THE MECHANISM OF FAILURE OF STRUCTURAL LIGHTWEIGHT CONCRETE INFILL OF IBS BLOCKS SUBJECTED TO FLEXURAL

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<u>أهـــــــــــــــداء:</u>

الي من رحمه الله تغشـــــــاه واسكنهُ في عليين بجوار النبيين والمرسلين من شجعني في صغــرى

(أبي)

الي من لم تنام عيناها الا بعد أن ترفع يداها تنآجي ربي ان يحفظني ومن صوتها وحنانها يبعث فيني الهمه

(أمي)

الي من ساعدوني ووقفوا بجانبي ورفعوا معنوياتي وكانوا لي سنداً في سبيل تحقيق أهدافي المرسومه

(أخواني وأخواتي)

الي من من عشت معهم أحلي لحظات غربتي و أنسجمت بمصادقتهم – وكانوا نوأباً عن أخواني لي بالغربه

(زملائي و أصدقائي)

To my parents and all my beloved family members

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ABSTRACT

Currently there is a strong inclination of the Malaysian construction industry to utilize industrialized building system (IBS) of lightweight concrete material. The use of lightweight material has the potential to offset the high cost of production and transportation of IBS components of normal dense concrete material. This research presents an experimental contacted testing on the mechanism of failure of structural lightweight concrete infill of IBS block-works subjected to flexural. Full-scale experimental push-out test frames were erected to investigate the ultimate behavior of lightweight concrete beams and blocks. The setup frame consists of lightweight beams supported at both ends with IBS lightweight infill blocks. Numerous dimensions and shapes of the lightweight IBS blocks were tested. Each lightweight IBS blocks were designed based on readily available steel formwork and proper means of fixing and assembling each IBS blocks to form a complete a full height lightweight panel. Push-out load (flexural load) is then applied up to failure to determine the behavior of the IBS panel due to incremental loading. The deflection, crack pattern, splitting strength, tensile strength and ultimate compressive strengths of the IBS blocks are recorded and compared with the results obtained with a similar panel of normal concrete in-fill.

ABSTRAK

Sekarang ini, terdapat kecenderongan dikalangan industri pembinaan di Malaysia untuk menggunakan Sistem Binaan Berindustri (IBS) yang menggunakan bahan konkrit ringan. Tidak seperti konkrit biasa, penggunaan konkrit ringan mempunyai potensi untuk menjimat kos yang tinggi bagi pengeluaran dan pengangkutan komponen IBS ini. Kajian ini membentangkan ujian eksperimen dihubungi mengenai mekanisme kegagalan struktur konkrit ringan blok IBS tertakluk kepada lenturan. Suatu kerangka tolak-keluar yang berskala penuh telah didirikan untuk meninjau tingkah laku muktamad rasuk dan blok konkrit ringan. Kerangka yang dibina ini terdiri daripada rasuk ringan yang disokong pada kedua-dua hujungnya dengan infill blok konkrit ringan IBS. Pelbagai dimensi dan bentuk blok IBS ringan telah diuji. Setiap blok ringan IBS telah direka bentuk berdasarkan acuan keluli yang sedia ada dan menggunakan kaedah pemasangan yang betul bagi setiap blok IBS untuk membentuk panel ringan yang lengkap dengan ketinggian penuh. Suatu beban sisi kemudian dikenakan sehingga tahap kegagalan untuk menentukan tingkah laku panel IBS semasa penambahan bebanan. Bacaan pesongan, corak retak, kekuatan pemisahan, kekuatan tegangan dan kekuatan mampatan muktamad blok IBS direkod dan perbandingan dibuat dengan keputusan yang diperolehi daripada panel infill konkrit biasa yang serupa.

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LIST OF ABBREVIATIONS

IBS	**-**	Industrial Building System
AAC	-	Autoclaved Aerated Concrete
OPC	-	Ordinary Portland Cement
ALC	-	Autoclaved Lightweight Concrete
MOR	-	Modulus Of Rupture
PA	-	Pumice Aggregate
CA	-	Crush Aggregate
SCC	-	Self-Consolidating Concrete
LWRC	-	Lightweight Reinforced Concrete
RC	-	Reinforced Concrete
L.W.C	-	Lightweight Concrete
RTD	-	Regional Transportation District

APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Background

Lightweight concrete (LWC) has been successfully used since the ancient Roman times and it has gained its popularity due to its lower density and superior thermal insulation properties [1]. Compared with normal weight concrete (NWC), LWC can significantly reduce the dead load of structural elements, which makes it especially attractive in multi-storey buildings. Yet, most studies on LWC concern "semi-lightweight" concretes, i.e. concrete made with lightweight coarse aggregate and natural sand. Although commercially available lightweight fine aggregate has been used in investigations in place of natural sand to manufacture the "total-lightweight" concrete (Chandra, S. and Berntsson L. 2002, Berra, M. And Ferrara, G 1990), more environmental and economic benefits can be achieved if waste materials can be used to replace the fine lightweight aggregate.

