MECHANICAL PROPER[illegible]DUST CONCRETE IN DIFFERENT ADDITIVES

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ABSTRACT

Increase in prices of raw materials for the construction industry resulted in the use of recycled materials as an alternative for replacing the conventional materials. One of that is sawdust that has a potential in application of lightweight concrete. However the problem that identified in sawdust cement concrete is an incompatibility between cement and wood in other to form a concrete. The presence of substance was found as inhibitor which retards the hydration and the hardening of cement process. In order to form the sawdust concrete, additives and mixing ratio is very important so that the concrete created will meet the desired quality. Hence, the main objective for this research is to determine the compressive strength of sawdust concrete as a full replacement coarse aggregate with different additives and different mix ratio of additives. The other objective is to study the effect of additives when mixed in the sawdust concrete. The methodology of this research consist three stages; collect data, samples preparation and testing. Four type of mixture were tested for compression test. Those are control sample, sawdust with lime, sawdust with cockle shell and sawdust with spent bleaching earth (SBE). The total samples are 90 samples for 7,14 and 28 days of strength. The highest 28 day compressive strength was achieved by 1:1:3:1 (lime) mix proportion which is 5.27 Mpa. Meanwhile the lowest 28 days compressive strength was achieved by 1:1:3:0.33 (SBE) which is 1.84 Mpa. According from that, it shows that sawdust concrete with different additives in having different mix ratio has a potential in the lightweight concrete industry.

ABSTRAK

Peningkatan kenaikan harga bahan mentah untuk industri pembinaan menyebabkan penggunaan bahan bahan kitar semula sebagai suatu alternatif untuk menggantikan bahan - bahan yang sedia ada. Salah satunya adalah habuk kayu yang mempunyai potensi dalam penggunaan sebagai konkrit ringan. Walaubagaimanapun, masalah yang dikenal pastidi dalam konkrit habuk kayu adalah ketidakserasian diantara simen dan habuk kayu untuk membentuk sebuah konkrit. Kehadiran bahan asing didapati sebagai perencat yang melambatkan penghidratan dan pengerasan proses simen. Dalam untuk membentuk konkrit habuk kayu, bahan tambah dan nisbah bancuhan adalah amat penting dimana konrit yang dihasilkan dapat memenuhi kualiti yang dikehendaki. Oleh itu, objektif utama kajian ini adalah untuk menentukan kekuatan mampatan habuk kayu sebagai pengganti penuh aggregat kasar dengan bahan tambah yang berbeza dan nisbah campuran bahan tamabah yang berbeza.. Objektif lain adalah untuk mengkaji kesan dari setiap bahan tambah yang digunakan dalam campuran konkrit habuk kayu. Metodology di dalam kajian ini terdiri kepada tiga peringkat; pengumpulan data dan maklumat, persediaan bahan dan pengujian sampe. Sebanyak empat jenis campuran telah diuji dengan ujian mampatan. Jenis campuran itu adalah sampel kawalan, habuk kayu berserta kapur, habuk kayu berserta kulit kerang dan habuk kayu berserta 'spent bleaching earth' (SBE). Jumlah sampel adalah sebanyak 90 sampel untuk 7, 14 dan 28 hari tempoh mencapai kekuatan. Kekuatan mampatan paling tinggi dicapai oleh 1:1:3:1 (kapur) iaitu 5.27 Mpa. Manakala kekuatan mampatan terendah dicapai oleh 1:1:3:0.33 (SBE) iaitu 1.84 Mpa. Berpandukan dari itu, ia menunjukkan bahawa konkrit habuk kayu dengan bahan tambah yang berbeza dan mempunyai nisbah bancuhan yang berbeza mempunyai potensi yang bagus di dalam industri konkrit ringan.

