QUELLE

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HANDBOOKS, TEXTBOOKS, MANUALS: RE-READING CLASSICAL SOURCES ON THE 'SCIENTIFICATION' OF BUILDING KNOWLEDGE IN THE NINETEENTH CENTURY

Torsten Meyer, Knut Stegmann & Christoph Rauhut

ETH Zurich, Switzerland

INTRODUCTION

"Dogmatic, boring, conservative" is the dictum given for textbooks that Thomas S. Kuhn established for the history of science for decades.[1] However, since the 1990s this notion has been challenged: recent research has underlined the importance of textbooks for the production of new scientific knowledge and the emergence of scientific disciplines.[2] This re-evaluation forms the starting point of our line of argument – focusing on polytechnic textbooks for building sciences of the nineteenth century. Against the background of the emergence of such an institutional polytechnic tradition in the first half of the nineteenth century, we discuss the structures of polytechnic textbooks.

The strategies of polytechnic knowledge production can be identified as processes of 'historicising', formalisation and economisation in respect to the field of building in the nineteenth century. Using Jean Rondelet's *Traité de L'Art de Bâtir* as an example, these strategies are explained.[3]

Focusing on the first decades of the nineteenth century, the processes of polytechnic 'scientification' of building, define this newly academic field as an encyclopaedic one. During the 1850/60s one can observe a change in the self-understanding and self-conception of this approach to building. It is reflected in many ways by the organisation of the Zurich Polytechnic School, founded in 1855. Furthermore, the change influenced the conception of polytechnic textbooks on building, as well as the strategies of knowledge production. Changes will be analysed by some textbooks written by teachers of the Zurich School of Architecture (*Bauschule*). In respect to the formerly constitutive processes of 'historicising', formalisation, economisation, aims of knowledge production and distribution began to undergo changes. Such bodies of building knowledge shifted away from their polytechnic roots – nonetheless they were still important for the daily practice of an architect. Thus, the novel genre of textbooks on building site supervision are sketched to illustrate links between science and practice.

Despite these allowances, the aim of this paper is clear: to re-establish handbooks on building as a source and means of 'scientification' of the field.

THE EMERGENCE OF THE POLYTECHNIC TRADITION

Founded in 1793/94 the École Polytechnique in Paris, was the institutional birthplace of the 'polytechnic tradition'.[4] Its foundation was influenced by two contemporary concepts: bureaucratic elites and the liberal bourgeoisie, both evaluated the development of institutions for technical education as the "royal road of industrialisation".[5] Scientific and technological knowledge was thus seen as a chance to take the industrial lead from the British. The general idea of social and economic progress received its corollary in the educational model of the École Polytechnique, which was shaped by mathematicians and natural scientists such as Gaspard Monge. Mathematics and the natural sciences dominated the polytechnic curriculum, whereas practice-oriented bodies of knowledge remained outside. This model was based on the assumption that the curriculum at the École Polytechnique imparted abstract, theoretical knowledge, which should serve as the foundation for applied sciences, and would allow graduates to solve problems in practice.[6] As such, contemporary figures regarded architecture and engineering as applied natural sciences. Such a didactic conception was appropriate to the contemporary structure of French academic institutions; where the majority of École Polytechnique graduates attended, thereafter, existing or newly established specialist schools. The German polytechnic institutions could only emulate the model to a limited extent in the nineteenth century, as they lacked associated specialist schools. By establishing so-called *Vorschulen* (preschools), they tried to unite the French structure into one institution. The curriculum at these preschools focused on mathematics, natural sciences and a number of general subjects, whereas the subsequent polytechnic curricula focused primarily on practice-orientated knowledge. An examination of the early curricula of polytechnic schools reveal that the subjects of architecture and engineering often only diverged during the last year of study with a number of separate construction projects. Thus, it might be stated, that early polytechnic curricula preserved the totality of the field of building. Contemporary criticism of this polytechnic education concept focused on two aspects: firstly, an argument ensued over the apparent lack of connection between the curricula of the preschools and those of the individual polytechnics. A second charge was that the teaching was too practical and not scientific enough. A fundamental reform was seen as the way to solve this problem, and it found its first manifestation at the polytechnic school in Karlsruhe in the 1840s. The successful reform created a new image for polytechnic education – characterised by a close and systematic combination of basic scientific disciplines and practical courses.[7] Furthermore, the schools started to establish scientific research as an independent endeavour. Architecture and engineering were no longer therefore, considered applied natural sciences but took on lives of their own.[8] In the mid-nineteenth century this polytechnic model was most clearly embodied in the schools of Karlsruhe and Zurich.

