2021 Seattle Existing Building Code:

Commentary on Significant Changes to URM Seismic Regulations

Contents

Introduction and Overview

This commentary provides additional context to the unreinforced masonry (URM) building seismic regulations adopted in the 2021 Seattle Existing Building Code (SEBC) as directed by the joint Seattle City Council and Mayoral Resolution 32033. This resolution guides the development of a mandatory URM retrofit program with the goal of reducing the risk of injury from collapse of URM buildings in the event of an earthquake. It also includes a brief history of changes to Seattle's building codes and regulations as they relate to URM buildings and seismic safety.

The intent of codifying the interim process for voluntary retrofit recognition was to provide URM owners assurance that, absent a public safety necessity, buildings strengthened to the minimum retrofit standard will be compliant with future mandatory seismic retrofitting legislation adopted by the city. This voluntary path helps avoid delays in retrofits by reducing uncertainty about future mandatory requirements.

Note that voluntary seismic improvements do not trigger the substantial alteration requirements of SEBC Section 311 unless other conditions, additions, or other alteration work meeting the substantial alteration thresholds in SEBC Section 311.1.1 are part of the scope. Additionally, the Alternate Method does not meet the substantial alterations requirements for seismic improvement mandated by SEBC Section 311.1.2 or those associated with new construction. The Alternate Method is a minimum retrofit standard and building owners are encouraged to consider higher performance levels during the retrofit design process. Currently, compliance with URM seismic regulations is voluntary unless owner-initiated changes significantly increase the occupant load per SEBC 304.5 Item 1.

Changes to the seismic regulations affecting URM buildings are found in four distinct areas of the SEBC.

- **Section 202**: General Definitions. Definitions are provided for Unreinforced Masonry, Unreinforced Masonry Building, and Retrofitted Unreinforced Masonry Building
- **Section 304.5:** Seismic regulations for unreinforced masonry buildings. This section contains criteria for when buildings must comply with the new seismic regulations and the methods for compliance.
- **Section 311.1.1, Item 5**: Removal of definition requiring a substantial alteration retrofit for URM buildings with a significant increase in occupancy.
- **Appendix Chapter A6**: Alternate Method for the Seismic Improvement of URM Buildings

Background

Seattle's Previous URM code provisions

Since 1942 when lateral seismic design forces were mandated by the Seattle Building Code (SBC), the city has incrementally addressed the seismic vulnerability of URM construction. In 1974, the Seattle City Council passed Ordinance 102902 requiring retrofitting of all existing URM buildings in Pioneer Square to meet prescriptive structural requirements for seismic forces. The structural requirements of the ordinance were repealed in 1978 due to the cost of implementing the upgrades. Also in 1974 the city council passed Ordinance 103125 requiring reinforcing of all new masonry construction within the City of Seattle and adopting the UBC as Seattle's model building code on May 7, 1977, when Washington State adopted the 1973 UBC as the official state building code.

Comprehensive seismic retrofits are required for projects deemed a substantial alteration since the adoption of the 1994 Seattle Building Code. Repair of significant damage, major renovations, reoccupying a vacant building, or changing the building's use or occupancy may classify the project as a substantial alteration. In such cases, parts of the building may need to comply with current life safety and energy code requirements in addition to the seismic retrofitting. Director's Rule 15-2021 requires substantial alteration projects include a comprehensive seismic evaluation report, as described in SEBC 311.1.3. If the report indicates the building is substantially out of compliance with current engineering standards for existing buildings, a seismic retrofit will be required. Previous versions of the SEBC included a URM-specific definition where a significant increase in the occupant load of a URM building triggered a substantial alteration, which has since been removed.

In 2013, Seattle Department of Construction and Inspections (SDCI)[1] enacted a policy to require mitigation of unbraced URM parapets and other appendages when applications for construction or mechanical permits require plan review. Bracing of URM parapets mitigates the portion of a URM building most vulnerable to damage in a seismic event and poses the greatest risk to public safety. SDCI can require mitigation of unsafe building appendages under 2021 SEBC Sections 101.14 and 302.8.

SDCI policy accepted the draft URM Retrofit Technical Standard (2012 or 2023 versions) as de facto design guidelines for URM retrofits prior to adoption of the 2021 SEBC. The draft standard addresses the most common deficiencies in URM construction and is the basis for the Alternate Method codified in the 2021 SEBC. However, the 2012 draft Technical Standard did not standardize seismic hazard forces and may have resulted in retrofits designed to lower force levels than are required by the Alternate Method.

The 2023 draft Technical Standard improved the earlier version and became official SDCI policy through Director's Rule 6-2023 (DR 6-2023). The Director's Rule took effect in alignment with Resolution 32111 that directed SDCI to create an interim voluntary URM retrofit pathway informed by the 2023 draft Technical Standard, thus establishing a retrofit compliance standard. DR 6-2023 provided building owners with assurance of compliance with future mandatory retrofit requirements.

SDCI maintains a database of all URM buildings identified in the city of Seattle and documents the retrofit compliance of the buildings. As of the date of publication, 1117 URM buildings are identified in the database, which is viewable on the SDCI URM website.

