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Title : **COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH OF OIL PALM SHELL LIGHTWEIGHT AGGREGATE CONCRETE CONTAINING CRUSHED COCKLE SHELL AS PARTIAL SAND REPLACEMENT**

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ABSTRACT

Cockle shell is a waste produced from cockle industry which dumped at landfill thus causing environmental pollution. In this thesis, crushed cockle shell has been used as partial replacement of sand in oil palm shell (OPS) lightweight aggregate concrete to determine the mechanical properties of OPS lightweight aggregate concrete. The amounts of sand replaced by crushed cockle shell are varies from 5, 10, 15 and 20%. The tests conducted on concrete samples are compressive strength test and flexural strength test. All specimens were prepared and subjected to water curing until the testing date. The result shows that the use of cockle shell as partial sand replacement increase the compressive strength and flexural strength of OPS lightweight aggregate concrete.

ABSTRAK

Kulit kerang merupakan sisa buangan dari industry kerang dimana dibuang di kawasan tapak pelupusan. Pembuangan kulit kerang ini menyebabkan pencemaran alam. Di dalam tesis ini, kulit kerang yang telah dihancurkan telah diguna untuk menggantikan sebahagian pasir dalam cengkerang kelapa sawit konkrit agregat ringan untuk menentukan ciri-ciri mekanikalnya. Bilangan pasir yang digantikan dengan kulit kerang yang telah dihancurkan adalah berbeza iaitu 5, 10, 15, 20 %. Ujian yang telah dijalankan ke atas sampel konkrit adalah ujian kekuatan mampatan dan ujian kekuatan lenturan. Hasil daripada ujian menunjukkan bahawa penggunaan kulit kerang sebagai bahan separa pengganti pasir boleh meningkatkan kekuatan OPS konkrit aggregat ringan.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Aquaculture industries are growing in Malaysia, other than fish, prawn and crab, cockles also been profitable. According to Department of Fisheries Malaysia (2010), production of cockles by looking at it retail value has increase 33.53% by RM91.60 million in 2010 from 68.60 million in 2008. As result, tones of cockle shells are left unattended and treated as waste because cockle shell has no economic value. Leaving cockle shell at dump site to decompose will lead to environmental problems. The shells that have been dumped and untreated may cause unpleasant smell and disturbing view to the surrounding (Mohamed *et al.,* 2012) Therefore, it is wise to use cockle shells in any possible way such as using it as one of ingredient in concrete. This will reduce the use of natural materials for concrete production.

Sand is granular particles which are byproduct of erosion of rock. It has been widely used in many projects such as construction, land reclamation, coastline stabilization and even making of artificial island. High demand of sand in many projects increases the process of sand mining. Sand mining is profitable, at the same time disastrous. It should however, be recognized that processes of prospecting, extracting, concentrating, refining and transporting minerals have great potential for disrupting the natural environment (Rabie *et al.,* 1994). Massive mining of sand will give negative impact toward surrounding area. Therefore using organic materials as replacement for sand will reduce the amount of sand used in construction.

1.2 PROBLEM STATEMENT

Mass producing of cockle from cockle trade produce abundant amount of cockle shell (CS) as it byproduct. This organic compound can decompose by itself. The problem is, CS will took long period of time to decompose, while its production are never ending. Waste landfill will soon be full by CS hence illegal dumping of CS will occur. Pollution will occur if CS is not treated well. At the same time, sand mining also cause unpleasant view. Since sand demands in industries are high, the rate of sand extraction will exceed the rate of natural process of generating sand. This will bring instability to the surrounding area. Water pollution will occur and biological resource such as fish will be gone.

1.3 OBJECTIVES

The objectives of this research are as follows:

i. To determine the effect of crushed cockle shell content as partial sand replacement on the compressive strength of oil palm shell lightweight concrete.
ii. To determine the effect of crushed cockle shell content as partial sand replacement on the flexural strength of oil palm shell lightweight concrete.

