IRON AS A CONSTRUCTION MATERIAL IN SWISS ARCHITECTURE BETWEEN 1825 AND 1875

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Although it is a well-known fact that Switzerland is a country short of raw materials, an iron industry has been in existence there for centuries: The extraction, smelting and processing of the material admittedly never attained very great importance by comparison with other branches of the economy, as the land is -- as specialists so well-meaningly circumscribe it -- "rich in poor deposits", the exploitation of which can only be justified under modern aspects with difficulty, even in times of need (1).
The raw products occuring in small quantities did, admittedly, have an excellent reputation. Iron from the Jura was particularly highly prized and also exported as a rich iron, low in sulphur and phosphate content, for special products (until the middle of the 19th century it was produced exclusively as charcoal iron).
For material, manufacturing-technical and transport reasons, as also through the particular political status of the Swiss Confederation prior to the creation of the modern state in 1848, the home production was soon no longer able to keep up with foreign competition. Iron rod produced within the country was four times more expensive than the imported Belgian product by the middle of the century (2). In the first half of the 19th century the country's own requirements increased many times, and it was no longer possible to cover it from Swiss production: four times as much had to be imported as was produced at home. The chief sources of supply were Belgium and then England. The iron demand in Switzerland about 1800 was relatively modest and did not exceed 1 kg per inhabitant. Already by 1858 the per capita quantity had reached 10 kg, thus a quantity which was already calculated as average for Great Britain in 1800.

These few figures must suffice as proofs for the rapid expansion of Swiss iron consumption in the first half of the 19th century. The reason for this expansion was the almost exclusive alignment of industry to the flourishing textile and textile machine industry of the country which had been mechanised after 1800 and had a large demand for machines. This specific orientation did not permit the construction of a rolling mill in Gerlafingen (by Roll) until 1836, indeed it was not until 1851 that Sulzer began with the production of steam engines in Winterthur. Thus it was only in the middle of the century that those pre-requisites were created which made it at all possible for the works to process iron in a modern fashion.
The iron industry's orientation towards machine and apparatus construction was almost complete owing to the absence of other customers for iron products and apart from this it was only possible to maintain ornamental casting as an important product. The pioneering technological research into the refinement and improvement of the material were particularly effective, even if only indirectly, for the Swiss iron industry. In this connection we would mention the life work of the metallurgist Johann Conrad Fischer (1775-1858) from Schaffhausen (3).
The brief description of the economic situation in the mid-nineteenth century causes one to suspect that no incunabula of iron construction need be expected in Switzerland in the period from 1800 to 1850 being covered here. The lack of spectacular works could now easily tempt one -- even if it is just an attack of megalomania -- to turn to the work of Swiss engineers abroad and their contributions to the history of iron construction. Names such als Rudolf Eduard Schinz(1812-) from Zürich, one of the designers and calculators of the Vistula bridge at Dirschau (1850-1855), Maurice Koechlin, one of the leading brains in the construction of the Eiffel Tower or Ludwig Werder, employed in a leading position during the construction of the Glass Palace in Munich, could provide material for discussion here. It is easy to dispense with this, not only because a number of leading foreign engineers were also active at the same time in Switzerland -- we would just name Carl Culmann and Carl von Etzel -- but because a number of works can be shown which surely deserve a modicum of interest.

