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APPLICATION OF INJECTION TECHNOLOGIES IN THE DEVICE OF GROUND CONSTRUCTIONS IN DIFFERENT GEOLOGICAL TERMS

1. INTRODUCTION

Building of transport pipelines above a terrene requires building of powerful supports. If to take length of pipeline into account, the geological terms of their buildings differ a considerable variety. It requires to take the credible weakening of grounds of buildings by reason of different complications into account. The variety of complications and their spatial vagueness, as a rule, does not allow to determine it on the stage of researches and simply predict factors which negatively influence on stability of buildings.

To such unforeseeable negative factors behave:

- local settling of soil under the action of technogenic waters,
- hyposthenic areas are in karsts soil,
- vagueness of slickenside at building on slopes,
- vagueness in seismic influence on soil as foundation.

For weakening of influence of unforeseeable factors in modern building usually increase cruelty of soils in the spot of building and in the nearest environs. The most progressive method of increase of cruelty is re-enforcement of soil.

Modern technology offers a few methods of reinforsing [1]:

- reinforsing of soil a net which allows to redistribute loading from building in horizontal direction,
- reinforsing of soils vertical piles from close-settled soil,

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– reinforsing of soils cement-soils piles,
– reinforsing on stream technology,
– reinforsing on injection technology.

Injection technology, to our opinion, is most flexible from all of transferred, suitable for most geological complications and allows to execute the repeated strengthening of foundation at the change of terms.

In obedience to the normative documents of Ukraine [2] cementation in building is utillized:

– as an auxiliary mean at the chemical fixing of soils for the increase of contact of building with foundation,
– for fixing of crumbling and semirocky breeds, including fragmental soils,
– for fixing of loess and other soils of low permeability in the mode of break of layer with re-enforcement of soil the voxels of cement solution.

At fixing clay and other soils the pressure injection of cement solutions in the mode of break of layer is a change of physic-mechanical descriptions of array because of:

– the compression of soil festerings of solution under constraint,
– strengthening of soil a cement stone.

These two factors increase bearing strength of foundation, diminish his deformability on the depth of festerings and diminish its soaking.

Concordantly to information of the article of [3] after an injection in soil the general module of deformation is increased in 2.5–3.2 time, first critical pressure in 1.23–2.2 time. Strength of reinforcing cement stone can attain 30 MPa, module of deformation depending on maintenance of cement from 50 to 500 MPa.

LTD TISSA for fixing of crumbling rocky breeds and siltages of low permeability applies different technology.

1.1. Technology of fixing crumbling rocky breeds

For fixing of crumbling rocky breeds bore a mining hole on a project depth. If sedimentary soils are present, layer them must be recovered on casing pipe-conductor. Festering is executed through paker or through the plug-forming valve of casing pipe. The chart of injection through paker is resulted on a figure 1.

The radius R of fixing is determined correlation of ratio [4]

$$R = \sqrt{\frac{V}{\pi M m}} \tag{1}$$

where:

M – power of the fastened breeds (depth of mining hole),
m – code is emptiness of breeds in obedience to researches,
V – volume of cement-silicate solution.

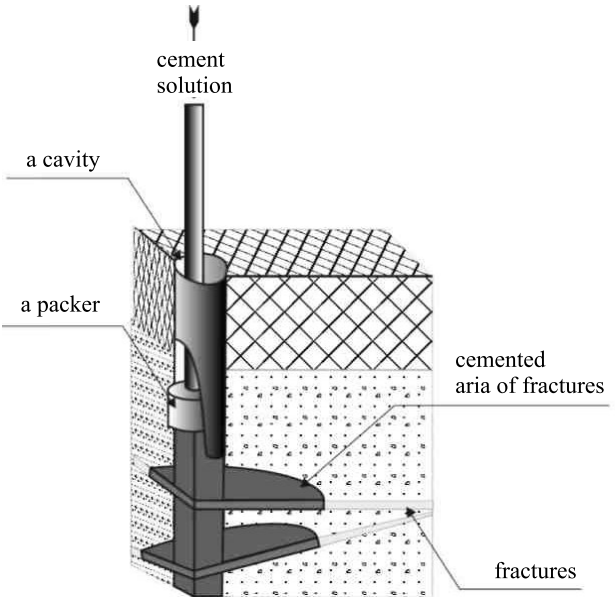

Fig. 1. Scheme of consolidation of crumbling rocks

Pressure P of festering must be more than losses of pressure at the flow of cement so lution on a crack

$$P \geq \frac{\tau_0 R}{\delta} \tag{2}$$

where:

τ_0 – dynamic resistance of change of fastening solution,

δ – width of cracks in obedience to researches.

