STRENGTH PERFORMANCE OF BANANA FIBER ASH MORTAR

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A report submitted in fulfillment the requirement for the award of the degree of
Bachelor of Civil Engineering with Honors

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

JULY 2015

ABSTRACT

In the history of the construction industry, mortars have been used for centuries to place masonry units more rapidly together. It is important for mortars to have the same basic characteristics as concrete in order for it to protect the units that it binds. Nowadays, mortars are being modified to produce mortars with improved properties such as better strength and workability. This research was conducted to determine the optimum cycle burning process and strength of mortar to produce good cementitious material by using banana fiber ash. Agriculture waste material can help to increase the strength of mortar. The source of natural fiber are found in plant and they are readily environmental friendly and cheap. In addition, natural fiber ash has an excellent potential to improve the performance of mortar. In this study, compressive strength test was conducted to know the strength of mortar with three different cycle burning process. Banana trunk is cut layer by layer and burn in furnace with three different cycle that is 1 cycle, 2 cycle, and 3 cycle at 500°C. A total of 27 cubes with 50 mm ×50 mm × 50 mm were used to determine the strength of mortar using banana fiber ash. All this specimens is cure for 7 days, 14 days and 28 days using water curing method. 2% of banana fiber ash was replaced with cement by weight. The materials use in this study was banana fiber ash, sand, cement and water. The result analysis shows, The highest number of cycle burning obtain in this research was by burned banana ash with 3 cycle at 500°C. while 1 cycle is the lowest when the mortar was curing for 28 days. The highest the number of cycle burning process the higher the strength of mortar can be obtained.

ABSTRAK

Dalam sejarah industri pembinaan, mortar telah digunakan sejak berkurun lamanya untuk memastikan blok atau bata dapat melekat dalam unit yang sama semasa diletakkan bersama. Adalah sangat penting untuk mortar mempunyai ciri-ciri yang sama seperti konkrit supaya dapat melindungi unit-unit bata yang telah disatukan. Pada masa sekarang, kebanyakkan mortar telah diubahsuai untuk menghasilkan mortar dengan ciri seperti kekuatan mampatan dan kebolehkerjaan yang lebih baik. Kajian ini dijalankan untuk menentukan bilangan proses kitaran bakar dan kekuatan mortar menggunakan abu serat pisang bagi menghasilkan mortar yang lebih berkualiti dari segi kekuatan. Bahan buangan yang berasaskan daripada industri pertanian boleh membantu meningkatkan kualiti mortar. Serat semula jadi yang terdapat di dalam tumbuhan-tumbuhan ini merupakan bahan yang boleh diklasifikasikan sebagai bahan mesra alam sekitar dan juga mudah untuk didapati. Di samping itu, serat semula jadi juga mempunyai potensi yang sangat baik untuk meningkatkan tahap kekuatan mortar. Melalui kajian ini, ujian kekuatan mampatan dijalankan untuk mengetahui kekuatan mortar dengan menggunakan proses kitaran pembakaran yang berbeza. Batang pisang dipotong lapisan demi lapisan dan dibakar di dalam mesin “furnace” dengan menggunakan tiga kitaran yang berbeza iaitu 1 kitaran, 2 kitaran , dan juga 3 kitaran pada suhu 500°C. Sebanyak 27 kiub bersaiz 50 mm x 50 mm × 50 mm telah digunakan. Kesemua kiub ini direndam di dalam air selama 7 hari, 14 hari dan 28 hari dengan menggunakan kaedah pengawetan air. 2% daripada abu pisang telah digantikan dengan simen. Bahan-bahan yang digunakan untuk menghasikan kajian ini adalah dengan menggunakan abu serat pisang, pasir, simen, dan juga air. Melalui kajian ini didapati bahawa dengan membakar abu serat pisang menggunakan 3 proses kitaran pembakaran pada suhu 500°C akan menghasilkan kekuatan mortar yang lebih tinggi manakala pada 1 kitaran akan menghasilkan kekuatan mortar yang lebih rendah. Semakin tinggi proses kitaran pembakaran abu serat pisang, semakin tinggi kekuatan mortar yang dapat dihasilkan.

