ENGINEERING PRO[illegible] [illegible]REGATE AS COARSE AGGREGATE REPLACEMENT IN CONCRETE

MOHD AL-ADHAM BIN ISMAIL

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Faculty of Civil Engineering And Earth Resources
Universiti Malaysia Pahang

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ABSTRACT

The experiment is carried out in order to investigate the properties of laterite aggregate used in producing concrete mix. Laterite aggregate is chosen because it is widely spread in tropical country like Malaysia. The aggregates, which turn up to be strongest and more durable upon exposure to repetitive sun and rain might also served as a perfect replacement for granite aggregates. The experiment was conducted in the laboratory to investigate the properties of the concrete in term of their aggregate, workability of fresh concrete and compressive strength. A total of four batches of concrete are produced, in which containing 0%, 10%, 20% and 30% laterite agggregate in concrete. In this experiment, properties of laterite aggregate are tested in term of strength,shape and surface texture. As for fresh concrete, slump, compacting factor and vebe consistometer are tested for the respective batches of the concrete mix. For hardened concrete only compressive strength is tested. All the tests have been carried out and the results had been recorded and analyzed in appropriate table and graph. The experimental results show that the strength of laterite aggregate concrete is lower than the granite aggregate concrete.

ABSTRAK

Eksperimen ini dijalankan untuk mengenalpasti sifat-sifat kelikir laterit yang digunakan dalam menghasilkan campuran konkrit. Kelikir laterit dipilih kerana taburannya meluas di negara tropika seperti Malaysia. Kelikir ini akan menjadi lebih kuat dan lasak sekiranya terdedah kepada hujan dan panas yang berterusan.dan sebagai gantian yang sesuai dengan kelikir granit. Eksperimen telah dijalankan dimakmal, untuk mengenalpasti sifat-sifat konkrit berdasarkan jenis kelikir, kebolehkerjaan konkrit dan kekuatan mampatan. Empat jenis bancuhan konkrit dihasilkan yang mana setiap bancuhan mengandungi 0%, 10%, 20% dan 30% kelikir laterit dalam konkrit. Dalam eksperimen ini, sifat-sifat kelikir laterit diuji berdasarkan kekuatan, bentuk dan permukaan tekstur. Sifat-sifat konkrit basah diuji melalui ujian runtuhan kon, ujian faktor padat dan vebe consistometer pada setiap bancuhan konkrit. Konkrit keras hanya diuji dengan ujian kekuatan mampatan. Semua ujian yang dijalankan telah direkodkan dan dianalisis dalam jadual dan graf yang sesuai. Keputusan eksperimen menunujukkan bahawa kekuatan konkrit kelikir laterit adalah lebih rendah daripada konkrit kelikir granit.

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must be appropriate in terms of physical and mechanical properties because it directly affects the characteristics in the concrete.

The focus of this project is to use laterite aggregate as a replacement of aggregate granite as coarse aggregate. Experiments on the performance of concrete using laterite aggregates to sure that alternative aggregates obey the concrete specification. Laterite stone is the potential for new sources are easily available in the tropics and subtropics. Examples of areas with laterite stone is Malacca, Johor, Johor, Kedah, Pahang and Kelantan.

1.2 Problem Statement

Our construction industry more advanced but the material for building more decreasing currently. Demand in construction material also increasing parallel to the quality of construction. Laterite stone easily available in Malaysia, thereby, the laterite aggregates can be used in lieu of granite aggregate. Previous studies shows, that the laterite aggregate suitable to replace the granite aggregates in the concrete based on physical and mechanical properties. Usually, laterite aggregates use in non-critical construction.

However, further research is needed to know the actual performance of laterite aggregate in the concrete mix strength, durability, workability and chemical reactions in the concrete mix itself. Laboratory tests should be done to know the properties of the aggregates test, fresh concrete test and hardened concrete test. The use of laterite aggregates can be a solution for decreasing of raw materials.

1.3 Importance of Study

In the construction industry, granite aggregates are significant in producing concrete. Many problems are occurring in the future when the world is in the shortage of granite aggregate. Therefore, this project carried out the important of determining the suitability of laterite aggregate to replace granite in concrete production. From many aggregates available, laterite aggregate is chosen because it is widely spread in Malaysia. Besides that, the engineering properties of this aggregate is merely the same as granite, therefore it is seemingly to act as a replacement material for granite.This project also important in providing necessary information on laterite aggregate concrete.

