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In-plane cyclic behaviour of a new reinforced masonry system: Experimental results

Francesca da Porto *, Flavio Mosele, Claudio Modena

Department of Structural and Transportation Engineering, University of Padova, Via Marzolo 9, 35131 Padova, Italy

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ABSTRACT

This paper describes the behaviour under cyclic shear compression of an innovative reinforced masonry system, composed of horizontally perforated units, having common steel bars or prefabricated trusses as horizontal reinforcement. At the wall edges or crossings, confining columns for vertical reinforcement are built with vertically perforated units. Experimental tests to obtain information on the in-plane cyclic behaviour of the construction system were performed on masonry panels made of horizontally perforated units and on completed reinforced masonry walls. Tests on the entire system were repeated for two wall aspect ratios and two vertical stress levels, in order to force shear type and flexural behaviour. In particular, this paper presents: (a) results of shear compression tests in terms of strength, ductility parameters, energy dissipation, viscous damping and stiffness degradation, (b) strains and the effectiveness of reinforcement, (c) the influence of various parameters such as axial load, aspect ratio, and reinforcement type on the behaviour of the reinforced masonry walls, and (d) comparison of walls built with and without vertical reinforcement.

1. Introduction

Reinforced and confined types of masonry were developed to exploit the strength potential of masonry and to solve its lack of tensile strength, significantly improving not only resistance, but also ductility and energy dissipation capacity. In the past few decades, a great variety of reinforced and confined masonry techniques have been proposed. The various masonry systems depend on many parameters: geometric shape and material of units, composition of mortar and/or grout, and quantity and layout of reinforcement [1].

Many reinforced masonry systems around the world are based on the use of hollow concrete units, which are reinforced with steel bars and grouted with concrete. Among others, some recent experimental investigations on this type of reinforced masonry systems have been carried out in the United States [2] and New Zealand [3]. Similar construction systems have recently been developed in Europe, in which hollow concrete units are partially grouted with mortar [4] or concrete units are replaced by hollow clay units fully grouted with concrete [5]. In Europe, reinforced masonry systems are frequently made with perforated clay units combined with concentrated vertical reinforcement (see, for example, [6–11]). Recently, some of these systems have been developed to resist out-of-plane forces [12,13].

Nevertheless, the general structural concepts for masonry buildings require that they resist earthquake actions with box-type behaviour. Under this assumption, horizontal seismic actions are transferred to walls parallel to the direction of loads [1,14]. Hence, experimental and numerical study of in-plane behaviour under combined vertical and horizontal loads remains the main issue when we examine the use of reinforced and confined masonry systems.

A new system of this type, with horizontally perforated units and confining columns with vertically perforated units for vertical reinforcement, has recently been developed within the DISWall project (2006–2008) [15]. As the new reinforced masonry system was designed for use in seismic areas, the main aim of the experimental programme was to assess its behaviour under in-plane cyclic actions. However, the effectiveness of horizontally perforated units in transferring horizontal loads to lateral confining columns may be reduced by unit brittleness and/or malfunctioning of the composite system at the interface between central masonry panels and confining columns. Hence, the basic properties of the constitutive materials (units, mortar and reinforcement) and the behaviour of the reinforced masonry system in compression have been extensively investigated [16]. The latter had seldom been studied in reinforced masonry previously (see [17], for traditional types of confined masonry, and [18,19] for slightly reinforced masonry).

* Corresponding author. Tel.: +39 049 8275631; fax: +39 049 8275631.
E-mail address: daporto@dic.unipd.it (F. da Porto).

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