FOUNDATION REPAIR ASSOCIATION

EXPECTATIONS OF UNDERPINNING

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with help from
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Foundation repair/remediation contractors usually provide some form of underpinning as one of their services to repair a failed foundation. While underpinning is critical to the repair of foundations, it is also crucial that customers, engineers, remodeling contractors and the general public understand the purpose of underpinning, or foundation shoring, and the limitations of same.

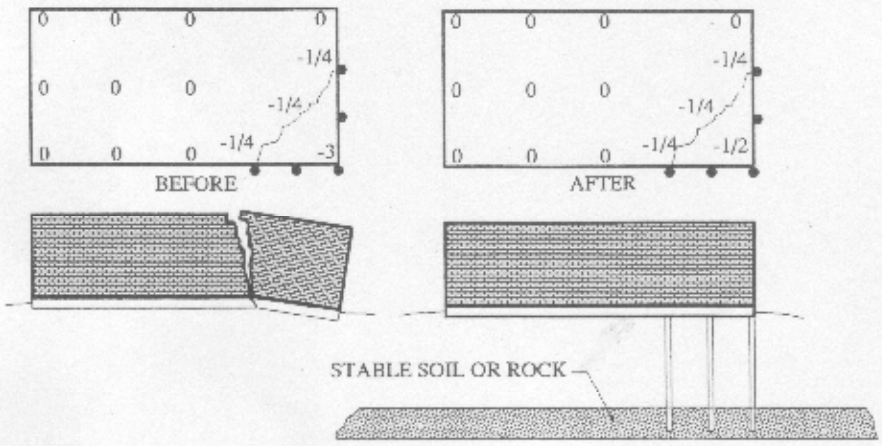
DEFINITION OF UNDERPINNING

Underpinning is the process of modifying an existing foundation system by extending it to or into subsurface strata that is deeper and more stable than the near surface soil that supports the existing foundation system. This is done to provide vertical support that is not present in the existing design. Methods of underpinning include the construction of footings, stem walls, driven piling or drilled piers.

PURPOSE OF UNDERPINNING

Many of the houses that forensic engineers and repair contractors are asked to evaluate were constructed with foundations that are inadequate for the conditions existing on site. Because of the lack of suitable land, homes are often built on marginal land that has insufficient bearing capacity to support the substantial weight of a structure. In addition, there are many areas of the country where the near surface soils consist predominantly of expansive clays that shrink and swell as their moisture content changes. As a result, underpinning is required to extend the foundation support to depths that provide greater bearing capacity and/or are less affected by climate, soil conditions and/or homeowner's actions. This underpinning, if properly designed and installed, provides the basis to lift the structure to a more acceptable elevation and provides vertical support to prevent the underpinned area from settling.

UNDERPINNING OF A LOW SEGMENT



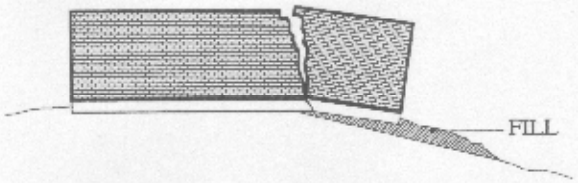
SLAB-ON-GRADE FOUNDATIONS

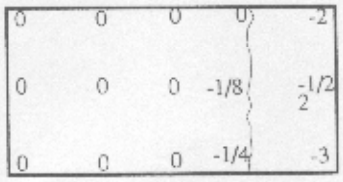
In many areas of the country, house foundations consist, wholly or in part, of concrete slabs supported directly by the soil. In some instances, the slab portion forms the ground or basement floor, which is structurally independent from the perimeter foundation. In other cases, a similar soil supported floor slab rests on top of, and is partially supported by, the perimeter foundation. In Texas, slabs are generally cast monolithically with perimeter as well as interior beams that are designed to provide sufficient support for the entire structure as well as to provide stiffness to resist differential soil movement enough to limit cracking in the foundation and finishes. Texas slabs are typically reinforced with conventional reinforcing steel (re-bar) and/or post-tensioned cables that are installed throughout both the slab and beam portions of the foundation.

LIMITATIONS OF SLAB-ON-GRADE FOUNDATIONS

- Settlement As A Result Of Poor Pre-Construction Compaction.

