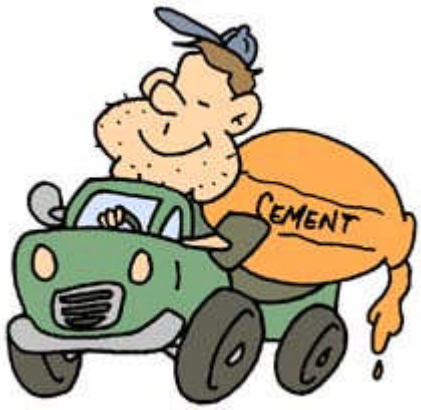
# FOOTINGS AND FOUNDATIONS

## City of Grand Rapids
## Building Safety Division

**218-326-7601**

**www.cityofgrandrapidsmn.com**






Because of the specialized nature, these construction types are not covered by this handout. For information on these foundation types, contact the Building Safety Division.

- Wood foundations
- Frost protected shallow foundations
- Insulating concrete form foundation walls

## SITE AND SOILS

The area around any building must be sloped a minimum of 6 inches in the first ten feet for drainage (R401.3).

For purposes of residential and garage construction, the following rules for soil bearing shall apply:

- Capacity of 2,000 pounds per sq. ft. shall be assumed except where clay, sandy clay, clayey silt, silt, or sandy silt occurs. When those soils exist, 1500 pounds shall be used. Higher bearing capacities than 2000 pounds may be used based on soil tests or site observation.
- Soil tests are required in areas likely to have expansive, compressive, shifting or other unknown soil characteristics. Table R401.4.1).

## FOUNDATION DEPTH FOR FROST PROTECTION

Except for detached garages, sheds and other detached accessory buildings; the bottom of foundations shall extend a minimum of 60 inches below finished grade. All exterior footings must extend 12 inches below undisturbed ground (R403.1.4)

The top surface of footings must be level. The bottom surface may slope not to exceed 1 unit vertical to 10 units horizontal. Footings must be stepped where it is necessary to change the elevation of the top of the footing or if the bottom surface of the footing will exceed a slope of more than 1:10 (R403.1.5).

## FOOTINGS ON OR ADJOINING SLOPES

Special care must be exercised whenever building foundations are placed on or adjacent to slopes steeper than 1 unit vertical to 3 units horizontal. When these conditions exist, a qualified engineer may be required to prepare foundation plans. For this reason, it is

recommended that applicants for building permits contact the Building Safety Division early in the building planning process if these conditions exist.

## MINIMUM SPECIFIED COMPRESSIVE STRENGTH OF CONCRETE FOR SEVERE WEATHERING POTENTIAL

**Table R402.2**

| TYPE OR LOCATIONS OF CONCRETE CONSTRUCTION | MINIMUM SPECIFIED COMPRESSSIVE STRENGTH [a] ($f'_c$) |
|---|---|
| **Basement walls, foundations and other concrete not exposed to the weather** | **2,500[b]** |
| **Basement slabs and interior slabs on grade, except garage floor slabs** | **2,500[b]** |
| **Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to weather** | **3,000[c]** |
| **Porches, carport slabs, and steps exposed to the weather, and garage floor slabs** | **3,500[c,d]** |

a. At 28 days psi.
b. Concrete in these locations that may be subject to freezing and thawing during construction shall be air-entrained concrete. Total air content (percent by volume of concrete) shall not be less than 5 percent or more than 7 percent.
c. Concrete shall be air entrained. Total air content (percent by volume of concrete) shall not be less than 5 percent or more than 7 percent.
d. The maximum weight of fly ash, other pozzolans, silica fume, or slag that is included in concrete mixtures for garage floor slabs and for exterior porches, carport slabs, and steps that will be exposed to deicing chemicals shall not exceed the percentages of the total weight of cement content.

## APPROXIMATE RATIO OF BAGS OF CEMENT TO COMPRESSIVE STRENGTH [a]

2,500 – 3000 #psi. = 5 bag mix
3,000 – 3500 #psi. = 5 ½ bag mix
3,500 – 4000 #psi. = 6 bag mix

a. Strength is a variable that also depends on the variations of water/cement, sand/cement, admixtures, etc. When ordering ready-mix concrete, it is best to explain the type of project to the ready-mix producer and specify the strength you desire or what is required by code and they will provide a mix to meet your needs.

