Reinforced Concrete Shear Wall Analysis And Design

The major objective of this study was to use the finite element method to study the cyclic response of slender, reinforced concrete shear walls. Material models which represent the cyclic response of concrete and reinforcing steel in shear walls were developed in this investigation. These material models were verified both at the element and structural levels; the results of the finite element analyses were compared with the experimental data from several experimental programs. After the material models had been satisfactorily tested and verified, the finite element method was used to extend the scope of the investigation of the response of slender reinforced concrete shear walls with different configurations, reinforcement details, and loading histories.
This thesis is the second stage of the shear wall project, and it focuses on numerical investigations of HMEs on structural wall responses. The thesis consists of three main phases, and each phase corresponds to one (available online or submitted) journal paper. The first two phases were restricted to isolated and two-dimensional RC shear wall models without considering cross-sectional torsional effect and interactions between different shear walls. On the other hand, the last phase investigated three-dimensional RC shear walls in the context of an existing building.
Standard ASCE/SEI 41-06 presents the latest generation of performance-based seismic rehabilitation methodology.

Forty scientists working in 13 different countries detail in this work the most recent advances in seismic design and performance assessment of reinforced concrete buildings. It is a valuable contribution in the mitigation of natural disasters.

Reinforced concrete structural (shear) walls are commonly used as lateral load resisting systems in high seismic zones because they provide significant lateral strength, stiffness, and deformation capacity. Understanding the response and behavior of shear walls is essential to achieve more economical and reliable designs, especially as performance-based design approaches for new buildings have become more common. Results of a case study of 42-story RC dual system building, designed using code-prescriptive and two different performance-based design approaches, are presented to assess expected performance. Median values and dispersion of the response quantities are, in general, well-below acceptable limits and the overall behavior of the three building designs are expected to be quite similar. However, the ability to define shear failure and collapse proved difficult and provided motivation to conduct additional studies. For both design of new buildings and evaluation/rehabilitation of existing structural wall buildings, an accurate assessment of median (expected) and dispersion of wall shear strength and deformation capacity are needed. A wall test database (124 specimens) was assembled to investigate the influence of various parameters on wall shear strength and deformation capacity, and to recommend alternative relations for strength and deformation capacity depending on expected wall behavior. Test results indicated that ACI 318-11 underestimates the shear strength of the shear-controlled walls. Mean curvature ductility ratios were obtained as about 3 and 7 for shear- and flexure-controlled walls, respectively. The new relations will allow improved damage and failure assessment of buildings utilizing structural walls for lateral load resistance. Failure assessment of RC shear walls also was conducted for the 15-story Alto Rio building which collapsed in the 2010 Chile earthquake. Possible reasons for collapse were identified using post-earthquake observed damage, structural drawings, and nonlinear static and dynamic response analyses. Analysis results indicate that collapse was likely influenced by various factors, including compression failure at the web boundary of T-shaped walls on the east side of the building, large shear demands at the filled-in corridor walls at the first level, and tensile fracture and splice failures at the west side of the building. Nonlinear modeling and analysis of the four-story RC building that was tested on E-Defense shaking table (2010) was investigated to assess current modeling approaches and assumptions, and to identify issues that require additional study. Including concrete tension strength, stiffness degradation, and strength degradation significantly improved the correlation between the analytical and test results.

Complete coverage of earthquake-resistant concrete building design Written by a renowned seismic engineering expert, this authoritative resource discusses the theory and practice for the design and evaluation of earthquakeresisting reinforced concrete buildings. The book addresses the behavior of reinforced concrete materials, components, and systems subjected to routine and extreme loads, with an emphasis on response to earthquake loading. Design methods, both at a basic level as required by current building codes and at an advanced level needed for special problems such as seismic performance assessment, are described. Data and models useful for analyzing reinforced concrete structures as well as numerous illustrations, tables, and equations are included in this detailed reference. Seismic Design of Reinforced Concrete Buildings covers: Seismic design and performance verification Steel reinforcement Concrete Confined concrete Axially loaded members Moment and axial force Shear in beams, columns, and walls Development and anchorage Beam-column connections Slab-column and slab-wall connections Seismic design overview Special moment frames Special structural walls Gravity framing Diaphragms and collectors Foundations

Past experimental results on reinforced concrete shear walls and analysis on themInelastic Analysis for In-plane Strength of Reinforced Concrete Shear WallsNonlinear Analysis of Reinforced Concrete Shear Wall StructuresQuasi-static and Dynamic Analysis of Reinforced Concrete Shear WallsBuilding Code Requirements for Structural Concrete (ACI 318M-08) and CommentaryBuilding Code Requirements for Structural Concrete (ACI 318-08) and CommentaryAmerican Concrete Institute

This report contains the results of investigations of shear wall assemblies for the Corps of Engineers. The models tested were one and two story assemblies containing two or three shear walls connected by diaphragms in all cases. Some assemblies contained front and back walls also. As might be expected, analysis of results showed that diaphragms are quite stiff and the distribution of load in three wall structures is largely dependent on the rigidity of the foundation structure and the supporting soil. Analytical approaches to the problems are suggested.

