DIVISION 94

VOLUNTARY - EARTHQUAKE HAZARD REDUCTION IN EXISTING HILLSIDE BUILDINGS

(Division 94 Added by Ord. No. 171,258, Eff. 8/30/96.)

SEC. 91.9401. PURPOSE.

(Amended by Ord. No. 172,592, Eff. 6/28/99, Oper. 7/1/99.)

The purpose of this division is to promote public safety and welfare by reducing the risk of death or injury that may result from the effects of earthquakes on existing hillside buildings constructed on or into slopes in excess of one unit vertical in three units horizontal (33.3% slope). Such buildings have been recognized as life hazardous as a result of partial or complete collapse that occurred during the Northridge Earthquake.

The provisions of this division are minimum standards for structural systems established primarily to reduce the risk of loss of life or injury resulting from earthquakes and will not necessarily prevent loss of life or injury or prevent earthquake damage to an existing building which complies with these standards.

This division provides voluntary retrofit standards under which buildings shall be permitted to be structurally analyzed and retrofitted. When fully followed, these standards will strengthen the portion of the structure that is most vulnerable to earthquake damage.

SEC. 91.9402. SCOPE.
(Added by Ord. No. 171,258, Eff. 8/30/96.)

The provisions of this division may be applied to all existing hillside buildings designed under building codes effective prior to June 19, 1995. If only a portion of the building is supported on or into the slope, these regulations may be applied to the entire building.

Seismic retrofit work as described in this division may be applied to the portion of the structure defined as the base-level-diaphragm and below. Non-habitable accessory buildings, decks not supporting the main building, and existing conditions above the base-level-diaphragm are exempt from these regulations.

Seismic strengthening constructed prior to the effective date of the ordinance may be evaluated in accordance with the provisions of this division.

SEC. 91.9403. DEFINITIONS.

For the purpose of this division, in addition to the applicable definitions, symbols and notations in this Code, certain additional terms are defined as follows:

BASE (BASE LEVEL) is the level at which the earthquake motions are considered to be imparted to the structure or the level at which the structure as a dynamic vibrator is supported.

BASE-LEVEL-DIAPHRAGM is the floor at, or closest to, the top of the highest level of the foundation.

DIAPHRAGM ANCHORS are assemblies that connect a diaphragm to the adjacent foundation at the uphill diaphragm edge.

DIAPHRAGM BACKSPAN is the horizontal cantilevered distance parallel to the direction of the lateral force, between the outermost vertical lateral force resisting elements and the edge of the diaphragm.

DOWNHILL-DIRECTION is the descending direction of the slope approximately perpendicular to the slope contours.

FOUNDATION is the concrete or masonry which supports a building, including footings, stem walls, retaining walls, and grade beams.

FOUNDATION EXTENDING IN THE DOWNHILL-DIRECTION is a descending foundation and approximately perpendicular to the uphill foundation.

FOUNDATION, UPHILL is a foundation parallel and closest to the uphill diaphragm edge, as defined herein.

HILLSIDE BUILDING is any wood frame building or portion thereof constructed on or into a slope steeper than one unit vertical in three units horizontal (33.3% slope).

PRIMARY ANCHORS are diaphragm anchors designed for and providing direct connection as described in Sections 91.9406.2 and 91.9406.3 between the diaphragm and the uphill foundation.

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

SECONDARY ANCHORS are diaphragm anchors designed for and providing a redundant diaphragm to foundation connection, as described in Section 91.9406.4.

UPHILL DIAPHRAGM EDGE is the edge of the diaphragm adjacent to or closest to the highest ground level at the perimeter of the diaphragm.

SEC. 91.9404. GENERAL REQUIREMENTS.
(Added by Ord. No. 171,258, Eff. 8/30/96.)

Except as modified herein, the analysis and design of the work within the scope of this division shall be in accordance with Division 16 of this Code.

SEC. 91.9405. PRE-DESIGN INVESTIGATION.
(Added by Ord. No. 171,258, Eff. 8/30/96.)

The engineer or architect shall prepare a pre-design field investigation report in accordance with Department guidelines and shall file the report when the plans are filed for permit. The plans shall include a description of the existing lateral force resisting system at and below the base.

SEC. 91.9406. ANALYSIS AND DESIGN.
(Added by Ord. No. 171,258, Eff. 8/30/96.)

91.9406.1. General. Every hillside building within the scope of this division shall be analyzed, designed, and constructed in accordance with the following provisions.

91.9406.1.1. Base for Seismic Design Defined. The base for seismic design is defined as follows:

1. **Downhill-Direction.** For seismic forces acting in the downhill- direction, the base of the building shall be the floor at or closest to the top of the highest level of the foundation.