## POST FOOTINGS

Post footings, or piers, are frequently used for decks. They are also used for screen and three season porches but these types of foundation systems have their limitations. Unlike continuous footings, post footings are prone to unpredictable subtle differential movement, especially those located where soil conditions are not ideal or where subjected to movement from frost. While this is seldom a problem with a deck, more rigid structures containing windows, doors, and drywall finishes may experience both aesthetic and functional defects. These include cracked drywall, cracked or broken glass, and windows or doors that stick in their frames. These defects do not constitute a code violation but anyone using post footings for certain building projects should be aware of their limitations and consider alternatives if the limitations are unacceptable

## FOOTINGS

All exterior walls of buildings must be supported on continuous concrete footings (R403.1). Compressive strength of 2,500 psi, with an approved admixture that provides a water and vapor resistance at least equivalent to 5,000 psi concrete.

| MINIMUM WIDTH OF CONCRETE OR MASONRY FOOTINGS IN INCHES [a, b, c] Table R403.1 | | | |
|---|---|---|---|
| | Load Bearing Value of Soil (psf) | | |
| | 1500 | 2000 | 3000 |
| **Conventional light-frame construction** | | | |
| 1-story | 12 | 12 | 12 |
| 2-story | 15 | 12 | 12 |
| 3-story | 23 | 17 | 12 |
| **4-inch brick veneer over light frame or 8-inch hollow concrete masonry** | | | |
| 1-story | 12 | 12 | 12 |
| 2-story | 21 | 16 | 12 |
| 3-story | 32 | 24 | 16 |

a. Footings must extend a minimum of 2-inches on either side of the foundation wall but may not extend more than the depth of the footing.
b. The minimum footing thickness is 6-inches.
c. Footings supporting piers and columns shall be sized according to tributary load and allowable soil pressures.

## FOUNDATIONS R404

**R404.1 Concrete and masonry foundation walls.** Concrete and masonry foundation walls shall be selected and constructed in accordance with the provisions of Section R404 or in accordance with ACI 318, ACI 332, NCMATR68–A or ACI 530/ASCE 5/TMS 402 or other approved structural standards. When ACI 318, ACI 332 or ACI 530/ASCE 5/TMS 402 or the provisions of Section R404 are used to design concrete or masonry foundation walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the jurisdiction having authority.

***Foundation walls must be laterally supported at the top and bottom.*** Foundation walls that meet all of the following shall be considered laterally supported:

1. Full basement floor shall be 3.5 inches thick concrete slab poured tight against the bottom of the foundation wall.
2. Floor joists and blocking shall be connected to the sill plate at the top of wall by the prescriptive method called out in Table R404.1(1), or; shall be connected with an approved connector with listed capacity meeting Table R404.1(1).
3. Bolt spacing for the sill plate shall be no greater than per Table R404.1(2).
4. Floor shall be blocked perpendicular to the floor joists. Blocking shall be full depth within three joist spaces of the foundation wall.
5. Where foundation walls support unbalanced loads on opposite sides of the building, such as a daylight basement, the rim board shall be attached to the sill with a 20 gage metal angle clip at 24 inches on center, with five 8d nails per leg, or an approved connector supplying 230 pounds per linear foot capacity.

**R404.1.1 Masonry foundation walls.** Concrete masonry and clay masonry foundation walls shall be constructed as set forth in Table R404.1.1(1), R404.1.1(2), R404.1.1(3) or R404.1.1(4) and shall also comply with the provisions of Section R404 and the applicable provisions of Sections R606, R607 and R608. Rubble stone masonry foundation walls shall be constructed in accordance with Sections R404.1.8 and R607.2.2. Cantilevered masonry foundation walls shall be constructed as set forth in Table R404.1.1(6), R404.1(7), or R404.1.1(8). Cantilevered means: foundation walls that do not have permanent lateral support at the top.

**R404.1.2 Concrete foundation walls.** Concrete foundation walls shall be constructed as set forth in Table R404.1.1(5) and shall also comply with the provisions of Section R404 and the applicable provisions of Section R402.2. Cantilevered concrete foundation walls shall be constructed as set forth in Table R404.1.1(6), R404.1.1(7), or R404.1.1(8). Cantilevered means: foundation walls that do not have permanent lateral support at the top.

**R404.1.3 Design required.** Concrete or masonry foundation walls shall be designed in accordance with accepted engineering practice when either of the following conditions exists:

1. Walls are subject to hydrostatic pressure from groundwater.
2. Walls supporting more than 48 inches of unbalanced backfill that do not have permanent lateral support at the top or bottom.

