



DAVID EVANS
AND ASSOCIATES INC.



2D Grillage Analysis of Curved Steel Box Girders

Presented by
Tim Link, PE

Introduction

Presentation Highlights:

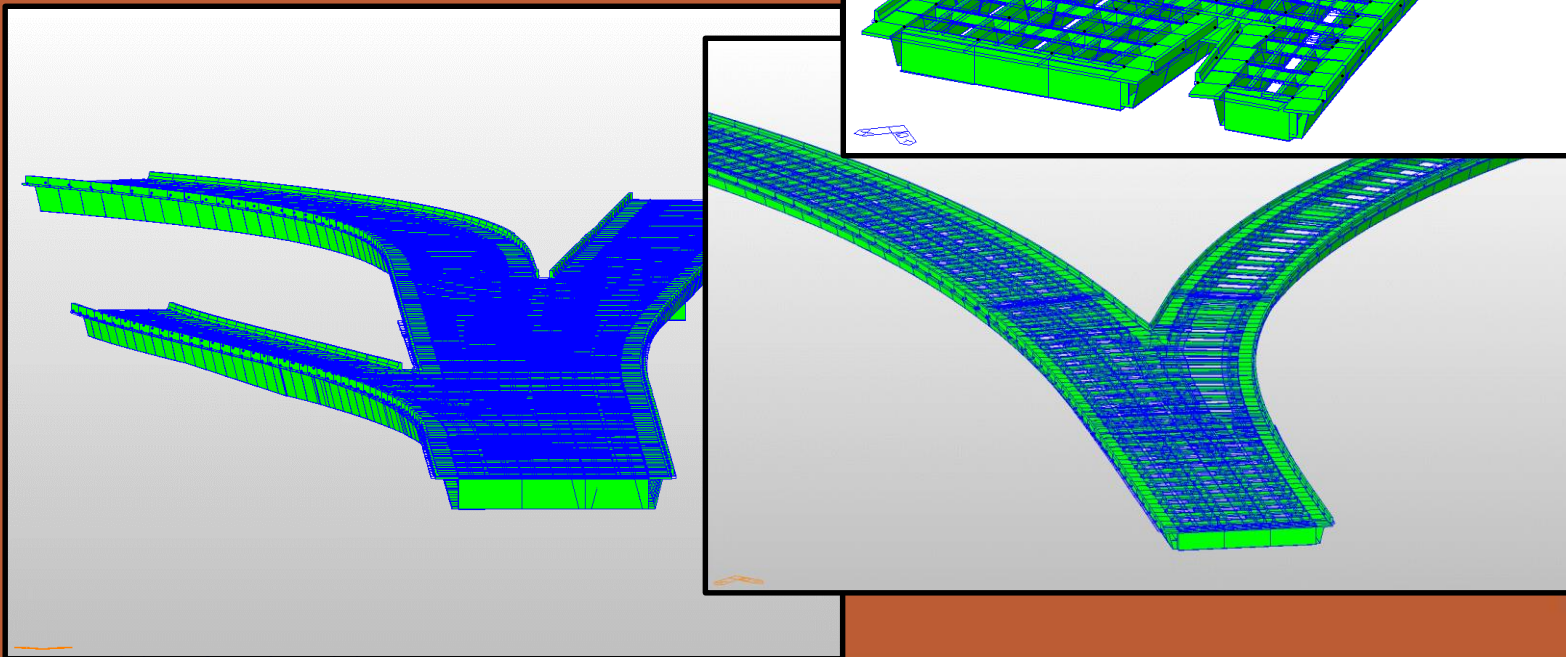
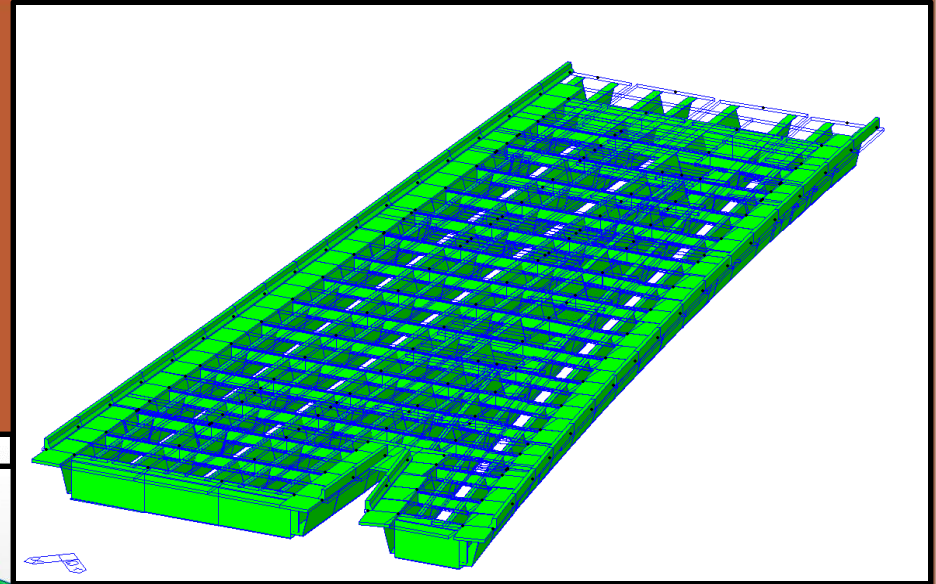
- Use of 2D grillage models as a refined analysis method when AASHTO LLDF can't be used
- Use of Midas MCT Command Shell tool to automate the creation of large complicated bridge models
- Use of Excel workbooks w/ macros to streamline and simplify data input
 - Functioned as the central tool
 - Export/import data from Cad files
 - Export data into Midas (create MCT files)
 - Import girder force effects from Midas and compute rating factors
- Ways to reduce analysis run time of complex Midas Civil Models



Introduction

Presentation Outline:

- Project Overview
- Load Rating Overview
- Fremont Bridge Overview
- Midas Modeling
- Conclusion
- Q&A



Project Overview


- The work I'm presenting was part of two separate projects for ODOT
- Rated 26 steel box girder (SBG) bridges in Oregon
 - Included bridges with curved girders, large skews, splayed/flared girders, bifurcated/splitting girders, splitting decks, and even two railroad car bridges
 - The bridges were split into 3 groups
- Developed SBG load rating procedures and tools for ODOT
 - Will be included in the next version of the ODOT LRFR manual
- Involved a large project team
 - Project managers:
 - Lwin Hwee, PE, PMP
 - Joel B. Tubbs, PE, SE
 - Matthew D. Harland, PE, ENV SP
 - Special recognition to Eric Ferluga, PE
 - Significantly contributed to the development of the Excel workbooks and macros used to generate the MCT files



Load Rating Overview

Topics:

- General load rating process
- ODOT LRFR procedures
- SBG load rating process
- SBG live load distribution factors (LLDF)



OREGON D.O.T. BRIDGE SECTION
LRFR LOAD RATING SUMMARY REPORT (PAGE 1)
Latest Revision: 10/5/2016

QUALITY CONTROL...

FIRM QC: Carly Clark, Rachel Bassil, Antonio Mittiero, Eric Ferluga, Joel Tubbs ODOT QC CHECK BY:

BRIDGE DATA...

BRIDGE #: 08958B NBI FEATURE: City Streets RR

BRIDGE NAME: Hwy 61 over City Strs & RR (E Fremont Bridge Appr)

HIGHWAY NAME: Stadium Freeway HIGHWAY #: 061

REGION: 1 DIST: 2B COUNTY: Multnomah MILEPOST: 3.72

YEAR BUILT: 1973 DESIGN LOADING: HS20 OWNER: ODOT

SPAN DESCR: 2 levels of 1-15' Cant, 1-162', 1-194', 1-190', 1-142' St Box Gir

OTHER DESCR: (2 levels of 703' St Box Gir: Units "EW-3" & "WE-4")

LOAD RATING ENGINEER DATA...

RATING DATE: 6/30/17 FIRM: David Evans and Associates, Inc LOAD RATER: Tim Link, Eric Ferluga CALCULATION BOOK:

LATEST INSPECTION DATA...

INSP. DATE: 2/7/17 ADT: 122,400 ADTT: 8,568 YEAR of ADT (2 digits): 14 A.C. DEPTH, INCHES: 0.0

DECK: 5 SUPERSTR.: 6 SUBSTR.: 7 IMPACT ASSESSMENT (Elem. 325): CS2

CONDITION RATINGS ---->

RATING DATA...

LRFR FACTORS: IMPACT 1+I: 1.20 γ_{DC} : 1.25 γ_{DW} : 1.50

LRFR RATINGS FOR N.B.I.: INVENTORY (Item 66): Tons 27.0 OPERATING (Item 64): Tons 35.0

SECTIONS EVALUATED: 1207 COMMENTS:

NBI STATUS ITEMS:

Operational Status (Item 41):	A
Bridge Posting Status (Item 70):	5
Temporary Status (Item 103):	

LOAD:	γ_L	1st rating control						2nd rating control							
		R.F.	Limit State	Force Type	Φ	CONTROLLING... MEMBER	SPAN	LOCATION	R.F.	Limit State	Force Type	Φ	CONTROLLING... MEMBER	SPAN	LOCATION
DESIGN & LEGAL VEHICLES															
HL93 (INVENTORY)	1.750	0.75	St1	-M	1.000	Tub A (L)	2 of 5	0.000L	0.89	St1	-M	1.000	Tub B (L)	2 of 5	0.000L
TYPE 3 (50K)	1.390	2.27	St1	-M	1.000	Tub A (L)	2 of 5	0.000L	2.38	St1	+M	0.900	Floorbeam	1 of 1	0.5L
TYPE 3S2 (80K)	1.390	1.71	St1	-M	1.000	Tub A (L)	2 of 5	0.000L	2.04	St1	-M	1.000	Tub B (L)	2 of 5	0.000L
TYPE 3-3 (80K)	1.390	1.80	St1	-M	1.000	Tub A (L)	2 of 5	0.000L	2.13	St1	-M	1.000	Tub B (L)	2 of 5	0.000L
TYPE 3-3 & LEGAL LANE	1.390	3.61	St1	-M	1.000	Tub D (L)	3 of 5	0.857L	3.78	St1	-M	1.000	Tub D (L)	3 of 5	0.157L



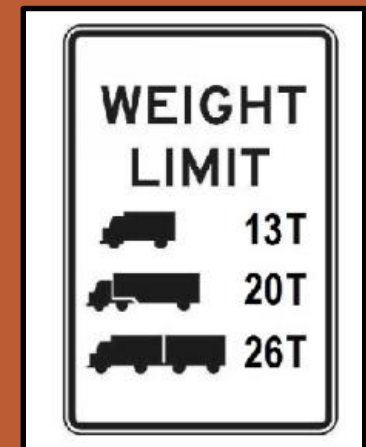
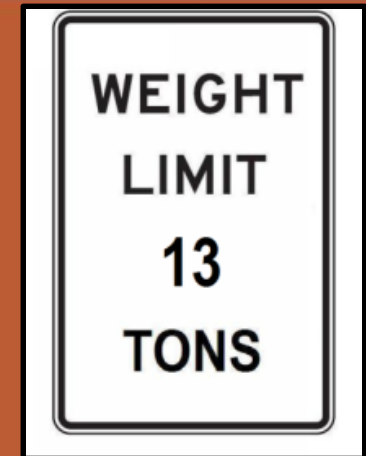
Load Rating Overview

General Load Rating Process

- Evaluates the bridge capacity (moment, shear, bearing, and service limits) to carry current vehicles (design, legal, permit)
 - Calculates a rating factor for each vehicle rather than a design ratio (capacity/demand)
- Accounts for the current bridge condition
- Used to identify the need for load posting or strengthening and make overweight-vehicle permit decisions
- Used in bridge management systems to prioritize bridge repairs and replacements

$$RF = \frac{\text{Available Load Capacity}}{\text{Load of Vehicle Considered}}$$

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_p)(P)}{(\gamma_L)(LL + IM)}$$



Load Rating Overview

ODOT LRFR Procedures

ODOT LRFR Manual



November, 2015



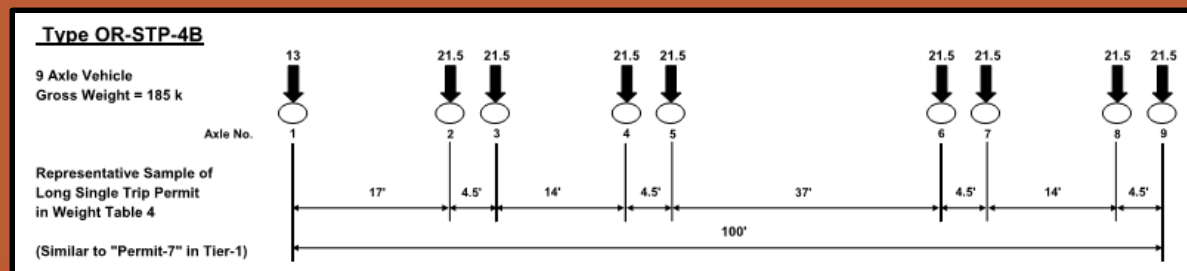
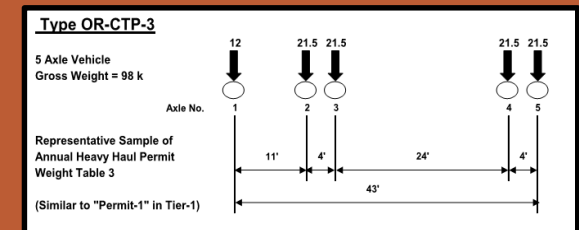
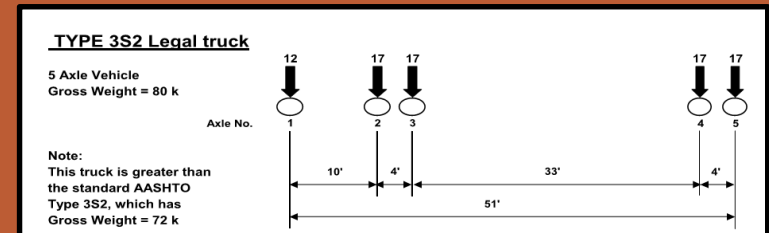
- ODOT LRFR Load Rating Manual outlines procedures for seven unique structure types, pin and hanger connections, and crossbeams
- Current manual version does not cover steel box girders
- BRASS is used as the primary analysis software
- Midas Civil is used for structure types not applicable to BRASS to determine load effects and Excel workbooks are used to calculate capacities and rating factors



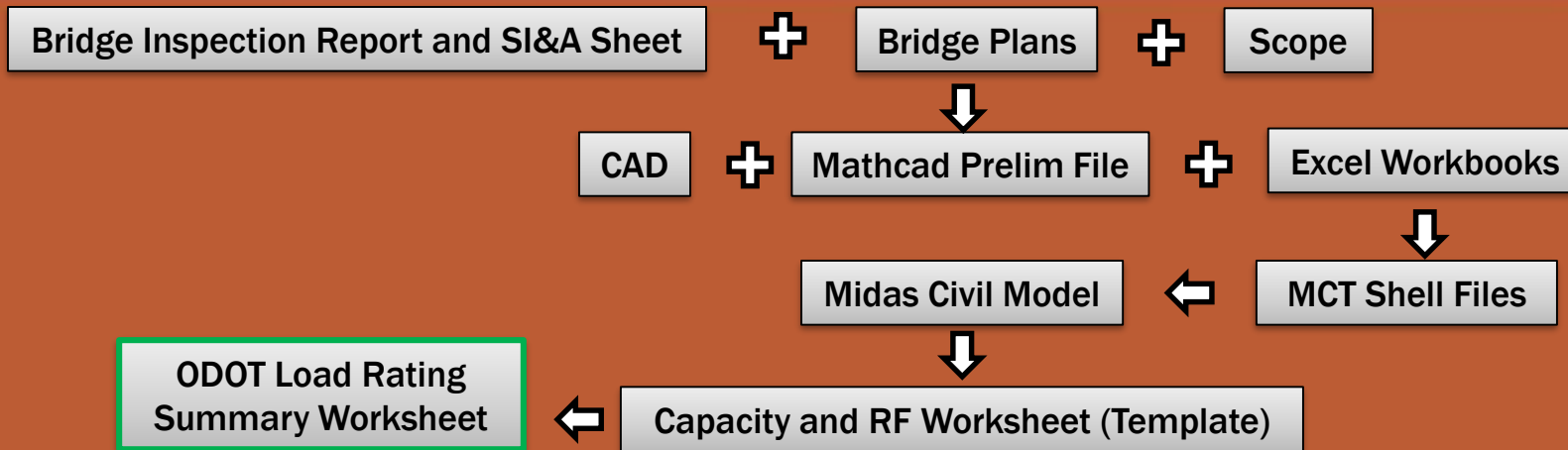
Load Rating Overview

ODOT LRFR Procedures

- Rating factors are computed for the design load, legal vehicles, and permit vehicles
 - 23-24 live load definitions
- Design Load
 - HL-93
- ODOT Legal Trucks
 - Used to base posting decisions
 - type 3, type 3S2, type 3-3, legal lane and combinations
 - ODOT type 3S2 is heavier than the vehicle in the MBE manual
- Specialized Hauling Vehicles (SHVs)
 - SU4, SU5, SU6, and SU7
- ODOT Continuous Trip Permit (CTP) Trucks
 - OR-CTP-2A, OR-CTP-2B, and OR-CTP-3
- ODOT Single Trip Permit (STP) Trucks
 - OR-STP-3, OR-STP-4A, OR-STP-4B, OR-STP-4C, OR-STP-4D, OR-STP-4E, and OR-STP-5BW



