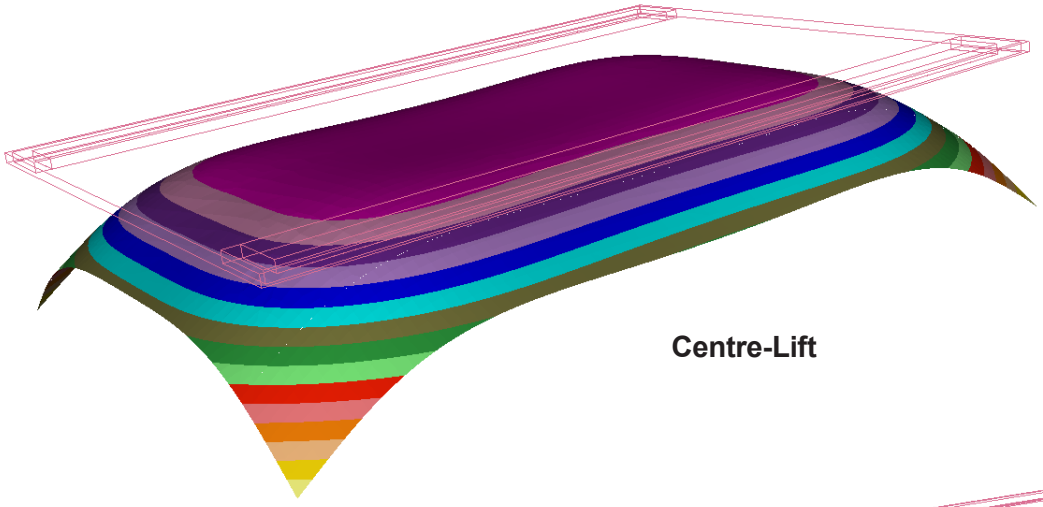
Expansive Soils

Shrink/swell soils pose great challenges to the building industry in Canada and the United States. Years of research and field tests have lead to many building solutions to avoid structural failures when building light structures on expansive soils. These solutions include, pile foundations and void forms, post tensioned slab on grade foundations and moisture monitoring systems, all of which greatly increase the cost associated when building on expansive soils.

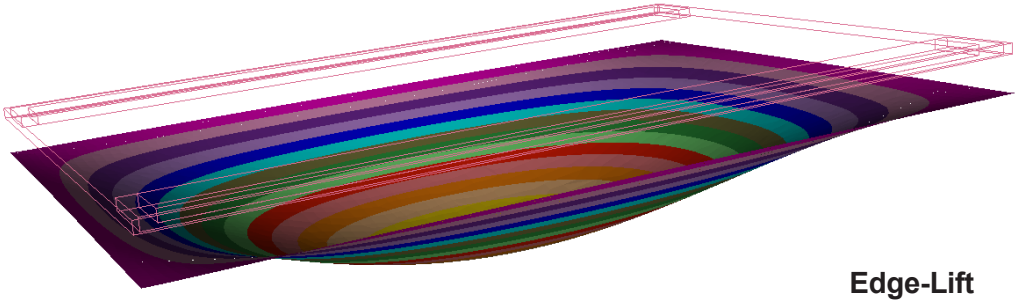
Shrinking and swelling of clay soils results from changes in the moisture content of the soil. This poses a real and very difficult problem for foundation designers when soil moisture content can be influenced by climatic conditions, changes in depth of water table, water uptake by vegetation, removal of vegetation, or the excessive watering of a lawn. Simply put, the building process itself can affect the soil moisture content of the soil.

There is currently no existing, industry wide, accepted method to classify the degree of expansivity of a soil nor a definitive method to avoid foundation design failure when building on unsaturated expansive soils. The industry has developed numerous soil parameters/indicators as tools for geotechnical engineers to help recommend foundation designs to building owners and engineers.

Simply put the predictability of soil behavior becomes difficult if you allow the soil moisture content to vary. Allowing a soil to shrink and swell leads to costly foundation design solutions.



Centre-Lift



Edge-Lift

The Legalett Way

The main challenge when building slab on grade on expansive soils is the edge effect. The slab acts as an impervious cover, but moisture change in the soil at the foundation perimeter can create either an edge lift or edge drop effect depending whether the soil is expanding or contracting.

Legalett has developed, over the past 30 years, a frost protected shallow foundation (GEO-Slab) for residential/commercial construction. In extreme cold weather areas, the GEO-Slab design utilizes perimeter skirting to avoid frost heave. The use of Expanded Polystyrene Insulation under a slab and for skirting effectively creates a moisture and heat transmission barrier between the underlying soil and the building. Stabilizing the soil temperature has the effect of stabilizing the soil moisture content. Insitu moisture migrates through soil from areas of high temperature to areas of low temperature.

