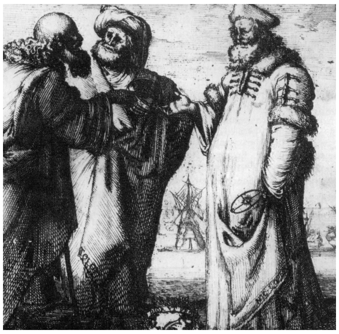
“To-day is the result of yesterday.
We must find out what the former would ere
we can find what it is the latter will have.”

Heinrich Heine, *French Affairs* (trans. C. G. Leland, 1893, vol. I, p. 158)



Chapter 1

The tasks and aims of a historical study of the theory of structures

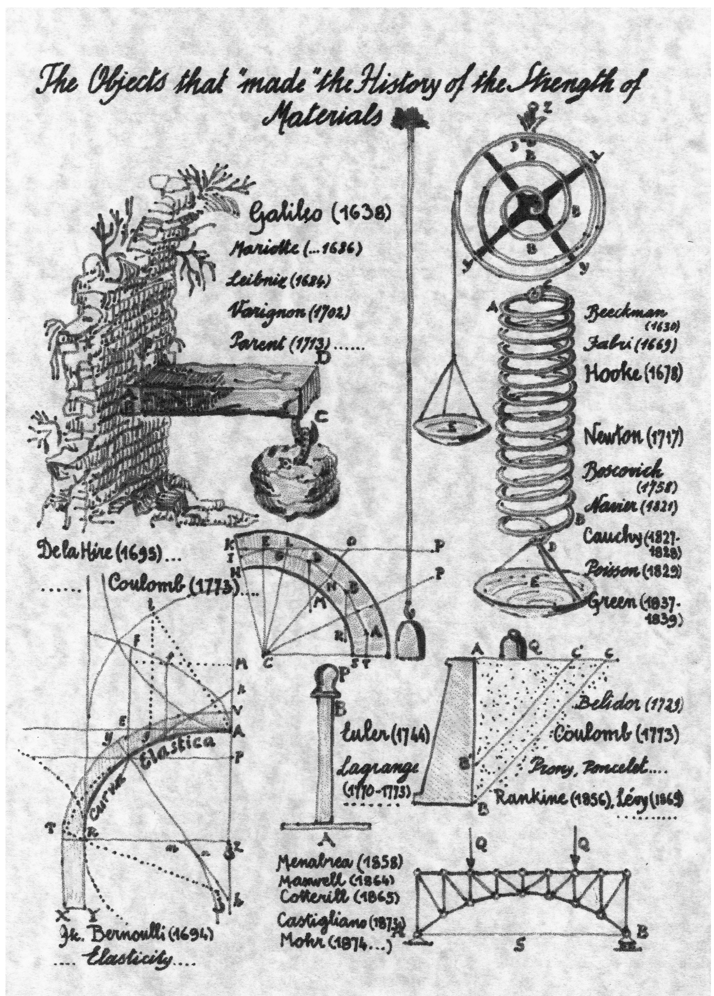


FIGURE 1-1
Drawing by Edoardo Benvenuto

Until the 1990s, the history of theory of structures (Fig. 1-1) attracted only marginal interest from historians. At conferences dealing with the history of science and technology, but also in relevant journals and other publications, the interested reader could find only isolated papers investigating the origins, the chronology, the cultural involvement and the social significance of theory of structures. This gap in our awareness of the history of theory of structures has a passive character; most observers still assume that the stability of structures is guaranteed a priori, that, so to speak, structural analysis wisdom is intrinsic to the structure, is absorbed by it, indeed disappears, never to be seen again. This is not a suppressive act on the part of the observer, instead is due to the nature of building itself – theory of structures had appeared at the start of the Industrial Revolution, claiming to be a "mechanics derived from the nature of building itself" [Gerstner, 1789, p. 4].

Only in the event of failure are the formers of public opinion reminded of structural analysis. Therefore, the historical development of theory of structures followed in the historical footsteps of modern building, with the result that the historical contribution of theory of structures to the development of building was given more or less attention in the structural engineering-oriented history of building, and therefore was included in this.

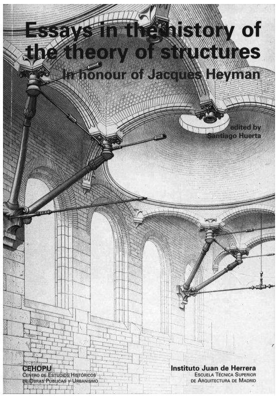
The history of science, too, treats the history of theory of structures as a sideline. Indeed, if theory of structures as a whole is noticed at all, it is only in the sense of one of the many applications of mechanics. Structural engineering, a profession that includes theory of structures as a fundamental engineering science discipline, only rarely finds listeners outside its own discipline.