SBG Load Rating Process



MCT Com

Unit System

Clipboard Font Alignment Number

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Tim Link Share

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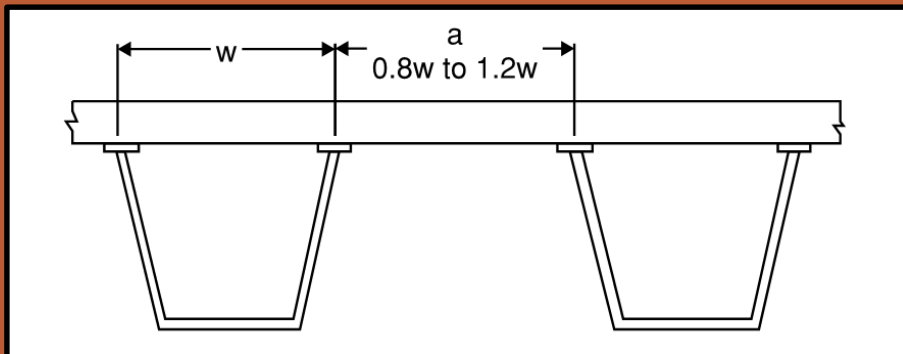
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Load Rating Overview

SBG Live Load Distribution Factors – AASHTO LRFD

- Special restrictions per sections 4.6.2.2 and 6.11.2.3
 - Bridge shall not be curved
 - Bearing lines shall not be skewed
 - Bridge shall consist of two or more single-cell box sections
 - The distance c-t-c (w) of the top flanges of individual tub girders shall be the same
 - The inclination of the web shall not exceed 1 to 4 (horizontal to vertical) to a plane normal to the bottom flange
 - Must be within a/w ratio limits
 - Deck overhang cannot exceed 60% of the average “ a ” distance nor 6ft
 - Deck width must be constant*
 - Beams have approximately the same stiffness

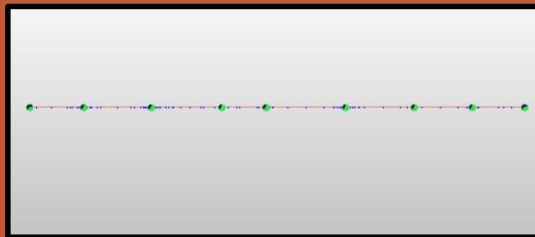


Load Rating Overview

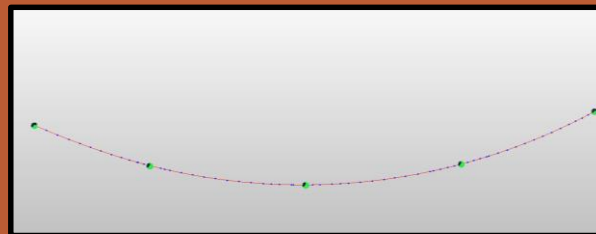
SBG Live Load Distribution Factors – Project Application

- The 26 SBG bridges in the project were split into 3 groups

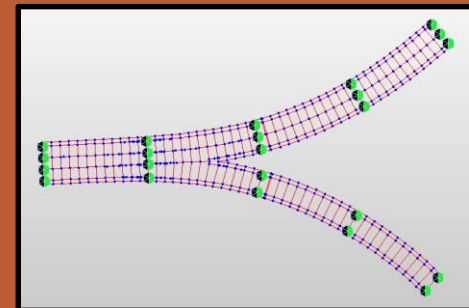
Group	Criteria	Model Description	Live Load Application
A	-slight to no curvature -parallel girders -up to approx. 10° skew	-single straight girder line models -span length = arc length for slight curvature	-AASHTO LLDF -Lever Rule when AASHTO LLDF girder spacing limit was exceed
B	-curved bridges -parallel girders -slight variable skews (11° max)	-single curved girder line models -model captured torsional effects due to the curvature	-Lever Rule
C	-highly complex -curved girders -splayed/flared girders -bifurcated/splitting girders -skews greater than approx. 10°	-2D grillage models	-Multiple lanes defined within the 2D grillage model



Group A



Group B



Group C



Fremont Bridge Overview

Topics:

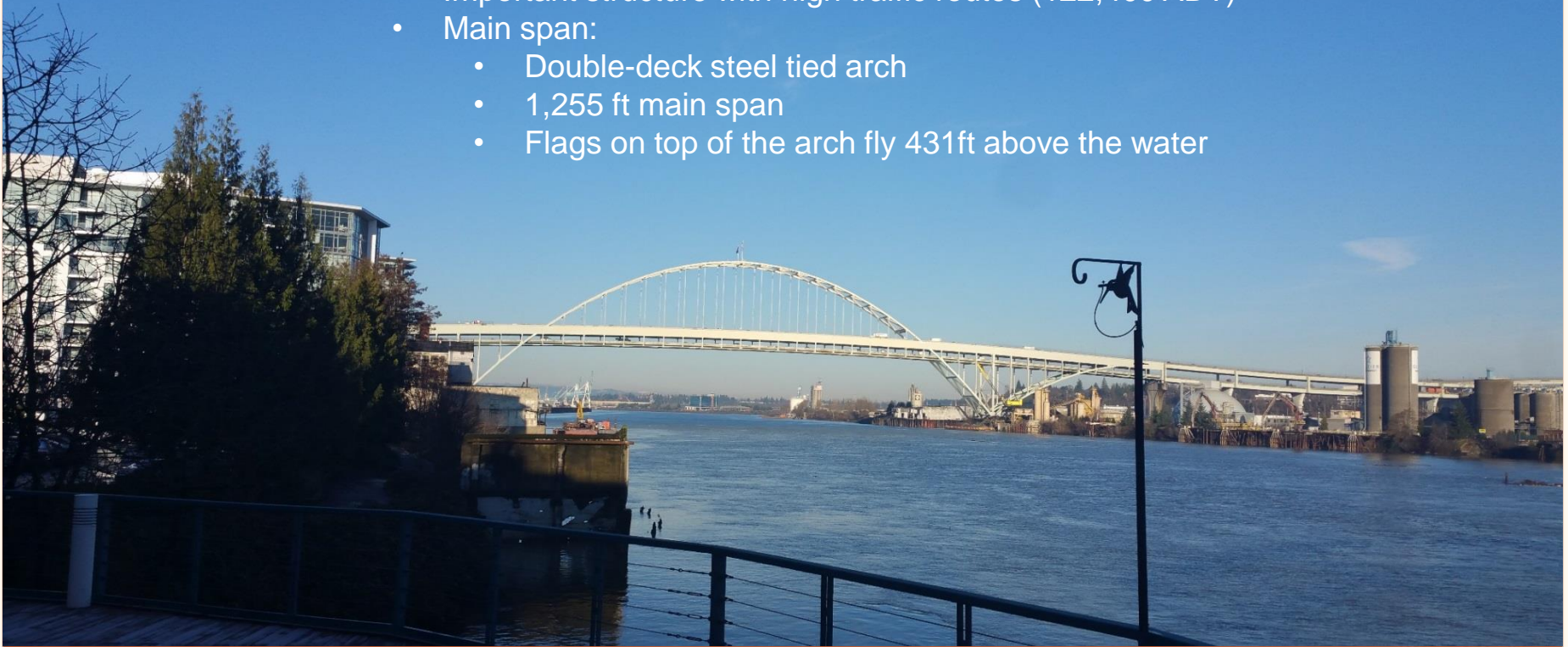
- General Bridge Information
- Primary East Approach Ramps — focus of this presentation



Fremont Bridge Overview

General Bridge Information

- Main span crosses the Willamette River in downtown Portland, Oregon
- Built in 1973
- Important structure with high traffic routes (122,400 ADT)
- Main span:
 - Double-deck steel tied arch
 - 1,255 ft main span
 - Flags on top of the arch fly 431ft above the water



Fremont Bridge Overview

General Bridge Information

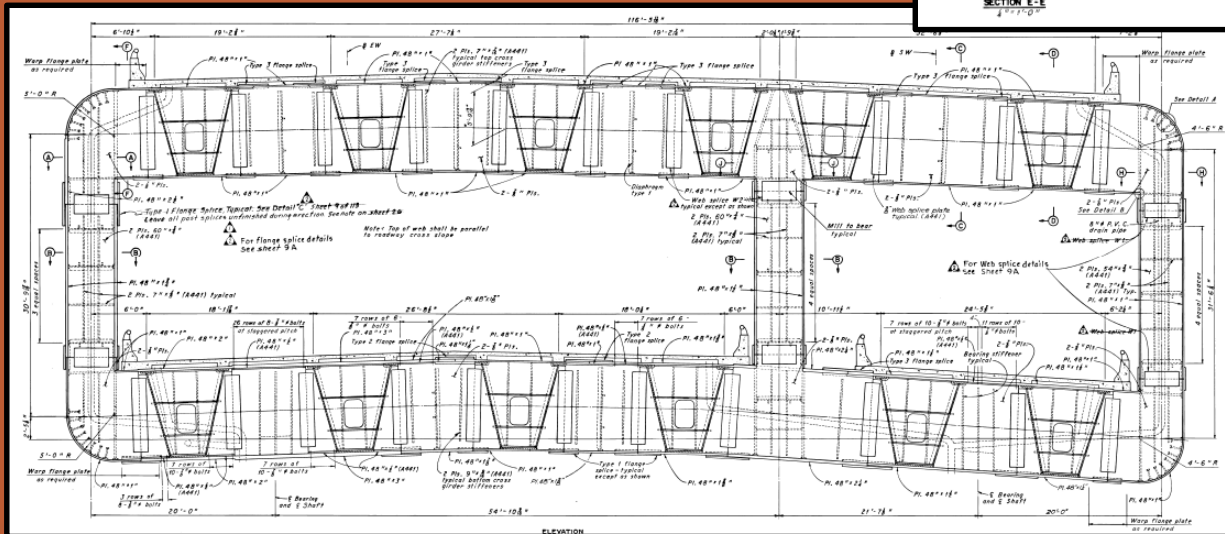
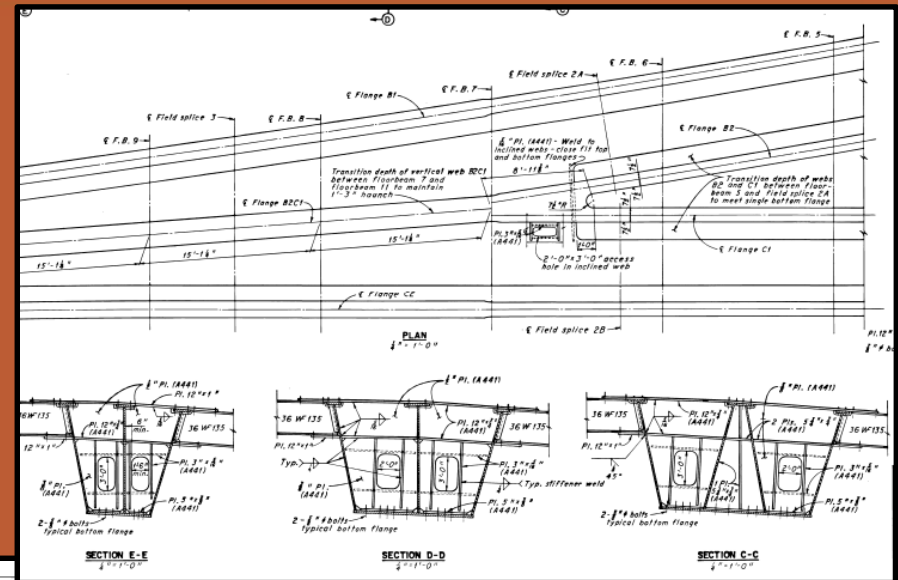
- Approach spans:
 - Steel box girders and reinforced concrete box girders
 - 15 different bridges
 - East approach ramps connection I-5 and city streets to I-405
 - West approach ramps connection Highway 30 to I-405
 - DEA load rated all of the approach bridges and inspected the East approach bridges



Fremont Bridge Overview

Primary East Approach Ramps:

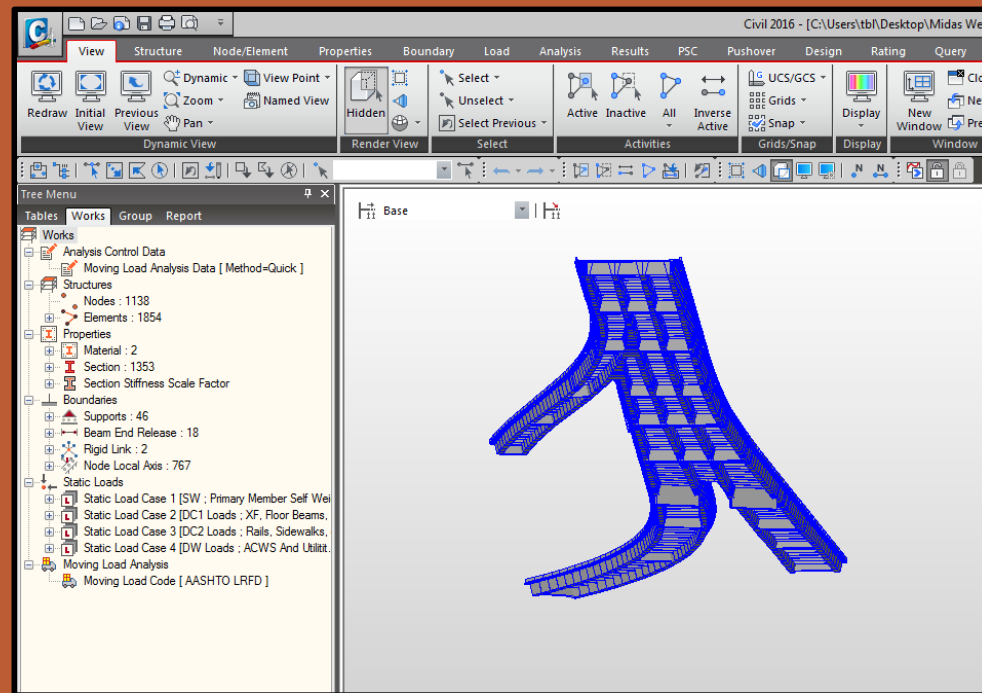
- Bridge Numbers 08958 and 08958B
- Double deck structures
- Up to six girder lines per deck
- Curved girders
- Splayed/flared girders
- Bifurcated/splitting girders
- Tapering web depths
- Many cross-section changes
- Skewed supports
- Splitting decks
- In-span pin and hanger expansion joints



Midas Modeling

Topics:

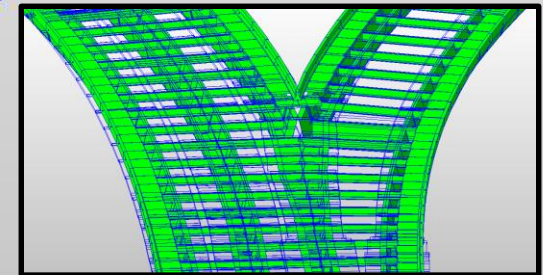
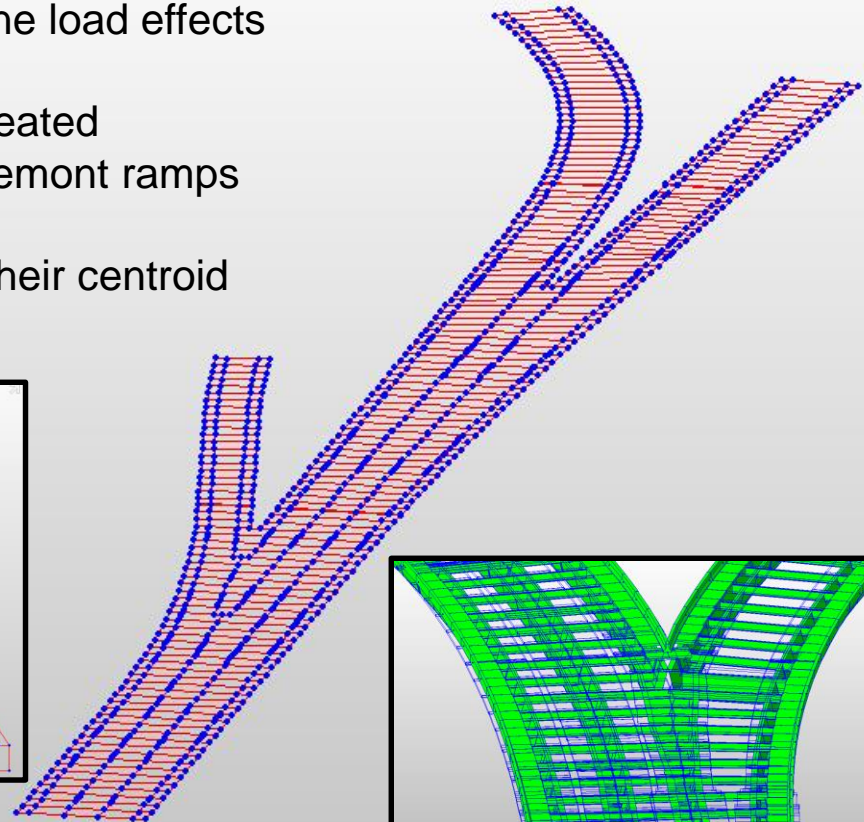
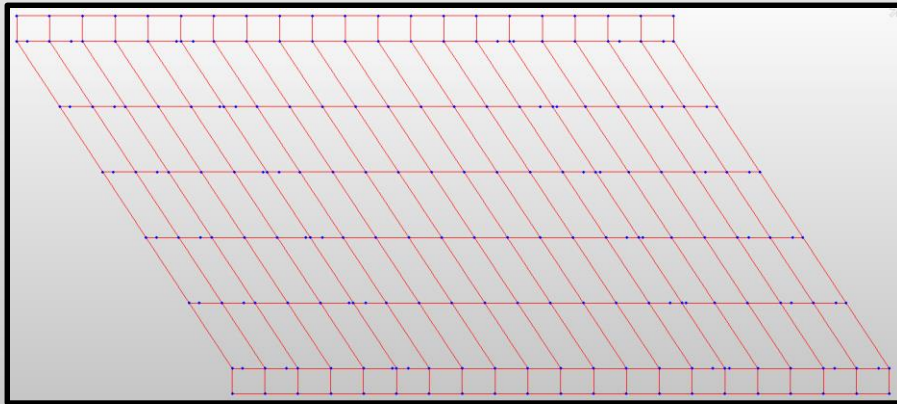
- 2D grillage models
- Model creation using Midas MCT command shell files
- Model analysis
- Model verification
- Model output



