City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

CODE ADVISORY COMMITTEE
Notice of
Regular Meeting of the
Structural Subcommittee

DATE: **November 12, 2013 (Tuesday)**
TIME: **9:00 AM to 11:00 AM** ***PLEASE NOTE***
LOCATION: **1660 Mission St., Room 6034** ***CHANGE IN LOCATION!!!***

This Subcommittee generally meets regularly on the second Tuesday of each month at 1660 Mission St., Room 2031. (DBI Office).

Note: Public comment is welcome and will be heard during each agenda item.
Reference documents relating to agenda are available for review at Technical Services Division.
For information or if you wish to be placed on a mailing list for agendas, please email to Yan Yan Chew as follows: Yanyan.chew@sfgov.org

AGENDA

1.0 Call to Order and Roll Call
Members: Stephen Harris, S.E.; Chair; Rene' Vignos, S.E.; Marc Cunningham; Tony Lau; Ned Fennie, A.I.A.

2.0 Approval of the minutes of the Structural Subcommittee special meeting of September 10, 2013.

3.0 Discussion and possible action on following Administrative Bulletins:
AB-107: Application of Engineering Criteria in SFBC 3406B

4.0 Discussion and possible action on updating Administrative Bulletins: AB-023, AB-036, AB-046, AB-058, AB-078, AB-082, AB-083, AB-084, AB-094. AB-98, AB-99, & AB-100 to 2013 San Francisco Building Code.

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5.0 Discussion and possible action on draft AB on Guidelines for the Structural Review of Special Moment Frame Beam Lateral Bracing used in Light Frame Wood Construction for Seismic Applications.

6.0 Discussion and possible action regarding Private School Earthquake Safety.

7.0 Discussion and possible action on SFBC Section 3404.7.2.

8.0 Discussion and possible action on AB-102 Substantial Change expanding applicability to R2 occupancy.

9.0 Subcommittee Member's and Staff's identification of new agenda items, as well as current agenda items to be continued to another subcommittee regular meeting or special meeting. Subcommittee discussion and possible action regarding administrative issues related to building codes.

10.0 Public Comment: Public comment will be heard on items not on this agenda but within the jurisdiction of the Code Advisory Committee. Comment time is limited to 3 minutes per person or at the call of the

Chair.

11.0 Adjournment

Note to Committee Members**:** Please review the appropriate material and be prepared to discuss at the meeting. **If you are unable to attend, please call Chairperson Stephen Harris, S.E. at (415) 495-3700.** The meeting will begin promptly. See attached materials for information about meeting accessibility.

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(Chapter 67 of the San Francisco Administrative Code)

Government's duty is to serve the public, reaching its decisions in full view of the public. Commissions, boards, councils and other agencies of the City and County exist to conduct the people's business. This ordinance assures that deliberations are conducted before the people and that City operations are open to the people's review.

The ringing of and use of cell phones, pagers and similar sound-producing electronic devices are prohibited at this meeting. Please be advised that the chair may order the removal from the meeting room of any person(s) responsible for the ringing or use of a cell phone, pager, or other similar soundproducing electronic devices.

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POLICY STATEMENT OF PUBLIC HEARING OR MEETING

Pursuant to Section 67.7-1(c) of the San Francisco Administrative Code, members of the public who are unable to attend the public meeting or hearing may submit written comments regarding a calendared item to Technical Services Division, at 1660 Mission Street, San Francisco, CA 94103 or at the place of the scheduled meeting. These written comments shall be made a part of the official public record.

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Individuals and entities that influence or attempt to influence local legislative or administrative action may be required by the San Francisco Lobbyist Ordinance (SF Administrative Code Sec. 16.520-16.534) to register and report lobbying activity. For more information about the Lobbyist Ordinance, please contact the Ethics Commission at 1390 Market Street #701, SF, CA 94102 or (415) 554-9510 voice, or (415) 703-0121 fax, or visit their website at http://www.sfgov/ethics/.

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In order to assist the City's efforts to accommodate persons with severe allergies, environmental illness, multiple chemical sensitivity or related disabilities, attendees at public meetings are reminded that other attendees may be sensitive to various chemical based products. Please help the City to accommodate these individuals.

The meeting will be held at the Department of Building Inspection, 1660 Mission Street. The closest accessible BART stations are the Civic Center Station at 8th (at the United Nations Plaza) and Market Street and 16th at Mission Street.

Accessible MUNI/Metro lines servicing this location are the, 42 - Downtown, 14 & 14 Limited - Mission, and F - Market bus lines. For information about MUNI accessible services call

(415) 923-6142.

The meeting room is wheelchair accessible. Accessible curb side parking spaces have been designated on Mission and Otis Streets. There is accessible parking available within the Department of Building Inspection parking lot. The entrance to this lot is on Otis Street.

Accessible seating for persons with disabilities (including those using wheelchairs) will be available. Assistive Listening devices will be available at the meeting. A sign language interpreter will be available upon request. Agendas and Minutes of the meeting are available in large print/tape form and/or readers upon request. Please contact Technical Services Division at (415) 558-6205, providing 72 hours notice will help to ensure availability.

To request a sign language interpreter, reader, materials in alternative formats, or other accommodations for a disability, please contact Technical Services Division at (415) 558-6205. Providing 72 hours notice will help to ensure availability.

Materials are available in alternate formats on request.

CODE ADVISORY COMMITTEE

Regular Meeting of the
Structural Subcommittee

DATE: September 10, 2013 (Tuesday)
TIME: 9:00 AM to 11:00 AM
LOCATION: 1660 Mission St., Room 6034

This Subcommittee meets regularly on the second Tuesday of each month at 1660 Mission St., Room 2031. (DBI Office). If you wish to be placed on a mailing list for agendas, please call (415) 558-6205.

Note: Public comment is welcome and will be heard during each agenda item.
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Draft MINUTES

Present	**Absent**
Stephen Harris, S.E	Tony Lau
Rene' Vignos, S.E.	
Ned Fennie,A.I.A.	
Marc Cunningham	

Other Present
David Bonowitz, S.E.
Behruz Vahdani, Matrix Seismic Group
Homer Yim, Simpson Strong-Tie
Louay Shamroukh, Simpson Strong-Tie
Robert Chun, DBI
David Leung, DBI

1.0 Call to Order and Roll Call.
Members: Stephen Harris, S.E.; Chair; Rene' Vignos, S.E.; Marc Cunningham; Tony Lau; Ned Fennie, A.I.A.

Meeting was called to order at 9:00 a.m. Quorum established with 4 members present.

2.0 Approval of the minutes of the Structural Subcommittee regular meeting of July 9, 2013.

A motion to approve the minutes. Seconded and approved.

3.0 Discussion and possible action on following Administrative Bulletins:
AB-106: Seismic Strengthening of Soft Story Wood Frame Buildings: Procedures
AB-107: Application of Engineering Criteria in SFBC 3406B

Drafts of AB-106, AB-107, Screening and Optional Evaluation Forms are discussed.
Reference shall be made to 2010 and 2013 San Francisco Building Code.
Checklist should be removed from AB-106 and to be worked on by DBI separately.
Certification statement needs to be added in Section 3 of Optional Evaluation Form.
Some formatting changes need to be done on AB-107.
A motion to forward AB-106 and AB-107 to full CAC. Seconded and approved.

4.0 Discussion and possible action on training for DBI staff on soft story

Training for DBI staff by SEAONC on soft story was scheduled on July 10, 2013.

5.0 Discussion and possible action on draft AB on Guidelines for the Structural Review of Special Moment Frame Beam Lateral Bracing used in Light Frame Wood Construction for Seismic Applications.

No discussion.

6.0 Discussion and possible action regarding Private School Earthquake Safety.

No discussion.

7.0 Discussion and possible action on SFBC Section 3404.7.2.

No discussion.

8.0 Discussion and possible action on AB-102 Substantial Change expanding applicability to R2 occupancy.

No discussion. This will be further discussed with possible input from SEAONC.

9.0 Items 3 thru 8 will be included to the agenda in next meeting.

10.0 Public Comment:

No public comment.

12.0 Adjournment.

The meeting was adjourned at 10:30 a.m.

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Acting Director

ADMINISTRATIVE BULLETIN

NO. AB-107 Draft #7 (RV Markup)

DATE	**:**	**September 10, 2013**
SUBJECT	**:**	**Seismic Strengthening of Soft Story Wood Frame Buildings**
TITLE	**:**	**Application of Engineering Criteria in SFBC 3406B**

PURPOSE **:** The purpose of this Bulletin is to establish acceptable design criteria, standards and technical provisions for complying with Chapter 34B of the 2010 and 2013 San Francisco Building Code, as amended by Ordinance No. 66-13.

REFERENCE **:**
Chapter 34B, 2010 and 2013 San Francisco Building Code
2012 International Existing Building Code, Appendix Chapter A4
ASCE 31-03, Seismic Evaluation of Existing Buildings
ASCE 41-06, Seismic Rehabilitation of Existing Buildings
ASCE 41-13, Seismic Evaluation and Retrofit of Existing Buildings
FEMA P-807, Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings With Weak First Stories
Administrative Bulletin AB-106, Procedures for Implementation of SFBC Chapter 34B.

BACKGROUND **:** SFBC Chapter 34B, created with Ordinance 66-13, mandates the seismic retrofit of certain wood-frame residential buildings. Section 3406B.4 calls for the development and publication of this Administrative Bulletin to "detail the technical requirements to be used for the evaluation and retrofitting of buildings required to meet the criteria established in Section 3406B.2."

SCOPE AND OUTLINE : This bulletin covers only SFBC Sections 3406B.2 through 3406B.4. It does not cover administrative or procedural requirements of Chapter 34B or of Ordinance 66-13. It is separate from, but intended to be in coordination with, other sections of Chapter 34B, other Administrative Bulletins, and other forms and instructions.

This bulletin ~~has two parts: Part A,~~contains General Requirements which ~~applies~~ apply to all projects seeking to comply with Chapter 34B, and ~~Part B, whose sections apply to the specific~~Procedure-Specific Requirements that relate to the compliance alternatives allowed in Section 3406B.2.

Effective Date of the Provisions of this Administrative Bulletin

The provisions of this administrative bulletin become effective on the operative date of Ordinance No. 66-13.

~~Part~~ A. ~~Requirements for all projects~~GENERAL REQUIREMENTS

~~Part A of this Bulletin applies to all evaluation and retrofit projects intended~~The following requirements apply to all retrofit projects undertaken to comply with SFBC Chapter 34B, regardless of the procedure chosen. ~~Unless noted otherwise, requirements in Part B are additional to, not in place of, requirements in Part A.~~

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A1. Compliance

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A1.1. Other SFBC requirements and Administrative Bulletins. Alterations and repairs required to meet the provisions of Chapter 34B shall comply with all other applicable structural requirements of the SFBC unless specifically waived by those requirements, by this Bulletin, or by related Administrative Bulletins.

*~~**CA1.1.**~~**Commentary:** See Administrative Bulletin AB-106 regarding procedural compliance with SFBC Chapter 34B, specifically Section 3406B.6.*

Comment [RV1]: Change to this throughout document.

A1.2. Qualified historic buildings. In addition to or in place of the criteria allowed by SFBC Section 3406B.2, qualified historical buildings shall be permitted to use structural engineering criteria provided in the latest edition of the California Historical Building Code (California Code of Regulations Title 24 Part 8), subject to the eligibility requirements of that code.

***CA1.2.** SFBC Section 3404B.5 also mentions the CHBC, but that provision is about historic preservation in accord with San Francisco Planning Department guidelines and has no direct bearing on the structural engineering criteria.*

A2. Seismicity, Soil, and Geotechnical issues

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A2.1. Site Class E. Buildings located in areas labeled “NEHRP E” on the latest USGS map of “Soil Type and Shaking Hazard in the San Francisco Bay Area” will be assigned to Site Class E unless site-specific investigation in accordance with ASCE 7-10 Chapter 20 indicates otherwise.

***CA2.1.** The map is available online at http://earthquake.usgs.gov/regional/nca/soiltype/map/*

A2.2. Site Class F. The requirement in ASCE 7-05 Section 11.4.7 for site response analysis of Site Class F sites is waived.

***CA2.2.** SFBC Chapter 34B does not require mitigation of existing geologic site hazards such as liquefiable soil. Also, many buildings subject to Chapter 34B would be exempt from site response analysis by the exception to ASCE 7-05 Section 20.3.1.*

A2.3. Seismic ground motion values. Where seismic ground motion values are calculated per ASCE 7-05 Section 11.4 or by similar provisions, the value of F_a shall be taken as 1.3 for Site Class E.

***CA2.3.** This requirement applies to any code-based procedure for calculating seismicity parameters, such as that used by IEBC Appendix Chapter A4 (see Bulletin part B.5) and application of “regular code” provisions through the California Historical Building Code. It* *also applies where criteria such as ASCE 31, ASCE 41, and FEMA P-807 apply equations similar to those in ASCE 7 Section 11.4.*

A3. Assessment of Existing Building Conditions

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A3.1. Building investigation and report. In support of an engineering evaluation or retrofit design, the owner shall conduct or cause to be conducted an investigation of the existing building. The engineer of record shall prepare a written report documenting procedures, findings, and conclusions of the investigation. The report may reference other materials submitted to demonstrate compliance or to support findings and conclusions.

A3.1.1. Scope of investigation. At minimum, the investigation shall comply with any investigation and assessment provisions in the engineering criteria selected from SFBC Section 3406B.2, as modified by ~~Part B~~subsequent sections of this Bulletin. Otherwise, the investigation scope and methods may generally be set at the discretion of the engineer of record, but all findings shall be reported. The Department is authorized to require additional investigation as needed to fulfill the purpose of the report and the intent of SFBC Chapter 34B. With the approval of the Department, field verification of assumed conditions may be performed during the construction phase.

As needed or required, the investigation shall include identification, verification, and assessment of existing conditions relevant to the engineering assumptions applied in the evaluation or retrofit design. The investigation shall be based on a combination of non-destructive testing or inspection, destructive testing or inspection, and reference to record documents. Where record documents are used to reduce the scope of testing or other on-site work, appropriate field verification is required.

> ***CA3.1.1.*** *With respect to evaluation, the primary purpose of the investigation is to identify or confirm the nature of the existing construction as needed to justify load drift curves, tributary floor weights, load path assumptions, etc. A secondary purpose is to provide condition assessment sufficient to rule out deterioration or construction defects significant enough to affect earthquake performance of the structure as a whole. The investigation should therefore seek evidence of damage, deterioration, or defective construction sufficient to affect significantly the performance of the seismic force-resisting system. With respect to retrofit design, the primary purpose of the investigation is to confirm design assumptions regarding the adequacy of existing seismic load path components within the context of the retrofitted structure. In addition, though it need not be stated in the provision, the Department is always authorized to require repair of damage, correction of defects, and elimination of dangerous conditions; hence the requirement that "all findings shall be reported."*

A3.1.2. Timing of investigation. Unless otherwise required by the engineering criteria selected from SFBC Section 3406B.2, as modified by ~~Part B~~subsequent sections of this Bulletin, with the approval of the Department, investigation may be deferred to a confirmation or construction phase. The deferred investigation shall be specified as a special inspection item in accordance with SFBC Chapter 17.

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CA3.1.2. *This allowance is offered for the benefit of owners for cases in which destructive investigation will be unusually disruptive or expensive. However, the owner will bear the risk of change orders, design revisions, and supplemental design review if actual conditions differ from those assumed by the evaluation or design. Approval of the Department is required to allow the Department to identify cases where deferred investigation will complicate its review and approval process. The Department may allow some parts of the investigation to be delayed while requiring other parts of the investigation to be completed prior to review of calculations.*

A3.2. Existing materials and components. Where the applicable engineering criteria specify material or structural properties of existing elements, those criteria shall be used. Otherwise, the general rules of this section apply.

A3.2.1. Damage and defects. The capacity of any element damaged by deterioration, wear, or other causes or constructed or altered so as differ from its intended condition shall be reduced based on the judgment of the engineer of record, subject to review of condition assessment findings and the approval of the Department. This provision shall apply where the applicable engineering criteria do not make an explicit provision for capacity reduction.

CA3.2.1. *This provision is consistent with ASCE 31-03 Section 4.2.4.4.*

A3.2.2. Relation of nominal and expected strength to allowable stress. Where element capacities are based on allowable stresses from codes and standards, nominal strengths shall be taken no greater than the allowable stresses multiplied by the following factors: 1.7 for steel; 2.5 for masonry; 2.0 for wood. Where the element is ductile or deformation-controlled, the expected strength shall be taken as 1.25 times the nominal strength.

CA3.2.2. *This provision is consistent with ASCE 31-03 Section 4.2.4.4.*

A3.2.3. Concrete footings and stem walls. Evaluation and design of existing concrete footings shall be permitted to assume default concrete strength based on ASCE 41-13.

A3.2.4. Unreinforced brick footings. The capacity of an existing brick footing to resist shear or pullout of an existing or new anchor shall be established by testing or by reference to approved tests of similar conditions. Where the capacity of an anchor is limited by failure of the footing or grout, the anchored wall or frame element shall be considered non-ductile or force-controlled.

CA3.2.4. *Because FEMA P-807 presumes ductile retrofit elements, the last sentence of this provision means that retrofit elements designed with FEMA P-807 may only be used with brick footings when testing has demonstrated that the anchor will develop the strength of the wall or frame element or will yield itself in a ductile fashion.*

~~**A3.2.5. Concrete or masonry retaining walls.**~~
~~*Reserved.*~~

Comment [RV2]: Remove throughout section

A3.2.6. Sheathed wood-frame walls and partitions. Wood-frame walls and partitions shall be permitted to use peak strength values from Bulletin Section B1.2.5.1.1. Where these values are used, they shall be taken as expected strengths and reduced to nominal strength per Bulletin

Comment [RV3]: Update throughout section

Section A3.2.2 where used on non-ductile or force-controlled elements. This provision is subject to the following limitations:

1. A wall assembly may be considered deformation-controlled if all sheathing materials that are individually force-controlled are ignored in the strength calculation.

2. Retrofit designs based on *R* values from the building code shall use only code-approved sheathing materials and combinations appropriate to the assumed *R* value.

~~**A3.2.6. Steel anchor bolts at wood sill plates.**~~
~~*Reserved*~~

A4. Structural Calculations and Project Documentation

A4.1. Submittals. Structural calculations and supporting documents shall be prepared and submitted as required by Bulletin Section A4.2. Other documents shall be prepared and submitted as required by Administrative Bulletin AB-106.

A4.2. Structural calculations and supporting documents. Structural calculations shall be submitted as required to confirm compliance with the selected engineering criteria. Calculations shall be specific to the engineering criteria used ~~(see Part B for criteria-specific requirements)~~ and shall include, at minimum:

1. A statement that the evaluation or retrofit design was prepared to demonstrate compliance with SFBC Chapter 34B.

2. Identification of the engineering criteria used for the evaluation or retrofit design, including the performance objective used with FEMA P-807, ASCE 41-06, or ASCE 41-13.

3. All building investigation, soils, geotechnical, or other supporting reports, as well as a summary of such reports indicating how the findings or conclusions are reflected in the structural calculations.

4. Identification of structural properties and capacities assumed for all existing materials and elements, including any capacity reductions for damage, deterioration, or defect.

5. Identification of structural properties and capacities assumed for all new materials and elements, including product literature for proprietary devices.

6. If requested by the Department, verification calculations for any engineering software used.

7. Other information as required by the Department.

A5. Construction Quality Assurance

Comment [RV4]: Clarify per discussion in 9/9 mtg

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A5.1 Testing and inspection. All work shall comply with inspection and testing requirements of the building code as they apply to existing buildings and structures. Additional field verification, structural observation, testing, and inspection may be required in accordance with the selected engineering criteria or as directed by the Department.

Part B. Application of specific engineering criteria

Part A of this Bulletin applies to all evaluation and retrofit projects intended to comply with SFBC Chapter 34B. Unless noted otherwise, requirements in Part B are additional to, not in place of, requirements in Part A.

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B1. APPLICATION OF FEMA P-807 TO EVALUATION AND RETROFIT DESIGN

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B1.1. Intent of 3406B.2 item 1 and 3406B.3

SFBC Section 3406B.2 item 1 allows the use of FEMA P-807 as follows:

> 1. FEMA P-807, Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings with Weak First Stories, as detailed in an Administrative Bulletin to be prepared pursuant to 3406B.3 of this ordinance, with the performance objective of 30 percent maximum probability of exceedance of Onset of Strength Loss drift limits with a spectral demand equal to 0.50 S_{MS}.

SFBC Section 3406B.3 allows an alternative objective as follows:

> A proposed seismic retrofit plan which fails to meet the criteria of 3406B.2(1) or 3406B.2(5) shall be deemed to comply with this Chapter if, with the approval of the Department, it satisfies the intent of FEMA P-807, Section 6.4.2 with a maximum acceptable Onset of Strength Loss drift limit probability of exceedance of 50 percent.
> **Exception:** Alternative retrofit criteria shall not apply to buildings in which the critical stories, basements, or underfloor areas contain other than parking, storage, or utility uses or occupancies.

The code language provided in FEMA P-807 Appendix B includes these caveats, repeated here for reference:

> **Limitations.** These evaluation and retrofit provisions are related to the onset of strength loss in wood-frame elements of the seismic force-resisting system, a condition that indicates a substantially increased potential for structural collapse. As such, they might not be adequate for predicting the likelihood of other damage states. The retrofit provisions are premised on the assumption that work will be constrained to the first story and the second floor diaphragm. As such, they do not necessarily provide a comprehensive retrofit to a stated performance objective. When followed, the retrofit provisions will improve performance, but they will not necessarily prevent damage or mitigate failure modes other than those related to weak-story conditions and associated torsion.

> **Coordination with other codes and standards.** Compliance with these provisions does not necessarily satisfy the requirements of *International Building Code* Chapter 34 or the *International Existing Building Code* as they apply to certain additions, alterations, repairs, or changes of occupancy. Compliance with

~~these provisions does not necessarily meet any performance level of ASCE/SEI 31-03, or any retrofit objective of ASCE/SEI 41-06, or ASCE/SEI 41-13.~~

~~B1.2.~~ Code language provisions

FEMA P-807, unlike the other documents cited by Section 3406B.2, is not a code or standard and is written in a guideline or narrative style. Enforceable provisions in “code language” are therefore provided here, adapted from FEMA P-807 Appendix B. In general, use of FEMA P-807 for compliance with SFBC Chapter 34B shall mean compliance with these code language provisions; FEMA P-807 itself constitutes a commentary to these provisions.

B~~1.2.~~1. General

Comment [RV5]: Remove throughout

~~**B1.2.1.1**~~

~~*Reserved.*~~

B~~1.2.~~1.~~2~~1. Performance Objective

Comment [RV6]: Renumber as needed

~~B1.2.~~B1.2.1. Hazard level. The spectral demand shall be 0.5S_{MS}, calculated in accordance with ASCE 7-05 Section 11.4 except that for sites in Site Class E, the value of F_a shall be taken as 1.3.

> ***C~~B1.2.~~B1.2.1.*** *The value of F_a is modified for Site Class E to adjust the demand for site effects not considered explicitly in the development of FEMA P-807 (see FEMA P-807 section 2.6.1).*

~~B1.2.~~B1.2.2. Performance level. Acceptable performance shall be based on drifts corresponding to the Onset of Strength Loss in the seismic force-resisting wood-frame elements.

> ***C~~B1.2.~~B1.2.2.*** *This provision merely reflects the requirements of the ordinance, referencing the Onset of Strength Loss performance level defined in FEMA P-807. It does not require any additional work by the engineer, since the Onset of Strength Loss criteria are already embedded in the criteria given in this Bulletin.*

~~B1.2.~~B1.2.3. Maximum drift limit probability of exceedance. The maximum drift limit *POE* for evaluation or retrofit design shall be 30 percent.

Exception: Where the story or underfloor area subject to evaluation or retrofit contains only parking, storage, or utility uses or occupancies, the maximum drift limit *POE* for evaluation or for retrofit design shall be 50 percent, as long as the additional requirements of Bulletin Section ~~B1.2.~~B7.3 are met.

> ***C~~B1.2.~~B1.2.3.*** *This Exception incorporates the alternative criteria given in SFBC Section 3406B.3. The alternative criteria apply to what FEMA P-807 calls “optimized retrofit,” as discussed in FEMA P-807 Sections 6.3.1 and 6.4.2.*

~~B1.2.~~B1.3. Required scope of work. Compliance with the provisions of SFBC Chapter 34B using FEMA P-807 requires:

1. Correction of all aspects of eligibility non-compliance per Bulletin Section ~~B1.2.~~B3, and
2. Correction of all building survey non-compliance per Bulletin Section ~~B1.2.~~B4, and either

3a. Demonstration of an acceptable existing condition per Bulletin Section ~~B1.2.~~B6, or

3b. Design and execution of a retrofit in accordance with Bulletin Section ~~B1.2.~~B7 and other applicable codes and regulations.

Where retrofit is required but the provisions of Bulletin Section ~~B1.2.~~B7 cannot be satisfied, the building shall be considered ineligible for compliance with SFBC Chapter 34B using FEMA P-807.

~~B1.2.~~B~~1.4~~
~~Reserved.~~

~~B1.2.~~B~~1.5~~
~~Reserved~~

~~B1.2.~~B2. Definitions

__C~~B1.2.~~B2.__ In some instances, the notation and terminology differ slightly from those in FEMA P-807 Chapters 1-7.

~~B1.2.~~B2.1. Terminology. Terms used in Bulletin Section B1 shall have the meanings provided here. Terms not defined here shall have the meanings provided in the building code.

CENTER OF STRENGTH. At each story, the location in plan that represents the weighted average location of the load in all wall lines, at the drift associated with the story strength.

DRIFT. For a given story, the calculated or postulated lateral deflection within that story divided by the story height, normally expressed as a percentage.

FIRST STORY. The story of interest with respect to evaluation or retrofit, spanning vertically between the first floor and the second floor. Depending on the building and its relationship to grade, the story designated as the First Story can be an underfloor area or cripple story, a basement, the first story above grade, or another story above grade. The First Story can be partial in plan. For a building with multiple stories of interest, the First Story can vary as each story of interest is analyzed.

LOAD-DRIFT CURVE. For a wall assembly, wall line, or story, the relationship characterizing the variation of shear resistance versus drift, for the full range of relevant drifts. For a wall assembly, the load value is given in units of force per unit length. For wall lines and stories, the load value is given in units of force.

LOAD-ROTATION CURVE. For a story, the relationship characterizing the variation of torsional resistance versus story rotation, for the full range of relevant rotations, given in units of torque as a function of rotation angle.

PROBABILITY OF EXCEEDANCE (*POE*). The desired or calculated probability that the structure will respond beyond the drift limits representing the desired performance level, in at least one direction, when subjected to a specified hazard level. Within SFBC Chapter 34B and this Bulletin, *POE* means the probability of exceeding the drift limits associated with Onset of Strength Loss.

__C~~B1.2.~~B2.1.__ As used in SFBC Chapter 34B and this Bulletin, POE is identical to what FEMA P-807 Chapters 1 through 7 typically call "drift limit POE."

QUALIFYING WALL LINE. For purposes of checking eligibility of floor or roof diaphragms, a wall line that contributes substantially to the peak story strength and has an adequate load path connecting it to the diaphragms it affects.

C~~B1.2.~~B2.1, continued. *See FEMA P-807 Section 2.6.4 for discussion of rules for "qualifying" wall lines. The definition is subject to the judgment of the engineer of record and the Department.*

SPECTRAL CAPACITY. For a given POE, the highest level of spectral acceleration a structure can sustain without responding beyond the drift limits representing the desired performance level, given as a multiple of the acceleration of gravity, and calculated separately in each principal direction.

SPECTRAL DEMAND. See Bulletin Section ~~B1.2.~~B1.2.1. The spectral demand is given as a multiple of the acceleration of gravity.

STORY. For purposes of applying engineering criteria in SFBC Section 3406B and this Bulletin, see the building code definition and this Bulletin's definition of First Story. The definition in SFBC Section 3403B applies only to the counting of stories for determining scope per SFBC Section 3402B.

STORY STRENGTH. The maximum load value from the story load-drift curve, calculated separately in each principal direction.

STORY STRENGTH, BASE-NORMALIZED. The story strength divided by the total seismic weight of the building.

STORY STRENGTH, STORY-NORMALIZED. The story strength divided by the sum of the tributary floor weights of all the floors above the story in question.

STORY TORSIONAL STRENGTH. The maximum torsional resistance value from the story load-rotation curve.

STRENGTH DEGRADATION RATIO. In each direction, a value between 0.0 and 1.0 calculated as the first story strength divided by the load corresponding to a drift of 3 percent from the first story load-drift curve.

TORSION COEFFICIENT. A value that need not be taken greater than 1.4, calculated as the first story torsional demand divided by the first story torsional strength.

TORSIONAL ECCENTRICITY. The absolute value of the plan distance, in x and y components, between the second story center of strength and the first story center of strength.

TRIBUTARY FLOOR WEIGHT. The total seismically active weight tributary to a single floor level comprising dead load and applicable live load, snow weight, and other loads as required by the building code.

UPPER STORY. Any story above the first story.

WALL ASSEMBLY. A unique combination of sheathing materials over wood-stud framing.

WALL LINE. A collection of full-height and partial-height wall segments or frames within a single story that satisfies the rules in Bulletin Section ~~B1.2.~~B5.1.2.

C~~B1.2.~~B2.1, continued. *A wood-frame wall line is generally assumed to contribute strength only in the direction parallel to its length. A wall line expected to contribute strength in a direction other than parallel to its length, such as a cantilever column or fixed-based moment frame, must be modeled appropriately.*

WALL SEGMENT. A portion of wood-frame wall made from a single wall assembly. For purposes of this definition, any sheathed run of wood-stud framing that could contribute to a story's lateral strength or stiffness shall be considered a potential wall segment, whether or not the framing and sheathing were intentionally designed, detailed, sized, or located to contribute that strength or stiffness.

B1.2.B2.2. Notation

A_U The base-normalized upper-story strength, calculated separately for each direction.
A_W The weak-story ratio, calculated separately for each direction.
C_D The strength degradation ratio, calculated separately for each direction.
C_T The torsion coefficient.
C_U The minimum of the story-normalized story strengths of any of the upper stories, calculated separately for each direction.
CB1.2.B2.2. *Where the story strength is roughly constant for all upper stories, C_U will generally be the story-normalized strength of the second story.*
COS_i The plan location, in x and y coordinates, of the center of strength of story i.
e_x, e_y The x and y components, respectively, of the torsional eccentricity.
f_w The load-drift curve for wall line w.
F_i The load-drift curve for story i, calculated separately for each direction.
h_w The floor-to-ceiling height of wall line w.
H_1 The floor-to-ceiling height of the tallest first story wall line, determined separately in each direction.
I A subscript index indicating floor or story. Story i is between floor i and floor $i+1$.
L_w The length of wall line w, taken as the longest possible length of wall that satisfies the rules in Bulletin Section 1.2.5.1.2, including the length of any openings within it.
L_x The overall building dimension in the x direction.
L_y The overall building dimension in the y direction.
POE Probability of Exceedance
Q_{open} The adjustment factor for openings in a wall line.
Q_{ot} The adjustment factor for overturning of a wall line.
Q_s The story height factor for the first story, calculated separately for each principal direction.
S_c The spectral capacity, calculated separately for each direction.
S_d The spectral demand.
t_i The load-rotation curve for story i.
T_i The story torsional strength of story i.
V_{1r} The story strength of the retrofitted first story, calculated separately for each direction.
V_i The story strength of story i, calculated separately for each direction.
V_U The story strength of the upper story that determines the value of C_U.
C1.2.2.2, continued. *Where the story strength is roughly constant for all upper stories, V_U will generally be the second story strength.*
w A subscript index indicating a single wall line.
W The total seismic weight of the building, equal to the sum of all the tributary floor weights.
W_i The tributary floor weight of floor i.
WSP Wood structural panel
x A subscript index indicating one of two principal directions.
$\alpha_{POE,0}$ The *POE* adjustment factor for a C_D value of 0.0.
$\alpha_{POE,1}$ The *POE* adjustment factor for a C_D value of 1.0.
δ_j Drifts at which load-drift curves are characterized. See Table 1.2.5.1.1.
Δ_i In each direction, the drift at which the story strength of story i occurs.
τ_1 The first story torsional demand.

~~B1.2.~~B3. Eligibility

~~B1.2.~~B3.1. General. Buildings that do not comply with the requirements of Bulletin Section ~~B1.2.~~B3 are not eligible for the procedures in this chapter.
Exception: Buildings in which all aspects of non-compliance will be eliminated through alteration or retrofit are eligible for the procedures in this chapter.

~~B1.2.~~B3.1.1. Massing
1. The building has no more than four stories above grade plane at any point around its perimeter.
2. The building's wood-framed stories are not supported by an above-grade podium structure.
__C~~B1.2.~~B3.1.1.__ Item 1 relies on the building code's definition of story above grade plane. Item 2 is referring to a concrete podium structure generally extending at least one story above grade and topped by a concrete diaphragm that provides a base for wood framing above. Item 2 is not intended to rule out concrete foundation elements or stem walls that extend above grade.

~~B1.2.~~B3.1.2. Upper stories
1. The upper-story seismic force-resisting systems are bearing wall or building frame systems of wood-frame walls with shear panels.
2. The upper-story floor-to-floor heights are between 8 feet and 12 feet and are constant within each story.
3. In each upper story, in each principal direction, the distance from the center of strength to the center of mass of the floor below it is no more than 25 percent of the corresponding building dimension.
__C~~B1.2.~~B3.1.2__ The intent of this approximate rule is to ensure that no upper story is prone to significant torsion, and that inertial forces from upper stories should transfer to the first story near the geometric center of the second floor. See FEMA P-807 Section 2.6.2.
4. No upper story or floor above an upper story has a weight irregularity as defined by ASCE/SEI 7-05 Table 12.3-2, Type 2.
5. No upper story has a vertical geometric irregularity as defined by ASCE/SEI 7-05 Table 12.3-2, Type 3.

~~B1.2.~~B3.1.3. First story, basement and foundation
1. The first story height may vary, but the maximum first story height, from top of foundation to top of second floor framing is between 8 feet and 15 feet.
2. The first story seismic force-resisting systems are bearing wall or building frame systems of wood-frame walls with shear panels or combine such systems with steel moment-resisting frame systems, steel cantilever column systems, or steel buckling-restrained braced frame systems.
__C~~B1.2.~~B3.1.3.__ FEMA P-807 is not suitable for evaluating or designing concentrically braced frames, concrete shear walls, or reinforced masonry shear walls. See FEMA p-807 Section 6.5. If these systems exist or are proposed for as retrofit elements, compliance must be demonstrated using one of the other methods allowed by SFBC Section 3406B.2.
3. The first story includes no full-height concrete or masonry walls.
__C~~B1.2.~~B3.1.3, continued.__ Buildings with full-height concrete or masonry walls at the full perimeter of the story of interest are expected to be exempt from SFBC Chapter 34B.

Buildings with a combination of full-height concrete or masonry walls and other systems (wood-frame walls, steel moment frames, etc.) might be required to comply with SFBC Chapter 34B but will not be able to use FEMA P-807 to demonstrate compliance.

4. The first story walls and frames have continuous concrete footings or concrete slab-on-grade foundations. If some or all of the first floor is raised over a crawl space, the crawl space has concrete stem walls to the underside of the first floor framing.

C~~B1.2.~~B3.1.3, continued. *Concrete stem walls are considered to provide a base similar to a concrete foundation. Wood-framed cripple walls, whether braced or unbraced by sheathing of any type, are not adequate to meet this provision.*

5. First story walls and frames may be partial height over a concrete or reinforced masonry retaining wall or foundation stem wall, but any partial-height wall or frame is at least four feet tall from top of stem wall to underside of second floor framing.

6. If the building has a basement, the basement walls and the floor diaphragm just above them are capable of transferring seismic forces between the foundation and the first story, and the basement story is laterally stronger than the first story above it.

~~B1.2.~~B3.1.4. Floor and roof diaphragms. Floor and roof diaphragms shall satisfy the eligibility requirements of this subsection.

Exception: Diaphragms shown to have no deficiencies or irregularities that would prevent development of the strength of any seismic force-resisting wall or frame or would otherwise control the overall seismic response of the structure need not satisfy the eligibility requirements in this subsection.

C~~B1.2.~~B3.1.4. *The intent of these approximate rules for diaphragms is to ensure that the structure does not develop a premature mechanism or failure mode. See FEMA P-807 Section 2.6.4 for additional explanation and guidance.*

1. No portion of the second floor diaphragm between qualifying wall lines has an aspect ratio greater than 2:1.
2. The second floor diaphragm does not cantilever more than 25 feet from a qualifying wall line.
3. If the second floor diaphragm cantilevers more than 10 feet from a qualifying wall line, diaphragm chords are adequate to develop the lesser of the strength of the diaphragm or the diaphragm forces associated with the peak strength of the qualifying wall line.
4. No floor or roof diaphragm has a reentrant corner irregularity in which either projecting leg of the diaphragm beyond the reentrant corner is longer than 15 percent of the corresponding plan dimension of the building, unless each leg of the diaphragm satisfies the aspect ratio and cantilever rules of this subsection.

C~~B1.2.~~B3.1.4, continued. *This provision differs from the irregularity defined in ASCE/SEI 31-03 or as Type 2 in ASCE/SEI 7-05 Table 12.3-1 in order to limit diaphragm demands. See FEMA P-807 Section 2.6.4.*

5. No floor or roof diaphragm has a vertical offset unless load path components are present and adequate to develop the diaphragm strength across the offset.
6. No floor or roof diaphragm has cutouts or openings within it such that, along any line across the diaphragm, the sum of the opening widths along that line is more than 25 percent of the overall diaphragm dimension along that line.

~~B1.2.~~B4. Building Survey

~~B1.2.~~B4.1. General. Structural components shall be investigated in accordance with Bulletin Section ~~B1.2.~~B4 as needed to confirm eligibility per Bulletin Section ~~B1.2.~~B3 and to support structure characterization per Bulletin Section ~~B1.2.~~B5, evaluation per Bulletin Section ~~B1.2.~~B6, and retrofit design per Bulletin Section ~~B1.2.~~B7.

~~B1.2.~~B4.2. Wall framing and sheathing. The investigation shall determine the length and location in plan of all wall segments and wall lines in all stories as needed to calculate load-drift curves.

The investigation shall determine the size and location of openings in each wall line as needed to calculate adjustment factors for openings and adjustment factors for overturning.

The investigation shall determine all unique frames or wall assemblies in the first story and representative wall assemblies in the upper stories. Where sheathing includes wood structural panels or where sheathing load-drift data is a function of nailing, the investigation shall also determine the nail size and edge nail spacing. Panel edge nailing shall be investigated over at least five nail spaces and as needed to confirm a reliable spacing assumption.

> ***C~~B1.2.~~B4.2.*** *Unless building-specific conditions indicate a need for more extensive investigation, the minimum recommended investigation should include one location of each distinct wall assembly in the first story and in any upper story, but not less than one perimeter and one interior wall line in the first story and in any upper story. If prior investigation reports based on destructive investigation are available, they may be relied on. If original drawings are available, they may be relied on to reduce the scope of investigation, but some investigation is still necessary to confirm the reliability of the drawings.*

~~B1.2.~~B4.3. Floor and roof framing and diaphragm. The investigation shall determine the construction of floor and roof framing and diaphragm sheathing, including the direction of framing and the mechanism of gravity load transfer, as needed for calculation of adjustment factors for overturning. The second floor shall be investigated. Subject to approval of the Department, the roof and upper floors need not be investigated in detail where there is evidence that their relevant attributes are similar to those of the second floor.

~~B1.2.~~B4.4. Load path components. The investigation shall determine the nature of the load path components and connections for transfer of forces between diaphragms and walls or frames as needed to confirm that the wall line will participate in resisting drift.

> ***C~~B1.2.~~B4.4.*** *For non-WSP sheathing, the intent is to confirm that fastening reasonably conforms to conventional construction requirements. For existing WSP shear walls with nail spacing closer than six inches, it should be confirmed at representative locations that shear wall top and bottom connection capacity is appropriate to the sheathing capacity.*

The investigation shall determine the presence or absence of hold-down hardware at the base of all first story walls, as well as the adequacy of installation of representative types at representative locations.

The investigation shall confirm that anchors are provided at the base of the first story walls.

Table ~~B1.2.~~B4.4 shows where the load path may be assumed adequate or is subject to investigation or confirmation. Table ~~B1.2.~~B4.4 applies only to walls whose strength is counted in the analysis. For any condition subject to investigation, the load path may be assumed lacking, and the corresponding wall strength may be ignored, but only if assumed so consistently throughout the building.

> ***C~~B1.2.~~B4.4.*** *The load path may be assumed lacking, but not selectively so as to "correct" torsion or other irregularities. This provision is similar to ASCE 31 and ASCE 41 limits on the designation of secondary components.*

Exception: Wherever the strength of two stories is being compared, an adequate load path must be assumed for all walls and partitions in the upper story.

> ***C~~B1.2.~~B4.4, continued.*** *The exception prevents underestimating the upper story strength. The exception will apply for calculations of weak story or soft story ratio in ASCE 31/41, IEBC A4, and other code-based procedures; application of the 1.3 cap on retrofit strength for ASCE 41 and IEBC A4 retrofits; and calculation of spectral capacity with FEMA P-807.*

The adequacy of an investigated load path may be confirmed by the judgment of the design professional, without calculations, but is subject to approval by the Department. Judgment should be based on the presence of a positive connection with multiple or redundant attachments distributed over the length of the wall line. For partitions perpendicular to floor framing above, blocking between floor joists nailed to the partition top plate (through a lath nailer, if present) should be deemed adequate for partitions with non-WSP sheathing.

