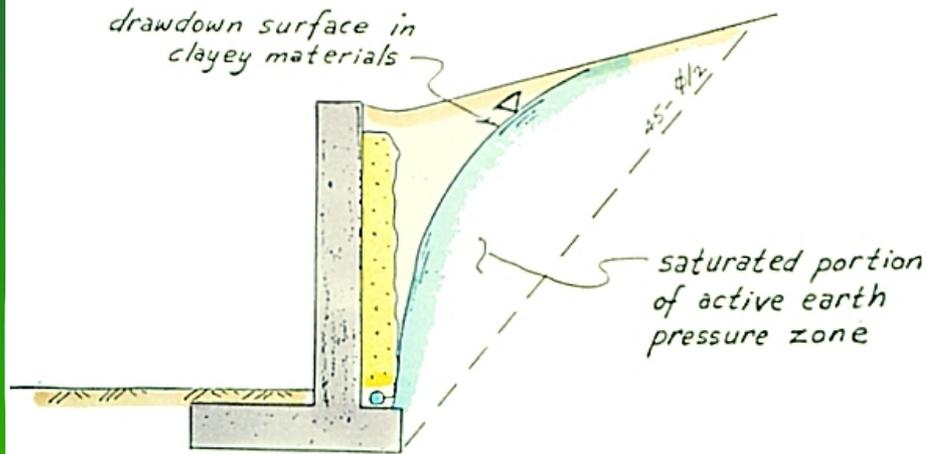
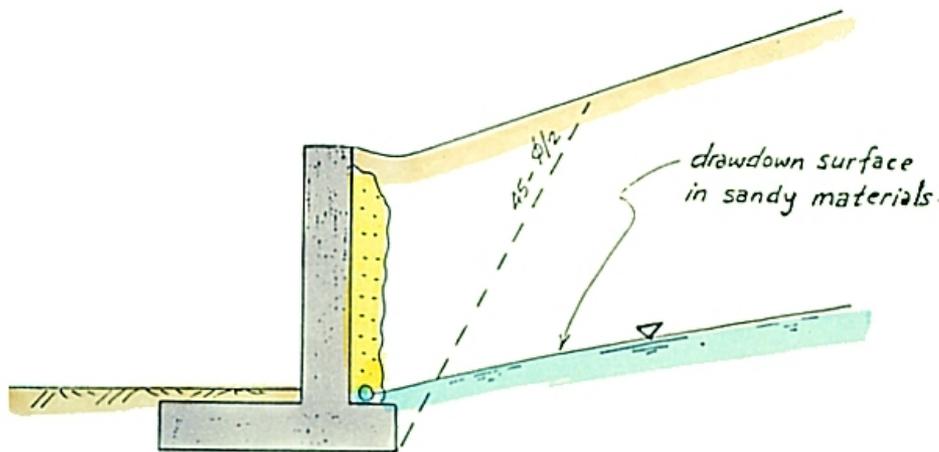


