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Review of studies of leoss soils in the territory of mongolia

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ABSTRACT: It has been established that loess-like subsiding soils of Quaternary age are common in 30% of the territory of Mongolia, and it is likely that these percentages will increase and other types of loess soils will be found as the volume of engineering geological survey increases. The issue of a thorough identification of the regional features of loess soils in the territory of Mongolia is an important task for researchers and specialists in this field. The practical significance of the work lies in solving these problems on the basis of comparative results of laboratory and field experiments, analytical calculations and numerical simulation of the subsidence soils of the foundation, pile foundations and artificial foundations and, based on them, the development of new innovative and improvement of existing engineering solutions.

KEYWORDS: Regional feature, Research methods, Properties of loess soils, Summary table, Base, Foundation.

I. INTRODUCTION

According to the results of previous studies, loess-like soils are distributed over about 30% of the territory of Mongolia and it is likely that these percentages will increase and other types of loess soils will be found as the volume of engineering and geological survey increases. Regional features of loess-like soils, common in the territory of Mongolia, are the predominance of el and partially el-proluval and delluval deposits of genetic origin, high macroporosity and undercompaction caused by the effect of sublimation occurring in the state of permafrost and seasonal deep freezing, low humidity, high content of silt particles (more than 50%) relatively high characteristics of bearing capacity and deformability due to structural compounds formed by the content of corbanate and other salt compounds, as a result of moistening of the latter, subsidence occurs.

Due to migration from rural areas, about half of the population of Mongolia lives in Ulaanbaatar (2021 statistics), as a result of which, both in the capital and large cities of the country, overcrowding, smoke, difficulties in organizing urban transport and other problems are observed. To solve these problems, in order to relocate part of the universities and the population from Ulaanbaatar to the cities of Darkhan and Erdenet, in 2019 the Government of Mongolia approved a program for the development of the construction of civil and industrial buildings, as well as the necessary infrastructure and highways to create comfortable conditions for the living population. The practical significance of the work lies in solving these problems on the basis of comparative results of laboratory and field experiments, analytical calculations and numerical simulation of the subsidence soils of the foundation, pile foundations and artificial foundations and, based on them, the development of new innovative and improvement of existing engineering solutions.

II. HISTORICAL ASPECTS OF THE STUDY

Since the middle of the 19th century, scientists from many countries have focused their attention on studying the geography, climate and geological conditions of Central Asia. For the first time in 1866, the American scientist Pumpelly R [1] noted the distribution of loose clay deposits of the Quaternary age of the Cenozoic era in northern China and Mongolia. The Russian scientist N.M. Prizhevalsky [2] and the American scientist Wright G.E [3] conducted repeated expeditions to Central Asia in 1870-1890. According to the study, it was found that clay deposits of Quaternary age are widespread in the territories of the regions of the Gobi part of Mongolia and Northern China.

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Richthofen, F. [4] wrote in his monograph that the genetic growth of the loess deposit in the desert part of North Asia covered the entire period of European glaciation and continued much longer than the Europian loess of formation. The period of active accumulation of loess in the North Asian region coincides with the period of development of the Nanshan-Tibetan icing. In no other country in the world does loess deposit cover such a vast area as in northern China. Here the loess formed an almost continuous cover, stretching for more than 1000 km from west to east and from east to north, and also for 300-400 km from west to northwest. In the early 1900s, Russian scientist V.A. Obruchev [5], American scientists J.G.Anderssen [6] and R.Ch.Andrews [7] studied the Mongolian Gobi and, as a result of archaeological excavations, discovered under the Quaternary loose deposits of continental origin, rare paleontological petrified remains of plants, bones and eggs of dinosaurs.

III. STUDY OF LEOSS SOILS IN MONGOLIA

Since the 1930s, aimag centers have been built up in some parts of the territory of Mongolia, including the cities of Sukhe Bator, the aimak center of Selenga, and its suburbs as soum centers, and in 1960-1980 large industrial cities of Darkhan, Erdenet were built again , Khutul and agricultural complexes, where loess-like subsidence clayey soils are common. Engineering-geological and geotechnical studies in this area were carried out by the expedition of the PNIIIS of Russia, which worked in Mongolia, and the Engineering and Survey Bureau of the Central Design Institute of Mongolia., since 1984 by the BIHUSH Institute, also since the 2000s by the Geotechnical Research Center of the Institute of Building Architecture SHUTIS.