1.4 SCOPE OF STUDY

This research was conducted to determine the effect of various percentage of crushed cockle shell as partial sand replacement in OPS lightweight aggregate concrete. The portions of crushed CS replacements were from 5, 10, 15 and 20%. OPS lightweight concrete with 0% of fine cockle shell will be the control specimen, where only river sands used as fine aggregate. Another type of mix, is the containing various percentage of crushed CS as partial sand replacement in OPS lightweight aggregate concrete. The cockle shells were crushed; to achieve the standard size of sand particle used in concrete. Cube is prepared to test compressive strength, while is used to

determine the flexural strength. The samples were subjected to water curing until the test date. The test date will be after curing for 7, 14 and 28 days.

1.5 SIGNIFICANT OF STUDY

This study helps us to understand more about organic waste effect, cockle shell on concrete as partial sand replacement. In addition, using cockle shell in construction will reduce the amount of waste generated by cockle at waste landfill. The reduction amount of cockle waste will reduce the pollution cause by it. Since cockle shells are used as partial sand replacement in concrete, we are able to minimize the usage of natural river sand in construction. Hence reduce the mining process of sand at riverside. Henceforth, river natural view will be undisturbed and water pollution due to sand mining can also be avoided. Environmental friendly concrete can be produced.

1.6 LAYOUT OF THESIS

In this thesis, there are five chapters which each chapter has its own function or deliveries. Chapter one consist of background of studies, which was the introduction of this study. From the background of study, it leads to the problem statement which the cause or the purposed why this study need to be conduct. Objectives of study also found in chapter one, and in this same chapter the scope of study and significance of study were stated.

Chapter two is the summary of information from previous research. Any research before that had connection with this thesis will be used as guide whether it is direct or indirectly related to my topic. Also in chapter two, information regarding to concrete, such as concrete mixing ingredient and its engineering properties will be discussed. Same goes to cockle shell, information related to cockle shell properties will also be included in this chapter.

Chapter three will focused on experimental details of oil palm shell lightweight aggregate concrete with fine cockle shell as partial sand replacement. In this chapter the preparation of materials, equipment and machinery used for casting and testing will be

illustrated. The procedure of sample testing such as compressive strength test, flexural strength test and modulus of elasticity test will be explained.

Chapter four will discuss about the result of the tests that have been done to the samples. All the recorded result will be present in this chapter in form of table, graph and also picture. Discussion will be done based on the result obtained from the previous experiment. Finally in chapter five, all the data will be summarized and conclusion will be made. Also in this chapter recommendation will also be stated.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In Malaysia, development occurs rapidly. Lot of buildings construction is made. Therefore raw materials, such as sand and granite are drastically consume. If things continue like this, raw material for construction will be depleted. Henceforth, new source of materials are needed as concrete ingredients. In looking for a new source of concrete material, engineers are looking forward using mass produced waste such as oil palm shell, palm oil fuel ash, rice husk and even byproduct from aquatic life such as cockle shell.

2.2 OIL PALM SHELL (OPS) LIGHTWEIGHT AGGREGATE CONCRETE

Oil palm shell lightweight aggregate concrete is a lightweight aggregate concrete that use oil palm shell as the lightweight aggregate. Lightweight aggregate is not a new invention in concrete technology; it has been use since ancient time (Shafigh, 2010). The fact that some of these structure are still in good condition validates the durability of concrete (Chandra and Berntsson, 2006). In year of 2010, Shafig has study about the mix design and mechanical properties of oil palm shell lightweight aggregate concrete. From his study, it found that OPS have water absorption capacity in range of 21-33%. While the density of OPS 19-20%.

2.2.1 Mixing Ingredient

The basic ingredients of OPS lightweight aggregate concrete are OPS, ordinary Portland cement (OPC), water and sand. In well-proportioned mixtures, the cement content and strength relationship is fairly constant for a particular source or one type to another (Shafigh et al., 2010). Trial and error are needed to be done in order to find the best mix design for OPS lightweight concrete. Mix design methods that apply to normal weight concrete are generally difficult to use with lightweight aggregate concrete (Shetty, 2005).

