

Computer Analysis Verification/Validation

Benjamin Szymanski, PE



“Design First, Then Compute”

“If you are not able to roughly design your structure by hand, you certainly have no business relying on your computer to do so.” – Stan Caldwell, P.E. *Structure Magazine*, Jul 2016

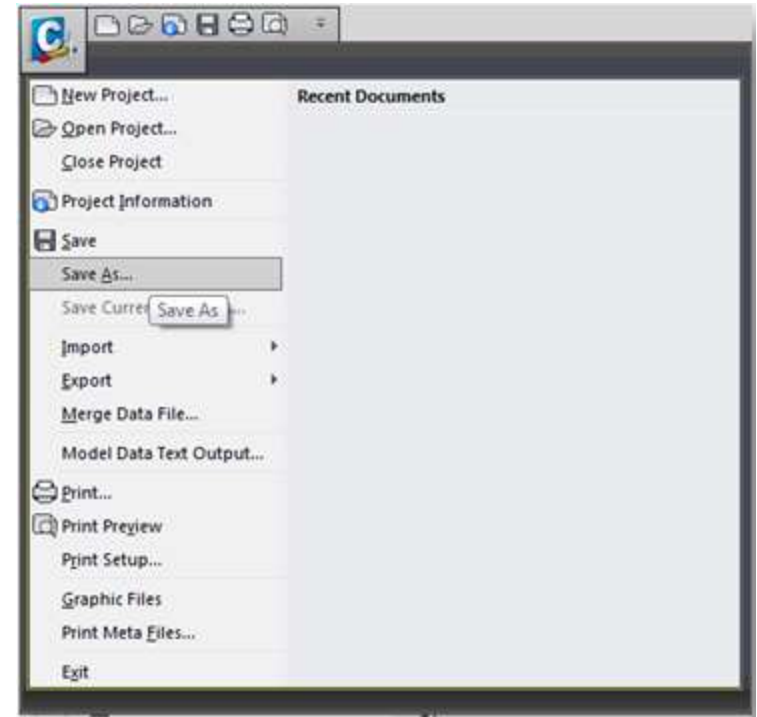
Overview

- Model Setup
- Debugging
- Validation Process
- Troubleshooting
- Best Practices

Model setup

Getting Started - Tips

- Name your model and associated spread based on:
 - Date created
 - Model description
- Create a “save-as” of your model often, specifically when major changes are made.
- Computer memory is cheap, you aren’t!
- Easy to go back if needed (i.e. file becomes corrupt)



Getting Started - Tips

- Work from your local (C:\) drive and backup to your network daily at a minimum.
- Faster on local drive.
- Keep a master version including all analysis
 - DL
 - Wind
 - Moving Load
 - Seismic
- Break the model out for more time consuming analysis:
 - Moving load
 - Seismic

Getting Started

- Keep your format as simple as possible
- Get your thought process on paper
- Begin documenting
- Establish a node/member/section property numbering system

 <b style="font-size: 24pt; font-weight: bold;">WSP	PARSONS BRINCKERHOFF	Sheet No. _____ of _____ Project # _____ Date <u>7/4/0</u>
Project <u>CONCRETE BRIDGE</u> Subject _____	Designed by <u>ATD</u> Checked by _____	Date _____ Date _____

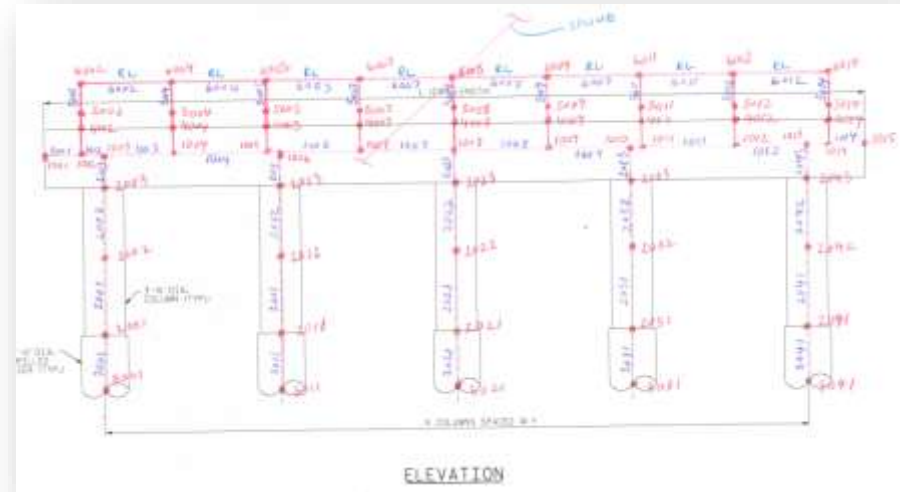
MODEL JOINT NUMBERING SYSTEM:



COMPONENT	SERIES
DECK	1000
GIRDER	2000
FLOOR BEAM	3000
BEARING MEMBER	4000
PIER CAP	5000
PIER COLUMN	6000
FOOTING	7000
BRID LINK	9000

Model Setup

- Minimize extraneous joints/members BUT keep in mind what sections will be required for design (i.e. location of M_{\max}^+ , M_{\max}^-)
- Use plan drawing or hand sketch to layout typical sections (i.e., typical pier numbering)



Model Setup

- In almost every situation, geometry or loading will change.
- Using a spreadsheet for a base is helpful.
- Different situations warrant different methodology
 - Spreadsheet input
 - DXF file import
 - User interface
- Future proof your work!

	1	2	3	4	5	6	7	8	9	10	11	12
Pier Geometry												
WING 1	Bridge 1				Footings 1				Footings 2			
	Plan	Section	Span	Slope Angle	Top of Deck	Top of Deck	Top of Deck	Pile Cap Thickness	Top of Cap	Pile Cap Thickness	Top of Cap	Pile Cap Thickness
	ft	ft	ft	deg	ft	ft	ft	ft	ft	ft	ft	ft
0.00	07	32+10.51	0.00	0	47.50	39.30	16.74	5.00	34.504	5.00	12.58	5.00
0.00	07	30+51.88	80.34	8	47.52	38.89	12.80	5.00	11.89	5.00		
0.00	07	09+48.81	85.18	8	48.52	40.09	8.87	5.00	9.47	5.00	11.85	5.00
0.00	06	08+19.21	338.89	8	49.76	40.30	8.52	5.00	9.88	5.00	7.82	5.00
0.00	05	07+18.89	112.54	88	50.95	48.04	11.36	5.00	11.68	5.00		
0.00	05	24+81.77	11.12	4	51.52	48.12	5.56	5.00	6.41	5.00		
0.00	07	44+10.89	47.07	2	51.52	48.12	5.51	5.00	5.30	5.00		
0.00	08	45+80.10	16.54	0	51.52	48.12	14.29	5.00	5.85	5.00		
WING 2	Plan	Section	Span	Slope Angle	Top of Deck	Top of Deck	Top of Deck	Pile Cap Thickness	Top of Cap	Pile Cap Thickness	Top of Cap	Pile Cap Thickness
	ft	ft	ft	deg	ft	ft	ft	ft	ft	ft	ft	ft
	ft	ft	ft	deg	ft	ft	ft	ft	ft	ft	ft	ft
-4.77	04-05	38+40.00	0.00	0	50.25	43.10	16.74	5.00	34.504	5.00	12.58	5.00
-1.54	04-02	37+48.50	88.47	0	45.40	36.53	12.80	5.00	12.517	5.00		
-2.94	04-05	36+68.75	99.85	0	49.41	51.38	8.57	5.00	6.478	5.00	11.85	5.00
-1.88	04-04	35+88.00	100.00	0	33.48	30.80	9.31	5.00	8.392	5.00	7.50	5.00
-0.30	04-05	34+50.00	117.88	01	35.12	28.54	11.85	5.00	11.663	5.00		
0.00	04-06	33+01.13	47.80	0	38.66	26.79	5.86	5.00	6.809	5.00		
0.00	04-07	32+01.88	47.18	0	38.66	26.79	6.63	5.00	8.000	5.00		
0.00	04-08	31+14.11	14.18	0	38.66	26.79	14.29	5.00	8.610	5.00		

