FERRO-CONCRETE

The Construction Industry enters the 20th Century

The new technology was introduced into Britain as Ferro-Concrete. Some trade journalists of the 1900s refused to use the term and Reinforced-Concrete took its place. In this article R0 y Day conforms to UK practice but recognises the historical importance of the earlier term.

Whilst the 18th and 19th centuries could be said to be the age of the limekiln and the late 19th century saw the consolidation of the craftsman/supplier network, so the 20th century opened with the appearance of a new technology which was to dominate the construction industry. This was the emerging science of reinforced-concrete design which developed from an academic study, mainly in France, into a practical method of building large, stable and comparatively cheap structures. It began in a curiously parochial way in the middle of the 19th century, finally shook off the constraints of inward-thinking in the 1880s, to develop rapidly in France, Germany and Belgium during the 1890s. lt arrived in Britain by 1897 and Bristol in 1903.

In 1854 William Boutland Wilkinson (1819-1902) took out British Patent No 2293, for floors containing iron reinforcements.[1] His firm, W B Wilkinson and Co Ltd, of Newcastle-upon-Tyne and London, built several dwelling houses and a cottage[2] embodying this new principle but little else was done in Britain to develop his ideas. In contrast, there was considerable activity in France at about this period and from 1848 when Jean-Louis Lambot developed a material he called 'ferciment' and built a concrete rowing boat reinforced with a rectangular mesh of iron rods[3], there was a constant stream of new ideas including those by Francois Coignet in 1854 and 1861[4], which mainly concerned improvements in concrete 'mix' and Joseph Monier who constructed reinforced-concrete tubs for orange trees. Monier, who was a gardener in Boulogne, later took out French Patents (77165 in 1867) and a Provisional British Patent (1999 in 1870) for portable containers, pipes, bridges and tanks[5].

The first official large-scale acceptance of the neW‘c0n-struction came in 1892 when Edmond Coignet (son of Francois) put forward a successful proposal for reinforced-concrete culverts in the new sewerage system for Paris and demonstrated the dramatic way in which material costs could be reduced.[6] In the meantime, although Joseph Monier was unsuccessful in making any money from his agricultural ideas, G A Wayss and his firm Wayss and Freitag of Frankfurt-am-Main were responsible for the erection of over 300 arched reinforced-concrete bridges in Germany and Austria between 1887 and 1891 based on Monier's design. However, as far as theory was concerned, France was the centre of activity but for the last two decades of the 19th century there was an interregnum whilst academics pondered reinforced-concrete design in the light of natural phenomena. Many learned papers were published.

Despite this pre-occupation with the discussion of theory there were several Frenchmen far-sighted enough to prepare for commercial exploitation and amongst these was Francois Hennebique (1842-1921). Hennebique was born at Neuvill-St-Vaast (now part of the Pas-de-Calais Industrial complex)[7] and after a short period on the family farm, became an apprentice stonemason with a small construction firm in Arras. In 1867 he set up his own business and twelve years later, after working mainly on church restorations, was commissioned to build a house at Lambardzeyde in Belgium for a client much concerned with fire risks[8]. His ultimate solution was to use a design of concrete, with iron enmeshed, as fire-resistant slabs to produce a ‘mock-up’ for structural tests. This he loaded to far beyond the demands of normal domestic usage, and completely satisfied, built his house selling it with a ‘fire resistance’ guarantee.

The next twelve years were spent developing structural design elements in his spare time, beams, columns and slabs, which were each tested to destruction and finally patented.[9] By the time Coignet's Paris sewer system was approved in 1892, Hennebique had a complete ferro-concrete building package, tried, tested, and legally protected from unauthorised use. He had also decided on his future business strategy which was to give up contracting and concentrate on a consultant/entrepreneurial role. Taking as his maxim for success ‘impeccable workmanship and constant supervision’, Hennebique established a network of ‘approved contractors’, took 10 per cent of the contract figure for directing work their way and demanded a very high standard of workmanship. [10] To become a Hennebique-approved contractor was a much sought-after accolade whilst to be removed from his list of concessionaires usually ended in bankruptcy.

