THE IRON STRUCTURES OF THE ROOF FRAME AND CENTRAL TOWER OF COLOGNE CATHEDRAL

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Cologne Cathedral around 1840

Cologne cathedral is the largest Gothic building in Germany. Construction was begun under Archbishop Konrad von Hochstaden in 1248. Baumeister Gerhard was in charge of construction. The choir was dedicated in 1322. Afterwards, building activities slowed down and came to a complete standstill around 1560. By that time, the choir, parts of the transept and the nave and a major part of the western tower in the south had been completed. Only in the period of the Romantic movement public opinion more and more demanded that the building be preserved from decay and perhaps even be completed. Friedrich Schlegel and Sulpiz Boisserée in particular should be mentioned here. The latter, together with architectural draftsmen and copper engravers, created a comprehensive volume of tables for completion of the building around 1823. Roughly at the same time restoration work was begun. In 1842 the cornerstone was laid for the completion of the cathedral after, in 1840, the Kölner Domverein had been founded with the support of the then King of Prussia, Friedrich Wilhelm IV. The decision to complete the cathedral opened the debate about the design and the material to be selected for the roof frame and, above all, the central tower.

Iron Structures as New Structural Elements

It had been undisputed for many centuries that structures of this type should be made of wood and of stone plus timber, respectively; now iron came to be considered as a material. The first cast iron bridge spanning about 31 m had been built over the River Severn near Brosely in western England already in 1773-1779. Other cast iron bridges followed, for instance, the bridge across the River Wear near Wearmouth, Sunderland with a span of about 72 m. However, cast iron had two majors flaws which made it rank second or even third to the qualities wrought and welding iron developed later. On the one hand, it soon became apparent that cast iron was very brittle. It was unable to accommodate major tensile stresses and prone to rupturing, or brittle fracture, as one would say today, especially in cold weather. On the other hand, it was soon realized that cast iron structural members were much heavier than wrought or rolled ones, which meant a waste of material.
The great era of iron construction thus only began in the early 19th century when, after the introduction of iron bottoms in puddle furnaces by Baldwin Rogers in 1780, it became possible to produce larger quantities of iron of a higher quality, namely pure wrought iron. The invention by Cort in 1783 of cast iron grooved rollers soon also resulted in the possibility to roll iron bars which had to be forged first. These iron bars and sections were first used for railway construction, especially for railway cars, rails and bridges. Iron bridge designs soon led to iron structures being adopted also in building construction. Up to that time, iron had only been used for ancillary structures, such as anchorages, as in 537 in Hagia Sophia church of Constantinople and, in 643, in the mosque of Sultan Amer in old Cairo, and for the support rings of domes, for instance in 1523 for St. Mark's church in Venice or, in 1580, for St.Peter's in Rome.

When, around 1840 and 1850, thinking started about the materials to be selected for the roof structure and the central tower of Cologne cathedral, practical examples of all-iron structures existed in Germany, France, Austria and England. In 1820, for instance, the spires of Rouen cathedral were made of cast iron; in 1828, Georg Moller built the eastern crossing tower of Mainz cathedral all of iron. That reconstruction had become necessary because the old structure had decayed. For this purpose, Georg Moller designed a tower with a pointed arch dome constructed of wrought iron and supported on an eight-sided wall. The roof structure of wrought iron consisted of 66 wrought iron ribs spaced 26 inches apart at the bottom. The span and the height of the dome were 43 feet each. The main rafters were made of flat sections about 1 inch wide and 10/12 inches thick. These main rafters were held in place by the so-called rims to which zinc plates were fastened. The whole iron structure weighed some 26,500 pounds.
However, the dome had to be disassembled as early as in 1870. The structural parts of the walls were in such desolate condition that no reinforcement was possible. In addition to the bad condition of the building, it is also safe to say, Moller's dome had been very much the object of criticism. In 1868 the "Mainzer Wochenblatt", commenting on plans to improve the desolate condition of the eastern tower,wrote, "one could surely prevent complete disintegration for another couple of years, but who would justify the expenditure of preserving late Gothic attachments which have always been foreign to the overall impression of the beautiful eastern facade of the church and, because of the semi-oriental metal dome built by Moller, must be considered to be in bad taste." Already in 1854 there were some drafts of a new roof structure of this eastern crossing tower, one of them made by Zwirner, who also suggested a dome.

