Building on expansive soils

Soils that expand and contract, can cause damage to homes and other structures. Millions of dollars of damage to structures has occurred in Colorado caused by inappropriate design of foundations placed on expansive soils.

To address this natural hazard, La Plata County requires soils reports for residential foundations where expansive soil is known to be present. Expansive soils are common throughout La Plata County, particularly on the Florida Mesa.

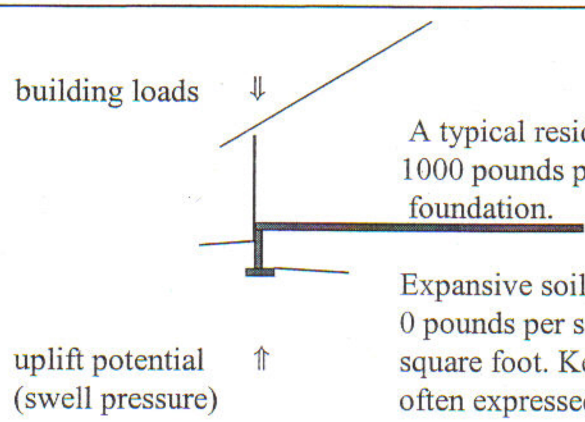
Expansive soils exert pressure and expand due to adsorption of water. The forces associated with this soil pressure can be severe enough to lift the home's foundation system causing damage to walls, roof, foundation and plumbing or mechanical systems.

The soils reports provide structural engineers with design values, and provide recommendations for foundation design. Generally, these recommendations provide engineering recommendations, like over excavation, and replacement of soils beneath the footings, a pier foundation system, etc. and a passive solution, intended to minimize the introduction of moisture into the foundation zone.

Often the builder incorporates the engineering solutions into the foundation work and the passive solutions, which can be the most important, are often neglected.

Soils reports classify the soils into three groups: **Non-expansive**, **moderately expansive** and **highly expansive**.

The **Foundation and Site Design Consideration Table** represents work required by the County Building Department where buildings are built on expansive soils.



A typical residence places a load of approx. 200 to 1000 pounds per square foot on the soil beneath the foundation.

Expansive soil can have uplift forces ranging from 0 pounds per square foot to 15,000+ pounds per square foot. Key to this is a volume change which is often expressed as swell potential.

When the uplift potential of the soil exceeds the weight of the house, and the swell potential exceeds 2%; the soil becomes a structural threat, and has the potential to lift the house and cause damage to the house and its foundation system. Wetting of the soil causes the soil to expand and drying of the soil causes the soil to shrink. This change in volume causes the home to move upward and downward with each wetting and drying cycle. If the moisture content of the soils remains stable the soils are not likely to expand and contract. The following pages represent important techniques designed to reduce the introduction of surface water into the foundation zone. These techniques will act to stabilize the soils moisture content; thereby reducing the opportunities for soils to expand and contract.

This **TABLE** is intended to provide important information to consider when a home is to be constructed on expansive soils. Buildings should have their foundations designed to accommodate the building's load path. Several foundation design options are available. The below assumes a simple structure with a simple load path, where a conventional footing and stem wall is to be used. Generally, the footing should be sized so that it places enough weight on the soil to resist the soil's uplift forces, but does not exceed the soil's allowable bearing capabilities. In the case of highly expansive soils, this cannot occur, and the foundation system, therefor, needs professional design.

FOUNDATION AND SITE DESIGN CONSIDERATION TABLE

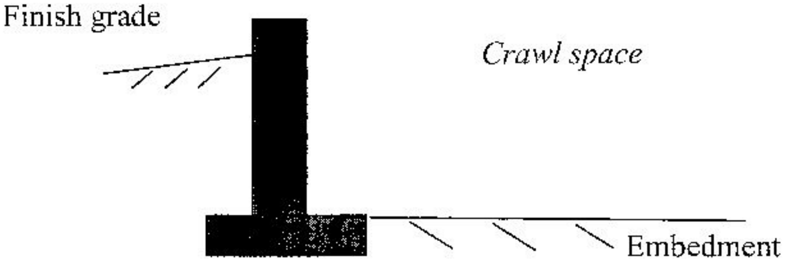
	Non-Expansive	Moderately Expansive	Highly Expansive
Footing Embedment	X	X 8" min.	X
Class 6 road base beneath footing or concrete slabs	NR	X 12" min. thickness 24" wider than footing	X
Compacted Backfill	X	X (non-expansive)	X (non-expansive)
Foundation Drain	NR	X	X
Reinforcement W/ 2-#5 bar top & bottom	NR	X	X
Minimum 48" stem wall height	NR	X *	X
Surface grade 5%; 10% on North side and beneath decks	NR *	X	X
Gutters and down spouts	NR	X	X
Underground moisture barrier at building parameter	NR	NR	X
Foundation designed by a licensed design professional	NR	NR *	X

