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CITY OF OAKLAND

SAFER HOUSING FOR OAKLAND PROGRAM (SHOP)

Annotated Edition of 2016 CEBC Chapter A4

This document combines the text of 2016 CEBC Chapter A4 with interpretations, commentary and additional requirements established by the Safer Housing for Oakland Program (SHOP). It is provided only for the convenience of program participants.

Revisions to CEBC provisions are shown in strikeout/underline format. Commentary is shown indented and italicized.

A complete description of program guidelines, including administrative provisions not shown here, is available at the program website:
https://www.oaklandca.gov/resources/safer-housing-for-oakland-program-shop

Excerpt from SHOP Engineering Requirements, Part B (12.14.2018)

B.1 Reference code. Required seismic retrofit work, as described in Section A.1.5, shall comply with Appendix Chapter A4 of the current edition of the *California Existing Building Code* (Chapter A4), as adopted and amended by Oakland Municipal Code Title 15 and as further modified and interpreted by Section B.2 of these Requirements. Any code references shall be construed to apply to the corresponding provisions of the *California Building Code* (CBC), the *California Existing Building Code* (CEBC), and their reference standards, as adopted and amended by the City of Oakland.

> ***Commentary:*** *The current CEBC is the 2016 edition. When the 2019 CEBC becomes effective, it will be applicable instead. The 2019 Chapter A4 will be based on the 2018 International Existing Building Code (IEBC) and is essentially identical to the 2015 IEBC (and 2016 CEBC) versions. Both editions as published by ICC are available in read-only mode at https://codes.iccsafe.org/public/collections/I-Codes. Until the 2019 CEBC becomes effective, the 2018 IEBC Chapter A4 may be used instead of the 2016 CEBC Chapter A4, with building official approval.*
> *Since SHOP criteria already involve a FEMA historic preservation review, these Requirements do not allow the use of the California Historical Building Code as alternative criteria.*
> *The commentary below also refers in places to FEMA P-807 (May 2012), titled Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings With Weak First Stories, available at: https://www.fema.gov/media-library-data/20130726-1916-25045-2624/femap_807.pdf*

Annotated CEBC Chapter A4

EARTEARTHQUAKE 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.~~

> ***Commentary:*** *In the context of SHOP, the applicability of Chapter A4 is established by program rules and procedures, reflected in part by Part A of the SHOP Engineering Requirements.*

SECTION A402
DEFINITIONS

A402.1 Definitions. Notwithstanding the applicable definitions, symbols and notations in the building code, the following definitions shall apply for the purposes of this chapter:

ASPECT RATIO. The span-width ratio for horizontal diaphragms and the height-length ratio for shear walls.

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.

> ***Commentary:*** *Within Chapter A4, the term ground floor generally means a target story. Alternately, depending on context, ground floor might mean the floor level at the base of a target story.*

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.~~

> ***Commentary:*** *This definition is omitted because it is unnecessary and to avoid conflict with "expected story strength" as used in Section A403.3.1. It is used only once in Chapter A4, in the definition of "weak wall line." See that definition for the clarification needed there.*

TARGET STORY. Either (1) a basement story or underfloor area that extends above grade at any point or (2) any story above grade, where the wall configuration of such basement, underfloor area, or story is substantially more vulnerable to earthquake damage than the wall configuration of the story above, except that a story is not a target story if it is the topmost story or if the difference in vulnerability is primarily due to the story above being a penthouse or an attic with a pitched roof.

> ***Commentary:*** *This definition is added as a preferred way to refer to the structural deficiency of interest in Chapter A4 and the subject of required seismic retrofit work within SHOP.*
>
> - *The definition simplifies and clarifies the Chapter A4 terminology. Chapter A4 and these Requirements call for consideration of whole stories, but Chapter A4 only defines its critical deficiencies in terms of wall lines and does not clearly recognize complexities posed by sloped sites (e.g. the target story might not be the ground story, and a building might have more than one target story). That said, any story that contains a soft wall line, a weak wall line, or an open-front wall line as defined in Chapter A4 would normally be considered a target story.*
> - *Because the definition is not quantitative, it usefully relies on the judgment of voluntary participants in SHOP and their consultants; any building accepted for participation in the program should be considered to have a qualifying target story.*
> - *By including underfloor areas, the definition avoids confusion about crawl spaces and the code definition of "story," especially on sloped sites.*
> - *The definition facilitates coordination with similar programs in Berkeley and San Francisco and with an ordinance recently introduced in Oakland.*

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 to be 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. For purposes of this definition, nonconforming structural materials shall not be considered.

