# The 19th Century iron architecture of industrial buildings. A formal and constructive comparison between two case studies

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ABSTRACT: The paper analyzes the features of the 19th century industrial architecture and the application of metallic structures combined with formal and architectural expressions that frequently concealed or mitigated their presence. The mix of engineering features for the industrial purpose and familiar perceptions of the traditional architecture is one of the characteristics of this typology. The cases – both belonging to the mining industry of the 1800s – feature both the structural innovations in the use of metallic - masonry structures and formalism that recall the Eclectic and aesthetic motifs as a mean to enhance the industrial function and the technological expression. The metallic elements are in fact frequently employed in the most important sections of the buildings and testify the influences of both the technical advance of the constructive theories and the stylistic formulas that, although belonging to a more aulic architecture, intensify the productivity and the performances. Finally a proposal of reuse for one of the case study aims to valorize the duplicity of the formal and the technological approach for this typology in order to give a new purpose to this symbol of the industrial epopee.

## 1 INTRODUCTION

In the Eighteenth century the architectural and constructive approach to the industrial building was mainly referable to the circulation and the development of engineering theories, metallurgy and mechanics in and between the most advanced Countries of Europe. France, German and Hapsburg Empires, Italy and Hungary were in fact connected in a cultural web of interpretations and solutions of technical issues regarding the construction and the formal issues in architecture: one of the most important consequences of this situation was the divulgation of concepts, theories and methods that involved certainly the industrial production in terms of buildings and materials. The technical dissemination involved both the translation of scientific volumes – often from German areas – and the penetration foreign expedients in the constructions thanks to the commercial, educational and trading exchanges to and from abroad. The Academies were also a place of development and diffusion of scientific and technological culture in Europe and soon they became the attractive poles for engineers, researchers and technicians to attend courses and practical workshops frequently resulting in publications and essays. In this field the predominance of German schools – first of all the *Bergakademie* in Freiberg – in the scientific and technical panorama led to a partition between the mainland and the United Kingdom, which developed a proper technical path in the evolution of constructive and formal criteria (Hitchcock, 1959).

In the passage to the 19th century the international relations between European Countries resulted in the penetration of foreign theories and experiences that led to a progressive modernization and development of techniques and investigations in various fields, such as metallurgy, mechanics, engineering and architecture: we may trace this aspect in the relations between France and Great Britain since the need of competences in metallurgical and mining fields both for civilian and military purposes was in fact promptly attended through the training of experts, technicians and scientists from those Countries. Regarding particularly the metal industry, France imported techniques and scientific notions from the United Kingdom in order to implement the iron and steel works mainly for military and industrial purposes: the productive processes were thus explored through visiting and publications, leading to a new phase of advanced production thanks to the updated approaches both from a scientific and a technological perspectives. The most valuable results of these approaches belonged to Berthollet, Monte, Vanderamonde who intended finally the connection between the chemical formulation and the behaviours of the iron and steel products. This led to a new era of international concurrence between the French and the British Empires, involving both the industrial, the engineering and the chemical sectors (Brianta, 2015).

Another consequence of the passage from a pioneering age to a rationalized and scientific production of steel and iron elements was the spread of works where the properties of the metallic materials were promptly exploited and put on duty at their best: bridges, railway stations, civilian and industrial facilities and so on. Mining activities were also touched by the introduction of new building techniques and the works were put under the control of the Bridge Corps and Mining Corps, which regulated the concessions, the use of materials and the modernization of this sector since the 1820s (Brianta, 2015).

Industrial architecture became soon the ideal context for the application of the new constructive typologies and techniques, mainly in those Countries where there were availability of primary goods, i.e. iron and coal, and a sensibility for the spatial and constructive skills of metallic building. Great Britain developed in that sense a very impressive number of facilities and infrastructures where the metallic components prevailed and frequently constituted the very essence of the project. In 1850s we find the pavilion in Paddington Station in London that featured a great hall, 74 meters long, with a framework consisting of bow beams with inner frames following the strains. These arched vaults covering huge surfaces were concealed externally by a sort of representative or “recognizable” façade, simulating a palatial front. The railway stations represented in fact the laboratory to experiment the new techniques, allowing to cover great areas with single, lighter elements, flooded with light and destined to house a representation of the incoming future, i.e. the machinery, the train, the modernity. The presence of the masonry in the façade was in that sense a mitigation of the impact with the new era, since it featured familiar characters, declined along with the sensibility and the stylistic tastes of the time in order to give to the people a sense of domestic ambiance and safety.

## 2 MATERIALS, FORMS AND INNOVATIONS

The structural principles basing on the independent frame date back to the end of the 18$^{th}$ century and were applied throughout the 19$^{th}$. Both in civilian and in industrial buildings we find new building techniques: innovations were then combined with the new architectural styles, which preferred a renovated reminiscence of the historical languages to conceal the new forms of construction, reflecting a dualism between structure and façade throughout the 19$^{th}$ century (Kostof, 1988). Factories were frequently designed as a proper typology in order to represent the new establishment, a new social class that owned great funds but that still needed a proper acceptable style: traditional forms and new functions, new machineries and techniques led to the innovative industrial language of the first decades of the 1800s, further evolving in a mix of independent frames, where the elements were no more concealed under the wall mass and the façades progressively abandoned the brickwork curtains.

