EFFECT OF PARTIAL REPLACEMENT OFCOARSEAGGREGATE WITH RECYCLED AGGREGATE ON CONCRETE

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ENG1503708

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN

DEPARTMENT OF STRUCTURAL ENGINEERING

FACULTY OF ENGINEERING

UNIVERSITY OF BENIN

BENIN CITY

JULY,2021.

CERTIFICATION

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DEDICATION

This work is dedicated to Almighty God for his love and inspiration for the success of this project. This work is also dedicated to my family loved once for their love and support towards the pursuit of academic excellence. To my supervisor, who guided and directed me throughout the project duration.

ACKNOWLEDGEMENT

I'm grateful to God almighty for seeing me through this tough journey .It wasn't easy! I thank God for His mercy, guidance, love, wisdom, strength and excellence during this time.

I express my gratitude to my late dad, Mr. Frederic Enato, for your love, care, and support during hard times.Thank you very much sir, I am grateful this would not have been possible without you.

To my siblings, Mr.Osaro Enato, Mrs. Stella Umorkhoro, Mr. Enato Obehi, Mr Enato Sebastine, Mr. Peter Enato, Mrs Patricial Onabulele, I thank you all for everything. You all have loved and cared for me as older siblings and I am grateful.

Special thanks to Engr.James Umorkhoro for your care, support and love. I would also like to thank my project supervisor Engr. Jeffrey Ogbeide for his utmost support and wisdom in making sure that this project went smoothly.

My profound gratitude goes to the Head of Department: Engr. (Dr) S. D. Iyeke, Engr Prof O. U. Orie., Engr (Dr) Ebuka Nwankwo, Engr Ukeme, Engr (Dr) Mrs. Ngozi Kayode Ojo, Engr (Dr) Ebuka Nwankwo, Engr Ukeme Engr (Dr) Roland ogirigbo, and Engr Blessing as well as all the wonderful lecturers in the department for their positive support and assistance in the undergoing of this project , thank you.

I also want to specially appreciate all my friends and colleagues whose support in one way or the other led to the successful completion of this work.

ABSTRACT

This work investigated the possibility of using waste concrete materials as partial replacement for coarse aggregates in concrete work and some of the properties of Recycled concrete aggregates.

The Recycled concrete aggregate used was gotten from waste samples in the laboratory of the Department of Civil/Structural Engineering of the University of Benin. These samples were dried and crushed, they were used to replace Natural Coarse Aggregate under different percentage of 0%, 20%, 40%, 60%. The test done was Aggregate Impact Value (AIV), Sieve Analysis, Slump Test, Compressive Strength and Split Tensile Strength Test. With a total of 36 cubes and 36 cylinder made, curing age of 7, 14 and 28 days were used to investigate the strength of the concrete made.

The results obtained show that the aggregate impact value of Natural coarse Aggregate was 27.43% and that of Recycled concrete Aggregate 35%. Slump value for 0%, 20%, 40%,60% are 40.50, 30.50, 30.30, 30.70mm. The compressive strength test of 0% is 23.30N/mm^2 at 28 days, 20% is 28.11 N/mm^2 at 28 days, 40% is 20.10N/mm^2 at 28 days, 60% is 26.96 N/mm^2 at 28 days, and the split tensile strength of 0% is 2.69 N/mm^2 at 28 days, 20% is 2.75 N/mm^2 at 28 days, 40% is 1.78 N/mm^2 at 28 days, 60% is 2.18 N/mm^2 at 28 days.

It was seen that Recycled concrete aggregate (RCA) decreases with increase in percentage of replacement and the maximum or optimum strength was obtained at 20% replacement.

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CHAPTER ONE

INTRODUCTION

1.0 Background of study

In the world of construction, concrete like other materials is playing an important role in development. concrete is a composite material which is a mixture of cement, fine aggregate , coarse aggregate and water. Concrete is a compound material used in buildings. Cements is a material that needs 1 to 1.5 metric ton of lime; uses a lot of energy for its production, around 4000MJ/metric ton and releases 0.8 to 2 metric ton of carbon dioxide to the atmosphere to produce the clicker (Kumar et al, 2006). The major constituents of which is natural aggregate such as gravel, sand, alternatively artificial aggregates such as sand furnace slag, fly ash, expanded clay, broken bricks and steel may be used where appropriate. It possesses many advantages including low cost, general availability of new material, adaptability, low energy requirement and utilization under different environmental conditions. Concrete is everywhere. It is the second most consumed material after water and it shapes our built environment. Thus, the necessity of finding appropriate solution to construction and demolition must be clear. Reducing, reusing and recycling appear to be profitable alternatives that will increase the lifetime of landfills an reduce exploration of natural resources (Ryu,et al 2002).

Aggregate is a mixture of materials in the concrete mix. It is a mixture of basic material in which the content are composed of water, cement and additives. Because the total quantity of aggregate found in a concrete mix is large, the strength and durability of concrete depend on the characteristics aggregate itself. It is known that concrete strength decreases with increasing water ratio of the design in terms of a ratio of cement to aggregate. (Athanas, et al 2011).

Aggregates are chemically inert materials which when bonded by cement paste to form concrete constitute the bulk of total volume of concrete & hence they influence the strength of concrete to a great extent. Depending upon their size, Aggregate are classified as fine aggregate and coarse aggregate. Normally, the strength of a concrete can be determined through water content and the quality of cement. Besides other conditions that affect are catalysts, temperature, type of mold. In Malaysia, the construction waste has cause a significant impact on the environment and also increasing the concern of the society (Chetna,et al 2006).

1.2Statement of problem

The development of new construction techniques and designs, modeling of structures as well as deterioration causes of varying of environmental conditions, repairing and demolishing of structure is on rise compare to before. With this much repair and demolishing of structure a huge amount of debris are produced. Construction and demolition materials can be recovered through re-use and recycling. The choice of what and how construction and demolition material can be recovered depends on many factors including type of project, working area and space on the site, cost effectiveness of recovery, project timeline and experience of contractor (Limbachiya, et al 2000). One of the major challenges of our present society is the protection of environment. Some of the important elements in this respect are the reduction of the consumption of energy and natural raw materials and consumption of waste materials. These topics are getting considerable attention under sustainable development nowadays. The use of recycled aggregates from construction and demolition wastes is showing prospective application in construction as alternative to primary (natural) aggregates. It conserves natural resources and reduces the space required for the landfill disposal.

The main problem of this project work is to determine whether these crushed concrete can be re-used for the production of new concrete.

1.3 Aim and Objectives

The aim of the work is to explore the effects of partial replacement of coarse aggregate with recycled aggregate on concrete both in fresh and hardened state.

The follow objectives were met;

i. To partially replace the granite in concrete work with varying percentage of crushed concrete.

ii. To determine the physical and mechanical properties of concrete in the fresh and hardened state.

iii. To determine the extent to which the crushed concrete aggregate can be used as partial replacement of granite in concrete work.

iv. To reduce the demand of Natural Coarse Aggregate.

1.4 Scope of study

This project research was made to investigate the use of recycled aggregates, its strength, its weakness and the overall effectiveness when the natural aggregate is replaced by recycled aggregate at particular proportions.

1.5 Significance of study

The increase in the production of concrete in recent years has led to the decrease of our natural aggregate. In these situations, it is not appropriate to rely on one source of aggregate with continuing increase in demand and it will cause the shortage of natural aggregate in future. Thus, other alternatives should be established for the preparation of the possible effects on the aggregate demand in the future.

Therefore, this study investigate the effectiveness of the use of crushed concrete produced from concrete waste in order to test the suitability and strength. It is hoped that this research will be the beginning of efforts to use recycled aggregate in construction material in Nigeria.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

Extensive research is being carried out globally on the use of recycled aggregates as a substitute to natural aggregates because it is an efficient way to ensure sustainable development and environment preservation.

Research conducted in the field of recycled concrete aggregate (RCA) so far has revealed in general low compressive and bending strength, durability resulting from higher permeability and more water requirements to achieve same workability, when compare to natural coarse aggregate.

There is little work done on this area of study in this part of the world. However, some researchers have carried out research in area related to this topic outside this continent and their works are review below.

YAN Chunling et al (2016), researches on two-factor analysis on compressive strength of recycle aggregate concrete. It was reported that the recycled coarse aggregate was obtained from waste samples of C30 in the laboratory through crushing, washing and screening and cube compressive strength test was conducted on RCA under different conditions. The results show that the compressive strength of recycled aggregate concrete decreases with the amount of RCA generally increase of the replacement ratio on recycled aggregate in the same water-cement ratio. However, when replacing 50% the natural coarse aggregate, the compressive strength of RCA appears to jump. Tow factor analyses is used to arrange the experiment by taking a full consideration of the factors which have effect on the compressive strength, such as water-cement ratio, coarse aggregate replacement ratio, and the interaction between water-cement ratio an replacement.

Valeria Corinaalesi (2010),investigate the mechanical behavior and elastic properties of recycled aggregate. It was reported that these concretes were prepared by alternatively using two different (coarse and finer coarse) recycled aggregate fractions' both made of recycled concrete coming from a recycling plant in which rubble from demolition is collected and suitably treated. Several concrete mixtures were prepared using only virgin aggregates with recycled aggregate. The correlation between elastic modulus and compressive strength of recycled aggregate concrete was found and compared.

P.J.Nixon (1978), present the state of knowledge on the use of recycled concrete as an aggregate in new concrete is reviewed and suggestions made as to what further work is necessary before a proper assessment of the material can be made. In his report it was stated where crushed uncontaminated concrete is used in the properties of the material as an aggregate and the basic engineering characteristic's if the concrete made with it are well established. Much less is known about the type of impurities which could occur in crushed concrete from general building rubble and the effect these would have on concrete made using such crushed concrete as aggregates.

JianHua et al (2011), researches on the properties of dry mortar with recycled concrete aggregate and powder of crushed clay bricks. It was reported that the sinking degree of fine recycled aggregate (FRA) mortar can be adjusted in the range of 70-90mm and their water-maintainability is superior at various ages decreases, compared to natural sand mortar under the condition of same mixed proportion. Compressive strength of FRA mortar is above 5.0 MPa with mass ratio of aggregate to cement lower than 6.0. Workability of fine recycled powder FRA and crushed clay brick (CCB) mortar is similar to fly ash mortar and their apparent densities are under the 2.0g/cm3. Compressive strength of FRP and CCB mortar is near to 8.5MPa at 28 days of age.

