# Central region loess type soil collapsibility and compressibility properties study of Mongolia

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## ABSTRACT

Concluding the accumulated data on site and laboratory experiments over many years on loess type soil which is commonly spread across the central regions of Mongolia, the integrated table of physical-mechanical properties is developed based on the Darkhan and Erdenet cases. The region's loess type soil comparative shrinkage index ($\varepsilon$), water coefficient(W), void ratio (e)- relationship variables were determined by linear regression method, which led to the iteration of the equation. Therefore, the deformation condition and factors of buildings in the region were assessed. Depending on the regional soil properties, the optimal foundation type is recommended. \

**Keyword:** collapsible soil, degree of humidity, pile foundation, soil bedding, compacting soil

## 1 INTRODUCTION

Assessment of the collapsing soil properties of deluvial-proluvial clay soil of Central Mongolia is the top priority, since this type of soil is the foundation soil of the most current buildings and structures under construction which is widespread in the intermountain valleys, in the middle and lower parts of the slopes of local elevations. These areas are primarily subject to construction development. In the Darkhan-Selenge and Erdenet-Orkhon regions, the infrastructures such as road, railway and sectors such as industrial and agriculture are rapidly developing.

## 2 ENGINEERING GEOLOGIC EXPLORATION

Most researchers have determined the main characteristics of loess rock as high content of dust particles (over 50%), low natural humidity (up to 15%) and less porosity /over 42% -45% /. The criteria mentioned above is associated with indirect indicators that are determined in the regulatory documents and the soil is classified as a collapsing soil according to the criteria above. Even though the sandy-loamy varieties that are common in the central regions of Mongolia do not meet the criteria, these varieties often have subsidence under specific conditions such as self-weight collapse loess and additional loads.

## 3 STUDIES OF THE PHYSICAL-MECHANICAL PROPERTIES

The result of the physical-mechanical properties studies which were conducted through 782 laboratory experiments reveals that the clay soil had minor properties of collapsing soil when it was exposed to a pressure of 0.2-0.3 MPa.

Most researchers have determined the main characteristics of loess rock to have high content of dust particles (over 50%), low natural humidity (up to 15%) and less porosity /over 42% -45% /. In the Darkhan region, the clay soil showing subsidence properties with a humidity degree of $\boldsymbol{S_r}$= 0.6 appeared in only 2 to 3 per cent of the cases with pressure of 0.2 to 0.3 MPa.

In the case of the clay soil with a degree of humidity $\boldsymbol{S_r}$= 0.7, it is very low to have relative subsidence ratio / $\boldsymbol{\varepsilon}$ / exceeding 0.01. At a pressure of 0.1 MPa, $\boldsymbol{\varepsilon}$ is 3%, at a pressure of 0.2 MPa, $\boldsymbol{\varepsilon}$ is 9% and at a pressure of 0.3 MPa, $\boldsymbol{\varepsilon}$ increases to 15% of the total number of samples. The data suggests that in terms of the parameter it is possible to separate potentially subsiding soils from non-subsurface soils. Analysis of the effect of natural humidity on the degree of manifestation of subsidence signs did not reveal a clear relationship, as is in the case with the parameter of the degree of humidity **(tab 1)**.

Table 1. Generalized table of the main physico-mechanical parameters of collapsing loess-like soils of the Darkhan-Selengian region

| generation number | Soil marking | Thickness | Particle composision 20 40 60 80 | Natural moisture, % 0.10 0.20 | Dry soil density, г/см$^3$ 150 160 170 | The number of plastics 0.10 0.20 | Relative subsiding parameter 0.01 0.02 0.03 0.04 0.05 0.06 | Type of soil |
|---|---|---|---|---|---|---|---|---|
| 1 | | 0.5-1.1 | | | | | | clay loamy average density |
| 2 | | 1.1-4.2 | | | | | | brown light yellow clay loam |
| 3 | | 4.2-7.5 | | | | | | yellowish silty sandstone |
| 4 | | 7.5-12.6 | | | | | | red-brown clay loam with sand-loving |
| 5 | | 12.6-13.9 | | | | | | large crustaceous soils with sandy bedrock |
| 6 | | 13.9-15.1 | | | | | | large crustaceous soils with clay loamy seals |
| 7 | | 15.1-17.8 | | | | | | large crustaceous sandy seals |

## 4 THE STUDY OF COLLAPSIBILITY AND COMPRESSIBILITY

The subsidence deformation is a process of soil pressure due to the appearance of structural strength during moisturizing under the influence of loads. Since the main factor that affects the magnitude of subsidence deformation is the "half solidfied" state, which is indicated by the density index / porosity coefficient (**e**) /, the results of determining the relative subsidence due to the primary soil density and vertical loads is calculated.

