Module 6: Problem soils

Module Objectives:

By the end of this session, participants will understand:

1. Why different types of ground (soils) found in South Africa is problematic for builders.

2. How different soil types behave and why this causes problems for builders.

3. What different foundation solutions are needed depending on how the building site is classified as regards soil type.

Module at a glance:

<table>
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<tr>
<th>Topic</th>
<th>You will learn</th>
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<tr>
<td>Problem soils</td>
<td>- The significance of water table levels</td>
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<td></td>
<td>- About expansive soils</td>
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<td></td>
<td>- About collapsible soils</td>
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<td></td>
<td>- About the problems posed by limestone and dolomite areas</td>
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<tr>
<td>NHBRC site classification</td>
<td>- How building sites are classified</td>
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<td></td>
<td>- The different foundation solutions which are prescribed for each building site class</td>
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Site classification, soil types & site topography

The need for geotechnical and site classification

There are various factors regarding ground conditions which need to be taken into account when the foundations are constructed for a new house. These are:

- Water table levels - run-off from sloping ground above and nearby vleis (wetlands)
- Expansive soils – clay
- Collapsible soils – sandy
- Dolomite and limestone areas
Many soils can prove problematic in geotechnical engineering because they expand, collapse, undergo excessive settlement, or are easily erodible.

**Expansive soils**

Most clay soils change in volume in a seasonal cycle as the moisture content of the soil varies with the seasons. Shrinkage occurs mainly in the dry season and swelling during the wet season. Damage to structures occurs, when the potential expansiveness of the soil has not been properly taken into account during the design of the foundations.

**Collapsible soils**

Collapsible soils undergo a sudden decrease in volume when trigger events occur. Such a trigger may be: wetting under load, stress changes or even stresses (loading) due to earth tremors. An underlying dolomitic or limestone bedrock, which is easily eroded by acid water, can cause sudden collapse (sinkholes) of the soil at the surface.

**Erodible soils**

Erodible soils are soils affected by flowing water. Water moving over or through soil will tend to physically remove particles from the exposed surface. Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil type.

Generally, soils with faster infiltration rates (velocity or speed at which water enters into the soil), higher levels of organic matter and improved soil structure, have a greater resistance to erosion. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils.
Site Classes

The NHBRC requires a Competent Person to classify the ground on each building site in accordance with a site classification designation (NHBRC Manual Part 1, Section 2, Table 1).

**Definition of a “Competent Person”...**
Defined by the NHBRC as a registered person in terms of the Engineering Professions of South Africa Act (Act 114 of 1990), or a person registered in terms of Section 11 of the Natural Scientific Professions Acts (Act 106 of 1993) and holding indemnity insurance in respect of the appropriateness and design of homes.

The following site classes are specified in the NHBRC manual (Part 1, Section 2, Page 11):

<table>
<thead>
<tr>
<th>Typical Founding Material</th>
<th>Character of Founding Material</th>
<th>Site Class</th>
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</thead>
<tbody>
<tr>
<td>Rock</td>
<td>Stable</td>
<td>R</td>
</tr>
<tr>
<td>Clays (fine grained soils with moderate to high plasticity)</td>
<td>Expansive</td>
<td>H</td>
</tr>
<tr>
<td>Sand (including silt &amp; gravel)</td>
<td>Compressible &amp; potentially collapsible</td>
<td>C</td>
</tr>
<tr>
<td>Fine grained clay silt, sand and gravel with low plasticity</td>
<td>Compressible</td>
<td>S</td>
</tr>
<tr>
<td>Contaminated soils, fills, dolomitic areas, marshes, reclaimed areas &amp; very soft areas</td>
<td>Variable</td>
<td>P</td>
</tr>
</tbody>
</table>

There are also a variety of sub-classes for H, C and P classes. Site classes and sub-classes are based on potential soil movements and - depending on the classification - reinforced foundation footings and slabs and/or sub-surface drains may be prescribed by a Competent Person.
What the Competent Person looks for on a building site

“Plasticity” (classes H and S): refers to the degree of adherence of moist soil particles one to another. A practical initial site test is to take a pinch of the moist soil and rub it together between thumb and forefinger. Soils with a high plasticity easily form a mouldable mass when rubbed together.

“Expansive” clay soils are prone to “heaving” and this condition is common with many clay soils. In the Western Cape clay soils tend to expand during the wet winter months and contract during the dry summers. In the summer rainfall areas of South Africa the opposite occurs.

Once the site has been classified, the Competent Person may instruct the builder to remove problem soils and to replace these soils with more suitable material.

It is also often necessary to remove sodden clay soils – this is because during rainy weather clay soils, once wet, cannot be adequately compacted prior to throwing a concrete slab. This is why it is important to grade surrounding ground levels away from foundation trenches, and to ensure that standing water is not allowed to pond in the trenches, prior to the pouring (throwing) of the concrete. If this happens during rain, then, depending on the soil type, the trenches may need to be enlarged prior to pouring concrete.

Warning...
Although this provision is frequently ignored by architects and draughtsmen, the NHBRC requires that the site class should be included on the site drawings (plans). NHBRC Manual Part 1 Section 3.1 states: “The site class as designated in terms of Part 1, Section 2, Table 1 shall be stated immediately above the title block on all drawings. When a Competent Person(s) is/are appointed then that person’s name, registration number and signature shall also be provided immediately above the title block.”
Compaction

Proper compaction is vital preparatory work that must be properly done before concrete footings or slabs are poured. The Module on Foundations deals with this subject in greater depth.