2008 URM Technical Committee

In 2001, the 6.8 magnitude Nisqually Earthquake shook Seattle, causing over $1 billion in damage in the Puget Sound region. Like previous earthquakes, the damage concentrated in URM buildings, and two-thirds of the buildings determined unsafe to occupy and red tagged by the city were URM buildings. The 2008 Technical Committee, made up of engineers, architects, and building owners, worked closely with the Structural Engineers Association of Washington (SEAW) and SDCI to produce a technical standard informed by California's Bolts+ retrofit standard as an alternative to the existing comprehensive method. The proposed method improved the affordability of earthquake retrofits for qualifying URMs and targeted inclusion in future mandatory URM retrofit legislation. The resulting minimum retrofit

[1] The City of Seattle building department has changed names over the years, but for the sake of consistency will be referred to only by its current name, Seattle Department of Construction and Inspections (SDCI), for the remainder of this document

standard, “Final Report from URM Technical Committee & Proposed Retrofit Standard”, published in March 2012, required:

- bracing of parapets
- structurally connecting floors and roofs to URM walls
- strengthening floors and roofs by interconnecting framing
- strengthening of weak interior and exterior bearing walls

Resolution 32033 and 2022 Technical Standard Task Group

Adopted in 2021, the joint Council and Mayoral Resolution 32033 guided the creation of SDCI’s URM Program. The resolution identified protecting “life safety by reducing the risk of injury from collapse of URMs in the event of an earthquake” as a primary policy goal for a mandatory URM retrofit program. The Resolution provided both technical and policy recommendations for a mandatory URM retrofit program. Technical recommendations included defining a retrofitted URM building and a minimum retrofit standard.

After Resolution 32033 passed, SDCI began developing a minimum retrofit standard that balanced reducing design and construction costs while addressing the primary structural deficiencies of URM buildings to improve life safety. SDCI engaged the SEAW Existing Building Committee (EBC) to form a new Technical Standard Task Group to ensure consensus in the review and update of the 2012 draft technical standard. The Task Group updated the draft technical standard to reflect current building codes, improve clarity, and address changes to the local seismic hazards.

The 2023 URM Retrofit Technical Standard, published June 30, 2023, received multiple rounds of review by the SEAW-EBC and the public before publishing to the SDCI URM webpage. The 2023 Retrofit Technical Standard includes new definitions for Unreinforced Masonry, Unreinforced Masonry Building and Retrofitted Unreinforced Masonry Building, and outlines the compliance criteria for recognizing a retrofitted URM. The report includes final recommendations for the “*Alternate Method for the Seismic Improvement of Unreinforced Masonry Buildings*”, an updated seismic retrofit standard targeting a minimum level of life safety risk and reduced costs associated with retrofit design and construction. Deliberations and decisions made by the Task Group are discussed in-depth in the code commentary portion of this document below.

Director’s Rule 6-2023 and Resolution 32111

SDCI published Director’s Rule 6-2023 September 23, 2023, as an interim step prior to adoption of the 2021 Seattle Existing Building Code for building owners eager to begin the retrofit process but apprehensive about meeting future retrofit compliance standards. This rule formally allowed voluntary use of the alternate method for retrofitting to a minimally acceptable level of structural performance through the installation of wall anchors, wall bracing, and parapet bracing. It also addressed testing and quality assurance of existing masonry construction and new wall anchors.

The adoption of Resolution 32111 on October 13, 2023, approved the use of DR 6-2023 to satisfy future mandatory URM compliance requirements. The Resolution also guided SDCI efforts to officially recognize retrofitted URM buildings in the city’s database upon demonstrating compliance DR 6-2023.

Upon adoption of the 2021 SEBC on November 15, 2024, DR 6-2023 became obsolete and has been rescinded. The following code commentary section discusses the additions and changes to the 2021 SEBC, and the rationale behind them.

2021 Seattle Existing Building Code Commentary

The following sections constitute the code commentary portion of this document, focusing on new code sections directly related to the URM seismic regulations.

Section 202: General Definitions

Section 202 includes new definitions related to unreinforced masonry and the URM seismic regulations of Section 304.5.

> **UNREINFORCED MASONRY (URM).** Includes burned clay, concrete or sand-lime brick, hollow clay block, or hollow clay tile.

For the purposes of Section 304.5, the definition of URM does not include unreinforced concrete masonry unit (CMU) construction. This definition differs slightly from the definition of URM in Chapter A1, which does include hollow concrete block for the use of that chapter's seismic strengthening provisions. CMU or hollow concrete block are excluded from the new seismic regulations due to the desire to address only the most vulnerable building types. CMU construction behaves better than brick in seismic events, even when the CMU is under- or unreinforced.

> **UNREINFORCED MASONRY (URM) BUILDING.** A building where one or more URM walls provide the primary support for vertical loads from floors or roofs and the URM walls rely on the tensile strength of masonry units, mortar and grout in resisting design loads.
>
> NOTE: URM buildings were generally constructed prior to 1945 and unlawful after adoption of the 1973 Uniform Building Code on May 7, 1977.

"Primary support for vertical loads..." is key in the definition of URM building. SDCI considered inclusion of URM partition and infill walls but ultimately determined that loss of support for gravity loads is the highest risk to building occupants. A building originally constructed or retrofitted to support all gravity loads independent of URM walls is not a URM building and can be removed from the database through an appeal process.

Unreinforced masonry buildings are typically multiple-story, red-brick structures found in many of the city's oldest neighborhoods and commercial centers. URM buildings are known to be unsafe in earthquakes because they are built without steel reinforcement or sufficient structural connections between the URM walls and the floors and roof. Collapsed buildings can endanger the lives of building occupants and nearby pedestrians, block public rights-of-way for emergency response, and delay overall recovery from the earthquake. A seismic retrofit can significantly reduce a URM building's risk of collapse in the event of an earthquake.

