論文 / 著書情報
Article / Book Information

論題(和文)	振動台実験によるレンガ組積造の非構造壁の面外性能評価 （その２）実験結果と面外抵抗の評価
Title(English)	Out-of-Plane Performance Evaluation of Brick Masonry Infill Wall Using Shaking Table Test Part 2 Experimental results and evaluation of the out-of-plane resistance
著者(和文)	PRADHAN SUJAN, 真田 靖士
Authors(English)	D G José Tomás, PRADHAN Sujan, HATA Ryuki, YOON Rokhyun, SANADA Yasushi, CHOI Ho, JIN Kiwoong
出典(和文)	日本建築学会大会学術講演梗概集, , , pp. 817-818
Citation(English)	, , , pp. 817-818
発行日 / Pub. date	2020, 9
権利情報	一般社団法人 日本建築学会

Out-of-Plane Performance Evaluation of Brick Masonry Infill Wall Using Shaking Table Test
Part 2 Experimental results and evaluation of the out-of-plane resistance

Infill wall　Lateral resistance
Nonstructural element　Out-of-Plane
Shaking Table

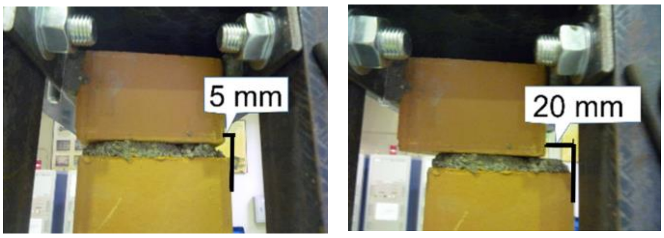
Member ○ D G José Tomás [1]　Member YOON Rokhyun[3]　Member CHOI Ho[5]
Member PRADHAN Sujan[1]　Member SANADA Yasushi[4]　Member JIN Kiwoong[6]
Member HATA Ryuki[2]

1. Introduction

Shaking table test of a full-scale brick masonry infill wall focusing on out-of-plane performance was planned as explained in **Part 1**. This part describes the experimental results and a proposal of analytical model to estimate the out-of-plane resistance of the brick walls.

2. Experimental results

Experiment was performed after 28 days of the specimen construction so that the specimen obtained its full strength. Shaking was performed in the X-X direction (**Part 1 Fig. 1**). After each shaking stage, visual observation was performed to evaluate the evolution of the specimen damage. Under the first two input stages, 10% (20 gal) and 30% (60 gal), the specimen seemed to behave as a rigid body, which was confirmed through the displacement distribution over the height of the specimen, as shown in **Fig. 1**; no damage was observed on it. At the 50% stage, bonding failure between the 1:6 mortar and brick was observed at the top where the axial force due to the self-weight was minimum, and the specimen (top brick layer) slid in the negative direction; thus, a permanent slide of 5 mm remained, as shown in **Photo 1**. At the 75% stage, the magnitude of the permanent slide increased to 20 mm, and a complete disconnection between the top layer of bricks and those in the layers below was observed. Hence, this stage was considered as the ultimate state of failure. At the 100% stage, after the slide reached an amount in which there was no contact between the top brick layer and the layer below it, the specimen collapsed towards the negative direction. **Photo 2** shows the instant when the specimen completely slipped towards the negative direction. Failure at the top is thought to have occurred due to the low axial force (from self-weight) occurring at this point. The displacement and acceleration values over the height of the specimen was recorded with a frequency of 1000 data per second (every 0.001 seconds). The distributions of the maximum displacement and acceleration observed by each transducer and accelerometer can be seen in **Figs. 1** and **2**, respectively. Displacement was not measured at the stage with 100%, as the laser transducers were covered to avoid damage from the collapsing wall. In addition, due to high noise in the recorded data, the moving average method was used to filter the high noise, with a frequency of 11 values per 0.010 sec.



