EFFECT OF SAW-DUST – SEA SHELL POWDER MIXTURE ON COMPRESSIVE STRENGTH OF CEMENT MORTAR

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ABSTRACT

Industrial waste materials as well as the municipal waste materials like saw-dust and sea shells produced each day is having a drastic increases with the rapid development of the technologies. These materials have been considered as materials which will lead to the negative impact to the environment and human life quality as well. With the increase awareness on the problem, more acceptable technologies are highly demand to minimize the quantity of these unused waste materials. In this research, saw-dust and sea shells powder have been added into the cement mortar mixture at the proportion of 1%, 2%, 3% and 4% to study the effect of these cement replacement materials on the workability of the fresh cement mortar and the compressive strength of the cement mortar cube at the ages of 7 days, 28 days and 56 days. Laboratory testing results showed the decrease in workability and compressive strength with the increase in the cement replacement materials. The compressive strength of the cement mortar was lower at the early curing age but improved significantly until the curing age of 56 days. From the testing, it had revealed that cement mortar with 1% of the cement replacement materials is adequate to have the maximum benefit in the gaining of the strength.

ABSTRAK

Bahan-bahan buangan industri dan juga bahan-bahan buangan domestik seperti habuk kayu dan cengkerang laut dihasilkan setiap hari mengalami peningkatan drastik dengan perkembangan teknologi yang semakan hari semakin pesat. Bahan-bahan ini telah dianggap sebagai bahan-bahan yang akan mendatangkan kesan-kesan negatif kepada alam sekitar dan kualiti hidup manusia seperti habuk kayu jika dihisap ke dalam anggota badan akan menyebabkan masalah penafasan. Dengan kesedaran kenaikan atas masalah ini, semakin banyak teknologi telah dibangunkan untuk mengurangkan jumlah bahan-bahan buangan yang tidak digunakan. Dalam kajian ini, habuk kayu dan serbuk cengkerang laut telah ditambah ke dalam campuran simen mortar dalam peratusan 0%, 1%, 2%, 3% dan 4% untuk mengkaji kesan bahan-bahan pengganti simen tersebut pada tahap kebolehkerjaan simen segar mortar dan kekuatan mampatan kiub simen mortar pada umur 7 hari, 28 hari dan 56 hari. Keputusan ujian makmal menunjukkan penurunan dalam kebolehkerjaan dan kekuatan mampatan dengan peningkatan dalam bahan penggantian simen. Kekuatan mampatan mortar simen adalah lebih rendah pada usia curing awal tetapi meningkat dengan ketara sehingga umur curing 56 hari. Daripada ujian, telah dibuktikan bahawa serbuk cengkerang laut dan habuk kayu sesuai di tambah ke dalam campuran simen dengan peratusan 1%.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In this rapid development era, humans are putting themselves in competitive stage in order to achieve better in their life and this included the technologies for construction. More and more skyscrapers erected as the symbol of the advancement of the civilization around the world and this scenario occurred at Malaysia as well. Since the pass decades, more and more mega projects commenced, and this had led to the increase of the demand of the construction materials and also the improvements of technologies involved. Cement, a building materials used since the ancient time had played an important role as until now, human kind still rely much on cement for construction and the demand is rising from years to years. Malaysia which is naturally rich in lime stone had made cement one of the cheapest and easiest to get as compared to others construction materials like steel. And because of this, since decades ago, Malaysia had been relying on this building material. Development and advancement of technologies had results in the revolution of the usage of cement in the building industries.

Mortar, a mixture of Ordinary Portland Cement (OPC), Sand, and water, is a workable paste used to bind construction blocks together like stone, brick, and cinder blocks and fill the gaps between them. United State had classified mortar into four types namely M, S, N, and O based on ASTM C270 with different field of application. The specification and characteristic of the Ordinary Portland Cement (OPC) mortar for example, compressive strength is largely influence by the proportion of the materials used for mixing and also the type of materials chosen. Over the year, researches have been done in order to increase the strength of the mortar and one of the methods used is

by adding the additive as cement replacement. Among the additive materials used are saw-dust and sea shell powder.

Saw-dust is an organic waste resulting from the mechanical milling or processing of timber into various shapes and sizes (Marthong, 2012). Malaysia which located at the equator regions is rich for her tropical rain forest. These tropical rain forest houses the valuable timber had contributed to the Malaysia economy. According to U.N. FAO, average of 96,000ha of the forest was deforested each year due to logging. It had results in large amount of saw-dust produced and these waste product if not handle properly will bring potential health risks to human. Saw- dust claimed to be a potential health problem when wood particles from processes become airborne. Breathing these particles may cause allergic respiratory symptoms and even cancer.

