IABSE Symposium 2019 Guimarães
Towards a Resilient Built Environment - Risk and Asset Management
March 27-29, 2019, Guimarães, Portugal

Dynamic identification and collapse assessment of Rubbianello Bridge

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Abstract

This paper investigates the causes of failure of Rubbianello Bridge, a multi-span masonry arch bridge located in Central Italy, which suffered the collapse of two of the seven spans due to foundation scour during a very severe flood in December 2013 and the collapse of two more spans during another major flood event in 2016. An accurate nonlinear 3D model of the bridge is developed. The elastic properties of the model are calibrated based on both material tests and an experimental campaign carried out for the dynamic identification (in terms of vibration frequencies and modal shapes) via operational modal analysis of the remaining part of the bridge. A numerical simulation of the scour hole progression is performed in order to identify the collapse mechanism of the bridge under the first major flood and estimate the level of scour that caused the bridge failure.

Keywords: masonry; bridges; scour; collapse; operational modal analysis; Abaqus; FEM.

1. Introduction

This paper investigates the causes of failure of Rubbianello Bridge, a multi-span masonry arch bridge [1] located in Central Italy, which suffered the collapse of two of the seven spans due to foundation scour during a very severe flood in December 2013. Subsequently, in 2016 two more spans collapsed, again during another major flood event. In 2018, an experimental campaign was carried out to characterize the dynamic properties of the remaining spans in terms of vibration frequencies and modal shapes. For this purpose, ambient vibration tests were performed, complementing the information already available from material characterization tests. In the first part of the paper, a finite element model of the remaining bridge portion is developed based on material tests data and calibrated using measured dynamic test data. Subsequently, an advanced nonlinear model of the full bridge is built to simulate the partial collapse of the bridge under the first major flood. The study results provide also useful information on the level of scour that caused the collapse.

2. Case study: Rubbianello bridge

Built in 1906, the investigated masonry arch bridge crosses the Aso river, located in Rubbianello municipality, a small town in Central Italy. The collapsed bridge originally consisted of seven spans, six masonry piers, a granular mixture fill and segmental brick vaults.

A very severe flood in December 2013 caused the collapse of two of the seven spans (Figure 1), due to the cumulated scour under and around the sixth pier foundation.

https://doi.org/10.2749/guimaraes.2019.0619
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