The oscillation in the polytechnic education between theory and practice is also reflected in contemporary polytechnic textbooks. They addressed students and practitioners alike and focused on disciplinary as well as on non-scientific practice. This concept reflected the contemporary conception of social and economic progress, in which technological and scientific development played a fundamental role. Standing in stark contrast to the dominant neo-humanist ideals of education of the nineteenth century, this conception allowed the polytechnics to secure and increase their social status.[9] The nexus between scientific methodology and practical relevance in polytechnic textbooks became ever stronger, not only because of their enlarged audience. The practice of building itself became a key source for the production of new scientific knowledge – clearly shown, for example, by the development of graphic statics by the Zurich professor Carl Culmann.[10] Thus, polytechnic textbooks were a double expression of the relationship between theory and practice, but they would also play an important role in the emergence of separate disciplines of the nineteenth and early twentieth century.[11]

POLYTECHNIC 'SCIENTIFICATION' OF CONSTRUCTION KNOWLEDGE

The task of building construction was the focal point of the process of 'scientification' in the polytechnic tradition, beginning in the very early nineteenth century – prominently expressed in Friedrich Schinkel's famous dictum 'architecture is construction'.[12] In this respect Rondelet's *Traité* could be said to especially mark the emergence of academic textbooks on polytechnic building.[13] The *Traité* represents the first attempt of an encyclopaedic polytechnic textbook on building construction structured and systematised solely according to aspects of building construction.[14] Three central processes influenced Rondelet's representation of knowledge: formalisation, economisation and historical inclusion of the bodies of knowledge themselves.

'Formalisation' applied to aspects of mathematical and experiment-led production and the representation of polytechnic construction knowledge. (Fig. 1) The importance of such formalised construction knowledge, for the subsequent emergence of modern civil engineering science from the second half of the nineteenth century onwards, is evident and well known in the field of construction history.[15]

'Economisation' – the *commodification* of building construction – was deeply rooted in a wider process of societal *commodification*.[16] Furthermore, by the end of the eighteenth century, access to labour force had radically diverged from the model of absolutist corporatism. 'Work' had attained a new level of monetisation. This economic re-evaluation played an important role in ensuring the physical concept of [labour] 'force' to become a central concept by the late eighteenth century. Physical measurability and the monetisation of (the labour) force formed mutually stabilising discursive elements.[17] They characterise Rondelet's geometrical method of cost calculation, whose principle aim was to overcome existing local and regional constraints.

'Historicising' focuses on the importance of historical bodies of knowledge for the construction practice in the nineteenth century. Its integration into polytechnic textbooks were based on the concept of *historia magistra vitae*. Historical knowledge was regarded as indispensable

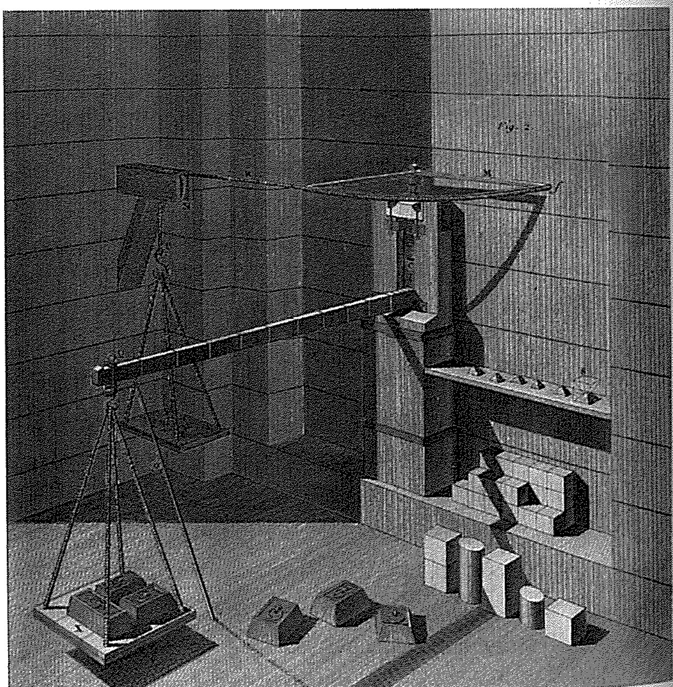

Figure 1. Rondelet's own experiments on the strength of building materials were based on his own invention and new machine. Experiment-led production of new polytechnic knowledge regarding building materials was an essential task in the 'scientification' process as such bodies of knowledge traditionally were tacit ones. (source: Jean Rondelet, *Theoretisch-praktische Anleitung zur Kunst zu bauen.* In fünf Bänden. Mit den 210 Kupfern der Pariser Original-Ausgabe. Nach der sechsten Auflage aus dem Französischen (Leipzig and Darmstadt: Karl Wilhelm Leske, 1833-36), plate VII)