Table ~~B1.2.~~B4.4. Investigation Requirements for Load Path between Partitions and Floor Framing Above

Condition	**First / Target Story**	**Second / Upper Stories**
Perimeter walls with non-WSP sheathing	May be assumed adequate	May be assumed adequate
Demising walls/partitions between units or between units and common areas	May be assumed adequate	May be assumed adequate
Any wall or partition with WSP sheathing where the top of the panel is nailed directly to a header beam, floor girder, or rim joist	May be assumed adequate	May be assumed adequate
Any wall or partition with WSP sheathing where the top of the panel is nailed only to a single or double top plate.	Confirm or provide load path	Confirm or provide load path
Room partitions within units, perpendicular to floor framing above	Investigate	May be assumed adequate
Room partitions within units, parallel to floor framing above	Investigate	Investigate

~~B1.2.~~B4.5. Foundation elements. The investigation shall determine the nature of the existing foundation elements and supporting soils as needed for calculation of adjustment factors for overturning.

~~B1.2.~~B5. Structure Characterization

~~B1.2.~~B5.1. Story strength

~~B1.2.~~B5.1.1. Wall assemblies. For each wall assembly present, a load-drift curve shall be computed by summing contributions from Table ~~B1.2.~~B5.1.1 at each drift level for each layer of sheathing. With approval of the Department, test results specific to the wall assembly or its components may be used in place of Table ~~B1.2.~~B5.1.1.

C~~B1.2.~~B5.1.1 *See FEMA P-807 Section 4.4 and Appendix F regarding the development of Table ~~B1.2.~~B5.1.1 and the use of alternate test data.*

The values in Table ~~B1.2.~~B5.1.1 are subject to the following additional requirements:

1. Horizontal wood sheathing or wood siding shall be at least 1/2" thick and fastened to existing studs with at least two nails per board per stud. Otherwise, the expected strength shall be taken as 0.

2. Where siding panel edges are lapped, each panel shall be nailed separately. Otherwise, the expected strength shall be taken as 0.

Table ~~B1.2.~~B5.1.1. Expected Strength for Load-Drift Curves [plf]

	Drift, δ_j [%]								
Sheathing Material	**0.5**	**0.7**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**4.0**	**5.0**
Stucco	333	320	262	0	--	--	--	--	--
Horizontal wood sheathing or wood siding	85	96	110	132	145	157	171	0	--
Diagonal wood sheathing	429	540	686	913	0	--	--	--	--
Plaster on wood lath	440	538	414	391	0	--	--	--	--
Plywood panel siding (T1-11), 6d@6	354	420	496	549	565	505	449	0	--
Gypsum wallboard	202	213	204	185	172	151	145	107	0
Plaster on gypsum lath	402	347	304	0	--	--	--	--	--
WSP, 8d@6	521	621	732	812	836	745	686	0	--
WSP, 8d@4	513	684	826	943	1,018	1,080	1,112	798	0
WSP, 8d@3	1,072	1,195	1,318	1,482	1,612	1,664	1,686	1,638	0

WSP, 8d@2	1,393	1,553	1,713	1,926	2,096	2,163	2,192	2,130	0
WSP, 10d@6	548	767	946	1,023	1,038	1,055	1,065	843	0
WSP, 10d@4	707	990	1,275	1,420	1,466	1,496	1,496	1,185	0
WSP, 10d@3	940	1,316	1,696	1,889	1,949	1,990	1,990	1,576	0
WSP, 10d@2	1,120	1,568	1,999	2,248	2,405	2,512	2,512	2,231	0

~~B1.2.~~B5.1.1.1. Wall assemblies without wood structural panel sheathing. The assembly load drift curve is the sum of the load drift curves for each of the sheathing layers.

~~B1.2.~~B5.1.1.2. Wall assemblies with wood structural panel sheathing. The assembly load drift curve is whichever of the following two load-drift curves has the larger peak strength:
1. The assembly load-drift curve using 50 percent of the strength of the wood structural panel layers and 100 percent of the strength of the other sheathing materials.
2. The assembly load-drift curve using 100 percent of the strength of the wood structural panel layers and 50 percent of the strength of the other sheathing materials.

~~B1.2.~~B5.1.2. Wall line assignment. Each segment of sheathed wall framing within a story shall be assigned to a wall line. Wall lines shall satisfy the following rules:
1. Full-height wall segments separated by window or door openings but connected by sheathed segments and continuous framing above or below the opening shall be assigned to the same wall line, unless other rules require them to be treated separately.
2. Wall segments assigned to the same wall line shall not be offset out-of-plane from adjacent segments by more than four feet.
3. At bay windows, the wall segments within the common plane shall be assigned to the same wall line if they satisfy the other rules, but the wall segments within the cantilevered portions of the bay shall not be counted toward the wall-line strength.
4. Wall segments of different heights, including wall segments along a stepped foundation, shall be assigned to separate wall lines.
5. A wall segment of varying height due to a sloped foundation shall be assigned to a separate wall line, and its height shall be taken as the average height of the segment.
6. Wall segments of different wall assemblies shall be assigned to separate wall lines.
7. Where hold-downs exist at each end of a wall segment, that segment may be considered a separate wall line.
8. Wall segments less than one foot long shall be treated as openings.
9. Wall segments between openings with height-to-length ratios greater than 8:1 shall be treated as openings.
10. Steel elements (moment frames, cantilever columns, etc.) shall be assigned to separate wall lines.
11. Wall segments or frames considered to have significant damage, deterioration, or construction defects may be counted toward a wall line's strength but shall have their load-drift strength values reduced.

~~B1.2.~~B5.1.3. Wall line load-drift curve. For each wall line, a load-drift curve shall be computed by multiplying the applicable wall assembly load-drift curve by the wall line's length and by applicable adjustment factors per Bulletin Equation ~~B1.2.~~B5.1.3-1.

$f_w = (v_w)(L_w)(Q_{open})(Q_{ot})$ (Equation ~~B1.2.~~B5.1.3-1)

where:

f_w is the load-drift curve of wall line w, expressed as a function of drift.

v_w is the load-drift curve of the wall assembly associated with wall line w, as derived per Bulletin Section ~~B1.2.~~B5.1.1 and adjusted for height variation per Bulletin Section ~~B1.2.~~B5.1.3.1.

~~B1.2.~~B5.1.3.1. Adjustment for height variation. Where first story wall lines in a given direction are of different heights, the load-drift curve of the wall assembly of each wood-frame wall line shall be adjusted to account for increased drift demands in all but the tallest first story wall line. This may be done by shifting the assembly load-drift curve from the standard set of drifts given in Table ~~B1.2.~~B5.1.1 to an adjusted set of drifts for each wall line, given by Equation ~~B1.2.~~B5.1.3.1-1.

$\delta_{jh} = (\delta_j)(h_w/H_1)^{0.7}$ (Equation ~~B1.2.~~B5.1.3.1-1)

~~B1.2.~~B5.1.3.2 Adjustment for openings. Each wall line load-drift curve shall account for the effects of openings within it. This may be done by applying the adjustment factor for openings, given by Equation ~~B1.2.~~B5.1.3.2-1 and Equation ~~B1.2.~~B5.1.3.2-2.

$Q_{open} = 0.92a - 0.72a^2 + 0.80a^3$ (Equation ~~B1.2.~~B5.1.3.2-1)

$$a = \frac{1}{\left(1 + \frac{\sum A_o}{h_w \sum L_f}\right)}$$ (Equation ~~B1.2.~~B5.1.3.2-2)

where:

$\sum A_o$ = sum of the areas of the openings within the wall line

$\sum L_f$ = sum of the lengths of the full-height wall segments within the wall line.

~~B1.2.~~B5.1.3.3. Adjustment for overturning. Each wall line load-drift curve shall account for the effects of overturning demand and resistance. This may be done by applying the adjustment factor for overturning, given by Equation ~~B1.2.~~B5.1.3.3-1 or, for existing upper-story wall lines only, by Table ~~B1.2.~~B5.1.3.3.

$$Q_{ot} = 0.4\left(1 + 1.5\frac{M_r}{M_{ot}}\right) \leq 1.0$$ (Equation ~~B1.2.~~B5.1.3.3-1)

where M_{ot} is the overturning demand on the wall line and M_r is the resisting moment due to all available dead loads tributary to the wall line plus the effects of any tie-down hardware.

C~~B1.2.~~B5.1.3.3. *See FEMA P-807 Section 4.5.3.2 for guidance on calculating Q_{ot}.*

Table ~~B1.2.~~B5.1.3.3. Default Adjustment Factor for Overturning, Q_{ot}, for Existing Upper Story Wall Lines

Number of stories above	Perpendicular to Framing	Parallel to Framing	Unknown or mixed
Two or more	0.95	0.85	0.85
One	0.85	0.80	0.80
None (Top story)	0.75	0.75	0.75

~~B1.2.~~B5.1.4. Story load-drift curves. For each story, in each direction, a load-drift curve shall be computed by adding the load-drift curves of all the walls in that story and aligned in that direction.

C~~B1.2.~~B5.1.4. *Where all the wall line load-drift curves are mapped to the same set of drifts, the summation is straightforward. Where some first story wall lines have load-drift curves mapped to a height-adjusted set of drifts, load values at the standard drift values should be determined by linear interpolation. Once interpolated values are calculated, the various load-drift curves can again be added in a straightforward way based on the standard drift values. See FEMA P-807 Section 4.6 for additional discussion.*

~~B1.2.~~B5.2. First story torsion

~~B1.2.~~B5.2.1. Center of strength. The center of strength for the first and second stories shall be determined based on the wall line loads at the drift at which the story strength in the corresponding story and direction occurs.

C~~B1.2.~~B5.2.1. *FEMA P-807 Section 4.6.4 illustrates the calculation of the center of strength.*

~~B1.2.~~B5.2.2. First story torsional demand. The first story torsional demand represents the effect of the first story strength acting at the torsional eccentricity, given by Equation ~~B1.2.~~B5.2.2-1.

$\tau_1 = e_x V_{1y} + e_y V_{1x}$ (Equation ~~B1.2.~~B5.2.2-1)

~~B1.2.~~B5.2.3. First story load-rotation curve. For the first story, a load-rotation curve shall be derived, relating torsion about the story center of strength to the resulting rotation of the story, assuming a rigid second floor diaphragm and accounting for the load-drift behavior of each first story wall line. The load-rotation curve shall consider rotation angles up to at least the rotation associated with 5 percent in-plane drift in at least one first story wall line.

C~~B1.2.~~B5.2.3. *FEMA P-807 Section 4.6.6 illustrates one method for calculating of the load-rotation curve, dividing the rotation range of interest into ten even increments.*

~~B1.2.~~B5.3. Characteristic coefficients

~~B1.2.~~B5.3.1. Base-normalized upper-story strength. The base-normalized upper-story strength shall be calculated for each principal direction per Equation ~~B1.2.~~B5.3.1-1.

$$A_U = \frac{V_U}{W} \qquad \text{(Equation ~~B1.2.~~B5.3.1-1)}$$

~~B1.2.~~B5.3.2. Weak-story ratio. The weak-story ratio shall be calculated for each principal direction per Equation ~~B1.2.~~B5.3.2-1.

$$A_W = \frac{V_1}{V_U} \qquad \text{(Equation ~~B1.2.~~B5.3.2-1)}$$

~~B1.2.~~B5.3.3. Strength degradation ratio. The strength degradation ratio, C_D, shall be calculated for each principal direction based on the first story load-drift curves.

> ***C~~B1.2.~~B5.3.3.*** *FEMA P-807 Section 4.7.4 illustrates the calculation of the strength degradation ratio.*

~~B1.2.~~B5.3.4. Torsion coefficient. The torsion coefficient, given by Equation ~~B1.2.~~B5.3.4- 1, need not be taken greater than 1.4.

$$C_T = \frac{\tau_1}{T_1} \qquad \text{(Equation ~~B1.2.~~B5.3.4-1)}$$

~~B1.2.~~B5.3.5. Story height factor. The story height factor shall be calculated for each principal direction per Equation ~~B1.2.~~B5.3.5-1, where H_1 is given in inches.

$$Q_s = 0.55 + 0.0047\, H_1 \qquad \text{(Equation ~~B1.2.~~B5.3.5-1)}$$

~~B1.2.~~B6 . Evaluation

~~B1.2.~~B6.1. Evaluation relative to the performance objective. Subject to the additional requirements of Bulletin Section ~~B1.2.~~B1.3, any eligible structure shall be deemed to comply with the requirements of this Bulletin if its spectral capacity in each principal direction exceeds the spectral demand.

~~B1.2.~~B6.1.1. Spectral capacity. Spectral capacity in each direction shall be calculated from Equations ~~B1.2.~~B6.1.1-1 through ~~B1.2.~~B6.1.1-5, using drift limit *POE* adjustment factors given in Table ~~B1.2.~~B6.1.1 for the drift limit *POE* specified in Bulletin Section ~~B1.2.~~B1.2. Drift limit *POE* adjustment factors for intermediate values of drift limit *POE* shall be calculated by linear interpolation.

CB1.2.B6.1.1. *SFBC Chapter 34B does not require the calculation of a POE. However, given a spectral demand, the POE of a structure can be calculated. See FEMA P-807 Section 5.4.2 or Appendix B model provision 6.2.*

$$S_c = C_D^3 S_{c1} + (1 - C_D^3) S_{c0}$$ (Equation B1.2.B6.1.1-1)

$$S_{c1} = \alpha_{POE,1} S_{\mu 1}$$ (Equation B1.2.B6.1.1-2)

$$S_{c0} = \alpha_{POE,0} S_{\mu 0}$$ (Equation B1.2.B6.1.1-3)

$$S_{\mu 1} = (0.525 + 2.24 A_W)(1 - 0.5 C_T) Q_s A_U^{0.48}$$ (Equation B1.2.B6.1.1-4)

$$S_{\mu 0} = (0.122 + 1.59 A_W)(1 - 0.5 C_T) Q_s A_U^{0.60}$$ (Equation B1.2.B6.1.1-5)

Table B1.2.B6.1.1. Drift limit probability of exceedance adjustment factors.

POE	$\alpha_{POE,1}$	$\alpha_{POE,0}$
2%	0.36	0.29
5%	0.44	0.37
10%	0.53	0.46
20%	0.66	0.60
30%	**0.77**	**0.73**
50%	**1.00**	**1.00**
60%	1.14	1.16
70%	**1.30**	**1.37**
80%	1.52	1.66

B1.2.B6.2
Reserved.

~~B1.2.~~B7. Retrofit

~~B1.2.~~B7.1. Retrofitted first story strength. The first story strength of the retrofitted structure shall account for all existing unaltered elements, existing altered elements, new elements provided to increase story strength, and new elements provided in accordance with Section ~~B1.2.~~B1.3 to correct aspects of eligibility or building survey non-compliance.
Exception: Out-of-plane or weak axis strength of existing or retrofit elements need not be considered where the sum of those strengths is deemed insignificant to the total story strength.

> ***C1.2.7.1.*** *The Exception is intended to allow wood frame walls and pin-based frames to be ignored in their weak directions, and to allow the Department to accept the engineer's judgment or to require modeling of fixed-based frames and cantilever columns in their weak directions.*

~~B1.2.~~B7.2. Retrofit compliance. The retrofit design shall demonstrate that both of the following conditions are true:

1. The retrofitted structure's spectral capacity in each principal direction exceeds the spectral demand.
2. The first story strength of the retrofitted structure in each principal direction satisfies Equation 1.2.7.2-1.

$$V_{1r} \le 1.1V_U\left(0.11A_U + 1.22\right)$$ (Equation ~~B1.2.~~B7.2-1)

> ***C~~B1.2.~~B7.2.*** *The intent of Equation ~~B1.2.~~B7.2-1 is to ensure that over-strengthening the first story is not miscounted as beneficial. Given the maximum POE, if the required first story strength cannot be achieved without exceeding this limit, it indicates that the proposed retrofit would push failure to the second story and would not achieve its intended effect. Where the exception to Bulletin Section ~~B1.2.~~B1.2.3 is applied, the higher POE value will give the same spectral capacity for less first story strength, effectively allowing a lighter retrofit that might satisfy the equation.*
>
> *FEMA P-807 Section 6.2.1 provides formulas for estimating the strength of the retrofitted first story needed to reach the required spectral capacity, but use of the estimating formulas is not required.*

~~B1.2.~~B7.3 Additional requirements where the Exception to Bulletin Section ~~B1.2.~~B1.2.3 is applied. The retrofit design shall demonstrate that all of the following additional conditions is true:

1. The first story strength of the retrofitted structure in each principal direction satisfies Equation ~~B1.2.~~B7.3-1.
2. *Reserved*.
3. The retrofit design satisfies the requirements of Bulletin Section ~~B1.2.~~B7.3.2.

$$V_{1r} \ge 0.9V_U\left(0.11A_U + 1.22\right)$$ (Equation ~~B1.2.~~B7.3-1)

~~**B1.2.B7.3.1**~~
~~*Reserved.*~~

~~B1.2.~~B7.3.2 Minimized torsional eccentricity. Retrofit elements shall be located along perimeter wall lines so as to minimize the torsional eccentricity of the retrofitted structure, or so as to satisfy Equations ~~B1.2.~~B7.3.2-1 and ~~B1.2.~~B7.3.2-2. This requirement may be waived with the approval of the Department to accommodate other building or planning code requirements or to avoid disproportionate construction costs.

$$e_x \leq 0.10L_x \qquad \text{(Equation ~~B1.2.~~B7.3.2-1)}$$

$$e_y \leq 0.10L_y \qquad \text{(Equation ~~B1.2.~~B7.3.2-2)}$$

~~B1.2.~~B7.4 Design criteria for retrofit elements. Retrofit elements shall conform to the following general requirements and to the applicable requirements in Bulletin Sections ~~B1.2.~~B7.4.1 through ~~B1.2.~~B7.4.8.

> ***C~~B1.2.~~B7.4.*** *See Bulletin Section ~~B1.2.~~B3.1.3 for discussion of retrofit systems for which FEMA P-807 is suitable.*

1. Where retrofit elements are sized based on unit strengths from codes or standards, the expected strength, without strength reductions or resistance factors, may be used.

> ***C~~B1.2.~~B7.4, continued.*** *The allowance of expected strength, which is typically greater than nominal strength (see Bulletin Section A3.2.2) is appropriate because FEMA P-807 requires retrofit elements to be ductile (or, in ASCE 31 or ASCE 41 terms, deformation-controlled).*

2. The load-drift curve of each retrofit element type shall be based on expected material properties, including overstrength. The full expected capacity, without strength reduction or resistance factors, shall be used to calculate load-drift curves and peak strengths.

3. Each retrofit element shall be such that a load-drift curve based on similar elements alone would have a strength degradation ratio, C_D, greater than or equal to 0.8.

4. The load-drift curve of each retrofit element type shall be defined up to five percent interstory drift or as needed to fully characterize the retrofit design per Bulletin Section ~~B1.2.~~B5.

5. Materials and systems for all retrofit elements shall be generally consistent with provisions of the building code for new construction of the same occupancy and risk category. 2012 IBC Section 3401.4.2 and other provisions that allow like materials for alterations do not apply to retrofits mandated by SFBC Chapter 34B. However, the Department may waive restrictions on certain systems based on building height, irregularity, seismic design category, or other conditions not related to the critical deficiencies of the story being evaluated or retrofitted.

> ***C~~B1.2.~~B7.4, continued.*** *FEMA P-807 presumes that retrofit elements will be reliably ductile (as indicated by the requirement for a minimum C_D value in item 3 above). Systems detailed as special should generally be deemed to comply with this requirement, but systems detailed as intermediate or ordinary may also be shown to be adequate. The final sentence of this provision allows intermediate and ordinary steel frames to be used in seismic design category D and E; see also ASCE 7-10 Sections 12.2.5.6 and 12.2.5.7.*

6. Design criteria for load path components and connections shall be appropriate to the performance objective and shall be based on the building code for new construction, appropriate provisions of other criteria allowed by SFBC Section 3406B.2, or principles of capacity design.

~~B1.2.~~B7.4.1. Wood structural panel shear walls. Load-drift curves for wood structural panel retrofit elements shall be calculated in accordance with Bulletin Section ~~B1.2.~~B5. Existing shear walls modified by replacing sheathing materials or by adding supplemental wood structural panels shall be considered retrofit elements.

~~B1.2.~~B7.4.2. Steel special moment-resisting frames. Steel retrofit elements that conform to the requirements of AISC 341-05 or AISC 341-10 for Special Moment Frames shall be deemed to comply with the provision requiring a C_D value greater than or equal to 0.8. The load-drift curve may be characterized per FEMA P-807 Figure 6-7 as follows: $V_y = ZF_{ye}$ with post-yield strengthening up to $1.2V_y$ at d_{max}, with $d_{max} = d_y + 4\%$.

~~B1.2.~~B7.4.3. Steel intermediate moment-resisting frames. For steel retrofit elements that conform to the requirements of AISC 341-05 or AISC 341-10 for Intermediate Moment Frames, the load-drift curve may be characterized per FEMA P-807 Figure 6-7 as follows: $V_y = ZF_{ye}$ with no post-yield strengthening, and $d_{max} = d_y + 2\%$.

~~B1.2.~~B7.4.4. Steel ordinary moment-resisting frames. For steel retrofit elements that conform to the requirements of AISC 341-05 or AISC 341-10 for Ordinary Moment Frames, the load-drift curve may be characterized per FEMA P-807 Figure 6-7 as follows: V_y per AISC 360 Chapter F, using F_{ye} instead of F_y, $d_{max} = 2\%$.

~~B1.2.~~B7.4.5. Steel special cantilever columns. For steel retrofit elements that conform to the requirements of AISC 341-10 for Special Cantilevered Column systems, the load-drift curve may be characterized per FEMA P-807 Figure 6-7 as follows: $V_y = ZF_{ye}$ with no post-yield strengthening, and $d_{max} = d_y + 2\%$.

~~B1.2.~~B7.4.6. Steel ordinary cantilever columns. FEMA P-807 shall not be used to demonstrate compliance of steel ordinary cantilever columns as retrofit elements.

~~B1.2.~~B7.4.7. Steel buckling-restrained braced frames. Steel retrofit elements that conform to the requirements of AISC 341-05 or AISC 341-10 for buckling-restrained braced frames shall be deemed to comply with the provision requiring a C_D value greater than or equal to 0.8.

> ***C~~B1.2.~~B7.4.7.*** *FEMA P-807 Section 6.5.5 offers further guidance on characterizing and designing these elements.*

~~B1.2.~~B7.4.8. Damping systems. FEMA P-807 may be used to demonstrate compliance of hysteretic damping systems that rely on the yielding of steel components by modeling the retrofit elements as bi-linear systems similar to other structural steel systems. The Department is authorized to require third party peer review at the expense of the permit applicant.

FEMA P-807 shall not be used to demonstrate compliance of other damping systems, including viscous- or friction-damped systems.

> ***C~~B1.2.~~B7.4.8.*** *Viscous- and friction-damped systems cannot be designed with FEMA P-807 because the FEMA P-807 surrogate models did not include these mechanisms.*

~~B1.2.~~B7.5 Design criteria for load path elements and components. The retrofit design shall confirm or provide a load path from the second floor diaphragm through the first story seismic force-resisting elements and their foundations, to the supporting soils. The ultimate strength of load path components shall be reduced with strength reduction factors as needed to ensure that the load-path elements are able to develop the strength and the intended mechanism of first story wall and frame elements. Specific design criteria may be derived from principles of capacity design, from other criteria allowed by SFBC Section 3406B.2, or from building code provisions for new construction involving the overstrength factor, Ω_0.

~~B1.2.~~B7.5.1. Foundations and overturning. New foundation elements shall be provided as needed to resist bearing, sliding, and overturning forces associated with the retrofit elements acting at their strength. Connections and load path components related to wall or frame overturning shall not assume any acting dead load except for the self-weight of the retrofit element unless the retrofit element incorporates existing gravity load-carrying framing or unless the design and construction explicitly transfer existing dead load to the retrofit element. The weight of foundation elements may be considered if adequately connected.

~~B1.2.~~B7.5.2. Second floor diaphragm. The second floor diaphragm shall be strengthened as needed to ensure that expected forces can be transferred between the diaphragm and the first-story elements.

~~B1.2.~~B7.5.3. Fixed-base frame columns. Moment-resisting frame systems and cantilever column systems whose capacity assumes other than a pin-based condition shall be provided with connection details demonstrated to develop the assumed fixity and the assumed column strength. In general, an anchor-bolted base plate without substantial embedment within a foundation element is not considered to provide a fixed-base condition.

B~~1.3~~8. Design quality assurance

B~~1.3~~8.1. Structural calculations. Structural calculations and documentation of evaluations and retrofit designs using FEMA P-807 shall include, at minimum:

1. Plans and/or elevations for each floor level identifying each wall line and showing the wall assembly, length, location, and openings.

2. A schedule of wall assemblies and load drift curves for existing, altered, and new elements.

3. A list or schedule of wall lines with overturning and opening adjustments.

4. Derivation of characteristic coefficients.

5. Spectral capacity calculations.

6. Site-specific spectral demand calculations.

~~**B1.3.2. Use of the FEMA P-807 Weak Story Tool**~~
~~*Reserved*~~

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~~B2~~C. APPLICATION OF ASCE 41-13 TO EVALUATION AND RETROFIT DESIGN

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Further development of this section is expected as needed to address issues specific to Chapter 34B. The sections outlined below cover broad issues consistent with Chapter 34B. Otherwise, use of this standard is subject to existing Department procedures for implementation of SFBC 104A.2.8, Alternate materials, design, and methods of construction.

~~**B2.1. Intent of 3406B.2 item 2**~~
~~SFBC Section 3406B.2 item 2 allows the use of ASCE 41-13 as follows:~~

> ~~2. ASCE 41-13, Seismic Evaluation and [Retrofit] of Existing Buildings, with the performance objective of Structural Life Safety in the BSE-1E earthquake.~~

~~B2.2.~~ Required scope of work

- No nonstructural evaluation or retrofit is required.
- For typical buildings (eligibility requirements to be defined) retrofit of the first story only shall be deemed to comply with the intent of Chapter 34B.
- Retrofit strength need not exceed 1.3 times the strength of the story above. Wherever the strength of two stories is being compared, an adequate load path must be assumed for all walls and partitions in the upper story.
  CB2.2. *This requirement prevents underestimating the upper story strength. It will apply for calculations of weak story or soft story ratio in ASCE 31/41, IEBC A4, and other code-based procedures; application of the 1.3 cap on retrofit strength for ASCE 41 and IEBC A4 retrofits; and calculation of spectral capacity with FEMA P-807.*

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~~B3~~D. APPLICATION OF ASCE 41-06 TO EVALUATION AND RETROFIT DESIGN

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Further development of this section is expected as needed to address issues specific to Chapter 34B. The sections outlined below cover broad issues consistent with Chapter 34B. Otherwise, use of this standard is subject to existing Department procedures for implementation of SFBC 104A.2.8, Alternate materials, design, and methods of construction.

~~**B3.1. Intent of 3406B.2 item 3**~~
~~SFBC Section 3406B.2 item 3 allows the use of ASCE 41-06 as follows:~~

> ~~3. ASCE 41-06, Seismic Rehabilitation of Existing Buildings, with the performance objective of Structural Life Safety in the BSE-1 earthquake with earthquake loads multiplied by 75 percent.~~

~~B3.2.~~ Required scope of work

- No nonstructural evaluation or retrofit is required.
- For typical buildings (eligibility requirements to be defined) retrofit of the first story only shall be deemed to comply with the intent of Chapter 34B.
- Retrofit strength need not exceed 1.3 times the strength of the story above. Wherever the strength of two stories is being compared, an adequate load path must be assumed for all walls and partitions in the upper story.
  CB2.2. *This requirement prevents underestimating the upper story strength. It will apply for calculations of weak story or soft story ratio in ASCE 31/41, IEBC A4, and other code-based procedures; application of the 1.3 cap on retrofit strength for ASCE 41 and IEBC A4 retrofits; and calculation of spectral capacity with FEMA P-807.*

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~~B4~~E. APPLICATION OF ASCE 31-03 TO EVALUATION

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Further development of this section is expected as needed to address issues specific to Chapter 34B. The sections outlined below cover broad issues consistent with Chapter 34B. Otherwise, use of this standard is subject to existing Department procedures for implementation of SFBC 104A.2.8, Alternate materials, design, and methods of construction.

~~**B4.1. Intent of 3406B.2 item 4**~~

~~SFBC Section 3406B.2 item 4 allows the use of ASCE 31-03 as follows:~~

> ~~4. For evaluation only, ASCE 31-03, Seismic Evaluation of Existing Buildings, with the performance level of Life Safety.~~

~~B4.2.~~ Required scope of work

- No nonstructural evaluation is required.
- Wherever the strength of two stories is being compared, an adequate load path must be assumed for all walls and partitions in the upper story.
  CB2.2. *This requirement prevents underestimating the upper story strength. It will apply for calculations of weak story or soft story ratio in ASCE 31/41, IEBC A4, and other code-based procedures; application of the 1.3 cap on retrofit strength for ASCE 41 and IEBC A4 retrofits; and calculation of spectral capacity with FEMA P-807.*

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~~B5~~F. APPLICATION OF 2012 IEBC APPENDIX CHAPTER A4 TO RETROFIT DESIGN

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~~**B5.1. Intent of 3406B.2 item 5**~~
~~SFBC Section 3406B.2 item 5 allows the use of Chapter A4 as follows:~~

~~5. For retrofit only, 2012 International Existing Building Code (IEBC) Appendix A-4.~~

~~**B5.2.**~~ **Modifications and interpretations of IEBC Appendix Chapter A4.** Compliance with SFBC Chapter 34B using 2012 IEBC Appendix Chapter A4 shall require compliance with that code chapter and its reference codes and standards except as otherwise modified, waived, or interpreted in Bulletin Section B5.2 and Bulletin Part A.

The following modifications and interpretations refer to Chapter A4 section numbers.

A401.1 Purpose

CA401.1. *This provision refers to "minimum standards." In the context of Chapter A4, this means minimum standards for policy equivalence with other criteria when retrofit is triggered elsewhere in the IEBC. In the context of SFBC Chapter 34B, the provisions of Chapter A4 might or might not require the same scope of retrofit as other criteria allowed by SFBC Section 3406B.2. The other criteria are acceptable even if they require less retrofit scope or produce retrofit designs with lower capacity than Chapter A4.*

A401.2 Scope. Omit.

CA401.2. *When used for compliance with SFBC Chapter 34B, the scope and applicability of Chapter A4 is established by Ordinance 66-13. The absence of any condition listed by Section A401.2 has no bearing on compliance with Chapter 34B.*

A402 Definitions. Add, omit, or revise the following definitions as follows:
BUILDING CODE. The current San Francisco Building Code.
GROUND FLOOR. A target story, generally a basement story that extends above grade or the first story above grade plane. Alternately, depending on context, GROUND FLOOR might mean the floor level at the base of a target story.
TARGET STORY. Either of: A basement or underfloor space that extends above adjacent grade at any point; any story above grade plane with a wall layout or plan configuration substantially different from the wall layout or plan configuration of the story above.

CA402. *Target Story is used to define the critical story or stories of interest instead of Chapter A4's reliance on soft, weak, and open front wall lines. In many cases, the key target story will be the first story above grade plane. In other cases, the key target story will be a basement story that extends above grade. Some buildings might have more than one target story.*

A403.1. Omit the exception and revise the first sentence as follows:
A403.1 General. All modifications required … the ~~*International Building Code*~~ <u>building code</u> provisions for new construction, except as modified by this chapter <u>and applicable Administrative Bulletins.</u>

CA403.1. *The exception is not necessary because Section A404 is omitted. See below.*

A403.2. Omit the exception and revise the provision as follows:
A403.2 Scope of analysis. This chapter requires the alteration, repair, replacement or addition of structural elements and their connections to meet the strength and stiffness requirements herein. The lateral-load-path analysis shall include the resisting elements and connections from the wood diaphragm immediately above any~~ soft, weak or open-front wall lines~~ target story to the foundation soil interface ~~or to the uppermost story of a podium structure comprised of steel, masonry, or concrete structural systems that supports the upper, woodframed structure~~. Stories above the uppermost target story ~~with a soft, weak, or open-front wall line~~ shall be considered in the analysis but need not be modified. The lateral-load-path analysis for added structural elements shall also include evaluation of the allowable soil-bearing and lateral pressures in accordance with the building code. Where any portion of a building within the scope of this chapter is constructed on or into a slope ~~steeper than one unit vertical in three units horizontal (33-percent slope)~~, the lateral force-resisting system at and below the ~~base level diaphragm~~ first story above grade plane shall be analyzed for the effects of concentrated lateral forces ~~at the base~~ caused by this hillside condition.

A403.3. Correct Δ_0 to Ω_0 in multiple places. Also, add the following sentences at the end of the section:
A403.3 Design base shear and design parameters. … Despite any other requirement of Section A403.3 or A403.4, the total expected strength of retrofit elements added to any target story need not exceed 1.3 times the expected strength of the story immediately above, as long as the retrofit elements are located symmetrically about the center of mass of the story above or so as to minimize torsion in the target story.

CA403.3. *The added sentence implements the SEAONC recommendation to cap the required strength, consistent with FEMA P-807.*

Add the following subsection:
A403.3.1 Story strength. Calculation of story strength and identification of irregularities in Section A403.3 shall be based on the expected strength of all wall lines, even if sheathed with nonconforming materials. Wherever the strength of two stories is being compared, an adequate load path must be assumed for all walls and partitions in the upper story. The strength of a wall line may be reduced to account for inadequate overturning resistance.

CA403.3.1. *The expected strength of the story above may be calculated using the FEMA P-807 criteria given in Bulletin Section ~~B1.2.~~B5.1. The requirement to assume an adequate load path prevents underestimating the upper story strength. It will apply for calculations of weak story or soft story ratio in ASCE 31/41, IEBC A4, and other code-based procedures; application of the 1.3 cap on retrofit strength for ASCE 41 and IEBC A4 retrofits; and calculation of spectral capacity with FEMA P-807.*

A403.5. Revise the subsection heading and the provision as follows:
A403.5. Deformation Compatibility and P Δ effects. The requirements of the building code shall apply, except as modified herein. All structural framing elements and their connections not required by design to be part of the lateral force-resisting system shall be designed and/or detailed to be adequate to maintain support of~~ design dead plus live~~ expected gravity loads when subjected to the expected deformations caused by seismic forces. ~~The stress analysis of~~

~~cantilever columns shall use a buckling factor of 2.1 for the direction normal to the axis of the beam.~~ Increased demand due to P ∆ effects and story sidesway stability shall be considered in retrofit stories that rely on the strength and stiffness of cantilever columns for lateral resistance.

__CA403.5.__ This revision is consistent with a change approved for the 2015 IEBC.

A403.8. Revise the provision as follows:

A403.8 Horizontal diaphragms. The strength of an existing horizontal diaphragm sheathed with wood structural panels or diagonal sheathing need not be investigated unless the diaphragm is required to transfer lateral forces from vertical elements of the seismic force-resisting system above the diaphragm to elements below the diaphragm because of an offset in placement of the elements.

~~Wood diaphragms with stories above shall not be allowed to transmit lateral forces by rotation or cantilever except as allowed by the building code; however, r~~ Rotational effects shall be accounted for when ~~unsymmetric~~ asymmetric wall stiffness increases shear demands.

~~**Exception:** Diaphragms that cantilever 25 percent or less of the distance between lines of lateral load-resisting elements from which the diaphragm cantilevers may transmit their shears by cantilever, provided that rotational effects on shear walls parallel and perpendicular to the load are taken into account.~~

__CA403.8.__ This revision is consistent with a change approved for the 2015 IEBC.

A403.9.1 Revise the provision as follows:

A403.9.1 Gypsum or cement plaster products. Gypsum or cement plaster products shall not be used to provide lateral resistance in a ~~soft or weak story or in a story with an open-front wall line,~~ target story. ~~whether or not new elements are added to mitigate the soft, weak or open-front condition.~~

A404. Omit Section A404 entirely.

__CA404__. Section A404 applies to two-story buildings only. Two-story buildings are exempt from SFBC Chapter 34B.

A405.1. Revise the provision as follows:

A405.1 New materials. New materials shall meet the requirements of the ~~*International Building Code*,~~ building code, except where allowed by this chapter or applicable Administrative Bulletins.

A407 Quality Control. Omit Section A407 entirely.

__CA407__. Bulletin Sections A4 and A5, as well as AB 106, apply instead.

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Part B6G. GUIDELINES FOR ALTERNATIVE RATIONAL DESIGN BASES

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Further development of this section is expected as needed to address issues specific to Chapter 34B. The sections outlined below cover broad issues consistent with Chapter 34B. Otherwise, use of this standard is subject to existing Department procedures for implementation of SFBC 104A.2.8, Alternate materials, design, and methods of construction.

B6.1 Intent of 3406B.2 item 6

SFBC Section 3406B.2 item 6 allows the use of alternative criteria as follows:

> 6. The building shall satisfy any other rational design basis deemed acceptable by the Department that meets or exceeds the intent of this Chapter.

B6.2

Reserved

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Tom C. Hui, S.E., C.B.O., Date
Acting Director
Department of Building Inspection

Approved by Building Inspection Commission on

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1

ADMINISTRATIVE BULLETIN

NO. AB-023

DATE : November 6, 2013 ~~October 12, 2010~~ [This bulletin supersedes Code Ruling BC-306(a) 21A-D1, (revised) dated April 8, 1991]

SUBJECT : Plan Review; Permit Process

TITLE : Crane Site Safety Plan / Tower Crane Foundation and Attachment permit

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PURPOSE : The purpose of this Administrative Bulletin is to detail procedures regarding tower crane safety which comply with the intent of 2013 ~~2010~~ San Francisco Building Code Section ~~1704.20~~ 1705.21.

Implementation of the intent of the code requires that a contractor identify the location of proposed crane operations on a Crane Site Safety Plan and agree to comply with all applicable tower crane safety regulations; to require the presence of a safety representative during tower crane erection, jumping, and dismantling and to prohibit, without prior agreement with DBI, DPW, MTA, the controlling contractor and the crane erector, these operations during typical rush hours; to require employment of a flag-person to redirect traffic when loads are lifted over public streets and walkways during typical rush hours; and to require the review, approval and permitting of the structural elements of tower crane foundations and tie-in attachments.

REFERENCE : 2013 ~~2010~~ San Francisco Building Code,
Section ~~1704.20~~ 1705.21
Administrative Bulletin AB-046: Special Inspection and Structural Observation Procedures
Title 8, Occupational Safety and Health Regulations (CAL/OSHA), Chapter 4, Subchapter 7: General Industry Safety Orders, Group 13, Article 90, Cranes and Other Hoisting Equipment.
Title 8, ~~,~~ Chapter 4, Subchapter 7: General Industry Safety Orders, Group 13, Article 96, Tower Cranes re: Requirements for erection, dismantling, operation, tests/examination of equipment and accessory gear.

DISCUSSION : Following a tower crane collapse in November 1989, the State of California passed legislation regulating certain tower crane operations. The San Francisco Board of Supervisors approved an ordinance, based on that state legislation,
that added a section regarding tower crane safety requirements to the San Francisco Building Code (SFBC).

Crane safety remains under the jurisdiction of the California Occupational Safety and Health Administration (Cal/OSHA), which requires an erection permit prior to the construction of foundation, anchorage and the erection of a tower crane. A Cal/OSHA operational permit is also required prior to the crane operation. While the San Francisco Department of Building Inspection (DBI) has no authority over, and its employees have no expertise in, the regulation of tower cranes, the following forms and procedures were developed to administer the San Francisco Building Code requirements.

Technical Services Division
1660 Mission Street – San Francisco CA 94103
Office (415) 558-6205 – FAX (415) 558-6401 – www.sfdbi.org

Definitions

For the purposes of this Administrative Bulletin, the following definitions apply:

1. *Contractor* is the building contractor, licensed by the State of California, responsible for tower crane site safety for the project.

2. *Tower crane* is a crane in which a boom, swinging (slewing) jib, or other structural member is mounted on a vertical mast or tower, and includes the following subcategories as defined by Cal/OSHA General Industry Safety Orders, Article 91, 4885(U)(1-4):

   a. *Tower crane (climber)* is a crane that may be raised or lowered to different floors or levels of the building or structure, that is erected upon, near to, and/or supported by a building or other structure.

   b. *Tower crane (free standing)* is a crane with a horizontally swinging or luffing boom which may be on a fixed base or mounted on rails and not attached to any other structure.

   c. *Tower crane (mobile)* is a tower crane which is mounted on a crawler, truck or similar carrier for travel or transit.

   d. *Tower crane (self-erector)* is a mobile tower crane that is truck-carrier mounted and capable of self-erection.

3. *Jumping* (climbing) a crane is the process of increasing or decreasing the height of a tower crane by raising the upper (slewing) section and inserting or removing modular tower sections beneath it.

4. *Safety Representative* shall mean a safety representative of the crane manufacturer, distributor, or a representative of a licensed crane certifier as per Cal/OSHA requirements.

General Requirements

A Crane Site Safety Plan and Tower Crane Foundation and Attachment Permit application shall be submitted to the Plan Review Services (PRS) Division for review, approval and issuance of a Tower Crane Foundation and Attachment Permit prior to the erection of the crane.

This administrative bulletin shall apply to climber tower cranes and to free standing tower cranes; mobile tower cranes and self-erector tower cranes are exempt from these regulations, but must meet all Cal/OSHA requirements.

