A STUDY ON COMPRESSIVE STRENGTH AND WATER ABSORPTION IN CEMENT BRICK USING RHA AS PART OF SAND REPLACEMENT

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ABSTRACT

This study is to investigate the Rice Husk Ash (RHA) as part of cement replacement in cement brick with different percentage. RHA is a waste material that produced after the rice husk has been burned in the paddy factory. By relating to this study, the RHA have the same texture and physical as normal sand. The field of studies covers crucial parameters in determining the compressive strength and water absorption ability. A total of 96 RHA cement bricks with dimensions of 215 mm in length, 117 mm in width, and 75 mm in depth were prepared and been divided into two group according to different type of testing. The compression test used 72 bricks while water absorption test used 24 brick. All of RHA cement brick in each of the test had four different replacements of RHA percentages. There were 10%, 20%, 30% and 0% as the control mixture. All the samples were only cured under water curing for 7 and 28 days before testing. The water to cement ratio of 0.5 and cement: sand ratio 1:10 were applied to all of the sample mixtures. In accordance to the compressive strength testing, the 20% RHA mixture shows the highest compressive strength compared to other percentage while 0% RHA mixture shows the greatest compressive strength since it is the control sample. By according to the BS 6073-1 (1981), it requires 7 N/mm^2 as a minimum compressive strength and the industry required the strength about 5 N/mm^2 for the building materials to be used in structural applications. The final result indicated that all sample did not achieved the minimum compressive strength. The study finally demonstrated that cement sand ratio should be higher to get better result.

ABSTRAK

Kajian ini adalah untuk menyiasat tentang Abu Sekam Padi sebagai sebahagian daripada bahan gantian untuk pasir dalam pembuatan batu bata simen menggunakan peratusan berbeza. Abu sekam padi adalah bahan buangan yang terhasil selepas proses pembakaran sekam padi di kilang padi. Dalam kajian ini, abu sekam padi mempunyai tekstur dan fizikal yang sama dengan pasir biasa. Kajian ini adalah untuk menentukan kekuatan mampatan dan keupayaan penyerapan air. Sebanyak 96 batu bata simen dengan dimensi 215 mm panjang, 117 mm lebar dan 75 mm tinggi telah disediakan dan telah dibahagikan kepada dua bahagian mengikut jenis ujian yang berbeza. Ujian kekuatan mampatan menggunakan 72 biji batu bata manakala ujian keupayaan penyerapan air menggunakan 24 biji batu bata. Semua sampel dibahagikan kepada empat kumpulan yang berbeza dari segi peratusan kandungan abu sekam padi iaitu 10%, 20%, 30% dan 0% sebagai campuran kawalan. Semua sampel dirawat menggunakan pengawetan air selama 7 dan 28 hari. Semua sampel menggunakan nisbah air simen sebanyak 0.5 dan nibah simen pasir sebanyak 1:10. Berdasarkan keputusan ujian kekuatan mampatan, campuran abu sekam padi sebanyak 20% menunjukkan kekuatan mampatan yang tertinggi berbanding dengan peratusan lain manakala campuran abu sekam padi sebanyak 0% iaitu sampel kawalan menunjukkan keputusan lebih tinggi. Merujuk kepada BS 6073-1 (1981), 7 N/mm^2 diperlukan sebagai kekuatan mampatan minimum dan industri memerlukan kekuatan kira-kira 5 N/mm^2 untuk bahan binaan yang akan digunakan dalam struktur binaan. Keputusan terakhir menunjukkan semua sampel tidak mencapai kekuatan minimum. Kesimpulannya kajian ini perlu menggunakan nisbah simen pasir yang lebih besar untuk mendapatkan keputusan yang lebih baik.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

σ	=	Stress
P	=	Maximum Load
A	=	Area of Specimen

LIST OF ABBREVIATIONS

RHA	=	Rice Husk Ash
ASTM	=	America Society for Testing and Materials
BS	=	British Standard
MS	=	Malaysian Standard
LPW	=	Limestone Powder Wastes
WSW	=	Wood Sawdust Wastes
UPV	=	Ultrasonic Pulse Velocity
DPC	=	Bricks for Damp Proof Courses
IRA	=	Initial Rate of Absorption
CW	=	Cotton Wastes
WGP	=	Waste Glass Powder
CW–LPW	=	Cotton Wastes - Limestone Powder Wastes
OPC	=	Ordinary Portland Cement
XRD	=	X-Ray Diffraction
BERNAS	=	Padiberas Nasional Berhad

