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Design Advances
for
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Contents

Preface	vii
1 Structural Considerations in the Design of Tall Buildings	1
J.P. Colaco	
1.1 Introduction	1
1.2 Architectural and Structural Interaction	2
1.3 Structural Systems	2
1.3.1 Office Buildings	2
1.3.2 Apartment Buildings	3
1.4 Structural Materials	7
1.5 Load and Site Considerations	8
1.6 Economics	9
1.7 Design Principles	10
1.7.1 Gravity Loads	10
1.7.2 Lateral Loads	10
1.7.3 Redundancy and Progressive Collapse	11
1.7.4 Fire Loads	11
1.7.5 Building Movement	11
1.8 Building Height Limitations	11
2 Effects of Wind in Tall Buildings: A Comparison for a Real Case and its Vibration Control using a Tuned Mass Damper	13
R.C. Barros, N.A.C. Ferreira and R. Delgado	
2.1 Introduction	14
2.2 Wind Actions under two Design Codes	14
2.2.1 Wind Actions according to RSAEEP	14
2.2.2 Wind Actions according to Eurocode EC1	17
2.3 Comparative Analysis between RSAEEP and EC1	28
2.4 Numerical Modeling of a Real Structure under Wind Action	32

2.4.1	Structural Description of the Building Case-Study (Tower 1 of WTC)	32
2.4.2	Modelling a Frame Equivalent to the WTC	34
2.4.3	Modelling Wind Dynamic Action	37
2.4.4	Modelling a Tuned Mass Damper for Passive Control of Vibrations	40
2.5	Analysis of Results by Design Codes	43
2.6	Analysis of Results Evaluated Computationally	45
2.7	Conclusions	48
3	Coupled Dynamic Wind Load Effects on Tall Buildings with Three-Dimensional Modes	55
	X. Chen and A. Kareem	
3.1	Introduction	56
3.2	Analysis of Coupled Response	58
3.2.1	Mean and Background Responses	58
3.2.2	Resonant Response	59
3.2.3	Total Peak Response	62
3.3	Modeling of Equivalent Static Wind Loads	62
3.3.1	Background Equivalent Static Wind Load	62
3.3.2	Resonant Equivalent Static Wind Load	63
3.3.3	Total Equivalent Static Wind Load	64
3.4	HFFB Technique for Buildings with Three Dimensional Coupled Modes	64
3.4.1	Generalized Forces	65
3.4.2	Dynamic Response Analysis	68
3.4.3	Equivalent Static Wind Loads	69
3.5	Application and Discussion	71
3.5.1	Coupled Building Response	71
3.5.2	Role of Crosscorrelation of Wind Loads	73
3.5.3	Role of Correlation of Modal Response	75
3.5.4	Comments on Tall Building Response Correlation	77
3.5.5	Equivalent Static Wind Loads	79
3.6	Concluding Remarks	80
4	Response of Tall Buildings to Weak, Long-distance Earthquakes	87
	J.M.W. Brownjohn and T-C. Pan	
4.1	Introduction	88
4.2	Singapore Seismicity	89
4.3	Dynamic Loading of Tall Buildings in Singapore	90

4.4	Monitoring of Ground Motions and Tall Buildings in Singapore	90
4.5	Example of a Tall Building for Monitoring: Republic Plaza	92
4.6	Dynamic Characteristics Obtained through Ambient Vibration Survey	93
4.7	Instrumentation System	95
4.8	Strategy for Capturing Tremor Data	96
4.9	Summary of Captured Signals	99
4.10	Transfer Functions, Response Spectra and Free Field Motions	104
4.11	Base Shear	108
4.12	'Boxing Day' Earthquake, Aceh, 26 Dec 2004	109
4.13	Discussion	110
5	Earthquake Damage Identification of Steel Mega Structures	115
	H. Takabatake and T. Nonaka	
5.1	Introduction	115
5.2	The Earthquake	116
5.3	Ashiyahama Residential Building Complex	116
5.4	Outline of Numerical Analysis	118
5.5	Results, Comparisons and Discussions	122
5.5.1	Design Principle against Earthquakes	122
5.5.2	Plastic Hinge Distribution	123
5.5.3	Response to the Earthquake	123
5.5.4	Characteristics of Earthquake Motion	126
5.5.5	Effect of Vertical Ground Motion	130
5.5.6	Treatment of Residential Unit	131
5.5.7	Modeling of the Dynamic Analysis	131
5.5.8	Axial Failure of Column-Column Joints	133
5.5.9	Failure through Brace and Column Connection	133
5.5.10	Measures against Fracture through Connections	137
5.6	Conclusions	137
6	Modern Structural Monitoring Arrays and Needs: GPS and other Developments	143
	M. Çelebi	
6.1	Introduction	143
6.2	Historical Perspective	145
6.2.1	General Summary	145
6.2.2	General Seismic Instrumentation Issues	146
6.3	Special Arrays: Looking to the Future	153
6.3.1	Special Arrays in Los Angeles, California	153

