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Bridge Inspection and Assessment

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Summary

The methodology and the main aspects of bridge inspection and assessment for concrete and steel bridges are presented in a synthetic form illustrated with the author's experience. Visual inspection and interpretation of test results are discussed. Two examples are presented: a reinforced concrete 35 years old arch bridge and a steel cable stayed 20 years old bridge.

Keywords: Bridge; Inspection; Assessment; Marine Environment

1 Introduction. Planning a Bridge Inspection

The paper covers both aspects of deterioration and structure safety assessment. A preliminary visit is essential, often in the stage of preparing the proposal or contract. This first visit will identify visible signs of deterioration or structure distress and will reveal the required means of access to inspect the bridge.

In what concerns the visual inspection it is very important to get near the structure surfaces what in general requires special means of access. In what concerns testing it is essential to define beforehand the objective of the inspection and to identify the visible problems so that suitable tests are chosen. The number and location of tests is then planned.

2 Inspection

The basic inspection includes the visual inspection and the fundamental tests strictly required to access the degree and extent of the deterioration and structure distress.

The visual inspection has the objective of producing a deterioration mapping and a description of the main visible defects in the superstructure, in foundations, in bearings and expansion joints and in non structural elements. At the same occasion the conformity of the geometry of the bridge with the design drawings shall be checked and hammering to detect delamination executed (very important do be done on this occasion if access is difficult).

Testing is needed to access the deterioration process which is in general a two phase process with an initiation stage where no defects are visible and a propagation phase, usually much shorter than the initiation one, which leads to visible defects.

For concrete bridges basic testing includes the hammering for delamination detection, the bar location and cover measurement, the measurement of the depth of carbonation and chloride penetration (this last one of special importance in bridges located near the sea).

For steel bridges, basic testing includes measuring the thickness and bond of the painting, the loss of section due to corrosion, the use of penetration liquids to identify cracks in welding, the measurement of distortions or deviations from flatness, the checking for loose bolts, ...

In some cases special testing may be required. For concrete bridges cores are a very important mean to see the concrete surface quality and to obtain samples to perform various tests. When depassivation of reinforcement occurs the rate of corrosion may be of special interest and then electrical potential, concrete resistivity and polarisation resistance are needed to be performed in selected areas.

For steel old (more than 50 years) bridges steel samples shall be taken from suitable locations to perform tests on the chemical composition, tensile strength and ductility, energy dissipation (Charpy) and fatigue resistance (of a vital importance for railway bridges).

3 Assessment

The assessment of the structure response and safety may require the following works: -topographic structure geometry definition; dynamic response to traffic excitation; measurement of live loads acting in the bridge; static or dynamic load tests; strain/stress evaluation.

The objective of assessment is to understand the causes and effects of the mechanisms of deterioration or structure distress or to assess the structure safety levels. In the paper the assessment of chloride penetration in a concrete bridge is presented and the structure assessment discussed.

4 Examples

The Arrabida Bridge Over River Douro in Oporto has a total length of 493.2 m and an arch with 278.4 m span, 52 m height. The bridge is located in an atmospheric marine environment and was designed and constructed 35 years ago with great care and quality for its period. A concrete cube strength of 40 MPa was specified (a design mix with w/c = 0.32 was used) and all concrete surfaces were painted. However significant visible deterioration was found, after 30 years, underside the deck and in particular in the lower corner of the beams. The inspection showed that only in areas of defects in concrete quality or very low cover, the deterioration reached the level of delamination or exposed bars. The depassivation of steel was due to the chloride penetration.

The Figueira da Foz Bridge Over River Mondego has a total length of 1 421 m including a cable stayed steel bridge 405 m long with a central span of 225 m. The bridge was constructed 20 years ago. The visual inspection showed that the steel paint is destroyed and that corrosion is progressing, mainly in the areas adjacent to the concrete slab, which cracked and lead to water leakage. The stays and deviators were open for inspection showing that the steel galvanised protection is still active. In the reinforced concrete elements corrosion and exposed bars are already visible in the mats and piers. The structure safety assessment revealed that an inadequate seismic design associated with the fixing conditions of the deck in the towers and piers resulting there in insufficient safety levels.