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The Largest Steel Bridge across the Changjiang under Erection

Le plus grand pont métallique en construction sur le Changjiang

Bau der grössten Stahlbrücke über den Changjiang

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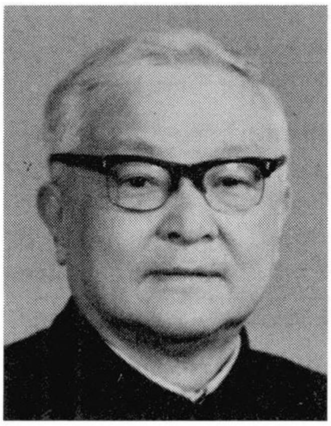

Yu Cheng Zhao, born 1929, obtained his Civil Engineering Degree at Shanghai Jiao-Tong University, China in 1950. Since then he has been engaged in bridge design and construction. Currently, he is a deputy chief engineer of Major Bridge Eng. Bureau and in charge of the construction of the bridge described.

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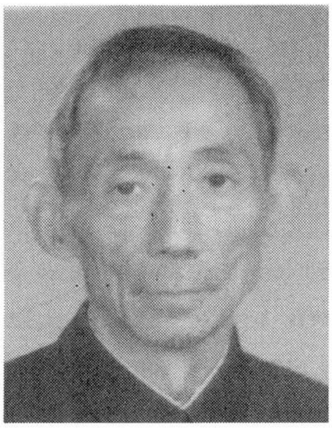


Qin Han Fang, born 1926, obtained his Civil Engineering Degree at Tsinghua University, Beijing, China in 1950. He has served as a bridge designer for 40 years. Fang, now in Major Bridge Eng. Bureau, is responsible for the design of the bridge described and also a visiting professor of Changsha Railways Institute.

SUMMARY

The bridge described is the largest rail-cum-road bridge ever built over the Changjiang River in China. The bridge proper is composed of 11 spans in which the main spans are rigid continuous truss girder strengthened with flexible arches, which incorporates a unit of 3 spans of 180+216+180 m. The side spans of the bridge proper are erected with the free cantilever erection method with the aid of stay cables strung from a temporary tower and the two sections of the bridge spans erected from both sides of the river are to be joined up in the middle of the largest span.

RESUME

Cet article fournit la description d'un pont combiné rail-route. Il s'agit du plus grand pont en construction sur la rivière Changjiang, à Jiujiang en Chine. L'ouvrage proprement dit se compose de 11 travées, dont les travées principales sont constituées par des poutres rigides continues en treillis et renforcées par des arcs flexibles; il comporte en outre 3 travées de 180+216+180 m de portée. Les deux travées latérales sont construites par encorbellement à l'aide de haubans reliés à un mât provisoire; les deux parties de pont, construites sur chaque rive, font leur jonction au milieu de la travée centrale.

ZUSAMMENFASSUNG

Dieser Beitrag behandelt eine kombinierte Eisen- und Autobahnbrücke über den Changjiang-Fluss in Jiujiang, China. Der Stahlträger der Strombrücke weist insgesamt elf Öffnungen auf und das Hauptfeld besteht aus einem Fachwerk mit drei durchlaufenden Stützweiten von 180 m, 216 m und 180 m. Die vollauskragende Montage des Stahlträgers vom Seitenfeld her verwendet das Hängseilgerüst mit dem schrägen Abspannseil als Hilfseinrichtung. Der Brückenträger wird in der Mitte der grössten Brückenöffnung zusammengefügt.

The Jiujiang Changjiang River Bridge, located at the foot of the Loushan Mountain - a picturesque tourist resort in Jiujiang city, Jiangxi province, is the fourth rail-cum-road bridge and also the largest one among those spanning across the Changjiang River in China. The bridge proper consists of 11 spans totalling 1806.6 m in length. The railway approach composed of 109 spans on the left bank and 35 spans on the right bank is a prestressed concrete box girder without ballast and sleeper which measures 39.6 m long for each span. The highway approach composed of 32 spans on the left bank and 33 spans on the right bank is a prestressed concrete T-girder which also measures 39.6 m long for each span.The total length of the bridge along the railway and highway decks is 7675.4 m and 4460 m respectively.