Loess-like subsidence clayey soils in the territory of Mongolia differ significantly from similar soils in Ukraine, Central Asia and other regions of the world in terms of propagation conditions, cryogenic state, physical-mechanical and physical-chemical properties. Since 1990 D. Dashzhamts [8] and S. Nyamdorj [9] summarized the results of earlier engineering geological surveys to determine the regional features of the genetic origin and distribution, the physical and mechanical properties of loess deposits common in Mongolia, and the results of these works were compared with identical characteristics of loess soils common in the Northern Caucasus, Central Asia, Western and Southern Siberia and beyond the Baikal Territory, and also Northern China. Based on the results of the work carried out on generalization and comparative analysis, a survey map of the distribution of loess soils in Mongolia was compiled (Fig. 1)..

OVERVIEW MAP OF THE DISTRIBUTION OF LOESS SOILS IN MONGOLIA

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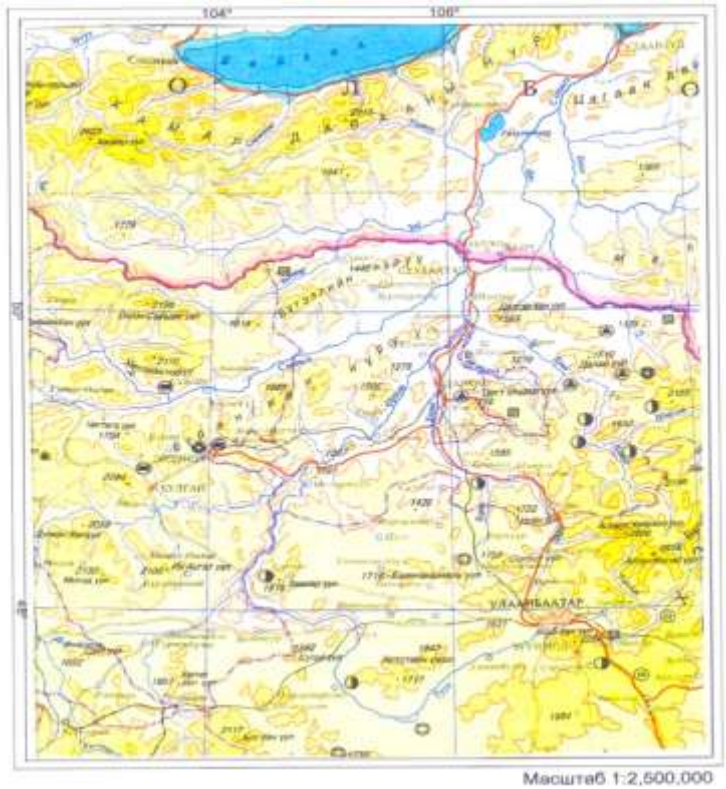
In the 1960s, a joint study was carried out by N.I. Krieger [10] and employees of the PNIIS of Mongolia and the Research Institute of the Earth's Crust of the Russian Academy of Sciences, as well as D. Dashjamts [11]. As a result of the research, it was found that the territory of Mongolia, where loess-like subsiding soils are widespread, is included in the zone of active earthquakes. Therefore, when designing and constructing buildings and structures on subsiding soils, special attention should be paid to earthquake issues.

IV. LOESS OF THE ORKHON-SELENGI REGION

In the Orkhon-Selenge river basin, located between the Khangai and Khenti mountain ranges in northern Mongolia, people lived a relatively sedentary lifestyle, engaged in animal husbandry, agriculture, handicrafts and mining. For example, the ancient "Silk Road", which connected Asia and Europe, passed through the Orkhon-Selenskaya basin and reached Russia through the Khiagt of Mongolia. Such scientists as M.N. Prizhevalsky [2], V.A. Obruchev [6], P.K. Kozlov [12], who traveled along this route, first discovered loessial rocks and studied the state of regional distribution and lithological structure

And at present, the territory of the Orkhon-Selengsky depress is the most important economic and industrial region of Mongolia. According to the current administrative division in the Orkhon-Seleng pit there are 5 aimags and more than 60 soums, their centers and settlements (Fig 2), including such large cities as Erdenet, Darkhan, Zuun Kharaa, Khutul and Sukhe Bator.



