**DRAFT LANGUAGE FOR SEISMIC RETROFIT CRITERIA FOR CERTAIN CONCRETE BUILDINGS AND CERTAIN RIGID-WALL-FLEXIBLE DIAPHRAGM (RWFD) BUILDINGS, APPLICABLE TO THE 2022 SAN FRANCISCO EXISTING BUILDING CODE. REFERENCE MAYOR'S DIRECTIVE 24-01.**

*The "Commentary" provides information to help users (code officials, engineers, building owners) interpret and implement the requirements. The commentary is not proposed as part of the code language but will be put into an Administrative Bulletin.*

## CHAPTER 5G: EARTHQUAKE RETROFIT CRITERIA FOR RIGID-WALL-FLEXIBLE-DIAPHRAGM BUILDINGS

### 501G – RESERVED

### 502G – RESERVED

### 503G – Definitions

**503G.1 Supplemental definitions.** In addition to or in place of definitions given in this code or in referenced provisions or regulations, the following definitions shall apply for purposes of this Chapter. The building official shall have the authority to interpret and expand any definition consistent with the intent of this Chapter.

**Rigid-wall, flexible-diaphragm building (RWFD building).** A one-story building or building portion, not counting mezzanines, with a seismic force-resisting system that would be classified by the latest edition of ASCE 41 as either PC1, RM1, or C2a with flexible roof diaphragm.

**Footprint area.** The area enclosed by the perimeter of the building where it meets grade, projected onto a horizontal plane, measured to the outside edge of the building enclosure. For purposes of this chapter, the footprint area need only consider the RWFD portions of the building.

### 504G – Structural Engineering Criteria

**504G.1 Engineering intent.** The structural criteria provided in this Chapter have been selected as appropriate to the intent of this Chapter. The structural retrofit criteria are expected to significantly reduce the collapse risk of subject buildings.

The structural retrofit criteria are intended to apply to wall anchorage systems of existing RWFD buildings to improve building performance while limiting retrofit costs and impacts. It is not the intent of this Chapter to require mitigation of all structural deficiencies, seismic or non-seismic, that might exist within or adjacent to the building. The structural criteria might not achieve the same performance as design requirements for new buildings or any full-building retrofit objective for existing buildings.

**504G.2 Structural seismic evaluation or retrofit.** Seismic retrofit or, where performed, seismic evaluation of each subject building shall comply with one of the following criteria.

**1.** Chapter A2 of the California *Existing Building Code*, as interpreted by the building official.

**2.** The latest edition of *Seismic Evaluation and Retrofit of Existing Buildings* ASCE/SEI 41 with a performance objective of Structural Collapse Prevention with the BSE-2E earthquake hazard level, as interpreted by the building official, with the scope limited to that prescribed in Chapter A2 of the California *Existing Building Code*.

**3.** For subject buildings qualified as historic, alternate building regulations of the *California Historical Building Code*, as interpreted by the building official.

### 505G – RESERVED

## CHAPTER 3: PROVISIONS FOR ALL COMPLIANCE METHODS

**Table 304.4.1: Dates required to demonstrate building compliance**

| Building type | Date of compliance | Model code (for reference) |
|---|---|---|
| Reinforced concrete moment-resisting frame (Type C1) | ~~12/28/1995~~ 7/1/1999 | UBC ~~1994~~ 1997 |
| Reinforced concrete shear walls (Types C2 & C2a) | ~~12/28/1995~~ 7/1/1999 | UBC ~~1994~~ 1997 |

**Commentary:** Per Section 503 (Alterations), certain alterations to existing buildings trigger requirements for seismic evaluation or retrofit. Per Section 304.4.1, buildings with permit dates for original construction after the benchmark dates in Table 304.4.1 are deemed to comply with such requirements. In the modifications shown here, the benchmark model code for reinforced concrete buildings is changed to the 1997 UBC because that code introduced important provisions for concrete gravity framing, i.e., members not designated as part of the seismic-force-resisting system. These changes to Table 304.4.1 are consistent with forthcoming changes to ASCE 41, which is the source of the benchmark dates in the table.

