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Restoration of arch bridge by additional horizontal prestressing

Ladislav Klusacek[a], Robin Peknik[a,]*

[a] *Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Brno University of Technology, Veveří 331/95, 602 00 Brno, Czech Republic*

Abstract

The general focus of the paper is to show a method of strengthening arch bridge that has longitudinal cracks. The process is done by new reinforced concrete spandrel walls stabilized by transverse prestressed monostrands. Specifically, the paper is aimed at the reconstruction of the brick arch railway bridge, which was in disrepair. At the beginning of the design work it had to be decided whether it would be effective to carry out reconstruction of the existing bridge, or to accede to build a new bridge on the existing place. For the decision-making process there was a comprehensive diagnostic survey made - the survey of experimental measurement of modulus and strain measurement masonry walls in the crown during the operational load using tough half-frames (ribes). After evaluating the measurement, it has been recommended to do reconstruction. After the work was done, new measurements were done during the operational load when the measured values should confirm the effectiveness and appropriateness of reconstruction. After the evaluation the strain of the top cross-section reduced to 40% of the values before amplification. The text will also be given a numerical model and its' calibration using the measured values of the deformation of the top section.

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Keywords: arch bridge; horizontal prestressing; masonry; deflection, strain

* Corresponding author. Tel.: +420-541-148-213.
E-mail address: peknik.r@fce.vutbr.cz

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1. Introduction

Currently in Czech Republic, there are a lot of functional arch bridges from stone and brick masonry in road and railway network – it is more than 2500 masonry arches in the railway network. From the age point of view there are more than 80% of brick bridge objects older than 100 years [1]; this shows that suggested lifespan is often distinctively exceeded. The masonry arch bridges have proved their effectivity from the time view, and that is why it is appropriate to be concerned about these constructions, and to pay them attention – with the proper maintenance and suitable reconstructive intervention, it is possible to prolong the lifetime of the construction, and to keep this heritage for the next generations.

In the past, the arches were designed with the help of bar model, when analytical formulas for solutions were derived and used. Usually, the arch was replaced by a 1 m wide brick strip. The impacting internal forces are just forces in vertical level (surface) – normal force (N) and bending moment (M). That is why bar model does not provide any forces in transverse direction, and thus no strains, that could disrupt the brick arch in the transverse direction. Nevertheless, the increasing operational load proved three-dimensional response of these constructions. The deformation on the top of the arch is different along the width of the arch. The different deformation is caused by:

- Uneven weight of over-layering, when larger over-layering often happens, especially in the center of the arch.
- Moving load that can occur throughout the whole width of the arch, or in case of an object with more railway tracks the load occurs in a close proximity of the arch edge.
- Stiffening impacts of the front walls, when the stiffness of the walls blocks free deformation of the arch edge.

In agreement with these causes there are emerging tensile forces that initiate the occurrence of longitudinal cracks in the arch. These cracks are often damage in arch bridge objects. By the joint influences of weather conditions, imperfect waterproof isolation system and freezing cycles it often turns to expansion of their widths, and subsequently to a split of the arch into individual arch strips that with crack widths in mm and higher units ease off their impact. Among additional effects, that can lead to expansion of longitudinal cracks belong: the temperature impact (especially uneven temperature impact) and dynamic traffic impact. That can lead to a shift of the front walls [2]. On the following picture on the left (Fig. 1a) is displayed the arch before reconstruction. It was damaged by longitudinal cracks; and therefore the front walls deflected. On the right (Fig. 1b) is shown exceeded deformation of this bridge on a shell model. A locomotive 560 with total weight of 74,4t was used as load.

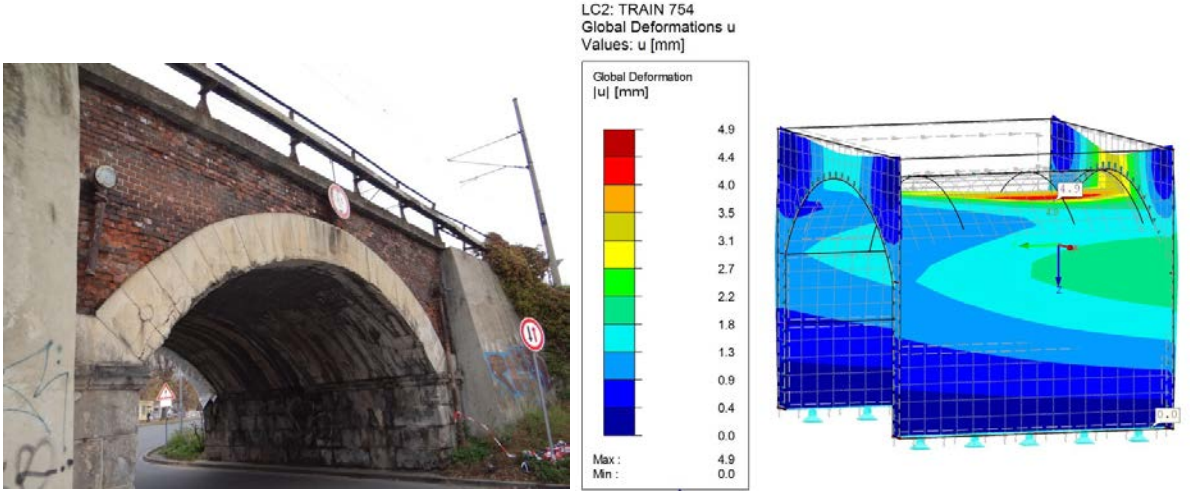

Fig. 1. (a) Brick railway arch damaged by longitudinal cracks; (b) Deformation of shell model from a movable load.