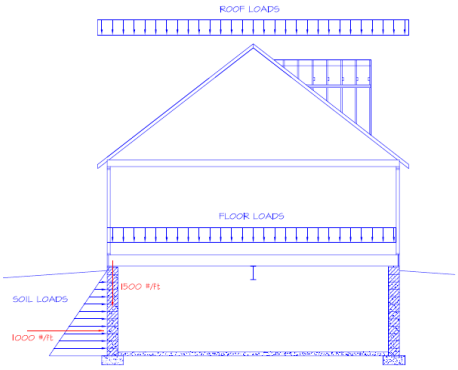
Basement Wall Cracking

Many times each year we are asked by concerned owners to visit their home and give them an assessment of cracking they have observed in their basement walls. Sometimes we are able to inform them that the cracking we observe is not a threat to the structural capacity and stability of the foundation. Other times, we must inform them that a potential for further cracking and damage exists and repair measures must be taken to stabilize the wall. If you are worried about cracking in your foundation wall, here are some things to consider:

What kind of loads are really on the wall?

The foundation wall serves two important functions for the building:

1. It carries the floor and roof loads to the footings below and helps to spread that load evenly on the soil under the footings.
2. It holds back the earth that is pushing on the basement wall from the outside.



Typical loads on a foundation

The vertical load on a basement wall from a typical roof and floor above might be 1,500 pounds per linear foot of wall length. The lateral load (the loads pushing inward on the wall) from the soil at the outside might be 1,000 pounds per linear foot. These loads will vary, of course, depending on the number of floors, span direction, span length, and the quality and height of soil being retained above the basement level.

While these loads may seem high, a well designed and constructed foundation wall will be capable of easily supporting and resisting these forces. To see the important elements that go into the construction of a good residential foundation wall, take a look at the drawing at the end of this document.

So What Causes the Cracking in My Wall?

Cracks in your basement walls are evidence of movement. The masonry and concrete that are used in the construction of foundation walls are strong in compression but not very strong in tension. Therefore, any movement that creates tension stresses in the wall will most likely cause cracking.

- One common type of cracking is sometimes referred to as "Stair Step" cracking. This is a diagonal zig-zag pattern that quite often follows the mortar joints. This type of cracking is usually the result of uneven settlement on either side of the crack.
- Another common crack is a vertical crack. This crack may not be perfectly vertical and may do some "stair stepping" of its own, but the crack usually passes through masonry units instead of following only the mortar joints and proceeds in a mostly vertical direction. This type of cracking is quite often the result of shrinkage and thermal movements of the wall.
- The other type of cracking, and the one that we structural engineers become quite concerned about, is a horizontal crack. This crack usually occurs near the midheight of the wall. Along with the cracking, the wall usually exhibits measurable inward bowing. This type of crack is the result of lateral soil loads pushing against the wall that exceed the strength of the block or concrete.

The following is a closer look at each of these crack types, with general recommendations and options for a homeowner to consider.

How Concerned Do I Need To Be About This Cracking?

Stair Step Cracking

Typical "Stair Step" Cracking

As mentioned above, this cracking is most likely the result of differential or uneven settlements of the footing and subgrade below the wall. This might be due to a change in loading on the wall or a soft spot in the soil below the footing. The first question to try to resolve is whether the wall is still moving or not. This can be done by monitoring the condition. This takes some time but since this type of crack is usually not a serious threat, time is available to record some data.

Mark several locations with a permanent marker and measure the width of the crack. Record this information including the date. Take photos of the condition if possible. Repeat this every month or so to see if the measurement changes over time.

Another method of monitoring the crack is to place a piece of tape across the crack and use a razor blade to split the tape at the crack location. Check back each month to see if the razor thin slit widens. Photos are also a good idea.

Crack monitors are available from several companies, one is Avongard (www.avongard.com). These are attached across the crack and have a grid and crosshair that allow you to measure movements to within 1 mm. Record this information at the initial installation and each following month using the data sheet provided with the crack monitor. It never hurts to keep taking photos.

