PROTAGONISTS OF IRON BUILDING CONSTRUCTION IN THE SECOND HALF OF THE NINETEENTH CENTURY

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Protagonists of iron building construction are characterized less by so-called inventions of a technical or artistic nature than by their ability to absorb the existing historic substance of architecture, namely structure and space, and adapt it to changed social conditions in the light of new problems.

What is called progress in architecture basically stems from modest, but specific interventions by individuals step by step elevating building design to higher technical and aesthetic levels and creating new, different spaces.

Thus, the use of iron as a building material in architecture per se does not constitute progress. It all depends on the way in which the very nature of this material is conceived and brought into harmony with the essence of a building.

In a fundamental distinction relative to stone and wood building, iron construction can develop only in an existing industrial production environment, as is well known. At a certain level, the nature of iron is developed not only by intuition, but by the exact sciences initiating and controlling its production process. The work incorporated in a structural component made of iron assigns to that part a high value, thus forcing it to be used only sparingly in most applications, i.e., restricted to the optimum structural minima. Where iron is used in building construction, new problems are involved: The needs for enlarged spans and reduced structural cross sections as required for bridges, railway station halls, markets, factory halls. The ability of iron to accommodate high tensile, compression and bending forces and the possibility to shape iron and thus, as in the parabolic arc, almost retrace the flow of forces inside the material, has enabled this material to fulfill these new duties.

In solving these problems, the man to control iron construction from the beginning was not the architect, but the engineer. For only he was accustomed to making full technical use of the characteristics of a material not yet fully investigated and, in doing so, proceed along unconventional lines: He dared to risk experiments. Above all, however, he was always able to build as a function of the material. Nevertheless, the right way towards developing an iron architecture fitting the needs and characteristics of the material and having a correspondingly useful thesaurus of forms was not at all clear from the outset.

Unencumbered with questions of style, the designing, as a function of the material, of such structural parts as beams, arches and girders, the shaping of sections with optimum load bearing characteristics, but also the aesthetic appearance were debated violently and controversially. The results obtained in practice during construction were very rapidly publicized in the engineering journals and included in the theoretical discussion. A particular position in engineering designs made of iron was held by the girder and beam systems made of cast iron or wrought iron and the lattice work known for a long time in timber construction. Initially, the correct shape of a beam as a ceiling support played a main role. The shape was the I-beam with a web, a top and a bottom flange, whose load carrying behavior could be improved even further by shaping it as an arch when using brittle cast iron of low tensile strength.

Although spans were then still relatively modest, straight beams could be extended by bottom trusses consisting of a central stiffener and a round bar. This type of beam, a fixed triangle, was combined by
Camille Polonceau into the system of roof girders bearing his name. Long and Howe also experimented with fixed triangles, but of timber, welded into a parallel lattice panel or girders may also apply to prototypes of lattice work structures, which Cullmann made calculable around 1890. Although these structures were quite progressive in that they made the most efficient use of material in relation to their large spans, they still owed much to timber, straight girders, and beams. At the same time, architecturally speaking, the limits of lattice work are more apparent. The single and most practical flow of force is to carry covered a space traversed by tensile members and rafters. In addition, the roof structure and the support structure were separate systems and the rigidity was not, and it was easy to separate. In the sixteenth century it was quite customary to rest on roof structures on solid brickwork. The only positive effect of these designs was the possibility to create well lighted rooms, but the shapes of these enclosed spaces remained essentially the same as those known throughout the history of the building (basilica). As Meyer stated in 1907, the lattice work structures, were "rigid and terribly practical" designs for covering spaces. About the noturns of the Vienna World Exhibition, which was 50 meters high, he wrote: "The motive of the tent roof, which had played a role in the history of styles especially as the outer roof of the Renaissance domes, became independent in the Vienna exhibition building and was enlarged to a tremendous scale." (Meyer, 1907, p. 121).

In lattice structures, iron was used "as a function of the materials," the system of girders with rigid and movable bearings, separated into tensile and compression functions, was minimized in the extreme, for the basis of this engineering structure was the calculation of the aesthetic dimension allowing viewers to experience the nature of iron. Polonceau, an engineer, stated in 1843: "Each structural design system must be arranged in accordance with their strengths in such a way that they can be given the smallest possible dimensions and their combination is the greatest simplicity," (C. Polonceau, NGA, Paris, 1843, column 27).

