Geotechnical problems related to the development of territories in the conditions of the Republic of Tajikistan

Problèmes géotechniques lies au développement de territoires dans les conditions de la République du Tadjikistan

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ABSTRACT: in this paper features of construction of buildings and constructions in difficult engineering-geological conditions of the Republic of Tajikistan are presented. Methods of design and construction of the bases and other foundations on loess collapsing soils, on weak water-saturated soil, and prospects of development of the hilly territories needing a difficult relief are considered.

RÉSUMÉ : Il est question dans cet article de la construction de bâtiments et de constructions dans des conditions difficiles à la fois d'ingénierie et de géologie rencontrées en république du Tadjikistan. On évoque les méthodes de calcul et de réalisation des radiers et autres fondations sur les sols lœssiques, sur les sols peu résistants saturés d'eau, ainsi que les perspectives de développement des territoires en terrains très accidentés nécessitant de difficiles reprises en sous-oeuvre.

KEYWORDS: loess collapsing soils, weak water-saturated soils, hilly territories, static and seismic influences.

1 INTRODUCTION

In the Republic of Tajikistan more than 90% of the territory are presented by a mountains, and the areas of plains are made by only 7%. The basis of development of a national economy of the republic is made by the agrarian sector which is based on irrigated agriculture under which about 70% of all flat territories are allocated. The deficiency of the earth being the main reserve for development of agricultural production, housing, industrial, etc. types of construction always represented a special problem and demands very reasonable and careful use.

Development of the country and growth of the population demands increase in volumes of agricultural production and construction of buildings of different function. Therefore, preservation and increase in land fund put before designers and builders of adoption of effective decisions. In this direction the most effective are:

- substantial increase of number of stores of buildings and constructions erected in flat territories that will allow to keep and free territories for development of agricultural production;
- development under construction of buildings and constructions of foothill (hilly) territories.

It should be noted that in the Republic of Tajikistan construction of buildings and constructions is carried out, generally in territories presented by loess collapsing and weak water-saturated soil, and in recent years as well on foothill (hilly) sites. Practically all territory of the republic is characterized by 8-9 mark seismic intensity. In the specified conditions design, construction and reliable operation of buildings and constructions is closely connected with use of effective methods of preparation of the artificial bases and devices of the foundations. Taking into account it in the republic the complex researches which results are generalized in considered article were conducted.

1.1 Construction on the loess collapsing soils

About 70% of flat territories of the republic are everywhere presented by loess collapsing soil which capacity changes from 5 to 300 m, and their thickness makes H_{sl} = 5…30 m, exceeds 30 m less often. More than 2/3 territories of the country are put by loess collapsing soil II of type, with the size of expected sag from a coefficient of relative collapsing ε_{sl} = 30…150 cm.

The majority of the cities, objects of civil and industrial function are erected in these territories. Thus till 80 years of the twentieth century, 4-6 floor buildings therefore for practical use researches were conducted were generally erected and the following superficial methods of consolidation of soil, the device of the bases and foundations (fig. 1) are developed(Musaelyan A.A. 1982, Krutov V. I. 1982, Galitsky V.G. and Popsuyenko I.K. 1985, Ruziyev A.R. and Usmanov R. A. 1991):

a) Consolidation by heavy tampers weighing 50…200 kN in combination with constructive and water protective measures. Advantages – simplicity and use of the simple equipment, rather low cost. Shortcomings – fast wear of the mechanisms, limited application in the conditions of dense building.

b) The device of the condensed soil pillows 3-5 m thick and more from a clay material in combination with constructive and water protective measures. Advantages – simplicity and use of the simple equipment, possibility of application in the conditions of dense building, rather low cost. Shortcomings – seasonality of work, big labor expenses when finishing soil to optimum humidity, increase in terms of construction at increase of thickness of a pillow.

c) Consolidation by energy of underwater explosions in combination with constructive and water protective measures. Advantages – simplicity and use of the simple equipment, low cost. Shortcomings – limited application in the conditions of dense building.

d) The device of the bases in tamping ditches with creation in their basis of broadenings from rigid materials. Advantages – use of the simple equipment, combination of processes of the device of a ditch and consolidation of collapsing soil, the minimum use of a timbering, decrease in reinforcing of the base to 50% and more, low cost. Shortcomings – fast wear of the mechanisms, limited application in the conditions of dense building.

