Earth Mechanics, Inc.

Geotechnical & Earthquake Engineering

DATE: September 22, 2022 **EMI PROJECT NO:** 22-120

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SUBJECT: ***Preliminary Site-specific Acceleration Response Spectra Recommended for Seismic Design of Redwood Multipurpose Marine Terminal, Humboldt Bay, Samoa, California***

INTRODUCTION

This memorandum presents our recommended preliminary acceleration response spectra for seismic design of the new proposed wharf structure at the above-referenced project site. It is to be noted that this document is intended to provide preliminary design response spectra.. Due to the presence of liquefiable materials and soft Young Bay Mud at the project site, site-specific probabilistic seismic hazard analysis (PSHA) and site-specific response analysis (SRA) are required to determine site-specific acceleration response spectra (ARS). Detailed seismic hazard analyses will be performed and the findings will be documented in a complete seismic hazard study report during the next phase of the project.

PRELIMINARY DESIGN RESPONSE SPECTRA RECOMMENDATIONS

It is our understanding that the new wharf structure is to be designed for three levels of earthquakes: Operational Level Earthquake (OLE) having 50% probability of exceedance in 50 years (72 years return period), Contingency Level Earthquake (CLE) having 10% probability of exceedance in 50 years (475 years return period), and design earthquake (DE) per ASCE 7-16 and CBC 2019 which define DE as two-thirds of the risk-targeted maximum considered earthquake (MCE_R).

Preliminary PSHA was performed using the 2018 National Seismic Hazard Model (NSHM) for the Conterminous United States ver. 1.2 (Shumway et al., 2021). Time-averaged shear wave velocity in the top 100 ft (30 m) of ground, $V_{s,30}$, was estimated to be 175 to 215 m/s based on the three seismic CPT measurements (CPT22-CS-01, -03, and -06). Liquefied soil conditions were considered in the analyses by using the 2018 NSHM results for the lowest available $V_{s,30}$ of 150 m/s. Pre-liquefaction subsurface conditions was included in the analysis by using upper-bound $V_{s,30}$ of 260 m/s. The PSHA was performed for the lower-bound and upper-bound $V_{s,30}$ of 150 and 260 m/sec, respectively, and the resulting acceleration response spectra were enveloped and used for design.

The resulting 5% damped ARS and displacement response spectra (DRS) for Level 1, Level 2, and DE events (horizonal component of ground motions) are presented in Figures 1 and 2. As noted earlier, these ARS curves are preliminary and subject to change based on the future detailed site-specific hazard analyses and site response analyses.

SEISMIC PARAMETERS FOR GEOTECHNICAL EVALUATIONS

For geotechnical evaluations, preliminary peak ground acceleration (PGA) and earthquake magnitude (M_w) of 0.27g and 7.0 for Level 1, 0.79g and 9.0 for Level 2, and 1.1g and 9.0 for DE and 1.65g and 9.0 for MCE_G event are recommended.

FUTURE WORK TO DEVELOP THE FINAL ARS/DRS, PGA, and M_W

The project site is located in close proximity of several faults (Crustal earthquake sources) and the Cascadia Subduction Zone. A detailed site-specific seismic hazard analysis as well as site response analysis is needed to account for seismic hazards contributed by each of the above seismic sources. The site-specific seismic ground motion study generally involves the following steps:

1. Subsurface Characterization. A subsurface characterization will be performed in order to select an appropriate reference firm ground or rock elevation. The corresponding ground condition will be defined by a representative shear wave velocity value (V_{s30}) at that depth.

2. Probabilistic Seismic Hazard Analysis (PSHA). PSHA will be performed to develop design horizontal ARS at the reference firm ground or rock elevation for the three level earthquakes [Operational Level Earthquake (OLE), Contingency Level Earthquake (CLE), and Design Earthquake (DE)]. The PSHA will be performed considering all relevant earthquake sources (crustal and subduction events) and utilizing the latest ground motion models (GMMs). The input parameter V_{s30} described above will be used to develop the acceleration response spectrum (ARS) for the reference firm ground or rock condition.

3. Startup Time Histories. Seven sets of startup time histories will be selected for each event level based on controlling source information obtained from the PSHA (de-aggregation). Each set will include two orthogonal horizontal components. The vertical component will not be assessed in this study.

