JIMMA UNIVERSITY

SCHOOL OF GRAUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT

LABORATORY INVESTIGATION ON THE EFFECTS OF BLENDED CRUSHED AND NATURAL AGGREGATES ON THE FRESH AND HARDENED PROPERTY OF C-25 CONCRETE.

A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Construction Engineering and Management.

By:

G/mariam Welay

September 2017

Jimma, Ethiopia

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Main Advisor: Engr. Elmer C. Agon (Asso.Prof.)

Co - Advisor: Engr. Mamuye Busier. (Asst. prof)

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Name	Signature	Date
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DECLARATION

I, the undersigned, declare that this thesis entitled "**laboratory investigation on the effects of blended crushed and natural aggregates on the fresh and hardened property of C-25 concrete**" is my original work, and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for theses have been duly acknowledged.

Candidate:

G/MARIAM WELAY

Signature_____________________________

As Master research Advisors, we here by certify that we have read and evaluated this MSc. research prepared under our guidance, by G/MARIAM WELAY entitled: "**laboratory investigation on the effects of blended crushed and natural aggregates on the fresh and hardened property of C-25 concrete**" We recommend that it can be submitted as fulfilling the MSc Thesis requirements.

	Signature	Date
1. Engr. Elmer C. Agon Advisor	___________________________	
2. Engr. Mamuye Busier. (MSc.) Co- Advisor	___________________________	

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ABSTRACT

Aggregates play a major role in determining the fresh and hardened properties of concrete. Various studies have been conducted on different types of natural coarse aggregate to determine the effectiveness of their use in concrete. Effort toward consuming locally available natural source and to investigate the engineering property of aggregate should be accepted or rejected in accordance to specification and standards has initiated the studies on river gravel as blending with crushed coarse aggregate material for the conventional concrete around the Jimma Zone and the study investigated the use of crushed stone sand as supportable alternative to natural river sand by blending together that is being conventionally used as fine aggregate in cement concrete.

The research program was divided into two main phases. First: the aggregate tests were carried out in accordance with the appropriate ES, ASTM, AASHTO, ACI, and BS. During laboratory test carried out, the aggregate quality test from Bulk Density, Specific Gravity, Absorption, Aggregate Impact Value moisture content, and silt content were conducted. In the second phase, Mix Design was carried out. In each case, cubes' compressive strength test and beam flexure tests were conducted.

The study showed that, blended crushed coarse aggregate with river gravel coarse aggregate at 0%, 10%, 20%, 30%, 40% and 50% and blended natural sand with manufactured sand at 0%, 10%, 20%, 30%, 40% and 50% have a compressive strength of 31.91Mpa,32.85Mpa 33.05Mpa,33.95Mpa,32.85Mpa and 30.77Mpa respectively at the age of 28 day of curing. On the other hand, at 0%, 10%, 20%, 30%, 40% and 50% blending of crushed coarse aggregate with river gravel coarse aggregate and blended at 0%, 10%, 20%, 30%, 40% and 50% natural sand blend with manufactured sand have a flexural strength 3.13Mpa, 3.14Mpa, 3.19Mpa, 3.41Mpa, 3.06Mpa and 2.93Mpa respectively at the age of 28 day of curing. In addition to this, the concrete mix having a slump value 52mm,46mm, 40mm, 32mm, 24mm, and 20mm for 0%, 10%, 20%,30%,40% and 50% blending of crushed coarse aggregate with river gravel coarse aggregate and natural sand blended with manufactured sand respectively.

All percentage of the blended of river gravel coarse aggregate with crushed coarse aggregate and manufactured sand blended with natural sand satisfies the specified compressive strength of concrete (fc). But the optimum compressive strength was achieved at the blended percentage of 30%. Hence it is recommended to blend up to 30%.