If rocky array filled clay material, pressure on the backwall of mining hole must be megascopic on the size of the first critical pressure *of* P_k of soil, filling cracks

$$P \geq \frac{\tau_0 R}{\delta} + P_k \tag{3}$$

1.2. Technology of fixing of little-permeable sedimentary soils

For fixing of little-permeable sedimentary soils LTD TISSA applies technology of perforated injector through which execute festering of cement-grout solution. The chart of injection through double paker is resulted on a figure 2.

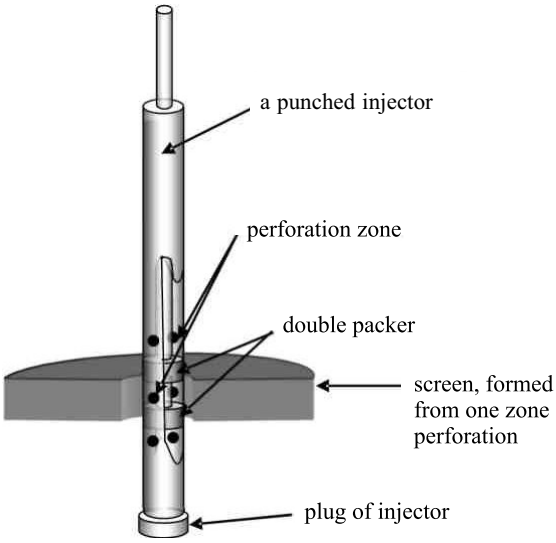

Fig. 2. Scheme of forsing a grout by dual packer

At a delivery of cement solution in soil through the perforation injector of cement lay-by. The thickness of cement expansion Δh_{cem} is determined properties of soil and pressure of festering [4]

$$\Delta h_{cem} = \frac{P}{E_0} m \tag{4}$$

where:

P – pressure of festering in packer, MPa,

E_0 – the module of general deformation of soil, MPa,

m – thickness made more a compact layer of soil or distance between the areas of perforation.

The radius of fixing soil is determined correlation

$$R = \sqrt{\frac{V}{\pi \Delta h_{cem}}} \tag{5}$$

Pressure of festering must be more than pressure of break of soil.

Experience of TISSA LTD on the device of grounds of buildings in the different geological terms of Crimea is the example of successful application of injection re-enforcement of soil.

2. STRENGTHENING OF SLOPE OF FOUNDATION PIT IN YALTA

Construction of building of recreational center in Yalta on the slope of mountain 13 m demanded building of foundation pit a depth and long 35 m.

Active pressure of soil on a protective wall – 29.5 t/m.

Soils are presented deluvium deposits – boulders of rocky breeds with the interboulder filling loams and sandy loam soils. There is additional complication, because loams have cockpite cavities. The walls of cockpite are hardpan a carbonate. A size of cockpite is 0.2–0.6 m.

A project is foreseen by the cable anchorage slope of foundation pit. Length of cable is 6–8 m. Calculation bearing strength of cable in loams at this diameter of the boring drilling 112 mm – less than 20 t. It is not enough for stability of slope. If to take into account probability of meeting with cockpite at the boring drilling, actual bearing strength can be less.

For the increase of bearing strength of cable it is decided to fill a drillhole cement solution under constraint. It must result in strengthening of soil round a drillhole. For realization of this project a drillhole was equipped a conductor by a diameter 127 mm and long 2 m. In conductor set one-sided paker through which executed festering of cement-silicate solution. Festering was made to achievement by pressure 1.0 MPa. The volume of festering made 0.6–2.5 m^3 at geometrical volume mining holes of 0.09 m^3. The purpose of strengthening of soil was attained (Fig. 3).