Today, theory of structures is, on the one hand, more than ever before committed to formal operations with symbols, and remains invisible to many users of structural design programs. On the other hand, some attempts to introduce formal teaching into theory of structures fail because the knowledge about its historical development is not adequate to define the real object of theory of structures. Theory of structures is therefore a necessary but unpopular project.

Notwithstanding, a historical study of theory of structures has been gradually coming together from various directions since the early 1990s. The first highlight was the conference "Historical Perspectives on Structural Analysis" – the world's first conference on the history of theory of structures – organised by Santiago Huerta and held in Madrid in December 2005. The conference proceedings (Fig. 1-2) demonstrates that the history of theory of structures already possesses a number of the features important to an engineering science discipline and can be said to be experiencing its constitutional phase. Another significant contribution to the historical study of theory of structures is the series of congresses initiated by Santiago Huerta in Madrid in 2003 and entitled "International Congress on Construction History", with events held every three years.

Articles examining the analysis of masonry loadbearing structures from the perspective of a historical theory of structures also appear in the

FIGURE 1-2
Cover of the proceedings of the first conference on the history of theory of structures (2005)



International Journal of Architectural Heritage, published bimonthly by Taylor & Francis since 2007. There are also essays on the history of theory of structures in *Engineering History and Heritage*, a journal published quarterly since 2009 by the Institution of Civil Engineers (ICE) as part of its *Proceedings*. When it comes to articles in German, it has been principally the journals *Bautechnik, Beton- und Stahlbetonbau* and *Stahlbau* – all published by Ernst & Sohn – that keep alive the interest in a historical study of construction in general and theory of structures in particular.

Following *Geschichte der Baustatik* (history of theory of structures, 2002) and the much more comprehensive study *The History of the Theory of Structures. From Arch Analysis to Computational Mechanics* (2008) by this author, it was the turn of Max Herzog to present his *Kurze Geschichte der Baustatik und der Baudynamik in der Praxis* (brief history of theory of structures and construction dynamics in practice) [Herzog, 2010].

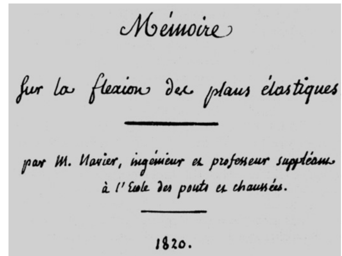
The above publications dealing with the history of theory of structures form one of the cornerstones of the scientific history of building, which has yet to get off the ground and together with the technical history of construction could form the scientific discipline of the history of building.

1.1 Internal scientific tasks

Like every scientific cognition process, the engineering science cognition process in theory of structures also embraces history in so far as the idealised reproduction of the scientific development included within the status of knowledge of an area of study forms a necessary basis for new scientific ideas; science is genuinely historical. Reflecting on the genesis and development of the object of theory of structures always then becomes an element in the engineering science cognition process when rival, or rather coexistent, theories are subsumed in a more abstract theory – possibly by a basic theory of a fundamental engineering science discipline. Therefore, the question of the inner consistency of the more abstract theory, which is closely linked with this broadening of the area of study, is also a question of the historical evolution. In the middle of the establishment phase of theory of structures (1850–1875), Saint-Venant's monumental historical and critical commentary [Saint-Venant, 1864] of the first section of the second edition of Navier's *Résumé des leçons* [Navier, 1833] was the first publication to shed light on historical elastic theory as the very essence of historical engineering science [Kurrer, 2012, pp. 51–52]. The classification of the essential properties of technical artefacts or artefact classes reflected in theoretical models is inherent in the formation of structural analysis theories. This gives rise to the task of the historically weighted comparison and criticism of the theoretical approaches, theoretical models and theories, especially in those structural analysis theory formation processes that grew very sluggishly, e. g. masonry arch theory. Examples of this are Emil Winkler's historico-logical analysis of masonry arch theories [Winkler, 1879/1880] and Fritz Kötter's evolution of earth pressure theories [Kötter, 1893] in the classical phase of theory of structures (1875–1900).