Commentary: *See the commentary at the definition of "story strength."*

WOOD FRAME TARGET STORY. A target story in which a significant portion of lateral or torsional story strength or story stiffness is provided by wood frame walls.

Commentary: *Together with the definition of target story, this definition identifies the deficiency of interest in Chapter A4 and the subject of required seismic retrofit work within SHOP. As with the definition of target story, the definition relies intentionally on the judgment of SHOP participants, and any building accepted for participation in the program should be considered to have a qualifying wood frame target story.*

SECTION A403
ANALYSIS AND DESIGN

A403.1 General. All modifications required by the provisions in this chapter shall be designed in accordance with the *California Building Code* provisions for new construction, except as modified or otherwise allowed by this chapter and by the SHOP Engineering Requirements.

~~**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.

Commentary: *The exception is omitted because the additional phrase "or otherwise allowed" makes it moot.*

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 wood frame target story ~~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 wood frame 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 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.~~

Commentary: *By substituting the definition of wood frame target story, this modification clarifies the scope of work. (It also makes the two sentences about podium structures and hillside*

conditions largely moot.) The exception is omitted because it improperly focuses on individual wall lines; any reduced retrofit scope should be justified by full-story calculations. Also, many cases that would be covered by the exception are also covered by the prescriptive solution of Section A404.

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~~ $\underline{\Omega_0}$, and the deflection amplification factor, C_d, shall be not 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~~ $\underline{\Omega_0}$ 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~~ $\underline{\Omega_0}$ 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~~ $\underline{\Omega_0}$ 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.

4. For retrofit systems involving different seismic force-resisting systems in the same direction within the same story, resisting elements are permitted to be designed using the least value of *R* for the different structural systems found in each independent line of resistance if the following conditions are met: (1) The building is assigned to Risk Category I or II (2) The building height is no more than four stories above grade plane, and (3) the seismic force-resisting systems of the retrofitted building comprise only wood structural panel shear walls, steel moment-resisting frames, steel cantilever columns, and steel braced frames. Values for C_d and Ω_0 shall be consistent with the *R* value used.

5. With reference to ASCE 7 Table 12.2-1, building height limitations on certain seismic force-resisting systems are not applicable where those systems are used only for retrofit of target stories.

Commentary: *More than one of the exceptions to Section 403.3 can apply in a single building. Added Exception 4 implements the SEAONC recommendation to allow retrofit schemes that involve different structural systems on different lines. Without this exception, a retrofit using an intermediate or ordinary steel frame along one line and wood structural panels elsewhere would be forced to over-design the wood elements. Exception 5 recognizes that height limits applicable when certain structural systems are used for a whole building should not apply when the same system is used only within a single story. In this regard, Exception 5 is like Exceptions 1 through 3, in that it decouples the design of the new retrofit system from non-conforming conditions in the existing structure. Where applicable, the allowance for a capped base shear coefficient in ASCE 7*

Section 12.8.1.3 may be applied so that the value of $0.75S_{DS}$, including the 75 percent factor allowed by Chapter A4 Section A403.3, need not be taken greater than 1.00.

A403.3.1 Expected story strength. 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 1.7 times the expected strength of the story immediately above in a two-story building, or 1.3 times the expected strength of the story immediately above in a three-story or taller building, 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. Calculation of expected 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. The strength of a wall line may be reduced to account for inadequate load path or overturning resistance.

Commentary: *This added provision implements the SEAONC recommendation to cap the required strength, consistent with FEMA P-807. The expected strength of the story above may be calculated using the FEMA P-807 criteria. If the strength is reduced to account for an inadequate load path, as allowed, the load path should be documented by field observation and condition assessment; otherwise, the strength calculation should assume an adequate load path to avoid underestimating the upper story strength.*

A403.3.2. Seismicity parameters, Site Class, and geologic hazards. Any building located in an area labeled "NEHRP E" on the latest USGS map of "Soil Type and Shaking Hazard in the San Francisco Bay Area" shall be assigned to Site Class E unless site-specific investigation in accordance with ASCE 7 Chapter 20 indicates otherwise. For any site designated as Site Class E, the value of F_a shall be taken as 1.3. Site-specific procedures are not required for compliance with the SHOP Engineering Requirements. The SHOP Engineering Requirements do not require mitigation of existing geologic site hazards such as liquefiable soil, fault rupture, or landslide.

