**DRAFT MEMO**

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| To: | City of Toronto | Date: | October 31, 2016 |
| From: | MMM Group | Job No.: | 3216026 |
| Subject: | Glen Road Pedestrian Bridge Existing Conditions and Recommendations | CC: | |

## 1.0 BACKGROUND

MMM Group Limited (MMM), on behalf of the City of Toronto (City), is undertaking a Class Environmental Assessment on the Glen Road Pedestrian Bridge. The purpose of the study is to address the deteriorated condition of the bridge.

### 1.1 Structure Location

The Glen Road Pedestrian Bridge, constructed in 1973, carries pedestrian traffic from Bloor Street East, north over Rosedale Valley Road, to the south end of Glen Road in the City of Toronto, Ontario. For the purpose of this memo, the bridge is assumed to run in the north – south direction.

### 1.2 Existing Structure

The existing structure is a three span rigid frame steel structure comprised of an 89 mm deep laminated timber deck supported by two atmospheric corrosion resistant (ACR) steel plate girders, of variable depth. The girders are connected by hollow structural sections (HSS) used as transverse beams as well as lateral bracing. The substructure is comprised of two conventional concrete abutments and two steel inclined pier legs connected integrally to the girders. These legs comprised of built-up steel I-shaped sections of variable depth.

There are two 29.2 m end spans and one 48.8 m main span for a total deck length of approximately 107.2 m. The overall width of the bridge, including railings, is 3.7 m. The articulation of the bridge is fixed at the piers and free to expand at the abutments.

See Figure 1 below for a general view of the existing bridge's elevation looking east.

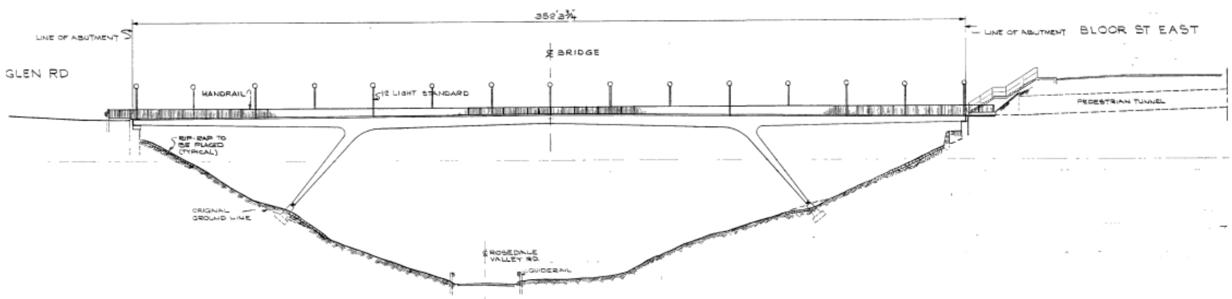


**Figure 1: West Elevation**

### 1.3 Rehabilitation History

The bridge was rehabilitated in 2002, which comprised the following works:

- replacement of the abutment and pier bearings;
- increasing the railing height to 1.375 m;
- localized girder web stiffening;
- localized bracing replacements;
- retaining wall repairs;
- replacement of concrete stairs;
- replacement of expansion joints;
- addition of intermediate stiffeners on the girders; and
- replacement of the timber deck at the abutments with precast deck slabs.

As a result of the inspection and evaluation completed in 2014, emergency repairs were performed in late 2014 / early 2015 to maintain the structure in a safe condition, and comprised the following:

- replacing the steel lateral bracing members (angles and channels) over the pier legs and also strengthening them with additional gusset plates bolted into the existing girder top flanges;
- strengthening existing deteriorated girder web stiffeners by welding additional plates to said stiffeners;
- strengthening existing deteriorated girder bottom flanges by bolting top and bottom cover plates at deteriorated locations;
- strengthening the pier legs by bolting additional web plates to existing web plates and by bolting additional angles at the web to flange connections;
- replacing corroded railing posts with new railing posts; and
- replacing sections of deteriorated timber decking.

The bridge was reopened to the public in January 2015.

### 1.4 2014 Structure Inspection and Evaluation

As a result of the findings during the 2014 biennial inspection of the structure, the structure was closed by the City and MMM was subsequently retained in June 2014 to undertake an enhanced inspection of the structural components and perform a structural evaluation of the bridge.  The following summarizes the findings of the inspection and evaluation.

The inspection of the bridge revealed substantial deterioration of various structural components.  There were cracks and perforations on the majority of the lateral bracing members and gusset plates connecting the pier legs, to the point that these members were not considered to be providing the required lateral support to the pier legs.

