AASHTOWare™ BRIDGE DESIGN AND RATING

Evaluation of State Legal Loads

Ralph DeStefano, PE — ProMiles

ProMiles®

Legal Loads – AASHTO – Type 3 Series

a. *AASHTO Trucks*—Apply for all span lengths and load effects.

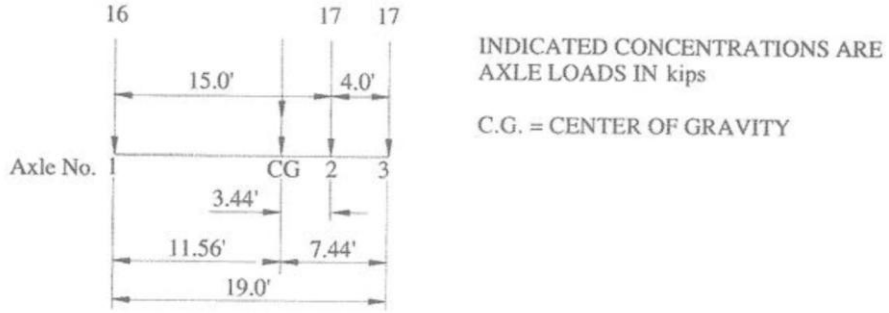


Figure D6A-1—Type 3 Unit; Weight = 50 kips (25 tons)

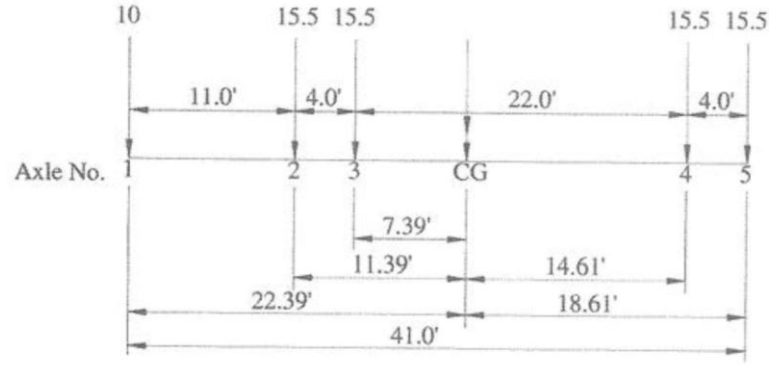


Figure D6A-2—Type 3S2 Unit; Weight = 72 kips (36 tons)

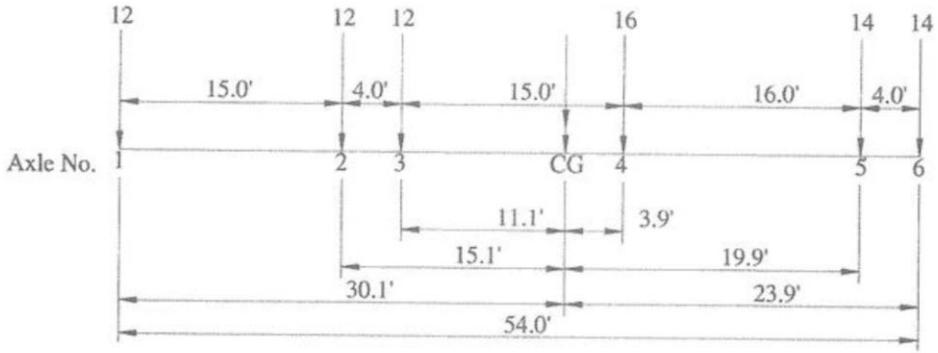


Figure D6A-3—Type 3-3 Unit; Weight = 80 kips (40 tons)

Legal Loads – AASHTO – Lane-type Legal

b. *Lane-Type Legal Load Model*—Apply for spans greater than 200 ft and all load effects.

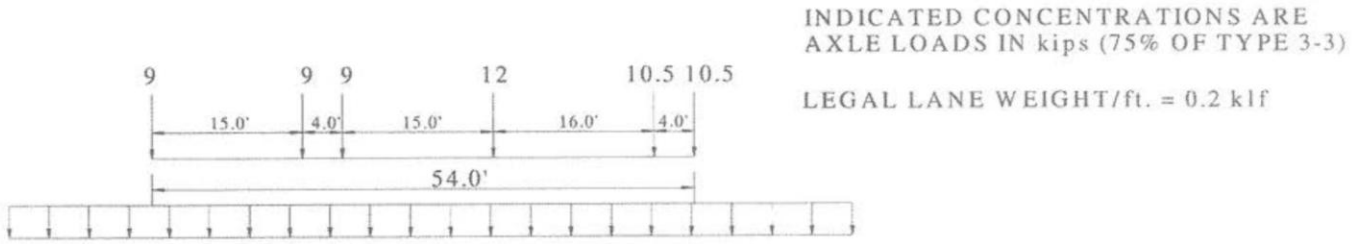


Figure D6A-4—Lane-Type Loading for Spans Greater than 200 ft

c. *Lane-Type Legal Load Model*—Apply for negative moment and interior reaction for all span lengths.

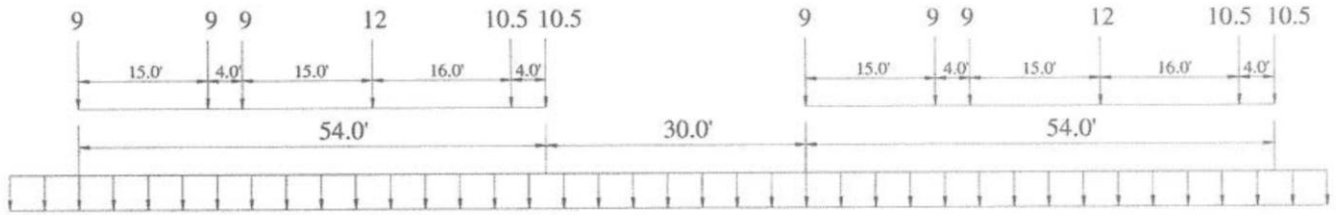
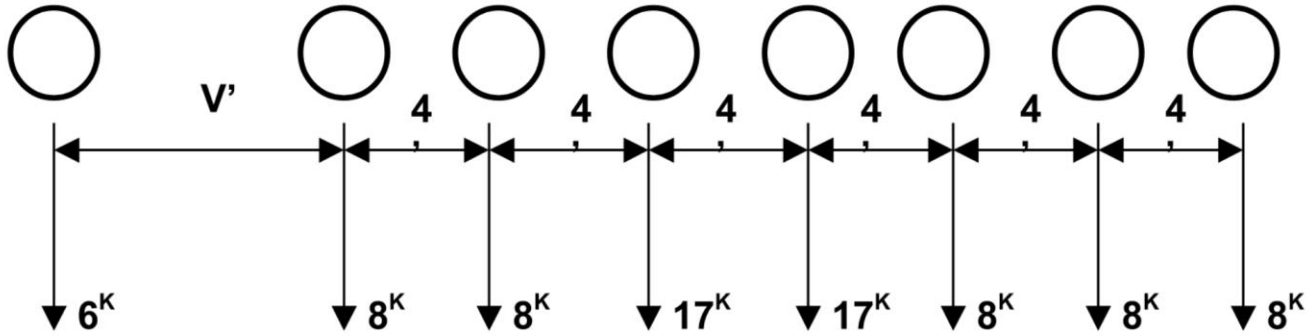


Figure D6A-5—Lane-Type Loading for Negative Moment and Interior Reaction

Legal Loads – AASHTO – Notional Rating Load

d. *Notional Rating Load*—Apply for all span lengths and load effects.



V=VARIABLE DRIVE AXLE SPACING—6'0" TO 14'0". SPACING TO BE USED IS THAT WHICH PRODUCES MAXIMUM LOAD EFFECTS.

AXLES THAT DO NOT CONTRIBUTE TO THE MAXIMUM LOAD EFFECTS UNDER CONSIDERATION SHALL BE NEGLECTED.

