THE EFFECT OF COCONUT SHELL AS PARTIALLY AGGREGATE REPLACEMENT TOWARD CONCRETE WORKABILITY AND STRENGTH

MUHAMMAD NASIRUDDIN BIN AHMAD YATIM

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Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

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ABSTRACT

Nowadays, the prices of building materials are rising day by day. The coarse aggregates are the main ingredients of concrete. Mainly, the selection of new materials in today's construction is due to resource constraint and cost-cutting measures thus, resulting in the selection of materials that do not have any value in the current market. By using these waste materials, concrete production cost can be reduced. This study presents the results of an investigation that was focus on laboratory test to determine the workability and compressive strength of the concrete using coconut shell as a concrete aggregate replacement. Concrete grade 30 was prepared and the coarse aggregate were replaced by 0%, 20%, 30%, 40%, 50% and 100% of coconut shell and were designated as Sample A, Sample B, Sample C, Sample D, Sample E and Sample F respectively. The objective of this study is to produce concrete by using waste material which is coconut shell. The size of coconut shell used is in the range of 10mm to 20mm. For the fresh concrete, slump test, vebe test and compaction factor test were conducted to determine the workability of the concrete. For hardened concrete, compressive strength test was conducted. 54 cubes with dimension 100mm x 100mm x 100mm have been prepared for this research. The specimens are tested at 7, 14 and 28 days. Type of curing used is water curing. The expected outcome from this research is the workability and strength of concrete will increase after using coconut shell as a partial aggregate replacement. The result obtain from this study shows that the increasing percentage of coconut shell replacement, make the workability of concrete which is medium workability for replacement at 0% to 50% while for 100%, workability become low. In term of compressive strength shows the same pattern as workability test. The compressive strength reduces as the coconut shell used in concrete.

ABSTRAK

Pada masa kini, harga bahan-bahan binaan semakin meningkat hari demi hari. Batu baur kasar merupakan salah satu bahan utama dalam konkrit. Secara umumnya,langkah pemilihan bahan-bahan baru dalam pembinaan hari ini adalah disebabkan oleh kekangan daripada kekurangan sumber dan juga untuk penjimatan menyebabkan penggunaan bahan yang tidak mempunyai apa-apa nilai di pasaran semasa dijalankan. Dengan menggunakan bahan-bahan buangan, kos pengeluaran konkrit dapat dikurangkan. Kajian ini membentangkan keputusan kajian yang memberi tumpuan kepada ujian makmal untuk menentukan kebolehkerjaan dan kekuatan mampatan konkrit menggunakan tempurung kelapa sebagai penggantian batu baur kasar dalam konkrit. Konkrit gred 30 telah disediakan dan batu baur kasar telah digantikan dengan 0%, 20%, 30%, 40%, 50% dan 100% kepada tempurung kelapa dan masing-masing telah dilabel sebagai Sample A, Sample B, Sample C, Sample D, Sample E dan Sample F. Objektif kajian ini adalah untuk menghasilkan konkrit dengan menggunakan tempurung kelapa sebagai bahan ganti kepada batu baur kasar. Saiz tempurung yang digunakan adalah dalam julat 10mm hingga 20mm. Bagi ujian konkrit baru, ujian runtuhan, ujian vebe dan ujian angkadar kepadatan telah dijalankan untuk menentukan kebolehkerjaan konkrit. Manakala bagi ujian konkrit keras, ujian kekuatan mampatan telah dijalankan. Sebanyak 54 kiub dengan dimensi 100mm x 100mm x 100mm telah disediakan untuk kajian ini. Spesimen telah diuji pada hari ke 7, 14 dan 28. Jenis pengawetan yang digunakan adalah pengawetan air. Hasil daripada kajian dijangka kebolehkerjaan dan kekuatan konkrit akan meningkat selepas menggunakan tempurung kelapa sebagai pengganti kepada batu baur kasar. Hasil daripada kajian ini menunjukkan bahawa peratusan penggantian tempurung kelapa yang semakin meningkat, menyebabkan kebolehkerjaan konkrit bagi penggantian dari 0% kepada 50% sebagai ketegori sederhana manakala bagi 100%, kebolehkerjaan ialah kategori rendah. Dari segi kekuatan mampatan menunjukkan corak yang sama seperti ujian kebolehkerjaan. Kekuatan mampatan berkurang selepas tempurung kelapa digunakan di dalam konkrit.