## CHAPTER 5H: EARTHQUAKE RETROFIT OF CERTAIN CONCRETE BUILDINGS

### 501H – Administration

**501H.1 Intent.** This Chapter is intended to advance public safety and improve the ability of the City and County of San Francisco to recover from a major earthquake, by reducing the likelihood of collapse of certain concrete buildings. In furtherance of this purpose, this Chapter establishes seismic retrofit requirements intended to reduce the collapse risk of the most vulnerable concrete buildings.

### 501H.2 Definitions

In addition to the definitions in San Francisco Building Code Chapter 2 and San Francisco Existing Building Code Chapter 2, the following shall apply for purposes of this Chapter:

**Wall pier.** A vertical wall segment within a structural wall, bounded horizontally by two openings or by an opening and an edge, with ratio of horizontal length to wall thickness less than or equal to 6.0, and ratio of clear height to horizontal length greater than 2.0.

**Commentary:** The definition of wall pier is per Section 2.3 of ACI 318-19.

### 501H.3 RESERVED

**501H.4 Design Professionals.** All work intended to comply with this Chapter shall be performed by appropriately licensed individuals, and all documents submitted for compliance shall be sealed by a California licensed civil or structural engineer.

**Commentary:** The State of California governs the registration of professional engineers and requires that engineers practice only in areas where they have demonstrated competence. The registration status of any licensed professional engineer can be checked at http://www.bpelsg.ca.gov/consumers/lic_lookup.shtml.

The successful execution of a seismic retrofit project and the resulting building performance in an earthquake rely heavily on the work done by the Owner's Engineer. Building owners are encouraged to seek references for the engineer that they plan to engage, and to understand the engineer's experience and qualifications applicable to the building type, size, and other characteristics.

Questions that an owner may want to ask a structural or civil engineer before selecting them include:

- Do you have experience with seismic retrofitting of concrete buildings?
- Do you have experience using the seismic evaluation and retrofit standard ASCE 41?

- Can you describe structures that you have evaluated or retrofitted that are most similar to my building?

**502H – Subject buildings**

**502H.1 General.** This Chapter applies to buildings that contain one or more of the following:

(a) vertical elements of concrete construction, such as walls or columns, that support gravity load from floors or roofs

(b) vertical elements of concrete construction that are part of the lateral-force-resisting system.

This Chapter refers to any such building as a subject building unless and until it is found to be exempt by screening. Any building for which the Department has sent notification or screening instructions referring to this Chapter is also a subject building until it is found to be exempt by screening.

**502H.2 Exemptions.** Buildings for which one or more of the following apply are exempt from compliance with this Chapter, upon submittal and Department approval of a Screening Form as required by Section 503H:

(a) **Age.** The building complies with Section 304.4.1.

**Commentary:** Exemption (a) exempts buildings designed in accordance with the benchmark dates of Table 304.4.1. A building complies with Section 304.4.1 if its original construction was after the date of compliance.

(b) **One-story.** The building has no more than one story above grade plane, as defined in SFBC Chapter 2, excluding mezzanines.

(c) **Two-story.** The building conforms to all the following:

- The building has no more than two stories above grade plane, excluding mezzanines.
- The building does not include concrete columns nor wall piers, as defined in Section 501H.2.
- The building includes a structural reinforced concrete diaphragm at the second floor, the roof, or both.

**Commentary:** Exemptions (b) and (c) relate to the total number of stories in the building, not the number of concrete stories. Per exemption (c), two-story rigid-wall-flexible-diaphragm buildings are not exempt; however, per Section 504H.4.1, two-story rigid-wall-flexible-diaphragm buildings are only required to satisfy requirements related to wall anchorage and collectors.

(d) **Complete steel frame.** Steel columns support all the gravity floor load and roof load, and steel columns are connected to steel beams.

**Commentary:** Exemption (d) is intended to exempt buildings for which the concrete walls are tied to a complete steel frame; there are no concrete columns and no concrete bearing walls, other than items such as foundation walls, retaining walls, or incidental elements not supporting substantial gravity loads. Steel frames in which the beams, columns, or both are encased in concrete, but otherwise conform to this exemption, are intended to be exempt.