> **RETROFITTED UNREINFORCED MASONRY (URM) BUILDING.** A URM building that meets a minimally acceptable level of life safety risk from earthquakes by demonstrating compliance with Section 304.5.1.

NOTE: Retrofitted URM buildings are eligible for a status change in the City of Seattle URM database.

The term “life safety risk” in this context should not be confused with the Life Safety structural performance objective level defined in ASCE 41. “Minimally acceptable level of life safety risk” refers to a retrofit that addresses the most pressing deficiencies in a building and reduces the risk of injury or loss of life because of earthquake damage. Buildings that meet the definition of a retrofitted URM building may have their status changed to Compliant Retrofit in the URM database.

Section 304.5: URM Retrofit Requirements

304.5 Seismic regulations for Unreinforced Masonry Buildings. URM buildings meeting any of the following criteria must comply with 304.5.1:

1. Where there is a significant increase in the occupant load of a URM building, as determined by the code official.
2. URM Buildings voluntarily seeking to be defined as a Retrofitted URM Building.

Previous editions of the SEBC included a substantial alteration definition specific to URM buildings in 2018 SEBC Section 307.1.1, definition #5. In the 2021 SEBC the definition moved to Item 1 of the URM seismic regulations and requires seismic retrofit work only. Upgrades to other fire / life safety systems are no longer associated with this URM-specific definition. The general structural notes in the seismic retrofit drawings should indicate if the retrofit is mandatory per Item 1 or voluntary per Item 2.

The primary goal of the URM program is to reduce the probability of collapse for all URM buildings in Seattle by requiring these buildings to meet a basic level of structural performance. The intent of codifying an interim voluntary process for recognizing a retrofitted URM building was twofold. First, to formally establish a minimum retrofit standard assuring URM owners that a retrofit completed to this standard will be compliant with future mandatory requirements. Second, to eliminate potential delays in life-saving retrofits due to uncertainty about future mandatory requirements. Compliance with SEBC 304.5 is currently voluntary unless owner-initiated rehabilitation work mandates compliance. SDCI is actively pursuing future mandatory retrofit requirements in accordance with Seattle City Council Resolution 32033.

304.5.1 URM Seismic regulations. URM buildings shall comply or be altered to comply with one of the following:

1. Section 304.4.2;
2. Appendix Chapter A6 Alternate Method for the Seismic Improvement of Unreinforced Masonry (URM) Buildings;
3. Previously permitted and completed retrofits that comply with one of the following:
    a. URM Buildings that have undergone a seismic retrofit due to a substantial alteration determination, permitted between September 16, 1996 and April 24, 2009 using the 1994 or later edition of the Seattle Building Code. A report confirming the retrofit work was completed shall be prepared by a licensed structural engineer and submitted to the code official.
    b. URM Buildings that have undergone a seismic retrofit due to a substantial alteration determination, permitted after April 24, 2009 using the 2006 or later edition of the Seattle Building Code.

c. Other seismic retrofits approved by the code official.

This section defines several compliance pathways, depending on the existing structural systems of the building, desired seismic performance, and past retrofit work.

Item 1 directs the engineer to the structural requirements for a substantial alteration with reduced seismic forces in SEBC Section 304.4.2. Retrofitting to Item 1 will result in a more robust retrofit resulting in a greater reduction of life safety risk and reduced building damage as compared to the Alternate Method. Of the options listed in SEBC Section 304.4.2 for evaluation and retrofit of an existing building, only the following two are applicable to URM buildings:

a) Follow the Appendix Chapter A1 procedures for seismic evaluation and design of URM bearing wall buildings which are only applicable to Risk Category I or II buildings.
b) Perform a Tier 1 screening and Tier 2 evaluation and retrofit for any identified deficiencies per ASCE 41. If a building does not qualify for Tier 1 screening, then a Tier 3 evaluation and retrofit is required.

Item 2, the Alternate Method, is based on the SEBC Appendix A1 Special Procedure and California Bolts+ retrofit methods. It addresses the most vulnerable components for qualifying buildings: wall anchorage, parapets, and out-of-plane wall bracing. The Alternate Method provides a minimally acceptable level of life safety risk with a reduced scope of retrofit work and thus a more economical means for retrofitting. The resulting level of structural performance is greater than an un-retrofitted URM but less than a retrofit per Item 1.

Item 3 is a codified means to recognize previously completed retrofits. Compliance of previously completed retrofits can be approved by following the instructions in the "Procedure to Apply for Retrofitted URM Status" document and submitting the "Application Form for Retrofitted URM Status in the URM Database" on the SDCI URM Program website. The form may be completed by the building owner or their authorized agent and must include the building address and SDCI permit number associated with the seismic retrofit work.

