INVESTIGATION INTO THE GEOTECHNICAL PROPERTIES OF FINE AND COARSE AGGREGATE

BY

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SUBMITTED TO

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DECLARATION

I **Saka Ahmed Ayomide** do declare that this project work tilted "**Investigation into the geotechnical properties of fine and coarse aggregate**" is my original work and to the best of my knowledge, it has not been submitted for any degree award in any institution. All information used and their sources have been duly acknowledged in the test and in the list of reference provided.

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ND/23/CEC/FT/ 0025   ***DATE***

CERTIFICATION

This is to certify that this research study was conducted by **Saka Ahmed Ayomide** with matric no. **ND/23/CEC/FT/0025** and had been read and approved as meeting the requirement for the award of National Diploma (ND) in Civil Engineering of the Department of Civil Engineering Institute of Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

I dedicate my research work to God Almighty for his guiding, protecting and unending grace upon my life all through my period of study.

ACKNOWLEDGEMENT

The success and final outcome of this project required a lot of guidance and assistance from many people and I am extremely privileged to have got this all along the completion of my project. All I have done is only due to such supervision and assistance and I would not forget to thank them.

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I wish to acknowledge the cooperation of my colleagues, and friends for the support, guidance, assisting during planning and development of this research work.

Importantly I'm really very much indebted to my parent in person of Mr. & Mrs. Saka for their undeniable love, support and encouragement all through the year spent as an under graduate.

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ABSTRACT

The problems of poor construction and collapse of building has really become a matter of concern in the construction industry today. The reason for the increase is due to the fact that quality control of engineering materials is not ascertain during construction works. Various tests of construction materials; fine and coarse aggregate was carried out in this project according to relevant standards. The methodologies used can be adopted for a relevant construction work to obtain a desired results.

CHAPTER ONE

1.1 INTRODUCTION

Many materials are used in construction industries; concrete is one of such material. This is because the constituent's material of concrete is mainly obtained. Concrete is the world most consumed man-made material (Naik, 2008).

Generally, concrete consist of cement, coarse aggregate and fine aggregate. Their proportion in the concrete is based on grade of concrete and it determines the strength also. Nowadays, use of this resources in the construction industry is very high. (Seetharam, 2008)

Its great versatility and relative economic in filling wide range of need has made it a competitive building material (Sashidaidar *et al.,* 2010). Concrete production is not only a valuable source of societal development, but it is also significant source of employment (Walk, 2008)

Production of concrete relies to a large extent on the availability of cement, sand and coarse aggregate such as granite. The cost of which have risen astronomically over the past years, despite the risen cost of production, the demand for concrete is increasing. The negative consequence of the increasing demand for concrete includes depletion of aggregate deposited, environmental degradation and economical imbalance. The possibility of complete depletion of aggregate resources in the near future can therefore not be over emphasized. (Short *et al*, 1978)

1.2 STATEMENT OF THE PROBLEM

Poor engineering works are due to lack of quality control of engineering materials on the site this can result into mismanagement of materials, collapse of buildings and poor constructions.

1.3 AIM AND OBJECTIVES OF THE STUDY

The main aim of the study is to investigate into the geotechnical properties of fine and coarse aggregate with following objectives;

1. To determine the properties of fine aggregate.
2. To determine the properties of coarse aggregate.

1.4 JUSTIFICATION OF THE STUDY

The need for quality control of engineering materials is important so as to ascertain the compliance to standard in the construction industry, hence the reason for the project work.

1.5 SCOPE OF STUDY

This project work is limited to investigation into the geotechnical properties of fine and coarse aggregate.

1.6 METHODOLOGY

The method that was adopted to achieve the aim and objectives of the project work are as follows:

1. Procurement of the materials needed such as fine aggregate (sharp sand) and coarse aggregates (granite),
2. Batching of the materials.
3. Laboratory tests on the fine and coarse aggregate.

CHAPTER TWO

2.1 LITERATURE REVIEW

According to Allen (2013), he describes concrete to be a composite material composed of fine and coarse aggregate bonded together with fluid cement (cement paste) that hardens (cures) overtime.

