

Foundation Systems 1, spread foundations

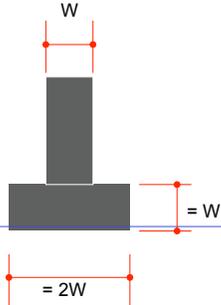
What's the point?

- The foundation's primary purpose is:
 - Distribute building loads to the soil
 - Prevent frost uplift of the building (act as frost barrier)
- Some foundation systems also provide a level, controlled surface from which the buildings walls are raised.

What types?

- Spread (aka strip) footings with stemwall foundations
- Pad footings with column foundations
- Pile footings with caps
- Caissons (aka drilled piers) with grade beams
- Mat (aka raft, slab) foundation with stemwalls

Spread Footings



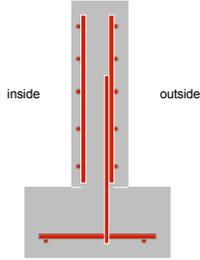
- Bottom of footing set on undisturbed earth or engineered fill and below frost line
- The rule of thumb for proportioning (always use a professional engineer!) is the footing is twice as wide as the foundation wall transferring load to it. It's thickness is at least equal to the width of the foundation wall.

Characteristics

- Light loads
- Low rise
- Stable soils
- Common in residential and light commercial
- Also used as a frost barrier with heavier foundation systems
- A shallow foundation system (usually within 25 feet of grade)

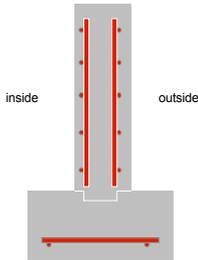


Strip footings



- Most common for low rise, low load conditions.
- A strip of reinforced concrete ready to accept a wall of some kind on top.
- Dowels, Reinforcing bars projecting from the top of the footing connect to wall reinforcing to limit sideslip of the stemwall.

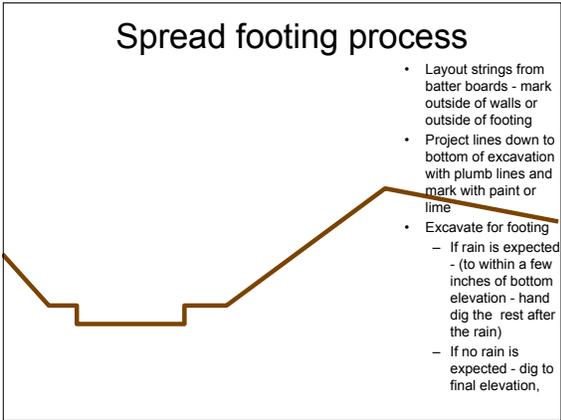
Strip footings



- An alternative to dowels is to make a slight depression in the top of the footing called a keyway.
- The keyway works when it is filled with concrete from the wall pour above. The concrete acts as a shear key preventing sideslip of the stemwall.

