Iron Load-bearing Structure and Formal Characteristics in the Nineteenth Century Historicist Architecture

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Abstract

This study analyzes the role played by load-bearing structures in determining the formal characteristics that distinguish the historicist architecture of the nineteenth century that uses iron load-bearing structures or components. As shown in the examples studied, except for some proportion or size changes, iron structures did not produce significant changes at the level of architectural space and form, being in most cases subject to the aesthetic rules imposed by established architectural language. In those few situations where the load-bearing system has brought significant changes, this issue was managed distinctively by historicist architecture: 1 - in an attempt to provide prestige and overall coherence, it has used the morphology of the established architectural language in order to subordinate through decoration; 2 - through new principles of order, derived from those that formed the basis of established architectural language, some of which later become paradigmatic in the modern architecture, it has provided the conceptual framework through which new typologies could be born.

The conclusion underlines that the iron load-bearing structures by them self were not able to determine any formal characteristics of the historicist architecture. Their role was that of a catalyst for change, opening up the established architectural language.

Rezumat

În cadrul acestui studiu s-a analizat rolul pe care structura portantă l-a avut în determinarea caracteristicilor formale care diferențiază arhitectura istoristă care utilizează structuri sau componente structurale metalice.

Așa cum rezultă din exemplele studiate, în cele mai multe cazuri, dincolo de eventuale modificări de proporție sau de gabarit, structura metalică, supusă regulilor impuse de limbajul arhitectural consacrat, nu a avut forța de a produce schimbări esențiale la nivelul spațiului și formei. În acele situații în care sistemul structural a adus schimbări importante, mai ales în ceea ce privește spațialitatea clădirii, problema a fost gestionată distinct de arhitectura istoristă: 1 - în încercarea de a oferi prestigiu și coerență ansamblului, limbajul arhitectural consacrat a căutat să subordonze prin decorație; 2 - noi principii de ordine, derivate din cele care au stat la baza limbajului arhitectural consacrat, și care au devenit paradigmatic mai târziu în arhitectura modernă, au oferit cadrul conceptual în care s-au putut naște noi tipologii.

Concluziile arată că structura metalică nu a determinat în sine caracteristici formale în arhitectura istoristă. Rolul ei a fost unul de catalizator al schimbării limbajului arhitectural consacrat.

Keywords: load-bearing structure, iron, historicist architecture, formal characteristics, catalyst for change

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1. Introduction

With the development of industrial processes and production techniques for obtaining cast iron, by the beginning of the nineteenth century, the amount of iron available in the construction market has grown considerably thus increasing its importance as a viable building material. Until the eighteenth century, one could speak of iron as nothing more than a material used for auxiliary structural elements, without any major influence on architectural design philosophy. However the rapid growth of iron production would bring it to the forefront, as a structural material worthy of use from the first stages of design, challenging through its undisputed qualities and opportunities the traditional ones like stone and wood.

However, especially within the field of public works, the mainstream architecture of the time responded to the excesses of the baroque and rococo through a recuperation of the classical language and morphology. Going through the examples offered by the history of architecture, it is easy to note that most significant and spectacular changes in architectural space and form would initially appear outside these historicist trends. Made possible mainly by the development of commercial buildings whose form showed little concern with stylistic elaboration, these changes came as pragmatic responses to the new requirements imposed by industrialization. We include here those buildings needed for production, storage, transport and trade, united by some authors under the name "architecture of the engineers" (Vasilescu, 1989)[1], which will prove to be extremely influential on the architecture of the following centuries. The goal of this study will be to put some light on the means through which, the development of the iron load-bearing structures, promoted by changes in the utilitarian buildings, has come to affect mainstream, historicist architecture of the nineteenth century. Furthermore we will identify the role that the load-bearing structure occupied in determining formal and structural characteristics which distinguished certain examples between the buildings of the historicist styles.