2. **Normal to the Downhill-Direction.** For seismic forces acting normal to the downhill-direction, the distribution of seismic forces over the height of the building using U.B.C. Section 1628.4, shall be determined using the height measured from the top of the lowest level of the building foundation. Retrofitting, however, shall only be required at the base-level-diaphragm and below.

91.9406.1.2. Design Base Shear. The design base shear shall be that required at the time of the original building permit, but not less than $V = 0.133\ W$.

91.9406.2. Base Shear Resistance in the Downhill-Direction.

91.9406.2.1. General. The base shear in the downhill-direction, including forces from the base-level-diaphragm, shall be resisted through primary anchors from diaphragm struts or collectors provided in the base level framing to the foundation.

91.9406.2.2. Location of Primary Anchors. A primary anchor and diaphragm strut or collector shall be provided in line with each foundation extending in the downhill-direction. Primary anchors and diaphragm struts or collectors shall also be

provided where interior vertical lateral force resisting elements occur above and in contact with the base-level-diaphragm.

The base-level-diaphragm shall be provided with primary anchors designed for the tributary forces spaced at a maximum 30 feet (9145 mm) on center. Where the floor below the base extends to the uphill foundation, and the foundation at the base is not adequate to resist the forces from the primary anchors, the base shear may be transferred to that lower level and the primary anchorage made at that lower level. The connection shall be made directly to the foundation. The existing foundation shall be evaluated as specified in Section 91.9406.11.

91.9406.3. Seismic Forces on Floor Levels Below the Base in the Downhill-Direction.

91.9406.3.1. General. All floor diaphragm connections between floor diaphragms below the base level diaphragm shall be designed in accordance with the provisions of this section.

91.9406.3.2. Design. Each floor level below the base defined in Section 91.9406.1.1 shall be designed for all tributary loads at that level using a minimum seismic force factor not less than the base shear coefficient.

91.9406.3.3. Direct Connections. (Each floor level shall be directly connected to the foundation through a system of primary anchors at that level as required for the base as specified in Section 91.9406.1.1.

91.9406.4. Secondary Anchors from Diaphragm to Foundation for Seismic Forces at and Below the Base in the Downhill-Direction.

91.9406.4.1. General. In addition to the anchors required by Sections 91.9406.2 and 91.9406.3, the floor diaphragm for levels at and below the base shall be anchored to the uphill foundation at the level of the diaphragm, as specified in this section.

EXCEPTION:
Secondary anchors are not required where:

1. the concrete or masonry foundations in the downhill-direction are spaced at not more than 30 feet (9145 mm) on center and extend up to and are directly connected to the base-level-diaphragm for at least 70 percent of the diaphragm depth; or
2. the diaphragm is separated from the mudsill at the uphill foundation by a cripple wall which has anchor bolts and is braced in the plane of the wall and constructed with studs that are no less than 12 inches (305 mm) in height and primary anchors are spaced a maximum of 20 feet (6096 mm) on center; or
3. the deflection of the plywood floor diaphragm between adjacent primary anchors is calculated to be less than 1/4 of an inch (6.4 mm).

91.9406.4.2. Diaphragm Anchors. Secondary anchors required by this section shall be provided at each level at and below the base of the building. Diaphragm anchors shall be fully developed into the diaphragm and be connected to the foundation at the uphill diaphragm edge to develop the forces required by this section.

91.9406.4.3. Anchor Spacing. Secondary anchors required by this section shall be uniformly distributed along the uphill diaphragm edge and shall be spaced a maximum of four feet (1219 mm) on center.

91.9406.4.4. Anchor Capacity for Floor Diaphragms at the Base and Below. Secondary anchors at the base and below shall be designed for a uniformly distributed minimum force equal to the total primary anchorage design force at that level divided by the length of the uphill diaphragm edge, but shall not be less than 300 pounds per lineal foot (4.37 kN/m). The existing foundation need not be checked to resist the additional forces induced by the system of secondary anchors; however, the existing foundation shall be evaluated as specified in Section 91.9406.11.

91.9406.5. Design of Anchorage.

91.9406.5.1. General. Primary and secondary anchors, and diaphragm struts and collectors, shall be designed in accordance with the provisions of this section.

91.9406.5.2. Anchorage. The structure shall be anchored to the foundation as specified in Sections 91.9406.2, 91.9406.3 and 91.9406.4.

