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9. The Bridge in the Radnička Street in Belgrade (Yugoslavia)

Owner: *The City of Belgrade*
Designer: *Construction: Directorate for Bridges, Belgrade*
Rehabilitation: University of Belgrade, Department of Civil Engineering
Contractor: *Construction and rehabilitation: Mostogradnja, Belgrade*
Date of construction: *1968*
Date of rehabilitation: *1984*

In order to increase capacity of the primary traffic route, a one-way road bridge at the Radnička street in Belgrade was constructed in 1968. The bridge was built across the five-gauge very busy railway line and the existing street, a temporary structure as the removal of the railway line from the location was anticipated. However, due to postponement of the railway network reconstruction, it appeared to be necessary to keep the bridge in exploitation for a significantly longer period.

The bridge is skewed, in vertical curvature with the biggest slope of 6%, the length being $9 \times 36 + 10 = 334$ m and the useful width 6 m, (Fig. 1). The main box girder, lateral compound I beams, horizontal bracing and box columns are made of steel. The connection between the main and lateral steel girders is presented in Fig. 2.

Rectangular prefabricated reinforced concrete deck slabs were supported by lateral girders perpendicular to main girders, their mutual distance being 2 m. The width of the slabs corresponded to the width of the bridge. The slabs were 15 cm thick with haunches of 9 cm on both supporting edges.

As the direction of lateral girders did not coincide with the skew position of the columns, unequal deflections of the lateral girders ends used to take place whenever a vehicle crossed the bridge and those girders were the supports of reinforced concrete deck slabs, Fig. 3.

The permitted movement of heavy vehicles by the right main girder only, still increased the unequal deflections of the lateral girders ends causing torsion and additional inconvenient stressing of reinforced concrete deck slabs.

Those slabs were connected to the upper chord of the lateral steel girders by tins anchored into the mass of concrete with four skrews on both supporting edges. In the course of time, the connection was weakened and permanent damages of bridge decks above lateral girders took place. The lateral joints in asphaltic bridge deck, placed on each 2 m along the length of the bridge caused, beside uncomfortable drive, constant unforseen dynamic impacts to the structure of the bridge. The repair of the bridge deck was practically impossible.

