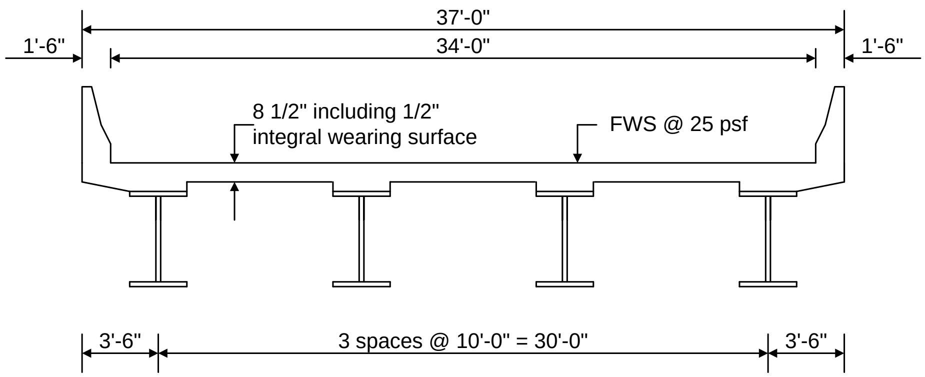
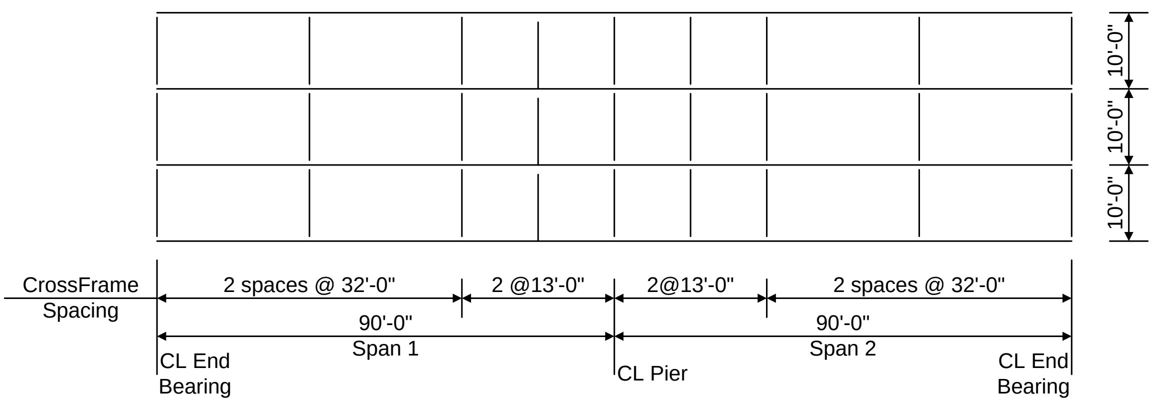
AASHTOWare BrDR 6.8

Steel Tutorial

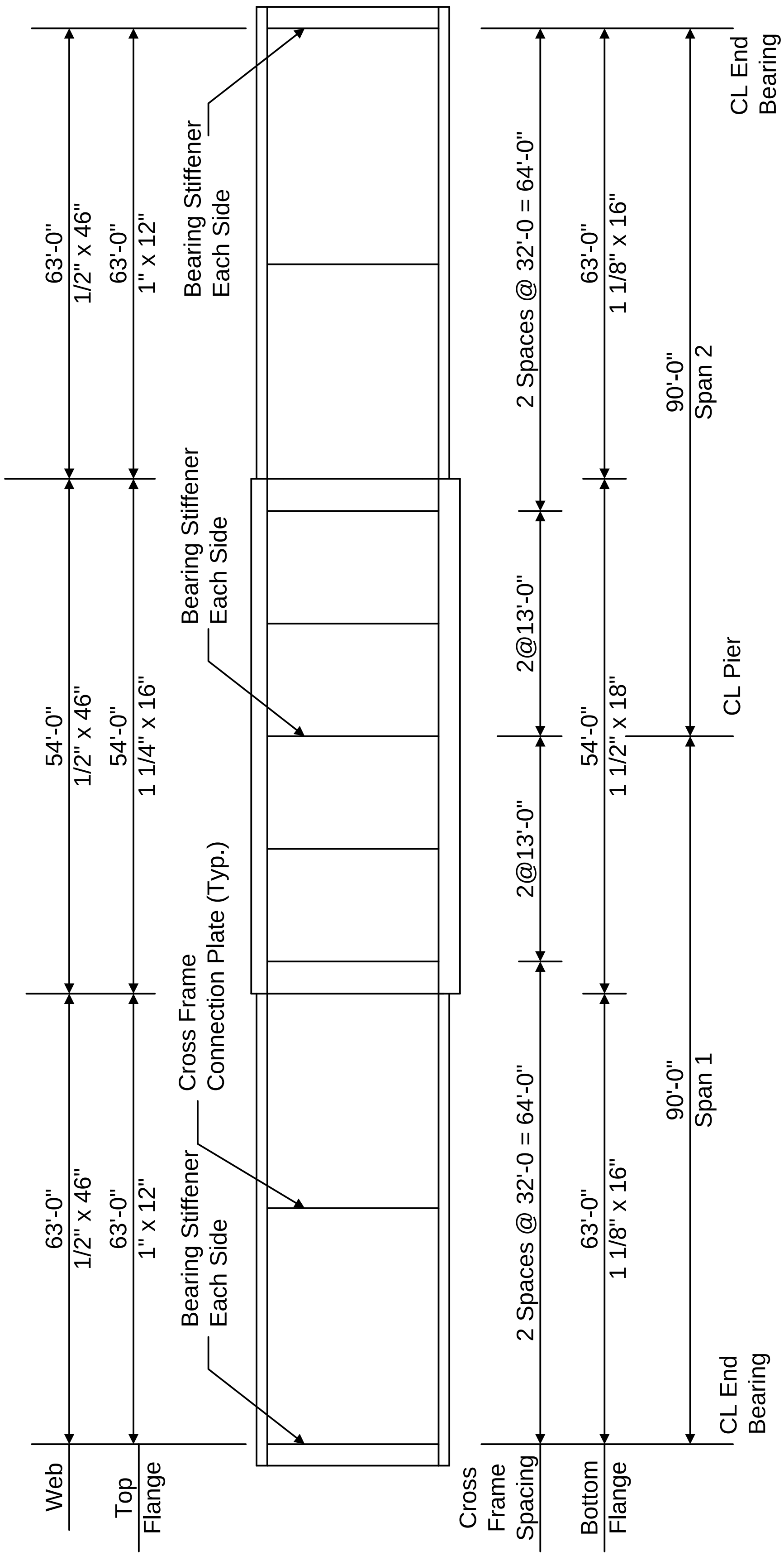
STL6 – Two Span Plate Girder Example

STL6 - Two Span Plate Girder Example (BrDR 6.5)

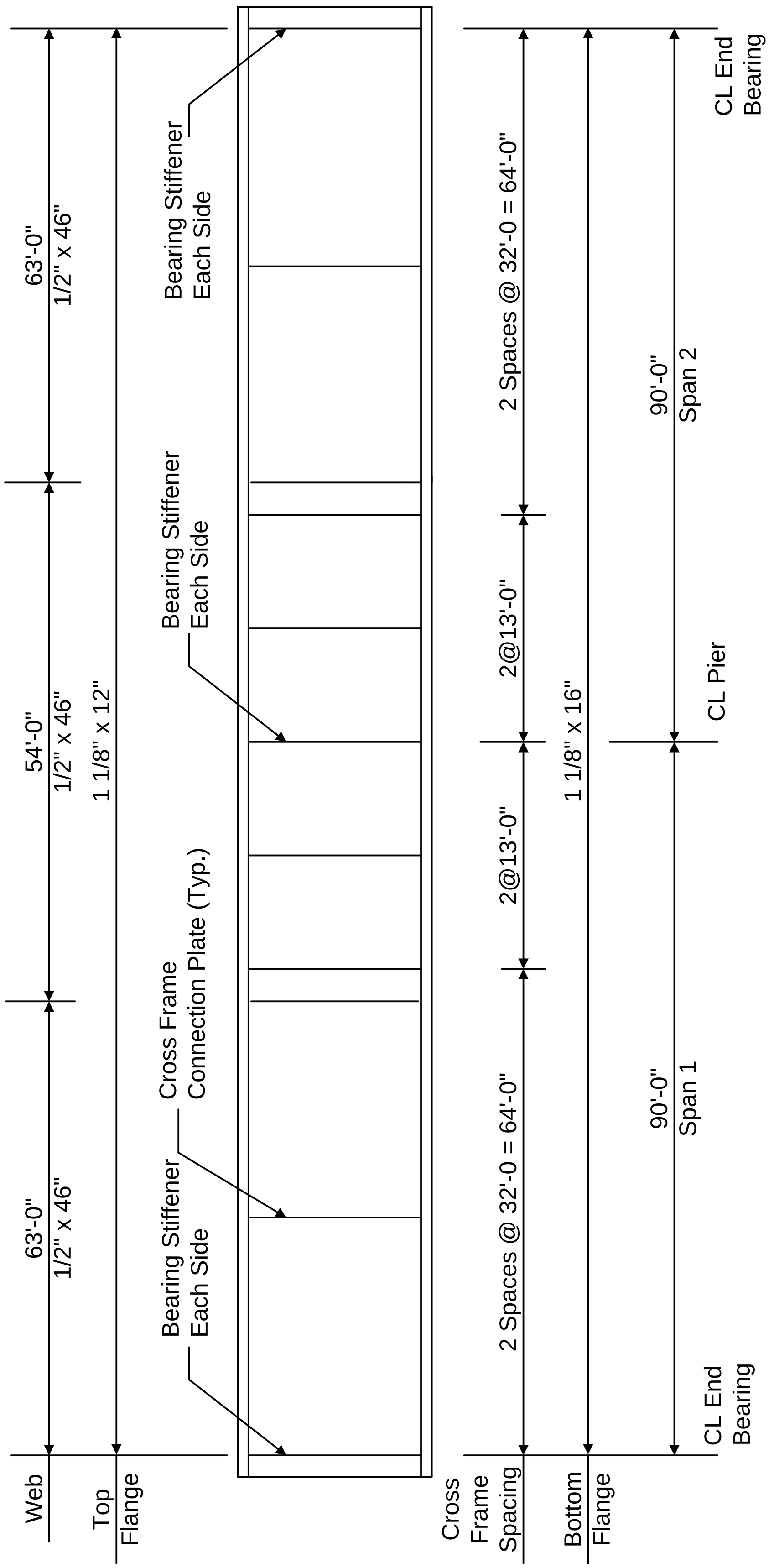




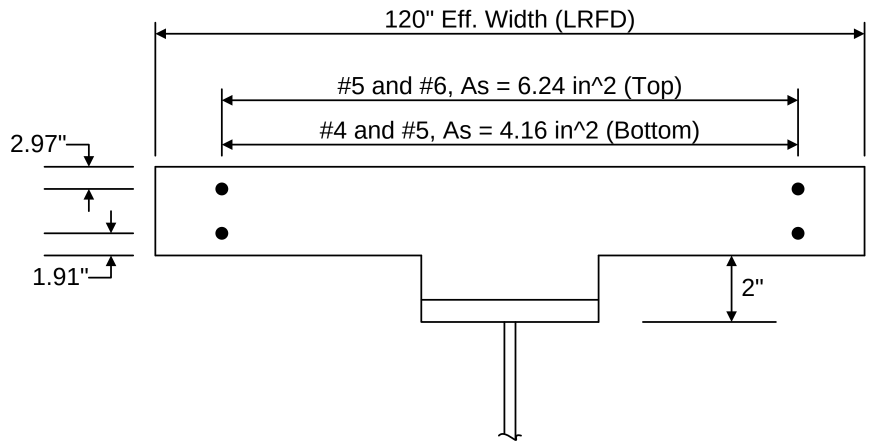
Framing Plan



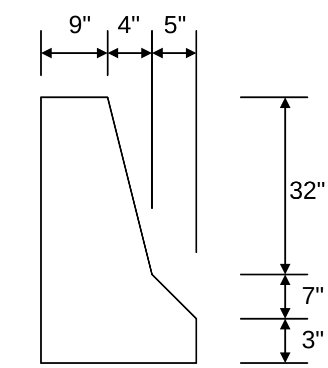
Elevation of Interior Girder



Elevation of Allow Moment Redistribution Girder

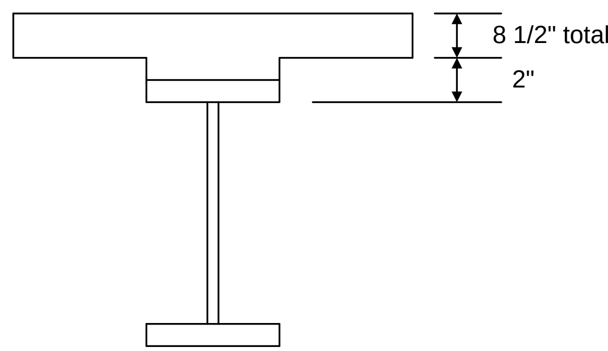


Composite Section at Pier



Weight = 536 plf

Parapet Detail



Haunch Detail

<u>Material Properties</u>

Structural Steel: AASHTO M270, Grade 50W uncoated weathering steel with Fy = 50 ksi
Deck Concrete: f'c = 4.0 ksi, modular ratio n = 8
Slab Reinforcing Steel: AASHTO M31, Grade 60 with Fy = 60 ksi

Cross Frame Connection Plates: 3/4" x 6"
Bearing Stiffener Plates: 7/8" x 9"

Topics Covered

- 2 span steel plate girder input as girder system.
- Selection of Specification Edition
- Steel Member Alt Control Options
  - Moment redistribution
  - Use Appendix A6 for flexural resistance
  - Allow plastic analysis
  - Ignore longitudinal reinforcement in negative moment capacity
- Export of steel girders to the AASHTO LRFD analysis engine
- AASHTO LRFD specification checking
- Output review
- Additional reporting (from VI5023)
- Moment redistribution
- New LRFR features
  - Specialized hauling vehicles, overriding legal load factors, permit lane loads and gapping out the lane load.

Selection of Specification Edition

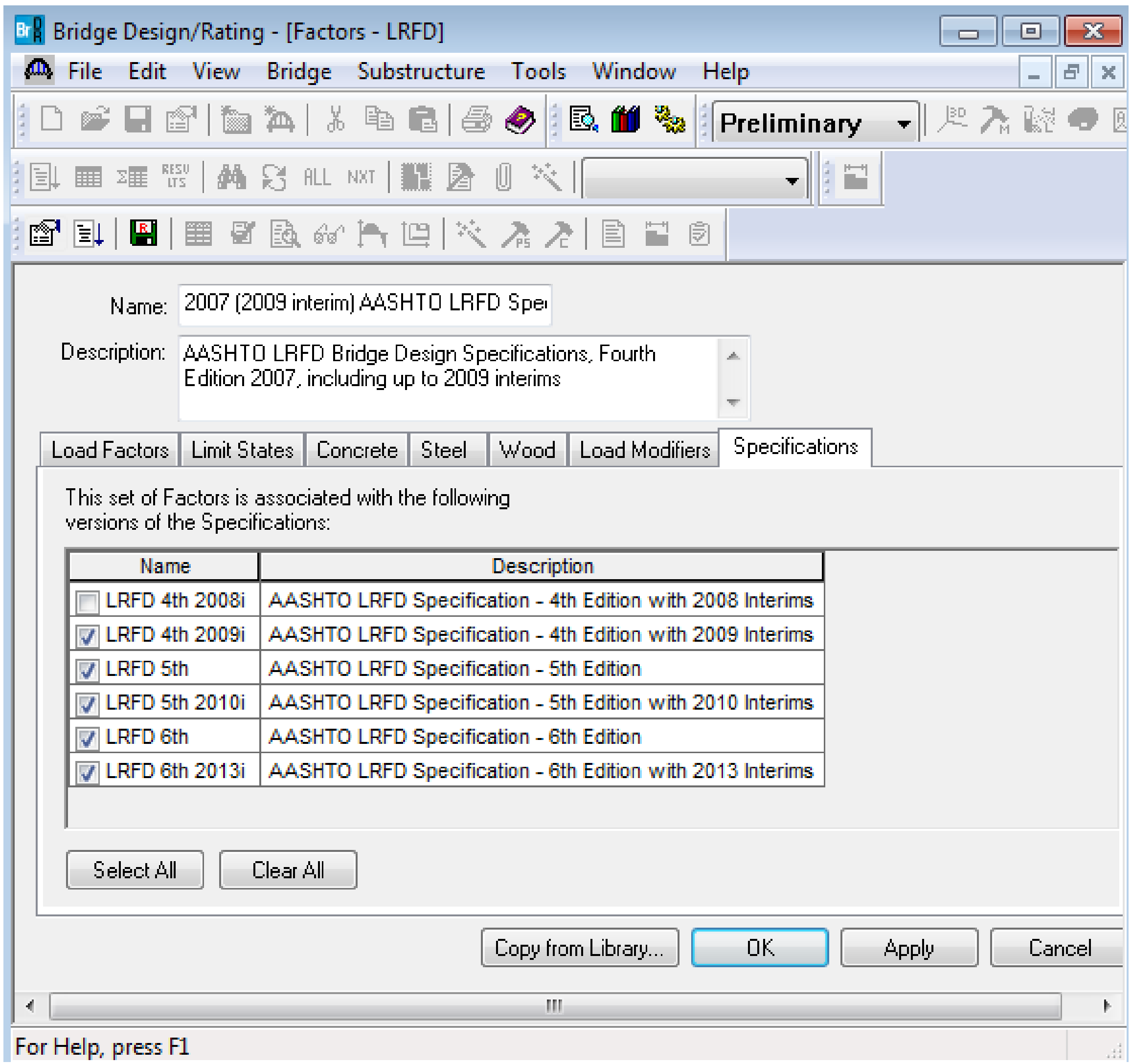
BrDR Version 6.8 allows you to pick from several versions of the AASHTO Specifications for the AASHTO analysis engines. The following LRFD and LRFR specifications are supported by the AASHTO engines:

