PERFORMANCE OF SAND CEMENT BLOCK UNDER AXIAL LOAD WITH DIFFERENT ECCENTRICITY

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ABSTRACT

The load carrying capacity of structures under eccentric loading is a primary issue for the assessment of several structural elements, such as walls, vaults, arches and pillars. Even though these structures are quite different, they may exhibit a stress concentration resulting from the eccentricity of the load, which may lead to the crushing failure of the material. From this situation, an experimental works on performance of sand cement block under axial load with different eccentricity were conducted. Three types of block prism namely Prism A, Prism B and Prism C were prepared. All samples were loaded with from the top and both from the top and bottom of block prism with varies of eccentricity which is 0mm, 5mm, 10mm, 15mm and 20mm respectively. Two types of block prism, which is sand cement block and lightweight foam concrete block, (LWFCB) were considered. The ultimate load for Prism A, were 117.5kN, 77kN, 63.75kN, 56.75kN and 44.5kN through eccentricity of 0mm, 5mm, 10mm, 15mm and 20mm respectively. Whilst, the ultimate load of Prism B was 78.75kN, 72.75kN, 54.75kN, 41.5kN and 30.75kN recorded due to five different eccentricities respectively. Prism C has gained the ultimate load of 43kN, 35.5kN, 11.5kN, 7.25kN and 6.25kN when eccentricity increased in 5mm interval respectively. All samples show the same crack pattern which is vertical crack.

ABSTRAK

Beban daya dukung struktur dengan pembebanan esentrisiti adalah masalah utama bagi penilaian beberapa elemen struktur seperti dinding, kubah, lengkungan dan tiang. Walaupun struktur ini sangat berbeza, mereka mungkin menunjukkan ketegangan akibat esentrisiti beban yang boleh menyebabkan bahan menjadi hancur. Dari situasi ini, sebuah eksperimen terhadap prestasi blok semen pasir bawah beban paksi dengan esentrisiti berbeza dilakukan. Tiga jenis prisma blok iaitu Prisma A, Prisma B dan Prisma C digunakan. Semua sampel dibebani dari atas dan dari atas dan bawah prisma blok dengan esentrisiti yang berbeza iaitu 0mm, 5mm, 10mm, 15mm dan 20mm. Dua jenis prisma blok digunakan iaitu blok semen pasir dan blok konkrit busa ringan, (LWFCB). Beban tertinggi untuk Prisma A adalah 117.5kN, 77kN, 63.75kN, 56.75kN dan 44.5kN berdasarkan esentrisiti 0mm, 5mm, 10mm, 15mm dan 20mm masing-masing. Sementara itu, beban tertinggi Prisma B ialah 78.75kN, 72.75kN, 54.75kN, 41.5kN dan 30.75kN, telah direkodkanmengikut lima esentrisiti yang berbeza. Prisma C menunjukkan beban akhir sebanyak 43kN, 35.5kN, 11.5kN, 7.25kN dan 6.25kN ketika esentrisiti meningkat pada selang 5mm masing-masing. Semua sampel menunjukkan pola keretakan yang sama iaitu retak menegak.

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CHAPTER 1

INTRODUCTION

1.1 Background

Occasionally, blocks concrete are design as wall for building. Blocks are widely used because of its cost and it is easy to take care of. There are many types of concrete blocks in Malaysia. For example, there are sand-cement blocks, masonry blocks, and lightweight foam concrete blocks. Sand-cement concrete blocks are usually used in construction of building or houses.

There are many advantages of using block concrete as a wall. It is an excellent choice as termites can infest and start to destroy a wood framed home that does not have adequate protection. Concrete block homes that include easy-to-install steel reinforcing can stand up to vicious hurricane winds. Fire typically does not cause a well-built

masonry home to collapse. These houses can often be restored with much less effort than a wood frame home destroyed by fire. Concrete block homes also work well in areas that suffer from earthquakes. Once again the architect or engineer simply has to specify inexpensive steel reinforcing rods that are inserted into any number of hollow voids in the concrete block. A wet concrete mixture of sand, cement and sometimes small rounded gravel is then poured into these voids. This wet mixture surrounds the reinforcing steel and once it cures and hardens imparts incredible strength to the structure.