Model Setup

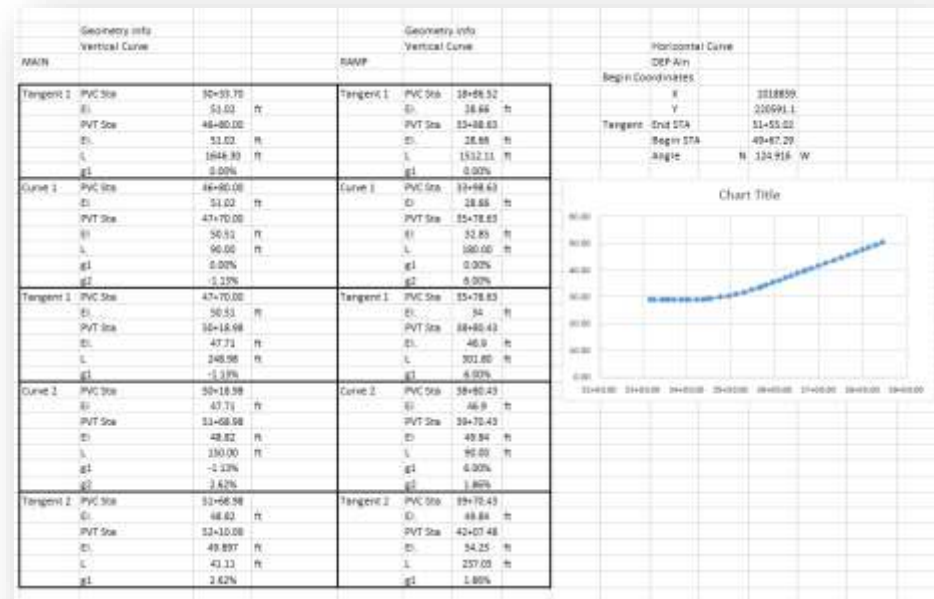
- Thoroughly document loading within spreadsheet or hand calculations.
- Break out each load type so future results can be easily identified. (i.e. barrier load, FWS, counterweight, etc.)

Span 1				Type	p	w	p
Loads to be applied to the model:					psf	k/ft	k
1	Connections			DC1	EGs = 120%, FBS = 115%		
2	Splices			DC1		1.219	
3	Stringers			DC1	SEE BELOW		
4	Utilities			DW	5.56		
5	Sub stringers			DC1	1.97		
6	Haunches			DC1	1.34		
7	Overlay			DW	11.64		
8	FWS			DW	25.86		
9	Add'l deck			DC1	4.48		
10	Barriers			DC2	13.33		
11	Pedestrian Rail and Fence			DC2	Applied as line loads		
12	Concrete fill			DC1	SEE TABLE		
13	Pier Cap			DC1		3.12	
14	Footings			DC1			2278.5

Model Setup

Bridge Model:

- Spreadsheet created for nodes, members, plates, section properties.
- Spreadsheet name associated with date and model
- Horizontal curves, Vertical profile and superelevations/cross-slopes developed from civil data.
- Simple input, flexible for the possibility of future change (it will happen).



Model Setup

Structure Weight Check:					
Superstructure:					
				Factor	W (kips)
Girders:	1971	kips		1.2	2,365
Floorbeams:	2288	kips		1.15	2,631
Deck:	11084	kips		1	11,084
Lateral Bracing:	41.85	kips		1	42
				Subtotal:	16,122 kips
Substructure:					
Pier 1					
				Factor	W (kips)
Cap:	1804.2	kips		1	1,804
Column 1:	375.92	kips		1	376
Column 2:	384.41	kips		1	384
Pier 2					
				Factor	W (kips)
Cap:	1804.2	kips		1	1,804
Column 1:	317.02827	kips		1	317
Column 2:	335.82477	kips		1	336
				Subtotal:	5,022 kips
Total Structure Weight:				33,658	kips
MIDAS Total SW Reaction:				34,511	kips
% Diff:				2.54%	

Bridge Model:

- Spreadsheet is linked throughout so that future changes are automatic.
- Consistency will help with a repetitive model.
- Add a check of geometry/loads in parallel of input section.

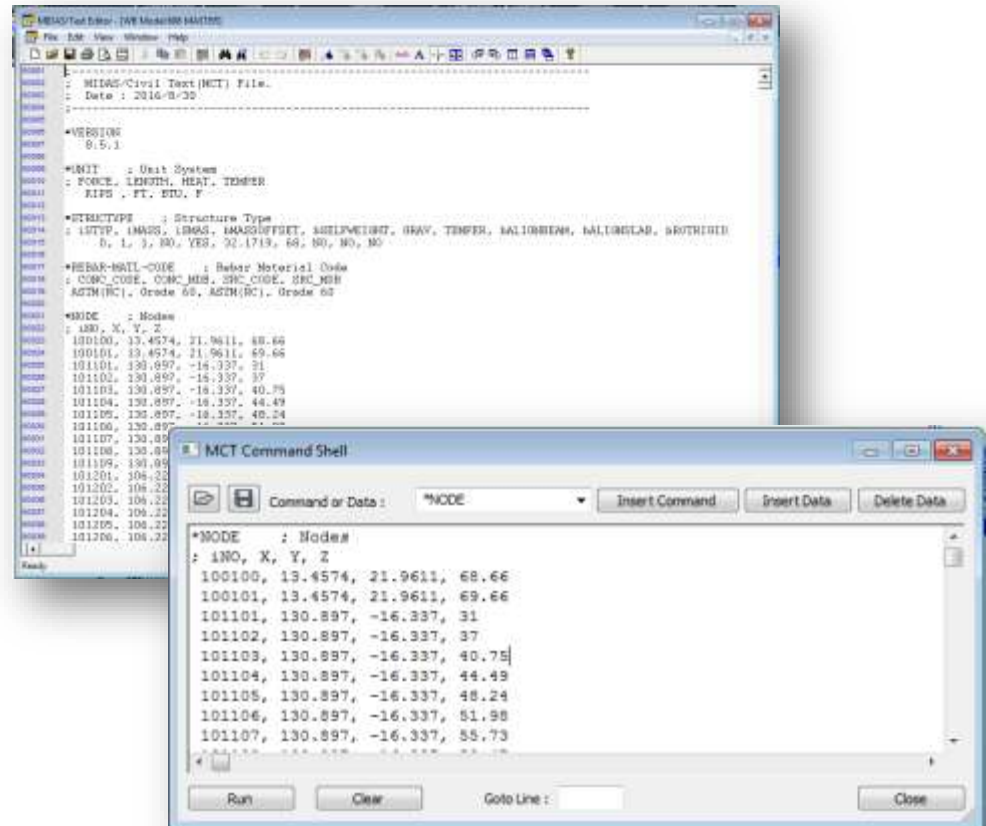
Model Setup

Bridge Model:

Spreadsheet data may be input using:

- MCB file or
- Piece by piece using “MCT Command Shell”