During the Legalett design process our engineers determine the skirt distance necessary to move the edge effect outside the building perimeter where it has no effect on the structure. The skirt design is impermeable to avoid the introduction of moisture near the foundation and directs the water from rainfall, etc, to a drainage system. Good building and landscaping practices for expansive soils still need to be followed, such as no trees, gardens, downspouts or lawn watering within 6' (watering) to 20' (trees) of the building (See page 3). The "Edge Moisture Variation Distance" (em) effectively starts at the skirting edge and not under the slab edge as with normal foundation systems.

In this way, the Legalett GEO-Slab does not allow the moisture content of the soil to vary below the slab avoiding the conditions necessary for shrink and swell. Thus Legalett provides a cost effective foundation solution for expansive soils.

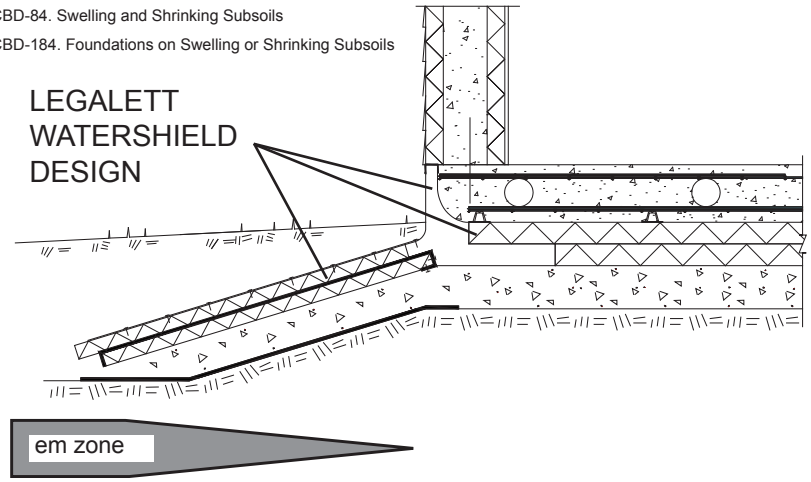
Additional Reading Material

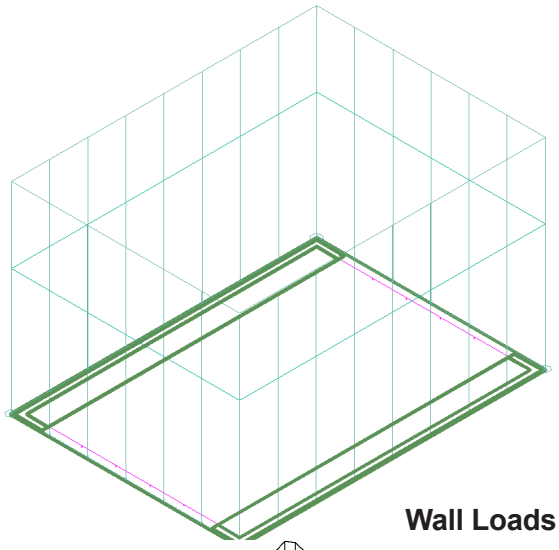
Numerical Modeling of Slab-On-Grade Foundations
M. D. Fredlund[1], J. R. Stianson[2], D. G. Fredlund[3], H. Vu[4], and R. C. Thode[5]
[1]SoilVision Systems Ltd., 2109 McKinnon Ave S., Saskatoon, SK S7J 1N3
PH (306) 477-3324; FAX (306) 955-4575; email: murray@soilvision.com
[2]University of Alberta, Department of Civil and Environmental Engineering, Edmonton Alberta, T6G 2W2

Reductions in swelling pressure of expansive soil stabilized using EPS geofoam and sand
S. B. Ikizler[1], M. Aytekin[2] and M. Vekli[3]
[1]PhD graduate, Civil Engineering Department, Karadeniz Technical University, Trabzon 61080, Turkey

