

Flexural and shear bond characteristics of thin layer polymer cement mortared concrete masonry



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HIGHLIGHTS

- Flexural and shear bonds of thin layer mortared concrete masonry are addressed.
- Polymer cement mortars improve the bond strength in masonry.
- Digital image correlation captures the interface shear strains.
- Bond strength in shear and flexure is approximately same in thin layer mortared masonry.

ARTICLE INFO

Article history:

Received 22 September 2012
Received in revised form 10 March 2013
Accepted 1 April 2013
Available online 17 May 2013

Keywords:

Thin layer mortared concrete masonry
Flexural bond strength
Shear bond strength
Polymer cement mortar
Digital image correlation
Concrete block

ABSTRACT

This paper presents an experimental investigation of the flexural and shear bond characteristics of thin layer polymer cement mortared concrete masonry. It is well known that the bond characteristics of masonry depend upon the mortar type, the techniques of dispersion of mortar and the surface texture of concrete blocks; there exists an abundance of literature on the conventional 10 mm thick cement mortared masonry bond; however, 1–4 mm thick polymer cement mortared masonry bond is not yet well researched. This paper reports a study on the examination of the effect of mortar compositions, dispersion methods and unit surface textures to the flexural and shear bond characteristics of thin layer mortared concrete masonry. A non-contact digital image correlation method was adopted for the measurement of strains at the unit–mortar interface in this research. All mortar joints have been carefully prepared to ensure achievement of the desired thin layer mortar thickness on average. The results exhibit that the bond strength of thin mortar layered concrete masonry with polymer cement mortar is higher than that of the conventional masonry; moreover the unit surface texture and the mortar dispersion methods are found to have significant influence on the flexural and shear bond characteristics. From the experimental results, a correlation between the flexural and the shear bond strengths has been determined and is presented in this paper.

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1. Introduction

Thin polymer cement mortar layered concrete masonry structural walls can offer significant productivity gains to the masonry industry through the development of a masonry construction technology suitable for onsite construction that does not require highly skilled masons and hence could address the severe problem of skills shortage. Thinner layer of mortar cannot be achieved without stringent control of the height of the concrete blocks. Currently blocks are available with height tolerance of ± 2 mm; however for thin layer mortared masonry, much tighter tolerance would be required, which could only be achieved through a process of grinding

the moulded and cured blocks. Grinding will alter the surface condition of the units – this variable was, therefore, included in this investigation.

For the development of the thin layer mortared concrete masonry construction, a fundamental understanding of its basic bond characteristics is essential. To date the bond development in thin mortar layered masonry is not well understood; therefore, an extensive series of bond tests were carried out with particular focus on the shear and flexural bond strengths of thin mortar layered concrete masonry by considering the block surface roughness, mortar application methods and the polymer content in the mortar as variables.

The results show that the bond strength of thin layer mortared masonry is affected by the surface texture of blocks; the smoother the surfaces the better the bond. A regression analysis shows that the shear bond strength of thin layer mortared masonry is approximately equal to its flexural bond strength.

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2. Review of masonry bond

Bond strength is essential for appropriate structural performance of masonry walls, especially those under the lateral loading, including wind and earthquake. In the conventional masonry, the bond between the units and the cementitious mortar is derived from the penetration of the cement hydration products, such as the calcium silicate hydrates in the mortar, into the units through the surface voids and pores.

Major factors that influence the bond between the mortar joints and masonry units, both in the conventional and thin mortar layered masonry are (1) the type of mortars (mix design, workability, water retention, setting characteristics and air content), (2) the type of masonry unit (absorption characteristics and the surface texture/roughness) and (3) workmanship (quality of filling the valleys of the unit surface, degree of pressure applied to masonry unit and the type of tooling used and productivity achieved).

To maintain uniform thin joint thickness, special tools are often used to control the rate of discharge of mortar. Although these tools might control the volume of mortar discharged over a short period of time, depending on the unit surface roughness (depth of valleys) and the pressure applied to fill the mortar into these valleys (thereby avoiding entrapped air), the response of the bond to flexure and shear will vary. Since the thin mortar layered masonry is relatively new, only few studies have been carried out on the bond behaviour of this form of masonry. Among the few studies that have been carried out so far on this form of masonry, it has been found that the characteristics of thin polymer cement mortar and those of the unit constituents enhance the bond strength and in many instances exceed the modulus of rupture of unit [19]. Marrocchino et al. [19], Nicholas et al. [21], Kanyeto and Fried [14] conducted flexural tests on thin mortar layered dense concrete masonry with polymer modified mortar and have independently concluded that the flexural strength of thin mortar layered masonry is two to three times higher than those specified in the British code of practice [10] compared to conventional mortars.