LEGEND NR denotes NOT REQUIRED
X denotes REQUIRED or AS PER ENGINEERED DESIGN
* denotes ENCOURAGED

Footing embedment

Footings must be embedded below the lowest adjacent grade when placed on natural undisturbed soils or on a blanket of compacted structural fill. Embedment acts to increase the bearing capacity of the soils, and acts to limit intrusion of water. Embedment also acts to increase the resistance to lateral pressure created by backfill and compaction.

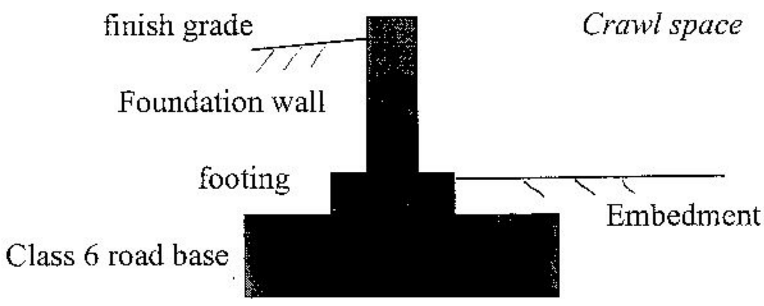
An illustration of the concept of embedment is provided below.



Typical footing embedment

Structural fill

Class 6 road base is frequently used beneath footings. Its purpose is to provide a uniform supporting surface for the footings and to help reduce the anticipated post construction settlement. This material also has weight which increases the dead load on the underlying soils. A blanket of structural fill, when properly compacted, will help reduce the influence of swelling soils that have become wetted. An illustration of a structural fill blanket is shown below.

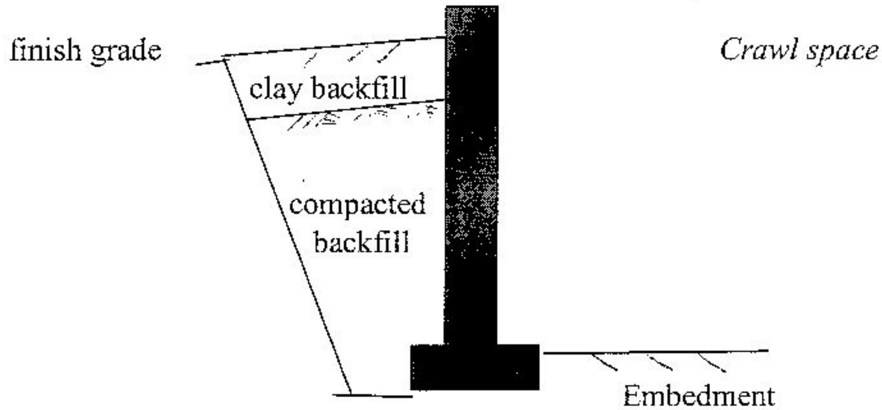


Structural fill mat

Compaction of backfill

The backfilling around the perimeter of a foundation is often done without proper care resulting in intrusion of water into the foundation zone and settlement of that backfill allows ponding of water adjacent to the foundation wall. Mechanical compaction of the backfill helps to reduce settlement, as well as the intrusion of water. The upper 18 inches of the backfill should be of a clay type of soil. Clays compact easily when moist and when compacted resist water intrusion.

The illustration below shown this concept.