Sea shell which composite of >90% of calcium carbonate ($CaCO_3$) by weight, shows the similar properties as the limestone powder or the powder produced by the grinding of the limestone for Portland cement production. According to Chiemchaisri et al, more than 15 million tons of municipal solid waste is collected each year and the amount has increased steadily during the last decade. Bones and seashells comprise approximately 0.9% of the total waste. Although most of these wastes currently are incinerated or land-filled (Chaiya and Gheewala, 2007), effective waste utilization process should be conducted due to environmental concern.

In this study, both saw-dust and sea-shell powder are added into the mortar as cement replacement to observe its effects on the compressive strength of the OPC mortar. These materials are added into the cement mixture in different proportion to study their effects towards the cement mortar.

1.2 PROBLEM STATEMENT

As time fly, more and more development had leads to the development of the usage of cement as well. Engineers start to think of new technologies to increase the strength of the cement paste and one of the most common way is to replace the cement with others admixture in order to increase the compressive strength of the ordinary

cement paste. In this study, saw-dust and sea shells powder are added as the additive to the mixture to study the effect of the admixture towards the compressive strength. Sea shell which consists of calcium carbonate ($CaCO_3$), give it the similar properties as the limestone powder. Usage of sea shell will not only increase the compressive strength of the cement mortal, it too will reduce the amount of municipal solid waste. Saw-dust results in concrete weight which is only 30% of the normal weight as well as with its insulating properties.

Saw-dust and sea shells are both materials easily available. Thus, there is the need to search for local materials as alternatives for the construction of functional but low-cost buildings (Raheen at al, 2012). By adding in these admixtures, it will reduce the cost and usage of cement as both saw-dust and sea shells serve as the replacement additive for cement.

Saw-dust has potential health problem when wood particles from processes become airborne. Breathing these particles may cause allergic respiratory symptoms and even cancer. Continuous generation of wastes arising from industrial by-products and agricultural residue, create acute environmental problems both in terms of their treatment and disposal (Raheem et al, 2012). Due to this reason, the sawdust has to be stored or used in industry in order to maintain environment. Sea-shell on the other hand which categorize as municipal solid waste will also have reduce in amount when it was used as cement replacement.

1.3 OBJECTIVE

The objectives of conducting this study are

i. To study the effect of saw dust-sea shell powder on the compressive strength of Ordinary Portland Cement paste
ii. To study the effect of saw-dust and sea shell powder on the modulus elasticity of cement paste
iii. To study the effect of the saw-dust and sea shells powder on the workability of the fresh cement mortar

1.4 SCOPE OF STUDY

In this study, ordinary Portland cement mortar pastes are produced to identify the compressive strength by using different percentage of additive as cement replacement. The total weight of cement was replaced by the additive, namely saw-dust and sea shell powder at five different percentages, from 0% to total of 4% of additive as replacement. The mixture of cement paste is done based on cement to water ratio of 0.4.

Cement cube of dimension 100mm × 100mm are prepared. For this study, a total of 15 cement cube are prepared which are divided into 5 parameters, the 0%, 1%, 2%, 3%, and 4% of additive. The cubes with 0% of additive will act as control for this study and 3 cubes are prepared for each parameter. The prepared cube sample will be left for water curing before the laboratory testing are conducted at seventh day, twenty-eighth days, and fifty-sixth days.

Table 1.1: Number of specimens replaced with saw-dust and Sea shell powder

Total Percentage		**0**	**1**	**2**	**3**	**4**
Percentage of Saw-dust (%)		0	0.5	1	1.5	2
Percentage of Sea shell (%)		0	0.5	1	1.5	2
Curing	7 days	1	1	1	1	1
	28 days	1	1	1	1	1
	58 days	1	1	1	1	1
Total		15 cubes				

1.5 SIGNIFICANT OF STUDY

The purpose of conducting this study is to identify the effect of additive to the compressive strength of Ordinary Portland Cement mortar paste. Cement plays an important role in Civil Engineering especially in construction in Malaysia as it is the most common and cheapest building materials available in Malaysia as compared to others materials like steel. Hence, a cement paste with higher compressive strength

should be used to increase the serviceability life and concrete strength to withstand the out coming forces that will fail the structure of the building.

