STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

May 2018

Log No. __________

1. State Building Code to be Amended:

- ☒ International Building Code
- ☐ ICC ANSI A117.1 Accessibility Code
- ☐ International Existing Building Code
- ☐ International Residential Code
- ☐ International Fire Code
- ☐ Uniform Plumbing Code
- ☐ International Mechanical Code
- ☐ International Fuel Gas Code
- ☐ NFPA 54 National Fuel Gas Code
- ☐ NFPA 58 Liquefied Petroleum Gas Code
- ☐ Wildland Urban Interface Code

For the Washington State Energy Code, please see specialized energy code forms

Section(s): 1613.4 Amendments to ASCE 7

Title: Voluntary Use of Multi-Period Response Spectra for Determination of Seismic Hazard

2. Proponent Name (Specific local government, organization or individual):

Proponents:

Kai Ki Mow, P.E., S.E. representing Structural Engineers Association of Washington Earthquake Engineering Committee (SEAW-EEC) [Committee Chair] and Seattle Department of Construction and Inspections (SDCI) [Principal Engineer]

Susan Chang, Ph.D., P.E. representing SEAW-EEC Multi-Period Response Spectrum Task Group [TG Chair] and SDCI [Geotechnical Engineering Group Supervisor]

Date: 1 February 2022

3. Designated Contact Person:

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4. **Proposed Code Amendment**. Reproduce the section to be amended by underlining all added language, striking through all deleted language. Insert new sections in the appropriate place in the code in order to continue the established numbering system of the code. If more than one section is proposed for amendment or more than one page is needed for reproducing the affected section of the code additional pages may be attached.

Code(s) 2018 IBC **Section(s)** 1613.4

User Note: The text highlighted in yellow is copied directly from ASCE 7-22, the latest version of the ASCE 7 standard.

Revise the heading of Section 1613.4 to read as follows, where the underlined portion denotes the change to the code:

1613.4 Amendments to ASCE 7. The provisions of Section 1613.4 shall be permitted as an amendment to the relevant provisions of ASCE 7. The text of ASCE 7 shall be amended as indicated in Sections 1613.4.1 through 1613.4.6.

Add new Section 1613.4.3 as follows:

1613.4.3 ASCE 7 Section 11.2 Amend ASCE 7 Section 11.2 to include the following definition:

USGS SEISMIC DESIGN GEODATABASE: A US Geological Survey (USGS) database of geocoded values of seismic design parameters and geocoded sets of multi-period 5%-damped risk-targeted maximum considered earthquake (MCE_R) response spectra. The parameters obtained from this database may only be used where referenced by Section 11.4.8.1.

User Note: The USGS Seismic Design Geodatabase is intended to be accessed through a USGS Seismic Design Web Service that allows the user to specify the site location, by latitude and longitude, and the site class to obtain the seismic design data. The USGS web service spatially interpolates between the gridded data of the USGS geodatabase. Both the USGS geodatabase and the USGS web service can be accessed at https://doi.org/10.5066/F7NK3C76. The USGS Seismic Design Geodatabase is available at the ASCE 7 Hazard Tool https://asce7hazardtool.online/ or an approved equivalent.

Add new Section 1613.4.4 as follows:

1613.4.4 ASCE 7 Section 11.4.8 Amend ASCE 7 Section 11.4.8 to include the following section:

11.4.8.1 Multi-Period Design Response Spectrum

As an alternative to the ground motion hazard analysis requirements of Section 11.4.8, and suitable for all structures other than those designated Site Class F (unless exempted in accordance with Section 20.3.1), a Multi-Period Design Response Spectrum may be developed as follows:

1. For exclusive use with the USGS Seismic Design Geodatabase in accordance with this section, the Site Class shall be determined per Section 20.6.

2. Where a Multi-Period Design Response Spectrum is developed in accordance with this section, the parameters S_{MS}, S_{M1}, S_{DS}, S_{D1}, and T_L as obtained by the USGS Seismic Design Geodatabase shall be used for all applications of these parameters in this standard.

