THE ROLE OF IRON IN ARCHITECTURAL THEORY IN THE SECOND HALF OF THE NINETEENTH CENTURY

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The second half of the nineteenth century can rightly be called the grand era of iron. This statement refers to the emerging industrial complex of machines beginning to move "under their own steam", such as the locomotive, and to reproduce themselves, as it were, namely the machine tools. In architecture, the inner frames of the large buildings made of cast iron and steel are products as well as initiators of industrial mass production. For, as iron moves into buildings, forming their backbones, buildings successively become "factored products": Building construction leaves the construction yard for the shop floor. These iron components, which are cast, forged, riveted, bolted, punched, smooth or embossed with ornaments, are not designed for use on one individual building lot, but for the world market; they no longer represent an individual's subjective wishes but sheer economy, mass production. In view of this real, and effective, revolution of building brought about by iron in the second half of the past century, the question arises about the role iron played in contemporary architectural theory.

We are interested here in the specific ideal or ideological, abstract scientific conditions attending to accompany, or rather indoctrinate, building practice.

This question would be superfluous, if theory and practice were a pair of identical twins, like Castor and Pollux, always pursuing the same goal, which used to be one of the favorite concepts of an early scientific age. But especially architectural theory in the nineteenth century is much more a theory of the science of perception, an aesthetic theory, than a theory guided by the production and the needs of industrial society and in this respect trying to influence building practice, as the discipline of the engineering sciences tries to. From today's point of view, the theory of architecture in those years seems to be science involuntarily appearing as a product of the division of labor already inherent in the very process of building construction: In the factory, as a domain of the engineer, and the attempt at a craftsman's synthesis in his studio as the domain of the architect. The more narrowly the objective "form of work" is pre-defined, the more the individual "form of art" becomes the main subject.

Architectural theory as a pure theory of nineteenth-century form exhibits a remarkable lack of interest in material processes of building construction, a lack of concern often turning into a downright hostile attitude towards practice, i.e., against technology. One can even go one step further and, with respect to our subject, state that it was almost hostile vis-à-vis iron construction. On the whole, architectural theory of the nineteenth century to us seems to be deeply imprisoned in pre-industrialized thinking. Readers of the aesthetic treatises devoted to problems of the "real style" and "moral impact" of building construction are given the illusion of a world beyond capital and its economic exploitation. Readers on the subject nowhere will find any confirmation of their living in the middle of the "iron century".

We are, of course, referring to the writings of officially recognized general architectural theory, such as those published by the Académie des Beaux Arts, the histories of building and style, etc. Yet, in the shade of esoteric evolutions of theory there can be found reflections on the role of iron for a new architecture, remarkably often in connection with the revolution of space design brought about by iron: a materialistic approach in the midst of an idealistic
The superstructure of matters of style, for the concept of space encompasses both structural design and the social needs that produced it. In an abstract form, these treatises advocate building in accordance with the characteristics of materials, except originating in crafts. However, at the same time, the same treatises consider iron a new product of industry, the banished soul of new space, to be connected with and form smooth, essential forms that, in contrast to the polemic pamphlets. In this point are the writings of Boetticher, Romberg,Semper, Baumeister, Ourlitt. Outside this theory of architecture which, although proposing materialistic concepts, yet remains firmly tied up in pre-industrial aesthetics, there is a large number of monographs by pragmatics who regard iron as a material, perceiving its new possibilities with engineers' eyes. They ardently advocate visible and, at the same time, filigree iron architecture, because they are fighting against the official theory of architecture, monographs express the Utopian moments of iron architecture, whose possibilities remain inexhaustible, which makes them polemic pamphlets. Let us only recall the early writings by Loudon, the proposals by Horeau, McIntosh, the "Sketches in Cultural History" by Bucher, the architectural visions of Baudot and Wagner and, last but not least, the "Aesthetics of Iron" by Meyer and Jordan. Both schools, considering the use of iron, want a truly modern architecture. However, they remain irreconcilable as far as meeting this goal is concerned. In this connection, also the writings by the declared opponents of the use of iron are important, because also negation clearly shows the actual role of iron in building construction. This applies to Ruskin and the arts-and-crafts movement he initiated in Britain. The methodological backbone of a theory of architecture as learned applied archaeology is furnished by Germany, Berlin being the center of such work. The thinking developed there grew less from an industrial background which, as we know, was less developed before 1850 than it was in Britain and France, but from materialistic philosophy, the writings of Kant, Fichte, Schelling and Hegel, especially Hegel. In his aesthetics outlined in the "Science of Art" on the art of building he considers all earlier epochs of architecture to be incorporated as results in the following one, i.e., raised to a higher level. While buildings in the "classical architecture" of early periods and in "classical architecture" still have their contents in themselves, i.e., are absolute, abstract spaces, "romantic architecture", building by the bourgeoisie, creates spaces whose contents for the first time are the concrete, self-conscious needs of society.

