Book Review: Fire Performance of Thin-Walled Steel Structures by Yong Wang, Mahen Mahendran, and Ashkan Shahbazian

CRC Press, Taylor & Francis Group, LLC, Boca Raton, FL, USA, 2020. 110 pp. ISBN 9781138540859 (hardback), ISBN 9781351011815 (ebook)

Thomas Gernay, Department of Civil and Systems Engineering, Johns Hopkins University, Baltimore, MD, USA*

The field of structural fire engineering is rapidly advancing. The emergence of calculation-based methods for fire design provides opportunities for engineers and designers to achieve the desired fire performance of structures while reducing the need for expensive fire resistance testing of the individual components. Meanwhile, thin-walled steel structures are increasingly used in building construction, primarily due to their high strength-to-weight ratio and ease of construction. Thin-walled steel, also referred to as light gauge steel or cold-formed steel, is used to form both load-bearing and non-load-bearing elements and structural systems. Owing to flexibility of the manufacturing methods, a large variety of thin-walled steel products are being made available to designers. In this context, this publication is the first book, to the reviewer's knowledge, that focuses on the calculation-based design of thin-walled steel structures under fire.

The authors have worked extensively in the field of performance-based fire design and thin-walled structures. Professor Wang leads the Structural Resilience research group at the University of Manchester and has authored two famous books on structural fire engineering. Professor Mahendran leads the Wind and Fire research lab at Queensland University of Technology and his research on the fire behavior of thin-walled steel structures has been widely cited in the literature and adopted in design standards. Dr. Shahbazian is an adjunct assistant professor at the University of Coimbra with expertise in thermal-structural analysis of thin-walled steel panels under fire. As the authors state in their "Preface", their objective with this book was to provide an authoritative account of the latest developments in the different aspects of the subject matter. The described calculation methods can offer more flexibility and opportunity for optimization in the design

*Correspondence should be addressed to: Thomas Gernay, E-mail: tgernay@jhu.edu

compared with restrictive prescriptive guidelines. Throughout the book, the authors provide extensive references for those wishing to obtain more in-depth knowledge, including references to both the current design standards and to the scientific literature. This book will be useful to students and researchers interested in this field. It will also be very valuable to structural and fire protection engineers who want to apply calculation-based methods to design thin-walled steel structures under fire.

The book is divided into six chapters. This organization guides the reader through the main topics pertaining to fire performance of thin-walled steel structures, including fire resistance testing, numerical modeling of heat transfer and mechanical response, properties of cold-formed steels and fire protection materials at elevated temperature, and calculation-based methods to determine the load-bearing capacity of thin-walled steel structures. The book is easily navigable. It is a relatively short publication, based on the CRC Focus book format, which aims at presenting a complete treatment of this niche topic in a straightforward and tightly focused manner. With this publication, the authors provide an excellent resource that covers the fundamental aspects of the fire performance and fire resistant design of thin-walled steel structures.

The first two chapters are devoted to an introduction to thin-walled steel construction and fire safety requirements. Starting with basic notions, the general fire safety requirements of buildings are presented, then their implications for thin-walled steel structures are discussed. The chapters provide useful information to introduce the reader to the methods of evaluating fire resistance of thin-walled steel structures. They also include a good introduction to the common products and recent advances in the cold-formed steel industry. The effects of key parameters on the fire performance of thin-walled steel construction systems are briefly explained, which will be explored further in the next chapters. The introductory chapter also serves to specify the scope of the book. The authors' main focus is on simplified heat transfer and load-carrying capacity models to address the insulation and load-bearing fire resistance requirements. As stated by the authors, these methods are best suited for everyday design, as they overcome the limitations of standard fire resistance testing while not requiring the level of specialist knowledge demanded by finite element modeling. Overall, the first two chapters manage to concisely and efficiently inform the reader unfamiliar with the topic on the basics of fire safety requirements and thin-walled steel construction.

Chapter 3 discusses standard fire resistance testing of thin-walled steel construction. The basics of standard fire resistance testing are briefly presented. Then, the fire resistance characteristics of thin-walled steel construction elements are discussed, with a focus on wall and floor systems. Particular emphasis is put on the effect of the complex detailing associated with the repetitive framing and presence of fire protection material on fire performance. The reader will find a comprehensive review of standard fire tests conducted over the last 25 years, with detailed observations on the failure modes and the behavior of the plasterboards and cavity insulation, amongst other points.

Chapter 4 presents the main features of numerical models for heat transfer analysis of thin-walled structures. The determination of the thermal exposure and

heat transfer response of thin-walled structures is necessary to obtain their temperatures, in order to evaluate their fire performance. The authors provide an overview of the fire models that are most commonly adopted, followed by a discussion of heat transfer modeling. The chapter also provides a simplified procedure, suitable for implementation in a spreadsheet, to calculate temperatures in panel members exposed to fire on one side. Only brief guidance is given on the numerical modeling of the mechanical response.

Chapter 5 addresses the elevated temperature properties of the materials. This issue is of particular importance with thin-walled structures because, first, cold-formed steel exhibits a mechanical response to elevated temperature distinct from that of hot-rolled steel, and second, thin-walled steel construction systems rely on board and insulation materials which thermal properties greatly influence the temperatures attained in the protected steel sections. The chapter provides a review of data on both mechanical properties of cold-formed steels and thermal properties of fire protection materials at elevated temperature. The reader will find extensive references as well as tables listing the most important temperature-dependent properties.

The last chapter presents simplified calculation methods for thin-walled steel members with uniform and non-uniform temperature distribution in the cross-section. Reference to the current design codes and standards are made, notably the Eurocode EN1993-1-2, the Australian/New Zealand standard AS/NZS 4600:2018 (which includes a performance-based design method for thin-walled steel members in fire), and the AISI S100-16 (which direct strength method at ambient temperature is discussed as it can be adapted to elevated temperature in some applications). As pointed out by the authors, thin-walled steel structures have non-uniform temperature distributions and exhibit different modes of buckling, resulting in a complex fire behavior for which there is still no universally accepted design calculation method. However, they show that the recent advances in the field and the methods provided in current standards can form the basis to robust and accurate design calculation methods for a range of applications. An illustrative design example is provided to help designers implement the direct strength method at elevated temperature.

In summary, *Fire Performance of Thin-Walled Steel Structures* is a valuable reference book for researchers and practitioners interested in understanding the behavior of thin-walled steel structures in fire and the rationale behind calculation-based methods for design of such structures under fire. It is highly recommended. As the first book devoted to this fast-growing topic, it manages to compile, in a clear and concise manner, a number of subjects which understanding is fundamental to approach the fire design of thin-walled structures.