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Gerüste Und Hilfskonstruktionen Im Historischen Baubetrieb: Geheimnisse Der Bautechnikgeschichte. (Scaffolding and Auxiliary Constructions in Historical Building Operations: Secrets of Construction History)

By Stefan Holzer (in German). 470 pp., 450 illustrations in colour and black and white. Berlin: Ernst und Sohn, 2021. 79€ (Hardback). ISBN 978-84-9728-587-2

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not have been correct at the time were so essential in their own decision in response to pit closures and other fundamental changes to the lives of miners and whole mining communities. Although academic in style, these interviews not only lighten the read but inform in a way no amount of theoretical context can do. I can recommend this book to anyone interested in how workers, resources, politics and technology interact. Although not a book much concerned with the technology of mining as such, the very significant changes in coal mining methods in the post-war period from pick and shovel to highly mechanised systems, were the backdrop against which everyone concerned was making decisions.

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Gerüste und Hilfskonstruktionen im historischen Baubetrieb: geheimnisse der Bautechnikgeschichte. (Scaffolding and Auxiliary Constructions in Historical Building Operations: Secrets of Construction History). By STEFAN HOLZER (in German). 470 pp., 450 illustrations in colour and black and white. Berlin: Ernst und Sohn, 2021. 79€ (Hardback). ISBN 978-84-9728-587-2

Many people interested in the history of construction will have been fascinated by the wonderful drawings in mediaeval manuscripts showing the construction of cathedrals, castles or buildings mentioned in the bible, such as the Tower of Babel. More recently, David

Macaulay's book *Cathedral*, intended for children, has fascinated many an adult. The vast majority of books on the history of construction and architecture concentrate on the finished buildings. Some authors have included their own ideas about how Gothic vaults or domes were built but, as often as not, reveal the author's ignorance of even basic building engineering and construction practices. This gap in the literature has now, more or less, been filled by the recent book by Professor Holzer from the ETH in Zurich. From the title of the book, it would seem to focus on scaffolding, centring and other temporary works used in construction. But the book is about much more since, to a large extent, the temporary works reveal the method and sequence of construction – both vital to understanding how great structures were built.

The book is arranged in six chapters, the first of which discusses how the history of scaffolding provides insight into the history of the construction site. By their very nature, temporary works are do not generally survive after a building is completed and so our knowledge of them must be based largely on books, drawings or models giving guidance or instructions on how a structure should be built, or drawings and, later, photographs, of actual construction sites. Indeed, sometimes construction works are included at the sides or in the background of pictures whose principal subject is in the centre or foreground. The author does not claim that the book is comprehensive but rather, for the first time, to give an overall context to the history of construction sites. The scope of the book is masonry construction using timber falsework and centring, from ancient times to the start of World War I, although only a few pages deal with structures built after 1860. There is virtually no discussion of temporary works used for structures made of iron, steel or reinforced concrete.

The second chapter looks at the elevated workplace, supported by access scaffolding built up from ground level or cantilevered out from stonework at a high level. The precariousness and daring of some scaffolding structures is nothing less than breathtaking. An interesting development in Austria, south Germany and Switzerland in the 17th century was scaffolding which had two sets of vertical timbers – one with long timbers that carried little vertical load and which gave stability to a second which consisted of short struts that supported the working platforms. While most scaffolding for new construction and renovation was stabilised and supported by the structure under construction, many larger works required free-standing scaffolding structures.

Chapter 3 aims to answer the question 'How do you build a vault?' The Romans used timber centring and shuttering for barrel vaults and groined vaults made of concrete, and also used centring for concrete vaults with a facing of brick. Sometimes forms were included to create coffered vaults. While the construction of ribbed vaults in the Gothic era is discussed, Holzer, like other authors before him, does not give a clear idea of how the brick or stone infill panels or webs between the ribs were supported until they were complete and could act as a shell. From the 14th century there survives in Sweden the centring used to construct a small vault in a tower. From the mid-18th century there survives a model of the design for the free-standing scaffold and centring used to construct the vaulted nave of the Church of St Anna in Augsburg in south Germany. This model would have been used rather than drawings to fix the design and to communicate it to the craftsmen involved.

The next chapter is devoted to the temporary works needed to construct masonry domes. After some discussion of Roman domes of concrete and brick, the chapter discusses three major case studies – Brunelleschi's dome on Florence, the dome of St Peters, and the Panthéon in Paris. Helpfully, Holzer mentions some ‚false tracks'or misunderstandings regarding centring for domes created by some early authors, particularly regarding the Florence dome.