(e) **Concrete used only for floors, roofs, foundations, or basements**. All concrete elements that define the building as a subject building extend less than four feet above adjacent grade.

**Commentary:** Exemption (e) is intended to exempt buildings where the only concrete elements are items such as floors (which are not vertical elements and would therefore not define the building as a subject building), foundation walls, retaining walls, or incidental elements not significantly affecting the building's seismic behavior.

(f) **Previous retrofit.** There is building permit documentation that the building has been seismically retrofitted to meet one of the following:

- Section 304.3 of the 2022 SFEBC
- Section 303.4 of the 2019 SFEBC
- Section 301.2 of the 2016 SFEBC
- Section 3401.10 of the 2013 SFBC
- Section 3401.8 of the 2010 SFBC
- Section 3403.5 of the 2007 SFBC

**Commentary:** Exemption (f) exempts buildings for which previous retrofit work satisfies triggered retrofit requirements of this Code, going back to the 2007 edition, such as retrofit work triggered by substantial structural alteration, non-structural alterations, or change of occupancy. Previous retrofit work that used the approach of 75% of the California Building Code forces satisfies this exemption. (However, the approach of 75% of the California Building Code forces is not allowed for retrofit work on concrete buildings having a permit application date after the effective date of this Chapter.)

**503H – RESERVED**

**504H – Structural engineering criteria**

**504H.1 Engineering criteria.** Each subject building that is required to comply by evaluation or retrofit shall satisfy one of the Engineering Criteria Options per Table 504H.1. Exception: For subject buildings qualified as historic, it shall be acceptable to comply with the alternate building regulations of the *California Historical Building Code*, as interpreted by the building official.

**Table 504H.1: Engineering Criteria Options**

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|---|---|
| Option (a) | Comply with all of the following:<br>1. ASCE 41 with a performance objective of Structural Collapse Prevention (S-5) with the BSE-1E earthquake hazard level.<br>2. For each seismic deficiency in Table 504H.2, demonstrate that the deficiency is not present, or address it by retrofitting. In a bulletin, the Department shall specify requirements for identifying, evaluating, and retrofitting the seismic deficiencies listed in Table 504H.2.<br>3. For all unreinforced masonry elements, ASCE 41 with a performance objective of Nonstructural Life Safety (N-C) with the BSE-1E earthquake hazard level. |
| Option (b) | Comply with all of the following:<br>1. ASCE 41 with a performance objective of Structural Collapse Prevention (S-5) with the BSE-2E earthquake hazard level.<br>2. For all unreinforced masonry elements, ASCE 41 with a performance objective of Nonstructural Life Safety (N-C) with the BSE-1E earthquake hazard level. |

**Commentary:** For Engineering Criteria Option (a), addressing the seismic deficiencies in Table 504H.2 is required, even if analysis indicates that the building satisfies Collapse Prevention for the BSE-1E earthquake level. Addressing the seismic deficiencies in Table 504H.2 is intended to enable gravity-load-resisting elements to undergo severe earthquake movements, greater than BSE-1E, while maintaining their capacity to support gravity loads. These seismic deficiencies can be critical contributors to the collapse vulnerability of concrete buildings; they do not include all possible seismic deficiencies.

**504H.2** For Engineering Criteria Option (b), item 1, the BSE-1E earthquake hazard level need not be evaluated, regardless of the Tier of evaluation.

**Commentary:** Engineering Criteria Option (b) uses the BSE-2E earthquake hazard level for Collapse Prevention, and equates to the requirements of ASCE 41 for the Basic Performance Objective for Existing Buildings (BPOE) except that non-structural evaluation and retrofitting is limited to elements of unreinforced masonry as indicated in Section 504H.3. Addressing the seismic deficiencies specified in Table 504H.2 is not necessarily required in meeting Engineering Criteria Option (b). For buildings assigned to Risk Category I or II, the criteria for Engineering Criteria Option (b) will typically also provide compliance with triggered retrofit requirements for Substantial Alteration.

