2018 International Residential Code

Foundation Wall Reinforcement Guide

Background Information

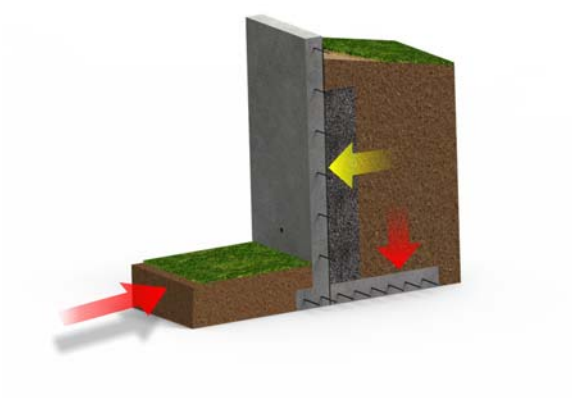
This guide was developed to aid home inspectors in using the 2018 IRC tables found in Section 404 to determine the proper selection of reinforcing steel size and spacing for poured concrete basement walls.

Note: The IRC tables referenced in this guide do not apply if the following conditions exists:

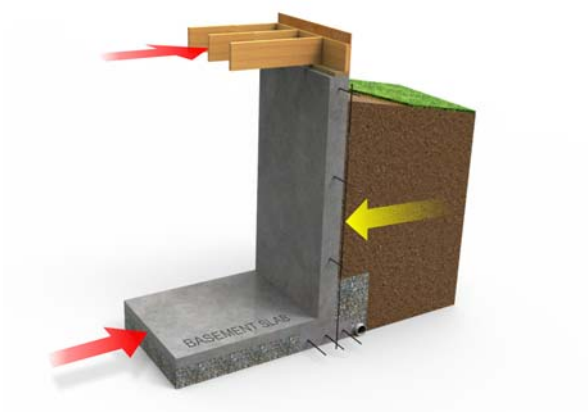
- Walls are subject to hydrostatic pressure from ground water.
- Walls supporting more than 48 inches of unbalanced backfill that do not have permanent lateral support at the top or bottom. The basement wall is considered adequately supported at the top when the subfloor system is in place. *This typically includes the sill plate bolted to the foundation, rim joist, floor joists and subfloor sheathing all nailed in place.* The basement wall is considered adequately supported at the bottom when the basement floor slab is in place and sufficiently cured to a minimum compressive strength of 2,500 psi.

Design Method

Engineers that developed the IRC tables referenced in this guide designed the basement wall as a *Restrained Retaining Wall*. The two diagrams below show the differences between a standard cantilevered retaining wall and a restrained retaining wall (i.e. Basement Wall).



Cantilevered Retaining Wall



Restrained Retaining Wall

Soil Type Classification

In order to use the IRC foundation reinforcement tables you need to know the properties of the retained soil. The IRC has classified the soil types using the **Unified Soil Classification System** shown in the IRC Table 405.1

The **Unified Soil Classification System** (**USCS**) is a soil classification system used in engineering and geology to describe the texture and grain size of a soil. The classification system can be applied to most soil materials, and is represented by a two-letter symbol. Each letter is described below (with the exception of **Pt**):

FIRST AND/OR SECOND LETTERS		SECOND LETTER	
LETTER	DEFINITION	LETTER	DEFINITION
G	Gravel	P	POORLY GRADED (UNIFORM PATRICLE SIZES)
S	Sand	W	WELL-GRADED (DIVERSIFIED PARTICLE SIZES)
M	Silt	H	HIGH PLACTICITY
C	Clay	L	LOW PLACTICITY
O	Organic		

If the soil has 5–12% by weight of fines passing a #200 sieve, both grain size distribution and plasticity have a significant effect on the engineering properties of the soil, and dual notation may be used for the group symbol. For example, GW-GM corresponds to "well-graded gravel *with silt*."

If the soil has more than 15% by weight retained on a #4 sieve, there is a significant amount of gravel, and the suffix "with gravel" may be added to the group name, but the group symbol does not change. For example, SP-SM could refer to "poorly graded SAND with silt" or "poorly graded SAND with silt and gravel."