**Exception:** Cantilevered concrete and masonry foundation walls constructed in accordance with Table R404.1.1(6), R404.1.1(7), or R404.1.1(8).

**TOP REACTIONS AND PRESCRIPTIVE SUPPORT FOR FOUNDATION WALLS[a]**
**TABLE R404.1(1)**

| MAXIMUM WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT (feet) | HORIZONTAL REACTION TO TOP (plf) | | |
|---|---|---|---|---|
| | | Soil Classes (Letter indicates connection types[b]) | | |
| | | GW, GP, SW and SP soils | GM, GG, SM-SC and ML soils | SC, MH, ML-CL and inorganic CL soils |
| 7 | 4 | 45.7 A | 68.6 A | 91.4 A |
| | 5 | 89.3 A | 133.9 B | 178.6 B |
| | 6 | 154.3 B | 231.4 C | 308.6 C |
| | 7 | 245.0 C | 367.5 C | 490.0 D |
| 8 | 4 | 40.0 A | 60.0 A | 80.0 A |
| | 5 | 78.1 A | 117.2 B | 156.3 B |
| | 6 | 135.0 B | 202.5 B | 270.0 C |
| | 7 | 214.0 B | 321.6 C | 428.8 C |
| | 8 | 320.0 C | 480.0 C | 640.0 D |
| 9 | 4 | 35.6 A | 53.3 A | 71.1 A |
| | 5 | 69.4 A | 104.2 B | 138.9 B |
| | 6 | 120.0 B | 180.0 B | 240.0 C |
| | 7 | 190.6 B | 285.8 C | 381.1 C |
| | 8 | 284.4 C | 426.7 C | 568.9 C |
| | 9 | 405.0 C | 607.5 D | 810.0 D |

a. Loads are pounds per linear foot of wall. Prescriptive options are limited to maximum joist and blocking spacing of 24 inches on center.
b. Prescriptive Support Requirements:

| Type | Joist/blocking Attachment Requirement |
|---|---|
| A | 8 – 8d per joist per Table R602.3(1) |
| B | 1 – 20 gage angle clip each joist with 5 – 8d per leg |
| C | 1¼-inch thick steel angle. Horizontal leg attached to sill bolt adjacent to joist/blocking, vertical leg attached to joist/blocking with ½-inch minimum diameter bolt. |
| D | 2 – ¼-inch thick steel angles, one on each side of joist/blocking. Attach each angle to adjacent sill bolt through horizontal leg. Bolt to joist/blocking with ½-inch minimum diameter bolt common to both angles. |

## MAXIMUM BOLT SPACING FOR SUPPORTED FOUNDATION WALL

TABLE R404.1.1(2)

| Max. Wall Height | Max. Unbalanced Backfill Height | Soil classes | Soil Load (pcf/ft) | Top of Wall Reaction (plf)[b] | ½" diameter Anchor Bolt Spacing (in.)[a] |
|---|---|---|---|---|---|
| 8' 0" | 7' 4" | GW, GP, SW and SP | 30 | 250 | 72 |
| | | GM, GC, SM-SC & ML | 45 | 370 | 72 |
| | | SC, MH, ML-CL & ICL | 60 | 490 | 48 |
| 9' 0" | 8' 4" | GW, GP, SW and SP | 30 | 320 | 72 |
| | | GM, GC, SM-SC & ML | 45 | 480 | 48 |
| | | SC, MH, ML-CL & ICL | 60 | 640 | 40 |

a. Sill plate shall be 2X6 minimum. Anchor bolt shall be minimum 0.5" diameter cast in place with 7" embed. Anchor bolt shall have a 2" diameter by 0.125" thick washer tightened and countersunk 0.25" into the top of the plate.
b. Minimum load to be used for sizing of accepted anchors or fasteners if bolts are not used.