e) Fixing of soil by way of silicification with activization of soil by carbon dioxide. Advantages – use of the simple equipment, high quality of fixing, possibility of fixing of soil in the basis of the emergency and deformed buildings. Shortcomings – very high cost and therefore, it is generally applied to strengthening of soil in the basis of the deformed buildings and constructions.

f) The device of the pile bases from lovering piles. Advantages – technological effectiveness, use of the high-performance equipment, ensuring appropriate quality. Shortcomings – difficulties at immersion of piles in soil of the firm and semi-firm consistence, limited application in the conditions of dense building, cost increase at increase in thickness of a collapsing layer of earth and removal of places of production of piles.

reduction of terms of consolidation of soil, rather low cost. Shortcomings - are similar to point "a".

c) The accelerated consolidation by preliminary soaking in combination with deep explosions. Advantages – improvement of quality of consolidation and decrease in risk of development of seismic deformations. Shortcomings – are similar to point "a".

d) Reinforcing of collapsing thickness by soil piles, including high-strength materials. Advantages – simplicity of production, use of the simple equipment, use of a local material, rather low cost. Shortcomings - application restriction in the conditions of dense building, fast wear of the equipment.

Note: at consolidation of soil on points "a", "b", "c" and "d" in the top part of the basis the buffer non condensed layer 3-5 m

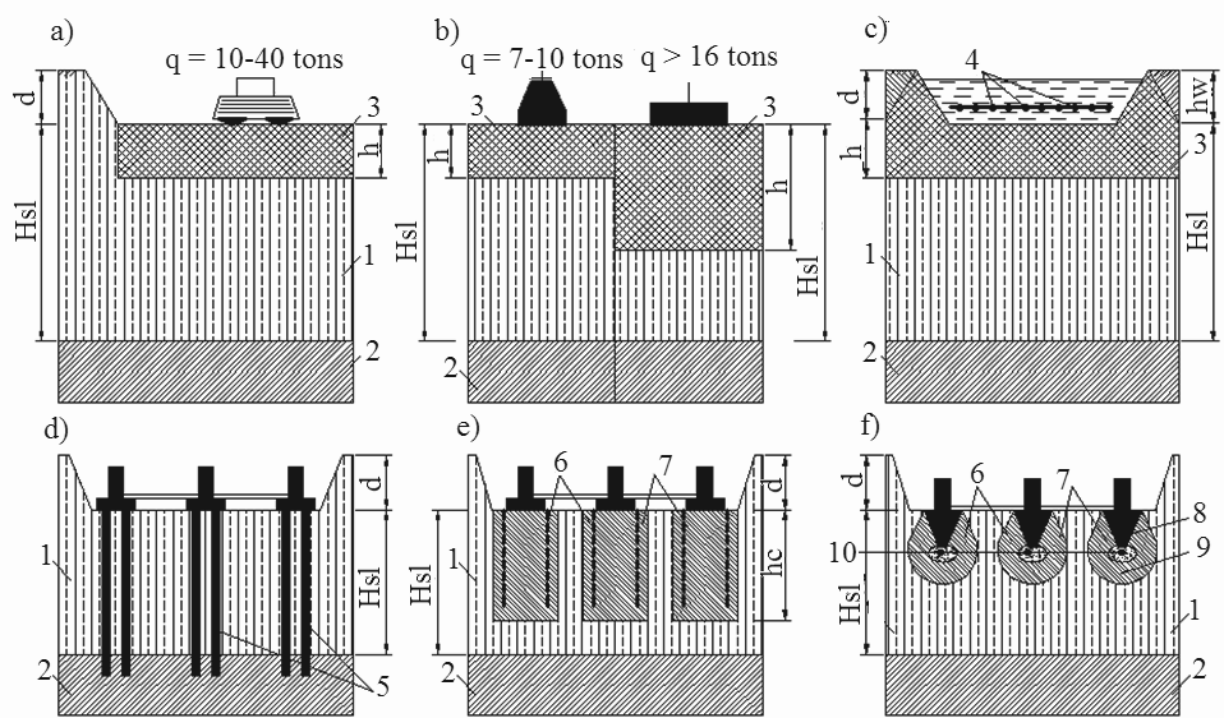

Figure 1. Methods of the device of the bases and the foundations on loess collapsing soil I of type:
1- loess collapsing soil; 2- non collapsing soil; 3- condensed soil pillow; 4- charges of explosive; 5- driven piles; 6- injektor for chemical fixing of soil; 7- fixed soil; 8- base in a tamping ditch; 9- condensed zone; 10- tamping rubble

All given methods of preparation of the bases and the device of the bases were investigated on joint action of static and seismic influences by intensity of 8-9 points on the basis of which the relevant normative documents on technology of the device and a calculation procedure were made. However the know-how showed on possibility of development of uneven deformations and violation of operational suitability of buildings and the constructions erected on the specified artificial bases. Use of these methods expediently and effectively in the conditions of collapsing soil I of type, and on collapsing soil II of type – in combination with deep methods of consolidation and fixing.