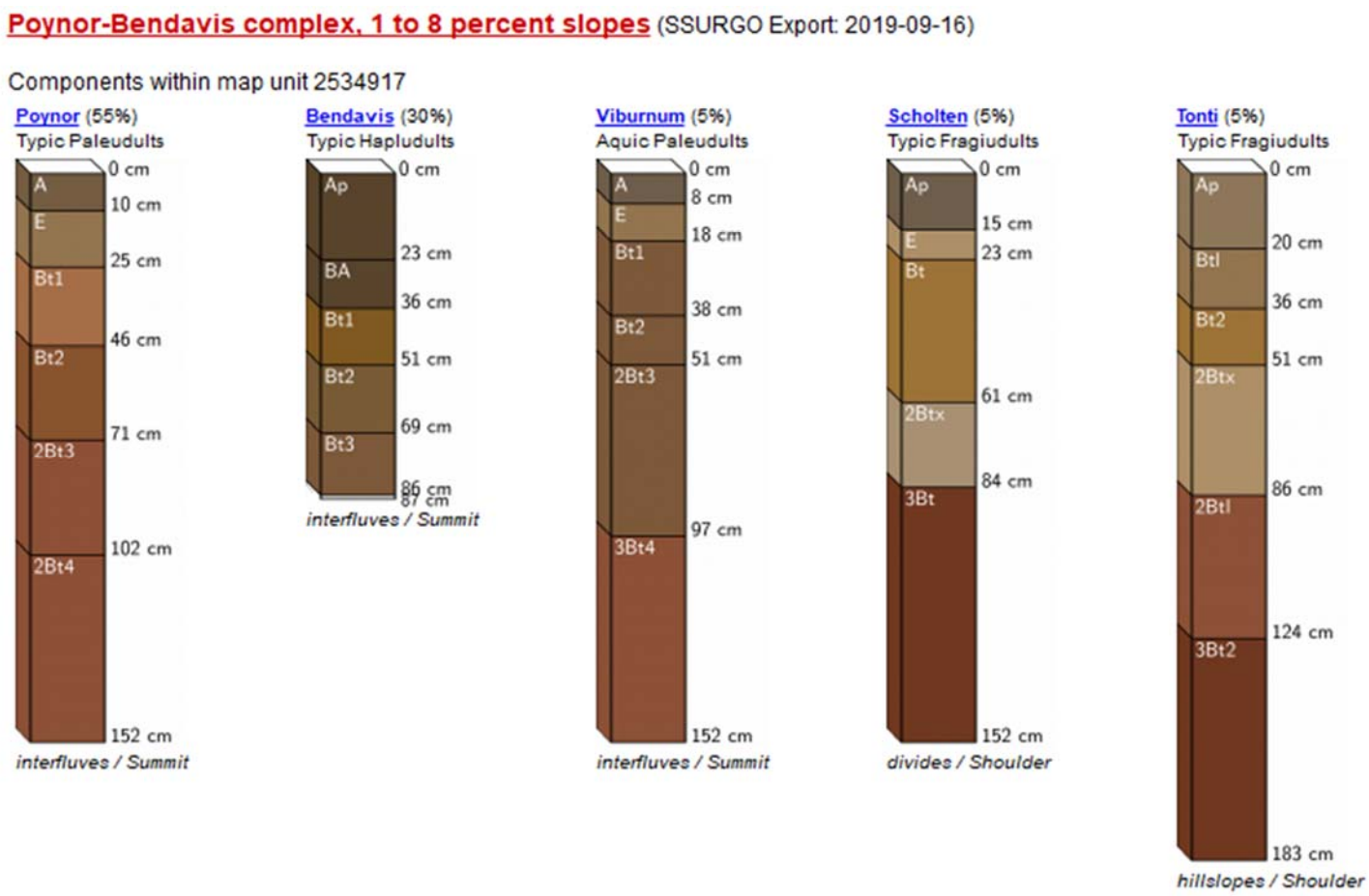
Finding Soil Name

Step 1—Go to https://casoilresource.lawr.ucdavis.edu/soil_web/kml/SoilWeb.kmz and save the file to your computer.