Commentary: *Other than this provision regarding Site Class E, Site Class shall be determined following the normal procedures for new construction, including the use of Site Class D as a default.*

The USGS map of Bay Area site classes is at https://earthquake.usgs.gov/hazards/urban/sfbay/soiltype/map/.

Seismic hazard parameters as needed may be obtained from the USGS application, using "2015 IBC" as the Design Code Reference Document, at https://earthquake.usgs.gov/designmaps/us/application.php.

The USGS application, however, does not implement the additional requirement to take F_a as 1.3 in Site Class E; engineers will need to make that adjustment separately. This requirement implements a SEAONC recommendation related to observed performance and recorded ground motions in the Loma Prieta earthquake.

The site-specific ground motion procedures normally required by ASCE 7 Section 11.4.8 are waived for these voluntary retrofit projects. Many buildings eligible for SHOP or CEBC Chapter A4 would be exempt from site response analysis by the exception to ASCE 7 Section 20.3.1.

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 where these effects produce rotation. Drift calculations shall be in accordance with the building code.

A403.4.1 Pole structures. The effects of rotation and soil stiffness shall be included in the calculated story drift where lateral loads are resisted by vertical elements whose required depth of embedment is determined by pole formulas. The coefficient of subgrade reaction used in deflection calculations shall be based on a geotechnical investigation conducted in accordance with the building code.

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 expected gravity loads when subjected to the expected deformations caused by seismic forces. Increased demand due to P Δ effects and story sidesway stability shall be considered in retrofit stories that rely on the strength and stiffness of cantilever columns for lateral resistance.

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.~~

> ***Commentary:*** *This provision is omitted because it conflicts with the overall intent of Section A403.2. Section A403.2 already requires a complete load path between the soil interface and the diaphragm above the uppermost target story. Collector elements, as needed, are already part of that load path (as are the diaphragms covered in Section A403.8). The "other portions of the building" mentioned in Section A403.7, however, would seem to conflict with the allowance in Section A403.2 that these other portions "need not be modified." The intent of the SHOP Engineering Requirements is that of Section A403.2.*

~~**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. Rotational effects shall be accounted for where asymmetric wall stiffness increases shear demands.~~

A403.8. Floor diaphragms. Floor diaphragms within the scope of Section A403.2 shall be shown to have adequate strength at the following locations:

1. For straight lumber sheathed diaphragms without integral hardwood flooring: Throughout the diaphragm. At the discretion of the building official, this requirement may be waived where the condition occurs only in relatively small portions of each dwelling unit.

2. For other diaphragms: At locations where forces are transferred between the diaphragm and a new or strengthened vertical element of the seismic force-resisting system. Collector elements may be provided to distribute the transferred force over a greater length of diaphragm.

Exception: Where the existing vertical elements of the seismic force-resisting system are shown to comply with the SHOP Engineering Requirements by evaluation, the diaphragm immediately above each target story need not be evaluated.

> ***Commentary:*** *This replacement implements a SEAONC recommendation considered appropriate for the limited objective of Chapter A4. The exception allows compliance by evaluation to focus on the vertical SFRS elements – the walls and frames – without considering a diaphragm deficiency by itself to justify an intrusive retrofit. This exception is not expected to apply to voluntary retrofits like those within SHOP; it is more for cases of mandatory or triggered retrofit.*
>
> *Straight lumber sheathed diaphragms without integral hardwood flooring are weaker and more flexible than other diaphragm systems. Though there are no known collapses due to this condition, expected poor performance could compromise the building's ability to meet even the limited objective of Chapter A4. Integral hardwood flooring – but not newer "floating" wood flooring – provides significant added strength and stiffness. Even in buildings with original hardwood flooring, some remodeled, carpeted, or tiled areas might have had the original wood flooring removed. Areas of the diaphragm that form a roof for the target story (such as the portion of a garage that extends beyond the wall line above, or at a lightwell or building setback) are also unlikely to have hardwood flooring to supplement the straight sheathing. These areas should be identified as part of the condition assessment and evaluated. Small isolated areas without hardwood flooring are not expected to affect overall building performance, so the provision grants a waiver for these cases. As a rule of thumb, an area up to 150 square feet per unit might represent such an acceptable condition.*
>
> *For other less vulnerable diaphragm types, the provision requires a local check for each new or strengthened SFRS element but does not require an overall analysis of the full diaphragm. The unit shear demand at each vertical element is calculated as the force in the element divided by the total length of the element and its collectors. The shear demand is then compared to the unit shear capacity of the diaphragm. Where demand is greater than capacity, either the diaphragm must be strengthened or the collector lengthened. An existing diaphragm can be strengthened by adding a wood structural panel soffit to the bottom of the floor joists in the critical area. Diaphragm capacity need not be checked at existing vertical elements that are not strengthened because (except for straight lumber sheathed diaphragms) it is assumed that the unit capacities of the existing vertical elements and the diaphragm are comparable.*

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. Where new sheathing is applied to existing studs to create new wood-framed shear walls, the new wall elements shall be designed as bearing wall systems.

