Chapter 3

EXPERIMENTAL APPARATUS

To investigate effects of inclined rock face on earth pressure at-rest, the instrumented model retaining wall facility at National Chiao Tung University (NCTU) was used. This chapter introduces the NCTU non-yielding retaining wall facility and the compactors used to densify the backfill. The NCTU model retaining wall facility consists of three parts: (1) model wall; (2) soil bin; and (3) data acquisition system (Chen and Fang, 2002). The details of the facility are described in the following sections.

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. With the application of earth pressure, the deformation of the wall could be neglected. 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 reduce avoid the lateral deformation of the box, twenty-four 20 mm-thick steel columns were welded vertically on the outsides of the box (Fig. 3.1). In addition, twelve C-shaped steel beams were welded horizontally around the box to achieve an at-rest stress condition in the box.

Based on the study 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 clear in the table that dense sand requires much less wall displacement to reach an active state than loose sand does. Navy Design Manual DM-7.2 (1982) reported that, for dense sand, a wall movement as little as 0.0005H would cause the active soil wedge to develop. That means for a 1.5 m-high retaining wall, the active earth pressure would be induced with the tiny wall movement of 0.75 mm. However, the maximum deflection of the NCTU model wall is only 0.16% of the wall-movement required to reach an active state. From a practical point of view, the earth pressure against the model wall would be nearly the earth pressure at-rest.

To investigate the distribution of earth pressure behind retaining wall, fifteen soil pressure transducers (SPT) were attached 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. 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 minimize the lateral deflection of sidewalls and the friction between the backfill and sidewalls. In Fig. 3.1, the sidewalls were fabricated of 1500 mm-wide, 1600 mm-high steel plates. The end-wall and sidewalls of the soil bin were made of 35 mm-thick steel plates. Outside the steel 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 for the effect of 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 to provide adequate friction between the soil and the base of the bin.

3.3 Data Acquisition System

The Data acquisition system used for this study is shown in Fig. 3.4. It is composed of the following four parts: (1) dynamic strain amplifiers (Kyowa: DPM601A and DPM711B); (2) NI card; (3) AD/DA card; and (4) PC. The analog obtained signals from the sensors are filtered and amplified by dynamic strain amplifiers. Analog Experimental data are converted digital data by the A/D – D/A card. The LabVIEW program is used to acquire experimental data finally. Experimental data are storage and analysis with the Pentium 4 personal computer.

3.4 Soil Compactors

To simulate compaction of backfill in the field, two vibratory soil compactors are used to simulate the backfill compacted in field. The acentric motor (Mikasa, KJ75-2P) is selected to be the source of vibration. The acentric force generated by the motor could be controlled by adjusting the number of acentric plates attached to the motor as illustrated in Fig. 3.5 (b). Fig. 3.5 (a) shows acentric steel plates were attached to the central rotating shaft of the motor. For this study, sixteen eccentric plates (8+8) were used. Detail information regarding the acentric motor is listed in Table 3.2. The design and construction of the two vibratory soil compactors used for this study are described in the following sections.

3.4.1 Square Vibratory Soil Compactor

The vibratory soil compactor with the base area of 225 mm × 225 mm is illustrated in Fig. 3.6 and Fig. 3.7. The acentric motor is fixed on the steel compaction plate of the compactor. The height of the handle is 1.0 m, and of the compactor is 12.1 kg (0.119kN). Chen (2002) reported the peck cyclic vertical force (static + dynamic) measured with a load cell placed under the base plate of the vibratory compactor was 1.767kN, and the frequency of vibration is 44 Hz. With the 225 mm × 225 mm compaction plate, the peck cyclic normal stress σ_{cyc} applied on the surface of soil was 34.9 kN/m^2.

3.4.2 Strip Vibratory Soil Compactor

A new vibratory soil compactor is designed and constructed for this study. The strip vibratory compactor is composed of compaction plate, acentric motor, steel tube, and switch as shown in Fig. 3.8. The front-view and side-view of strip compactor are shown in Fig. 3.9 (a) and (b). Fig. 3.9 (c) shows the strip compacting plate is 0.09

m-wide and 0.5 m-long. An acentric motor is fixed on a steel plate on the top of compactor as shown in Fig. 3.9 (d). The total mass of the compactor is 25 kg (0.245 kN). The cyclic vertical force (static + dynamic) measured with a load cell placed under the compactor was 0.33 kN, and the frequency of vibration is 30 Hz. The peck cyclic stress σ_{cyc} applied on the surface of soil was 7.33 kN/m^2.

Fig. 3.10 (a) shows the compaction of backfill with the 0.225 m × 0.225 m square compactor. Fig. 3.10 (b) shows the compaction of loose backfill with the interface inclination of α = 70^o for H = 0.6 m. Since the spacing between the wall and interface plate is quite narrow, it is possible for the square compactor to do the job. However, in Fig. 3.10 (b), the new vibratory compactor can be used to compact the backfill comfortably. If an even narrorer reach is to be compact the extended cushion shown in Fig. 3.11 can be attached to the bottom of the compacting plate to compact these parts.