In order to give the survey some sort of arrangement, the material is to be presented thematically. The main accents set there,ornamental casting - bridge construction - building construction, at the same time also correspond roughly to the chronological course of the spread of iron.
Until the first decade of the 19th century, iron was worked in the traditional way as wrought iron in Switzerland: garden portals, balcony railings, window lattice-work and further ornamental pieces of high quality were created. In the second decade, the first firms began with ornamental casting and soon pushed the blacksmith's craft into the background: in 1811 the Georg Neher firm in Schaffhausen cast the first iron floor blocks, in the 1820's came the von Roll and Klus firms with ornamental casting and in 1834 also Gebrüder Sulzer in Winterthur. All three firms had departments specialising in ornamental casting and obviously produced for the whole Swiss market. Smaller foundries such as in Undervelier (Jura) or Schnell & Schneckenburger, Burgdorf, were never able to emerge successfully as larger competitors and were mainly only of local importance (4).
Initially, the programme encompassed simple things of everyday life, such as buckets, tubs or hooks, then especially machine parts and whole machines. For instance, the well-known overshot water wheel of Messrs. Weniger, St. Georgen - St. Gallen, produced in 1837, with a diameter of 17.5 m, and which was in operation until 1892, was constructed partly in metal (5).
As the surviving catalogues from the firms show, the programme was rapidly expanded: for architectural purposes, cast-iron supports, balcony railings, door panels and garden surrounds became particularly important, occurring ever more frequently on buildings from the late 1820's onwards. It was particularly those architects trained in England and Germany, from the generation of about 1800-1815 -- we would mention Leonhard Zeugheer (1812-1866), Ferdinand Stadler (1813-1870), Gustav Albert Wegmann (1812-1858) and Johann Jakob Breitinger (1814-1880), all from Zürich, then Melchior Berri (1801-1854) and Amadeus Merian (1808-1889), from Basle -- who were the first to attempt to integrate the new building material and who also dealt with it.
Thus Berri, who had been trained in Karlsruhe under Weinbrenner and in Paris under Jean Nicolas Huyot, opened a school of architecture in Basle in 1829, the teaching curriculum of which included, in addition to stone cutting and wood construction, also "Iron constructions and their manifold application"(6).
Cast forms were rapidly adopted in building practice. Hans Conrad Stadler employed cast-iron balcony lattice-work and door panels for the balcony railings of his house "Zum Kronentor" in Zürich in 1828. Ferdinand Stadler, his nephew, also employed cast veranda construction for the Villa Forcart in 1832. For the Villa Volkart in Winterthur, Leonhard designed cast-iron veramdas, a frequent motif in Swiss classicist architecture and the Sulzer company supplied the railings for the Münster Bridge constructed by Negrelli in Zürich in 1836.
The construction (according to the catalogue from 1839/67) was cast

by the von Roll company (recast and renovated in 1877). At the same time, cast-iron pillars were also employed for the first time in church construction. In 1836, Zeugheer supported the galleries in his Neumünster church with cast-iron pillars, in 1842, the little Neo-Gothic church in Berlingen in Thurgau followed (7).
Other available casting details were employed: Melchior Berri planned cast-iron capitals for his museum building in Basle in 1844. The work was, however, actually carried out in terracotta in 1846 (8). The Sulzer Foundry in Winterthur supplied particularly lavish portals in Graeco-Roman style for the same museum. The portals for the boys' school (today Stiftung Oskar Reinhardt) in Winterthur, built by Zeugheer in 1838, were somewhat more modest, selected mainly from the catalogue and also cast by Sulzer (9).
Finally in this connection, a series of cast-iron works by Gottfried Semper for the Confederation Polytechnical College should be mentioned, especially the candelabras in front of the main and side entrances. Other designs from his hand were obviously not carried out (10).
In both cases, it is not a question of catalogue works, but of castings in accordance with specially manufactured moulds.

