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STRUCTURAL PERFORMANCE OF A MEDIEVAL STONE MASONRY ARCH BRIDGE

D.V. Oliveira[1], R. Allahvirdizadeh[2], A. Sánchez[3], B. Riveiro[3], N. Mendes[1], R.A. Silva[1], F. Fernandes[4]

[1]ISISE & IB-S, Department of Civil Engineering, University of Minho, Azurém, Guimarães, Portugal.
[2]Division of Structural Engineering and Bridges, KTH Royal Institute of Technology, Stockholm, Sweden.
[3]Department of Materials Engineering, Applied Mechanics and Construction, University of Vigo, Vigo, Spain.
[4]Faculty of Engineering and Technologies, University Lusiada – Norte, Famalicão, Portugal.

e-mail: danvco@civil.uminho.pt

SUMMARY

Many masonry historical bridges are still under service, particularly in Europe. Their significant cultural value, key role in transportation network systems and deterioration condition requires assessing their safety with respect to different scenarios, particularly earthquakes, which masonry structures are inherently vulnerable. This assessment requires collecting detailed information such as geometry, material properties, boundary conditions and existing damages to construct reliable numerical models. However, their significant cultural value prevents conducting destructive and even minor-destructive tests. The structural assessment of Barcelos Bridge, a medieval stone masonry arch bridge in northern Portugal, by means of a numerical approach is discussed in the current article. In this regard, a 3D advanced finite element model was prepared, in which the external geometry and internal morphology were extracted from laser scanning and ground penetrating radar survey, respectively. Then, outcomes of indirect sonic tests were adopted to characterize material characteristics and dynamic properties (i.e. frequencies and mode shapes) obtained from ambient dynamic identification were employed to update the FE model. Two load scenarios including gravity and lateral transversal loadings were taken into account to assess the performance of the bridge. Thus, incremental nonlinear pushdown and pushover analyses were performed, which resulted in evaluating current safety level of the bridges and possible failure modes.

Keywords: *Historical constructions, Stone masonry arch bridge, Nondestructive tests, Finite element modelling, Model Updating, Pushover analysis.*

1. INTRODUCTION

Importance of the bridge safety assessments as one of the most key components in transportation networks is well understood, not only in the research community but also by decision-makers. However, a variety of uncertainties arising from different sources such as those related to the resistance (material characteristics), geometry, imperfections, existing damage and loading scenarios make the aforementioned assessment to be a challenging task. Those uncertainties may significantly increase by the age or type of the bridge. Given these circumstances, numerous historical bridges mostly dating back to Roman or Medieval periods exist all over Europe; which still a significant portion of them are under service. For instance, it is estimated that about 14% of the European railway bridges to be over 100 years old arch bridges [1].

In this study, Barcelos Bridge (see Fig. 1) situated in northern Portugal is considered as the case study to investigate the application of the non-destructive testing methodologies accompanied by advanced numerical modelling in safety assessment of historical bridges. This five-span Gothic style granite masonry arch bridge was constructed between 1325 and 1330 to connect Barcelos (right shore in Fig. 1) to Barcelinhos (left shore in Fig. 1) by crossing Cávado River; which is still under service for car traffic and pedestrians passages.

Hereof, 3D laser scanning and Ground Penetrating Radar (GPR) tests have been conducted to extract accurate external geometry and internal morphologies, respectively. Then, indirect sonic and ambient

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