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays the issue on environment preservation and sustainability has lead into a new finding on the new material that has been generates by product from the industrial sector. Construction material also has been developed. Many waste materials have been used as the replacement in the construction material such as concrete and brick. Many productions of lightweight concrete had been designed and among them are by the use of lightweight aggregates and artificial aggregates such as fly ash and slag (Idawati *et. al.*, 2003). The purpose of the replacement should give the good effect to the economy and environment while maintain the standard strength of the material. Every materials use in building construction has their own advantages like wood which resistance to acids, petroleum products, and salts. Another material like steel have high tensile strength, high modulus elasticity which responsible for economical use of concrete, it also have same temperature coefficient of expansion (imparts zero thermal stresses) and it is cheaply available in abundance. While brick advantages are high in durability and strength, low cost, uniform shape and size, easy handling and availability.

Brick usage has been used since ancient times and it has proved with existing of bricks at Egypt pyramid and Great Wall of China. Mostly in the past, bricks made primarily from limestone material. While nowadays there are variety of bricks that manufactured based on concrete, clay, limestone and others. A brick is a block of ceramic material used in masonry construction, usually laid using various kinds of mortar. It has been regarded as one of the longest lasting and strongest building materials used throughout history. Nowadays there are two main types of brick use in conctruction that are clay brick and sand brick.

Many observations by many researchers have been conducted by civil engineers and researchers to improve the brick performance. There are various experiment conducted by researchers as example the use of technologically byproduct agricultural wastes in various segments of the brick and tile industry is increasing continuously. The additives, mixed into the raw clay ignite during the firing process, adding extra thermal energy from inside the mixture decreasing the energy requirements of the manufacturing process (Viktor and Laszlo, 2008). There are also study of sewage sludge ash as brick material conducted by Deng and Huang (2001) presented that the results of Atterberg limits tests of molded ash-clay mixtures indicated that both plastic index and dry shrinkage decrease with an increasing amount of ash in the mixture. Results of tests indicated that the ash proportion and firing temperature were the two key factors determining the quality of brick.

Investigating of Rice husk ash (RHA) as material replacing sand in brick is a new study in civil engineering field and therefore the study of this material will be carried out.

1.2 Problem Statement

River sand is the major material in construction industry. It is also the main material in brick manufacturing. Since the increasing of demand and cost of river sand on building materials in the last decade, the civil engineers and researchers have been challenged to convert any excessives material as additional material into useful building and construction materials. Accumulation of unmanaged excessives material especially at the developing countries has resulting in an increase on environmental concern. Uses of such excessives material as building materials appears to be a viable solution not only to solve such environmental problem but also to problem of river sand reduction. Environmental problem that caused by excessive intake of river sand can be explained as effects the flow of the rivers and damaging the island's ecological system.

Rice milling generates a by product known as husk. This surrounds the paddy grain. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process . This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica.

For this study, RHA is used as excessive material and will use with river sand as a material in brick. It will be used in the study because it can be categorized as wastage material which located at rice mill. This study will be done in order to know the suitability of the RHA as the sand replacement in brick. It is also to reduce the cost of brick manufacturing process. In the end of the study, the experiment result will be used to ensure how the suitability and performance of the brick if this ratio use in brick mixture.

1.3 Objectives of Study

The objectives of this study are:

i. To determine the compressive strength of brick with ratio 1:10 by replacing the sand with RHA percentage of 0%, 10%, 20% and 30%.
ii. To determine the water absorption of bricks with ratio 1:10 by replacing the sand with RHA percentage of 0%, 10%, 20% and 30%.

1.4 Scope of Study.

The scope of this study is based on the source of material added and proportion of the material according to British Standard Code 3921, 1985 (BS3921 1985). Below are the scopes of work for this study:

i. The sample of RHA was sieved to classify into grade of sizes.
ii. The percentages that will be used is for replacing are 0%, 10%, 20%, 30% of weight sand.
iii. The prism of brick will go through water curing until days 28^{th}.
iv. The cement:sand ratio is 1:10.
v. The water cement ratio is 0.5.
vi. The compression test according to BS 1881-116 (1983).
vii. The water absorption test according to BS 1881-122 (1983).
viii. Testing on day 7^{th} and 28^{th}.

