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Erection Methods for Longspan Steel Composite Bridges

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Summary

In order to reduce the time, risk and cost and in some cases, the environmental impact, longspan steel composite bridges are often erected by launching and lifting or the combination of both. The hereby obtained speed of erection is a definite advantage in comparison with prestressed concrete bridges.

1. Launching

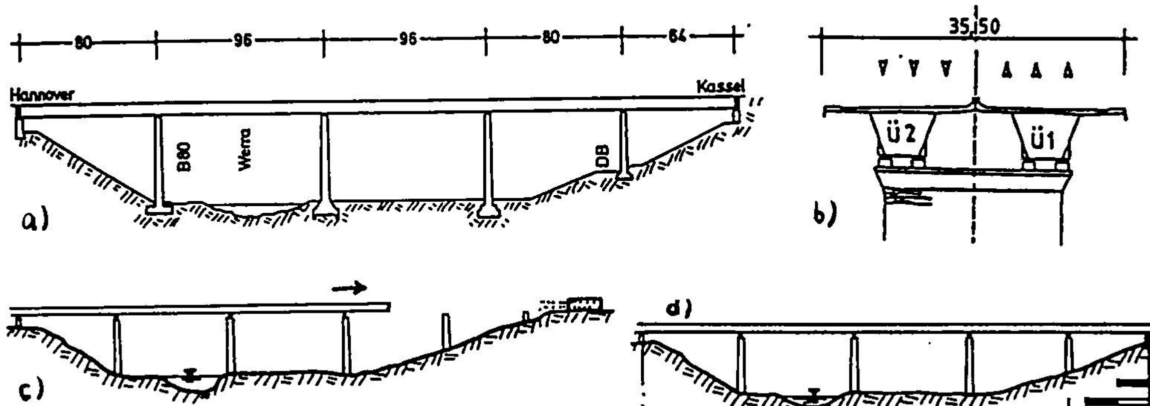
1.1 Steel Structure
Example: Highway bridge across the Werra Valley at Hedemünden Germany

1.1.1 Design

The highway bridge across the Werra Valley has spans of 80 - 96 - 96 - 80 - 64 = 416 m. The increased traffic required to widen the bridge from 21,5 m to 37,5 m. The bridge has steel composite superstructures with trapezoidal box girders. and a construction depth of 5,85 m correspondingly to 1/16,4 of the biggest spans.

1.1.2 Construction

Due to environmental considerations, the steel structure of both superstructures was launched without intermediate piers and later the roadway slab cast using the pilgrims step method, again without auxiliary piers.



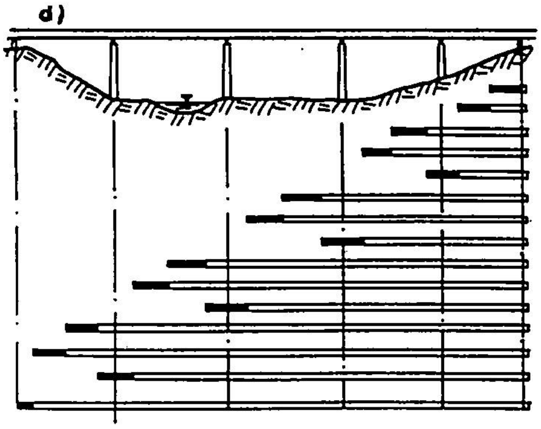


Fig. 1: Werra-Valley Bridge at Hedemünden, Germany:
a) Layout
b) Cross-section
c) Launching at the steel structure
d) Casting of the concrete slab

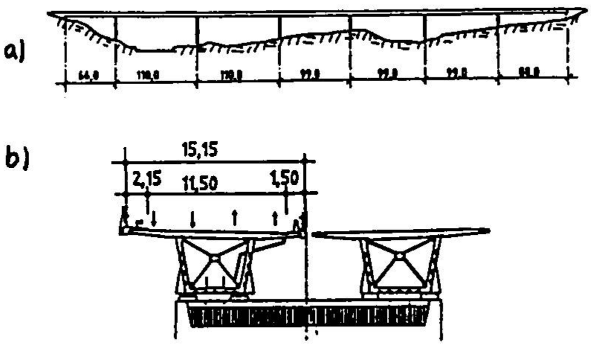
1.2 Complete Cross-Section
Example: Highway bridge at Wilkau-Haßlau, Germany

1.2.1 Design

The existing bridge, built in 1938/39 as part of the highway Chemnitz-Hof, crosses the valley of the „Zwickauer Mulde“ with spans of 69,9 - 110,0 - 110,0 - 99,0 - 99,0 - 99,0 - 88,0 = 674,9 m. The bridge deck was a plate girder with 4 webs and had a width of 24,5 m, whilst the new bridge has a width of 30,30 m. Both roadways have steel composite superstructures with trapezoidal box girders. The construction depth is 5,08 m corresponding to 1/21,6 of the biggest span, and the roadway is longitudinally reinforced and transversely prestressed.