3. The S_S and S_1 parameters obtained by the USGS Seismic Design Geodatabase are only permitted to be used in development of the Multi-Period Design Response Spectrum and are not permitted to be used in other applications in this standard. The mapped parameters S_S and S_1 as determined by Section 11.4.2 and peak ground acceleration parameter PGA_M as determined by Section 11.8.3 shall be used for all other applications in this standard.

4. At discrete values of period, T, equal to 0.0 s, 0.01 s, 0.02 s, 0.03 s, 0.05 s, 0.075 s, 0.1 s, 0.15 s, 0.2 s, 0.25 s, 0.3 s, 0.4 s, 0.5 s, 0.75 s, 1.0 s, 1.5 s, 2.0 s, 3.0 s, 4.0 s, 5.0 s, 7.5 s, and 10.0 s, the 5%-damped design spectral response acceleration parameter, S_a, shall be taken as 2/3 of the multi-period 5%-damped MCE_R response spectrum from the USGS Seismic Design Geodatabase for the applicable site class.

5. At each response period, T, less than 10.0 s and not equal to one of the discrete values of period, T, listed in Item 4 above, S_a, shall be determined by linear interpolation between values of S_a, of Item 4 above.

6. At each response period, T, greater than 10.0 s, S_a shall be taken as the value of S_a at the period of 10.0 s, factored by $10/T$, where the value of T is less than or equal to that of the long-period transition period, T_L, and shall be taken as the value of S_a at the period of 10.0 s factored by $10T_L/T^2$, where the value of T is greater than that of the long-period transition period, T_L.

7. Where an MCE_R response spectrum is required, it shall be determined by multiplying the Multi-Period Design Response Spectrum by 1.5.

8. For use with the equivalent lateral force procedure, the spectral acceleration S_a at T shall be permitted to replace S_{D1}/T in Equation (12.8-3) and $S_{D1}/T_L/T^2$ in Equation (12.8-4).

Add new Section 1613.4.5 as follows:

1613.4.5 ASCE 7 Section 20.6 Amend ASCE 7 Chapter 20 to include the following section:

Section 20.6 Site Classification Procedure For Use With Section 11.4.8.1

For exclusive use in determining the Multi-Period Design Response Spectrum and associated spectral parameters in accordance with Section 11.4.8.1, the Site Class shall be determined in accordance with this section. For all other applications in this standard the Site Class shall be determined per Section 20.1.

20.6.1 Site Classification

The site soil shall be classified in accordance with Table 20.6-1 and Section 20.6.2 based on the average shear wave velocity parameter, $\overline{v}_s$, which is derived from the measured shear wave velocity profile from the ground surface to a depth of 100 ft (30 m). Where shear wave velocity is not measured, appropriate generalized correlations between shear wave velocity and standard penetration test (SPT) blow counts, cone penetration test (CPT) tip resistance, shear strength, or other geotechnical parameters shall be used to obtain an estimated shear wave velocity profile, as described in Section 20.6.3. Where site-specific data (measured shear wave velocities or other geotechnical data that can be used to estimate shear wave velocity) are available only to a maximum depth less than 100 ft (30 m), $\overline{v}_s$ shall be estimated as described in Section 20.6.3.

Where the soil properties are not known in sufficient detail to determine the site class, the most critical site conditions of Site Class C, Site Class CD and Site Class D, as defined in Section 20.6.2, shall be used unless the Authority Having Jurisdiction or geotechnical data determine that Site Class DE, E or F soils are present at the site. Site Classes A and B shall not be assigned to a site if there is more than 10 ft (3.1 m) of soil between the rock surface and the bottom of the spread footing or mat foundation.

20.6.2 Site Class Definitions

Site Class types shall be assigned in accordance with the definitions provided in Table 20.6.2-1 and this section.

