5.5 Examples and Applications

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5.5.1 Fast Bridge 48 Military Bridge, Sweden [Höglund]

5.5.1.1 General description

Fast Bridge 48 is a 48 m single-span bridge system for loads up to Military Class 70 (MLC70, approximately 64 metric tonnes) according to North Atlantic Treaty Organization (NATO) standards. The bridge is made of extra high strength steels (HPS steels S960 and S1100) and can be deployed in less than 90 minutes and retrieved in the same time from either side of a river or dry gap.

The bridge is the result of about eight years of research and development in cooperation mainly between the Swedish Defence Material Administration (FMV) and Karlskronavarvet AB. The design is patented.

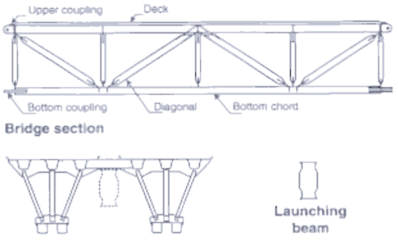

Fig. 5.5.1: Cross section of the Fast Bridge 48

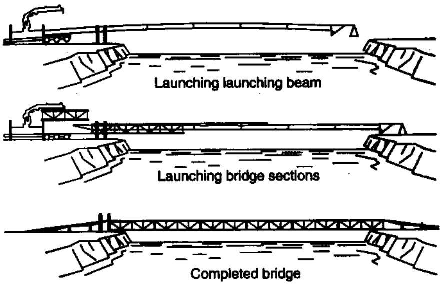

Fig. 5.5.2: Launching procedure of the Fast Bridge 48

5.5.1.2 Conceptual Design

The span length can range from 32 m to 48 m, made up by four to six 8 m sections, width 4 m and depth about 1.6 m, see Figure 5.1.1. The deck is made of a plate of S1100, thickness 5 mm, which is stiffened by cold-formed channel sections with web folds. Also the bottom chord is made of cold-formed sections whereas the diagonals in the truss are made of S460 rectangular hollow sections. The coupling plates are made of 50 mm S960 plates. The Fast Bridge 48 required steel with 1100 MPa in yield point and impact toughness 40 J at -40°C. Such steel is not included in existing regulations which is why it was necessary to verify whether existing criteria for the design and manufacturing methods were valid. Extensive tests on components concerning local and distortional buckling were made as well as fatigue tests and static tests on welded components and examination of welding procedures. For instance, it turned out that the Swedish Code for cold-formed structures was applicable, in spite of exceeding the strength and thickness limits in the code to a great extent.

5.5.1.3 Benefit of High Strength Steel

As there are no limitations of the deflections of military bridges the strength of HPS steels can be fully utilized. This results in a light-weight structure which can compete with aluminum alloys and polymers. The great benefit commonly gained with modern steel with improved performance is:

- weight savings
- increased life
- reduced fabrication costs

A further development of the bridge makes it possible to span up to 200 m with intermediate supports dropped from the bridge during launching.

5.5.1.4 Reference Data

Owner: Swedish Armed Forces
Purchaser and project manager: Swedish Defense Material Administration
Steel designer: Kockums AB, Karlskronavarvet and Royal Institute of Technology, Stockholm

5.5.2 Hybrid Girder Bridge, Mittådalen, Sweden [Collin]

5.5.2.1 General Description

The bridge is located in Mittådalen in the middle of Sweden. It replaces an outdated existing bridge at the same site.

5.5.2.2 Conceptual Design

The bridge is simply supported with a span of 25.6 m, and a free width of 7 m. The girder height is 1245 mm, and the steel weight 103 kg/m^2 deck area. The cost of the steel contract was 43.4 kEUR, including bearings. Since the site is located far away from the nearest concrete plant, the deck of the bridge was prefabricated, with joints cast in situ. At the abutments, back-walls are connected to the end-plates of the bridge with headed shear connectors. The bridge rests on four steel roller bearings, with a roller diameter of 180 mm. The use of S690 in the bottom flange meant that the following design criteria were met at the same time:

- The Ultimate Limit State
- The Serviceability Limit State (no yielding)
- The Serviceability Limit State (δ<L/400)

Hybrid girders are now included in the Swedish Bridge Code. The limitation is mainly that the effective area of the web is based on the yield strength of the stronger flange plates, which must not exceed 1.5 times the strength of the web plate.