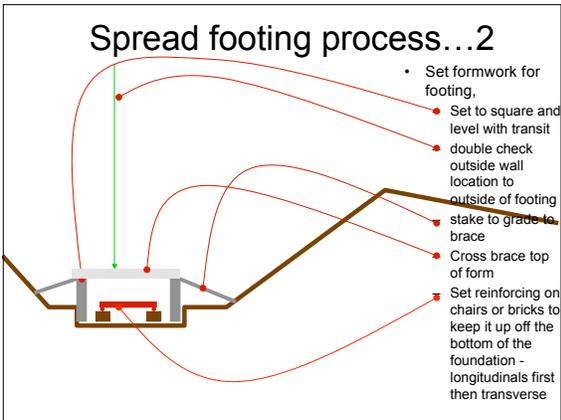


Spread footing process



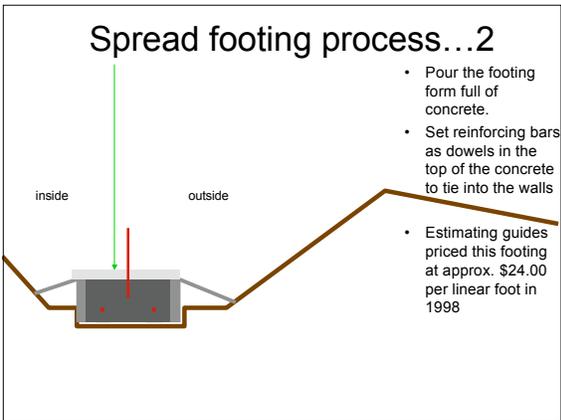
- Layout strings from batter boards - mark outside of walls or outside of footing
- Project lines down to bottom of excavation with plumb lines and mark with paint or lime
- Excavate for footing
 - If rain is expected - (to within a few inches of bottom elevation - hand dig the rest after the rain)
 - If no rain is expected - dig to final elevation,

Spread footing process...2



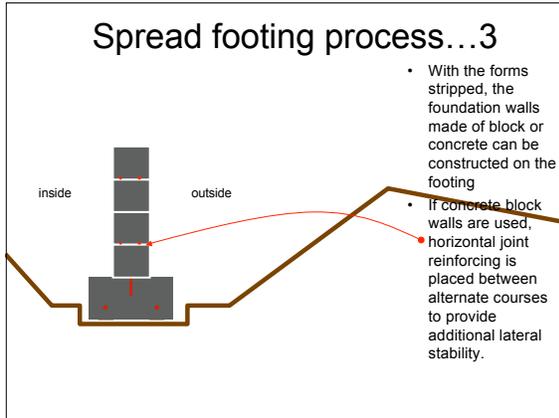
- Set formwork for footing,
 - Set to square and level with transit
 - double check outside wall location to outside of footing
 - stake to grade to brace
 - Cross brace top of form
- Set reinforcing on chairs or bricks to keep it up off the bottom of the foundation - longitudinals first then transverse

Spread footing process...2



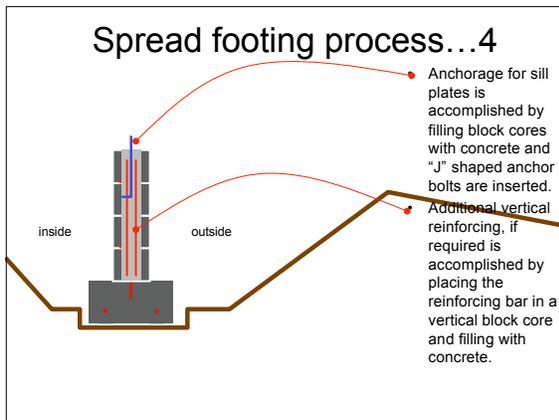
- Pour the footing form full of concrete.
- Set reinforcing bars as dowels in the top of the concrete to tie into the walls
- Estimating guides priced this footing at approx. \$24.00 per linear foot in 1998

Spread footing process...3



- With the forms stripped, the foundation walls made of block or concrete can be constructed on the footing
- If concrete block walls are used, horizontal joint reinforcing is placed between alternate courses to provide additional lateral stability.

Spread footing process...4



- Anchorage for sill plates is accomplished by filling block cores with concrete and "J" shaped anchor bolts are inserted.
- Additional vertical reinforcing, if required is accomplished by placing the reinforcing bar in a vertical block core and filling with concrete.

Cast in Place stemwall foundations

- Where high lateral forces, high hygroscopic pressures or high masonry costs are found, foundation walls are often made of cast in place concrete
- It's a premium foundation wall - often most expensive
- Cost is high because we build a wood wall (forms) fill it with a steel wall (rebar) and cover that with a concrete wall...then throw the wood wall away!



Begin with Forms

- Formwork is usually built from the outside - in.
- The exterior form (plywood) is constructed on a layer of vertical studs (to brace the plywood) these vertical studs are then braced with horizontal studs (walers) to make the form stiffer
- Then the reinforcing is installed, wired together at each vert/horiz intersection



Begin with Forms

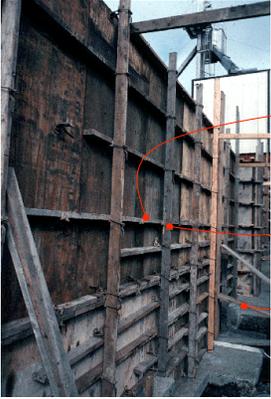
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Ties that bind...and separate!

