



**RESIDENTIAL CODE MANUAL  
COUNTY OF LOS ANGELES  
DEPARTMENT OF PUBLIC WORKS  
BUILDING AND SAFETY DIVISION  
Based on the 2017 LACRC**

**No. 1014  
R404.4  
Article 1  
07-12-17  
Page 1 of 9**

## **DESIGN OF RETAINING WALLS**

### **ISSUE**

Section R404.4 of the Residential Code states: "retaining walls... shall be designed to ensure stability against overturning, sliding, excessive foundation pressure, and water uplift..." In addition, Section 106.4.2 states: "the building official may require plans and specifications to be prepared and designed by an engineer... licensed or registered by the state to practice as such." Therefore, any retaining wall design requiring a building permit shall be performed by a registered design professional. As an option, the professional may elect to design such wall under similar provisions of BCM 1807.2, Article 1, as follows:

Section 1807.2.1 of the Building Code requires retaining walls to be designed to ensure stability against overturning, sliding, excessive foundation pressure, and water uplift, and Section 1807.1.5 requires foundation walls to be designed in accordance with Chapter 19 (Concrete) and/or 21 (Masonry). In addition, Section 1803.5.12 states that the retaining walls shall include lateral pressures due to earthquake motions in Seismic Design Categories D through F. Such walls shall be designed for a safety factor of 1.5 against lateral sliding and overturning, but "where earthquake loads are included, the minimum safety factor for retaining wall sliding and overturning shall be 1.1" pursuant to Section 1807.2.3. Section 1610.1 requires foundation (basement) and retaining walls to be designed to resist the soil lateral loads specified in Table 1610.1, unless otherwise specified by a soils investigation report.

### **POLICY**

As stated in Section 1803.5.12 of the 2015 International Building Code (IBC) Commentary, "because the requirement can be onerous for small structures and retaining walls, the applicability is limited to those walls that are higher than 6 feet." The County of Los Angeles is adopting the provision of this Section:

### **1803.5.12 Seismic Design Categories D through F**

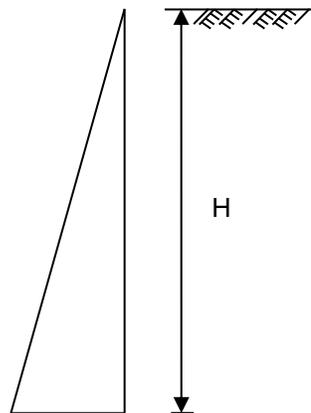
For structures assigned to Seismic Design Category D, E, or F the geotechnical investigation required by Section 1803.5.11 shall also include all the following as applicable:

1. The determination of dynamic seismic lateral earth pressures on foundation walls and retaining walls supporting more than 6 feet (1.83 m) of backfill height due to design earthquake ground motions.

Due to the variability in soil properties throughout the County of Los Angeles, the design professional must take care in his or her analysis of basement and site retaining walls. Without the substantiation of a soils investigation to recommend otherwise, the following tables shall be used to determine the equivalent fluid pressure for design of retaining walls in place of Table 1610.

**Case 1 - Design of Retaining Wall ( $H_{\text{retaining}} \leq 6$  feet):**

Active pressure shall be distributed vertically based on triangular loading. Note that "Table of Equivalent Fluid Weights for Active Pressure Based on Expansive Soil Condition" values are minimum lateral loads and do not account for any surcharge and seismic lateral earth pressures other than the slope as shown. The design professional is responsible for complete analysis in accordance with Section 1807 for retaining walls and site walls supporting a maximum of 6 feet high backfill as measured from the top of the footing.



Active  
Pressure

**TABLE OF EQUIVALENT FLUID WEIGHTS FOR ACTIVE PRESSURE BASED ON EXPANSIVE SOIL CONDITION**

Surface slope of Retained material Horizontal to vertical*	<u>Cantilever</u> equivalent Fluid weight ( <i>active pressure</i> ) (pcf)
LEVEL	45
5 to 1	49
4 to 1	53
3 to 1	57
2 to 1	61

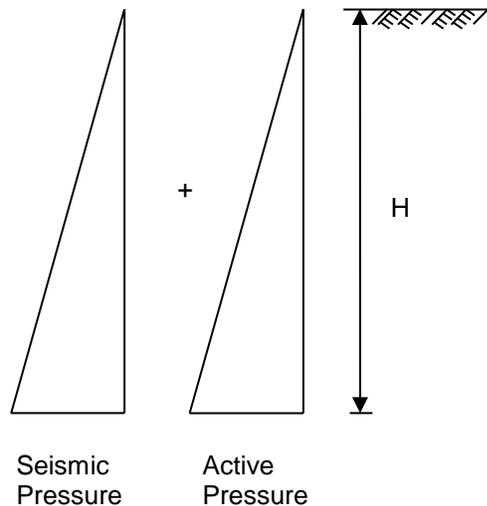
\* If the retained earth has a surface slope that varies, then the design surface slope shall be based on an imaginary line starting from the top of the retaining wall to the highest point of the slope.

