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Shrinkage and Swelling of Soils

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Abstract

The soil shrinkage is defined as the specific volume change of soil relative to its water content and is mainly due to clay swelling properties. Shrinkage is due to the volume change of the soil plasma and to some extent of the structural porosity with water content. Shrink / swell potential is the relative change in volume to be expected with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil.

Introduction

Shrinkage is due to the volume change of the soil plasma and to some extent of the s tructural porosity with water content. Shrinking and swelling are generally associated with fine-grained clay soils. Distinguish between soils having different magnitude of swelling, as well as the consequences on soil structural behaviour. In this popular article the shrinkage and swelling of soils and its mechanisms were discussed below.

Objectives

- Understand soil swelling and shrinkage mechanisms, and the development of desiccation cracks;
- Distinguish between soils having different magnitude of swelling, as well as the consequences on soil structural behaviour;
- Know methods to characterize soil swell / shrink potential;
- Construct soil shrinkage curves, and derive shrinkage indices, as well to apply them to assess soil management effects.

Shrinkage and Swelling

- Some soils will change volume significantly depending upon their moisture content.
- This poses a special problem for pavement design because this volume change can cause overlying pavements to sink down or heave up unevenly potentially resulting in a cracked or uneven pavement.
- Jones and Holtz (1973) estimated that shrinking and swelling soils cause about $2.3 billion of damage annually in the U.S. alone.

Affected Soils

Shrinking and swelling are generally associated with fine-grained clay soils.

Shrinkage Soils

Soil shrinkage is generally confined to the upper portions of a soil. Shrinkage and shrinkage cracks are caused by a reduction in soil moisture content through:

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• Evaporation from the soil surface in dry climates.
• Lowering of the groundwater table.
• Desiccation of soil by trees during temporary dry spells in otherwise humid climates.

Shrinkage Soil – Mechanism

• As moisture content decreases, capillary stress in the void spaces increases due to the increased surface tension.
• This increased surface tension tends to pull adjacent soil particles closer together resulting in an overall soil volume decrease.
• As moisture content continues to decrease, capillary stress continues to increase, which continues to reduce overall volume.
• The point where no further volume reduction occurs but the degree of moisture saturation is still 100 percent is called the shrinkage limit (SL), which is an Atterberg limit, just as plasticity index (PI).
• At this point the capillary menisci just begin to retreat below the soil surface, which can be seen by a change in surface appearance from shiny to dull.
• The shrinkage limit is not commonly tested because of various difficulties.
• However, a soil near the shrinkage limit typically has lower void ratios that can be achieved by compaction because of the associated high capillary stress.
• When the climate changes and the shrunken soils again have access to water they tend to swell.

Swelling (Expansive) Soils

• Swelling soils, also known as expansive soils, are ones that swell in volume when subjected to moisture.
• These swelling soils typically contain clay minerals that attract and absorb water.
• When water is introduced to expansive soils, the water molecules are pulled into gaps between the soil plates.
• As more water is absorbed, the plates are forced further apart, leading to an increase in soil pore pressure (Handy, 1995).

Extensively Swelling Vertisol

• If this increased pressure exceeds surcharge pressure (including the weight of the overlying pavement) the soil will expand in volume to a point where these pressures are once again in balance.
• Swelling pressures can be on the order of 100 - 200 kPa (14.5 - 29 psi) and have been measured as high as 1000 kPa (145 psi).

Stages of Soil Swelling

When a dry soil wets, during-

• The first stage it undergoes three dimensional (3-D) volumetric expansions, because its desiccation cracks are still opened (Figure 1)

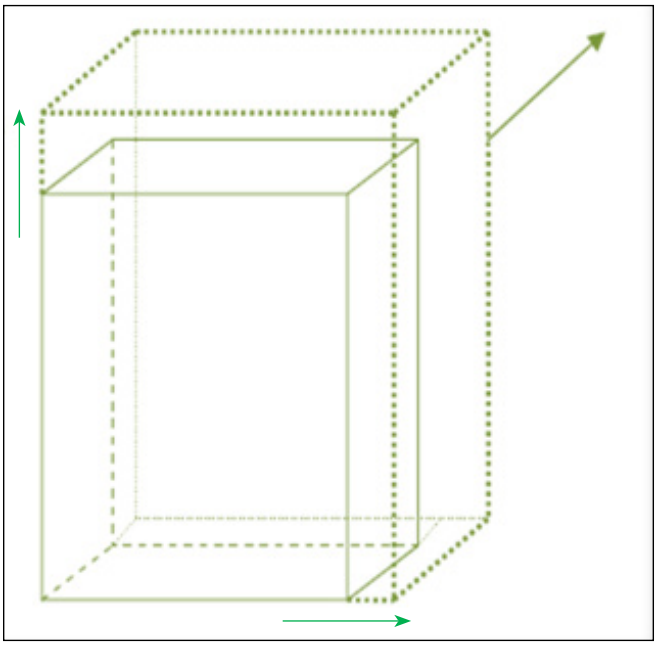

Figure 1: First stage undergoes three dimensional volumetric expansions

• In a second stage, after desiccation cracks were closed, soil volumetric expansion is only 1-D, causing the rising of soil level (Figure 2).

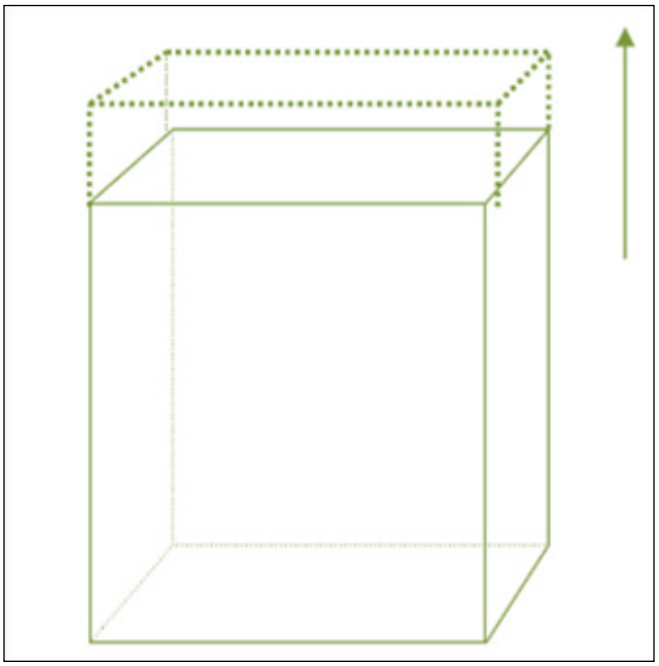

Figure 2: Second stage of soil volume expansion

Problems by Shrinkage and Swellings

• Problems-Clay groups with a high shrink-swell capacity tend to damage crops during dry spells, as the soil contracts, pulling roots apart.

• Additionally in wet periods expansion of the clay can lead to ground heave, which can damage the foundations of buildings.

Conclusion

This popular articles stated that the process of soil shrinkage and swelling and factors attributing the effects and problems behind the process of soil shrinkage and swelling properties. The literature will provide thorough knowledge to the people those who are practicing agriculture with appropriate prevailing weather parameters to cope up with different abiotic factors.

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