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EXTENDED ABSTRACTS

Investigation of Lateral Earth Pressure Distribution Against a Rigid Retaining Wall Under Uniform Surcharge in Single and Two-Layer Soil Through Small- Scale Physical Modeling

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1. Introduction

In the current study, a series of physical model tests was conducted to evaluate active earth pressure behind a translating rigid retaining wall under a uniform surcharge. Experimental results were compared with the predictions from proposed formulations to estimate the magnitude and distribution of lateral pressures in the failure zone behind a translating rigid wall under a uniform surcharge. The effect of arching is also investigated in single and two-layer soils through small-scale physical modeling and different surcharge combinations.

2. Methodology

As presented in Fig. 1, the experiments were conducted in an acrylic box with a metal frame measuring 100cm height* 70cm length* 31cm width. A vertical retaining wall, 800 mm high, was supported near the top and at the bottom. As shown in Fig. 2, the wall is enabled to slide horizontally about the base. Five miniature pressure cells were mounted into individually sized cavities in a rigid thick wall. Circular flat pressure cells with a total diameter of 35mm and an effective diameter of 19 mm with a capacity of 35kPa were used. The retaining wall facing was covered by sandpaper No.80 except for the pressure cell face, allowing a fully rough condition.

3. Results and discussion

3.1. Lateral earth pressure analysis and Influence of surcharge

In total, ten experiments were carried out with different surcharges as follows: Q = 0, 0.49, 0.72, 1.2, 2.9 kN/m^2. At the rest condition, the experimental results show good agreement with the Jaky (1948) horizontal earth pressure profile. The reason for the slight difference between experimental and theoretical values is the model preparation process. Due to a lack of compaction and density near the vertical boundary of the acrylic box, the experimental values are lower than the corresponding theoretical values.

Besides, the local arch at the toe of the retaining wall caused by slight soil settlement during the preparation of the model and increasing the height of the retained backfill led to a decrease in lateral earth pressure at the toe. Similar behavior was also reported by Khosravi and Pipatpongsa (2013) in their physical modelling of a retaining wall. By moving the wall in a translation mode with a constant rate, the magnitude of the earth pressure decreases gradually. When the wall displacement reaches its active value, the normalized horizontal earth pressures reach their lowest value and there is no further considerable decrease in the values measured

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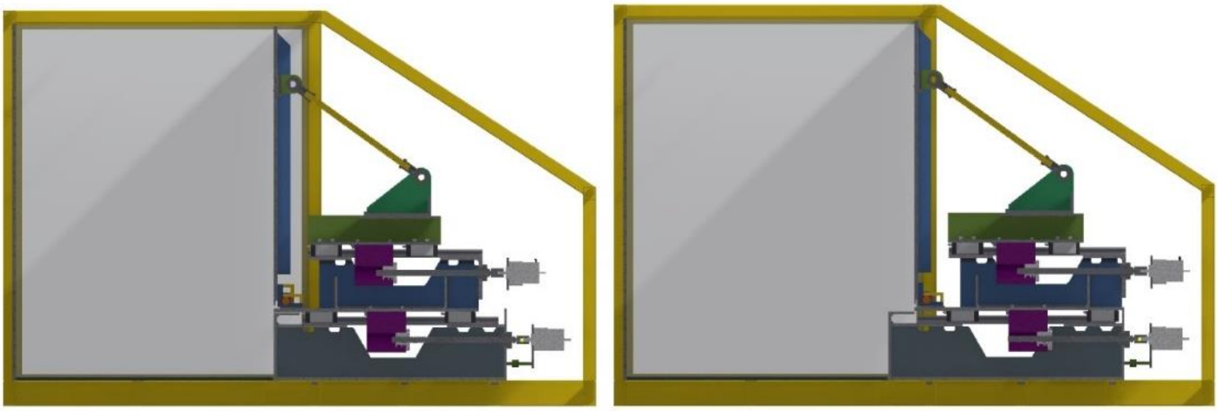
at every pressure cell with further increases in the wall translation. According to recorded values, an active wall movement of about 0.0035-0.006 times the wall height, is required to reach the active state. These values of the required displacement are in good agreement with the results reported by Lambe & Whitman, 1969 and Handy & Spangler,2007 for full-size retaining walls. However, they are more than the values measured for the laboratory model of retaining walls in some of the literature (e.g. Fang & Ishibashi, 1986; Khosravi & Pipatpongsa, 2012). The reason for this might be the scale effect in the laboratory models.

