External Post-Tensioning Retrofit and High- and Low-Cycle Fatigue Study of Connections and Joints in Steel-Concrete Box-Girder Bridges

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Summary

This paper reports the study of a viaduct retrofit by means of external post-tensioning. The structure is a steel-concrete box-girder bridge and the retrofit has been necessary mainly owing to an advanced corrosion state which has affected the structural steel of the boxes. During the design two solutions have been conceived: i) cables with a parabolic development; ii) cables with a rectilinear development. The advantages and the drawbacks of these solutions designed by S.I.GE.S s.a.s. are here presented. In parallel with this problem, an on going study is being carried out on the: i) dynamic regime in order to identify the sensitive details; ii) validation of the Finite Element (FE) model by means of output-only ambient vibration tests; iii) optimization and physical testing of the critical details. This study is devoted to improve both the high- and low-cycle fatigue strength in steel-concrete box-girder bridges and the results achieved so far are here reported.

Keywords: steel-concrete composite bridge, external post-tensioning retrofit, high- and low-cycle fatigue behaviour.

1. Introduction

Steel-concrete composite bridges represent a design option that is being increasingly adopted: i) in road networks; ii) in areas prone to high-intensity seismic events. The success of this design solution is due both to the advantages that composite elements offer in terms of stiffness, resistance and ductility and to the speed and ease of their erection. Moreover, the structural service-life has assumed a big importance in the design of structures, underlining the fact that the durability concept should be considered in the choice both of the material and of the structural typology. The durability of structural systems can be defined as the capacity to preserve the initial performance. It is thus linked to the capacity of the material of construction to keep its physical and mechanical properties unchanged within a given environment and under given working conditions. The steel-concrete composite action is particularly advantageous for bridges as it leads to enhanced stiffness, ultimate capacities and ductility. On the other hand, their non-homogeneity leads to significant problems at service conditions. Furthermore, it has to be considered that, for bridge structures, environmental conditions and types of loads increase the degradation of the material and in particular the most common degradation phenomenon is related to the corrosion of rebars in the concrete slabs. Bridges are, in fact, subjected to fatigue which leads to an increase of the cracks which, in turn, give rise to the penetration of the aggressive agents (e.g. chlorides, de-icing salts). In addition, an inaccurate maintenance, especially of the expansion joints, could lead to aggressive environments in closed box-girder composite bridges which could undermine the structural steel owing to corrosion.

In this framework, an interesting technique for the rehabilitation and the retrofit of bridges is the post-tensioning by means of external slipping cables which can be straight or draped along the steel beam by means of deviators.

Moreover, a peculiar issue is the lack of an accurate knowledge about dynamic effects, in particular in end-diaphragms and bearing regions which result to be very sensitive parts owing to stress

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