Chapter 13 Bridge Load Rating — Contents

Chapter 13 Bridge Load Rating

13.1 General

Bridge load rating is a procedure to evaluate the adequacy of various structural components to carry predetermined live loads. The Bridge Load Rating Engineer in the WSDOT Bridge Preservation Office is responsible for the bridge inventory and load rating of existing and new bridges in accordance with the National Bridge Inspection Standards (NBIS) and the AASHTO *Manual for Bridge Evaluation* (MBE), latest edition. Currently, only elements of the superstructure will be rated, however, if conditions warrant, substructure elements may need to be rated. The superstructure shall be defined as all structural elements above the column tops including drop crossbeams.

Load ratings are required for all new, widened, or rehabilitated bridges where the rehabilitation alters the load carrying capacity of the structure or changes the loading on any element of the structure. Load ratings shall be done immediately after the design is completed and shall be updated based on as built changes if applicable, and prior to bridge opening to traffic. Rating calculations shall be filed separately per Section 13.4 and files shall be forwarded to WSDOT's Load Rating Engineer.

The Bridge Preservation Office is responsible for maintaining an updated bridge load rating throughout the life of the bridge based on the current condition of the bridge. Conditions of existing bridges change over time, resulting in the need for reevaluation of the load rating. Such changes may be caused by damage to structural elements, extensive maintenance or rehabilitation work, or any other deterioration identified by the Bridge Preservation Office through their regular inspection program.

New bridges that have designs completed after October 1, 2010 shall be load rated based on the Load and Resistance Factor Rating (LRFR) method per the MBE and this chapter. Ratings shall be based on the HL-93 loading and shall be reported as a rating factor (RF). For bridges designed prior to October 1, 2010, partially reconstructed or rehabilitated bridges where part of the existing structure is designed by the Allowable Stress or by the Load Factor methods (LFR), ratings can be based on any rating method. The rating factors shall be based on HS 20 loading and reported in tons when using the Load Factor (LFR) or Allowable stress (ASR) methods. For State owned structures, the LRFR method shall be used unless approved otherwise by WSDOT's Load Rating Engineer. By definition, the adequacy or inadequacy of a structural element to carry a specified truck load will be indicated by the value of its rating factor; that is, whether it is greater than or less than 1.0.

13.1.1 LRFR Method per the MBE

13.1.1.A Rating Equation

$$RF = \frac{(C - \gamma_{DC}\,DC - \gamma_{DW}\,DW \pm \gamma_p\,P)}{\gamma_{LL}\,LL\,(1+IM)} \quad (13.1.1A\text{-}1)$$

Where:

RF = Rating factor
C = $\phi c\ \phi s\ \phi n\ R_n$, where $\phi c\ \phi s \geq 0.85$ for strength limit state
C = f_R for service limit state
R_n = Nominal Capacity of member
f_R = Allowable Stress per LRFD
DC = Dead load due to structural components and attachments
DW = Dead load due to wearing surface and utilities
P = Permanent loads other than dead loads
LL = Live load effect
IM = Dynamic load allowance (Impact)
$^*\gamma_{DC}$ = Dead load factor for structural components and attachments
γ_{DW} = Dead load factor for wearing surface (ACP/HMA) and utilities
γ_P = Load factor for permanent load other than dead =1
γ_{LL} = Live load factor
ϕ_c = Condition factor
ϕ_s = System factor
ϕ_n = Resistance factor based on construction material

** for concrete overlays use* γ_{DC}

When rating the full section of a bridge, like a box girder or 3D truss, or crossbeams, with two or more lanes, the following formula applies when rating emergency vehicles and overload trucks.

$$RF = \frac{C - \gamma_{DC}DC - \gamma_{DW}DW \pm \gamma_P P}{\gamma_{LL}(LL + LL_{lgl})\,(1 + IM)} \quad (13.1.1A\text{-}2)$$

The formula above assumes that there is one overload truck occupying one lane, and one legal trucks occupying each of the remaining lanes. Trucks shall be placed in the lanes in a manner that produces the maximum forces. The live load factor for both of the legal truck and permit truck shall be equal and are dependent on the permit truck. The LL_{lgl} shown in the equation above corresponds to the maximum effect of the legal truck(s).

13.1.1.B Condition Factor (ϕ_c)

Condition factor is based on the Bridge Management System (BMS) condition state of the element per the most recent inspection report. The engineer should consider the quantity of each element in a fair or poor condition state and the notes describing the condition of an element when determining the appropriate condition factor.

Structural Condition of Member	ϕ_c
Good or Satisfactory, BMS Condition State 1 or 2	1.00
Fair, BMS Condition State 3	0.90
Poor, BMS Condition State 4	0.85

13.1.1.C System Factor (ϕ_s)

The system factors shown in the table below apply to load ratings for flexural and axial forces; use a system factor of 1.00 when rating shear.

Super Structure Type	ϕ_s
Welded Members in Two Girder/Truss/Arch Bridges	0.85
Riveted Members in Two Girder/Truss/Arch Bridges	0.90
Multiple Eyebar Members in Truss Bridges	0.90
Three-Girder Bridges with Girder Spacing 6′	0.85
Four Girder Bridges with Girder Spacing ≤ 4′	0.95
All Other Girder and Slab Bridges	1.00
Floorbeams with Spacing >12′ and Noncontinuous Stringers	0.85
Redundant Stringer Subsystems Between Floorbeams	1.00

13.1.1.D Limit States and Load Factors

Bridge Type	Limit State	γ_{DC}	γ_{DW}	$\cancel{\gamma_p}$	Inventory HL-93	Operating HL-93	Legal, NRL & EV*	Permit
Reinforced Concrete	Strength I	1.25	1.50	~~--~~	1.75	1.35	Table 13.1-1	--
	Strength II	1.25	1.50	~~1.0~~	--	--	--	Table 13.1-1
Prestressed Concrete	Strength I	1.25	1.50	~~1.0~~	1.75	1.35	Table 13.1-1	--
	Strength II	1.25	1.50	~~1.0~~	--	--	--	Table 13.1-1
	Service III	1.00	1.00	~~1.0~~	1.00	--	1.00	--
	Service I	1.00	1.00	~~1.0~~	--	--	--	1.00
Steel	Strength I	1.25	1.50	~~1.0~~	1.75	1.35	Table 13.1-1	--
	Strength II	1.25	1.50	~~1.0~~	--	--	--	Table 13.1-1
	Service II	1.00	1.00	~~1.0~~	1.30	1.00	1.30	1.0

Per MBE, for prestressed concrete elements, the Service III rating for Legal Loads, and Service I rating for permit loads are optional except for segmentally constructed bridges. Service ratings can be ignored at the discretion of the Load Rating Engineer if the structural elements being rated show no evidence of distress/cracking. Girders that have high load hits shall be rated for Service.

13.1.1.E Live Load Factors for Legal, Permit and Emergency Vehicles (EV) Loads

Table 13.1-1

Truck	Live Load Factor	ADTT ≤ 1000	ADTT > 1000	ADTT Unknown
Legal & NRL	γ_{LL}	1.30	1.45	1.45
Permit	γ_{LL}	1.20	1.20	1.20
EV*	γ_{LL}	1.30	1.30	1.30

*Emergency Vehicle

In cases where RF for legal loads is less than 1, which would require the bridge to be posted, live load factors may be reduced (interpolated based on ADTT), per Section 6A.4.4.2.3 of the MBE.