## PLAIN MASONRY FOUNDATION WALLS

TABLE R404.1.1(1)

| MAXIMUM WALL HEIGHT (feet) | MAXIMUM UNBALANCED BACKFILL HEIGHT[c] (feet) | PLAIN MASONRY[a] MINIMUM WALL THICKNESS (inches) | | |
|---|---|---|---|---|
| | | Soil classes[b] | | |
| | | GW, GP, SW and SP | GM, GC, SM, SM-SC and ML | SC, MH, ML-CL and inorganic CL |
| 5 | 4 | 6 solid[d] or 8 | 6 solid[d] or 8 | 6 solid[d] or 8 |
| | 5 | 6 solid[d] or 8 | 8 | 10 |
| 6 | 4 | 6 solid[d] or 8 | 6 solid[d] or 8 | 6 solid[d] or 8 |
| | 5 | 6 solid[d] or 8 | 8 | 10 |
| | 6 | 8 | 10 | 12 |
| 7 | 4 | 6 solid[d] or 8 | 8 | 8 |
| | 5 | 6 solid[d] or 8 | 10 | 10 |
| | 6 | 10 | 12 | 10 solid[d] |
| | 7 | 12 | 10 solid[d] | 12 solid[d] |
| 8 | 4 | 6 solid[d] or 8 | 6 solid[d] or 8 | 8 |
| | 5 | 6 solid[d] or 8 | 10 | 12 |
| | 6 | 10 | 12 | 12 solid[d] |
| | 7 | 12 | 12 solid[d] | Footnote e |
| | 8 | 10 solid[d] | 12 solid[d] | Footnote e |
| 9 | 4 | 6 solid[d] or 8 | 6 solid[d] or 8 | 8 |
| | 5 | 8 | 10 | 12 |
| | 6 | 10 | 12 | 12 solid[d] |
| | 7 | 12 | 12 solid[d] | Footnote e |
| | 8 | 12 solid[d] | Footnote e | Footnote e |
| | 9 | Footnote e | Footnote e | Footnote e |

a. Mortar shall be Type M or S and masonry shall be laid in a running bond. Ungrouted hollow masonry units are permitted except where otherwise indicated.
b. Soil classes are in accordance with the Unified Soil Classification System.
c. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.
d. Solid grouted hollow units or solid masonry units.
e. Wall construction shall be in accordance with Table R404.1.1(2) or a design shall be provided.

## AFFECTS OF ADDING WATER ON CONCRETE STRENGTH

The principal factors affecting the strength of concrete are age and the water-cement ratio. Concrete continues to gain strength as it ages although the greatest increase in strength occurs during the first 28 days. Strength of concrete also increases as the water-cement ratios decrease. While adding water to the mix increases the ease with which concrete is placed, significant reductions in strength can occur if too much water is added. Increasing the recommended water-cement ratio by 25% can reduce the strength of the concrete by as much as 40%. In addition to strength reductions, concrete with higher water-cement rations may also experience reductions in durability, permeability, and wear resistance. Water should only be added in minimal amounts until the desired workability is reached.

| Maximum Permissible Water-Cement Ratios for Concrete When Strength Data from Field Experience or Trial Mixtures Are Not Available | | |
|---|---|---|
| Specified 28-day compressive strength, $f'_c$ psi | Water-cement ratio by weight (Weight of the water to the weight of cement) | |
| | Non-air-entrained concrete | Air-entrained concrete |
| 2500 | 0.67 | 0.54 |
| 3000 | 0.58 | 0.46 |
| 3500 | 0.51 | 0.40 |
| 4000 | 0.44 | 0.35 |

## AIR ENTRAINED CONCRETE

Air entrained concrete is required by the code whenever the concrete will or may be exposed to freezing temperatures. Air entrainment is exactly as the name implies which is the production of bubbles of air in the concrete by adding an air-entraining admixture at the mixer or by using air-entraining cement or by a combination of both methods. Within limits, air in concrete has several benefits.

- The resistance of hardened concrete to freezing and thawing in a moist condition is significantly improved by the use of intentionally entrained air, especially when various deicers are involved.
- Entrained air improves the workability of concrete and is particularly effective in lean mixes that would otherwise by harsh and difficult to work.
- Air entrained concrete is more resistant to attack from sulfate soils and waters.

## REINFORCEMENT

Properly positioned reinforcement is used to reduce crack widths and minimize horizontal separation and is recommended in concrete and masonry foundations, footings, and slabs.

Rebar should be minimum Grade 40 reinforcing steel unless a higher grade is required above. Welded wire fabric should be minimum WWF 6x6-10/10. Reinforcing steel should be properly tied with wire to rigidly support it in its proper position. Both reinforcing steel and welded wire fabric should be provided with supports of metal, concrete, plastic or other approved material to keep the reinforcement off the ground and so that it will not be displaced during pouring operations. Rebar should always be bent cold. The diameter of the bend should be at least six times the bar diameter. For a ½ " rebar, the inside of the bend should have a diameter of at least 3 inches.

