Thin Shell Concrete Structure Design And Construction

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.

Textile Fibre Composites in Civil Engineering provides a state-of-the-art review from leading experts on recent developments, the use of textile fiber composites in civil engineering, and a focus on both new and existing structures. Textile-based composites are new materials for civil engineers. Recent developments have demonstrated their potential in the prefabrication of concrete structures and as a tool for both strengthening and seismic retrofitting of existing concrete and masonry structures, including those of a historical value. The book reviews materials, production technologies, fundamental properties, testing, design aspects, applications, and directions for future research and developments. Following the opening introductory chapter, Part One covers materials, production technologies, and the manufacturing of textile fiber composites for structural and civil engineering. Part Two moves on to review testing, mechanical behavior, and durability aspects of textile fiber composites used in structural and civil engineering. Chapters here cover topics such as the durability of structural elements and bond aspects in textile fiber composites. Part Three analyzes the structural behavior and design of textile reinforced concrete. This section includes a number of case studies providing thorough coverage of the topic. The final section of the volume details the strengthening and seismic retrofitting of existing structures. Chapters investigate concrete and masonry structures, in addition to providing information and insights on future directions in the field. The book is a key volume for researchers, academics, practitioners, and students working in civil and structural engineering and those working with advanced construction materials. Details the range of materials and production technologies used in textile fiber composites Analyzes the durability of textile fiber composites, including case studies into the structural behavior of textile reinforced concrete Reviews the processes involved in strengthening existing concrete structures

Structures by Design: Thinking, Making, Breaking is a new type of structures textbook for architects who prefer to learn using the hands-on, creative problem-solving techniques typically found in a design studio. Instead of presenting structures as abstract concepts defined by formulas and diagrams, this book uses a project-based approach to demonstrate how a range of efficient, effective, and expressive architectural solutions can be generated, tested, and revised. Each section of the book is focused on a particular manner by which structural resistance is provided: Form (Arches and Cables), Sections (Beams, Slabs, and Columns), Vectors (Trusses and Space Frames), Surfaces (Shells and Plates), and Frames (Connections and High-Rises). The design exercises featured in each chapter use the Think, Make, Break method of reiterative design to develop and evaluate different structural options. A variety of structural design tools will be used, including the human body, physical models, historical precedents, static diagrams, traditional formulae, and advanced digital analysis. The book can be incorporated into various course curricula and studio exercises because of the flexibility of the format and range of expertise required for these explorations. More than 500 original illustrations and photos provide example solutions and inspiration for further design exploration.

Shells are basic structural elements of modern technology. Examples of shell structures include automobile bodies, domes, water and oil tanks, pipelines, ship hulls, aircraft fuselages, turbine blades, laudspeaker cones, but also balloons, parachutes, biological membranes, a human skin, a bottle of wine or a beer can. This volume contains full texts of over 100 papers presented by specialists from over 20 countries at the 8th Conference "Shell Structures: Theory and Applications", 12-14 October, 2005 in Jurata (Poland). The aim of the meeting was to bring together scientists, designers, engineers and other specialists in shell structures in order to discuss important results and new ideas in this field. The goal is to pursue more accurate theoretical models, to develop more powerful and versatile methods of analysis, and to disseminate expertise in design and maintenance of shell structures. Among the authors there are many distinguished specialists of shell structures, including the authors of general lectures: I.V. Andrianov (Ukraine), V.A. Eremeyev (Russia), A. Ibrahimbegovic (France), P. Klosowski (Poland), B.H. Kröplin (Germany), E. Ramm (Germany), J.M. Rotter (UK) and D. Steigmann (USA). The subject area of the papers covers various theoretical models and numerical analyses of strength, dynamics, stability, optimization etc. of different types of shell structures, their design and maintenance, as well as modelling of some surface-related mechanical phenomena.

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.

Born in Sondrio, Italy, in 1891, Per Luigi Nervi was a pioneer in the engineering and architecture of reinforced concrete. His buildings showed how the use of reinforced concrete expanded the possibilities of form and structure. His methods, meanwhile, ingrained his structures with patterns that came directly out of his economical, manual construction processes. The results were buildings that matched awe-inspiring spans with surprisingly human scale. Beauty's Rigor offers a comprehensive overview of Nervi's long career. Drawing on the Nervi archives and a wealth of photographs and architectural drawings, Thomas Leslie explores celebrated buildings like Palazetto dello Sport built for the 1960 Rome Olympics, St. Mary's Cathedral in San Francisco, and the UNESCO headquarters in Paris. He also sheds new light on unbuilt projects such as the Pavilion of Italian Civilization for the Universal Exposition of Rome E42. What emerges is the first complete account of Nervi's contributions to modern architecture and his essential role in a revolution that realized concrete's potential to match grace with strength.