Step 2—If you do not have *Google Earth Pro* on your computer you can download it at https://www.google.com/earth/versions/#earth-pro , otherwise open *Google Earth Pro* and load the **soilweb.kmz** file you downloaded in the previous step. *Google Earth Pro* will overlay the map with yellow lines, which define the different soil types. Now find the location where the foundation will be constructed and click on the screen as close as possible. A box will popup on your screen showing the various soil types starting with the most predominate soil type by percentage on the left, see diagram below:

Step 3—While in *Google Earth Pro* place your cursor on the foundation site as close as possible and record the latitude and longitude displayed in the lower right corner of your screen. This information maybe needed later.

Alternate Method—Download the application **SOILWEB** for Apple or Android phones at https://casoilresource.lawr.ucdavis.edu/soilweb-apps/. This app requires you to be at the foundation site to work.



In this example the two most dominant soil types were combined to name the soil **Poynor-Bendavis**. With this soil name you can search the PDF version of a Soil Survey Report or go online to find the unified soil classification for the soil profile at the foundation site.

Online Soil Surveys (Option A)

In order to find the type of soil at a specific location you need access to the **United States Department of Agriculture (USDA)** county soil survey report for your state and county.

Go to the following website link (https://www.nrcs.usda.gov/wps/portal/nrcs/soilsurvey/soils/survey/state/) and click on your state then scroll down to your county. The county list shows the date the soil survey was taken and if the soil survey is archived as a PDF file. If the soil survey is archived as a PDF and the date is 1960 or newer click the county name to download the document for reference.

Search this document for engineering properties and find the soil name at the foundation construction site, see diagram below.

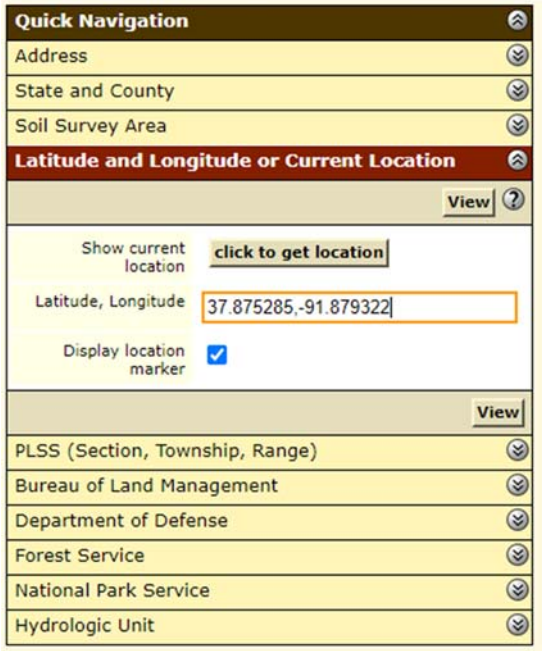
Table 17.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage Passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
73175:												
Poynor------	0-5	Very gravelly silt loam	GC, GC-GM, GM	A-4, A-2-4	0-5	0-20	35-55	30-50	30-50	25-40	10-30	2-10
	5-11	Very gravelly silt loam	GC-GM, GC, GM	A-2-4, A-4	0-5	0-20	35-55	30-50	30-50	25-40	10-30	2-10
	11-17	Very gravelly silt loam	GC	A-2-6, A-6	0-5	0-20	35-55	30-50	30-50	25-40	25-35	10-15
	17-60	Clay	CH	A-7, A-7-6	0	0-5	90-100	85-100	80-95	70-85	50-75	30-50
Bendavis-----	0-5	Very gravelly silt loam	GC, GM, GC-GM	A-2-4	0-5	0-5	35-50	30-45	30-45	25-35	10-25	2-10
	5-9	Very gravelly silt loam, gravelly silt loam	GC, GM	A-2-4	0-5	0-5	35-65	30-60	30-60	25-50	10-25	2-10
	9-25	Very gravelly silt loam, very gravelly silty clay loam	GC	A-2-4, A-2-6	0-5	0-5	35-50	30-45	30-45	25-35	25-35	5-15
	25-60	Unweathered bedrock			---	---	---	---	---	---	---	---

