International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 1325-1329 www.ijaem.net ISSN: 2395-5252

Method for determining the mechanical parameters of subsiding soils taking into account regional features

S.Nyamdorj[1], D.Dashjamts[2], R.A.Mangushev[3]
[1,2]*Mongolian State University of Science and Technology,Ulaanbaatar. Mongolia.*
[3]*State Construction and Architectural University of St. Petersburg. Saint Petersburg. Russia.*

Date of Submission: 15-10-2022 Date of Acceptance: 31-10-2022

ABSTRACT:Depending on the regional features of the loess-like subsidence soil, common in Mongolia, in some cases it does not correspond to the category of subsidence soils in terms of physical and mechanical indicators, regulated in the norms and regulations of the Russian Federation and other countries. Based on this, it becomes necessary to increase the accuracy of determining the value of the mechanical parameters of subsiding soils, depending on the class of responsibility of the building being constructed. Due to these negative factors, many buildings built in the study area suffer from deformations and damage due to uneven settlements in excess of the allowable value. It takes a lot of time and money. Unfortunately, as a result of repair and reinforcement work, it is not possible to fully restore the buildings to the requirements specified in the BNbD and SNiP, especially since the territory of Mongolia is located in an active seismic zone, the building remains at great risk in case of possible earthquakes. For this reason, this article discusses the results of studies aimed at determining the mechanical parameters of the soil depending on the class of the building according to the degree of responsibility with great accuracy and relatively low cost.

KEYWORDS:loess soils, soil moistening, structural bond, strength indicators, deformation indicators, subsidence.

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 surveys increases (Nyamdorj S.[1]). Regional features of loess-like soils common in 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 silty particles (more than 50%) as a result of repeated cyclic freezing-thawing of the soil, solid particles are crushed, in addition to them, in their natural state they have 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 moistening of the latter, a drawdown occurs.

II. THEORETICAL BASIS

The main factors affecting the strength of subsiding soils cemented with natural carbonate and other salts are natural moisture, chemical composition, structural cemented soil bond and their interaction with water. These parameters mainly depend on the regional features of the origin of loess soils, the geochronology of its formation, and also on the rheological characteristics of the soil. Consequently, the strength and deformation parameters of the loess soil is determined by analytical calculation depending on the change in humidity C=f(W); φ=f(W) and E=f(W).

There are a number of proposed theoretical calculation methods for determining the variability of mechanical characteristics depending on the increase in the moisture content of subsidence clay soil (Mustafaev A.A. [2], Robert L.Parsons et al. [3], Крутов В.И. et al.[4], Mangushev R.A. et al. [5], Agnieszka Lal [6], Дашжамц Д.[7], Bingli Gao, Lulu Su [8], Laishuan Zhoo, Tiehai Wu [9]). According to the author, the most acceptable for this condition is the method of analytical calculation proposed by Professor

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 1325-1329 www.ijaem.net ISSN: 2395-5252

Mustafaev A.A. [2]. He put forward a theoretical hypothesis that a moist loess-like subsiding soil is a quasi-homogeneous and quasi-heterogeneous solid body with viscous-plastic compressibility, and the equation of state for such a body has the form:

$$\sigma = \sigma^{п} + \sigma^{в} = \sigma^{у};$$
$$e = e^{у} + e^{п}; \quad e^{п} = e^{в}; \qquad (1)$$

where: У, В, П - are indices that correspond to the stress-strain state of the elastic and viscous-plastic state at compressibility.