.mcb file:

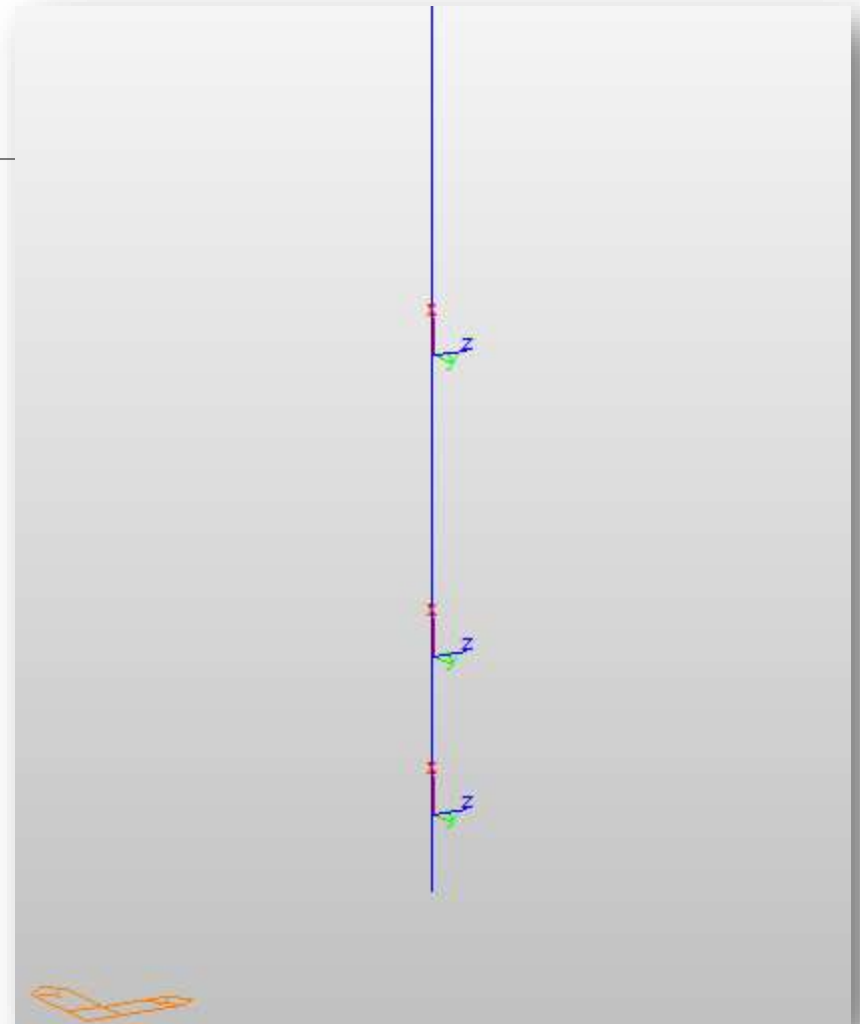


MCT Command Shell

Model Setup

Bridge Model:

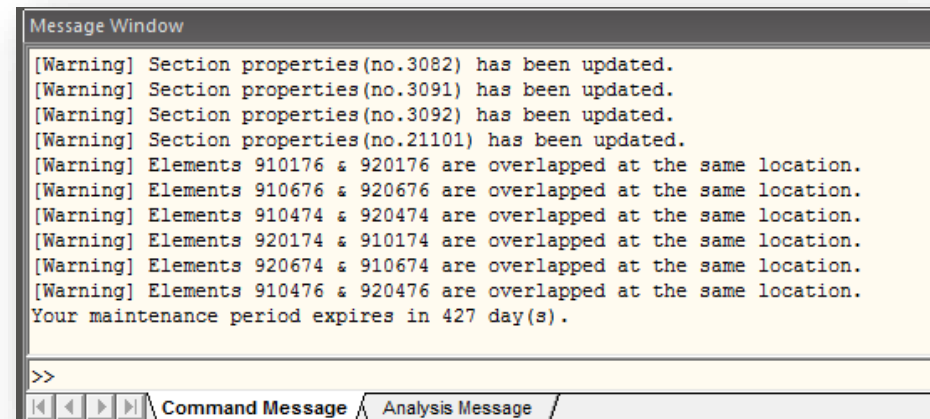
- Majority of data input using text
- Member orientations and geometry verified in user interface.
- Consistent member orientation is important.



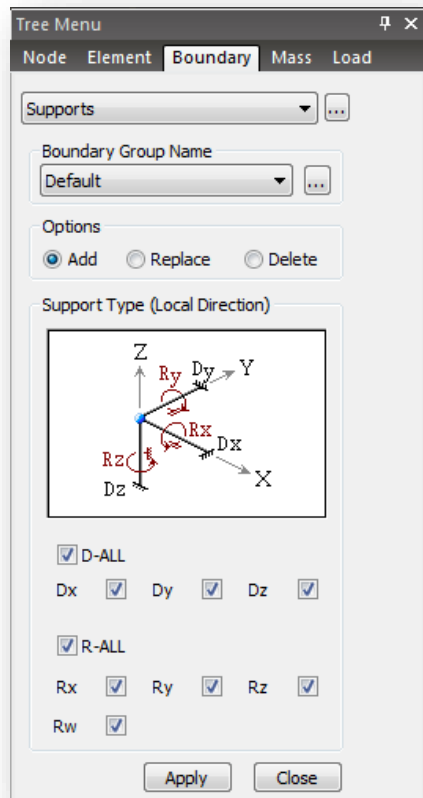
Debugging

Debugging

- Even the most carefully set up model can have errors or warnings.
- Error or warning message often further downstream from the problem.
- Errors must be resolved.
- Warnings don't always need to be addressed.



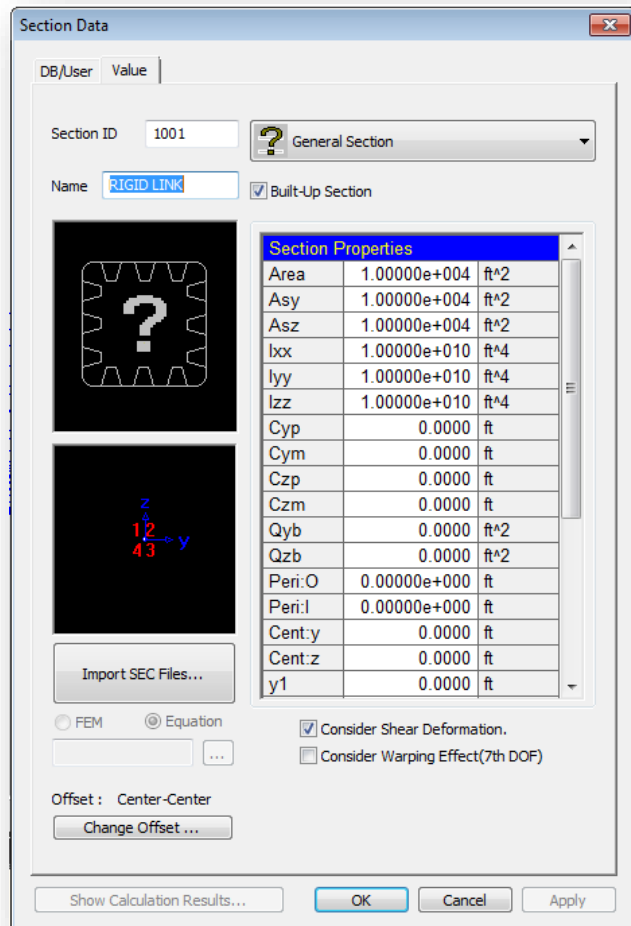
Debugging



Common Sources of Error:

- Boundary Conditions
 - Effects the structure stability
- Members incorrectly defined.
 - Double check spreadsheet, make changes within spreadsheet.
 - Make sure this problem isn't repetitive.
- Changes made directly in .mcb file or MCT Command Shell
- Tapered section groups.