JianZhuang Xiao et al, (2012) developed a report that provides a compressive review of the related findings of research on mechanical properties of RCA in china. On their report, the influence of the recycled aggregate on the strength and deformation characteristic’s of concrete, the statistical chaRCAteristics for the strength of RCA, stress-strain relationships under uniaxial compression, uniaxial tension as well as pure shear were all discussed.

L Evangelista et al, (2007), reported that the use of fine recycled concrete aggregate to partially replace natural fine aggregate in the production of structural concrete. To evaluate the process, an experimental procedure was implemented in order to monitor the mechanical behavior of such concrete. The results of the test are reported as; compressive strength split tensile strength, modulus of elasticity an abrasion resistance. From the result obtained it was concluded that the use of fine recycled concrete result, particularly if finer coarse recycle concrete aggregate is added to the mixture, lower strains could be detected especially for earlier curing time.

Diogo Pedro et al, (2015), reported that the mechanical an durability performance of concrete made with coarse recycle concrete aggregates obtained using two crushing processes: Primary crushing (PC) and the primary plus secondary crushing (PSC). The RA used resulted from precast products with strength classes of 20MPa,45MPa, 65MPa, and from the laboratory made concrete with the same compressive strength. The evaluation of concrete was made with the following tests: Compressive strength; splitting tensile strength; modulus of elasticity; Carbonation aggregates does not jeopardize the mechanical properties of concrete, for replacement ratio of 30%.

AhsanulKabir et al,(2015),study the effect of normal and higher cement proportion on the properties of concrete made with recycled concrete aggregate without adding any water reducing admixture. In his report workability and concrete strength was the principal target of investigation. Recycled aggregates were prepared from the concrete laboratory wastes of concrete cylinder/cubes dumped after routine strength tests in the lab courtyard for disposal. Waste concrete cylinders were usually tested at their 28^{th}days strength but their waste life span in the courtyard ranged from 2 months to 2 years. Several sets of RCA were made by varying the percentage of RCA from zero to 100%. After Mixing the RCA in different proportions with required amount of Fine Aggregate, three different water cement ratio (w/c) of 0.41,0.46,0.5 were used for each group of mix proportion. The result of the test show that there was relatively low slump for concrete mixes with normal cement content of 370g/cm3 for w/c less than 0.5. But workability increased reasonably with higher cement for all the mixes. Strength gain pattern with ages was found to be similar to normal aggregate concrete in all cases with different RCA replacement. Concrete strength with RCA was found to be lower compared to natural aggregate concrete (NAC) for normal cement content. But 30% increase in cement concrete strengths increased and were found comparable for all RCA replacements with that of NAC for a particular age.

Ajibola I Tijani et al,(2015),report on enhancing the performance of recycled aggregate concrete with micro silica. It was discussed that recycled aggregate was used in the replacement for crushed gravel between 0-100% with an increment of 25%. Synthetic macro fibre and micro silica were added to some of the concrete mixes to improve their mechanical properties. The results of the test show reduction in the physical and mechanical properties with increasing recycled aggregate content. Addition of synthetic macro fiber had no significant effect on the concrete compressive strength. However, the concretes with synthetic macro fibre had higher flexural strength, splitting tensile strength, and elastic modulus compared with those without synthetic macro fibre. Addition of 5% micro silica to the mix with50% recycled coarse aggregate produced a 28-day compressive strength slightly higher than the target mean compressive strength of 63MPa.

Jose MV Gomez-Soberon (2002) present an experimental analysis of samples of recycled aggregate(RC) with replacement of natural aggregate (NA) by recycled aggregate originating from concrete. The results of the tests of mechanical properties of RC were used for comparison with rests of mercury intrusion porosimetry (MIP), in which the distribution of the theoretical pore radius pore ratio, the surface area of the concrete, threshold ratio and average pore radius were studied at ages of 7, 28, and 90 days. The results discussed show some variation in the properties of the RC with respect to natural concrete.

MostafaTavakoli et al, (1996) experimented to determine the compressive, splitting tensile, and flexural strengths of recycled coarse aggregate concrete and to compare them with those of concrete made using natural crushed stone. The properties of the aggregate were also compared. The fine aggregate for recycled and conventional concrete was 100% natural sand. Two sources of recycled aggregate (concrete pavement from U.S.23 and 1-75 projects in Michigan) and one source of natural aggregate (crushed limestone) were used. Two maximum sizes of aggregates, two levels of water-cement ratio, and two levels of dry mixing time of coarse aggregate were selected to perform the experiments based on a full factorial design. The results shows that the strength chaRCAteristics of recycled aggregate concrete are influenced by key factors, such as the strength of the original concrete, the ratio of coarse to fine aggregate in the original concrete to that of the recycled aggregate, and the Los Angeles abrasion loss and water absorption of recycled aggregate.

Torben C et al,(1983) studied the compressive strength of hardened concretes made from recycled concrete aggregates as a function of the compressive strength of original concretes from which the coarse aggregate where derived. Also studied the properties of fresh concrete made from recycled aggregates, grading of crusher products, properties of recycled aggregates and the amount of old mortar that remains attached to various grades and size fraction of recycled aggregate. It was found that the compressive strength of recycled concrete is largely controlled by the water-cement ratio of the original concrete when other factors are essentially identical. If the water-cement ratio of the original concrete is the same as or lower than that of the recycled concrete, the new strengths will be as or better than the original strengths and vice versa.

DENG Xu-hua (2005) investigates the water-cement ratio on effects of compressive strength of natural and recycled aggregate concrete. The results gotten from the test shows that compressive strength of concrete concerns water cement ratio very nearly. When water-cement ratio is above 0.57, compressive strength of recycled aggregate decreases with water-cement ratio increased. This is similar to one of natural concrete. However when water-cement is below 0.57, compressive strength of recycled aggregate concrete increases with water cement ratio increased.

N. Fonseca et al,(2011) studied the influence of different curing conditions on the mechanical performance of concrete made with coarse recycled aggregate from crushed concrete. The properties analyzed include compressive strength, splitting tensile strength, modulus of elasticity, and abrasion resistance, and concluded that the mechanical performance of recycled aggregate concreted is affected by curing conditions in the same way as conventional concrete.

Cesar Medina et al,(2014) studied the influence of mixed recycled aggregate on physical-mechanical properties of recycled concrete. The mixed recycled aggregate used had a high asphalt an floating material content. Workability, density, compressive and tensile strength, water absorption and sorptivity were studied in a series of concretes containing 25 or 50% of the recycled aggregate with and without floating materials. The results showed that using up to 50% of the recycled aggregate ha no adverse effects on fresh concrete workability. Most of the physical and mechanical properties of hardened concrete were observed to decline with rising recycled aggregate replacement ratios and floating particle content. Overall, considering the strength and other properties achieved, the concrete containing the mixed recycled aggregates studied were found to be apt for housing construction.

The function of aggregate has the influence of the construction quality; therefore, the type and quality of aggregate are very important to be concerned. The fine and coarse aggregates generally use 10% to 25% of the concrete volume and will influence the concrete freshly mixed and hardened properties, mixture proportions, and economy .Moreover, fine aggregate usually consists of natural sand with particles around 4.75mm (0.2 in.); then in terms of coarse aggregate it is usually combination of gravels with particles larger than 4.75mm (0.2 in.) and generally between 9.5mm and 37.5mm (3/8 in. and 11/2 in.) (Gomez, 2003). Then, the natural aggregate consists of gravel and sand can be used after those materials through processing. The process of materials for natural aggregate is only minimal process through the dug from a pit, lake, river, (Gomez, S.M 2003).

2.1 Crushed aggregate concrete

The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled aggregates produced from all but the poorest quality original concrete can be expected to pass the same test required of conventional aggregates. Recycled aggregate can be batched, mixed, transported, placed and compacted in the same manners as conventional concrete. Special care is necessary when using fine recycled aggregate. Only up to 10% - 20% recycled fine aggregate is beneficial. The aggregate should be tested at several substitution rates to determine the optimal rate.

2.2 Size distribution

Generally, a series of successive crushers are used, with oversize particles being returned to the respective crusher to achieve desirable grading. The best particle distribution shape is usually achieved by primary crushing and then secondary crushing, but from an economic point of view, a single crushing process is usually most effective. Primary crushing usually reduces the Construction and Demolition concrete rubble to about 50 mm pieces and on the way to the second crusher, electromagnets is used to 2006)

2.3 Classification of aggregates

Aggregates are generally classified as below

I. Natural Aggregate: Construction aggregates produced from natural source such as granite and sand, and extractive products such as crushed rocks, sand and granite, crushed river granite or gravel.

II. Manufactured Aggregate: Aggregates produced from selected naturally occurring materials, by products of industrial processes. Examples are Formed Blast Furnace slag (FBS), Fly Ash Aggregate, Manufactured sand, Polystyrene Aggregate (PSA), Expanded Clays, Shale’s and Slates.

III. Crushed Aggregate: Aggregates gotten from the processing of materials previously use in a product and/or in construction, some of the examples are Recycled Concrete Aggregate (RCA), Recycled Concrete and Masonry (RCM), Reclaimed Aggregate (RA), Reclaimed Asphalt Pavement (RAP), Reclaimed Asphalt Aggregate (RAA), Glass Cullet, Scrap tiers, used foundry sand.

2.4 Uses of recycled aggregate concrete

Recycling concrete is a option to decrease the demand on high quality natural resources and to limit the amount of waste that is dispose in landfills. Recycled concrete has been primary used as a unbound material in embankments, bases, and sub-bases. Engineers have also used recycled concrete as an aggregate in the construction of new structures such as concrete pavements but with limited frequency BILAL RIAL et al (2013).

Khan Sajjad Ali (2005) recycled aggregate is used in different parts of pavement systems, like crushed aggregates are used as sub-base and base layer for surfacing low traffic or temporary applications. Its use also improves unstable sub grade material.

Recycled aggregate is also used as bedding material inutility installations, which serves several purposes. For example, it makes the bedding compact easily around [pipes and other features. The bedding also bears and distributes loads from pipes or other conduits. It is also used in shoulders, porous fills, and in limited quantity in concrete for rigid pavement.

2.5 Sources of recycled aggregates concrete

Traditionally, Portland concrete aggregates from the demolition construction are used for 1andfill. But now days, Portland concrete aggregate can be used as a new material for construction. Crushed aggregates are mainly produced from the crushing of Portland concrete structure and buildings as the source for aggregate, because a huge amount of crushed demolition Portland cement concrete can be produced.

