My House Is Headed South!

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Last year we received a panic call from a client declaring “My house is headed south on me. Can you help?”

Recently, Eastern Ontario has been experiencing publicity about sinking homes built on unsuitable soil conditions. These conditions are as old as the Champlain Sea. I first experienced these issues back in the early 1980’s while inspecting a development east of Ottawa. Several homes were sinking to an alarming degree; some were salvageable at a great expense, and others were beyond repair, as the cost for remediation far exceeded the cost of demolition and re-construction.

Over the years, I have experienced similar problems throughout all of Eastern Ontario where houses have been built on the Champlain Sea deposits. Soil conditions vary quite significantly in this region, from Leda clay problems to radon gas issues. Radon will be the subject of my next article.

The Champlain Sea and its soil conditions and settlement issues are complex and interesting. I will attempt to summarize these conditions and then follow up with some of the typical remedial work performed in a recent residential development experiencing differential settlement problems.

Background:

The following comments are provided to promote an understanding of the cause of the house settlement, which is often the result of compression of underlying layers of clay in the Eastern Ontario.

A thick deposit of sensitive clay underlies much of eastern Ontario, including the eastern communities in Ottawa. The clay deposit is commonly known as Leda clay, though engineers call it Champlain sea clay (aptly named after the Champlain sea, which covered eastern Ontario until about 10,000 years ago, and within which that clay was deposited). Like all soils, that clay is composed of small mineral particles. However unlike coarser soils, such as sand, where the particles are visible to the human eye, the particles in a clay soil are very small, platy, and arranged in a “house of cards” like structure. The voids between those small particles are relatively large and are filled with water. In that regard, the soil’s structure is somewhat analogous to a sponge.

The clay deposit, when loaded beyond a certain “strength” level, can compress significantly. When that occurs, the voids in the clay become smaller, and the water is “squeezed” out of the voids. This process is comparable to squeezing the water out of a sponge. The small size of the clay particles and their plate-like shape allow clay soils to have a very large volume of

voids in comparison to a coarser soil, such as sand. Because of that larger portion of voids, clay soils can compress a lot more (i.e. can reduce much more in volume when overloaded) than most other soils.

However, the analogy between clay soil and a sponge is not exact, in that the clay has a strength level, known as the “preconsolidation pressure,” below which the soil compresses very little. That is, if the clay is loaded to a level below the preconsolidation pressure, very little settlement occurs. Once the preconsolidation pressure is approached or exceeded, however, the clay will compress significantly.

For a residential subdivision, the loading on the underlying clay soil results from the following three main factors:

1. The loads from the house foundations, which are transferred to the supporting soil by the house footings;

2. The weight of the soil placed around the house as landscape fill; and,

3. Lowering of the water level in the ground.

The impact of the first type of loading is fairly obvious. However the second load type is generally the more significant. Most subdivision sites end up with grades that are raised to a higher level~~,~~ for a variety of reasons, which include the desire to re-use the soils excavated during construction of the basement as well as the need to place the houses above the level of the sewers that exist beneath the streets.

The third load type is generally more difficult to understand. The water in the ground that fills the voids in the clay exerts a buoyant pressure on the soil particles, effectively pushing them apart. A lowering of the water level reduces those pressures, adding load to the soil particles, and potentially causing settlement.

Understanding the causes of settlements:

In summary, settlements are often the result of compression of a thick layer of clay, primarily from the weight of the backfill soils around and within the houses. Nevertheless, several alternative explanations are often advanced in the media and amongst the public at large. **Many of these are incorrect and Home Inspectors should be aware of this**. For example, settlements are **not** generally a result of:

1. Groundwater level lowering: Wrong. Although a lowering of the groundwater level can lead to compression of the clay, water levels are typically close to the pre-construction values.

2. Development in a "swamp": Wrong again. Prior to development, many sites are low lying, poorly drained (i.e., submerged at wetter times of the year), and overlain by peat. That peat layer, though compressible and not a suitable material to construct upon, is usually removed prior to house construction and foundations are designed to reflect the found soil conditions.

3. Excessive footing loads: Another fallacy. Houses typically conform to conventional house design standards and therefore exert typical house footing loads on the underlying soil. Moreover, footing loads are usually a small fraction of the overall load on the underlying soil, ***in comparison to the weight of the backfill within and around the houses.***

Home Inspectors should have a clear understanding of the actual cause of the settlements, so that we can understand the purpose of the remedial measures. To re-iterate, the cause of the settlements is often the compression of an underlying thick layer of clay, and not the other explanations listed above.

FOUNDATION MONITORING AND REMEDIAL MEASURES

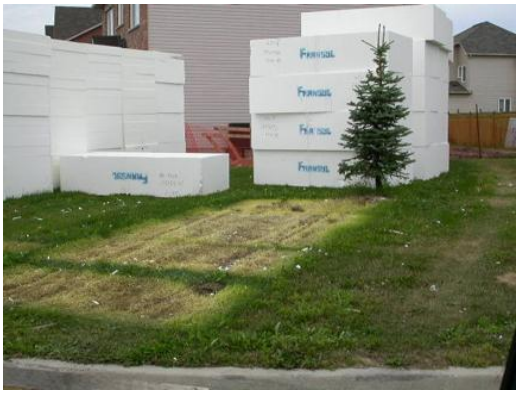
The pattern of settlement within a subdivision can be variable. ***In many cases neighbouring houses can experience very different levels of damage.*** As discussed above, settlement of clay soils involves the water being squeezed out of the voids in the soil. But clay has a very low "permeability." That is, it is very hard to push water through clay; it flows very slowly. Therefore it takes a long time for the clay to settle.