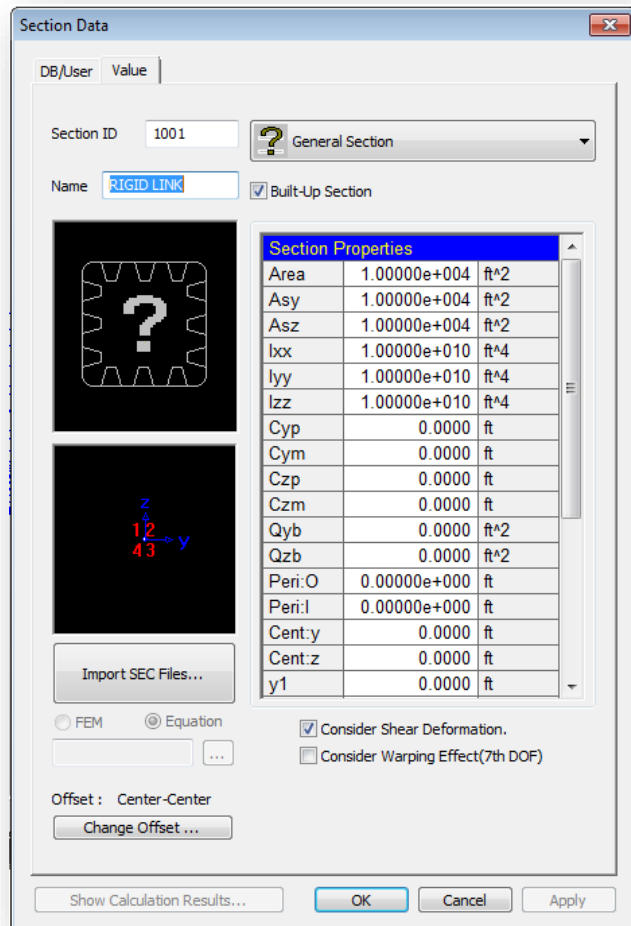
Debugging



Common Sources of Error:

- Rigid links too stiff.
 - User defined Rigid links should have stiffness 10^3 times as the stiffest member it is connected to.
- Rigid links too soft.
 - May not be flagged as an error by the program.

Debugging



Rigid Links:

- Beyond runtime errors, improperly defined rigid links may cause incorrect results.
- Rigid links must be calibrated. (iterative)

Validation Process

Model Validation

- You should have an idea of how you expect your model to behave.
- Computer model is a tool, not the end-all, be-all.
- Are your results making sense?
- Garbage-in, Garbage-out



Model Validation

Dead Loads:


- After basic model setup and dead loads have been added.
- Hand calculate (or in Excel):
 - Reactions
 - Overall model weight
- Compare to model results.
- May also add temporary test loads to simply verify that load path is as expected and 100% of the loads are accounted for.

WSP | **PARSONS BRINCKERHOFF**

Project: PHASE 2: AS-BUILT - CPSC | Calculated by: ETJ | Date: 11/19
Sheet: _____ | Checked by: _____ | Date: _____

STRUCTURAL WEIGHTS


PIER 1
PIER CAP



$A = 1' \times 1' = 56 \text{ ft}^2$
 $LENGTH = 18'$

$WEIGHT = 56 \text{ ft}^2 \times 50 \frac{\text{lb}}{\text{ft}^2} \times 0.150 \text{ KCF}$
 $= 422 \text{ K}$

COLUMN



$EXT. CAP \text{ EL} = 23.8'$
 $INT. FTG. \text{ EL} = 0.0'$
 $H = 23.8'$

$A = \frac{\pi}{4} (6')^2 = 10.6 \text{ ft}^2$

$WEIGHT = 10.6 \text{ ft}^2 \times 2 \text{ COL} \times 23.8' \times 0.150 \text{ KCF}$
 $= 113 \text{ K}$

PIER 1 TOTAL WEIGHT:

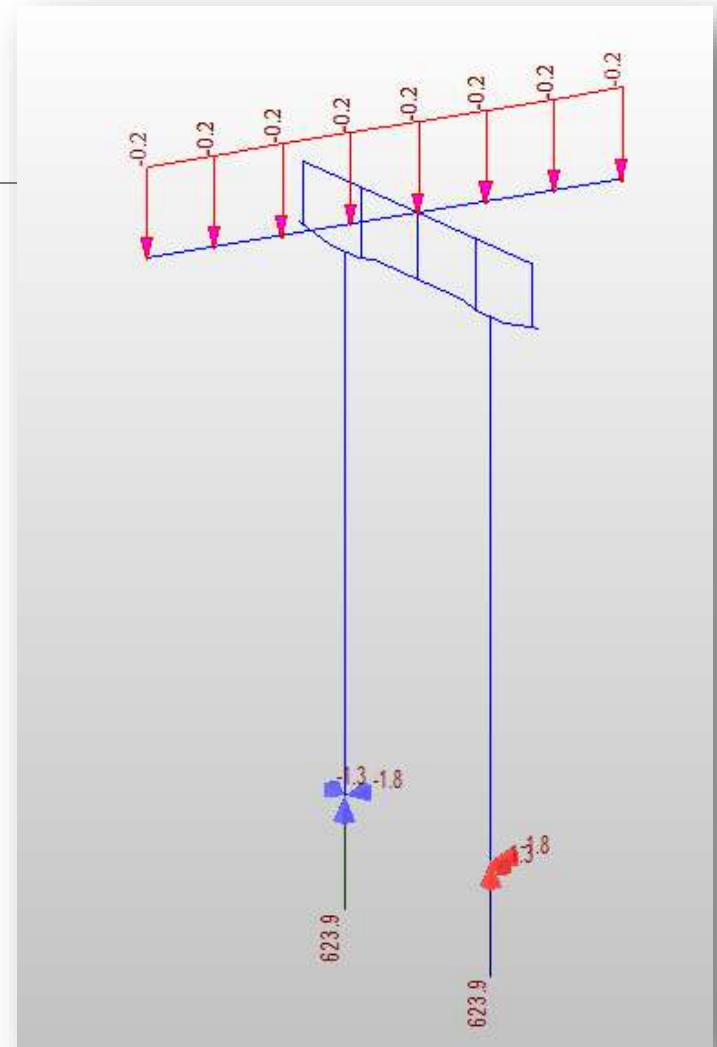
722
<u>+ 113</u>
<u>835 K</u>

527 IN MODEL ✓

Model Validation

Dead Loads:

- Check magnitudes and directions of forces and reactions are as expected.
- Forces applied are vertical, are the reactions?
- Are forces following the expected load path from the applied load.

