Mandatory Retrofit Program for Wood Frame Buildings with Soft, Weak or Open-Front Wall Lines

STRUCTURAL DESIGN GUIDELINES

The purpose of this information bulletin is to provide structural design guidelines per the minimum standards of Division 93, Los Angeles Municipal Code (Ordinance 183983 and 184081) to mitigate the hazards from the deficiencies in wood-framed soft-story buildings. These buildings have ground floor parking or other similar open space that causes soft, weak, or open-front wall lines. Adherence to these minimum standards will improve the performance of these buildings during earthquakes and reduce, but not necessarily prevent, the loss of life, injury or earthquake-related damage.

Definitions

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 an excessive cantilever beyond parallel lines of shear wall. Diaphragms that cantilever more than 25% of the distance between lines of lateral force resisting elements from which the diaphragm cantilevers and exterior balconies of 6 feet or more in width shall be considered excessive.

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

SOFT WALL LINE is a wall line, the lateral stiffness of which is less than what is required by story drift limitations or deformation compatibility requirements of this division. In lieu of the engineering analysis required by this division to determine whether a wall line's lateral stiffness is less than the aforementioned story drift limitations or deformation compatibility requirements, a soft wall line 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 STRENGTH is the total strength of all seismic-resisting elements sharing the same story shear in the direction under consideration.

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

WEAK WALL LINE is a wall line at the ground floor where the wall strength is less than 80% of the strength of the wall above in the direction under consideration.

I. **Design Methods**

A. **Analysis and Design Requirements.** The retrofit shall meet the strength and stiffness in conformance to the 2023 LABC except as modified under Section 9309. 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 the parking or similar open space shall be evaluated to determine the soft, weak, or open-front wall lines.

1. **Building Design Base Shear.**

a) The design base shear shall be 75 percent of the value specified in ASCE 7-16 Section 12.8.1 [2023 LABC Section 9309.2]

b) **Response Modification Factor, R**. The value of R used in any direction shall not exceed the value at any story above, in the same direction.

(1) **Exception**: R need not be less than 3.5, provided the structural systems are not cantilevered column systems. [2023 LABC Section 9309.2]

(2) If using R greater than 3.5, the existing lateral system assumed on upper level must be verified to comply with specifications of same lateral system listed in ASCE 7-16, Table 12.2-1.

c) **Seismic Weight.** Following loads shall be considered:

(1) 10 psf for partition loads per ASCE 7-16 Chapter 12 Section 12.7.2 and shall be 15 psf for office buildings where partition locations are subject to change per ASCE 7-16 Chapter 4 Section 4.3.2

(2) 15 psf minimum for roof and floor dead load or provide detailed roof and floor dead load calculation,

(3) 8 psf for stucco cover of ceiling in parking area,

(4) 15 psf exterior wall weight, per sf of wall, or provide detailed exterior wall dead load calculations,

(5) 15 psf for floor dead load due existing concrete topping, if applicable, and

(6) 5 psf for existing or possible future installation of solar panels on the roof.

d) **Redundancy factor, ρ**

(1) ρ shall be 1.3 unless the criteria in ASCE 7-16 Table 12.3-3 is met for the line being strengthen.

(2) For drift calculation and, members and connection design loads using overstrength factor, ρ shall be 1.0. [ASCE 7-16 Section 12.3.4.1]

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

2. **Strengthening Systems and Limits**

a) **Concrete walls, masonry walls, or steel braced frames shall <u>not</u> be permitted.** The use of and/or strengthening of existing masonry or concrete walls is permitted.

b) **Steel Moment Frames**

(1) **Special** moment frames shall be designed per AISC 341-16 Section E3 using a prequalified connection per AISC 358-16.

(2) **Intermediate** moment frames are <u>not</u> permitted in Seismic Design Category E or F unless the following conditions are met.

(i) The building is of light framed construction, which height is not more than 35 feet, total dead load is not more than 35 psf per floor, and exterior wall dead load is not more than 20 psf.

(ii) IMF shall be designed per AISC 341-16 Section E2 using a prequalified connection per AISC 358-16.

(3) **Ordinary** moment frames are <u>not</u> permitted in Seismic Design Category D, E, or F unless the following conditions are met.

(i) The building is of light framed construction, which height is not more than 35 feet, total dead load is not more than 35 psf per floor, and exterior wall dead load is not more than 20 psf.

(ii) Connections are designed per AISC 341-16 Section E1 meeting one of the requirements below:

(a) Fully restrained moment connections designed per AISC 341-16 Section E1-6b (a), (b), or (c).

(b) Partially restrained moment connections per AISC 341-16 Section E1-6c.

(4) At minimum, the top of the moment frame columns shall be braced per AISC 360-16 Appendix 6 unless a

more detailed analysis is provided in accordance with AISC 360-16 Chapter C.

c) **Special cantilevered columns** shall comply with AISC 341-16 Section E6. SCCS shall be designed using the load combinations including the amplified seismic load with overstrength factor.

