Retrofit Grants Guidelines for Voluntary Seismic Retrofit of Tilt-up and Other Rigid Wall – Flexible Diaphragm (RWFD) Buildings

Contents

Format

Guidelines requirements, including enforceable interpretations of reference codes and standards, are shown in plain text.

> *Commentary, which gives additional background and explanation and is intended to aid both permit applicants and design professionals, is shown indented and italicized.*

Part A. Intent, Scope, and Administrative Procedures

A.1 Intent of the Guidelines

A.1.1. Retrofit Grants Program. These Guidelines are intended to support the City of Berkeley's program of retrofit grants for seismically vulnerable buildings.

> *Additional information about the program, including rules and procedures, is available at https://www.cityofberkeley.info/retrofitgrants/.*

A.1.2. Safety basis. These Guidelines reflect the Retrofit Grants Program emphasis on safety in certain types of seismically vulnerable buildings. These Guidelines are intended for buildings with recognized seismic safety deficiencies related to their wall anchorage

systems.

A.1.3. Participation and compliance. Participation in the Retrofit Grants Program is voluntary. Cost reimbursements under the Retrofit Grants Program, however, are contingent on compliance with these Guidelines.

> *In addition to these engineering Guidelines, other program rules and requirements apply. Design professionals should familiarize themselves with FEMA historic preservation review requirements, described on the Program website.*

A.2 Scope of the Guidelines

A.2.1. Eligible buildings. Except as noted in Section A.2.2, any rigid wall – flexible diaphragm (RWFD) building, as defined in Section B.1.4, is eligible to use these Guidelines. With the approval of the building official, a building with portions that do not meet the definition of an RWFD building may also be deemed eligible to use these Guidelines.

> *An RWFD building is defined in Section B.1.4 as a building up to 3 stories above grade plane with flexible roof diaphragms in which the main seismic force-resisting system in each direction predominantly comprises concrete or reinforced masonry shear walls. A flexible diaphragm is a roof or floor sheathed with plywood, wood decking (1x or 2x), or metal deck without a concrete topping slab.*
>
> *With this provision, eligibility is not limited to classic "tilt-up" buildings with precast concrete walls. Following are examples of buildings that are expected to be eligible to use these Guidelines:*
>
> - *RWFD buildings with sawtooth, Northlight, or clerestory roofs, as long as the roof is a flexible diaphragm.*
> - *RWFD buildings in which steel braced frames provide a portion of the lateral strength or stiffness.*
> - *RWFD buildings in which a portion of the building up to about 3 stories, typically at one end of the building footprint, has a non-RWFD seismic force-resisting system.*
> - *Two- or three-story RWFD buildings in which the floor diaphragms are rigid but the roof diaphragm is flexible.*
> - *Partially or previously retrofitted RWFD buildings that do not satisfy the retrofit criteria in Part B.*

A.2.2. Non-eligible buildings. Any building meeting one or more of the following criteria is not eligible to use these Guidelines:

- A building assigned to Risk Category IV, unless the Risk Category IV assignment is related only to the presence of toxic materials.

> *Buildings assigned to Risk Category (RC) IV because of their overall use or occupancy are expected to provide fast functional recovery. These Guidelines, which focus only on structural safety, are therefore inappropriate for RC IV buildings. An exception is made for buildings assigned to RC IV only because they contain toxic or hazardous materials, whose safe storage is largely independent of the structure. For such buildings, these Guidelines may be used*

to address the structural safety issues. Separate codes, standards, or guidelines, applied outside the Retrofit Grants Program, should be used to address the risks posed by toxic or hazardous materials.

- A building in which the main seismic force-resisting system in either direction comprises steel or concrete moment frames with concrete or masonry infill.

  Even though concrete or masonry infill can sometimes perform as shear walls, infilled frames are not eligible to use these Guidelines because the Guidelines do not include provisions needed to address the full range of existing conditions and potential deficiencies associated with infilled frames.

A.2.3. Work not eligible for grant support. Even in an eligible building, some voluntary or triggered work not specifically required by these Guidelines might not be eligible for reimbursement. See the Retrofit Grants Program rules.

A.3 Administrative procedures

A.3.1. General. Unless otherwise specified, all code requirements applicable to alteration projects shall apply to any project covered by these Guidelines. Supplemental requirements are given in the following subsections.

A.3.2. Compliance with Retrofit Grants Program requirements. The owner or permit applicant is responsible for complying with any rules or procedures established by the Retrofit Grants Program. During the plan check process, the City will review the retrofit design for compliance with these Guidelines. Issuance of a building permit shall not be construed as approval of a Retrofit Grant application.

Owners are encouraged to complete the following steps before submitting permit application materials:

- *Receive approval or provisional approval of the Retrofit Grant application and available funding amount.*
- *Confirm with Program staff the scope of work eligible for grant support.*

A.3.3. Permit application. The permit application shall include:

- As part of the "Brief Description of Work" field, the following statement: "This project is intended to comply with the Retrofit Grants Guidelines for Voluntary Seismic Retrofit of RWFD buildings."
- If phased construction is intended, a description of the work to be completed in each phase. Eligibility for grant funding for phased projects is subject to pre-approval by the Retrofit Grants Program.

A.3.4. Plans. Submitted plans shall include all information and details needed to properly construct all of the required seismic improvements. In addition, submitted plans shall include:

- In the Project Summary, the following statement: "Intent to comply with the Retrofit Grants Guidelines for Voluntary Seismic Retrofit of RWFD buildings".
- If phased construction is intended, identification of the work to be completed in each phase. Eligibility for grant funding for phased projects is subject to pre-approval by the Retrofit Grants Program.
- Identification of non-seismic work triggered by the intended seismic retrofit scope. For grant reimbursement purposes, the building official is authorized to require that

some or all of this triggered work be completed under separate permits.

- Identification of voluntary additional work not required by the intended seismic retrofit scope.
- The Statement of Special Inspections.

A.3.5. Structural calculations. Submitted calculations shall include all information needed to support and validate the submitted plans and to demonstrate compliance with the requirements of these Guidelines.

> *Information needed "to demonstrate compliance" is expected to include condition assessment and testing reports as required by Section B.2 and completed ASCE 41 Tier 1 checklists as required by Section B.5.4. Recommended practice for completing Tier 1 checklists involves adding a brief note or specific reference to calculations or record documents to justify the evaluation status of Compliant (C), Noncompliant (NC), Not Applicable (NA) or Unknown (U).*

Part B. Design and Construction Provisions

B.1 Applicable codes and standards

B.1.1. Governing building codes. All work performed to comply with these Guidelines shall comply also with the current edition of the *California Building Code* (CBC) and the *California Existing Building Code* (CEBC), as adopted by the City of Berkeley. Any code references shall be construed to apply to the corresponding provisions contained within the current edition of the *California Building Code* (CBC) and the *California Existing Building Code* (CEBC), as adopted by the City of Berkeley. The codes and standards listed in Section B.1.2 shall be considered part of these Guidelines to the extent prescribed in each such reference.

B.1.2. Reference codes and standards. These Guidelines reference and incorporate portions of the following codes and standards with interpretations specified in Sections B.4 and B.5.

