Footings and Foundations for Residential Construction

Footings and Foundations

- Footings and Foundations can be found in Chapter 4 of the 2012 Virginia Residential Code and Chapter 18 of the 2012 Virginia Construction Code. Free online access to the 2012 VA USBC is available at http://codes.iccsafe.org/Virginia.html

Footing Inspection

- Footings
  - Footings must be inspected prior to placement of concrete

Footing Inspection

- How deep and how wide?
  - Depth to bottom of footing
    - Virginia Residential Code states “All exterior footings shall be placed at least 12 inches below undisturbed ground surface” (R403.1.4), but allows the jurisdiction to determine the depth for frost protection (Table R301.2(1)). Washington County has traditionally enforced a depth of 18”. Soft areas including fill must be excavated until suitable bearing soil is exposed. If a soils report is required, the footing trench bottoms are to be excavated to the depth required by the report.
    - Bottom of footing has to be resting <u>on undisturbed natural soils or engineered fill</u> (R403.1)
    - All mud, soft areas, loose dirt, frozen soil, water, roots, and organic material shall be removed

Footing Inspection

Load-Bearing value of the soil is important in determining the size of the footing. In lieu of obtaining a soil test, the code allows the use of the following table.

R401.4.1 Geotechnical evaluation. In lieu of a complete geotechnical evaluation, the load-bearing values in Table R401.4.1 shall be assumed.

TABLE R401.4.1
PRESUMPTIVE LOAD–BEARING VALUES OF FOUNDATION MATERIALS[a]

CLASS OF MATERIAL	LOAD-BEARING PRESSURE (pounds per square foot)
Crystalline bedrock	12,000
Sedimentary and foliated rock	4,000
Sandy gravel and/or gravel (GW and GP)	3,000
Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000
Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500[b]

For SI: 1 pound per square foot = 0.0479 kPa.

a. When soil tests are required by Section R401.4, the allowable bearing capacities of the soil shall be part of the recommendations.

b. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

Footing Inspection

- Width (R403.1.1)
  - Either the Size and depth shown on approved plans, or
  - Reference Table R403.1

TABLE R403.1 MINIMUM WIDTH OF CONCRETE, PRECAST OR MASONRY FOOTINGS (inches)				
	LOAD-BEARING VALUE OF SOIL (psf)			
	1,500	2,000	3,000	≥ 4,000
Conventional light-frame construction				
1-story	12	12	12	12
2-story	15	12	12	12
3-story	23	17	12	12
4-inch brick veneer over light frame or 8-inch hollow concrete masonry				
1-story	12	12	12	12
2-story	21	16	12	12
3-story	32	24	16	12
8-inch solid or fully grouted masonry				
1-story	16	12	12	12
2-story	29	21	14	12
3-story	42	32	21	16

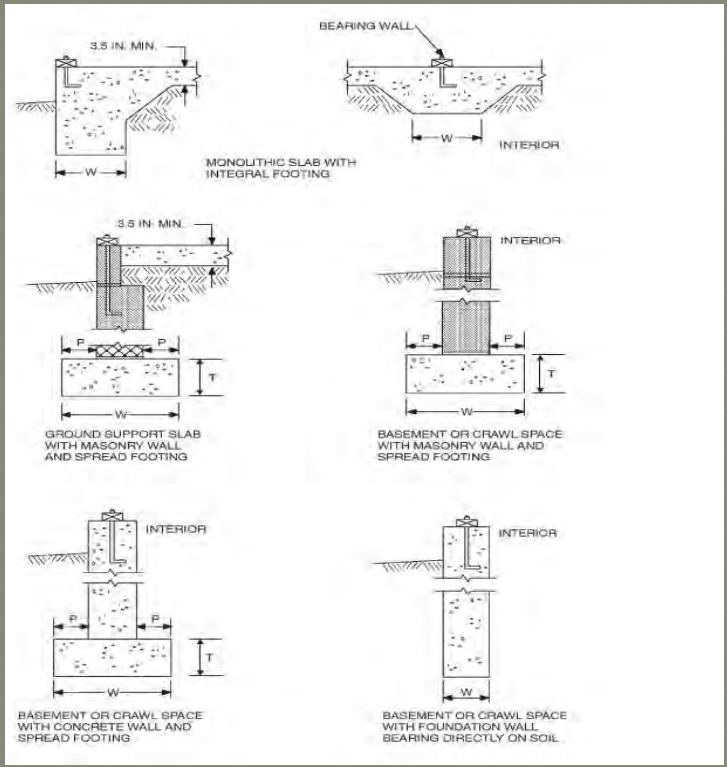
Footing Inspection

- Size (R403.1.1)
  - Minimum thickness of footing shall be 6”
    - Different circumstances require thicker footings. For example, a footing for a chimney requires a minimum of a 12” footing.
  - Footing thickness has to be marked at time of inspection
    - NO wood stakes
    - Can use rebar
    - Can mark sides of trench to show depth

