Improving The Earthquake Resistance Of Small Buildings

Written for engineers without a background in seismic design. Provides design standards and parameters, explaining how to interpret and apply them. Examines and recommends procedures to accommodate the enormous forces and variations in effects common to major earthquakes. Covers practical aspects of soil behavior and structural and foundation design. Gives tips on special construction situations: foundations, dams and retaining walls, strengthening existing structures and construction over active faults.

In the past, facilities considered to be at the end of their useful life were demolished and replaced with new ones that better met the functional requirements of modern society, including new safety standards. Humankind has recently recognised the threats to the environment and to our limited natural resources due to our relentless determination to destroy the old and build anew. With the awareness of these constraints and the emphasis on sustainability, in future the majority of old structures will be retrofitted to extend their service life as long as feasible. In keeping with this new approach, the EU's Construction Products Regulation 305/2011, which is the basis of the Eurocodes, included the sustainable use of resources as an "Essential Requirement" for construction. So, the forthcoming second generation of EN-Eurocodes will cover not only the design of new structures, but the rehabilitation of existing ones as well.

Most of the existing building stock and civil infrastructures are seismically deficient. When the time comes for a decision to prolong their service life with the help of structural and architectural upgrading, seismic retrofitting may be needed. Further, it is often decided to enhance the earthquake resistance of facilities that still meet their functional requirements and fulfil their purpose, if they are not earthquake-safe. In order to decide how badly a structure needs seismic upgrading or to prioritise it in a population of structures, a seismic evaluation is needed, which also serves as a guide for the extent and type of strengthening. Seismic codes do not sufficiently cover the delicate phase of seismic evaluation nor the many potential technical options for seismic upgrading; therefore research is on-going and the state-of-the-art is constantly evolving. All the more so as seismic evaluation and rehabilitation demand considerable expertise, to make best use of the available safety margins in the existing structure, to adapt the engineering capabilities and techniques at hand to the particularities of a project, to minimise disruption of use, etc. Further, as old structures are very diverse in terms of their materials and layout, seismic retrofitting does not lend itself to straightforward codified procedures or cook-book approaches. As such, seismic evaluation and rehabilitation need the best that the current state-of-the-art can offer on all aspects of earthquake engineering. This volume serves this need, as it gathers the most recent research of top seismic experts from around the world on seismic evaluation, retrofitting and closely related subjects.

Encompassing theory and field experience, this book covers all the main subject areas in earthquake risk reduction, ranging from geology, seismology, structural and soil dynamics to hazard and risk assessment, risk management and planning, engineering and the architectural design of new structures and equipment. Earthquake Risk Reduction outlines individual national weaknesses that contribute to earthquake risk to people and property; calculates the seismic response of soils and structures, using the structural continuum 'Subsoil - Substructure - Superstructure - Non-structure'; evaluates the effectiveness of given designs and construction procedures for reducing casualties and financial losses; provides guidance on the key issue of choice of structural form; presents earthquake resistant designs methods for the four main structural materials - steel, concrete, reinforced masonry and timber - as well as for services equipment, plant and non-structural architectural components; contains a chapter devoted to problems involved in improving (retrofitting) the existing built environment. Compiled from the author's extensive professional experience in earthquake engineering, this key text provides an excellent treatment of the complex multidisciplinary process of earthquake risk reduction. This book will prove an invaluable reference and guiding tool to practicing civil and structural engineers and architects, researchers and postgraduate students in seismology, local governments and risk management officials.