1.2.2 Construction

Due to the extremely reduced construction time and due to the auxiliary piers required for the dismantling of the existing bridge, the complete cross-section was launched, following a proposal of the contractor.



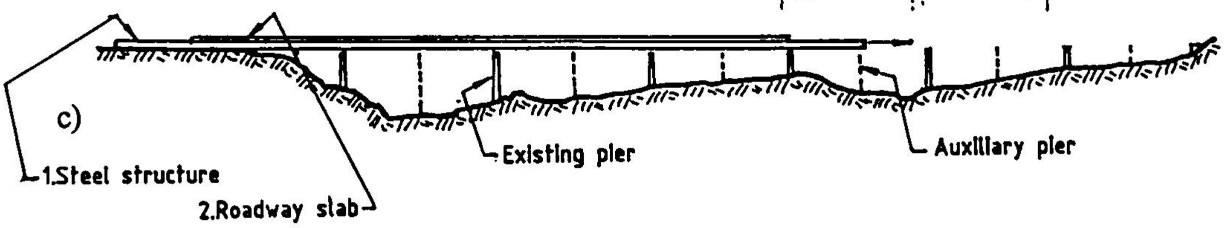


Fig. 2: Highway bridge at Wilkau-Haßlau, Germany:
a) Layout, b) Cross-section, c) Construction of superstructure

1.3 Steel Structure with Variable Depth
Example: Highway-Railway Bridge across Caroni River at Ciudad Guayana, Venezuela

1.3.1 Design

The main structure is a continuous beam with spans of 45 - 82,5 - 213,75 - 82,5 - 45 = 478,75 m, Fig. 3a. The construction depth of 5 m at the centre line and 14 m at the piers corresponds to slenderness ratios of 1:43 and 1:15 respectively.

The cross-section is a two-cell box girder in the main span and the long side spans, and an I-beam with 3 webs in the short side spans.

The bottom chord is of steel in the area of positive moments of the main span and in the short side spans, and of concrete in the area of negative moments up to the side span piers, Fig. 3b.

1.3.2 Construction

The steel erector proposed to assemble the steel structure behind the abutment and to launch it. During launching of the steel structure, the rear of the bridge deck was supported by an auxiliary pier fixed to the bridge and sliding on a runaway behind the abutment, whilst the main span slid on the intermediate and main piers respectively. The variable depth of the haunch was compensated for by an auxiliary truss girder.

a)

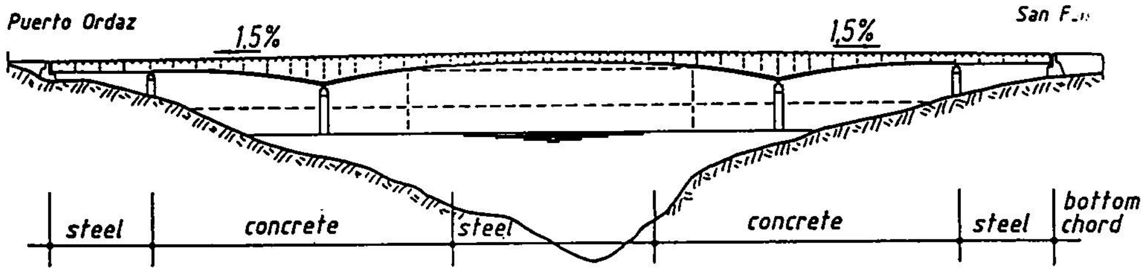
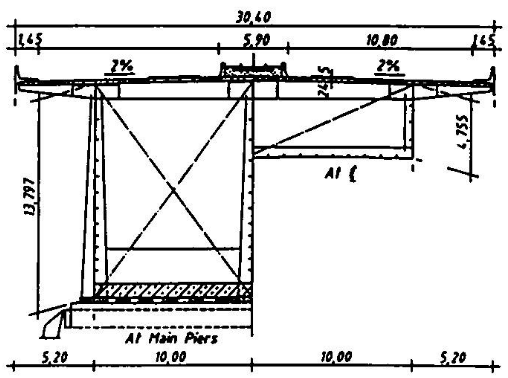