2. Neoclassical Architecture

Neoclassical style, already defined years before the abundance of iron in the construction market, began as a purist movement in search of intellectual truth. It represented in terms of style a manifestation against Baroque architecture, which was considered 'untrue' because of the emphasis on illusion and applied ornament [2]. Using over time various classical sources as stylistic inspiration, sources that had been considered 'true' (the purity of Roman art, the ideal of the ancient Greece and later the Renaissance architecture) but finally accepting as 'true' source even the contested Baroque architecture, the Neoclassical architecture would become the language of the École des Beaux-Arts, representing the paradigmatic approach for most public buildings of the nineteenth century. Characteristic to a very long period, this style continues with various stages that are intertwined in the historicist eclectic manifests of the early twentieth century that has culminated in the Belle Epoche and in the periods of dictatorship started before the Second World War [3]. Considered in the late nineteenth century anti-modern or even reactionary [3] - although rigorous, simple volumes and innovative use of spatial effects come to impose it, by several prominent representatives as Boullee, Ledoux and Schinkel as source of inspiration to modern architecture - Neoclassical architecture has, most often, incorporated or dressed in a decorative language, the new construction material in question. Since the theory on which it was based was founded on established building solutions, taking into account a relationship between load-bearing structure and architectural form, joint detailing and applied ornament¹, in neoclassical architecture iron was not considered a necessary building material. Within this architectural language, cast iron

¹ the load-bearing structure, based on compression resistant materials that carries load trough mass, is part of the determining force in the global form; the jointing detail has a strong relationship with the applied ornament, this having the role of articulating and emphasizing the structural components
or wrought iron load-bearing components correctly sized, would not produce the right and required proportion, being too flimsy against the bulkiness of the massive stone carved classical orders. However, some of the most important buildings attributed to this style contain load-bearing components of cast or wrought iron. In such buildings iron, taken as an alternative, replaces conventional materials for various reasons, highlighting the material versatility. Fireproofing requirements imposed it in some roof or floor load-bearing structures. Simple economic reasons brings classically shaped iron columns - casting columns with classical decorative moldings proving less expensive than carving them. It's high resistance and rigidity made it the material of choice for beams dedicated to take over large spans, as well as for more slender columns thus freeing up the space. No less important is the use of iron in neoclassical architecture in masonry reinforcement. The effect was felt in the size and proportion of the masonry load-bearing elements. Commercial buildings are among the few situations where the utilitarian iron load-bearing structures are adjoined or enclosed by neoclassical walls. As an exception to the rule we find Henry Labrouste’s Bibliothèque Sainte-Geneviève and Bibliothèque Nationale as two absolutely remarkable examples commissioned in the field of public buildings. Labrouste, who would later become the symbol of structural rationalism was, as Giedion argues, ..., a man who unites the ability of both the engineer and the architect ...” (1941 :218)[5]. Such examples already represent certain models of exploiting both, the expressive qualities and the load-bearing potential of the iron structures.

The Marble Palace (1768-72) in St. Petersburg, conceived by the architect Antonio Rinaldi Fig.1-a in early neoclassical style, is one of the first buildings to use iron beams (Hitchcock, 1958: 116)[6]. In 1779-1781 one of the first representatives of the French neoclassicism, “... the very technically minded architect of the Paris Pantheon ...”, Jacques Germain Soufflot, has used an iron roof structure over the stair-hall leading up to the Grande Galerie of the Louvre, Paris (idem)[6]. “Horrified by the recurrent fires at Palais Royal ...”, the new roof designed by Victor Louis, the architect of the new French Theatre (1786-1790), uses some principles developed by two “... rather obscure French architects ... “ Ango and Eustache Saint-Fart - iron frame and ceramic hollow tiles (idem)[6]. Sir John Soane, one of the revolutionary innovators of the British neoclassicism, avoids the use of wood in the fireproof vaults of the Bank Stock Office, London 1794, using also ceramic elements set within an iron frame (idem: 117)[6]. Alone the oculus in the central dome, covered with iron and glass Fig.1-b, allows the observer to read some of the metal structural components. At the Buckingham Palace in London (1825-30) the columns on the north wing are cast to the classical proportion [7]. The amorphous metal submits to the normative language imposed by the Doric style design of the architect John Nash Fig.1-c. Given the need to maintain a fluid space, in order to support the gallery of the main hall of the Royal High School, Edinburgh, 1825-9, the
architect Thomas Hamilton defines a new interior spatiality using unusually proportioned cast iron columns with floral decorated capitals (Mignot, 1983: 39). Faced with the conflicting situation presented by the need to support the gallery while at the same time maintaining the continuity of the space, the architect has used iron as the only material capable of producing columns slender enough to respond to both, functional and structural requirements.

