Transportation

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MEMORANDUM TO: Project Engineers
Project Design Engineers

FROM: T. K. Koch, P.E.
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SUBJECT: Engineering Judgement Load Rating

To ensure all bridges are appropriately evaluated for their safe load carrying capacity, the National Bridge Inspection Standards (NBIS) [23 Code of Federal Regulations §650.313] stipulates all structures, longer than twenty feet on publicly owned roads, are to be load rated in accordance with the AASHTO *Manual for Bridge Evaluation* (MBE).

Typically, a conventional bridge analysis and load rating model is used to compute the safe load carrying capacity. This approach allows bridge owners to make decisions regarding the safe load carrying capacity for legal and permitted loads or when emergencies arise. However, in some situations an analysis and load rating model cannot be developed due to a lack of information.

This policy addresses the appropriate use of engineering judgement load ratings as a means of complying with the NBIS requirements for structures that cannot be load rated due to a lack of sufficient information. This policy should not be confused with the concept of assigning ratings for certain bridges based on the design load, as presented in the 2nd edition of the MBE (2011). The policy does not address the use of assigned load rating.

Field Evaluation and Engineering Judgement

Prior to performing an engineering judgement load rating, make every effort to locate the structure plans or obtain the field data required to perform the analysis and load rating. Engineering judgement load ratings shall only be given to structures where a load rating analysis cannot be performed due to a lack of necessary information and/or field measurements and shall be based on field evaluation and engineering judgement.

The term "field evaluation and engineering judgement" as it relates to the load rating of structures, should not be confused with the practice of applying engineering knowledge to provide solutions to problems. For the purposes of load rating, field evaluation and engineering judgement is the use of information gathered by a qualified bridge inspector or load rating engineer as the basis to use professional judgement to determine the load rating. The load rating engineer must use the inspection information and data, available knowledge of the design live load, live load history and the current condition of the structure to support the engineering judgement load rating. Plans from a similar structure, with known details, designed or built during the same time period may also provide the basis for an engineering judgement load rating.

Typically, engineering judgement ratings will be limited to structure types identified in this policy, unless approved by the State Load Rating Engineer.

Structures Where Engineering Judgement Ratings Shall Not Be Applied

Steel Bridges

Steel bridges without plans can be analyzed and load rated using information and data/measurements collected from the field. Ensure the bridge inspection report provides sufficient data/measurements, such as the plate girder or beam dimensions and remaining thickness of the steel section, to perform the analysis and load rating.

Use the structure year built and the MBE - Table 6A.6.2.1-1 to establish the steel material properties. The year built is documented in the Structure Inventory & Appraisal data sheet (NBI Item #27). In addition, assume the following:

- Non-composite action for beams on bridges with concrete decks, unless the physical inspection reveals the deck is composite with the beams.
- Fully braced compression flange for beams on bridges with a timber floor if the timber nailers are sound and in good condition.
- Unbraced compression flange if the timber nailers are decayed.

Timber Bridges

Analyze and load rate timber structures based on data/measurements collected from the field. Use the Working Stress (Allowable Stress) method and assume the timber is Southern Pine (dense select structural). Material properties shall be in accordance with the *National Design Specification for Wood Construction* (NDS).

Structural Plate

Structural plate structures are typically corrugated metal (steel or aluminum) plate (CMP) structures which depend on the interaction with the backfill material for stability and the ability to carry loads. When properly constructed, CMP structures perform as a compression ring with little bending resistance.

Load rate corrugated metal plate structures based on data/measurements collected from the field. When information on the structure type and components cannot be determined in the field, contact the supplier/manufacturer and request the information necessary to perform a load rating. In addition, the supplier/manufacturer may be able to provide assistance with the load rating.

When load rating CMP structures, investigate defects that may affect the load rating, such as:

- Flattening of the top arch elements or sides.
- Differential settlement or undermining.
- Erosion of material from underneath and alongside of the structure due to water infiltrating the material.

Structures Where Engineering Judgement Ratings Are Acceptable

Engineering judgement load ratings will apply to concrete superstructures and concrete box culverts with unknown reinforcement. Since engineering judgement ratings are not calculated, there is substantial reliance on the physical inspection condition rating. Assign load ratings to concrete structures using the guidance provided in this section.

In accordance with the MBE Article 6.1.4, concrete structures with unknown details need not be load posted if they have been carrying normal traffic for an appreciable period and show no significant signs of visible structural distress.