- *AASHTO LRFD Bridge Design Specifications, 4th Edition, with 2008 interims*
- *AASHTO LRFD Bridge Design Specifications, 4th Edition, with 2009 interims*
- *AASHTO LRFD Bridge Design Specifications, 5th Edition*
- *AASHTO LRFD Bridge Design Specifications, 5th Edition, with 2010 interims*
- *AASHTO LRFD Bridge Design Specifications, 6th Edition*
- *AASHTO LRFD Bridge Design Specifications, 6th Edition, with 2013 interims*
- *AASHTO LRFD Bridge Design Specifications, 7th Edition*
- *AASHTO LRFD Bridge Design Specifications, 7th Edition, with 2015 interims*
- *AASHTO LRFD Bridge Design Specifications, 7th Edition, with 2016 interims*

- *AASHTO Manual for Bridge Evaluation, 1st Edition*
- *AASHTO Manual for Bridge Evaluation, 1st Edition, with 2010 interims*
- *AASHTO Manual for Bridge Evaluation, 2nd Edition*
- *AASHTO Manual for Bridge Evaluation, 2nd Edition, with 2011 interims*

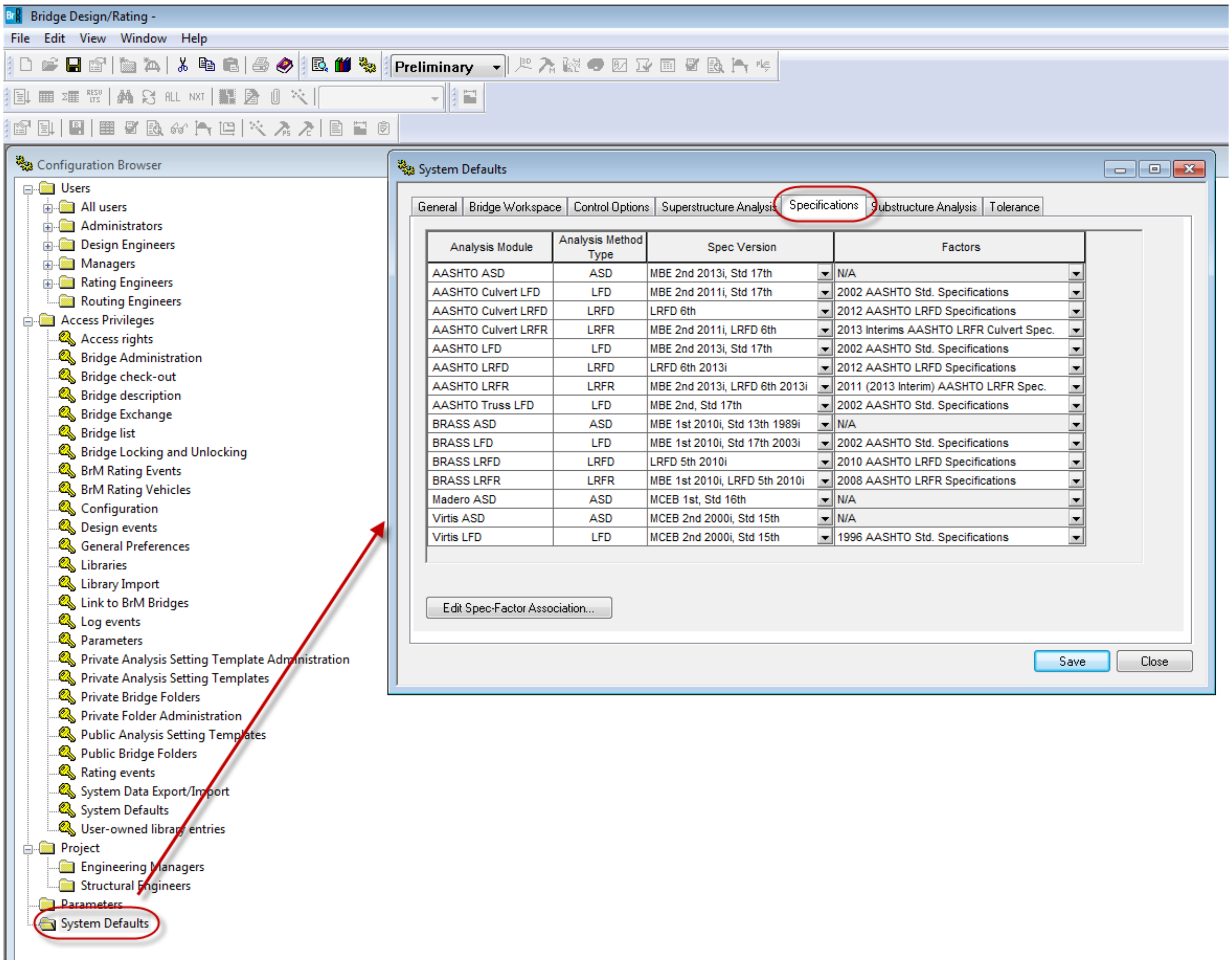
- *AASHTO Manual for Bridge Evaluation, 2ndEdition, with 2013 interims*
- *AASHTO Manual for Bridge Evaluation, 2ndEdition, with 2014 interims*
- *AASHTO Manual for Bridge Evaluation, 2ndEdition, with 2015 interims*
- *AASHTO Manual for Bridge Evaluation, 2ndEdition, with 2016 interims*

Along with this new feature, Factors are now associated with versions of the specification. This was done since different versions of the spec can have different limit states and load factors. Below is the Library LRFD Factors window for the factors that correspond to the Fourth Edition with 2009 interims specifications.



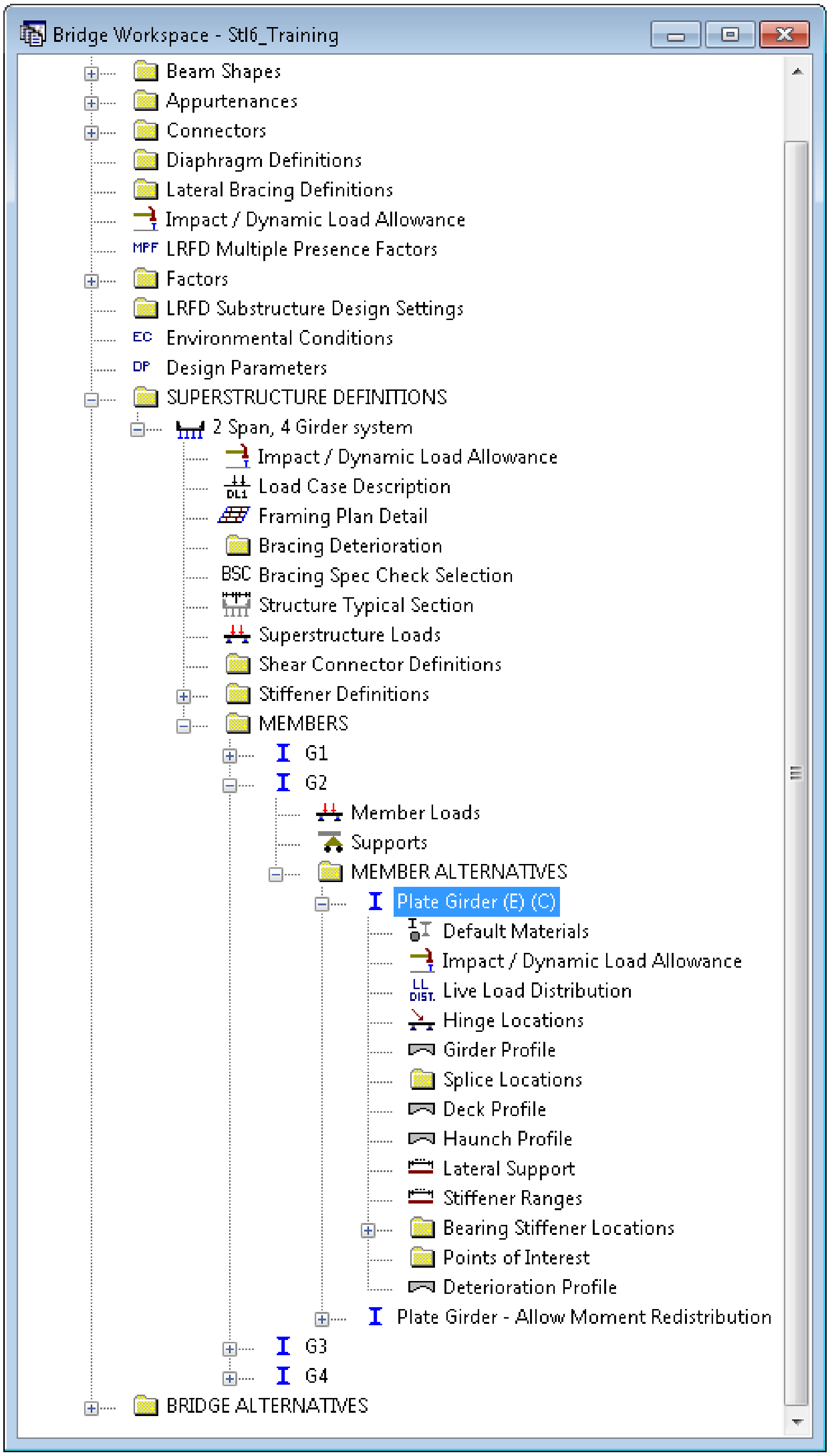
This set of factors cannot be applied to any versions of the specification prior to 2009 since they contain Fatigue I and Fatigue II limit states that were revised in the 2009 interims.

System Default specifications can be set as follows:



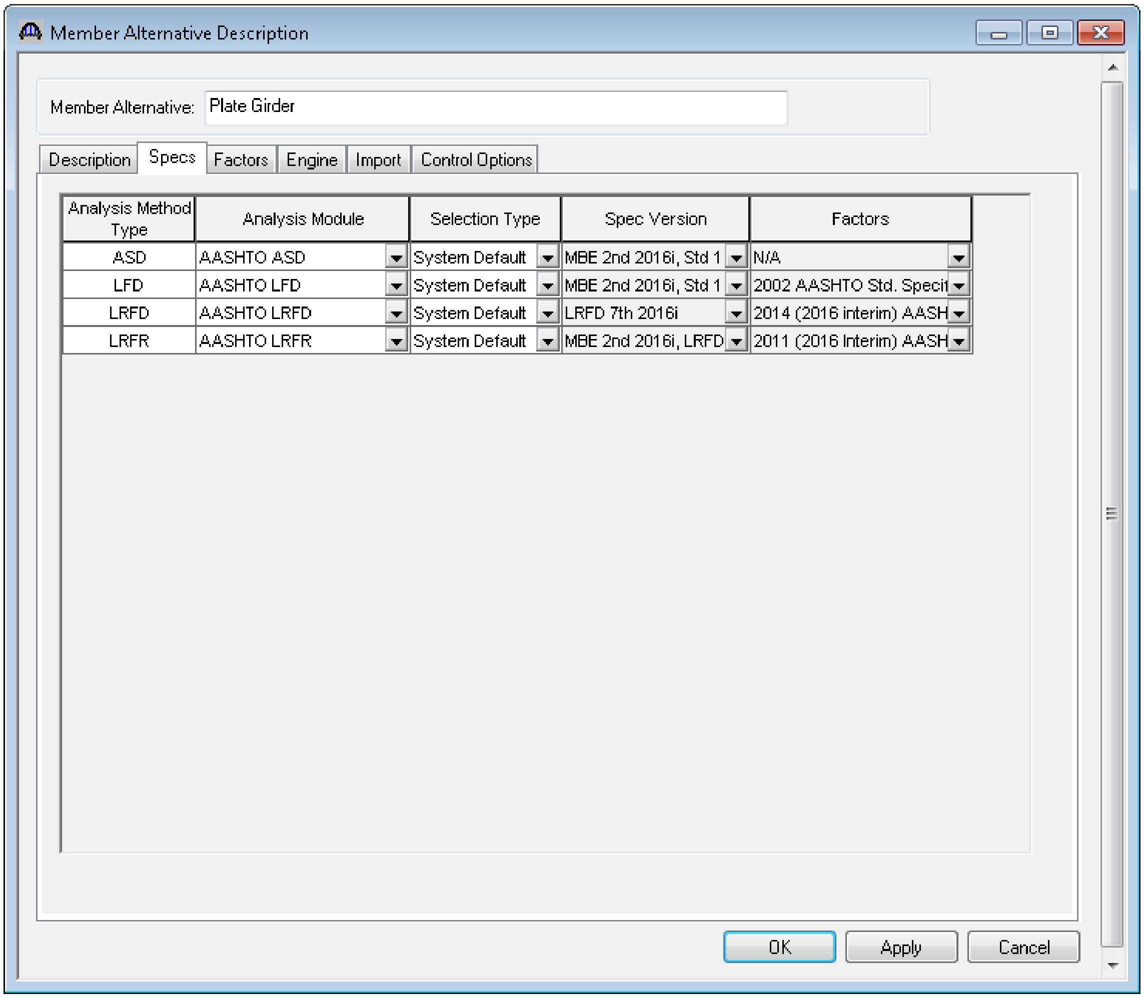
The default specifications and factors selected above will be used when new member alternatives are created.

Import and open the Bridge Workspace for 'STL6 - AASHTO Steel Plate Girder.xml. Expand the Bridge Workspace tree to show the member alternative for Member G2. The Bridge Workspace is shown below.



Select the Member Alternative for Member G2 and go to the Specs tab.

Make sure the analysis engines are set to the AASHTO engines for all analysis methodologies.

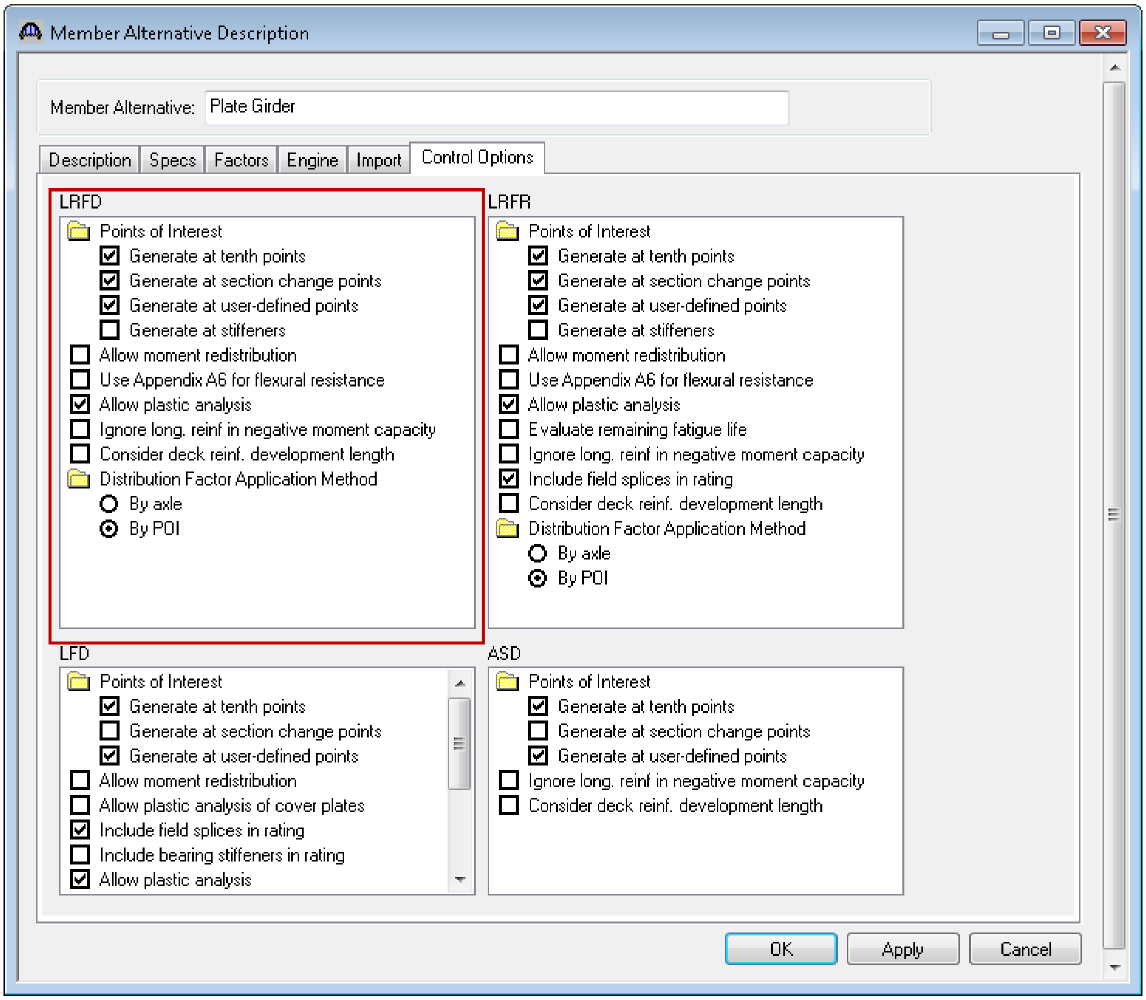


You will end up with the following:

Analysis Method Type	Analysis Module	Selection Type	Spec Version	Factors
ASD	AASHTO ASD	System Default	MBE 2nd 2016i, Std 1	N/A
LFD	AASHTO LFD	System Default	MBE 2nd 2016i, Std 1	2002 AASHTO Std. Specit
LRFD	AASHTO LRFD	System Default	LRFD 7th 2016i	2014 (2016 interim) AASH
LRFR	AASHTO LRFR	System Default	MBE 2nd 2016i, LRFD	2011 (2016 Interim) AASH

The table above provides an analysis engine for each analysis method. With each engine there may be various specification editions to choose from. Each specification edition may provide various load factor sets the user may choose from.