![Figure 2](image1.png)

Figure 2. a - King's Library; b - St. Isaac; c - British Museum reading room.

The extraordinary dimensions (91m length, 12m height, 9m width, with a central section of 18m) required by the space of the King's Library 1823-7 Fig 2-a, in the British Museum imposed the use of cast iron beams. The very idea of designing such a space could not be uttered without the capabilities of the newly discovered material. While exploiting the freedom to choose larger openings, architect Robert Smirke does not feel the need to betray, or even highlight the solution that allows such a performance. Although it represents a remarkable technical innovation, enabling an absolutely exceptional opening, comparable with the great openings of the cupolas in the Renaissance and Baroque, without the efforts implied by the construction of a masonry dome, the cast iron skeleton proposed by the architect August Augustovich Monferan for the dome of the St. Isaac Cathedral, erected in St. Petersburg in 1842 (Hitchcock, 1958: 116), remains also hidden behind the classical scenery Fig.2-b. A similar position in respect to the iron structure can be observed with the covering of the new reading room in the British Museum Fig 2-c, conceived in 1857 by Sidney Smirke (Hitchcock, 1958: 127).

![Figure 3](image2.png)

Figure 3. a - Westminster Arcade, b - atrium.

At the beginning of the nineteenth century, the shopping galleries introduced a new building typology. The spatiality of such a building was strongly linked to the expressive and structural potential of iron structures. Besides providing protection from the weather elements, the specific iron and glass roof was the only one that could provide the necessary amount of light for the main space, represented by the atrium, with its multilevel galleries that assures the large surfaces required for the modern presentation of the commodities. At the Westminster Arcade in Providence, Rhode Island Fig.3-a,b, one of the oldest galleries in the United States, designed by the architects Russel Warren and James Bucklin in 1828, as a great temple of commerce (Smith, 1996: 172), we have an example of such a building being treated with the aesthetic consideration deserved by only
the most important public edifices. The early neoclassical style, that organizes the masonry construction that encloses the great atrium is intended here to provide prestige to this new building program.

Figure 4. a - Gare de l'Est; b - Dianabad.

In a context in which the stylistic concern was to rather mask “... the success with which new functional needs were satisfied in this period by the bold use of the new materials and new types of construction.” (Hitchcock, 1958: 76)[6], Gare de l'Est Fig.4-a, built in Paris between 1847-52 after the drawings of architect François Duquesney, as a major monument of the Classical rationalism, serves as a reference for this new critical approach. Here, the facade chooses to express some of the spatiality of the utilitarian interior marked by the great iron and glass roof that cover the rails. Offering shelter to another novel function, the first covered pool on the European continent, Dianabad in Vienna Fig.4-b, conceived by the architect Ludwig Förster together with the architect-engineer Karl Etzel and erected between 1841-3, also presents an elegant cast iron roof, sincerely exposed in the interior. “... the circular bracing of the iron principals, a frequent motif in large openwork members of cast iron at this time, was most appropriate to the Rundbogenstil detailing of the masonry walls.” (Hitchcock, 1958: 123)[6].

Figure 5. a - Bauakademie; b- Bibliothèque Sainte-Geneviève exterior view, c - reading room.