Footing Inspection

- Slope (R403.1.5)
  - Top surface of finished footing must be level
  - Bottom surface of footing <u>must not exceed 1 unit vertical in 10 units horizontal</u>
    - If the bottom surface exceeds 1 in 10, must be stepped footings using bulkheads (bottom surfaced stepped also, not sloped)
    - Bulkheads must project minimum of thickness of footing, with bottom of bulkheads no lower than the top of the lower footing

Figure R403.1(1)



Footing Inspection

- Reinforcing Steel (re-bar)
  - If re-bar is installed in footing, it MUST be used as part of the grounding electrode system for the electrical service (E3608)
  - Re-bar installed in footings must be secured to their supports and to adjoining re-bar so that they cannot be displaced (securely tied). Re-bar is to have a minimum clearance from earth of 3” under and 2” at sides and ends. “Chairs” used for re-bar support shall be 3” steel, plastic or other material approved by the Concrete Reinforcing Institute and manufactured for this purpose, or steel dowels driven into the ground with re-bars tied at the minimum required 3” height. Horizontal re-bars are to be spliced (generally 40 times the bar diameter, Table R611.5.4(1)) and tied. All mud, ice, oil, or other foreign substances to be removed from the surface of the re-bar before installation.

Footing Inspection

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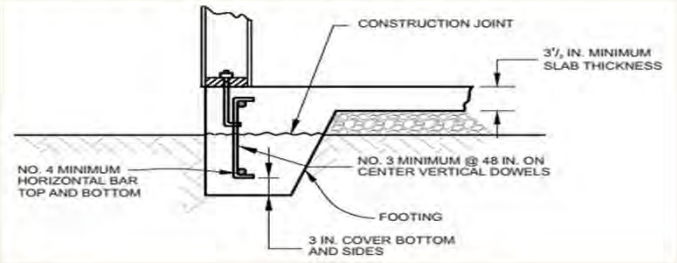
R403.1.3.1 Foundations with stemwalls.
Foundations with stem walls shall have installed a minimum of one No. 4 bar within 12 inches (305 mm) of the top of the wall and one No. 4 bar located 3 inches (76 mm) to 4 inches (102 mm) from the bottom of the footing.

R403.1.3.2 Slabs-on-ground with turned-down footings.
Slabs on ground with turned down footings shall have a minimum of one No. 4 bar at the top and the bottom of the footing.

Exception: For slabs-on-ground cast monolithically with the footing, locating one No. 5 bar or two No. 4 bars in the middle third of the footing depth shall be permitted as an alternative to placement at the footing top and bottom.

Where the slab is not cast monolithically with the footing, No. 3 or larger vertical dowels with standard hooks on each end shall be provided in accordance with Figure R403.1.3.2. Standard hooks shall comply with Section R611.5.4.5.



R404.1.2.3.7 Reinforcement.

R404.1.2.3.7.1 Steel reinforcement.
Steel reinforcement shall comply with the requirements of ASTM A 615, A 706, or A 996. ASTM A 996 bars produced from rail steel shall be Type R. In buildings assigned to Seismic Design Category A, B or C, the minimum yield strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa). In buildings assigned to Seismic Design Category D_0, D_1 or D_2, reinforcing steel shall comply with the requirements of ASTM A 706 for low-alloy steel with a minimum yield strength of 60,000 psi (Grade 60) (414 MPa).

R404.1.2.3.7.5 Lap splices. Vertical and horizontal wall reinforcement shall be the longest lengths practical. Where splices are necessary in reinforcement, the length of lap splice shall be in accordance with Table R611.5.4.(1) and Figure R611.5.4(1). The maximum gap between noncontact parallel bars at a lap splice shall not exceed the smaller of one-fifth the required lap length and 6 inches (152 mm). See Figure R611.5.4(1).

