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Deformations of soil foundation reinforced with pre-stressed synthetic fabrics

Déformations d'une fondation renforcée par des textiles synthétiques précontraints

Resume. Deformations de fondation de terre armée ont été mesurée. La fondation a été fait de couche de sable compacte en haut et le sable pas compacte en bas. Armature de textile a été poséeparmi les deux couches.
Trois types des experiments ont été effectués: avec l'armature pre-contrainte, avec l'armature posée librement, sans l'armature.
La plaque de 0.3 dia a été utilizée pour appliquer la charge verticale au fondation .
Les resultats des mesures ont montrée que les tassements de la fondation sont les plus grandes en cas sans armature et les plus petits en cas de l'armature pre-contraint.

During last decade reinforcing soil with tension-resistent materials (patented by a French engineer A.Vidal) has been widely implemented into practice. Generally it is used for strengthening soil foundation and most experimental and theoretical studies have been devoted to reinforced soil-filled foundations strength evaluation methods. Model tests /1/ have shown that reinforcement both increases strength and rigidity of soil foundation. Now metal is generally used for manufacturing the reinforcement but we believe that soon synthetic materials will be widely applied for the same purpose. The reinforcement made of different fabrics, non-woven materials, films possesses such favorable qualities as low cost, chemical stability, light weight, easy transportation (for example in rolls), easy joining (by means of heating or glueing together), high mechanical strength etc.

Chemical stability of these materials enables to manufacture very thin sheets that provides for much larger surface areas without increasing the weight. This is important because larger surface area means larger contact area with soil that in turn contributes to better soil-reinforcement performance.

Recently synthetic reinforcement has been widely implemented into construction on soft water saturated soils especially into road construction (/2/-/4/) where non-woven synthetic "Bidim" type materials have been used. Application of such reinforcement also provides for better drainage.

The paper gives the results of tests aimed to study how synthetic reinforcement influences soil foundation compressibility.

Prestressed reinforcement for concrete has been being used for many decades. That was the reason why we included the case of prestressed reinforcement in our testing programm although we did not hope to score the same success. We believed that the effect of prestressing should be studied because it contributes to better soil-reinforcement interaction, iniatiates soil precompression (similar to preloading) and may have other positive effects.

The tested soil foundation consisted of upper layer 0.3m thick and lower layer 2.1m thick. Synthetic fabric was between the layers. The value of 2.1m is 0.2m more than "compressible layer" calculated according to /5/.

The soil of foundation was medium quartz sand, with uniformity factor of 3. Physical and mechanical characteristics of the sand are given in the table 1.

Table 1

Sand characteristics	Unit mass, kg/m^3	void ratio	Relative humidity %	Angle of internal friction	Cohesion kPa
Upper layer	1660--1700	0.66-0.61	3-4	34°	2
Lower layer	1.44--1.59	0.91-0.71	3-4	32°	0

The reinforcement was non-woven drainage fabric (sample No.501) manufactured of polypropelene staple capron-sewn fibres with tension resistence of 200 N/cm and maximum relative elongation of 50%.

The tested foundation was precompressed by average pressure of 0.01 MPa equal to the weight of the road over-structure. This superload consisted of a concrete slab with ballast. In the center of the slab there was a hole for a test-plate of 0.34m dia. Vertical load applied to the test-plate had been increasing gradually providing for 0.01 MPa average pressure increments up to 0.45 MPa with stabilization during 5min at each step. Settlements were measured by displacement meters with accuracy of 0.1mm. The area (910 cm^2) of the test-plate was about the same as a truck wheel contact area with soil. Three different groups of tests have been staged (fig.1):

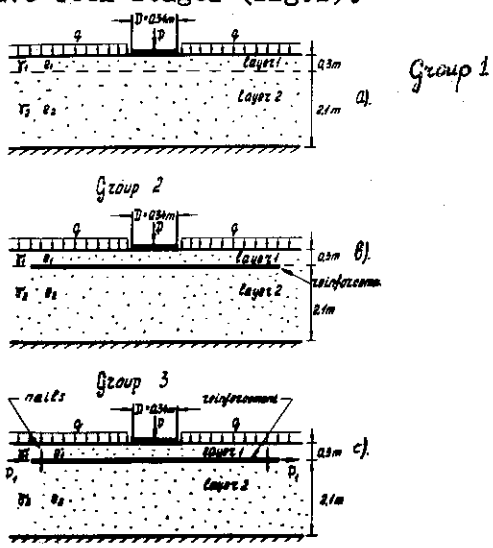

fig.1. Plate tests diagram for two layers foundation
a) without reinforcement
b) with free reinforcing synthetic fabric
c) with prestressed reinforcing synthetic fabric.