When the wall moves beyond the active state, the recorded pressure values at the toe of the wall increase again after experiencing a period of stability. That might be the result of the elimination of the arching effect at the toe. Furthermore, the study of the distribution of lateral pressure along the wall shows that the distribution is nonlinear with depth. Also, experimental data shows good agreement with the pressures predicted by the equation proposed by Khosravi (2012). However, at the toe of the wall, due to the difference between analytical and physical models, the experimental active earth pressure is not zero. Whilst, with increasing the surcharge value, the arching effect becomes more obvious and the pressure decreases at the base of the wall and get closer to zero. The results of the investigation of the pressure values in the pressure cell installed at the base of the wall reveal that the pressure recorded in the translation active state in surcharges equal to 0, 0.49, 0.72, and 1.2 kN/m^2 is 68.6, 64.2, 61.4, and 51.6% of the value calculated by the Rankine's equation. In the layered backfill, the pressure recorded in the translation active state is 40.3, 36.3, 35.6, and 32.2% of the value calculated by the Rankine's equation.

Fig. 1. The experimental set-up



(a)

(b)

Fig. 2. A schematic view of the experimental set-up: a) initial condition of the wall, b) horizontal translation

3.2. Displacement and strain analysis by PIV

Monitoring of deformation shows that during wall movement the distinction between the stationary and failure zones becomes more obvious. When the wall movement reached its active value, the failure zone was completely distinguished from the stationary zone. Furthermore, when the wall horizontally translated in an active mode, multiple nearly parallel shear zones were observed during tests which started to merge at the top of the retaining wall and propagated towards the free boundary. The Shear zone behind the wall was almost straight starting and propagating from the wall base. In a single-layer of soil, the mean inclination of the main shear zones to the horizontal was 75 degrees. The shear zone thickness is about 5mm when the wall reaches its active state. As the wall moves beyond the active state, the inclination of the main shear zones to the horizontal decreases to 63 degrees. Based on Rankine's formulation, with the assumption of the linear distribution of active earth pressure against the wall, the angle of the slip plane to the horizontal is $\alpha = \pi/4 + \varphi/2 = 61.5°$. whilst, in these experiments because of side friction, conventional values were roughly reproduced in active states and the angle α measured from experiments is more than its theoretical value (75 degrees). The results show that as the wall moves beyond the active state, the angle of the slip line to the horizontal has good agreement with the theoretical value (63 degrees). On the other hand, in a two-layer soil, the thickness of the shear zone increases. So, it can be deduced with increasing the grain size, the width of the shear zone increases.

4. Conclusions

A series of physical model tests were conducted to evaluate active earth pressure behind a translating rigid retaining wall under uniform surcharge. PIV method was used to investigate the soil behavior and the failure wedge. Different combinations of Steel balls were used as a uniform surcharge on the retained soil.

At the rest condition, due to a lack of compaction and density near the vertical boundary of the acrylic box, the experimental values are lower than the corresponding theoretical values.

Experimental data show good agreement with the pressures predicted by the equation proposed by Khosravi (2012). However, at the toe of the wall, due to the difference between analytical and physical models, the experimental active earth pressure is not zero. With increasing the surcharge value, the arching effect becomes more obvious and the pressure decreases at the base of the wall and get closer to zero.

Besides, the local arch at the toe of the retaining wall caused by slight soil settlement during the preparation of the model and increasing the height of the retained backfill led to a decrease in lateral earth pressure at the toe. By moving the wall in a translation mode with a constant rate, the magnitude of the earth pressure decreases gradually. When the wall moves beyond the active state, the recorded pressure values at the toe of the wall increase again after experiencing a period of stability. That might be the result of the elimination of the arching effect at the toe.

Monitoring of deformation shows that during wall movement the distinction between the stationary and failure zones becomes more obvious. The Shear zone behind the wall was almost straight starting and propagating from the wall base. In a two-layer soil, the thickness of shear zone increases. So, it can be deduced with increasing the grain size, the width of shear zone increases.

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