The small selection of cast works of art also belonged to such special works. The catalogues of the industry exhibitions of 1848 and 1857 in Berne give evidence of smaller groups, we would just refer to the portrait of the industrialist, von Roll, which was produced in the workshops at Kus at the end of the 1830's, and to the tomb of the Schaffhausen industrialist, Johann Conrad Fischer, which the Neher company cast.
A further group of works by the Swiss foundries are fountains. Neher, in particular, had them as his speciality. One of the earliest examples today stands in the park of the Paradies monastery, the present-day Iron Library, and dates from 1847. Neher also had more extravagant examples in his programme, especially as far as the superstructure is concerned. Apart from secular works, the von Roll Company also supplied church furnishing in particular. Of the cast-iron church pews which were in the programmes from the 1850's on, only the furnishings for the village of Salgesch in Valais have been preserved (1887). It has not, as yet, been possible to determine the foundry of the cast-iron pulpit installed in Aigle in 1863 (11).
The variety of the range was considerable, and could be documented by further examples. The company of Johann Georg Neher in Lauffen near Schaffhausen began, for example, in 1811 with iron floor blocks, but also included iron roof coverings in their programme and then began in 1814 with the casting of mortars and art metal plates. By 1845, apart from wheel hubs, machine parts and even fonts, they also had grave crosses, garden gates and small household objects available from stock (12).
Parallel to the very rich production of ornamental casting in the first half of the century, iron was tested as a construction material for bridge building in a quite different fashion. In the 18th century, the wooden construction techniques had attained an internationally recognised standard in Swiss bridge building, we would just recall the constructions by Hans Ulrich Grubenmann (1709-1783) from Appenzell, which even enraptured academicians from the Ecole des Ponts et Chaussées in Paris. On the basis of careful calculations, the Geneva engineer and general in the Swiss army, Guillaume-Henri Dufour (1787-1875), together with the Frenchman Marc Séguin, ventured the construction of the first permanent cable suspension bridge in the world, which spanned the moat of Calvin's native city in two parts (13). The two spans of forty metres each were borne on three pylons. Dufour built two further similar bridges in 1826/27 in Geneva. He continued his research and built a longer cable bridge across the

Rhône using a new principle with underslung cables. However, the work which he published in 1834 had no resonance (14).
In 1832, Dufour was also involved in the planning of the great cable bridge over the Saane near Fribourg. The Lyons engineer, Joseph Chaley (1795-1861), took over the task of carrying out the bold construction in accordance with a project of his own. This bridge with a span of 273 metres was the longest free-span bridge until 1849. After a series of tests, Chaley used cables from the Bözingen Cable Factory near Bienne. Here cable had been produced exclusively from Jura iron since 1634. The experiments showed that the Bözingen cables had good one third more tensile strength than the remaining foreign competitors (15).

Further cable bridges in Switzerland followed the Fribourg bridge, thus in 1836 two by Jeanrenaud at Arconciel in Canton Fribourg and near Aarburg over the Aare (16).
Until the middle of the century little changed in the relationship between wood and iron in bridge construction. Wood was still the only construction material for smaller structures in 1850 (17). The competition for the construction of the new Aare bridge at Aarau seems characteristic for this situation. Until the mid-1840's, wood construction was preferred, only at a later phase did the cable or chain projects by people such as Chaley, Jeanrenaud, Kraft and the local engineers, such as Locher, Meyer and Eberhard, prevail. The project for a chain bridge with stiffening beams by the Alsatian, Jean Caspar Dollfuss (1812-1889), was carried out in 1849/50 (18). Only the Parisian engineer, Kraft, envisaged a cast-iron pylon. If he also applied formulae from stone architecture for iron, such as the pillars on which the inner arch rested, the slender elegance and the transparency of the construction combined with the massive and powerful anchorage towers in Dollfuss's project is noticeable.
The Swiss iron industry might possibly have been in a position, even at that time, to construct both those beams, as the import of iron reached its first peak at the middle of the century. But there was no company before 1870 dealing with such large structures and manufacturing such ambitious constructions (19).

With the Aarau chain bridge, the first phase of the large bridge construction with iron components in Switzerland came to a close. The railway construction which began after 1852 required new solutions in the special and topographically difficult situation in the country. From the multiplicity of structures, we would just mention two interesting constructions here.

In 1853, the Basle engineer, Friedrich Stehlin, designed a wrought-iron arched bridge witz 147 metres span for the St. Gallen-Toggenburg railway over the Sitter ravine. The apex of the arch was a good sixty metres above the highest level of the river. Stehlin's project is parallel in time to the construction of the Arcole bridge in Paris, which is described as the first larger wrought-iron arched bridge, but which posed quite different technical problems from the point of view of progress in construction. Apparently these caused the owners to delay and Carl von Etzel (1812-1894) constructed a lattice bridge in accordance with his own project. This bridge is the first monumental iron construction in Switzerland, because the longitudinal beams rest on 47 metre high cast-iron supports of extended octagonal section and span widths of two times 38 and 36 metres. The incomparably larger Saane bridge near Fribourg (20) was also constructed on the same principle by von Etzel.

