THE USE OF QUARRY DUST AS A PARTIAL REPLACEMENT OF SAND IN CONCRETE

BY

NWOGA JOEL CHIBUIKE

PGD/CIVIL ENGR/2009/063

DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

MARCH, 2012.

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THIS PROJECT IS SUBMITTED TO THE POST GRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARE OF POST GRADUATE DIPLOMA IN CIVIL ENGINEERING

MARCH, 2012

DECLERATION

I hereby declare that this project titled: The Use of Quarry Dust as a Partial Replacement of Sand in Concrete. Is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

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20/04/2012

NWOGA JOEL CHIBUIKE DATE

REG NO: PGD/CIVIL ENGR/2009/063

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA, NIGERIA.

CERTIFICATION

This is to certify that this project was carried out by NWOGA JOEL CHIBUIKE, Reg. number PGD/CIVIL ENGR/2009/063 of civil Engineering Department, Federal University of Technology, Minna under the supervision of Mr Olayemi James.

.... 21 – 05 - 2012
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Mr O. James
(Project Supervision)

DATE

....
....

Prof. S. Sadiku
(Head of Department)

DATE

....
....

External Examiner

DATE

DEDICATION

TO ALMIGHTY GOD

ACKNOWLEDGEMENTS

I owe a debt of gratitude to almighty God for his mercy and compassion throughout the stages of this academic pursuit, to my supervisor Mr. Olayemi James for his kindly advice, suggestions, patience and immediate approval, I thank you. I also appreciate effort of the head of department Prof. S. Sadiku and the rest of the academic staff of the department notably among them are Engr. Dr J.I. Aguwa, Engr. Dr. P.N Ndoke, Engr. Dr T.Y Tsado for the knowledge impacted in me during my stay in this Campus as Post-graduate student and my colleagues for their support, collaboration and exchange of ideas. Also my family who has been there for me in all aspect of this Research work mostly Sunday Nwoga for being handy for all internet materials needed. God bless you.

ABSTRACT

This research work focused on the use of quarry dust as a partial replacement for sand in concrete production. The physical tests were carried out on the aggregates while workability tests on the fresh concrete were also carried out. 0, 25, 50, 75 and 100 percentage replacement of sand with quarry dust was use to cast concrete cubes for grade 20 concrete, the concrete cubes were cure for 28 days and their compressive strength was obtained by using crushing machine, from the results obtain it shows that at 100% sand replacement with quarry dust gives values of the compressive strength to be higher than that in the design mix target strength. The water absorption tests were also carried out on the cubes made from various mixes. The results shows increase in water absorption rate as the proportion of quarry dust increases in the concrete mix when compared with the control. The summary of the results obtained is as shown in table 4.6.6.

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CHAPTER ONE

1.0 Introduction

1.1 General

Concrete is an artificial conglomerate stone made essentially of Portland cement, water, sand and coarse aggregates. The mixture of the materials results in a chemical reaction called hydration and a change in the mixture from plastic to a solid state.

The need for obtaining the desired strength of any concrete product is of great importance to Civil Engineers, in any construction industry, so as to reduce the risk of structural collapse in any concrete components, hence save life, properties, time and resources.

A lot of research and studies have been carried out by different researchers on occurrence of concrete as construction materials. Quarry Dust is a very good material for construction, which can replace fine aggregate. It has more strength than fine aggregate with an appropriate water cement ratio. The replacement of fine aggregate with quarry dust in concrete work will bring another alternative for a construction material in theses modern days. *Quarry Rock Dust can be defined as residue, tailing or other non-valuable waste material after the extraction and processing of rocks to form fine particles less than*

4.75mm. A fine aggregate as define in BS 882: 1965 is a natural soil resulting from the crushing of hard rock (normally) granite rock/igneous and gravel mainly passing a *3/8* (9.5mm) BS410 coarse test sieve.

This project focuses on the utilization of quarry dust to improve the quality of concrete, it was found that the stress parameter in concrete increases with the introduction of stone, for the high strength requirement, quarry dust can also be used as fine aggregate due to high crushing strength obtain in the rocky aggregate when subjected to compressive force. Quarry dust on the other hand has two important properties, it compact well and prevent future setting and also drains water easily. Quarry dust improves the quality of sub-base in highway construction effectively as compare with other engineering material. Though Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete.

1.2 BACKGROUNDS

Quarry dust has been used in improving the quality of sub-base in highway construction. It has also been used as partial replacement of cement in the stabilization of *laborite* block. The use of the quarry dust generally improved the strength of the structure. However quarry dust is more expensive then natural sand (i.e. fine aggregates) and concrete produce with it (quarry dust) will be more expensive. Thus, it is in light of this that this research set to particularly use quarry dust as fine aggregate in the production of high strength concrete.

1.3 JUSTIFICATION

The result of this research work will be useful in using Quarry dust appropriately and perhaps may lead to its use in Civil Engineering Structures such a water retaining structures. Though the cost of producing concrete with quarry dust is high, but it may provide a concrete with the required strength and also may enhances austerity of concrete depending on the result of this research.

1.4 AIM AND OBJECTIVES OF THE RESEARCH

1.4.1 Aim

The aim of carrying out this research is to partially replace sand in percentage with quarry dust during the production of concrete.

1.4.2 Objectives

I. To determine the workability of concrete with various percentage replacement of sand with quarry dust.

2. To determine the compressive strength of concrete made with various percentages of quarry dust and natural sand as fine aggregates.

3. To determine the water absorption of concrete made with partial replacement of sand with quarry dust.

1.5 SCOPE AND LIMITATION

I.5.l Scope

This research work will be based on grade 20 concrete with 0%, 25%, 50%, 75% and 100% partial replacement of sand with quarry dust respectively, in order to test and obtain the average compressive strength of the concrete cubes (10 each) after 28 days of curing.

1.5.2 Limitation

This research work does not cover the physical, mechanical and flexural strength properties of the materials, but the performance of the concrete-cubes at 28 days, for their respective strength and also their water absorption test at 28 days.

1.6 METHODOLOGY

The test will be carried out by sieving the sand and quarry dust to obtain the percentage pass and retain of the materials, also concrete grade 20 cubes will be moulted with partial replacement of sand with various percentage of quarry dust with 100% sand as the control for the research work. The concrete cubes are to be weighed immediately before and after curing, after 28 days curing of the concrete, the cubes will be removed from water, weighed and tested for compressive strength, obtained from testing ten replicate of $(150\ \text{mm})^3$ cubes for each combination of mix. The compressive strength is obtain by dividing the crushing load from the machine for each cube by its cross sectional area of the concrete cubes.

1.7 SIGNIFICANCE

Care must be exercised in the interpretation of the significance of compressive strength determinations by this test method since strength is not a fundamental or intrinsic property of concrete made from given materials. Values obtained will depend on the size and shape of the specimen, batching, mixing procedures, methods of sampling, molding, age, temperature, and moisture conditions during curing.

The results of this test method are used as a basis for quality control of concrete proportioning, mixing, and placing operations; determination of compliance with specifications, also the result of this research work will be useful in using quarry dust as a partial replacement of sand in civil Engineering concrete structures where high comprehensive strength is required. Thus, it can be concluded that the replacement of natural sand with Quarry Rock Dust, as full replacement in concrete is possible. However, it is advisable to carry out trial casting with Quarry Rock Dust proposed to be used, in order to arrive at the water content and mix proportion to suit the required workability levels and strength requirement.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

Concrete is a multiphase or composite material made by mixing together a number of constituents, the constituents include; Cement, Water, Sand and Stones (which together comprises the aggregate) and sometimes there are additive known as admixture added to modify certain properties of resultant concrete.

The principal constituents of concrete is the binding medium used to bind the aggregate particles together to form a hard composite medium, the hardened cement paste is the fundamental material in concrete because it provides the strength that allows concrete to be used structurally, other principal constituent which is natural aggregate such as gravel and sand or crushed stones are essential, it gives rigidity and dimensional stability to concrete and its cheapness in relative to cement.