For footings, reinforcement is recommended as follows: two rows of #4 (1/2") rebar under the foundation and 3 inches minimum from the bottom of the footing.

For garage slabs, two rows of #4 rebar are recommended around the perimeter, one above the other. The bottom row should be 3 inches minimum from the bottom of the perimeter footing. The top row should be placed approximately 1/3 of the distance from top of the perimeter footing.

When overlapping rebar, the length of the overlap should be at least 40 bar diameters. The laps should be tied together with wire.

The slab itself should be reinforced by either the use of rebar or wire mesh. Rebar should be placed in a grid pattern with bars 30-36" apart.

## ***REINFORCEMENT AND WALL BRACING***

***Warning*** - Some of the wall bracing requirements, especially for walls containing garage doors, require special foundation or slab reinforcement. Planning the proper reinforcement is dependent on knowing what framing methods will be used and will require cooperation between the foundation and framing contractors.

## HOT AND COLD WEATHER ISSUES

### Hot Weather

Hot weather can result in accelerated setting of the concrete that will reduce workability and finishing time. To combat this, additional water is often added. Unfortunately this is the wrong thing to do because it results in weaker concrete and greater likelihood of decreased durability, non-uniform appearance, and increased tendency for drying shrinkage and cracks. To avoid these problems, pouring of concrete should be planned to avoid warm days if possible. Proper curing methods are also more important during warmer weather than when temperatures are more moderate.

### Cold Weather

Concrete can safely be poured in temperatures above freezing. Any snow or ice must be removed before concrete is poured and concrete should never be poured on frozen ground. Once poured, concrete should be protected from freezing for at two to three days after it is poured by the use of insulating blankets, enclosures, or other means. Concrete that is frozen before proper curing will suffer strength reductions and will not be as resistant to weathering or watertight as concrete that has not been frozen. Use of air-entrained concrete is more important for concrete that has the potential to be frozen, as it will improve the strength characteristics of the concrete.

## CURING METHODS FOR CONCRETE

Maintaining a satisfactory moisture content and temperature in concrete following pouring is an important goal which influences durability, strength, water tightness, abrasion resistance, volume stability and resistance to freezing and thawing and deicer salts. The following are two recommended methods for curing concrete:

1. Immersion, spraying or fogging, or application of saturated wet coverings. This can be accomplished with garden hoses, lawn sprinklers or burlap coverings.
2. Sealing the surface by means of plastic sheets or membrane-forming curing compounds.

## UNDER FLOOR AREAS

- Wood columns in proximity to concrete floors must be wood of natural resistance to decay or approved pressure preservatively treated wood except that columns supported on piers or metal pedestals at least one inch above the floor may be of any species (R319.1.4).
- Wood posts, poles, or columns that are embedded in concrete in direct contact with the ground or embedded in concrete exposed to the weather must be pressure preservatively treated wood suitable for ground contact use (R319.1.2).
- All wood posts, poles, or columns must be a minimum of 4-inches by 4-inches nominal dimension (R407.3).
- Steel columns in proximity to concrete floors shall be given a shop coat of rust-inhibitive paint on both the inside and outside surfaces of the column. Steel columns may not be less than 3-inch diameter standard pipe or approved equivalent (R407.2).

- All columns must be mechanically restrained at their bottom end with anchor bolts, pins, or approved connectors except that columns less than 48 inches in length located in enclosed crawl spaces need not be restrained (R407.3).
- The ends of wood girders entering foundation walls must have clearances of not less than ½ " on tops, sides, and ends (R319.1).
- Crawl spaces must be cleaned of all vegetation and organic material. All wood forms and construction material must be removed (R408.5)
- An access opening not less than 18 inches by 24 inches for floor openings and 16 inches by 24 inches for wall openings must be provided to all under floor spaces (R408.4).
- Exterior ventilation must be provided for the under-floor areas of foundations (R408) except when:
  1. The exposed earth is covered with a vapor retarder with all joints and laps sealed or taped and edges sealed to the stem wall and;
  2. Ventilation air is circulated as required in R408.3
- When exterior ventilation is provided, it must comply with the following:
  1. The net area of ventilation openings must be not less than 1 square foot for each 150 square feet of under floor area. One opening must be located within 3 feet of each corner of the building.
  2. Openings must be covered with corrosion resistant wire mesh or other approved covers provided perforations not exceeding ¼ inch are provided.