In their history of strength of materials, Todhunter and Pearson had good reasons for focusing on elastic theory [Todhunter & Pearson, 1886

& 1893], which immediately became the foundation for materials theory in applied mechanics as well as theory of structures in its discipline-formation period (1825–1900) and was able to sustain its position as a fundamental theory in these two primary engineering science disciplines during the consolidation period (1900–1950). The mathematical elastic theory first appeared in 1820 in the shape of Navier's *Mémoire sur la flexion des plans élastiques* (Fig. 1-3). It inspired Cauchy and others to contribute significantly to the establishment of the scientific structure of elastic theory and induced a paradigm change in the constitution phase of theory of structures (1825–1850), which was essentially complete by the middle of the establishment phase of theory of structures (1850–1875). One important outcome of the discipline-formation period of theory of structures (1825–1900) was the constitution of the discipline's own conception of its epistemology – and elastic theory was a substantial part of this. Theory of structures thus created for itself the prerequisite to help define consciously the development of construction on the disciplinary scale. And looked at from the construction side, Gustav Lang approached the subject in his evolutionary portrayal of the interaction between loadbearing assemblies and theory of structures in the 19th century [Lang, 1890] – the first monograph on the history of theory of structures.


Mémoire

sur la flexion des plans élastiques

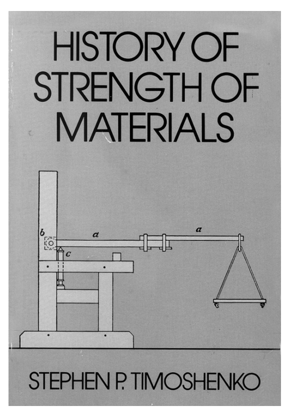
par M. Navier, ingénieur et professeur suppléant à l'École des ponts et chaussées.

1820.

FIGURE 1-3
Lithographic title page of Navier's *Mémoire sur la flexion des plans élastiques* [Roberts & Trent, 1991, p. 234]

Up until the consolidation period of theory of structures (1900–1950), the structural analysis theory formation processes anchored in the emerging specialist literature on construction theory contained a historical element that was more than mere references to works already in print. It appears, after all, to be a criterion of the discipline-formation period of theory of structures that grasping the relationship between the logical and the historical was a necessary element in the emerging engineering science cognition process. If we understand the logical to be the theoretical knowledge reflecting the laws of the object concerned in abstract and systematic form, and the historical to be the knowledge and reproduction of the genesis and evolution of the object, then it can be shown that the knowledge of an object's chronology has to be a secondary component in the theoretical knowledge of the object. This is especially true when seen in terms of the leaps in development during the discipline-formation period of theory of structures. Whereas Pierre Duhem pursues the thinking of natural philosophy from the theory of structures of the Middle Ages to the end of the 17th century in his two-volume work *Les origines de la Statique* [Duhem, 1905/06], the comprehensive contributions of Mehrtens [Mehrtens, 1900 & 1905], Hertwig [Hertwig, 1906 & 1941], Westergaard [Westergaard, 1930], Ramme [Ramme, 1939] and Hamilton [Hamilton, 1952] to the origins of the discipline of theory of structures provide reasons for the historical study of theory of structures in a narrower sense. Timoshenko's famous book on the history of strength of materials (Fig. 1-4) contains sections on the history of structural theory [Timoshenko, 1953].

FIGURE 1-4
Cover of Timoshenko's *History of Strength of Materials* [Timoshenko, 1953]

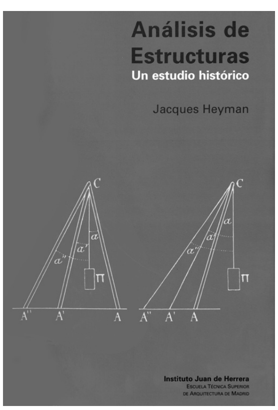


In the former USSR, Rabinovich [1949, 1960 & 1969] and Bernstein [1957 & 1961] contributed to the historical study of strength of materials and theory of structures in particular and structural mechanics in general. But of all those monographs, only one has appeared in English [Rabinovich, 1960], made available by George Herrmann in the wake of the Sputnik shock. In that book, Rabinovich describes the future task of a type of universal history of structural mechanics as follows: "[Up] to the present time [early 1957 – the author], no history of structural mechanics exists. Isolated excerpts and sketches, which are the elements, do not fill the place of one. There is [a] need for a history covering all divisions of the science with reasonable thoroughness and containing an analysis of ideas and methods, their mutual influences, economics, and the characteristics of different countries, their connection with the development of other sciences and, finally, their influence upon design and construction" [Rabinovich, 1960, p. 79]. Unfortunately, apart from this one exception, the Soviet contributions to the history of structural mechanics were not taken up in non-Communist countries – a fate also suffered by Rabinovich's monograph on the history of structural mechanics in the USSR from 1917 to 1967 (Fig. 1-5).