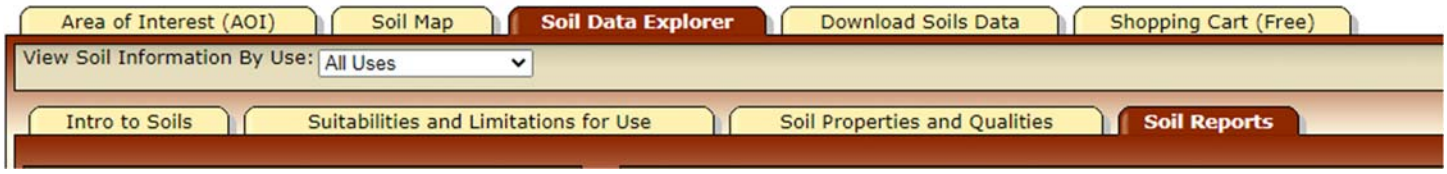
In this example the Unified Soil Classification is listed in the fourth column. The first 5 inches of the Poynor soil is listed as *"Very gravelly silt loam"* followed by the symbols **GC**, **GC-GM**, **GM**. The bottom layer 17 to 60 inches deep is listed as *"Clay"* followed by the symbol **CH**. These symbols will be used to determine the correct reinforcing steel needed in the 2018 IRC code book.

Online Soil Surveys (Option B)

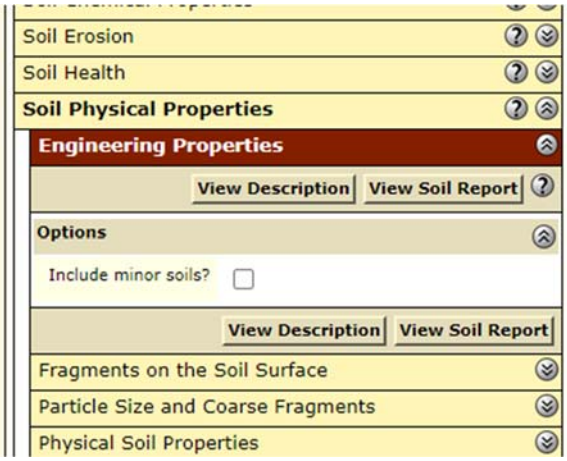
Go to https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm and click Green Start button. In the Quick Navigation area on the left click the dropdown arrow on the section labeled *"Latitude and Longitude or Current Location"* in enter latitude and longitude of the construction site. When using *Google Earth Pro* these values are displayed in the lower right corner of your computer screen. Then click **View**.



The computer screen will pin point that Latitude and Longitude you just entered. Now at the top of your screen you select the AOI (area of interest) button and draw a box around the construction site. Next click the tab **Soil Data Explorer** then **Soil Reports**.



Next in the left hand column select **Soil Physical Properties**, then **Engineering Properties**, followed by **View Soil Report**. Now scroll down until you find your soil type **Poynor-Bendavis**. The data in this table is the same as found in **Option A** with only minor differences.



Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number —				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
73175—Poynor-Bendavis complex, 1 to 8 percent slopes														
Poynor	55	D	0-5	Very gravelly silt loam	GC, GM	A-1-b, A-4, A-6	0- 0- 5	0- 0- 20	35-55-55	30-50-50	30-50-50	25-40-40	18-22-39	2-3 -15
			5-11	Very gravelly silt loam	GC, GC-GM, GM	A-1-b, A-2-4, A-6	0- 0- 5	0- 0- 20	35-40-55	30-35-50	30-35-50	25-30-40	17-21-34	2-5 -15
			11-17	Very gravelly silt loam	GC	A-2-6, A-6	0- 0- 5	0- 0- 20	35-50-55	30-45-50	30-45-50	25-35-40	27-33-38	12-15-19
			17-79	Clay	CH	A-7-6	0- 0- 0	0- 5- 5	90-90-100	85-85-100	80-80-95	70-70-85	53-76-80	31-50-52
Bendavis	30	C	0-5	Very gravelly silt loam	GM	A-1-b, A-2-4	0- 0- 5	0- 0- 5	35-45-50	30-40-45	30-40-45	25-30-35	20-30-35	2-7 -10
			5-9	Gravelly silt loam, very gravelly silt loam	GC, GM	A-1-b, A-4, A-2-4	0- 0- 5	0- 0- 5	35-45-65	30-40-60	30-40-60	25-30-50	17-27-31	2-8 -10
			9-25	Very gravelly silt loam, very gravelly silty clay loam	GC	A-2-4, A-2-7	0- 0- 5	0- 0- 5	35-45-50	30-40-45	30-40-45	25-30-35	25-28-41	9-10-21
			25-79	Bedrock	—	—	—	—	—	—	—	—	—	—

