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Experimental Investigation of a Two-Span Masonry Arch Repaired With FRP

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Introduction

Masonry arch bridges make a significant contribution to the road and rail infrastructure in many countries. FRP composites repair or strengthening is an attractive method for extending the life of structures. This poster presents an experimental study on a 1/3 scale two span masonry arch bridge (Fig.1) repaired with FRP. Both spans were loaded to establish a 4-pin mechanism of cracks and then repaired by externally bonded CFRP plates to their intrados (Fig. 2). The preliminary results on the northern arch is presented.

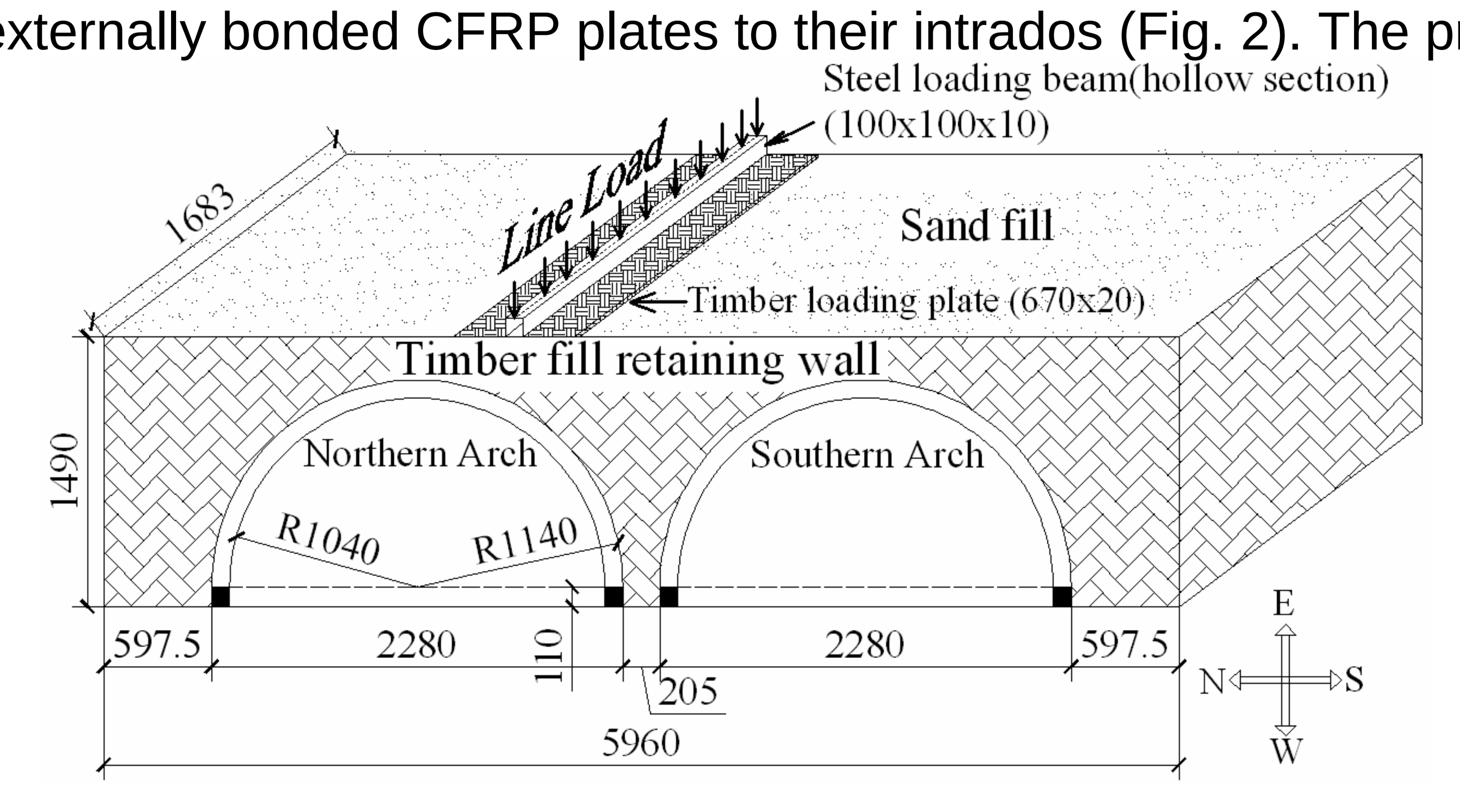


Fig.1 Large scale model (mm)

