Chapter 1

INTRODUCTION

Traditionally, civil engineers adopt the Jaky's formula (1944) (K_o = 1-sinϕ) to estimate the at-rest earth pressure acting on non-yielding retaining walls. However, if rock faces existed adjacent to the wall, estimation of earth pressure with Jaky's formula may be conservative.

1.1 Objective of Study

Fig. 1.1 shows that after the basement excavation, hard rock faces exist adjacent to the basement wall. The distance between the basement wall and rock face is d. In this case, the distribution of lateral earth pressure acting on the basement wall may not be linear. In Fig. 1.2, there is a vertical rock face located at a distance d from the abutment. The distribution of lateral earth pressure on the abutment is not the same as Jaky's prediction. To increase the fill's bearing capacity or to reduce fill settlement, the backfill behind the wall is after compacted to a dense condition ($D_r \geq 70\%$) with vibratory compactors. Effects of compaction on earth pressure are more complicated and the distribution of earth pressure would be more difficult to estimate.

Some retaining walls, such as the fascia wall shown in Fig. 1.3, are built in front of an unstable rock face, not so much to retain soil as to prevent rockfalls. Granular backfill placed in the relatively narrow gap between the wall and the natural rock outcrop is partly supported by friction in each side, from the wall and from the outcrop. Since the main function of fascia walls is to prevent rockfalls, backfill behind the wall may be filled directly to the narrow gap without compaction.

Lateral pressure of agriculture products against the walls of grain-storage containers is similar to the problems. Fig. 1.3 and Fig. 1.4 show a circular storage silo and a rectangular storage bunker filled with granular material (grain, or coal), respectively. It is important for the designer to know how much lateral pressure is acting on the inside of silo walls. The lateral pressure of agriculture products against the non-yielding silo wall is similar to the situation shown in Fig. 1.1 and Fig. 1.2. However, the granular materials filled in silos or bunkers are generally not compacted.

There are a few theories or empirical equations to estimate the earth pressure which is affected by an adjacent vertical rock face. Spangler and Handy (1982) reported a theoretical equation to estimate the earth pressure near a rock face. Frydman and Keissar (1987) used centrifuge modeling technique to investigate the distribution of earth pressure near a rock face. Janssen (1895) and Reimbert and Reimbert (1976) derived theoretical equations to estimate material pressure acting on silos and bunkers. However, until now, no test results studied with full-scale model walls have been reported.

To obtain a better understanding of the lateral pressure at-rest near a vertical rock face, the large-scale non-yielding wall system at National Chiao Tung University (NCTU) is employed. An interface plate simulating the rock face and its supporting system, which consists of a steel interface plate, a top supporting beam, a base supporting frame, and base spacing plate were designed and constructed. Air-dry Ottawa sand is used as backfill material. For a loose backfill, the soil was placed behind the wall with the air-pluviaiton method to achieve a relative density of 35%. For a dense backfill, the soil was compacted by a strip vibratory compactor to achieve the desired relative density of 72%. Different spacing d (d = 50, 100, 200, 300, 400, 500, 700, 900, 1100, and 1500 mm) between the model wall and interface plate (covered with Safety-Walk) was adopted. The earth pressure acting on the wall is monitored with soil pressure transducers mounted on the model wall. Parameters considered in this research include the distance d between interface and model wall, and the relative density D_r of backfill.

In this study, by applying different distance d between the model wall and the interface plate, the effects of distance to rock face d on lateral earth pressure are investigated. Through the measurement on an instrumented full-scale model wall, test results of this study would offer valuable information and experience, for the engineer to design retaining structures near a rock face and storage bunkers.

1.2 Research Outline

This study utilizes the NCTU model retaining-wall facility and the interface plate system to investigate the earth pressures near a vertical rock face. Chapter 2 discusses the at-rest earth pressure theory, effects of soil compaction, and methods of estimating the K_o near a rock face, silo, and storage bunker. Details of the NCTU non-yielding model wall system and the vibratory compactor used for experiments are discussed in Chapter 3. To simulate a vertical rock face, a vertical interface plate (covered Safety-Walk) and its supporting system designed and constructed, which are introduced in Chapter 4. Characteristics of the backfill, friction of the model wall, friction of the side wall, friction of the interface plate, and soil density control are described in detail in Chapter 5.

To determinate the friction angle between the backfill and the interface plate, special direct shear tests were conducted. Test results for loose sand placed with air-pluviation method are discussed in Chapter 6. Test results for dense sand, and the effects of soil compaction are discussed in Chapter 7.