In this example the Unified Soil Classification is listed in the sixth column. The first 5 inches of the Poynor soil is listed as *"Very gravelly silt loam"* followed by the symbols **GC**, **GM**. The bottom layer 17 to 79 inches deep is listed as *"Clay"* followed by the symbol **CH**. These symbols will be used to determine the correct reinforcing steel needed in the 2018 IRC code book.

Foundation Geometry

Now that the soil type has been identified as Poynor-Bendavis the sext step is to determine the width and height of the foundation walls. Remember only basement walls supported at both at the top and bottom are covered in the 2018 IRC code book.

DESIGN EXAMPLE 1:

Foundation material: Reinforced concrete

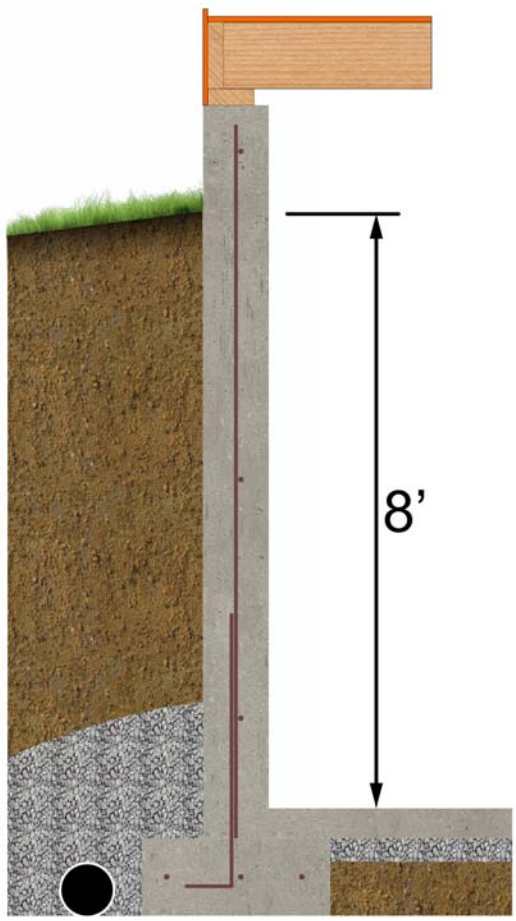
Concrete: 2500psi minimum

