This master should be used by designers working on Port of Portland construction projects and by designers working for PDX tenants (“Tenants”). Usage notes highlight a few specific editing choices, however the entire section should be evaluated and edited to fit specific project needs.

Use this section for PDX projects only and coordinate with Port Engineer, [Tom Wharton](mailto:tom.wharton@portofportland.com), to discuss if this section is appropriate for the project.

SECTION 014100 – NON-STRUCTURAL SEISMIC DESIGN CRITERIA

1. GENERAL
   * + 1. DESCRIPTION
          1. This section describes minimum seismic design criteria for non-structural systems and for the designated systems, listed in the table below, required to be operational after a seismic event. This section applies to work of other sections required for the installation of each system indicated in this section.
          2. This section describes modifications to Chapter 13 of American Society of Civil Engineers (ASCE) 7.
          3. The required seismic performance for each system listed below is defined in Article 1.2. All systems and their anchorage shall meet the requirements of ASCE 7, Chapter 13.

Use the table below to list systems in the project that require seismic design and their designated performance levels (as defined in the following article). Add or delete rows as necessary.

|  |  |  |
| --- | --- | --- |
| Designated System | Reference Section(s) | Seismic Performance Level |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

* + - 1. DEFINITIONS
         1. Immediate Occupancy: Minor cracking of facades, partitions, and ceilings; equipment and contents are generally secure, but may not operate due to mechanical failure or lack of utilities; elevators can be restarted; fire protection operable.
         2. Operational: Minor cracking of facades, partitions, and ceilings; negligible damage occurs; power and other utilities are available, possibly from standby sources; and all systems important to normal operation are functional.
         3. Designated Non-Structural System: System which are required to function following an earthquake or which must maintain containment of flammable or hazardous materials.
         4. Seismic Qualification Certificates of Compliance: Certification from the manufacturer for each piece of designated non-structural active mechanical and electrical equipment that must remain active following the design earthquake ground motion.
         5. Active Equipment: Equipment containing moving or rotating parts, electrical parts such as switches or relays, or other internal components that are sensitive to earthquake forces and are critical to the function of the equipment.
      2. REFERENCES
         1. ACI: American Concrete Institute

ACI 318-14 – Building Code Requirements for Structural Concrete & Commentary

ACI 355.2 – Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary

* + - * 1. AISC: American Institute of Steel Construction

AISC Steel Construction Manual

* + - * 1. ASCE: American Society of Civil Engineers

ASCE 7-10 – Minimum Design Loads for Buildings and Other Structures

ASCE 41-13 – Seismic Evaluation and Retrofit of Existing Buildings

* + - * 1. ICC Evaluation Service, Inc.

AC 156 – Acceptance Criteria for Seismic Qualification by Shake-table Testing of Nonstructural Components and Systems

Mechanical anchorage capacities shall be based on the current ICC Evaluation Report for the specific product

* + - * 1. OSSC: Oregon State Specialty Code
      1. SUBMITTALS
         1. Delegated-Design Submittal: Submit for each system indicated to comply with the performance requirements and design criteria of this section, including drawings and structural calculations stamped and signed by a qualified structural engineer, licensed in the state of Oregon.
         2. Anchorage Design Drawings:

Include plans, elevations, sections, mounting, and attachment details.

Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection as necessary to communicate the assumptions made in the seismic anchorage engineering calculations.

* + - * 1. Seismic Qualification Certificates:

Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation. Describe specific testing criteria, including seismic ground motion and accelerations.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

* + - * 1. Quality Assurance Plan: Prepare in accordance with Appendix 11A of ASCE 7, Sections 11A.1.2 through 11A.4.
      1. QUALITY ASSURANCE
         1. Perform work of this section in accordance with the OSSC and ASCE, except as modified by this section.
      2. PERFORMANCE REQUIREMENTS
         1. Delegated Design: Engage a qualified professional engineer to design non-structural systems to comply with the occupancy and operational performance specified in Article 1.1 above.
         2. Installed systems shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 as modified in this section.

The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified.

The system shall be fully operational to the level specified after the seismic event.