Another perspective on the classical norms is offered by the Bauakademie of Berlin Fig.5-a, remarkable, among others, for the innovative approach, almost completely devoid of applied ornament. Critically interpreted, classical language is resumed here to the ordering of the construction. Erected between 1831-6, this seminal work by Karl Friedrich Schinkel3 includes iron beams that support brick arches in a system, that the architect studied in England (Darley, 2003: 26-30)[12], while researching the technologies of the industrial revolution. The load-bearing system, with iron beams supported on masonry piles, designed in collaboration with the engineer Peter Beuth (Adam, 2004: 11)[13], is considered one of the precursors of the skeletal load-bearing system. The Sainte-Geneviève library in Paris Fig.5-b,c, built between 1843-50 after the plans conceived by Henry Labrouste in the years 1839-42 is one of the first public buildings that uses

3 Karl Friedrich Schinkel (1781-1841) one of the most influential architects of the nineteenth century. His work represents an important source of inspiration for the architects of the first half of the XX century. [11]
“openly and extensively” an iron load-bearing structure (Hanser, 2006: 34-38)[14]. Radically different from the conventional solutions, this library counts on the principles on which the English factories were built: the Neorenaissance masonry, avoiding historical references, integrate „... like the works of a watch in its case.” (Giedion, 1941: 220)[5], an elegant iron structure with arcs and columns, that could be considered having Gothic influences (Blanc, 1993: 6)[15]. This answer came as the result of a rational thinking, in them functional requirements have been those who imposed the approach. Much like in industrial buildings, nothing seems here to be arbitrary. 

Sober to the point of austerity - there is almost no decoration - its facade is neither pretty nor even elegant. There are no classical orders and no reference to any buildings from the historical past. To many contemporaries, the building had no style. Labrouste wanted its functions and its real, undisguised structure to order his building. Any ornament was to derive from the latter and help the public understand the former. They should be able to read his building "like a book". (Hanser, 2006: 36)[14]

Figure 6. a - Bibliothèque Nationale reading room plan, b - interior view.

Built between 1862-1868, the reading room of the Bibliothèque Nationale in Paris Fig.6-a,b, would already represent an important technical advance (Hitchcock, 1958: 128)[6]. The design of Labrouste proposes eight sky-lighted terracotta domes carried by wrought-iron arches and slender cast iron columns, in a load-bearing system that will amaze (or confuse) its contemporaries through its spatiality, elegance and functionality. The solution offered by Labrouste for the central book depository, as an answer to the increasing needs of storage space imposed by the book production of the nineteenth century, certainly represents another masterpiece. The use of the cast iron grid plates for the floor construction, characteristic maybe for the engine rooms of the steamships, unveils “the germ of new artistic possibilities” (Giedion, 1941: 226)[5].

3. Neogothic Architecture

The use of large scale iron load-bearing elements has it's origin at the beginning of the Neogothic style in architecture. This period, dominated by sentimentalism and the picturesque, less attractive in terms of style, was defined by the abundance of cast iron on the building material market. This availability has thus encouraged the search for the most diverse applications. The Gothic pillars, the Gothic ornaments, originally carved in stone, found their cheap substitute in iron elements that could be easily replicated by casting. The first Gothic iron load-bearing structures constructed in this period, represent an ideological irony. Through their industrialized production techniques they were in utter contradiction with the romantic medieval revival theories that prophesied a return to an idyllic agrarian craft based society. Superficially, this doctrinal interpretation has led inevitably to the rejection of iron as a building material suitable for Gothic edifices. More profound, this principle emphasizing the primacy of the construction methods rather than the image obtained by

footnote: the construction methods, here medieval, considered to be the result of a healthy social organization, provided the basis, the forms resulted implicitly

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simply copying ornamental details, would become referential in the decisive step towards the modern utilization of functionally determined iron parts in slender, exposed structural systems. This principle has opened the horizon to the first attempts to adapt the formal language to the new needs and new means of building. In fact, the rationalist thinking, introduced with the systematic archaeological research that begins in the early nineteenth century, in contrast with the romantic origins, brings an essential contribution in the use and development of skeletal iron and steel load-bearing systems: encouraging freedom of expression and structural honesty, ideals that may be considered the essential engines of the modern movement. Even if the claims of representation were fundamentally different, the great structures of the mid nineteenth century (Crystal Palace or The glass roof of the Oxford University Museum) can be considered both the result of this rationalist thinking.