1.6 EXPECTED OUTCOME

The compressive strength of the cement mortar with saw-dust and sea shell powder replacement is expected to be higher as compared to normal cement without any cement replacement. Different proportion of the additive will affect the compressive strength of the cement mortar differently as well.

1.7 CONCLUSION

Cement mortar which played an important role in the construction had been one of the core materials used for construction. Different application required different strength results in advancement of technologies to increase the strength of the cement mortar

The effect of the saw-dust and sea shells as cement replacement will be studied in this research. Additives are added at different proportions and the waste materials can be utilized for construction purpose.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Mortar, a mixture of Ordinary Portland Cement (OPC), Sand, and water, is a workable paste used to bind construction blocks together like stone, brick, and cinder blocks and fill the gaps between them. The rapid development results in high demand of high strength mortar. Researches were done to study the cement mortar and new methods were developed to increase the strength of the traditionally produced Ordinary Portland Cements. Among the method developed was by replacing the materials with alternative materials, normally waste materials like saw-dust or sea-shell powder.

Many researchers are being done on the possible use of locally available materials to partially replace cement in concrete as cement is widely noted to be most expensive constituents of concrete (Marthong,2012). Research has shown that replacement of cement with substitute's materials will process a pozzolanic properties which results in concrete with better resistance to sulphate attack and better concrete strength. Some industrial wastes have been studied for use as supplementary cementing materials (Siddique, 200). In this study, saw-dust and sea-shell powder are added into the mixture to produce the cement mortar. To study the effects of the replacement materials towards the compressive strength of cement mortar, different proportion of materials and replacement materials are mixed.

2.2 CEMENT MORTAR

2.2.1 Introduction to Cement Mortar

Cement Mortar is type of cement works which is produced by mixing together cement, sand and water with its own proportion either mixed on site or by mixer. Common ingredient used were Ordinary Portland cement, fine grained sand which will act as the aggregates and clean water without any foreign agent in it. The proportion of the materials should be designed and mixed properly to obtain a blend or mix of the cement mortar which the properties of the mortar are applicable. Ordinary Portland cement had been widely used as the binding ingredient in modern times as compared to old time which usually rely on lime stone which produced lime mortar which work as Cement Mortar. Ordinary Portland Cement Mortars are mixed with aggregates, normally fine grained sand in the proportion by volume of 1:3. This proportion is said to be able to produce a high strength, superior durability, density and hard cement mortar. The ASTM Standard C270 categorize the cement mortar into five different types each type with its own application. The five specifications are referred to the strength of the mortar needed. The names for these mortar types are Type M, S, N, and O adapted from the word "MASON WORK" with type M mortar having the highest strength and type O cement mortar having the lowest compressive strength.

Table 2.1: ASTM C270 Property Specification of Cement Mortar

Mortar Type	Average Compressive Strength at 28 days (min. psi)	Retention (min. %)	Air Content (max. %)	Aggregate Ratio
M	2,500	75	12	$\geq 2^1/_4$ and ≤ 3 times sum of the separate volumes of compendious materials.
S	1,800	75	12	
N	750	75	14	
O	350	75	14	

Advancement in the knowledge of man kinds had result the revolution of the traditional cement mortar. The high demand for the fast development in construction required the cement mortar to have higher strength and larger range of applications. It was done by designing different cement mortar with different proportion of cement, sand and water content ratio or by adding the additive as cement replacement usually the waste materials from agriculture or municipal solid waste. These materials are chosen as substitute materials due to their nature specification which will help to strengthen the concrete itself. For instance, saw-dust and sea shell powder are used as the cement replacement materials. The nature and proportions of the materials used highly influence the properties of the cement mortar. The development of modern mortars has provided enhanced performance in, structural stability and durability.

2.2.2 History of Mortar

The development of mortar can be traced back to the ancient time. Some of the ancient applicant of mortar can be dated back about 5,000 years during the Mesopotamia civilization which now survived as the masonry ruins. Although survived as ruins, it still remains durable after centuries which proven the nature of long lasting of the masonry.

The development of modern cement mortars was referred to Bry Higgis for the manufacturing of a calcareous cement compound. Higgis had patented the cement which had been used in external rendering in the year 1779 and his work was published in a paper on the manufacture of cement one year later in 1780. On the other hand, John Seaton from Yorkshire had developed rapid setting cement which later he used it for joining blocks of granite. John Smeaton an engineer from Yorkshire developed rapid setting cement which he used to join blocks of granite for the construction of the fourth Eddystone lighthouse in the period 1756-1759. Joseph Aspin a Leeds bricklayer patented Portland cement in 1824, which was so called because of the resemblance to Portland stone. The material was first produced commercially in Wakefield in the late 1920s.

