Chapter 3

NCTU NON-YIELDING RETAINING WALL FACILITY

To investigate the effects of earth pressure at-rest with the different distance d between the retaining wall and a rock face, an instrumented model retaining wall facility at National Chiao Tung University (NCTU) was used. The facility consists of four components: (1) model wall; (2) soil bin; (3) data acquisition system; and (4) soil compactor. For more information regarding the facility, the readers are referred to Chen and Fang (2002).

3.1 Model Wall

The model wall shown in Fig. 3.1 is 1500 mm-wide, 1600 mm-high, and 45 mm-thick. To achieve an at-rest condition, the wall material should be nearly rigid. As a result, a solid steel plate with a Young’s modulus of 210 GPa was chosen as the wall material. As indicated in Fig. 3.1, the model wall is actually the front-side of the reinforced steel box. To avoid the lateral deformation of the box, twenty-four 20 mm-thick steel columns were welded vertically on the outside of the box. In addition, twelve C-shaped steel beams were welded horizontally around the box to achieve an at-rest stress condition in the box.

Assuming 1.5 m-thick cohesionless backfill with a unit weight $\gamma = 17.1\ \mathrm{kN/m^3}$, and an internal friction angle $\phi = 41^\circ$ was pluviated into the box. The estimated deflection of the model wall would be only 1.22×10^{-3} mm. Therefore, it can be concluded that the lateral deformation of the model wall is negligible and at-rest condition can be achieved.

Based on the studies by Sowers and Sowers (1961), Mackey and Kirk (1967), Matteotti (1970), Bros (1972), NAVFAC DM-7.2 (1982), Bowles (1988), and Fang et al. (1997), the wall displacements required to achieve an active state are summarized in Table 3.1. It is seen that dense sand requires much less wall displacement to achieve an active state of stress compared with sand in loose state. NAVFAC Design Manual DM-7.2 (1982) assumes that, for dense sand, a wall movement as little as 0.0005H would cause the active soil wedge to develop, implying that for a 1.5 m-high retaining wall, the active earth pressure would develop at a wall movement of 0.75 mm. However, the maximum deflection of the NCTU non-yielding wall is only 0.16% of the wall-movement required to reach an active state. From a practical point of view, the NCTU model wall would produce state of stress similar the earth pressure at-rest.

To investigate the distribution of earth pressure with depth, sixteen soil pressure transducers (SPT) were embedded in the central zone of the model wall as illustrated in Fig. 3.2. The soil pressure transducers are strain-gage-type transducers (Kyowa PGM-02KG, capacity = 19.6 kN/m^2) as shown in Fig. 3.3. Besides, another three transducers (SPT 17,18,19) were mounted horizontally between the central zone and sidewall could be used to investigate the effects of sidewall friction. To eliminate the soil-arching effect, all soil-pressure transducers were quite stiff and were installed flush with the wall.

3.2 Soil Bin

To constitute a plane strain condition for model test, the soil bin is designed to be almost rigid. The sidewalls were fabricated of 1500 mm-wide, 1600 mm-high and 35 mm-thick steel plates as illustrated in Fig. 3.1. The end-wall and two sidewalls of the soil bin were made of 35 mm-thick steel plates. Outside the steel side walls, vertical steel columns and horizontal steel beams were used to confine the lateral movement of the end-wall and sidewalls. From a practical point of view, the deformation of the sidewalls could be considered negligible.

To reduce the friction between backfill and sidewalls, a lubrication layer consists of plastic sheets (Fang et al. 2004) was furnished for all model wall experiments. The “thick” plastic sheet was 0.152 mm thick, and it is commonly used for construction, landscaping, and concrete curing. The “thin” plastic sheet is 0.009 mm thick, and it is widely used for protection during painting, and therefore it is sometimes called painter’s plastic. Both plastic sheets are readily available and neither is very expensive. The lubrication layer consists of one thick and two thin plastic sheets were hung vertically on each sidewall of the soil bin before the backfill was deposited. The thick sheet was placed next to the soil particles. It is expected that the thick sheet would help to smooth out the rough interface as a result of plastic-sheet penetration under normal stress. Two thin sheets were placed next to the steel sidewall to provide possible sliding planes. The experimental results regarding the sidewall friction will be discussed in Section 5.3.

The model wall, sidewalls, end-wall, and base plate of the soil bin were welded carefully to ensure its structural integrity. The bottom and end-wall of the soil bin were covered with a layer of anti-slip material (Safety-Walk by 3M) to provide adequate friction between the soil and the base of the bin.

3.3 Data Acquisition System

All signals collected by the soil pressure transducers are processed by a data acquisition system indicated in Fig. 3.4. The analog signals from the sensors were filtered and amplified by the dynamic strain amplifiers (Kyowa DPM601A and DPM711B), then digitized by an analog-to-digital converter. Finally, the digital data was transmitted to the computer for storage and analysis.

3.4 Soil Compactor

To simulate the backfill compacted in the field, a strip vibratory compactor (90 mm Ｘ 500 mm) was made by attaching an acentric motor (Mikasa, KJ75-2P) to a 245 mm ×

230 mm flat steel plate at the top of the compactor (Fig. 3.5). The reason to design a compactor with a rectangular compaction plate of 90 mm × 500 mm is to compact the soil placed in the narrow trench between model wall and the rock face. The strip compactor was designed with a 1850 mm-long steel tube so that the compacting plate could be inserted in to the narrow-trench and the soil at the bottom could be properly compacted. Technical information associated with the acentric motor are listed in Table 3.2. As illustrated in Fig. 3.5 and shown in Fig. 3.6, the strip soil compactor consists of four components: (1) handle; (2) acentric motor; (3) steel tube; and (4) compactor plate. The 90 mm × 500 mm compacting plate was welded to the 1850 mm-long (50 mm-outer diameter) steel tube. The steel tube transmitted the compaction energy down to the backfill. The total mass of the strip soil compactor is 25 kg. A number of acentric steel plates were attached to the central rotating shaft of the motor to control the intensity of compaction applied to the soil. Fig. 3.7 shows the relationship between the number of acentric plate and the generated acentric fore offered by the manufacturer. The cyclic vertical force (static + dynamic) measured with a load cell placed under the base of the vibratory compactor was 0.33 kN, and the measured frequency of vibration is 30 Hz. Assuming the distribution of contact pressure between the base plate and soil is uniform, the cyclic normal stress σ_{cyc} applied on the surface of soil would be 7.33 kN/m^2. For this study, sixteen acentric plates (8 + 8) were used to achieve the dense backfill.