Example from the Avongard website

Movements that lead to "stairstep" type of cracking are usually short lived and reach a steady state within a short period of time, say 2 to 4 months. When there does not appear to be any more movement taking place, the crack can usually be patched.

If the movement does not appear to be stopping, or if you notice lateral movement of the wall (you run your finger across the crack and find that one side of the wall has moved inward more than the other side) it would be wise to contact an engineer or contractor to look at the condition. It is possible that there is still nothing to be highly concerned about, but it may be good to have a professional look things over.

Once you are convinced that very little, if any movements are taking place, the repairs are relatively easy. The loose mortar should be removed at the crack and the gap can be patched with a premixed mortar that you buy from the hardware store. For narrow cracks you may need to do a little chipping or sawcutting to make them wide enough to accept the mortar.

This type of crack probably extends through the wall and is mirrored on the exterior face. This means that the movement may have ruptured the waterproofing or dampproofing on the outside face of the wall. Not much can be done about this unless you decide to dig down alongside the wall to expose the exterior face. But you can do some good preventive landscaping work at the surface to make sure that the rain and snowmelt from the roof will drain away from the building wall and will be less likely to soak the earth next to this crack and leak inside. Take a look at the quality and condition of the gutters and downspouts as well so that they carry water away from the foundation wall.

Typical vertical cracking

Vertical Cracking

This type of cracking is often due to shrinkage of the masonry or concrete as it dries out or movements due to changes in the temperature of the wall. Block and concrete are constructed in a very wet condition. Water is present in the concrete, the mortar and the grout. The free water, the water that is not required to create the chemical bond in the Portland cement, eventually has to evaporate out of the wall. This evaporation occurs during the curing process and the loss of water will cause a slight loss of volume. The wall wants to shrink to compensate for this loss. Every other part of the building is trying to hold the wall in a rigid position and prevent it from actually shrinking. So rather than shrink from the ends, the wall will develop cracks along its length. A well designed wall will actually develop hundreds of microscopic cracks along its entire length that will compensate for the shrinkage. Sometimes, however the wall will find a weak plane and decide to make up all of the shrinkage at one location. It seems inevitable that the wall will choose the most noticeable and objectionable spot to produce the new crack.

It is also possible that temperature changes can cause a similar volume change in the walls. A wall that is subjected to a cold environment for an extended period and then warmed to room temperature, or vice versa, will undergo some volume change. Other phenomenon, such as chemical changes in the block and concrete, can cause volume changes over a longer period of time as well and create cracking.

In most cases, this condition is not of great concern and usually does not seriously threaten the stability or strength of the wall. The procedure for monitoring and repairing the crack is the same as for the "stair step" crack described above. This type of crack may also affect the waterproofing or damproofing. Consider some of the same steps mentioned above for the stair step cracking to avoid excess water around the base of the wall.

Horizontal Cracking

A fairly long horizontal crack observed in a masonry or concrete foundation wall, particularly one that is retaining soil, is a condition that gets us structural engineers immediately concerned. This crack and the measurable inward bowing that usually accompanies it is a sign that the wall has theoretically failed. This failure does not necessarily mean that the wall is minutes away from collapsing and spilling dirt into your basement, but the laws of physics and statics tell us that the factor of safety against collapse has been reduced considerably.

It is possible that the small size of the crack and the lack of inward bowing of the wall mean that the wall is still stable and capable of adequately supporting the vertical and lateral loads. But we have found in the past that this is not likely or that the factor of safety has been reduced to a level that is unacceptable.

Example of a horizontal crack

What causes this type of cracking?