Walls are structure that's need to be very strong because it will support the load from above structures likes upper floor, roof and etc. Each layer of blocks is layered with mix of concrete or also known as mortar before another concrete blocks is place above or beside the concrete blocks. These types of blocks are called prism blocks. These prism blocks can only give their maximum strength if loading form upper structure is place axially on the prism blocks. This paper will study the performance of sand cement block under axial load with different eccentricity.

1.2 Problem Statement

This study is focused on the effects of eccentricity on prism block from upper structure to the strength of the block prism. In Malaysia, there are many unskilled workers at construction site. Workers only know how to do the work without knowing the behavior of the structural itself. An engineer will design the placement of load into the structure based on eccentricity, e equal to 0mm, but workers will be construct not equal what the engineer has design. From this situation, this study was seeing how much the eccentricity will effects the whole structural elements.

1.3 Objectives of Research

These are the main goals by completing these studies

i. To determine effect of eccentricity to the ultimate load of block prism.

ii. To determine the effect of the different load condition to the ultimate load of block prism

iii. To observe mode of failure of prism block under axial test due to different eccentricity

1.4 Scope of Study

In this study, sand cement block with dimension 390mm x 98mm x 197mm (length:width:height) will be used. It is a commercial block which is used by most construction work. This sand cement block is 15 kilogram in weight. The sample will be produce by a establish company in Kuantan area.

In this study, four sand cement blocks will be assemble to form a prism block. The blocks will be arranged in stretcher. Figure 1 shows the arrangement of the block and mortar to form prism block. The mortar with mix proportion of 1.0:0.5:4.5 (cement:lime:sand) will be used to assemble a sand cement block to form a block prism. According to British Standard BS 5628 and ASTM C-270, this mix proportion was classified as a medium strength standard and it is recommended for housing construction.

Thickness of each layer will be choose between the block is 10mm.Too large thickness will lead the mortar to dry and shrink, leaving gaps which will allow water and cold air to penetrate through the wall. Water cement ratio and sand cement ratio of 0.5 and 1.0 respectively will be considered.

The tests for block prism will be lined up two blocks vertically. All samples will be test under compression test machine with capacity of 1000kN. Cylinder rod will be use as a contact from loading to prism block surface during the testing. Table 1.1 shows the detail of the eccentricity value. The prism block will be test under compression test and the ultimate load and crack pattern will be observed.

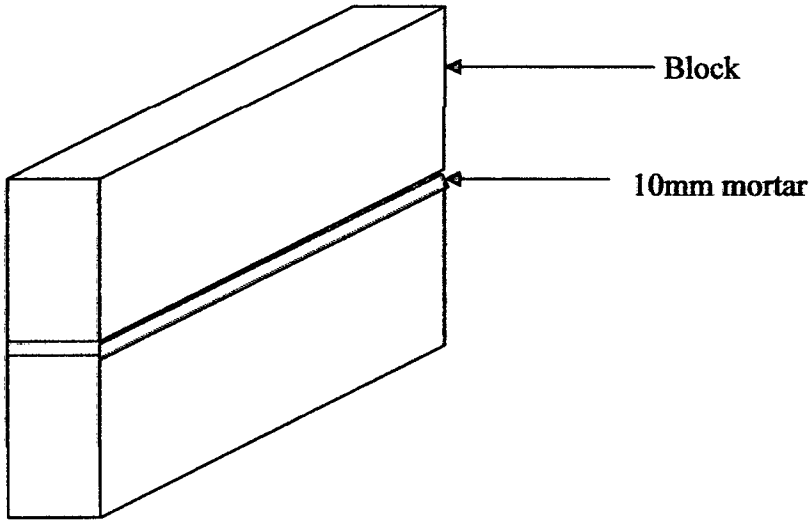

Figure 1: Sample of block prism

Table 1.1: Detail for Prism Block

Sample	Eccentricity,e (mm)	No. of Sample	Dimension (mm)		
			Length	Width	Height
1	0	2	390	98	197
2	5	2	390	98	197
3	10	2	390	98	197
4	15	2	390	98	197
5	20	2	390	98	197