Part 5

COMMON FAILURE MODES OF RETAINING WALLS

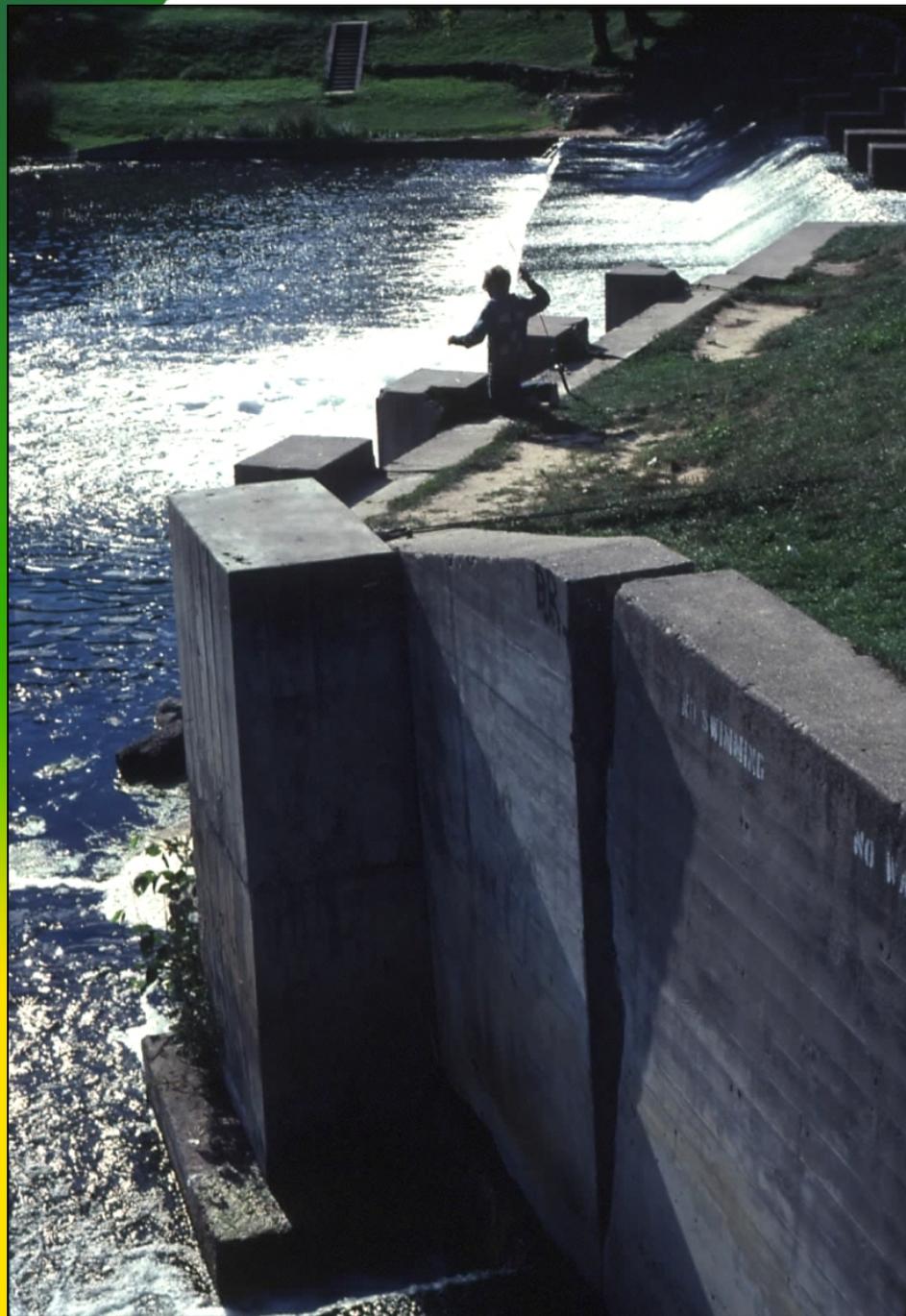


CASE FOR CLAYEY SLOPES



CASE FOR SAND/GRAVEL SLOPES

- **Partial saturation of the active pressure zone commonly increases loading of walls with clayey backfill, sketched at upper left**
- **Walls backfilled with free draining materials will tend to fare much better**



- **Titling cantilever wall in Grand Rapids, Michigan**
- **A tilt of 10° increases the load by 20%**
- **This problem likely exacerbated by undercutting of the footing by the Grand River, at left.**
- **Note cables attached to wall and strung to a dead man anchor, out-of-view to right.**



- **Distressed cantilever wall in Cincinnati, Ohio is tilting about 10 degrees. It was buttressed by three steel H-piles embedded in drilled piers and faced with masonry to “blend” in with the neighborhood’s many masonry walls (far right). Note weepholes that aren’t weeping much.**



- **Stacked crib walls placed too close to one another at a resort in Vail, CO.**
- **Any design of stacked walls should consider the area of the passive reaction wedge, which may extend 6X the wall height out in front of the foot of the wall, depending on soil friction.**