Chapter 5, extending to 100 pages, looks mainly at the most essential piece of plant used in construction – the crane. A Roman relief showing a large crane powered by a

tread wheel shows that lifting technology developed little until the advent of steam powered cranes in the 1840s. Many such tread wheels survive from the 15th century and later, but rather few pulleys that were of no less importance. As well as fixed wheels in the roof space of cathedrals, free-standing cranes, able to rotate through 360° and also powered by tread wheels, were already common in the 15th century. An especially effective variant, that became known as a 'French crane', had a fixed central post and only the top part of the crane rotated. Within this chapter is also a section on moving large objects horizontally by means of winches, ropes and pulleys, as well as lifting them. The moving of the Vatican Obelisk by Fontana in the 1580s is perhaps the best known example, but not the only one. In the 1450s an entire stone tower in Bologna, 25 m high, was moved on rollers a distance of just 13 metres. Finally, in the 1840s lifting machines entered a new age with the use of steam powered cranes, either fixed at the side of a building under construction, or mounted on a frame that ran on rails, or on a railway wagon, which allowed much easier horizontal transport of heavy materials.

The final and longest chapter concentrates on what the author calls the king of temporary works structures – the centring used to build bridges. The exposed structure of masonry bridges means that it is easier to see evidence of the centring used in their construction – from the Roman Pont du Gard up to 1900. One small bridge in the Austrian Tirol, dating from around 1640, is of particular note as the timber centring used for its construction is still in place. This has enabled precise information to be collected regarding the erection of the centring and enabled Holzer to show in ten drawings the method and sequence of its construction. Because of their importance in the development of cities, we are also fortunate that the construction of a number of large bridges, especially in France and Britain, between about 1720 and 1820, was recorded in highly detailed drawings. It is in the design of bridge centring that we find the first attempt to use engineering science (statics) to determine the loads on the centring and the forces in the individual members. In 1726 Henri Pitot (remembered for the Pitot tube used to measure the speed of fluid flow) applied ideas about equilibrium and the parallelogram of forces proposed by Varignon to the compare two alternative designs for a centring structure. A few decades later, John Smeaton also used arguments based on statics to compare alternative design for centring. There follow several examples of falsework and centring used to construct a masonry viaducts for trains built during the second half of the 19th century, including some extraordinary timber structures that were hardly less spectacular than the viaducts themselves. The chapter ends with a few examples of falsework structures used in the construction of some iron girder bridges. One omission from this chapter is the falsework used for the construction of the Iron Bridge in 1789, as illustrated in the picture by Elias Martin. The extremely flimsy structure was in stark contrast to the elaborate timber structures used for masonry bridges constructed at the same time.

The text of the book is supported by over a 1000 footnotes and around 600 references to publications and other sources. The book itself is produced to the highest of standards, on high quality paper and with excellent pictures.

Although what is presented in the book is excellent, I do have some reservations regarding its scope. For example, there could have been some coverage of formwork used to provide shape to mortar and concrete construction, which is no less important than scaffolding and centring. Also, there is no mention of the temporary support of excavations, either for building foundations or for retaining structures used when constructing the piers of bridges. Again, tthese were no less important than scaffolding and bridge centring. Likewise, there is no mention of the pile driver which was a machine of equal importance to the crane, at least with regard to foundations and in order to install retaining structures. It would have been interesting to learn about the supporting structures used when constructing tunnels, for example the Thames Tunnel built by the Brunels,

father and son. Finally, it would probably have been better to limit the book to masonry construction rather than end with a few token pages devoted to iron girder bridges.

The book is in German and I would unhesitatingly recommend it to all German speakers who are interested in the history of construction methods. However, I would also recommend it highly to those who do not read German since its great strength is the large number (450) of excellent illustrations it contains, many of which are in colour, the quantity, quality and variety of which are unprecedented in a single book.

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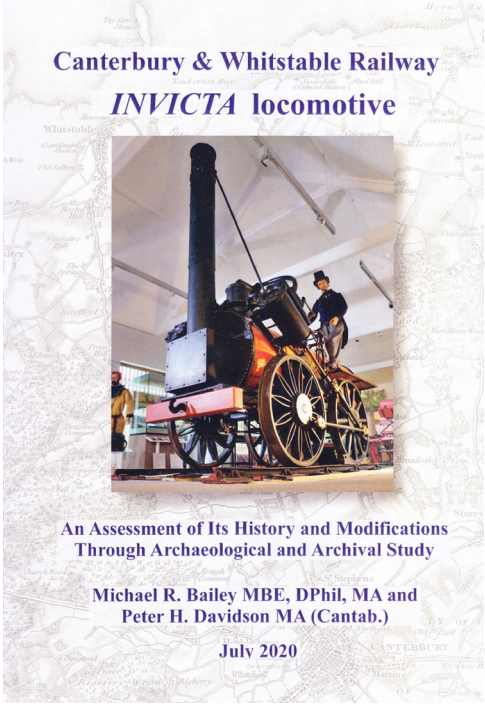
Canterbury & Whitstable Railway INVICTA locomotive – An Assessment of its History and Modifications Through Archaeological and Archival Study. By Michael R. Bailey and Peter H. Davidson. 120 pp., over 200 illustrations and drawings. Whitstable: Whitstable Community Museum and Gallery, 2020. £18 plus £5 postage and packing from Whitstable Community Museum. ISBN 978-1-8383317-1-9



The work of past President of the Newcomen Society Dr Michael Bailey and his colleagues John Glitheroe and Peter Davidson will be known to many. Beginning his