THE USE OF BANANA TRUNKS ASH AS CEMENT REPLACEMENT IN MORTAR

MUHAMAD LUKMAN HAKIM BIN WAHAB

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Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

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ABSTRACT

Nowadays, construction industry had growing up to become one of important industry in Malaysia. One of the important components in construction industry is mortar, which act as a binder to give strength to hold bricks with different size and also to patch hole in the wall of the building. As stated, this research is done to determine the best portion of banana trunks ash can be replace the cement in the making of mortar and also to determine the strength of mortar that can be achieve by using banana trunks ash. The banana trunks ash is an agriculture waste that has potential to replace one of construction material which is cement. Banana trunks ash contains a pozzolanic reaction that usually occurs in Portland cement. The banana trunks ash was produced from the process of burning the dried banana trunk into furnace at 500°C for 2 hours. In this research, compression test was conducted to determine the compressive strength of the mortars that replace the cement with 1%, 2% and 3% weight of banana trunks ash. A total of 27 specimens with size of 50mm x 50mm x 50mm were prepared by using timber mould. All the specimens were curing for 7 days, 14 days and 28 days by using water curing method. Based on the test and analysis that have be done, the normal mortar has highest compressive strength at 28 days with 15.484MPa, followed by 2% with 9.149MPa,1% with 8.349MPa and lastly,3% with 8.709MPa.

ABSTRAK

Pada masa kini, industri pembinaan telah berkembang sehingga menjadi salah satu industri penting di Malaysia. Salah satu komponen penting dalam industri pembinaan adalah mortar, yang bertindak sebagai pengikat untuk memberi kekuatan untuk memegang batu bata dengan saiz yang berbeza dan juga untuk menampal lubang di dinding bangunan. Seperti yang dinyatakan, kajian ini dilakukan untuk menentukan kuantiti yang terbaik daripada abu batang pisang boleh menggantikan simen dalam pembuatan mortar dan juga untuk menentukan kekuatan mortar yang boleh dicapai dengan menggunakan abu batang pisang. Abu batang pisang adalah sisa pertanian yang berpotensi untuk menggantikan salah satu daripada bahan binaan yang bersimen. Abu batang pisang mengandungi reaksi pozzolanic yang biasanya berlaku dalam simen Portland. Abu batang pisang telah dihasilkan dari proses pembakaran batang pisang kering ke dalam dapur pada 500 ° C selama 2 jam. Dalam kajian ini, ujian mampatan dijalankan untuk menentukan kekuatan mampatan mortar yang menggantikan simen dengan 1%, 2% dan 3% daripada berat badan batang pisang abu. Sebanyak 27 spesimen dengan saiz 50mm x 50mm x 50mm telah disediakan dengan menggunakan acuan kayu. Semua spesimen telah disembuhkan selama 7 hari, 14 hari dan 28 hari dengan menggunakan kaedah pengawetan air. Berdasarkan ujian dan analisis yang telah dilakukan, mortar biasa mempunyai kekuatan mampatan paling tinggi pada 28 hari dengan 15.484MPa, diikuti oleh 2% dengan 9.149MPa, 1% dengan 8.349MPa dan akhir sekali, 3% dengan 8.709MPa.

TABLE OF CONTENT

CHAPTER 4 RESULT AND DISCUSSION

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOL

kN	kiloNewton
MPa	MegaPascal
N/mm^2	Newton per milimeter square
mm	Milimeter
g	grams
Kg	Kilograms
V	Volt
°C	Degree Celcius
%	Percent

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Nowadays, mortar is the important component in construction industry and it is composed of cement, fine aggregate and water. Mortar is used as a binder that help to increase the strength to hold brick with different size .The mortar also used to patch holes in wall buildings .Mortar will become hard when it exposed to water and cause in a firm aggregate structure. The ingredients in cement mortar differ somewhat, depending on the manufacturer specifications. A typical mortar will include both sand and cement, with lime added to the mix. Other types of aggregates may be added, depending on the texture that is desired for the mortar. Cement as main component in construction material is used to fasten coarse and fine aggregate. The demand of cement for construction is very high and cause maximum production of the material in Malaysia. Cement is material with adhesive and cohesive properties and its function is to bind fine and coarse aggregate together. Cement also act as filler to any void in between the aggregates and also form a compact mass.