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Al_2O_3	Aluminium Oxide
CaO	Calcium Oxide
°C	Degree Celsius
Fe_2O_3	Iron Oxide
LOI	Loss of Ignition
MgO	Magnesium Oxide
OPC	Ordinary Portland Cement
%	Percent
P_2O_5	Phosphorus Oxide
SiO_2	Silicon Dioxide
Na_2O	Sodium Oxide
SO_3	Sulphur Trioxide
POFA	Palm Oil Fuel Ash
RHA	Rice Husk Ash
BLA	Bamboo Leaf Ash
BA	Bagasse Ash

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Mortars especially have been used to place masonry units more rapidly together. It is important for mortars to have the same basic characteristics as concrete in order for it to protect the units that it binds. Mortar is basically a construction material that consists of cements, sand and water. The composition of the mixture is determined during mixing and results in the fresh mortar hardening into hardened mortar. The water cement ratio is the key factor that determines the strength of the mortar, with a lower ratio yielding a stronger and more durable concrete.

When mortar hardens, it needs to achieve the level of strength and hardness that is required for a certain construction. Curing is performed so that the mortar is hydrated which lowers the permeability and increases the strength, resulting in a higher quality material. A lot of research conducted by various researchers has shown that the increase in the quality of the properties of mortar could be achieved by adding chemical admixtures. However, it must also consider a realistic budget and cost, and the affects the chemicals could have on the environment.

Furthermore, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone like material with many uses such as use to build building, apartment, tunnel, dam, bridge and other. Concrete and mortar also have own disadvantages such as weak on crack propagation and have a low impact strength.

The application and use mineral additive in cement and mortar have been widely studied and use other material to add strength on mortar such as used natural fiber as cementitious material. The investigation has been carried out using several waste

materials as cementitious material such as parm kernel shell, bamboo, rice husk, banana and other. (Rodrigo C. Kanning,2014)

1.2 HISTORY OF MORTAR

The earliest known mortar was used by the ancient Egyptians and was made from gypsum. This form was essentially a mixture of plaster and sand and was quite soft. It was used in the mid nineteenth century, as part of scientific efforts to develop stronger mortars than existed at the time. It was popularized during the late nineteenth century, and by 1930 it had superseded lime mortar for new construction.

The main reason is hard and more quickly, that allows a faster rate of construction. However this type of mortar should not be used for the repair purpose of older buildings which constructed in lime mortar, which require the flexibility, softness and breath ability of lime if they are to function correctly. The Portland cement mortar is the basic for concrete, which known as the mixture that usually composed with particular mortar with the addition of gravel.

Meanwhile lime mortar is the mortar created by mixing sand, slaked lime, and water. The earliest known use of lime mortar dates to about 4000 before century in Ancient Egypt. Lime mortars have been used throughout the world, notably in Roman Empire buildings throughout Europe and Africa.

The vast majority of pre-1900 masonry buildings in Europe and Asia are built from lime mortar. There are two types of lime mortar which is known as non-hydraulic and hydraulic lime mortar. The hydraulic lime mortar will set very slowly and the hydraulic lime mortar will set fast. Lime mortar is considered as breathable so it can allow moisture to move freely through it and it will also let water to evaporate from its surface.

1.3 PROBLEM STATEMENT

Nowadays agriculture waste is a material from agriculture sector that can be use with different function and give many advantages in construction industries. It does not only economical but can prevent the environmental problem such as global warming.

Most all the agriculture waste is usually disposed into landfill or dispose by open burning that may cause environmental pollution.

This waste material can be used to increase the strength performance of mortar .The chemical composition are found in each plant and they are can give advantage as well as cheapest. Banana fiber ash has high potential to improve properties of material and can be used to test the performance of mortar.

1.4 RESEARCH OBJECTIVE

The main objective of this research is to determine the best cycle burning process to prove the strength performance of mortar, while the sub objective of the research are :

i. To determine the compressive strength of mortar using banana fiber ash with 3 type cycle burning process.
ii. To obtain the best cycle burning process to produce high strength mortar.

1.5 SCOPE OF STUDY

This study was conducted to analysis the different on 3 type cycle burning process and determines the strength of mortar using banana fiber ash. The scopes of study are:

i. The material uses are banana fiber ash, cement, sand and water using ratio 1:3.
ii. The banana fiber burnt in furnace and the testing of banana fiber ash burnt with 500°C.
iii. 2% of banana fiber ash was use to replace the use of cement by weight.
iv. A total number 27 cube with 50 mm x 50 mm x 50mm used to determine compressive strength.
v. Curing process for 7 days, 14 days and 28 days using water curing at the Civil Engineering Concrete Laboratory (FKASA lab).
vi. Compressive strength test was conducted to determine the strength of mortar with cycle of time about 1, 2 and 3 cycle.