Fig.3: Highway-Railway Bridge across Caroni River at Ciudad Guayana, Venezuela
a) Layout, b) Cross-section

b)



Before casting the concrete of the bottom slab in lengths of about 14 m, the tip of the steel cantilever had to be lifted in order to reduce steel stresses virtually to zero. This was on the San Felix side achieved by an auxiliary stay cable system, and on the Puerto Ordaz side by a coupling device at the centre.

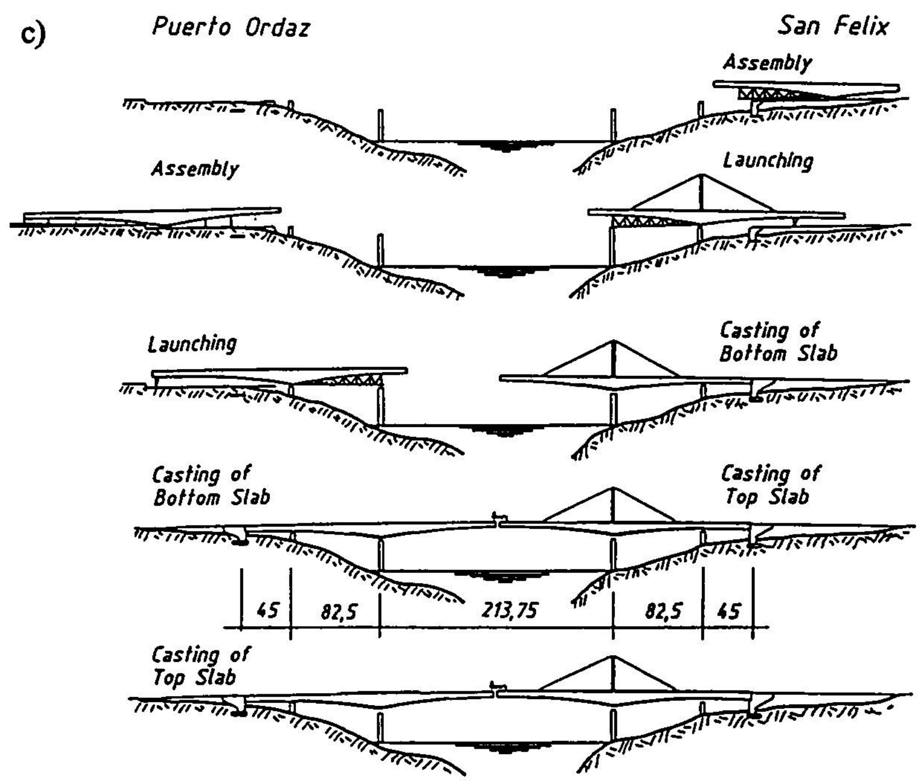


Fig. 3 Highway-Railway Bridge across Caroni River at Ciudad Guayana, Venezuela: c) Construction sequence

2. Lifting

Example: Railway Bridge across Main River at Nantenbach, Germany

2.1 Design

The double track railway bridge across the Main River at Nantenbach links the new high-speed railway line Hannover-Würzburg to the existing trunk line Würzburg-Aschaffenburg. Due to local conditions, the bridge has a slope of 1,25 % and a radius in plan of 2650 m.

For the main bridge, a continuous truss girder with spans of 83,2 - 208 - 83,2 = 374,4 m was found to be the best solution from economical, ecological and aesthetical points of view, Fig. 4. The construction depth varies between 7,66 m at the centre of the main span and at the abutments, and 15,66 m at the main piers, corresponding to slenderness ratios of 1:27 and 1:13, respectively.