* + - * 1. Design systems to comply to the following minimum requirements as demonstrated through verification testing and design:

Design and anchorage of non-structural systems shall be in accordance with Chapter 13 of ASCE 7-10 and as modified by this section.

Non-structural systems shall be assigned to Seismic Design Category F.

The importance factor Ip shall be assumed to equal 1.5.

The structure shall be assigned to Risk Category IV.

Design and anchorage of non-structural systems shall also meet the “Position Retention” requirements of ASCE 41-13 Chapter 13.

Designated non-structural systems that are required to satisfy the Operational performance objective shall be certified in accordance with the requirements of ASCE 7-10, Section 13.2.2.

* + - * 1. The short period spectral acceleration, Sxs, and component importance factor, Ip, for the design of all non-structural systems shall be in accordance with the General Structural Notes in the drawings.
      1. MODIFICATIONS TO ASCE 7, CHAPTER 13
         1. Replace ASCE 7 Section 13.1.3 with the following:

13.1.3 Component Importance Factor: All components shall be assigned a component importance factor, Ip, as indicated by this section. Use Ip = 1.5 unless noted otherwise.

* + - * 1. Replace ASCE 7 Section 13.2.5 with the following:

13.2.5 Testing Alternative for Seismic Capacity Determination: As an alternative to the analytical requirements of Sections 13.2 through 13.6, testing shall be deemed as an acceptable method to determine the seismic capacity of components and their supports and attachments. Seismic qualification by testing based upon a nationally recognized testing standard procedure, such as AC 156, acceptable to the authority having jurisdiction shall be deemed to satisfy the design and evaluation requirements provided that the substantiated seismic capacities equal or exceed the seismic demands determined in accordance with all of the following:

Seismic design forces determined in accordance with Section 13.3.1,

Seismic design forces associated with the dynamic response of the component when subjected to the floor acceleration for the applicable floor where the component is anchored. The floor accelerations are listed in the table below in section C.3.

Seismic relative displacements determined in accordance with Section 13.3.2.

* + - * 1. Replace ASCE 7 Section 13.3.1 with the following:

Section 13.3.1 Seismic Design Force: The horizontal seismic design force (Fp) shall be applied at the component’s center of gravity or distributed relative to the component’s mass distribution and shall be determined in accordance with Equation 13.3-1:

|  |  |
| --- | --- |
|  | (13.3-1) |

Fp shall not be taken as less than

|  |  |
| --- | --- |
|  | (13.3-1) |

where

Fp = seismic design force.

Sxs = spectral response acceleration parameter at short periods, as determined in this section.

ap = component amplification factor, as determined in this section.

Ax = story acceleration at level x, as determined in this section.

Ip = component importance factor, as determined in this section.

Wp = component operating weight.

Rp = component response modification factor, as determined in this section.

Fp shall be applied concurrently in two orthogonal horizontal directions in combination with service loads associated with the component, as appropriate. In addition, the component shall be designed for a concurrent vertical force determined in accordance with Equation 13.3-3:

|  |  |
| --- | --- |
|  | (13.3-3) |

Fp shall not be taken as less than

|  |  |
| --- | --- |
|  | (13.3-4) |

where

Fp = component horizontal seismic design force, determined in accordance with Equations 13.3-1 and 13.3-2.

Fpv = component horizontal seismic design force applied vertically at the center of gravity of the component or distributed according to the mass distribution of the component.

Sxs = spectral response acceleration parameter at short periods, as determined in this section.

Wp = component operating weight.

Where non-seismic loads on non-structural systems exceed Fp, such loads shall govern the strength design but the detailing requirements and limitations of this section shall apply.

Section 13.3.1.1 Component Fundamental Period: The component fundamental period, Tp, shall be determined in accordance with Equation 13.3-5:

|  |  |
| --- | --- |
|  | (13.3-5) |

where

Tp = component fundamental period.

Wp = component operating weight.

g = gravitational acceleration.

Kp = elastic stiffness of the support system of the component, its bracing, and its attachment, determined in terms of load per unity deflection at the center of gravity of the component.