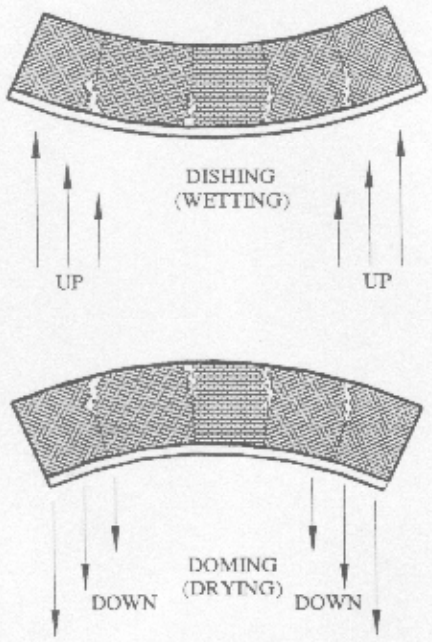
Slab-on-grade foundations depend upon the uppermost soil layer(s) to provide sufficient bearing capacity to support the structure and to keep the foundation stable. If the bearing soil was insufficiently compacted prior to construction, the foundation is subject to settlement as the supporting soil consolidates.





Settlement As A Result Of Poor Pre-Construction Compaction

Foundation Movement Resulting From Seasonal Moisture Changes



- Foundation Movement Resulting From Soil Moisture Changes

Shallower soils are also generally the most affected by seasonal moisture changes. If the bearing soils consist of expansive clays that are subjected to changes in moisture content, differential foundation movement can occur if wetting and drying of the clays does not occur uniformly across the entire slab. This differential movement can result in "dishing" or "doming" of the foundation, and can become quite pronounced, especially in areas where the local climatic conditions include extended seasonal periods of both hot, dry weather and cooler, wetter weather.

In either case (consolidation or differential shrink/swell movement), inadequate design and/or construction of the foundation can result in unacceptable performance of the slab-on-grade.

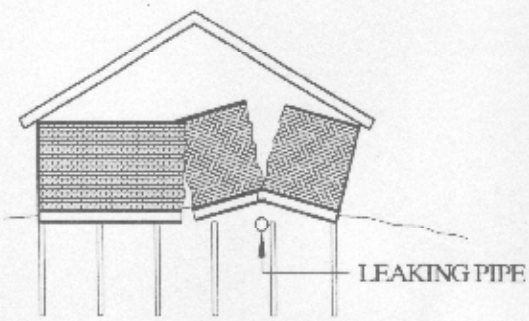
CAUSES AND MODES OF FOUNDATION MOVEMENT

- Movement As A Result Of Seasonal Moisture Changes

As mentioned above, foundations that are built directly on expansive soils that are subjected to non-uniform changes in the soil moisture content can suffer from differential movement. During extended periods of dry weather, the expansive supporting soil shrinks causing foundation settlement. During extended periods of wet weather, the expansive supporting soil swells causing upward movement of the foundation (upheaval). Localized site and environmental factors that promote or limit the flow of water into and out of the supporting soil as well as non-uniform distribution of the expansive soil under the foundation affect the magnitudes of the movement (either upward or downward) at different locations of the foundation. It is important to understand that it is *differential*, not the *total* movement of the foundation that causes damage to the structure. In other words, the performance of a foundation that moves up and down uniformly with the changing seasons is superior to a foundation where the movement is not uniform.

- Slab/Foundation Movement Caused By Plumbing Leaks

A slab-on-grade foundation acts as a vapor barrier by resisting soil moisture variations due to evaporative moisture loss and by shielding the under-slab soil from rainfall. Under optimum conditions, the soil moisture under the slab will achieve a degree of equilibrium. When a plumbing leak occurs under a slab, the moisture equilibrium is distorted. As moisture is added to the soil from the leak, soil and foundation movement often result. The type and degree of movement depends upon soil type and expansiveness, soil density, soil moisture content prior to the leak, the length of time over which the leak has occurred, the quantity of moisture being added to the soil over a given period of time and a few other factors.



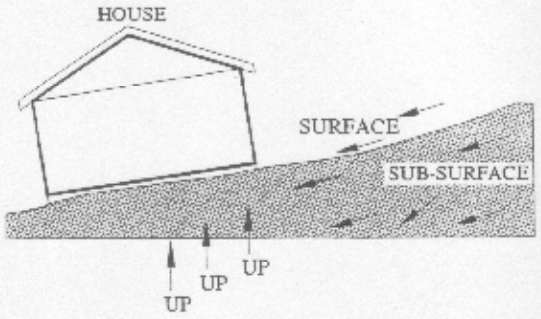
UPHEAVAL TO A SLAB-ON-GRADE CAUSED BY A PLUMBING LEAK

Typical examples:

1. If the soils are expansive and were dryer than optimum prior to the leak and have a high density, the foundation/slab will heave (move upward) in the vicinity of the leak and corresponding damages will be apparent in the structure. In this example, the soil will probably not contract significantly after the leak is repaired, which will result in a permanent dome in the slab.
2. If the soil is at optimum density and moisture prior to the leak, there is an opportunity for the soil to contract. It is possible, but not probable, that the slab will regain its original elevation profile because clay soil expansion/ contraction generally does not follow a linear progression as moisture is added and then reduced. The slab could be permanently left above or below its initial elevation.
3. Should a leak occur under the slab where the soil is of very low density, the additional moisture often lubricates the solid clay particles and causes consolidation of the support soil prior to leak repair. After the leak is repaired under this example, the slab will often "dish" or settle (move downward) even more.

NOTE: Concrete and steel will often develop a "stress memory" after deformation that will not allow the slab to return to its original shape. This may be the result of soil or concrete chips filling cracks in the slab, which prevents the slab from "coming back together" completely. In a post-tensioned slab, stress in the post-tensioning cables may resist the tendency for the slab to move back into place.

UPHEAVAL TO A SLAB-ONGRADE CAUSED BY NEGATIVE DRAINAGE



In a conventionally reinforced slab, permanent deformation (yielding) of the steel reinforcing bars may prevent the slab from returning to its original shape.

- Foundation Upheaval Caused by Poor Drainage

Since additional moisture can cause expansive soils to swell, areas of poor drainage near the foundation can cause the soil under the foundation nearby to swell, resulting in upward movement of the foundation.

LIMITATIONS OF PIER AND BEAM FOUNDATIONS

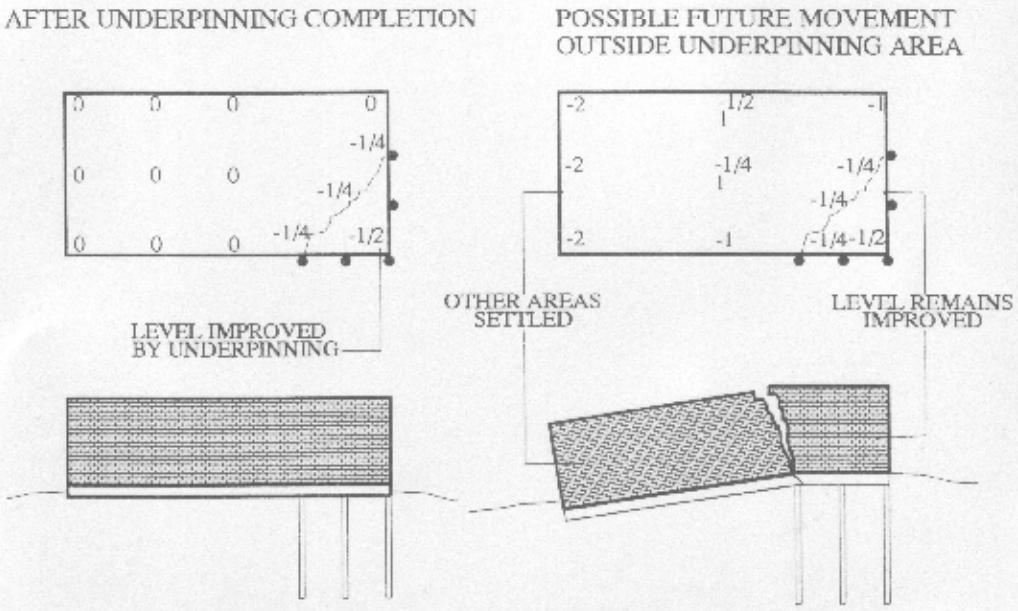
- Foundation Upheaval Caused by Poor Drainage

Although pier and beam foundation systems, if properly designed and constructed, will provide protection against settlement; the potential for foundation upheaval due to poor drainage is sometimes present. If, for instance, the perimeter and/or interior grade beams were constructed upon expansive clay soil, without providing a void under the beam for soil expansion, swelling of the underlying soil may push the beam upward. Swelling soil can also push the supporting piles or piers upward, if they are not designed and constructed to adequately resist uplift. As a result, the grade beam will lift causing differential movement and subsequent cosmetic, and potentially structural, damage. It is, therefore, a good idea to maintain adequate drainage away from any type of foundation, especially where expansive soils are present.

