Sustainable Bridge Constructions – Elegant arches – filigree structures – cost effective design

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St. Kilian viaduct: Superior lightness

Behind the bureaucratic-sounding title “Verkehrsprojekt deutsche Einheit Nr. 16”, which refers to the upgrade of the A 73 federal autobahn in Thuringia, is one of the most exceptional bridges in the German landscape. The St. Kilian viaduct at kilometre 14.2 of the A 73 is one of the few autobahn viaducts to be constructed as a composite steel tube truss structure. The result gives reason to hope – and not simply from an aesthetic point of view – that this may mark the start of a trend towards high-quality bridges with visible structural hollow steel sections.

Usually it is a question of the location and the natural surroundings. Composite steel bridges, whose carriageway deck is supported on a filigree steel tube truss structure and slim piers, which carry it overvalleys and bridges, are especially preferable to normal prestressed concrete bridges when a “soft” compromise is sought between protection of the landscape on the one hand and hard transport necessities on the other. In Switzerland, as on the A 73 federal autobahn to the north of Schleusingen, in Thuringia, an especially harmonious solution was sought. The increased sensitivity of clients, local residents and countryside campaigners were decisive factors influencing the decision in favour of the slim and elegant, and above all light and transparent, steel composite bridge.

After consideration of the technical and architectural aspects, the variant presented by structural design planner Prof. Weyer was selected. The bridge consists of a total of eight spans with widths 55.35 m, 5 x 61.5 m, 49.2 m and 36.9 m, and rests on parallel tubular lattices, 14 metres above pairs of slim reinforced concrete columns. The height of the structure is 5.0 metres and the total width is 28.5 metres. Two separate composite framework superstructures define the four-lane viaduct over its whole length. The bottom chord of a 4.40 metre high three-chord main girder consists of a structural hollow steel section with a diameter of 610 millimetres, while the diagonals, which are also made of MSH sections, have a cross section of 299 millimetres. Both top chords consist of I-sections with welded stud shear connectors and are concreted into the carriageway as composite girders. The reinforced carriageway deck, which is longitudinally prestressed, ranges in thickness from 23 centimetres at the cantilever arm end to 106 centimetres over the diagonals. The bearing support of the framework on the piers is provided by V-shaped struts made of MSH sections, which are connected to the superstructure framework by cast steel joints. The superstructure rests on seven pairs of round, reinforced concrete piers built on shallow foundations.

A total of 525 tonnes of MSH sections, made in the V & M TUBES production plants at the Düsseldorf-Rath, Mülheim, Aulnoye and St. Saulve sites, were supplied via ThyssenKrupp Materials Austria to the MCE Stahl- und Maschinenbau GmbH & Co., Linz, which was responsible for the steel construction work. Almost half – exactly 333 tonnes – consisted of hollow sections with a diameter of 610 millimetres and wall thicknesses of 50, 55 or 60 millimetres, which were...
used as bottom chords and V-shaped bearing struts. The two diagonals were created using MSH sections with a diameter of 299 millimetres. The steel superstructure was preassembled on site, span by span, and hoisted onto the piers and neighbouring auxiliary supports by truck cranes. The reinforced concrete carriageway deck could then be constructed section by section using one formwork carriage per superstructure.

Several corrosion-resistant coatings – the final one in striking blue – protect the structure against weathering. It is a pity that the car drivers who cross the viaduct miss the best view of it. However, the filigree framework design can be admired by drivers on road 247, as they cross the Erle valley below the St. Kilian viaduct.

Traffic project „Deutsche Einheit Nr. 16, A 73 Lichtenfels-Suhl“
Commissioned by: Federal Republic of Germany, represented by the Federal Ministry of Transport, Building and Urban Affairs
Delegated administration: Free State of Thuringia represented by DEGES Deutsche Einheit Fernstraßenplanungs und -bau GmbH, Berlin

Design/Structural design planning: Weyer beratende Ingenieure GmbH, Dortmund

Construction supervision/Construction preparation: Prof. Dr.-Ing. H. Bechert + Partner, Schleiz
Testing engineer: Prof. Sedlacek + Partner Technologien im Bauwesen GmbH, Aachen

Construction work/Constructional steelwork: ARGE Hochtief Construction AG, Frankfurt/Main / MCE Stahl- und Maschinenbau GmbH & Co., Linz

MSH sections: a total of 525 tonnes of round MSH sections measuring (diameter x wall thickness) 114 x 20 (32) mm, 299 x 55 (60) mm, 406 x 50 (60) mm und 610 x 50 (55/60) mm for the framework superstructure.