NOTIONAL ASPECT OF LOADING

MAXIMUM GVW = 80 KIPS

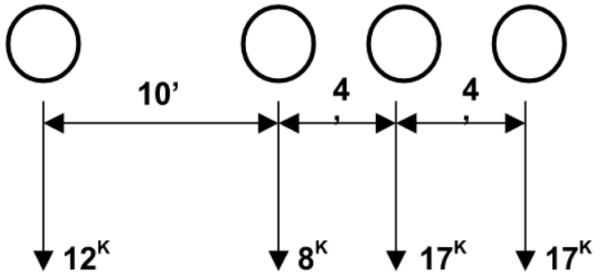
AXLE GAGE WIDTH = 6'0"

Figure D6A-6—Notional Rating Load (NRL) for Single-Unit SHVs that Meet Federal Bridge Formula B

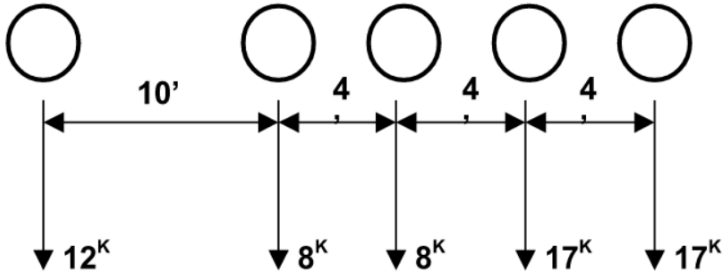
Legal Loads – AASHTO – Special Hauling

e. Single-Unit Bridge Posting Loads

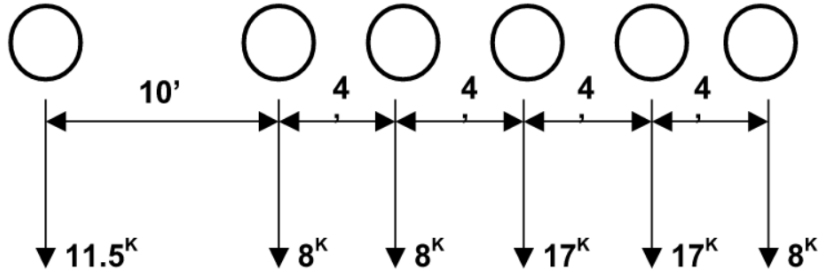
SU4 TRUCK
GVW = 54 KIPS



SU5 TRUCK
GVW = 62 KIPS



SU6 TRUCK
GVW = 69.5 KIPS



SU7 TRUCK
GVW = 77.5 KIPS

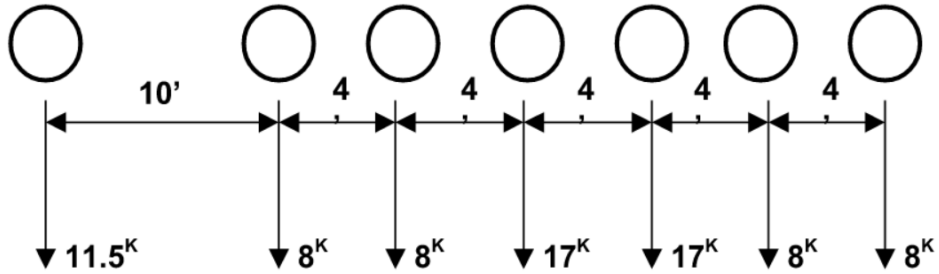


Figure D6A-7—Bridge Posting Loads for Single-Unit SHVs that Meet Federal Bridge Formula B

Legal Loads – FAST Act – Emergency Vehicles

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **ACTION:** Load Rating for the FAST Act's Emergency Vehicles

Date: November 3, 2016

From: /Original signed by/
Joseph L. Hartmann, Ph.D., P.E.
Director, Office of Bridges and Structures

In Reply Refer To: HIBS-1

To: Division Administrators
Federal Lands Highway Division Directors

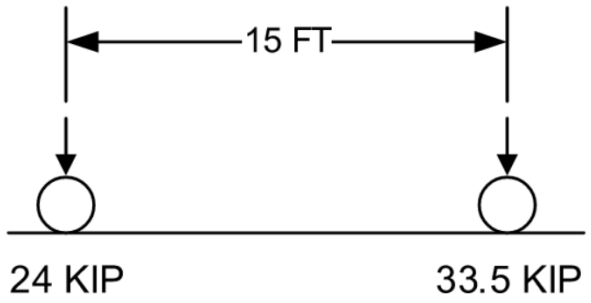
On December 4, 2015, the President signed into law the *Fixing America's Surface Transportation Act* (FAST Act) (Pub. L.114-94). Section 1410 of the FAST Act amended 23 U.S.C. 127, *Vehicle weight limitations—Interstate System*, by revising the weight limits for certain vehicles on the Interstate System. The purpose of this memorandum is

1. Type EV2 - for single rear axle emergency vehicles

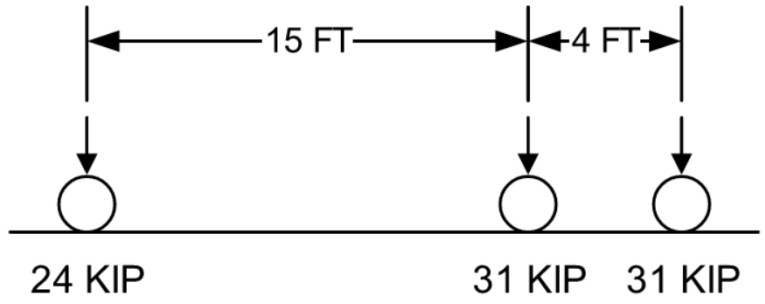
   Front Single Axle: 24,000 pounds
   Rear Single Axle: 33,500 pounds
   Wheelbase: 15 ft.

2. Type EV3 – for tandem rear axle emergency vehicles

   Front Single Axle: 24,000 pounds
   Rear Tandem Axle: 62,000 pounds (two 31,000 pound axles spaced at 4 ft.)
   Wheelbase: 17 ft. (distance from front axle to the centerline of rear tandem axle)



EV2 (Single Rear Axle Emergency Vehicle)



EV3 (Tandem Rear Axle Emergency Vehicle)

Legal Loads - Pennsylvania

- Other than standard H20 & HS20 vehicles, Pennsylvania considers only two other vehicle configurations for load posting evaluation
- ML-80 and TK527 vehicle configurations have been found to envelope the force effects of AASHTO Type 3 series, Special Hauling series & FAST ACT EV2 & EV3

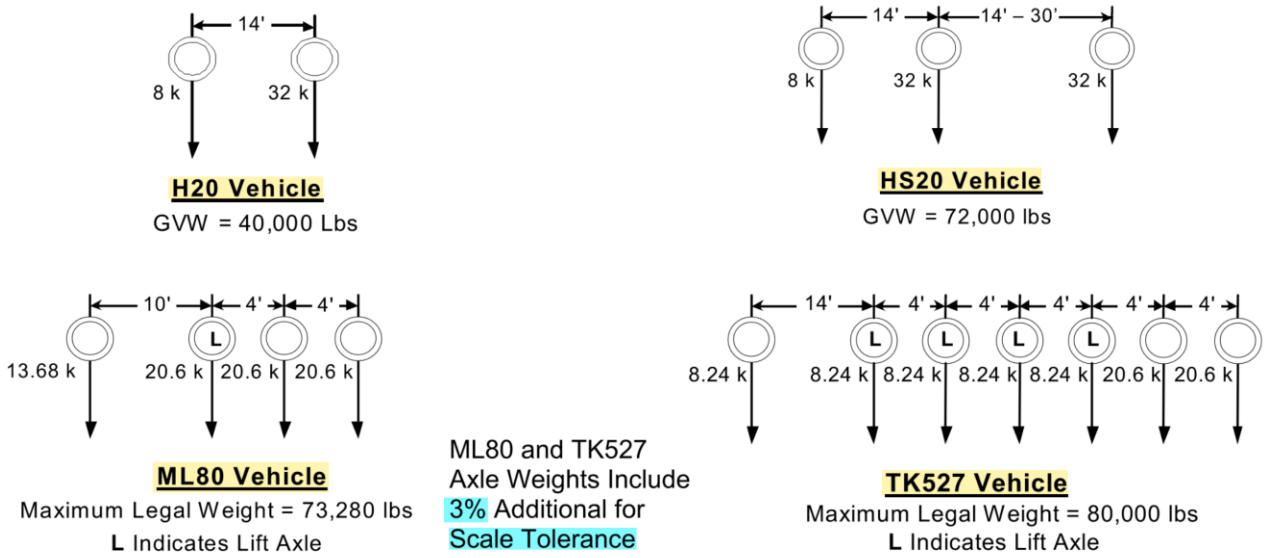


Figure IP 3.2.2.2-1 Bridge Posting Vehicles – Axle Configuration and Axle Weights

Legal Loads – Pennsylvania *(continue)*

Publication 238 (2026 Edition), Appendix IP 04-A
Bridge Load Posting Recommendation Form

BRIDGE RATING ANALYSIS:									
Controlling Member(s):						Controlling Span(s):			
☐ Non-Redundant		☐ Fatigue Sensitive			☐ Interior/Fascia Girder *(if multi-girder)*				
Inventory Ratings:	Full Lanes:	H	tons	HS	tons	ML-80	tons	TK527	tons
	One Truck:	H	tons	HS	tons	ML-80	tons	TK527	tons
Operating Ratings:	Full Lanes:	H	tons	HS	tons	ML-80	tons	TK527	tons
	One Truck:	H	tons	HS	tons	ML-80	tons	TK527	tons
SLC Ratings:	Full Lanes:	H	tons	HS	tons	ML-80	tons	TK527	tons
	One Truck:	H	tons	HS	tons	ML-80	tons	TK527	tons
	☐ AASHTO Line Girder with Simplified (S-Over) LL Distribution Factors ☐ AASHTO Line Girder with NCHRP LL Distribution Factors								

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‘Legal’ & ‘Permit’ Vehicle Categories for ASR & LFR Analyses

