New Load Rating Policy 2016

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Presentation Agenda

- Purpose of Presentation
- Load Rating Definitions and Rating Check Types
- Load Rating Specifications and Guidelines
- Computer Software for Load Rating
- Load Rating Triggers
- Old Policy v/s New Policy- Changes
- Load Rating Formulae for LRFR and LFR
- Condition Factors, System Factors
- Vehicle Table and Load Rating Flowchart
- Load Rating Process: Steps in the flowchart
- Load Rating Submittal: Summary Sheet, Uploads
- Assigned Load Rating
- Engineering Judgment
- Conclusion/Questions

Purpose

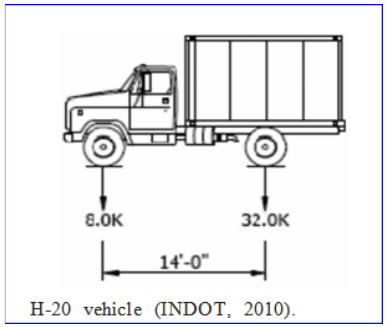
- FHWA Metric 13: Indiana not in compliance with 23CFR 650.313
- Not Current with AASHTO MBE Guidelines: PCA by FHWA
- Live Load Demands: Heavier Axle Loads affect Bridge Conditions
- Emphasis on Maintaining and Preserving Bridges: Accurate Load Ratings essential
- H20 and HS20 no longer envelope all legal loads: need to check
- Bridge Inspection Part 3: Chapters 1 to 9 Update to comply MBE
- Ensure Greater Safety and extend life of structures

Load Rating Definitions

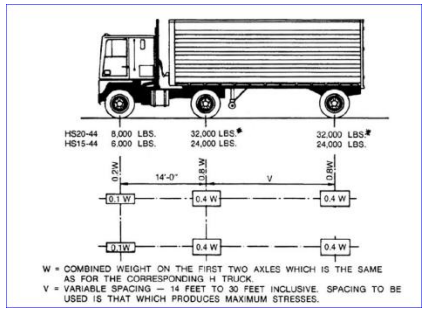
- Load Rating is the task of evaluating the Safe Load Capacity of a Bridge for Live Loads using analytical and other methods to ensure Bridge Safety

- Load Rating Factor should be preferably greater than 1.0 for the design live load

- Load Rating Factor is the ratio of the net capacity of the superstructure to the live load demand



H-20 vehicle (INDOT, 2010).



Load Rating Check Types

- Design Level Load Rating Check: Load Rating performed at Stage 3 of plan development of newly designed or replacement bridges for the design live loads specified in the design plans

- Current Load Rating Check: A load rating performed for a variety of state specific rating vehicles to encompass all force effects from legal loads on an existing bridge that reflects the current condition of all primary structural components.

- Rating Factor (Inventory) (LRFR) for New Bridges shall be greater than 1.06 for the design live load (Six percent buffer for accommodating increase in loads such as barriers and overlays. Rating Factor (Inventory) for LFR rated bridges shall be greater than 1.0

Load Rating Levels

- Inventory Level of Rating: Load Rating performed to evaluate minimum safe load capacity at Design Stage based on condition and materials when the bridge was built.
- Operating Level of Rating: A load rating performed to evaluate the maximum safe load capacity permissible on a bridge based on current live loads.

- Rating Factor (Inventory) check is RF > 1.0 generally

- Rating Factor (Operating) shall not be < 1.0 else post the bridge.

Load Rating Specifications and Guidelines

- **Applicable Codes and guidance**
  - AASHTO "The Manual for Bridge Evaluation" 2nd Edition 2012 with 2016 revisions
    - Load Rating Guidelines
  - AASHTO Standard Specifications for Highway Bridges (17th Edition)
    - LFR or ASD Analysis
  - AASHTO LRFD Bridge Design Specifications (6th Edition)
    - LRFR Analysis
  - Indiana Bridge Inspection Manual 2015 (being updated)
  - FHWA Memorandums
  - INDOT Central Office Memorandums

Computer Software for Load Rating

- Mandated software is AASHTOWARE BridgeRating 6.7.0 or BrR 6.7.0 (previously known as VIRTIS)
- CANDE for arch and underfill structures
- SMARTCULVERT for arches and conspan type structures
- MIDAS/ABACUS/GT-STRUDL and BrR combo for FEM analysis including secondary effects for steel truss frame analysis as well as post tensioned curved concrete box structures
- Spread sheets and MathCAD sheets for custom development (example for Gusset Plate analysis)
- Conspan and Merlin-DASH also offer some load rating analysis but are not comprehensive. Ratings will be checked using BrR by INDOT

Load Rating Triggers

- In addition to the Design Load Rating, changes in the condition of the primary structural components may cause a need for performing a load rating. Some of the triggers are:
- Section loss to primary structural component
- Cracks in steel beam or girder tension zones
- Loss of fasteners in gusset plates, holes in gusset plates
- Severed or corroded strands in prestressed box beams
- Severe cracking and spalling in concrete superstructure
- Beam sag and differential settlement
- Drop in condition rating of a primary superstructure to 4 or below
- A Critical Finding showing severe section loss, cracks, strand loss
- Widening or additional loads on the superstructure eg.- LMC overlay
- Heavier Live Loads and newer live load types
- Superloads or Permit Loads

