CITY OF PASADENA

BUILDING AND SAFETY DIVISION

175 North Garfield Avenue, Pasadena, CA 91101-1704
(626) 744-4200 Fax: (626) 744-3979
www.cityofpasadena.net

SEISMIC DESIGN GUIDELINES

FOR EXISTING WOOD FRAMED BUILDINGS WITH SOFT, WEAK OR OPEN FRONT WALLS

INTRODUCTION

The purpose of the City Seismic Design Guidelines is to provide additional information and clarification to Civil or Structural Engineers in order to comply with Section 14.08 of the Pasadena Municipal Code for existing buildings with soft, weak, or open front wall lines.

Additional information can be found via the following web link:
https://ww5.cityofpasadena.net/planning/soft-story-retrofit-ordinance/

DEFINITIONS

BUILDING CODE is the current Building Code of the City of Pasadena

CRIPPLE WALL is a wood-framed stud wall extending from the top of the foundation wall to the underside of the lowest floor framing.

GROUND FLOOR is any floor within the wood-frame portion of a building 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 grades.

HISTORICAL BUILDING is any building designated as “qualified historical building” as defined in Part 8, Title 24 of the California Code of Regulations.

OPEN-FRONT WALL LINE is an exterior Wall Line, without vertical elements of the lateral force-resisting system, which requires tributary seismic forces to be resisted by diaphragm rotation or contains an excessive cantilever beyond parallel lines of shear walls. Diaphragms that cantilever more than 25% of the distance between lines of lateral force resisting elements from which the diaphragm cantilevers shall be considered excessive. Cantilevers shall not exceed more than 6 feet. Diaphragm cantilevers or exterior balconies of 6 feet or less in width shall not be considered excessive cantilevers.

OWNER or BUILDING OWNER is the individual(s), firm, corporation, or entity having legal possession, equitable interest in the property, or rights to sanction evaluation or Retrofit of a building.

RETROFIT is an improvement of the lateral force system by alteration of existing structural elements and/or addition of new structural elements.

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SOFT WALL LINE is a deficiency in a Wall Line in which the lateral stiffness is less than what is required by story drift limitations and deformation compatibility requirements of this guideline. In lieu of the engineering analysis required by these guidelines to determine whether a wall line's lateral stiffness is less than the aforementioned story drift limitations and deformation compatibility requirements, a Soft Wall Line deficiency may be defined as a Wall Line in a Story where the wall stiffness is less than 70% of the stiffness of the exterior wall above for the direction under consideration.

STORY is as defined in the Building Code, but includes any basement or underfloor space of a building with Cripple Walls exceeding four feet in height.

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

SWOF BUILDING COMFIGURATIONS are the Soft, Weak, or Open-Front Wall configurations as indicated in the Screening Report.

WALL LINE is any length of a wall along a principal axis of the building used to provide resistance to lateral loads.

WEAK WALL LINE Weak Wall Line is a deficiency of a Wall Line at the Ground floor in which the wall strength is less than eighty percent (80%) of the strength of the wall above in the direction under consideration.

RETROFIT SCOPE

The scope of the ordinance intends to reduce the risk of full or partial collapse in multi-story wood building containing exterior Soft, Weak, or Open-Front Walls (SWOF) lines. The ordinance therefore mandates the evaluation and possible strengthening of exterior SWOF lines around the building. The City has identified buildings that typically contain these SWOF lines. The minimum strengthening required to meet the intent of the ordinance is as follows:

Evaluate and strengthen, where needed, the soft, weak, and open front wall lines by providing new lateral force resisting system(s). The connections to the floor diaphragm directly above the new lateral force resisting system(s) and the foundation of the new system must be included in the design. Where existing diaphragms ratios exceed 3:1, the existing diaphragm should be shown to be adequate, strengthened if needed or new lateral force resisting lines should be added.

The first page of the retrofit drawings shall include a statement that clearly identifies the scope, design criteria, and extent of the retrofit.

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DESIGN METHODS

The retrofit shall meet the strength and stiffness prescribed herein including the following considerations:

- The lateral-load-path analysis shall include the resisting elements and connections from the wood frame diaphragm immediately above any soft, weak, or open wall lines and down to the foundation.
- Stories above the weak wall line shall be considered in the analysis but need not be modified.
- Wall lines along parking or similar open space shall be evaluated to determine the soft, weak, or open-front wall lines.
- Weakening the existing lateral force resisting system above the weak line shall not be permitted as a form of meeting the ordinance.