Luitpold Bridge: Bamberg’s new bridge arch

In just 22 months the most important bridge in the city of Bamberg was demolished and replaced by an imposing new one. The view of the new Luitpold Bridge is dominated by a harmonic, rounded steel structure, consisting of three-dimensional truss arches. The harmonious visual aspect of the arch design was achieved by using MSH sections of constant diameter and different wall thicknesses.

One of Bamberg’s main urban thoroughfares runs between Kunigundendamm and Heinrichsdamm. It is important not only for car traffic across the Main-Donau Canal but also for the local public passenger transport system, whose routes between the main station and the central bus station have always crossed the Luitpold Bridge. The old bridge, which dated from 1932, was long past its prime
and clearly deficient in many regards. Even a thorough restoration could hardly have returned the bridge to a condition that would have satisfied contemporary transport engineering demands, taking into account modern gas, water, electricity and telecommunications networks.

In May 2005, Bamberg’s city council had to select the contractor for the prestigious project. There were eight bidders. The choice of the Max Bögl group of companies, which has considerable experience in large-scale steel construction projects, was attributable to the quality of the submitted design and the complex project requirements and circumstances. The very cramped building site, the need to take traffic safety into account, and the importance of causing a minimum of inconvenience and stoppages to shipping traffic on the Main-Donau Canal meant that experience, precise project planning and strict schedule adherence were essential. The contractor had just 17 months of construction time before the specified date of opening in early December 2006.

The new Luitpold Bridge is a three span structure, consisting of two approach spans (shore spans 1 and 2) and the connecting tied arch bridge. The shore spans, each of which consists of the abutment, four pier sheets running parallel to the longitudinal axis of the bridge, and a concrete slab are made of reinforced concrete. They span the tow path at each side of the Main-Donau Canal (effective span widths 10.50 and 10.63 metres). The dominant style element is the steel central section of the bridge, the tied arch bridge, which rests on the pads of the shore spans. It has an effective span width of 80 metres and the arch rise is 14.0 metres. The structure leaves a clearance of 7.50 metres between the bridge deck and the Main-Donau Canal.

The main span at the centre of the structure – a steel-tied arch with a suspended deck – consists of three-chord three-dimensional truss arches, made of round curved MSH sections from V & M TUBES. The lattice girders consist of two parallel top chords and a bottom chord. The side lengths between top and bottom chords vary between 1.30 metres at the foot of the arch and 2.31 metres at the apex. A total of four cast joints form the corners of the steel structure which, despite its bearing capacity, has a filigree appearance. The joints connect together the arches, the two horizontal ties and the cross girders at both ends. The tie extending along the bridge between the cast joints is also based on MSH sections – two horizontal continuous tubes with a plate between them, through which they are connected.

With a total of 28 round steel hangers, positioned at 5-metre intervals, the tie and cross girder structure is suspended from the arch girder. The deck of the new Luitpold Bridge consists of a 30-centimetre thick reinforced concrete slab, on which is the carriageway. A total of 387 tonnes of round MSH sections in only four different diameters were needed to cover the various structural functions and the static requirements of the steel structure. The largest diameter tubes (406.4 millimetres), which were used for welded and curved sections in the arch structure and for the horizontal ties, were adjusted to satisfy the specific physical structural requirements simply by varying the wall thickness (30, 40 and 50 mm).

The Max Bögl group, whose civil engineering and steel construction companies participated in the Bamberg bridge project, manufactured all the steel construction elements of the tiedarch bridge at its headquarters in Neumarkt. Heavy load transporters delivered the individual modules “just in time” to the cramped building site for immediate installation. After the longitudinal and transverse girders had been screwed and welded into place, the truss arches were erected with the help of erection towers, which were set up beside the old centre pier to provide additional support. The existing river piers of the historic Luitpold Bridge were not demolished until the new bridge was complete. Exactly on schedule, the completion of the bridge was celebrated on 30 November and the dedication ceremony and opening of the bridge for traffic took place on 1 December 2006. The progress of the project is documented in detail, in text and photos, on the website www.stadt.bamberg.de.
Commissioned by: City of Bamberg

Structural design planning: Richard J. Dietrich, Büro für Ingenieur- Architektur, München, Rieger und Brandt Planungsgesellschaft im Bauwesen mbH, Nürnberg

Construction work/Constructional steelwork: Max Bögl Stahl- und Anlagenbau GmbH & Co.KG, Neumarkt

Fig. 2: St. Luitpold Bridge – Bamberg – Germany

MSH sections: a total of 387 tonnes of round MSH sections measuring (diameter x wall thickness) 193.7 x 12.5 mm, 219.1 x 16 mm, 323.9 x 20 mm, 406.4 x 30/40/50 mm for the arch structure and the ties.

