Masonry arch bridges in the 21st century

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Abstract

Masonry arch bridges have proved to be resilient, long-lasting structures, and continue to form a crucial part of the railway and regional highway networks of the UK and many other countries. Given this, and the comparatively low embodied carbon associated with natural stone as a building material, the masonry arch form looks set to once again become attractive to designers. However, some aspects of their behaviour remain poorly understood. This can unfortunately lead to existing bridges being needlessly strengthened (or even demolished and replaced), or, alternatively, being subjected to loading regimes that cause long-term damage. In this contribution key elements of the recently published CIRIA C800 guidance on the assessment of masonry arch bridges are highlighted, including how the presented advice may in future be applied in the design of new bridges.

Keywords: masonry; arch bridges; assessment; design.

1 Introduction

There are currently around one million masonry arch bridges in service around the world, with the majority being over a century old. These bridges are now carrying traffic that is significantly different to that anticipated by their builders. Masonry arch bridges incorporate one or more arched elements and have a wide range of construction details. Given the significant numbers of these bridges in use, it is crucial for bridge owners to manage them effectively, enabling them to direct limited maintenance budgets appropriately. A key aspect of this management involves gaining insights from periodic assessments of bridges.

In the mid-20th century, the MEXE assessment method was developed to evaluate the load carrying capacity of masonry arch bridges [1]. This method sought to ascertain service load capacity and encompassed both calculation-based and observational components. However, due to issues with the underpinning assumptions, the calculation-based aspect of the method [2], the observational component has arguably proved more valuable, albeit it does not provide a predictive capability. Shortcomings of the MEXE method have led to a decline in its usage in recent years, with the current UK assessment code for highway bridges [1] now specifying that the MEXE method is unsuitable for bridges with spans less than 5m or greater than 18m. Instead, limit analysis methods (following Heyman [3]) have become more prevalent. These methods determine the Ultimate Limit State (ULS) load, with a safety factor often subsequently applied to establish a Serviceability Limit State (SLS) load, due to the absence of widely accepted SLS criteria for masonry arch bridges.

Assessing a masonry arch bridge necessitates the availability of a competent engineer, who has access to effective assessment tools. However, two issues can adversely affect the accuracy of an assessment:

- A significant number of assessment engineers lack familiarity with masonry arch bridges and

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