FIGURE 1-5
Dust cover of the monograph *Structural Mechanics in the USSR 1917–67* [Rabinovich, 1969]

In his dissertation *The art of building and the science of mechanics*, Harold I. Dorn deals with the relationship between theory and practice in Great Britain during the preparatory period of theory of structures (1575 – 1825) [Dorn, 1971]. T. M. Charlton concentrates on the discipline-formation period of theory of structures in his book [Charlton, 1982]. He concludes the internal scientific view of the development of theory of structures in so far as the historical study of theory of structures was now entering its initial phase. And as early as 1972, Jacques Heyman's monograph *Coulomb's memoir on statics: An essay in the history of civil engineering* [Heyman, 1972/1] was not only lending a new emphasis to the treatment and interpretation of historical sources, but was also showing how practical engineering can profit from historical knowledge. He demonstrated this, in particular, through the structural analysis of masonry arches [Heyman, 1982 & 1995/1], which he expanded to create a "historical arch theory" [Kurrer, 2012, pp. 52 – 56]. This was followed nine years later by Edoardo Benvenuto's universal work *La scienza delle costruzioni e il suo sviluppo storico* [Benvenuto, 1981], the English edition of which – in a much abridged form – did not appear until 10 years later [Benvenuto, 1991]. Heyman's later monographs in particular, e. g. *Structural Analysis. A Historical Approach* [Heyman, 1998/1], demonstrate that the historical study of theory of structures is able to advance the scientific development of structural analysis in the sense of a historical structural analysis within the scope of a "historical engineering science" [Kurrer, 2012]. Many of Heyman's books have been published in Spanish in the *Textos sobre teoría e historia de las construcciones* series founded and edited by Santiago Huerta (see, for example, Fig. 1-6).

FIGURE 1-6
Dust cover of the Spanish edition of Heyman's *Structural Analysis. A Historical Approach* [Heyman, 2004]



In 1993 Benvenuto initiated a series of international conferences under the title of *Between Mechanics and Architecture* together with the Belgian science historian Patricia Radelet-de Grave. The conferences gradually became the programme for a school and after Benvenuto's early death were continued by the Edoardo Benvenuto Association headed by its honorary president Jacques Heyman. Only six results of this programme will be mentioned here:

– The first volume in this series edited by Benvenuto and Radelet-de Grave and entitled *Entre Méchanique et Architecture. Between Mechanics and Architecture* [Benvenuto & Radelet-de Grave, 1995].
– *Towards a History of Construction* edited by Becchi, Corradi, Foce and Pedemonte [Becchi et al., 2002].
– *Degli archi e delle volte* [Becchi & Foce, 2002], a bibliography of the structural and geometrical analysis of masonry arches past and present with an expert commentary by Becchi and Foce.
– The volume of essays on the history of mechanics edited by Becchi, Corradi, Foce and Pedemonte (Fig. 1-7) [Becchi et al., 2003].
– The collection of articles on the status of the history of construction, *Construction History. Research Perspectives in Europe*, edited by Becchi, Corradi, Foce and Pedemonte [Becchi et al., 2004/2].
– The reprint of Edoardo Benvenuto's principal work *La scienza delle costruzioni e il suo sviluppo storico*, made available by Becchi, Corradi and Foce [Benvenuto, 2006].
– The collection of articles *Mechanics and Architecture between Epistéme and Téchne* edited by Anna Sinopoli [Sinopoli, 2010].

Erhard Scholz investigated the development of graphical statics in his habilitation thesis [Scholz, 1989] from the viewpoint of the mathematics historian. Dieter Herbert's dissertation analyses the origins of tensor calculus from the beginnings of elastic theory with Cauchy (1823 and 1827) to its use in shell theory by Green and Zerna [Herbert, 1991] at the end of the consolidation period of theory of structures (1900 – 1950). The two-volume work by Gérard A. Maugin [Maugin, 2013 & 2014] provides deep insights into the history of continuum mechanics.

