STUDY ON THE LOAD-DISPLACEMENT RELATIONSHIP OF INTERLOCKING BRICK WALLS DURING LATERAL LOADING

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1. INTRODUCTION

Masonry material is one of the most commonly used building material in developing countries due to its inexpensiveness and its accessibility as a construction material. While masonry material is intrinsically strong against gravity compression forces, it is weak in resisting both lateral and horizontal forces generated by earthquake. To reduce the risk of structural collapse of masonry structure due to earthquake in developing countries, it is necessary to find a new reinforcement method which utilize accessible materials, easy to implement and cost-efficient.

In this paper, a reinforcing method for masonry structure which utilize interlocking brick [1] is introduced. Interlocking brick is a brick which utilize interlocking system to reinforce the brick's arrangement by strengthening the connection between the bricks. In rectangular brick's arrangement, when a joint failure occurred, the external force on the wall will be resisted only by friction force. However, in interlocking brick's arrangement, when a joint failure occurred, the external force will be resisted by both friction and the interlocking shape of the bricks. This study sought to observe the effectiveness of interlocking brick in resisting lateral load. The effect of brick shape was investigated through comparing the performance of three types of brick shape during the in-plane loading condition.

2. MATERIAL AND METHOD

In this study, rectangular shaped brick, I-shaped interlocking brick and wave-shaped interlocking brick, were chosen to be the subject of the lateral loading experiment (**Figure 1**). The bricks were made from materials which consist of 25% high early strength Portland cement, 60% of sand and 15% water. The brick was arranged into 24 cm × 30 cm × 10 cm sized wall and then was installed to a steel frame. The steel frame and the wall specimen were installed on a fatigue testing machine (**Figure 2**). The fatigue testing machine was used to give axial load to the specimen. This axial load was applied to the specimen in form of displacement-controlled load. The lateral load was exerted on the upper part of the steel frame by using, manually controlled, hydraulic jack (maximum capacity of 20 kN). A Load cell was installed between the hydraulic jack and the steel frame to measure the applied lateral load. Displacement transducers were installed at the opposite side of the hydraulic jack to measure the lateral displacement of the specimen. To understand the specimen's deformation throughout the experiment, Digital Correlation's VIC-3DTM System [2] was used. Using this system, the strain contour of the specimen throughout the experiment was able to be observed.

Each type of brick was tested under three different initial vertical load conditions of 0.2, 0.4 and 0.6 N/mm^2, which was assumed to be the vertical load acting on the first floor of 2, 4 and 6-story buildings. After the initial axial loading was finished, lateral load was applied to the specimen by using the hydraulic jack. The rate of pumping of the hydraulic jack was kept at low speed and at a constant pace. The lateral load was applied to the wall until it reached failure condition.


(a)Rectangular-shaped


(b)I-shaped


(c)Wave-shaped

Figure 1. Test specimens of brick walls

Figure 2. Testing machine

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3. EXPERIMENT RESULTS

The load-displacement relationships for three different initial vertical load was shown in **Figure 3**. The strain contour of the specimen for the case of 0.2 N/mm^2 is shown in **Figure 4**. The red color indicates larger horizontal strain.

3.1 Rectangular-shaped brick wall

Sliding movement was observed in the three specimens as shown in **Figure 4(a)**. This sliding movement occurred because the applied lateral force is larger than the resisting friction force. As the vertical load increases, the lateral force of the specimen also increases as shown in **Figure 3**. This increase of lateral force was caused by the increase of normal force as the vertical force increase.

3.2 I-shaped brick wall

Due to the existence of interlocking system, the lateral force resisting mechanism of I-shaped interlocking brick is different from that of the rectangular shaped brick. No sliding movement were observed throughout the lateral loading process. The lateral force kept on increasing until it reaches the ultimate peak strength. Due to the formation of cracks throughout the loading process, the lateral force started to decrease after the ultimate peak strength was reached. The ultimate peak strength of the specimen occurred earlier in higher vertical loading condition. As the vertical load becomes larger, the brick wall shows more brittle behavior and cracks formed in the specimen at faster rate.

