EFFECTIVENESS OF R ’LACEMENT ON FOAM C C)

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ABSTRACT

The goal of this study is to assess the possibilities of incorporating red gypsum in production of foamed concrete. Invention of lightweight composite design and construction utilizes existing technology which has become an alternative choice in current markets to make construction project getting easier and faster. The reuse of red gypsum waste is the areas where great opportunity exists for cost saving in the construction industry red gypsum as cement replacement in foam concrete in different percentage show improvement in the development of strength. In water and air curing condition, it shows that the samples in water curing possess higher strength compare to the air curing samples. But the strength achieved by RGFC was still lower than the control foam concrete. By comparing to four mixes, the strength of the lower percentage RG was higher than higher percentage of RG. This can be concluded that 5% was not capable to be use but there maybe some condition that needed for this type of concrete.

ABSTRAK

Matlamat kajian ini adalah untuk menilai kemungkinan menggabungkan gipsum merah dalam pengeluaran konkrit berbusa. Penciptaan reka bentuk komposit yang ringan dan pembinaan menggunakan teknologi yang sedia ada yang telah menjadi satu pilihan alternatif dalam pasaran semasa untuk membuat projek pembinaan semakin mudah dan lebih cepat. Penggunaan semula sisa gipsum merah adalah kawasan di mana peluang besar wujud untuk penjimatan kos dalam industri pembinaan gipsum merah sebagai pengganti simen dalam konkrit busa dalam berbeza peningkatan peratusan menunjukkan dalam pembangunan kekuatan. Dalam keadaan air dan pengawetan udara, ia menunjukkan bahawa sampel dalam pengawetan air mempunyai kekuatan yang lebih tinggi berbanding dengan sampel pengawetan udara. Tetapi kekuatan yang dicapai oleh RGFC masih lebih rendah daripada konkrit busa kawalan. Dengan membandingkan empat campuran, kekuatan peratusan yang lebih rendah RG adalah lebih tinggi daripada peratusan yang lebih tinggi RG. Ini dapat disimpulkan bahawa 5% tidak mampu untuk menjadi penggunaan tetapi ada mungkin beberapa keadaan yang diperlukan untuk jenis konkrit.

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LIST OF ABBREVIATIONS

RG – Red gypsum

FC – Foam concrete

RGFC– Red gypsum foam concrete

ASTM– American Society for Testing and Materials

FKASA– Fakulti Kejuruteraan Awam dan Sumber Alam

UMP – University Malaysia Pahang

Kg/m^3 – Kilogram per meter cube

N/mm^2 – Newton per milimeter square

MPa – Mega Pascal

Kg – Kilogram

^oC – Celcius

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays, the construction industry is well developed in developing countries especially Malaysia. The rapid infrastructure development in the country makes the increasing in numbers of construction project. For this, concrete is widely used in construction due to it is usually the cheapest and most readily composite material.

Invention of lightweight composite design and construction utilizes existing technology which has become an alternative choice in current markets to make construction project getting easier and faster. (Haq.M & Liew.A).This technology is extremely useful for the developing countries in special areas of construction such as residential and other commercial construction. Foam concrete is a mixture of cement, fine sand, water and special foam which results in a strong lightweight concrete containing evenly distributed air bubbles. (Z. Fahrizal &Ramli.M, 2011).

Recycled materials like palm oil shell, rice husk and more were becoming popular ingredients in lightweight concrete because of public awareness about environmental issues.(M.R.Jones, et.al, 2005). The new invented concrete mix design by using a new waste material is now applicable in building construction to reduce the problem of wastage production in Malaysia. Red gypsum (RG) is a waste product during the extraction of titanium (IV) oxide from ilmenite ores. The production of RG which is a reddish brown mud, at least 340,000 tons per year.(Kamarudin & Zakaria, 2007). In the cement industry, RG can used as partial replacement of cement production in order to reduce the environmental hazard problem.(Gazquez, Bolivar, Vaca, García-Tenorio, & Caparros, 2013).