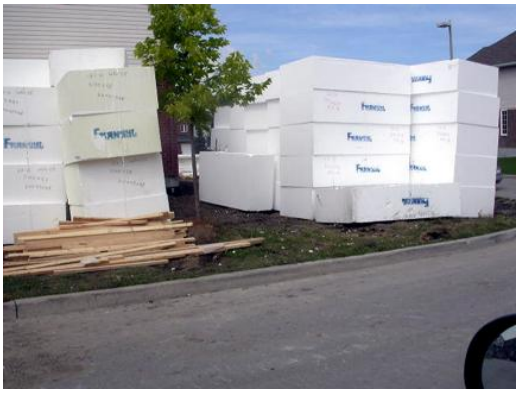
A house can experience both total and differential settlement (tilt) of the house. It must be understood that it is not the overall settlement of a house that causes damage. Rather it is *differences in the settlement between different points on a house*, what engineers call "**differential settlement**," that causes the damage. The extent of damage at each house is often related to small differences in the strength of the clay beneath that house, combined with differences in the loading from different house models. Some house models are also better able, by nature of their size and the layout of the walls, to withstand more differential settlement before experiencing foundation cracking.

Examples of some remedial work recently performed:

The following are a series of photos outlining the remediation work performed on re-aligning houses that experienced differential settlement. The costs per house varies upon the amount of differential settlement, suffice to say that it can be well beyond the $100,000. per house. OUCH!

One of the sure telltale signs of remedial work being performed in a subdivision is the evidence of the following, as seen in these pictures below.





All existing yard appurtenances are removed (e.g. planting, furniture, interlock and wood decks etc.).

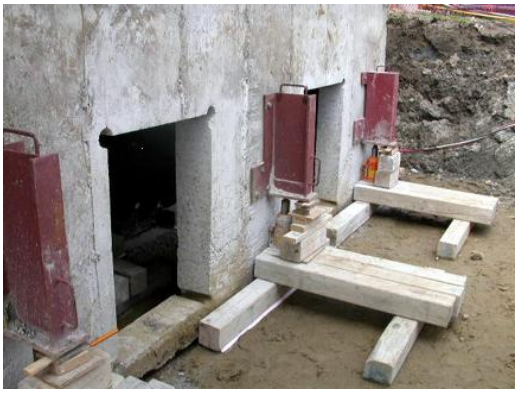
The work begins with the excavation of the soil as directed by the engineer (typically to the top of the footing and about 3 m out from home) and services are suspended as seen here.

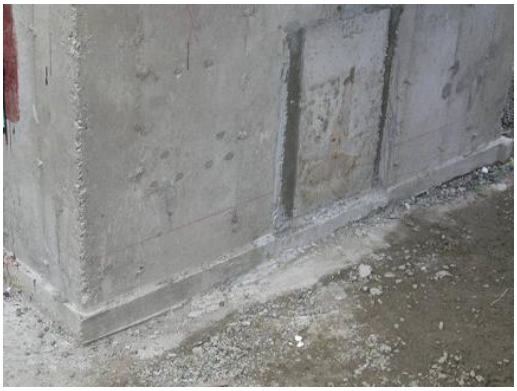
A catwalk from the street to the main entrance of the residence is erected. In fact, the excavation looks a little like a rabbit warren once all of the soil from around all of the foundation is removed. Houses stand without

any infill as workers remove every bit soil from around the houses for about 3 metres or so. During this process the drainage tile and moisture barriers are removed and disposed of, exposing the foundation in its entirety.

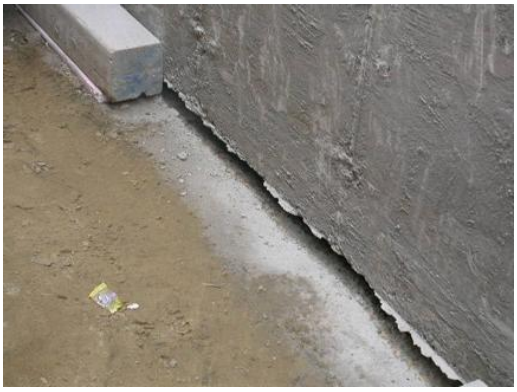
Garage floors are removed and excavated down to the interior footings, as seen below. Below are the before and after photos of the garage area. Access to the home is maintained throughout and there is limited effect on occupancy.

If leveling is required (note that the home usually rebounds significantly (20 mm) when soil loads are removed from around the foundation), brackets are installed on the foundation and the foundation is reinforced (typically straps fastened / bonded to the top and bottom of the wall). Jacks are then placed on the brackets and the foundation wall is jacked off the footing until level. The next photos show the “before” and “after” of this process.