for human designs on the future.[18] Natural history had an enduring methodological influence on the newly emerging academic domains of knowledge regarding the man-made world. Around 1800, the idea of evolution and Carl von Linné's botanical classification model, had been brought together and unified, to form the basis of a theory of invention. Referring to Rondelet's *Traité*, Valérie Nègre said, 'history might serve to show one system predates another.'[19] The concept of an evolutionary model of history is illustrated by many aspects of Rondelet's textbook.[20] His model of invention appears to be grounded in the theoretical principle of 'transfer'. Stated in general terms: any new use of a material is facilitated by transferring existing knowledge onto the constructive techniques of how that material was previously used. This form of transfer is the *conditio sine qua non* for the introduction of new building materials. Because new building techniques and materials had no other existing contemporary sources of knowledge to draw upon,[21] the process of 'historicising' was considered a sensible strategy of invention.

The strategies described were formative for the process of polytechnic knowledge production on building construction and its recording in textbooks during the first half of the nineteenth century. Even the relevant textbooks used for teaching at schools of architecture retained an encyclopaedic character; an example being Ludwig Friedrich Wolfram's *Vollständiges Lehrbuch der gesammten Baukunst*.[22] During the second half of the nineteenth century this character loosened, the strategies of 'scientification' and the aims of knowledge-recording also changed. The latter aspect can be highlighted in textbooks written by teachers at the Zurich Polytechnic School. Furthermore, the function of textbooks for the establishment of new disciplines may be clarified.

'HISTORICISING' – POTENTIAL BODIES OF KNOWLEDGE

Tracking the process of 'historicising', one can observe two shifts in the 1850/60s: on one hand the actual relevance of historic bodies of building knowledge became a potential one; on the other hand authors focused more and more on the aesthetics of architectural forms. These shifts caused different strategies of knowledge production and recording:

The Zurich professor of structural theory and construction materials, Ernst Gladbach published a number of books on the 'Swiss Style' between 1868 and 1893,[23] which are relevant examples of historical bodies of construction knowledge.[24] Gladbach's interest in vernacular architecture focused on securing implicit knowledge, as he believed that 'these structures are not only of interest for Switzerland but can rather serve more generally as models for all times.'[25] A new strategy for the 'production' of knowledge accompanied the approach. It was based on the contemporary methods of historic building research that Gladbach became acquainted with while contributing to his Uncle Georg Moller's publication, *Denkmäler der deutschen Baukunst* (1815–51).[26] An individual's own 'visual perception' – the academically trained view of the architect, formed the basis for the findings and documentation. 'Documentation' in this context means firstly to sketch the construction on the basis of measurements with tools like cords and measuring sticks, secondly to edit the sketches and finally to publish them, accompanied by an introductory text. Furthermore, Gladbach's field studies can be closely connected to the methodology of 'hiking through a field of knowledge' as propagated by the Munich professor for cultural history, Wilhelm Heinrich Riehl. Research on the folk-life (*Volksleben*) was, in Riehl's opinion, to a lesser extent about the analysis of written sources and more about anthropological observation.[27] In Gladbach's research, the analysis of written sources scarcely played a role. The reason for this was not only his wish to use time economically and to analyse as many buildings as possible; in Gladbach's works, historic bodies of knowledge lose their contempory nature. This is mirrored by the ambivalent character of his published drawings on the 'Swiss Style'. While on the one hand he presents precise drawings of construction details, on the other hand he uses a crude manner of representation in his efforts for the appreciation of vernacular architecture.

Historic bodies of knowledge were especially important for the teaching of subjects on aesthetics. In this respect, the Zurich school played an important role: its *spiritus rector*, Gottfried Semper, explained architectural aesthetics in his book *Der Stil*, by referring to actual scientific theories of optics and physiology, but he remained unique in this respect.[28] More typical were textbooks based on results of art history and archaeological research.[29] *Die Baukunst in ihrer chronologischen und constructiven Entwicklung* by Georg Lasius is a valid example. In comparison to Gladbach's textbooks, the translation of the research into the 'language of architects' is constitutive. Thus, on the first glance, Lasius' textbook seems to be presenting scientific knowledge. Nonetheless, its central concern was the formulation of a doctrine of aesthetic taste, intended for application to contemporary building tasks – without which, architecture could not achieve its 'sanctification' (*Weihe*).[30] In an age of different tendencies in the architectural mainstream, the historic canon of forms served as guidance – but guidance based on individual preferences of the author.