The cast iron column was the first structural material produced through industrial methods to be used in constructions (Chueca Goita, 1979). In 1780s this new element replaced the former wooden pillars to support the roofing in the textile factories in Great Britain. The iron pillars, generally, were used along with traditional masonry and concealed inside the bricked or stoned portions since they were perfectly able to support compression strains but not deflections. This resulted in the frequent substitution of masonry with iron or cast-iron columns that allowed to light in the ground floors, especially in the commercial and leisure buildings.

The traditional barn was in this case the referring model, but the risk of fire and disastrous events led to the search of new constructive solutions to prevent accidents in the factories: the first episode of a whole cast-iron frame in an industrial facility comes from the Flax mill in Ditherington, designed by its owner Charles Bage in 1797 where the cross-shaped cast-iron columns were combined with metallic beams and bricked arches forming the slabs. Obviously the presence of the metallic frame was not left exposed, but concealed through bricked masonry that gave to the factory a reassuring character inspired to the traditional buildings with masonry structure (Sutherland, 2016) (d’Alpoim Guedes, 2010). Cast-iron was then replaced by iron as the metallurgic industry gradually improved and the introduction of new machineries and water wheels required new building layouts: the *mise au point* of the riveted assemblage of single elements allowed in fact to amplify the sections and the spans of the frames. The aesthetic looked at the stylistic embellishment and the formal combination of decorative languages that frequently enhanced the lightness and the slimness of the vertical sections, increasing the spatial sense of productivity and modernity of the industrial building. The façades that initially concealed the presence of the inner frame – although declaring it through the presence of glazed portions and windows to flood in the light – are progressively conceived to underline the presence of the independent skeleton thanks to the application of Eclectic formalisms that reflect outside the structural elements (Chueca Goita, 1979). Furthermore new iron (and then steel) trellises formed the bone of most industrial or expositive buildings thanks to the greater lightness, allowing to design more transparent buildings where the light could flood in from multiple directions (Sutherland, 2016).

In the early decades of the Nineteenth century we assist then to a proliferation of new constructive possibilities offered both by inventors and designers that had recognized the iron as an ideal material for creative designs, embellishments and building resistance: the tailor-made design proposed by the architects working for the industrial establishment was accompanied by the inventors’ prerogative for the elaboration of new generalized systems applied to a wider market, where already well known solutions could be combined and adapted to suit specific requirements for the industries (Munce, 1960). One of the most relevant examples is the truss patented by the French engineer Camille Polonceau in 1839, who aimed to make all the elements of the truss working at their best: the gable roof consisted of two inclined beams and a central tie, which underwent to tension (Nieuwmeijer, 2001) (Holzer, 2010). The result was a simple but efficient solution, inexpensive if compared to material costs (Brebbia, 2011) and easy to calculate thanks to the graphic statics. The application of this truss spread rapidly and it was frequently used in a great variety of buildings.

## 3 THE 19TH CENTURY CULTURAL BACKGROUND: THE TECHNICAL LITERATURE

The technical development in the construction industry makes essential to ongoing training and dissemination of ideas, patents and structural solutions on a large scale beyond the boundaries of individual States. This contribution, mainly aimed at designers, students and builders, required the preparation of appropriate handbooks – given the poor circulation of magazines – frequently updated and prepared by the same inventors of the constructive methods or by the teachers of the Universities and academic courses of the moment. Very often the editions of the handbooks were updated and re-edited into service of new examples or new discoveries, theories on the performances of materials and stress or challenges for the design.

The handbooks also allowed the dissemination of ideas not only within the regional borders but in reality of the pre-unified Italy and across States’ boundaries, collecting contributions from the most famous characters in the French, English and German scientific worlds. The Universal Exhibitions are the first carrier of the development of innovations and the time of inventions, introducing new definitions of the relationship between function and type, again suggesting the differentiation among the protagonists of building practice that wants on one side the architects associated to the sphere of arts and Academies, hardly approachable to the scientific world and the static calculation of the proportion; on the other the trained and qualified engineers according first to the French models and then to the German ones (Guenzi, 1993).

In this period the treatise is still unrelated to empirical practice of construction and appeals to connoisseurs and amateurs of the disciplines, however taking important conclusions and technical developments from the realizations and the experiences that we find in France as the architecture of bridges, roads and public works, at the base of which several experiments are conducted; in England it is instead the technical entrepreneur that forms himself on the thrust of the practical experience to obtain a scientific and theoretical feedback, as in the case of Joseph Paxton. In Italy and France also, we are witnessing the gradual disappearance of the guilds, which give way to the professional class for solving computational problems concerning primarily public works such as railways and bridges, demonstrating the impact of theory and innovation prevailing on the practice and on the reiteration of past models.

