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Calculation and Construction of Foundations on Subsidence Soils

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ANNOTATION

Classic design solutions for foundation construction are considered and a new design scheme for strengthening the loess base is proposed. Classical methods include preliminary moistening and compaction of loess under the foundation with heavy compaction, installation of soil cushions, installation of driven piles cutting through the subsidence layer, etc. In addition to classical methods, as a new constructive solution for strengthening the base composed of loess soils, the installation of an artificial geo massive of resin-sand composition is proposed.

KEYWORDS: *loess soils, settlement of natural soils, subsidence of soils during soaking, macropores, the second group of limit states calculation, design solutions for foundations on loess rocks.*

Soil called subsidence when, under the influence of external factors (soaking, external load and/or load from its own weight), it changes its structure and moves in the vertical direction. These include loess soils (loess), as well as loess-like loams [1].

Loess rocks are widespread throughout the world. The issue of subsidence of loess soils is being actively studied in Uzbekistan, which is associated with the wide distribution of loess in these territories.

Despite the fact that the term “loess” (German: Löß) was first introduced in the early 1820s. and since then its physical and deformation properties have been actively studied; the problem of loess rocks has not been exhausted to this day. Firstly, the origin of the breed is still a matter of active research. Secondly, due to subsidence, specialists in the field of geology and construction are actively studying the design of foundations and foundations on strata formed by loess soils, which is a very serious problem. For example, in the Samarkand region, when the groundwater level rose, loess subsidence and deformation of the load-bearing structures of buildings occurred [2]. Subsidence of the thickness is possible even up to 80 m.

It is worth noting that at the moment there are shortcomings in the calculation models of loess soil [3]: the methodology defined by building codes, codes of practice and educational literature does not take into account the location of macropores and the dissimilarity of their sizes, as well as the nature of changes in the structure of the soil during subsidence.

The above, as well as the fact that the construction of foundations on loess soils compared to soils without specific properties leads to an increase in the cost of work by almost 50%, leaves the question of designing foundations and foundations in the presence of thick loess rocks open and relevant [4].

The mechanism of loess subsidence is shown in Fig. 1. The soil is moistened, water softens and dissolves crystallization bonds and causes disjoining stress of film water. This reduces the strength of bonds between particles, the soil becomes compacted under pressure - macropores are reduced, and vertical movement occurs.

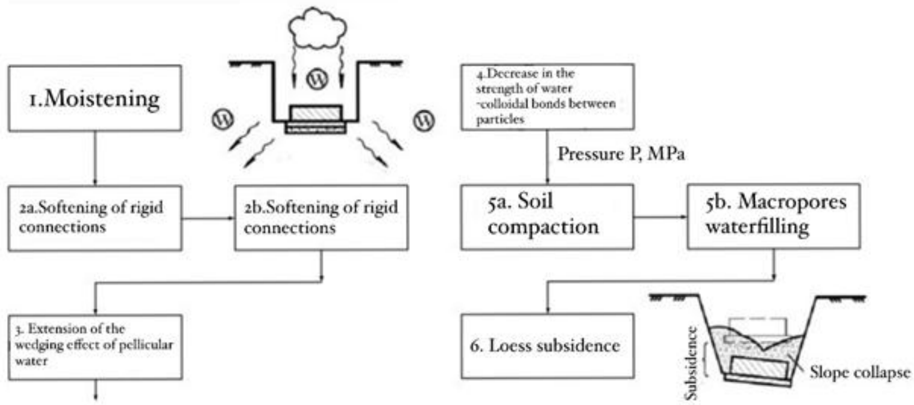

Fig. 1. Scheme of subsidence of loess soil

Based on the exertion of subsidence properties, loess soils are divided into two types – I and II [3] in accordance with Fig. 2.

Designing foundations on loess rocks, there are two main directions, the features of which must be taken into account:

Direction №.1. Elimination of unacceptable settlements when calculating foundations for limit states group II.

Direction №.2. Constructive measures to eliminate (limit) subsidence.