With a free span of 230 metres, the pedestrian bridge at Weil am Rhein is the longest of its type. Linking the French town of Huningue and the German town of Weil am Rhein, it is also of huge symbolic significance, emphasizing the strong bonds between these two European countries. And last but not least, the bridge symbolises the togetherness of those who live on the right and left banks of the Rhine. In the words of the speech by Mayor Wolfgang Dietz at the official opening of the bridge on 30 June 2007, “If we want to build human bridges, we have to build physical bridges too.”

In a symbolically charged gesture, a bridge was constructed between Weil am Rhein, Germany, and Huningue, France. Its filigree design is the perfect expression of its allegorical significance. In view of its elegance and lightness, it is hard to believe that it has the widest span – 230 metres – of any cycle and pedestrian bridge of its type in the world.

Transnational links and communication between Germany and France have a practical and a symbolic dimension on the Rhine knee. Here, where the river separates two cultures, it has been bridged in many ways down the years. Traffic can cross the Rhine between Greater and Lesser Basle by means of five bridges, a weir bridge and four ferries. Pedestrians and cyclists, however, were disadvantaged and had to make do with a bridge located some distance below the Pont Palmrain.

In 2001, Weil am Rhein, on behalf of the commissioning parties (the town of Weil am Rhein and the Communauté des Trois Frontières), organised an architectural competition that was won by Feichtinger Architectes, Paris, in collaboration with Leonhardt, Andrä und Partner, Berlin. The winning design was for a filigree, elegant, steel arch bridge, which would completely traverse the imposing width of the Rhine with a single 230-metre span. In terms of urban planning, the significance of the bridge is the connection of two roads. On the German side it forms the extension of the Hauptstrasse in Weil and on the French side it joins the Rue de France, which comes out onto the central Place Abbatucci after 200 metres. The bridge is not just a continuation of road structures for those in the immediate vicinity, however; now the citizens of Lesser Basle can also profit from the benefits of a direct cycle route into Alsace. And of course this car and lorryfree bridge is also an ideal vantage point: upstream there is a view of the shipping off the inland port of Basle, and in the...
background the Novartis campus is arising – an international research, development and management centre.

To avoid spoiling the view of the historic tower on the main square of Huningue, the bridge is on the north of the two newly connected road spaces - a sensitive move on the part of the planners and something which is not always a matter of course these days. In addition, the support structure has an asymmetric design. The north arch is visibly stronger and consists of two hexagonal tubes. The southern arch, a round tube, leans towards the first, so that the line of sight between the neighbouring towns remains open. The deck serves as a horizontal tie, so that, besides wind forces, only vertical bearing pressures have to be accommodated. The arch shape was gradually modified during the design phase in order to give it an optically rounded, harmonic, gentle flow. The extremely flat arch, with its low rise of only 24 metres, gives the final shape its tension and elegance. The cross section of the steel structure is asymmetrical and is open to the centre line. The main structural element is a vertical arch consisting of two hexagonal tubes. A simple tube arch, whose inclination extends the line of sight, leans against this arch on the piling side. The arch supports are located in the bank zone.

The lightness suggested by the harmonic arch is continued in the bank zone by the choice of a three-dimensional lattice instead of the usual massive end piers to resolve the incident forces. The arches therefore rest elegantly on the filigree base piers near the bank. Two strong compression struts transfer the horizontal thrust to the end of the deck, which carries the combined tensile forces across the river. The remaining vertical components are anchored below ground by two tension bars. Optically, the compression bars form a prelude to the large arch and ensure a dynamic transition. In all, the design and execution are convincing down to the last detail. For example, the penetrations of the carriageway edge supports and the arches are formed using high quality cast steel elements.

All other joints, members and force connection points were developed with functionality in mind and are precision-manufactured. The integrated lighting in the handrail underlines the clear shape of the bridge and contributes to the sensitive integration of the structure into the river landscape.

Special structures are always the result of competent alliances. For the bridge in Weil am Rhein, Feichtinger Architectes, structural design planning specialist Ingenieurbüro Leonhardt, Andrä and Partner and the constructional steelwork experts of Max Bögl joined together to create a first class project group. Architect Dietmar Feichtinger celebrated the official opening of his Simone-de-Beauvoir footbridge over the Seine in Paris last year, Leonhardt, Andrä and Partner can look back to the firm’s founder, Fritz Leonhardt, and a long tradition of structural engineering, and in Wolfgang Strobl, civil engineering group leader in the Berlin office, have a proven specialist in the development of software for static and dynamic calculations for demanding structures. Last but not least, Max Bögl has been involved in progressive constructional steelwork projects such the spectacular Cargolifter Hall in Brand, the roof structure of Hamburg Airport and, just recently, the new Luipold Bridge in Bamberg.

