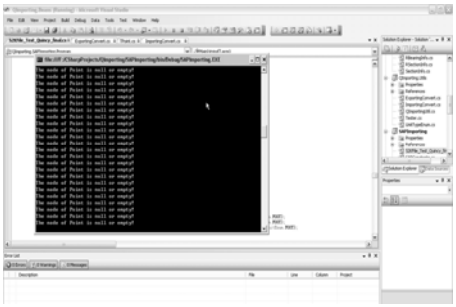
## S07 XML to SAP2000

C# code used to generate text input file

Read data: Degree of Freedom


## S07 XML to SAP2000

Run C# code

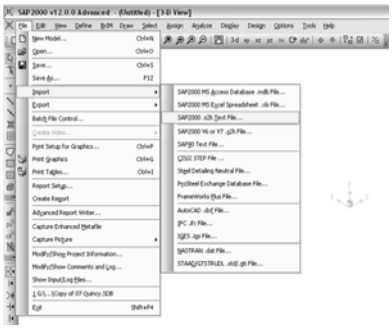



## S07 XML to SAP2000

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

## S07 XML to SAP2000

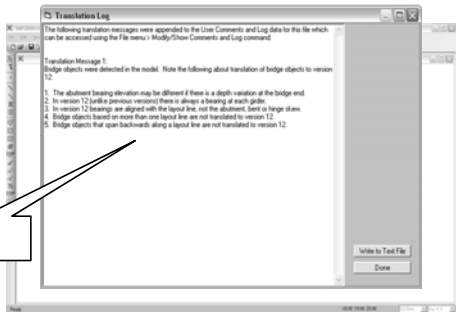
Import text input file (*.s2k file)



## S07 XML to SAP2000

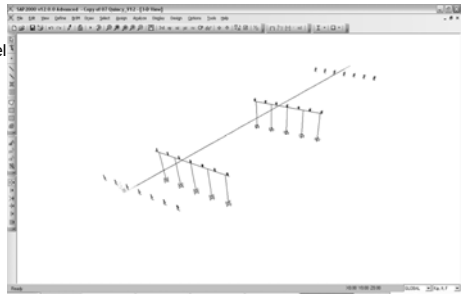
Import log: error and warning information