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P	The Maximum Load At Failure
A	Area of Cube

LIST OF ABBREVIATIONS

CS	Coconut Shell
CSA	Coconut Shell Aggregate
ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BS	British Standard
OPC	Ordinary Portland cement
w/c	water cement ratio
PCC	Portland Composite Cement

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Many studies have been carried out in the area of concrete materials that resulted in the introduction of various types of materials to be introduced and added to the production of the concrete. In order to produce a strong and durable concrete, there are new methods have been introduced such as the use of waste material from industries as the main components. Mainly, the selection of new materials in today's construction is due to resource constraint and cost-cutting measures thus, resulting in the selection of materials that do not have any value in the current market. By using these waste materials, concrete production cost can be reduced.

The coconut can be found throughout the tropic and subtropics area, the coconut is known for its great versatility as seen in the many domestic, commercial, and industrial uses of its different parts. Coconuts are part of the daily diet of many people. However, the wastes from the coconuts are often thrown away in many places. Most of the villagers who use their own oil will burn the waste. Things like this will result in environmental pollution. Despite the removal of waste, efforts to reuse coconut waste should be reviewed to prevent pollution, it can be used in the making of concrete as a replacement for the original materials in making concrete such as aggregate and so on.

The coconut shell-cement composite is compatible and no pre-treatment is required. Coconut shell (CS) concrete has better workability because of the smooth surface on one side of the shells. Compared with conventional concrete, the impact resistance of CS concrete is high. Water absorbing and moisture retaining capacity of CS are also higher than conventional aggregate.

The presence of sugar in the CS as long is not in a free sugar form, so it will not affect the setting and strength of concrete. Although the wood based materials, being hard and of organic origin found in CS, it will not contaminate or leach to produce toxic substances once they are bound in a concrete matrix. CS also can be used for applications of both non-structural and structural.

1.2 PROBLEM STATEMENT

In Malaysia, coconut is the fourth important industrial crop after oil palm, rubber and paddy in term of total planted area. Most of the cultivation is focused on rural areas and near the beach. In year 2010, coconut plantation area was about 150,000 hectares. Nevertheless, the coconut shells are often discarded or burned. Therefore, this agriculture waste should be managed properly or reused to produce another product.

Reduction of natural stone deposits due to high demand for concrete in the construction using normal weight aggregates such as gravel and granite has damaged the environment and causing ecological imbalance (Short and Kinniburgh, 1978). It reveals that, natural raw materials that become more limited such as aggregate. It can be outlined that, the need for other alternative materials from the waste industrial product as an alternative material to replace natural materials. To face this problem, it is essentials to study the effectiveness of this waste industrial or agricultural product as an aggregate replacement within the suitable percent of coconut shell.

However, it must fulfill the engineering requirements in term of physical properties and strength of concrete. Besides that, natural raw materials that become more limited have caused the need for other alternative materials to replace natural materials.

1.3 OBJECTIVE OF STUDY

The objectives of this study are:

i) To determine the effect of fresh concrete containing coconut shell toward concrete workability.

ii) To determine the compressive strength of concrete with different percentage of coconut shell as course aggregate replacement.

1.4 SCOPE OF STUDY

In conducting research, the scope boundary needs to be defined and a few limitation factors to be drawn to avoid a very wide scope of research and unfocused study. The scope of this study will focus on laboratory test to determine the workability and compressive strength of concrete using coconut shell (CS) as course aggregate replacement in term of fresh concrete test and hardened concrete test.

The CS is collected from the coconut milk's processing store around Kuantan and Pekan, Pahang. Conventional materials that will be used include Portland cement, aggregate, sand, coconut shell and water. Coconut husk that attached on the CS was cleaned by using a metal brush to avoid impurities on concrete. Then, CS was crushed using a jaw crusher in the laboratory to become a coconut shell aggregate (CSA). After that, CSA was sieved to obtain aggregate size with range 10mm to 20mm.

Testing for compressive strength of concrete specimens conducted with 54 concrete cubes size 100mm x 100mm x 100mm. The concrete grade for each series of concrete cube is grade 30. A 0.54 water cement ratio (w/c) was used in this study. The 6 mix design was designated as Sample A (0%), Sample B (20%), Sample C (30%), Sample D (40%), Sample E (50%) and Sample F (100%). The coconut shell will be replaced by the total volume of the aggregate. Type of curing use is water curing. The specimens will be tested at 7, 14 and 28 days.

1.5 SIGNIFICANCE OF STUDY

In the ancient period, construction work was mostly carried out with the help of mudstone from industry. Concrete is widely used in the construction of housing, highway, pavement, foundation, architectural and many more. The significance of this research is producing the concrete by using waste materials as partially aggregate and reduces the uses of raw materials. The using of waste material can affect the properties of the concrete, so the research is done to examine the concrete workability, compressive strength of concrete by using coconut shell as partially aggregate. Coconut shell (CS) has high strength and has the potential to use as concrete material. By using CS as partially aggregate can reduce the using of natural raw material.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Concrete can be defined as a stone like material that has a cementitious medium within which aggregates are embedded. According to ACI Committee 116, the binder is composed of a mixture of hydraulic cement and water in hydraulic cement concrete (ACI Committee 116).

