Strengthening and Rehabilitation of Quesnell Bridge, Edmonton, Canada

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Summary

Quesnell Bridge (1968) in Edmonton, Alberta, Canada, is a six span, 315 m long bridge consisting of parabolic precast post-tensioned girders with a cast in place deck. Rehabilitation and widening of this bridge is part of City of Edmonton's Transportation infrastructure upgrading program. Initial investigations showed that girders would be deficient in shear capacity and serviceability stresses for the new Canadian 800 kN design truck load. The deck assessment determined that significant levels of corrosion existed in the reinforcing and that replacement of deck would also be required. The objective of this paper is to review the available options for strengthening including FRP fabric for shear strengthening, FRP plates for negative moment connection over the internal supports, and external post-tensioning for improving stresses. The results of the analysis that led to the selection of strengthening procedure and some of the issues complicating strengthening design are discussed.

Keywords: Bridge, rehabilitation, shear strengthening, external post-tensioning, FRP fabric, FRP plate, stress improvement, precast concrete, time dependent effects, differential shrinkage

1. Introduction

The Quesnell Bridge, Edmonton, Alberta, is a major river crossing that currently carries Whitemud Drive vehicle traffic and pedestrians over the North Saskatchewan River. As a result of significant traffic growth the City of Edmonton initiated the Whitemud Drive and Quesnell Bridge widening project and retained CH2M HILL as consulting team. The project required widening of the existing roadway for future traffic. The results of initial investigations showed that girders would be deficient in shear capacity and serviceability stresses. After studying different possibilities the option including deck replacement, strengthening of existing girders, and adding new girders for the new lanes was adopted.

2. Existing condition of super structure and strengthening options

The bridge is a six span structure, consisting of a 50 m single span, a three equal span continuous structure of 54.9 m and a two span continuous structure of 53.3 m and 46.6 m. Superstructure consists of ten lines of parabolic precast post-tensioned girders with a cast in place deck. Each of the girders has either nine or ten post-tensioning cable ducts. Between six to eight cables were post-tensioned before the girders were erected, with the remaining cables stressed after the deck was placed. The girders were typically found to be in good condition.

As part of our preliminary design both a two dimensional line model and a three dimensional grillage model were created for the bridge. Stresses at different stages were studied using a

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program that considers all of time dependent effects as well as construction staging. Our girder analysis determined that the existing girders were significantly deficient in shear for new loads. Girders were found to have adequate capacity in both ultimate positive and negative moment bending. However, the issue with the girders is related to the service stress condition, where significant lengths of the bottom flange of the girders go into tension with the new concrete deck and CL-800 design truck.

3. Selection of strengthening procedure

Girder strengthening options were investigated to find the best method to increase the girder shear capacity and also reduce or eliminate the tension overstress in the bottom flanges. Strengthening options considered include external shear stirrups, FRP fabric wrap shear strengthening, externally bonded FRP plates, and straight or draped external post-tensioning. The results of the study that led to the selection of strengthening method is summarized below and the procedure is shown in Fig.1.

Stress redistribution after deck removal - There was a concern of overstressing the girder and causing cracks over the internal supports at the time of old deck removal. Time dependent stress analysis showed that this was not an issue and stresses in the girders and closure sections over the internal supports would be within acceptable limits.

Strengthening for stresses at service - Results of stress analysis showed high tensile stresses at the bottom of girders due to new loads at service. External post tensioning was considered for improving stresses. Finding a place to anchor external post tensioning was a challenge as most of the girder space was occupied by existing cables. After studying different profiles, straight profile slightly above the bottom of girders and anchored at lower parts of end blocks was chosen.

Continuity at internal supports during deck pour - It was found beneficial to maintain the continuity over the internal supports during slab pour as it would reduce tensile stresses at the bottom of the girders. Existing system relies on deck slab reinforcement for moment continuity and there are no negative moment connections or post tensioning through the girders over the supports. Externally bonded FRP plates on top of the girders were selected to provide negative moment connection at construction stage.

Differential shrinkage - Shrinkage of new slab would be resisted by the old girders and this would cause tensile stresses both in the new slab and bottom of the girders. Using a special mix design for slab concrete and enhanced curing were considered as options to reduce tensile stresses.

Selection of deck and wearing surface system - Due to extensive corrosion in deck slab it was decided to replace the existing slab. A number of different deck slab and wearing system were considered. Stress analysis showed that there will be tensile stresses in the deck slab that could cause cracking. The conclusion was to use a cast in place concrete deck slab with an asphaltic membrane system and 80 mm asphalt wearing surface. According to past experience this would provide a good protection for girders in case of cracking of deck slab.

Shear Strengthening - Girders were found to be deficient for shear capacity under new loads. Applying CFRP wraps on the web and around the bottom flange was selected for strengthening. Two layers of horizontal wraps at top and bottom of the straight part of the web were used to help with anchorage of vertical layers and prevent pulling out due to tension at top of the bottom flange.

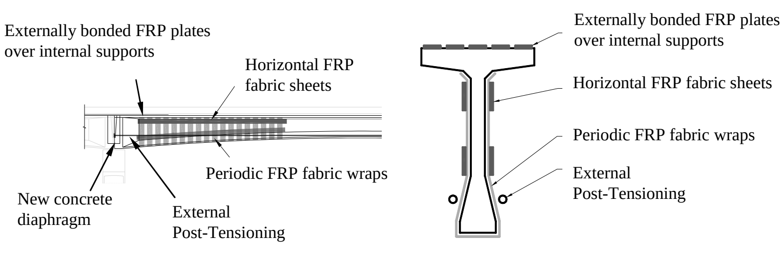

Fig. 1: Selected strengthening procedure for Quesnell Bridge.