This is the second edition of a book which has proved useful to large numbers of engineers and architects

since it was first published.
In the last few decades, a considerable amount of experimental and analytical research on the seismic behaviour of masonry walls and buildings has been carried out. The investigations resulted in the development of methods for seismic analysis and design, as well as new technologies and construction systems. After many centuries of traditional use and decades of allowable stress design, clear concepts for limit state verification of masonry buildings under earthquake loading have recently been introduced in codes of practice. Although this book is not a review of the state-of-the-art of masonry structures in earthquake zones, an attempt has been made to balance the discussion on recent code requirements, state-of-the-art methods of earthquake-resistant design and the author's research work, in order to render the book useful for a broader application in design practice. An attempt has also been made to present, in a condensed but easy to understand way, all the information needed for earthquake-resistant design of masonry buildings constructed using traditional systems. The basic concepts of limit state verification are presented and equations for seismic resistance verification of masonry walls of all types of construction, (unreinforced, confined and reinforced) as well as masonry-infilled reinforced concrete frames, are addressed. A method for seismic resistance verification, compatible with recent code requirements, is also discussed. In all cases, experimental results are used to explain the proposed methods and equations. An important part of this book is

dedicated to the discussion of the problems of repair, retrofit and rehabilitation of existing masonry buildings, including historical structures in urban centres. Methods of strengthening masonry walls as well as improving the structural integrity of existing buildings are described in detail. Wherever possible, experimental evidence regarding the effectiveness of the proposed strengthening methods is given. Contents:Earthquakes and Seismic Performance of Masonry BuildingsMasonry Materials and Construction SystemsArchitectural and Structural Concepts of Earthquake-Resistant Building ConfigurationFloors and RoofsBasic Concepts of Limit States Verification of Seismic Resistance of Masonry BuildingsSeismic Resistance Verification of Structural WallsMasonry Infilled Reinforced Concrete FramesSeismic Resistance Verification of Masonry BuildingsRepair and Strengthening of Masonry Buildings Readership: Practising engineers and students.

Base isolation technology offers a cost-effective and reliable strategy for mitigating seismic damage to structures. The effectiveness of this new technology has been demonstrated not only in laboratory research, but also in the actual response of base-isolated buildings during earthquakes. Increasingly, new and existing buildings in earthquake-prone regions throughout the world are making use of this innovative strategy. In this expanded and updated edition, the design methods and guidelines associated with seismic isolation are detailed. The main focus of the book is on isolation systems that use a damped natural rubber. Topics covered include coupled lateral-torsional response, the behavior of multilayer bearings under compression and bending, and the buckling behavior of elastomeric bearings. Also featured is a section covering the recent changes in building code requirements.

Seismic retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes. The planning of changes to existing buildings differs from new planning through an important condition; the existing construction must be taken as the basis of all planning and building actions. The need for seismic retrofitting of an existing building can arise due to several reasons like: building not designed to code, subsequent updating of code and design practice, subsequent upgrading of seismic zone, deterioration of strength and aging, modification of existing structure, change in use of the building, etc. Seismic retrofit is primarily applied to achieve public safety, with various levels of structure and material survivability determined by economic considerations. In recent years, an increased urgency has been felt to strengthen the deficient buildings, as part of active disaster mitigation, and to work out the modifications that may be made to an existing structure to improve the structural performance during an earthquake. Seismic retrofitting schemes can be either global or local, based on how many members of the structures they are used for. Global Retrofit methods include conventional methods (increase seismic resistance of existing structures) or non-conventional methods (reduction of seismic demand). Strengthening and Retrofitting of Existing

Structures is a compendium of cutting-edge trends of the research and existing practices in strengthening and retrofitting of structural elements, as well as the findings of a research endeavor initiated by the authors to investigate and develop a robust structural retrofitting scheme by utilizing elastomeric polymers to enhance the resistance of reinforced concrete (RC) structures. It addresses in detail specific techniques for the strengthening of traditional constructions, reinforced concrete buildings, bridges and their foundations. It also presents insight into the key issues relevant to seismic retrofit of concrete frame buildings. Many guidelines are reviewed regarding seismic rehabilitation of school, office, hospital and apartment buildings.