The crack is evidence of horizontal movement and inward bowing of the wall. The soil on the outside is pushing the wall and the wall does not have enough strength to resist this movement. It is possible that the wall was not designed properly, but it is also possible that the forces are greater than a reasonable design might anticipate. If drainage is poor and the soil adjacent to the wall becomes saturated or if the winter is particularly severe, and frost penetration becomes severe, the force pushing against the wall may become extremely high. It is also possible that the movement took place during construction if the wall was not adequately braced during the backfilling procedure.

If the cracking that you are experiencing looks like this type of movement, we would suggest that you contact an engineer or contractor right away to have them assess the problem and make recommendations. In severe cases it might be wise to install temporary supports for the floor joists that bear on this wall. But remember, the foundation is also supporting the exterior wall and roof immediately above and temporary shoring in the basement will not necessarily carry these loads unless the temporary shoring extends all the way up to the underside of the roof members. Very seldom are we comfortable instructing an owner to monitor this condition and wait to see if anything changes. We usually make immediate plans to investigate the problem and design a repair. What are the repair options? Here are a few ideas:

A. **Removal and reconstruction of the wall**. This will be the most expensive solution, but it might be the repair that gives you the greatest piece of mind. The steps involved include; excavating to the footing level, shoring the floor(s) and roof that bear on the wall, wall demolition and reconstruction. The wall reconstruction should consider the forces that caused the original cracking and bowing and the wall should be designed to adequately resist these forces. A well designed wall will most likely include vertical reinforcing, anchoring to the footing and the floor above, drain tile, waterproofing or damproofing, and clean granular backfill. You will definitely want to work with a contractor who has done this type of work before.

One basement wall undergoing complete replacement

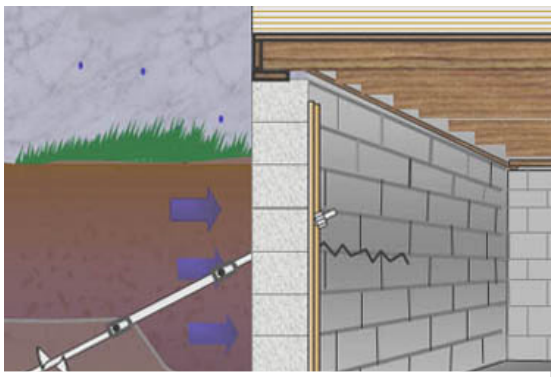
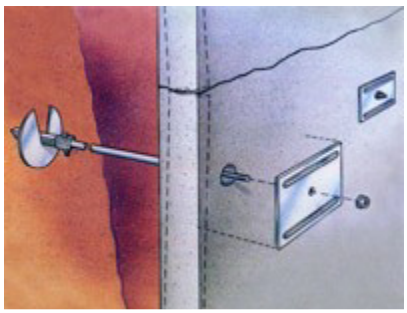


Illustration from a supplier's website

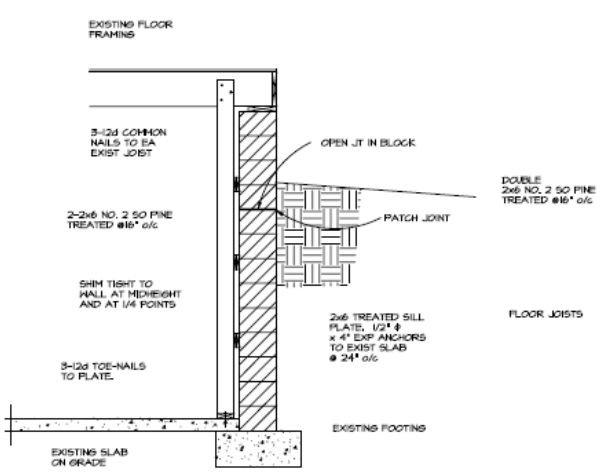
B. **Bracing of the wall with tie backs**. A specialty contractor can install helical tie backs that pass through the wall to the soil beyond the building foundation. These tie backs are typically spaced 6' to 8' on center and are attached to the inside of the wall with vertical or horizontal steel tubes or bars. The walls might be able to be drawn back to a plumb position with these tie backs, but some soil excavation might be necessary to accomplish this. Even if the wall cannot be straightened, the tie backs will be designed to reinforce the walls and provide adequate strength to resist the horizontal loads that will be imposed in the future. The tie backs will need to extend an adequate distance from the building wall into the soil (maybe 10' to 12'). If your property line is very close to the wall needing repair, this may not be a possible option. Even though the ties are buried below grade, you are not allowed to cross the property line onto your neighbors land, at least not without an easement agreement.