Number of Lanes	Multiple Presence Factor
1 Lane	= 1.20
2 Lanes	= 1.00
3 Lanes	= 0.85
> 3 Lanes	= 0.65

The table above shows the Multiple Presence Factors based on the number of loaded lanes. For cases where a permit truck or an emergency vehicle is combined with legal trucks, the multiple presence factor for the total number of loaded lanes in each case shall be applied to all loads. For cases where a permit truck is loaded in a single lane with no other trucks present, the multiple presence factor for 1 lane does not apply. For all trucks, if the Live Load Distribution Factor for single lane based on the Lever Rule controls, the multiple presence factor for 1 lane isn't applicable.

Dynamic Load Allowance (Impact)

Dynamic load allowance is dependent on the approach onto the bridge and condition of the deck and joints based on the latest inspection report.

Truck	IM	Element 7681	BMS Flag 322
HL 93 (All Span Lengths):			
Inventory	33%	N/A	N/A
Operating	33%	N/A	N/A
Legal, Permit Trucks & Emergency Vehicles:			
Spans 40′ or less	33%	N/A	N/A
Legal, Permit Trucks & Emergency Vehicles Spans greater than 40′:			
Smooth Riding Surface Along Approach onto the Bridge, Bridge Deck and Expansion Joints	10%	8	1, 2 or none
Minor Surface Deviations and Depressions	20%	6	3
Severe Impact to the Bridge	30%	3	4

Verify the conditions of the deck and joints to identify any deficiencies in the deck that would cause impact to the structure. For potholes less than 1″ deep use 20 percent impact, and use 30 percent for depths greater than 1″. For multi span bridges, take into consideration the type and location of the deficiency and whether Impact would be applicable to the entire structure or not. If the Inspection report has no Code 7681 or BMS Flag 322, then assume Smooth approaches.

Live Loads

The moving loads shall be per the configurations shown in Section 13.1.5. Inventory and operating ratings shall be calculated for the HL-93 loading. In cases where the rating factor for the Notational Rating Load (NRL) is below 1.00, then the single unit vehicles SU4 through SU7 shall be evaluated for posting, see MBE for SU truck configurations. Legal Lane configuration shall be rated for applicable structures and shall be reported on the load rating summary sheet for the structure.

13.1.2 Load Factor Rating Method (LFR)

The load factor method can be applied to structures designed prior to October 2010. Ratings shall be performed per the MBE. Capacities, resistance factors, and distribution factors shall be based on the AASHTO *Standard Specifications* 17th edition.

13.1.2.A Ultimate Method (LFR)

13.1.2.A.1 *Rating Equation*

$$RF = \frac{\Phi C - \gamma_{DL} D \pm S}{\gamma_{LL} LL\,(1+IM)} \qquad (13.1.2\text{-}1)$$

Where:

RF	=	Rating factor
C	=	Nominal member resistance
Φ	=	Resistance factor based on construction material
D	=	Unfactored dead loads
LL	=	Unfactored live loads
S	=	Unfactored prestress secondary moment or shear
IM	=	Impact
γ_{DL}	=	Dead load factor for structural components and attachments
γ_{LL}	=	Live load factor

13.1.2.B Dead and Live Load Factors

Dead load factor = 1.30
Live load factor = 2.17 (Inventory)
= 1.30 (Operating)

Impact Factor (IM)

Truck	IM	Element 7681	BMS Flag 322
Design and Legal loads (Inventory & Operating)	Span dependent	N/A	N/A
Permit Loads:			
Smooth Riding Surface Along Approach onto the Bridge, Bridge Deck and Expansion Joints	10%	8	1, 2, or none
Minor Surface Deviations and Depressions	20%	6	3
Severe Impact to the Bridge	30%	3	4

If the inspection report has no Code 7681 or BMS Flag 322, then assume smooth approaches.

Impact (*IM*) for design and legal loads is span dependent:

$$IM = \frac{50}{(125+L)} \qquad (13.1.2\text{-}2)$$

Where:
L is equal to span length

When rating the full section of a bridge, like a box girder or 3D truss, or crossbeams, which have two or more lanes, the following formula applies when rating emergency vehicles or overload trucks.

$$RF = \frac{C - \gamma_{DL} D \pm S}{\gamma_{LL}(LL + LL_{lgl})(1+IM)} \qquad (13.1.2\text{-}3)$$

The formula above assumes that there is one overload truck occupying one lane, and one of the legal trucks occupying each of the remaining lanes. Trucks shall be placed in the lanes in a manner that produces the maximum forces. The LL_{lgl} shown in the equation above corresponds to the maximum effect of the legal trucks(s). The γ_{LL} corresponds to the live load factor for the overload truck and is the same for both legal and overload trucks. The same multiple presence factor for the total number of lanes loaded should be applied to all loads.

13.1.2.C Resistance Factors (LFR) Method

The resistance factors for SNBI ratings shall be per the latest AASHTO *Standard Specifications*. Following are the resistance factors assuming the member is in good condition:

Steel members:	1.00 (Flexure) 1.00 (Shear)
Prestressed concrete	1.00 (Flexure, positive moment) 0.90 (Shear)
Post-tensioned, cast-in-place:	0.95 (Flexure, positive moment) 0.90 (Shear)
Reinforced concrete:	0.90 (Flexure) 0.85 (Shear)

For prestressed and post-tensioned members, where mild reinforcing steel is used to resist negative moment, the resistance factors for reinforced concrete section shall be used in the ratings.

In cases where there is deterioration in a member, the cross section shall be reduced based on the inspection report. For cases where deterioration in members is described in general terms, reduce resistance factors of member by 0.10 for BMS Condition State of 3, and reduce resistance factors by 0.20 for BMS Condition State of 4. The engineer should consider the quantity of each element in a fair or poor condition state and the notes describing the condition of an element when determining the appropriate resistance factor.

13.1.2.D Service Method (LFR)

Prestressed and post-tensioned members in positive moment regions, and where post-tensioning is continuous over the supports, shall also be rated based on allowable stresses at service loads. The lowest rating factor between service and ultimate methods shall be the governing inventory rating.

13.1.2.E Inventory Rating

Concrete Tension:

$$RF = \frac{6\sqrt{f'_c} - (F_d + F_p + F_s)}{F_l\,(1+IM)} \qquad (13.1.2\text{-}4)$$

Concrete Compression:

$$RF = \frac{0.60 f'_c - (F_d + F_p + F_s)}{F_l\,(1+IM)} \qquad (13.1.2\text{-}5)$$

$$RF = \frac{0.40 f'_c - {}^1\!/_2\,(F_d + F_p + F_s)}{F_l\,(1+IM)} \qquad (13.1.2\text{-}6)$$

Prestressing Steel Tension:

$$RF = \frac{0.80 f_y^* - (F_d + F_p + F_s)}{F_l\,(1+IM)} \qquad (13.1.2\text{-}7)$$

13.1.2.F Operating Rating

Prestressing Steel Tension:

$$RF = \frac{0.90 f_y^* - (F_d + F_p + F_s)}{F_l\,(1+IM)} \tag{13.1.2-8}$$

Where:

RF = Rating factor
f'_c = Compressive strength of concrete
F_d = Dead load stress
F_p = Prestressing stress
F_s = Stress due to secondary prestress forces
F_l = Live load stress
IM = Dynamic load allowance (Impact)
f_y^* = Prestressing steel yield stress

Allowable concrete stress shall be increased by 15 percent for overload vehicles. Impact is calculated same as ultimate method.