There's never been a better time to "be prepared." Matthew Stein's comprehensive primer on sustainable living skills—from food and water to shelter and energy to first-aid and crisis-management skills—prepares you to embark on the path toward sustainability. But unlike any other book, Stein not only shows you how to live "green" in seemingly stable times, but to live in the face of potential disasters, lasting days or years, coming in the form of social upheaval, economic meltdown, or environmental catastrophe. When Technology Fails covers the gamut. You'll learn how to start a fire and keep warm if you've been left temporarily homeless, as well as the basics of installing a renewable energy system for your home or business. You'll learn how to find and sterilize water in the face of utility failure, as well as practical information for dealing with water-quality issues even when the public tap water is still flowing.

You'll learn alternative techniques for healing equally suited to an era of profit-driven malpractice as to situations of social calamity. Each chapter (a survey of the risks to the status quo; supplies and preparation for short- and long-term emergencies; emergency measures for survival; water; food; shelter; clothing; first aid, low-tech medicine, and healing; energy, heat, and power; metalworking; utensils and storage; low-tech chemistry; and engineering, machines, and materials) offers the same approach, describing skills for self-reliance in good times and bad. Fully revised and expanded—the first edition was written pre-9/11 and pre-Katrina, when few Americans took the risk of social disruption seriously—When Technology Fails ends on a positive, proactive note with a new chapter on "Making the Shift to Sustainability," which offers practical suggestions for changing our world on personal, community and global levels.

Earthquake-resistant design, Structures, Structural design, Seismology, Structural systems, Buildings, Seismic coefficient, Seismic loading, Earthquakes, Stability, Repair, Design calculations, Mathematical calculations, Ductility, Mechanical properties of materials, Strength of materials, Stiffness, Laboratory testing, Building maintenance, Concretes, Structural timber, Damage, Masonry work, Steels, Safety measures

Earthquake Resistant Design and Risk Reduction, 2nd edition is based upon global research and development work over the last 50 years or more, and follows the author's series of three books Earthquake Resistant Design, 1st and 2nd editions (1977 and 1987), and

Earthquake Risk Reduction (2003). Many advances have been made since the 2003 edition of Earthquake Risk Reduction, and there is every sign that this rate of progress will continue apace in the years to come. Compiled from the author's wide design and research experience in earthquake engineering and engineering seismology, this key text provides an excellent treatment of the complex multidisciplinary process of earthquake resistant design and risk reduction. New topics include the creation of low-damage structures and the spatial distribution of ground shaking near large fault ruptures. Sections on guidance for developing countries, response of buildings to differential settlement in liquefaction, performance-based and displacement-based design and the architectural aspects of earthquake resistant design are heavily revised. This book: Outlines individual national weaknesses that contribute to earthquake risk to people and property Calculates the seismic response of soils and structures, using the structural continuum "Subsoil – Substructure – Superstructure – Non–structure" Evaluates the effectiveness of given design and construction procedures for reducing casualties and financial losses Provides guidance on the key issue of choice of structural form Presents earthquake resistant design methods for the main four structural materials – steel, concrete, reinforced masonry and timber – as well as for services equipment, plant and non-structural architectural components Contains a chapter devoted to problems involved in improving (retrofitting) the existing built environment This book is an invaluable reference and guiding tool to practising civil and structural engineers and architects, researchers and postgraduate students in earthquake engineering and engineering seismology, local governments and risk management officials.

An all-encompassing guide to environmental planning for earthquakes. Discusses prediction and preparation as well as emergency management and recovery. Examines how to enact and evaluate protection strategies. Considers site selection, seismic hazard assessment and improving earthquake resistance of buildings. Addresses loss estimation, risk and vulnerability analysis. Assesses possibilities for reducing earthquake disasters. Includes recommendations for further reading.