For this latest project, Max Bögl assembled the bridge from individual segments at the pre-assembly site on the French side; it was then floated out to its final position on 12 November 2006. Exquisite engineering and assembly work require high-quality structural materials. The MSH sections from V&M TUBES therefore played an important role in the design and structure of the pedestrian bridge at Weil am Rhein. A total of 199 tonnes of seamless circular hollow sections in S355J2H steel with 3.2 certificate were used to construct the bridge. The sizes used were 610 x 36 mm for the arch, 457 x 25 mm as bracing tubes and 323 x 25 mm as unilateral edge contour along the south side of the carriageway.
Bridges create links, but can also block views of the neighbouring natural and cultural landscapes. One of the best features of the lightweight pedestrian bridge at Weil am Rhein is therefore its transparency. It ensures that the views between the two countries are undisturbed, and therefore promotes visual communication. The process of building the bridge also created opportunities for genuine communication. The collective 90-minute vibration test, for example, for which the town of Weil and the Communauté required 600 volunteers. In fact, a total of 1 500 people crossed the new pedestrian bridge on 13 January 2007 under the supervision of the statics experts in order to set the bridge vibrating. Even more spectators and guests – about 50,000 over two days – attended the official opening celebrations after completion of the final installation and anti-corrosion measures in the summer of 2007.

Commissioned by: The town of Weil am Rhein on behalf of the Communauté des Trois Frontières, Alsace

Architects: Feichtinger Architectes, Paris

Structural design planning: Leonhardt, Andrä und Partner Beratende Ingenieure VBI, Stuttgart
Construction work/Construcional steelwork: Max Bögl Stahl- und Anlagenbau GmbH & Co. KG, Neumarkt

MSH sections: A total of 199 tonnes of MSH sections measuring (diameter x wall thickness) 323.9 x 25 mm, 457 x 25 mm and 610 x 36 mm for the arch structure and as bracing tubes, material: S355J2H with 3.2 certification.

The bridge over Bayerstrasse, Munich

Sometimes, the easier it seems, the harder it gets - technically and in practice. This certainly applies to the pedestrian and bicycle bridge over Bayerstrasse, Munich. The supporting structure employs high-strength fine-grain structural steel – a material hitherto chiefly used in cranes, offshore installations, shipbuilding, and other high-performance steel structures. For this project, tests and expert evaluations came up with new ways to use fine-grain structural steel in civil engineering. The result: architects and civil engineers can now design lighter, more delicate structures.

It's a fact that the "Bridge to the Wiesn", as the pedestrian and bicycle bridge over Munich's Bayerstrasse has already been fondly dubbed by the local press, is an essential transit point for Oktoberfest visitors on their way between Hackerbrücke – the nearby underground station – and their pleasure destination. Looking at the immediate urban environment either side, the bridge links Kurt-Härtl-Passage north of Bayerstrasse to the European Patent Office, the "town balcony", on the south side; hence weekday office users can now safely cross the street. With a 38 metre span and 4 metres wide, the structure is column-free. Its gentle arch (2.16 metres of rise) crosses four lanes and two tramway tracks at one of the busiest traffic junctions in Munich.

Size is often a minor issue when assessing the visual impact of a structure. In the case of the bridge over Bayerstrasse, it is certainly the use of high-strength fine-grain structural steel in the supporting structure - hitherto rare in bridge construction – that justifies a closer look. Steel grade S 690 - the
technical designation of the high-strength special steel used here – is what gives the bridge its
delicate appearance. The original plan for arch construction had been to use the standard grade S
355 (St 52) solid material of 219 mm diameter. But the Munich engineering office Christoph
Ackermann thought otherwise and went for the lighter alternative of S 690 – and this was backed up
by the V&M Applications Technology Service. However there was a problem – no valid national
technical approval from DIBt (German Institute for Structural Engineering) was in force for the use
of S 690 steel in bridge construction. So there had to be a detailed assessment before the building
authority approval could be given in this case. The appointed expert was Prof. Dr.-Ing. Ömer Bucak
of Munich Technical University – a materials specialist who had done intensive research in various
programmes devoted to both hollow sections and high-strength steel.