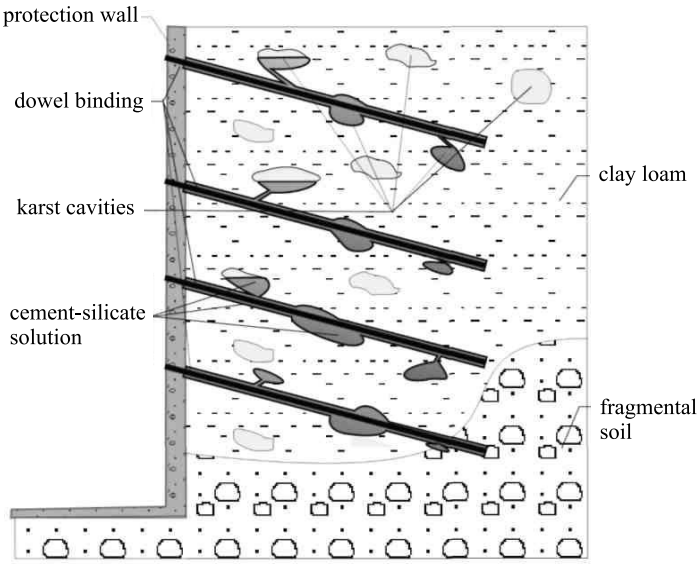

Fig. 3. Scheme of consolidation of cable soils

Tests rotined bearing strength of pin on soil of 31.2 t, that is technologically acceptable in these terms.

3. STRENGTHENING OF SLOPE ON A CAPE CRYSTAL (SEVASTOPOL)

Building of sporting and cultural complex on a beach Crystal make in accordance with the General layout of building Sevastopol, Artillery bay and bay Omega.

A sporting and cultural complex is located along a beach near a rocky array.

Therefore an array on a construction site is chosen to formation of vertical slope a height 6.0–13.5 m.

The analysis of geological data shows that an array is difficult crumbling and by the karst limestones of small durability. Cracks are often filled clay material. There are layers of loam with a thickness to 1.5 m. Corner of natural slope – not more than 38^{o}.

The sources of underwaters in an array are not noticed. Crumbling of array is not instrumental in the accumulation of atmospheric water. These factors show instability of vertical slope of cape Crystal.

For this reason it is necessary to execute defence of building of all of complex.

For prevention of transmission pressure of mountain breeds on building a project provides for:

- to erect a protective wall with the cable fixing,
- to organize the system of drainages of atmospheric water in an order to prevent washing out of soil near-by a supporting wall.

The calculation specific loading on a protective wall on length of building makes 87.59 t/m. Calculation bearing strength of cable on soil, if to take descriptions of limestone without the layer of clay, at length of cable 8 m – 39.6 t. A necessary amount of cables on a supporting wall is 94 cables. It is impossible to take into account diminishing of bearing strength of anchor due to the layers of clay from the statistical vagueness of distribution of cracks which are filled material of clay.

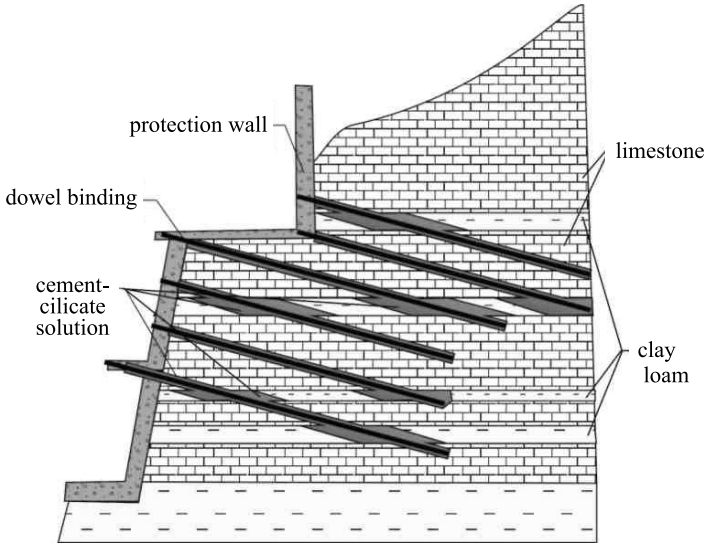

Fig. 4. Scheme of consolidation a multi-stratum soil

A decision to force cement-silicate solution under constraint is accepted for this reason, which must provide penetration of solution in cracks and increase of bearing strength of anchor (Fig. 4).

Festering of solution was executed through conductor by a diameter 127 mm. The volume of the forced solution made one drillhole 0.12–0.25 m^3 at the geometrical volume of mining hole of 0.09 m^3.

On results tests an anchor lost bearing strength at loading 46 t. It suits project.

4. FIXING OF CABLE SOILS IS IN FOUNDATION OF BUILDING BY DRILL-INJECTING PILES

For building of pool in a cultural complex in the beach area of cape Crystal clay soil in foundation of foundation was transferable a hoggin. Power of loose soil made 3 m. A project was it is foreseen to erect foundation on a pilework. Foundation of piles is a weak limestone on a depth 5.5 m. The diameter of drill-injecting piles makes are 200 mm. Calculation loading – 20 t on a pile.

Durability of limestone in foundation of piles unsuffices to provide necessary bearing strength and building stability at the horizontal loadings of seismic influence. It is necessary to increase cruelty of foundation.

