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Use of geosynthetic materials for increase bearing capacity of clayish beddings

Adolf Bartolomey, Andrey Ponomaryov & Vladimir Kleveko
Perm State Technical University, Russia

Vadim Ofrikhter
Joint-Stock Company 'Uralenergostroy', Perm, Russia

ABSTRACT: Vast regions of Russia have overwet dust-clay and soft soil. Erection of foundations on this kind of soil needs expensive materials and constructions and leads to the enormous work-expences for the construction erection. The results of recent scientific researches demonstrate the strengthening effect of using synthetic materials in soft soils.

Reinforcing of foundations by geotextile materials is a direction of building of artificial foundation constructions and reinforcement of soft ground. The use of reinforcing elements increases firmness and deformative characteristics of soil, raises stability of foundation and reduces irregularity of constructions settling and leads to the possibility to make more economical constructions. The use of reinforced soil in the constructions foundations of many kinds makes possible to cut down expenditure on the ground and transport works. In the reinforcing of local grounds which in the most cases are wet, the highest economical effect is reached by the use of the reinforced foundations. Today experience of using reinforced foundations in the world is big enough. Different contructions of the reinforced foundations are used. On the whole, two types of constructions are used: a single-layer reinforcing of the upper layer and multilayer reinforcing with the horizontal interlayers.

In general, effectiveness the reinforcement depends on the firmness and deformation characteristics of the reinforcing interlayers with regard to the level of the foundation surface, on the size of reinforcement blocking in the soil, on the qualities of soil and technology of the foundation erection, the number of reinforceent lines and distance between them, etc.

As the reinforcing materials the following elements may be used: unwoven synthetic materials, geoplastics, steel and alluminium stripes, metal and synthetic nets, etc. For filling coarse-fragmental grounds, sands, sandy-gravel and ground-concrete mixtures, metallurgic slags are recommended. The use of clayey soil is not recommended for the insufficient analysis of the work of such constructions. However, the use of the local clayey soil in the structure of the reinforced foundations may give the maximum economical effect. For the research of influence of reinforcement on the carrying capacity and deformation ability of foundations, model punch tests of different constructions of the reinforced foundations in the clayey soil of different consistence (0,2 - 0,8) were held at the Perm State Technical University.

Tests were held in the specially equipped tray with the front transparent wall. Die was an inflexible round plate. Blocking of the reinforcement into the ground was considered as equal to the die diameter. Two types of reinforcement were tested: one- and two-layer reinforcement. Reinforcing material was put into the ground on the depth of 0,2d in the case of the one-layer reinforcement, and on the depth of 0,2d and 0,5d in the case of the two-layer reinforcement. As a reinforcement we used two types of materials: unwoven synthetic material (USM) and glass-cloth which have different mechanical and deformative characteristics. Unwoven synthetic material had the following characteristics: the tensile strength on the length of the roll was 15,0-16,0 kN/m, on the width of the roll - 9,0-10,0 kN/m, rupture extension was 55-60%, modulus of deformation on the length of the roll was 25,0-28,0 kN/m, on the width of the roll - 16,0-17,0 kN/m. On the testing of the glass-cloth the following characteristics were received; the tensile strength was 45,2 kN/m, rupture extension - 2,16%, modulus of deformation - 104,6 kN/m. The ground was the clayey soil with the number of plasticty Ip=15.

Die loading was made by a screw-jack through the dinamometer. Loading was made in intervals of 0,025 MPa in the soil of the soft- and fluidplastic consistence and intervals of 0,05 MPa in the soil of the semihard and tightplastic consistence.

During the testing the quicker consolidation of soil was noted in the constructions reinforced with the unwoven synthetic cloth, it was caused by a good filtering ability of this material. Maximum tension stress in the reinforcing interlayers in the given interval of the loading was not reached, reinforcement breaking was not observed. The results of testing were worked up and graphical charts were made (see Fig. 1-3), where dependence of the modulus of total deformation, bearing capacity and relative bearing capacity for the soils of different consistence is shown. Bearing capacity of the ground foundation was agreed on condition that the loading of the die was 20mm. The relative bearing capacity is agreed as the ratio between the bearing capacity of the reinforced foundation and the bearing capacity of the unreinforced foundation.