Inside the wide and extremely variegated literature production in technical and structural fields during the 19th century, one the most relevant example of technical literature is the *Theoretical Practical Treaty of the Art of Edifying* by Jean-Baptiste Rondelet, followed in the Italian context by Nicola Cavalieri di San Bertolo's *Institutions of Static Architecture and Hydraulics*: the French handbook has in fact the merit of introducing two fundamental components for the practical Treatises, i.e. the use of stereometry according to functional geometric designs of Gaspard Monge (Guenzi, 1993) and the mathematical calculation of the beams, based on Navier's, Belidor's and Gauthey's contributions. Rondelet introduced the possibility to prefabricate the individual constructive piece, by virtue of the design of complex parts, the mechanical couplings between different materials and perfect joints between the different parts, especially in those extremely complex works such as arched bridges, lighthouses, stairs etc. suggesting therefore a combination between the performance of the material and the physical laws that must guide the design. The Italian treaty was intended as an aid to architects and engineers, focusing on structural constructive details, as befitted the mentality of the time towards the industrial production of increasingly larger scales, finishing then to put aside the question of aesthetics to the advantage of rapidity of assembly the structural components (Trivellin, 1998).

The didactic interest searched mediation between the theoretical principles, widely practiced building traditions and exceptional embodiments, which are presented as codes to be replicated in front of particularly complex cases (Trivellin, 1998). An innovation that will be frequently applied in the industrial buildings from the 1850s onward is the one introduced in the field of iron buildings by Camille Polonceau in the *Revue Generale de l'Architecture et des Travaux Publics* in 1840: it is the technical explanation (Polonceau, 1840) of a new timber and iron roofing system which will be called "*Polonceau* truss". The author explained in fact all the advantages and the structural safety that his invention provided, from saving in the employ of timbers, the reduction of thrusts on walls, the lightness and the greater spans, the easiness of assembling and dissembling, the structural resistance, the availability of various sections and lengths and so on.

One of the common features of all these handbooks and treaties is the presence of illustrated volumes to accompany the theoretical principles and chapters, allowing therefore the comprehension of the practical translation of theories into real works and projects: furthermore in the last decades of the century a great attention is paid to highlight practical examples of construction in order to focus more on "how it's made" than on the scientific aspects. The latter are analysed in that branch of scientific literature at the light of the theories of the newly formed Science of Construction, such as in Adolf Breymann's work of 1849, entitled *Baukonstruktionslehre* (Breymann, 1894). The latter part clearly indicates the author's intention to present scientific and technological innovations on the modern building science that is fully developed from the 1850s and on the latest manufacturing technologies along with the theories of computation intended as integration with the purely technical dissertation.

## 4 CASE STUDIES

The case studies belong to two different realities of the industrial architecture dating to the mid of the 19th century, which can be confronted in order to trace common points from a linguistic and technical points of view: the first is the Monteponi mine in Sardinia, owned by the homonymous Company and settled in 1850; the second case is the mining complex of Grand

Hornu in Belgium, started in 1810 by Henri De Gorge, a French captain of industry (Watelet, 1990). Both the cases reflect the influences and the tastes related to the industrial conceive of factories and mining facilities, since we find numerous analogies between the stylistic and the constructive concepts that define the heritage of these sites. The different geographical position in fact is not a factor of divergence in the matter of linguistic and technological features, but on the contrary remarks how the building approaches and the cultural tastes were divulgated in the European context during the century: we may note a similitude both in the use of materials, in the functional conceive of the main buildings of these cases, in the use of technical expedients and applications of similar concepts to underline the hierarchy of different elements of the spatial configuration.

The analogies are not to be intended as a homologating feature, since we are analyzing different contexts and buildings, but they might be considered as witnesses of the common cultural field in which the designers, the managers and the builders worked in the same period.

### 4.1 *Monteponi mine and Sella Shaft*

Monteponi mine is located in Southwest Sardinia and its exploitation dates back to the Roman Empire thanks to the presence of deposits of lead and galena. After centuries of exploitations by by the Pisans, the Aragons, the Spanish and the Savoy, the mine was finally rented in 1850 by the Monteponi Company, founded in Genoa. Since that year we saw the proliferation of many industrial facilities for the extraction of minerals and furthermore for the treatment of rough products and the metallurgical works. Between the 1860s and the 1920s we assisted to an impressive modernization and technological innovation of mining buildings and machineries, with the creation of masterpiece of mining engineering such as a dewatering gallery, an inclined plane, a railway and numerous workshops. The technological development is due mainly to two managers, who searched for the enhancement both of the mining buildings and of the standards of production: Adolfo Pellegrini, from 1860s to 1875, and Erminio Ferraris, from 1875 to 1906. They promoted the main buildings of the mine, which can be grouped in mining shafts, workshops, transport facilities, foundries, mechanic washeries and metallurgical plants (Società Monteponi, 1950).