1.5 Significance of Study

Producing this cement brick containing RHA might effect to availability and strength of this cement brick. It also might be affected to long life structure. The Rice Husk Ash (RHA) is a waste that is already used in variety of applications like roofing shinles, water proofing chemicals, oil spill absorbent, and flame retardents. In this study, RHA is a new material that will be use as the sand replacement in brick. The result may show the effect of RHA to the cement brick strength.

There are many material in the world that can be categorized as waste material including RHA. RHA will accomodate the lack of river sand and might reduce the cost to provide a cement brick. Therefore an alternative way to propose a new concrete brick mixture is needed. This should be a crucial step in the development of construction industry to be more realistic and flexible.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Concrete brick or sand brick is a material that has been used as engineering material. In manufacturing, it is made with a blend of fine-grain sand, a cementitious material such as polymer cement or Portland cement, and water.

Over recent years, many researches done on the wastage or excessives materials in brick construction. Wastes or excessives materials, such as sludge, limestone powder, glass powder may be used with conventional materials as binder enhancement or sand replacement.

Turgut and Algin (2006) has conducted a study on abandoned limestone powder wastes (LPW) and wood sawdust wastes (WSW) as new brick material. He stated that the obtained compressive strength, flexural strength, unit weight, ultrasonic pulse velocity (UPV) and water absorption values satisfy the relevant international standards.

By referring to Turgut and Algin (2006) study, it can be related to this study whether the rice husk ash (RHA) can improves the compressive strength of concrete brick. In this study, if the using of RHA in brick is success, it will show advantages in economical use of river sand and already to be used safely in the construction field. It supported by Turgut and Algin (2006) study that using admixture like LPW and WSW combination as a fine aggregate in its natural form has allowed economical and environmental-friendly new composite material.

2.2 Brick

A brick is a block of ceramic material used in masonry construction, usually laid using various kinds of mortar. It has been regarded as one of the longest lasting and strongest building materials used throughout history. There are many types of brick in the world. It can be categorized with different use like load bearing wall, non-load bearing wall, insulation wall and covering wall. Three types of brick that usually used in construction are sand-lime brick, clay brick and concrete brick.

First type of brick is sand- lime brick which is made with mix of lime, sand and water and it use steel or wood mould to form it. After casting, the brick will go through the curing process to high compressive strength and hard brick. Normally, the design is not produce a good appearance and come out with rough surface.

Second type of brick is clay brick. It can be categorized into three types that are normal brick, face brick and engineering brick. Normal brick is ordinary bricks which are not designed to provide good finished appearance or high strength. They are therefore in general and cheapest bricks available. While face brick is designed to give attractive appearance, hence they are free from imperfection such as cracks. It's produces in variety of color. It's no need plaster when used as wall. The last one is engineering brick that is design base on engineering characteristic. It's designed primarily for strength and durability. They are high density and well fired. Normally, it's will be used as retaining wall, load bearing wall and sewerage.

The last type of brick is concrete brick. This brick is made with mix of cement, sand and water. These will using steel or wood mould to form it. Normally, the design are not produce a good appearance and come out with rough surface.

2.2.1 Compressive Strength of Brick

Sadek and Roslan (2010) has conducted a study on bricks and stabilized compressed earth blocks. In his study, he stated that compressive strength of brick is important as an indicator of masonry strength and as a result brick strength has become an important requirement in brickwork design. The Malaysian standard (MS 76, 1972) categorized compressive strength into classes of engineering A and B presented in Table 2.1. These classifications of bricks commonly used for construction with aesthetics and strength requirements.