Development in construction material is being increased by time. There are many researches about utilization of agriculture waste to substitute the material in construction. The waste product such sugarcane, eggshell and others waste product can be used as replacement for construction material. These waste products are high probability to replace the cement, fine aggregate and coarse aggregate.

Banana fibre ash is one of example of agriculture waste. Banana leaves ash (BLA) can be used as pozzolanic material in civil structures with advantages such as lower costs and the equivalent reduction of environmental impacts resulting from the accumulations of this type of residue in the field. The concrete dosage with 10% BLA

materials were satisfactory casted as cross arms for electrical distribution network factory production. (R.C. Kanning et al.2014) .

In this research, banana trunks ash is use as replacement for cement. It is use as cementitious material to produce high strength of mortar. The composition of the banana trunks have good characteristic to be use as binder in the mortar.

1.1 PROBLEM STATEMENT

Cement industry is a developing industry and important to the process of modern world but the industry generates dust during its production. The dust causes many respiratory diseases like obstructive lung diseases and other respiratory diseases. The Cement industry is known as industry that emitting Carbon Dioxide (CO_2). The amount of CO_2 emitted by cement industry is nearly 900 kg for every 1000 kg cements produced. The produce of excessive CO_2 will cause the increase temperature of atmosphere and it will affect the climate and also all living being. According to the World Business Council for Sustainable Development (WBCSD), emissions from Portland cement manufacturing vary in different regions of the world from 0.73 to 0.99 kg of CO2 per kg of cement produced.

Agriculture waste is a raw material for industry nowadays. It does not only economical but also can lead to air pollution such as global warming (R.Srinivasan , 2010). Agriculture waste material usually disposed into landfill or dispose by open burning that may lead to air pollution. The agriculture waste can be use as replacement or additive for construction material. For example, Coconut fibre can be use as additive to concrete, palm oil kernel can be use as coarse aggregates in concrete and agriculture waste as replacement of cement in mortar.

To overcome this problem, this research is carried out to determine the waste product such as banana trunks ash can be use to replace cement in the making of mortar and able to solve the environment problem.

1.2 OBJECTIVE OF STUDY

i. To determine the best portion of banana trunks ash can be replace the cement in the making of mortar.
ii. To determine the strength of mortar that can be achieve by using banana trunks ash.

1.3 SCOPE OF WORK

Based on the objective, this research focused on how to overcome the problem that occurred in construction industry regarding the strength of banana trunks ash as cement replacement in mortar.

i. Banana trunks are collected around Gambang.
ii. The banana trunks are cut into small pieces and burn in the furnace machine at 500 C for 2 hours to produce banana trunks ash.
iii. The design specimens are 50 mm × 50mm × 50 mm.
iv. The ratio of the mortar is 1:3 with water cement ratio is 0.5.
v. The materials for this research are cement, water, fine aggregate and banana trunks ash.
vi. 27 cubes of mortar are made with 3 different percentage weight of banana trunks ash.
vii. 1%, 2% and 3% of banana trunks ash are used to replace cement by weight.
viii. This test will be conducted at 7 day, 14 day and 28 days of water curing to get the strength and the results will be recorded.
ix. The compression test is to test compressive strength of the specimens.

1.4 SIGNIFICANCE OF STUDY

From this research, we can identify the best portion of the banana trunks ash can be used to replace the cement by conducted compression test. The result will be compare with mortar with using Ordinary Portland Cement. If the requirement strength can be achieved, the waste product can be used as alternative product to replace cement.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Construction industry is a main industry in the world. The development of the industry caused several effects to the environment and also living thing. To reduce from getting worse, many researchers was taking an alternative to use the natural fibre as replacement of construction material like sugarcane bagasse, coconut fibre and other agriculture waste. The characteristic of the waste product is suitable to replace material such as cement, aggregates and additive.