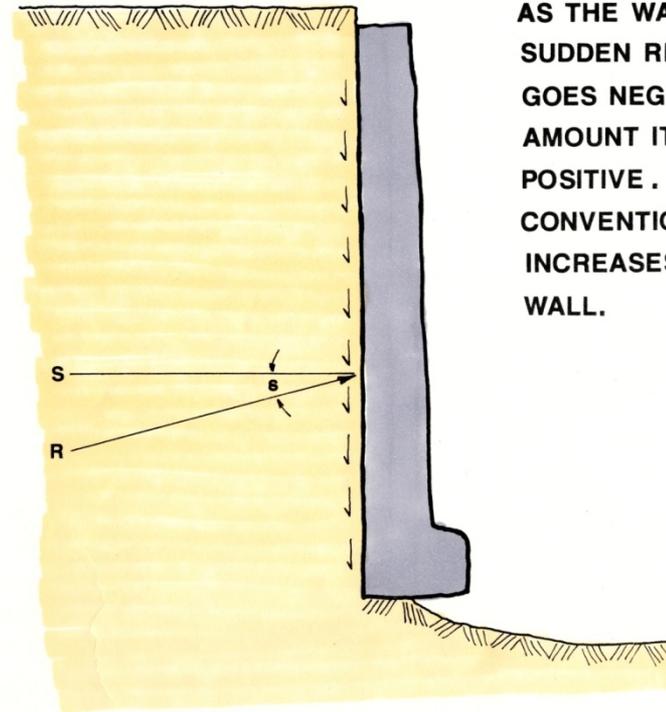
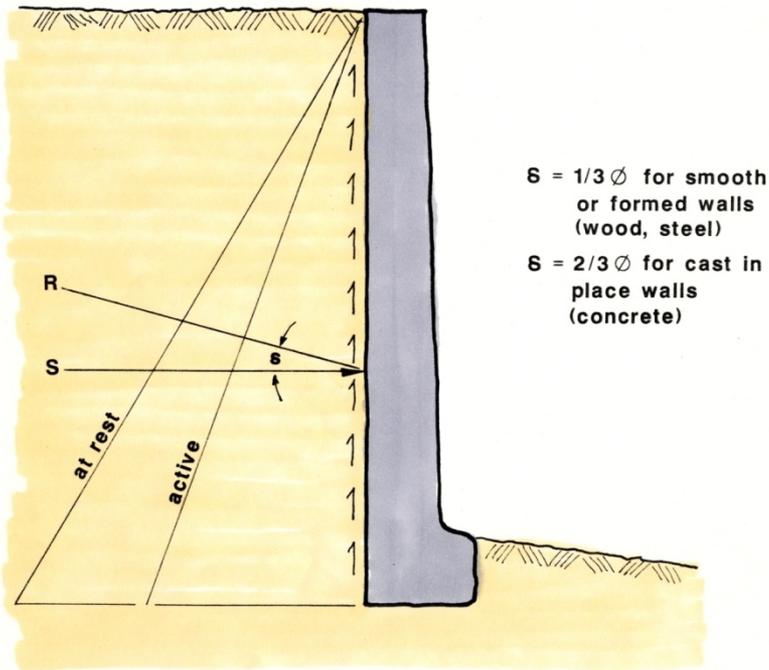


- **Incipient failure** of a masonry block unit (MBU) wall.
- MBU walls cost 40% less than an equivalent section reinforced concrete wall, but with a 75% reduction in moment capacity.