In the early time, limes are previously used to produce the masons with the acceptable working properties. However, the strength gain for these masons was in a very low rate and the condition worsens especially during cold conditions. Due to this problem, the construction proceed in a low pace with little proceed. The availability of the new Ordinary Portland cement soon had changes the situation and solved the problem faced by the lime mortar previously. It enables the construction projects to be carried out throughout the year. The availability of the new Portland cements changed this situation and enabled construction to carry on throughout the year. Whilst the Ordinary Portland cement and crushed or ground stone was utilized for cement mortar production in United Kingdom, North America was using the mixtures of ordinary Portland cement together with hydrated lime and air entrainment for the production of the mortar.

The concept of the mixture of the cement mortar has been incorporated into the Code of Practice BS 5628.

2.2.3 Application and the Properties of Mortar

Until the 19th century, construction is much relies on the cement mortar, also known as masonry with results in solid masonry structures. However, it was then started to get unpopular as the primary construction materials. It is now used for cladding for the structural elements, such as steel, wood, cement blocks or concrete.

Among the properties of the mortar that are taken into consideration is the coefficient of expansion. The mobilization of the brick should be accommodated by the mortar or the way will experience cracking. The mortar should be able to hold a compressive strength itself without failure and it is normally tested at, early age of 7 days, 28 days and long time 360 days. Apart from that, a mortar too shows the properties of modulus of elasticity which allowing minor movements without cracking.

2.3 CEMENT REPLACEMENT MATERIALS

The construction industries are relying on cement as the development of the infrastructural facilities and the shelter. The increasing cost of the cement lead to the development of cement replacement with waste materials. As a result of the increase in the cost of construction materials especially cement, crushed stone, fine sand; there is the need to investigate the use of alternate building materials which are locally available (Idusuyi, 2012). A portion of cement is replaced by other alternative materials which normally a waste materials from agriculture or municipal solid waste. Over the years, variety of the materials had been used to replace the cement for mixing purpose. According to Micheal, adding of admixtures into the concrete will improve the workability, hardening, concrete strength and also will result in the reduction of the cost for the concrete construction. An admixture is a material other than cement, water and aggregates that is used as an ingredient of concrete and is added to the batch immediately before or during mixing (Shetty, 2005). The presence of Ordinary Portland cement replacement materials in the concrete production is known to impart significant improvements of the durability, workability and substantial energy and also can be cost saving.

Alabadan et al. also stated that various research works in the recent past had look into the utilization of agricultural wastes that are known to be pozollanas to partially substitute cement that is major component of concrete. According to Marthong, many researches are being done on the possible use of locally available materials to partially replace cement in concrete as cement is widely noted to be most expensive constituents of concrete. Also some of the alternative materials were identified to give the properties which strengthen the strength of the concrete itself. This can be proved through Raheem et al. research which shows that saw-dust Ash is consist of 73.07% of the combination of SiO_2, Al_2O_3, and Fe_2O_3 which is more than 70%, indicating that saw-dust ash is a good pozzolanic material Some industrial wastes have been studied for use as supplementary cementing materials such as fly ash (Wang and Baxter 2007). Previous studies have included saw-dust, sea shells, rice husks, and oil palm fuel ash (POFA) as the cement replacement materials for concrete or mortar productions.

2.3.1 Saw-dust

2.3.1.1 Introduction to Saw-dust

According to Raheen et al. saw dust is a waste material from the timber industry which is produced daily as timber is sawn into planks at saw mills and this process is a daily activity which caused the generation of saw-dust every day. Aigbomian and Fan defined sawdust as a loose particles or wood chippings obtained as by-products from sawing of timber into standard useable sizes where the size of sawdust particles depends on the kind of wood from which the sawdust is obtained and also on the size of the teeth of the saw. Marthong also state that sawdust is an organic waste resulting from the mechanical milling or processing of timber into various size and shape for commercial purpose. Saw-dust which is one of the major underutilized by product from sawmilling operations, generation of wood wastes in sawmill is an unavoidable hence a great efforts are made from the utilization of such waste (Bdeir, 2012) and because of this, it had been used as one of the alternative building materials for the past 30 years but not widely as compared to others materials like Palm Oil Fuel Ash (POFA). Although seriously limited by its low compressive strength, saw-dust concrete can made to perform well in certain floor and wall applications (Marthong, 2012). Between 10% and 13% of total content of log is reduced to sawdust in milling operations, depending largely on the average width of the blade, thickness of the timber sawed and technology of the sawing process (Chung, 2005). Saw-dust is abundance in Malaysia especially the State of Pahang at Peninsular Malaysia and also the State of Sabah and Sarawak located on the Borneo Island where the area is largely covered by forest.