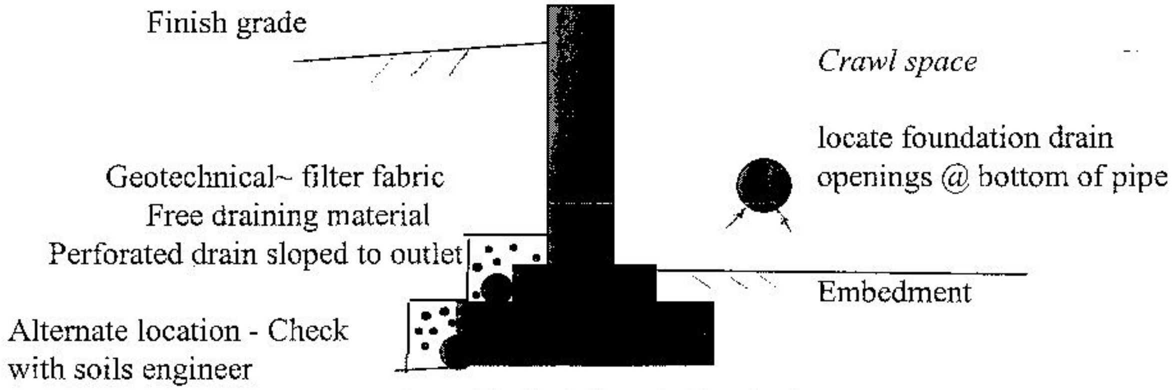


Typical backfill details

Foundation drain

Foundation drains can be used anywhere where sufficient slope exists to allow the foundation drain to empty. In some cases, a foundation drain which cannot empty by gravity is drained to a sump, which then ejects the water above grade. Foundation drains are important to remove water from the foundation zone.

The sketch below illustrates the concept.



Typical foundation drain

Foundation wall height and reinforcement

Additional wall height and additional reinforcement of the foundation wall increase the beam strength of the wall, allowing the wall to carry loads more uniformly. The added height acts to allow for deeper embedment of the foundation, and/or, to allow for increases in the surface slope away from the foundation.

Surface drainage

The minimum slope away from the foundation, is 5%, this must be increased to 10% along the North side of the structure and beneath decks. The importance of good drainage practices cannot be overemphasized. The increased slope on the North and beneath decks is to encourage surface drainage without saturation of the soils where shade restricts the melting of snow accumulation, or drying of the soils.

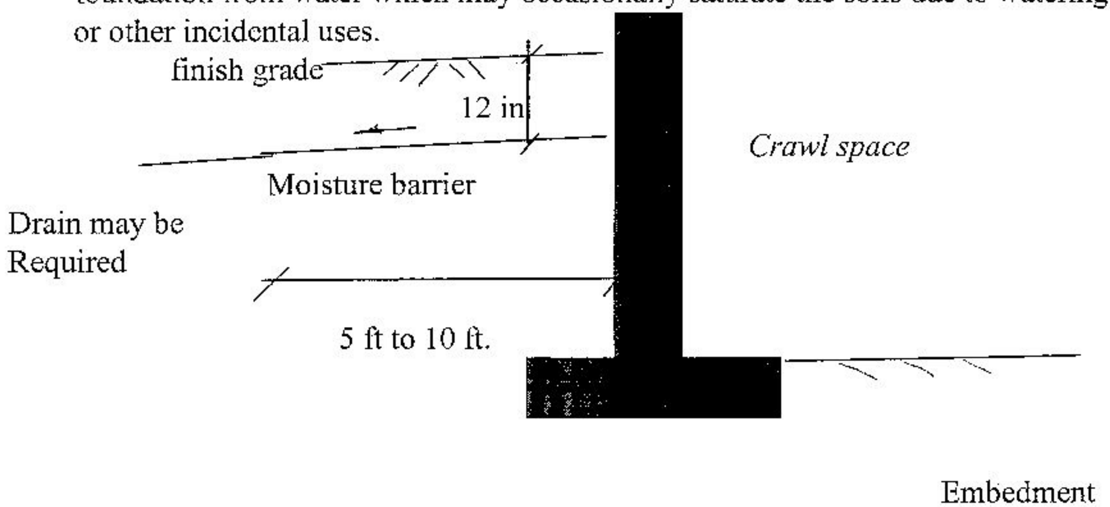
The ground should be sloped towards a drainage swale located at least 10 feet from the building. The swale must slope at lease 2% and not be allowed to pond water.

Gutters and down spouts

Roof water should be piped or panned a minimum of 5 ft. to 10 ft. away from foundation and disposed of at an appropriate location. Roof drains must never be connected to foundation drains. To do so will act to increase the likelihood of water within the foundation zone.

Underground moisture barrier

An underground moisture barrier is like having a roof below the ground. It protects the foundation from water which may occasionally saturate the soils due to watering plants, or other incidental uses.



Underground moisture barrier

Engineered foundation

A engineered foundation is required only where the potential for soils pressure is extreme. If the soils are extremely expansive, they are likely to expand sometime during the life of the home. These soils can easily lift the home and its foundation. When a engineer designs the foundation, he will need a copy of your soils report and he will attempt to balance the loads of the home to generate the maximum load possible on the soils below the home. Good drainage practices, as discussed above, are a necessary part of his design.

