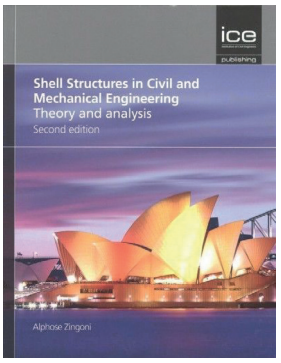
Review

This seminal textbook is an essential – and highly enjoyable – read for any structural engineer involved with the design of shell structures, concludes Tim Ibell.

Shell structures in civil and mechanical engineering: Theory and analysis (2nd ed.)



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It has been such a pleasure to read this book. Shell structures have so much to offer our profession, and this book demonstrates their extraordinary scope of application. It leads the reader rather beautifully through the increasing complexity of applications of shell structures, providing full derivations throughout to problems of real practical importance.

The first edition was published in 1997 and was regarded as a seminal work on shell analysis. Twenty years later, the second edition has appeared as a considerably expanded version. It features 13 chapters, the last three of which are completely new. The first nine chapters retain all the elements that accounted for the success of the first edition, but more importantly, they incorporate aspects of the author's own research over the past 20 years. The result is an extraordinary work that stands out above other books on the subject.

Shells have been extensively studied since the second half of the 19th century, but there are very few books that manage to strike the right balance between mathematical rigour and engineering practicalities. This book does just that. For students, the theory of shells has long had a reputation of being a difficult subject, and for practitioners, shell analysis has always posed many challenges, with designers never too sure whether their results are correct or not. In many aspects, this book hits the right spots. It is rigorous, logical in progression, cognisant of a variety of potential new applications of shells, and a joy to read.

The book adopts a unique strategy that allows simple closed-form solutions to be obtained from complex sets of differential equations, making it very easy for the structural practitioner to obtain the relevant internal shell actions while understanding what is going on, and then design the shell accordingly. It is this feature that distinguishes this book from many others on the subject.

The first chapter gives a fascinating historical perspective of the subject, and explains how shells resist loading. The concepts of 'curvature' and 'surface' are central to the discussion. The membrane hypothesis and its limitations are thoroughly discussed. In a world where material efficiency and sustainability can no longer be ignored, the need for shells that exploit membrane action as much as possible (and that avoid bending) has never been greater. This philosophical chapter is essential reading to students of engineering and architecture alike.

Chapter 2 develops the membrane theory of shells of revolution based on a curvilinear coordinate system, and features ample free-body diagrams to illustrate the equilibrium of actions, and how this ultimately leads to the governing differential equations.

Chapter 3 is an impressive collection of membrane solutions to all sorts of problems. An alternative formulation of the membrane equations based on a Cartesian system of coordinates is also presented. This is extremely useful from a practical point of view, as engineering drawings are usually based on horizontal and vertical dimensions.

Other chapters presenting membrane solutions for shells are Chapter 4 (shells of revolution subject to non-axisymmetric loading), Chapter 9 (cylindrical shells of non-circular cross-section and barrel roofs) and Chapter 10 (shells of arbitrary shape, and elliptic and hyperbolic paraboloids).

Bending theory of shells is generally more complicated than membrane theory. In Chapters 5 and 6, the author skilfully derives the relevant governing equations for cylinders and general shells of revolution respectively; while in Chapters 7 and 8, he presents closed-form solutions for edge effects in pressure vessels, liquid-containment vessels and roof domes.

No treatment on shells would be complete without consideration of buckling, finite-element analysis and design standards. Users of this book will be delighted to see these issues, previously not included, now being addressed in the last three chapters.

The author, a world-renowned authority on analytical shell research, must be congratulated for yet another seminal contribution to the literature. It is a book that every structural engineer and architect must have on their shelf, whether they are already involved with the design of shell structures, or contemplating the use of shells in providing efficient and sustainable solutions to their projects.

The many benchmark solutions that are included in the book make it indispensable to research students involved with the numerical modelling of shells, as well as engineers involved with the development of finite-element software.

Tim Ibell
BSc(Eng), PhD, CEng, FREng, FIStructE, FICE, FHEA
Tim Ibell is Professor of Structural Engineering in the Department of Architecture and Civil Engineering at the University of Bath. He is a Fellow of the Royal Academy of Engineering, and was President of the Institution of Structural Engineers in 2015.