At the end of the 19th century Louis Gustave Mouchel, a French engineer, went to live near Swansea in South Wales, became French Consul and later Conseiller du

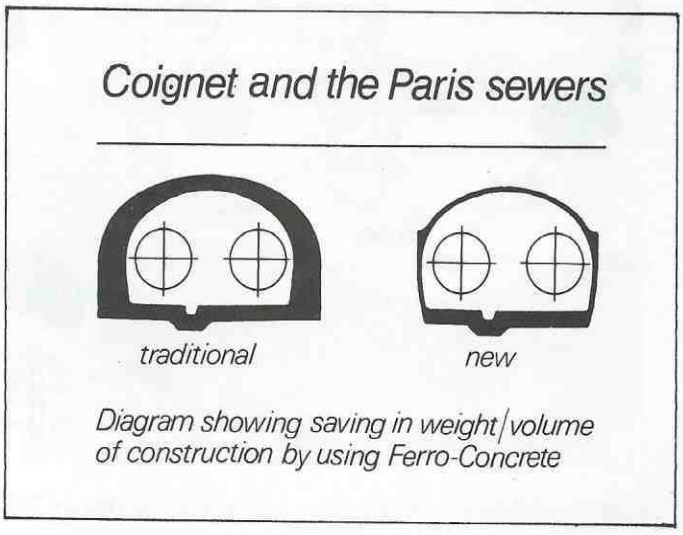
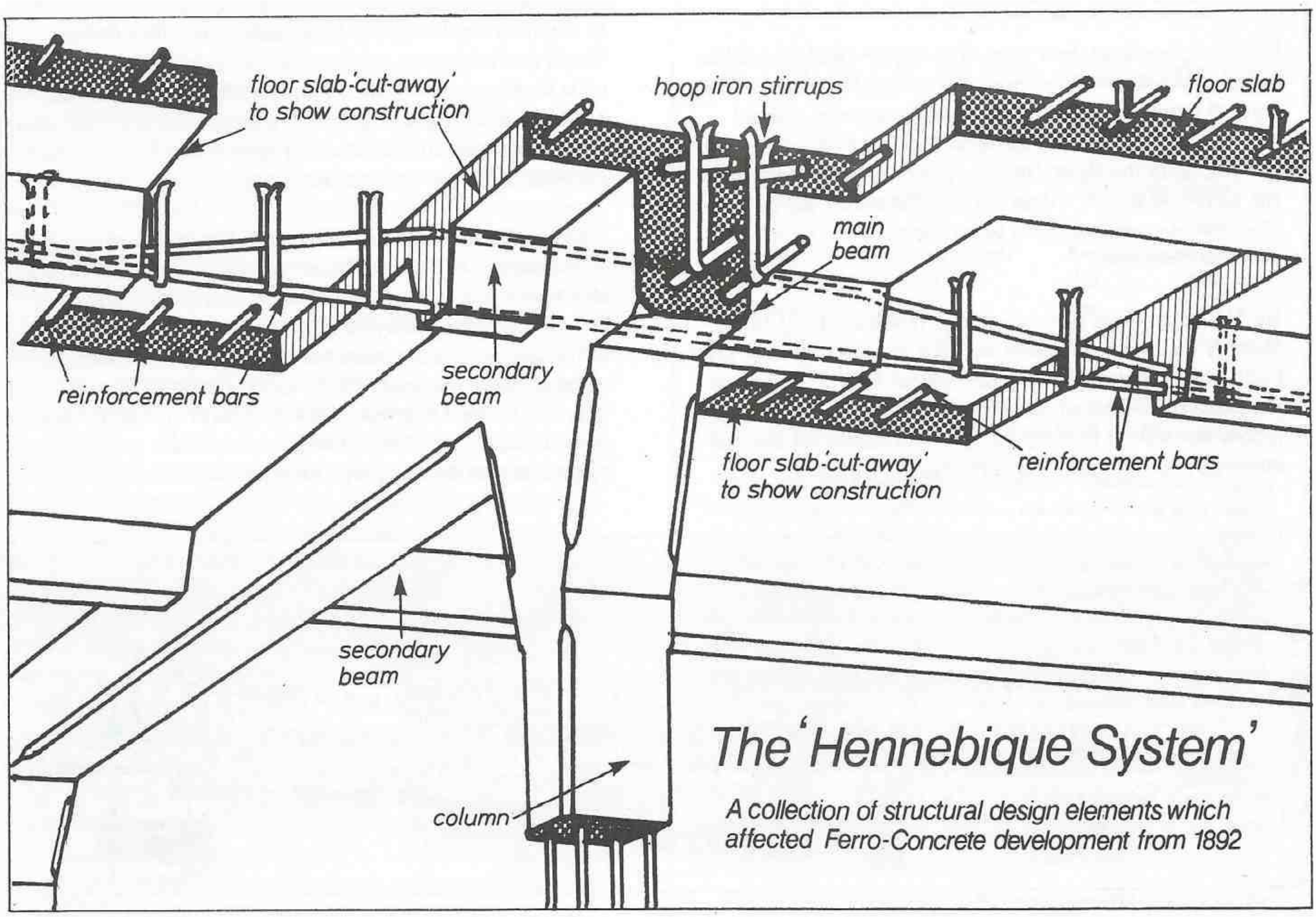