The steel truss girder of the bridge proper is arranged in 4 units as shown in Fig.1. The main spans are of rigid continuous truss girder strengthened by flexible archs,which incorporates a unit of 3 spans of 180+216+180 m. The side spans flanking left and right of the main spans are respectively of 2 units of 2X162 m and a unit of 2X126m continuous truss girder.The principal part of the structure is designed as Warren truss with verticals. The height of the truss is 16 m and the panel length is 9 m. The third stiffening chords to increase truss height by 14 m for side spans and 16 m for main spans are provided near the supports. The main spans are also strengthened with stiffening-flexible archs with the rise of the archs over the 180-m span being 24m and over the 216-m span 32m counted from the centre of the upper chord. The width of the truss is 12.5m centre to centre. The railway is arranged on lower deck while the highway on upper deck,see Fig.2.

The main kind of steel used for the truss structure is of 15MnVN normalized low-alloy steel with yield strength reaching 420 MPa. The maximum thickness of the steel plate is 56 mm. The plate thickness of this kind of steel has been proved not to obviously influence the mechanical properties of the steel through testing. In order to improve the weldability of the steel, the contents of C, V, N are decreased to appropriate amounts and the detrimental impurities are minimized wherever possible.

The 15 MnVN steel is classified into three grades of A, B, C in which grade C is the best and used for members against tensile force and fatigue. The chemical compositions and mechanical properties of the steel are given in Tables 1 and 2.

The low-temperature impact values and the aging impact values in Table 2 hereinafter are from U-notch tests. The aging samples are taken at right angles to the rolling direction. The cold-drawing deformation of the samples for aging impact testing is 10%, and the samples are then kept hot for 1 hour under temperatures of 250°C.The aging impact values are thus obtained after dry colding and the actual mean values of the mechanical properties are based on tests of 780 samples of 15 different plate thickness ranging from 16 to 56 mm. The 5 indices of the steel plate of different thickness are found almost the same.

Table 1 Analysis of Chemical Compositions of Grade C Steel

Chemical Compositions (%)	C	Si	Mn	P	S	V	N
Accepted Standard in Contract	<0.18	0.2/0.6	1.3/1.7	⩽0.02	⩽0.015	⩽0.18	⩽0.018
Desired Standard	⩽0.16	0.2/0.6	1.3/1.7	⩽0.02	⩽0.015	0.1/ 0.16	0.01/ 0.015
Actual Mean Value	0.1585	0.3978	1.5208	0.0160	0.0095	0.1375	0.0122
Standard Deviation	0.0131	0.0476	0.0699	0.0047	0.0040	0.0075	0.0024

Table 2 Analysis of Mechanical Properties of Grade C Steel

Mechanical Properties	Yield Strength (MPa)	Ultimate Strength (MPa)	Elongation (%)	-40°C Impact Toughness (J/cm^2)	Aging Impact Value (J/cm^2)
Accepted Standard in Contract	⩾420	⩾560	⩾19	⩾50	⩾50
Desired Standard	⩾420	⩾560	⩾19	⩾70	⩾70
Actual Mean Value	449.68	606.83	23.05	94.43	98.35
Standard Deviation	26.58	30.51	2.62	21.72	29.67

The cross sections of most truss members are of H shape. Only the compression diagonals and arch ribs are of box members. In addition to the 15 MnVN steel,the 16 Mn steel with yield strength being 340 MPa is also used.The contour width of the principal truss members is 720 mm, the maximum height is 1120 mm.The welding parameters of the shop-made members, such as the linear energy input, are determined by technological procedure tests and the extension bars are regularly used to check if the mechanical properties of the welded joint are up to the quality requirements. The test results of fillet welding of 15 MnVN grade C steel checked by using extension bars are given in Table 3.

The steel templates with machined bushings are used for drilling field connection holes. The holes in some gusset plates with complicated dimensions are to be drilled with the computer-aided numerically controlled drilling machines.The members used are interchangable and checked by trial assembling in shop.The surfaces for field connection are shot-blasted and coated with sprayed aluminium before delivery. The slip factor in shop would not be less than 0.55.