1.6 EXPECTED OUTCOME

Banana fiber ash has a good potential and performance in terms of fresh state parameter and mechanical behavior in the hardened cement state. The different time on cycle burning process make the chemical composition become stronger for strength concrete and mortar. Therefore, banana fiber ash material can be used to partial and reduce the use of cement for concrete and mortar.

CHAPTER 2

LITERATURE REVIEW

2.1 MORTAR

Mortar, just as concrete is used more than any manmade material on this planet as it is the most important element in the construction industry. Generally, mortar consists of cement, sand, and water. In certain circumstances, admixtures are added to produce mortar with different characteristics not obtainable with plain mortar mixes. The mix design that is usually used is defined as the required 28 day compressive strength. The mortar used is of grade 30 with a compressive strength of 30 N/mm2 at 28 days. (A.M. Neville, 2002)

To produce high quality mortar, it is important for us to understand and observe carefully the basic and fundamental procedures of mortar mixing. The quality of mortar depends on the compositions used such as the proportion of cement, sand, water-cement ratio, method of mixing, degree of compaction and curing.

If the materials used are of low quality or the methods practiced do not follow the right procedures, the mortar that is produced would be of low quality and may not even be able to sustain load or pressure. If this happens, a structural failure will occur that would be very dangerous to buildings.

This truly states that all of the mortar that is produced must go through a series of tests and verification that is permitted, before it is able to be used for construction works. The possibility to place masonry units more rapidly is due to the development of mortars that hardened and gained strength rapidly. A thicker joint provided a cushion for dimensional variations in masonry units. There are 3 main purposes of mortar; first to create a tight seal between concrete masonry units and to join adjacent units. Second

purpose, to make up for the slight size variations that are unavoidable in the manufacture of concrete masonry units and the last is to provide architectural quality.

2.2 MECHANICAL PROPERTIES OF MORTAR

2.2.1 Consistency

Consistency is best described as the degree of workability of the mortar. It is related to the ease of handling and placing of the mortar. The word workability is defined as the amount of work needed to compact the mortar without any segregation or ability of a fresh mortar mix to fill the mold properly with the vibration and without reducing the mortar's quality. (Shan Somayaji, 2001)

Workability is the ease with which the mortar can be handled as it is related to its plasticity. It is easier to mix to a uniform composition if the mortar is more plastic and workable. A mortar has good workability if placed on a trowel, snapped, and then turned upside down but still manages to stick. It should also be able to slide from the trowel easily and be easy to spread to a uniform thickness (Shan Somayaji,2001).

Workability is very important in the construction industry because the processing of fresh mortar is actually carried out on site. The mortar must be capable of being transported by dumper or mixer truck, flowing into all corners of a mould or formwork, being thoroughly compacted to expel air to achieve the maximum potential strength and durability of hardened mortar and giving a good finish direct from the formwork, without honeycombing or an excessive number of blowholes or other surface defects.

The main factors that influence the workability of mortar are water content, properties of aggregate, and properties of cement. Among the test that can be performed to determine the level of workability of mortar are compressive test.

2.2.2 Water Retentivity

Water retentivity is the property of mortar to resist water loss by absorption into the masonry units known by the suction process and to the air, due to varying temperature, wind and humidity. Water retentivity is also related to the workability of

mortar. A mortar that have a good water retentivity will remain at plastic condition for a long period to allow the masonry units to be aligned and plumbed without breaking the internal bond between the mortar and the units (M. A. Wilson, 2003).

Masonry units that have low absorption when in contact with mortar with high-water retentivity may float and move out of alignment. In this case, water retentivity should be neither too low nor too high. Adjustments can be made by varying the amount of entrained air, amount of fine aggregates, admixtures, lime and cement. Loss of moisture due to poor water retentivity, in addition to loss of plasticity may greatly reduce the effectiveness of the bond to the masonry units (M. A. Wilson, 2003)

2.2.3 Strength of Mortar

In the construction industry, mortar is used to produce structures that are capable of sustaining loads. Hence, according to BS 1881: Part 111 (1985), mortar of high durability and quality has to pass the minimum requirements with regards to the design mix or mortar grade of age 28 days.