## FOUNDATION ANCHORAGE

The wood sole plate for all exterior walls on monolithic slabs and foundations shall be anchored with bolts spaced a maximum of 6 feet apart and within 12 inches of but not less than seven bolt diameters from each end. Walls less than 24 inches in length require one anchor bolt in the center one third of the wall. Walls less than 12 inches in length need no anchor bolts. Bolts must be at least ½" diameter and extend at least 7 inches into the slab or wall. Plates must be tightened to the bolt with a nut and washer. When vertical reinforcing is required by other sections of the code, foundation anchor bolts shall align with the reinforcing. Anchor bolts installed in masonry shall be grouted in place with at least one inch of grout between the bolt and masonry. Where anchor straps are used, they must be designed and installed in a manner equivalent to anchor bolts. Interior bearing wall sole plates on monolithic slabs must be positively anchored with approved fasteners. (R403.1.6).

## WOOD SILL PLATES – R319

Wood sill plates must have a minimum thickness of 2 inches (nominal). Sill plates that rest on a concrete slab that is not separated from the ground with a 6 mil vapor retarder or that rest on a foundation and are less than 8 inches from exposed ground must be wood of natural resistance to decay or pressure preservatively treated wood.

## FOUNDATION DRAINAGE AND DAMPPROOFING

See the Building Safety Division handout on this subject.

## MASONRY FOUNDATION WALLS WITH REINFORCING[a]

**TABLES R404.1.1(2, 3, 4)**

| WALL HEIGHT | HEIGHT OF UN-BALANCED BACKFILL[e] | MINIMUM VERTICAL REINFORCEMENT[b, c] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Soil classes and later soil load[d] (psf per foot below grade) | | | | | | | | |
| | | GW, GP, and SP soils 30 | | | GM, GC, SM-SC and ML soils 45 | | | SC, MH, ML-CL and inorganic CL soils 60 | | |
| | | 8 Inch | 10 Inch | 12 Inch | 8 Inch | 10 Inch | 12 Inch | 8 Inch | 10 Inch | 12 Inch |
| 6 feet 8 inches | 4 feet (or less) | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 5 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 6 feet 8 inches | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #5 @ 56” | #4 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” |
| 7 feet 4 inches | 4 feet (or less) | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 5 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 6 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #4 @ 56” | #5 @ 72” |
| | 7 feet 4 inches | #5 @ 48” | #4 @ 56” | #4 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 40” | #5 @ 56” | #6 @ 72” |
| 8 feet | 4 feet (or less) | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 5 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 6 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #5 @ 56” | #5 @ 72” |
| | 7 feet | #5 @ 48” | #4 @ 56” | #4 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 40” | #6 @ 56” | #6 @ 72” |
| | 8 feet | #5 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 48” | #6 @ 56” | #6 @ 72” | #6 @ 32” | #6 @ 48” | #6 @ 64” |
| 8 feet 8 inches | 4 feet (or less) | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 5 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #4 @ 56” | #4 @ 72” |
| | 6 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #4 @ 56” | #4 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” |
| | 7 feet | #5 @ 48” | #4 @ 56” | #4 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 40” | #6 @ 56” | #6 @ 72” |
| | 8 feet 8 inches | #6 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 32” | #6 @ 48” | #6 @ 72” | #6 @ 24” | #6 @ 32” | #6 @ 48” |
| 9 feet 4 inches | 4 feet (or less) | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 5 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #4 @ 56” | #4 @ 72” |
| | 6 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” |
| | 7 feet | #5 @ 48” | #4 @ 56” | #4 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 40” | #6 @ 56” | #6 @ 72” |
| | 8 feet | #6 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 40” | #6 @ 56” | #6 @ 72” | #6 @ 24” | #6 @ 40” | #6 @ 56” |
| | 9 feet 4 inches | #6 @ 40” | #6 @ 56” | #6 @ 72” | #6 @ 24” | #6 @ 40” | #6 @ 48” | #6 @ 16” | #6 @ 24” | #6 @ 40” |
| 10 feet | 4 feet (or less) | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” |
| | 5 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #4 @ 56” | #4 @ 72” |
| | 6 feet | #4 @ 48” | #4 @ 56” | #4 @ 72” | #5 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 48” | #5 @ 56” | #5 @ 72” |
| | 7 feet | #5 @ 48” | #5 @ 56” | #4 @ 72” | #6 @ 48” | #6 @ 56” | #6 @ 72” | #6 @ 32” | #6 @ 48” | #6 @ 72” |
| | 8 feet | #6 @ 48” | #5 @ 56” | #5 @ 72” | #6 @ 32” | #5 @ 48” | #6 @ 72” | #6 @ 24” | #6 @ 40” | #6 @ 48” |
| | 9 feet | #6 @ 40” | #6 @ 56” | #6 @ 72” | #6 @ 24” | #6 @ 40” | #6 @ 56” | #6 @ 16” | #6 @ 24” | #6 @ 40” |
| | 10 feet | #6 @ 32” | #6 @ 48” | #6 @ 64” | #6 @ 16” | #6 @ 32” | #6 @ 40” | #6 @ 16” | #6 @ 24” | #6 @ 32” |