Midas Modeling

2D Grillage Models

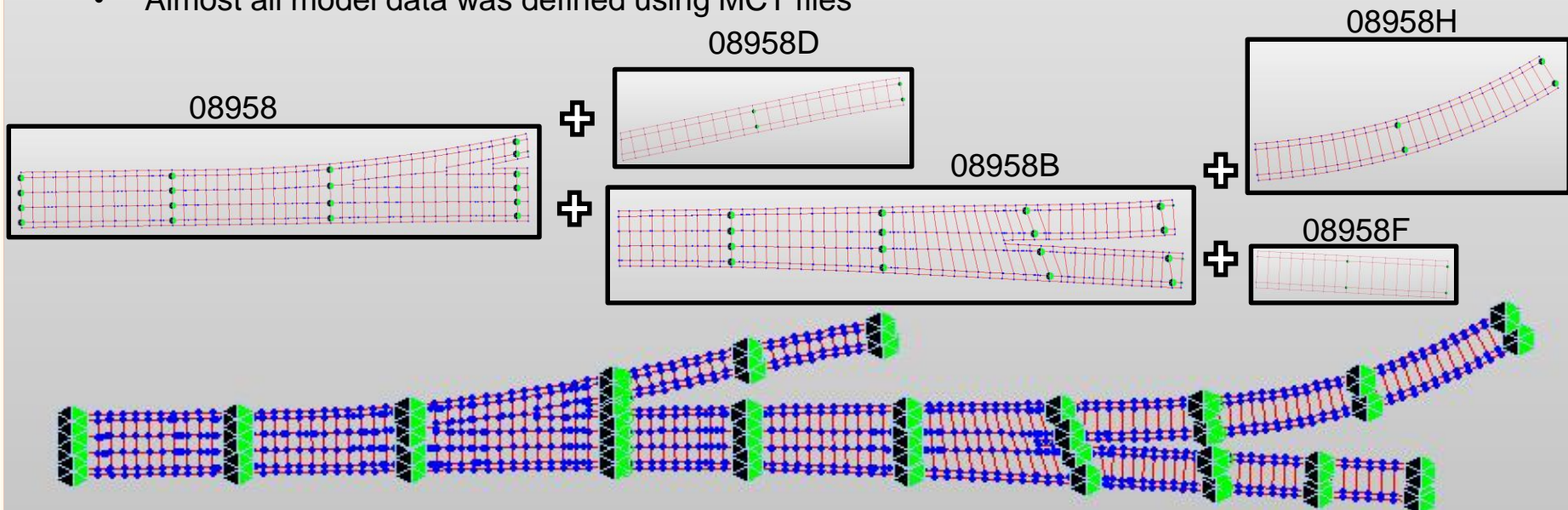
- Refined analysis method used to determine load effects for the bridges in Group C
 - 9 unique 2D grillage models were created
 - 3 complex double-deck bridges – Fremont ramps
 - 3 heavily skewed bridges
- 2D model – All elements modeled about their centroid on a horizontal x-y plane



Midas Modeling

2D Grillage Models – Lower 08958 / 08958B Model

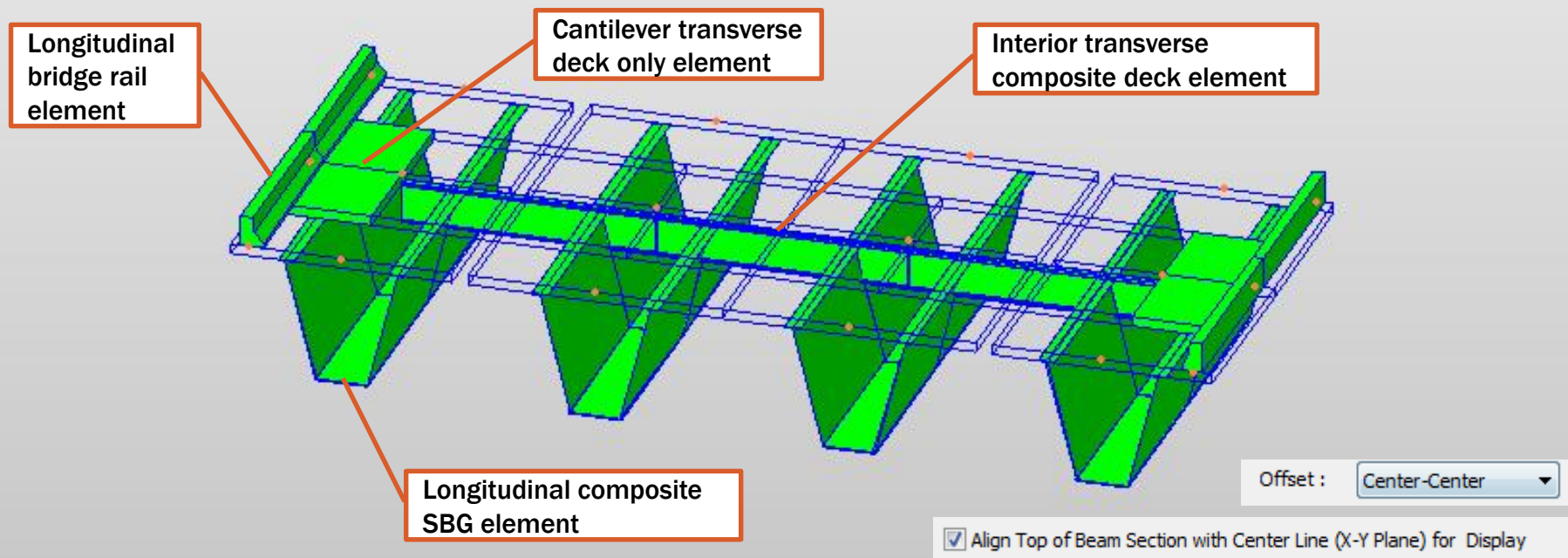
- Bridges 08958 and 08958B were modeled together
 - Using two separate models would require applying dead and live load reactions to the supporting pin and hanger span
- Two spans of three additional approach ramp bridges included
- 1,138 nodes, 1,835 elements, and 1,352 sections
- Multiple traffic line lanes applied for each girder – LL applied to crossbeams
- Almost all model data was defined using MCT files



Midas Modeling

2D Grillage Models – Lower 08958 / 08958B Model

- Individual girder lines are connected with interior transverse composite deck elements at floorbeam and pier nodes
- Cantilever transverse deck only elements are used to model the deck overhang
- Longitudinal bridge rail elements connect free end of cantilever transverse elements

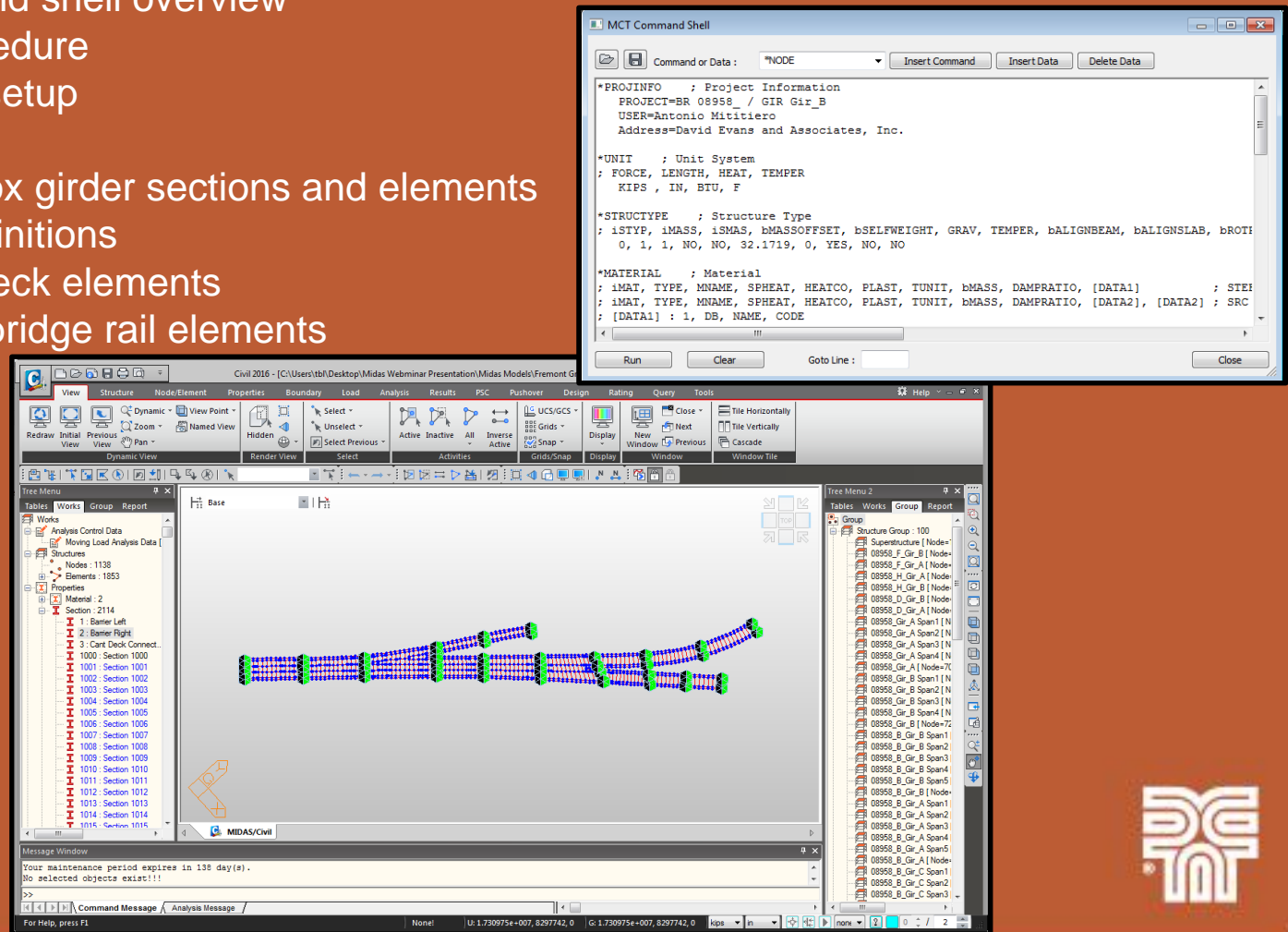


Midas Modeling

Model Creation Using Midas MCT Command Shell Files

Topics

- MCT command shell overview
- General procedure
- Initial model setup
- Nodes
- Composite box girder sections and elements
- Boundary definitions
- Transverse deck elements
- Longitudinal bridge rail elements
- Dead loads
- Live loads



Midas Modeling

MCT Model Creation – MCT Command Shell Overview

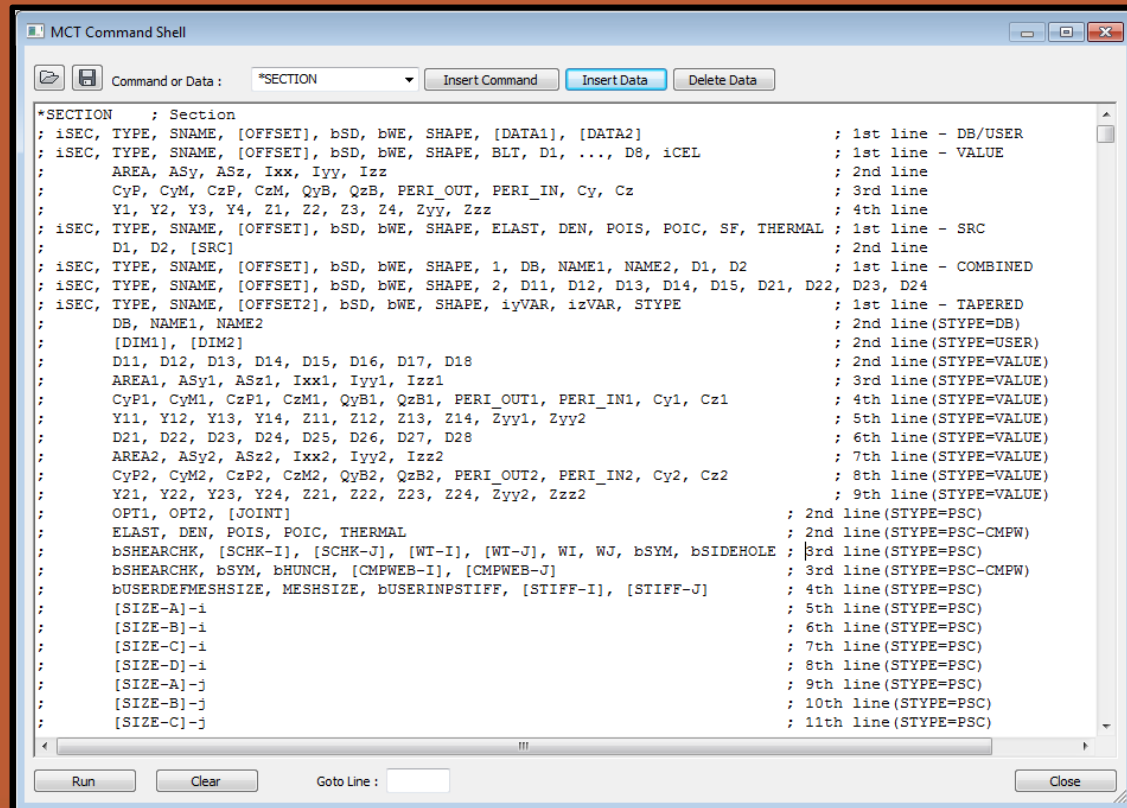
- Allows the use of text commands to create the model data instead of creating the data within the GUI environment
- Speeds up model data creation for repetitive definitions
- Valuable tool for complex models where defining model data in the GUI environment or Bridge Wizard is not practical
- Can reduce errors in model data
 - Less buttons to click
 - Avoids accidentally element/node selections
 - Can use checked developed workbooks to automate the creation of the MCT shell files
- Almost everything can be defined with MCT files
- ODOT has several MCT files available to use to define live load definitions, analysis options, dynamic report data, etc.



Midas Modeling

MCT Model Creation – MCT Command Shell Overview

- Inserting a command within the MCT Command Shell window populates the text command AND a description of the command parameters
- Can create MCT file from model data defined within the GUI environment
 - Very helpful for getting familiar with the format of different commands



The screenshot shows the MCT Command Shell window. At the top, there is a menu bar with 'Command or Data' and a dropdown menu showing '*SECTION'. Below the menu bar are three buttons: 'Insert Command', 'Insert Data', and 'Delete Data'. The main area of the window contains a list of commands and their parameters, organized into sections. The commands are listed on the left, and their descriptions are on the right. The commands are: *SECTION, iSEC, AREA, CyP, Y1, iSEC, iSEC, iSEC, DB, [DIM1], AREA1, CyP1, Y11, D21, AREA2, CyP2, Y21, OPT1, ELAST, bSHEARCHK, bSHEARCHK, bUSERDEFMESH, [SIZE-A], [SIZE-B], [SIZE-C], [SIZE-D], [SIZE-A], [SIZE-B], [SIZE-C]. The descriptions are: Section, iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, [DATA1], [DATA2], iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, BLT, D1, ..., D8, iCEL, AREA, ASy, ASz, Ixx, Iyy, Izz, CyP, CyM, CzP, CzM, QyB, QzB, PERI_OUT, PERI_IN, Cy, Cz, Y1, Y2, Y3, Y4, Z1, Z2, Z3, Z4, Zyy, Zzz, iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, ELAST, DEN, POIS, POIC, SF, THERMAL, D1, D2, [SRC], iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, 1, DB, NAME1, NAME2, D1, D2, iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, 2, D11, D12, D13, D14, D15, D21, D22, D23, D24, iSEC, TYPE, SNAME, [OFFSET2], bSD, bWE, SHAPE, iyVAR, izVAR, STYPE, DB, NAME1, NAME2, [DIM1], [DIM2], D11, D12, D13, D14, D15, D16, D17, D18, AREA1, ASy1, ASz1, Ixx1, Iyy1, Izz1, CyP1, CyM1, CzP1, CzM1, QyB1, QzB1, PERI_OUT1, PERI_IN1, Cy1, Cz1, Y11, Y12, Y13, Y14, Z11, Z12, Z13, Z14, Zyy1, Zyy2, D21, D22, D23, D24, D25, D26, D27, D28, AREA2, ASy2, ASz2, Ixx2, Iyy2, Izz2, CyP2, CyM2, CzP2, CzM2, QyB2, QzB2, PERI_OUT2, PERI_IN2, Cy2, Cz2, Y21, Y22, Y23, Y24, Z21, Z22, Z23, Z24, Zyy2, Zzz2, OPT1, OPT2, [JOINT], ELAST, DEN, POIS, POIC, THERMAL, bSHEARCHK, [SCHK-I], [SCHK-J], [WI-I], [WI-J], WI, WJ, bSYM, bSIDEHOLE, bSHEARCHK, bSYM, bHUNCH, [CMPWEB-I], [CMPWEB-J], bUSERDEFMESH, MESH, MESH, bUSERINPSTIFF, [STIFF-I], [STIFF-J], [SIZE-A]-1, [SIZE-B]-1, [SIZE-C]-1, [SIZE-D]-1, [SIZE-A]-J, [SIZE-B]-J, [SIZE-C]-J. The descriptions are: 1st line - DB/USER, 1st line - VALUE, 2nd line, 3rd line, 4th line, 1st line - SRC, 2nd line, 1st line - COMBINED, 2nd line (STYPE=DB), 2nd line (STYPE=USER), 2nd line (STYPE=VALUE), 3rd line (STYPE=VALUE), 4th line (STYPE=VALUE), 5th line (STYPE=VALUE), 6th line (STYPE=VALUE), 7th line (STYPE=VALUE), 8th line (STYPE=VALUE), 9th line (STYPE=VALUE), 2nd line (STYPE=PSC), 2nd line (STYPE=PSC-CMPW), 3rd line (STYPE=PSC), 3rd line (STYPE=PSC-CMPW), 4th line (STYPE=PSC), 5th line (STYPE=PSC), 6th line (STYPE=PSC), 7th line (STYPE=PSC), 8th line (STYPE=PSC), 9th line (STYPE=PSC), 10th line (STYPE=PSC), 11th line (STYPE=PSC). At the bottom, there are buttons for 'Run', 'Clear', 'Goto Line', and 'Close'.