2.2 MORTAR

Mortar was the bonding agent used to join masonry unit into an integral structure in order to bonding the units together. The void between the units must be close by mortar to prevent the masonry unit penetrated by air or moisture. Mortar was composed by cementitious materials such as fine aggregate, Ordinary Portland Cement, and water (William P. Spence 1998).

Figure 2.1: Fresh Mortar

Richard Ti Kreh, Sr (2003) described that besides binding the masonry materials into permanent structure, the mortar also used as a bond for assorted parts of the structure such as anchor bolts, metal ties, and reinforcement rods so they may become an integral part of the wall. For engineered construction and load bearing applications, mortar strength and performance were as critical as unit strength and workmanship. In 2690B.C, the Great Pyramid of Giza was built in Egypt which was made of the huge blocks and the structures were cemented together with mortar made from burned gypsum and sand. However, in 1824, the development of Portland cement was stronger than had been used before.

Based on the McKee and Harley J, (1973), the first mortars were made from clay or mud. In addition, the natural cements had higher clay contents compare to the hydraulic lime products and it allowed for better strength development. When masonry was subjected to moisture and high levels of strength, the natural cement mortar was used in construction. These materials were used for the construction at that time because of its low price and availability. The Egyptians utilized gypsum mortars to lubricate the beds that were made by large stones when they were being moved into position.

2.3 MORTAR MATERIAL

Mortar is one of the main components in construction. It is usually used to connect the masonry units such as bricks in wall construction. There are three main materials in the mortar which are:

i. Ordinary Portland Cement
ii. Fine aggregates
iii. Water

2.3.1 Ordinary Portland Cement

Ordinary Portland cement (OPC) is material that adhesive and cohesive properties and it is common type of cement used in construction. OPC is important because it is largely effect in construction structure. It is usually dark in colour. Portland cement is and will remain a major construction material of choice in Civil Engineering construction. It is the most important constituent of concrete. Unfortunately, cement manufacturing consumes large amount of energy amounting about 7.36 $x10^6$ kJ per ton of cement (Tarun, 1996).

According to U.S Geological Survey, USGS (2011), the OPC is produced nearly 3.3 billion metric ton per year. The production of OPC release highly amount of Carbon Dioxide. The amount of Carbon Dioxide (CO_2) emitted by cement industry is nearly 900 kg for every 1000 kg cements produced. Therefore, it is a vital to the industry to minimise the use of concrete in construction, cement content in concrete and clinker in cement (Kemal Celik et al, 2014).

Figure 2.2: Ordinary Portland Cement

According to Portland Cement Association (2009), the basic ingredient of cement is a chemical combination of calcium, silicon, aluminium, iron and small amounts of other ingredients .Gypsum is added in the final grinding process to regulate the setting time of the concrete lime and silica make up about 85% of the mass. Common among the materials used in its manufacture are limestone, shells and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand and iron ore.

Table 2.1: Estimate Interval Limitation of Portland cement

Binder	**Percentage (%)**
Silicon Trioxide (SiO_3)	21.8
Aluminium Oxide(AL_2O_3)	4.2
Calcium Oxide(CaO)	65.1
Iron Oxide (Fe_2o_3)	2.5
Potassium oxide(K_2O)	0.72
Sulphur trioxide(SO_3)	2.4
Others	3.15

Table 2.1 shows the percentage of chemical composition of Ordinary Portland Cement. Based on Table 2.1, the highest percentage of chemical composition for Portland cement is Calcium Oxide (CaO) which is 65.1% followed by Silica (SiO_3), 21.8% and Alumina (AL_2O_3), 4.2%. The lowest percentage of chemical composition for Portland cement was Sodium (Na_2O) which is 0.13%, followed by Potassium Oxide

(K_2O), with 0.72% and Sulphur Trioxide (SO_3), 2.4%. In addition, increasing lime and silica content in Portland cement help to increase the setting time but lime provide a high early strength.