Fig. 5.5.3: Mittådalen hybrid bridge girder

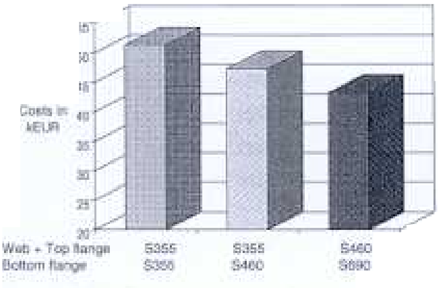

Fig. 5.5.4: Comparison of costs

5.5.2.3 Use and Benefit of High Strength Steel

By using S690 in the bottom flange, the following advantages can be obtained:
- smaller butt weld volume
- cheaper steel plates
- easier handling and transport
- smaller area to paint

One limitation for the concept with HPS can be that the time for delivery of material might be critical. Furthermore, on heavily trafficked roads, the fatigue strength may very well govern the dimensions of the flanges.

5.5.2.4 Reference Data

Owner: National Road Administration
Steel designer: Scandiaconsult, Luleå
Steel contractor: DEM-VERK MEK AB

5.5.3 Road Bridge over the River Rhine at Düsseldorf-Ilverich, Germany [Müller]

5.5.3.1 General Description

The Rhine bridge Düsseldorf-Ilverich is a cable-stayed road bridge of the highway A44 near Düsseldorf (Figure 5.5.5). The bridge was built in the period 1998 – 2002. For the steel structure 7180 t of steel grade S355 and 520 t of grade S460 were used.

Fig. 5.5.5: Rhine bridge Düsseldorf-Ilverich

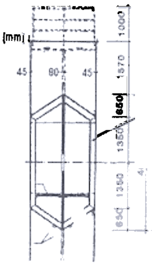

Fig. 5.5.6: Cross section of tension ties made of S460 TM

5.5.3.2 Conceptual Design

The main span of the bridge consists of two V-shaped steel pylons supporting the main girder by steel cables. The V-shaped pylons were necessary in order to keep the height of the towers small because of the proximity to the Düsseldorf-Airport. The approach bridges were made in prestressed concrete and the piers in reinforced concrete.

5.5.3.3 Use and Benefit of High Strength Steels

In order to transmit the horizontal cable forces between the two sides of the V-shaped pylons, they are connected in the upper part by tension ties consisting of a welded hollow steel cross section see Figure 5.5.6. For these tension ties a thermo-mechanical rolled steel grade S460ML was used for two reasons:
- minimum plate thickness to keep the weld volume for butt welds small
- welding without preheating

Both arguments helped to improve the economy and the quality of welds.

5.5.3.4 Reference Data

Owner: Federal Republic Germany, represented by Straßenbauverwaltung Nordrhein-Westfalen
Steel contractor and designer: Stahlbau Plauen

5.5.4 Composite Bridge near Ingolstadt, Germany [Müller]

5.5.4.1 General Description

This composite highway bridge near Ingolstadt is a multi-span bridge having span lengths of 24.0, 5×30.0 m and 20.0 m, carrying a 15.0 m wide concrete slab, see Fig. 5.5.7. The bridge is designed as an integral structure where the steel girders are directly connected to the columns by flexible steel plates, meaning that no bearings were needed.

Fig. 5.5.7: Composite bridge near Ingolstadt, Germany

Fig. 5.5.8: Detail of the bridge bearing

5.5.4.2 Use and Benefit of High Strength Steels

For the semi-rigid connections between the composite piers and steel girders lamellas of steel grade S690QL was used, see Fig. 5.5.8. In order to ensure a semi-rigid connection the flexible steel plates must be designed for the following requirements for stiffness and strength:

- The plate thickness must be small enough to reduce restraints from translatory and rotatory movements of the structure at the columns.
- The plates must be thick enough to resist the normal forces and the restraining moments from movements safely.