Reinforcing Steel: Grade 60

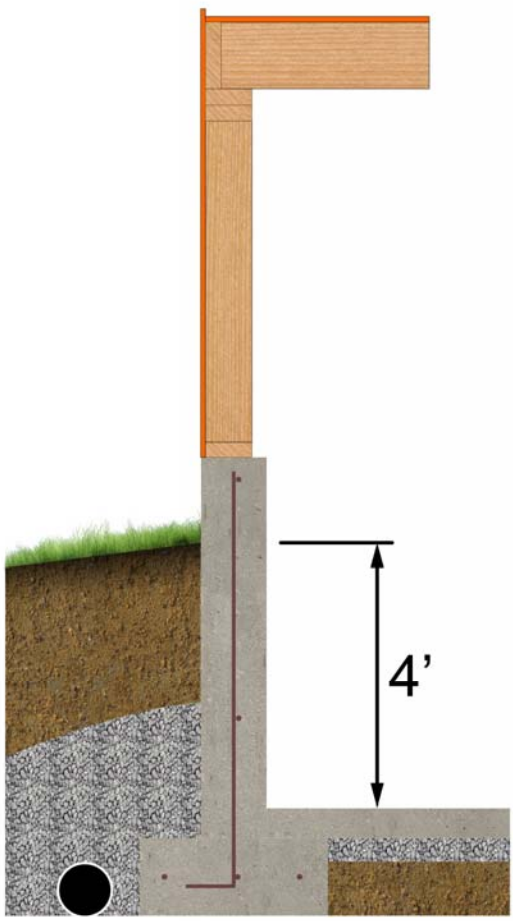
Wall Height: 9 feet

Wall width: 8 inches

Unbalanced fill height: 8 feet

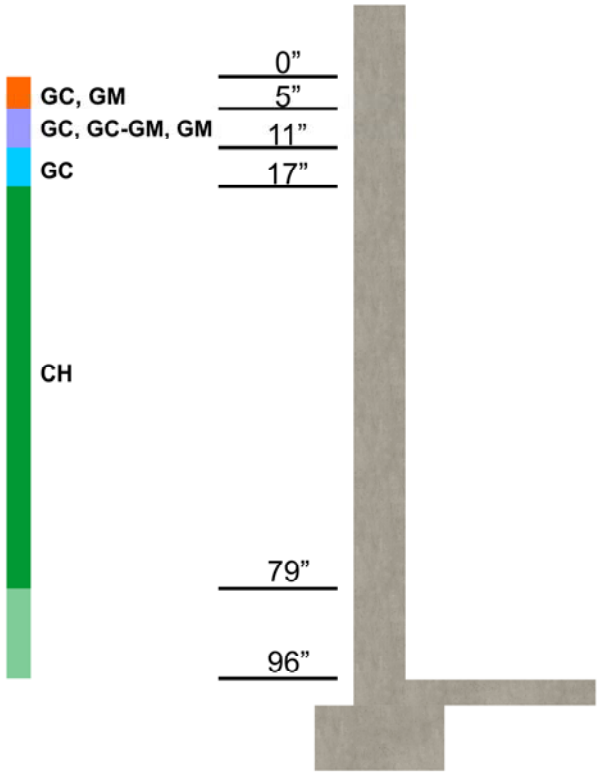


9’ Wall
(full height)



5’ Wall
(step-down)

For the 9 foot wall section with 8 foot unbalanced fill using Table R404.1.2(3) in the 2018 IRC you have three columns to choose from depending on the soil type. Looking at the soil profile below the bulk of the soil is classified as **CH** or inorganic clays of high plasticity usually called fat clay. In practice during foundation excavation all the soil profiles get mixed. If this excavated soil is used as backfill the soil with the poorest drainage characteristics should be used, in this case **CH** or the inorganic clay with the high plasticity is used.