2.6. Material properties

2.6.1 Water

Tap water can be used and suitable for manufacturing brick. Water used should be of portable quality if possible. (Kim Basham, PHD PE FACI, 2004) says the amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strength, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life. Water from standing ponds or swamps may be high in organic materials and it is not suitable to use in brick mixture. The mass ratio of water to cement is the main factor that determines the strength of brick.

2.6.2. Cement

The most common hydraulic cement is ordinary Portland cement, a finely pulverized material that develops its binding property using water. The term hydraulic cement is referred as any cement that turns into a solid product in the presence of water, resulting in a material that does not disintegrate in water. The raw materials used to manufacture Portland cement are lime, silica, alumina, and iron oxide. It is manufactured by heating a mixture of limestone and clay until it almost fuses and then grinding the clinker to a fine powder.

2.6.3 Fine aggregate

Fine aggregates are usually sand or crushed stone that are less than 9.55mm in diameter. Sand occurs naturally and is composed of fine rock material particles. Its composition is variable depending on the source. It is defined by size, being finer than gravel and coarser than silt.Fine aggregates is an Aggregate most of which passes 4.75mm IS sieve and contains only so much coarser material as permitted." It may be

i. Natural sand: Fine aggregate resulting from the natural disintegration of rock and which has been deposited by streams.
ii. Crushed stone sand: Fine aggregate produced by crushing hard stone.
iii. Crushed gravel sand: Fine aggregate produced by crushing natural gravel.

CHAPTER THRE

RESEARCH METHODOLOGY

3.0 Introduction

Investigation to determine aggregate impact value, slump test, sieve analysis, compressive test, split tensile test were carried out. The total of thirty six (36) concrete cubes and thirty-six (36) concrete cylinders of different mixes proportions were prepared with varying percentage. From each mixture 3 cubical specimens of 100mm x 100mm x 100mm and 3 cylindrical specimen of 200mm x 100mm were prepared and strength were determined at 7, 14, 28 days of curing ages.

3.1 Batching

An electronic weighing machine was used to obtain various proportions of the constituent materials used for the concrete mix.

3.1.1. Material Used

Materials used includes

1. Ordinary Portland cement
2. Sand
3. Granite
4. Crushed Concrete (used concrete gotten from the lab)
5. Water

Table 3.1: Proposed mixes proportions by weight

S/N	CRUSHED CONCRETE(%)	NATURAL GGREGATE GRANITE (%)
1	0	100
2	20	80
3	40	60
4	60	40

Table 3.1.2 Quantity of materials required for each mix

Materials	**Mix 1 0% of crushed Concrete**	**Mix 2 20% of crushed concrete**	**Mix 3 40% of crushed concrete**	**Mix 4 60% of crushed concrete**
Cement (KG)	7.5	7.5	7.5	7.5
Water (KG)	4.75	5.25	5.25	5.25
Coarse Aggregate (KG)	30	30	30	30
Fine Aggregate (KG)	15	15	15	15

3.2. **Aggregate Impact Value Test**

Aggregates both natural and recycled coarse aggregate was placed on the aggregate impact value apparatus to determine the classification and strength of each aggregates particles. The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock, in which some differs from its resistance to a slow compressive load. The test sample consists of 5mm aggregate (both natural and recycled coarse aggregate) the whole of which passes a 13.5mm sieve and retained on a 5mm sieve. The recycled coarse aggregate test sample was unwashed and dried, but the natural coarse aggregate test sample was dried at room temperature for twenty-four hours. The measure is filled about one-third full with the aggregate and tamped with twenty-five (25) strokes of the rounded end of the tamping rod. A further quantity of aggregates is added and a further twenty-five (25) strokes. The measure is finally filled to overflowing, tamped 25 times and the surplus aggregate is struck off, using the tamping rod as a straight edge. The net weight of aggregate in the measure is determined to the nearest gram (weight M). A cup of 102mm internal diameter and 50mm deep is fixed firmly in position on the base of the machine and the whole sample is placed in it and compacted by tamping with 25 strokes.

The hammer is raised until its lower face is 380mm above the upper surface of the aggregate in the cup, and allowed to fall freely on aggregate. The test sample is subjected to a total of 15 blows each being delivered at an interval of not less than one second. The crushed aggregate is then removed from the cup and the whole of it is sieved in 2.36mm sieve until no further significant amount passes the sieve. The fraction passing the sieve is weighed to an accuracy of 0.1g (weight N). The fraction retained on the sieve is also weighed (weight P) and if the total weight (N +P) is less than the initial weight (M) by more than one gram, the result is discarded and a fresh test is made. Three test are made. The ratio of weight of fines formed the total sample weight in each test are expressed as a percentage, recorded to the first decimal place:

Aggregate Impact Value =N/P x100

Where N =weight of fraction passing 2.36mm sieve.

M =weight of dried sample.

3.3 Sieve Analysis Test

Sieve analysis test (particle size distribution or gradation) was carried out to determine the finest modulus.

The test is done by weighing the mass of the specimen, and arranging the sieve in order, that is the big at the top and the smaller one at the bottom and the specimen is poured into the first sieve. The arranged sieves are placed on the sieve shaker and allowed to shake for 15 minutes. After shaking, the specimen retained on each sieve is weighed.

The cumulative method requires that each sieve beginning at the top be placed in the previously weighed pan, weighed, the next sieve contents is added to the pan, and the total weighed. This process is repeated until all sieves and the bottom pan have been added and weighed.

3.4 Tests on fresh concrete

3.4.1 Slump Test

Slump test is used to measure the consistency of concrete. It is also used to determine the workability of concrete. A slump cone measuring 200mm diameter, 100mm top diameter and 300mm height was used to carry out the test. The cone is damped with oil and placed on a smooth horizontal surface and filled in three layers each. Each layer of concrete is rammed 25 times with a 16mm diameter straight rod. The strokes were distributed uniformly over the cross section of the cone. After ramming the concrete in three layers, the top is leveled with a trowel and the cone is gradually lifted to avoid any disturbance of the concrete mass. The cone is then placed near the settled concrete mass and the slump measured by placing the tamping rod across the top of the cone. The vertical distance from the center of the concrete mass to the bottom of the tamping rod is the slump. The result are given in the next chapter.

3.5 Test on hardened concrete

3.5.1 Compressive test

The specimens are cast in the metallic mold measuring 100mm x 100mm x 100mm. Before the specimen were cast in the mold, the molds are assembled, their meeting surfaces were coated with engine oil and the inside surfaces was also oiled in order to prevent the development of bond between the mold and the concrete.

The mold is then filled with the mixed concrete specimen and compacted with the vibrator table until it is slurry, and then the surface is smoothened with a trowel. The cubes are then stored at room temperature for 24 hours. The cubes are remolded after 24 hours and immediately cure in water for 7, 14, 28 days for this tests

The cube was placed in the universal testing machine (crushing machine), the load was applied to opposite sides of the cube. The load was applied gently at the rate of 15mm^2.and gradually therefore increase in the compression leads to increase in the load till the cube reaches yield limit. Readings are taken as soon as it reaches yield limit.

3.5.2 Split tensile test

The specimens are cast in a rubber cylindrical mold of diameter 100mm x 200mm. The mold was coated with oil before use to prevent adhesion of concrete. The mold is then filled with the mixed concrete specimen and compacted with the vibrator table until it is slurry then the surface of the concrete is smooth with a trowel.

The test specimens are stored at room temperature for 24 hours. After this period the specimen are removed from the mold to be submerged in clean water for 7, 14, 28 days.

The cylindrical sample, of dimension 100mm diameter and 200mm depth was placed in the universal machine to determine the tensile strength and failure which is represented by cracking of cylinder into two halves.

CHAPTER FOUR

PRESENTATION OFRESULT, ANALYSIS AND DISCUSSION

4.0 The results of various tests carried out on this project work are presented and discussed in this chapter.

4.1 Aggregate impact value test results (AIV)

4.1.2 Aggregate Impact Value for 5mm Granite (Natural Aggregate)

Test 1

Wi………………………………0.325g

Wp………………………………0.096g

Wr………………………………0.229g

AIV=Wp/Wi X 100

AIV= 0.096/0.325 X 100 = 29.54%

Test 2

Wi………………………………0.340g

Wp………………………………0.094

Wr……………………………….0.247

AIV= Wp/Wi X 100

AIV= 0.094/0.340 X 100 = 27.64%

Test 3

Wi…………………………………0.346

Wp…………………………………0.088

Wr………………………………….0.258

AIV = Wp/Wi X 100

AIV = 0.088/0.346 X 100 = 25.43%

Average AIV = $\frac{29.54 + 27.64 + 25.43}{3}$

AIV = 27.53%

4.1.3 Aggregate Impact Value for crushed Concrete (Recycled Aggregate Concrete)

Test 1

Wi……………………………………0.289g

Wp……………………………………0.092g

Wr…………………………………….0.198g

AIV = Wp/Wi X 100

AIV = 0.092/0.289 X 100 = 31.83%

Test 2

Wi……………………………………0.290g

Wp…………………………………..0.101g

Wr……………………………………0.190g

AIV = Wp/Wi X 100

AIV = 0.101/0.290 X 100 = 34.83%

Test 3

Wi…………………………………….0.277g

Wp……………………………………0.104g

Wr…………………………………….0.123g

AIV = Wp/Wi X 100

AIV = 0.104/0.277 X 100 = 37.54%

Average AIV = $\frac{31.83 + 34.83 + 37.54}{3}$

=34.73% or 35%

4.2 Sieve **analysis results**

Table 4.2a Sieve Analysis of Fine Aggregate

Sieve Size (mm)	Mass Retained (g)	% Retained	Cumulative % Retained	% Passing
2.260	10.70	2.14	2.14	97.86

2.000	3.16	0.63	2.77	97.23
1.180	20.27	4.05	6.83	93.17
0.600	248.37	49.67	56.50	43.50
0.425	50.15	10.03	66.53	33.47
0.300	90.97	18.19	84.72	15.28
0.212	56.49	11.29	96.02	3.98
Pan	19.89	-	-	-
Total	500	315.51		