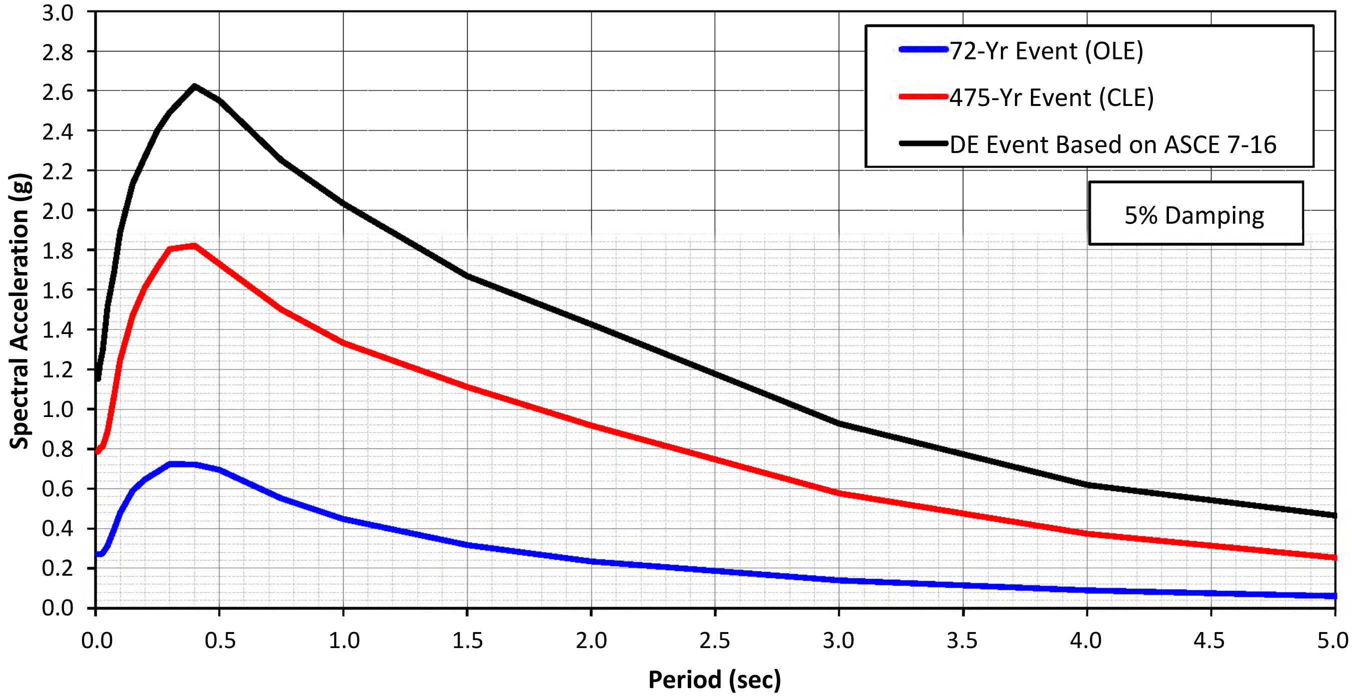
4. Spectrum Matching. The startup time histories will be modified such that their corresponding response spectra will generally match the reference firm ground or rock spectra, while preserving the important characteristics of the original motions as much as possible. The resulting reference firm ground or rock spectrum-compatible time histories will represent the design ground motions at the reference firm ground or rock elevation.

5. Site Response Analysis. Site response analysis will be performed in order to account for wave propagation effects (e.g., amplification and damping) between the reference firm ground or rock elevation and the ground surface. Based on preliminary observations, subsurface conditions are highly variable on the landside and along the pier. In order to account for the site variability, multiple site response analysis models will be developed at different locations.

In addition, significant amounts of complex materials exist at the site, such as potentially liquefiable soils and deep soft clay layers whose dynamic engineering behavior is relatively uncertain. Uncertainty in dynamic behavior will be addressed by considering a range of parameters for each site model (e.g., Lower Estimate, Upper Estimate, and Liquefied Condition).

6. Design Ground Motion Recommendation. We will review the results of all of the site response analysis runs described above to provide design ARS, DRS, PGA and M_w for the three level earthquakes.

We appreciate the opportunity to work with you on this project. If you have any questions, please do not hesitate to call us.



Period	72-Yr Event (OLE)	475-Yr Event (CLE)	DE Event Based on ASCE 7-16
(sec)	SA (g)	SA (g)	SA (g)
0.010	0.271	0.787	1.151
0.020	0.270	0.807	1.233
0.030	0.277	0.813	1.296
0.050	0.314	0.889	1.517
0.075	0.395	1.066	1.686
0.100	0.478	1.246	1.888
0.150	0.590	1.471	2.133
0.200	0.647	1.611	2.267
0.250	0.685	1.713	2.400
0.300	0.724	1.803	2.491
0.400	0.722	1.822	2.624
0.500	0.694	1.729	2.550
0.750	0.551	1.500	2.250
1.000	0.448	1.332	2.033
1.500	0.316	1.112	1.668
2.000	0.235	0.917	1.425
3.000	0.139	0.577	0.927
4.000	0.089	0.373	0.619
5.000	0.060	0.255	0.466
7.500	0.029	0.122	0.312
10.000	0.016	0.071	0.186

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Humboldt Redwood Multipurpose Terminal Redevelopment