(1) **Pole Structures** shall include the effects of rotation and soil stiffness. Deflection calculations shall be based on approved Soils/Geology Report.

(i) Where new columns are installed below existing gravity members, these existing members shall be analyzed and detailed to resist the additional rotational moment in each orthogonal direction.

d) **Deflection amplification factor**, C_d, and the **overstrength factor**, $\Omega_{0,}$ shall be as follows:

(1) For cantilever column systems: values as listed in ASCE 7-16, Table 12.2-1.

(2) For moment Frames: 3.0 and 3.0, respectively.

3. **Vertical distribution of seismic forces** over the height of the structure shall be based on ASCE 7-16 Section 12.8.3.

4. **Additional Anchorage Requirements for Buildings on Hillsides.** [2023 LABC Chapter 3909.6] Where a building or a 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 must comply with the provisions of 2023 LABC Chapter 94.

5. **Story Drift Limitations**

a) The calculated story drift shall not exceed the lesser of either of the following:

(1) Allowable deformation compatible with all vertical load-resisting elements.

(2) 0.025 times the story height.

b) In lieu of verifying that the stiffness of the story with the new strengthening system(s) is greater than 70% of the stiffness of the story above, the drift shall be limited to 2% of the story height.

6. **P-delta effects.** The stress analysis of load bearing cantilevered columns shall use an effective length factor of 2.1 in the direction normal to the axis of the beam.

7. **Horizontal Diaphragms**.

   a) Cantilever diaphragms shall be designed for shear transfer.

   b) Limit diaphragm ratio to 3:1 by adding a new lateral resisting element.

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

   a) The integrity of the existing LFRS and its load path shall be maintained at the transition between the existing and proposed LFRS. Where the existing LFRS above the soft, weak or open front wall line consists of stucco, drywall or other shearwall systems, the Engineer of Record shall provide analysis and details demonstrating how shear transfer is maintained at the existing shearwalls.

   b) Where eccentricity exists between the new and existing elements (e.g. offset between new lateral resisting elements and the existing diaphragm). Provide analysis and details to demonstrate additional demands on elements due to offset can be properly transferred. Demands shall be amplified per ASCE 7-16 Section 12.4.3.

9. **Collector elements.** Design of collectors and drag struts shall be per ASCE 7-16 Section 12.10.2.1:

   a) **Steel Moment Frames**

      (1) Drag members, drag member connections to the frame, and drag splices shall be designed for the larger of $\Omega_0 F_x$, $\Omega_0 F_{px}$, and F_{px} min. Forces need not exceed F_{px} max.

      (2) 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.

   b) **Light-framed Shear Walls**

      (1) 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.

   c) 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”.

10. **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.

11. **Orthogonal Direction.** Where new LFRS columns are installed below existing gravity members, these existing members shall be analyzed and detailed to resist the additional rotational moment in each orthogonal direction.

12. **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.

13. **Foundations** shall be designed for bearing, overturning, sliding, and punching shear.

B. **Alternate Design Methods**:

Pursuant to Section 104.2.6, the department may approve alternate design methods that improve the entire first story seismic performance and are at least equivalent to those prescribed in Division 93. The retrofit design using alternate methods shall achieve the "life safety" objectives intent established by Division 93. The following are approved alternate design methods.

1. Appendix Chapter A4, 2023 Los Angeles Existing Building Code. The entire first story must be analyzed and designed per this standard.

2. ASCE 41-17, Seismic Evaluation and Retrofit of Existing Buildings,

   a) Design to meet the Rehabilitation Objective (Section 1.4) (Life Safety Performance Level: S–3) for the BSE–1E earthquake hazard level.

   b) Retrofit strength need not exceed 1.3 times the strength of story above.

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

   a) The entire weak first story must be analyzed and designed per this standard.

   b) The spectral demand shall be $0.5S_{MS}$, calculated in accordance with ASCE 7-16 section 11.4.

   c) Acceptable performance level shall be based on drifts corresponding to Onset of Strength Loss in the seismic force-resisting wood-frame elements.

d) The maximum limit probability of exceedance (POE) for evaluation or retrofit design shall be 20%.

e) Limit diaphragm ratio to 2:1.

f) Maintenance of Building Affidavit must be recorded to ensure that all existing walls and other structural components shall remain and unaltered.

g) Owner shall sign a covenant to maintain all walls and the covering material as assumed in the calculations and shown on the plans. No future alterations can be made unless the entire building has been analysis and approved by LADBS.

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

II. Existing Materials

All existing components and materials shall be in sound conditions and constructed in conformance to the 2023 LABC before they can be used to resist lateral loads.

A. **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

B. **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)

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 = 1500 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

III. Declaration (Engineer's or architect's 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 regulations of the Mandatory Earthquake Hazard Reduction in Existing Wood-Frame Buildings with Soft, Weak, or Open-Front Walls (2023 LABC Chapter 93).