Table 3 Meachanical Properties of Fillet Welding of Extension Bar

Yield Strength (MPa)	Ultimate Strength (MPa)	Elongation (%)	Cold Bending d=3a	-40°C Impact Toughness (J/cm²)		Aging Impact Value(J/cm²)	
				Weld Metal	Fusion Zone	Weld Metal	Fusion Zone
504 / 603	623 / 698	21 / 27	Qualified	50 / 108	75 / 145	48 / 76	53 / 81

The M27 high-strength bolts are used for connecting members of the principal truss and the M24, M22 (Steel 20 MnTiB) bolts for those of the remaining parts. These bolts should be brought through the wedge load tests before they are delivered. The slope angle of wedge washer is 10°. The tensile load and fracture of the bolts should meet with the requirements stipulated in Chinese Standard Specifications.

The high-strength bolts are tightened up on site according to torque method. The M27, M24 bolts are tightened with electric fixed torque spanner while the M22 bolts by manual wrench with sound alarm.

The designed pre-tensioned forces for three kinds of bolts used in this bridge are 300 KN for M27, 240 KN for M24 and 200 KN for M22 bolts. The mean values of the torque coefficients for the bolts produced in one batch are required to be 0.110 - 0.150 with the standard deviation less or equal to 0.010.

With the exception of the first span (erected on temporary piers) on either bank, all spans over the river are erected with the free cantilever erection method in aid of stay cables strung from the tower temporarily installed on the truss over the pier support so as to decrease the erection stresses. An anchor point provided with 6 cables is set respectively on the anchor and cantilever spans for each truss when the 162-m spans are being erected, and another pair of anchor points composed of 4 cables is added when the 180-m span is being erected, see Photos 1 and 2. Each cable consists of 169 Ø5-mm high-strength wires able to carry a load of 2000 KN. The cable tower on the left side is used for erection of 6 spans by moving it forward span by span. the tower on the right side is a fixed one used for erection of one span of 180 m only. The height of the tower is

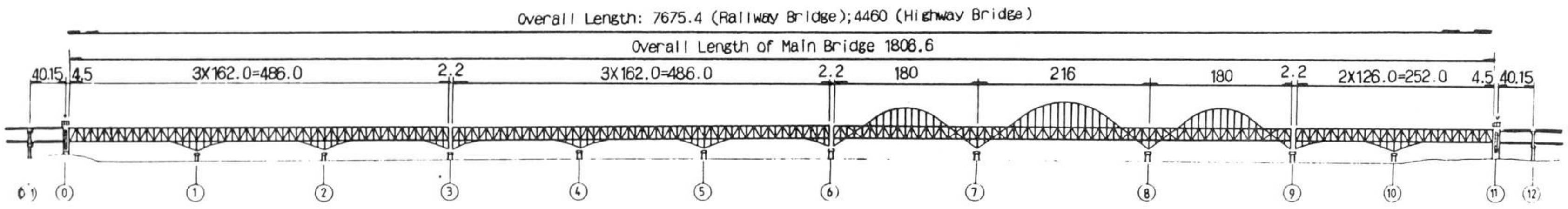
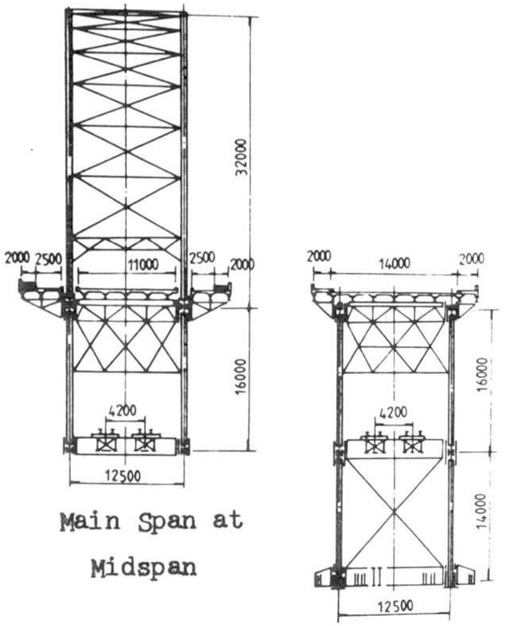