Diagram showing saving in weight/volume of construction by using Ferro-Concrete

Commerce Exterieur. About 1895 he was involved in the erection of reinforced~concrete industrial buildings and dwelling houses at Briton Ferry[11] and shortly afterwards made the acquaintance of a director of the firm of Weaver and Company. In 1897 Weavers decided to expand their business by building a second flour-mill in Swansea and, impressed by the enthusiasm of Mouchel for reinforced-concrete structures, sent their architect, a Mr H C Portsmouth to Paris to report on the work being carried out by Hennebique. This was the opportunity Francois Hennebique had been waiting for. On his return to Wales the architect convinced his directors that they should invest in this new technology and the contract was signed on 20 October 1897.



It was for a flourmill and grain silo, the main building being 127 ft long by 48 ft wide and six stories high. The contract price was £4,150 and there was a penalty clause amounting to £2 per day for all construction time over and above 30 May 1898.

The work was carried out by a local firm under the supervision of French chargehands and the cement and aggregates were imported from France in order that Hennebique should be dealing with materials he knew.[12] However, the time schedule had been over-ambitious and the warehouse was not finally handed over until the autumn with the final account signed on 15 September 1898. Even so, the total bill of £4,430 was only £280 (6¾ per cent) more than the contract figure and it included a £214 time penalty. Of course it was a 'special price', what I suppose we would now call a 'loss-leader' but Hennebique made his point. This is emphasised by the fact that Weaver and Company offered Mouchel-Henneblque a further contract in 1899 and were prepared to pay the economic costing of £15,478 for a similar amount of work, so pleased had they been with the original warehouse.