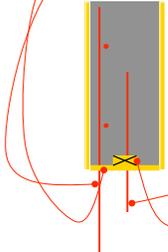
- To keep the forms the proper distance apart, wire ties with plastic cones are inserted between forms. The cones keep the inside and outside form boards apart.
- The loops in the ends of the forms allow the ties to be tensioned so the forms don't spread apart.
- They push and pull at the same time



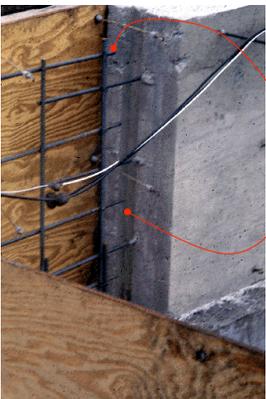


- The wet concrete mix is pretty heavy, the forms have to be braced both horizontally and vertically to resist the hydraulic load imposed by the mix
- Horizontal 2x4's (wales) are attached to the back of the plywood formwork to be the first bracing layer
- Then vertical 2x's are clamped to the horizontals to become the second bracing layer
- Finally, diagonal braces are added and staked to the ground, now the form bracing is complete

Forming a pour joint



- To stop the pour, a plywood cap is made by drilling holes in a piece of plywood, and attaching it to the plywood forms on each side of the wall, making sure the rebar passes through the holes
- A 2x4 is often nailed to the inside of this plywood cap to displace concrete and form a shear key
- The pour joint begins with continuity of the reinforcing
- Sometimes an additional dowel is placed to insure the joint will resist lateral displacement



- Often, the foundation cannot be poured all at once. To stop a pour, we detail a **pour joint** that will let the reinforcing pass through and be continuous (so the two pours structurally behave like one pour)
- The combination of continuity of reinforcing and a vertical shear key prevents lateral movement of the second pour relative to the first.



Keep it dry ...dampproofing

- Keeping the foundation wall dry is accomplished in degrees.
- The lowest level of protection is termed "dampproofing"
- Dampproofing coatings are applied to the outside face of the foundation.
- Usually dampproof coatings do not have the ability to bridge across cracks which develop in the foundation
- Dampproof coatings are carried down the foundation wall and over the top of the footing to minimize leakage through the foundation/footing joint.
- Dampproof coatings are usually brush applied and can be cementitious (thoro seal) or asphaltic

Keep it dry ...water resistant coatings

- Water resistant coatings are the next step up in keeping the foundation dry.
- These coatings usually have the ability to span cracks to a modest degree.
- Water resistant coatings are usually applied with a trowel and are often asphaltic or bituminous materials (black sticky stuff)
 - Asphaltic and bituminous coatings are UV sensitive, they need to be backfilled or protected from the sun in less than 30 days or they begin to become brittle. (crack easily)



Keep it dry...waterproof coatings

- Waterproof coatings offer the highest level of water protection for the foundation wall.
- Waterproofing systems fall into three categories
 - Applied sheet membranes
 - Spray applied membranes
 - Attached board membranes
- All offer superior waterproofing qualities when correctly applied.
- All are fragile! When backfilling they should be protected from scuffing, scraping, bashing, or similar injury.
- If the membrane is punctured during backfilling operations, the damage won't be known until that first rain....

Keep it dry...waterproof coatings

- Some popular membranes...
 - Bituthene - a roll of heavy polyethylene backed with a thick layer of sticky mastic protected by paper. With the paper removed it sticks to the foundation wall and spans cracks to keep water out.
 - Volclay panels - sheets of cardboard filled with bentonite clay mechanically fastened (nail, screws...) to the foundation. In the presence of water, the clay expands to 15 times dry volume forming an impervious clay layer outside the wall.
 - Spray applied modified bitumen - a spray on membrane, depending on thickness to develop the ability to span.