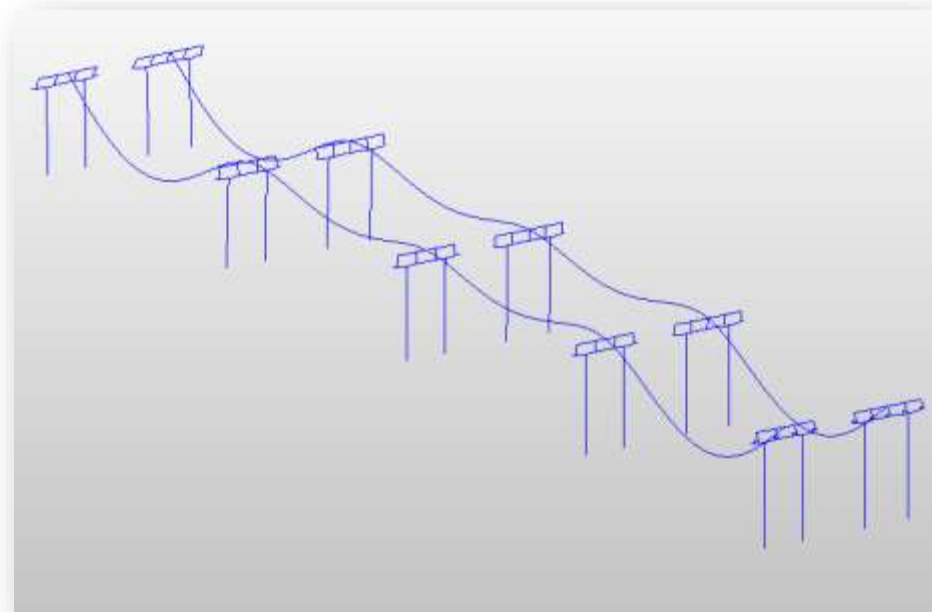


Model Validation

Dead Loads:

Deflected shape

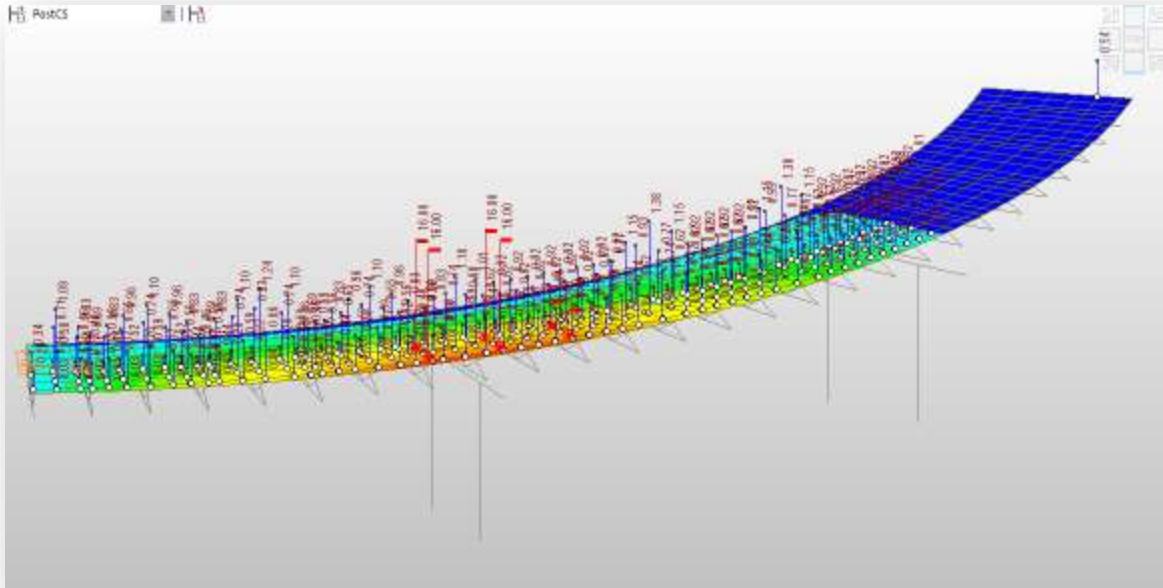
- Is the model superstructure/substructure deflecting as expected?
- Are the magnitudes reasonable?
- Look at the deflected shape for each of the broken out load types and compare.
- Deflections may be plotted in Excel to compare magnitudes from each contributing load



Model Validation

Live loads:

- Applied loading and moving load cases should be documented externally.
- Look at each case using:
 - Moving load tracer
 - Influence Surface/Lines
- Check key locations:
 - Max reaction at a pier
 - Girder M_{\max}^-
 - Girder M_{\max}^+
 - Etc.



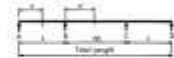
Model Validation

Live loads:

Spot check using hand calculations.

- *AISC Manual of Steel Construction* continuous beam tables
- *AISC Moments, Shears and Reactions for Continuous Highway Bridges*

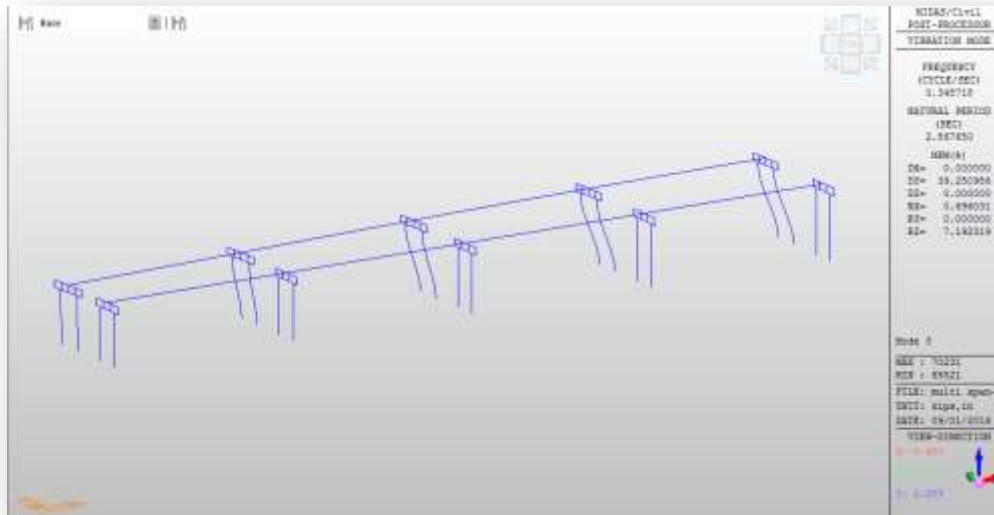
TABLE 3.1
Symmetrical three-span continuous beam.
Constant moment of inertia.
AASHTO HS20-44 loading.



