

Application of Smart Façade System in Reduction of Structural Response During Wind Loads

by
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Certificate of authorship/originality

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ABSTRACT

Strong wind causes severe shaking, mostly lateral, over a large area that applies strong excitation to building structures. These winds are extreme actions, from which buildings may not survive unless being properly designed in advance. In recent years, many new devices, such as energy-absorber systems, have been introduced. But, most of them have some disadvantages such as complexity of design and requirement of large spaces for installation. To date the engineering community has seen structural facade systems as non-structural elements with a high aesthetic value and a barrier between the outdoor and indoor environments. As an integral part of all structural buildings, they are susceptible to potential failure when subjected to severe environmental forces such as earthquake and high wind in case they are not designed properly. Wind loads can potentially impose a significant loading on the facade system and may lead to damage and racking in the case of an insufficient connection detailing correspondingly.

The role of facades in energy use in a building has been also recognized and the industry is witnessing the emergence of many energy efficient facade systems. Despite these advancements, the facade has been rarely considered or designed as a potential wind-induced vibration absorber for structural buildings. Development and implementation of advanced facade systems for enhancing the wind response of building structures have been a topic of debate for structural and architectural engineers. Considering this issue,

An alternative method using façade systems incorporated with energy-absorbing devices were proposed in order to damp the amount of energy transferred to the main structure during wind activities.

Various configuration and specification scenarios of the proposed system were suggested in this thesis. Multiple design variations were evaluated as well. To prove the concept and find the optimum value of damper properties, a series of non-linear structural analysis and finite element modelling was done in ANSYS program. First, conventional façade brackets were replaced with the so-called smart elements, which can have back and forth movement during wind load. Predefined elastic-plastic behaviour was suggested for the façade bracket elements in a double skin façade system. Second, façade bracket properties in terms of stiffness and damping of the proposed system were optimized to obtain the desired response. Third, the potential of utilizing a movable exterior facade in a double-skin facade was investigated and it was found that, with optimal choices of façade out-plane movement and appropriate bracket

stiffness, a substantial portion of wind-induced vibration energy can be dissipated, which could lead to avoiding expensive wind designs.

A series of dynamic time history analyses was also carried out to determine the behaviour and response of the proposed system on typical concrete frame structures under different intensity wind. ANSYS and Matlab programs were used for the numerical analyses in all phases of the feasibility study. The initial works demonstrated that the wind response for mid- and high-rise structural buildings subjected to wind loads can be substantially reduced by the introduction of a smart design of a double skin system. Application of flexible connections in façade systems can, if properly designed, reduce the top acceleration response of structural models in comparison with the case without flexible connections.

KEYWORDS: Façade Systems, Multi-Skin Façade, Tall Building, wind Load

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Table of Contents

List of Figures.....	xii
Chapter 1	1
1 INTRODUCTION	2
1.1 The Need for Using Façade as a Structural Element.....	2
1.2 Thesis Aims, Objectives and Methodology.....	2
1.2.1 Thesis Aims.....	3
1.2.2 Objectives.....	3
1.2.3 Methodology	4
1.2.3.1 Analytical Façade Models	4
1.3 Thesis Overview	4
2 Literature Review on Facade Systems.....	8
2.1 Introduction	8
2.2 Façade Systems.....	9
2.2.1 Curtain Walls.....	10
2.2.1.1 Stick System	11
2.2.1.2 Unitized Curtain Wall.....	12
2.2.1.3 Spandrel Panel Ribbon Glazing.....	14
2.2.1.4 Panelized Curtain Wall.....	14
2.2.1.5 Bolted Glass Façade	15
2.2.1.6 Double Skin Façade (DSF).....	16

2.2.1.6.1	Definition	16
2.2.1.6.2	History of Façade Systems	17
2.2.1.6.3	Examples	18
3	Characteristics of wind loads and methods of mitigating wind effects	21
3.1	Introduction	21
3.2	Classification of Wind Load	21
3.3	Combination of Wind Loads	23
3.4	Wind Directionality Factor	23
3.5	Reference Height and Velocity Pressure	23
3.6	Wind Load on Structural Frames	24
3.7	Wind Load on Components/Cladding	25
3.8	Wind Loads in a Crosswind and Torsional Directions	25
3.9	Vortex Induced Vibration and Aeroelastic Instability	25
3.10	Small-scale Buildings	25
3.11	Effect on Neighbouring Buildings	26
3.12	Assessment of Building Habitability	26
3.13	Shielding Effect by Surrounding Topography or Buildings	26
3.14	Wind Characteristics	26
3.14.1	Wind-Excited Motion of Tall Buildings	28
3.14.2	Along-Wind Motion	29
3.14.3	Cross-Wind Motion	30
3.14.4	Torsional Motion	32