Evaluation of the Life Safety performance level for the BSE-1E earthquake level need not be evaluated, because for San Francisco earthquake hazard parameters, it will not govern over Collapse Prevention for the BSE-2E level. This is because the ratio between these earthquake ground motion levels is typically around 1.8, while the ratio between the Collapse Prevention and Life Safety acceptability limits in ASCE-41 does not exceed 4/3.

The option (in Section 304.3.1) to use 75 percent of the prescribed forces of the new building code is not permitted for use in this Chapter because this option does not make clear how to address (a) the design of gravity framing for imposed deformations and (b) a concrete seismic-force-resisting system that does meet detailing requirements of any system that is permitted in high seismic design categories.

Buildings assigned to Risk Category III or IV, for the purposes of this Chapter, are permitted to meet the performance objective for Risk Category II (Structural Collapse Prevention (S-5) for the BSE-2E earthquake hazard level).

**504H.3 Nonstructural components.** For either Engineering Criteria Option, unreinforced masonry shall be removed or retrofitted to satisfy Nonstructural Life Safety performance at the BSE-1E level.

**Commentary:** This requirement addresses the safety risk from elements such as unreinforced masonry chimneys, hollow clay tile partitions, and brick masonry walls falling out-of-plane. Except for these elements, this Chapter does not require seismic retrofitting of nonstructural components.

**504H.4 Flexible diaphragms.** For buildings with one or more flexible diaphragms, compliance with Chapter A2 are sufficient to comply with the portions of these requirements related to the wall anchorage system and collectors.

**504H.4.1 Two-story rigid-wall-flexible-diaphragm buildings.** For buildings satisfying all of the following, compliance with Chapter A2 is sufficient to meet the structural requirements of this Chapter:

(a) The building has no more than two stories above grade plane, excluding mezzanines.

(b) The building does not include concrete columns nor wall piers, as defined in Section 501H.2.

(c) The building's floor and roof diaphragms are both flexible in-plane, meaning sheathed with plywood, wood decking (e.g., 1x or 2x), or metal deck without concrete topping slab.

**Commentary:** One-story rigid-wall-flexible-diaphragm buildings are addressed in Chapter 5G. Two-story rigid-wall-flexible diaphragm buildings are addressed by this section, which specifies, similar to Chapter 5G, that the wall-to roof diaphragm and wall-to-floor diaphragm anchorage system and collectors are the only structural aspects of such buildings that are required to be addressed per this Chapter.

**504H.5 Building separation.** Where buildings abut adjacent properties, building separation limitations (e.g. Section 7.2.13 of ASCE 41) need not be considered. For separation joints within the same property, the potential for pounding at the separation joints shall be considered in seismic evaluation and retrofit design.

**504H.6 Liquefaction or landslide risk.** If the building is located in a zone of high or very high risk of soil liquefaction or landslide, as indicated by [xxx map], the Owner's Engineer shall notify the Owner in writing of this and provide the owner with their professional opinion on voluntary measures or additional investigations that could be taken to address the risk. Otherwise, soil liquefaction, lateral spreading, and landslide need not be addressed in the seismic evaluation or retrofit design.

**Commentary:** This exemption from consideration of the geotechnical hazards of liquefaction and landslide does not apply to lateral earth pressure. For example, for buildings that are subject to the requirements of this Chapter, forces from earth pressure on walls shall be considered in the analysis in combination with other forces on the structure.

**504H.7 Other retrofit triggers.** If the project involves a Substantial Structural Alteration as defined in Section 503.11 or Non-structural Alteration as defined in Section 503.11.1 , the building shall meet the more restrictive of the provisions of this Chapter and those of Section 304.4 (Minimum lateral force for existing buildings).

**504H.8 Masonry infill.** For subject buildings with masonry infill, the seismic evaluation and retrofitting shall account for the effect of the infill considering ASCE 41 requirements, and for Tier 2 and Tier 3 evaluations shall consider:

- The peak strength that the infill can develop
- The potential for strength degradation of the infill
- The potential for a weak story or story concentration of deformation, because of the locations of infill in the building, or because of potential concentrations of damage to infill
- Plan torsion effects because of the location of infill in the building, or because of potential concentrations of damage to infill.