In order to ensure that laterite aggregate can be a replacement material for granite aggregate, a series of lab test need to be carried out for the fresh and hardening concrete in obtaining necessary data for analysis. After analyzed the results, then only a conclusion can be drawn whether it is possible to replace granite aggregate with laterite aggregate in concrete production.

1.4 Objectives of Study

The main objectives of this study are;

i. To determine the properties of laterite aggregate in term of strength, shape and surface texture.

ii. To determine the workability of fresh concrete containing 10%, 20% and 30% of laterite aggregate.

iii. To determine the compressive strength of hardened concrete containing 10%, 20% and 30% of laterite aggregate at age 7, 14 and 28 days.

1.5 Scope of Study

In this experimental study, properties of laterite aggregate and mechanical properties of concrete containing different laterite aggregate as course aggregate replacement in term of compressive strength was tested. Hence the workability of fresh concrete with different percentage of laterite aggregate was examined.

The laterite stone was collected from Rantau Panjang,Kelantan and was crush to 20 mm in size by using jaw crusher at Concrete Laboratory, Universiti Malaysia Pahang (UMP). The properties of laterite aggregate were observed in term of strength, shape and surface texture while the mechanical properties of concrete was tested in term of workability and strength of laterite aggregate concrete.

Four different mix proportion of concrete containing of 0%, 10%, 20% and 30% of laterite aggregate was designated as Sample A, Sample B, Sample C and Sample D respectively. Concrete was designed for grade 30 N/mm^2 with a water cement ratio (w/c) of 0.57 was considered. Table 1.1 showed the concrete mix design for 0.0333 m^3. Design form for concrete mix design attached at Appendix B.

The workability of fresh concrete was examined through slump test, vebe consistometer test and compacting factor test. A total of 36 of cubes mould with size of 150 mm x 150 mm x 150 mm were prepared. All samples are water cured and were tested at age 7, 14 and 28 days. Table 1.2 showed all the standard and specifications for corresponding test.

Table 1.1: Concrete Mix Design

Designated Sample	Cement (kg)	Water (L)	Fine Aggregate (kg)	Coarse Aggregate (kg)	
				Laterite	Granite
Sample A	13.32	7.50	27.60	0.00	31.08
Sample B	13.32	7.50	27.60	3.11	27.97
Sample C	13.32	7.50	27.60	6.22	24.86
Sample D	13.32	7.50	27.60	9.32	21.76

Table 1.2: Standard and Specification Test

Testing	Standard and Specifications
Sieve Analysis	BS 882: 1983
Aggregate Impact Value	BS 812: Part 3
Aggregate Crushing Value	BS 812: Part 3
Slump Test	BS 1881: Part 102:1983
Compaction Factor Test	BS 1881: Part 103: 1983
Vebe Consistometer	BS 1881:Part 104: 1983
Concrete Compression Test	BS 1881: Part 116: 1983

CHAPTER 2

LITERATURE REVIEW

2.1 General

Concrete have been used widely in construction industry ever since it is introduced to the construction world. Generally, concrete is a construction material produced by the reaction between raw materials which includes of cement , coarse aggregates, fine aggregates, water and sometimes in the presence of admixture in a certain proportion. This section of writing was focus on the aggregate and its importance in concrete, definition and properties of laterite aggregates

2.2 Aggregates

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. 60-70 percent of total volume of concrete is from aggregates.

Portland Cement Association (2011) shows aggregates can be divided into two distinct categories fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch (9.5-mm) sieve. Coarse aggregates are any particles greater than 0.19 inch (4.75 mm), but generally range between 3/8 and 1.5 inches (9.5 mm to 37.5 mm) in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

2.3 Importance of Aggregate in Concrete

Aggregate is of significant importance in concrete. Being the cheapest and biggest portion of raw material in concrete, coarse aggregates contributes to the strength of concrete whereas fine aggregates help to fill up all possible voids among the coarse aggregates. It wills creates interlocking structure between the raw materials, holding them together and upon undergo the hydration process of portland cement, resulting in a denser concrete, which means higher compressive strength.