Understanding how gravity loads and wind and earthquake loads flow through a building is of utmost importance to all structural engineers and architects. Paradoxically, this critical idea is practically not addressed in any textbook on the market. Meant as a companion to the author’s Structures: A Geometric Approach, this textbook fills that need with qualitative techniques as well as quantitative tools that use state of the art visual representation of forces and deformations in structures. Structures: A Studio Approach reaches out to both structural engineers and designers by presenting structural engineering topics in an interdisciplinary studio environment. Using many graphical techniques, it offers a very rigorous approach, but also enables creativity. Cutting edge finite element as well as parametric modeling tools are used, and state of the art visual representations of force flow help both groups of students realize that understanding three dimensional load flow in a building is a requirement for channeling that flow in a structurally efficient and visually expressive manner. Ultimately, the reader is able to develop a unique structural sensibility; an ethos that places structural design on an equal footing with the design of program, skin, massing and site.

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.

*** 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 gradient-based methods and meta-heuristic techniques. • Part IV contains precedent studies of realised shells and gridshells describing their innovative design and construction methods.

The authors present a modern continuum mechanics and mathematical framework to study shell physical behaviors, and to formulate and evaluate finite element procedures. With a view towards the synergy that results from physical and mathematical understanding, the book focuses on the fundamentals of shell theories, their mathematical bases and finite element discretizations. The complexity of the physical behaviors of shells is analysed, and the difficulties to obtain uniformly optimal finite element procedures are identified and studied. Some modern finite element methods are presented for linear and nonlinear analyses. A state of the art monograph by leading experts.

Thin Shell Concrete StructuresMcGraw-Hill CollegeDesign Principles and Analysis of Thin Concrete Shells, Domes and FoldersCRC Press

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.

Dr. Wilson's book is a reference text on the construction of concrete thin shell structures, specifically written for engineers, architects, builders and students of those disciplines.

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.

The definitive guide to formwork design, materials, and methods--fully updated Formwork for Concrete Structures, Fourth Edition, provides current information on designing and building formwork and temporary structures during the construction process. Developed with the latest structural design recommendations by the National Design Specification (NDS 2005), the book covers recent advances in materials, money- and energy-saving strategies, safety guidelines, OSHA regulations, and dimensional tolerances. Up-to-date sample problems illustrate practical applications for calculating loads and stresses. This comprehensive manual also includes new summary tables and equations and a directory of suppliers. Formwork for Concrete Structures, Fourth Edition, covers: Economy of formwork Pressure of concrete on formwork Properties of form material Form design Shores and scaffolding Failures of formwork Forms for footings, walls, and columns Forms for beams and floor slabs Patented forms for concrete floor systems Forms for thin-shell roof slabs Forms for architectural concrete Slipforms Forms for concrete bridge decks Flying deck forms

Physical models have been, and continue to be used by engineers when faced with unprecedented challenges, when engineering science has been non-existent or inadequate, and in any other situation when the engineer has needed to raise their confidence in a design proposal to a sufficient level to begin construction. For this reason, models have mostly been used by designers and constructors of highly innovative projects, when previous experience has not been available. The book covers the history of using of physical models in the design and development of civil and building engineering projects including bridges in the mid-18th century, William Fairbairn?s Britannia bridge in the 1840s, the masonry Aswan Dam in the 1890s, concrete dams in the 1920s, thin concrete shell roofs and the dynamic behaviour of tall buildings in earthquakes from the 1930s, tidal flow in estuaries and the acoustics of concert halls from the 1950s, and cable-net and membrane structures in the 1960s. Traditionally, progress in engineering has been attributed to the creation and use of engineering science, the understanding materials properties and the development of new construction methods. The book argues that the use of reduced scale models have played an equally important part in the development of civil and building engineering. However, like the history of engineering design itself, this crucial contribution has not been widely reported or celebrated. The book concludes with reviews of the current use of physical models alongside computer models, for example, in boundary layer wind tunnels, room acoustics, seismic engineering, hydrology, and air flow in buildings.