50% input stage　　75% input stage

Photo 1 Permanent slide development

Complete slide　　Collapse

Photo 2 Slipping and failure of the specimen

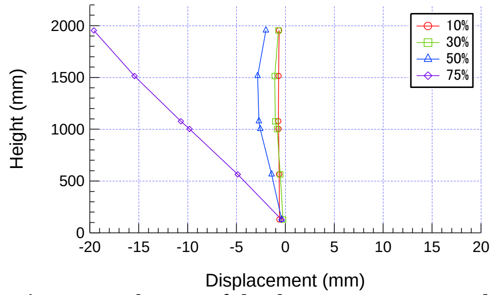


Fig. 1 Distribution of displacement at Max. value

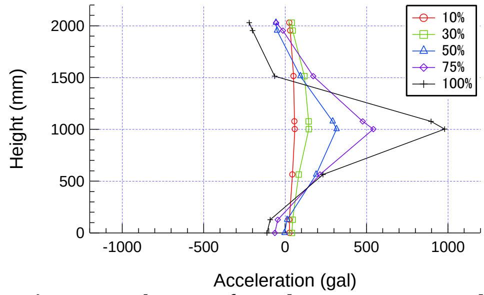


Fig. 2 Distribution of acceleration at Max. value

3. Proposal of a lateral-resistance evaluation method

A conservative analytical model was proposed to predict the lateral resistance of the brick wall in the out-of-plane direction. From the experimental data of the acceleration distributions over the specimen height, a uniform acceleration distribution (a) of equivalent area was determined for every instant of time, as in **Fig. 3**. Then, a relation of the assumed uniformly distributed load (w), mass (m), height (H) of the specimen, and the equivalent uniform acceleration (a) was established as **Eq. (1)**.

$$w = \frac{m \times a}{H} \tag{1}$$

振動台実験によるレンガ組積造の非構造壁の面外性能評価
（その２）実験結果と面外抵抗の評価

D G José Tomás, Pradhan Sujan, 畠 龍樹, 尹ロク現,
真田 靖士, 崔 琥, 晉 沂雄

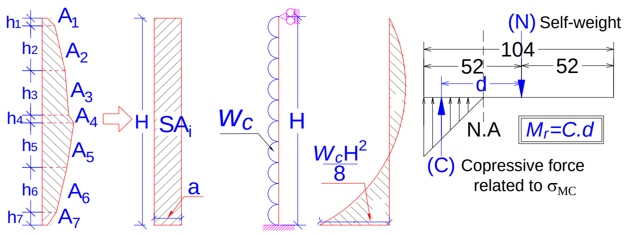


Fig. 3 Equivalent acceleration, BMD and X-section analysis

Furthermore, the analytical lateral resistance of the specimen was evaluated as a capacity of w (hereafter w_c), which depends upon the moment of resistance (M_r) and the maximum moment (M_m) of/on the specimen. To determine the w_c of the specimen, a uniformly distributed load representing the capacity w_c due to the horizontal acceleration was assumed to be acting on the specimen. Thus, a bending moment diagram (BDM) under a roller-fixed support condition (**Part 1 Section 2.1**) was evaluated as shown in **Fig. 3**. The maximum moment (M_m) that arises at the fix bottom end is evaluated by **Eq. (2)**.

$$M_m = \frac{w_c \times H^2}{8} \qquad (2)$$

Moreover, the resistance moment (M_r) was evaluated by cross-section analysis of the specimen using material testing data from **Part 1 Section 2.1**. Here, the flexural tensile strength (σ_t) was neglected because of its lower value compared to the compressive strength of the joint mortar (σ_{MC}). The forces