Item 3a applies to older seismic retrofits permitted after Director's Rule 32-96 (DR 32-96) was in effect. DR 32-96 was the first guideline adopted by the City of Seattle to standardize retrofitting of existing buildings. To demonstrate compliance under Item 3a, a report shall be authored by a licensed structural engineer describing the force levels, evaluation procedure, structural retrofit design and scope of work performed, similar to the reporting requirements found in ASCE 41 for benchmark buildings. Review of the record drawings of the structure shall be performed to confirm that the primary elements of the seismic force-resisting system and their detailing were designed in accordance with the applicable code in effect at the time. Specifically indicate that the following elements were addressed: wall anchorage; diaphragm shear transfer; out-of-plane wall bracing; parapets and appendage bracing. The Director's Rule included a broad list of acceptable documents to guide the analysis and design of retrofits. That list, along with other acceptable seismic retrofit codes and standards published afterwards, is included below:

1. Seattle Building Code
2. NEHRP Handbook for the Seismic Evaluation of Existing Buildings (FEMA 178).
3. The 1991 Uniform Code for Building Conservation (for unreinforced masonry buildings only)
4. Methods for Evaluating the Seismic Strength of Existing Buildings (ATC -14)

5. Department of Defense Tri-services manual
6. Handbook for the Seismic Evaluation of Buildings (FEMA 310)
7. Pre-standard and Commentary for the Seismic Rehabilitation of Buildings (FEMA 356)
8. ASCE 31-03 Seismic Evaluation of Existing Buildings
9. ASCE 41-06 Seismic Rehabilitation of Existing Buildings
10. Other alternate methodologies approved by the building official

The report must include a signed attestation by the structural engineer that the work appears to be completed per the original construction documents and that significant deterioration of structural materials has not occurred. Field verification shall be performed to confirm that the building was constructed in general conformance with record drawings and that no modifications have been made that significantly affect the expected performance of the lateral force-resisting system.

Item 3b applies to retrofits completed after the publication of Director's Rule 7-2009 (DR 7-2009), which superseded DR 32-96, and specifies ASCE 31-03 and 41-06 (or later versions) as the retrofit standards. SDCI will use this information to confirm a permit was issued, appropriate design criteria were used, and construction was completed in general conformance with the building code at the time. Photographic evidence of the retrofit must be submitted along with the completed form. Additional information may be requested by SDCI during the review process.

Item 3c allows for the recognition of previously completed retrofits not covered by Items 3a or 3b and are subject to the discretion of the code official. A licensed Structural Engineer shall submit satisfactory evidence demonstrating the building and any applicable seismic retrofits meet the structural performance intent of SEBC 304.5, subject to approval by SDCI.

Other seismic retrofits may include:

i. seismic retrofits in compliance with 2021 SEBC Section 304.4.2 using reduced IBC seismic forces
ii. draft versions of the URM Retrofit Technical Standard or DR 6-2023
iii. other retrofits that meet the minimum retrofit standard defined in the SEBC Section 304.5 for a retrofitted URM building

Prior to submitting a 3c application, the building owner or authorized agent should contact the URM Program by emailing SCI_URM@seattle.gov to determine the reporting requirements based on the specifics of the project.

Where Item 3a and 3c require a seismic evaluation report to establish compliance, the Structural Engineer can use the following as examples for stating compliance:

- The evaluation of the building has found the existing seismic retrofit substantially compliant with the definition of a retrofitted URM building as defined in 2021 SEBC Section 202.
- The evaluation of the building has found the existing seismic retrofit substantially compatible with 2021 SEBC Chapter A6: Alternate Method by addressing the following deficiencies: [list deficiencies addressed].
- An ASCE 41 Tier 1 screening of the building has found the existing seismic retrofit substantially compatible with the comprehensive retrofit requirements as defined in 2021 SEBC Section 404.4.2.

Appendix Chapter A6: Alternate Method

Recognizing the high cost of a comprehensive seismic retrofit, the Alternate Method was developed as an alternative when certain qualification criteria are met. A building that meets the qualification criteria will implicitly have a relatively complete lateral system, albeit may potentially lack adequate strength and ductility when compared to modern seismic design standards. The scope of work for the Alternate Method addresses four common deficiencies associated with URM construction: (1) parapet bracing; (2) in-plane diaphragm-to-wall connections; (3) out-of-plane diaphragm-to-wall connections; and (4) out-of-plane wall bracing for slender URM walls. It should be stressed that the Alternate Method is a minimum approach that provides a level of structural performance lower than new construction or even structural work for *substantial alterations*. Additional scope of work beyond the Alternate Method minimum is encouraged for all URM retrofits.

The verbiage of Chapter A6 intentionally mirrors Appendix Chapter A1: Seismic Strengthening Provisions for URM Bearing Wall Buildings and ASCE 41 Section 16.2: Special Procedure for Unreinforced Masonry. Engineers experienced in designing seismic retrofits with those standards will find familiarity with many of the provisions in Chapter A6. The sections below discuss the significant differences between Chapters A6 and A1.

Section A601: General

The performance goal of the Alternate Method is to reduce the probability of collapse during the most probable seismic events, thus reducing injury and loss of life. The Alternate Method provides a minimally acceptable level of life safety risk from earthquakes for qualifying buildings, lower than the ASCE-41 Basic Performance Objective for Existing Buildings and is a lesser level of structural performance than the substantial alteration seismic regulations established in SEBC Section 311.1.2.

When Chapter A6 is used, the construction documents should include a statement on the structural notes indicating that the retrofit design intent is to comply with Chapter A6. The following is an example of what should be included in the structural general notes.

> The building evaluation and retrofit is part of a seismic improvement that meets the Alternate Method for the seismic improvement of URM buildings as written in SEBC Chapter A6. The design is based on 75% of ASCE 7-22 seismic hazard parameters. The intent of the retrofit is to comply with a future City of Seattle URM building retrofit ordinance.