2.3.2 Fine Aggregate

Aggregate is an important in construction industry. It is produce from mostly natural rock, crushed stone and natural sands. Aggregates are vital in construction industry because it acts as a reinforcement to provide the strength to the concrete. Approximately, 60% to 80% of mortar or concrete composed of the aggregates. The aggregates must conform to America Standard and Testing Material (ASTM) The aggregates must be clean, hard, free of absorbed chemical, and free of coating of clay to ensure the good quality of mortar.

According to A.K.H Kwan et al. (2014), there is excess of fine aggregates coating the coarse aggregates particles to mitigate the particle interlocking action and improve the flow and passing ability of the concrete produced. Usually, fine aggregates are used in mortar. Fine aggregates are smaller particle than 4.75 mm and equal or larger than 75 μm. There are four types of fine aggregates which are Pit sand, River Sand, Manufactured Sand and Sea Sand as shown in Figure 2.3.

(a) Pit Sand

(b) River Sand

(c) Manufactured Sand

(d) Sea Sand

Figure 2.3: Type of fine aggregates

Fine aggregates occupy 60% to 80% of mortar. Sand must be obtained from river because this type of sand can avoid sulphate attack. Sulphate attack usually happens in beach that will cause failure strides in durability and weaken the strength of concrete building (A.M Neville, 1996). Sand type also has significant influence on mortar properties (De Schutter and Poppe, 2004).

2.3.3 Water

Water is transparent fluid and also a major constituent of fluid of the living thing. In mixing process, water must be clean from injurious of substances such as oil, acid, alkalis or other organic material. Portable water, such as water in wells is accepted to be mix in mortar. The other characteristic of water that can be used is water that containing pH value less than 6.Seawater containing up to 35,000 parts per million

(ppm) of dissolved salts is generally suitable is generally suitable as mixing water for unreinforced concrete (A.F.Abdul Wahab,2011)

2.4 PROPERTIES OF HARDENED MORTAR

Mortar is composed of Ordinary Portland Cement, fine aggregates, and water. It has its own properties compared to concrete. According to Vladimir et al, (2011), the knowledge about the fresh and hardened mortar is fundamental to ensure a good performance of masonry walls. There are five properties of mortar which are:

i. Bond strength
ii. Compressive strength
iii. Durability
iv. Appearance
v. Water retention

2.4.1 Bond Strength

Bond strength was the degree of contact between the mortar and the masonry units or in other words was the tensile bond strength available for resisting forces that tend to pull the masonry units apart (William P. Spence 1998). Tensile bond strength was required to withstand forces such as wind, structural movement, expansions of clay masonry units, shrinkage of mortar or concrete masonry units, and temperature changes. Bond was low on the smooth surface and high on the texture surfaces. Bond of the masonry units was influence by the suction rates and it tend to retain moisture after they were cured and have relatively low from the mortar, establish a bond between them. If the brick were wetted before using, it will result a poor bond and thus the surface of the brick should be permitted to dry before use.

Cement content is a factor that can influence the bond strength. The cement is known as the binder of aggregates and contributed to strengthen the bond between masonry units. In other word, the higher the cement contents in mortar, the greater the bond strength.

Workmanship also can affect the bond strength .the minimum time elapsed between spreading the mortar is important to produce greater bond strength. Once the masonry unit is aligned to the place, it must be avoid from moving to prevent from initial bond breaking. Other than that, freshly laid mortar must be prevent from excessive sun heat and wind to avoid the mortar from drying before hydration process is complete. The moisture of mortar can be retained by covering the laid unit with plastic during curing process.