The spire of St. Stephan's cathedral of Vienna was made of cast and wrought iron in 1841. However, it may not have been known at that time, or the builder did not take into account properly experience showing that iron and stone behaved differently under thermal expansion conditions. For this reason, the connection between the walls and the iron structures was soon lost. The iron structure of the spire of the tower of St. Stephan's of Vienna built in 1841 therefore had to be dismantled very soon. In 1849, Corès/Cibon introduced the I-beam, which was rolled for the first time in Germany by the Phoenix company in 1857. In 1850 the London Crystal Palace was built with 3500 tons of cast iron and some 500 tons of wrought iron; it was followed by the Glas-Palast of Munich in 1854.

The first use of Z-iron sections is said to have been by the Bayenthal works of Cölnische Maschinenbau Aktiengesellschaft in building iron bridges for the Ruhr-Sieg railway line.
Zwirner's concepts of the choice of materials for the roof and the central tower thus were able to make use of practical examples and previous experience.
In 1855 Zwirner visited France to study iron roof structures of churches. At Rouen, the central tower of the cathedral was made of iron, at Chartres it was the roof structure erected after the timber roof had burned down in 1836, and in Notre Dame of Paris it was the roof structure again.

Roof Frame and Central Tower

Many splendid Mediaeval monuments were destroyed by fire in the course of time. Fires in the expensive oak roof structures as a rule not only destroyed those, but also the capped vaults, which in most cases were only 6 inches thick. They were unable to offer any resistance to the burning masses of wood coming down, so fires often penetrated into the interior of church buildings. In addition, timber roof frames often had limited lifetimes also for reasons of weathering. Also the roof and the roof structure over the choir of Cologne cathedral were in such a desolate condition in the middle of the first half of the 19th century, due to insufficient maintenance of the lead roofing, that even before completion of the cathedral was begun, the roof of the choir had to be renewed in order to protect the vaults from the weather.

In connection with the completion of the cathedral also the question of the material to be used for the roof frame had to be solved. While, in the Middle Ages, the use of iron had not yet been customary for constructions of roof frames, because iron was too expensive, sufficient examples were available, when completion of Cologne cathedral was considered, to show that iron could be used quite well as a structural material for bridges and roofs. In addition, more recent iron smelting techniques produced larger quantities of iron than the old methods. However, for the time being this can be taken only in the relative sense, because one of the first iron bridges, Coalbrookdale Bridge in England, consumed some 380 tons of cast iron, at that time the annual output of one ironworks.
In addition to the advantage of improved fire resistance, an iron roof structure over the nave and the transept of the cathedral was favoured also because these structures were lighter in weight. Even in terms of cost there seemed to be some advantage of iron structures.
"Compression forces, tensile stresses and thrust can be controlled by an iron structure, even in storms". This is another contribution by Zwirner to a debate in which he pleaded in favour of an iron roof frame. Since architectural or aesthetic disadvantages, as Voigtel expressed it, did not exist, the decision to build the roof structure of iron was taken relatively quickly. Supported by the then Crown Prince Friedrich-Wilhelm, Zwirner even managed to squash a flat roof design initially planned by Schinkel in 1834. While the decision in favour of the iron roof frame was relatively easy, deliberations about the material to be used for the crossing tower or the central tower took much longer to come to a result. From the existing buildings it was impossible to see whether the old plans had actually provided for the construction of a central tower. Above all, the two western pillars of the choir did not show any design features indicative of the subsequent accommodation of a central tower. Only the chords for the subsequent vault structure were found. In addition, the two existing crossing piers were in very bad shape.
They had not only deteriorated greatly in the course of time, but appeared not to have been built properly from the start, as would have been necessary for them to support high loads. The masses of walls 150 feet high evidently had moved. Still in 1826, anchors had to be inserted into the piers at the level of the main bases of the vaults to keep together the flying buttresses which tended to move apart.
The Royal Technical Building Commission of Berlin had been called in to help in the treatment of technical and architectural problems. In addition to drafting precise plans for completion of the central tower, the Commission also conducted load tests of the stone that

had been used. These tests clearly indicated that a massive central tower was unfeasible because of its very weight.
With regard to the question of whether a central tower was to be built at all, Zwirner reports as follows: "The basic question referred to above, whether a central tower should be erected above the intersection as an integral part of the profile of the entire building and as its organic completion, was answered in the affirmative for architectural and aesthetic reasons and on the basis of analogies drawn from similar monuments from the same period".
Zwirner had submitted four drafts for the decisive meeting of June 18, 1853:

Draft I: Sketch by Zwirner in a conversation with Friedrich-Wilhelm to demonstrate that a central tower belonged on the intersection, as was evident also from Notre Dame in Paris.