If structural modification is necessary to meet the qualification criteria, notes should clearly indicate which of the seven qualification criteria the original building configuration does not meet and what has been modified to qualify for the Alternate Method. If the retrofit work is proposed to be completed under separately permitted phases, the plans should clearly indicate which deficiencies are being addressed and which are being deferred.

Section A603: Qualification Criteria

A building must meet seven qualification criteria to use the Alternate Method. Engineering judgement should be exercised during evaluation of the qualification criteria to ensure that the building meets the intent of the Alternate Method. Generally, a qualifying building should include a complete load path from roof to foundations and has attributes inherent to a basic lateral system. It is possible to modify the building to qualify if the building does not meet all criteria. An Alternate Method questionnaire is available on the SDCI URM website to determine eligibility and prepare for a pre-submittal conference.

Buildings that demonstrate compliance with, or are altered to comply with, qualification criteria (1)-(7) below are permitted to be strengthened in compliance with the Alternate Method.

(1) The building is no more than 6 stories above the seismic base of the structure.

The story height limitation aligns with the maximum number of stories permitted by Appendix A1 and the California Bolts+ retrofit standard

(2) The building shall not be classified as Risk Category IV.

Risk Category IV (RC-IV) includes fire stations, hospitals and other emergency services that should remain operational after an earthquake. Because of the importance of RC-IV buildings and vulnerability of the occupants, the Alternate Method cannot be used for their retrofit. The Task Force debated whether Risk Category III (RC-III) buildings, such as schools, should also be excluded. They decided that doing so may discourage voluntary retrofitting and delay passage of a mandatory ordinance due to funding concerns. Incentivizing retrofits with the more affordable Alternate Method scope of work makes retrofitting more likely and some level of retrofit is better than no retrofit. SDCI encourages all URM retrofits to exceed the minimum scope, especially higher risk buildings.

(3) The building does not have a Weak Story vertical irregularity as defined by ASCE 7-16 as referenced by the SBC.

Post-elastic drift demands caused by weak story irregularities are not accurately captured by linear analysis, such as that performed for the Alternate Method. Weak stories are a common deficiency in URM buildings and can be mitigated by adding a supplemental lateral system to qualify for the Alternate Method. Addition of a supplemental lateral system to comply is discussed further in qualification Item (7) below.

(4) The building has a mortar shear strength, v_{to}, as determined by Section A604.2, of 30 psi or more for all masonry classes.

30 psi mortar shear strength is generally recognized as a minimally acceptable mortar strength by other methods such as ASCE 41 Tier 1 screening and SEBC Appendix A1. Alternate Method validation studies used 30 psi mortar shear strength to determine acceptable wall lengths and in-plane demand-capacity ratios (DCR) per qualification criteria Item (7) below. A minimum mortar shear strength keeps the walls within the predicted overstress levels that have been deemed acceptable. Walls that do not meet the minimum strength may be repointed to meet the requirement. Most proprietary post-installed anchorage requires a minimum shear strength of 30 psi, with some anchors requiring up to 80 psi.

(5) The building has wood or plywood diaphragms at all levels above the base of the building.

Flexible diaphragm behavior inherent to wood diaphragms are a fundamental assumption of the Special Procedure from which the Alternate Method was developed. The expected building behavior is through the seismic action of flexible diaphragms resisting actions from relatively heavy out-of-plane URM walls. Other non-flexible diaphragm types may result in behavior inconsistent with the assumptions used for the Alternate Method. Flexible diaphragms also reduce the likelihood of torsion negatively impacting the building behavior by distributing the out-of-plane forces relatively evenly to the supporting walls. The building must have flexible wood diaphragms at all story levels to qualify for the Alternate Method.

(6) The building does not have straight sheathed floor or roof diaphragms.

Exceptions:

i. Straight sheathed floor diaphragms with finished wood flooring with offset or perpendicular board edges.

ii. Straight sheathed floor or roof diaphragms without finished wood flooring with offset or perpendicular board edges where any of the following conditions are met:

(1) The building has crosswalls below the non-compliant level at a spacing that does not exceed 40 feet on center; or

(2) The diaphragm span is less than 24 feet and the diaphragm aspect ratio is less than 2-to-1.

Item (6) is intended to ensure adequate diaphragm strength and stiffness. Straight sheathed diaphragms, common with URM construction, have low in-plane shear strength and are unable to develop out-of-plane forces and transfer these forces to the vertical lateral force resisting system. Exception (i) allows for straight sheathed floors with finished floor overlay parallel or perpendicular to the subfloor by counting it as a double straight sheathed diaphragm, which is known to have considerably greater in-plane strength and stiffness. Exception (ii) allows for straight sheathed floor or roof diaphragms where either crosswalls exist or diaphragm spans are relatively short with a low aspect ratio. Crosswalls can reduce diaphragm deflections reducing the risk of failure of the out-of-plane walls during cyclic loading.

It is expected that many historical URM floor diaphragms will qualify for exception (i) given that floors were often constructed with wood flooring perpendicular to the supporting decking. However, the same cannot be assumed for roof diaphragms which are typically a single layer of straight sheathing and crosswalls typically discontinue at the attic. Installation of plywood sheathing overlay may be necessary at some roof diaphragms for the building to meet Item (6) and should be a consideration when planning roofing replacements.