***Keyword**: Blending, compressive strength crushed aggregate, flexural strength, natural aggregate and workability.*

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ABREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AIV	Aggregate Impact Value
ASTM	American Society for Testing and Materials
BS	British Standard
CCA	Crushed Coarse Aggregate
ES	Ethiopian Standard
fck, cube	Mean Concrete Cube Compressive Strength
fcu	Specified characteristic cube Compressive Strength
FM	Fineness Modulus
GCCA	Specific Gravity of Crushed Coarse Aggregate
GRGCA	Specific Gravity of River Gravel Coarse Aggregate
G_s	Specific Gravity
JU	Jimma University
KN	Kilo Newton
MFA	Manufacture Fine Aggregate
MS	Manufacture Sand
N.M	Newton Meter
NS	Natural Sand
ODOT	Ohio Department of Transportation
OPC	Ordinary Portland Cement
PCC	Portland cement Concrete
PCCA	Percentage of Crushed Coarse Aggregate
PRGCA	Percentage of River Gravel Coarse Aggregate
PSD	Particle Size Distribution
RGCA	River gravel Coarse aggregate
SCM	Supplementary Cementing Material

SPR	Simplified Practice Recommendation
SSD	Saturated Surface Dry
UTM	Universal Test Machine
WOD	Weight of Oven Dray

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Concrete is a mixture of hydraulic cement, aggregates, and water, with or without admixtures, fibers, or other cementations materials. Aggregates are granular materials such as sand, gravel, crushed stone, crushed hydraulic-cement concrete, or iron blast-furnace slag. Coarse aggregate is that portion retained on the 4.75 mm (No. 4) sieve. Fine aggregate is that portion passing the 4.75 mm (No. 4) sieve and predominantly retained on the 75 µm (No. 200) sieve. Aggregate classifications include normal weight, lightweight, or heavyweight. The selection of aggregate to be used for concrete mixtures depends on the intended concrete properties. For instance, heavyweight aggregates such as barite, magnetite, hematite, or steel are used in heavyweight concrete mixtures. Heavyweight concrete is used for applications such as radiation shielding, ballast for offshore pipelines, or other similar applications. Lightweight aggregate, such as expanded or sintered clay, shale, slate, diatomaceous shale, perlite, vermiculite, slag, pumice, scoria, volcanic cinders, tuff, diatomite, sintered fly ash, or industrial cinders, are used in lightweight concrete applications[2].

Coarse and fine aggregate constitute approximately 60 to 75 percent of the concrete mixture. Therefore, the properties of the aggregates have a significant influence on the properties of the concrete mixture. Aggregate properties significantly affect the workability of plastic concrete, and the durability, strength, volume stability, and density of hardened concrete [2].

Aggregates may be broadly classified as natural or manufactured, both with respect to source and method of preparation. Natural sands and gravels are the product of weathering and the action of wind or water whereas manufactured crushed fine aggregate and crushed stone are produced by crushing natural stone. Screening and washing may be used to process either natural or manufactured aggregates. Aggregates may be produced from igneous, sedimentary, or metamorphic rocks, but the presence or absence of any geological type does not, by itself, make an aggregate suitable or unsuitable for use in concrete. The acceptance of an aggregate for use in concrete on a particular job or in a specification should be based on specific information obtained from tests used to measure the aggregate quality, its service record, or both. A typical consensus specification for both fine and coarse concrete aggregate is ASTM C33 [1].

To understand the role played by aggregate in the performance of concrete, it is necessary to define specific aggregate properties and show their effect on concrete properties.

There are several reasons for specifying both grading limits and maximum aggregate size. The aggregate gradation and content will impact properties such as finish ability, work-ability, strength, permeability, and shrinkage [24].

Aggregates having a smooth grading curve and neither a deficiency nor an excess of any one particle size will generally produce mixtures with fewer voids between particles. Because cementations materials are typically more expensive than aggregates, and the cementations paste requirement for concrete increases with increasing void content of the combined aggregates, it is desirable to keep the void content as low as possible. If there is not enough fine aggregate to fill the voids between coarse aggregate particles, the space must be filled with cementations paste. These under-sanded mixtures also tend to be harsh and difficult to finish. On the other hand, aggregate combinations with excessive amounts of fine aggregate or excessively fine sands may produce undesirable concretes because of the larger specific surface area of finer particles. If aggregate voids are minimized; the amount of paste required for filling these voids is also minimized maintaining workability and strength [24].

