STRUCTURAL IN-PLANE BEHAVIOR OF MASONRY WALLS EXTERNALLY RETROFITTED WITH FIBER REINFORCED MATERIALS

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https://doi.org/10.15017/1398305

出版情報：九州大学, 2013, 博士（工学）, 課程博士
バージョン：

（様式３）

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論文題名　：　STRUCTURAL IN-PLANE BEHAVIOR OF MASONRY WALLS EXTERNALLY RETROFITTED WITH FIBER REINFORCED MATERIALS
（繊維補強材料によって表面から補強した組積造壁体の構造的な面内挙動）

区　　分　：　甲

論　文　内　容　の　要　旨

There is high stock of existing buildings including historical and cultural monuments around world constructed with unreinforced masonry (URM). In recent earthquakes, it has been proved that many of URM structures, such as ordinary houses, schools and so far, are highly vulnerable and as a result there is a serious need for proposing appropriate seismic retrofitting techniques for them.

This thesis focuses on the in-plane retrofitting of the URM walls. Improvement of the in-plane behavior of URM walls by means of the external application of engineered cementitious composite (ECC) and aramid fiber reinforced polymer (AFRP) was investigated in this research. This dissertation was organized in seven chapters.

A general overview on masonry buildings, types of construction and their seismic response are reviewed in Chapter 1. Also, the main vulnerability resources of these structures are discussed. Based on the earthquake experiences, inadequate in-plane and out-of-plane responses of the load bearing walls are mainly responsible for partial damage and total collapse of URM structures. In this study, the in-plane behavior of URM walls was investigated.

The structural characteristics of URM walls such as compressive, shear, tensile and biaxial behaviors are discussed in Chapter 2. Tension softening, cyclic behavior and the failure criterion of URM walls are described as well. Also, in-plane failure modes of URM wall are explained.

An extensive comparative study was conducted on the existing URM retrofit strategies. The comparison process and results are described in Chapter 3. It was revealed that the surface treatment is the most suitable method from both applicability and cost-performance viewpoints in the case that the covering of the wall surface is acceptable due to architectural reasons. Also, it was found out that materials with high deformation and tensile capacity exhibit better in-plane performance in terms of shear strength and deformability. Retrofitting of URM wall with ECC as a new composite material was considered in this research work. ECC is a cement-based composite material with a strain-hardening tensile behavior with an excellent capability to control the width of crack. Improving the low tensile strength, strain-softening and brittle behavior of URM walls with such a ductile strain-hardening material was the main motivation of this research part. Also, AFRP sheet along with confining band system was applied to URM walls as another retrofit solution. As it has been reported in several research works, pre-mature debonding of FRP from substrate limits its efficiency. In present study, in order to eliminate this undesirable behavior, confining bands were utilized.

Since numerical analysis was conducted on the retrofitted masonry wall in this study, the available modeling strategies of URM are discussed in Chapter 4. This chapter was organized in two parts such as modeling of unreinforced and retrofitted masonry walls. The simple micro-model technique was employed for URM in the research. In case of retrofit modeling, new models for ECC and AFRP retrofitting methods were adopted and proposed. These models are also introduced in Chapter 4.

Chapter 5 deals with the conducted experimental program. The tests were conducted on the ECC and AFRP retrofitted masonry wall specimens. The performance of each retrofit method was evaluated based on the comparison between the results of tests on bare and retrofitted URM specimens in terms of load resistance and deformability. Experiments conducted on the ECC retrofitted masonry showed that the shear resistance of URM was improved by an average factor of 3 per 10 mm retrofit overlay. Also, a significant enhancement in the deformation capacity by an average factor of 30 was observed in this retrofit method. In case of AFRP retrofitting, the shear capacity was increased by an average factor of 1.5. Also, the deformability of AFRP retrofitted masonry was obtained as about 5 times of URM. Moreover, the pre-mature debonding behavior of AFRP sheet was successfully controlled by the confining band system and lead to a more deformability.

Analytical studies on the retrofitted masonry with ECC and AFRP are described in Chapter 6. A simple shear model was introduced for ECC retrofitting which its results were in good agreement with experimental data. Efficient strain approach was adopted for URM and the contribution of confining band system to the efficient strain of the AFRP sheet was evaluated. It was found out that the efficiency factor of confining is inversely proportional to the axial rigidity of AFRP sheet. Employing simple micro-model approach, numerical FEM analysis was conducted on the ECC and AFRP retrofitted specimens. An elasto-plastic material model adopted for numerical model of ECC retrofitting. A good agreement was found out between the analytical and experimental results of ECC-URM in terms of shear capacity and deformation. Also a new bilinear tensile model for AFRP-resin assemblage was proposed. It was revealed that this model is able to predict the compressive load-deformation relation of the retrofitted diagonal specimens with a good agreement to experimental data.

The summary, major findings, conclusion remarks and recommendations for future studies are described in Chapter 7.