N=1.1

Panel Length ft	Span Length ft	Max. Reaction Kips		Max. Shear Kips		Max. Moment Kip-ft		Impact Coefficient				Mid-Span Kip-ft	
		at A	at B	at A or B	at C or D	at A or B	at C or D	1	2	3	4		
10	30.0	91.1	92.2	-12.9	51.1	218.1	-142.2	142.2	0.00	0.00	0.00	19.4	14.3
20	30.0	48.8	88.4	-15.1	24.4	275.2	-222.2	222.2	0.00	0.00	0.00	22.4	17.1
30	30.0	31.4	68.9	-16.2	10.9	298.4	-274.4	274.4	0.00	0.00	0.00	25.4	19.9
40	30.0	22.4	57.2	-16.9	5.4	304.4	-304.4	304.4	0.00	0.00	0.00	27.4	20.9
50	30.0	17.4	48.2	-17.1	3.4	307.4	-307.4	307.4	0.00	0.00	0.00	28.4	21.4
60	30.0	14.4	40.2	-17.1	2.4	308.4	-308.4	308.4	0.00	0.00	0.00	29.4	21.9
70	30.0	12.4	34.2	-17.1	1.4	309.4	-309.4	309.4	0.00	0.00	0.00	30.4	22.4
80	30.0	10.4	29.2	-17.1	0.4	310.4	-310.4	310.4	0.00	0.00	0.00	31.4	22.9
90	30.0	8.4	24.2	-17.1	0.4	311.4	-311.4	311.4	0.00	0.00	0.00	32.4	23.4
100	30.0	6.4	19.2	-17.1	0.4	312.4	-312.4	312.4	0.00	0.00	0.00	33.4	23.9
110	30.0	4.4	14.2	-17.1	0.4	313.4	-313.4	313.4	0.00	0.00	0.00	34.4	24.4
120	30.0	2.4	9.2	-17.1	0.4	314.4	-314.4	314.4	0.00	0.00	0.00	35.4	24.9
130	30.0	0.4	4.2	-17.1	0.4	315.4	-315.4	315.4	0.00	0.00	0.00	36.4	25.4
140	30.0	0.4	4.2	-17.1	0.4	316.4	-316.4	316.4	0.00	0.00	0.00	37.4	25.9
150	30.0	0.4	4.2	-17.1	0.4	317.4	-317.4	317.4	0.00	0.00	0.00	38.4	26.4
160	30.0	0.4	4.2	-17.1	0.4	318.4	-318.4	318.4	0.00	0.00	0.00	39.4	26.9
170	30.0	0.4	4.2	-17.1	0.4	319.4	-319.4	319.4	0.00	0.00	0.00	40.4	27.4
180	30.0	0.4	4.2	-17.1	0.4	320.4	-320.4	320.4	0.00	0.00	0.00	41.4	27.9
190	30.0	0.4	4.2	-17.1	0.4	321.4	-321.4	321.4	0.00	0.00	0.00	42.4	28.4
200	30.0	0.4	4.2	-17.1	0.4	322.4	-322.4	322.4	0.00	0.00	0.00	43.4	28.9
210	30.0	0.4	4.2	-17.1	0.4	323.4	-323.4	323.4	0.00	0.00	0.00	44.4	29.4
220	30.0	0.4	4.2	-17.1	0.4	324.4	-324.4	324.4	0.00	0.00	0.00	45.4	29.9
230	30.0	0.4	4.2	-17.1	0.4	325.4	-325.4	325.4	0.00	0.00	0.00	46.4	30.4
240	30.0	0.4	4.2	-17.1	0.4	326.4	-326.4	326.4	0.00	0.00	0.00	47.4	30.9
250	30.0	0.4	4.2	-17.1	0.4	327.4	-327.4	327.4	0.00	0.00	0.00	48.4	31.4
260	30.0	0.4	4.2	-17.1	0.4	328.4	-328.4	328.4	0.00	0.00	0.00	49.4	31.9
270	30.0	0.4	4.2	-17.1	0.4	329.4	-329.4	329.4	0.00	0.00	0.00	50.4	32.4
280	30.0	0.4	4.2	-17.1	0.4	330.4	-330.4	330.4	0.00	0.00	0.00	51.4	32.9
290	30.0	0.4	4.2	-17.1	0.4	331.4	-331.4	331.4	0.00	0.00	0.00	52.4	33.4
300	30.0	0.4	4.2	-17.1	0.4	332.4	-332.4	332.4	0.00	0.00	0.00	53.4	33.9
310	30.0	0.4	4.2	-17.1	0.4	333.4	-333.4	333.4	0.00	0.00	0.00	54.4	34.4
320	30.0	0.4	4.2	-17.1	0.4	334.4	-334.4	334.4	0.00	0.00	0.00	55.4	34.9
330	30.0	0.4	4.2	-17.1	0.4	335.4	-335.4	335.4	0.00	0.00	0.00	56.4	35.4
340	30.0	0.4	4.2	-17.1	0.4	336.4	-336.4	336.4	0.00	0.00	0.00	57.4	35.9
350	30.0	0.4	4.2	-17.1	0.4	337.4	-337.4	337.4	0.00	0.00	0.00	58.4	36.4
360	30.0	0.4	4.2	-17.1	0.4	338.4	-338.4	338.4	0.00	0.00	0.00	59.4	36.9
370	30.0	0.4	4.2	-17.1	0.4	339.4	-339.4	339.4	0.00	0.00	0.00	60.4	37.4
380	30.0	0.4	4.2	-17.1	0.4	340.4	-340.4	340.4	0.00	0.00	0.00	61.4	37.9
390	30.0	0.4	4.2	-17.1	0.4	341.4	-341.4	341.4	0.00	0.00	0.00	62.4	38.4
400	30.0	0.4	4.2	-17.1	0.4	342.4	-342.4	342.4	0.00	0.00	0.00	63.4	38.9
410	30.0	0.4	4.2	-17.1	0.4	343.4	-343.4	343.4	0.00	0.00	0.00	64.4	39.4
420	30.0	0.4	4.2	-17.1	0.4	344.4	-344.4	344.4	0.00	0.00	0.00	65.4	39.9
430	30.0	0.4	4.2	-17.1	0.4	345.4	-345.4	345.4	0.00	0.00	0.00	66.4	40.4
440	30.0	0.4	4.2	-17.1	0.4	346.4	-346.4	346.4	0.00	0.00	0.00	67.4	40.9
450	30.0	0.4	4.2	-17.1	0.4	347.4	-347.4	347.4	0.00	0.00	0.00	68.4	41.4
460	30.0	0.4	4.2	-17.1	0.4	348.4	-348.4	348.4	0.00	0.00	0.00	69.4	41.9
470	30.0	0.4	4.2	-17.1	0.4	349.4	-349.4	349.4	0.00	0.00	0.00	70.4	42.4
480	30.0	0.4	4.2	-17.1	0.4	350.4	-350.4	350.4	0.00	0.00	0.00	71.4	42.9
490	30.0	0.4	4.2	-17.1	0.4	351.4	-351.4	351.4	0.00	0.00	0.00	72.4	43.4
500	30.0	0.4	4.2	-17.1	0.4	352.4	-352.4	352.4	0.00	0.00	0.00	73.4	43.9
510	30.0	0.4	4.2	-17.1	0.4	353.4	-353.4	353.4	0.00	0.00	0.00	74.4	44.4
520	30.0	0.4	4.2	-17.1	0.4	354.4	-354.4	354.4	0.00	0.00	0.00	75.4	44.9
530	30.0	0.4	4.2	-17.1	0.4	355.4	-355.4	355.4	0.00	0.00	0.00	76.4	45.4
540	30.0	0.4	4.2	-17.1	0.4	356.4	-356.4	356.4	0.00	0.00	0.00	77.4	45.9
550	30.0	0.4	4.2	-17.1	0.4	357.4	-357.4	357.4	0.00	0.00	0.00	78.4	46.4
560	30.0	0.4	4.2	-17.1	0.4	358.4	-358.4	358.4	0.00	0.00	0.00	79.4	46.9
570	30.0	0.4	4.2	-17.1	0.4	359.4	-359.4	359.4	0.00	0.00	0.00	80.4	47.4
580	30.0	0.4	4.2	-17.1	0.4	360.4	-360.4	360.4	0.00	0.00	0.00	81.4	47.9
590	30.0	0.4	4.2	-17.1	0.4	361.4	-361.4	361.4	0.00	0.00	0.00	82.4	48.4
600	30.0	0.4	4.2	-17.1	0.4	362.4	-362.4	362.4	0.00	0.00	0.00	83.4	48.9
610	30.0	0.4	4.2	-17.1	0.4	363.4	-363.4	363.4	0.00	0.00	0.00	84.4	49.4
620	30.0	0.4	4.2	-17.1	0.4	364.4	-364.4	364.4	0.00	0.00	0.00	85.4	49.9
630	30.0	0.4	4.2	-17.1	0.4	365.4	-365.4	365.4	0.00	0.00	0.00	86.4	50.4
640	30.0	0.4	4.2	-17.1	0.4	366.4	-366.4	366.4	0.00	0.00	0.00	87.4	50.9
650	30.0	0.4	4.2	-17.1	0.4	367.4	-367.4	367.4	0.00	0.00	0.00	88.4	51.4
660	30.0	0.4	4.2	-17.1	0.4	368.4	-368.4	368.4	0.00	0.00	0.00	89.4	51.9
670	30.0	0.4	4.2	-17.1	0.4	369.4	-369.4	369.4	0.00	0.00	0.00	90.4	52.4
680	30.0	0.4	4.2	-17.1	0.4	370.4	-370.4	370.4	0.00	0.00	0.00	91.4	52.9
690	30.0	0.4	4.2	-17.1	0.4	371.4	-371.4	371.4	0.00	0.00	0.00	92.4	53.4
700	30.0	0.4	4.2	-17.1	0.4	372.4	-372.4	372.4	0.00	0.00	0.00	93.4	53.9
710	30.0	0.4	4.2	-17.1	0.4	373.4	-373.4	373.4	0.00	0.00	0.00	94.4	54.4
720	30.0	0.4	4.2	-17.1	0.4	374.4	-374.4	374.4	0.00	0.00	0.00	95.4	54.9
730	30.0	0.4	4.2	-17.1	0.4	375.4	-375.4	375.4	0.00	0.00	0.00	96.4	55.4
740	30.0	0.4	4.2	-17.1	0.4	376.4	-376.4	376.4	0.00	0.00	0.00	97.4	55.9
750	30.0	0.4	4.2	-17.1	0.4	377.4	-377.4	377.4	0.00	0.00	0.00	98.4	56.4
760	30.0	0.4	4.2	-17.1	0.4	378.4	-378.4	378.4	0.00	0.00	0.00	99.4	56.9
770	30.0	0.4	4.2	-17.1	0.4	379.4	-379.4	379.4	0.00	0.00	0.00	100.4	57.4
780	30.0	0.4	4.2	-17.1	0.4	380.4	-380.4	380.4	0.00	0.00	0.00	101.4	57.9
790	30.0	0.4	4.2	-17.1	0.4	381.4	-381.4	381.4	0.00	0.00	0.00	102.4	58.4
800	30.0	0.4	4.2	-17.1	0.4	382.4	-382.4	382.4	0.00	0.00	0.00	103.4	58.9
810	30.0	0.4	4.2	-17.1	0.4	383.4	-383.4	383.4	0.00	0.00	0.00	104.4	59.4
820	30.0	0.4	4.2	-17.1	0.4	384.4	-384.4	384.4	0.00	0.00	0.00	105.4	59.9
830	30.0	0.4	4.2	-17.1	0.4	385.4	-385.4	385.4	0.00	0.00	0.00	106.4	60.4
840	30.0	0.4	4.2	-17.1	0.4	386.4	-386.4	386.4	0.00	0.00	0.00	107.4	60.9
850	30.0	0.4	4.2	-17.1	0.4	387.4	-387.4	387.4	0.00	0.00	0.00	108.4	61.4
860	30.0	0.4	4.2	-17.1	0.4	388.4	-388.4	388.4	0.00	0.00	0.00	109.4	61.9
870	30.0	0.4	4.2	-17.1	0.4	389.4	-389.4	389.4	0.00	0.00	0.00	110.4	62.4
880	30.0	0.4	4.2	-17.1	0.4	390.4	-390.4	390.4	0.00	0.00	0.00	111.4	62.9
890	30.0	0.4	4.2	-17.1	0.4	391.4	-391.4	391.4	0.00	0.00	0.00	112.4	63.4
900	30.0	0.4	4.2	-17.1	0.4	392.4	-392.4	392.4	0.00	0.00	0.00	113.4	63.9
910	30.0	0.4	4.2										