Old Policy v/s New Policy: Nutshell

- Old Policy considered H20 Inventory and HS20 Inventory as standard live loads to govern the load ratings; however may not encompass all Indiana and AASHTO legal loads currently operating Indiana roads
- New Policy considers looking at all legal loads and specialized hauling vehicles (SHV's) in addition to the standard loads
- Old policy posted at 80% of H20 Inventory (16T)
- New Policy gives the option of posting for the lowest rated vehicle from the list of H20, HS20, HS25, AASHTO legal loads and posting for the most critical vehicle or post at 80% of H20 Inventory (whichever has lower tons value)
- Old policy allowed use of R12-1 single weight limit sign only
- New Policy allows either R12-1 or R12-5 (Silhouette Sign)
- Old Policy allowed Assigned Load Ratings, New policy does not
- New Policy mandates AASHTOWare BrR as main software for ratings

Load Rating Formulae and What Matters

- **LRFR Load Rating Equation (MBE 6A.4.2)**
  - C = Capacity
  - R_n = Nominal Resistance
  - γ = Load Factor
  - φ = Resistance Factor
  - φ_c= Condition Factor
  - φ_s= System Factor
  - γ_{LL}= Live Load Factor

Inventory Rating = 1.75*

Operating Rating = 1.35*

* The above factors have been modified to be less conservative per latest NCHRP study adopted by AASHTO to be published in the latest MBE.

$$RF = \frac{\phi_c \phi_s \phi R - \gamma_{DC} DC - \gamma_{DW} DW \pm \gamma_P P}{\gamma_L L(1+IM)}$$

Where:

- RF = Rating Factor
- γ_{DC} = LRFD Load factor for structural components and attachments
- γ_{DW} = LRFD Load factor for wearing surfaces and utilities
- γ_P = LRFD Load factor for permanent loads other than dead loads
- γ_L = Evaluation live load factor
- ϕ_c = Condition factor
- ϕ_s = System factor
- ϕ = LRFD resistance factor
- R = Nominal member resistance
- DC = Dead load effect due to structural components and attachments
- DW = Dead load effect due to wearing surface and utilities
- P = Permanent loads other than dead loads
- L = Live Load effect
- IM = Dynamic Load Allowance

Load Rating Formulae and What Matters

- **LRFR Condition Factor, φ_c**
  - Resistance reduction based on SI&A Condition Rating

Table 6A.4.2.3-1—Condition Factor: φ_c

Structural Condition of Member	φ_c
Good or Satisfactory	1.00
Fair	0.95
Poor	0.85

Table C6A.4.2.3-1—Approximate Conversion in Selecting φ_c

Superstructure Condition Rating (SI & A Item 59)	Equivalent Member Structural Condition
6 or higher	Good or Satisfactory
5	Fair
4 or lower	Poor

Load Rating Formulae and What Matters

- **LRFR System Factor, φ_s**
  - Resistance reduction based on Redundancy and Fatigue Prone Details

Table 6A.4.2.4-1—System Factor: φ_s for Flexural and Axial Effects

Superstructure 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 ft	0.85
Four-Girder Bridges with Girder Spacing ≤4 ft	0.95
All Other Girder Bridges and Slab Bridges	1.00
Floorbeams with Spacing >12 ft and Noncontinuous Stringers	0.85
Redundant Stringer Subsystems between Floorbeams	1.00

Load Rating Formulae and What Matters

- **LFR Load Rating Equations**
  - Manual For Bridge Evaluation 6B.4

$$RF = \frac{C - A_1 D}{A_2 L(1+I)}$$

    - C = Capacity
    - A1 = 1.3
    - A2 = 2.17 for Inventory Rating and 1.3 for Operating Rating
    - D = Dead Load Effect
    - L= Live Load Effect
    - I = Impact Factor (Dynamic Load Allowance)

Load Rating Formulae and What Matters

LRFR

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

For the Strength Limit States:

$$C = \phi_C \phi_S \phi R_n$$

LFR

$$RF = \frac{C - A_1 D}{A_2 L(1+I)}$$

- C = Capacity
- A1 = 1.3
- A2 = 2.17 for Inventory Rating and 1.3 for Operating Rating
- D= Dead Load Effect
- L= Live Load Effect
- I= Impact Factor (Dynamic

- Indiana uses LFR (H20/HS20) for older bridges and LRFR (HL 93) for newer bridges
- Looking at LRFR and LFR formula above:
  - Desirable condition is Load Rating Factor is > 1.0
    - This is possible if Capacity is higher (C or Rn is higher) or the section of component is higher
    - This is combined with lighter dead loads and wearing surface loads
    - This is also combined with lower live loads actually travelling on the bridge (lower gross weights or axle loads)
    - Lower C or R or deterioration equals lower rating

Load Rating and What Affects It

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

For the Strength Limit States:

$$C = \phi_C \phi_S \phi R_n$$

$$RF = \frac{C - A_1 D}{A_2 L(1+I)}$$

Factors affecting or lowering load rating are:

LOWER C (Deterioration/Spalling/Loss of Prestress/Non Composite)

HIGHER D

(Higher dead loads- Overlays/Barrier Upgrades)

HIGHER L

(Higher Live Loads With Higher Impact or Dynamic Load Allowance)