A Complete Guide to Solving Lateral Load Path Problems The Analysis of Irregular Shaped Structures: Diaphragms and Shear Walls explains how to calculate the forces to be transferred across multiple discontinuities and reflect the design requirements on construction documents. Step-by-step examples offer progressive coverage, from basic to very advanced illustrations of load paths in complicated structures. The book is based on the 2009 International Building Code, ASCE/SEI 7-05, the 2005 Edition of the National Design Specification for Wood Construction, and the 2008 Edition of the Special Design Provisions for Wind and Seismic (SDPWS-08). COVERAGE INCLUDES: Code sections and analysis Diaphragm basics Diaphragms with end horizontal offsets Diaphragms with intermediate offsets Diaphragms with openings Open front and cantilever diaphragms Diaphragms with vertical offsets Complex diaphragms with combined openings and offsets Standard shear walls Shear walls with openings Discontinous shear walls Horizontally offset shear walls The portal frame Rigid moment-resisting frame walls--the frame method of analysis

The quality and testing of materials used in construction are covered by reference to the appropriate ASTM standard specifications. Welding of reinforcement is covered by reference to the appropriate AWS standard. Uses of the Code include adoption by reference in general building codes, and earlier editions have been widely used in this manner. The Code is written in a format that allows such reference without change to its language. Therefore, background details or suggestions for carrying out the requirements or intent of the Code portion cannot be included. The Commentary is provided for this purpose. Some of the considerations of the committee in developing the Code portion are discussed within the Commentary, with emphasis given to the explanation of new or revised provisions. Much of the research data referenced in preparing the Code is cited for the user desiring to study individual questions in greater detail. Other documents that provide suggestions for carrying out the requirements of the Code are also cited.

Unified Theory of Concrete Structures develops an integrated theory that encompasses the various stress states experienced by both RC & PC structures under the various loading conditions of bending, axial load, shear and torsion. Upon synthesis, the new rational theories replace the many empirical formulas currently in use for shear, torsion and membrane stress. The unified theory is divided into six model components: a) the struts-and-ties model, b) the equilibrium (plasticity) truss model, c) the Bernoulli compatibility truss model, d) the Mohr compatibility truss model, e) the softened truss model, and f) the softened membrane model. Hsu presents the six models as rational tools for the solution of the four basic types of stress, focusing on the significance of their intrinsic consistencies and their inter-relationships. Because of its inherent rationality, this unified theory of reinforced concrete can serve as the basis for the formulation of a universal and international design code. Includes an appendix and accompanying website hosting the authors' finite element program SCS along with instructions and examples Offers comprehensive coverage of content ranging from fundamentals of flexure, shear and torsion all the way to non-linear finite element analysis and design of wall-type structures under earthquake loading. Authored by world-leading experts on torsion and shear

Sets out basic theory for the behavior of reinforced concrete structural elements and structures in considerable depth. Emphasizes behavior at the ultimate load, and, in particular, aspects of the seismic design of reinforced concrete structures. Based on American practice, but also examines European practice.

This report describes a recommended methodology for reliably quantifying building system performance and response parameters for use in seismic design. The recommended methodology (referred to herein as the Methodology) provides a rational basis for establishing global seismic performance factors (SPFs), including the response modification coefficient (R factor), the system overstrength factor, and deflection amplification factor (Cd), of new seismic-force-resisting systems proposed for inclusion in model building codes. The purpose of this Methodology is to provide a rational basis for determining building seismic performance factors that, when properly implemented in the seismic design process, will result in equivalent safety against collapse in an earthquake, comparable to the inherent safety against collapse intended by current seismic codes, for buildings with different seismic-force-resisting systems.