Consequently, optimal mixture proportioning will produce good-quality concrete with a minimum amount of cement. Within limits, the less paste at a constant water-cement ratio, the more durable the concrete [24]. The workability of concrete changes significantly with grading. Mixtures with high void contents require more paste for a given level of workability. In conclusion, minimizing the aggregates voids content should be one of the objectives of optimization of concrete mixtures. Mixture proportioning methods should encourage concrete optimization and consequently aggregate optimization.

Different researchs shows that there is a clear relationship between shape, texture, and grading of aggregates and the voids content of aggregates [24]. In fact, flaky, elongated, angular, and unfavorably graded particles lead to higher voids content than, cubical, rounded, and, well-graded particles.

From the production of concrete, cement is the most expensive material and can account for up to 60% of the total materials cost [21]. Its manufacturing process is also the largest greenhouse gas contributor, and the most energy and resource intensive. Approximately 5% of global carbon dioxide emissions are attributed to the manufacturing of cement. The paste fraction of a concrete mix is usually 25% to 40% of the total volume. A portion of cement can be substituted by supplementary cementing materials (SCMs), but there is greater potential to reduce the cement content needed for concrete mixes by optimizing the combined aggregate gradation of mixes. Optimizing the packing of the aggregate particles will improve concrete's: i) sustainability and cost by reducing cement content required; ii) durability by decreasing its permeability and potential for drying shrinkage cracking; iii) workability by decreasing segregation potential; and iv) structural performance by decreasing porosity and increasing the total aggregate volume. The shape and texture of the aggregates have a significant effect on the packing ability of individual aggregates, and, therefore, potential for optimizing blended aggregates [21].

1.2. Statement of the Problem

Concrete mixtures with fine aggregate grading near the minimum for percent passing in the0.3mm (No. 50) and 0.15mm (No. 100) sieve may pose some problems with workability, pumping or excessive bleeding [6]. A fine aggregate that is too coarse will lead to harshness, bleeding, and segregation, but fine aggregate that is too fine will result in an increased water demand and segregation [12]. There is also an increase in water demand as dust of fracture (micro fines) percentage is increased. This increase is attributed to an increase in the specific surface due to the particle size decrease [17].

The worldwide consumption of natural sand is very high, due to the wide use of concrete or mortar. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructure growth, in this situation developing countries facing shortage in good quality natural sand [61]. Therefore, particularly nowadays development of infrastructures is becoming number one priority in Ethiopia. So, there are great demands within the construction industries for river sand as fine aggregate used in the production of concrete. This has created a very difficult situation; natural sand deposits are being short and causing serious hazard to environment as well as increasing the cost of river sand time to time. And also Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, excavating of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc. are few examples. Hence, the needs to find materials which are inexpensive and available to partially blend river aggregate with crushed aggregate in the production of concrete.

Natural sources for aggregates include gravel pits, river run deposits, and rock quarries. Generally, gravel comes from pits and river deposits, whereas crushed stones are the result of processing rocks from quarries. Usually, gravel deposits must also be crushed to obtain the needed size distribution, shape, and texture. In general, natural gravel and sand have a smooth texture, whereas crushed aggregates have a rough texture. For preparing Portland cement concrete, it is desirable to use rounded and smooth aggregate particles to improve the workability of fresh concrete during mixing. In Portland cement concrete, 60% to 75% of the volume and 79% to 85% of the weight is made up of aggregates. Therefore, maximizing the amount of aggregate, to a certain extent, improves the quality and economy of the mix [28]. Studies showed that, the natural gravel coarse aggregates (Uncrushed) not more suitable used as a coarse aggregate for conventional concrete because of poor bond cement past and less contact surface between the aggregate textures. Here in the study area; people try to use those (river gravel aggregate) as aesthetic purpose but not use for conventional concrete. The reason for this might be the absence of guidelines and a research study that indicates river gravel aggregate can be used as a coarse aggregate for normal weight concrete. In order to investigate the possibility of using uncrushed coarse aggregates in concrete, it was first necessary to investigate the physical properties of the aggregates themselves, as these properties will affect the properties of fresh and hardened concrete. In Jimma zone there are lacks of concrete making ingredient especially natural sand aggregates. To mitigate this shortage, contractors and owners are facing to another place which is far from Jimma, like from Gambbela, Dema and Worabe etc. On the other hand river gravel as a source around Jimma zone is local available material but people not used for conventional concrete.

