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| University of pretoria |
| Foundation on expansive soils |
| Department of Geology |
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| **Sedzani Elia Muravha 28234422** |
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| Topic 9 |

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Abstract

The report focus on the tendency of swelling and shrinking of expansive soils on different foundations types and the properties as well as characteristics of the soil. There are various foundation types that can be contructed on expansive soils, namely: shallow foundations, mat foundations, pile foundations and caissons. When construction foundation on expansive soils the engineering properties of the soil such as strength, permeability, excavatability, density as well as plasticity index has to be considered.

Introduction

Foundation is the lowest load-bearing part of engineering infrastructures such as building and dams, typically below ground level. Foundation on expansive soils can be affected by various engineering properties and characteristic of the soil. Creating a foundation on expansive soils one has to consider the engineering problems and type of foundation support that can be utilised. Testing methods and foundation reinforcement on expansive soils are thus vital in engineering geology.

Objectives

* The report will focus on the characteristics and the behaviour of expansive soils on foundation. The main focus on the characteristics and behaviour is the swelling-shrinkage properties of the soil
* The foundation types to be applied on expansive soils will also be elaborated.
* The engineering properties, problems and solution need to be considered when constructing a foundation on expansive soils.

Characteristics of expansive soils

The expansion potential of expansive soil on a foundation is determined by the amount of clay and type of particular clay in the soil. Expansive soils form mainly by the alteration of other minerals through the action of chemical weathering (Mclean and Gribble 2005). The type of soil formed depends on the composition of the parent material that has undergone weathering and the climatic conditions where weathering took place (Mclean and Gribble 2005). The engineering properties of expansive soils depend on the grain size, mineralogy and water content, all of which are inter-related (Waltham 2002).

Chemical weathering of parent rock in high rainfall climatic conditions mainly form primary minerals. The primary minerals altered through chemical weathering processes into secondary minerals. For example, the hydrothermal alteration of primary ferromagnesian minerals can result in secondary chlorite (Mclean and Gribble 2005). Chemical decomposition of primary minerals of the rock are altered to secondary minerals such as the smectite group, mainly montmorillonite which is a 1:2 clay type mineral which further weathers to kaolinite ,which is a 1:1clay mineral as moisture content of the soil increase (Brink 1983).



Figure 1: The structure of montmorillonite (Mclean and Gribble 2005).

Expansive soils have swelling tendencies which are quantified by the swell potential and swelling pressure parameters (Al-Rawas and Goosen 2006). Al-Rawas and Goosen (2006)defined swelling pressure and swell potential **“**The swell pressure of a soil is the external pressure that needs to be placed over a swelling soil to prevent volume increase, while the swell potential of an expansive soil is the magnitude of heave of a soil for a given final moisture content and loading condition**.** There are different ways to recognise expansive soils in the field before constructing a foundation.

Field recognition of expansive soils (Waltham 2002):

* Stick when wet
* Polished glaze on cut dry surfaces
* Dry lump dropped in water expands so fast that it breaks up explosively.

Engineering properties

1. The strength of the foundation

The strength of material in which the foundation is built, depends on the topography and climatic conditions in which the material is exposed to (Brink 1983). When slope angle is greater than the angle of repose, slope failure occurs (Brink 1983). All soils fail in shear strength, which is a combination of cohesion and internal friction expressed by Coulomb failure envelope (Waltham 2002).

1. Permeability

Expansive soils are highly impervious and have a tendency of contracting and expanding due to the amount of moisture content present, which then causes further change in volume and density. They absorb and attract the moisture thus reducing evaporation of moisture by the permeability.

1. Excavatability

Expansive soil can easily be excavated using a shovel, pick or a bulldozer (Brink 1983).

1. Density

Soil density increases with an increase in moisture content (Brink 1983). During construction, the compaction of soil is very important to increase the cohesive force between soil particles, hence strengthening the soil (Brink 1983). The N-values refers to different climatic conditions under which the expansive soils can be found.

1. Plasticity index

Expansive soils are highly plastic and they contain high moisture content due to the attraction and absorption of water (Shi *et al.* 2002). Changes in the moisture content in expansive soils may exhibit a degree of shrink-swell reversibility which exerts large pressures against non-yielding structures (Shi et al. 2002). Expansive soils have high shearing strength and high plasticity index (Brink 1983).

Foundation types

There are different types of foundation that can be applied in geotechnical engineering: Shallow foundations, mat foundations, pile foundations, and caisson foundations (Rajapakse 2008).

1. Shallow foundations

 Figure 2: Shallow foundation (Rajapakse 2008).

Shallow foundations are applied when the soil beneath the footing is strong enough to sustain the load of the building and is compressible (Rajapakse 2008).

1. Mat foundations



Figure 3: The figure shows a Mat foundation and the picture shows the mat foundation (Rajapakse 2008).

Mat foundation is a common type of found also known as raft foundation which is a spread-like mat in which the building is distributed over a large area (Rajapakse 2008).

1. Pile foundations

Figure 4: Pile foundation (Rajapakse 2008).

Pile foundation can be utilised when the load-bearing soil is at greater depth where the load has to be transferred to the load-bearing soil stratum (Rajapakse 2008).

1. Caissons

 Figure 5: Shows the caissons foundation type (Rajapakse 2008).

Caissons are lager piles that can be utilised to replace pile group and in some situation, caissons can be the best alternative to pile group (Rajapakse 2008).

Engineering problems

The activity of the expansive soil should be considered whenever construction has to done on such soils. Swelling and shrinking of soil is a major problem in foundation constructions. Depending on the amount of moisture content in expansive soil, there will be a corresponding percentage of volume change (Mclean and Gribble 2005). Foundation on expansive soils can cause lifting of a slab or other structure during periods of high moisture. When there is less moisture content the soil will collapse and may result in extensive damage of buildings. The expansive potential of soil influence the magnitude of heave experienced at the site (Brink 1983).

Brink (1983) states that “the climate, and the thickness and permeability of the near-surface horizons of the soil profile, will determine whether the state of heaving under the edges of the building will be transitional or permanent”. Shrink-swell soils that have expanded contain high moisture content which reduces the strength of the soil thus increasing the instability of foundation and slope failure (Waltham 2002).

Engineering solutions

When constructing a foundation on expansive soils one should know types of foundation to be utilised. There are different types of foundation solution that can be applied, namely: (Brink 1983)

* Partial demolition and rebuilding on piles
* Under pinning with piles
* Reinforcement of sections of a building with tie-bars
* Building wall that provide the degree of flexibility
* Total removal of expansive soils and build on strong rock or non-expansive soils
* Post-wet the whole area and pave with bricks or blocks laid on the plastic membrane, covering will prevent vegetation growth hence retaining the moisture by preventing evaporation and thus preventing heave in expansive soils.

Construction may also require fully instrumental test wall reinforced with bearing reinforcement (Horpibulsuk 2011).

Conclusion

Expansive soils are very problematic during the construction of foundations. Foundation on expansive soils is affected by the behaviour of soil under different moisture content. The swelling tendency of expansive soils on foundation can be quantified by the swell potential and swelling pressure parameters. The major engineering problem of expansive soils on foundation is shrink-swelling characteristics of the soil. Engineering problems and solutions need to be defined to assess a type of foundation to be constructed. Foundation types that can be utilised on expansive soils are pile, raft, shallow and caissons foundation.

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