R611.5.4.4 Development of bars in tension. Where bars are required to be developed in tension by other provisions of this code, development lengths and cover for hooks and bar extensions shall comply with Table R611.5.4(1) and Figure R611.5.4 (2). The development lengths shown in Table R611.5.4(1) also apply to bundled bars in lintels installed in accordance with Section R611.8.2.2.

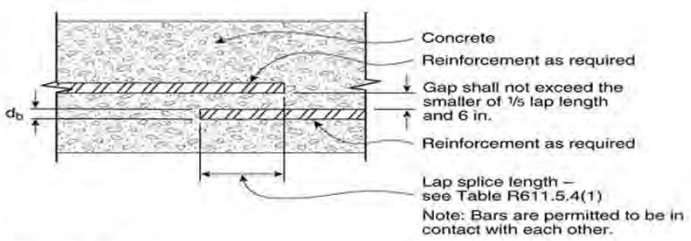
Footing Inspection

R611.5.4 Reinforcement installation details.

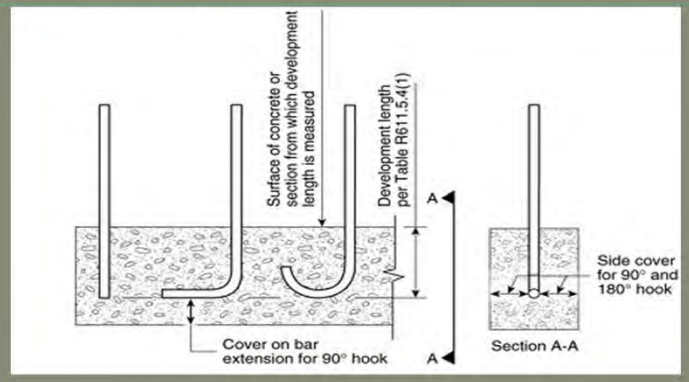
TABLE R611.5.4(1) LAP SPLICE AND TENSION DEVELOPMENT LENGTHS

	BAR SIZE NO.	YIELD STRENGTH OF STEEL, f_y- psi (MPa)	
		40,000 (280)	60,000 (420)
		Splice length or tension development length (inches)	
Lap splice length-tension	4	20	30
	5	25	38
	6	30	45
Tension development length for straight bar	4	15	23
	5	19	28
	6	23	34
Tension development length for: a. 90-degree and 180-degree standard hooks with not less than $2^1/_2$ inches of side cover perpendicular to plane of hook, and b. 90-degree standard hooks with not less than 2 inches of cover on the bar extension beyond the hook.	4	6	9
	5	7	11
	6	8	13
Tension development length for bar with 90-degree or 180-degree standard hook having less cover than required above.	4	8	12
	5	10	15
	6	12	18

For SI: 1 inch = 25.4 mm.

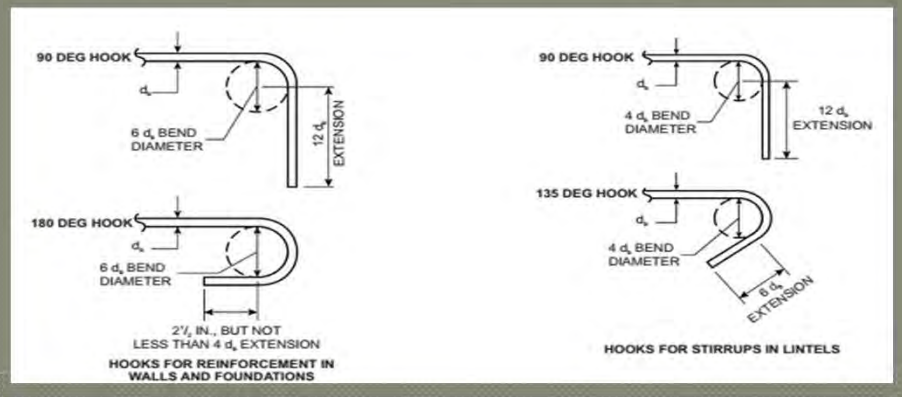


For SI: 1 inch = 25.4 mm.



For SI: 1 degree = 0.0175 rad.