In fact, using aggregate makes concrete much stronger, with the aggregate acting as a type of reinforcement. The aggregate increases the lifetime of the concrete, and makes it more durable. In order for aggregate to be effective, it must be strong. Weak aggregate materials will weaken the resulting concrete, which is not desirable. Aggregate must also be hard, so that it keeps its shape without deforming in the concrete. Finally, it must be clean, which in the construction sense means that it is free of chemicals, clays, and various leached materials which could interact with the concrete and interfere with the way it sets.(Smith, 2011)

2.4 Fresh Concrete

Fresh concrete is a material with continuously changing properties. It is mean, that the concrete can be handled, transported, placed , compacted and finished to form a homogenous, usually void- free, solid mass that realizes the full potential hardened concrete.(Newman & Choo, 2003)

2.4.1 Workability

Workability means how easy it the concrete to place, handle, compact and finish a concrete mix. Concrete that is stiff or dry may be difficult to handle, place, compact and finish and, if not constructed properly, will not be as strong or durable when finally hardened.

2.4.1.1 Slump Test

The slump test is the familiar test and widely used test method to characterize the workability of fresh concrete. Usually, used on job sites to determine rapidly whether a concrete batch should be accepted or rejected. Four types of slumps are commonly encountered, as shown in Figure 2.1.

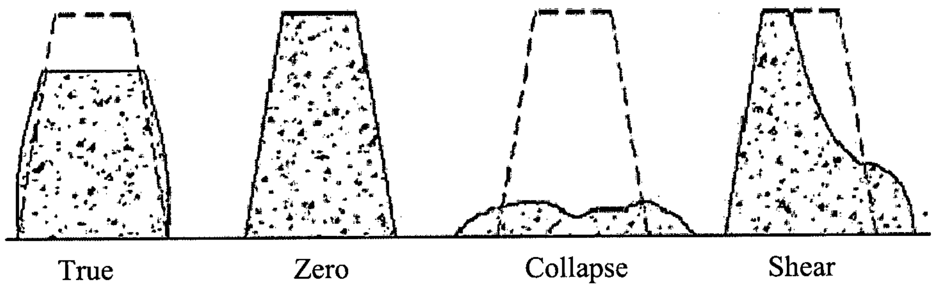

Figure 2.1: Four Types of Slump (Koehlar & Fowler, 2003)

A true slump remains the concrete intact and retains a symmetric shape. A zero slump and a collapsed slump are both outside range of workability that can be measured with the slump test. A concrete that showed a shear slump is not sufficiently cohesive and should be rejected. (Koehlar & Fowler, 2003)

2.4.1.2 Compacting Factor Test

The compacting test is to measures the amount of work (height of fall) on compaction. The compaction factor is defined as the ratio of the mass of the concrete compacted in the compaction factor apparatus to the mass of fully compacted concrete. This test gives more information about compatibility than the slump test. The test also is a dynamic test and thus is more appropriate than static tests for highly thixoptropic concrete mixtures. Therefore, there are still have the disadvantages in this test, which are the large and bulky nature of the devices reduces its usefulness in the field. Further, the test method requires a balance to measures the mass of the concrete in the cylinder. (Koehlar & Fowler, 2003)

2.4.1.3 Vebe Consistometer

The vebe consistometer measures the remolding ability of concrete under vibration. The test results reflect the amount of energy required to remold a quantity of concrete under vibration conditions. The vebe consistometer is applicable to concrete with slumps less than ±50mm or 2 inches. The vebe consistometer is a dynamic test and can be used on concretes that are too dry for the slump test. The test device is standardized in ASTM identified by ACI Committee 211 (2002) in its guide for proportioning low slump concrete and the results are obtained directly. (Koehlar & Fowler, 2003)

2.5 Definition of Laterite

Laterite is a residual ferruginous rock, commonly found in tropical regions and has close genetic association with bauxite. The term'laterite' was originally used for highly ferruginous deposits first observed in Malabar Region of coastal Kerala and Dakshin Kannad and other parts of Karnataka. It is a highly weathered material, rich in secondary oxides of iron, aluminium or both. It is either hard or capable of hardening on exposure to moisture and drying.

Schellmann (1981) defined laterite are products of intense sub aerial weathering whose Fe and/or Al content is higher and Si content is lower than in merely kaolinised parent rocks. They consist predominantly of mineral assemblages of goethite, hematite, aluminum hydroxides, kaolinite minerals and quartz. He considered that the $SiO_2/(Al_2O_3+Fe_2O_3)$ ratio of 'laterite' must be lower than that of kaolinised parent rock, in which all of the alumina of the parent rock is present in the form of kaolinite, all the iron in the form of iron oxides, and which contains no more silica than is fixed in the kaolinite, plus the primary quartz.