ANALYSIS & DESIGN PARAMETERS

Building Design Base Shear. The minimum design base shear for buildings, including Historical buildings, shall be 75 percent of the value specified in ASCE 7-10 Section 12.8.1.

Response Modification Factor, R. The value of R shall be per ASCE 7-10 Table 12.2-however, the value of R used in any direction shall not exceed the value at any story above, in the same direction per ASCE 7-10, 12.2.3.1.

Exceptions:

1. R need not be less than 3.5, provided the lateral force resisting system R Value as listed in ASCE 7-10, Table 12.2-1 are not less than 3.5.
2. R values greater than 3.5 shall meet the following requirements:
   - Retrofit shall mitigate the soft or weak wall line as defined in the ordinance.
   - The design professional shall perform additional investigation on the walls above the new system to prove the existing materials and details meet the requirements of ASCE 7-10, Table 12.2-1 for the proposed R value. Investigation shall be documented and submitted to the Building Official for review and approval.

Seismic Weight. Following loads shall be considered as the minimum unless shown otherwise:

- 10 psf for partition loads per ASCE 7-10 chapter 12
- 15 psf minimum roof dead load or provide detailed dead load calculation

- 15 psf (+8 psf for stucco soffit cover in parking area as applicable) minimum floor dead load or provide detailed dead load calculation
- 15 psf exterior wall weight, per sf of wall, or provide detailed exterior wall dead load calculations
- +15 psf for floor dead load due to existing concrete topping, if applicable
- +5 psf for existing solar panels on the roof as applicable

Redundancy factor, ρ. ρ shall be 1.3 unless the criteria in ASCE 7-10 Section 12.3.4.2 is met for the line being strengthen. For drift calculation, members, and connection design loads using overstrength factor, ρ shall be 1.0.

Importance factor shall be equal to 1.0 for all residential buildings.

Vertical distribution of seismic forces over the height of the structure shall be based on ASCE 7-10 Section 12.8.3.

Story Drift Limitations. The calculated story drift for each retrofitted story line shall not exceed the allowable deformation compatible with all vertical load- resisting elements and 0.025 times the story height. Where a cantilever column system utilizes pole footings or single spread footings, soil interaction shall be considered when determining the drift.

Deflection amplification factor, Cd, and the overstrength factor, Ω_0, shall be as follows:

For Lateral Force Resisting Systems using an R value equal to 3.5: 3.0 and 3.0, respectively.

For All other Lateral Force Resisting Systems: values as listed in ASCE 7-10, Table 12.2-1.

P-delta effects shall be considered for new lateral force resisting systems using the tributary area to the system. Where a cantilever column system utilizes pole footings or single spread footings, soil interaction shall be considered when evaluating P-delta effects.

Deformation Compatibility. All structural framing elements and their connections not required to be part of the lateral system, shall be adequate to maintain support of design dead and live loads when subject to expected deformation of seismic loads. Focus should be placed on the existing columns/post along the retrofit line to ensure they are positively attached so they can maintain support of the vertical gravity loads during a seismic event. Deformation compatibility shall also be satisfied for the vertical elements of the new lateral force resisting systems which rely on fixity at the base connection. To satisfy this requirement, the vertical elements of the lateral force resisting system shall be connected to the diaphragm and designed for the forces associated with the drift in the perpendicular direction to the line of strengthening. Unless a full building analysis is performed to determine drift demands, a 3% drift demand shall be assumed. The analysis may account for flexibility in the foundation and connection.

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Existing Materials

All existing components and materials shall be in sound conditions and constructed in conformance to the Pasadena Municipal Code before they can be used to resist lateral loads.

Existing shear walls that require analysis shall be permitted to use the values as follows unless a detailed verification of materials is performed by the engineer:

EXISTING MATERIALS OR CONFIGURATION OF MATERIALS	ALLOWABLE VALUES
Wood stud walls with lath and plaster or stucco	100 lbs. per foot

Existing Horizontal wood diaphragms that require analysis, shall be permitted to use the values as follows unless a detailed verification of materials is performed by the engineer:

EXISTING MATERIALS OR CONFIGURATION OF MATERIALS	ALLOWABLE VALUES
1. HORIZONTAL DIAPHRAGMS	
a. Roofs with straight sheathing and roofing applied directly to the sheathing.	100 lbs. per foot
b. Roofs with diagonal sheathing and roofing applied directly to the sheathing.	400 lbs. per foot
c. Floors with straight tongue-and-groove sheathing.	150 lbs. per foot
d. Floors with straight sheathing and finished wood flooring	300 lbs. per foot
e. Floors with diagonal sheathing and finished wood flooring.	450 lbs. per foot
f. Floors and roofs with straight sheathing and plaster applied to the joist or values for items 1 (a) and 1(c) rafters	Add 50 lbs. per foot to the allowable values for items 1(a) and 1(c)

For all other existing structural members, allowable design values are as follows unless a detailed verification of materials is performed by the engineer:

EXISTING MATERIALS OR CONFIGURATION OF MATERIALS	ALLOWABLE VALUES
1. Plain or reinforced concrete footings	$f'_c = 2500$ psi unless otherwise shown by tests
2. Douglas fir wood	Allowable stress same as No. 1.D.F.
3. Reinforcing steel	$f_s = 0.4\ F_y$, maximum 18 ksi
4. Structural steel	$f_b = 0.6\ F_y$, maximum 20 ksi
5. Anchor Bolts	Current code values

NEW SEISMIC STRENGTHENING SYSTEMS AND LIMITS

Special Steel Moment Frames (SMF)

- SMF shall be designed per AISC 341 E3 using a prequalified connection per AISC 358.
- At minimum, the top of the moment frame columns shall be braced per AISC 360 Appendix 6 unless a more detailed analysis is provided in accordance with AISC 360 Chapter C. See deformation compatibility section for additional requirements.

Intermediate Steel Moment Frames (IMF)

- IMF shall be designed per AISC 341 E2 using a prequalified connection per AISC 358.
- At minimum, the top of the moment frame columns shall be braced per AISC 360 Appendix 6 unless a more detailed analysis is provided in accordance with AISC 360 Chapter C. See deformation compatibility section for additional requirements.

Ordinary Steel Moment Frames (OMF)

- OMF Connections shall be designed per AISC 341 E1 meeting one of the requirements below:
  - Fully restrained moment connections designed per AISC 341 E1-6b (a), (b), or (c).
  - Partially restrained moment connections per AISC E1-6c.
- At minimum, the top of the moment frame columns shall be braced per AISC 360 Appendix 6

unless a more detailed analysis is provided in accordance with AISC 360 Chapter C. See deformation compatibility section for additional requirements.

Light-Frame Shear Walls shall be designed per ANSI/AF&PA NDS.

Special Cantilevered Column Systems (SCCS)

- SCCS columns shall comply with AISC 341 E6 and shall be designed using the load combinations including the amplified seismic load with overstrength factor. The design of SCCS shall consider soil interaction.
- A minimum of two columns are required per strengthened line.

Ordinary Cantilevered Column Systems (OCCS) are not permitted.

New Concrete Walls, Masonry Walls, or Steel Braced Frames are permitted provided a full building analyses considering diaphragm stiffness and torsional behavior is performed per ASCE 7-10 with design base shear requirements listed above or appropriate methodologies listed in the Alternative Design Methods section included in these guidelines.

ADDITIONAL DESIGN CONSIDERATIONS

Horizontal Structural Irregularities as defined in ASCE 7-10 for buildings with 3 or more stories including either type 2, 3, 4 or 5 shall meet the additional requirements of those sections referenced in the table for the SWOF lines being considered.

Horizontal Diaphragms shall be designed as follows:

- Cantilever diaphragms shall be designed for shear transfer.
- Limit the existing diaphragm ratio to 3:1 by adding a new lateral resisting element.

Transfer Diaphragms shall consider the following:

- Where a diaphragm is utilized to transfer shear load to the new lateral force resisting system from an existing wall above, omega need not be considered if the diaphragm can be shown to satisfy the max load that can be delivered to the diaphragm.
- A maximum horizontal cantilever diaphragm of 10 feet shall be permitted without the addition of a new lateral force resisting element if the diaphragm is designed to transfer the horizontal shear load.

Ties and continuity. Design all the new elements in the lateral load resisting path to transfer seismic loads from the diaphragm to the foundation.

unless a more detailed analysis is provided in accordance with AISC 360 Chapter C. See deformation compatibility section for additional requirements.

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- Where a diaphragm is utilized to transfer shear load to the new lateral force resisting system from an existing wall above, omega need not be considered if the diaphragm can be shown to satisfy the max load that can be delivered to the diaphragm.
- A maximum horizontal cantilever diaphragm of 10 feet shall be permitted without the addition of a new lateral force resisting element if the diaphragm is designed to transfer the horizontal shear load.