13.1.3 Allowable Stress Rating Method (ASR)

The allowable stress method is applicable to only timber structures. Impact is not applied to timber structures.

Rating Equation:

$$RF = \frac{F_a - F_d}{F_l} \tag{13.1.3-1}$$

Where:

RF = Rating factor
$^*F_a$ = Allowable stress
F_d = Dead load stress
F_l = Live load stress

$^*F_a$, for inventory rating, shall be per AASHTO *Standard Specifications*. For operating rating, F_A shall be increased by 33%

13.1.4 Live Loads

Live loads shall be per the configurations shown in Section 13.1.5. In cases where the operating rating factor for the NRL load is below 1, then the single unit vehicles SU4 through SU7 shall be evaluated for posting, see MBE for SU trucks configurations.

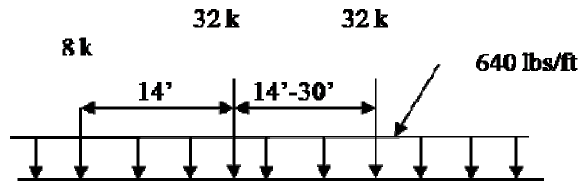
Live load reduction factors (LFR Method).

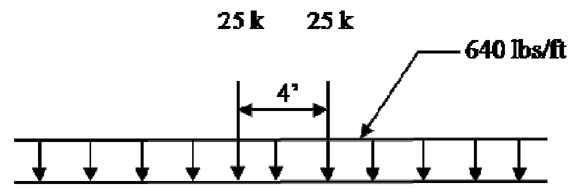
Number of Lanes	Reduction Factor
1 Lane	= 1.0
2 Lanes	= 1.0
3 Lanes	= 0.90
>3 Lanes	= 0.75

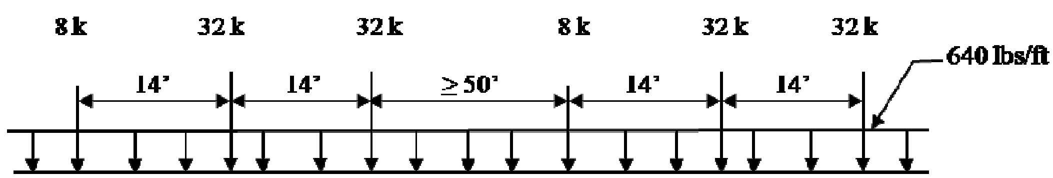
13.1.5 Rating Trucks

13.1.5.A Design Trucks

HL-93 Load (LRFR Method):

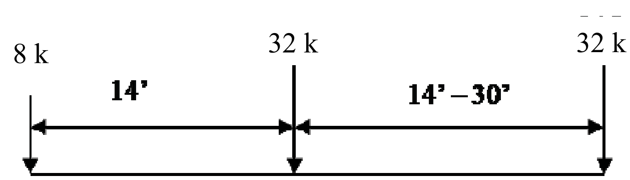


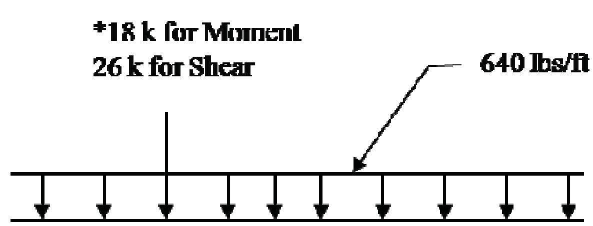




For negative moment and interior reaction (Reduce all loads to 90%).

HS-20 Load (LFR Method):

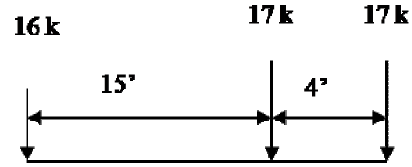




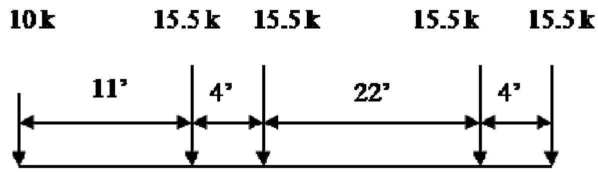
*In negative moment regions of continuous spans, place an equivalent load in the other spans to produce maximum effect.

13.1.5.B Legal Trucks

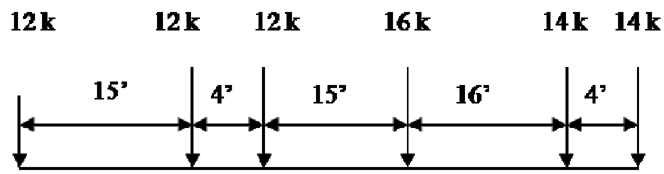
Type 3 (LRFR & LFR Methods):



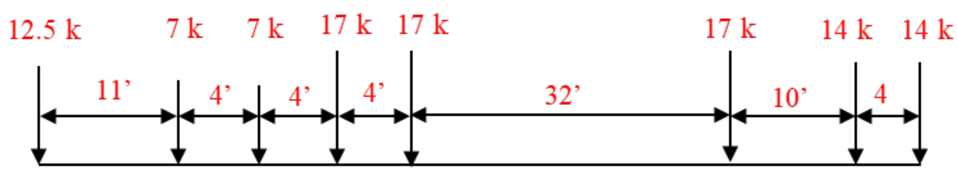
Type 3S2 (LRFR & LFR Methods):



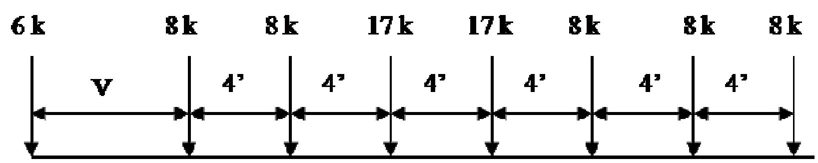
Type 3-3 (LRFR & LFR Methods):



WA –105 (LRFR & LFR Methods):

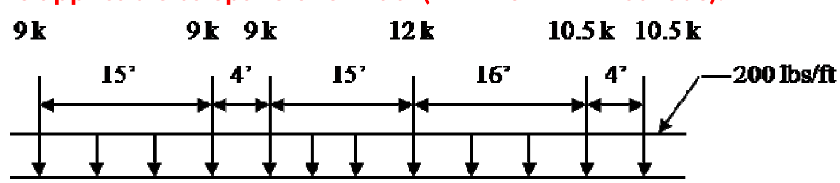


Notional Rating Load (NRL) (LRFR & LFR Methods):