Bishopp (1937) define that laterite is process of rock degradation which may stop short at the formation of the hydrated silicates—clays or lithomarges—or continue right on to hydrate according to chemical and physical environment and nature of the parent rock. Harrison's studies of deposits in British Guiana show that lithomarge and bauxite are associated with each other in all possible proportions, with or without the hydrates iron (which does not appear to pass through a secondary hydrated silicate or "kaolin" stage), and free silica, which on one occasion has been recorded in the form of tridymite. These substances are mixed in all degrees, and can only be distinguished by laboratory tests. The point which decides whether one of such rocks should be classed as a laterite or a lithomarge seems to be quite arbitrary, unless it is agreed that a laterite should contain an excess of hydrates over hydrated silicates.

2.5.1 Laterite Formation

Laterite are the products of intensive and long lasting tropical rock weathering which is intensified by high rainfall and elevated temperatures . Formation of most of the laterite started in the Tertiary. For a proper understanding of laterite formation we must focus on the chemical reactions between the rocks exposed at the surface and the infiltrated rain water. These reactions are above all controlled by the mineral composition of the rocks and their physical properties (cleavage, porosity) which favor the access of water. The second relevant factor for the formation of laterite are the properties of the reacting water (dissolved constituents, temperature, acidity pH, redox potential Eh) which are themselves controlled by the climate, vegetation and the morphology of the landscape.

Tropical and subtropical areas show generally a rather high annual precipitation but its temporal distribution varies strongly from countries with pronounced and long lasting dry seasons to equatorial areas with a more continuous precipitation. Chemical weathering slows down in dry seasons at least above the fluctuating water table. Aqueous dissolution of minerals proceeds when a chemical equilibrium is not arrived i.e. when the dissolved constituents are removed in the water. The chemical reactions are further controlled by the activity of water which is equal to one in freely moving water but lowered within small pores in the soil. Stability and reaction rate vary from mineral to mineral; e.g. quartz is more stable than feldspar. Minerals of the same species e.g. kaolinite can show different crystallinity which equally controls their stability. Strongest alteration proceeds at the surface of the parent rock whereas it is lower in the regolith above the rock. (Schellmann, 1991).

2.5.2 Properties of Laterite Aggregate

The mean value of selected physical properties of laterite aggregates are presented in Table 2.1. The highly indurate gravels which are characterised by high contents of iron oxides and low amounts of quartz and kaolinite, have high specific gravity, bulk density and impact strength but lower values of absorption(total pore space). In general the values of the physical properties reflect the strong influence of iron oxide content The physical quality of the aggregate improves as the content of iron oxide increases. This should be expected because higher iron content means greater degree of cementation and indurations. (Akpokodje & Hudec, 1992)

Table 2.1: Mean Values of Selected Physical Properties of the Laterite Aggregates Samples (Akpokodje & Hudec, 1992)

Sample	Specific gravity	Absorption (%)	Microp /Macrop vol.	Agg.Imp. Value (dry) (%)	Agg.Imp. Value (wet) (%)	Abrasion (%)
Ngho	3.472	4.654	0.888	30.000	23.328	3.625
Jos	3.451	3.263	0.404	29.717	28.320	5.182
Nsukka	3.471	5.183	0.214	24.295	25.215	3.650
Enugu	4.424	4.892	0.285	31.250	33.565	7.654
Wadil	3.314	3.951	0.356	35.100	36.450	8.590
Bukana	3.108	7.573	0.151	40.576	44.170	16.334
Horin	3. 120	8.758	0.147	43.859	48.875	18.978
Maiduguru	2.972	7.763	0.166	41.950	45.210	16.950
Okene	3.101	6.554	0.195	38.855	43.442	16.255
Damaturu	2.951	8.579	0.138	42.758	47.955	19.10
Granite	2.780	0.518	2.456	17.600	19.150	-

Note: Microp/Macrop vol: Ratio of micro pore volume.