This type of foundation solution is provided by contractors who are licensed by the tie back equipment manufacturer. They are most likely very experienced with this type of work. This is not a repair that you want to try to do yourself. If you search for "basement wall tie backs" or "helical tie backs" for your area on the internet, you will most likely find several contractors and suppliers that provide this type of repair.

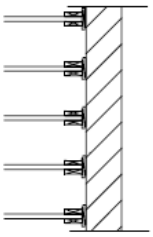


Supplier's recommended wall attachment.

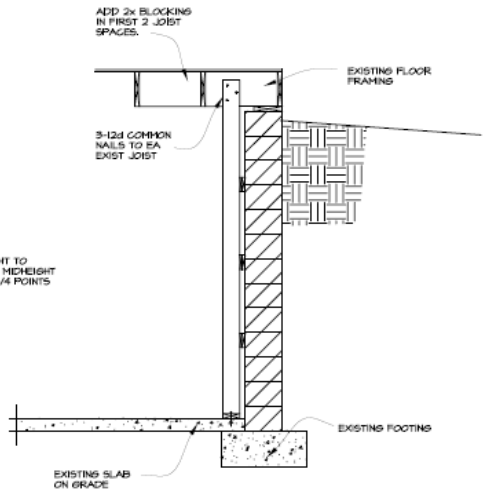
C. **Bracing the wall with internal studs or posts**. An engineer can design steel or treated wood posts, placed on the inside face of the wall to brace the wall and transfer the lateral force to the basement floor and the first floor diaphragm. This might be the least costly solution but it will reduce the interior space and may not be able to restore the wall to the upright plumb position. The internal studs act as a type of "second wall" inside the original masonry wall and pushes back against the masonry wall when it wants to bow further inward. The design for this type of repair is specific to each condition and depends on the load on the wall, the height of the wall and how capable the floor above is of resisting the lateral loads. For a wood framed bracing method, it is not uncommon to have double 2x8's spaced every 16" on center to properly assure that the wall will remain stable. The connection to the basement slab is a normal treated plate with expansion anchors into the slab, or if the slab is in poor condition, a new concrete footing is poured in a trench next to the wall. The connection at the top of the wall, to the first floor framing, might be simply nailing of the new studs to the floor joists. The loads and height of the wall may dictate the need for lags or bolts for connection of the members. If steel members are used for the bracing members, the spacing might be larger, but the connections to the floor above and slab below become more difficult.



An example of one bracing method where the floor joists are perpendicular to the wall.



Plan view



An example of one bracing method where the floor joists are parallel to the wall.

Some examples of bracing using steel members

D. Carbon Fiber Straps. An engineer can design the spacing required for the installation of carbon fiber straps (CFS) to be adhered to the inside face of the wall to relieve the tension forced on the concrete or masonry caused by the lateral soil pressure. Carbon fiber is ten times stronger than steel which allows it to remain low profile without compromising its strength. The CFS's are multiple carbon fibers woven into fabric. The CFS will not stretch and are nearly unbreakable. (Carbon fibers are even used to make aircraft carriers.) The installation is relatively quick and easy compared to other methods making this a lower cost option. The CFS are adhered to the cleaned surface of the wall with a high strength epoxy or resin. The CFS act to replace the reinforcement that is in a well-designed wall. If the wall is bowing, the reinforcement was likely not installed as part of the original construction or is inadequate.