In the aesthetics of architecture in German idealistic philosophy we, for the first time, find a fundamental expression of the concept of progress in space design and building construction mentioned as connected to the development of societal needs: "Romantic art cannot work for sensual perception, but for subjective introspection," for bourgeois individuality.

"Introspection triumphs over external appearance."

The concept of regarding the design of space and building construction, not the style, as a criterion of progress is advanced by Schinkel and his school. The discussion about style uses the aspects of "technique", structural aspects, space design and adequate structural design, thus dominating the theory of architecture in Germany well into the second half of the 19th century. Of course, this discussion often was only an excuse for exercising styles from the past in experimental ways. "Emulating the old is certainly a very modern activity." (Ourlitt, p. 650)

The theoretical conscience of Schinkel's school and of its approach towards "practical aesthetics" is represented by Carl Boetticher (1806-1899). As late as in 1879 Tuchernann confirmed, "Boetticher must be regarded as the writing hand of Schinkel."

In his chief work, "Die Tektionik der Hellenen" (Berlin, 1843), Boetticher takes up the case for the connection of ancient art, each part of architecture not only had a specific service function within the whole space, but also should represent that function. Ornaments, however, are assigned no function to express and interpret the way of design. With his concept of the dialectic interrelationship between "form of work" and "form of art," Boetticher at the same time develops a new dogma of functionalism, the dogma of the adequacy of form and function. However, this is a new abstraction in an aesthetic functionalism inasmuch as not man is directly regarded as the content, but the logical design of space, which means a static purpose and its representation by art. However, Boetticher's theory of building as a function of material and design did preserve the societal element, yet without referring to it explicitly. Thus, Romberg, the editor of "Praktische Baukunst", in his article entitled "On Building our Present Dwellings," in 1850 demanded that "houses be built from the inside out, starting from the needs of their inhabitants."

In 1846, Boetticher held his speech on Schinkel, in which he further expanded the theory that it is ultimately the mode of design and construction which determines space and all its components, from which he draws conclusions about the ways in which a new art of building could be made to work: "He postulates an architecture of tenable stresses, saying that the future belongs to iron architecture. ... In 1846, this is not really a revolutionary view, but to say validly: Students have a need for iron architecture than Boetticher." (Posner, 1981, p. 11).

In the same speech, following up on the battle of opinions in the theory of architecture about true style, he raises the decisive question of the new way of building. His reply is the thesis that the key to each new way of building be it Hellenic-Roman or Germanic-Gothic in its structural design principle of each new ceiling which forms a space. For: "The essence of any original style of building is expressed in the system in which the ceiling covering a space is organized in distinct sub-units or structural elements and arranged spatially in such a way that all structural forces which can be exploited in building and .... which are included in matter as absolute, relative and reactive strengths design, free and compressed."

In the course of history, the "Hellenic way of building" used relative strength in the form of a stone span ceiling. In Roman arches and pointed arches of Gothic-Germanic buildings were thoroughly expressed structurally. At the same time, Boetticher finds that the historic mission of stone building construction had been fulfilled in its "celling series ceiling systems. A new structural system could not be "formed" of stone only. Both the modes of reactive and relative strength of the stone have been fully exploited. A new, still independent union of a ceiling which, of course, will immediately entail a new series of forms of art, therefore can materialize only as soon as a material not unknown, but not primarily used for architectural application begins to be accepted. It would have to be a material which, in a static structure, produced a lighter and, at the same time, wider
spanned and yet more reliable ceiling system than could be achieved by the exclusive use of stone. When employed to create spaces and design structures, it should be able to match any form of plan and space meeting the needs of human life. At the same time, at a minimum of material expenditure for the enclosing walls, especially the tremendous masses of abutments weighing so heavily on stone arch systems would no longer be necessary. Finally, the whole load of the ceiling system would be reduced to a verticalized load to a verticalized level of structural strength, say, to the reactive strength of the walls and supports." (Boetticher, 1846, p. 23).