a. Mortar shall be Type M or S and masonry shall be laid in running bond.

b. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of reinforcement does not exceed 72 inches.

c. Vertical reinforcement shall be Grade 60 minimum. The distance from the face of the soil side of the wall to the center of the vertical reinforcement shall be at least 5 inches for 8 inch walls, 6.75 inches for 10 inch walls, and 8.75 inches for 12 inch walls.

d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure.

e. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.

a. The minimum thickness is permitted to be reduced 2 inches, provided the minimum specified compressive strength of concrete $f'_c$, is 4,000 psi.
b. A plain concrete wall with a minimum thickness of 11.5 inches is permitted, provided minimum specified compressive strength of concrete, $f'_c$, is 3,500 psi.
c. Concrete shall have a specified compressive strength of not less than 2,500 psi at 28 days, unless a higher strength is required by not g or h.
d. "DR" means a design is required in accordance with ACI 318 or ACI 332.
e. "PC" means plain concrete.
f. Where vertical reinforcement is required, horizontal reinforcement shall be provided in accordance with the requirements of Section R404.4.6.2 for ICF foundation walls.

## Cantilevered Concrete and Masonry Foundation Walls

**Table R404.1.1(6)**

| Maximum Wall Height[j] (feet) | Maximum Unbalanced Backfill Height[e] (feet) | Minimum Vertical Reinforcement Size and Spacing for Soil Classes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | GW, GP, SW, and SP | | | GM, GC, SM, SM-SC, and ML | | | SC, MH, ML-CL, and inorganic CL | | |
| | | 8" Nominal Wall Thickness abcefjk | 10" Nominal Wall Thickness abcefjk | 12" Nominal Wall Thickness abcefjk | 8" Nominal Wall Thickness abcefjk | 10" Nominal Wall Thickness abcefjk | 12" Nominal Wall Thickness abcefjk | 8" Nominal Wall Thickness abcefjk | 10" Nominal Wall Thickness abcefjk | 12" Nominal Wall Thickness abcefjk |
| 4 | 3 | None required | None required | None required | None required | None required | None required | None required | None required | None required |
| | 4 | None required | None required | None required | None required | None required | None required | # 4 @ 72 in. o.c. | None required | None required |
| 5 | 3 | None required | None required | None required | None required | None required | None required | None required | None required | None required |
| | 4 | # 4 @ 72 in. o.c. | None required | None required | # 4 @ 56 in. o.c.[h] | # 4 @ 72 in. o.c. | None required | # 4 @ 40 in. o.c.[g] | # 4 @ 64 in. o.c.[g] | # 4 @ 72 in. o.c. |
| | 5 | # 4 @ 72 in. o.c. | # 4 @ 72 in. o.c. | # 4 @ 72 in. o.c. | # 4 @ 56 in. o.c.[h] | # 4 @ 72 in. o.c. | # 4 @ 72 in. o.c. | # 4 @ 40 in. o.c.[g] | # 4 @ 56 in. o.c.[g] | # 4 @ 72 in. o.c. |
| 6 | 3 | | None required | None required | | # 4 @ 72 in. o.c. | None required | | # 4 @ 72 in. o.c. | None required |
| | 4 | | # 4 @ 72 in. o.c. | None required | | # 4 @ 72 in. o.c. | None required | | # 4 @ 64 in. o.c.[h] | # 4 @ 72 in. o.c. |
| | 5 | | # 4 @ 64 in. o.c.[h] | # 4 @ 72 in. o.c. | | # 4 @ 40 in. o.c.[gh] | # 4 @ 56 in. o.c.[h] | | # 4 @ 48 in. o.c.[gh] | # 4 @ 40 in. o.c.[g] |
| | 6 | | # 4 @ 64 in. o.c.[h] | # 4 @ 72 in. o.c. | | # 4 @ 40 in. o.c.[gh] | # 4 @ 56 in. o.c.[g] | | # 4 @ 48 in. o.c.[gh] | # 4 @ 32 in. o.c.[gh] |
| 7 | 3 | | | None required | | | None required | | | None required |
| | 4 | | | None required | | | # 4 @ 72 in. o.c. | | | # 4 @ 72 in. o.c. |
| | 5 | | | # 4 @ 72 in. o.c.[h] | | | # 4 @ 56 in. o.c.[h] | | | # 4 @ 40 in. o.c.[g] |
| | 6 | | | # 4 @ 48 in. o.c.[h] | | | # 5 @ 48 in. o.c.[gh] | | | # 6 @ 48 in. o.c.[gh] |
| | 7 | | | # 4 @ 48 in. o.c.[h] | | | # 5 @ 40 in. o.c.[gh] | | | # 6 @ 48 in. o.c.[gh] |