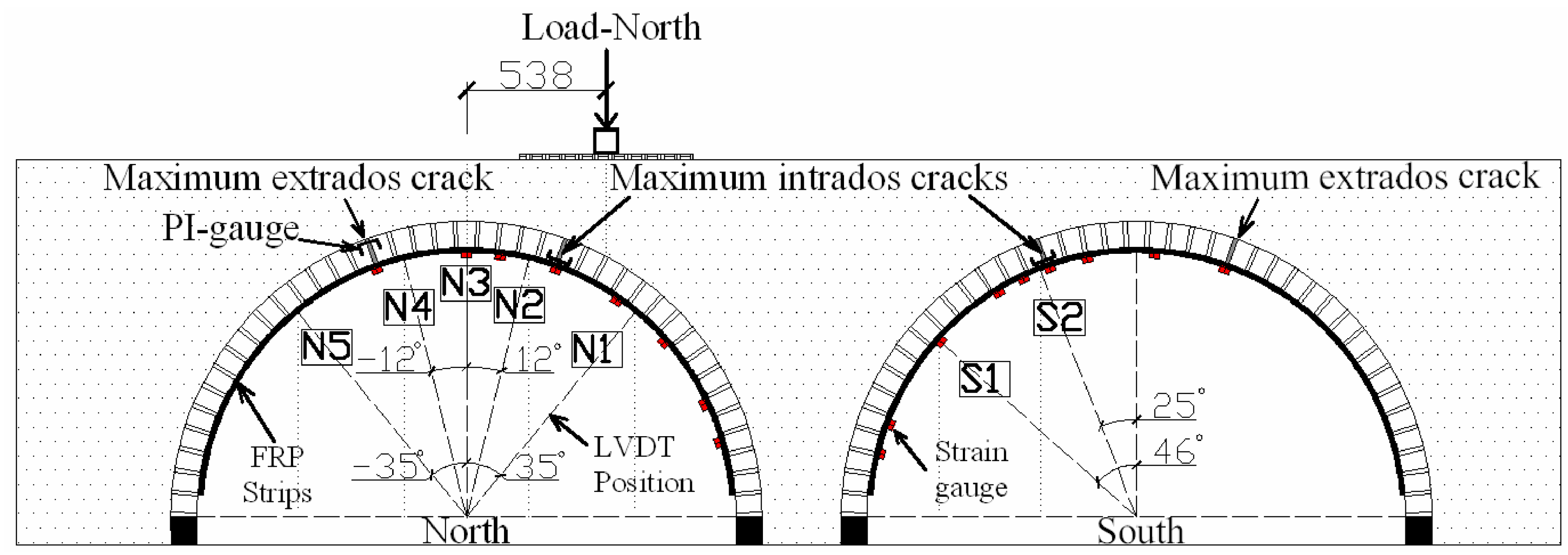


Fig.2 Position of CFRP plates and instrumentations

Experimental Investigation

Test on original arch: A line load was applied to the quarter span of the unstrengthened arch in turn (Figs 1 and 2). Each arch was loaded until cracks fully developed to establish the four-hinge failure mechanism. It was estimated that the ultimate load capacities of the unstrengthened arches were almost reached.

Test on repaired arch: CFRP plates were bonded to the damaged arches using an epoxy resin. Three CFRP plates were applied to the intrados of the northern arch, and six plates to the southern arch. In addition to the instrumentation used during the initial tests, PI-gauges were added to measure the crack opening widths on either side of the arches, and 25 strain gauges were bonded to the centre of the FRP plates (Fig. 2). The arches were again loaded at the quarter span.