The Control Options tab allows you to select the following control features.



Allow moment redistribution

This control allows you to consider moment redistribution as per Appendix B6 of the Specifications. In the moment redistribution process, some of the negative moment at the pier is redistributed along the beam. This option will first initiate the spec checks in Appendix B6.2 to determine if moment redistribution is permissible as per the specifications. If redistribution is not permissible then it will not occur even if this option is selected.

Use Appendix A6 for flexural resistance

This control allows you to consider Appendix A6 of the Specifications for flexural resistance. Using Appendix A6 can result in flexural resistances greater than the yield moment, My, for certain types of sections. The program will first check if Appendix A6 is permissible by checking the requirements in Article 6.10.6.2.3. If the use of Appendix A6 is not permissible then it will not be used even if this option has been selected.

Allow plastic analysis

This control allows you to consider the plastic moment capacity for compact, composite sections in positive flexure. If you select this option, the program will evaluate Articles 6.10.7.1.1 and 6.10.7.1.2. If you do not select this option, Articles 6.10.7.1.1 and 6.10.7.1.2 will not be evaluated and all positive flexure sections will be considered non-compact.

Ignore long. reinforcement in negative moment capacity

This control allows you to ignore the contribution of the longitudinal deck reinforcement when computing the negative moment capacity of the section.

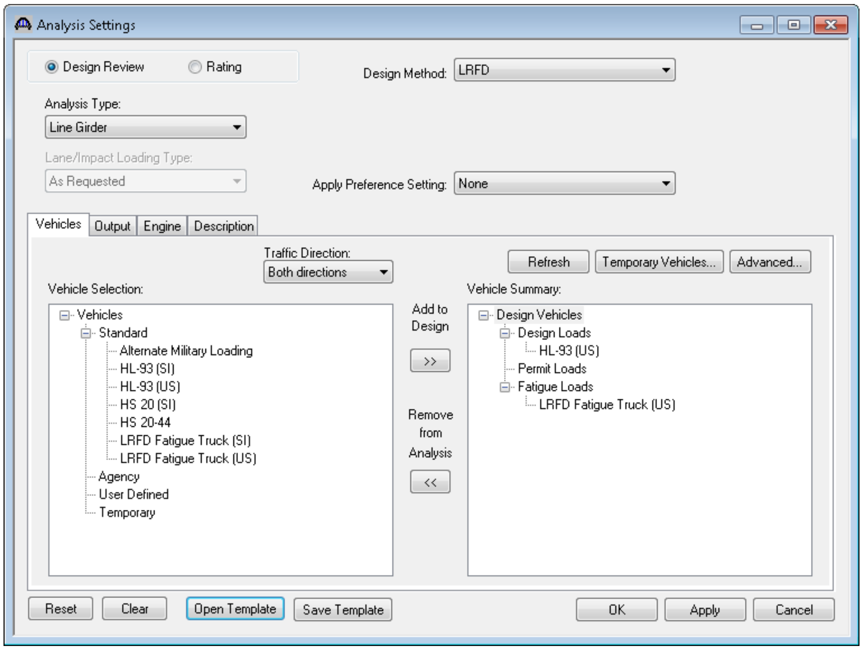
Distribution Factor Application Method

Select the method to be used for the application of live load distribution factors.

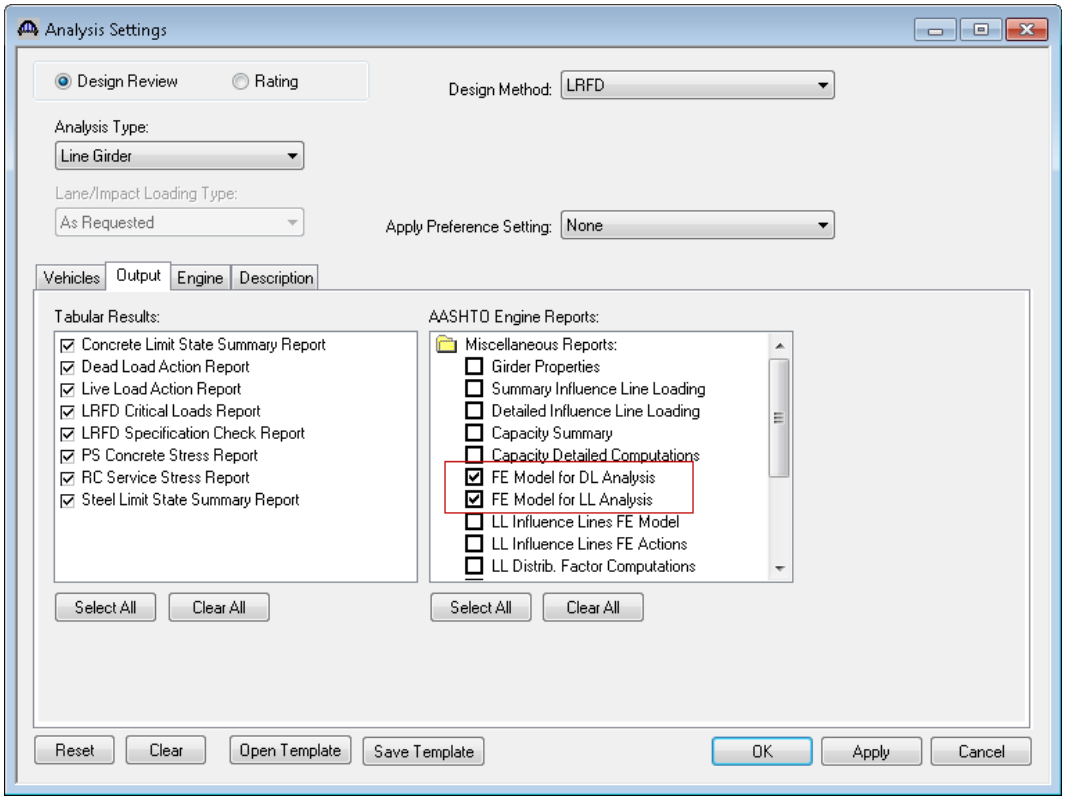
- By axle - causes the distribution factor at the location of the axle to be used for each axle.
- By POI - causes the distribution factor at the location of the point of interest to be used for all axles.

Similar behavior applies for lane load.

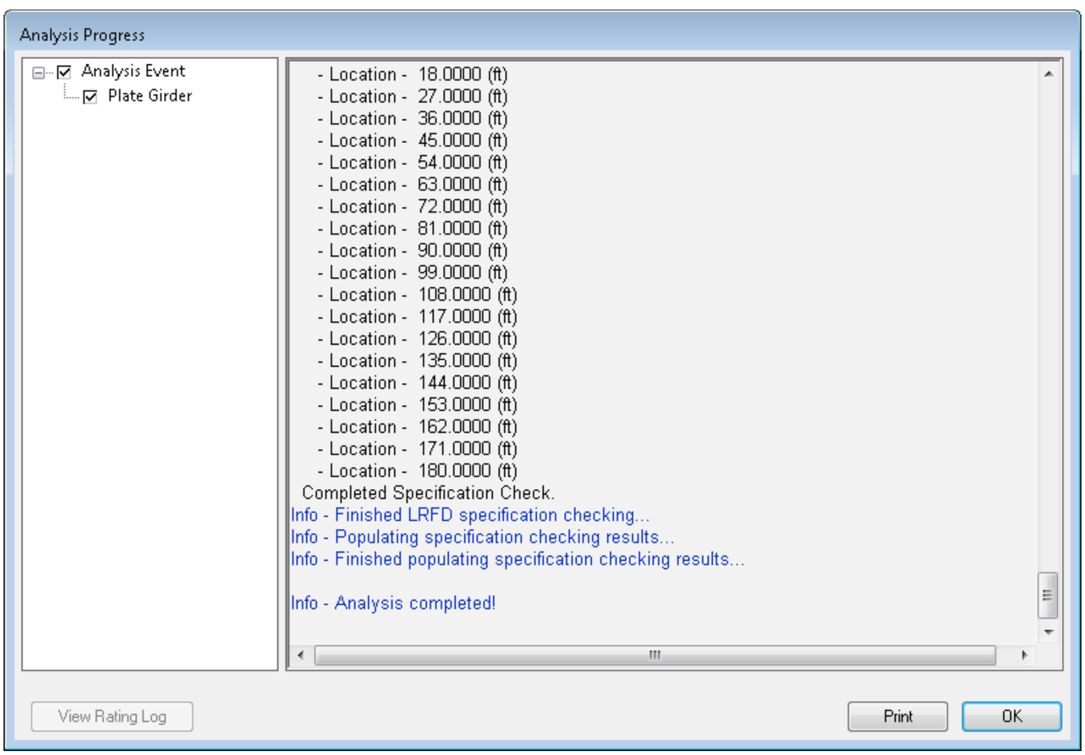
To perform a design review, select the View Analysis Settings button on the toolbar to open the window shown below. Use the “HL-93 Design Review” template to select the vehicles to be used.



On the Output tab, you can select the reports that you would like to have generated during the analysis.



Next, click the Analyze button on the toolbar to perform the design review. The Analysis Progress dialog will appear and should be reviewed for any warning messages.



The following steps are performed when doing a design review of a steel girder using the AASHTO LRFD analysis engine:

1. Finite element models are generated for the dead load and live load analyses. A Stage 1 FE model is generated for the beam dead load and non-composite dead loads. A Stage 2 FE model is generated for dead loads applied to the long-term composite section properties. A Stage 3 FE model is generated for the live load analysis.

   Stage 2 models contain section properties corresponding to the sustained modular ratio factor entered in BrD (e.g., 3n). Stage 3 models contain section properties corresponding to the modular ratio (n). The FE model will take into account the presence of shear connectors when setting the composite properties in the FE models. Regions that do not contain shear connectors will use non-composite section properties in the Stage 2 and 3 FE models.

   In addition to the points selected on the Member Alternative: Control Options tab, the model generated by the export to the AASHTO LRFD analysis engine will always contain node points at brace point locations and locations midway between the brace points. Only the articles required to compute stresses are processed at these points if the point is not being processed for one of the options chosen on this tab. The stresses at these locations are required when determining the flexural capacity of the steel girders.

2. The specification checking occurs in two phases. The first phase determines the type of flexure present at each point for each controlling load combination. This is necessary because the flexural articles to be considered in the Specification are dependent on the type of the flexure the beam is subject to. The second phase performs the specification checks taking into consideration the flexure type determined in the first phase.

   Phase 1:

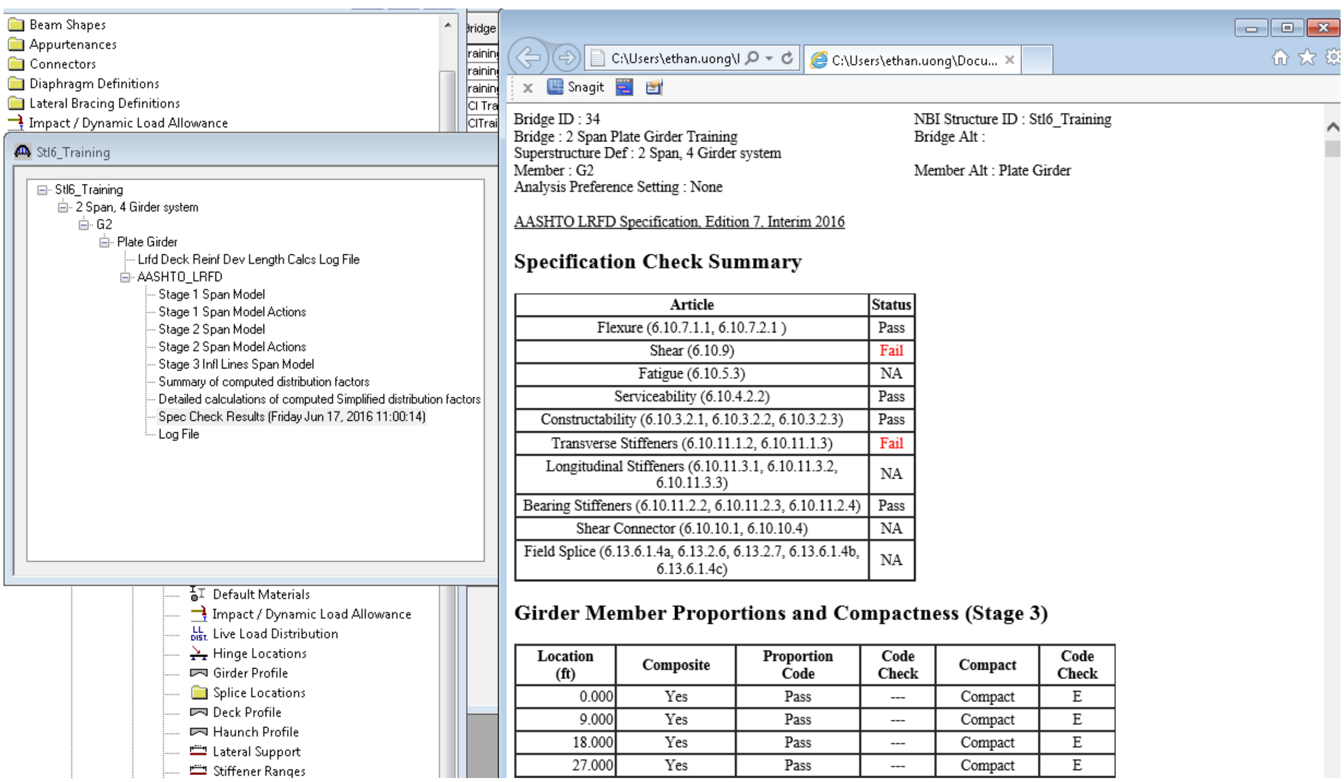
   Positive flexure is defined as the bending condition that produces compressive stress (denoted by a negative sign in the program) in the slab for composite construction or the top flange for non-composite construction. Negative flexure is defined as the bending condition that produces tensile stress (denoted by a positive sign) in the slab or top flange. As per Article 6.10.1.1.1b, the stress in the top of the slab (or top flange for non-composite construction) is first computed using the positive flexure section properties. If this stress is compressive, the stresses in each component of the beam (slab, longitudinal reinforcement, flanges, cover plates, and web) are computed using the positive flexure section properties. If the stress in the top of the slab (or top flange for non-composite construction) is tensile, the stresses in each component of the beam are computed using the negative section properties.

If the resulting computed stress in the bottom flange is tensile, the beam is considered to be in positive flexure for the load combination. If the resulting computed stress in the bottom flange is compressive, the beam is considered to be in negative flexure for the load combination.

Phase 2:

The remaining articles are evaluated taking into consideration the flexure type determined in the first phase.

A summary report of the specification check results is also available. This summary report lists the design ratios for each spec article at each spec check location point. The design ratio is the ratio of capacity to demand. A design ratio less than one indicates the demand is greater than the capacity and the spec article fails. A design ratio equal to 99.0 indicates the section is subject to zero demand.