1.2 Problem Statements

The usage of construction material like Ordinary Portland Cement (OPC) has begun since the very first building that was being built. Rapid development in our country makes the excessive uses of OPC. OPC is a chemical compound and were used every day around the globe and finally the cost of. So, the solution for this problem is to find a new substitute material that is Red Gypsum (RG) to replace the OPC. The reuse of red gypsum waste is the areas where great opportunity exists for cost saving in the construction industry. (Haizal et.al,2005). The production of RG which is a reddish brown mud, at least 340,000 tons per year. By using this material with concrete mixture, the problem of disposal of RG to landfill and pollution hazards due to substantial oil content in the earth can be reduced. (Gazquez et al., 2013)

1.3 Significance of Study

The significance of this study is to learn about the performance of RG lightweight foam concrete in mechanical properties. Besides that, this study is using RG as the waste material is becoming useful and makes benefits to the construction industry for a better environment. Other than that, the wastage of RG will be reduced at the mining industry.

1.4 Objectives of Study

The goal of this study is to investigate the effectiveness of the Red Gypsum as cement replacement on the foamed concrete properties. The specific objectives of this study are:

1.4.1 To determine the workability, consistency and stability of fresh properties of RGFC mixes

1.4.2 To determine the oven dry density, water absorption and porosity of RGFC mixes

1.4.3 To determine the compressive strength of RGFC mixes

1.4.3 To observe the crack pattern of RGFC mixes

1.5 Scope of Study

This study has investigated to determine the performance of RG in lightweight foam concrete. The Red Gypsum is taken from UMP Green Technology Sdn. Bhd. Meanwhile, the RG is waste product which originally produce from trioxide(Malaysia) Sdn. Bhd that located at Kawasan Perindustrian Teluk Kalung, Kemaman, Terenganu. The red gypsum is brown in colour.

Laboratory test such as density test, porosity test , compressive strength test and water absorption to study the performance of RG foam concrete mixture. The RG waste had process to air-dry for 1 week to make sure there is no wet inside the RG particles. After that, the RG waste was sieved and grinding to make the particles of RG become fine and small.

During the preparation of sample, fresh properties, compressive strength and physical properties of foam concrete were tested. For fresh properties, the fresh density test and flow table test were conducted to determine the workability of foam concrete according ASTM C1437. For compressive strength, the compressive strength test was conducted to identify the mechanical strength of foam concrete. Meanwhile, the physical properties includes oven dry density test, porosity test, and water absorption test were conducted. The types of curing for the sample was air curing and water curing. The days of testing were at day 3, day 7, day 14 and day 28. The size of specimen is in cube dimension, 100mm x 100mm x 100mm. There were four types of sample that prepared for this study, foam concrete control sample, 5% RGFC,10%RGFC and 15% RGFC. 3 cubes were needed for each testing at each different days of testing respectively. That means the total specimens were 96 cubes. All the material and specimen preparation based on standard code practice requirement of ASTM. The experiment testing and setup will be conducting in FKASA Laboratory.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed previous study related to the effect of red gypsum on foamed concrete in term of engineering properties of the foamed concrete. Besides that, this chapter also reviews the performance of the red gysum on foamed concrete in the existing application.