3.14.5	Wind Records	33
3.15	Means to Reduce Wind-Induced Vibration of Tall Buildings.....	34
3.15.1	Architectural Modifications.....	35
3.15.2	Modifications in Structural Systems.....	35
3.15.3	Cladding Isolation.....	36
3.15.4	Addition of Damping Systems	36
3.16	Damping Systems	38
3.16.1	Passive Damping Systems	38
3.17	Variable Damping Devices.....	40
3.17.1	Variable-friction dampers.....	41
3.17.2	Controllable-fluid dampers.....	42
3.18	Variable Stiffness Devices.....	42
3.19	Traditional Linear Tuned Mass Damper	44
3.20	Tuned Liquid Damper (TLD).....	46
3.21	Multiple Tuned Mass Dampers	47
3.22	Nonlinear Tuned Mass Dampers (NTMD).....	50
3.23	Pendulum Tuned Mass Damper (PTMD).....	54
3.24	Semi-active Tuned Mass Damper (STMD).....	55
3.25	Analytical Method for Analyzing Nonlinear Systems	58
3.25.1	Perturbation Method: Multiple Scales Method	58
3.25.2	Local Stability Analysis.....	59
3.26	Numerical Methods For Analyzing Nonlinear Systems.....	60

3.26.1	Time Integration Method.....	60
3.26.2	Continuation Method.....	61
3.27	Summary.....	64
4	Structural Response Under Wind Excitation 2D/3D Analysis.....	66
4.1	Mid-Rise (30 Storey) Structure - 2D Analysis.....	66
4.1.1	Introduction.....	66
4.1.2	Structural Modelling.....	66
4.1.3	Façade Systems.....	75
4.1.4	Sensitivity Analysis under yearly wind.....	79
4.1.4.1	Assessed Performance and Façade Displacement.....	79
4.2	Mid-Rise Structure 3D Analysis.....	83
4.3	High-Rise Structure 2D Analysis.....	86
4.3.1	Structural Modelling.....	87
4.3.2	Concept for High-Rise Buildings.....	91
4.4	High-rise Structure 3D Analysis.....	95
4.4.1	Conclusions of the Preliminary Analyses.....	97
5	Behaviour of Nonlinear Double skin façade in suppressing wind loads.....	99
5.1	Introduction.....	99
5.2	System Modelling.....	100
5.3	Dynamic Responses of the System.....	101
5.4	Case Study.....	103
5.5	Conclusions.....	115

6 Sensitivity Analysis	117
6.1 Introduction	117
6.2 Wind pressure coefficient.....	117
6.3 Sensitivity Analysis on Stiffness effect.....	118
6.4 Sensitivity Analyses Based on Mass and Stiffness Ratio.....	124
6.5 Sensitivity Analyses Based on the Length of Second Slope (soft stiffness)	147
6.6 Figure Gain of System.....	153
6.7 Conclusion.....	153
7 Financial.....	156
7.1 Introduction	156
7.2 Additional cost of the movable facade to building structure.....	157
7.2.1 Introduction	157
7.2.2 Design or re-design procedure	157
7.2.3 Maintenance	158
7.2.3.1 Preventive maintenance strategies and their cost	158
7.2.3.2 Quarterly and annual reporting of the proposed system.....	160
7.2.4 Importance of thermal performance.....	161
7.3 Building cost drivers.....	162
7.4 Investigated Markets.....	165
7.5 Investigated Parameters	166
7.5.1 Definitions.....	166
7.5.2 Total construction costs.....	167

7.5.2.1	Material Costs.....	169
7.5.2.2	Labour Costs.....	170
7.5.2.3	Construction time	171
7.5.3	Rental price and capitalization rate	173
7.5.4	Damper façade price.....	175
7.6	Test case definition.....	176
7.6.1	Comparative approach.....	177
7.7	Case Study Results	179
7.7.1	Mid-rise Building Results	179
7.7.2	High-rise Building Results	183
7.8	Summary and conclusion.....	184
8	Conclusions and Recommendations for Future Research	189
8.1	General Conclusion	189
8.2	Application and contribution of this research to design	192
8.3	Recommendation for future research	193
8.4	Further research that would improve and complement this thesis	193
	Appendix A	198
	REFERENCES	215