FM = Cumulative % retained/100

FM = 3.2

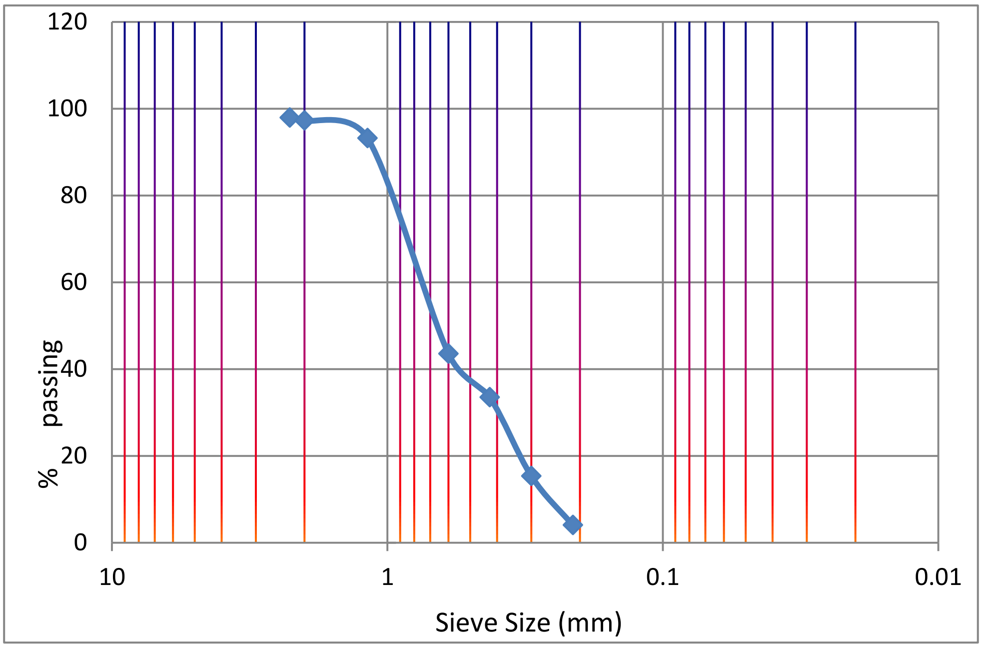

Figure 4.2a: Particule size distribution of fine aggregate (sieve analysis graph)

Table 4.2b:Sieve Analysis for Coarse Aggregate (Natural CoarseAggregate)

Sieve Size (mm)	Mass Retained (g)	% Retained	Cumulative % Retained	% Passing
20.00	715.36	57.11	57.11	42.89
10.00	457.25	36.50	93.63	6.37
6.30	65.77	5.25	98.88	1.12
5.00	8.95	0.71	99.59	0.41
2.36	3.95	0.32	99.91	0.09
Pan	1.3	-	-	-
	1252.60		**449.12**	

FM = Cumulative % retained/100

FM = 449.12/100

FM = 4.5

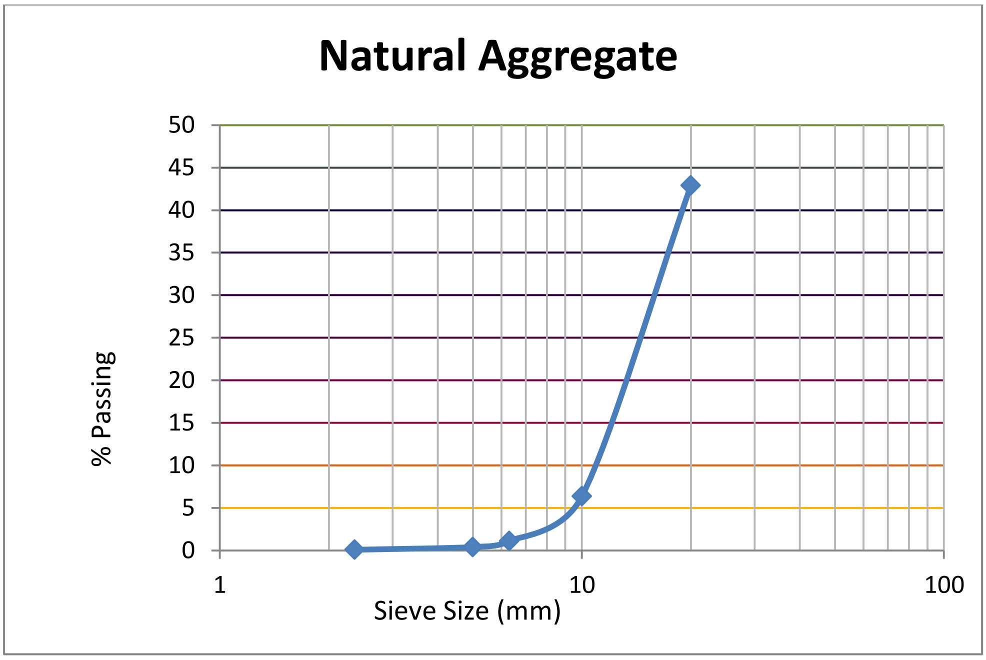

Figure 4.2b : Particule size distribution of Coarse Aggregate (sieve analysis graph)

4.2c Sieve Analysis of Crushed Concrete (Recycled aggregate)

Table 4.2c below shows the particles size distribution of crushed concrete used

Sieve Size (mm)	Mass Retained (g)	% Retained	Cumulative % Retained	% Passing
20.00	0.00	0.00	0.00	100.00
10.00	565.35	37.35	37.35	62.65
6.30	799.01	52.78	90.13	9.87
5.00	87.25	5.76	95.89	4.11
3.35	60.11	3.97	99.86	0.14
Pan	2.10	0.139	-	-
Total	1513.71		323.23	

FM = Cumulative % Retained/100

FM = 323.23/100

Fm = 3.2

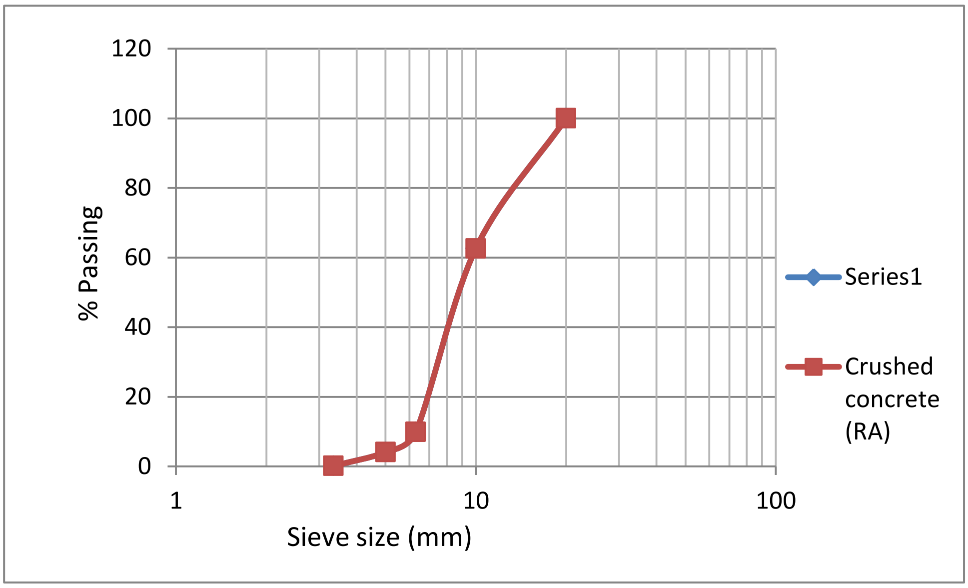

Figure 4.2c: Particle size distribution of crushed concrete (sieve analysis graph)

4.3Workability test result for fresh concrete

Table 4.3 shows the workability of concrete manufactured with different mix proportion.

Mix NO	**Materials used in mixed (%)**	**Mix Ratio**	**w/c ratio**	**Slump Measured (mm)**
A	0 (RCA)	1:2:4	0.70	40.5
B	20 (RCA)	1:2:4	0.70	30.5
C	40 (RCA)	1:2:4	0.70	30.3
D	60 (RCA)	1:2:4	0.70	30.7

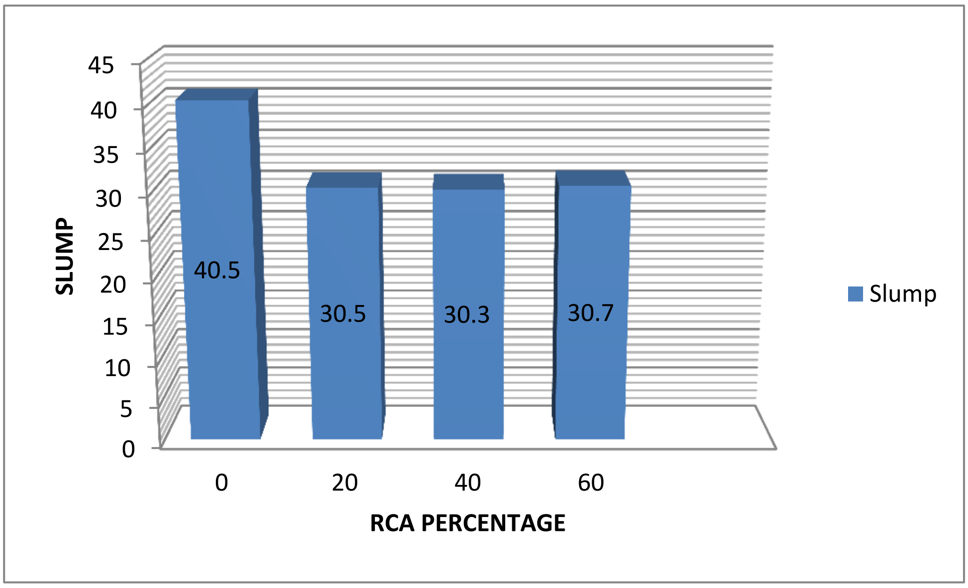

Figure 4.3 shows the workablity of concrete manufactured with different proportion of mix number (A to D) of RCA to NA at w/c 0.70

4.4 Compressive strength of hardened concrete

Table 4.4a : Compressive strength for Natural Coarse Aggregate

COMPRESSIVE STRENGTH FOR NATURAL AGGREGATE AT 0% RCA					
AGE	WEIGHT (G)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)	
7 days	2.504 2..471 2.341	183.000 171.000 171.000	18.300 17.100 17.100	17.500	
14 days	2.547 2.378 2.333	176.511 180.413 188.961	17.651 18.041 18.896	18.200	
28 days	2.437 2.539 2.482	232.278 216.595 250.933	23.227 21.659 25.093	23.300	