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LIST OF ABBREVIATIONS

SBE	Spent Bleaching Plant
SC	Sample control (cement: sand: sawdust)
SL – 0.33	Sawdust + 0.33 Lime
SL – 0.67	Sawdust + 0.67 Lime
SL – 1.00	Sawdust + 1.00 Lime
SCS – 0.33	Sawdust + 0.33 Cockle Shell
SCS – 0.67	Sawdust + 0.67 Cockle Shell
SCS – 1.00	Sawdust + 1.00 Cockle Shell
SB – 0.33	Sawdust + 0.33 Spent Bleaching Plant
SB – 0.67	Sawdust + 0.67 Spent Bleaching Plant
SB – 1.00	Sawdust + 1.00 Spent Bleaching Plant
%	Percentage
Mpa	Mega pascal (Pressure unit)
g	Gram (Weight unit)
N	Newton (Force unit)

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays, the world becomes more advanced but the construction industry is highly dependent on conventional materials such as cement, aggregate and sand for concrete production. The increasing of demand has been placed on construction material industry especially in the last decade owing to increasing the human population and country development will cause a chronic shortage of building materials and the increasing of cost materials construction (Turgut & Algin, 2007).

To meet with that, the consideration using cheaper and locally available materials to meet desired needs will enhance self-efficiency and for sustainable development. Recycling the sawdust is another way of solution to problem of economical design of the building but also to the pollution problem (Turgut & Algin, 2007). Therefore, the lightweight concrete has been introduced. In lightweight concrete, many researchers do the study about a problem that related to the sawdust concrete and relation additives to sawdust concrete.

The problems that are identified in sawdust concrete are affecting the setting and hardening of sawdust concrete, the needed of pre-treatment of sawdust and mixing difficulty. The setting is to determine the end of workability and hardening is responsible for stiffness development and strength gain for that concrete. As generally, when water is added to cement to form a sawdust concrete material, cement paste is formed which gradually stiffens and then hardens. The stiffening of cement paste is setting. The extractives were found in the wood has been determined as inhibitors that inhibits the setting of cement and adversely affect the hydration of cement.

In this research, the sawdust concrete is added with different additives that are lime, cockle shell and spent bleaching earth. The study is conducted to know the potential of sawdust concrete as a lightweight concrete with determining the mechanical properties of that sawdust concrete and to determine the compressive strength of the sawdust concrete in using different additives and different mix ratio of additives.

1.2 PROBLEM STATEMENT

The construction industry is developing rapidly due to the development and modernisation of the developing country and due of increasing of growth rate of population. It gives a high demand to the material construction especially the usage of cement, sand, granites and gravels in concrete production. .The use of raw materials day by day has resulted the sources of granite and gravel is decreasing and causes a chronic shortage of building materials.

In another scenario, in the timber industry produces an industrial waste that is sawdust. This kind of industrial waste will cause a nuisance both to the health and

environment when not properly disposed. Recycling back of sawdust appears to be a viable solution to overcome the problems. Thus, the lightweight concrete application in industry is one of the solutions that can overcome the decreasing of the raw sources. In lightweight concrete, the usage of sawdust has been introduced.

However the problem that identified in sawdust cement concrete is an incompatibility between cement and wood in other to form a concrete. The presence of substance was found as inhibitor which retards the hydration and the hardening of cement process.

In this research, the changes of mechanical properties of sawdust concrete when using different additives need to pay attention. Additives that will be use is lime, cockleshell and spent bleaching earth and mix ratio of every additives that added together with sawdust concrete is 0.33, 0.67 and 1.00.

1.3 OBJECTIVE OF STUDY

The main objective for this research is to determine the compressive strength of sawdust concrete by using Portland Composite Concrete.

Other sub objectives that may follow this research is :

1. To determine the compressive strength of sawdust concrete when added with additives and to determine the compressive strength of sawdust concrete when having a different mix ratio sawdust concrete and additives
2. To study the effect of lime, cockle shell and spent bleaching earth when

1.4 EXPECTED OUTCOMES

What I will expect in the end of this research is the potential of sawdust concrete as a lightweight concrete. Other than that I expected is the positive results of mechanical properties when these sawdust concrete is added with different additives and in different mix ratio. At the end of 28 days of age of strength, the result of compressive strength of sawdust concrete can be more than 3.5 Mpa according American Standard Testing Machine (ASTM) C-129, specification for non-loading bearing concrete masonry units that required minimum 3.5 Mpa.