- Chapter A2 of the 2015 *International Existing Building Code* (IEBC), as adopted by Berkeley Municipal Code 19.28.060. Chapter A2 of the 2018 IEBC is considered an approved alternative.
- ASCE/SEI 41-17 (ASCE 41), superseding the references to ASCE/SEI 41-13 in the 2016 CEBC and Berkeley Municipal Code 19.28.070.

> *In addition to these two documents, the governing building codes specified in Section B.1.1 already reference ASCE 7-10, of which Section 12.11 is especially relevant to wall anchorage systems. CBC Section 1613.5.1 makes a minor modification to ASCE 7 Section 12.11, but that modification is not relevant in the context of these Guidelines because IEBC Chapter A2 already duplicates or replaces that material.*
>
> *For the purposes of these Guidelines, ASCE 7-16 is considered an approved alternative to ASCE 7-10. Section 12.11 is essentially unchanged in ASCE 7-16. The 2018 I-Codes and 2019 CBC and CEBC, which reference ASCE 7-16, are already published and are expected to be adopted during the course of the Retrofit Grants Program.*
>
> *Chapter A2 of the 2018 IEBC is identical to the 2015 edition. Both editions as*

published by ICC are available in read-only mode at https://codes.iccsafe.org/public/collections/I-Codes. An annotated version of Chapter A2, with commentary, for use with these Guidelines is included in Section B.4.2.

ASCE 7, ASCE 41, and the IEBC have published commentaries that might be useful to design professionals. The following resources might be useful as well:

- *SEAONC (2001). Guidelines for Seismic Evaluation and Rehabilitation of Tilt-up Buildings and Other Rigid Wall/Flexible Diaphragm Structures, where not in conflict with these Guidelines. This document provides useful illustrations and discussion of recognized retrofit approaches to common conditions in RWFD buildings.*
- *SEAOC (2009). 2009 IEBC SEAOC Structural/Seismic Design Manual, where not in conflict with these Guidelines.*
- *SEAOC (2016). 2015 IBC Structural/Seismic Design Manual, Volume 2. This document provides design examples for new buildings, including of wall anchorage to flexible diaphragms and the design of flexible wood diaphragms.*

B.1.3. Classification of work. Seismic retrofit work performed in accordance with these Guidelines shall be classified as "voluntary seismic improvements" pursuant to CEBC Section 403.9 and are deemed to comply with that section.

The reference to CEBC Section 403.9 facilitates the work to be performed under these Guidelines and avoids questions of whether additional structural work is triggered. Each project performed under these Guidelines is voluntary from the perspective of the building code. Even so, as noted at Section A.1.3, compliance with these Guidelines is required to receive cost reimbursements.

B.1.4. Definitions. The following definitions apply to these Guidelines and to the reference codes and standards when used to comply with these Guidelines.

- Flexible diaphragm. A roof or floor sheathed with plywood, wood decking (1x or 2x), or metal deck without a concrete topping slab.

  This definition is nearly identical to that in IEBC Section A203.1. It is also consistent in principle with ASCE 7 Section 12.3.1.1, which allows such diaphragms to be idealized as flexible in buildings with concrete or masonry shear walls.

- Rigid wall – flexible diaphragm (RWFD) building. Any building up to 3 stories above grade plane with flexible roof diaphragms in which the main seismic force-resisting system in each direction predominantly comprises concrete or reinforced masonry shear walls.

  A "tilt-up" building is a special case of an RWFD building with precast concrete walls and is distinguished by its method of construction.

  The "3 stories" limit represents the City's judgment considering Berkeley's building stock. The large majority of Berkeley's RWFD buildings are one story only (except perhaps at the non-RWFD portion at one end of the building footprint).

- Wall segment. Any length of concrete or reinforced masonry wall not interrupted or intersected by a pilaster or vertical construction joint.

B.1.5. Terminology. These Guidelines use the following terms to refer to structural elements and components typical of RWFD buildings.

- Wall anchorage system. The components comprising a complete load path for out-of-plane wall forces from the wall to the main diaphragm. With reference to ASCE 7 Section 12.11.2.2.1, the wall anchorage system typically includes an anchor embedded in or fastened to the wall; rods, straps, plates, hold-downs or other hardware (typically steel); subdiaphragms; cross-ties; and continuity connectors. Separate from the wall anchorage system, the main diaphragm and collectors, where needed, complete the load path from the wall to the vertical elements of the building's seismic force-resisting system.
- Cross-ties. Members continuous across the main diaphragm that connect opposite wall lines and transfer out-of-plane wall anchorage forces into the diaphragms.
- Struts. Members continuous across a subdiaphragm that transfer out-of-plane wall anchorage forces into the subdiaphragm.
- Continuity connectors. Components (typically plates, rods, straps, or hold-downs) that ensure load path continuity along the full length of a cross-tie or strut.

  Some RWFD retrofit references, including the Los Angeles Building Code and parts of SEAOC (2001), refer to continuity connectors as "continuity ties." Continuity connectors is the more traditional term and is preferred in part because "continuity ties" is easily confused with the phrase "continuous cross-ties."

- Subdiaphragms. Portions of the main diaphragm provided with their own chords and analyzed as free bodies to transfer wall anchorage forces by spanning between cross-ties.
- Collectors. Members or components that transfer horizontal diaphragm forces to a partial-length wall in the plane of the wall. Collectors are typically needed to address potential deficiencies at reentrant corners.

B.2 Condition assessment

B.2.1. Scope and criteria. On-site investigation and condition assessment shall be performed in accordance with ASCE 41 Section 4.2.1. The investigation shall be based on a combination of non-destructive testing or inspection, destructive testing or inspection (if warranted), and reference to record documents. Where record documents are used to reduce the scope of testing or other on-site work, appropriate field verification is required.

The building official is authorized to require additional investigation as needed to fulfill the purpose of the report, as specified in Section B2.2, and the intent of these Guidelines. With the approval of the building official, field verification of assumed conditions may be performed during the construction phase.

Condition assessment is different from evaluation. Evaluation is meant to assess the capacity of the structural system relative to design loads. Condition assessment is meant to confirm and document existing conditions, with the findings later used in an evaluation or retrofit design.

B.2.2. Report. A written report of all investigations and findings shall be submitted for review with the structural calculations. The report shall establish where and how adjustments to material and member capacities are being made.

Where ASCE 41 provisions apply, the phrase "adjustments to material and member capacities" includes derivation of knowledge factors in accordance with ASCE 41 Sections 5.2.6 and 6.2.4.

B.2.3. Testing to establish adequacy of existing wall anchors. Testing to comply with the exception to IEBC Section A206.2 shall show that the existing anchors can sustain a test load of 1.5 times the design tension load without noticeable deformation or damage to the anchor, to the masonry or concrete element, or to any part of the existing load path between the anchor and new retrofit components. Three anchors of each existing detail type shall be tested, and all three shall satisfy the requirement. Prior to testing, the design professional shall submit a test plan for building official approval identifying the expected locations of the existing anchors in question, the locations of the proposed tests, and the test procedure and criteria. After testing, the design professional shall submit a report of the satisfactory testing showing the test results, the design strengths derived from them, and the size and spacing as confirmed by investigation.