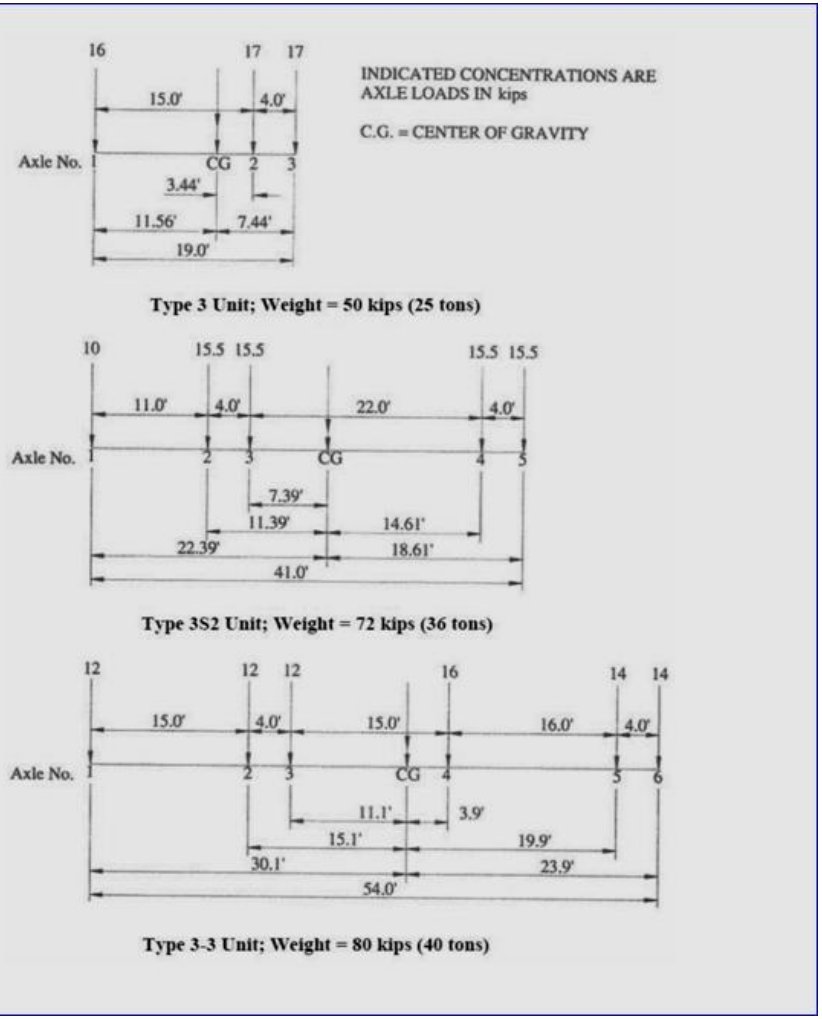
Worst Combo Would Be Lower C and Higher D and L

Application of Rating Vehicles

	State (non-STRAHNET)	Local (non-NHS)	Local (NHS)	Extra Heavy Duty Highway System	Toll Road and all state and local roads within 15 miles of a Toll Gate	STRAHNET or NHS
H-20	X	X	X	X	X	X
HS-20 *	X	X	X	X	X	X
HL-93 **	X	X	X	X	X	X
HS25	X	X	X	X	X	X
AASHTO Legal Type 3	X	X	X	X	X	X
AASHTO Legal Type 3S2	X	X	X	X	X	X
AASHTO Legal Type 3-3	X	X	X	X	X	X
Special Haul Vehicle SU4	X	X	X	X	X	X
Special Haul Vehicle SU5	X	X	X	X	X	X
Special Haul Vehicle SU6	X	X	X	X	X	X
Special Haul Vehicle SU7	X	X	X	X	X	X
Alternate Military			X			X
Toll Road 89.4 K					X	
Toll Road 90 K					X	
Toll Road 126 K					X	
Michigan Train Truck #5				X	X	
Michigan Train Truck #8				X	X	
Super Load 11 Axle 258 K Loading	X		X	X	X	X
Super Load 13 Axle 267 K Loading	X		X	X	X	X
Super Load 14 Axle 350 K Loading	X		X	X	X	X
Super Load 19 Axle 305 K Loading	X		X	X	X	X
Super Load 19 Axle 480 K Loading	X		X	X	X	X

