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Final report from URM Technical Committee & Proposed Retrofit Standard
November, 2011

This memo outlines a proposed standard for retrofit of unreinforced masonry buildings. The proposal was developed by the Unreinforced Masonry Building Technical Committee, with much assistance from the Structural Engineers Association of Washington Existing Buildings Committee (SEAW). The goal of the proposed standard is to establish a cost-effective retrofit requirement that would be effective in reducing the likelihood of collapse of URM buildings during an earthquake. The standard is intended to protect the lives of building inhabitants and those nearby, but would not be expected to prevent all injuries to people and buildings.

The proposal uses the current editions (2009) of the Seattle Building and Existing Building codes, and American Society of Civil Engineers (ASCE) Standards 31 and 41 as the primary methods for compliance. Buildings that meet certain criteria are given the option to use a prescriptive method based on the San Francisco retrofit ordinance, commonly referred to as "Bolts Plus". Bolts Plus was chosen as a model because it is less costly than compliance with standards used for new construction, but will provide significantly improved performance for most unreinforced masonry buildings. It requires retrofit of wall anchorage to current code standards, but addresses other structural deficiencies less comprehensively. For some buildings this amount of upgrade will provide a satisfactory increase in the likelihood the building will not completely collapse during an earthquake. The primary issue before the Technical Committee was how to determine which buildings should be allowed to use this prescriptive method.

The proposal modifies portions of the San Francisco ordinance that describe the conditions where the prescriptive method may be used. It allows buildings with diaphragm discontinuities such as split-level floors and roofs, and out-of-plane offsets in which one story is offset relative to the continuation of that element in an adjacent story (See Figure A below), to use the prescriptive method. It also allows all occupancy groups and buildings with any number of stories to use the prescriptive method.

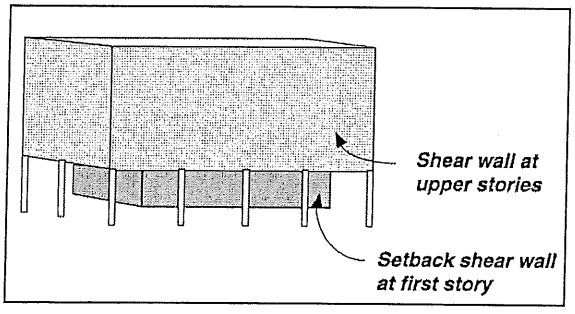

Figure A: Typical Building with Out-of-Plane Offset

The knottiest part of this proposal the question of whether Seattle should accept a potentially high level of shear wall overstress, as proposed in this draft, which is similar to the approach used in San Francisco. The alternative is to require a larger number of URM buildings to incur the additional expense of complying with the non-prescriptive methods. See Item 5 of Section 22.120.030 of the draft proposal.

To assist in this decision, SEAW analyzed 3 hypothetical building types to get more information about the affect of number of stories and length of walls, percentage of solid wall, seismic hazard, and site class. SEAW used the special procedure of ASCE 31 with the life safety standard. It should be noted that since the analysis includes only a small number of examples of hypothetical buildings, it shows trends but does not predict the performance of particular buildings. A summary of the analysis is attached. After reviewing the results of the study, SEAW recommends using a 40% solid wall as the threshold for the prescriptive method.

To be allowed to use the prescriptive method in San Francisco, a building must have 2 lines of resistance in the lateral force resisting system parallel in each direction. A wall must have solid masonry on at least 40% of its length to be considered a line of resistance.

The recommendation of the URM Technical Committee, and of SEAW, is to require 40% solid walls. The Committee considered allowing the prescriptive path to be used for 25% solid walls walls on most sites, and 40% solid walls for Site Class E which is the least stable site condition. However, the Committee decided that approach could result in too many buildings that would not be expected to perform well in an earthquake. Buildings that comply with ASCE 31 with a maximum design capacity ratio of 2.0 could also use the prescriptive method. The results of the SEAW analysis showed little difference between 25% and 40%.

URM Retrofit Proposal

This proposal locates the requirements for unreinforced masonry building retrofits in a new chapter in the Seattle Municipal Code.

Chapter 22.120 Unreinforced masonry buildings.

22.120.010 **Definition of unreinforced masonry building.** A building with one or more bearing walls made of plain clay brick or clay tile masonry that provide the primary support for vertical loads from floors or roofs that was constructed prior to May 7, 1977.

22.120.020 **Selection of method.** All buildings, regardless of occupancy or number of stories shall either be shown to be in compliance with or altered to comply with one of the following methods:

(1) Section 1613 of the 2009 *Seattle Building Code.*

(2) ASCE 31-03 *Seismic Evaluation of Existing Buildings.* Life Safety performance level.

(3) ASCE 41-06 *Seismic Rehabilitation of Existing Buildings*, with supplement #1. Life Safety performance level.

(4) 2009 *International Existing Building Code*, Appendix A, Chapter A1.

The BSE-1 spectral response acceleration parameters as defined in Section 1.6.1.2 of ASCE 41-06 is permitted for methods (2) through (4).

22.120.030 **Use of alternate method**. Buildings that comply with or that are altered to comply with Items (1) through (6) or with Item (7) of this section may be strengthened in compliance with Section 22.120.040.