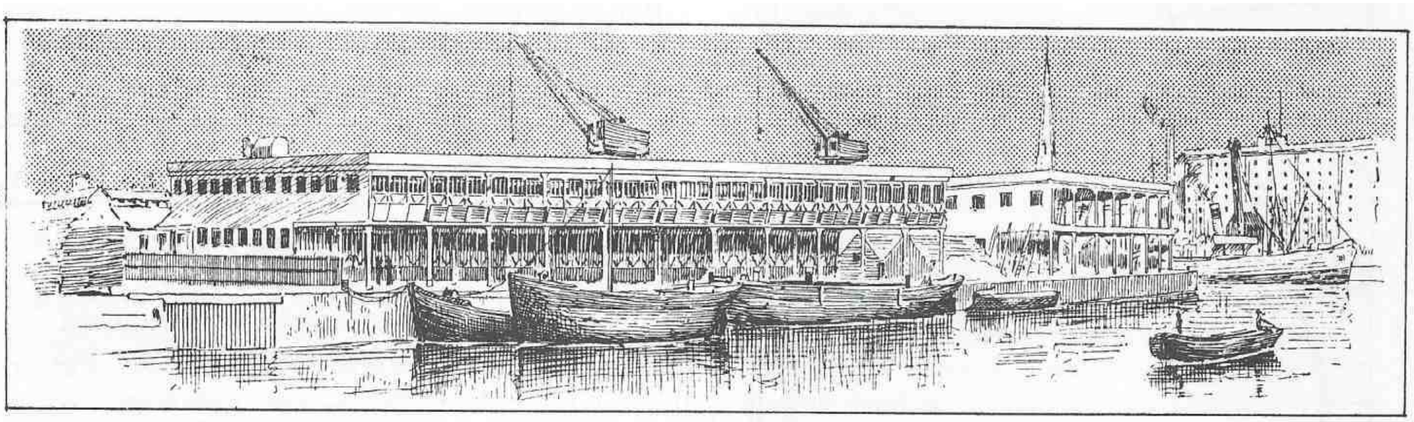
This building is still extant (GR SS 6611 9314) and has been spotlisted by the DoE as the first remaining example of British reinforced-concrete construction [13] . This development marks the beginning of Francois Hennebique's association with the United Kingdom construction industry and seems to have been pre-conceived. At the same time as Hennebique was seeking French Patent protection he had also applied to the British authorities.[14] British Patent 14530 (1892) covered floor construction, 30143 (1897) was for his continuous beam, an extremely important development, and 30144 (also 1897) described precast reinforced-concrete slabs jointly with L G Mouchel and, from 1897 (possibly earlier) until 1904, the Mouchel-Hennebique combination had a complete monopoly of design in Britain. As far as construction is concerned, it seems likely that no reinforced-concrete structure, other than by Mouchel-Hennebique, was completed until 1908. Apart from the innovation of the design of Mouchel-Hennebique buildings, they had a considerable impact on the architectural scene and the Weaver Warehouse, for example, was said to have 'set a new standard for adventurous structural design' and its heavily loaded cantilevered construction 'Startled British engineering circles . . . by the unaccustomed boldness of its shape'. [15]

Introducing a new method is often difficult. Apart from the natural conservatism of those in a position to place orders there is, what is often referred to as, 'resistance to change' and the serious obstacle of having no yardstick against which to measure the advantages claimed. This last point proved to be extremely difficult for Hennebique. At the end of the 19th century, Britain was just starting to emerge from the 'great depression' which began around 1874 and ended about 1896. This had meant that most development which had taken place over the preceding ten years had been financed by the public sector. It would be quite difficult today to persuade national and local-government civil engineers, whose finances are controlled by a committee, that a particular scheme with no comparable costs ought to be proceeded with. This was exactly the problem with the Mouchel-Hennebique system. All the existing archives of construction costs were based on stone, brick or steel-framed methods and to talk of concrete with steel reinforcements was to venture into the unknown.

Someone, however, had to be first and in 1897, as well as building the Weaver Warehouse, Mouchel-Hennebique had erected a retaining wall on reinforced-concrete piles at _ Southampton where the London and South-Western Railway ran alongside the River ltchen. The client was John Dixon[16] the LSWR engineer, whose convictions about the quality of Mouchel-Hennebique were to influence 'official' engineers in the next ten years.

By 1899 there was a crane jetty at Woolston built for Mordey Carney [17] followed by dock developments at Liverpool for the Mersey Dock and Harbour Board [18] and two years later, the first of many projects for the Admiralty, a jetty extension at Devonport. [19] This surely set the seal of approval on reinforced-concrete marine works.