6.3.2	Displacement Measurement Needs and Arrays	153
6.4	Summary	175
7	Interference Effects on Wind-Induced Coupled Motion of Tall Buildings	183
	S. Thepmongkorn, G.S. Wood and K.C.S. Kwok	
7.1	Introduction	184
7.2	Interference Excitation of Tall Buildings	185
7.3	Interference Effects of Tall Buildings	187
7.3.1	Along-Wind and Cross-Wind Responses of Tall Buildings without Coupled Motion	188
7.3.2	Torsional Response of Tall Buildings without Coupled Motion	194
7.3.3	Along-Wind, Cross-Wind and Torsional Response of Tall Buildings with Coupled Motion	195
7.4	Design Considerations and Codifications	202
7.5	Conclusion	206
8	Field Measurements of Tall Buildings in High Winds	211
	Y.L. Xu and J. Chen	
8.1	Introduction	211
8.2	Instrumentation for Field Measurement of Tall Buildings in High Winds	212
8.2.1	Overview	212
8.2.2	Field Measurements of Di Wang Tower	214
8.3	Wind Characteristics	216
8.3.1	Stationary Wind Model	217
8.3.2	Non-Stationary Wind Model	218
8.3.3	Time-Varying Mean Wind Speed	219
8.3.4	Typhoon York	220
8.3.5	Wind Characteristics of Typhoon York	221
8.4	Dynamic Characteristics of Tall Buildings	225
8.4.1	Overview	225
8.4.2	The EMD-HT Method	227
8.4.3	Natural Frequencies of the Di Wang Tower	228
8.4.4	Modal Damping Ratios of the Di Wang Tower	229
8.5	Wind-Induced Response of Tall Buildings	230
8.5.1	Overview	230
8.5.2	Dynamic Displacement Response of the Di Wang Tower	232
8.5.3	Acceleration Response of the Di Wang Tower	233
8.5.4	Human Comfort in Tall Buildings	234

8.6	Concluding Remarks	235
9	Towards Smart Tall Buildings: New Concepts for Active Vibration Control and Health Monitoring of Structures	239
	H. Adeli and X. Jiang	
9.1	Introduction	239
9.2	Dynamic Fuzzy WNN Model	246
	9.2.1 Creating State Space Vectors from Sensed Data	246
	9.2.2 Creating Dynamic Fuzzy WNN Model	247
9.3	Structural Damage Detection	248
	9.3.1 Dynamic Fuzzy WNN Model for Damage Detection	248
	9.3.2 Power Density Damage Evaluation Method	250
9.4	Nonlinear Control of Structures	251
	9.4.1 Nonlinear Dynamics of Three Dimensional Buildings	251
	9.4.2 Control Strategy for Building Structures	252
	9.4.3 Genetic Algorithm for Structural Control	253
	9.4.4 Neuro-Genetic Algorithm for Active Control of Structures	253
9.5	Numerical Implementation	254
	9.5.1 Example 1: Thirty-Eight Storey Reinforced Concrete Building	254
	9.5.2 Example 2: Twelve Storey Irregular Steel Building	255
10	The Significance of the 21 September 1999 Chi-Chi Earthquake, Taiwan on Tall Buildings	265
	M. Lew and F. Naeim	
10.1	Introduction	265
10.2	Similarities between Taiwan and California	266
10.3	Design Practices in Taiwan	267
	10.3.1 Building Codes in Taiwan	267
	10.3.2 1982 Edition of the Taiwan Building Code as Supplemented in 1991	267
10.4	Typical Construction Practices for Tall Buildings	270
	10.4.1 Summary	270
	10.4.2 Typical Construction Types and Associated Configuration Issues	271
	10.4.3 Common Deficiencies of Reinforced Concrete Construction	274
	10.4.4 Steel Construction	282
10.5	What are the lessons to be learned?	286

10.5.1	Soft/Weak Storeys Are Deadly	286
10.5.2	Material Quality and Workmanship is Critical	288
10.5.3	Poor Detailing can be Disastrous	289
10.5.4	Poor Configurations and Unanticipated Torsional Response Can Be Disastrous	292
10.5.5	Strong Column Weak Girder Design and Preventing Punching Shear Failures are Vital	292
10.5.6	No Seismic Resistance without Adequate Load Paths	294
10.5.7	Components Not Designed for Lateral Resistance cannot be Ignored	294
10.5.8	Structural Analysis Should Reflect the Reality of the Building	296
10.6	Conclusions	297
11	Blast Loading of Tall Buildings	299
	T.A. Rose and P.D. Smith	
11.1	Introduction	299
11.2	Quantification of Blast Loads	300
11.2.1	Explosions in Air	300
11.2.2	Blast Wave Reflection	301
11.2.3	Blast Wave Clearing on Solitary Buildings	303
11.2.4	The Effect of the Confinement and Shielding Provided by Urban Settings	304
11.2.5	The Effects of Explosions Inside Buildings	306
11.3	The Special Case of Blast Loads on Tall Buildings	307
11.4	The Need for Robust Building Façades and Glazing Systems	313
11.5	Design Features to Improve Building Robustness	314
11.6	Conclusions	316
	Index	319

Preface

As the height of tall buildings increases beyond the design guidance of existing codes of practice, there is a need for the codes to be updated to include advanced materials, new methods, advice from designers, construction professionals, users experiences and expert researchers conclusions to ensure continued confidence that codes of practice incorporate the latest knowledge and innovations. A major structural requirement is the accurate determination of the loads acting on the tall building, how these loads are resisted and how the loads are transmitted effectively to the foundations.