1.5 LIMITATION OF STUDY

The main focus of this study is to determine the compressive strength of the sawdust concrete samples with presence of different additives. In this study, sawdust will be used as a substitute to the coarse aggregate. It is due to its lightweight properties with fine absorbing characteristic. The cement that will use in produce samples of sawdust concrete is Portland Composite Cement or PPC.

The ratio of the mixture for the cement PPC, sand and sawdust is 1:1:3 and the design of the mixture according to design by volume. These sawdust concrete will be added with additives that are lime, cockle shell and spent bleaching earth. The amount of additives that added into the sawdust concrete is according to mix ratio that is 0.33,0.67 and 1.00. The water cement ratio for this study is 0.8 (Adeagbo,1999).

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The trend of inflation in the economy of developing countries and depletion of their foreign monetary reserves has led to increases in the prices of conventional building materials. Many research efforts in recent times in the developing nations have been directed toward the utilisation of cheap and readily available local materials such as industrial and agricultural by product in terms to reduce material and construction costs to levels that can make homes affordable (Udoeyo *et al*, 2006).

Research has been directed towards in finding the methods to solve it. Sawdust concrete has been receiving some attention in application of lightweight concrete in building construction couple years ago. Since sawdust is available in abundance in tropical countries and is relatively inexpensive, many attempts have been made by researchers to investigate the suitability of this material for possible usage in building construction especially in Malaysia region (Paramasivam & Loke, 1980). In Malaysia, timber industry

gives big revenue gross to the national's economy. This is because Malaysia is a tropical country and has a lot of rain forest.

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nailbility and lessened the dead weight. The use of lightweight concrete has been widely spread across countries such as USA, United Kingdom and Sweden.

2.2 LIGHTWEIGHT CONCRETE

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nailibility and lessened the dead weight. Lightweight concrete, similar to normal weight concrete, is a mixture of water, Portland cement or Ordinary Portland Cement (OPC), and aggregate. The mixture of lightweight concrete may from organic materials or inorganic materials.

It is classified as structural or nonstructural concrete depending on strength and compression rating, generally determined by the type of aggregate material used in the concrete mix. Lightweight aggregate concrete uses a variety of aggregates with lower density than normal weight concrete.

The use of lightweight aggregates in concrete offers numerous advantages, including;

1. Foundations with smaller dimensional and lighter structures due to the reduction of the weight of the building which may reduce the usage of a cement and steel
2. Lighter and smaller pre – molded elements that required smaller transportation
3. Reduction of the dimension of columns, beams and slab with resulting a more availability of space
4. Improved thermal insulation

2.3 SAWDUST

The sawdust can be obtained from the timber factory that is generated from cutting, drilling and milling operations. Sawdust generally is a loose particles or wood chippings that obtained by product from the sawing of timber into standard useable size (Olutoge, 2010). The size of sawdust particles depends on the kind of wood from which the sawdust is obtained and the size of the teeth of the saw that sawing the wood.

In other terms, sawdust is an industrial waste that comes from the timber industry and if the sawdust are not properly disposed, it will causes a nuisance both health or the environment. Since wood is used in large quantities in variedsectors such as manufacture of furniture, formwork in construction, stationary like pencil or ruler and it is a part of our everyday life. That means the volume from that industry will generate a large volume of sawdust.

The geographical location and industrial process are significantly influenced of the physical and chemical of sawdust. Hardwood usually produces more dust than softwoods.

Hardwood also was producing more bark and leaves from softwood. Leaves generally produce more wood dust than the inner wood parts of the tree. Wood that will produce a sawdust is chemically heterogeneous and its components can be divided into two groups that is a structural component of high molecular weight and non-structural component of low molecular weight.