These test requirements are consistent with ASCE 41-17 Section 10.2.2.4.1, which addresses testing of cast-in-place and post-installed anchors in concrete, and which reads, in part, "If the test load is used as the basis for anchor strength calculation, the available anchor strength shall not be taken as greater than 2/3 of the test load." Thus, successful tests to 1.5 times the design strength will justify use of the existing anchors. The requirement to test three existing anchors is also consistent with ASCE 41, though ASCE 41 requires testing 5 percent of the existing anchors as well, so in large buildings, the ASCE 41 requirement can be more conservative.

B.2.4. Testing to establish adequacy of existing steel deck connections. Testing to comply with IEBC Section A206.2 shall show that the existing construction can sustain a test load of 1.5 times the design load without noticeable deformation or damage to the deck, to the fasteners, or to any part of the existing load path. Three tests of each existing detail type shall be tested, and all three shall satisfy the requirement. Prior to testing, the design professional shall submit a test plan for building official approval including the findings of the condition assessment, the expected locations of each detail type in question, the locations of the proposed tests, and the test procedure and criteria. After testing, the design professional shall submit a report of the satisfactory testing showing the test results and the design strengths derived from them.

See the commentary to Section B.2.3.

B.3 Seismic retrofit scope and criteria

B.3.1. Compliance. Compliance with these Guidelines requires retrofit to address each of the scope items in table B.3.1-1 using the tabulated criteria, unless evaluation of the scope item shows that it complies without retrofit.

Table B.3.1-1. Seismic Retrofit Scope and Criteria

Scope item	Evaluation/Retrofit Criteria
1. Wall anchorage system	IEBC Chapter A2[1]
2. Collectors	IEBC Chapter A2[1]
3. Reentrant corner and interior wall line vulnerabilities	IEBC Chapter A2[1]
4. Mezzanines	IEBC Chapter A2[1]

Scope item	Evaluation/Retrofit Criteria
5. Non-RWFD portions of the structure	ASCE 41[2] or, if applicable, Retrofit Grants Guidelines for Concrete Buildings. In either case, the work shall account for load path and deformation compatibility between the RWFD and non-RWFD portions.
6. Roof diaphragm	ASCE 41[2] or ASCE 7 Section 12.10 using 75 percent of the forces required for the design of new buildings. Retrofit of the roof diaphragm, if needed, shall ensure that the retrofitted diaphragm satisfies the assumptions and intent of IEBC Chapter A2 regarding completeness of the wall anchorage system.
7. Concrete shear walls at the RWFD portion of the building	ASCE 41[2] considering in-plane and out-of-plane earthquake loads
8. Reinforced masonry shear walls at the RWFD portion of the building	ASCE 41[2] considering in-plane and out-of-plane earthquake loads
9. Other vertical elements of the seismic force-resisting system, such as steel braced frames, steel moment frames, or light frame shear walls.	ASCE 41[2]

[1] As interpreted and supplemented by Guidelines Section B.4.

[2] As interpreted by Guidelines Section B.5.

> *IEBC Chapter A2 addresses only scope items 1 through 4. The Guidelines add scope item 5 to accommodate the Berkeley building stock, which includes a number of RWFD buildings with non-RWFD portions. The Guidelines add scope items 6 through 9 to ensure that major deficiencies are not overlooked, since IEBC Chapter A2 was developed primarily for tilt-up buildings in which diaphragm and wall deficiencies are rare; some Berkeley buildings are different. The criteria for scope items 6 through 9 (see Section B.5) are relaxed even relative to typical retrofit criteria to avoid adding disproportionate costs for secondary deficiencies. The assumption inherent in IEBC Chapter A2 is that scope items 1 through 4 represent the clearest deficiencies in a typical RWFD building. The intent of the Guidelines is therefore to identify other potentially severe deficiencies and only require retrofit for scope items 6 through 9 when those deficiencies approach the severity of scope items 1 through 4.*

B.3.2. Seismicity parameters and Site Class. Regardless of the criteria used, 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. Site-specific procedures are not required for compliance with these Guidelines. These Guidelines do not require mitigation of existing geologic site hazards such as liquefiable soil.

The USGS map is at https://earthquake.usgs.gov/hazards/urban/sfbay/soiltype/map/.

The site-specific ground motion procedures normally required by ASCE 7 Section 11.4.8 or ASCE 41 Section 2.4 are waived for these voluntary retrofit projects.

Seismic hazard parameters as needed may be obtained from the USGS application, using "2015 IBC" or "2013 ASCE 41" as the Design Code Reference Document, at https://earthquake.usgs.gov/designmaps/us/application.php.

B.4 Interpretation of IEBC Chapter A2 and supplemental requirements

B.4.1. Interpretation of IEBC Chapter A2. For purposes of the Retrofit Grants Program, certain provisions of IEBC Chapter A2 shall be interpreted and enforced as shown in Guidelines Appendix 1.

Guidelines Appendix 1 provides a complete copy of IEBC Chapter A2 annotated with applicable interpretations and commentary.

B.4.2. Supplemental requirements. For purposes of the Retrofit Grants Program, the requirements of IEBC Chapter A2 shall be supplemented as shown in Guidelines Appendix 1.

Guidelines Appendix 1 includes supplemental requirements and commentary for anchorage stiffness and for anchor spacing with IEBC Section A206.2.

B.5 Application and interpretation of ASCE 41

B.5.1. Evaluation or retrofit objective. Where ASCE 41 is used to address scope items 5 through 9 specified in Section B.3.1, the minimum evaluation or retrofit performance objective shall be Structural Collapse Prevention with a BSE-1E hazard. Where ASCE 41 is optionally used to address scope items 1 through 4 specified in Section B.3.1, the minimum evaluation or retrofit performance objective shall be Structural Life Safety with a BSE-1E hazard.

Because the performance objective is given here, ASCE 41 Sections 2.2 and 2.3 are not needed for compliance with these Guidelines.

As discussed in the commentary to Guidelines Section B.3.1, the RWFD retrofit scope is intended to focus on the most common and worrisome deficiencies in RWFD buildings (scope items 1 through 4 in Table B.3.1-1) and takes a less conservative approach to other potential deficiencies. The resulting approach is less conservative than a traditional retrofit with Life Safety criteria for the whole building, but it is more thorough (and thus more conservative) than the alternative cost-saving simplification of using IEBC Chapter A2 for scope items 1 through 4 while ignoring other potential deficiencies entirely.

How do the resulting Guidelines scope and objective compare with those of retrofits triggered by the CEBC? Where the CEBC would trigger retrofit for major repairs or alterations, it would allow the use of IEBC Chapter A2 alone for a pure RWFD building. For these buildings, the CEBC would therefore be less thorough and thus potentially less conservative than the Guidelines, which also consider scope items 6 through 9. For a hybrid building (with scope item 5), the CEBC would not allow Chapter A2; it would require a full-building approach (with ASCE 41 Life Safety or code-based reduced loads) and would thus be more conservative than the Guidelines. For retrofit triggered by an addition or change of occupancy, the CEBC would require a full building approach with code-

equivalent loads, making it significantly more conservative than the Guidelines.