6B.2—RATING LEVELS

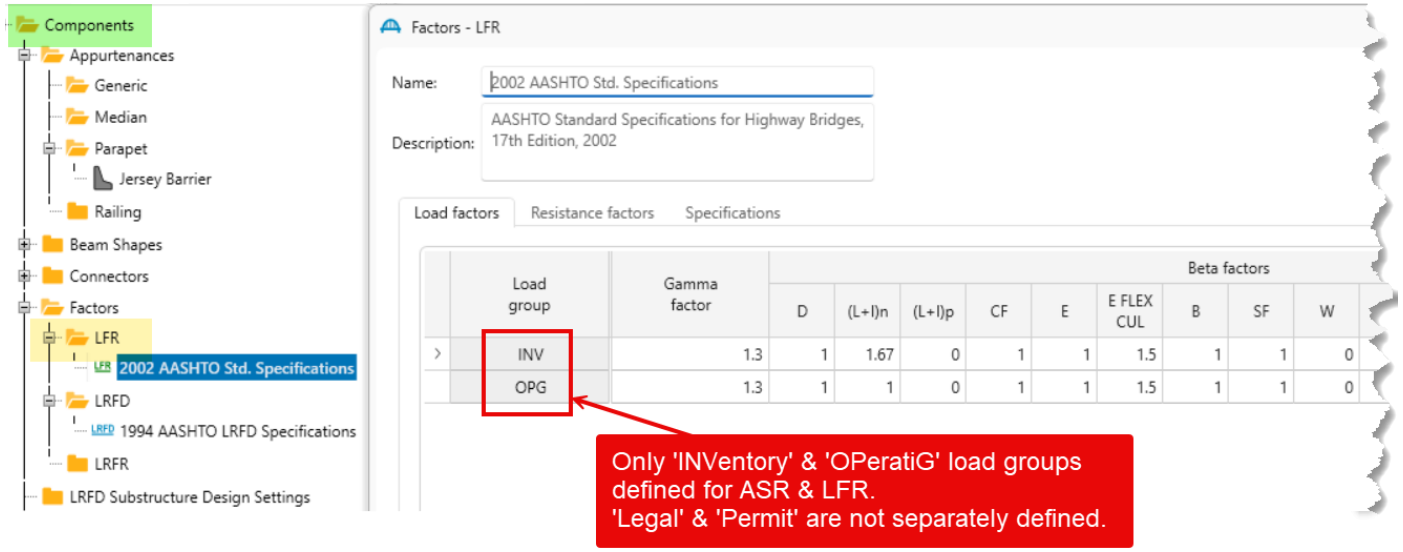
Each highway bridge should be load rated at two levels, inventory and operating levels.

6B.2.1—Inventory Rating Level

The inventory rating level generally corresponds to the customary design level of stresses but reflects the existing bridge and material conditions with regard to deterioration and loss of section. Load ratings based on the inventory level allow comparisons with the capacity for new structures and, therefore, results in a live load, which can safely utilize an existing structure for an indefinite period of time.

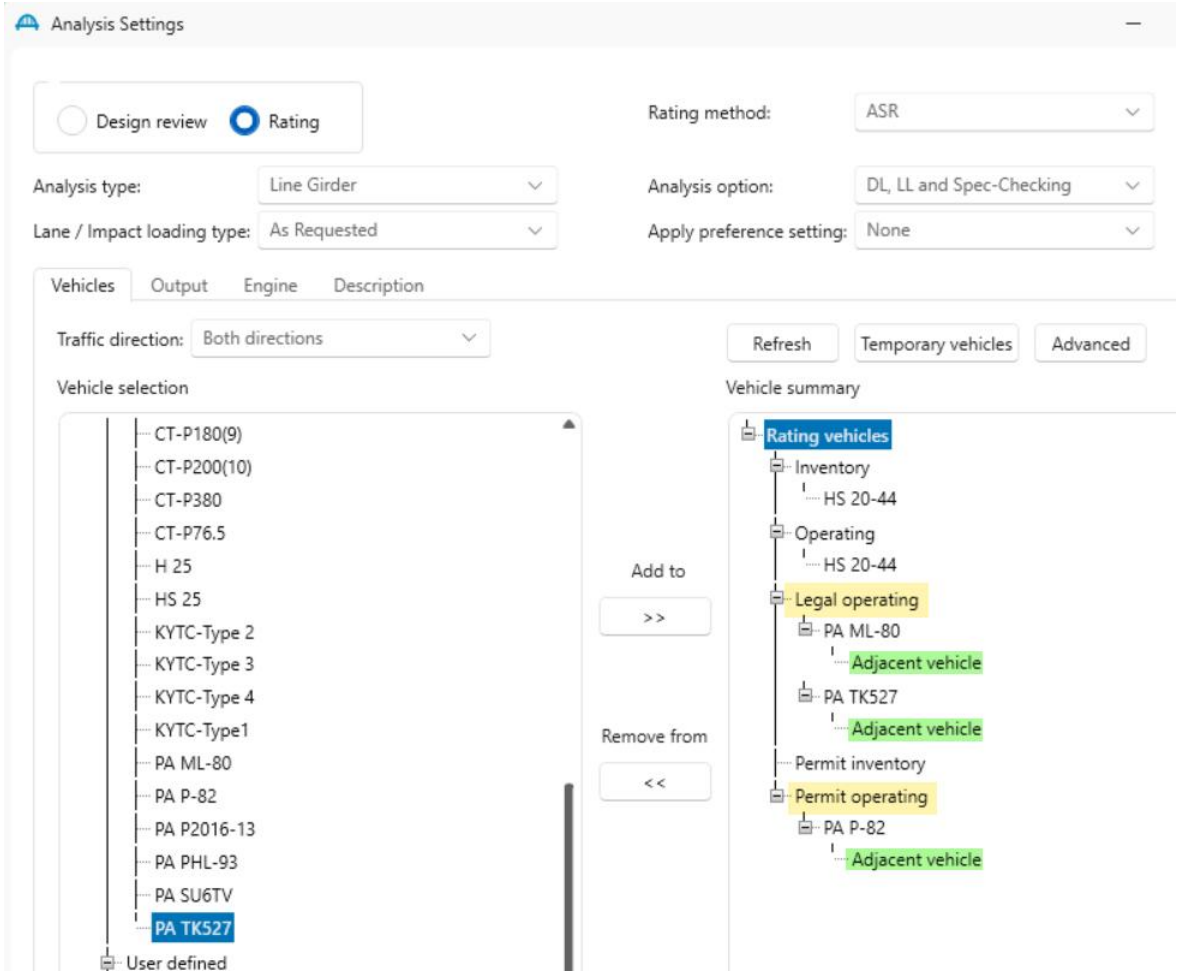
6B.2.2—Operating Rating Level

Load ratings based on the operating rating level generally describe the maximum permissible live load to which the structure may be subjected. Allowing unlimited numbers of vehicles to use the bridge at operating level may shorten the life of the bridge.



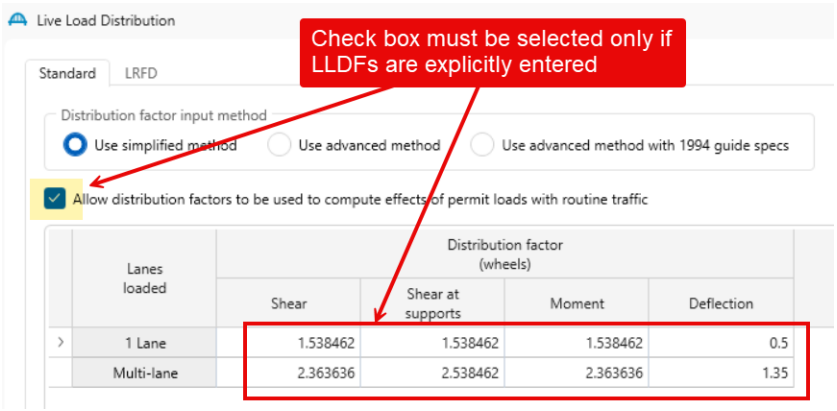
‘Legal’ & ‘Permit’ Vehicle Categories for ASR & LFR Analyses