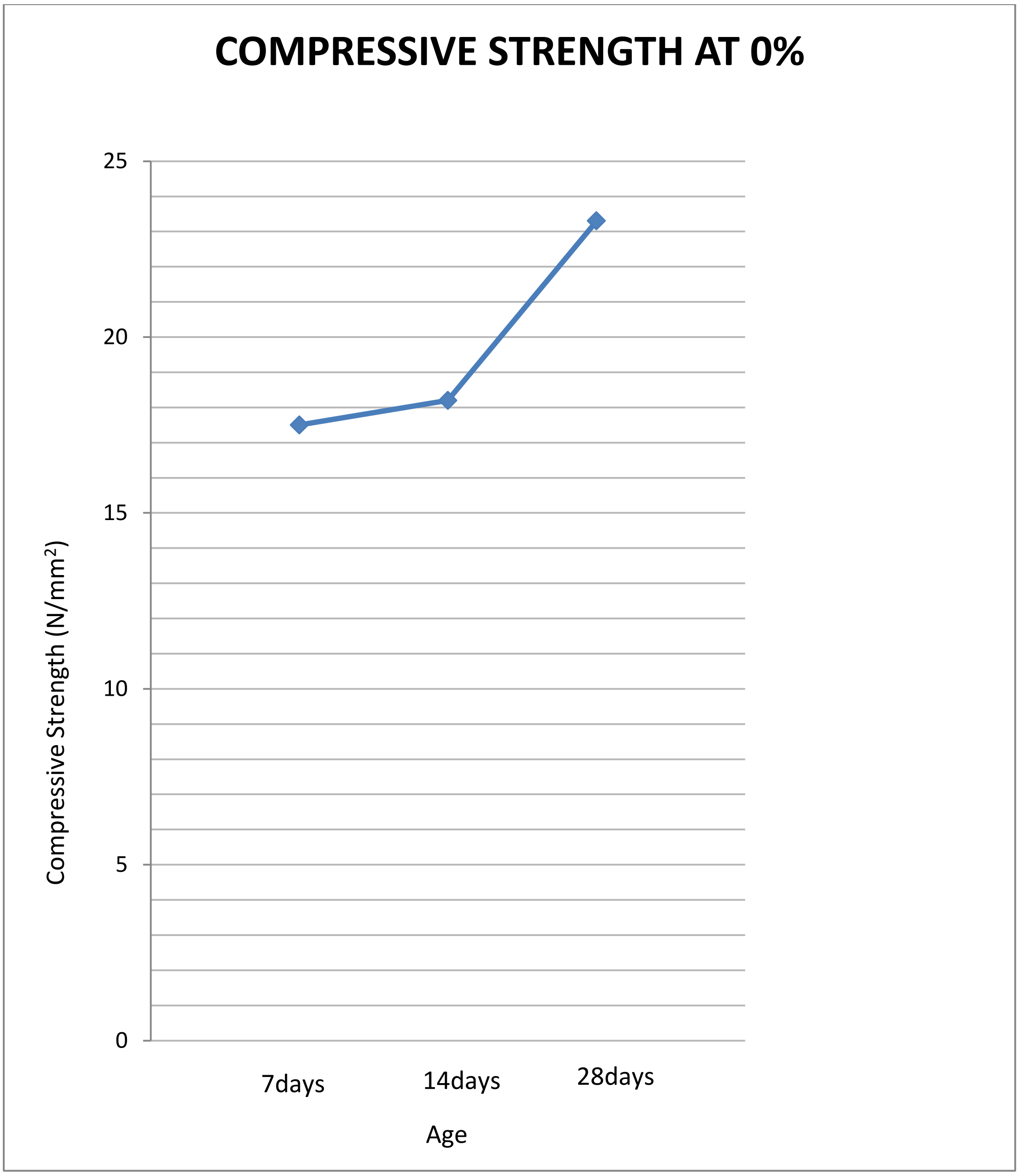

Figure 4.4: Shows the graph of compressive strength at 0% of RCA

Table 4.4b: Compressive strength for Recycled Aggregate at 20% Replacement

COMPRESSIVE STRENGTH FOR RECYCLED AGGREGATE AT 20% RCA				
AGE	WEIGHT (G)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
7 days	2.537 2.538 2.490	204.610 210.490 210.100	20.46O 21.050 21.010	20.800
14 days	2.284 2.230 2.490	228.295 227.267 216.306	22.830 22.730 21.630	22.400
28 days	2.569 2.489 2.644	274.292 280.052 289.011	27.430 28.010 28.900	28.110

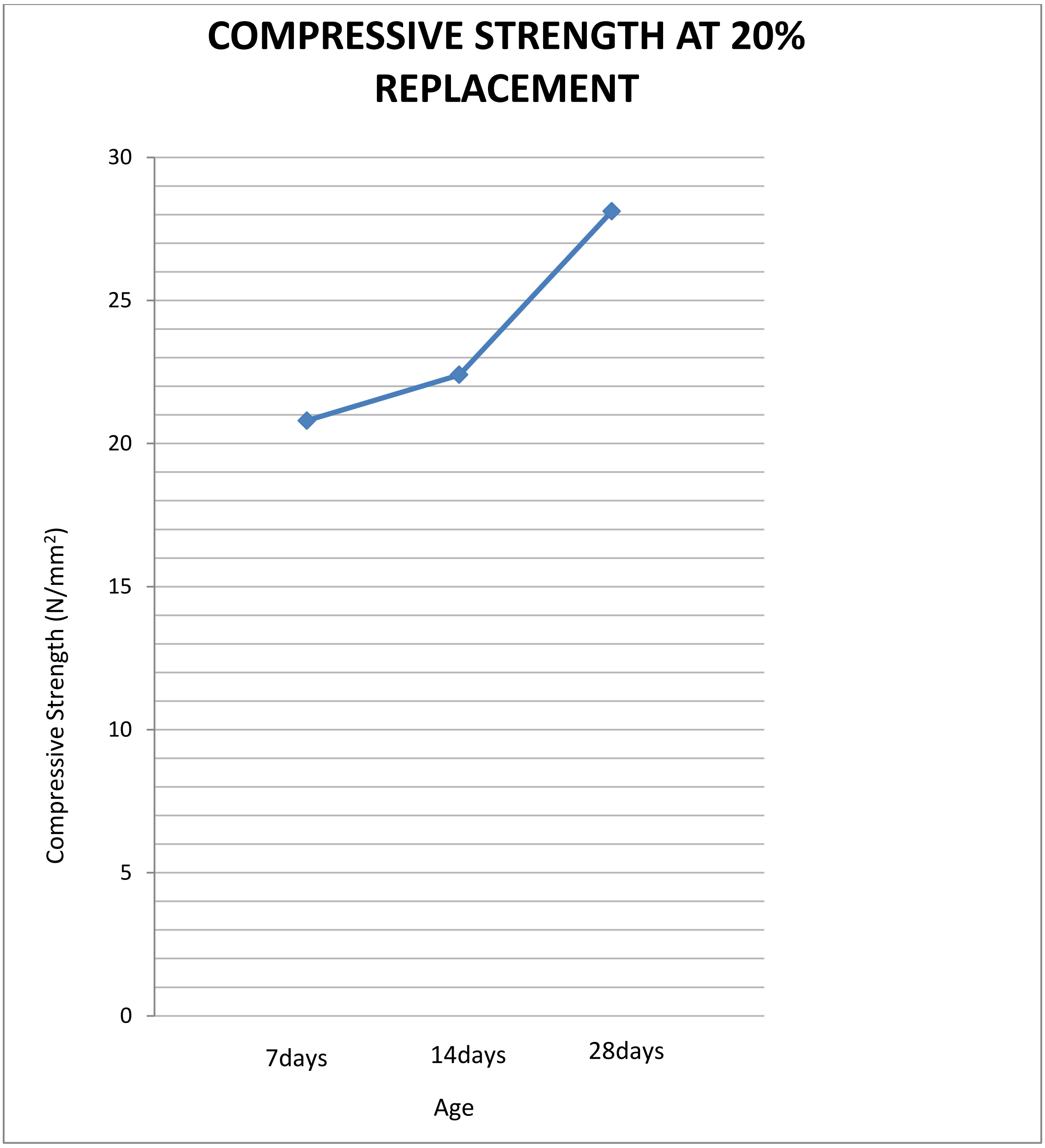

Figure 4.4b: Compressive Strength for Recycled Aggregate at 20% Replacement

Table 4.4c: Compressive Strength for Recycled Aggregate at 40% Replacement

COMPRESSIVE STRENGTH FOR RECYCLED AGGREGATE AT 40% RCA				
AGE	WEIGHT (G)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
7 days	2.388 2.297 2.437	171.750 164.510 175.190	17.180 16.450 17.650	17.000
14 days	2.375 2.398 2.457	182.110 189.880 196.480	18.210 18.990 19.650	18.900
28 days	2.537 2.291 2.431	205.740 191.690 204.070	20.570 19.170 20.410	20.100