Inside Monteponi's heritage, there is a building that could be considered as emblematic of the whole scenario thanks to the formal and constructive features that were brought to the highest levels of celebration of the industrial purpose, to highlight both the prestige of the mining Company and the evolution of the stylistic and technical tastes: Sella Shaft. In addition to its great mole, constructively and linguistically it is identifiable for its evocative character and for the equipment of the formal and structural choices as a perfectly resolved synthesis of the conjugation between Eclectic languages and technological Modernity: the decorative motifs and the stereometrical concept are in fact equally conceived as well as the structural solutions in line with the international technical literature of the time.

Sella Shaft (fig. 1) was built during the years 1873 - 1875 to house a dewatering pump system for the groundwater and the extracting machine for mining works. The designer was the German engineer Franz Stiglitz, arrived in Sardinia in the early Sixties. The complex is composed by three contiguous buildings, pivoted around the central volume with a rectangular plan to which are attached the two smaller lateral wings, made of load-bearing masonry with variable thickness in cut stone, fireclay bricks and ordinary bricks (Lai, 2004). The two wings, containing originally the boilers room, the machine workshops and the forges, elevate up to 9,30m to the ridge, dominated in the original intentions by two skylights, supported by a system of *Polonceau* trusses with a span of 16,20 m. In the central volume the load-bearing walls assume the relevant thickness of 1,54 m to support the grandiose system of cantilevers supporting the beam carrying the first floor . The coverage of this central body is entrusted to wooden beams and mixed king post in wood and iron, in which the tie rods intersect at the centre, while wooden beams connect the east and west walls of the building.

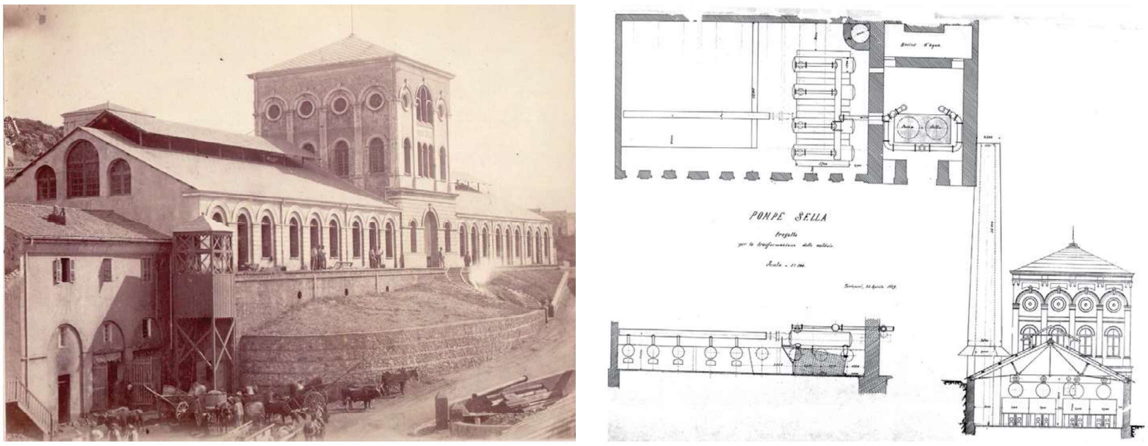

Figure 1. Sella Shaft in 1875 (left) and the project of the boilers room (right).

Formally Sella Shaft is characterized by the coexistence of elements borrowed from the Neo-Renaissance and Neoclassical language and by a long series of arches and pilasters that mark the score of the openings along the main front. Round arches and pilasters frame the windows and doors and amplify in the central volume, expanding into a large arch, flanked by two smaller arched windows, which becomes at the same time both the portal of the Shaft room – occupying a third of the height – and a New Renaissance base treated as a fake smooth ashlar. This amplification results even stronger by a thick stringcourse frame, tripartite by three large arches in which the decorative elements identify the openings: the high pilasters incorporate the upper bull's eyes and two arched windows, while the large central arch houses the two *trifora*. Oculi and arched windows then become the decorative matrix and the functional characteristic of all the façades of the central body, drawing a clear Eclectic polyline that intercepts the prospectuses and divides them into regular spans to accommodate the openings.

Sella Shaft could be therefore considered as an intermediate building, offering a dialogue between the formal celebration of the industrial purpose and the exaltation of the technological progresses and the technical apparels: on one side it was conceived as a technical building, housing forges, foundries, pumps etc., and featured as an industrial building; on the other it exalted its role through a heavy formal language, carefully designed in order to amplify the significance of its purposes and recalling a sort of a "temple of the industry": the "holy cell" is the great central volume, towering over the other compounds and keeping that sense of vital functions enhanced through the stylistic expressions that combine Eclectic and Neoclassical evocations, influenced by external approaches and the coeval literature. In the whole architectural panorama, this is indeed the only building which underwent the lightest modifications keeping its formal and functional features until nowadays, thanks to the extraordinary completeness and accuracy of its design both in the technological and in the decorative apparatuses.

