Associated Engineering | GLOBAL PERSPECTIVE. LOCAL FOCUS.

TECHNICAL MEMORANDUM

Issue Date:	October 31, 2022	**File No.:**	2021-3190-00
To:	Barry Kolenosky, CAO	**Previous Issue Date:**	N/A
From:	Sydney Reinbolt, M.Eng., P.Eng.	**Project No.:**	2021-3190
Client:	Municipal District of Lesser Slave River No. 124		
Project Name:	BF71600 - Athabasca River Bridge		
Subject:	Load Rating		

1 INTRODUCTION

The Municipal District of Lesser Slave River (MDLSR) retained Associated Engineering (AE) to complete a Bridge Assessment of Bridge File (BF) 71600, located on Range Road 11A over the Athabasca River (NW 23-70-01-W5M). As part of the assessment, a site inspection to verify the existing condition and a load rating were completed. AE completed a site visit on July 12, 2022, photos taken during the site visit are included in **Attachment 1**.

2 EXISTING BRIDGE

BF 71600 was constructed in 1945 and consists of 3 - 8.5 m timber spans on the south end, 1- 4.9 m steel span on the north end, and three steel truss spans with an interior span arrangement of 61.0 m - 76.2 m – 61.0 m totaling to an overall length of 229 m on concrete piers. The bridge accommodates a single lane with a clear width of 5.5 m and a height restriction of 4.4 m. The bridge is located on a local road over the Athabasca River (NW 23-70-01-W5M) and serves as an alternate route to the Town of Slave Lake 55 km north of the Hamlet of Smith. BF 71600 was identified for load rating assessment due to most recent BIM reports indicating several components with severe damages requiring either replacement or repair.

3 BRIDGE CONDITION

Several existing steel truss members have been damaged. The main impacted elements are the portal struts located at the entrance of the trusses in both directions and the cross bracing. The damages are most likely a result of high load damage from vehicles driving on the bridge unaware of the load clearance, striking the elements causing them to bend and crack. Minor impacted elements were recorded in verticals, diagonals, end post, bottom chord and strut members. Minor damages are likely caused by deterioration over time. The damaged members found in the UT report are as listed in **Table 3-1**.

Table 3-1
Damaged Truss Members

Span	Member	Damage
Span 4	L0U1W	Two 20 mm notches
	U5L5E	40 mm crack at cross bracing connection
	Portals	High Load Damage
	L2L3E	Bent - 30 mm
	U7L6E	3 mm crack at U7
	U5U5	Bent
Span 5	U8L8E	Bent - 25 mm x 500 mm
	U9L9E	Bent - 20 mm
	Portals	High Load Damage
Span 6	Portals	High Load Damage
	U9L10WE	Cracked Wedge Washers
	U3L3	Bent
	U2U2	Bent
	U3U3	Bent

The damages found in the trusses during the July 12, 2022, site visit confirmed the findings listed on the UT report by AECOM dated July 6, 2020. Furthermore, the status of the top deck planks and wheel guard based on the BIM report dated July 6, 2020, were confirmed. It was noted that the curb edge has worn out, and the guardrail at the north entrance of the bridge is damaged.

A review of the available record information confirmed some truss members have been replaced or strengthened. Some of these members are: the portal struts and the stringers.

4 GENERAL ANALYSIS CONSIDERATIONS

The load rating was conducted based on the requirements of the Alberta Transportation Bridge Load Evaluation Manual Version 1.1 (BLEM) and the Canadian Highway Bridge Design Code S6-19 Section 14 (CHBDC).

4.1 Rating Procedure and Assumptions

The following assumptions and clauses were used for the evaluation:

- Evaluation was carried out based on the ultimate limit states using load and resistance factors as per Clause 14.5.3.2 of CHBDC.
- Material strength was assumed based on the date of bridge construction in accordance with Clause 14.7.4 of CHBDC
- Shrinkage, creep, bearing frictions, wind loading, temperature and settlement differential were not considered in the evaluation of the ultimate limit states. Wind was considered when checking the damaged portal frames and bracing.
- The bridge is considered a “One Trucked Bridge” allowing only 1 vehicle on the bridge at a time.
- No exceptional loads are expected for this bridge.

During the initial analysis diagonal member U7L6 on the east truss of span 4 was removed from the model due to the damaged condition of the member, however, this made the model unstable and increased the loading on other members to an unreasonable amount. Therefore, the load rating is based on the assumption that U7L6 will be replaced.

4.2 Load Rating Vehicles

The bridge is currently rated for a single unit truck at 32.0 tonnes, a double unit truck at 45.0 tonnes, and truck train at 64.0 tonnes.

The load rating vehicles will be the BLEM standard non-permit evaluation vehicles: 28.0 tonnes CS1 truck, 49.0 tonnes CS2 truck, and 63.5 tonnes CS3 truck as stated in Clause 6.1.

4.3 Load Factors

The live and dead load factors were determined based on the appropriate target reliability index for each component of this bridge structure. The dead load factors are as per Table 14.6 of S6-19. The live load factors are as per Table 14.7 of S6-19.

4.4 Target Reliability Index Resistance Modification Factor

The target reliability index was calculated using a system factor, inspection category, and element behaviour category based on the information available and engineering judgment.

The system factor for the truss system is S1, as it is a two-truss system. The stringers are considered S3 and the cross beams are considered S2.

The inspection level is a judgement of how often and how well the bridge can be reviewed for deterioration that could affect its structural capacity. The latest BIM report and ultrasonic testing report from 2020 and the AE site inspection from 2022 were used to evaluate the condition of this bridge. Therefore, an Inspection Level 2 (INSP 2) was used.

The Element Behaviour Category used for the stringers and cross beams in bending is E3 in all instances.