A typical structure of hardened concrete shows that aggregate (Fine - coarse occupies 60 - 80% of the volume of concrete leaving 20 - 40% volume for the binding materials, with 1 - 2% voids). In its hardened state concrete is a rock like material with a high compressive strength and low tensile strength, because of the comparatively low tensile strength of concrete steel bars are normally incorporated into it, in its structural applications so as to resist any tensile forces (i.e. reinforced concrete). Though Concrete is a substance designed to sustain large compressive forces, it is commonly known that concrete density is directly proportional to its compressive strength. Consequently, in the past, contractors used to produce high-density concrete in order to maximize the compressive strength of the building he or she wished to create. However, the dead load on the building became so high that the concrete could not even hold its own weight and therefore cracked. In order to avoid this, lightweight concrete has been extensively researched. Lightweight concrete can be created by using either chemical admixtures or lightweight aggregates.

2.2 COMPOSITION OF CONCRETE

2.2.1 Cement

Portland cement is the chief ingredient in cement paste - the binding agent in Portland cement concrete (PCC). It is a hydraulic cement that, when combined with water, hardens into a solid mass. Interspersed in an aggregate matrix it forms PCC. As a material, Portland cement has been used for well over 175 years and, from an empirical perspective, its behaviour is well-understood. Chemically, however, Portland cement is a complex substance whose mechanisms and interactions have yet to be fully defined. ASTM (**American Society for Testing**

and Materials) C 125 and the Portland Cement Association (PCA) provide the following precise definitions:

Hydraulic cement: An inorganic material or a mixture of inorganic materials that sets and develops strength by chemical reaction with water by formation of hydrates and is capable of doing so under water.

Portland cement: Hydraulic cement composed primarily of hydraulic calcium silicates.

Table 1: Main Constituents in a Typical Portland Cement (Mindess and Young, 1981)

Chemical Name	Chemical Formula	Shorthand Notation	Percent by Weight
Tricalcium Silicate	$3CaO{\cdot}SiO_2$	C_3S	50
Dicalcium Silicate	$2CaO{\cdot}SiO_2$	C_2S	25
Tricalcium Aluminate	$3CaO{\cdot}Al_2O_3$	C_3A	12
Tetracalcium Aluminoferrite	$4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$	C_4AF	8
Gypsum	$CaSO_4{\cdot}H_2O$	CSH_2	3.5

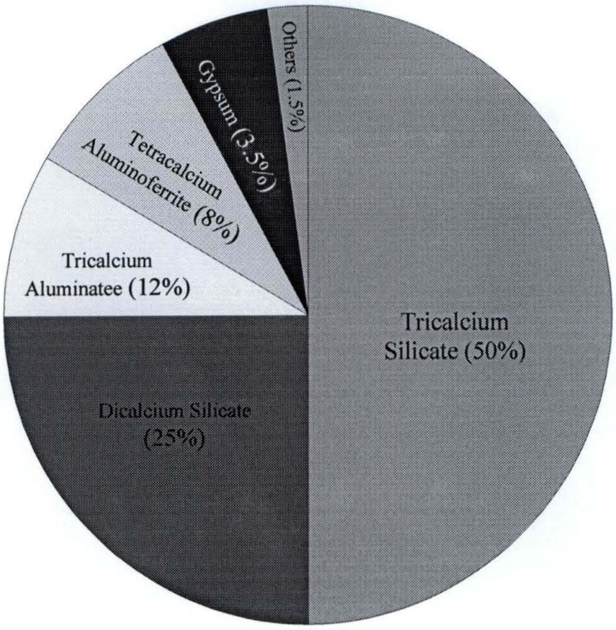


Fig 1: Typical Oxide Composition of a General-Purpose Portland cement (Mindess and Young, 1981)

2.2.1.1 Hydration of Portland Cement

When Portland cement is mixed with water its chemical compound constituents undergo a series of chemical reactions that cause it to harden (or set). These chemical reactions all involve the addition of water to the basic chemical compounds listed in Table 1. This chemical reaction with water is called "hydration". Each one of these reactions occurs at a different time and rate. Together, the results of these reactions determine how Portland cement hardens and gains strength.

- *Tricalcium silicate (C_3S).* Hydrates and hardens rapidly and is largely responsible for initial set and early strength. Portland cements with higher percentages of C_3S will exhibit higher early strength.

- *Dicalcium silicate (C_2S).* Hydrates and hardens slowly and is largely responsible for strength increases beyond one week.
- *Tricalcium aluminate (C_3A).* Hydrates and hardens the quickest. Liberates a large amount of heat almost immediately and contributes somewhat to early strength. Gypsum is added to Portland cement to retard C_3A hydration. Without gypsum, C_3A hydration would cause Portland cement to set almost immediately after adding water.
- *Tetracalcium aluminoferrite (C_4AF).* Hydrates rapidly but contributes very little to strength. Its use allows lower kiln temperatures in Portland cement manufacturing. Most Portland cement color effects are due to C_4AF.

2.2.1.2 Types of Cement

Knowing the basic characteristics of Portland cement's constituent chemical compounds, it is possible to modify its properties by adjusting the amounts of each compound. In the U.S., AASHTO *(American Association of State Highway and Transportation Officials)* M 85 and ASTM C 150, *Standard Specification for Portland cement*, recognize eight basic types of Portland cement concrete (see Table 2). There are also many other types of blended and proprietary cements that are not mentioned here.

Table 2: ASTM Types of Portland cement

Type	Name	Purpose
I	Normal	General-purpose cement suitable for most purposes.
IA	Normal-Air Entraining	An air-entraining modification of Type I.
II	Moderate Sulfate Resistance	Used as a precaution against moderate sulfate attack. It will usually generate less heat at a slower rate than Type I cement.
IIA	Moderate Sulfate Resistance-Air Entraining	An air-entraining modification of Type II.
III	High Early Strength	Used when high early strength is needed. It is has more C_3S than Type I cement and has been ground finer to provide a higher surface-to-volume ratio, both of which speed hydration. Strength gain is double that of Type I cement in the first 24 hours.
IIIA	High Early Strength-Air Entraining	An air-entraining modification of Type III.
IV	Low Heat of Hydration	Used when hydration heat must be minimized in large volume applications such as gravity dams. Contains about half the $C_3S$and C_3A and double the C_2S of Type I cement.
V	High Sulfate Resistance	Used as a precaution against severe sulfate action - principally where soils or ground-waters have high sulfate content. It gains strength at a slower rate than Type I cement. High sulfate resistance is attributable to low C_3A content.

2.2.1.3 Fineness of Grading Portland Cement

Fineness or particle size of Portland cement affects hydration rate and thus the rate of strength gain. The smaller the particle size, the greater the surface area-to-volume ratio, and thus, the more area available for water-cement interaction per unit volume. The effects of greater fineness on strength are generally seen during the first seven days (PCA, 1988).

Fineness can be measured by several methods:

- AASHTO T 98 and ASTM C 115: Fineness of Portland cement by the Turbidimeter.
- AASHTO T 128 and ASTM C 184: Fineness of Hydraulic Cement by the 150-mm (No. 100) and 75-mm (No. 200) Sieves
- AASHTO T 153 and ASTM C 204: Fineness of Hydraulic Cement by Air Permeability Apparatus
- AASHTO T 192 and ASTM C 430: Fineness of Hydraulic Cement by the 45-mm (No. 325) Sieve

2.2.2 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. Aggregates, which account for 60 to 80 percent of the total volume of concrete, are divided into two distinct categories-fines and coarse. However, research has shown that aggregate in fact plays a substantial role in determining workability, strength, dimensional stability, and durability of the concrete. Also, aggregates can have a significant effect on the cost of the concrete mixture. 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.

Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular subbases, soil-cement, and in new concrete. Aggregate processing consists of crushing, screening, and washing the aggregate to obtain proper cleanliness and gradation. If necessary, a benefaction process such as jigging or heavy media separation can be used to upgrade the quality.