The enterprise of TISSA suggested to increase cruelty of foundation by means of festering of cement solution through the lateral surface of drill-injecting piles. Therefore drill-injecting piles were reinforced perforated steel pipe. Through the perforation of double packer cement-silicate solution was forced in forsing soil to achievement of pressure 0.5 MPa. Volume of injection – 0.3 m^3 in one horizon of perforation. For power of forsing soil 3 m and middle vacuum 40% it is equivalent forming of piles a diameter 0.8 m. (Fig. 5).

Bearing strength of piles is certain tests – 35 t. It higher what project loading.

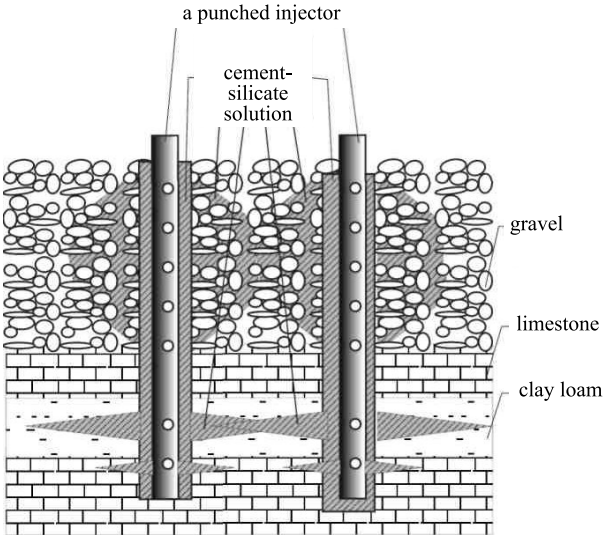

Fig. 5. Scheme of consolidation of a lose gravel

5. BUILDING OF PILEWORK IS IN SILTY SOILS (GURZUF)

Soils in foundation of building on a street Artekovskaya Gurzuf consist of loose soils in 3 m thick, plastic loams by power 7 m and strong fractured mudstone on a depth more than 10 m. A project was foresee a pilework on strong argillity.

Geological terms are complicated that there are layers of moist silt in loams.The layer of silt complicates work of piles in the conditions of seismic activity complicated and reduces reliability of foundation. To beginning of works it was impossible to define distribution of lenses of moist silt. It was decided to increase cruelty of foundation of building, that it is possible to attain soils by the injection fixing.

TISSA LTD suggested to reinforce the drill-injecting piles a pipe injector, perforated on all of length. A pipe was cemented in a drillhole. When solution of cement thermoseted, the ring of cement was torn and forced cement-silicate solution in soil by means of double packer. The volumes of festering arrive at 0.5 m^3 in one horizon of perforation. Pressure of festering arrives at 1.5 MPa.

As a result of the executed works the factor of porosity of soil is diminished on 30%. It means that homogeneity of soil in foundation of building was megascopic. Bearing strength of piles attained 150 t. Reliability of foundation is assured (Fig. 6).

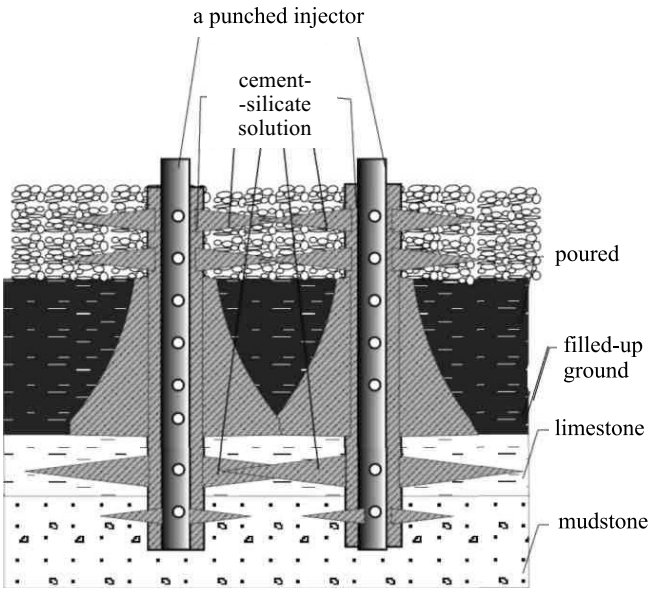

Fig.6. Scheme of consolidation of a soft soil

These examples are shown by the prospects of injection re-enforcement of soils for the increase of homogeneity and cruelty of grounds of buildings.

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