"The material indeed is iron, the use of which for such purposes has already begun in this century. It will certainly be iron which will be used as a basis for ceiling systems, once its structural possibilities have been thoroughly examined and recognized, and for structural purposes it will rise above Hellenic and mediaeval building construction systems in the same way as the framework and ceiling systems of the Middle Ages were superior to the monolithic stone slab ceiling systems of the old world. Aside from easily destroyed wooden ceilings, which cannot be used for comparison in this respect, and expressing these statements in mathematical terms, one can say that indeed it is iron which introduces into the art of building systems also the last of the three structural forces, hitherto unused, namely absolute strength." (Boetticher, 1846, p. 24).

After this plea in favor of a new iron architecture, which is advanced with an engineer's logic, readers now would expect that Boetticher would try to achieve the truth of architecture, in keeping with his architectural and structural designs, such as stanchions and load bearing components, fully visible in the structure, for all, and not yet recognized as such. However, Boetticher hesitated to take this step towards "practical aesthetics," which would have helped to launch a new individual style of iron architecture. His proposal of "a completely new way of building" was satisfied with using the tensile strength of iron in anchor beams. Essentially, Boetticher stuck to types of application that had already existed in Renaissance building, and he had not yet estimated very well what the possibilities were due to his new invention. As far as outward appearance is concerned, he insisted that the Hellenic principle of form be applied according to which the members of columns are represented by columns of art. The result of this surprising synthesis is the "veiling" or iron. One of its main functions is to ensure the "most extensive spans" in the same rib design.

"Poet, now, and in what artistic shape the structural and space forming character could be expressed in that newly structured system of ceilings is a question answered very easily by anybody thinking about this concept. Nor is there a need to explain, from the technical side, that iron as a material prepared for structural forms not only can be completely protected against destruction by oxidation when galvanized or coppered chemically, but such cladding would also enclose the iron in a thickness necessary to allow the decorative expression in it which each part of the ceiling should have." (Boetticher, 1846, p. 24).

We quoted so extensively from the writings of Boetticher published shortly before the beginning of the second half of the century because sentences clearly indicate the dual nature of aesthetic theory in the nineteenth century, which also influenced the practice of iron construction. On the one hand, building is to be modern, practical and true, and the truth of the time, namely growing industrial production, was not resistant. But on the other hand, suppression was even stricter submission to the laws of industry: MASS ornaments made of copper, plaster and stucco were the renaissance of the "decorative form". Decorative designs are not explained, but removed from view in artistic "transfiguration". Eclecticism in the second half of the century could not have thrived, even economically, without ornaments manufactured on an industrial scale.

In the context of Boetticher, the disparity between the ideal art of building and reality can still be explained by the sluggish development of industry as reflected in the production of iron. However, it is surprising to see that, roughly at the time that Boetticher's theoretical tendency was articulated in Britain, against the background of a growing industry, which radically rejected the use of iron in architecture, the illusion, still fostered by Schinkel's school, that building could be reserved to the crafts, could no longer be maintained in Britain, where the destruction of crafts by mass production was going on. In view of the complete revolution of the methods of production and, thus, also of culture, architectural theory can no longer exist for its own sake, which it still could in Boetticher's case, but must expand into comprehensive social criticism. In this way, John Ruskin's treatise, "The Seven Lamps of Architecture," becomes an accusation against "technical progress" threatening to overwhelm the established social order. Ruskin's views about the emergence of a new art of building are pessimistic compared with Boetticher, but he also expresses himself in favor of ethics of architecture, "a true art of building," which gets rid of "artificial dishonesty." Among the main architectural decepts he counts structural deceit, deception about the material employed, and the use of "cast or machine made ornaments." In his view, as that of Boetticher's, looking at Gothic architecture: To him, architecture is structural design improved by ornaments. Architecture, in his view, is produced by what, basically speaking, is dispensable. This reminds one of the sentence by Karl Kraus that architecture represents "what is not necessary, yet is fecund elevated to the level of necessities. All the more important is the true ornamentation, which is human labor turned into objects. Viewers enjoy it by experiencing once more the trouble and the time taken to make it."

