DISCUSSIONS

DISCUSSION ON APPLIED SOIL MECHANICS

Recent Results of an Experimental Investigation into Soil Pressure on Rigid Walls*

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Retaining walls must frequently be designed for live operational loads applied in different ways on the surface of the backfill. The live load is then the principal design load, governing the dimensions and cost of the entire structure. Most experimental investigations have been carried out without this load. The strict methods for determining the pressure at the equilibrium threshold appearing during the last 20-25 years and the methods taking account of kinematic factors were developed mainly for systems with the load absent at the surface of the back fill or situated immediately at the wall and extending well beyond the face. Considering the excessive complexity of the physical phenomena occurring with different types of load application it is proposed that development of the theory will be particularly successful if preceded by appropriate experimental investigations.

Results of investigations carried out by the authors at the Odessa Institute of Naval Engineers are set out below. The investigations were carried out in an experimental trough 109 cm high, 100 cm wide and 177.5 cm long. The contact pressures and the stresses in the mass of the back fill were measured by means of strain-gage dynamometers designed by the authors. The wall model was a rigid panel weighing 400 kg made of 10 x 10 cm timber beams supported on a frame of No. 20 H girder and No. 10 channel.

Pressure on a Fixed Wall with Repetitive Loading by Uniformly Distributed Load on the Backfill. On filling the trough with sand the displacement at the bottom of the model amounted to 0.002 mm and at the top 0.025 mm, allowing the model to be considered as fixed. After filling (Fig. 1, curve 1) a uniformly distributed load was applied in three layers at the surface of the sand, covering the whole surface of the fill in the trough from the face of the wall. The pressure of the first layer was 663 kg/m$^2$, of the first and second layers 1,305, and of all three layers 1,947 kg/m$^2$ (Fig. 1, curve 2).

While the load was being applied, the pressure on the wall increased generally in proportion to the loading. The experiments showed that both with application of the load and without it the resultant pressure of the soil on the fixed wall considerably exceeded the pressure as determined from Coulomb (by 36-42%). The experiment was carried out so that unloading commenced after placing the third layer; the third layer was removed (Fig. 1, curve 3), then the second (Fig. 1, curve 4) and finally, after removing the first layer (Fig. 1, curve 5), the surface of the fill was completely free of load.

It is seen from Fig. 1 that removal of the third and second rows of the load had practically no effect on the pressure diagram (the resultant pressure diminished only by 5.3% of the pressure increment $\Delta E$ occurring as a result of application of the three layers of load with an overall intensity $q=1947$ kg/m$^2$). Only on removing the first layer of the load did the pressure fall sharply, falling by 38.4% of $\Delta E$. The pressure fell mostly at the surface of the fill and only within the limits of the top two-thirds of the wall height.

It is most interesting to observe that on completely relieving the fill of the load 56.3% of the pressure increment $\Delta E$ during application of the load was maintained, while the pressure after relieving the load amounted to 249% of the pressure before applying the load.

A second loading and unloading was carried out in a similar manner, when the earlier proportionality between increase in load and increase in pressure on the wall was not observed. On placing the first and second layers of the load, the pressure increased only slightly and only in the top half of the wall.

On laying the third layer of the load, the pressure increased at a greater rate but the resultant pressure after the second loading increased by only 1.8% as compared with the resultant after the first loading.

*For an earlier discussion see "Gidrotekhnicheskoe Stroitel'stvo," 1966, No. 1, 3, 5, and 7; 1967, No. 1, 3-6, 8, 9 and 12; 1968, No. 1-5.

During the second unloading the phenomena observed during the first unloading were in their entirety repeated. The pressure on the wall after the second unloading was 8.6% up on the pressure after the first unloading.

After the third loading (Fig. 1, curve 6) the resultant pressure on the wall amounted to 105.8% of the pressure with the first loading and 103.9% of the pressure with the second loading. The pressure on the wall after the third unloading (Fig. 1, curve 7) was accordingly greater by 11.3% than the pressure after the first unloading and 3.8% after the second.

The pressure curves on the vertical wall with repetitive loading and unloading of the backfill were obtained for the first time as proposed here. The observations indicate that:

a) in the operation of retaining structures and in their reconstruction it is essential to know the actual soil pressure and soil-pressure distribution on the wall for the given conditions. The investigations described demonstrated that the application of ordinary calculation procedures to this case, considering only the nature of the loading on the surface of the backfill at the time of the calculation and disregarding the previous loadings on the wall can produce results which in no way reflect the actual stress. It is essential to take into account that the principle of proportional pressure change on the wall with variation in the live load occurs only rarely in nature; b) under actual conditions it has to be expected that with the initial loading the pressure on the wall and on the foundation will rise at a sharp rate in proportion to the increase in load. During this period big displacements in the wall must be anticipated. With subsequent loads the increase in pressure falls behind the increase in the load and only with considerable loads may the pressure increase out of proportion, as the result of which the wall may reach a critical state. The problem is fairly complex and requires further experimental and theoretical investigations.

Pressure on the wall with different arrangements of the load on the backfill. Effect of wall displacement. At the Fourth International Congress on Soil Mechanics and Foundation Construction Professor Kerisel stated: "Information on soil-pressure distribution at the surface of bearing structures and on variations in the pressure distribution due to all manner of deformations and displacements of the structures is still very sparse and contradictory. This sector of soil mechanics has been generally neglected. Strict solutions exist only in regard to the overall determination of soil pressure and not the calculation of the pressure distribution over the surface." Considering this appraisal, one of the main problems in the study of soil