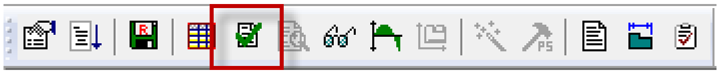


Article	Status
Flexure (6.10.7.1.1, 6.10.7.2.1)	Pass
Shear (6.10.9)	Fail
Fatigue (6.10.5.3)	NA
Serviceability (6.10.4.2.2)	Pass
Constructability (6.10.3.2.1, 6.10.3.2.2, 6.10.3.2.3)	Pass
Transverse Stiffeners (6.10.11.1.2, 6.10.11.1.3)	Fail
Longitudinal Stiffeners (6.10.11.3.1, 6.10.11.3.2, 6.10.11.3.3)	NA
Bearing Stiffeners (6.10.11.2.2, 6.10.11.2.3, 6.10.11.2.4)	Pass
Shear Connector (6.10.10.1, 6.10.10.4)	NA
Field Splice (6.13.6.1.4a, 6.13.2.6, 6.13.2.7, 6.13.6.1.4b, 6.13.6.1.4c)	NA

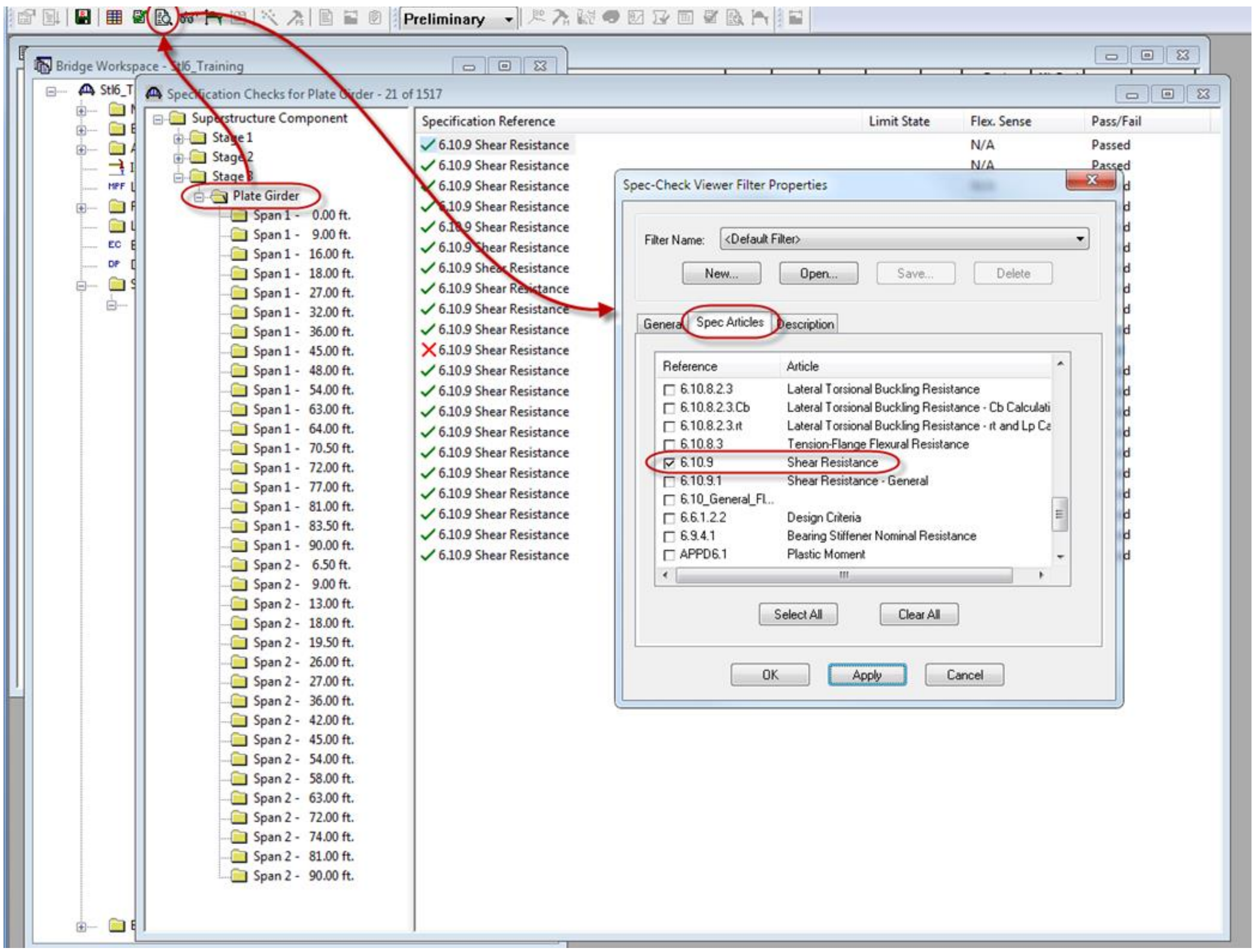
Girder Member Proportions and Compactness (Stage 3)

Location (ft)	Composite	Proportion Code	Code Check	Compact	Code Check
0.000	Yes	Pass	---	Compact	E
9.000	Yes	Pass	---	Compact	E
18.000	Yes	Pass	---	Compact	E
27.000	Yes	Pass	---	Compact	E

The specification checks can be viewed by selecting the “View Spec Check” button.



We can then use the Filter to limit the articles shown to just the Shear Resistance article by hitting “Clear All” and then selecting just the 6.10.9 article. Then hit OK to close the Filter.



Opening this article shows the following:

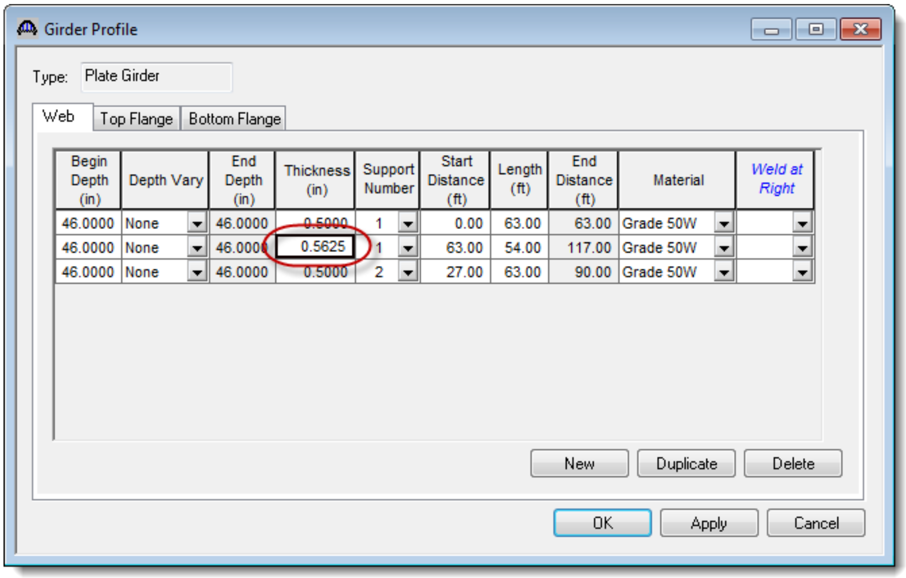
Spec Check Detail for 6.10.9 Shear Resistance

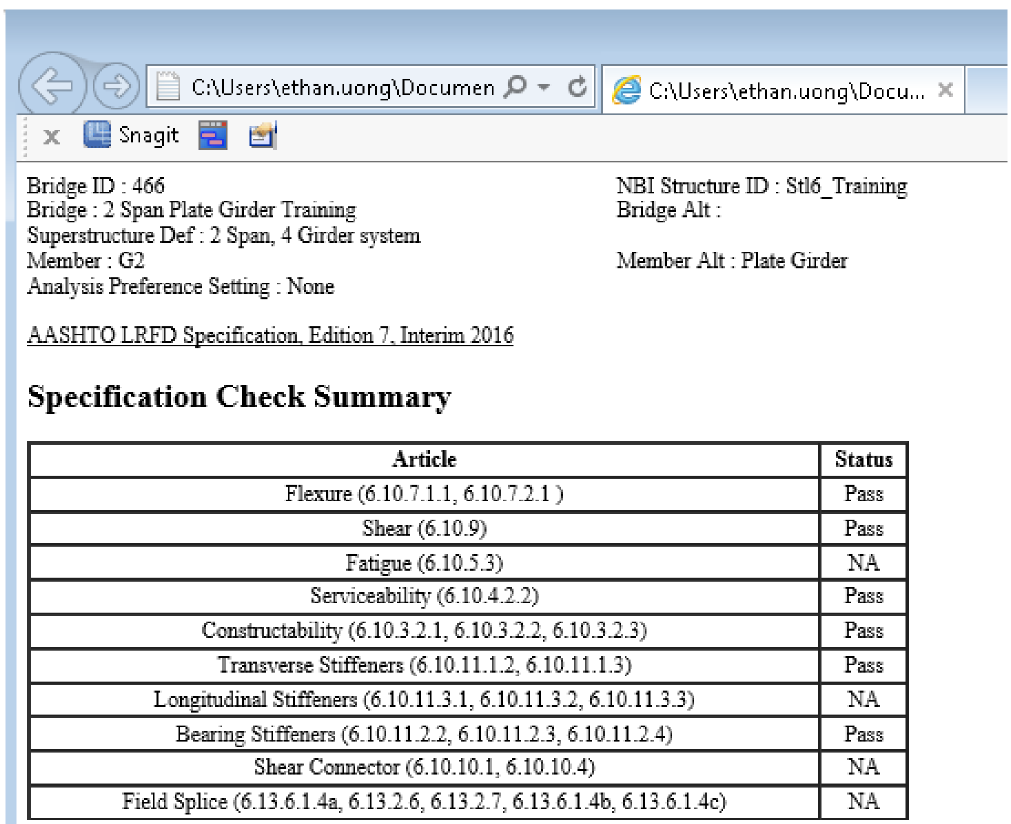
```
(AASHTO LRFD Bridge Design Specifications, Seventh Edition - 2014, with 2016 Interims)

Steel Plate - At Location = 90.0000 (ft) - Left     Stage 3

Section at Brace Point


Article 6.10.9.2-1 Unstiffened Panels


INPUT:
Top Flange bf =   16.0000 (in)
Top Flange tf =    1.2500 (in)
Web D         =   46.0000 (in)
Web tw        =    0.5000 (in)
Bot Flange bf =   18.0000 (in)
Bot Flange tf =    1.5000 (in)

Fyw =   50.0000 (ksi)
do  =  192.0000 (in)
phi =    1.0000

SUMMARY:

k = 5.0

D/tw = 92.0000

Limit 1:  1.12*SQRT(E*k/Fyw) = 60.3138

Limit 2:  1.40*SQRT(E*k/Fyw) = 75.3923

D/tw > Limit2 therefore

      1.57*(E*k/Fyw)
C =  ---------------                          (6.10.9.3.2-6)
        (D/tw)^2

C = 0.5379

Vp = 0.58*fyw*D*tw                            (6.10.9.3.2-3)
Vp = 667.0001 (kip)

Vn = Vcr = C * Vp                             (6.10.9.2-1)

Vn = 358.7962 (kip)

Vr = phi*Vn  = 358.80


Note: If the capacity has been overridden, the Resistance is computed as override phi*override capa
      Otherwise the Resistance is computed as per the Specification.
```

Limit State	Load Combo	Vu (kip)	--- Override --- Phi (kip)	Vn (kip)	Vr (kip)	Design Ratio	Code
STR-I	1	-104.19			-358.80	3.44	Pass
STR-I	1	-361.84			-358.80	0.99	Fail
STR-I	2	-104.19			-358.80	3.44	Pass
STR-I	2	-322.22			-358.80	1.11	Pass

OK

Open the Girder Profile window and revise the web thickness to 0.5625” in the region near Pier 1. Re-run the HL93 Design Review and review the Spec Check summary report.





Bridge ID : 466
Bridge : 2 Span Plate Girder Training
Superstructure Def : 2 Span, 4 Girder system
Member : G2
Analysis Preference Setting : None

NBI Structure ID : Stl6_Training
Bridge Alt :

Member Alt : Plate Girder

AASHTO LRFD Specification, Edition 7, Interim 2016

Specification Check Summary

Article	Status
Flexure (6.10.7.1.1, 6.10.7.2.1)	Pass
Shear (6.10.9)	Pass
Fatigue (6.10.5.3)	NA
Serviceability (6.10.4.2.2)	Pass
Constructability (6.10.3.2.1, 6.10.3.2.2, 6.10.3.2.3)	Pass
Transverse Stiffeners (6.10.11.1.2, 6.10.11.1.3)	Pass
Longitudinal Stiffeners (6.10.11.3.1, 6.10.11.3.2, 6.10.11.3.3)	NA
Bearing Stiffeners (6.10.11.2.2, 6.10.11.2.3, 6.10.11.2.4)	Pass
Shear Connector (6.10.10.1, 6.10.10.4)	NA
Field Splice (6.13.6.1.4a, 6.13.2.6, 6.13.2.7, 6.13.6.1.4b, 6.13.6.1.4c)	NA

Open the spec check detail window for Article 6.10.8.1.3 at the 90' location. The following is noted for this window, other spec articles are similar:

```
Steel Plate - At Location = 90.0000 (ft) - Left     Stage 3
Section at Brace Point

INPUT:
Phif = 1.000

Section Type: Composite
Top Flange Laterally Supported: Yes
Allow Moment Redistribution Control Option: No
Moment Redistribution : No, Moment Redistribution did not occur

SUMMARY:

fbu <= Phif * Rh * Fyf              (6.10.8.1.3-1)

Resist = Phif * Rh * Fyf

Design Ratio = Resist/fbu
```

Limit State	Load Combo	Flexure Type	Component	fbu (ksi)	frd (ksi)	Rh	Fyf (ksi)	Resist (ksi)	Design Ratio	Status
STR-I	1	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-I	1	Neg	Top Flange	42.98	---	1.00	50.00	50.00	1.16	Pass
STR-I	2	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-I	2	Neg	Top Flange	40.85	---	1.00	50.00	50.00	1.22	Pass
STR-I	3	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-I	3	Neg	Top Flange	48.66	---	1.00	50.00	50.00	1.03	Pass
STR-III	1	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-III	1	Neg	Top Flange	28.57	---	1.00	50.00	50.00	1.75	Pass
STR-III	2	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-III	2	Neg	Top Flange	28.57	---	1.00	50.00	50.00	1.75	Pass
STR-III	3	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-III	3	Neg	Top Flange	28.57	---	1.00	50.00	50.00	1.75	Pass
STR-V	1	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-V	1	Neg	Top Flange	39.69	---	1.00	50.00	50.00	1.26	Pass
STR-V	2	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-V	2	Neg	Top Flange	38.05	---	1.00	50.00	50.00	1.31	Pass
STR-V	3	Neg	Top Flange	19.88	---	1.00	50.00	50.00	2.52	Pass
STR-V	3	Neg	Top Flange	44.07	---	1.00	50.00	50.00	1.13	Pass

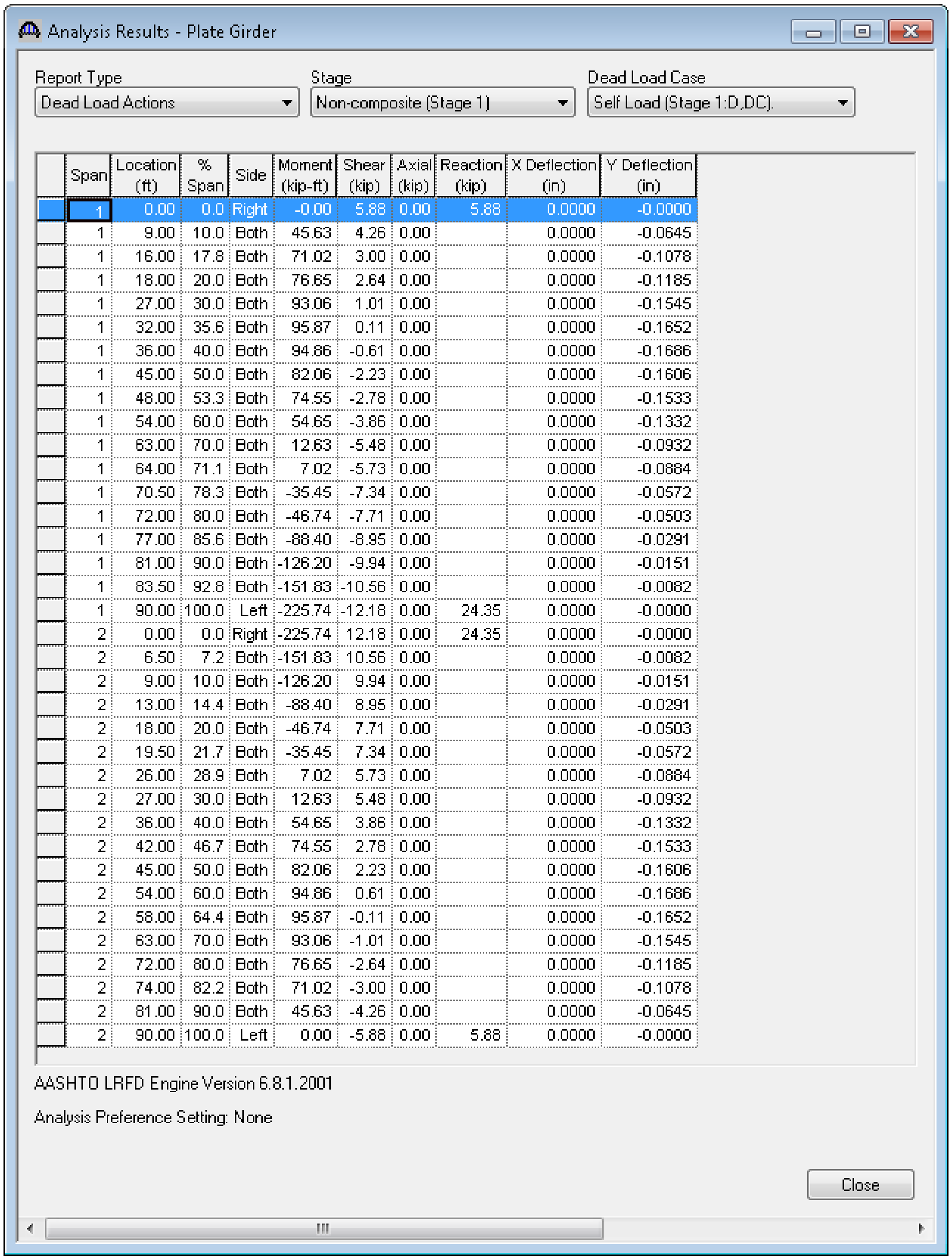
Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane
3	HL-93 (US) - 90%(Truck Pair + Lane)
4	LRFD Fatigue Truck (US) - Truck