A comparative design analysis of solid material versus hollow sections in S 690 yielded various
factors in favour of the lighter solution. Thus, the use of solid material would have doubled the steel
weight of the bridge which would, among other things, have meant higher erection costs. Moreover,
the comparative analysis of fabrication characteristics was also clearly in favour of S 690: because
of their smaller cross section, hollow sections are significantly easier to weld than solid material.
What's more, inspecting the welded joints in a structure of solid material is much more complicated
than in a hollow section structure. So the use of MSH hollow sections has also significantly reduced
the cost of welding.

The terms of reference to be addressed by Prof. Bucak, the expert, were manifold, including
verification of the steel joints' strength using stress-strain analysis in accordance with the current
European Draft Norm EC 3 Part 1.8. Tests, some of which were carried out at Munich Technical
University's Steel and Light Metal Construction Laboratory, confirmed the validity both of the
verification method and the wall thickness ratios chosen for the S 690 sections. In addition, an
existing DIBt approval for S 690 steel, valid until the end of 2003, was available as a reference. The
deviations from the approval in the case of the sections for bridge construction concerned the
(larger) wall thicknesses as well as a special alloy variant of the steel. This had been modified with
a view to improving the surface condition, an objective that was naturally favoured by the civil
engineers. Tests revealed that the modified chemical composition makes no difference to suitability
for welding. After all these technical details had been sufficiently cleared up, the responsible
Munich civil engineering authority granted a project-specific approval.

The tubes in fine-grain structural steel not only reduced the weight by 50 per cent, they also allowed
a design to be planned with significantly smaller tube diameters. About 18 tonnes of S690 structural
steel was delivered by Benteler Rohrhandel, Munich, destined for the supporting structure of the
bridge over Bayerstrasse. This represents a weight saving of 17.5 tonnes compared with the solid
material proposed in the original design. The reduction in material can be seen in the extraordinary
airiness which distinguishes the bridge's supporting structure. A brief glimpse at the technical side
of the design: the support principle uses a hybrid structure in the form of a frame arch made up of
two segments coupled with a beam. The two-hinged arches – made of S 690 MSH sections – are a
hyperbolic approximation of the thrust line and provide for uniform transmission of the load -
especially the weight of the concrete deck – to the abutments. The stiffening girder consists of the
20 cm thick deck as top chord, the bottom chord, and the diagonal and upright members, which are
rigidly welded together. The arch and steel beam are joined together via hinged eyebars.

Given the complexity of the bridge design and the underlying materials concept, intensive
cooperation between all those involved was essential at each project phase. The construction
concept – from prefabrication of the steel structure at the workshop through to concreting of the
deck on a falsework off the construction site – was planned and calculated in detail by the
engineering firm Ackermann. A decisive element in the success of the project – and certainly the
most spectacular task – was undertaken by Maurer Söhne. The choice of the unusual procedures
was dictated by the specific importance of the traffic junction to be bridged. Traditional assembly
methods would have paralysed Bayerstrasse for months, and so Maurer Söhne, together with the principal (Bayerische Hausbau GmbH, Munich) organised a pre-assembly site some 500 metres way from the final assembly location. The steel structure prefabricated at the workshop as two modules was erected on a precisely dimensioned falsework which was then transported to the pre-assembly site. There the last welds were carried out and the shuttering for the concrete deck was completed with millimetre accuracy.

Once the concrete had set, ties were attached to the four corners of the structure; in order to stabilise the bridge during mobile crane transportation to its destination, until the forces of its weight were eventually transmitted to the abutments, thus stabilising the bridge in situ over its length and width. To allow the precision erection of the 40 metre long 110-tonne bridge element, Bayerstrasse only had to be closed for a single day. Thereafter, to the great joy of all commuters, it was re-opened – at least to motor traffic – while the final stage of fixing the glass parapet was underway. Even if the layman perceives this little bridge only in terms of its spectacular airiness, all the specialists involved are convinced that it was worth the effort of the unusual construction and authorisation process. The new experience with S 690 steel and, above all, the prospect that many a future project can be designed and realised in a much lighter and more attractive style, has left experts, civil engineers, architects, and fabricators happy and convinced that the importance of the successfully completed bridge project cannot be measured in dimension units. And V&M TUBES, manufacturer of the structural steel sections, will certainly help to spread the good news of the new technical findings.

