EXPERIMENTAL EVALUATION FOR A NOVEL CONCRETE MASONRY WALL WITHOUT MORTAR PASTE

I.S. Choi¹, J.W. Lee², D.H. Kim³, B.K Joung³ and J.H. Kim⁴

ABSTRACT

This study proposes that a modular concrete masonry wall system can attain sufficient compressive and shear strength without mortar paste. Two types of concrete block module were used; 1) module A: 400x200x200mm, 2) module B: 133x133x200mm. Module B reinforce shear resisting performance by inserted inside of module A with different height. To examine the seismic resisting performance of the concrete masonry wall system, prism test and diagonal shear test were conducted to obtain the compressive strength and shear strength. The experimental results were compared with the values presented in design code for unreinforced masonry wall to verify structural safety of proposed concrete masonry wall system. There is no standard for dry concrete masonry wall system, so compressive and shear strength were compared based on wet method. The results indicate that the concrete masonry wall system meets the current design criteria for unreinforced masonry only for the compressive strength even without mortar paste. The shear strength of proposed concrete masonry wall system is equivalent to 74% of the shear strength based on wet method with mortar paste.

¹PhD Candidate, Dept. of Architecture and Architectural Engineering, Yonsei University, Engineering Hall 1,475, Yonsei-ro 50, Seodaemun-gu, Seoul, South Korea, 03722
²Associate Professor, Dep. of Architecture, Shin Ansan University, 671, Choji-dong Danwon-gu, Ansan-city, Gyeonggi-do, South Korea, 15435.
³Graduate Student Researcher, Dept. of Architecture and Architectural Engineering, Yonsei University, Engineering Hall 1,475, Yonsei-ro 50, Seodaemun-gu, Seoul, South Korea, 03722
⁴Associate Professor, Dept. of Architecture and Architectural Engineering, Yonsei University, Engineering Hall 1,475, Yonsei-ro 50, Seodaemun-gu, Seoul, South Korea, 03722, (email: junhkim@yonsei.ac.kr)

Experimental Evaluation for a Novel Concrete Masonry Wall without Mortar Paste

I.S. Choi¹, J.W. Lee², D.H. Kim³, B.K. Joung³ and J.H. Kim⁴

ABSTRACT

This study proposes that a modular concrete masonry wall system can attain sufficient compressive and shear strength without mortar paste. Two types of concrete block module were used; 1) module A: 400x200x200mm, 2) module B: 133x133x200mm. Module B reinforce shear resisting performance by inserted inside of module A with different height. To examine the seismic resisting performance of the concrete masonry wall system, prism test and diagonal shear test were conducted to obtain the compressive strength and shear strength. The experimental results were compared with the values presented in design code for unreinforced masonry wall to verify structural safety of proposed concrete masonry wall system. There is no standard for dry concrete masonry wall system, so compressive and shear strength were compared based on wet method. The results indicate that the concrete masonry wall system meets the current design criteria for unreinforced masonry only for the compressive strength even without mortar paste. The shear strength of proposed concrete masonry wall system is equivalent to 74% of the shear strength based on wet method with mortar paste.

Introduction

Structures that are deficient in seismic performance can be safely protected against earthquake by appropriate seismic retrofitting method. The seismic retrofitting of structure can be achieved by increasing the energy dissipation capacity by installing damper on the structure [1]. Another method is to increase the shear resistance capacity of structure by installing shear wall between the columns [2]. The method of constructing the shear wall by pouring the concrete in situ is advantageous in securing the seismic performance of structure. However, concrete masonry block

¹PhD Candidate, Dept. of Architecture and Architectural Engineering, Yonsei University, Engineering Hall 1,475, Yonsei-ro 50, Seodaemun-gu, Seoul, South Korea, 03722
²Associate Professor, Dep. of Architecture, Shin Ansan University, 671, Choji-dong Danwon-gu, Ansan-city, Gyeonggi-do, South Korea, 15435.
³Graduate Student Researcher, Dept. of Architecture and Architectural Engineering, Yonsei University, Engineering Hall 1,475, Yonsei-ro 50, Seodaemun-gu, Seoul, South Korea, 03722
⁴Associate Professor, Dept. of Architecture and Architectural Engineering, Yonsei University, Engineering Hall 1,475, Yonsei-ro 50, Seodaemun-gu, Seoul, South Korea, 03722, (email: junhkim@yonsei.ac.kr)

wall system is widely used because the shear wall has the low workability.

In this study, a modular masonry wall system is proposed for securing the shear resistance performance by increasing the integration of concrete block without mortar paste (see Figure 1). The full-scale prism test and diagonal shear test were performed to determine the compressive and shear strength of masonry wall system. In addition, the safety of the modular masonry wall system was examined by comparing the experimental results and values presented in design code.

