

# George Massey Tunnel Seismic Retrofit, Vancouver, Canada



George Massey Tunnel North Entrance.

The seismic retrofit of the 2063 ft long, 43-year-old immersed George Massey Tunnel located outside Vancouver, Canada pose a unique challenge to the design team of Buckland & Taylor Ltd. and Ben C. Gerwick, Inc. The pre-cast tunnel with a rectangular shaped cross-section sits in a shallow trench excavated into very loose, liquefiable sandy and silty Fraser River deposits in excess of 980 ft in depth, backfilled with loose-jetted sand.

The seismic retrofit design was performed for the Ministry of Transportation of BC, with Dr. P. Byrne and Dr. D. Anderson as peer reviewers.

The grossly under-reinforced tunnel section, based on current standards, was required to be retrofitted for seismic safety to withstand a 475-year return period design earthquake at the firm ground level having a PGA of 0.25 g.

The project was a true soil-structure interaction challenge that involve analysis

of and remediation measures for tunnel flotation, post-liquefaction differential settlement, concrete cracking and water ingress into the tunnel. Ben C. Gerwick Inc.'s expertise and experience from their work on the Posey-Webster Tunnel led to the choice of a comprehensive soil-structure interaction approach for the analysis and design of the structure.

Ground densification using stone columns on each side of the tunnel was chosen to reduce the risk of tunnel flotation and the post-liquefaction tunnel differential settlement. The tunnel section will be lined with new reinforced concrete bonded to the existing section to improve the section ductility and reduce the size of cracks and hence the flow of water.

Centrifuge testing of the tunnel cross section was performed at Rensselaer Polytechnic Institute using an in-flight shaker and a laminar box. The main objectives of centrifuge testing was to

Year of Completion: 2002

Construction Cost: \$50M

Client: Ministry of Transportation and Highways, British Columbia

#### Services Performed:

- Seismic Analyses
- Soil-Structure Interaction
- Liquefaction
- Concrete Durability
- Constructability Studies

understand soil behavior under the given circumstances, to observe tunnel flotation, settlement and lateral movement, and to calibrate the numerical models.

Field-testing of gravel drains by blasting (to cause ground liquefaction) was also conducted to assist the design of gravel drains. The effectiveness of the drains and installation methods were examined.

The soil-structure interaction analysis approach in combination with the centrifuge testing has played a major role in the seismic retrofit design of the George Massey Tunnel.