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Book Review

Review of History of the Theory of Structures, K.E. Kurrer. Ernst & Sohn Verlag fuer Architektur und technische Wissenschaften, GmbH & Co. KG (A Wiley Company) (2008). 848 pp., ISBN:978-3-433-01838-9

To read this prodigious work is to take a journey in space and time. With a reference to the influence of Aristotle, this history basically starts with the enlightenment of science, which can be said to have started with Galileo. It then traces the development of understanding the science involved in the design of major structures to the modern day through the author's description of four periods, Preparatory, 1575–1825, Discipline Formation, 1825–1900, Consolidation, 1900–1950, and Integration, 1950 to the present. The first three are broken down into separate phases. The foundation of any science, and in this case, the science of structural design, is mathematics, which is the expression in symbols to describe models created by designers to represent their intended creations. Consequently, the book traces the evolution of mathematics used to define the characteristics of a proposed structure, and how they are applied by practical engineers. Ultimately, the essential characteristics are internal loads in structures induced by the external loads of the weights of structures themselves (dead weight or dead load or, as expressed in the book, self-weight), the external loads of items traveling over or located within structures, and the environmental effects of wind, snow, and temperature. The author also describes the development of understanding of strength of materials and structural stability to determine the ability of structures to maintain integrity. He shows how it is necessary to determine the deformation characteristics of structures, not only to resolve indeterminacies in their support systems, but also to insure proper functioning of structures themselves.

The title *The History of the Theory of Structures* led me to expect to read the story of the development of analytical methods for structural design. But "theory" is used in a much more general way in this book, because there are many descriptions of design configurations and methods of construction. It is more than a description of advances in technology, since Dr. Kurrer expresses many ideas in a philosophical, even poetic, manner.

The book contains a wealth of information and will be an important reference text for engineers and historians who wish to understand or write about any specific aspect of the history of structures. Especially, those who teach this subject should find this book to be a rich source of information. It does much more than to discuss the science, however, because we meet the major figures who played significant roles and we learn much about them personally. Pictures and biographies of the key figures are presented at the end, together with an excellent index and a huge wealth of references. Students in the US learn about the major figures, such as Castigliano, Cauchy, d'Alembert, Euler, Hooke, Lagrange, Mohr, Navier, and Rankine, but the vast majority of the names are not well known here, and it is illuminating to read about their important contributions. This reviewer was a student of Eric Reissner at MIT in 1946, before he had the beard shown on page 579, and once saw his father, Hans Reissner, at the MIT swimming pool! Both made significant contributions, as described in Kurrer's book.

This history is mainly about achievements in the structures subspecialty of civil engineering, although the author regards structural engineering as a separate field. It includes developments in aeronautical structures toward the end, but the main emphasis is on heavy structures, bridges, buildings, and construction tools, such as cranes. There are descriptions of them in various countries, mostly in Europe; however, the central theme is about activities in Germany throughout the 1800s and 1900s. Notwithstanding the length of the book, I would have liked to have seen more discussion about cable-stayed bridges, the design configuration of many long bridges today, such as the Oresund Bridge between Denmark and Sweden. In addition, with the bias of having been a specialist in structural dynamics, I believe that more attention should have been paid to the problems of dynamics in large construction. The collapse of the Tacoma Narrows Bridge was discussed, correctly describing it as an aeroelastic failure, and that led to the requirement for flutter analyses of all suspension bridges thereafter. Another aspect of the influence of dynamics on structural analysis is the fact that an accurate depiction of the stiffness of a structure is vital for dynamicists, whereas strength is the goal for structural designers. The latter therefore make conservative assumptions about load paths, which tend to lead to high estimates of stiffness, these being unconservative for dynamicists. This factor was a driving force behind the development of direct-stiffness methods of analysis in the aircraft industry, leading to the development of finite-element methods, now used by both civil and aeronautical engineers. The history and the essence of finite-element methods are covered extensively in this book.

This book is not easy to read, although surely worth the effort. I find it necessary to make some comments about language. Dr. K.-E. Kurrer wrote the volume originally in German, updated it, and had it translated into English. The fact that the spelling corresponds to British practice, and that the metric system is used in many places, is not a big problem for American readers, who have become familiar with those practices. More of a problem is the use of many very literary words, which are rarely, if ever, used in the United States. There are also many complex philosophical observations about the mental processes that led to the scientific achievements. These make for "heavy" reading. Another aspect of the language issue is that the character of the manner of expression in the original language affects the translation. Although the translator tried his best to carry over the thought of the author, it did not come out the way it would have been written by a native English-speaking author. I found myself looking up many words in my German–English dictionary to get a better feel for the original thought. Also, words in one language

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span several meanings of another. An example is the word "Konstruktion" in German, which has more the meaning of "design" than "construction," where "Bau" refers to construction. But the translator has used "construction" in many places where "design" probably should have been used. Some comment should also be made about the format of the book, which is unusual. The text is confined to about two-thirds of the normal width and the majority of the figures and pictures are small enough to be placed in the enlarged margin. This locates them close to the text that refers to them. Although it makes for more pages, this is a very clever approach.

The History of the Theory of Structures should be a good addition to the technical and philosophical libraries of schools and teachers of the subject. Any structural engineer curious about the history of his/her field will find it worthwhile to peruse this tome. Kurrer ends his discourse with a plea to introduce the ideas of this book into the teaching of civil engineers with an emphasis that is really a systems approach to design. I hope that some American writers use this material as the basis for specialized discussions of particular aspects of the history as they apply to developments in this country.

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