Figure 1. Proposed concrete masonry wall without mortar paste (a) 3D view, (b) detail information of module B (unit: mm).

**Experiment and Result**

Two experiment programs were conducted in order to obtain the compressive and shear strength of a modular masonry wall system.

**Prism Test**
The prism test was performed according to ASTM C1314[3]. A total of three specimens labeled P1–3 were used, and the dimensions of the specimen were 600mm (height) × 400mm (width) × 200mm (thick). The specimens were tested using a universal testing machine (UTM), and rubber plate with a thickness of 10mm were inserted between the specimen and the transfer beam so that external load could be evenly distributed as shown in Figure 2(a). The design compressive strength of the concrete was 21MPa and the compressive strength of prism test specimens was 23MPa on the test date.

As shown in Figure 3(b), the specimen showed typical compressive failure mode. The prism test results were summarized in Table 1. The average compressive strength of prism test specimen is 575.5kN and the prism compressive strength $f'_{m}$ obtained according to ASTM C1314 is 6.19MPa. The used correction factor, which is determined from height-to-thickness ratio, is 0.86.

**Diagonal Shear Test**
Diagonal shear test was performed according to ASTM E519[4]. A total of two specimens labeled D1–2 were used, and the dimensions of the specimen were 1,200mm (height) × 1,200mm (width) × 200mm (thick). The specimens were tested using UTM as shown in Figure 2(b), and the both edge of the specimens were inserted into the void space inside of the transfer beam so that external load could be evenly distributed. The design compressive strength and the compressive strength of diagonal test specimen on the test date were same as those of the prism test.

Figure 3(c) and Figure 3(d) showed the results of the diagonal shear test. As the external load increased, crack occurred in the diagonal part and the separation of module A and module B proceeded. The results of the diagonal shear test were summarized in Table 1. The average shear
strength of the diagonal shear test specimen is 62.5kN and the shear stress $S_s$ obtained according to ASTM E519 is 0.18MPa.

Figure 2. Test setup (a) prism test, (b) diagonal shear test.

Figure 3. Test results (a) prism test load-displacement curve, (b) failure mode of prism test, (c) diagonal shear test load-displacement curve, (d) failure mode of diagonal test.

Comparison of Experimental Results and Design Code

To evaluate the safety of the concrete masonry wall system, the compressive strength $P_n$ and the shear strength $V_n$ were calculated using Eq. 1 and Eq. 2, respectively [5].

$$P_n = 0.80 \left( 0.80 A_n f'_{m} \left[ 1 - \left( \frac{h}{140r} \right)^2 \right] \right)$$  \hspace{1cm} (1)

$$V_n = 0.125 \sqrt{f'_{m} A_n}$$  \hspace{1cm} (2)

where $P_n$ is nominal axial strength for member having an $h/r$ ratio not greater than 99, $A_n$ is net cross-sectional area of masonry, $h$ is effective height of masonry wall, $r$ is radius of gyration, and $V_n$ is nominal shear strength.

The compressive strength and shear strength calculated according to the design criteria are divided into sectional areas for comparison with the experimental values and summarized in Table 1. While the experimental compressive strength was 1.56times higher than the design criteria on average, the experimental shear strength was 0.74times lower than the design criteria on average.
Table 1. Results of prism test and diagonal shear test, and comparison of compressive and shear strength between experimental and code values.

<table>
<thead>
<tr>
<th>Label</th>
<th>Test Results</th>
<th>Design Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Load (kN)</td>
<td>Compressive Strength, $f_m$ (MPa)</td>
</tr>
<tr>
<td>P1</td>
<td>611.9</td>
<td>6.59</td>
</tr>
<tr>
<td>P2</td>
<td>595.0</td>
<td>6.40</td>
</tr>
<tr>
<td>P3</td>
<td>519.5</td>
<td>5.59</td>
</tr>
<tr>
<td>Average</td>
<td>575.5</td>
<td>6.19</td>
</tr>
<tr>
<td>D1</td>
<td>56.9</td>
<td>-</td>
</tr>
<tr>
<td>D2</td>
<td>68.1</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>62.5</td>
<td>-</td>
</tr>
</tbody>
</table>

Conclusions

The compressive and shear strength of a modular masonry wall system without mortar paste were evaluated from the prism test and diagonal shear test, respectively. The experimental results indicate that the compressive strength of the proposed system satisfies the design criteria but the shear strength does not satisfy the design criteria. Although the shear strength of the proposed system does not satisfy the design criteria for shear strength, which is related the unreinforced masonry wall with mortar paste, it is expected that it could be used practically for filling walls requiring low shear strength.

Acknowledgments

This research was supported by a grant(17CTAP-C129738-01) from Technology Advancement Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government and Basic Science Research Program through a National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2017R1D1A1B03028404)

References