In 1853, the Central Railway did utilize Stehlin's project. "As a result of further information from the author, the system of wrought-iron arches was employed several months later, namely across the Aare at Olten", Stehlin himself reports in Förster's Allgemeine Bauzei-

tung (21). Under the direction of Carl von Etzel, a solid side sheet arched bridge with three arches of 31.5 m span each was constructed (22).
The constructively interesting works in Swiss bridge construction naturally increase the interest in building construction. The same picture also appears here. Even more pronouncedly than in the case of bridge construction, architects remained loyal to the traditional building material, wood. The establishment of the existence of a certain backwardness in comparison to other European nations, the sluggish application of iron as a building material are adequately explained by the relative wealth of wood available, the highly sophisticated wood construction techniques, the high costs of iron and the iron industry's specific orientation towards machine construction. Carl Ferdinand von Ehrenberg (1806-1841), Prussian government architect and the enterprising promoter of a "Periodical for the whole Building Industry" (Zürich 1836-1839), and also founder of the Swiss Architects' and Engineers' Association, saw this in a more general fashion: "However much", he wrote in 1836, "Switzerland distinguishes herself in other respects by machine construction and enthusiasm for industry and science, she is still behind in the building industry when compared with her neighbours" (23). In the early part of the 19th century there were thus only isolated attempts at employing iron as a construction material, if one discounts the ornamental elements and cast forms mentioned in the introduction. It is hardly astonishing that the two earliest known examples are to be seen together with the Neo-Gothic movement. When the reconstruction of the lantern tower of the cathedral in Lausanne was being discussed after the fire in 1826, the otherwise unknown architect, Charles Kinkelin, presented a design for a cast-iron lantern tower as an alternative project to the official designs by the cathedral architect Perregaux. The filigree-like tracery closely resembles a design for a monument and is also close in form to small structures in parks (24). Kinkelin's project came just as little to fruition as a comparable design for the Berne Minster spire recently rediscovered in the archives and which can, apparently, be dated to the first third of the 19th century (25).

These two early and isolated examples of the planned application of iron are an expression of the technically restricted possibilities of the period. They are more easily compared with the foundry products which we mentioned at the beginning -- fountains, monuments -- than with real architectural products. On the same level also, at the point of transition to an architectural creation is Melchior Berri's design for a bridge portal, produced in 1853 for the Rhine Bridge in Basle, conceived as a purely cast-iron construction (26). Structures on a smaller scale, for instance portal structures such as Ferdinand Stadler's design for a pergola-like structure in front of the entrance to Laufen Castle at the Rhine Falls in 1844, belong to the same category and in the subsequent period developed into cast-iron small architectural works for garden arbours and similar structural parts.
The step towards the constructive application of iron in building construction was apparently taken in the 1840's. In 1847 the Basle state architect, Amadeus Merian (1808-1889), designed a project for Basle main post office. The inner courtyard, just a few metres wide, was to be illuminated through a glass roof resting on a simple roof truss, a construction often encountered in factory roof structures in England around 1815. Johann Jakob Stehlin Jr. (1836-1894), who built the post office in accordance with his own designs, adopted the glass-roofed hall from the Merian project without going another way constructively. In his design, the cast-iron trusses of the roof rest directly on the side wall, recalling simple wooden roof frames.