Once processed, the aggregates are handled and stored in a way that minimizes segregation and degradation and prevents contamination. Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregates is an important process. Although some variation in aggregate properties is expected, characteristics that are considered when selecting aggregate include:

- grading
- durability
- particle shape and surface texture
- abrasion and skid resistance
- unit weights and voids
- absorption and surface moisture

Grading refers to the determination of the particle-size distribution for aggregate. Grading limits and maximum aggregate size are specified because grading and size affect the amount of aggregate used as well as cement and water requirements, workability and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength. When gap-graded aggregate are specified, certain particle sizes of aggregate are omitted from the size continuum. Gap-graded aggregate are used to obtain uniform textures in exposed aggregate concrete. Close control of mix proportions is necessary to avoid segregation.

2.2.2.1 Classification of Aggregate

Generally, BS 882 places the aggregate in three main categories viz:

1. Fine aggregate or sand: Containing particles, the majority of which are smaller than 5.00mm.
2. Coarse aggregate: Containing particles, the majority of which are larger than 5.00mm.
3. All-in-aggregate: Containing both fine and coarse aggregate.

Aggregate are grouped into normal, heavy weight and lightweight aggregates.

Normal Aggregates consists of natural materials including gravels, igneous rocks and Sedimentary rocks.

Lightweight Aggregates are mostly artificial material which includes foamed lag, pulverized fuel ash, expanded clay pellets as well as natural materials like volcanic materials.

The Heavy Weight Aggregate on the other hand includes barites (barium sulphate) and steel shot. They are used in concrete for radiation shielding. The normal aggregate apart from including crushed rock and gravel, also include sand, which in practice called fine aggregate which are normally required to confirm to any one of the three standard grading limits (BS 882) or zones, all of which are suitable for concrete provided suitable mix proportions are used.

2.2.2.2 Grading of Fine and Coarse Aggregates

The grading of an aggregate defines the proportions of particle of different size in the aggregate. The size of the aggregate particle normally used in concrete varies from 37.5mm to 0.15mm. BS 882 place aggregate in the main categories of fine aggregate or sand containing particles, the majority of which are smaller than 5.00mm, Coarse aggregate containing particles the majority of which are more than 5.00mm and all in aggregate comprising both fine and coarse. The grading of an aggregate can have considerable effect on the workability and stability of concrete mix and the most important factor is concrete mix design. In the UK the grading of natural aggregate is generally required to be within the limit Specific in BS 882, the fine aggregate are generally required to be conform to any one of the three standard limits.

2.2.2.3 Quarry Dust

The utilization of Quarry Dust which can be called manufactured sand has been accepted as a building material in the industrially advances countries for the past three decades. As a result of sustained research and development work undertaken with respect to increasing application of this industrial waste. The level of utilization of Quarry Dust to the Industrialized Nations like Australia, France, Germany and United Kingdom has reached more than 60% of its total production (R. Ilangovan, Dr. K. Nagamani, (2007)).

2.2.3 WATER

Another major component of concrete mixes is water, which is mixed with the dry cement to hydrate it and make it a binder. The water/cement ratio (w/c) has a major effect on concrete properties. It can be calculated by using the following equation: w/c = water in mix/cement in mix ---------- eqn (1). The w/c of a concrete mix is inversely proportional to its compressive strength and directly proportional to its permeability/workability. The w/c of a concrete mix should be less than or equal to 0.5 when it is expected to be exposed to moist conditions, cold conditions, or deicing chemicals

Water used in concrete, in addition to reacting with cement and thus causing it to set and harden also facilitates mixing, placing and compacting of the finished concrete. It is also used for washing aggregate and curing purposes. Generally, the water required in making concrete is water fit for drink such as tap water. Water filled with impurities like salt, clay, acids, alkalis and other salts as well as organic matter and sewage are deleterious to concrete. The use of sea water has been found not to affect the strength and durability of Portland cement concrete but it is known to cause dampness efflorescence and staining of the surface.

2.3 PROPERTIES OF CONCRETE

2.3. 1 Properties of Fresh Concrete

Fresh Concrete is assumed to be concrete mixture that has not set, that has not reached its hardened state. The object of mixing is to coat the surface of all aggregate particles with cement paste and to blend all the ingredients of concrete into a uniform mass. This uniformity must furthermore not be disturbed by the process of discharging from the mixer, the characteristics of fresh concrete which affect full compactability, these three characteristic are known as workability.

2.3.1.1 Workability of Fresh Concrete

Workability is defined as the ease with which a concrete mix can be handled from the mixer to its finally compacted shape. Generally, precaution should be taken to preserve the workability of ready mixed concrete by speeding the delivery and placement. The three main characteristics of the property of workability are:

1. Consistency: Is a measure of wetness or fluidity of concrete. Ordinary concrete is regarded as having the correct consistence when it is adequately

plastic.

2. Mobility: Is described as the ease with which a mix can flow into and completely fill the formwork or mould.

3. Compactability: Is the ease with which mixed concrete can be fully compacted, all trapped air being removed.

Workability of a mix depends not only on the characteristics and relative proportions of the constituents' material but also on:

1. The method employed for conveyance and compaction.
2. The size, shape and surface roughness of the formwork or mould.

2.3.1.2 Stability of Fresh Concrete

As a result of difference between the particle and specific gravities of the constituent materials, there exists a natural tendency for them to cause segregation in fresh concrete. Composition should be such that its constituent materials remain uniformly distributed in the concrete mass. The extent of material separation depend on the methods of transportation, placing and compaction and if not properly transported, placed and compacted it leads to fatalness such as segregation and bleeding.

2.3.1.3 Bleeding And Segregation of Fresh Concrete

Bleeding can be described as separation of water from a mix as a result of natural tendency for solid particles depending on size and specific gravity to exhibit a downward movement, while segregation is the tendency for the large and finer particulars in a mix to become separated. This is more readily seen in less cohesive mix and is always manifested in form of porous layers and honey combing.

2.3.2 PROPERTIES OF HARDENED CONCRETE

Hardened concrete is regarded as fresh concrete that had undergone the process of hydration and setting. Whereas the properties of fresh concrete are important only for few hours in mixing, placing and compacting. The properties of hardened concrete are retained for the remaining useful Life of the concrete. The properties of hardened concrete include: strength, deformation under load, durability, permeability and shrinkage.

The properties of hardened concrete is known to change with age and its environment, hence it is not possible to attribute absolute values to any of them but rather laboratory test may give only an indication of the properties which concrete may have in the actual structure as the quality of the concrete depends on the workmanship on site.

The compressive strength of a hardened concrete is the most common measure for judging the quality of concrete, usually the characteristics strength of concrete is based on 28 days cube strength that is the crushing strength of 150mm cube at the age of 28 days after mixing and curing. The tested cubes should certify the code provision on the characteristic strength at any given age. This is always carried out in mix design.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 MATERIALS INVOLVED IN THE TEST

The materials used for this practical test include ordinary patterned cement, coarse aggregate (gravel passing through 20mm B.S Sieve) sharp sand, Quarry dust and water.

3.1.1 Cement

The cement used for this work is ordinary Portland cement manufactured by Dangote Cement PLC. The cement was bought from a dealer at Tunga Market in Minna. Proper care was taken to ensure that the cement was a recent supply.

3.1.2 Coarse Aggregate

The Coarse aggregate used for this project research work was made of crushed stone obtained from a private Quarrying Center in Minna.BS Sieve was used for sieving particles (coarse aggregate) between 5mm to 20mm for the experiment.

3.1.3 Fine Aggregate

The fine aggregate used in this research work was naturally occurring clean sharp sand obtained from IZOM River along Suleja/Minna and was found to be suitable for experiment works. Sieve analysis of the sand indicates that, the sand passes through Zone I. Sieve analysis graph for fine aggregate is shown in Fig 3.

3.1.4 Quarry Dust

The Quarry dust used in this research work was made of crushed stone obtained from a Private Quarry Centre in Minna, B.S Sieve 10mm to 75μm was used to obtain the percentage retained on each sieve and the graph for the sieve analysis is shown in Fig 4.

3.1.5 Water

The Water used for this research work is pure and clean Tap Water which is suitable and fit for drinking.