Documentation required for load ratings based on field evaluation and engineering judgement includes, but is not limited to the following information:

- Statement of efforts made to obtain design plans.
- Summary of the field evaluation noting the Bridge Inspector's condition ratings and comments on structural defects.
- Description of the structure load path, e.g. level of redundancy, traffic history and evidence of damage due to routine traffic or overloads.
- Engineering judgement applied and methodical justification for the load rating and/or load posting, when applicable.
- Conclusive statement that the load rating is based on "field evaluation and engineering judgement" to facilitate proper coding of NBI Items #63 and #65.

Reinforced Concrete Box Culverts (RCBCs)

Historically, an inventory rating of HS20 and operating rating of HS26 has been assigned to RCBCs. HS26 is an intermediate rating between the inventory rating and the corresponding operating rating. This practice, which is in variance with MBE Article 6B.7.1, will be continued since it has been successfully used over a significant period of time and satisfactorily envelopes force effects of NC legal vehicles; i.e. $RF_{Op} = 1.0$ for legal loads and load posting is not required.

For proprietary culvert systems, such as the Con/Span® and Bebo® precast arch systems, make every effort to contact the producer of the structure to obtain additional details or plans and assistance with the load rating.

For the HS-20 design load, assign HS20 ($RF_{Inv} = 1.0$) for the inventory load rating and HS26 ($RF_{Op} = 1.3$) for the operating load rating to cast-in-place RCBCs that satisfy all of the following criteria:

- Unknown reinforcement details.
- Fill depths $\geq$ 2.0 ft.
- Carrying normal traffic for an appreciable period (> 5 years).
- Condition grade $\geq$ 5 (NBI Item #62).

Culverts that do not satisfy the criteria above may be assigned alternate load ratings. Review inspection reports for evidence of structural distress, such as flexural or shear cracks. Use the culvert condition rating (NBI Items #62) and Table 1 to assign a load rating. Consider whether the NBI Condition Rating reflects the load carrying capacity of the structure. If a low condition rating is due to a deficiency, such as significant scouring at the ends of the culvert, that does not affect the structure’s load carrying capacity, a higher engineering judgement rating is appropriate, if adequate justification is furnished.

Table 1: RCBCs – Engineering Judgement Load Rating

NBI Condition Rating	Inventory Rating ($RF_{Inv.}$)	Operating Rating ($RF_{Op.}$)
9	HS20.0 (1.00)	HS26.0 (1.30)
8	HS20.0 (1.00)	HS26.0 (1.30)
7	HS20.0 (1.00)	HS26.0 (1.30)
6	HS20.0 (1.00)	HS26.0 (1.30)
5	HS16.6 (0.83)	HS21.6 (1.08)
4	HS8.0 (0.40)	HS10.4 (0.52)
3 or 2	• Assign appropriate rating less than that for NBI Condition Rating of 4.	
0 or 1	• Culvert closed.	

For culverts with a condition rating < 5, use engineering judgement to also estimate a safe load carrying capacity for single vehicles (SV) with 2 to 7 axles and truck tractor semi-trailers (TTST) with 3 to 7 axles. Culverts with a NBI condition rating ≤ 3 and are open to traffic will require extensive justification for the engineering judgement load rating.

This policy provides guidance for complying with the NBIS requirements for structures without plans. However, there are cases where assigning a load rating to a structure with plans is appropriate. For example, when the load rating of a RCBC with known reinforcement results in $RF_{Op} < 1.0$, and this result is clearly inconsistent with the in-service performance of the structure. In accordance with MBE Article 6B.7.1 the RCBC need not be load posted; so long as the other three criteria are met from paragraph three of this section, then use the guidance for RCBCs with unknown reinforcement details to propose an engineering judgement load rating for approval by the State Load Rating Engineer.

Reinforced Concrete Bridges

Reinforced concrete bridges in the State primarily consist of cast-in-place deck slab superstructures (slab bridges) and reinforced concrete deck girders (RCDGs). RCDGs are reinforced concrete beams which were cast monolithically with the reinforced concrete deck and are typically analyzed as reinforced concrete T-beams.

Review inspection reports for evidence of structural distress, such as flexural or shear cracks. For reinforced concrete bridges that are in fair or better condition; i.e. superstructure condition grade ≥ 5 (NBI Item# 59), use the structure year built (NBI Item#27) and Table 2 to assign a load rating.