2.3 COMPRESSIVE STRENGTH

Compressive strength is one of the important criteria in defining whether the mortar is of good or bad quality. To achieve this criterion, we have to make sure that the materials used are of good quality and the method of mixing is done carefully and according to procedure.

Mortar has relatively high compressive strength and is mainly able to sustain compression load. The test that is usually done to obtain the compressive strength of mortar is the cube test, mainly because it is easier and simpler. The cube size that is usually used is 50 mm x 50 mm x 50 mm.

The cube test does not necessarily provide us with accurate information regarding the strength of mortar. There are other properties such as tensile strength that could give us a closer in sight on the actual strength of mortar. This test is mainly for us to know the potential that the mortar has in terms of strength.

2.4 DURABILITY OF MORTAR

Durability of mortar is also a main property that should be considered. Durability of a mortar defined as the ability of the mortar to resist any aggressive conditions during its design life. The agents that can deteriorate the mortar are water, frost, soluble salts and temperature change. Actually when the cement content in the mortar increased, the durability of the mortar will also increase. Other than that, the addition of air entrainment in mortar improves the resistance of the mortar to the damage caused by freeze-thaw process (Shan Somayaji, 2001).

Soluble sulfates are one of the main salts that can deteriorate mortar. It is found in the masonry units, soil, and atmosphere. When the masonry unit becomes wet, the sulfates may dissolve in the water and become active. Once it is active, it can react with the mortar. It will combine with the cement compounds in the mortar and will cause 15expansions and crumbling of the mortar. In certain situation it is necessary to use mortar mixture with adequate sulfate resisting properties. Durability of the mortar must be adequate to overcome this problem.

According to Shan Somayaji, (2001), Mortar that did not have good durability can only be applied for the internal use. It may be suitable for internal walls but could weather very badly on exposed condition. As an example, a mortar of lower strength than the masonry unit is used in chimney stacks, any water flow will tend to take place preferentially through the mortar joint. Degradation occurs due to freezing and thawing, is less important than damage to the units themselves.

It is because the mortar joint may be replaced easily. Meanwhile, if a high dense and impermeable mortar is used with more permeable masonry, any flow of water that take place will tend to pass preferentially through the masonry unit rather than through the mortar joint. This situation will lead to salt crystallization on the surface of the masonry and the masonry unit will degrade due to freezing and thawing. The durability test for the mortar is often required but the development of this test in practice is difficult. It is also hard to practice it in construction site.

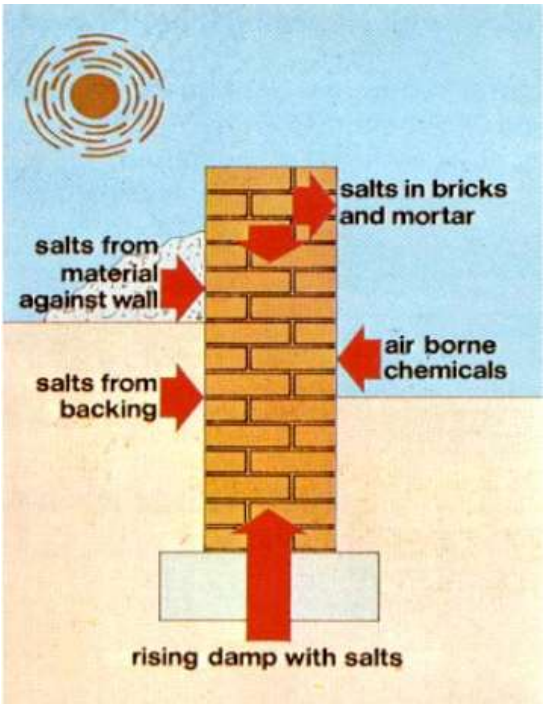

Figure 2.1: Agents that can decrease the durability of mortar

Source : Shan Somayaji, (2001)

2.5 FACTORS INFLUENCING THE STRENGTH OF MORTAR

The strength of mortar is considered as a valuable property, although it may pale in comparison to other characteristics such as durability and permeability. Besides, strength usually gives an overall picture of the quality of mortar and is a vital element of structural design.

The ultimate strength of mortar is influenced by a lot of factors. Among the main factors are water-cement ratio, gain of strength with time, degree of compaction and curing.