Among the architects who have embraced this style, between them those in France that were all amateur archaeologists who had restored at least one Gothic building before dedicating to their own projects [2], Viollet-Le-Duc, one of their leading exponents, saw the architecture of the nineteenth century based on a rational construction and composition system, found in the Gothic style, without the imitative ornamental detail. His treaties (Entretiens sur l’architecture), published between 1863 and 1872, as a set of unrealized projects that combine iron with masonry construction Fig.7-a,b, would later become a major source of inspiration for modern architects.

Figure 7. a,b - plates from Entretiens sur l’architecture; c - St. Anne's Church; d - Carlton House Conservatory.

Maybe the first example of using iron at „truly architectural scale” is offered by the columns that support the gallery of the St. Anne Neo-gotic church in Great Richmond street, Liverpool, Fig.7-c constructed between 1770-2 (Hitchcock 1958: 116)[6]. The Palace in Kew, designed by the architect James Wayatt for George III in a „Castellated style”, includes already an iron skeleton structure (idem: 117)[6].

In a period in that greenhouses were constructed in masonry, with large glazed areas between stone pillars and opaque roofs, the Carlton House Conservatory in London 1811-12 Fig.7-d, designed by architect Thomas Hopper (Hitchcock, 1958: 117)[6] searches also to exploit, in a super-ornate Neo-gotic version, the potential of the iron load-bearing structures. Even if the Gothic form completely subordinates the form of the load-bearing elements, this building is not without the merits. Much like in the Gothic load-bearing structural philosophy of design this representative ensemble, shows the extraordinary capacity of cast iron to be used in unprecedented slender structural components. The churches in Liverpool, conceived in Neogothic style by the architect Thomas Rickmann and the iron-master John Cragg, emphasize another advantage of iron load-bearing structures, that of prefabrication. The first church, St. George in Everton 1812-14 Fig8-a, constructed around a cast

5 the ornament, here Gothic, the Gothic forms generally, have been considered to be the result of a process with deep cultural roots, they could not be obtained others than recovering the cultural values that constituted the foundation of their birth, so purely formal imitation been rejected.

6 „the last great theorist in the world of architecture” John Summerson 'Viollet-le-Duc and the Rational Point of View', in: Summerson, Heavenly Mansions and other essays on architecture (1948), New York 1963, p 135 (retrieved from Kruft, 1985 :282)[16]
iron skeleton, impressive through the slender proportion of the load-bearing members, became a model for St. Michael in Hamlet 1813-15 Fig.8-b. Reusing of the casting molds from St. George for the prefabrication of the load-bearing and decorative elements for St. Michael, will bring substantially cost reduction [17]. Cast iron, used initially only in the interior, takes at St. Michael every details possible, becoming to be expressed even at the facade level [18].

Kreuzberg Memorial in Berlin, built between 1818-21 Fig.8-c, after the design of Karl Friedrich Schinkel (Mignot, 1984: 42) [8], is an early example of the use of iron in the Neogothic architecture outside the British island. The cast iron imitates Gothic detailing in a purely formal way, Schinkel exploiting here only its capacity to submit to form, to take without any difficulties the most complex ornamental shapes.

Substantially influenced by the doctrinaire, anti-industrial writings7 of Gothic-revival theorist Augustus Welby Northmore Pugin's8, the building of the Westminster Palace in London 1840 Fig.8-d, designed by the architect Charles Barry, at which Pugin himself took part as the main detail designer, would solve the problem of fire resistance by relying, on iron load-bearing components for the roofs and floor construction elements. (Hitchcock, 1958: 122)[6]. Carefully hidden from the eye of the beholder, these solutions were in the fact the culmination of technological development at the time.