After the 80th years design and construction 9-12 floor and more buildings in this connection researches were conducted began and the following methods of deep consolidation of soil and a design of the pile bases are recommended for practical application:

a) Consolidation by preliminary soaking. Advantages – simplicity and low cost. Shortcomings – application restriction in the conditions of dense building, long terms of consolidation, need for large volume of water, need of the device of no filtration veils in the conditions of dense building.

b) The accelerated consolidation by preliminary soaking with application of drainage wells. Advantages – considerable

thick (h_f) which needs to be condensed further with heavy tampers is formed or to replace with the condensed soil pillow.

e) The device of the bored piles with a diameter from 0,5 to 1,2 m cutting all collapsing thickness. Advantages – possibility of the device in various conditions with use of the modern equipment. Shortcomings – use of the expensive equipment, complexity of quality control of works, need of carrying out expensive static tests of piles, rather high cost.

f) The device of the combined pile bases when in advance drilled well the pile of factory production is established, and a cavity of a well is filled with cement and sand solution. Advantages – simplicity of the device and use of the simple equipment, control and improvement of quality of the device of the pile bases, decrease in their cost. Shortcomings – restriction of possibility of application and cost increase at increase in length and distances of transportation of piles.

All above-mentioned methods were investigated on joint action of static and seismic influences by intensity of 8-9 points on the basis of which the relevant normative documents on technology of the device and a calculation procedure were made. Researches and operating experience testifies to opportunity and expediency of their application at the device of the bases and the foundations of high-rise buildings. In the

conditions of the republic application of the slabby and pile bases which well proved in practice of high-rise construction of many countries is also expedient.