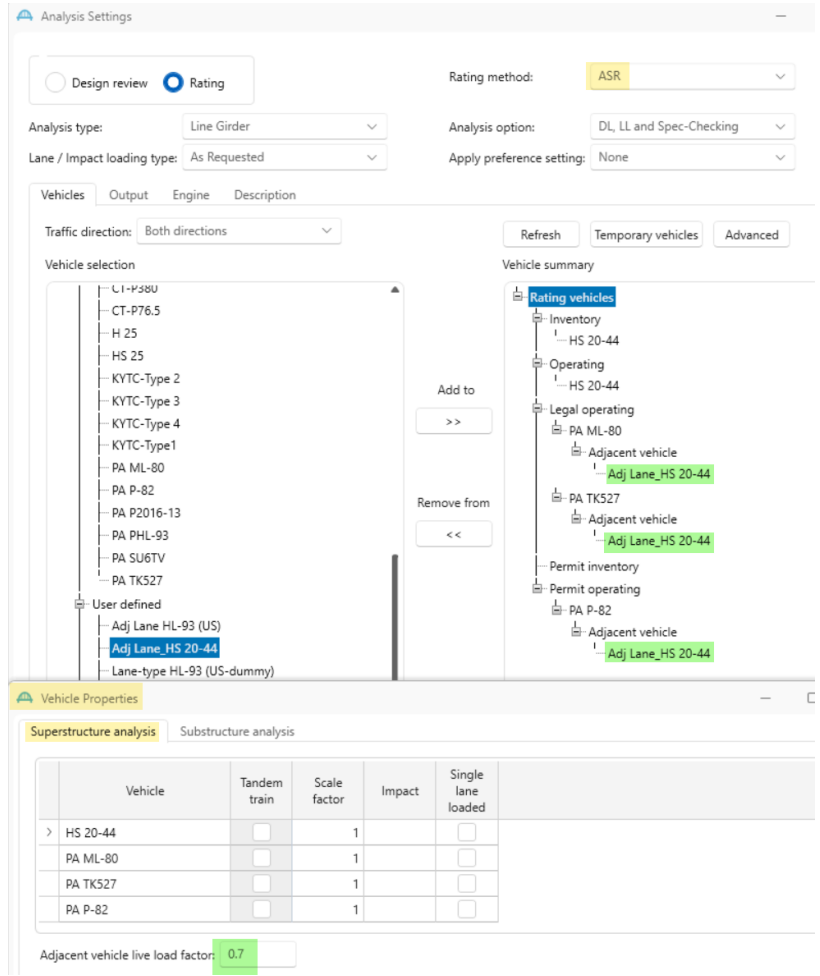
- ‘Legal’ & ‘Permit’ vehicle categories are used in BrR only for purpose of performing ‘adjacent vehicle’ analysis
- If ‘adjacent vehicle’ effect is not being considered in analysis, ‘Inventory’ or ‘Operating’ categories should be used to avoid confusion



‘Legal’ & ‘Permit’ Vehicle Categories for ASR & LFR Analyses

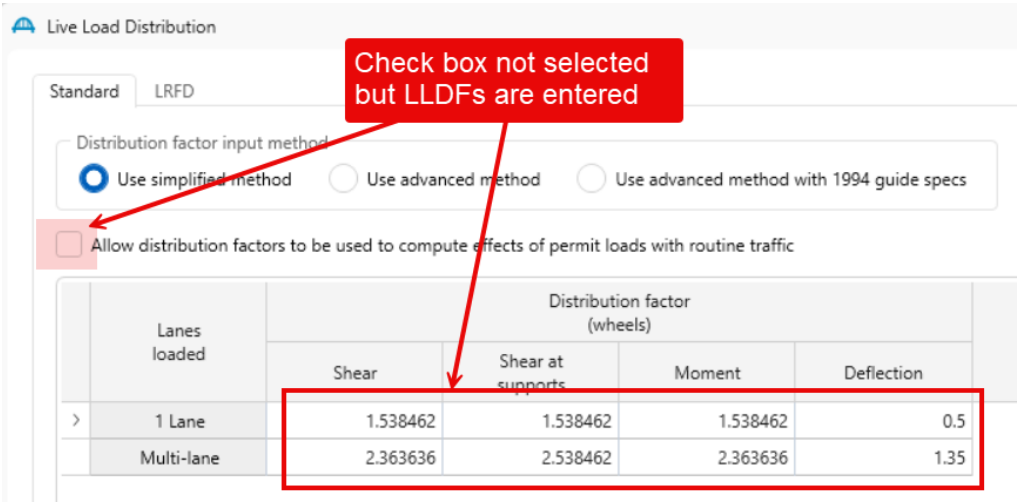
- If an ‘adjacent vehicle’ is assigned, the ‘adjacent vehicle’ is used for all vehicles in all categories
- ‘Adjacent vehicle live load factor’ must be entered on ‘Advanced’ window or runtime error occurs
- ‘Allow distribution factors …’ check box must be selected on ‘Live Load Distribution’ factor input window only if override LLDFs have been entered

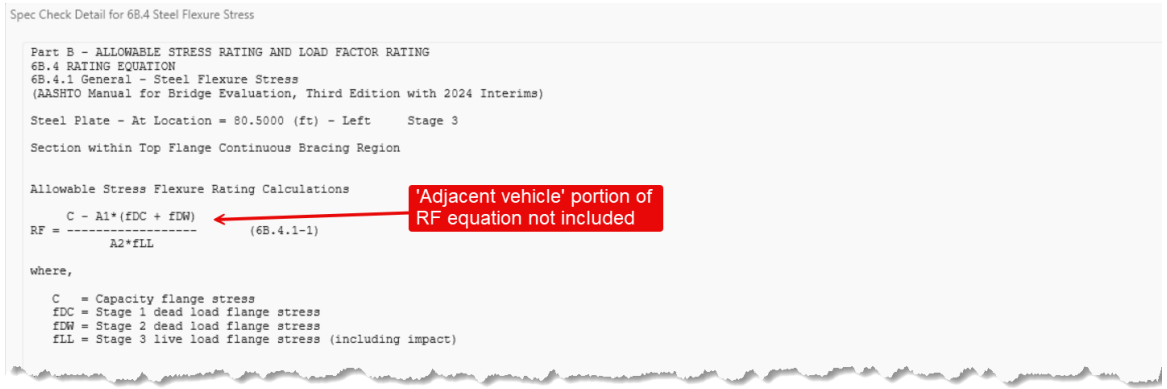


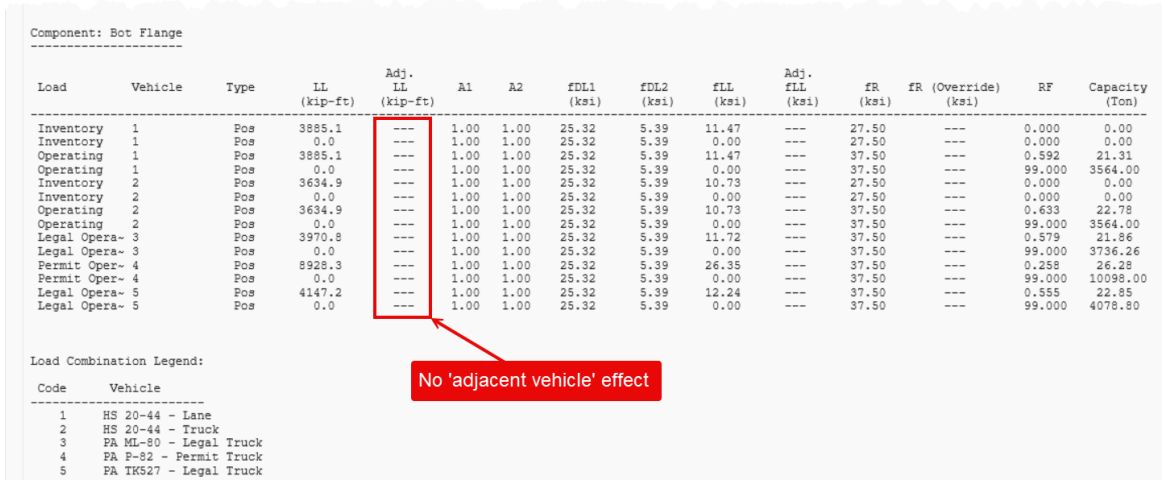


‘Legal’ & ‘Permit’ Vehicle Categories for ASR & LFR Analyses

- If LLDFs are entered in ‘Live Load Distribution’ input window and *‘Allow distribution factors to be used …’* is NOT checked, analysis does not include ‘Adjacent vehicle’ effect even if an ‘adjacent vehicle’ is assigned in analysis settings

