LESSONS LEARNED FROM THE NAIRN AVENUE OVERPASS CONCRETE GIRDER & PIER REPAIRS

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1. ABSTRACT

The Nairn Avenue Overpass is a 213 m long, 11-span, 4-lane + sidewalk precast prestressed concrete I-girder bridge over the CP Keewatin Subdivision line in Winnipeg, MB. The superstructure consists of three continuous segments with deck joints at piers #3 and #8. The structure was built in 1967, and underwent major strengthening and rehabilitation of the deck, girders, and bearings in 1985. Piers consist of a cast-in-place pier cap approximately 18 m long supported on two cast-in-place columns approximately 7 to 8 m tall supported on concrete pile caps over timber raft-pile foundations.

Leaking omega-style strip seal deck joints at Pier #3 and Pier #8 have exposed the piers and girder ends to chloride contaminated run-off from the deck. In 2002, the pier caps were re-faced on three sides and provided with galvanic anode cathodic protection, and the pier columns received local patch repairs only.

In 2014, during a deck rehabilitation project that included rehabilitating the deck joints, Morrison Hershfield (the Consultant) noted significant deterioration of pier column concrete including staining, moderate-to-severe cracking and localized spalling. The Consultant was subsequently engaged by the City of Winnipeg (City) to conduct a field investigation to quantify the degree of deterioration, evaluate alternatives, and undertake design and construction administration of the preferred solution. This presentation describes these steps, and lessons learned from the Contractor, Consultant, and Owner’s perspective.

Keywords: bridge, construction, rehabilitation, concrete, galvanic

2. PROBLEM INVESTIGATION & QUANTIFICATION

In Fall 2014, the Consultant undertook a complete condition assessment of the two piers (#3 and #8). The investigation program included: a visual inspection following the Ontario Structure Inspection Manual (OSIM), a complete concrete cover survey, delamination survey, half-cell corrosion potential survey, local demolition and repair to obtain sample measurements of steel reinforcement cross-section loss, and two concrete cores per column in order to visually assess the condition of the concrete with depth and obtain water soluble chloride profiles. It was determined that 30-50% of each column’s fascia was in poor condition visually, 25-40% of each column’s surface area had delaminated, and the area of delamination included the majority of concrete patches applied during the 2002 rehabilitation. The probability of reinforcement corrosion based on ASTM C876 standard half-cell ranges was greater than 90% on over 90% of one pier column, and over 50% of the three remaining pier columns. Chloride profiles indicate that chlorides had penetrated beyond the vertical reinforcement in all four columns. Section loss on tie bars and longitudinal bars ranged from medium to severe. The pier caps, which had been rehabilitated in 2002 were in visually good condition. The elastomeric bearings were in fair condition, with surface corrosion of steel parts, but remained functional. Local concrete spalling was noted on girder and end diaphragm soffits.
3. REHABILITATION RECOMMENDATIONS

To address the pier deterioration, recommendations were made to remove the source of the chlorides. The deck joint seals had been replaced in 2014, which included in-situ refurbishment of expansion joint hardware to obtain a tighter seal. In the present rehabilitation program (2015), chloride access to the pier columns was further reduced by drainage improvements including drip edges and extending the deck drains down to the existing grade to prevent salt spray on the piers. Recommendations were also made to address minor maintenance items, including performing local patch repairs to the girders and end diaphragms and renewing galvanic protection of the bearings. Additionally, as the service life of the pier cap galvanic protection was nearing the end of its useful life, hot applied spray-on zinc cathodic protection was applied to both the pier cap and at local patches of the girders and end diaphragms.

The City’s initial criteria for the project included that there to be no restrictions on bridge traffic and for there to be no use of costly supplementary shoring. This limited the extent of permissible column concrete removals to the outside face of the longitudinal reinforcement to avoid compromising the column capacity. Pier column renewal with a reinforced concrete jacket using self compacting concrete was recommended based on condition thresholds for delamination and corrosion potential in the MTO Structure Rehabilitation Manual. A load evaluation performed by the Consultant demonstrated significant reserve capacity in the columns which, coupled with the robust configuration of existing column ties and the soundness of concrete observed at the surface (Schmidt hammer tests) and at depth (concrete cores), provided sufficient confidence to perform the concrete cover removals over the entire column height without face-by-face staging. This also allowed pouring each stage of the column jackets around the full perimeter of the columns. Three alternatives for cathodic protection of the pier columns were considered to further extend the service life of the rehabilitation, including hot-applied spray-on galvanizing, chloride extraction, and chloride mitigation by long-life embedded zinc anodes. This last alternative was selected on the basis of a comparative evaluation. A monitoring system was installed at one zinc anode location to aid the City in the future in determining when the useful life of the embedded zinc anodes has expired. The rehabilitation was successfully completed in September 2015 and is expected to extend the life of the rehabilitated pier columns by 25 years.

4. CONSTRUCTION

The project was tendered in April 2015 and Vector Construction Ltd. was the successful proponent at a capital construction cost of approximately $0.5M. The critical path for construction was relatively sequential, including: concrete removals; scaffolding erection; sandblasting; rebar placement; embedded anode placement; modular form placement; stage 1 (lower half) concrete pour & curing; modular form relocation; and stage 2 (upper half) concrete pour & curing. The project was completed in October 2015 on schedule and on budget.

5. LESSONS LEARNED

The Owner, Contractor, and Consultant discussed challenges and lessons learned from this project.

1. From the Contractor’s perspective, unexpected conditions were the primary challenge. Site runoff management implemented early in the work would have avoided several rainfall flooding events which impacted the schedule and required some galvanic anodes to be replaced. Existing pier column reinforcement was extremely dense and was not placed as expected, which caused challenges for the selected prefabricated form system. For future work, the Contractor would consider site-fabricated forms and would consider pouring the concrete jacket pour in a single stage, for schedule savings.

2. From the Consultant’s perspective, unexpected conditions and material quality management were the primary challenges. Providing additional thickness in the original design of the concrete encasement may have alleviated some of these issues. Due to the lack of supplementary shoring, tight monitoring of the condition of existing reinforcement was required, and supplementary confinement steel was added to maintain confidence in column performance during construction where existing column ties showed excessive section loss once exposed.

3. From the Owner’s perspective, the project had overall positive outcomes, and the asset management considerations were met. The intervention was correctly timed as the rehabilitation at the two damaged piers provides a meaningful life cycle extension for the entire substructure of the bridge. Regular expansion joint maintenance is important to limit chlorides that may pass to the substructure. The monitoring station for the embedded cathodic protection provides a useful asset management tool for the City to plan future rehabilitations. Lastly, clear & prompt team communication and collaboration was key to the project’s success.