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# **DESIGN OF STEEL STRUCTURES**

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# **DESIGN OF STEEL STRUCTURES**

**Eurocode 3: Design of steel structures  
Part 1-1 – General rules and rules for buildings**

**Luís Simões da Silva  
Rui Simões  
Helena Gervásio**



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## FOREWORD

The development program for the design manuals of the European Convention for Constructional Steelwork (ECCS) represents a major effort for the steel construction industry and the engineering profession in Europe. Conceived by the ECCS Technical Activities Board under the leadership of its chairman, Professor Luis Simões da Silva, the manuals are being prepared in close agreement with the final stages of Eurocode 3 and its national Annexes. The scope of the development effort is vast, and reflects a unique undertaking in the world.

The publication of the first of the manuals, *Design of Steel Structures*, is a signal achievement which heralds the successful completion of the Eurocode 3 work and brings it directly to the designers who will implement the actual use of the code. As such, the book is more than a manual – it is a major textbook that details the fundamental concepts of the code and their practical application. It is a unique publication for a major construction market.

Following a discussion of the Eurocode 3 basis of design, including the principles of reliability management and the limit state approach, the steel material standards and their use under Eurocode 3 are detailed. Structural analysis and modeling are presented in a chapter that will assist the design engineer in the first stages of a design project. This is followed by a major chapter that provides the design criteria and approaches for the various types of structural members. The theories of behavior and strength are closely tied to the Eurocode requirements, making for a unique presentation of theory into practice. The following chapters expand on the principles and applications of elastic and plastic design of steel structures.

The many design examples that are presented throughout the book represent a significant part of the manual. These will be especially well received by the design profession. Without a doubt, the examples will facilitate the acceptance of the code and provide for a smooth transition from earlier national codes to the Eurocode.

**Reidar Bjorhovde**  
Member, ECCS Editorial Board

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## FOREWORD

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## PREFACE

The General rules and rules for buildings of part 1-1 of Eurocode 3 constitute the core of the code procedures for the design of steel structures. They contain the basic guidance for structural modeling and analysis of steel frameworks and the rules for the evaluation of the resistance of structural members and components subject to different loading conditions.

According to the objectives of the ECCS Eurocode Design Manuals, it is the objective of this book to provide mix of “light” theoretical background, explanation of the code prescriptions and detailed design examples. Consequently, this book is more than a manual: it provides an all-in-one source for an explanation of the theoretical concepts behind the code and detailed design examples that try to reproduce real design situations instead of the usually simplified examples that are found in most textbooks.

This book evolved from the experience of teaching Steel Structures according to ENV 1993-1-1 since 1993. It further benefited from the participation in Technical Committees TC8 and TC10 of ECCS where the background and the applicability of the various clauses of EN 1993-1-1 was continuously questioned. This book covers exclusively part 1-1 of Eurocode 3 because of the required level of detail. Forthcoming volumes discuss and apply most of the additional parts of Eurocode 3 using a consistent format.

Chapter 1 introduces general aspects such as the basis of design, material properties and geometric characteristics and tolerances, corresponding to chapters 1 to 4 and chapter 7 of EN 1993-1-1. It highlights the important topics that are required in the design of steel structures. Structural analysis is discussed in chapter 2, including structural modelling, global analysis and classification of cross sections, covering chapter 5 of EN 1993-1-1. The design of steel members subjected to various types of internal force (tension, bending and shear, compression and torsion) and their combinations is described in chapter 3, corresponding to chapter 6 of EN 1993-1-1. Chapter 4 presents the design of steel structures using 3D elastic analysis based on

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## PREFACE

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the case study of a real building. Finally, chapter 5 discusses plastic design, using a pitched-roof industrial building to exemplify all relevant aspects.

Furthermore, the design examples provided in this book are chosen from real design cases. Two complete design examples are presented: i) a braced steel-framed building; and ii) a pitched-roof industrial building. The chosen design approach tries to reproduce, as much as possible, real design practice instead of more academic approaches that often only deal with parts of the design process. This means that the design examples start by quantifying the actions. They then progress in a detailed step-by-step manner to global analysis and individual member verifications. The design tools currently available and adopted in most design offices are based on software for 3D analysis. Consequently, the design example for multi-storey buildings is analysed as a 3D structure, all subsequent checks being consistent with this approach. This is by no means a straightforward implementation, since most global stability verifications were developed and validated for 2D structures. The authors are indebted to Prof. Reidar Bjorhovde who carried out a detailed technical review of the manuscript and provided many valuable comments and suggestions. Warm thanks to Prof. David Anderson who carried out an additional detailed revision of the book and also made sure that the English language was properly used. Further thanks to Liliana Marques and José Alexandre Henriques, PhD students at the University of Coimbra, for the help with the design examples of chapter 4. Additional thanks to Prof. Tiago Abecasis who spotted innumerable “bugs” in the text. Finally, thanks to Filipe Dias and the staff of cmm and ECCS for all the editorial and typesetting work, making it possible to bring to an end two years of work in this project.

**Luís Simões da Silva**

**Rui Simões**

**Helena Gervásio**

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