2.2 PREPARATION OF AGGREGATES

Aggregates constitute the major component in concrete therefore determination of their properties is very important. Important aggregate properties are:

2.2.1 AGGREGATE COMPOSITION

This is the material that constitutes the aggregate. Materials that can react with alkalis in cement are not to be used. Materials which expand excessively crack or cause the deterioration of the concrete mix are not to be used.

2.2.2 AGGREGATE SIZE, SHAPE AND TEXTURE

The size and shape of the aggregate has a great influence on the quantity of cement in the concrete mix. Therefore, aggregates sizes and shape is a major contributor to the economic aspect of the concrete mix.

Larger aggregate sizes are more economical to use but also the specification standards have to be adhered to in order to determine the most appropriate size. Rough textured, angular, and elongated aggregates require more water to produce workable concrete than smooth compact aggregates. Consequently the cement quantity must also be increased to maintain the cement water ratio. The shape and surface texture of aggregates influence to some extent of strength of concrete, more so, the flexural strength. It is because they both influence the bonding between the aggregate and the cement paste. A rougher texture surface such as those of crushed particles results in greater adhesion between the particles in the cement matrix. Smooth surfaced particles have very poor bond which gives concrete of lower strength which are unsatisfactory.

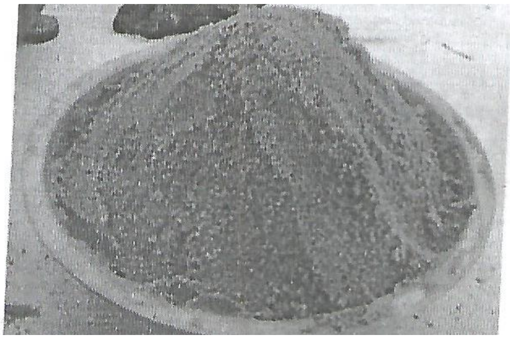

Plate 2.1(a) Fine Aggregate

Plate 2.1(b) Coarse

2.2.3 THE SPECIFIC GRAVITY

It is mean to decide the suitability of the aggregate. Low specific gravity generally indicates porous, weak and absorptive materials, where as high specific gravity indicates materials of good quality specific gravity of major aggregates fall within the range of 2.6 to 2.9 specific gravity values are also used while designing concrete mix.

2.2.4 MOISTURE CONTENT

It is very important when developing the water/cement ratio. All aggregate contain some moisture depending on their porosity and moisture content by the storage environment. There are different moisture states that are relevant in getting the aggregate moisture content but two of these are;

- The sun/oven dried
- The saturated surface dried

These are used in calculating the moisture content. In order to know the amount of water the aggregates will either add or subtract from the cement paste, absorption and surface moisture need to be calculated.

2.2.5 BULK DENSITY

Measures the volume of graded aggregates will occupy in concrete and the voids in between them. The weight of the aggregate is dependent on the moisture content of the aggregates so the moisture content need be determined and it is done through oven dried aggregates. Bulk density helps in the volume method of mixture proportioning.

2.2.6 GRADING AND SIEVE ANALYSIS

Sieve analysis determines the distribution of aggregate particles by size, within a given sample. It is a gradation of a text (AASHTOT27). It is done to conform to design production, control, requirements and specifications required. A known weight of material is placed upon the top of a group of sieves with the top sieve having the largest screen openings and the screen opening sizes decreases with each sieve down to the bottom sieve which has the smallest opening size screen for the type of material specified (Openings diameter specified in the BS 410:1976) and shaken by mechanical means for a period of time. After shaking the material through the sieves, the material retained on each of the sieve which is weighed. The cumulative method requires that each sieve beginning at the top be placed in a previously weighed pan (known as the tare weight) weighed the next sieves contents added to the pan and the total weighed. This is repeated until all sieves and the bottom pan have been added and weighed. The results of sieve analysis are represented graphically in charts known as grading curves/charts. By using these charts, it is possible to see at a glance if the grading of a given sample confirms to that specified or it is too fine or coarse or deficient on a particular size. In the curves, the ordinates represent cumulative percentages passing and the abscissa the sieve sizes plotted in algorithm scale.

2.3 DESIGN OF CONCRETE MIXES

This is the process of selecting the correct proportions of cement, fine and coarse aggregate, water and sometimes admixtures to produce concrete having the properties specified and desired i.e workability compressive density and durability requirements by means of specifying the minimum or maximum water/cement ratio.