Canons Marsh transit sheds in 1907 Drawing S Loxton



In 1903, the newly appointed New Works Engineer of the GWR, W Y Armstrong, commissioned Mouchel's firm to build Jeffries Wharf in Bristol City Docks and in 1904 J H Yabbicom/Bristol City Council gave instructions for the Brandon Wharf to be constructed.

As can be seen, the railway companies were amongst the first organisations to recognise the advantages of reinforced-concrete structures and in 1903 the North Eastern Railway Company and their architect William Bell FRIBA began building a large Mouchel-Hennebique reinforced-concrete goods station in New Bridge Street, Newcastle-upon-Tyne. [20] This particular structure attracted a great deal of attention and within a year William W Squire, Engineer to the Bristol City Docks Committee had commenced two large reinforced-concrete transit sheds at Canons Marsh. These buildings, the larger being 275 ft long and the smaller over 200 ft long, are still intact in the City Docks as 'Y' and 'Z' sheds, and whilst no one would describe them as attractive, they remain relatively sound examples of early Mouchel-Hennebique work. Further transit sheds were built at Avonmouth in 1907 and in the same year several culverts and bridges were constructed for the Avonmouth and Filton Railway, a line which connected Avonmouth docks (at Hallen Marsh Junction) with the Great Western Railway London and South Wales line (at Stoke Gifford) and had been authorised in 1904.[21] The order for this development was also instigated by W Y Armstrong and the bridge carrying the railway track over an accommodation road, near Hallen, is claimed by Mouchel and Partners to be the first mainline railway bridge in reinforced-concrete to be built in Great Britain.[22] The Bristol Harbour Railway was opened by the GWR in 1872 and gradually extended to Wapping Wharf and after the turn of the century along the northern side of the Floating Harbour. Eventually it ran into Canons Marsh and a large, new goods station 541 ft long by 133 ft wide was built during the period 1906/1908. Again the contract was handled by W Y Armstrong for the GWR and again the design and supervising agency was Mouchel and Partners using the Hennebique system.

1908 probably marks the end of the Mouchel-Hennebique dominance in British reinforced-concrete construction and although the combination had an influence on concrete building in this country for many years, examples of other designers' work were now beginning to appear. Chief amongst these designers seems to have been Edmond Coignet who had opened a design office in Britain in 1904[23] and who claimed that 'One of the most important contracts carried out on the Coignet system, as well as one of the earliest, was the construction of the second Tobacco Warehouse for the Bristol Corporation in 1908, under the supervision of Mr W W Squire.'[24]

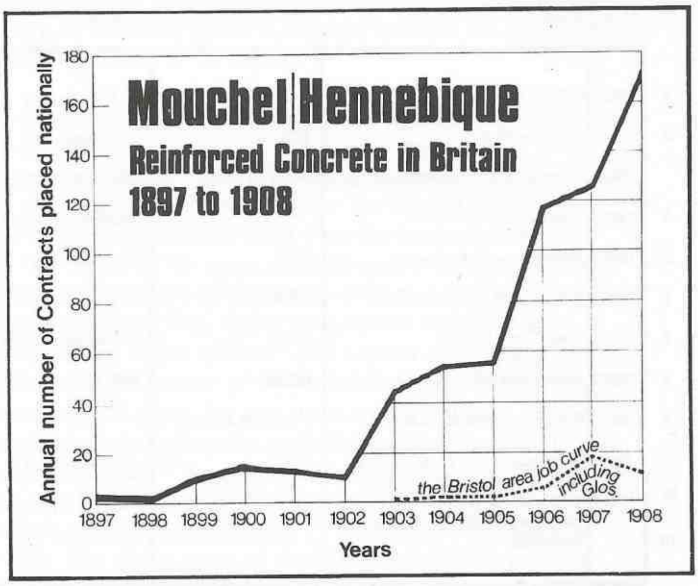
Mouchel had moved from South Wales to London soon after he began operations in reinforced concrete and, from his office in Victoria Street Westminster, soon established a technical organisation with district offices in different parts of the country under the charge of qualified engineers. This enabled him to maintain the Hennebique philosophy: 'Impeccable workmanship and constant supervision', and thus control the quality of his projects. In a similar manner to that of his mentor he only let contracts to authorised contractors of adequate experience. The success of this procedure is borne out by a survey of early reinforced-concrete structures and buildings carried out in 1954 by the Building Research Station and the Cement and Concrete Association. Dr Stanley Hamilton and A H Bray FR IBA, visited a considerable number of buildings of varying types and the results of their detailed examinations were tabulated. [25] Structures erected as early as 1899 (Brentford Docks Warehouse) were checked and the dates noted of their subsequent essential repairs.