Also in the case of iron constructions in buildings, the important fact was that the efforts in the field of railway construction had a very fruitful effect. About the middle of the century, a number of construction companies then also came into being, which could at least be engaged for smaller contracts (28). When in 1861, after the disastrous town fire in Glarus, the non-denominational town parish church was to be rebuilt, the Baden architect, Caspar Josef Jeuch (1811-1895), was engaged to prepare a cheap alternative project. Jeuch planned the church as a mixed structure with an inner iron construction which was to serve as the base for a serrated wooden roof. Costs would be reduced by nearly half through this, with the same cubic content. The Neue Glarner Zeitung described Jeuch's economy church in relation to Stadler's Neo-Romanesque project variant as "roughly like an industrial hall against a noble church structure" (29). But here, Jeuch had let himself be guided completely in his motifs by contemporary wooden constructions which were very popular in Switzerland at the middle of the century. We only need bring one example for this, Gustav Albert Wegmann's project for the Grossmünster chapel in Zürich in 1858 where all that differs from the original plan is whether it was to be an iron or wooden construction. The erection of this chapel by Johann Jakob Breitinger shows, moreover, the two-fold evaluation of the material in ecclesiastical construction at the time. For static reasons, cast-iron columns were the most suitable, but Breitinger concealed them under a layer of plaster in order to give the church the necessary dignity and style (30). Only one example of visible iron construction in an ecclesiatical structure which was actually built is known to me, the Catholic town parish church in Winterthur, built by Wilhelm Bareiss 1864-1867. The simple iron roof trusses, in the fashion of Glarus, were, however, concealed behind an underslung ceiling already in the last century when the parish raised sufficient funds. (31)

The new structural tasks of the railway station buildings, which were rapidly appearing at the time, could no longer just be coped with by wooden constructions. The first structures, even the larger stations in Zürich in 1847 by Wegmann, in Geneva in 1858 by Etzel and in Basle in 1860 by Ludwig Maring, were wooden constructions. In the competition projects in 1861 for the new station in Zürich, the first larger hall constructions appear. The architects invited, Ferdinand Stadler, Johann Jakob Breitinger, Leonhard Zeugheer and Gottfried Semper, had to roof a hall area of 43 x 169 metres. All selected an iron construction. Zeugheer's project has not survived. The other three architects arrived at very varied solutions. Breitinger was the only one to show the hall cross section openly. In this he followed the much admired model of the Gare de l'Est in Paris (1847-1852). He envisaged a trussed beam, slightly elliptic on the outside, supported on consoled and set fairly high. Stadler's iron construction can be compared with a truss in wood construction, a tension anchor was intended to correct too great a thrust sidewards. The architect, who had been trained as a carpenter, is clearly still thinking in terms of his trade, the construction principles of which he is here conscientiously applying to the new material. Just like Stadler, Gottfried Semper also did not want to show his iron construction openly; he required an underslung wooden ceiling.
Semper's proposal, a trussed beam resting on pilasters on the side wall, was put into effect by the architect in charge of the construction, Jakob Friedrich Wanner (1830-1903). The calculations were made by the railway engineer, Friedrich Seitz, the static checks were carried out by Carl Culmann (32).
The trussed beams have a free span of 43.3 metres and are connected with one another by light, arch-shaped wrought constructions. For climatic reasons, a glass and iron wall was incorporated on the western side, supported on the beam and only fixed at two points on