In recent years, there are many efforts have been made to reduce the use of raw materials in concrete. Most of the studies are using waste materials to replace the aggregate or cement. The excessive amount of coconut shell that might be burnt or thrown away without usage can be used in the making of concrete as a replacement for the original materials in making concrete such as aggregate and so on.

There are three general categories for concrete based on its compressive strength which is low strength concrete (less than 20MPa), moderate strength concrete (20-40MPa) and high strength concrete (more than 40MPa). Moderate strength concrete or the other name for it, ordinary concrete is used for most structural work. The use of high strength concrete is for special application. (Metha and Monteiro, 2006)

It has been established that in some pozzolanic materials which is amorphous silica reacts with lime more readily than those of crystalline form. Use of such pozzolan can lead to increased compressive and flexural strength. (Utsev and Taku, 2012)

2.2 PROPERTIES OF CONCRETE

There many properties of fresh concrete such as workability, strength, expansion and shrinkage cracking, elasticity and many others. This study only covers only two of the properties of concrete which is the workability of fresh concrete and the compressive strength of concrete.

2.2.1 Workability

According to American Concrete Institute (ACI) Standard 116R - 90 (ACI 1990b) defines that workability property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, consolidated, and finished.

Workability also can be defined as the effort required manipulating a concrete mixture with a minimum of segregation. Workability is affected by every component of concrete and essentially every condition under which concrete is made.

Size, shape, surface texture and grading of aggregates, water-cement ratio, use of admixtures and mix proportion are important factors affecting workability. (Deodhar, 2010).

Coconut shell (CS) concrete has better workability because of the smooth surface on one side of the shells and the size of CS used. (Gunasekaran, Annadurai and Kumar, 2012).

There are five types of degree of workability which is extremely low, very low, low medium and high. Table 2.1 shows the degree of workability for slump test, vebe test and compacting factor test according to Taylor (2000).

Table 2.1: Degree of workability of fresh concrete.

Degree of Workability	Slump (mm)	Vebe time (s)	Compacting factor	Applications
Extremely Low	0	Over 20	0.65-0.7	Lean mix concrete for roads (compacted by vibrating roller). Precast paving slabs.
Very Low	0-10	12-20	0.7-0.75	Roads compacted by power operated machines.
Low	10-30	6-12	0.75-0.85	High quality structural concrete. Mass concrete compacted by vibration.
Medium	30-60	3-6	0.85-0.95	Nominal purposes reinforced concrete compacted by vibrating poker or manually.
High	60-180	0-3	0.95-1.0	Areas with congested reinforcement, concrete for placing underwater.

2.2.1.1 Slump Test

The concrete slump test is one of the experiments to test the workability of the concrete. Slump test is carried out to determine the texture or consistency of fresh concrete and to check its uniformity. Consistency or uniformity of concrete is important to a successful concrete project. The slump test is suitable for slumps of medium to high workability. The slump in the range of 25-125 mm is defined as medium to high workability. The test fails to determine the difference in workability in stiff mixes which have zero slumps, or for wet mixes that give a collapse slump. (Nagalakshmi, 2013). Figure 2.1 shows the type of slump test.

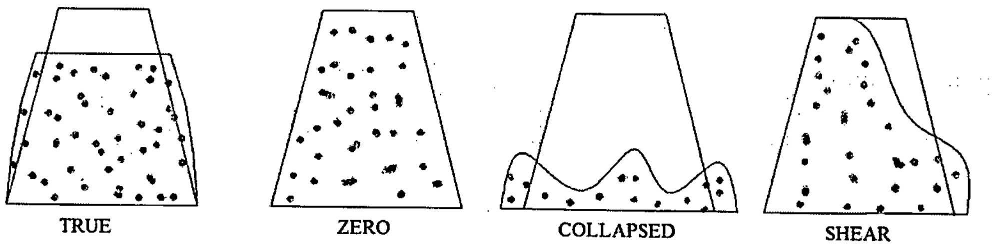


Figure 2.1: Type of slump test

The slump test is the most widely used device worldwide. In fact, the test is so well known that often the terms workability and slump are used interchangeably, even though they have different meanings. The slump test is simple, rugged, and inexpensive to perform. Results are obtained immediately. The results of the slump test can be converted to yield stress in fundamental units based on various analytical treatments and experimental studies of the slump test.

