



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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2018



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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

Thesis Summary	i
Acknowledgment	ii
Table of Contents	iii
List of Figures	vii
Chapter 1: Introduction	1
1.1 General	1
1.2 Thesis objectives	1
1.3 Thesis outline	4
Chapter 2: Literature Review	5
2.1 Sources of Soil structure interaction	5
2.1.1 Kinematic interaction	5
2.1.2 Inertial interaction	6
2.2 Methods of soil structure interaction modeling	8
2.2.1 The direct approach [15-16]	8
2.2.2 The Substructure approach [17]	9
2.3 Methods of soil representation	12
2.3.1 The Winkler model	12
2.3.2 The multi-Parameter model [19-20]	13
2.3.3 The elastic half space (EHS) model	13
2.4 Available solutions in practice	14
2.4.1 The uncoupled manually iterative method	15
2.4.2 The conventional method in practice	17
2.5 Conclusions	20

Chapter 3: Used Numerical Methods and Softwares	21
3.1 Introduction	21
3.2 The finite element method (FEM) [32]	21
3.2.1 Advantage of the FEM	21
3.2.2 Disadvantage of the FEM	22
3.3 The SAP software [32]	22
3.3.1 SAP modeling and simulation capabilities	23
3.3.2 SAP analysis capabilities	23
3.4 The boundary element method (BEM) [34]	24
3.5 The Variational boundary element method (VBEM)	24
3.6 Raft terminology used in BEM/PLPAK	26
3.6.1 Raft foundation	27
3.6.2 Boundary elements	27
3.6.3 Nodes	27
3.6.4 Extreme points	27
3.6.5 Colum load modeling	27
3.6.5.1 Column load modeling without rotational stiffness	28
3.6.5.2 Column load modeling with rotational stiffness	28
3.6.6 Wall load modeling in PLPAK	28
3.7 Soil terminology used in BEM/PLPAK	29
3.7.1 Subgrade reaction (K)	29
3.7.2 Elastic modulus(E)	29
3.7.3 Poisson's ratio (ν)	30
3.7.4 Soil layers	30
3.7.5 Soil cells/divisions	30
3.8 The PLPAK software package	32

3.8.1	The PlGen	34
3.8.2	PLView	34
3.8.3	PL.exe	34
3.8.4	PLPost	35
3.8.5	PLCoreman	35
3.9	Soil modeling in PLPAK	36
3.9.1	Winkler model	36
3.9.2	EHS modeling	37
3.10	Conclusions	38
Chapter 4:	The Proposed New Technique	39
4.1	Introduction	39
4.2	Analysis of Superstructure with the VBEM program	40
4.2.1	Shell Element Program	40
4.2.1.1	Input Files	40
4.2.1.2	Output Files	43
4.3	Illustrative Example	46
4.4	Methodology	49
4.5	Conclusions	52
Chapter 5:	Numerical examples	53
5.1	Introduction	53
5.2	Example (1)	53
5.3	Example (2)	61

Chapter 6: Summary, Conclusions and Recommendations for Future Work	69
6.1 Summary	69
6.2 Conclusions	69
6.3 Recommendations for future work	70
References	71

List of Figures

Figure 1.1 The proposed new method of static condensation.....	3
Figure 2.1(a) The effect of soil flexibility on the lateral deformation.....	7
Figure 2.1(b) The effect of neglecting soil flexibility.....	7
Figure 2.2 The direct approach of soil-structure interaction.....	9
Figure 2.3 The substructure method of soil-structure interaction.....	11
Figure 2.4 Soil representation using Winkler springs.....	12
Figure 2.5 The Uncoupled iterative technique used in design firms.....	16
Figure 2.6 The conventional method used in practical design firms (a),(b)..	18&19
Figure 3.1 Soil and boundary elements discretization for a typical raft on Winkler foundation.....	29
Figure 3.2 Soil and boundary elements discretization for a typical raft on EHS..	31
Figure 3.3 Flow chart show the PLPAK components.....	33
Figure 3.4 The Winkler cell discretization in the PLView.....	36
Figure 3.5 Practical raft on Winkler modeled using PLGen.....	37
Figure 3.6 EHSPAK add-on start menu.....	38
Figure 4.1 Flow chart illustrating the sequence of solution.....	45
Figure 4.2 The structural drawings using AutoCAD.....	46
Figure 4.3 The SAP 3D model.....	47
Figure 4.4 Extracting data needed from SAP.....	48
Figure 4.5 The raft model in PLGEN.....	49
Figure 4.6 The raft model in PLPost.....	49
Figure 5.1 Example 1 plan.....	54
Figure 5.2 The SAP2000 3D model of superstructure.....	55
Figure 5.3 The raft model in PLGEN.....	56
Figure 5.4 The raft model in PLPost.....	56

