The Barra Bridge – Assessment and Rehabilitation

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Abstract

The Barra Bridge, in Aveiro, designed by Prof. Edgar Cardoso in 1971, opened to traffic in 1975. Due to its location in a very aggressive maritime environment at the Aveiro estuary the Bridge, was badly deteriorated. The repair and strengthening studies encompassed two distinct problems – the need to repair its constitutive materials and extend its service life and the need to confer the bridge satisfactory structural capacity.

The repair and strengthening sides of the rehabilitation project were developed in a system of mutual collaboration and constant information interchanging, in order to achieve a perfect harmonization between the strengthening and repair works.

Keywords: Assessment, bridge, concrete, environment, maritime, rehabilitation.

1. Introduction

The present paper refers to the rehabilitation of the Barra Bridge over the Mira Canal, in Aveiro, inserted in the national road E.N. 109-7. The bridge was designed by Professor Edgar Cardoso in 1971, and was opened to traffic in 1975.

Soon after its opening to traffic, an excessive deflection of the central span longitudinal cantilevers was detected. Since then, several inspections have been carried out, revealing the existence of many other problems, especially relevant to the conservation of the bridge.

2. Description of the Bridge

The Barra Bridge has a total length of 578 meter, between abutments (*Fig. 1*). The central span has a length of 80 meter and the access viaducts, symmetrical to the central span, consist of a 25 meter long end span and 32 meter long current spans.

The viaducts' deck is composed by four longitudinal beams connected by the top slab. The beams, of variable height, are longitudinally pre-stressed. The slab, of variable thickness, is transversally pre-stressed.

In the three central spans, the deck consists of a variable height double box girder with constant thickness webs. The central span is formed by two 34 meter length cantilevers, connected by an isostatic span. This 12 meter length span is composed by four reinforced concrete longitudinal beams connected by a transversally pre-stressed top slab.

The piers, in reinforced concrete, are essentially composed by two superposed portal frames. The first frame, directly supporting the deck, consists of a cross beam and two shafts, both with rectangular cross section. The second frame consists of a lintel, where the shafts of the first frame are built in, and two cylindrical caissons foundation.

Fig. 1 General view of the Barra Bridge

3. Structural Repair Works

On the repair side, the necessary steps were to halt the major deterioration mechanism, consisting in the accelerated decay of the concrete and the progressive corrosion of the reinforcement due to penetration of air and water chloride ions, and to take all needed steps to prevent the consequences of the continued action of the aggressive environment, ensuring the bridge a lifetime compatible to its social and economical relevance.

With the information provided by the analysis of the reports of previous site inspections as well as the analysis of the local environment, it was possible to characterize and quantify the level of degradation in each and every structural element of the bridge and then to establish the repair procedures, considered necessary and appropriate in each case.

Such a relevant Project has imposed the development of very detailed drawings, regarding particularly the precise definition of the required specifications concerning the methods and the products to be applied (*Fig. 2,3)*.

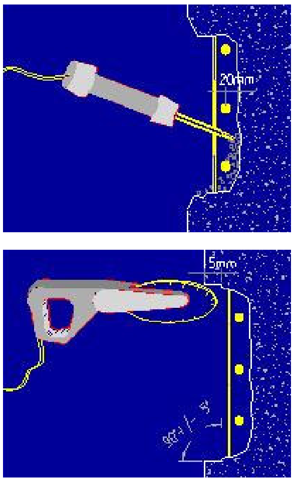

Fig. 2 An example of the procedures defined on the Project drawings

Fig. 3 An example of the translation of the Project requirements into the execution

4. Strengthening of the Structure

The objective of the strengthening design was to adapt the bridge to the new code rules, notably, new live loads, seismic actions and durability aspects, thus securing the improvement of the bridge performance levels. The various inspections and the structural analysis data were carefully analyzed and the global and local load capacity and response levels of the structure were evaluated.

The structural analysis revealed the need to proceed with a global and local strengthening of the structure. Various measures were adopted, such as the installation of external pre-stressing in the deck (*Fig. 4*) and in some piers, the piers strengthening with carbon fiber laminates, the strengthening of the box girders with structural steel (*Fig. 5*), the installation of viscous fluid dampers and other local strengthening solutions.

Fig. 4 External pre-stressing of the deck

Fig. 5 Strengthened box girders' bottom slab