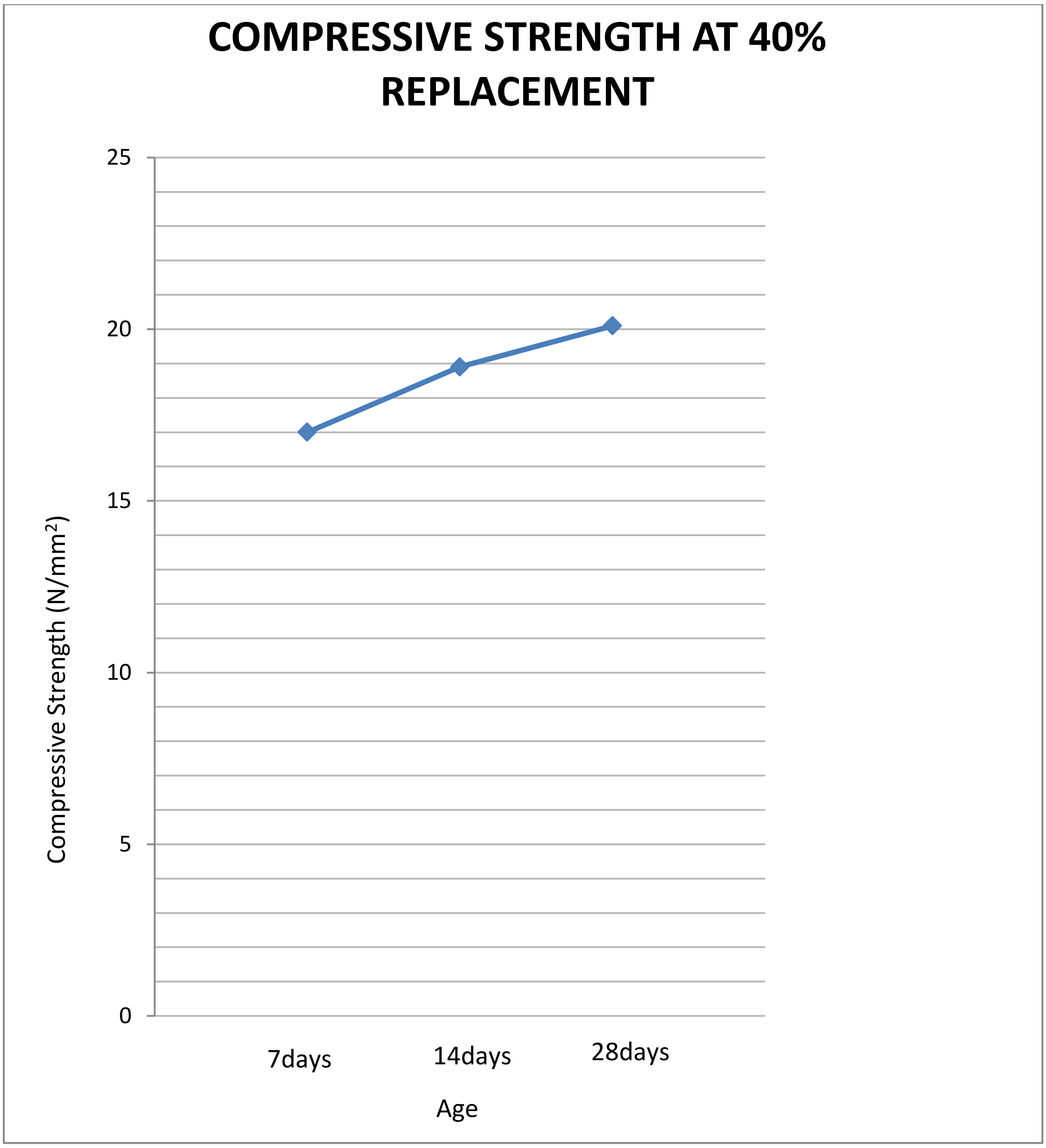

Figure 4.4c: Compressive Strength for Recycled Aggregate at 40% Replacement

Table 4.4d: Compressive Strength for Recycled Aggregate at 60% Replacement

COMPRESSIVE STRENGTH FOR RECYCLED AGGREGATE AT 60% RCA				
AGE	WEIGHT (G)	FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
7 days	2.266 2.449 2.282	196.230 190.910 186.650	19.620 19.090 18.670	19.130
14 days	2.388 2.493 2.550	224.450 218.290 209.280	22.450 21.830 20.930	21.730
28 days	2.287 2.548 2.392	267.534 274.432 267.073	26.753 27.443 26.707	26.967

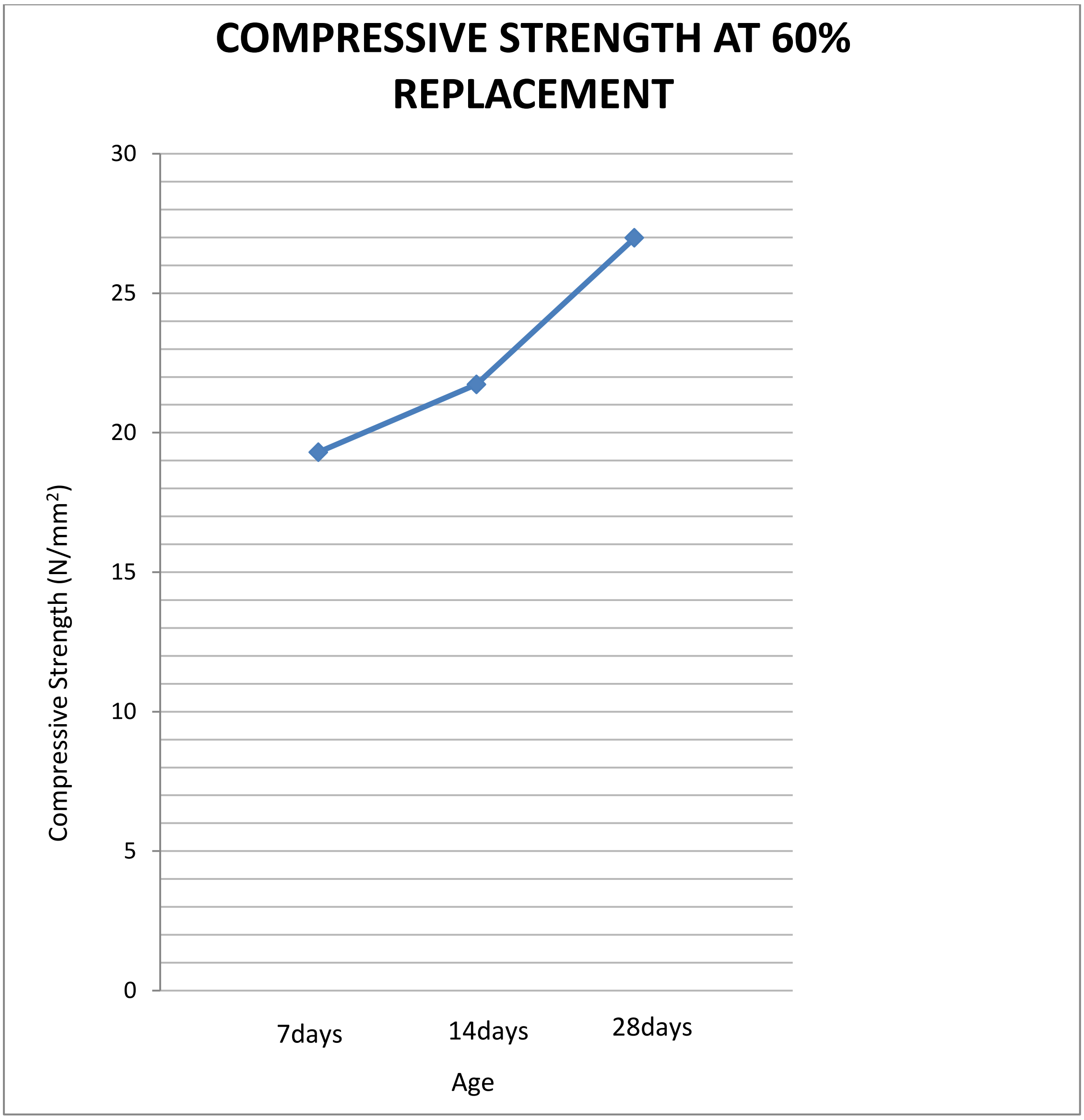

Figure 4.4d: Compressive Strength for Recycled Aggregate at 60% Replacement

Table 4.4e: Compressive Strength of Varies Percentage of Recycled Concrete Aggregate (Crushed Concrete)

Age of concrete	Proportion of RCA to NA (N/mm^2)			
	0%	20%	40%	60%
7 days	17.5	20.8	17.0	19.1
14 days	18.2	22.4	18.9	21.7
28 days	23.3	28.1	20.1	26.9

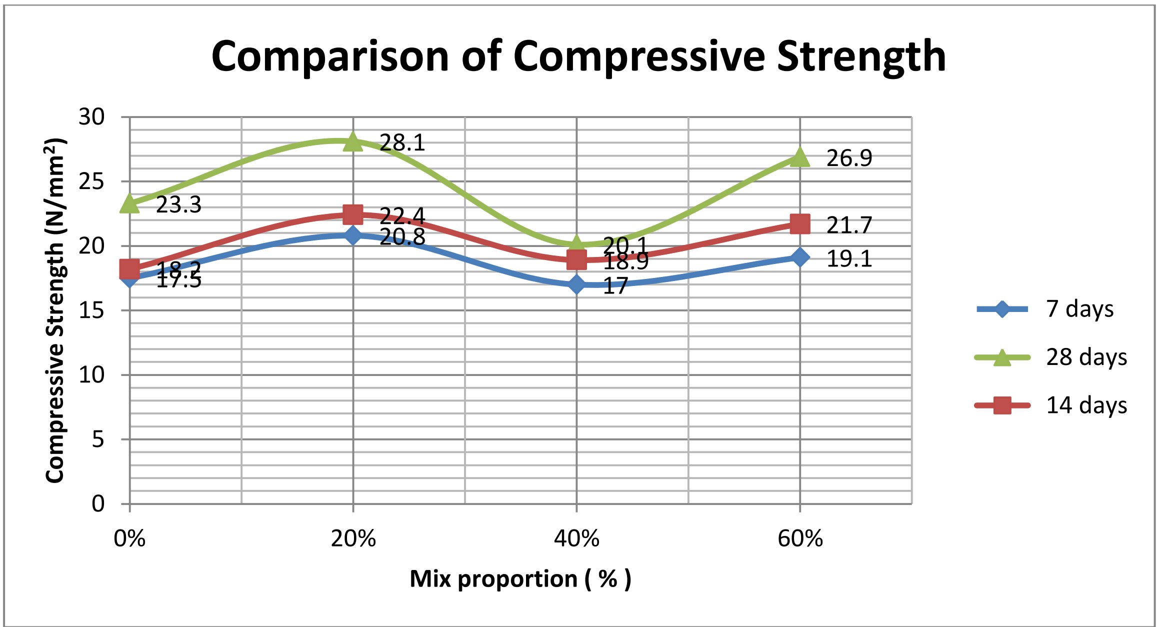

Figure 4.4e Comparison of Compressive Strength

4.5: Split tensile strength test result

Table 4.5a: Split Tensile Strength at 0% Replacement (RCA)

Age of Concrete	Weight (G)	Load (p) (KN)	Strength (2p/πdl) (N/mm^2)	Average Strength (N/mm^2)
7	4.347	40.500	1.288	
	4.369	54.600	1.610	1.550
	4.412	55.200	1.756	
14	4.388	60.260	1.921	
	4.386	60.380	1.917	1.930
	4.342	61.090	1.944	
28	4.404	80.980	2.577	
	4.566	82.350	2.620	2.690
	4.394	90.480	2.879	