**Table 504H.2: Seismic deficiencies to be addressed by Engineering Criteria Option (a)**

**Weak story:** The structure includes one or more stories having lateral strength less than the story above.

**Lateral-force-resisting-element irregularity:** The lateral force-resisting system includes one or more concrete walls or frames that are not continuous to the foundation.

**Non-ductile moment frame:** The main lateral-force-resisting-system includes concrete moment frames that do not satisfy strong-column-weak-beam requirements or that have shear-governed columns or beams.

**Shear-governed concrete column or wall pier:** The structure includes one or more concrete columns or wall piers that is shear-governed and is susceptible to failure resulting in loss of gravity load support.

**Punching shear in concrete slab:** One or more concrete floor or roof slabs is supported by one or more columns without beams framing into the column and is susceptible to loss of gravity load support following punching shear failure.

**Weak connection of concrete wall to flexible diaphragm:** The structure includes one or more concrete walls connected to one or more flexible diaphragms, where the wall is not adequately anchored to the diaphragm.

**Inadequate length of bearing connection:** One or more concrete beams or slabs is supported by a bearing connection with short bearing length.

| **Commentary:** The following are recommended requirements for identifying, evaluating, and retrofitting the seismic deficiencies listed in Table 504H.2, to be specified and clarified in a bulletin. | | |
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| **Potential deficiency** | **Requirements** | **Commentary** |
| **Weak story:** The structure includes one or more stories having lateral strength less than the story above. | The structure shall not have vertical structural irregularity of Type 5a nor Type 5b in Table 12.3-2 of ASCE 7 | If the structure has a weak story or extreme weak story, to meet Engineering Criteria Option (a) the weak story must be eliminated by retrofitting. Otherwise the structure must meet Engineering Criteria Option (b) |
| **Lateral-force-resisting-element irregularity:** The lateral-force-resisting system includes one or more concrete walls or frames that are not continuous to the foundation. | The building shall not have a horizontal structural irregularity Type 4 of Table 12.3-1 or vertical structural irregularity Type 4 of Table 12.3-2 of ASCE 7. | If the structure has either of the specified irregularities—in-plane or out-of-plane offset or discontinuity—to meet Engineering Criteria Option (a), the irregularity must be eliminated by retrofitting. Otherwise the structure must meet Engineering Criteria Option (b) |
| **Non-ductile moment frame:** The main lateral-force-resisting-system includes concrete moment frames that do not satisfy strong-column-weak-beam requirements or that have shear-governed columns or beams. | Comply with all of the following:<br>1. Moment frame columns shall satisfy Section 18.7.3 of ACI 318 and Section 18.7.6.1 of ACI 318.<br>2. Moment frame beams shall satisfy Section 18.6.5.1 of ACI 318. | Section 18.7.3 requires strong-column weak-beam strength proportions. Section 18.6.6.1 requires columns to be flexure governed. Section 18.6.5.1 requires beams to be flexure governed. Such requirements are essential for ductile behavior of concrete moment frames. |

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| **Shear-governed concrete column or wall pier:** The structure includes one or more concrete columns or wall piers that is shear-governed and is susceptible to failure resulting in loss of gravity load support. | For each column or wall pier, comply with at least one of the following:<br><br>1. Columns and wall piers shall have design shear strength satisfying Section 18.7.6.1 of ACI 318 or greater than the maximum shear that can be delivered to the column or wall pier. For wall piers, joint faces shall be taken as the top and bottom of the clear height of the wall pier.<br><br>2. Provide or demonstrate an alternate load path to support design gravity load assuming a failure of the column or wall pier such that it cannot support gravity load.<br><br>3. For wall piers in buildings that do not have a torsion irregularity ratio *TIR* per Section 12.3.2.1.1 of ASCE 7 exceeding 1.4, demonstrate compliance with the Tier 1 Quick Check for shear stress in concrete walls in that story in each plan direction per Section 4.4.3.3 of ASCE 41. Pseudo seismic force *V* shall be 2 times the pseudo seismic force at the BSE-1E earthquake level, but need not exceed that at BSE=2E. System modification factor $M_s$ shall be for Collapse Prevention performance. | 1. Shear governed columns or wall piers can be a serious deficiency that leads to building collapse. Retrofitting columns or wall piers by jacketing, such as with fiber reinforced polymer (FRP), can be used to make the elements flexure governed.<br><br>2. If failure of columns or wall piers can be shown not to cause collapse because of an alternate load path for gravity load, the shear-governed behavior is permitted.<br><br>An example of an acceptable alternate load path is a beam that can span over a failed column or wall pier to supports not susceptible to failure, or an added column adjacent to the susceptible column or wall pier. The alternate load path is to be a complete load path, i.e. to the foundation and supporting soil, that does not rely on non-compliant elements.<br><br>3. If the building meets the quick-check for shear at the specified level and does not have a *TIR* greater than 1.4, it is judged that there is enough wall that the consequences of shear failure of wall piers will be limited. Option 3 is not permitted for structures with high plan-torsion irregularity because of a concern that columns or wall pier on one side of the building plan could suffer undo damage in such a case. |

