TYPES OF EXPANSIVE-SHRINKABLE SOIL IN CHINA AND THEIR ENGINEERING GEOLOGICAL CHARACTERISTICS

LES SOLS SUJETS A GONFLEMENT ET RETRAIT EN CHINE ET LEURS PROPRIETES GEOTECHNIQUES

HOU Shitao, Hubei Comprehensive Survey and Prospect Institute, Wuhan, China

Summary

Distribution and mineralogical characteristics of various types of expanding-shrinking soils in China are discussed. Properties are related to lithological structure, variations in moisture content and geomorphological setting. Examples are given of the behaviour of buildings affected by swelling and shrinking, the types and location of damage, and the long term performance.

Résumé

La distribution et les caractéristiques minéralogiques de divers types de sols sujets à gonflement et retrait, en Chine, sont discutées. Les propriétés sont liées à la texture lithologique, aux variations de teneur en eau et à la position géomorphologique. Des exemples sont donnés de comportement de bâtiments affectés par un gonflement ou retrait, des types et localisation des dommages et du comportement à long terme.

Along with the development of the socialist construction, various types of expansive-shrinkable soil have been found in vast area of China. In order to solve increasing geotechnical problems, scientific research on this special soil has been organized by our country and two National Symposia with rich achievements were held respectively in 1975 and in 1977.

It is reported that engineering problems of the expansive-shrinkable soil have arisen in as many as over 20 provinces, municipalities (autonomous regions).

As regards the research work in Sichuan, Yunnan, Guangxi, Hubei, Anhui, Henan, Hebei, Shaanxi, Shandong, Guizhou, Shanxi, Guangdong provinces, the distribution area of the expansive-shrinkable soil has been around some hundred thousand square kilometres and economic loss has reached up to some hundred millions Renminbi Yuan.

Based on the work in the mentioned area, this paper deals briefly with the main types of expansive-shrinkable soil in China, their engineering geological characteristics, deformation of buildings in the expansive-shrinkable soil and the failure characteristics.

Main types of the expansive-shrinkable soil in China

According to the cause of formation, the expansive-shrinkable soil in China may be classified into three basic types as follows:

Type 1. Lacustrine facies deposit of the Neogene period and the early Quaternary period

Type 2. Fluvioglacial deposit of the Quaternary period, pluvial-alluviation, eluvial-diluviation

Type 3. Ehuivial-diluvial deposit of the Quaternary period in the limestone area

Description in detail is as follows:

Type 1. Lacustrine facies deposit of the Neogene system (N1):

In the main these are the set of grey, grey green, grey white, grey yellow clays; shales, calcareous mudstone, marlile and the weathered layers distributed in the lake basin of the Neogene period in Yunnan and the southwest part of Guangxi.

Type 2. Lacustrine facies deposit of the early Quaternary period (Q1):

In the main these are the set of grey white, grey green clays distributed in the lake basin of the early Pleistocene epoch in the central part of China.
Extensional geological characteristics of the expansive-shrinkable soil in China

The expansive-shrinkable soil has its own particular lithological structure and geomorphology. This is due to the comprehensive effects of various geological forces on the inherent property of the soil in the long geological history, and this also serves as a guide to understand the inherent properties.

**Lithological structure**

**Lithology:** The expansive-shrinkable soils in China are generally clayey. Particularly, Type I and Type 3, due to the ratio of the fine grains, are high plastic clays. The average index of plasticity is over 25%. The eluvial-diluvial type of expansive-shrinkable soil mixes more coarse-grained materials with small ratio of fine grains, so that the index of plasticity as low as around 20%. Rare mild clay with the index of plasticity below 17% also exists.

**Colour:** Colours of the expansive-expandable soils may be classified into two categories. Taking grey as the basic colour, grey, grey green, yellow, yellow brown, red yellow clays and mild clays are presented for Type 1 expansive-shrinkable soil; while for Type 2, 3, “yellow” is taken as the basic colour and yellow, yellow brown, red yellow clays are presented. But banded or nodulized grey, grey white clays are interfaced with this type of expansive-shrinkable soils taking “yellow” as the basic colour.

**Structural state:** In the natural state, the liquidity-index of the expansive-shrinkable soil almost approaches to “zero” or below “zero”, so the state generally is hard to hard-plastic. This state only exists in the case of natural water content (usually around 20~25%). When the soil is immersed in water or saturated through with water, it is rapidly softened and collapses. There is an old popular Chinese saying describing this state of the expansive-shrinkable soil “as hard as a knife on the fine days, and as muddy as a marsh land on the rainy days”.

Development of fissures is one of the important characteristics of the expansive-shrinkable soil. Particularly for various oblique cracks, the fissure faces are smooth with compression water-logging marks or the fissures are filled with black brown, grey white, grey mineral films. Within a certain depth, though the fissures of the expansive-shrinkable soil are in the close state, the strength of the soil body greatly decreases. The fissures develop rapidly as soon as they are exposed after excavation. Some fissures are linked together to form a weak face leading to a slide or failure. All kinds of fissures and joints cut the earth body into different sized blocks or prisms. The structure of the expansive-shrinkable soil has a close relation with the expansive-shrinkage property. The 1~2 cm prism-shaped structure has the largest potentials of expansion-shrinkage.

**Inclusions:** The main inclusions in the expansive-shrinkable soil in China are the calcareous nodules and ferro-manganese nodules. The former mostly exist in Type I expansive-shrinkable soil while the latter spread in the other types. Generally these inclusions are scattered, but sometimes are enriched into layers. Rock chips or sands mixed within some eluvial-diluvial type of expansive-shrinkable soil may also be regarded as inclusions.

From the above general field characteristics, types of the expansive-shrinkable soils can be summed up as follows:

**Type 1.** Fluvial-glacial deposit of the Quaternary period, fluvial-alluviation

**Type 2.** Fluvial-glacial deposit of the middle Pleistocene series of the Quaternary period (Q2 gl): In the main there are binary structural sediments. The upper part of which is yellow, yellow brown, red yellow clayey soil, i.e., the expansive-shrinkable soil, distributed in Sichuan basin.

**Type 3.** Fluvial-diluvial deposit of the middle-upper Pleistocene series of the Quaternary system (Q2 gl-al):

- **Mainly, it is a set of yellow, yellow brown, red yellow clayey soil distributed in the high terrace along rivers of Hubei, Anhui, south part of Shaanxi, Shandong provinces, etc.
- **Residual “red clay” of the Quaternary system (Qel-dl):**

A special set of “red clay” has been deposited in the karst cycle within the vast limestone area of Guangxi, Guizhou of the southwest part of China and the north part of Guangdong. This is another type of the expansive-shrinkable soil.

**Residual “red clay” of the Quaternary system (Qel):**

- **Residual “red clay” in the karst cycle is a set of yellow red, brown high plastic clays.
- **Re-migrated “red clay” of the Quaternary system (Qel-pl-al):**

Re-migrated deposit of the red clay in the limestone area is a set of yellow red, brown clays with coarse materials such as pebble gravels.

**Engineering geological characteristics of the expansive-shrinkable soil in China**

The expansive-shrinkable soil has its own particular lithological structure and geomorphology. This is due to the comprehensive effects of various geological forces on the inherent property of the soil in the long geological history, and this also serves as a guide to understand the inherent properties.