A non-structural component of low molecular weight containing extractive and inorganic component and that are major cell wall component and a structural component of high molecular weight containing natural polymer substances such as cellulose, lignin and hemicellulose. The substance that contains in sawdust has to been known that retard the hydration of cement.

The content of polymer substances are cellulose in 40 – 42 %, lignin in 26 – 28 %, hemicellulose in 29 – 34% and extractive in 5 – 10 %.Cellulose is organic solvents, alkaline solution and insoluble in water. It does not mediate under the influence of the organic solvent, alkaline solution and water. Lignin is the most complex polymer. Lignin is naturally occurring high molecular weight materials. It does not disintegrate under the influence of the various organic solvents, alkaline solutions and water. Hemicelluloses are differing from cellulose in term of containing various sugar units with much shorter chains.

They are soluble in alkali and some hardwood polyoses are even soluble in water. Disintegration of hemicellulose to the constituents in the alkaline solution will increase the amount of extractive. The extractive are non-polymeric and by solving the extractive in the water or organic solvents may make them separated from the insoluble cell materials. Vaickelionis & Vaickelioniene (2006) stated that with presence of the extractive results in corrosion of metal in contact with wood, inhibition of setting of concrete.

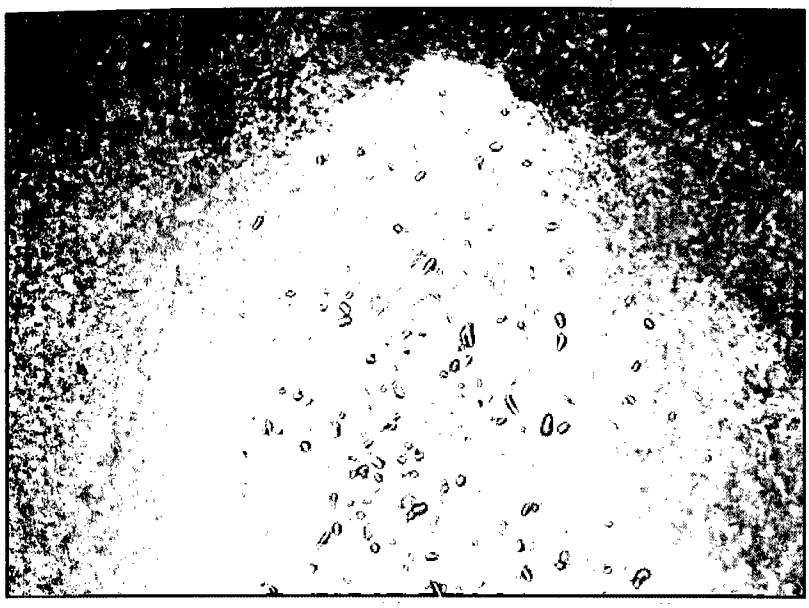

Figure 2.1: Sawdust in a coarse particle

2.4 SAWDUST CONCRETE

Sawdust concrete is a concrete that outcome from mix of sawdust and cement and was classified as a lightweight concrete.. The sawdust concrete is high absorption and have a comparatively low water resistance to compare with normal concrete. Most commonly used proportion is 1:3 (cement : concrete) will get the strength of sawdust concrete of 10 to 20 percent of that normal concrete (Forest Service, US Department of Agriculture, 1948). Olutoge (2010) in his study was use a sawdust as aggregates replacement of 0%, 25%, 50%, 75% and 100% and all the samples was imposed a compressive strength test. The value of compressive strength in 28 days was obtained for 0%, 25%, 50%, 75% and 100% are 21.6 Mpa, 15.9 Mpa, 10.3 Mpa, 8.0 Mpa and 6.1 Mpa. From that, increasing the total replacement of sawdust will decrease a value of compressive strength.