List of Figures

Figure 2.1 Typical components of a façade panel (Milgard)	10
Figure 2.2 Stick system façade (Permasteelisa 2009)	11
Figure 2.3 Typical assembly of stick system façade (Permasteelisa 2009)	12
Figure 2.4 Unitized curtain wall (Permasteelisa 2009)	13
Figure 2.5 Installation of curtain wall (Permasteelisa 2009)	13
Figure 2.6 Example of spandrel panel ribbon glazing (Permasteelisa 2009)	14
Figure 2.7 Penalized curtain wall (Permasteelisa 2009)	15
Figure 2.8 Independent assembly (Permasteelisa 2009)	15
Figure 2.9 Suspended assembly (Permasteelisa 2009)	16
Figure 2.10 Suspended assembly (Permasteelisa 2009)	18
Figure 2.11 Suspended assembly (Permasteelisa 2009)	19
Figure 3.1 Fluctuating wind forces based on wind turbulence and vortex generation in the wake of building	22
Figure 3.2 Definition of reference height and velocity pressure	24
Figure 3.3 Wind velocity profile in ideal atmospheric boundary layer	27
Figure 3.4 Typical trace of longitudinal wind speed	28
Figure 3.5 Wind pressure trend used for analysis	34
Figure 3.6 Schematic model of a variable-orifice damper	41
Figure 3.7 Schematic model of a controllable-fluid damper	42
Figure 3.8 Semi-Active and Independently Variable Stiffness (SAIVS) device and STMD [2]	43

Figure 3.9 Illustration of a schematic model of a TMD	44
Figure 3.10 Illustration of a schematic model of a TLD	46
Figure 3.11 Schematic model of multiple TMD (MTMDs) in parallel	47
Figure 3.12 Schematic model of multiple TMD (MTMDs) in series	48
Figure 3.13 Schematic model of nonlinear TMD (NTMD)	51
Figure 3.14 Illustration of the PTMD installed in Taipei 101. Adapted from sources	54
Figure 4.1 Finite element model of structure equipped with shear wall using shell elements	68
Figure 4.2 Finite element model of structure with shear wall using brace system	69
Figure 4.3 Deformed and undeformed structure equipped with shear wall subjected to linear static load	70
Figure 4.4 Deformed and undeformed structure equipped with a diagonal bracing system subjected to linear static load	70
Figure 4.5 Finite element model of structure with façade system	71
Figure 4.6 Response of structure the façade system subjected to wind load	72
Figure 4.7 Schematic elevation view of the mid-rise structural model with movable façade on one side	73
Figure 4.8 Detail of façade connection to the primary structure and modelling assumption in ANSYS	74
Figure 4.9 The first natural frequency of the mid-rise structure and façade system	76
Figure 4.4.10 The displacement response of conventional façade vs smart façade (mean wind speed of 20 m/s)	76
Figure 4.4.11 The displacement response of conventional façade vs smart façade from 50sec to 80sec (means wind speed of 20 m/s)	77

Figure 4.4.12 Behaviour of smart damper due to wind excitation (means wind speed of 20 m/s)	77
Figure 4.4.13 Cumulative density function of conventional vs smart façade response due to wind excitation (means wind speed of 20 m/s).....	78
Figure 4.4.14 Max daily wind speeds in 2012 in Sydney (at 10m above ground).....	79
Figure 4.4.15 Maximum daily wind speed in 2012 in Sydney (10m above ground).....	80
Figure 4.4.16 Performance spectrum of the system	81
Figure 4.4.17 Façade vibration versus mean speed wind.....	81
Figure 4.4.18 Efficiency of façade damper system during the year (Acceleration)	82
Figure 4.4.19 Efficiency of façade damper system during the year (Displacement)	82
Figure 4.4.20 Efficiency of façade damper system during the year.....	83
Figure4.4.21 Finite element model of 3D Structure model	83
Figure4.4.22 Finite element model of 3D Structure model subjected to the wind load	84
Figure 4.4.23 Behaviour of smart damper due to wind excitation (Means Speed 23 m/s).....	85
Figure 4.4.24 Acceleration response of structures with and without damper façade system subjected to 23m/s mean wind speed.....	85
Figure 4.4.25 Finite element model of Structure with shear wall using brace system	88
Figure 4.4.26 Finite element model of Structure subjected to lateral static load.....	89
Figure 4.4.27 Detail of façade connection to the primary structure and modelling assumption in ANSYS	90
Figure4.4.28 The first two natural frequencies of the high-rise structure and façade system	92
Figure4.4.29 High-rise structure with traditional façade system response tuned to the second mode versus smart façade system.....	92