Section 13.3.1.2 Story Acceleration and Component Amplification Factor: The story acceleration, Ax, shall be determined from the table below for the applicable floor level.

The component amplification factor, ap, shall be determined as follows:

Rigid components, Tp < 0.0625 seconds (16 Hz): ap = 1.0.

Flexible components, Tp > 0.0625 seconds (16 Hz): ap = 2.5 unless justified by detailed dynamic analysis.

Add Ax values in the below table, as appropriate. Add or delete floor levels as appropriate for the building.

|  |  |
| --- | --- |
| Floor | Ax [g] |
|  |  |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| Roof |  |

Section 13.3.1.3 Component Response Modification Factor: The component response modification factor, Rp, shall be determined from the Table 13.5-1 or 13.6-1.

Exceptions:

The ratio of Rp/Ip used for the design of architectural, mechanical, and electrical components, supports, and attachments shall not exceed 6.0 unless the component is certified by the manufacturer as seismically qualified to satisfy the performance objective. Certification of seismic qualification shall be satisfied by at least two of the following methods:

Analysis.

Testing in accordance with the alternative set forth in Section 13.2.6.

Experience data in accordance with the alternative set forth in Section 13.2.6.

* + - * 1. Replace ASCE 7 Section 13.3.2 with the following:

13.3.2 Seismic Relative Displacements: The effects of seismic relative displacements shall be considered in combination with displacement caused by other loads as appropriate. The Design Professional(s) responsible for each non-structural system shall coordinate and make provision in their designs to ensure that seismic impact between adjacent systems is eliminated.

Seismic relative displacements, Dp, shall be determined in accordance with Sections 13.3.2.1 and 13.3.2.2.

The effects of seismic relative displacements shall be considered in combination with displacements caused by other loads and as indicated on the structural drawings, as appropriate.

13.3.2.1 Seismic Relative Displacements: For two connection points on the same Structure A or the same structural system, one at a height hx, and the other at height hy, Dp, shall be determined as:

|  |  |
| --- | --- |
|  | (13.3-6) |

where

Dp = relative seismic displacement that the component must be designed to accommodate.

= maximum story drift between floors immediately above and below the connection points of the component. The maximum story drift shall be obtained from the table below.

hx = height of Level x to which upper connection point is attached.

hy = height of Level y to which upper connection point is attached.

Add drift values in the below table, as appropriate. Add or delete story levels as appropriate for the building.

|  |  |
| --- | --- |
| Story | Maximum Story Drift |
|  |  |
|  |  |
| 1 – 2 |  |
| 2 – 3 |  |
| 3 – 4 |  |
| 4 - Roof |  |

13.3.2.2 Displacements Between Structures: For two connection points on separate Structure A and B or separate structural systems, one at a height hx and the other at a height hy, Dp, shall be determined as:

|  |  |
| --- | --- |
|  | (13.3-7) |

where

Dp = relative seismic displacement that the component must be designed to accommodate.

= deflection at building Level x of Structure A, as tabulated on the structural drawings.

= deflection at building Level y of Structure B, as tabulated on the structural drawings.

* + - * 1. Replace ASCE 7 Section 13.4.2.1 with the following:

13.4.2.1 Anchors in Concrete: Anchors in concrete shall be designed in accordance with Appendix D of ACI 318. The ratio of Rp/Ip shall not exceed 1.0 unless the requirements of Sections D.3.3.4 or D.3.3.5 of ACI 318 are satisfied.

Exception: Section D.3.3.6 of ACI 318 need not be satisfied.

* + - * 1. Replace ASCE 7 Section 13.4.2.2 with the following:

13.4.2.2 Anchors in Masonry: Anchors in masonry shall be designed in accordance with TMS 402/ACI 503/ASCE 5. Anchors shall be designed to be governed by the tensile or shear strength of a ductile steel element.

Exception: Anchors shall be permitted to be designed so that the attachment that the anchor is connecting to the structure undergoes ductile yielding at a load level corresponding to anchor forces not greater than their design strength, or anchor forces corresponding to a ratio of Rp/Ip equal to 1.0.

