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The early German production and use of modern hydraulic binders: between English influences and the search for a scientific approach, 1817-1839

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Introduction

A general need to improve building standards strongly characterizes the German “art of building” in the first decades of the nineteenth century. As a consequence, the interest towards technical aspects of buildings increases and the publication of several technical treatise and periodicals is an evidence of that. The preface to the first issue of the periodical Sammlung nützlicher Aufsätze und Nachrichten, die Baukunst betreffend published by the Preußisches Ober-Bau Departement from 1797 to 1806 can be considered as a manifesto of the technical approach to architecture. Art and science should merge together in architecture otherwise “the artist risks weirdness”, asserts one of the focal concepts of this preface.[1]

It is in such a context that the interest in hydraulic binders increases and it was driven by the need for more efficient and durable mortars in hydraulic engineering as well as for plasters and artificial stones. The ability to produce and apply efficient hydraulic binders in Germany seems to have lagged behind France and England.[2] Several French and British chemists conducted significant research on hydraulic lime and mortars from the eighteenth century, while master builders, masons, brick makers, entrepreneurs or just inventors managed to improve methods for producing and applying them. One of those inventors is the British clergyman James Parker who patents a new calcareous hydraulic binder that is known as Parker’s or Roman cement. Unlike lime, which is normally used close to the site of its production, Roman cement can be packaged and transported far away, as any another manufacturing product. It is an efficient hydraulic binder as well as a great manufacturing opportunity, arousing therefore the interest of master builders and of all those who were involved in the process of industrialisation in Germany.

Investigations on Roman cement

From 1806 to 1814, the embargo known as “Continental Blockade” prevented relations and exchanges between the United Kingdom and European countries. After 1814, British trade resumed and, in 1817, a Roman cement dealer named Benjamin Dodson sets up in Hamburg[3]. Dodson worked on behalf of a London manufacturer and beside cement he also supplies “the tools that allow the use of cement” - probably moulds.[4] Not only trade resumed after 1814 but also the so-called “Technologische Reise”. The expression “Technologische Reise” describes journeys undertaken by German technicians, businessmen or civil servants to investigate new industrial products and manufacturing processes abroad. England was the main goal of these journeys. Most travellers were interested in mechanical things but some attention was also paid to new building techniques and materials.

It must have been quite impossible for German travellers not to notice the Roman cement plasters and decorations that spread all over in London after the lapse of the Parker’s patent in 1810. It is probably
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thanks to such a traveller that prince Leopold of Bavaria received a report about Roman cement by the London department of building. The prince handed the report over to Christoph Arzberger (1772-1822), a mathematician and civil servant of high rank in Coburg. Arzberger analysed the report and wrote a short article that was published in the Kunst- und Gewerbe- Blatt des polytechnischen Vereins für das Königreich Bayern in 1819[5]. Arzberger describes Roman cement as a fine milled powder made of clayish limestone that has been burnt in brick kilns and is suitable for composing mortar to use in hydraulic engineering as well as for plaster and for moulded decorations. Arzberger also presumes that Roman cement could be reproducible in Germany by burning stones composed of lime and clay, the so-called calcareous marls.

Another significant investigation on Roman cement is that of [Johann Heinrich] Krahmer, master builder at the Prussian Oberbaudeputation.[6] Krahmer went on a technological journey to England in 1821, during which he visits the house of Charles Francis, owner of the greatest Roman cement factory of that time, together with his associated John Bazley White. Upon his return to Berlin, Krahmer reported to the Oberbaudeputation about what he has seen and learnt in England. He synthetically describes the composition and the properties of Roman cement, and lists all the applications that he has observed in Francis's garden: several plaster works on walls, staircases, pavements, basins of fountains and many moulded decorations (Figs 1-2). Krahmer also reports to have seen some gothic style moulded decorations in the newly restored New College Chapel in Oxford. While on one hand Krahmer appears to be impressed by the quality of the Roman cement mortar and plaster he has observed, on the other he complains about the impossibility to get detailed information about the raw materials and the manufacturing process of cement. As Arzberger before, Krahmer also believed that it could be possible to produce Roman cement in Germany after having investigated its composition through chemical analysis. Consequently, he brought from England to Berlin two casks of Roman cement and handed them over to Johann Albert Eytelwein (1764-1849), head of the Oberbaudeputation, and to Peter Christian Wilhelm Beuth (1781-1853), head of the Technische Deputation and of the Verein zur Beförderung des Gewerbefleißes in Preußen (Gewerbverein).

