

Dynamic analysis of buildings for earthquake-resistant design¹

Murat Saatcoglu and Jag Mohan Humar

Abstract: The proposed 2005 edition of the National Building Code of Canada specifies dynamic analysis as the preferred method for computing seismic design forces and deflections, while maintaining the equivalent static force method for areas of low seismicity and for buildings with certain height limitations. Dynamic analysis procedures are categorized as either linear (elastic) dynamic analysis, consisting of the elastic modal response spectrum method or the numerical integration linear time history method, or nonlinear (inelastic) response history analysis. While both linear and nonlinear analyses require careful analytical modelling, the latter requires additional considerations for proper simulation of hysteretic response and necessitates a special study that involves detailed review of design and supporting analyses by an independent team of engineers. The paper provides an overview of dynamic analysis procedures for use in seismic design, with discussions on mathematical modelling of structures, structural elements, and hysteretic response. A discussion of the determination of structural period to be used in association with the equivalent static force method is presented.

Key words: dynamic analysis, earthquake engineering, elastic analysis, fundamental period, hysteretic modelling, inelastic analysis, National Building Code of Canada, seismic design, structural analysis, structural design.

Résumé : L'édition 2005 du Code National du Bâtiment du Canada spécifie l'analyse dynamique comme méthode de calcul de préférence afin de déterminer les forces de conception sismiques et les déflexions, tout en maintenant la méthode de force statique équivalente pour les régions à faible sismicité et pour les bâtiments ayant certaines limitations en hauteur. Les procédures d'analyse dynamique sont catégorisées comme étant linéaire (élastique) avec des méthodes de spectre de réponse modale élastique et des méthodes temporelles d'intégration numérique linéaire, ou des méthodes temporelles non-linéaires (inélastiques). Bien que les deux types d'analyse (linéaire et non-linéaire) requièrent une modélisation analytique soignée, cette dernière requière des considérations additionnelles afin de simuler correctement la réponse d'hystérésis et nécessite une étude spéciale, qui comporte une révision détaillée de la conception et des analyses secondaires provenant d'équipes indépendantes d'ingénieurs. Cet article procure un survol des procédures d'analyse dynamique utilisées pour la conception sismique, avec des discussions sur les modèles mathématiques des structures, éléments structurels et réponse d'hystérésis. Une discussion sur la détermination de la période structurale a été utilisée en association avec la méthode de force statique équivalente est présentée.

Mots clés : analyse dynamique, génie sismique, analyse élastique, période fondamentale, modèle d'hystérésis, analyse inélastique, Code National du Bâtiment du Canada, conception sismique, analyse structurale, conception structurale.

[Traduit par la Rédaction]

Introduction

Structural response to earthquakes is a dynamic phenomenon that depends on dynamic characteristics of structures

and the intensity, duration, and frequency content of the exciting ground motion. Although the seismic action is dynamic in nature, building codes often recommend equivalent static load analysis for design of earthquake-resistant buildings due to its simplicity. This is done by focusing on the predominant first mode response and developing equivalent static forces that produce the corresponding mode shape, with some empirical adjustments for higher mode effects. The use of static load analysis in establishing seismic design quantities is justified because of the complexities and difficulties associated with dynamic analysis. Dynamic analysis becomes even more complex and questionable when non-linearity in materials and geometry is considered. Therefore, the analytical tools used in earthquake engineering have been a subject for further development and refinement, with significant advances achieved in recent years.

The seismic provisions of the 1995 edition of the National Building Code of Canada (NBCC 1995) are based on the equivalent static load approach with dynamic analysis permitted for obtaining improved distribution of total static base

Received 7 March 2002. Revision accepted 5 December 2002. Published on the NRC Research Press Web site at <http://cjce.nrc.ca> on 23 April 2003.

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Written discussion of this article is welcomed and will be received by the Editor until 31 August 2003.

¹This article is one of a selection of papers published in this Special Issue on the Proposed Earthquake Design Requirements of the National Building Code of Canada, 2005 edition.

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Dynamic Analysis Of Buildings For Earthquake Resistant Design

Hugo Bachmann, Peter Linde, Thomas Wenk, European Conference on Earthquake Engineering

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Bangash,2011-08-19 This concise work provides a general introduction to the design of buildings which must be resistant to the effect of earthquakes A major part of this design involves the building structure which has a primary role in preventing serious damage or structural collapse Much of the material presented in this book examines building structures Due to the recent discovery of vertical components it examines not only the resistance to lateral forces but also analyses the disastrous influence of vertical components The work is written for Practicing Civil Structural and Mechanical Engineers Seismologists and Geoscientists It serves as a knowledge source for graduate students and their instructors Dynamic Analysis and Earthquake Resistant Design: Methods of dynamic analysis ,1997 *Simplified Dynamic Analysis of High-Rise Buildings*

Hideo Takabatake,Yukihiko Kitada,Izuru Takewaki,Akiko Kishida,2019-04-30 This book presents a simple analytical method based on the extended rod theory that allows the earthquake resistance of high rise buildings to be easily and accurately evaluated at the preliminary design stage It also includes practical software for applying the extended rod theory to the dynamic analysis of actual buildings and structures High rise buildings in large cities built on soft ground consisting of sedimentary rock tend to have low natural frequency If ground motion due to an earthquake occurs at distant hypocenters the vibration wave can be propagated through several sedimentary layers and act on skyscrapers as a long period ground motion potentially producing a resonance phenomenon that can cause severe damage Accordingly there is a pressing need to gauge the earthquake resistance of existing skyscrapers and to improve their seismic performance This book was written by authors who have extensive experience in tall building seismic design in Japan The software included enables readers to perform dynamic calculations of skyscrapers resistance to vibrations As such it offers a valuable resource for practitioners and engineers as well as students of civil engineering **Dynamic Analysis and Earthquake Resistant Design** ,2000

Modal Analysis Methods in Seismic Design for Buildings William K. Stockdale,1975 **Earthquake Resistant Building Design and Construction** Norman B. Green,1981 DESIGN OF CONCRETE STRUCTURES

BANDYOPADHYAY, J. N.,2008-07-07 This text primarily analyses different methods of design of concrete structures as per IS 456 2000 Plain and Reinforced Concrete Indian Standard Code of Practice 4th revision Bureau of Indian Standards It gives greater emphasis on the limit state method so as to illustrate the acceptable limits for the safety and serviceability requirements of structures Besides dealing with yield line analysis for slabs the book explains the working stress method and its use for designing reinforced concrete tension members theory of redistribution of moments and earthquake resistant design of structures This well structured book develops an effective understanding of the theory through numerous solved problems presenting step by step calculations The use of SP 16 Design Aids for Reinforced Concrete to IS 456 1978 has also been explained in solving the problems KEY FEATURES Instructional Objectives at the beginning of the chapter highlight

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