2.5.1 Water-Cement Ratio

There is no doubt that the water-cement ratio is the factor in influencing the strength of mortar. It single-handedly determines the porosity of the hardened cement paste at any stage of hydration and affects the volume of voids in mortar.

According to Duff A. Abrams, (1919), states that the strength is taken to be inversely proportional to the water-cement ratio. From The Generalization of Abraham's Law, it is stated that:

$$\text{Strength, fc} = \frac{K1}{K2^{w/c}}$$

$$w/c = \frac{\text{water}}{\text{Cement ratio mix}}$$

Where; K1 and K2 is empirical constants

w/c is the water cement ratio

Although established independently, Abram's rule is similar to a general rule formulated in that they both relate strength to the volumes of water and cement.(Rene Feret ,1896) Feret's rule is stated as:

$$\text{Strength, fc} = K\left(\frac{c}{c+w+a}\right)$$

Where, c is absolute volumetric proportions of cement

w is absolute volumetric proportions of water

a is absolute volumetric proportions of air

The porosity of the hardened cement paste at any stage of hydration is determined by the water/cement ratio. Hence, the volume of voids in concrete is affected by the water/cement ratio and degree of compaction, which explain why the volume of air is included in Feret's expression.

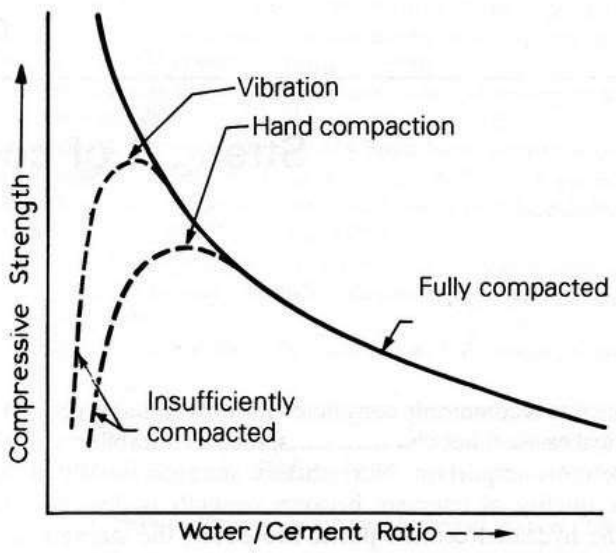

Figure 2.2: The relationship between strength and water/cement ratio

Source: A.M. Neville, (2002)

2.5.2 Gain of Strength with Time

The strength of mortar is normally characterized by the 28 day value as usually early cements gained strength slowly and it was necessary to base the strength when the process of hydration of cement has taken place significantly. In modern Portland cement, the rate of hydration is much greater in the past as they have much better fineness and have higher Tricalcium Silicate (C_3S) content. It could be argued that for the characterization of strength, a shorter period than 28 days could be used; however the age of 28 days have acquired an immutable position. This means that whenever a certain strength of concrete is referred, the strength at 28 days is usually used. (Praveen Kumar K, 2009).

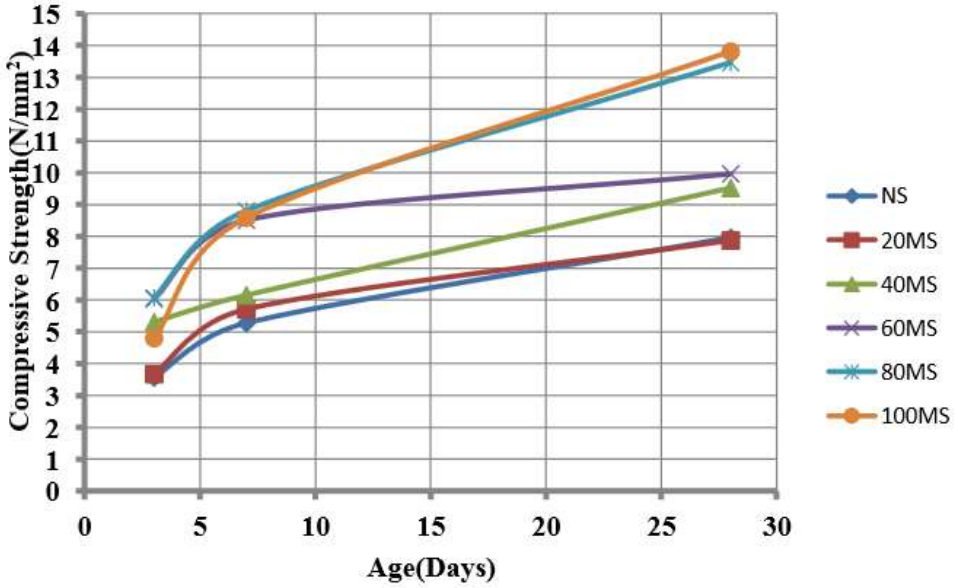

Figure 2.3: Compressive Strength Mortar Graph

Source: Praveen Kumar K, (2009)

