Influence of Anchor Length and Drilled Hole on Mechanical Behaviour of Masonry Column Structures Strengthened with Bonded Anchor

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Abstract

Masonry structures like stone lanterns are collapsed by lateral forces and cracked by deterioration. Some of them should be repaired without changing their original appearance as heritage structures. One way to solve the problems is bonded anchoring, but the design criteria are not established in Japan. Therefore, this paper conducted pull-out tests to investigate the mechanical behaviour of strengthened parts with a bonded anchor. The maximum load and stiffness in load versus pull-out displacement were proportional to embedment length in any failure modes, whereas they did not vary by drilled-hole diameter. Three modes; cone failure, combined failure of cone and pull-out failure, and split failure were confirmed. Since the split failure occurred regardless of embedment length and drilled hole diameter, it seems to be related to initial cracks or compositions and uneven distribution of composed minerals and particles in the strengthened stone.

Keywords: Masonry Column Structures; Bonded Anchor; Pull-Out Tests; Ultimate Resistance

1 Introduction

Masonry structures like stone lanterns and stone bridges are utilized as historical heritage and regional transport. However, they are collapsed by lateral earthquake forces with high possibility, as shown in Figure 1. In Figure 2, deterioration of existing stone bridges like cracks of components and lack of handrail height have also been reported. Moreover, some damaged or collapsed masonry structures should be repaired without changing their original appearance as heritage structures. One way to solve these problems is bonded anchoring shown in Figure 3, as the bonded anchoring will enhance the shear and pull-out resistance rather than traditional ways and secure the original appearance. However, the design criteria of the bonded anchor are not established in Japan, as its structural effect is not elucidated. Therefore, it is difficult to utilize bonded anchoring and suggest structural details of bonded parts. In this paper, pull-out tests of cubic sandstone strengthened with the bonded anchor were conducted to investigate the mechanical behaviour and the relationship between failure modes and the maximum load, focused on the embedment length and drilled hole diameter.

2 Experimental program

2.1 Specimens

Figure 4 shows the dimension of test specimens, and Table 1 shows the design ultimate resistances of each case. As shown in Figure 4, 300mm cubic sandstones called Kimachi sandstone were prepared for test specimens, which has stable material properties and is most often used in rock mechanics research in Japan [1~4]. High-strength thread rod and epoxy resin were used to confirm cone failure and pull-out failure because the