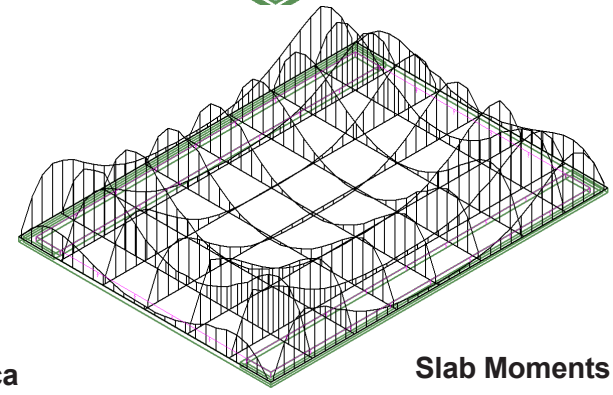
CBD-84. Swelling and Shrinking Subsoils

CBD-184. Foundations on Swelling or Shrinking Subsoils





Wall Loads



Slab Moments

Additional Notes for Slab Maintenance

The GEO-Slab is to be provided with adequate drainage, and the soil properly prepared to minimize changes in soil moisture and differential movement.

1- Removal of vegetation: Existing trees and other heavy vegetation must be removed. New plantings of like items installed during post construction landscaping are not to be located within a minimum distance from the structure ranging from 1 to 1.5 times the height of the mature tree.

2- Leveling of site: Natural soil fills compacted at the natural water content and the natural density of the in situ adjacent soil minimize differential movement between cut and fill areas of sloping ground, trenches, or holes caused by removal of vegetation. The volume of cut portions should be kept to a minimum. Cut areas reduce the overburden pressure on underlying swelling soil and lead to time-dependent heave.

3- Excavation: Construction in new excavations (within a few years of excavating) without replacement of a surcharge pressure equal to the original soil overburden pressure should be avoided where possible because the reduction in effective stress leads to an instantaneous elastic rebound plus a time-dependent heave. The reduction in overburden pressure results in a reduction of the pore water pressure in soil beneath the excavation. These pore pressures tend to increase with time toward the original or equilibrium pore pressure profile consistent with that of the surrounding soil and can cause heave. Drainage is provided by surface grading and subsurface drains.

4- Grading: A positive slope must be provided away from the structure. The slope should be adequate to promote rapid runoff and to avoid collecting, near the structure, ponded water, which could migrate down the foundation/soil interface. Minimum slope of 5 percent within 10 feet of the slab.
   (1) Depressions or water catch basin areas should be filled with compacted soil to have a positive slope from the structure, or drains should be provided to promote runoff from the water catch basin areas. Six to twelve inches of compacted, clear stone placed on the site prior to construction of the GEO-Slab can ensure the necessary grade and contribute additional uniform surcharge pressure to reduce uneven swelling of underlying expansive soil.
   (2) Grading and drainage should be provided for structures constructed on slopes, particularly for slopes greater than 9 percent, to rapidly drain off water from the cut areas and to avoid ponding of water in cuts or on the uphill side of the structure.

5- Subsurface drains: Subsurface drains are to be used to control a rising water table, groundwater and underground streams, and surface water penetrating through pervious or fissured and highly permeable soil. Drains can help control the water table before it rises but may not be successful in lowering the water table in expansive soil. Furthermore, since drains cannot stop the migration of moisture through expansive soil beneath foundations, they will not prevent all of the long-term swelling.
   (1) Location of subsurface drains. These drains are usually 4 inch-diameter perforated pipes placed adjacent to and slightly below the baseline of the external wall to catch free water. An impervious membrane should be placed beneath the drain in the trench to prevent migration of surface moisture into deeper soil. The perforated pipe should be placed at least 12 inches deeper than the top of the stone layer. An impervious membrane should also be placed on the bottom and sides of the drain trench.
   (2) Outlets. Drains should be provided with outlets or sumps to collect water and pumps to expel water if gravity drainage away from the foundation is not feasible. Sumps should be located well away from the structure. Drainage should be adequate to prevent any water from remaining in the drain (i.e., a slope of at least 1/8 inch per foot of drain or 1 percent should be provided).
   (3) Drain trench material. The intrusion of fines in drains may be minimized by setting the pipe in filter fabric and pea gravel/sand.

6- Continuous maintenance: Maintenance programs are directed toward promoting uniform soil moisture beneath the foundation. A good program consists of the following:
   (1) Maintenance of a positive slope of about 5 percent around the structure for drainage and elimination of water catch areas.
   (2) Maintenance of original drainage channels and installation of new channels as necessary.
   (3) Maintenance of gutters around the roof and diversion of runoff away from the structure.
   (4) Avoidance of curbs or other water traps around flower beds.
   (5) Elimination of heavy vegetation within 10 to 15 feet of the foundation or 1 to 1.5 times the height of mature trees.
   (6) Limited watering around the structure during droughts to replace lost moisture.