Draft II: Massive tower with a square support structure emanating from the interesection, and an octagonal central tower which could have been built as an iron structure.

Draft III: Massive tower.

Draft IV: Central tower erected as an iron structure on an octagonal floor plan.

All designs and sketches were considered to be "precisely in the style of the entire cathedral and its details and implemented with the proper architectural skill and knowledge".
However, the massive solutions had to be eliminated. One solution considered in which, according to draft II, the square bottom section would have been made of stone and the octagonal part above of iron up to the spire, was dropped, because "a solution of this kind would contradict the organic development of the tower from the intersection".
"The construction of a so-called ridge turret which, according to draft No. IV, would have been made all of metal as a decorative element of the roof, would benefit the whole building. Neither from aesthetic, nor from artistic or structural points of view would there be any objections to the implementation of such a plan."
After further deliberations and studies of the "reactive strength of the stone material" (which would be called compressive strength today) the Royal Technical Building Commission on December 19, 1854 finally rejected draft No. II, proposing draft No. IV for implementation.
The report by Zwirner goes on to say: "Accordingly, it has pleased His Royal Majesty, by Cabinet Order referred to above (dated April 4, 1855), to authorize draft No. IV for construction of the central tower and the special details of the building plan".

Design Drafts

The roof structure of the nave and the transept of the cathedral mainly consists of the 32 roof trusses spaced approcimately 12 feet apart. In addition, there are the four valley rafters of the intersection of the roof. The chief structural element of the main roof trusses, which consist of the rafters, the support arches and the connecting bars, is a rolled I-beam 1/2 inch thick. The horizontal angle is 4 3/4 inches wide, the vertical angle 3 1/2 inches high (excluding the thickness of the horizontal leg). Even if the design of the main truss is rather unusual by today's standards, the use of a standardized section for all bars of the roof truss must be regarded as very modern from the point of view of fabrication technology.The reason is probably less any particular consideration for fabrication

processes, but the method of fabrication of the rolled bars.
The individual roof trusses are interconnected by 9 purlins on each side of the roof, various valley girders and, at each roof level, two interconnected round iron bars. These round iron bars have tension locks and can be prestressed. The purlins, which were still referred to as angular sections in the tendering documents, were later modified to I-beams after some bending tests. They are spaced approximately 5 feet apart and are supported on the roof trusses by cast iron purlin supports. The purlins act as supports for the small rafters consisting of square iron bars 1 3/4 inches thick. These small rafters are spaced approcimately 2 1/4 feet apart. The roofing consists of fir boards 5/4 inches thick with a lead cover of 5 pounds per square foot, which is 2 1/2 kg per square foot or 22.96 kg/m^2 weight for a thickness of 2 mm. The ridge iron, an I-section, carries the rooftop 4 feet high whose zinc ornaments are cast with a wall thickness of 2 1/2 lines (approximately 5.25 mm). To prevent electrochemical decomposition, the spaces between the iron bars and the ornaments were filled with asphalt.
To permit free longitudinal changes due to temperature, the purlins have slots. Designers knew about the immense forces that can be developed by iron structures prevented from extending lengthwise. In fact, there had been earlier negative experiences, for instance, in Vienna.