The two institutions led by Beuth were committed to developing industry in Prussia. In 1822 the Gewerbverein promotes a competition divided into several sections one of which concerns the invention of a mortar similar to cement and suitable as artificial stone to produce moulded objects and decorations.[7] This competition is probably inspired by Krahmer's experience in London but, because of the lack of literature and any other knowledge or experience about Roman cement, participants are invited to read German and French literature about hydraulic lime, and to refer to a previous attempt at producing artificial stone that was carried out in Berlin about ten years before by the master builder Paul Ludwig Simon (1771-1815).[8]

While the competition does not yield the expected results, it nevertheless contributed to raising the interest in hydraulic binders and to spreading the notoriety of Roman cement in other German states. In 1823, the king of Württemberg, Wilhelm I, asks his industrial spy in England, Friedrich Schmidt, to search for information about Roman cement focusing on its quality, its price and its suitability to plaster buildings in Stuttgart.[9] In June 1823, Schmidt sends the king two reports in which he asserts that Roman cement is an appropriate binder for plaster, and describes briefly how to produce it. Just like Arzberger and Krahmer before, even Schmidt believes that Roman cement could be produced in Germany and furthermore he thinks that cement manufacturing could become an important field of the rising industry in Württemberg. He therefore suggested searching for clayish limestone along rivers but, unfortunately, the search, that actually takes place around 1823, does not give the expected results. The available amount of clayish limestone was judged too small and no cement manufacturing was undertaken.
Despite attempts and efforts, around 1825 no hydraulic binder similar to Roman cement had been produced in Germany. Roman cement was, however, imported in small amounts, and some masters of building began to employ it to plaster walls or just to seal masonry joints that are exposed to water or damp. Around 1826, Krahmer himself experimented with the use of Roman cement in a suburban villa nearby Berlin.[10] He plastered some exterior walls and staircases, some pavements in the house basement, and finally he sealed the joints of a dock along the Spree, the Berlin River. Roman cement was also used to seal the joints of the Friedrich-Wilhelm Canal sluices and in 1827 to seal the joints of the new lighthouse of Kap Arkona on the Rügen Island. The definitive plans of the lighthouse are elaborated by August Adolph Günther (1779-1842) probably in collaboration with Karl Friedrich Schinkel (1781-1841) around 1825.[11]

In 1826, Schinkel went on a journey to France and England together with his friend Beuth. In London they visit the building site of the first Thames tunnel conceived by the engineer Marc Isambard Brunel (1769-1849) who personally led them around. In his travel diary, Schinkel drafts two sections of the tunnel structure and notices that the main building materials are bricks and Roman cement mortar.[12] One year later, in the magazine of the Gewerbverein, Beuth publishes an article about the construction of the Thames tunnel in which he writes on the huge quantity of Roman cement that Brunel has been using (Fig. 3).[13]

Schinkel’s journey to England actually happens during the construction of the Kap Arkona lighthouse but it would be difficult to prove that Schinkel himself suggested the use of Roman cement to finish the lighthouse joints. On the contrary it is an evidence that, after the journey of Schinkel and Beuth, the Gewerbverein begins to plan a new competition, which should be clearly focused on the reproduction of Roman cement. To make the task easier, the Interior Minister Friedrich von Schuckmann bought two casks of Roman cement from the factory of Francis and White and gives them to the Gewerbverein in order to conduct experiments and better understand the properties of Roman cement.[14] The experiments take place around 1828 and aimed to verify if Roman cement mortar set under water, if it binds bricks and if it works efficiently as a plaster for walls and water containers (Fig. 4). The results are not extraordinary as the plaster of water containers cracks.[15] Furthermore the Gewerbverein technicians judge Roman cement too expensive for hydraulic engineering while they consider normal lime efficient enough to plaster buildings. Roman cement therefore appears suitable just to seal founding walls against rising damp, to build masonry vaults that are exposed to rain and to plaster wet walls. The following year, the Gewerbverein set aside the idea of a competition focused on the reproduction of Roman cement and asked for the development of a hydraulic mortar that should have all properties identified as necessary during the tests on Roman cement mortar, i.e. the mortar should set under water as well as at air without cracks, it should be suitable for hydraulic engineering as well as for ordinary masonry and it should cost no more than six time the price of ordinary lime mortar.[16]

Like the previous one, even this competition had no winner. The efforts undertaken to discover a binder with similar properties to those of Roman cement appeared fruitless, partly because the exact knowledge of the manufacturing process remained unknown and partly because the suitable raw materials were still to be found.[17]

The cement production in the northwest regions

Since the late 1820s some calcareous cements similar to Roman cement have been produced in the northwest regions, from the Frisian coast to the city of Kassel. That resulted from the initiatives of private entrepreneurs who could easily learn about British manufacturing processes, owing to the intense relationships that these regions maintained with England. Initially, even raw materials were sometimes
imported from England, as it happens for the cement production that Claus Shipmann undertook in Hamburg in 1829.[18] Two years later Reinhard Wollmann (1757-1837), a hydraulic engineer in Hamburg, wrote a report about the Shipmann cement, asserting that this cement is suitable to plaster buildings and can be used for hydraulic engineering or the construction of concrete walls.[19] Neither concrete walls nor concrete mixed with cement were common in Germany in the 1830s when concrete was still composed with lime and Traβ or brick powder, and was used in few cases just to build foundations for hydraulic engineering.