(7) The building has or will be provided with a minimum of two lines of vertical elements of the lateral force-resisting system parallel to each axis located near or on the perimeter of the building. Where the lateral force resisting system is a masonry wall:

i. The piers shall have a height-to-width ratio that does not exceed 2 to 1.

ii. The piers shall occupy not less than 40 percent of the wall's length.

iii. The piers shall not be comprised of hollow clay block or hollow clay tile.

Lateral force-resisting frames or walls added to provide a minimum of two lines of vertical elements of the lateral force-resisting system must comply with the seismic regulations for Substantial Alterations per the Seattle Existing Building Code.

Exception:

Item seven qualification criteria for masonry walls do not apply if the applicant submits a report prepared by a licensed Structural Engineer that shows all walls comply with a maximum demand/capacity ratio of 2.5 for in-plane forces. One of the following two methods shall be used to determine the demand/capacity ratio:

i. ASCE 41 Chapter 16: Special Procedure for Unreinforced Masonry where seismic hazard is determined using Section 604.1 of this Appendix with $S_{XS} = S_{DS}$ and $S_{X1} = S_{D1}$; or

ii. Appendix A1 of the Seattle Existing Building Code where seismic hazard is determined using Section 604.1 of this Appendix.

In 2008 a calibration study was conducted to quantify URM walls as having adequate strength for resistance of in-plane forces. The study established a baseline for defining minimum wall pier dimensions using methodology from the California Bolts+ program. Three typical URM building configurations were evaluated to study the effect of wall pier length on demand-capacity ratio. The following variables were studied: (i) number of stories; (ii) percentage of solid wall; (iii) seismic hazard, S_1; and (iv) site class. S_1 was chosen as the calibration data point because of response characteristics of flexible diaphragm URM buildings. The analysis was based on the Special Procedure of ASCE 31 with the life safety performance objective and BSE-1E (10%/50 year) seismic hazard. This hazard correlated well with 3/4 of the design earthquake commonly used for comprehensive seismic retrofits. Note that since the study includes a small number of hypothetical buildings it shows trends but does not predict the performance of specific buildings. The results indicated that buildings which did not meet the prescriptive wall length requirement but had a demand-capacity ratio less than 2.0 could also use the prescriptive method. This level of overstress will result in significant damage to the building, but walls should retain their gravity load bearing capacity.

The DCR study was revisited in 2022 when the qualification criteria were updated for the latest codes and seismic hazards. ASCE 7-16 incorporated updated geological data which increased the seismic hazard for long-period structures on soft soils by almost 50 percent. The geologic effects on seismic hazard are determined by applying ASCE 7-16 Section 11.4.8 Exception 2 or conducting a ground motion hazard analysis that accounts for the Seattle region's basin effects. ASCE 7-22 results in a similar seismic hazard but without the extensive work required when using ASCE 7-16. The updated DCR study correlated with 3/4 of the ASCE 7-16 and ASCE 7-22 seismic hazards to retain compatibility with the Appendix A1 method applicable for comprehensive retrofits. Comparison of the various response spectrums can be found in Figure 1 which illustrates the change in seismic hazard, particularly between the original DCR study and what is anticipated with the adoption of ASCE 7-22.

The considerable increase in seismic hazard – an increase of around 50 percent – presented a dilemma. The 2008 study established that a DCR less than 2.0 would be an appropriate limit for use of the Alternate Method. The DCRs from the new seismic hazard increased to around 3.0 which was unacceptably high for maintaining gravity load bearing capacity. The acceptable DCR was revised to 2.5 to avoid potentially excluding a large number of buildings from qualifying for use of the Alternate Method.

Because the calibration studies were based on solid brick masonry construction, hollow-clay tile (HCT) walls are explicitly excluded from prescriptively qualifying for use of the Alternate Method using the 40 percent solid pier allowance. Buildings with HCT walls may still qualify for use of the Alternate Method by demonstrating compliance with the DCR limit.

