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Research Article

ASSESSMENT OF THE DESIGN RESISTANCE OF SANDY SOILS UNDER VIBRATIONAL LOADING CONDITIONS IN UZBEKISTAN

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ABSTRACT
This study focuses on evaluating the bearing capacity of sandy soils subjected to dynamic (seismic) loading conditions, particularly within the geological and seismic context of Uzbekistan. Due to the country's high seismic activity and widespread sandy soil deposits, understanding the interaction between seismic waves and soil behavior is critical for safe and sustainable construction practices. The research involves analyzing site-specific soil characteristics, assessing seismic vulnerability, and applying both empirical and analytical methods to determine soil resistance under vibrational stress. Results from this study can help improve the design of foundations, enhance risk mitigation strategies, and inform building codes in seismically active regions of Central Asia.

Keywords: *Seismic Loading, Sandy Soils, Bearing Capacity, Soil-Structure Interaction, Ground Motion, Uzbekistan Geology, Earthquake Engineering, Dynamic Soil Behavior, Foundation Stability, Geotechnical Assessment, Soils, Physical-Mechanical Properties, Strength Indicators, Soil Composition, Soil Classification*

INTRODUCTION

In the regions of the Republic of Uzbekistan where sandy soils are widespread, it is of great importance to forecast potential emergency situations that may arise under seismic loading during the construction of buildings and structures, and to mitigate their consequences, taking into account the engineering-geological and hydrogeological conditions. Therefore, a number of scientists have studied the changes in the resistance of sandy soils under seismic loading and expressed their opinions.

Nowadays, large-scale construction work is underway in our country. The projecting and construction of buildings and structures in complex climatic conditions require specific researches. Engineering-geological surveys on soil-based sections with high humidity are carried out according to a special program specified in the terms of reference. The software and terms of reference are developed jointly by the project and exploration organizations. The materials obtained as a result of the search should, in general, allow you to:

1. Quantitative assessment of the stability of the foundation;
2. Predict the value and duration of the subsidence of the base in the consolidation process.

In general, these materials should be evaluated to ensure that the high-moisture layer can be used as the lifting base material.

The program can be edited after receiving the current information by the project organization during the search. In the projecting and construction of buildings and structures in complex climatic conditions, engineering-geological surveys can include the following types of work:

1. Collection, analysis and summarization of search and previous years materials;
2. Obtaining and decoding aerospace survey materials;
3. Recognition inspection in conjunction with aerial and route observations;
4. Crossing mountain carvings;
5. Geophysical study of the area;

6. Field inspection of soils;
7. Hydrogeological research;
8. Stationary observations;
9. Study of soil and water in the laboratory;
10. Predicting possible changes in engineering-geological conditions;
11. Processing of materials in the room;
12. Preparation of technical report (conclusions).

The composition, classification and strength of soils depend on their internal bonds, which are divided into 2 groups: crystalline and aqueous-colloidal bonds. *Crystalline bonds* - depending on the chemical composition of the soil, they are very weak, but brittle, they do not recover when broken. The strength of these bonds depends on the minerals. *Aqueous - colloidal bonds* - depending on the amount of water, can be more or less restored after breaking, are sticky, plastic, soft, reversible [1].

Construction of buildings and structures in our country is often carried out in complex engineering-geological conditions, especially in areas with saline soils. These soils cover numerous regions of Uzbekistan such as Bukhara, Jizzakh, Syrdarya, Fergana, Khorezm and large areas of the Republic of Karakalpakstan. In Uzbekistan, saline soils, which can be used as a basis for the construction of buildings and structures, consist of saline, saline, saline and bald soils, differing in the composition and amount of slightly soluble salts. They are often formed in the depressions of the relief: mountain slopes, lowlands, saline lake shores, cliffs, desert zones formed as a result of suffocation, mineralized waters close to the surface (1 - 3 m). The main factor in the formation of saline soils is the mineralized groundwater and saline rocks that lie close to the surface [2]. The main condition for salinization is the impossibility of water flow in places and the fact that the amount of evaporation is greater than the amount of precipitation.

Analysis of the existing literature on saline soils and experience in the design and construction of buildings and structures in different regions of the country, as well as special studies on saline soils show that changes in the composition, structure and physical and mechanical properties of substances during wetting and alkaline leaching. and this phenomenon needs to be taken into account in design work.

As a result of flooding and wetting of areas composed of saline soils, a number of major affects can occur in buildings and structures [3].

Soils are made up of fine particles. In nature, soils erode to form fine particles. The more fine particles in the soil, the higher its contact with the environment. Depending on the type of substances in the soil, their strength varies, and soils consisting of fine particles consist of 3 parts: solid, liquid and gaseous.