These contradictory requirements lead to an optimization problem which was satisfactorily solved by using S690QL.

5.5.4.3 Reference Data

Owner: IFG Industrie-Förder-Gesellschaft, Ingolstadt, Germany
Steel designer: Hilzinger Bettcher-Zeitz Habisreutinger, München, Germany
Steel construction: Max Bögl, Bauunternehmung GmbH&CoKG, Neumark, Germany

5.5.5 Roof Truss of the Sony Centre in Berlin, Germany [Müller]

5.5.5.1 General Description

Various storeys of a hotel building at the Sony Centre in Berlin are suspended from a roof truss to protect an old masonry building from overloading with the "Kaisersaal" integrated in the hotel building, see Fig. 5.5.9.

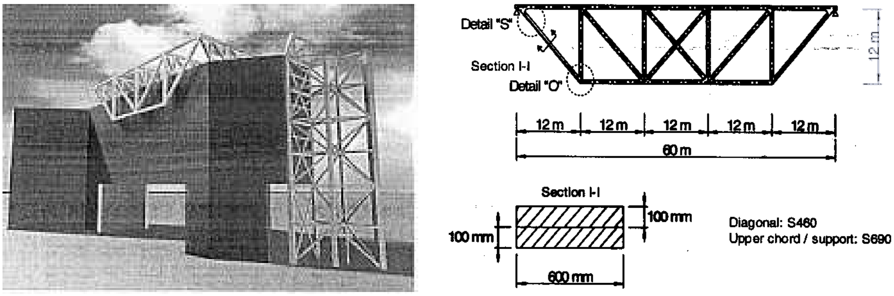

Fig. 5.5.9: Overview on the roof truss of the Sony Centre in Berlin, Germany

5.5.5.2 Use and Benefit of High Strength Steels

The truss structure composed of components with a solid rectangular shape was made of steel grade S460 and S690. High strength steel was used to keep the dimensions of the cross sections small that were provided with an envelope for fire protection.

5.5.5.3 Verification to avoid Brittle Fracture

The verification to avoid brittle fracture at low temperatures was performed by calculation according to the European design code EN 1993-1-10 [5.5] assisted by testing. The structural detailing and the dimensions of the "large scale test specimens" are given in the following figure.

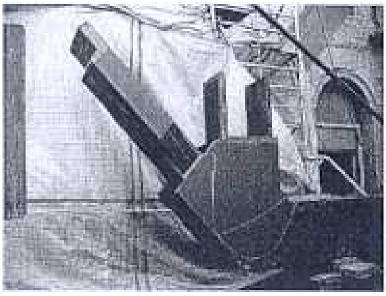

Fig. 5.5.10: Truss joint of the roof structure

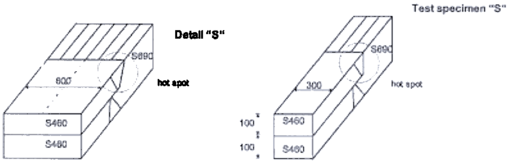

Fig. 5.5.11: Test specimens for the verification to avoid brittle fracture

5.5.5.4 Reference Data

Owner: Sony
Steel contractor: Waagner Biró Binder AG, Wien, Austria

5.5.6 Millau Viaduct, France [Schröter]

5.5.6.1 General Description

This 320 million Euro viaduct is the last link in the French highway A75 between Clermont-Ferrand and Béziers closing a gap across the valley of the river Tarn next to the city of Millau. The search for an aesthetic solution led to the adoption of a multi-span cable stayed bridge with a light steel deck crossing the river at a height of 270 m. With a total construction height of 343 m the bridge takes the world record of the highest bridge in the world.

