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Dynamic assessment of partially damaged historic masonry bridges under blast-induced ground motion using multi-point shock spectrum method

Kemal Hacıefendioğlu*, Varol Koç

Ondokuz Mayıs University, Department of Civil Engineering, 55139 Samsun, Turkey

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ABSTRACT

We studied the partial damage effects on historic masonry bridges exposed to blast-induced ground motion. For this purpose, a historic masonry bridge in Turkey was selected to estimate its shock spectral behaviour. In order to determine these results, first, various damage was created on the restored bridge finite element model. This damage was generally selected by searching for damaged historic masonry bridges in the literature. Various critical regions on an example bridge were detected and corresponding regions were removed from the restored finite element model. Thus, partially damaged historic masonry bridge models were obtained. Dynamic calculations of the bridge are presented by using the multi-point shock response spectrum method obtained from ground motions due to a blast load. Acceleration time histories of blast-induced ground motions are obtained depending on a deterministic shape function and a stationary process. Shock response spectra determined from ground shock time histories are simulated using a MATLAB-based BlastGM computer program developed by us. The frequency-varying shock response spectra are applied to each support of the two-span historic masonry bridge. The influences of various charge weights and distances from the charge centre are also investigated in the analyses. The results from the analyses demonstrate the importance of partial damage on the historic masonry bridge, blast-induced ground motion effects, and charge weight and distance from the blast centre.

1. Introduction

Historic masonry bridges, which have great artistic value for the humanity and history of architecture, reflect lifestyle and cultural changes of their location and reveal the region's cultural identity, are structures to be protected. These structures lasting for many centuries are still under threat from natural circumstances and growing global population. Fires, floods, and wars can all be given as examples. These effects can cause major damage to historic bridges. Moreover, there are other effects causing historic bridges to be partially destroyed. First, water freezing is of the most important factors causing partial damaged or destroying historic bridges. When water freezes, it makes a wedge effect and leads to the growth of cracks by entering into the cracks and breaking large parts. Secondly, various kinds of trees have roots on and in front of neglected historic bridges by seeds being brought and placed into the cavity walls, discharged into the joints of these bridges by wind.

* Corresponding author.
E-mail addresses: kemalheo@gmail.com, hckemal@omu.edu.tr (K. Hacıefendioğlu), kvarol@omu.edu.tr (V. Koç).

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Fig. 1. Upstream view of collapsed arches and piers [1].

Fig. 2. Damage of a masonry bridge [3].

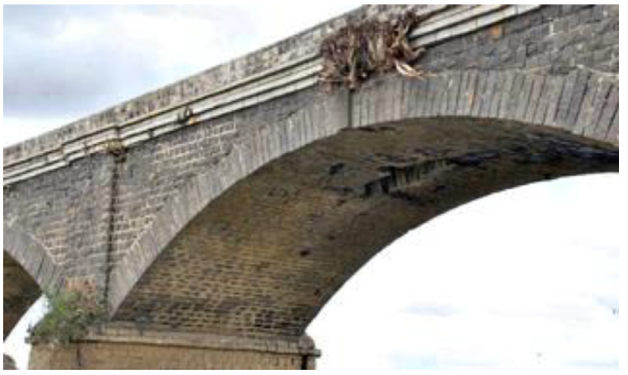

Fig. 3. Kurikota bridge [4].

Wind, especially together with sea salt and other components, may cause rapid and severe abrasion. Thirdly, groundwater can leave structures unsupported by dragging soil under the foundation of historic bridges.

A few partially damaged or destroyed bridges have been illustrated. Fig. 1 shows the D. Zameiro Bridge, located about 40 km north of Porto, in the northern part of Portugal [1]. The bridge was closed in March 2001 because of existing damage. This was partial collapse of a pier, longitudinal cracks along the intrados of some arches, either on the upstream or downstream sides, material degradation, the presence of cement mortar in some joints and absence of mortar in other joints, inter alia.

In Fig. 2, a masonry arch bridge is shown, which was damaged during the 1997 Umbria and Marche earthquake occurred in the regions of Umbria and Marche, central Italy on the morning of September 26. The collapse of the central span arch wall, as well as the exposure of the arch filling material, are possible failures such as the partial out-of-plane collapse of the arch walls [2,3].

Finally, one of the arches of the bridge was damaged, as some of the stones in the structure fell off (Fig. 3) [4].

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