2.5.3 Laterite Aggregate Concrete

In general, laterite can be considered as a material, highly weathered, rich in secondary oxides of iron, aluminum or both. The necessary characteristic of the material according to Alexander and Cady is that it is either hard or is capable of becoming hard upon exposure to alternate wetting and drying. According to Maignien, laterite is sesquioxide rich, highly weathered, clayey material that changes irreversibly to concretions, hard pans or crusts, when dehydrated and the hardened relics of such material mixes with entrapped quartz and other diluents.

Raju and Ramakrishan (1972) conducted several mixes of laterite aggregate concrete were made with varying water cement and aggregate-cement ratios to study the properties like workability, compressive, flexural, tensile strength and Modulus of elasticity. The tests indicate that the workability decreases with increasing aggregate-water ratio. The compressive strength of laterite aggregate concrete is considerably lower than crushed granite aggregate concrete for the range of aggregate and water cement ratio.

CHAPTER 3

METHODOLOGY

3.1 General

This chapter were discuss in detail the procedure in carrying out the experimental work and laboratory test to achieve the objective as set in this project. There are a variety of testing to be carried out in this project. These test ranges from aggregates testing such as sieve analysis, aggregate impact value (AIV), aggregate crushing value (ACV) and fresh concrete testing such as slump test, compacting factor test, vebe consistometer test and for hardened concrete testing such as compressive strength test.

3.2 Methodology Chart

The experimental process-flow for laterite aggregate concrete was outline in Figure 3.1.