Landscaping

Installation of plants, lawns and trees must be done in such a way as to minimize the introduction of water into the foundation zone.

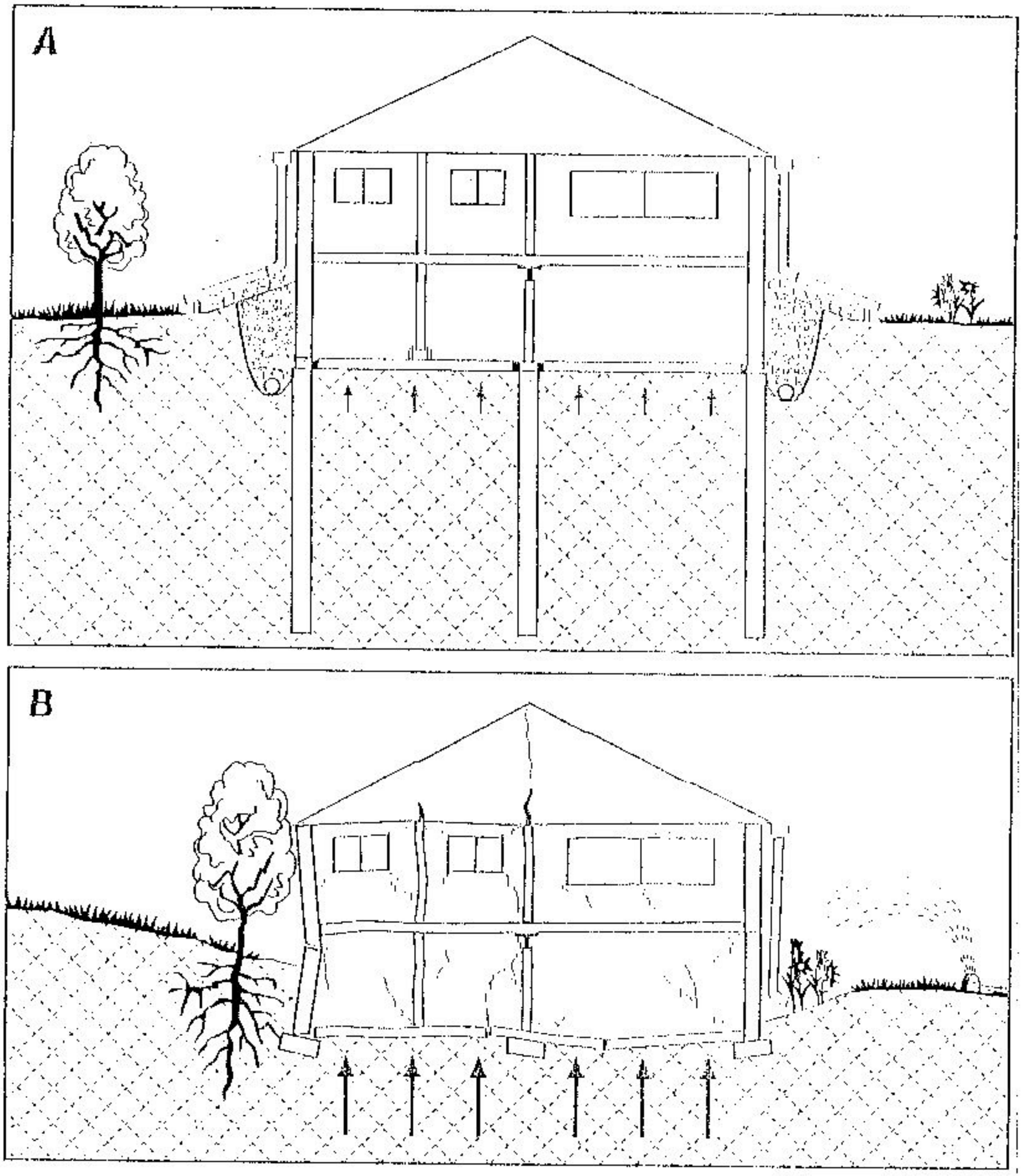


Figure 37. The results of A) proper versus B) improper design, construction, landscaping, and homeowner maintenance for homes built on swelling soils. (Modified from Holtz and Hart, 1978.)

