SCDOT Load Rating
Standard BrR Assumptions
August 4, 2020

[R*emove notes in brackets when used for a project. These are provided for clarification*]

Abbreviations:
BrR *– AASHTOWare Bridge Rating program*
LFR *– Load Factor Rating*
LRFR *– Load and Resistance Factor Rating*
LRGD *– SCDOT Load Rating Guidance Document*
LRSF *– SCDOT Load Rating Summary Form*
MBE *– AASHTO Manual for Bridge Evaluation*

Typical Assumptions

1. As-built plans xxxxx, As-let plans xxxx, Shop Drawings xxxx, or Detailed Site Assessment Form dated (MM/DD/YYYY) were used for the rating.

2. Based on the year built, 19xx, the following material properties were used:
   - Concrete compressive strength = X ksi
   - Reinforcing steel yield strength = X ksi
   - Structural steel yield strength = X ksi

3. A load of 16 pounds per square foot [*or as indicated on plans*] was applied to account for the weight of stay-in-place (SIP) forms and the extra concrete. [Presence of SIP forms to be confirmed during the Site Assessment and/or via Google street view imagery of underside, if available].

4. Per the LRGD, an additional 5% of self-load was applied to all steel girders to account for materials such as welds, bolts, plates, etc.

5. Per the LRGD and Technical Note 01, an additional 10% of self-load was applied to all steel girders of Spans 2 and 3 to account for materials such as welds, bolts, transverse stiffener plates, splice plates, etc.

6. Sacrificial wearing surface = x" per LRGD Section xx.xx. [*9.2 for reinforced concrete, 10.2 for prestressed concrete girders, 11.2.1.1 #6 for steel girders, 12.2 for steel truss*]. Sacrificial wearing surface is the depth of the deck that will be worn away over time. This depth is deducted from the overall depth of the deck for purposes of computing section properties and strength; however, the full deck thickness is included in the bridge model as dead load.

7. A xx" thick [*specify type*] overlay was applied to the as-built structure based on information gathered during the (Month DD, YYYY) site assessment.

8. Traffic data was input into BrR using Directional % = XX% (in accordance with LRGD Section 6.11.1.2) and Truck % = XX% (in accordance with LRFD Table C3.6.1.4.2-1).

9. Traffic data was input into BrR using Directional % = XX% (in accordance with LRGD Section 6.11.1.2) and Truck % = XX% (per 2018 NBI Datasheet).

10. Reinforced concrete end bent caps (abutments) were rated using CSi Bridge version 20.1.0 and Mathcad 15.

11. Bridge geometry for load rating is based on field measurements obtained on (Month DD, YYYY).

12. Structure length used for load rating is xxx feet as opposed to yyy feet shown in Section 1 of the LRSF. [*Explain why*]

13. The following assumptions were made for the utilities referenced in the (Month DD, YYYY) site assessment:
    - X" waterline [*description as reported in the site assessment*] – used weight of X" (nominal pipe size) Schedule 40 steel pipe, full of water
    - X" telephone ducts [*description as reported in the site assessment*] – used weight of X" (nominal pipe size) Schedule 40 PVC, empty

14. Barrier rail stiffness was considered in load rating analysis. Inspectors shall verify condition of barrier rail and how it's connected to the deck during inspection.

15. Spans 1-3 are all linked together under one superstructure definition in BrR. Results shown on the LRSF for Span 1 (i.e., Controlling Location *1.X*) apply to all 3 spans.

16. The as-built plans have no information which clearly states the prestressed beams were designed to be continuous for live load. Therefore, per LRGD Section 10.2(#4), the effect of the closure diaphragms was neglected and the continuous spans (X-X) were modeled as simple spans in BrR.

17. Per Technical Note 06, continuous span behavior (for SDL and LL) was modeled because the bridge was designed after January 8, 2008, and based on engineering judgement, the criteria of Bridge Design Memorandum DM0108 have been met.

18. Per Technical Note 06, continuous span behavior (for SDL and LL) was modeled because one of the requirements of LRFD Section 5.12.3.3.5 is satisfied and a BMO Approvals Form has been approved.

19. Based on the (Month DD, YYYY) inspection report and the (Month DD, YYYY) site assessment, there are no visible signs of shear distress in the prestressed concrete girders (such as diagonal cracking or vertical rebar corrosion). Therefore, as per LRGD Section 10.2.1.2 (#8), the "Ignore design and legal load shear" control option was checked in BrR and the shear limit state was not included in the LRFR design and legal load ratings.