3.2. PRELIMINARY TESTS

3.2.1 Determination of Particle Size Distribution of Aggregates (Sieve Analysis).

The particle size distribution of an aggregate has a considerable influence on the workability of fresh concrete. In designing of a concrete mix, grading zones of aggregates are used to classify the particle size distribution of aggregates. This test was carried out as specified and in accordance with B.S 1377: Part 2: 1990. It covers a quantitative determination of the particle size distribution in an essentially cohesionles soil down to the fine aggregate.

3.3 STANDARD MIX DESIGN

Mix ratio design can simply be defined as the process of selecting suitable ingredient of concrete and determining their relative quantities with the purpose of producing as economically as possible a concrete of certain minimum properties notably uniform strength and durability. The design mix in this research work was based on grade 20 concrete in accordance with DOE (1975) mix design method.

GENERAL REQUIREMENTS

1.	Characteristics Strength	-	$20N/mm^2$ at 28 days curing
2.	Cement Type	-	Ordinary Portland cement
3.	Slump	-	5mm - 20mm (assumed)
4.	Maximum Size of Coarse Aggregate	-	20mm
5.	Maximum Free Water Cement Ratio	-	0.5 (assumed)
6.	Fine Aggregate Specific Gravity	-	2.6
7.	Coarse Aggregate Specific Gravity	-	2.7
8.	Standard Deviation	-	$8N/mm^2$

CONCRETE GRADE 20 (CONTROL)

QUANTITIES

Cement	=	1441 kg/m^3 (from Table 4.2.3)
Water	=	720.5 kg/m^3 (from w/c of 0.5)
Fine Aggregate	=	1550 kg/m^3 (from Table 4.2.2)
Coarse Aggregate	=	1487 kg/m^3 (from Table 4.2.1)

BATCHING MIXING

Required quantities

Cement = 1441 kg/m^3

Water = 720.5 kg/m^3

Fine Aggregate = 1550 kg/m^3

Coarse Aggregate = 1487 kg/m^3

Volume of Mould = 0.15 x 0.15 x 0.15 = 0.003375m^3

Number of cubes to be cast in each case = 10 Cubes

The volume is multiplied by 10 in each case and 10% waste was adopted

:. 0.003375 x 10 = 0.03375m^3

Mix ratio = 1:2:4

= 1 + 2 + 4 = 7 parts

Volume of cement = $\frac{1}{7}$ x 0.03375 = 0.0048m^3

Volume of Fine aggregate = $\frac{2}{7}$ x 0.03375 = 0.0096m^3

Volume of Coarse aggregate = $\frac{4}{7}$ x 0.03375 = 0.0193m^3

Recall, Density = $\frac{Mass}{Vol}$

:. Mass = Density x Vol.

Mass of cement required = (1441 x 0.0048) + 10% waste

= 6.9168 + 0.6917

= **7.6085kg**

Mass of fine aggregate required = (1550 x 0.0096) + 10% waste

= 14.8800 + 1.4880

= **16.3680kg**

Mass of Coarse aggregate required = (1487 x 0.0193) + 10% waste

= 28.6991 + 2.8699

= **31.5690kg**

Table 3: PARTIAL REPLACEMENT OF SAND WITH QUARRY DUST

Mass of fine aggregate required = 16.3680 kg

SAND (kg)		QUARRY DUST (kg)	
100%=	16.37	0%=	0.00
75%=	12.28	25%=	4.09
50%=	8.18	50%=	8.18
25%=	4.09	75%=	12.28
0%=	0.00	100%=	16.37

3.4 UNIFORMITY OF MIXING

In any form of concrete mix it is essentially necessary that, sufficient inter change between the constituents' materials of concrete take place in order to produce a uniform concrete. Both segregation and bleeding in concrete can all be avoided with adequate uniformity in the mix of the concrete. The mix is properly done with various percentage replacement of sand with Quarry dust and cement before the introduction of coarse aggregate and water.

3.4.1 Variation in the Percentage Replacement of Sand with Quarry Dust.

As earlier explained, quarry dust is to be introduced into the concrete as a partial replacement of sand. The replacement is to be based on the specified percentage at which sand is to be removed in the concrete mix and be replaced with quarry dust. The batching is done by weight, therefore the percentage of sand replacement with quarry dust was calculated by weight and exact replacement was made. Detailed calculations of percentage of sand replaced by quarry dust are shown in the table 3.

3.5 PERFORMANCE TESTS

3.5.1 Batching, Mixing, Casting and Compaction

The batches were thoroughly mixed in the laboratory by manual means, the mixed concrete was cast into moulds and compacted in three layers using tamping rod. A total number of 50 cubes were cast, for instance, the cubes were cast for percentage of 0%, 25%, 50%, 75% and 100% replacement of sand with quarry dust. The cubes were given identification marks on top (percentage and date) in order to avoid mix up.

3.5.2 Slump Test

The slump cone of 300mm high with 200mm and 100mm as bottom and top diameter respectively were used. Prior to the experiment, the Cone was clean and oiled. The cone was filled in three layers; each layer was compacted with 25 strokes of rod of 20mm diameter, 60mm long. The strokes are distributed in uniform manner over the cross section of the mould. The top of the mould was leveled after the last layer and the mould was withdrawn vertically upward and the slump was measured in millimeters.

3.5.3 Curing of Concrete Cubes

After casting, the cubes were removed after 24 hours and dipped into water tank for curing. Before the curing, the cubes are weighed on weighing balance to obtain their respective weights.

3.5.4 Compressive Strength Test

After the 28 days of casting and curing, the concrete cubes were removed dried and weighed, they were then tested for compressive strength. The crushing machine applied direct axial load on the cubes until the maximum load was reached after the cubes fail by crushing and the load corresponding to the crushed concrete cube was recorded as the failure load.

3.5.5 Water Absorption Test

The rate at which water is been taken by the concrete cubes, during the period of curing is term as "water absorption". For each percentage of sand replaced with quarry dust, cubes were cast and cured for 28 days. The weights of the cube were obtained before and after curing. The cubes were oven dried for another 24 hours and reweigh to obtain their respective oven dried weight.

CHAPTER FOUR

4.0 PRESENTATION OF DATA AND DISCUSSION

4.1.0 ANALYSIS OF RESULTS

4.1.1 Specific Gravity

The Summary of Results on the specific gravities of different aggregates are presented in the table 4.1.1 and 4.1.2 below:

Table 4.1.1 SPECIFIC GRAVITY OF COARSE AGGREGATE

SPECIFIC GRAVITY TEST FOR COARSE AGGREGATE		
Test No	Test 1	Test 2
Wt of Cylinder (w_1) g	552.30	552.30
Wt of Cylinder + Sample (w_2) g	827.00	799.10
Wt of Cylinder + Water +Sample (w_3) g	1718.30	1700.10
Wt of Cylinder + water (w_4) g	1547.00	1547.00
Wt of Water (w_4-w_1)g	994.70	994.70
Wt of water added to the Sample (w_3-w_2)g	891.30	901.00
Wt of Sample (w_2-w_1)	274.70	246.80
Wt of Water displaced by Sample (w_4-w_1) - (w_3-w_2) = w	103.40	93.70
Specific gravity = (w_2-w_1)/w	2.66	2.63
Average	2.65	

Table 4.1.2 SPECIFIC GRAVITY OF FINE AGGREGATE

SPECIFIC GRAVITY TEST FOR FINE AGGREGATE		
Test No	Test 1	Test 2
Wt of Cylinder (w_1) g	114.40	97.60
Wt of Cylinder + Sample (w_2) g	172.00	146.60
Wt of Cylinder + Water +Sample (w_3) g	398.20	376.40
Wt of Cylinder + water (w_4) g	362.50	346.50
Wt of Water (w_4-w_1)g	248.10	248.90
Wt of water added to the Sample (w_3-w_2)g	226.20	229.80
Wt of Sample (w_2-w_1)	57.60	49.00
Wt of Water displaced by Sample (w_4-w_1) - (w_3-w_2) = w	21.90	19.10
Specific gravity = (w_2-w_1)/w	2.63	2.57
Average	2.60	