Procedure

For the review, approval and issuance of a Tower Crane Foundation and Attachment Permit, the following procedure shall be used;

1. The contractor shall submit to DBI two copies of the following:

   - Crane Site Safety Plan Submittal Form and Safety Compliance Agreement (Attachment A)
   - Plans showing street locations, crane location, path of boom swing, designated loading areas and designated staging areas. Note: A site plan showing which streets will be impacted by the moving, erection, and operation of the tower crane is required by DPW in order to obtain a street use permit for crane erection. That site plan can be used as the crane site safety plan by adding the additional information noted above.
   - Completed permit application form for tower crane foundation and attachment.
   - Plans showing tower crane foundation and building tie-in attachment details
   - Structural calculations supporting the design shown on the plans
2. The plans examiner will review the submittals to determine that all documents comprising the Crane Site Safety Plan are complete and the Submittal Forms and Safety Compliance Agreements are signed by a California licensed contractor or civil engineer where required. If the documents are not complete they will be returned to the contractor for correction and re-submittal.

3. If the tower crane foundation was not included in the approved building permit or the approved foundation addendum to a site permit, then the tower crane foundation shall be included as part of the Crane Site Safety Plan / Tower Crane Foundation and Attachment permit. The contractor shall submit to DBI for review, drawings and calculations for the tower crane foundation prepared by a civil engineer licensed in the State of California. If the foundation was included in the approved building permit or the approved foundation addendum to a site permit, the application shall reference such plans and calculations.

4. If the tower crane attachments (tie-ins) are required but not included in the approved building permit or the approved superstructure addendum to a site permit, then the attachments shall be included as part of the Crane Site Safety Plan / Tower Crane Foundation and Attachment permit. The contractor shall submit to DBI for review, drawings and calculations for the tower crane attachments (tie-ins) prepared by a civil engineer licensed in the State of California. If the attachments were included in the approved building permit or the approved superstructure addendum to a site permit, the application shall reference such plans and calculations.

5. If the submittal documents are in compliance with all applicable codes and this administrative bulletin, the plans examiner shall stamp as "approved" both copies of the submitted Crane Site Safety Plan / Tower Crane Foundation and Attachment permit documents.

6. The plans examiner shall attach these documents to the approved Crane Site Safety Plan / Tower Crane Foundation and Attachment permit for inclusion in the permanent project record and shall provide one copy to the contractor for posting at the job site..

7. The contractor shall submit to DBI a copy of a tower crane inspection certificate issued by a Cal/OSHA approved inspection agency following erection of the tower crane and prior to its use. This may be done by mail or in person. This submittal must indicate the site permit or building permit application number for the project and the application number for the Tower Crane Foundation and Attachment Permit.

8. All special inspections and structural observations required for the crane foundation and crane attachments shall be listed in the application and shall be attached to the Crane Site Safety Plan / Tower Crane Foundation and Attachment permit. Copies of the special inspections reports shall be maintained by the contractor, posted at the job site, and forwarded to DBI. The contractor shall verify that all required special inspections and structural testing results are documented and determined to be in conformance with design specifications. The crane erector shall be provided such documents prior to erection or climbing of a tower crane.

9. All documents submitted to DBI related to the Crane Site Safety Plan / Tower Crane Foundation and Attachment permit shall be archived as part of the approved permit documents.

____

Tom C. Hui, S.E., C.B.O. Date
Director
Department of Building Inspection

Approved by the Building Inspection Commission on March 18, 2009.

Attachment: Crane Site Safety Plan Submittal Form and Crane Safety Compliance Agreement.

AB-023

CRANE SITE SAFETY PLAN SUBMITTAL FORM & CRANE SAFETY COMPLIANCE AGREEMENT

[Attach form to each copy of plans submitted]

Project Address________________________ Permit Application No.________________ Date_______________

Name of Applicant____ Phone_____________

☐ A. Attached are two (2) copies of a Crane Site Safety Plan which includes the required information, circled and marked with applicable numbers on the plans:

1. Location of tower crane on the construction site
2. Path of the boom swing
3. Location of crane-related designated loading areas
4. Location of crane-related designated storage areas
5. Tower crane foundation and attachment design and details, or reference to such design and details on the building site plan, foundation, superstructure addendums, or tower crane supplier drawings.
6. Special Inspections forms per AB-046.

☐ B. Copy of Cal/OSHA permit for the erection and operation of a crane is attached, **or proof that such permit has been applied for**, and, if required, a copy of California crane operator(s) license(s).

☐ C. I will comply with all of the following requirements:

1. Applicable CAL/OSHA safety requirements.
2. Crane manufacturer safety requirements.
3. Safety representative: I shall not allow installing, increasing the height (“jumping”), or dismantling of a crane without a safety representative of the crane manufacturer, distributor, or a representative of a licensed crane certifier being present on site for consultation during all such procedures.
4. Prohibited hours: Without prior agreement with DBI, DPW, MTA, controlling contractor, and erector, I shall not allow installing, increasing the height (“jumping”), or dismantling of a crane during the weekday hours (excluding holidays) of 7:00 a.m. to 9:00 a.m., between the hours of 4:00 p.m. and 6:00 p.m., or prior to 1 hour after sunrise or later than 1 hour before sunset.
5. Flag person: I shall assure that no crane will lift a load over roadways or pedestrian walkways during the hours of 7:00 a.m. through 9:00 a.m. and during the hours of 4:30 p.m. through 7:00 p.m. without a flag person directing the flow of pedestrian and automobile traffic away from the area where the load is being lifted.

☐ D. I will submit a copy of the Cal/OSHA operational permit to DBI after erection of the crane and prior to its use.

☐ E. I understand that failure to comply with these requirements (Items C 1. through 5.) will result in the notification of Cal/OSHA of such failure and may result in the suspension of the right to operate this crane.

______________________________________ ___________________________
Contractor responsible for Crane Site Safety CA Contractor License No.

______________________________________ Date______________________
Contractor representative

Reviewed by: ____________________________ Date______________________
DBI Plan Reviewer

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1
ADMINISTRATIVE BULLETIN

NO. AB-036 : (Previously numbered BC-5802-1, supercedes Ruling 75-9 and BC-5602-1)

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : Inspection

TITLE : Special inspection for demolition work

PURPOSE : For demolition of buildings of Types I, II, III and IV construction, and which are over 2 stories or 25 feet in height, a special inspector shall be on the site to observe and/or supervise the work to assure it is proceeding in a safe manner.

REFERENCES: **2013** ~~**2010**~~ San Francisco Building Code (SFBC)
- 1705.8 ~~1704.17~~; Demolition
- 3307 ~~3307.4~~; Protection of Adjoining Property
- 3303.8 ~~1704~~; Special Inspection

DISCUSSION : Demolition work creates ongoing, and often sudden, life hazards. The general requirements for special inspection in SFBC Sec. 1705.8 ~~1704.17~~; are made more specific in this ruling to reflect the need for extra supervision of such work.

REQUIREMENT

The Demolition Contractor or permit applicant shall identify the Special Inspector for demolition work before a demolition permit is issued. For buildings over 6 stories high, the Contractor and Special Inspector shall meet with the Department of Building Inspection (DBI) District Inspector to review the demolition work and arrive at a clear understanding on what is expected of all parties prior to the start of work. The Demolition Contractor shall notify the Special Inspector and the District Inspector at least two days prior to the start of the demolition operations. By obtaining the permit, the applicant acknowledges the authority of the Special Inspector over the demolition work as described below.

The Special Inspector:

1. Shall be a registered Civil Engineer or licensed Architect, and preferably, the individual who prepared the approved demolition sequence. Shall be at the site at all times when dismantling or demolition work is proceeding on any component which, when removed, reduces the stability of the building. These include, but are not limited to, the following:

   a. Exterior walls
   b. Bearing walls
   c. Beams, girders and columns
   d. Diaphragms (roof and floors which contribute stability to building)

2. Shall observe and /or direct that the work conforms with the sequence of operations which was approved by DBI. In the event a potentially hazardous situation develops as a result of conditions uncovered or unintentionally created by the demolition work, the Special Inspector shall notify DBI by telephone as soon as possible, and at that point shall require and allow only corrective work to take place to substantially reduce the hazards present. The Special Inspector shall then not allow any more work to be done until a revised demolition sequence has been submitted to DBI and approved.

In the event an unexpected development occurs which jeopardizes the public, such as materials falling onto the street or partial collapse of a wall, the Inspector may allow the demolition work to continue only if all the following conditions are complied with:

a. No continuing hazards to the public exist after the incident.
b. No significant deviations from the approved sequence are necessary as a result of the incident.
c. The Contractor provides/establishes measures and assurances that such incidents will not occur again, to the satisfaction of the Inspector.
d. The Special Inspector reports the incident to DBI in writing as soon as possible. The report shall explicitly address the issues in conditions a through c above.

If the above conditions are not met, the Special Inspector shall stop the job and notify DBI. The Special Inspector shall not allow the work to resume until DBI gives permission.

In the event deviations from the approved sequence are necessary due to unexpected field conditions, and potentially hazardous conditions are not present or would not be created, the inspector may allow or direct such deviations be made without stopping the work. Such deviations shall be reported in his next report to DBI.

3. Shall make written reports to DBI on a weekly basis or as required by DBI. Such reports shall include information on the progress of the demolition, any deviations which were not reported previously, and a statement that the demolition work is adhering to the approved sequence.

4. May be an employee of the Special Inspector only when the following conditions are complied with:

a. The employee is a registered Civil Engineer or licensed Architect.
b. The employee shall be under the immediate supervision of the Special Inspector. The Special Inspector shall provide to DBI a written statement in which he acknowledges complete responsibility for the inspection work, actions and decisions of the employee.
c. All reports shall be signed by the Engineer or Architect.

Tom C. Hui, S.E., C.B.O. Date
Director
Department of Building Inspection

Approved by the Building Inspection Commission Date

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1

ADMINISTRATIVE BULLETIN

NO. AB-046

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : Permit Process; Inspection

TITLE : **Special Inspection and Structural Observation Procedures**

PURPOSE : The Purpose of this Administrative Bulletin is to describe the procedures to be used in the administration and enforcement of special inspection and structural observation requirements of the *San Francisco Building Code*. It is intended as an aid for design professionals in their preparation of inspection and observation programs. It provides information for building owners, architects and engineers, contractors, and special inspection agencies about their responsibilities regarding special inspection and structural observation and includes standardized forms and formats applicable to these functions.

REFERENCES : **2013** ~~2010~~ San Francisco Building Code
Section 108A.4. Inspections, General
Chapter 17. Structural Tests and Special Inspections

ASTM E329-07. Standard Specification for Agencies Engaged in Construction Inspection and/or Testing

I. DEFINITIONS

A. Special Inspection

Special Inspection is the monitoring of materials and workmanship that are critical to the integrity of building structures or are otherwise required for public safety. Special inspection is intended to ensure that the approved plans and specifications are being followed and that relevant codes and ordinances are being observed. The special inspection process is in *addition* to the regular inspections conducted by Department of Building Inspection building inspectors and the periodic structural observation by the engineer or architect of record. The special inspectors furnish continuous or periodic inspection as required by the *San Francisco Building Code* (SFBC). Good communication between the special inspector and the designers, contractor, and building department is an essential part of project quality assurance.

B. Structural Observation

Structural Observation is visual observation of the structural system, for general conformance with the approved plans and specifications, at significant construction stages and at completion of the structural system, as required by SFBC Section 1704.5 ~~1710~~. Structural observation does not include or waive the responsibility for the inspections required by Section 108A, 1704, 1705, or other sections of this code. [SFBC Sec. 202]

II DUTIES AND RESPONSIBILITIES OF THE PARTIES RESPONSIBLE FOR SPECIAL INSPECTION PROGRAM AND STRUCTURAL OBSERVATION PROGRAM

A. Duties and Responsibilities of the Project Owner

1. The project owner, or the owner's agent, is responsible for funding special inspection services.

2. The owner, or the owner's agent, shall employ the engineer or architect responsible for the structural design, or another engineer or architect designated by the engineer or architect responsible for the structural design, to perform structural observation as defined in SFBC Section 202.

3. Before final building inspection, the owner, or the owner's agent, shall submit to DBI final compliance reports covering each item requiring special inspection and structural observation. Final reports shall be wet signed and stamped by the responsible engineer of the special inspection agency, geotechnical firm, engineer or architect of record - as appropriate to the type of report. See Exhibit No. 2, *Special Inspection Final Compliance Report* and Exhibit No. 3, *Structural Observation Final Compliance Report.*

B. Duties and Responsibilities of the Engineer of Record

The Engineer of Record (or Architect of Record) has many duties and responsibilities related to special inspection and structural observation activities. These include the following:

1. Identify the need for special inspection and structural observation services

The project plans that are submitted to the Building Official shall clearly indicate the design parameters and material selection. The Engineer of Record shall analyze the critical elements of the design and determine where special inspection and structural observation are required, in accordance with ~~2010~~ SFBC Sections 1704 and 1705 ~~1710~~. The Engineer of Record shall submit the *Special Inspection and Structural Observation Form* (Exhibit No. 1) to DBI. The Engineer of Record shall also indicate the required special inspection and structural observation requirements on the submitted drawings. This can be accomplished by including a copy of the form on the drawings, or by including the same information on the drawings in another manner.

2. Respond to field discrepancies

The Engineer of Record is instrumental in the process of deficiency correction. The engineer or architect of record is responsible for any design changes in addition to acknowledgment and approval of shop drawings, which may detail structural information, and for submission of such changes to DBI for approval.

3. Prepare final compliance report

The Engineer of Record prepares an overall final compliance report for submittal to DBI, stating that all items requiring special inspection and structural observation were performed in accordance with the approved plans, specifications, and applicable workmanship provisions of the SFBC. See Exhibit No. 2, *Special Inspection Final Compliance Report* and Exhibit No. 3, *Structural Observation Final Compliance Report.*

C. Duties and responsibilities of the engineer responsible for the structural observation program

Observed deficiencies shall be reported in writing to the owner's representative, special inspector, contractor and the Director. The structural observer shall submit to the Director a written statement declaring that the site visits have been made and identifying any reported deficiencies that, to the best of the structural observer's knowledge, have not been resolved. See Exhibit No. 3 - *Structural Observation Final Compliance Report.*

D. Duties and Responsibilities of the Special Inspector

The special inspectors are individuals with highly developed, specialized skills who observe those critical building or structural features which they are qualified to inspect. Duties of the special inspectors and/or inspection agencies include the following:

1. Observe all work for which they are responsible

Special inspectors shall inspect all work for conformance with the Department of Building Inspection approved drawings and specifications and applicable provisions of the code.

2. Provide timely reports

The special inspector should complete written inspection reports for each inspection visit and provide the reports in a timely manner. The special inspector or inspection agency shall furnish these reports directly to the building official, engineer or architect of record and to the general contractor. Special inspectors shall bring all non-conforming items to the immediate attention of the contractor. If any such item is not resolved in a timely manner or is about to be incorporated in the work, the engineer or architect of record and the building official shall be notified immediately. See Exhibit Nos. 5 to 8.

3. Respond to field discrepancies

Material and design discrepancies shall brought to the attention of the Engineer of Record and the Building Official.

4. Submit a final signed report

Special inspectors or inspection agencies shall submit a final report (signed by the registered engineer or licensed architect who is responsible for the special inspection) to the Department of Building Inspection stating that all items requiring special inspection and testing were constructed, to the best of their knowledge, in conformance with the approved design drawings, specifications, approved change order and the applicable provisions of the code. See Exhibit No. 2 - *Special Inspection Final Compliance Report.*

E. Duties and Responsibilities of the Director

1. Review and examine plans for compliance.

The Director is charged with the legal authority to review the plans for compliance with the code requirements, including special inspection and structural observation requirements

2. Monitor the special inspection and structural observation activities

The Director shall monitor the jobsite to see that special inspection and structural observation is being performed and that an adequate number of special inspection staff is present depending upon the extent and complexity of the project.

3. Review inspection reports

The Director receives, reviews and makes the inspection reports part of the inspection records.

4. Review the final report

The Certificate of Occupancy shall not be issued until the final report has been received and approved by the Director.

F. Duties and Responsibilities of the Contractor

The contractor's duties include the following:

1. Notify the special inspector

The contractor is responsible for notifying the special inspector or agency regarding special inspections required by DBI. Adequate notice shall be provided so that the special inspector has time to become familiar with the project.

2. Provide access to approved plans

   The contractor is responsible for providing the special inspector with access to approved plans at the job site.

3. Retain special inspection records

   The contractor is responsible for retaining at the job site all special inspection records submitted by the special inspector, and providing these records for review by the Department of Building Inspection inspector upon request.

III SPECIAL INSPECTOR QUALIFICATIONS: [SFBC Sec. 1704]

The San Francisco Department of Building Inspection will accept special inspection and testing agencies working on projects in San Francisco who are recognized by the Special Inspection Joint Review Committee of participating Bay Area jurisdictions, which reviews the qualifications of inspection and testing agencies including conformance with ASTM E329 and inspector certification and experience criteria. The current list of the Joint Review Committee's Recognized Special Inspection and Testing Agencies is available from DBI.

Alternatively, special Inspectors shall be one of the following:

A. A qualified person employed by an approved inspection and testing agency conforming insofar as applicable to the requirements of ASTM E329.

   Except for testing of materials and reporting of numerical results from such tests, the inspector shall work under the general supervision of a registered Civil Engineer, and all reports and certification of compliance must be signed by the engineer.

B. A registered Civil Engineer or licensed Architect who can demonstrate to the satisfaction of the Director that he or she has the experience and expertise to qualify as a special inspector for the specific type of inspection work, and has appropriate equipment to conduct such inspections and tests.

   Note: The above applies to any engineer or architect who is not the engineer or architect of record for the project. Qualifications must be approved by the Director.

C. For life-safety provisions required by SFBC Section 403, construction review and validation testing shall be performed by, or under the supervision of a registered Electrical or Mechanical Engineer responsible for those areas of work involving his or her design. All reports on construction review and testing, and certification of compliance and full operational status, shall be signed by the engineer and endorsed by the design professional of record for the building. The design professional of record shall bear overall responsibility for the proper installation and testing of the life-safety system. When approved by the Director this responsibility may be borne by an approved independent testing agency.

D. The Engineer (or Architect) of Record.

   Note: The engineer who prepared the geotechnical report may be considered the engineer of record for the geotechnical work requiring special inspection.

E. For plant fabrication of precast concrete elements, a registered civil engineer who supervises all phases of quality control work. The registered civil engineer shall be subject to the approval of the Director.

IV SPECIAL INSPECTION AND STRUCTURAL OBSERVATION OPERATIONAL PROCEDURE WITHIN DEPARTMENT OF BUILDING INSPECTION

A. Plan Review Services (PRS) - Plan Check Engineers/Inspectors

1. Review the *Special Inspection and Structural Observation Form*. Usually the engineer or architect of record prepares the form. See Exhibit No. 1, *Special Inspection and Structural Observation Form*. Verify special inspection and structural observation items.

2. Plan checker affixes the "SPECIAL INSPECTION" stamp on the back of the application when signing that permit is approved for issuance. The plan checker makes one copy of the *Special Inspection and Structural Observation Form* and attaches it to the applicant's copy of the permit application, then gives the original to the Special Inspection Services staff.

3. Special Inspection Services Staff set up the special inspection file and enter the types of special inspection and structural observation required for the project in the computer record for the permit application.

4. During construction, DBI Special Inspection Services Staff distribute special inspection progress reports to assigned staff. If reports indicate problems that need to be brought to the attention of the district building inspector, Special Inspection Services Staff forwards a copy of the report to the appropriate district building inspector. District building inspector will notify the contractor who in turn shall notify the engineer of record to resolve the field problems. Resolution reports shall be submitted to PRS for review and file. See Exhibit No. 4, *Special Inspection/Structural Observation Transmittal Letter.*

5. When final reports are submitted, DBI staff will review for final compliance. If documentation is not sufficient, DBI staff will notify the Engineer of Record regarding missing items. If compliance has been verified, DBI staff signs and dates Special Inspection and Structural Observation Program form.

6. DBI staff enters final compliance approval in the computer by entering the approval date and their name for each item requiring special inspection.

7. DBI staff sends completed special inspection and structural observation files quarterly to DBI storage.

8. For permits issued **over the counter** when special inspection is required, DBI staff will make copy of the Special Inspection form and distribute as follows:

   a. One copy to applicant

   b. Original to DBI staff with the approval date.

B. Central Permit Bureau (CPB)

Staff shall give one copy of the approved Special Inspection to applicant together with the approved drawings.

C. Building Inspection Division (BID)

1. Special Inspector shall be identified to the District Building Inspector prior to start of the work for which special inspection is required. See Exhibit No. 1, *Notice - Special Inspection Requirements and Structural Observation Requirements.*

2. District building inspectors monitor the special inspection activities at the project site. In the event that district building inspectors discover that required special inspection is not being performed, or is not in compliance with the approved plans, they are authorized to suspend or stop the progress of the work.

Tom C. Hui, S.E., C.B.O. Date
Director
Department of Building Inspection

Approved by the Building Inspection Commission on September 18, 2002

Attachments (Exhibits):

1. Special Inspection and Structural Observation Requirements
2. Special Inspection Final Compliance Report
3. Structural Observation Final Compliance Report
4. Special Inspection/Structural Observation Transmittal Letter
5. Special Inspection Record
6. Special Inspection Daily Report
7. Special Inspection Weekly Report
8. Special Inspection Discrepancy Notice
9. Sample matrix
10. Agency Summary and Letter of Agreement
11. Waiver Agreement
12. Responsible Engineer's Statement of Agreement

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

Exhibit No. 1

NOTICE

SPECIAL INSPECTION REQUIREMENTS

Please note that the Special Inspections shown on the approved plans and checked on the Special Inspections form issued with the permit are required for this project. The employment of special inspectors is the direct responsibility of the owner or the engineer/architect of record acting as the owner's representative.

These special inspections are required *in addition to* the called inspections performed by the Department of Building Inspection. The name of the special inspector shall be furnished to the district building inspector prior to start of work for which special inspection is required.

For questions regarding the details or extent of required inspection or tests, please call the Plan Checker assigned to this project or **415-558-6132**. If there are any field problems regarding special inspection, please call your District Building Inspector or 415-558-6570.

Before final building inspection is scheduled, documentation of special inspection compliance must be submitted to and approved by the Special Inspection Services staff. To avoid delays in this process, the project owner should request final compliance reports from the architect or engineer of record and/or special inspection agency soon after the conclusion of work requiring special inspection. *The permit will not be finalized without compliance with the special inspection requirements.*

STRUCTURAL OBSERVATION REQUIREMENTS

Special Inspection Services
1660 Mission Street – San Francisco CA 94103
Office (415) 558-6132 – FAX (415) 558-6474 – www.sfdbi.org

Structural observation shall be provided as required per Section 1710. **The building permit will not be finalized without compliance with the structural observation requirements.**

Special Inspection Services Contact Information

1. Telephone: (415) 558-6132
2. Fax: (415) 558-6474
3. Email: dbi.specialinspections@sfgov.org
4. In person: 3rd floor at 1660 Mission Street

Note: We are moving towards a 'paperless' mode of operation. All special inspection submittals, including final letters, may be emailed (preferred) or faxed. We will also be shifting to a paperless fax receipt mode.

SPECIAL INSPECTION AND STRUCTURAL OBSERVATION

A COPY OF THIS DOCUMENT SHALL BE KEPT WITH THE APPROVED STRUCTURAL DRAWING SET

JOB ADDRESS______________________ APPLICATION NO.______________________ ADDENDUM NO.______

OWNER NAME______________________________ OWNER PHONE NO. (__________)__________________

Employment of Special Inspection is the direct responsibility of the OWNER, or the engineer/architect of record acting as the owner's representative. Special inspector shall be one of those as prescribed in Sec.1704. Name of special inspector shall be furnished to DBI District Inspector prior to start of the work for which the Special Inspection is required. Structural observation shall be performed as provided by Section 1704.5 ~~1710~~. A preconstruction conference is recommended for owner/builder or designer/builder projects, complex and highrise projects, and for projects utilizing new processes or materials.

In accordance with Sec. 1701;1703;1704;1705 (2013 ~~2010~~ SFBC), Special Inspection and/or testing is required for the following work:

1. [ ] Concrete (Placement & sampling)
2. [ ] Bolts installed in concrete
3. [ ] Special moment - Resisting concrete frame
4. [ ] Reinforcing steel and prestressing tendons
5. **Structural welding:**
   - A. **Periodic visual inspection**
     - [ ] Single pass fillet welds 5/16" or smaller
     - [ ] Steel deck
     - [ ] Welded studs
     - [ ] Cold formed studs and joists
     - [ ] Stair and railing systems
     - [ ] Reinforcing steel
   - B. **Continuous visual inspection and NDT** (Section 1705 ~~1704~~)
     - [ ] All other welding (NDT exception: Fillet weld)
6. [ ] High-strength bolting
7. [ ] Structural masonry
8. [ ] Reinforced gypsum concrete
9. [ ] Insulating concrete fill
10. [ ] Sprayed-on fireproofing
11. [ ] Piling, drilled piers and caissons
12. [ ] Shotcrete
13. [ ] Special grading, excavation and filling (Geo. Engineered)
14. [ ] Smoke-control system
15. [ ] Demolition
16. [ ] Exterior Facing
17. **Retrofit of unreinforced masonry buildings:**
    - [ ] Testing of mortar quality and shear tests
    - [ ] Inspection of repointing operations
    - [ ] Installation inspection of new shear bolts
18. **Bolts Installed in existing concrete or masonry:**
    - [ ] Concrete [ ] Masonry
    - [ ] Pull/torque tests per SFBC Sec.1607C & 1615C
19. [ ] Shear walls and floor systems used as shear diaphragms
20. [ ] Holdowns
21. **Special cases:**
    - [ ] Shoring
    - [ ] Underpinning: [ ] Not affecting adjacent property [ ] Affecting adjacent property: PA__________
    - [ ] Others
22. [ ] Crane safety (Apply to the operation of tower cranes on highrise building) (Section 1705.21 ~~1704.20~~)
23. [ ] Others: "As recommended by professional of record"______________________________

[ ] Reinforcing steel; and [ ] NDT required [ ] Pre-installation inspection for embedded bolts ______________________________

[ ] Moment-resisting frames [ ] Pull/torque tests per SFBC Sec.1607C & 1615C

[ ] Others______________________

24. **Structural observation per Sec. 1704.5 ~~1710~~ (2010 SFBC) for the following:** [ ] Foundations [ ] Steel framing

[ ] Concrete construction [ ] Masonry construction [ ] Wood framing

[ ] Other:____

25. Certification is required for: [ ] Glu-lam components

Prepared by: __________ ______________________ Phone: (__________)______________________

Engineer/Architect of Record

Required information:

FAX: (__________)______________________ Email:______________________________________

Review by: ____________________________________ Phone: (415) 558-______________________

DBI Engineer or Plan Checker

****

APPROVAL (Based on submitted reports.)

____

DATE DBI Engineer or Plan Checker / Special Inspection Services Staff

QUESTIONS ABOUT SPECIAL INSPECTION AND STRUCTURAL OBSERVATION SHOULD BE DIRECTED TO:

Special Inspection Services (415) 558-6132; or, dbi.specialinspections@sfgov.org ; or FAX (415) 558-6474

Exhibit No. 2
(Required Format)

SPECIAL INSPECTION FINAL COMPLIANCE REPORT

[Date]

[Special Inspection Coordinator]
City and County of San Francisco

Department of Building Inspection
1660 Mission Street, 3rd Floor
San Francisco, CA 94103

Re: Project Address:
Permit Application No. ___________________

In accordance with Section 1704 and 1705 of the 2013 ~~2010~~ San Francisco Building Code, we have provided special inspection for the following items:

Based upon inspections performed and our (my) substantiating reports, it is our (my) professional judgment that, to the best of our (my) knowledge, the inspected work was performed in accordance with the approved plans, specifications, and applicable workmanship provisions of the San Francisco Building Code.

Signed: ______________________________________

Print full name:________________________________

Inspection Agency:

[Agency Responsible Engineer's stamp]

cc: Client/Project Owner
Engineer/Architect

Exhibit No. 3
(Required Format)

STRUCTURAL OBSERVATION FINAL COMPLIANCE REPORT

[Date]

[Special Inspection Coordinator]
City and County of San Francisco
Department of Building Inspection
1660 Mission Street, 3rd Floor
San Francisco, CA 94103

Re: Project Address:
Permit Application No. ________________

In accordance with Section 1704.5 ~~1710~~ of the 2013 ~~2010~~ San Francisco Building Code, I have provided structural observation for the following items:

Based upon inspections performed and my substantiating reports, it is my professional judgment that, to the best of my knowledge, the observed structural work was performed in accordance with the approved plans, specifications, and applicable workmanship provisions of the San Francisco Building Code.

Signed: ________________________________
Print full name:____________________________

[Stamp of Engineer/Architect of Record performing structural observation]

cc: Client/Project Owner

Exhibit No. 4
(Required Format)

Special Inspection/Structural Observation Transmittal Letter

From: ______________________________________ **(415-558-**
DBI Engineer or Plan Checker
Phone

To:
DBI District Building Inspector

Address of Project:

Application Number:

- ❑ **The attached special inspection/structural observation report(s) show(s) discrepancies:**
  - ❑ **Contact plan checker for discussion on proposed action.**
  - ❑ **Issue correction notice to resolve discrepancy(s)**
  - ❑ **Stop work in the area(s) of discrepancy(s)**
  - ❑ **Stop all work. Conference with Chief building Inspector and Plan Check Manager Required**
  - ❑ **Other**
- ❑ **All final reports were received and are acceptable. Final building inspection may be scheduled.**

Exhibit No. 5
(Recommended for Format Purposes only)

SPECIAL INSPECTION RECORD

Project Address: ______________________Permit Application No.:

NOTE: Each special inspector shall complete for for each day's inspection. Post this card adjacent to building permit inspection record card. Weekly reports to be submitted by each special inspector/inspection agency agency to the building department.

When attached to the job inspection record card, this card becomes a part of the inspection record.

INSPECTION TYPE	SPECIAL INSPECTOR	ID NO.	DATE	NOTES	TIME	
					ARR	LEFT

Exhibit No. 6
(Recommended for Format Purposes only)

SPECIAL INSPECTION DAILY REPORT

Permit Application No. ____________________ **Date**

Project Name/Address:

Inspection Type(s)/Coverage: ____

☐ **Continuous** ☐ **Periodic; frequency:**

Inspections made, including locations:

Tests performed:

Items requiring 1) Correction, 2) Correction of previously listed items, and 3) Previously listed uncorrected items:

Changes to approved plans authorized by engineer or architect of record:

Comments:

To the best of my knowledge, work inspected was in accordance with the building department approved plans, specifications, and applicable workmanship provisions of the SFBC except as noted above.

Special Inspector: ______________________________ **Inspection Agency:**

Exhibit No. 7
(Recommended for Format Purposes only)

SPECIAL INSPECTION WEEKLY REPORT

Permit Application No. ________________ **Date**

Project Name/Address:

Inspection Type(s)/Coverage:

☐ Continuous ☐ Periodic; frequency:

Total inspection time each day:

Date							
Hours							
Inspector							

Inspections made, including locations:

Tests performed:

Items requiring 1) Correction, 2) Correction of previously listed items, and 3) Previously listed uncorrected items:

Changes to approved plans authorized by engineer or architect of record:

Comments:

To the best of my knowledge, work inspected was in accordance with the building department approved plans, specifications, and applicable workmanship provisions of the SFBC except as noted above.

cc: Building Department
Engineer/Architect

Exhibit No. 8
(Recommended for Format Purposes only)

SPECIAL INSPECTION DISCREPANCY NOTICE

Permit Application No. ____________________ Date

Project Name/Address:

Inspection Type(s)/Coverage:

☐ Continuous ☐ Periodic; frequency:

Notice delivered to: ☐ Contractor ☐ Engineer/Architect ☐ Building Department

The following discrepancies require correction and inspection approval prior to proceeding with this phase of the work:

Signed: ____________________________________ Inspection Agency:

Print full name:_______________________________ ID Number:

DO NOT REMOVE THIS NOTICE

Post with building permit inspection record card

Exhibit No. 9
(Recommended for Format Purposes only)

SAMPLE MATRIX
INSPECTOR QUALIFICATION MATRIX

Inspector Name	Date of Hire	ACI Grade-1	RC *	SM	PC	HSB	SW	NDT	SWC	FP	URM
Inspector A	5/4/99	X	X	X	I-T	I-T					
Inspector B	7/31/98	X	X	X				X	X	X	X
Inspector C	10/1/00	X	X		X	X	X	X			
Inspector D	10/1/00	X	X	X	I-T	I-T	X		X	X	X
Inspector E	10/1/00				I-T				X	X	X

Legend:

RC= Reinforced Concrete
SM= Structural Masonry

HSB = High-strength Bolting
SW = Steel Welding

FP= Fireproofing
PC=Prestressed Concrete

SWC = Structural Wood Construction
NDT = Nondestructive Testing

URM = Unreinforced Masonry Push/Torque Test Only

I-T= In training as lacking certification and/or experience
X= Meets experience and certain certification criteria
*= American Concrete Institute (ACI) Grade 1 - is required

Exhibit No. 10: SPECIAL INSPECTION AGENCY SUMMARY AND LETTER OF AGREEMENT

Company Name ____

Company Address ____

Telephone Number ____

Responsible Engineer ____

Name and Address of Testing Laboratory ______________________________
(if different from the info. above)

Special Inspection Categories: RC ( ) PC ( ) SM ( ) SSW ( ) URM ( ) FP ( )
I understand that any changes to this, or other required categorical information must be reported within 60 days, in writing, to the participating jurisdictions. I further understand that failure to report these changes may result in forfeiture of the participating jurisdiction's qualification of this agency. This agency agrees to abide by these conditions and will submit a report of any changes to the information submitted.

____
Responsible Engineer (print name)

____
Responsible Engineer (signature)

____ ________________________
Date Affix Stamp Here

Exhibit No. 11:
Waiver Agreement

Company Name: ____

Company Address: ____

Company Telephone Number: ____

As the responsible engineer for the company located at the address referenced above, I have requested a joint review by a number of local jurisdictions that may share information including, but not limited to agency performance, appeals, and any pending complaints or disciplinary hearing information. Our application may be shared and retained by all participating jurisdictions.

I further acknowledge the joint review process is not mandatory. Each participating jurisdiction will make all decisions individually and independently after sharing information and pertinent materials.

____
Responsible Engineer (print name)

____
Responsible Engineer (signature)

______________________________________ ______________________
Date Affix Stamp Here

Exhibit No.12:
RESPONSIBLE ENGINEER'S STATEMENT OF AGREEMENT

A. *I am the "full time employee" responsible for the supervision of technical staff and that all qualification requirements and the local building code requirements are followed by the agency and its employees.*

B. *I certify that Special Inspectors will perform in accordance with CBC Chapter 17. Each Special Inspector will be identified, and qualified issued ID cards according with certification requirements set forth in ASTM E 329 Appendix X1.1.*

C. *I assure that Testing and Inspection Services will be performed in compliance with procedures specified in ASTM E 329, in particular, paragraph 10.1: "It shall be the responsibility of the agency to ensure that its employees perform only tests and inspections, or both, for which it is adequately equipped and staffed, and that its employees perform only tests and inspections, or both, for which they are adequately trained."*

____
Responsible Engineer (print name)

____
Responsible Engineer (signature)

____
Date

____
Affix Stamp Here

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1

ADMINISTRATIVE BULLETIN

NO. AB-058

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : Building Seismic Instrumentation

TITLE: : Procedures for Seismic Instrumentation of New Buildings

PURPOSE : To describe requirements and procedures for installing, monitoring, and reporting data from required or voluntarily installed seismic instruments in buildings.

REFERENCE : 2013 ~~2010~~ SFBC Section 1604.12 Earthquake Recording Instrumentation
2013 California Building Code Appendix L
Federal Emergency Management Agency, July 2000, Recommended Post-earthquake Evaluation and Repair Criteria for Existing Welded Steel Moment-Frame Buildings, FEMA 352. Washington, D.C.

CSMIP (California Strong Motion Instrumentation Program) Document: CGS/DGS SYSREQ 2007-TR
State of California: System Requirements: Integrated Tri-Axial Accelerograph, Downloadable at:
http://www.conservation.ca.gov/cgs/smip/Documents/SystemRqmts-TriaxialAccelerograph.pdf

DISCUSSION : Information regarding building performance in earthquakes is important in improving construction practices to further reduce the risk of future earthquake damage by developing codes, standards, and mitigation measures. Such information helps to understand the movement of buildings following earthquakes and provides data to guide in the inspection, testing and repair of post-earthquake building damage. ***San Francisco has adopted*** ~~***amended***~~ California Building Code Appendix L ~~Chapter 16~~, ***requiring provision of instrumentation for the collection of*** building seismic data.

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1660 Mission Street – San Francisco CA 94103
Office (415) 558-6205 – FAX (415) 558-6401 – www.sfdbi.org

A. REQUIRED INSTRUMENTATION

Installation
As detailed in California Building Code Appendix L ~~***SFBC Section 1604.12***~~***, e***very ***new*** building ***in San Francisco*** over six stories in height with an aggregate floor area of 60,000 square feet (5574 m^2) or more, and every new building over 10 stories in height regardless of floor area, shall be provided with not less than three approved recording accelerographs (with triaxial seismic sensors). The accelerographs shall be interconnected for common start and common timing.

Location
The instruments shall be located in the basement, midportion, and near the top of the building. Each instrument shall be located so that access is maintained at all times and is unobstructed by room contents. A sign stating MAINTAIN CLEAR ACCESS TO THIS INSTRUMENT shall be posted in a conspicuous location.

Guidelines for installation of accelerographs:

1. *General. The preferred locations for the instruments are in small, seldom-used rooms or closets near a column (in a vertically aligned stack), with adequate space to mount the instrument and an approved protective enclosure securely to the floor. The proposed locations shall be marked on the floor plans and submitted to DBI for approval and transmittal to CSMIP. Each instrument requires AC power and a dial-up telephone line is required at the base-level instrument.*

2. *Installation Details. All instruments shall be installed with the same orientation relative to the building, with the orientation chosen such that the reference or long dimension of the instrument is aligned with a major axis of the building. The orientation shall be clearly marked on the floor plan and documented by as-installed photos that include a permanent orientation mark on the floor nearby. The instrument triggering threshold shall be set to 1% g, nominal. Auxiliary devices (e.g. telephone switch) shall be secured to the floor or the enclosure. The required sign shall include the phone numbers of the local building contact and DBI.*

3. *Long Term Monitoring and Data Recovery. The owner of the building shall be responsible for the correct installation and the required documentation of the accelerographs. Upon acceptance of the installation, CSMIP shall agree to perform long term monitoring of the instruments meeting the System Requirements to help assure their correct operation, performing periodic state-of-health checks and function tests remotely via the provided phone line. CSMIP will notify the building contact person and DBI when any repair actions are needed, and after a significant earthquake, recover the recorded data, process it and provide results to the building contact and to DBI, and with the approval of DBI, put it at the CSMIP web site with the location identified only generically.*

Maintenance
Programs for the maintenance and service of the instruments, and remote and onsite access to the data, shall be provided by the owner of the building, subject to approval by the Director of DBI. Once each year, the building owner shall submit a form to DBI certifying that the equipment is in operating order and describing any changes in the equipment or access procedures. (See attached Appendix B). For instruments monitored by *CSMIP, equipment operation will be remotely checked and the building owner will be notified of needed repairs. Needed repairs shall be made by the*

building owner.

Data
Data produced by the instruments shall be made available to DBI upon request. Data shall be retrievable remotely by internet connection or modem.
If the basement acceleration exceeds 5% g then the set of records must be transmitted to the owner and *DBI*.

B. VOLUNTARY INSTRUMENTATION

Voluntary instrumentation of new and existing buildings *not* required to be instrumented is encouraged. Compliance to the guidelines in this Administrative Bulletin is recommended for voluntary instrumentation.

If inspections are required, data from instrumentation systems meeting the minimum standards of California Building Code Appendix L ~~SFBC Section 1604.12~~ will be considered for reduction of connection inspection requirements following an earthquake. More comprehensive instrumentation is strongly recommended, particularly for tall or irregular buildings.

APPENDIX A

CABLING, COMMUNICATIONS AND EQUIPMENT SPECIFICATIONS

Cabling

. *a) Communication: A continuous 4-pair communications cable (plenum-rated Category 5 such as Belden 1624P or approved equal) is required between the instruments.*
b) Interconnection: A continuous 4-pair interconnection cable (plenum-rated RS485 cable similar to Belden 9844 or approved equal) is required between the instruments. (Conduit is only required where the cable is likely to be damaged.)
c) Alternate communication and interconnection methods using dedicated building cabling between the instruments may be approved after review.

Communications

A four-port AC-powered telephone switch (such as ComSwitch 7500 or approved equal) is to be installed at the base-level instrument (with the default port connected to that instrument), to allow communication with all three instruments via one phone line. The other telephone switch ports are to be connected to the other instruments via the communication cable.
Alternate methods of communication between the instruments may be approved after review.

Equipment Specifications

The minimum performance requirements for the accelerographs is as follows:

The instruments should be comprised of either a central-recording system with simultaneous sampling of the sensors or of three interconnected individual accelerographs located as required above. In either case, the system shall be digital recording, of a type *approved and in use by the CGS or USGS strong motion programs,* and meet the following criteria:

1. Sampling rate: 200sps.
   Full scale recording capability: >3 g.
2. Rms noise of system shall be less than *40* micro-g measured over a 0-80Hz band.
3. If separate accelerographs are used, they must have common triggering and common timing, with timing to better than 2 milli-seconds.
4. The accelerograph system *may* extract peak accelerations and velocities in real time, and transmit these together with event time and location, by email to the building owner or his agent.
5. Owners are encouraged to employ more than the minimum three instruments.
6. Instruments meeting the referenced System Requirements will be monitored to assure correct operation by CSMIP at the owner's request.