Translate successfully



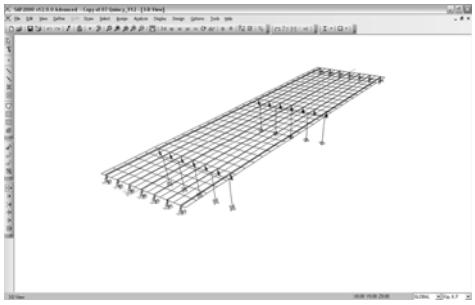

## S07 XML to SAP2000

SAP2000 stick model generated by text input file



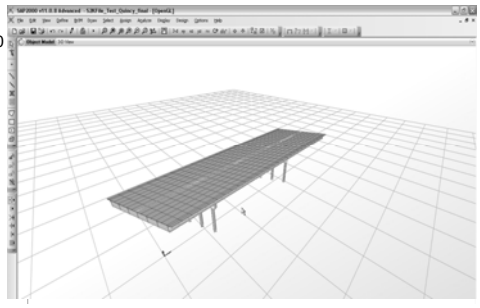
## S07 XML to SAP2000

SAP2000 finite element model



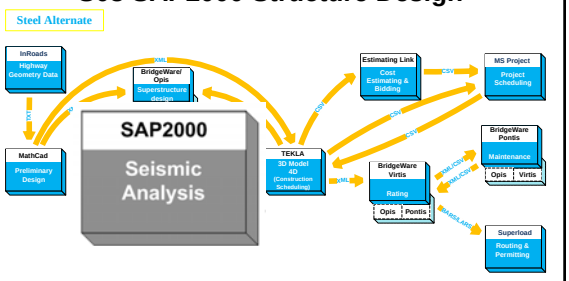
## S07 XML to SAP2000

SAP2000 finite element model extruded view



## Substructure Design in SAP2000

## S08 SAP2000 Structure Design

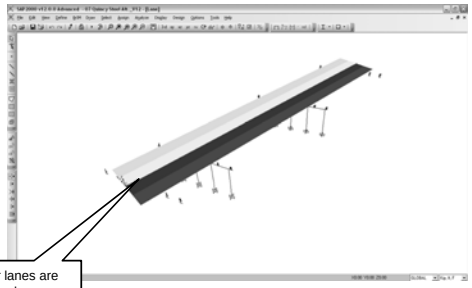



## S08 SAP2000 Structure Design

Define live load: Lane number and Lane width

## S08 SAP2000 Structure Design

Bridge lanes: 4 lanes defined

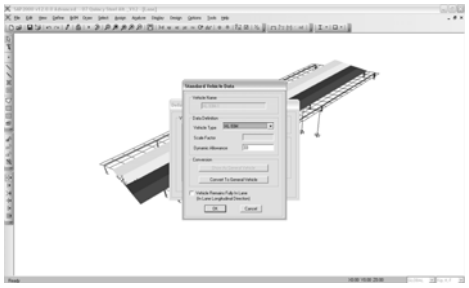


## S08 SAP2000 Structure Design

Bridge lanes on finite element model

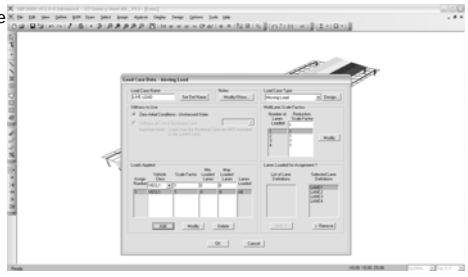
## S08 SAP2000 Structure Design

Define standard vehicle: HL-93



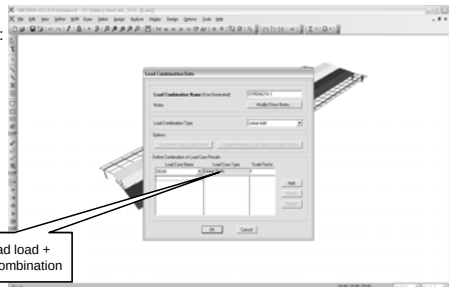
## S08 SAP2000 Structure Design

Define live load case



## S08 SAP2000 Structure Design

Define load combination: Strength 1



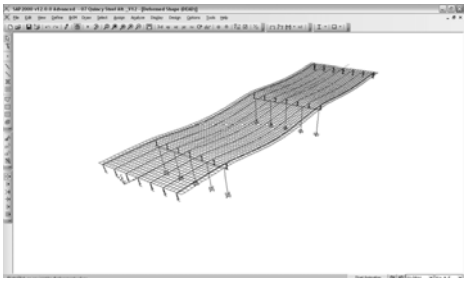
Define dead load + live load combination

## S08 SAP2000 Structure Design

Run analysis: Dead load and live load cases

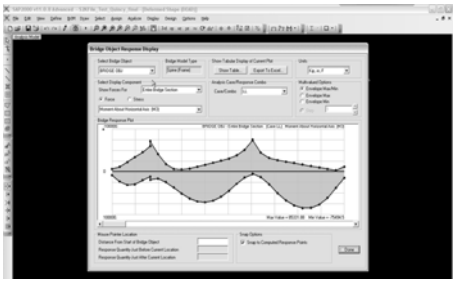
## S08 SAP2000 Structure Design

Deformed shape under dead load



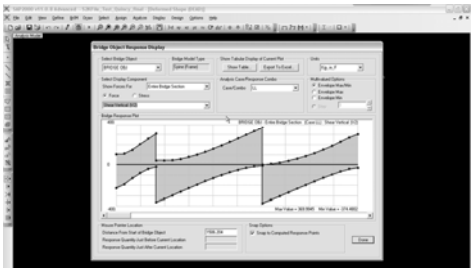
## S08 SAP2000 Structure Design

Moment envelope



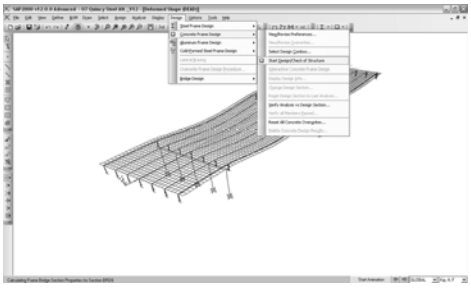
## S08 SAP2000 Structure Design

Shear force envelope



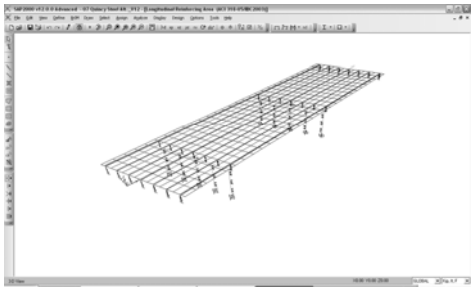
## S08 SAP2000 Structure Design

Start design and check of whole structure



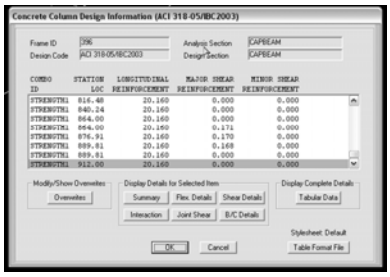
## S08 SAP2000 Structure Design

Sub-structure Design result



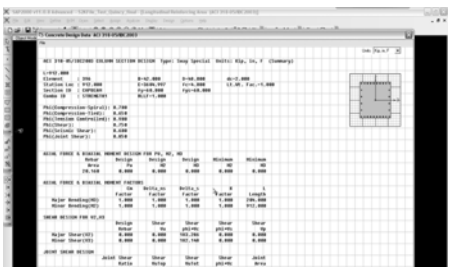
## S08 SAP2000 Structure Design

Substructure design result



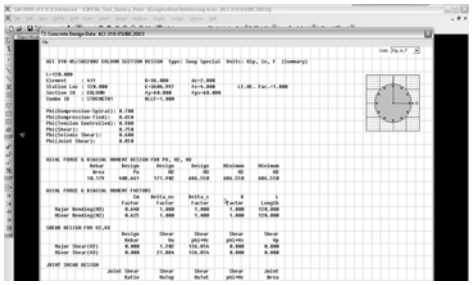

## S08 SAP2000 Structure Design

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…)