Keep it warm...insulation

- Heat loss through the foundation has been found to be a significant source of energy consumption in residential and small commercial buildings.
- Rigid foam boards are the most common means of insulating the foundation wall.
- Often the insulation is placed on the outside of the foundation wall to keep the mass warm...
- This also keeps the rocks, logs, disco boots, broken bottles which may be part of the backfill from poking a hole in the waterproofing!

Insulation flavors... plain vanilla

- Expanded polystyrene ("beadboard or EPS") - available in
 - white
 - light grey
- Open cells - Holds water (which reduces "R" value)
- "R" value approx 3.5 per inch
- Lowest price range

Rainbow flavors

- Extruded polystyrene ("styrofoam") - available in
 - blue (dow)
 - Pink (Owens Corning)
 - Green (Amoco)
 - Yellow (Certainteed)
- Closed cells - Won't hold water
- "R" value approx 5 per inch
- Middle price range



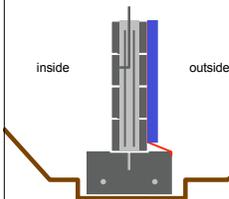
Dirty yellow

- Polyisocyanurate ("polyiso") - available in
 - yellow
- Closed cells - Won't hold water
- "R" value approx 10 per inch
- highest price range

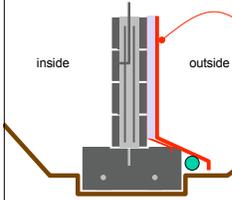


Keep it warm...*insulation*

- Rigid board insulation comes in three commonly used types
 - Expanded polystyrene R=3.5 per 1" thickness (usually white, aka "beadboard") holds water inside the board between the beads, decreasing thermal effectiveness. Least expensive (\$.61/sf)
 - Extruded polystyrene R= 5 per 1" thickness (usually blue, yellow, pink, lime green) doesn't hold water inside, moderately expensive (\$.75/sf)
 - Polyisocyanurate R=7.5 per 1" thickness (usually a dirty yellow to orange color) can hold water, most expensive. (\$.78/sf)

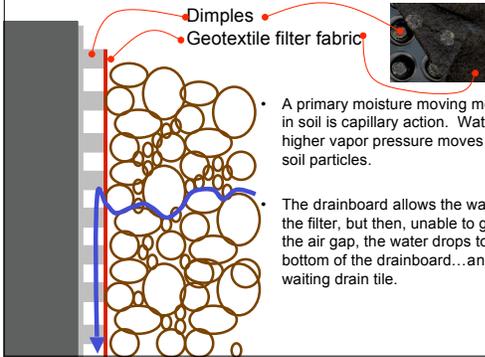


The belt and suspenders...*drainboard*



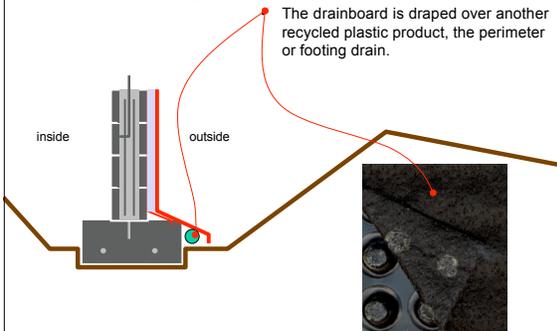
- Additional insurance in the form of dry foundation walls can be added by installing an air gap between the backfill and the foundation wall assembly.
- Making dirt conform to an air gap is difficult, but a component called a drainboard makes it simple.
- The drainboard is a plastic (often a recycled plastic) sheet which is vacuum formed into a surface of dimples and valleys.
- Attached to the top of the dimple is a geotextile fabric, also called a filter fabric. This fabric keeps large soil particles from clogging the spaces between the dimples.

Dropping water...*drainboard*



- A primary moisture moving mechanism in soil is capillary action. Water at a higher vapor pressure moves between soil particles.
- The drainboard allows the water through the filter, but then, unable to get across the air gap, the water drops to the bottom of the drainboard...and into a waiting drain tile.

Getting rid of water...*perimeter drain*



- The drainboard is draped over another recycled plastic product, the perimeter or footing drain.



