Seismic Bridge Design

Structural Capacity and Seismic Demand

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Research Program Title:
Seismic Bridge Design

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Multiple projects, 2007-2013

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Summary
Alaska DOT&PF's research on seismic bridge design resolved multiple design issues previously unaddressed by national and state design codes. RDT2's research into structural capacity and seismic demand in frozen soils led to revisions of Alaska and AASHTO design standards.

Problem/Objective
Alaska is America's most seismically-active state, yet national bridge design codes do not address specific cold-region factors that impact the strength and ductility of bridge pilings and foundations.

- How do arctic climates influence the strength of bridge pilings and foundations?
- How do 1) steel-reinforced concrete tubes, and 2) all-steel pilings respond to seismic loading in -40 temperatures?
- How does liquefied frozen soil increase the force acting upon bridge foundations during a seismic event?
- How should designers assess the top five-to-eight feet of frozen soil when designing or assessing bridges?

Previously, no design codes existed to address these issues.

Outcomes and Products
-Improved Pile Assessment: The first quantified evaluation of loads imposed on bridge foundations by a frozen crust with liquefaction and lateral spreading showed a 50% variation in pile performance.
-Design Certainty: Cyclic cold-weather testing of steel-reinforced concrete performance realized a 30% to 40% strength increase in concrete and a 10% increase in steel.
-Finding: Pile performance is very sensitive to crust conditions, and the pile's internal forces like bending moment and shear force vary by roughly 50% when the crust freezes.
-Finding: Because frozen soils, especially on permafrost, significantly change ground motion characteristics, it is generally safe for designers to disregard the effects of seasonally frozen ground on site response.
-Finding: It is imprudent to classify permafrost soil sites using only the seismic motion of the upper 30 meters of frozen or unfrozen soil, or to utilize code-defined site coefficients for seismic design.

Implementation
AASHTO's seismic bridge design guide (2011 AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition) governs aspects of seismic bridge design. Findings from this research have been integrated into sections 7 and 8, addressing structural steel and reinforced concrete components. They include language on several specific components, such as the mechanism for calculating the strength capacity of concrete filled steel pipes, and the design of column-to-beam joints. At the state level, Alaska's seismic bridge design protocol has been rewritten to include these advances through Alaska DOT&PF.