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*SECTION ; Section
; iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, [DATA1], [DATA2] ; 1st line - DB/USER
; iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, BLT, D1, ..., D8, iCEL ; 1st line - VALUE
; ; 2nd line
; AREA, ASy, ASz, Ixx, Iyy, Izz ; 3rd line
; CyP, CyM, CzP, CzM, QyB, QzB, PERI_OUT, PERI_IN, Cy, Cz ; 4th line
; Y1, Y2, Y3, Y4, Z1, Z2, Z3, Z4, Zyy, Zzz ; 4th line
; iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, ELAST, DEN, POIS, POIC, SF, THERMAL ; 1st line - SRC
; D1, D2, [SRC] ; 2nd line
; iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, 1, DB, NAME1, NAME2, D1, D2 ; 1st line - COMBINED
; iSEC, TYPE, SNAME, [OFFSET], bSD, bWE, SHAPE, 2, D11, D12, D13, D14, D15, D21, D22, D23, D24
; iSEC, TYPE, SNAME, [OFFSET2], bSD, bWE, SHAPE, iyVAR, izVAR, STYPE ; 1st line - TAPERED
; DB, NAME1, NAME2 ; 2nd line (STYPE=DB)
; [DIM1], [DIM2] ; 2nd line (STYPE=USER)
; D11, D12, D13, D14, D15, D16, D17, D18 ; 2nd line (STYPE=VALUE)
; AREA1, ASy1, ASz1, Ixx1, Iyy1, Izz1 ; 3rd line (STYPE=VALUE)
; CyP1, CyM1, CzP1, CzM1, QyB1, QzB1, PERI_OUT1, PERI_IN1, Cy1, Cz1 ; 4th line (STYPE=VALUE)
; Y11, Y12, Y13, Y14, Z11, Z12, Z13, Z14, Zyy1, Zyy2 ; 5th line (STYPE=VALUE)
; D21, D22, D23, D24, D25, D26, D27, D28 ; 6th line (STYPE=VALUE)
; AREA2, ASy2, ASz2, Ixx2, Iyy2, Izz2 ; 7th line (STYPE=VALUE)
; CyP2, CyM2, CzP2, CzM2, QyB2, QzB2, PERI_OUT2, PERI_IN2, Cy2, Cz2 ; 8th line (STYPE=VALUE)
; Y21, Y22, Y23, Y24, Z21, Z22, Z23, Z24, Zyy2, Zzz2 ; 9th line (STYPE=VALUE)
; OPT1, OPT2, [JOINT] ; 2nd line (STYPE=PSC)
; ELAST, DEN, POIS, POIC, THERMAL ; 2nd line (STYPE=PSC-CMPW)
; bSHEARCHK, [SCHK-I], [SCHK-J], [WI-I], [WI-J], WI, WJ, bSYM, bSIDEHOLE ; 3rd line (STYPE=PSC)
; bSHEARCHK, bSYM, bHUNCH, [CMPWEB-I], [CMPWEB-J] ; 3rd line (STYPE=PSC-CMPW)
; bUSERDEFMESH, MESH, MESH, bUSERINPSTIFF, [STIFF-I], [STIFF-J] ; 4th line (STYPE=PSC)
; [SIZE-A]-1 ; 5th line (STYPE=PSC)
; [SIZE-B]-1 ; 6th line (STYPE=PSC)
; [SIZE-C]-1 ; 7th line (STYPE=PSC)
; [SIZE-D]-1 ; 8th line (STYPE=PSC)
; [SIZE-A]-J ; 9th line (STYPE=PSC)
; [SIZE-B]-J ; 10th line (STYPE=PSC)
; [SIZE-C]-J ; 11th line (STYPE=PSC)
```



Midas Modeling

MCT Model Creation – MCT Command Shell Overview

- MCT File Quick Reference
 - http://manual.midasuser.com/EN_TW/Civil/820/Start/14_Appendix/MCT_File_Quick_Reference.htm
 - Describes common command parameters in a more use friendly manner

MCT File Quick Reference



***COMMAND** (Functions of midas Civil)

Brief descriptions of the Commands

; Variables that make up the Commands

Description of each variable (method of expression) {initialized value}

* X,Y,Z axis: Basis of Global coordinates

x,y,z axis: Basis of nodal or element local coordinates

***VERSION**

Shows the version of midas Civil



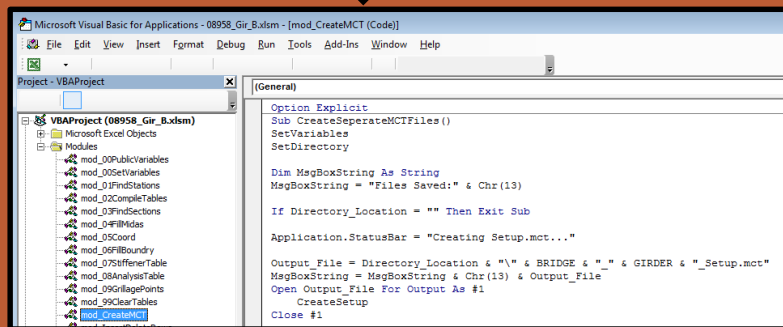
Midas Modeling

MCT Model Creation – General Procedure

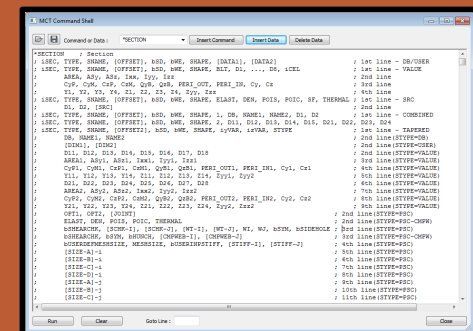
- 1) Create Excel workbook to input model data parameters
- 2) Create macros within the workbook to transform the input data into the appropriate MCT command shell format
- 3) Open and run the created MCT file in Midas

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							
13																							
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15																							
16																							

1) Excel Workbook



2) Macro



3) Midas MCT



Midas Modeling

MCT Model Creation – General Procedure

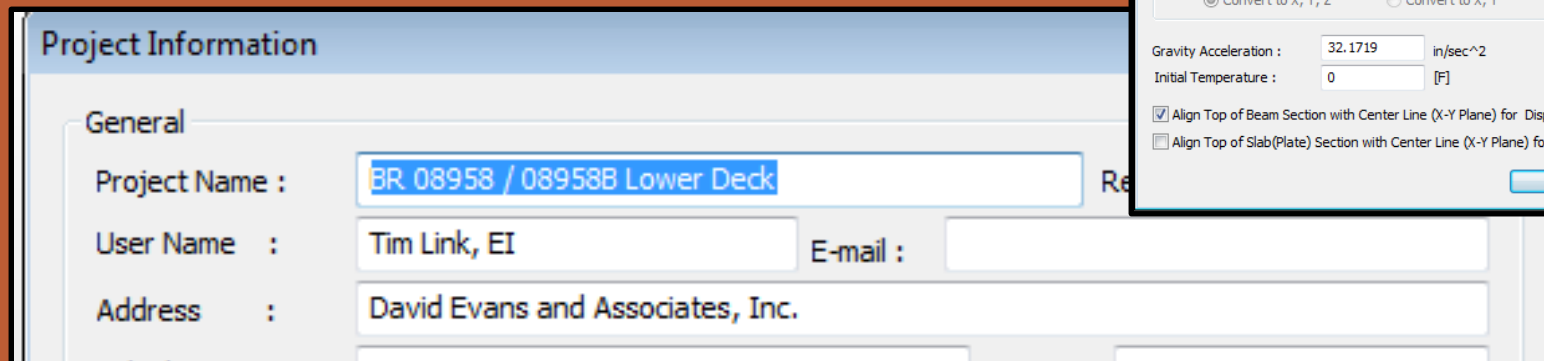
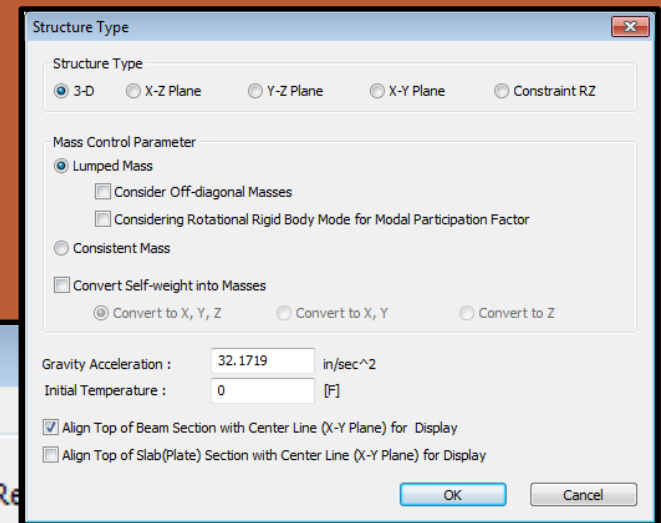
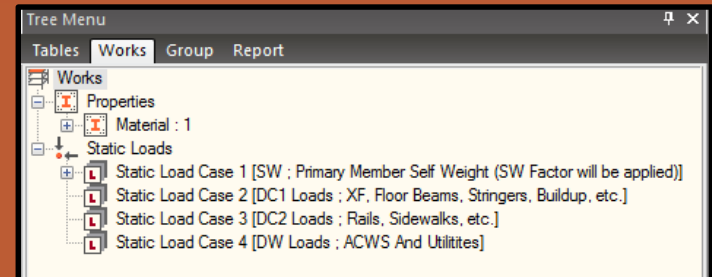
- 1) Use a workbook to create MCT files for each girder line of each bridge
 - MCT files creates initial model setup, nodes, supports, sections, elements, loads, and structure groups for each span
- 2) Use a workbook to create MCT files for the interior transverse deck elements
 - MCT files creates modified concrete material property, composite/noncomposite deck sections, interior deck elements, and structure groups
- 3) Use a workbook to create MCT files for the exterior transverse deck elements and longitudinal bridge rail elements
 - MCT files create edge of deck nodes at each floorbeam/pier, cantilever deck section, stiffness scale factors, bridge rail elements, and structure groups
- 4) Use a workbook to create MCT files for the moving load definitions
 - MCT files create moving load code, vehicles, moving load cases, moving load sub cases, and traffic line lanes



Midas Modeling

MCT Model Creation – Initial Model Setup

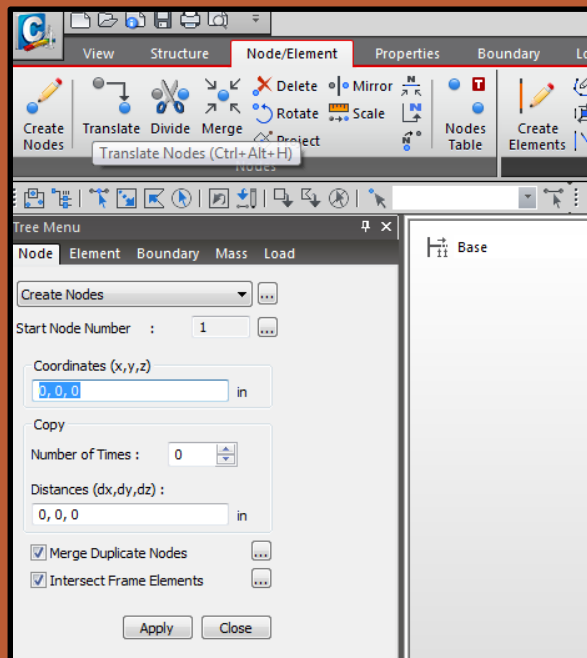
- Project info (*PROJINFO)
- Units (*UNIT)
- Structure type (*STRUCTYPE)
- Material properties (*MATERIAL) – Steel only
- Static load cases (*STLDCASE)
- Selfweight definition (*USE-STLD & *SELFWEIGHT)
- Load combinations (*LOADCOMB)
- Boundary groups (*BNDR-GROUP)
- Custom dynamic report tables (*DYNAGEN-TABLE)



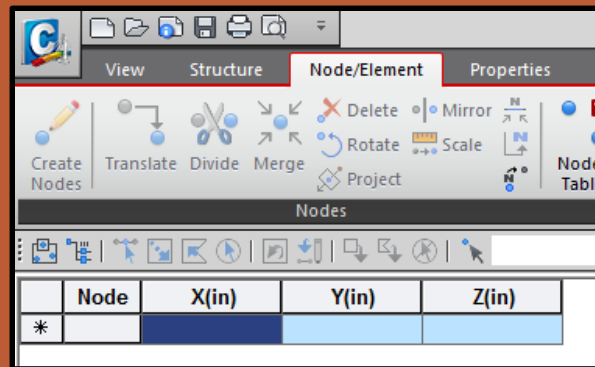
Midas Modeling

MCT Model Creation – Nodes

- Defining nodes in the GUI environment for complicated curved geometry is not practical
- Can also directly copy and paste an Excel nodal coordinates table directly into the Midas Node Table



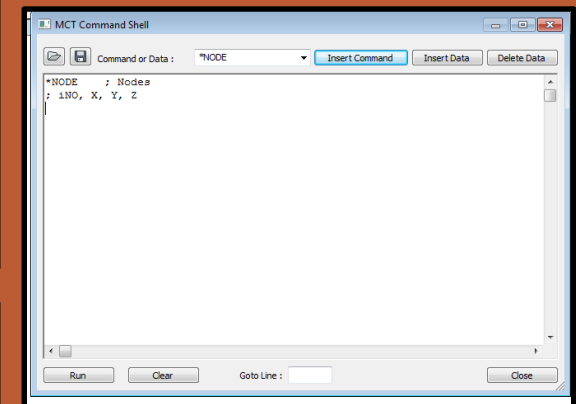
GUI Method



The screenshot shows an Excel spreadsheet with a table of nodal coordinates. The table has columns for Node ID, Station, Bridge Station, Offset from Alignment, and Node Coordinates (X, Y, Z) in inches. The data is organized into rows, with the first row being a header and subsequent rows containing numerical values.

Node ID	Station	Bridge Station	Offset from Alignment	Xc (in)	Yc (in)	Zc (in)	Xy (in)	Yy (in)	Zy (in)	Node Local Axis Angle (°)
5022	0.000	310+03.59	4.802	1.442 145 095	691 141 440	0.000	17 305 741 136	8 293 697 281	0.000	58 906
5023	11.500	310+08.63	4.803	1.442 144 595	691 140 618	0.000	17 305 735 187	8 293 687 416	0.000	58 892
5024	183.375	310+54.30	4.810	1.442 137 192	691 128 351	0.000	17 306 646 308	8 293 540 207	0.000	58 786
5025	367.362	310+29.00	4.794	1.442 129 231	691 115 259	0.000	17 306 550 766	8 293 383 196	0.000	58 533
5026	551.095	310+23.70	4.789	1.442 121 151	691 102 204	0.000	17 305 454 295	8 293 226 448	0.000	58 452
5027	622.906	310+17.72	4.833	1.442 118 062	691 097 093	0.000	17 306 416 746	8 293 165 111	0.000	58 437
5028	734.648	310+08.42	4.960	1.442 113 171	691 089 159	0.000	17 305 358 048	8 293 069 913	0.000	58 218
5029	862.906	309+97.74	4.977	1.442 107 514	691 080 873	0.000	17 305 290 162	8 292 960 880	0.000	57 997
5030	917.978	309+93.16	5.010	1.442 105 075	691 076 185	0.000	17 305 260 894	8 292 914 219	0.000	57 778
5031	1 101.090	309+77.92	5.120	1.442 096 903	691 063 281	0.000	17 305 162 831	8 292 759 368	0.000	57 464
5032	1 284.468	309+62.65	5.228	1.442 088 428	691 050 406	0.000	17 305 063 538	8 292 604 666	0.000	56 294
5033	1 287.468	309+61.67	5.960	1.442 092 039	691 046 984	0.000	17 305 104 470	8 292 561 812	0.000	53 644
5034	1 465.719	309+46.84	8.896	1.442 082 925	691 035 161	0.000	17 304 995 098	8 292 421 926	0.000	52 185
5035	1 647.331	309+31.73	7.812	1.442 073 564	691 023 180	0.000	17 304 882 767	8 292 278 162	0.000	51 838
5036	1 761.496	309+21.71	7.694	1.442 063 327	691 015 289	0.000	17 304 807 825	8 292 183 469	0.000	51 580
5037	1 828.878	309+16.62	6.728	1.442 064 128	691 011 268	0.000	17 304 769 538	8 292 135 214	0.000	51 369
5038	2 006.830	309+01.88	5.670	1.442 054 852	690 999 713	0.000	17 304 658 219	8 291 996 560	0.000	52 679

Table Method



MCT Method



Midas Modeling

MCT Model Creation – Nodes

Steps:

- 1) Create bridge alignments and framing plans in CAD
- 2) Create Excel workbook to combine and sort all of the analysis and additional geometry nodes
- 3) Use the workbook to export the node station and offsets into CAD
- 4) Export the node global coordinates from CAD back into the workbook and calculate node local axes
- 5) Use created macro in workbook to create the node MCT file
- 6) Open and run the node MCT file in Midas Civil

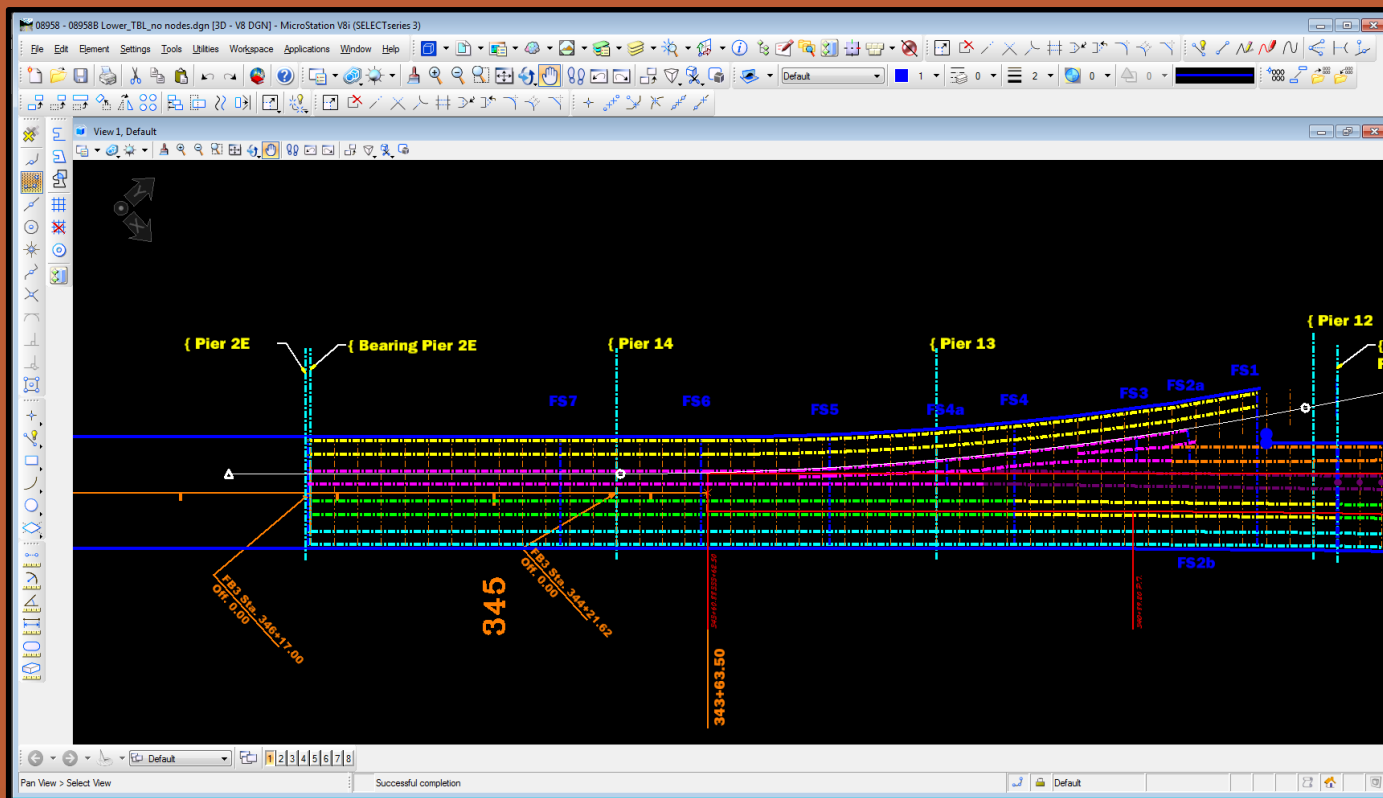


Midas Modeling

MCT Model Creation – Nodes

Step: 1) Create bridge alignments and framing plans in CAD

- Only the alignment is needed to obtain the girder nodal coordinates
- Framing plan serve as a geometry check for the Midas model
- Framing plan was also used to determine bridge geometry inputs that were difficult to directly obtain from the bridge plans



Midas Modeling

MCT Model Creation – Nodes

Step: 2) Create Excel workbook to combine and sort all of the analysis and additional geometry nodes

	A	B	C	D	E	F	G	H	I	J	K	L
1			Export Station & Offset	<input type="radio"/> AutoCAD			Import Coord. from CAD	Reset Coordinates			Find Node Local Axis Angle	
2				<input checked="" type="radio"/> MicroStation								
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												

Midas Coordinate Table										
Midas Node ID	Midas Station (in)	Bridge Station (ft)	Offset from Alignment (ft)	Node Coordinates (from CAD)			Node Coordinates Adjusted for Input into Midas			Node Local Axis Angle (°)
				X _C (ft)	Y _C (ft)	Z _C (ft)	X _M (in)	Y _M (in)	Z _M (in)	
5022	0.000	310+69.59	4.802				0.000	0.000	0.000	
5023	11.500	310+68.63	4.803							
5024	183.375	310+54.30	4.810							
5025	367.362	310+39.00	4.794							
5026	551.099	310+23.70	4.790							
5027	622.906	310+17.72	4.833							
5028	734.648	310+08.42	4.900							
5029	862.906	309+97.74	4.977							
5030	917.978	309+93.16	5.010							
5031	1,101.090	309+77.92	5.120							
5032	1,284.468	309+62.65	5.230							
5033	1,287.468	309+61.67	9.960							
5034	1,465.719	309+46.84	8.896							

Bridge Station and Offset Table			
Description	Midas Station (in)	Bridge Station (ft)	Offset from Alignment (ft)
Bearing Expansion Joint 12	0.000	310+69.59	4.80
Pier 12	183.375	310+54.30	4.81
end of divide (1'1" before FB3)	538.099	310+24.80	4.78
FB3	551.099	310+23.70	4.79
FB 7	1,284.468	309+62.65	5.23
3in after FB 7	1,287.468	309+61.67	9.96
FB 11	2,006.030	309+01.88	5.67
FB 15	2,733.936	308+41.47	4.78
3in after FB 15	2,736.936	308+40.75	9.40
Pier 13	3,100.687	308+10.99	8.01
FB 22	4,150.285	307+23.80	4.95
FS 6	4,900.660	306+61.37	2.98
Pier 14	5,549.750	306+07.43	2.40
Pier 2E	7,894.313	304+12.05	2.40



Midas Modeling

MCT Model Creation – Nodes

Step: 3) Use the workbook to export the node station and offsets into CAD

The screenshot shows the Midas software interface with several windows open:

- Files to Process:** A table showing files to be processed.
- Export Coordinates:** A dialog box for exporting coordinates.
- Batch Process:** A window for batch processing tasks.
- Microsoft Excel:** A window showing the files saved.
- Select Command File:** A window for selecting a command file.

Files to Process:

#	File	Model	S
1	...08958 - 08958B Lower_TBL...	Default	F

Export Coordinates:

Filename: _Gir_B_CogoPoints.txt

Order: X,Y,Z
Format: Sub
Accuracy: 1234
Separator: Comma
View: 1
Prefix:
Suffix:
Point #: 1

Batch Process:

Command File: 08958_Gir_B_StaOffset.txt
Initial Model: All Models
Process Tasks:

#	File	Model
1	...08958 - 08958B Lower_TBL_no nodes...	Default

Microsoft Excel:

Files Saved:
P:\O\ODOT00000898\0600INFO\0610 Load Rating
Folder\08958_08958B\Lower\Worksheets\08958 Gir B MCT Shell
Files\08958_Gir_B_StaOffset.txt

Select Command File:

Look in: CAD

Name	Date modified	Type	Size
08958_FB3_Barrier Terminatio...	6/26/2017 1...	TXT File	1 KB
08958_Gir_B_CogoPoints.txt	6/25/2017 1...	TXT File	3 KB
08958_Gir_B_StaOffset.txt	6/25/2017 1...	TXT File	2 KB
08958_B_FB15_Barrier Termin...	6/25/2017 1...	TXT File	1 KB



Midas Modeling

MCT Model Creation – Nodes

Step: 4) Export the node global coordinates from CAD back into the workbook and use the workbook to calculate node local axes

	A	B	C	D	E	F	G	H	I	J	K	L
1			Export Station & Offset	<input type="radio"/> AutoCAD			Import Coord. from CAD	Reset Coordinates				Find Node Local Axis Angle
2				<input checked="" type="radio"/> MicroStation								
3			Midas Coordinate Table									
4		Midas Node	Midas Station	Bridge Station	Offset from Alignment	Node Coordinates (from CAD)			Node Coordinates Adjusted for Input into Midas			Node Local Axis Angle (°)
5		ID	(in)	(ft)	(ft)	X _C (ft)	Y _C (ft)	Z _C (ft)	X _M (in)	Y _M (in)	Z _M (in)	
7		5022	0.000	310+69.59	4.802	1,442,145.095	691,141.440	0.000	17,305,741.136	8,293,697.281	0.000	58.906
8		5023	11.500	310+68.63	4.803	1,442,144.599	691,140.618	0.000	17,305,735.187	8,293,687.416	0.000	58.892
9		5024	183.375	310+54.30	4.810	1,442,137.192	691,128.351	0.000	17,305,646.308	8,293,540.207	0.000	58.786
10		5025	367.362	310+39.00	4.794	1,442,129.231	691,115.259	0.000	17,305,550.766	8,293,383.106	0.000	58.533
11		5026	551.099	310+23.70	4.790	1,442,121.191	691,102.204	0.000	17,305,454.286	8,293,226.448	0.000	58.452
12		5027	622.906	310+17.72	4.833	1,442,118.062	691,097.093	0.000	17,305,416.746	8,293,165.111	0.000	58.437
13		5028	734.648	310+08.42	4.900	1,442,113.171	691,089.159	0.000	17,305,358.048	8,293,069.913	0.000	58.218
14		5029	862.906	309+97.74	4.977	1,442,107.514	691,080.073	0.000	17,305,290.162	8,292,960.880	0.000	57.997
15		5030	917.978	309+93.16	5.010	1,442,105.075	691,076.185	0.000	17,305,260.894	8,292,914.219	0.000	57.778
16		5031	1,101.090	309+77.92	5.120	1,442,096.903	691,063.281	0.000	17,305,162.831	8,292,759.368	0.000	57.464
17		5032	1,284.468	309+62.65	5.230	1,442,088.628	691,050.406	0.000	17,305,063.538	8,292,604.866	0.000	96.094
18		5033	1,287.468	309+61.67	9.960	1,442,092.039	691,046.984	0.000	17,305,104.470	8,292,563.812	0.000	93.644
19		5034	1,465.719	309+46.84	8.896	1,442,082.925	691,035.161	0.000	17,304,995.098	8,292,421.926	0.000	52.185
20		5035	1,647.331	309+31.73	7.812	1,442,073.564	691,023.180	0.000	17,304,882.767	8,292,278.162	0.000	51.838
21		5036	1,767.499	309+21.73	7.094	1,442,067.327	691,015.289	0.000	17,304,807.925	8,292,183.469	0.000	51.588
22		5037	1,828.879	309+16.62	6.728	1,442,064.128	691,011.268	0.000	17,304,769.538	8,292,135.214	0.000	51.369



Midas Modeling

MCT Model Creation – Nodes

Step: 5) Use created macro in workbook to create the node MCT file

- Node coordinates (*NODE)
- Node local axis (*LOCALAXIS)

The screenshot displays the Microsoft Excel interface with the '08958_Gir_B.xlsm' workbook open. The 'Home' tab is active, and the 'Formulas' ribbon is visible. The 'Midas Input' table is shown, with columns for Station, Midas Node, Midas Section, Element, Analyze, Section, Transv. Stiff, Uniform Loads, and Point Loads. The table contains data for 17 rows, with the last row (17) showing a station of 1,284.468 and midas nodes 5032 and 5026.

A VBA macro window titled 'Microsoft Visual Basic for Applications - 08958_Gir_B.xlsm - [mod_CreateMCT (Code)]' is open, showing the 'mod_CreateMCT' module. The macro is a sub procedure named 'CreateNodes' that generates node coordinates and local axes for the model. The code includes comments for unit systems and node numbering, and uses loops to iterate through the nodes.

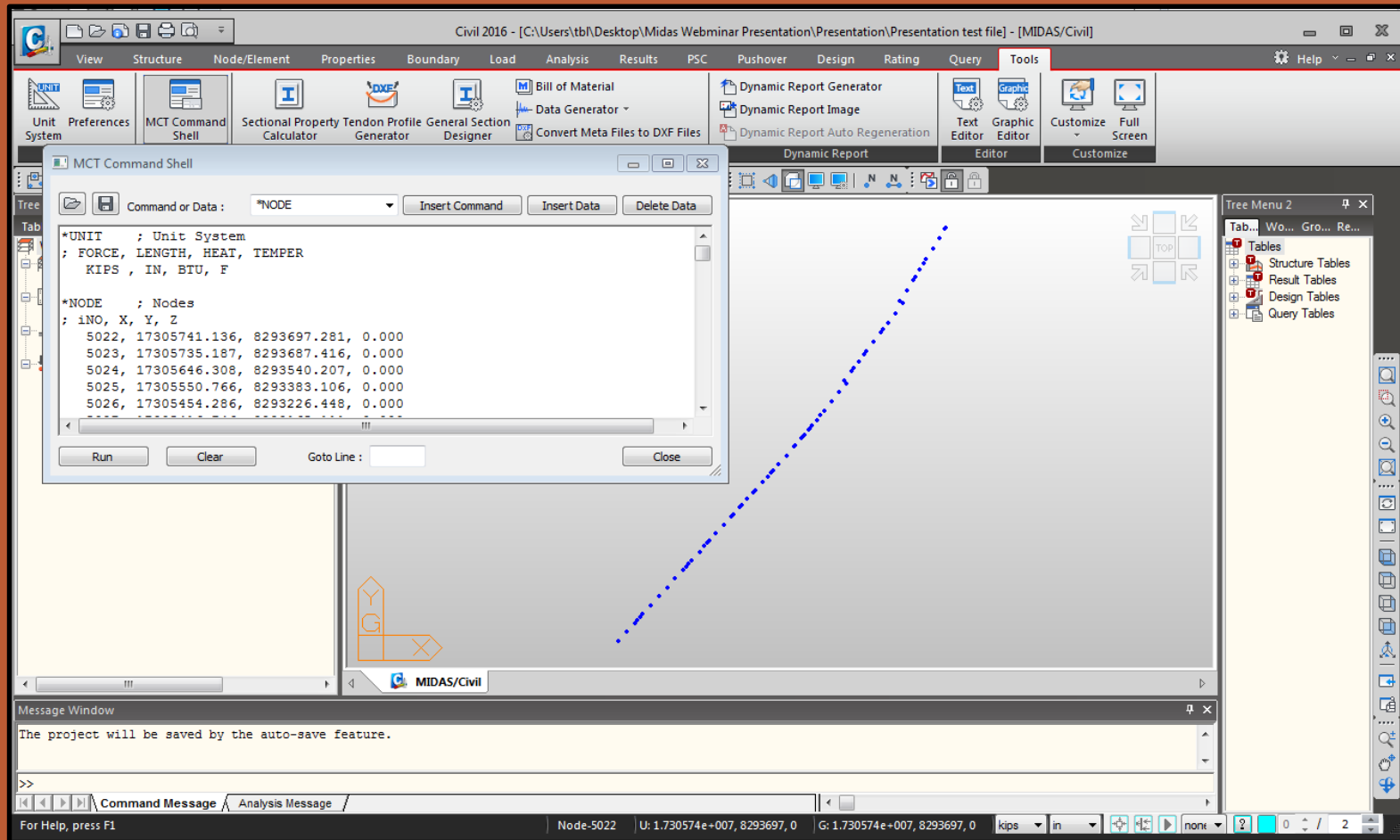
```
Sub CreateNodes()  
    Print #1, ""UNIT : Unit System"  
    Print #1, ": FORCE, LENGTH, HEAT, TEMPER"  
    Print #1, " KIPS , IN, BTU, F"  
    Print #1, ""  
    Print #1, ""NODE : Nodes"  
    Print #1, ": iNO, X, Y, Z"  
    i = 1: Do While Coord_Node(i) <> ""  
        Print #1, Spc(3); Coord_Node(i) & " , " & Format(Coord_Xm(i), "0.000") & " , " & Format(Coord_Ym(i), "0.000") & " , " & Format(Coord_Zm(i), "0.000")  
        i = i + 1: Loop  
    Print #1, ""  
    Print #1, ""LOCALAXIS : Node Local Axis"  
    Print #1, ": NODE_LIST, iMETHOD, ANGLE-x, ANGLE-y, ANGLE-z : iMETHOD=1"  
    Print #1, ": NODE_LIST, iMETHOD, FOX, F0Y, F0Z, F1X, F1Y, F1Z, P2X, P2Y, P2Z : iMETHOD=2"  
    Print #1, ": NODE_LIST, iMETHOD, V1X, V1Y, V1Z, V2X, V2Y, V2Z : iMETHOD=3"  
    i = 1: Do While Midas_Node(i) <> ""  
        Print #1, Spc(3); Coord_Node(i) <> " , 1, 0, 0 , " & Coord_Angle(i)  
        i = i + 1: Loop  
    Print #1, ""  
End Sub
```



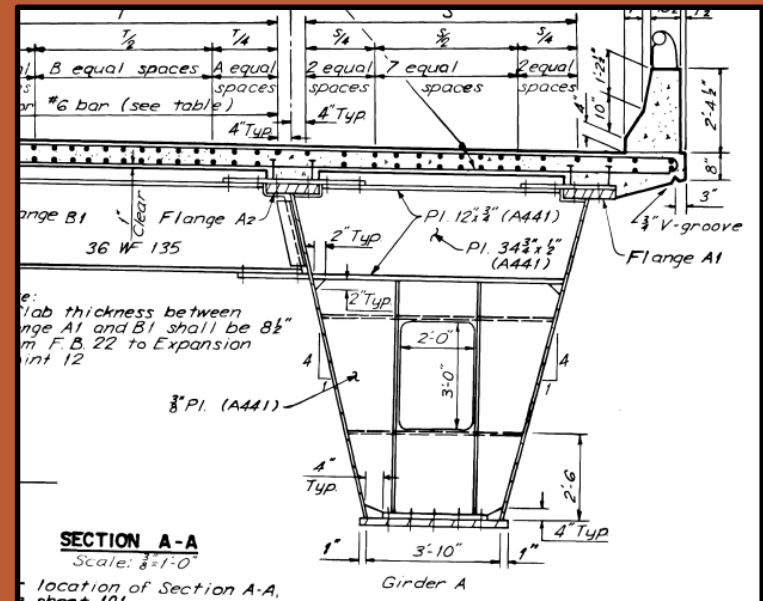
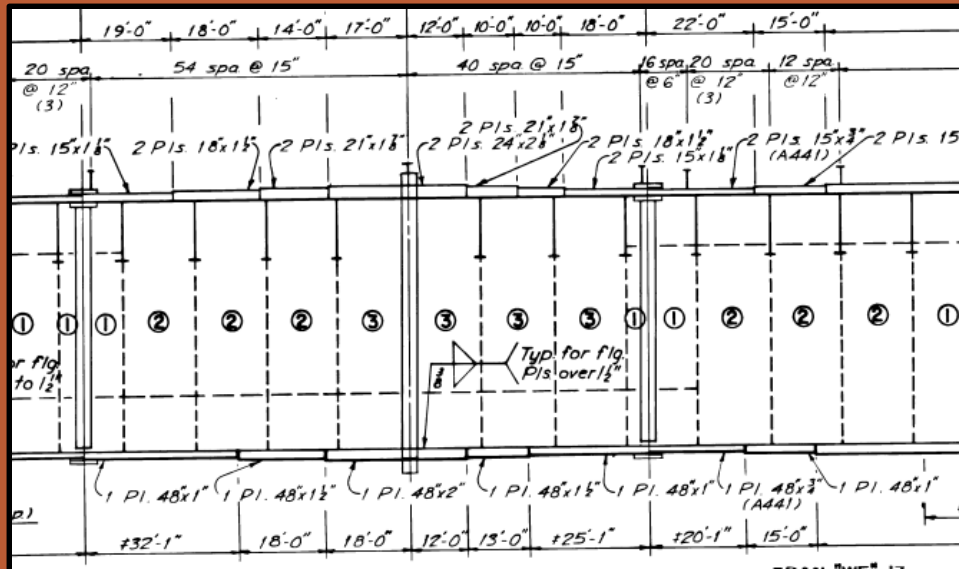
Midas Modeling

MCT Model Creation – Nodes

Step: 6) Open and run the node MCT file in Midas Civil



MCT Model Creation – Composite Box Girder Sections & Elements



- Excel workbook allows for cross-section components to be entered individually
 - Streamlines process
 - Reduces errors and makes QC easier for complex girders
 - Reduces the number of duplicate sections
 - Eliminates the need to manually calculate component dimensions along a tapering element



Midas Modeling

MCT Model Creation – Composite Box Girder Sections & Elements

Bridge Length Calculations and Web Thickness						
Span No	Start Station X_i (in)	End Station X_j (in)	Length Along Flange 1 L_1 (ft-in)	Length Along Flange 2 L_2 (ft-in)	Length Along CL L (in)	Web Thickness t_w (in)
1	0.000	183.375	15' - 3 3/8"	15' - 3 3/8"	183.375	0.438
2	183.375	622.906	36' - 7 9/16"	36' - 7 1/2"	439.531	0.438
2	622.906	1,160.937	45' - 6 1/8"	44' - 1 15/16"	538.031	0.438

Deck Thickness & Uniform Loads				
Start Station X_i (in)	End Station X_j (in)	Description	Deck Thickness t_d (in)	Deck to top of web t_h (in)
0.000	183.375	Bear. Exp. Joint 12 to Pier 12	8.750	16.250
183.375	538.099	Pier 12 to end of divide	8.750	16.250

Top Flange											Bottom Flange							
Span No	Start Station	End Station	Length Along Flange 1	Length Along Flange 2	Average Length	Length Adjust.	Flange Width	Flange Extension	Flange Thickness		Span No	Start Station	End Station	Length Along CL Girder	Average Length	Length Adjust.	Flange Extension	Flange Thickness
	X _i (in)	X _j (in)	L _f (ft-in)	L ₂ (ft-in)	L (in)	L _{adj} (in)	B _f (in)	Y _f (in)	t _f (in)			X _i (in)	X _j (in)	X _j (in)	L _{CL} (ft-in)	L (ft)	L _{adj} (in)	Y _f (in)
1	0.000	183.375	15' - 3 3/8"	15' - 3 3/8"	183.375		15.000	7.500	0.750	0.000	1	0.000	183.375	15' - 1 7/8"	183.375	1.500	1.000	0.750
2	183.375	622.906	36' - 7 9/16"	36' - 7 1/2"	439.531		15.000	7.500	0.750	0.000	2	183.375	622.906	36' - 8 9/16"	439.531	-1.032	1.000	0.750
2	622.906	862.906	20' - 0"	20' - 0"	240.000		15.000	7.500	1.125	0.000	2	622.906	862.906	20' - 1"	240.000	-1.000	1.000	1.125

Overall Girder Geometry										
Description	Station X (in)	Web Height (along web) H (in)	Web Height (vertical) H_w (in)	Web Slope #V:1H	Slope Angle from Vert. (degrees)	Web Spa. at Bottom B_{wb} (in)	Web Spa. at Top B_{wt} (in)	Tributary Width Left B_L (in)	Tributary Width Right B_R (in)	Eff. Deck Width B_{eff} (in)
Bearing Expansion Joint 12	0.000	113.000	109.626	4.000	14.036	46.000	100.813	83.407	95.656	179.063
Pier 12	183.375	113.000	109.626	4.000	14.036	46.000	100.813	83.407	95.719	179.125
end of divide	538.099	113.000	109.626	4.000	14.036	46.000	100.813	83.407	95.469	178.875

Midas Sections												Girder Area A_G (in ²)	Deck Area A_D (in ²)	Tapered Sections		
ID	Top Flange Bf_1 (in)	tf_1 (in)	Web H_w (in)	t_w (in)	Bot. Flange Bf_2 (in)	tf_2 (in)	Top Flange Bf_3 (in)	B_1 (in)	Bot. B_2 (in)	Deck Slab B_c (in)	t_c (in)	$H_h + tf_1$ (in)		Midas Section ID	i-end Section	j-end Section
5013	15.000	0.750	109.626	0.438	1.000	0.750	7.500	85.813	46.000	179.065	8.750	7.500	157.4	5611	5013	5014
5014	15.000	0.750	109.626	0.438	1.000	0.750	7.500	85.813	46.000	179.096	8.750	7.500	157.4	5612	5014	5015
5015	15.000	0.750	109.626	0.438	1.000	0.750	7.500	85.813	46.000	179.060	8.750	7.500	157.4	5613	5015	5016

- Workbook Macro compiles inputs and creates MCT file
 - Composite sections (*SECTION) – includes tap
 - Elements (*ELEMENT)



Midas Modeling

MCT Model Creation – Boundary Definitions

- Excel workbook includes inputs for supports and expansion joints
- Workbook macro creates MCT file
 - Supports (*CONSTRAINT)
 - Expansion joints (*FRAME-RLS) – beam end release

The screenshot displays the Midas Modeling software interface. On the left, an Excel workbook is open, showing a table of bridge data. On the right, the MCT Command Shell window is open, displaying the command *CONSTRAINT and its parameters.

Excel Workbook Data:

Span No	Span Fraction (#/L)	Station X (in)	Description	Support	Hinge	Node Point L (k)	Node Point R (k)	ID
1	0.000	0.000	Bearing Expansion Joint 12		100010	5.000		5,022
1	0.005	11.500	FB1					5,023
2	0.000	183.375	CL Pier 12	111000				5,024
2	0.005	367.362	FB2					5,025
2	0.011	551.099	FB3					5,026
2	0.016	734.648	FB4					5,028
2	0.021	917.978	FB5					5,030
2	0.026	1,101.090	FB6					5,031
2	0.031	1,284.468	FB7					5,032
2	0.037	1,465.719	FB8					5,034
2	0.042	1,647.331	FB9					5,035
2	0.047	1,828.879	FB10					5,037
2	0.052	2,006.030	FB11					5,038
2	0.057	2,191.915	FB12					5,039
2	0.063	2,373.464	FB13					5,041
2	0.068	2,555.138	FB14					5,043
2	0.073	2,733.936	FB15					5,044
2	0.078	2,918.843	FB16					5,046
3	0.000	3,100.687	CL Pier 13	111000				5,047

MCT Command Shell:

```
*CONSTRAINT ; Supports
; NODE LIST, CONST (Dx,Dy,Dz,Rx,Ry,Rz), GROUP
5024, 111000, pinned
5047, 111000, pinned
5074, 111000, pinned
5093, 111000, pinned
```

Buttons: Run, Clear, Goto Line, Close



Midas Modeling

MCT Model Creation – Transverse Deck Elements

Multiple transverse elements defined - interior deck elements

- Composite floorbeam w/ trib deck width
- Composite cross-girder w/ trib deck width
- Deck only – used at splitting deck locations

1

2

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Bridge #		09268_
Can Deck XB by Stiffness Mod Factor		50
FB Steel Poisson's Ratio		0.3
FB Steel modulus of elasticity (ksi)		29,000
FB Steel unit weight (lb/cf)		0.00029
FB Steel thermal coefficient		6.93E-06
Steel SV Factor		1.15
Concrete Material Property #		2
Deck Concrete Strength (ksi)		4.00
Deck Concrete Poisson's Ratio		0.2
Deck concrete thermal coefficient		6.00E-06
Ratio of thermal coefficients (Tc/Ts)		1.00
Deck Concrete Unit Weight, w (pcf)		0.00008
Deck Concrete Modulus of Elasticity (ksi)		3.644
Ratio of modulus of elasticity (Ec/Es)		7.950
Ratio of unit weights (Dc/Ds)		3.757

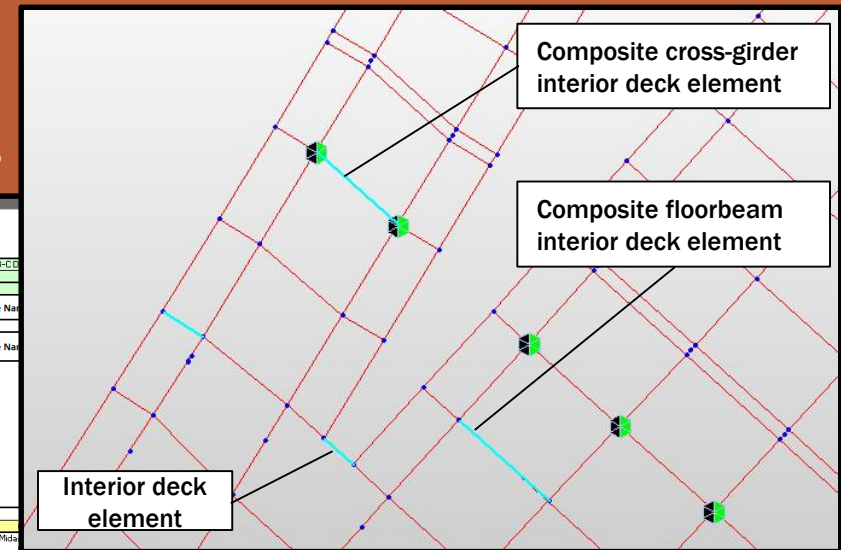
LL Girder:

08958_Gir_A

Girder 1 Nodes						
Notes	Girder		Cant (Y/N)			
	B		NO	NO	NO	NO
	Midas Station (in)	Midas Node ID	Model X (in)	Model Y (in)	Deck Thickness (in)	Tributary Width Left, B _L (in)
						Tributary Width Right, B _R (in)
CL Bearing Pier 2w	0.000	3.000	17,283,593.174	8,267,093.951	7.50	116.531
FB1	177.734	3.001	17,283,460.573	8,267,093.971	7.50	116.899
FB2	355.469	3.002	17,283,340.980	8,267,026.936	7.50	117.267

Notes		Girder	
		B	
	Midas Station (in)	Midas Node ID	Model X (in)
			Model Y (in)
CL Bearing Pier 2w	0.000	4.000	17,283,407.321
FB1	177.734	4.001	17,283,287.633
FB2	355.469	4.002	17,283,167.886

Expansion Joint (Yes / No)



<table border="1"> <tr><td colspan="10">Composite I Sections</td></tr> <tr><td>FB Size</td><td>H_v (in)</td><td>B₁ (in)</td><td>t_{f1} (in)</td><td>t_w (in)</td><td>B₂ (in)</td><td>t_{f2} (in)</td><td></td><td></td><td></td></tr> <tr><td>FB_1</td><td>30WF108</td><td>28.300</td><td>10.484</td><td>0.760</td><td>0.548</td><td>10.484</td><td>0.760</td><td></td><td></td></tr> <tr><td>FB_2</td><td>36WF135</td><td>33.962</td><td>11.945</td><td>0.794</td><td>0.538</td><td>11.945</td><td>0.794</td><td></td><td></td></tr> <tr><td>FB_3</td><td>27WF94</td><td>25.416</td><td>9.990</td><td>0.747</td><td>0.490</td><td>9.990</td><td>0.747</td><td></td><td></td></tr> <tr><td>FB_4</td><td>09268_XB_2w</td><td>93.134</td><td>12.000</td><td>1.000</td><td>0.500</td><td>12.000</td><td>1.000</td><td></td><td></td></tr> <tr><td>FB_5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table>										Composite I Sections										FB Size	H _v (in)	B ₁ (in)	t _{f1} (in)	t _w (in)	B ₂ (in)	t _{f2} (in)				FB_1	30WF108	28.300	10.484	0.760	0.548	10.484	0.760			FB_2	36WF135	33.962	11.945	0.794	0.538	11.945	0.794			FB_3	27WF94	25.416	9.990	0.747	0.490	9.990	0.747			FB_4	09268_XB_2w	93.134	12.000	1.000	0.500	12.000	1.000			FB_5																			
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<table border="1"> <tr><td colspan="10">Composite Box Sections</td></tr> <tr><td></td><td>H_v (in)</td><td>t_w (in)</td><td>B₁ (in)</td><td>B₁ (in)</td><td>t_{f1} (in)</td><td>B₂ (in)</td><td>B₂ (in)</td><td>t_{f2} (in)</td><td></td></tr> <tr><td>09268_XB_1</td><td>91.678</td><td>0.875</td><td>50.500</td><td>1.750</td><td>5.000</td><td>50.500</td><td>1.750</td><td>3.000</td><td></td></tr> <tr><td>09268_XB_3</td><td>77.611</td><td>0.750</td><td>44.500</td><td>1.750</td><td>1.625</td><td>44.500</td><td>1.750</td><td>1.625</td><td></td></tr> <tr><td>09268_XB_3</td><td>84.402</td><td>0.875</td><td>44.500</td><td>1.750</td><td>1.750</td><td>44.500</td><td>1.750</td><td>1.750</td><td></td></tr> <tr><td>09268_XB_4</td><td>77.611</td><td>0.500</td><td>44.500</td><td>1.750</td><td>1.375</td><td>44.500</td><td>1.750</td><td>1.375</td><td></td></tr> <tr><td>09268_XB_4</td><td>84.402</td><td>0.875</td><td>44.500</td><td>1.750</td><td>1.750</td><td>44.500</td><td>1.750</td><td>1.750</td><td></td></tr> <tr><td>Deck Only</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr> </table>										Composite Box Sections											H _v (in)	t _w (in)	B ₁ (in)	B ₁ (in)	t _{f1} (in)	B ₂ (in)	B ₂ (in)	t _{f2} (in)		09268_XB_1	91.678	0.875	50.500	1.750	5.000	50.500	1.750	3.000		09268_XB_3	77.611	0.750	44.500	1.750	1.625	44.500	1.750	1.625		09268_XB_3	84.402	0.875	44.500	1.750	1.750	44.500	1.750	1.750		09268_XB_4	77.611	0.500	44.500	1.750	1.375	44.500	1.750	1.375		09268_XB_4	84.402	0.875	44.500	1.750	1.750	44.500	1.750	1.750		Deck Only									
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09268_XB_3	84.402	0.875	44.500	1.750	1.750	44.500	1.750	1.750																																																																																	
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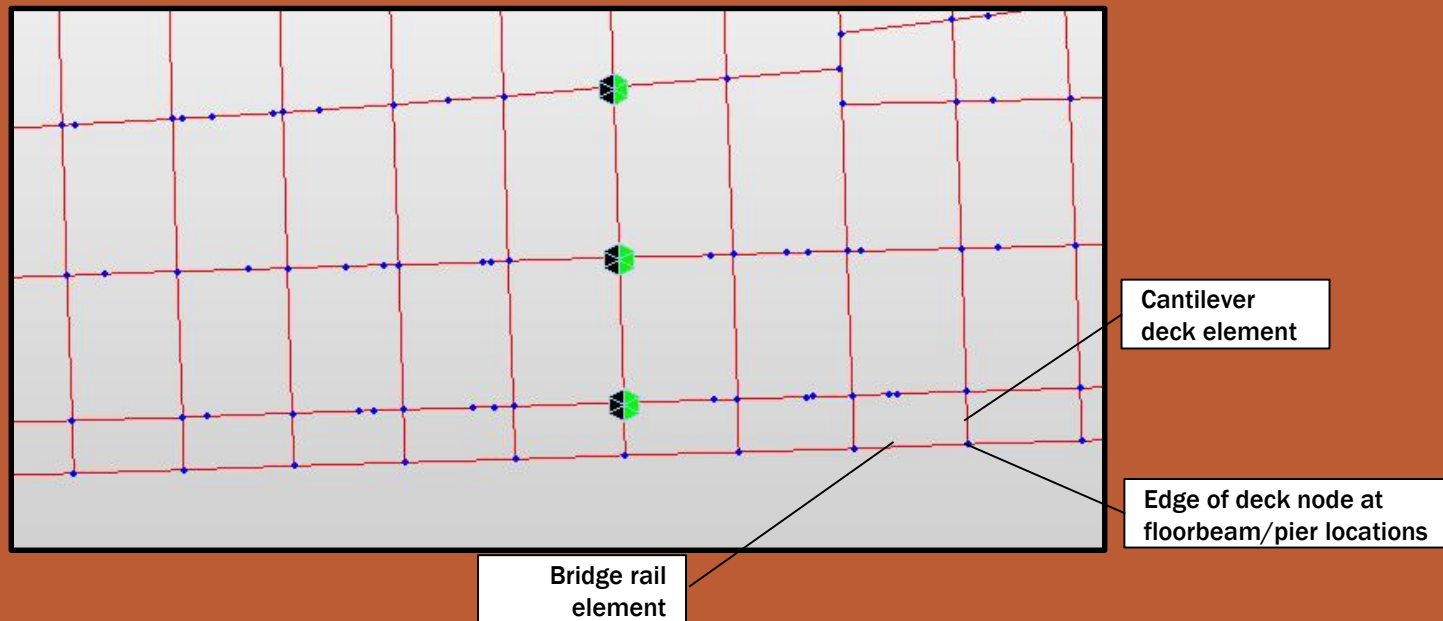


Midas Modeling

MCT Model Creation – Transverse Deck Elements

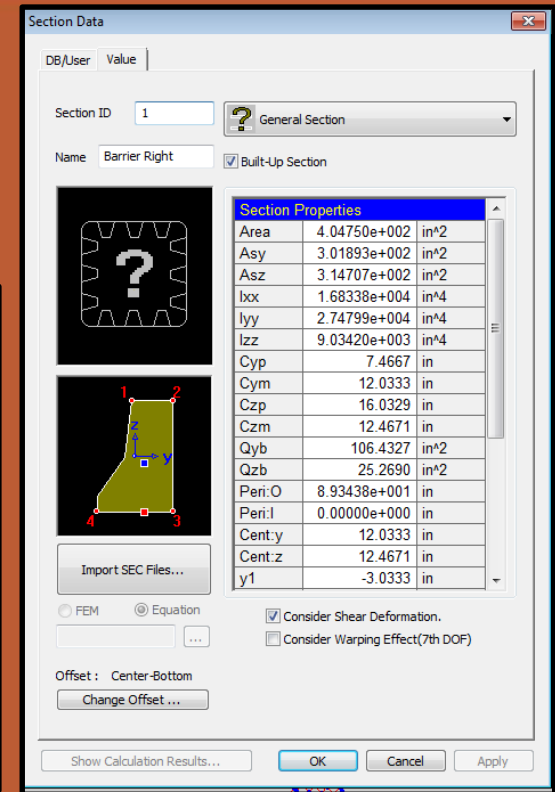
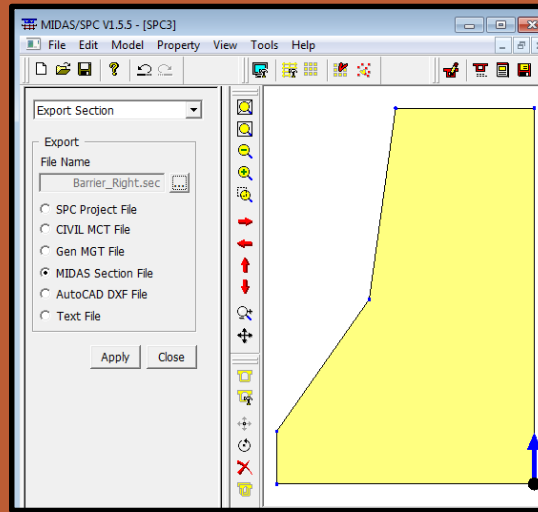
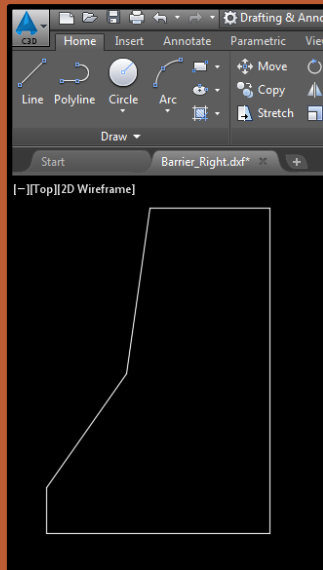
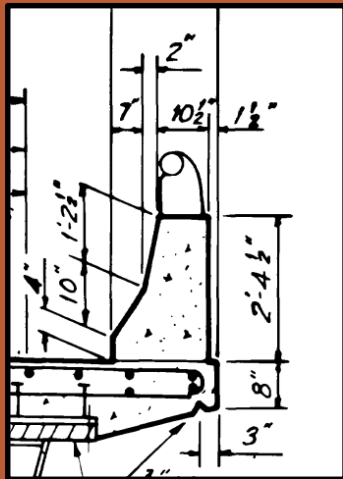
Multiple transverse elements defined - exterior deck elements

- Used to model deck overhang
- Placed at floorbeam and pier nodes
- Oriented normal to the exterior girder
- Section is deck only with a 50% increase in flexural stiffness to account for the actual location of the exterior web



Midas Modeling

MCT Model Creation – Longitudinal Bridge Rail Elements



Plans



AutoCAD



Section Property Calculator



Midas Civil Section

- Modeled the concrete bridge rail as a longitudinal beam element
- Connects adjacent cantilever transverse deck elements at the free end
- Used as the reference beam element for exterior girder live load lane definitions
- Utilized the Midas Section Property Calculator tool with the AutoCad import features

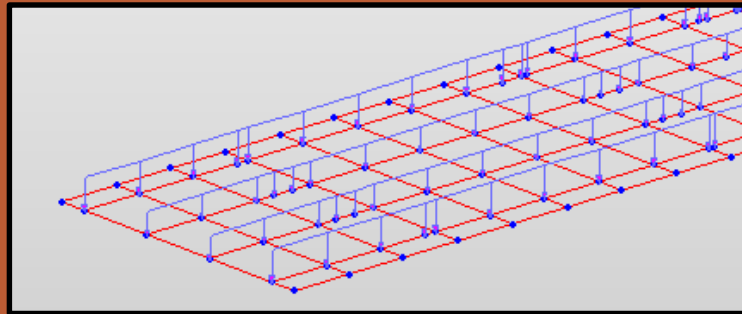


Midas Modeling

MCT Model Creation – Dead Loads

Applied loads

- SW factor
 - Conservatively set as 15%
 - Accounts for stiffeners, splice plates, bolts, welds, and miscellaneous steel components other than the primary SBG steel elements
 - Applied to only steel elements – use modified concrete density
- Composite SBG – steel weight only (Set $D_s/D_c=0$)
- Deck – transverse deck elements



Selfweight

- Loads are applied to SBG elements and nodes
 - Primary expansion joint components selfweight
 - Top flange buildup
 - Wearing surface
 - Additional bridge rail components – metal rail, fence, etc.
 - Utilities

Load Cases and Factors		
	LoadCase	Factor
