The Influence of Standards and Regulations for Steel and Reinforced Concrete on the Development of Modern Architecture in Pre-WW1 Paris and Brussels

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Introduction

How did technical standards and associated building regulations for steel and reinforced concrete influence the development of modern architecture in preWW1 Paris and Brussels? This is the core research question of my PhD project at the Universities of Kent and Lille begun in September 2020. The paper sets out some initial markers on the topic, results of a scoping exercise I have undertaken since September and from which I hope to elicit wider contributions from peers.

Our state of existing technical and practical knowledge about the specifications and use of building materials in the past is founded on a plethora of published literature by academics and professionals studying in a broad range of fields, which can be usefully brought together under the collective umbrella of construction history. There is considerable research evidence available on the use of metals and concrete in monumental, industrial and other buildings in Britain, France and then the USA during the eighteenth and nineteenth centuries.

Research context

The PhD project began by examining the current state of knowledge about materials, standards and regulations in construction history for the period and region to be researched. Because physical archival research in year two of the project will aim to establish valid connections between the emergence of technical standards and regulations for specifically steel and reinforced concrete and the development of modern architecture, a theoretical basis for such an approach will need to be fully ascertained with sufficient conviction to allow useful progress towards completion by the end of year three.

Standards and regulations for new building materials existed in the same space as developing late nineteenth-century and early twentieth-century architecture. The architects, engineers and contractors involved in construction during the period of the Belle Epoque in Paris and Brussels devised new technological approaches, increasingly driven by enabling factors such as speed of construction, economy of resource usage and overall lightness of structure, all for the newer materials when compared to traditional ones such as masonry, brick and iron. Standards were enabling mechanisms for the transfer of new knowledge, which had already been set down within patents or similar technical specifications. My research will investigate how building material standards were drawn up and by whom. It will seek to establish if there was a clear mechanism for dialogue between innovators and exploiters of new, sometimes untested materials, and state-led regulators who were tasked to minimise the risk of any wider harm these materials might cause through, for example, potential structural failure. This regulation process sat within a broader social and political framework within which appeared a growing concern for public health and safety.

The PhD is taking a methodological approach to identifying the historical evidence, starting with a scatter gun shot across all available sources informed by background reading, and then becoming gradually more focused as distinct themes

begin to emerge around the new materials being studies. By looking at evidence from examples of the systematic use of these materials, we can begin to piece together a more granular picture of the key construction (and hopefully architectural) developments at this time and in this geography. However, such an approach acknowledges caution in choosing the most applicable historical resources and case studies; it requires justifying such choices explicitly and objectively, and ensuring that a significant element of intra- and inter-geography comparison emerges from findings so as to maximise relevant analysis and discussion.

Architectural history in nineteenth-century France and Belgium

The intellectual background for the building interests of French and Belgian architects, engineers and contractors of the pre-WW1 period is an equally important context to the PhD, which will study the relationship between technical/tectonic change and aesthetic/decorative continuity through one specific lens linked to new materials.

The dominant nineteenth-century school of architecture in the region was the Ecole des Beaux-Arts in Paris, through which innumerable architects from France and abroad passed on their way to professional practice. The Ecole's heritage had emerged from preceding centuries of professional development, as the French autocratic state moved to control all facets of the built environment through a dedicated body of practitioners. These were at first approved architects and military engineers serving the monarch's monumental and war projects, but over time *civil* engineers developed as distinctive construction professionals. The Ecole des Ponts et Chaussées provided a corpus for these men and the French Revolution solidified their key role in a radical new society which now valued personal merit over the old privileged hierarchy [1].

In parallel, a more scientific approach was being applied to architectural thinking during the later eighteenth century, as it began to question the status of classical orders and styles derived from ancient Graeco-Romano traditions. Iron emerged as a reinforcing material for masonry and brick, and then in its own right as a key structural feature which could better adapt to fireproofing requirements in urban settings as well as the desire for physically and visibly lighter spaces. Paris had many examples of its use in the early nineteenth century, well before London's Crystal Palace. The sub-discipline of architectural technology, concerning the physical nature of buildings as opposed to their purely aesthetic features, acquired an increasingly theoretical basis pushing iron towards potential new uses. In 1872 the French architect and conservator Eugène-Emmanuel Viollet-le-Duc published the second volume of his popular lectures 'Entretiens sur l'architecture' – he was called by Summerson the first theorist of modern architecture, though he walked in the footsteps of others and was at heart a proponent of historicist styles. In the same year, the initial modernisation of the 'Bon Marché' department store was finished in Paris, a 'polite' iron-framed structure naturally lit by glass panes, co-designed by father and son architects Louis-Auguste and Louis-Charles Boileau with civil engineer Armand Moissant. The latter had simultaneously been working on the Menier Chocolate Factory in Noisel, a unique iron-skeleton industrial building on the outskirts of the French capital [2].