In the past three decades we have seen specialists gradually working through more and more of the backlog in the history of modern structural mechanics. The development of modern numerical engineering methods was the subject of a conference held in Princeton by the Association for Computing Machinery (ACM) in May 1987 [Crane, 1987]. Ekkehard Ramm provides a fine insight into the second half of the consolidation period (1900 – 1950) and the subsequent integration period of theory of structures (1950 to date) [Ramm, 2000]. As a professor at the Institute of Theory of Structures at the University of Stuttgart, Ramm has supervised dissertations by Bertram Maurer, *Karl Culmann und die graphische Statik* (Karl Culmann and graphical statics) [Maurer, 1998], and Martin Trautz, *Entwicklung von Form und Struktur historischer Gewölbe aus der Sicht der Statik* (development of form and structure in historical arches from the structural viewpoint) [Trautz, 1998]. Following many years of research into the relationship between the development of loadbearing systems in iron/steel construction and structural calculations, Ines Prokop was able to complete her dissertation *Eiserne Tragwerke in Berlin. 1850 – 1925* (iron/steel structures in Berlin, 1820 – 1925) at Berlin's University of the Arts in 2011 and publish her work as a book (Fig. 1-8).

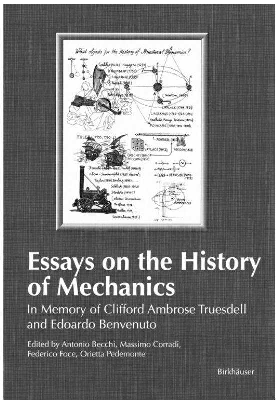
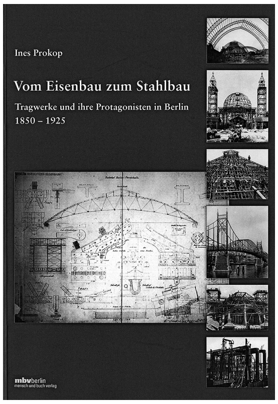


FIGURE 1-7
Cover of *Essays on the History of Mechanics* [Becchi et al., 2003]

FIGURE 1-8
Cover of *Vom Eisenbau zum Stahlbau* [Prokop, 2012]



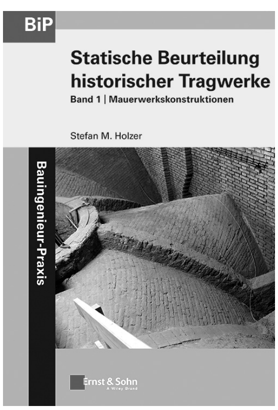
The biographical tradition popular in the Soviet historical study of mechanics is evident, in particular, in Malinin's book *Kto jest' kto v soprotivlenii materialov* (who's who in strength of materials) [Malinin, 2000]. In this respect, Grigolyuk's work *S. P. Timoshenko: Zhizn' i sud'ba* (Timoshenko: life and destiny) [Grigolyuk, 2002] is also worth mentioning.

Publications by Samuelsson and Zienkiewicz [Samuelsson & Zienkiewicz, 2006] plus Kurrer [Kurrer, 2003] have appeared on the history of the displacement method. Carlos A. Felippa deals with the development of matrix methods in structural mechanics [Felippa, 2001] and the theory of the shear-flexible beam [Felippa, 2005]. On the other hand, the pioneers of the finite element method (FEM) Zienkiewicz [Zienkiewicz, 1995 & 2004] and Clough [Clough, 2004] concentrate on describing the history of FEM. It seems that a comprehensive presentation of the evolution of modern structural mechanics is necessary. Only then could the historical study of theory of structures make a contribution to a historical engineering science in general and a historical theory of structures in particular, both of which are still awaiting development.

1.2 Practical engineering tasks

Every structure moves in space and time. The question regarding the causes of this movement is the question regarding the history of the structure, its genesis, utilisation and nature. Whereas the first dimension of the historicity of structures consists of the planning and building process, the second dimension extends over the life of the structure and its interaction with the environment. The historicity of the knowledge about structures and their theories, and in turn their influence on the history of the structure, form the third dimension of the historicity of structures. In truth, the history of the genesis, utilisation and nature of the structure form a whole. Nevertheless, the historicity of structures is still always broken down into its three dimensions. Whereas historicity in the first dimension is typically reduced to the timetable parameters of the participants in the case of new structures, understanding the second dimension is an object of history of building, preservation of heritage assets and construction research plus the evolving history of construction and design. One vital task of a historical study of theory of structures would be to help develop the third dimension, e. g. through preparing, adapting and re-interpreting historical masonry arch theories. Stefan M. Holzer's two-volume work [Holzer, 2013 & 2015] demonstrates in exemplary fashion how a historical study of theory of structures can be productively exploited for the structural assessment of historic loadbearing structures (Fig. 1-9).

