

Preface

Concepts from different fields of mathematics are combined to obtain powerful tools and algorithms for efficient analysis of structures. Many structures are either symmetric or regular, and some others can be made symmetric or regular by addition or elimination of a small number of nodes and/or members. For these structures, the matrices have canonical forms and the corresponding equations can easily be solved using some concepts from matrix algebra, linear algebra, graph theory, and group theory.

The methods and algorithms developed in this book make the analysis of large-scale structures possible by reducing their computational time and storage, fulfilling the requirements for a faster analysis of complex systems. The power of the presented methods becomes more evident when analysis needs to be repeated many times, as is the case with optimum design of structures utilizing different meta-heuristic algorithms.

The author has been involved in various developments and applications of graph theory in the last four decades. The present book contains part of this research, suitable for matrix analysis of symmetric and regular structures.

Methods of this book can efficiently be used in computer-aided analysis and design, and commercial software developments. Though these methods are mainly illustrated through skeletal structures, some continuum models have also been included to show the generality of the algorithms.

The present book is intended to serve as a textbook for the optimal analysis of large-scale structures utilising concepts of symmetry and regularity. Special attention is focused on efficient methods for eigensolution of matrices involved in static, dynamic and stability analyses of symmetric and regular structures, or those general structures containing such components. Powerful tools are also developed for configuration processing, which is an important issue in the analysis and design of space structures and finite element models.

In Chap. 1, an introduction is provided to the definitions and basic concepts of symmetry and regularity. Chapter 2 presents a background of the mathematics extensively used in this book, consisting of definitions from graph theory and algebraic graph theory. Standard definitions of graph products and their extensions

are provided in Chap. 3 and utilised in the important topic of configuration processing of structures. Basic definitions of canonical forms and their properties involved in symmetric and regular structures are discussed in Chap. 4. The canonical forms are applied to two important combinatorial optimisation problems consisting of nodal ordering to improve the patterns of the structural matrices, and graph partitioning for use in parallel computing in Chap. 5. Chapter 6 utilises graph products for similar purposes as in the previous chapter. Canonical forms have important applications in structural mechanics. These applications are discussed in Chap. 7. Graph products make the efficient analysis of regular structures feasible, providing closed-form solutions for this purpose as discussed in Chap. 8. Some structural models are not regular but can be made regular by adding and/or deleting of some members. Chapter 9 contains efficient methods for eigensolution and analysis of such structures using direct methods. Iterative methods for similar purposes are presented in Chap. 10. Group theory is known as the language of symmetry. Basic concepts and applications of group theory are discussed in Chap. 11. Finally, the interrelation of canonical forms, graph products and group theory and their applications to the analysis of symmetric-regular structures are presented in Chap. 12.

I would like to take this opportunity to acknowledge a deep sense of gratitude to a number of colleagues and friends who in different ways have helped in the preparation of this book. Mr. J.C. de C. Henderson, formerly of Imperial College of Science and Technology, first introduced me to the subject with most stimulating discussions on various aspects of topology and combinatorial mathematics. Professor F. Ziegler encouraged and supported me to write this book. My special thanks are due to Mrs. Silvia Schilgerius, the senior editor of the applied sciences of Springer, for her constructive comments, editing and unfailing kindness in the course of the preparation of this book. My sincere appreciation is extended to our Springer colleagues Mr. C. Bachem and Ms. G. Umamaheswari.

I would like to thank my former Ph.D. and M.Sc. students, Dr. H. Rahami, Dr. H. Fazli, Dr. M. Nikbakht, Dr. K. Koohestani, Dr. M.A. Sayarinejad, Dr. B. Salimbahrami, Dr. L. Shahryari, Dr. M. Nouri, Dr. H.A. Rahimi Bonderabady, Mr. H. Mehanpour, Mr. F. Nemati and Mr. S. Najafian and Mr. S. Beheshti, for permitting me to use our joint papers and for their help in various stages of writing this book. I would like to thank the publishers who permitted some of our papers to be utilised in the preparation of this book, consisting of Springer Verlag, John Wiley and Sons, and Elsevier.

My warmest gratitude is due to my wife, Mrs. Leopoldine Kaveh, for her continued support in the course of preparing this book and my son, Mr. Babak Kaveh, for proof reading.

Every effort has been made to render the book error free. However, the author would appreciate any remaining errors being brought to his attention through the following email address: alikhavah@iust.ac.ir.

Optimal Analysis of Structures by Concepts of Symmetry
and Regularity

Kaveh, A.

2013, XVI, 463 p., Hardcover

ISBN: 978-3-7091-1564-0