B.5.2. Administrative provisions. ASCE 41 administrative provisions addressing topics already covered by CBC, CEBC, and BMC, including ASCE 41 Sections 1.5.9 and 1.5.10, are not applicable.

B.5.3. ASCE 41 Section 2.4. See Guidelines Section B.3.2.

B.5.4. ASCE 41 Chapter 17 Tier 1 Checklists. Where ASCE 41 is used to address scope items 6, 7, or 8 specified in Section B.3.1, implementation of ASCE 41 Tier 1 procedures need only consider the issues shown in Table B.5.4-1.

Guidelines Appendix 2 provides these abbreviated sets of Tier 1 evaluation statements. For a building where scope item 5 or scope item 9 applies, the design professional is responsible for identifying the applicable ASCE 41 provisions.

Table B.5.4-1 provides an abbreviated evaluation scope deemed appropriate for these voluntary retrofits. Relative to the full ASCE 41 Tier 1 checklists, it omits some issues considered to be of lesser urgency (for reasons given in the commentary to Guidelines Sections B.3.1 and B.5.1) and many that are already covered by the wall anchorage system requirements for scope items 1 through 4 in Table B.3.1-1.

Table B.5.4-1 applies only to roof diaphragms and typical RWFD concrete or masonry walls (scope items 6, 7, and 8 from Table B.3.1-1). For scope items 5 and 9, which are less generic, all applicable ASCE 41 provisions must be considered, with the performance objective given in Guidelines Section B.5.1.

Following ASCE 41 procedures, any of the required issues for which the Tier 1 checklist item is marked Unknown (U) or Noncompliant (NC) must be addressed by further Tier 2 evaluation or by retrofit. It is not expected that ASCE 41 Tier 3 will be needed for RWFD buildings.

Table B.5.4-1. ASCE 41 Tier 1 Issues

ASCE 41 Table	Issues to be considered
Table 17-2	Load path
Table 17-24, for cast-in-place concrete walls only	Redundancy Shear stress check Reinforcing steel Connections Transfer to shear walls Foundation dowels Diaphragms Diaphragm continuity Openings at shear walls Straight sheathing Spans Diagonally sheathed and unblocked diaphragms Other diaphragms
Table 17-25, for cast-in-place concrete walls only	Wall thickness[1]
Table 17-28, for precast concrete walls only	Redundancy Wall shear stress check Reinforcing steel Wall thickness Connections Transfer to shear walls Girder-column connection Precast wall panels Diaphragms Straight sheathing Spans Diagonally sheathed and unblocked diaphragms Other diaphragms
Table 17-28, for all walls	Wall openings
Table 17-34, for reinforced masonry walls only	Redundancy Shear stress check Reinforcing steel Connections Transfer to shear walls Foundation dowels Girder-column connection Diaphragms Openings at shear walls Openings at exterior masonry shearwalls Straight sheathing Spans Diagonally sheathed and unblocked diaphragms Other diaphragms

[1] Table 17-25 normally applies only to Immediate Occupancy performance. For Collapse Prevention, the evaluation statement may be revised to read, “Thicknesses of bearing

walls are not less than 1/40 the unsupported height or length, whichever is shorter, nor less than 4 in."

B.6 Construction quality assurance

B.6.1. Governing regulations. With reference to Guidelines Section B.1.1, all work performed to comply with these Guidelines shall comply also with CBC Chapter 17 as adopted by the City of Berkeley and with the additional provisions in Guidelines Sections B.6.2 and B.6.3.

B.6.2. Structural observation. Structural observation in accordance with CBC Section 1704.6 is required.

The building official is authorized to require structural observation by CBC Section 1704.6.1 item 5. This requirement is also consistent with IEBC Section A205.4.

B.6.3. Additional special inspection. Work done to comply with these Guidelines shall not be eligible for Exception 1, 2, or 3 to CBC Section 1704.2 or for Exception 3 to CBC Section 1705.12 or for the Exception to CBC Section 1705.12.2. In addition to the requirements of CBC Section 1705.12, special inspection shall be required for:

- Installation of anchors into existing concrete or masonry walls to form part of a wall anchorage system.
- Installation of continuity connectors along the length of cross-ties, to ensure that fastener holes are not oversized and that the cross-tie stiffness satisfies the supplemental stiffness requirement given in Guidelines Section B.4.2.
- Fastening of new or existing steel deck forming part of a wall anchorage system.

This requirement is consistent with IEBC Section A206.2.

Appendix 1

Application of IEBC Chapter A2 for the Retrofit Grants Program

The following annotation of 2018 IEBC Chapter A2 shows (with indented, italicized text) the interpretations and supplementary provisions applicable to the Retrofit Grants Program, together with commentary.

EARTHQUAKE HAZARD REDUCTION IN EXISTING REINFORCED CONCRETE AND REINFORCED MASONRY WALL BUILDINGS WITH FLEXIBLE DIAPHRAGMS

SECTION A201
PURPOSE

A201.1 Purpose. The purpose of this chapter is to promote public safety and welfare by reducing the risk of death or injury as a result of the effects of earthquakes on reinforced concrete and reinforced masonry wall buildings with flexible diaphragms. Based on past earthquakes, these buildings have been categorized as being potentially hazardous and prone to significant damage, including possible collapse in a moderate to major earthquake. The provisions of this chapter are minimum standards for structural seismic resistance established primarily to reduce the risk of life loss or injury on both subject and adjacent properties. These provisions will not necessarily prevent loss of life or injury, or prevent earthquake damage to an existing building that complies with these standards.

SECTION A202
SCOPE

A202.1 Scope. The provisions of this chapter shall apply to wall anchorage systems that resist out-of-plane forces and to collectors in existing reinforced concrete or reinforced masonry buildings with flexible diaphragms. Wall anchorage systems that were designed and constructed in accordance with the 1997 *Uniform Building Code,* 1999 *BOCA National Building Code,* 1999 *Standard Building Code* or the 2000 and subsequent editions of the *International Building Code* shall be deemed to comply with these provisions.

> ***Commentary:*** *The benchmark codes listed in this provision indicate technical sufficiency. Eligibility rules established for the Retrofit Grants Program might set different cutoff dates. In particular, at the discretion of program staff, a building that qualifies as compliant by this benchmark provision might still be deemed eligible for the program if it is shown to be deficient relative to the requirements of the Guidelines.*
>
> *For new buildings, wall anchorage design requirements changed significantly with the 1997 Uniform Building Code (UBC) and have remained essentially unchanged since then. Buildings designed with adopted versions of earlier model codes are presumed to pose higher risks. The 1997 UBC provisions were incorporated into the 1998 CBC and became effective statewide on July 1, 1999.*

SECTION A203
DEFINITIONS

A203.1 Definitions. For the purpose of this chapter, the applicable definitions listed in Chapters 16, 19, 21, 22 and 23 of the *International Building Code* and the following shall apply.