APPENDIX B

INSTRUMENTATION PROGRAM AND ANNUAL RENEWAL

TO BE SUBMITTED ON INSTALLATION DATE AND EACH YEAR BEFORE ANNIVERSARY OF ORIGINAL INSTALLATION

Building Address: ____________________________________San Francisco, California.

Staff Building Engineer or other local contact person:

Name: ___________________________________.

Address: _________________________________.

Work Phone: ______________________________.

Fax No.: _________________________________.

Pager: ___________________________________.

Cell Phone: _______________________________.

Home Phone: ______________________________.

Email: ___________________________________.

[ ] All seismic instrumentation equipment has been checked to be in operating order

[ ] The building owner has changed. The new owner is:

____

[ ] Equipment or access procedures have changed as follows:

____

*(signature)*_______________________________________ Date: _________________
(typed name)

The updated documentation for this building has been accepted by the Department of Building Inspection.

Accepted by:_____________________________________Date: ___________________

RETURN ONE COPY OF THIS FORM TO BUILDING OWNER AFTER REVIEW & ACCEPTANCE

AB-058

Tom C. Hui, S.E., C.B.O. **DATE**
Director
Department of Building Inspection

Approved by the Building Inspection
Commission on March 19, 2008

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1
ADMINISTRATIVE BULLETIN

NO. AB-078

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : Plan Review and Permit Process

TITLE : Criteria for Waiving Special Inspection Requirements for Signs, Awnings and Canopies

PURPOSE : The purpose of this Administrative Bulletin is to establish criteria for waiving the special inspection requirements for signs, awnings and canopies meeting the conditions of this Administrative Bulletin.

REFERENCES : **2013** ~~**2010**~~ San Francisco Building Code
Section 108A.1 Inspections, General
Chapter 17 Structural Tests and Special Inspections
Section 3107 Signs
Section 3105 Awnings and Canopies
DBI Administrative Bulletin AB-046, Special Inspection and Structural Observation Procedure

DISCUSSION : SFBC Section 1704.2 ~~1704.1~~ Exception 1 says that "Special inspections are not required for work of a minor nature or as warranted by conditions in the jurisdiction as approved by the building official".

This Administrative Bulletin is to establish criteria for waiving the special inspection requirements for signs, awnings and canopies which are less than the sizes, weights and projection as specified below.

Conditions of Waivers

A. Awnings and canopies:

For fabric awnings and canopies, engineering calculations and special inspection on welding are waived.
For fabric awnings and canopies, special inspection on anchor bolts is waived, provided that:
(1) All expansion bolts are installed with the required torque per manufacturer's ICC report, and
(2) There are at least 4 bolts per connection and bolts are at least 3/8" diameter and embedded at least 3 inches.

B. Signs:

For signs weighing less than 250 lbs., less than 24 sq. ft. in area and less than 4 feet projection, engineering calculations and all special inspection are waived, provided that all expansion bolts are installed with the required torque per manufacturer's ICC report.

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For signs less than 24 sq. ft. in area but exceeding the weight and projection limits above, special inspection on welding is waived. Special inspection on anchor bolts is also waived, provided that:

(1) Structural calculations are submitted showing that the stress level is not more than 25% of the design allowables, and
(2) All expansion bolts are installed with the required torque per manufacturer's ICC report, and
(3) There are at least 4 bolts per connection and bolts are at least 3/8" diameter and embedded at least 3 inches.

____

Tom C. Hui, S.E., C.B.O. **DATE**
Director
Department of Building Inspection

Approved by the Building Inspection Commission

____

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1

ADMINISTRATIVE BULLETIN

NO. AB-082

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : Permit Processing and Issuance

TITLE : **Requirements and Guidelines for Structural Design Review Procedures**

PURPOSE : The purpose of this Administrative Bulletin is to present requirements and guidelines for Structural Design Review. Structural Design Review may be required by the SFBC or by other Administrative Bulletins.

REFERENCES: **2013** ~~**2010**~~ San Francisco Building Code:

- Section 101A.2, Purpose
- Section 104A.2, Powers and Duties of Building Official
- Section 104A.2.8, Alternate for materials, design, tests and methods of construction
- Section 105A.6, Structural Advisory Committee
- Chapter 16, Structural Design ~~Requirements~~

ASCE 7-10 ~~7-05~~:

- Section 16.2.5 Design Review, Seismic Response History Procedures
- Section 17.7 Design Review, Seismically Isolated Structures
- Section 18.8 Design Review, Structures with Damping Systems

DISCUSSION:

1. STRUCTURAL DESIGN REVIEWER

The Director may request the assistance of a Structural Design Reviewer (SDR) to provide additional and specialized expertise to supplement the DBI plan-check.The SDR is distinct from a Structural Advisory Committee (SAC), which is a formal, public body that the Director may convene regarding matters pertaining to special features or special design procedures. The SDR meets with the Engineer of Record (EOR) and with Department staff as the need arises throughout the design process, providing the Director with a report of its findings after completion of his/her work.

Review by the SDR is not intended to replace quality assurance measures ordinarily exercised by the EOR in the structural design of a building. Responsibility for the structural design remains solely with the EOR, and the burden to demonstrate conformance of the structural design to the letter and intent of SFBC provisions resides solely with the EOR. The responsibility for conducting the structural review for the plan check resides with the Director and any plan check review consultants.

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The SFBC (through reference to ASCE 7) requires design review by independent registered design professionals in several cases. These include use of seismic response history procedures, use of seismic isolation and use of seismic dampers. The SDR will provide this review where required by the SFBC. The SDR will also provide review as required by DBI Administrative Bulletins and when otherwise deemed necessary by the Director. Structural Design Review, as discussed herein, and design review, as discussed in ASCE 7, are equivalent.

Qualifications and Selection of Structural Design Reviewer

The SDR shall be a recognized expert in relevant fields, such as structural engineering, earthquake engineering research, performance-based earthquake engineering, nonlinear response history analysis, building design, earthquake ground motion, geotechnical engineering, geological engineering, and other such areas of knowledge and experience relevant to the project.

The SDR shall be selected by the Project Sponsor from a project specific list provided by the Director. That firm or individual may then engage sub-consultants for assistance as appropriate. SDR shall bear no conflict of interest with respect to the project and shall not be part of the design team for the project. The responsibility of the SDR is to assist the Department in ensuring compliance of the structural design with the San Francisco Building Code. While the SDR will contract with the Project Sponsor, his/her responsibility is to DBI.

The SDR shall be registered as a Professional Engineer in California. The SDR shall sign all written communication with the Director.

2. PROJECTS REQUIRING STRUCTURAL DESIGN REVIEW

The Director may require Structural Design Review for any project at his discretion. The following types of projects will generally require Structural Design Review:

1. Projects incorporating non-prescriptive or performance-based design.
2. Projects incorporating building heights that exceed 240 feet.
3. Projects incorporating seismic response-history analyses per Chapter 16 of ASCE 7.*
4. Projects incorporating seismic isolation per Chapter 17 of ASCE 7.*
5. Projects incorporating seismic damping per Chapter 18 of ASCE 7.*
6. Projects with irregular and unusual configurations or systems.

Project sponsors are strongly encouraged to contact the Department early in the design to determine Structural Design Review requirements.

*Note: "To the extent design review is required under ASCE 7-10 ~~7-05~~, Sections 16.2.5, 17.7 or 18.8, such review process shall be conducted in accordance with the specific requirements of the Building Code and all applicable law."

3. SCOPE OF STRUCTURAL DESIGN REVIEW SERVICES

The scope of services for the SDR shall be indicated by the Director to provide required expertise to supplement the DBI plan-check. It may therefore be only for specific portions or structural elements of a project. This scope of services may include, but shall not be limited to, review of the following:

1. Earthquake hazard determination.
2. Site-specific ground motion characterization.
3. Seismic performance goals.
4. Basis of Design, design methodology and acceptance criteria.
5. Mathematical modeling and simulation.

6. Interpretation of analysis results.
7. Member selection and design.
8. Detail concepts and design.
9. Construction Documents, including drawings and specifications.
10. Isolator or damper testing requirements and quality control procedures.
11. At the discretion of the Director, the scope of services for the SDR may include the review of other building aspects, including design for wind resistance, design of special foundation or earth retaining systems, or the design of critical non-structural elements.

4. STRUCTURAL DESIGN REVIEW PROCESS

The SDR should be engaged as early in the structural design phase as practicable. This affords the SDR opportunity to evaluate fundamental design decisions, which could disrupt design development if addressed later in the design phase. Early in the design process, the EOR and the SDR should jointly establish the frequency and timing of SDR review milestones, and the degree to which the EOR anticipates the design will be developed for each milestone.

The SDR shall provide written comments to the EOR, and the EOR shall prepare written responses thereto. The SDR shall maintain a log that summarizes SDR comments, EOR responses to comments, and resolution of comments. The SDR shall make the log available to the EOR as requested. The SDR may also issue interim reports as appropriate relative to the scope and project requirements. At the conclusion of the review the SDR shall submit to the Director a written report that references the scope of the review, includes the comment log and supporting documents, and indicates the professional opinions of the SDR regarding the design's general conformance to the requirements and guidelines in this bulletin.

Commentary: None of the reports or documents from the SDR are Construction Documents. Under no circumstances should letters or other documents from the SDR be put into the EOR's drawings or reproduced in any other way that makes SDR documents appear to be part of the Construction Contract Documents. The EOR is solely responsible for the Construction Contract Documents. Documents from the SDR will be retained as part of the DBI's project files.

5. DISPUTE RESOLUTION

The EOR and the SDR shall work in a collegial manner, as independent and reasonable professionals. The SDR shall prepare comments in a respectful manner and shall make reasonable requests of the EOR for additional analyses or backup information. The EOR shall address the SDR comments cordially and respond directly and clearly.

The EOR and the SDR shall attempt to develop a consensus on each issue raised by the SDR. If the EOR and the SDR are unable to resolve particular comments, the SDR shall report the impasse to the Director.

The Director, as Building Official, makes the final decision concerning all permits; however, the Director, should the need arise, may address differences of opinion between the EOR and the SDR in whatever method he or she deems appropriate. The Director also may engage additional outside experts to assist in issue resolution.

6. ADMINISTRATION OF STRUCTURAL DESIGN REVIEW

The project sponsor is responsible for the payment of hourly fees and other expenses for the professional services of the members of SDR. The SDR shall include a written scope of work in his/her contract with the project sponsor. The scope of services in the contract (and any changes made thereto) shall be approved by the Director.

Tom C. Hui, S.E., C.B.O. Date
Director
Department of Building Inspection

Approved by the Building Inspection Commission on March 18, 2008.

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1

ADMINISTRATIVE BULLETIN

NO. AB- 083

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : **Seismic Design Procedures for New Tall Buildings**

TITLE : **Requirements and Guidelines for the Seismic Design of New Tall Buildings using Non-Prescriptive Seismic-Design Procedures**

PURPOSE : The purpose of this administrative bulletin is to present requirements and guidelines for the seismic structural design and building permit submittals for new tall buildings in San Francisco that use non-prescriptive seismic design procedures.

REFERENCES : **2013** ~~**2010**~~ San Francisco Building Code (SFBC) Section 104A.2.8 Alternate materials, design and methods of construction

SEAONC, 2007, *Recommended Administrative Bulletin on the Seismic Design & Review of Tall Buildings Using Non-Prescriptive Procedures*, Prepared by Structural Engineers Association of Northern California (SEAONC) AB-083 Tall Buildings Task Group, San Francisco, California.

ASCE, 2011 ~~2005~~, *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI 7-10 ~~7-05, including Supplement No. 2~~), Prepared by the Structural Engineering Institute of the American Society of Civil Engineers, Reston, Virginia.

2003 NEHRP Recommended Provisions For New Buildings And Other Structures Part 1: Provisions and Part 2: Commentary (FEMA 450)

SEAONC, 1999, *Contractual Provisions to Address the Engineer's Liability when Using Performance-Based Seismic Design*, Structural Engineers Association of Northern California, San Francisco, California, 7 pages, June

SEAOC, 2001, "Seismology Committee Background and Position Regarding 1997 UBC Eq. 30-7 and Drift," Structural Engineers Association of California, Sacramento California, September (http://www.seaoc.org/seismpdfs/UBC/30_7.pdf)

DISCUSSION :

1. SCOPE

This bulletin presents requirements and guidelines for seismic structural design and building permit submittals, for new tall buildings in San Francisco that use non-prescriptive seismic design procedures.

Commentary: It is intended that buildings designed to the requirements and guidelines of this bulletin will have seismic performance, at least equivalent to that intended of code-prescriptive seismic designs, consistent with the San Francisco Building Code sections indicated below. To demonstrate that a building design is capable of providing code equivalent seismic performance, a three-step procedure shall be performed as specified in Section 4 of this administrative bulletin. Intended code seismic performance can be found in the commentary of FEMA 450.

This bulletin intentionally contains both requirements, which are stated in mandatory language (e.g., "shall") and guidelines, which use non-mandatory language.

This bulletin is not written to cover essential facilities.

For the purposes of this bulletin, a non-prescriptive seismic design is one that takes exception to one or more of the prescriptive requirements of the San Francisco Building Code (SFBC) and Chapter 12 of ASCE/SEI 7-10 ~~7-05~~ and the standards referenced therein, by invoking Section SFBC Section 104A.2.8, which permits alternative materials and methods of construction, where they are approved and authorized by the Building Official.

For the purposes of this bulletin, tall buildings are defined as those with h_n greater than 160 feet above average adjacent ground surface.

The height, h_n is defined in the SFBC as the height of Level *n* above the average level of the ground surface adjacent to the structure. Level *n* is permitted to be taken as the roof of the structure, excluding mechanical penthouses and other projections above the roof whose mass is small compared with the mass of the roof.

Procedures other than those presented herein may be acceptable pursuant to the approval of the Director of the Department of Building Inspection (DBI).

Commentary: ASCE/SEI 7-10 ~~7-05~~ Sections that discuss non-prescriptive or "alternative" seismic design procedures are reproduced below:

11.1.4 Alternate Materials and Methods of Construction. Alternate materials and methods of construction to those prescribed in the seismic requirements of this standard shall not be used unless approved by the authority having jurisdiction. Substantiating Evidence shall be submitted demonstrating that the proposed alternate, for the purpose intended, will be at least equal in strength, durability, and seismic resistance.

12.1.1 Basic Requirements. …An approved alternative procedure shall not be used to establish the seismic forces and their distribution unless the corresponding internal forces and deformations in the members are determined using a model consistent with the procedure adopted.

SFBC Sections that discuss non-prescriptive or "alternative" seismic design procedures are reproduced below:

104A.2.8 Alternate materials, design and methods of construction. The provisions of this code are not intended to prevent the use of any material, alternate design or method of construction not specifically prescribed by this code, provided any alternate has been approved and its use authorized by the building official.

The building official may approve any such alternate, provided the building official finds that the proposed design is satisfactory and complies with the provisions of this code and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in suitability, strength, effectiveness, fire resistance, durability, safety and sanitation.

The building official shall require that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding its use. The details of any action granting approval of an alternate shall be recorded and entered in the files of the code enforcement agency.

1604.4 Analysis ~~**1605.2 Rationality**~~**.** Any system or method of construction to be used shall be based on a rational analysis in accordance with well-established principles of mechanics. Such analysis shall result in a system that provides a complete load path capable of transferring all loads and forces from their point of origin to the load-resisting elements.

~~**1629.10.1 [Alternative Procedures] General.** Alternative lateral force [i.e., seismic design] procedures using rational analyses based on well-established principles of mechanics may be used in lieu of those prescribed in these provisions.~~

2. STRUCTURAL DESIGN REVIEW

Structural Design Review shall be in accordance with AB-082. At the conclusion of the review, the Structural Design Reviewer (SDR) shall provide a written statement that, in his/her professional opinion, the strength, durability, and seismic resistance of the building as designed are equivalent to those of a building designed according to the prescriptive provisions of the SFBC.

3. SUBMITTAL REQUIREMENTS

Project submittals shall be in accordance with the SFBC and DBI interpretations, bulletins, and policies. In addition, documents relevant to the Structural Design Review shall be submitted by the EOR to the Director and to the SDR.

As early as practicable, the EOR shall submit to the Director an initial Seismic Design Criteria along with a description and initial drawings of the structure. The Seismic Design Criteria shall be consistent with the requirements of this bulletin, and shall be updated to incorporate issues resolved during the Structural Design Review process.

The Seismic Design Criteria shall describe the proposed building and structural system, proposed analysis methodology, and acceptance criteria. The Seismic Design Criteria shall include any proposed exceptions to the prescriptive provisions of the SFBC, modeling parameters, material properties, drift limits, element force capacities and deformation capacities. The Seismic Design Criteria shall identify all exceptions to the SFBC prescriptive requirements the EOR proposes. The Seismic Design Criteria shall be subject to review by the SDR and approval by the Director. A summary of the EOR's final Seismic Design Criteria shall be included in the general notes of the structural drawings.

4. SEISMIC DESIGN REQUIREMENTS

The EOR shall evaluate the structure at the levels of earthquake ground motion as indicated in the subsections below.

If nonlinear response is anticipated under any of the Maximum Considered Earthquake (MCE) ground motions specified in Section 4.3, the EOR shall apply capacity design principles and design the structure to have a suitable ductile yielding mechanism, or mechanisms, under nonlinear lateral deformation. The code-level analysis shall be used to determine the required strength of the yielding actions. The EOR shall include in the Seismic Design Criteria all assumptions and factors used in the application of capacity design principles.

Commentary: The purpose of each level of seismic evaluation is as follows:

The code-level evaluation of Section 4.1 is used to identify the exceptions being taken to the prescriptive requirements of the SFBC and to define the minimum required strength and stiffness for earthquake resistance. Minimum strength is defined according to SFBC minimum base shear equations, with a response modification coefficient *R*, proposed by the EOR, reviewed by the SDR, and approved by the Director Minimum stiffness is defined by requiring the design to meet SFBC-specified drift limits, using traditional assumptions for effective stiffness. Providing a non-prescriptive seismic design with minimum strength and stiffness comparable to code-prescriptive designs helps produce seismic performance at least equivalent to the code. Minimizing the number of exceptions to prescriptive requirements also helps achieve this aim.

As indicated in Section 4.2, a service-level evaluation is required by this bulletin to demonstrate acceptable seismic performance for moderate earthquakes.

The MCE-level evaluation of Section 4.3 is intended to verify that the structure has an acceptably low probability of collapse under severe earthquake ground motions. The evaluation uses nonlinear response-history analysis to demonstrate an acceptable mechanism of nonlinear lateral deformation and to determine the maximum forces to be considered for structural elements and actions designed to remain elastic.

4.1 Code-Level Evaluation

The seismic structural design shall be performed in accordance with the prescriptive provisions of the SFBC, except for those provisions specifically identified by the EOR in the Seismic Design Criteria as Code Exceptions.

Commentary: Code exceptions that have typically been taken for non-prescriptive designs of tall buildings in high seismic design categories include exceeding the height limitations of ASCE/SEI 7-10 ~~7-05~~ Table 12.2.1. Other exceptions, including provisions related to *R*, □, □$_0$, limitations on *T*, and various detailing requirements, may be considered at the discretion of the Director. The EOR is required to justify all exceptions to prescriptive code provisions. The scope of structural design review shall include all proposed code exceptions.

The lower limit of ASCE/SEI 7-10 ~~7-05~~ Eq. 12.8-5 and 12.8-6 for the calculation of the Seismic Response Coefficient applies to the scaling process of ASCE/SEI 7-10 7-05 Section 12.9. The value of *R* used shall be indicated in the Seismic Design Criteria, and shall not be greater than 8.5.

The EOR shall demonstrate that the structure meets the story drift ratio limitations of the SFBC using a code-level response-spectrum analysis and the following requirements:

a) The design lateral forces used to determine the calculated drift need not include the minimum base shear limitation of ASCE/SEI 7-10 ~~7-05~~ eq. 12.8-5 and 12.8-6.

b) Stiffness properties of non-prestressed concrete elements shall not exceed 0.5 times gross-section properties.

c) Foundation flexibility shall be considered, using recommendations provided by the Geotechnical Engineer of Record that are defined in the Seismic Design Criteria.

d) The analysis shall account for P-delta effects.

Commentary: ASCE/SEI 7-10 ~~7-05~~ requires the consideration of the minimum base shear of Eq. 12.8-5 and 12.8-6 for checking design story drifts relative to allowable story drifts. However, the consensus of SEAONC's AB-083 Task Group for this administrative bulletin, approved by the SEAONC Board, is that UBC Formula 30-7 (equivalent to ASCE/SEI 7-10 ~~7-05~~ Eq. 12.8-6) need not be applied to the check of drift limits for tall buildings designed according to this bulletin, because the MCE-level Evaluation of Section 4.3 includes a check of drift for site-specific ground motions. Such ground motions are required to take account of near-fault and directivity effects. The consensus of the task group is that this is an appropriate and more explicit way of addressing the intended purpose of applying Formula 30-7 to the check of drift limits.

Actual concrete stiffness properties may vary significantly from the value of 0.5 times gross-section properties referenced for the code-level check of story drift limits. This assumption is specified to provide a consistent requirement for minimum building stiffness. This requirement is intended to lead to earthquake serviceability performance related to story drift that is at least comparable to that expected of prescriptively-designed tall buildings designed to the SFBC.

For the deformation compatibility evaluation of critical non-structural elements, such as exterior curtain wall and cladding systems and egress stairways, the drift ratio demand shall be calculated using the minimum base shear limitations of ASCE/SEI 7-10 ~~7-05~~ Eq. 12.8-5 and 12.8-6. In lieu of this requirement, these critical non-structural elements may be designed for drift ratios at the MCE-level.

4.2 Service-Level Evaluation

A service-level evaluation of the primary structural system is required to demonstrate acceptable, essentially elastic seismic performance at the service-level ground motion.

Commentary: To ensure code-equivalent seismic performance, the Director is requiring a service-level evaluation for new tall buildings utilizing non-prescriptive design procedures.

There are circumstances where there is a reason to believe that the serviceability performance of the design would be worse than that anticipated for a code-prescriptive design. Some of these circumstances have been identified as follows:

a) Where the EOR has taken any exception to code-prescriptive requirements for non-structural elements (ASCE/SEI 7-10 ~~7-05~~, Chapter 13)

b) Where the stiffness representation of any structural element in the code-level evaluation is significantly less than the effective linear-elastic stiffness described in applicable research

c) For a structure that exhibits disproportionably large drift or accelerations for ground motions less than the SFBC Design Basis Ground Motion (not reduced by *R*).

While this bulletin does not require checking all non-structural elements at the service-level evaluation, it is expected that the building cladding will remain undamaged and that egress from the building will not be impeded when the building is subjected to the service-level ground motion.

For the purposes of this bulletin, the service-level ground motion shall be that having a 43-year mean return period (50% probability of exceedance in 30 years).

Structural models used in the service-level evaluation shall incorporate realistic estimates of stiffness and damping considering the anticipated levels of excitation and damage. The evaluation shall demonstrate that the elements being evaluated exhibit serviceable behavior.

Commentary: While essentially elastic performance is required in the service-level ground motion, it is not the intent of this bulletin to require that a structure remain fully linear and elastic. It is permissible for the analysis to indicate minor yielding of ductile elements of the primary structural system, provided such results do not suggest appreciable permanent deformation in the elements, strength degradation, or significant damage to the elements requiring more than minor repair. It is permissible for the analysis to indicate minor and repairable cracking of concrete elements.

Where numerical analysis is used to demonstrate serviceability, the analysis model should represent element behavior that is reasonably consistent with the expected performance of the elements. In typical cases it may be suitable to use a linear response spectrum analysis, with appropriate stiffness and damping, and with the earthquake demands represented by a linear response spectrum corresponding to the service-level ground motion. Where response history analysis is used, the selection and scaling of ground motion time series should comply with the requirements of ASCE/SEI 7-10 ~~7-05~~, Section 16.1.3, with the service-level response spectrum used instead of the design basis earthquake response spectrum, and with the design demand represented by the mean of calculated responses for not less than seven appropriately selected and scaled time series.

As expressed by SEAONC [1999], it should be understood “that the current state of knowledge and available technology is such that the design profession’s ability to accurately predict the earthquake performance of a specific building is limited and subject to a number of uncertainties.” Actual performance may differ from intended performance.

4.3 MCE-Level Evaluation

Ground Motion: The ground motion representation for this evaluation shall be the Maximum Considered Earthquake (MCE) as defined in ASCE/SEI 7-10 ~~7-05~~, Chapter 21.

A suite of not less than seven pairs of appropriate horizontal ground motion time series shall be used in the analyses. The selection and scaling of these ground motion time series shall comply with the requirements of ASCE/SEI 7-10 ~~7-05~~, Chapter 16, with the following modifications:

a) The MCE response spectrum shall be the basis for ground motion time series scaling instead of the design response spectrum.

b) Either amplitude-scaling procedures or spectrum-matching procedures may be used.

c) Where applicable, an appropriate number of the ground motion time series shall include near fault and directivity effects such as velocity pulses producing relatively large spectral ordinates at relatively long periods.

Commentary: The procedures for selecting and scaling ground motion records, as presented here, represent the current state of practice. The procedures are written to retain some flexibility so that engineering judgment can be used to identify the best approach considering the unique characteristics of the site and the building.

Selection and scaling of earthquake ground motion records for design purposes is a subject of much current research. The EOR may wish to consider alternative approaches recently proposed; however, some of the proposed approaches have not been adequately tested on tall buildings so their adoption should only be considered with caution. Aspects of particular concern include the long vibration period of many tall buildings and the contributions of multiple vibration “modes” to key response quantities.

At near-fault sites, the average fault-normal response spectrum usually is larger than the average fault-parallel response spectrum due to the presence of a rupture directivity pulse in the fault-normal component of the ground motion. It is important to include in the suite of ground motions an appropriate number of motions that include near-fault and directivity effects so that design drift demands are appropriately determined, especially considering that Section 4.1 permits the design to be exempt from applying Equations 12.8-5 and 12.8-6 to drift calculations. If spectral matching is used, individual ground motion components should account for the distinction between fault-normal and fault-parallel hazard.

Mathematical Model: The three-dimensional mathematical analysis model of the structure shall conform to ASCE/SEI 7-10 ~~7-05~~ Section 12.7.3.

The analyses shall consider the interaction of all structural and non-structural elements that materially affect the linear and nonlinear response of the structure to earthquake motions, including elements not designated as part of the lateral-force-resisting system in the code-level analysis (Section 4.1).

Commentary: This requires explicit modeling of those parts of the structural and non-structural systems that affect the dynamic response of the building. In addition, the effect of building response on all materially affected parts of the building must be evaluated.

The stiffness properties of reinforced concrete shall consider the effects of cracking and other phenomena on initial stiffness.

Commentary: In addition to cracking, effective stiffness can be affected by other phenomena. These include bond slip, yield penetration, tension-shift associated with shear cracking, panel zone deformations, and other effects.

The effective initial stiffness of steel elements embedded in concrete shall include the effect of the embedded zone. For steel moment frame systems, the contribution of panel zone (beam-column joint) deformations shall be included.

The EOR shall identify any structural elements for which demands for any of the response-history runs are within a range for which significant strength degradation could occur, and shall demonstrate that these effects are appropriately considered in the dynamic analysis.

Commentary: For typical situations, element strength degradation of more than 20% of peak strength should be considered significant.

P-□ effects that include all the building dead load shall be included explicitly in the nonlinear response history analyses.

Documentation submitted for SDR review shall clearly identify which elements are modeled linearly and which elements are modeled nonlinearly. For elements that are modeled as nonlinear elements, submitted documentation shall include suitable laboratory test results or analyses that justify the hysteretic properties represented in the model.

The properties of elements in the analysis model shall be determined considering earthquake plus expected gravity loads. In the absence of alternative information, gravity load shall be based on the load combination $1.0D + L_{exp}$, where D is the service dead load and L_{exp} is the expected service live load.

Commentary: In typical cases it will be sufficient to take $L_{exp} = 0.2L$, where L is the code-prescribed live load without live load reduction.

The foundation strength and stiffness contribution to the building seismic response shall be represented in the model. The foundation strength and stiffness characterization shall be consistent with the strength and stiffness properties of the soils at the site, considering both strain rate effects and soil deformation magnitude.

Analysis Procedure: Three-dimensional nonlinear response history (NLRH) analyses of the structure shall be performed. Inclusion of accidental torsion is not required. When the ground motion components represent site-specific fault-normal ground motions and fault-parallel ground motions, the components shall be applied to the three-dimensional mathematical analysis model according to the orientation of the fault with respect to the building. When the ground motion components represent random orientations, the components shall be applied to the model at orientation angles that are selected randomly; individual ground motion pairs need not be applied in multiple orientations.

Commentary: Three-dimensional analyses are required to represent the inherent torsional response of the building to earthquake ground shaking. This is done by including in the NLRH model the actual locations and distribution of the building mass, stiffness, and strength. Accidental torsion is not required to be included in the NLRH analyses. (Accidental torsion is required for the code-level analysis of Section 4.1.)

The EOR shall report how damping effects are included in the NLRH analyses. The equivalent viscous damping level shall not exceed 5%, unless adequately substantiated by the EOR.

Commentary: The effects of damping in an analysis depend on the type of damping model implemented. Some models may over-damp higher modes or have other undesirable effects.

For each horizontal ground motion pair, the structure shall be evaluated for the following load combination:

$$1.0D + L_{exp} + 1.0E$$

Alternative load combinations, if used, shall be adequately substantiated by the EOR.

Demands for ductile actions shall be taken not less than the mean value obtained from the NLRH. Demands for low-ductility actions (e.g., axial and shear response of columns and shear response of walls) shall consider the dispersion of the values obtained from the NLRH.

Commentary: In typical cases the demand for low-ductility actions can be defined as the mean plus one standard deviation of the values obtained from the NLRH. Procedures for selecting and scaling ground motions, and for defining the demands for low-ductility actions, should be defined and agreed to early in the review process.

Acceptance Criteria: Calculated force and deformation demands on all elements required to resist lateral and gravity loads shall be checked to ensure they do not exceed element force and deformation capacities. This requirement applies to those elements designated as part of the lateral-force-resisting system in the code-level analysis (Section 4.1), as well as those elements not designated as part of the lateral-force-resisting system in the code-level analysis but deemed to be materially affected.

Commentary: Elements not designated as part of the lateral-force-resisting system in the code-level analysis (gravity systems) may be subjected to substantial deformations and forces, including axial forces accumulated over many stories, as they interact with the primary lateral-force-resisting system. Non-structural elements such as cladding are evaluated according to code requirements. This bulletin does not require checking non-structural elements at the MCE level.

The EOR shall identify the structural elements or actions that are designed for nonlinear seismic response. All other elements and actions shall be demonstrated by analysis to remain essentially elastic.

Commentary: Essentially elastic response may be assumed for elements when force demands are less than design strengths. Design strengths for non-ductile behaviors (e.g., shear and compression) of these essentially elastic elements are defined as nominal strengths, based on specified material properties, multiplied by strength reduction factors as prescribed in the SFBC. Design strengths for ductile behaviors of these essentially elastic elements are defined as nominal strengths, based on expected material properties, multiplied by □ =1.0. Alternative approaches to demonstrating essentially elastic response may be acceptable where appropriately substantiated by the EOR.

For structural elements or actions that are designed for nonlinear seismic response, the EOR shall evaluate the adequacy of individual elements and their connections to withstand the deformation demands. Force and deformation capacities shall be based on applicable documents or representative test results, or shall be substantiated by analyses using expected material properties.

The average result, over the NLRH analyses, of peak story drift ratio shall not exceed 0.03 for any story.

All procedures and values shall be included in the Seismic Design Criteria and are subject to review by the SDR and approval by the Director.

Tom C. Hui, S.E., C.B.O. Date
Director
Department of Building Inspection

Approved by the Building Inspection Commission on March 18, 2008.

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1
ADMINISTRATIVE BULLETIN

NO. AB-084

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : **Plan Check; Inspection**

TITLE : **Guidelines for the Structural Review of Continuous Tiedown Systems Used to Resist Overturning of Light-Framed Wood Shear Walls**

PURPOSE : The purpose of this Administrative Bulletin is to establish guidelines for the structural design, analysis, and plan check review and approval of continuous tiedown systems used to resist overturning forces within light-framed wood shear walls caused by wind and seismic loads. This Administrative Bulletin is not applicable to light-framed wood shear walls framed with cold formed steel studs, nor to shear walls sheathed with material other than wood structural panels.

REFERENCES :

2013 ~~**2010**~~ San Francisco Building Code *(SFBC)*
2013 ~~2010~~ *California Building Code (CBC)*
Product Standard PS 1-95 (for Construction and Industrial Plywood) of the United States Department of Commerce, and National Institute of Science and Technology Calculation of Diaphragm Action, an Engineering Standard of the International Code Council
Federal Emergency Management Agency, *FEMA-450-1/2003 Ed., NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Part 1: Provisions*
Federal Emergency Management Agency, *FEMA-450-2/2003 Ed., NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Part 2: Commentary*
Nelson, R. F., Patel, S. T., *"Continuous Tie-Down Systems . . . for Wood Panel Shear Walls in Multi Story Structures",* Structure, March 2003, pages 18 - 20.
Ghosh, A., Pryor, S., Arevalo, R., *"Multi-Story Light-Frame Construction, Understanding Continuous Tiedown Systems",* Structure, June 2006, pages 14 – 19.

DISCUSSION : Light-framed wood shear walls, when incorporated into a structure's lateral force resisting system, will experience overturning forces arising from wind and seismic loads on the structure. These overturning forces are typically resisted by the use of tiedown devices that anchor the ends of the shear walls to the foundation. The tiedown system shall either be ICC listed or meet all the requirements of this administrative bulletin.

A "conventional" tiedown system typically utilizes cold-formed metal hardware bolted to the wood end posts of the shear wall and anchored to the foundation. Tensile overturning forces are carried by the wood end posts. A "continuous tiedown" system utilizes a continuous or coupled rod or cable assembly comprising bearing plates, shrinkage compensating devices, and couplers, wherein tensile overturning forces are carried by the rod(s) or cable(s), ~~and~~ not the wood end posts ~~are required to resist the tension in the rod at the tension end and to resist the compression forces at the compression ends~~. Continuous tiedown systems are not explicitly addressed by current prescriptive code requirements.

Requirements

Plan check review and approval of continuous tiedown systems for any project shall be on a case-by-case basis in accordance with this Administrative Bulletin. The following requirements shall be the basis for plan check review and approval of continuous tiedown systems used within light-framed wood shear wall systems.

1. Shear walls shall be designed to comply with the drift requirements of ASCE 7-10 ~~7-05~~ Section 12.8.6. Shear wall displacements shall be computed in accordance with CBC Section 2305.3. The component "d_a" of Equation 23-2 in CBC Section 2305.3 shall include, but not be limited to, elongation of the rod or cable, and deformations and displacements of shrinkage compensating devices, coupling hardware and steel bearing plates.

2. In a multi-story shear wall installation, the continuous tiedown system shall be restrained by bearing plates at each story of the multi-story shear wall. Skipping of stories, where bearing plates are omitted at intermediate stories, resulting in multiple stories being tied together, is prohibited. Shrinkage compensating devices shall be provided at each story of the shear wall.

3. The computed rod or cable elongation or stretch, together with computed deformations of shrinkage compensating device, coupling hardware and steel bearing plate, within any story under strength level (Load and Resistance Factor Design) short-term duration loading, such as wind or earthquake loads, shall not exceed 0.250 ~~0.185~~ inch, and ~~For~~ for working stress level (Allowable Stress Design) short-term loading, ~~elongation or stretch within any story~~ they shall not exceed 0.179 ~~0.132~~ inch. Elongation or stretch shall be computed as the product PL/EAe, where P is the axial load (pounds), L is the initial rod or cable length at the story under consideration (inches), E is the rod or cable modulus of elasticity (psi), and Ae is the effective tensile ~~nominal~~ cross sectional area of the rod or cable (in^2).

4. Calculations demonstrating compliance with the foregoing shall be provided for plan check review.

5. Construction documents, signed and sealed by the engineer of record for the design of the building, shall specify the particular proprietary system or systems.

6. Any modification to the tiedown system proposed after a building permit has been approved shall require filing of a new permit application documenting the proposed modification. Plan check review of the proposed modification shall be in accordance with the requirements of this Administrative Bulletin.

7. Mixing of conventional and continuous tiedown systems within shear walls along a common line ~~a common shear wall~~ is prohibited.

~~If the upper floor wall is not equal in length to the lower floor wall, with one end of each aligned, these walls are common, provided that the engineer uses a continuous tiedown system at the aligned end, the unaligned end of the upper floor wall and the unaligned end of the lower floor wall. The same applies if the wall at the upper floor is offset but along the same orthogonal line as the lower wall.~~

8. In addition to other inspections required by SFBC 1705 ~~1704~~, special inspection of continuous tiedown systems shall be provided. In addition to structural observations required by SFBC 1704.5 ~~1710~~, the engineer of record for the design of the building shall provide structural observation of continuous tiedown installations, including shear wall boundary nailing, shear wall end post sizes, bearing plates, couplers, shrinkage compensating devices, and anchor bolts, to verify conformance of the installed tiedown system to the structural design intent.

~~9. Any system proposed for a project shall have a current ICC Evaluation Services report. Alternatively, if the engineer chooses to design their own system, including all the components of their system, they shall provide calculations and specifications for all the components. Also, test data or an ICC Evaluation Services report shall be submitted to substantiate their design of the shrinkage compensating device.~~

Tom C. Hui, C.B.O. Date
Director
Department of Building Inspection

Approved by the Building Inspection Commission

May 18, 2011

City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Director

DRAFT #1
ADMINISTRATIVE BULLETIN

NO. AB-094

DATE : **October 8, 2013** ~~**October 12, 2010**~~

SUBJECT : Permit Review and Operation

TITLE : **Definition and Design Criteria for Voluntary Seismic Upgrade of Soft-Story, Type V (wood-frame) Buildings**

PURPOSE : The purpose of this Bulletin is to establish definitions and acceptable design criteria for voluntary seismic upgrade projects for soft-story Type V (wood-frame) buildings that may qualify for various incentives, such as expedited permit review and fee adjustments.

REFERENCE : **2013** ~~**2010**~~ San Francisco Building Code
Section 1613, Earthquake Loads
Section 3401.10 ~~3401.8~~, Lateral Force Design requirements for Existing Buildings
Section 1604.11, Minimum Lateral Forces for Existing Buildings
City and County of San Francisco Ordinance 54-10, Seismic Strengthening of Soft-Story, Wood-Frame Buildings
AB-004, Priority Permit Processing Guidelines
2012 ~~2009~~ International Existing Building Code, Appendix Chapter A4 ~~with SEAOC recommendations~~
2013 ~~2010~~ California Historical Building Code, Chapter 8-7 and 8-8
ASCE/SEI Standard 31-03~~, 2003~~, Seismic Evaluation of Existing Buildings
ASCE/SEI Standard 41-06~~, 2007~~, Seismic Rehabilitation of Existing Buildings~~, with Supplement 1~~
Ordinance 54-10, Seismic Strengthening of Soft-Story, Wood-Frame Buildings

DISCUSSION: A clear definition of "soft-story Type V (wood-frame) building" and the basic design criteria for seismic upgrades to such buildings is essential to the permit submittal and approval of projects that wish to take advantage of City-sponsored voluntary incentives to implement seismic upgrades of potentially seismically hazardous buildings.

Permits for voluntary structural work that do not reference meeting a specific code standard or that do not qualify for incentives for voluntary seismic upgrade work permit processing may meet any level of upgrade if such work does not increase the hazard of the building.

Technical Services Division
1660 Mission Street – San Francisco CA 94103
Office (415) 558-6205 – FAX (415) 558-6401 – www.sfdbi.org

IMPLEMENTATION

Building owners who wish to take advantage of voluntary seismic upgrade incentives must meet the definition of a soft-story Type V (wood-frame) building and must comply with the retrofit standards as detailed below.

DEFINITIONS

For the purpose of this Administrative Bulletin the following definitions shall apply:

Soft-story Type V (wood-frame) building means a building that meets the following criteria:

A. a Type V (wood-frame) building as defined in the San Francisco Building Code, and
B. was constructed prior to May 21, 1973, and
C. has a ground floor (1st story) level in which
    a. at least 50% of the floor area of the ground floor is used for Occupancy Classifications A (assembly), B (business), M (mercantile), S (storage, open or enclosed parking garages), or U (private garages), or
    b. the building has been determined to have either a Weak Story or Soft Story deficiency when evaluated using the ASCE 31 Tier 2 procedure, or
    c. the building has been determined to have a soft-story deficiency based on engineering analysis acceptable to the Building Official.

RETROFIT STANDARDS

The standards to be applied to the seismic upgrade of soft-story wood-framed buildings in order to qualify for voluntary upgrade incentives shall be one of the following:

A. Meets the requirements of Appendix Chapter A4 of the 2012 ~~2009~~ International Existing Building Code, IEBC [Attachment A] ~~with amendments by SEAOC (Structural Engineers Association of California) [Attachment B]~~, or

B. Meets the requirements of ASCE 41 for the Partial Rehabilitation Objective (Section 1.4.3) (Life Safety Performance Level: S-3) in the BSE-1 earthquake hazard level, or

C. Meets any other alternate rational design and/or construction methodology that demonstrates compliance with the intent of San Francisco Building Code Section 1604.11.

For qualified historic buildings, seismic upgrade designs may use the provisions and analysis techniques referenced in the California Historical Building Code, Chapter 8-7, Structural Regulations, and Chapter 8-8, Archaic Materials and Methods of Construction to assist in meeting the retrofit standards [Attachment C].