FIGURE 1-9
Cover of *Statische Beurteilung historischer Tragwerke – Mauerwerkskonstruktionen* (structural assessment of historic loadbearing structures – masonry structures) [Holzer, 2013]



Nevertheless, the task of a historical study of theory of structures for everyday engineering is not limited to the province of the expanding volume of work among the historic building stock. Knowledge gleaned from a historical study of theory of structures could become a functional element in the modern construction process because unifying the three dimensions of the historicity of structures is elementary to this; for engineering science theory formation and experiments, the conception, calculation and design as well as the fabrication, erection and usage can no longer be separated from the conversion, preservation and upkeep of the building stock. The task of the historical study of theory of structures lies not only in feeding the planning process with ideas from its historical knowledge database, but also in incorporating its experience of work on historic structures into the modern construction process. In this sense, a historical study of theory of structures could be further developed into a productive energy for engineering.

When engineers conceive a building, they have to be sure – even before the design process begins – that it will function exactly as envisaged and planned. That applies today and it also applied just the same to engineers in Roman times, in the Middle Ages, in the Renaissance and in the 19th century. All that has changed are the methods with which engineers achieve this peace of mind. Bill Addis has written a history of design engineering and construction which focuses on the development of design methods for buildings (Fig. 1-10).

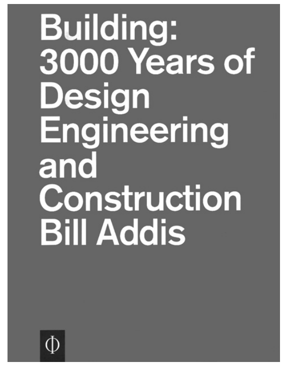


FIGURE 1-10
Cover of *Building: 3000 Years of Design Engineering and Construction* [Addis, 2007]

Bill Addis looks at the development of graphical and numerical methods plus the use of models for analysing physical phenomena, but also shows which methods engineers employ to convey their designs. To illustrate this, he uses examples from structural engineering, building services, acoustics and lighting engineering drawn from 3,000 years of construction history. Consequently, the knowledge gleaned from a historical study of theory of structures serves as one of the cornerstones in his evolution of the design methods used by structural engineers.

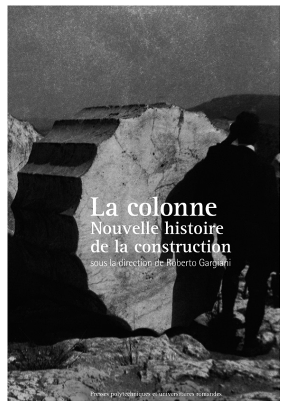


FIGURE 1-11
Cover to the collection of essays on columns *Nouvelle Histoire de la Construction. La Colonne* [Gargiani, 2007]

Roberto Gargiani pursues an artefact-based approach in his collection of essays on columns (Fig. 1-11), which are presented from the history of building, history of art, history of construction, history of science and history of theory of structures perspectives. In a second volume, numerous authors analyse historic beam and suspended floor systems in detail from the history of design and history of science viewpoints [Gargiani, 2012]. The discipline-oriented straightforwardness of a historical study of theory of structures is especially evident in both volumes.

1.3 Didactic tasks

The work of the American Society for Engineering Education (ASEE), founded in 1893, brought professionalism to issues of engineers' education in the USA and led to the formation of engineering pedagogy as a subdiscipline of the pedagogic sciences. In the quarterly *Journal of Engineering Education*, the publication of the ASEE, scientists and practitioners have always reported on progress and discussions in the field of engineering teaching. For example, the journal reprinted the famous *Grinter Report* [Grinter, 1955], [Harris et al., 1994, pp. 74 – 94], which can be described as a classic of engineering pedagogy and which calls for the next generation of engineers to devote 20% of their study time to social sciences and the humanities, e. g. history [Harris et al., 1994, p. 82]. Prior to L. E. Grinter, another prominent civil engineering professor who contributed to the debate about the education of engineers was G. F. Swain. In his book *The Young Man and Civil Engineering* (Fig. 1-12), Swain links the training of engineers with the history of civil engineering in the USA [Swain, 1922].