Concrete shear walls are used as the seismic force resisting system in many high-rise buildings in Western Canada. During earthquake, the response of a high-rise concrete wall as it undergoes severe cracking of concrete and yielding of reinforcement is very complex. In particular, the nonlinear shear behaviour of concrete shear walls is not well known; therefore available analysis programs generally use very primitive models for nonlinear shear behaviour. Gérin and Adebar (2004) quantified the observed experimental results on reinforced concrete membrane elements and presented a simple nonlinear shear model that included the influence of concrete diagonal cracking, yielding of horizontal reinforcement and ultimate shear capacity. There are a number of important issues in the design of high-rise concrete shear walls where shear deformations play a very important role and hence nonlinear shear behaviour will have a significant influence. In this dissertation, three different seismic design issues where nonlinear shear response plays a significant role are investigated. The first issue which is of considerable concern to designers is the large reverse shear force in high-rise concrete walls due to rigid diaphragms below the flexural plastic hinge. The nonlinear analyses that were carried out in this study show that diagonal cracking and yielding of horizontal reinforcement significantly reduce the magnitude of reverse shear force compared to what is predicted by using linear analysis procedures. A second issue where nonlinear shear behaviour has a significant influence is associated with the shear force distribution between inter-connected high-rise walls of different lengths. The results presented in this work, show that when diagonal cracking is included in the analysis, significant redistribution of shear forces takes place between walls and all walls do not necessarily yield at the same displacement. The third issue is related to the dynamic shear demand caused by.

This volume consists of papers presented at the International Workshop on Concrete Shear in Earthquake, held at the University of Houston, Texas, USA, 13-16 January 1991.

"The objective of this research project is to investigate the inelastic behavior and hysteresis rules of low-rise RC perforated shear walls through a series of experimental and analytical studies based on various types of monotonic and earthquake loads. The results derived are then applied to seismic response analysis of box type structures as well as typical low-rise shear wall buildings. The studies also involve development of backbone curves of load-displacement relationship of individual walls, equivalent viscous damping of the walls, and sensitivity analysis of design paramenters for building systems. By observing the failure of cracked shear wall experimentally, a set of semi-empirical equations for backbone curve of perforated shear wall is obtained. Comparison between experimental results and calculated curves is favorable. Concept of energy dissipation is used to establish hysteresis rules which are based on dissipated energy envelopes calculated from experimental data for different loading states. Analytical formulation for a perforated shear wall element model is developed by using three springs: one nonlinear equivalent shear spring; two nonlinear axial springs. Total lateral displacement of a shear wall is a result of both flexure and shear. A four-story industrial building of box type consisting of solid shear walls without boundary columns and a three-story commercial building consisting of isolated columns as well as walls with boundary columns are studied for evaluating various design parameters in building code by using monotonic static analysis. The three-story building is also studied on the basis of dynamic analysis with Lorna Prieta earthquake (1989) and six simulated earthquakes. The sensitivity study of design parameters includes ductility reduction factor, force reduction factor, overstrength factor, and ratio of displacement amplification to force reduction factor. Results are recommended for future building code development"--Abstract, leaf iii.

This volume provides an in-depth, state-of-the-art exploration of the entire gamut of modern masonry construction -- properties and performance of masonry materials, design criteria and methods in reinforced masonry, complete design applications for both low and high-rise masonry, and environmental features. This new edition reflects the landmark changes in the philosophy in the 1992 Uniform Building Code (e.g., introduction of Strength Design concepts of bearing and shear wall analysis; changes in lateral force levels; revision of the Base Shear Formula). Integrates design principles with the governing Uniform Building Code throughout; demonstrates the symbiotic relationships that exist among the various structural components (e.g. beams, columns, lateral force resisting systems); presents complete designs for reinforced concrete and structural steel; contains problem examples demonstrating how to design various structural components, and features four case studies (numerical examples) showing how to integrate the various structural components into a complete system. For structural designers, draftsman, and engineers.

The Nuclear Power Engineering Corporation (NUPEC) of Japan is performing multi-axis loading tests of reinforced concrete (RC) shear wall models. The project, which includes both static and dynamic cyclic tests, started in 1994 and is scheduled to be completed in 2004. The static tests are performed on single elements, box type and. cylindrical type structures. Both unidirectional and multidirectional loads are placed on the models during the static test phase. The dynamic tests will be performed on a shaking table for both the box type and cylindrical type structures. As part of collaborative efforts between the US and Japan the US Nuclear Regulatory Commission (NRC) and Brookhaven National Laboratory (BNL) are participating in the multi-axial cyclic static loading tests and the shaking table tests. The multi-axis loading tests are unique and will provide significant insights into the effect of out-of-plane loads on the capacity of shear wall structures. Current analysis methods use simplified assumptions and do not specifically take this effect into account. Since the fragility levels of RC shear walls are key elements in a seismic PRA of a nuclear plant, it is important to verify the methodology for determining these levels. The NUPEC tests will provide valuable data for this purpose. Pre-test predictions of the box type structure's response to the multi-axis static loading are discussed in this paper. The tests were performed by NUPEC between June and August 2000. Two models are used to make these predictions. The first is au engineering model typical of those used in current design analyses. The second is a finite element model of the structure utilizing the ANSYS computer code. In both cases cyclic load behavior into the inelastic range is considered.

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