2.3.1 PRINCIPLES OF DESIGN STRENGTH MARGIN

Due to variability of concrete strength the mix must be designed to have higher mean strengths than the characteristic strength. The difference between the two is the margin. The margin is based on the variability of concrete strengths from previous production date expressed as a standard deviation.

2.3.2 WORKABILITY

The workability of the concrete mix was determined by the slump test which is more appropriate for higher workability mixes free water.

The total water in a concrete mix consists of water absorbed by the aggregate to bring it to standard surface dry condition and the free water available for hydration of cement and for the workability of the fresh concrete. The workability of fresh concrete depends on a large extent on its free-water content .In practice, aggregate are often wet and they contain both absorbed water and free surface water so that the water added to the mixer is less than the free- water content. The strength of concrete is relatively to the free- water/cement ratio since on this basis, the strength of concrete does not depend on the absorption characteristics of the aggregates.

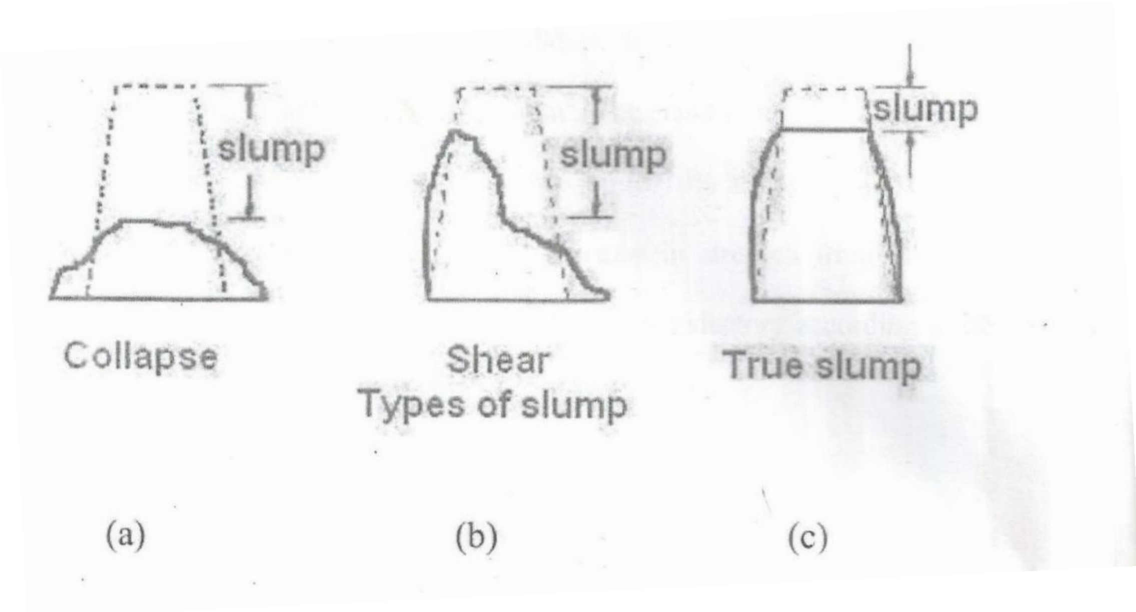

Figure 4 (a) Collapse Slump

Figure 4 (b) Shear Slump

Figure 4 (c) True Slump

2.3.3 TYPES OF AGGREGATES

Two characteristics of aggregates particles that affect the properties of concrete core particle shape and surface texture. Particle shape affects work ability of the concrete and the surface texture affects the band between the cement matrix and the aggregate particles and thus the strength of concrete, two types of aggregates are considered for design in this base.

1. Crushed aggregate
2. Uncrushed aggregate

2.3.4 AGGREGATE GRADING

The design of the mixes must comply with specific grading curves of the aggregates. The curves of fine aggregates must comply with grading zone of Bs 882.

2.4 MIX PARAMETERS

The approach adopted for specifying mix parameters will be with reference - the weights of materials in a unit volume of fully compacted concrete. This approach will require the knowledge of expected density of fresh concrete which depends primarily on the relative density of the aggregate and the water content of the mix. This method will result in the mix being specified in terms of the weights in kilograms of different materials required to produce $1m^3$ of finished concrete.