Metallic elements – Polonceau trusses, the iron cantilevers, the girders, the riveted plates, the stairs – are accompanied by the presence of the bearing masonry, which reveals itself necessary in order both to bear the elements such as the trusses and the beams and to carry at the same time the formal apparatus that exalts from the outside the technical completeness of the inside, through the perforation of the walls by the long series of windows, doors and bull's eyes that reconcile the technical elements with the celebrating appeal. The attention for these aspects is in fact traceable if we look at the projects of the Shaft by Stiglitz: we find drawings dedicated to the definition of the formal motifs such as decorations and friezes of the main façade, consisting of arches, windows, mouldings and sections in a scale of 1:10 and 1:1 of the stones used for the decoration, with a precise indication of the cutting edges (Fig. 2). But this precision is also traceable when we analyze the drawings of the metallic trusses and cantilevers to be settled in the main rooms: one of the most interesting shows a decomposition of the single elements of the Polonceau trusses (Fig. 2) in the scales 3:100, 1:10 and 1:5 in order to indicate the assembling and the dimensional control of each component, matching perfectly Camille Polonceau's original drawings; the cantilevers, designed in a scale of 1:20, show both the dimensional features and the decorative elements that contribute to conciliate their impressive dimensions (2,70m long each) with the surrounding features and with the extracting machineries, which represent the most important element of the building.

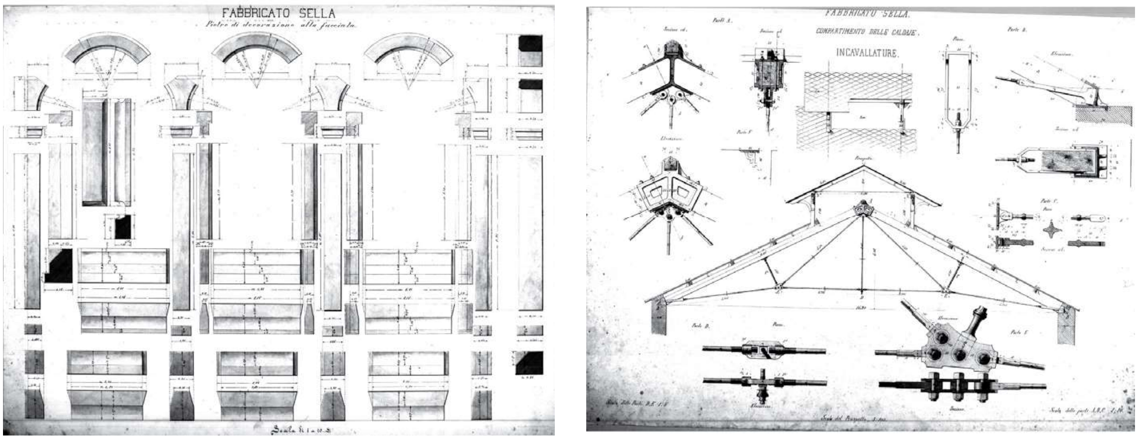

Figure 2. On the left: details of the stone decorations. On the right: the details of the *Polonceau* trusses.

The evolution of this stylistic and technical approach, however, ended in the following years with the prevalence of the latter on the first: Sella Shaft represents in this sense the highest celebration of the Eclectic formalism used to evocate the technological and industrial power of the Company and the importance of the functions, therefore the parable of the linguistic expression had arrived at a turning point. As an opposite case to Sella Shaft we may consider the building of the Calamine Washery (Fig.3) in Monteponi, built in 1887 by Erminio Ferraris: we see that the celebrative intents are replaced by a synthetic and more aseptic language, consisting mainly in the dualism of masonry parts and metallic structure. The purpose of the building was in fact the treatment of zinc minerals through a modern and a mechanized process in order to achieve higher standards of production: here the formal role of decorative elements, borrowed by former architectural styles as in the Eclecticism, is not as relevant as in the other case since the structures play the role of communicating the function of the building through a visible declaration. Pillars, trellises, beams, trusses are left completely exposed to the view from the outside, counterbalanced on the lowest level by a thick masonry, pierced by arches and bull’s eyes that lighten the heaviness of the bearing sections.

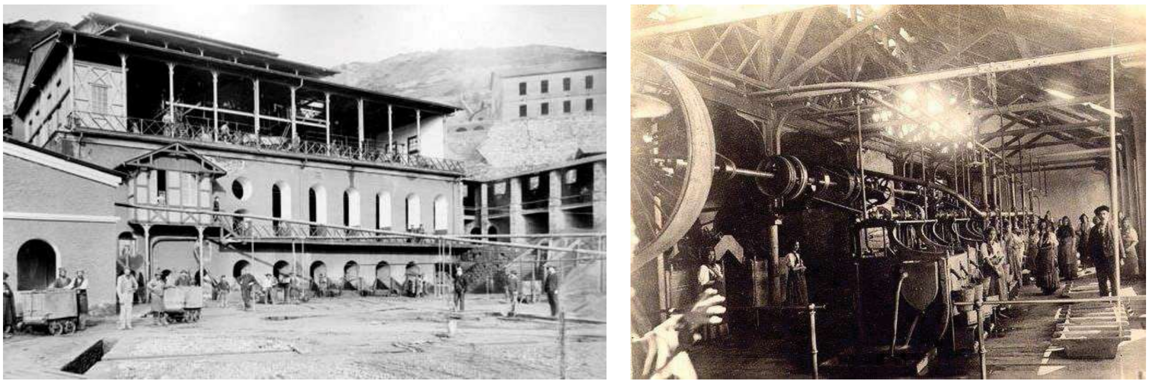
Figure 3. The Calamine Washery: outside (left) and inside (right).