* + - * 1. Replace ASCE 7 Section 13.4.2.3 with the following:

13.4.2.3 Post-Installed Anchors in Concrete Masonry: Post-installed anchors in concrete shall be pre-qualified for seismic applications in accordance with ACI 355.2, AC 193 or AC 308. Post-installed anchors in masonry used for component anchorage shall be pre-qualified for seismic applications in accordance with AC 01, AC 58 or AC 106.

* + - * 1. Replace ASCE 7 Section 13.4.2.5 with the following:

13.4.2.5 Powder Actuated Fasteners: Power actuated fasteners in concrete or steel shall not be used to resist tension loads or for brace applications. Power actuated fasteners in masonry are not permitted unless approved for seismic loading.

* + - * 1. Replace ASCE 7 Section 13.4.3 with the following:

13.4.3 Anchors in Steel: Anchors in steel shall be designed in accordance with the AISC Steel Construction Manual. The ratio of Rp/Ip shall not exceed 1.0 unless the attachment that the anchor is connecting to the structure undergoes ductile yielding at a load level corresponding to anchor forces not greater than their design strength.

* + - * 1. Replace ASCE 7 Section 13.5.1 with the following:

13.5.1 General: Architectural components, and their supports and attachments, shall satisfy the requirements of this section. Appropriate coefficients shall be selected in accordance with this specification.

* + - * 1. Replace Item d of ASCE 7 Section 13.5.3 with the following:

d: All fasteners in the connecting system such as bolts, inserts, welds, and dowels and the body of the connectors shall be designed for the force (Fp) determined by Section 13.3.1 with values of Rp and ap taken in accordance with this specification and applied at the center of mass of the panel.

* + - * 1. Replace ASCE 7 Section 13.5.6 with the following:

13.5.6 Suspended Ceilings: Suspended ceilings shall be in accordance with this section.

* + - * 1. Replace ASCE 7 Section 13.5.6.2.2 with the following:

13.5.6.2.2 Seismic Design Categories D through F: Acoustical tile or lay-in panel ceilings in Seismic Design Categories D, E, and F shall be designed and installed in accordance with ASTM C635, ASTM C636, and ASTM E580, Section 5 – Seismic Design Categories D, E, and F as modified by this section. Acoustical tile or lay-in panel ceilings shall also comply with the following.

The width of the perimeter supporting closure angle or channel shall be not less than 2 inches. Where perimeter supporting clips are used, they shall be qualified in accordance with approved test criteria. In each orthogonal horizontal direction, one end of the ceiling grid shall be attached to the closure angle or channel. The other end in each horizontal direction shall have a 0.75-inch clearance from the wall and shall rest upon and be free to slide on a closure angle or channel.

For ceiling areas exceeding 2,500 square feet, a seismic separation joint or full height partition that breaks the ceiling up into areas not exceeding 2,500 square feet, each with a ratio of the long to short dimension less than or equal to 4, shall be provided unless structural analyses are performed of the ceiling bracing system for the prescribed seismic forces that demonstrate ceiling penetrations and closure angles or channels provide sufficient clearance to accommodate the anticipated lateral displacement. Each area shall be provided with closure angles or channels in accordance with Section 13.5.6.2.2.a and horizontal restraints or bracing.

Corridors and Lobbies: A seismic separation joint shall be provided in the ceiling at intersections of corridors and at junctions of corridors and lobbies or other similar areas.

Lay-In Panels: Metal panels and panels weighing more than 1/2 pound per square foot other than acoustical tiles shall be positively attached to the ceiling suspension runners.

Lateral Force Bracing: Lateral force bracing is required for all ceiling areas except that they shall be permitted to be omitted in rooms with floor areas of up to 144 square feet when perimeter support in accordance with ASTM E 580 Section 5.2.2 and 5.2.3 are provided and perimeter walls are designed to carry the ceiling lateral forces. Substantiating design calculations or test reports shall be provided to demonstrate that the ceiling is capable of spanning horizontally between the perimeter supports under the specified prescribed forces and displacements for the component as determined by Sections 13.3.1 and 13.3.2.