the cornices of the towers of the train shed. Its guide to the side is made by a joint in the towers. Construction of the iron structures was carried out by the specialist Nuremberg company, Klett. In 1868 the shed had already been roofed in iron sheet and the iron and glass façade had been erected (33). The Zürich station shed is of mixed construction. The trusses rest on the stone exterior walls. The trussed beams give the longitudinal section a rhythm and thus also help to form the exterior roof covering and the side façade. The three solutions presented, all dating from the same period, apart from the individual features of the three architects, reveal basic attitudes in iron construction: Breitinger is the real constructer who intends to apply iron in the tradition of the great French hall constructions. The starting point is to be found in works like the Gare de l'Est or the Halle des Douane aux Marais. Stadler applies wood technology to iron, the constructive possibilities of which he is obviously not able to employ. Semper, on the other hand, and following him Wanner, employ the roof construction as an auxiliary construction for the architectural language of form: Semper's proposed wooden facing reveals this just as much as the fact that the exterior structure obviously enjoyed priority and not the iron construction of the roof.
Despite this, at the end of the 19th century, the roof of Zürich Central Station was listed among the important and great constructions of the 19th century in the Italian publication L'Architettura del Ferro (34). Again it should be pointed out that this large contract was also awarded to a specialist foreign company, as those companies already in existence in Switzerland were not yet equipped for such constructions. At the same time as Zürich Central Station, the Fleischhalle, the municipal meat market hall, was constructed in the city, a structure for which a number of iron constructions could have served as model. The municipal architect, Hanhart, chose a mixed method of construction in solid construction (exterior covering), iron (interior sectional system) and wood (roof) (35). The building, which was disrespectfully nicknamed "calf's foot mosque" by the local populace, was conservative in its measurements and construction, but is one of the earliest buildings in the country constructed mainly in iron.
Even in the case of building works which were not particularly suitable for iron and glass construction, such as the plant houses for the Botanic Garden, the purely iron method of construction prevailed in the third quarter of the 19th century. Characteristic in this respect is the decision of 1836 to select a wood and glass construction for the plants house of the Botanic Garden in Zürich. This decision was taken, after consideration of all advantages and disadvantages, for technical reasons -- radiation of warmth,heating -- and also for reasons of cost. The architect in charge of construction, Gustav Albert Wegmann, certainly knew the relevant buildings from his own observations, for he had previously constructed the greenhouses for Heinrich Hübsch in Heidelberg (36). Wegmann's building was renovated without any change being made to the iron construction in 1876/77. In 1863 the Basle master locksmith, Boos, erected the great palm house for the Botanic Garden in Basle, a domed construction which was already replaced in the 19th century, and the constructions supplied in 1877 for Zürich by Messrs. Rieter in Winterthur, such as the octagonal pavilion, are technically simple solutions using rolled angle iron (37).

The voliary of Pregny Castle near Geneva, which has also already been attributed to the Englishman, Joseph Paxton, is probably from this period. George Henry Stokes and Henry Paxton had designed a palace-like residential building in 1858 for Baron Adolphe de Rothschild. More recent studies have, however, shown that the rolled cross section and the iron connection of the structure cannot be linked with Paxton's work (38). Within the course of the development sketched up to now, the surprising feature is the lightness of the construction, the formal unity of the bird house, in which there are only hints of historicising structural forms, such as the use of the smallest of capitals. Longitudinal rectangle and circular arch in a simple arrangement are the only decorative elements. A look at winter gardens, such as are to be found, for instance, in the Villa Steinburg in Richterswil, does, however, show that in the 1870's Pregny's range of forms was already popular and was being employed as a standard solution (39). However, Pregny was a climax within Swiss iron architecture by nature of the balanced treatment of forms.
The fact that the sensational iron constructions of the mid-nineteenth century in England and France only became effective in Switzerland a good quarter of a century later can be shown here with the projects for a smaller vegetable hall in the centre of Zürich (40).

The project began shortly after the completion of the Central Station and continued until the mid-1870's without success. The group of iron structures which are of interest to us in this connection show a leaning towards Paris both in overall attitude as also in details. The design by Otto Weber (1844-1898), the later Cantonal Inspector of Buildings of the Canton of Zürich, most obviously reflects Baltard's "Halles". Behind a solid decorative wall, necessary here for reasons of city planning as the building was intended to directly adjoin the Fraumünster, Weber developed an iron construction which relied on Baltard for its layout and copied him directly in the arrangement of the structures. The sketch-like design does not permit any evaluation of construction details. In the project by Alfred Friedrich Bluntschli (1842-1930), Semper's successor at the Polytechnic, the similarities are less obvious, being reduced more to the general principle. Bluntschli's symmetrically arranged halls have a basilican cross-section, the illumination comes through clerestories and through the side walls, the lanterns had a more decorative than functional importance. The municipal architect, Caspar Conrad Ulrich (1846-1893), proposed the most interesting solution from the point of view of form and construction. In general he adopted the layout and organisational system of a Baltard pavilion, carrying the clerestories forward to the façade and crossing the longitudinal hall with three short transverse arms. The wheel motif -- present especially in the semi-arch of the façade -- recalls the solutions which Paxton, for example, had proposed for the exercise room of a London hospital (41).
Ulrich's project shows the study of Baltard's "Halles" in details: what has been directly copied is the lower part of the façade with latticed brick plinth right down to the motif of the round arch frieze above the segmental arch. With the vegetable hall projects we have already gone beyond the limits set for this colloquium by a quarter of a century. It can be seen that in Switzerland it is this period which brings the actual breakthrough for iron as a construction material. This is also expressed in the fact that in the following years a number of ambitious iron constructions, thus, for instance, the bridges on the Gotthard railway, could be undertaken by Swiss undertakings. The economic reasons mentioned in the brief introduction prevented a real "iron culture" in Switzerland. The application of the material always remains subsidiary and is mainly of an experimental nature. Iron was expensive and remained expensive, even when it was possible to import it in larger quantities (railway construction!), but it was inconceivable for mass application until the last quarter of the 19th century, so that ornamental casting