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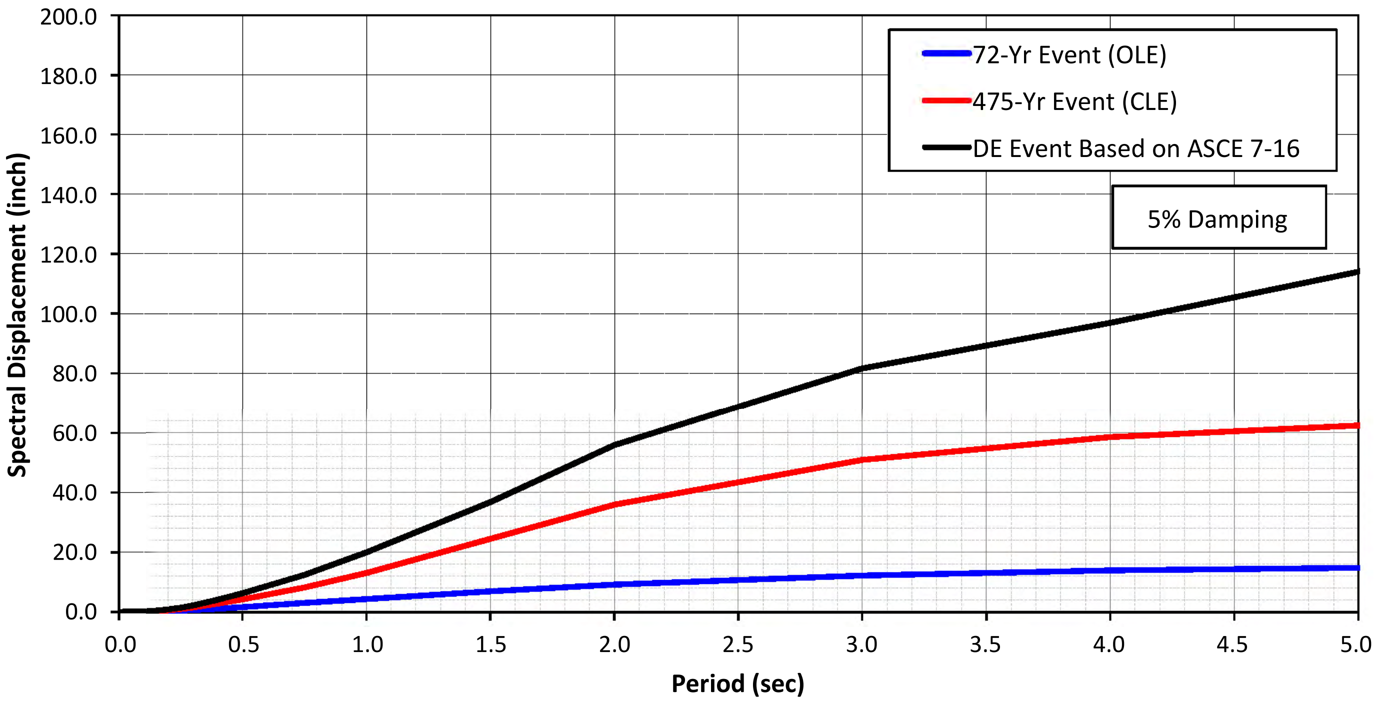
Recommended Preliminary Acceleration Response Spectra

Figure 1



Period	72-Yr Event (OLE)	475-Yr Event (CLE)	DE Event Based on ASCE 7-16
(sec)	Disp (inch)	Disp (inch)	Disp (inch)
0.010	0.000	0.001	0.001
0.020	0.001	0.003	0.005
0.030	0.002	0.007	0.011
0.050	0.008	0.022	0.037
0.075	0.022	0.059	0.093
0.100	0.047	0.122	0.185
0.150	0.130	0.324	0.470
0.200	0.253	0.631	0.887
0.250	0.419	1.048	1.468
0.300	0.638	1.588	2.194
0.400	1.131	2.853	4.109
0.500	1.698	4.230	6.240
0.750	3.032	8.258	12.387
1.000	4.387	13.039	19.902
1.500	6.967	24.479	36.740
2.000	9.184	35.919	55.807
3.000	12.216	50.856	81.647
4.000	13.941	58.448	96.895
5.000	14.756	62.344	114.006
7.500	15.986	67.081	171.773
10.000	15.854	69.866	182.410

Recommended Preliminary Displacement Response Spectra

REFERENCES

ASCE, 2016, “Minimum Design Loads for Buildings and Other Structures”, ASCE/SEI Standard 7-16.

California Building Code (CBC), 2019, International Code Council, Inc., Chapters 16 and 31F.

Shumway, A.M., Clayton, B.S., and Rukstales, K.S., 2021, Data Release for Additional Period and Site Class Data for the 2018 National Seismic Hazard Model for the Conterminous United States (ver. 1.2, May 2021): U.S. Geological Survey data release, https://doi.org/10.5066/P9RQMREV.