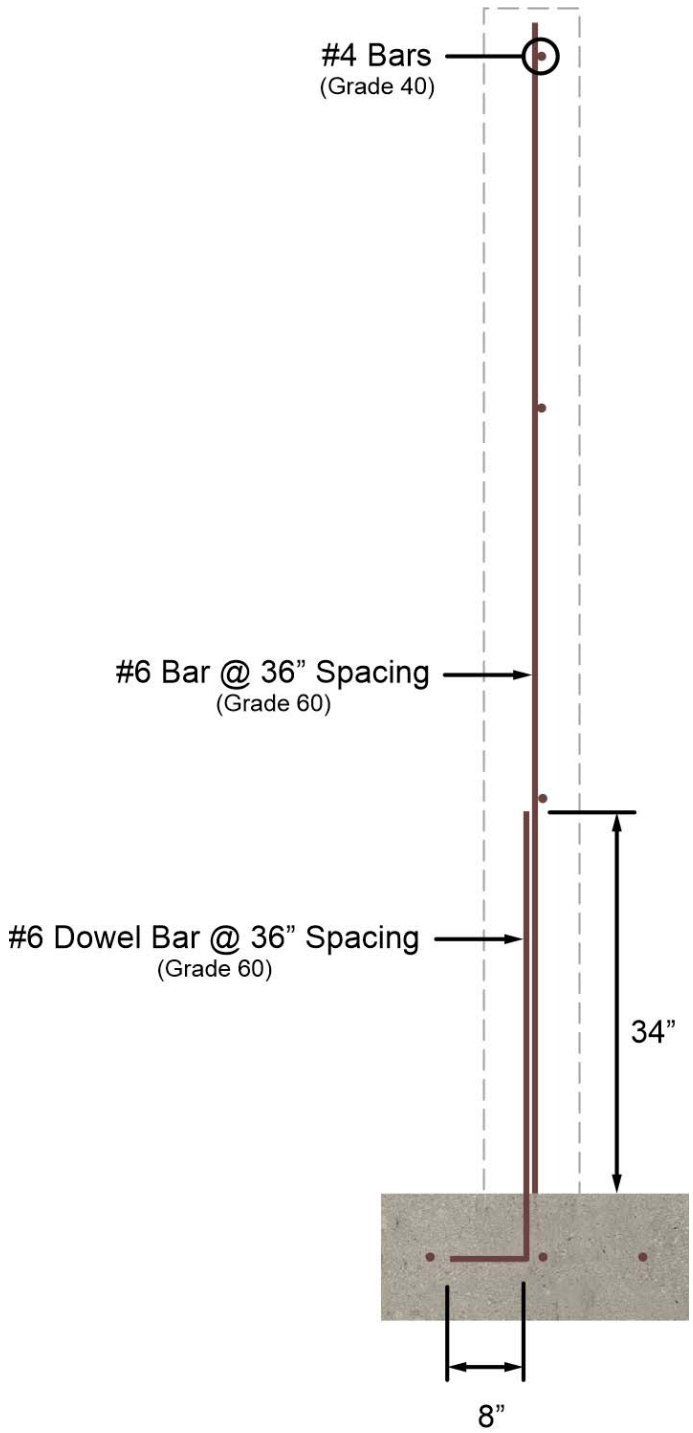
Soil Profile

Looking at Table R404.1.2(3) in the 2018 IRC the soil classification **CH** is not in the table. If you look at the foot note (j) at the bottom of the table it states *“The use of this table shall be prohibited for soil classifications not shown”*. This means the contractor cannot backfill the foundation with this soil type. Looking at Table R405.1 only Group I and Group II soils can be used. Group III and Group IV soils have poor to unsatisfactory drainage characteristics. The best option is to backfill with clean 1 inch rock and cap off the top 8 to 12 inches with topsoil, anything less will not likely have the necessary nutrients and moisture to grow grass.

The contractor could theoretically bring in backfill material from Group I or Group II in Table R405.1, however only soils classified as GW, GP, SW, SP could be visually identified without testing. Once silts or clay material is introduced into the mix laboratory testing for Atterberg limits, Plasticity Index (PI), and Liquid Limit (LL) will be needed to properly classify the soil type.

In this example lets assume the contractor takes the easy path and backfills with clean 1 inch rock. Then the first column in Table 404.1.2(3) in the 2018 IRC can be used to select the required minimum vertical reinforcement. According to the table a 9 foot wall with 8 foot unbalanced fill will need #6 Grade 60 reinforcing steel spaced at 36 inch centers placed in the center of the wall.

If the contractor elected to install #6 Grade 60 dowel bars in the footing instead of installing the full length bars for the 9 foot wall then you should look in Table R608.5.4(1) for a tension lap splice length to be sure the dowel bars are long enough. In this case the length of the #6 Grade 60 dowel bar should be 34 inches with a standard 90 degree hook 8 inches long according to IRC Table R608.5.4(1) for Lap Splice and Tension Development Lengths.



Horizontal Steel

The horizontal reinforcement, typically referred to as temperature /shrinkage steel , can be found in Table R404.1.2(1) in the 2018 IRC. With 9 foot walls the requirements are: One #4 bar Grade 40 within 12 inches of the top of the wall and #4 bars at 1/3 points in the wall.

Alternate Size and Grade of Steel

The contractor can substitute a different bar size or use Grade 40 steel. In this case Table R404.1.2(9) in the 2018 IRC can be used.

EXAMPLE:

If the contractor elects to use #5 Grade 40 reinforcing steel, then according to the tables the new spacing is #5 bars at 17 inch centers. The dowel bar lap splice length would be reduced from 34 to 19 inches and the horizontal leg in the footing would be reduced from 8 to 7 inches.

