AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Structural Engineering

BOUNDARY ELEMENT LATERAL ANALYSIS OF TALL BUILDINGS INCLUDING SOIL-STRUCTURE INTERACTION EFFECTS

A Thesis submitted in partial fulfillment for the requirements of the degree of Master of Science in Civil Engineering (Structural Engineering)

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01 December 2018

Statement

This thesis is submitted as a partial fulfillment of Master of Science in Civil Engineering Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

In this thesis, a new technique for the analysis of buildings including soil-structure interaction (SSI) is suggested. The new analysis is based on sub-structuring approach where the system is partitioned into two main parts which are the superstructure part and the raft-soil part. A static condensation technique is implemented at the wall-raft interface. Deformations of supports at wall-raft interface are obtained. Current practical analysis of SSI is implementing the static condensation at the raft-soil interface which is time consuming and tedious job. The new analysis has shown less time and effort in the modeling and analysis. This technique of analysis is presented here only for linear analysis and shear wall buildings rested on piled raft. However, this technique can be extended to include the other methods of SSI such as EHS and nonlinear analysis such as no tension SSI, soil nonlinearity SSI and analysis of frame buildings.

Keywords:

BEM; Soil-structure interaction; condensation; Lateral Analysis; tall buildings;

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Table of Contents

List of Figures

Chapter 1 Introduction

1.1 General

According to many reports [1], construction industry undergoining a very rapid developmant particularly in tall buildings because of orientation to urbanization and industrial development.

Considering tall building from 5 to 10 stories with raft foundations , it is common in structural engineering mainly in the analysis of buildings at design companies not taking into account the flexibility of the substructure (underneath soil and foundations) in the analysis of the superstructure. They always carry out design as two independent parts.

Generally, buildings are assumed to be hinged or fixed at the ground level. As a consequence, the evaluated responses because of different types of load cases especially the lateral loads (earthquakes and wind loads) do not exactly present the accurate behavior of the structure. Soil and raft stiffness will add more flexibility to the structure; so that the overall stiffness will be decreased and a more realistic and optimized designs could be optained. On the other hand, the lateral deflection and the inter-story drift will increase by increasing the soil flexibility. Although this is more conservative for the structures, the safety of the structure due to lateral deflection should be re-evaluated so, it is very important to consider soil-structure interaction in the analysis.

1.2 Thesis objectives

The main objective of this work is to develop a tool to analyze multistory shear wall buildings rested on piled raft foundation under static lateral loads considering soil-structure interaction taking into consideration the limited number of stories due to shortage of computer facilities. The new idea is based on the availability of the SAP program [32] as an input data interface to a program based on variational boundary

element and that for superstructure analysis presented in chapter 3 in section 3.3. Also, there is a program called PLPAK [38] see chapter 3 section 3.4 through which soil can be modeled as piled raft. Unlike the uncoupled iterative technique presented in section 2.4.1, this technique is based on a static condensation at the raft-walls interface as shown in figure 1.1. This will produce much less degrees of freedom and hence much less effort and computation time. The new technique is planned to be automated; also a graphical user interface for the work is going to be developed to easily use for engineers in the practice.

The thesis objectives can be summarized as below.

- To develop a new algorithm to couple the structure with the soil in the analysis of tall buildings rested on piled raft foundations to consider the effect of static soil-structure interaction.
- To implement this tool to couple a program based on variational boundary element which used for analysis of superstructure with a boundary element based program named PLPAK which is used for the analysis of slabs and foundation on elastic half space.

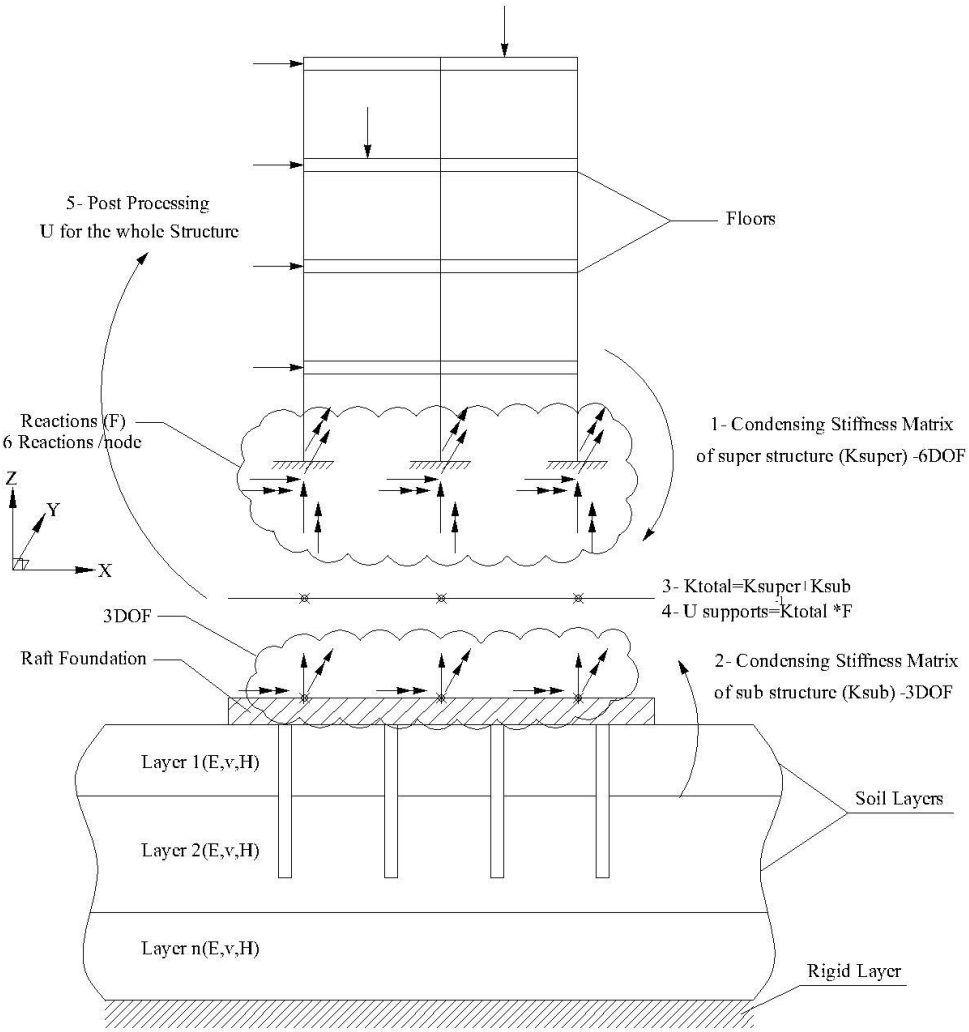

Figure 1.1 The proposed new method of static condensation.