91.9406.5.3. Fasteners. All bolted fasteners used to develop connections to wood members shall be provided with square plate washers at all bolt heads and nuts. Washers shall be minimum 3/16 inch (4.8 mm) thick and two inch (51 mm) square for 1/2-inch (12.7 mm) diameter bolts, and 1/4 inch (6.4 mm) thick and 2-1/2 inch (64 mm) square for 5/8 inch (15.9 mm) diameter or larger bolts. Nuts shall be wrench tightened prior to covering.

91.9406.5.4. Fastening. The diaphragm to foundation anchorage shall not be accomplished by the use of toe nailing, nails subject to withdrawal, or wood in cross grain bending or cross grain tension.

91.9406.5.5. Size of Wood Members. Wood diaphragm struts, collectors, and other wood members connected to primary anchors shall not be less than three inch (76 mm) nominal width members or doubled two inch (51 mm) nominal width members. Doubled two inch (51 mm) nominal width members shall be fastened together according to the provisions of Division 23 of this Code. Secondary diaphragm anchors as specified in Section 91.9406.4 may be developed through existing two inch (51 mm) nominal width framing members. The effects of eccentricity on wood members shall be evaluated as required per Section 91.9406.5.9.

91.9406.5.6. Design. Primary and secondary anchorage, including diaphragm struts, splices, and collectors shall be designed for 125 percent of the tributary force.

91.9406.5.7. Allowable Stress Increase. (Amended by Ord. No. 172,592, Eff. 6/28/99, Oper. 7/1/99.) The one-third allowable stress increase permitted under C.B.C. Section 1612.3 or 2316.2 shall not be permitted for materials using allowable stress design methods.

91.9406.5.8. Seismic Load Factor. (Amended by Ord. No. 172,592, Eff. 6/28/99, Oper. 7/1/99.) Steel elements of the diaphragm anchorage systems and continuity ties shall be designed by the allowable stress design method using a load factor of 1.7. The strength design specified in C.B.C. Section 1923.2, using a load factor of 2.0 in lieu of 1.4 for earthquake loading shall be used for the design of embedment in concrete.

91.9406.5.9. Symmetry. All seismic lateral force foundation anchorage and diaphragm strut connections shall be symmetrical. Eccentric connections may be permitted when demonstrated by calculation or tests that all components of force have been provided for in the structural analysis or tests.

91.9406.5.10. Load Path.

91.9406.5.10.1. Primary Anchors. The load path for primary anchors shall be fully developed into the diaphragm and into the foundation. The foundation must be shown to be adequate to resist the concentrated loads from the primary anchors and must be shown to comply with the following:

1. Soil maximum bearing capacity for conventional footings shall be limited to 3000 psf (143.7 kPa) unless an approved geotechnical report permits higher bearing values.

2. Conventional continuous footings shall be analyzed for uplift forces induced by primary anchors.

3. Soil capacities need not be investigated for grade beam and caisson or pile foundations.

4. Shear stress in grade beams and tie beams shall be investigated for vertical component of primary anchor forces. Unless otherwise known, a maximum 2000 psi (13.8 MPa) concrete strength shall be assumed.

91.9406.5.10.2. Secondary Anchors. The load path for secondary anchors need not be developed beyond the connection to the foundation.

91.9406.5.10.3. Above Base Uplift Forces. The load path for uplift forces generated from above the base shall be analyzed and fully developed into the below base structural system.

91.9406.6. Base Shear Resistance Normal to the Downhill-Direction.

91.9406.6.1. General. Lateral force resisting elements acting in the normal to the downhill-direction shall be designed in accordance with the requirements of following Sections.

91.9406.6.2. Base Shear. In developing the base shear for seismic design, the structural system factor (Rw) shall not exceed six for bearing wall and building frame systems.

91.9406.6.3. Vertical Distribution of Seismic Forces. The distribution of seismic forces acting normal to the downhill-direction shall be determined using ~~U.B.C. Section 1628.4~~ C.B.C. Section 1630.5. The height of the structure in ~~Equation (28-8) of U.B.C. Section 1628.4~~ Equation (30-15) of C.B.C. Section 1630.5 shall be taken from the base which shall be measured from the top of the lowest level of the building foundation.

91.9406.6.4. Drift Limitations. The interstory drift below the base-level- diaphragm shall not exceed 0.005 times the story height. The total drift from the base-level-diaphragm to the top of the foundation shall not exceed 3/4 inch (19 mm). Where the story height or the height from the base-level-diaphragm to the top of the foundation varies because of a stepped footing or story offset, the height shall be measured from the average height of the top of the foundation. The calculated story drift shall not be reduced by the effect of horizontal diaphragm stiffness.