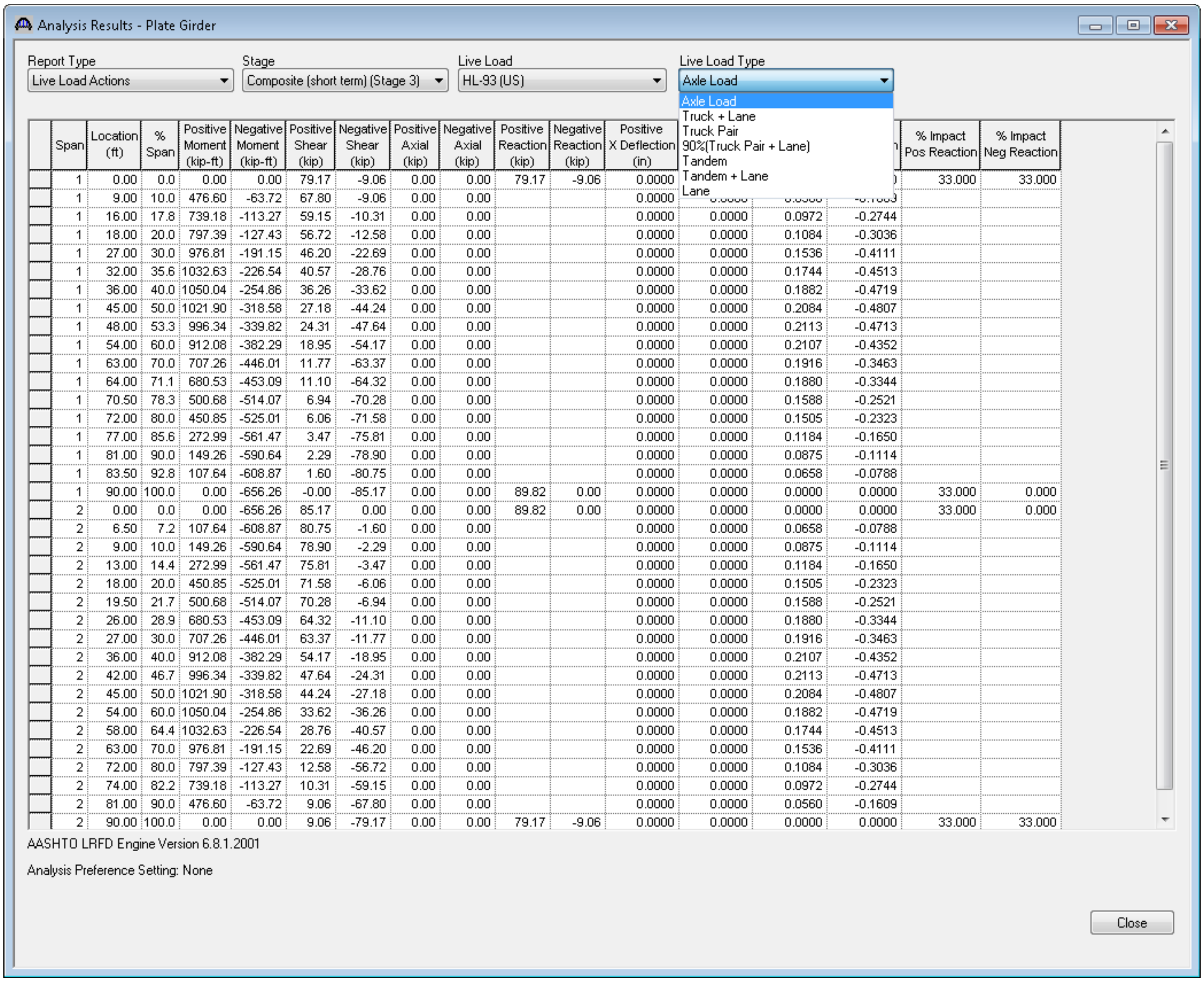
1. For each spec check location, both the left and right sides of the point are evaluated. The Deflection article is an exception to this since deflection must be the same between the left and right sides of a point.
2. The design ratio is printed out for the article. The design ratio is the ratio of capacity to demand. A design ratio less than one indicates the demand is greater than the capacity and the spec article fails. A design ratio equal to 99.0 indicates the section is subject to zero demand.
3. For steel members, the Strength-I, Strength-II (for Permit vehicles), Strength-III, Strength-V, Service II and Fatigue limit states are the only limit states investigated. For each limit state, the max and min force effect is checked for each vehicle. Thus each limit state shows two rows of data for each vehicle.
4. The LL vehicle is identified by the load combination is shown in this column.

5. The ‘frd’ column displays the stresses due to the redistribution moments. If moment redistribution was not processed, this column shows ‘---‘.

Tabular dead load and live load analysis results are available in the Analysis Results window.



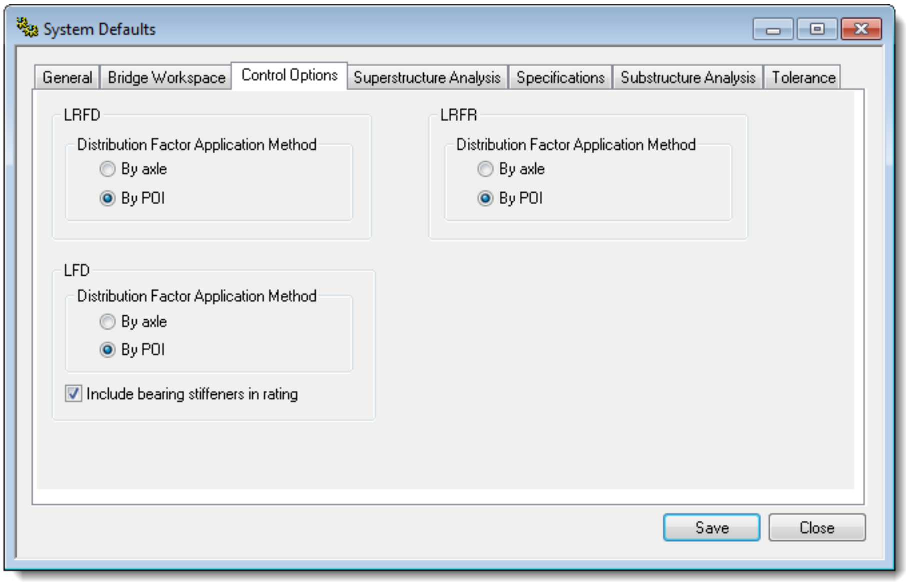
Span	Location (ft)	% Span	Side	Moment (kip-ft)	Shear (kip)	Axial (kip)	Reaction (kip)	X Deflection (in)	Y Deflection (in)
1	0.00	0.0	Right	-0.00	5.88	0.00	5.88	0.0000	-0.0000
1	9.00	10.0	Both	45.63	4.26	0.00		0.0000	-0.0645
1	16.00	17.8	Both	71.02	3.00	0.00		0.0000	-0.1078
1	18.00	20.0	Both	76.65	2.64	0.00		0.0000	-0.1185
1	27.00	30.0	Both	93.06	1.01	0.00		0.0000	-0.1545
1	32.00	35.6	Both	95.87	0.11	0.00		0.0000	-0.1652
1	36.00	40.0	Both	94.86	-0.61	0.00		0.0000	-0.1686
1	45.00	50.0	Both	82.06	-2.23	0.00		0.0000	-0.1606
1	48.00	53.3	Both	74.55	-2.78	0.00		0.0000	-0.1533
1	54.00	60.0	Both	54.65	-3.86	0.00		0.0000	-0.1332
1	63.00	70.0	Both	12.63	-5.48	0.00		0.0000	-0.0932
1	64.00	71.1	Both	7.02	-5.73	0.00		0.0000	-0.0884
1	70.50	78.3	Both	-35.45	-7.34	0.00		0.0000	-0.0572
1	72.00	80.0	Both	-46.74	-7.71	0.00		0.0000	-0.0503
1	77.00	85.6	Both	-88.40	-8.95	0.00		0.0000	-0.0291
1	81.00	90.0	Both	-126.20	-9.94	0.00		0.0000	-0.0151
1	83.50	92.8	Both	-151.83	-10.56	0.00		0.0000	-0.0082
1	90.00	100.0	Left	-225.74	-12.18	0.00	24.35	0.0000	-0.0000
2	0.00	0.0	Right	-225.74	12.18	0.00	24.35	0.0000	-0.0000
2	6.50	7.2	Both	-151.83	10.56	0.00		0.0000	-0.0082
2	9.00	10.0	Both	-126.20	9.94	0.00		0.0000	-0.0151
2	13.00	14.4	Both	-88.40	8.95	0.00		0.0000	-0.0291
2	18.00	20.0	Both	-46.74	7.71	0.00		0.0000	-0.0503
2	19.50	21.7	Both	-35.45	7.34	0.00		0.0000	-0.0572
2	26.00	28.9	Both	7.02	5.73	0.00		0.0000	-0.0884
2	27.00	30.0	Both	12.63	5.48	0.00		0.0000	-0.0932
2	36.00	40.0	Both	54.65	3.86	0.00		0.0000	-0.1332
2	42.00	46.7	Both	74.55	2.78	0.00		0.0000	-0.1533
2	45.00	50.0	Both	82.06	2.23	0.00		0.0000	-0.1606
2	54.00	60.0	Both	94.86	0.61	0.00		0.0000	-0.1686
2	58.00	64.4	Both	95.87	-0.11	0.00		0.0000	-0.1652
2	63.00	70.0	Both	93.06	-1.01	0.00		0.0000	-0.1545
2	72.00	80.0	Both	76.65	-2.64	0.00		0.0000	-0.1185
2	74.00	82.2	Both	71.02	-3.00	0.00		0.0000	-0.1078
2	81.00	90.0	Both	45.63	-4.26	0.00		0.0000	-0.0645
2	90.00	100.0	Left	0.00	-5.88	0.00	5.88	0.0000	-0.0000

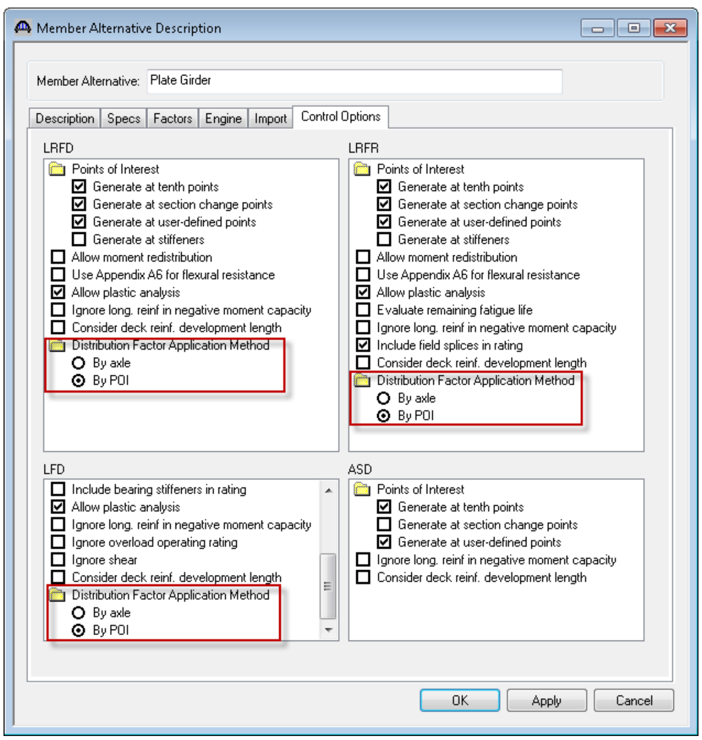


Span	Location (ft)	% Span	Positive Moment (kip-ft)	Negative Moment (kip-ft)	Positive Shear (kip)	Negative Shear (kip)	Positive Axial (kip)	Negative Axial (kip)	Positive Reaction (kip)	Negative Reaction (kip)	Positive X Deflection (in)				% Impact Pos Reaction	% Impact Neg Reaction
1	0.00	0.0	0.00	0.00	79.17	-9.06	0.00	0.00	79.17	-9.06	0.0000	[illegible]	[illegible]	[illegible]	33.000	33.000
1	9.00	10.0	476.60	-63.72	67.80	-9.06	0.00	0.00			0.0000	[illegible]	[illegible]	[illegible]		
1	16.00	17.8	739.18	-113.27	59.15	-10.31	0.00	0.00			0.0000	0.0000	0.0972	-0.2744		
1	18.00	20.0	797.39	-127.43	56.72	-12.58	0.00	0.00			0.0000	0.0000	0.1084	-0.3036		
1	27.00	30.0	976.81	-191.15	46.20	-22.69	0.00	0.00			0.0000	0.0000	0.1536	-0.4111		
1	32.00	35.6	1032.63	-226.54	40.57	-28.76	0.00	0.00			0.0000	0.0000	0.1744	-0.4513		
1	36.00	40.0	1050.04	-254.86	36.26	-33.62	0.00	0.00			0.0000	0.0000	0.1882	-0.4719		
1	45.00	50.0	1021.90	-318.58	27.18	-44.24	0.00	0.00			0.0000	0.0000	0.2084	-0.4807		
1	48.00	53.3	996.34	-339.82	24.31	-47.64	0.00	0.00			0.0000	0.0000	0.2113	-0.4713		
1	54.00	60.0	912.08	-382.29	18.95	-54.17	0.00	0.00			0.0000	0.0000	0.2107	-0.4352		
1	63.00	70.0	707.26	-446.01	11.77	-63.37	0.00	0.00			0.0000	0.0000	0.1916	-0.3463		
1	64.00	71.1	680.53	-453.09	11.10	-64.32	0.00	0.00			0.0000	0.0000	0.1880	-0.3344		
1	70.50	78.3	500.68	-514.07	6.94	-70.28	0.00	0.00			0.0000	0.0000	0.1588	-0.2521		
1	72.00	80.0	450.85	-525.01	6.06	-71.58	0.00	0.00			0.0000	0.0000	0.1505	-0.2323		
1	77.00	85.6	272.99	-561.47	3.47	-75.81	0.00	0.00			0.0000	0.0000	0.1184	-0.1650		
1	81.00	90.0	149.26	-590.64	2.29	-78.90	0.00	0.00			0.0000	0.0000	0.0875	-0.1114		
1	83.50	92.8	107.64	-608.87	1.60	-80.75	0.00	0.00			0.0000	0.0000	0.0658	-0.0788		
1	90.00	100.0	0.00	-656.26	-0.00	-85.17	0.00	0.00	89.82	0.00	0.0000	0.0000	0.0000	0.0000	33.000	0.000
2	0.00	0.0	0.00	-656.26	85.17	0.00	0.00	0.00	89.82	0.00	0.0000	0.0000	0.0000	0.0000	33.000	0.000
2	6.50	7.2	107.64	-608.87	80.75	-1.60	0.00	0.00			0.0000	0.0000	0.0658	-0.0788		
2	9.00	10.0	149.26	-590.64	78.90	-2.29	0.00	0.00			0.0000	0.0000	0.0875	-0.1114		
2	13.00	14.4	272.99	-561.47	75.81	-3.47	0.00	0.00			0.0000	0.0000	0.1184	-0.1650		
2	18.00	20.0	450.85	-525.01	71.58	-6.06	0.00	0.00			0.0000	0.0000	0.1505	-0.2323		
2	19.50	21.7	500.68	-514.07	70.28	-6.94	0.00	0.00			0.0000	0.0000	0.1588	-0.2521		
2	26.00	28.9	680.53	-453.09	64.32	-11.10	0.00	0.00			0.0000	0.0000	0.1880	-0.3344		
2	27.00	30.0	707.26	-446.01	63.37	-11.77	0.00	0.00			0.0000	0.0000	0.1916	-0.3463		
2	36.00	40.0	912.08	-382.29	54.17	-18.95	0.00	0.00			0.0000	0.0000	0.2107	-0.4352		
2	42.00	46.7	996.34	-339.82	47.64	-24.31	0.00	0.00			0.0000	0.0000	0.2113	-0.4713		
2	45.00	50.0	1021.90	-318.58	44.24	-27.18	0.00	0.00			0.0000	0.0000	0.2084	-0.4807		
2	54.00	60.0	1050.04	-254.86	33.62	-36.26	0.00	0.00			0.0000	0.0000	0.1882	-0.4719		
2	58.00	64.4	1032.63	-226.54	28.76	-40.57	0.00	0.00			0.0000	0.0000	0.1744	-0.4513		
2	63.00	70.0	976.81	-191.15	22.69	-46.20	0.00	0.00			0.0000	0.0000	0.1536	-0.4111		
2	72.00	80.0	797.39	-127.43	12.58	-56.72	0.00	0.00			0.0000	0.0000	0.1084	-0.3036		
2	74.00	82.2	739.18	-113.27	10.31	-59.15	0.00	0.00			0.0000	0.0000	0.0972	-0.2744		
2	81.00	90.0	476.60	-63.72	9.06	-67.80	0.00	0.00			0.0000	0.0000	0.0560	-0.1609		
2	90.00	100.0	0.00	0.00	9.06	-79.17	0.00	0.00	79.17	-9.06	0.0000	0.0000	0.0000	0.0000	33.000	33.000

Note these values include dynamic load allowance, distribution factors and any live load scale factor entered on the Analysis Settings window.

