



## **DESIGN OF RETAINING WALLS**

### **ISSUE:**

Building Code Section 1807.2.1 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 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 of 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 2012 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 of the following as applicable:

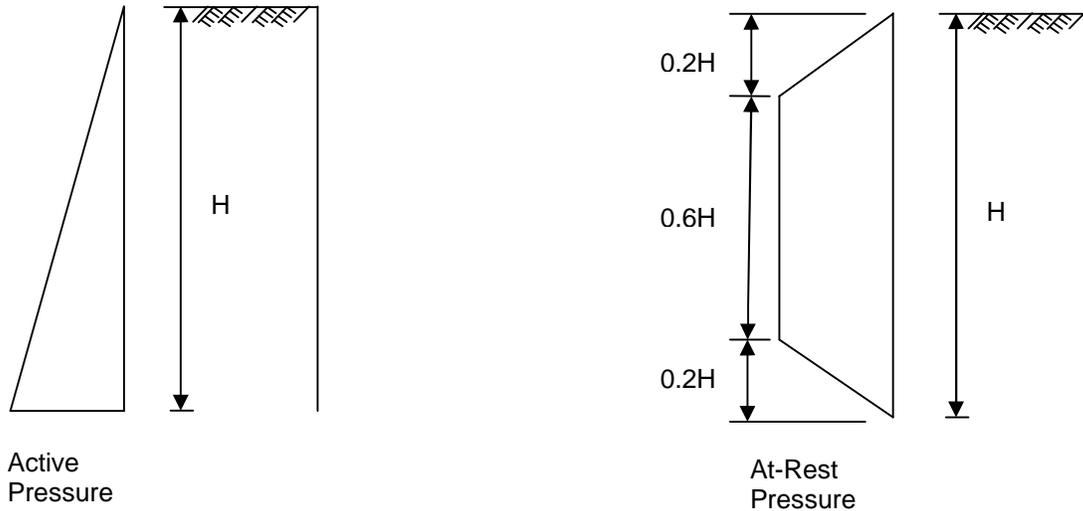
1. The determination of dynamic seismic lateral earth pressures on foundation walls and retaining walls supporting more than 6 feet (1.83 m) of backfill height due to design earthquake ground motions...

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 basement and retaining walls in place of Table 1610.

The use of such at-rest pressure from “Table of Equivalent Fluid Weights For Active Pressure And At-Rest Pressure Based on Expansive Soil Condition” for basement wall designs shall be limited to only basement walls that serve as site walls and are not structural elements of habitable structures. Site walls may be structural elements of decks, carports, patios, storage buildings, etc. in which these structures are non-habitable and support only their roofs.

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

Active pressure shall be distributed vertically based on triangular loading and at-rest pressure shall be distributed based on rectangular loading. Note that “Table of Equivalent Fluid Weights For Active Pressure And At-Rest 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 ft high backfill as measured from the top of the footing.



**TABLE OF EQUIVALENT FLUID WEIGHTS FOR ACTIVE PRESSURE AND AT-REST PRESSURE BASED ON EXPANSIVE SOIL CONDITION**

Surface slope of Retained material Horizontal to vertical*	Cantilever equivalent Fluid weight (active pressure) (pcf)	Restrained equivalent Fluid weight (at-rest pressure) For walls supporting 6' max backfill with a rigid diaphragm** (pcf)
LEVEL	45	60
5 to 1	49	64
4 to 1	53	68
3 to 1	57	72
2 to 1	61	76

\* 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.

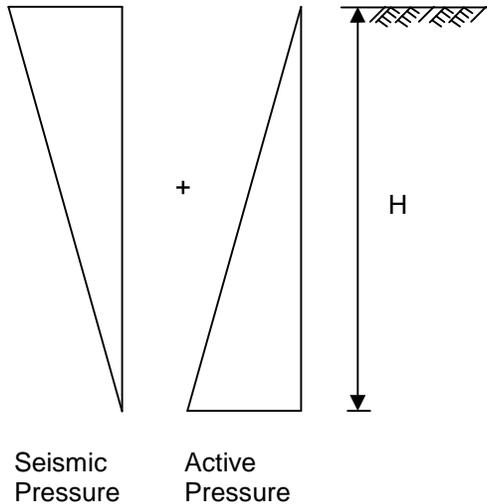
\*\* Top of wall shall be restrained by rigid diaphragm. Rigid diaphragm shall be a structural slab or equivalent with capacity to resist deflection of the top of the wall. Exception: Basement walls may be designed using active pressure, provided the basement wall is 6-feet or less in height and is supported by a flexible floor system.

**Case 2 - Design of Retaining Wall ( $6 \text{ ft} < H_{retaining} \leq 8 \text{ ft}$ ):**

Where the backfill is greater than 6 feet, but less than or equal to 8 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 an inverted triangular

loading per the values of “Table of Equivalent Fluid Weights For Active Pressure Based on Non-Expansive Soil Condition” (see below). (Walls designed with an at-rest pressure shall submit a geotechnical report that includes seismic lateral forces.) Note that these Table values are minimum lateral loads and do not account for any surcharge other than the slope as shown.