1.5 Significant of Study

From this study, perhaps it can help other to take precautions step in order to make sure that the prism blocks can be use in maximally usage and quality. With the ultimate loads for various value of eccentricity that has been choose, it can show the differences between them. With all the results from this experiment, perhaps it can show the relationship between values of eccentricity with the maximum axial load that can be support by the prism block. This is important because it can influence the strength of the prism block.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A concrete block, sometimes called a cement block, cinder block, or foundation block, is a rectangular brick used in the construction of walls. Concrete blocks are made from cast concrete, Portland cement and aggregate, sand and gravel for high-density blocks, cinders of fly ash or bottom ash for lower density blocks, or aerated concrete for lightweight blocks. Concrete blocks, and the walls created using them, come in many sizes. Typically, a common block size in the U.S. is 8 inches in width by 8 inches in height by 16 inches in length. However, most blocks are actually sized slightly smaller to allow for mortar joints. The color of concrete blocks and unpainted concrete block walls

is typically ashen to grey. Many concrete blocks have a hollow center, sometimes with a dividing piece of concrete running through the middle of the rectangle.

Concrete block walls, especially when reinforced with tie beams and concrete columns, are a very common and wise choice for load-bearing walls of homes and other buildings. Many homes in the U.S. are built on a concrete foundation and employ a concrete block wall on the perimeter of the structure. Large buildings, such as those used for commercial offices or apartments, typically use large amounts of concrete block in their construction. Concrete blocks are being relied on more frequently due to recent natural disasters that easily destroyed homes built using wood or other materials. Glazing is sometimes applied to concrete to produce a hard finish that is water-resistant, which is especially useful in areas prone to moisture, such as locker rooms, commercial kitchens, car washes, shower stalls, and cafeterias. The National Concrete Masonry Association in the U.S maintains concrete block wall construction and masonry standards.

Concrete block walls have numerous benefits over other types of walls. They are fire resistant and made of non-combustible materials, which makes them ideal for use in hazardous areas. Concrete walls are also weather resistant and can withstand heavy storms, sub-zero temperatures, extreme heat, high winds, and U.V. degradation. When used in homes, concrete block walls offer resistance against termites, protection from mold, fungus, and rotting, and provide better sound proofing than wood or other traditional building materials. Moreover, concrete block walls require very little maintenance and are environmentally friendly.

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Concrete block walls are used for a variety of reasons and purposes. They provide structural support for homes and other buildings, and are used to frame outdoor areas, line gardens, and prevent erosion when used as retaining walls for soil. They are relatively easy to construct, and require less time and training to erect than walls made of brick or other materials. When reinforced with steel, concrete block walls enable builders to construct larger buildings without compromising safety. However, many people find the appearance of concrete block unappealing, and so the surface is typically painted or covered with stucco, siding, or brick for decorative reasons.

2.2 Historical Development of Sand Cement Block as a Wall Structure

Block walls in one variation or another have been around for more than 6000 years and have been used in the construction of such monuments as the Great Wall of China, the Taj Mahal and even the pyramids of Giza.

Concrete is by no means a twentieth-century innovation. A mixture of cement, sand, water, and stone aggregates, it has been around since classical times, and a number of patented procedures for casting it into "artificial stone" emerged in the nineteenth

century. Not until 1900, however, was the widespread production of concrete block possible. (Pamela H. Simpson, early 1900s). Harmon S. Palmer (early 1900s) has obtained a United States patent for his durable and practical cast-iron machine, with removable core and adjustable sides that spelled the beginning of the modern concrete block industry.

Even with Palmer's invention, economical hollow concrete blocks would not have appeared had it not been for another development-the improved techniques for grinding and firing Portland cement. Cement, the binder in concrete, is made of lime and clay, fired at a high temperature and then finely ground. Portland cement, named for the limestone it resembled, had been invented in 1824, but late nineteenth-century improvements in its production increased its reliability and lowered its cost. The Portland cement and concrete block industries were thus quite literally bound to each other, and both experienced phenomenal growth in the first decade of the twentieth century. As one writer noted in 1906, Concrete blocks were practically unknown in 1900, but it is probably safe to say that at the present moment more than a thousand companies and individuals are engaged in their manufacture in the United States.