FIGURE R611.5.4(2) DEVELOPMENT LENGTH AND COVER FOR HOOKS AND BAR EXTENSION



Footing Inspection

- Sides of footing <u>must be dug straight up and down, not angled in at the bottom</u>. Bottom of footing maximum of 1 in 10 slope, top of finished footing must be level
- Pipes going through the footing or foundation wall must be provided with a relieving arch or a pipe sleeve 2 pipe sizes larger

Footing Inspection

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Foundation Inspection

R403.1.6 Foundation anchorage.
Sill plates and walls supported directly on continuous foundations shall be anchored to the foundation in accordance with this section.

Wood sole plates at all exterior walls on monolithic slabs, wood sole plates of *braced wall panels* at building interiors on monolithic slabs and all wood sill plates shall be anchored to the foundation with anchor bolts spaced a maximum of 6 feet (1829 mm) on center. Bolts shall be at least $^1/_2$ inch (12.7 mm) in diameter and shall extend a minimum of 7 inches (178 mm) into concrete or grouted cells of concrete masonry units. A nut and washer shall be tightened on each anchor bolt. There shall be a minimum of two bolts per plate section with one bolt located not more than 12 inches (305 mm) or less than seven bolt diameters from each end of the plate section. Interior bearing wall sole plates on monolithic slab foundation that are not part of a *braced wall panel* shall be positively anchored with *approved* fasteners. Sill plates and sole plates shall be protected against decay and termites where required by Sections R317 and R318. Cold-formed steel framing systems shall be fastened to wood sill plates or anchored directly to the foundation as required in Section R505.3.1 or R603.3.1.

Exceptions:

1. Foundation anchorage, spaced as required to provide equivalent anchorage to $^1/_2$-inch-diameter (12.7 mm) anchor bolts.

2. Walls 24 inches (610 mm) total length or shorter connecting offset *braced wall panels* shall be anchored to the foundation with a minimum of one anchor bolt located in the center third of the plate section and shall be attached to adjacent *braced wall panels* at corners as shown in item 8 of Table R602.3(1).

3. Connection of walls 12 inches (305 mm) total length or shorter connecting offset *braced wall panels* to the foundation without anchor bolts shall be permitted. The wall shall be attached to adjacent *braced wall panels* at corners as shown in item 8 of Table R602.3(1).

Foundation Inspection

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CHAPTER 16 STRUCTURAL DESIGN

1604.8 Anchorage.
Buildings and other structures, and portions thereof, shall be provided with anchorage in accordance with Sections 1604.8.1 through 1604.8.3, as applicable.

1604.8.1 General.
Anchorage of the roof to walls and columns, and of walls and columns to foundations, shall be provided to resist the uplift and sliding forces that result from the application of the prescribed loads.

1604.8.2 Structural walls.
Walls that provide vertical load-bearing resistance or lateral shear resistance for a portion of the structure shall be anchored to the roof and to all floors and members that provide lateral support for the wall or that are supported by the wall. The connections shall be capable of resisting the horizontal forces specified in Section 1.4.5 of ASCE 7 for walls of structures assigned to Seismic Design Category A and to Section 12.11 of ASCE 7 for walls of structures assigned to all other seismic design categories. Required anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall. See Sections 1609 for wind design requirements and 1613 for earthquake design requirements.

Foundation Inspection

- Cinderblock foundation one of most common in Washington County
  - Size of block, grouting of block, size and placement of rebar are determined by height of foundation wall as well as unbalanced backfill
  - Tables R404.1.1(1), R404.1.1(2), R404.1.1(3), and R404.1.1(4)
    - Unless information is provided from a soils engineer, the third column is used for determination
    - For example, Using Table R404.1.1(1), a 9' foundation wall, with 5' of unbalanced backfill has to be a minimum of 12" block. The same wall with 6' of unbalanced backfill will have to be a minimum of 12" solid (grout filled). The same wall with 7' of unbalanced backfill, Table R404.1.1(1) directs you to one of three following tables to determine re-bar size and placement. This example is a 12" masonry wall, which directs the user to Table R404.1.1(4). With a 9'4" wall height (table divides up into 8" block runs), and 7' of unbalanced backfill, column 3 requires #6 rebar run vertically at least every 72"

Foundation Inspection

TABLE R404.1.1(1) PLAIN MASONRY FOUNDATION WALLS

MAXIMUM WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT[c] (feet)	PLAIN MASONRY[a] MINIMUM NOMINAL 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 or 8	6 solid or 8	8
	5	8	10	12
	6	10	12	12 solid
	7	12	12 solid	Footnote e
	8	12 solid	Footnote e	Footnote e
	9	Footnote e	Footnote e	Footnote e

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 Pa.

a. Mortar shall be Type M or S and masonry shall be laid in running bond. Ungrouted hollow masonry units are permitted except where otherwise indicated.

b. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

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 either Table R404.1.1(2), Table R404.1.1(3), Table R404.1.1(4), or a design shall be provided.