Central Tower

The ridge turret or central tower has a height of 200 feet above the gallery and an inner diameter of 25 feet. The iron structure rests on the four large wall arches of the intersection which enclose a square of 41 feet with a thickness of 4 feet 2 inches. The four corners of the intersection in addition include four smaller stone arches to complete the octagon and to provide full support to the bottom sections of the eight tubular supports in the lower part of the iron structure. The iron structure of the central tower as seen from the bottom consists of eight tubular supports (approx. 26 feet high), eight rectangular cross sections (approx. 40 feet high), eight pentagonal sections (approx. 34 feet high) and eight conical lattice bars (approx. 100 feet high). The eight tubular supports are inclined by 70° and are embedded at the bottom and the top in cast iron column supports and column heads, respectively. The tubes were cast on end in foundry pits, have diameters of 20 1/2 inches and wall thicknesses of 2 inches. For better force transmission they were machined on both sides. The tubular structure is held in place by two horizontal chords and by interconnections made of wrought iron which prevent it from twisting.
The horizontal forces delivered by the tubular supports because of their inclined position are retained, on the one hand, by one tie rod each 3 inches in diameter terminating in a central tension ring. The tension ring proper is supported from four tie rods.
On the other hand, the support plates are interconnected by a circular anchor which can be prestressed by couplings between two support plates each.
At the top, the eight tubular supports of the bottom component terminate with their top plates in the first "chord plate" on which the eight rectangular supports, standing vertically, of the lower central section begin. These five supports have three walls of rolled sheet metal (1/2 inch thick) and one wall of crossed flat iron bars towards the interior of the tower. The eight supports of the upper central section have similar cross sections, but they carry another edge on the outside of the centre to make the cross sections pentagonal.

While the bottom sections of the central field are reinforced by diagonal bonds, no such bonds exist in the open upper part of the central tower. Reinforcement is achieved by the arched terminal plates bolted on at the top and, on the inside, by the arched attachments joining in a rim.
On this platform the spire rises from the conical lattice bars. Horizontal bulkheads are installed every 10 feet. The whole spire is additionally "protected against torsion" by diagonal bonds which, according to present technology, protect against bending of the lattice bars at the roof level. The levels of the central section of the ridge turret terminate in small Gothic spires. The lattice bars of the spire have Gothic spires at the levels of the horizontal bulkheads. The spire proper is crowned by a golden morning star.

Tendering Procedure

On August 30, 1859 the Cölnische Zeitung carried the following announcement: "Construction of the iron roof structure with the central tower connected to it is to be allocated in a tendering procedure for Cologne cathedral".
It was also indicated that construction plans could be inspected at the offices of the Cathedral Bureau in the period between September 1 and 14, 1859 and that tenders had to be submitted there not later than by 11 o'clock, September 14, 1859. The conditions for tendering are interesting even with respect to present procedures, because they contain almost all tendering criteria currently used. In addition to demonstrations of technical and financial capability, the administrative part offers very detailed invormation, for instance, about the offer, guarantees and payments. The technical section contains precise provisions about accounting by weight on the basis of specimen bars 1 foot long, the accuracy of drillings, quality of materials, e.g., the absence of cracks, separations; slate free of slag, cold and red shortness etc. In casting large pipes, for instance, the process had to be conducted free from voids and models had to take into account shrinkage.

The material weights (in lbs.) contained in the tendering documents were:

Part	Roof	Tower	Total
Cast iron	15,083	111,000	126,083
Wrought iron	303,000	162,000	465,000
Total	318,083	273,000	591,083 lbs.

Accordingly, the whole structure at that time was estimated to weith approcimately 295.5 tons.

The tendering conditions also made detailed reference to measures to be implemented to permit longitudinal changes as a result of differential temperatures. In this connection, a letter written by Zwirner to his deputy and later successor Voigtel on April 13,1860 is of interest. With reference to the corresponding paragraph in the conditions, Zwirner wrote: "For this reason, the longitudinal connecting pieces between the roof trusses must be installed so as to leave proper space according to our information and must be equipped with slots at the ends for the bolts". He goes on: "Since this rule has not been obeyed, precise measurements must be made immediately and the contractual conditions stipulated above must be met, about which you are supposed to watch in agreement with Director General Goldstein".

In the same letter, Zwirner adds: "Moreover, I had instructed you to ensure that the parts of the iron connections contacting each other are again painted properly to prevent (?) corrosion; what has been neglected here, shall be repaired right away." Another reference is made to careful and cautious assembly. Voigtel, in a handwritten note on the same letter, found the longitudinal expansion at a differential temperature of 25° C and a length of 100 feet to be 6554 lines, which is 16.52 mm. The correct value is 9.15 mm. The results of the tendering procedure indicate the following pattern:

Company	Prices in Talers per 1000 lbs.of weight				
	Roof		Central Tower		Notes
	Wrought iron	Cast iron	Wrought iron	Cast iron	
Die Aktiengesell-schaft Bergwerksver-ein Friedrich-Wilhelm-Hütte,Mülheim/Ruhr (Sep.13,1859)	110	30	120	38	
Cölnische Maschinen-bau Aktiengesell-schaft Bayenthal (Sep.12, 1859)	74 1/2	37	86	39 1/2	was awarded the contract by letter by the Ober-präsident dated Sep.22,59.
Gutehoffnungshütte zu Sterkrade (Sep.13,1859)	76 1/2	50	88	75	Instead of round cast iron pillars, riveted rectangular cross sections were offered.
Engberth u.Cünzer u.Fuhse, Eschwei-ler-Hassels/Aachen					

The terms and conditions of tendering already demand that a basic paint coat of red lead oxide be attached in the shop. In the order for the painter written on June 18, 1860 it says that two coats of oil paint with red lead oxide should be applied, the paint being composed on the basis of linseed oil with finely dispersed red lead oxide. The paint coat should be applied twice so as to cover properly the base. Moreover, the contract adds that all joints must be cemented, except for those left for the "iron to expand". The price for this work at that time was 7 1/2 pfennigs per square foot.

Execution of the Work

In a letter written by the Oberpräsident der Rheinprovinz on September 22,1859 the contracts were awarded to Cölnische Maschinenbau Aktiengesellschaft of Bayenthal. In the shops of that company the different structural elements were manufactured under the supervision of the Dombaumeister and his agent, respectively. Two things should be mentioned specifically; The accounts were to be settled on the basis

of the weight determined, the weight being controlled in so-called specimen sections 1 foot long, which were weighed precisely.Single components had to meet the standard weight with a tolerance of + 2 %. Originally, angular sections had been planned for the purlins. Strain tests carried out by the manufacturer after the contract had been awarded showed that the purlins would bend excessively. Bending tests on I-sections resulted in a much better behaviour, so the sections were changed for building construction. The contractual date for complete assembly of the structures was June 30,1860. For conditions at that time this was certainly a very short period. However, the deadline was exceeded slightly, also because of the changes in sections of the purlins.
The contract had been awarded including transport and assembly, but the hoisting equipment was made available by the Dombauhütte, the cathedral building organization. On October 15, 186o the Dombaumeister put the gold-plated morningstar on the top of the central tower.

Destructions in World War II

One of the reasons which had caused Zwirner to build an iron roof frame was the experience that all the fires which had destroyed cathedrals in the Middle Ages had started in the roof frames. Iron does not burn. This would greatly reduce the fire hazard of the roof and would prevent the roof structure proper from catching fire.
In those considerations Zwirner certainly could not guess that his farsightedness would pay more than eighty years later. Between 1943 and 1945 the cathedral was hit by 14 large high-explosive bombs, 19 grenades and, in one night, by more than loo incendiary bombs. No major air raid failed to hit the ridge turret and the roof structure, but they stood and were damaged only by some direct hits. Since the structure proper had not been destroyed, damaged spots were relatively easily repaired, even if with often unsatisfactory means. Shortly after the end of the war the whole roof frame was again ready for covering. Especially at that time it was found that also the corrosion protection coating that had been applied, in many places still the original paint coat of 1860, had been of very high quality.

Iron Staircase in the Central Tower

In 1882 an iron spiral staircase was installed in the central tower. It begins in the so-called gallery at a level of 100 feet and ends at the gallery of the cathedral. The staircase weighs 10.85 tons, of which 4400 kg is due to the treadboards and risers, 1610 kg to the corrugated sheet metal at the bottom of the staircase on the first floor, and 1800 kg to the filling of the railing made of ornamental cast iron. The balance is due to girders, spindles, bolts and railing supports. In addition to the iron staircase there was also a decorative wooden staircase, popularly called the Emperor's staircase. The wooden staircase also survived the World War II unscathed. However, it had to be replaced by a steel staircase for reasons of fire protection after the war.

