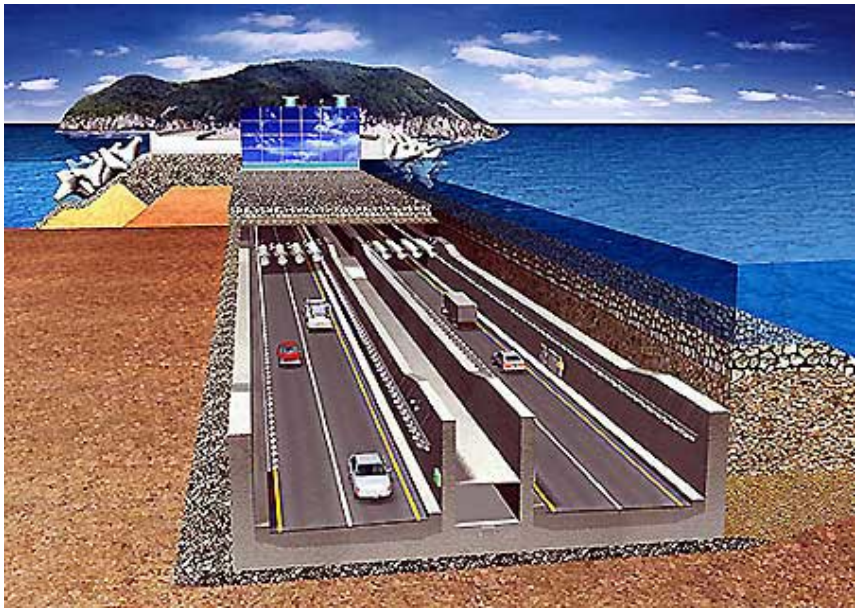
Busan - Geoje Tunnel, South Korea

The 2-mile long Busan-Geoje immersed tunnel will be constructed as part of a 5-mile four-lane fixed link highway between Busan, and the island of Geoje. The immersed tunnel will be one of the longest in the world, and at 164 ft water depth, it will be the deepest road tunnel ever constructed. The tunnel consists of 18 elements, each 590 ft long. The cross-section is 32 ft high and 85 ft wide. The tunnel is designed with flexible joints to accommodate differential movement between segment elements. The immersion joints between elements consist of a Gina gasket as the initial water seal surrounding a primary internal Omega seal. Shear keys in the vertical walls and horizontal slabs of each segment help transfer shear and reduce differential settlement across joints.



Busan-Geoje Tunnel.

Soils along the tunnel consist of a soft marine clay layer, 80 ft deep above 30 ft of dense gravely sand that overlies bedrock. Because of potential differential settlement, the marine-clay layer is improved using deep cement mixing to reduce compressibility and enhance bearing capacity. The seismicity of South Korea is governed by the Tsushima offshore and the Yangsan onshore fault systems located in the depression between the Pohang Bay and Busan.

Ben C. Gerwick, Inc. performed the seismic design of the tunnel using-state-of-the-art seismic soil-structure interaction analyses to evaluate the tunnel seismic behaviour. Modeling of ground motion effects on tunnel structures involved two tasks: (1) modeling of the free-field ground motion with variations along the tunnel, and (2) modeling of soil-structure interaction.

For the first task, Ben C. Gerwic, Inc. developed 18 different displacement time histories, for each direction, that reflect the spatial variation in ground motion along the tunnel as a result of wave passage, wave incoherency, and different ground conditions. For the second task, the complex seismic soil-structure interaction of the immersed tunnel and its foundations was divided into components that could be readily modelled and analyzed. This included three types of tunnel responses to ground motions as characterized by: (1) Axial compression and extension along the extended length of the tunnel, (2) Longitudinal bending and curvature (vertical and horizontal) including the affects of joints, and (3) Distortion of transverse cross-sectional geometry due to local soil deformations (racking).

Ben C. Gerwick, Inc. analyzed the first and the second responses using a longitudinal (global) model. Ground motion was introduced to the model by free-field displacement time histories applied to the soil springs. The third response was analyzed by using 2D pseudo-static and dynamic finite element transverse models of the tunnel and foundations. The models were then used to estimate the size openings at the joints and forces in the shear keys during the design seismic events.

Services Performed:

- **Seismic Design**
- **Structural Design**

Year of Completion: 2009

Construction Cost: $300M

Client: Daewoo Engineering & Construction Co. Ltd.