You may find different live load values between various analysis engines due to a difference in how the live load distribution factors are applied. For example, the BRASS™ engine (which is no longer supported) applies the LL distribution factor based on the region where the analysis point is located. The AASHTO engines have a choice to do the same thing or it applies the LL distribution factor based on the region where the axle is positioned. This can be defined by the user in the System Defaults and in the Control Options for a member.





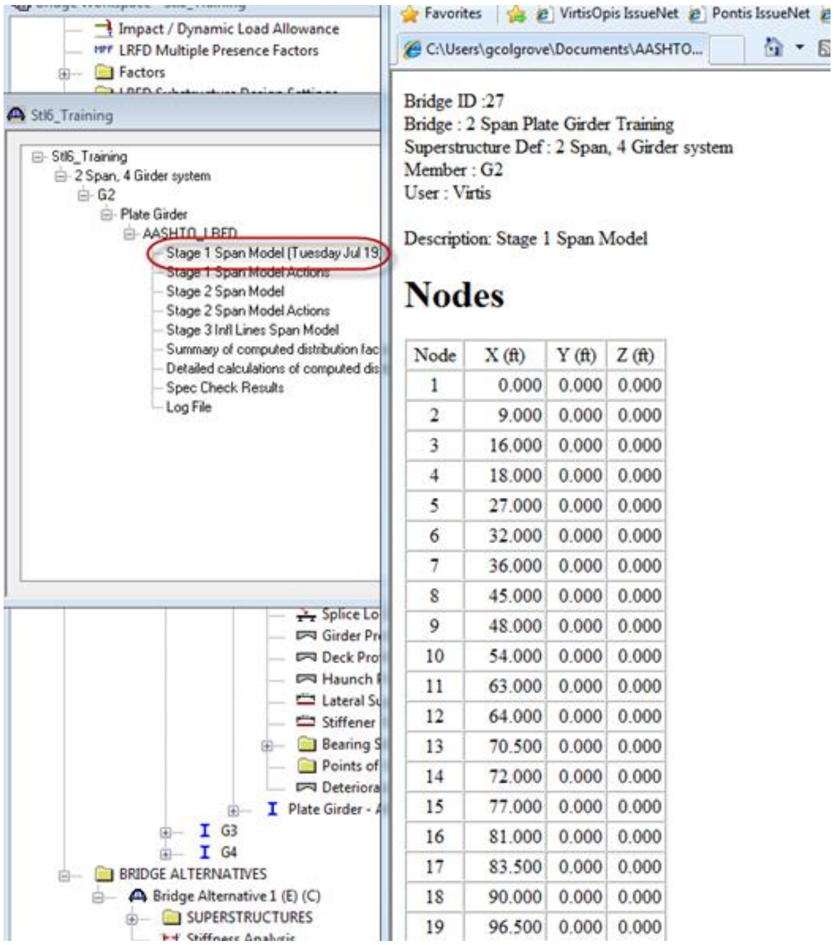
Explanation of the Distribution Factor Application Method

The user will select the method to be used for the application of live load distribution factors. The choices are:

- By axle - causes the distribution factor at the location of the axle to be used for each axle.
- By POI - causes the distribution factor at the location of the point of interest to be used for all axles.

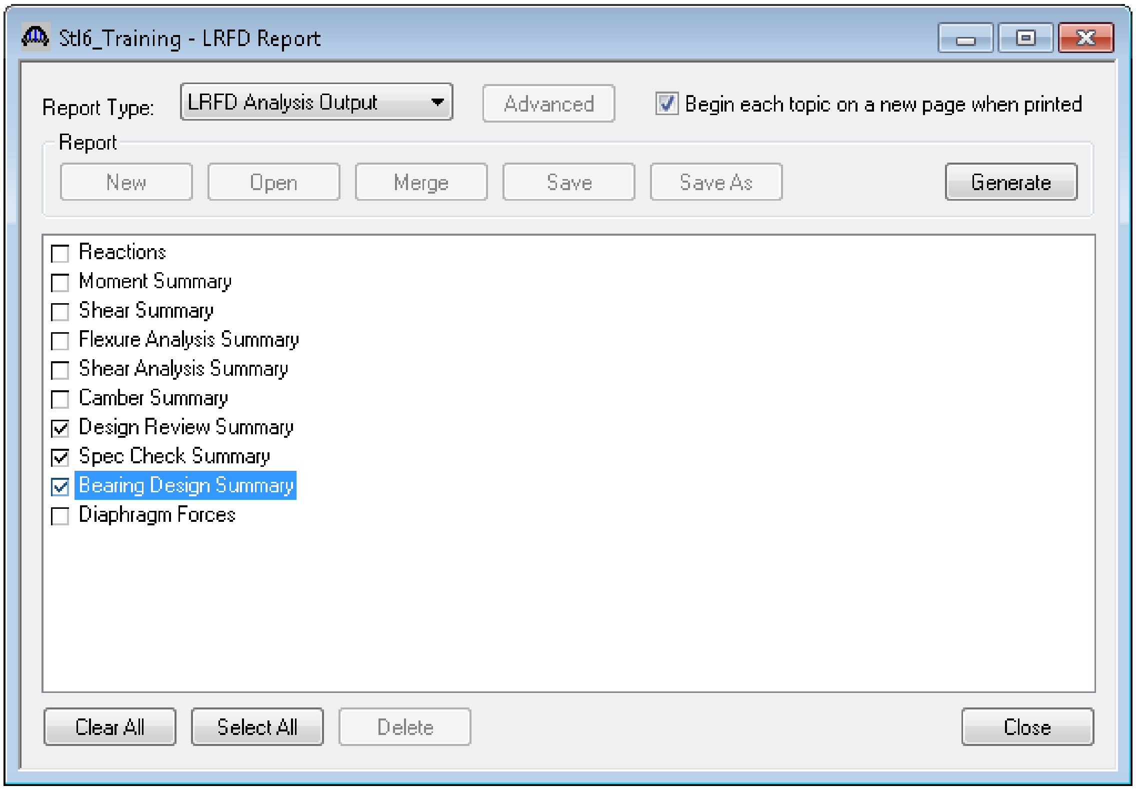
Similar behavior applies for lane load.

The FE model output that we turned on in the Analysis Settings window is available from the Analysis Output window:



Node	X (ft)	Y (ft)	Z (ft)
1	0.000	0.000	0.000
2	9.000	0.000	0.000
3	16.000	0.000	0.000
4	18.000	0.000	0.000
5	27.000	0.000	0.000
6	32.000	0.000	0.000
7	36.000	0.000	0.000
8	45.000	0.000	0.000
9	48.000	0.000	0.000
10	54.000	0.000	0.000
11	63.000	0.000	0.000
12	64.000	0.000	0.000
13	70.500	0.000	0.000
14	72.000	0.000	0.000
15	77.000	0.000	0.000
16	81.000	0.000	0.000
17	83.500	0.000	0.000
18	90.000	0.000	0.000
19	96.500	0.000	0.000

Additional reporting has been added to the Report Tool for steel beams. Select the 'LRFD Analysis Output' report in the Report Tool, click 'Clear All' and then select the last 3 reports. Click 'Generate' to generate these 3 reports.



Design Review Summary:

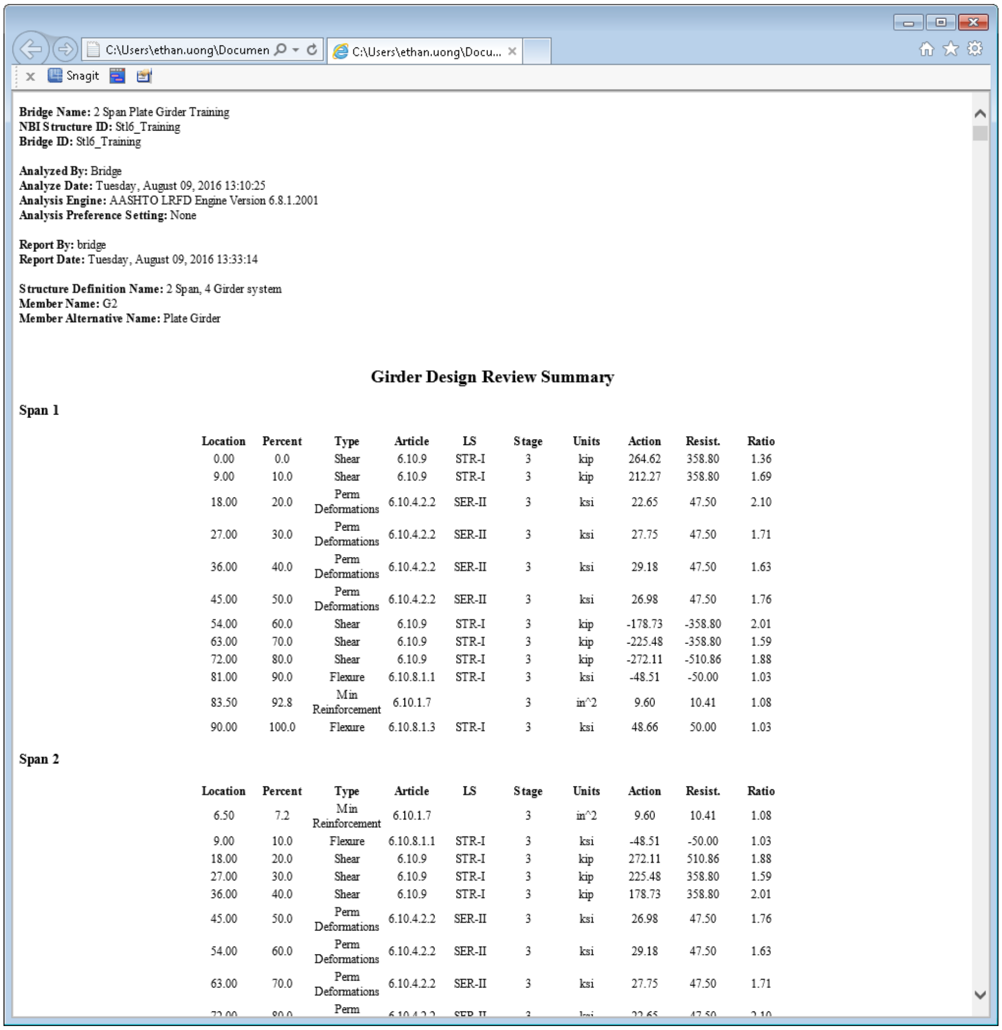
This report contains the minimum design ratio at each analysis point along the beam.

Spec Check Summary:

This report lists a summary of the spec check results for each article for each loading at each analysis point.

Bearing Design Summary:

This report lists factored and unfactored bearing reactions and rotations to be used in a bearing design.



Bridge Name: 2 Span Plate Girder Training
NBI Structure ID: Stl6_Training
Bridge ID: Stl6_Training

Analyzed By: Bridge
Analyze Date: Tuesday, August 09, 2016 13:10:25
Analysis Engine: AASHTO LRFD Engine Version 6.8.1.2001
Analysis Preference Setting: None

Report By: bridge
Report Date: Tuesday, August 09, 2016 13:33:14

Structure Definition Name: 2 Span, 4 Girder system
Member Name: G2
Member Alternative Name: Plate Girder

Girder Design Review Summary

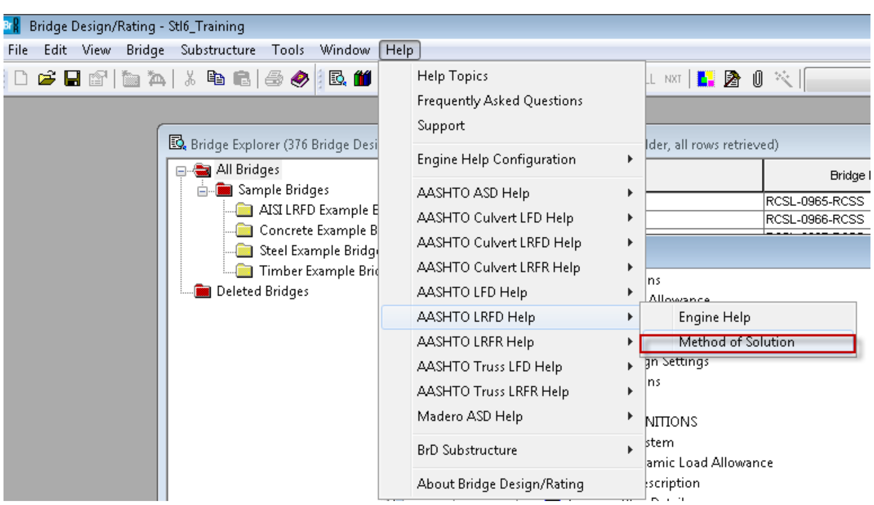
Span 1

Location	Percent	Type	Article	LS	Stage	Units	Action	Resist.	Ratio
0.00	0.0	Shear	6.10.9	STR-I	3	kip	264.62	358.80	1.36
9.00	10.0	Shear	6.10.9	STR-I	3	kip	212.27	358.80	1.69
18.00	20.0	Perm Deformations	6.10.4.2.2	SER-II	3	ksi	22.65	47.50	2.10
27.00	30.0	Perm Deformations	6.10.4.2.2	SER-II	3	ksi	27.75	47.50	1.71
36.00	40.0	Perm Deformations	6.10.4.2.2	SER-II	3	ksi	29.18	47.50	1.63
45.00	50.0	Perm Deformations	6.10.4.2.2	SER-II	3	ksi	26.98	47.50	1.76
54.00	60.0	Shear	6.10.9	STR-I	3	kip	-178.73	-358.80	2.01
63.00	70.0	Shear	6.10.9	STR-I	3	kip	-225.48	-358.80	1.59
72.00	80.0	Shear	6.10.9	STR-I	3	kip	-272.11	-510.86	1.88
81.00	90.0	Flexure	6.10.8.1.1	STR-I	3	ksi	-48.51	-50.00	1.03
83.50	92.8	Min Reinforcement	6.10.1.7		3	in^2	9.60	10.41	1.08
90.00	100.0	Flexure	6.10.8.1.3	STR-I	3	ksi	48.66	50.00	1.03