Buildings for which Mouchel had been responsible were highly commended. A multi-storey warehouse erected in 1900 for the CWS at Newcastle-upon-Tyne had given no trouble whatsoever in a life of over 50 years, the only repair carried out being the replacement of a ceiling damaged by fire in 1916. A factory erected in Hull for Rose, Downs and Thompson Ltd is cited as an example of a building which had stood quite rough usage with negligible maintenance for over 50 years and was ‘in remarkably good condition’. Again no repairs had been needed although the outside had received ‘coatings of cement paint from time to time’. Canons Marsh Goods Station was amongst those selected for inspection and, apart from a few cracks where the steel reinforcement rods had originally received insufficient cover, was in good condition This examination had taken place some 46 years after it had been built, and in 1977, 23 years later, Bristol City Planning Department considered it capable of being further developed.[26] Given the finance for this project (and without it Canons Marsh Station is likely to remain very much as it is) we could have an early Mouchel-Hennebique structure surviving, and fulfilling a useful function, well into the 21st century.

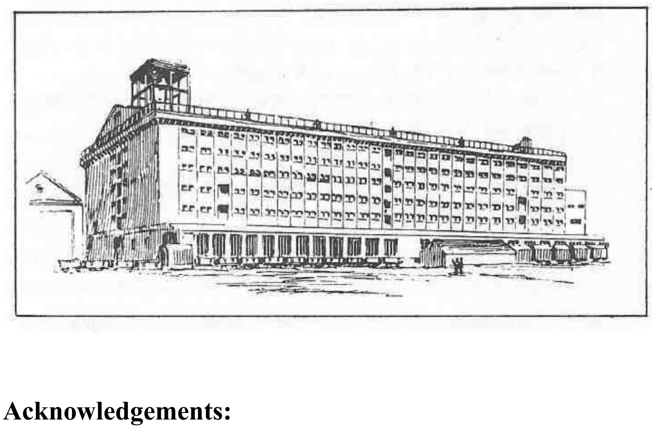
So much for the hardware. It is worth mentioning the measure of control which resulted from this completely new building method arriving in Britain. Once the Mouchel-Hennebique monopoly had been broken by the expiring of patents, the number of firms advertising themselves as reinforced-concrete designers and contractors escalated rapidly. Some were competent, others not so good, and building authorities became anxious to have some means of regulating the standard. Three separate events took place in 1906, each one of which resulted in the status of reinforced-concrete construction being enhanced.[27] One was the appearance of a new monthly publication entitled *Concrete and Constructional Engineering*, the second was the convening of a Reinforced-Concrete Committee by the Royal Institute of British Architects and the third was the creation of a Special Commission on Concrete Aggregates. This latter organisation was appointed by the British Fire Prevention Committee, a body composed of officers of Government Departments and Municipal Authorities, scientists and members of professional institutions. There was an overlap between the several events but the final outcome was exactly what was required.