Concrete block was indeed quick, cheap, and easy. A machine could cost as little as $60 and its manufacturers promised that experience was really unnecessary, that anyone can do this work. Concrete also unquestionably attracted customers because of its ornamental potential. Any number of wreaths, scrolls, or cobblestone faces could be reproduced. Most in demand was rock-face, the imitation of quarried stone which became the standard unit on all Sears's machines.

2.3 Advantages of Sand Cement Prism Block

Nowadays sand cement block are nowadays widely used as wall structure whether for a small or big building. These blocks provide many advantages to the people, cost and energy. The thermal mass created in a concrete block home has numerous advantages. There is far less air infiltration if the home is built well. Concrete block homes are virtually soundproof if you purchase high-quality windows and doors that have excellent weather stripping. The void space between the window and block must also be sealed well to stop air that acts as a sound-transmission conduit between outdoor noise and your ears inside the home. Americans used mud and masonry homes to stay cool in the extreme temperatures of the desert Southwest.

Resistance to fire is one of particular importance since fire services in the countryside tend to be further away and take longer to arrive at the scene of the fire. Concrete blocks are incombustible and will not burn, so the house structure will stay intact in the event of fire. In contrast, if a timber frame structure catches fire it will burn to the ground quickly.

Concrete block is an extremely flexible building material. Building with concrete block means you have the flexibility to do just about anything you want. Whether it be a one- story home or a three story home with such options as columns, arches, high ceilings and tall windows concrete block provides the needed flexibility for every type of job.

Concrete is one of the most durable materials on Earth. It is unquestionably the most practical home building material. There's no rotting or wall warping. No extensive

maintenance or upkeep requirements. Concrete block homes are more energy efficient than wood homes, especially hot, humid, sun baked climate weather. That's because the mass factor of block acts as a reservoir to trap and store heat from the sun, so that interiors stay cooler longer.

The Florida Energy Code recognizes the value of mass by requiring much less insulation for block walls than for wood frame walls. Another point is air infiltration from wall leaks is estimated to cause up to 39% of home energy loss. Concrete block walls, which are more airtight than wood frame walls, seal in air conditioned air far better – while keeping out hot, humid air.

After a hurricane passes, weather resistance may be the most important benefit to a home buyer nowadays. In a concrete block home a family will enjoy increased safety and peace of mind during dangerous weather. At the same time, your insurance rates will be lower, which can add up to considerable savings. Moreover, unlike wood, block does not deteriorate in any way, further protecting the value of your investment.

2.4 Physical Properties of Sand-Cement Blocks

Sand-cement blocks have relatively high compressive strength but significantly lower tensile strength, and usually reinforced with materials that are strong in tension (often steel). The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develop. A Sand-cement block has a very low coefficient of thermal expansion, and as it matures concrete shrinks. All

concrete structures will crack to some extent, due to shrinkage and tension. Concrete which is subjected to long-duration forces is prone to creep.

2.4.1 High Compressive Strength

Sand cement blocks can be design to provide a wide range of mechanical and durability properties to meet the design requirements of a structure. The compressive strength of a sand cement blocks is the most common performance measure used by the engineer in designing building and other structure. The compressive strength is measured by breaking specimens in compression-testing machines. The compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load and reported in units of pound-force per square inch (psi) in US Customary units or megapascals (MPa) in SI units. Sand cement blocks compressive strength requirements can vary from 2500psi (17MPa) for residential concrete to 4000psi (28MPa) and higher commercial structures. Higher strength up to and exceeding 10000psi are specified for certain applications.

2.4.2 Durability

Durability means standing the test of time. It's what protects you and your business from the outside storm. Over the last few years Florida has had to deal with an increased number of storms and hurricanes. During that time, Concrete Block has proven to be both durable and impact resistant. Another part of Concrete Block's durability is

little to no maintenance costs. You will never have any mold growth, warping or rotting with a Concrete Block Building.

