UNIVERSITI PUTRA MALAYSIA

POUNDING BETWEEN ADJACENT BUILDINGS IN CONSIDERATION OF SOIL STRUCTURE INTERACTION

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FK 2011 131
POUNDING BETWEEN ADJACENT BUILDINGS IN CONSIDERATION OF SOIL STRUCTURE INTERACTION

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

November 2011
POUNDING BETWEEN ADJACENT BUILDINGS IN CONSIDERATION OF
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Earthquake is known as one of the most devastating natural disasters to human and their environment that causes catastrophic failure of their life and belongings particularly buildings. The main cause of numerous building failures is collision of adjacent buildings during the earthquake which is called building pounding. It occurs when the separation gap between adjacent buildings is less than minimum distant required for them to vibrate freely. As consequence of building pounding, seismic responses of buildings are altered and in some occasions it produces larger forces and displacements than the design limits which causes building damage.

The aim of this research project is to numerically investigate seismic responses of two adjacent buildings due to earthquake induced building pounding. As the buildings are usually constructed on the soil; interaction between building and soil and further interaction between two buildings through the soil are considered in this
research project. Other parameters affecting building pounding such as separation gap, dynamic property of building and earthquake excitation are studied too.

In order to achieve the aim of this research project, a new analytical model of building pounding considering soil effect is developed. The proposed model consists of two adjacent shear buildings connected with linear visco-elastic contact force model during pounding constructed on a homogenous half-space soil. This model is then implemented into a computer program and calibrated and validated. It is found that the proposed model is efficient and accurate to evaluate seismic responses of buildings with soil effect considerations due to building pounding.

A comprehensive number of analyses are then performed and results are explained and interpreted graphically in terms of building displacement and story shear. When a tall and flexible building is pounded to an adjacent short and stiff building, displacements of tall and flexible building are reduced but displacements of short and stiff building are increased. Considering soil effect (structure-soil-structure interaction, SSSI), produced displacements in both buildings due to pounding are greater than fixed-based (FB) buildings. On the other hand, building pounding causes increment of story shears of both buildings and this increment is pronounced if SSSI condition is considered. In conclusion, building pounding worsens buildings conditions and underlying soil amplifies this detrimental effect.

Further analyses are performed to clarify effects of separation gap, dynamic property of building and earthquake excitation in building pounding. Separation gap between two adjacent buildings is found to be very critical. Number of collisions and intensity
of pounding forces are increased due to reduction of separation gap. Therefore, wider separation gap is necessary to prevent building pounding when the soil is considered, particularly if the soil is soft. In addition, evaluation of variation of buildings dynamic properties (building height) indicates more intense building pounding for tall and flexible building when the period ratio of the buildings is about half. While for short and stiff building, the most critical condition is referred to the least period ratio. Finally, the results show that each earthquake produces unique effect for different buildings and underlying soils. Thus seismic responses of adjacent buildings due to earthquake induced pounding should be analyzed in case by case basis and soil effects, particularly soft soils must be taken into consideration.
Abstract tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

GETARAN DIANTARA BANGUNAN BERSEBELAHAN DENGAN MENGAmbILKIRA KESAN INTERAKSI STRUKTUR DAN TANAH

Oleh

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Gempa bumi merupakan salah satu kejadian yang paling dahsyat kepada manusia dan alam sekitar yang boleh mengakibatkan kesan kegagalan katastopik keatas kehidupan dan harta benda manusia terutamanya bangunan. Punca utama kerosakan bangunan semasa gempa bumi adalah disebabkan oleh pelanggaran diantara dua bangunan yang bersebelahan, ini dinamakan getaran bangunan. Ianya berlaku apabila jurang pemisahan antara bangunan bersebelahan adalah kurang daripada jarak minimum yang diperlukan bagi bangunan bergegar bebas. Akibat dari getaran bangunan, tindakbalas seismik bangunan akan berubah dan dalam sesetengah keadaaniaakanmenghasilkan daya dan anjakan yang melebihi had reka bentuk yang dibenarkan dan mengakibatkan kerosakan bangunan.

Matlamat projek penyelidikan ini adalah untuk menjalankan penyiasatan berangka kesan seismik terhadap dua bangunan bersebelahan yang disebabkan oleh gempa bumi yang mengakibatkan getaran bangunan. Oleh kerana kebiasaanbangunan dibina di atas tanah; interaksi antara bangunan dan tanah dan seterusnya interaksi di
antara dua bangunan dan tanah dipertimbangkan dalam projek penyelidikan ini.
Parameter lain yang mempengaruhi getaran bangunan adalah seperti jurang pemisahan, keadaan dinamik bangunan dan ujaan gempa bumi turut dikaji.

Bagi mencapai matlamat projek penyelidikan ini, satu model analitik baru bagi bangunan bergetar dengan mengambil kira kesantanah telah dibangunkan. Model yang dicadangkan terdiri daripada dua bangunan ricih bersebelahan yang disambungkan dengan model kontekdaya linear visco-anjal semasa getaran yang dibina diatas tanah ruang-separa yang homogeneus. Model ini kemudiannya dilaksanakan melalui program komputer dan ditentukur dan disahkan. Didapati model yang dicadangkan adalah model yang cekap dan tepat untuk menilai kesan seismik pada bangunan dengan mengambilkira kesan tanah akibat dari getaran bangunan.