TABLE R404.1.1(4) 12-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE d > 8.75 INCHES[a, c]

WALL HEIGHT	HEIGHT OF UNBALANCED BACKFILL[e]	MINIMUM VERTICAL REINFORCEMENT[b]		
		Soil classes and lateral soil load (psf per foot below grade)		
		GW, GP, SW and SP soils 30	GM, GC, SM, SM-SC ar ML soils 45	CL soils 60
6 feet 8 inches	4 feet (or less)	#4 at 72	#4 at 72	#4 at 72
	5 feet	#4 at 72	#4 at 72	#4 at 72
	6 feet 8 inches	#4 at 72	#4 at 72	#5 at 72
7 feet 4 inches	4 feet (or less)	#4 at 72	#4 at 72	#4 at 72
	5 feet	#4 at 72	#4 at 72	#4 at 72
	6 feet	#4 at 72	#4 at 72	#5 at 72
	7 feet 4 inches	#4 at 72	#5 at 72	#6 at 72
8 feet	4 feet (or less)	#4 at 72	#4 at 72	#4 at 72
	5 feet	#4 at 72	#4 at 72	#4 at 72
	6 feet	#4 at 72	#4 at 72	#5 at 72
	7 feet	#4 at 72	#5 at 72	#6 at 72
	8 feet	#5 at 72	#6 at 72	#6 at 64
8 feet 8 inches	4 feet (or less)	#4 at 72	#4 at 72	#4 at 72
	5 feet	#4 at 72	#4 at 72	#4 at 72
	6 feet	#4 at 72	#4 at 72	#5 at 72
	7 feet	#4 at 72	#5 at 72	#6 at 72
	8 feet 8 inches	#5 at 72	#7 at 72	#6 at 48
9 feet 4 inches	4 feet (or less)	#4 at 72	#4 at 72	#4 at 72
	5 feet	#4 at 72	#4 at 72	#4 at 72
	6 feet	#4 at 72	#5 at 72	#5 at 72
	7 feet	#4 at 72	#5 at 72	#6 at 72
	8 feet	#5 at 72	#6 at 72	#6 at 56
	9 feet 4 inches	#6 at 72	#6 at 48	#6 at 40
10 feet	4 feet (or less)	#4 at 72	#4 at 72	#4 at 72
	5 feet	#4 at 72	#4 at 72	#4 at 72
	6 feet	#4 at 72	#5 at 72	#5 at 72
	7 feet	#4 at 72	#6 at 72	#6 at 72
	8 feet	#5 at 72	#6 at 72	#6 at 48
	9 feet	#6 at 72	#6 at 56	#6 at 40
	10 feet	#6 at 64	#6 at 40	#6 at 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 the reinforcement does not exceed 72 inches.

c. Vertical reinforcement shall be Grade 60 minimum. The distance, *d*, from the face of the soil side of the wall to the center of vertical reinforcement shall be at least 8.75 inches.

d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure. Refer to Table R405.1.

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 levels. Where an interior concrete slab-on-grade is provided and in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height is permitted to be measured from the exterior finish ground level to the top of the interior concrete slab is permitted.

Foundation Inspection

- Keep in mind, on final inspection of the structure, grade must be at least 6” of fall in the first 10’ out from the foundation to ensure drainage (R401.3). This area also has to be stabilized to prevent erosion (grass seed and straw).

Footings and Foundations

- Points to remember
  - Masonry foundation must extend minimum of 6” above finished grade (R404.1.6)
  - Wood joists or the bottom of wood structural floor must be 18” above exposed ground in crawlspace, wood girders must be 12” above exposed ground (R317.1 #1).
  - All wood framing members that rest on concrete or masonry exterior foundation walls and are less than 8” from the exposed ground must be pressure treated (R317.1 #2).

Footings and Foundations

- For information, go to: www.washcova.com
- To access the VA 2012 Uniform Statewide Building Code (USBC), go to: http://codes.iccsafe.org/Virginia.html