A Comparison Between Finite Element Analysis and the Wide Arm Analogy for Lift Core Structure in Medium Rise
Reinforced Concrete Shear Wall BuildingSeismic Performance, Modeling, and Failure Assessment of Reinforced Concrete
Shear Wall BuildingsNonlinear Analysis of Low-rise Reinforced Concrete Shear Wall Buildings Subjected to Multicomponent
Seismic InputAnalysis of Reinforced Concrete Shear Wall-frame Structures [microform]Earthquake Response Analysis and
Resistant Design of Moderately Ductile Reinforced Concrete Shear Walls Considering Higher Mode Effects Seismic
Performance Evaluation of Reinforced Concrete Shear Wall Seismic Force Resisting Systems In Situ Dynamic
Characteristics of Reinforced Concrete Shear Wall BuildingsUnified Theory of Concrete StructuresConcrete Shear in
EarthquakeNon - Linear Finite Element Analysis (NLFEA) of Reinforced Concrete Coupled Shear Wall Structures Three
Dimensional Analysis of Non-planar Coupled Shear Walls (DARC: Inelastic Damage Analysis of Reinforced Concrete
Frame-shear-wall StructuresFinite Element Analyses for Seismic Shear Wall International Standard Problem Reinforced
Masonry Design Modeling and Nonlinear Seismic Simulation of Shear Walls in Multistory Reinforced Concrete
BuildingsApplied Mechanics ReviewsPREDICTION OF NUPECS MULTI-AXIS LOADING TESTS OF CONCRETE SHEAR
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Loading Dynamic Analysis of Reinforced Concrete Shear Wall Buildings A Theoretical Analysis of the Post-elastic Dynamic
Behaviour of a Reinforced Concrete Shear Wall Nonlinear Analysis of Reinforced Concrete Shear Wall Structures Design of
Structures to Resist the Effects of Atomic Weapons: Shear wall structuresNonlinear Three-dimensional Behavior of Shear-
wall Dominant Reinforced Concrete Building StructuresSeismic Design, Analysis, and Behavior of Reinforced Concrete
Coupled Shear Wall Systems with Post-tensioned Coupling BeamsAnalysis Procedure for Earthquake Resistant
StructuresNonlinear Seismic Analysis and Design of Reinforced Concrete BuildingsNumerical Analysis Tools for Modelling
Reinforced Concrete Shear Wall Buildings Subjected to Earthquake LoadingQuasi-static and Dynamic Analysis of
Reinforced Concrete Shear WallsAnalysis of Pierced Concrete Shear Wall System Advances in Building Technology Studies
of Reinforced Concrete Shear Wall Assemblies Hysteresis Rules of Perforated Low-rise Reinforced Concrete Shear Walls
and Seismic Design Parameters Assessment of BuildingsSeismic Analysis of Lightweight Concrete Shear Wall-frame
StructuresAnalysis and Design of Pierced Shear-walls Analysis of Shear WallsAnalysis of Reinforced Concrete Shear Wall
Frame StructuresStructural Engineering and Mechanics, An International Journal. Volume 1. Number 1Interactive Analysis
and Design of Reinforced Concrete Frame-shear Wall Buildings

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.

This book presents an analysis procedure for structures that are exposed to the lateral loads such as earthquake and wind.
It includes the process for calculating and distributing the effective load into structural elements, as well as for calculating
the displacements for different types of structures, e.g. reinforced concrete and steel framed structures. The book provides
civil engineers with clear guidelines on how to perform seismic analysis for various building systems, and how to distribute
the lateral load to the structural components. This book consists of 4 chapters: The first chapter offers an introduction, while
Chapter 2 discusses moment resistance frame. The final two chapters explore shear wall frames and brace frames
respectively. Each chapter follows the same structure, explaining step by step all the necessary algorithms, equations and
procedures for calculating 1) loads, 2) the centre of mass, 3) stiffness of structures, 4) centre of stiffness, 5) lateral loading,
6) the distribution of lateral loads, and 7) the lateral displacement. Demonstrating the implementation of real building
analysis, the book provides architectural drawings and structural plans at the beginning of each chapter.

This set of proceedings is based on the International Conference on Advances in Building Technology in Hong Kong on 4-6
December 2002. The two volumes of proceedings contain 9 invited keynote papers, 72 papers delivered by 11 teams, and
133 contributed papers from over 20 countries around the world. The papers cover a wide spectrum of topics across the
three technology sub-themes of structures and construction, environment, and information technology. The variety within
these categories spans a wide spectrum of topics, and these proceedings provide readers with a good general overview of recent
advances in building research.