20.6.2.1 Soft Clay Site Class E

Where a site does not qualify under the criteria for Site Class F per Section 20.3.1 and there is a total thickness of soft clay greater than 10 ft (3 m), where a soft clay layer is defined by s_u < 500psf (s_u < 25 kPa), $w \geq 40\%$, and $PI > 20$, it shall be classified as Site Class E. This classification is made regardless of $\overline{v}_s$, as computed in Section 20.4.

20.6.2.2 Site Classes C, CD, D, DE and E

The assignment of Site Class C, CD, D, DE, and E soils shall be made based on the average shear wave velocity, which is derived from the site shear wave velocity profile from the ground surface to a depth of 100 ft (30 m), as described in Section 20.4.

20.6.2.3 Site Classes B and BC (Medium Hard and Soft Rock)

Site Class B can only be assigned to a site on the basis of shear wave velocity measured on site. If shear wave velocity data are not available and the site condition is estimated by a geotechnical engineer, engineering geologist, or seismologist as Site Class B or BC on the basis of site geology, consisting of competent rock with moderate fracturing and weathering, the site shall be classified as Site Class BC. Softer and more highly fractured and weathered rock shall either be measured on site for shear wave velocity or classified as Site Class C.

20.6.2.4 Site Class A (Hard Rock)

The hard rock, Site Class A, category shall be supported by shear wave velocity measurement, either on site or on profiles of the same rock type in the same formation with an equal or greater degree of weathering and fracturing. Where hard rock conditions are known to be continuous to a depth of 100 ft (30 m), surficial shear wave velocity measurements to maximum depths less than 100 ft are permitted to be extrapolated to assess $\bar{v}_s$.

Table 20.6.2-1 Site Classification

Site Class	$\bar{v}_s$ Calculated Using Measured or Estimated Shear Wave Velocity Profile (ft/s)
A. Hard Rock	> 5,000
B. Medium Hard Rock	> 3,000 to 5,000
BC. Soft Rock	> 2,100 to 3,000
C. Very Dense Sand or Hard Clay	> 1,450 to 2,100
CD. Dense Sand or Very Stiff Clay	> 1,000 to 1,450
D. Medium Dense Sand or Stiff Clay	> 700 to 1,000
DE. Loose Sand or Medium Stiff Clay	> 500 to 700
E. Very Loose Sand or Soft Clay	≤ 500

20.6.3 Estimation of Shear Wave Velocity Profiles

Where measured shear wave velocity data are not available, shear wave velocity shall be estimated as a function of depth using correlations with suitable geotechnical parameters, including standard penetration test (SPT) blow counts, shear strength, overburden pressure, void ratio, or cone penetration test (CPT) tip resistance, measured at the site.

Site Class based on estimated values of $\bar{v}_s$ shall be derived using $\bar{v}_s$, $\bar{v}_s/1.3$, and $1.3\bar{v}_s$ when correlation models are used to derive shear wave velocities. Where correlations derived for specific local regions can be demonstrated to have greater accuracy, factors less than 1.3 can be used if approved by the Authority Having Jurisdiction. If the different average velocities result in different Site Classes per Table 20.6.2-1, the most critical of the site classes for ground motion analysis at each period shall be used.

Where the available data used to establish the shear wave velocity profile extends to depths less than 100 ft (30 m) but more than 50 ft (15 m), and the site geology is such that soft layers are unlikely to be encountered between 50 and 100 ft, the shear wave velocity of the last layer in the profile shall be extended to 100 ft for the calculation of $\bar{v}_s$ in Equation (20.4-1). Where the data does not extend to depths of 50 ft (15 m), default site classes, as described in Section 20.6.1, shall be used unless another site class can be justified on the basis of the site geology.