4.2.0 THE BULK DENSITY

The Summary of Results on the bulk densities of different materials used are presented in the table 4.2.1, 4.2.2 and 4.2.3 below:

Table 4.2.1 BULK DENSITY OF COARSE AGGREGATE

	Compacted		**Un-compacted**	
Test No	Test 1	Test 2	Test 1	Test 2
Wt of empty Cylinder (w_1) kg	1.0739	1.0739	1.0739	1.0739
Vol of Container (vo) ($x10^{-3}$)	1.7289	1.7289	1.7289	1.7289
Wt of Sample divider + sample (w_2)	3.8700	3.9920	3.5980	3.6900
Wt of Sample (kg) (w_2-w_1)	2.7961	2.9181	2.5241	2.6161
Bulk Density (kg/m^3)	1617	1688	1460	1513
Average	**1653(kg/m^3)**		**1487(kg/m^3)**	

Table 4.2.2 BULK DENSITY OF FINE AGGREGATE

	Compacted		Un-compacted	
Test No	Test 1	Test 2	Test 1	Test 2
Wt of empty Cylinder (w_1) kg	1.0739	1.0739	1.0739	1.0739
Vol of Container (vo) ($x10^{-3}$)	1.7289	1.7289	1.7289	1.7289
Wt of Sample divider + sample (w_2)	4.1100	3.9990	3.6680	3.8400
Wt of Sample (kg) (w_2-w_1)	3.0361	2.9251	2.5941	2.7661
Bulk Density (kg/m^3)	1756	1692	1500	1600
Average	**1724(kg/m^3)**		**1550(kg/m^3)**	

Table 4.2.3 BULK DENSITY OF CEMENT

Test No	Test 1	Test 2
Wt of empty Cylinder (w_1) kg	1.0739	1.0739
Vol of Container (vo) ($x10^{-3}$)	1.7289	1.7289
Wt of Sample divider + sample (w_2)	3.6200	3.5090
Wt of Sample (kg) (w_2-w_1)	2.5461	2.4351
Bulk Density (kg/m3)	1473	1408
Average	**1441(kg/m3)**	

4.3.0 MOISTURE CONTENT

The summaries of moisture content test results of the entire fine aggregate used in this research are been presented in the table 4.30 and 4.31.

Table 4.3.1 Summary of moisture content for the Sand.

CAN No	1	2	3
Wt of CAN (g)	21.30	31.20	25.20
Wt of CAN + wet Sample (g)	55.60	68.30	82.18
Wt of CAN + dry Sample (g)	55.20	67.90	81.56
Wt of Moisture (g)	0.40	0.40	0.62
Wt of dry Sample (g)	33.90	36.70	56.36
Moisture content	1.180	1.09	1.10

Table 4.3.2 Summary of moisture content for the Quarry Dust.

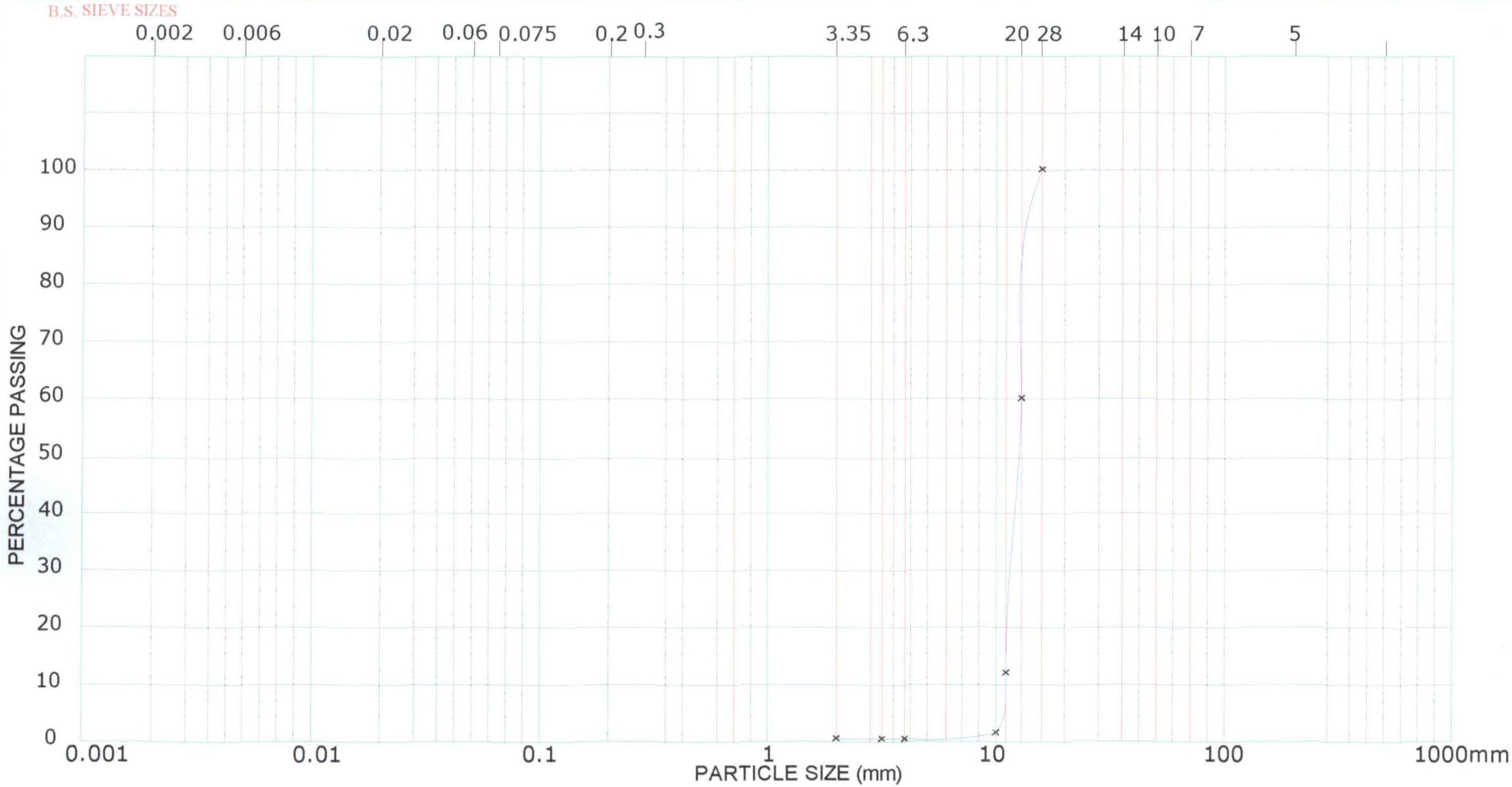
CAN No	1	2	3
Wt of CAN (g)	31.10	26.50	28.20
Wt of CAN + wet Sample (g)	52.20	35.10	43.37
Wt of CAN + dry Sample (g)	52.20	35.00	43.20
Wt of Moisture (g)	0.00	0.10	0.17
Wt of dry Sample (g)	21.00	8.40	15.00
Moisture content	0.00	1.19	1.10

4.4.0 SIEVE ANALYSIS

Table 4.4.1 Particle size analysis for coarse aggregate

Weight of sample: 1000g

Sieve No	Weight Retained	Cum. Weight Retained	% Retain	Cum. % Retain	% Passing
28.0mm	0	0	0	0	100
20.0mm	403.2	403.2	40.32	40.32	59.68
14.0mm	476.5	879.7	47.65	87.97	12.03
10.0mm	107.2	986.9	10.72	98.69	1.31
6.30mm	12.6	999.5	1.26	99.95	0.05
5.00mm	0.0	999.5	0.00	99.95	0.05
3.35mm	0.0	999.5	0.00	99.95	0.05
Pan	0.5	1000	0.05	100	0



CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL	COBBLES	BOULDERS

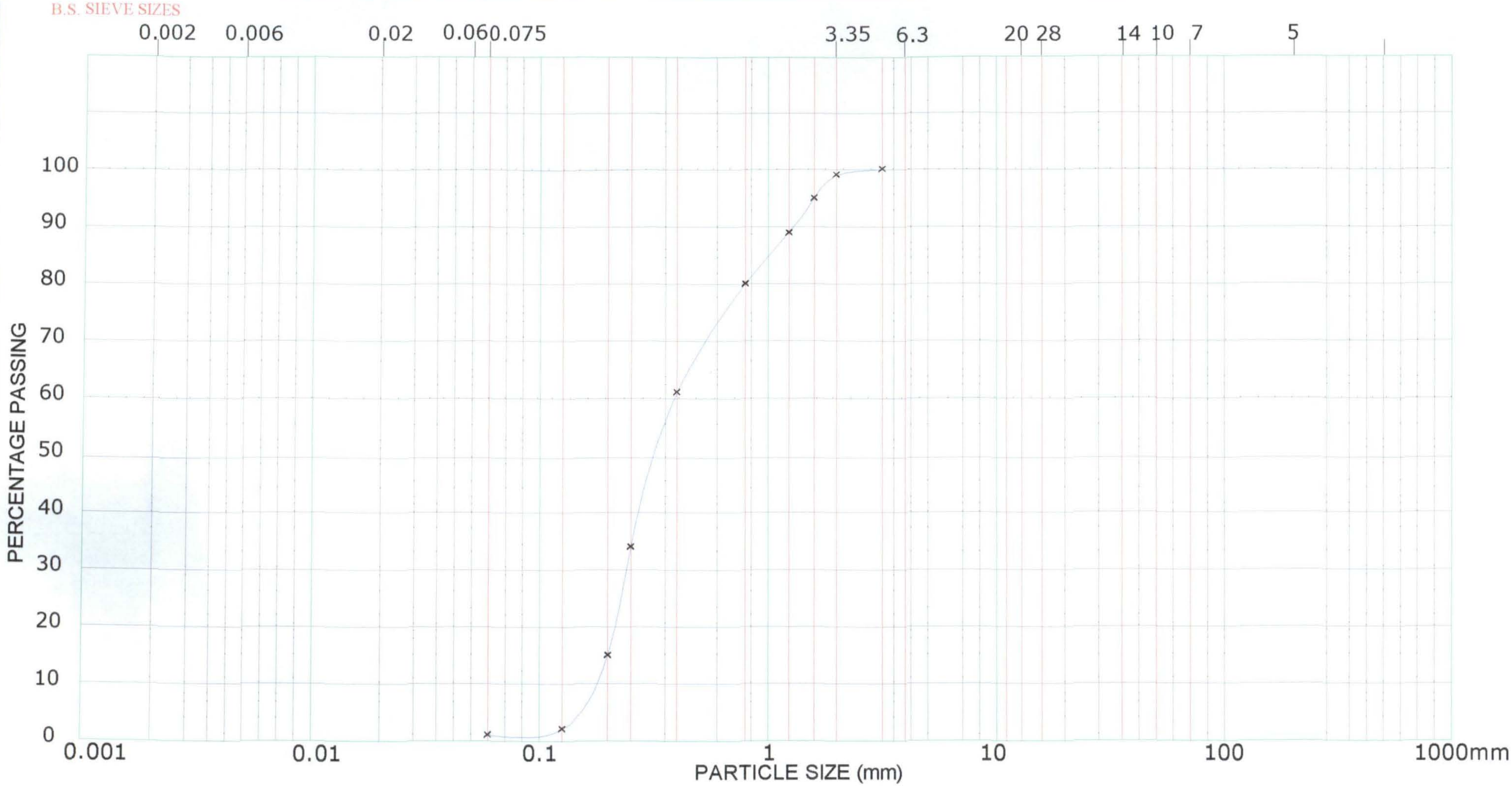
Specimen Identification	Description of sample	Sample Depth (m)	EMC %	LL %	PL %	PI %	No. 5	No. 7	No. 10	No. 14	No. 18	No. 25	No. 36	No. 52	No. 72	No.100	No.150	No.200	CLAY %	C KN/m	Ø	Perme-ability mm/sec	Specific Gravity (mg/m^3)
GRAVEL	CRUSHED GRAVEL	0.6						93.7	89.0	86.9		81.3	80.8		73.1	71.2		67.7					2.58

Fig 2: Particle Size Distribution Curve for Coarse Aggregate

Table 4.4.2 Particle size analysis for Sand.

Weight of sample: 500g

Sieve No	Weight Retained	Cum. Weight Retained	% Retain	cum. % Retain	% Passing
5.00mm	0	0	0.00	0.00	100.00
3.35mm	4.4	4.4	0.88	0.88	99.12
2.00mm	17.2	21.6	3.44	4.32	95.68
1.18mm	34.2	55.8	6.84	11.16	88.84
850µm	41.2	97	8.24	19.40	80.60
600µm	98.1	195.1	19.62	39.02	60.98
425µm	134	329.1	26.80	65.82	34.18
300µm	98	427.1	19.60	85.42	14.58
150µm	64	491.1	12.80	98.22	1.78
75µm	5.8	496.9	1.16	99.38	0.62
pan	3.1	500	0.62	100.00	0.00



CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL	COBBLES	BOULDERS

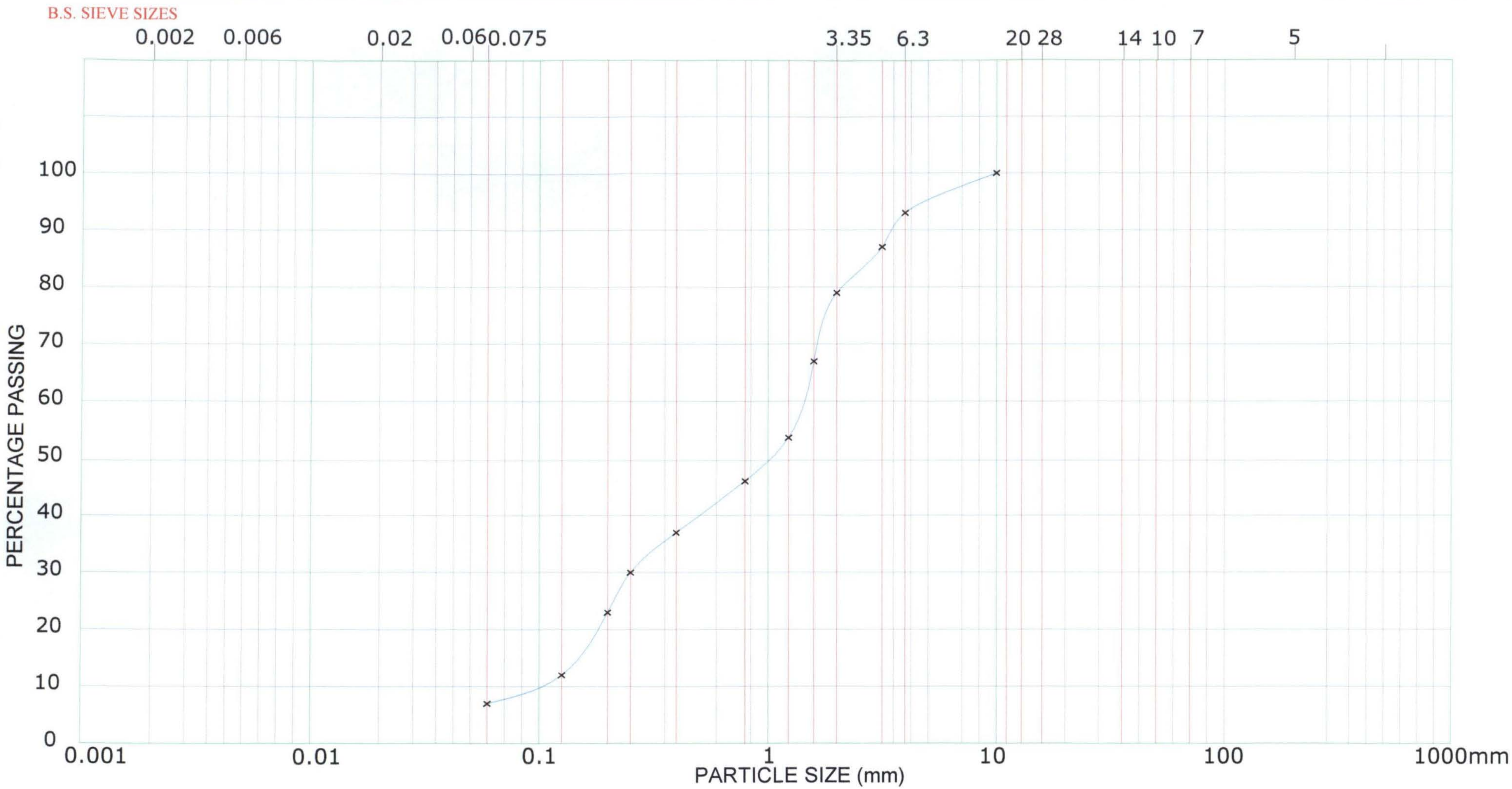
Specimen Identification	Description of sample	Sample Depth (m)	EMC %	LL %	PL %	PI %	No. 5	No. 7	No. 10	No. 14	No. 18	No. 25	No. 36	No. 52	No. 72	No.100	No.150	No.200	CLAY %	C KN/m	Ø	Perme-ability mm/sec	Specific Gravity (mg/m^3)
SAND	SHARP SAND	0.6						93.7	89.0	86.9		81.3	80.8		73.1	71.2		67.7					2.58