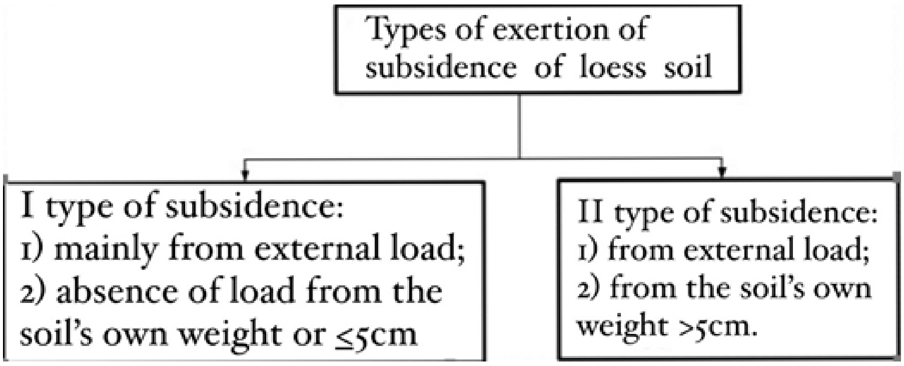

Fig. 2. Types of exertion of subsidence of loess soil

Within the first direction, bases and foundations are calculated taking into account the total settlement of soils in their natural state and subsidence when exposed to moisture. Within the second direction, the subsidence properties of the foundation are eliminated or preserved by constructive methods [1]. The preservation of the subsidence properties of loess is limited in application due to the danger of subsidence and is used with proper justification, which can be the construction of low-rise individual buildings with a significant estimated cost of measures aimed at eliminating the subsidence of loess. In this case, it is necessary to preserve the natural topography next to the building, design a blind area around the entire perimeter more than 2 m wide with a slope towards reinforced concrete trays, and install water-impermeable trays under the underground sewerage and water supply pipelines to drain water from the subsidence layer.

The calculation of foundations for group II limit states, in contrast to soils without specific properties, is carried out taking into account the settlement s_p of soils in the natural state and the settlement of soils s_{sl} during soaking in accordance with Fig. 3.

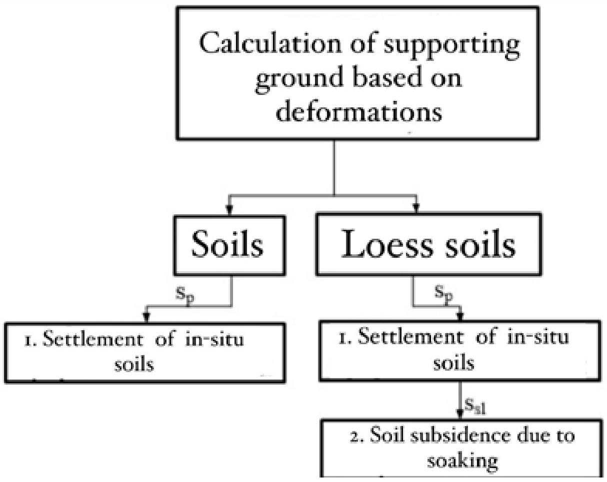

Fig. 3. Scheme for calculating supporting ground based on deformations for non-specific soils and loess soils

The calculation is made based on the condition that the total deformation does not exceed the permissible value:

$S = S_P + S_{sl} \leq S_u$. (1)

All formulas for determining settlement are given in sections 5 and 6 of the updated version of SNiP "Foundations of buildings and structures". In comparison with section 3 of SNiP 2.02.01–83* in section. 6.1. SP 22.13330.2011 calculations of foundations formed by loess rocks have undergone some changes. So, for example, from the list of main parameters characterizing loess (namely: relative subsidence – ε_{sl} and initial subsidence pressure – p_{sl}), the minimum humidity w_{sl} at which subsidence occurs was excluded.

This probably happened due to the exclusion from the updated version of the division of the relative base subsidence depending on the complete ε_{sl} and incomplete $\varepsilon_{s'l}$ water saturation of the soil, as well as eliminating the formula for calculating the relative subsidence of the soil when it is incompletely saturated with water. SP 22.13330.2011 provides a unified formula for determining ε_{sl}. This simplifies calculation variations and ensures reliability when designing the foundation, eliminating the error of incorrectly identifying the soil as not completely saturated.

Also, the updated version and SNiP define factors that are taken into account when designing foundations composed of loess. These are subsidence of the upper zone from the external load $s_{sl,p}$, subsidence of the lower zone from the own weight of the soil $s_{sl,q}$, as well as the unevenness of soil subsidence Δs_{sl} and its horizontal movement u_{sl}. In addition to these factors, the SP included loss of slope stability, additional loads from the formation of a "water dome" in the thickness, and additional sediments of the underlying loess soils.

All this is important and affects the values of the total settlement when calculating the foundations.

The calculated resistance of the foundation bed soil is determined depending on the possibility/impossibility of soaking, and the updated version provides an explanation of the coefficients of operating conditions when determining it - they are accepted as for clayey soils with the corresponding fluidity index. The coefficient of working conditions with a focus on clay soils is not accidental - loess is loam in its granulometric composition.

It is important to note that both standards establish a requirement according to which, provided that the stresses on the soil from the external load and its own weight are not more than the initial subsidence pressure, and the loess, by the nature of its subsidence, belongs to type I, calculations taking into account subsidence are not made. Moreover, if the relative subsidence of the layers is less than 0.01, then the calculation is also not performed.

The positive point is that the SP has developed the boundaries for determining the filler thickness h_{sl} and a method for dividing it into separate layers.

The updated version does not include the requirement of clause 3.12 of SNiP, according to which for soils of type I subsidence it is allowed to eliminate subsidence only on 2/3 of the entire thickness when the value of subsidence and its unevenness does not exceed 1/3 of the maximum permissible values. This tightens the calculation and provides a margin of deformation properties.