Foundation Geometry

DESIGN EXAMPLE 2:

Foundation material: Reinforced concrete

Concrete: 2500psi minimum

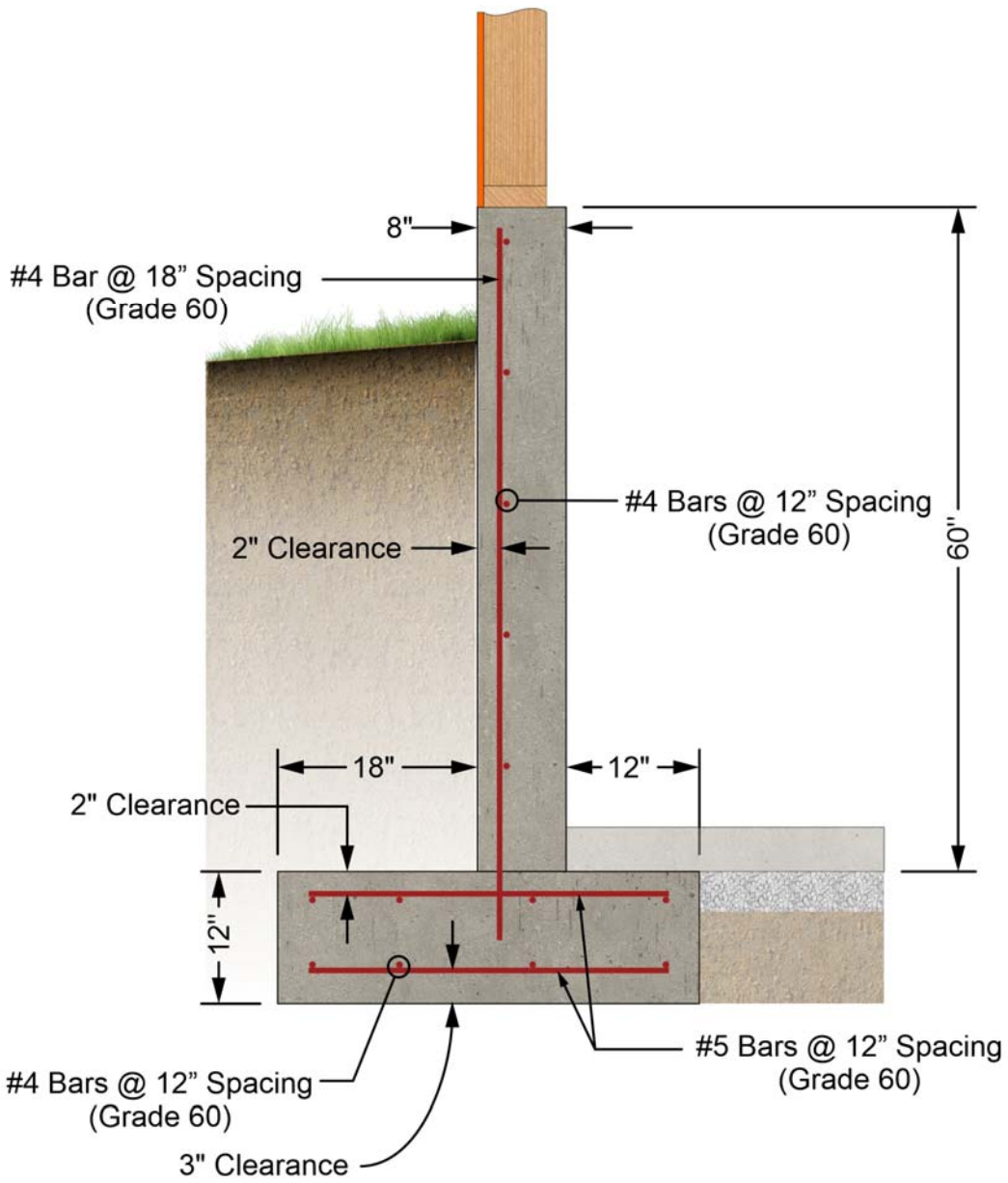
Reinforcing Steel: Grade 60

Wall Height: 5 feet

Wall width: 8 inches

Unbalanced fill height: 4 feet

The 5 foot step-down wall section with 4 foot unbalanced fill according to Section R404.1.1 in the 2018 IRC will require engineering design because it does not have lateral support at the top. Although designing this wall section as a cantilevered wall is outside the scope of a home inspector's SOP I have included an engineered retaining wall below for reference.



Step-Down Wall