A step forward compared with purely mathematically correct structural design is marked by a process resulting in a design, in which iron carries on the carrying function also for the compression function. This restores an aesthetic function demanded of architecture in the nineteenth century, which we do not want to miss even today. "Art, however, wants to represent the battle between force and load as an easy, pleasant game, express its solution in a free interaction of parts and establish equilibrium as a peaceful, calming conclusion. Although the mere establishment of static conditions and forms will always remain the main task of architecture, firm basic conditions and symmetry, the more knowledge that a building will collapse does not evoke any response, does not cause any higher sensations. Such impressions are desirable and necessary for the structural members can be made to come alive, as it were, so that they voluntarily and gladly seem to exercise their functions easily and safely; these impressions are those of a battle between forces and loads, which come to an end and concluding in full peace," (Seumeister, 1866, p. 21).

In these quotations from a textbook on design for engineers, structural design is essentially regarded as a living, moving system of forces in order to battle against loads. The inner play of forces is to be expressed aesthetically by means of the beams, stanchions and gussets in such a way that even a viewer unskilled in the science of engineering will be able to surmise it.

In an essay by Richard Lucass entitled "On the Power of Space in Architecture," which discusses the "great vestibules" of the large railway stations in England, he repeated: "And lastly, we are striking a blow at the conception of the space created by this space is both the assurance with which the immense ceiling, supported only by the walls on both sides, hangs from a vast scaffolding of columns, and the conquest of distance in an undivided room without any supports. In one word, it is the grandiose. We feel that the genius which created this space is the same spirit which conquered it outside, in overcoming rivers and penetrating the Alps. However, it is the sheer size which almost exclusively makes its impact here, at least in most of the rooms so far developed in this category. They have been dedicated to such prosaic purposes that, except for some cases, it was felt that they could almost do without any art at all, and yet the other forces of space, especially light and form, if they were used for artistic purposes, could elevate even these rooms to a higher aesthetic level. Without idealizing in an unhealthy way its purpose of space, a wall a few meters away, one could at the same time make the grandiose idea underlying the design of this type of ceiling an ideal image of beauty which gets lost in the distance, as if crossing iron rods and iron cables, would come to a rest and find enjoyment, if the individual examples of this calculation expressed in which the girders are only from our windows and in a clear system of units, showed them visually in a fashion pleasant to the eye." (R. Lucass, 1869, pp. 398, 399).

This result, in which the sum of forces appears to be concentrated in such a case would be the wide arch of a railway station hall, such as St. Pancras of London, whose tension member is buried in the ground.

The semi-circular or parabolic arched trusses made of iron indeed not only represent a design principle born from iron, but also create a new type of space, the aesthetics of which reflect statics: This red type of statics, the "dome building," whose profile is taken from solids of revolution, flat, parabolically curved roofs, sometimes reaching up to tall bell shapes, or longitudinal halls with the cross sections of an arc. The characteristic of these arched structures have in common is the absence of any distinction between ceilings and walls. It is well known that these forms of spaces can be traced back to London's modest experiments with curvilinear transoms, coming to a culminating point in the grandiose spaces of the nineteenth century. Another culminating point are the domed railway stations and exhibition halls, e.g., St. Pancras of London and the magnificent Hall by Contamin and De Graann, of course, the bridges representing a new shape as three-dimensional lattice structures. In all these arched buildings we find embodied what engineers, in their noblest symbols, call the "symbol of the loaded cross section." Indeed, load diagrams in most cases correspond to a flowing, parabolic line. Only for this reason, e.g., Gaudi, although he built in stone, was able to arrive at the curves of his arches in the Sagrada Familia church by using stressed cables.
of practical, but ugly industrial buildings, or is disguised in the
dresses of stone and wood constructions. In the Schönbrunn Palm House,
as the excellent arts writer Ilg expresses it, the shape of the whole
building matches the material; only the curve controls the contour.
The overall aspect is that of an artistic impression, the cause for
which we do not fully realize. It does express the artistic power of
the material in this appropriate artistic treatment, but we do not yet
understand the reasons underlying that impression. We are still at
the beginning of a new, dark path in an unknown territory. However,
looking at this building, I feel as if the rod of a diviner trying
to find a spring of water had twitched ever so slightly." (Illustrierte

Notes
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