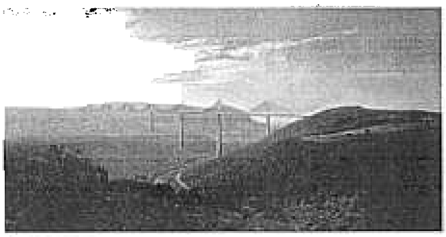

Fig. 5.5.12: Visualisation of the Millau Viaduct

Fig. 5.5.13: Launching with pylon

5.5.6.2 Conceptional Design

The 2460 m long deck is composed of 6 main spans of 342 m each and two side spans of 204 m each. The deck is composed of a steel girder with a total height of up to 4.20 m and a total width of 32.00 m in order to optimize the resistance against high wind loads in the valley. The cross section consists of a central box, which is also linked to the steel pylons, lateral connecting panels as well as lateral side boxes. Boxes and panels are stiffened by trapezoidal stiffeners. The 7 steel pylons are erected in an inverted Y-shape and hold two times 11 cables each.

Fig. 5.5.14: The cross section of the bridge

5.5.6.3 Use and Benefit of High Strength Steel.

In total 43,000 t of steel plates have been applied for the deck and the pylons. High-strength steel grade S460ML (nominal yield stress of 460 MPa) has been used for the entire central box and some connecting elements with a thickness up to 80 mm in order to:

- resist high loads without increasing the amount of steel used,
- reduce cantilever bending moments during launching of the bridge,
- apply a more efficient welding process,
- reduce transport weights from the workshop to the site,

Furthermore, the pylons have been constructed in S460ML steel grade in a thickness of up to 120 mm.

5.5.6.4 Launching

The deck was launched from platforms on either side of the river Tarn. The deck was equipped with a launching nose and with one pylon at each end in order to increase stiffness during launching. With the use of auxiliary piles in the middle of each span the launching cycle was 171 m. After connecting the two deck spans the five remaining pylons were welded together, brought to their final position and erected. Then the cable-stays were assembled and tightened and the auxiliary piles removed.

5.5.6.5 Reference Data

Owner: Eiffage Group, France
Steel designer: Greisch, Belgium
Steel contractor: Eiffel Construction Métallique, France

5.5.7 Verrand Viaduct, Italy [Miazzon]

5.5.7.1 General Description

The Verrand viaduct is an orthotropic deck bridge, part of the Mont Blanc-Aosta highway, located in the third building lot, Mont Blanc Tunnel-Morgex. In particular, the viaduct is located at Prè Saint Didier (Aosta), near Courmayeur, at the side of the existing S.S.26 (Mont Blanc Tunnel-Aosta) and it is necessary to overpass the valley with the country road and the Dora Baltea river. It was finished in August 2002 after 2 years of work and with a total steel quantity of 6100 t. More information is given in [5.36]

Fig. 5.5.15: Connection of the bridge parts, built in two different yards (Aosta and Mont Blanc sides)

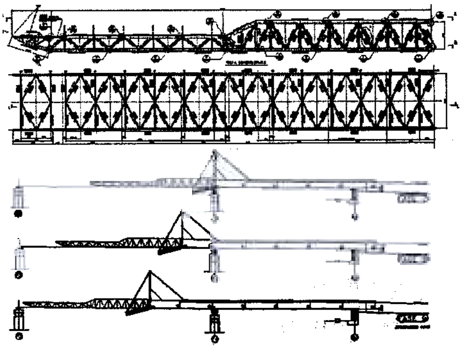

Fig. 5.5.16: Lattice launch girder using S690. Lateral prospect and plan – Some launching phases

5.5.7.2 Conceptual Design

The possible structural alternatives were all characterized by the choice to realize a unique motorway viaduct for all the roadways, with width of around 20 m. It was decided to use an orthotropic deck bridge, with two principal beams and interior bracing, of five spans, respectively, 97.5+135+135+135+97.5 m, with four intermediate piers.

5.5.7.3 Use and Benefit of High Strength Steel

The lattice launch girder with a length of 85 m was realized using high strength steel tubular sections of grade S690. Thereby the weight of the launch girder could be significantly reduced which finally allowed a design process of the final steel-deck bridge with no changes in cross sectional dimensions because of the launching process.

5.5.7.4 Reference Data

Owner: R.A.V. (Valley of Aosta highway) S.p.A., Rome, Italy
Steel designer: SPEA S.p.A., Milan, Italy
Steel contractor: OMBA I.&E. S.p.A., Torri di Quartesolo, Vicenza, Italy

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