"This results from our consciousness of its being the work of poor, inarticulate men. Its true delight is in discovering in it the record of thoughts, and intents, and trials, and heartbreakings - of recoveries and joyfulnesses of success: all this can be traced by a practised eye; but the thing is an exact image, it is presumed of understood; and in that is the worth of the thing, just as much as the worth of any thing else we call precious. The worth or value of a work is simply the understanding of the time it must take to look for it before it is found. The worth of an ornament is the time it takes to find it before it can be put... Machine ornament pretends to a worth which it has not; it is an imposition, a vulgarity, an impertinence: it is no good, it is sin. Down with it. Leave its ragged place upon the wall, rather; you have not paid for it, you have no business with it, you do not want it. Nobody wants cheapness in this world, but everybody wants integrity... Leave your walls as bare as a plain boarded barn, put the bale of straw, the mud and chopped straw, if need be; but do not rough-cast them with..."
falsehood," (Ruskin, 1849, p. 49).
Ruskin extends his rejection of machine punched ornaments to all machine production, consequently also to iron as a building material. For, if truth were demanded in an ornament, application to iron architecture would introduce into this concept the hateful mass work of ornaments. In his rejection he personifies iron and, referring to the collapse of Woodich Pier, talks of the "anarchy of iron," a substructure of crystalline components in a concept which of which no builder had complete control (Ruskin, 1849, p. 76). On the role of iron as a building material, Ruskin comments as follows: "This rule is, however, that metals may be used as ornamental materials, not as a support.... But the moment that the iron in the least degree takes the place of the stone, and acts by its resistance to crushing, and bears superincumbent weight, or if it acts by its own weight as a counter rise, it so suppresses the use of stone and makes even in resisting a lateral thrust, or if, in the form of a rod or girder, it is used to do what wooden beams would have done as well, that instant the building ceases, so far as such applications of metal extend, to be true architecture," (Ruskin, 1849, p. 38).
Now, basically also Boetticher is against the use of iron, if its structural function, e.g., when used as a girder, does not express a structural principle that is new compared to stone building. However, Ruskin's criticism points in a different direction: True architecture in principle excludes the use of iron as a structural material. (Ruskin, 1849, p. 59).
At the time this utterance was made, Britain produced 2.25 million tons of iron, which was half the world's production (for comparison, Denmark, only 0.210, which is less than one tenth the British output) (Kohlmayer/Sartory, 1981, p. 228).
Despite his bias, Ruskin is much too intelligent to fail to predict in the iron an iron construction, namely, in connection with the development of "a new system of laws adapted entirely to metallic construction," (Ruskin, 1849, p. 36).
After all, he has already been a passenger on some of the trains leaving London from Paddington Station. Here he must have personally felt what he rejects from the bottom of his soul. Out of this shock, he clairvoyantly formulates one of the fundamental reasons for rejecting iron constructions. As in the case of ornament, it is again the concept of time: Like trains, the station hall with its busy life represents the restless world of production, the endless turnover of persons and goods, the utilisation of time as the most precious commodity. Should this leave architectural space untouched? The death of ornaments has already been prepared by the increased haste of movement, the increased impatience of contemporary perception on the part of the beholder. "Another of the strange and evil tendencies of the present day is the decoration of the railroad station. Now, if there be any place in the world where the phrase 'time' has been arrived of that form of industry and discretion which are necessary to the contemplation of beauty, it is there. It is in the very temple of discomfort, and the only charity that can extend to us is to show us, plainly as may be, how soonest to escape from it. The whole system of railroad travelling is addressed to people who, being in a hurry, are therefore, for the time being, miserable. No one would travel in that manner who could help it - who had time to go leisurely over hills and between hedges. Instead of through tunnels and between banks; at least those who would, have no sense of beauty so acute as that we need consult it at the station. The railroad is in all its relations a matter of earnest business, to be got through as soon as possible. It transforms a man from a traveller into a living parcel ... Do not ask him to admire anything ... Carry him safely, dismiss him soon; he will thank you for nothing else. All attempts to please him in any other way are mockery, and insult to the things by which you endeavour to do so. Give large salaries to efficient servants, large prices to good workmen, let the iron be tough, and the brickwork solid, and the carriage strong ... to increase expense in any other direction is madness. Better bury gold in the railroad than to keep it about it! Every traveller be willing to pay an increased fare on the condition that there be no coach, because the columns of the terminus are covered with patterns from Nineveh! He will only care less for the Ninevite ivories in the British Museum ..."
