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Tall Buildings:
Design Advances
for
Construction

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SAXE-COBURG
PUBLICATIONS

published 2014 by
Saxe-Coburg Publications
Civil-Comp Ltd, Dun Eaglais, Station Brae
Kippen, Stirlingshire, FK8 3DY, Scotland

Saxe-Coburg Publications is an imprint of Civil-Comp Ltd

Computational Science, Engineering and Technology Series: 33
ISSN 1759-3158
ISBN 978-1-874672-25-8

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Publisher's production & editorial team: Steven Miller, Jane Tabor, Rosemary Brodie
Printed in Great Britain by Bell & Bain Ltd, Glasgow

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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.

I wish to thank the chapter authors for their diligence in ensuring the high quality of their work and also the publishers for ensuring the quality production of this book.

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