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EXPERIMENTAL INVESTIGATION OF BRICK MASONRY ARCHES' (VAULT AND RIB COVER) BEHAVIOR UNREINFORCED AND REINFORCED BY C-FRP UNDER VERTICAL AND HORIZONTAL LOAD SIMULTANEOUSLY

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Brick masonry arches with vault and rib cover are one of the most common elements in old building structures. Although many researches have been done in the world on historical structures, however, due to the poor behavior of masonry materials in tensile and shear, more reliable seismic evaluation methods, under dynamic (earthquake) and vertical loads, are needed. In this research, the masonry arch (vault and spring) is based on the pillar in real dimensions under lateral and vertical load in an unreinforced and reinforced structures and is subject to laboratory study until the loading rate of the structure and its behavior under vertical and horizontal loading were determined, as well as the amount of bearing capacity and the degree of ductility with structural reinforcement were increased by FRP fibers. In two structures, vertical load was applied by pouring sand on the spring and lateral load was applied by horizontal jack at the span of the vault. There was no crack under the vertical loading of the structure, but in the horizontal loading on the unreinforced structure, the first cracks started from the place of loading and being moved at the spring. By continuing the horizontal load, the separation between mortars from the brick, and also the vault and the rib cover. The shearing-slipping cracks in the pillar and the spring, the movement of the outside of the plate at the pillar, as well as opening during a quarter at the bottom of the vault was appeared. After identifying the weaknesses and installing the C-FRP 300 fibers polymer, the structure was strengthened and tested. Under lateral loading, first crack appeared in the rib cover and the spring, and then, with increasing load, the mode is changed, and the location of the crack, fracture and displacement towards the pillar in the structure was distorted. According to the results, the displacement in the pillar decreased in the unreinforced structure from 6 cm to 1.5 cm in the reinforced structure Figure 1.

(a) (b) (c)

Figure 1. (a) The unreinforced structure before loading; (b) Reinforced structure after loading; (c) A view of the masonry arch (vault and spring).

The results of experiments on these two types of structures show that the weaknesses in the unreinforced structure included vault, springs, base plate as well as arc connection to base in the reinforced structure performs better, and the crack, fracture and displacement rates in these locations are reduced. However, the separation of the cement mortar and C-FRP fiber strip in several areas of the reinforced structure are significant. In the unreinforced structure, due to the lateral

load, it was observed the shearing-slipping cracks that led to move the pillar out of the base plate. But in the reinforced structure, this phenomenon was obviously reduced. Structural lateral loads were increased from 30 KN in reinforced structures to 45 KN in unreinforced structures, that 33% improvement observed in the bearing and structural strength. The seven displacement gauges installed on each structure and comparing the record of displacements, displacement on the right side of the structure, due to base and columns moved out of the plate in the unreinforced structure, its value from 4.15 mm to 0.76 mm was decreased, which it is significantly decreasing. Due to the lack of fragmentation in the bricks, the recorded strains were not submitted, just only opening and slipping of the mortar and the bricks, as well as inappropriate location in their installation. In reinforced structure at the spring is about 44% reduction in strain rate recorded. Based on the observations made on the structures, the analysis of the results and graphs, we can state that by increasing the stiffness and ductility of the structure with reinforcing it at the different points where damage has been observed, the load on the structure has increased as well as the amount of displacement of the structure has been reduced and the amount of damage to the structure has been greatly reduced.

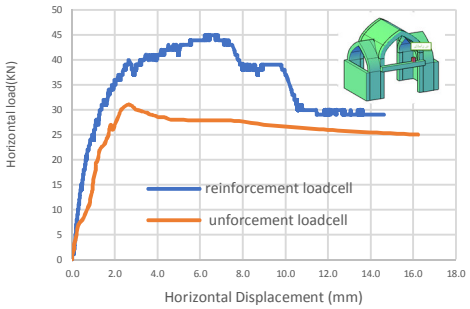

Figure 2. The displacement-force diagram: in the lateral load at the load cell in the reinforced and unreinforced structure.

Figure 3. Separating Mortar and fiber reinforcement from bricks in the reinforced structure.

Figure 4. Opening between the vault and the rib cover in the unreinforced structure.

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