deserves increased attention as the only important element.
The cautious acceptance of iron is certainly not due to lack of awareness of European developments or to a specific disinclination on the part of Swiss engineers and architects, for the specialists trained -- especially from the 1820's onward -- mainly abroad, thus in Munich, Karlsruhe, Berlin and Paris, whereas stays in England remained rarer, although they can be shown for individual leading architects.
However, as Switzerland only really began with railway construction after 1852 and as no main railway linked the country with the European railway network before 1860, enormous difficulties had to be overcome just for the transport of iron. It is precisely the high cost of transport and the protective customs tariffs which made wood and solid construction perfectly competitive up until the middle of the 19th century.
A periodisation would have to be based on these economic and transport technical considerations for Swiss conditions, and for this reason, at least as far as the pioneer period is concerned, it lags a good quarter of a century behind European development in the centres, England and France.
The great period of iron construction begins after 1875 and reaches a peak with the bridge structures for the Alpine railways. Building structures remain rare, even the great national exhibitions of the last quarter of a century made no difference here, for here too wooden structures dominate in a field which would have been ideal for a series of iron constructions.
Even the relative blossoming of iron construction was very brief. Already in the 1890's a construction material appears which succeeds in becoming adopted astonishingly quickly in Switzerland, namely reinforced concrete (43), and this was also soon used for technical and formal climaxes; we would just recall the work of the engineer Robert Maillart.

Notes

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17) Roellin, Peter, Nach Flüssen geordnet: Das Schweizer Holzbrückeninventar, Unsere Kunstdenkmäler 28 (1977), P.370-373.
18) Festschrift zur Einweihung der neuen Aarebrücke in Aarau 1949, Aarau 1949. - Krafts Alternativentwurf zeigt einen Pylon, der sehr nahe mit der 1842/44 ausgeführten Eisenbrücke über die Ruhr bei Mühlheim verwandt ist.
19) Vgl. die Bemerkungen in 100 Jahre AG Arnold Bosshard 1856-1956, Näfels 1956. - 1874/75 Bau der ersten Brücke für die Zürichseelinie bei Ziegelbrücke durch Bosshard. - 1876 Ausführung der ersten Brücke bei Mellingen durch Bell, Kriens.
20) Allg.Bauzeitung 20 (1855), P. 111-113, 349-351. - Ebd., 21 (1856), P.2-7,133-139. - Heinzerling, F., Die Brücken in Eisen, Leipzig 1870, P. 334/35. - L'architettura del ferro, Milano o.J. (um 1890), Tafelband und Appendix.
21) Allg.Bauzeitung 20 (1855), P.111-113.
22) Mehrtens, Georg, Der deutsche Brückenbau im XIX.Jahrhundert, Berlin 1900 (Abb.). - Heinzerling (wie Anm.20), P.334/35.
23) Ehrenberg (see Note 16), Einleitung in Vol.1 (1836).
24) Cathédrale de Lausanne. 700e anniversaire de la consécration solennelle. Cataloque de l'exposition, Lausanne 1975, Kat.No.166.
25) Vom Finder des Planes konnten noch keine näheren Angaben erhalten werden.
26) Germann (see Note 6), P.309 (Kat.No.89). - Reinle, Adolf, Kunstgeschichte der Schweiz, Vol. IV, Frauenfeld 1962, P.21 (Abb.).
27) Staats-Archiv Basel, Plan O 6.43. - Basler Baurisse 1800-1860. Katalog der Ausstellung 1967 (Typoskript), No.55.
28) 1844 Burckhardt AG, Basel; 1846 Geilinger & Co., Winterthur; 1850 Walzwerk von Moos, Emmen; 1855 Bell, Kriens; 1856 Bosshard, Näfels.
29) Neue Glarner Zeitung vom 29. Mai 1862. Freumdl.Mitteilung von J.Davatz, Näfels.
30) Archiv der Kirchgemeinde Grossmünster, Zürich.