(1) The building does not have a vertical irregularity of Type 5A or 5B (Weak Story) as defined in ASCE 7-05 Table 12.3-2.

(2) The building has a mortar shear strength, v_t, as determined by Section A106.3.35 of the 2009 *International Existing Building Code*, of 30 psi or more for all masonry classes.

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

(4) The building does not have straight sheathed diaphragms without finished wood flooring with offset or perpendicular board edges.

Exception: Straight sheathed diaphragms without finished wood flooring with offset or perpendicular board edges are acceptable if any of the following conditions are met:

a. The building has crosswalls below the non-compliant level as defined in Section A111.3 of the 2009 *International Existing Building Code* at a spacing that does not exceed 40 feet on center.

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

(5) 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. ~~Existing and new lines of resistance shall fully comply with Section 22.120.020.~~ Masonry walls shall have wall piers with a height-to-width ratio that does not exceed 2 to 1. Wall

piers shall occupy not less than 40 percent of the wall's length for the wall to be considered as providing a line of resistance.

Exception: The above requirements for vertical elements do not apply if the owner submits a report prepared by a structural engineer licensed by the State of Washington that shows all walls comply with Section 22.120.020(2) with a maximum demand/capacity ratio of 2.0

(6) In buildings containing one or more party walls, Section 22.120.030 shall not be used unless each building sharing a party wall individually complies with all of the limitations set forth above and the owner of each such building consents to the use of the procedure in writing.

(7) Buildings that have undergone substantial alterations may be strengthened in compliance with Section 22.120.040 if it can be demonstrated that the building is in full compliance with the requirements of FEMA-178 Av, Aa=0.3.

22.120.040 Alternate method.

Elements shall be in compliance with or altered to comply with the requirements listed in this section:

Elements	*2009 International Existing Building Code* Section
Wall Anchorage (tension bolts)	A113.1
Diaphragm Shear Transfer (shear bolts)	A113.2
Out-of-plane wall bracing	A113.5
Parapets and appendage bracing	A113.7 (A113.6 2009 IEBC)

The BSE-1 spectral response acceleration parameters as defined in Section 1.6.1.2 of ASCE 41-06 are permitted to be used.

Attachment: Summary of SEAW URM Pier Study

Summary of SEAW URM Pier Study

By: PWS Date: 8/ 3/11 Time: 12:17PM

File: C:\Users\pws\Documents\Professional\DFD\URM Policy\SEAW EBC\[EBC URM 4-story.xls]Summary

Four-Story, 120' x 120' Building

Ground Motion	Site Class	Sd1	25% Solid (4' piers)	40% Solid (4' piers)	40% Solid (7' piers)	60% Solid (10' piers)
10%/50yr (475yr)	C	0.376	2.8	2.3	1.8	1.5
20%/50yr (224yr)	C	0.269	1.9	1.5	1.3	1.1
50%/50yr (72yr)	C	0.140	1.0	0.8	0.7	0.6
10%/50yr (475yr)	D	0.463	3.2	2.6	2.2	1.9
20%/50yr (224yr)	D	0.353	2.5	2.0	1.7	1.5
50%/50yr (72yr)	D	0.197	1.4	1.1	1.0	0.8
10%/50yr (475yr)	E	0.733	4.1	3.3	2.9	2.5
20%/50yr (224yr)	F	0.544	3.8	2.9	2.5	2.2
50%/50yr (72yr)	E	0.288	1.9	1.7	1.4	1.2

Three-Story, 50' x 120' Building

Ground Motion	Site Class	Sd1	Short Wall 25% Solid	Long Wall 25% Solid	Short Wall 40% Solid	Long Wall 40% Solid	Short Wall 60% Solid
10%/50yr (475yr)	C	0.376	1.5	1.1	2.4	1.1	2.3
20%/50yr (224yr)	C	0.269	1.8	0.8	1.7	0.8	1.8
50%/50yr (72yr)	C	0.140	0.9	0.4	0.9	0.4	0.9
10%/50yr (475yr)	D	0.463					
20%/50yr (224yr)	D	0.353					
50%/50yr (72yr)	D	0.197					
10%/50yr (475yr)	E	0.733	3.7	2.1	3.5	2.1	3.5
20%/50yr (224yr)	E	0.544	3.6	1.5	3.4	1.5	3.3
50%/50yr (72yr)	E	0.288	1.9	0.8	1.8	0.8	1.9

One-Story, 60' x 120' Building

Ground Motion	Site Class	Sd1	25% Solid	40% Solid (4' piers)	40% Solid (9' piers)	60% Solid
10%/50yr (475yr)	C	0.376	1.5	1.6	1.5	1.0
20%/50yr (224yr)	C	0.269	1.0	1.1	1.1	0.7
50%/50yr (72yr)	C	0.140	0.5	0.6	0.6	0.4
10%/50yr (475yr)	D	0.463		1.5		
20%/50yr (224yr)	D	0.353		1.2		
50%/50yr (72yr)	D	0.197				
10%/50yr (475yr)	E	0.733	1.9	2.0	1.8	1.3
20%/50yr (224yr)	E	0.544	1.8	2.0	1.8	1.3
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