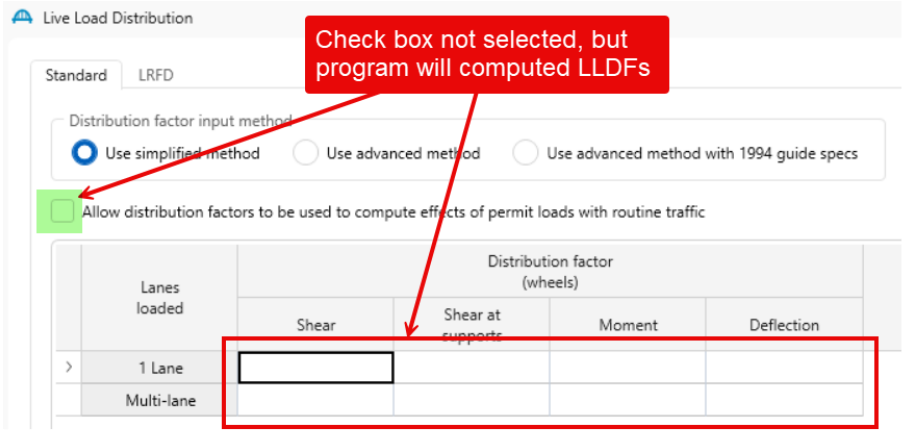






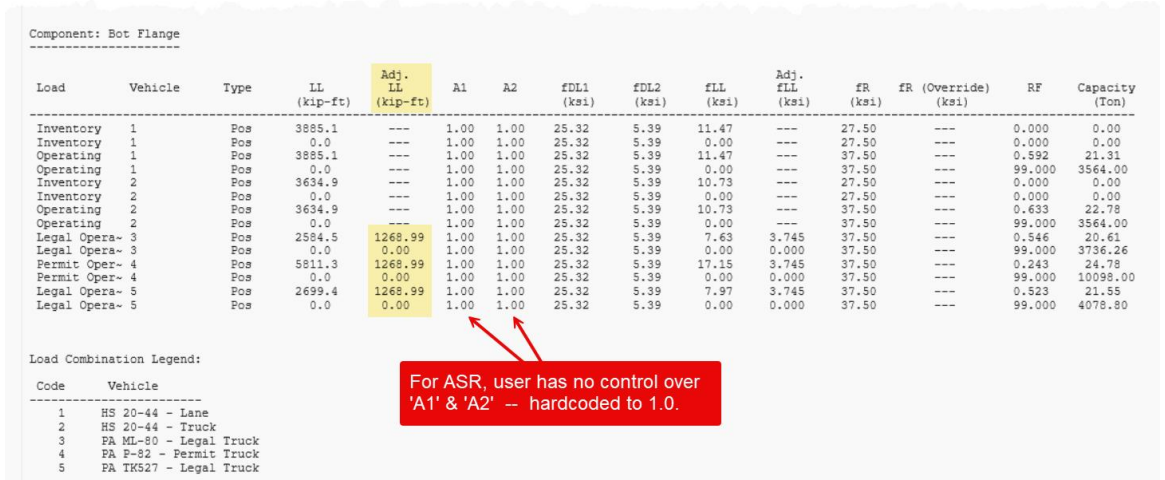
‘Legal’ & ‘Permit’ Vehicle Categories for ASR & LFR Analyses

- If *‘Allow distribution factors to be used …’* check box is not selected but LLDFs have not been explicitly entered, ‘Adjacent vehicle’ effect will be considered



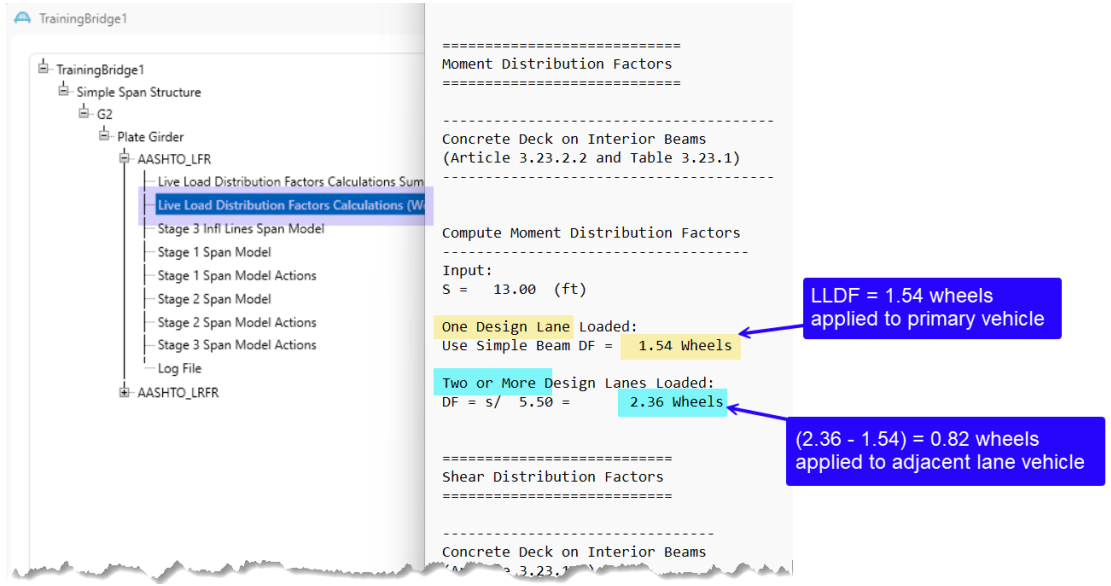
Following message is included in 'LLDF computation' engine output:

```
The lever rule criteria of LRFD 4.6.2.2.5 are satisfied so the 'Allow distribution
factors to be used to compute effects of permit loads with routine traffic' box will be
checked on the Live Load Distribution window and adjacent vehicles will be considered.
This can be overridden through the 'Live Load Distribution' window by using the 'Compute from
 typical section...' button or directly entering the distribution factors then manually
unchecking the box.
```



‘Legal’ & ‘Permit’ Vehicle Categories for ASR & LFR Analyses

- LRFD Article 4.6.2.2.5 ‘adjacent lane’ analysis approach for **line girder** analysis



4.6.2.2.5—Special Loads with Other Traffic

Except as specified herein, the provisions of this Article may be applied where the approximate methods of analysis for the analysis of beam-slab bridges specified in Article 4.6.2.2 and slab-type bridges specified in Article 4.6.2.3 are used. The provisions of this Article shall not be applied where either:

- The lever rule has been specified for both single-lane and multiple-lane loadings; or
- The special requirement for exterior girders of beam-slab bridge cross-sections with diaphragms specified in Article 4.6.2.2.2d has been utilized for simplified analysis.

Force effects resulting from heavy vehicles in one lane with routine traffic in adjacent lanes, such as might be considered with Load Combination Strength II in Table 3.4.1-1, may be determined as:

$$G = G_p\left(\frac{g_1}{Z}\right) + G_D\left(g_m - \frac{g_1}{Z}\right) \qquad (4.6.2.2.5\text{-}1)$$

where:

G = final force effect applied to a girder (kip or kip-ft)
G_p = force effect due to overload truck (kip or kip-ft)
g_1 = single-lane live load distribution factor
G_D = force effect due to design loads (kip or kip-ft)
g_m = multiple-lane live load distribution factor
Z = a factor taken as 1.20 where the lever rule was not utilized, and 1.0 where the lever rule was used for a single-lane live load distribution factor

C4.6.2.2.5

Because the number of loaded lanes used to determine the multiple-lane live load distribution factor, g_m, is not known, the multiple-lane multiple presence factor, m, is implicitly set equal to 1.0 in this equation, which assumes only two lanes are loaded, resulting in a conservative final force effect over using the multiple presence factors for three or more lanes loaded.

The factor Z is used to distinguish between situations where the single-lane live load distribution factor was determined from a specified algebraic equation and situations where the lever rule was specified for the determination of the single-lane live load distribution factor. In the situation where an algebraic equation was specified, the multiple presence factor of 1.20 for a single lane loaded has been included in the algebraic equation and must be removed by using $Z = 1.20$ in Eq. 4.6.2.2.5-1 so that the distribution factor can be utilized in Eq. 4.6.2.2.5-1 to determine the force effect resulting from a multiple-lane loading.

This formula was developed from a similar formula presented without investigation by Modjeski and Masters, Inc. (1994) in a report to the Pennsylvania Department of Transportation in 1994, as was examined in Zokaie (1998).

Structures/Components having ‘Adjacent Vehicle’ Limitations

- Timber decks, corrugated metal decks and metal & concrete culverts are analyzed on a ‘per unit width’ basis; therefore, ‘adjacent vehicle’ concept **does not apply**
- Since ‘adjacent vehicle’ concept does not apply to these structure types/components, the ‘Legal’ & ‘Permit’ vehicle categories produce same results as being assigned to ‘Operating’ category
- For corrugated metal decks and RC culverts, LFR analysis is not currently performed for vehicles assigned to the ‘Legal’ or ‘Permit’ categories
- Inconsistent reporting of load rating results for ASR & LFR analyses has been identified, and future changes are in-progress

MBE LRFR Legal-lane Type Loading

- Article 6A.4.4.2.1a – Special live load model with specific application rules
- Use AASHTO legal vehicles and/or STATE legal loads

b. *Lane-Type Legal Load Model*—Apply for spans greater than 200 ft and all load effects.

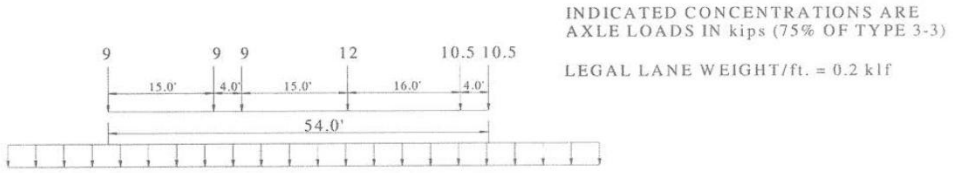


Figure D6A-4—Lane-Type Loading for Spans Greater than 200 ft

c. *Lane-Type Legal Load Model*—Apply for negative moment and interior reaction for all span lengths.

