Chapter 6

EXPERIMENTAL RESULTS FOR LOOSE SAND

This chapter reports the effects of a nearby rock face on the horizontal earth pressure against a non-yielding wall. Loose Ottawa sand with the unit weight γ = 15.6 kN/m^3 (D_r = 35%) is used as backfill material for the experiments. Base on direct shear tests, the corresponding internal friction angle ϕ and wall friction angle δ_w would be 31.3^o and 9.3^o, respectively. The γ, ϕ, and δ_w values are used to calculate the Jaky and Rankine earth pressure, and the pressure prediction based on Janssen, Reimbert and Reimbert, and Spangler and Handy theories. Different spacing d between model wall and interface plate adopted in the experiment are 1500, 1100, 900, 700, 500, 400, 300, 200, 100, and 50 mm. The induced earth-pressure is monitor with soil pressure transducers instrumented on the NCTU non-yielding model wall facility. The testing program for this study is summarized in Table 6.1.

6.1 Distribution of Earth Pressure at-Rest

The earth pressure at-rest was measured by soil pressure transducer (SPT) after backfill was filled up to 1.5 m. Surface of backfill was horizontal for all experiments. The method of air-pluviation is adopted to prepare the backfill and the relative density D_r achieved for the loose sand is 35%. Experimental results are compared with Jaky, Rankine, Janssen, Reimbert and Reimbert, and Spangler and Handy's predictions. It should be noted that in the calculation Janssen, Reimbert and Reimbert, and Spangler and Handy methods the model wall, side-wall and the interface plate are assumed to be the same material.

Fig. 6.1 shows loose Ottawa sand was filled up to 1.5 m and the distribution of horizontal earth pressure for d = 1500 mm was recorded. In Fig. 6.1, it is obvious that test results are in good agreement with Jaky's solution. Mayne and Kulhawy (1982), Mesri and Hayat (1993) reported that Jaky's equation is suitable for backfill in its loosest state. However, in Fig. 6.1 the lateral earth pressures measured near the base of the wall are lower than Jaky's prediction. This is most probably due to the sudden change of stiffness at the soil-steel base plate interface. During calculating the magnitude ($K_{o,h}$) and the point of application (h/H) of at-rest soil thrust, horizontal earth pressure σ_h at the base of the wall was assumed to be the same as that at the elevation of 0.05 m.

Fig. 6.1 indicates that the Reimbert and Reimbert obvious overestimated the horizontal earth pressure acting on the retaining wall adjacent to a rock face. Janssen appears to underestimate the lateral pressure. The test results are in relatively good agreement with Spangler and Handy's solution.

Fig. 6.2 illustrates the test results for d = 1100 mm. From Fig. 6.2 it can be found that Reimbert and Reimbert, and Spangler and Handy's predictions are both conservative. Test results for d = 1100 mm appears to be in relatively good agreement with Janssen's solution and Rankine active pressure. Fig. 6.3 shows the test results for d = 900 mm. It is found that the distribution of earth pressure is lower than Reimbert and Reimbert and Spangler and Handy's prediction, and is in fairly good agreement with Janssen's solution.

Fig. 6.4 illustrates the test results for d = 700. It can be found that, test results for d = 700 mm are slightly lower than Janssen's prediction. Spangler and Handy's and Reimbert and Reimbert's solution is much too conservative. Fig. 6.5 indicates that for d = 500mm, the test data are in fairly good agreement with Janssen's solution.

Fig. 6.6 through 6.9 show the test results for d = 400 to 100 mm. In these figures, at the wall base, the measured earth pressure σ_h is lower than the theoretical solutions. Fig. 6.7 shows that all theories solutions overestimate the σ_h for d = 300 mm. It is noted that test results for d = 300 mm (the rock face is very close to the model wall) is even lower than Rankine's active pressure.

Fig. 6.8 illustrates test results for d = 200. It is obvious that all theoretical solutions can not properly estimate the earth pressure. For d = 100 mm, the earth pressure on the wall (Fig. 6.9) appears not to change with depth.

Fig. 6.10 shows the test results for d = 50 mm (the rock face is only 0.05 m from wall), it is found that theory solutions apparently overestimate the test results. Distribution of earth pressure for d = 50 mm appears to be a constant value which is not affected by the depth Z.

Fig. 6.11(a) shows that, if water is filled into the spacing d = 200 mm between the interface plate and model wall up to 1.5 m, the horizontal water pressure would increase linearly with depth ($u = \gamma_w Z$). However, Fig. 6.11(b) indicates that if the spacing d = 200 mm is filled with sand up to 1.5 m, the overburden pressure σ_v acting on the soil at depth Z may not equal to γZ. Due to the friction on two ends (f_i and f_w) of the soil lamina, the overburden pressure σ_v transmitted to the lower elevation was carried over by the side friction. Assuming the pressure coefficient $K_{o,h}$ remains the same, since $K_{o,h} = \sigma_h / \sigma_v$, a reduction of σ_v would result in a low horizontal earth pressure σ_h.

In Fig. 6.12, the horizontal earth pressure (σ_h) decreases with the decreasing of spacing d. However, all the measured σ_h is lower than Jaky's solution. Jaky's solution can be considered as the limiting distribution of horizontal earth pressure near a vertical rock face filled with loose sand.

6.2 Magnitude of at-Rest Soil Thrust

Fig. 6.13 shows the magnitude of at-rest soil thrust $K_{o,h}$ decreases with the decrease of the wall-rock face spacing d. All test results are less than Jaky's K_o value of 0.48. Jaky, Reimbert and Reimbert, and Spangler and Handy methods appear to overestimate the magnitude of at-rest soil thrust $K_{o,h}$. In Fig. 6.14, at a small d/H, Jaky's solution significantly overestimated the magnitude of the soil thrust. It appears Janssen's method provides a best estimation for the $K_{o,h}$ coefficient. It is noted that error of $K_{o,h}$ is defined as the ratio of the difference of $\Delta K_{o,h}$ between theory value and test result to the experiment $K_{o,h}$, as indicated in Fig. 6.14.

6.3 Point of Application of at-Rest Soil Thrust

Fig. 6.15 shows the point of application h/H of at-rest soil thrust at different wall-interface spacing d. It can be found that the point of application (h/H) increase with the decrease of spacing d, and all test data are higher than the value of h/H = 0.33. From Fig. 6.15, it is observed that Jaky's prediction (h/H = 0.33) is the lower limit of the data points. Fig. 6.16 shows the distribution of overturning moments about the base for loose sand with different spacing d. From Fig. 6.16, it is obvious that Jaky's solution (M_o = constant) is not appropriate. Reimbert and Reimbert overestimate the overturning moments (M_o) and Spangler and Handy's prediction is conservative. Fig. 6.16 indicates that Janssen's prediction is the best estimation for overturning moments about the wall base.