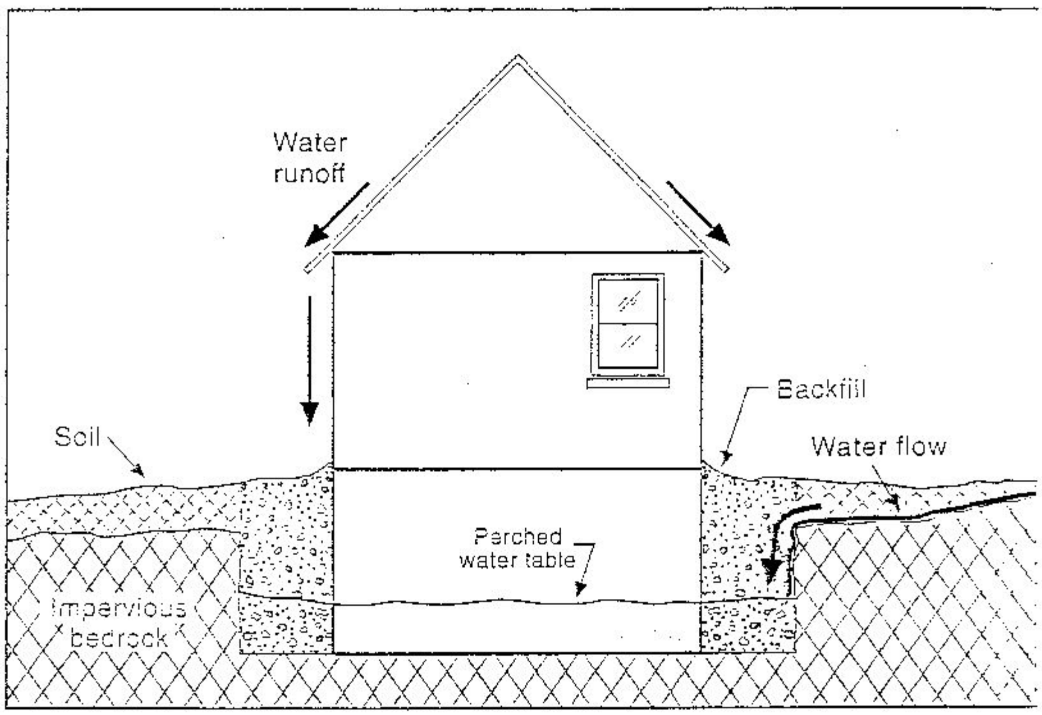


Figure 11. Perched water table in a house excavation dug into impervious bedrock (modified from Jochim, 1987). This is an unwanted situation because runoff water is filling the excavation and infiltrating the bedrock.

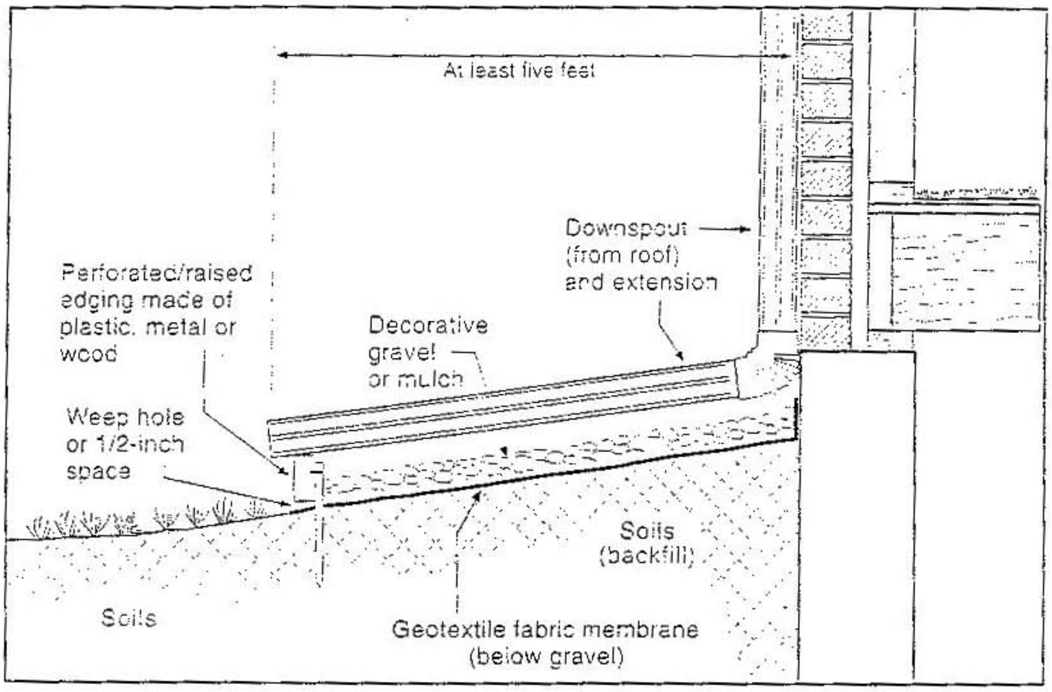


Figure 28. Properly designed runoff slope next to a house foundation. Note that roof drainage is carried by a downspout extension to a point beyond the slope. (From Holtz and Hart, 1978.)

