Digest Report of the Research Project

Stabilization of Slopes by Inserted Retaining Panels

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1. Research Aim

If bearing capacity and stability of a slope is to be improved or a creeping slope shall be stabilized, then this can be achieved by inserting retaining panels into the slope which for example may be made of mono-grained concrete or grouted soil. However, until now the question remained unanswered how such a stabilizing measure could be designed in a quantifying manner. Therefore this was done by relatively unsystematically provided experience.

It is of special interest to know about the panels distance necessary to obtain the desired level of safety for agiven height of the slope.

To investigate this matter, during 1989 / 90 the Institute of Geotechnics of the University of Stuttgart performed 10 model tests with varying geometry at the centrifuge laboratory of Bochum University.

These tests aimed at getting an experimentally based design rule for retaining panels in ground engineering practice.

2. Research Procedure

Since creeping slopes generally consist of clayey-silty ground, pure kaolinitic clay was chosen for model soil purposes. It consists of 60% clay and 40% silt. Its plasticity index is 16.3 %. For the construction of the panels micro-concrete was used.

Following two pilot tests, the main test series was run as follows:

- Kaolin powder and water were mixed by stirring into a slurry having a water content of double the liquid limit water content. The slurry was filled into a container having an area of 85 by 85 cm^2 and a height of 50 cm. The slurry cake then was hydraulically pressed for first stage consolidation until about 36% water content.

- The kaolin cake was cut into halves yielding samples of each 85 by 42.5 by 50 cm. The sample was turned over into a lying position to allow forming the slope model in terms of either a trapezoidal shape with both a 45^0 and a 60^0 inclination or a unilateral 60^0 inclination. Also, the panel grooves with 1 cm width were cut.

- Micro concrete was filled into the grooves. Further, displacement gauges and piezometers were applied. Then, the slope was covered by a foil and the space in front of the slope was filled with sand up the crest.

- The model was set into the centrifuge and by stepwise accelerations until 100·g further consolidated for about two hours. The water content yielded to about 36% (index of consistency between 0.40 and 0.55). The sand fill in front of the slope was then sucked up, similar to executing a cut by excavation.

- The centrifuge was started and increased its acceleration force in 10·g steps. At each load level the performance of the model was observed by video monitoring for some minutes and the slope section was photographed. The test was continued until collapse of the slopes.

The first test was performed without panels to get a reference, and it was also repeated once. With the other 6 tests, 3 got the trapezoidal shaping - which allowed for having two different inclinations tested in one run - and 3 got the unilateral 60^0 slope.

During the test runs piezometer readings were continuously taken in the central section between the panels at 5 and 10 cm depth and at three different positions. The surface displacements were also recorded along the central line.

After the tests, the collapsed slopes were photographed and the water contents determined again. Further, the undrained cohesive strength of the clay was determined by use of the laboratory vane test device. A value of 40.5 kN/m^2 was found as an average.

3. Summing up the Results

3..1 Since the panels collapsed together with the soil between them - although partially at smaller displacements - the obtained results are on the safe side for practical applications, because in practice such panels often are set on top of firm lower ground layers.

3.2 Both for the 45^0 slope and the 60^0 slope similar relations were found for the acceleration level at failure versus the ratio "panel distance / slope height".

3.3 A notable stabilizing effect was found to begin by distances of less than the double slope height; a remarkable improvement needs a distance of less than the slope height.

3.4 The test soil volume did not show a notable change of ist water contents; the tests , therefore, may be considered as to have been truly undrained.

3.5 For the design of such retaining panels it seems sufficient to apply the routine failure circle analysis (see e.g. DIN 4084). The retaining effect of the panels may then be quantified by the experimentally evidenced increase in terms of stable height.

3.6 With the application of the partial safety concept, it is recommended to introduce the design values of undrained strength, c_{ud}, into the limit state equation and then to analyse at which panel distance becomes the allowable value of H larger than the given one.