Twenty years later during the 1890s, innovative technical and craft approaches to the design of townhouses emerged in Brussels and Paris, having already influenced Anton Gaudi in Barcelona the decade before. The 'Art Nouveau' architectural genre as it came to be known, spread quickly through derived forms to other European cities, sweeping away the more traditional Beaux-Arts approaches before it disappeared just as rapidly, with some distinctive exceptions, before the outbreak of the Great War [3].

The new building materials

Britain had been the world's first industrialising nation, with its textile mills employing iron columns for fireproofing from the end of the eighteenth century, and it had created some unique and much-imitated structures with cast iron frames and plate glass, including the world-renowned Crystal Palace and subsequent railway termini such as those at Paddington

and St Pancras, all in nineteenth century London. Similarly, France had become a global leader in the novel use of iron in public structures through key architects such as Henri Labrouste, Henri Baltard, Louis-Auguste and Charles Boileau and Ferdinand Dutert as well as renowned civil engineers such Armand Moisant and Gustave Eiffel. The last-named had completed the eponymous iron tower in Paris despite considerable aesthetic criticism from French peers, many of whom later retracted their initial condemnation [4].

By contrast, international research on the first use of *steel* in polite buildings from the 1880s on has focused on early skyscrapers in the United States, as well as a selection of well-known British structures, mainly in London, including office buildings, hotels and department stores [5]. French and Belgian polite steel-framed buildings have received less academic attention by comparison, with some notable exceptions. One of these is the steel-framed La Samaritaine Magasin 2 department store in central Paris, completed in 1910 by the French architect Frantz Jourdain who employed distinct Art Nouveau features. The American scholar Professor Meredith Clausen first researched Jourdain in the 1980s, and more recently there has been considerable focus on the La Samaritaine department store complex, which has been extensively renovated and is due to reopen in 2021 [6].

Considerably more research in France and Belgium has focused on the early use of reinforced concrete at the turn of the twentieth century; in particular the use of a novel framing system patented by the Belgium-born inventor François Hennebique and adapted superbly by the Perret Brothers in Paris and others elsewhere. While there will be leads in this well-covered area, my own archival research will concentrate more on the activities of the French civil engineer Armand Considère, who invented his own reinforced concrete system in competition with Hennebique [7].

Technical standards for building materials

The crux of this PhD's research is its initial focus on new voluntary technical standards for steel and (components of) reinforced concrete which were first published in 1903 and 1904 by the Engineering Standards Committee, the precursor to the British Standards Institute (BSI) which had been established in 1901 and served the vast British Empire. Over time these were integrated into a worldwide set of standards currently overseen by the International Standards Organisation (ISO) and its other affiliates; these include the Association Française de Normalisation (AFNOR) established in 1926, and the precursor to the current Bureau de Normalisation (NBN) in Belgium, established the following year. All these standards bodies have worked and continue to collaborate closely with parallel governmental laboratories, originally set up in the nineteenth century to standardise scientific and engineering physical measurements [8].

According to Sir John Wolfe Barry, the 'father' of British Standards, in a 1917 lecture, the famous lexicographer Dr. Johnson defined a Standard as "that which is of undoubted authority; that which is the test of other things of the same kind". Agreed technical standards and specifications for the manufacture and use of steel and reinforced concrete became increasingly important as these new materials started to replace timber, bricks, masonry and iron as a more flexible option for building construction, but importantly at increasingly affordable prices. David Yeomans in particular has examined in considerable detail the first British Standards relevant to the construction industry from 1900 [9].

Wolfe Barry reinforced in his 1917 speech the merits of early voluntary standardisation, highlighting the campaign by Sir Joseph Whitworth begun around 1841 for the use of his famous screw thread as a norm for all other similar products. Responding favourably to the eminent civil engineer's speech was the British wartime Minister for Labour, John Hodge MP, who singled out his own pre-war experience working in a rolling-mill, producing a plethora of non-standardised iron and steel sections and parts for demanding engineers and 'faddish' architects [10].

Professors JoAnne Yates and Craig Murphy have examined the history of international engineering standards in a comprehensive 2019 book. They place the historical role of these standards significantly within the mainstream of the world's developing economies over time:

These standards have shaped the course of industrial development by fixing the technological platforms on which further innovation occurs … Without such standards, most of what we buy would be more difficult to produce, and conflicts between merchants and customers would likely be more intense … this kind of private standardization has come to provide a critical infrastructure for the global economy [11].

