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Upgrading of the North Viaduct of the Suspension Bridge in Lisbon

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Summary

The purpose of this paper is to describe the works of strengthening, improvement and elimination of expansion joints, in the North Viaduct of the Tagus River Suspension Bridge.

Keywords: External Prestressing ; Vertical Prestressing ; Assesment ; Upgrading ; Strengthening ; Epoxy Resin ; Repair Mortar

1. Introduction

The suspension bridge over the Tagus River in Lisbon – Portugal, was one of the largest in the world, when opened to traffic in 1966,.

The bridge comprise the suspension bridge itself, in steel, with a total length of 2300 m and a central span of 1013 m (the longest in Europe at the time), and the viaduct over the North embankment (North Viaduct), in concrete, with a total length of 950 m .

The bridge, which was initially used for roadway traffic, was submitted to large works for the installation of the railway traffic, in a new deck built under the existing roadway platform.

The North Viaduct is a prestressed concrete bridge with typical spans of 76 m. It was built by the balanced cantilever method with expansion joints at every mid spans.

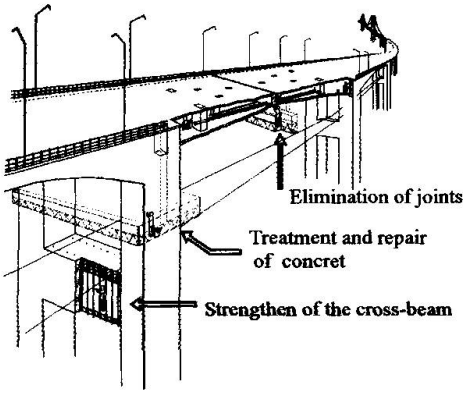
The railway installation in the viaduct, obliged to the strengthening of some structural elements, and the elimination of the most part of the expansion joints existing in the roadway deck. Besides the general good behaviour of the viaduct, a general repair was carried out with the closing of the cracks and the substitution of the degraded concrete.

In this paper is presented a general description of the execution of the works in the viaduct, which were strongly affected by the specific conditions of the works, namely the fact they, were executed in an urban area, the large height of the columns, and the need of non stopping the roadway traffic.

The pathologies observed in the viaduct were due to:
- the deficient concrete cover that justifies the stage of degradation;
- the absence of prestressing, which leads to crack formation.

2 - Injection of Epoxy Resins and Repair of Concrete

The cracked zones of the roadway deck and of the columns, and specially the edges of the cantilevers, were submitted to a treatment by injection of epoxy resin by the BICS method.
In places where the structural concrete was disintegrated, it was removed and repaired with non-retractile high resistance mortars.



The main work carried out were:

- Strengthening of the cross-beams of the columns;
- Elimination of expansion joints;
- Treatment and repair of the degraded concrete.

3 - Strengthening of the Cross-Beams of the Columns

To support the new railway platform the cross-beams between the column shafts had to be reinforced because of their insufficient shear resistance. To strengthen the cross-beams, the following works were carried out:

- Increasing of the cross-beam wall by the execution of filling concrete walls, on the interior side, with 0.30 m thickness and solidarized to the existing structure by connectors.
- Application of vertical prestressing to the cross-beam walls, obtained through the stressing of prestressing steel bars that cross the walls of the filling concrete and the slabs of the existing structure.
- Increasing of the thickness of the cross-beam top slab and execution of plinths to support the steel beams of the railway platform.

4 - Elimination of the Joints on the Roadway Deck

The deficient behaviour of the expansion joints on the roadway deck, led to relative vertical displacements between the edges of the cantilevers, which caused deterioration, as well as cracking of the concrete of the structure.
So, it has been decided to eliminate of eight of the twelve existing joints on the platform.
The structural modification of the spans continuity, was effected through the placing of exterior prestressing cables anchored on columns disposed symmetrically on the balances of the adjacent cantilevers. These columns were connected on the base to horizontal beams, solidarized to the bottom flange of the box girder and on the top to the superior flange, through indentation.
The joints eliminated showed important relative displacements between cantilevers, caused mainly by the traffic. To proceed to the joint elimination it was firstly necessary to nullify these displacements.
This immobilization was effected through the opening of the joint using hydraulic jacks, interposition of metallic plates, placed on both sides and on all extension of the joint, and application of longitudinal prestressing through the joint.