In the first half of the 1830s, after Shipmann’s cement mill, several others are founded in the above-mentioned area.[20] Two are located in the Frisian villages of Carolinsiel and Emden, one in Buxtehude near Hamburg, one in Hameln in the south of Hannover, one in Barbs near the Harz Mountains and another one in Kassel.

The cement mills in Hameln and the one in Kassel had a particularly good reputation. The engineer Georg Theodor Wendelstadt (1790-1860) and the banker Adolph Meyer (1807-1866) found the first one in 1833.[21] The factory is located along the Weser River, next to the future building site of the suspended bridge of Hameln. There is a connection between the foundation of the cement mill and the project for the suspended bridge in Hameln.[22] Wendelstadt himself was charged with the project for the bridge, which provided him the opportunity to learn more about Roman cement thanks to studies of previous works and personal contacts with other specialists. An important reference for Wendelstadt’s project was the Menai Suspension Bridge built by Thomas Telford (1757-1834) between 1819 and 1826. The pillars of which are made of stones and mortar partly composed with hydraulic lime, while the joints are scaled with Roman cement mortar.[23] Furthermore, around 1833-34, Wendelstadt orders some strength tests on metal chains that take place in Kassel, in the foundry of Carl Anton Henschel (1780-1861) who had just been to England to study railways and did meet Brunel, the engineer of the Thames tunnel. At that time, Brunel was testing the force of adhesion between cement mortar and bricks through the experimental construction of an impressive half arch (Fig. 5).[24] Henschel learnt about the potential of combining cement mortar and bricks - as the construction of his new foundry some years later demonstrates - and he could have talked to Wendelstadt about Roman cement. The project for the bridge in Hameln was approved in 1836 and the bridge was built between 1836 and 1839, using huge quantities of cement produced by the factory of Wendelstadt and Meyer for the masonry of pillars and for the anchorages of the metal braces into the earth (Fig. 6).

Around the time the Hameln cement mill was founded, the entrepreneur Ernst Martin Koch (1786-1860) began producing cement in Kassel. The fame of Koch’s cement was primarily due to two events. The first one concerns the publication in 1833 of an instruction booklet that is probably the first German manual entirely dedicated to cement. The second event concerns the building of the dome for the above-mentioned new foundry of Henschel in 1837, for which Koch delivers the cement.[25] Henschel himself designed the dome that is made of hollow circular frustum-shaped bricks bonded with cement mortar. Henschel did not use any centring to build the dome, he just exploits the property of cement mortar to set in few minutes and strongly adhere to bricks, as he had probably learnt from Brunel in London.

The scientific approach to the production of hydraulic lime in Bavaria

While in the northwest and central regions some entrepreneurs launch the production of cements similar to the Roman cement, in Bavaria some master builders begin to produce and use hydraulic lime. British influences are mostly absent in this case as the use of the expression “hydraulic lime” instead of the term “cement” demonstrates. Moreover, the manufacturing process of hydraulic lime in Bavaria derives from the implementation of a scientific theory rather than from the imitation of a foreign manufacturing
process and the role of the Bavarian State in supporting scientific research as well as the production and use of hydraulic lime is much more important than the role of private entrepreneurs.

Towards to end of the 1820s, Johann Nepomuk von Fuchs (1774-1856), a Bavarian chemist, was charged by the director of the ministerial building department Von Purgel to study lime and mortar.[26] Based on precedent researches carried out mostly by French and German chemists since the end of the eighteenth century, Fuchs defines a theory to explain the chemical processes that concern clay and lime during lime burning and during mortar hardening. The practical implications of Fuchs’s theory are no less important than the chemical aspects of it. Fuchs encourages master builders to produce hydraulic lime using the Bavarian marls and asserts that hydraulic lime is suitable both for hydraulic engineering and for conventional buildings. In 1829, Fuchs read a dissertation about the results of his research at a sitting of the Polytechnischer Verein für das Königreich Bayern arising partly interest and partly the opposition of those who believe that the best hydraulic lime ever is the Roman cement and that Bavarians should acquire in England the principles of cement manufacturing rather that investing in researches.[27] Some others even believe that the production of hydraulic lime in Bavaria would be impossible because of the lack of coke that is used to burn Roman cement in England.[28]