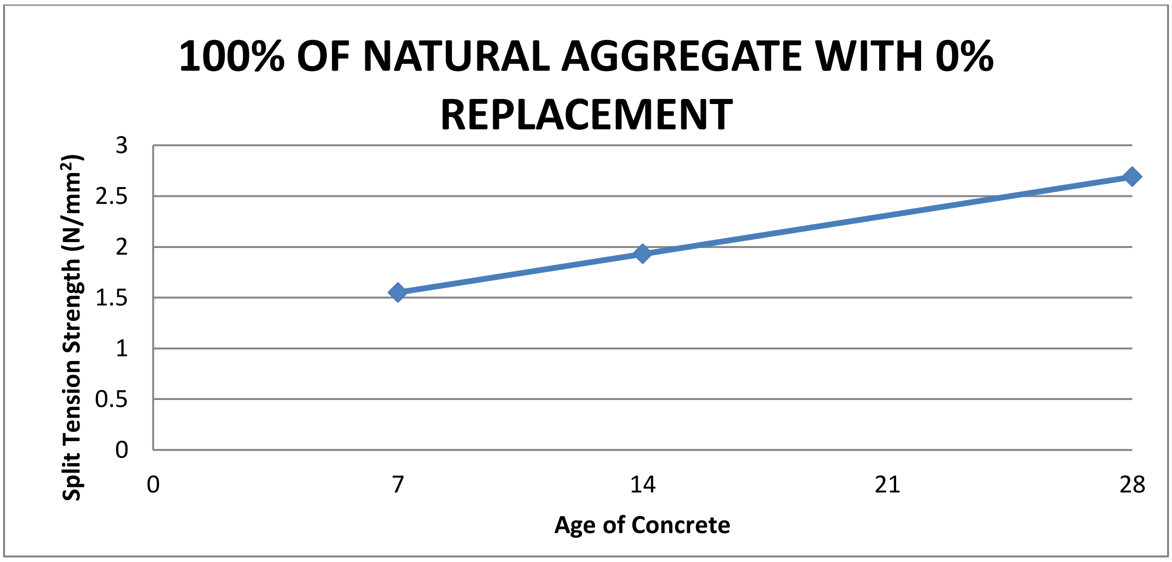

Figure 4.5: Show the graph of 0% replacement of Natural Aggregate with Recycled Aggregate Concrete

Table 4.5b: Split Tensile Strength at 20% Replacement (RCA)

Age of Concrete	Weight (G)	Load (p) (KN)	Strength (2p/πdl) (N/mm^2)	Average Strength (N/mm^2)
7	4.428	42.310	1.346	
	4.464	59.590	1.896	1.710
	4.471	60.110	1.913	
14	4.421	64.480	2.052	
	4.403	66.660	2.121	2.120
	4.470	69.060	2.197	
28	4.415	80.766	2.570	
	4.497	88.836	2.827	2.750
	4.488	89.400	2.845	

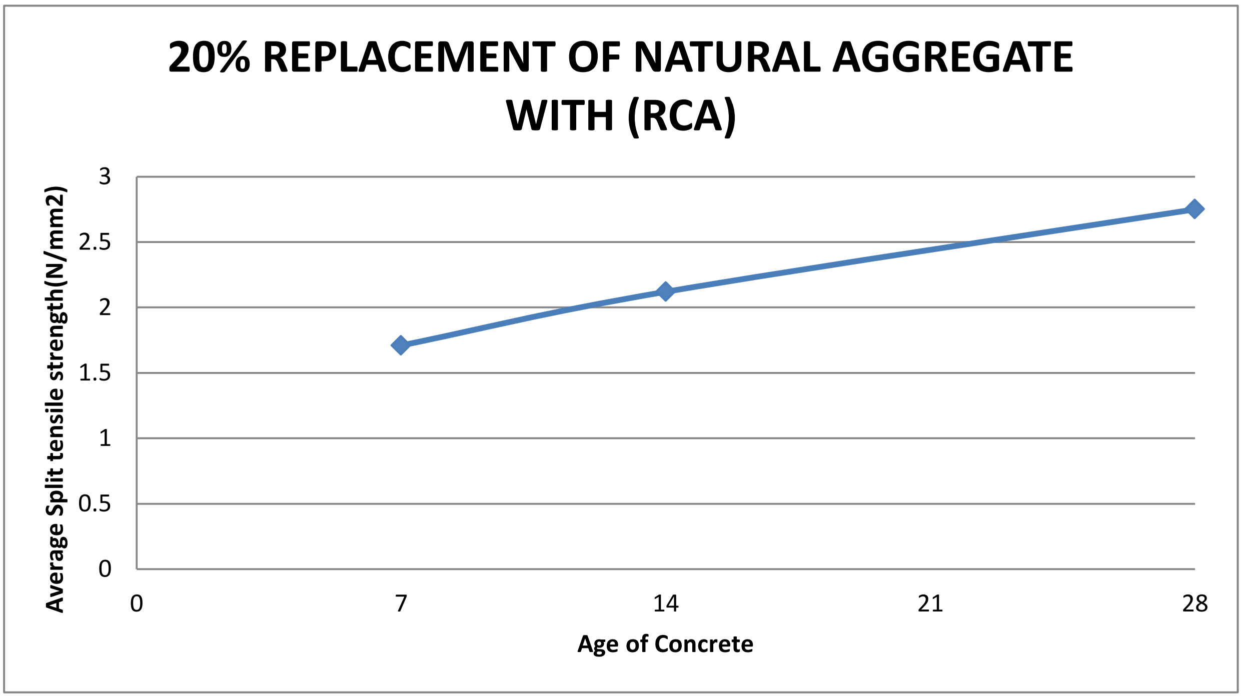

Figure 4.5b: Show the graph of 20% replacement of Natural Aggregate with Recycled Aggregate Concrete

Table 4.5c: Split tensile Strength at 40% Replacement (RCA)

Age of Concrete	Weight (G)	Load (p) (KN)	Strength (2p/πdl) (N/mm^2)	Average Strength (N/mm^2)
7	4.257	55.465	1.601	
	4.350	50.309	1.765	1.750
	4.337	59.557	1.895	
14	4.356	46.562	1.513	
	4.289	57.416	1.827	1.760
	4.305	60.567	1.927	
28	4.395	46.917	1.493	
	4.330	58.022	1.846	1.780
	4.347	62.403	1.986	

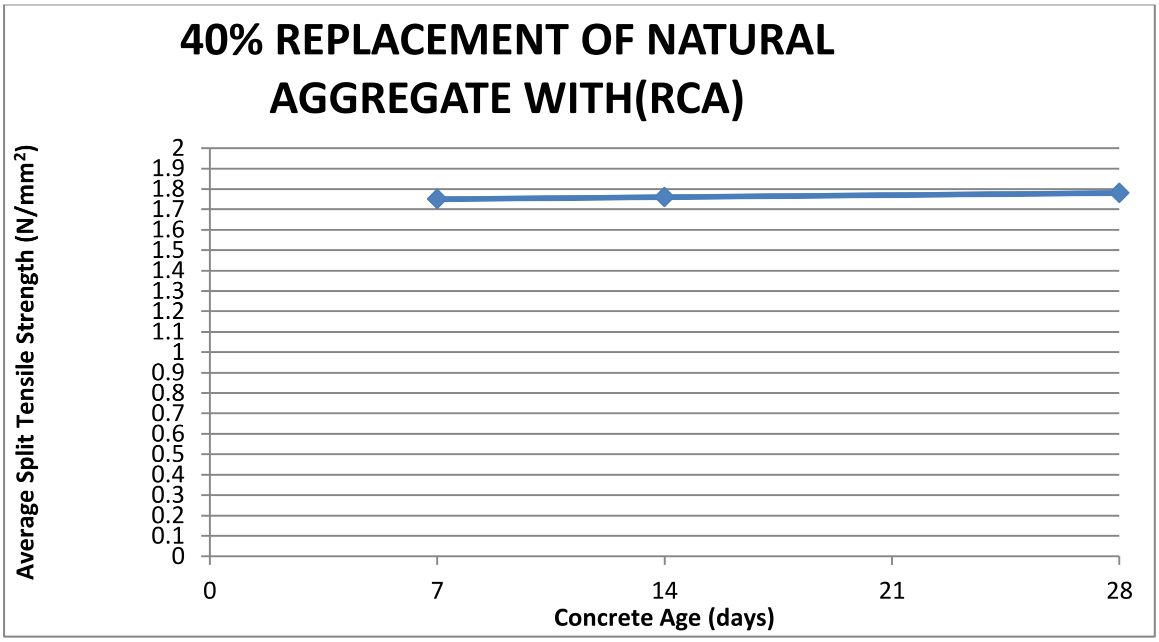

Figure 4.5c: Show the graph of 40% replacement of Natural Aggregate with Recycled Aggregate Concrete

Table 4.5d: Split Tensile Strength at 60% Replacement (RCA)

Age of Concrete	Weight (G)	Load (p) (KN)	Strength (2p/□dl) (N/mm^2)	Average Strength (N/mm^2)
7	4.285	39.241	1.248	
	4.310	43.871	1.396	1.359
	4.326	45.025	1.433	
14	4.314	65.446	2.080	
	4.330	67.233	2.140	2.136
	4.326	68.662	2.190	
28	4.361	71.841	2.280	
	4.346	60.771	1.930	2.183
	4.442	73.456	2.340	