Figure 4.4.30 Behaviour of smart damper due to wind excitation (mean wind speed of 23 m/s)	93
Figure4.4.31 The acceleration response of conventional façade vs smart façade (mean wind speed of 23 m/s).....	94
Figure4.4.32 Cumulative density function of conventional vs smart façade response due to wind excitation (mean wind speed of 23 m/s)	95
Figure 4.4.33 Acceleration response of conventional façade versus smart façade (Means Speed 20 m/s).....	96
Figure 4.4.34 Displacement response of conventional façade versus smart façade (Means Speed 20 m/s).....	96
Figure 4.4.35 Cumulative density function of conventional vs smart façade system due to wind excitation (mean wind speed of 20 m/s)	96
Figure4.4.36 Behaviour of smart damper due to wind excitation (mean wind speed of 20 m/s)	97
Figure 5.1 Simplified model of the primary structure and façade system connected by movable brackets	100
Figure 5.2 Dynamic amplification factors for (a) the primary structure (H) and (b) DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) =50	104
Figure 5.3 Dynamic amplification factors for the primary structure (H) and DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) =0.5	105
Figure 5.4 Dynamic amplification factors for the primary structure (H) and DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) = 0. 4 with 20% damping	107
Figure 5.5 Dynamic amplification factors for the primary structure (H) and DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) =0.4 with 40% damping	108

Figure 5.6 Dynamic amplification factors for the primary structure (H) and DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) = 0.6 with 20% damping	110
Figure 5.7 Dynamic amplification factors for the primary structure (H) and DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) =0.6 with 40% damping	112
Figure 5.8 Dynamic amplification factors for the primary structure (H) and DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) =0.7 with 20% damping	113
Figure 5.9 Dynamic amplification factors for the primary structure (H) and DSF outer skin (H _f) with f (DSF outer skin frequency/primary structure frequency) =0.7 with 40% damping	114
Figure 6.1 Schematic of wind-induced pressures on a building	118
Figure 6.2 Comparing different stiffness values on damper behaviour	119
Figure 6.3 The acceleration response of the conventional building versus one with smart damper (K=2 kN/mm)	119
Figure 6.4 The acceleration response of the conventional building versus one with smart damper (K=2 kN/mm)	120
Figure 6.5 The relative displacement response of damper with K=2 kN/mm	120
Figure 6.6 Comparing the acceleration response of the conventional building versus one with smart damper (K=1kN/mm)	121
Figure 6.7 The relative displacement response of damper with K=1 kN/mm	121
Figure 6.8 Comparing the acceleration response of the conventional building versus one with smart damper (K=0.5 kN/mm)	122
Figure 6.9 The relative displacement response of damper with K = 0.5 kN/mm	122

Figure 6.10 Comparing the response of the conventional structure versus one with smart damper ($K=0.2\text{kN/mm}$)	123
Figure 6.11 The relative displacement response of damper with $K=0.2\text{ kN/mm}$	123
Figure 6.12 Comparing the displacement responses of dampers	124
Figure 6.13 Performance of the conventional structure versus Structure equipped with smart façade ($m=100, K=0.1\text{ kN/mm}$).....	125
Figure 6.14 Performance of the conventional structure versus structure equipped with smart façade ($m=200, K=0.1\text{kN/mm}$).....	125
Figure 6.15 Cumulative density function of smart façade response, assuming 100kg vs 200kg per panel weight.....	126
Figure 6.16 Performance of the conventional structure versus structure equipped with smart façade ($m=400, K=0.1\text{kN/mm}$).....	126
Figure 6.17 Cumulative density function of smart façade response, assuming 100kg, 200kg and 400kg per panel weight	127
Figure 6.18 Performance of the conventional structure versus structure equipped with smart façade ($m=1000, K=0.1\text{kN/mm}$).....	127
Figure 6.19 Cumulative density function of smart façade response, assuming 100kg, 200kg and 400kg and 1000kg per panel weight	128
Figure 6.20 Performance of the Conventional Structure versus Structure Equipped with Smart Façade ($m=100, K=0.2\text{kN/mm}$)	129
Figure 6.21 Cumulative density function of smart façade response, considering $K=0.1\text{kN/mm}$ and 0.2kN/mm with 100kg per panel weight	130
Figure 6.22 Performance of the conventional structure versus structure equipped with smart façade ($m=200, K=0.2\text{kN/mm}$).....	130
Figure 6.23 Cumulative density function of smart façade response, assuming 100kg, 200kg per panel weight.....	131