1.3 .Objective of the Study

1.3.1. General Objective

The main objective of this study was to investigate the effects of blending crushed and natural aggregates on the fresh and harden properties of C-25 concrete.

1.3.2. Specific Objectives

i. To determine the workability of fresh concrete due to the effects of blending crushed and natural aggregates of C-25 fresh concrete.
ii. To determine the compressive and flexural strength of C-25 concrete due to the blended of crushed and natural aggregate through experimental study.
iii. To determine the maximum compressive and flexural strength of the blended percentage of crushed and natural aggregates and to determine the amount of aggregate to blended for C-25 concrete.

1.4. Research Questions

i. What is the workability of fresh concrete due to the effects of blending crushed and natural aggregate?
ii. What is the compressive and flexural strength of concrete due to the effects of blended crushed and natural aggregate?
iii. What is the maximum compressive and flexural strength of the blended percentage of crushed and natural aggregate and the amount of aggregate to be blended for C-25 concrete?

1.5. Significance of the Study

- ❖ In the surrounding areas Jimma zone there are so many rivers with useful amount of aggregate .i.e. both the fine and coarse aggregate. Which may it be used for the construction of building material (coarse aggregate in concrete).Even if locally available river stones have been exist, people had not enough information about the properties of those material; so they did not use for the and other reason. The present investigation imagines the potential utilization of river stone as a coarse aggregate in replacement of crushed stone aggregate in concrete.
- ❖ It has reduced the cost of material and cost of hauling large quantities of aggregates in locations where poor performing aggregates are present and natural aggregate will be conserve.
- ❖ Private/governmental organizations or construction firms that use the data for construction purposes in order to minimize the use of scarce resource of natural (river) sand.

- The City Administration of Jimma will benefit from the study as a source of information and foundation for the construction industry that can help to improve and control qualities of the materials regarding to standard and specifications.
- Environmental organizations seeking to understand interactions of natural sand with the environment.

1.6. Scope and Limitation of Study

This study will be conducted in Oromia National Regional State around Jimma Zone to investigate the effects of blending crushed and river aggregate for the production of C-25 concrete using fresh concrete property and harden concrete strength. Even if there are other parameters which will affects the strength of concrete, this research study will go on only at pre mentioned ingredients and parameters also the researcher did not use any admixtures to improve the workability and strength.

CHAPTER TWO
REVIEW OF RELATED LITERATURE

2. 1. Constituents of concrete

If a concrete is to be suitable for a particular purpose, it is necessary to select the constituent materials and combine them in such a manner as to develop the special qualities required as economical as possible. The selection of materials and choice of method of construction is not easy, since many variables affect the quality of the concrete produced, and both quality and economy must be considered [27].

The characteristics of concrete should be evaluated in relation to the required quality for any given construction purpose. The closest practicable approach to perfection in every property of the concrete would result in poor economy under many conditions, and the most desirable structure is that in which the concrete has been designed with the correct emphasis on each of the various properties of the concrete, and not solely with a view to obtaining of maximum possible strength [27].

2.1.1. Aggregate

Aggregates are the materials basically used as filler with binding material in the production of concrete and provide concrete with better dimensional stability and wear resistance. They are derived naturally from igneous, sedimentary and metamorphic rocks or manufactured from blast furnace slag, etc. [9]. It is therefore significantly important to obtain right type and quality of aggregates (fine and coarse) because aggregates occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy [9]. So that to proportion suitable concrete mixes, certain properties of aggregate which influence the paste requirement of fresh concrete such as shape and texture, size gradation, moisture content, specific gravity and bulk unit weight must be known [15].