Commonly thin mortar layered masonry mortars contain polymers; depending on the proportion of polymers in the mortar, the process of gaining bond strength differs. Polymer mortars undergo polymerisation in the presence of water. Dry curing is said to improve polymerisation and the strength of mortar [12]; because, the film produced due to polymerisation can block the pores and seal the moisture into the young mortar and avoid escaping to the atmosphere; the initial water added is thereby retained and is available for the hydration of the cement in the mortar. In other words, unlike the non-polymer/cementitious mortars that cure well under moist condition, polymer mortars will not require additional moisture for curing, which is an advantage for its sustainability. Due to these fundamental differences between the polymer based and the conventional mortars in masonry applications, it appears prudent to characterise the flexural and shear bond strengths of the thin mortar layered concrete masonry. The research reported in this paper is part of an ongoing investigation into the complex mechanisms of the thin mortar layered masonry bond.

Since the flexural and shear bond strengths are important parameters for the design of masonry, especially for the in-plane and out-of-plane flexure and shear of masonry walls, in the past many attempts have been made to understand the bond characteristics in conventional masonry. Various test set-ups have been used for the characterisation of tensile and shear bond behaviour of the unit–mortar interface. These include (1) uniaxial tensile test on couplets (2) four-point beam tests and (3) bond wrench pier tests. For the evaluation of the flexural bond response of masonry, four-point beam test and bond wrench pier tests are commonly

practiced. Obtaining the pure shear condition in the joint is more challenging. Ven der Pluijm [25] proposed a test set-up which minimises bending stresses at mortar–unit interface, however this set-up is quite complex and is not used in this research. Couplet and triplet tests are widely used to determine the shear bond strength of masonry.

The parameters influencing the bond strength are the consistency of mortar, additives in mortar and treatments of the unit surfaces were examined by Sarangapani et al. [23]. They have showed that it is important to use either a high-cement mortar or a mortar with plasticising additives to produce better bonding in the conventional masonry. They also concluded that the surface texture of the units affects the bond strength.

Reddy and Gupta [22] showed that smooth surface (with many finer pores) on the surface of the units lead to increase in bond strength. This is because surfaces with many finer pores (smoother surface) can be uniformly 'coated' with mortar relatively easier than the surfaces containing fewer – however larger pores (rough surface) – given the pressure of application the same. A similar finding was also noted from the studies on dental plaster bond reported by Ariyaratnam et al. [4] and AS3700 [17], Leong et al., 2006 where the bond strength was shown significantly influenced by the surface characteristics – with the smoother surfaces exhibiting higher bond strength.

Many other conventional masonry bond studies are also reported in the literature [28,18,3,15,7,27,22,26,29], where each author has used different bricks/blocks and mortar types in their examination of various parameters that affect the bond strength of the conventional masonry containing 10 mm cement–lime mortar. Similar studies on thin mortar layered masonry are fewer, if any and hence this study. In the present study, an attempt is made to characterise the bond strength of thin mortar layered concrete masonry using various combinations of blocks and polymers; all work has been carried out in various laboratories of the Queensland University of Technology, Australia.

3. Experimental program

The primary purpose of this investigation is to determine the flexural and shear bond characteristics of thin polymer cement mortar layered concrete masonry, with due consideration to the parameters influencing the bonding between the surfaces of concrete unit and mortar. The flexural bond strength was determined using four point bending (beam) test using the provisions for the conventional masonry in ASTM [6], AS3700 [5]. To determine the shear bond strength; the triplet test for the conventional masonry provided in European standard [13] has been adopted.

The effects of the surface textures of the concrete unit, polymer mortar types and mortar application methods to the thin mortar layered masonry bond have particularly been examined.

3.1. Surface textures

Solid concrete blocks (390 mm × 90 mm × 90 mm) were cut into 45 mm × 90 mm × 90 mm slices using a diamond saw cutter of blade thickness approximately 2 mm. The characteristics of the cut surfaces of the concrete unit were altered as follows:

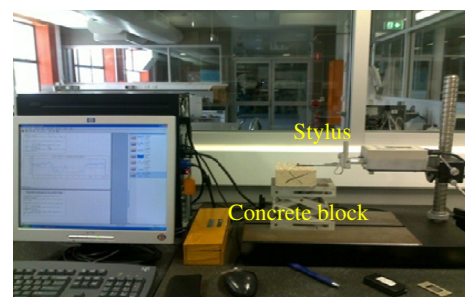


Fig. 1. The view of Talysurf stylus surface measurement machine.

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