In France, “... a work of considerable scale and technical elaboration ... “, was the iron roof that protected the vaults of Chartres Cathedral Fig.9-a, conceived and constructed by C.J. Baron and Nicolas Martin between 1837-9 (Hitchcock 1958: 108)[6]. Although hidden for the common viewer, this solution would become the prototype for similar construction. One such example could be found at the Sainte-Clotilde Basilica Fig.9-b, whose construction started in 1846 after the design of architect Franz Christian Gau, realized in 1836. These seemly first Neo-gotic church built in Paris would be completed by the architect Théodore Ballu in 1857 (Hitchcock 1958: 108)[6] Impressive trough it’s iron spires which foresee the opportunities offered by the use of the new material, this building ultimately fails much like the others to find alternatives for established formal patterns. Moreover, the questionable proportions, the “characterless” and “deadly mechanical” detailing constitute questionable realities, critically emphasized in Hitchcock’s presentation (1958: 108)[6]. A great example, rather by it's dimension that places it between the highest spires in France (151m), is the iron spire of the Rouen Cathedral Fig.9-c, that replaces the old lead covered wood spire. This construction, having as source of inspiration the spire of the Salisbury Cathedral, started in 1848 by architect Jean-Antoine Alavoine and completed by architects Eugene Bartheley and L.F. Desmarest in 1877, presents at most a fascinating open cast

7 We talk here about Contrasts (1836) and The True Principles of Pointed or Christian Architecture (1841) writings that marks “... a point in architectural theory at which non-architectural and non-aesthetic considerations gained the upper hand.” (Kruft, 1985: 327)[16].
8 Augustus Welby Northmore Pugin (1812-52), architect, designer, theoretician, “... introduced a new polemical and ideological tone in the Gothic debate.” (Kruft, 1985: 327)[16].
iron structure. The first church in Paris built on a structure almost entirely of iron seems to be Saint Eugene, 1854-5 Fig.9-d, designed by architect Louis-Auguste Boileau (Hitchcoock, 1958: 128)[6]. Without offering extraordinary architectural spaces or forms, at most confusing through the unusual dimension of the Gothic members, such examples remain witnesses to the potential provided by the skeletal structures made of the new material. The huge importance of the Gothic ornament in the consciousness of the Christian era can be observed in the prefabricated churches that were exported worldwide in the early 1850's, whose industrial image is sweetened using a number of Gothic details.

![Figure 9. a - Chartres Cathedral - roof; b - Sainte-Clotilde; c - Rouen Cathedral; d - Saint Eugene Church; e - Oxford University Museum.](image)

One of the few critical alternatives of using iron load-bearing structure in Neogothic buildings is to be found in the iron and glass covered courtyard of the Oxford University Museum, 1855-60 Fig.9-e, constructed after the design provided by the architects Thomas Deane and Benjamin Woodward. The style, strongly influenced by John Ruskin⁹ seems to be, as Hitchcock remarks, the possible answer to the question: “How would medieval builders have used structural iron had it been readily available to them?” (1958: 176)[6]. Materialized under the supervision of iron-master E.A. Skidmore, after a huge failure, the first structure that mainly used wrought-iron was unable to support his own weight [20], this building stands out between so many structures constructed at the time without architectural control. Noteworthy is the articulated character of the structure and the wrought-iron ornament whose development seems to be made to meet production technology. As Hitchcock remarks (idem)[6], this building could be “the first echo in England of the theories of Viollet-Le-Duc”.

4. Eclectic Architecture

Paradoxically or not, the Eclectic architecture would pay great attention to the new, technically innovative solutions. “Apparently obsessed [more than ever] with stylistic elaboration” (Hitchcook, 1958: 154)[6], with finding the national architectural language, the appropriate source of inspiration, architects were preoccupied to incorporate in their buildings whatever could better satisfy the needs that constituted the base of edification, including the latest technical advance. Among the stylistic components which diversifies their source of inspiration, non-discriminatory coming from every historical period, from ancient Egypt to Louis XVI, taken with or without discernment structural principles, archetypal forms, plans or merely ornaments, one could find iron structures expressed with great boldness. However, even if economic and functional considerations lead to consistent use of iron as a load-bearing solution, its exposure remains rather exceptional. In

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⁹ John Ruskin (1819-1900) - thinker, artist and art critic that significantly influenced the Arts and Crafts movement, known in architecture specially trough his writings *The Seven Lamps of Architecture* (1949) and *The stones of Venice* (1851-3). In his vision, “art is an expression of the values of a society”, architecture being the most public of the arts. According to this point of view, architecture “most fully expresses the whole spirit of the people” [19].
most cases, buildings that house new architectural programs, in which the iron structures respond to the functional requirements, were treated with a decorative ambiguous language. In an attempt to express prestige, trough style, or to impose trough grandeur, the new material remains behind the scenes, supporting unseen, shapes whose foundation could not be found neither in the constructional system, nor in the stylistic dogmas that ordered the initial building composition. If this architectural style has not succeeded in finding the proper image for the new material or the new building systems, iron, in all its applications, has certainly been openly abused in the service of this style - most of the stylistic aberration that would be brought to light in this period would not have been possible without the contribution of the prefabrication industry, working in the service of the applied ornament [8].