But applying standards to the real world takes time; Yates and Murphy have observed that France had to wait until 1840 to fully adopt the metric system introduced in 1799 by Napoléon Bonaparte. Hence they single out a consensus-based approach, involving voluntary industrial participation, as being essential to the long-term adoption of engineering standards. This proved feasible early on in the new realm of electricity, a novel form of both industrial and domestic power. In 1883, the Société International des Electriciens was established by French electrical engineers, and in the following year a Belgian analogue appeared [12].

Building regulations

Building regulations or codes have been developed globally by local and central government authorities to set and monitor accepted norms in construction – they are legally-tested benchmarks for compliance by individuals and companies. Urban construction codes have pushed architectural styles down more limited routes, and the outcomes of this have not always been welcomed by designer-builders, their clients and even the wider public. The biggest fear for occupants of large buildings still remains uncontrolled fire, evidenced in recent years by raging tower block infernos in global cities. Other concerns about the health and welfare of the general population started to emerge in late nineteenth-century France and Belgium as enlightened liberalism came to the fore, often in response to the threat of radical social upheaval [13].

A seminal paper presented to the 2017 Construction History Society Annual Conference in Cambridge, compared the first building regulations for reinforced concrete in a number of European Countries at the start of the 20th Century. The paper covers the emergence of these regulations in Prussian Germany (1904), France and Belgium (1906), Switzerland (1909), The Netherlands (1912), and the United Kingdom (1915). Of interest to my PhD are the regulations in France and Belgium, though the comparisons between all the systems in place is highly informative. It was the collapse of those new structures using the material which spurred official action. In France this happened with a pedestrian bridge disaster at the 1900 Universal Exposition and so gave reinforced concrete immediate media attention. The published regulations for reinforced concrete, based as they were on the latest scientific and technical standards, came into force in 1906 in France (adopted at the same time by Belgium), though only for public sector civil engineering projects. The Germans and Swiss by contrast were more thorough and extensive in their application of reinforced concrete regulations. A strand of the PhD research will seek to make comparisons between their relative influence on the development of modern architecture in the respective regions [14].

Other examples of published research on building regulations include the 1997 book by Yeomans on British construction materials since 1900, which examines the role of specifications and codes of practice in a range of contemporaneous materials; and a paper by Dr Inge Bertels and Krista de Jonge presented to the 2009 International Congress on Construction History, which studied the evolution of specifications for public building in 19th-century Belgium at various governmental levels [15].

While covering a slightly later period than my PhD and not focusing on the role of standards or regulations, Jonathan Clarke in his recent PhD research on interwar speculative office buildings in London notes that, despite being adopted almost throughout the country as the standard for reinforced concrete construction, the 1915 London County Council regulations for the new material quickly proved restrictive. Concrete frames became more expensive for many types of buildings [16]. Clarke compares this with the London steel regulations of six years earlier, where the allowable stresses and loads were also extremely conservative. But many engineers and reinforced concrete contractors learned quickly how to use the new material and became frustrated with the restrictions. Even well into the 1920s concrete-frame construction

remained relatively rare in London. The same cannot be said of Paris and Belgium, which operated under different regulatory regimes.

Potential illustrating examples

My scoping exercise has included the task of identifying potential examples to illustrate the relationship between technical standards and building regulations for the new materials within the region, with possible leads towards key architectural change. This has required undertaking a trawl of original archival and other contemporary materials that make strong enough connections between the use of steel and reinforced concrete and the new opportunities for, or resulting limitations on, the architectural design processes. Suggestions for examples from colleagues with expert knowledge of this area are always very welcome, but below are a few possibilities to begin with.

La Samaritaine Department Store in Paris

The selection of the La Samaritaine department store in Paris as a potential example is related to both the availability of original archival sources and the nature of the key materials covered by the research. La Samaritaine was built as an expanding shopping complex in the Les Halles district of Paris. The site had followed in the footsteps of other well-known nineteenth-century Parisian department stores such as Le Bon Marché and Le Printemps, which had been built with iron framing and plate glass [17].

The respected Art Nouveau advocate Frantz Jourdain was recruited by the owners of La Samaritaine to extend the floor area and improve the attractiveness of the offer to everyday Parisian shoppers. Jourdain had previously advised the French writer Emile Zola on a fictional avant-garde department store for his novel *Au Bonheur des Dames*, and many of its futuristic features appeared in his later designs. The flamboyantly decorated 'Magasin 2' was completed in stages between 1905-10 using steel framing in the core structure and steel and reinforced concrete in an under-road passageway connecting the parts of the complex (Figs. 1-3).