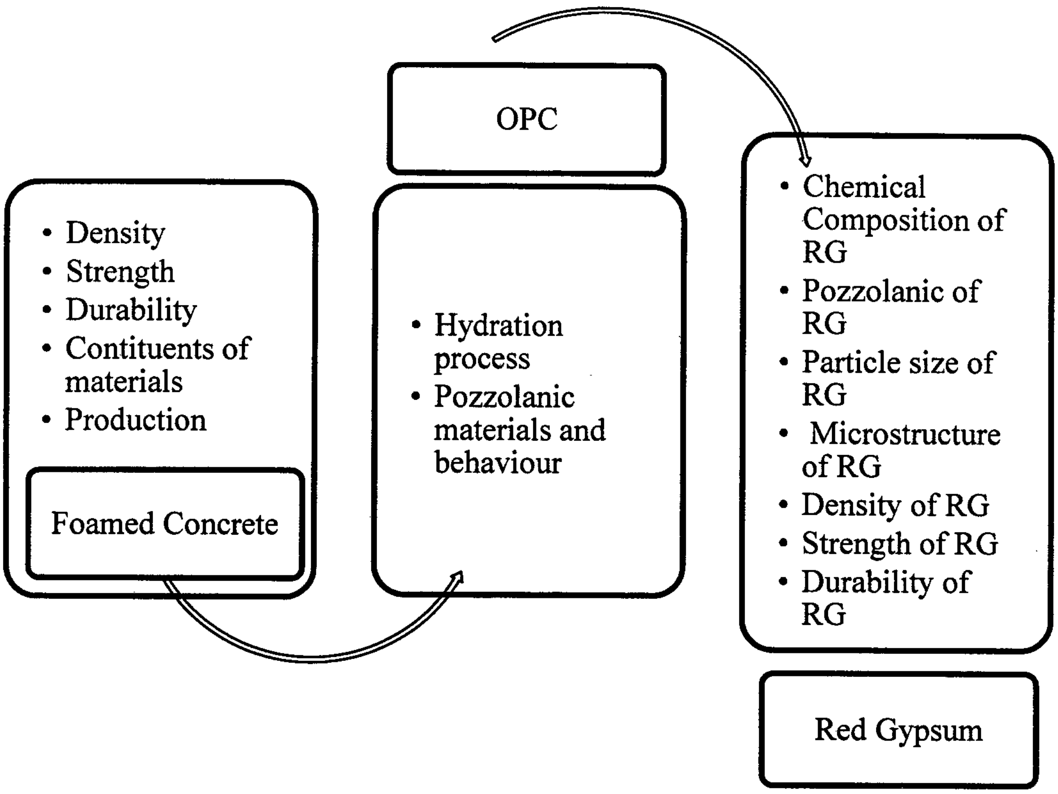

Figure 2.1: Flow chart of literature review

2.2 Foamed Concrete

2.2.1 History

Foamed concrete is not a peculiarly new material, it is first recorded to use in early 1920s. The application of foamed concrete for construction works was not acknowledged until the late 1970s, when it starts to be used in Sweden in 1929s.

The first large foamed concrete project, which was in UK at Falkirk Tunnel in 1980. This tunnel was placed about $4500m^3$ of $1100kg/m^3$. Substantial improvements in production method and quality of foaming agent over the last 16 years have made to the production of blocks and void fills. The uses of foamed concrete have been widely spread across the worldwide (Andrew & Willian, 1978).

2.2.2 Application in construction

In Malaysia the first major application of lightweight foamed concrete in Malaysia is at the SMART tunnel project in Kuala Lumpur. The lightweight foamed concrete specified was density 1800 kg/rn3 which achieved compressive strength of 3 N/mm2 at the age of 28 days. Otherwise lightweight foamed concrete inert, materials such as powdered waste plastic, rice husk and others are also being experimented. The composition is proposed to be injected at prescribed locations with innovative precast lightweight hollow-core concrete pile to effect replacement of portions of the soft soil.. The system is expected to provide cost effective geotechnical solution as the surrounding soft ground becomes compacted while foamed concrete solidifies in situ. Foundation system with the utilization of used tyres are being experimented in some housing project in Malaysia. Successful deployment of-the system is expected -to -provide a fast. track 11 method for affordable quality assured housing. The system is applicable for the homeless people who urgently need a shelter. Technical specification has been prepared for an industrialized building system complying with modular coordination (Lee, 2005).

2.3 Properties of Foamed Concrete

2.3.1 Density

Foamed concrete is manufactured by entrain relatively large volume of air into the cement paste by use the foam agent. High volume of air contents result in lower densities, higher porosity. Density can be either in fresh or hardened state. Fresh density is required for mix design and casting control purposes. A theoretical equation for finding fresh density may not be applicable as there can be scatter in the results caused by a number of factors including continued expansion of the foam after its discharge, loss of foam during mixing. Many physical properties of foam concrete depend upon its density in hardened state. While specifying the density, the moisture condition needs to be indicated as the comparison of properties of foam concrete from different sources can have little meaning without a close definition of the degree of dryness.

According to Kearsley & Mostert (2005) have come out a mix design for foamed concrete mix, show the casting density clearly indicated that the mix design is suitable because the difference between the target densities aimed for and the actual measured are within 5%.cement content and foamed content should be established in designer. Besides that, Jones & McCarthy (2005), show that it is difficult to design for a specified dry density as foamed concrete will desorbs between 50 and 200 kg/m3 of the total mix water, depending on the concrete plastic density. McCormick (2005) studied the effect of types of fine aggregate, aggregate gradation, type of foam and sand–cement ratio on the wet density of foam concrete and reported that wet densities within about 5% of the design densities can be achieved by using solid volume calculations.