FLEXIBLE DIAPHRAGMS. Roofs and floors including, but not limited to, those sheathed with plywood, wood decking (1-by or 2-by) or metal decks without concrete topping slabs.

> ***Interpretation:*** *Instead of the definitions referenced or provided here, the definitions of the CEBC and of Guidelines Section B.1.4 shall apply.*

SECTION A204
SYMBOLS AND NOTATIONS

A204.1 General. For the purpose of this chapter, the applicable symbols and notations in the *International*

Building Code shall apply.

SECTION A205
GENERAL REQUIREMENTS

A205.1 General. The seismic-resisting elements specified in this chapter shall comply with provisions of Section 1613 of the *International Building Code* and its reference standards, except as modified herein.

> ***Commentary:*** *By referencing Section 1613 of the IBC (as adopted by the CBC), Chapter A2 is indirectly referencing ASCE 7. Here is a summary of the provisions in ASCE 7 Section 12.11, some of which are duplicated or restated with the same intent in IEBC Chapter A2:*
>
> - *12.11.2: Anchorage design force, with amplification for longer diaphragms. (See IEBC Section A206.1 for reduced forces.)*
> - *12.11.2: Walls shall be evaluated/retrofitted for bending between anchors if anchor spacing exceeds 4 ft. This provision does not apply to existing walls evaluated or retrofitted to comply with IEBC Chapter A2. See Guidelines Section B.3 for requirements related to walls.*
> - *12.11.2.2.1: Continuous cross-ties required.*
> - *12.11.2.2.1: "Positive" diaphragm connections required.*
> - *12.11.2.2.1: Subdiaphragms allowed to carry anchorage forces between anchors and cross-ties.*
> - *12.11.2.2.1: Maximum subdiaphragm length to width ratio of 2.5.*
> - *12.11.2.2.2: Except for anchor bolts and rebar, steel components of wall anchorage system subject to 1.4 increase on design force.*
> - *12.11.2.2.2: Anchorage to wood diaphragms shall comply with AWC SDPWS Section 4.1.5.1, which makes the same requirements already in ASCE 7 Section 12.11.2.2.2.*
> - *12.11.2.2.3: Wood diaphragm sheathing does not count toward requirement for cross-ties. IEBC Section A206.3 makes the same requirement.*
> - *12.11.2.2.3: Anchorage to wood diaphragms may not use toenails, nails in withdrawal, or wood components in cross-grain bending or cross-grain tension. IEBC Section A206.3 makes the same requirement.*
> - *12.11.2.2.4: In corrugated steel deck diaphragms, the direction parallel to the flutes may be used as a cross-tie but the direction across the flutes may not.*
> - *12.11.2.2.5: Detailing of embedded strap anchors. This does not apply to most retrofit conditions.*
> - *12.11.2.2.6: Wall anchorage design must account for load eccentricities. IEBC Section A206.5 makes the same requirement.*
> - *12.11.2.2.7: Wall anchorage design must account for load path through pilasters. IEBC Section A206.4 makes the same requirement.*

A205.2 Alterations and repairs. Alterations and repairs required to meet the provisions of this chapter shall comply with applicable structural requirements of the building code unless specifically modified in this chapter.

> ***Commentary:*** *This section is for work triggered by alterations and repairs. It does not apply to the voluntary seismic improvements covered by the Guidelines.*

A205.3 Requirements for plans. The plans shall accurately reflect the results of the engineering investigation and design and shall show all pertinent dimensions and sizes for plan review and construction.

The following shall be provided:

1. Floor plans and roof plans shall show existing framing construction, diaphragm construction, proposed wall anchors, cross-ties and collectors. Existing nailing, anchors, cross-ties and collectors shall also be shown on the plans if they are considered part of the lateral-force-resisting systems.
2. At elevations where there are alterations or damage, details shall show roof and floor heights, dimensions of openings, location and extent of existing damage and proposed repair.
3. Typical wall panel details and sections with panel thickness, height, pilasters and location of anchors shall be provided.
4. Details shall include existing and new anchors and the method of developing anchor forces into the diaphragm framing, existing and/or new cross-ties, and existing and/or new or improved support of roof and floor girders at pilasters or walls.
5. The basis for design and the building code used for the design shall be stated on the plans.

Commentary: *Refer to Guidelines Section A.3.4 for additional requirements.*

A205.4 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.

Commentary: *Refer to Guidelines Section B.6 for specific quality assurance requirements, which take precedence over general provisions in Section A205.4.*

SECTION A206
ANALYSIS AND DESIGN

A206.1 Reinforced concrete and reinforced masonry wall anchorage. Concrete and masonry walls shall be anchored to all floors and roofs that provide lateral support for the wall. The anchorage shall provide a positive direct connection between the wall and floor or roof construction capable of resisting 75 percent of the horizontal forces specified in Section 1613 of the *International Building Code.*

Commentary: *The "75 percent" reduced forces are customary for prescriptive safety-based retrofit provisions. The commentary to ASCE 41 Sections 2.2.1 and 2.4.1.3 offers more background. With reduced forces, the key equation for evaluation and retrofit of the wall anchorage system, ASCE 7 Eq. 12.11-1, becomes:*

$$F_p = 0.75*0.4*S_{DS}k_aI_eW_p = 0.3*S_{DS}k_aI_eW_p$$

For values of S_{DS} and Site Class provisions, see Guidelines Section B.3.2.

For the evaluation or design of most steel elements in the wall anchorage system, ASCE 7 Section 12.11.2.2.2 requires an additional 1.4 factor, further modifying the equation to:

$$F_p = 0.42*S_{DS}k_aI_eW_p$$

Consensus interpretation of Section 12.11.2.2.2 holds that the 1.4 factor need not be applied to steel fasteners such as nails, bolts, or screws, where the fastener capacity is governed by the wood member. The 1.4 factor applies to the strength of anchor bolts but need not be applied to the required embedment depth, which is governed by the concrete. Further, the 1.4 factor need not be applied to proprietary steel elements if catalog capacity values are already reduced to reflect the intent of the factor. For additional discussion of the 1.4 factor, see SEAOC (2016), cited in the commentary to Guidelines Section B.1.2.

The k_a factor will range from about 1.2 for the shortest diaphragm spans to 2.0 for spans of 100 ft or longer. Recent work has suggested that shorter diaphragms should also use

the larger design force with k_a taken as 2.0 (see FEMA P-1026). Since this finding has not yet been vetted for inclusion in a consensus code or standard, however, it is not required here.

The redundancy factor may be taken as 1.0 (that is, ignored) per ASCE 7 Section 12.3.4.1 item 9.

ASCE 7 Section 12.3.3.4, which would impose an additional 25 percent increase on the design force in certain cases, does not apply. That 25 percent increase is meant for irregularities that lead to unusual distributions of base shear. It is not meant to apply to the out-of-plane anchorage force referenced here.

A206.2 Special requirements for wall anchorage systems. The steel elements of the wall anchorage system shall be designed in accordance with the building code without the use of the 1.33 short duration allowable stress increase when using allowable stress design.

Commentary: *This provision is obsolete, since applicable LRFD or strength design provisions for steel elements of the wall anchorage system no longer use a 1.33 factor.*

Wall anchors shall be provided to resist out-of-plane forces, independent of existing shear anchors.