Figure 6.24 Performance of the conventional structure versus structure equipped with smart façade (m=400, K=0.2kN/mm).....	131
Figure 6.25 Cumulative density function of smart façade response, for 100kg, 200kg and 400kg per panel weight.....	132
Figure 6.26 Performance of the conventional structure versus structure equipped with smart façade (m=1000, K=0.2kN/mm).....	132
Figure 6.27 Cumulative density function of smart façade response, for 100kg, 200kg and 400kg and 1000kg per panel weight.....	133
Figure 6.28 Performance of the conventional structure versus structure equipped with smart façade (m=100, K=0.5kN/mm).....	134
Figure 6.29 Cumulative density function of smart façade response, considering K=0.2 kN/mm and 0.5 kN/mm with 100 kg per panel weight.....	135
Figure 6.30 Performance of the conventional structure versus structure equipped with smart façade (m=200, K=0.5kN/mm).....	135
Figure 6.31 Cumulative density function of smart façade response, assuming 100kg, 200kg per panel weight.....	136
Figure 6.32 Performance of the conventional structure versus structure equipped with smart façade (m=400, K=0.5kN/mm).....	136
Figure 6.33 Cumulative density function of smart façade response, for 100kg, 200kg and 400kg per panel weight.....	137
Figure 6.34 Performance of the conventional structure versus structure equipped with smart façade (m=1000, K=0.5kN/mm).....	137
Figure 6.35 Cumulative density function of smart façade response, assuming 100kg, 200kg,400kg and 1000kg per panel weight.....	138
Figure 6.36 Performance of the conventional structure versus structure equipped with smart façade (m=100, K=1kN/mm).....	139

Figure 6.37 Cumulative density function of smart façade response, considering $K=0.5\text{kN/mm}$ and 1kN/mm with 100kg per panel weight	139
Figure 6.38 Performance of the conventional structure versus structure equipped with smart façade ($m=200$, $K=1\text{kN/mm}$).....	140
Figure 6.39 Cumulative density function of smart façade response, assuming 100kg , 200kg per panel weight.....	140
Figure 6.40 Performance of the conventional structure versus structure equipped with smart façade ($m=400$, $K=1\text{kN/mm}$).....	141
Figure 6.41 Cumulative density function of smart façade response, assuming 100kg , 200kg and 400kg per panel weight	141
Figure 6.42 Performance of the conventional structure versus structure equipped with smart façade ($m=1000$, $K=1\text{kN/mm}$).....	142
Figure 6.43 Cumulative density function of smart façade response, assuming 100kg , 200kg , 400kg and 1000kg per panel weight	142
Figure 6.44 Performance of the conventional structure versus structure equipped with ..	143
Figure 6.45 Cumulative density function of smart façade response, considering $K=1\text{kN/mm}$ and 2kN/mm with 100kg per panel weight	144
Figure 6.46 Performance of the Conventional Structure versus Structure Equipped with Smart Façade ($m=200$, $K=2\text{kN/mm}$)	144
Figure 6.47 Cumulative density function of smart façade response, assuming 100kg , 200kg per panel weight.....	145
Figure 6.48 Performance of the conventional structure versus structure equipped with smart façade ($m=400$, $K=2\text{kN/mm}$).....	145
Figure 6.49 Cumulative density function of smart façade response, assuming 100kg , 200kg and 400kg per panel weight	146