2.2.1.2 Compacting Factor Test

The compacting factor test is another test to determine the workability of concrete. The compacting factor test is determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. This test gives the behavior of concrete under the action of external forces. If measures the compatibility of concrete, by measuring the amount of compaction (Nagalakshmi, 2013).

The compaction factor test gives more information (compatibility) than the slump test. The test is a dynamic test and thus is more appropriate than static tests for highly thixotropic concrete mixtures.

Compacting factor = (Weight of partially compacted concrete) / (Weight of fully compacted concrete)

2.2.1.3 Vebe Test

The Vebe consistometer method is basically having the same principle of the slump cone test method which is for the determination of the workability of concrete. However, it has the advantage of a mechanized action. This test is to determine the amount of work expressed by time in seconds of working the vibrating machine required to transform the shape of concrete from the slump cone to a cylindrical shape.

The main use of the test has been in the laboratory and in the precast industry, where low slump concrete mixes are commonly used (Bartos, 1992).

This test device is identified by ACI Committee 211 (2002) and standardized in ASTM in the guide for the proportioning low slump concrete. There are several advantages in using Vebe consistometer test is this test is dynamic test. It can be used on concrete that are too dry for the slump test. The result for this test also can be obtained instantly.

2.2.2 Compressive Strength Test

For this study, the hardened concrete was tested by using a compression test to determine the compressive strength of the concrete.

There are several factors can be considered for this reduction of strength. Water-cement ratio, quality of cement, efficiency of curing, curing temperature, grading of aggregates, degree of compaction, age at the time of testing, impact and fatigue are the examples of the factors that influencing the strength (Deodhar and Mishra 2010).

As the post-peak portion of its stress-strain diagram descends deeply with an increase in compressive strength, high strength concrete is considered as a relatively brittle material (ACI committee, 1993, Veera and Seshagiri, 2007).

A compression test is a method for determining the behavior of materials under a compressive load. The compression test is used to determine elastic limit, proportionality limit, yield point, yield strength and compressive strength. Structural components such as columns and struts are subjected to compressive load in applications. These components are made of high compressive strength materials.

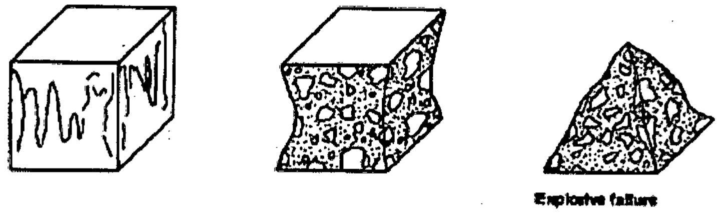
The strength of concrete is affected by a number of factors, one of which is the length of time for which it is kept moist or known as curing. Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration. Water curing for 3 days may increases the concrete strength up to 60%, whilst 28 days water curing increases the concrete strength up to 95%. The equation used to calculate the compressive strength of concrete are as follows.

Cube compressive strength : P/A

Where P: The Maximum Load at Failure

A: Area of Cube.

According to BS 1881-116:1983, there are two types of failure, which is satisfactory failure and unsatisfactory failure. There are several types of concrete cube failure. The Figure 2.2 and Figure 2.3 are showing the type of failure.

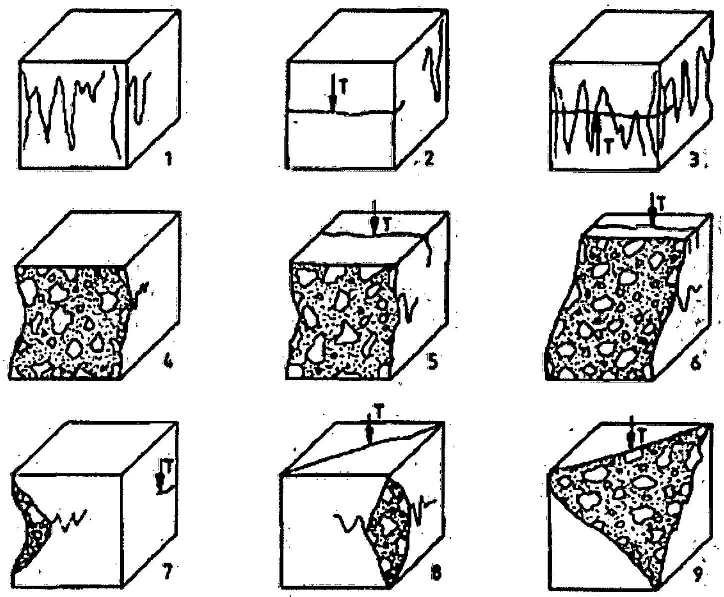


NOTE All four exposed faces are cracked approximately equally, generally with little damage to faces in contact with the platens.