Test Results

Failure mechanisms

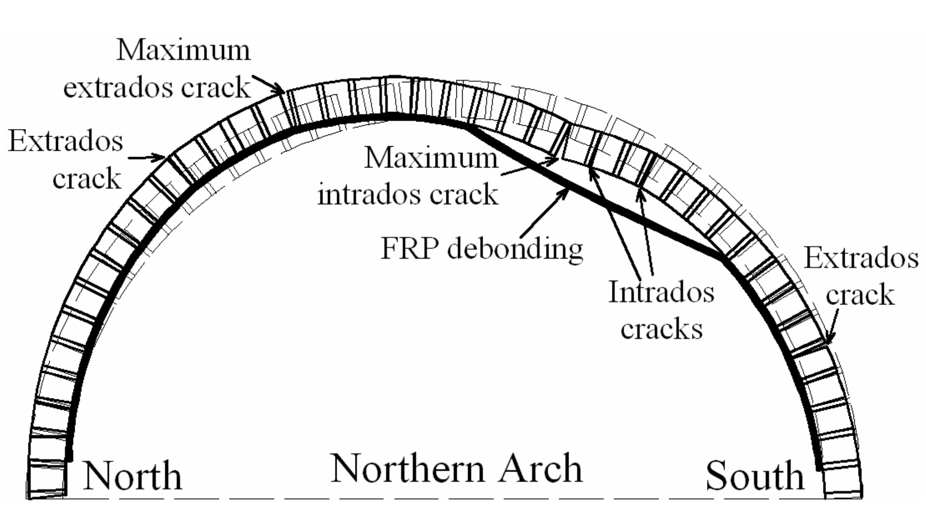


Fig. 3 Failure mechanism of scheme of northern arch (western view)