The Element Behaviour Category for truss members in compression or net section tension is E1, for truss members in bending, shear, or gross section yielding is E3.

Table 4-1 summarizes the target reliability indexes used.

Table 4-1
Target Reliability Index

Truss Member	System Factor	Inspection Level	Element Behaviour	Target Reliability Index
Top & Bottom Chord	S1	INSP2	E1	3.75
Cross Beams	S2	INSP2	E3	3.00
Stringers	S3	INSP2	E3	2.75

4.5 Structural Steel

This bridge was built in 1945. The structural steel grade was not specified on the drawings, therefore the historical steel grades used from BLEM Section 4.1 Table 1 were used. The material properties used for the load rating were: yield strength of 230 MPa and an ultimate tensile strength of 420 MPa. The replaced/strengthened members listed a steel yield strength of 300 MPa.

5 SUMMARY OF RESULTS

The Live Load Rating Factor (LLRF) for the all the truss members checked is greater than 1.0 for all failure modes considered, except the stringers in bending. As shown in Table 5-1 the stringers have an LLRF of 0.84. Therefore, the repairs listed in Table 5-2 should be completed and the bridge should be load restricted to the following loads: CS1 (23.5 tonnes), CS2 (41.1 tonnes), and CS3 (53.3 tonnes).

Table 5-1
Live Load Rating Factor at Critical Locations

Truss Member	Live Load Rating Factor (LLRF)			
	Tension	Compression	Shear	Moment
Stringers	NA	NA	1.71	0.84

Table 5-2
Recommended Repairs for Damaged Members

Span	Damaged Member	Recommendation
Span 4	L0U1W	No repairs required
	U5L5E	Repair weld at cross bracing connection
	Portals	No repairs required
	L2L3E	No repairs required
	U7L6E	Replace
	U5U5	Replace
Span 5	U8L8E	No repairs required
	U9L9E	No repairs required
	Portals	No repairs required
Span 6	Portals	No repairs required
	U9L10WE	Replace cracked washers
	U3L3	No repairs required
	U2U2	No repairs required
	U3U3	No repairs required

6 RECOMMENDATION

It is recommended to implement the load rating of CS1 (23.5 tonnes), CS2 (41.1 tonnes), and CS3 (53.3 tonnes) on the bridge with appropriate signage for the load restriction and the One Trucked Bridge restrictions. It is recommended to complete the following repairs until the bridge can be replaced: replace span 4 members U7L6 and U5U5, repair the connection weld on span 4 U5L5E, and replace damaged and missing connections throughout.

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The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Attachment 1 – BF71600 Photosheet

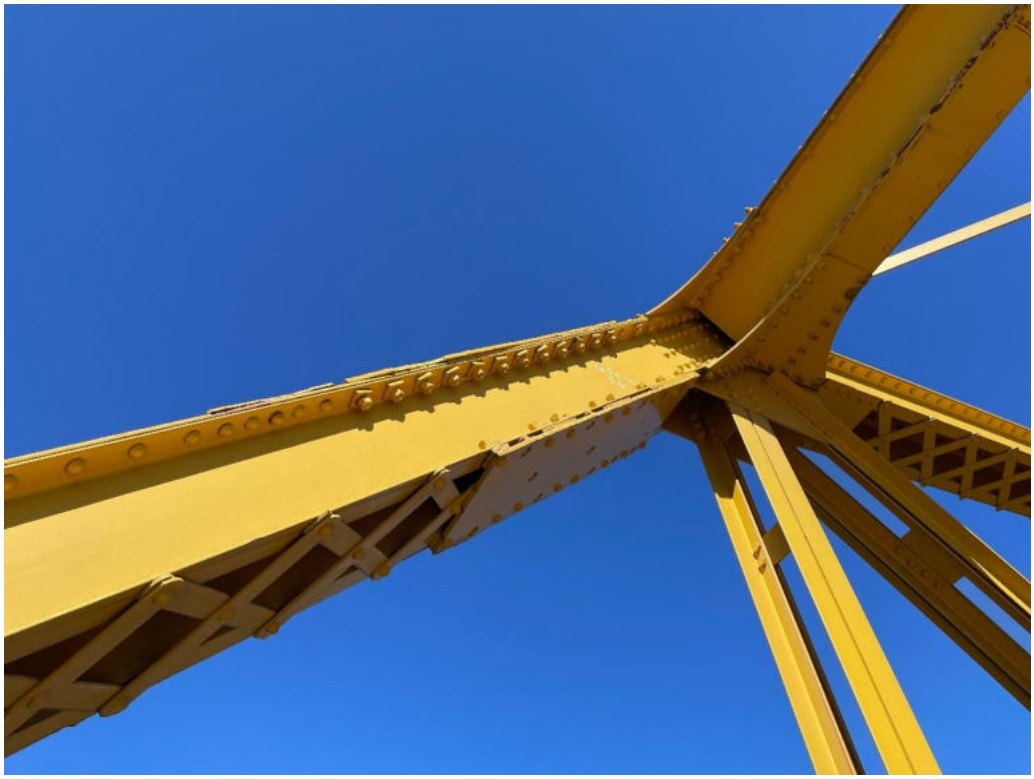
1. S6 - U1U1 damaged

2. S6 – U2U2 damaged

3. S6 – U3U3 damaged

4. S6 – L3U3 damaged

5. S6 -U9U9 damaged



6. S6 – U9L10 W damaged

7. S6 – U9L10 E damaged

8. S5 – U1U1 E damaged

9. S5 – U11U11 E damaged

10. S5 – L8U8 damaged

11. S5 – L9U9 damaged

12. S4 – U1U1 damaged

13. S4 – U5U5 damaged

14. S4 – U5L5 E damaged

15. S4 – L6U7 E damaged

16. S4 – U9U9 damaged