It can be observed that compressive strength increase with age as expected. The strength of the cement mortar increases with increase in percentage replacement of M and compressive strength of cement mortar with 100% manufactured sand is 73% more when compared to cement mortar with natural sand as fine aggregate. (Praveen Kumar K, 2009).

2.5.3 Degree of Compaction

The degree of compaction plays an important role in determining the compressive strength of mortar. This is due to the fact that the mortar that has the highest strength and durability is the mortar that contains the least amount of water and is fully compacted. Compaction is done to make sure that the soil contains lesser air and the bond between cement and aggregate becomes stronger.

Fresh mortar that has low workability needs more compaction compared to concrete with a higher workability. This is to make sure all of the air voids in the mortar is fully removed. However, if over compaction happens, segregation and bleed water would occur to the mortar. Therefore, the compressive strength of the mortar sample might not achieve the initial target strength.

Table 2.1: Compaction Level and Affect

Compaction Level	Affect
Less air/good compaction	The bond between cement and aggregate become strong
High air/less compaction	The bond between cement and aggregate weak
Over compaction	Segregation and bleed water

2.5.4 Curing

In order to obtain good mortar, mortar must be cured as the cement requires time to fully hydrate before it acquires strength and hardness. It consists of a control of temperatures and of the moisture movement from and into the mortar. A moist environment promotes hydration, since increased hydration lowers permeability and increases strength resulting in a higher quality material (Akeem Ayinde Raheem, 2013)

However, improper curing can lead to several serviceability problems including cracking, increased scaling, and reduced abrasion resistance. It must be pointed out that, it is not necessary for all of the mortars to be fully hydrated to acquire a satisfactory development of strength as it is rarely achieved in practice (Akeem Ayinde Raheem, 2013).

The mortar or concrete specimens were cured using six different techniques until when their compressive strength were determined at ages 3, 7, 14, 21 and 28 days. The curing techniques that were applied are:

i. Water Submerged Curing: This involved the submersion of the concrete cube specimens in water.
ii. Spray Curing: This involved the spraying of water on the concrete cube specimens twice daily.

iii. Polythene Curing: The specimens were covered with at least two layers of polythene membrane to prevent moisture movement from the concrete specimens.

iv. Burlap Curing: This involved covering the concrete cube specimens underneath burlap which was kept wet periodically.

v. Moist Sand Curing: This involved burying the entire concrete cube specimens in wet sand which was kept moist by wetting with water on a daily basis.

vi. Air Curing: This served as the control. It involved no form of active curing by just exposing the specimens to ambient air in the Laboratory.

All the curing methods except that of moist sand were carried out in the laboratory under the same environmental conditions of 27°C temperature and 75% relative humidity. Moist sand curing was done outside the laboratory and exposed to varying environmental condition. (Akeem Ayinde Raheem, 2013).

2.6 MORTAR MATERIAL

The major material used in construction is Ordinary Portland Cement (OPC).The raw materials required for the manufacture of OPC material such as limestone or chalk and argillaceous materials such as shale or clay. A mixture of these materials is burnt at a high temperature as burning process, milling process and manufacturing process.

According to R.Srinivasan, (2010), aggregate also important to assist in producing the uniformity and workability of concrete and to provide bonding to the mortar. Commonly the size of aggregate is about 20mm.Moreover, aggregate is one material that makes up ingredient in mortar to produce strength that accept the shrinkage tension and produce less shrinkage. With natural fiber ash as cementitious material, it can create better mixes with less aggregate quantities.

According to Duff Abrams, (1919), the single most important thing to start with is the water cement ratio. The less water used the higher the strength of the mortar since too much water leaves lots of pores in the paste portion of the mortar. Besides, the water cement ratio should be between 0.4 and 0.5. Lower for lower permeability and higher strength. When the water content is low, the result is in very stiff mixtures that are difficult to place.