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OREGON DEPARTMENT OF TRANSPORTATION

SPR Quarterly Progress Report

July 1, 2016 through September 30, 2016

Date: October 20, 2016

TO: Technical Advisory Committee Members:

Bruce Johnson, ODOT
Albert Nako, ODOT
Craig Shike, ODOT
Jan Six, ODOT
Tim Rogers, FHWA

1. Project

Impact of Cascadia Subduction Zone Earthquake on the Seismic Evaluation Criteria of Bridges
SPR 770

2. Project Investigator

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3. Project Coordinator

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4. Key Dates

Project start date: 1/2/2014
Project completion date: 9/30/2016

5. **Project Status** (Completed by project investigator)

Task 1: Literature Review

Percent completed reported in last quarterly report: 100%
Percent completed after this quarter: 100%

Key Progress-To-Date

- started to investigate the deaggragation tools provided by USGS and associated documentation
- obtained literature on attenuation relationships used by USGS for subduction zone earthquakes for 2002 seismic hazard
- summary of the literature review completed and used in report on deaggregation data results.

Specific Progress This Quarter

- NA

Problems

- NA

Work Planned for Next Quarter

- NA

Task 2: Deaggregate PSHA Data

Percent completed reported in last quarterly report: 100%
Percent completed after this quarter: 100%

Key Progress-To-Date

- Using a geographical matrix for Western Oregon, identified the subduction hazard using available USGS deagragation tool for 1000 year return period. The attenuation relationships from Task 1 were used to obtain the associated deterministic accelerations for the subduction hazard. The geographical grid was chosen with equal latitude/longitude spacing rather than focusing on specific bridge site, with the intent of interpolating and refining results as needed in the future.
- Processed deaggragation data for the selected locations for 500 and 1000 year return period for peak ground accelerations.
- Expanded the deaggregation to include spectral acceleration values for 0.2sec and 1.0 sec as well as data an additional return period of 2500 years.

Specific Progress This Quarter

- NA

Problems

- NA

Work Planned for Next Quarter

- NA

Task 3: Contrast CSZ with PSHA Design Values

Percent completed reported in last quarterly report: 100%
Percent completed after this quarter: 100%

Key Progress-To-Date

- Obtained PSHA data for the same sites for 500 year and 1000 year return periods.
- Contrasted 500 year and 1000 year PSHA data based on results from Task 2 to the deagragated accelerations in the form of ArcGIS maps for Western Oregon.
- Expanded comparison to include spectral acceleration values for 0.2sec and 1.0 sec as well as data for an additional return period of 2500 years.
- Included in the contrast values provided by USGS to ODOT for a scenario CSZ earthquake.
- Generated a written summary of Tasks 1, 2 and 3 via a preliminary report on the comparisons.
- Met with TAC to discuss results; the main takeaway being that the CSZ values generated by the deaggregation process were higher than anticipated prior to the study and higher than values generated by USGS scenario of CSZ.

Specific Progress This Quarter

- Met with TAC and teleconferenced with USGS (Art Frankel) regarding the results contained in the summary report and potential differences to USGS scenario accelerations. The outcome of the meeting with TAC and teleconference with USGS was that the group decided to pursue CSZ acceleration values from a specific rupture zone and have the values attenuated based on 2014 National Seismic Hazard Maps.

Problems

- NA

Work Planned for Next Quarter

- NA

Task 3a: Scenario CSZ Accelerations

Percent completed reported in last quarterly report: 100%
Percent completed after this quarter: 100%

Key Progress-To-Date

- Location of rupture zones had been obtained from USGS and literature search has been conducted into the relevant attenuation relationships as implemented in 2014 uniform hazard spectra by USGS.
- Completed update of CSZ14 model reflecting weighing of the attenuation as per documentation for the uniform hazard.

- Completed comparison to USGS acceleration values for Scenario A and B via contour maps. The results were submitted to Art Frankel for independent review.
- Completed ratio comparisons between CSZ14 model and previous CSZ models as well as to uniform hazard of various return periods from 2002. Serviceability and Life Safety recurrence rates were taken into account.
- Documentation of the comparison of seismic hazard models for the Cascadia Subduction Zone is in the draft form.
- Incorporated the logic tree based on 2014 methodology including attenuation and calculated acceleration values at randomly selected points to verify values.
- Acceleration values caused by a full rupture, corresponding to approximately M9 CSZ earthquake were obtained. Acceleration values for PGA, 0.2s, and 1.0s were generated by the model for a longitude latitude fine grid covering the entire state of Oregon. Partial scenario and partial aspects of the logic tree and attenuation values were compared to USGS values. Inconsistencies were eventually found and rectified.
- The existing scripts were also used to generate acceleration values for selected sites in California to support ODOT Bridge section efforts to unify design among the states.
- Data has been validated with collaboration with USGS.
- Maps have been completed and comparisons generated to uniform hazard spectra re-done.

Specific Progress This Quarter

- Web tool had been developed and made available to ODOT.