2.1.1.1 Classifications of aggregate according to size

A) Coarse aggregate

Coarse aggregate generally occupies about 30 to 40% of the volume of concrete and is therefore expected to influence the performance of concrete significantly [28]. Coarse aggregate may be available in several different size groups, such as 19 to 4.75 mm (3/4 in.to No. 4), or 37.5 to 19 mm (1-1/2 to 3/4 in.). ASTM C 33, ―Standard Specifications for

Concrete Aggregates,'' lists several such size groups using the Simplified Practice Recommendation (SPR) number designation. The number and size of sieves selected for a sieve analysis is dependent upon the particle sizes present in the sample and the grading requirements specified [28].

B) Fine Aggregate (Sand)

Sand is the one of the main constituents of concrete making about 35% of volume of concrete of concrete used in concrete in construction industry. . The property of the aggregate greatly affects the property of the resulting concrete. An ideal aggregate would be one that is inert; but this is not the case for most. The physical, chemical, mechanical and thermal properties of aggregates manipulate the quality of the concrete. The use of aggregate in concrete greatly reduces the needed amount of cement, which is important from both technical and economical standpoints [29].

According to ACI E1-07 Aggregates may be broadly classified as natural or artificial, both with respect to source and to method of preparation. Natural sands and gravels are the product of weathering and the action of wind or water, while manufactured crushed fine aggregate and crushed stone coarse and fine aggregate are produced by crushing natural stone. Crushing, screening, and washing may be used to process aggregates from either sand and gravel deposits or stone quarries. Synthetic aggregates may be either by products of an industrial process, in the case of blast-furnace slag, or products of processes developed to manufacture aggregates with special properties, as in the case of expanded clay, shale, or slate used for lightweight aggregates [29].

Aggregates can be further classified based on different basis but the most commonly used classifications are based on size as coarse and fine; mineralogy and petrography as Igneous, Metamorphic and Sedimentary; chemical composition as Argillaceous, Siliceous and Calcareous; weight as heavy, normal and light; source as natural and artificial; and finally based on particle size and shape. The last one is the most frequently used classification. Based on this classification, this research generally focuses only on the natural type of fine aggregates. On this basis, one can differentiate between the fine aggregates, consisting mostly of small particles, and the coarse aggregates, consisting mostly of large particles [29].

2.1.1.2 Classıfıcatıon of Aggregates According to Source:

1. Natural aggregate: Native deposits with no change in their natural state other than washing, crushing & grading. (Sand, gravel, crush stone)

2.Artificial aggregates:They are obtained either as a by-product or by a special manufacturing process such as heating. (blast furnace slag, expanded perlite).

Figure2.1River Gravel coarse aggregate (source: http//www.chapter5 aggregate for concrete).

Figure2.2Crushed coarse aggregate and River Gravel coarse aggregate (source: http// www.chapter5 aggregate for concrete).

2.1.1.3 Classification of aggregate According to Petrologic Characteristics:

A) Aggregates from Igneous Rocks: are formed by solidification of molten lava. Most igneous rocks make highly satisfactory concrete aggregate because they are normally hard, tough and dense. The most widespread of all the igneous rocks are basalts. Basalts are dark colored, fine grained extrusive rocks. The mineral grains are so fine that they are impossible to distinguish with the naked eye or even a magnifying glass. Most basalt is volcanic in origin and was formed by the rapid cooling and hardening of the lava flows. Some basalt is intrusive having cooled inside the Earth's interior [8].

B) Aggregates from Sedimentary Rocks: are obtained by deposition of weathered & transported pre-existing rocks or solutions.

The quality of aggregates derived from sedimentary rocks will vary in quality depending upon the cementing material and the pressure under which these are originally compressed. Some siliceous sand stones have proved to be good concrete aggregate. Similarly, the limestone also can yield good concrete aggregate.