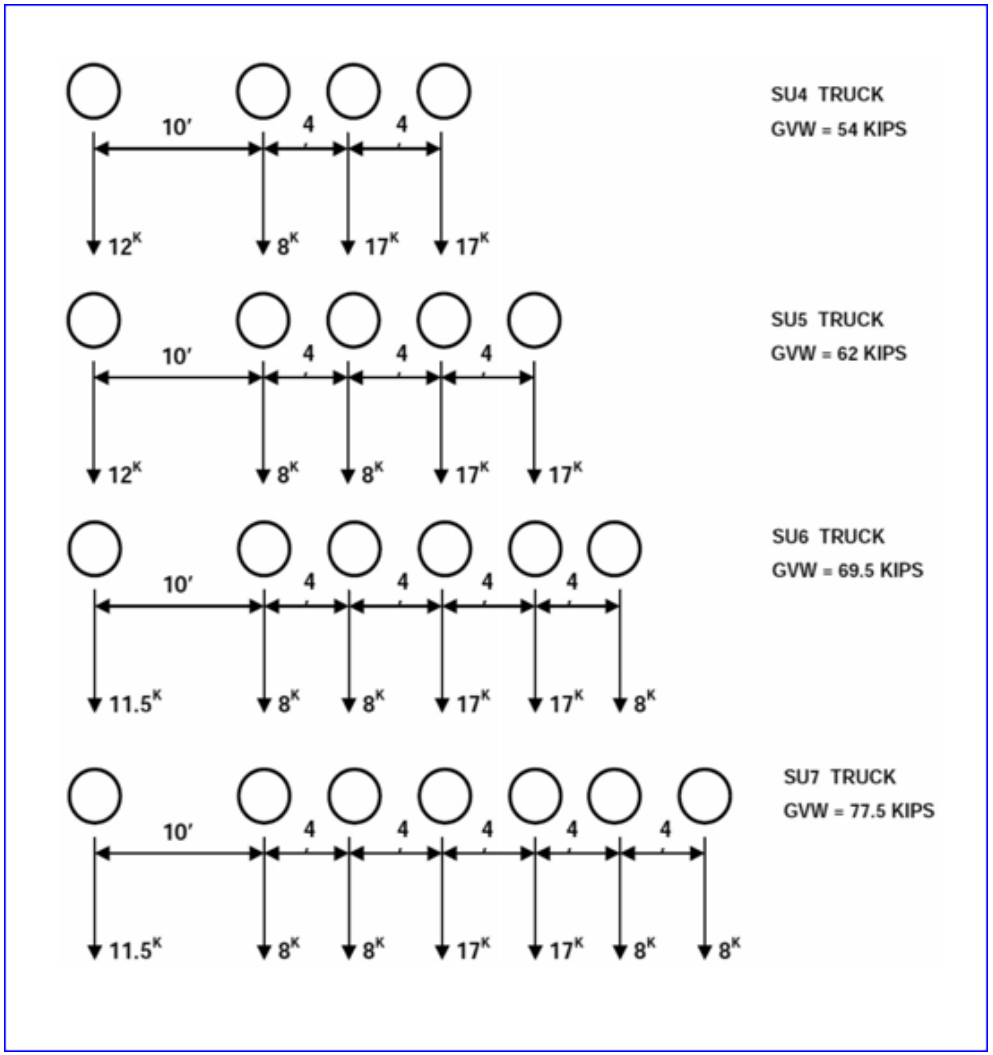
* Load Factor Rating (LFR) Design Loading
** Load Resistance Factor Rating (LRFR) Design Loading