FORMALISATION – NOVEL MATERIALS AND THE ROLE OF EXPERIMENTS

In the early nineteenth century, knowledge on building materials was still largely based on 'unsecured experiential' knowledge of craftsmen. With the emergence of new building materials and the advent of large construction companies, organised in an 'industrialised' manner, secured and formalised material knowledge gained significance.[31] Soon, material testing laboratories were established at polytechnic schools. One such laboratory was the *Eidg. Anstalt für die Prüfung von Baumaterialien* established by Ludwig Tetmajer at the Zurich Polytechnic School in 1880 (Fig. 2). This laboratory not only published the test results by order of awarding authorities and industry;[32]) but Tetmajer also planned a multi-volume textbook based on the results of the tests entitled *Die Baumechanik. Auf Grundlage der Erfahrung.*[33] The series title already makes a stand against contemporary efforts to achieve 'scientification' of building knowledge, (which concentrated on theory and mathematics). Instead, Tetmajer emphasised the importance of the experiment, something that had already been well established in the natural sciences. Moreover, the former student of Carl Culmann argued in his textbook for the idea of an application-oriented science.[34] Tetmajer's strong emphasis on applicability is explained by the target audience of the book, as well as the close relationship of the publication to his teaching at the Zurich Polytechnic School. The first volume of the series, *Die angewandte Elasticitäts-und Festigkeitslehre*[35] (1889) covered a section of Tetmajer's lectures on structural mechanics at the School of Architecture.[36] Tetmajer did not complete the other intended volumes, but there were two revised editions of the first volume in 1904 and 1905.[37] The close connection of theory and experiment set a precedent. In the early twentieth century, the Zurich professor, Emil Mörsch, established an application-oriented theory for reinforced concrete whose success was mainly based on its verification by experiments.[38] At the same time, Tetmajer's concept affected the establishment of new disciplines. While initially professors of the chemical department taught technology of building materials at the School of Architecture and the School of Engineering, Tetmajer focused the subject towards a increased constructional approach, which was taught by civil engineers.

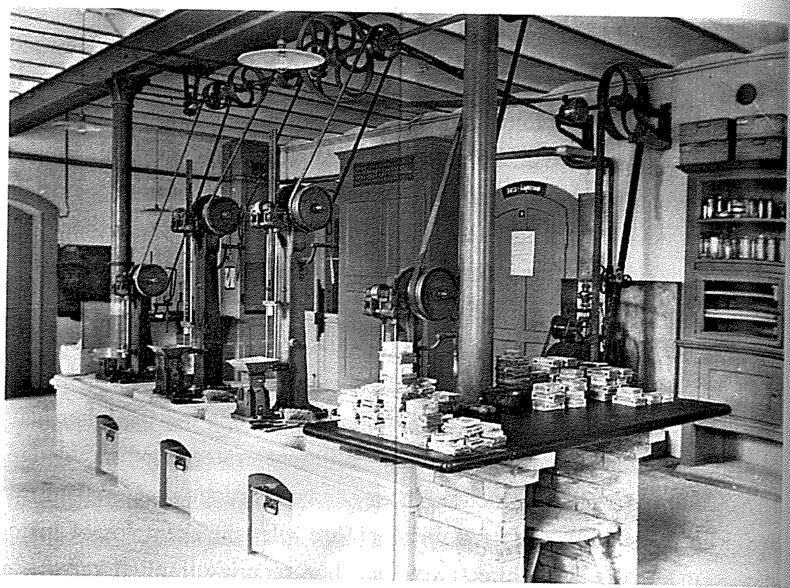

Figure 2. Laboratory for the testing of cement, photo circa 1890s. The Eidg. Anstalt für die Prüfung von Baumaterialien with its systematic testing contributed considerably to the quality of Portland cement. This in turn was one of the main foundations for the introduction and establishment of concrete construction in Switzerland. The testing results were also used to review theoretical derivations on concrete construction. (source: Ludwig Tetmajer, *Bericht über den Neubau, die Einrichtung und die Betriebsverhältnisse der schweizer. Materialprüfungs-Anstalt*, 2nd rev. ed. (Zurich: self-published 1896), plate 11)