2.2.2 Mechanical Properties

Several studies proved that OPS lightweight aggregate compressive strength are in range of typical lightweight aggregate concrete. Okafor (1988) reported that the maximum compressive strength of lightweight concrete produced using this agricultural shell is approximately 25 to 35 MPa. The water to cement ratio also affect the strength of OPS lightweight concrete. By using 480 kg/m^3 cement, a free water to cement ratio of 0.41 and mix proportion of 1:1.71:0.77 by weight of cement, sand and OPS aggregate, the 28-day compressive strength of OPS concrete is between 20 and 24 MPa depending on the curing (Mannanand Ganapathy, 2001). Present of pozzolanic material and supperplasticizer also affect its compressive strength. The highest 28-day compressive strength, of about 36 MPa, was achieved by using fly ash and silica fume, a sand to cement ratio of 1.6 and a water to binder (SF+FA) ratio of 0.35 was reported elsewhere (Alengaram *et al.*, 2008).

2.3 SAND FOR CONCRETE MAKING

Sands are by product of granite which is produce naturally. It is small in size, passing through sieve 4.75mm, which makes it appropriate to become fine aggregate in concrete. Porosity of sand influences the workability of concrete. Excess water in sand will change the water cement ratio of concrete. The shape and surface area of sands

affect workability and also the cement needed in concrete. The rougher the surface the more cement will be needed to increase concrete workability.

2.3.1 Sand Consumption in Malaysia

Sand mining is large in Malaysia. The sand is mined to be distribute for construction, infrastructure industries and also for sale. In other words, sand is important mineral which bring lot of profits for miners. The real problem in sand consumption in Malaysia is the illegal sand mining which is caused by irresponsible people. A report quoted an estimate by the State government which showed that there are at least 30 illegal mining sites operating in Selangor with output capacity of up to 400,000 tonnes a month or 4.8 million tonnes a year (Malaysian insider, May, 2010). The impact of illegal mining is not just toward the economy but it also affects the environment.

2.4 COCKLE SHELL

Cockle is a common name for small and edible clamp. It is from a family of cardiidae. Usually, cockle lives in sandy, sheltered area at beach. It has round shell with almost hearted like shape. In Malaysia cockles are being breed manually by local investor as in food industries cockles are really profitable. The cockle shells are the waste of cockle which it is not edible.

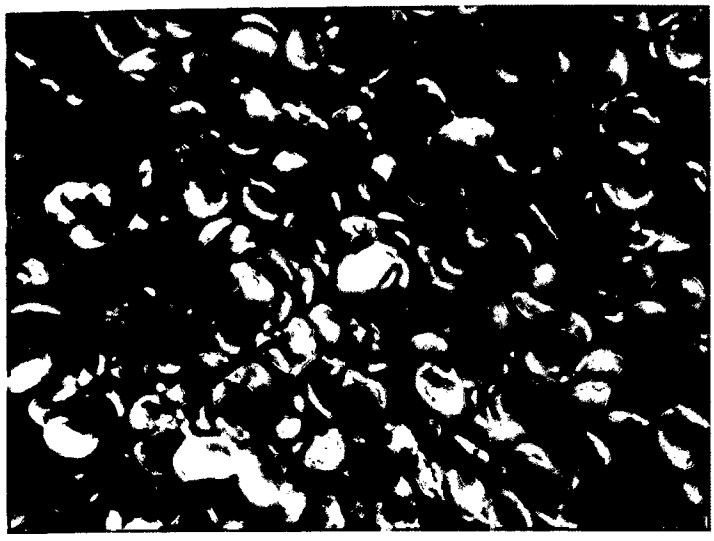

Figure 2.1: Cockle Shell

2.4.1 Properties of Cockle Shell

Cockle shell is not as hard as granite; it is far more fragile and it can be crush easily. The surface of the cockle shell is rough due to the ribs like pattern on its surface. Even though cockle shell is low in physical strength, in chemical it contain high amount of calcium. Cockle shell contain high amount of calcium (Ca) which is 98.11% compared to other mineral (Mohammad, 2010).

Table 2.1: Mineral composition of cockle shell

Minerals	Concentration (%)
Al_2O_3	0.25
CaO	98.11
TiO_2	0.13
V_2O_5	0.062
Cr_2O_3	0.04
MnO	0.022
Fe_2O_3	0.503
CuO	0.034
SrO	0.402
RuO	0.43

Source: Mohammad (2010)

2.4.2 Cockle Shell in Concrete Research

In 2004, Kim *et. al.* has done a research using cockle shell as fine aggregate. In his research he compared normal concrete without fine cockle shell and concrete with cockle shell. From his research he found out that concrete with cockle shell has higher compressive strength with 15 and 20% of cockle shell used as fine aggregate replacement.