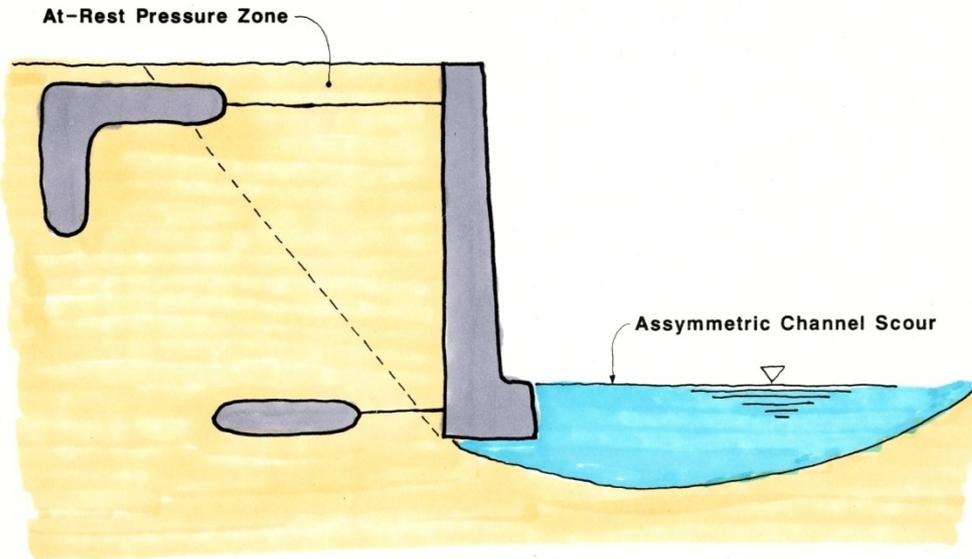
- **This MBU wall probably failed because of a lack of adequate subdrainage just below a landscaped yard. Other factors may have included slope creep and corrosion of the stem wall reinforcement**

**CONVENTIONAL ANALYSIS:
RESULTANT SOIL LOAD IS A FUNCTION
OF WALL SKIN FRICTION, δ**

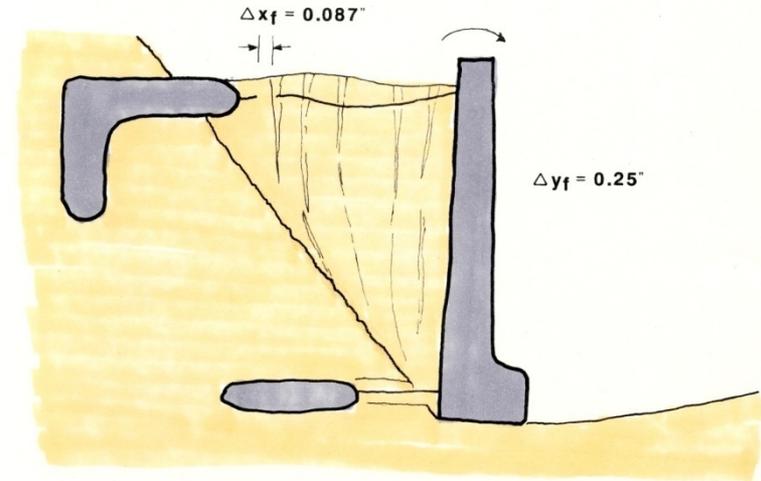


Beware of potential for **reversal of skin friction** against the back side of the retaining wall! You should also be aware of the **difference** in assumed skin friction, depending on whether the wall stem was poured in-place against the roughened earth, or poured against smooth concrete forms.

LOAD REVERSAL CAUSES IMMEDIATE
30% INCREASE IN RETAINING WALL LOADING



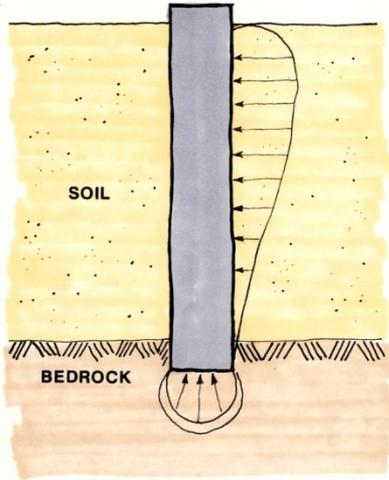
DOWNWARD DEFLECTION OF 0.26 INCHES CAUSES
STRAIN OF 0.11 INCHES ON TIE-BACK CABLE,
WHOSE LIMITING STRAIN IS 0.087 INCHES.
FAILURE OF SYSTEM QUICKLY ENSUES



Acceptable Strain on tie-back cable is
a function of un-sheathed cable length

If the wall is retrained by deadman anchors or tiebacks, a reversal of the skin friction acting against the back of the wall can suddenly **increase the lateral load by 30%**, and failure can be triggered by **excessive strain** on the anchor bar or cable, as depicted at right.