This testing makes us come to the following conclusions:

1.Reinforcement of foundation causes the increase of rigidity and carrying capacity of the whole range of humidities of the clayey soil.

2. The most effective reinforcement is the one provided that the liquidity index of soil is from 0,4 to 0,6.

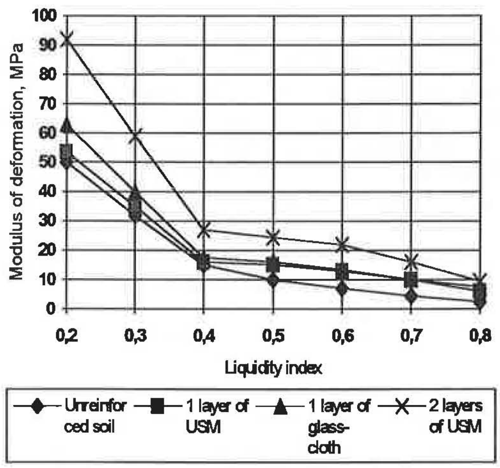

Fig.1 Dependence of modulus of the total deformation of the reinforced foundations constructions on the liquidity index.

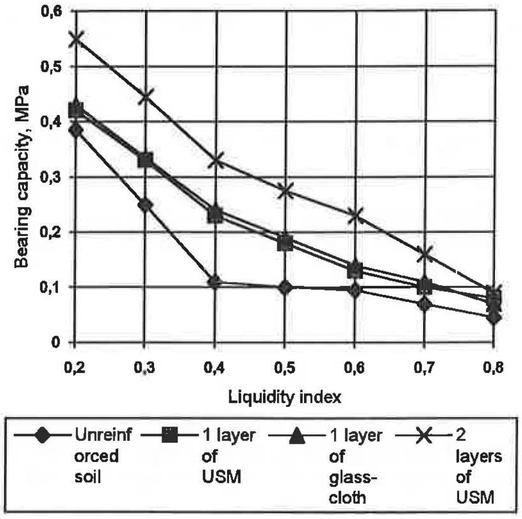

Fig.2 Dependence of the bearing capacity of the reinforced foundation constructions on the liquidity index.

3. The use of the two-layer reinforcement of the clayey soil makes the foundation more firm and rigid as compared with the one-layer reinforcement.

4. Strength and deformative characteristics of the reinforcing materials in the one-layer reinforcement in the given interval of loading practically do not influence the carrying capacity and deformaion ability of foundation, whereas in two-layer reinforcement the highest indexes were achieved with the help of the reinforcement which had the highest firmness and modulus of deformation.

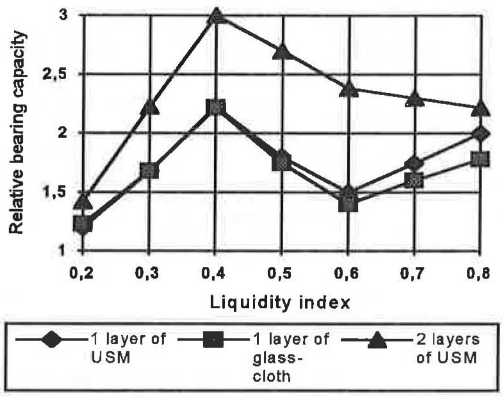

Fig.3 Dependence of the relative carrying capacity of the reinforced foundations constructions on the index of soil flowability.