Beberapa analisis yang komprehensif telah dilaksanakan dan keputusannya dijelaskan dan ditafsirkan secara grafik dari segi anjakan bangunan dan tingkat ricih. Apabila bangunan tinggi dan flexibel digetarkan bersebelahan dengan bangunan rendah dan kaku, anjakan bangunan tinggi dan flexibel berkurangan tetapi anjakan bangunan rendah dan kaku akan meningkat. Apabila kesan tanah (struktur-tanah-struktur interaksi, SSSI) dipertimbangkan, anjakan yang dihasilkan oleh kedua-dua jenis bangunan akibat getaran bangunan adalah lebih besar daripada bangunan berasaskan tetap (FB). Sebaliknya, getaran bangunan menyebabkan peningkatan tingkat ricih bagi kedua-dua bangunan dan ia sangat ketara apabila SSSI diambil kira. Sebagai kesimpulannya, getaran bangunan menyebabkan keadaan bangunan
menjadi lebih teruk dan apabila dasar tanah diambil kira, ia meningkatkan lagi kesan bahaya ini.

ACKNOWLEDGEMENT

I wish to take this opportunity to express my deep sincere gratitude to my parents whom I received their constant, unlimited and unconditional support in my whole life and especially during my research program at the University Putra Malaysia. They made the task of dealing with everyday life easier and more pleasant while I am not really able to give my appreciation just by words.

I would like to thank my supervisor, Dr. Farah Nora Aznieta binti Abdul Aziz, for her encouragements, guidance and valuable comments during my research program.

I also would like to thank Dr. Raizal Saifulnaz bin Muhammad, for being my supervisory committee member.

Special thank is extended to my good friend, Dr. Hassan Pourmohammad, for his encouragements and precious advices throughout my research endeavours.
I certify that a Thesis Examination Committee has met on 10 November 2011 to conduct the final examination of Sadegh Naserkhaki on his thesis entitled "Pounding between Adjacent Buildings in Consideration of Soil Structure Interaction" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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DECLARATION

I declare that this thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not currently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

SADEGH NASERKHAKI

Date: 10.11.2011
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>v</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>viii</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>ix</td>
</tr>
<tr>
<td>DECRALATION</td>
<td>xi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xv</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xviii</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xxviii</td>
</tr>
</tbody>
</table>

## CHAPTER 1 INTRODUCTION

1.1 Overview 1
1.2 Why Considering Soil Effects in Building Pounding? 2
1.3 Problem Statement 3
1.4 Objectives 6
1.5 Scope of the Research 7
1.6 Research Contribution 9
1.7 Outline of Thesis 9

## CHAPTER 2 LITERATURE REVIEW

2.1 Introduction 11
2.2 Building Pounding Definitions and Classifications 13
2.3 Building Pounding Evidences 15
2.4 Separation Gap in Building Codes 20
2.5 Experimental Works in Building Pounding 24
2.6 Numerical Studies on Building Pounding 31
2.7.1 Spatially Varying Earthquakes 43
2.7.2 Soil-Structure Interaction (SSI) 45
2.8 Software Used in Building Pounding Analysis 49
2.9 Concluding Remarks of Literature 49

## CHAPTER 3 DEVELOPMENT OF ANALYTICAL MODEL AND ITS CHARACTERISTICS

3.1 Introduction 52
3.2 Building Model 54
3.2.1 Idealization 54
3.2.2 Discretization 55
3.2.3 Formulation of Mass, Damping and Stiffness Building (MDS Building) 57
3.3 Soil Model
  3.3.1 Soil-Structure Interaction (SSI) 64
  3.3.2 Structure-Soil-Structure Interaction (SSSI) 69
3.4 Contact Model
  3.4.1 Contact Stiffness 74
  3.4.2 Contact Damping 79
3.5 Pounding of Two Adjacent Buildings Considering Soil Effect
3.6 Building Characteristics 81
3.7 Soil Characteristics 83
3.8 Earthquake Characteristics 84
3.9 Conclusion 86

4 SOLUTION AND VALIDATION OF ANALYTICAL MODEL
4.1 Introduction 87
4.2 Solution of the Equation of Motion 89
  4.2.1 Newmark (1959) Step by Step Method 90
  4.2.2 Building Pounding Computer Program Code (BPCPC) 92
  4.2.3 Input of BPCPC 92
  4.2.4 Time Step (∆t) 92
  4.2.5 Dynamic Properties 97
  4.2.6 Body of BPCPC 101
  4.2.7 Output of BPCPC 102
4.3 Numerical Examples and Validation 102
  4.3.1 1DOF Pounding Case 103
  4.3.2 2DOF Pounding Case 112
  4.3.3 MDOF Pounding Case 115
4.4 Conclusion 119

5 SEISMIC RESPONSES OF BUILDINGS DUE TO EARTHQUAKE INDUCED POUNDING
5.1 Introduction 120
5.2 Effect of Underlying Soil 121
  5.2.1 Dynamic Properties of FB and SSSI Buildings 121
  5.2.2 Seismic Responses of FB and SSSI Buildings 126
5.3 Effect of Separation Gap 149
5.4 Effect of Building Dynamic Properties 158
5.5 Effect of Earthquake 165
5.6 Conclusion 170

6 SUMMARY, CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH
6.1 Summary 172
6.2 Conclusion 174
6.3 Recommendations for Future Research 180

REFERENCES 181