



## Detailed analysis of a post-tensioned box-girder bridge for explaining the observed cracking patterns

### Mário PIMENTEL

Assistant Professor  
University of Porto, Faculty  
of Engineering  
Porto, Portugal  
[mjsp@fe.up.pt](mailto:mjsp@fe.up.pt)

Mário Pimentel, born 1978, received his PhD degree from the Univ. of Porto. His current research interests concern the numerical modelling of concrete structures, analytical design methods and the condition evaluation of existing bridges.



### Joaquim FIGUEIRAS

Full Professor  
University of Porto, Faculty  
of Engineering  
Porto, Portugal  
[jafig@fe.up.pt](mailto:jafig@fe.up.pt)

Joaquim Figueiras, born 1947, received his PhD from the Univ. of Wales Swansea and the aggregation from the Univ. of Porto. His current research interests concern the development and application of structural health monitoring systems.



## Summary

The N. S. da Guia bridge is a post-tensioned box-girder bridge built in the late seventies according to the balanced cantilever method. During a routine inspection several cracks were detected in the webs and in the bottom slab. The working program that was devised to perform the condition examination of the bridge is shortly described. Special attention is devoted to the numerical and analytical studies that were developed to explain the origin of the observed crack patterns and to assess if these cracks can be expected with the prestressing steel in good conditions or, on the contrary, if they are indication of ongoing corrosion leading to a decrease of the effective prestressing force. The observed cracks could be satisfactorily explained with the detailed analysis of the local stress fields surrounding the tendon anchorages and are likely due to the adopted tendon layout and detailing options. A nonlinear analysis of the full bridge was also performed and the computed cracking patterns shown a strong resemblance to those observed in-situ.

**Keywords:** Concrete bridges, post-tensioning, condition evaluation, cracking, finite element analysis, nonlinear analysis.

## 1. Introduction

The built infrastructure, of which bridges are an important component, is a hugely valuable economic and political asset. For the existing highway bridge stock in all 27 countries of the European Union, the replacement costs were estimated at €400 billion [4] in 2004. Due to the large sums involved, the financing of the maintenance, repair and renewal activities needs to be put on a rational basis. There is consensus regarding the need for specific procedures for the assessment of existing bridges and the importance of adequate bridge management strategies. This is crucial for minimizing and rationalizing the increasingly growing maintenance costs and associated traffic disturbances, for contributing to environmental sustainability and for ensuring the adequate safety levels to the infrastructure users.

The key for extending the service life of an existing bridge is a detailed examination of its condition and an accurate structural safety evaluation. In general, a stepwise approach is recommended to identify which bridges are at an unacceptably high level of risk so that appropriate remedial measures can be taken. In this paper, the working program that was devised to perform the condition examination of the N. S. da Guia Bridge (see Fig. 1) is described. The N. S. da Guia bridge is a post-tensioned bi-cellular box-girder bridge built in the late seventies and one of the first bridges built in Portugal according to the balanced cantilever method. During a routine inspection several cracks were detected in the webs, some of them continuous with cracks in the bottom slab. Special attention is devoted to the numerical and analytical studies that were developed to explain the origin of the observed crack patterns and to assess if these cracks can be expected with the prestressing steel in good conditions or, on the contrary, if they are indication of ongoing corrosion leading to a decrease of the effective prestressing force. This information is important in order to decide on the best rehabilitation strategies.