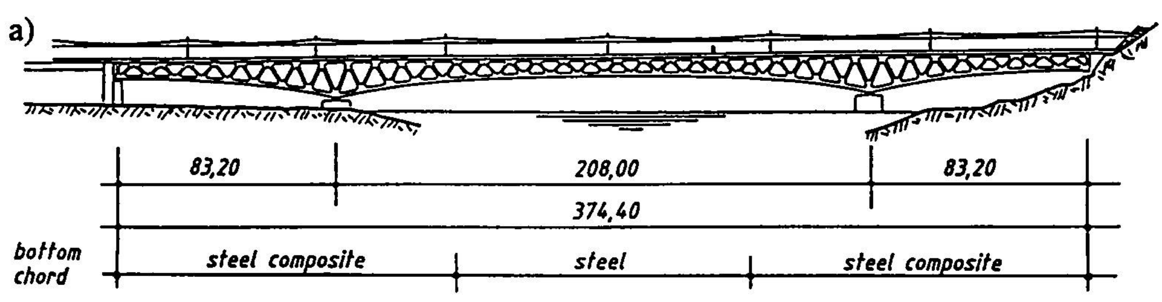
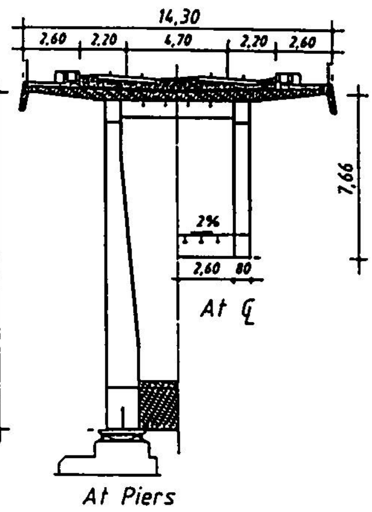


Fig. 4: Railway Bridge across Main River at Nantenbach, Germany: a) Layout

2.2 Construction

The side spans were erected on auxiliary piers, and the first 44 m of the main span steel truss were erected by free cantilevering from the main pier towards the river. After concreting the bottom chord, the central part of the main span, with a length of 140 m and a weight of about 1600 tons, was floated in and lifted, Fig. 4c. After closure of the joints, the tops slab was cast from the centre of the main span towards the abutments.

b)



c)

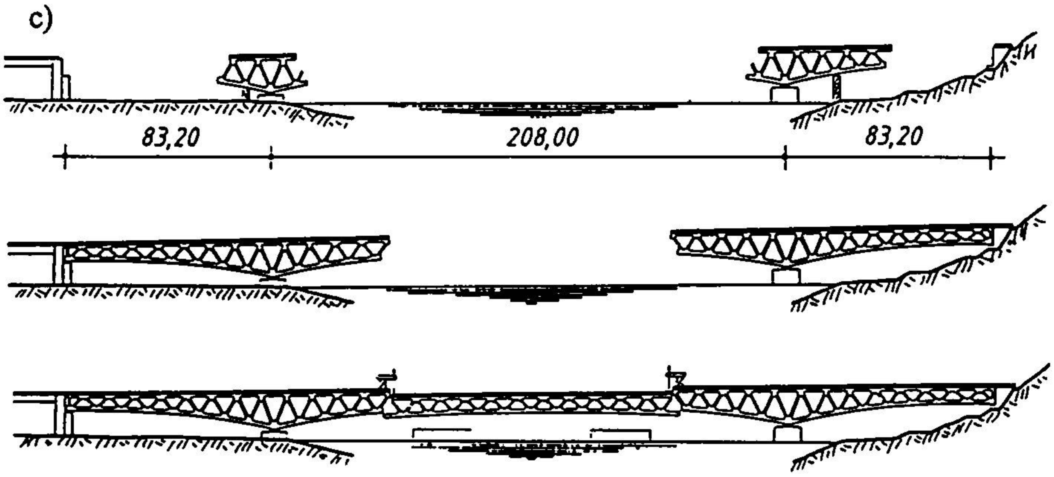


Fig. 4: Railway Bridge across Main River at Nantenbach, Germany
b) Cross-section, c) Construction sequence

3. Launching and Lifting
Example: Kap Shui Mun Bridge, Hong Kong

3.1 Design

The Kap Shui Mun Bridge is a double deck cable-stayed bridge with spans of 80 - 80 - 430 - 80 - 80 = 750 m, Fig. 5a. The prestressed concrete part of the superstructure is a 3 cell box girder, Fig. 5b. The steel composite part of the superstructure consists basically of the steel main girders and cross frames and the concrete top and bottom slabs, Fig. 5c.