One of the examples of the romantic eclecticism, practiced before the period of glory, is the Royal Pavilion in Brighton, an early neoclassical building that was to be transformed in 1818-21 by the architect John Nash, which gives it an oriental „festive and frivolous” atmosphere, with Chinese and Indian influence (Hitchcook, 1958: 93-94,117)[6]. The kitchen and several of the rooms attached by Nash offer some of the first noteworthy examples for the use of iron in it’s own scale, given the quality of the material, and not imitating masonry dimensions. Although the first sketches showed slender columns, without capitel, the ones which were put in place would be decorated with floral motifs to soften their visual impact Fig.10-a. Invisible, the load-bearing skeleton of the great bulb-shaped dome, is also made of iron (idem: 117)[6]. Another example of free use of iron load-bearing systems imposed by functional requirements is the Coal Exchange in London, built between 1846-9 after the drawings of architect James Bunsone Bunning. The “... two palazzo blocks set at a fairly sharp angle to one another and loosely linked by a very Picturesque round tower, free-standing in its upper stages ...”, hides here an interior hard to guess: nearly invisible, the masonry leaves place to “... an elegant cage of iron elements rising to the glazed hemisphere above (Hitchcook, 1958: 123)[6] Fig.10-b,c. The US Capitol dome in Washington, built between 1855-1865 Fig.11-a,b, distinguished mainly by its size (Lee-Thorp, 2006: 103)[21], which can rival the greatest domes of Baroque in Europe, presents the typical hidden iron structure. A shape similar to that of Michelangelo’s dome, decorated by the architect Thomas U. Walter in Second Empire style, hide an iron structure motivated by the ease of execution, low weight that could be supported by a pre-existing structure and reduced costs compared with those of a masonry dome. Paleis voor Volksvlijt in Amsterdam Fig.11-c,d, built in 1856 after the plans of architect Cornelis Outshoorn (Hitchcock, 1958: 126)[6] on the model of crystal palaces, presents a solution in which the iron structure again submits stylistically to the second Empire, the neo-Renaissance decoration seeking an 'improvement' of its expression.
Alexander Greek Thomson’s churches, built in the second half of the nineteenth century, Vincent Street Church 1859 and Queen's Park Church 1867 Fig.12-a from Glasgow, also exposed iron on the inside. At Queen's Park, which combines the neoclassical style with a tower of Hindu influence, iron elements are used with a remarkable logic: “Both the heavy masonry tower - which is, of course, invisible from the interior - and the heavy clerestory are carried on these delicately proportioned metal columns with a frankness and boldness hardly equaled before the twentieth century.” (Hitchcock, 1958: 62)[6]. In the same period, Saint-Augustin Church in Paris Fig.12-b, built between 1860-7, a mixture of Romanesque, Byzantine and Italian Renaissance, that complements the image of the apartment buildings aligned to the Hausmanian boulevards, offered also an example, perhaps less inspired, of using iron load-bearing components. Hitchcock criticizes the way the architect Victor Baltard, who conceived Les Halles in 1853, articulates the iron arches of the roof to the Romantic-Renaissance design of the masonry (1958: 142)[6]. Also an example of exposed iron gives St. Mary's Church Fig.12-c, built between 1866-73 in the suburb of Ealing, after the Gothic-Byzantine design of architect Samuel Sanders Teulon (Hitchcock, 1958: 180)[6]. Here columns and arches support with great nonchalance the visible corrugated sheets that make up the roof covering.