After certain transformations and replacements of the above equation, I received the following equation, which expresses a complex stress state.

$$\sigma = C - \rho_d(1+e)y + W(y,z) + \lambda\left(e_y + \frac{2}{3}\mu\right)(2 - f\partial ey\partial t; \qquad (2)$$

In the state of incompletely saturated loess soil, when the moisture content goes into the state $W_{cr} \leq W \leq W_{sat}$ the pattern of change in strength and deformation can be expressed by the mathematical law of the second-order curve [2]. For example: the mechanical parameters of wet soil change according to the following law:

$$C_W = C_H - C_H J_L(2W_{sat} + W_i); \qquad (3)$$

$$\varphi_W = \varphi_H - \varphi_H J_L(W_{sat} + \frac{W}{2}); \qquad (4)$$

$$E_W = E_H - E_H J_L(W_{sat} + 0.5W); \qquad (5)$$

where: C_H- adhesion force of soil with natural moisture 8, φ_H - angle of internal friction of soil with natural moisture; E - soil deformation modulus with natural moisture; J_L, W_L, W_p, J_p- are accepted based on the results of engineering and geological research; W_{sat} -moisture content of loess soil at water saturation;

$$W_{sat} = \frac{e\,\rho\,W}{\rho_s}, \qquad (6)$$

where: e-coefficient of porosity of loess soil;

$$e = \frac{\rho_s - \rho_d}{\rho_d}, \qquad (10)$$

III. MATERIALS AND METHOD

Using these dependencies, established by A.A. Mustafaev, the mechanical parameters (C, φ, E) of silty sandy loamy soil, common in the territory of Darkhan-Selengiyskiy and Edenet-Orkhonskiy districts, are calculated, depending on the change in humidity (W_i), taking into account regional features ([10]). The calculation results are presented in tables 1 and 2, respectively.

Table of dependence of mechanical characteristics (C, φ, E) on changes in moisture content (W_i) of sandy loamy soil of the Darkhan-Selengsky region

Table-1

№	W_i	J_L	C_w, кПа	φ_w, град	E_w, мПа
1	0.04	-0,523	14.18	24.27	11.89
2	0.06	-0,256	12.23	24.13	11.76
3	0.08	0,000	7.95	23.35	11.27
4	0.10	0,328	7.06	21.31	10.85
5	0.12	0,615	6.83	18.90	5.18
6	0.148	1,000	6.24	17.81	3.91
7	0.16	1,217	5.95	17.05	3.15
8	0.18	1,485	5.64	16.68	2.68

Table of dependence of mechanical characteristics (C, φ, E) on changes in moisture content (W_i) of loamy soil of Orkhon-Erdenet region

Table-2

№	W	J_L	C_w, кПа	φ_w, град	E_w, мПа
1	0.06	-	47.21	22.31	12.92
2	0.08	-0,623	46.83	22.10	12.34
3	0.10	-0,381	43.55	21.60	11.98
4	0.12	0,000	27.91	20.32	9.12
5	0.14	0,431	17.83	18.61	4.87
6	0.16	0,762	14.67	17.72	4.05
7	0.18	1,243	13.05	17.30	3.29
8	0.20	1,520	11.81	16.82	2.76
9	0.22	1,836	10.71	16.47	2.68

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 1325-1329 www.ijaem.net ISSN: 2395-5252

IV. RESULTS AND DISCUSSION

Based on the methodology of A.A. Mustafaev developed a calculation method for determining the patterns of changes in the mechanical parameters of subsiding soils when moistening the loess-like sandy soil of the Darkhan-Seleng and Erdenet-Orkhon regions in the form of a calculated nomogram. The method of using nomograms is shown in Figures 1…4.

a. Method for determining the value of the flow indexJ_L

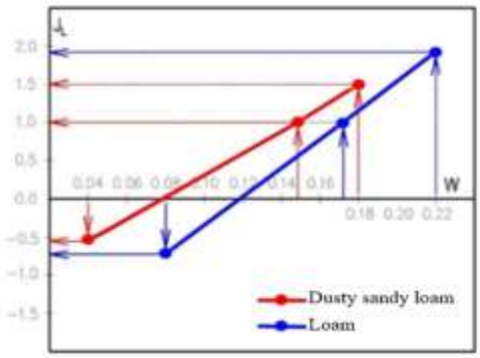

Fig. 1. Nomogram for determining the value of the flow index depending on the increase in soil moisture J_L=f(W_i).