Example of installed carbon fiber strap system

This solution will not make the wall plumb again, but can make the wall structurally stable. If the wall is out of plumb by two inches or more, a CFS system may not be a good solution. Additionally, if the wall has begun to slide at the bottom or tilt out at the top, the CFS system will not prevent further movement of the wall because it is not anchored to the foundation or the floor above. A CFS system can be part of the solution, but cannot act alone in these cases.

Due to the ease of installation, you may be tempted to tackle this project on your own. However, only an engineer or the supplier can determine the spacing required for the CFSs and if the wall is a good candidate for the CFS system. There are several local contractors qualified

If I am worried about my basement walls how should I start?

The descriptions that we have provided above, about the common causes and types of wall cracks, will hopefully answer some of the questions that you might have. Look this information over and compare some of the descriptions to the condition that you are concerned about. If we have been able to put your mind at ease, great! We are glad that you found this information helpful. But if you have one of the conditions that we described as a potential problem, or you are still not comfortable making decisions about your wall condition without the help of a professional, please do not hesitate to give us a call. We will be more than willing to assess the problem that you are experiencing and provide recommendations for repairs or enhancements if needed.

Sincerely,
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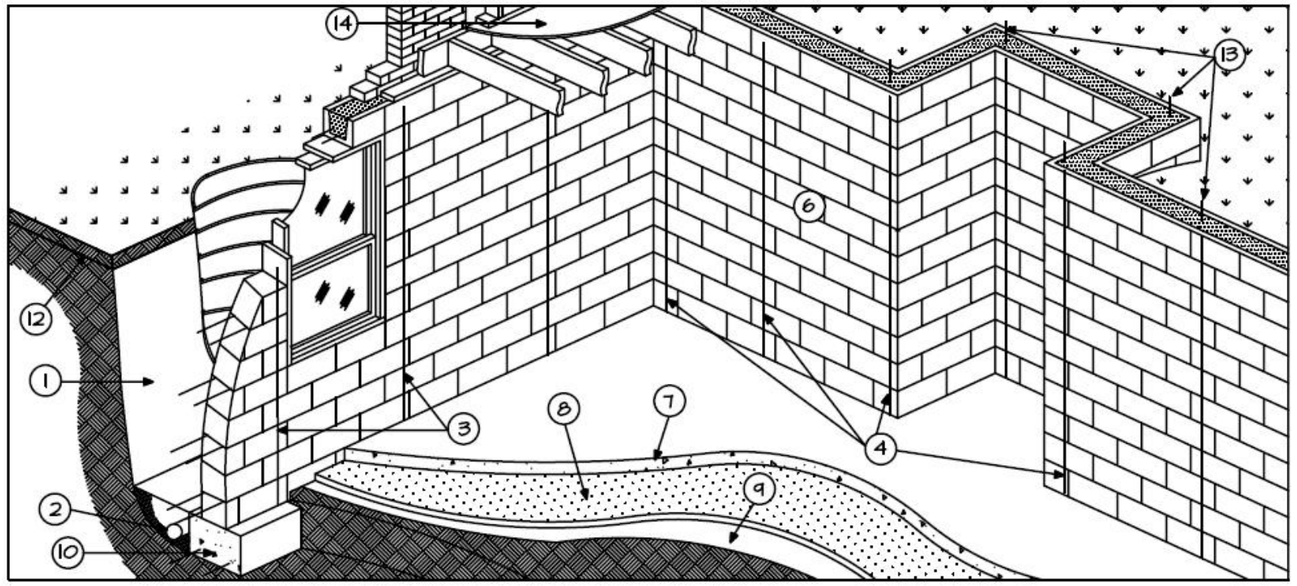
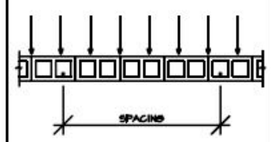
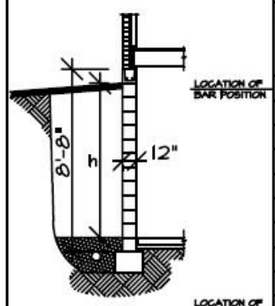