~~20. The Service III limit state was not included in the ratings per the BMO approval form received on (Month DD YYYY). The (Month DD, YYYY) inspection report and the (Month DD, YYYY) site assessment showed no signs of shear or flexural distress in the prestress concrete I-girders.~~ [*voided 1/27/2020 per Help Desk #46*]

21. Based on the (Month DD, YYYY) inspection report and the (Month DD, YYYY) site assessment, there is no evidence of shear or flexural distress in the prestressed girders under normal traffic and the structure has been in service for an appreciable amount of time. Therefore, Service III concrete tensile stress was not considered for the LRFR legal load ratings.

22. As a workaround to a bug in BrR [*provide short description of bug and a reference to the BRDRSUP ticket number (if applicable)*], the Legacy AASHTO LRFR analysis engine was used to rate the girders.

23. Based on the (Month DD, YYYY) inspection report and the (Month DD, YYYY) site assessment, there is no measurable deterioration to warrant a Deteriorated structure model in BrR.

24. Based on the (Month DD, YYYY) inspection report and the (Month DD, YYYY) site assessment, the following changes were made for the Deteriorated structure model in BrR:
    - The girder condition factor was changed to "Fair"/"Poor". [*Also add the following if deterioration is based on field measurement of losses*] The "Field

Measured Section Properties" box is checked so that BrR applies the optional 0.05 increase in condition factor per MBE Table 6A.4.2.3-1.

- The following section losses were applied to the structure: [*for steel type structures, show a deterioration summary table; for example, see table below*]

Span(s)	Girder	Start Distance (ft)	Length (ft)	Location	Comments
1	G1	0.00	12.00	Web & Bottom Flange	0.6% & 15% section loss, respectively
2	G2	65.75	5.00	Web & Bottom Flange	8 % & 35 % section loss, respectively

- The following losses were applied: [*for reinforced concrete beams & slabs, show a rebar deterioration summary table; for example, see table below*]

Span(s)	Girder	Start Distance (ft)	Length (ft)	End Distance (ft)	Loss Description
1	G2	6.25	1.00	7.25	10% loss to one "BS" shear stirrup bar
3	G7	0.00	0.50	0.50	100% loss to one "B5" longitudinal bar

Channel Specific Typical Assumptions:

1. The dead load from the curb was evenly distributed to the three exterior channel beams in the As-built model. In the deteriorated model, the full curb load was applied to the exterior beam due to severe reflective cracking in the asphalt, which is indicative of individual beam behavior.

2. Shear reinforcing bars were considered to be fully developed per SCDOT guidance based on field testing results.

3. [for skinny leg channels]

   Based on the June 13, 2019 inspection report and January 30, 2020 site assessment, the following changes were made for the Deteriorated superstructure model in BrR in accordance with the "Skinny Leg Channel Guide" produced by WSP included with Technical Note 07:

   a. The Span 1 Live Load Distribution Factors were revised to 0.5 lanes (LRFR) / 1.00 wheels (LFR) due to the severe deck reflective cracking and loose transverse tie rods.

   b. The Span 2 Live Load Distribution Factors were revised to 0.35 lanes (LRFR) / 0.70 wheels (LFR) due to the moderate deck reflective cracking.

   c. The site assessment Additional Notes indicate an exposed rebar on Span 1 Beam 10. Photos of the area are unclear. No modifications were made to the analysis for this deterioration. Supplementary inspection information is required to determine if there is any strand exposure that would require removal of prestressing for analysis. Future deteriorated models may need to be adjusted accordingly.

4. [for wide leg channels]
   The AASHTO LRFD Specifications Article 4.6.2.2.2b has an applicability limit of 4' to 10' stem spacing for the concrete beams used in multibeam decks. Double-tee beams have a stem spacing of 2' and beam spacing of about 3', which are outside the applicability limit. The AASHTO Standard Specifications does not have a similar limit on spacing. The following live load distribution factors are assumed:
   - As-built: Use Lever Rule for LRFR; Use AASHTO Standard Specifications Article 3.23.4 (BrR calculated) for LFR.
   - Deteriorated: Lever rule with beams acting independently for both LRFR and LFR

Culvert Specific Typical Assumptions:

1. As-built plans xxxxx, As-let plans xxxx, Shop Drawings xxxx, or Detailed Site Assessment Form dated (MM/DD/YYYY) were used for the rating.

2. The culvert was originally constructed in xxxx and was extended in xxxx according to the as-built plans, as-let plans, or site assessment, etc. Analysis was performed for the original and extended culvert sections.

3. The original culvert was constructed as two sections with unique geometry and reinforcing; therefore, both sections were analyzed in BrR.