> ***Commentary:*** *Since existing studs are presumed to carry existing gravity loads, the walls they frame must be considered bearing walls, as opposed to "building frame" systems. This affects the selection of seismic design coefficients R, C_d,* and *Ω_0.*

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, whether or not new elements are added to mitigate the soft, weak or open-front condition.~~ Gypsum or cement

plaster products shall not be used to provide the strength required by Section A403.3 or the stiffness required by Section A403.4.

> ***Commentary****: Since Chapter A4 is based on code provisions for new construction, code provisions and standards that allow like materials do not apply, and non-conforming materials are not allowed to be counted toward the minimum required strength. They must be considered, however, if the cap in Section 403.3.1 is applied, which is why the provision is modified.*

A403.9.2 Wood structural panels.

A403.9.2.1 Drift limit. Wood structural panel shear walls shall meet the story drift limitation of Section A403.4. Conformance to the story drift limitation shall be determined by approved testing or calculation. Individual shear panels shall be permitted to exceed the maximum aspect ratio, provided the allowable story drift and allowable shear capacities are not exceeded.

A403.9.2.2 Openings. Shear walls are permitted to be designed for continuity around openings in accordance with the building code. Blocking and steel strapping shall be provided at corners of the openings to transfer forces from discontinuous boundary elements into adjoining panel elements. Alternatively, perforated shear wall provisions of the building code are permitted to be used.

A403.9.3 Hold-down connectors.

A403.9.3.1 Expansion anchors in tension. Expansion anchors that provide tension strength by friction resistance shall not be used to connect hold-down devices to existing concrete or masonry elements.

A403.9.3.2 Required depth of embedment. The required depth of embedment or edge distance for the anchor used in the hold-down connector shall be provided in the concrete or masonry below any plain concrete slab unless satisfactory evidence is submitted to the code official that shows that the concrete slab and footings are of monolithic construction.

A403.10 Steel retrofit systems. Steel retrofit systems shall have strength and stiffness sufficient to resist the seismic loads and shall conform to the requirements of this section.

A403.10.1 Special moment frames. Steel special moment frames shall comply with all applicable provisions of AISC 341, including but not limited to connection design and lateral bracing of beams.

Exception: The "strong-column/weak-beam" provision of AISC 341-10, Section E3.4a is waived, provided that the columns carry no gravity load.

It is permitted to employ approved commercially available proprietary frame systems to achieve the special moment frame classification.

A403.10.2 Intermediate or ordinary moment frames. Steel intermediate or ordinary moment frames shall comply with all applicable provisions of AISC 341.

> ***Commentary:*** *See Section A403.3 Exception 5 as added by the SHOP Engineering Requirements for a waiver on height limits otherwise applicable to these systems.*

A403.10.3 Cantilevered column systems. Steel special or ordinary cantilevered column systems shall comply with all applicable provisions of AISC 341.

A403.10.4 Inverted moment frame systems. Cantilevered column systems shall be permitted to be designed as inverted special, intermediate, or ordinary moment frames, with corresponding moment frame seismic design coefficients, where the system satisfies the following conditions:

1. The columns carry no gravity load.

2. The columns are configured in pairs (or larger groups) connected by a continuous reinforced concrete foundation or grade beam.

3. The foundation or grade beam shall be designed to resist the expected plastic moment at the base of each column, computed as R_yF_yZ in accordance with AISC 341.

4. The flexibility of the foundation or grade beam, considering cracked section properties of the reinforced concrete, shall be included in computing the deformation of the steel frame system.