### 4.2 *The Grand Hornu Shaft*

At the end of 1850s mining buildings in northern France and Belgium featured the influences of multiple linguistic styles, combined with a heavy structural presence. The latter consisted mainly of wooden and cast – iron elements, perfectly integrated with the formal attention paid to the concept of the whole building, along with the decorative accents and the machineries. The first impression is that of a compromise between the technological application of modern building solutions and the reminiscence of formal motifs that are borrowed from different architectural styles, such as the Neoclassical and the Neo – Renaissance: in that sense the representative intentions were imposed both in the outer and inner design of the industrial building through the modulation of the masonry and of the bearing parts and the wise use of the Eclectic language to exalt the most important components: we find thick bearing walls combined to the single metallic elements that parted and divided the surface to create different areas. Moreover the light is provided through rows of openings that recall the arcades of the Classical buildings, declined in a Neo – Renaissance manner to elegantly pierce the most representative façades. Frames, protrusions and recesses are intended to add movement to the whole building but at the same time to limit its extension and to define its consistence: this is the same attitude that we find in Sella Shaft where the long and apparently endless arcades in the main façade are stopped by the presence of frames and reinforcements in the masonry, by pilasters and recessions that lighten and pause the openings.

The building of the extraction and the triage (sorting) of coal in Grand Hornu Shaft in Belgium is set on an overturn L that contains in sequence the hangar of triage, the steam machine, the miners' barrack, the forges and a resting room. We may notice the permanence of the masonry, featuring protrusions and recesses that articulate all the façades containing the arched windows and the decorative oculus. Although the presence of walled sections, we perceive a light spatial composition where the surfaces are balanced in an equilibrate and rational way that allows the hall of the steam machine to be counterbalanced by the barrack, which contains the main paths and routes involved in the whole building (Glépin, 1854). The structure is based on a 0,60m thick masonry, identifying the different areas and elevating until the lowest level of the roofing to separate the areas destined to the workers and those for the machinist. The slabs and the roofing are made of a wooden framework consisting of horizontal and vertical beams and diagonal struts reinforcing and sustaining the strains in the highest level, under the ridge (Fig. 4).

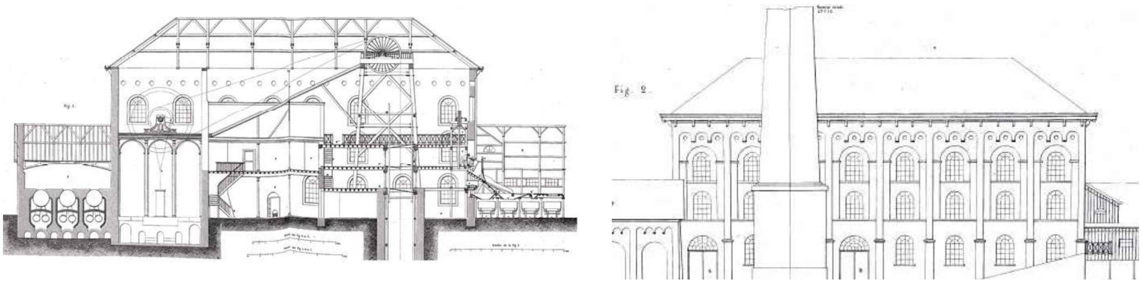

Figure 4. Grand Hornu Shaft: section and façade.

Along with the masonry there are also cast – iron pillars (designed and produced by the Grand Hornu Company itself) sustaining the slabs in the mid span both in the workers' barrack and in the room of the forges, where the pit stands. These pillars feature a mixture of different stylistic approaches that evolve from a synthetic appearance to an eloquent Eclectic evocation: in the room of the forges, containing the pithead, the pillars remember Neoclassic Doric columns placed around the wooden structure of the pithead sustaining the beams of the upper slabs in the levels of the accesses to the pit. In the next area, the barrack, we see that the pillars feature a Neo – Renaissance design on the ground floor to enhance the growth in height of this central room; in the first floor the reduction of the height is supplied by Doric pillars sustaining the adorned trabeation. In the most important area of the building, the hall of the steam machine, we find an amplification of the decorative approaches dedicated to the structural components: the cast iron pillars here look like long, thin and grooved Doric responds that frame the round arches set over shorter Doric responds sustaining a thick corniced trabeation.

Moreover, the machinist's station is sustained by a lighted cast iron girder whose structural presence is overwhelmed by the Neo – Gothic balustrade (Fig. 5), consisting of elaborated ogival figures forming an intricate web that recalls more the Cathedrals and the Venetian palaces instead than a mining facility. The interest for the decorative language is even more evident due to the way this is generally applied both to structural elements – in the moulding of the pillars, the arches, the trabeation – and to accessorial elements such as the balustrades and the cornices: we may state then that the sense of this design is to formally celebrate the role of the most important machinery in the whole exploiting process through the application of the highest Eclectic expressions.