Sample Rating Vehicles: Legal Loads



AASHTO Legal Loads

Sample Rating Vehicles: SHV's



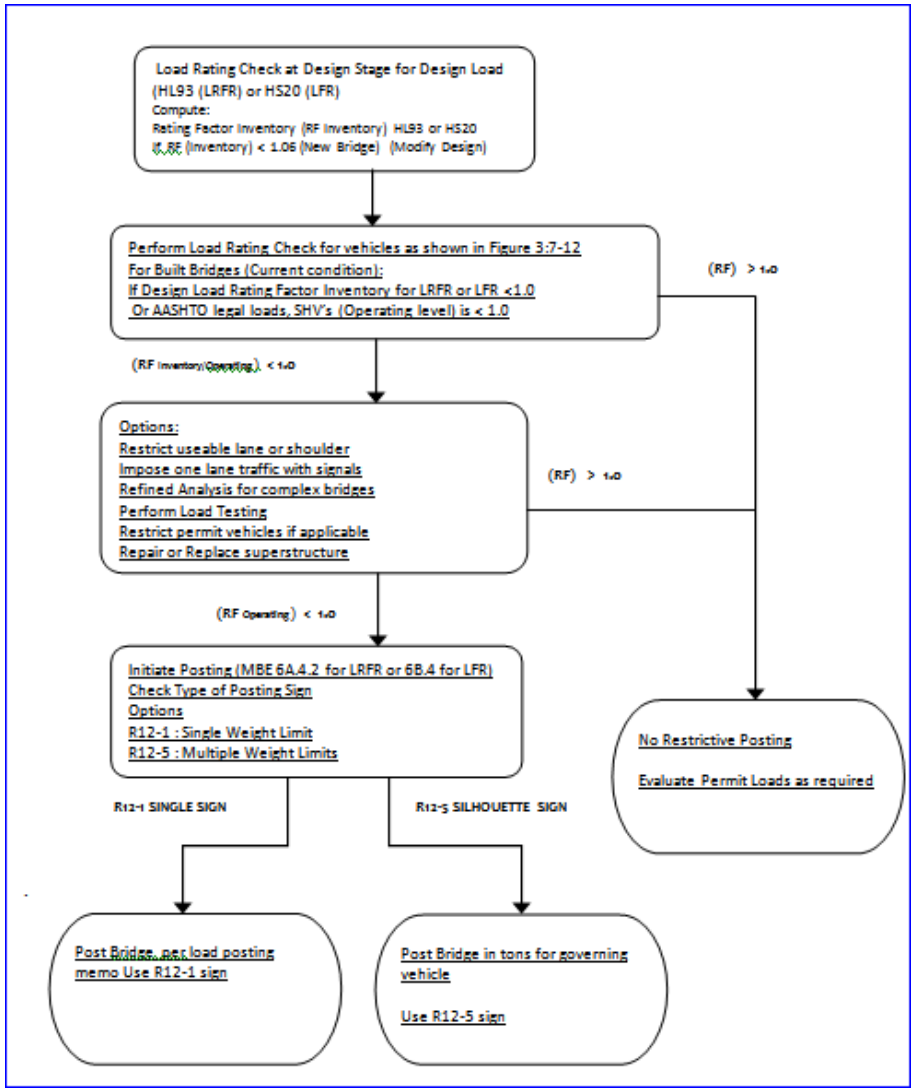
SPECIALIZED HAULING VEHICLES

Sample Rating Vehicles: SHV's

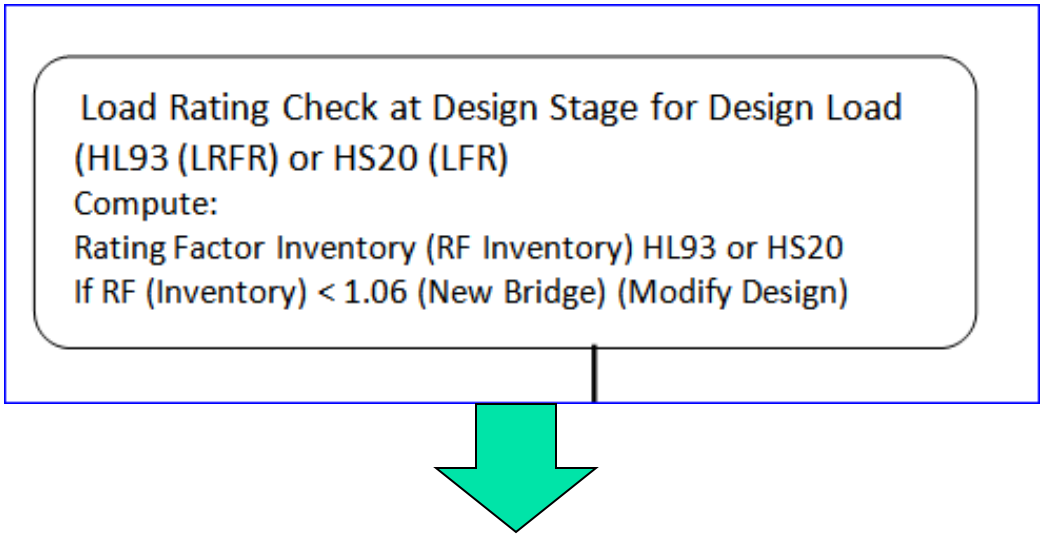
SU7

SU5

Load Rating Flowchart



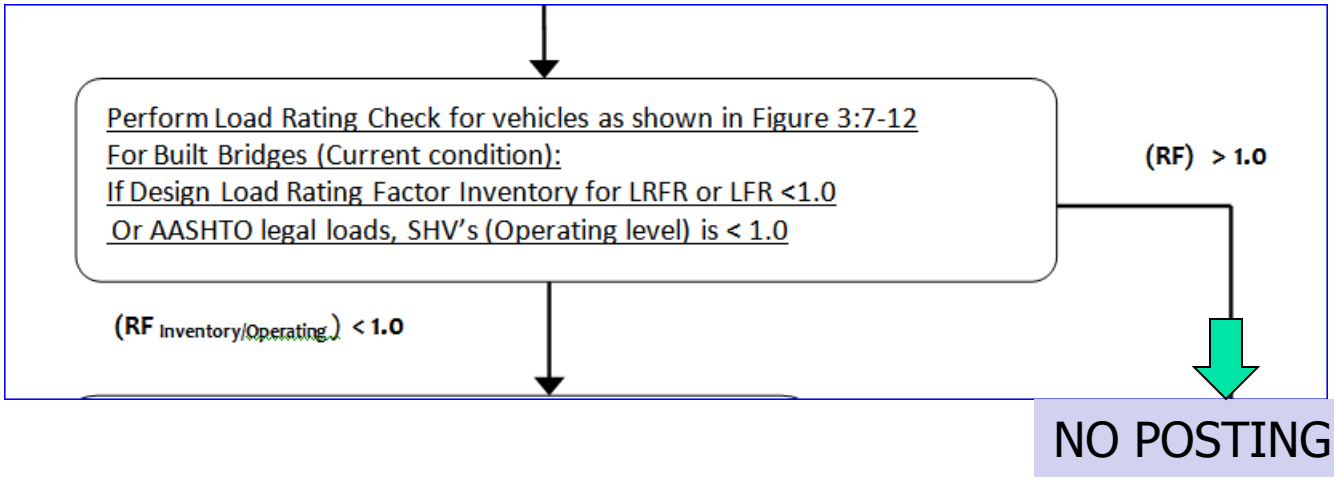
Various Steps of the Flow Chart



RATING CHECK AT STAGE 3 OF DESIGN- CHANCE TO MODIFY

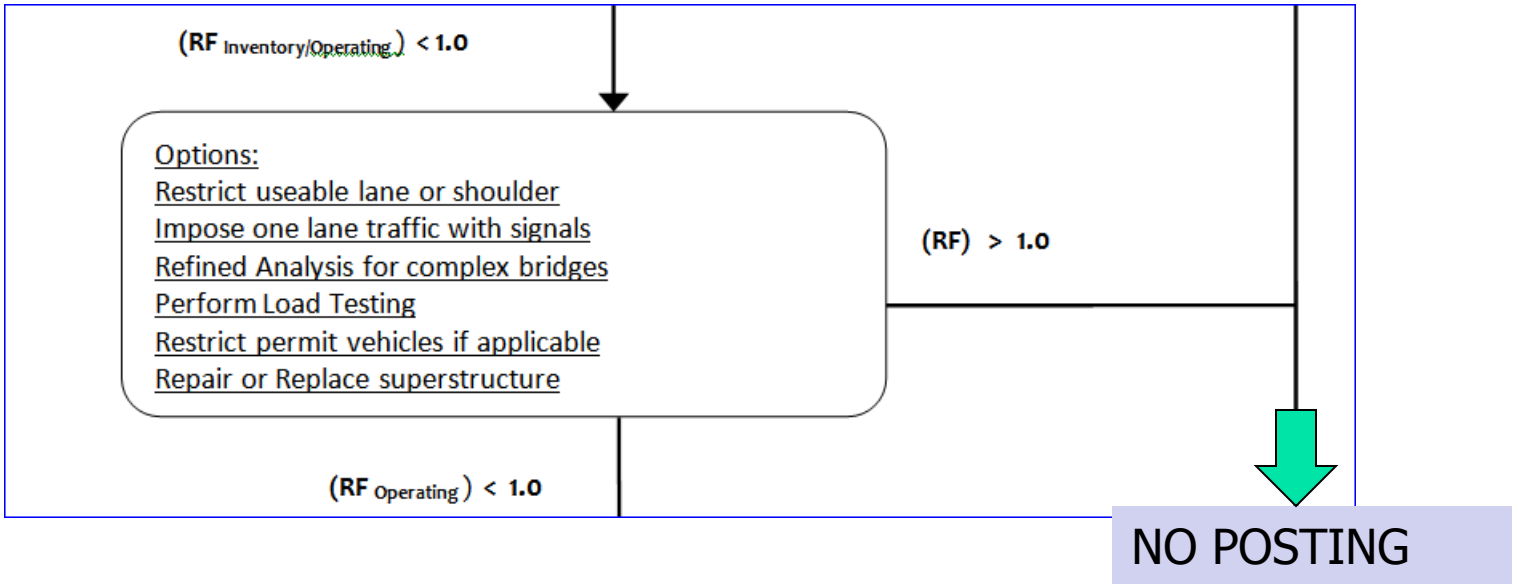
Various Steps of the Flow Chart