Ceiling fixtures: Fixtures installed in acoustical tile or lay-in panel ceilings shall be mounted, braced and anchored in a manner that will not compromise ceiling performance.

Partitions: Where the suspended ceiling system is required to provide lateral support for the permanent or relocatable partitions, the connection of the partition to the ceiling system, the ceiling system members and their connections, and the lateral force bracing shall be designed to support the reaction force of the partition from prescribed loads and displacements applied perpendicular to the face of the partitions. Partition connectors, the suspended ceiling system and the lateral-force bracing shall be designed to suit the individual partition application and shall be specifically documented in the shop drawings.

* + - * 1. Replace ASCE 7 Section 13.5.7.2 with the following:

13.5.7.2 Special Access Floors: All access floors shall be considered to be “special access floors” and shall be designed to comply with the following considerations:

Connections transmitting seismic loads shall consist of mechanical fasteners, anchors satisfying the requirements of Appendix D of ACI 318, welding, or bearing. Design load capacities shall comply with recognized design codes and/or certified test results.

Seismic loads shall not be transmitted by friction, power actuated fasteners, adhesives, or by friction produced solely by the effects of gravity.

The design analysis of the bracing system shall include the destabilizing effects of individual members buckling in compression.

Bracing and pedestals shall be of structural or mechanical shapes produced to ASTM specifications that specify minimum mechanical properties. Electrical tubing shall not be used.

Floor stringers shall be designed to carry axial seismic loads and shall be mechanically fastened to the supporting pedestals.

* + - * 1. Replace ASCE 7 Section 13.5.8.1 with the following:

13.5.8.1 General: Partitions that are tied to the ceiling and all partitions greater than 5 feet in height shall be laterally braced to the building structure. Such bracing shall be independent of any ceiling lateral force bracing. Bracing shall be spaced to limit horizontal deflection at the partition head to be compatible with ceiling deflection requirements as determined in Section 13.5.6 for suspended ceilings and elsewhere in this section for other systems.

Lateral bracing shall not be installed within 24 inches of an orthogonal partition unless provision is made in the partition detailing to accommodate differential lateral movement without damaging the partitions. The design of partition head-tracksand lateral bracing shall be coordinated with this requirement.

* + - * 1. Replace ASCE 7 Section 13.6.1 with the following:

13.6.1 General: Mechanical and electrical components and their supports shall satisfy the requirements of this section. The attachment of mechanical and electrical components and their supports to the structure shall meet the requirements of Section 13.4. Appropriate coefficients shall be selected in accordance with this specification.

Exception: Light fixtures, lighted signs, and ceiling fans not connected to ducts or piping, which are supported by chains or otherwise suspended from the structure, are not required to satisfy the seismic force and relative displacement requirements provided they meet all of the following criteria:

The design load for such items shall be equal to 1.4 times the operating weight acting down with a simultaneous horizontal load equal to 1.4 times the operating weight. The horizontal load shall be applied in the direction that results in the most critical loading for the design.

Seismic interaction effects shall be considered in accordance with Section 13.2.3.

The connection to the structure shall allow a 360° range of motion in the horizontal plane.

Where design of mechanical and electrical components for seismic effects are required, consideration shall be given to the dynamic effects of the components, their contents, and where appropriate, their supports and attachments. In such cases, the interaction between the components and the supporting structures, including other mechanical and electrical components, shall also be considered. The Design Professional responsible for each component shall coordinate their Delegated-Design Submittal(s) with the design of other adjacent components to ensure that this requirement is satisfied.

* + - * 1. Replace ASCE 7 Section 13.6.5.6 with the following:

13.6.5.6 Conduit, Cable Tray, and Other Electrical Distribution Systems (Raceways): Raceways shall be designed for seismic forces and seismic relative displacements as required in Section 13.3. Conduit greater than 2.5-inch trade size and attached to panels, cabinets, or other equipment subject to seismic relative displacement, Dp, shall be provided with flexible connections or designed for seismic forces and seismic relative displacements as required in Section 13.3.