ECONOMISATION – SUBORDINATE FOR SCHOOL, DECISIVE FOR PRAXIS

The discursive process of economisation originates in the late eighteenth century. Next to Rondelet's *Traité,* a number of other works mirror the growing importance of this idea in the first half of the nineteenth century. One could name various books on cost-estimation, and ones which treat the entire building process such as Franz Sax' *Bau-Technologie und Bau-Oekonomie.*[39] Sax explicitly mentions the need of economical elements in textbooks on building.[40] However, looking at textbooks written by teachers at the Zurich School of Architecture, economic inventories of building knowledge seem to play a subordinate role. One could speak of a continual exclusion of such matters – a development also mirrored in the curriculum of the school itself. This shift may be an effect of the harsh criticism on the commercialisation of *Baukunst* made by Semper,[41] but it also correlates with the emergence of polytechnic books on building construction, which were not intended to serve as textbooks to be used at school, but rather to be used in practice. The inherent idea of self-teaching is the crucial difference.[42] The emergence of this concept reflects a contemporary bias: matters relating directly to the building process are considered to be better communicated in books focusing solely on the practice, not those including any theoretical inventories of knowledge. An author making this exclusion very clear is Josef Emil Zeller. He published two books he intended to be an explanation of and guidance for the building process: *Das Gesamte in der Bauführung* in 1843 and *Der Bauführer* in 1867.[43] Not only did he state 'that the relevant subject [construction site supervision] is not being taught' at schools such as the Polytechnic School in Zurich', but he also pointed out that a 'graduation' of the book has to take place in practice.[44] Nevertheless, he still considered the content to be part of the polytechnic inventory of knowledge on building.[45] Economisation as a concept appears in a number of ways within Zeller's books: He linked his books to the genre of handbooks on cost estimation,[46] in which the economic re-evaluation of 'work' can be observed mo prominently. Likewise, he considered the physical measurement of building materials and the labour force to be the key for an explanation of the building process. However, he took the idea further when speaking about 'the different trades and their smooth interlocking' and therefore stressing the importance of the building process.[47] Economisation can only be reached by communicating an understanding of what might be the result of a decision. It is his first and foremost aim to teach the practicing architect the 'optimal' processes for a building site. Zeller's books were the starting point for a number of publications on construction site supervision, inheriting the same characteristics. These books were not only a reaction to chances in praxis, but they also proved the importance of textbooks for the production of novel inventories of knowledge and the influence of books for institutional teaching. Not only was the role of construction site-supervision first described, as a self-contained duty with correlating bodies of knowledge, but the books could also be linked to the new self-contained subject of construction site-supervision at the higher technical schools, which became increasingly important over the nineteenth century.[48]

CONCLUSION

By tackling such a range of different books, the scope of this paper may seem rather broad. However, due to the variety of progress made in the nineteenth century, and due to the continuous oscillation of building knowledge between 'theory' and 'practice', such a broad approach is crucial.

Explanations are deduced from the perspective of historical science, although it is also necessary to include a non-disciplinary context. For instance, in the case of Rondelet's *Traité,* such an approach reveals a precise understanding of his specific strategies for the 'scientification' of building knowledge. Moreover, dealing with a number of textbooks allows an insight into the process of knowledge production in academic fields. If sufficient sources are available, a deeper re-construction and understanding may be made possible as to how textbooks are produced. Furthermore, in the particular case of architecture, textbooks can be characterised as 'open' – they do not necessarily represent valid knowledge of an academic community as a whole, but only the author's point of view, as exemplified by Lasius' book.

Even though the issues addressed here can only be discussed briefly, the evidence is set out: especially in the case of – in modern terms – applied sciences where a re-evaluation of these textbooks is fruitful. It therefore becomes apparent that such textbooks could be considered as 'interesting, open, and stimulating'.

