Model investigations of reinforced undermined base bearing capacity

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ABSTRACT: Base reinforcing is a new perspective trend in the field of creating imitated base optimum constructions and methods of reinforcing soft, undermined soils. This paper considers the problems of reinforcing base by reinforcing its upper part located under foundation or so called a contact layer.

1 INTRODUCTION

Due to the use of reinforcing elements in soil we can change strong and deformable properties, increase base stability and decrease settlement uneveness of constructions. The aim of these investigations is to give qualitative estimation to undermined bases. Model investigations were carried out to study the effect of horizontal strains of reinforced undermined base on the change of base stiff characteristics. While modelling an equivalent soil having strong and deformable characteristics can be used as a base soil (side by side with a natural soil).

2 MODEL TESTS

Values of cohesion and agnle of internal friction can be used as determining characteristics in the first approach when selecting equivalent - materials of granular and stratified soils (Zhusupbekov and Baytasov 1989). Mixture consisting of 97% of fine quartz sand and 3% of spindle oil (by weight) is used as soil base model material. It is possible to model cohesive soils due to cohesion of these materials. They are also suitable because creep strains damp rapidly after applying next in turn step of load. Physical and mechanical characteristics of natural soil (Karaganda loam) and equivalent material are shown in Table 1. A model and natural foundation linear scale determined by equivalent material and loam strong properties (cohesion) relation is equal to 1 : 40.

Table 1. Physical and mechanical characteristics.

Material of soil	γ, kN/m^3	c, kPa	φ, degree	E, MPa	ν
Loam	20	40	22	20	0.3
Equivalent soil	17	0.9	33	2.6	0.75

Model experiments are carried out on a voluminous stand which makes it possible to set horizontal strains to soil base. The stand for modelling building undermined base strains is presented by a tray fixed on the supporting frame. A tray consists of four movable side walls and bottom which are not connected. Movable side walls are presented by vertical elements (channels, connected through rubber layings by bolted connections. Bottom is presented by channels layed horizontally on frame and covered by whole flexible sheet on which steel plates are fixed on ball supports. Channels lower part is supported by regulated stops (bolts) which are used for transferring vertical strains. Device of wall horizontal displacement is set on frame. Device consists of regulators - bolts fixed on frame; plates which can easily move along supporting frame. Plates are connected with corbels where rolls are hung up. Stand for modelling building and construction base strains is used in the following way: model base is layed in a tray fixed on supporting frame by the way described

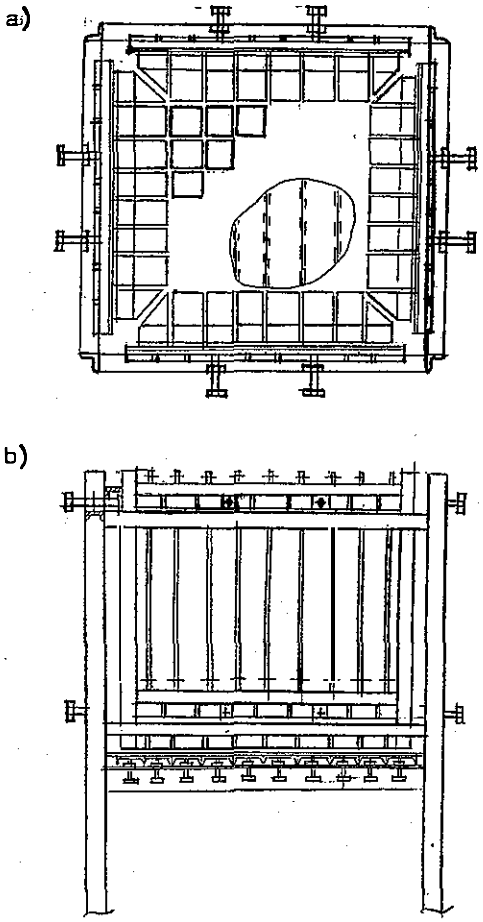

Fig.1 Diagram of voluminous stand for modelling undermined base strains : a) top view; b) side view

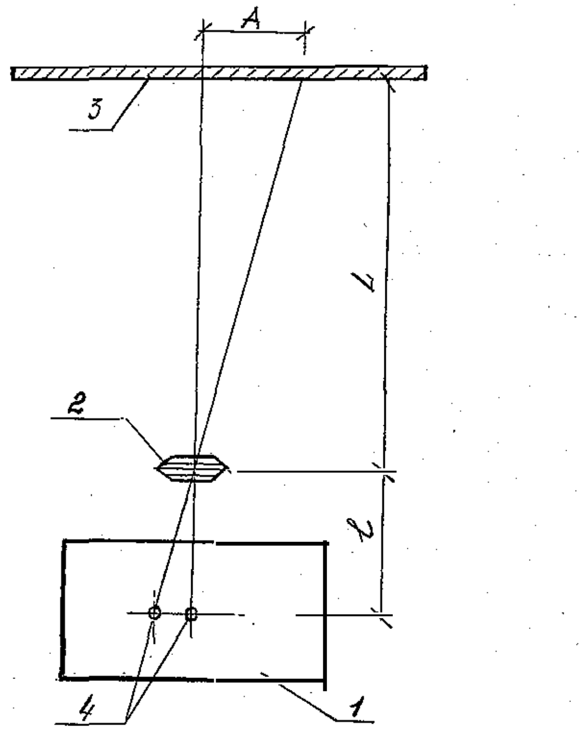

Fig.2 Diagram of determining strained soil surface displacement by tensiometers: 1) undermined base; 2) optical lense; 3) screen; 4) soil channel as an electrical lamp