Exception: Design for the seismic forces and relative displacements of Section 13.3 shall not be required for raceways supported by hangers and each hanger in the raceway run is 3 inches or less in length from the raceway support point to the supporting structure, and the total weight is less than 5 pounds per foot. Where rod hangers are used, they shall be equipped with swivels to prevent inelastic bending in the rod. Alternatively, the rods and anchorage shall be designed to resist combined shear and bending forces due to the eccentrically applied seismic forces

* + - * 1. Replace ASCE 7 Section 13.6.7 with the following:

13.6.7 Ductwork: HVAC and other ductwork shall be designed for seismic forces and seismic relative displacements as required in Section 13.3. Components that are installed in-line with the duct system and have an operating weight greater than 75 lb (334 N), such as fans, heat exchangers, and humidifiers, shall be supported and laterally braced independent of the duct system and such braces shall meet the force requirements of Section 13.3.1. Appurtenances such as dampers, louvers, and diffusers shall be positively attached with mechanical fasteners. Un-braced piping attached to in-line equipment shall be provided with adequate flexibility to accommodate the seismic relative displacements of Section 13.3.2.

* + - * 1. Replace ASCE 7 Section 13.6.8.1 with the following:

13.6.8.1 ASME Pressure Piping Systems: Pressure piping systems, including their supports, shall be designed to meet the seismic performance objectives of this specification. Where a standard such as ASME B31 is used as the basis for design and construction, the Design Professional shall submit additional analytical evidence to demonstrate compliance with the seismic performance objectives. Materials meeting the toughness requirements of ASME B31 shall be considered high-deformability materials.

* + - * 1. Replace ASCE 7 Section 13.6.8.2 with the following:

13.6.8.2 Fire Protection Sprinkler Piping Systems: Fire protection sprinkler piping, pipe hangers, and bracing shall be designed to meet seismic performance objectives of this specification. Where a standard such as NFPA 13 is used as the basis for design and construction, the Design Professional shall submit additional analytical evidence in accordance with the seismic force and relative displacement requirements of this specification to demonstrate compliance with the seismic performance objectives. The design and construction shall envelope the requirements of NFPA 13 and this specification.

The exceptions of Section 13.6.8.3 shall not apply.

* + - * 1. Replace ASCE 7 Section 13.6.8.3 with the following:

13.6.8.3 Exceptions:

The piping is supported by hangers and each hanger in the piping run is 2 inches or less in length from the top of the pipe to the supporting structure. Where pipes are supported on a trapeze, the trapeze shall be supported by hangers having a length of 3 inches or less. Where rod hangers are used, they shall be equipped with swivels, eye nuts, or other devices to prevent bending in the rod. Alternatively, the rods and anchorage shall be designed to resist combined shear and bending forces due to the eccentrically applied seismic forces.

Piping having an Rp in Table 13.6-1 of 4.5 or greater is used and provisions are made to avoid impact with other structural or nonstructural components or to protect the piping in the event of such impact and where the nominal pipe size shall be 1 inch or less.

* + - * 1. Replace ASCE 7 Section 13.6.10.3 with the following:

13.6.10.3 Seismic Controls for Elevators: Elevators shall be provided with seismic switches. Seismic switches shall provide an electric signal indicating that structural motions are of such a magnitude that the operation of the elevators may be impaired. Seismic switches in accordance with Section 8.4.10.1.2 of ASME A17.1 shall be deemed to meet the requirements of this section.

Exception: In cases where seismic switches cannot be located near a column in accordance with ASME A17.1, they shall have two horizontal axes of sensitivity and have a trigger level set to 20 percent of the acceleration of gravity where located at or near the base of the structure and 50 percent of the acceleration of gravity in all other locations. Upon activation of the seismic switch, elevator operations shall conform to the requirements of ASME A17.1, except as noted in the following text. The elevator shall only be used after the seismic switch has triggered provided that:

The elevator shall operate no faster than the service speed.

Before the elevator is occupied, it is operated from top to bottom and back to top to verify that it is operable.

END OF SECTION 014100