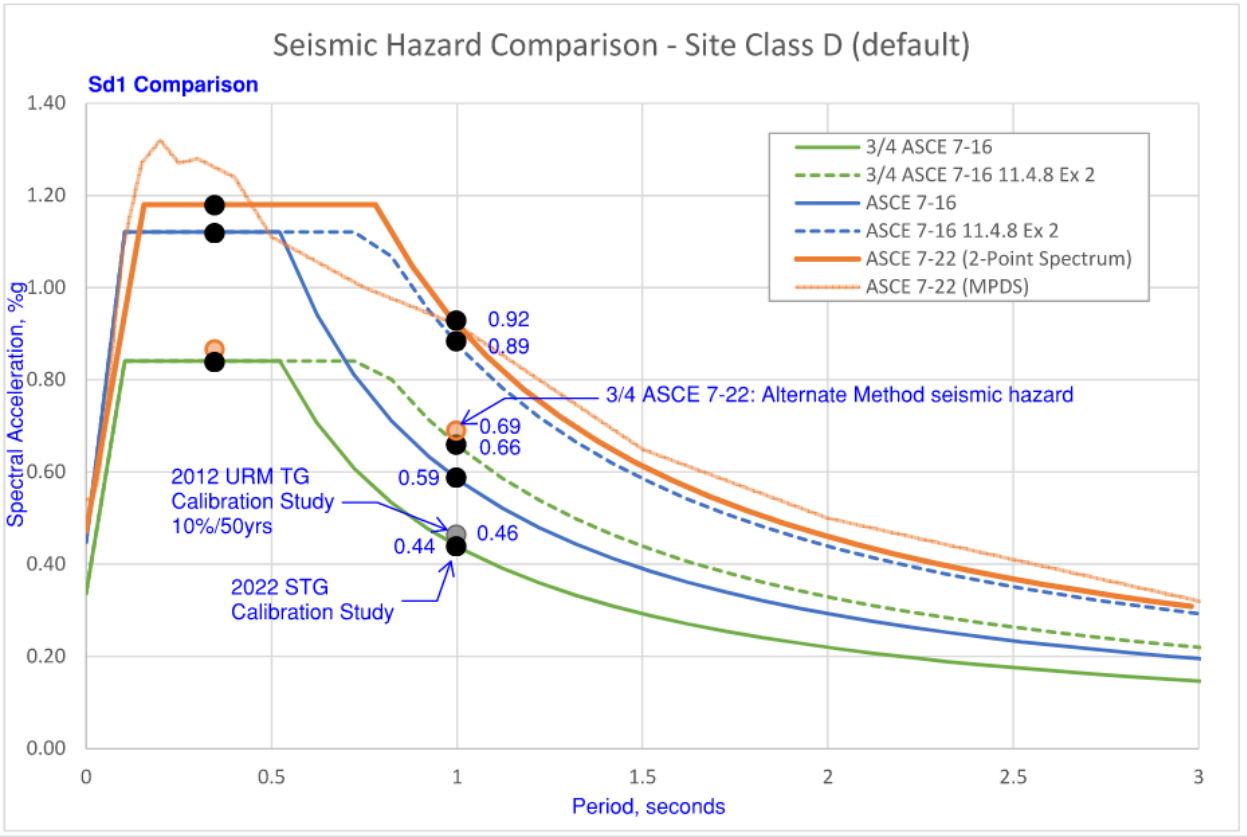

FIGURE 1: SEISMIC HAZARD PLOT FOR CALIBRATION STUDY

Section A604.1: Seismic Hazard

The Alternate Method specifies two seismic hazards which can be used for the calculation of forces:

(1) 75 percent of the values established in ASCE 7-16 as referenced by the 2021 Seattle Building Code; or

(2) 75 percent of the values established in ASCE 7-22, and the site class, as defined in ASCE 7-22, shall be determined by a qualified geotechnical engineer. In lieu of a geotechnical engineer determination, site class may be determined utilizing available Seattle Department of Construction and Inspections (SDCI) map, Director's Rule 2-2023 Update of Environmentally Critical Area (ECA) Liquefaction-Prone Areas Map, that defines Liquefaction Prone Areas (type ECA5). Where the project site is Type ECA5, Site Class E shall be used. Where the site is not ECA5, the default site class shall be used.

Item 1 uses the current ASCE 7-16 seismic hazard with all requirements for site class considerations, including site-specific procedures as required. Unless geological site hazards require site-specific ground motion procedures it is expected that most Alternate Method retrofits would use Site Class D – default. Item 1 will be updated each code cycle to reference the ASCE 7 version current to the SEBC edition in use.

Item 2 provides the option of using the ASCE 7-22 seismic hazard, which is not yet adopted by the SEBC. Significant changes to the site-specific procedures in ASCE 7-22 no longer require the calculation of Fa and Fv values and instead uses a multi-period response spectrum for calculating SDS and SD1 values. To

save on geotechnical report costs for buildings located on liquefiable prone soils, as determined by SDCI Director's Rule 2-2023, designers may use Site Class E instead of a site-specific geotechnical study.

ASCE 7-22 ground motions will become the standard for the Alternate Method for perpetuity, however, there will always be the option of utilizing current code. ASCE 7-22 will continue to be allowed even when future editions of ASCE 7 are published as referenced by the SEBC. This standardization of seismic forces provides a buffer against future seismic hazard increases to not penalize retrofits that occur later.

Section A604.2: Material requirements

To reduce the overall cost of Alternate Method retrofits, the material testing requirements for Chapter A6 are less than the testing requirements for Chapter A1. Like A1, A6 requires categorization of all unreinforced masonry into one or more classes based on shear strength, quality of construction, condition, etc. Where more than one class of masonry exists in a building, e.g. clay brick and hollow clay tile, each class is required to have a full classification profile as described herein. Each class of masonry reported on the plans requires no less than one test per 1500 sq ft of wall area, but not less than 8 tests total. One test per in-plane wall line resisting seismic forces is required per floor, except in taller buildings. For buildings over four stories it may be permitted, at the code officials' approval, to test the ground floor, top floor and only alternating floors in between them. Chapter A1 testing requires two tests per wall line at the first and top stories, and one test per wall line at all stories in between. For a typical four-story building, Chapter A1 would require 24 test locations while the Alternate Method would only require 12.

The mortar in-plane shear strength must meet the same 30 psi minimum requirements from Chapter A1. Note that this must be a tested value and cannot be assumed as a minimum default strength as is permitted in ASCE 41 for Tier 1 and Tier 2 procedures. When mortar tests results are below 30 psi, pointing is required per A604.2.3.3 and the repaired masonry must be retested. Even when the 30 psi minimum is met, pointing may be necessary to meet the minimum in-plane shear strength requirements for proprietary anchors which may require as much as 80 psi, depending on the product used. The designer should consult the ICC-ES report prior to specifying a product to ensure compliance. Through-bolts with rosettes do not require mortar strength beyond the Alternate Method minimums.