1. without fabric
2. with free fabric
3. with prestressed fabric.

The value of the tension applied to fabric was equal to 2.5÷3 N/cm and has been kept unchanged by means of special steel nails driven into sand along the perimeter of the fabric. The test results are presented on fig.2. by graphs of average test-plate settlements (S) versus average pressure (p) for every group of tests. The band of 0.85 probability of mean settlements is also given there.

Analysis of the results has yielded a fact that differences among three groups of tests are not occasional. This fact is illustrated by the table 2 showing what is the probability of every group to belong to the group as a whole. These results show that the higher is the pressure the stronger is the effect of reinforcement. The discrepancy has been estimated using Student coefficient approach /6/.

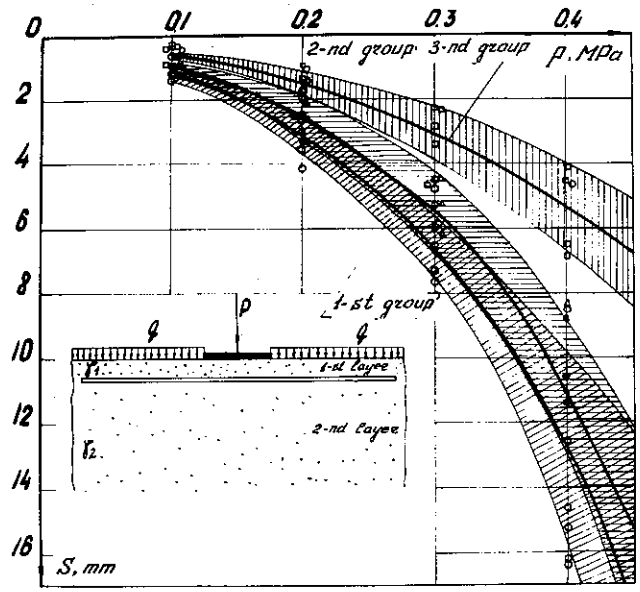

fig.2. Test plate settlements (S) versus average pressure (p) curves for 3 types of foundation

Table 2

The type of the foundation	Probability value for distribution centers of different groups of tests to coincide with the results of all the tests for pressure (MPa)		
	0.1	0.2	0.3
with free reinforcement	0.67	0.72	0.86
with prestressed reinforcement	0.035	0.017	0.001
without reinforcement	0.24	0.12	0.033

The test results show that application of not prestressed reinforcement decrease settlements only in the case of relatively high average pressures.($p \geqslant 0.3$MPa). The effect of reinforcement for lower average pressures ($p \leqslant 0.2$) can not be considered to be proved (table 3).

Table 3

test plate pressure /p/=/MPa/	probability of groups of tests 1 and 2 to coincide
0.1	0.8
0.2	0.47
0.3	0.18

Analysis of data for the 2nd and 3rd groups of tests has proved that prestressing reinforcement decrease settlements about 40% as compared to the case of free reinforcement (fig.3). And this phenomenon has been

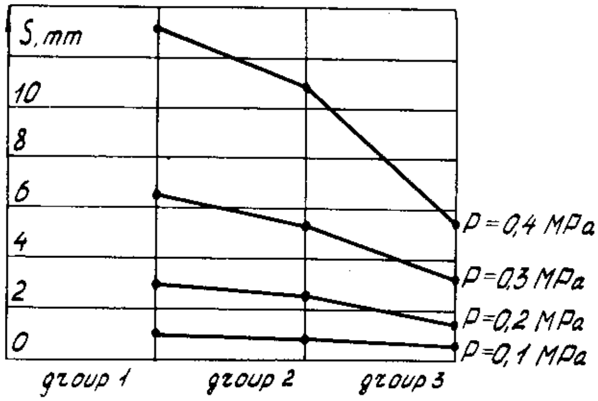

Fig.3. Test plate settlements (S) versus the type of the foundation for different values of average pressure (p)

observed at the first stages of loading. The probability value of this conclusion for higher pressures is higher but in any case it is (if $p \geq 0.1$MPa) more than 0.95

Conclusions

Textile reinforcement of soil foundation decreases its settlements. If prestressed the reinforcement provides for more rigid soil foundation than in the case when it is free (not prestressed).

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