City and County of San Francisco
Department of Building Inspection

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ADMINISTRATIVE BULLETIN

NO. AB-098

DATE : 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 : 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

2010 California Historical Building Code, CCR 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

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 PRODECURES

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

Damage Pattern	Triggering Damage	
	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	
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.	

Damage Pattern	Triggering Damage	
	Substantial Structural Damage	Disproportionate Damage
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.
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 Pattern	Triggering Damage	
	Substantial Structural Damage	Disproportionate Damage
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 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.

Tom C. Hui 7/2/2012

Tom C. Hui, S.E. Date
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, multiunit 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, Ω_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, Ω_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, Ω_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, Ω_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.