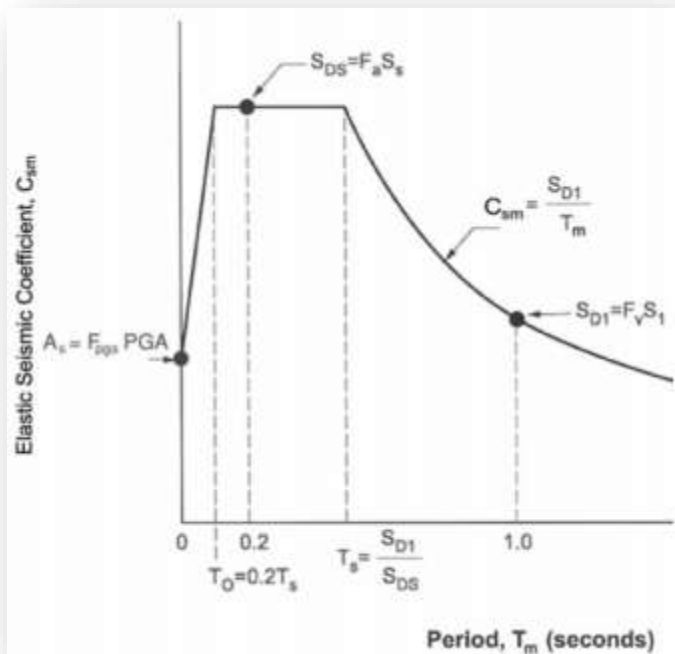
Model Validation



Seismic Loading:

- Look at your mode shapes. (At least first 10)
- Fundamental frequency/period
- Mass Participation
- % Mass Participation
 - > 90% in horizontal directions
 - > 80 % in vertical direction

Model Validation



Weight

Seismic Loading:

- Spot check and hand calculations can be done using the Single-Mode Spectral Method.
- Using fundamental period

Troubleshooting

Troubleshooting

Dead Load

- Weight does not match hand calculation
 - Verify weight is accounted for in either “self weight” or applied loads
 - Verify material densities (check the “automatic properties” are correct)
- Very large deflections
 - Check that rigid links defined properly.
 - Check member releases

Material Data

General

Material ID: 1100 Name: RIGID LINK

Elasticity Data

Type of Design: User Defined

User Defined

Standard: None

DB:

Concrete

Code:

DB:

Type of Material

☒ Isotropic ☐ Orthotropic

User Defined

Modulus of Elasticity : 4.1760e+006 kips/ft²

Poisson's Ratio : 0.3

Thermal Coefficient : 6.5000e-006 1/[F]

Weight Density : 1e-017 kips/ft³

☐ Use Mass Density: 0 kips/ft³/g

☐ Concrete

Modulus of Elasticity : 0.0000e+000 kips/ft²

Poisson's Ratio : 0

Thermal Coefficient : 0.0000e+000 1/[F]

Weight Density : 0 kips/ft³

☐ Use Mass Density: 0 kips/ft³/g

Plasticity Data

Plastic Material Name: NONE

Thermal Transfer

Specific Heat : 0 Btu/kips*[F]

Heat Conduction : 0 Btu/ft*hr*[F]

Damping Ratio : 0.02

OK Cancel Apply

Troubleshooting

Live Load

Resulting loads/forces are off

- Is multiple presence properly defined?
- Is impact included?
- Are combination of trucks/lanes defined properly?
- Look at moving load tracer

