High Level Bridge Feasibility Study and Conceptual Bridge Modification Strategy Report

Structural Feasibility Study for Multi-Modal Usage Improvements on High Level Bridge

Prepared for:
City of Edmonton

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Executive Summary

Scope of Work

In May 2017, the City of Edmonton retained Stantec Consulting Ltd. (Stantec) to perform a concept level feasibility study and bridge modification strategy assessment of High Level Bridge (HLB) for a limited number of potential modifications for multi-modal usage, as follows:

1. Widening of sidewalks on the lower deck to 4.2m clear width (Option 1);
2. Addition of two (2) LRT tracks and two (2) 4.2m wide Shared Use Paths on the top deck (Option 2);
3. Combination of both scenarios 1 and 2 (Option 3).

A review of the feasibility of widening the south approach sidewalks to accompany these scenarios was also included in the assessment, and all options were considered such that the existing vehicle travel lanes on the lower deck will be maintained. Limited inspection and analysis was provided only to support conceptual level findings and costing.

Background

Opened in 1912, the HLB is a relatively complex structure, with two deck levels, numerous span and truss configurations, and a variety of substructure components. There are over 5,000 individual steel members in the structure and a thousand different member sizes and configurations, with a long history of modifications. When the City of Edmonton took over the HLB from CP Rail, the bridge required major rehabilitation to be able to carry the desired roadway and pedestrian loads (with railway removed). Main truss members had serious loss of section and required strengthening or replacement, the road deck required full rehabilitation, and the entire structure required re-coating. In 1995, to extend the life of the structure to 2045, many main truss and pier bent members were strengthened or replaced and most the structure received a new coating, requiring removal of the original lead based paint; remaining parts did not have the coating removed at all. Upper deck steel members had reached their theoretical fatigue life, governing what possible future loadings could be considered on the upper deck.

Overall condition of the structure, including corrosion and loss of section of the steel members remains a serious concern since so much of the structure has lost strength. The coating is no longer protecting the steel in some areas; some of the connection plates have deteriorated due to section loss, and pack-rust is bending the plates and weakening the connection.

It is important to note that 1995 strengthening work did not restore the capacity of the structure to support rail loading; past damage and the current condition of the structure will both affect the ability of the structure to carry any proposed new large load increases.

Summary of Findings

From visual inspection and thickness measurements, we estimate that the average section loss of truss members that was 44% in 1994 has increased by 5%, which is also true of upper deck railway stringers and floor beams (58% and 50% respectively in 1994).

1. **Option 1**

   - This option is possible from an overall truss load capacity perspective without strengthening truss members. However due to the large 4.2 m clear cantilever, major structural steel struts are required and we have significant concerns about the need for localized truss strengthening to support the consequent reactions. The option is considered **marginally feasible** but if an alternative can be found that does not involve excessive struts and local truss strengthening then that alternative should be considered [1].

   Concept level cost estimate $23.7m (in 2017 terms)[2]

2. **Option 2 (Option 3 similar)**

   - The load combination of two LRT tracks and wide Upper Deck SUP (Option 2 or 3) exceeds the total baseline service load for the substructure and superstructure by 26% and over 70% respectively. These are significant demands for a 100+ yr. old structure that has lost a significant amount of its capacity due to corrosion.

   - The load combination of LRT and Upper Deck SUP, with or without lower deck widening (Option 2 or 3) overloads the substructure such that all land foundations would need to be investigated and strengthened/underpinned. It is recommended that neither Option 2 or 3 is viable / **NOT feasible** for this reason.

   - The load combination of LRT and Upper Deck SUP, with or without lower deck widening (Option 2 or 3) overloads the superstructure such that about **50%** of all the truss members would need to be strengthened or replaced. We recommend that due to the extensive strengthening required to support the proposed loading, and given the age of the bridge, this option is not practical / **NOT feasible**.

   Concept level cost estimates are available for both Option 2 and 3 in Section 6.

[1] Widening the lower sidewalks will not meet capacity and separation requirements set out in TAC guidelines. Based on the volumes, separation of modes will be required to support expansion to the City's cycling network to HLB and allow safe operations

[2] Class D +/- 50%

Discussion of Risks of LRT on HLB[3]

1. **General Risk of Committing LRT to 100+ yr. old bridge.**
There is a general risk of committing new LRT lines to a 100+ yr. old bridge that has suffered serious corrosion and section loss prior to 1994, with some further deterioration since. Beyond capacity and strengthening issues for LRT loading, there are concerns regarding uncertain present and future corrosion and section loss, fatigue, and the ability of the structure to provide the desired service life. <u>Given this, we do not consider it prudent to invest large expenditures to modify the structure when future bridge closure or replacement may be required.</u>

2. **Achieving Desired 100 Year Service Life**
In 1995, the structure was rehabilitated with a desire to extend life by an additional 50 yrs. (i.e. to 2045). The current LRT Design Guidelines require a design service life of 100 years. i.e. 2130 if completed in 2030. This is a demanding requirement that is not practical for a 100-yr. old structure with existing damage due to corrosion, uncertain future deterioration, and fatigue issues. Given the City's current maintenance effort on HLB, a design life to 2045 is achievable for current loading, and there is margin of safety because the structure is not stressed to the limit under current loading. If the structure condition deteriorates, design (truck) loading can be reduced without impacting general use of the bridge. With nominal LRT loading the strengthened structure would be more highly stressed; the only option to reduce loads would be to restrict LRT loading, which is not desirable. <u>In our opinion the desired 100 yr. service life cannot be achieved with any certainty.</u>

3. **Increased Loading of Aging, Deteriorated, and Riveted Structure**
Constructed between 1906-1912, the HLB steel superstructure and pier bents comprise built-up steel plate members fastened with rivets, and riveted plates connect individual members. In 1995, deterioration of these connection plates was slowed using a corrosion inhibitor followed by coating of the entire structure. The extent of ongoing deterioration inside the connections is unknown (not visible); pack rust will build inside the connection, causing plates to bend, rivets to be overloaded, and the connection is in jeopardy. If this is not mitigated then very costly repairs consisting of removal and replacement with new plates and bolts will be required or loading must be reduced on the bridge.

   With heavy rail loading removed, loading on HLB is less than original and in 1995 only a few connections with visible severe section loss were replaced. With increased corrosion, and significant increase in loading, this assumption will not be valid; the consequences of connection failure can be serious. Together with corrosion and section loss in the rest of the structure, these are causes for concern when a large increase in load is considered on aging structure of this type. <u>Because of this, we cannot recommend a significant increase in loading on the bridge.</u>

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[3] For lower loads and non-dynamic loads, these risks are non-applicable or less severe.