Table 2.1: Classification of Bricks by Compressive Strength and Water Absorption (MS 76, 1972)

Designation	Class	Average compressive strength MN/m2 not less than	Average absorption boiling or vacuum percent weight not greater than
Engineering Brick	A	69.0 (10,000 lbf/in2)	4.5
	B	48.5 (7,000 lbf/in2)	7.0
Load bearing brick	15	103.0 (15,000 lbf/in2)	No specific requirements
	10	69.0 (10,000 lbf/in2)	
	7	48.5 (7,000 lbf/in2)	
	5	34.5 (5,000 lbf/in2)	
	4	27.5 (4,000 lbf/in2)	
	3	20.5 (3,000 lbf/in2)	
	2	14.0 (2,000 lbf/in2)	
	1	7.0 (1,000 lbf/in2)	
Bricks for damp proof courses	DPC	as required	4.5

2.2.2 Water Absorption of Brick

The initial rate of absorption (IRA) is the amount of water absorbed in one minute through the bed face of the brick. It is a measure of the brick's suction and can be used as a factor in the design of mortars that will bond strongly with units. As mortars other than the 'deemed to comply' mortars are rarely used, the impact of the IRA is primarily on the bricklayer. Bricklayers, through practical experience, adjust the mortar, the height of a wall built in a day and the length of time before ironing the joints, according to the suction.

The bond between the masonry unit and mortar is largely influenced by the capacity of the brick to absorb water and the ability of the mortar to retain the water that is needed for the proper hydration of cement. If the brick sucks the water too quickly from the mortar, the next course may not be properly bedded. If the mortar retains too much water, the units tend to float on the mortar bed, making it difficult to lay plumb walls at a reasonable rate. In either case there will be poor bond.

Yap (2010) stated that the bricks contain pores that will allow passage of water. Due to capillary action at the pores of the bricks, the pores will absorb the water content from mortar that lay on the bricks. The absorption of water affects the properties of the mortar and thus affects the bonding of mortar between brick. If too much moisture is drawn from the mortar, the mortar may dried and harden faster than the bonds made with the brick. The bonds between mortar and bricks may be not strong enough although the mortar has hardened. Table 2.1 also shows the limits of total water absorption that each of the bricks had to comply.

2.2.3 Flexural Characteristics of Brick

Flexural strength is also known as bend strength or fracture strength. It is a mechanical parameter for brittle material. It is also defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. Algin and Turgut (2007) has conducted a study on cotton and limestone powder wastes as brick material. In their study, as shown in Figure 2.1, the relationship between the average flexural strength and the compressive strength values that are inversely proportionate with the Cotton Wastes (CW) content in the test samples. It is observed that the addition of waste glass powder (WGP) content in cotton wastes - limestone powder wastes (CW–LPW) combination increases the flexural strength.

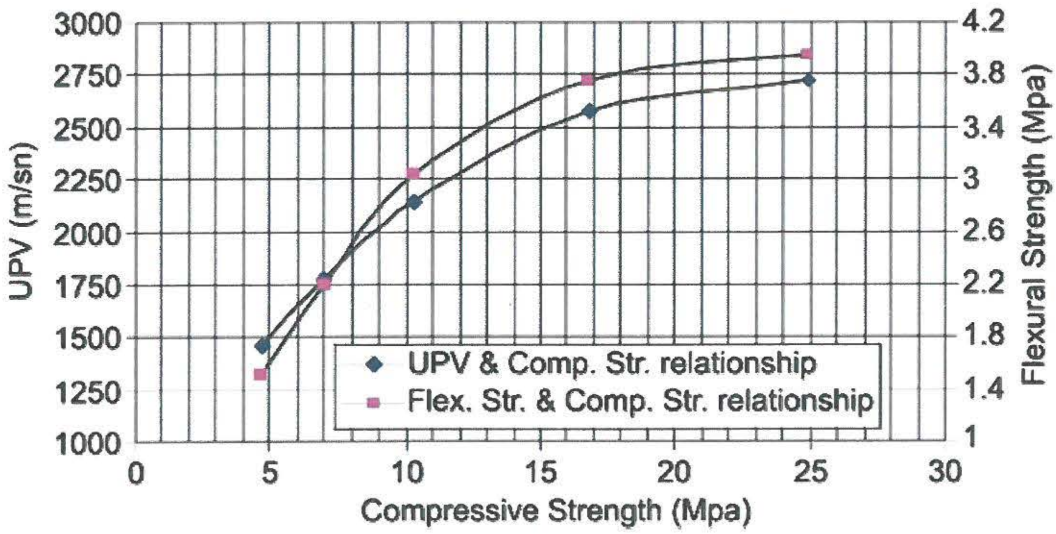

Figure 2.1: The Relation Between the Average Compressive Strength Values and the Average Flexural Strength and UPV Values (Algin and Turgut, 2007)