Ties and continuity. Design all the new elements in the lateral load resisting path to transfer seismic loads from the diaphragm to the foundation.

Collector elements. Design of collectors and drag struts shall be per ASCE 7-10 Section 12.10.2.1:

Steel Moment Frame Collector Elements

- Drag members, drag member connections to the frame, and drag splices shall be designed for the larger of Ω0 Fx, Ω0Fpx, and Fpx min. Forces need not exceed Fpx max.
- Connections from drag member to diaphragm and frame to diaphragm shall be designed for the larger of Fx, Fpx, and Fpx min. Forces need not exceed Fpx max.

Light-Frame Shear Wall Collector Elements

- Drag members, drag member connections to walls, drag splices and connections from drag member to diaphragm and frame to diaphragm shall be designed for the larger of F_x, F_{px}, and F_{px} min. Forces need not exceed F_{px} max.
- Size and spacing of all existing elements in the shear path used in shear transfer calculations shall be clearly identified in the plans as "To be verified in field during construction".

Perpendicular to open wall line. If side of open wall line is also open, then the wall line in perpendicular direction shall be checked for soft/weak story definition and be retrofitted if required. System should be design for entire line where diaphragm is continuous.

Foundations for New Lateral Force Resisting Systems shall be designed as follows:

- Foundation shall be designed for bearing, overturning, sliding, shear, flexure, and punching shear.
- Foundations and superstructure-to-foundation connections shall be designed per CBC 12.13.1.1.

  Exception: For cantilever columns systems utilizing pole footings or single spread footings, Ω_0 level forces shall be applied.
- Use of CBC Alternative Load Combinations is allowed.
- Sliding check may be considered satisfied if minimum 2 feet thick footings are provided.
- Minimum presumptive load-bearing values per CBC Section 1806 may be assumed.
- For cantilever columns, systems utilizing pole footings, the coefficient of sub-grade reaction shall be based on an approved geotechnical investigation.

Additional Anchorage Requirements for Buildings on Hillsides. Where a building within the scope of the ordinance or any portion thereof is constructed on or into a slope steeper than a 33% slope, the lateral-force-resisting system, at and below the base level diaphragm, shall also be analyzed for the effects of concentrated lateral loads caused at the building base from the hillside conditions and comply with the provisions of the Building Code. Refer to LARUCP for the definition of concentrated lateral loads. Existing foundations are not required to satisfy this section.

ALTERNATE DESIGN METHODS

Additional Alternate Design Methods. The Building Official may approve alternate analysis and/or design methodologies that meet the same performance intent as those prescribed in the ordinance and that achieve the objectives established by the ordinance. A design criteria indicating the design methodology and existing material verification (as applicable) shall be submitted to the City for review and approval prior to submission of plans.

For methods not listed below, please submit a request for modifications prior to completing the design and/or submittal. Provide ample justification for consideration. The modification request will be reviewed case by case by the building official. Approval of the request shall not apply for any other cases/structures.

Appendix Chapter A4, 2016 California Existing Building Code

- The entire first story must be analyzed and designed per this standard.
- Retrofit strength need not exceed 1.3 times the strength of story above.

ASCE 41-13, Seismic Evaluation and Retrofit of Existing Buildings

- Design to meet the Rehabilitation Objective (Section 1.4) (Life Safety Performance Level: S–3) for the BSE–1E earthquake hazard level.
- A Tier 2 or Tier 3 analysis shall be conducted.
- Retrofit strength need not exceed 1.3 times the strength of story above.

FEMA P-807, Seismic Evaluation and Retrofit of Multi-Unit Wood- Frame Buildings with Weak First Stories

- The entire weak first story must be analyzed and designed per this standard.
- The spectral demand shall be 0.5SMS, calculated in accordance with ASCE 7-10 section 11.4 except that for sites in site class E, the value of Fa shall be taken as 1.3.
- Acceptable performance level shall be based on drifts corresponding to Onset of Strength Loss in the seismic force- resisting wood-frame elements.
- The maximum limit probability of exceedance (POE) for evaluation or retrofit design shall be 20%.
- Limit diaphragm ratio to 2:1.
- Where open line is not retrofitted, the cantilever diaphragm shall be analyzed and shown to be adequate.

- A detailed building survey which documents the existing sheathing materials for walls and diaphragms shall be provided for approval.