Principal: Bayerische Hausbau GmbH, Munich

Support structure and project planning: Dipl.-Ing. Christoph Ackermann, consulting engineers for civil engineering, Munich

Architect: Ackermann und Partner Architekten BDA, Munich

Construction and Assembly: Maurer Söhne GmbH & Co. KG, München

Expert on high-strength steel and glass parapet: Prof. Dr.-Ing. Ömer Bucak, Munich

Welding supervision and qualification testing: Laboratory for steel and light metal construction, Munich Technical University

MSH sections used: 18 tonnes circular MSH sections 168.3 mm x 30 mm and 127.9 mm x 30 mm (diameter x wall thickness) in high-strength S 690 grade steel produced at the Mülheim mandrel mill.

_Dättwil Bridge (CH) - Easing pressure on tunnel traffic_

Not only expanding suburbs but also tunnel bottlenecks produce traffic chaos on Europe's roads. Construction measures aimed at easing the stress are consequently under heightened deadline pressure, as the traffic situation becomes drastically more critical during the actual building period. Here the composite bridge, with its speedy assembly engineering, is a structural type which is both economically and aesthetically attractive. Switzerland already has several such bridges.
The traffic situation is only to well known in many congested areas: the national highways from Berne and Basle join in the Swiss region around Baden. Four lanes are reduced to two in the Zurich direction. The upshot: traffic is forced through the Baregg Tunnel with all the consequences of such a bottleneck – traffic jams, accidents, and intolerable noise and air pollution for those living nearby. No wonder, for since the twintube Baregg Tunnel opened in 1970, traffic through it has increased more than six-fold. In order to ease the situation, the building department of the Aargau Canton with Federal and other support is building a third tube for the Tunnel. It will lie to the north of the two existing tubes and have three lanes, which will normally be for traffic towards Berne.

The construction of the Dättwil Bridge, planned to guarantee the smooth in- and outflow of traffic for the third tunnel tube once it is opened, began in March 2000 and was completed after only eight months. This was an extremely short time for a bridge some 214 metres long requiring 1,450 m² of structural concrete with 170 tonnes of steel reinforcement, 43 tonnes of reinforcing steel for the pre-stressed concrete and 315 tonnes of structural steel. Time was at a premium, even though the third tunnel tube was not scheduled to open until 2004, for after its completion the bridge was to be an access route and installation base for the tunnel heading operations and construction of the third tunnel tube. The choice of a site-assembled three-dimensional truss structure was based on studies carried out at the preliminary stage. This is a modern bridge type, innovative in both its composite construction and assembly technology, which had until recent years been overshadowed by the prestressed concrete bridge. Dr. Hans-Gerhard Dauner, whose engineering office was responsible for planning a very similar type of bridge on the Swiss A1 near Lully*, sees both pragmatic and aesthetic reasons for this renaissance: "As far as durability is concerned, prestressed concrete bridges have failed to meet all the expectations placed in them, but composite bridges have exceeded them. The corrosion argument is no longer an obstacle, now that the qualities of corrosion protection are more fully appreciated. At the same time, we are also witnessing a revival of interest in the wide possibilities open to the designers of steel constructions, as seen especially in the 19th century truss bridges with their wealth of fine lattice cagework." The client praises the Dättwil Bridge project in its publications:

"The truss girder makes the bridge appear light, gives it character, and a contem-porarary look." Associations with natural tree trunks and branches soon come to mind, and are intended, given the bridge's scenic setting.

What characterises this type of bridge is above all the super-structure. It is a three-dimensional truss structure formed from circular MSH sections and V & M TUBES, which were supplied for this project via the steel merchants Brütsch Ruegger AG, Regensdorf (CH). The road deck lying on the truss is made of concrete. With this type of bridge, the truss and the concrete deck are finally joined together in a forcelocking style so that they function structurally as a composite section. The truss girders themselves have a triangular cross section. Two steel tubes each 324 mm in diameter and between 16 mm and 36 mm in wall thickness form the overarch. The underarch is an MSH section 508 mm in diameter with walls 50 mm thick. Both inclined planes are in 267-mm-diameter tube and they form the latticework as seen from the side. In all, the truss is over 200 m in length and was prefabricated in 13 individual sections at the steel fabricators', Zwahlen + Mayr SA in Aigle. Parts weighing between 15 and 35 tonnes were transported to the construction site on special trucks and assembled there with a mobile crane. Continuous welds were used for all of the lattice girder joints and they were sub-sequently tested using ultrasonic equipment.