PIER SKIN FRICTION



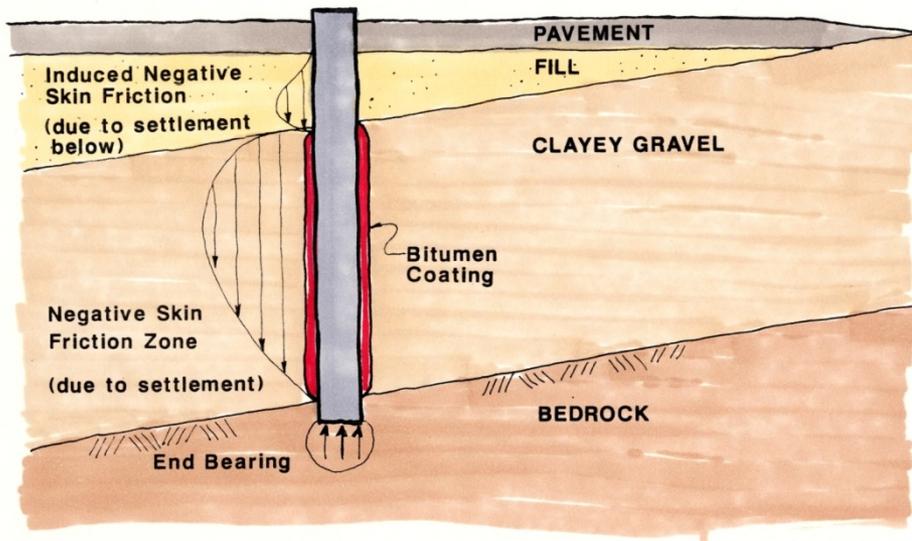
AVOID END-BEARING PIERS;
97% of available skin friction
must be mobilized before
end-bearing resistance begins
to mobilize

Loss of Skin Friction and downdrag

Left above: Most cast-in-ground straight-shaft cylindrical drilled piers derive their load bearing capacity from skin friction, unless drilled through soft compressible materials

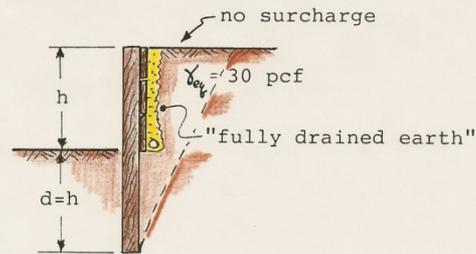
Left below: When caissons or piers extend through compressible materials they can develop significant downdrag forces, which can hasten unexpected settlement and loss of bearing capacity. Bitumen coatings are often employed to reduce downdrag, but never eliminate it.