Soils distributed in nature are divided into 4 classes according to their specific characteristics, based on their classification: the most common in nature, which serve as the foundation of the building, the internal bonding and bearing capacity: rocky soils, coarse-grained soils, sands, clay soils [4].

As a result of the treatment of water-saturated sandy soils, their balance is disturbed and their structure changes and becomes fluid, the movement in the sands is faster, because the water flows together inseparably from the sand.

The process in such sands is called coagulation. Sandy soils are loose soils and cannot retain their shape when subjected to force. The strength of loose soils depends on their density and moisture, and in the compacted state it is a loamy soil, otherwise it is a faulty soil [5, 6].

Literature review. Existing guidelines and normative literature provide recommendations for determining the mechanical properties for saline soils with easy and moderately soluble salts, but the amount of difficult-to-dissolve salts is not taken into account. Studies suggest that in order to ensure the safe operation of buildings and structures built on saline soils, it is necessary to study the process of leaching of insoluble salts, especially when the mechanical properties of the soil are exposed to long-standing water. An experimental study of the laws of change of mechanical properties of water from saline soils over a long period of time. This is because the issues of assessing the change in the mechanical properties of saline soils in the long-term exposure to water to insoluble salts have not been fully studied. Many scientists have worked on engineering-geological research and their use. Including, M.D. Braja, G.P. David, W. Kuhn, B.G. Neal, A.R. Harutyunyan, I.L. Bartholomey, V.M. Bezruk, P.B. Babakhanov, A.A. Glaz, A.I. Grot, R.S.Ziangirov, N.P.Zatenatskaya, M.F.Уerusalimskaya, M.O.Karpushko, A.K.Kiyalbанeв, A.A.Kirillov, N.A.Klapatovskaya, Уu.V.Kuznetsov, A.D. Kayumov, T.Kh. Qalandarov, S.S. Mordovich and many scientists [7]. The following scientists also studied the deformation and strength parameters of soils containing ocon and moderately soluble salts: Bezruk B.I., Glaz A.A., Dolmatov B.I., Lomize L.N., Povilonckiy V.M., Petrukhin V.P., Rozhdectvenckiy E.D., Ukhov C.B., Chokhonelidze G.N., Shulginoy V.P. and others. In 1983, V. M. Bezruk developed classifications of saline soils for the construction of buildings and structures [8]. The specificity of this classification is as follows: the amount of salts in the ground is taken into account starting from 0.3%, in which salinity is divided into two types: 1) chlorinated and chlorinated-chlorinated; 2) saturated, chloride-saturated and coda salinity. V.P. Petrukhin developed a classification in which the minimum amount of water-soluble salts depends on the density of soils in accordance with the design goals of civil and commercial buildings and constructions [9,10].

MATERIALS AND METHODS

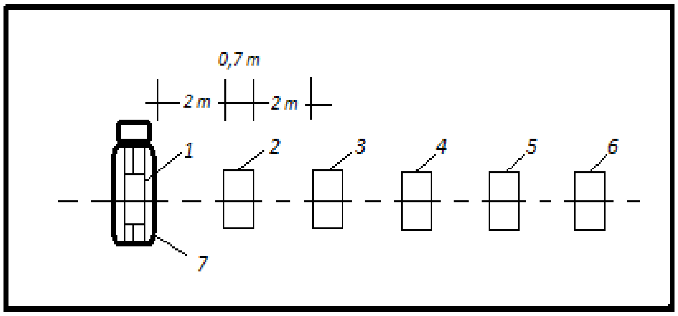
In order to study the changes in the resistance of sandy soils under seismic effects, a number of field investigations were carried out. The fieldwork was conducted at specially prepared test sites located in the Termiz and Jarqo'rg'on districts of the Surkhandarya region (Figure 1). The test site, particularly at the "Oqtepa" location, consists of sandy soils with the physical and mechanical properties presented in Table 1.

Table 1. Average indicators of sandy soils in the village of "Oqtepa"

Names of properties	Borehole number					
	№1	№2	№3	№4	№5	№6
Moisture content	1.91	1.91	1.91	1.91	1.91	1.91
Natural density	1.50	1.51	1.50	1.52	1.50	1.51
Porosity	40.2	39.8	40.1	39.7	39.9	39.8
Void ratio	0.652	0.648	0.649	0.647	0.648	0.649
Angle of internal friction. degrees	38	38	38	38	38	38
Cohesion. MPa	0.005	0.005	0.005	0.005	0.005	0.005

Groundwater in the area is located 10 - 15 meters below the surface. To apply vibrational motion to the sandy soils at the experimental site. a DU-62 vibratory roller was used. Under the influence of vibrations. to determine the changes in density. moisture content. and strength characteristics of the sand - specifically. cohesion and angle of internal friction - five test pits were excavated beneath and along the axis of the vibratory roller at intervals of 2 meters (see Figure 1).

a)



b)

Figure 1. Experimental site at the "Oqtepa" area
a) - schematic view. b) – general view.
1-6 - test pits; 7 - vibratory roller.