Figure 1 — Satisfactory failures

Figure 2.2: Satisfactory Failure

Source: BS EN 12390-3:2002



NOTE T = tensile crack

Figure 2 — Some unsatisfactory failures

Figure 2.3: Unsatisfactory Failure.

Source: BS EN 12390-3:2002

2.3 APPLICATION OF CONCRETE

Concrete has been used for construction since ancient times. Modern day concrete application includes dams, bridges, swimming pools, homes, streets, patios, basements, balustrades, plain cement tiles, mosaic tiles, pavement blocks, kerbs, lampposts, drain covers, benches and so on.

Other applications of concrete are beams, drain tiles, piers, steps, post, deck, and pilasters, round column forms, brick ledge application, hardscape (pavers), high performance admixtures, masonry, soil solidification, stucco (tilt-up), insulating concrete form, motorways/roads, overpasses and parking structures, brick/block walls and bases for gates, fences and poles, building structure, fences and poles

2.4 AGGREGATES

Mixes consisting only of hydraulic cement and water will harden in the shape of any mould in which they are placed but they are of no practical use. They are too expensive and they shrink unacceptably during hydration. Mixing with insoluble non-cementitious particles, known as aggregate is a common practice to overcome this problem.

Many materials are used to form aggregate such as sand, gravel, stone, crushed rock, and sometimes even waste slug from iron and steel industry. There are two types of aggregate used in concrete making which is fine aggregate and coarse aggregate. Fine aggregates or sand mainly passing 5.0 mm BS test sieve and containing no coarser material than is permitted for the various gradings in BS 882: 1992. Coarse aggregate mainly retained on a 5.0 mm BS test sieve and containing no finer material than is permitted in BS 882: 1992.

Aggregates may be broadly classified as natural or artificial, both with respect to the source and to the method of preparation. Natural sands and gravels are the product of weathering and the action of wind or water, while manufacturing crushed fine aggregate and crushed stone coarse and fine aggregate are produced by crushing natural stone.

Aggregates provide the volume of concrete, industrial wastes and agricultural wastes should be new source of building material (Gunasekaran and Kumar, 2008).

Factors affecting the compressive strength of concrete are water-cement ratio and cement to aggregate ratio. Besides that, the bond between mortar and aggregate, grading, shape, strength and size of the aggregate and the degree of compaction are also affecting the strength. (Rocco and Elices, 2009; Elices and Rocco, 2008).

2.4.1 Size Distribution

It is important to consider the effect of size and shape while estimating the ultimate compressive strength of a concrete member under various loading conditions. The size and shape of coarse aggregate effects on the compressive strength of concrete are practically generalized in some degree for normal weight concrete and also can be considered in standard and code of provisions (Sim, Yang and Jeon, 2013).

2.4.2 Strength of Aggregate

The shear strength of concrete depends significantly on the ability of the coarse aggregate to resist the shearing stresses. Compared with natural aggregates, recycled aggregates usually have greater porosity and water absorption, lower density, and lower strength than normal aggregate (Wang, Kou, and Xing. 2013).

2.4.3 Coconut Shell as Partial Aggregate

Coconut Shell (CS) which is one of the most common agricultural solid wastes in many tropical countries including Malaysia. CS concrete could be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly.

In physiology, the coconut shell was the most hard compared to the other part. Hard structures caused by silicate (SiO_2) found in the coconut shell. Weight and thickness of coconut shell is determined by the type of coconut. Coconut shell weight is around (15-19) % of the total weight of oil, while the thick around (3-5) mm. Chemical composition of coconut shell according to Husseinsyah and Mostapha (2011) is described in Table 2.2.

Table 2.2: Chemical Composition of Coconut Shell

Composition	Percentage (%)
Lignin	29.4
Pentosans	27.7
Cellulose	26.6
Moisture	8
Solvent Extractives	4.2
Uronic Anhydrides	3.5
Ash	0.6

CS is a natural organic source which has high toughness, abrasion resistant properties and good durability characteristics. As the good properties come along with the coconut shell, it can be used as partial components of the concrete mixture (Herrera, 2007).

2.5 EFFECT OF COCONUT SHELL ON WORKABILITY OF FRESH CONCRETE

The shape and the texture of coconut Shell (CS) is different compare to natural aggregate used in concrete. CS has flat shape and also has rough and smooth surface while natural aggregate have irregular bodies such as rounded, angular, flaky and many others.