Figure 6.50 Performance of the conventional structure versus structure equipped with smart façade (m=1000, K=2kN/mm).....	146
Figure 6.51 Cumulative density function of smart façade response, assuming 100kg, 200kg, 400kg and 1000kg per panel weight	147
Figure 6.52 Panel movement, variable in length.....	148
Figure 6.53 Damper behaviour when the second slope length is 1mm	148
Figure 6.54 Time history response of conventional vs smart façade when the second slope has 1 mm length.....	149
Figure 6.55 Comparing the cumulative density function of top acceleration response with second slope length of 1 mm	149
Figure 6.56 Time history response of conventional vs smart façade with second slope length of 40 mm.....	150
Figure 6.57 Comparing panel movement when the second slope length is 1mm versus 40mm	150
Figure 6.58 Comparing the cumulative density function of top acceleration response when the second slope of 40 mm in length	151
Figure 6.59 Time history response of conventional vs smart façade when the second slope has 60 mm length.....	151
Figure 6.60 Comparing panel movement when the second slope length is 1mm versus 60mm	152
Figure 6.61 Comparing the cumulative density function of top acceleration response when the second slope of 40 mm in length	152
Figure 6.62 The damper façade beneficial effect trend.....	153
Figure 7.1 Relative elemental cost for Low and High rise office buildings in Central London [1]	163

Figure 7.2 Typical elemental build up High-rise offices buildings in London, Middle East and Far East [1].....	164
Figure 7.3 Typical shell and core construction costs: Office vs Residential Towers in London [1]	164
Figure 7.4 Case study: investigate markets.....	165
Figure 7.5 GEA, GIA and NIA definitions by a building plant example	167
Figure 7.6 Investigated parameters – Construction cost and construction costs percentages	168
Figure 7.7 Investigated markets – material costs	170
Figure 7.8 Investigated parameter – labour cost	171
Figure 7.9 Expected construction time for traditional façade and façade damper by constant workers or constant time.....	173
Figure 7.10 Investigated parameter – Rental price	174
Figure 7.11 Investigated parameter – Capitalization rate	174
Figure 7.12 (a) Hyper-elastic material model (b) Façade damper device concept for wind	175
Figure 7.13 Damper façade as traditional façade combined with damper device and new bracket design	176
Figure 7.14 Mid-rise and high-rise test case building floor plant	176
Figure 7.15 Mid-rise and high-rise major input data	177
Figure 7.16 Definition of the wind speed design time-history.....	178
Figure 7.17 Typical comparisons for acceleration at the top of the building with traditional and damper façade	178
Figure 7.18 Building frame design with conventional façade and with damper (Smart) façade	179

Figure 7.19 Construction costs for Conventional Façade and damper (Smart) Façade (Sydney).....	180
Figure 7.20 Saving percentage on construction costs (Sydney).....	180
Figure 7.21 Construction time and labour cost savings (Sydney)	181
Figure 7.22 Additional incomes from additional area and earlier entrance (Sydney)	181
Figure 7.23 Profit breakdown of the damper façade against the conventional façade versus the six selected cities.....	182
Figure 7.24 Total profit of the damper façade against the conventional façade versus the six selected cities	182
Figure 7.25 Building frame design with conventional façade and with damper (Smart) façade	183
Figure 7.26 Profit breakdown of the damper (Smart) façade against the conventional façade versus the six selected cities	184
Figure 7.27 Total profit of the damper façade against the conventional façade versus the six selected cities.....	184
Figure 8.1 Multi-linear behaviour	190
Figure 8.2 Details of proposed connection for attachment of façade outer skin to slab of main structure.....	194
Figure 8.3 South-west sketch of the building structure and elevation of the specimen....	196
Figure 8.4 Sketch details of experimental model.....	197
Figure A. 1 The acceleration response of conventional façade versus smart façade (Means Speed 15 m/s).....	199
Figure A. 2 The displacement response of conventional façade versus smart façade (Means Speed 15 m/s).....	199