For the purposes of this bulletin, mitigation of soft-story conditions at the ground floor (1st story) shall be considered the part of the voluntary soft-story wood-frame upgrade work eligible for incentives. Additional seismic upgrade work may be undertaken on the floors above the ground floor; however such additional seismic retrofit work is not considered part of the voluntary soft-story upgrade work and will be subject to standard permitting requirements.

PERMIT PROCESSING

Submittal Documents and Building Permit Application

Building permit applications for voluntary, soft-story Type V (wood-frame) building upgrade work must clearly state the intention to qualify for voluntary incentives in the Project Description portion of the building permit application form. Submittal documents should include the following:

A. Dimensioned plans showing all exterior walls, interior partitions and any lateral load-resisting, or plans showing Occupancy Classifications and uses of the ground floor if that is the method of qualifying as a soft-story building under this Administrative Bulletin, and
B. A photograph of the building exterior, and
C. Structural upgrade plans and necessary supporting calculations and documents prepared by a licensed design professional showing how seismic upgrade will meet the standards adopted in this Administrative Bulletin. Included in these submittal documents should be a listing of archaic materials and values for those materials, if these are to be used as part of the lateral force resisting system.

Expedited Permit Processing

Building permit applications for voluntary soft-story wood-frame seismic retrofit will be expedited as authorized under AB-004 and will be tracked by the Department of Building Inspection for reporting purposes.

____
Tom C. Hui, S.E., C.B.O. Date
Director
Department of Building Inspection

Signed by:
Vivian L. Day, C.B.O. April 21, 2010
Director
Department of Building Inspection

Approved by the Building Inspection Commission on April 21, 2010

~~Attachment A Excerpts from 2009 International Code for Existing Buildings with SEAOC (Structural Engineers Association of California) amendments (public document compilation)~~

~~Attachment B Excerpts from California Historical Building Code, Chapter 8-7 and 8-8~~

~~Attachment C Excerpts from Ordinance 54-10, Seismic Strengthening of Soft-Story, Wood-Frame Buildings~~

ADMINISTRATIVE BULLETIN

Draft #1

NO. AB-098

DATE : November 6, 2013 ~~July 2, 2012~~

SUBJECT : Permit Review and Operations

TITLE : **Post-Earthquake Repair and Retrofit Requirements for Wood-Frame Residential Buildings with Three or More Dwelling Units**

PURPOSE : The purpose of this Bulletin is to establish policy for interpreting the San Francisco Building Code regarding post-earthquake damage retrofit triggers for wood-frame residential buildings with three or more dwelling units and to detail the scope and criteria for such triggered retrofits.

REFERENCE : 2013 ~~2010~~ San Francisco Building Code
- Section 3401.10, Lateral force design requirements for existing buildings
- Section 3402, Definition of Disproportionate Damage [*Pending code revision*]
- Section 3402, Definition of Substantial Structural Damage
- Section 3405, Repairs

2013 ~~2010~~ California Historical Building Code, CCR Title Part 8

2012 ~~2012~~ International Existing Building Code, Appendix Chapter A4, or 2009 International Existing Building Code, Appendix Chapter A4 with NCSEA/SEAOC amendments

ASCE/SEI Standard 31-~~03~~, 2003, Seismic Evaluation of Existing Buildings

ASCE/SEI Standard 41-~~06~~, 2007, Seismic Rehabilitation of Existing Buildings, with Supplement 1

California Health and Safety Code, Section 17920.3 .

CAPSS Report, Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Post-Earthquake Repair and Retrofit Requirements (ATC-52-4 Report), http://www.sfcapss.org/PDFs/PostQuakeRepair.pdf

DISCUSSION : San Francisco Building Code Section 3405.2 triggers seismic evaluation, and possibly retrofit of buildings, when earthquake-related damage reaches the level of "substantial structural damage to vertical elements of the lateral-force-resisting system." Substantial structural damage is defined in Section 3402 as, in essence, a loss of lateral capacity of 20 percent or more in any horizontal direction. The code does not give specific rules for identifying a 20-percent capacity loss nor guidance as to how to calculate capacity loss, so implementation of these code provisions relies on interpretation by the Department of Building Inspection. This Bulletin presents the Department's interpretation of 20-percent lateral capacity loss in terms based on visual indicators of such damage, and details the scope of required retrofit for buildings that exhibit earthquake-induced substantial structural damage.

In addition to substantial structural damage, San Francisco Building Code Section 3405.4 triggers structural evaluation and possibly retrofit when earthquake-related damage reaches the level of disproportionate damage, which is defined in Section 3402 as, in essence, a lateral capacity loss of 10 percent or more in an earthquake of limited intensity. This Bulletin presents the Department's interpretation of a 10-percent capacity loss based on visual indicators of such damage and provides evaluation and retrofit scope for buildings with such earthquake induced disproportionate damage. [*provisional, pending San Francisco Building Code adoption of provisions for disproportionate damage.*]

Residential buildings that incur substantial structural damage or disproportionate damage as detailed in this Bulletin are considered to be "substandard" per California Health and Safety Code Section 17920.3 (b) Structural hazards and (o) Inadequate structural resistance to horizontal forces.

APPLICABILITY

A building is eligible to apply the interpretations and provisions of this Bulletin if all of the following criteria are met:

A. The building has at least one story in which the seismic force-resisting system is a wood light-frame system in at least one direction, and

B. The building has only wood floor and wood roof diaphragms, and

C. The building has a continuous foundation, and

D. The building contains a residential occupancy group R-1, R-2, R-3.1, or R-4 as defined in San Francisco Building Code Section 310. At the discretion of the Department of Inspection, a building in occupancy group R-3 with one or two residential units may be deemed eligible if it is structurally and architecturally similar to the typical residential buildings with three or more units addressed in this Bulletin.

Buildings of other construction types and occupancies may also apply the provisions of this Bulletin on a case-by-case basis when approved by the Department of Building Inspection. Other methods of determining capacity loss based on analysis, testing, or other objective data may be allowed at the discretion of the Department.

Qualified historic buildings are permitted to be evaluated or retrofitted using the provisions in the California Historical Building Code, provided that such standards do not result in seismic performance less than the evaluation and retrofit engineering criteria detailed in this Bulletin.

EVALUATION PROCEDURES

For the purpose of determining if a building has incurred substantial structural or disproportionate damage, visual observation and classification of damage patterns may be used in lieu of a calculation of percentage loss of capacity. All determinations of substantial structural or disproportionate damage, including visual observation and classification of damage, shall be made by a licensed design professional and shall be submitted in accordance with San Francisco Building Code Section 3405.2.1. For damage not deemed to be either substantial structural damage or disproportionate damage, repairs shall restore the building to its permitted pre-earthquake condition by methods acceptable to the Department.

Buildings with Substantial Structural Damage
Substantial structural damage to vertical elements of the lateral force-resisting system shall be deemed to exist when a "triggering damage pattern" is observed in any system or components listed in Table 1. Table 1 also includes earthquake-induced substantial structural damage indicators for gravity load-carrying components. These are defined in San Francisco Building Code, Section 3402.1 as "any component, or any group of such components, that supports more than 30 percent of the total area of the structure's floor(s) and roof(s)," and the remaining capacity of any damaged components, "with respect to all dead and live loads, is less than 75 percent of that required by this code for new buildings of similar structure, purpose and location." Per San Francisco Building Code, Section 3405.3.1, the provisions of this Bulletin apply to substantial structural damage to gravity load-carrying components only when that damage has been caused by earthquake.

Buildings with Disproportionate Damage
Disproportionate damage to vertical elements of the lateral force-resisting system shall be deemed to exist when any of the earthquake "triggering damage patterns" is observed in any system or component listed in Table 1. Table 1 also includes disproportionate damage indicators for gravity load-carrying systems, which include any component, or any group of components, that supports more than 10 percent of the total area of a structure's floor(s) and roof(s), and in which the remaining capacity of any damaged components, with respect to all dead and live loads, is less than 75 percent of that required by this code for new buildings of similar structure, purpose and location. The provisions of this Bulletin apply to disproportionate damage to gravity load-carrying components only when such damage has been caused by earthquake, as SFBC Section 3405.4.1 notes that a building with disproportionate damage is subject to the provisions and requirements for substantial structural damage.

Table 1: Substantial Structural Damage and Disproportionate Damage Patterns for Wood Frame Residential Buildings with Three or More Dwelling Units

	Triggering Damage	
Damage Pattern	*Substantial Structural Damage*	*Disproportionate Damage*
Wood-frame shear panels (wall segments or piers) and sheathing. When any of the following damage patterns is observed: • Stucco or plaster loose at more than one wall stud, or • Nail pull-through at wood or gypsum board sheathing at more than one wall stud, or • Visible permanent in-plane racking, or • Diagonal shear cracking across half or more of a plaster or stucco panel, or • Horizontal flexural cracking across half or more of a plaster or stucco panel, or • Loss of nailing connection from sheathing to top plate or sole plate, or • Any other indicators of sheathing delamination or panel mechanism.	In any story, **in any direction**, where the sum of the length of all wall segments and piers with any of the listed damage patterns is 20 percent or more of the total length of wall segments and piers in that story and direction. Only wall segments or piers contributing significant strength or stiffness to each wall line of the pre-damaged structure shall be considered. Large openings do not count toward the summation or total length of wall segments and piers.	In any story, **along any wall line**, where the sum of the length of wall segments and piers with any of the listed damage patterns is 20 percent or more of the total length of wall segments and piers along that wall line in that story. Only wall segments or piers contributing significant strength or stiffness to each wall line of the pre-damaged structure shall be considered. Large openings do not count toward the summation or total length of wall segments and piers.
Connections and load path elements. When any of the following damage patterns is observed: • Hold-down pullout or stud fracture at hold-down, or • Sliding of sole plate at floor line, or • Sliding of sill plate at top of footing, or • Any other indicators of lateral load path failure.	Any	

Table 1: Substantial Structural Damage and Disproportionate Damage Patterns for Wood Frame Residential Buildings with Three or More Dwelling Units

Damage Pattern	*Triggering Damage*	
	Substantial Structural Damage	***Disproportionate Damage***
Connections and load path elements When any of the following damage patterns is observed: • Failure of diaphragm-to-wall connections at rim joist or blocking, or • Collector or chord failure.	At any floor level, where the damage affects the load path to more than one pier or wall segment, or affects the load path to the only pier or wall segment along a wall line.	
Gravity load-carrying members, connections, and load path elements. When any of the following damage patterns is observed: • Floor framing-to-column/wall shear connection damage, or • Loss or substantial reduction of seat bearing, or • Crushing, fracture, or shortening of posts, wall studs, or similar components, or • Column, post, or pier damage due to deformation incompatibility, or • Subsidence or differential settlement of foundation, or • Any other indicators of member failure, load path failure, or loss of bearing capacity.	In gravity load-carrying components defined in San Francisco Building Code Section 3402.1 as supporting, as a group, "more than 30 percent of the total area of the structure's floor(s) and roof(s)," and the remaining capacity of any damaged components, "with respect to all dead and live loads, is less than 75 percent of that required by this code for new buildings of similar structure, purpose and location."	In gravity load-carrying components supporting, as a group, more than 10 percent of the total area of the structure's floor(s) and roof(s), and the remaining capacity of any damaged components, with respect to all dead and live loads, is less than 75 percent of that required by this code for new buildings of similar structure, purpose and location.

Table 1: Substantial Structural Damage and Disproportionate Damage Patterns for Wood Frame Residential Buildings with Three or More Dwelling Units

Damage Pattern	Triggering Damage	
	Substantial Structural Damage	*Disproportionate Damage*
Permanent lateral deformation indicating increased P-delta instability.	When permanent story drift of 2 percent or more is observed in any story.	• When permanent story drift of 1 percent or more is observed in any story, or • A pattern of jammed doors or windows repairable only by structural repair and not by minor adjustments or rehanging doors or windows.
Damage indicating torsional instability.	• When there is significant stiffness loss on more than one perimeter wall line, or • Significant strength loss not balanced between wall lines on opposite sides of the building.	• When there is significant stiffness loss on more than one perimeter wall line, or • Significant strength loss not balanced between wall lines on opposite sides of the building, or • Any visually noticeable permanent torsional deformation.

Further Evaluation and Retrofit Scope for Buildings with Substantial Structural Damage
For buildings with substantial structural damage, further evaluation and retrofit shall proceed in accordance with San Francisco Building Code Section 3405.2 subject to the following guidelines:

A. Evaluation and retrofit shall consider the entire structure, including all stories and all directions, regardless of where in the structure the triggering damage occurred, except that for certain building types and damage patterns, partial retrofit may be permitted under one of the alternative criteria documents given in the "Evaluation and Retrofit Engineering Criteria" section of this Bulletin.

B. Gravity load-carrying components need not be considered for evaluation and retrofit except when they are also part of the building's seismic force-resisting system or are subject to San Francisco Building Code Section 3405.3.1.

C. Nonstructural components need not be considered for evaluation or retrofit unless subject to separate building code requirements, ordinances, or regulations.

D. Load combinations that include wind or earthquake effects shall be considered.

Further Evaluation and Retrofit Scope for Buildings with Disproportionate Damage
For buildings with disproportionate damage, further evaluation and retrofit shall proceed in accordance with San Francisco Building Code Section 3405.4.1 subject to the following guidelines:

A. Evaluation and retrofit shall consider the entire structure, including all stories and all directions, regardless of where in the structure the triggering damage occurred, except that for certain building types and damage patterns, partial retrofit may be permitted under one of the alternative criteria documents given in the "Evaluation and Retrofit Engineering Criteria" section of this Bulletin.

Exception: When the disproportionate damage is limited to connections or load path elements and does not affect wood-frame wall segments, piers, or other vertical elements of the lateral force-resisting system, the evaluation and retrofit scope may be limited to components throughout the building in directions similar to or performing the same function as the components with damage.

B. Gravity load-carrying components need not be considered for evaluation and retrofit except when they are also part of the building's seismic force-resisting system or are subjected to San Francisco Building Code Section 3405.3.1.

C. Nonstructural components need not be considered for evaluation and retrofit unless subject to separate building code requirements, ordinances, or regulations.

D. Load combinations that include earthquake effects shall be considered. Load combinations that include wind effects may be ignored.

EVALUATION AND RETROFIT ENGINEERING CRITERIA
If, after evaluation, the pre-earthquake building is determined to satisfy the criteria of San Francisco Building Code, Section 3405.2, then the building need not be retrofitted, but shall be restored to its pre-earthquake capacity. When retrofit is triggered by earthquake damage at any level, the engineering criteria for retrofit shall be permitted to use earthquake loads that are 75 percent of those prescribed by the San Francisco Building Code for new construction, in accordance with SFBC Section 3405.2.
Alternatively, any of the following codes, standards, or guidelines may be used as alternative evaluation or retrofit criteria for qualifying buildings:

A. Meets ASCE 31-03 for the Life Safety Performance Level, or

B. Meets ASCE 41-06 for the Life Safety Performance Level (S-3) in a BSE-1 earthquake hazard level, or

C. If the triggering damage involves only a soft, weak, or open front first story, meets 2012 IEBC Appendix Chapter A4 [See Attachment A.] or 2009 IEBC Appendix Chapter A4 with NCSEA/SEAOC amendments, or

D. Meets 2010 San Francisco Building Code Section 3401.10.

Signed:
Tom C. Hui, S.E. 7/2/2012
Acting Director
Department of Building Inspection

Approved by the Building Inspection Commission on 6/20/2012

Attachment A: Excerpt from 2012 International Code for Existing Buildings, Appendix Chapter A4

ATTACHMENT A

Chapter A4 - Earthquake Risk Reduction in Wood-Frame Residential Buildings with Soft, Weak or Open Front Walls

SECTION A401 GENERAL

A401.1 Purpose.

The purpose of this chapter is to promote public welfare and safety by reducing the risk of death or injury that may result from the effects of earthquakes on existing wood-frame, multi-unit residential buildings. The ground motions of past earthquakes have caused the loss of human life, personal injury and property damage in these types of buildings. This chapter creates minimum standards to strengthen the more vulnerable portions of these structures. When fully followed, these minimum standards will improve the performance of these buildings but will not necessarily prevent all earthquake-related damage.

A401.2 Scope.

The provisions of this chapter shall apply to all existing Occupancy Group R-1 and R-2 buildings of wood construction or portions thereof where the structure has a soft, weak, or open-front wall line, and there exists one or more stories above.

SECTION A402 DEFINITIONS

Notwithstanding the applicable definitions, symbols and notations in the building code, the following definitions shall apply for the purposes of this chapter:

GROUND FLOOR. Any floor whose elevation is immediately accessible from an adjacent grade by vehicles or pedestrians. The ground floor portion of the structure does not include any floor that is completely below adjacent grades.

NONCONFORMING STRUCTURAL MATERIALS. Wall bracing materials other than wood structural panels or diagonal sheathing.

OPEN-FRONT WALL LINE. An exterior wall line, without vertical elements of the lateral force-resisting system, that requires tributary seismic forces to be resisted by diaphragm rotation or excessive cantilever beyond parallel lines of shear walls. Diaphragms that cantilever more than 25 percent of the distance between lines of lateral force-resisting elements from which the diaphragm cantilevers shall be considered excessive. Exterior exit balconies of 6 feet (1829 mm) or less in width shall not be considered excessive cantilevers.

RETROFIT. An improvement of the lateral force-resisting system by alteration of existing structural elements or addition of new structural elements.

SOFT WALL LINE. A wall line whose lateral stiffness is less than that required by story drift limitations or deformation compatibility requirements of this chapter. In lieu of analysis, a soft wall line may be defined as a wall line in a story where the story stiffness is less than 70 percent of the story above for the direction under consideration.

STORY. A story as defined by the building code, including any basement or underfloor space of a building with cripple walls exceeding 4 feet (1219 mm) in height.

STORY STRENGTH. The total strength of all seismic-resisting elements sharing the same story shear in the direction under consideration.

WALL LINE. Any length of wall along a principal axis of the building used to provide resistance to lateral loads. Parallel wall lines separated by less than 4 feet (1219 mm) shall be considered one wall line for the distribution of loads.

WEAK WALL LINE. A wall line in a story where the story strength is less than 80 percent of the story above in the direction under consideration.

SECTION A403 ANALYSIS AND DESIGN

A403.1 General.

All modifications required by the provisions in this chapter shall be designed in accordance with the International Building Code provisions for new construction, except as modified by this chapter.

> **Exception:** Buildings for which the prescriptive measures provided in Section A404 apply and are used.

No alteration of the existing lateral force-resisting system or vertical load-carrying system shall reduce the strength or stiffness of the existing structure, unless the altered structure would remain in conformance to the building code and this chapter.

A403.2 Scope of analysis.

This chapter requires the *alteration*, *repair*, replacement or *addition* of structural elements and their connections to meet the strength and stiffness requirements herein. The lateral-load-path analysis shall include the resisting elements and connections from the wood diaphragm immediately above any soft, weak or open-front wall lines to the foundation soil interface or to the uppermost story of a podium structure comprised of steel, masonry, or concrete structural systems that supports the upper, wood-framed structure. Stories above the uppermost story with a soft, weak, or open-front wall line shall be considered in the analysis but need not be modified. The lateral-load-path analysis for added structural elements shall also include evaluation of the allowable soil-bearing and lateral pressures in accordance with the building code. Where any portion of a building within the scope of this chapter is constructed on or into a slope steeper than one unit vertical in three units horizontal (33-percent slope), the lateral force-resisting system at and below the base level diaphragm shall be analyzed for the effects of concentrated lateral forces at the base caused by this hillside condition.

> **Exception**: When an open-front, weak or soft wall line exists because of parking at the ground floor of a two-story building and the parking area is less than 20 percent of the ground floor area, then only the wall lines in the open, weak or soft directions of the enclosed parking area need comply with the provisions of this chapter.

A403.3 Design base shear and design parameters.

The design base shear in a given direction shall be permitted to be 75 percent of the value required for similar new construction in accordance with the building code. The value of R used in the design of the strengthening of any story shall not exceed the lowest value of R used in the same direction at any story above. The system overstrength factor, Δ_0, and the deflection amplification factor, C_d, shall not be less than the largest respective value corresponding to the R factor being used in the direction under consideration.

Exceptions:

1. For structures assigned to Seismic Design Category B, values of R, Δ_0 and C_d shall be permitted to be based on the seismic force-resisting system being used to achieve the required strengthening.

2. For structures assigned to Seismic Design Category C or D, values of R, Δ_0 and C_d shall be permitted to be based on the seismic force-resisting system being used to achieve the required strengthening, provided that when the strengthening is complete, the strengthened structure will not have an extreme weak story irregularity defined as Type 5b in ASCE 7 Table 12.3-2.

3. For structures assigned to Seismic Design Category E, values of R, Δ_0 and C_d shall be permitted to be based on the seismic force-resisting system being used to achieve the required strengthening, provided that when the strengthening is complete, the strengthened structure will not have an extreme soft story, a weak story, or an extreme weak story irregularity defined, respectively, as Types 1b, 5a and 5b in ASCE 7 Table 12.3-2.

A403.4 Story drift limitations.

The calculated story drift for each retrofitted story shall not exceed the allowable deformation compatible with all vertical load-resisting elements and 0.025 times the story height. The calculated story drift shall not be reduced by the effects of horizontal diaphragm stiffness but shall be increased when these effects produce rotation. Drift calculations shall be in accordance with the building code.

A403.5 PΔ effects.

The requirements of the building code shall apply, except as modified herein. All structural framing elements and their connections not required by design to be part of the lateral force-resisting system shall be designed and/or detailed to be adequate to maintain support of design dead plus live loads when subjected to the expected deformations caused by seismic forces. The stress analysis of cantilever columns shall use a buckling factor of 2.1 for the direction normal to the axis of the beam.

A403.6 Ties and continuity.

All parts of the structure included in the scope of Section A403.2 shall be interconnected as required by the building code.

A403.7 Collector elements.

Collector elements shall be provided that can transfer the seismic forces originating in other portions of the building to the elements within the scope of Section A403.2 that provide resistance to those forces.

A403.8 Horizontal diaphragms.

The strength of an existing horizontal diaphragm sheathed with wood structural panels or diagonal sheathing need not be investigated unless the diaphragm is required to transfer lateral forces from vertical elements of the seismic force-resisting system above the diaphragm to elements below the diaphragm because of an offset in placement of the elements.

Wood diaphragms with stories above shall not be allowed to transmit lateral forces by rotation or cantilever except as allowed by the building code; however, rotational effects shall be accounted for when unsymmetric wall stiffness increases shear demands.

Exception: Diaphragms that cantilever 25 percent or less of the distance between lines of lateral load-resisting elements from which the diaphragm cantilevers may transmit their shears by cantilever, provided that rotational effects on shear walls parallel and perpendicular to the load are taken into account.

A403.9 Wood-framed shear walls.

Wood-framed shear walls shall have strength and stiffness sufficient to resist the seismic loads and shall conform to the requirements of this section.

SECTION A404 PRESCRIPTIVE MEASURES FOR WEAK STORY

A404.1 Limitation.

These prescriptive measures shall apply only to two-story buildings and only when deemed appropriate by the *code official.* These prescriptive measures rely on rotation of the second floor diaphragm to distribute the seismic load between the side and rear walls of the ground floor open area. In the absence of an existing floor diaphragm of wood structural panel or diagonal sheathing, a new wood structural panel diaphragm of minimum thickness of 3/4 inch (19 mm) and with 10d common nails at 6 inches (152 mm) on center shall be applied.

A404.2 Minimum required retrofit.

A404.2.1 Anchor size and spacing.

The anchor size and spacing shall be a minimum of 3/4 inch (19 mm) in diameter at 32 inches (813 mm) on center. Where existing anchors are inadequate, supplemental or alternative approved connectors (such as new steel plates bolted to the side of the foundation and nailed to the sill) shall be used.

SECTION A405 MATERIALS OF CONSTRUCTION

A405.1 New materials.

New materials shall meet the requirements of the International Building Code, except where allowed by this chapter.

A405.2 Allowable foundation and lateral pressures.

The use of default values from the building code for continuous and isolated concrete spread footings shall be permitted. For soil that supports embedded vertical elements, Section A403.6 shall apply.

A405.3 Existing materials.

The physical condition, strengths, and stiffnesses of existing building materials shall be taken into account in any analysis required by this chapter. The verification of existing materials conditions and their conformance to these requirements shall be made by physical observation, material testing or record drawings as determined by the registered design professional subject to the approval of the *code official.*

SECTION A406 INFORMATION REQUIRED TO BE ON THE PLANS

A406.1 General.

The plans shall show all information necessary for plan review and for construction and shall accurately reflect the results of the engineering investigation and design. The plans shall contain a note that states that this retrofit was designed in compliance with the criteria of this chapter.

A406.2 Existing construction.

The plans shall show existing diaphragm and shear wall sheathing and framing materials; fastener type and spacing; diaphragm and shear wall connections; continuity ties; and collector elements. The plans shall also show the portion of the existing materials that needs verification during construction.

A406.3 New construction.

A406.3.1 Foundation plan elements.

The foundation plan shall include the size, type, location and spacing of all anchor bolts with the required depth of embedment, edge and end distance; the location and size of all shear walls and all columns for braced frames or moment frames; referenced details for the connection of shear walls, braced frames or moment-resisting frames to their footing; and referenced sections for any grade beams and footings.

SECTION A407 QUALITY CONTROL

A407.1 Structural observation, testing and inspection.

Structural observation, in accordance with Section 1709 of the *International Building Code*, shall be required for all structures in which seismic retrofit is being performed in accordance with this chapter. Structural observation shall include visual observation of work for conformance to the approved construction documents and confirmation of existing conditions assumed during design.

Structural testing and inspection for new construction materials shall be in accordance with the building code, except as modified by this chapter.

ADMINISTRATIVE BULLETIN

Draft #1

NO. AB-099

DATE : ~~July 2, 2012~~ November 6, 2013

SUBJECT : Permit Review and Operations

TITLE : **Post-Earthquake Repair and Retrofit Requirements for Concrete Buildings**

PURPOSE : The purpose of this Bulletin is to establish policy for interpreting the San Francisco Building Code regarding post-earthquake damage retrofit triggers for concrete buildings constructed before May 21, 1973 and to detail the scope and criteria for such triggered retrofits and other repairs.

REFERENCE : ~~2010~~ 2013 San Francisco Building Code
- Section 3401.10, Lateral force design requirements for existing buildings
- Section 3402, Definition of Disproportionate Damage [*pending code revision*]
- Section 3402, Definition of Substantial Structural Damage
- Section 3405, Repairs

~~2010~~ 2013 California Historical Building C ode, CCR Title Part 8

ASCE/SEI Standard 31-~~03~~, ~~2003~~, Seismic Evaluation of Existing Buildings

ASCE/SEI Standard 41-~~06~~, ~~2007~~, Seismic Rehabilitation of Existing Buildings, with Supplement 1

California Health and Safety Code, Section 17920.3

CAPSS Report, *Here Today – Here Tomorrow: The Road to Earthquake Resilience in San Francisco*, Post-Earthquake Repair and Retrofit Requirements (ATC-52-4 Report), http://www.sfcapss.org/PDFs/PostQuakeRepair.pdf

1997 NHERP Guidelines for the Seismic Rehabilitation of Buildings (FEMA 273)

FEMA 306: Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings: Basic Procedures Manual (FEMA, 1999)

FEMA 308: The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings (FEMA, 1999)

FEMA 356: Prestandard and Commentary for the Seismic Rehabilitation of Buildings (FEMA, 2000)

DISCUSSION : San Francisco Building Code, Section 3405.2 triggers seismic evaluation, and possibly retrofit, of buildings when earthquake-related damage reaches the level of "substantial structural damage to vertical elements of the lateral-force-resisting system." Substantial structural damage is defined in Section 3402 as, in essence, a loss of lateral capacity of 20 percent or more in any horizontal direction. The code gives no specific rules for identifying a 20-percent loss or guidance as to how to calculate capacity loss, so implementation of these code provisions relies on interpretation by the Department of Building Inspection. This Bulletin presents the Department's interpretation of a 20-percent lateral capacity loss for concrete buildings constructed before May 21, 1973.

In addition to substantial structural damage, San Francisco Building Code, Section 3405.4 triggers seismic evaluation, and possibly retrofit, when earthquake-related damage reaches the level of disproportionate damage, defined in Section 3402 [*provisional, pending San Francisco Building Code adoption of provisions for Disproportionate Damage*] as, in essence, a lateral capacity loss of 10 percent or more in an earthquake of limited intensity. This Bulletin presents the Department's interpretation of a 10-percent capacity loss for concrete buildings constructed before May 21, 1973.

For concrete shear wall and infill buildings, the evaluation procedures developed in FEMA 306 and the simplified version of the methodology in FEMA 308 are used determine whether a building with substantial structural damage or disproportionate damage needs to be restored to its pre-earthquake capacity or retrofitted. Substantial structural damage or disproportionate damage may also be deemed to exist when damage to specific building components or conditions reaches the severity of "earthquake triggering damage" based on visual observation and classification .

For concrete moment-frame buildings, repair and retrofit requirements are based only on visual observation and classification of specific components damage.

Residential buildings that incur substantial structural damage or disproportionate damage as detailed in this Bulletin are considered to be "substandard" per California Health and Safety Code Section 17920.3(b) Structural hazards and (o) Inadequate structural resistance to horizontal forces.

APPLICABILITY:

A building is eligible to apply the interpretations and provisions of this Bulletin if all of the following criteria are met:

A. The building has cast-in-place concrete bearing walls or cast-in-place concrete frames, and

B. The building has at least one floor diaphragm constructed with cast-in-place concrete.

Buildings of other construction types may also apply the provisions of this Bulletin on a case-by-case basis when approved by the Department of Building Inspection. Other methods of determining capacity loss based on analysis, testing, or other objective data may also be allowed at the discretion of the Department.

Qualified buildings may be permitted to be evaluated or retrofitted using the provisions in the California Historical Building Code, provided that such standards do not result in seismic performance less than the evaluation and retrofit engineering criteria detailed in this Bulletin.

DEFINITIONS:

For the purpose of this bulletin, the following definitions shall apply:

- **CONCRETE SHEAR WALL:** A concrete wall which resists lateral forces applied parallel to the plane of the wall.
- **CONCRETE MOMENT FRAME:** A building frame system in which seismic shear forces are resisted by shear and flexure in members and joints of the frame, including slab-column moment frames.
- **CONCRETE INFILL FRAME:** A concrete moment frame having panel(s) of masonry that participate in resisting lateral forces that are placed within the frame members.

- **NONSTRUCTURAL REPAIR**: Repairs that improve the visual appearance of damage to a component. These repairs may also restore the nonstructural properties of a component, such as weather protection. Any structural benefit is negligible. This is defined as "Cosmetic Repair" in FEMA 308.

EVALUATION PROCEDURE AND RETROFIT SCOPE

Concrete Shear Wall and Infill Frame Buildings

General

Substantial structural damage to elements of the lateral force-resisting system shall be deemed to exist when the results of a FEMA 306 evaluation shows that capacity loss exceeds 20% for a concrete shear wall or infill frame building, or when any of the "triggering damage" criteria for substantial structural damage described in Table 1 is observed in an eligible building.

Additionally, disproportionate damage shall be deemed to exist when a FEMA 306 evaluation shows a capacity loss exceeding 10%, or when any of the "triggering damage" for disproportionate damage described in Table 1 is observed in an eligible building.

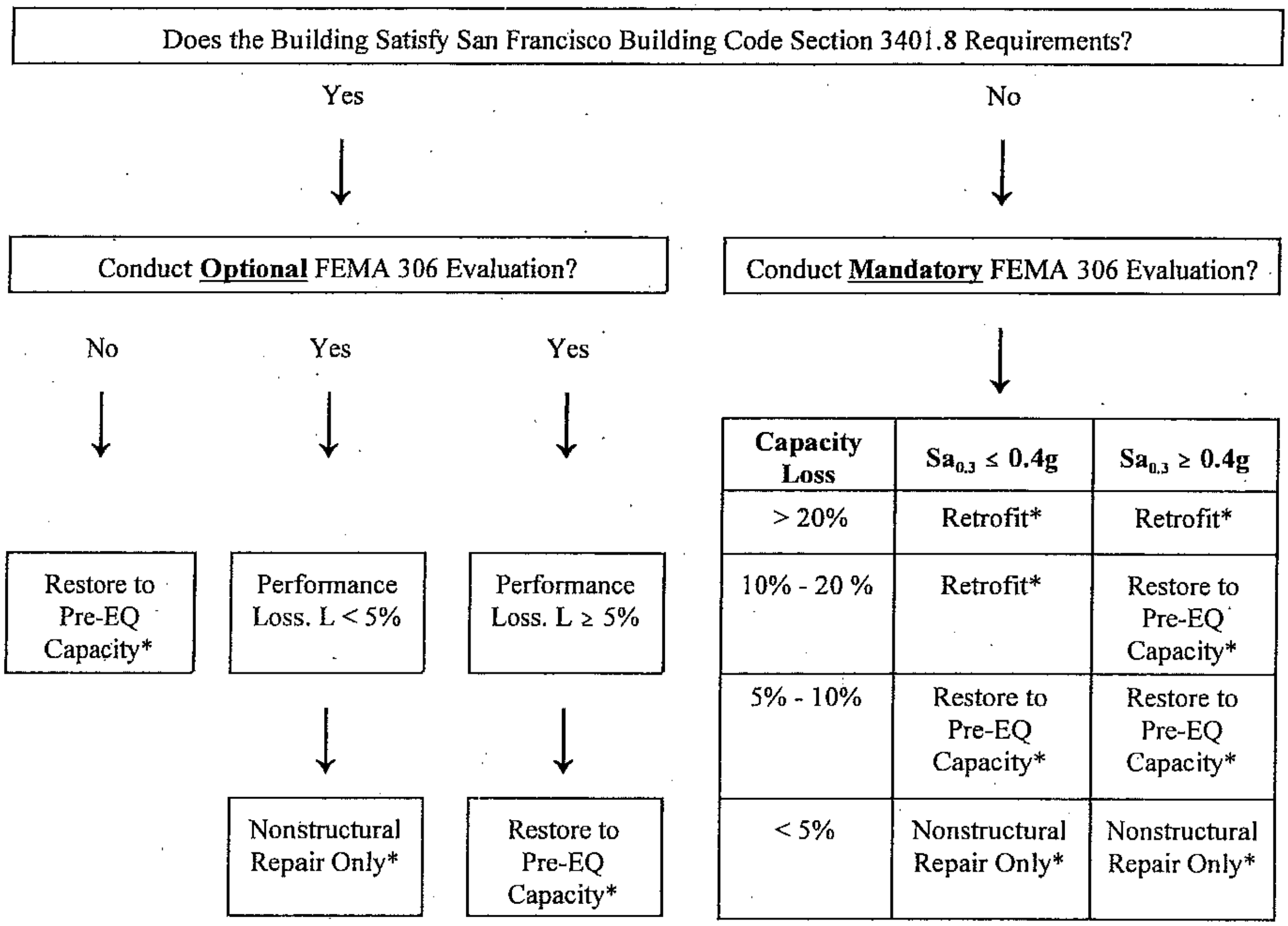
Overview

The flowchart in Figure 1 shall be followed to determine the post-earthquake damage repair or retrofit requirements related to substantial structural damage to concrete shear wall and infill frame buildings.

The process begins with a determination of whether the damaged building has sufficient pre-earthquake capacity to satisfy San Francisco Building Code, Section 3401.10, which references the May 21, 1973 milestone requirements of San Francisco Building Code, Section 1604.11.1. If the building in its pre-damaged state satisfies this code provision, then the building need not be retrofitted regardless of the level of damage, and restoration to pre-earthquake capacity is sufficient. Alternatively, if a full FEMA 306 evaluation (labeled as "Optional FEMA 306 Evaluation" in Figure 1) shows a capacity loss of less than 5 percent, nonstructural repair to the building instead of restoration to pre-earthquake capacity shall be permitted, except that individual component damage or condition repair per Table 1 is also required.

If the building does not meet the San Francisco Building Code, Section 1604.11.1 requirements per San Francisco Building Code Section 3401.10, then a full FEMA 306 evaluation (labeled as "Mandatory FEMA 306 Evaluation" in Figure 1) is required, and nonstructural repair, restoration to pre-earthquake capacity, or retrofit requirements may be triggered as shown in Figure 1. In addition, individual component damage or condition repair per Table 1 is required.

Figure 1: Flowchart for Post-Earthquake Repair and Retrofit of Concrete Shear Wall and Infill Frame Buildings



* Also address any Table 1 requirements. * Also address any Table 1 requirements.

FEMA 306 Evaluation Process

A FEMA 306 evaluation process for the pre-event structure and the damaged structure shall be performed using the guidelines below:

1. The evaluation shall use the nonlinear static procedures defined in FEMA 306 to determine the capacity for pre-event and damaged conditions [Attachment A]. FEMA 306 was developed at the time FEMA 273 was also in development, prior to the publication of FEMA 356. Since then, additional research and development effort was incorporated into FEMA 356 and later into ASCE 41. Therefore, the comparable, more current equations in ASCE 41 shall be used in performing a FEMA 306 evaluation rather than the FEMA 273 equivalents.

2. The global displacement demand shall be determined in accordance with ASCE 41.

3. The performance objective shall meet the requirements of ASCE 41 for Life Safety Structural Performance Level (S-3) at 75% of the spectral demand associated with the current code value at the building site.

Simplified FEMA 308 Evaluation Process

The following simplified version of the FEMA 308 approach, based on loss in performance, L, may be used for the purpose of determining threshold triggers for restoration to pre-earthquake capacity and retrofit. The process is similar to that outlined in Figure 1. The FEMA 308 parameters shall be determined using the guidelines as follows. For further definition of the FEMA 308 parameters needed for the evaluation, see Attachment B.

1. To use this method, first determine the following performance capacity and loss indices:

2. • **Pre-event (Undamaged) Performance Index**:

$$P = d_c / d_d,$$

where d_c is the global displacement capacity for the selected performance objective and d_d is the maximum global displacement demand for the selected ground motion. This performance index is calculated using component properties for the pre-event conditions in accordance with the methodology outlined in FEMA 306.

- **Damaged Performance Index**:

$$P' = d'_c / d'_d,$$

where the prime symbol (') denotes that the global displacement capacity and demand, d'_c and d'_d, respectively, are determined for the components in their damaged state using FEMA 306.

- **Loss**:

$$L = 1 - (P'/P),$$

where L is the performance loss of a building due to earthquake damage, and is given by the ratio of the damaged performance index, P', to the undamaged performance index, P, for a specific performance objective. L ranges between 0 and 1.

3. To determine whether earthquake damage is acceptable and neither restoration to pre-earthquake capacity nor retrofit is triggered, the performance loss, L, is compared against the FEMA 308 Table 3-1 [Attachment B] threshold parameters defined below:

- $L_{r(min)}$: The Loss threshold below which neither restoration to pre-earthquake capacity nor retrofit is triggered, shall be defined as follows:
  - $L_{r(min)}$ = 0.05 for earthquake event with $Sa_{0.3} \le 0.4g$
  - $L_{r(min)}$ = 0.05 for earthquake event with $Sa_{0.3} > 0.4g$
- $L_{r(max)}$: The Loss threshold above which either restoration to pre-earthquake capacity or retrofit is triggered. For this simplified procedure, $L_{r(max)}$ may be taken to be the same as $L_{r(min)}$ since Lr does not vary:
  - $L_{r(max)}$ = 0.05 for earthquake event with $Sa_{0.3} \le 0.4g$

- $L_{r(max)}$ = 0.05 for earthquake event with $Sa_{0.3} > 0.4g$

Alternatively, the Damaged Performance Index, P' may be used to determine whether earthquake damage is acceptable and neither restoration to pre-earthquake capacity nor retrofit is triggered by comparing P' against the FEMA 308 Table 3-1 [Attachment B] limit parameters defined below:

- P'_{min}: The Damage Performance Index limit below which restoration to pre-earthquake capacity or retrofit is triggered, is not used since L_r does not vary for the simplified method.
- P'_{max}: The Damage Performance Index limit above which neither restoration to pre-earthquake capacity nor retrofit is triggered regardless of the value of Loss, L, shall be defined as 1.0.

4. If a building is required to be restored to its pre-earthquake capacity or retrofitted per step 2, the Performance Loss, L, is compared against the FEMA 308 Table 3-2 [Attachment B] threshold parameters defined below to determine if retrofit is triggered:

- $L_{u(min)}$: The Loss threshold below which earthquake damage does not trigger retrofit but requires restoration to pre-earthquake capacity, shall be defined as below:
  - $L_{u(min)}$ = 0.10 for earthquake event with $Sa_{0.3} \leq 0.4g$
  - $L_{u(min)}$ = 0.20 for earthquake event with $Sa_{0.3} > 0.4g$
- $L_{u(max)}$: The Loss threshold above which earthquake damage triggers retrofit, shall be taken to be the same as $L_{u(min)}$ since L_u does not vary for the simplified method:
  - $L_{u(max)}$ = 0.10 for earthquake with $Sa_{0.3} \leq 0.4g$
  - $L_{u(max)}$ = 0.20 for earthquake with $Sa_{0.3} > 0.4g$

Alternatively, the Undamaged Performance Index, P may be used to determine whether restoration to pre-earthquake capacity or retrofit is triggered by comparing P against the FEMA 308 Table 3-2 limit parameters defined below:

- P_{min}: The Pre-event Performance Index limit below which existing earthquake damage triggers retrofit, is not used since L_u does not vary for the purpose of the simplified method.
- P_{max}: The Pre-event Performance Index limit above which existing earthquake damage does not trigger retrofit and restoration to pre-earthquake capacity is sufficient regardless of the value of Loss, L, shall be taken as 1.0.