It is not usable where high structural strength. Even though the sawdust concrete has a low strengths, but it has an advantages such as improved thermal insulation and sound absorbent properties due to its high void ratio, reduce damage and prolonged life of form work due to lower pressure being exerted, easier handling, mixing and placing as compared with other types of concrete, high economy when compared to heavy and normal concrete. Nails can be driven and firmly hold in sawdust concrete to compare to other lightweight concrete.

Sawdust concrete has a several unique characteristic which make it competitive among the other building materials;

1. It is made of green and ecologically pure staff
2. It controls interior humidity level
3. It is frost proof
4. It has favorable thermal mass and sound proofing properties
5. It is fireproof
6. It is not resistant
7. It is not subject to mold and fungi
8. It is light

2.5 SAWDUST CONCRETE INCOMPATIBILITY

There are a problem that related with sawdust concrete such as affect the setting and hardening of sawdust concrete, the needed of pre-treatment of sawdust and mixing difficulty. Chemical incompatibility between cement and wood is a significant problem.

Sugar, that are present in varying amount in most woods known as retarders of cement. Hemicelluloses is soluble in an alkaline environment may reduce the strength and hydration rate of cement. Extractives like terpenes and resins may migrate to the surface of wood particles during drying and create a layer on the surface that inhibits bonding between the wood and cement (Hachmi & Campbell as cited Stahl et al, 2002).

Sawdust has been known to contain substance which retard the hydration and the hardening of cement in the process to make a sawdust – sandcrete blocks (Oyekan, 2007). Setting can be defined as the transition from fluid state to a plastic state. This transformation of cement and concrete is obtained by chemical reactions between particles and water. Hardening is a process which the concrete has set it begins to gain strength and harden. When water is added to the cement, paste is formed which gradually stiffens and then hardens. The phase of when cement paste is having stiffening is called setting.

The extractives that contained in the wood that produce sawdust have been found to interfere seriously with the chemistry of cement setting. Generally, preparing the concrete mixtures with sawdust are requiring big amounts water (Vaickelionis & Vaickelioniene, 2006). The statement from Vaickelionis & Vaickelioniene is true where the workability of sawdust concrete depends to water cement ratio. Adeagbo (1999) in his reseach about effect water cement ratio on the properties of sandcrete cubes when partially replaced with sawdust was stated that water cement ratio 0.8 is a useful parameter in practical field construction. In his research, the different water cement ratio; 0.40, 0.60 and 0.80 with different mix proportion of cement: sand: sawdust; 1:5:1; 1:4:2; 1:3:3; 1:2:4 and 1:1:5 were tested to the compressive strength. As conclusion, all the water cement ratio 0.8 for every mix proportion 1:5:1; 1:4:2; 1:3:3; 1:2:4 and 1:1:5 obtained the maximum compressive strength with 9.78 Mpa, 5.69 Mpa, 3.57 Mpa, 1.70 Mpa and 0.44 Mpa to compare with other water cement ratio.

The needed of big amount of water because the water dissolves the extractive material that retard the hardening of Portland cement. It is a chemical process of cement hardening is the processes of hydration which occurs at mixing cement with water. The extractives also found that act as an inhibitor that adversely affect the exothermic hydration characteristic of Portland cement which eventually will turn affects the sawdust – cement concrete compatibility. In that cases, using the appropriate additives is a solution to overcome the behavior of concrete that produced by organic such as sawdust to increase the workability of that concrete.

2.6 ADDITIVES

Additives are ingredients that added to the concrete and it may be added before or during mixing. When additives are used to add into a sawdust concrete mix, it will change the mechanical properties of sawdust concrete. This is because the composition of the sawdust concrete is not usual. The additives may either reduce or improve the quality of the sawdust concrete. The changing that happens to a sawdust concrete's properties is an important thing to be determined before using in construction.

The types of additives are mineral additives, chemical admixtures, pigments and fibers. Concrete additives could be used to alter various characteristics involving normal concrete. Building experts assume that selection of right concrete additive will help in constructing the very best structures.