The next step of our scientific research is to work out earth constructions located on the strong-compressible cohesive soil. Today the construction of the sedimentation tanks of industrial wastes with the system of water supply is worked out by the scientists. Their main objectives were: firstly, to work out the most economical construction avoiding the necessity of the traditional expensive procedure of substitution of soft cohesive ground by non-cohesive dispersed soil; secondly, to work out the most safe construction. Taking into account the facts of the quick soil consolidation in the case of the use of he reinforcing materials, having good filtering characteristics which are not desirable in the exploitation of the water- supply systems, it was decided to use counter-filtration screen made of geomembrane HDPE with the modified construction as a reinforcing material.Working as an antifiltering screen, geomembrane HDPE extends itself along the bottom and sets up to the slope parts of the restricting dams. For use as a reinforcing element, it was suggested extending of the geomembrane along the area of the tank (including the area under the dams). The next step is the pouring of restricting dams over the reinforcing material layed into the chart. After the pouring of the embankment dams, their upper slopes are protected from infiltration by the geomembrane HDPE. In the lower point of the upper slope the antifiltering screen is welded with the reinforcing element, made on the first stage, and on the upper part of the slope the screen is folded on the crest of the dam.

Numerical modelling showed the effectiveness of this construction and reveals the most interesting feature of it in the conditions of undrained reinforced system - i.e. self-levelling of the sedimentation tank as far as its filling.

On the Fig.4 a joint of the described construction is shown. Geomembrane HDPE is shown by the thick line. On the Fig.5,6 results of numerical modelling are shown. On the Fig.5 the deformed mesh of finite elements (scale representation) for the empty tank at he moment of the end of building is shown. The maximm deformations of the point A, located on the base of the upper slope are 0,004442 m. On the Fig. 6 the same mesh is drawn, provided that the tank is filled with the slime. deformations of the same point A constitute only 0,00257 m.

Foundation is the clayey soft soil with the following characteristics: γ=15,0kN/m^3; ν=0,35; G=6400kN/m^2; c=23kN/m^2; φ=15°.

During the testing tank is located on the layer of peat δ=400mm with the following characteristics: γ=8,37kN/m^3; γ_d=2,00kN/m^3 ν=0,3; G=860kN/m^2; c=1,0kN/m^2; φ=15°.

On the Fig.7 the graphical chart of settling-loading for the point A demonstrates the positive effect from the loading of foundation.

Today the authors work out the technology of the works and prepare the building of the sedimentation tank according to the proposed construction. During the building of the tank the measuring-registering devices will be put in order to check up the results of modelling in the field-conditions.

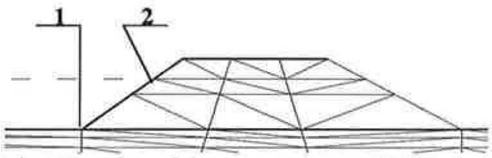

Fig.4 Location of the geomembrane HDPE (1 - reinforcing element, 2 - antifiltering screen).

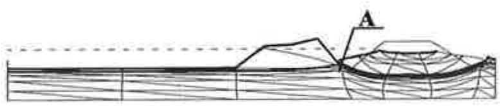

Fig.5 Deformed mesh (scaled) of the finite elements (construction is finished, tank is not filled with the slime). Max. deformation is 0,00442 m (point A).

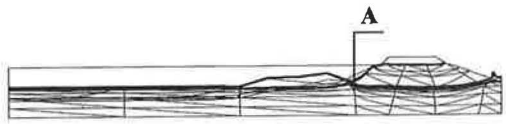

Fig.6 Deformed mesh (scaled) of finite elements (tank is filled with slime). Max. deformation is 0,00257 m (point A).

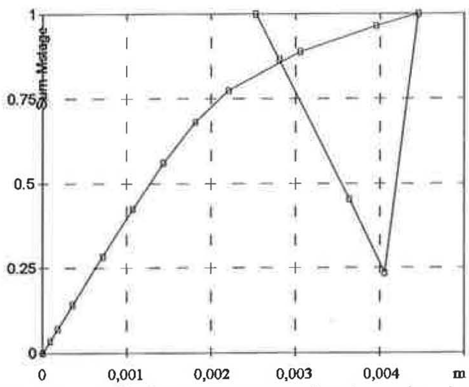

Fig.7 Load-displacement curve for the point A (the last four points correspond to the fully filled tank).