Review of *The History of the Theory of Structure, from Arch Analysis to Computational Mechanics* by Karl-Eugen Kurrer

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Harry H. West, Ph.D., P.E.
Professor Emeritus of Civil Engineering, The Pennsylvania State University. E-mail: hhw@psu.edu

In the preface of the first German edition of *The History of the Theory of Structures, from Arch Analysis to Computational Mechanics*, Karl-Eugen Kurrer refers to his long-term interest in the history of structural analysis and how his original effort was to "add substance to the unmasking and discovery of the logical nature of structural analysis." He goes on to tell how gradually his "collection of data on the history of structural analysis—covering the didactics, theory of science, history of engineering science and construction engineering, cultural and historical aspects, aesthetics, biographical and bibliographical information—painted a picture of that history." The "picture" painted by Kurren's data is transformed by his masterful presentation of it. He uses the specific components of his data collection as the "seven gates to the knowledge of the history of the theory of structures" to develop an exhaustively comprehensive survey of the field of structural analysis from its roots in antiquity to the full-blown discipline that it has become. It is a fascinating read that will help both the student and the practicing structural engineer to more fully appreciate the discipline.

The author introduces a series of time periods that he further subdivides into time phases, to serve as a time line to which he refers throughout the book. He very effectively uses this framework as he proceeds from Galileo's *Dialogue* to the early applications of mathematics to construction problems, the developments of the classical methods of analysis along with solution techniques, the introduction of computer-friendly methods that eventually lead to finite element analysis, and finally the diffusion of structural engineering as a process within a system in which actual calculations are no longer the focus.

Kurrer probes the nature of engineering and seeks to establish that the theory of structures is indeed a fundamental engineering science discipline. His discussion of the connection between philosophy and the theory of structures is interesting, and his use of the early theory and practice of suspension bridges as an example of the cooperative relationship between natural-science based engineering and engineering-based natural science is insightful.

The author's personal explorations into the "mysteries" of the masonry arch are thorough. He then effectively traces the progress from early empiricism to elastic theory, ultimate load theory, photoelastic studies, and finite element methods.

During the late 1800s and beyond, the focus in the development of the theory of structures somewhat mirrored the demands related to specific structural systems and the emergence of the building materials of the respective times. The author traces these developments with skill as he considers structures of iron and steel, composite steel-concrete structures, reinforced concrete, and prestressed concrete. Along the way, he intertwines crucial theoretical developments, such as torsion theory, buckling, and plastic design, and the applications to specific structural systems, such as cranes and spatial frameworks.

The book offers a comprehensive treatment of the transition from the classical to the modern theory of structures. Kurrer follows the path from the introduction of mathematical symbols in structural theory to modern computational mechanics. First, the force method is discussed in relationship to statically indeterminate structures, and then he moves on to the introduction of the displacement method and the emergence of matrix methods of structural analysis. This, of course, set the stage for computer-based structural analysis, which in turn led to finite element methods and eventually to the inclusion of nonlinear analysis. The description of the advances in sophistication in analysis techniques as applied to increasingly complex applications, from the early matrix methods to present-day finite element methods, is very well done.

The author concludes his work by offering some thoughtful perspectives on the theory of structures. He expresses concern about the present-day reduction of the structural engineer to a mere manipulator of symbols. In contrast, the author attempts to create an "inherent aesthetic value for structural calculation," and he surveys some computer-assisted graphical analysis techniques. He speaks of the importance of aesthetics in structures. He expresses concern about the animosity that exists between architects and structural engineers and the ways in which computer-based graphical analysis could help to reduce that tension. In the end, Kurrer presents an innovative plan for the historico-genetic teaching of the theory of structures, and he outlines a four-step model for the content of such an approach that would provide an integrated course of study in architecture and structural engineering.

At the end of the book, there is a marvelous collection of 175 brief biographies of the leading personalities in the development of structural engineering, as well as structural mechanics. As is true of any collection of this type, one will always find that a favorite person is missing, but Kurrer's selection most certainly does not include anyone who does not deserve to be included. In addition, an exhaustive bibliography is provided.

Kurrer's book is truly a masterpiece. In the 800-plus pages, one finds no end of new and interesting pieces of information that contribute to the history of the theory of structures. This being so, it seems almost inappropriate to cite what appear to be exclusions. The work focuses on European contributions to the development of structural theory, and it is most certainly true that Europe has been the seat of much of what we know regarding the theory of structures. Yet, it must be said that the author fails to note some important contributions made in other parts of the world. For example, I find no mention of the so-called Great Stone Bridge—or the An Gi Bridge—in northern China. This segmental arch, constructed in A.D. 610, predates anything comparable in the West by 700 years. I would also have expected some mention of the Quebec Bridge failure and the stability issues related to that event. And, as an American reviewer, I find it surprising that Othmar Ammann, the most famous of all American bridge engineers, is mentioned only tangentially in the bibliography of David Steinman, and that James Eads and his St. Louis bridge are not mentioned at all. These issues are minor ones that relate to the reviewer's bias toward bridge engineering.

It is recognized that the emphasis is on the development of structural theory; however, the author does include construction engineering among his "seven gates," and he includes several construction-related applications. This being the case, I would have expected some mention of the unique analysis/design/construction issues of high-rise buildings, shell structures, and cable-stayed bridges.

But obviously, not everything can be included, and none of these observations is meant to detract from Kurrer's outstanding treatise on the history of the theory of structures. Such an effort could only have been undertaken by someone with extraordinary knowledge of the discipline; and the revised, expanded, and updated English version provides a valuable resource for the structural engineering community.