Section A604.4: Strength values for existing materials

Strength values for existing and new materials are largely the same as Chapter A1. In Table 2, a default f'_m value of 285 psi is provided for calculating the capacity of shear bolt anchors grouted in 2.5inch diameter grouted holes with a minimum of 8-inch embedment. Previously, calculation of these anchor capacities was permitted per TMS 402, but required testing to establish the f'_m value. Testing is still permitted to establish f'_m values greater than the default value.

Default values for existing materials are provided in Table 1 to eliminate the requirement for testing and to align with ASCE 41 default values.

Prequalification testing performed per A604.3.3.3 can be used for alternative anchor designs that do not meet the requirements of an independent evaluation report.

Section A604.5: Wall Anchorage

Out-of-plane wall anchors to the diaphragm are the same as Chapter A1 and are designed to resist 0.9 S_{DS} times the tributary weight, but not less than 200 lbs. Diaphragm strength checks are not required as

a part of the Alternate Method, however it is required that all in-plane and out-of-plane forces from wall anchorage and parapet bracing be developed into the diaphragm. Sub-diaphragms can be used to develop forces into the diaphragm however the full diaphragm is not required to have sufficient strength to transfer the out-of-plane forces to the resisting elements.

Section A604.6: Diaphragm shear transfer

In-plane wall anchor design forces are specified in A604.6.1 and maximum and minimum wall spacings in A604.6.2 instead of listing the requirements in multiple sections as in Chapter A1. The maximum anchor spacing of 6 ft on center and 2 ft from corners are the same in both chapters.

Section A604.7: Out-of-plane wall bracing

Out-of-plane wall aspect ratio and parapet bracing considerations in A604.7 consolidate information from various sections of A1. Out-of-plane forces for wall bracing are $0.4S_{DS}$ times the tributary weight but not less than 10 percent of the wall weight. The allowable aspect ratio ranges from 9 to 15 for most stories in a building. ASCE 41-23 decreases the aspect ratio to 8 in most cases, however this was not adopted into the Alternate Method as the focus is on achieving minimally acceptable performance.

Section A604.8: Parapets

Parapet bracing is required to resist a minimum force of $0.48\ S_{DS}$ times the tributary weight. This is derived from ASCE 7-16 Equation 13.3-1 using I_p=1.0, a_p=1.0, R_p=2.5, and z/h = 1. Coefficients are for" cantilever elements (braced to structural frame above its center of mass)" from Table 13.5-1.

Optional statement for ASCE 7-22: Parapet bracing is required to resist a minimum force of $0.72\ S_{DS}$ times the tributary weight. This is derived from ASCE 7-22 Equation 13.3-1 using I_p=1.0, H_f=3.5, R_μ=1.3, C_{AR}=1 and R_{po}=1.5. Coefficients are for "cantilever elements (braced to structural frame above its center of mass)" from Table 13.5-1.

References

Technical References

Director's Rule 32-1996 - Seismic Survey and Report Requirements

Director's Rule 7-2009 - Seismic Survey and Report Requirements for Buildings Undergoing Substantial Alterations or Repair

2012 Final Report from URM Technical Committee & Proposed Retrofit Standard

Director's Rule 15-2021 - Seismic Evaluation Report Requirements for Buildings Undergoing Substantial Alterations

Director's Rule 2-2023, Update of ECA Liquefaction-Prone Areas Map

2023 URM Retrofit Technical Standard

Director's Rule 6-2023 A Method for the Seismic Improvement of Unreinforced Masonry (URM) Buildings

2021 Seattle Existing Building Code

Seattle City Ordinances and Resolutions

Ordinance 102902 – Minimum structural standards for buildings in the Pioneer Square Historic District

Ordinance 103125 – Prohibit URM design and construction

Resolution 32033 – Establish the SDCI URM Program

Resolution 32111 –Recognize retrofitted URM buildings designed with DR 6-2023

SDCI Policies

SDCI URM Webpage

URM Database

Procedure to Appeal URM Building Designation

Procedure to Apply for Retrofitted URM Status

Application Form for Retrofitted URM Status in the URM Database

Alternate Method questionnaire

Acknowledgements

Adoption of URM seismic regulations in the 2021 SEBC is the culmination of decades of work by the City of Seattle and the Seattle structural engineering community. SDCI is grateful for the input of the SEAW Existing Building Committee and the following individuals and firms for their contributions in crafting the URM seismic regulations.

2022 URM Technical Task Force

Beatriz Arostegui, Magnusson Klemencic Associates
Greg Coons, SSF Engineers
Wes Neeley, PCS Structural
Andy Quinn, Carter Quinn Norlin
Francesca Renouard, SSF Engineers
Peter Somers, Magnusson Klemencic Associates
David Sommer, Degenkolb Engineers
Abby Van Harpen, Magnusson Klemencic Associates
Bryan Zagers, Coughlin Porter Lundeen

SDCI Staff

Nathalie Boeholt, Technical Codes Manager
Susan Chang, Civil Engineering Supervisor
Nancy Devine, Senior Structural Plans Engineer (retired)
Amanda Hertzfeld, URM Program Manager
Kai Ki Mow, Principal Engineer
Derek Ohlgren, URM Program Lead Engineer
Dennis Pradere, Senior Structural Plans Engineer
Jon Siu, Principal Engineer and Building Official (retired)
Kevin Solberg, Structural Plans Engineer Supervisor