2.4.1 STAGES IN MIX DESIGN

STAGE 1: Selection of target water/cement (w/c) ratio

STAGE 2: Selection of free water content

STAGE 3: Determination of cement content

STAGE 4: Determination of total aggregate content

STAGE 5: Selection of fine and coarse aggregate content

STAGE 6: Mix proportioning

2.4.2 BATCHING OF CONCRETE MATERIALS

Following the mix design process, concrete materials cement, fine and coarse aggregates) should be prepared early enough before the concrete works begins. This allows the smooth running of the projects batching of materials was done by weight basis. The advantage of weight method is that bulking of aggregates (especially fine aggregates) does not affect the proportioning of materials by weight unlike batching by volume method. Bulking of sand results in a smaller weight of 5 and occupying a fixed volume of measuring container thus the resulting mix becomes deficient in sand and appears stony and the concrete may be prone to segregation and honey combing concrete yield may be reduced.

Batching of concrete materials by weight is exposed as follows;

Wt. (c) tWt. (CA) tWt. (FA) tWt. (Air) = Wt. (CC)

Where;

Wt. (C) = Weight of cement

Wt. (CA) = Weight of coarse aggregate

Wt. (FA) = Weight of fine aggregate

Wt. (Air) = Weight of entrained air

Wt. (CC) = Weight of compacted concrete

2.5 CONCRETE MIX DESIGN

Mix design by weight was used to proportion the constituent material using a mix ratio of 1:2:4. The mass of each constituent was determined relatively to the mass of cement required in the mix using absolute equation as shown in Eqn 1.0

Eqn 1.0

2.6 DETERMINATION OF QUANTITY OF MATERIALS USED

Normal mix ratio 1:2:4 was used

No of steel mould = 3   water/cement ratio =0.5

Relative density of fine aggregate = 2500kg/m^3

Relative density of coarse aggregate = 2600kg/m^3

Relative density of cement = 3150kg/m^3

Relative density of water = 1000kg/m^3

Shrinkage value = 1.3

Mass

Mass of cement = c

Mass of water = 0.5c

Mass of fine aggregate = 2c

Mass of coarse aggregate = 4c

$$\frac{(\text{Mass})}{\text{Volume}} = 1m^3$$

$$\frac{0.5c}{1000} + \frac{c}{3150} + \frac{2c}{2500} + \frac{4c}{2600} = 1m^3$$

$0.0005c + 0.0003175c + 0.0008c + 0.001538c = 1m^3$

$0.0031555c = 1m^3$

C = 1/0.0031555

C = 316.9kg/m^3

Cement = 316kg/m^3

Fine aggregate = 2 x 316.9 = 633.8kg/m^3

Coarse aggregate = 4 x 316.9 = 1,267.6kg/m^3

Water = 0.5 x 316.9 = 158.45kg/m^3

Volume of steel mould $\frac{150}{1000} = 0.15m^3 \times 3 = 0.003375 \times 3 = 0.010125m^3$

Add shrinkage and wastage value.

Shrinkage volume = 1.3 x 0.010125m^3

Total volume of mould = 0.0131625m^3

Mass of cement = 316.9 x 0.0131625 = 4.171kg

Mass of fine aggregate = 633.8 x 0.0131625 = 8.342kg

Mass of coarse aggregate = 1,267.6 x 0.0131625 = 16.684kg

Mass of water = 158.45 x 0.0131625 = 2.085kg

For 9 cubes

Mass of cement = 3 x 4.171 = 12.513kg

Mass of fine aggregate = 3 x 8.342 = 25.026kg

Mass of coarse aggregate = 3 x 16.684 = 50.052kg

Mass of water = 3 x 2.085 = 6.255kg

CHAPTER THREE

3.1 METHODOLOGY

3.2 LABORATORY TESTS OF THE PROPERTIES OF AGGREGATES

3.2.1 PARTICLE SIZE DISTRIBUTION

Grading is the arrangement of the proportion of the different particles in aggregate found by sieving. The sieves used should confirm to BS 410 or BS En 933 - 2. The tests were carried out in accordance with the procedure given in BS 312 or BS EN 933 - 1. An aggregate containing a high proportion of large particles is referred to as being "coarsely" graded and one containing a high proportion of small particles as "finely" graded.