Problems

- While the deliverable for this task had originally been formulated to be data at selected Vs30 values (corresponding to NEHRP classifications), through conversations with the Bridge Section a change to this deliverable was pursued. The change involved the ability of the user to obtain a response spectrum at any desired value of Vs30 (within an appropriate range). Furthermore, the delivery mechanism to the user by developing a website was initiated. This was an increase in scope without additional budget or time, whereby PSU made the effort to aid the Bridge Section in providing an applied outcome that would help in dissemination of the research. This goal was achieved within the project timeframe and additional effort absorbed by PSU and the task had been completed.

Work Planned for Next Quarter

- NA.

Task 4: Contrast Structural Damage Effect from Long Duration Earthquakes

Percent completed reported in last quarterly report: 90%
Percent completed after this quarter: 100%

Key Progress-To-Date

- Detailed design and associated fabrication drawings of the test setup. The test setup has been fabricated and delivered to the laboratory.
- Completed building of three 18” diameter (½ scale) reinforced concrete columns, one of which will be subjected to a crustal earthquake and the other two subjected to two different subduction zone earthquake records.
- Completed upgrading and configuration of the servo-controller for communications with the hydraulics.
- Completed installation of the mass rig system and erected safety mechanism to catch the concrete block in case of collapse.
- Completed instrumentation and data acquisition setup for experimental monitoring of column test specimens.
- Large-scale shake table testing of 6 columns using a crustal earthquake record and two subduction zone records. Total of 5 were originally planned and an additional column was made possible within the budget scope.

Specific Progress This Quarter

- Data analyses of the experiments was conducted.

Problems

- NA.

Work Planned for Next Quarter

- NA.

Task 5: Evaluate the impact on the dual design criteria

Percent completed reported in last quarterly report: 30%
Percent completed after this quarter: 100%

Key Progress-To-Date

- Evaluated previous experiments on bridge bent to assess the steel and concrete strain limits and correlated the strain limits to the dual performance criteria. Summarized findings in a brief memo sent to Bridge Section.

Specific Progress This Quarter

- Additional analyses was conducted of past tests on square columns and on the shake table tests from this research.

Problems

- NA

Work Planned for Next Quarter

- NA.

Task 6: Final Report

Percent completed reported in last quarterly report: 75%
Percent completed after this quarter: 100%

Key Progress-To-Date

- Documented work to date on deaggragation and comparisons from task 1, 2 and 3 are in the draft form of the final report.
- Documentation of the scenario CSZ acceleration from Task 3a is completed including all the observations from last meeting with ODOT. This section of the final report (including the generated data) will be made into a standalone report to summarize Task 3a, for ODOT's consideration in updating BDDM.
- Documentation of the design of the test specimen is in the draft form of the final report.
- Documentation of test setup, test procedure, ground motion selection and instrumentation in the draft form.
- Test setup and specimen detail drawings were included in the report.
- Report on Task 3a was completed as a standalone document for ODOT Bridge Section.

Specific Progress This Quarter

- Draft report was completed and submitted to ODOT Research Section.

Problems

- NA

Work Planned for Next Quarter

- NA.

6. <u>Project Coordinator's Comments</u> (Completed by ODOT)

This project is wrapping up. Following TAC review, the final report should be published before the end of the year.

7. **Finances** (Completed by ODOT)

SPR Project Summary

VENDOR	FY14	FY'15	FY'16	FY'17	TOTALS
ORIGINAL BUDGET	**$ -**	**$ -**	**$ -**	**$ -**	$ -
WORK PLAN BUDGET	**$ 23,263**	$ 127,185	$ 51,345	**$ -**	$ 201,793
REVISED BUDGET	**$8,006**	**$97,318**	**$103,000**	**$ 5,480**	**$ 213,804**
EXPENDITURES - VENDOR	$ 8,006	$ 97,318	$ 81,400	$ -	$ 186,724
BALANCE	$ -	$ -	$ 21,600	$ 5,480	$ 27,080
ODOT	FY14	FY'15	FY'16	FY'17	TOTALS
ORIGINAL BUDGET	**$ 50,500**	**$ 99,000**	**$ 50,500**	**$ -**	$ 200,000
REVISED BUDGET	**$ 4,415**	**$ 4,576**	**$ 7,000**	**$ 7,679**	**$ 23,670**
EXPENDITURES - ODOT	$ 4,415	$ 4,576	$ 4,835	$ 920	$ 14,746
BALANCE	**$ -**	$ -	$ 2,165	$ 6,759	$ 8,924
PROJECT	FY14	FY'15	FY'16	FY'17	TOTALS
ORIGINAL BUDGET	$ 50,500	$ 99,000	$ 50,500	$ -	$ 200,000
REVISED BUDGET	**$12,421**	**$ 101,894**	**$ 110,000**	**$ 13,159**	**$ 237,474**
EXPENDITURES - PROJECT	$ 12,421	$ 101,894	$ 86,235	$ 920	$ 201,470
BALANCE	**$ -**	$ -	$ 23,765	$ 12,239	FALSE