論 文 の 要 旨

題 目　Reinforced Effect on Brick Wall Using Timber Wall as a Retrofitting Method
（改修方法として木材壁を使用したレンガ壁への補強効果）

氏名　Ariunaa Ganbaatar

There are many ways to strengthen an unreinforced brick masonry wall. One of the strengthening methods applies timber, which is a lightweight and easy installation. In this research, the strengthening method of brick wall is used with timber material. The main point of this research covers the material properties, the connection between brick and timber, and reinforced effect of the brick wall using timber wall.

Chapter I involves introduction, including background, literature review, objective, and method. Background section mentioned seismic assessment and failure caused by the earthquake to the unreinforced masonry buildings. In unreinforced masonry structures, retrofitting measures are carried out by various materials. In the literature review section, the results of a wood-reinforced study are presented. This study proposed a retrofitting method using timber and included the objective and method.

Chapter II includes the material properties of red clay brick, cement mortar, brick-mortar interface element and small masonry specimen. Material properties was determined by laboratory experiments. The flexural strength (3.9 N/mm2), compression strength (31.4 N/mm2) and elastic modulus (1201 N/mm2) of the clay brick were defined by destructive testing method according to corresponding ASTM standards. Cement mortar experiment was conducted in this study and the flexural strength is 2.5 N/mm2 at 28 days. The compression strength of cement mortar is 5.9 N/mm2 at 28 days and 10.9 N/mm2 for 6months. and elastic modulus is 3225 N/mm2 measured by transducers at 6 months. From the brick-mortar interface element, frictional coefficient is 0.68 and the initial shear strength is 0.41 N/mm2. In that test, the brick-mortar specimens were tested under three different pre-compression stresses. The shear strength depended on the pre-compression stress. The mean compression strength of five specimen is 14.4 N/mm2 for small masonry specimen. The ratio of shear and elastic modulus was obtained by the result of the experiment.

Chapter III consists of the strength properties of connection between brick and timber.　The connection between the timber and the brick masonry wall plays an important role. In this study, the experimental and theoretical methods were investigated, and the pullout and shear strengths of the chemical anchor were employed as the connection between clay brick and SPF (spruce, pine, fir) lumber. Three bolt diameters (ø8, ø10, ø12 mm) were utilized in nine pullout tests and two types of eighteen shear tests. Four types of prediction models estimated the pullout strength of the chemical anchor. The European Yield Theory (EYT) expected the shear strength of the chemical anchor, involving six failure modes. The results of all experiments were discussed as failure mode, strength, and stiffness under monotonic load. Finally, the effective result of this study highlights A12 specimens using ø12 mm bolt and employing the epoxy resin in brick and lumber. The maximum pullout load of A12 specimens is 12.1 kN, and the yield shear load is 11.2 kN.

Chapter IV consists of the experimental result of the reinforced effect of the brick wall evaluated by the cyclic horizontal load. This research aimed to utilize timber material to enhance the in-plane shear strength and deformation capacity of the brick wall. The proposed strengthening method is light-weight and easy to assemble, and includes a timber frame, plywood panel, M12 threaded rod with chemical epoxy, and the hold-down anchor. To evaluate the effectiveness of the strengthened brick wall, three walls, including the brick wall (BW wall), the strengthened brick wall with timber (BW-T wall), and the strengthened brick wall with timber and the hold-down anchor (BW-TA wall), were tested under the cyclic horizontal load and the static compression load. Failure of the BW and BW-T walls was the rocking. But the timber part kept the original shape of the brick wall because the BW-T wall's failure was observed in the lowest part of the wall. The diagonal failure occurred on the BW-TA wall and the horizontal load increased by 22 percent, and the shear deformation.

Chapter V covers the prediction of BW wall and BW-TA wall. In this study, the load-drift angle relationship of BW wall is predicted by the bi-linear curve. The in-plane shear capacity of the unreinforced brick wall was calculated by the simple theories, and masonry wall was assumed by elastic and homogeneous. BW-TA wall was assessed by the proposed prediction method of Kamiya and Inayama Murakami model. The initial stiffness and ultimate horizontal load were obtained by the Kamiya and Inayama Murakami model.

Chapter VI summarized the results, conclusions, limitations, and future study of this research.