5. The columns shall be considered as twice their actual height when checking lateral torsional buckling.

Commentary: *This provision implements a SEAONC recommendation developed to accommodate a modification of traditional cantilevered column systems. Cantilevered column systems for new construction are normally assigned seismic design coefficients that severely limit their use. When used for retrofit of wood frame structures, however, the columns are less vulnerable to buckling failure because they carry no gravity load. SEAONC has therefore recommended that these cantilever column systems, configured as upside-down moment frame bents (with concrete cross beams), should be allowed to be designed as moment frame systems.*

SECTION A404
PRESCRIPTIVE MEASURES FOR WEAK STORY

A404.1 Limitation. These prescriptive measures shall apply only to two-story buildings ~~and only where 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 (19.1 mm) and with 10d common nails at 6 inches (152 mm) on center shall be applied.

Commentary: *These prescriptive measures are deemed appropriate for SHOP.*

A404.1.1 Additional conditions. To qualify for these prescriptive measures, the following additional conditions need to be satisfied by the retrofitted structure:

1. Diaphragm aspect ratio L/W is less than 0.67, where W is the diaphragm dimension parallel to the soft, weak or open-front wall line and L is the distance in the orthogonal direction between that wall line and the rear wall of the ground floor open area.

2. Minimum length of side shear walls = 20 feet (6096 mm).

3. Minimum length of rear shear wall = three-fourths of the total rear wall length.

4. No plan or vertical irregularities other than a soft, weak or open-front wall line.

5. Roofing weight less than or equal to 5 pounds per square foot (240 N/m2).

6. Aspect ratio of the full second floor diaphragm meets the requirements of the building code for new construction.

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 (19.1 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.

A404.2.2 Connection to floor above. Shear wall top plates shall be connected to blocking or rim joist at upper floor with a minimum of 18-gage galvanized steel angle clips 4-1/2 inches (114 mm) long with 12-8d nails spaced no farther than 16 inches (406 mm) on center, or by equivalent shear transfer methods.

A404.2.3 Shear wall sheathing. The shear wall sheathing shall be a minimum of 15/32 inch (11.9 mm) 5-Ply Structural I with 10d nails at 4 inches (102 mm) on center at edges and 12 inches (305 mm) on center at field; blocked all edges with 3 by 4 board or larger. Where existing sill plates are less than 3-by thick, place flat 2-by on top of sill between studs, with flat 18-gage galvanized steel clips 4-1/2 inches (114 mm) long with 12-8d nails or 3/8-inch-diameter (9.5 mm) lags through blocking for shear transfer to sill plate. Stagger nailing from wall sheathing between existing sill and new blocking. Anchor new blocking to foundation as specified above.

A404.2.4 Shear wall hold-downs. Shear walls shall be provided with hold-down anchors at each end. Two hold-down anchors are required at intersecting corners. Hold-downs shall be approved connectors with a minimum 5/8-inch-diameter (15.9 mm) threaded rod or other approved anchor with a minimum allowable load of 4,000 pounds (17.8 kN). Anchor embedment in concrete shall be not less than 5 inches (127 mm). Tie-rod systems shall be not less than 5/8 inch (15.9 mm) in diameter unless using high-strength cable. High-strength cable elongation shall not exceed 5/8 inch (15.9 mm) under a 4,000 pound (17.8 kN) axial load.

SECTION A405
MATERIALS OF CONSTRUCTION

A405.1 New materials. New materials shall meet the requirements of the *California 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 A403.4.1 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.

> ***Commentary:*** *While an overall condition assessment is often beneficial, this provision is applicable primarily to the existing structural elements that will be relied on to provide the required strength and stiffness. If the cap allowed in Section 403.3.1 is used, this will include all existing elements contributing to the expected story strength in each target story and the story above, as well as diaphragms and foundations. If the cap is not used, the condition assessment may be limited to just the structural scope identified in Section A403.2. ASCE 41-17 provisions and commentary for condition assessment may be useful as a guide to the work. The investigation should 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 normally required. The building official is authorized to require additional investigation as needed to fulfill the purpose of the condition assessment. Findings of the condition assessment should be included with the structural calculations per Section A.2.4 of the SHOP Engineering Requirements. With the approval of the building official, field verification of assumed conditions may be performed during the construction phase; in these cases adjustments to previously approved structural calculations and plans might be needed, which is why Section A.2.3 of the SHOP Engineering Requirements calls for field verification items to be shown on the plans.*

A405.3.1 Wood-structural-panel shear walls.

A405.3.1.1 Existing nails. Where the required calculations rely on design values for common nails or surfaced dry lumber, their use in construction shall be verified by exposure.

A405.3.1.2 Existing plywood. Where verification of the existing plywood is by use of record drawings alone, plywood shall be assumed to be of three plies.