2.2.4 Shrinkage Characteristics of Brick

In concrete there are 4 main types of shrinkage associated which is plastic, autogenous, carbonation and drying shrinkage. Relating to this study, drying shrinkage was happened to concrete brick since the water content in concrete can be loses when the environment is a dry atmosphere. It can be simplified that when concrete is exposed to its service environment it tends to reach equilibrium with that environment. The rate of evaporation will depend on the relative humidity, temperature, water-cement ratio and the area of the exposed surface of the concrete. The first water to be lost is that held in the large capillary pores of the hardened concrete. The loss of this water does not cause significant volume change. However, as drying continues, loss of water from small capillary pores and later from bigger size of pores takes place. With the reduction in the vapour pressure in the capillary pores, tensile stress in the residual water increases.

David (2002) has conducted a study on development of concrete shrinkage performance specification. They said that the composition of concrete shrinkage was influence by many factor such as water and cement ratio, chemical admixtures and curing. They also said that, the longer the curing time, the less shrinkage will occur. Watering twice a day, burlap, polyethylene, and air curing were all found to result in high shrinkage rates. Other methods were recommended to reduce the shrinkage rate. Sealing the concrete with resin modified wax or watering the concrete four to five times a day may decrease the shrinkage rate of the concrete.

2.3 Portland Cement

In general word, cement is categorized as a binder. It is a substance that sets and hardens independently. The main function of cement is to bind other materials together. Cement is produced from raw materials such as limestone, chalk, shale, clay, and sand. These raw materials are quarried, crushed, finely ground, and blended to the correct chemical composition. Small quantities of iron ore, alumina, and other minerals may be added to adjust the raw material composition. Cement is a hydraulic binder and is defined as a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes which , after hardening retains its strength and stability even under water. There are many type of cement in industry. The type of cement is shown in Table 2.2.

Table 2.2: Type of Portland Cement

Type	ASTM	MS	Properties	Uses
Ordinary Portland Cement	Type I	522	Ordinary	General
Super High Early Strength Portland Cement	Type III	522	Rich in C3S, Finer ground, high early strength	Winter, Urgent
Moderate Heat Portland Cement	Type III		Low in C3S, low in C3A, low heat of hydration & high long term strength	Dam, mass concrete
Low Heat Portland Cement	Type IV		Low heat of hydration, low early strength	Dam, mass concrete
Sulphate Resisting Cement	Type V	1037	Low in C3A, high chemical resistance	Underground Water
White Portland Cement		888	Minute in iron, pure white, fine ground, high early strength	Buildings, arts

The generally use in construction is Ordinary Portland Cement (OPC). Ordinary Portland Cement (OPC) is one of several types of cement being manufactured throughout the world. Ordinary Portland Cement (OPC) is the most use type of cement that use nowadays. Pearce (1997) stated that Ordinary Portland Cement results from the calcination of limestone and silica in the following reaction;

- Limestone + silica (1450°C) = portland cement + carbon dioxide $5CaCO_3 + 2SiO_2 \rightarrow (3CaO, SiO_2)(2CaO, SiO_2) + 5CO_2$

2.3.1 Physical Properties of Portland Cement

The mechanical and physical properties of the cements are measured and hydrated products, formed after 1–28 days, are identified by means of X-Ray Diffraction (XRD). The composite cements present significant differences as far as the clinker fineness, the development of the strength, the water demand and the hydration rate is concerned, Voglis *et al.* (2005).

2.4 Water

Water is use in most activity in human life. In construction, water usually use in work like concreting. In brick production, the water plays very important role. The water that will be use must not contain any substances that might effect the hydration of cement affect to the brick strength. Generally water will be used as the solvent. As we know, water is a good solvent that capable of dissolving another substance. The highly polar nature of water makes it an excellent solvent, especially for other polar compounds such as salts, alcohols, carboxyl compounds and so on. More substances dissolve in water than any other solvent. More than half of the known elements can be found in water, some in high concentrations, and others only in trace amounts (Charles, N.D). Other than solvent, water also used in curing method for the brick.