A major consideration in a tall buildings design requirement is to control deflections and the buildings vibrational response. These requirements are gaining added significance as there is now a desire to design and construct very high tall buildings and to make their structure lighter.

The loads on tall buildings include dead loads and live loads that act vertically, which must be transmitted through the structure to the foundations. The wind load, which for low rise buildings usually involves a static analysis, will, for tall buildings, require significant further consideration as wind at higher levels introduces horizontal forces and dynamic components not amenable to static analysis.

In compact urban areas complex unconventional tall building shapes require considerable expertise in analysing loads, especially wind loads. There is also a need to consider earthquake and tsunami loads in seismic areas.

In the design of tall buildings aspects including: blast loading, design improvements, dynamic response, earthquake damage, evacuation, fire safety, health monitoring, mass damping structural considerations, vibration control and wind-induced motion all require high quality active research. In the following chapter, many of these factors are considered.

Chapter 1 considers the design of tall building from the point of view of architectural and structural interactions, economics, height limitations, loads, materials, site considerations, structural systems and design principles.

Chapter 2 addresses basic concepts regarding the wind effects on tall buildings and the tall buildings wind responses. A simplified method for quantifying the dynamic action on tall buildings is adopted to study techniques for vibration control of wind induced building response in terms of displacements and accelerations. For tall buildings, a comparison is made between the tall buildings response under dynamic wind action both with and without a Tuned Mass Damper.

Chapter 3 presents a framework for the analysis of 3D coupled dynamic response

of buildings with complex geometric shapes or structural systems with noncoincident centres of mass and resistance, and modelling the equivalent static wind loads. Utilizing a tall building with 3D mode shapes the framework for the analysis of coupled dynamic load effects and modelling of 3D equivalent static wind loads is demonstrated.

In Chapter 4, starting with a building monitoring program directed at identifying wind loads, the focus is changed to include the capture of ground motion and response signals for distant tremors, as these were thought to have a stronger dynamic effect. These 'weak motion' gave a better understanding of local ground motions and identified whether to include seismic hazard in a code provision for accidental eccentricity. The results showed that there was no cause for concern. However ground motions are strongest in the 0.5 Hz to 1.0 Hz range, coinciding with fundamental natural frequencies of buildings in the 15-30 storey range and need to be considered.

Chapter 5 is based on past observations of structural damage to tall buildings and studies carried out to determine the cause of damage and the failure mechanisms of those buildings. A description is given of the 1995 Kobe Earthquake and the structural layout of the building, followed by damage features, analysis outline, numerical results and discussions on the relationship between the observations and the simulation results. Suggestions for future improvements in earthquake resistant design principles are given.

Chapter 6 presents a summary of seismic monitoring issues, past, present and new developments to meet the needs of the engineering and the user community. A number of examples are included that show recent developments used for the verification of design and construction practices, real-time applications for the functionality of the built environment and the assessment of damage conditions of structures. Technology is described that is used to obtain displacements, drift ratios, damage condition, functionality of a structure, soil-structure interaction and wave propagation.

Chapter 7 presents the interference effects from a single neighbouring building on wind-induced responses of square and rectangular tall buildings. Results of wind tunnel tests on buildings without coupled translational-torsional motion are reviewed and discussed in terms of response characteristics, excitation force and wake spectra and give an understanding of the excitation mechanisms.

Chapter 8 provides an overview of the concepts and methodologies involved in the field measurement of tall buildings during high winds. Using field measurements from the Di Wang Tower during Typhoon York, instrumentation, characteristics of high winds over complex terrain, identification of dynamic characteristics of tall buildings, wind-induced building response and human comfort are discussed.

Chapter 9 introduces the evolution of tall buildings and presents new concepts for active vibration control and health monitoring of smart tall building structures. Multidisciplinary methodologies and innovative computational models are reviewed for health monitoring and nonlinear active control of tall structures subject to extreme dynamic loadings such as wind or earthquake loading.

Chapter 10 uses the 21 September 1999 Chi-Chi, Taiwan earthquake as a testing case for modern tall buildings designed using knowledge and experience learnt from

recent past earthquakes. However, the performance of the tall buildings was a disappointment and illustrates that past lessons need to be fully appreciated.

Chapter 11 is concerned with the establishment of blast loads on tall buildings from the knowledge of the perceived threat and the external building geometry so that the building does not cause collapse and that load on the facade material should not result in loss of life and prolonged disruption to buildings function.

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