31) Keller, Karl, Wilhelm Bareiss (1819-1885). Winterthurs erster Stadtbaumeister, Unsere Kunstdenkmäler 20 (1969), P.383-394, bes. P.389 (Abb.).
32) Stutz, Werner, Bahnhöfe der Schweiz, Zürich 1976, P.174,177. Die Probebelastung der Konstruktion erfolgte unter der Aufsicht von Prof. Zenner, der den verhinderten Prof.Culmann ersetzte. - Breitingers Eisenkonstruktion darf durchaus mit gleichzeitigen englischen Konstruktionen verglichen werden, s. etwa die Agricultural Hall von F. Peck (1862) in London Islington, dazu: Matheson, E., Works in iron, London 1873, P.271-274.
33) Stutz (see Note 32), P.177/78.
34) L'architettura del ferro. Raccolta di motivi per costuzioni civili, ferroviarie ed artistiche compilata col concorso dei migliori ingegneri, architetti e costruttori italiani, Milano o.J. (um 1890).
35) Stadtarchiv Zürich, Baugeschichtliches Archiv, Plansammlung . - Das Gebäude 1965 einer Strassensanierung geopfert.
36) Germann, Georg, Stutz, Werner, Die Bauten des Botanischen Gartens in Zürich. Gutachten zuhanden der Kantonalen Denkmalpflege, Mai 1975 (Ms., Archiv der Denkmalpflege). - Schinz, Hans, Der Botanische Garten und das Botanische Museum der Universität Zürich, Beiblatt zur Vierteljahresschrift der Naturforschenden Gesellschaft in Zürich, 29 (1937).
37) Planserie im Hochbauamt des Kantons Zürich, Mappe Botanischer Garten.
38) Freundliche Mitteilung von Markus Vogel, Zürich, der eine grössere Arbeit über J. Paxton vorbereitet. - Gubler, Jacques, Barbey, Gilles, Château Adolphe de Rothschild, Pregny GE, werkarchithèse 6 (1977), P.32/33, schlagen Paxton als Schöpfer vor.
39) Die Villa entstand 1865, der Wintergarten wurde erst nach Vollendung des Baues zugefügt. - Die Firma Boos, später Vohland & Bär, Basel, entwickelte sich in den 1870iger Jahren zum eigentlichen Spezialisten für Wintergärten und Gewächshäuser, vgl. 50 Jahre Vohland & Bär, Basel o.J.
40) Stadtarchiv Zürich, Baugeschichtliches Archiv, Plansammlung. - Fröhlich, Martin, Steinmann, Martin, Imaginäres Zürich, Die Stadt, die nicht gebaut wurde, Frauenfeld 1975, P.42/43,46-49.
41) Schild, Erich, Zwischen Glaspalast und Palais des Illusions. Form und Konstruktion im 19. Jahrhundert, Berlin, Frankfurt, Wien 1967, P.59.
42) Schild (see Note 41), P.67-77.
43) Birkner, Othmar, Zweihundert Jahre Betonbau, Unsere Kunstdenkmäler 23 (1972), P.100-110 (Sonderdruck).