

Designing Concrete Structures: Buried Concrete Basement Wall Design



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Reported by ACI Committee E702

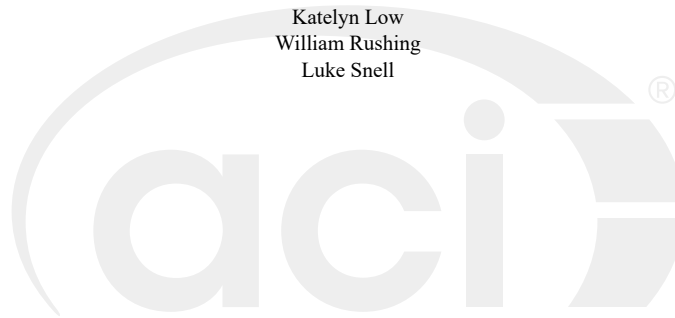
Kimberly Waggle Kramer, Chair

John Aidoo
Bryan Castles
Om Dixit
Claude Goguen
Todd Hawkinson

*Primary author

Carl Larosche
Lei Lou
Katelyn Low
William Rushing
Luke Snell

Lawrence Taber*
Jairo Uribe
Kari Yuers



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ACI E702.4-21 Designing Concrete Structures: Buried Concrete Basement Wall Design.

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Example Problem: Buried Concrete Basement Wall Design

Problem Statement

Provide a detailed strength design (durability and other considerations not included) for a new buried concrete basement wall in a single-story masonry building using the given information.

Given Information

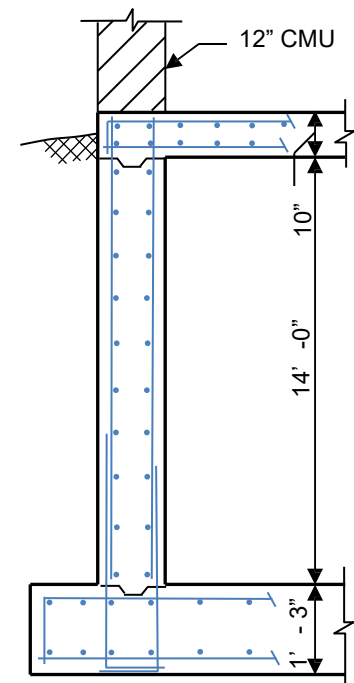
Refer to Fig. 1 for general layout and dimensions of wall section.

Given Information	Additional Guidance
Applicable design code is ACI 318-19	<i>referenced by major building codes (IBC, etc.)</i>
Concrete compressive strength $f'_c = 5000$ psi	<i>common industry value; see project guidelines</i>
Reinforcement yield strength $f_y = 60,000$ psi	<i>common industry value; ASTM A615, Grade 60</i>
Soil equivalent fluid pressure = 60 psf/ft	<i>obtain from geotechnical report; varies widely</i>
Use 2 ft additional soil surcharge to account for compaction pressure	<i>common technique for short walls and vehicle loading; other techniques exist for deeper walls</i>
Groundwater table is deep below structure	<i>no buoyancy concerns; simplifies soil loading</i>
Structure in a low seismic region	<i>seismic forces do not control design</i>
Top slab acts as diaphragm	<i>pinned top support for wall</i>
Total service-level vertical dead load on wall = 2.5 k/ft (including slab self-weight)	<i>reasonable value for example purposes; determine load path and sum loads to get value</i>
Total service-level vertical live load on wall = 1.5 k/ft	<i>reasonable value for example purposes; determine load path and sum loads to get value</i>

Designer's Assumptions

- Design wall with fixed base and pinned top (*propped cantilever*)
- Neglect corner regions (*wall span is one-way for the example*)
- Top slab is in place and has achieved full strength prior to backfilling (*no construction case considered in example*)
- Use center-to-center of supports dimension of 15 ft for both moment and shear calculations (*simplification, will be conservative for shear and moment calculations*)
- No vehicular traffic around building; compaction pressure used
- No eccentricities associated with vertical load (*simplification for example purposes only*)

Discussion: In practice, a designer would also need to consider a partially fixed and/or pinned base. Realistically, the base support acts somewhere between fully fixed and fully pinned, depending on the soil, relative wall/slab thicknesses, and reinforcing detailing. A design check is also be needed at the building corners where the wall will attempt to span both vertically and horizontally.