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| **Punching shear in concrete slab:** One or more concrete floor or roof slabs is supported by columns without beams and is susceptible to loss of gravity load support following punching shear failure. | Comply with one or more of the following:<br><br>1. Demonstrate compliance with Section 18.14.5 of ACI 318 with earthquake force *E* and design story drift $\Delta_x$ taken as 2 times the earthquake force and story drift at the BSE-1E earthquake level, but need not exceed that at BSE-2E, determined in accordance with Section 7.4. of ASCE 41.<br><br>2. Demonstrate compliance with at least one of the following in each plan direction at each column:<br><br>(a) Section 8.7.4.2.2 of ACI 318. The slab bottom bars must be continuous through the column or spliced using mechanical or welded splices.<br><br>(b) Section 8.7.5.6 of ACI 318.<br><br>3. Provide an alternate load path to support design gravity load, assuming a failure at the slab-column interface such that the slab-column interface cannot support gravity load. | 1. Section 18.14.5 addresses acceptable punching shear stress from gravity load as a function of story drift, a key indicator of susceptibility to punching shear of slab-column connections.<br><br>2. Section 8.7.4.2.2 requires two slab bottom bars to pass between the column cage longitudinal bars in each plan direction. Section 8.7.5.6 requires two prestressing tendons to pass through the column cage in each plan direction. The slab bottom bars or tendons help prevent collapse of the slab if punching shear initiates.<br><br>3. If the existing condition is susceptible to punching shear, a possible retrofit solution is to provide a path of support such as a collar at the top of a column that supports the bottom of the slab beyond the expected punching shear failure plane. |
| **Weak connection of concrete wall to flexible diaphragm:** The structure includes one or more concrete walls supporting one or more flexible diaphragms, where the wall is not adequately anchored to the diaphragm. | For each flexible floor or roof diaphragm, comply with Chapter A2, or ASCE 41 with a performance objective of Structural Collapse Prevention with the BSE-2E earthquake level. | The objective of this item is to make it unlikely that a concrete wall will separate from a flexible floor or roof diaphragm in a way that could lead to floor or roof collapse.<br><br>For floor or roof diaphragms that have timber framing in combination with a complete grid of concrete floor beams, Chapter A2 may be used to demonstrate that existing concrete floor beams are connected to the walls in such a way that they resist out-of-plane forces on the walls at least equal to the forces prescribed in Chapter A2. |

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| **Inadequate length of bearing connection:** One or more beams or slabs is supported by a bearing connection with short bearing length. | Provide bearing length to support gravity load, such that the bearing length satisfies all of the following:<br><br>1. Section 18.14.4.1(d) of ACI 318.<br><br>2. Two times the displacement demand at the BSE-1E earthquake level, determined in accordance with Section 7.4 of ASCE 41, but need not exceed that at BSE-2E. | In some cases, including at building expansion joints, concrete floor structures, either cast-in-place or precast, have bearing supports. In older structures such bearing supports may not have adequate bearing length compared to earthquake displacement demands.<br><br>1. Section 18.14.4.1(d) requires a bearing length of 5 inches for beams, or 2 inches + L/180 for slabs. |