Interpretation: *This provision is interpreted to apply to existing tension anchors as well as existing shear anchors. See also the exception and its commentary.*

Expansion anchors are only allowed with special inspection and approved testing for seismic loading.

Interpretation: *This provision applies only to new retrofit components. The sentence is interpreted to mean that expansion anchors are allowed when installed and inspected in accordance with building code provisions for anchors subject to cyclic loads.*

Attaching the edge of plywood sheathing to steel ledgers is not considered compliant with the positive anchoring requirements of this chapter. Attaching the edge of steel decks to steel ledgers is not considered as providing the positive anchorage of this chapter unless testing or analysis are performed to establish shear values for the attachment perpendicular to the edge of the deck. Where steel decking is used as a wall anchor system, the existing connections shall be subject to field verification and the new connections shall be subject to special inspection.

Commentary: *The 1.4 factor required by ASCE 7 Section 12.11.2.2.2 applies to the steel deck and to welded connections. Consistent with ASCE 7 Section 12.11.2.2.4, corrugated steel deck may only be used to carry tension parallel to the flutes.*

Interpretation: *For the purposes of this program, both analysis and testing are required to justify the use of existing steel deck as a wall anchorage element or as cross-ties; analysis alone is not sufficient. See Guidelines Section B.2.4 for testing criteria. Analysis of existing steel deck fasteners shall consider that they might be simultaneously loaded in directions parallel and perpendicular to the wall.*

Exception: Existing cast-in-place shear anchors are allowed to be used as wall anchors if the tie element can be readily attached to the anchors, and if the engineer or architect can establish tension values for the existing anchors through the use of approved as-built plans or testing and through analysis showing that the bolts are capable of resisting the total shear load (including dead load) while being acted upon by the maximum tension force due to an earthquake. Criteria for analysis and testing shall be determined by the building official.

Interpretation: *This exception applies to the provision above regarding "existing shear anchors." Both the provision and this exception are interpreted to apply to existing tension anchors as well as existing shear anchors.*

In the exception, "existing cast-in-place shear anchors" refers to anchors intended to transfer gravity load and/or horizontal earthquake shear between the diaphragm and the wall. In most cases these existing shear anchors were not explicitly designed to carry out-of-plane wall forces into the diaphragm. For both shear and tension anchors, the Guidelines require new anchors unless the adequacy of the existing anchors is

demonstrated as allowed by the exception. See Guidelines Section B.2.3 for testing criteria to comply with the exception. The intent of the exception is to set a high bar for the use of existing anchors. Thus, "maximum tension force" is interpreted to mean "tension due to earthquake loads normal to the wall, vertical shear due to dead load, and simultaneous shear due to earthquake loads parallel to the wall." Existing shear or tension anchors from previous retrofits, though not "cast-in-place," may be addressed in a similar way.

Supplemental anchorage stiffness requirement: *The wall anchorage system (excluding the diaphragm, subdiaphragms, and existing roof or floor framing members) shall be shown to be stiff enough to limit the relative movement between the wall and the diaphragm to no more than 1/8" before engagement of the anchors.*

Commentary: *This supplemental requirement is consistent with ASCE 41 Table 17-34. It has the same intent as a stiffness requirement discussed in the SEAOC commentary to IEBC Chapter A2 and implemented by the City of Los Angeles Department of Building and Safety. The SEAOC and Los Angeles approach limits the elongation under load. The ASCE 41 approach, which is the approach adopted here, limits the slack in the system (including continuity connectors along the length of the cross-ties) provided by the detailing and construction.*

Supplemental anchor spacing requirement: *The maximum spacing between wall anchors shall be 8 ft, and each wall segment shall have at least two wall anchors.*

Commentary: *See the definition of wall segment in Guidelines Section B.1.4. The requirement for two anchors per wall segment is consistent with a similar provision for precast concrete wall panels in ASCE 41 Table 17-28.*

A206.3 Development of anchor loads into the diaphragm. Development of anchor loads into roof and floor diaphragms shall comply with Section 1613 of the *International Building Code* using horizontal forces that are 75 percent of those used for new construction.

Commentary: *This provision means that the wall anchorage loads specified by Section A206.1 must be developed into roof and floor diaphragms.*

Subdiaphragms, as contemplated by ASCE 7 Section 12.11.2.2.1, may be used to transfer wall anchorage forces to cross-ties. Each subdiaphragm is designed to carry the total of the wall anchorage forces tributary to it. Consistent with the SEAOC commentary, subdiaphragms may be designed for the shear associated with the total wall anchorage force without considering additional effects of global diaphragm shear.

In wood diaphragms, anchorage shall not be accomplished by use of toenails or nails subject to withdrawal. Wood ledgers, top plates or framing shall not be used in cross-grain bending or cross-grain tension. The continuous ties required in Section 1613 of the *International Building Code* shall be in addition to the diaphragm sheathing.

Commentary: *"Continuous ties required in Section 1613" means the cross-ties described in Guidelines Section B.1.5. Cross-ties must be continuous across the full width of the diaphragm and must be provided with continuity connectors as needed.*

Lengths of development of anchor loads in wood diaphragms shall be based on existing field nailing of the sheathing unless existing edge nailing is positively identified on the original construction plans or at the site.

Commentary: *This provision ensures conservative assumptions regarding existing nailing between a strut (typically a purlin or subpurlin) and the diaphragm sheathing. A subdiaphragm strut might not align with the edge of one plywood (or OSB) sheet. Further, plywood (or OSB) sheathing is typically staggered so that any strut longer than 8 ft will have field nailing over at least part of its length.*

Interpretation: *This provision should be understood to require that only field nailing be assumed as the default condition.*

If original construction plans do not reliably show the nailing at the strut location, then nailing other than the default field nailing may be confirmed by visual observation or non-destructive testing, subject to building official approval of documented condition assessment. If even the default field nailing cannot be reliably assumed, then a program of inspection and testing must be proposed and approved.

Where additional or new nailing is proposed (including new nailing to connect retrofit components), the design must account for the possibility of existing nails in terms of splitting due to over-nailing and code requirements for 3x members for closely-spaced nails.

Exception: If continuously tied girders are present, the maximum spacing of the continuity ties is the greater of the girder spacing or 24 feet (7315 mm).

Interpretation: *This exception is interpreted as:*

- *Where new members are added as cross-ties, they should be spaced no more than 24 ft apart.*
- *If existing girders are used as cross-ties, their actual spacing will be deemed adequate even if it exceeds 24 ft as long as the girders are provided with adequate continuity connectors.*

Commentary: *This exception is potentially confusing because of inconsistent use of the terms "continuous cross-tie," "continuity tie," and "continuity connector."*

Taken together, the two parts of the interpretation allow the common practice of using existing girders as cross-ties. Regardless of cross-tie spacing, however, the maximum subdiaphragm length-to-width ratio from ASCE 7 Section 12.11.2.2.1 still applies, and the retrofit design must still include confirmation of the full load path.