Endnotes

1. Cf. Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962).
2. Cf. e. g.: Andres Lundgren and Bernadette Bensaude-Vincent (eds.), *Communicating Chemistry. Textbooks and Their Audiences, 1789–1939* (Canton/Mass.: Watson Publishing, 2000).
3. On Jean Rondelet see: Robin Middleton and Marie-Noelle Baudouin-Matuszek, *Jean Rondelet. The Architect as Technician* (New Haven and London: Yale University Press, 2007).
4. See Uta Hassler, "Die polytechnische Tradition der Bauforschung," in id. (ed.), *Bauforschung. Zur Rekonstruktion des Wissens* (Zürich: vdf, 2010), 80-131.
5. "Königsweg zur Industralisierung" Wolfgang König, "Ingenieur, Abschnitt 6. Ausbildung," in *Enzyklopädie der Neuzeit 1450–1850, vol. 5*, edited on behalf of the editorial board by Friedrich Jaeger (Stuttgart and Weimar: Metzler, 2007), 976.
6. Cf. Jean Dhombres and Nicole Dhombres, *Naissance d'un nouveau pouvoir: Sciences et savants en France, 1793-1824* (Paris: Payot, 1989).
7. Cf. Wolfgang König, "Spezialisierung und Bildungsanspruch. Zur Geschichte der Technischen Hochschulen im 19. Jahrhundert," *Berichte zur Wissenschaftsgeschichte 11* (1988), 219-25; Klaus Mauersberger, "Die Entwicklung der technischen Hochschulen und ihrer Ausbildungskonzeptionen im 19. Jahrhundert," *Dresdner Beiträge zur Geschichte der Technikwissenschaften* 17 (1989), 18-36.
8. Cf. Mathias Heymann, *"Kunst" und Wissenschaft in der Technik des 20. Jahrhunderts. Zur Geschichte der Konstruktionswissenschaft* (Zürich: vdf, 2005), 39-82.
9. Cf. Wolfgang König, "Spezialisierung und Bildungsanspruch. Zur Geschichte der Technischen Hochschulen im 19. Jahrhundert," *Berichte zur Wissenschaftsgeschichte 11* (1988), 219-25.
10. In the preface to *Die Graphische Statik* Culmann stated, "it has cost us untold trouble to acquire the necessary prerequisite knowledge for our students, so that the school might declare geometry a compulsory subject... to the engineer, and even the technician, a knowledge of geometry is of no less importance than that of analytic. As he has always to cope with the representation of spatial forms, how useful it would be, if his powers of spatial perception have been formed to the extent, that he can, with ease, complement flat projections to bodies and perceive spatially the work to be executed in buildings and machinery in their entirety." *"Unsägliche Mühe hat es uns gekostet, die nothwendigen Vorkenntnisse bei unseren Zuhörern zu erlangen, zu erlangen, dass man von der Schule aus die Geometrie der Lage obligatorisch erklärt werde... Für den Ingenieur, für den Techniker überhaupt, ist die geometrische Bildung nicht minder wichtig als die analytische; hat er es doch immer mit der Darstellung räumlicher Gebilde zu thun, wie nützlich ist es, wenn sein räumliches Anschauungsvermögen einigermassen ausgebildet worden ist und er mit Leichtigkeit flache Projectionen zu Körpern ergänzen kann und das Ganze auszuführender Bauwerke und*

Maschinen räumlich durchblickt." Carl Culmann, *Die graphische Statik* (Zürich: Meyer & Zeller, 1866), VIII.

11. Cf. e. g.: Torsten Meyer, "Technologie," in *Enzyklopädie der Neuzeit 1450-1850, vol. 13*, edited on behalf of the editorial board by Friedrich Jäger (Stuttgart and Weimar: Metzler, 2011), 442-65.

12. *"Architectur ist Construction."* Handwriting of Schinkel quoted according to: Goerd Peschken, *Das Architektonische Lehrbuch.* Series: Karl Friedrich Schinkel. Lebenswerk (München: Deutscher Kunstverlag, 1979), 115.

13. In more detail cf. Torsten Meyer, "The Science of Building as Polytechnic Discipline in the 19th Century," in *Proceedings of the 4th International Congress on Construction History* (Paris: 2012), in press.

14. Valerie Nègre, "Some Considerations on Traité de L'Art de Bâtir by Rondelet and the Technical Literature of his time," in Werner Lorenz, Karl-Eugen Kurrer and Volker Wezk (eds.), *Proceedings of the 3rd International Congress on Construction History* (Berlin: NEUNPLUS1, 2009), vol. 3, 1094.

15. Cf. e. g.: Karl-Eugen Kurrer, *Geschichte der Baustatik* (Berlin: Ernst & Sohn, 2002).

16. Cf. Joel Mokyr, "The European Enlightenment and the Origins of Modern Economic Growth," in Jeff Horn, Leonhard N. Rosenband and Merrit Roe Smith (eds.), *Reconceptualizing the Industrial Revolution* (Cambridge/Mass. and London: MIT Press, 2010), 65-86.

17. Cf. Thomas Brandstetter, *Kräfte messen. Die Maschine von Marly und die Kultur der Technik* (Berlin: Kadmos, 2008).

18. Cf. Reinhart Koselleck, "'Erfahrungraum' und 'Erwartungshorizont' – zwei historische Kategorien," in Reinhart Koselleck, *Vergangene Zukunft. Zur Semantik geschichtlicher Zeiten* (Frankfurt/Main: suhrkamp, 1989), 349-75.