Add new Section 1613.4.6 as follows:

1613.4.6 ASCE 7 Section 21.3.1 Amend ASCE 7 Section 21.3 to include the following section:

Section 21.3.1 Alternate Minimum Design Spectral Response Accelerations
As an alternate approach to Section 21.3, the lower limit of S_a is permitted to be determined according to this section. The design spectral response acceleration at any period shall not be taken less than 80% of the Multi-Period Design Response Spectrum as determined by Section 11.4.8.1.

For sites classified as Site Class F requiring site-specific analysis in accordance with Section 11.4.8, the design spectral response acceleration at any period shall not be less than 80% of S_a determined for Site Class E.

EXCEPTION: Where a different site class can be justified using the site-specific classification procedures in accordance with Section 20.6.2.2, a lower limit of 80% of S_a for the justified site class shall be permitted to be used.

5. **Briefly explain your proposed amendment, including the purpose, benefits and problems addressed.**

This amendment provides a simplified method to develop seismic design parameters for seismic design of buildings. The current method in ASCE 7-16 for developing seismic design response spectra is very complex, and it requires additional ground motion hazard analyses for many more building sites than required in previous versions of the code.

Ground motion hazard analyses are an advanced approach to develop the earthquake ground motions and response spectra needed for seismic design. They require additional geophysical testing of the soil and advanced computer modeling. The process of obtaining a ground motion hazard analysis requires geotechnical engineer with significant seismic expertise, and greatly increases the cost and time needed to complete a project.

The requirement for ground motion hazard analyses for more types of sites in Washington State also makes the job of municipal review agencies more difficult. Most jurisdictions do not have the expertise to review these analyses. Thus, they will need to contract with third-party reviewers or accept the analyses with little to no review. The first option is costly and time-consuming; the second option is dangerous and a critical life/safety issue because ground motion hazard analyses require a geotechnical engineer with significant seismic expertise to perform them correctly.

This proposal provides an alternative to the ground motion hazard analysis requirements in ASCE 7-16 by permitting an optional multi-period response spectra (MPRS) approach as described in ASCE 7-22. The primary inputs to this simplified method are the latitude/longitude of the site and the average shear wave velocity of the site, which can be obtained through standard geotechnical testing. The engineer would then obtain the equivalent of ground motion hazard analysis results from a U.S. Geological Survey website developed as part of the National Seismic Hazard Mapping project and adopted in ASCE 7-22. This simplified approach reduces the complexities, and it will result in more consistent, understandable estimation of ground motions for building design. This simplified process also results in ground motion parameters for seismic design that achieve the same level of risk and earthquake return periods that are assumed in ASCE 7-16.

This alternative would be allowed for all Soil Site Classes except Site Class F (e.g. liquefiable sites), meaning it could be used for most sites in the State of Washington. In addition, the MPRS may also be used to develop the code minimum spectrum when ground motion hazard analysis is required. The resulting MPRS would continue to be used within the framework of the current code, ASCE 7-16.

The use of the ASCE 7-22 MPRS as an option in lieu of the ground motion hazard analysis requirements of ASCE 7-16 will simplify the estimation of seismic forces for building design and streamline the design and review process of buildings throughout Washington.

6. **Specify what criteria this proposal meets.** You may select more than one.

- ☒ The amendment is needed to address a critical life/safety need.
- ☐ The amendment clarifies the intent or application of the code.
- ☒ The amendment is needed to address a specific state policy or statute.
- ☐ The amendment is needed for consistency with state or federal regulations.

☐ The amendment is needed to address a unique character of the state.
☐ The amendment corrects errors and omissions.

7. Is there an economic impact: ☒ Yes ☐ No

This code change would decrease the cost of development on sites where the current building code requires ground motion hazard analysis by providing an alternative approach that does not necessitate the added costs (i.e. building owners hiring geotechnical engineer of record with significant seismic expertise to perform ground motion hazard analyses, and municipal review agencies contracting third-party ground motion hazard analysis reviewers) associated with the current building code requirements.

Please send your completed proposal to: sbcc@des.wa.gov