The lower 0.3 m of the girder webs above the legs was noted to have 20% - 30% section loss. The radial stiffeners at the pier to girder connections were severely corroded (50% section loss was estimated). The top and bottom flanges of each girder were covered with rust flakes up to 25 mm thick. Severe to medium section loss (greater than 10%) was noted in the vertical stiffeners, webs and bottom flanges.

The railing supports on the girder flanges had completely failed at over 50% of the support locations and posed a safety risk to users of the bridge.

It was noted during the inspection that the ACR steel used at this site had not developed the protective patina to mitigate progressive corrosion, and had resulted in the on-going corrosion of the structural steel members.

The structure was evaluated in accordance with Section 14 of the Canadian Highway Bridge Design Code (CHBDC), considering the deterioration at the time of inspection, including the loss of lateral bracing members between pier legs. The evaluation results indicated that the bridge had insufficient load carrying capacities in accordance with the CHBDC pedestrian loading, thus repairs were warranted.

## 2.0 STRUCTURAL DEFICIENCIES

MMM has an intimate knowledge of the structure and its prominent characteristics and concerns, as MMM has completed numerous inspections of the structure, an evaluation of the structure, detailed design for the emergency repairs, and administered the recent emergency repairs contract.

The emergency repairs completed in early 2015 were required in less than the typical 25-year span between rehabilitation cycles. This indicates that there has been some acceleration in the overall rate of deterioration of the structure.

Despite the emergency work, the bridge remains in poor condition, specifically:

- there is medium to very severe ongoing corrosion (with 20% - 30% section loss) on primary members (girders, lateral bracing members, gusset plates, and pier legs);
- the concrete retaining walls have localized areas of disintegration;
- the timber deck has localized areas in poor condition including splitting of the timber; and
- the existing ACR steel has not adequately developed a protective patina (which is imperative for the materials’ longevity).

In the absence of a tightly adhering, patina, already corroded primary members (composed of ACR steel) will continue to corrode, and in some cases, may exhibit accelerated corrosion rates. This ongoing corrosion will continually affect member capacities. For steel to form a tightly adhering patina, it must undergo alternating wet and dry cycles. Frequently humid / wet environments and the application of chlorides (such as de-icing salts) are detrimental to the formation of a patina.

Based on observations made on site, suitable environmental conditions are not present to develop a protective patina, and are summarized below:

- de-icing salts are applied to the bridge deck in the winter months;
- the deep valley with significant foliage surrounding the bridge provides a humid / wet environment; and
- the open-type wood plank decking permits water laden with chlorides to flow directly onto the steel members below. On typical highway bridges, runoff is directed into deck drains and away from the supporting members.

## 3.0 RECOMMDENDATIONS

Based on the repair works completed to date, the evaluation findings, and the current rate of primary member deterioration, the estimated remaining life expectancy of the bridge is 5 to 10 years (i.e. replace between 2020 to 2025), and a detailed visual inspection has been recommended every 12 months. Inspections will focus on the progressive corrosion in the main members and in the connection between bracing members and main members (girders and legs). The result of these inspections may warrant additional works / inspections if any significant deterioration is found, including additional emergency repairs and / or bridge closure.

As indicated in the paragraph above, the existing bridge is nearing the end of its service life. As the bridge continues to deteriorate, it is anticipated that rehabilitation work may be required, comprising the following:

- additional strengthening of locally deteriorated members by bolting or welding additional plates, angles, channels, stiffeners, etc. as required; and
- full replacement of members when local strengthening is not feasible due to the extent of ongoing deterioration (i.e. not enough material section to bolt / weld strengthening members to).

As indicated in Section 2.0, a 25-year span is typically expected between rehabilitation cycles. Since its construction in 1973, rehabilitations have taken place in 1999, 2001, 2002, and 2014. It is anticipated that the above noted rehabilitation will be required at progressively shorter intervals of 5-10 years or less until such a point that repairs to severely deteriorated primary members, such as the piers and girders, are no longer feasible. Moreover, the frequency of on-going maintenance is expected to increase.

In addition to the economic disadvantages of maintaining the bridge beyond its estimated remaining service life, additional impacts of more frequent rehabilitations /maintenance that should be considered include the following:

- Need for diversion of pedestrian / cyclist traffic;
- Impacts to TTC;
- Impacts to Bloor Street Traffic;
- Impacts to Glen Road Traffic; and
- Impacts to nearby residents.

Therefore it is MMM's structural engineering recommendation that the bridge be replaced as soon as planning and design can be completed and funding is available.

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