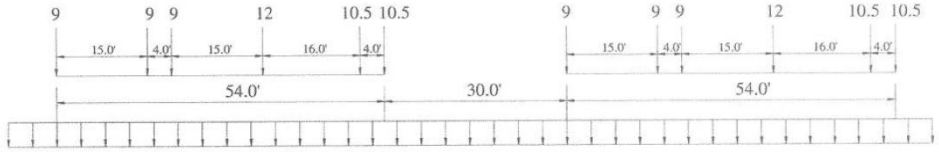


Figure D6A-5—Lane-Type Loading for Negative Moment and Interior Reaction

6A.4.4.2—Live Loads and Load Factors

6A.4.4.2.1—Live Loads

6A.4.4.2.1a—Routine Commercial Traffic

The AASHTO legal vehicles and lane-type load models shown in Figures D6A-1 through D6A-5 shall be used for load rating bridges for routine legal commercial traffic.

For all span lengths the critical load effects shall be taken as the larger of the following:

- For all load effects, AASHTO legal vehicles (Type 3, Type 3S2, Type 3-3; applied separately) or state legal loads.
- For negative moments and reactions at interior supports, a lane load of 0.2 klf combined with two AASHTO Type 3-3 vehicles or state legal loads multiplied by 0.75 heading in the same direction separated by 30 ft.

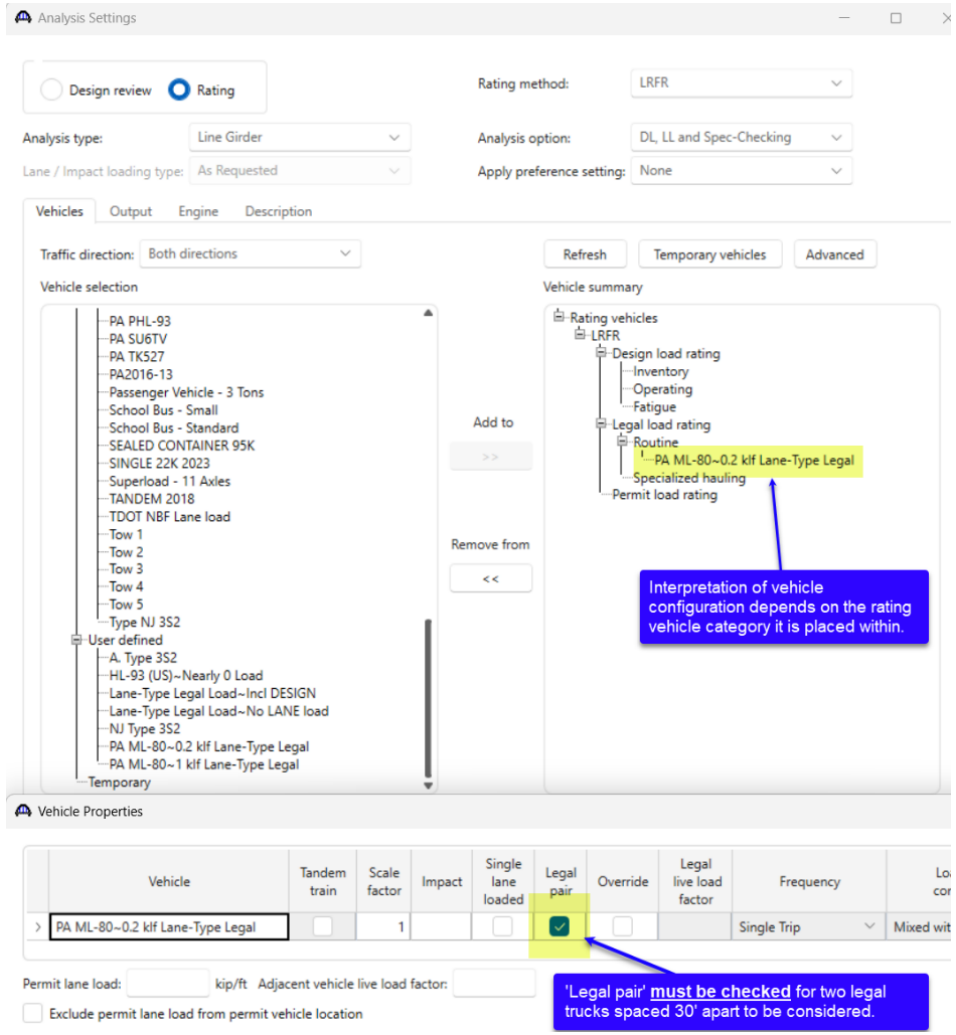
Take the largest of Type 3, Type 3S2, Type 3-3 vehicles, or state legal loads plus lane loads. The lane load model is common to all truck types. In addition, for span lengths greater than 200 ft, critical load effects shall be created by:

- AASHTO Type 3-3 or state legal load multiplied by 0.75 and combined with a lane load of 0.2 klf.

Dynamic load allowance shall be applied to the AASHTO legal vehicles and state legal loads but not the lane loads. If the *ADTT* is less than 500, the lane load may be excluded and the 0.75 factor changed to 1.0 if, in the Engineer's judgment, it is warranted.

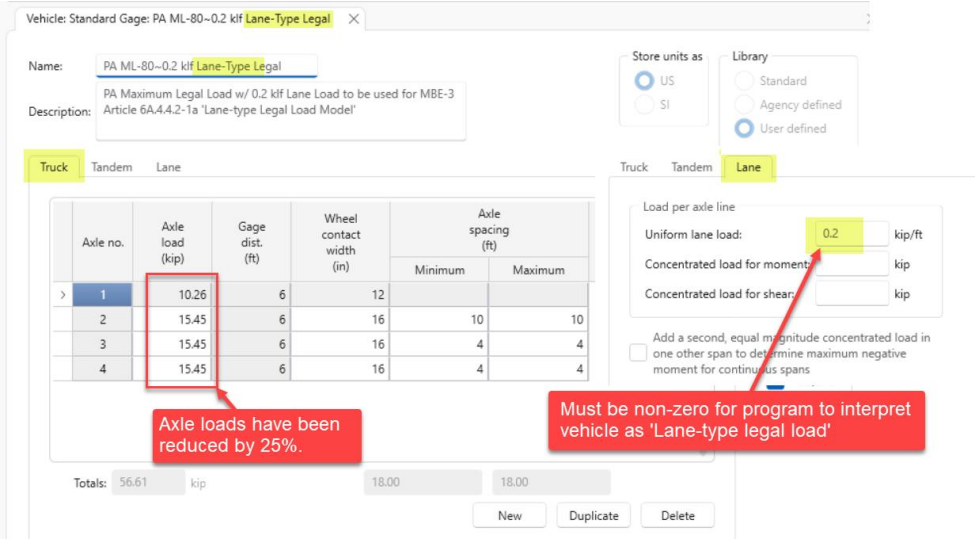
MBE LRFR Legal-lane Type Loading

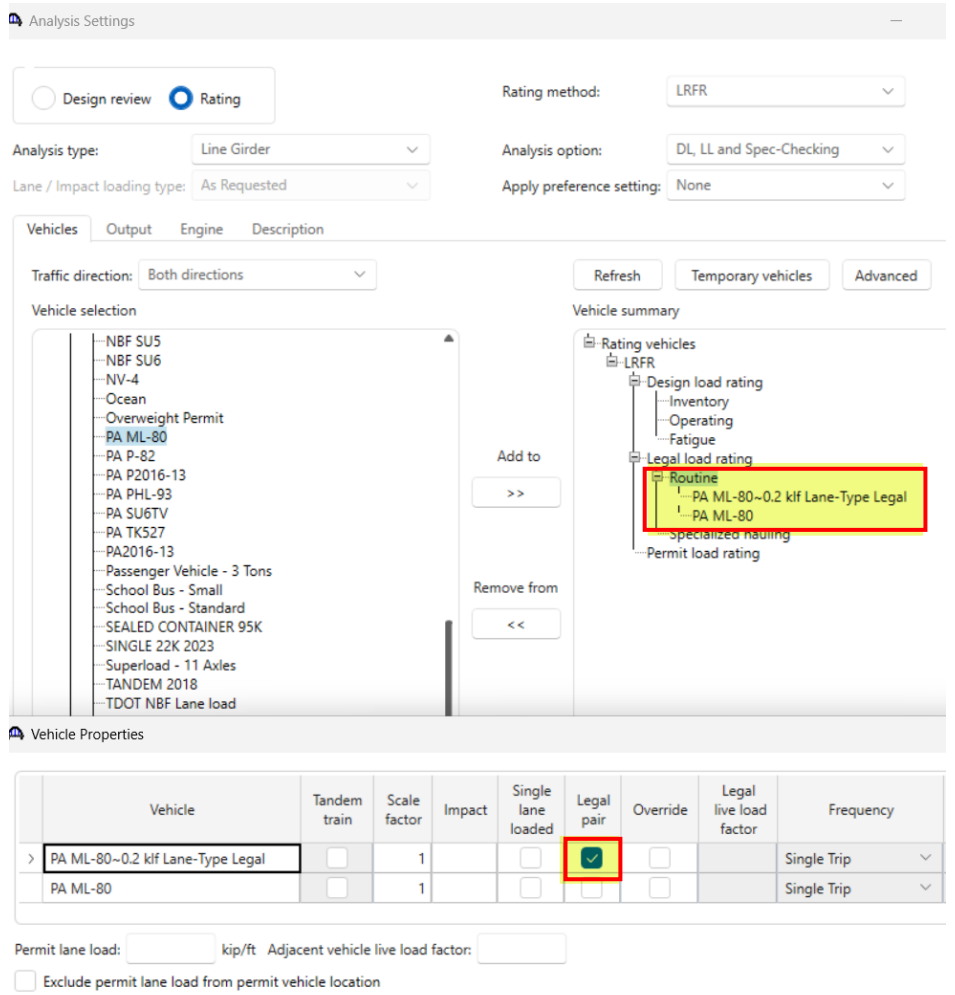
- Important to recognize BrR has built-in vehicle definition interpretation rules
- For a STATE legal-lane type loading to be recognized and correct application rules used, vehicle definition must be assigned to one of the ‘Legal load rating’ categories
- For truck PAIR to be applied correctly for negative moment and interior support reactions, **‘Legal pair’ check box must be selected** on ‘Advanced’ vehicle properties window. The 30’ separation distance between truck pairs is hardcoded.