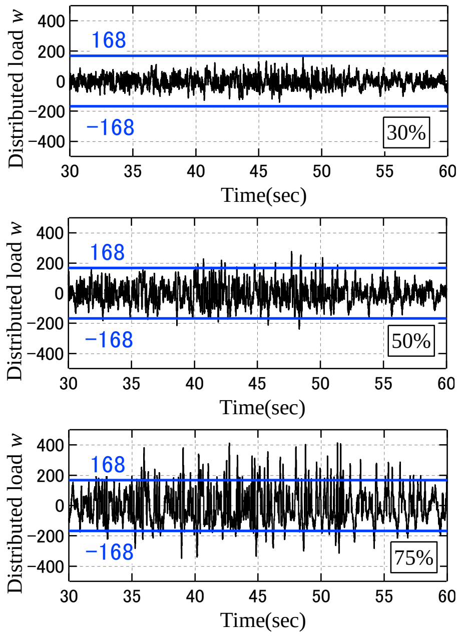


Fig. 4 Comparison of experimental distributed load and analytically evaluated resistance

(—— Experimental —— Analytical)

considered for the cross-section analysis are as shown in **Fig. 3**. Finally, the analytical lateral resistance w_c was evaluated by relating the maximum moment (M_m) to moment of resistance (M_r) of the specimen. **Figure 4** shows the comparisons of experimental w and analytical w_c.

4. Verification of the proposed evaluation method

At the 10% and 30% input stages, the experimental w was much lower compared to the capacity w_c, which was consistent to the test result that no damage was observed. At the 50% input stage, the experimental w slightly exceeded the analytical w_c (**Fig. 4**), explaining the 5 mm permanent slide at the top (**Photo 1**). At the 75% input stage, the experimental w significantly exceeded the analytical w_c (**Fig. 4**), resulting in an increase of permanent slide to 20 mm (**Photo 1**); and at 100% input stage, a complete slide and further collapse of the specimen occurred. This suggests that the proposed method can be used to predict the out-of-plane performance of the brick masonry wall conservatively.

5. Conclusions

1) Damage/failure of the specimen was observed at the top of the specimen where the axial force due to the self-weight was minimum.
2) An analytical evaluation method of the out-of-plane lateral resistance of this type of wall was proposed and verified that it can be used to make a conservative prediction of the out-of-plane lateral resistance.

[Acknowledgments]

The background data used in this research were supported by the SATREPS project under JICA/JST supervision headed by Prof. Yoshiaki Nakano, the University of Tokyo. In addition, the authors acknowledge the students in Dr. Jin's laboratory, Meiji University for their support.

[References]

[1] Maidiawati, Sanada Y. (2016), "R/C Frame-Infill Interaction Model and its Application to Indonesian Buildings", Earthquake Engineering Structural Dynamics. DOI: 10.1002/eqe.2787.

[2] Pradhan, S., Li, Y., Sanada Y., Katayama, H., Fukui, S., Bhetwal, K.K., Choi, H., Kusunoki, K. (2019), "Seismic Performance Evaluation of an RC Residential Building with Brick Masonry Infill Walls in Nepal", Proceedings of 21th Japan-Korea-Taiwan Joint Seminar on Earthquake Engineering for Building Structures SEEBUS, pp. 290-300.

[3] JIS A 1149, 2010, "Method of test for static modulus of elasticity of concrete", Japanese Standards Association.

[4] Bangladesh National Building Code: Version 2015, pp. 6-94-6-104.

[5] 大崎順彦 (1994) ：新・地震動のスペクトル解析入門, 鹿島出版会.

[1] Graduate Student, Graduate School of Eng., Osaka Univ.
[2] Former Graduate Student, Graduate School of Eng., Osaka Uni.
[3] Asst. Prof., Graduate School of Eng., Osaka Univ., Dr. Eng.
[4] Prof., Graduate School of Eng., Osaka Uni., Dr. Eng.
[5] Assoc. Prof., School of Sci.& Eng., Shizuoka Inst. of Sci. & Tech., Dr. Eng
[6] Senior Asst. Prof., School of Sci. and Tech., Meiji Uni., Dr. Eng

[1] 大阪大学大学院工学研究科　大学院生
[2] 大阪大学大学院工学研究科　元大学院生
[3] 大阪大学大学院工学研究科　助教・博士（工学）
[4] 大阪大学大学院工学研究科　教授・博士（工学）
[5] 静岡理工科大学建築学科　准教授・博士（工学）
[6] 明治大学理工学部建築学科　専任講師・博士（工学）