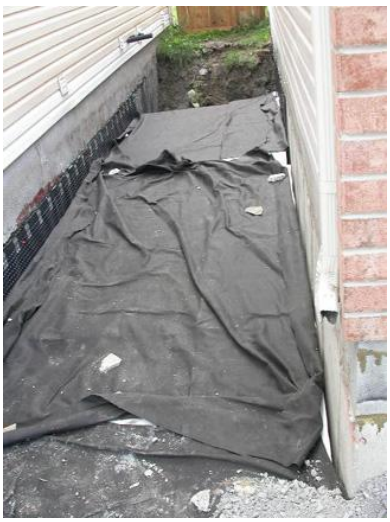


The resulting space is grouted, as seen in the photo below at left. The photo at right is a sample of a typical level structure in its finished state.

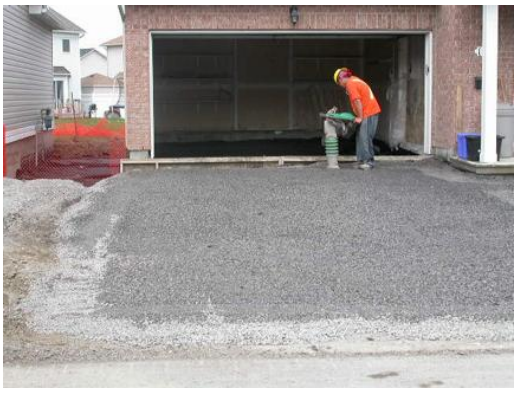


Granulars and drainage management are installed and then lightweight fill (foam blocks) are placed to about 0.3 m below the finished grade.

It is important to note that the weeping tile system is installed **at the perimeter of the lightweight fill and <u>not around the perimeter of the foundation</u>.** The weepers are then connected to the previously existing drains.



Landscape cloth is used to keep fill from subsiding into cracks, prior to backfilling and finishing of the landscape.



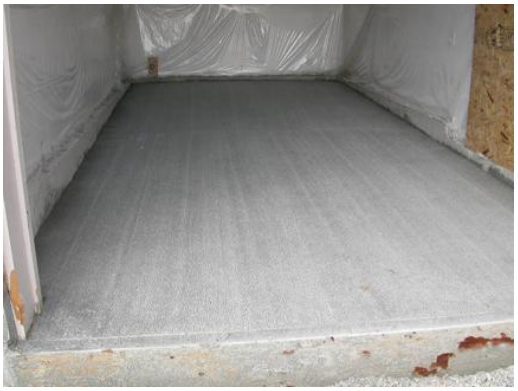
The lightweight fill is then topped with topsoil, and driveways, planting, sod, etc. is installed. Garages and driveway areas are capped with granulars to provide for proper slope and finished as per specifications and requirements.

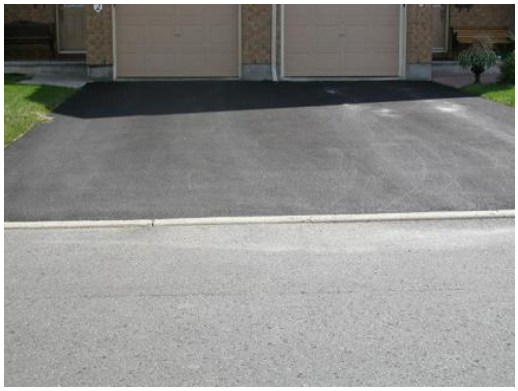
NOTE: The lightweight fill strength varies depending on the application, and special placement is used under driveways to accommodate frost tapers, etc. There are no real use restrictions on lightweight fill as it behaves similar to soil —planting, fences, decks, pools, additions, etc. can all be accommodated with no special treatment.

Once the above is completed other foundation cracking is repaired using normal techniques and / or reinforcement as appropriate. Interior repairs to the house are then conducted as required.

The Finished Product

The photographs below are of the completed garage floor and driveway as viewed from the street after completion of the above remediation process. All of the remedial work was done under a building permit and the warranty period odometer reset back to zero for the homeowners involved in this case.





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For discretionary purposes, this project, its location, street names, house numbers and close up photos of the personnel working on this remediation have been omitted at the request of all parties involved.

Will this procedure stand the test of time? Who knows? It is the best scientific remediation that engineers can currently offer to resolve this type of situation. One more reason why we always recommend to clients whose homes are built on the Champlain Sea to always obtain the soils engineering report prior to purchasing.

Paul Wilson is a Registered Home Inspector (RHI) with OAHI/CAHPI-Ontario, and a member of ASHI. He is also a National Certificate Holder with the National Certification Authority of CAHPI. Paul is currently the Head Instructor with *The Home Inspectors Institute*®. A private educational facility in Ottawa that offers an "Introduction to Residential Home Inspection" course for professionals and related tradespersons wishing to find out more about this rewarding career. He can be reached at: pwilson@home-inspectors.com, or visit him online at: www.home-inspectors.com