## 5 THE REGRESSION EQUATION AND THE PROBABILITY DIAGRAM

As a result of numerical studies mentioned above, the linear regression equation and compiled tables of the main physical and mechanical parameters according to the region is generated using R-Plus software package.

$$l_g\delta_1 = -1.744S_r + 0{,}886e_0 - 2{,}1542;\ n=69;$$

$$S^1_{res}(l_g\delta_1) = 0{,}2116 \qquad (1)$$

$$l_g\delta_2 = -1.806S_r + 0{,}885e_0 - 2{,}093;\ n=121;$$

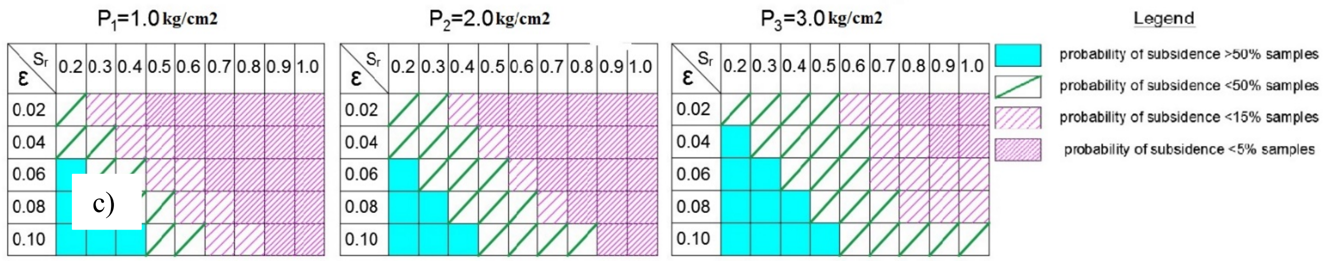
$$S^2_{\text{ост}}(l_g\delta_2) = 0{,}2115 \qquad (2)$$

$$l_g\delta_3 = -1.641S_r + 0{,}922e_0 - 1{,}9972;\ n=147;$$

$$S^3_{\text{ост}}(l_g\delta_3) = 0{,}4387 \qquad (3)$$

By using the linear regression equations, a qualitative prediction of the tendency of clay soils to result in subside deformations can be made and based on the diagram **(fig 1)**, the probability of subsidence properties in the planned soils can be estimated .

a) b)




## 6 CAUSES OF DEFORMATION IN BUILDINGS AND STRUCTURES

Most of the structures are equipped with water heating, water transfer pipe and sewage system, i.e. During the blueprint reproduction stage, it is mandatory to take the possibility of water leaks from the networks and soaking of base soil and bedding below floor into account. It is also required to consider the cases of soaking of soil by surface water due to improperly executed planning of the construction sites or the absence of necessary elements of water protection and landscaping-hard coatings, drainage channels, ditches; cases of soaking by water appearing at the sites as a result of accidents at water-passage structures or as a result of improper operation.

In recent years, there have been sharp increase in soil moisture and a significant rise in the groundwater level due to techno genic factors. There are many cases of deformations and defects of buildings and structures on subsiding soil due to the following shortcomings:

1. Incomplete information about the collapsible soil given in the reports on engineering geological surveys and, as a result, complete or partial neglect of subsidence in projects.
2. Violations of norms, rules and recommendations associated with projects on the construction of foundation, bedding and backfilling methods.

## 7 VARIOUS DESIGN METHODS

There are numerous design methods in construction practice for designing and constructing buildings and structures on subsiding soil. In the presence of possible soaking of the ground soil, the following methods are most commonly used:

1. Elimination of subsidence properties of soil;
2. Penetrating of subsiding soil with foundations;
3. A set of measures including preparation of the base, water protection and constructive measures.

**CONCLUSION:**

1. The subsident loess-like soil is spread over more than 30% of total area of Mongolia, and in the future as the geotechnical studies are expected to be refined, the percentage may increase. Particularly, sharp continental climate (annual temperature amplitude of -35 ° C to + 35 ° C) creates special conditions for the formation of loess-like soil. Significant seasonal freezing (from 3.2 m to 4.5 m) of the soil, due to the small snow fall and a prolonged period of negative temperatures with severe frosts, will add to frost weathering, manifested in an increase in the dust fraction by crushing the sand particles and reducing the structural strength of the soil ultimately increases its subsidence.

2. A distinctive feature of the building properties of subsurface soil in Mongolia is relatively low humidity (**W**<18%), density (**ρ** = 1.42-1.63 $g/cm^3$), degree of humidity ($\boldsymbol{S_r}$<0.47), and minimum porosity (**n**= 40%). The content of sand and dust particles is more than 50% in sandy loams and clay loams. The mineralogical composition is relatively constant both in terms of and in depth by subsidence mainly type I, very rarely type II. According to the lithology, the Quaternary loess-like deposits are deposited from the dive surface of the earth at a depth of 4.5 to 10.0 m, below which solid clay with pebble inclusions and coarse soil with different fillings. Groundwater level below 15.0m and more.

3. As a result of experimental and theoretical studies, it concludes that in the conditions of subsidence loess-like soil in Mongolia, driving and bored piles, foundations in rammed pits, soil compaction with heavy tamping under conditions of preliminary soaking of the foundation soil, and soil bedding with reinforcement are the most expedient methods.

4. As a result of field and laboratory tests of the dilution of the subsident loess soil of Darkhan, it was established that the ratio of deformation moduli at natural moisture and water-saturated state is 3 to 5, then after compaction this ratio decreases to 1.2 to 2.

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