MBE LRFR Legal-lane Type Loading

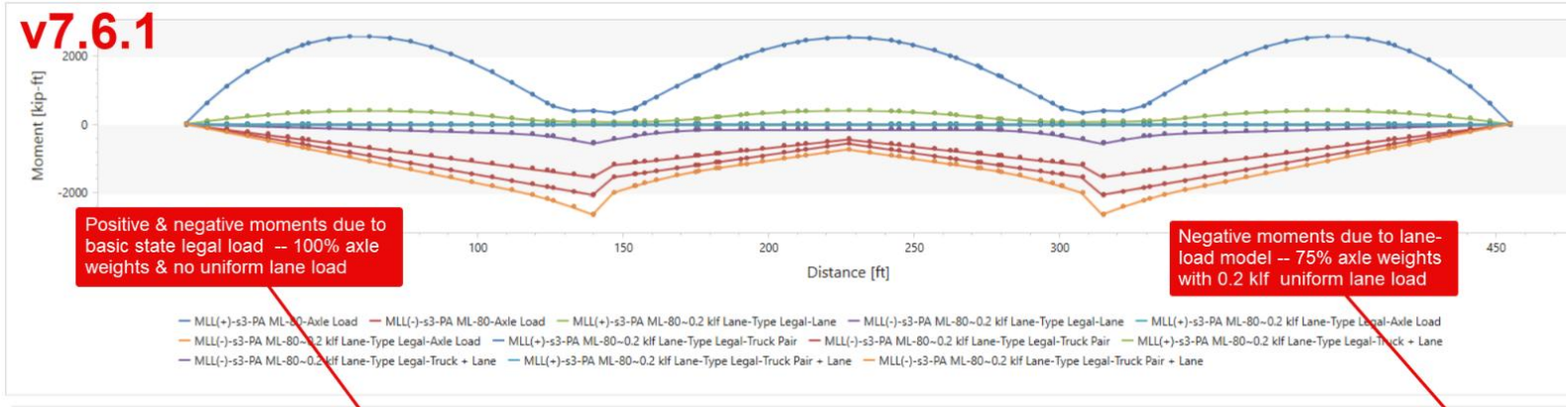
- Two separate state legal load definitions need defined and used for complete force generation coverage:
  - Standard vehicle definition
  - Special definition with axle weights reduced by 25% with non-zero lane load *(lane load can be any non-zero value)*





MBE LRFR Legal-lane Type Loading

- Standard vehicle generates 100% (+) & (-) moment with single truck + lane full bridge length
- Special vehicle generates (-) moments only with truck pair + lane full bridge length