Retrofit Triggers due to Specific Component Damage or Conditions

In addition to the retrofit triggers per the FEMA 306 and 308 methodologies described above, damage to any of the specific components or other conditions noted in Table 1 below shall trigger retrofit shown in the "Action Required" column of the table if damage is observed to reach the severity of "triggering damage." The conditions noted in Table 1 are primarily related to gravity-load-carrying component damage, load path failures, or significant damage in individual components. For damage less than the "triggering damage," repairs shall be made to return the building to original strength or condition by methods acceptable to the Department of Building Inspection.

Table 1: Triggers for Specific Components or Conditions in Concrete Buildings

Components or Conditions	***Triggering Damage***		***Action Required***
	Substantial Structure Damage	***Disproportionate Damage***	
Shear cracks in gravity load-carrying columns or bearing walls supporting less than 30% of the area of a roof or an individual floor.	Preemptive diagonal tension crack meeting the "Moderate" or worse criteria of the RC2H component in Section 5.5 of FEMA 306 or any component with "Extreme" damage per Section 5.5 of FEMA 306 [See Attachment A].	Preemptive diagonal tension crack meeting "Moderate" criteria of the RC2H component in Section 5.5 of FEMA 306, except that inclined crack widths are to be taken as between 1/16″ and 1/8″. [See Attachment A].	Replace component.
Shear cracks in gravity-load-carrying columns or bearing walls supporting 30% or more of the area of a roof or an individual floor.	Preemptive diagonal tension crack meeting the "Moderate" or worse criteria of the RC2H component in Section 5.5 of FEMA 306 or any component with "Extreme" damage per Section 5.5 of FEMA 306 [Attachment A].	Preemptive diagonal tension crack meeting "Moderate" criteria of the RC2H component in Section 5.5 of FEMA 306, except that inclined crack widths are to be taken as between 1/16″ and 1/8″ [Attachment A].	Replace component and retrofit lateral system to SFBC Section 3405.3.
Leaning story (excessive drift) in a concrete moment-frame building.	Permanent lateral displacement of 1% of the story height or more resulting from earthquake damage.	Permanent lateral displacement of 0.5% of the story height or more resulting from earthquake damage.	Retrofit lateral system to SFBC Section 3405.3.
Beam-column joint shear at joints with at least one exterior face in columns supporting less than 30% of the area of a roof or individual floor.	Cracking representative of joint shear at the beam-column joint with cracks at least 1/8″ wide or offset along the crack at least 1/16″		Replace component.
Beam-column joint shear at joints with at least one exterior face in columns supporting more than 30% of the area of a roof or individual floor.	Cracking representative of joint shear at the beam-column joint with cracks at least 1/8″ wide or offset along the crack at least 1/16″.		Replace component and retrofit lateral system to SFBC Section 3405.3.

Table 1: Triggers for Specific Components or Conditions in Concrete Buildings			
Components or Conditions	***Triggering Damage***		***Action Required***
	Substantial Structure Damage	***Disproportionate Damage***	
Punching shear damage at slab around columns without intersecting beams in columns supporting less than 30% of the area of a roof or individual floor.	Evidence representative of potential punching shear such as fresh circular cracking in the slab around a column with or without vertical offset at the crack.		Replace component.
Punching shear damage at slab around columns without intersecting beams in columns supporting more than 30% of the area of a roof or individual floor.	Evidence representative of potential punching shear such as fresh circular cracking in the slab around a column with or without vertical offset at the crack.		Replace component and retrofit lateral system to SFBC Section 3405.3.
Separation of floor-to-wall connections.	• Permanent separation or sliding at joint of 1″ or more, or • Permanent movement that results in inadequate bearing of supported member.		Retrofit connection using forces from SFBC Section 3405.3.
Delamination of more than 30% of cast-in-place topping from precast floor or roof framing where topping serves as the diaphragm.	Permanent separation of topping from precast members.		Replace damaged topping slab and tie new slab to underlying precast members using SFBC Section 3405.3 forces and current detailing.
Fractured bars at diaphragm chords or collectors.	• Permanent separation or sliding at joint of 1″ or more, or • Permanent movement that results in inadequate bearing of supported member.		Replace damaged bars and tie or splice new components to surrounding structural elements using SFBC Section 3405.3 forces and current detailing.

Concrete Moment-Frame Buildings

The process for determining whether repair or retrofit is triggered for a concrete moment-frame building begins with a determination of whether the damaged building has adequate pre-earthquake capacity to comply with San Francisco Building Code, Section 3401.10, which references the May 21, 1973 milestone requirements of the San Francisco Building Code, Section 1604.11.1. If this is satisfied, then the building need not be retrofitted regardless of the level of damage, and restoration of the building to its pre-earthquake capacity shall be undertaken. Unlike concrete shear-wall and infill buildings, nonstructural repairs shall not be permitted even if a full FEMA 306 evaluation has determined that the capacity loss is below 5 percent. For non-complying buildings, if any of the component damage or conditions given in Table 1 is present, the building shall be retrofitted as required by Table 1.

For concrete frame buildings with any interacting walls, in addition to the Table 1 checks, the evaluation procedure and retrofit scope given above for concrete shear wall and infill frame buildings shall be applied. When a FEMA 306 analysis is used to determine loss of capacity outlined in this bulletin for concrete shear wall and infill frame buildings, the moment-frame capacity may not be included in development of the force-displacement pushover curve.

EVALUATION AND RETROFIT ENGINEERING CRITERIA

When retrofit is triggered by earthquake damage at any level, the engineering criteria for retrofit shall be permitted to use earthquake loads that are 75 percent of those prescribed by the San Francisco Building Code for new construction, in accordance with SFBC Section 3405.2.

In addition, any of the following alternative codes, standards, or guidelines may be used as alternative evaluation or retrofit criteria for qualifying buildings:

A. Meets the requirements of ASCE 31-03 for the Life Safety Performance Level, or

B. Meets the requirements of ASCE 41-06 for the Life Safety Performance Level (S-3) in the BSE-1 earthquake hazard level, or

C. Meets the requirements of 2010 San Francisco Building Code 3401.10.

Signed:
Tom C. Hui, S.E. 7/2/2012
Acting Director
Department of Building Inspection

Approved by the Building Inspection Commission on 6/20/2012

Attachment A: Excerpt from FEMA 306: Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings: Basic Procedures Manual, Chapters 4-5

Attachment B: Excerpt from FEMA 308: The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings, Chapter 3

ATTACHMENT A

FEMA 306 BASIC PROCEDURES MANUAL

Chapter 4: Evaluation of Earthquake Damage and Chapter 5: Reinforced Concrete

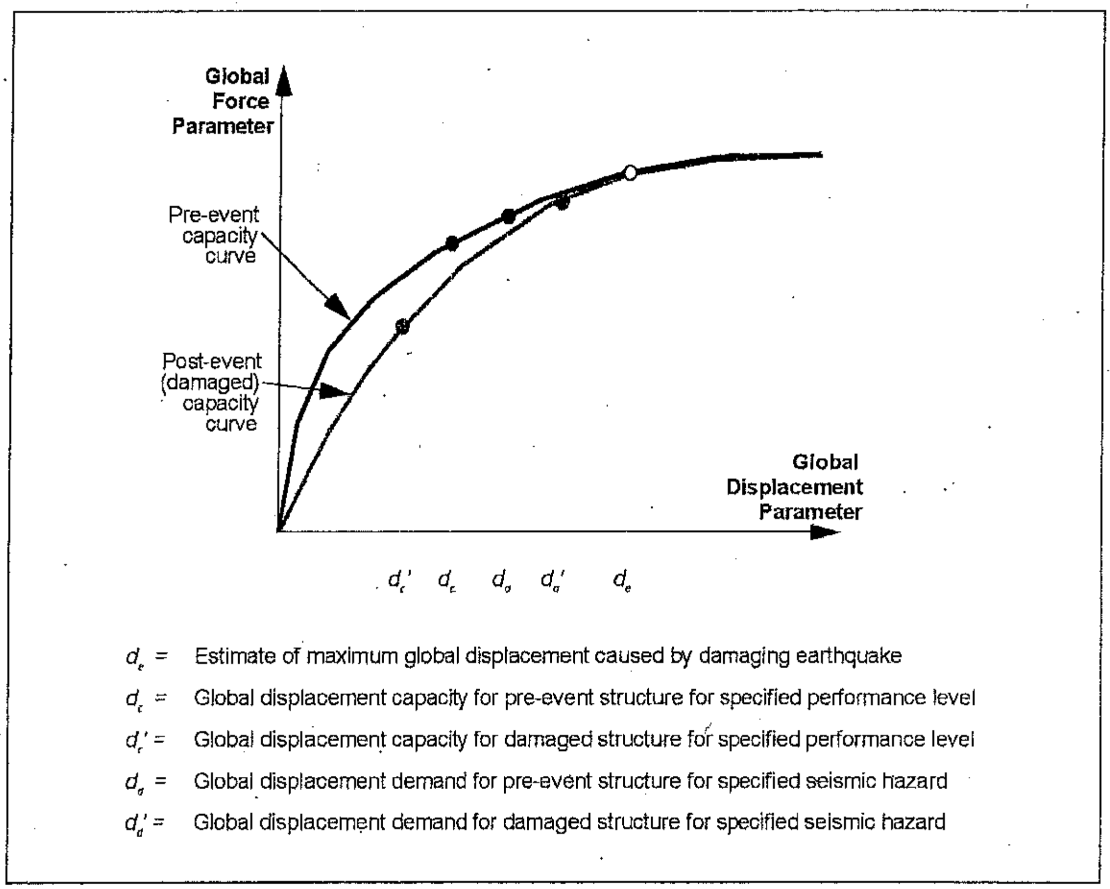


Figure 4-1 Displacement Parameters for Damage Evaluation

however, is relatively less restrictive for concrete and masonry wall buildings because of their tendency to repond in the fundamental mode. Future development of the procedures may also allow improved treatment for higher modes (Paret et al., 1996). Nonlinear static procedures must be carefully applied to buildings with flexible diaphragms.

The basic steps for using the procedure to measure the effect of damage caused by the damaging ground motion on future performance during the performance ground motion is outlined as follows:

1. Using the properties (strength, stiffness, energy dissipation) of all of the lateral-force-resisting components and elements of the pre-event structure, formulate a capacity curve relating global lateral force to global displacement.

2. Determine the global displacement limit, d_c, at which the pre-event structure would just reach the performance level specified for the performance objective under consideration.

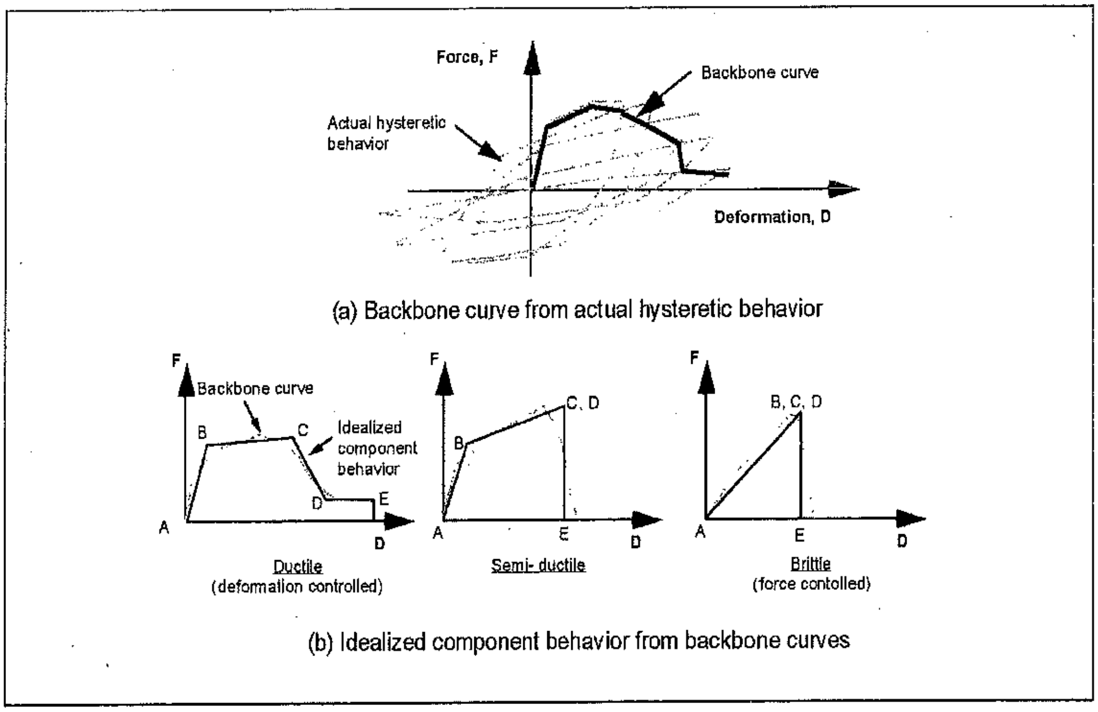


Figure 4-2 *Idealized Component Force-Deformation Relationship*

3. For the specified performance ground motion, determine the hypothetical maximum displacement for the pre-event structure, d_d. The ratio of d_c to d_d indicates the degree to which the pre-event structure satisfies the specified performance objective.

4. Using the results of the investigation of the effects of the damaging ground motion, modify the component force-deformation relationships using the Component Damage Classification Guides in Chapters 5 through 8. Using the revised component properties, reformulate the capacity curve for the damaged building and repeat steps 2 and 3 to determine d'_c and d'_d. The ratio of d'_c to d'_d indicates the degree to which the damaged structure satisfies the specified performance objective.

5. If the ratio of d'_c to d'_d is the same, or nearly the same, as the ratio of d_c to d_d , the damage caused by the damaging ground motion has not significantly degraded future performance for the performance objective under consideration.

6. If the ratio of d'_c to d'_d is less than the ratio of d_c to d_d, the effects of the damage caused by the damaging ground motion has diminished the future performance characteristics of the structure. Develop hypothetical actions in accordance with Section 4.5, to restore or augment element and component properties so that the ratio of d^*_c to d^*_d (where the * designates the restored condition) is the same, or nearly the same, as the ratio of d_c to d_d.

4.4.2 Global Displacement Performance Limits

The global displacement performance limits (d_c, d'_c, d^*_c) are a function of the acceptability of the deformation of the individual components of the structure as it is subjected to appropriate vertical loads and to a monotonically increasing static lateral load distributed to each floor and roof level in an assumed pattern. The deformation of the components depends on both their geometric configuration in the model and their individual force-deformation characteristics (see Section 2.4) compared to those of other components. The plot of the total lateral load parameter

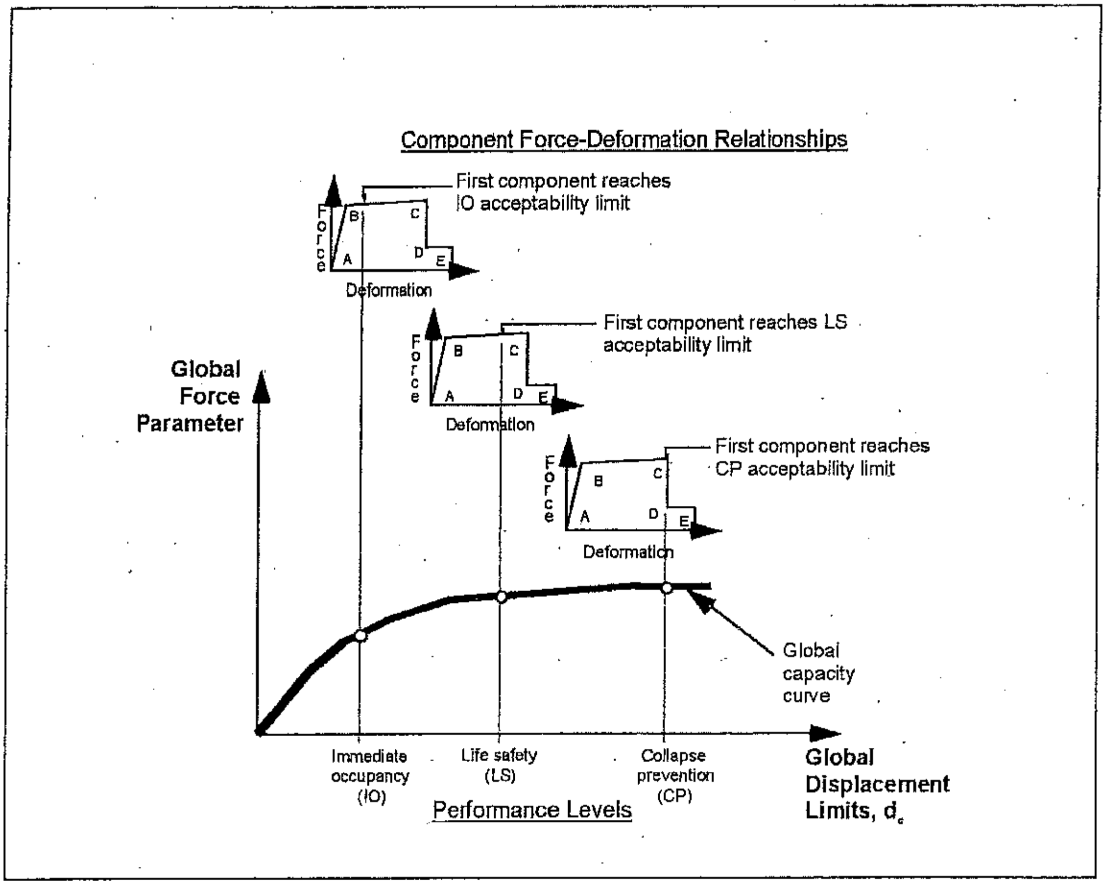


Figure 4-3 Global Displacement Limits and Component Acceptability used in FEMA 273/274

versus global displacement parameter represents the capacity curve for the building for the assumed load pattern. Thus, the capacity curve is characteristic of the global assembly of individual components and the assumed load pattern.

The current provisions of FEMA 273 limit global displacements for the performance level under consideration (e.g., Immediate Occupancy, Life Safety, Collapse Prevention) to that at which any single component reaches its acceptability limit (see Figure 4-3). The provisions of FEMA 273/274 allow for the re-designation of such components as "secondary." Secondary components have higher deformation acceptability limits but the remaining primary lateral load resisting system components must be capable of meeting acceptability criteria without them. The same allowance may be made for relative performance analysis of earthquake damaged buildings as long as it is applied appropriately to both the pre-event and damaged models.

The acceptability limits were developed for FEMA 273 to identify and mitigate specific seismic deficiencies in buildings to improve anticipated performance. As such, they are intended to be conservative. In a relative performance analysis, the degree of conservatism should be same for both the pre-event and damaged models to give reliable results to estimate the scope of
restoration repairs. In an actual earthquake, some "unacceptable" component behavior may not result necessarily in unacceptable global performance. In the future, it is possible that alternative procedures for better estimating global displacement limits will emerge. These also may be suitable for relative performance analyses provided that they are applied consistently and appropriately to both the pre-event and the damaged models.

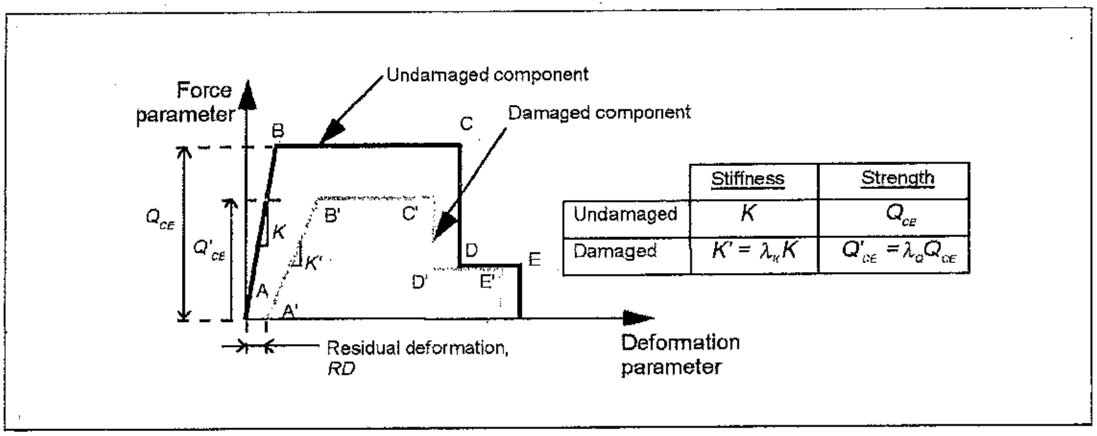


Figure 4-4 *Component Modeling Criteria*

4.4.3 Component Modeling and Acceptability Criteria

4.4.3.1 Pre-Event Building

In determining the capacity curve for the pre-event building, component properties are generated using the procedures of FEMA 273/274 or ATC-40, modified, if necessary, to reflect the results of the damage investigation. Modifications may be warranted for two reasons:

1. The procedures assume a normal, relatively minor, degree of deterioration of the building due to service conditions. If the investigation reveals preexisting conditions (see Section 3.4) that affect component properties beyond these normal conditions, then the "pre-event" component properties must be modified to reflect the condition of the structure just before the earthquake.

2. If the verification process (see Section 3.6) indicates component types or behavior modes inconsistent with the FEMA 273/274 or ATC-40 predicted properties, then the pre-event component properties are modified to reflect the observed conditions.

4.4.3.2 Damaged Building

The effects of damage on component behavior are modeled as shown generically in Figure 4-4. Acceptability criteria for components are illustrated in Figure 4-5. The factors used to modify component properties are defined as follows:

λ_K = modification factor for idealized component force-deformation curve accounting for change in effective initial stiffness resulting from earthquake damage.

λ_Q = modification factor for idealized component force-deformation curve accounting for change in expected strength resulting from earthquake damage.

λ_D = modification factor applied to component deformation acceptability limits accounting for earthquake damage.

RD = absolute value of the residual deformation in a structural component, resulting from earthquake damage.

The values of the modification factors depend on the behavior mode and the severity of damage to the individual component. They are tabulated in the Component Guides in Chapters 5 through 8. The notation λ^* is used to denote modifications to pre-event properties for restored components. These also vary by behavior mode, damage severity, and type of restoration measure, in accordance with the recommendations of Chapters 5 through 8. Figure 4-6 illustrates the general relationship between damage severity and the modification factors. Component stiffness is most sensitive to damage, so this parameter must be modified even when damage is slight. Reduction in strength implies more significant damage. After relatively severe damage, the magnitudes of acceptable displacements are reduced.

4.4.3.3 Establishing λ Factors by Structural Testing

The component modification factors (λ factors) for an earthquake damaged building can be established by*

*** Editor's note:**

As set forth in AB-099. Original text ended at page break.

Pseudo-dynamic test sequences may need to be carefully selected to produce enough cycles in each direction.

4.4.4 Global Displacement Demand

Prior earthquake damage may alter the future seismic response of a building by affecting the displacement demand and the displacement capacity. Effects of prior damage on the future displacement demands may be evaluated according to methods described in this section. Effects of prior damage on displacement capacity are described in Section 4.4.3.

FEMA 307 describes analytical and experimental studies of effects of prior damage on future earthquake response demands. A primary conclusion is that prior earthquake damage often does not cause a statistically significant change in maximum displacement demand for the overall structural system in future earthquakes under the following circumstances:

a. there is not rapid degradation of resistance with repeated cycles.

b. the performance ground motion associated with the future event produces a maximum displacement, d_d, larger than that produced by the damaging ground motion, d_e.

c. the residual drift of the damaged or repaired structure is small relative to d_e.

If the performance ground motion produces a maximum displacement, d'_d less than that produced by the damaging ground motion, d_e, the response of the damaged structure is more likely to differ from that of the pre-event structure, d_d (see Figure 4-8).

There are several alternatives for estimating the displacement demand for a given earthquake motion. FEMA 273 relies primarily on the displacement coefficient method. This approach uses a series of coefficients to modify the hypothetical linear-elastic response of a building to estimate its nonlinear-inelastic displacement demand. The capacity spectrum method (ATC 40) characterizes seismic demand initially using a 5% damped linear-elastic response spectrum and reduces the spectrum to reflect the effects of energy dissipation in an iterative process to estimate the inelastic displacement demand. The secant stiffness method (Kariotis et al., 1994), although formatted differently, is fundamentally similar to the capacity spectrum method. Both these latter two methods can be related to the substitute structure method (Shibata and Sozen, 1976). The use of each of these approaches to generate estimates of global displacement demand (d_d, d_d', and d_d*) is summarized in the following sections. Generally, any

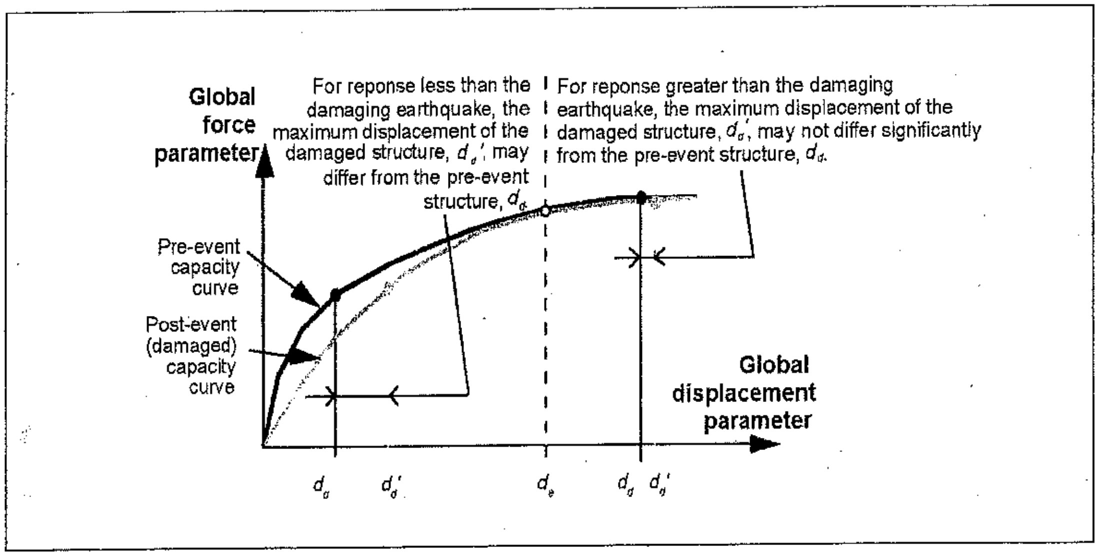


Figure 4-8 ***Maximum Displacement Dependency on Damaging Earthquake***

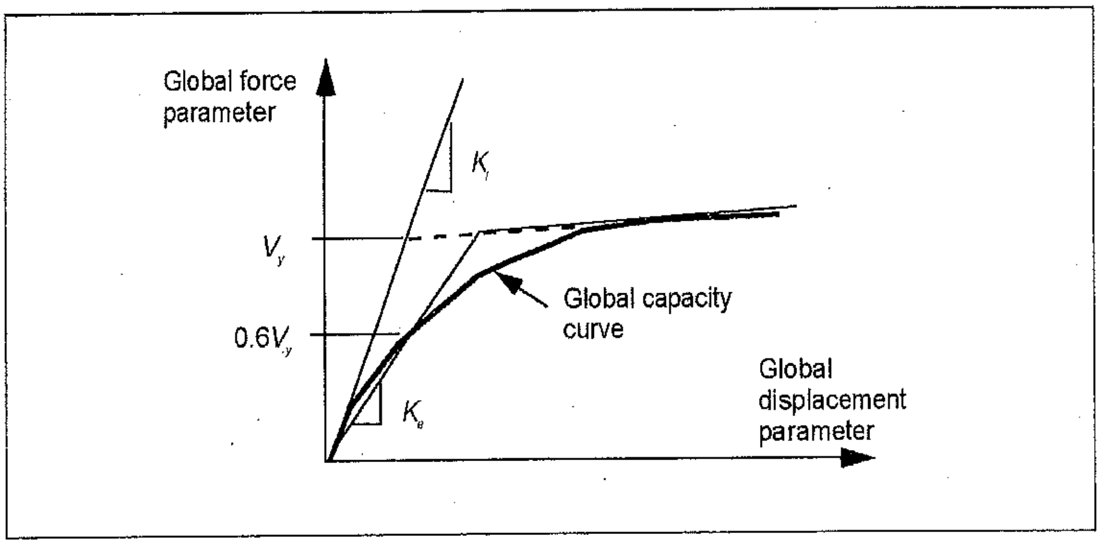


Figure 4-9 ***Global Capacity Dependency on Initial and Effective Stiffness***

of the methods may be used for the evaluation of the effects of damage; however, the same method should be used to calculate each of the global displacement demands (d_d, d_d', and d_d*) when making relative comparisons using these parameters.

4.4.4.1 Displacement Coefficient Method

The displacement coefficient method refers to the nonlinear static procedure described in Chapter 3 of ASCE-41. ~~FEMA 273.~~ The method also is described in Section 8.2.2.2 of ATC 40. The reader is referred to those documents for details in application of the procedure. A general overview and a description of the application of the method to damaged buildings are presented below.

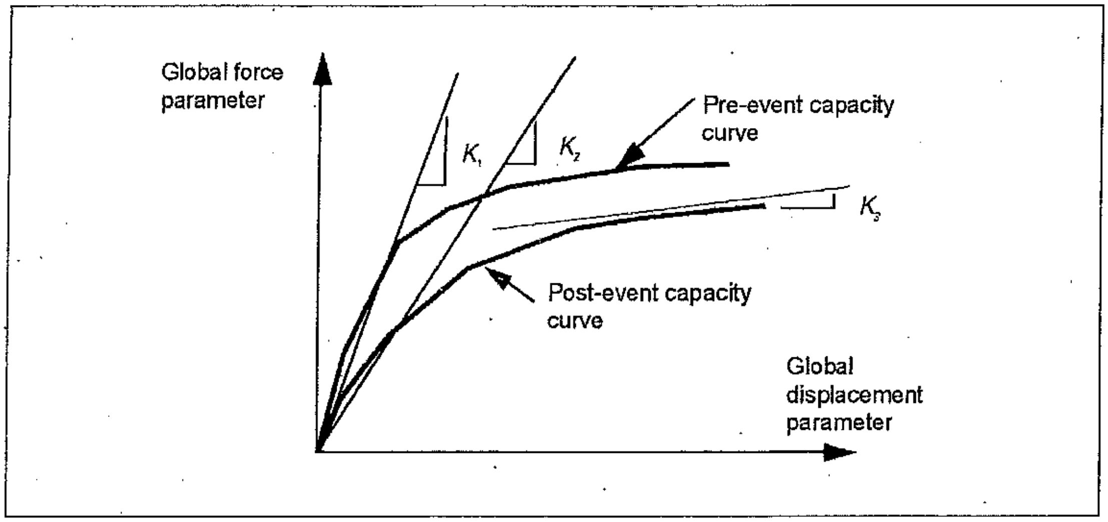


Figure 4-10 Pre- and Post-Event Capacity Curves with Associated Stiffnesses

The displacement coefficient method estimates the earthquake displacement demand for the building using a linear-elastic response spectrum. The response spectrum is plotted for a fixed value of equivalent damping, and the spectral response acceleration, S_a, is read from the spectrum for a period equal to the effective period, T_e. The effective period is defined by the following:

$$T_e = Ti \sqrt{\frac{K_i}{K_e}} \tag{4-1}$$

where T_i is the elastic fundamental period (in seconds) in the direction under consideration calculated by elastic dynamic analysis, K_i is the elastic lateral stiffness of the building in the direction under consideration (refer to Figure 4-9), and K_e is the effective lateral stiffness of the building in the direction under consideration (refer to Figure 4-9). As described in ASCE-41, ~~FEMA 273,~~ the effective lateral stiffness is taken as a secant to the capacity curve at base shear equal to $0.6V_y$. For a concrete or masonry wall building that has not been damaged previously by an earthquake, the effective damping is taken equal to 5% of critical damping.

The target displacement, δ_t, is calculated as:

$$\delta_t = C_0 \cdot C_1 \quad C_2 \quad C_3 \quad C_a \frac{T_e^2}{4\pi^2} \tag{4-2}$$

where C_0, C_1, C_2, C_3 are modification factors defined in ASCE-41, ~~FEMA 273,~~ and all other terms are as defined previously.

The maximum displacement, d_d, of the building in its pre-event condition for a performance ground motion is estimated by applying the displacement coefficient method using component properties representative of the pre-event conditions. To use the displacement coefficient method to estimate the maximum displacement demand, d'_d during a performance ground motion for a building damaged by a previous earthquake use the following steps: (See Figure 4-10.)

1. Construct the relation between lateral seismic force (base shear) and global structural displacement (roof displacement) for the pre-event structure. Refer to this curve as the pre-event capacity curve. Pre-event force-displacement relations should reflect response characteristics observed in the damaging earthquake, as discussed in Section 3.6.

2. Construct a similar relationship between lateral seismic force and global structural displacement for the structure based on the damaged condition of the structure, using component modeling parameters defined in Section 4.4.3. Refer to this curve as the post-event capacity curve.

3. Define effective stiffnesses K_1, K_2, and K_3 as shown in Figure 4-10. K_1 is K_e (see Figure 4-9) calculated from the pre-event capacity curve. K_2 is K_e (see Figure 4-9) calculated from the post-event capacity curve. K_3 is the effective post-yield stiffness from the post-event capacity curve.

4. Apply the displacement coefficient method as defined in FEMA 273 with the effective stiffness taken as $K_e = K_1$, effective damping equal to 5% of critical damping, post-yield stiffness defined by stiffness K_3, and effective yield strength defined by the intersection of the lines having slopes K_1 and K_3 to calculate δ_1 using Equation 4-2. Assign the displacement parameter d'_{d1} the value calculated for δ_1.

5. Apply the displacement coefficient method as defined in FEMA 273 with the effective stiffness taken as $K_e = K_2$, effective damping as defined by Equation 4-3, post-yield stiffness defined by stiffness K_3, and effective yield strength defined by the intersection of the lines having slopes K_2 and K_3 to calculate the displacement parameter d'_{d2}.

6. Using the displacement parameters d'_{d1} and d'_{d2}, estimate the displacement demand, d'_d, for the structure in its damaged condition as follows:

   a. If d'_{d1} is greater than d_e, then $d'_d = d'_{d1}$

   b. If d'_{d1} is less than d_e, then $d'_d = d'_{d2}$

The effective damping as defined by Equation 4-3 is consistent with experimental results obtained by Gulkan and Sozen (1974),

$$\beta = 0.05 + 0.2\left[1 - \left(\frac{K_2}{K_1}\right)^{0.5}\right] \tag{4-3}$$

For a restored or upgraded structure, the displacement demand, d^*_d, for a performance ground motion may be calculated using the displacement coefficient method with 5% damping using a capacity curve generated using applicable properties for existing components, whether repaired or not, and any supplemental components added to restore or upgrade the structure.

4.4.4.2 Capacity Spectrum Method

The capacity spectrum method is described in Section 8.2.2.1 of ATC 40. The reader is referred to that document for details in application of the procedure. A general overview and a description of the application of the method to damaged buildings are presented below.

The capacity spectrum method estimates the earthquake displacement demand for the building using a linear-elastic response spectrum. The response spectrum is plotted for a value of equivalent damping based on the degree of nonlinear response, and the spectral displacement response is read from the intersection of the capacity curve and the demand curve. In some instances of relatively large ground motion, the curves may not intersect, indicating potential collapse. In these cases the displacement coefficient method could be used as an alternate method for damage evaluation.

The maximum displacement of the building in its pre-event condition, d_d, for a performance ground motion is estimated by applying the capacity spectrum method using component properties representative of the pre-event conditions. To use the capacity spectrum method to estimate the maximum displacement demand, d'_d, during a performance ground motion for a building damaged by a previous earthquake, use the following steps:

1. Construct the relation between lateral seismic force (spectral acceleration) and global structural displacement (spectral displacement) for the structure assuming the damaging ground motion and its resultant damage had not occurred. Pre-event component force-deformation relationships should reflect response characteristics observed in the damaging earthquake as discussed in Section 3.6. Refer to this curve as the pre-event capacity curve.

2. Construct a similar relation between lateral seismic force and global structural displacement for the structure based on the damaged condition of the structure, using component modeling parameters defined in Section 4.4.3. Refer to this curve as the post-event capacity curve.

3. Apply the capacity spectrum method using the pre-event capacity curve to calculate the displacement parameter d'_{d1}.

4. Apply the capacity spectrum method using the post-event capacity curve to calculate the displacement parameter d'_{d2}. For determining the effective damping, the yield strength and displacement for the post-event capacity curve should be taken identically equal to the yield strength and displacement determined for the pre-event capacity curve. (See Equation 4-3.)

5. Using the displacement parameters d'_{d1} and d'_{d2}, estimate the displacement demand, d'_d, for the structure in its damaged condition as follows:

    a. If d'_{d1} is greater than d_e, then $d'_d = d'_{d1}$

    b. If d'_{d1} is less than d_e, then $d'_d = d'_{d2}$

For a restored or upgraded structure the displacement demand for a performance ground motion, d_{d*}, may be calculated using the capacity spectrum method based on a capacity curve using applicable properties for existing components, whether repaired or not, and any supplemental components added to restore or upgrade the structure.

4.4.4.3 Secant Stiffness Method

The secant stiffness method is described in Section 8.4.2.1 of ATC-40, *Seismic Evaluation and Retrofit of Concrete Buildings* (ATC, 1996). The reader is referred to that document for details in application of the procedure. To use the method for damaged buildings, the general procedure should be applied based on the properties of the damaged building.

4.4.4.4 Nonlinear Dynamic Procedure

As an alternative to the nonlinear static procedures described above, nonlinear dynamic response histories may be computed to estimate the displacement demand for the building. This dynamic analysis approach requires that suitable ground motion records be selected for both the damaging event and the performance ground motion. It also requires that representative structural models be prepared for the building in its pre-event (no superscript), damaged ('), and restored or upgraded (*) conditions. Detailed procedures have not been developed for the use of nonlinear dynamic response histories in relative performance analyses. The following sections offer general guidance on

Chapter 5: Reinforced Concrete

RC2H	COMPONENT DAMAGE CLASSIFICATION GUIDE	System: **Reinforced Concrete**
		Component Type: **Weaker Pier**
		Behavior Mode: **Preemptive Diagonal Tension**

How to distinguish behavior mode:

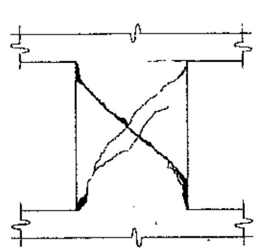
By observation:
For lower levels of damage, indications will be similar to those for other behavior modes, although flexural cracks may not be apparent. Damage quickly becomes heavy when diagonal cracks open up. Because flexural reinforcement never yields, flexural cracks should not have a width greater than 1/8 in.

Preemptive diagonal shear typically occurs in wall piers that have inadequate (or no) horizontal reinforcement, and that may have heavy vertical reinforcement. May be more prevalent in wall piers with low M/Vl_w ratio.

By analysis:
Strength in shear at low ductility is less than the capacity corresponding to moment strength, foundation rocking strength, or lap-splice strength (at low ductility).

Refer to Evaluation Procedures for:

- Identifying flexural versus shear cracks.
- Calculation of moment, shear, lap-splice, and foundation rocking strength.

Severity	**Description of Damage**	**Performance Restoration Measures**
Insignificant $\lambda_K = 0.9$ $\lambda_Q = 1.0$ $\lambda_D = 1.0$	*Criteria:* • No shear cracking <u>and</u> • Flexural crack widths do not exceed 1/8 in. *Typical Appearance:* Similar to RC2A except no shear cracking and smaller crack widths.	See **RC1A**
Slight	Not Used	
Moderate $\lambda_K = 0.5$ $\lambda_Q = 0.8$ $\lambda_D = 0.9$	*Criteria:* • No crack widths exceed 1/8 in. <u>and</u> • No vertical cracking or spalling *Typical Appearance:* Similar to insignificant damage except thin shear cracks may be present.	Inject cracks $\lambda_K^* = 0.8$ $\lambda_Q^* = 1.0$ $\lambda_D^* = 1.0$
Heavy $\lambda_K = 0.2$ $\lambda_Q = 0.3$ $\lambda_D = 0.7$ Note: λ_Q can be calculated based on shear strength at high ductility. See Section 5.3.6	*Criteria:* Shear crack widths exceed 1/8 in. but do not exceed 3/8 in. Cracking becomes concentrated at one or more cracks. *Typical Appearance:* 	• Replacement or enhancement is required for full restoration of seismic performance. • For partial restoration of performance, Inject cracks. $\lambda_K^* = 0.5$ $\lambda_Q^* = 0.8$ $\lambda_D^* = 0.9$
Extreme	*Criteria: Typical Indications:* • Reinforcement has fractured. • Wide shear cracking typically concentrated in a single crack.	Replacement or enhancement required.

ATTACHMENT B

FEMA 308 REPAIR OF EARTHQUAKE DAMAGED CONCRETE AND MASONRY WALL BUILDINGS
Chapter 3: Performance-Based Policy Framework

Table 3-1 Parameters governing whether damage is acceptable (see Figure 3-7a)

$L_{r(min)}$ =	Performance loss threshold below which restoration is not required regardless of the Damaged Performance Index, P'. (Avoids requiring restoration when the effects of damage on performance are small. This threshold would be comparatively lower for damaging earthquakes with small relative displacement demand (S) and higher for large ones.)
P'_{min} =	Damaged Performance Index limit below which restoration is required unless the Performance Loss is less than $Lr(min)$. (Limits how far the Damaged Performance Index (P') can fall and still be acceptable without restoration. This limit would be comparatively lower for damaging earthquakes with large relative displacement demand (S) and higher for smaller ones.)
$L_{r(max)}$ =	Performance Loss threshold above which restoration is required unless the Damaged Performance Index exceeds P'_{max}. (Requires restoration for relatively large losses unless the Damaged Performance Index (P') is high. The threshold would be comparatively lower for damaging earthquakes with small relative displacement demand (S) and higher for larger ones.)
P'_{max} =	Damaged Performance Index limit above which restoration is not required regardless of the Performance Loss. (Establishes when the Damaged Performance Index (P') is acceptable without restoration. This limit would be comparatively lower for damaging earthquakes with large relative displacement demand (S) and higher for smaller ones.)

