

# Table of Contents

<b>1. Introduction</b>	<b>1</b>
1.1. Introduction and Motivation . . . . .	1
1.1.1. Systems Identification techniques applied in Civil Engineering . . . . .	1
1.1.2. Finite Element Model Updating Techniques . . . . .	2
1.2. Objectives . . . . .	3
1.2.1. General Objective . . . . .	3
1.2.2. Specific Objectives . . . . .	3
1.3. Dissertation outline . . . . .	4
<b>2. Sequential Finite Element Model Updating for Joint estimation of Parameters and Input Forces</b>	<b>5</b>
2.1. Output-Only Non-linear system and input identification . . . . .	5
2.2. Sequential Finite Element Model Updating using Model Linearization . . . . .	7
2.3. Transference of the Extended Parameter vector between Consecutive Estimation Windows . . . . .	9
2.4. FE response sensitivities using FDM . . . . .	11
2.5. Correction for Constraints . . . . .	11
2.6. Adaptive Scaling of the Unknown Model Parameters . . . . .	12
2.7. Algorithm . . . . .	14
2.8. Simulation Case . . . . .	15
<b>3. Description of the Building</b>	<b>19</b>
3.1. Structural Characteristics of the Building . . . . .	20
3.2. Structural Plans . . . . .	21
3.3. Instrumentation System of the Building . . . . .	26
3.4. Previous Studies . . . . .	29
3.4.1. Environmental conditions . . . . .	29
3.4.2. Strong earthquakes conditions . . . . .	29
<b>4. Description of Seismic Events and Chilean Chamber of Construction Building Modal Parameter Identification</b>	<b>33</b>
4.1. Earthquake's characteristics . . . . .	33
4.2. Distribution of Maximum Accelerations on the Building . . . . .	35
4.3. Modal Parameters Identification using Seismic Records . . . . .	38
4.3.1. Identification method: Spectrogram . . . . .	38
4.3.2. Identification method: MOESP . . . . .	42
<b>5. Finite Element Model of the Building</b>	<b>62</b>

5.1.	The Finite Element Method . . . . .	62
5.2.	Analytical Model . . . . .	62
5.2.1.	Transfer model to OpenSees (TMOS) . . . . .	66
5.2.2.	Mesh Analysis . . . . .	67
5.2.3.	OpenSees model validation . . . . .	69
5.2.4.	Time-history Analysis and Parallel Computing . . . . .	71
5.3.	Identifiability Assessment of the FE Model Parameters . . . . .	72
5.3.1.	Identifiability Assessment Based on Information Entropy and Mutual Information . . . . .	73
5.3.2.	Parameter Selection Stage . . . . .	73
<b>6.</b>	<b>Finite Element Model Updating</b>	<b>78</b>
6.1.	Simulation Case . . . . .	78
6.2.	Model Updating using the real data measured . . . . .	82
6.2.1.	Results for real data measured before damage to the building . . . . .	82
6.2.2.	Results for real data measured after damage to the building . . . . .	86
6.3.	Summary of results for each event. . . . .	89
6.3.1.	Final Parameters Estimates . . . . .	89
6.3.2.	Algorithm Performance . . . . .	96
<b>7.</b>	<b>Conclusions</b>	<b>103</b>
7.1.	Summary of research work performed . . . . .	103
7.2.	Limitations of the research work and summary of major findings . . . . .	104
7.3.	Recommendations for future research work . . . . .	106
	<b>Bibliography</b>	<b>108</b>
	<b>Appendix A. Input Sensitivity in LTI Systems</b>	<b>112</b>
	<b>Appendix B. Earthquakes' Database</b>	<b>115</b>
	<b>Appendix C. Spectrograms of Seismic Records</b>	<b>120</b>
	<b>Appendix D. Structural responses predicted using final-updated FE model</b>	<b>136</b>