A405.3.2 Existing wood framing. Wood framing is permitted to use the design stresses specified in the building code under which the building was constructed or other stress criteria approved by the code official.

A405.3.3 Existing structural steel. All existing structural steel shall be permitted to be assumed to comply with ASTM A36. Existing pipe or tube columns shall be assumed to be of minimum wall thickness unless verified by testing or exposure.

A405.3.4 Existing concrete. All existing concrete footings shall be permitted to be assumed to be plain concrete with a compressive strength of 2,000 pounds per square inch (13.8 MPa). Existing concrete compressive strength taken greater than 2,000 pounds per square inch (13.8 MPa) shall be verified by testing, record drawings or department records.

A405.3.5 Existing sill plate anchorage. The analysis of existing cast-in-place anchors shall be permitted to assume proper anchor embedment for purposes of evaluating shear resistance to lateral loads.

A405.3.6 Existing masonry partitions. Masonry partitions or fire separation walls within a target story shall be investigated to determine their capacity to resist story shears and deformations, whether intended as seismic force-resisting elements or not. The investigation shall consider their material strength and condition, grouting and reinforcing, connections and continuity to stories above and

foundation below, and related detailing and load path as they relate to likely performance in in-plane shear, out-of-plane shear, overturning moment, and uplift. Based on the investigation, the design professional shall document and substantiate a design approach and acceptability criteria.

> ***Commentary:*** *Some Oakland buildings are known to have concrete masonry fire separation partitions that might act as de facto seismic force-resisting elements, even if not designed to carry lateral forces and not detailed for ductile response. Since the construction of these partitions is not well documented, it is the responsibility of the design professional to understand their likely performance and to account for it in the retrofit design. In some cases, the walls might be usable as SFRS elements (as is, or as strengthened). In other cases, it might be preferable to isolate them from the seismic response by breaking the load path, as long as necessary fire safety is maintained.*

A405.3.7 Existing 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.

> ***Commentary:*** *Older buildings might have unreinforced brick footings. In general, these are unlikely to be adequate for new or strengthened shear walls, but the added provision allows a method to substantiate their capacity. Where inadequate existing foundation elements require replacement, the design professional is encouraged to consult with the SHOP office regarding eligibility.*

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.~~

> ***Commentary:*** *Section A.2.3 of these requirements replaces Chapter A4 Section A406.1.*

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. If the cap allowed by Section A403.3.1 is used to limit the scope of retrofit, the foregoing information shall be shown for each target story and at least one story above the uppermost target story. If the cap allowed by Section A403.3.1 is not used, the foregoing information need only be shown for each target story and for the floor immediately above the uppermost target story.

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.

A406.3.2 Framing plan elements. The framing plan shall include the length, location and material of shear walls; the location and material of frames; references on details for the column-to-beam connectors, beam-to-wall connections and shear transfers at floor and roof diaphragms; and the required nailing and length for wall top plate splices.

A406.3.3 Shear wall schedule, notes and details. Shear walls shall have a referenced schedule on the plans that includes the correct shear wall capacity in pounds per foot (N/m); the required fastener type, length, gage and head size; and a complete specification for the sheathing material and its thickness. The schedule shall also show the required location of 3-inch (76 mm) nominal or two 2-inch (51 mm) nominal edge members; the spacing of shear transfer elements such as framing anchors or added sill plate nails; the required hold-down with its bolt, screw or nail sizes; and the dimensions, lumber grade and species of the attached framing member.

Notes shall show required edge distance for fasteners on structural wood panels and framing members; required flush nailing at the plywood surface; limits of mechanical penetrations; and the sill plate material assumed in the design. The limits of mechanical penetrations shall be detailed showing the maximum notching and drilled hole sizes.

A406.3.4 General notes. General notes shall show the requirements for material testing, special inspection and structural observation.

SECTION A407
QUALITY CONTROL

A407.1 Structural observation, testing and inspection. Structural observation, in accordance with Section ~~1709~~ 1704.6.1 of the *California 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.

The work shall not be eligible for Exception 1, 2, or 3 to *California Building Code* Section 1704.2 or for the Exception to *California Building Code* Section 1705.12.2.

> ***Commentary:*** *The Chapter A4 requirement for structural observation provides the specific requirement contemplated by CBC Section 1704.6.1 item 5. The added sentence rules out exceptions that are appropriate for new wood construction but are not appropriate for retrofit work.*