Span 2

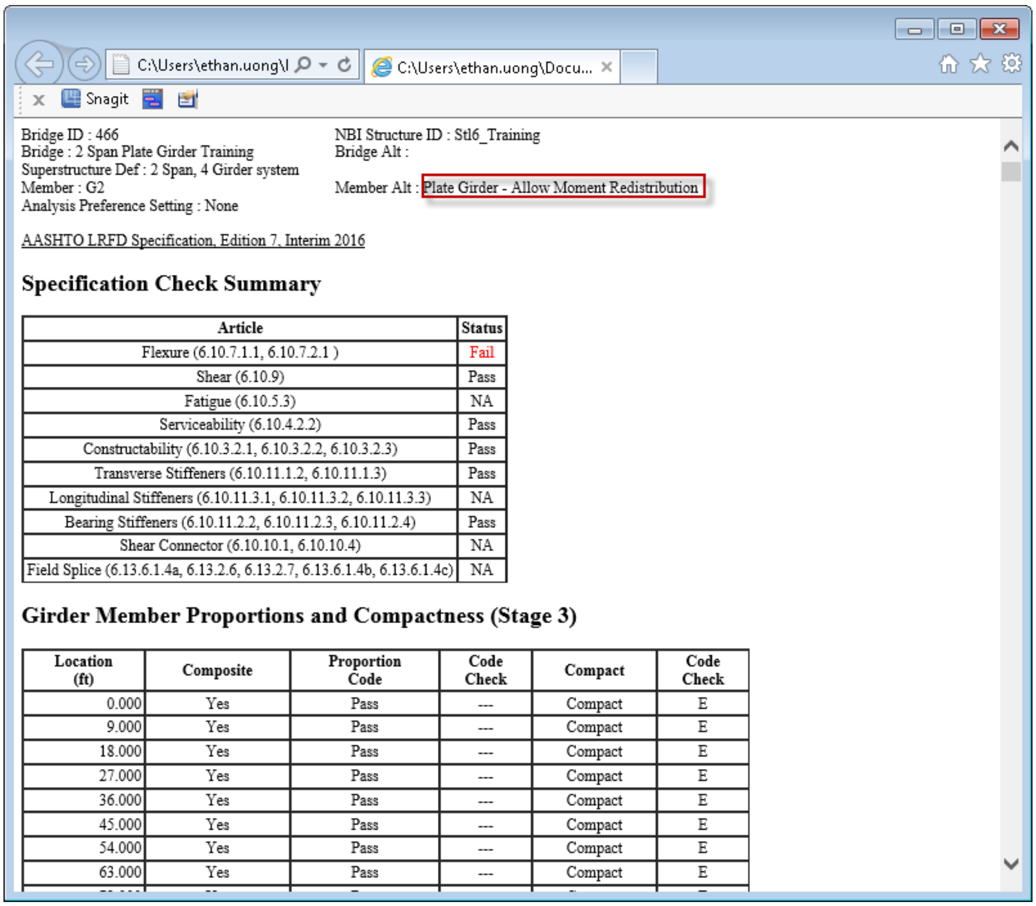
Location	Percent	Type	Article	LS	Stage	Units	Action	Resist.	Ratio
6.50	7.2	Min Reinforcement	6.10.1.7		3	in^2	9.60	10.41	1.08
9.00	10.0	Flexure	6.10.8.1.1	STR-I	3	ksi	-48.51	-50.00	1.03
18.00	20.0	Shear	6.10.9	STR-I	3	kip	272.11	510.86	1.88
27.00	30.0	Shear	6.10.9	STR-I	3	kip	225.48	358.80	1.59
36.00	40.0	Shear	6.10.9	STR-I	3	kip	178.73	358.80	2.01
45.00	50.0	Perm Deformations	6.10.4.2.2	SER-II	3	ksi	26.98	47.50	1.76
54.00	60.0	Perm Deformations	6.10.4.2.2	SER-II	3	ksi	29.18	47.50	1.63
63.00	70.0	Perm Deformations	6.10.4.2.2	SER-II	3	ksi	27.75	47.50	1.71

A copy of the AASHTO LRFD engine Method of Solution manual is available.



Moment Redistribution

Run an HL93 Design Review for the member alternative “Plate Girder – Allow moment redistribution”. This is a streamlined version of the previous alternative. It does not contain any flange transitions. View the spec check summary and see that flexure fails for this beam.



Bridge ID : 466
Bridge : 2 Span Plate Girder Training
Superstructure Def : 2 Span, 4 Girder system
Member : G2
Analysis Preference Setting : None

NBI Structure ID : Stl6_Training
Bridge Alt :
Member Alt : Plate Girder - Allow Moment Redistribution

AASHTO LRFD Specification, Edition 7, Interim 2016

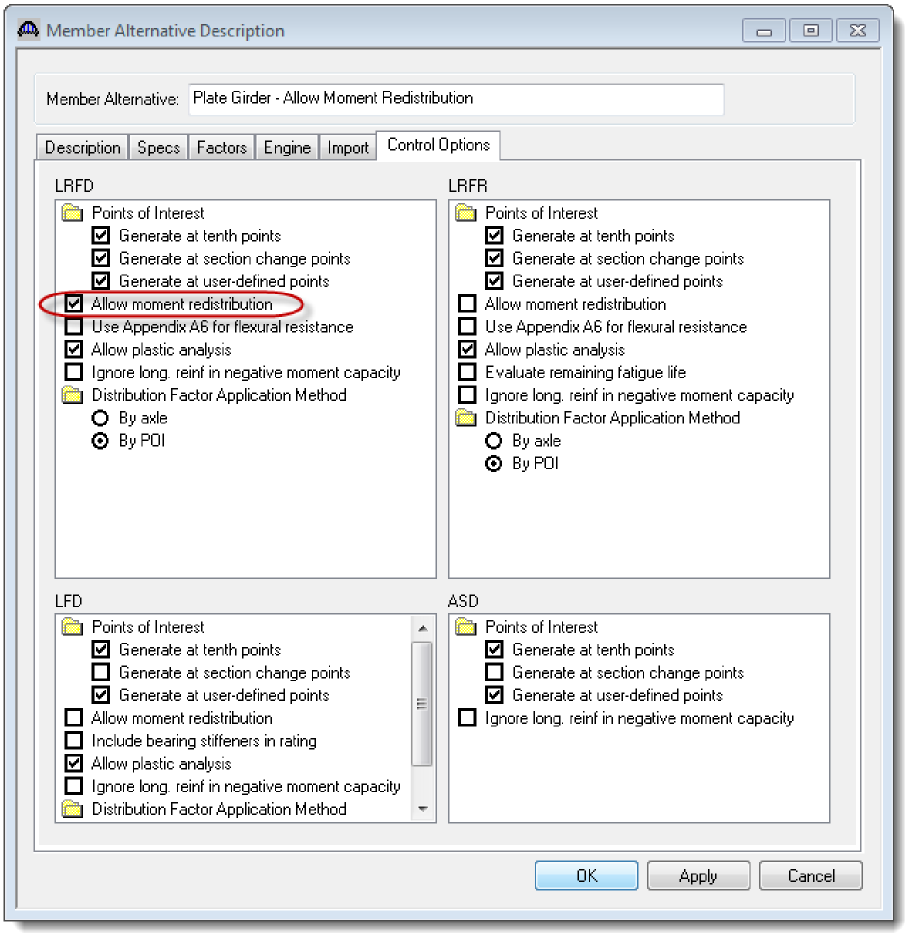
Specification Check Summary

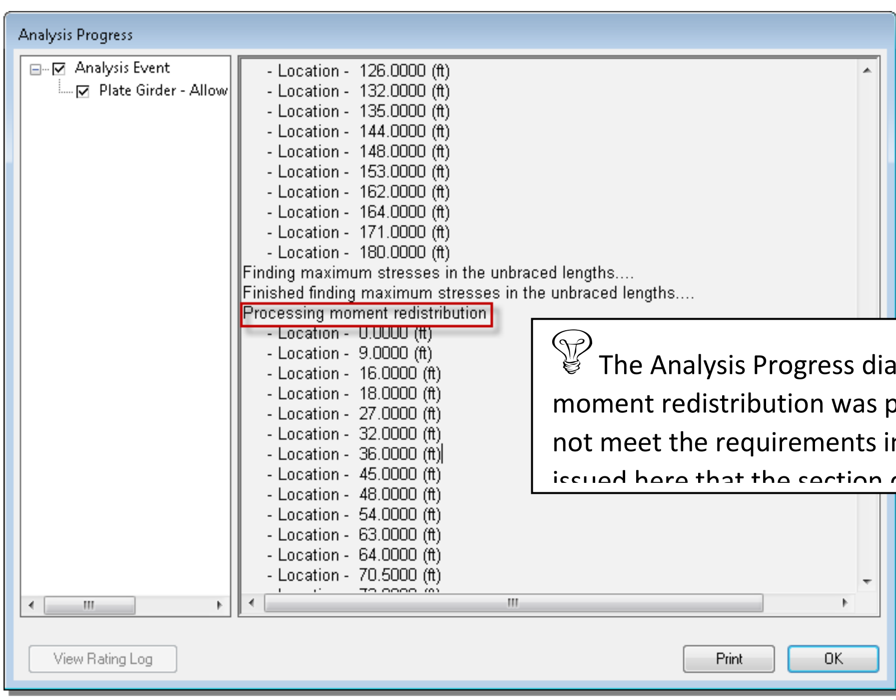
Article	Status
Flexure (6.10.7.1.1, 6.10.7.2.1)	Fail
Shear (6.10.9)	Pass
Fatigue (6.10.5.3)	NA
Serviceability (6.10.4.2.2)	Pass
Constructability (6.10.3.2.1, 6.10.3.2.2, 6.10.3.2.3)	Pass
Transverse Stiffeners (6.10.11.1.2, 6.10.11.1.3)	Pass
Longitudinal Stiffeners (6.10.11.3.1, 6.10.11.3.2, 6.10.11.3.3)	NA
Bearing Stiffeners (6.10.11.2.2, 6.10.11.2.3, 6.10.11.2.4)	Pass
Shear Connector (6.10.10.1, 6.10.10.4)	NA
Field Splice (6.13.6.1.4a, 6.13.2.6, 6.13.2.7, 6.13.6.1.4b, 6.13.6.1.4c)	NA

Girder Member Proportions and Compactness (Stage 3)

Location (ft)	Composite	Proportion Code	Code Check	Compact	Code Check
0.000	Yes	Pass	---	Compact	E
9.000	Yes	Pass	---	Compact	E
18.000	Yes	Pass	---	Compact	E
27.000	Yes	Pass	---	Compact	E
36.000	Yes	Pass	---	Compact	E
45.000	Yes	Pass	---	Compact	E
54.000	Yes	Pass	---	Compact	E
63.000	Yes	Pass	---	Compact	E

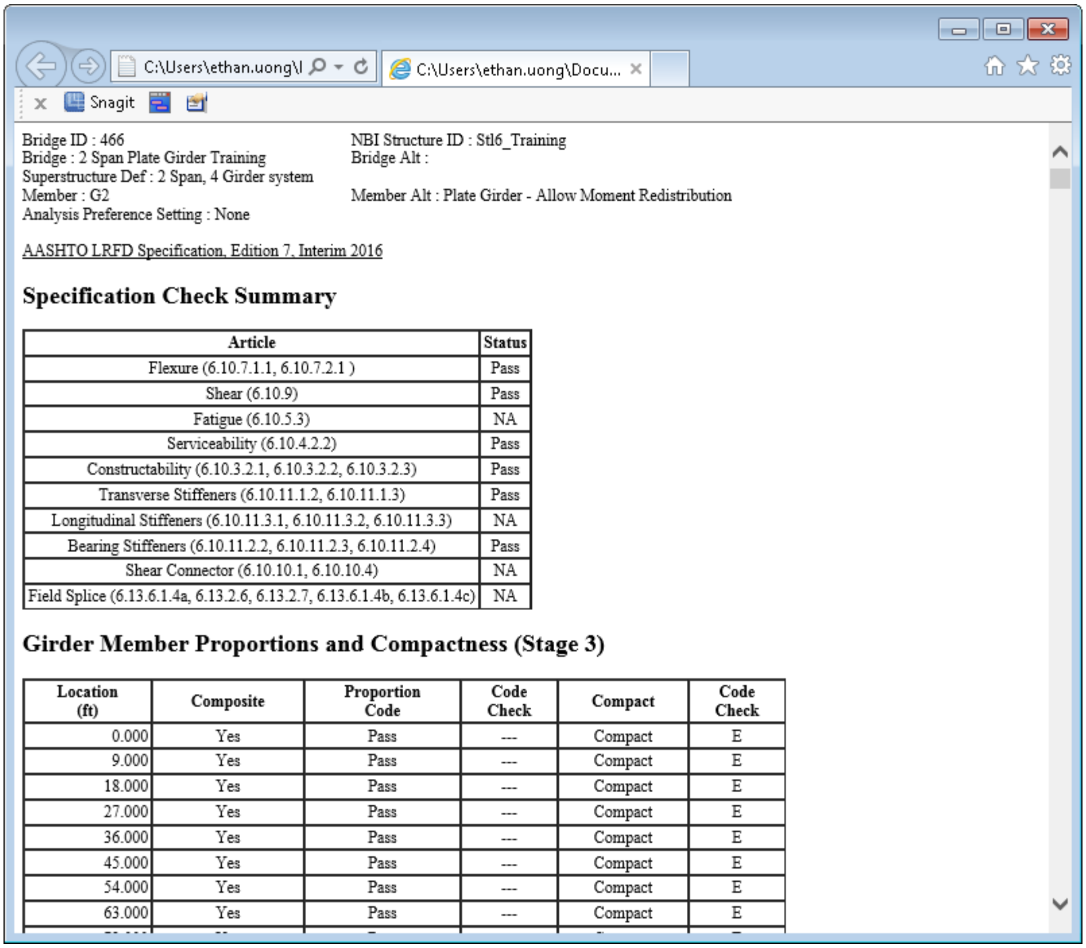
In the Member Alternative: Control Options tab, select the box to allow moment redistribution. Run the HL93 Design Review analysis again.





The Analysis Progress dialog will let you know if moment redistribution was processed. If the beam does not meet the requirements in App B6.2, a message will be issued here that the section did not qualify for moment

The spec check results summary now shows all articles passing.



Bridge ID : 466
Bridge : 2 Span Plate Girder Training
Superstructure Def : 2 Span, 4 Girder system
Member : G2
Analysis Preference Setting : None

NBI Structure ID : Stl6_Training
Bridge Alt :
Member Alt : Plate Girder - Allow Moment Redistribution

AASHTO LRFD Specification, Edition 7, Interim 2016

Specification Check Summary

Article	Status
Flexure (6.10.7.1.1, 6.10.7.2.1)	Pass
Shear (6.10.9)	Pass
Fatigue (6.10.5.3)	NA
Serviceability (6.10.4.2.2)	Pass
Constructability (6.10.3.2.1, 6.10.3.2.2, 6.10.3.2.3)	Pass
Transverse Stiffeners (6.10.11.1.2, 6.10.11.1.3)	Pass
Longitudinal Stiffeners (6.10.11.3.1, 6.10.11.3.2, 6.10.11.3.3)	NA
Bearing Stiffeners (6.10.11.2.2, 6.10.11.2.3, 6.10.11.2.4)	Pass
Shear Connector (6.10.10.1, 6.10.10.4)	NA
Field Splice (6.13.6.1.4a, 6.13.2.6, 6.13.2.7, 6.13.6.1.4b, 6.13.6.1.4c)	NA

Girder Member Proportions and Compactness (Stage 3)

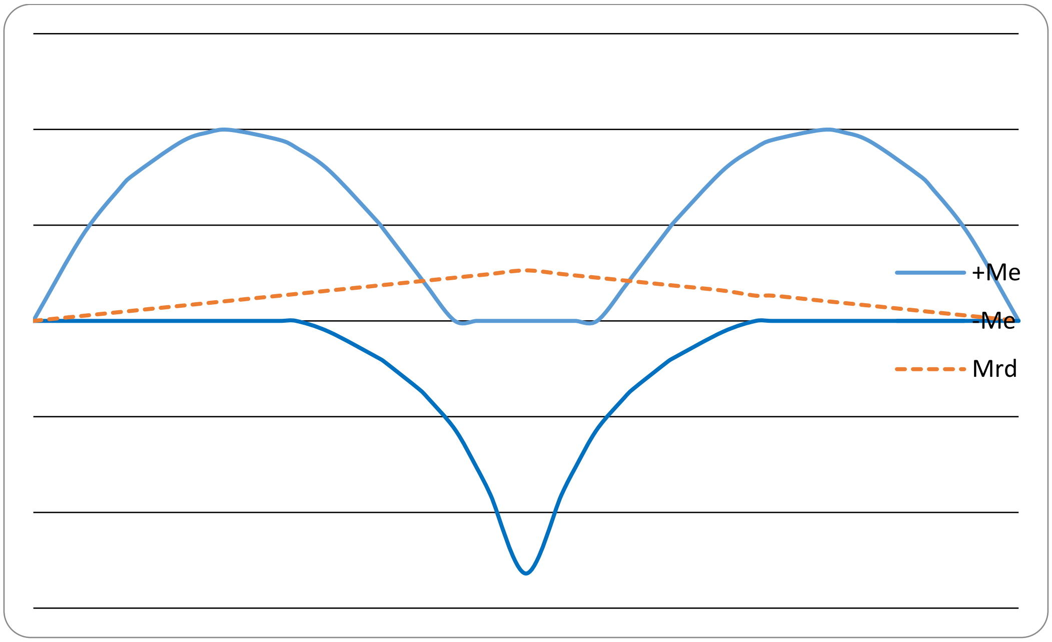
Location (ft)	Composite	Proportion Code	Code Check	Compact	Code Check
0.000	Yes	Pass	---	Compact	E
9.000	Yes	Pass	---	Compact	E
18.000	Yes	Pass	---	Compact	E
27.000	Yes	Pass	---	Compact	E
36.000	Yes	Pass	---	Compact	E
45.000	Yes	Pass	---	Compact	E
54.000	Yes	Pass	---	Compact	E
63.000	Yes	Pass	---	Compact	E

Moment redistribution takes some of the negative moment at the pier and distributes it to the positive moment regions.