In recent decades, improvement in construction and design practices and better estimation in seismic demands has led to an increasing number of reinforced concrete special moment resisting frame (SMRF) buildings with height and member sizes exceeding those typically built in the past. While current codes improved greatly over the years, many design specifications introduced around the prevailing practices from decades ago remain in effect. The aim of this dissertation is to address some potentially problematic areas in current design standards and propose ways to improve them. Specifically, the focal points of the work presented concern with two separate areas in the design of reinforced concrete SMRF buildings. The first topic is the investigation of the transverse steel spacing requirements in the plastic hinge zones of reinforced concrete SMRF beams. Two large reinforced concrete SMRF beams were built and subjected to earthquake-like damage in the laboratory test with the goal: (a) to demonstrate that the maximum hoop spacing limits specified in the concurrent 2008 ACI 318 Code could produce a beam with performance inferior to the implied expectations at design level ground shaking intensity, and (b) to evaluate the effect of reducing this hoop spacing limit and recommend code changes for the 2011 ACI 318 Code. The experiments included two 30 in. x 48 in. beams with identical size, material properties, and longitudinal reinforcement ratio, but different transverse hoop spacing, which were subjected to reverse cyclic displacement history to simulate the earthquake-induced deformations expected at the design earthquake (DE) hazard level. The first specimen, Beam 1, was designed with the 2008 ACI 318 hoop spacing requirement and exhibited limited ductility before experiencing sudden and significant loss of load bearing capacity at a displacement ductility of 3.4. The second specimen, Beam 2, built with reduced hoop spacing, showed notable improvement in response and was capable of sustaining 90% of its load bearing capacity up to a displacement ductility level of 6.5. Of the two specimens, only Beam 2 sustained the deformation levels compatible with the DE shaking intensity without significant loss of strength. Both beams, however, failed due to longitudinal bar buckling, which pointed to potential vulnerability in the current transverse reinforcement detailing using multiple piece hoops consisting of stirrups with vertical and horizontal crossties and bracing only alternate longitudinal bars with vertical crossties. Further experimental research in this area is strongly recommended. The second topic concerns with the global nonlinear response of reinforced concrete SMRFs under strong ground motion, with emphasis placed on seismic shear demand in SMRF columns. Current ACI 318 specifications offer two different approaches in calculating the seismic shear demand, however with some ambiguity and much room for free interpretation that can vastly impact the shear capacity of the column and potentially result in unconservative design. Total of eight numerical models of buildings with perimeter SMRFs of varying configurations were analyzed in two separate studies (four buildings are presented in Chapter 5 and the other four in Chapter 6) under multiple ground acceleration records to find the mean shear envelopes in the columns. Depending on the interpretation of the ACI 318 code, various levels of conservatism in estimating column shears were achieved. A common design approach to estimate seismic column shear from the joint equilibrium with beams having reached the probable moment strengths, while the unbalanced moment is distributed evenly between the columns above and below, was shown to lead to unconservative seismic shear estimate, in some cases resulting in half of the actual demand computed in the nonlinear dynamic analyses. It is demonstrated that the seismic shear demand on columns is better estimated with a method based on amplifying the seismic shear calculated with the elastic code-prescribed modal response spectrum analysis with the system overstrength and dynamic amplification factors.

This comprehensive and well-organized book presents the concepts and principles of earthquake resistant design of structures in an easy-to-read style. The use of these principles helps in the implementation of seismic design practice. The book adopts a step-by-step approach, starting from the fundamentals of structural dynamics to application of seismic codes in analysis and design of structures. The text also focusses on seismic evaluation and retrofitting of reinforced concrete and masonry buildings. The text has been enriched with a large number of diagrams and solved problems to reinforce the understanding of the concepts. Intended mainly as a text for undergraduate and postgraduate students of civil engineering, this text would also be of considerable benefit to practising engineers, architects, field engineers and teachers in the field of