3.3 Wave-shaped brick wall

Similar to the I-shaped interlocking brick, due to the existence of interlocking system in the wall, no sliding movement was observed throughout the loading process. The lateral force keeps on increasing until it reaches the ultimate peak strength and then decreases as the brick wall entered its failure state. Unlike I-shaped brick, the ultimate peak strength of the wave-shaped brick occurred at almost the same lateral displacement. Thus the increases of vertical load does not affect the brittleness of the wave-shaped brick wall. By comparing **Figure 4(b)** and **4(c)**, the wave-shaped brick wall seems to have less strain concentration due to its smooth shape compared to the I-shaped brick wall. This seems to be the reason why the brittle failure was less observed in the wave-shaped brick wall.

4. CONCLUSIONS

The results obtained from the lateral loading experiment show that interlocking brick does provide reinforcement for the brick wall in resisting lateral load. Due to brittle behavior of I-shaped interlocking brick, wave-shaped interlocking brick shows a better performance in resisting lateral load.

REFERENCES [1] Sanada, Y. et al.: Seismic performance of masonry walls using interlocking units, Proceedings of the First European conference on earthquake engineering and seismology, Paper No.508, 2006. [2] Corelated Solution: The VIC-3D 8 System, available: http://correlatedsolutions.com/vic-3d/. [Accessed 20 March 2018].

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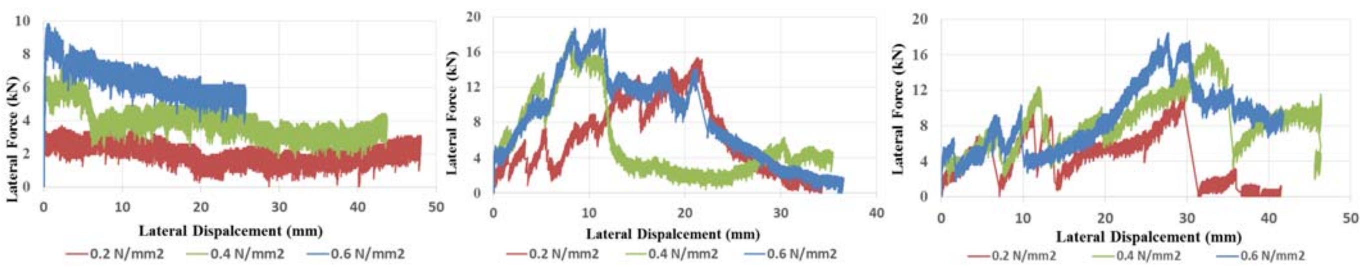
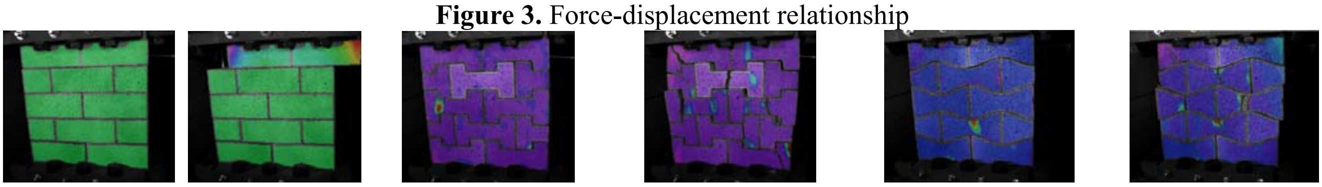


(a)Rectangular-shaped brick (b)I-shaped brick (c)Wave-shaped brick

Figure 3. Force-displacement relationship



at peak load at max. disp. at initial peak load at ultimate peak load at initial peak load at ultimate peak load

(a)Rectangular-shaped brick (b)I-shaped brick (c)Wave-shaped brick

Figure 4. Deformation and horizontal strain contour (0.2 N/mm^2)