Figure 5.5 The SAP2000 3D model of the whole structure including soil – Direct Method.....	57
Figure 5.6 The SAP2000 3D model of the whole structure including soil – Direct Method.....	56
Figure 5.7 Lateral Deflection in X-direction for example 1.....	59
Figure 5.8 Lateral Deflection Ratio SSI/NSSI in X-direction for example 1....	59
Figure 5.9 Inter Story Drift in X-direction for example 1.....	60
Figure 5.10 Drift Ratio SSI/NSSI in X-direction for example 1.....	60
Figure 5.11 Example 2 plan.....	62
Figure 5.12 The SAP2000 3D model of superstructure.....	63
Figure 5.13 The raft model in PLGEN.....	64
Figure 5.14 The raft model in PLPost.....	64
Figure 5.15 The SAP2000 3D model of the whole structure including soil – Direct Method.....	65
Figure 5.16 The SAP2000 3D model of the whole structure including soil – Direct Method.....	66
Figure 5.17 Lateral Deflection in X-direction for example 2.....	67
Figure 5.18 Lateral Deflection Ratio SSI/NSSI in X-direction for example 2...	67
Figure 5.19 Inter Story Drift in X-direction for example 2.....	68
Figure 5.20 Drift Ratio SSI/NSSI in X-direction for example 2.....	68

Chapter 1 Introduction

1.1 General

According to many reports [1], construction industry undergoing a very rapid development 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 obtained. 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.

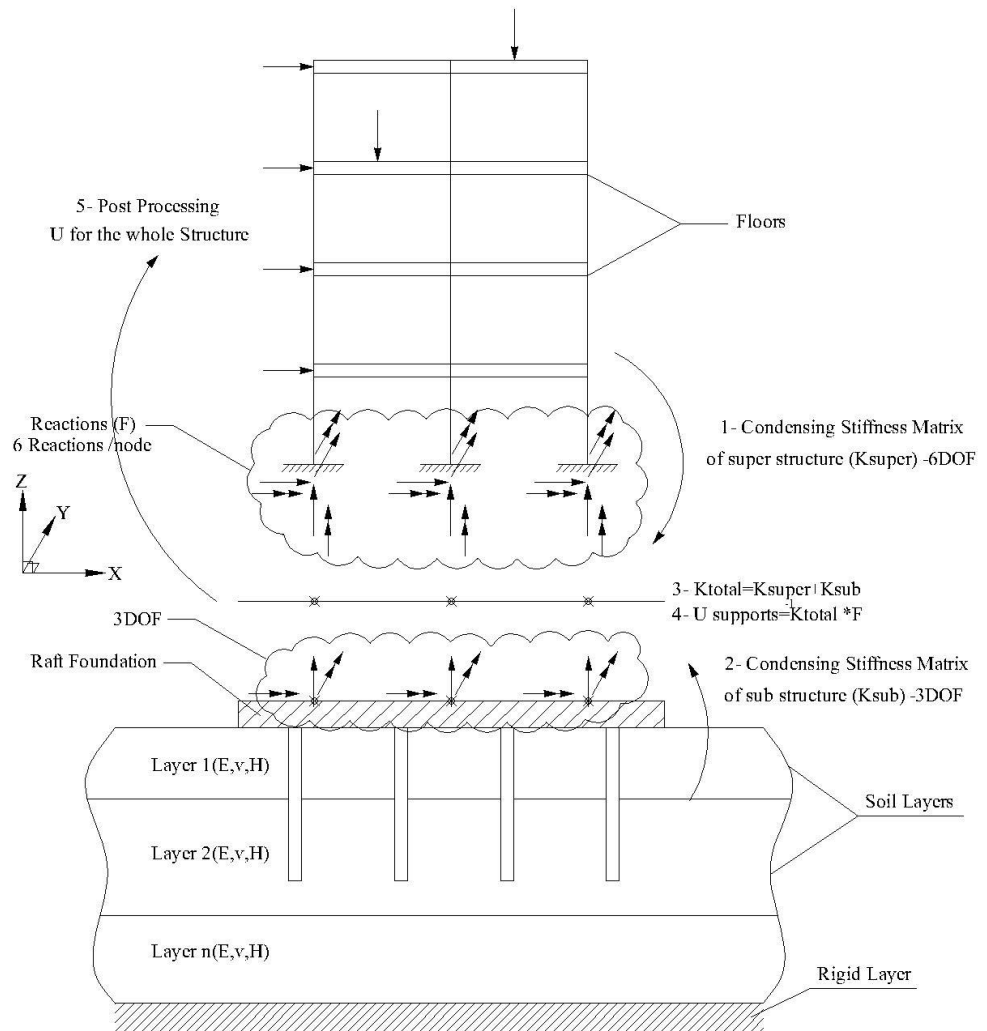


Figure 1.1 The proposed new method of static condensation.