The use of lightweight concrete in reinforced concrete structures has several advantages when compared with ordinary concrete or normal concrete such as crossing of larger spans, high earthquake resistance, , heat conductivity property, and fire strength etc. (Hüsem, 1995; Neville, 1975; Durmuş, 1988; Karaca, 1996) [6,7]. Because of the advantages cited above lightweight concrete is being used in many industrial countries. Although lightweight concrete has so many advantages and superiorities over ordinary concrete, thus, the usage of this type of concrete is not as common as ordinary concrete. The reasons for low usage of lightweight concrete are the high prices of aggregates in countries whose lightweight aggregate resources are poor, lack of experience, and knowledge of workers about lightweight concrete (Karaca, 1996).

Lightweight concrete may also contain normal or lightweight, fine and/or coarse aggregates. The rigid foam air cell system differs from conventional aggregate concrete in the methods of production and in the more extensive range of end uses. Lightweight concrete may be either cast-in-place or pre-cast. Lightweight concrete mix designs in general are designed to create a product with a low density and resultant relatively lower compressive strength (when compared to plain concrete) (J.L.Clarke, 1993). When higher compressive strengths are required, the addition of fine and/or course aggregate will result in a stronger lightweight concrete with resultant higher densities. We should note that most lightweight concrete applications call for a lightweight material. When considering the addition of course aggregate, one must consider how appropriate this heavy aggregate will be to a project, which typically calls for lightweight material. The inclusion of aerated aggregate, particularly course aggregate may be counter-productive to the materials intended performance (J.L.Clarke, 1993).

Structural lightweight concrete has an in-place density (unit weight) on the order of 90 to 115 lb/ ft^3 (1440 to 1840 kg/m^3) compared to normal-weight concrete with a density in the range of 140 to 150 lb/ ft (2240 to 2400 kg/m^3). For structural applications the concrete strength should be greater than 2500 psi (17.0 MPa). The concrete mixture is made with a lightweight coarse aggregate or in some cases the engineers can use a portion or the entire may be a lightweight product. Lightweight aggregates used in structural lightweight concrete are naturally expanded shale, clay or slate materials that have been fired in a rotary kiln to develop a porous structure. Other products such as air-cooled blast furnace slag are also used. There are other classes of non-structural lightweight concretes with lower density made with other aggregate materials and higher air voids in the cement paste matrix, such as in cellular concrete (AC1213R).

In this study, the aerated rock (Pumice) is the type of aggregate used, in order to produce industrial building block with structural lightweight concrete forms. Pumice (aerated aggregate) aggregate is a low density highly vesicular, volcanic glass consisting mainly of silica SiO2. The high silica content (70% per g/100g) positively affects the quality of pumice increasing the hardness of the material and its resistance to chemical attack. Pumice Aggregate (aerated aggregate) is highly recommended in lightweight concrete blocks either blended or as an all in pumice mix. In cast stone as a lightweight backing mix and chimney flue liners. Lightweight precast structures including IBS concrete block. In continuation, this project presents the performance of aerated concrete aggregate which is used to produce structural lightweight concrete block, in function to inspire the construction industries to use it and design such structural IBS elements, for instance, the industry building system (IBS) platform can use this type of light aggregate to make the IBS system with satisfy and high structural compressive strength and low density which is less 20%-25% than the use of conventional crashed aggregate.

1.2 Problem statements

There are many beneficial use of a structural lightweight concrete such as to reduce the dead load of a concrete block, which then allows the structural designer to produce a such size of IBS concrete block (with high strength and low density), to reduce the size of block and other load bearing elements in case to let them to stand up to carry the structure loads imposed upon them from various partitions of structural load. However, structural lightweight concrete provides a more efficient strength-to-weight ratio in structural elements. In most cases, the marginally higher cost of the lightweight concrete is offset by size reduction of structural elements, less reinforcing steel and reduced volume of concrete, resulting in lower overall cost, For instance, in this study it has been planning to produce such samples of IBS block with structural lightweight concrete mix design with Ordinary Portland cement (OPC), a full replacement of conventional crashed aggregate by lightweight aggregate (aerated aggregate) and to check the failure of the samples under flexural.