▶	SW(ST)	1.1500
	DC1 Loads	1.0000
*		

Tree Menu

Node Element Boundary Mass Load

Self Weight

Load Case Name
SW

Load Group Name
Default

Self Weight Factor

Wgt. Z
Wgt. Y
Wgt. X

Z
Y
X

X 0
Y 0
Z 0

Load Case	X	Y	Z	Group
SW	0	0	-1	Default

Operation

Add Modify Delete

Close



Midas Modeling

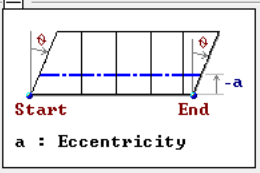
MCT Model Creation – Live Loads

- LL demands were determined by defining multiple lanes for each girder
- Excel workbooks were created to allow for quick definitions of moving load parameters and to determine lane locations
- Workbook macro created MCT files to define LL parameters
 - Moving load code
 - 21 vehicles
 - 1 vehicle class
 - Multiple traffic line lanes with span start locations
 - 20 moving load cases with sub load cases

Define Design Traffic Line Lane

Lane Name : Five Lanes L1

Traffic Lane Properties



a : Eccentricity

Lane Width : 120 in

Eccentricity : 0 in

Wheel Spacing : 72 in

☐ Traffic Lane Optimization

Vehicular Load Distribution

☐ Lane Element ☒ Cross Beam

Cross Beam Group

ALL DECK ELEMENTS

Skew

Start 0 End 0 [deg]

Moving Direction

☐ Forward ☐ Backward ☒ Both

Selection by

☒ 2 Points ☐ Picking ☐ Number

0, 0, 0 in

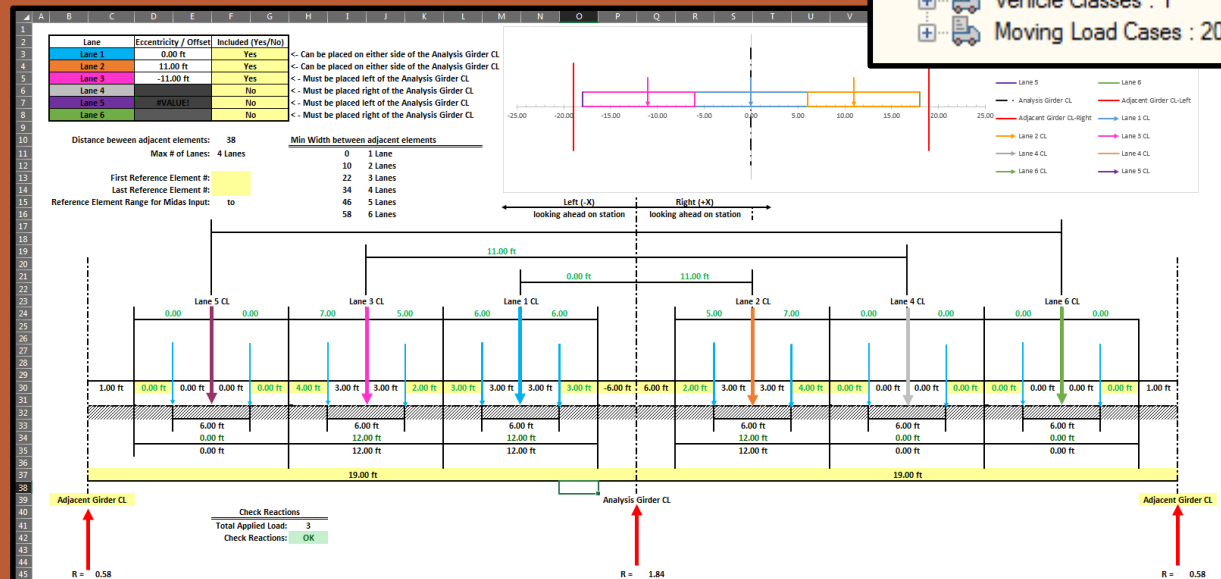
0, 0, 0 in

Operations

Add Insert Delete

No	Elem	Eccen. (in)	Span Start
1	94000	-81	
2	94001	-81	
3	94002	-81	

OK Cancel Apply



Moving Load Analysis

- Moving Load Code [AASHTO LRFD]
- Traffic Line Lanes : 5
- Lane Supports-Negative Moments : 1
- Lane Supports-Reactions : 5
- Vehicles : 21
- Vehicle Classes : 1
- Moving Load Cases : 20

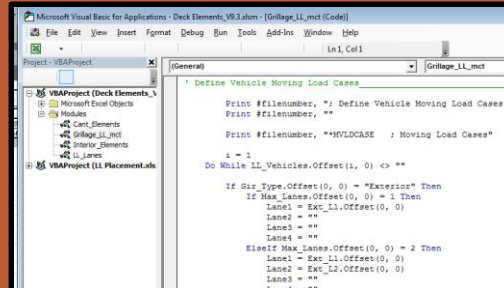
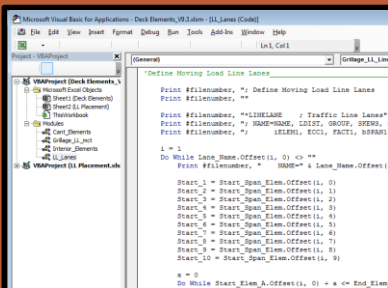
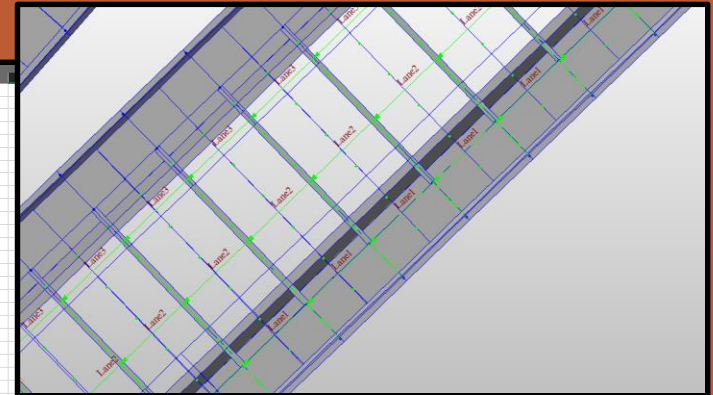


MCT Model Creation – Live Loads

Exterior Girder Live Load

- Lanes were shifted as close as possible to face of the barrier (2ft)
- Longitudinal bridge rail element was used as the reference beam element for lane eccentricity inputs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2														
3	Create LL Load Cases MCT File		Output File Name:		09268_Gir_A_LL_Load_Cases									
4														
5	Analyst Grid (Interior/Exterior):		Exterior											
6	Maximum Number of Lanes Loaded:		2											
7	Exterior2													
8	Exterior Girder Lane Names													
9	Lane 1: Lane1													
10	Lane 2: Lane2													
11	Lane 3: Lane3													
12	Lane 4: Lane4													
13	Four Lane Loaded Girder Lane Name													
14	Create Load Case:		No											
15	Lane 1: FourLanesL1													
16	Lane 2: FourLanesL2													
17	Lane 3: FourLanesL3													
18	Lane 4: FourLanesL4													
19	Five Loaded Girder Lane Name													
20	Create Load Case:		Yes											
21	Lane 1: FiveLanesL1													
22	Lane 2: FiveLanesL2													
23	Lane 3: FiveLanesL3													
24	Lane 4: FiveLanesL4													
25	Lane 5: FiveLanesL5													
26	Six Loaded Girder Lane Name													
27	Create Load Case:		No											
28	Lane 1: SixLanesL1													
29	Lane 2: SixLanesL2													
30	Three Loaded Girder Lane Name													
31	Create Load Case:		No											
32	Lane 1: ThreeLanesL1													
33	Lane 2: ThreeLanesL2													
34	Lane 3: ThreeLanesL3													
35	Seven Loaded Girder Lane Name													
36	Create Load Case:		No											
37	Lane 1: SevenLanesL1													
38	Lane 2: SevenLanesL2													
39	Lane 3: SevenLanesL3													
40	Lane 4: SevenLanesL4													
41	Lane 5: SevenLanesL5													
42	Lane 6: SevenLanesL6													
43	Lane 7: SevenLanesL7													
44	Eight Loaded Girder Lane Name													
45	Create Load Case:		No											
46	Lane 1: EightLanesL1													
47	Lane 2: EightLanesL2													
48	Lane 3: EightLanesL3													
49	Lane 4: EightLanesL4													
50	Lane 5: EightLanesL5													
51	Lane 6: EightLanesL6													
52	Lane 7: EightLanesL7													
53	Lane 8: EightLanesL8													
54	Create LL Line Lanes MCT File		Output File Name:		09268_Gir_A_LL_Lanes									
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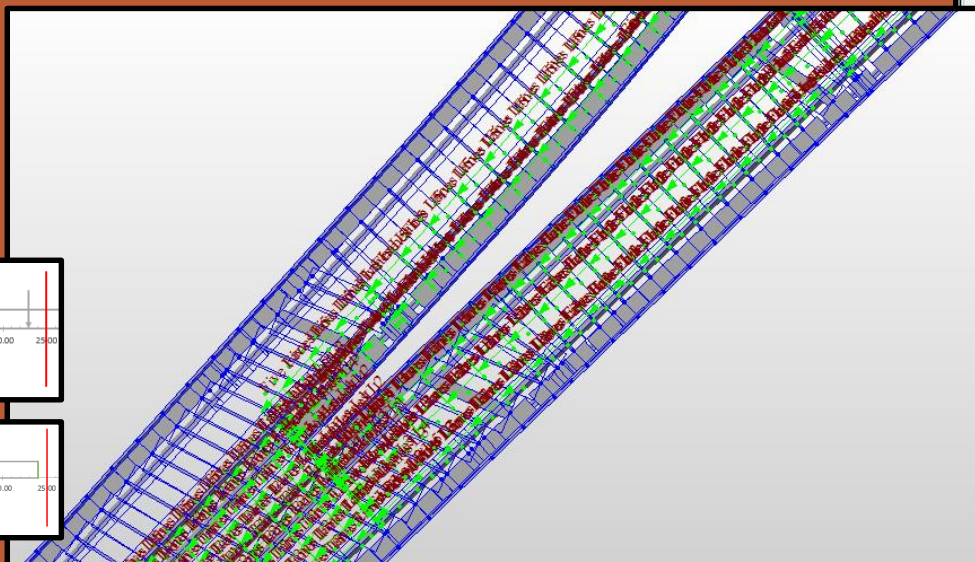
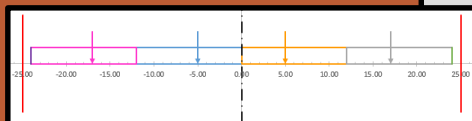
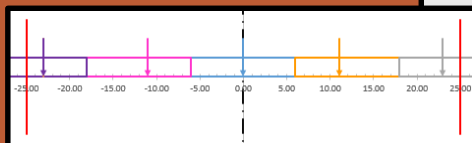
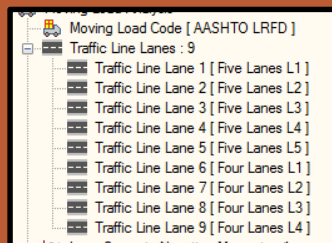


Midas Modeling

MCT Model Creation – Live Loads

Interior Girder Live Load

- Moving load sub-load cases were defined to allow for different lane combinations (odd/even)
- Up to 9 unique lanes were defined for some interior girders
- Splitting decks required multiple lane reference elements (both bridge rail elements and SBG elements) for a single lane definition



Define Moving Load Case

Load Case Name : HL93

Description :

☐ Load Case for Permit Vehicle

Multiple Presence Factor

Num of Loaded Lanes	Scale Factor
1	1.2
2	1
3	0.85
> 3	0.65

Sub-Load Cases

Loading Effect

☐ Combined
 ☒ Independent

Vehicle class	Scale	Lane1
VC:HL93	1	Four La...
VC:HL93	1	Five La...

Add

Modify

Delete

OK

Cancel

Apply

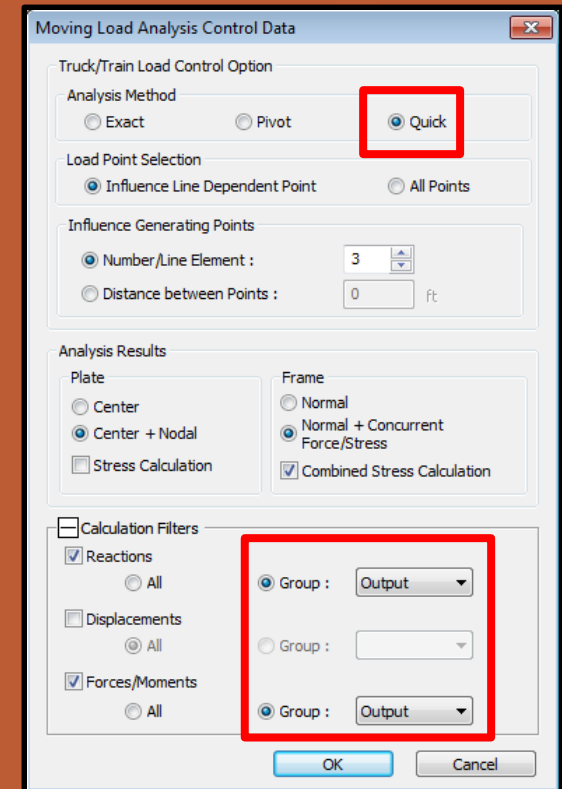
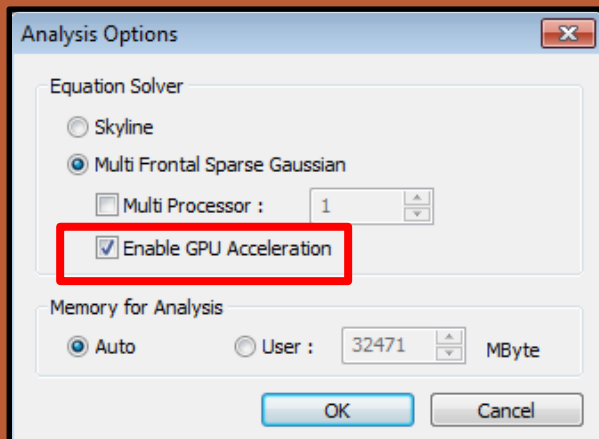
Lane Name	Lane Segment A			Lane Segment B			Lane Segment C		
	Start Element #	End Element #	Eccentricity	Start Element #	End Element #	Eccentricity	Start Element #	End Element #	Eccentricity
Five Lanes L1	94,000	94,081	-6.75 ft	5,033	5,043	-5.00 ft	5,045	5,092	-5.00 ft
Five Lanes L2	94,000	94,081	-18.75 ft	5,033	5,043	-17.00 ft	5,045	5,092	-17.00 ft
Five Lanes L3	95,000	95,024	6.75 ft	5,033	5,043	5.00 ft	5,045	5,092	5.00 ft
Five Lanes L4	95,000	95,024	18.75 ft	5,033	5,043	17.00 ft	5,045	5,092	17.00 ft
Five Lanes L5	94,000	94,081	-30.75 ft						



Midas Modeling

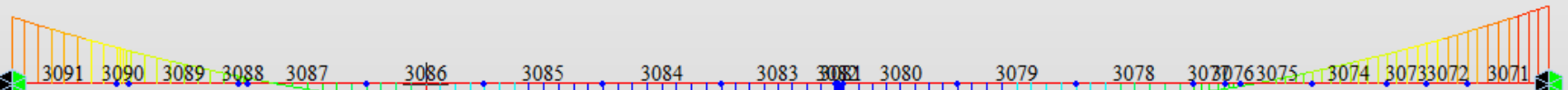
Model Analysis

- Running the analysis can take a very long time (hours)
- Run analysis on local hard drive
- Create copies of base model for each girder w/ unique lane locations
- Enable GPU acceleration
- Adjust Moving Load Analysis Control Data
 - Use the Quick Analysis method
 - Significant reduction in runtime with limited loss of accuracy
 - Can use the Quick Analysis option for preliminary results then use the Exact method after results have been confirmed
 - Use Calculation Filters to limit analysis to structure group (girder) of interest and only the desired result type (reactions, displacements, force/moments)



Midas Modeling

Model Verification

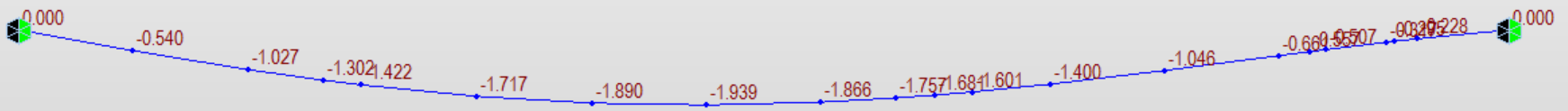


- 08958_B_Gir_B Span 4 (Node=22, Element=21)
- 08958_B_Gir_B Assign
- 08958_B_Gir_B Assign Plus
- 08958_B_Gir_A Assign Minus
- 08958_B_Gir_A Select
- 08958_B_Gir_A Unselect
- 08958_B_Gir_A Active
- 08958_B_Gir_C Inactive
- 08958_B_Gir_C Delete