Based on the results of the analysis of the nomogram, the dependencies J_L = f(W_i) are established:
- for sandy loam: with an increase in soil moisture W = 0.04÷0.08, the fluidity index changes J_L = -0,60 ... 0.00, with a further increase in humidity W = 0.08 ... 0.18, the index J_L = 0.00 ... 1.50 increases linearly in proportion;
- for loam: with an increase in soil moisture W = 0.08 ... 0.12, the fluidity index changes J_L = -0.75 ... 0.00, with a further increase in humidity W = 0.12 ... 0.22, the fluidity index J_L = 0, 00…1.80 increases linearly proportionally.

b. Method for determining the value of the adhesive force C_w

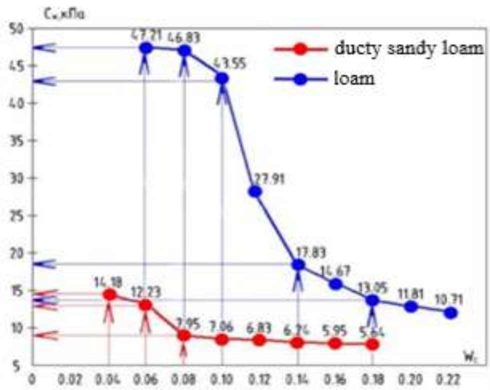

Fig. 2. Nomogram for determining the value of the adhesion force C_w = f(W_i) depending on the increase in the moisture content of clay soils.

According to the results of the analysis of the nomogram, the dependencies C_w = f(W_i)are established:
- for sandy loam: with an increase in soil moisture W = 0.04 ... 0.08, the adhesion force changes C_w = 14.18 ... 7.95, with a further increase in humidity W = 0.08 ... 0.18, index C_w = 7, 95…5.64 decreases according to a non-linear dependence;
- for loam: with an increase in soil moisture W = 0.06 ... 0.14, the adhesion force decreases in the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 1325-1329 www.ijaem.net ISSN: 2395-5252

range Cw = 47.21 ... 17.38, with a further increase in humidity W = 0.14 ... 0.22, the adhesion C_w = 17, 38 ... 10.71 decreases according to a non-linear dependence.

c. Method for determining the value of the angle of internal friction φ_w

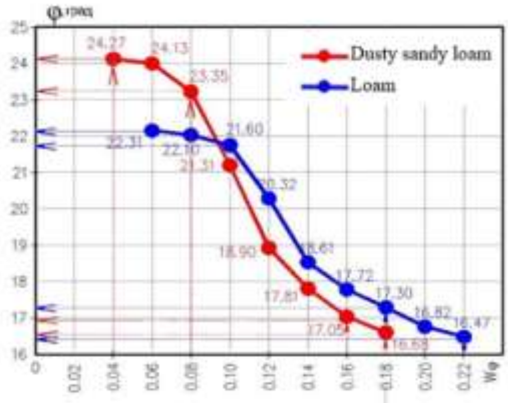

Fig. 3. Nomogram for determining the value of the angle of internal friction $\varphi_w = f(W_i)$depending on the increase in the moisture content of clay soils

According to the results of the analysis of the nomogram, the dependences $\varphi_w = f(W_i)$are established:

- for sandy loam: with an increase in soil moisture W = 0.04 ... 0.18, the angle of internal friction φ_w= 24.27 ... 16.68 decreases according to a non-linear dependence;

- for loam: with an increase in soil moisture W = 0.06 ... 0.22, the angle of internal friction φ_w= 22.31 ... 16.47 decreases according to a non-linear dependence.