Fig 3: Particle Size Distribution Curve for Fine Aggregate

Table 4.4.3 Particle size analysis for Quarry dust.

Weight of sample: 861.4g

Sieve No	Weight retained	Cum. Weight retained	% retain	cum. % retain	% passing
10.00mm	0	0	0.00	0.00	100.00
6.30mm	61.6	61.6	7.15	7.15	92.85
5.00mm	48.1	109.7	5.58	12.74	87.26
3.35mm	71.5	181.2	8.30	21.04	78.96
2.00mm	102.5	283.7	11.90	32.93	67.07
1.18mm	112.5	396.2	13.06	45.99	54.01
850µm	67.7	463.9	7.86	53.85	46.15
600µm	77.3	541.2	8.97	62.83	37.17
425µm	61.8	603	7.17	70.00	30.00
300µm	58.4	661.4	6.78	76.78	23.22
150µm	97.3	758.7	11.30	88.08	11.92
75µm	40.3	799	4.68	92.76	7.24
pan	62.4	861.4	7.24	100.00	0.00



CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL	COBBLES	BOULDERS

Specimen Identification	Description of sample	Sample Depth (m)	EMC %	LL %	PL %	PI %	No. 5	No. 7	No. 10	No. 14	No. 18	No. 25	No. 36	No. 52	No. 72	No.100	No.150	No.200	CLAY %	C KN/m	Ø	Perme-ability mm/sec	Specific Gravity (mg/m³)
QUARRY DUST	FINE GRADED QUARRY DUST	0.6						93.7	89.0	86.9		81.3	80.8		73.1	71.2		67.7					2.58

Fig 4: Particle Size Distribution Curve for Quarry Dust

4.5.0 WORKABILITY OF CONCRETE

The Summary of Results on the workability of concrete are as presented in the table 4.5.1 below:

Table 4.5.1 Slump Test

% Sand Replacement with Quarry Dust	Slump (mm)
0% Quarry Dust	16
25% Quarry Dust	15
50% Quarry Dust	13
75% Quarry Dust	10
100% Quarry Dust	07

4.6.0 COMPRESSIVE STRENGTH

The results of compressive strength of the concrete cubes are as presented in tables below:

Table 4.6.1: 0% Quarry Dust and 100% Sand

`Cube Marks	Area of cubes	Date cast	Age of testing	Date tested	Wt of cubes	Density of cubes (kg/m^3)	Crushing load(KN)	Crushing strength (N/mm^2)	Mean crushing strength
A1	150 x150	20/9/11	28	19/10/11	7.60	2251.85	478.00	21.24	
A2	150 x150	20/9/11	28	19/10/11	7.10	2103.70	426.00	18.93	
A3	150 x150	20/9/11	28	19/10/11	7.30	2162.96	475.00	21.11	
A4	150 x150	20/9/11	28	19/10/11	7.50	2222.22	436.00	19.38	
A5	150 x150	20/9/11	28	19/10/11	7.40	2192.59	475.00	21.11	
A6	150 x150	20/9/11	28	19/10/11	7.50	2222.22	468.00	20.80	
A7	150 x150	20/9/11	28	19/10/11	7.32	2168.89	456.00	20.27	
A8	150 x150	20/9/11	28	19/10/11	7.44	2204.44	474.00	21.07	
A9	150 x150	20/9/11	28	19/10/11	7.40	2192.59	472.00	20.98	
A10	150 x150	20/9/11	28	19/10/11	7.20	2133.33	436.00	19.38	**20.43**

Table 4.6.2: 25% Quarry Dust and 750% Sand

Cube Marks	Area of cubes	Date cast	Age of testing	Date tested	Wt of cubes	Density of cubes (kg/m^3)	Crushing load(KN)	Crushing strength (N/mm^2)	Mean crushing strength
B1	150 x150	20/9/11	28	19/10/11	7.86	2328.89	500.00	22.22	
B2	150 x150	20/9/11	28	19/10/11	7.68	2275.56	478.00	21.24	
B3	150 x150	20/9/11	28	19/10/11	7.54	2234.07	470.00	20.89	
B4	150 x150	20/9/11	28	19/10/11	7.59	2248.89	500.00	22.22	
B5	150 x150	20/9/11	28	19/10/11	7.60	2251.85	474.00	21.07	
B6	150 x150	20/9/11	28	19/10/11	7.77	2302.22	470.00	20.89	
B7	150 x150	20/9/11	28	19/10/11	7.48	2216.30	472.00	20.98	
B8	150 x150	20/9/11	28	19/10/11	7.56	2240.00	480.00	21.33	
B9	150 x150	20/9/11	28	19/10/11	7.60	2251.85	474.00	21.07	
B10	150 x150	20/9/11	28	19/10/11	7.44	2204.44	476.00	21.16	**21.31**

Table 4.6.3: 50% Quarry Dust and 50% Sand

Cube Marks	Area of cubes	Date cast	Age of testing	Date tested	Wt of cubes	Density of cubes (kg/m^3)	Crushing load(KN)	Crushing strength (N/mm^2)	Mean crushing strength
C1	150 x150	20/9/11	28	19/10/11	7.50	2222.22	526.00	23.38	
C2	150 x150	20/9/11	28	19/10/11	7.40	2192.59	516.00	22.93	
C3	150 x150	20/9/11	28	19/10/11	7.38	2186.67	512.00	22.76	
C4	150 x150	20/9/11	28	19/10/11	7.42	2198.52	510.00	22.67	
C5	150 x150	20/9/11	28	19/10/11	7.51	2225.19	490.00	21.78	
C6	150 x150	20/9/11	28	19/10/11	7.48	2216.30	500.00	22.22	
C7	150 x150	20/9/11	28	19/10/11	7.44	2204.44	510.00	22.67	
C8	150 x150	20/9/11	28	19/10/11	7.52	2228.15	514.00	22.84	
C9	150 x150	20/9/11	28	19/10/11	7.40	2192.59	398.00	17.69	
C10	150 x150	20/9/11	28	19/10/11	7.52	2228.15	500.00	22.22	**22.12**