earthquake resistant design of structures.
In its 11th year, and reporting on the latest research on preparation for and mitigation of future earthquakes, this volume examines an area of increasing importance to many countries around the world. ERES 2017 assembled experts from around the world to present their basic and applied research in the fields of earthquake engineering relevant to the design of structures. As the world's population has concentrated in urban areas resulting in buildings in regions of high seismic vulnerability, we have seen the consequences of natural disasters take an ever higher toll on human existence. Protecting the built environment in earthquake-prone regions involves not only the optimal design and construction of new facilities, but also the upgrading and rehabilitation of existing structures including heritage buildings, which is an important area of research. Major earthquakes and associated effects, such as tsunamis, continue to stress the need to carry out more research and a better understanding of these phenomena is required to design earthquake resistant buildings and to carry out risk assessment and vulnerability studies. Some of the subject areas covered are: Seismic isolation and energy dissipation; Building performance during earthquakes; Numerical analysis; Performance based design; Experimental studies; Seismic hazards and tsunamis; Safety engineering; Liquefaction; Innovative technologies; Paraseismic devices and Lifelines and resilience.
In spite of mankind's triumph in taming nature for his survival and benefit, succumbing to the vagaries of nature has become a regular global concern. Out of the array of different catastrophes, earthquakes and cyclones together are responsible for an overwhelming majority of the global damages caused by natural disasters in the last decade, leaving millions homeless. The loss of property and life are

primarily due to failure of structures to withstand such catastrophes, caused often due to lack of implementation of a few guidelines. The evolution of these guidelines is rooted in understanding the principles of the mechanics that regulate the behaviour of the structures under lateral dynamic loading imparted by earthquakes and cyclones.In this context, Improving Earthquake and Cyclone Resistance of Structures: guidelines for the Indian subcontinent, is an attempt to introduce guidelines for the types of building structures frequently observed and built in the Indian subcontinent as well as in other developing countries. The guidelines are meant for both architectural and structural features, and include constructional aspects as well. The book introduces these guidelines in such a manner that all aspects can be properly understood, related, and implemented by practising engineers and architects. On the whole, the book may help develop awareness and sensitized technical manpower for combating the threats posed by natural disasters like earthquakes and cyclones.

Structural Studies, Repairs and Maintenance of Heritage Architecture XVII The importance of retaining the built cultural heritage cannot be overstated. Rapid development and inappropriate conservation techniques are threatening many heritage unique sites in different parts of the world. Selected papers presented at the 17th International Conference on Studies, Repairs and Maintenance of Heritage Architecture are included in this volume. They address a series of topics related to the historical aspects and the reuse of heritage buildings, as well as technical issues on the structural integrity of different types of buildings, such as those constructed with materials as varied as iron and steel, concrete, masonry, wood or earth. Restoration processes require the appropriate characterisation of those materials, the modes of construction and the structural behaviour of the building. This knowledge can be gained through a series of material characterisation techniques, preferably via non-destructive tests. Modern computer simulation can provide accurate results demonstrating the stress state of the building and possible failure mechanisms affecting its stability. Of particular importance are studies related to their dynamic and earthquake behaviour aiming to provide an assessment of the seismic vulnerability of heritage buildings. Contributions originate from scientists, architects, engineers and restoration experts from all over the world and deal with different aspects of heritage buildings, including how to formulate regulatory policies, to ensure effective ways of preserving the architectural heritage. Earthquake Resistant Engineering Structures XIII Papers presented at the 13th International Conference on Earthquake Resistant Engineering Structures form this volume and cover basic and applied research in the various fields of earthquake engineering relevant to the design of structures. Major earthquakes and associated effects such as tsunamis continue to stress the need to carry out more research on those topics. The problems will intensify as population pressure results in buildings in regions of high seismic vulnerability. A better understanding of these phenomena is required to design earthquake resistant structures and to carry out risk assessments and vulnerability studies. The problem of protecting the built environment in earthquake-prone regions involves not only the optimal design and construction of new facilities but also the upgrading and rehabilitation of existing structures including heritage buildings. The type of highly specialized retrofitting employed to protect the built heritage is an important area of research. The included papers cover such topics as Seismic hazard and tsunamis; Building performance during earthquakes; Structural vulnerability; Seismic isolation and energy dissipation; Passive earthquake protection systems.