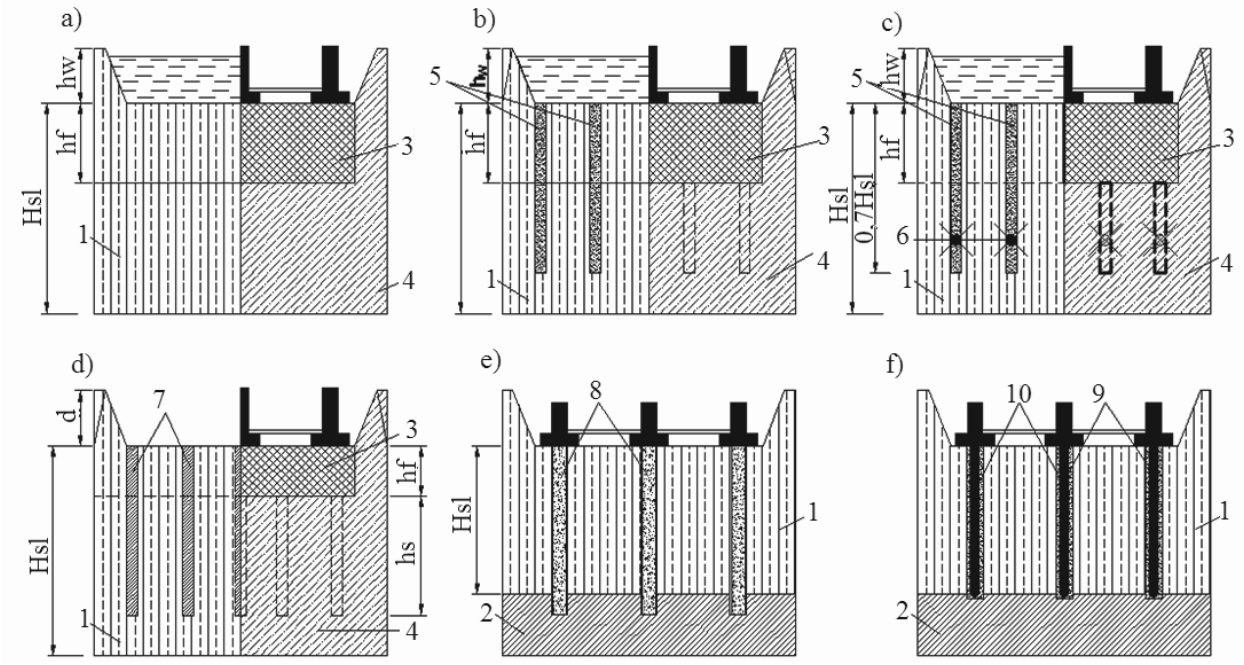

Figure 2. Methods of the device of the bases and the foundations on loess collapsing soil II of type:
1- loess collapsing soil; 2- non collapsing soil; 3- condensed soil pillow; 4- condensed thickness of soil; 5- drainage wells; 6- charges of explosive; 7- soil piles; 8- bored piles; 9- lowering driving piles; 10- cement and sand filler

1.2 Construction on weak water-satureted soils

In the Republic of Tajikistan, as a result of influence of a number of natural and technogenic factors sharp lifting of level of underground waters and flooding of the extensive territories put by big thicknesses of earlier low-damp loess soil owing to what they pass to category weak and strong compressibly ($R \leq 100$ kPa, $E \leq 5$ MPa) is observed. Thus processes of flooding of territories promote increase of seismic intensity of sites of construction on 1…2 points. Now about 40% of the mastered areas in the republic are presented by the specified soil and the steady tendency of their increase is observed.

Effective design, construction and operation of buildings on the specified soil are connected with application of various methods of the device of the artificial bases and the foundations taking into account high seismic activity of mastered sites. In this direction the corresponding researches were conducted and the following methods of the device of the bases and the foundations (fig. 3) are offered for practical application (Usmanov R. A. 2009):

a) The device high-condensed ($\rho_d \geq 2{,}2$ t/m^3) sandy, gravel and pebble pillows. Advantages – use of the simple equipment and simplicity of the device; low cost and small labor input; high reliability; existence of large volume of a local material. Shortcomings – difficulties at the device during the winter period; scope restriction with buildings to 6 floors.

b) The device of the bases from the driving and stuffed piles which are cutting through a weak layer of earth. Advantages – use of the modern equipment, reliability. Shortcomings – substantial increase of cost and restriction of a scope of driving piles at increase in thickness of weak soil; difficulties of quality control of production of a stuffed pile and increase of its cost at increase in length.

c) Fixing of soil by limy piles. Advantages – simplicity of technology of the device and low cost of a method, refusal of metal and cement application. Shortcomings – use of the special equipment, complexity of quality control of works.

d) Consolidation of soil by vertical sandy piles. Advantages – simplicity of technology of the device and low cost; existence of sufficient volume of a sandy material; refusal of metal and cement application. Shortcomings – use of the special equipment; difficulties of quality control of works; considerable labor inputs at the device and removal of a loading embankment.

e) Consolidation of soil by vertical sandy drains. Advantages – simplicity of technology of the device and low cost; existence of sufficient volume of a sandy material. Shortcomings – use of the special equipment; difficulties of quality control of works; considerable labor inputs at the device and removal of embankment.

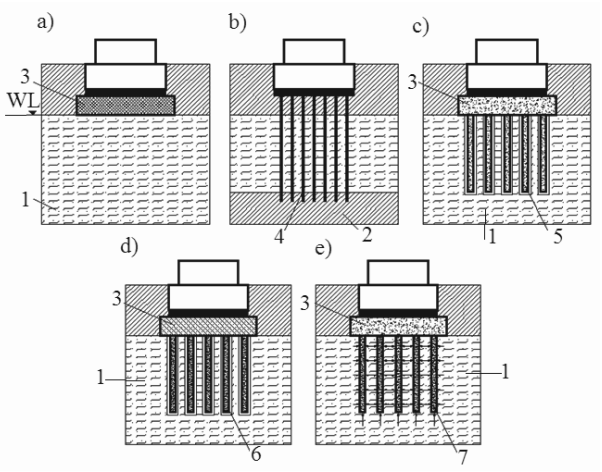

Figure 3. Methods of preparation of the bases and the device of the foundations on weak water-saturated loess soils
1- weak soil; 2- strong layer; 3- soil condensed pillow;
4- driving and stuffed piles; 5- limy piles;
6- sandy piles; 7- vertical sandy drains

All above-stated methods were investigated on joint action of static and seismic (seismoexplosive) influences by intensity of 8-9 points. Except the device of the high-condensed soil pillows, other methods of preparation of the bases and the device of the foundations can be recommended for the device of the bases and the foundations of high-rise buildings. And

effective application of the slabby and pile bases also is expedient.