The road deck is also worth mentioning, for its prefabrication in individual concrete elements is a key to the bridge type's cost and scheduling advantages. Longitudinally and transversely prestressed slab segments (unit weight approx. 48 tonnes) 3.2 metres long, 15.9 metres wide and, on average, 38 cm thick, were aligned on the side and then lifted in their final position with the aid of a crane.
This, too, is a special technique which was developed and finetuned in order to synchronize the deck construction with the swift laying of the steel supports. In August 2004, there was at last light at the end of the tunnel! The third tube opened to traffic and the beautiful Dättwil Valley Bridge has now eventually come into its own: a fine approach to the tunnel that eases traffic stress on the busy roads between Berne/Basle and Zurich.

Commissioned by: Building Department of Aargau Canton (CH)
Project author: Dr. Hans G. Dauner
Planning and works supervision: Ingenieurgemeinschaft

Fig. 5: Dättwill Bridge - Swiss

(INGE) Bänziger + Bacchetta + Partner, Baden (CH); Dauner Ingenieurs Conseils SA, Aigle (CH)
General contractor: Rothpletz, Lienhard & Cie AG, Aarau (CH)
Structural steel: Zwahlen & Mayr SA, Aigle (CH)
MSH sections: 352 tonnes of MSH sections in dimensions/wall thicknesses 101.6 x 10 mm to 508 x 50 mm; Material S355 J2H
-Further information on the Internet: www.baregg.ch

Bridge over Nesenbach Valley - Lightness is Key

An architecturally remarkable bridge, which exploits the structural and creative advantages of a lattice of structural hollow steel sections (MSH), has been constructed in Stuttgart.

Increasingly, builders, planners and the population at large are becoming attuned to environmental concerns – and as a result, they want road and bridge construction projects to provide innovative structural solutions. These projects must be integrated into the landscape as carefully as possible — without compromising on operational and cost issues. For instance, if inner city and town centre road traffic comes to a standstill, planning offices have no option but to carry out building work. Bypasses, detours, bridges and tunnels can improve traffic flow – but they often pass through previously undeveloped areas. This calls for creative compromises that take account of both the need to protect the environment and the need for smooth traffic circulation.

The Stuttgart based civic planners showed great sensitivity to these issues by unanimously voting in favour of design by Schlaich Bergermann and Partners, in a competition among five engineering companies. The brief was to design a navigable bridge around 150 m long, which would form part of the 1.9 km east bypass and help reduce traffic in the Vaihingen district of Stuttgart. A major factor in the design brief was the bridge’s location: the bridge would have to cross the Nesenbach Valley, a largely unspoilt fruit-growing area, which also serves as a “green belt” for Stuttgart. The winning entry’s sensitivity to the surrounding landscape was a major factor in the decision taken by the prize jury.

For outsiders, this shrewd decision is easy to understand: the lightness and transparency of the completed bridge gives it maximum visual integration into its surroundings. The bridge spans the valley by means of a widely spaced truss structure made of steel tubes, whose appearance recalls branching trees. The supporting structure rests on centred individual supports formed of steel tubes that are grouped together in tree-like fashion. On top of the supporting structure is the two-lane 7.50 m-wide concrete roadway. The basic concept of lightness also shaped the execution of the noise
barrier: It consists of steel tube bends mounted on the roadway at intervals of around 5 m. The gaps are filled with adjustable sound barrier slats. Above this, on the oval tunnel formed by the steel tube bends, is a second service level, with a 3.50 m wide pedestrian and cycle path that links up to the existing path network and benefits non-traffic users.

Why have very few bridges so far been built with this delicate steel tube/concrete combined structure? This question highlights a special design and construction feature of the Nesenbach Valley bridge: Instead of conventional, i.e. welded joints, it has circular MSH sections joined by means of steel castings. This kind of joint does away with the need for complex cut shapes at the tube ends. Instead, the straight-cut MSH sections are simply joined directly at the specially shaped cast joints. The section and casting form an extremely strong joint, which can be processed very cost-effectively, and also requires little maintenance to protect it against corrosion. The engineers at Schlaich Bergermann and Partners – specialists in bridge construction, among other areas – are convinced that this technology can be used to build bridges with highly demanding structural engineering requirements. Proof of this can be seen in the Humboldt hafen Bridge at Lehrter railway station in Berlin – the first railway bridge built with a support structure using steel tube-steel casting technology, based on another design by this Stuttgart-based company.

For construction projects where form, function and surroundings are equally important to the overall architecture, the intelligent use of structural hollow sections from V & M TUBES can play a major part in the design. MSH sections can be used as a visual design element, in the form of truss structures, or accentuated using colour – and can be used to support a wide variety of wall thicknesses, without detriment to the structure’s outward appearance. Structural hollow sections make it possible to build elegant, delicate and yet extremely strong structures that are visually pleasing and have minimum impact on their surroundings. But their greatest strength is their lightness!