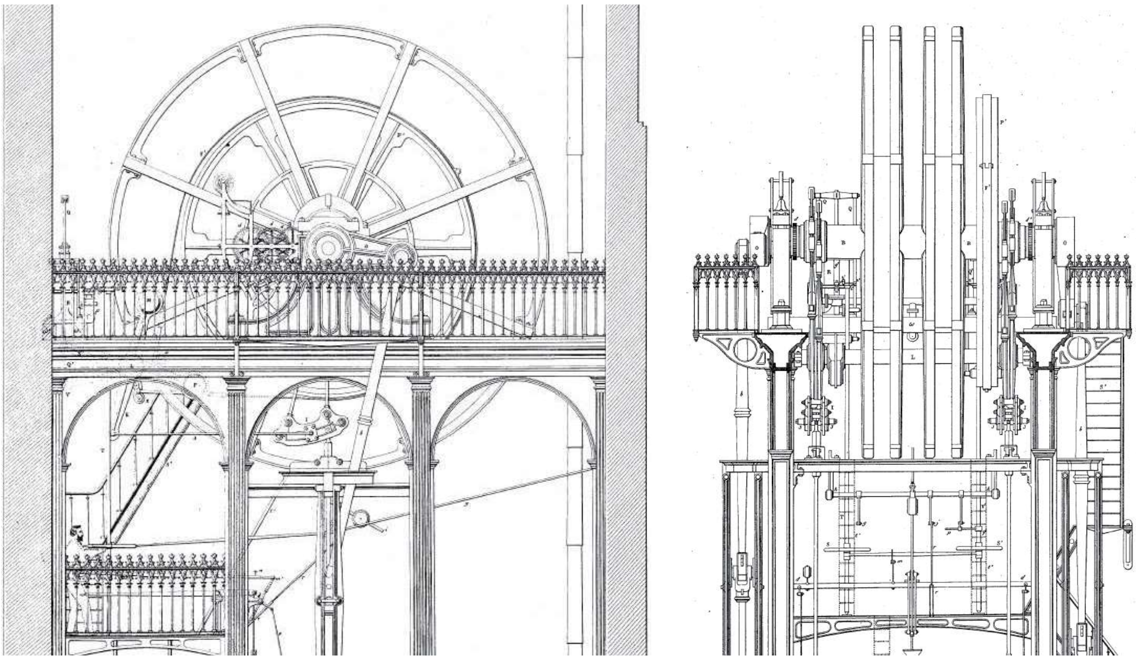

Figure 5. The metallic balustrade in the machinery room (side and front view).

## 5 CONCLUSIONS

In order to trace the parallelisms linking reciprocally Sella Shaft and Grand Hornu firstly we may state that the bearing masonry represents a constant element in the whole building panorama of the mining heritage of the 19th century: walls with a structural function are both a component of the building scheme and a mean to divide the spatial composition. The functional separation is in fact a common feature, since buildings housed different but complementary facilities that might be linked to each other or kept separated. In Sella Shaft this condition is presented through the triple articulation of volumes: the wings containing the forges, the foundries and the mechanical workshops and the main tower containing the machinery, the carpentry and the access to the pit. In Grand Hornu the partition involved the house of the machinery, the workers' rooms, the headframe and the transporting / distribution services in order to distinguish the various pertinences and the competences of each sector, according to the assembly line.

Regarding metallic elements, the presence of iron structural components is often reserved to the most important sections of the buildings or those where there is a need of spatial freedom – such as in the workshops, the house of the machinery, the headframe and so on. In Sella Shaft this occurs in the lateral wings, where the Polonceau trusses display along the whole length allowing to free the floors for the machinery, while in the central volume the huge system of iron beams and girders sustain the pumps. In Grand Hornu the use of metallic components is brought to a high celebrative intent that could be observed in the finishing of pillars, railings, capitals and arcades in order to underline the fundamental role exerted by the machinery, which becomes therefore the core of the mechanization in the exploitation process.

Moreover, the abacus of the building elements features a variety of profiles and declination of the design of the girders that offers an idea of how the studies and researchers on metallic structures had amplified in the mid of the century: double T beams, girders, riveted parts, assembled beams, pillars and reticulated girders represent the materialization of the attention paid for the structural balance, in accordance to the permanence of masonry and bearing walls, which however are mainly relied to the perimeter of the buildings. The partitions are in fact frequently avoided in order to achieve the best possible circulation inside and outside the facility and to allow the installation of further plants and machinery when occurred.