(Sketch not to scale)

Fig. 1

Calculations

References

Load Determination*Soil pressure:*

- Max soil pressure q_{max} at base = $(60 \text{ psf/ft})(15 \text{ ft} + 2 \text{ ft})$
 $= 1020 \text{ psf}$
 $= 1.02 \text{ ksf}$
- Min soil pressure q_{min} at top = $(60 \text{ psf/ft})(2 \text{ ft})$
 $= 120 \text{ psf}$
 $= 0.12 \text{ ksf}$

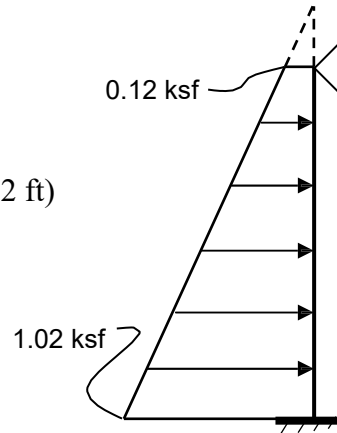


Fig. 2

NOTE: All references are for ACI 318-19 (UNO)

Service-level shear and moment from soil pressure at base of wall:

- From third-party software: $V_{soil,max} = 6.53 \text{ k/ft}$
 $M_{soil,max} = 16.9 \text{ k-ft/ft}$

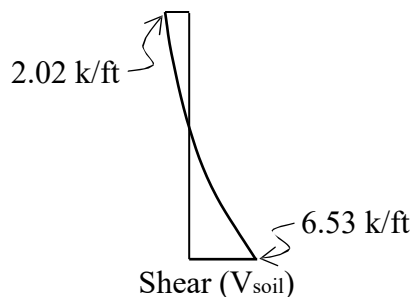


Fig. 3

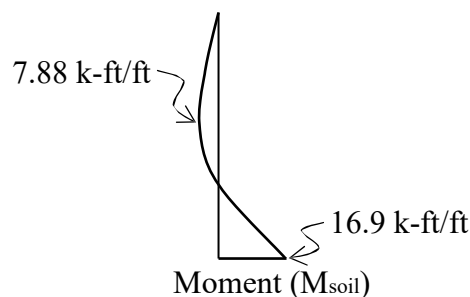


Fig. 4

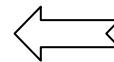
11.4, 5.3, 6.6

Discussion: In practice, a designer would need to check both the positive and negative moments and shears in the wall for all load combinations. A designer can optimize the amount of reinforcement at individual locations (that is, inside face vs outside face). To limit constructability concerns and associated cost impacts, a designer should limit the use of multiple reinforcement sizes or spacing callouts.

Factored shear and moment from soil pressure at base of wall:

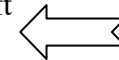
- Using Eq. 5.3.1.b with $1.6H$ added per Section 5.3.8. Dead, live, roof, snow & rain loads have zero lateral component in this example.

- Shear: $V_u = 1.6(6.53 \text{ k/ft}) = 10.4 \text{ k/ft}$
- Moment: $M_u = 1.6(16.9 \text{ k-ft/ft}) = 27.0 \text{ k-ft/ft}$

*Factored vertical axial force from building, elevated slab above and self-weight:*

- For example purposes only, assume total live load given accounts for roof, snow, and rain. A 15 in. thick wall is initially assumed here; verify later in calculation.

- Total service dead load: $2.5 \text{ k/ft} + (14 \text{ ft})(1.25 \text{ ft})(0.15 \text{ kcf}) = 5.1 \text{ k/ft}$
- Factored axial force: $P_u = 1.2(5.1 \text{ k/ft}) + 1.6(1.5 \text{ k/ft}) = 8.6 \text{ k/ft}$



Note: by inspection, the other load combinations in Section 5.3 do not control.

5.3.8; Eq. (5.3.1.b) w/ $1.6H$ added per 5.3.8