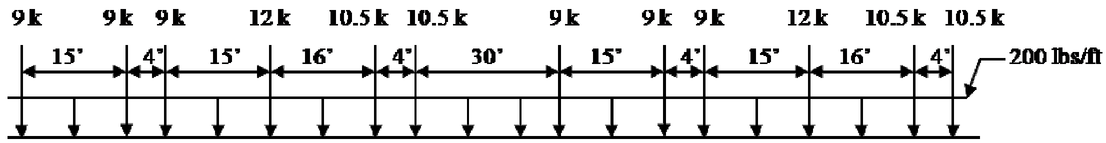


V varies from 6′-0″ to 14′-0″

Legal lane is applicable to spans over 200' (LRFR & LFR Methods):

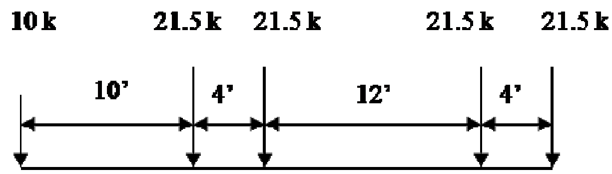


Legal Lane for continuous spans and reactions at interior pier (LRFR Method):

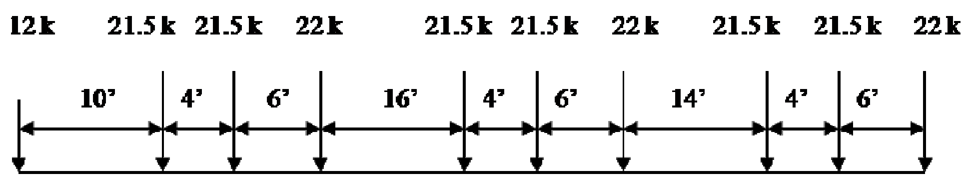


13.1.5.C Overload Trucks

Overload 1* (LRFR & LFR Methods):



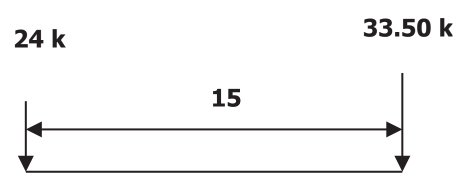
Overload 2* (LRFR & LFR Methods):



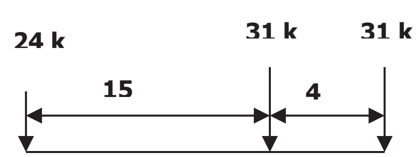
**When using the LRFR method for the overload trucks, for spans greater than 200 apply 0.20 k/ft additional lane load to simulate closely following vehicles. The lane load can be superimposed on top of the permit load.*

13.1.5.D Emergency Vehicles

Type EV2 (LRFR & LFR Methods):



Type EV3 (LRFR & LFR Methods):



Note: *EV"s are considered legal trucks on the Interstate and within one roadway mile off the Interstate.*

13.2 Special Rating Criteria

13.2.1 Dead Loads

Use 155 pcf for weight of the concrete; 140 pcf for weight of ACP/HMA and 150 pcf for concrete overlay. Use 50 pcf for weight of timber.

If concrete overlay (LMC) isn't called out on the plans or not provided, assume 1.50 inch thick.

Use the dead loads shown in the table below for miscellaneous bridge rails.

Bridge Rails and Traffic Barrier Dead Loads

Type of Rail	Weight in lbs/ft
Thriebeam attached to existing rail	**20**
Thriebeam attached to posts	**30**
Metal Rail on top of Bridge rail	**20**
Bridge rail w/openings (doesn't include curb) used	**150**
In 1920’s through 1950’s	
Std. Plan E29, 9.50" high curb includes bridge rail	
9" wide curb	**370**
18" wide curb	**465**
3' wide sidewalk	**665**
4' sidewalk	**800**
5' sidewalk	**935**
6' sidewalk	**1100**
Std. Plan E29, 11" high curb includes bridge rail	
9" wide curb	**395**
18" wide curb	**510**
3' wide sidewalk	**735**
4' sidewalk	**890**
5' sidewalk	**1100**
6' sidewalk	**1200**
Traffic Barriers:	
32" F-Shape	**460**
42" F-Shape	**710**
34" Single Slope	**490**
42" Single Slope	**670**

13.2.2 Live Load Distribution Factors

Live Load Distribution Factors (LLDF) shall be per the corresponding AASHTO Specification based on the method used to perform the load rating.

For exterior line member analysis, when using simplified equations per AASHTO Specifications, the LLDF shall not be taken greater than the result of the Lever Rule.

For emergency vehicles, when using simplified equations per AASHTO Specifications, use the appropriate equation based on the number of design lanes. In cases where a 3D analysis is performed, or when rating a X-beam, place an EV in one lane and a legal truck in remaining lanes (NRL truck typically controls).

For overload trucks, a single lane distribution factor shall be used when rating longitudinal members on per member basis and the multiple presence factor shall be divided out when using the LRFR method. In cases where a 3D analysis is performed, or when rating a X-beam, place an overload in one lane and a legal truck in remaining lanes (NRL truck typically controls).

The number of lanes is dependent on the roadway width. For roadway width less than 18′, assume one lane for all trucks/loads. For roadway width between 18′ and 20′, the number of lanes for legal and permit loads shall correspond to the number of striped lanes on the bridge, and for the design trucks/loads use one lane. For roadway width between 20′ and 24′ use two lanes, each is equal to half the roadway width for all trucks/loads. For roadway width greater than 24′, the number of lanes shall be equal to the integer of the roadway width divided by 12 for all trucks/loads.

13.2.3 Reinforced Concrete Structures

For conventional reinforced concrete members of existing bridges, the service check shall not be part of the rating evaluation.

Rating for shear shall be performed for all rating trucks.

Shear capacity shall be based on the Modified Compression Field Theory (MCFT) when using the LRFR method, longitudinal reinforcement should be checked for increased tension caused by shear.

13.2.4 Prestressed Concrete Structures

Allowable stresses for concrete shall be per the design specification corresponding to the method used in the rating. Note that for the LRFD method in this manual (Chapter 5) uses “0 ksi” tension stress limit, however for rating purposes follow the design specifications.

Rating for shear shall be performed for all rating trucks.

Shear capacity shall be based on the MCFT when using the LRFR method, longitudinal reinforcement should be checked for increased tension caused by shear.

13.2.5 Concrete Decks

Typically bridge decks will not require rating unless the deck is post-tensioned. Bridge decks with SNBI condition of 4 or less may be load rated at the discretion of WSDOT's Load Rating Engineer.

When rating of the deck is required, live load shall include all vehicular loads as specified in Section 13.1.5.

13.2.6 Concrete Crossbeams

Live loads can be applied to the crossbeam as moving point loads at any location between the curbs for integral crossbeams, or when it is conservative to do so. Otherwise, live loads shall be applied through the girder.

For integral crossbeams on prestressed girder bridges, the composite section shall be considered for all loads for the rating. The rating equation does not provide a method for considering staged load conditions.

13.2.7 In-Span Hinges

For in-span hinges, rating for shear and bending moment should be performed based on the reduced cross-sections at the hinge seat. Diagonal hairpin bars are part of this rating as they provide primary reinforcement through the shear plane.