2.6.1 Lime

Another material that will use as an additives limes. Limes can be dividing into three categories that are eminently hydraulic, semi – hydraulic and non-hydraulic. Eminently hydraulic is similar with Ordinary Portland cement but will harden or set as quickly. It contains many impurities such as alumina, silica and iron oxide Semi – hydraulic limes contains small amounts impurities which means it will harden slowly. Usually it are added to the sand to provide a workable mortar for non – loading bearing walls. Non – hydraulic limes are also known as 'fat' limes and not set under water.

With adding the lime to the sawdust concrete, it should neutralize the acid constituents of the wood and prevent a possible effect that might have on the hydration process of the cement (Graf & Johnson, 1930). According to the Turgut & Murat (2007), combination of the lime and sawdust can give a potential to be a brick material. Based on their research also shows that combination of the 10%, 20% and 30% of wood to the mixture of lime and cement will reduce the compressive strength with the value that obtained is 16.6 Mpa, 11.0 Mpa and 7.2 Mpa. That means the lime has an effect to the hydration process meanwhile adding the sawdust that contains extractives will inhibit the setting of cement. Meanwhile increasing the total of lime into sawdust concrete, it will increase the compressive strength (Graf & Johnson, 1930). From his study, lime was add into sawdust mixture by mix ratio 0.25, 0.50 and 1.00 and the value of compressive strength that was obtained is 5.86 Map, 5.86 Mpa and 6.08 Mpa.

2.6.2 Cockle Shell

Cockle shell or *anadaragranosa* is a type of bivalve shellfish that grows well in muddy coastal area in Malaysia as a by-product from seafood industry. This waste is not yet exploited in other applications except that it has been used in small-scaled craft production. The mineral composition of the cockleshell which consist of Calcium (Ca), Carbon (C), Magnesium (Mg) and Silica (Si)which is similar to that sand, gravel and cement suggest its potential as an alternative material of construction.

According to Sahari & Mijan (2011) stated that cockle shell powder that added to the concrete mixture can improve the mechanical strength due to the existence of calcium carbonate on the cockleshell. In their studies also do comparisons between cockle shell in different shape or form such as piece, chip, powder, powder + chip and powder + piece. The cockle shell in powder form obtained the higher compressive strength value with 162.85 to compare with other shape. However, in Akram (2013) study found that adding the cockle shell powder in different mix ratio created the inconsistencies of compressive strength of sawdust concrete. The optimum mix ratio of cockle shell powder that was obtained is 0.67 with compressive strength value 1.94 Mpa whether compressive strength for mix ratio 0.33 and 1.00 are 191 Mpa and 1.81 Mpa. Average for compressive strength value for cockle shell powder is 1.89 Mpa.

2.6.3 Spent Bleaching Earth

Pre – treatment of crude palm oil in refinery which is involving degumming and bleaching will generates plenty of spent bleaching earth (SBE). Beshara & Cheeseman (2008) stated that spent bleaching earth is a hazardous waste and is an acid – activated

bentonite clays. Spent bleaching earth is a very fine powder and its main component is silicon dioxide. It is prepared by treating montmorillonite clay with mineral acids and by eluting basic components such as aluminium, iron and magnesium (Loh et all, 2013). It is noted that spent bleaching earth can present a fire hazard because it ususally contains 20 – 40 % oils by weight (Tee, 2010).

Many researchers interested to study about uses of spent bleaching earth and effect from that. Ann (2010) has done an experimental study about spent bleaching earth. Her study was investigated the compressive strength and flexural strength of concrete with partial replacement 0f 30 % and 40 % spent bleaching earth. In compressive strength, SBE with 30 % obtained 9.89 Mpa higher than SBE 40 % that obtained 8.60 Mpa. She also concluded that SBE have a potential to implement in lightweight concrete which lead to another choice in the current markets for greener environment.