While in year 2012, Muthusamy, has done a research regarding to potential of cockle shell as partial coarse aggregate replacement in concrete which lead to result that using cockle shells as coarse aggregate reduce the workability of fresh concrete due to shell rough surface area. However, at 20% cockle shell as coarse aggregate replacement the compressive strength of concrete increase.

Another research of cockle shell as concrete material has been done by Nor Hazurina, also in year 2012, where cockle shell ash is used as partial cement

replacement. Based on her result, the workability of concrete increase as great amount of cockle shell ash is used. Initial setting time and final setting also increase. However compressive strength at 28 days is lower if lot amount of cockle shell ash is used. According to her research, the best cockle shell replacements are at 5 and 10 %.

From the previous research it there is possibility that cockle shell will be used as partial OPS lightweight concrete ingredients. Since there research have been done to replace aggregate and cement content, I looking forward to study the effect of crush cockle as partial sand replacement.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Chapter 3 more on method for preparation and test used in this experiment. This chapter will start with the flow of methodology for this study which is the summary of methodology for this project. It will be continued by the preparation of materials, where the materials are water, cement as paste agent, superplasticizer, river sand as the fine aggregate, oil palm shell (OPS) as coarse aggregate and crushed cockle shells (CS) as partial sand replacement. Next in this chapter will discuss about samples preparation. Samples involve are cubes and beam. It will explain how the samples are made. Finally, it will follow up by explanation of testing method. Laboratory testing involve in this section is compressive strength and also flexural strength test.

3.2 METHODOLOGY FLOW

The summary of methodology flow is presented in figure 3.1. It is simplified in chart flow to give an early picture for the whole process.