a. Mortar shall be Type M or S and masonry shall be laid in a running bond. Minimum unit compressive strength is 1,900 psi.
b. Alternative reinforcing bar sizes and spacing having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of reinforcement does not exceed 72 inches.

c. Vertical reinforcement shall be Grade 60 minimum. The distance from the face of the soil side of the wall to the center of vertical reinforcement shall be not greater than 2.5 inches.
d. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
e. Interior concrete floor slab-on-grade shall be placed tight to the wall. The exterior grade level shall be 6 inches minimum below the top of wall. Maximum height from top of slab-on-grade to bottom of floor joists is 10 feet, 0 inches. Unbalanced backfill height is the difference in height of the exterior finish ground levels and the top of the interior concrete slab-on-grade.
f. Minimum footing size of 20 inches by 8 inches shall be placed on soil with a bearing capacity of 2,000 psf. Minimum concrete compressive strength of footings shall be 3,000 psi.
g. Provide propped cantilever wall: top of footing shall be 16 inches below the bottom of the concrete floor slab minimum.
h. Provide #5 Grade 60 dowels, 1 foot, 6 inches long, to connect footing to wall. Embed dowel 5 inches into footing. Place dowels in center of wall thickness spaced 32 inches o.c. maximum. No dowels are required where length of the foundation wall between perpendicular walls is two times the foundation wall height or less.
i. This table is applicable where the length of the foundation wall between perpendicular walls is 35 feet or less, or where the length of the foundation laterally supported on only one end by a perpendicular wall is 17 feet or less.
j. Maximum wall height is measured from top of the foundation wall to the bottom of the interior concrete slab-on-grade.
k. Install foundation anchorage per Section R403.1.6.

## TABLE 2-B TYPES OF SOILS AND THEIR PROPERTIES

| SOIL GROUP | UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL | SOIL DESCRIPTION | DRAINAGE CHARACTERISTICS | FROST HEAVE POTENTIAL | VOLUME CHANGE POTENTIAL EXPANSION | LOAD-BEARING PRESSURE (lbs/sq") |
|---|---|---|---|---|---|---|
| Group I | GW | Well-graded gravels, gravel sand mixtures, little or no fines | Good | Low | Low | 3000 |
| | GP | Poorly graded gravels or gravel sand mixtures, little or no fines | Good | Low | Low | |
| | SW | Well-graded sands, gravelly sands, little or no fines | Good | Low | Low | 2000 |
| | SP | Poorly graded sands or gravelly sands, little or no fines | Good | Low | Low | |
| | GM | Silty gravels, gravel-sand-silt mixtures | Good | Medium | Low | |
| | SM | Silty sand, sand-silt mixtures | Good | Medium | Low | |
| Group II | GC | Clayey gravels, gravel-sand-clay mixtures | Medium | Medium | Low | |
| | SC | Clayey sands, sand-clay mixtures | Medium | Medium | Low | |
| | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity | Medium | High | Low | 1500 |
| | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | Medium | Medium | Medium to Low | |
| Group III | CH | Inorganic clays of high plasticity, fat clays | Poor | Medium | High | |
| | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts | Poor | High | High | |
| Group IV | OL | Organic silts and organic silty clays of low plasticity | Poor | Medium | Medium | |
| | OH | Organic clays of medium to high plasticity, organic silts | Unsatisfactory | Medium | High | |
| | Pt | Peat and other highly organic soils | Unsatisfactory | Medium | High | |