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The Nevers Bridge: Design of the Steel Concrete Composite Box Girder

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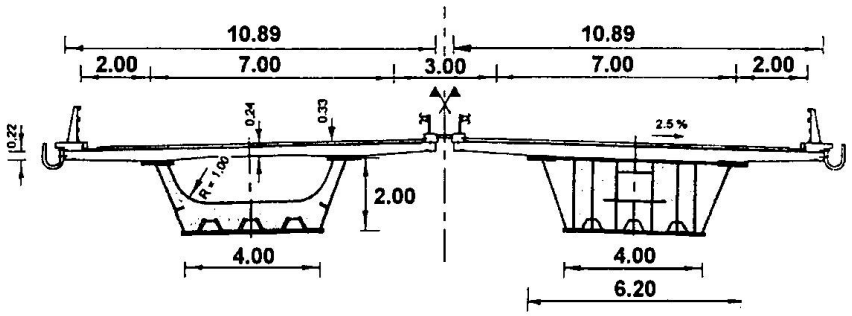
1. General design of Loire crossing bridge for a road by-passing Nevers.

The Nevers Bridge built between 1992 and 1995 was designed by ***SETRA*** . It is composed of two independent composite box girders, each one 420 meters long. ***J. Richard-Ducros*** for the steel structure and ***Dalla Vera*** for other civil engineering works were the contracting companies. For a more complete description of the bridge, see the article "Cracking control in the concrete slab of the Nevers composite bridge" in the same book.
The alignment of the Loire crossing is straight, and with a small 6 degrees skew angle between the river and the bridge. But every unmechanic skew alignments of bearings is avoided for the structure. This type of composite bridge was economically competitive.



Cross section of the steel-concrete composite box girders (half standard and half on pier).

2. Decisive advantages of a composite box girder solution.

When the Nevers bridge was designed, the use of plate girders was regarded as less expensive than the use of box girders for steel concrete composite bridges, box girders requiring more fabrication time.
In order to tide over this handicap,

- We designed the steel box with modest outer dimensions to make fabrication, and erection easy. In addition, shear lag and local buckling would make too wide flanges inefficient.
- The alignment of the Nevers box girders is straight, which allowed us to incline webs without geometrical difficulties that appear with highly curved bridges. If webs were vertical, bottom flange would be much too wide to be efficient. Inclined webs reduce the bottom flange width in a favorable way. In addition, the width between upper flanges is free to be optimised. The goal is to reduce distortion solicitation in the intermediate cross frames due to fatigue loads at the connection point between steel and concrete.

- We realized that transport and welding in site of the elements were often in fact the reasons for an overestimated cost of a box-girder solution when compared with the plate-girder solution. The Nevers bridge segments were small enough to be transported in one piece by road. Sections could be fabricated in the full width at the shop, and the best economy was achieved because longitudinal welding on site was avoided all the long of the bridge at the middle of the box.

Transport of segments

Diaphragm on pier

Composite box girders have however several advantages over plate girders which make their use attractive. The following advantages were decisive for the choice of the Nevers bridge structure :

- A neater appearance since the stiffening can remain invisible in the box.
- All places outside of the bridge are avoided where water could be caught in a trap. Most of the common causes of corrosion disappear which increases the service live and reduces the maintenance costs.
- Because of the low renewing rate of oxygen, the inside of a composite box is usually exposed to far less risk of corrosion than the outside. Very light colors were chosen for painting the steel inner surfaces of the Nevers boxes. This facilitates inspection because corrosion points or eventual fatigue cracks will be easier to detect in the future.
  In order to reduce maintenance costs an important point is to avoid birds flying inside the box using smallest openings, birds droppings being very corrosive.
- The width of the box girder plates, especially the bottom plate width, allows large span to depth ratio, to cross the clearance to be allowed for hydraulic, which reduces scale and cost of the road embankments at each end of the bridge.
- Very high torsional rigidity: In closed box girders, torque is resisted mainly by Saint-Venant shear stresses. This is an important advantage for a fatigue sensible structure like a road bridge.

3. Important details : temporary bracings and diaphragms on piers.

The torsionnal stiffness of the box girders is also essential during their construction. Composite box girders only achieve their torsional rigidity after concreting. During erection and concreting, they require temporary bracings.
According to the procedure used by contractors, bracings were only removed on one 20 meters long standard segment just before concreting it, when all other previous concrete segments were hard. This procedure could prevent deformations, that may occur when removing bracings where the deck is not achieved, which dramatically reduces the torsionnal stiffness of an open composite box girder.

Local effects on bearings cause complex states of stress in the supports on piers. We designed a diaphragm on piers to obtain a great rigidity to resist local distortion, and avoid detachment between steel and concrete parts of the composite structure.