d. Method for determining the value of the modulus of deformation E_w

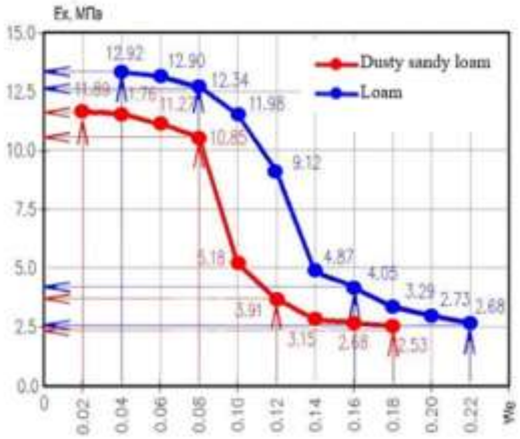

Fig. 4. Nomogram for determining the value of the deformation modulus $E_w = f(W)$ depending on the increase in the moisture content of clay soils

Based on the results of the analysis of the nomogram, the dependences $E_w = f(W_i)$ are established:

- for sandy loam: with an increase in soil moisture W = 0.02 ... 0.18, the value of the deformation modulus E_w= 11.89 ... 2.53 MPa decreases according to a non-linear dependence;

- for loam: with an increase in soil moisture W = 0.04 ... 0.10, the value of the deformation modulus E_w = 12.92 ... 2.68 MPa decreases according to a non-linear dependence.

V. CONCLUSION

According to the results of the analysis of the numerical values of the mechanical parameters of subsidence clay soils on the nomograms J_L=f(W_i), C_w =f(W_i), 〖φ〗_w=f(W_i), E_w=f(W_i) depending on the properties of the subsidence soil and the mode changes in the humidity of these areas, the possibility of application is established taking into account the probability of a change within ± 5.0% and the compatibility of the numerical values determined by the nomogram in comparison with the classification characteristics established by the MNS "Soil Classification" standard is with an error of 3.0-9.0%.

REFERENCES

[1]. Nyamdorj S. 2021. Bases and foundations of buildings and structures erected on subsidence soils //Monography. UB. Publishing house of SHUTIS. 248p.
[2]. Mustafaev A.A. 1967. Theoretical foundations of the process of moistening loess soils. //In the book: Issues of the mechanics of subsidence soils. Account.notes.T.4.(12). Azerbaijan Polytechnic Institute Baku.
[3]. Robert L.Parsons et al. 2009. Characterization of leoss for Deep Foundation //University Kansas. USA. DEI JOURNAL. Vol 3, №2, November 2009.
[4]. Krutov V.I., Kovalev A.S., Kovalev V.A. 2016. Design and installation of bases and foundations on subsidence soils. Ed. DIA. -M: 2016, 544C.
[5]. R. A. Mangushev, A. I. Osokin, R. A. Usmanov. 2018. Device and reconstruction of bases and foundations on weak and structurally unstable soils, ed. R.A. Mangushev. St. Petersburg: Lan, 2018. 460 p.
[6]. Agnieszka Lal. 2019. Research of the collapsibility of the European leoss-Review //Lublin University of Technology. Budownictwo i Architekture. 18(1), (2019). pp5-10.
[7]. Dashjamts D. 1998. Theoretical basis for optimal solutions for designing foundations and foundations of buildings in structurally unstable soils. // Autoref. diss...doct. of Science (Sc.D). -UB.: 1998. SHUT-1001.37P.
[8]. Bingli Gao, Lulu Su. 2020. Triaxil Mechanical Testing of Undisturbed and Unsaturated Leoss //Soil Mechanics and Foundation Engineering. pp57-64.
[9]. Laishuan Zhoo, Tiehai Wu. 2022. Exploration on mechanical test metod of inproved leoss under dry-wet cycles //MATEC Web of Conferences. 358. 01031. 2022.
[10]. Nyamdorj S. 2022. Review of studies of leoss soils in the territory of Mongolia.//International Journal of Advances in Engineering and Management (IJAEM). India. Volume 4, Iusue 9. Sep. 2022. Pp1573-1578.