Thus, we can conclude that the updated version of SNiP 2.02.01–83* “Foundation beds of buildings and structures” has tightened the requirements for subsidence calculations. This is a positive factor and partially compensates for the macropore sizes not taken into account in calculation methods; the nature of soaking with the dynamics of deformation development. Moreover, if we take into account the Decree No. 1512 of Uzbekistan dated December 26, 2014, which came into force, which states that it is mandatory to comply with the requirements of sections 5 and 6 of SP 22.133330.2011 when making calculations, such tightening of the provisions will lead to a reduction in the risk of unacceptable deformations and accidents during the operation of buildings.

There was no fundamental change in the calculation in the approved code, but a number of the provisions given above were changed or cancelled. The educational literature that exists today describes the old calculation methodology, while the symbols of factors influencing subsidence and calculated values diverge greatly from the normative literature, therefore designers, engineers, as well as future specialists and bachelors must use normative literature.

The second and important direction when designing foundations on loess rocks is the choice of a rational structural design of foundations and artificially improved foundations.

Classic schemes for eliminating (reducing) the subsidence properties of the foundation in accordance with educational and normative-technical literature, depending on the type of subsidence, are shown in the table.

In addition to classical methods [5], as a new constructive solution for strengthening a foundation composed of loess soils, the construction of an artificial geo massive with a resin-sand composition is proposed. A detailed description of the model and the nature of its operation in sandy conditions is presented in article [6]. During the experiment using a geo massive on a sandy compacted base, the relationship “pressure P, kPa – settlement S, mm” was obtained, which clearly demonstrates that the settlement of a reinforced base is approximately 2 times less than the base without reinforcement elements. The mass is a horizontal injection of a solution of resin with a hardener made using the resinization method by mixing it with the soil under the foundation. In this case, the protrusion of the geo massive along the width of the base of the strip foundation on both sides is equal to the width of the base. The distance from the base to the top of the “resinized” geo massive soil is 0.15 of the width of the base of the foundation. Since the resinization method applies to loess, sand and rocky soils, it is assumed that this design solution will limit and reduce settlements of foundations resting on the thickness of subsidence soil. The amplification circuit is shown in Fig. 4

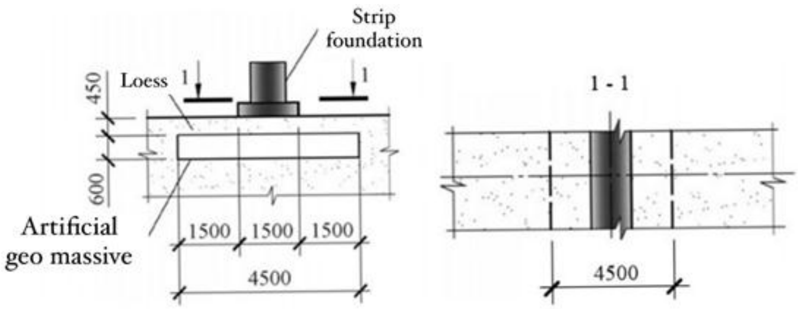

Fig. 4. Scheme of strengthening the loess thickness by creating an artificial geo massive under the base of the foundation to scale

Thus, we can conclude that today there is a calculation of loess soil, it has become more stringent than the calculation in accordance with SNiP [4], but nevertheless it is not perfect, it does not take into account the size of pores, the rate of subsidence, etc. and so on. These shortcomings can be eliminated when designing foundations in calculation systems, improving them day by day. The problems of constructive solutions for foundations and strengthening the foundation are also not completely resolved. More and more economical solutions are being offered, which is important, since there are regions in Uzbekistan, which are actively faced with the problems of design and construction of foundations on loess to this day.

Bibliography

1. Dalmatov B.I. Soil mechanics, bases and foundations: a textbook for universities. – 2nd ed. – L.: Stroyizdat, 1988. – 415 p.
2. Khalturina L.V., Krivorotov A.P., Kuskovsky V.S. Determination of the depth of the compressible thickness of the base, taking into account the characteristics of soils // Polzunovsky vestnik. – 2012. – No. 1–2. – pp. 121–125.
3. Tulakov E.S., Mamatkulova Z.Sh., Sattorov A.A. Slab-frame foundations erected on subsiding soils. “Innovation, integration, economy in architecture and construction” scientific-practical on-conference 2021, May 5-6. Tashkent-2021.
4. Tulakov E.S, Ph.D.; Inoyatov D.T., Kurbonov AS, assistant; International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020. Page No.: 4832-4835.
5. Vestnik “Architect, XXI century” // Information and analytical magazine, Issue 3 (15), 2004.
6. https://findpatent.ru/patent/249/2496943.html
7. https://edrid.ru/rid/218.016.4ca6.html