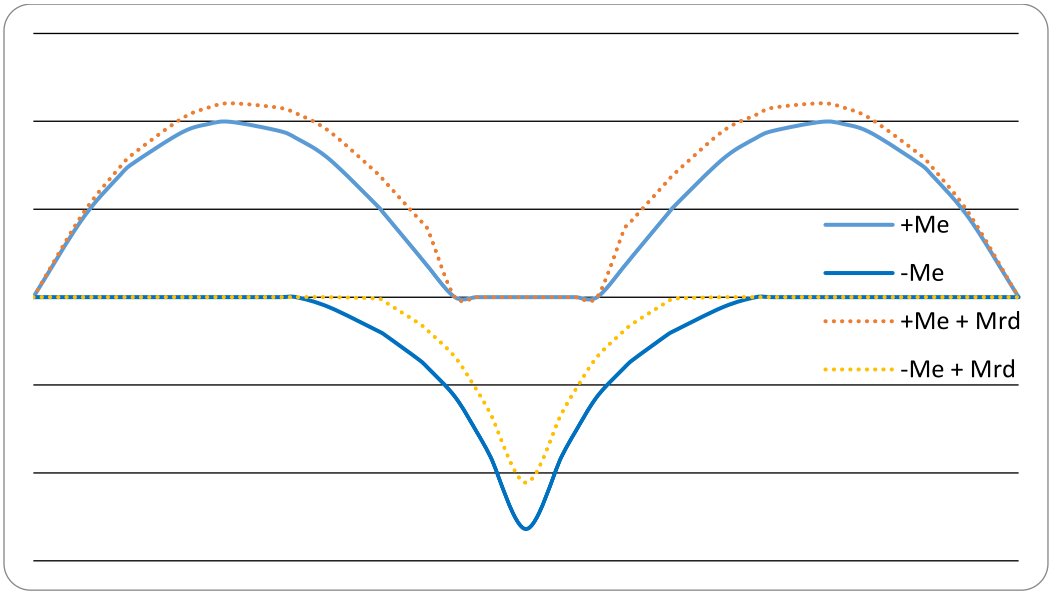
After the elastic stresses are computed in the first phase of spec checks, the articles in Appendix B6.2 are evaluated to determine if moment redistribution is permissible. If it is permissible, the effective plastic moment at the piers is determined. This moment is then used to compute the redistribution moments, Mrd, at the piers and at all other points using linear interpolation. After the redistribution moments are computed, the stresses due to the redistribution moments are computed. The redistribution stresses are then combined with the elastic stresses and the flexure type is re-determined for this total stress.

The specification articles then take into account the redistribution stresses when computing the design ratios.

The following sketch shows the elastic moment envelope for Strength I and the computed Mrd envelope.



The following sketch shows how the redistribution moments increase the positive moments and reduce the negative moments.



The following article shows the effects of moment redistribution:

Spec Check Detail for 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression

6 Steel Structures
6.10 I-Section Flexural Members
6.10.8 Flexural Resistance-Composite Sections in Negative Flexure and Noncomposite Sections
6.10.8.1 General
6.10.8.1.3 Continuously Braced Flanges in Tension or Compression
(AASHTO LRFD Bridge Design Specifications, Seventh Edition - 2014, with 2016 Interims)

Steel Plate - At Location = 72.0000 (ft) - Left   Stage 3

INPUT:
Phif = 1.000

Section Type: Composite
Top Flange Laterally Supported: Yes
Allow Moment Redistribution Control Option: Yes
Moment Redistribution : Yes, Moment Redistribution did occur

SUMMARY:

fbu <= Phif * Rh * Fyf   (6.10.8.1.3-1)

Resist = Phif * Rh * Fyf

Design Ratio = Resist/fbu

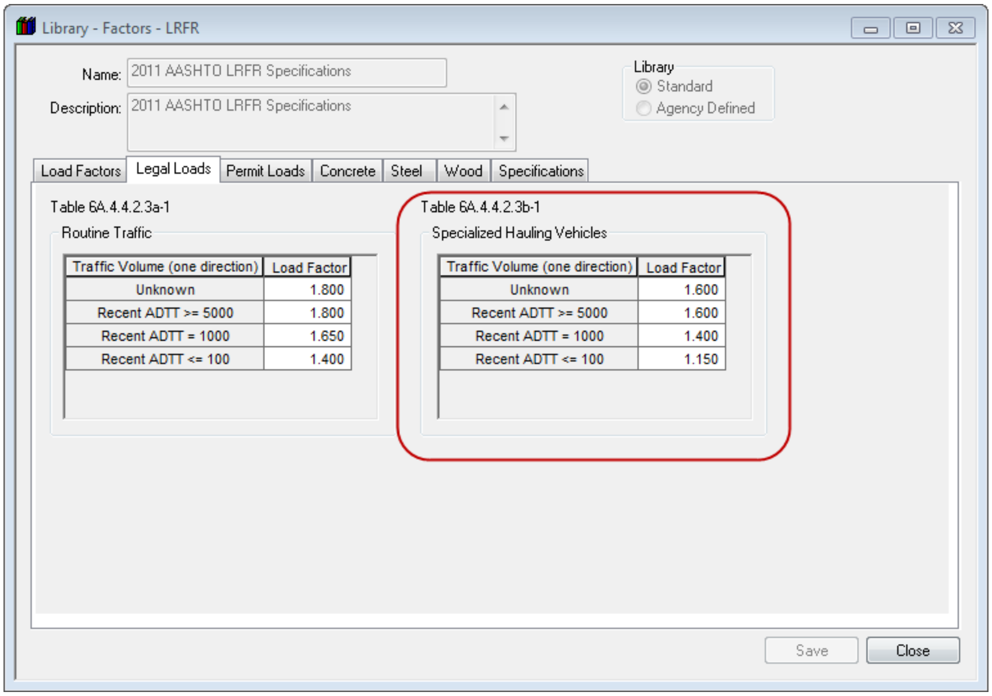
Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
Otherwise the Resistance is computed as per the Specification.

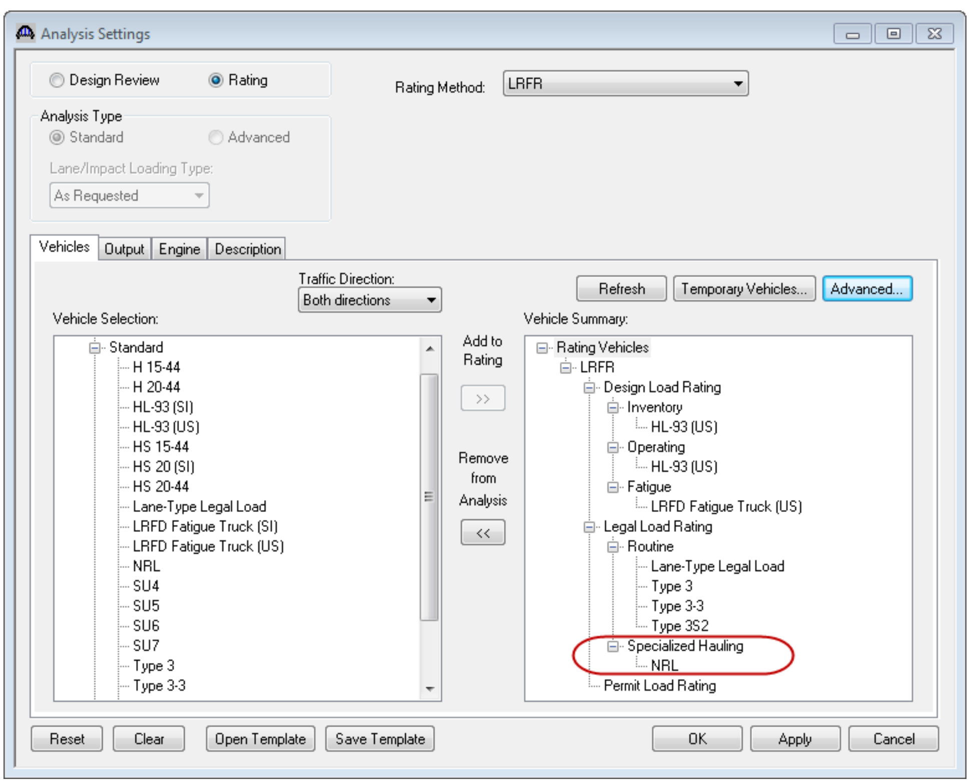
Limit State	Load Combo	Flexure Type	Component	fbu (ksi)	frd (ksi)	Rh	Fyf (ksi)	Override Phi (ksi)	Override Fyf (ksi)	Resist (ksi)	Design Ratio	Status
STR-I	1	Pos*	---	---	---	---	---	---	---	---	---	---
STR-I	1	Neg	Top Flange	15.50	-2.49	1.00	50.00	---	---	50.00	3.84	Pass
STR-I	2	Pos*	---	---	---	---	---	---	---	---	---	---
STR-I	2	Neg	Top Flange	13.60	-2.49	1.00	50.00	---	---	50.00	4.50	Pass
STR-I	3	Neg	Top Flange	3.91	-2.49	1.00	50.00	---	---	50.00	35.25	Pass
STR-I	3	Neg	Top Flange	14.50	-2.49	1.00	50.00	---	---	50.00	4.16	Pass
STR-III	1	Neg	Top Flange	3.56	0.00	1.00	50.00	---	---	50.00	14.04	Pass
STR-III	1	Neg	Top Flange	5.61	0.00	1.00	50.00	---	---	50.00	8.91	Pass
STR-III	2	Neg	Top Flange	3.56	0.00	1.00	50.00	---	---	50.00	14.04	Pass
STR-III	2	Neg	Top Flange	5.61	0.00	1.00	50.00	---	---	50.00	8.91	Pass
STR-III	3	Neg	Top Flange	3.91	0.00	1.00	50.00	---	---	50.00	12.78	Pass
STR-III	3	Neg	Top Flange	5.61	0.00	1.00	50.00	---	---	50.00	8.91	Pass
STR-V	1	Pos*	---	---	---	---	---	---	---	---	---	---
STR-V	1	Neg	Top Flange	13.24	-1.49	1.00	50.00	---	---	50.00	4.25	Pass
STR-V	2	Pos*	---	---	---	---	---	---	---	---	---	---
STR-V	2	Neg	Top Flange	11.77	-1.49	1.00	50.00	---	---	50.00	4.86	Pass

OK

Specialized Hauling Vehicles (SHV's)

A new category of Legal Loads is available as per the MBE specifications:





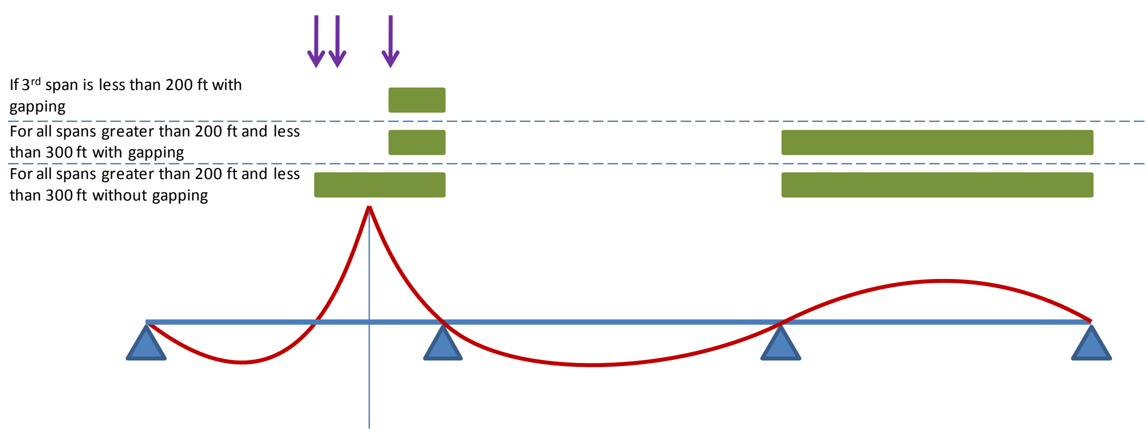
Permit Lane Load and "Gapping"

New to Version 6.3 is the ability to enter a lane load to be applied with a permit truck as specified by the MBE. Where the truck is placed the lane load is to be removed or "gapped." The MBE does also allow the lane load to be superimposed on top of the permit vehicle for ease of analysis.

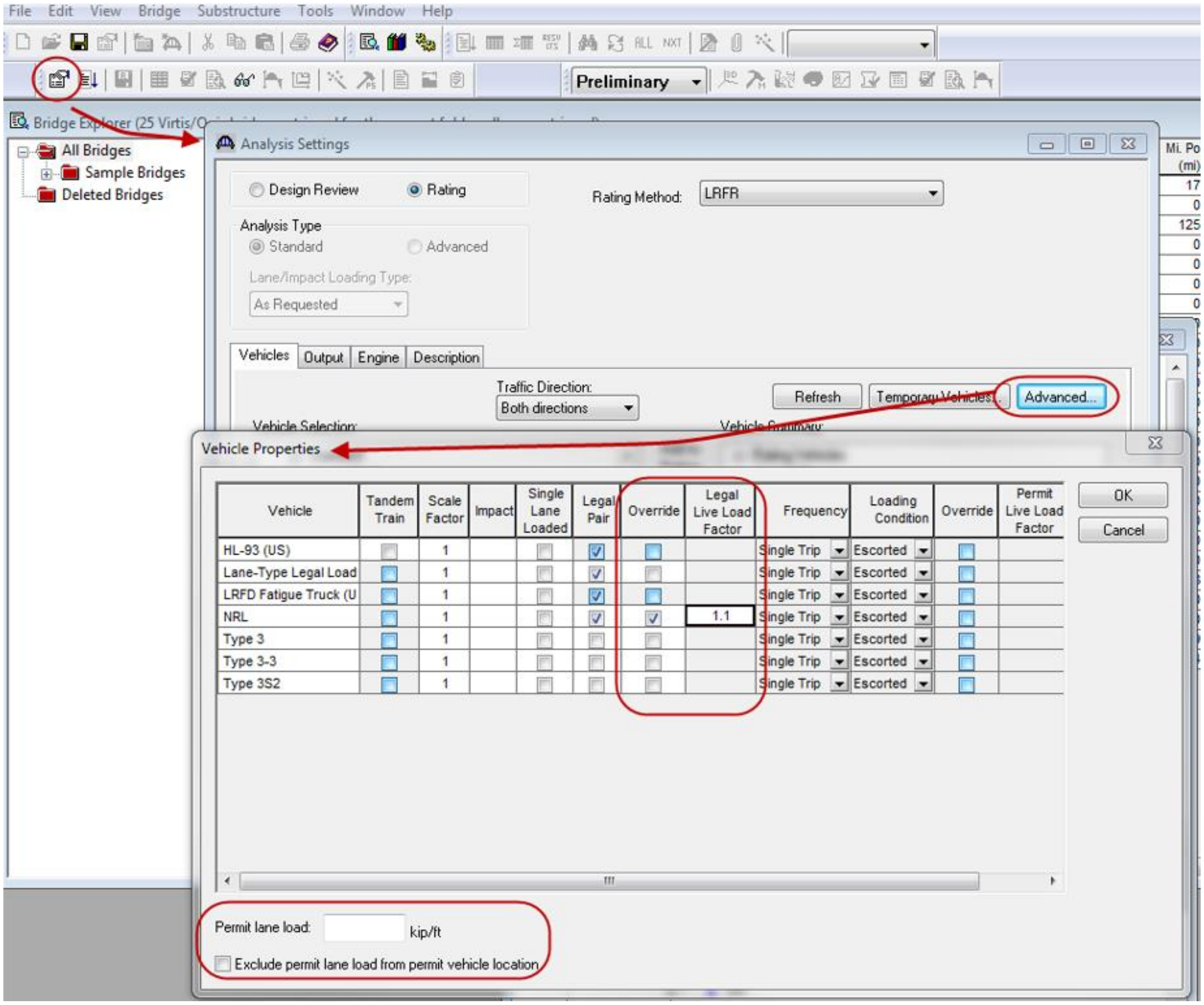
The permit lane load is applied as follows:

- For negative moment - lane load should always be applied for negative moment regions regardless of span length.
- For positive moment - apply the lane load for span length between 200 and 300 feet regardless where the point of interest is.

The following illustrates this procedure for positive moment.



To exclude the lane load where the permit truck is placed, click on “Exclude permit lane load from permit vehicle location.”



The user may also override the internal Legal Load Live Load Factor as shown above.