After generating vibrations using the vibratory roller. data were collected using the UNI-T UT315A portable vibrometer. The processed results showed that the vibration frequency ranged from 12 to 25 Hz and the vibration acceleration reached up to 6000 mm/s^2. According to various authors [1-4]. such vibration frequency and acceleration correspond approximately to 6 – 8 seismic intensity points; based on the current standard RST Uz 836-97 [5]. this can be considered equivalent to 7 points.

RESULTS AND DISCUSSION

To study the change in resistance of sandy soils under seismic influence. vibrational motion was generated at the "Oqtepa" site using the DU-62 vibratory roller. During the experiment. vibration frequencies were set at 12.5 Hz and 23.5 Hz. and the vibration durations were 30 seconds and 90 seconds. respectively.

After applying vibrations at a frequency of 12.5 Hz and a duration of 30 seconds. the acceleration. velocity. and displacement of the sand were measured both at the surface and at a depth of 2 meters (via driven stakes) at distances of 0. 2. 4. 6. 8. and 10 meters from the axis of the vibratory roller using the UT315A portable device.

As a result of the vibrational motion. the "K" coefficient was quantitatively determined based on the ratio of the angle of internal friction of the vibrated and non-vibrated sandy soil massifs at various depths and distances. That is. it was calculated using the expression:

$K = \varphi^{s}_{gr}/\varphi^{d}_{gr}$

The obtained values are presented in Table 2.

Table 2. Quantitative values of the "K" coefficient under vibrational motion by depth and distance

Depth. m	Distance from DU-62 vibratory roller. m					
	0	2	4	6	8	10
0.5	1.18	1.15	1.12	1.09	1.05	1.02
1.0	1.17	1.14	1.10	1.08	1.03	1.00
2.0	1.15	1.12	1.07	1.06	1.01	0.95

The analysis of this table shows how the mechanical properties of sandy soils change under dynamic loads as depth and distance from the vibratory roller increase. After vibrating the sandy soil using the DU-62 vibratory roller. it was observed that the soil becomes denser at depth compared to its natural state. and that this densification decreases with increasing depth. At the same time. under dynamic impact. the mechanical characteristics of the sand also change - particularly the coefficient "K" of the internal friction angle of sandy soils. which varies from 1.18 to 1.02.

The maximum value of K = 1.17 was observed at a depth of 2 meters directly beneath the vibratory roller. while the minimum value of K = 1.02 was recorded at 2 meters depth and 10 meters distance from the roller.

The analysis of the "K" coefficient values based on depth and distance from the vibratory roller indicates that its maximum value occurs when both depth and distance are zero. For example. K = 39/33 = 1.18. This implies that during the design of buildings and structures. it is necessary to take seismic effects into account by adjusting the design resistance (R) of the soil accordingly.

In Figure 1. the values of the calculated resistance (R) for sandy soils in the Termiz and Jarqo'rg'on districts of Surkhandarya Region - after the influence of vibrations - were determined based on Building norms SHNQ 2.02.01-19 [6]. and a schematic map was developed to represent these results.

Thus. from the above. it can be concluded that in regions with sandy soils. it is essential to account for a reduction in the calculated soil resistance (R) under the effect of dynamic forces during the design of buildings and structures. In this case. the maximum correction coefficient for design resistance "R" is 1.18. and this should be factored into engineering design. That is. if seismic activity generates vibrational motion. the design resistance of sandy soils should be increased by a factor of 1.18 when designing buildings and infrastructure.

CONCLUSION

This study highlights the critical importance of considering dynamic loading effects on sandy soils. particularly in seismic-prone regions of Uzbekistan such as Surkhandarya. Experimental investigations using the DU-62 vibratory roller demonstrated that vibrational motion significantly influences the mechanical properties of sandy soils. including their density. moisture content. cohesion. and internal friction angle. The observed changes in soil resistance under vibration - expressed through the coefficient "K" - show a clear dependence on both depth and distance from the source of vibration. The maximum increase in soil strength parameters was recorded near the vibratory roller at shallow depths. while further away and deeper layers exhibited reduced effects.

Based on these findings. it is essential to adjust the calculated soil resistance (R) values used in the design of buildings and structures in sandy soil regions to account for dynamic effects. Specifically. an increase of up to 18% (K = 1.18) in design resistance should be considered to ensure structural safety under seismic loading. Incorporating these adjustments into design standards and construction practices will contribute to more reliable and resilient infrastructure development in Uzbekistan's sandy soil zones. mitigating risks associated with earthquake-induced soil vibrations.

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