UNIVERSITI PUTRA MALAYSIA

STRUCTURAL BEHAVIOUR OF INTERLOCKING HOLLOW BLOCK CONCRETE WALL WITH SUBJECTED TO AXIAL AND ECCENTRIC LOADS

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The use of structural masonry may result in cheaper and faster construction of structures compared with the conventional approach of framed building construction. In Malaysia the supply of houses by both public and private is still far from meeting the demand especially in low cost housing sector. Hence the search for fast, safe and economical masonry system becomes a necessity to meet the demand for housing in Malaysia. Interlocking block system is promoted, as a new building technique that may result to more economical construction. The main concept of interlocking hollow block system is the elimination of the mortar layers and instead the blocks are interconnected through providing key connection (protrusion and groove). The use of interlocking load bearing hollow blocks in building construction will speed up the construction process as a result of the elimination of mortar layers. Furthermore, due to the self-aligning features of the interlocking hollow blocks, the walls can be assembled much faster by unskilled workers compared to mortar masonry construction.

Putra block is an interlocking block system used in the construction of load bearing wall (Waleed et al.(2005)). The structural behavior of the walls constructed using Putra block was presented by Jaafar et al. (2006) and Waleed et al. (2007). The structural behavior of interlocking hollow blocks load bearing wall is not fully explored due limited research on its structural response under the applied load till failure. Moreover, the effect of window opening on the structural response of the interlocking wall especially on the stress distribution in the wall and its failure mechanism are not yet addressed and require special attention for safe and accurate design of walls.

This study presents experimental testing of interlocking hollow block walls having window opening under concentric and eccentric vertical compressive load. The experimental testing focuses on the effect of different layout of the reinforced stiffener around the opening on the structural response of the wall and its failure mechanism.

Eight wall panels having dimension of 1.5 m x 1.6 m (length x height) with a rectangular opening occupying 20% of the wall area were assembled using Putra block. The specimens are differing in the layout of reinforced stiffener around the opening. These wall specimens were subjected to a vertical load of 0 mm, 40 mm, and 55 mm eccentricities. The response was investigated in terms of deformation characteristics, strain variation, failure load and failure mechanism.

The results indicate that the responses of interlocking hollow block wall with opening are similar to the bonded masonry system. The presence of window opening

of an area equal to 20% of the surface area of the wall may reduce the axial efficiency of the interlocking wall up to 50% of the solid wall capacity. Furthermore, the layout of the stiffeners plays a significant effect in the structural response of the interlocking wall and leads to completely different failure mechanism of the wall.

Abstrak tesis yang dikemukakan kepada senat universiti Putra Malaysia sebagai memenuni keperluan untuk ijazah master sains

KELAKUAN STRUKTUR DINDING KONKRIT BLOK BERONGGA BERKUNCI DENGAN BUKAAN DI BAWAH BEBANAN PAKSI DAN SIPI

Oleh

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Perggunaan masonri struktur membolehkan pemblnaan struktur yong lebih murah dan cepat jika dibandingkan dengan pendekatan tradisional pembinaan bangunan berangka. Di Malaysia, pembinaan rumah oleh sektor awam dan swasta masih belum memenuhi permintaan terutama di dalam sektor perumahan kos rendah. Oleh itu, pencarian untuk sistem masonri yang cepat, selamat dan ekonomi menjadi satu keperluan untuk memenuhi permintaan perumahan di Malaysia. Pengenalan kepada sistem blok berkunci sebagai teknik bangunan baru yang dapat menyumbang kepada pembinaan lebih berekonomi. Konsep utama sistem blok berongga berkunci ialah penyingkiran lapisan mortar dan sebaliknya blok adalah disambung berterusan melalui hubungan kunci (unjuran dan liang). Penggunaan blok berongga berkunci dalam perbinaan bangunan akan mempercepatkan pembinaan akibat penyingkiran lapisan mortar. Tambahan pula, disebabkan blok berongga berkunci yang boleh memadan antara sendiri, dinding boleh dibina dengan lebih cepat oleh pekerja tidak mahir jika dibandingkan dengan pembinaan masonri mortar.

Blok Putra ialah sistem blok berkunci yang digunakan dalam pembinaan dinding tahanan bebanan (Waleed et.al, 2005) kelakuan struktur dinding yang dibina dengan blok Putra telah dikaji oleh (Jaafar et. al, 2006) dan (Waleed et al. 2007). Kelakuan struktur dinding tahanan bebanan blok berongga berkunci masih belum lagi dikaji sepenuhnya disebabkan kajian terhad ke atas tindakbalas struktur di bawah bebanan khidmat sehingga kegagalan. Tambahan pula, kesan bukaan tingkap ke atas tindakbalas struktur dinding berkunci terutama yang melibatkan agihan tekanan di dalam dinding dan mekanisme kegagalannya masih belum lagi diberi perhatian dan ini memerlukan perhatian khas bagi rekabentuk dinding yang selamat.

