The History of the Theory of Structures: from Arch Analysis to Computational Mechanics

by Karl-Eugen Kurrer

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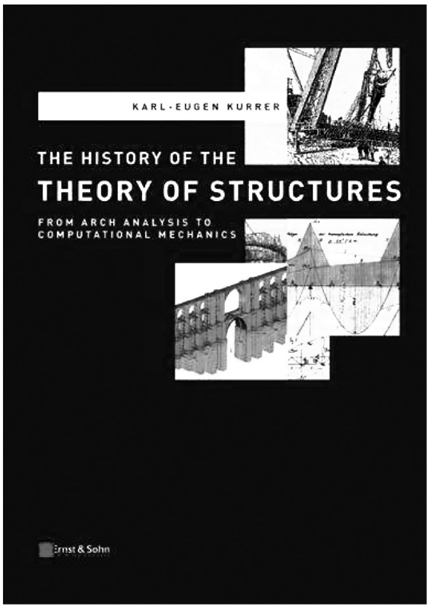

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This substantial volume is at once an English version of the author's "Geschichte der Baustatik" (Ernst & Sohn, 2002) and a significantly expanded second edition, making it the most comprehensive book on the subject in any language. As well as dealing fully with the origins and development of mathematical methods underlying structural analysis, the book also covers many aspects of the wider context within which structural science was developed, especially the research and teaching undertaken in many institutions.

The structure of the book makes it a joy to read, for it avoids the sequential approach taken in many subject histories, in favour of a thematic approach which allows the reader to follow the key issues in depth without being sidetracked by developments in unrelated fields. The author also provides a well-balanced narrative of mathematical details, practical engineering, and the people themselves involved with various aspects of the history of structural theory.

Kurrer identifies four phases of the historical development of his enormous subject - the Preparatory Period (1575–1825); the Discipline Formation Period (1825–1900); the Consolidation Period (1900–1950) and the Integration Period (1950 until today). However, the individual chapters of the book follow developments of structural themes that cross these implied time boundaries, and create a richly-woven tapestry.

Kurrer begins with eleven introductory essays giving an multifaceted view of his subject: *What is structural analysis?; From the lever to the truss; The development of higher engineering education; Insights into bridge-building and theory of structures in the 19th century; The industrialisation of steel bridge building between 1850 and 1900; Influence lines; The beam on elastic supports; The displacement method; Second-order theory; The ultimate load method; and Structural law - Static law - Formation law.*

The book continues with chapters on the emergence of the fundamental disciplines of structural science - the theory of structures, strength of materials and applied mechanics - in the Preparatory Period, during which statical models were developed to explain the stability and collapse of masonry arches and vaults, and the behaviour of beams and arches of timber and wrought iron was represented using elastic models. Following chapters deal in great detail with the appearance and continuing development of many methods for analysis and design - for structural steelwork, spatial frameworks, reinforced concrete, and the analytical methods suited to processing by computers, including matrix methods and the Finite Element Method.

The final two chapters of the book are fascinating essays that approach the subject from altogether different viewpoints. The first is a discussion of twelve scientific controversies that arose at different times between rival academics - including the dispute in the 1740s surrounding the dome of St Peters, the controversy about graphical and algebraic analysis of structures in the 1860s, the controversy between the joint founders of modern soil mechanics, Karl Terzaghi and Paul Fillunger, regarding the consolidation of porous soils, and the rivalry between the advocates of elastic and plastic analysis of structures in the 1960s. The final chapter looks at a number of milestones in the recurring debates about the aesthetics of structures and different approaches to teaching the theory of structures. The book concludes with 175 short biographies of principal engineers and academics, and a bibliography occupying over fifty pages.

While Kurrer covers most strands of his subject, two important aspects of the theory of structures that are overlooked are worth mentioning. One is the use of non-dimensional constants to interpret the results of tests on scale models enabled the analysis and design of structures such as shells and gridshells whose behaviour was too complex for analysis by conventional means. This approach, pioneered notably by Torroja and Nervi, was developed in the 1930s and widely used in the 1950s and '60s before computers became easily available. Also largely absent from the book is the theme of lightweight cable net and membrane structures, first developed by Frei Otto and his colleagues in the 1950s.

Kurrer's book (almost inevitably) presents a view of the subject through German eyes and the contributions of some French and British names is given less prominence that they receive at the hands of historians in those countries - the work on hypar shells by Bernard Lafaille and on tensile structures by René Sarger in France, for example, and the immense contribution to developing the Finite Element Method by Olek Zienkiewicz in Britain. Such under-emphasis, however, is more than outweighed by the enormous wealth of information about the work of the great engineers and scientists from German speaking lands, many of whom are hardly known outside these countries - August Föppl, Franz Joseph Gerstner, August Hertwig, Emil Mörsch, Hubert Rüsch and Johann Schwedler, to name just a few. One name entirely new to me was Konrad Zuse who, in 1936, conceived "calculating machines" controlled by a "computer plan" fed with commands from a punched tape.

Kurrer's achievement in compiling this book is colossal, and I commend it to anyone interested in the subject. It will, for a long time, stand well along side the other classics of the field - Timoshenko's "History of Strength of Materials", and Eduardo Benvenuto's "Introduction to the History of Structural Mechanics".

Bill Addis is a consulting engineer and author of "Building: 3000 years of design, engineering and construction" (London, Phaidon, 2007).