**Case 2 - Design of Retaining Wall<sup>1</sup> (6 ft < H<sub>retaining</sub> ≤ 12 feet):**

Where the backfill is greater than 6 feet but less than or equal to 12 feet in height, such proposed walls shall be designed with an active pressure vertically distributed based on triangular loading and an additional seismic lateral pressure vertically distributed based on a triangular loading per the values of "Table of Equivalent Fluid Weights for Active Pressure Based on Non-Expansive Soil Condition" (see below). Note that these table values are minimum lateral loads and do not account for any surcharge other than the slope as shown.

<sup>1</sup>GMED Administrative Manual S004.0, January 19, 2017 by LA County Geotechnical and Materials Engineering Division

The prescriptive retaining wall design with active and seismic pressures shall be compared with a retaining wall design of equivalent height using only active pressure from "Table of Equivalent Fluid Weights for Active Pressure Based on Expansive Soil Condition" (see above). The more restrictive design shall govern.



The following guidelines shall be used when designing a situational "Case 2" retaining wall with seismic pressure:

Combined effect of static and seismic lateral force<sup>1</sup>:

$$P_{AE} = F_1 + F_2$$

$$F_1 = 1/2 * A * H^2$$

F<sub>1</sub> resultant acting at a distance of H/3 from base of the wall

Cantilevered (unrestrained wall with level backfill):

$$F_2 = 1/2 * \gamma * H^2 * (0.42 * PGA_m / g)$$

Cantilevered (unrestrained wall with sloping backfill, sloping backfill defined as slopes steeper than 3:1 and less than 2:1):

$$F_2 = 1/2 * \gamma * H^2 * (0.7 * PGA_m / g)$$

F<sub>2</sub> resultant acting at a distance of (0.4\*H) from base of the wall

Where:

F<sub>1</sub> = Static Force (plf) based on active pressure

F<sub>2</sub> = Seismic Lateral Force (plf) based on seismic pressure

γ = 120 pcf

PGA<sub>m</sub> = Peak Ground Acceleration found at

<https://earthquake.usgs.gov/designmaps/us/application.php> and calculated based on 2010 ASCE 7 under the Design Code Reference Document field. Note that  $PGA_M$  shall not be reduced when using the above equations.

$g = 32.17 \text{ ft/sec}^2$   
A = Active Pressure (pcf)  
H = Height of retained soil (ft)

**TABLE OF EQUIVALENT FLUID WEIGHTS FOR ACTIVE PRESSURE  
BASED ON NON-EXPANSIVE SOIL CONDITION**

Surface slope of Retained material Horizontal to vertical*	<u>Cantilever</u> equivalent Fluid weight ( <i>active pressure</i> ) (pcf)
LEVEL	30
5 to 1	32
4 to 1	35
3 to 1	38
2 to 1	43

\* If the retained earth has a surface slope that varies, then the design surface slope shall be based on an imaginary line starting from the top of the retaining wall to the highest point of the slope.

**Case 3 - Design of Retaining Wall ( $H_{\text{retaining}} > 12$  feet):**

Where the backfill is greater than 12 feet in height, such proposed walls shall be designed per a geotechnical investigation and report prepared by a licensed geotechnical engineer and shall include an additional seismic lateral force.

**General Design Requirements**

Retaining walls designed using code tabulated values shall meet the conditions cited below:

1. Fill materials behind retaining walls shall be fully drained of water and other fluids by means of sub-drain, weep holes and/or other approved method at least equivalent to the attached detail.

2. All superimposed loads, other than retained earth, shall be considered as surcharges and accounted in the design. Uniformly distributed loads may be considered as equivalent added depth of retained earth. Surcharge loads due to continuous or isolated footings shall be determined by equivalent methods acceptable to the Building Official.
3. Walls located in Flood Hazard Areas shall be designed in accordance with Building Code Section 1612. The Regional Drainage Engineer shall notify the building plan check engineer when flood loads are required to be considered and shall be responsible for verifying the forces on the walls. The building plan check engineer shall verify the adequacy of the wall for the given flood loads.
4. Loads applied within a horizontal distance equal to wall stem height, measured from the back face of the wall shall be considered as a surcharge.
5. The resultant of all vertical loads and lateral pressures shall pass through the middle one third of the footing.
6. Walls shall be restrained against sliding by one or more of the following methods using values from Building Code Table 1806.2 for Class 5 Materials:
  - a. Lateral Sliding Resistance equal to 130 psf of contact area or 1/2 the dead load in accordance with Section 1806.3.2, whichever is less.
  - b. Lateral Bearing against the soil as measured in feet below natural grade.
  - c. A rigid element such as a slab on grade may be used provided it is designed for the reaction force of the footing it supports.
7. If keys are used, the depth of lateral bearing shall be measured from the top of the footing to the bottom of the key unless a compaction report is provided to justify a greater depth.
8. Wood shall not be employed in the construction of retaining walls.
9. Special inspection is required as specified in the Building Code, Section 1705.4 except for those retaining walls (cantilever and restrained) with one of the following conditions:
  - a. Case 1 and 2 where retaining walls are accessory to a residential occupancy.

