

Preface

During the past few decades, advanced methods and computational techniques have been developed for a better description and understanding of the dynamic behaviour of structural systems. Taking advantage of the most recent developments in computers and their technology, the scientific field of computational mechanics has steadily emerged as a discipline initiating revolutionary changes to the theoretical treatment of computers as well as to the engineering practice through innovative design methodologies. These dramatic changes had a profound impact on all fields of structural dynamics such as earthquake engineering, offshore engineering, bridge aerodynamics, vibro-acoustics, soil–structure and fluid–structure interaction, wind-induced vibrations, man-made motions, multi-body dynamics, structural control, etc. The purpose of this volume is to bring together the scientific communities of computational mechanics and structural dynamics with a focus on earthquake engineering. The volume will facilitate the exchange of ideas in topics of mutual interest and can serve as a platform for establishing links between research groups with complementary activities.

The basic idea of this book is to include all the aforementioned research topics into a volume taking advantage of the connecting link between them, which is computational methods and tools. In this direction, the book consists of 15 chapters in total, dealing with the topic of computational methods in Earthquake Engineering. The first of this book chapter addresses the problem of the numerical modelling of buried pipelines subjected to faulting. The advantages and disadvantages of available numerical approaches are highlighted. The impact of fault type on the pipeline mechanical behaviour is investigated, while numerical considerations, such as the geometrical nonlinearity, the ovalization and the internal pressure are evaluated using a simple, well-established and reliable numerical approach. The second chapter presents a recently proposed new method, which allows the explicit determination of the parameters of the pulse contained in pulse-like records. The Mavroeidis and Papageorgiou wavelet is used for the mathematical representation of the pulse but the proposed methodology can be easily modified to cover other types of wavelets as well.

The third chapter deals with the finite element analysis of the sloshing phenomenon occurring in liquid storage tanks under external excitations. The governing equations for the fluid and structure and their solution methodologies are clarified and current nonlinear FE modelling strategies for interactions between liquid, tank and soil are presented in detail. Chapter four presents a procedure based on the analysis of a set of accelerograms recorded in a chosen site to take into account their time and frequency variability. In particular, the generation of artificial fully non-stationary accelerograms is performed using a three-step procedure.

The objective of the fifth chapter is to present the main theoretical features of a recently developed higher-order beam element, accompanied by an illustrative application to members with linear elastic behaviour. The beam performance is assessed by comparison against refined solid finite element analyses, classical beam theory results, and approximate numerical solutions. In the sixth chapter an analytical approach based on small displacement theory is derived using the force analogy method to calculate the plastic rotations of plastic hinges at various locations of moment-resisting frames. Both static and dynamic analyses with nonlinear geometric effects are incorporated in the derivation, together with the element stiffness matrices using a member with plastic hinges in compression, and therefore the coupling of geometric and material nonlinearity effects is included from the beginning of the derivation.

In the seventh chapter a parametric study is conducted on five RC frame structures designed according to Eurocode 8. It is shown that Eurocode formulation for the evaluation of the seismic demand on non-structural components does not fit well the analytical results for a wide range of periods, particularly in the vicinity of the higher mode periods of vibration of the reference structures. A novel formulation is proposed for an easy implementation in future building codes based on the actual Eurocode provisions. In the eighth chapter three methodologies are proposed for the design of Reinforced Concrete Sections with single reinforcement according to EC2-1-1 and the rectangular stress distribution. The purpose of the design is to calculate the necessary tensile steel reinforcement given the forces (bending moment and axial force) acting on the section. Apart from the direct problem, the inverse problem is also addressed, where the steel reinforcement is given and the purpose is to find the maximum bending moment that the section can withstand.

Chapter nine extends the approach of base isolation and investigates the potential effectiveness of multi-storey structures with seismic isolators at different storey-levels. The control concept provides numerous options for the designer in respect to the desired seismic performance of the building. The effectiveness of the proposed control system is investigated in parametric studies. The tenth chapter discusses the role of integration step size in time integration analysis, specifically, from the points of view of accuracy and computational cost. It presents discussions on conventionally accepted comments, codes regulations, and some modern methods for assigning adequate values to the integration step sizes in constant or adaptive time integration.

In the eleventh chapter the seismic vulnerability of smart structures is assessed based on a fragility analysis framework. A three-storey steel frame building employing the nonlinear smart damping system is selected as a case study structure in order to demonstrate the effectiveness of the seismic fragility analysis framework. In chapter twelve the implementation of actuator connections that divide a structure in several substructures is proposed. These connections can be installed on the structure during construction or retrofit; while as it is demonstrated, they can be controlled and excite each substructure separately.

In the thirteenth chapter a fuzzy neural network model is presented capable to compute the structural response of a structural system by training the model for two earthquakes using fuzzified ground motion data. The trained NN is then used to simulate earthquakes by feeding various intensities, exhibiting good predictions for practical purposes. The fourteenth chapter presents a smart fuzzy control algorithm for mitigation of dynamic responses of seismically excited bridge structures equipped with control devices. The smart fuzzy controller is developed through the combination of discrete wavelet transform, backpropagation neural networks and Takagi–Sugeno fuzzy model.

Finally, chapter fifteen presents a methodology for real-time planning of emergency inspections of urban areas. This methodology is based on two nature-inspired algorithms, Harmony Search Algorithm (HS) and Ant Colony Optimization (ACO). HS is used for dividing the area into smaller blocks while ACO is used for defining optimal routes inside each created block.

The aforementioned collection of chapters provides an overview of the present thinking and state-of-the-art developments in the application of advanced computational techniques into the framework of structural dynamics and earthquake engineering. The book is targeted primarily to researchers, postgraduate students and engineers that are active in areas related to earthquake engineering and structural dynamics. We believe that the collection of these chapters in a single volume will be useful to both academics and practicing engineers.

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