NEGATIVE SKIN FRICTION

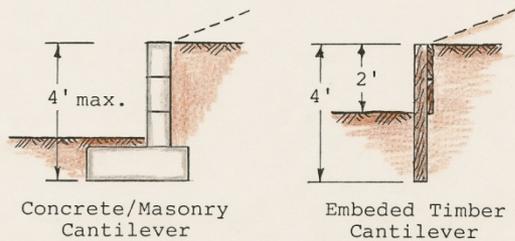


Non-engineered Walls

Uniform Building Code
§2308 Wall



Uniform Building Code
§301 Wall
Exempt from Engineering or Permit

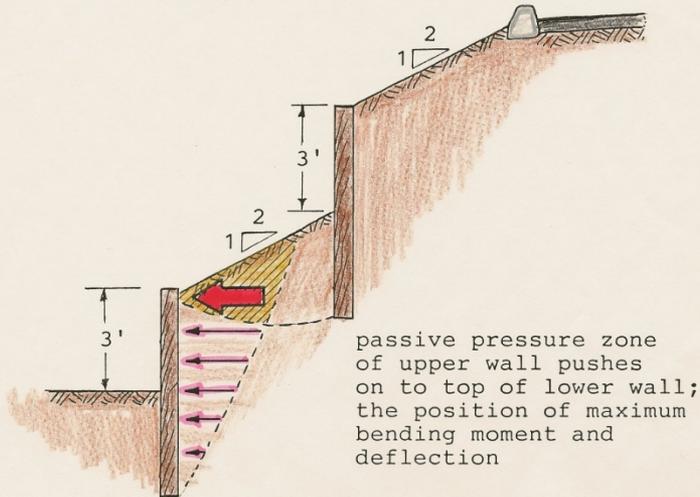
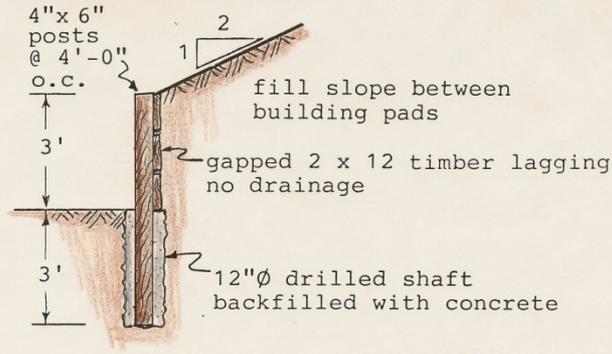


Note: No mention is made of Drainage provisions or slope/structure/vehicle surcharges!



The IBC allows walls less than 4 ft high to be exempt from engineering requirements, known as ‘NED walls’ (for “non-engineered design”). Cantilever wood walls are the most common type of NED wall, as seen at right.

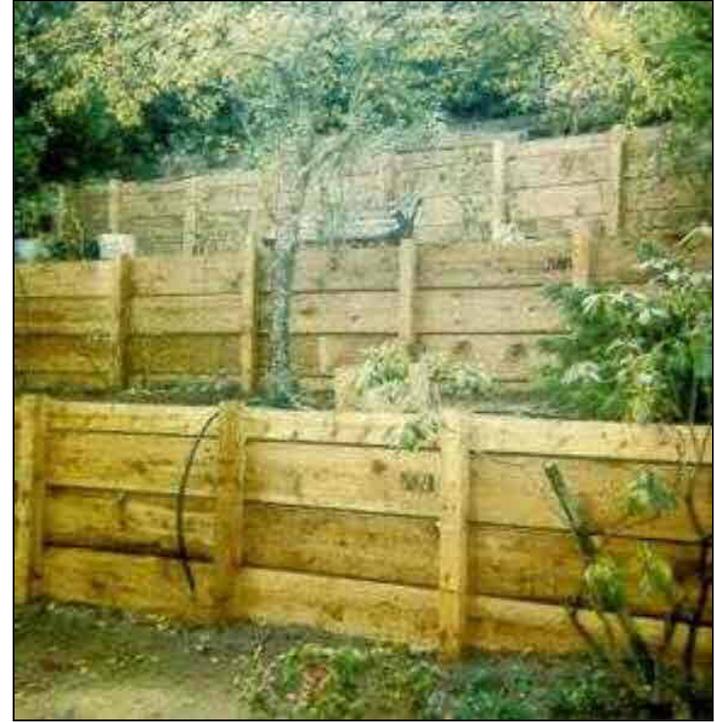
Types of "UBC EXEMPT" Walls We Usually See



Cantilever walls with slope surcharge are almost always problematic, because they are not designed for the slope load, or for the increased seepage pressures that often develop

Stacked wood walls, like that sketched at lower left, are often employed to circumvent permitting, by assuaging it to be nothing more than two adjacent 'NED walls.' This combination almost ALWAYS leads to failure, at some future time.