New Roof Frames on Old Churches

While the iron roof structure of Cologne cathedral is almost 120 years old, many former timber roof frames in churches were replaced by steel structures right after the end of World War II. In most cases the reasons were the reduced fire hazard compared with wooden structures and the lower weight compared with a structure made of steel concrete. Three examples will be mentioned briefly.
The roof of St.Stephan's cathedral in Vienna had been completely destroyed in the war. Reconstruction of the roof structure of steel

was completed in 1948-1950. The total weight of the steel structure is appro mately 600 tons. The design of St.Stephan's can be compared with the design of the roof of Cologne cathedral. The inclination of the roof is approximately 64°. However, the iron frame girders above the nave are designed in three parts; there are two bottom sections, each of them anchored to the outer flying buttress and held in place by struts above the central pillars. The central part it is striking to see that the lower chord, which is still an arched beam in Cologne cathedral, perhaps following Gothic examples, is a straight member, thus corresponding to the direction of force. Moreover, it should be added that, unlike the design used in Cologne cathedral, the roof has different heights in the areas of the nave and the choir and also has different inclinations in those areas.

St. Ludwig's church in Darmstadt was built by Georg Moller in 1822 to 1826. Originally, the roof had been designed and built as a timber structure. This roof structure was completely destroyed in the last World War and was rebuilt of steel in 1954. The steel roof structure of the dome consists of 28 steel frame trusses converging in a thrust collar at the top. This steel structure weighs 90 tons.

The Church of the Benedictine Abbey of Neresheim some 90 kilometers east of Stuttgart is the last major work of the architect Balthasar Neumann and was built around the middle of the second half of the 18th century. In this abbey church not only destruction by the war was a reason for rebuilding the roof structure, but false static assumptions already at the time of construction necessitated such reconstruction. Originally, it had been planned to suspend the sensitive domes of plastered wood from the roof structure, for it was not possible to support them on the columns. However, since the roof structure was weaker than the dome, especially the large dome in the intersection, load conditions soon reversed and the roof pressed on the dome, the main dome above the intersection thus settling on the four columns. As a consequence, the dome developed cracks and the valuable fresco paintings by Martin Knoller were in danger. More or less effective makeshift solutions had been adopted over the centuries. However, by the mid-sixties of this century a fundamental decision had to be taken.

Again, steel was found to be a most suitable material for the problem at hand. The roof structure above the main dome had to be replaced without causing any damage to the dome. For this purpose, a large hall first had to be built around and above the church roof to protect the sensitive dome from the weather during the construction period. After this additional roof had been completed, the timber structure could be replaced by a steel structure step by step. An aggravating factor was found to be the need to leave the timber frame beams,which had been installed in 1827-28, in place for overall stability of the building. After assembly of the four main steel girders at the edge of the dome the main timber suspension beams of the dome were connected with this frame structure in their lower connections by means of the rods. Then began the difficult job of moving the dome from the timber beam to the steel structure. After the dome had finally been secured in place, an overhead crane was installed to assemble a new support structure also for the roof.

The roof frame and the central tower of Cologne cathedral are interesting designs dating from the early days of modern steel construction. The structure has survived its almost 120 years of existence without any damage. Minor damage by war in the second World War was quickly repaired. The corrosion protection coating applied at the time of erection is still largely in place.

Reconstruction of the roofs of St.Stephan's cathedral of Vienna and St.Ludwigskirche of Darmstadt, which had been destroyed in the war, has shown that also in old churches destroyed structures can be replaced successfully by steel structures without in any way detracting from the overall architectural impression. The repair of the roof structure of the Benedictine Abbey church of Neresheim near Stuttgart in addition proves that steel as a material offers solutions for the conservation of old works of art even in difficult problems of restoration.

Notes

1. 35. Baubericht über den Ausbau des Domes zu Köln vom 22.Mai 185[illegible] (Archiv, Dombauverwaltung, Cologne).
2. 44. Baubericht über den Ausbau des Domes zu Köln vom 15.Januar 1860 (Archiv, Dombauverwaltung, Cologne).
3. Voigtel, Die Eisenkonstruktion des Dachstuhles auf dem Dome zu Cöln, Zeitschrift für Bauwesen 1862.
4. Voigtel, Construction des Dachreiters auf der Kreuzvierung des Domes zu Cöln, Zeitschrift für Bauwesen 1862.
5. Original building records of the years 1850-1882 (Archiv, Dombauverwaltung, Cologne).
6. Pieper, Rettung für eine Klosterkirche bei Stuttgart (D):Feuerverzinktes Stahltragwerk für Hauptkuppel und Dach acier-stahl-steel 7-8/1977.
7. Deurer-Bury, Der Dom aus Eisen, Stahlbau Informationen, DSTV Cologne, issue 1/78.