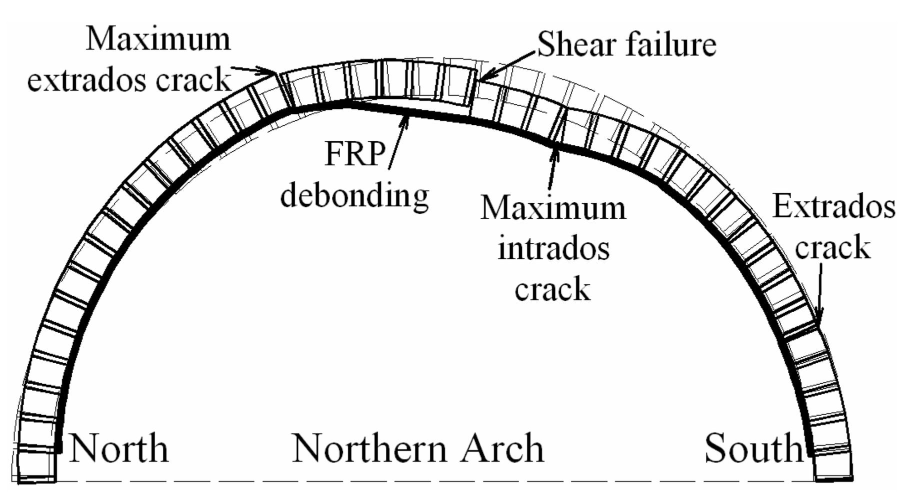
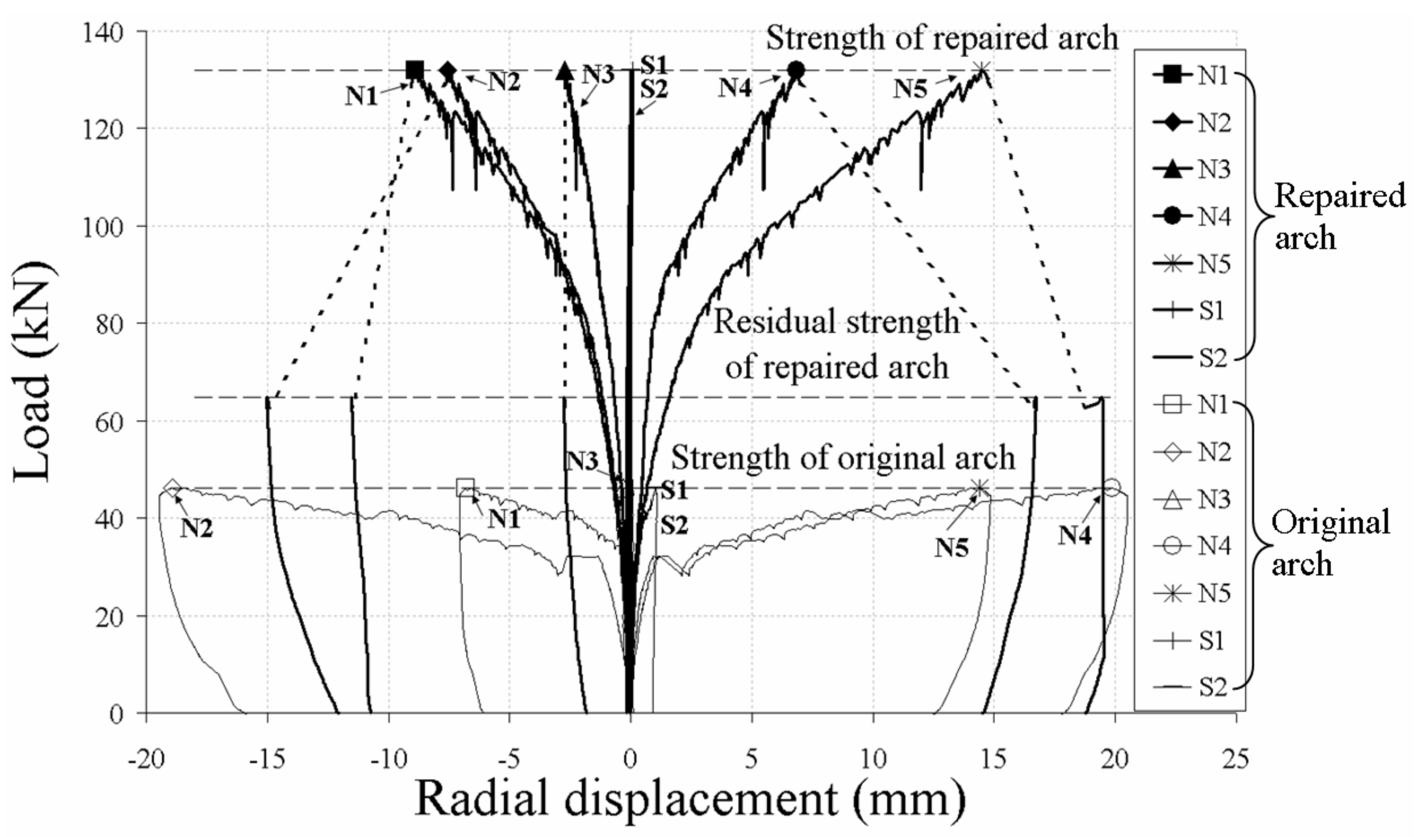
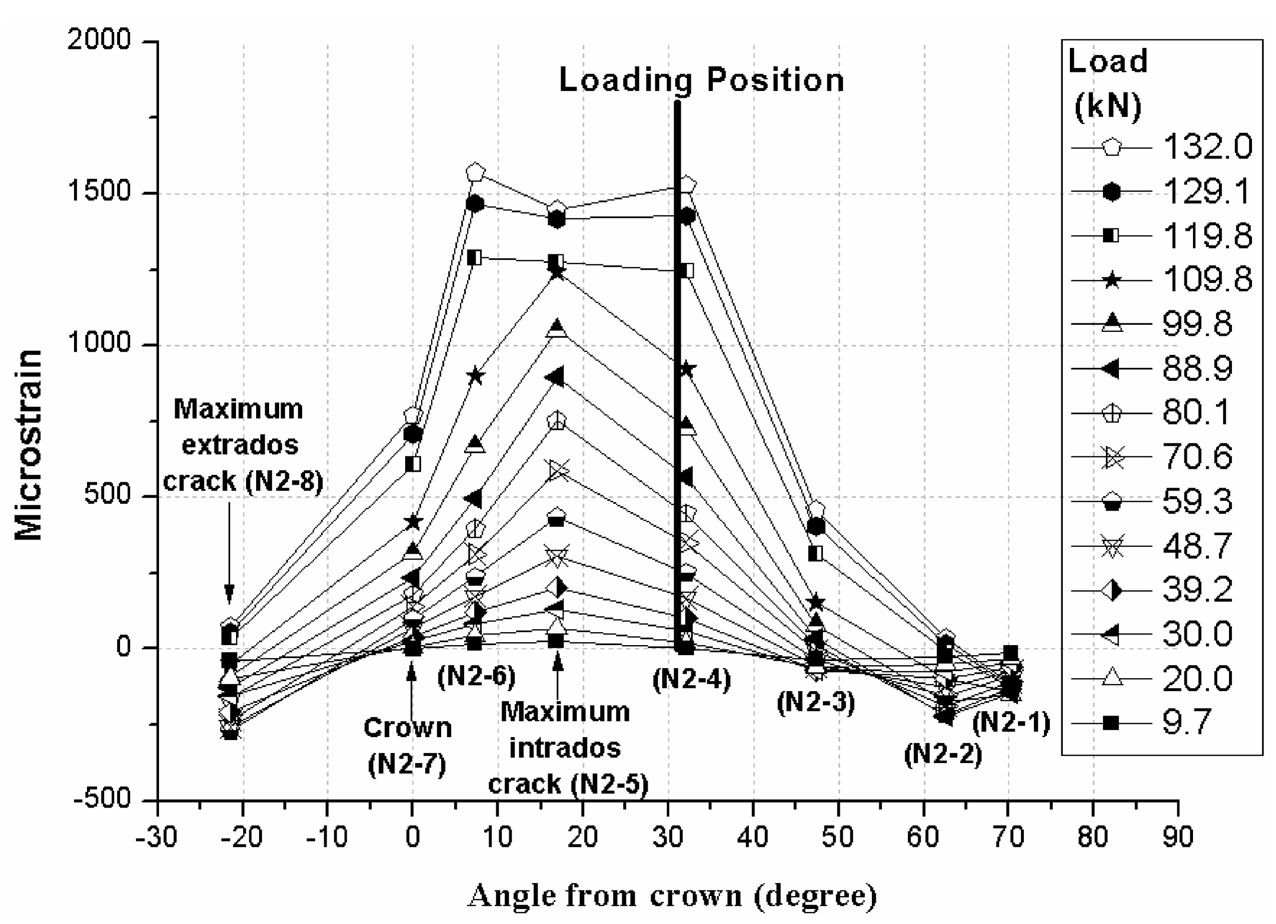