A206.4 Anchorage at pilasters. Anchorage at pilasters shall be designed for the tributary wall-anchoring load per Section A206.1, considering the wall as a two-way slab. The edges of the two-way slab shall be considered fixed when there is continuity at pilasters and shall be considered pinned at roof and floor. The pilasters or the walls immediately adjacent to the pilasters shall be anchored directly to the roof framing such that the existing vertical anchor bolts at the top of the pilasters are bypassed without permitting tension or shear failure at the top of the pilasters.

Commentary: *The first two sentences of this provision account for the stiffening effect of pilasters. Their intent is the same as that of ASCE 7 Section 12.11.2.2.7. The commentary to Section 12.11.2.2.7 provides a diagram of the tributary area concept. The "two-way slab" means the wall spanning horizontally between pilasters and vertically between the foundation and the roof. The "edges" means the side edges.*

The intent of the third sentence is to avoid failure of typically vulnerable existing anchors at the tops of pilasters by ensuring a completely separate load path.

Interpretation: *For clarity, the third sentence is interpreted as "The pilasters and adjacent wall sections shall be anchored directly to the roof framing so that existing anchor bolts embedded in the top of the pilasters are bypassed to prevent tension or shear failure."*

The minimum anchorage force at a floor or roof between the pilasters shall be that specified in Section A206.1.

Commentary: *This provision, consistent with ASCE 7 Section 12.11.2.2.7, means that anchorage along the wall adjacent to the pilaster may not be reduced just because the anchorage at the pilaster is made stronger to account for its stiffening effects. Thus, the stronger anchorage at the pilaster supplements, but does not replace, the typical anchorage along the length of the wall.*

Exception: If existing vertical anchor bolts at the top of the pilasters are used for the anchorage, additional exterior confinement shall be provided as required to resist the total anchorage force.

Commentary: *This is an exception to the provision's requirement to bypass the existing bolts in the top of the pilaster. As such, it is less an exception than an alternative means of compliance. "Exterior" confinement means around the outside surface of the pilaster.*

A206.5 Symmetry. Symmetry of wall anchorage and continuity connectors about the minor axis of the framing member is required.

Exception: Eccentricity shall be allowed where it can be shown that all components of forces are positively resisted. The resistance must be supported by calculations or tests.

Commentary: *The exception allows for compliance of non-symmetric details that load the strut, cross-tie, or other member eccentrically, consistent with ASCE 7 Section 12.11.2.2.6. Calculation or testing must be used to demonstrate adequate positive resistance.*

A206.6 Combination of anchor types. New anchors used in combination on a single framing member shall be of compatible behavior and stiffness.

A206.7 Anchorage at interior walls. Existing interior reinforced concrete or reinforced masonry walls that extend to the floor above or to the roof diaphragm shall be anchored for out-of-plane forces per Sections A206.1 and A206.3. Walls extending through the roof diaphragm shall be anchored for out-of-plane forces on both sides, and continuity ties shall be spliced across or continuous through the interior wall to provide diaphragm continuity.

Interpretation: *For clarity, this provision is interpreted as, "Existing interior reinforced concrete or reinforced masonry walls shall be anchored for out-of-plane forces per Sections A206.1 and A206.3. Walls extending through the roof diaphragm shall be anchored for out-of-plane forces on both sides, and cross-ties shall be spliced across or continuous through the interior wall as needed to provide diaphragm continuity."*

A206.8 Collectors. If collectors are not present at reentrant corners or interior shear walls, they shall be provided. Existing or new collectors shall be designed for the capacity required to develop into the diaphragm a force equal to the lesser of the rocking or shear capacity of the reentrant wall or the tributary shear based on 75 percent of the horizontal forces specified in Chapter 16 of the *International Building Code*. The capacity of the collector need not exceed the capacity of the diaphragm to deliver loads to the collector. A connection shall be provided from the collector to the reentrant wall to transfer the full collector force (load). If a truss or beam other than a rafter or purlin is supported by the reentrant wall or by a column integral with the reentrant wall, then an independent secondary column is required to support the roof or floor members whenever rocking or shear capacity of the reentrant wall is less than the tributary shear.

Commentary: *This provision is the only part of Chapter A2 not directly related to the topic of wall anchorage systems. It addresses two issues associated with reentrant corners: (1) The need for collectors to mitigate deformation incompatibilities between the diaphragm and the reentrant corner walls and to deliver tributary earthquake loads (full building loads, not just wall anchorage forces) to the reentrant corner walls, and (2) The damage that can occur when a short reentrant corner wall rocks or fails under in-plane loads.*

The provision calls for a capacity design approach. Alternatively, evaluation or retrofit of collectors to satisfy the requirements of ASCE 7 Section 12.10 should be deemed to comply with this provision. The ASCE 7 criteria are expected to be more conservative in most cases. If ASCE 7 criteria are used, the design loads may be reduced using the 75 percent factor but must include overstrength factors where specified by Section 12.10 and/or load increases where required by Section 12.3.3.4.

Section A206.8 requires a collector and collector connections adequate to carry the smallest of three values. For a 1-story building, the three values may be calculated as follows (adapted from the SEAOC commentary):

- *V_R, the maximum in-plane rocking capacity of the wall. This is the horizontal load,*

hypothetically delivered through the diaphragm and collectors, that will cause the wall to uplift or rotate about the edge of its footing by overcoming the resisting moment from dead load, soil weight, and reactions from continuous footings. Live load may be omitted, but dead load factors from the most critical applicable load combination should be applied. For this provision, it is unconservative to underestimate V_R.

- *V_n, the nominal shear capacity of the wall. This is the horizontal shear strength of the reinforced concrete or masonry, with no strength reduction factor.*
- *V_d, the maximum force that can be delivered by the diaphragm. This may be calculated as $V_d = (v)(L_1 + L_2)$, where:*
    - *L_1, L_2 = Depth of the diaphragm, parallel to the reentrant wall, along each side of the wall/collector.*
    - *v = Diaphragm nominal unit shear capacity from SDPWS as referenced by CBC Chapter 23. For diaphragm construction not addressed by SDPWS, the nominal unit shear capacity may be taken as the expected strength Q_{CE} from ASCE 41 Table 12-2 or as the expected strength from the City of Berkeley Framework Guidelines for Soft, Weak or Open Front Building Retrofit Design (i.e. the nominal strength from Table B.2.7 increased by 1.25 in accordance with Section A.3.2.2).*

The final sentence of Section A206.8 is intended to protect against collapse of floor or roof framing. Repetitive framing members (purlins or subpurlins, in the terminology of these Guidelines) are generally exempt from this requirement, but judgment should be applied to building-specific conditions.

The "tributary shear" to the reentrant corner wall is derived from the maximum design force in the collector to the reentrant corner, including Ω_0 greater than 1.0, but need not exceed the capacity of the diaphragm to deliver that force. The tributary shear is compared with the lesser of V_n and V_R defined above.

The "independent secondary column" should be separated from the end of the reentrant corner wall in question to prevent it being damaged by the same wall failure. The column, together with a footing as needed, should be capable of supporting all dead loads that would flow to it in the event that the rocking or damaged reentrant corner wall is unable to support its tributary gravity loads.