2.3.2 Compressive Srength

The strength of concrete originates from the strength of the hardening cement paste, which is, in turn, originates from hydration products. Compressive strength of foamed concrete influenced by many factor such as density, age, curing method, component and mix proportion. Kearsely (2000) noted that dry density of foam concrete between 500 kg/m3 and 1000 kg/rn3 , the compressive strength decreases with an increase in void diameter. For densities higher than 1000 kg/M3, as the air-voids are far apart to have an influence on the compressive strength, the composition of the paste determines the compressive strength. Jones et al., (2005) reported that small changes in the water to cement ratio does not affect the strength of foam concrete but the compression strength increased due to higher water and cement ratio.

2.3.3 Water Absorption

Kearsley & Wainwright (2001) investigate that, the water absorption of the paste and the foamed concrete mixtures (as expressed by the increase in mass as a percentage of dry mass) is plotted as a function of dry density as shows in Figure 2.4, from these results it could be concluded that because the mixtures with lower density absorb more water than higher densities. However, water absorption maybe expressed either as increase in mass per unit of dry mass.

For the foamed concrete mixtures reported, there are significant differences in density (1000 to 1500 kg/m3) and expressing water absorption as the increase in mass per unit volume as shown in Figure 2.5. It is now apparent that that foamed concrete mixtures with low densities absorb only marginally more water than those with higher densities. It is also apparent that the cement paste mixture containing no ash (w/c=0.6) absorbs more water than any of the foamed concrete mixtures. It can also be seen that there is a trend of increased absorption with decreasing density for all mixtures but the increase absorption is much more significant in the paste (no foam) mixtures than in the foamed concrete mixtures.

2.3.4 Porosity

The strength of concrete is affected by the volume of air void inside the concrete. According to G.C.Hoff (1972), water cement ratio and density is related to the porosity of foam concrete. The strength of foam concrete decreases as the porosity increases. The strength of mixtures with low porosity was influenced more by small changes in porosity than the strength of mixtures with higher porosity.

2.4 Contituents of materials

Generally the fine aggregate shall consist of natural sand, manufactured sand or combination of them. The fine aggregate for concrete that subjected wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any material that reactive in cement to cause excessive expansion of mortar concrete. Recommend that only fine sands suitable for concrete (to ASTM C33) or mortar (to ASTM C270) having particle sizes up to about 4 mm and with an even distribution of sizes should be used for foamed concrete. This is mainly because coarser aggregate might settle in a lightweight mix and lead to collapse of the foam during mixing

The water used for foamed concrete should be potable. This is crucial when using a protein based foaming agent because organic contamination can have an adverse effect on the quality of the foam, and hence the concrete produced. The water/cement (w/c) ratio of the base mix required to achieve adequate workability is dependent upon the type of binder(s), the required strength of the concrete, and whether or not a water reducing or a plasticizing agent has been used. In most cases the value will be between 0.4 and 0.8. The higher values are required with finer grained binders, and the lower values where either a high strength is required or a super plasticizer has been employed. Where the water content of the mix would be inadequate to ensure full hydration of the cement, water will be extracted from the foam and might lead to its disintegration. On the other hand whilst high w/c ratios do not significantly affect the porosity of the foamed concrete they do promote segregation and increase drying shrinkage (Gambhir, 2004).

Synthetic or protein-based foaming agents can be used to produce foam. Because of the possibility of degradation by bacteria and other organisms, natural protein based agents (i.e. fatty acid soaps) are rarely used to produce foamed concrete for civil engineering works. However research is underway on the use of protein-based agents for developing high strength, i.e... The chemical composition of a surfactant must be stable in the alkaline environment of concrete. Because all surfactants are susceptible to deterioration at low temperatures they should be stored accordingly. The properties of foamed concrete are critically dependent upon the quality of the foam. There are two types of foaming agent:

I. Synthetic-suitable for densities of 1000 kg/m3 and above.

II. Protein-suitable for densities from 400 to 1600 kg/m3

Protein-based foaming agents come from animal proteins out of horn, blood, bones of cows, pigs and other remainders of animal carcasses. Its surfactants might therefore be best suited to the production of foamed concrete of relatively high density and high strength. Optimum performance of foam is commonly attained at a ratio of 1:25, but the optimum value is a function of the type of surfactant and the method of production (Gambhir, 2004).