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| Research Article

Methods for Determining the Critical Acceleration of Loess Soil Oscillation

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Annotation
The article considers the issues of determining the critical acceleration of loess soil vibrations by computational and laboratory methods. Examples are given for determining the critical acceleration of loess soil by computational methods. The results of determining the critical acceleration of the loess soil oscillation by laboratory methods, depending on various internal and external factors, are also presented.

Keywords: critical acceleration, seismic acceleration, liquefaction, loess soil, deformation, seismic resistance, structure, angle of internal friction, adhesion (connectivity), density.

Introduction. The overall strength and stability of the soil in dynamic (seismic) conditions and the development of extreme plastic deformations in the base under the sole of the foundations depends primarily on $\alpha_{кр}$ i.e. on the critical acceleration of the oscillation. One of the most reliable methods to ensure the strength and stability of the operation of structures, the assignment of the calculated pressure on the base and the calculation of the limitation of the average precipitation and the resulting difference in precipitation of individual neighboring foundations, would be to comply with the condition when $\alpha_{кр} > \alpha_c$ (where $\alpha_{кр}$, α_c are, respectively, the values of critical and seismic accelerations of vibrations of soil particles) during all points of the base. Here α_c, i.e. the intensity of seismic vibrations serves as a factor of external influence, leading to a violation of the soil structure, the exact definition of which is of great fundamental importance from the point of view of the stability of structures erected on them. The value of α_c is determined by the seismic microzoning map, compiled on the basis of special studies to determine the increment of the score in relation to the data of the seismic zoning map of the territory of a certain country. The value of the maximum seismic acceleration α_c for approximate calculations can be determined according to the data of S.V. Medvedev, established for earthquakes with periods of 0.1–0.5 seconds (Table 1). It is known that each type of soil, depending on its composition, condition and properties, has its own critical acceleration of vibrations of soil particles. The critical acceleration of $\alpha_{кр}$ is what most authors call this

Table 1. Values of seismic accelerations on the MSK-1964 scale

Earthquake strength, point	Calculated acceleration, мм/с^2
5	$120 < \alpha_c \leq 250$
6	$250 < \alpha_c \leq 500$
7	$500 < \alpha_c \leq 1000$
8	$1000 < \alpha_c \leq 2000$
9	$2000 < \alpha_c \leq 4000$
10	$4000 < \alpha_c \leq 8000$

acceleration of the vibration of soil particles, at which the soil is in a state of extreme equilibrium and a slight excess of acceleration against the critical one is sufficient for the water-saturated soil to pass into a state of loss of its dynamic stability, i.e. into a state of "liquefaction". As a result of liquefaction, the structural strength of the soil decreases and significant plastic deformations develop, both in soils lying in the zones bordering the foundation and in the basement zone of the foundation, leading to unacceptable deformations of the structure itself. The conditions when $\alpha_{кр}$ > α_c can be achieved mainly by increasing the strength characteristics of soils. One of the ways to increase the strength characteristics of soils is to seal them.

Many scientists both in our country and abroad have been engaged in determining the critical acceleration of soil vibrations, in particular E. Bazant, H.B.Sid, R.Wittman, O.A.Savinov, D.D.Barkan, N.N.Maslov, Yu.Ya.Velli, H.Z.Rasulov, Yu.N.Chastoyedov, S.Saifiddinov, G.A.Khakimov and others.

Methods, analysis and results. The critical acceleration of ground vibration is mainly determined by two methods: the computational and laboratory method.

When determining the critical acceleration by the calculation method, the formula proposed by Prof.H.Z.Rasulov can be used:

a) for clay soils

$$\alpha_{кр} = \frac{2\pi g\left(\sigma_{дин} tg\varphi_w + C_w\right)}{\gamma_w T_п \upsilon_{сд}} \quad (1)$$

где, g - acceleration of gravity;

φ_w – the angle of internal friction of the soil at humidity w;

C_w - the adhesion (connectivity) of the soil corresponding to the humidity w;

γ_w - density of wet soil;

$T_п$ - the oscillation period;

$\upsilon_{сд}$ - the velocity of transverse seismic waves;

б) for sandy soils, i.e. when c_w=0

$$\alpha_{кр} = \frac{2\pi g \sigma_{дин} tg\varphi_w}{\gamma_w T_п \upsilon_{сд}} \quad (2)$$

here, $\sigma_{дин} = \gamma_w z + P_0$ (где, $\gamma_w z$ – the net weight of the soil covering the horizon) for the case $P_0 = 0$ и $c_w = 0$, we will get

$$\alpha_{кр} = \frac{2\pi g z tg\varphi_w}{T_п \upsilon_{сд}} \quad (3)$$

and for plastic loess soils

$$\alpha_{кр} = \frac{2\pi g\, c_w}{\gamma_w T_п \upsilon_{сд}} \quad (4)$$

From these formulas it can be seen that the magnitude of the critical acceleration is determined mainly by the strength characteristics of the soil, and all other things being equal, the critical acceleration decreases with deterioration of soil properties.

Example. We determine the magnitude of the critical acceleration for the surface layer of plastic loess soil, characterized by the following data: the adhesion force (connectivity) c_w - 0,5 т/$м^2$; $\upsilon_{сд}$ – the velocity of propagation of transverse seismic waves – 150 m/s; the oscillation period T = 0.2 s; the density of wet soil – 1,6 т/$м^3$.

For plastic soils, when P_0=0 (here P_0= weight of the structure), the critical acceleration is determined by the formulas (4).

$$\alpha_{кр} = \frac{2\pi g\, c_w}{\gamma_w T_п \upsilon_{сд}} = \frac{2 \text{ x } 3{,}14 \text{ x } 9{,}81 \text{ x } 0{,}5}{1{,}6 \text{ x } 0{,}2 \text{ x } 150} = 0{,}641 \text{ м}/с^2 = 641 \text{ мм}/с^2$$

To determine the critical acceleration in laboratory conditions, a vibrating installation with horizontally forced vibrations was used. This vibrating system creates horizontal harmonic oscillations with amplitudes from 0.1 to 6.0 mm and frequencies from 1 to 12 Hz. The vibration parameters (frequency, amplitude) created by this experimental vibration installation are close to the parameters of seismic vibrations (for example, the frequency of the devastating Tashkent-Uzbekistan earthquake on April 26, 1966 was 10 Hz.).

Smooth adjustment of the number of revolutions of the electric motor by changing the voltage in the electric motor circuit using a laboratory autotransformer allows you to create vibration effects of varying intensity, taking into account the amplitude and frequency of the oscillation. The intensity of the vibration effect is estimated by the harmonic oscillation formula:

$$\alpha = 4\pi^2 f^2 A \quad (5)$$

where, α- acceleration of oscillation;

f- oscillation frequency;

A- the amplitude of the oscillation.

At the installation, it is possible to examine soils, both disturbed and undisturbed structures at various oscillation accelerations. Using this formula, we can create any value of seismic acceleration on a vibration installation. To perform only preliminary calculations, it is allowed to use the seismic acceleration value given in Table.1. The magnitude of critical accelerations of soil vibrations varies depending on many internal factors, such as composition (granulometric, mineralogical, chemical), state (density-humidity), properties (mechanical) of soils and external factors, such as the intensity of vibration and its parameters (duration, frequency, amplitude Yu.Ya.Velli was engaged in determining the critical acceleration of clay soil in laboratory conditions, and he suggests taking such an acceleration of oscillatory motion as a critical acceleration for connected soils, under the influence of which for 5 minutes. the cohesive soil remains at rest. The critical acceleration of clay soil increases with increasing soil connectivity, i.e., the number of soil plasticity increases with increasing.

Studies have been conducted to determine the critical acceleration for subsident loess soils, which have established the main and sometimes decisive role of soil connectivity in the duration necessary for the manifestation of the destruction of its structure. Depending on the strength of the bonds, the required duration of soil structure disturbance is determined at a certain intensity of shaking. Analysis of the data from our experiments shows that soil deformation (violation of the soil structure) in the process of oscillation in many cases begins after 10-30 seconds. and more since the application of a dynamic load on the soil, which is a characteristic feature for cohesive soils. This is explained by the fact that when a loess soil is shaken, which has some connectivity between the particles, the dynamic load is perceived primarily by these connections, which require a certain amount of time to completely disrupt. The nature of the change in connectivity over time obviously depends on the physico-chemical phenomena in the soil occurring during the oscillation process. This circumstance confirms the previously made conclusion that there is no deformation of the soil if the adhesion forces are not violated during vibrations, i.e. when the critical acceleration is greater than the seismic acceleration. Apparently, in the experiments of Yu.Ya.Welli, clay soils with a sufficiently high value of connectivity were used, the destruction of which took time within 5 minutes.

In laboratory experimental studies, special attention was paid to the influence of various internal and external factors on the change in the critical acceleration of the oscillation of moistened loess soil. With an increase in pressure from 0.05 to 0.3 MPa, the critical acceleration increased 1.5-2.0 times. As the overload increases, the critical acceleration increases, i.e. there is a linear relationship between them.

For a loam sample having 18% humidity and a load of P= 0.075 MPa, at a dry soil density of грунта $\rho_{d=}$1,40 т/$м^3$, the critical acceleration is approximately 1000 мм/$с^2$, and at a density of $\rho_{d=}$1,60 т/$м^3$, the critical acceleration It is equal to 3000 мм/$с^2$, i.e. the critical acceleration increased 3 times. During the experiment, the tested soil samples were given different humidity by artificially soaking them. At a humidity of 5-9%, even with oscillation accelerations of 4000-5000 мм/$с^2$,, which exceeds the values of the maximum seismic accelerations of the oscillation with a 9-point seismic impact, there was no violation of the soil structure, and the soil did not experience any vertical deformations. When humidity reached 14-15%, the critical acceleration value decreased. This is due to the weakening of the connectivity (decrease in strength) of rocks with increasing humidity. It is known that additional saturation of the rock with water is always accompanied by swelling of the soil, associated with thickening of the aqueous shells of particles. At the same time, the soil particles move away from each other, leaving the zones of molecular attraction, weakening the forces of connectivity between the particles. The force of attraction of water to a particle depends in turn on the thickness of the water shells, with an increase in which the force of molecular attraction decreases. This circumstance indicates a relatively slight violation of the structure of loess soils and a decrease in the magnitude of the critical acceleration with increasing humidity. This decrease continues to the degree of humidity Sr = 0.8 and then the magnitude of the critical acceleration tends to a constant value. It follows that the loss of dynamic stability of the studied soils occurs most intensively in the humidity range from optimal to water saturation.

As the results of laboratory experimental studies have shown, the critical acceleration of the oscillation of loess soil increases with an increase in external loading, density and connectivity of the soil. The critical acceleration decreases with increasing humidity, soil porosity, and others. The critical acceleration of moistened loess soil also depends on the duration of the oscillation. In long-term fluctuations, the critical acceleration decreases due to a decrease in the strength characteristics of the soil. The change in the magnitude of the critical acceleration is also influenced to a certain extent by the nature of the dynamic oscillation (in amplitude and frequency). As it is known, high-frequency earthquakes are the most dangerous for the foundations of buildings and structures, from the point of view of violation of dynamic stability. Conclusions and recommendations. The conducted experimental research on the study of methods for determining the critical acceleration of the oscillation of loess soil showed the following:

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Conclusions and recommendations. The conducted experimental research on the study of methods for determining the critical acceleration of the oscillation of loess soil showed the following:

1. Under dynamic (seismic) influences, a violation of the structure and liquefaction of moistened loess soil does not occur in all cases, but only after overcoming some critical acceleration by the current seismic acceleration.
2. After overcoming some critical acceleration by the current dynamic (seismic) acceleration, a sharp decrease in the strength characteristics of soils occurs and this will lead to uneven deformations of structures. These deformations of the foundations during earthquakes in most cases determine the degree of destruction of structures.
3. The critical acceleration of clay soil increases with increasing soil connectivity, i.e., the number of soil plasticity increases with increasing.
4. With an increase in the density of dry soil, all other things being equal, the magnitude of the critical acceleration increases. This is apparently due to an increase in soil adhesion with an increase in their density, since adhesion in loose moistened loess varieties is characterized by a small value and can be relatively easily and quickly disrupted by shaking, thereby ensuring intensive soil compaction, and a large intensity of oscillatory motion is required to disrupt the adhesion of dense soils. These results indicate that the critical acceleration also depends on density.
5. With an increase in humidity, the soil structure is easily disrupted, and the critical acceleration decreases and this occurs most intensively in the humidity range from optimal to water elevation, and then the magnitude of the critical acceleration tends to a constant value.

6. The overall strength and stability of the soil in dynamic (seismic) conditions depends primarily on $\alpha_{кр}$, i.e. on the critical acceleration of the oscillation. The conditions when $\alpha_{кр} > \alpha_c$ can be achieved mainly by increasing the strength characteristics of soils.One of the ways to increase the strength characteristics of soils is to seal them.

Reference

1. Khakimov, G. A. (2020). Changes in the Strength Characteristics of Glinistx Soils under the Influence of Dynamic Forces International Journal of Engineering and Advanced Technology, IJEAT. *Exploring innovation*, 639-643.
2. Khakimov, G. A. (2022). The nature of the change in the connectivity of moistened loess soils during vibration. *American Journal of Applied Science and Technology*, *2*(06), 26-41.
3. Khakimov, G. A. CHANGES IN PLASTIC ZONES IN LESS BASES UNDER SEISMIC VIBRATIONS. *Journal of Nev Zealand*, 742-747.
4. Khakimov, G. A., & Muminov, M. A. (2022). CONSTRUCTION OF BUILDINGS ON WEAK MOIST CLAY SOILS IN SEISMICALLY ACTIVE ZONES OF UZBEKISTAN. *Web of Scientist: International Scientific Research Journal*, *3*(12), 755-760.
5. GMFN, D., Kh, S. S., & Muminov, M. M. (2022). DEFORMATION OF MOISTENED LOESS FOUNDATIONS OF BUILDINGS UNDER STATIC AND DYNAMIC LOADS.
6. Khajiev, N. M. (2022). CHANGE IN THE CONSISTENCY CHARACTERISTICS OF THE WETTED LUSSIC BASES (GRUNTS) OF BUILDINGS UNDER THE INFLUENCE OF SEISMIC FORCES. *Академические исследования в современной науке*, *1*(13), 261-267..
7. Khakimov, G. A., Kh, S. S., Muminov, A. A., Berdimurodov, A. E., & Muminov, J. A. (2023). COMPACTION OF LOESS BASES OF BUILDINGS AND STRUCTURES, AS WELL AS BULK SOILS AROUND THE FOUNDATION USING VIBRATORY ROLLERS IN SEISMIC AREAS. *Galaxy International Interdisciplinary Research Journal*, *11*(4), 306-311.
8. Gayrat, G. K., Abduraimova, K., Muminov, A., Berdimurodov, A., & Sobirova, Z. (2023). CONSTRUCTION OF BUILDINGS AND STRUCTURES IN DIFFICULT SOIL CONDITIONS AND SEISMIC REGIONS OF THE REPUBLICS OF CENTRAL ASIA. *International Bulletin of Applied Science and Technology*, *3*(6), 315-319.
9. Khakimov, G., Abduraimova, K., Muminov, A., Berdimurodov, A., & Sobirova, Z. (2023). DETERMINATION OF THE CALCULATED (PERMISSIBLE) PRESSURE ON THE LOESS FOUNDATION OF BUILDINGS AND STRUCTURES IN SEISMIC CONDITIONS. International Bulletin of Engineering and Technology, 3(6), 61-66.
10. Khakimov, G., Abduraimova, K., Askarov, M., & Khakimova, M. (2023). INFLUENCE OF HUMIDITY ON CHANGES IN THE STRENGTH CHARACTERISTICS OF LESS SOILS UNDER SEISMIC INFLUENCE. *International Bulletin of Engineering and Technology*, *3*(6), 274-281.
11. Khakimov, G. (2023). FORMATION AND DEVELOPMENT OF SEISMOPROSADOCHNOY DEFORMATION AND UVLAJNYONNYKH LYOSSOVYKH OSNOVANIYAX ZDANI I SOORUJENI. *International Bulletin of Applied Science and Technology*, *3*(6), 1339-1345.
12. Khakimov, G. (2023). CONSTRUCTION OF BUILDINGS AND STRUCTURES IN DIFFICULT GROUND CONDITIONS AND SEISMIC AREAS. International Bulletin of Applied Science and Technology, 3(2), 203-209.

13. Хакимов, Г. А., Муминов, М. А., Аскаров, М. Т., & Генжибаев, Т. (2023). РАЗВИТИЕ ПЛАСТИЧЕСКОЙ ДЕФОРМАЦИИ ЛЁССОВЫХ ГРУНТОВ В ПОДФУНДАМЕНТНОЙ ЧАСТИ ОСНОВАНИЯ ПРИ СЕЙСМИЧЕСКИХ ВОЗДЕЙСТВИЯХ. *GOLDEN BRAIN*, *1*(1), 130-135.
14. Gayrat, G. K., & Abduraimova, K. (2023). INCREASING DAMAGE TO STABILITY OF BUILDINGS ERECTED ON LESS SOILS IN SEISMIC AREAS, DEPENDING ON SOME FACTORS. *International Bulletin of Engineering and Technology*, *3*(9), 61-69.
15. Khakimov, G., & Abduraimova, K. (2023). RESULTS OF EXPERIMENTAL RESEARCH ON STUDYING THE DEPENDENCE OF THE CRITICAL ACCELERATION OF GROUND VIBRATIONS FROM VARIOUS FACTORS UNDER CONVERSATION CONDITIONS. International Bulletin of Applied Science and Technology, 3(10), 330-337.
16. Khakimov, G. A., Kh, S. S., Muminov, A. A., Berdimurodov, A. E., & Muminov, J. A. (2023). Experience of compaction of the bases of large buildings and cores of earthen dams of waterworks in seismic areas with optimal humidity of loess soil. *Academia Science Repository*, *4*(04), 365-372.
17. Хакимов, Г. (2023). Повышение сейсмической устойчивости увлажнённых лёссовых оснований. *Сейсмическая безопасность зданий и сооружений*, *1*(1), 170-178.
18. Хакимов, Г., Байматов, Ш., & Муминов, Ж. (2023). Юқори сейсмик туманларда грунтли тўғонларнинг ядросини лёссимон грунтлардан барпо этиш амалиёти. *Сейсмическая безопасность зданий и сооружений*, *1*(1), 115-121.
19. Хакимов, Г., & Байматов, Ш. (2023). Биноларни лёссимон заминларда лойиҳалашда сейсмик кучлар таъсирида пайдо бўладиган деформацияларни ҳисобга олиш. *Сейсмическая безопасность зданий и сооружений*, *1*(1), 161-165.
20. Хакимов, Г. (2023). Изменение прочностных характеристик виброуплотнённых увлажнённых лёссовых грунтов во времени. *Сейсмическая безопасность зданий и сооружений*, *1*(1), 165-170.
21. Rakhmonkulovna, K. G. A. A. K. (2024). INCREASING THE STRENGTH CHARACTERISTICS OF LOESS SOILS OVER TIME AFTER VIBRATION. *Synergy: Cross-Disciplinary Journal of Digital Investigation (2995-4827)*, *2*(2), 39-44.
22. Akramovich, K. G., Xushvaqtovich, B. S., Abduvakhobjonovich, R. S., Sunnatovich, T. Z., & Zarofatkhan, A. (2024). Investigation of the Patterns of Changes in the Structural Strength of Moistened Loess Soils Under Dynamic (Seismic) Influences. *International Journal of Scientific Trends*, *3*(2), 1-9.
23. Akramovich, K. G., Xushvaqtovich, B. S., Abduvakhobjonovich, R. S., Sunnatovich, T. Z., & Zarofatkhan, A. (2024). Problems of Design and Construction of Buildings and Structures in Seismic Areas, on Weak Moistened Clay and Subsidence Loess Bases. *International Journal of Scientific Trends*, *3*(2), 19-26.
24. Machmudov S. M., Samieva S. K. Quantitative assessment of the reliability of the system" foundation-seismic isolation foundation-building" //Central Asian Journal of STEM. – 2021. – Т.– №. 2. – С. 445-452. https://scholar.google.com/citations?view_op=view_citation&hl=ru&user=kzGnBtQAAAAJ&citation_for_view=kzGnBtQAAAAJ:9yKSN-GCB0IC
25. Махмудов С. М., Самиева Ш. Х. КОНСТРУКТИВНЫЕ РЕШЕНИЯ СЕЙСМОИЗОЛИРУЮЩИХ ФУНДАМЕНТОВ ЗДАНИЙ //НАУЧНЫЕ РЕВОЛЮЦИИ КАК КЛЮЧЕВОЙ ФАКТОР РАЗВИТИЯ НАУКИ И ТЕХНИКИ. – 2021. – С. 36-38. https://os-russia.com/SBORNIKI/KON-393.pdf#page=36

26. Khushvaqtovna S. S. Prof. Makhmudov Said Makhmudovich //Study of the Operation of a Building Model with a Seismic Isolation Sliding Belt//INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS ISSN (print). – С. 2643-9840. https://scholar.google.com/scholar?cluster=11592764159241392371&hl=en&oi=scholarr
27. Maxmudov S. M., Samiyeva S. X., Ruziyev S. I. ZILZILA PAYTIDA BINONING ZAMIN BILAN O'ZARO TA'SIRINI VA SEYSMIK TA'SIRNING O'ZGARISHINI HISOBGA OLISH //GOLDEN BRAIN. – 2023. – Т. 1. – №. 1. – С. 151-153. https://researchedu.org/index.php/goldenbrain/article/view/4325
28. Makhmudov S. M., Samiyeva S. X., Roziev S. I. MODELING OF SEISMIC PROTECTION USING VISCOUS AND DRY FRICTION DAMPERS //GOLDEN BRAIN. – 2023. – Т. 1. – №. 1. – С. 70-73. https://researchedu.org/index.php/goldenbrain/article/view/4304
29. Самиева Ш., Махмудов С. Экспериментальные исследования сейсмостойкости зданий //Сейсмическая безопасность зданий и сооружений. – 2023. – Т. 1. – №. 1. – С. 271-274. https://inlibrary.uz/index.php/seismic-safety-buildings/article/view/27518
30. Махмудов С. и др. Special sliding belt supports that protect buildings and structures from earthquakes //Сейсмическая безопасность зданий и сооружений. – 2023. – Т. 1. – №. 1. – С. 90-94. https://inlibrary.uz/index.php/seismic-safety-buildings/article/view/27570
31. Khushvaqtovna S. S., Makhmudovich M. S. SEISMIC REACTION OF FRAME BUILDINGS WITH A COMBINED SEISMIC PROTECTION SYSTEM //IMRAS. – 2024. – Т. 7. – №. 2. – С. 151-157. https://journal.imras.org/index.php/sps/article/view/1080
32. Makhmudov S. M. et al. Modeling the Joint Operation of the" Building-Floor" System in the Calculation of Seismic Force //Innovative: International Multidisciplinary Journal of Applied Technology (2995-486X). – 2024. – Т. 2. – №. 8. – С. 1-7. https://multijournals.org/index.php/innovative/article/view/2072
33. Samiyeva, Shakhnoza K., and Said M. Makhmudov. "SEISMIC ISOLATION SYSTEM AND SEISMIC DAMPERS." (2022): 15-17. https://elibrary.ru/item.asp?id=50343163
34. Khushvaqtovna, Samiyeva Shakhnoza, and Makhmudov Said Makhmudovich. "SEISMIC REACTION OF FRAME BUILDINGS WITH A COMBINED SEISMIC PROTECTION SYSTEM." *IMRAS* 7, no. 2 (2024): 151-157. https://journal.imras.org/index.php/sps/article/view/1080