Whether it is classified as romantic or a rational phase of Neoclassicism (Hitckook, 1958: 27)[6], as a national eclectic style combining the rigor of classic romantic-mediaval language, or just a version of the Neorenaissance (Collins, 1965: 98)[22], the Rundbogenstil can be considered the result of adapting the architectural style to the new requirements and means. We speak about a style, whose flexibility, typical to the eclecticism, allows the architect, as Collins notes, “... to select - and even to invent for himself - such compositional and decorative forms as might be considered suitable for the occasion.”[1965: 98][22]. As Hitchcock notes (1958: 154)[6], Rundbogenstil was to prove very well suited to order the composition dominated by the huge iron arched load-bearing structure of the Anhalter Bahnhof in Berlin (1872-80) Fig.13-a,b. Designed by architect Franz Schwechten,
this station was a major step forward in clarity and coherence of functional organization. Equally impressive through the 62m span of the platform roof, the largest on the continent at that time (Hitchcock, 1954: 154)[6], designed by engineer Heinrich Seidel, Anhalter Bahnhof gives us a synthesis, already typical at the time, of the cooperation between the formal and technical field of specialization (Zietz, 1999: 15)[23]. A somewhat similar style will be found at Amsterdam Central Station (1881-9) Fig.13-a,b, designed by architects Pierre Cuypers and A.L. van Gendt, which incorporate the platform covering structure designed by the engineer I.J. Eijmer and built by ironmaster Andrew Handyside from Derby, England. Even if the issues raised by the load-bearing structure of the platforms covering, amplified by the difficult foundation conditions, have claimed at first the intake of engineering professionals, the desire to meet the need of representing the Dutch nation was to prove decisive to assign the work to an architect, rather then to an engineer. No less important to note that the interior decorative elements and arrangements were made in close cooperation with artistic professionals (Langmead, 2001: 14-15)[24]. The complexity of such constructions, both in terms of needs which had to be fulfilled and means of execution, made the collaboration between several specialists inevitable.

![Figure 13. a - Anhalter Bahnhof, b - roof montage; c - Amsterdam Central Station, d - interior view.](image)

**5. Conclusions**

The use of iron load-bearing structures or structural components in Neoclassical, Neogothic, or Eclectic architecture, do not automatically generate consequences at the level of architectural space or form. In most cases, such use may go unnoticed. Exposed or not, in such cases, iron load-bearing structures or structural components are obedient to formal decisions imposed by the established architectural language.

Noticeable changes at the level of architectural space and form were rather the consequence of cumulating factors, between whom some unprecedented requirements, that only unusual structural forms were able to meet, have been instrumental. In such cases, the architecture deliberately takes, not only the load-bearing system but also the formal typology that the use of the load-bearing system has generated. Embedding of such major parts in the established architectural language, while maintaining the overall coherence, has required a substantial effort to restructure the architectural concept. This has been done in two major ways: by accepting eclectic solutions in which the composition and the decoration have sought to control the mixture resulting from the use of the best of that what art and technology offered at the time (Eclecticism); by challenging, and critical use of, the principles that have generated the accepted architectural language (Neoclassical and Neogothic structural rationalism). We can even assume that decisions on acquisition of new load-bearing systems were influenced by the ability of the architects to predict and control the outcome.

For structural form to reach a major influence on architectural form, including the level of decorative language, to allow for its expressive potential to be highlighted, structural development was not sufficient. It was necessary that architects find, on the principles that provided the basis of

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[11] The building seats on three artificial islands in the river IJ, been founded on 26,000 wooden piles (Langmead, 2001: 14)[24]
established, accepted, architectural language, ways to organize, control and mediate the expression of the building as a whole. Thus, in the historicist architecture of the nineteenth century, the potential of the iron load-bearing structures has been exploited only to the extent that the architects have had the ability to foresee and control the enormous expressive power associated with them. This conclusions underline the fact that, although crucial in producing changes, the role of the iron load-bearing structure, was not to define formal characteristics of the historicist architecture. Its role was rather that of a catalyst for change, for opening or even 'deconstructing’ the established architectural language.

6. References


6. Figures

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