2.4.3 Density of Concrete Block

For block concrete, high density is probably the most characteristic feature. It depend primary on the aggregate density and the proportions of aggregate because the particle density of individual grading fraction can differ considerably and thus will affect the density of concrete. In addition, this property also influenced by the cement, water and air contents (ACI Committee 213, 2003).

A wide range of density can be obtained by varying the size block, and composition which in turn will affects the pore structures, size and distribution. A stable and preferably spherical shell structure is vital for optimum structural and functional properties. The distribution of pores also plays an important role which must be distributed evenly to achieve a uniform density. The density of a block can only be obtained after the casting process.

2.5 Mechanical Properties of Concrete Block

Concrete block have its own mechanical properties such as thermal insulation and fire resistance.

2.5.1 Thermal Insulation

Insulated concrete blocks can accommodate many walls in a home. Their cores are filled with insulation (except for those cells requiring structural steel reinforcing and concrete infill), which raises the average wall R-value. Khedari (2004) stated that either closed or open window it can reduce significantly room temperature as a result of the increase of natural ventilation. The better concrete masonry units reduce the area of connecting webs as much as possible. Concrete blocks can be used with various insulation materials to satisfy the requirements of the 1991 Building Regulations for thermal insulation of external walls. Table 1 shows the effect of thickness to R value. R value can be obtain from equation as below

$$R = \Delta T/Q_A$$

R = thermal resistance

ΔT = temperature difference

Q_A = heat flow per unit area

Table 2.1: Effects of Block thickness to R value

Block Thickness mm	R (m^2 K/W)
100	0.77
150	1.15
200	1.54

2.5.2 Fire Resistance

The fire resistance ratings of block concrete walls are determined by heat transmission measured by temperature rise on the cold side. A block concrete wall will not let flames or smoke through even after the temperature of the wall on the cold side has risen above required levels. Few walls fail due to load during the fire test, during cooling under the fire hose, or during the double load test that follows. Fire endurance can be calculated as a function of the aggregate type used in the block and the equivalent solid thickness of the wall. Fire-rated walls made of gypsum wallboard are not required to endure the same fire-hose test.

The hose-stream test provides a meaningful measure of durability during a fire. It provides an indication of how well the wall can endure fire exposure as well as falling debris, pressure waves due to explosion, actual fire hose-streams and other rough usage often occurs during a real fire, which can never be truly replicated in a laboratory test.

2.6 Effects of Slenderness Ratio

Loading a structural element or a specimen will increase the compressive stress until the reach of compressive strength. According to the properties of the material, failure will occur as yield for materials with ductile behavior.

This is supported by Heidarpour and Bradford (2007) mentioned that under the combined loading, the elastic local buckling coefficient and the web slenderness limit that classifies a non compact section are dependent on the thermal gradient, the depth of the compression zone in the representation of the mechanical strain and on the values of the shear strain.

2.7 Factor Affecting the Compressive Strength of Block

Compressive strength is widely conducted either in the testing in laboratory or even on site to determine the strength of concrete. Compressive strength of concrete is very much dependent on the water binder ratio decrease and the strength of coarse aggregate. In general, the strength of concrete decrease as the water/cement ratio increases. The compressive strength increased with a decrease in aggregate/cement ratio. Poon (2007). However, when coarse aggregates are not strong enough in comparison with the strength of the hydrated cement paste, the compressive strength of concrete does not increase significantly as the water/binder decrease. (Hamidah et al., 2003)

According to Neville (1985), strength of concrete compression actually gives comprehensive picture with regard to concrete quality because compressive strength is directly related with hardest cement paste structure. Concrete strength can be influenced by several factors. Among major factors which influenced the strength were types of cement, content, size and form of aggregate, water cement ratio, degree of density curing process and age.

2.8 Mortar

Cement mortar is an intimate mixture of cement and sand mixed with sufficient water to produce a plastic mass. The amount of water will vary according to the proportion and condition of the sand, and had best be determined independently in each case. Sand is used to avoid cracks due to shrinkage of cement in setting. Where great strength is required, there should be at least sufficient cement to fill the voids or air