13.2.8 Girder Structures

Girders shall be rated on a per member basis.

13.2.9 Box Girder Structures

Bridges with spread box girders shall be rated on a per box basis. Otherwise, the rating can be based on the full bridge cross-section for all applied loads or on a per web basis. The number of lanes applied to a full section box girder shall be the roadway width divided by the design lane width rounded down to the nearest integer. In cases where sections of the deck are covered with landscaping (lid structures) or the skew between the piers varies by more than 10 degrees along the structure, or the bottom slab width of the box is greater than 60 ft, then the box shall be rated on a per web basis.

13.2.10 Segmental Concrete Bridges

Segmental Concrete Bridges shall be rated per the latest edition of the MBE. Temperature effects shall be considered for service ratings. Service III limit State shall include principal stress check.

13.2.11 Concrete Slab Structures

Cast-in-place (CIP) solid slabs shall be rated on a per foot of width basis. Precast panels shall be rated on a per panel basis. CIP voided slabs shall be rated based on a width of slab equal to the predominant center-to-center spacing of voids.

When rating flat slabs on concrete piling, assume pin-supports at the slab/pile interface.

13.2.12 Steel Structures

Checking of fatigue shall not be part of the rating evaluation.

For horizontally curved bridges, flange lateral bending, diaphragms and cross frames shall also be rated.

Pin and hanger assemblies shall be rated. Analyze pins for bearing and combined shear and flexure. Analyze hanger plates for bearing, shear, block shear, tension yielding on the gross section and fracture on the net section.

Splices of fracture critical members shall be rated.

13.2.13 Steel Floor Systems

When rating floorbeams and stringers assume they are pinned at the supports. Assume lengths for analysis as the distance from outside face to outside face of end connections. Live loads shall be applied to the floorbeam as moving point loads at any location between curbs, which produce the maximum effect.

Rating of connections is not required unless there is evidence of deterioration.

13.2.14 Steel Truss Structures

Typical steel trusses are rated on a per truss basis assuming all truss members have pinned connections. In some special cases, a 3D analysis may be required or fixed connections may be assumed.

In general, rate chords, diagonals, verticals, end posts, gusset plates, splice plates, stringers and floorbeams. For state bridges, gusset plates shall be rated based on WSDOT's criteria (contact Load Rating Engineer for criteria) otherwise, follow the latest version of the Manual for Bridge Evaluation. Structural pins shall be rated; analyze pins as noted in Section 13.2.12.

Tension members and splices subjected to axial tension shall be investigated for yielding on the gross section and fracture on the net section.

For truss members that have been heat-straightened three or more times, deduct 0.1 from the resistance factor.

13.2.15 Timber Structures

Unless the species and grade is known, assume Douglas fir. Use select structural for members installed prior to 1955 and No. 1 after 1955. The allowable stresses for beams and stringers shall be as listed in the AASHTO Specifications.

The nominal dimensions should be used to calculate dead load, and the net dimensions to calculate section modulus. Unless the member is notched or otherwise suspect, shear need not be calculated.

13.2.16 Widened or Rehabilitated Structures

A new load rating of the entire structure shall be performed anytime a structure is widened, rehabilitated, or the loading on the structure is altered unless approved otherwise, in writing, by WSDOT Load Rating Engineer. For example, if the overlay thickness changes by ± 2 inches and the structural elements condition is 6 and higher, and minimum rating factors for any of the rating trucks other than the design truck is 1.1, an updated load rating might not be required.

For widened crossbeams, assume a hinge at the interface between new and existing portions of the X-beam.

13.2.17 Buried Structures

The distribution of live load thru fill shall be per the corresponding AASHTO Design Specification used for the rating. Use the load rating equation for box culverts and corresponding factors per the latest MBE and interims.

For the LRFR Method, HL-93 load rating, a single lane distribution factor with multiple presence factor shall be used. For Legal, EV and overload trucks a single lane distribution factor shall be used; the multiple presence factor shall be divided out. The live load factor for Legal loads shall be 2.0; for EV and overloads, the live load factors shall be per Table 13.1-1.

Buried structures will not require load rating if they meet the following criteria:

- Single span structures where fill depth exceeds clear span.
- Single span structures up to 24 ft. clear span and depth of fill is greater than 13 ft.
- Multiple span structures where depth of fill exceeds the distance between inside faces of end walls.

A note shall be included in the letter file for structures that meet the criteria stated above.

13.2.18 Overloads

If the rating factor for either of the permit vehicles is less than 1.0 when rating full longitudinal cross-sections where distribution factors are not used (3D Model), or crossbeams, analyze them with a single overload truck and report the rating factors for both single and multiple lanes on the Load Rating Summary Sheet.

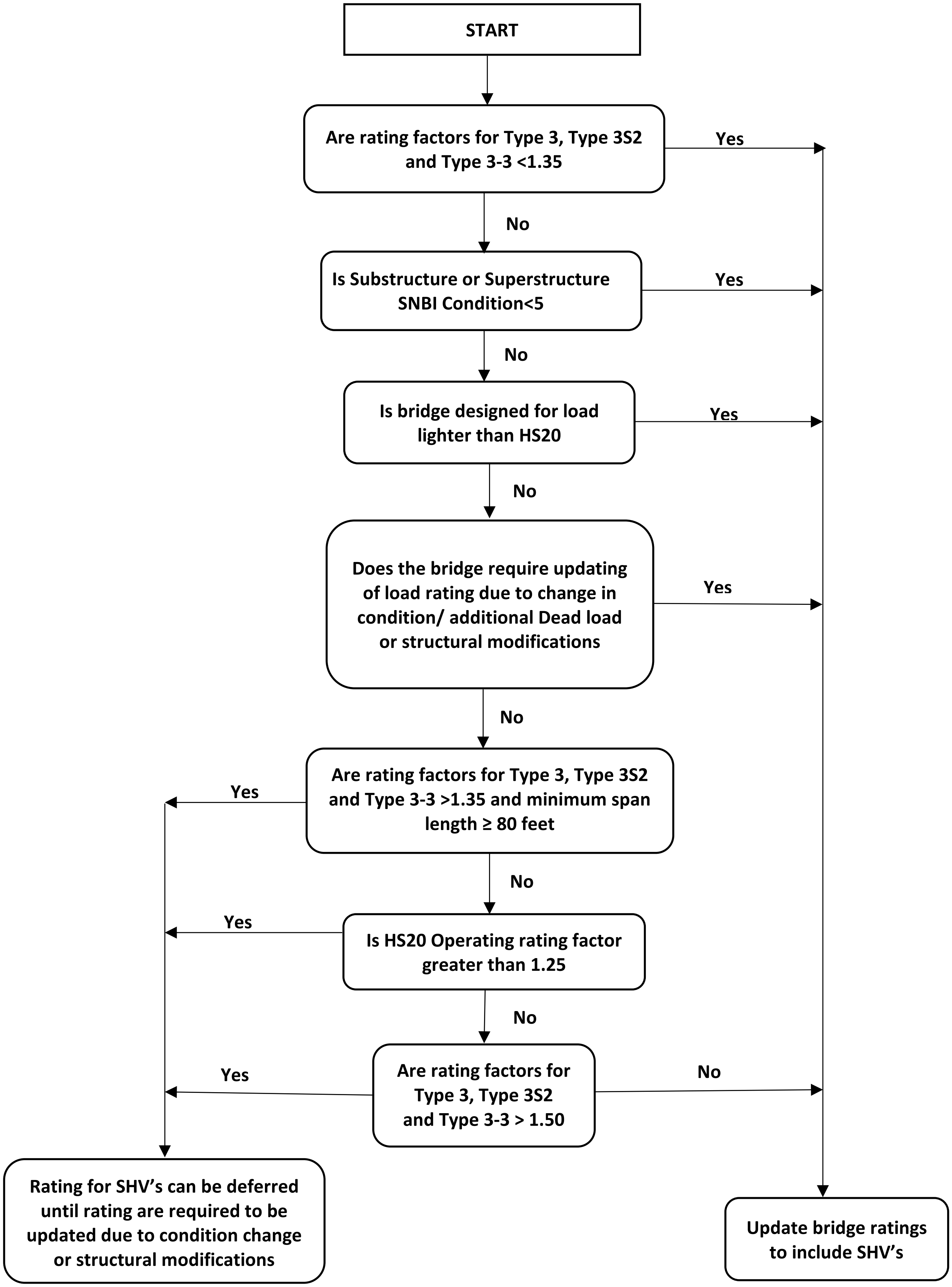
13.2.19 Specialized Hauling Vehicles (SHVs)

