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Thin Shell Concrete Structures Reinforced Concrete Structures: Flat Slabs and Concrete Shell Roofs Shell Structures for Architecture An Introduction to Shell Structures Thin Shell Concrete Structures Design and Construction of Concrete Shell Roofs Prestressed Thin Shell Concrete Structures The Shell Concrete Structures Processing of Slender Concrete Shells - Fabrication and Installation Theory and Design of Concrete Shells Special Issue on Design of Shell Concrete Structures A Segmental Approach to Thin Shell Concrete Structures Concrete Shell Structures Computer-Generated Shapes for Thin Shell Concrete Structures R. Sundaram and Modern Thin Shell Concrete Structures Computer Aided Design of Axisymmetric Thin Shell Concrete Structures Design of Reinforced Concrete Shells and Folded Plates Building for the Future Concrete Shell Structures Proceedings of a Conference on Thin Concrete Shells, June 21 to 23, 1954 Concrete Shell Structures Buckling of Reinforced Concrete Shell Structures Concrete Shell Structures Design Principles and Analysis of Thin Concrete Shells, Domes and Folders Simple Concrete Shell Structures Development of CSMM-based Shell Element for Reinforced Concrete Structures Thin Shell Concrete Structures

Computational Modelling of Concrete Structures Analysis Of Thin Concrete Shells Formwork for Concrete Shell Structures A Bibliography on Structural Model Analysis, with Particular Emphasis on Concrete Structures History of Reinforced Concrete to 1950 Nervi's Design and Construction Methods for Two Thin-shell Structures Concrete Shell Structures Nonlinear Analysis of 2D and Shell Reinforced Concrete Structures Including Creep and Shrinkage Practical Designs of Special Structures: Shell structures Computer-aided Analysis of Reinforced Concrete Thin Shell Structures Extreme Dynamic Loading Effects on Steel and Concrete Shell Structures Design and Analysis of Shell Structures Reinforced Conrete Structure

*** Featuring a foreword by Pritzker Prize Winner Shigeru Ban *** Bringing together experts from research and practice, Shell Structures for Architecture: Form Finding and Optimization presents contemporary design methods for shell and gridshell structures, covering form-finding and structural optimization techniques. It introduces architecture and engineering practitioners and students to structural shells and provides computational techniques to develop complex curved structural surfaces, in the form of mathematics, computer algorithms, and design case studies. • Part I introduces the topic of shells, tracing the ancient relationship between structural form and forces, the basics of shell behaviour, and the evolution of form-finding and structural optimization techniques. • Part II familiarizes the reader with form-finding techniques to explore expressive structural geometries, covering the force density method, thrust network analysis, dynamic relaxation and particle-spring systems. • Part III focuses on shell shape and topology optimization, and provides a deeper understanding of gradientbased methods and meta-heuristic techniques. • Part IV contains precedent studies of realised shells and gridshells describing their innovative design and construction methods. With The Rapid Utilization Of Shell Structures, The Conventional Method Of Design Based On Empirical Or Approximate Solution Is Giving Way To More Realistic And Sound Mathematical Analysis. This Book Presents A Balanced Treatment Of The Mathematical Analysis And Design Aspects Of Shell Structures. A Systematic Development Of Basic Equations With Method Of Analysis Through Numerical Analysis Has Been Presented To Help The Reader To Understand The Mechanics Of Shell Structures. The Book Deals With Both Membrane And Bending Analysis And The Limitations Of Membrane Analysis Have Been Brought Out Clearly Through Examples. The Book Would Be Of Great Interest To Graduate Students As Well As Design Engineer Shell structures is a term defining concrete or steel vaults of present century architecture that derive from the masonry vaults and domes of the past. Since 1984 the EURO-C conference series (Split 1984, Zell am See 1990, Innsbruck 1994, Badgastein 1998, St Johann im Pongau 2003, Mayrhofen 2006, Schladming 2010) has provided a forum for academic discussion of the latest theoretical, algorithmic and modelling developments associated with computational simulations of concrete and concrete structure One of the main goals of a good and effective structural design is to decrease, as far as possible, the self-weight of structures, because they must carry the service load. This is especially important for reinforced concrete (RC) structures, as the self-weight of the material is substantial. For RC structures it is furthermore important that the whole structure or most of the structural elements are under compression with small eccentricities. Continuous spatial concrete structures satisfy the above-mentioned requirements. It is shown in this book that a span of a spatial structure is practically independent of its thickness and is a function of its geometry. It is also important to define which structure can be called a spatial one. Such a definition is given in the book and