3.2.2 OBJECTIVES

- To determine the particle size distribution of the given aggregate
- To draw the various grading curve of the given aggregates

3.2.3 APPARATUS

- Test Sieves
- Data sheet for recording results

The sizes of the different sieves used were 37.5mm, 20mm, 15mm, 10mm and 4.75mm.

3.2.4 PROCEDURE

The test sieves specified above were arranged from top to bottom in order of decreasing aperture sizes with pen and lid to form a sieving column. The aggregate sample when poured into the sieving column and thoroughly shake manually.

The sieves were removed one by one starting with the largest at aperture sizes and each sieve shaken manually ensuring that no material is lost. All the material which passed each sieved was returned into the column before continuing with the operation with that sieve.

The retained material on the sieve with the largest aperture size was weighed and its weight recorded with its corresponding sieve size. The same operation was carried out for successive sieve in the column and their weights recorded. The screened material that remained in the pan was weighed and its weight was recorded.

3.2.5 CALCULATIONS

1. The ironous masses were recorded in the test data sheet
2. The mass that retained on each sieve was expressed as a percentage of the original dry mass.
3. The cumulative percentage of the original dry mass passing each sieve down to the smallest aperture size was calculated.

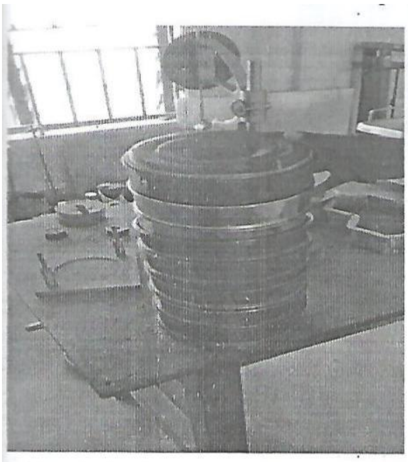

Plate 3.2 (a) Sieve arrangement

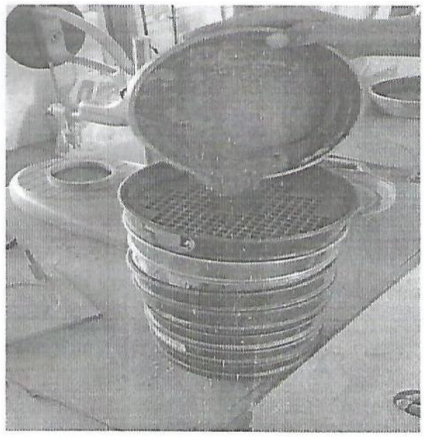

Plate 3.2(b) Fine aggregate sieve analysis

3.2.6 BULK DENSITY

Bulk density is the mass of the particles of the aggregate divided by the total volume they occupy.

3.2.7 OBJECTIVE

- To determine the bulk density and percentage of voids.

3.2.8 APPARATUS

- A container that was smooth inside water tight, rigid enough to retain the form under rough conditions and the protected against corrosion.
- Balance accurate to 50g and of adequate capacity.
- Steel rod of 16mm diameter by 600mm long and rounded at one end.

3.2.9 PROCEDURE

The container uses filled with water to the brim and the mass of the water was determined. The container was fill about one third full with aggregate being discharged as near as possible above the top of the container. Compacting blows, 25 where then given by allowing a tamping steel rod to full freely from a height of 50mm above the surface of the aggregate. With the blows airy evenly distributed over the surface. A further two similar quantities of aggregates was added in the same manner to fill the container. The container was filled to oven-flow and the tamping rod was rolled across and in contact with the top of the container to obtain a smooth surface that flush with the top.

3.2.10 CALCULATIONS

The mass of the aggregate in the container was then determined and the bulk density calculated using the calibrated volume. The bulk density of the aggregate was calculated as the mass of the aggregate over the mass of equal volume of water.

Bulk Density = mass of aggregate/mass of an equal volume of water

3.2.11 SPECIFIC GRAVITY

The specific gravity for the aggregates was done to the BS 812-2: 1995 specifications. The granite aggregates had a 2.6 surface dry specific gravity and 2.5 sun dried specific gravity. The acceptable limit is between 2.5 - 3.0.