- 08958_B_Gir_C Rename

CBmax: Max Moment

MAX : 3083

MIN : 3071



CAMBER TABLE																								
Girder	Camber	Pier 2E	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	F.S. 7	0.9	Pier 14	0.1	0.2	F.S. 5	0.3	0.4	0.5	0.6	F.S. 5	0.7	0.8	
A	Vert. curvature	0	-1/8"	-1/8"	-1/8"	-1/8"	-2/8"	-2/8"	-2/8"	-2/8"	-1/8"	-1/8"	0	-1/8"	-2/8"	-2/8"	-1/8"	-1/8"	-1/8"	-1/8"	-1/8"	-1/8"	-1/8"	
	Dead load	0	2"	3 1/2"	4 1/2"	5 1/2"	5 1/2"	5 1/2"	3 1/2"	2 1/2"	2 1/2"	1 1/2"	0	-2"	-3 1/2"	-3 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	
	Shrinkage	0	1/8"	3/8"	4 1/8"	5 1/8"	5 1/8"	5 1/8"	3 1/8"	2 1/8"	2 1/8"	1 1/8"	0	0	0	0	0	0	0	0	0	0	0	
	Total	0	1 7/8"	3 7/8"	4 7/8"	4 7/8"	4 7/8"	3 7/8"	1 7/8"	1 7/8"	1 7/8"	1 1/8"	0	-2"	-3 1/8"	-3 1/8"	-4 1/8"	-4 1/8"	-4 1/8"	-4 1/8"	-4 1/8"	-4 1/8"	-4 1/8"	
	Horiz. curvature	0	0	0	0	0	0	0	0	0	0	0	0	0	1 1/2"	2 1/2"	3 1/2"	4 1/2"	5 1/2"	5 1/2"	5 1/2"	5 1/2"	4 1/2"	
	Vert. curvature	0	-1/8"	-1/8"	-1/8"	-1/8"	-2/8"	-2/8"	-2/8"	-2/8"	-1/8"	-1/8"	0	-1/8"	-2/8"	-2/8"	-1/8"	-1/8"	-1/8"	-1/8"	-1/8"	-1/8"	-1/8"	
	Dead load	0	2"	3 1/2"	4 1/2"	4 1/2"	5 1/2"	5 1/2"	5 1/2"	3 1/2"	2 1/2"	2 1/2"	1 1/2"	0	-2"	-3 1/2"	-3 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	-1 1/2"	

- Use of structure groups to easily view individual girder lines
- Check beam diagrams to insure appropriate shear and moment shapes
- Check dead load deflections against as-built camber tables



Model Output – Result Tables

	Elem	Load	Part	Component	Axial (kips)	Shear-y (kips)	Shear-z (kips)	Torsion (in*kips)	Moment-y (in*kips)	Moment-z (in*kips)
	5022	HL93(ma	J[5022]	Moment-y	0.00	0.00	0.00	0.00	0.00	0.00
	5022	HL93(ma	J[5023]	Moment-y	0.00	-7.55	-26.31	-1137.80	303.10	192.99
	5023	HL93(ma	J[5023]	Moment-y	1.88	-0.66	-16.61	101.35	323.69	17.47
	5023	HL93(ma	J[5024]	Moment-y	2.73	-1.96	-22.14	701.34	4057.08	136.33
	5024	HL93(ma	J[5024]	Moment-y	4.07	-0.90	-41.95	4594.46	5434.16	-271.67
	5024	HL93(ma	J[5025]	Moment-y	6.38	-1.82	-121.52	4784.54	25597.99	-190.99
	5025	HL93(ma	J[5025]	Moment-y	8.42	-0.71	-66.08	5453.74	25383.81	-310.88
	5025	HL93(ma	J[5026]	Moment-y	8.06	-0.93	-103.49	2403.51	41194.36	-116.89
	5026	HL93(ma	J[5026]	Moment-y	-1.45	0.26	4.37	1812.90	41276.43	156.51
	5026	HL93(ma	J[5027]	Moment-y	-1.45	0.26	4.37	1812.67	40964.07	138.11
	5027	HL93(ma	J[5027]	Moment-y	-1.45	0.25	4.37	1948.47	40957.85	138.11
	5027	HL93(ma	J[5028]	Moment-y	-2.01	0.27	-5.05	2825.18	40841.93	62.75
	5028	HL93(ma	J[5028]	Moment-y	-1.71	0.11	-5.35	3006.13	40839.62	43.98
	5028	HL93(ma	J[5029]	Moment-y	-1.80	0.05	-11.64	2618.70	41853.76	24.50
	5029	HL93(ma	J[5029]	Moment-y	-1.80	0.05	-11.64	2758.01	41844.80	24.50
	5029	HL93(ma	J[5030]	Moment-y	-1.76	-0.01	-29.33	2974.18	43023.75	19.19
	5030	HL93(ma	J[5030]	Moment-y	-1.56	-0.29	-28.04	3003.66	42985.25	0.25
	5030	HL93(ma	J[5031]	Moment-y	-1.56	-0.31	-31.99	3048.21	48826.56	54.91
	5031	HL93(ma	J[5031]	Moment-y	-1.54	-0.37	-29.32	3191.68	48773.22	32.62
	5031	HL93(ma	J[5032]	Moment-y	-1.65	-0.39	-30.73	3302.23	54303.63	98.20
	5033	HL93(ma	J[5033]	Moment-y	0.60	-1.09	-64.50	3833.31	100643.25	-26.70
	5033	HL93(ma	J[5034]	Moment-y	0.60	-1.09	-68.14	3729.69	112342.29	168.55
	5034	HL93(ma	J[5034]	Moment-y	0.39	-0.53	71.26	1221.08	111966.86	121.28
	5034	HL93(ma	J[5035]	Moment-y	0.49	-0.67	-0.68	1375.64	105872.27	238.93
	5035	HL93(ma	J[5035]	Moment-y	0.44	-0.34	79.44	44.26	105670.58	156.16
	5035	HL93(ma	J[5036]	Moment-y	0.49	-0.46	32.19	519.15	98339.07	209.80
	5036	HL93(ma	J[5036]	Moment-y	0.50	-0.45	32.19	829.39	98336.94	209.80
	5036	HL93(ma	J[5037]	Moment-y	0.51	-0.49	16.03	1444.87	97755.59	242.05
	5037	HL93(ma	J[5037]	Moment-y	0.39	-0.26	116.20	-89.19	97552.64	158.57
	5037	HL93(ma	J[5038]	Moment-y	0.46	-0.35	56.48	430.93	82292.15	222.46
	5038	HL93(ma	J[5038]	Moment-y	0.20	-0.15	121.16	-5099.43	82004.75	143.05
	5038	HL93(ma	J[5039]	Moment-y	-0.12	-0.22	42.27	-584.29	66444.87	89.73
	5039	HL93(ma	J[5039]	Moment-y	-0.28	-0.07	114.03	582.30	66532.34	51.38
	5039	HL93(ma	J[5040]	Moment-y	-0.27	-0.07	111.41	348.98	60418.49	54.88
	5040	HL93(ma	J[5040]	Moment-y	-0.27	-0.07	111.41	551.50	60416.97	54.88

	A	B	C	D	E	F	G	H	I	J
1	Max Moment									
2										
3										
4										
5										
6	Elem	Load	Part	Component	Axial (kips)	Shear-y (kips)	Shear-z (kips)	Torsion (in-kips)	Moment-y (in-kips)	Moment-z (in-kips)
7	5022	HL93(max)	I[5022]	Moment-y	0	0	0	0	0	0
8	5022	HL93(max)	J[5023]	Moment-y	0	0	0	0	0	0
9	5023	HL93(max)	I[5023]	Moment-y	4.72	-3.89	-11.19	473.55	104.28	-276.63
10	5023	HL93(max)	J[5024]	Moment-y	5.39	-5.44	-17.33	47.11	3082.91	615.3
11	5024	HL93(max)	I[5024]	Moment-y	5.1	0.65	-43.91	4449.24	4780.26	122.48
12	5024	HL93(max)	J[5025]	Moment-y	7.06	-0.47	-122.5	4635.36	25453	-73.72
13	5025	HL93(max)	I[5025]	Moment-y	8.59	0.07	-67.08	5310.4	25241.04	-161.57
14	5025	HL93(max)	J[5026]	Moment-y	8.22	-0.09	-104.11	2280.08	41301.7	-106.79
15	5026	HL93(max)	I[5026]	Moment-y	-1.56	0.35	4.33	1757.49	41399.84	169.57
16	5026	HL93(max)	J[5027]	Moment-y	-1.56	0.35	4.33	1757.45	41088.61	144.68
17	5027	HL93(max)	I[5027]	Moment-y	-1.57	0.34	4.33	1893.47	41082.56	144.68
18	5027	HL93(max)	J[5028]	Moment-y	-2.12	0.36	-5.08	2769.04	40978.04	59.29
19	5028	HL93(max)	I[5028]	Moment-y	-1.84	0.11	-5.29	2953.28	40976.17	41.74
20	5028	HL93(max)	J[5029]	Moment-y	-1.93	0.06	-11.57	2562.87	41989.89	21.86
21	5029	HL93(max)	I[5029]	Moment-y	-1.93	0.05	-11.57	2702.62	41981.13	21.86
22	5029	HL93(max)	J[5030]	Moment-y	-1.91	-0.01	-29.28	2914.91	43161.81	16.16
23	5030	HL93(max)	I[5030]	Moment-y	-1.7	-0.31	-27.89	2942.55	43122.68	-2.37
24	5030	HL93(max)	J[5031]	Moment-y	-1.7	-0.32	-31.84	2985.93	48938.41	54.39
25	5031	HL93(max)	I[5031]	Moment-y	-1.67	-0.38	-29.08	3124.26	48884.08	31.94
26	5031	HL93(max)	J[5032]	Moment-y	-1.78	-0.39	-30.49	3235.85	54369.57	99.14
27	5033	HL93(max)	I[5033]	Moment-y	0.52	-1.11	-64.42	3789.42	100805.1	-34.84
28	5033	HL93(max)	J[5034]	Moment-y	0.53	-1.11	-66.06	3685.76	112489.4	164.23
29	5034	HL93(max)	I[5034]	Moment-y	0.31	0.54	71.38	1174.17	111213.7	116.89

Midas Output Tables



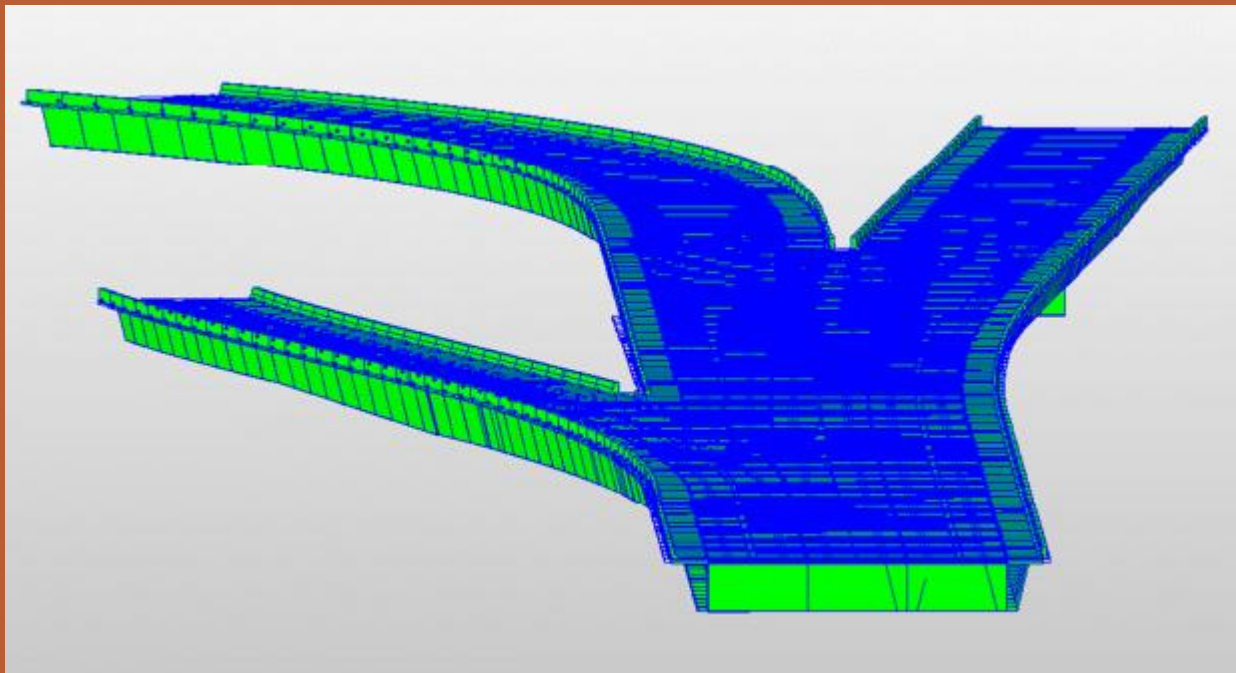
Capacity & RF Workbook

- Able to quickly copy and paste results form Midas into Excel



Conclusion

- 2D grillage models are an effective refined analysis option for complex bridges and when live load distribution factors are not applicable
- Using MCT command shell files to create large and/or complex models can save time and reduce errors
- Excel spreadsheets and macros can be used to create MCT files to stream line the process





DAVID EVANS
AND ASSOCIATES INC.



2D Grillage Analysis of Curved Steel Box Girders QUESTIONS?

**Presented by
Tim Link, PE**