Figure A. 3 Cumulative density function of conventional vs smart façade response due to wind excitation (Means Speed 15 m/s).....	200
Figure A. 4 The acceleration response of conventional façade versus smart façade (Means Speed 18 m/s).....	200
Figure A. 5 The displacement response of conventional façade versus smart façade (Means Speed 18 m/s).....	201
Figure A. 6 Behaviour of smart damper due to wind excitation (Means Speed 18 m/s) ..	201
Figure A. 7 Cumulative density function of conventional versus smart façade response due to wind excitation (Means Speed 18 m/s).....	202
Figure A. 8 Behaviour of smart damper due to wind excitation (mean wind speed of 27 m/s)	202
Figure A. 9 The acceleration response of conventional façade vs smart façade (mean wind speed of 27 m/s).....	203
Figure A. 10 The displacement response of conventional façade vs smart façade (mean wind speed of 27 m/s).....	203
Figure A. 11 Cumulative density function of conventional vs smart façade response due to wind excitation (mean wind speed of 27 m/s)	204
Figure A. 12 The acceleration response of conventional façade vs smart façade (mean wind speed of 30 m/s).....	204
Figure A. 13 The displacement response of conventional façade vs smart façade (mean wind speed of 30 m/s).....	205
Figure A. 14 Behaviour of smart damper due to wind excitation (mean wind speed of 30 m/s)	205
Figure A. 15 Cumulative density function of conventional vs smart façade response due to wind excitation (mean wind speed of 30 m/s)	206

Figure A. 16 Acceleration response of structure with and without smart façade system subjected to 15m/s mean wind.....	206
Figure A. 17 Behaviour of smart damper due to wind excitation (mean wind speed of 15 m/s)	207
Figure A. 18 Behaviour of smart damper due to wind excitation (mean wind speed of 20 m/s)	207
Figure A. 19 Acceleration response of structure with and without smart damper façade system subjected to 20m/s mean wind speed.....	208
Figure A. 20 Behaviour of smart damper due to wind excitation (Means Speed 25 m/s)	208
Figure A. 21 Acceleration response of structures with and without smart damper façade system subjected to 25m/s mean wind.....	209
Figure A. 22 The acceleration response of conventional façade versus smart façade (mean wind speed of 12m/s)	209
Figure A. 23 Cumulative density function of conventional versus smart façade response due to wind excitation (mean wind speed of 12m/s)	210
Figure A. 24 Behaviour of smart damper due to wind excitation (mean wind speed of 12m/s)	210
Figure A. 25 Behaviour of smart damper due to wind excitation (mean wind speed of 15m/s)	211
Figure A. 26 The acceleration response of of conventional vs smart façade response due to wind excitation (mean wind speed of 15m/s)	211
Figure A. 27 Cumulative Density Function of Conventional vs Smart Façade Response due to wind excitation (mean wind speed of 15m/s)	211
Figure A. 28 Behaviour of smart damper due to wind excitation (mean wind speed of 18 m/s)	212

Figure A. 29 The acceleration response of conventional façade versus smart Façade (mean wind speed of 18 m/s)	212
Figure A. 30 Cumulative density function of conventional vs smart façade response due to wind excitation (mean wind speed of 18 m/s)	213
Figure A. 31 The acceleration response of conventional façade vs smart façade (mean wind speed of 20 m/s)	213
Figure A. 32 Behaviour of smart damper due to wind excitation (mean wind speed of 20 m/s)	214
Figure A. 33 Cumulative density function of conventional vs smart façade response due to wind excitation (mean wind speed of 20 m/s)	214

List of Tables

Table 4.1: Properties of façade system components	74
Table 4.2: Material properties of main mid-rise concrete structure.....	75
Table 4.3: Mid-rise structural model dynamic properties	75
Table 4.4: Material properties of main mid-rise structure	75
Table 4.5 Properties of façade system components	90
Table 4.6 Material properties of main high-rise structure.....	91
Table 6.1 Standard deviation of the response of structure equipped with different facade damper.....	128
Table 6.2 Standard deviation of the response of structures equipped with different facade dampers.....	133
Table 6.3 Standard deviation of the response of structure equipped with different facade dampers.....	138
Table 6.4 Standard deviation of the response of structure, which equipped with different facade damper	143
Table 6.5 Standard deviation of the response of structure which equipped with different facade damper	147
Table 7.1 Details of additional price of smart façade system	158
Table 7.2 Proposed quarterly and yearly spreadsheet for inspection of each damper/connector components	161
Table 7.3 Spreadsheet for expected expenses per square meter of façade panel	161
Table 7.4 Case study: investigated markets	166
Table 7.5 Investigated parameter – Construction cost of offices (Class A).....	168
Table 7.6 Investigated parameter – Material cost	169

Table 7.7 Investigated parameter – Labour cost, overhead included.....	170
Table 7.8 Investigated parameter – Construction time	172
Table 7.9 Investigated parameter – Construction cost	172
Table 7.10 Investigated parameter – Rental Price.....	173

Chapter 1