Chapter 1

INTRODUCTION

Traditionally, civil engineers build retaining structures to resist the earth pressure. The retaining wall would support not only the horizontal pressure caused by the soil mass behind the wall, but also the pressure increase due to surcharge loading. Various types of loading may be applied on the surface of the backfill, such as a heavy roller, mechanical equipment, and passing vehicles. The various surcharge loadings may cause different lateral pressure increment on the wall as shown in Fig. 1.1. The earth pressure distribution behind the wall has a great influence on the safety of the retaining structure. It influences not only the stress within the body, but also the structural safety. Therefore, the increment of lateral earth pressure due to surcharge loading on the retaining wall should be carefully considered.

The estimation of increment of lateral pressure on the wall due to various types of surcharge loading is base on the elastic solution. The application of elastic theory is limited to perfect elastic, homogeneous, and isotropic materials. Terzaghi (1954) proposed equations to estimate the horizontal stress due to a line load. The equations suggested by Terzaghi are widely adopted by design manuals, such as the U.S. Navy Facilities Design Manual DM-7.2. The empirical method was based on method of image (Mindlin, 1936) and field test data (Gerber, 1929). The method of images assumed that the pressure on a unyielding wall would be double the elastic solution.

Although there were considerable amount of studies regarding horizontal pressure increase due to surcharge loading, however, the surcharge loading is generally assumed to be uniform. It implies that a flexible foundation is built on top of the backfill. In reality foundations are not totally flexible.

Fig. 1.2 shows the contact pressure and settlement profile of flexible and rigid foundation on sand. In Fig. 1.2(a) for a flexible foundation resting on a cohesionless soil, the distribution of contact pressure will be uniform. However, the edges of the foundation will undergo a layer settlement then the center. This occurs because the soil located near the edge lacks lateral pressure and hence possesses less strength. In Fig. 1.2(b), a rigid foundation resting on a san layer will settle uniformly. The contact pressure on the foundation will increase from zero at the edge to a maximum at the center.

The purpose of this research is to observe the horizontal pressure increase against the non-yielding wall due to flexible and rigid footing surcharge on the backfill, to estimate the solution mentioned above.

1.1 Objective of Study

To obtain a better understanding of the lateral pressure increase due to surcharge, the large-scale non-yielding model retaining wall system at National Chiao Tung University (NCTU) is employed. A surcharge loading system consists of the reaction frame, vertical-force loading apparatus, strip footing, and settlement measuring system was designed and constructed. Air-dry Ottawa sand is used as backfill material. Dry sand is placed behind the wall by air-pluviation method to achieve a relative density of 35%. Vertical strip loading is applied on the top of the backfill, and the horizontal pressure on the wall is monitored with soil pressure transducers. Parameters considered in this research include the foundation stiffness, magnitude of surcharge, and horizontal distance from surcharge to the model wall.

1.2 Research Outline

This research utilizes the NCTU non-yielding model wall facility to investigate the earth pressure due to flexible and rigid strip footing applied on the surface of the backfill. The theories and experimental findings associated with the lateral pressure induced by surcharge are summarized in Chapter 2. The NCTU non-yielding model wall system is discussed in Chapter 3. The details of the surcharge loading system used for experiments are discussed in Chapter 4. Characteristics of backfill are introduced in Chapter 5.

To constitute a plane-strain condition for model wall tests, the shearing stress between the backfill and the sidewalls should to be minimized to nearly frictionless. This is accomplished by creating a lubrication layer between the sidewall and the backfill with plastic sheets.

The earth pressure at-rest was measured after the soil bin was filled up to 1.5m. The measured earth pressure at-rest was compared with the Jaky's formula. To estimate the ultimate bearing capacity q_{all} of the backfill, the strip load was applied at the center of the soil bin and the load-settlement relationship was measured until failure. To maintain a factor of safety of 3.0 for bearing capacity, in this study, the surcharge intensity q applied was controlled to be less than $q_{all}/3$. The lateral pressure increment on the wall due to surcharge loading applied at 0.1H, 0.2H, and 0.4H from the wall were measured (H is wall height). The experimental results are compared with theoretical solutions, and the existing methods to estimate earth pressure increment due to surcharge loading are be carefully evaluated.

1.3 Organization of Thesis

This thesis is divided into the following parts:

1. Review of theories for estimating increment of earth pressure and past investigations with model tests (Chapter 2)
2. Description of NCTU non-yielding retaining-wall facility. (Chapter 3)
3. Description of surcharge loading system (Chapter 4)
4. Backfill characteristics, soil density, and side wall friction effect. (Chapter 5)
5. Experimental results of pressure increase due to surcharge loading (Chapter 6)
6. Conclusions. (Chapter 7)