- b. A stem wall height less than 6 feet 10-inches measured from top of footing to top of stem wall where the allowable design masonry stresses are reduced by one-half.
10. Specify new/existing buildings and structures on project site and adjacent properties that may surcharge the retaining walls.
11. Indicate on the plans all construction and temporary conditions that may undermine or destabilize existing structures.
12. Show any slopes that impact the proposed retaining wall and provide cross section(s). Include topography or gradient (H:V).

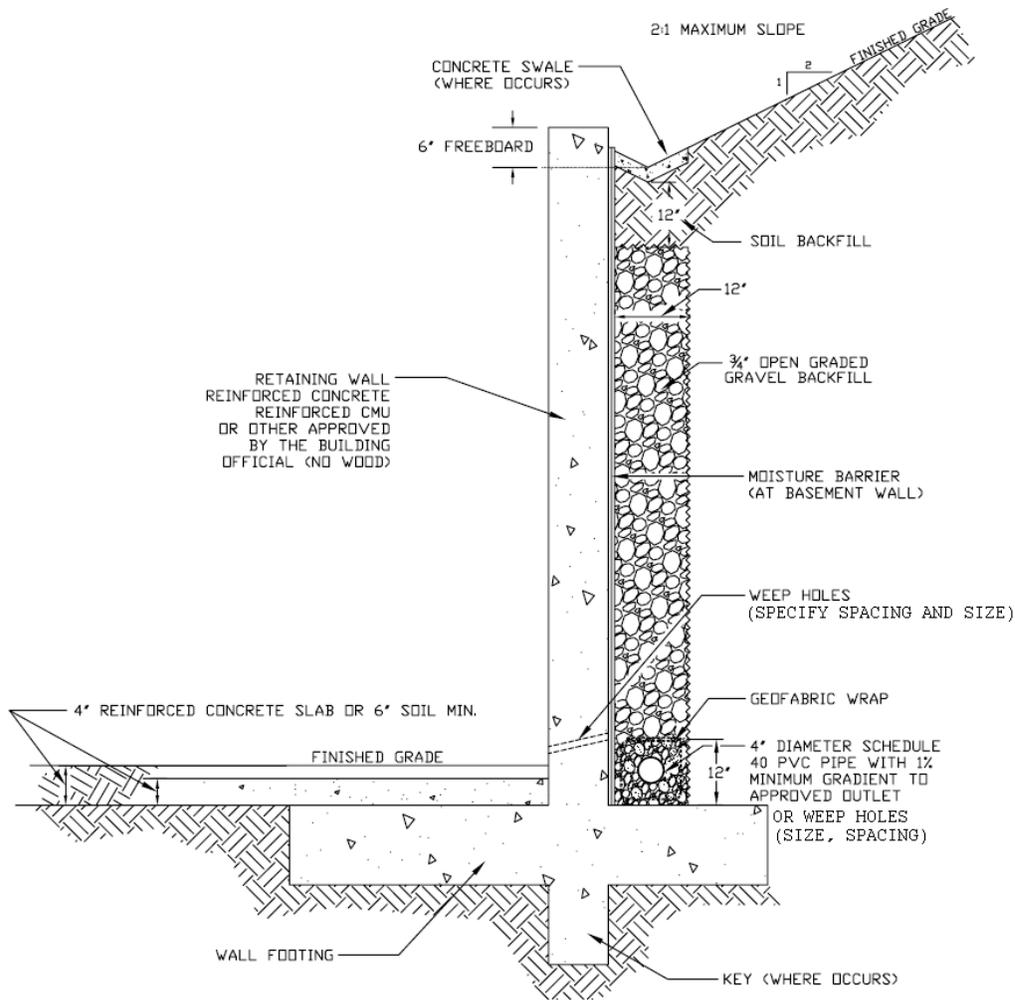
### **GEOTECHNICAL AND MATERIALS ENGINEERING DIVISION**

Referral to the Geotechnical and Materials Engineering Division (GMED) for review and approval shall be based on the following:

1. "Referral Policy to GMED for Seismic Hazard Zone Chart" of BCM 1803.5.11, Article 1.
2. A geotechnical investigation and report are required for buildings and structures consisting of foundation walls below grade (basement walls) with usable areas.
3. Retaining walls designed for active pressure greater than 12 feet with a geotechnical report that includes seismic lateral forces.
4. Retaining walls supporting slopes steeper than 2:1

The Building Official, at any time and based on site specific information, may require the preparation and submittal of a geotechnical report for any project, even if it meets the exemption criteria specified above.

Supersedes RCM R404.4 Article 1 dated 10-25-12



Prescriptive Backfill Drainage Measures

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