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Washington State Ferry System Terminals Evaluation

Lowering the cost of increasing safety with smart scientific analysis and creative retrofit designs for aging timber trestles

The busy Mukilteo-Clinton ferry route serves Whidbey Island visitors, 60,000 full-time residents and 29,000 weekenders.

Overview

The Washington State Ferry System (WSF), the fourth-largest ferry system in the world, transports 23 million passengers and 10 million vehicles across the waters of Puget Sound each year. The State-funded system includes 20 aging ferry terminals and docks that were not constructed to current seismic standards. Of particular concern are the timber trestles that support the docks, as WSF has determined that these trestles will pose the highest risk to life and continued operation of the ferry terminals if or when an earthquake occurs.

To decrease these risks, WSF has developed and implemented a timber-replacement program and has replaced timber trestles with new, code-compliant structures at five terminals, with two more slated for replacement soon. However, a projected $1.3 billion dollar funding shortfall for the next 10 years now threatens WSF's ability to replace the remaining facilities as planned.

With our project partners, KPFF Consulting Engineers and BIS Asset Management Services, GeoEngineers proposed questioning the standard assumption that replacing the timbers was the only viable course of action for WSF. The team recommended investigating the effectiveness of trestle retrofitting programs that might cost WSF less and provide a higher return on investment. WSF was open to this new approach in the context of the asset management program its Terminal Engineering group is implementing to evaluate spending choices in terms of cost/benefit and avoided risk.

EXPERTISE
- Geotechnical

MARKET
- Transportation

LOCATION
- Puget Sound, Washington

Approach

The project team set out to provide WSF with scientific and economic information the agency could use to determine whether its total-replacement approach was the only cost-effective means for mitigating seismic risk at each terminal. The team sought to establish the viability and cost savings of trestle retrofitting compared to replacement by quantifying risk (i.e. probability multiplied by consequence cost) for a range of seismic events. Key project components were:

- **Seismic hazard and structural engineering analyses** to identify facilities with the highest risk to human safety and safe operation after an earthquake
- **Innovative geotechnical designs** for retrofitting trestles and reducing seismic risk at lower cost than replacing them
- **Life-cycle cost scenarios** to enable WSF to weigh the true costs—not just labor and materials—of replacing versus retrofitting trestles

Innovation

The team's unique approach coupled **trestle failure scenarios** with **life-cycle cost-modeling techniques** to assess the risks associated with doing nothing, retrofitting the existing trestles, or undertaking complete trestle replacement. Their failure scenarios considered site-specific characteristics such as trestle condition, seismicity, and liquefaction and/or lateral spreading potential.

Results

- **Scientific and structural analyses identified facilities at greatest risk —** GeoEngineers' seismic and geotechnical analyses and KPFF's structural analyses of the existing docks and trestles and the soils beneath them showed how these structures would react to shaking, ground liquefaction, settling and lateral spreading during and after an earthquake. The project team used the data to rank the human safety risk of each existing terminal and dock, as well as the likelihood that the facilities could remain operational after a quake.

  The project team's fragility analyses revealed that piles would fail and decks would move excessively such that facilities would likely be unusable in some earthquake scenarios. WSF can now use this seismic risk information to prioritize upcoming costs and create budgets for future safety improvement projects.

- **Trestle retrofitting designs demonstrated dramatic decrease in seismic risk —** The team analyzed the seismic performance of two retrofit design options KPFF had created, using the geotechnical data they had gathered. Both design options provided sufficient seismic protection by strengthening the existing trestles. Ferry service would not need to be interrupted during retrofitting construction—a distinct advantage over replacing the trestles.

- **True-cost models revealed the significant cost savings of retrofitting —** Life-cycle cost modeling captured the true costs associated with trestle replacement or retrofitting options. For each option, the team's cost scenarios quantified and compared estimated loss of revenue and loss of use associated with facilities closures, as well as the estimated first costs and longer-term costs of installation, operation and maintenance.

  Overall, the economic analysis showed that retrofitting the trestles instead of tearing them down and rebuilding would reduce costs by tens of millions of dollars per terminal, while improving safety and maintaining ongoing operation of the facilities.

With the team's innovative engineering and economic assessment of risks and costs in hand, WSF is charting a course for a safer ferry system, while maximizing the State's limited resources.

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