Research Problem Statement

ODOT Research Section
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I. TITLE

17-025 Seismic Performance Criteria for Bridge Bent Design Considering CSZ Demands

II. PROBLEM

Seismic design of new bridges as well as seismic retrofit of existing bridges are designed for two-level performance criteria; life safety and operational. Life safety performance criteria is intended to ensure that the bridge does not collapse, however the bridge is expected to sustain significant damage. Operational performance criteria is intended to limit the seismic damage for a specific level event such that functionality of the bridge is minimally impacted. Within the Western parts of the state, the seismic design is often governed by the operational performance criteria and not the life safety criteria.

The bridge bent is critical in effectively resisting the seismic loads. The current methodology of designing for operational performance criteria has two main components: use of a specific seismic hazard, which has traditionally been lower than that used for life safety performance, and limit of the material strains to stricter levels than those used for life safety. The issue is that despite governing the bridge bent design, limited confidence exists in the selection of the appropriate material limits for achieving rapid return to operational condition. This lack of knowledge has cascading effects on the cost and constructability of new bridges, and even more so when considering retrofit of existing bridges.

III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

The proposed research is for experimentally evaluating large-scale reinforced concrete subassemblies representing critical parts of bents that are typical of Oregon bridge construction. These primarily represent column-to-crossbeam and column-to-foundation aspects of the bent. Of key interest from the experiments are the monitoring of material strains and deformations under the earthquake demands imposed by subduction zone events, similar to that expected from the Cascadia Subduction Zone (CSZ). Recently concluded research (Dusicka et al 2015) has shown that the long duration effects of subduction zone earthquakes result in a large total number of cycles, but only a few of those are of high ductility. Consequently, the number and amplitude of damaging cycles from subduction earthquakes is vastly different to crustal earthquakes. Laboratory performance data from subduction type events is scarce and yet the impact on performance measures is expected to be significant.

Test specimen variables will be established with considerations for geometry, axial load and reinforcing details. Reinforcing details will consider the presence and absence of splices within hinge zones to include existing bridge configurations. The simultaneously occurring axial load in the columns will be considered to vary with lateral demand to more closely replicate the seismic forces imposed on the columns in multi-column bents. This is in contrast to majority of past research that considered a simple constant axial load. Multi-column bents are typical for bridges in Oregon and are therefore more representative of the need to gather performance related data. After subjecting the assemblies to specific target earthquake demands, the ultimate capacities will be experimentally evaluated in order to assess the subsequent operational performance of the assembly. Then, the tested configurations will be numerically analyzed using current techniques, such as moment curvature based on pushover that is often used for design (FHWA 2006, 2011). The results will be contrasted to the experimentally obtained capacities from the subduction based response such that recommendations for design can be made.

IV. POTENTIAL BENEFITS

The benefit to ODOT relates directly to cost and mobility. Recent bridge designs, especially for retrofit, have highlighted the need to better understand performance criteria because those bridge designs had been governed by the operational performance limits; driving the cost of the project. The hypothesis is that the current strain limits may be conservative, even for the long duration subduction zone events.

The mobility aspect is especially important as ODOT aims to maintain dedicated life routes following CSZ earthquake (ODOT 2014). While the operational criteria currently uses a lower hazard, the design is potentially moving to explicitly consider CSZ as an operational performance level in the near future. As such, the seismic demand considerations for operational criterial in certain parts of the state are likely to increase, making the need to better understand the underlying assumptions even more vital.

The research outcomes will have additional technical reach within ODOT. The experimental data will provide knowledge on existing bridge performance at varying levels of demand and as such could also inform post disaster inspection.

V. IMPLEMENTATION

The main product of the research will be the development of performance criteria recommendations for seismic bridge design of bridge bents in Oregon. The standards engineers could use these findings to guide their design or be a resource to them via appropriate dissemination among the designers.

Given the unique data that will be generated, the findings will be of interest to the profession as the field of structural engineering moves closer toward performance based design. As such, technical papers will be presented in appropriate conferences and submitted to journal publications.

VI. LIST OF REFERENCES *(optional)*

Dusicka, P., Bazaez, R., and Knoles, S. (2015) “Bridge Seismic Retrofit Measures Considering Subduction Zone Earthquakes”, Report to Oregon Department of Transportation.

FHWA (2006), “Seismic Retrofitting Manual for Highway Structures”, Federal Highway Administration, Washington, DC.

FHWA (2011) “AASHTO Guide Specifications for LRFD Seismic Bridge Design”, Federal Highway Administration, Washington, DC.

ODOT (2014), “Oregon Highway Seismic Plus Report”, Oregon Department of Transportation, Bridge Engineering Section.

VII. CONTACT INFORMATION

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