91.9406.7. Lateral Force Resisting Systems at the Base and Below in the Downhill-Direction.

91.9406.7.1. General. As an alternative to providing primary anchor connections from diaphragms to foundation in the downhill-direction, the following systems may be used, provided their location and spacing is maintained as specified in Section 91.9406.2.2 for primary anchors.

91.9406.7.2. Wood Shear Walls. Wood structural panels or existing wood diagonal sheathed shear walls may be used provided:

1. The minimum length of shear wall shall be eight feet (2438 mm).

2. The minimum level length between steps in the shear wall sill shall be eight feet (2438 mm) and the maximum step height between adjacent sills shall be two feet eight inches (813 mm).

3. Sill plates do not slope and they bear on a level surface.

4. The design lateral forces shall be distributed to lateral force resisting elements of varying heights in accordance with the stiffness of each individual element. The stiffness of a stepped wood structural panel shear wall may be determined by dividing

the wall into adjacent rectangular elements, subject to the same top of wall deflection. Deflections of shear walls may be estimated by U.B.C. Standard 23-2 Section 23.223 or other equivalent methods. Sheathing and fastening requirements for the stiffest section shall be used for the entire wall. Each section of wall shall be anchored for shear and uplift at each step as an independent shear wall.

5. Actual configuration of steps shall be determined in the field at the time of pre-design investigation.

6. The drift limitations of Section 91.9406.6.4 are not exceeded.

91.9406.7.3. Braced Frames. Structural steel braced frames with concentric connections may be used as part of the lateral force resisting system. All members in braced frames shall be designed to resist tension and compression forces. Seismic forces shall not induce flexural stresses in any member of the frame, in diaphragm struts, or in the collectors. Where existing anchor bolts are used for anchorage, existing confinement shall be verified and additional confinement provided where necessary. When the braced frame is not rectangular, distribution of forces to members shall account for the variations in slope.

91.9406.7.4. Rod-Braced Frames and Diaphragms. Existing tension only braces may be used provided they resist five times the design force, and the connections have the capacity to resist the yield strength of the braces. Tension braces and their connections shall be exposed for evaluation. Existing anchor bolts shall be tested in shear and tension to five times the design force.

91.9406.7.5. Cement Plaster and Lath and Gypsum Wallboard. The sheathing materials listed in Section 91.2513 of this Code are not permitted to resist seismic lateral forces below the base-level-diaphragm.

91.9406.8. Lateral Force Resisting Systems at the Base and Below and Normal to the Downhill-Direction. Lateral force resisting systems acting normal to the downhill-direction may include steel moment frames and those systems permitted under Section 91.9406.7, provided the drift limitations of Section 91.9406.6 are not exceeded.

91.9406.9. Diaphragms.

91.9406.9.1. General. Diaphragms at the base and below may be of straight one- inch by six-inch (25 mm by 152 mm) or two-inch by six-inch (51 mm by 152 mm) sheathing, provided vertical lateral force resisting elements in the downhill-direction or primary anchors are spaced no more than 20 feet (6096 mm) apart and the diaphragm shear forces do not exceed 100 plf (1.46 kN/m).

91.9406.9.2. Existing Diaphragms. Existing plywood and diagonally sheathed diaphragms need not be investigated.

91.9406.9.3. Existing Cantilevered Diaphragms. Existing cantilevered wood diaphragms are acceptable provided they do not cantilever more than one-half the diaphragm backspan (anchor span).

91.9406.9.4. Wood Diaphragm Rotation. Diaphragm rotation is not permitted in resisting lateral forces.

91.9406.10. Steel Beam to Column Connections.

91.9406.10.1. General. All steel beam to column connections shall be braced at supports and locations of concentrated loads. The beam to column connection shall be designed to prevent rotation of the beam.

91.9406.10.2. Steel Beams. Steel beams shall have stiffener plates installed on each side of the beam web at the column supports and points of concentrated load. The stiffener plates shall be welded to each beam flange and beam web. This requirement applies at the base and below and only to those connections which are part of the lateral load resisting system or lateral load path.

91.9406.10.3. Column Bracing. All single length multi-level height columns shall be braced in each orthogonal direction at each diaphragm level.

91.9406.11. Foundations.

91.9406.11.1. Existing Foundations. Foundation soundness shall be verified by the engineer or architect. Foundation types such as unreinforced masonry, stone and ungrouted concrete block and unreinforced concrete shall be retrofitted to resist lateral loads applied through the diaphragm anchors.