Saw-dust ash (SDA) which consists of the chemical composition of 73.07% of the combination of SiO_2, Al_2O_3, and Fe_2O_3 which is more than 70%, indicating that saw-dust ash is a good pozzolanic material (Raheem et al., 2012). According to Raheem et al. research, the saw-dust ash (SDA) contains 55% of particles in the fine sand division.

2.3.1.2 Saw-dust as Cement Replacement

Saw-dust had been used as the replacement of cement long time ago. Cheah and Ramli investigated the implementation of wood waste ash as a partial cement replacement material in the production of structural grade concrete and mortar. Dry sawdust concrete weighs only 30% as much as normal weight concrete and its insulating properties approximate those of wood (Marthong.2012). Although application of saw-dust as cement replacement materials is highly limited by its low compressive strength, it is still considerable in the reduction for the structure weight due to lighter concrete weight, whereby it will reduce the dead loads transmitted to the foundation, more economy as compared to normal weight concrete, reducing the damage and prolonged life of formwork due to its low pressure. Udoeyo also state that saw-dust as a partially replacement of sand concrete can attain the same order of strength as conventional concrete at longer curing periods. Sawdust concrete is light in weight and has satisfactory heat insulation and fire resisting value (Idusuyi, 2012). Nails can be driven and firmly hold in sawdust concrete compared to other lightweight concrete which nail can also easily drive in but fail to hold (Peatfield, 1982). Lots of research regarding the saw-dust had been done. Experimental investigation to evaluate the possibility of using saw-dust as construction materials has been reported by Sumaila and Job. The compressive strength of sandcrete blocks increases as the curing age increases (Raheen, 2012) shows that usage of Saw-dust as cement replacement increases the compressive strength of the cement mortar. Research done by Raheem et al. also shows that concrete containing saw-dust ash (SDA) gain strength slowly at early curing age. This is in line with previous findings that concrete containing pozzolanic materials gained strength slowly at early curing ages (Hossain, 2005). Raheem also mentioned that concrete become less workable as the saw-dust ash (SDA) percentage increases meaning more water is required to make the mixes more workable.

Saw-dust ash (SDA) which consists of the chemical composition of 73.07% of the combination of SiO_2, Al_2O_3, and Fe_2O_3 which is more than 70%, indicating that saw-dust ash is a good pozzolanic material (Raheem et al., 2012). According to Raheem et al. research, the saw-dust ash (SDA) contains 55% of particles in the fine sand division. Marthong finding shows that SDA is of finer size as comparable to cement

particles which is expected to have appreciable influence on the strength development of the concrete.

2.3.2 Sea-shell Powder

2.3.2.1 Introduction to Sea-shell

A seashell or sea shell, sometimes refer as a shell, is a hard, protective outer layer. It was created by ocean living creatures which served as part of their body. The sea shells normally easily available at the sea side or the municipal solid waste. For instance, the bivalve type sea shells were easily found especially in the municipal solid waste. This type of sea shells is available from clam, one of the common sea food consumed. The chemical composition of shells is >90% calcium carbonate ($CaCO_3$) by weight (Mosher et al., 2010). This composition is similar to limestone powder or dust like stone powder from grinding limestone to produce Portland cement (Lertwattanaruk, 2012). Mosher et al also stated that some sea shells like the green mussel and cockle shells are largely consists of aragonite and calcite which shows higher strengths and densities as compared to limestone powder which had been used for cement production.

Research conducted by Etuk et al. shows that shell ashes show the composition of chemical compounds of cement namely, CaO, SiO_2, Al_2O_3, and Fe_2O_3 similar in most of the Ordinary Portland Cement.

2.3.2.2 Sea-shell Powder as Cement Replacement

Numerous studies had been conducted to investigate the effects of the sea-shell powder as the cement replacement on the compressive strength of the cement mortar. The use of ground oyster shells to replace sand does not significantly decrease the compressive strength of the mortar (Yoon et al., 2004). The higher the replacement levels of ground shell in sand, the higher the rate of the development of compressive strength, and the lower the elasticity modulus (Yang et al., 2005). Increasing the percentage replacement of ground seashells in Portland cement improved the water requirement and the setting times of the mortar (Lertwattanaruk, 2012). According to