based on this definition, five types of spatial concrete structures were selected: translation shells with positive Gaussian curvature, long convex cylindrical shells, hyperbolic paraboloid shells, domes, and long folders. To demonstrate the complex research, results of experimental, analytical, and numerical evaluation of a real RC dome are presented and discussed. The book is suitable for structural engineers, students, researchers and faculty members at universities. Provides engineers and engineering students with the requisite fundamental knowledge of the behavior of concrete shells, and solutions of different spatial problems of practical importance. Describes both rigorous mathematical solutions and approximate methods. The third edition (2nd was 1978) is augmented with chapters on using a personal computer for the calculations, and a detailed index. Annotation(c) 2003 Book News, Inc., Portland, OR (booknews.com) Lightweight structures and material optimized systems are of major relevance in the building industry and particularly in the design of concrete structures. This is not only for aesthetic reasons, but also to use material in a resource conserving way. The increase of strength characteristics, as one measure to reduce cross section dimensions, postulates the prefabrication of cementitious materials under laboratory conditions. This thesis examines the contradiction of the possibility to realize slender concrete elements and the complexity of the discontinued homogeneity arising from necessary segmentations. Proposals of implementation strategies are demonstrated and verified on the basis of selected case studies. Shell structures are widely used in the fields of civil, mechanical, architectural, aeronautical, and marine engineering. Shell technology has been enhanced by the development of new materials and prefabrication schemes. Despite the mechanical advantages and aesthetic value offered by shell structures, many engineers and architects are relatively unacquinted with shell behaviour and design. This book familiarizes the engineering and architectural student, as well as the practicing engineer and architect, with the behaviour and design aspects of shell structures. Three aspects are presented: the Physical behaviour, the structural analysis, and the design of shells in a simple, integrated, and yet concise fashion. Thus, the book contains three major aspects of shell engineering: (1) physical understanding of shell behaviour; (2) use of applied shell theories; and (3) development of design methodologies together with shell design examples. The theoretical tools required for rational analysis of shells are kept at a modest level to give a sound grasp of the fundamentals of shell behaviour and, at the same time, an understanding of the related theory, allowing it to be applied to actual design problems. To achieve a physical understanding of complex shell behaviour, quantitative presentations are supplemented by qualitative discussions so that the reader can grasp the `physical feeling' of shell behaviour. A number of analysis and detailed design examples are also worked out in various chapters, making the book a useful reference manual. This book can be used as a textbook and/or a reference book in undergraduate as well as graduate university courses in the fields of civil, mechanical, architectural, aeronautical, and materials engineering. It can also be used as a reference and design-analysis manual for the practicing engineers and architects. The text is supplemented by a number of appendices containing tables of shell analysis and design charts and tables. Reinforced concrete (RC) shell structures have been widely used in a variety of modern engineering applications. It is found from the earthquake reconnaissance that the RC shell structures, such as nuclear containments, cooling towers, roof domes, shear walls, are the key elements to resist earthquake disturbances. This research presents the development of a finite element analysis (FEA) program to predict the inelastic behavior of RC shell structures. In the program, a new shell element, so-called CSMM-based shell element, was developed based on the formulation of the degenerated shell theory with layered approach and taking into account the Cyclic Softened Membrane Model developed at the University of Houston. An analysis procedure was developed to perform nonlinear analyses of RC shell structures using the developed CSMM-based shell element. To develop the FEA program, the developed shell element and the proposed analysis procedure were implemented into a finite element program development framework, OpenSees, which was developed at University of California, Berkeley. Several large-scale structural tests were used to validate the developed FEA program, including panels subjected to pure shear or combination of shear and bending, a three-dimensional (3D) RC shear wall, a cylindrical RC tank, and circular and rectangular RC hollow bridge columns. More importantly, the versatile application of the developed finite element analysis program SCS-3D was further investigated by the modeling of two 1/13-scaled nuclear containment vessel specimens and a two-story unsymmetrical RC building subjected to reserved cyclic