91.9406.11.2. Damaged Foundations. Damaged foundations shall be evaluated by the engineer or architect. Cracks in excess of 1/8 inch (3.2 mm) or differential displacement in excess of 1/4 inch (6.4 mm) shall be further investigated and repaired where necessary. Specifications for the restoration of the earth to wood separation shall be included and be made a part of the plans.

91.9406.11.3. Stud Wall Attachment. Shot pinned anchors shall not be used to resist lateral forces. Lateral force resisting systems which utilize shot pins shall be retrofitted with approved drilled anchors.

91.9406.11.4. Existing Framing Connections. Deteriorated framing and connections shall be repaired or replaced.

91.9406.11.5. Metal Connectors. Metal connectors shall not be in contact with, or below earth unless the connectors are hot dipped galvanized and further protected from earth with four inches of concrete.

91.9406.12. Existing Materials.

91.9406.12.1. Allowable Stresses. Existing materials may be used as part of the lateral load-resisting system provided that the stresses in these materials do not exceed the values shown in Table 94-A.

SEC. 91.9407. HISTORICAL BUILDINGS.
(Amended by Ord. No. 172,592, Eff. 6/28/99, Oper. 7/1/99.)

Qualified Historical Buildings shall be allowed to use alternate building regulations or deviations from this division in order to preserve their original or restored architectural elements and features. See Section 91.8119 for these standards.

SEC. 91.9408. QUALITY CONTROL.
(Added by Ord. No. 171,258, Eff. 8/30/96.)

91.9408.1. General. All hillside building construction shall comply with the requirements specified in this section.

91.9408.2. Department Called Inspections. (Amended by Ord. No. 172,592, Eff. 6/28/99, Oper. 7/1/99.) All anchors installed in accordance with Sections 91.9406.2, 91.9406.3 and 91.9406.4 shall be inspected by the Department prior to installation of any construction which might restrict access to the anchors or prevent a visual inspection from the floor level above the anchors.

91.9408.3. Structural Observation by the Engineer or Architect of Record. The owner shall employ the engineer or architect of record, or other engineer or architect designated by the engineer or architect of record, to perform structural observations as required by Section 91.1702.

91.9408.4. Anchor Installation. No installed anchor shall be covered prior to all required Department framing inspections and structural observation by the architect or engineer.

SEC. 91.9409. INFORMATION REQUIRED ON PLANS.
(Added by Ord. No. 171,258, Eff. 8/30/96.)

91.9409.1. General. The licensed engineer or architect responsible for the seismic analysis of the building shall record the information required by this section on the approved plans. The plans shall accurately reflect the results of the engineering investigation and design and show all pertinent dimensions and sizes for plan review and construction. The plans shall show existing framing construction, diaphragm construction, proposed primary, alternate and secondary anchors, proposed shear walls and collectors for the base and below. All structural elements that are part of the design including existing nailing, anchors, ties, and collectors, shall be shown on the plans. The plans shall indicate existing construction that has not been exposed and needs verification at the time of construction.

91.9409.2. Building Elevations. Elevations showing the existing conditions shall be drawn to scale. Elevations shall show roof and floor heights, dimensions of openings, location and extent of existing damage, and proposed repair and strengthening.

91.9409.3. Shear Walls. Plans shall include all information pertinent to shear walls, including typical wall panel thickness, length, and the location and size of all anchors.

91.9409.4. Details. Details shall include the existing lateral bracing systems to be utilized including work required for the lateral and vertical load systems and new anchors and the method of development of anchor forces into the diaphragm framing.

91.9409.5. Engineer's or Architect's Statement. The responsible engineer or architect shall state on the approved plans the following:

"I am responsible for designing the strengthening for this building's base level and below in compliance with the minimum regulations of Division 94 of the Los Angeles Building Code; and either I or someone under my responsible charge has performed the pre-design investigation."

or when applicable:

2. "The Registered Deputy Inspector, required as a condition of the use of structural design stresses requiring continuous inspection, will be responsible to me as required by Section 91.1701.1 of the Los Angeles Building Code."

TABLE 94-A

VALUES FOR EXISTING MATERIALS

Existing Materials or Configuration of Materials [1]	**Allowable Values**
1. Plain or reinforced concrete footings	f'_c = 2000 psi (13.8 MPa) unless otherwise shown by tests.
2. Douglas fir wood	Allowable stress same as No. 2 D.F.
3. Reinforcing steel	$f_s = 0.4\ F_y$, maximum 16 ksi (110 MPa).
4. Structural steel	$f_b = 0.6\ F_y$, maximum 22 ksi (152 MPa).
5. Anchor bolts	Current code values.
6. Wood structural panels/diagonal sheathing	Current code values.

[1] Material must be sound and in good condition.