below. Horizontal strains are set by consecutive displacement of four walls of a tray by "device of wall horizontal displacement" regulators - bolts and bolts causing vertical elements (channels) displacement of tray two walls. Uniformity of model base soil straining is achieved. Undermined base vertical strains are set on the stand by regulating bolts providing rise of any channel of tray bottom. Standart measures of a stand are 1220 x 1220 x 1320 mm (Figure 1); working volume of a tray is 0.4 m .
Imitation of undermined base strain within the limits: relative horizontal strains $0 \leqslant \varepsilon \leqslant 0.02$; curvature with radius $-4km \leqslant R \leqslant 4$ km.

2.1 Testing programme

Model soil (taken as equivalent to natural) is layed on the following way:
1. Model soil is made even by a special device (to make soil surface a horizontal plane);
2. Model soil is layed in the stand by layers 30 mm thick;
3. Even soil layer is rolled through rubber bed by a heavy roller (fifty full cycles of rolling are carried out to pack each layer).

Control of required quantity of soil compaction - determination of volume weight by method of cutting ring - is carried out periodically and between experiments. Exact control of model base strains plays an important role(Zhusupbekov 1991). Optical tensiometers are used to measure strains.

2.2 Optical tensiometers construction

Special tiny lamps on wire pillars are deepened into soil along profile line on model base (Figure 2). To determine lamps displacement we project their lightening filaments(through lenses of the optical system fixed on rigid frame to stand) en the vertical screen located at a distance of 2 m from the lenses.
Calculated maximum displacement of lamps

to 5mm/m does not exceed 0.01 mm and at the value from 5 mm/m to 12 mm/m does not exceed 0.3% of the measured value of model points displacement. Optical tensiometer increase is propotional to the distance up to the screen and is determined by equation:

$$a = A \frac{F}{L - F} = A \frac{l}{L} \qquad (1)$$

where a – displacement of an electric lamp (a soil channel); A is displacement of filament projection on the screen; l is distance from an electric lamp to a lense; L is distance from a lense to a screen; F is focus distance of lense = 50 mm.

The diagram of determining base surface displacement by soil channels (electric lamps) is shown in Figure 2.

It should be noted that lamp displacement value is limited by fokus distance and is defined by equation:

$$a \leqslant 0.25F, \qquad (2)$$

where a is displacement of an electric lamp; F is focus distance of a lense =50mm.

2.3 Test procedure

An attempt of qualitative estimation of reinforced bases bearing capacity (with soil different saturation by reinforcing elements) with setting horizontal strains and without them was made during these model investigations. Reinforcing material was emery paper as a) strips 10 mm wide and l = 2B = 100 mm long, where B is quadratic stamp width; b) quadratic sheets side b = 2B = 100 mm.

Isolated foundations models were wooden stamps 50 x 50 x 20 mm which were layed on soil model surface. Stamps settlement was measured by 6 PAO Aystov flexometer.

Stamps were statically loaded. Transfer from one step of load to another was carried out after quadratic stamp relative stabilization characterized by displacement difference no more than 0.01 mm for last 15 min observing.

Model investigations were carried out in the following way:

1. Investigation of isolated stamp models without horizontal strains .
2. Investigation of isolated stamp models at setting horizontal strains.

At first stamps were loaded with and without reinforcement up to ultimate load by the way shown in Figure 3.

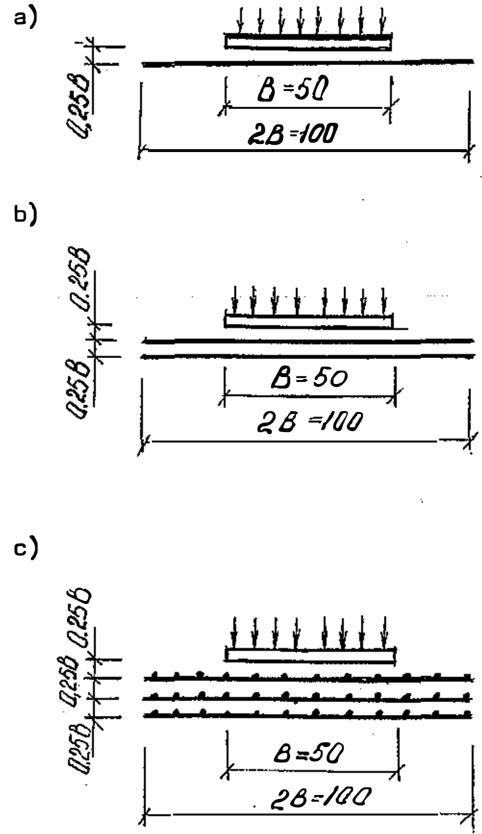

Fig. 3 Diagram of reinforcement by strips and net reinforcement:
a) single – layered reinforcement;
b) two – layered reinforcement;
c) net reinforcement

Applied "load – settlement" diagrams were drawn on the basis of obtained data. Then investigations of stamp models with setting relative horizontal strains ε = 0.003; 0.006; 0.009 for loaded stamps were carried out.