A206.9 Mezzanines. Existing mezzanines relying on reinforced concrete or reinforced masonry walls for vertical or lateral support shall be anchored to the walls for the tributary mezzanine load. Walls depending on the mezzanine for lateral support shall be anchored per Sections A206.1, A206.2 and A206.3.

Exception: Existing mezzanines that have independent lateral and vertical support need not be anchored to the walls.

***Commentary:** This provision merely ensures that where partial floors or mezzanines exist, they are attached to the walls and included as part of the wall mass so as to provide an integral response consistent with the chapter's basic assumptions about RWFD building behavior. The provision does not require or ensure a complete evaluation or retrofit of the mezzanine framing itself.*

SECTION A207
MATERIALS OF CONSTRUCTION

A207.1 Materials. Materials permitted by the building code, including their appropriate strength or allowable stresses, shall be used to meet the requirements of this chapter.

Appendix 2

Abbreviated ASCE 41 Tier 1 Checklists for Guidelines Scope Items 6, 7, & 8

The following checklist items from ASCE 41, abbreviated and edited as described in Guidelines Section B.5.4, are provided for the convenience of the design professional.

The checklist items provided here apply only to roof diaphragms and typical RWFD concrete or masonry walls (scope items 6, 7, and 8 from Guidelines Table B.3.1-1). For other scope items, all applicable ASCE 41 provisions must be considered, with the performance objective given in Guidelines Section B.5.1.

Following ASCE 41 procedures, any of the required issues for which the Tier 1 checklist item is marked Unknown (U) or Noncompliant (NC) must be addressed by further Tier 2 evaluation or by retrofit.

ASCE 41 Table 17-2

Status				Evaluation Statement
C	**NC**	**N/A**	**U**	LOAD PATH: The structure contains a complete, well-defined load path, including structural elements and connections, that serves to transfer the inertial forces associated with the mass of all elements of the building to the foundation.

ASCE 41 Table 17-24, for cast-in-place concrete walls only

Status				Evaluation Statement
C	**NC**	**N/A**	**U**	REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2.
C	**NC**	**N/A**	**U**	SHEAR STRESS CHECK: The shear stress in the concrete shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than the greater of 100 lb/in^2 or 2sqrt(f'$_c$).
C	**NC**	**N/A**	**U**	REINFORCING STEEL: The ratio of reinforcing steel area to gross concrete area is not less than 0.0012 in the vertical direction and 0.0020 in the horizontal direction.
C	**NC**	**N/A**	**U**	TRANSFER TO SHEAR WALLS: Diaphragms are connected for transfer of seismic forces to the shear walls.
C	**NC**	**N/A**	**U**	FOUNDATION DOWELS: Wall reinforcement is doweled into the foundation with vertical bars equal in size and spacing to the vertical wall reinforcing directly above the foundation.
C	**NC**	**N/A**	**U**	DIAPHRAGM CONTINUITY: The diaphragms are not composed of split-level floors and do not have expansion joints.
C	**NC**	**N/A**	**U**	OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls are less than 25% of the wall length.
C	**NC**	**N/A**	**U**	STRAIGHT SHEATHING: All straight sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered.
C	**NC**	**N/A**	**U**	SPANS: All wood diaphragms with spans greater than 24 ft consist of wood structural panels or diagonal sheathing.
C	**NC**	**N/A**	**U**	DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft and aspect ratios less than or equal to 4-to-1.

Status				Evaluation Statement
C	NC	N/A	U	OTHER DIAPHRAGMS: Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing.

ASCE 41 Table 17-25, for cast-in-place concrete walls only

Status				Evaluation Statement
C	NC	N/A	U	WALL THICKNESS. Thicknesses of bearing walls are not less than 1/40 the unsupported height or length, whichever is shorter, nor less than 4 in.

ASCE 41 Table 17-28, for precast concrete walls only

Status				Evaluation Statement
C	NC	N/A	U	REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2.
C	NC	N/A	U	WALL SHEAR STRESS CHECK: The shear stress in the precast panels, calculated using the Quick Check procedure of Section 4.4.3.3, is less than the greater of 100 lb/in^2 or $2sqrt(f'_c)$.
C	NC	N/A	U	REINFORCING STEEL: The ratio of reinforcing steel area to gross concrete area is not less than 0.0012 in the vertical direction and 0.0020 in the horizontal direction.
C	NC	N/A	U	WALL THICKNESS. Thicknesses of bearing walls are not less than 1/40 the unsupported height or length, whichever is shorter, nor less than 4 in.
C	NC	N/A	U	TRANSFER TO SHEAR WALLS: Diaphragms are connected for transfer of seismic forces to the shear walls.
C	NC	N/A	U	GIRDER–COLUMN CONNECTION: There is a positive connection using plates, connection hardware, or straps between the girder and the column support.
C	NC	N/A	U	PRECAST WALL PANELS: Precast wall panels are connected to the foundation.
C	NC	N/A	U	STRAIGHT SHEATHING: All straight sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered.
C	NC	N/A	U	SPANS: All wood diaphragms with spans greater than 24 ft consist of wood structural panels or diagonal sheathing.
C	NC	N/A	U	DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft and aspect ratios less than or equal to 4-to-1.
C	NC	N/A	U	OTHER DIAPHRAGMS: Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing.

ASCE 41 Table 17-28, for all walls

Status				Evaluation Statement
C	NC	N/A	U	WALL OPENINGS: The total width of openings along any perimeter wall line constitutes less than 75% of the length of any perimeter wall when the wall piers have aspect ratios of less than 2-to-1.

ASCE 41 Table 17-34, for reinforced masonry walls only

Status	Evaluation Statement
C NC N/A U	REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2.
C NC N/A U	SHEAR STRESS CHECK: The shear stress in the reinforced masonry shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than 70 lb/in^2.
C NC N/A U	REINFORCING STEEL: The total vertical and horizontal reinforcing steel ratio in reinforced masonry walls is greater than 0.002 of the wall with the minimum of 0.0007 in either of the two directions; the spacing of reinforcing steel is less than 48 in., and all vertical bars extend to the top of the walls.
C NC N/A U	TRANSFER TO SHEAR WALLS: Diaphragms are connected for transfer of seismic forces to the shear walls.
C NC N/A U	FOUNDATION DOWELS: Wall reinforcement is doweled into the foundation.
C NC N/A U	GIRDER–COLUMN CONNECTION: There is a positive connection using plates, connection hardware, or straps between the girder and the column support.
C NC N/A U	OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls are less than 25% of the wall length.
C NC N/A U	OPENINGS AT EXTERIOR MASONRY SHEAR WALLS: Diaphragm openings immediately adjacent to exterior masonry shear walls are not greater than 8 ft long.
C NC N/A U	STRAIGHT SHEATHING: All straight sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered.
C NC N/A U	SPANS: All wood diaphragms with spans greater than 24 ft consist of wood structural panels or diagonal sheathing.
C NC N/A U	DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft and aspect ratios less than or equal to 4-to-1.
C NC N/A U	OTHER DIAPHRAGMS: Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing.