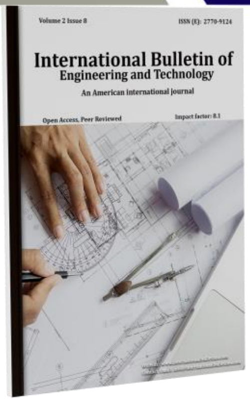

INCREASING DAMAGE TO STABILITY OF BUILDINGS ERECTED ON LESS SOILS IN SEISMIC AREAS, DEPENDING ON SOME FACTORS

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Abstract. This scientific article presents the results of experimental studies on the study of some internal and external factors that significantly affect the increase in the violation of the stability of buildings and structures erected on loess soils in seismic areas.

Keywords: moisturized; water-saturated; loess soils; seismic areas; intensity; duration; earthquakes; stability; amplitude; frequency; ground water level.

Introduction. It is known that the construction of buildings and structures on weak, structurally unstable soils (which include moist loess soils), in seismic regions, ensuring their strength, stability and reliable operation is one of the most difficult problems of modern construction. From the practice of construction, one can cite a lot of cases of deformation of buildings and structures erected on moist loess soils in seismic regions. These deformations are caused mainly by the uneven immersion of buildings into the weakened soil during earthquakes. The study of the patterns of change in the structural strength of weak clayey, as well as moist loess subsidence soils under dynamic (seismic) impacts, depending on various internal and external factors, in order to combat the development of plastic zones under the base of the foundation, is certainly of considerable scientific and practical interest.

The increase in the violation of the stability of buildings and structures erected on loess soils in seismic regions is influenced by a lot of internal and external factors. Let's look at some of them.

1. Moistening of the soils of the foundations of buildings and structures:

a) preliminary soaking of soils during the preparation of the foundation for construction, carried out as a fight against subsidence;

b) damage to some engineering communications during an earthquake, water supply, sewerage, heat pipelines, etc.;

c) in case of ordinary damage to the water supply network, not related to an earthquake;

d) runoff of atmospheric precipitation during the operation of buildings;

e) when watering the garden.

2. Large porosity and subsidence of loess soils.

3. Large capacity of subsiding loess soils.

4. Weak connectivity of young alluvial loess soils.

5. High level of groundwater.

6. High intensity of seismic vibrations.

7. The duration of seismic vibrations.

These factors lead to a weakening of the seismic stability of the foundations, and in connection with this, there is a general drop in the bearing capacity of the foundation. Below we consider in detail the most significant of them.

Results and Discussion. 1. Influence of the intensity of seismic vibrations. Violation of stability, i.e. deformation of loess soils under dynamic (seismic) impact on them is a very complex process occurring in the soil thickness, which cannot be assessed by individual indicators. In this case, internal factors play a significant role: the state of density and moisture content of the soil, the presence of colloidal minerals, particle size distribution, the angle of internal friction, cohesion forces, etc. On the other hand, under certain conditions, external factors can also be of no small importance: the magnitude of the external load, the nature, duration and intensity of the dynamic impact. Among these factors, special importance is attached to the intensity of dynamic impact in the degree of deformability of loess soils. In accordance with the task set, to study the dependence of the deformability of moistened loess soils on the vibration intensity, a series of experiments was performed on samples of loess-like soil.

The studied soils were subjected to fluctuations with intensity from 100 to 4000 mm/s2. (Earthquake strength 4-9 points on the international scale MSK-64). As an example, Fig. 1 shows the results of testing water-saturated loess soils for vibration at a vertical pressure P=0.3 MPa.

These experiments made it possible to establish the nature of soil deformability as a function of vibration intensity, which is expressed by a sharp increase in the intensity of soil deformation with increasing vibration acceleration.

An analysis of the experimental data shows that the deformation of soils in the process of vibration in many cases begins after 3-30 seconds. And more from the moment of applying the dynamic load on the soil, which is a characteristic feature for cohesive soils.

An inverse relationship has been established between the intensity of dynamic impact and the onset of soil deformation, which is a very important factor for predicting the seismic stability of structures built on analogous soils.

The presence of initial strength in the structure of cohesive soils due to cohesive forces requires a certain time for their violation during intense vibrations. This circumstance confirms the previously made conclusion about the absence of soil deformation if the cohesion forces during vibrations are not violated, i.e. when the critical acceleration is greater than the seismic (dynamic) acceleration.

It is known that each type of soil, depending on its composition, state and properties, has its own critical acceleration of vibrations of soil particles. Most authors call critical acceleration such an acceleration of vibrations of soil particles, upon reaching which the soil is in a state of limiting equilibrium and a slight excess of acceleration against the critical one is sufficient for the water-saturated soil to go into a state of loss of its dynamic stability, i.e. into a state of "liquidation". As a result of liquefaction, the structural strength of the soil decreases in the development of significant plastic deformations both in soils lying in the zones bordering the foundation and in the sub-foundation zone of the base, leading to unacceptable deformations of the structure itself.

The intensity of vibration plays a large role in weakening the strength of the soil. A rapidly increasing nature of soil deformation after overcoming the critical acceleration, i.e. after reaching when the seismic acceleration is greater than the critical acceleration. This is apparently due to the fact that after overcoming the critical acceleration with an increase in external vibration accelerations, the strength characteristics of loess soils sharply decrease, which leads to an increase in deformation. This conclusion is confirmed by the studies of many specialists (Kh.Z. Rasulov-Uzbekistan, A.N. Musaelyan-Tajikistan, etc.). Further, with an increase in the acceleration of the oscillation, the deformability increases to a certain value, in the future, its growth stabilizes. It should be noted that for each individual type of soil there is a point where the growth of soil deformation stops with increasing acceleration.

So, for loess-like loams with a density of 1.40-1.50 t/m3, there is an increase in deformation from 10 to 70 mm/m with an increase in the vibration acceleration up to 4000 mm/s 2. A further increase in the oscillation acceleration does not significantly affect the deformation of the soil. This situation is explained by the fact that during prolonged shaking at a particular load, a significant strengthening of structural bonds occurs, requiring for their destruction already new very significant dynamic effects exceeding those originally applied.

There is no doubt that the seismic resistance of soils decreases with increasing accelerations. However, it is necessary to highlight the most significant influence of vibration frequency on the seismic resistance of soils. As construction practice and analysis of the consequences of earthquakes show, the most dangerous for the foundations of structures (from the point of view of violating dynamic stability) are high-frequency earthquakes (the frequency of the Tashkent earthquake of 1966 is 10 Hz, the Gazli earthquake is 16 Hz).

The author conducted experiments to determine the role of vibration frequency in changing the deformation of loess soil. Figure 2 shows the dependence of soil deformation on vibration frequency. The experiments were carried out on four types of loess-like soil with the following parameters: acceleration = 2000 mm/s2, load P = 0.3 MPa, amplitude A = 0.3-3 mm, moisture degree S = 0.8. As follows from the experiments performed the deformability of the soil subjected to research depends on the frequency of vibration. The influence of dynamic action on soil deformability turns out to be more effective if, all other things being equal, this action is characterized by a high frequency.

2.The influence of the duration of seismic vibrations. The duration of seismic vibrations also has a significant impact on the stability (deformation) of soils. Soil deformation increases depending on the duration of the shaking, which is very important from a practical point of view. Figure 3 shows a graph of the dependence E = F(t) (where, E is the soil deformation, t is the duration of vibrations) at α = const. (where, α is the acceleration of vibrations).

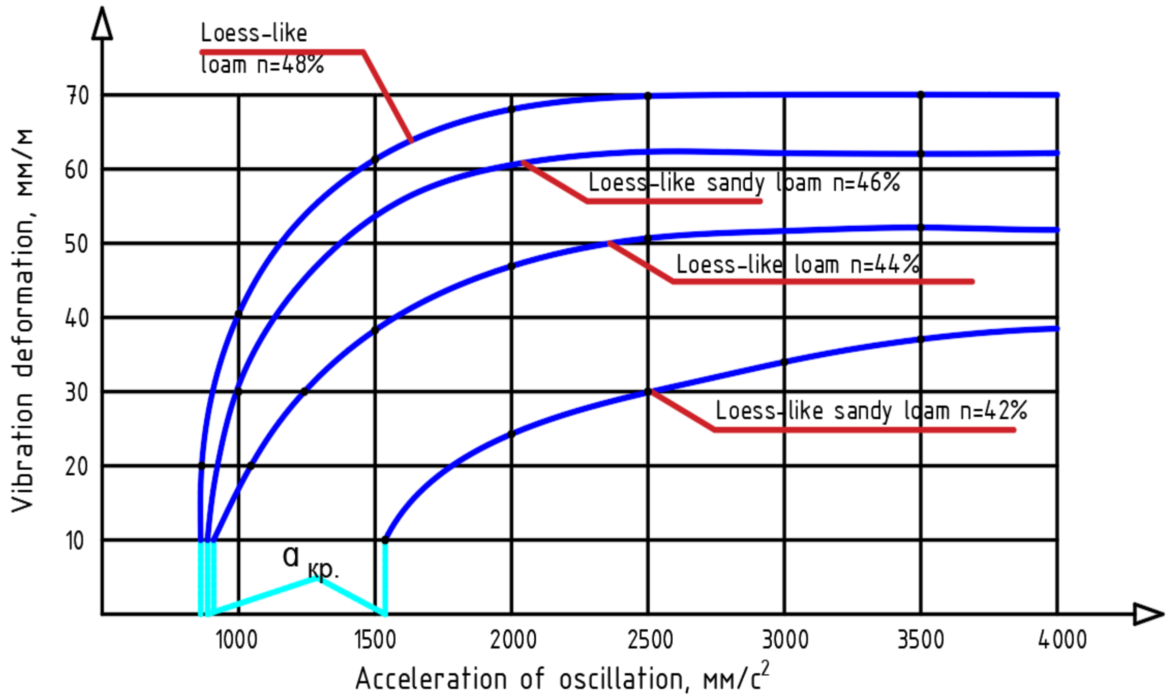

Fig. 1 The nature of the increase in subsidence of loess-like soils depending on the acceleration of shaking.

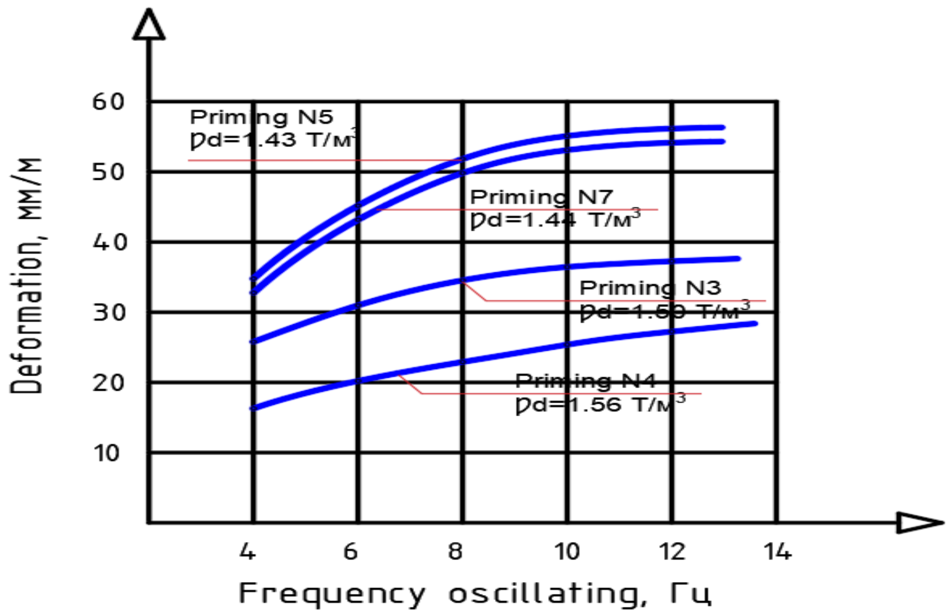

Fig. 2 Influence of intensity (frequency) of vibrations on the amount of settlement of loess-like soils

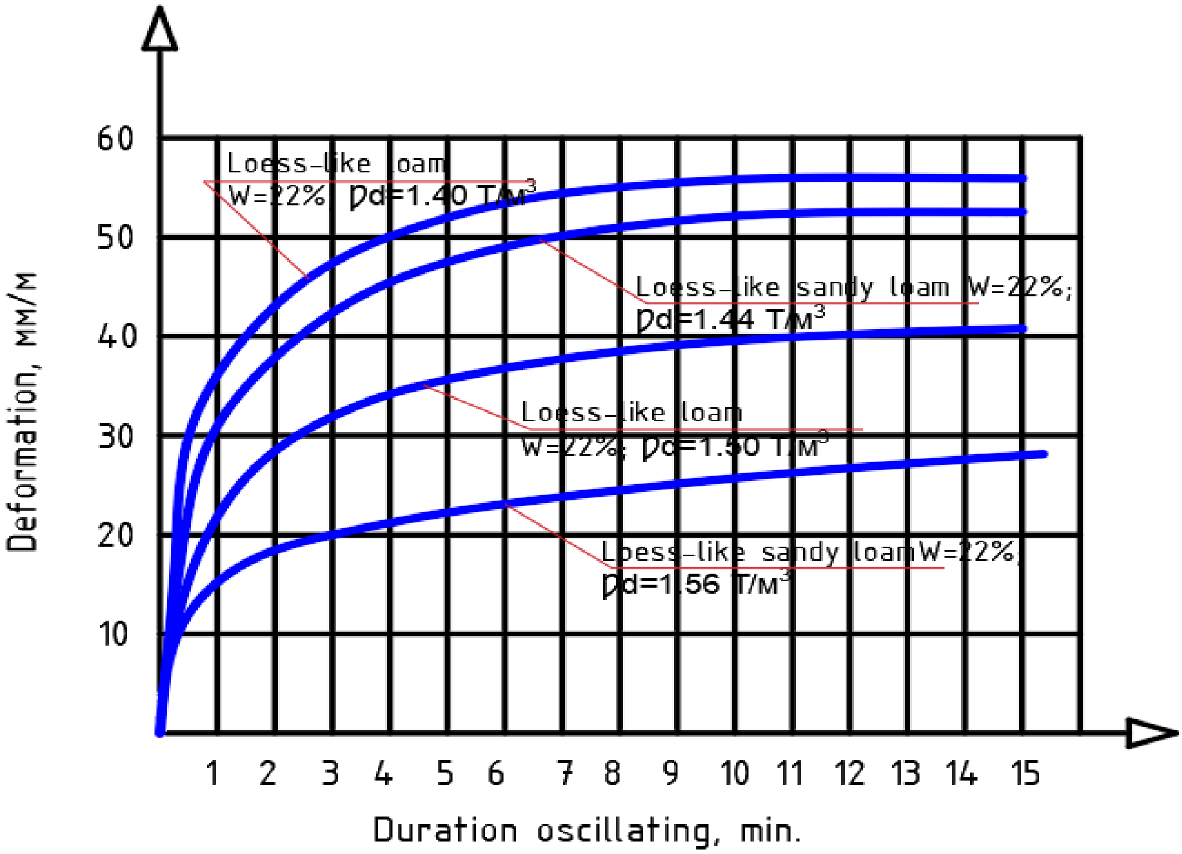

Fig.3 The nature of changes in subsidence of loess-like soils with increasing duration of vibrations

As can be seen from these graphs, the most intense soil compaction occurs during the first three minutes. The complete process of compaction stabilization for the soils we studied is completed in approximately 10-15 minutes. Further vibration of the ground leads to strengthening of structural bonds, the destruction of which requires a more significant vibration intensity. As noted above, the beginning of soil compaction corresponds to 3-30 seconds. after application of dynamic impact. This time is determined by the magnitude of the cohesive force inherent in each type of soil, depending on its condition, also on the magnitude of the dynamic impact.

Despite the almost identical physical and mechanical properties of the studied soils, the effect of their deformation as a result of vibrations of different durations is different.

Soil deformation increases depending on the duration of vibration.

3. Influence of soil conditions in damage to buildings. As is known, the soils of construction sites have a wide variety of lithological compositions and physical, mechanical, and strength properties. The geomorphological features and hydrogeological regime at the construction site are also different. In this regard, the unification of a fairly large territory into one score, as it is divided when compiling seismic microzoning maps, can be considered conditional. Since this entails inconsistencies, an increase or decrease in the calculated seismicity of buildings.

In seismic areas, builders are faced with the task of ensuring the seismic resistance of designed and constructed buildings and structures, and this must be solved within the framework of economic feasibility, since the cost of anti-seismic measures carried out with an increase of even one design point is more than 4% of the total cost of the facility.

In seismic areas, when determining the calculated seismic load of the largest buildings and structures, it is advisable to proceed in each particular case from specific soil conditions, physical, mechanical and strength characteristics.

As an example, consider the seismic microzonation map of Tashkent. compiled by V.M. Mirzaev in 1965. On the seismic zoning map of the CIS territory (former union republics of the USSR), compiled in 1962, the city of Tashkent belongs to the eight-point seismicity zone. In the geological structure of the Tashkent city region there are various deposits from the youngest alluvial to relatively ancient proluvial (thickness from 5 to 70 m or more). Under the city there are bulk loose redeposited layers, reaching 5-10 m in places, as well as coarse soils of varying thickness.

As studies have shown, loess-like soils in the city are different in density and humidity, which was the reason for clarifying the city's score, established by the seismic zoning map of the CIS territory.

As noted above, based on instrumental studies of the consequences of the earthquake in various areas, V.M. Mirzaev compiled a map of seismic microzoning of the city and its compilation is based on the following conclusions of the author:

a) all other things being equal, the intensity of ground vibration depends on the thickness of the soil layer. The map identifies a 7-point zone, where the thickness of the loess-like soil is up to 5 m, an 8-point zone, where the thickness of the loess-like soil is from 5 to 50 m, a 9-point zone, where the thickness of the loess-like soil is more than 50 m.;

b) also, the increase in the intensity of ground shaking depends on its moisture. At the same time, an increase in intensity by one point was noted in loess-like soils, where the groundwater level is above 6 m. From the above it is clear that with the seismic microzonation map of Tashkent, the city's territory is divided into 3 seismic zones with an intensity of 7, 8 and 9 points.

This information shows that even within a small area there are significant differences in soil conditions, which confirms the inadequacy of determining its score by one value.

D.D. Barkan, Yu.G. Trofimenkov and M.N. Golubtsova established an increase in seismic intensity for cohesive soils depending on the strength properties of soils. They propose introducing a correction factor Kgr. to take into account the influence of soil conditions on the value of the seismicity coefficient Ks. The calculated value of the seismicity coefficient К_C^P is determined from the expression:

$К_С^Р$= Кгр. Кс.

To determine the coefficient of soil conditions Kgr. the authors proceed from the value of the design pressure on the soil Pp, calculated on the basis of the strength characteristics of the soil at a specific construction site.

As an average seismic characteristic of the soil, by which the seismic intensity of the area is determined, a design pressure of about 2.5 kgf/cm2 (0.25 MPa) is recommended, which leads to some convention. For such soils Кгр. = 1, for all others the magnitude increment is set in the form:

Кгр. = $\frac{2,5}{Pp}$

It should be noted that the results of these studies allow a fairly reasonable assessment of the calculated rating of buildings and structures.

Where, Кгр.- soil conditions coefficient;

$К_С^Р$ - calculated value of the seismicity coefficient;

Рр –расчётное давление на грунт;

Кс– seismicity coefficient corresponding to the intensity of the area and determined for average soil conditions according to tables of building codes and regulations (for example, according to the international scale MSK-64 for 7 points - 0.025, for 8 points - 0.05 and for 9 points - 0.1).

Conclusions. 1. As is known, the settlement of foundation soil during earthquakes in most cases determines the degree of destruction of buildings and structures.

2. With the weakening of soil strength and a decrease in the overall stability of foundations during earthquakes, uneven deformations of buildings and structures erected on moist loess soils occur.

3. In seismic areas, when designing buildings, it is first necessary to determine the expected additional deformation of structures, taking into account the possible duration and intensity of the earthquake and changes in the mechanical characteristics of soils under these conditions. The decrease in the strength of soils at the base during earthquakes and the associated deformations of structures increase with increasing intensity and duration of seismic vibrations.

4. As construction practice and analysis of the consequences of earthquakes show, high-frequency earthquakes are the most dangerous for the foundations of structures (from the point of view of violating dynamic stability).

5. Soil deformation increases depending on the duration of vibration.

6. From the above data we can conclude that the own weight of the thickness of water-saturated soils has a positive effect on increasing their dynamic stability. However, during the oscillation process, a decrease in the value of its own weight is observed due to the suspension of soil particles by back pressure (dynamic pressure).

7. The experiments carried out showed a directly proportional relationship between the strength characteristics of the soil and its seismic stability.

8. Along with factors such as loading and the soil's own weight, the magnitude of the critical acceleration is also positively influenced by the depth of the foundation.

9. The value of critical acceleration increases linearly with the value of normal stresses from the load.

10. In seismic areas, when determining the calculated seismic load of the largest buildings and structures, it is advisable to proceed in each particular case from specific soil conditions, physical, mechanical and strength characteristics, since basically the increase in the intensity of ground shaking depends on its moisture, layer thickness, physical and mechanical characteristics, etc.

11. For rocky, semi-rocky and especially dense coarse clastic rocks with groundwater occurring at a depth of h≥15 m, the seismic score is reduced by one; for loess soils (clays in a plastic state, sandy loams, loams) and sands at h≤4 m, as well as coarse rocks at h≤3 m, the seismic score increases by one.

References:

1. Khakimov, G. A. "Changes in the Strength Characteristics of Glinistx Soils under the Influence of Dynamic Forces International Journal of Engineering and Advanced Technology, IJEAT." Exploring innovation (2020): 639-643.
2. Khakimov, Gayrat Akramovich. "The nature of the change in the connectivity of moistened loess soils during vibration." American Journal of Applied Science and Technology 2.06 (2022): 26-41.
3. Khakimov, Gayrat Akramovich. "CHANGES IN PLASTIC ZONES IN LESS BASES UNDER SEISMIC VIBRATIONS." Journal of Nev Zealand, 742-747.
4. Khakimov, G. A., and M. A. Muminov. "CONSTRUCTION OF BUILDINGS ON WEAK MOIST CLAY SOILS IN SEISMICALLY ACTIVE ZONES OF UZBEKISTAN." Web of Scientist: International Scientific Research Journal 3.12 (2022): 755-760
5. GMFN, Dos, Samiyeva Sh Kh, and Master MA Muminov. "DEFORMATION OF MOISTENED LOESS FOUNDATIONS OF BUILDINGS UNDER STATIC AND DYNAMIC LOADS." (2022).
6. Khajiev, N. M. "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 (2022): 261-267.
7. Miralimov, Mirrakhim Mirmakhmutovich. "Principles of Regulation of Thermal Protection of Enclosing Structures and Their Impact on the Energy Efficiency Of Buildings." Design Engineering (2021): 496-510.
8. Хакимов, Ғайрат, et al. "ЭНЕРГИЯТЕЖАМКОР ВА ПАСТ ЭНЕРГИЯ ЭҲТИЁЖЛИ ЗАМОНАВИЙ БИНОЛАР ҚУРИЛИШИНИНГ ЖАҲОН АМАЛИЁТИ ВА УНДАН ЎЗБЕКИСТОН ШАРОИТИДА ФОЙДАЛАНИШ ИСТИҚБОЛЛАРИ." Talqin va tadqiqotlar 1.19 (2023).
9. Khakimov, Gayrat. "CONSTRUCTION OF BUILDINGS AND STRUCTURES IN DIFFICULT GROUND CONDITIONS AND SEISMIC AREAS." International Bulletin of Applied Science and Technology 3.2 (2023): 203-209.
10. Akramovich, Khakimov Gayrat, and Islamova Nargiza Abdukarimovna. "MAIN ASPECTS OF ENERGY CONSERVATION IN CIVIL ENGINEERING." Open Access Repository 9.4 (2023): 116-123.
11. GA Khakimov,SS Kh, AA Muminov, AE Berdimurodov, JA Muminov. "COMPACTION OF LOESS BASES OF BUILDINGS AND STRUCTURES, AS WELLAS BULK SOILS AROUND THE FOUNDATION USING VIBRATORY ROLLERS IN SEISMIC AREAS". Galaxy International Interdisciplinary Research Journal 11 (4), 306-311.
12. Gayrat, Gayrat Khakimov, et al. "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 (2023): 315-319.
13. Khakimov, Gayrat, et al. "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 (2023): 61-66.
14. Khakimov, Gayrat. "NEW GENERATION BUILDINGS THAT EFFECTIVELY USE ENERGY AND THEIR UZBEK EXPERIENCE." International Bulletin of Engineering and Technology 3.2 (2023): 74-78.
15. Khakimov, Gayrat, et al. "INFLUENCE OF HUMIDITY ON CHANGES IN THE STRENGTH CHARACTERISTICS OF LESS SOILS UNDER SEISMIC INFLUENCE." International Bulletin of Engineering and Technology 3.6 (2023): 274-281.

16. Khakimov, Gayrat. "FORMATION AND DEVELOPMENT OF SEISMOPROSADOCHNOY DEFORMATION AND UVLAJNYONNYKH LYOSSOVYKH OSNOVANIYAX ZDANII SOORUJENI." International Bulletin of Applied Science and Technology 3.6 (2023): 1339-1345
17. Editor Journals and Conferences. (2023, April 12). 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. https://doi.org/10.17605/OSF.IO/XH85C TIAC Khakimov G.A. g.m.f.n., Dos. Samiyva Sh. Kh. Doctoral Student (PhD… Web of Scientist International Scientific Research Journal, 4(04), https.
18. Хакимов, Г. А., et al. "РАЗВИТИЕ ПЛАСТИЧЕСКОЙ ДЕФОРМАЦИИ ЛЁССОВЫХ ГРУНТОВ В ПОДФУНДАМЕНТНОЙ ЧАСТИ ОСНОВАНИЯ ПРИ СЕЙСМИЧЕСКИХ ВОЗДЕЙСТВИЯХ." GOLDEN BRAIN 1.1 (2023): 130-135.