3 INVESTIGATION RESULTS

"Applied load – settlement" diagrams at corresponding value were drawn on the basis of obtained data. When quadrate cells of reinforcing set are measuring 3x3 or 7x7, strips are 10 mm wide and 100 mm long investigations have shown that quadrate cells in reinforcing net should be less than stamps radius in order to increase base bearing capacity. Base strains decrease 1.5 – 2 times and bearing capacity increases 2.5 – 3 times due to reinforcing (Figure 4; 5; 6) .

The quantity of reinforcement in soil

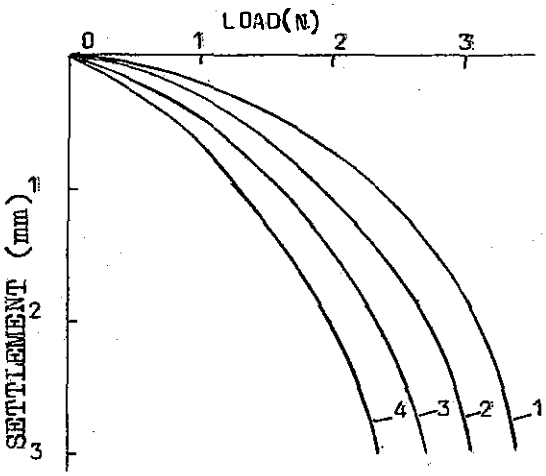

Fig. 4 Diagram of load - settlement wit - hout reinforcement by horizontal strains: 1) $\varepsilon = 0$; 2) $\varepsilon = 0.003$; 3) $\varepsilon = 0.006$; 4) $\varepsilon = 0.009$

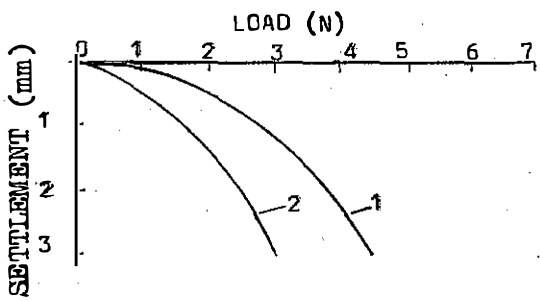

Fig. 5 Diagram of load - settlement with single - layered reinforcement by hori - zontal strains: 1) $\varepsilon = 0$; 2) $\varepsilon = 0.009$

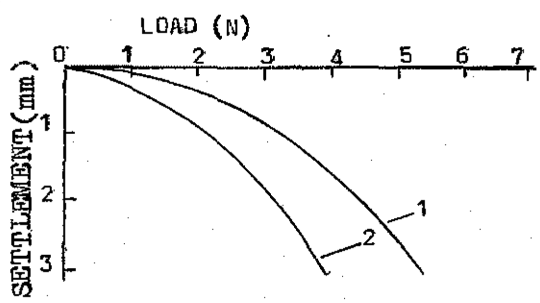

Fig.6 Diagram of load - settlement with two - layered reinforcement by horizontal strains: 1) $\varepsilon = 0$; 2) $\varepsilon = 0.009$

more effects bearing capacity than base strain (Figure 7).

4 CONCLUSIONS

The results of experiments carried out on

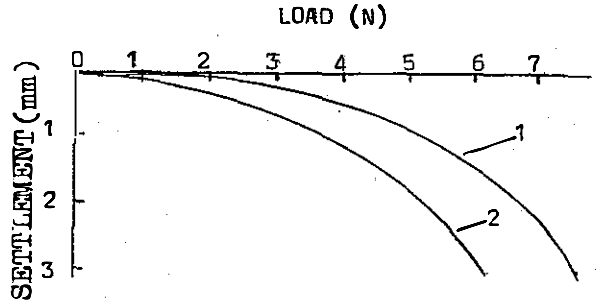

Fig.7 Diagram of load - settlement with net reinforcement by horizontal strains: 1) $\varepsilon = 0$; 2) $\varepsilon = 0.009$

reinforced model bases (while undermining) give us more physical idea about their work and an opportunity to study different factors effect on bearing capacity. Model investigations have shown that the use of reinforcing elements on undermined plots decreases considerably the effect of soil massif horizontal tensile strains on be - aring capacity and base straining.

Correct prognosis of reinforced base bearing capacity plays an important role in safe exploitation of building and con - structions on undermined territories.

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