TABLE I BASEMENT WALL REINFORCEMENT



VERTICAL REINFORCEMENT
BAR SIZE AND MAXIMUM BAR SPACING

	HEIGHT OF BACKFILL, h				
	8 Ft.	7 Ft.	6 Ft.	5 Ft.	4 Ft.
BAR SIZE	#5	#4	#4	#4	NOT REQ'D
SPACING	40 IN.	40 IN.	56 IN.	72 IN.	72 IN.



HORIZONTAL JOINT REINFORCEMENT

MORTAR JOINT		HEIGHT OF BACKFILL, h				
		8 Ft.	7 Ft.	6 Ft.	5 Ft.	4 Ft.
13		-	-	-	-	-
12	⊖	-	-	-	-	-
11		8 ga.	9 ga.	9 ga.	9 ga.	9 ga.
10		-	-	-	-	-
9		8 ga.	9 ga.	9 ga.	9 ga.	9 ga.
8		-	-	-	-	-
7		8 ga.	9 ga.	9 ga.	9 ga.	9 ga.
6		-	-	-	-	-
5		8 ga.	9 ga.	9 ga.	9 ga.	9 ga.
4		-	9 ga.	9 ga.	9 ga.	9 ga.
3	⊖	8 ga.	9 ga.	9 ga.	9 ga.	9 ga.
2		-	-	-	-	-
1		-	-	-	-	-
ANCHOR BOLTS & SPACING		1/2"ϕ 32"O.C.	1/2"ϕ 32"O.C.	1/2"ϕ 48"O.C.	1/2"ϕ 72"O.C.	1/2"ϕ 72"O.C.

LEGEND

1. FREE DRAINING BACKFILL. (40 PSF EQUIV. FLUID PRESSURE)

2. FOUR INCH PERFORATED PIPE PERIMETER DRAIN WITH 12 INCHES OF COVER.

3. VERTICAL REINFORCING BARS IN CELLS ADJACENT TO OPENINGS. (BAR SIZE SELECTED FROM TABLE 1) REINFORCEMENT HELD IN PLACE BY BAR POSITIONERS.

4. VERTICAL REINFORCING BARS IN CELLS AT ALL CORNERS AND AT MAXIMUM SPACING SPECIFIED IN TABLE 1. REINFORCEMENT HELD IN PLACE BY BAR POSITIONERS.

5. 3/8 INCH MORTAR JOINT USING TYPE S MORTAR. FACESHELL MORTAR BEDDING. EXCEPT AT CELLS CONTAINING GROUT. MORTAR TO CONFINE GROUT.

6. HOLLOW CONCRETE MASONRY, GROUTED AT CELLS CONTAINING VERTICAL REINFORCEMENT.

7. FOUR INCH CONCRETE FLOOR SLAB. MINIMUM f'c OF CONCRETE SHALL BE 2500 PSI.

8. TWO INCH SAND OR GRAVEL LEVELLING BED.

9. WATERPROOF MEMBRANE BELOW SLAB. IF REQ'D.

10. MINIMUM 8 INCH THICK FOOTING CAST AGAINST UNDISTURBED SOIL OR COMPACTED FILL.

11. EDGE OF CONCRETE FLOOR SLAB CAST AGAINST WATERSTOP MATERIAL TURNED UP FROM BENEATH SLAB ALONG THE BASEMENT WALL.

12. TOP SOIL, COMPACTED AND SLOPED TO DRAIN WATER AWAY FROM THE BASEMENT WALL.

13. 1/2 INCH ANCHOR BOLTS TO SECURE SILL PLATE TO WALL. BOLTS ARE TO BE LOCATED AT CORNERS AND AS SPECIFIED IN TABLE; AND EMBEDDED A MINIMUM DEPTH OF 15 INCHES.