Capacity Based Design

- The retrofit demand to the Open Line, based on the Design Base Shear, shall be permitted to be limited based on the maximum force that can be delivered to the new lateral force-resisting system, in accordance with ASCE 7-10 Section 12.14.3.2. The maximum force may be calculated based on either:
  - The combined capacity of the entire second story wall immediately above the new lateral force-resisting system plus the capacity of the second floor diaphragm along the entire line being considered, or
  - By using a ratio of the full 2nd story capacity to the 2nd story design shear, to derive a scale factor on the Design Base Shear.
  - A continuous collector element shall be provided along the entire wall line, designed in accordance with the Additional Design Considerations above.
- A detailed building survey which documents the existing sheathing materials for walls and diaphragms shall be provided for approval.
- The following Minimum Strength Values shall be assumed based on the findings of the survey. For shear walls, Minimum Strength Values represent a single layer of sheathing for one side of a wall. The listed values shall be additive based on the total layers of sheathing materials considering each side of the wall.

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EXISTING MATERIALS OR CONFIGURATION OF MATERIALS FOR SHEAR WALLS	MINIMUM STRENGTH VALUES
Stucco	333 plf
Horizontal Wood Sheathing	171 plf
Diagonal Wood Sheathing	913 plf
Plaster on wood/metal lath	538 plf (wood lath)
Gypsum Wall board	213 plf
Plaster on gypsum lath	402 plf
WSP, 8d@4" O.C.	1112 plf
WSP, 8d@2" O.C.	2192 plf
WSP, 10d@4" O.C.	1496 plf
WSP, 10d@2" O.C.	2512 plf

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EXISTING MATERIALS OR CONFIGURATION OF MATERIALS FOR DIAPHRAGMS	MINIMUM STRENGTH VALUES
Single Straight Sheathing	120 plf (w/out wood flooring) 1500 plf (w/ wood flooring)
Double Straight Sheathing	600 plf (chorded) 400 plf (unchorded)
Single Diagonal Sheathing	600 plf (chorded) 420 plf (unchorded) 1800 plf (w/ wood flooring)
Double Diagonal Sheathing	900 plf (chorded) 625 plf (unchorded)
Straight tongue-and-groove sheathing	300 plf
WSP[5], 8d@4" O.C.	1080 plf
WSP[5], 8d@2" O.C.	1800 plf
WSP[5], 10d@4" O.C.	1275 plf
WSP[5], 10d@2" O.C.	2190 plf

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QUALITY ASSURANCE

Structural Observation

All structures affected by this ordinance require structural observations by this ordinance. The owner shall employ the Engineer of Record responsible for the structural design or another registered Engineer designated by the Engineer of Record to perform structural observations as defined in the Building Code.

The designated design professional shall visit the site to verify applicable existing materials and framing details in the location of the new work. Where the condition of the materials is observed to be deteriorated or structurally compromised the design professional shall submit a testing and/or repair program for City review and approval. Where access is not available, the design professional shall clearly identify on the construction drawings the elements that need to be verified in the field prior to fabrication and erection.

All structures to be retrofitted require structural observation during construction in accordance with the Building Code. The design professional shall list on the construction drawings the milestones of when the contractor shall notify the design professional to visit the site. One of the milestones shall include verification of critical existing elements and/or connections between new and existing elements utilized in the load path transfer.

Special Inspection(s)

Special Inspections shall be provided as required by the Building Code. Additional inspections shall be noted on drawings as required by the Building Official.

DECLARATIONS

Engineer's or Architects Statement

At a minimum, the responsible engineer or architect shall provide the following statement on the approved plans:

"I am responsible for designing this building's seismic strengthening in compliance with the minimum standards of the Mandatory Seismic Strengthening Provisions for Existing Wood-Frame Buildings with Soft, Weak, or Open-Front Walls (Chapter 14.08)."

Engineer's or Architects Close Out Letter

The responsible engineer or architect shall provide a letter to the Building Official at the end of the construction indicating that they have conducted the required structural observations and that the final construction meets the intent of the drawings.

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Owners Statement

At a minimum, the Owner or Owner's representative shall provide the following statement on the approved plans:

> *"I, _____, understand the seismic evaluation and strengthening performed under this project is limited to that specified in the Mandatory Seismic Strengthening Provisions For Existing Wood Frame Buildings With Soft Weak or Open-Front Walls (Chapter 14.08) which is intended to reduce the risk under a seismic event. I understand the full building has not been evaluated nor strengthened for other potential structural deficiencies that may cause a life safety concern, injury, or property damage risk under a seismic event."*