Seismic Retrofit Chronology

The Government of B.C. is moving forward to replace the George Massey Tunnel with a new 10-lane bridge. It is the site of the worst traffic bottleneck in the province and it has about 10 years left before the major components like the lighting, ventilation and pumping systems need to be replaced.

In addition, while seismic upgrades were completed in the early 2000s, to allow the Tunnel to withstand smaller earthquakes (up to approximately 6.5 on the Richter scale); it is not able to withstand a major earthquake.

Summary of Seismic Upgrades to the George Massey Tunnel:

The 629-metre long George Massey Tunnel was constructed in the 1950s, the first project in North America to use immersed tube technology. It was built to the standards of the day, when seismic considerations were in their infancy, and no soil strengthening was undertaken prior to placement of the Tunnel's six concrete segments.

In 2000, the Ministry of Transportation and Infrastructure retained Buckland & Taylor Ltd. to develop a seismic retrofit strategy for the George Massey Tunnel. Buckland & Taylor's comprehensive report (300+ pages in two volumes) took about two years to complete and recommended a two-phased approach including (1) structural reinforcement and (2) geotechnical strengthening. Buckland & Taylor also prepared a detailed design for this work in 2001.

- The proposed structural reinforcement phase comprised longitudinal strengthening by installing steel braces along the Tunnel and reinforcing the joints to strengthen the integrity of the six immersed tubes. The purpose was to reduce structural damage and prevent the tubes from separating or collapsing in the event of a significant seismic event.
- The proposed geotechnical strengthening phase was designed to reinforce the soil along the sides of the Tunnel to reduce the risk of soil liquefaction that would cause the Tunnel to float or become unstable in the event of a significant seismic event.

At the completion of detailed design and before going to tender the ministry undertook a value engineering review of the proposed seismic retrofit and decided to implement the work as two separate contracts: Phase 1 – Structural Modifications and Phase 2 – Geotechnical Modifications.

In June 2004, the ministry announced plans for Phase 1: Structural Modifications, with a project budget of $22.2 million. The upgrade included reinforcing the top and bottom slabs of the immersed tunnel, installing steel plate connectors at joints between the Tunnel sections, repairing the concrete, sealing cracks and installing new lights in the Tunnel.

Kenaidan Contracting completed the two-year project using Buckland & Taylor's detailed design with nighttime work during which the Tunnel remained open for single-lane alternating traffic. The Project ensured a high standard for structural seismic safety for existing infrastructure.

At the completion of the Phase 1 work, the province commissioned a second Value Engineering Study in 2007 to review Buckland & Taylor's original recommendations; to identify and risk-assess current and additional options. This study highlighted some key risks associated with proceeding with Phase 2: Geotechnical Modifications that questions its value for taxpayers, specifically:

- While technically feasible, Phase 2 carried a significantly higher risk to the Tunnel during construction, including serious concerns that the Tunnel could shift during the required instream excavation and stone columns installation, both of which would have to take place in close proximity to the Tunnel.
- Phase 2 could not fully eliminate geotechnical risk of liquefaction, because soil densification adjacent to the Tunnel could not be achieved.

Based on these findings, the ministry instead installed an early warning system to limit tunnel use for greater than 1:275 year seismic events as a means to further improve the Tunnel's seismic safety. The Weir-Jones Group completed this work in **2008**. The early warning system comprises sensors at each end of the Tunnel that will, on detecting seismic waves of sufficient magnitude, trigger a series of electronic signs to allow traffic in the Tunnel to safely exit and prevent new traffic from entering.

Following this work, the ministry retained Buckland & Taylor to estimate the level of earthquake that the structurally retrofitted Tunnel could tolerate without life safety damage, having completed Phase 1 but not undertaking Phase 2. The study, completed in **2009**, confirmed that the Phase 1 design objectives had been achieved and that the Tunnel could withstand a 1-in-275-year seismic event.

Planning for a Tunnel Replacement:

By **2009**, with the Tunnel more than 50 years old and with increasing congestion-related concerns from some municipalities and members of the public, discussions about an eventual replacement for the Tunnel were underway. Given the risk profile of Phase 2, and the expectation that a more comprehensive study of Tunnel capacity/replacement options would begin in the short to medium term, the ministry determined to undertake no further seismic improvements until such time as a long-term solution for the crossing was confirmed.

In **2012**, following several years of discussion, the province announced its intent to begin technical planning for a replacement, including consideration of options that would retain and further upgrade the Tunnel. In **2013**, following two phases of consultation, traffic data collection and technical analysis, the province determined to replace the Tunnel with a new bridge.

George Massey Tunnel Seismic and Safety Limitations:

The George Massey Tunnel was **built in the 1950s**, a time when seismic considerations were minimal. As a result, the Tunnel was built on liquefiable soils with no base preparation.

Since then, the seismic engineering profession has learned a lot from catastrophic earthquakes around the world, and seismic code standards for new structures as well as retrofitting existing structures are rigorous.

These new standards add significant costs to projects, but are there to protect the safety of those who use them, and to ensure the structures remain viable for emergency response and recovery efforts.

Scientists also now know that the entire west coast of Vancouver lies in a high seismic zone, with more than 1,600 earthquakes recorded last year. There is also historical evidence that the region has experienced several major earthquakes.

The above noted technical analyses confirmed that bringing the existing Tunnel to modern day seismic standards is not practical due to the risk of damage and the limitations of densifying soils under the Tunnel. Other important safety considerations include:

- The Tunnel's height and width are below modern day standards. Many trucks have been stuck in the Tunnel and several fires have occurred.
- The Tunnel's size also prevents practical solutions to bring lighting to modern standards. While several options have been investigated, tests of new systems either negatively affected drivers' range of vision or were routinely damaged by trucks.
- Ventilation and electrical systems have reached the end of their useful life, and spare parts are increasingly difficult to find)**.**

The Tunnel cannot be made wider, higher or meet current seismic codes. A new structure built to modern day standards will reduce crashes and other incidents and provide a safer facility in the event of an earthquake. Given these findings, the province's decision to replace the Tunnel is logical and cost effective.

For more information, visit:

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