COST is an intergovernmental framework for European Cooperation in Science and Technology, allowing the coordination of nationally-funded research on a European level. Part of COST was COST Action C26Urban Habitat Constructions Under Catastrophic Events which started in 2006 and held its final conference in Naples, Italy, on 16-18 September 201

The Kingdome, John (“Jack”) Christiansen’s best-known work, was the largest freestanding concrete dome in the world. Built amid public controversy, the multipurpose arena was designed to stand for a thousand years but was demolished in a great cloud of dust after less than a quarter century. Many know the fate of Seattle’s iconic dome, but fewer are familiar with its innovative structural engineer, Jack Christensen (1927–2017), and his significant contribution to Pacific Northwest and modernist architecture. Christiansen designed more than a hundred projects in the region: public schools and gymnasiums, sculptural church spaces, many of the Seattle Center’s 1962 World’s Fair buildings, and the Museum of Flight’s vast glass roof all reflect his expressive ideas. Inspired by Northwest topography and drawn to the region’s mountains and profound natural landscapes, Christiansen employed hyperbolic paraboloid forms, barrel-vault structures, and efficient modular construction to echo and complement the forms he loved in nature. Notably, he became an enthusiastic proponent of using thin shell concrete—the Kingdome being the most prominent example—to create inexpensive, utilitarian space on a large scale. Tyler Sprague places Christiansen within a global cohort of thin shell engineer-designers, exploring the use of a remarkable structural medium known for its minimal use of material, architectually expressive forms, and long-span capability. Examining Christiansen’s creative design and engineering work, Sprague, who interviewed Christiansen extensively, illuminates his legacy of graceful, distinctive concrete architectural forms, highlighting their lasting imprint on the region’s built environment.

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.

Thin-walled structures are designed with advanced numerical analysis techniques and constructed using sophisticated fabrication processes. There are, however, a number of factors that may result in a structure that is not exactly coincident with what was considered during the design calculations. These features may be associated with changes in the properties of the structure, in the geometry, and many others. But even small changes in the structure may sometimes produce significant changes in the response. The present work is intended to introduce professionals and researchers to the effects of imperfections on the stresses in thin-walled structures. The main idea behind the presentation is that small imperfections may introduce changes in the stresses that are nearly equal to the stresses due to the loads. The book is organized into two main parts. The first part (Chapters 1 to 6) covers the techniques for analyzing imperfections. In the second part the emphasis is on applications, which at present may be found scattered throughout many scientific and professional journals. More practical aspects of imperfections may be found in Chapter 12. It is assumed that the reader is familiar with finite element techniques, and with the basics of shell structures.

Fabric-cast concrete involves casting concrete in forms made with flexible formwork. This provides the potential to produce forms that are both structurally efficient and architecturally exciting in a relatively inexpensive and practical manner. By careful shaping of the fabric it is possible to produce complex shapes that would otherwise be difficult and expensive to produce using conventional formwork systems. This book contains six essays that describe the collaboration between the Universities of Edinburgh and East London, together with the Centre for Architectural and Structural Technology (CAST) at the University of Manitoba, in their detailed and practical research into concrete casting and formwork. Richly illustrated with photographs and diagrams and containing new and innovative research this book offers the architect, engineer and student inspiration and technical guidance in this re-emerging material.

Although the disciplines of architecture and structural engineering have both experienced their own historical development, their interaction has resulted in many fascinating and delightful structures. To take this interaction to a higher level, there is a need to stimulate the inventive