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 And At-Rest 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:

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

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

Resultant acting at a distance of H/3 from base of wall

$$F_2 = 3/8 * K_h * \gamma * H^2$$

Resultant acting at a distance of (0.6\*H) from base of 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

K<sub>h</sub> = S<sub>DS</sub>/2.5

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</i> pressure) (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 ( $H_{retaining} > 8$  ft):**

Where the backfill is greater than 8 ft 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 for 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  $\frac{1}{2}$  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 1704.5 except for those retaining walls (cantilever and restrained) with 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.

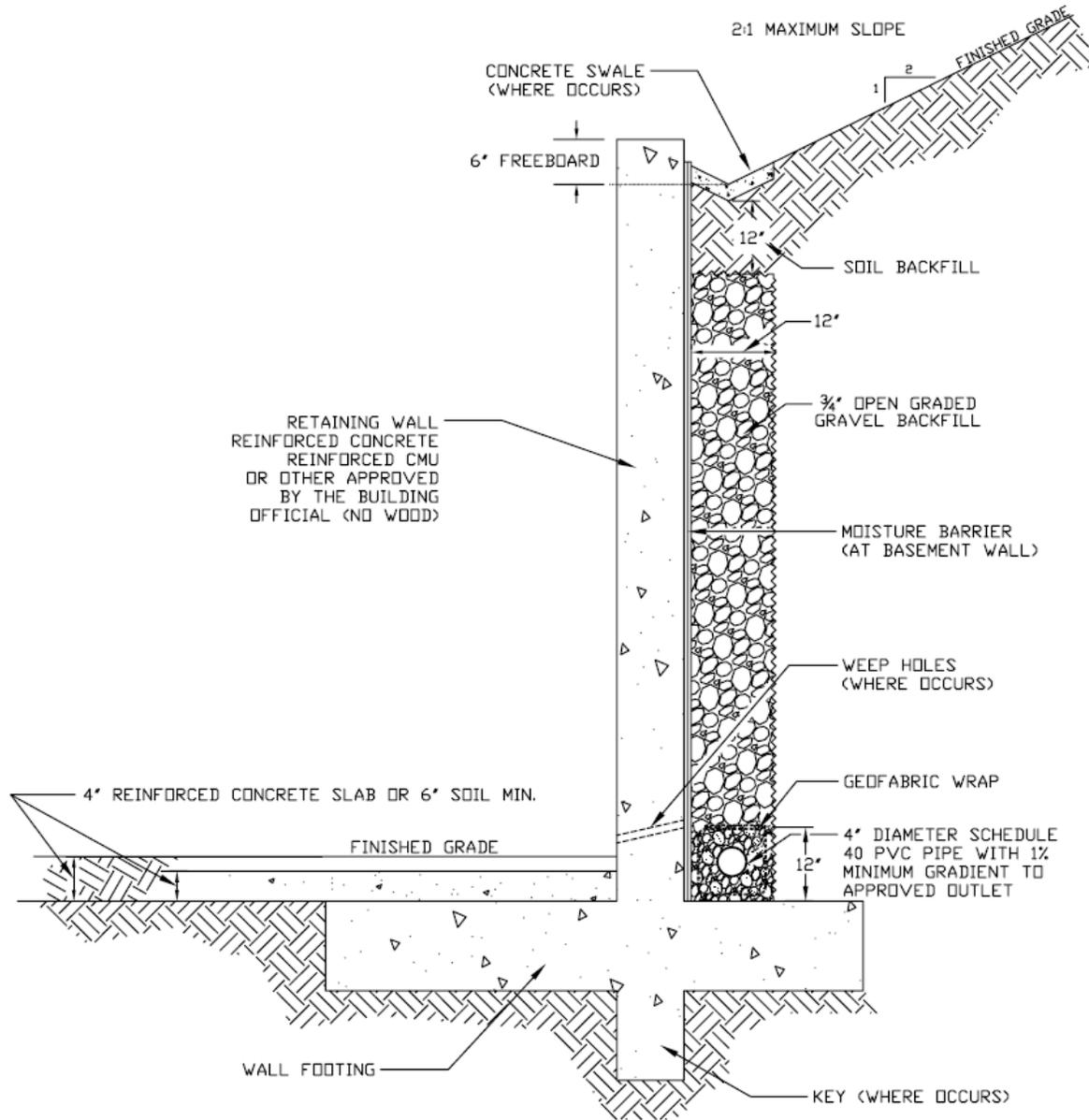
### ***GEOTECHNICAL AND MATERIALS ENGINEERING DIVISION***

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. Buildings and structures with foundation walls below grade (basement walls) shall be designed per geotechnical investigation and report, other than basement walls that serve as site walls and are not structural elements of habitable structures using the Tables above.
3. Retaining walls designed for at-rest pressure greater than 6 feet with a geotechnical report that includes seismic lateral forces.
4. Retaining walls designed for active pressure greater than 8 feet with a geotechnical report that includes seismic lateral forces.

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 BCM 1806.1 Article 1 dated 07-21-08



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