This book introduces practising engineers and post-graduate students to modern approaches to seismic design, with a particular focus on reinforced concrete structures, earthquake resistant design of new buildings and assessment, repair and strengthening of existing buildings.

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.

Earthquake engineering is the ultimate challenge for structural engineers. Even if natural phenomena involve great uncertainties, structural engineers need to design buildings, bridges, and dams capable of resisting the destructive forces produced by them. These disasters have created a new awareness about the disaster preparedness and mitigation. Before a building, utility system, or transportation structure is built, engineers spend a great deal of time analyzing those structures to make sure they will perform reliably under seismic and other loads. The purpose of this book is to provide structural engineers with tools and information to improve current building and bridge design and construction practices and enhance their sustainability during and after seismic events. In this book, Khan explains the latest theory, design applications and Code Provisions. Earthquake-Resistant Structures features seismic design and retrofitting techniques for low and high raise buildings, single and multi-span bridges, dams and nuclear facilities. The author also compares and contrasts various seismic resistant techniques in USA, Russia, Japan, Turkey, India, China, New Zealand, and Pakistan. Written by a world renowned author and educator Seismic design and retrofitting techniques for all structures Tools improve current building and bridge designs Latest methods for building earthquake-resistant structures Combines physical and geophysical science with structural engineering

A Turkish widow, dressed from head to toe in black, stood near to the heap of fractured concrete and twisted reinforcement that had claimed the lives of her family. She saw the two English engineers who had come to examine the aftermath of the Kocaeli Earthquake and she had a question for them. In a quiet, slightly trembling voice she asked, "Neden?" - "Why?" Her question is the same as that of the vast numbers of people who, in recent decades, have lost family and friends, homes and livelihoods, health and well-being to the destructive power of earthquakes. The question is deceptively simple - the answer is complex and multi-layered. But it is the right question. This conference forms part of the response. Impressive advances have occurred in our understanding of the factors (technical and human) that determine the impact of seismic events. With the papers on this CD you will find developments in seismology and improvements in our understanding of site effects. The lessons of recent earthquakes are discussed leading to better understanding of vulnerability and improved mitigation strategies. The recent rapid strides in seismic code development are presented together with improved methods of structural analysis and testing. Novel techniques and applications for improving the earthquake resistance of structures and infrastructure are considered. The more we know, the more we realise we have yet to understand. However, we can be sure that communities across Europe and our neighbours in other parts of the 'Global Village' will continue to be menaced by savage earthquakes. Our developing knowledge of earthquake science, engineering and mitigation brings with it responsibility. We each have a responsibility to redouble our efforts so that no longer will people with shattered lives have to ask, "Why?" Dr Robert E May Chairman of Conference Organising Committee 12th European Conference on Earthquake Engineering

Engineers are always interested in the worst-case scenario. One of the most important and challenging missions of structural engineers may be to narrow the range of unexpected incidents in building structural design. Redundancy, robustness and resilience play an important role in such circumstances. Improving the Earthquake Resilience of Buildings: The worst case approach discusses the importance of worst-scenario approach for improved earthquake resilience of buildings and nuclear reactor facilities. Improving the Earthquake Resilience of Buildings: The worst case approach consists of two parts. The first part deals with the characterization and modeling of worst or critical ground motions on inelastic structures and the related worst-case scenario in the structural design of ordinary simple building structures. The second part of the book focuses on investigating the worst-case scenario for passively controlled and base-isolated buildings. This allows for detailed consideration of a range of topics including: A consideration of damage of building structures in the critical excitation method for improved building-earthquake resilience, A consideration of uncertainties of structural parameters in structural control and base-isolation for improved building-earthquake resilience, and New insights in structural design of super high-rise buildings under long-period ground motions. Improving the Earthquake Resilience of Buildings: The worst case approach is a valuable resource for researchers and engineers interested in learning and applying the worst-case scenario approach in the seismic-resistant design for more resilient structures.