The water absorption for granite aggregate was 2.9%

3.2.12 SPECIFIC GRAVITY TEST

This test was carried out in accordance with ASTM C127.

3.2.13 WATER ABSORPTION TEST

This test was carried out in accordance with BS 1881-122+A:2020. Water absorption is the amount of water that an aggregate can absorb. Water absorption tends to be an excellent indicator of the strength of the aggregate. The absorption of the aggregate can influence such properties of concrete the bond between it and the cement influence on the strength of the concrete chemical stability and resistance to abrasion. The method of measuring water absorption in aggregates is described in BS 812.

3.2.14 OBJECTIVE

- To determine the water absorption of crushed in academic shells

3.2.15 PROCEDURE

Approximately 1kg of aggregate sample was added to a clean container filled with water. The material was soaked for 24hours after which the water was drained to achieve a saturated surface dry state. A test sample of roughly 400g was removed and the mass was determined. The test sample was then placed in an oven for 24hours to dry after which it was weighed.

3.2.16 CALCULATION

The water absorption calculated by the weight of wet aggregate less (minus) the weight of oven dry aggregate over the weight of the oven dry aggregate and expressed as a percentage.

Water absorption = weight of wet aggregate - weight of oven dry aggregate/

weight of oven dry aggregate x 100

CHAPTER FOUR

4.1 LABORATORY TEST RESULTS

4.2 PARTICLE SIZE DISTRIBUTION

Sieve Analysis is a very important process in determining the performance of materials used in concrete. The normal aggregates in concrete were graded. This was done to standard of BS410: 1986. The fine aggregate lie in the envelope required. The normal granite aggregates also lie in the envelope between the maximum and minimum requirements.

Table 4.1: Particle Size Distribution Results for Fine Aggregates

Fine Aggregate (River Sand) Sieve Size (mm)	**Mass retained (g)**	**Mass passed (g)**	**Mass retained (%)**	**Cumulative passed (%)**
14	0.0	1722.0	0.0	100.0
10	12.5	1709.5	0.73	99.3
4.76	45.8	1663.7	2.6	96.6
2.36	90.6	1573.1	5.3	91.4
1.18	200.9	1372.2	11.7	79.7
0.6	500.7	871.5	29.1	50.6
0.3	640.9	230.6	37.2	13.4