loadings. Both test programs were undertaken as part of an international collaboration projects between the National Center for Research on Earthquake Engineering (NCREE) in Taipei, Taiwan, and the University of Houston (UH), Houston, Texas. The experimental work was performed at NCREE, and the specimen design and study of the experimental results were performed at UH. The creation of reinforced concrete, a composite, is based on the inventions of Portland cement and the rolled steel bar. This dual concept was in force in the 1880s, rapidly enforcing the composite on the market, gradually phasing out the materials of natural stone and wood in construction works. Simultaneously, simple computation models were developed, allowing calculations of the building material for constructions, useful as flooring, beams, columns, bridges, road pavements, cisterns, trusses, tubes etc. Though simple, the first design theory in 1887 became very useful as it reduced the dimensions of structures by about 50 %. In 1890, P. Neumann, a pioneer from the Vienna school, contributed to a more scientific model of properties, though slowly utilized in practice, which inspired the design theories launched by three outstanding pioneers, E. Mörsch, R. Saliger and E. Suenson after the turn of the twentieth century. Meanwhile J. Melan and F. Emperger in Vienna and A. Ostenfeld in Copenhagen started the era of bridge designing from Monier vaults. Emperger, occupied in the USA with bridge designing 1890- 1897, contributed to the very rapid development of bridge-building in the USA. Much in the same manner, F. Hennebique and his peer E. Fryssinet were in charge of the amazing development of monolithic reinforced structures and pre-stressed bridges in Europe 1892-1940. The ultimate calculation method for reinforced concrete became a reality when a pioneer from the Danish school, A. Ingerslev launched theories for flat slabs. Despite a very short active period, Ingerslev's theory was employed in Denmark after 1921. His follower K. W. Johansen, occupied with the subject for three decades, brought the flat slab theory to its peak. Slowly, due to very late translations, it gained acceptance in all countries dealing with flat slab structures. The ultimate use of the composite appeared in thin shell structures: Orly hangars erected in 1921-1923, the spherical dome in Jena in 1924 and elliptical shaped shell structures in Spain and Switzerland in the 1930s, due to E. Torroja and R.Maillart. Finally, after the failure of the hotel Goldener Bär in Bern in 1901, the building code for concrete was rapidly enforced, in 1903 in Switzerland, soon followed by codes in Austria and Germany. The higher safety of concrete structures, due to the increased strength of the materials, was soon followed by more sophisticated design theories, based on prismatic failure stresses. Using the modern computerized analysis, the special purpose computer program SLOOFSAN can be successfully applied for the evaluation if thin structure strength limits in presence of extreme dynamic loading phenomena. This program correctly solves wave-propagation-type of problems involving short transient (very rapid loading-time sequence) and including shock-wave response from impulsive loading (explosion or blast wave) and impact loading (missile impact). SLOOFSAN program is based on a finite element shell formulation using the Semiloof element and has been developed for transient dynamic non-linear analysis applying an efficient explicit direct time integration technique. SLOOFSAN 3-D capabilities in the fields of structural safety assessment and anti-missile design are illustrated in the paper. (Author). This thesis studies two major thin-shell concrete structures by Pier Luigi Nervi (1891- 1979) - the Leverone Field House and Thompson Arena. These two similar parabolic vaults are two of the few international structures he has completed in the United States. Situated across the street from each other at Dartmouth College, these two thin-shell concrete structures designed only a few years apart and in a such mature stage of Nervi's engineering career deserve a closer look. Access to Nervi's original calculations, specifications, and correspondences with Dartmouth College reveal a new level of refinement in his design methods and decisions. This study analyzes his structural design methods and compares them with approximated hand calculations assuming an asymmetric load on a 3-hinged parabolic arch. The maximum moment was calculated to be within 7% of Nervi's results. An arch was also explored by building a Finite Element (FE) model in SAP2000, however, the results proved the model to be an unreliable representation of the behavior of the funicular concrete arch. Furthermore, never before published construction photos give clues to the construction of the first structure built with the "Nervi System" in the United States. Slight changes were made to the construction method from his previous structures with the Nervi System in Rome. The types of different precast panels were reduced to increase repetition and refinement was made to the multi-step formwork system to reduce the amount of wooden formwork while keeping a high level of accuracy for the shape of the precast panels.