The opposition to Fuchs’s theory soon became outdated thanks to the first practical experiences with Bavarian hydraulic lime. The main promoter of Fuchs’s theory implementation is Friedrich Panzer (1794-1854), an engineer at the Bavarian public administration. Panzer himself experimented with the production of hydraulic lime from marls, undertook strength tests and uses it to compose mortar and plaster for a barn that he built in Würzburg in 1830, and for a bridge over the River Main that he built in the village of Schonungen in 1831 (Figs 7-8). Several Bavarian master builders and masons follow the example of Panzer and begin to burn and use hydraulic lime to compose mortar and plaster.[29] Beyond the building activities, Panzer also wrote essays. In 1831, he published the first that is entirely focused on hydraulic lime and mortar.[30] In the preface Panzer affirms that the existence of a scientific theory is the inescapable condition to spread knowledge and practices about hydraulic lime. He wrote: “For long time hydraulic lime was known in Italy and Holland, later on in England and France, but the lack of scientific justification did not allow the further spread of it”. [31] Panzer’s efforts deeply change the approach to the question of hydraulic binder in Bavaria and even in near Württemberg. This is clearly expressed in an article published on the Polytechnisches Journal of Stuttgart in 1831, which states the following: “until now hydraulic lime has been considered a rare natural product and it has been thought that the best hydraulic lime ever was available only in England. Lime of the same quality is conversely available in abundance in all Bavaria. Until now, it was neither known nor used because of the lack of a foundational theory”.[32]

In 1832, Fuchs’s theoretical research and Panzer’s practical activities were highly recognised by the Hollandsche Maatschappij van Wetenschappen (Dutch Society of Sciences) as well as by the Polytechnisches Verein für das Königreich Bayern. The first institution awarded Fuchs the first prize for a competition aimed to discover the composition and properties of hydraulic cements, and to define the chemical process that takes place during the solidification of cements. The second institution awarded Panzer the first prize for a competition aimed to reward “that engineer, master builder or mason who, following the instructions given by Dr. Fuchs ...., discovers a domestic hydraulic lime” suitable to prepare a mortar able to resist to water and damp.[33] After that, the Polytechnisches Verein also decided to award Fuchs a medal in recognition of his contributions to the scientific theory of mortars and to the improvement of the art of building.

The full recognition of Fuchs and Panzer’s works is also an acknowledgement of the Bavarian scientific approach to the question of hydraulic lime as well as a hard critic of those who had claimed the necessity
to search abroad for the knowledge and practice to produce hydraulic lime. This point is clearly expressed in an article published in the Kunst- und Gewerbe- Blatt des polytechnischen Vereins für das Königreich Bayern in 1832. The author finds it regrettable that after the publication of Fuchs’s theory “someone was sent at the expense of the State to acquire the method for producing hydraulic lime in England. A place, where there had been no theoretical developments on the subject. Where hydraulic lime was produced from only one type of raw material and by following a quite empirical method. Where nobody was able to provide any explanation based on general principles”.[34]

Conclusions

The cement that was produced in the north and the hydraulic lime that is produced in the south of Germany are two very similar hydraulic binders, even identical in some cases. Cement of that time can be considered a good hydraulic lime. “Cement properties are those of a highest quality hydraulic lime” states in 1835 B. W. Rodewick, a cement producer in Emden.[35] Three years later, Carl Wilhelm Dempp, who taught at the Königliche Baugewerbeschule in München, confirmed this point by writing: “the art of building distinguishes ... aerial lime from the hydraulic one that is also named cement”. [36]

The approach to the manufacturing of these binders was very different in the North and in the South, resulting from different cultural backgrounds. The approach followed in Bavaria was representative of the efforts carried out in some regions of Germany to find an autonomous character for the German Baukunst that should be based on the exaltation of scientific and technical aspects. The search for establishing theories and general principles also characterises the future development of German hydraulic binders and enables Germany to become, some years later, the first country to develop a set of norms for the production and the delivery of cement.

References

[2] Regardless of the political form of Great Britain, German authors of the first half of the eighteenth century mainly refer to England in technical literature about cement. Actually England was the main aim of their interest.


[17] Von Schuckmann, (Note 15). More than ten years later, in the Gewerbverein Protocol, it is stated that “the theory for producing cement is well known and many cements had already been produced in Prussia” but what still misses is “a place where great quantity of suitable raw materials cold be found”, Anon., “Angelegenheit des Vereins: Protokoll April 1841”, Verhandlungen des Vereins zur Beförderung des Gewerbefließes in Preußen, vol. 20, 1841, p. 62.


[20] Ibid., p. 89.


[25] The building is still in existence and it is used as conference hall of the University of Kassel.

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[31] Panzer, Anleitung, (Note 32), p. 3.


[34] Anon., (Note 30), col. 759.
