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Book review

The History of the Theory of Structures. From Arch Analysis to Computational Mechanics, K.-E. Kurrer, Ernst & Sohn, Berlin, 848 pp., 667 Figures, Hardcover 17 × 24 cm, ISBN: 978-3-433-01838-5

What is the theory of structures? There is no single term that expresses comprehensively the meaning of theory of structures. It covers mechanics, structural analysis and applied mathematics, and also the intuition and synthesis necessary to create a loadbearing structure. The title of the book also contains the word "history". Readers that expect to find a deep historical treatise on the subject will not be disappointed – and they will also find much more.

The author introduces the history with "11 introductory essays". It starts with the preparatory period (1575–1825), when empirical knowledge prevailed in the design of buildings and structures. Names like Galileo, Hooke, Bernoulli, Euler and Coulomb are representative of this period. This is followed by the discipline-formation period (1825–1900), when Navier introduced the bending theory of structures, Culmann developed graphical statics and Mohr founded, with others, the methods of strength of materials. Then comes the consolidation period (1900–1950), with Cross, who developed the iterative method of calculating statically indeterminate systems, and the computers invented by Zuse. The integration period (1950 to date) follows, in which the development of the method of finite elements was the most notable achievement; it is directly linked to the use of the computer and is used nowadays in all fields of structural analysis (buildings, civil engineering structures, aircrafts, ships, etc.). The "11 introductory essays" cover aspects such as the principle of virtual forces, the education of engineers in France, Germany, Austria, Russia and the United States, the industrialisation of bridge-building and the ultimate load method, to mention just a few. All statements are exemplified by famous structures.

After this concise and chronological chapter, 10 more thematic chapters follow. The first one is called "The first fundamental engineering science disciplines: theory of structures and applied mechanics". This conceptual chapter describes numerous attempts to define the meaning of engineering science in a fundamental and, often, philosophical way. Three chapters are devoted to structures made of specific construction materials such as stone and masonry, iron and steel, and reinforced concrete. The chapter "From masonry arch to elastic arch" is a thorough discourse on the equilibrium of arches made of a material with zero tensile strength to arches with tensile strength. If contains reflections on the line of thrust, the ultimate load approach and collapse mechanisms, all illustrated with practical examples. The chapter "From construction with iron to modern structural steelwork" is a compendium of iron structures and the theories and experiments behind them; it closes with modern lightweight steel construction. The chapter on reinforced concrete is entitled "Reinforced concrete's influence on theory of structures". It starts with the early work of Monier and then systematically develops the analytical methods for bending, shear and torsion. Structural elements such as beams and columns, plates and shells are dealt with here. The principles of prestressing and post-tensioning are described as well as the calculation of the service limit state and the ultimate limit state.

Between the materials-oriented chapters there are six detailed chapters dealing with the development of the theory of structures, recalling the steps of the introduction. The beginnings are discussed, the formation of the disciplines, the expansion into three dimensions, i.e. the spatial framework. The chapter "From classical to modern theory of structures" is dedicated to the development of the theories of elasticity and plasticity, which led to the computer-based method of finite elements and what is now called computational mechanics. The chapter provides a thorough overview, from the beginnings to the latest developments. The chapter "Twelve scientific controversies in mechanics and theory of structures" shows how theories emerge and give rise to heated debates between scientists – even with fatal consequences (Fillunger). Later, as theories progress, so the differences sometimes evaporate. The last chapter delves into questions about the relationship between engineer and architect and the aesthetics of structures as well as engineering education in a holistic way. The book closes with curricula vitae of 175 prominent scientists and engineers.

K.-E. Kurrer's book is a comprehensive and ambitious treatise on the theories that are used to analyse and design structures – from the earliest days (Archimedes' lever principle) to the present (finite element method). It treats the subjects partly chronologically and partly systematically. One can read the individual chapters in isolation and still get a complete picture of the material of interest. The book is well illustrated with pictures, graphs, historical drawings and sketches, which makes for entertaining reading. It contains a wealth of information and is therefore ideal as a textbook for historians, especially those interested in the history of technology, but also professional engineers and graduate students of engineering and art history. It is a must for libraries and engineering departments.

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