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비보강 주거용 조적조의 지진 거동 실험

Seismic Response of Unreinforced Masonry Residential Building

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ABSTRACT

우리나라에 있는 대부분의 주거용 조적조 건물은 내진설계가 되어 있지 않은 비보강 조적조이다. 비보강 조적조 건물에 막대한 피해를 준 1989년의 Loma Prieta 지진을 통해 알 수 있듯이 이들에 대한 실험적이고도 이론적인 연구가 필요하다.

우리나라의 비보강 조적조의 지진거동을 알아보기 위해 1/3로 축소된 전형적인 2층 조적조 모델을 제작하였고, 진동대 위에서 지진모의 실험을 수행하였다. 실험 결과 1층에서의 전단파괴가 지배적으로 나타났다. 하지만 예상했던 것 보다는 비보강 조적조 모델의 내력이 큼을 확인할 수 있었다.

1. Itroduction

Most unreinforced masonry residential buildings in Korea are not designed for earthquake loading. However, considering the heavy damage of unreinforced masonry (URM) buildings caused by the 1989 Loma Prieta earthquake, it may be necessary to study the seismic behavior of URM building by both experiment and analysis method. This paper describes the research-in-progress on an experiment program for the investigation of the seismic behavior of URM residential buildings constructed according to the traditional construction procedure in Korea. A two-story reduced-scale URM building was tested on shaking table to investigate the seismic behavior and the patterns of damage under the dynamic loading. Through shaking table tests, it is found that the shear failure was dominant for the 1st floor, and then the upper part of the model behaves as a rigid body. The response of reduced-scale URM building was significantly stronger than our expectation.

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2. Experimental Program

2.1 Material Test

The brick dimensions are based upon a prototype brick of 90x190x57cm (width, length, and height) which is commonly used in Korean URM buildings and scaled down to 1/3 (30x64x19).

Brick compression tests, prism tests, and diagonal tension tests (McNary 1985; Costley 1996) were performed for both prototype and 1/3 scaled models. Table 1. shows the average strength values of these tests.

Table 1. Result of material tests. (kgf/cm^2)

	Brick Compressive Strength	Prism Compressive Strength	Diagonal Tension Strength
Prototype	303.6	116.0	13.9
1/3 scaled model	274.5	138.7	3.0

2.2 Description of Test Structure

The test model represents the general two-story URM building in Korea. The bricks were laid with English bond pattern type and reduced scale bricks were used. Fig. 1, Fig 2, and Fig. 3 are the drawings of the test structure and the location of measuring instruments. L1~L6 are the displacement transducers and A1~A9 are the accelerometers.

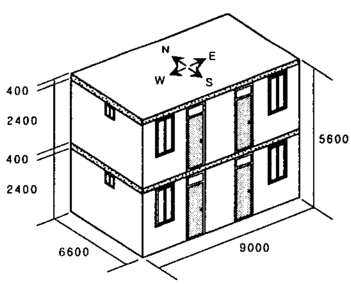


Fig. 1 Prototype house

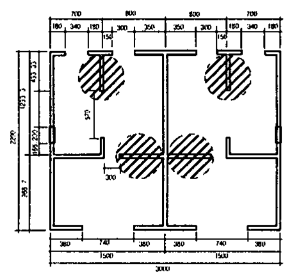


Fig. 2 Top view of model

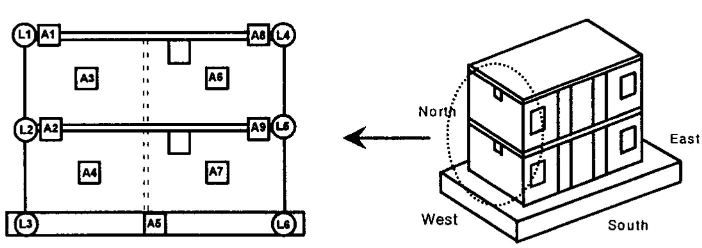


Fig. 3 Location of measuring instruments

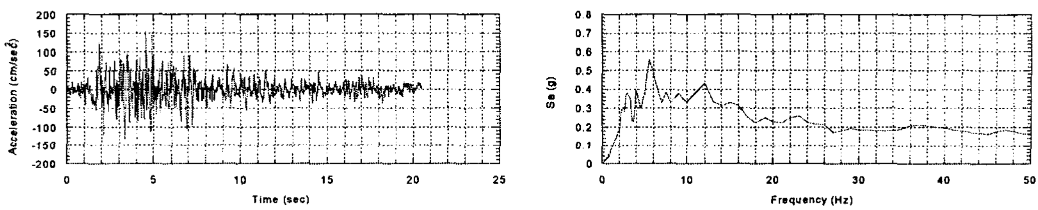
We used artificial mass simulation method (Tolles, 1990) to satisfy the similarity between prototype and model. The mass of test structure is 4.5ton and artificial mass to be added is 9.0ton. This artificial mass was laid on each floor's slab by using the steel blocks.