In continuation, some of the reasons of using aerated aggregate are to produce lightweight concrete IBS interlocking wall block of size of 900mm in length, 700mm in height and 200mm in width and wall rectangular beam with size is 2100mm in length, 500mm in height and 200mm in width. These sizes are considered too suitable to comply with RTD rule and placement on transport cargo. Due to this successful function, it will lead to customer convincing attitude as they need to provide not more transportation for assembly of the components due to the reduction in weight is followed by savings in transport and greater ease of operation on the site; there is less human fatigue and lead to faster speed of erection and hence to a reduction of funding costs, also a powerful way to put new buildings to useful and profitable employment as early as possible. In this study, the component is divided into smaller transportable ‘lego’ sizes shaped block. The component will be made into two or four cuts of component and analysis for best design for assembly and disassembly with similar predecessor.

1.3 Objectives of research

The objectives of this research are:

1- To study the properties and behavior of aerated aggregate and use it as structural lightweight concrete block-works aggregate on accordance to BS1881: part 125-102 and BS 5328.
2- To investigate the flexural capacity of structural lightweight concrete of IBS block-works and beam with a full replacement of conventional crashed aggregate by aerated aggregate with Ordinary Portland cement (OPC).
3- To check the deflection, cracks, splitting strength, tensile strength and ultimate compressive strengths of the IBS blocks and beam samples under ultimate loads @ 28 days on accordance to BS1881: part 120 and compare the results with a normal concrete in-fill.

1.4 Significance of study

The significance of this research and its findings will inspire the develop a suitable mix design of lightweight concrete with aerated aggregate, in order to produce a new approach of structural lightweight concrete block.

1- To develop a new potential technique to produce structural lightweight concrete block, with an above average of structural compressive strength and a lower density.
2- To produce a sample of structural lightweight concrete block with different shape of IBS, in function to encourage the construction industry to made it as a new approach for future use in IBS building and construction sectors.
3- To encourage of solving the problem of low and middle income earners to purchase it.

1.5 Scope of study

The study was almost experimental in natural and it consists of three-phase study scheme. **First phase** was focusing on the research of development based on the existed studies and preparing the calculation of the structural lightweight mix design. **The second** phase is preparing the reinforcements, the casting moulds and testing the casted blocks @ 28days for the IBS blocks which are showing below in figure 1.1. **The third** phase was concerning about the analysis and discussion of the results of the IBS blocks samples.

The attempt of this study is to check the ultimate strength behavior of IBS interlocking block system. The performance of this specimen will be estimated through the capacity test. The crack at frame faces and its deflection will be monitored during the test in order to get the expected results and fulfill the aims, significant, objectives and scope of this study. The component consists of lightweight infill’s that have been use for wall, and a frame which including beams and blocks.

The size of the IBS block is 800 mm × 700mm × 200mm and the size of the IBS rectangular beam is 2100mm × 450mm × 200mm with length, height and width respectively.

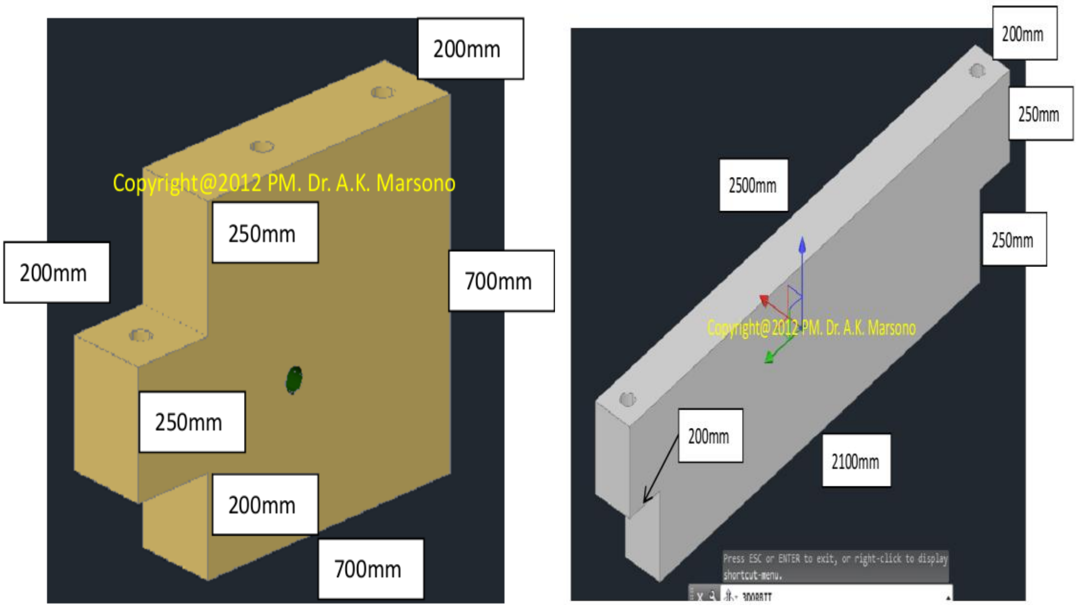

Figure 1.1: IBS lightweight concrete block

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