14. FLOOR DIAPHRAGM, INCLUDING JOISTS AND SUBFLOOR, TO PROVIDE LATERAL SUPPORT TO TOP OF WALL. BLOCK JOIST SPACE PARALLEL TO WALL 24" O.C.

15. TREATED WOOD SILL PLATE, 2" X 4" NOMINAL, BOLTED TO TOP OF WALL.

16. SEE NOTES 3 AND 4. VERTICAL BARS HELD IN POSITION AT TOP AND BOTTOM WITH BAR POSITIONERS.

17. DAMPPROOFING.

18. 2 - NO. 4 BARS IN BOND BEAM AT TOP OF WALL. ALTERNATIVELY, A SOLID UNIT CAP CAN BE INSTALLED TO SEAL THE TOP OF THE WALL.

19. FLASHING.

20. WEEP HOLES IN HEAD JOINTS, SPACED 32 INCHES O.C.

21. VERTICAL BAR POSITIONER IN MORTAR BED JOINT ONE COURSE BELOW BOND BEAM AND 2 COURSES ABOVE FOOTING. BAR LOCATION TO BE 9 1/8 INCHES FROM OUTSIDE (EARTH SIDE OF WALL).

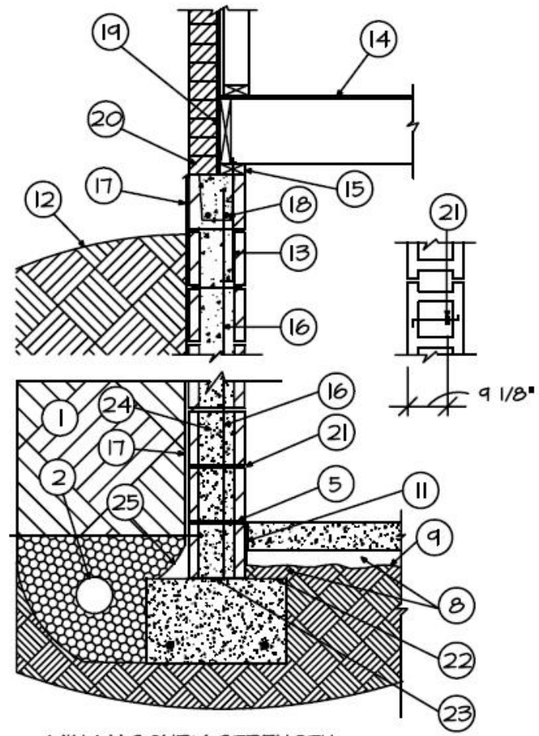
22. TOP OF FOOTING WITHIN 1/2 INCH OF SPECIFIED ELEVATION. FOOTING THICKNESS SHALL BE A MINIMUM OF 8 INCHES. WIDTH SHALL BE AS REQ'D.

23. FIRST BLOCK COURSE TO BE SET IN FULL MORTAR BED. USE TYPE S MORTAR THROUGHOUT THE WALL.

24. CELLS CONTAINING VERTICAL REINFORCING BARS TO BE GROUTED. GROUT PROPORTIONS TO BE 1 PART PORTLAND CEMENT, 2 1/4 TO 3 PARTS SAND, PLUS (OPTIONAL) 1 TO 2 PARTS GRAVEL. GROUT TO BE CONSOLIDATED BY PUDDLING OR VIBRATING. F'c = 3000 p.s.i.

25. MOLD COVE IN PARGING TO DIRECT WATER AWAY FROM WALL AND TOWARD DRAIN.

The Important Parts of a Good Foundation Wall



MIN MASONRY STRENGTH
f'm = 1750 p.s.i.
REINF. = ASTM A615 GRADE 40
ACTIVE SOIL PRESS. = 40 PSF/FT DEPTH