Table 3-2 Parameters governing whether restoration is acceptable (see Figure 3-7b)

$L_{u(min)}$ =	Performance Loss threshold below which upgrading is not required regardless of the Pre-event (Undamaged) Performance Index. (Avoids requiring upgrading when the effects of damage on performance are small. The threshold would be relatively lower for damaging earthquakes with small relative displacement demand (S) and higher for larger ones.)
P_{min} =	Pre-event Performance Index limit below which upgrading is required unless the Performance Loss is less than $L_{u(min)}$. (Establishes when the Pre-event Performance Index (P) is acceptable without upgrading. This limit would be relatively lower for damaging earthquakes with high relative displacement demand (S) and higher for smaller ones.)
$L_{u(max)}$ =	Performance Loss threshold above which upgrading is required unless the Pre-event Performance Index exceeds P_{max}. (Requires upgrading for relatively large losses unless the Pre-event Performance Index (P) is high. The threshold would be comparatively lower for damaging earthquakes with small relative displacement demand (S) and higher for larger ones.)
P_{max} =	Pre-event Performance Index limit above which upgrading is not required regardless of Performance Loss. (Establishes when the Pre-event Performance Index (P) is acceptable without upgrading. This limit would be comparatively lower for damaging earthquakes with large relative displacement demand (S) and higher for smaller ones.)

upgrading might not be required since the change in performance is negligible. This concept is represented by the horizontal line at $L_{r(min)}$. If the loss exceeds the minimum, then the decision on whether to accept the damage is controlled by how close the damaged performance index is to P'_{min} and P'_{max}. The lower end of the sloping portion of the restoration boundary represents the limit (P'_{min}). As the loss increases there is logically less tolerance for a lower damaged performance index (P'). As the loss increases further, there comes a point $L_{r(max)}$, at which the damaged performance index must be greater than P'_{max} ($P' > P'_{max}$) if damage is to be acceptable regardless of the loss. If the damaged performance index (P', L) is within the restoration boundary, then either restoration or upgrading is required.

The parameters affecting the decision between upgrade or restoration are illustrated in Figure 3-7b. The decision between upgrade or restoration is controlled by the loss (L) and the pre-event performance index (P). The upgrade boundary is delineated similarly to the restoration boundary using the parameters in Table 3-2.

ADMINISTRATIVE BULLETIN

Draft #1

NO. AB-100

DATE : November 6, 2013 ~~July 12, 2012~~

SUBJECT : Permit Review and Operation

TITLE: : **Post-Earthquake Repair and Retrofit Requirements for One- and Two-Family Units**

PURPOSE : The purpose of this Bulletin is to establish policy for interpreting the San Francisco Building Code regarding post-earthquake damage retrofit triggers for one- and two-family dwellings of wood-frame construction and to detail the scope and criteria for such triggered retrofits. The Bulletin also provides guidance on the scope of required building repair if retrofits are not triggered.

REFERENCE : 2013 ~~2010~~ San Francisco Building Code

- Section 3401.8, Lateral force design requirements for existing buildings
- Section 3402, Definition of Disproportionate Damage [pending code revision]
- Section 3402, Definition of Substantial Structural Damage
- Section 3405, Repairs

2013 ~~2010~~ California Historical Building C ode, C.C.R. Title Part 8

2012 International Existing Building Code, Appendix Chapter A4, or 2009 International Existing Building Code, Appendix Chapter A4 with NCSEA/SEAOC amendments

ASCE/SEI Standard 31-~~03~~, ~~2003~~, Seismic Evaluation of Existing Buildings

ASCE/SEI Standard 41-~~06~~, ~~2007~~, Seismic Rehabilitation of Existing Buildings, with Supplement 1 California Health and Safety Code, Section 17920.3

CAPSS Report, *Here Today – Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Post-Earthquake Repair and Retrofit Requirements* (ATC-52-4 Report), http://www.sfcapss.org/PDFs/PostQuakeRepair.pdf

CUREE EDA-2: General Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings, (CUREE, 2010)

FEMA 306: Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings: Basic Procedures Manual (FEMA, 1999)

DISCUSSION : San Francisco Building Code, Section 3405.2 triggers seismic evaluation, and possibly retrofit of buildings, when earthquake-related damage reaches the level of "substantial structural damage to vertical elements of the lateral-force-resisting system." Substantial structural damage is defined in San Francisco Building Code, Section 3402 as, in essence, a loss of lateral capacity of 20 percent or more in any horizontal direction. The code does not give specific rules for identifying a 20-percent capacity loss nor guidance as to how to calculate capacity loss, so implementation of these code provisions relies on interpretation by the Department of Building Inspection. This Bulletin presents the Department's interpretation of a 20-percent lateral capacity loss based on visual indicators of such damage, and details the evaluation procedure and retrofit scope for buildings that exhibit earthquake-induced substantial structural damage. The Bulletin also provides guidance on the scope of required repair of building components or assemblies if such retrofits are not triggered.

In addition to substantial structural damage, San Francisco Building Code, Section 3405.4 triggers structural evaluation and possibly retrofit when earthquake-related damage reaches the level of disproportionate damage, which is defined in San Francisco Building Code, Section 3402 as, in essence, a lateral capacity loss of 10 percent or more in an earthquake of limited intensity. This Bulletin presents the Department of Building Inspection's interpretation of a 10 percent capacity loss based on visual indicators of such damage and provides evaluation procedures and retrofit scope for buildings with such earthquake induced disproportionate damage. [*provisional, pending San Francisco Building Code adoption of provisions for Disproportionate Damage.*]

Residential buildings that incur substantial structural damage or disproportionate damage as detailed in this Bulletin are considered to be "substandard" per California Health and Safety Code Section 17920.3(b) Structural hazards and (o) Inadequate structural resistance to horizontal forces.

APPLICABILITY

A building is eligible to apply the interpretations and provisions of this Bulletin if all of the following criteria are met:

A. The building includes at least one story in which the seismic force-resisting system consists of a wood light-frame system in at least one direction, and

B. The building has only wood floor and roof diaphragms, and

C. The building contains a residential occupancy group R-3 as defined in San Francisco Building Code, Section 310. At the discretion of the Department of Building Inspection, a building in this group may be evaluated and repaired or retrofitted using the criteria for a residential building with three or more units under AB-098 if the building is structurally and architecturally similar to that group of buildings.

Buildings of other construction types and occupancies may also apply the provisions of this Bulletin on a case-by-case basis when approved by the Department of Building Inspection. Other methods of determining capacity loss based on analysis, testing, or other objective data may also be allowed at the discretion of the Department.

Qualified buildings may be permitted to be evaluated or retrofitted using the provisions in the California Historical Building Code provided that such provisions do not result in seismic performance that is less than the evaluation and retrofit engineering provisions detailed in this Bulletin.

EVALUATION PROCEDURES AND RETROFIT SCOPE

For the purpose of determining if a building has incurred substantial structural damage or disproportionate damage per San Francisco Building Code, visual observation and classification of damage and severity may be used in lieu of a calculation of percentage loss of capacity. All determinations of substantial structural damage or disproportionate damage, including visual observation and classification of damage and severity, shall be made by a licensed design professional, and evaluation shall be submitted in accordance with San Francisco Building Code, Section 3405.2.1. For damage not deemed to be either substantial structural damage or disproportionate damage, repairs shall restore the building to its original strength or condition by methods acceptable to the Department of Building Inspection.

Buildings with Substantial Structural Damage

Earthquake-induced substantial structural damage to elements of lateral force-resisting system of a building shall be deemed to exist when any of the components and conditions is observed to reach the severity of "triggering damage" given in Table 1. For buildings with such substantial structural damage, evaluation and retrofit, where required, shall proceed in accordance with the "Action Required" column shown in Table 1 and the "Further Evaluation and Retrofit Engineering Criteria" section.

Buildings with Disproportionate Damage

Disproportionate damage to elements of the lateral force-resisting system of a building shall be deemed to exist when any of the components and conditions is observed to reach the severity of "triggering damage" given in Table 1. For buildings with such disproportionate damage, evaluation and retrofit, where required, shall proceed in accordance with the "Action Required" column shown in Table 1 and the "Further Evaluation and Retrofit Engineering Criteria" section.

Table 1: Substantial and Disproportionate Damage Triggers for Repair and Retrofit of One and Two-Family Dwellings

<table>
<tr><th rowspan="2">Components and Damage Condition</th><th colspan="2">Triggering Damage</th><th rowspan="2">Action Required</th></tr>
<tr><th>Substantial Structural Damage</th><th>Disproportionate Damage</th></tr>
<tr><td>Stone or masonry veneer, incidental URM wall (non-chimney)</td><td>• Appearance similar to "Heavy Damage" as described in Section 7.5 of FEMA 306 [Attachment B], or
• Failure of anchorage to backing in over 20% of the wall area</td><td>• Appearance similar to "Moderate Damage" as described in Section 7.5 of FEMA 306 [Attachment B], or
• Visible failure of anchorage to backing anywhere</td><td>Remove and replace damaged elements.</td></tr>
<tr><td>• URM foundation piers
• Continuous footings with crawl space or under-floor area</td><td colspan="2">• "Moderate Damage" as described in Section 7.5 of FEMA 306 [Attachment B], or
• Visible relative movement of supported joist or beams on support of 1″ or more, or
• Permanent movement that results in inadequate bearing of supported member</td><td>Retrofit crawl space or under-floor area.</td></tr>
<tr><td rowspan="2">Cracks in continuous footings without visible related soil failure or movement</td><td colspan="2">Crack width of less than 0.25″</td><td>No retrofit required. Repair to original strength in accordance with Section 4A.3 of CUREE EDA-2.</td></tr>
<tr><td colspan="2">Crack width or offset of greater than 0.25″</td><td>No retrofit required. Obtain design professional guidance for repair.</td></tr>
</table>

Table 1: Substantial and Disproportionate Damage Triggers for Repair and Retrofit of One and Two-Family Dwellings

Components and Damage Condition	*Triggering Damage*		*Action Required*
	Substantial Structural Damage	*Disproportionate Damage*	
Cracks in continuous footings with visible related soil failure or movement	Cracks and visible related soil failure or movement		• Obtain design professional guidance for mitigation of soil movement and repair of footing, and • Mitigate any soil issues as recommended by design professional.
• Post-and-beam crawl space or under-floor area • Cripple wall with stud height not exceeding 4 feet	• Permanent lateral displacement of 2″ anywhere, or • Visible relative movement of 1″ or more between supported joists or beams and their supports, or • Permanent movement that results in inadequate bearing of over 50% of the supported members	• Permanent lateral displacement of 1″ anywhere, or • Visible relative movement for more than 50% of the supported joists or beams and their supports	Retrofit crawl space or under-floor area in accordance with IEBC Chapter A3.
Anchorage of floor/wall framing to foundations	Permanent movement of 1″ anywhere		Retrofit crawl space or under-floor area in accordance with IEBC Chapter A3 [Attachment A].
• Hillside structure where height of supports from foundation to the point of bearing for the floor assembly above exceeds 4 feet	• Permanent lateral displacement of 2″ or 2% drift, whichever is greater, at downhill cripple wall stud in any direction, or	• Permanent lateral displacement of 1″ or 1% drift, whichever is greater, at downhill cripple wall stud in any direction, or	Retrofit from the foundation level to a level above with a full-plate diaphragm, specifically addressing the torsion created by walls of varying height, supports, or other causes.

Table 1: Substantial and Disproportionate Damage Triggers for Repair and Retrofit of One and Two-Family Dwellings

Components and Damage Condition	*Triggering Damage*		*Action Required*
	Substantial Structural Damage	*Disproportionate Damage*	
• Cripple wall with stud height exceeding 4 feet.	• Failure of connections in downhill supports if post-and-beam braced frame or moment frame, or • Separation of uphill framing from foundation support or indication of relative movement during shaking of 1″ or more in the direction parallel to the slope	• Signs of movement that could lead to failure of the downhill supports, or • Visible relative movement of the uphill support in the direction parallel to the slope	
Weak Story: when any story has less than 80% of the strength of the story above in either direction	• Permanent lateral displacement of 2″ or more, or • Indication of any lateral movement in story of 4″ or more during shaking in any direction		Retrofit soft story and any support system below.
Stories other than weak stories	• Permanent lateral displacement of 2″ or more anywhere in any direction, or • Permanent lateral displacement of 1″ anywhere if torsional displacement is observed, or • Indications of excessive response such as severe cracking of brittle walls nail fracture or pullout in wood, multiple jammed doors, and/or broken windows		• Retrofit from damaged story down to the foundation, and • Repair walls not part of the designated lateral force-resisting system in accordance with Section 5.8 of CUREE EDA-2.
Connection between two parts of a structure including wings, split levels, porches, and beam to post connections	• Permanent separation or sliding at joint of 1″ or more, or • Permanent movement that results in inadequate bearing of a supported member		Provide structural separation with independent gravity support for each structure or a seismic tie that will transfer 20% of the weight of the lighter portion across the joint.

Table 1: Substantial and Disproportionate Damage Triggers for Repair and Retrofit of One and Two-Family Dwellings

Components and Damage Condition	*Triggering Damage*		*Action Required*
	Substantial Structural Damage	*Disproportionate Damage*	
Unreinforced masonry chimneys	Damage patterns described in Chapter 7 of CUREE EDA-2 that require replacement of any chimney bricks or flue tiles or substantial extent of mortar	Earthquake caused horizontal cracking at roof line or at the top of fire box	Minimum retrofit/replacement according to Appendix 7A of Chapter 7 of CUREE EDA-2.
Any chimney	• Earthquake induced separation of chimney from the surrounding or adjacent wood framing, or		**For Substantial Structural Damage:** Repair/replace attic ties if present. If no tie to wood framing is evident, provide new engineered tie or replace chimney according to Appendix 7A of CUREE EDA-2
	• Clear movement from a hand pushed "rock test" as described in Section 7.7.3 of CUREE EDA-2.		**For Disproportionate Damage:** Repair/replace chimney according to Appendix 7A of CUREE EDA-2.
Ceiling plaster	Falling or delaminated ceiling plaster greater than 10% of area within any room.		Determine extent of delamination or deteriorated plaster and replace.
Ceiling material	Cracks in ceiling material indicating permanent movement or local crushing of ceiling material at crack.		If cracks are caused by movement of joists at their supports, provide tie across area of slippage. Otherwise, repair.
Roof tiles	Damage to anchorage of roof tiles, unanchored or slipped tiles.		Determine extent of missing or deteriorated anchorage and replace damaged tiles.

FURTHER EVALUATION AND RETROFIT ENGINEERING CRITERIA:

If, after an evaluation per San Francisco Building Code, Section 3405.2, the pre-earthquake building is determined to satisfy the criteria, then the building need not be retrofitted, but shall be restored to its pre-earthquake capacity. When retrofit is triggered by earthquake damage at any level, the engineering criteria for retrofit shall be permitted to use earthquake loads that are 75 percent of those prescribed by the San Francisco Building Code for new construction, in accordance with San Francisco Building Code, Section 3405.2.

Alternatively, any of the following codes, standards, or guidelines may be used as alternative evaluation or retrofit criteria for qualifying buildings:

A. Meets the requirements of ASCE 31-03 for the Life Safety Performance Level, or

B. Meets the requirements of ASCE 41-06 for the Life Safety Performance Level (S-3) in a BSE-1 earthquake hazard level, or

C. Meets the requirements of 2012 IEBC Appendix Chapter A4 or 2009 IEBC Appendix Chapter A4 with NCSEA/SEAOC amendments, or

D. Meets the 2010 San Francisco Building Code, Sections 3415 – 3420.

Signed:
Tom C. Hui, S.E. 7/2/2012
Acting Director
Department of Building Inspection

Approved by the Building Inspection Commission on 6/20/2012

Attachment A: Excerpt from 2012 International Code for Existing Buildings, Appendix Chapters A3 & A4

Attachment B: Excerpt from FEMA 306: Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings: Basic Procedures Manual, Chapter 7, Section 5

Attachment C: Excerpts from CUREE Publication No. EDA-02: General Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings

ATTACHMENT A

2012 INTERNATIONAL CODE FOR EXISTING BUILDINGS,
Appendix Chapters A3 & A4

Chapter A3 – Prescriptive Provisions for Seismic Strengthening of Cripple Walls and Sill Plate Anchorage of Light Wood-Frame Residential Buildings

SECTION A301 GENERAL

A301.1 Purpose.

The provisions of this chapter are intended to promote public safety and welfare by reducing the risk of earthquake-induced damage to existing wood-frame residential buildings. The requirements contained in this chapter are prescriptive minimum standards intended to improve the seismic performance of residential buildings; however, they will not necessarily prevent earthquake damage.

This chapter sets standards for strengthening that may be approved by the code official without requiring plans or calculations prepared by a registered design professional. The provisions of this chapter are not intended to prevent the use of any material or method of construction not prescribed herein. The code official may require that construction documents for strengthening using alternative materials or methods be prepared by a registered design professional.

A301.2 Scope.

The provisions of this chapter apply to residential buildings of light-frame wood construction containing one or more of the structural weaknesses specified in Section A303.

Exception: The provisions of this chapter do not apply to the buildings, or elements thereof, listed below. These buildings or elements require analysis by a registered design professional in accordance with Section A301.3 to determine appropriate strengthening:

1. Group R-1, R-2 or R-4 occupancies with more than four dwelling units.
2. Buildings with a lateral force-resisting system using poles or columns embedded in the ground.
3. Cripple walls that exceed 4 feet (1219 mm) in height.
4. Buildings exceeding three stories in height and any three-story building with cripple wall studs exceeding 14 inches (356 mm) in height.
5. Buildings where the code official determines that conditions exist that are beyond the scope of the prescriptive requirements of this chapter.
6. Buildings or portions thereof constructed on concrete slabs on grade.

A301.3 Alternative design procedures.

The details and prescriptive provisions herein are not intended to be the only acceptable strengthening methods permitted. Alternative details and methods may be used where designed by a registered design professional and approved by the code official. Approval of alternatives shall be based on a demonstration that the method or material used is at least equivalent in terms of strength, deflection and capacity to that provided by the prescriptive methods and materials.

Where analysis by a registered design professional is required, such analysis shall be in accordance with all requirements of the building code, except that the seismic forces may be taken as 75 percent of those specified in the building code.

SECTION A302 DEFINITIONS

For the purpose of this chapter, in addition to the applicable definitions in the building code, certain additional terms are defined as follows:

COMPOSITE PANEL. A wood structural panel product composed of a combination of wood veneer and wood-based material, and bonded with waterproof adhesive.

CRIPPLE WALL. A wood-frame stud wall extending from the top of the foundation to the underside of the lowest floor framing.

EXPANSION ANCHOR. An approved post-installed anchor, inserted into a pre-drilled hole in existing concrete or masonry, that transfers loads to or from the concrete or masonry by direct bearing or friction or both.

ORIENTED STRAND BOARD (OSB). A mat-formed wood structural panel product composed of thin rectangular wood strands or wafers arranged in oriented layers and bonded with waterproof adhesive.

PERIMETER FOUNDATION. A foundation system that is located under the exterior walls of a building.

PLYWOOD. A wood structural panel product composed of sheets of wood veneer bonded together with the grain of adjacent layers oriented at right angles to one another.

SNUG-TIGHT. As tight as an individual can torque a nut on a bolt by hand, using a wrench with a 10-inch-long (254 mm) handle, and the point at which the full surface of the plate washer is contacting the wood member and slightly indenting the wood surface.

WAFERBOARD. A mat-formed wood structural panel product composed of thin rectangular wood wafers arranged in random layers and bonded with waterproof adhesive.

WOOD STRUCTURAL PANEL. A structural panel product composed primarily of wood and meeting the requirements of United States Voluntary Product Standard PS 1 and United States Voluntary Product Standard PS 2. Wood structural panels include all-veneer plywood, composite panels containing a combination of veneer and wood-based material, and mat-formed panels such as oriented strand board and waferboard.

SECTION A303 STRUCTURAL WEAKNESSES

A303.1 General.

For the purpose of this chapter, structural weaknesses shall be as specified below.

1. Sill plates or floor framing that are supported directly on the ground without a foundation system that conforms to the building code.

2. A perimeter foundation system that is constructed only of wood posts supported on isolated pad footings.

3. Perimeter foundation systems that are not continuous.

   Exceptions:

   1. Existing single-story exterior walls not exceeding 10 feet (3048 mm) in length, forming an extension of floor area beyond the line of an existing continuous perimeter foundation.

   2. Porches, storage rooms and similar spaces not containing fuel-burning appliances.

4. A perimeter foundation system that is constructed of unreinforced masonry or stone.

5. Sill plates that are not connected to the foundation or that are connected with less than what is required by the building code.

   Exception: Where approved by the code official, connections of a sill plate to the foundation made with other than sill bolts may be accepted if the capacity of the connection is equivalent to that required by the building code.

6. Cripple walls that are not braced in accordance with the requirements of Section A304.4 and Table A3-A, or cripple walls not braced with diagonal sheathing or wood structural panels in accordance with the building code.

SECTION A304 STRENGTHENING REQUIREMENTS

A304.1 General.

A304.1.1 Scope.

The structural weaknesses noted in Section A303 shall be strengthened in accordance with the requirements of this section. Strengthening work may include both new construction and alteration of existing construction. Except as provided herein, all strengthening work and materials shall comply with the applicable provisions of the building code.

A304.1.2 Condition of existing wood materials.

All existing wood materials that will be a part of the strengthening work (sills, studs, sheathing, etc.) shall be in a sound condition and free from defects that substantially reduce the capacity of the member. Any wood material found to contain fungus infection shall be removed and replaced with new material. Any wood material found to be infested with insects or to have been infested with insects shall be strengthened or replaced with new materials to provide a net dimension of sound wood at least equal to its undamaged original dimension.

A304.1.3 Floor joists not parallel to foundations.

Floor joists framed perpendicular or at an angle to perimeter foundations shall be restrained either by an existing nominal 2-inch-wide (51 mm) continuous rim joist or by a nominal 2-inch-wide (51 mm) full-depth block between alternate joists in one-and two-story buildings, and between each joist in three-story buildings. Existing blocking for multistory buildings must occur at each joist space above a braced cripple wall panel.

Existing connections at the top and bottom edges of an existing rim joist or blocking need not be verified in one-story buildings. In multistory buildings, the existing top edge connection need not be verified; however, the bottom edge connection to either the foundation sill plate or the top plate of a cripple wall shall be verified. The minimum existing bottom edge connection shall consist of 8d toenails spaced 6 inches (152 mm) apart for a continuous rim joist, or three 8d toenails per block. When this minimum bottom edge-connection is not present or cannot be verified, a supplemental connection installed as shown in Figure A3-8A or A3-8C shall be provided.

Where an existing continuous rim joist or the minimum existing blocking does not occur, new 3/4-inch (19 mm) or 23/32-inch (18 mm) wood structural panel blocking installed tightly between floor joists and nailed as shown in Figure A3-9 shall be provided at the inside face of the cripple wall. In lieu of wood structural panel blocking, tight fitting, full-depth 2-inch (51 mm) blocking may be used. New blocking may be omitted where it will interfere with vents or plumbing that penetrates the wall.

A304.1.4 Floor joists parallel to foundations.

Where existing floor joists are parallel to the perimeter foundations, the end joist shall be located over the foundation and, except for required ventilation openings, shall be continuous and in continuous contact with the foundation sill plate or the top plate of the cripple wall. Existing connections at the top and bottom edges of the end joist need not be verified in one-story buildings. In multistory buildings, the existing top edge connection of the end joist need not be verified; however, the bottom edge connection to either the foundation sill plate or the top plate of a cripple wall shall be verified. The minimum bottom edge connection shall be 8d toenails spaced 6 inches (152 mm) apart. If this minimum bottom edge connection is not present or cannot be verified, a supplemental connection installed as shown in Figure A3-8B, A3-8C or A3-9 shall be provided.

A304.2 Foundations.

A304.2.1 New perimeter foundations.

New perimeter foundations shall be provided for structures with the structural weaknesses noted in Items 1 and 2 of Section A303. Soil investigations or geotechnical studies are not required for this work unless the building is located in a special study zone as designated by the code official or other authority having jurisdiction.

A304.3 Foundation sill plate anchorage.

A304.3.1 Existing perimeter foundations.

Where the building has an existing continuous perimeter foundation, all perimeter wall sill plates shall be anchored to the foundation with adhesive anchors or expansion anchors in accordance with Table A3-A.

Anchors shall be installed in accordance with Figure A3-3, with the plate washer installed between the nut and the sill plate. The nut shall be tightened to a snug-tight condition after curing is complete for adhesive anchors and after expansion wedge engagement for expansion anchors. All anchors shall be installed in accordance with manufacturer's recommendations. Where existing conditions prevent anchor installations through the sill plate, this connection may be made in accordance with Figure A3-4A, A3-4B, or A3-4C. The spacing of these alternate connections shall comply with the maximum spacing requirements of Table A3-A. Expansion anchors shall not be used where the installation causes surface cracking of the foundation wall at the locations of the bolt.

A304.4 Cripple wall bracing.

A304.4.1 General.

Exterior cripple walls not exceeding 4 feet (1219 mm) in height shall be permitted to be specified by the prescriptive bracing method in Section A304.4. Cripple walls over 4 feet (1219 mm) in height require analysis by a registered design professional in accordance with Section A301.3.

A304.5 Quality control.

All work shall be subject to inspection by the code official including, but not limited to:

1. Placement and installation of new adhesive or expansion anchors installed in existing foundations. Special inspection is not required for adhesive anchors installed in existing foundations regulated by the prescriptive provisions of this chapter.

2. Installation and nailing of new cripple wall bracing.

3. Any work may be subject to special inspection when required by the code official in accordance with the building code.

Chapter A4 – Earthquake Risk Reduction in Wood-Frame Residential Buildings with Soft, Weak or Open Front Walls

SECTION A401 GENERAL

A401.1 Purpose.

The purpose of this chapter is to promote public welfare and safety by reducing the risk of death or injury that may result from the effects of earthquakes on existing wood-frame, multi-unit residential buildings. The ground motions of past earthquakes have caused the loss of human life, personal injury and property damage in these types of buildings. This chapter creates minimum standards to strengthen the more vulnerable portions of these structures. When fully followed, these minimum standards will improve the performance of these buildings but will not necessarily prevent all earthquake-related damage.

A401.2 Scope.

The provisions of this chapter shall apply to all existing Occupancy Group R-1 and R-2 buildings of wood construction or portions thereof where the structure has a soft, weak, or open-front wall line, and there exists one or more stories above.

SECTION A402 DEFINITIONS

Notwithstanding the applicable definitions, symbols and notations in the building code, the following definitions shall apply for the purposes of this chapter:

GROUND FLOOR. Any floor whose elevation is immediately accessible from an adjacent grade by vehicles or pedestrians. The ground floor portion of the structure does not include any floor that is completely below adjacent grades.

NONCONFORMING STRUCTURAL MATERIALS. Wall bracing materials other than wood structural panels or diagonal sheathing.

OPEN-FRONT WALL LINE. An exterior wall line, without vertical elements of the lateral force-resisting system, that requires tributary seismic forces to be resisted by diaphragm rotation or excessive cantilever beyond parallel lines of shear walls. Diaphragms that cantilever more than 25 percent of the distance between lines of lateral force-resisting elements from which the diaphragm cantilevers shall be considered excessive. Exterior exit balconies of 6 feet (1829 mm) or less in width shall not be considered excessive cantilevers.

RETROFIT. An improvement of the lateral force-resisting system by *alteration* of existing structural elements or *addition* of new structural elements.

SOFT WALL LINE. A wall line whose lateral stiffness is less than that required by story drift limitations or deformation compatibility requirements of this chapter. In lieu of analysis, a soft wall line may be defined as a wall line in a story where the story stiffness is less than 70 percent of the story above for the direction under consideration.

STORY. A story as defined by the building code, including any basement or underfloor space of a building with cripple walls exceeding 4 feet (1219 mm) in height.

STORY STRENGTH. The total strength of all seismic-resisting elements sharing the same story shear in the direction under consideration.

WALL LINE. Any length of wall along a principal axis of the building used to provide resistance to lateral loads. Parallel wall lines separated by less than 4 feet (1219 mm) shall be considered one wall line for the distribution of loads.

WEAK WALL LINE. A wall line in a story where the story strength is less than 80 percent of the story above in the direction under consideration.

SECTION A403 ANALYSIS AND DESIGN

A403.1 General.

All modifications required by the provisions in this chapter shall be designed in accordance with the *International Building Code* provisions for new construction, except as modified by this chapter.

> **Exception**: Buildings for which the prescriptive measures provided in Section A404 apply and are used.

No *alteration* of the existing lateral force-resisting system or vertical load-carrying system shall reduce the strength or stiffness of the existing structure, unless the altered structure would remain in conformance to the building code and this chapter.

A403.2 Scope of analysis.

This chapter requires the *alteration, repair, replacement* or *addition* of structural elements and their connections to meet the strength and stiffness requirements herein. The lateral-load-path analysis shall include the resisting elements and connections from the wood diaphragm immediately above any soft, weak or open-front wall lines to the foundation soil interface or to the uppermost story of a podium structure comprised of steel, masonry, or concrete structural systems that supports the upper, wood-framed structure. Stories above the uppermost story with a soft, weak, or open-front wall line shall be considered in the analysis but need not be modified. The lateral-load-path analysis for added structural elements shall also include evaluation of the allowable soil-bearing and lateral pressures in accordance with the building code. Where any portion of a building within the scope of this chapter is constructed on or into a slope steeper than one unit vertical in three units horizontal (33-percent slope), the lateral force-resisting system at and below the base level diaphragm shall be analyzed for the effects of concentrated lateral forces at the base caused by this hillside condition.

Exception: When an open-front, weak or soft wall line exists because of parking at the ground floor of a two-story building and the parking area is less than 20 percent of the ground floor area, then only the wall lines in the open, weak or soft directions of the enclosed parking area need comply with the provisions of this chapter.

A403.3 Design base shear and design parameters.

The design base shear in a given direction shall be permitted to be 75 percent of the value required for similar new construction in accordance with the building code. The value of *R* used in the design of the strengthening of any story shall not exceed the lowest value of *R* used in the same direction at any story above. The system overstrength factor, Δ_0, and the deflection amplification factor, C_d, shall not be less than the largest respective value corresponding to the R factor being used in the direction under consideration.

Exceptions:

1. For structures assigned to Seismic Design Category B, values of R, Δ_0 and C_d shall be permitted to be based on the seismic force-resisting system being used to achieve the required strengthening.

2. For structures assigned to Seismic Design Category C or D, values of R, Δ_0 and C_d shall be permitted to be based on the seismic force-resisting system being used to achieve the required strengthening, provided that when the strengthening is complete, the strengthened structure will not have an extreme weak story irregularity defined as Type 5b in ASCE 7 Table 12.3-2.

3. For structures assigned to Seismic Design Category E, values of R, Δ_0 and C_d shall be permitted to be based on the seismic force-resisting system being used to achieve the required strengthening, provided that when the strengthening is complete, the strengthened structure will not have an extreme soft story, a weak story, or an extreme weak story irregularity defined, respectively, as Types 1b, 5a and 5b in ASCE 7 Table 12.3-2.

A403.4 Story drift limitations.

The calculated story drift for each retrofitted story shall not exceed the allowable deformation compatible with all vertical load-resisting elements and 0.025 times the story height. The calculated story drift shall not be reduced by the effects of horizontal diaphragm stiffness but shall be increased when these effects produce rotation. Drift calculations shall be in accordance with the building code.

A403.5 *P Δ* effects.

The requirements of the building code shall apply, except as modified herein. All structural framing elements and their connections not required by design to be part of the lateral force-resisting system shall be designed and/or detailed to be adequate to maintain support of design dead plus live loads when subjected to the expected deformations caused by seismic forces. The stress analysis of cantilever columns shall use a buckling factor of 2.1 for the direction normal to the axis of the beam.

A403.6 Ties and continuity.

All parts of the structure included in the scope of Section A403.2 shall be interconnected as required by the building code.

A403.7 Collector elements.

Collector elements shall be provided that can transfer the seismic forces originating in other portions of the building to the elements within the scope of Section A403.2 that provide resistance to those forces.

A403.8 Horizontal diaphragms.

The strength of an existing horizontal diaphragm sheathed with wood structural panels or diagonal sheathing need not be investigated unless the diaphragm is required to transfer lateral forces from vertical elements of the seismic force-resisting system above the diaphragm to elements below the diaphragm because of an offset in placement of the elements.

Wood diaphragms with stories above shall not be allowed to transmit lateral forces by rotation or cantilever except as allowed by the building code; however, rotational effects shall be accounted for when unsymmetric wall stiffness increases shear demands.

> **Exception**: Diaphragms that cantilever 25 percent or less of the distance between lines of lateral load-resisting elements from which the diaphragm cantilevers may transmit their shears by cantilever, provided that rotational effects on shear walls parallel and perpendicular to the load are taken into account.

A403.9 Wood-framed shear walls.

Wood-framed shear walls shall have strength and stiffness sufficient to resist the seismic loads and shall conform to the requirements of this section.

SECTION A404 PRESCRIPTIVE MEASURES FOR WEAK STORY

A404.1 Limitation.

These prescriptive measures shall apply only to two-story buildings and only when deemed appropriate by the *code official*. These prescriptive measures rely on rotation of the second floor diaphragm to distribute the seismic load between the side and rear walls of the ground floor open area. In the absence of an existing floor diaphragm of wood structural panel or diagonal sheathing, a new wood structural panel diaphragm of minimum thickness of 3/4 inch (19 mm) and with 10d common nails at 6 inches (152 mm) on center shall be applied.

A404.2 Minimum required retrofit.

A404.2.1 Anchor size and spacing.

The anchor size and spacing shall be a minimum of 3/4 inch (19 mm) in diameter at 32 inches (813 mm) on center. Where existing anchors are inadequate, supplemental or alternative approved connectors (such as new steel plates bolted to the side of the foundation and nailed to the sill) shall be used.

SECTION A405 MATERIALS OF CONSTRUCTION

A405.1 New materials.

New materials shall meet the requirements of the *International Building Code*, except where allowed by this chapter.

A405.2 Allowable foundation and lateral pressures.

The use of default values from the building code for continuous and isolated concrete spread footings shall be permitted. For soil that supports embedded vertical elements, Section A403.6 shall apply.

A405.3 Existing materials.

The physical condition, strengths, and stiffnesses of existing building materials shall be taken into account in any analysis required by this chapter. The verification of existing materials conditions and their conformance to these requirements shall be made by physical observation, material testing or record drawings as determined by the registered design professional subject to the approval of the *code official*.

SECTION A406 INFORMATION REQUIRED TO BE ON THE PLANS

A406.1 General.

The plans shall show all information necessary for plan review and for construction and shall accurately reflect the results of the engineering investigation and design. The plans shall contain a note that states that this retrofit was designed in compliance with the criteria of this chapter.

A406.2 Existing construction.

The plans shall show existing diaphragm and shear wall sheathing and framing materials; fastener type and spacing; diaphragm and shear wall connections; continuity ties; and collector elements. The plans shall also show the portion of the existing materials that needs verification during construction.

A406.3 New construction.

A406.3.1 Foundation plan elements.

The foundation plan shall include the size, type, location and spacing of all anchor bolts with the required depth of embedment, edge and end distance; the location and size of all shear walls and all columns for braced frames or moment frames; referenced details for the connection of shear walls, braced frames or moment-resisting frames to their footing; and referenced sections for any grade beams and footings.

SECTION A407 QUALITY CONTROL

A407.1 Structural observation, testing and inspection.

Structural observation, in accordance with Section 1709 of the *International Building Code*, shall be required for all structures in which seismic retrofit is being performed in accordance with this chapter. Structural observation shall include visual observation of work for conformance to the approved construction documents and confirmation of existing conditions assumed during design.

Structural testing and inspection for new construction materials shall be in accordance with the building code, except as modified by this chapter.

ATTACHMENT B

BASIC PROCEDURES MANUAL FEMA 306

Chapter 7.5 Unreinforced Masonry Component Guides

The following Component Damage Classification Guides contain details of the behavior modes for unreinforced masonry components. Included are the distinguishing characteristics of the specific behavior mode, the description of damage at various levels of severity, and performance restoration measures. Information may not be included in the Component Damage Classification Guides for certain damage severity levels; in these instances, for the behavior mode under consideration, it is not possible to make refined distinctions with regard to severity of damage. See also Section 3.5 for general discussion of the use of the Component Guides and Section 4.4.3 for information on the modeling and acceptability criteria for components.

URM1F	COMPONENT DAMAGE CLASSIFICATION GUIDE	System: **URM**
		Component Type: **Solid Wall**
		Behavior Mode: **Flexural Cracking/Toe Crushing/Bed Joint Sliding**

How to distinguish behavior mode:

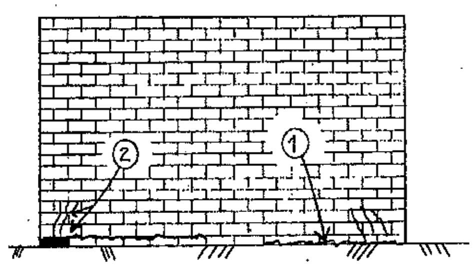
By observation:
This type of moderately ductile behavior has been experimentally observed in walls with $L/h_{eff} \approx 1.7$ in which bed joint sliding and toe crushing strength capacities are similar. Damage occurs in the following sequence. First, flexural cracking occurs at the heel of the wall. Then diagonally-oriented cracks appear at the toe of the wall, typically accompanied by spalling and crushing of the units. In some cases, toe crushing is immediately followed by a steep inclined crack propagating upward from the toe. Next, sliding occurs along a horizontal bed joint near the base of the wall, accompanied in some cases by stair-stepped bed joint sliding at upper portions of the wall. With repeated cycles of loading, diagonal cracks increase. Eventually, crushing of the toes or excessive sliding leads to failure.

By analysis:
At higher damage levels, cracking may be similar to URM1H; however, in URM1F, the bed joint sliding will occur at the base of the wall, in addition to the center of the wall. Confirm by analysis that bed joint sliding capacities are sufficiently low to trigger URM1F.

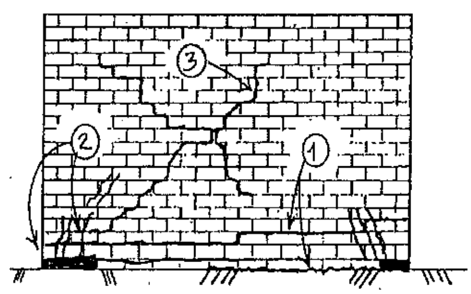
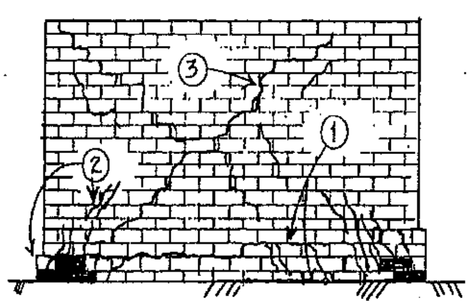
Caution: At low damage levels, flexural cracking may be similar to cracking that occurs in other modes.

Refer to Evaluation Procedures for:

- In-plane wall behavior: See Section 7.3.2

Level	Description of Damage	Typical Performance Restoration Measures
Insignificant $\lambda_K = 1.0$ $\lambda_Q = 1.0$ $\lambda_D = 1.0$ $\mu_\Delta \leq 1.5$	*Criteria:* 1. Horizontal hairline cracks in bed joints at the heel of the wall. 2. Possibly diagonally-oriented cracks and minor spalling at the toe of the wall. *Typical Appearance:* 	Not necessary for restoration of structural performance. (Measures may be necessary for restoration of nonstructural characteristics.)
Slight	Not Used	

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** — URM

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Moderate $\lambda_K = 0.9$ $\lambda_Q = 0.6$ [1] $\lambda_D = 0.9$ 1. As an alternative, calculate as V_{bjs} / V_{tc} $\Delta / h_{eff} \leq 0.8\%$	*Criteria:* 1. Horizontal cracks/spalled mortar at bed joints at or near the base of the wall indicating that in-plane offset along the crack has occurred up to approximately 1/4″. 2. Possibly diagonally-oriented cracks and spalling at the toe of the wall. Cracks extend upward several courses. 3. Possibly diagonally-oriented cracks at upper portions of the wall which may be in the units. *Typical Appearance:* 	• Replace/drypack damaged units. • Repoint spalled mortar and open head joints. • Inject cracks and open head joints. • Install pins and drilled dowels in toe regions. $\lambda_K^* = 1.0$ [1] $\lambda_Q^* = 1.0$ [1] $\lambda_D^* = 1.0$ [1] 1. In some cases, grout injection may actually increase strength, but decrease deformation capacity, by changing behavior from bed joint sliding to a less ductile behavior mode (see FEMA 307, Section 4.1.3).
Heavy $\lambda_K = 0.8$ $\lambda_Q = 0.6$ [1] $\lambda_D = 0.9$ 1. As an alternative, calculate as V_{bjs2} / V_{tc} $\Delta / h_{eff} \leq 1.2\%$	*Criteria:* 1. Horizontal bed joint cracks near the base of the wall similar to Moderate, except width is up to approximately 1/2″. 2. Possibly extensive diagonally-oriented cracks and spalling at the toe of the wall. Cracks extend upward several courses. 3. Possibly diagonally-oriented cracks up to 1/2″ at upper portions of the wall. *Typical Appearance:* 	• Replace/drypack damaged units. • Repoint spalled mortar and open head joints. • Inject cracks and open head joints. • Install pins and drilled dowels in toe regions. $\lambda_K^* = 1.0$ [1] $\lambda_Q^* = 1.0$ [1] $\lambda_D^* = 1.0$ [1] 1. In some cases, grout injection may actually increase strength, but decrease deformation capacity, by changing behavior from bed joint sliding to a less ductile behavior mode (see FEMA 307, Section 4.1.3).