RATING CHECK AT CURRENT CONDITION

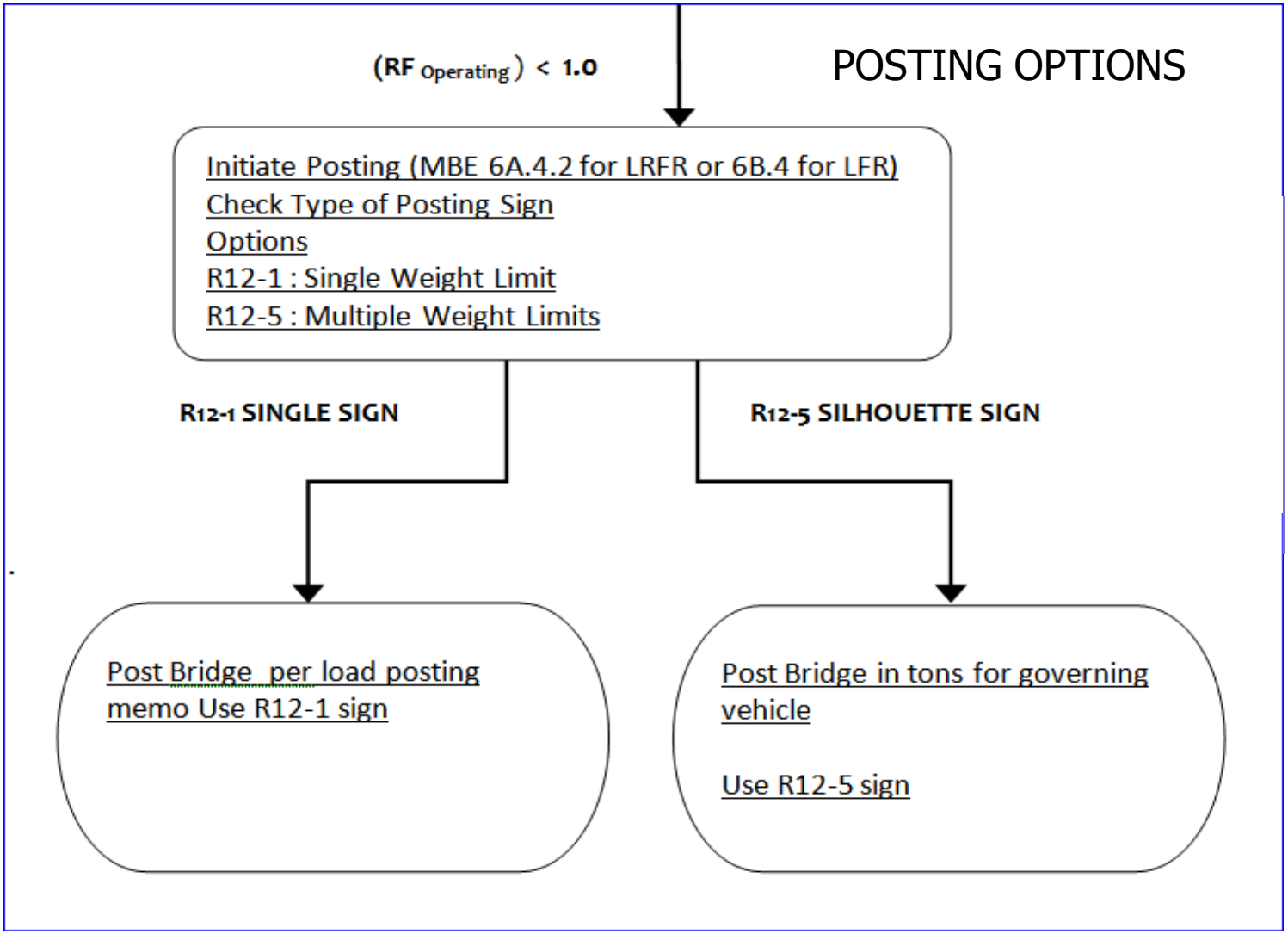


Various Steps of the Flow Chart

OPTIONS

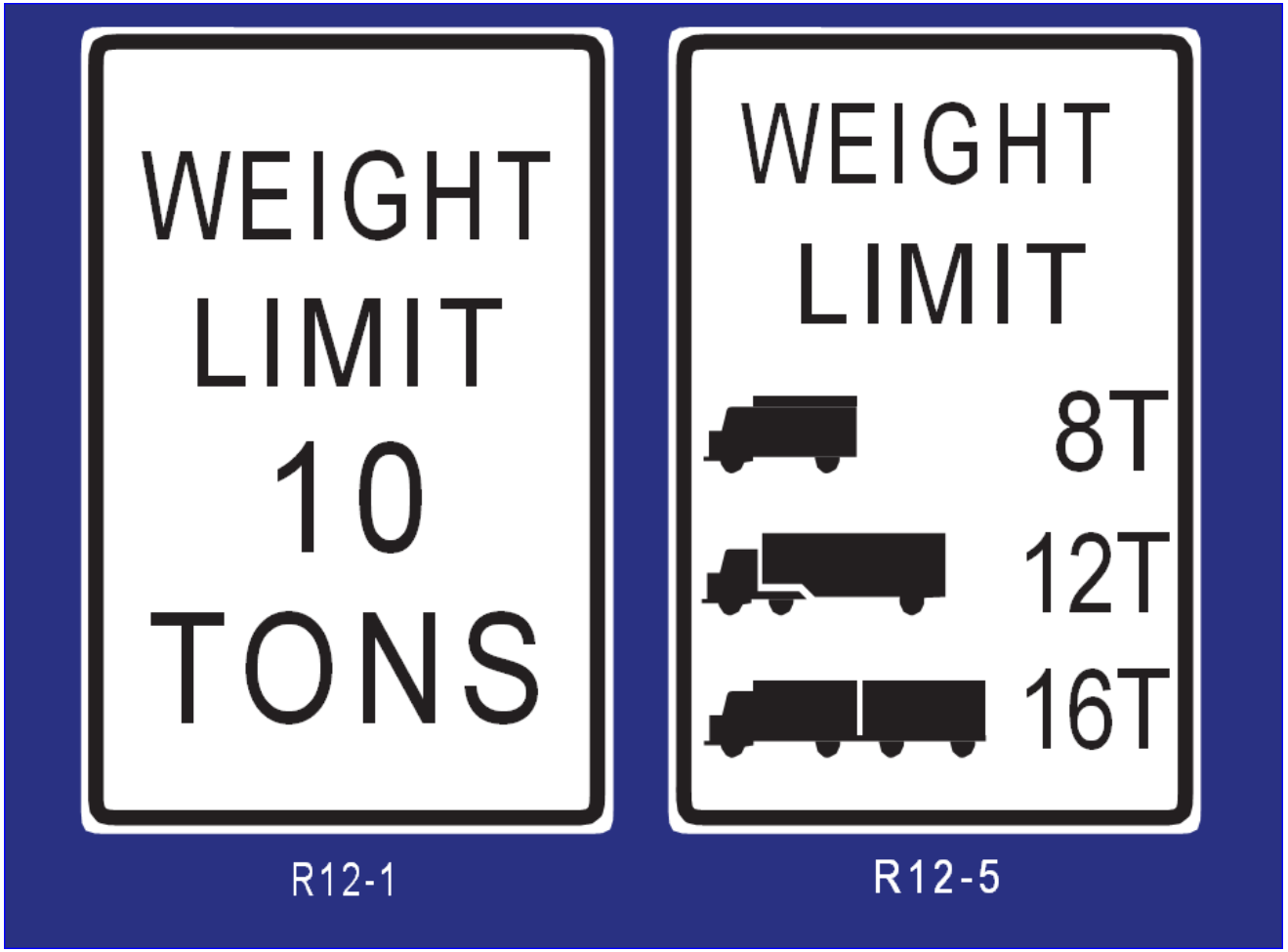


Various Steps of the Flow Chart



Various Steps of the Flow Chart

WEIGHT LIMIT SIGNS



LOAD RATING SUBMITTAL

- AASHTOWare Bridge Rating BrR utilized for rating
- Current Version is BrR 6.7.0
- New Policy applies to all Indiana Bridges- State, local, Toll and Extra Heavy Duty Highways
- All load ratings shall undergo a quality check, by another load rating engineer and be signed and sealed by a State of Indiana PE.
- Local Bridge Ratings shall follow the same procedure.
- The Load Rating Summary shall be uploaded to the "Other" folder in BIAS
- Consultants performing the load rating shall submit the xml file to Central Office
- For P3 and Design Build Projects, Load Rating Design Check shall be a part of the contract process and shall pass a RF check to be greater than 1.06