Table 4.6.4: 75% Quarry Dust and 25% Sand

Cube Marks	Area of cubes	Date cast	Age of testing	Date tested	Wt of cubes	Density of cubes (kg/m^3)	Crushing load(KN)	Crushing strength (N/mm^2)	Mean crushing strength
D1	150 x150	20/9/11	28	19/10/11	7.06	2091.85	504	22.40	
D2	150 x150	20/9/11	28	19/10/11	7.72	2287.41	510	22.67	
D3	150 x150	20/9/11	28	19/10/11	7.70	2281.48	508	22.58	
D4	150 x150	20/9/11	28	19/10/11	7.68	2275.56	598	26.58	
D5	150 x150	20/9/11	28	19/10/11	7.74	2293.33	518	23.02	
D6	150 x150	20/9/11	28	19/10/11	7.66	2269.63	528	23.47	
D7	150 x150	20/9/11	28	19/10/11	7.70	2281.48	504	22.40	
D8	150 x150	20/9/11	28	19/10/11	7.74	2293.33	512	22.76	
D9	150 x150	20/9/11	28	19/10/11	7.60	2251.85	500	22.22	
D10	150 x150	20/9/11	28	19/10/11	7.68	2275.56	508	22.58	**23.07**

Table 4.6.5: 100% Quarry Dust and 0% Sand

Cube Marks	Area of cubes	Date cast	Age of testing	Date tested	Wt of cubes	Density of cubes (kg/m^3)	Crushing load(KN)	Crushing strength (N/mm^2)	Mean crushing strength
E1	150 x150	20/9/11	28	19/10/11	7.70	2281.48	530.00	23.56	
E2	150 x150	20/9/11	28	19/10/11	7.60	2251.85	528.00	23.47	
E3	150 x150	20/9/11	28	19/10/11	7.52	2228.15	536.00	23.82	
E4	150 x150	20/9/11	28	19/10/11	7.50	2222.22	526.00	23.38	
E5	150 x150	20/9/11	28	19/10/11	7.70	2281.48	530.00	23.56	
E6	150 x150	20/9/11	28	19/10/11	7.50	2222.22	528.00	23.47	
E7	150 x150	20/9/11	28	19/10/11	7.54	2234.07	524.00	23.29	
E8	150 x150	20/9/11	28	19/10/11	7.56	2240.00	526.00	23.38	
E9	150 x150	20/9/11	28	19/10/11	7.70	2281.48	530.00	23.56	
E10	150 x150	20/9/11	28	19/10/11	7.50	2222.22	520.00	23.11	**23.46**

Table 4.6.6 Summary of the results Obtained

Age (Days)	% Sand Replacement with Quarry Dust	Mean compressive strength N/mm^2	% increase in compressive strength	Mean density kg/m^3
28	0	20.43	0	2185.479
28	25	21.31	4.31	2255.407
28	50	22.12	8.27	2209.484
28	75	23.07	12.92	2260.148
28	100	23.46	14.83	2246.517

4.7.0 WATER ABSORPTION

Summary of the results on water absorption test are presented in the table 4.7.1 below:

Table 4.7.1 Summary of water absorption test

% Replacement of Sand with Quarry Dust	Test no	Weight of saturated surface dry sample(kg)	Weight of oven dry sample (kg)	Increase in Weight (kg)	Water Absorption	Average water Absorption
0	1	8.31	7.60	0.71	0.093	0.10
	2	7.81	7.10	0.71	0.100	
	3	8.01	7.30	0.71	0.097	
25	1	8.73	7.86	0.87	0.111	0.11
	2	8.54	7.68	0.86	0.112	
	3	8.41	7.54	0.87	0.116	
50	1	8.48	7.50	0.98	0.131	0.13

	2	8.38	7.40	0.98	0.132	
	3	8.36	7.38	0.98	0.133	
75	1	8.16	7.06	1.10	0.156	0.15
	2	8.83	7.72	1.11	0.143	
	3	8.81	7.70	1.11	0.144	
100	1	9.05	7.70	1.35	0.175	0.18
	2	8.94	7.60	1.34	0.176	
	3	8.86	7.52	1.34	0.178	

Increase in Weight = Weight of saturated surface dry sample - Weight of oven dry sample

Water Absorption = Increase in Weight ÷ Weight of oven dry sample

Average water Absorption = Summation of Water Absorption of three samples ÷ 3

4.9.0 DISCUSSION OF RESULTS

4.9.1 Specific Gravity

The specific gravities obtained from both fine and coarse aggregates are within the range which ensures uniform mix and non segregation of constituent materials in concrete mix.

The specific gravities of aggregates are used in the calculation of quantities of materials required in mix design when American method of Mix design is deployed, which states that:

$V_C = W/1000 + C/(1000xS_C) + Fa/(1000xS_{fa}) + Ca/(1000xS_{ca}) + Va$ ......eq 2

However, in this research work, the Direct Approach method was used in determining the quantities of materials required. See item 3.3

4.9.2 Bulk Density

From the result of bulk density tests shown in table 4.2, it is found that uncompacted weight has a less bulk density than compacted weight. However, the uncompacted bulk density was adopted for this research work because constituent materials are uncompacted during the batching process.

The bulk density of a material was used in determining the quantities of materials required in mix design using British method.

4.9.3 Absorption

The result obtained from table 4.7.1 shows that the rate at which water is been absorbed in concrete with percentage replacement of sand with quarry dust increases with an increase in percentage of sand been replaced. This is expected because Quarry Dust has a large surface area than sharp sand.

4.9.4 Moisture Content

Results of moisture content test performed on the Quarry Dust gives a value of moisture content of Zero (0) at first trial. This is much expected because the Quarry Dust is very dry and has a high degree of water absorption. The moisture content of this range means that the Quarry Dust will absorb high amount of water from the concrete and therefore, this situation caused a reduction in the workability of concrete to some an extent.

4.9.5 Sieve Analysis

Sieve analysis otherwise called particle size distribution is the separation of an aggregate into fractions through the openings of standard test sieves. Table 4.4.1 gives the results of the sieve analysis performed on coarse aggregate while Table 4.4.2 and Table 4.4.3 give the results of the sieve analysis performed on sand and Quarry Dust respectively.

Curves were plot (Grading Curves) for both coarse aggregates, fine aggregates (Sand) and Quarry Dust as shown in fig 2, 3 and 4 respectively. Aggregate do not rigidly conform to particular Grading Curves but they fall within certain zones referred to as the Grading Zones, though most times the Grading do not fall completely within the normal zones for the standard aggregate, hence what is referred to as the gap grading in which one or more intermediate size fractions are omitted.

Base on the graph obtained, fine aggregate (Sand) and Quarry Dust graphs are both well-graded aggregates because well-graded aggregate is an aggregate that have a reasonable amount of aggregate retained on each sieve, while the coarse aggregate is poorly-graded aggregate.

4.9.6 Slump Test

The results presented in Table 4.5.1 give values of lump to be between 7mm to 16mm. The values of slumps decrease as the percentage replacement of sand increases which conforms with the statement made on last sentence of section 1.1 "Though Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete". However, it still shows fairly workability of the concrete, in terms of placing and compacting of the concrete.

4.9.7 Compressive Strength

The Table 4.6.6 shows the summary of the results obtained from the compressive strength tests of the concrete cubes and for the various percentage replacement of sand with quarry dust. It could be observed from the result that the compressive strength of the concrete increased with increase percentage of Quarry.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

From the experimental results obtained in this project the following can be deducted as the conclusion of this research work;

1. The compressive strength of the cubes increases with increase in percentage replacement of sand with quarry dust at 28 days.

2. The percentage increase in compressive strength of the concrete at 28 days gives value from 4% to 15% increment in strength (see table 4.6.6).

3. Percentage water absorption in the concrete cube increases with an increase in Quarry Dust content.

5.2 RECOMMENDATIONS

Based on the experiment carried out, the following recommendations were made;

1. 50% to 75% quarry dust could be used to replace sand in concrete, where average compressive strength of about 8 - 12% increase in strength is required.

2. 25% to 50% quarry dust replacement for sand gives lesser percentage of water absorption when compare with 75% to 100% quarry dust replacement, this range of replacement (25% to 50% quarry dust replacement) can be used to replace sand in any water retaining structure.

3. For economic consideration, quarry dust is expensive compared to sand, it is advisable to replace sand with 25% – 75% quarry dust in civil engineering works depending on the nature of civil engineering structure to attain an average strength.

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