Redundancy evaluation of integral bridges under lateral loads and effect of FRP reinforcement on system behavior

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Summary

A numerical method based on [1] is used to evaluate structural redundancy of an integral bridge under lateral loads. The paper compares the results obtained from a probabilistic approach to those of a simplified deterministic analysis. These methods require the implementation of a non-linear static analysis by means of a 3D spatial frame model. System capacity is evaluated in its original configuration, in a deteriorated configuration due to corrosion of the rebar steel in the columns, and in a strengthened situation in witch the deteriorated columns are wrapped with FRP obtaining a confinement effect. The variation of redundancy is monitored along the life-steps of the example structure.

Keywords: Redundancy, Robustness, Reliability, Rehabilitation, FRP strengthening, non-linear.

1. Introduction

The design of bridges has traditionally been performed on a member by member basis and little consideration is usually provided to the remaining capacity of the system after the failure of one structural element. As a consequence of several tragic collapses that followed the failure of single elements, the evaluation of structural redundancy and robustness of bridges has become of primary importance.

Since redundancy is related to the overall system behavior, this study attempts to bridge the gap between a component by component design and the system effect. The aim of this work is to numerical evaluate the capability of the structural system to resist loads after the design load.

1.1 Measures of redundancy

According to [1] and [2], redundancy is defined as the capability of the system to continue to carry load after the failure of one main member. Redundancy is measured by means of three parameters. Two measures are related to the intact configuration of the structure and permit to evaluate the redundancy in collapse and in service conditions. The third measure is calculated on a damaged configuration of the structure and permits to evaluate the capability of the system to carry some emergency load after the damage in one main member (figure 1). These measures are:

$$R_u = LF_u / LF_1$$
$$R_f = LF_f / LF_1 \quad (1)$$
$$R_d = LF_d / LF_1$$

where:

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