Compaction is usually done with mechanical compactors – plate compactors for light duty work (such as paving) and “whackers” (also known as a pogo compactor) - for more penetrating compaction. Watch your feet when operating a whacker!

Soil and fill must be properly compacted in layers and the Competent Person will usually test for suitable compaction using a device known as a *penetrometer*. This is a weighted metal cone which is dropped onto the compacted material and the depth of the indentation the cone leaves is an indication to the Competent Person as to whether the fill has been properly and uniformly compacted. Core samplings of the fill may also be used.

Foundation design in problem soils

The NHBRC requirements for foundation design, building procedures and precautionary measures for single storey houses to be built on expansive or collapsible soils, are listed in the NHBRC Manual Part 1; Section 2; Tables 5-7. These requirements can be summarised as follows:

**Site Class H**

Expansive clay and silt soils: Estimated total heave less than 7.5mm.

Normal construction (strip footing or slab-on-the-ground (raft foundation)). Attend to site drainage issues.
**Site Class H1**

Expansive clay and silt soils: Estimated total heave between 7.5-15mm.  
Lightly reinforced strip footings; light reinforcement in masonry and articulation joints at all external/internal doors and openings.  

**OR**  
A raft foundation (A raft foundation is a type of foundation that spreads the load from a building or structure over a large area. A raft foundation is generally a slab of concrete that extends over the entire area of the building. This concrete can be stiffened by ribs or beams in order to provide extra strength and to help with the distribution of the load.) with the removal of all problem (expansive) soil to 1 m beyond the perimeter of the building, and replacement with compacted inert backfill. Attend to site drainage issues.

**Site Class H2 and H3**

Expansive clay and silt soils: Estimated total heave between 15-30mm.  
Reinforced raft foundation OR Piled foundations with suspended floor slabs, with or without ground beams. Reinforce masonry and install movement joints. Attend to site drainage issues.

**Site Class C**

Compressible and collapsible sandy and gravel soils: Estimated total settlement less than 5mm.  
Normal foundations (strip footings or slab-on-the-ground). Attend to site drainage issues.
Site Class C1

Compressible and collapsible sandy and gravel soils: Estimated total settlement between 5-10mm. Reinforced strip footings; and/or remove and replace material below foundations; or deep strip foundations founded on a solid horizon below the problem horizon; or remove in situ material and construct raft foundation. Attend to site drainage issues.

Site Class C2

Compressible and collapsible sandy and gravel soils: Estimated total settlement more than 10mm. Stiffened strip footings or stiffened raft with reinforced slab; or reinforced ground beams or solid slabs on piled foundations. Attend to site drainage.

Site Class S

Fine grained compressible soils: Estimated total settlement less than 10mm. Normal strip footing or slab-on-the-ground. Good site drainage.

Site Class S1

Fine grained compressible soils: Estimated total settlement 10-20mm. Same as C1.

Site Class S2

Fine grained compressible soils: Estimated total settlement more than 20mm. Same as C2.
Building on contaminated soils

Site Class P

Contaminated soils, controlled fill, dolomitic areas, landfill and marshy areas with shallow water tables. A competent person must be appointed to investigate the installation of subsurface drains in marshy areas or areas with a shallow water table. Building in dolomite and limestone areas

Dolomites and limestone

These are rock formations which can be dissolved by percolating water – resulting in cave systems, low density materials and voids. The well-known Cango Caves are such a formation. Catastrophic surface ground movements can be caused should the material above the weakened rock formations collapse. In South Africa the risk of collapse and subsidence is usually more severe and prevalent in dolomite areas, rather than in limestone areas.

Building on soils which overlie dolomite or limestone formations, is subject to investigation of the depth and type of the overlay of and the state of the water horizons.

True or False...
Dolomitic areas, which after investigation, are deemed safe for township development are classified as Class P if the risk of sinkholes is accepted by the NHBRC. Answer: true
Inspection guidelines from this module

Practical application of your technical knowledge

Many of these SAHITA modules conclude with a section entitled: “Inspection Guidelines”. The idea is to help you focus on a practical application of the theoretical knowledge you have just been exposed to in the module. Being a good home inspector is the art of evaluating an inspected house using a solid background of knowledge and experience.

The home inspector should become familiar with the main problem soil types which occur in the inspector's area of operation and should evaluate and report on the condition of the inspected house, in the light of known local soil conditions.

However, while the inspector may be operating, for instance, in an area known for its expansive soils, this does not mean that the soil type on the inspected property is definitely expansive (clay). It is merely an indication that expansive soils are prevalent in this area.

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If the inspected house shows extensive settlement cracking, then that is an additional indication that a problem soil type exists.

Extensive and serious settlement cracks are also an indication that the designer/builder failed to properly take this problem soil into account, when designing and installing the foundation footings for the house.

On all new housing the NHBRC requires (1.3.1.) that the site class, as designated in terms of NHBRC 1.2. Table 1, must be stated immediately above the title block of all drawings. This requirement is routinely ignored by many architects/draftsmen.

The known problem soil type should be included in the inspector’s report and should be related to actual damage observed on the inspected structures.

Before you take the online test, please......
Make sure that you are thoroughly familiar with the material in this module before completing the online test. The more familiar you make yourself with the information presented in this Module the better you will be as a professional home inspector. Review thoroughly all areas of this module before and during the open book online test.