On July 21st 1908 representatives of all the interested parties, together with chemists, cement manufacturers, designers and contractors, met to launch the Concrete institute which set about drafting ‘Codes of Practice’. It later changed its name to the institution of Structural Engineers, which is now a constituent member of the Council of Engineering Institutions and has upwards of 14,000 members. Amongst them are principals of the firm of L G Mouchel and Partners, a respected member of the consulting engineering professional register with a branch office in Bath. The 'practice description' in the Consulting Engineers‘ Who's Who and Year Book includes the statement that ‘A substantial part of the firm‘s practice is in building structure design in reinforced concrete . . .'

After Mouchel-Hennebique lost their monopoly of reinforced concrete works it becomes difficult to quantify individual projects but we know that the Imperial Tobacco Company, London County Westminster and Parrs Bank, E S and A Robinson Limited, The Weber Chocolate Co. Ltd, J Robertson and Co Ltd., Georges Bristol Brewery Ltd, J S Fry and Sons Ltd and St Anne's Board Mills Co. Ltd, were amongst their clients, and that by 1910 over 40,000 Mouchel-Hennebique structures had been completed in Britain.



Other Bristol landmarks with which they were associated include Bristol General Hospital, and the University of Bristol Wills Memorial Building in Queens Road. Edmond Coignet Limited, apart from their work on the second Tobacco Warehouse, built a 50,000 gallon water storage tank at Ham Green and a 150,000 gallon reservoir for the Bristol Electricity Department in their early days. They were also involved with the Bristol Royal Infirmary (BRI) and built grain silos for the Co-op at Avonmouth. Sir William Arrol and Co Ltd built 3,500 ft of wharves, two transit sheds, a 12,000 ton silo and a 20,000 ton granary building for the Royal Edward Dock Extension at Avonmouth, Considere Constructions Ltd. worked for the Distillers Company Limited in Bristol, building Maltings, Concrete Piling Limited were involved during the early days of the National Smelting Company at Avonmouth and Nott Brodie and Co. Ltd., assisted with the construction of the Portway. All this work was carried out prior to 1923.



Avonmouth granary 1907
Drawing S Loxton

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Reinforced Concrete work carried out by Mouchel-Hennebique in Bristol and Avonmouth between 1903 and 1909
Abbreviations: GWR (Great Western Railway), BCC (Bristol City Council), BCDC (Bristol City Docks Committee)

	Year	Project	Client	Eng/Arch		Year	Project	Client	Eng/Arch
1	1903	Jeffries Wharf	GWR	W Y Armstrong	20	1907	Hauling way	Baker. Baker and Co	Foster, Wood and Awdrv
2	1904	Brandon Wharf	BCC	J H Yabbicom	21	1908	Canons Marsh Goods Station and Warehouse	GWR	W Y Armstrong
	1904	Canons Marsh Transit Sheds	BCDC	W W Squire					
4	1905	Coach and Horses Hotel		Bromet and Thornton	22	1908	Western Counties Agric. Assn. Warehouse floors	WCA	W H Brown
5	1906	River Frome Covering	BCC	J H Yabbicom	23	1908	Avonmouth Elec. Station	BCDC	H Faraday Proctor
6	1907	Avonmouth Transit Sheds	BCDC	W W Squire	24	1908	Engine Shed founds. Pits. etc. St Philips Marsh	GWR	W Y Armstrong
7	1907	Elect. Trans. Station	BCC	H Faraday Proctor	25		Flour Mill founds. at Avonmouth	Co-op Wh. Soc.	F E L Harris
8	1907	Granary and Silos Avonmouth	BCDC	W W Squire					
9	1907	Strengthening brick arches	E P Smith and Co		26 to 28	1908	Three main line Railway Bridges at St Philips Marsh	GWR	W Y Armstrong
10 to 19	1907	Avonmouth and Filton Railway Five culverts and three sets of piled railway bridge foundations plus one road bridge and one railbridge	GWR	W Y Armstrong	29	1908	River Avon retaining wall	Hall and Sons Ltd	Charles Thompson

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