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** | URM

Level	**Description of Damage**		**Typical Performance Restoration Measures**
Extreme	*Criteria:* *Typical Indications:*	• Vertical load-carrying ability is threatened • Stair-stepped movement is so significant that upper bricks have slid off their supporting brick. • Toes have begun to disintegrate. • Residual set is so significant that portions of masonry at the edges of the pier have begun or are about to fail.	• Replacement or enhancement required.

URM1H	COMPONENT DAMAGE CLASSIFICATION GUIDE	System: **URM**
		Component Type: **Solid Wall**
		Behavior Mode: **Flexural Cracking/Toe Crushing**

How to distinguish behavior mode:

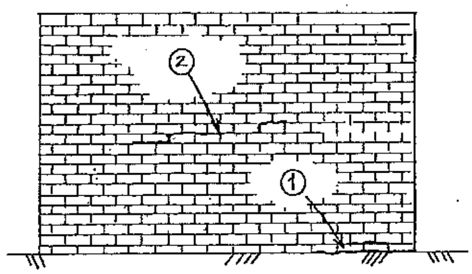
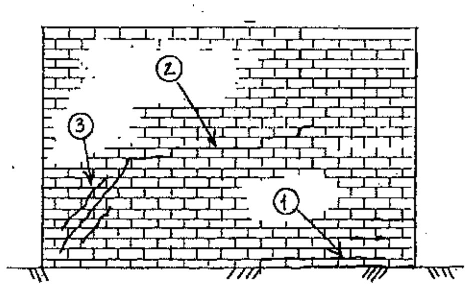
By observation:
This type of behavior typically occurs in stockier walls with $L/h_{eff} > 1.25$. Based on laboratory testing, four steps can usually be identified. First, flexural cracking happens at the base of the wall, but it does not propagate all the way across the wall. This can also cause a series of horizontal cracks to form above the heel. Second, sliding occurs on bed joints in the central portion of the pier. Third, diagonal cracks form at the toe of the wall. Finally, large cracks form at the upper corners of the wall. Failure occurs when the triangular portion of wall above the crack rotates off the crack or the toe crushes so significantly that vertical load is compromised. Note that, for simplicity, the figures below only show a single crack, but under cyclic loading, multiple cracks stepping in each direction are possible.

By analysis:
Stair-stepped cracking may resemble a form of bed joint sliding; confirm by analysis that toe crushing governs over bed joint sliding.

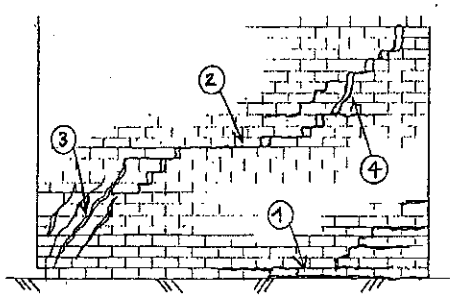
Refer to Evaluation Procedures for:

- In-plane wall behavior: See Section 7.3.2

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** — URM1H

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Insignificant $\lambda_K = 0.9$ $\lambda_Q = 1.0$ $\lambda_D = 1.0$ $\mu_\Delta \leq 1.5$	*Criteria:* 1. Horizontal hairline cracks in bed joints at the heel of the wall. 2. Horizontal cracking on 1 - 3 cracks in the central portion of the wall. No offset along the crack has occurred and the crack plane is not continuous across the pier. 3. No cracks in masonry units. *Typical Appearance:* 	Not necessary for restoration of structural performance. (Measures may be necessary for restoration of nonstructural characteristics.)
Slight	Not Used	
Moderate	Not Used	
Heavy $\lambda_K = 0.8$ $\lambda_Q = 0.8$ $\lambda_D = 1.0$ $\Delta / h_{eff} \leq 0.3\%$	*Criteria:* 1. Horizontal hairline cracks in bed joints at the heel of the wall. 2. Horizontal cracking on 1 - 3 cracks in the central portion of the wall. Some offset along the crack may have occurred. 3. Diagonal cracking at the toe of the wall, likely to be through the units, and some of units may be spalled. *Typical Appearance:* 	Replacement or enhancement is required for full restoration of seismic performance. For <u>partial</u> restoration of performance: • Repoint spalled mortar. • Inject cracks. $\lambda_K^* = 0.9$ $\lambda_Q^* = 0.9$ $\lambda_D^* = 1.0$

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** | URM1H

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Extreme $\lambda_K = 0.6$ $\lambda_Q = 0.6$ $\lambda_D = 0.9$ $\Delta / h_{eff} \leq 0.9\%$	*Criteria:* 1. Horizontal hairline cracks in bed joints at the heel of the wall. 2. Horizontal cracking on 1 or more cracks in the central portion of the wall. Offset along the crack will have occurred. 3. Diagonal cracking at the toe of the wall, likely to be through the units, and some of units may be spalled. 4. Large cracks have formed at upper portions of the wall. In walls with aspect ratios of $L/h_{eff} > 1.5$, these cracks will be diagonally oriented; for more slender piers, cracks will be more vertical and will go through units. *Typical Appearance:*  	Replacement or enhancement is required for full restoration of seismic performance. For <u>partial</u> restoration of performance: • Replace/drypack damaged units. • Repoint spalled mortar. • Inject cracks. • Install pins and drilled dowels in toe regions. $\lambda_K{}^* = 0.9$ $\lambda_Q{}^* = 0.8$ $\lambda_D{}^* = 1.0$

URM1M	COMPONENT DAMAGE CLASSIFICATION GUIDE	System: **URM**
		Component Type: **Solid Wall**
		Behavior Mode: **Out-of-Plane Flexural Response**

How to distinguish behavior mode:

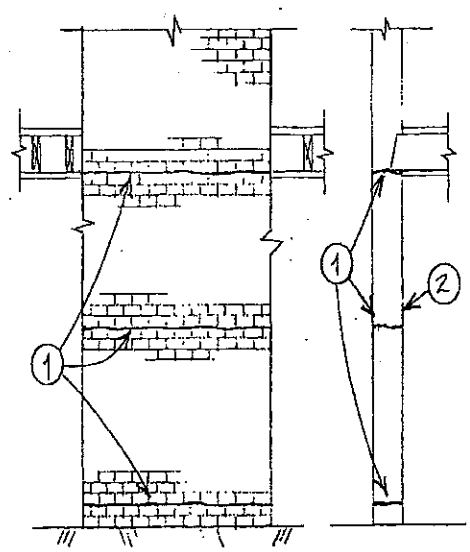
By observation:
Out-of-plane failures are common in URM buildings. Usually they occur due to the lack of adequate wall ties, as discussed in Table 7-1. When ties are adequate, the wall may fail due to out-of-plane bending between floor levels. One mode of failure observed in experiments is rigid-body rocking motion occurring on three cracks: one at the top of the wall, one at the bottom, and one at midheight. As rocking increases, the mortar and masonry units at the crack locations can be degraded, and residual offsets can occur at the crack planes. The ultimate limit state is that the walls rock too far and overturn. Important variables are the vertical stress on the wall and the height-to-thickness ratio of the wall. Thus, walls at the top of buildings and slender walls are more likely to suffer damage.

By analysis:
None required.

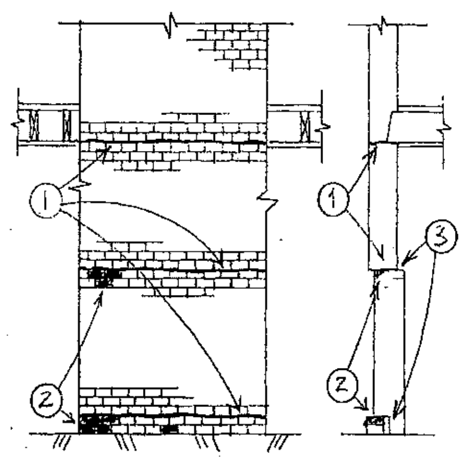
Caution:
If horizontal cracks are located directly below wall-diaphragm ties, damage may be due to bed joint sliding associated with tie damage. For piers, if horizontal cracks are observed at the top and bottom of the pier but not at mid-height, see URM2A. Confirm whether the face brick is unbonded to the backing brick. If so, the thickness in the *h/t* requirement is reduced to the thickness of the backing wythes.

Refer to Evaluation Procedures for:

- In-plane wall behavior: See Section 7.3.5

Level	Description of Damage	Typical Performance Restoration Measures
Insignificant For out-of-plane loads: $\lambda_{h/t} = 1.0$ For in-plane modes given previously, assume out-of-plane damage leads to Moderate damage for URM2B and Insignificant damage for all other modes.	*Criteria:* 1. Hairline cracks at floor/roof lines and midheight of stories. 2. No out-of-plane offset or spalling of mortar along cracks. *Typical Appearance:* 	Not necessary for restoration of structural performance. (Measures may be necessary for restoration of nonstructural characteristics.)

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** URM1M

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Slight	Not Used	
Moderate For <u>out-of-plane loads</u>: $\lambda_{h/t} = 0.9$ For *in-plane modes*, see Insignificant damage	*Criteria:* 1. Cracks at floor/roof lines and midheight of stories may have mortar spalls up to full depth of joint and possibly: 2. Out-of-plane offsets along cracks of up to 1/8″. *Typical Appearance:* See Insignificant damage above.	• Repoint spalled mortar: • For out-of-plane loads: $\lambda_{h/t} = 1.0$ • For in-plane loads: use Moderate for URM2B and Insignificant for all other modes.
Heavy For <u>out-of-plane loads</u>: $\lambda_{h/t} = 0.6$ For in-plane modes given previously, assume out-of-plane damage leads to Heavy for all other modes.	*Criteria:* 1. Cracks at floor/roof lines and midheight of stories may have mortar spalls up to full depth of joint. 2. Spalling and rounding at edges of units along crack plane. 3. Out-of-plane offsets along cracks of up to 1/2″. *Typical Appearance:* 	Replacement or enhancement is required for full restoration of seismic performance. For partial restoration of out-of-plane performance: • Replace/drypack damaged units • Repoint spalled mortar $\lambda_{h/t} = 0.8$
Extreme	*Criteria:* • Vertical-load-carrying ability is threatened *Typical Indications* • Significant out-of-plane or in-plane movement cations at top and bottom of piers (“walking”). • Significant crushing/spalling of bricks at crack locations.	• Replacement or enhancement required.

URM2A	COMPONENT DAMAGE CLASSIFICATION GUIDE	System: **URM**
		Component Type: **Weaker Pier**
		Behavior Mode: **Wall-Pier Rocking**

How to distinguish behavior mode:

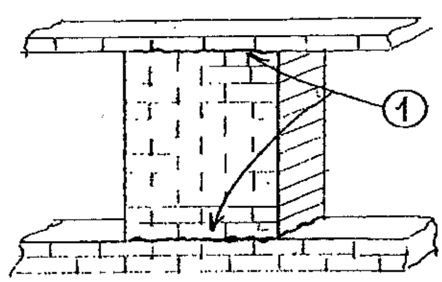
By observation:
Rocking-critical piers form horizontal flexural cracks at the top and bottom of piers. Because the cracks typically close as the pier comes back to rest at the end of ground shaking, these cracks can be quite subtle when only a few cycles of rocking have occurred and when pier drift ratios during shaking were small. As damage increases, softening of the pier can occur due to cracking, and the pier may begin to "walk" out-of-plane at the top and bottom. At the highest damage levels, crushing of units at the corners can occur.

By analysis:
As damage increases to the Moderate level and beyond, some small cracking within the pier may occur. Confirm by analysis that rocking governs over diagonal tension and bed joint sliding.

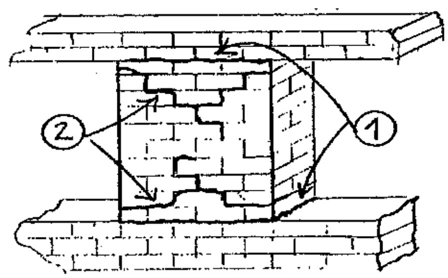
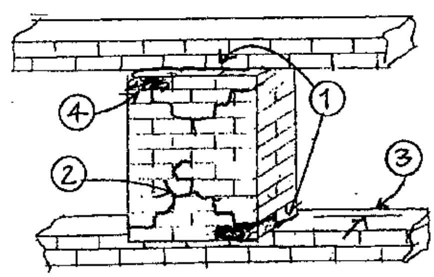
Caution: If horizontal cracks are located directly below wall-diaphragm ties, damage may be due to bed joint sliding associated with tie damage. If a horizontal crack is observed at midheight of the pier, see URM1M.

Refer to Evaluation Procedures for:

- In-plane wall behavior: See Section 7.3.2

Level	**Description of Damage**		**Typical Performance Restoration Measures**
Insignificant $\lambda_K = 0.8$ $\lambda_Q = 1.0$ $\lambda_D = 1.0$ $\mu_\Delta \leq 1.5$	*Criteria:* *Typical Appearance:*	• Hairline cracks/spalled mortar in bed joints at top and bottom of pier. 	Not necessary for restoration of structural performance. (Measures may be necessary for restoration of nonstructural characteristics.)
Slight	Not used.		

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** URM2A

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Moderate $\lambda_K = 0.6$ $\lambda_Q = 0.9$ $\lambda_D = 1.0$ $\Delta / h_{eff} \leq h_{eff} / L_{eff}^*$ 0.4%	*Criteria:* 1. Hairline cracks/spalled mortar in bed joints at top and bottom of pier. 2. Possible hairline cracking/spalled mortar in bed within piers. *Typical Appearance:*  	Replacement or enhancement is required for full restoration of seismic performance. For partial restoration of performance: • Repoint spalled mortar. $\lambda_K^* = 0.8$ $\lambda_Q^* = 0.9$ $\lambda_D^* = 1.0$
Heavy $\lambda_K = 0.4$ $\lambda_Q = 0.8$ $\lambda_D = 0.7$ $\Delta / h_{eff} \leq h_{eff} / L_{eff}^*$ 0.8%	*Criteria:* 1. Hairline cracks/spalled mortar in bed joints at top and bottom of pier, plus one or more of: 2. Hairline cracking/spalled mortar in bed joints within piers, but bed joints typically do not open. 3. Possible out-of-plane or in-plane movement at top and bottom of piers ("walking"). 4. Crushed/spalled bricks at corners of piers. *Typical Appearance:*  	Replacement or enhancement is required for full restoration of seismic performance. For partial restoration of performance: • Replace/drypack damaged units • Repoint spalled mortar • Inject cracks $\lambda_K^* = 0.8$ $\lambda_Q^* = 0.9$ $\lambda_D^* = 1.0$
Extreme	*Criteria:* *Typical Indications:* • Vertical load-carrying ability is threatened. • Significant out-of-plane or in-plane movement at top and bottom of piers ("walking"). • Significant crushing/spalling of bricks at corners of piers.	• Replacement or enhancement required.

URM2B	COMPONENT DAMAGE CLASSIFICATION GUIDE	System: **URM**
		Component Type: **Weaker Pier**
		Behavior Mode: **Bed Joint Sliding**

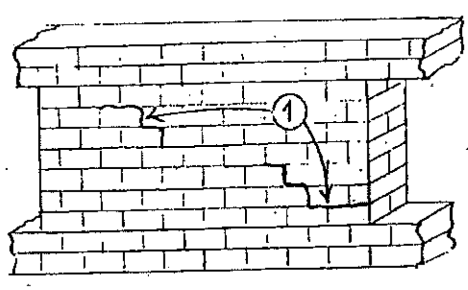
How to distinguish behavior mode:

By observation:
In this type of behavior, sliding occurs on bed joints. Commonly observed both in the field and in experimental tests, there are two basic forms: sliding on a horizontal plane, and a stair-stepped diagonal crack where the head joints open and close to allow for movement on the bed joint. Note that, for simplicity, the figures below only show a single crack, but under cyclic loading, multiple cracks stepping in each direction are possible. Pure bed joint sliding is a ductile mode with significant hysteretic energy absorption capability. If sliding continues without leading to a more brittle mode such as toe crushing, then gradual degradation of the cracking region occurs until instability is reached. Theoretically possible, but not widely reported, is the case of stair-stepped cracking when sliding goes so far that an upper brick slides off a lower unit.

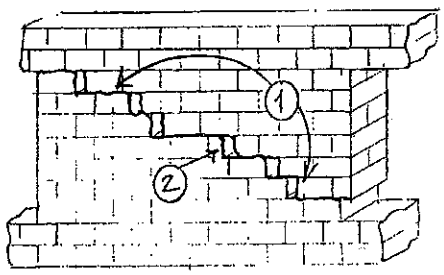
By analysis:
Stair-stepped cracking may resemble a form of diagonal tension cracking; confirm by analysis that bed joint sliding governs over diagonal tension.

Refer to Evaluation Procedures for:

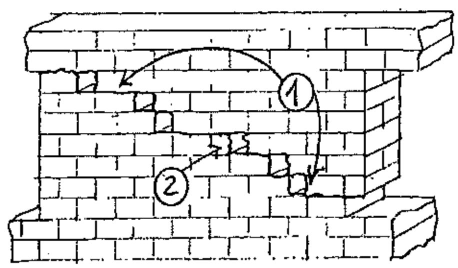
- In-plane wall behavior: See Section 7.3.2

Level	Description of Damage		Typical Performance Restoration Measures
Insignificant $\lambda_K = 0.9$ $\lambda_Q = 0.9$ $\lambda_D = 1.0$ $\mu_\Delta \le 1.5$	*Criteria:* *Typical Appearance:*	1. Hairline cracks/spalled mortar in head and bed joints either on a horizontal plane or in a stair-stepped fashion have been initiated, but no offset along the crack has occurred and the crack plane or stair-stepping is not continuous across the pier. 2. No cracks in masonry units. 	Not necessary for restoration of structural performance. (Measures may be necessary for restoration of nonstructural characteristics.)
Slight		Not used.	

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** URM2B

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Moderate $\lambda_K = 0.8$ $\lambda_Q = 0.6^*$ $\lambda_D = 1.0$ *As an alternative, calculate as V_{bjs2}/V_{bjs1} $\Delta / h_{eff} \leq 0.4\%$	*Criteria:* 1. Horizontal cracks/spalled mortar on bed joints indicating that in-plane offset along the crack has occurred and/or opening of the head joints up to approximately 1/4″, creating a stair-stepped crack pattern. 2. 5% of courses or fewer have cracks in masonry units. *Typical Appearance:* 	Replacement or enhancement is required for full restoration of seismic performance. For partial restoration of performance: • Repoint spalled mortar and open head joints. • Inject cracks and open head joints $\lambda_K^* = 0.8$ $\lambda_Q^* = 0.8^*$ $\lambda_D^* = 1.0^*$ *In some cases, grout injection may actually increase strength, but decrease deformation capacity, by changing behavior from bed joint sliding to a less ductile behavior mode (see FEMA 307, Section 4.1.3).

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** | URM2B

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Heavy $\lambda_K = 0.6$ $\lambda_Q = 0.6$* $\lambda_D = 0.9$ *As an alternative, calculate as V_{bjs2}/V_{bjs1} $\Delta / h_{eff} \leq 0.8\%$	*Criteria:* 1. Horizontal cracks/spalled mortar on bed joints indicating that in-plane offset along the crack has occurred and/or opening of the head joints up to approximately 1/2″, creating a stair-stepped crack pattern. 2. 5% of courses or fewer have cracks in masonry units. *Typical Appearance:* 	Replacement or enhancement is required for full restoration of seismic performance. For partial restoration of performance: • Repoint spalled mortar and open head joints. • Inject cracks and open head joints $\lambda_K* = 0.8$ $\lambda_Q* = 0.8$* $\lambda_D* = 1.0$* *In some cases, grout injection may actually increase strength, but decrease deformation capacity, by changing behavior from bed joint sliding to a less ductile behavior mode (see FEMA 307, Section 4.1.3).
Extreme	*Criteria:* *Typical Indications* • Vertical load-carrying ability is threatened. • Stair-stepped movement is so significant that upper bricks have slid off their supporting brick. • Cracks have propagated into a significant number of courses of units. • Residual set is so significant that portions of masonry at the edges of the pier have begun or are about to fall.	• Replacement or enhancement is required.

URM2K	COMPONENT DAMAGE CLASSIFICATION GUIDE	System: **URM**
		Component Type: **Weaker Pier**
		Behavior Mode: **Diagonal Tension**

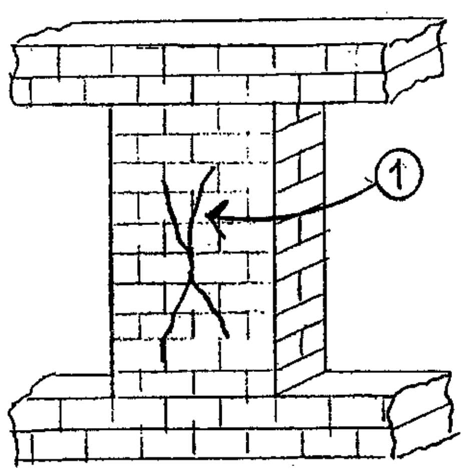
How to distinguish behavior mode:

By observation:
Typical diagonal tension cracking – resulting from strong mortar, weak units, and high compressive stress – can be identified by diagonal cracks ("X" cracks) that propagate through the units. In many cases, the cracking is sudden, brittle, and vertical load capacity drops quickly. The cracks may then extend to the toe and the triangles above and below the crack separate. In a few cases, the load drop may be more gradual with cracks increasing in size and extent with each cycle. A second form of diagonal tension cracking also has been experimentally observed with weak mortar, strong units and low compressive stress where the cracks propagate in a stair-stepped manner in head and bed joints. The first (typical) case is shown below.

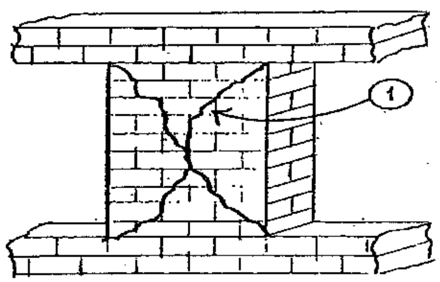
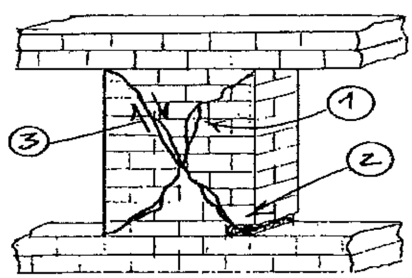
By analysis:
Since the stair-stepping form of cracking would appear similar to the early levels of stair-stepped bed joint sliding, confirm by analysis that diagonal tension governs over bed joint sliding. Since deterioration at the corners in the Heavy damage level may resemble toe crushing, also confirm that diagonal tension governs over toe crushing.

Refer to Evaluation Procedures for:

- In-plane wall behavior: See Section 7.3.2

Level	Description of Damage	Typical Performance Restoration Measures
Insignificant $\lambda_K = 1.0$ $\lambda_Q = 1.0$ $\lambda_D = 1.0$ $\mu_\Delta \leq 1$	*Criteria:* 1. Hairline diagonal cracks in masonry units in fewer than 5% of courses. *Typical Appearance:* 	Not necessary for restoration of structural performance. (Measures may be necessary for restoration of nonstructural characteristics.)
Slight	Not used.	

COMPONENT DAMAGE CLASSIFICATION GUIDE **continued** | URM2K

Level	**Description of Damage**	**Typical Performance Restoration Measures**
Moderate $\lambda_K = 0.8$ $\lambda_Q = 0.9$ $\lambda_D = 1.0$ $\mu_\Delta \approx 1.5$	*Criteria:* 1. Diagonal cracks in pier, many of which go through masonry units, with crack widths below 1/4″. 2. Diagonal cracks reach or nearly reach corners. 3. No crushing/spalling of pier corners. *Typical Appearance:* 	• Repoint spalled mortar. • Inject cracks. $\lambda_K{}^* = 0.8$ $\lambda_Q{}^* = 1.0$ $\lambda_D{}^* = 1.0$
Heavy $\lambda_K = 0.8$ $\lambda_Q = 0.9$ $\lambda_D = 1.0$ $\mu_\Delta > 1.5$	*Criteria:* 1. Diagonal cracks in pier, many of which go through masonry units, with crack widths over 1/4″. 2. Some minor crushing/spalling of pier corners and/or 3. Minor movement along or across crack plane. *Typical Appearance:* 	Replacement or enhancement is required for full restoration of seismic performance. For <u>partial</u> restoration of performance: • Replace/drypack damaged units. • Repoint spalled mortar. • Inject cracks. $\lambda_K{}^* = 0.8$ $\lambda_Q{}^* = 0.8$ $\lambda_D{}^* = 1.0$
Extreme	*Criteria:* • Vertical load-carrying ability is threatened. • Significant movement or rotation along crack plane. • Residual set is so significant that portions of masonry at the edges of the pier have begun or are about to fall. *Typical Appearance:*	• Replacement or enhancement is required

ATTACHMENT C

Excerpt from CUREE Publication No. EDA-02
For full document, go to: http://www.curee.org/projects/EDA/docs/CUREE-EDA02-2-pubiic.pdf

GENERAL GUIDELINES FOR THE ASSESSMENT AND REPAIR OF EARTHQUAKE DAMAGE IN RESIDENTIAL WOODFRAME BUILDINGS
February 2010

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Consortium of Universities for Research in Earthquake Engineering
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4 Foundations and Slabs-on-Grade

4A.3 Footings or Stem Walls

1. For footings or stem walls surrounding a crawlspace, access as much of one side as possible and as much of the other side as practical (accounting for possible obstruction by plantings, hardscape, property line limits, etc.). On the backside, seal the crack down to firm soil; on the front side (the exposed side from which the grout is injected), excavate to bottom of footing. Do not excavate beneath the footing. Clean crack, install ports, seal, and inject crack with appropriate grade material.

2. For footings or thickened edges surrounding slab-on-grade floors, only one-sided access is practical. Expose the concrete to the bottom of the footing. Do not excavate beneath the footing. Clean crack, install ports, seal, and inject crack with appropriate grade material.

3. For either one-sided or two-sided access, injection should begin at the lowest port and proceed upward to the top of the stem wall or footing.

5 Walls

5.8 Repair Methodologies

The appropriate repair of lateral system and bearing walls must consider the nature, extent, cause, and significance of the damage. Where earthquake damage has occurred in other components of the house, wall repair should be considered as one component of a more general repair plan. For example, if the house has been racked out of plumb, it should be straightened prior to repairing wall finishes, doors, and windows. Where the damage is structurally significant, a structural repair will be necessary. In all other cases, a nonstructural repair is appropriate.

Table 5-1 gives appropriate repair methods for typical earthquake damage patterns. If the cause of an observed damage pattern cannot be determined, or if the damage is outside the description given in the table, a structures specialist should be retained to specify appropriate repair. The repair methods listed in the table are further discussed below.

Note: The repair methods presented in this chapter presume that the building materials are free of regulated levels of hazardous materials. If testing as recommended in Section 9.2.4 indicates the presence of regulated levels of asbestos or lead, the abatement and waste disposal recommendations of the environmental consultant should be incorporated into the overall scope of repair.

Some California jurisdictions have local building code provisions that impose additional repair requirements if the earthquake damage exceeds either a certain percentage of the wall line's strength or if the cost of repair exceeds a certain percentage of the wall line's replacement cost. Damage patterns described above as structurally insignificant represent less than a ten percent capacity loss. Repair cost as a percentage of replacement cost may be estimated by a contractor. If the structural significance of the damage or the application of building code provisions are in question, an assessment should be performed by a structures specialist.

Table 5-1 does not include any jurisdiction-specific upgrade requirements. If such requirements apply, then an engineered repair will likely be needed.

5.8.1 Crack Repair

5.8.1.1 Stucco

- Fine cracks (i.e., 1/64-inch wide or narrower) should not be patched, especially if the stucco is not painted. On painted stucco, cracks this fine will be sealed by a fresh coat of paint. When determining the area to be painted, consideration should be given to obtaining a reasonably uniform appearance.

5.8.1.2 Drywall

- Where cracking follows panel joints or corner beads, existing tape and compound should be removed. The joint should then be retaped, retextured, and repainted. When determining the area to be retextured and repainted, consideration should be given to obtaining a reasonably uniform appearance.
- Short (less than about 6-inches long) cracks less than about 1/64-inch wide extending from the corners of openings may be patched using drywall tape and joint compound, retextured and repainted. When determining the area to be retextured and repainted, consideration should be given to obtaining a reasonably uniform appearance.
- Where cracks greater than about 6-inches long extend through the drywall, the cracked piece should be removed to the nearest stud on either side of the crack (32-inch minimum width, 48-inch height) and replaced, retextured, and repainted. When determining the area to be retextured and repainted, consideration should be given to obtaining a reasonably uniform appearance.
- Nail pops may be repaired by adding a drywall screw adjacent to the nail pop, resetting or removing the "popped" fastener, patching, retexturing to match the adjacent finish and repainting. When determining the area to be retextured and repainted, consideration should be given to obtaining a reasonably uniform appearance.

5.8.1.3 Gypsum Lath and Plaster

Where the plaster is cracked but remains firmly attached to the lath, repairs can be accomplished by cleaning the crack and patching, texturing, and painting to match the existing surface texture and finish. When determining the area to be retextured and repainted, consideration should be given to obtaining a reasonably uniform appearance.

5.8.2 Construction Joints

Where minor movement has occurred at construction joints, only cosmetic repairs are necessary. Where these joints were simply painted, the appropriate repair is to clean and repaint the joint. Where caulking and/or grout along the joints has cracked or spalled (such as along shower enclosures), the appropriate repair is to remove the cracked material, clean the separation, and recaulk or regrout the joint where necessary. It should be noted that even after the repairs are complete, cracks and/or separations may reappear due to the normal effects of material shrinkage, temperature changes, and minor differential movements of supporting elements (soil or structure). The reoccurrence of damage is unrelated to the earthquake. If damage occurred because there was no joint where there should have been one, then again, the damage is generally not structurally significant.

5.8.3 Technical Consultant Repair Recommendations

The following repair procedures are typical repairs that might be recommended in a structures specialist report. They should not be used in the absence of recommendation by a structures specialist and are presented here for reference only.

5.8.3.1 Stucco Repair

Where the stucco has buckled, delaminated, detached from the framing, or is severely cracked, the existing stucco should be removed back to intact, securely attached stucco. The underlying building paper should be repaired or replaced as necessary, and any new paper should be properly lapped with the existing paper. New wire mesh should be installed and nailed to the framing and it should overlap existing mesh by at least 6 inches. Stucco should be applied, in three coats, to match the existing thickness and surface finish. The stucco should be refinished as necessary to match adjacent areas. When determining the area to be refinished, consideration should be given to obtaining a reasonably uniform appearance.

5.8.3.2 Drywall Repair

Fractured gypsum wallboard panels should be replaced in kind. Where the attachment of the drywall to the framing has loosened significantly, new fasteners should be installed around the wall perimeter and along panel joints showing signs of relative movement. The repaired areas should be refinished as necessary to match adjacent areas. When determining the area to be refinished, consideration should be given to obtaining a reasonably uniform appearance.

5.8.3.3 Plaster Repair

Where the lath has fractured (or where plaster damage suggests fracture of the gypsum lath), the damaged pieces should be removed to soundly attached plaster and/or lath, new lath installed and the area replastered. Where larger areas of repair are involved, and it is more economical to do so, lath and plaster should be removed to the limits of the wall panel and replaced with drywall.[53] When determining the area to be refinished, consideration should be given to obtaining a reasonably uniform appearance.

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[53] If drywall is used, modification of trim at ceilings, floors, windows, and doors, may be necessary. If the plaster being replaced is 5/8-inch thick plaster reinforced with expanded metal lath over 3/8-inch gypsum lath, it may be necessary to install 1/2-inch plywood sheathing beneath the drywall to restore the strength of the wall assembly. Installation of 1/2-inch plywood will eliminate the need for modification of trim, in most cases.

5.8.3.4 Framing Repair

Severe damage to stucco or interior wall finishes indicates substantial wall racking and the possibility of damage to woodframing members, especially nailed connections at the sill or top plates. These conditions call for assessment by a structures specialist. If framing damage is found, replacement, renailing, or "sistering" of the affected members is usually the appropriate repair, but that judgment should be left to the structures specialist.

5.8.3.5 Building Realignment

When a building has been permanently racked out of plumb by more than 1/2 inch over a height of eight feet, as evidenced by a consistent pattern of damage to finishes, inoperable doors and/or windows, and out-of-plumb measurements of door and window jambs, it will generally be necessary to remove finishes from the racked walls, plumb the building, and reinstall finishes. It is essential to distinguish between overall earthquake-induced racking of the building and normal construction tolerances or other pre-existing conditions.

5.8.4 Permits, Upgrades, and Retrofits

Depending upon the nature and scope of damage and proposed repair, building permits and other government agency approvals may be required by the local jurisdiction. In addition to normal changes in the building code over time, some jurisdictions have building code requirements that mandate upgrading portions or all of the building, if certain damage thresholds are exceeded. Check with the local building department to determine the existence of any, applicable local requirements.

- For cracks up to 1/8-inch wide, the crack should be opened to the brown coat by beveling the crack edges to accept patching material. Patch with flexible vinyl base patching compound. Stucco should be applied to match the existing surface texture, as necessary. The stucco should be refinished as necessary to match adjacent areas. When determining the area to be refinished, consideration should be given to obtaining a reasonably uniform appearance.

Table 5-1. Repair methods not requiring technical consultant assistance for nominal earthquake damage to woodframe wall surface materials|

Wall Component	Earthquake Damage Pattern	Repair Method*
Stucco	Cracks up to 1/64-inch wide	No crack repair
	Cracks up to 1/8-inch wide, no delamination, no spalling	Rout, patch, and refinish
	Extensive minor cracking	Remove color coat, rout, patch, and recoat
Drywall	Short cracks up to 1/64-inch wide	Patch and refinish
	Cracks following taped joints or corner bead	Remove existing tape and joint compound, retape, and refinish
	Cracks up to 1/8-inch wide through drywall	Remove and replace drywall to nearest studs beyond crack (minimum 32 × 48 inches), refinish
	Nail pops	Add drywall screw 1 inch from original fastener, set or remove original fastener, patch and refinish
Gypsum lath and plaster	Short cracks up to 1/64-inch wide	Patch and refinish
	Cracks up to 1/8-inch wide, no delamination or significant spalling	Rout, patch, and refinish
Construction joints	Minor movement	Caulk, patch, or repaint to match pre-earthquake condition

* Repair methods presented in this table presume that the building materials are free of regulated levels of hazardous materials. If testing as recommended in Section 9.2.4 indicates the presence of regulated levels of asbestos or lead, the abatement and waste disposal recommendations of the environmental consultant should be incorporated into the overall scope of repair.

- When the number of cracks to be patched becomes extensive, it may be more economical to remove the existing finish coat with sandblasting and then apply a new finish coat. The process of sandblasting will accentuate cracks visible in the finish coat and expose cracks in the brown coat. It is important to note that cracks exposed by the sandblasting are shrinkage cracks that date from the original application of the stucco and not earthquake-induced cracking. A stucco finish coat, even if painted with latex paint, has no ability to conceal earthquake-induced cracking of stucco. When determining the area to be refinished, consideration should be given to obtaining a reasonably uniform appearance.

Appendices Section 7

7A Guidelines for Repair of Earthquake Damaged Masonry Chimneys

Following is Information Bulletin I-2004 issued by the Building and Safety Division of the Community Development Department of the City of San Luis Obispo as published on the website of the California Seismic Safety Commission (http://www.seismic.ca.gov/HOG/Chimney%20Bulletin1.pdf).

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City and County of San Francisco
Department of Building Inspection

Edwin M. Lee, Mayor
Tom C. Hui, S.E., C.B.O., Acting Director

ADMINISTRATIVE BULLETIN

NO. AB-XXX DRAFT #1

DATE : August 11, 2013

SUBJECT : Permit Processing and Issuance

TITLE : Guidelines for the Structural Review of Special Moment Frame Beam Lateral Bracing used in Light Frame Wood Construction for Seismic Applications.

PURPOSE : The purpose of this Administrative Bulletin is to establish a guideline for the structural design, analysis, plan check review and approval of Special Moment Frame Beam Lateral Bracing in Light Frame Wood Construction for Seismic Applications.

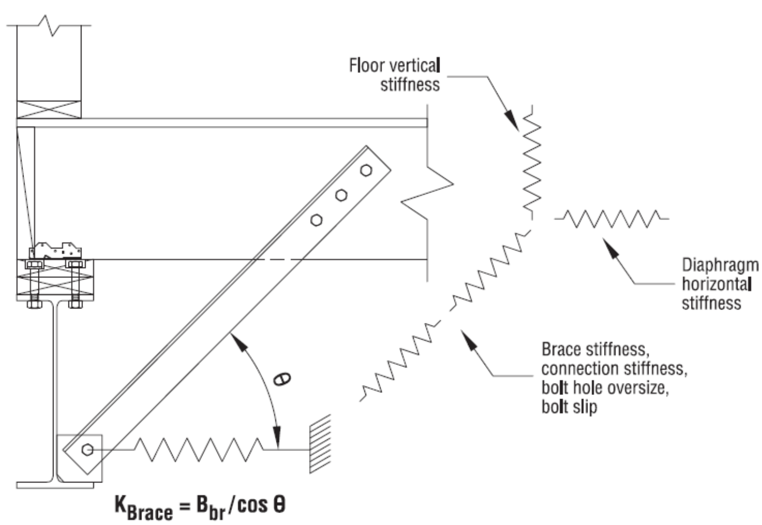
REFERENCE :
- 2013 San Francisco Building Code
- AISC 360-10, Specification for Structural Steel Buildings
- AISC 341-10, Seismic Provisions for Structural Steel Buildings
- Paul McEntee, “Steel Moment Frames – History and Evolution”, Structural Engineering Magazine-February 2009.

DISCUSSION :
:

Beams in Typical Special Moment Frames have the tendency, without lateral bracing, to twist or buckle out-of plane. AISC 360-10 Appendix 6 provides beam bracing stiffness and strength requirements and AISC 341-10, Section D2 provides the lateral bracing requirements at the beam’s plastic hinge. This administrative bulletin covers the nodal bracing of these requirements. The lateral bracing provides stability for the beam prior to the occurrence of the plastic hinge. Special Moment Frame, when incorporated into the structure’s lateral force resisting system, is expected to experience an inelastic deformation. The absence of the lateral bracing will lead to a reduction in the frame capacity and performance, which is due to the occurrence of the beam buckling failure during or prior to the formation of the plastic hinge.
Plan check review and approval of the Special Moment Frame Beam Lateral Bracing for any project shall be on a case-by-case basis in accordance with this Administrative Bulletin.
The following requirements shall be the basis for plan check review and approval for beam lateral bracing of typical special moment frames used in seismic lateral force resisting systems of light frame wood construction:

1. Both flanges of beams shall be laterally braced between the points of supports with a maximum spacing of L_b=0.086r_yE/Fy.
2. The inflection point shall not be considered a braced point unless bracing is provided at that location.
3. Braces shall meet the specifications of AISC360-10:
    a. Strength between the points of support:
        I. $P_{rb} = 0.02M_rC_d/ho$ (A-6-7)
    b. Stiffness between the points of support:
        I. $B_{br} = 1/Ø(10M_rC_d/L_bh_o)$ (A-6-8) LRFD
        II. $B_{br} = \Omega(10M_rC_d/L_bh_o)$ (A-6-8) ASD
4. Required Flexural Strength of beam:
    a. $M_r = R_yF_yZ$ (D1-1a) LRFD
    b. $Mr = R_yF_yZ/1.5$ (D1-1b) ASD
5. Bracing is required at concentrated forces, changes in cross section and where plastic hinges occur.
6. Special Bracing adjacent to the plastic hinges shall meet AISC 341-10 Seismic provisions requirements.
    a. Strength of lateral bracing
        I. $Pu=0.06\ R_yF_yZ/h_o$ (D1-4a) LRFD
        II. $Pa=(0.06/1.5)R_yF_yZ/h_o$ (D1-4b) ASD
    b. Strength of torsional bracing
        I. $Mu=0.06R_yF_yZ$ (D1-5a) LRFD
        II. $Ma=(0.06/1.5)R_yF_yZ$ (D1-5b) ASD

7. Deflection due to the oversized bolt or screw holes, the floor vertical movement, and the diaphragm horizontal movement shall be accounted for to meet the brace stiffness requirement in the aforementioned section 3b.



AB-XXX

For propriety special moment frames with the latest technologies, some of the pre-manufactured frames may not require AISC 360-10 beam bracing requirements, AISC 341-10 special beam bracing adjacent to plastic hinges or both. The propriety special moment frames shall be recognized by a current ICC-ES evaluation report in accordance with ICC-ES Acceptance Criteria for Steel Moment Frame Connection Systems (AC129). The beam bracing design shall be in compliance with the Lateral Bracing Requirements of a current ICC-ES evaluation report.