0.15	230.6	0.0	13.4	0.0
0.075	0.0	0.0	0.0	0.0
Total	1722.0		100.0	

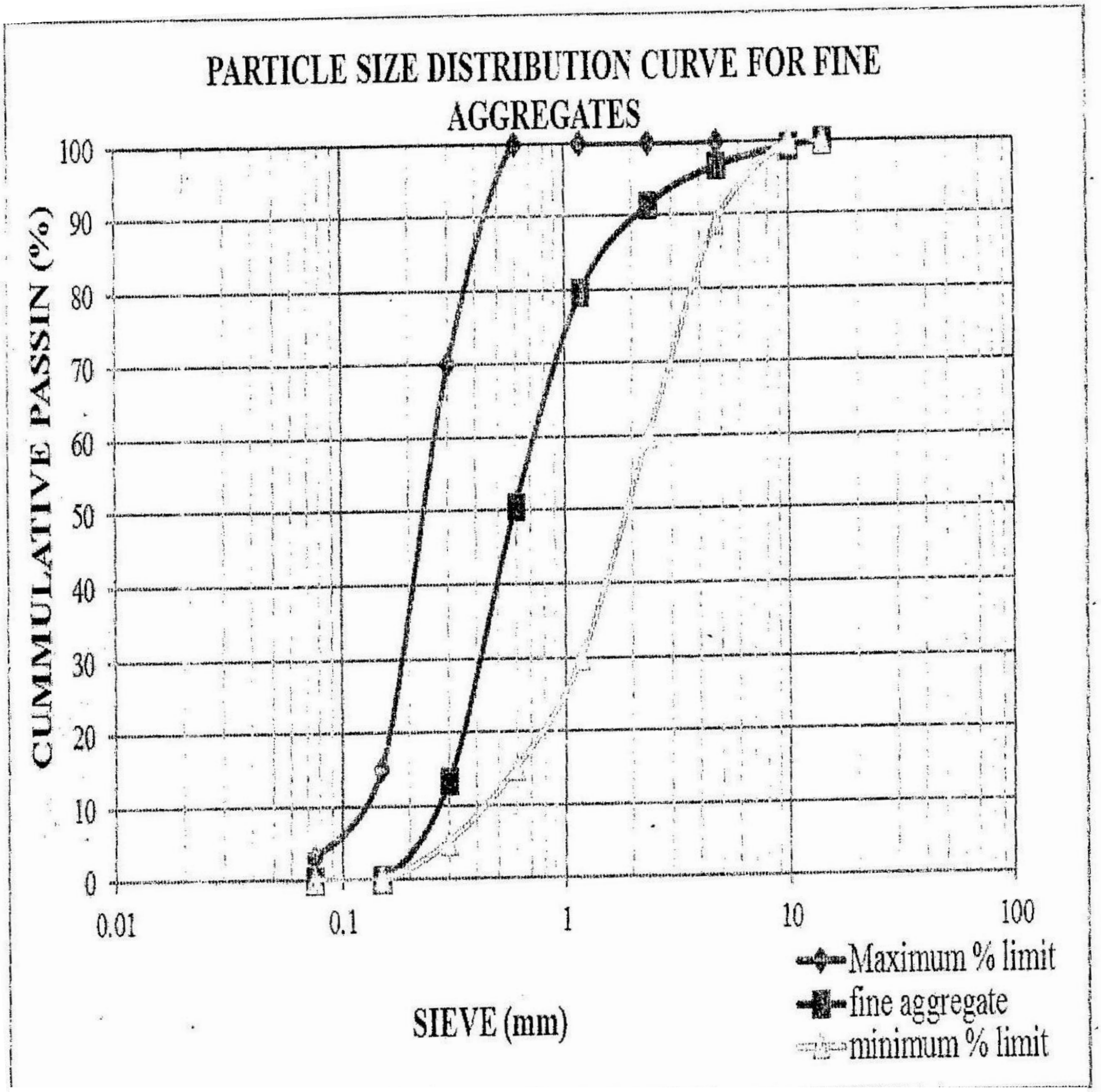

Figure 4.1: Particle size distribution curve for fine aggregate (river sand)

Table 4.2: Particle Size Distribution Results for Coarse Aggregate

Coarse Aggregate (granite) Sieve Size (mm)	Mass retained (g)	Mass passed (g)	Mass retained (%)	Cumulative passed (%)
37.5	0	2500	0.0	100.0
20	175.4	2324.6	7.0	93.0
14	320.8	2003.8	12.8	80.2
10	1125.1	878.7	45.0	35.1
5	770.5	108.2	30.8	4.3
2.36	108.2	0	4.3	0.0
Total	2500.0		100.0	