Kajian ini mengenai ujian secara eksperimen ke atas dinding blok berongga berkunci yang mempungai bukaan tingkap di bawah bebanan mampatan paksi dan sipi. Ujian secara eksperimen memberi tumpuan kepada kesan pelbagai susunan pengukuh meneguhkan di sekeliling bukaan ke atas tindakbalas struktur dinding dan mekanisme kegagalannya.

Lapan panel dinding berdimensi 1.5m x 1.6m (panjang x tinggi) dengan bukaan segiempat tepat yang memenuhi 20% keluasan dinding telah dipasang dengan blok Putra. Spesimen adalah berbeza dari segi susunaan pengukuh di sekeliling bukaan. Spesimen dinding ini telah didedahkan kepada bebanan menegak dengan kesipian 0 mm, 40 mm dan 55 mm. Tindukbalas telah dikaji dari segi ciri kegagalan, variasi ketegangan, bebanan gagal dan mekanisme kegagalan.

Keputusan eksperimen menunjukkan tindakbalas dinding blok berongga berkunci dengan bukaan adalah sama dengan sistem masonry terikat. Kehadiran bukaan

tingkap dengan keluasan 20% daripada luas mukaan dinding mungkin mengurangkan kecekapan paksi dinding berkunci sehingga 50% kapasiti dinding tanpa bukaan. Tambahan pula susunan pengukuh memainkan kesan signifikan di dalam tindakbalas struktur dinding berkunci dan membawa kepada mekanisme kegagalan dinding yong berlainan sama sekali.

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ABBREVIATION

W_s	saturated weight of specimen, kg,
W_d	dry weight of specimen, kg,
W_l	lab environment weight of specimen, kg
V_n	net volume of specimen, m^3
f_b	compressive strength of the block, N/mm^2
f_p	compressive strength of the prism, N/mm^2
e	eccentricity of the load, mm
t	thickness of the wall, mm

CHAPTER I

INTRODUCTION

1.1 Introduction

Interlocking hollow block masonry systems were developed recently to reduce the construction time of traditional bonded masonry system. The main feature of interlocking hollow block masonry system is the replacement of mortar layer commonly used in bonded masonry with interlocking keys (protrusion and grooves).

The interlocking hollow block masonry system has self-aligning features enabling easy assemblage by unskilled workers. Furthermore, the elimination of mortar layers will reduce the cost, construction time and enhance the structural behavior compared to traditional masonry system.

Putra block is an interlocking hollow block masonry system used in the construction of load bearing wall. It was developed by Housing Research Centre at UPM (Waleed et al. (2005)). The structural behavior of prisms, small wall panel constructed by using Putra blocks system was presented by Jaafar et al.(2006).

Extensive research has been carried out to investigate the compressive strength of the system under concentric and eccentric loading using, individual blocks, prisms, walls. Shear characteristic of the system have been investigated using a

modified triplet test setup under different pre-compression loads. Full scale walls were assembled using Putra block and tested under axial eccentric loads by Waleed et al. (2007). Furthermore, finite element programmed was developed and used to study the structural behaviour of interlocking hollow block system (Walled et al.(2007)).

1.2 Problem Statement

The above experimental and theoretical analyses of interlocking hollow block masonry system using Putra blocks showed that the structure response of interlocking hollow block masonry system is similar to traditional bonded masonry system. However, the effect of window opening on the structural response of the Putra block interlocking hollow block masonry system was not yet addressed and investigated. It requires a special attention for safe, accurate and economical design of the system. This study presents experimental testing of interlocking hollow block walls having window opening under axial and eccentric vertical load.

1.3 Objectives

1. To determine the structural response of interlocking hollow block masonry wall having window opening using Putra block under axial and eccentric vertical load.

2. To determine the effect of different layouts of stiffeners around the window opening on the structural behavior of the interlocking hollow block masonry system.

1.4 Scope and Limitations

The following are the scope of this research:

1- The structural response are evaluated based on the deformation characteristic, stress distribution, failure load, and failure mechanism of interlocking hollow block wall with opening.

2- The behaviours are based on tested on three different eccentricities i.e. 0 mm, 40 mm, and 55 mm on the interlocking hollow block walls with opening as well as with and without stiffeners.

3- Only wall with dimension 1.6 m x 1.5 m were tested in the experimental work.

4- The load subjected vertically to the wall panel.

1.5 Layout of Thesis

The thesis is divided into five chapters as follows:

Chapter one: Presents problem's definition, scope and objectives of the study.

Chapter two: Discuss the critical literature review on interlocking blocks and traditional masonry.

Chapter three: highlight the experimental work of the research with computer analysis for the size specimens.

Chapter four: highlight the out come of the result of the experimental work.

Chapter five: highlight the reached conclusion of the research and the recommendation for the future work.