Nevertheless, students of the engineering sciences still experience the division of their courses of study into foundation studies, basic specialist studies and further studies as a separation between the basic subjects and the specific engineering science disciplines; and the latter are often presented only in the form of the applications of subjects such as mathematics and mechanics. Even the applied mechanics obligatory at the fundamental stage in many engineering science disciplines is understood by many students as general collections of unshakeable principles – illustrated by working through idealised technical artefacts. Closely related to this is the partition of the engineering sciences in in-depth studies; they are not studied as a scientific system comprised of specific internal relationships, for example, but rather as an amorphous assemblage of unconnected explicit disciplines whose object is only a narrow range of technical artefacts. The integrative character of the engineering sciences thus appears in the form of the additive assembly of the most diverse individual scientific facts, with the result that the fundamental engineering science disciplines are learned by the students essentially in the nature of formulas. The task of a historical study of theory of structures is to help eliminate the students' formula-like acquisition of structural theory. In doing so, separating the teaching of theory of structures into structural analysis for civil and structural engineers and structural engineering studies for architects presents a challenge. Stefan Polónyi carried out groundbreaking work to overcome this separation. In an essay on the structural engineer and the science of structural engineering [Polónyi, 1982], he criticised the deductive self-conception of structural analysis and developed the framework for an inductive method for structural engineering studies [Kurrer, 2014/1] using the historico-logical approach. Encouraged by Polónyi's work, Rolf Gerhardt developed proposals for a didactic approach to structural engineering studies based on history and tests on models [Gerhardt, 1989]. Introducing the historical context into the teaching material of project studies in theory of structures in the form of a historico-genetic teaching of structural theory could help the methods of structural engineering to be understood, experienced and illustrated as a historico-logical development product, and hence made more popular. An initial concept for this was presented by the author [Kurrer, 1998/3 & 1999/2], which was later worked out in more detail in the first edition of this book (pp. 455 – 459) and then integrated into the newly created framework of the historical engineering sciences [Kurrer, 2012, pp. 57 – 59]. Werner Lorenz, Chair of Construction History and Loadbearing Structure Maintenance at Brandenburg University of Technology, inaugurated a course on history of theory of structures in the winter semester 2013/14. This series of seminars was aimed at bachelor students of structural engineering in their fifth semester. Werner Lorenz had three objectives in mind:

- a sound understanding of structural methods gained through the analysis of their successive historical evolution,
- a historico-genealogical approach to supplement the systematic/deductive approach in the teaching of basic structural theory,

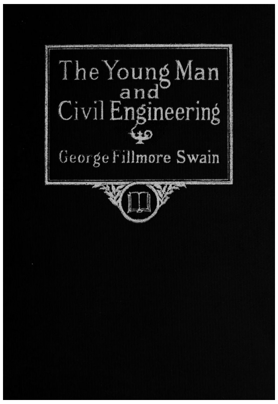


FIGURE 1-12
Cover of Swain's *The Young Man and Civil Engineering* [Swain, 1922]

– fundamental knowledge of the historical development of theory of structures and strength of materials.

This innovation in the teaching of structural theory in a structural engineering course of study enabled Werner Lorenz to take a decisive step towards a formalised historical approach to teaching this subject. The historical study of theory of structures could thus become a significant knowledge database for an evolving historico-genetic method of teaching for all those involved in the building industry. Proposals for this within the scope of a historical theory of structures are developed in section 14.2.3.

1.4 Cultural tasks

There is an elementary form of the scientist's social responsibility: the democratising of scientific knowledge through popularising; that is the scientist's account of his or her work – and without it society as a whole would be impossible. Popular science presentations are not just there to provide readers outside the disciplinary boundaries with the ensuing scientific knowledge reflected in the social context of scientific work, but rather to stimulate the social discussion about the means and aims of the sciences. Consequently, the historical study of theory of structures, too, possesses an inherent cultural value. The author Christine Lehmann, together with her partner, the mathematics teacher Bertram Maurer, has written a biography of Karl Culmann (Fig. 1-13) based on Maurer's dissertation [Maurer, 1998] in which the results of research into the history of theory of structures are presented to the layman in an understandable, narrative fashion within an appealing literary framework.

FIGURE 1-13
Cover of the biography of Karl Culmann [Lehmann & Maurer, 2006]

The individual sciences physics, biology and even chemistry transcend the boundaries of their scientific communities again and again. This might be due to their role as constituents of worldly conceptions and the close bond with philosophy and history. But the same does not apply to the engineering sciences; even fundamental engineering science disciplines find it difficult to explain their disciplinary intent in the social context. The fragmentation of the engineering sciences complicates the recognition of their objective coherence, their position and function within the ensemble of the scientific system and hence their relationship as a whole to the society that gave birth to them and which surrounds them. This is certainly the reason why the presentations, papers and newspaper articles of the emeritus professor of structural analysis Heinz Duddeck plead for a paradigm change in the engineering sciences, which, in essence, would result in a fusion between the engineering sciences and the humanities [Duddeck, 1996]. As the historical study of theory of structures forms a disciplinary union between structural analysis and applied mechanics with input from the humanities (philosophy, general history, sociology, histories of science, technology, industry and engineering), it is an element of that fusion. It can therefore also assist in overcoming the "speechlessness of the engineer" [Duddeck, 1999].