Moment
- Dead Load
- Live Load

Shear
- Dead Load
- Live Load

Axial
- Dead Load
- Live Load

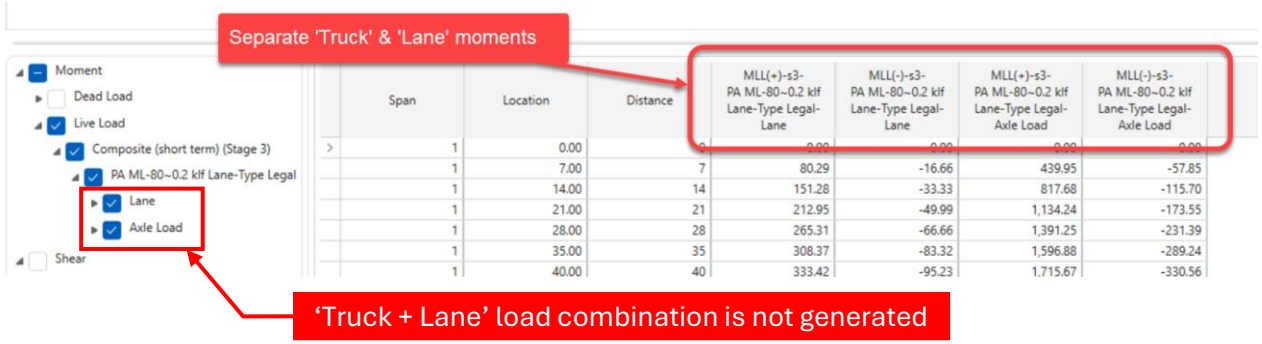
Torsion
- Dead Load
- Live Load

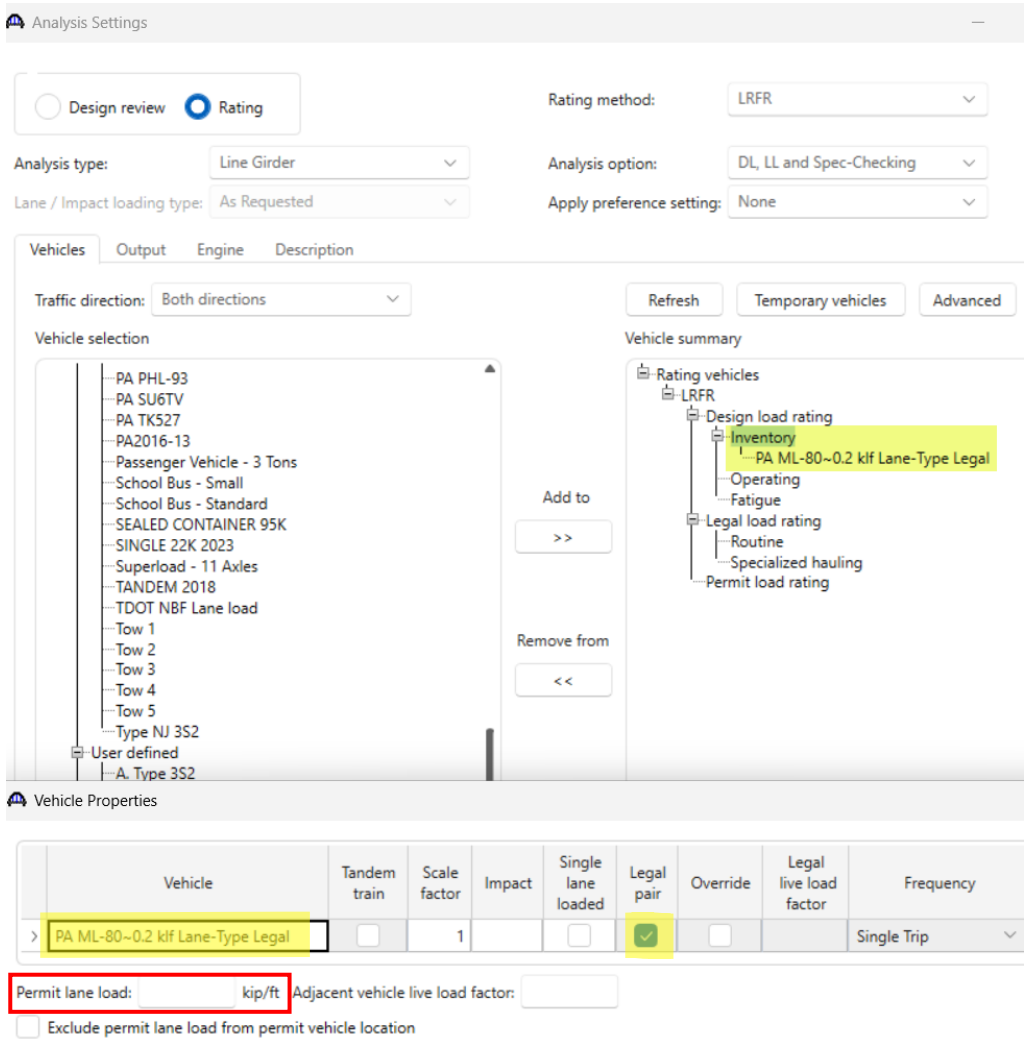
Deflection
- Dead Load
- Live Load

Span	Location	Distance	MLL(+)-s3-PA ML-80-Axle Load	MLL(-)-s3-PA ML-80-Axle Load	MLL(+)-s3-PA ML-80~0.2 klf Lane-Type Legal-Lane	MLL(-)-s3-PA ML-80~0.2 klf Lane-Type Legal-Lane	MLL(+)-s3-PA ML-80~0.2 klf Lane-Type Legal-Axle Load	MLL(-)-s3-PA ML-80~0.2 klf Lane-Type Legal-Axle Load	MLL(+)-s3-PA ML-80~0.2 klf Lane-Type Legal-Truck Pair	MLL(-)-s3-PA ML-80~0.2 klf Lane-Type Legal-Truck Pair	MLL(+)-s3-PA ML-80~0.2 klf Lane-Type Legal-Truck + Lane	MLL(-)-s3-PA ML-80~0.2 klf Lane-Type Legal-Truck + Lane	MLL(+)-s3-PA ML-80~0.2 klf Lane-Type Legal-Truck Pair + Lane	MLL(-)-s3-PA ML-80~0.2 klf Lane-Type Legal-Truck Pair + Lane
1	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7.00	7	586.60	-77.13	80.29	-16.66	0.00	0.00	0.00	-104.23	0.00	0.00	0.00	-120.89
1	14.00	14	1,090.24	-154.26	151.28	-33.33	0.00	0.00	0.00	-208.45	0.00	0.00	0.00	-241.78
1	21.00	21	1,512.32	-231.39	212.95	-49.99	0.00	0.00	0.00	-312.68	0.00	0.00	0.00	-362.67
1	28.00	28	1,855.00	-308.53	265.31	-66.66	0.00	0.00	0.00	-416.90	0.00	0.00	0.00	-483.56
1	35.00	35	2,129.17	-385.66	308.37	-83.32	0.00	0.00	0.00	-521.13	0.00	0.00	0.00	-604.45
1	40.00	40	2,287.56	-440.75	333.42	-95.23	0.00	0.00	0.00	-595.57	0.00	0.00	0.00	-690.80
1	42.00	42	2,340.31	-462.79	342.11	-99.99	0.00	0.00	0.00	-625.35	0.00	0.00	0.00	-725.34
1	49.00	49	2,478.79	-539.92	366.54	-116.65	0.00	0.00	0.00	-729.58	0.00	0.00	0.00	-846.23
1	56.00	56	2,547.40	-617.05	381.67	-133.32	0.00	0.00	0.00	-833.80	0.00	0.00	0.00	-967.12
1	63.00	63	2,549.85	-694.18	387.48	-149.98	0.00	0.00	0.00	-938.03	0.00	0.00	0.00	-1,088.01
1	70.00	70	2,503.95	-771.32	383.99	-166.65	0.00	0.00	0.00	-1,042.25	0.00	0.00	0.00	-1,208.90
1	77.00	77	2,402.70	-848.45	371.18	-183.31	0.00	0.00	0.00	-1,146.48	0.00	0.00	0.00	-1,329.79
1	84.00	84	2,246.38	-925.58	349.06	-199.98	0.00	0.00	0.00	-1,250.71	0.00	0.00	0.00	-1,450.68
1	91.00	91	2,040.34	-1,002.71	317.64	-216.64	0.00	0.00	0.00	-1,354.93	0.00	0.00	0.00	-1,571.57
1	98.00	98	1,790.61	-1,079.84	276.90	-233.31	0.00	0.00	0.00	-1,459.16	0.00	0.00	0.00	-1,692.46
1	105.00	105	1,504.63	-1,156.97	226.85	-249.97	0.00	0.00	0.00	-1,563.38	0.00	0.00	0.00	-1,813.35
1	112.00	112	1,190.67	-1,234.11	167.71	-266.85	0.00	0.00	0.00	-1,667.61	0.00	0.00	0.00	-1,934.46
1	119.00	119	856.41	-1,311.24	116.64	-301.11	0.00	0.00	0.00	-1,771.83	0.00	0.00	0.00	-2,072.94
1	124.00	124	610.96	-1,366.33	92.61	-343.73	0.00	0.00	0.00	-1,846.28	0.00	0.00	0.00	-2,190.01
1	126.00	126	511.06	-1,388.37	85.66	-364.77	0.00	0.00	0.00	-1,876.06	0.00	0.00	0.00	-2,240.83
1	133.00	133	356.88	-1,465.50	71.19	-454.25	0.00	0.00	0.00	-1,980.28	0.00	0.00	0.00	-2,434.54
1	140.00	140	375.66	-1,542.63	69.11	-565.44	0.00	0.00	0.00	-2,084.51	0.00	0.00	0.00	-2,649.94
2	0.00	140	375.66	-1,542.63	69.11	-565.44	0.00	0.00	0.00	-2,084.51	0.00	0.00	0.00	-2,649.94
2	7.12	147.12	308.99	-1,195.18	61.48	-444.17	0.00	0.00	0.00	-1,568.66	0.00	0.00	0.00	-2,012.83

MBE LRFR Legal-lane Type Loading

- Legal-lane load vehicle assigned to categories other than ‘Legal load rating’ gets interpreted differently:
  - For the ‘Design load rating’ category, a ‘Truck + Lane’ load combination is only generated when ‘HL-93’ appears in vehicle name
  - For ‘Permit load rating’ category, ‘Permit lane load’ entered on Advanced window is used

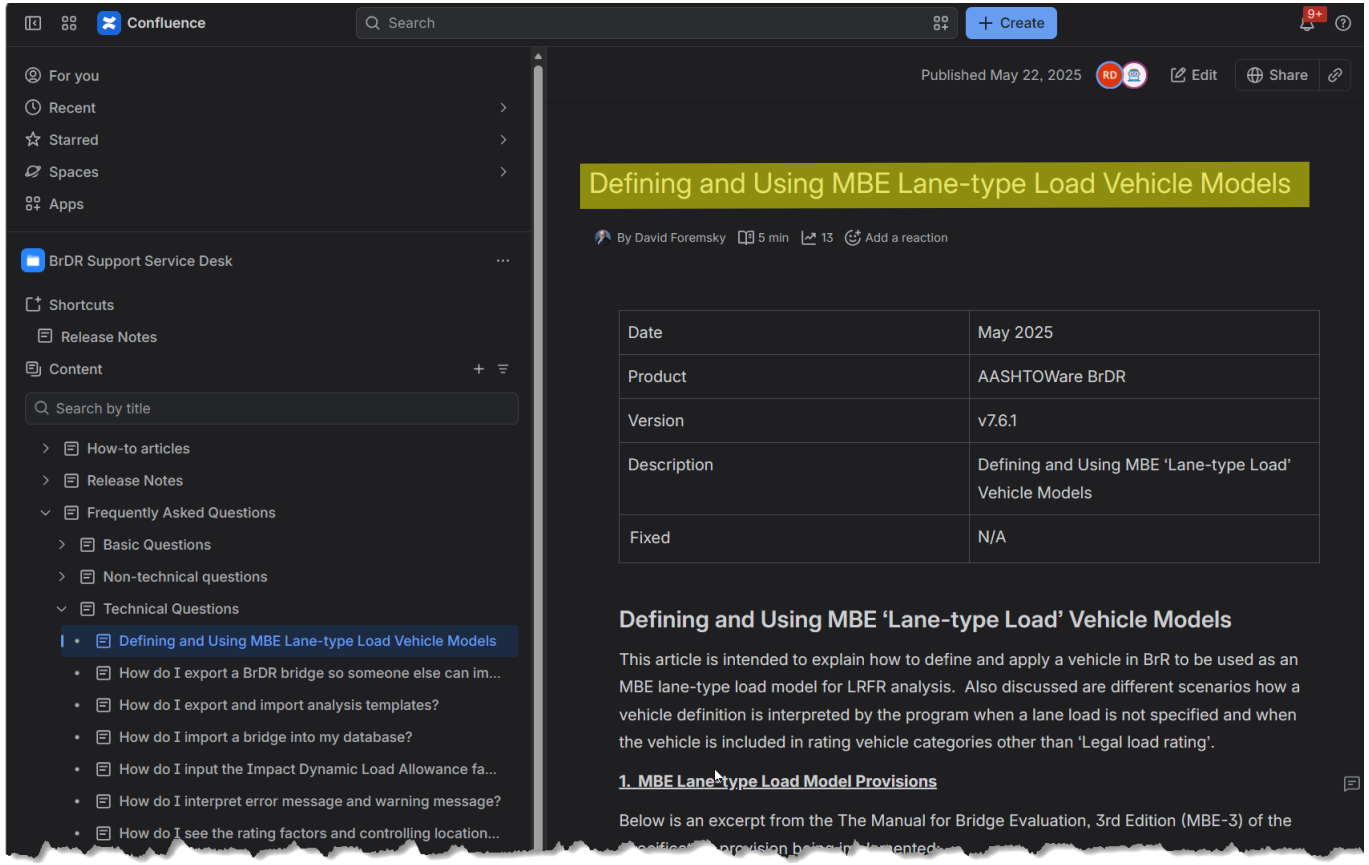




MBE LRFR Legal-lane Type Loading

- Jira Confluence Article available:

  BrDR Support Service Desk - Confluence - Defining and Using MBE Lane-type Load Vehicle Models




THANK YOU!
QUESTIONS?