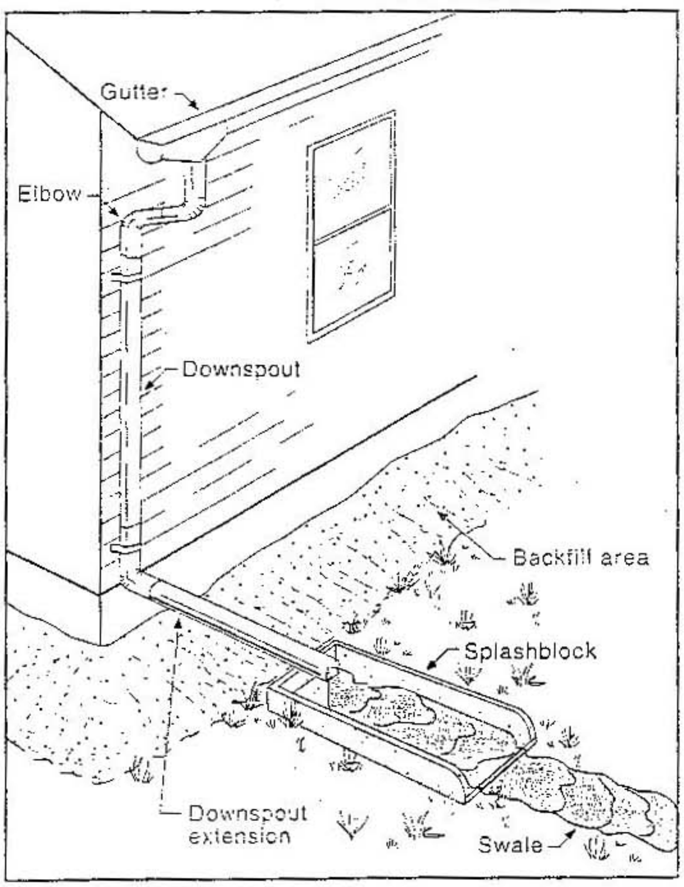


Figure 26. Components of a roof drainage system. (Modified from Jochim, 1987.)

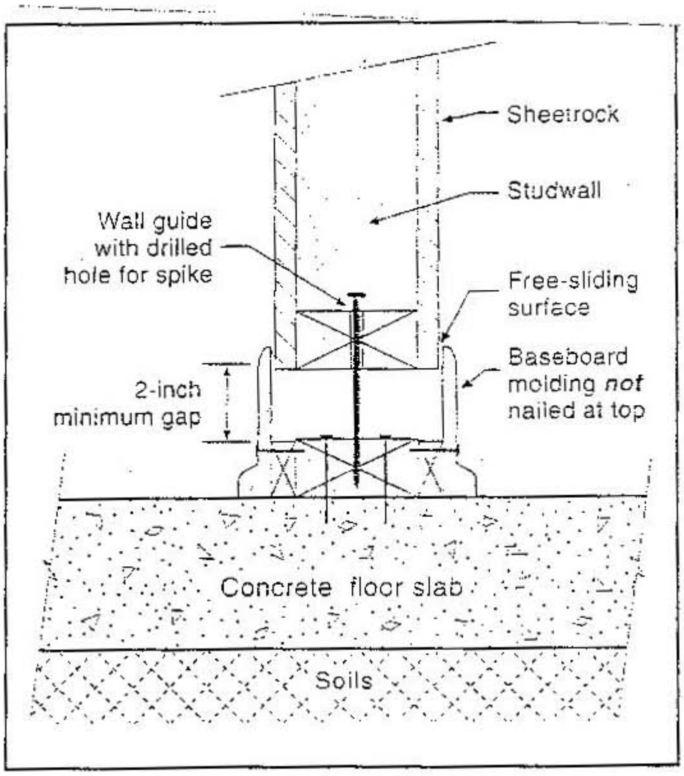


Figure 18. Detail of the bottom part of a suspended, non-load-bearing interior wall. (Modified from Holtz and Hart, 1978.)