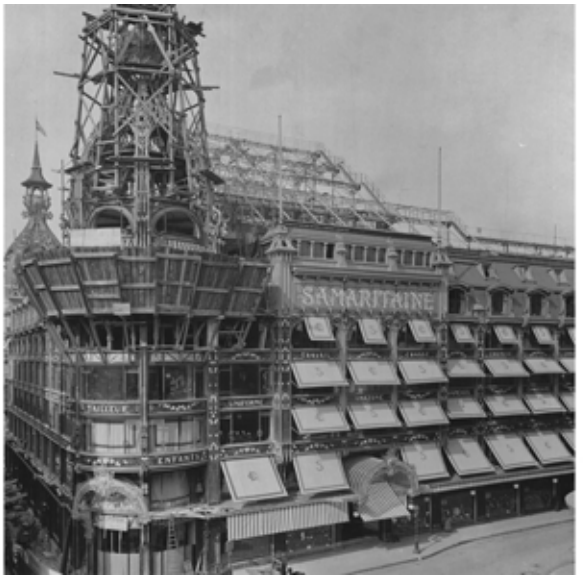

Figure 1. Magasin 2 La Samaritaine, Paris. Architect, Frantz Jourdain. View of completed façade on right, c. 1910. Unknown photographer, La Samaritaine Archives.

Jourdain went on the build a separate Samaritaine de Luxe (1914-17) near the Opera Garnier aimed at a wealthier clientele and then, after the war, began designing an extension to Magasin 2 towards the historic north embankment of the Seine – this work was eventually taken over by Jourdain's protégé Henri Sauvage, who was more diplomatic in adjusting his creative impulses to the needs of others. He designed a plainer, quasi-monumental exterior to the extended steel framing, which was clad in more respectable stone; this was seen by many contemporaries as a natural 'Art Deco' successor to Sauvage's embryonic personalised style, typified by his combined store and office block Immeuble Majorelle in pre-WW1 Paris (1913).

Figure 2. Magasin 2 La Samaritaine, Paris. Architect, Frantz Jourdain. Construction of main atrium using steel framing, c. 1905-10. Unknown photographer, La Samaritaine Archives.

Figure 3. La Samaritaine, Paris. Architect, Frantz Jourdain. Construction of subterranean passageway showing use of steel beams, c. 1905-10. Unknown photographer, La Samaritaine Archives.

Apartment blocks in Brussels and Paris

Another example for the archival research stage would be the development of apartment blocks in Brussels and Paris at the end of the nineteenth century. The emerging French Art Nouveau architect Hector Guimard completed his highly original apartment block Castel Beranger in Paris in 1898 using traditional materials – it remains with us as testimony to his creativity. A group of younger architects with social consciences started to design affordable blocks of flats serving the urban masses called Habitations à Bon Marchés (HBMs). In Brussels the extant HBM at 32 Rue Marconi built by Belgian architect Leon Govaerts in 1901 was the first to use reinforced concrete, though the exact type employed is still to be determined – Govaerts had employed the Hennebique system for some of his other buildings. Four years later, the French architect Henri Provensal completed an HBM at 8 rue de Prague in Paris using reinforced concrete and steel; it was referred to at the time as the 'Louvre of HBMs' [18].

Armand Considère

A final example would centre on a key civil engineer and his consulting business during the period. Armand Considère was a highly-regarded French civil engineer during the late nineteenth and early twentieth centuries, who developed a patent for a new method of constructing reinforced concrete columns he called beton fretté. Considère set up in competition with Hennebique immediately after both had contributed actively to the findings of the French National Commission on reinforced concrete [19]. There is some existing research on the wider technical impact of this rivalry in both France and Britain, much less for Belgium, hence this would need addressing – some potential examples exist in the industrial city of Roubaix which lies between Paris and Brussels and is where the Considère business archives are to be found [20].

Conclusions

As emphasised throughout this paper, it is still early in the PhD project which has operated under the cloud of the COVID-19 lockdowns. However, I have tried to prepare the main research groundwork as thoroughly as possible through a scoping exercise using remotely accessible materials. At the time of writing, I have not yet been able to physically visit any of the examples mentioned, which I very much hope will happen as soon as travel restrictions ease.

It seems clear that any examples chosen must cover both built structures *and* systems/organisations that were a sufficient part of the development of modern architecture during the period and in the region being examined. Through multiple triangulations of research evidence it is expected that a clear, thematic picture will emerge, illustrating the extent to which the key relationships and changes depended on the role of technical standards and associated regulations for steel and reinforced concrete.

One emerging theme is likely to be the fire protection facets of the new materials, which were often promoted exactly for their improved resistance to degradation and structural weaknesses caused by extreme temperatures. Another would be international comparisons between what happened in Paris and Brussels and other relevant localities during the period – new German and Swiss reinforced concrete regulations have already been mentioned, but the USA and Britain would also be good contrasts for their use of early steel framing in multi-storey buildings.

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