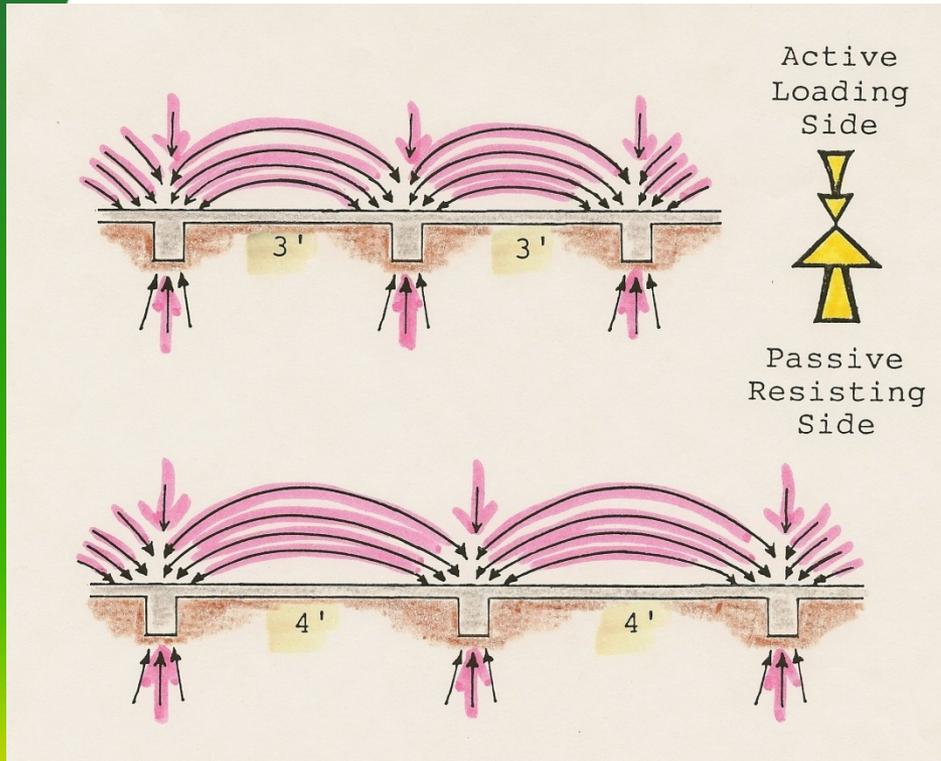
Examples Stacked Wood Walls



It's everyone's favorite way to go, much less expensive than other support systems. If you have some, be sure to pay your homeowner's insurance.



Watch the post spacings



The examples provided Online and in do-it-yourself Handy Man books usually show supporting posts 2 ft on center, as shown here.

The way the wood walls usually get built, is with the posts 3 to 8 ft on center. Anything beyond 4 ft is almost impossible to support with calculations. Note the physical difference between the active pressure and resisting passive pressure loading wedges.

BEWARE!



The state of earth stress in a **landslide complex** is generally divisible into three components:

1. **Active earth pressures** in the tensile pull-apart zone generally confined to the upper third of the landslide. This area is undergoing dilation.
2. **At-Rest earth pressures** in the neutral axis of the slide mass, which is a restricted zone where there is little dilation or contraction of the ground mass
3. **Passive earth pressures** in the lower two thirds of the slide mass, where the ground is in compression. Lateral pressures in this zone are typically 10X to 20X higher than in the headscarp area.



- Earth pressures on retaining walls generally ignore considerations of so-called “**global stability;**” which *pertains to those geotechnical loads pertaining to gross slope stability.* This shows the impact of incipient land slippage on an MBU wall, causing it to fail



- **Bending failure of a 36-inch wide flange H-beam retaining wall constructed at the base of a creeping slope in Richmond, California, along a state route.**
- **The wall was not designed to resist the passive loads to which it was subjected.**