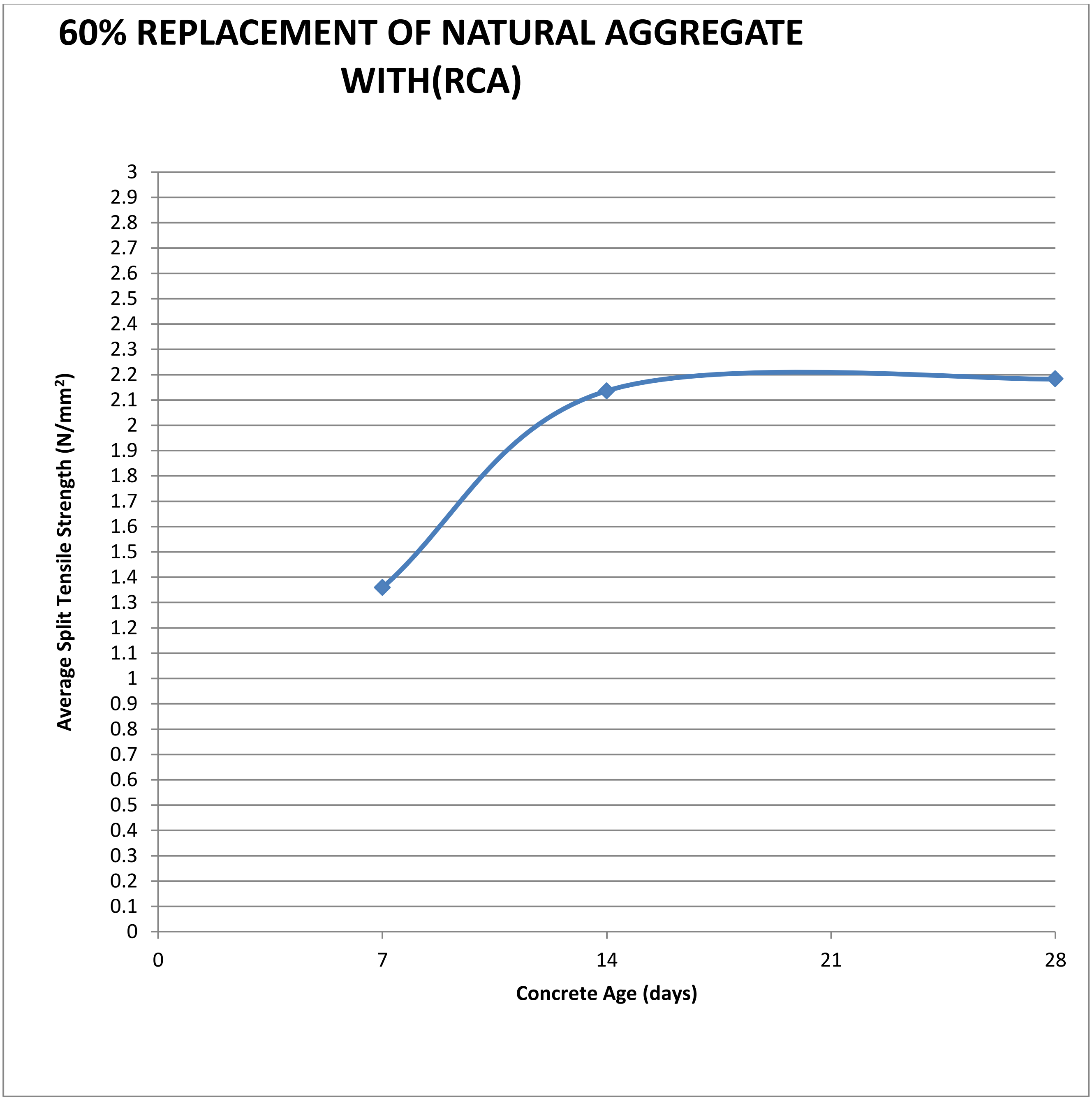

Figure 4.5d: Show the graph of 60% replacement of Natural Aggregate with Recycled Aggregate Concrete

Table 4.5e: Split Tensile Strength of Vary Percentage of Recycled Concrete Aggregate (Crushed Concrete)

Age of concrete	Proportion of RCA to NA (N/mm^2)			
	0%	20%	40%	60%
7 days	1.55	1.71	1.75	1.36
14 days	1.93	2.12	1.76	2.14
28 days	2.69	2.75	1.78	2.18

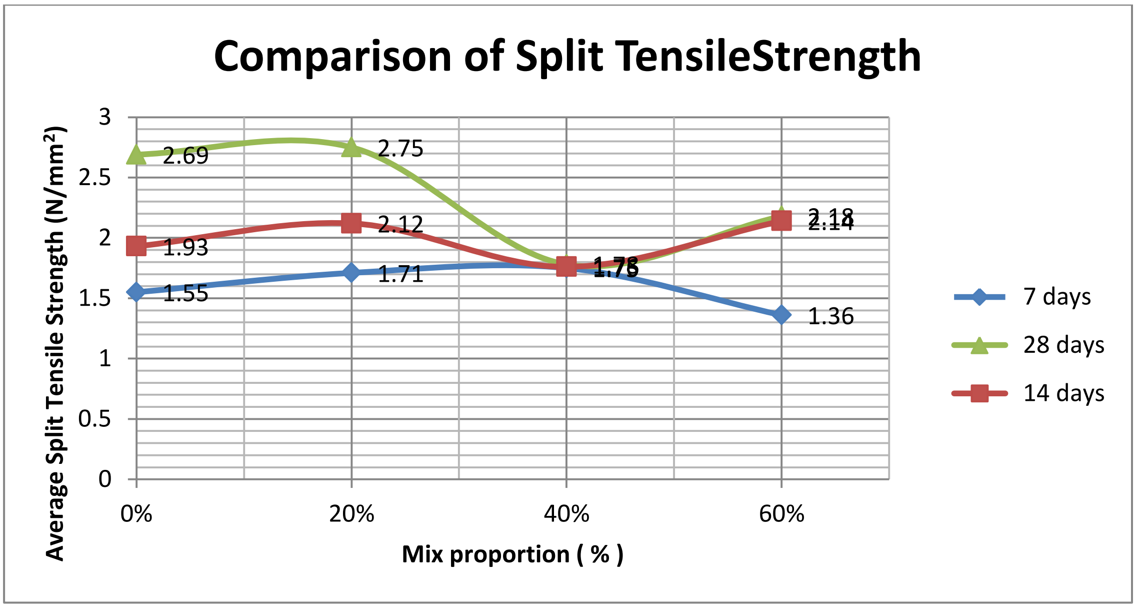

Figure 4.5e: Comparison of Split Tensile Strength

Discussion

The Aggregate Impact Value indicates a relative measure of the resistance of the aggregate to sudden shock which in some aggregates differs from its resistance to a slow compressive load. From the calculation done in clause 4.1.2 and 4.1.3 and comparing it with BS 812 (1990) specifications, I came to know that 5mm Natural Coarse Aggregate (NCA) is satisfactory for road surfacing (10-30%) and 5mm Recycled Concrete Aggregate (RCA) are also suitable for construction purpose but they are weak for road surfacing (>35%).

The sieve analysis of fine aggregates result presented in table 4.2 shows that the fine aggregates is distributed over 2.260mm to 0.212mm BS sieve and falls within medium fine sands. While for the NCA, from table 4.2b when compared to the standard grading limits of coarse aggregates falls within 20.00 to 5.00mm for graded aggregates. From table 4.2c, the RCA is distributed over 20.00mm to 5.00mm BS sieve.

Slump test shows the workability of concrete manufactured with recycled concrete aggregate as well as natural coarse aggregate was investigate, keeping in view the variation of proportion of RCA to NCA for a constant water cement ratio and mixed design. From table 4.3, it has been observed that the workability has been reduced by increasing the ratio of RCA to NCA.

From table 4.4a, it is seen that the compressive strength of concrete made 0% RCA (100% granite) increased with the curing age from 7 to 28 days and attained a strength of 23.30 N/mm2 at 28 days.

Table 4.4b, shows the compressive strength of concrete made with 20% RCA and 80% granite increases appreciably with curing age. And attained a high strength of 28.11 N/mm^2 at 28 days, which is the highest strength in all the concrete made. This is seen from fig 4.4e as the peak of the three graphs occurs at 20% replacement.

Table 4.4c, it is seen that the compressive strength of concrete made with 40% RCA and 60% granite is lesser to that of 0%, 20% and 60% replacement. Which are 17.00, 18.90 and 20.11 N/mm^2 as against 17.50, 18.20 and 23.30 N/mm^2 (100% granite concrete), 20.80, 22.40, and 28.11 N/mm^2 (20% replacement), 19.13, 21.73 and 26.97 N/mm^2 (60 % replacement). From the graph it is seen that tangible decrease in compressive strength occurs at 40% partial replacement.

From table 4.4d and figure 4.4e, it is seen that the compressive strength of the concrete made with 60% RCA and 40% replacement which are 19.13, 21.73, 26,97 N/mm^2 and 17.00, 18.90, 20.10 N/mm^2 attained strength higher than 0% (100% granite).

From the graph in figure 4.5e, it is seen that when the content of Recycled Aggregate concrete is increased from 0% to 20% (1.55, 1.93, 2.69 N/mm^2 to 1.71, 2.12, 2.75 N/mm^2), there is an increase in split tensile strength with maximum value of 2.75 N/mm2 at 28 days of 20% replacement. However when the RCA content is increased beyond this percentage a downward slope is observed from the graph and this is as a result of tensile failure that occurs due to the dislocation of atoms and molecules.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results obtained in the partial replacement of Natural Coarse Aggregate with Recycled Concrete Aggregate (crushed concrete) in concrete work, the following conclusions are made.

1. 1.The aggregate impact value (AIV) of crushed concrete having a value of 35% showed that it can be used for construction work but not on road surfacing because they are weak.
2. The maximum compressive strength in this project is obtained at 20% replacement (20.80, 22.40, 28.11 N/mm^2 at 7, 14, 28 days), strength decreases on increase in partial replacement of Natural Coarse Aggregate.
3. The split tensile strength decreases on increase in percentage of replacement. That is 1.15, 1.19, 2.69 N/mm2 (0%), 1.71, 2.12, 2.75 N/mm^2 (20%), 1.75, 1.76, 1.78 N/mm^2 (40%), 1.36, 2.14, 2.18 N/mm^2 at 7, 14 and 28 days of curing.
4. The slump (workability) of Recycled Concrete Aggregate is lower than Natural Coarse Aggregate because the rate of absorption of RCA is higher than NAC.
5. The proper use of Recycled Aggregate in construction work will save energy, cost of excavation and movement of our natural resources and also reduce the influence of waste on our environment.

5.2 Recommendation

1. The influence of various mixed design ratio can also be study for future concrete work.

2. In this project work, RCA was obtained from used concrete in the lab, however the RCA sample of different concrete work can be study.
3. More work should be done on the behavior of RCA on other properties of concrete such as water absorption rate, flexural strength, permeability of concrete and modulus of elasticity.

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APPENDIX

Old concrete sample from the laboratory

Crushing old concrete

Crushed concrete

Fine Aggregate

Slump test

Compaction of concrete using vibrating table

Curing tank

Weighing the mass of concrete

Cylindrical specimen

Universal compressive testing machine

Sieve Analysis test

Aggregate Impact Value Test