Fig.1 General Layout of Steel Truss of Bridge Proper (m)



Main Span at Midspan

Side Span over Support

Fig.2 Sectional View of Steel Truss of Bridge Proper (mm)

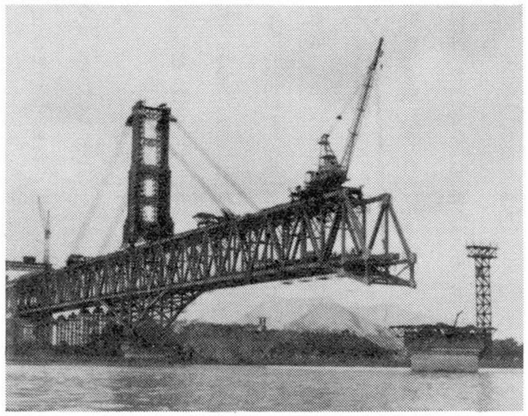


Photo 1 Full View of Steel Truss under Cantilever Erection

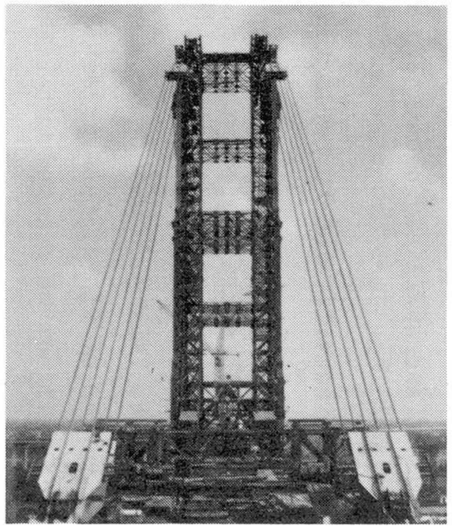


Photo 2 Side View of Temporary Cable-Stayed Tower

52.4 m, which totally weighs 934 t in which the weight of 40 cables accounts for 95.4 t, 16 anchorage housings 220 t, 32 ∅0.7-m travelling wheels and wheel box 66.1 t, column 308.9 t and auxiliary connecting members 234.7 t.

When the 162-m span is cantilevered forward, the truss is supported with the cables anchored at the place 81 m from the pier, just in the middle of the span, and when the 180-m span is cantilevered, the truss is supported with the internal and external cables anchored at 81 and 99 m from the tower. Seven and a half spans are erected on the left side while three and a half on the right side, they will be joined up in the middle of the largest 216-m span. The archs over the three longest spans will not be erected until the closure of the sections of the truss girder is completed.

The truss elevation at the two intermediate supports of the three longest spans should be raised to facilitate the closure in the middle of the 216-m span. The jacking equipment allowing the truss to move in both longitudinal and transverse directions are provided on the four supporting piers and the supplementary jacking, pulling devices are also furnished at the location where the two sections of the truss girder (216-m span) will meet. When the closure of the girder completes, the hinges are temporarily inserted and then replaced with the permanent parts, such as gusset plates, after final adjustment.

The elevations at the supports of the three longest spans will continue to be adjusted and the closure sections of the three arch ribs will be jacked simultaneously so as to make them arrive at their designed positions one by one, and the temporary hinges are then inserted, the permanent splice plates are installed. At this time, the stresses of the critical truss members should be monitored in order to avoid overloading. According to the temporary loading on the truss, the jacking forces at the closure sections and the elevation at the supports of the three longest spans are calculated, the permanent structure is gradually adjusted until it conforms to the designed internal forces, cambering and alignment.

The closure of truss spans or arch ribs should be carried out at the time when the weather is calm, without sunshine and greater temperature variation. The elevation at all supports and the jacking forces at the closure parts should be correctly calculated and checked by computer on the basis of the temporary construction load distribution and the observed deflection data. In order to ensure the closure to be completed successfully, some temporary measures may be taken in advance if necessary.