and creative design of architectural structures and to persua
Papers from the Fifth International PhD Symposium in Civil Engineering held in Delft 2004, featuring research projects from PhD candidates from twenty-eight countries on current ongoing research in Civil Engineering.
The study ofthree-dimensional continua has been a traditional part of graduate education in solid mechanics for some time. With rational simplifications to the three-dimensional theory of elasticity, the engineering theories of medium-thin plates and of thin shells may be derived and applied to a large class of engi neering structures distinguished by a characteristically small dimension in one direction. Often, these theories are developed somewhat independently due to their distinctive geometrical and load-resistance characteristics. On the other hand, the two systems share a common basis and might be unified under the classification of Surface Structures after the German term Fliichentragwerke. This common basis is fully exploited in this book. A substantial portion of many traditional approaches to this subject has been devoted to constructing classical and approximate solutions to the governing equations of the system in order to proceed with applications. Within the context of analytical, as opposed to numerical, approaches, the limited general ity of many such solutions has been a formidable obstacle to applications involving complex geometry, material properties, and/or loading. It is now relatively routine to obtain computer-based solutions to quite complicated situations. However, the choice of the proper problem to solve through the selection of the mathematical model remains a human rather than a machine task and requires a basis in the theory of the subject.
In recent years knowledge of concrete and concrete structures has increased, as has its applications. New types of concrete challenged scientists and engineers, and ecological constraints encouraged the implementation of life cycle design of concrete structures, moving the focus more and more to maintenance and uprating of structures. And since buildings are not only designed for safety and serviceability, but also for flexibility and adaptability, the design of performance based materials and structures has become more and more important. Tailor Made Concrete Structures. New Solutions for our Society comprises the proceedings of the International fib Symposium 2008 (Amsterdam, 19-22 May 2008), and considers these new perspectives and developments, including sections on new materials (i.e. fire resisting concrete, ultra-high performance fibered concrete, textile reinforced concrete, bacteria-based self healing concrete) and codes for the future (i.e. the American P2P Iniative, fibre-reinforced polymer (FRP) applications in construction, Codes for SFRC Structures). The book includes contributions from leading scientists and professionals in concrete and concrete structures worldwide, and covers: – Life cycle design – Design strategies for the future – Underground structures – Monitoring and Inspection – Diagnosis – Innovative materials – Codes for the future – Modifying and adapting structures – Architectural Concrete – Developing a modern infrastructure – Designing structures against extreme loads – Increasing the speed of construction Tailor Made Concrete Structures. New Solutions for our Society includes the state-of-the-art in research on concrete and concrete structures, and will be invaluable to professionals, structural engineers and scientists.
Since 1997, the Structural Engineers Association of New York has hosted a lecture series in honour of the structural engineer Felix Candela. This book presents all eight lectures in written form for the first time. The lectures cover varying topics related to structural engineering, and have been given by some of the most prominent structural engineers working and teaching today. Each essay is fully illustrated.
This publication presents the perspectives and insights of the world's present-day authorities on bridge aesthetics and design. Bridge engineers and architects representing 16 nations examine and highlight the aesthetic appearance of existing bridges with the goal of improving tomorrow's bridge design. Supplementing the individual papers is a comprehensive bibliography on bridge aesthetics, containing annotated references to more than 250 books, papers, and articles. There are 245 black-and-white photographs and numerous line drawings plus 24 pages of color plates. Author biographical information is provided and an index of bridges and locations is included. Individual entries into the TRIS data base have been made for the 22 papers and the bibliography.
This book reflects and expands on the current trend in the building industry to understand, simulate and ultimately design buildings by taking into consideration the interlinked elements and forces that act on them. Shifting away from the traditional focus, which was exclusively on building tasks, this approach presents new challenges in all areas of the industry, from material and structural to the urban scale. The book presents contributions including research papers and case studies, providing a comprehensive overview of the field as well as perspectives from related disciplines, such as computer science. The chapter authors were invited speakers at the 7th Symposium “Impact: Design With All Senses”, which took place at the University of the Arts in Berlin in September 2019.
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
This authoritative text concentrates on the derivation of simple but reasonably accurate mathematical solutions, and the actual presentation of closed-form results for quantities that are of interest to the designer of shell structures.
The Kingdome, John ("Jack") Christiansen's best-known work, was the largest freestanding concrete dome in the world. Built amid public controversy, the multipurpose arena was designed to stand for a thousand years but was demolished in a great cloud of dust after less than a quarter century. Many know the fate of Seattle's iconic dome, but fewer are familiar with its innovative structural engineer, Jack Christensen (1927-2017), and his significant contribution to Pacific Northwest and modernist architecture. Christiansen designed more than a hundred projects in the region: public schools and gymnasiums, sculptural church spaces, many of the Seattle Center's 1962 World's Fair buildings, and the Museum of Flight's vast glass roof all reflect his expressive ideas. Inspired by Northwest topography and drawn to the region's mountains and profound natural landscapes, Christiansen employed hyperbolic paraboloid forms, barrel-vault structures, and efficient modular construction to echo and complement the forms he loved in nature. Notably, he became an enthusiastic proponent of using thin shell concrete--the Kingdome being the most prominent example--to create inexpensive, utilitarian space on a large scale. Tyler Sprague places Christiansen within a global cohort of thin shell engineer-designers, exploring the use of a remarkable structural medium known for its minimal use of material, architectually expressive forms, and long-span capability. Examining Christiansen's creative design and engineering work, Sprague illuminates Christensen's legacy of graceful, distinctive concrete architectural forms, highlighting their lasting imprint on the region's built environment.