

## **QEW-Highway 403 at Ford Drive Bridge Repairs**

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This paper will describe the site inspection, preliminary and detailed design, construction, and post-construction monitoring for the repairs to 4 steel box girder bridges at a heavily trafficked freeway interchange west of Toronto, Ontario. These bridges were originally built in 1979. Each structure carries three lanes of highway traffic (36-45,000 AADT with 15% truck traffic) over a local road (Ford Drive). The bridges consist of simple 39.62 metre spans, each with three trapezoidal steel box girders. There was no external bracing between boxes, but internal x-bracing had been installed at 5 locations along each girder.

In the spring of 1999, a detailed visual and Non-Destructive Testing inspection was carried out inside and outside the box girders. This was a follow-up to a visual survey the previous autumn, which had discovered cracking in the webs of the girders. It was found that the webs had cracked through (up to 40% of their depth at the most severe area), and also along the web to bottom flange connection (up to 450 mm length), this at 119 out of 120 locations where an internal x-bracing angle connected to near the bottom of a web stiffener. The stiffeners were not connected to the bottom flange of the box girder. These details were commonly accepted and used in the 1970's & 80's. Neither were there any external K-frames between boxes. Finite element modeling was carried out in order to investigate distortion of the boxes under live loads, and secondary stresses. Several repair strategies were assessed in detail. It was found that very high out-of-planes stresses were occurring under truck loads, much exceeding the fatigue endurance limits for these particular details. A repair procedure was adopted to:

1. Install new internal k-frames located away from the damaged areas by one stiffener location, first providing a connection between the stiffener and bottom flange to reduce secondary bending stresses in the webs;
2. Cut out the internal x-bracing lines at the damaged web areas;
3. Carry out further NDT, drill crack arrest holes at damaged areas, prepare the internal and external surfaces for high-strength non-slip bolted repair assemblies;
4. Install repair plate assemblies, also restoring the web to bottom flange connection;
5. Install new external k-frames to reduce longitudinal bending stresses, further reduce secondary stresses in the webs, and reduce transverse moments in the concrete deck slab.

However all the design, detailing and repair works had to consider the very restricted non-negotiable conditions/requirements as follows:

1. The QEW and 403 highways were not allowed to close down at any time, as this is the only highway corridor to the US States in Southern Ontario.
2. Closing any lane on the QEW and 403 Highways was highly restricted. A maximum one-lane closure for a few hours in the night could have been permitted, but only if it was deemed absolutely necessary for the repair construction work. (Actually all repair works were carried out under "live traffic" without closures.)
3. The fatigue damage investigation, repair design, detailing, contract documents, contract tendering and repair construction works had to be completed in less than 6 months, before the cold winter arrived. There was a very serious concern that the cracks would extend to the bottom flange plates, and the bridges/highways would have to be closed down if the repair could not be completed quickly. During the repair work it was noted that several cracks had indeed grown since the inspection and design phase a few months earlier (**It was a bold, but well considered and determined engineering decision based on carefully examining/analyzing all the fatigue damage, to permit the bridges/highways to remain in service during the preliminary and detailed design and tendering period, and during the repair work.**)

The repairs were thus implemented from below and inside the boxes without closures to the QEW or Highway 403. They are designed to be permanent, replacing the damaged web areas, and enhancing the strength of the bridges with the introduction of additional bracing. The paper will include data from the MTO's work in carrying out post-construction strain gauge monitoring at these structures.



Photo: Cracks at one box girder web. Web to bottom flange connection was also cracked completely through



Photo: Typical new K-frame details



**Typical repair plate detail.  
Note the field weld connecting the New stiffener to  
the existing stiffener.**

Photo: Typical repair plate assembly inside box girder