The debate between the architect, as the carrier of aesthetic theory, and the engineer was won by the latter. Engineers implemented in practice what the proponents of architectural aethetics basically did not want to do, despite their theoretical insights: Their constructive systems, developed in exclusion from the engineering sciences, firmly rooted in the past, could not be transferred to iron construction. The old structural system of stone building, the rigid systems of structural members, which did not know bending stresses and made only limited use of tensile stresses, still were the concrete ideal of beauty in art; its secret lies in the anthropomorphic equation expressed by this architecture, in its representation of imposing and carrying the weight.
Every break in a brickwall has been wrestled from statics, light is admitted to rooms only in carefully chosen ways. Iron structures with their stability are absolutely based on completely different viewing habits, which had to be synchronized with industrial development.
This process adaptation of the eye and, at the same time, the abandonment of dear former viewing habits were slow and painful experiences in the lives of people in the nineteenth century, just as their accommodation to the new types of work and the value put on time has been painful experiences. The new space and time are clumsily interrelated. For, space can be opened up by human action. Without any compassion, the new space designed by iron architecture is displayed where the old space was closed in, the traffic form: not in the traffic itself, but in buildings owing their existence to a large city, such as railway stations, factories, market halls, world exhibitions - giant bazaars of the new time.
The theory of architecture, with its orientation chiefly towards the preindustrial era, ever disinterested in profane architecture, was unable to apply an aesthetic theory of iron even for the mere purpose of supporting practical reality. As a consequence, engineers and anonymous military designers were left to cope with the aesthetic design of their structures almost without any outside help. What is so striking about the architectural theory of new rationalism, which extends from Duret, Boetticher, Semper to Viollet-le-Duc, is the dual face of its utility concept: The needs of the time should be met by the simplest and most straight-forward means and structural design and ornament should become a unity. At the same time, people like Semper regarded iron architecture as being devoid of any power to communicate and go leisurely over hills and between hedges. Instead of through tunnels and between banks; at least those who would, have no sense of beauty so acute as that we need consult it at the station. The railroad is in all its relations a matter of earnest business, to be got through as soon as possible. It transforms a man from a traveller into a living parcel ... Do not ask him to admire anything ... Carry him safely, dismiss him soon; he will thank you for nothing else. All attempts to please him in any other way are mockery, and insult to the things by which you endeavour to do so. Give large salaries to efficient servants, large prices to good workmen, let the iron be tough, and the brickwork solid, and the carriage strong ... to increase expense in any other direction is madness. Better bury gold in the railroad than to keep it about it! Every traveller be willing to pay an increased fare on the condition that there be no coach, because the columns of the terminus are covered with patterns from Nineveh! He will only care less for the Ninevite ivories in the British Museum ...
Notes
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PROTAGONISTS OF IRON BUILDING CONSTRUCTION IN THE SECOND HALF OF THE
NINETEENTH CENTURY

Barna von Sartory

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,
mainly 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 en-
larged 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,
embrace 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 use of the characteristics of a material
not only exploited but developed: He dared to risk experiments. Above all, however,
nevertheless, the right way toward developing an iron architecture fitting
the needs and characteristics of the material and having a correspon-
dingly 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 charac-
teristics, but also the aesthetic appearance were debated violently
and controversially. The results obtained in practical 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, the beam,
and the system made of 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