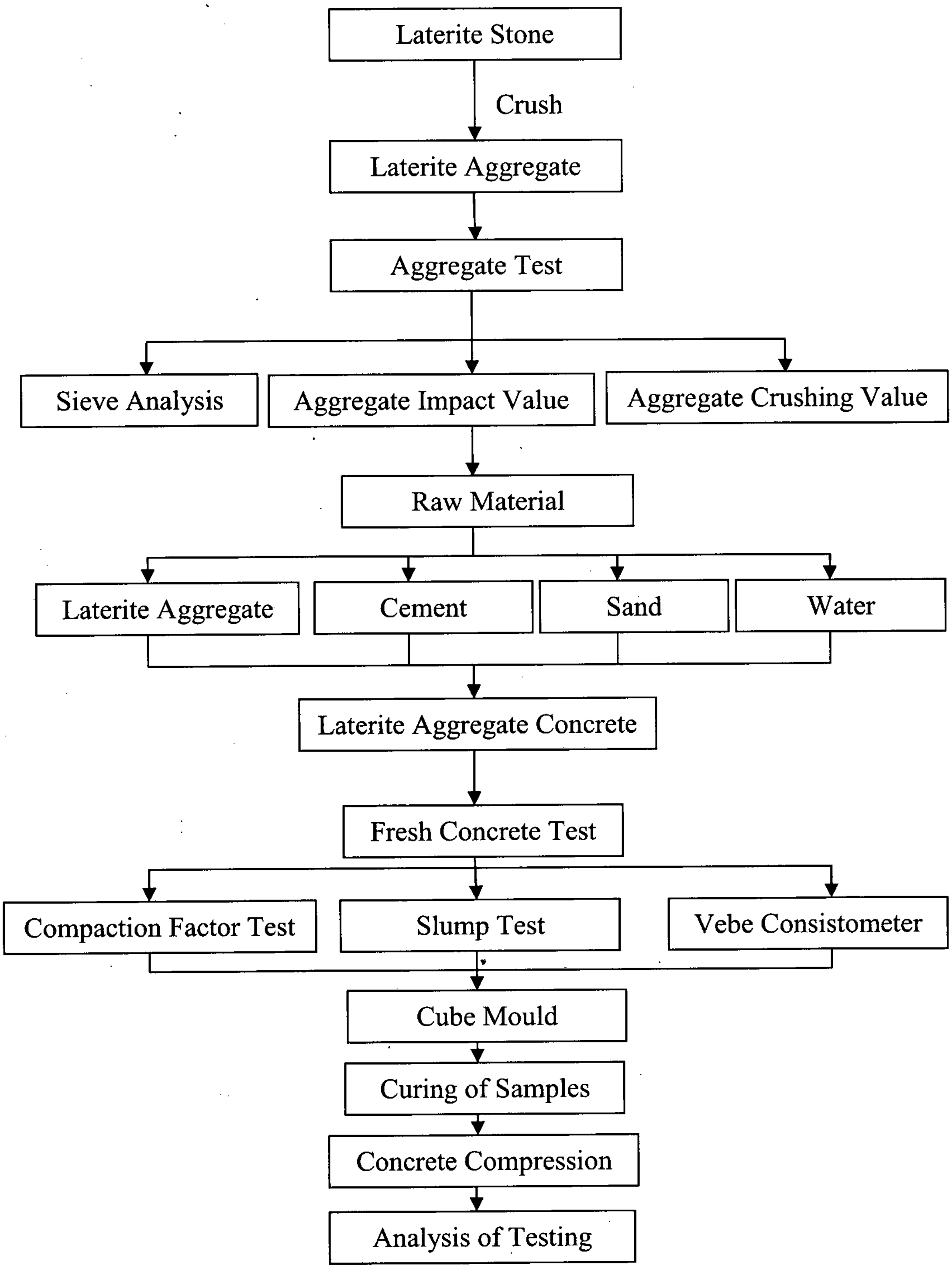

Figure 3.1: Overall Flow of Work

3.3 Preparation of Laterite Aggregate

In this experiments, the laterite stone samples were taken from Rantau Panjang,Kelantan. The laterite stone was been crush using jaw crusher and 20 kg of laterite aggregates was prepared. Figure 3.2 and Figure 3.3 showed the laterite stone and jaw crusher.

Figure 3.2: Laterite Stone

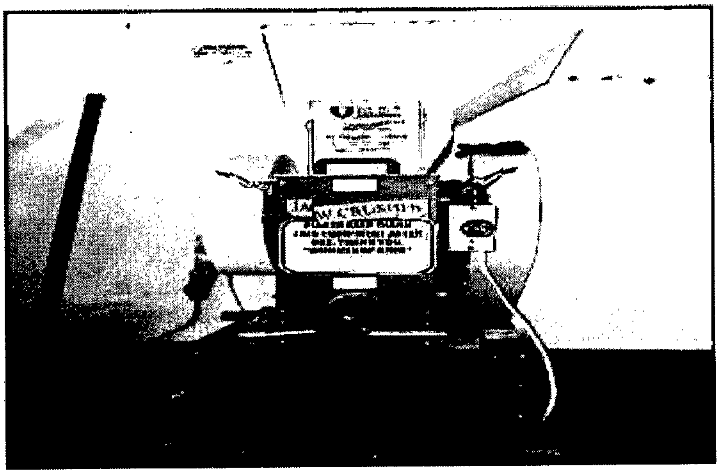

Figure 3.3: Jaw Crusher

3.4 Aggregate Test

In this experiment, the methods to be carried out are through laboratory tests. The types of testing to be carried out on the aggregate are as follows:-

i. Sieve analysis test
ii. Aggregate impact value test
iii. Aggregate crushing value test

3.4.1 Sieve Analysis Test

The particle size distribution of the coarse and fine aggregates is determined by sieve analysis. It is customary for aggregates for concrete to be continuously graded from their maximum size down to the size of cement grain, since this ensures that all voids between larger particles are filled without an excess of fine material In this research, the aggregate size required is 20 mm. In the grading process, the coarse aggregate was sieved using a sieve size 20 mm, 14 mm, 10 mm, 5 mm and 2.36 mm (BS 882: 1983).

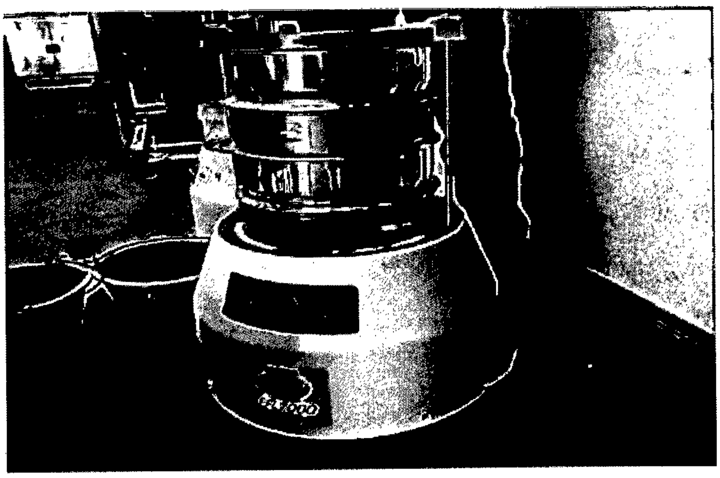

Figure 3.4: Sieve Apparatus