2.4.2 Compressive Strength

Compressive strength of mortar is a property of mortar that easy to measure. A good compressive strength of mortar can be achieved by increasing the cement content in the mortar mixture. Although cement added will increase the compressive strength, vertical cracking can occurs when load are applied. If cracking occurs, it tends to follow the joint. Occurred cracking can easily repair. The factors that affect the compressive strength of mortar are the sanding grading, cement content and water content.

When the element such as fine content of sand, the content of air and water are increased in mortar, it will decrease the compressive strength of mortar. By adding the cement content, it will provide the greater strength to the mortar. Fortunately, compressive strength of mortar does not influenced massively to the strength of the masonry construction. The strength of wall can be increased about 10% for strength of mortar is increased to 130%. Compressive strength must comply with ASTM C-109 which is standard test method for compressive strength of mortar.

2.4.3 Durability

Durability of mortar also considered as a main element in mortar. Durability of mortar can be defined as the ability of the mortar withstands any aggressive condition. The examples of the aggressive condition are water, soluble salts, frost and change of temperature. The durability of mortar is directly proportional to cement contents in

mortar. The resistance of mortar to the damaged from freeze-thaw can improve by adding the air entrainment.

One of the main salts that can deteriorate mortar is soluble sulphates. The soluble sulphates can be found in the masonry units, soil and atmosphere. The soluble sulphates will become active when the masonry units become wet. Active soluble sulphate will mix with cement in mortar and cause crumbling and expansion in mortar.

2.4.4 Appearance

The overall appearance of a masonry structure can be affect by the colour and shade of mortar joint. Usually, 15%-20% of visual surface is composed of mortar. Thorough measurement and mixing is important to maintain the mortar uniformity. An appropriate care must be taken to maintain uniformly pigmented mortars.

2.4.5 Water Retention

Refer to the H. Leslie Simmons (2007), the water retention in a mortar was to prevent rapid loss of the mixing water to the air when the mortar contacts a masonry unit with a high absorption rate. Water retention was the mortar's ability to retain its plasticity so that the mason can carefully align and level the units without affect the bond between mortar and unit. Mortar must have a good or high degree. Water retention in order to resists a mortar from bleeding when it contact with a masonry unit that has a low absorption rate. A mortar made with only Portland cement and sand, without any lime, would have high compressive strength but low water retention. In contrast, a mortar made with only lime and sand, without Portland cement, would have low compressive strength but high water retention.

Water retention was important not only to enhance workability but also to extend board life and assure that adequate water was available to hydrate cementitious components of the mortar. According to Palmer et al (1934), water retention of the mortar becomes more important as the absorption rate of the masonry increase or the temperature during installation process. If the high-suction units laid in hot and dry

weather, mortar that has low water retention was required and for low-suction units laid in cold and wet weather, mortar that has low water retention was required. In addition, the plasticity was a good predictor of water retention through some research. Water retention by itself was not a predictor of plasticity.

In addition, William P. Spence (1998) express that by entrained that by entrained air, very fine aggregate or cementitious material, water retention of mortar might increased. The table shows the two types of flow test to measure the water retention limit of mortar that was initial flow and after suction test made in a laboratory as described in ASTM C91 (Standard Specification for Masonry Cements). The allowable initial flow should be in a range of 100% to 115% and the flow after suction should be in the range of 70% to 75%. The flow test was similar with the concrete slump test, but flow test was performed on flow table that was rapidly vibrated up and down for several seconds.

Table 2.2: Flow of Mortar

Condition	The flow before suction	The flow after suction
Range	100% to 115%	70% to 75%

2.5 AGRICULTURE WASTE (AW)

Agriculture waste is defined as wastes that produce from agriculture industry such as bagasse, banana fibre, coconut fibre and others waste. Agriculture waste usually can be obtain in rural area because of the production of agriculture require such a big area. Nowadays, development of agriculture industries are increased because of maximum demand of agriculture product such as fruits, vegetables, and many more. These situations may bring to others problems like setting out the agriculture waste.