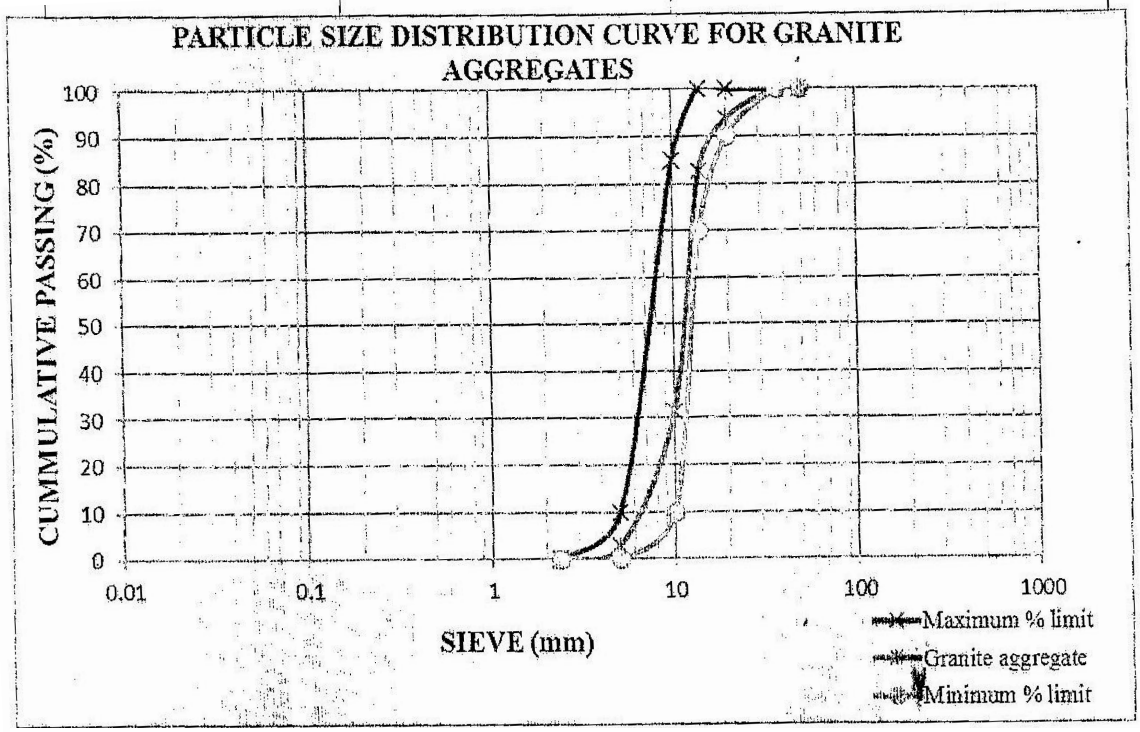

Figure 4.2: Particle size distribution curve results for coarse aggregate (granite)

Table 4.3: Bulk Density

Weight of can + weight of aggregate sample	4720g	7450g
Weight of can	2570g	2570g
Weight of aggregate sample	4720-2570 = 2150g	7450-2570 = 4880g
Volume of water	2800cm^3	2800cm^3

Bulk density = 4880kg/2800cm^3 = 1.743g/cm^3

For Normal Aggregate = 1743kg/m^3

4.3 SPECIFIC GRAVITY AND WATER ABSORPTION RATIO OF AGGREGATE AND IMPACT VALUE TEST RESULTS

Based on the laboratory works carried out, the results on specific gravity test, water absorption test, aggregate impact test are presented on Tables 4.4-4.6

Table 4.4: Specific Gravity Test Result on Sand, Granite

	Sand		**Granite**	
Trial	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Weight of empty bottle (M_1)g	1476	1476	1476	1476
Weight of bottle + sample (M_2)g	4500	4498	3940	3940
Weight of bottle + sample + water (M_3)g	6800	6796	6927	6931
Weight of bottle + water (M_4)	5426	5426	5426	5426
Specific gravity = $\frac{M2 - M1}{(M4 - M1) - (M3 - M2)}$	1.83	1.81	2.55	2.56
Average specific gravity =	**1.82**		**2.55**	

Table 4.5: Water absorption test result on granite

	Granite	
Trial	**Trial 1**	**Trial 2**
Weight of dry sample (W_b)g	700	700
Weight of wet sample (W_s)g	745	747
Increase in mass (W_s - W_b)g	45	47
Water absorption capacity (Wbc) = $\frac{Ws-Wb}{Wb}$ x 100	6.4%	6.7%
Average Water absorption capacity =	**6.5%**	

Table 4.6: Impact value test Result on Granite

	Granite	
Observation	**Trial 1**	**Trial 2**
Total weight of dry sample (W_1)gm	900	900
Weight of portion passing 2.36mm sieve (W_2)gm	279	274
Aggregate impact value (percent) = $W_{2/}W_1$ x100	31%	30%
Aggregate impact mean value	30.5%	

4.4 DISCUSSION OF RESULTS

Sieve analysis results for crushed granite shows the aggregate can be classified as single sized (20mm) coarse aggregate in accordance to (B.S 882-103.1).

The results obtained from water absorption test shows that crushed granite have a lower water absorption rate of 6.5,

The result obtained from the impact value test shows that crush granite was 30%, this shows that impact value of granite can be used under sudden shock.

CHAPTER FIVE

5.1 CONCLUSION AND RECOMMENDATION

5.2 CONCLUSION

From the investigation carried out on this work, the following conclusions are made:

1. Quality control of engineering materials is essential in the construction site for good quality job void of waste of materials and failure of engineering constructions.

2. Test of engineering materials in compliance with relevant standard is essential in construction.

5.3 RECOMMENDATION

The methodologies and various tests should be carried out in relevance to engineering standard.

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