ORKHON - SELENGE REGION

Taking into account the review of engineering-geological studies of the indicated area: in the 1960s, according to Yu. V. Krylkov [13], the granulometric composition of clay soils is very fine and homogeneous, and according to the classification of the plasticity number, they belong to the category of light loams. In 1970, Yu. V. Syrokomsky [14] for the first time carried out a detailed study of the physical and mechanical properties of loess deposits in the Erdenet-Darkhan area. According to the results of these studies, in clay and sandy soils, coarse particles occupied 6-13%, and the proportion of silty particles was 52-62%, while 40% in loamy soil and 65% in sandy soil were found, and also under the condition of the

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degree of humidity Sr=0.7 under external pressure, subsidence of loess-like soil is observed.

V. RESEARCH METHODS

According to the research conducted by Minaev A.N. [15] in 1985 in the area of Erdenet, in 1985-1989, Ch.Lkhamsuren [16] established that there is a wide distribution of perennial frozen island soils. T. G. Ryashenko [17] and Ch. Lkhamsuren [16] in 1985 studied the granulometric composition and internal structural structure of the Neogene-Quaternary deposits of the Orkhon-Selensky region and Mongolia.

In the 1990s, D. Dashzhamts [18] tested samples of sandy and loamy soils from the Darkhan and Erdenet districts at the TIS Soil Mechanics Laboratory; specific adhesion at natural humidity and after additional moistening ranged from C=0.27 to 0.08. kg⁄cm^2, the angle of internal friction decreased from φ=24° to 19°. The value of the deformation index increased after soil moistening.

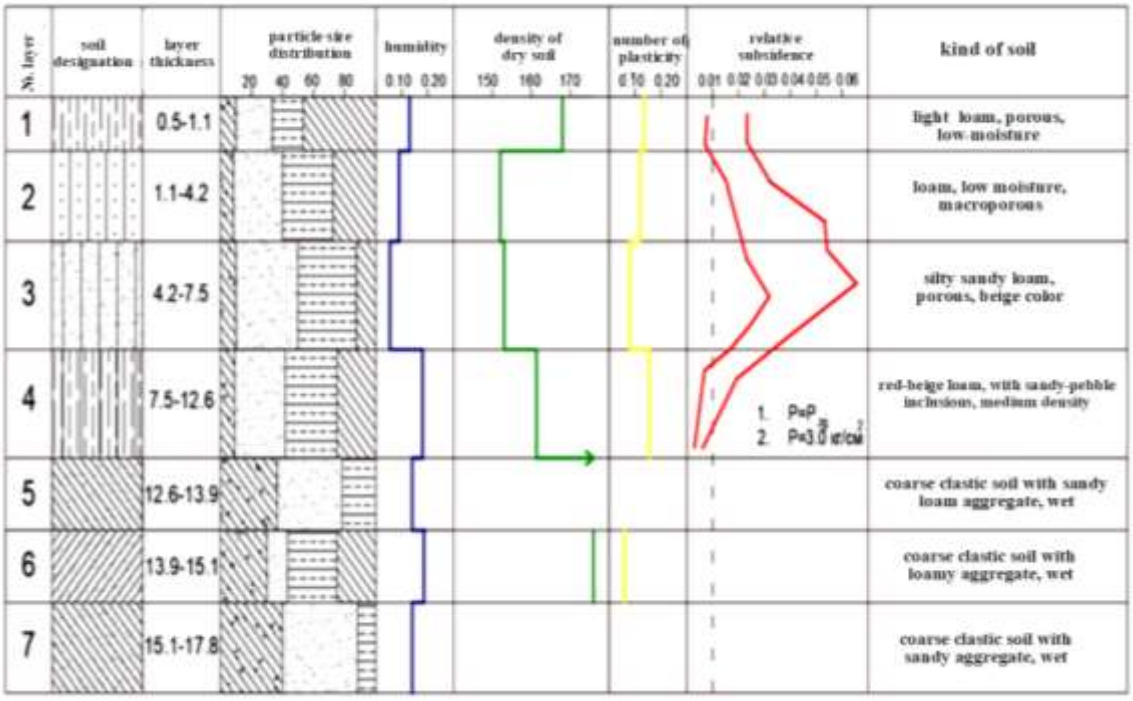
Since the 1990s, N. Batsukh [19] has been engaged in engineering-geological and geoecological studies of the river basin. Selenga. The Selenga river basin is the most subject to anthropogenic activity in our country, and the issue of its protection was worked out by studying anthropogenic changes in soil, water and air in the future.

The Selenga river basin is the most subject to anthropogenic activity in our country, and the issue of its protection was worked out by studying technogenic changes in soil, water and air in the future. At the beginning of 1990, M. Myagmarzhav [20] conducted a study and established a quantitative relationship between the physical and mechanical properties of loess deposits in the Orkhon-Selensky basin.