- Foundation Settlement Caused by Inadequate Pier Depth

The piers supporting many older pier and beam foundations may not extend below the zone of expansive soil that is affected by the climate. During periods of dry weather, these shallow piers may not provide sufficient support to portions of the foundation, which may result in differential settlement.

MOVEMENT OUTSIDE UNDERPINNED AREA



LIMITATIONS OF UNDERPINNING

- Movement Outside of the Underpinned Area

If a single area of a foundation is underpinned, only that area will resist downward movement. For example, if only one corner of the foundation is supported by piers, only that corner will resist settlement forces. The rest of the structure will be subject to seasonal settlement as clay soils shrink during dry periods. Therefore, an area that was originally the low portion of the foundation may now become the high point of the house during dry periods. It is also possible that cracking will occur at the last pier if the unsupported area settles and is resisted at this hinge point. It is, therefore, important to carefully evaluate and balance site risk factors against cost savings when electing to partially underpin a foundation.

- Upheaval

When underpinning is installed to a stratum that is competent and capable of supporting the structure, it will stop downward movement of the area of the foundation that is supported. Underpinning is generally not designed to keep the foundation from moving upward if the original support clays swell due to an increase in moisture. Plumbing leaks, negative drainage and/or acts of man or nature, can increase the moisture content of the bearing clays. Subsequent upward movement will often occur, which will result in a distorted foundation and racking in the finishes.

- Interior Floor Instability As A Result Of Interior Settlement and/or Perimeter Upheaval

It is possible that cracks may occur at doors that are perpendicular to the perimeter walls as the interior slab settles from shrinking of clay soils. Where the wall is tied in to the ceiling and roof structure, a separation can occur between wall and floor. When the floor is secured to the slab, there may be separations between wall and ceiling. In the case of a pier and beam foundation, the wood floor can appear "bouncy" as a result of the floor beams being lifted off the interior piers in response to perimeter upheaval.

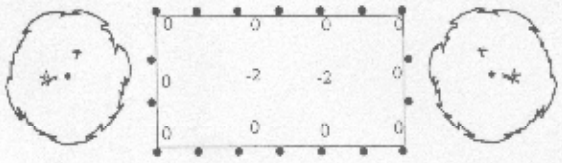
- Damage From Vegetation

Trees, bushes and other vegetation will draw moisture from under the foundation during times of drought. If the perimeter of a slab-on-grade foundation is underpinned and trees withdraw moisture from under the slab, the interior bearing soil will dry and shrink in volume. As a result, the interior slab may settle and cracking will likely occur in the interior of the home. It is also possible that tree roots under a slab will grow large enough to push the slab upward.

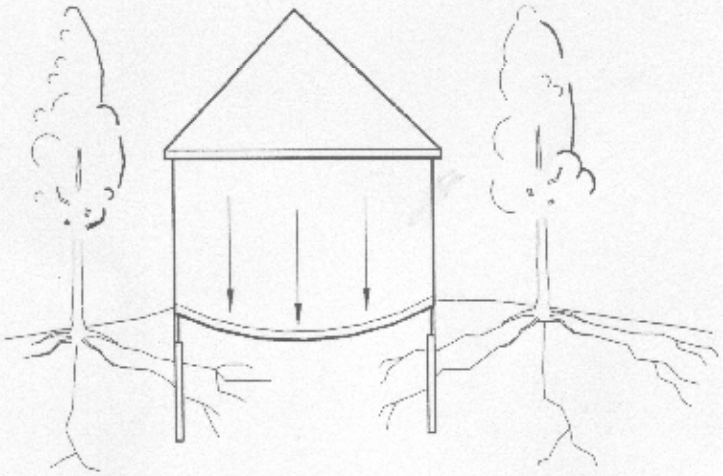
- Point Of Contact

Underpinning is only as good as the contact or connection point between pier/pile and the structure. If the grade beam, thickened slab, or steel beam support is faulty, pier support will not be fully transferred to the foundation and downward movement may occur.

INTERIOR SETTLEMENT AS A RESULT OF A DROUGHT
AFTER UNDERPINNING COMPLETION



PLAN VIEW



CROSS SECTIONAL VIEW

SUMMARY

Successful underpinning requires proper design and proper installation of piers/piles. However, even the best design and installation may not ensure a "permanent fix". Generally, when the underlying soil moves, the structure resting upon the soil will move correspondingly. Special attention must be given to maintaining a consistent soil moisture level around and beneath the foundation slab, especially in areas with highly expansive clay soils and/or environmentally induced swings in moisture availability.