Table 2: Reinforced Concrete Bridges – Modified Design Load Rating

Span (ft.)	Built Prior to 1950*		Built After 1950**	
	Inventory	Operating	Inventory	Operating
15	HS15.0	HS19.5	HS20.0	HS26.0
20	HS15.0	HS19.5	HS20.0	HS26.0
25	HS14.5	HS18.8	HS19.3	HS25.1
30	HS13.1	HS17.0	HS17.5	HS22.7
35	HS12.3	HS16.0	HS16.4	HS21.3
40	HS11.5	HS15.0	HS15.4	HS20.0
45	HS11.0	HS14.3	HS14.7	HS19.1
50	HS10.6	HS13.8	HS14.2	HS18.5
55	HS10.4	HS13.5	HS13.8	HS18.0
60	HS10.1	HS13.2	HS13.5	HS17.6
65	HS10.0	HS13.0	HS13.3	HS17.3
70	HS9.8	HS12.8	HS13.1	HS17.0
75	HS9.7	HS12.6	HS12.9	HS16.8
80	HS9.6	HS12.5	HS12.8	HS16.6
85	HS9.5	HS12.4	HS12.7	HS16.5
90	HS9.4	HS12.3	HS12.6	HS16.3
95	HS9.4	HS12.2	HS12.5	HS16.2
100	HS9.3	HS12.1	HS12.4	HS16.1
105	HS9.2	HS12.0	HS12.3	HS16.0
110	HS9.2	HS12.0	HS12.3	HS15.9
115	HS9.2	HS11.9	HS12.2	HS15.9
120	HS9.1	HS11.9	HS12.2	HS15.8

* Assumes at least H-15 design load was used for structures built before 1950.
** Assumes at least H-20 design load was used for structures built in 1950 or later.

Most reinforced concrete bridges with unknown structural details have been carrying normal traffic for decades without a need for load posting. The engineering judgement load ratings provided in the table above are derived from an assumed design load, but may not reflect the as-built condition or in-service performance of the structure. Reinforced concrete bridges that exhibit no signs of structural distress or significant deterioration need not be load posted, in accordance with MBE Article 6.1.4.

For reinforced concrete bridges that exhibit structural distress, significant deterioration or have a superstructure condition rating of 4, use engineering judgement to also estimate a safe load carrying capacity, for single vehicles (SV) with 2 to 7 axles and truck tractor semi-trailers (TTST) with 3 to 7 axles. Structures with a NBI superstructure condition rating ≤ 3 and are open to traffic will require extensive justification for the engineering judgement load rating. Justification should include, but is not limited to an assessment of the following:

- Condition of load carrying components.
- Level of load path redundancy.
- Reconstruction or modifications to the structure.
- Measurable deformations.
- Comparison to comparable structures of known design.
- Observed performance of the structure under traffic.

Prestressed Concrete Bridges

Review inspection reports for evidence of structural distress, such as flexural or shear cracks. For prestressed concrete bridges use the lower of the superstructure or substructure condition ratings (NBI Items #59 and #60) and Table 3 to assign a load rating. Consider whether the condition rating reflects the load carrying capacity of the structure. If a low condition rating is due to a deficiency that does not affect the structure's load carrying capacity, a higher engineering judgement rating is appropriate, if adequate justification is furnished.

Table 3: Prestressed Concrete Bridges – Engineering Judgement Load Rating

Lowest NBI Condition Rating (Superstructure and Substructure only)	Inventory Rating ($RF_{Inv.}$)	Operating Rating ($RF_{Op.}$)
9	HS20.0 (1.00)	HS33.4 (1.67)
8	HS20.0 (1.00)	HS33.4 (1.67)
7	HS19.0 (0.95)	HS31.7 (1.59)
6	HS16.6 (0.83)	HS27.7 (1.39)
5	HS12.6 (0.63)	HS21.0 (1.05)
4	HS8.0 (0.40)	HS13.4 (0.67)
3 or 2	• Assign appropriate rating less than that for NBI Condition Rating of 4.	
0 or 1	• Bridge closed.	

For structures with a superstructure condition rating < 5, use engineering judgement to also estimate a safe load carrying capacity, for single vehicles (SV) with 2 to 7 axles and truck tractor semi-trailers (TTST) with 3 to 7 axles. Structures with a NBI superstructure condition rating ≤ 3 and are open to traffic will require extensive justification for the engineering judgement load rating. Justification should include, but is not limited to an assessment of the following:

- Condition of load carrying components.
- Level of load path redundancy.
- Reconstruction or modifications to the structure.
- Measurable deformations.
- Comparison to comparable structures of known design.
- Observed performance of the structure under traffic.

This policy for engineering judgement load ratings is effective immediately. The Inspection Manual will be updated at a later date.

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