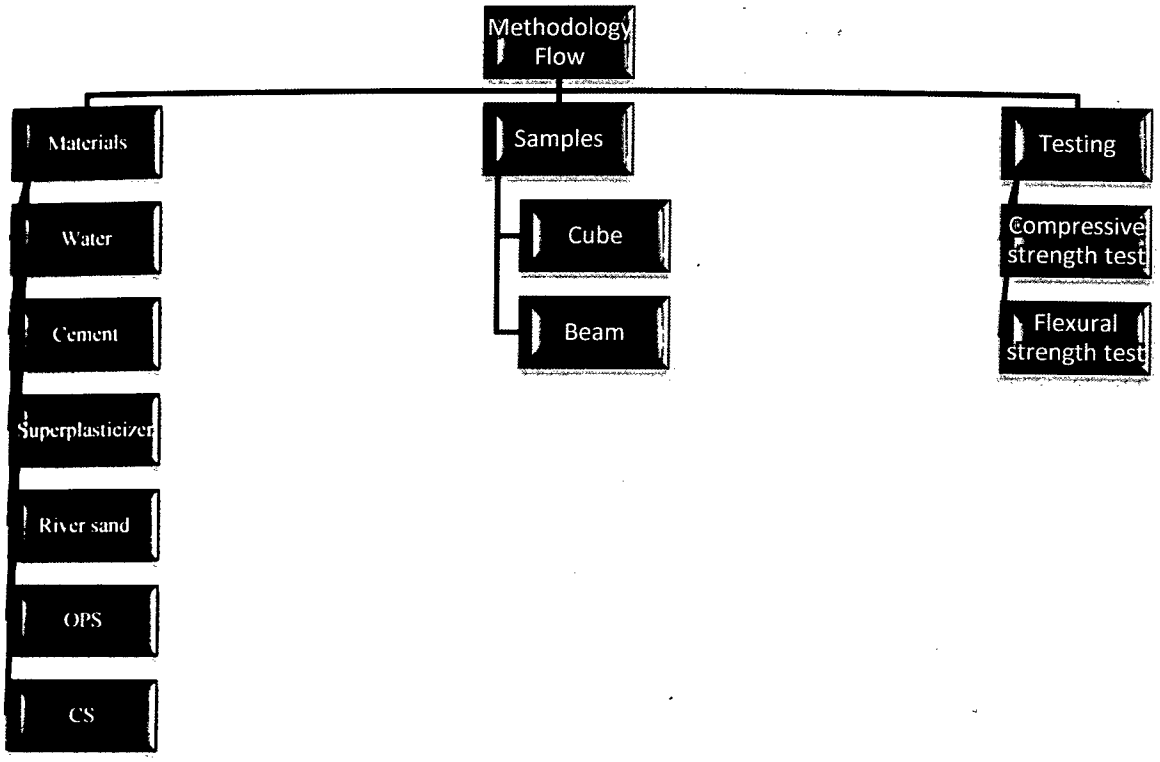

Figure 3.2: Methodology flow

3.3 MATERIALS

3.3.1 WATER

Water is essential in concrete as it allow hydration process to occur. Without water, there will be no reaction between cement and other concrete materials. Water will react with cement to produce C-S-H gel. In any mix, water use should not be contaminated. It should be in neutral state, with pH level not less or more than 7. In this research, the water use is tap water which is supply nearby concrete lab in UMP. The reason why tap water is use, are;

Easy to obtain

It is in neutral state (7pH)

Figure 3.2 shows the tap water used.

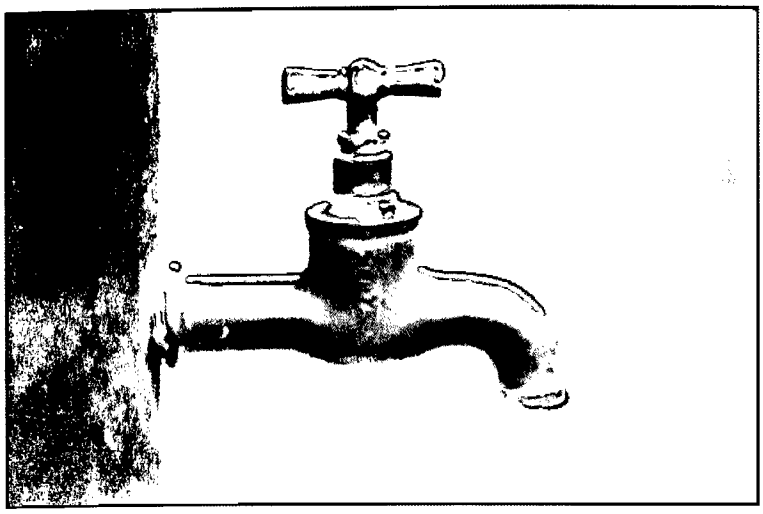

Figure 3.3: Tap water

3.3.2 Cement

In concrete, cement act as a binder. It will bind the aggregate together to become one fine solid concrete. Cement becomes a binder once it reacts with water. Immediately after cement is in contact with water, a chemical process will occur. The process is known as hydration process. In hydration process, cement and water will combine and produce substances such as lime crystal, $Ca(OH)_2$, some unhydrated cement and calcium silicate hydrate gel (C-S-H). The substance that responsible for binding all the materials is CSH gel. It will act as a paste and bond all the material to become a solid concrete.

There are lots of cement type, such as rapid hardening cement, ordinary Portland cement and so on. For this project, the cement use is the ordinary Portland cement (OPC) with grade 30. Figure 3.3 shows the OPC that used in this project.

