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CHAPTER 1

INTRODUCTION

1.1 General

Slabs are the flooring systems of most structures including office, commercial and residential buildings, bridges, sports stadiums and other facilities building. The main functions of slabs are generally to carry gravity forces, such as loads from human weight, goods and furniture, vehicles and so on. In modern structure design particularly for high rise buildings and basement structures, slabs as floor diaphragms help in resisting external lateral actions such as wind, earthquake and lateral earth load.

Depending on the structure framing configuration, architectural requirement, analysis and design methods selected by the engineer, slabs can be uniform thickness or ribbed spanning in one way or two ways between beams and/or walls. These flooring systems can be cast-in-situ reinforced concrete, metal deck with in-situ concrete, precast concrete or prestressed concrete. Concrete slabs which are resting on support columns only either with or without column heads and drop panels are defined as flat slabs.

1.2 Background

In general, reinforced concrete floor slabs are often analyzed and designed as uniform plate elements which only possess out-of plane stiffness to carry loads acting normal to the plane of the slab. In other words, slabs are designed to resist only the bending moment in two orthogonal directions as well as twisting moments .

Besides that, slabs also contribute to the lateral load resistance and stability by transmitting the forces to main framing systems, that are, the floor beams, columns, shear walls or core walls. This is based on the assumption that in-plane stiffness of slabs is so great that it act as a rigid diaphragm. Three common types of lateral actions on a structure are the lateral earth pressures, wind forces and seismic loads.

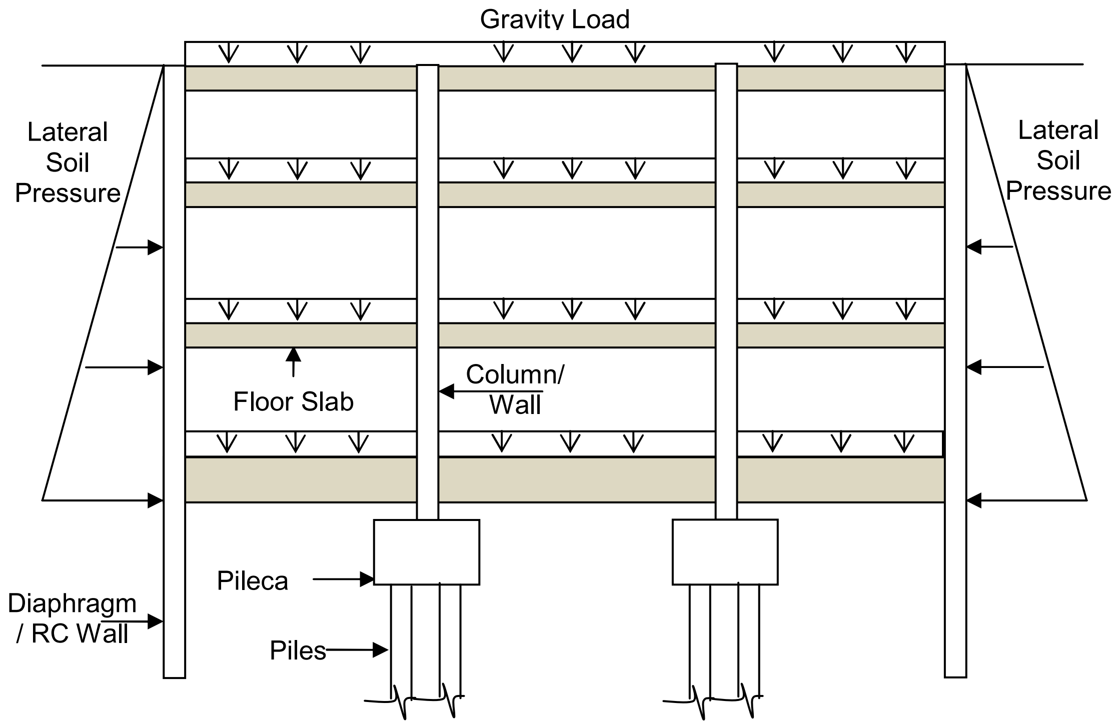

Figure 1.1: A Typical Basement Floor Structure

However, an important issue which is often overlooked by the design engineers is that in order for a slab to provide ideal diaphragm actions, the slabs must possess adequate thickness [1]. The diaphragm stresses in slab due to in-plane forces, might have exceeded the concrete resistance capacity and often slabs are not checked regarding this matter. The cast-in-situ reinforced concrete connection between slabs and beams or between slabs and columns or walls is another important feature that is often not carefully reviewed and detailed by the end of design stage to tally with the preceding analysis assumption.

In addition, when slabs are subjected to out-of-pane bending moment due to gravity load and significant compressive forces due to lateral forces simultaneously, they would behave like uniaxial bending slender columns. There might be significant secondary moment and shear forces due to axial forces acting on the deflected slab. This is difficult to identify based on the first order linear elastic analysis that are usually adopted for slab design.

The additional deflection and stresses due to additional lateral forces, improper connection detailing and secondary effect of combined actions, may cause slabs to crack or even fail, should these are not taken into consideration of analysis and design. Once the slabs start to crack, the stiffness would be reduced affecting the performance of the floor system as well as the diaphragm effect on structural stability. For example, cracks are often observed at basement floor slabs where the structure may be subjected to both lateral load and gravity load simultaneously. Figure 1.1 illustrate a typical basement floor structure subjected both gravity loads and lateral soil loads.

1.3 Objectives

The main objectives of this project are as below:

i. To study the behaviour of reinforced concrete solid slabs at basement floor subjected to combined actions of gravity loading and lateral earth loading and investigate the possibility of cracking,

ii. To investigate the impact of second order analysis on slender solid floor slabs, considering nature of geometrical non-linear, concrete short term and long term modulus of elasticity.

iii. To propose recommendation for design and detailing requirement of reinforced concrete solid floor slabs, depending local floor stresses, framing configuration and support systems.

1.4 Scope of Study

In this study, only numerical analysis has been carried out and there is no experimental work or laboratory test. The structural analysis is based on static analysis of combined gravity loads and lateral forces on slabs. The study focuses on a proposed conventional type of car park floor model with typical design superimposed load of $0.5kN/m^2$ and imposed load of $2.5kN/m^2$. Besides carrying gravity load, the basement slabs also act as a strut system to a series of diaphragm walls or reinforced concrete walls that retains the surrounding earth. As the loads acting on the structures are stationery or very slowly over time, the dynamic effect is assumed insignificant and not considered in the analysis.

Prior to the analysis, suitable thickness for the slab models is determined using the simple calculation span-to-effective-depth ratio method as recommended by the code of practice The critical force is later compared with some calculated lateral soil loads, assuming the slabs to be constructed at basement floor with both functions of flooring and strutting system to earth retaining wall.

Then, first order linear and second order elastic analysis using finite element method is carried on the proposed slab models which are applied with gravity force and followed by combined gravity and lateral forces. The results of internal forces, displacements, bending moments and shear forces for both types of analysis are observed and discussed. Possible cracks in slabs due to the stresses and strains are checked and identified by comparing with the typical design provision and detailing.

Based on the analysis results, some designs and detailing requirements of reinforced concrete basement slabs are proposed to optimize the design and to avoid slab cracking and failure.