LOAD RATING SUBMITTAL

- P3 and Design Build Project Rating Summary and xml file shall be submitted to INDOT Load Rating Engineer for review
- New Load Rating Database BRADIN (Bridge Rating Database Indiana) being tested
- BRADIN shall be used to populate AASHTO legal loads, SHV's and Permit Loads specified in the Manual.
- Upload Summary in the "Other" folder till BRADIN in Production Mode
- Summary Sheet Samples on Next Sheet

Summary Sheet: Page 1

BRIDGE RATING DATA/OUTPUT

For

BRIDGE LOAD CAPACITY RATING

BRIDGE NUMBER

NBI NUMBER

Summary Sheet: Page 2

Bridge #: _____
NBI #: _____
Structure Type: _____

Description: _____
_____

By: _____ Date: _____
Checked: _____ Date: _____

Load Rating Method: _____ (LFR/LRFR/Bridges with unknown components (MBE 6.1.4)
Load Rating Program: _____

Year Built: _____
Year Reconstructed: _____
Design Loading: _____
Units: _____

Location Information
County: _____
District: _____
Reference Post: _____

Bridge Geometry
Spans: _____
Girder Spacing: _____
O-To-O Coping: _____
Clear Roadway: _____
Left Overhang: _____
Skew: _____

Slab
Total Depth = _____
Structural Depth = _____
Wearing Surface: _____
SIP: _____

Materials
Resteel: _____
Deck Concrete: _____
Beam: _____
Beam Concrete: _____
_____
Strands: _____

Rehab Summary:

Notes: (comments by the Engineer, information from drawings,field measurements,material and load test results, sketches, beam typical cross sections, Bridges with unknown structural components (MBE 6.1.4))

Summary Sheet: Page 3

Subject: Load Rating Analysis
Bridge #:
NBI #:

Code: **Member:**
LLD Factor: **Length:**

DESIGN LOADS	INV. (Location, ft)	OPER. (Location, ft)
H20-44		
HS20-44		
HL 93		
Fatigue Truck		
HS 25		
Michigan Train #5		
Michigan Train #8		
Military Loading		
Toll Road Truck 126k		
Toll Road Truck 89.6k		
Toll Road Truck 90k		

Notes:
1. Michigan trucks conservatively modeled in multiple lanes.

Summary Sheet: Page 4

Subject: Load Rating Analysis
Bridge #:
NBI #:

Code: **Member:**
LLD Factor: 0.000 **Length:**

LEGAL LOADS	OPER. (Location, ft)
AASHTO Type 3 (25 tons)	
AASHTO Type 3-3 (40 tons)	
AASHTO Type 352 (36 tons)	
Lane-Type	
NRL	
SHV - SU4 (27 tons)	
SHV - SU5 (31 tons)	
SHV - SU6 (34.75 tons)	
SHV - SU7 (38.75 tons)	

PERMIT LOADS	OPER. (Location, ft)
SuperLoad - 11 Axles	
SuperLoad - 13 Axles	
SuperLoad - 14 Axles	
SuperLoad - 19 Axles (305k)	
SuperLoad - 19 Axles (480k)	

Notes:
1. SuperLoad trucks conservatively modeled as standard gage (6ft).

PE SEAL
SIGN
DATE

Assigned Load Ratings

- FHWA Memo dated Sept. 29, 2011 for Assigned Load Rating (Five conditions)
- Condition that an evaluation is completed that force effects from state legal loads or permit loads do not exceed from the design load
- Purdue working on SPR3913 – needs to augment scope. Data from IOWA pooled study to be used.
- IOWA study phase 1 completed- still working.
- Due to this Assigned Load Ratings shall not be used till a study is complete and approved.

Engineering Judgment

- MBE 6.1.4 applies Engineering Judgment to bridges with unknown structural components
- Concrete bridges with condition rating at least 6
- Field measurements not feasible
- No plans available
- Perform a field inspection by a qualified PE
- Establish a rational criteria
- No change in condition from the previous inspection (drop in condition rating)
- Inspection reveals that bridge carries normal traffic without any distress due to live load
- Upload and Submit document sealed and signed by a qualified PE
- Sample sheet on next slide

Engineering Judgment

Str. No.

NBI:

Year Built:
Design Load: Unknown
Structure Type:

Superstructure Condition Rating		
Inspection Date		

Inspector:

In accordance with **"Manual for Bridge Evaluation, Second Edition, 2010, including interims through 2015"**

Section 6.1.4

Necessary details for this bridge are unavailable. A physical inspection of the bridge was performed by a qualified inspector and evaluated by a qualified engineer to establish an approximate load rating based on rational criteria.

This structure has been carrying normal traffic for years, and shows no increased signs of distress due to live load.

Notes/Comments:

Inventory Rating: **36 Tons**
Operating Rating: **45 Tons**
H Rating: **20 Tons**

Evaluated by:

PE SEAL/STAMP

Conclusion

- INDOT commencing to implement new policy immediately starting with State Bridges
- Completion date for Indiana is November 2019
- Major need to load rate per rating vehicles shown in figure 3:7-12 and follow up on any potential postings
- Update BIAS and database accordingly
- Completion will close FHWA PCA and bring Indiana up to date at National Level
- Ensure better Safety and reduce liability to INDOT

Questions?

Contact Information

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