Fig. 6: Bridge over Nesenbachtal – Stuttgart – Germany

What price aesthetics?

Aesthetic impact and harmonious integration in the landscape are important criteria in any assessment of bridge structures. Alongside such considerations, however, the costs must not be forgotten – especially when money is in short supply.

Viewed purely in terms of absolute cost, a conventional reinforced concrete or composite steel bridge is less expensive than a bridge constructed using cast steel joints and hollow sections.
However, the difference in costs is not excessively disproportionate, as the diagram shows. The diagram is taken from the reprint “Entwurf und Gestaltung von Ingenieurbauwerken – Brückenbau – Großer Beleg” of the Institut für Tragwerke und Baustoffe of the Technische Universität Dresden, and expanded using examples of tube structures. The diagram shows the manufacturing costs ($3/\text{m}^2$) as a function of the effective bridge area ($\text{m}^2$). The cost spectrum of conventional bridges usually lies between the two dotted lines. It can be seen that the cost of bridges with cast steel joints tends to be in the top part of this range, but is still at an acceptable level. A cost analysis must take into account that each bridge structure is a specific, individual design, and that local circumstances and the purpose for which the bridge is built cannot be ignored. It is difficult to compare an autobahn viaduct with a pedestrian bridge, simply because of the difference in their widths. Moreover, a spectacular solution in an exposed location cannot be judged by the same criteria as other structures. Examples of such solutions include the Kronprinzenbrücke (Crown Prince Bridge) in Berlin and the Ripshorst cycle and pedestrian bridge near the new city centre of Oberhausen. In the case of the Humboldt harbour bridges it must be remembered that they were the first to be constructed by a totally new method, and the specifications of Deutsche Bahn AG, which commissioned them, necessitated extensive, large-scale, preliminary load-bearing and fatigue tests.

![Bridge construction costs](image)

**Fig. 7: Bridge construction costs**

Research and development in bridge building

An overview of current FOSTA and CIDECT projects

Spatially resolved framework structures made of hollow steel sections offer constructional and design advantages that have increased their popularity, also for bridge building. However, the dimensions of the sections used in bridge building are not covered by the current general rules. It was therefore necessary to initiate a whole series of projects to obtain the missing information and rules, thus providing planning engineers with the tools they need. These research projects are carried out both nationally and internationally. In Germany they are usually under the overall control of FOSTA (Forschungsvereinigung Stahlanwendung e. V.) while, on the international level,
CIDECT (www.cidect.com), an international association of leading manufacturers of hollow sections and pipes, is usually in charge.

The following projects are currently in progress:

1. Extending the life of existing and new steel structures (Refresh), FOSTA project P702

This project is studying the extent to which the life of a structure subject to fatigue can be extended by post-welding treatment. Two high-frequency hammer methods have been developed, whose effectiveness is being tested. These are the UIT (Ultrasonic Impact Treatment) and HiFit methods (High Frequency impact treatment). The HiFit method differs from the UIT method in that the impulse is not introduced contact-free but by means of a mechanical drive.

2. Scale effects on welded hollow section joints, CIDECT project 7Z

The existing rules are based on the results of research carried out many years ago. Only relatively small external dimensions and wall thicknesses were examined. If hollow sections are to be used in bridge building, information is needed about larger sizes and wall thicknesses.

3. Amendment and extension of the general rules for hollow section joints in Eurocode 3 and the CIDECT Design Guides for steels up to S690, CIDECT project 5BT

In the past very few test results were available, if any, for higher strength steels. For the first version of EN 1993-1-8, therefore, the general rules were formulated to be on the safe side. The tests carried out since then for proposed bridge projects show, however, that – at least in wide parameter ranges – the reduction factors specified for steels S460 and S690 are not necessary or can be revised downwards. This means that economic solutions are possible using these steels.

4. Economic construction of road and rail bridges made of hollow steel profiles, FOSTA-project P591

This research project can now be closed. Publication of the final report is imminent. It can then be obtained from FOSTA (www.stahlforschung.de). The following aims were formulated within the framework of this research project:

- Guideline to selecting the type of joint (welded joints or cast steel joints) and optimising design details
- New S/N curves for various details
- Recommendations about the selection of materials and notch tolerances in relation to the predicted load (static, dynamic, stress range)
- Competitiveness of steel by reducing fabrication costs of framework structures made from hollow sections
- Promotion of steel structures through improved design methods

This research report gives planning engineers a guideline with which they can structure and design bridge projects using hollow steel sections step by step in an economically meaningful manner.