4. Based on the year built, 19xx, the following material properties were used:
   - Concrete compressive strength = X ksi
   - Reinforcing steel yield strength = X ksi
   - Structural steel yield strength = X ksi

5. Traffic data was input into BrR using Directional % = XX% (in accordance with LRGD Section 6.11.1.2) and Truck % = XX% (per 2018 NBI Datasheet).

6. ~~Per LRGD Section 17.2.1(#1), the reinforcing steel on the inside face of the exterior walls was increased until the culvert rating was above 1.00.~~ [*replaced with #7 & #8 below*].

7. In accordance with LRGD Section 17.2.1(#1) and the March 2020 Culvert Guidance Document, the (top slab/bottom slab/wall) reinforcing steel was increased and/or the (concrete/reinforcing steel) material strength was increased until all legal load rating factors were greater than 1.0.
   Summary of changes:
   a. Spacing of ( ) bars in the culvert (exterior wall) was decreased from X" shown on the plans to X" in the BrR model. This represents a X% increase in steel area.
   b. Concrete compressive strength was increased from X ksi shown on the plans to X ksi in the modified BrR model.
   c. Reinforcing steel yield strength was increased from X ksi shown on the plans to X ksi in the modified BrR model.

8. This culvert is under deep fill and does not need to be load rated for live loads per MBE Section 6A.5.12.10.3a. In accordance with LRGD Section 17.2.1(#3), the reinforcing in the (top slab/bottom slab/wall) was increased and/or the (concrete/reinforcing steel) material strength was increased such that the culvert capacity overcame the permanent

load effects. The rating file is only to be used for inputting into the SCDOT automated permitting system.

Summary of changes:

a. Spacing of ( ) bars in the culvert (exterior wall) was decreased from X" shown on the plans to X" in the BrR model. This represents a X% increase in steel area.
b. Concrete compressive strength was increased from X ksi shown on the plans to X ksi in the modified BrR model.
c. Reinforcing steel yield strength was increased from X ksi shown on the plans to X ksi in the modified BrR model.

9. The resulting HL-93 LRFR ratings in the modified BrR model are 0.0. Since the LFR ratings in the modified model are all passing, in accordance with Help Desk notification #58 and the March 2020 Culvert Guidance document, NBI items 64 & 66 are coded as 1.0.

10. Due to limitations in BrR, reinforcement for truss bars in top and bottom slabs were input as straight bars with lengths equal to true straight lengths plus half the distance of the inclined section of the truss bar. Ends were considered fully developed at transition points between top and bottom bars. Additionally, a straight, fully developed, bar equal to the horizontal dimension of the bend was input midway between the top and bottom straight bars at the corner locations.

11. The weight of the rail was not included in the analysis as the rail falls outside of the traveled way.

12. The thickness of the top slab varies from X" to X" from the edge of the culvert to midspan. An average thickness of X" was used in BrR.

13. According to plan sheet no. X, the fill height ranges from X' to X'. Analysis was performed for both fill cases. The asphalt wearing surface was assumed to be 6" thick and was included as part of both fill cases in BrR.

14. As per the (Month DD, YYYY) site assessment, the average fill height across the culvert is approximately X'. The asphalt wearing surface was assumed to be 6" thick and was included as part of the X' fill depth in BrR.

15. According to the (Month DD, YYYY) inspection report, there is a New Jersey median barrier along the centerline of the roadway. Due to limitations in BrR, this load was accounted for as an increase to the wearing surface thickness. See Excel calculations for further information.

16. Based on the (Month DD, YYYY) inspection report, and the (Month DD, YYYY) site assessment, there is no deterioration to warrant a Deteriorated structure model in BrR. The exposed [*or deteriorated if IR/SA mentions it was deteriorated*] rebar at the inlet face was not included in the analysis as the location falls outside the traveled way.

17. While BrR produces an error message in the analysis progress window, the rating of the culvert successfully runs to completion. Inspection of the detailed output file for the exterior wall at the locations noted show no error. The issue in BrR has been reported for investigation.

18. Based on the (Month DD, YYYY) site assessment, the following deterioration was applied to the culvert:

Barrel	Bar Mark	Section Loss	As-Built Spacing (in)	Equivalenting Deteriorated Spacing (in)	Description
2	G3	10%	18.00	18.68	4 exposed bars in the left wall
3	A3	10%	12.00	12.31	4 exposed bars in the top slab

Notes:

- Due to limitations in BrR, this deterioration is accounted for by adjusting the typical bar spacing (as shown in the table) rather than by applying a reduced bar area.
- No section loss was indicated in the site assessment. A 10% section loss was assumed.
- The site assessment provided multiple areas of similar deterioration. The worst-case deterioration was used.
- Bar Mark A3 refers to the bottom portion of the truss bar “A”.