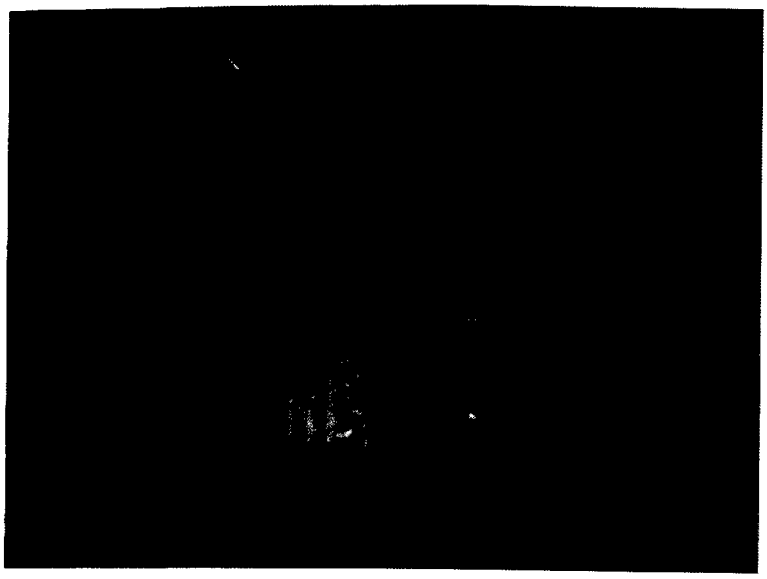

Figure 3.4: Ordinary portland cement

3.3.3 SUPERPLASTICIZER

Superplasticizer (SP) is a chemical admixture used to achieve well-dispersed particle suspension. It is to prevent segregation between aggregates of concrete to occur due to lack of water in concrete mix and at the same time improving the workability of concrete. In my research, the type of SP used is Sika ViscoCrete-2199. Only small amount of SP is use in each sample.

3.3.4 FINE AGGREGATE

Sand is used as fine aggregate in concrete. The main function of fine aggregate is to make the concrete denser. Sand is small in size, which allows it to slip through into void between coarse aggregate. The lesser the void inside concrete the denser it will be. Hence it will increase it mechanical strength and durability. River sand is used as the fine aggregate in my concrete. Figure 3.4 shows the river sand that used in my research.

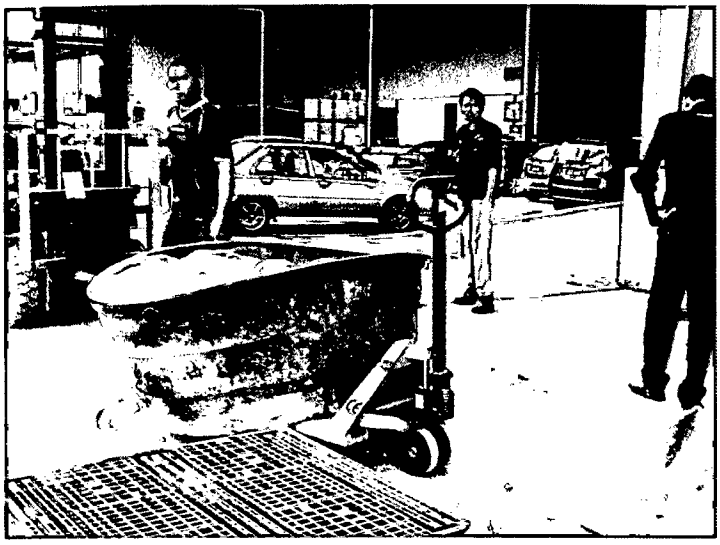

Figure 3.5: River sand

3.3.6 COARSE AGGREGATE

The lightweight aggregate used in this research is oil palm shell (OPS). The OPS is obtained from nearby oil palm factory. Figure 3.5 shows the picture of OPS in factory.

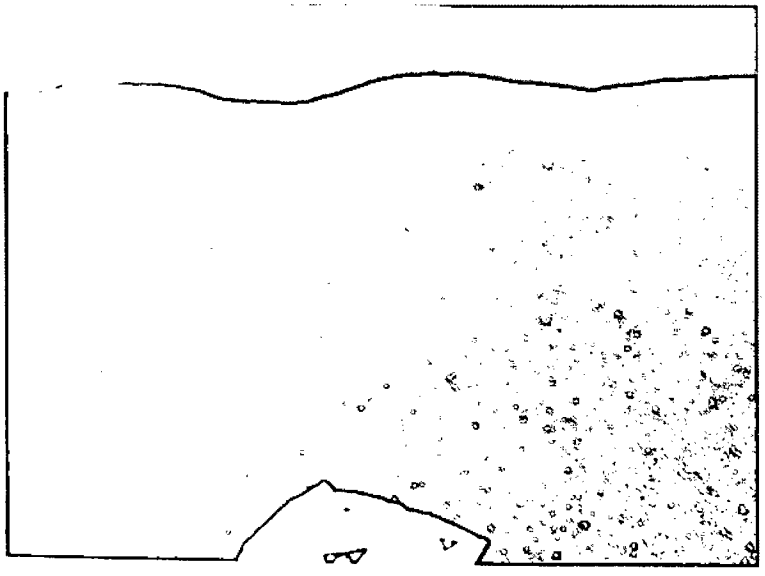

Figure 3.6: Oil palm shell