19. Valerie Nègre, "Some Considerations on Traité de L'Art de Bâtir by Rondelet and the Technical Literature of his time," in Werner Lorenz, Karl-Eugen Kurrer and Volker Wezk (eds.), *Proceedings of the 3rd International Congress on Construction History* (Berlin: NEUNPLUS1, 2009), vol. 3, 1094.

20. Jean Rondelet, *Theoretisch-praktische Anleitung zur Kunst zu bauen. In fünf Bänden. Mit den 210 Kupfern der Pariser Original-Ausgabe. Nach der sechsten Auflage aus dem Französischen* (Leipzig and Darmstadt: Karl Wilhelm Leske, 1833-36), vol. 1, 1.

21. Cf. Andrew Saint, *Architect and Engineer. A Study in Sibling Rivalry* (New Haven and London: Yale University Press, 2007).

22. Ludwig Friedrich Wolfram, *Vollständiges Lehrbuch der gesammten Baukunst.* 3 vol., (Stuttgart and Vienna: Hoffmansche Verlagsbuchhandlung, 1833-38).

23. Cf. Ernst Gladbach, *Der Schweizer Holzstyl in seinen cantonalen und constructiven Verschiedenheiten vergleichend dargestellt mit Holzbauten Deutschlands* (Darmstadt: Köhler, 1868); Ibid, *Die Holz-Architectur der Schweiz* (Zurich: Orell Füssli, 1876); Ibid, *Der Schweizer Holzstyl in seinen cantonalen und constructiven Verschiedenheiten*. 2nd series (Zurich: Schmidt, 1883); Ibid, *Charakteristische Holzbauten der Schweiz vom 16. bis 19. Jahrhundert, nebst deren innerer Ausstattung* (Berlin: Claesen, 1893).

24. Cf. Knut Stegmann, "Analyzing Historical Timber Structures – A Case Study on Ernst Gladbach (1812–1896) and his Research on the 'Swiss Style'", in *Proceedings of the 4th International Congress on Construction History* (Paris: 2012), in press.

25. Ernst Gladbach, *Der Schweizer Holzstyl in seinen cantonalen und constructiven Verschiedenheiten vergleichend dargestellt mit Holzbauten Deutschlands* (Darmstadt: Köhler, 1868), s. p. (preface).

26. Cf. Georg Moller (ed.), *Denkmäler der deutschen Baukunst.* 3 vol. (Darmstadt: Leske, 1815–51).

27. Cf. Wilhelm Heinrich Riehl, *Die Naturgeschichte des Volkes als Grundlage einer deutschen Social-Politik. 4th volume: Wanderbuch.* 2nd edition (Stuttgart: Cotta, 1869), 1-41.

28. Gottfried Semper, *Der Stil in den technischen und tektonischen Künsten oder Praktische Aesthetik. Ein Handbuch für Techniker, Künstler und Kunstfreunde,* 2 vols. (München: Friedrich Bruckmann,1860/63).

29. See Petra Brouwer, *De wetten van de bouwkunst. Nederlandse architectuurboeken in den negentiende eeuw* (Rotterdam: NAi Uitgevers, 2011), 205-299.

30. Georg Lasius, *Die Baukunst in ihrer chronologischen und constructiven Entwicklung. Dargestellt und erläutert durch eine Auswahl charakteristischer Denkmale vom Alterthum bis auf die Neuzeit* (Darmstadt: Carl Koehler, 1863-1868), VI.

31. Concrete companies, for example, began to carry out systematic experiments. Cf. Knut Stegmann, Das Bauunternehmen Dyckerhoff & Widmann – *Zu den Anfängen des Betonbaus in Deutschland 1865–1918* (Tübingen/Berlin: Wasmuth, 2012), in press.

32. For instance publications on the testing of steel, steel wire ropes or hydraulic binders. All published by Ludwig Tetmajer in the series of the laboratory *Mitteilungen der Anstalt zur Prüfung von Baumaterialien am eidgen. Polytechnikum in Zürich*, 1884ff.

33. Cf. Ludwig Tetmajer, *Die angewandte Elastizitäts- und Festigkeitslehre.* 2nd revised edition (Leipzig and Wien: Franz Deuticke, 1904), s. p. (Preface of the 1st edition).

