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LIFE-CYCLE ANALYSIS OF CONCRETE ROADWAY BRIDGES

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Life Cycle Costs, Deterioration, Maintenance.

INTRODUCTION

The bridges are very singular constructions in the roadways. For that reason the restraining of the utilization of a bridge, or imposing load limits in a bridge, causes always a great disturb of the normal flow of traffic, even when the rupture of the bridge is not taken in consideration.

In all the second half of the past century in Portugal, and in the most part of the developed countries, we have been witness of a heavily investment in new road infrastructures. The continuous aging of the bridge stock will require the redirection of the investment for the maintenance, of the existing bridges, instead of buildings new bridges.

Actually, one of the most important challenges of our society is to perform the maintenance\repair operations, of those existing bridges, with the scarce resources that are allocated, by governments, to these activities. It is reported that most of the funds are distributed to existing bridges instead of applying them in new structures (FHWA, 2005).

The magnitude of the problem can be observed in FWHA (2006). In the United States of America, and per year in the period of 2003 to 2005, the obligation of federal funds for bridge projects averaged $7.200.000.000. In the United States of America, of a stock of around 600,000 bridges, 25% as some kind of deficiency, 52% of those bridges are classified as functional obsolete and in that group around 52% of them are classified as obsolete.

OBJECTIVES

The aim of this research is the creation of a tool that enables the optimization of the funds involved in the maintenance\repair of concrete road bridges. This optimization is performed considering, over the time, the behaviour of materials, establishing different scenarios for the maintenance\repair strategies. The optimization the life-cycle costs is performed considering not only the direct costs of the reparation but also the users costs. The consideration of the user costs in the analysis is fundamental because the functional costs may be, in certain scenarios, more than 10 times the direct costs (Branco and de Brito, 2004).

METHODOLOGY

The work is based on materialization of three different stages:

1st stage – Modelation of the main mechanisms that lead to corrosion of steel in concrete due to action of chloride and carbonation and the consequent deterioration of reinforced concrete structures. The modulation of the deterioration is materialized considering the action of chlorides and carbonation in the reinforced concrete.

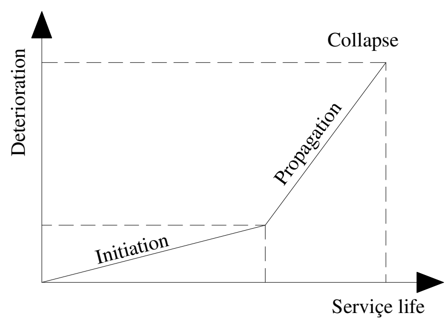

Figure 1: Deterioration mechanism due to corrosion of steel in concrete (Tuutti, 1982).

The choice of the timings for the applications of the maintenance measures results from the time of initiation and propagation of corrosion due to the effect of the chlorides and carbonation.

2nd stage – Determination of the effect of different intervention strategies. In this stage the issues that are evaluated in the intervention strategies are: determination of the time for the first application; effect on the reliability of the structure; possibility of reapplication; time between reapplications and life extent.

This study is materialised with two approaches: new bridges and bridges in use.

For the new bridges is determined the effect of different strategies of maintenance for different scenarios. All the comparisons are related to a base case. In the scenarios created exists the possibility comparing different possibilities of utilization of materials like: physical barriers; stainless steel; epoxy coating of rebar; concrete mix modifications and cathodic prevention.

For the bridges in use it is applied the same strategy considering the following measures: traditional intervention; physical barriers; cathodic protection concrete realkalinization and electrochemical chloride removal.

3rd stage – Optimisation of the investment plan, for a predetermined lifetime value, through the determination of life cycle costs, in net present values, for the different alternatives established.

This optimization is performed considering the behaviour of materials over time, establishing after different scenarios of maintenance\repair strategies. Optimization the life-cycle costs is performed considering not only the direct costs of reparation itself (materials, labour, etc.) but also the costs of users (detours, delays, etc.).

For the direct costs of each technique is considered the costs of the application; lifetime of the technique; number of reapplications; etc..

For the functional costs are considered the costs related with the users, the quantification of costs is realized with the quantification of the costs for de delay caused to the users; diverted traffic; costs related with traffic accidents; etc..

All of the comparative studies are realized utilising the net present value for each scenario.

CONCLUSIONS

The application of the methodology for determining the life-cycle costs, of different maintenance strategies, adopted provides a tool for the optimization of choice in relation to the costs of each strategy. That will allow determinate the direct costs of the agencies responsible for the maintenance operations, and the users costs for all the assumed strategies for the new bridges and for bridges in use.

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JOSÉ CARLOS ALMEIDA was born in 1973 in Palaiseau, France. He went to the Faculdade de Engenharia da Universidade do Porto, where he studied Civil Engineering and obtained his degree in 1998. He went to the Escola de Engenharia da Universidade do Minho and obtained is Master degree in Civil Engineering in 2003. He is, since 2007, a PhD Student at the Escola de Engenharia da Universidade do Minho. Actually he has is professional activity in the Instituto Politécnico da Guarda as a lecturer in the Civil Engineering course.