For State owned structures, WSDOT will make use of the commentary under Section C6A.4.4.2.1b of the ERRATA for Manual Bridge Evaluation, 3rd Edition (MBE-3) in evaluating whether to update load ratings of existing structures to comply with FHWA’s November 2013 memo. In addition, WSDOT performed a parametric study to compare the forces on structures exerted by AASHTO Special Hauling Vehicles (SHVs) SU4, SU5, SU6 and SU7 to the three AASHTO legal trucks, Type 3, Type 3S2 and Type 3-3. The study consisted of modeling the SHVs and AASHTO legal trucks running on simple span structures that ranged in length from 10 to 150 feet as well as on two continuous equal spans that ranged in length from 10 to 150 feet each as well. Maximum moments and shears generated by the Legal trucks and SHVs were compared for both models. Results showed that structures with rating factors for the three AASHTO legal trucks greater than 1.50 can safely carry the SHVs. Accordingly, the following criteria will be used to evaluate the need to rate existing structures for SHVs (see also SHVs Load Rating Process Flowchart):

- Bridges with rating factors for the Type 3, Type 3S2 and Type 3-3 less than or equal to 1.35 will be rated for the AASHTO SHVs.
- Bridges with SNBI condition rating for Super or Substructure less than 5 will be rated for AASHTO SHVs.
- Bridges designed for a load lighter than an HS20 will be rated for AASHTO SHVs.
- Bridges that require updating of the load rating due to change in condition, additional dead load or structural modification that will affect capacity of the structure will be rated for AASHTO SHVs.
- Bridges with Operating rating factor for the HS20 > 1.25 are determined to be adequate to carry AASHTO SHV loads.
- Bridges with rating factors for the Type 3, Type 3S2 and Type 3-3 greater than 1.35 for bridges with minimum span length of 80 feet are determined to be adequate to carry AASHTO SHV loads.
- Bridges with rating factors for the Type 3, Type 3S2 and Type 3-3 greater than 1.50 are determined to be adequate to carry AASHTO SHV loads.

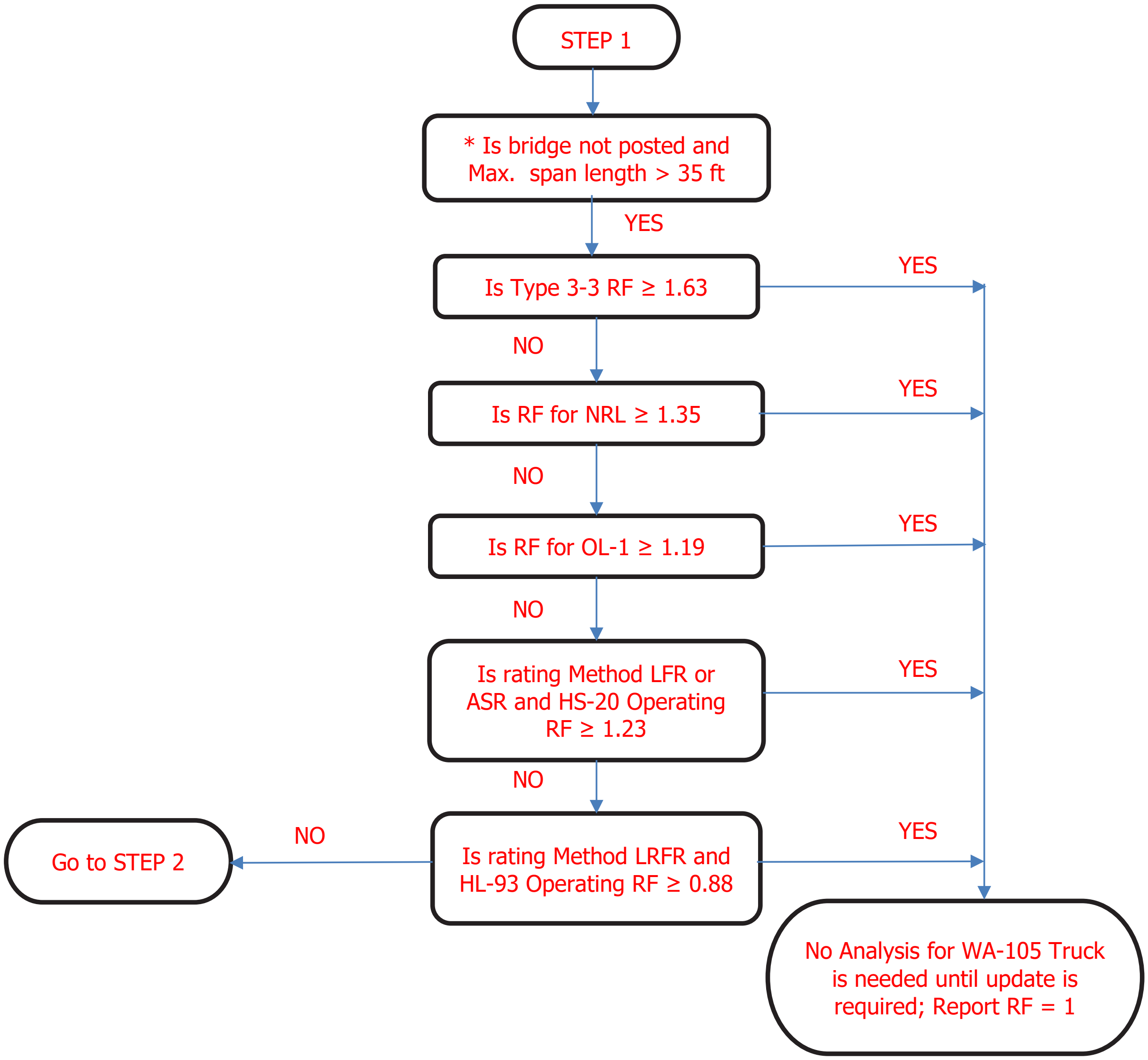
For structures that meet the above guidelines, WSDOT will create a new stamped summary sheet/letter to be included in the bridge file stating that the ratings are adequate to carry AASHTO SHV loads based on the criteria in this manual.

