The Pattullo Bridge Emergency Repair

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Abstract

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The Pattullo Bridge was completed in 1937, and serves as a major link between the communities of New Westminster and Surrey in the Metro Vancouver Area, carrying up to 70,000 vehicles per day, which is a significant portion of all traffic crossing the Fraser River. During construction of the bridge 3 timber spans were added to the Surrey end in place of 18m of granular embankment due to the excessive settlements experienced during construction. In 2007 TransLink identified the timber spans as requiring replacement due to their age, condition and susceptibility to fire damage, and had hired Buckland & Taylor in early 2008 to prepare a design for their replacement.

On January 18, 2009 the timber spans were destroyed by fire, completely closing the bridge to all traffic (car, truck, pedestrian and cyclist) and disrupting the movement of goods and people throughout a large portion of the Metro Vancouver area. Post-fire demolition and disposal of the structure was complicated by the fact that the timbers were treated with creosote, and that the asphalt wearing surface of the bridge was potentially asbestos containing. Within 8 days of the fire the damaged timber structure was demolished, and a replacement structure was located, re-engineered, modified, installed and opened to traffic through the hard work, cooperation of numerous stakeholders and dedication of the Owner, Consultant and Contractor.

Introduction

The Pattullo Bridge design was completed by W.G. Swan in 1935 as a depression era stimulus project for the British Columbia Department of Public Works. The bridge was initiated to replace the use of the adjacent double decked swinging truss bridge which was shared with the railway. Construction was undertaken between 1935-1937 by the Dominion Bridge Company. Serving up to 70,000 vehicles per day, the bridge spans between New Westminster and Surrey British Columbia and is one of only four crossings of the Fraser River. Ownership of the bridge was transferred to the South Coast British Columbia Transportation Authority (TransLink) in 1999.

The original design initially called for a total of 9 steel truss spans varying in length from 200' (60.9m) to 450' (137.2m) and 23 concrete spans varying from 58'-8" (17.9m) to 104' (31.7m). The total length was originally to be 4008 ft (1221.6 m). The bridge cross section consists of four 10ft (3.0m) traffic lanes and a single 6ft (1.8m) sidewalk on the downstream side.

A number of changes occurred during the course of construction; however, of note to this paper was the change to the south approach. The initial design called for a granular embankment to extend to the final cantilevered span of the concrete spans at the south end of the structure. However, this region is noted for the presence of highly compressible soils and during construction of the approach roadway and embankment significant settlement occurred. Three timber spans were constructed in place of a section of the embankment (Figure 1). Timber was chosen as a method of light weight construction in order to mitigate the loads on the approach soils, and reduce future settlement. Additionally the timber spans had the advantage of being tolerant of differential and total settlement, and also of being relatively easy to shim when required.

The timber structure was composed of three spans of 19' (5.8m). There was approximately 7" (175mm) of asphalt surfacing over two layers of timber decking. The most recent drawings called for an upper layer of 2 ¾" x 11" (70mm x 280mm) biased decking and a lower layer of 4 ¾" x 11" (120mm x 280mm) transverse decking. The design also called for 8" x 22" (200mm x 560mm) floor stringers on 3' (914mm) centres: however these were supplemented at a later time by 6" x 16" (150mm x 406mm) stringers between each original stringer. The stringers are supported on an upper cap beam, supported in turn by posts and a sill beam. The sill beams are in turn supported on timber bearing blocks.

Over the years numerous repairs have taken place to the timber spans including several repavings, and shimming of the spans. The structure has also been re-decked several times, and as described above additional stringers have been installed. In addition the sidewalk on the timber spans structure had been widened. Settlement records indicate that in excess of 600mm of settlement has occurred in some locations at the timber spans since construction.

Previous Work

In 2006 Sandwell Engineering was retained to develop a preliminary design for the rehabilitation and seismic upgrade of the entire Pattullo Bridge. As part of this work a live load rating was performed on the timber structure indicating that if "in good" condition the structure would have sufficient capacity for CL625 loads. However, a condition assessment was also performed which noted deterioration of the spans.

Coinciding with the preliminary design was the initiation of a corridor study to evaluate the future traffic demands and needs for the Pattullo Bridge corridor and to evaluate potential replacement options of the bridge. Detailed design of a major rehabilitation of the Pattullo Bridge was to be deferred until the Corridor Study was completed, in order to best determine the required life cycle for the work.

However, in late 2007, the decision to proceed with the design and procurement of a replacement for the timber spans was approved, regardless of the results of the corridor study, due to the condition of the spans and the requirements for ongoing repairs to the spans to meet even the earliest estimated bridge replacement timelines. Additionally, the vulnerability of the structure to fire, and the challenges with securing the area spurred the decision to replace the structure. Buckland &Taylor Ltd were retained to evaluate replacements options and to prepare a detailed design on the preferred option. The terms of reference included a requirement to meet TransLink's desired construction window, a maximum48-72 hour total closure of the bridge occurring over a weekend.

Buckland & Taylor were provided with historical information related to the existing structure and preexisting geotechnical investigative and interpretative work in the corridor.

Buckland & Taylor's conceptual report outlined three potential replacement options. The first was an in-kind timber replacement structure. While this option addressed the structural condition issues it was dismissed as it did not address the issues related to fire susceptibility. The second was a prefabricated bridge structure supported on micro piles at one end and a spread footing at the other. This option addressed the technical issues, but was dismissed due to the uncertainty related to the installation of the micro-piles. The third option was a structure supported by extruded polystyrene (EPS). This was the preferred option, due to the minimal change in ground loading and the flexibility of the structure as a whole in terms of future settlement. Detailed design was commenced on the EPS structure and was nearing completion.

The Fire

On Sunday January 18, 2009 at approximately 2:52am a call was received by emergency services, indicating that the Pattullo Bridge was on fire. Police and Fire responded at approximately 3:00am, by which time the three timber spans were fully involved.

TransLink staff was notified at 3:30am and were on site by 4:15am. At this time Fire services had not yet begun fully suppressing the fire due to the presences of electrical conduits. The conduits were de-energized and more aggressive fire suppression was initiated.

The Fire was extremely difficult to extinguish due to the congestion of timber and creosote treatment and reignited several times in joints and behind splice plates. TransLink managed to get a close proximity inspection at approximately 6am. At that time visibility was poor due both to smoke and thick fog. A further inspection was required at first light to conclusively evaluate the damage to the structure. Further to the second inspection, the structure was noted to be damaged beyond repair with significant section loss occurring in several members (Figures 2 & 3).

Buckland & Taylor were contacted shortly after 9am and asked to attend the site to make a second independent assessment, and to discuss recovery options. They arrived on site shortly after 10am and agreed with TransLink's assessment of the structure's condition. At this time discussions began in relation to a permanent or temporary repair. Unfortunately, the nearly completed EPS design could not be used, as EPS requires a long lead time to procure, and would potentially hold up the repair by many weeks. During that later part of the morning several suppliers were contacted to determine what, if any, bridge components were in stock. Of all of the suppliers contacted, Surespan Contracting Ltd. (Surespan) appeared to have something in stock that would work. At this time it was estimated that 4-6 weeks would be required to replace the timber spans.

On Sunday afternoon, a meeting was set up with affected stakeholders including representatives from the cities of Surrey and New Westminster, Emergency Services, the British Columbia Ministry of Transportation and Infrastructure, and TransLink's subsidiaries Coast Mountain Bus Company and British Columbia Rapid Transit Company. At the meeting action plans for dealing with the traveling public including modifying existing transit services and modifying counter-flow operations on other structures were discussed. Furthermore the decision to demolish and replace the structure was confirmed and put into action.

The decision to demolish the structure was further confirmed as the correct course of action when the smoldering timber spans reignited in the early morning hours on Monday, more than 24 hours after the fire started.

Technical Solution

The selected replacement structure that Surespan had in their yard was originally used as a temporary bridge for the Canada Line Rapid Transit Project then underway in Vancouver. The structure in its original configuration consisted of 3 parallel unconnected structures. Each of these structures was designed as a 70' (21.3m) span, and was designed to support CL625 truck loading in a non-composite configuration, and L165 (150 tonne) Off Highway Logging Truck loading in a composite configuration.

Each span consisted of twin steel plate girders spaced at 3.6m. The girders supported 7 - 3m long x 4.8m wide crowned pre-cast reinforced concrete deck panels. The deck panels were attached by a clip retainer system for use for use in CL625 configuration. Traffic on the temporary installation at 41st and Cambie in Vancouver ran on the exposed concrete panel surface. The girders were supported on unreinforced elastomeric bearings which in turn were supported on pre-cast reinforced concrete footings.

For use at the Pattullo site the structures required numerous modifications including:

- Shortening of the girders by 3m,
- Removal of three of the twenty one deck panels,
- Installation of shear studs,
- New bearing plates,
- New stiffener plates
- Fabrication of an edge beam for the edge adjacent to the existing bridge
- Fabrication of new cap beams
- Fabrication of taper bearing plates
- Installation of an asphalt overlay

A piled foundation was selected for the new structure to minimize the potential of future settlements. Six 610 x12mm open ended pipe piles were driven at each end of the span (effectively one per girder end). Based upon the previous geotechnical investigations a granular layer was expected at approximately 20m below ground, and an estimated total length of 35m per pile was required to develop the require axial capacity for the new structure.

The piles were filled with concrete and capped with a steel plate. Two wide flange beams were placed side by side to act as a cap beam between piles and bearing assemblies were welded to the cap beams to support the girder and deck.

Demolition

As mentioned previously, the asphalt wearing surface on the timber spans was potentially asbestos containing. A specialized contractor (Enviro-vac) that had previously been retained to demonstrate the effectiveness of a non-standard pavement removal method was brought in to undertake demolition of the fire damaged timber spans. To maintain the non friable nature of the asbestos the asphalt needed to be scraped and removed intact, rather that being ground from the deck. Contaminated asbestos material needed to be contained at all times, and all workers in the containment zone were required to wear special protective equipment (Figures 4 & 5). The creosote treated timber required less onerous handling; however, the two waste streams had to be separated as they had to be transported to two different disposal sites (Figure 6). Cross contamination of the waste would cause the waste to be rejected from either waste site. Demolition commenced in the late afternoon of Monday January 19, 2009 and was completed by Wednesday, however transportation of the contaminated material continued until the following morning (Figure 7).

Design

Concurrently with the start of the demolition, TransLink and Buckland & Taylor met with Surespan to discuss the proposed structure, included contractual arrangements and the necessary modifications. Late Monday, Buckland & Taylor and TransLink made a visit to the yard were the structure was being stored to inspect the condition of the components. Once the decision was made to proceed with the Surespan structure, meetings were held multiple times daily to discuss design and fabrication issues. The pile design was completed Monday afternoon, and piles were ordered Tuesday. Other modifications were designed, and sketches were supplied to Surespan over the course of Wednesday and Thursday. Throughout the duration of the construction, a representative of Buckland & Taylor was on site full time to ensure that there were no delays in responding to site conditions.

Construction

Surespan began mobilizing equipment and staff from various location across BC and the Yukon on Tuesday, with equipment and manpower arriving at the Pattullo site on Wednesday. Surespan mobilized redundant equipment in the event of breakdowns, such as multiple sets of pile driving leads and two cranes. Thursday morning pile driving commenced and continued throughout the night using a combination of drop, vibro and diesel hammers (Figure 8). Pile driving was completed early Saturday morning. Concurrently with the pile driving operations, a steel fabrication shop was making all of the necessary changes to the steel girders.

Saturday morning the piles were filled with concrete, and the pile caps were erected immediately afterwards. The girders were erected in pairs during the day, and deck panels were placed throughout the evening (Figures 9, 10 &11). Each of the stud pockets was grouted overnight, along with the gap between the new span and the existing Structure.

By Sunday morning all of the major structure components were in place and the abutment backwall was installed. Backfilling commenced during the afternoon, along with the installation of railing posts (Figures 12 & 13). Once the backfilling was completed asphalt paving on the span commenced.

Concurrently with the construction of the replacement span, TransLink took the opportunity to remove and repave approximately 20% of the asbestos contaminated asphalt on the remainder of the bridge, an operation that is highly disruptive to traffic.

After only 8 days, the bridge was open to all four lanes of traffic (Figures 14 &15) at approximately 4:15am on Monday January 26, 2009, several weeks ahead of initial estimates.

Conclusion

The availability of the materials, manpower and equipment for the work; in addition to the work activities such as the pile driving proceeding as anticipated and the favorable weather for paving were all critical elements leading to the success of the project. However, ultimately the success of the project was due to the cooperation and dedicated efforts of the Owner, the Engineer, the Contractors and stakeholders involved. Without the collaborative effort of all of the participants, repair of the affected spans and overall response and recovery could have taken significantly more time, which would have resulted in prolonged major economic impact to the Metro Vancouver region.

Figure 1. Undamaged Pattullo Bridge Timber Spans

Figure 2. Fire Damaged Timber Spans

Figure 3. Close up of Fire Damage

Figure 4. Specialized Person Protection for Demolition of Asphalt

Figure 5. Containment of Asphalt Waste

Figure 6. Demolition of Creosote Timbers

Figure 7. Site after Full Demolition

Figure 8. Pile Driving Underway

Figure 9. Erection of a Pair of Girders

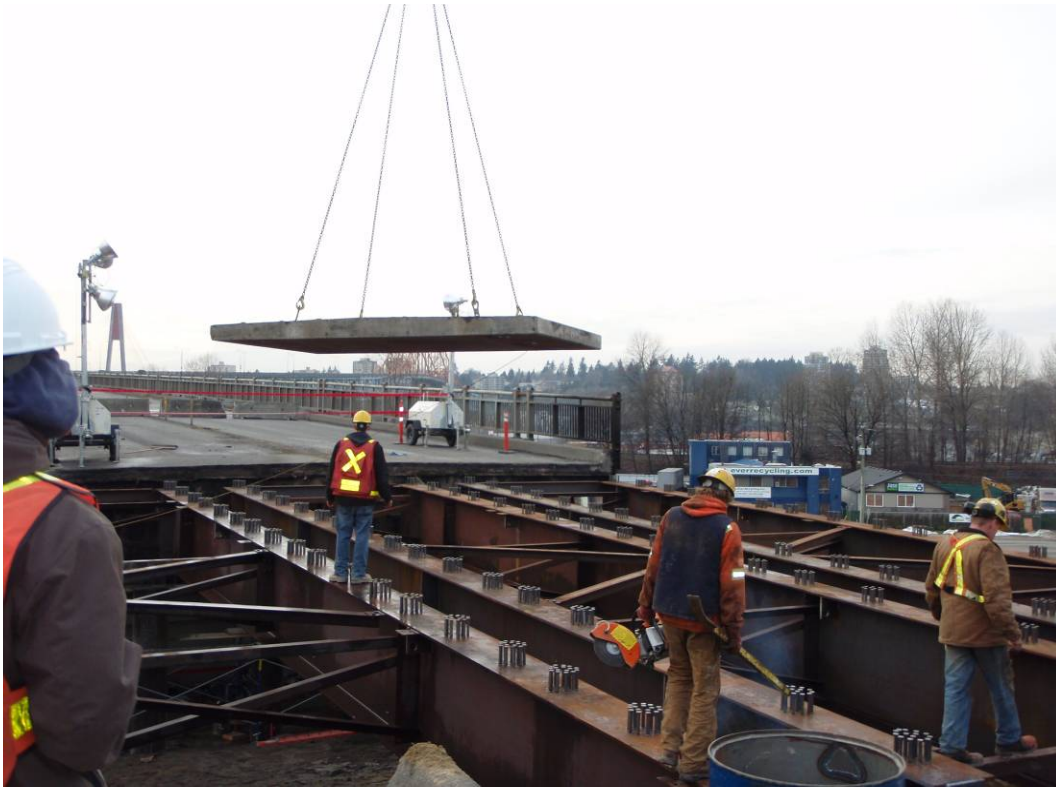

Figure 10. Erection of a deck panel

Figure 11. Work Continues through the night

Figure 12. Installation of Railing

Figure 14. Backfilling and preparation for paving

Figure 15. Completed Bridge Surface

Figure 16. Completed Bridge