Aims 1.5

The aim of a historical study of theory of structures therefore consists of solving the aforementioned scientific, practical engineering, didactic and cultural tasks. This book, written from the didactic, scientific theory, history of science, history of construction, aesthetic, biographical and bibliographical perspectives (Fig. 1-14), aims to provide assistance.

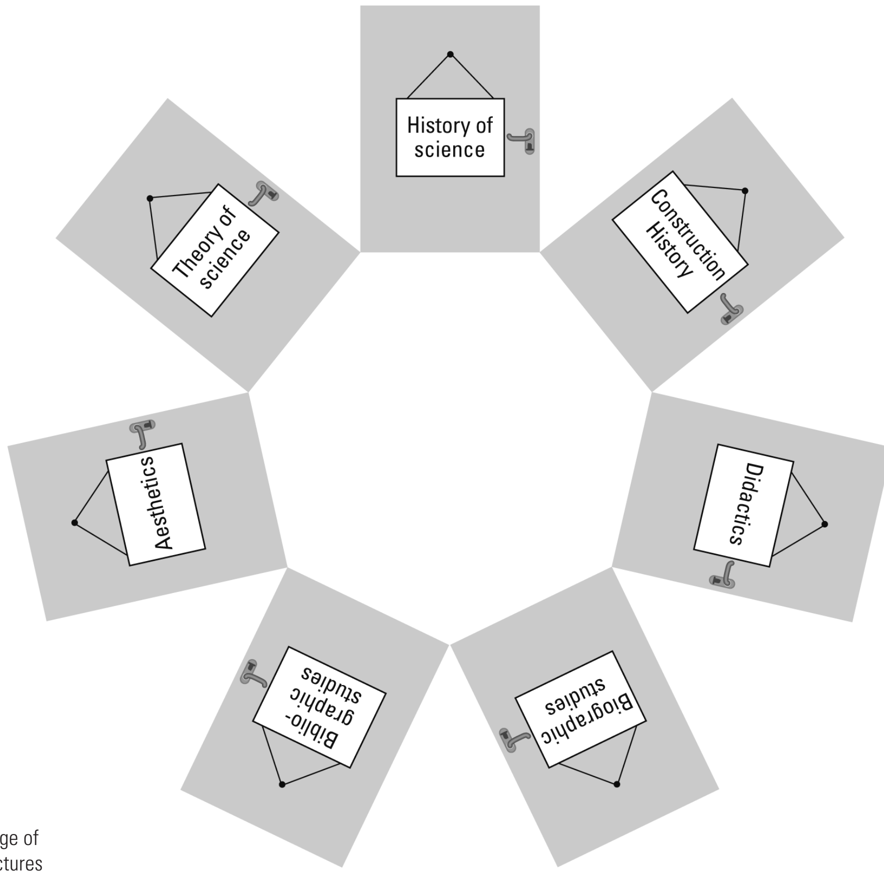


FIGURE 1-14
Seven gates to the knowledge of the history of theory of structures

An invitation to take part in a journey through time to search for the equilibrium of loadbearing structures 1.6

In Franz Kafka's parable of the gatekeeper from the chapter entitled "In the Cathedral" in his novel *The Trial* published in 1925 (see [Kafka, 1970, pp. 148–149], for example), Josef K. searches in vain for a way to enter the law via a gate guarded by a gatekeeper. Kafka's protagonist Josef K. might easily have studied structural engineering or architecture. For him, acquiring the fundamentals of theory of structures was duly spoiled. Because theory of structures is imparted in the form of rigid laws, without any reference to building.

Dear reader! There are gates through which the laws of structural analysis can be learned with joy (Fig. 1-14). You choose which phantasmagorical gatekeeper you can evade most easily. But let me tell you this: The gatekeepers don't exist! Simply open any gate, pass through it and then let yourself be surprised by the form in which theory of structures appears to you. If your inquisitiveness allows you to pass through all seven gates, then all the highways and byways of the past and future of theory of structures will lie before you in a panorama.

With this in mind, I would like to invite you, dear reader, to join me in a journey through time to search for the equilibrium of loadbearing structures. Experience the moment, make it your own and give it as a gift.