Figure 13.2-1 SHV's Load Rating Process Flowchart

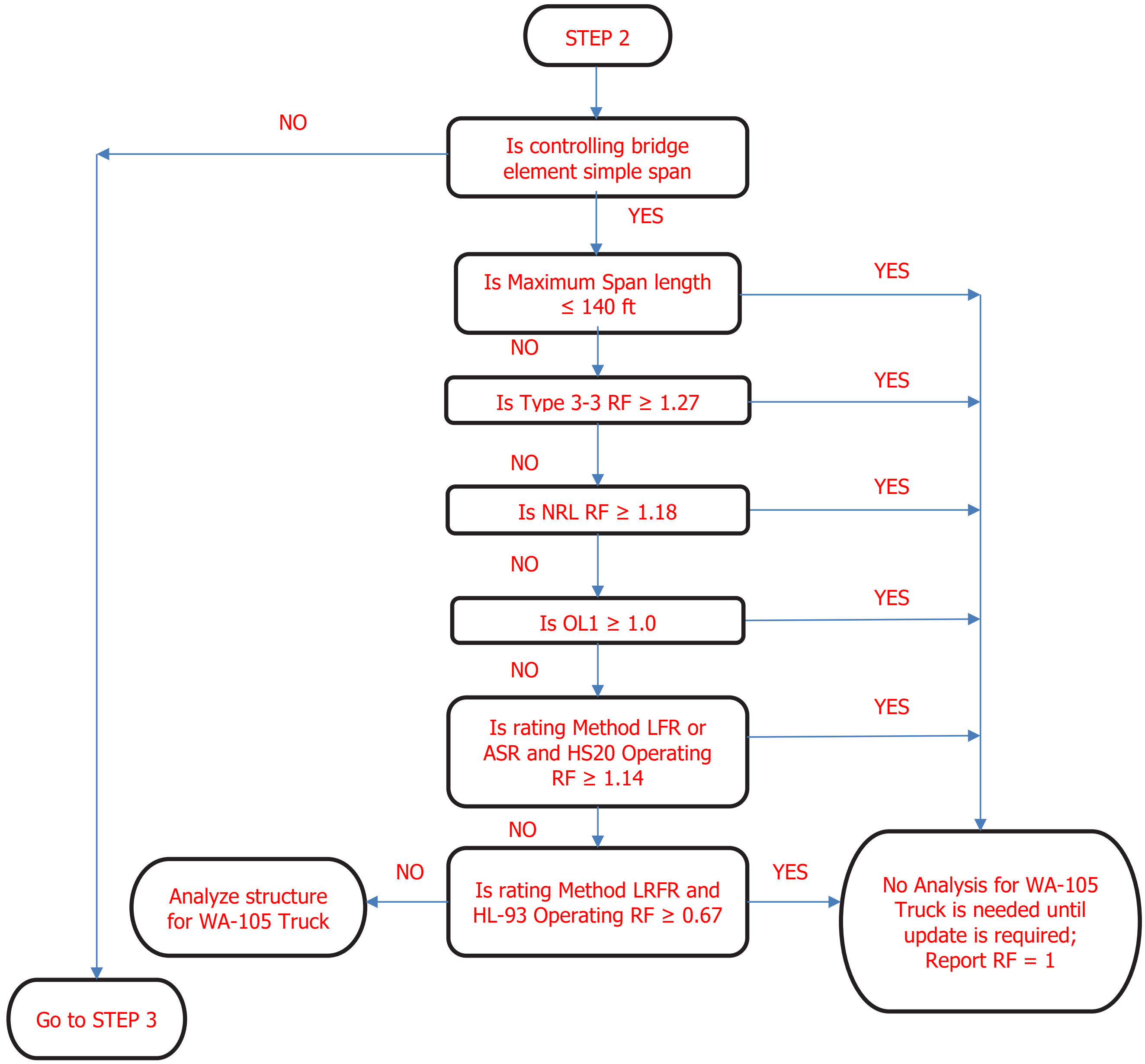


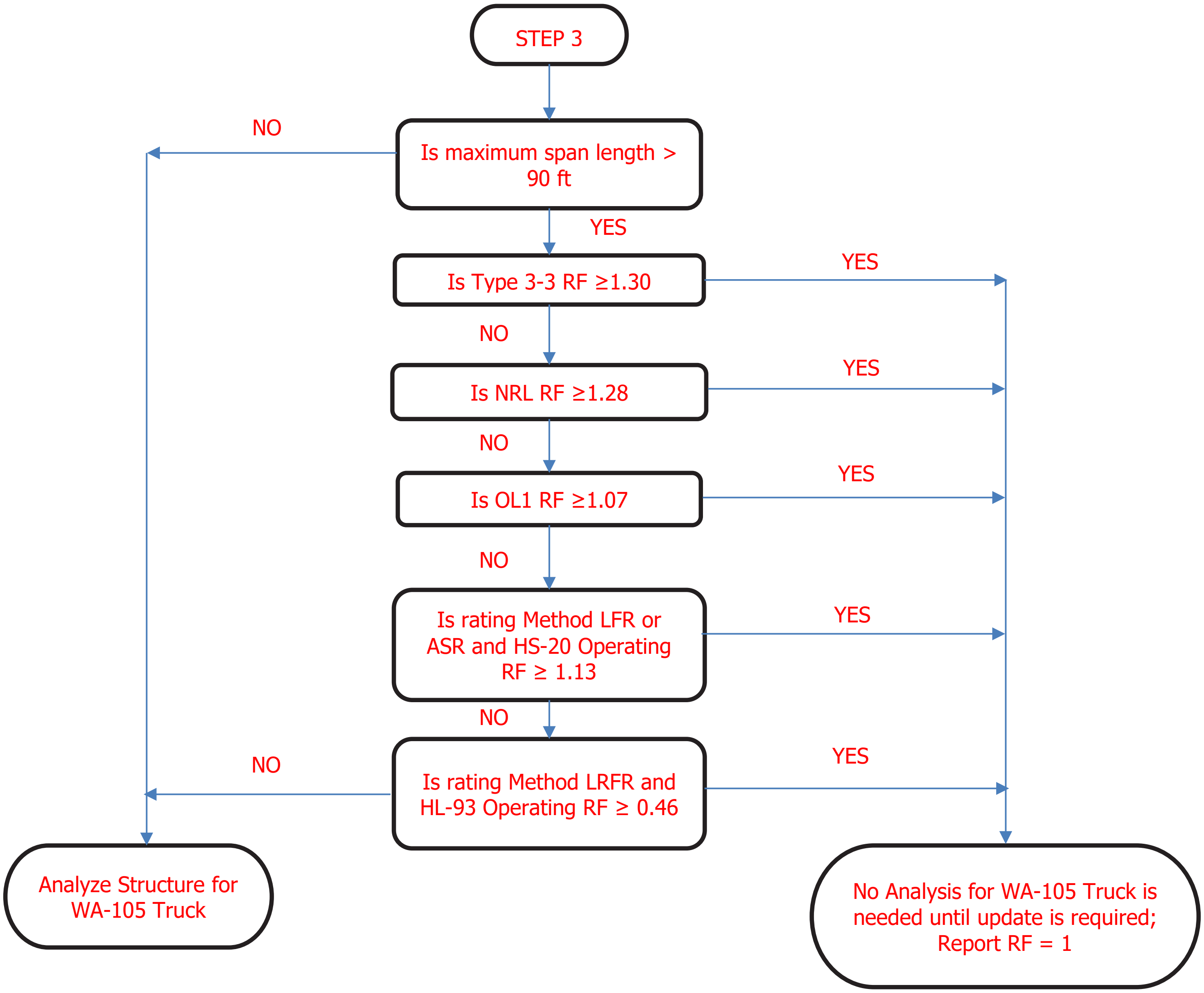
13.2.20 WA-105 Legal Truck

New load ratings and updates to ratings of existing structures shall include the WA-105 truck configuration. Structures which have been load rated shall follow steps 1 through 3 in the flow charts below to address the new NBI reporting requirement.



* If the structure is posted for Type 3S2 or Type 3-3 trucks, then WA-105 should comply with the posting, Report the rating factor of the lowest Type 3S2 or Type 3-3 for WA-105. If posting is limited to SHV's, either analyze the structure for the WA-105 or post the structure to 40 Tons maximum GVW and report a RF of 80/105.5=0.76 for the WA-105. For structures that have a maximum span of 35 ft and are not posted, use a RF =1 for WA-105.


STEP 2
Is controlling bridge element simple span
NO
YES
Is Maximum Span length ≤ 140 ft
YES
NO
Is Type 3-3 RF ≥ 1.27
YES
NO
Is NRL RF ≥ 1.18
YES
NO
Is OL1 ≥ 1.0
YES
NO
Is rating Method LFR or ASR and HS20 Operating RF ≥ 1.14
YES
NO
Is rating Method LRFR and HL-93 Operating RF ≥ 0.67
NO
Analyze structure for WA-105 Truck
YES
No Analysis for WA-105 Truck is needed until update is required; Report RF = 1
Go to STEP 3


STEP 3
Is maximum span length > 90 ft
NO
YES
Is Type 3-3 RF ≥1.30
YES
NO
Is NRL RF ≥1.28
YES
NO
Is OL1 RF ≥1.07
YES
NO
Is rating Method LFR or ASR and HS-20 Operating RF ≥ 1.13
YES
NO
Is rating Method LRFR and HL-93 Operating RF ≥ 0.46
NO
YES
Analyze Structure for WA-105 Truck
No Analysis for WA-105 Truck is needed until update is required; Report RF = 1

13.3 Load Rating Software

BridgeLink or Bridg shall be used when rating concrete members. Bridg shall also be used when rating steel girder and truss structures where no jacking forces were applied during construction. Ericksson software shall be used for typical concrete Buried Structures, CANDE software or electronic calculations such as excel can be used for metal Buried Structures. Obtain WSDOT's Load Rating Engineer approval for the use of the proper software prior to commencing any work.

For more complex structures such as curved steel or concrete box girders, segmental structures, bascules, and arches, or any structure that can't be rated using the software stated above, CSiBridge shall be used. Loads and capacities shall be tabulated in a manner that will make it simple for WSDOT to work with the data in the future. Method of tabulation shall be approved by WSDOT's Load Rating Engineer prior to commencing any work. Microsoft Excel shall be used for tabulation, and all cells in the spreadsheets shall be unlocked, and any hidden code or functions shall be explained thoroughly in the report. Hand calculations shall be provided to verify all spreadsheets.

The above requirements apply to State owned structures.

13.4 Load Rating Reports

Rating reports shall be organized in such a manner that it is easy to follow, and all assumptions are clearly stated. For large complex structures, include a table of contents and number the pages in the report. For State owned structures, load rating reports shall be submitted in an electronic format (PDF).

The report shall consist of:

1. A Bridge Rating Summary sheet, as shown on Form 305-017 (LRFR) and Form 305-018 (LFR) reflecting the lowest rating factor. The summary sheet shall be stamped, signed, and dated by a Professional Engineer licensed in the State of Washington. The electronic stamp and signature shall follow the State of Washington Board of Registration for Professional Engineers and Land Surveyors guidelines. A single load rating summary sheet, stamped signed and dated, shall be provided in cases where different sections of a structure were designed and rated by different consultants. The summary sheet shall reflect the lowest rating factors for the different trucks for all sections of the structure. Legal Lane rating factors shall be reported where applicable.
2. A brief report of any anomalies in the ratings and an explanation of the cause of any rating factor below 1.00.
3. Computer output files and any other calculations such as, but not limited to dead loads, distribution factors or any required special analysis.

The electronic submittal shall consist of:

1. A single pdf file containing the stamped signed and dated summary sheet and shall be page one of the report, table of contents as needed, description of any anomalies, preliminary calculations used in the rating, and all output files and calculations supporting the load rating results. Transmittal letters shall not be included in the Load rating report.
2. A complete electronic set of plans for the bridge (applies to new designed bridges), shall be provided as a separate file, PDF format.
3. One set of electronic files containing the final versions of all input and output files, and other calculations created in performing the load rating that can be opened and utilized in the appropriate program.

Electronic submittals shall be delivered to WSDOT via email, ftp site or USB drive.

A minimum of 30 days is required for the Bridge Preservation Office review of any load rating submitted as part of a Design Build Contract. The review submittal shall include all electronic files used to perform the load ratings.

When the load rating calculations are produced as part of a design project (new, widening, or rehabilitation), the load rating report and design calculations shall be bound separately. All calculations required to complete the load rating shall be included in the report; in other words, reference to design calculations isn't acceptable.

13.5 Structure Posting

Structures with a Load Rating Factor less than 1 for any of the Legal Trucks shall be posted. Type 3 (AASHTO 1), Type 3S2(AASHTO 2), Type 3-3 (AASHTO 3), WA-105, SU4 through SU 7, and Legal Lane are considered legal loads. EV2 and EV3 are also considered legal loads on the Interstate and within one roadway mile.

WA-105 truck configuration is similar to Type 3S2 and Type 3-3 trucks except it is longer and has more axles. So, in cases where Type 3S2 or Type 3-3 rating factors are less than 1, then those posting limits would apply to the WA-105. In cases where the WA-105 rating factor is less than 1, and Type 3S2 and Type 3-3 are 1 and greater, then the structure shall be posted for 36 Tons and 40 Tons for Type 3S2 and 3-3 respectively.

See Chapter 5 of the *Bridge Inspection Manual* for posting process\requirements.

13.99 References

1. See Section 1.99.
2. AASHTO *Standard Specifications for Highway Bridges*, 17th edition
3. AASHTO *Manual For Bridge Evaluation*
4. WSDOT *Bridge Inspection Manual* M 36-64