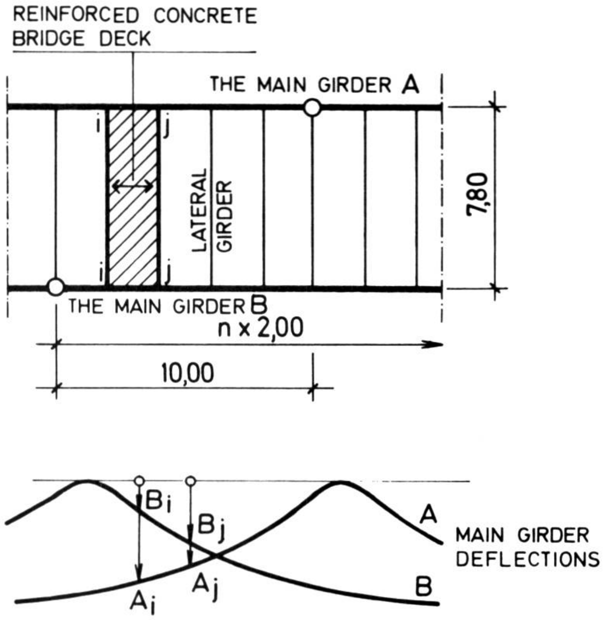

Fig. 2 The connection between main and lateral steel girders

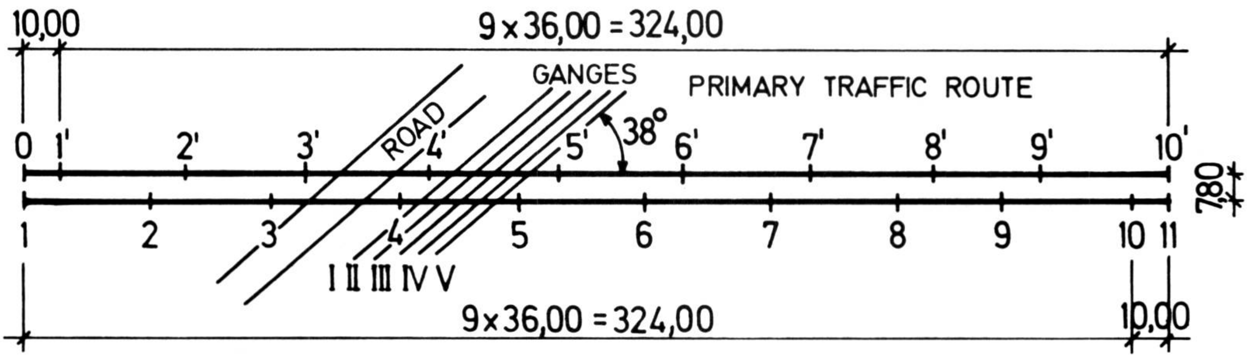

Fig. 1 Location plan of the bridge

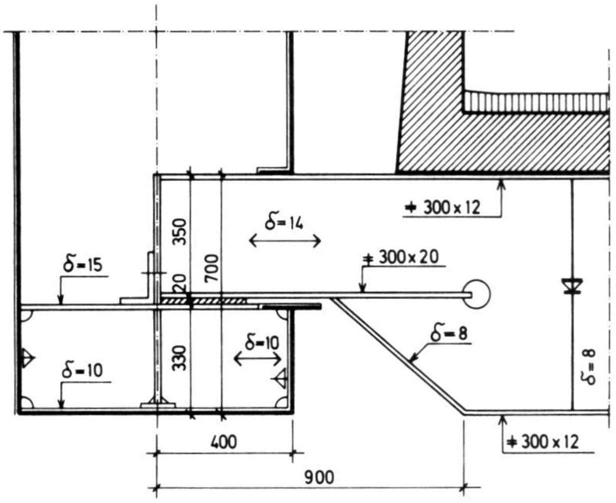

Fig. 3 Unequal deflections on lateral girders ends by which reinforced concrete deck slabs were supported

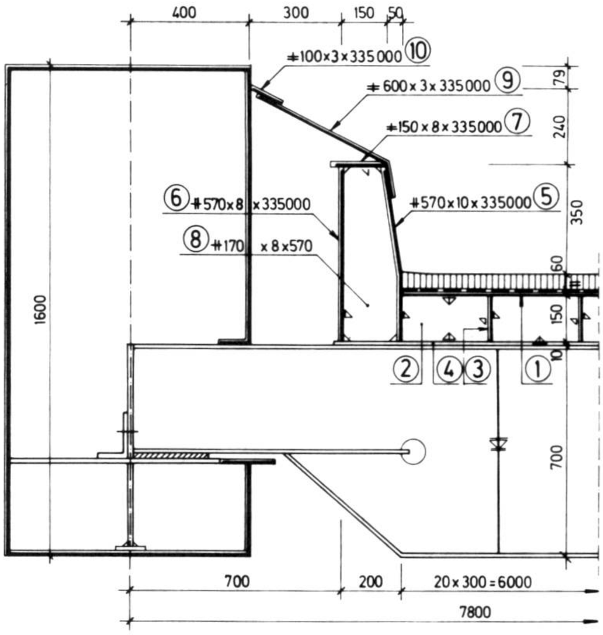

Fig. 4 The cross section of the bridge after rehabilitation

That was why, in 1981, rehabilitation of the bridge had to be done. All prefabricated reinforced concrete bridge slabs were replaced by the new slabs with the increased reinforcement without haunches. Through 1 cm thick rubber strips and arbolite substratum the slabs were elastically supported by the lateral girders. The interconnection of slabs was also elastic, achieved by four longitudinal bars sealed by epoxy putty. The strains between the slabs were sealed with a soft material. The basic idea was to enable independent deformation of individual slabs when vehicle crossed the bridge.

However, the rehabilitation did not give the expected results so the bridge had to be rehabilitated again.

A relatively expensive but from the engineering point of view the most correct alternative solution was applied. The reinforced concrete bridge deck slabs were replaced by a orthotropic steel plate. However, due to the required minimum traffic brake and due to the existing connection between lateral and main girders, a modified orthotropic steel plate instead of the classical one was applied. Prefabricated, 10 m long assemblies of the orthotropic plate were delivered to the site and, in order to facilitate erection, their width was half the width of the bridge so that the medium longitudinal seam was welded on the site. The connection of the orthotropic plate with the upper chord of the lateral girders was achieved by welding to the lower flange of the orthotropic plate, (Fig. 4).

Beside a correct engineering solution for the specific case, the application of the orthotropic steel plate achieved a decreased dead load of the structure which in the course of time proved very convenient for the increased live load.

During the detailed inspection of the bridge structure, which was carried out before rehabilitation, other failures were noticed which were removed during the rehabilitation. The first lateral girder was most badly damaged as is was completely subjected to the impact of vehicles when they were coming to the bridge so that it had to be fully reconstructed. The damaged parts of the steel structure were repaired together with the replacement of strains, corrosion protection and other maintenance works.

After such rehabilitation the bridge is in full operation for four years already, without any problems.

(G. Nenadić, A. Pakvor, Ž. Darijević)