34. He would "leave the common path [in order to] ... harmonise the relevant theoretical analysis with reality by using applicable coefficients and then shape them to a form convenient for application." Er weiche *"von den gewöhnlich betretenen Wegen ab, [... um] die Ergebnisse der einschlägigen theoretischen Untersuchungen durch Einführung passender Koeffizienten mit der Wirklichkeit in Übereinstimmung, sodann in eine für die Anwendung bequeme Form zu bringen."* Ludwig Tetmajer, *Die angewandte Elastizitäts- und Festigkeitslehre.* 2nd revised edition (Leipzig and Wien: Franz Deutike, 1904), s. p. (Preface of the 1st edition).

35. Cf. Ludwig Tetmajer, *Die Baumechanik. 2nd volume, 1st half: Die angewandte Elasticitäts- und Festigkeitslehre* (Zürich: Zürcher und Furrer, 1889).

36. The lecture is also documented by an autograph: cf. Ludwig Tetmajer, *Bau-Mechanik. Als Manuscript autographiert.* Diverse volumes (Zürich: self-published 1877/78) and Ibid: *Die angewandte Elastizitäts- und Festigkeitslehre.* 2nd revised edition (Leipzig and Wien: Franz Deuticke, 1904), IX.

37. Ludwig Tetmajer, *Die angewandte Elastizitäts- und Festigkeitslehre.* 2nd revised edition (Leipzig and Wien: Franz Deuticke, 1904) and 3rd revised edition (Leipzig and Vienna: Franz Deuticke, 1905).

38. Mörsch's theory mainly spread through his textbooks. See e. g. Emil Mörsch, *Der Eisenbetonbau. Seine Theorie und Anwendung.* 2nd revised edition (Stuttgart: Konrad Wittwer, 1906).

39. Franz Sax, *Bau-Technologie und Bau-Oekonomie*, 4. vols. (Wien: Anton Doll, 1814). Common books on cost estimation at the time are e.g.: August Friedrich Triest, *Handbuch zu Berechnung der Baukosten für sämtlichen Gegenstände der Stadt- und Landbaukunst*, 18. vols. (Berlin: Duncker und Humblot, 1824-31); J. Manger, *Hülfsbuch zur Anfertigung von Bau-Anschlägen und Feststellung von Bau-Rechnungen* (Berlin: Ernst & Korn, 1853).

40. *"Bey dem Ueberflusse an Baubüchern scheint es doch noch an einem brauchbaren Inbegriffe für Baukünstler und solche Personen zu fehlen, welche sich ausschließlich den Baugeschäften widmen."* ("despite the abundance of books on buildings, architects and other such persons seem to be lacking a useful embodiment that is solely dedicated to the *Baugeschäfte*"). Franz Sax, *Bau-Technologie und Bau-Oekonomie* (Wien: Anton Doll, 1814), vol. 1, 3.

41. Gottfried Semper, *Der Stil in den technischen und tektonischen Künsten oder Praktische Aesthetik. Ein Handbuch für Techniker, Künstler und Kunstfreunde*, 2 vols. (München: Friedrich Bruckmann,1860/63), vol. 1, XII.

42. Cf. Christoph Rauhut, "Handbooks on Construction Site Supervision in the 19th Century", in *Proceedings of the 4th International Congress on Construction History* (Paris: 2012), in press.

43. Josef Emil Zeller, *Das Gesamte der Bauführung* (Stuttgart: Wachendorf'sche Buchhandlung, 1843); Josef Emil Zeller, *Der Bauführer* (St. Gallen: Altwegg-Weber z. Treuburg, 1867).

44. *"auf den Schulen, wie namentlich auch im Polytechnikum in Zürich, [wird] der fragliche Gegenstand nicht gelehrt"* Josef Emil Zeller, *Der Bauführer* (St. Gallen, Altwegg-Weber z. Treuburg: 1867), 6, see also 283–4.

45. Josef Emil Zeller, *Der Bauführer* (St. Gallen: Altwegg-Weber z. Treuburg, 1867), 6.

46. Josef Emil Zeller, *Das Gesamte der Bauführung* (Stuttgart: Wachendorf'sche Buchhandlung, 1843), 4.

47. *"Die verschiedene Gewerke und ihr richtiges Ineinandergreifen"* Josef Emil Zeller, *Der Bauführer* (St. Gallen: Altwegg-Weber z. Treuburg, 1867), 275.

48. Cf. Christoph Rauhut, "Handbooks on Construction Site Supervision in the 19th Century", in *Proceedings of the 4th International Congress on Construction History* (Paris: 2012), in press. In regards to higher technical schools cf.: Eckard Bolenz, *Vom Baubeamten zum freiberuflichen Architekten* (Frankfurt a.M. et al: Peter Lang, 1991), 182–93.