The behavior of shear-wall dominant, low-rise, multistory reinforced concrete shear-wall dominant building structures
commonly built in Chile, Japan, Italy and Middle East countries are investigated. Because there are no beams or columns
and the slab and wall thickness are approximately equal, available codes give little information relative to design for gravity
and lateral loads. Items which effect the analysis of shear-wall dominant building structures, i.e. material nonlinearity
including rotating crack capability, 3-D behavior, slab-wall interaction, floor flexibilities, stress concentrations around the
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openings, the location and the amount of the main discrete reinforcements are investigated. For this purpose 2 story and 5 story building structures are modelled. To see the importance of 3-D modelling, the same structures are modelled by both 2-D and 3-D models. Loads are applied first the vertical then lateral loads which are static equivalent earthquake loads. The 3-D models of the structures are loaded in both the longitudinal and transverse directions. A nonlinear isoparametric shell element with arbitrarily placed edge nodes and with variable edge orders (from linear to cubic) is developed in order to consider the amount and location of the main reinforcement at the edges and around the openings, and in order to use higher order elements where the stress gradients are expected to be high. The stress concentrations and distributions around the openings are observed that they are affected by the location of the existing reversed walls in 3-D nonlinear analysis of shear-wall dominant building structures. Slab-wall interaction effects with different size of openings and possible hinge locations are investigated while lateral loads are applied in weak directions. The importance of 3-D effects due to T-C coupling of walls are indicated with basic force mechanisms.

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 an 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.

The seismic behavior of reinforced concrete shear walls in Chile generally demonstrated adequate performance as seen from the response of most Chilean multistory shear-wall reinforced concrete buildings after the 1985 and 2010 earthquakes. While shear walls are widely used in building construction, models for simulating the nonlinear response of shear walls have seen limited advances. The need to accurately model shear wall behavior is becoming more important as increased confidence in the seismic behavior of RC walls has led to more relaxed requirements for reinforcement and confinement of typical wall configurations. For example, walls built prior to the 1985 earthquake in Chile were based more on traditional practice and were not necessarily enforced by seismic codes. The majority of post-1985 construction was based on ACI-318 guidelines with relaxed provisions for the confinement of the walls. The changes in the structural configurations and reinforcement details of post-1985 shear-walls in Chile resulted in different behavior and observed damage compared to the pre-1985 walls. In this study, typical Chilean walls are modeled and analyzed so to evaluate the effectiveness of a wall macro-model developed to reproduce the observed behavior of these walls during the 2010 Chilean earthquake. Due to its simplicity and lower computational cost, a multi spring macro-model is used for the simulation. Since the modeling of an entire building presents numerous modeling and computational challenges, a 2D section of the building is modeled using OpenSEES. The calibration of the 2D section model is performed through comparison of the dynamic properties with a 3D elastic model of the entire building developed in SAP2000. The macro-model development includes recommendations for modeling shear behavior of selected structural walls. The research also provides guidelines for calibrating the spring properties of the macro-element as a function of the slenderness ratio of the wall, and the wall web reinforcement ratio. Findings from the study will be useful in advancing nonlinear simulation models for analysis of shear wall structures.

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.

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..
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The behavior of shear-wall dominant, low-rise, multistory reinforced concrete building structures is investigated. Because there are no beams or columns and the slab and wall thicknesses are approximately equal, available codes give little information relative to design for gravity and lateral loads. Items which effect the analysis of shear-wall dominant building structures, i.e., material nonlinearity including rotating crack capability, 3-D behavior, slab- wall interaction, floor flexibilities, stress concentrations around openings, the location and the amount of main discrete reinforcement are investigated. For this purpose 2 and 5 story building structures are modelled. To see the importance of 3-D modelling, the same structures are modelled by both 2-D and 3- D models. Loads are applied-first tile vertical then lateral loads which are static equivalent earthquake loads. The 3-D models of the structures are loaded in both in the longitudinal and transverse directions. A nonlinear isoparametric plate element with arbitrarily placed edge nodes is adapted in order to consider the amount and location of the main reinforcement. Finally the importance of 3-D effects including the T-C coupling between walls are indicated. Finite element, Nonlinear analysis, Reinforced concrete, Shear-walls.

In the seismic design of shear wall structures, e.g., nuclear reactor buildings, a linear FEM analysis is frequently used to quantify the stresses under the design loading condition. The final design decisions, however, are still based on empirical design rules established over decades from accumulated laboratory test data. This paper presents an overview of the state-of-the-art on the application of nonlinear FEM analysis to reinforced concrete (RC) shear wall structures under severe earthquake loadings based on the findings obtained during the Seismic Shear Wall International Standard Problem (SSWISP) Workshop in 1996. Also, BNL's analysis results of the International Standard Problem (ISP) shear walls under monotonic static, cyclic static and dynamic loading conditions are described.

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.

*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 parameters 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 Loma 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.

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.

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.

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