Fig. 4 Failure mechanism of scheme of northern arch (eastern view)

Load-displacement response of arches



FRP strain responses



Failure mechanisms: The masonry hinge beneath the loading point opened up across the western and central portions of the arch and led to debonding of the FRP from the masonry (Fig. 3). On the eastern side, a shear failure occurred at the crown of the arch, and this resulted in peeling along the adhesive joint (Fig. 4).

Load-displacement response: The strengthen of arch was dramatically increased by FRP and large residual strength existed after debonding. The fluctuations in curves are a result of the progressive build up of micro-crack damage in the masonry and softening at the interface between the FRP and the masonry. The greater drop may indicate the coalescing of micro-cracks into macro-cracks at the interface between the FRP and the masonry.

FRP strain responses: A particularly significant increase in FRP strain to either side of the crack when the load increased from 110 to 120kN indicated the crack propagated from the hinge location.

Conclusions

1. The loading capacity of the arch bridge can be significantly increased by bonding FRP strips to their intrados.
2. By restricting the opening of hinge cracks, the FRP can significantly increase the stiffness of the arch.
3. The repaired arch failed through cracking within the masonry accompanied by brittle debonding along the FRP-masonry adhesive joint.
4. The displacement and strain responses of the structure indicate the progressive production of micro-cracks as the load increased, which coalesced into macro-cracks that led to debonding failure along the FRP-masonry interface.