Define Standard Vehicular Load

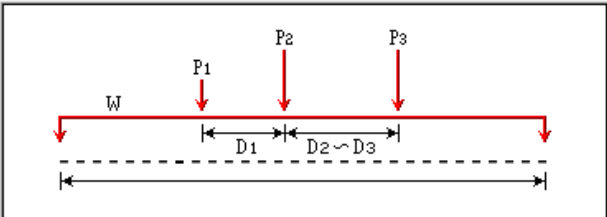
Standard Name: AASHTO LRFD Load

Vehicular Load Properties

Vehicular Load Name:

Vehicular Load Type: HL-93TRK

Dynamic Load Allowance: 33 %



No	Load(kips)	Spacing(ft)
1	8	14
2	32	14
3	32	30

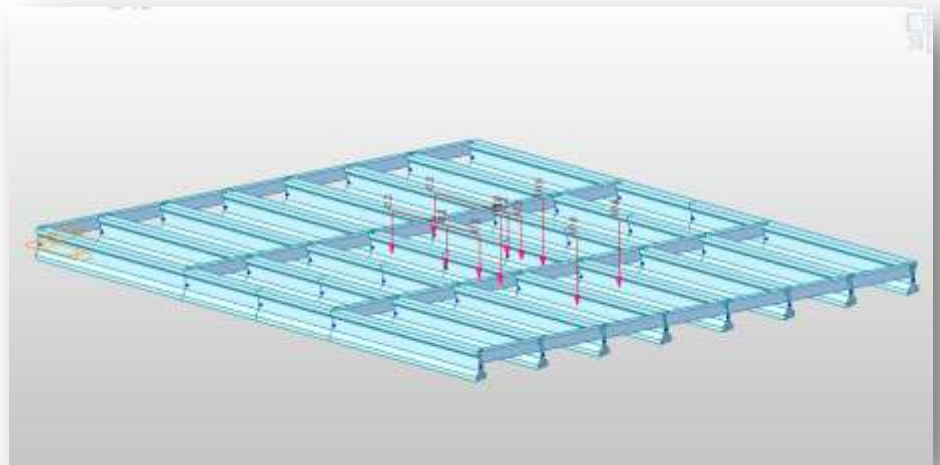
W	0.64	kips/ft
Ps	0	kips
Pm	0	kips
dW1	0	kips/ft
dD1	0	ft
dW2	0	kips/ft
dD2	0	ft

OK Cancel Apply

Troubleshooting

Live Load

- Create static load simulating Live Load case, compare to moving load
- Move to key locations to verify expected results by hand calculation

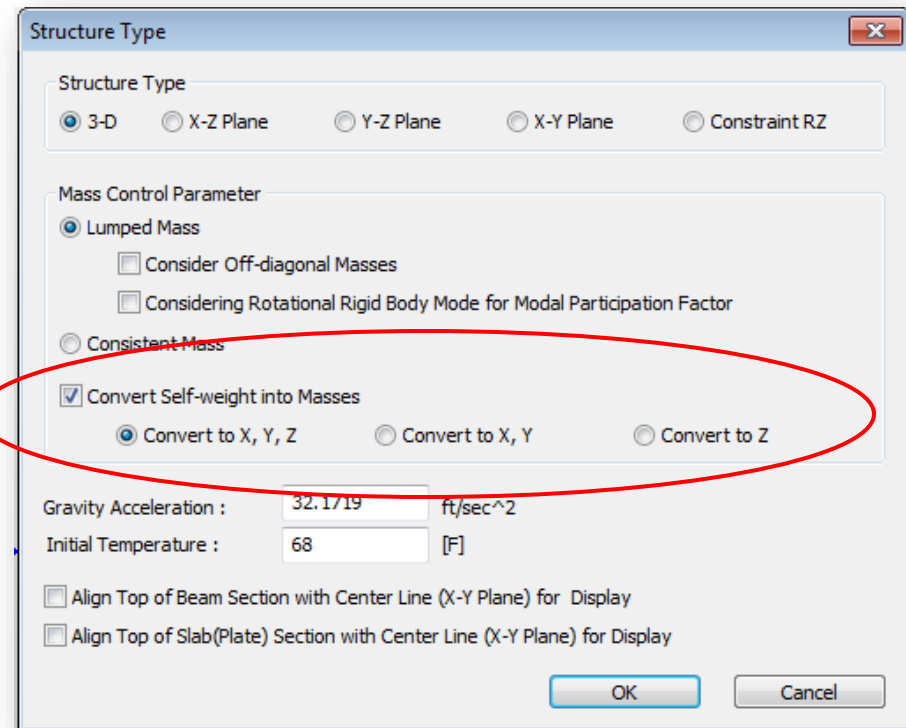


Troubleshooting

Seismic

Mass Participation is low.

- Increase the number of modes.
- Verify that option to convert self weight to mass is checked.
- Verify “Loads to Mass” function has accounted for all mass.



Troubleshooting

Seismic

Fundamental Period is unreasonably high, check:

- Member connectivity
- Support definitions
- Member releases
- Rigid link or general link stiffness.

Add/Modify General Link Properties

Name : Appr to Bearings

Description :

Application Type
☒ Element ☐ Force

Property Type : Spring Inelastic Hinge Properties...

Self Weight
Total Weight : 0 kips
Lumped Weight Ratio:
I-end : J-end = 0.5 : 0.5

☐ Use Mass
Total Mass : 0 kips/g
Lumped Mass Ratio:
I-end : J-end = 0.5 : 0.5

Linear Properties

DOF	Stiffness	Damping
<input checked="" type="checkbox"/> Dx	99999960 kips/ft	0 kips*sec/ft
<input checked="" type="checkbox"/> Dy	99999960 kips/ft	0 kips*sec/ft
<input checked="" type="checkbox"/> Dz	99999960 kips/ft	0 kips*sec/ft
<input checked="" type="checkbox"/> Rx	10000000 ft*kips/[rad]	0 ft*kips*sec/[rad]
<input checked="" type="checkbox"/> Ry	10000000 ft*kips/[rad]	0 ft*kips*sec/[rad]
<input checked="" type="checkbox"/> Rz	10000000 ft*kips/[rad]	0 ft*kips*sec/[rad]

Coupled

Nonlinear Properties

DOF	Properties...
<input type="checkbox"/> Dx	Properties...
<input type="checkbox"/> Dy	Properties...
<input type="checkbox"/> Dz	Properties...
<input type="checkbox"/> Rx	Properties...
<input type="checkbox"/> Ry	Properties...
<input type="checkbox"/> Rz	Properties...

☐ Shear Spring Location
Distance Ratio From End I
Dy : 0.5 Dz : 0.5

OK Cancel Apply

Troubleshooting

Do a “save as” of your model

Break it down piece-by-piece

Simplify in order to pinpoint problem & speed up run time

Back of the envelope hand calculations

Best Practices

Best Practices

1. Documentation

- Before you start your model
- Step-by-step along the way
- Include notes, methodology, model associated with spreadsheet
- Model screenshots with results

2. Backup your work

- Save a version every time a major change is made
- Save as on a routine basis

3. Descriptive naming and methodology

- Date
- Simple description

4. Future proof your work

- Easy to modify spreadsheets

Best Practices

5. Expected results

- Understand the problem you are solving.
- Think about what results you expect.
- Look at the big picture

6. Hand check your work

- Back-of-the-envelope calculations

7. Validate model after major changes

- Mode shapes
- Fundamental period
- Reactions
- Deformed shapes

Thank You

References

1. AASHTO. 2014. *AASHTO LRFD Bridge Design Specifications, 7th Edition, 2015 and 2016 Interim*. American Association of State Highway and Transportation Officials, Washington, DC.
2. Adams, Scott. "Dilbert." N.p.: n.p., n.d. Print.