Also natural illumination is a common feature of both the cases, since it relies on openings always characterized by two elements: the semicircular profile and the decorative frames, headstones, windowsills and arches that fit the windows creating a rhythmical partition in the façades. These are plastically pierced by embossing or recessing alternating lights and shadows. The rhythm of openings and frames create thus a complex co – penetration of structural and accessorial components, highlighted through an apparently endless display of hollows and fillings. Linguistic formalisms feature the influences of different stylistic approaches that we might recollect all under the Eclectic vision of the whole building process: where structural parts are combined inside through articulated solutions of various materials (cast – iron, iron and timber) we find an explicit counterbalance consisting of multiple, decorative and bearing – simulating elements (such as pilasters, buttresses and arches) jointly with frames, cornices, crenellation and so on that compose the aesthetic scenario where the industrial function is exerted and pursued.

Both the cases suffered from a long period of abandon and a peril of demolition mainly due to the dismissal of mining activities and several economic crises. Grand Hornu was fortunately saved from demolition at the beginning of the Noughties thanks to a project of conversion into a Museum of Contemporary Arts, designed by architect Pierre Hebbelink. Sella Shaft, however, is settled into a very compromised reality, where environmental and architectural issues are far to be solved: the proposal for the reuse looks therefore to the valorization of the building through the setting of cultural itineraries that collect the Shaft to the other elements of the mining heritage on the same area but also to the environmental elements that represent a memorandum of the past activities (slag heaps). On the same path of Grand Hornu, the conversion into a Museum of the History of the Mine would be a good occasion to promote the knowledge and the dissemination of the cultural values of the architecture and technique of this site, through a project of restoration of damaged elements (mainly masonry and beams) and the creation of touristic routes for the promotion of the site. Sella shaft would thus be converted into a cultural facility where visitors could discover the functions and the processes conducted in the building and the galleries – which could be reopened thanks to the direct connection to the shaft. Finally, the display of original machinery, mainly abandoned in other appurtenances, would complete the general perception of how the mine was run in the period of its hardest activity.

## REFERENCES

Brebbia, C. A. Binda, L. (Eds.). 2011. *STREMAH Structural Repairs and Maintenance of Heritage Architecture*. Ashurst Lodge, Ashurst, Southampton: WIT Press, vol. XII.

Breymann, G. A. 1894. *Baukonstruktionslehre*. Voll. 1 – 5 Leipzig: Gebhardt's Verlag.

Brianta, D. 2007. *Europa mineraria. Circolazione delle élites e trasferimento tecnologico (secoli XVIII-XIX)*. Milano: FrancoAngeli.

Chueca Goita, F. 1979. *Historia de la Arquitectura Occidental. Tomo V (El Siglo XX: de la Revolución Industrial al Racionalismo)*. Madrid: Dossat, vol. 11.

d'Alpoim Guedes, P. P. 2010. *Iron in building, 1750 - 1855: Innovation and cultural Resistance*. [PhD Thesis] School of History, Philosophy, Religion & Classics, University of Queensland, December 2010.

Glépin, G. 1854. Mémoire sur le nouveau mode d'Extraction et Triage de la Houille Appliqué aux Mines du Grand-Hornu (Belgique.) *Bulletin de la Société de l'Industrie Minérale. Atlas de la Société de l'Industrie Minérale vol. XV*. Saint-Étienne: Imprimerie De Théolier Aimé. pp.213 – 240.

Guenzi, C. (Ed.). 1993. *L'Arte di edificare. Manuali in Italia 1750 – 1950*. Milan: Be – Ma Editrice.

Hitchcock, H. R. 1958. *Architecture: 19th and 20th Centuries*. New Heaven and London: Yale University Press.

Holzer, S. 2010. The Polonceau Roof and its Analysis. *International Journal for the history of Engineering and Technology*, 80 (1). pp.22–54.

Kostof, S. 1988. *Historia de la Arquitectura*. Madrid: Alianza Ed.
Lai, M. B. 2004. Pozzo Sella. Le fonti documentarie. MiBACT et al. (Eds.), *Eclettismo e Miniere. Riflessi europei nell'architettura e nella società sarda tra '800 e '900. Mostra fotografica e documentaria*. Cagliari: Graphic sas.
Munce, J. F. 1960. *Industrial Architecture An analysis of international building practice*. New York: F. W. Dodge Corporation.
Nieuwmeijer, G. 2001. Polonceau-spanten. *Monumenten*, n. 11, pp.20-23.
Polonceau, C. 1840. Notice sur un Nouveau Système de Charpente en bois et en fer. *Revue Générale de l'Architecture et des Travaux Publics,* vol. 2. Paris: Ducher et al.. pp.27-32.
Società di Monteponi. (Eds.). 1950. *Società Monteponi. Centenario1850 – 1950*. Torino: Vincenzo Bona.
Sutherland, R. J. M. 2016. *Structural Iron 1750–1850.* London: Routledge.
Trivellin, E. 1998. *Storia della tecnica edilizia in Italia: dall'unità ad oggi*. Florence: Alinea.
Watelet, H. 1990. Un site exceptionnel d'archéologie industrielle en Belgique: Les établissements et la cité ouvrière du Grand-Hornu, 1820-1835. *Journal of the Canadian Historical Association*, vol. 1, n. 1: 273 – 292.