3.2 Construction

The side spans were constructed by incremental launching, with a length of the segments of about 18,30 m, Fig 5d. The launching nose is formed by the first 3, specially designed elements of the steel composite main span. The steel composite bridge deck of the main span is erected by free cantilevering simultaneously from both towers, Fig. 5e. The individual elements are erected together with their slabs, yielding an erection weight of 500 tons.

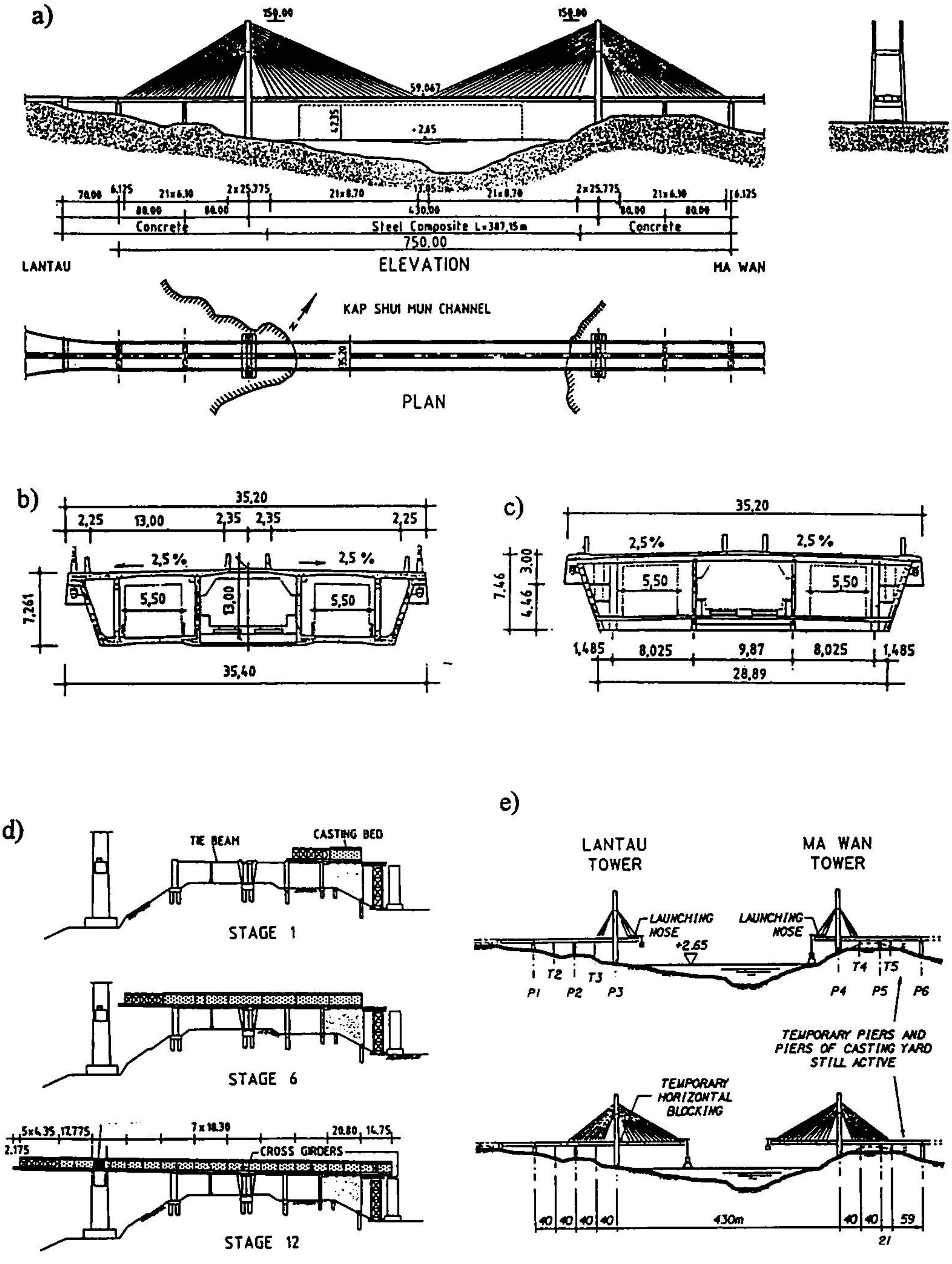


Fig. 5: Kap Shui Mun Bridge, Hong Kong:
a) Layout, b) Cross-section of side span, c) Cross-section of main span, d) Launching of Ma Wan side span, e) Erection of main span