Chapter 7

EXPERIMENTAL RESULTS FOR COMPACTED SAND

This chapter reports the effects of a nearby rock face on the horizontal earth pressure against a non-yielding wall. Dense Ottawa sand, which was compacted with a strip vibratory compactor (50 mm × 900 mm), with the unit weight γ = 16.5 kN/m^3 (D_r = 72%) is used as backfill material for the experiments. Based on direct shear tests, the corresponding internal friction angle ϕ, wall friction angle δ_w would be 40.1° and 13.3°, respectively. The γ, ϕ, and δ_w values are used to calculate the Jaky, Rankine 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 thus study are 1500, 1100, 900, 700, 500, 400, 300, 200, and 100 mm, as illustrated in Fig. 7.1. Earth pressure on the wall is monitor with soil pressure instrumented on the NCTU non-yielding retaining wall. The testing program for this study is summarized in Table 6.1.

7.1 Distribution of Earth Pressure at-Rest

The earth pressure at-rest was measured by soil pressure transducer (SPT) after the loose sand is placed and compacted in fifteen lifts. Each lift is 0.1 m-thick after compaction. The surface of backfill is horizontal for all experiments. Relative density D_r achieved for the dense sand is 72%. The method of air-pluviation was used to fill in each lift and then vibratory compactor is adopted to prepare specimens. Experiment results are compared with Jaky, Rankine, Janssen, Reimbert and Reimbert, and Spangler and Handy's predictions. It should be noted that calculation in the Janssen, Reimbert and Reimbert, and Spangler and Handy methods, the model wall, side-wall and the interface plate are assumed to as same material.

Fig. 7.2 shows the distribution of horizontal earth pressure (σ_h) for compacted sand with the spacing d = 1500 mm. Before compaction, the earth pressure at-rest can be properly estimated with Jaky's equation. However, after compaction by the strip compactor (Fig. 3.6), it is obvious that an extra horizontal stress $\Delta\sigma_{h,ci}$ was induced by compaction. The effective depth of comapction from the backfill surface is about 0.7H, where H is the backfill (H = 1.5 m). The lateral stress measured near the top of backfill is almost identical to the passive earth pressure estimated with Rankine theory.

Fig. 7.3 shows the distribution of earth pressure for d = 1100 mm after compaction. Near the top of backfill, the lateral pressure measured is similar to the Rankine passive pressure. It is obvious that no theoretical solution in the figure can properly estimate the earth pressure after compaction, because the theories did not consider the effect of compaction. The effective depth of compaction is about 0.57H from the fill surface.

Fig. 7.4 through Fig. 7.10 show the earth pressure distribution acting on the model wall with d = 900 mm to 100 mm. In these figures, the earth pressure measured near the top of the wall is similar to the Rankine passive pressure. It should be noted that with the decrease of spacing d, the extra earth pressure inducing by compaction $\Delta\sigma_{h,ci}$ near the top increases. Since compaction was conducted for soils filled in a small gap d, the compaction energy was constrained by the interface plate and the non-yielding wall and could not transmitted to the surrounding soils. As a result, the compaction energy was concentrated on the soils in the narrow gap, thus induces greater lateral pressure near the top of the wall. It can be found in Fig. 7.2 to Fig .7.10 that, below the effective compaction depth, the measured σ_h is in general lower than Jaky, Janssen, Reimbert and Reimbert, and Spangler and Handy's predictions.

In Fig. 7.11, the distributions of horizontal earth pressure acting on the model with different spacing d are shown. Due to compaction, above the depth of 0.1H from the surface, the earth pressure increases with depth. Between the depth of 0.1H and 0.77H from surface, the effects of compaction gradually vanish, and earth pressure decreases with increasing depth.

7.2 Magnitude of at-Rest Soil Thrust

Fig. 7.12 illustrates the magnitude of at-rest soil thrust ($K_{o,h}$) induced by compaction with different spacing d. It is obvious that $K_{o,h}$ decreases with the decreasing of d. All theories underestimate the test result since these theories did not consider the effect of compaction. Fig. 7.13 shows the % of error of $K_{o,h}$ estimated with 4 different methods. However, none of the theory provide good ideas to estimate the σ_h acting on a retaining structure with compacted backfill near a vertical rock face.

7.3 Point of Application of at-Rest Soil Thrust

Fig. 7.14 illustrates the point of application (h/H) of the at-rest soil thrust for compacted sand with different spacing d. Experiment results show that h/H varies between 0.5 and 0.6. The four theories overly underestimate the h/H, because they did not consider compaction effect. It should be noted that the underestimation of h/H is not on the safe-side.

7.4 Comparison between Loose and Compacted Sand

Fig. 7.15 illustrates the comparison of magnitude of at-rest soil thrust ($K_{o,h}$) for loose and compacted sand with different spacing d. It is obvious that due to the effect of compaction, the $K_{o,h}$ is almost doubled from $K_{o,h}$ for loose sand. Fig. 7.16 shows the comparison of point of application of the at-rest soil thrust for loose and compacted backfill. It can be found in Fig. 7.16 that, the compaction induced extra stress $\Delta\sigma_{h,ci}$ located near the top of the wall lifts of the soil thrust from h/H = 0.35 for loose sand to h/H = 0.6 for compacted sand.