2.3 Test Method

We performed 3 series of test (test series #1, #2, #3) with following loading step table and used Taft N21E earthquake data which occurred in 1952, USA (Fig 4). After the test series #1, we removed the shaded interior walls in Fig. 2 to observe the effect of that wall's stiffness. The loading direction was west-east and loading was applied step by step in each test (Table 2).

Table 2. Loading Step

Loading Step	1	2	3	4	5	6	7	8
EPGA	0.05g	0.10g	0.15g	0.20g	0.25g	0.30g	0.35g	0.40g



a) Acceleration time history

b) Response spectrum (5% damping)

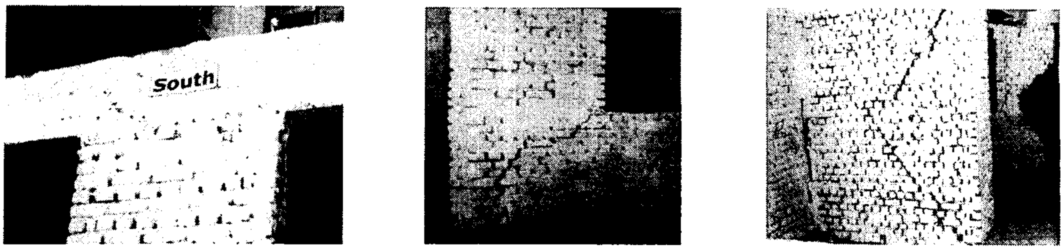
Fig. 4 Input ground motion (Taft earthquake)

3. Measured Dynamic Response

At each loading step, the transfer function is calculated to see the frequency response characteristics of the model. The fundamental frequency of the model was about 18 Hz at the first load step of test series #1. The crack initiates at exterior wall, especially the interface between the slab and the brick layer (Fig 5. a). Any noticeable propagation of the crack was not observed during the test series #1.

We performed the second test to estimate the effects of interior wall by removing the shaded interior walls in Fig. 2. The loading steps are the same as the test series #1. The propagation of the cracks was observed (Fig 5. b). The Fig 7 was the transfer function at test series #2, and showed the effect of removing of interior walls.

The last test was performed to observe the global failure mode of the model. The exterior wall failed abruptly, and macro cracks develops at interior wall (Fig 5. c). The shear failure was dominant for the 1st floor, and then the upper part of the model behaved as a rigid body. The separation between walls developed during the tests.



a) Southern exterior wl (Loadstep 2, Test series #1)

b) Southern exterior wall (Load step 5, Test series #2)

c) Interior wall (Load step 7, Test series #3)

Fig. 5 Failure shapes

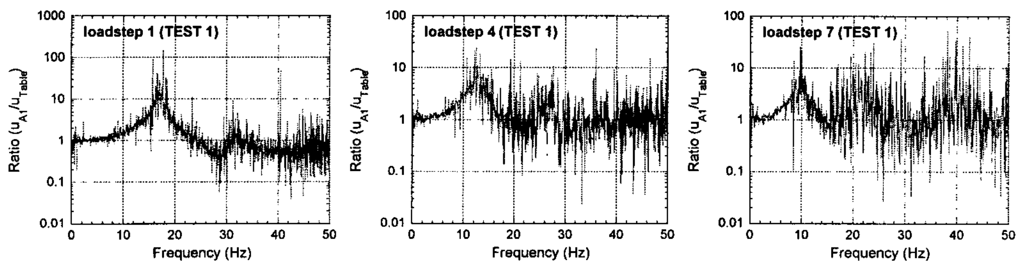


Fig. 6 Transfer function at test series #1

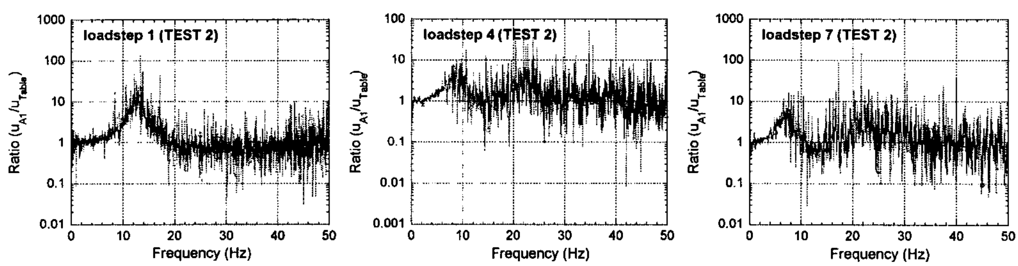


Fig. 7 Transfer function at test series #2

4. Conclusions

The two-story reduced-scale URM building was tested on shaking table to investigate the seismic behavior and the patterns of damages under the dynamic loading. Through shaking table tests, it was observed that the shear failure was dominant for the 1st floor, and then the upper part of the model behaved as a rigid body. The response of reduced-scale URM building was stronger than our expectation.

Acknowledgement

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