VI. THE DISCUSSION OF RESULTS

According to the results of the studies mentioned above, loess-like soils common in the Erdenet-Orkhon river basin are dominated by loamy particles, and soils common in the basin of the Darkhan-Selenga river are dominated by sandy ones. Based on the results of analyzes of numerous laboratory and field experiments, a summary table was compiled to identify the patterns of variability of the main physical and mechanical indicators along the vertical axis and depths are shown in tables 1.

Table 1 Summary table of physical and mechanical characteristics of soils in the Erdenet-Orkhon region



The use of tables of physical and mechanical indicators of soils in the Erdenet-Orkhon and Darkhan-Seleng districts for a preliminary assessment of solutions for the bases and foundations of buildings by responsibility classes I and II, and the use of building foundations

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for calculations by responsibility classes III and IV can make it possible to save the costs of engineering and geological research and time (Nyamdorj S.[21]).

VII. REGIONAL FEATURE

Based on these provisions, based on the results of the above-mentioned theoretical and experimental studies, construction experience and lessons learned on the causes of subsidence and deformation of buildings built on subsidence soils, the main solutions that meet the regional characteristics of Mongolia are:

Due to the fact that the territory of Mongolia is located at the height of the Central Asian Plateau, the thickness of the vegetation layer and snow cover in winter is relatively small, the average annual temperature of the territory is about 0℃, and the average number of days with a negative temperature is about 200. According to the norm BNbD "Climatology of the territory of Mongolia", the depth of seasonal freezing of soils is 3.5÷5.0 m, in rare cases, permafrost is found under it.

1. As a result of the sublimation process of permafrost ice (the most recent Altai-Tunguska ice age, which covered most of the Euro-Asian region 15-18 thousand years ago) and seasonal deep frozen soils, occurring for many years in deep frozen subsidence soils, the structure is decompacted, as a result of the latter, porosity n=(50÷65)%, porosity coefficient e = (0.70÷0.84), density of dry soil ρ_d=(1.35÷1.60) t/m^3 or undercompacted, moisture content of sandy loam W=(0.04÷0.06) and loam W=(0.05÷0.08), as a result of repeated freezing and thawing, cracking and grinding of the solid part of the soil occurs, based on this, the content of silty parts is 50-60%.
2. Settling clayey soils of Mongolia in their natural state have a relatively high content of water-soluble and slightly soluble carbonate and other salt compounds and due to their cemented and crystallized structural bonds it has relatively high mechanical properties, but the mechanical properties due to the weakening of structural bonds during soaking sharply decrease to the value c=7.0÷10.2 kPa, φ=16÷20°, E=3.5÷4.5 MPa and subsidence begins depending on the type of soil at a pressure P=1.5 kg/cm^2 and W=(6.7 ÷8.6)% or $W_{(sat)}$ while the relative subsidence index is ε_{sl}>0.01. At pressure P=2.0 kgh/cm^2 and W=(6.1÷7.6)%, subsidence begins, and at pressure P=2.5 kg/cm^2 and W=(5.2÷6.9)% the slump begins. These moisture values are considered respectively at given pressures as the initial settling moisture W_{sl}.
3. Loess-like clayey soils, common in some regions of Mongolia, do not belong to the category of subsiding soils according to the soil classification standards of other countries, including Russia, but at different pressures and increasing humidity, a significant drawdown is observed, so there is a need for classification by indirect signs (Nyamdorj S. [22]).

VIII. CONCLUSION

1. Based on the results of the above experimental and theoretical studies, a number of regional features of loess-like subsiding soils common in Mongolia have been established, they must be taken into account when conducting engineering geological surveys and design, and also in the stages of construction and operation of buildings and structures. But some loess-like deposits, common in this area, do not belong to the classical classification by subsidence, although for them, with respect, a subsidence is observed, therefore, it is inevitable to classify them according to indicators of indirect signs.
2. As a result of the analysis of the causes of deformation and subsidence of bases and foundations of more than 70 buildings and engineering structures built in conditions of loess-like subsiding soils in various regions of Mongolia, 70÷80 percent are due to problems in engineering and geological surveys, estimated inaccuracies and non-optimal design solutions for the base and foundation. It has been established that these reasons are due to the fact that buildings and structures are designed without taking into account regional characteristics and man-made negative impacts during operation, and the remaining 30–20 percent are due to the quality of concrete and other materials for construction, as well as violations of the technological regime of construction and requirements to operation.

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