1.3 Development of foothill territories

Foothill (hilly) territories meet in all areas of the republic, are presented by the difficult (dismembered) relief and their area makes more than 5400 sq.km. Development of these territories under building of buildings and constructions of different function is one of the most effective directions of a solution of the problem of deficiency of the earth in the republic.

Hilly territories are characterized by existence of slopes by the steepness α = 20 … 65 ° and more, are put by loess collapsing soil thickness $H_{sl} \geq 20…30$ m relating to the II type on a collapse. Development of these territories under building represents very complex challenge and its effective decision is connected with development of such methods of the device of the bases and the foundations which allow to provide stability of slopes and at the same time are counter collapse actions in the conditions of essential change of humidity of the massif of soil and high seismic activity of sites of construction.

Purposeful development of hilly territories for housing, industrial and civil engineering began from 80th years of the last century. For the solution of this problem complex experimental and theoretical researches were conducted, the purpose and which tasks was identification of effective methods of counter collapse and protection of slopes against landslide. Methods of the device of the bases, allowing to eliminate collapse properties of soil and to provide stability of slopes are given in fig. 4 (Ruziyev A.R. and Usmanov R. A. 1991, Usmanov R. A. 2002, Akhmedov D. D. and Lekarkin V. K. 2002):

a) the device of the condensed pillows of the increased thickness with water protective measures;

b) thickness reinforcing by soil piles, including high-strength elements;

c) slotting loess collapsing soil driving and bored piles of big length;

d) consolidation of loess collapsing soil by preliminary soaking, including energy of deep explosions

In the conditions of the republic one of important questions is development of a method of calculation of stability of slopes of the various steepness, with identification of real surfaces of sliding since purpose of the relevant activities for ensuring its stability depends on it as a choice of rational methods of preparation of the bases and the device of the foundations, and. In practice the method of circular-cylindrical slip surfaces of sliding is widely used. However researches of the last years testify that in seismic conditions of the republic fluidifying landslides when there is a slipping of the top layer of a slope 5-7 m thick are often observed. Therefore, now one of key questions - the forecast and a method of calculation of stability of slopes of the various steepness with definition of real surfaces of sliding remains open and demands the decision.

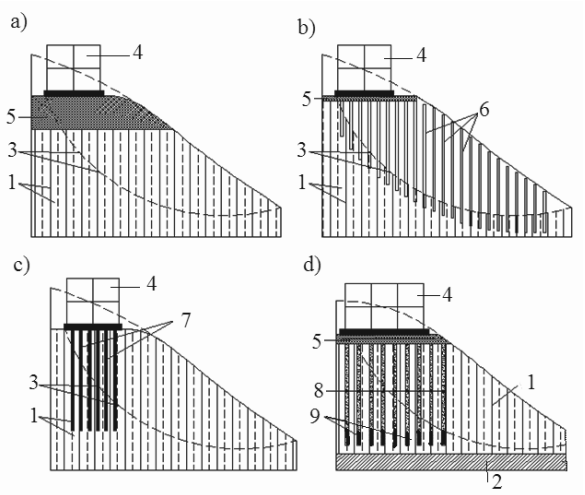

Figure 4. Methods of the device of the bases and the foundations in the conditions of a foothill territories:
1- loess collapsing soil; 2- non collapsing soil; 3- surface of sliding; 4- the projected building; 5- condensed soil pillow; 6- reinforcing elements; 7- driving or bored piles; 8- drainage and explosive wells; 9- charges of explosive

2 CONCLUSIONS

1. Design and construction of constructions in the Republic of Tajikistan is carried out in difficult geological and seismic conditions that considerably complicates and increases construction cost. Deficiency of the earth demands development under construction of unsuitable territories for agricultural production which are presented by problem soil, and also substantial increase of number of storeys of buildings and rational use of underground space of the cities.

2. One of the most effective directions is development of the foothill territories presented by a difficult relief and big thickness of loessial collapsed soil for which successful decision it is necessary to continue experimental and theoretical researches with application of modern technologies and calculation methods.

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