The thickness of the stratification of sedimentary rock may vary from a fraction of a centimeter to many centimeters. If the stratification thickness of the parent rock is less it is likely to show up even in an individual aggregate and thereby it may impair the strength of the aggregate. Such rocks may also yield flaky aggregates. The degree of consolidation, the type of cementation, the thickness of layers and contamination, are all important factors in determining the suitability of sedimentary rock for concrete aggregates [8].

C) Aggregates from Metamorphic Rocks: are formed under high heat & pressure change of either igneous & sedimentary rocks.

Many metamorphic rocks particularly quartzite and gneiss have been used for production of good concrete aggregates [8].

2.1.2. Cement

Portland cements are hydraulic cements composed primarily of hydraulic calcium silicates. The most common hydraulic cement used in construction today is Portland cement. Hydraulic cements set and harden by reacting chemically with water. During this reaction, called hydration, cement combines with water to form a stone like mass, called paste. When the paste (cement and water) is added to aggregates (sand and gravel, crushed stone, or other granular material) it acts as an adhesive and binds the aggregates together to form concrete, the world's most versatile and most widely used construction material [36].

2.1.2.1 Chemical compounds of Portland cement

The raw material used in the manufactures of Portland cement comprises four principal compounds. These compounds are usually regarded as the major constituents of cement and tabulated with their abbreviated symbols, in Table 2.1

Table2.1 Composition of ordinary Portland cements [7].

Name of compound	Oxide composition	Abbreviation
Tricalcium silicate	3CaO.SiO2	C3S
Dicalcium silicate	2CaO.SiO2	C2S
Tricalcium aluminate	3CaO.AlO3	C3A
Tetracalcium aluminoferrite	4CaO.Al2O.FeO3	C4AF

These compounds interact with one another in the kiln to form a series of more complex products. Portland cement is varied in type by changing the relative proportions of its four predominant chemical compounds and by the degree of fineness of the clinker grinding. A small variation in the composition or proportion of its raw materials leads to a large variation in compound composition.

Calculation of the potential composition of Portland cement is generally based on the Bogue composition (R.H Bogue). In addition to the main compounds, there exist minor compounds such as MgO, TiO_2, K_2O and Na_2O; they usually amount to not more than a few percent of the mass of the cement. Two of the minor compounds are of particular interest: the oxides of sodium and potassium, K_2O and Na_2O, known as the alkalis. They have been found to react with some aggregates, the products of the reaction causing disintegration of the concrete and have also observed to affect the rate of gain of strength of cement [38].

Present knowledge of cement chemistry indicates that the major cement compounds have the following properties [37].

a) **Tricalcium Silicate:** C3S hardens rapidly and is largely responsible for initial set and early strength development. The early strength of Portland cement concrete is higher with increased percentages of C3S.
b) **Dicalcium Silicate**: C2S hardens slowly and contributes largely to strength increase at ages beyond one week.
c) **Tricalcium aluminate**: C3A liberates a large amount of heat during the first days of hardening. It also contributes slightly for early strength development. Cements with low percentages of this compound are especially resistant to soils and waters containing sulphate.
d) **Tetracalciumaluminoferrite:** C4AF reduces the clinkering temperature. It acts as afflux in burning the clinker. It hydrates rather rapidly but contributes very little to

strength development. Most color effects are due to C_4AF series and its hydrate [37].

Table2.2 Oxide Content of Portland cement raw materials

Oxides	Ranges
Lime (CaO)	60-70%
Silica(SiO2)	17-25%
Alumina(AL_2O_3)	3-8%
Iron Oxide (Fe_2O_3)	0.5-6%
SulphurTriOxide(SO_3)	1.0-3%
Magnesia (MgO)	0.1-4%
Soda (Na_2O) and potash(K_2O)	0.5-1.3%

The above constituents forming the raw materials used in the manufacturer of Portland cement combine to form compounds in the finished product. The following four compounds are regarded as the major constituents of cement: tricalcium silicate ($3CaO.SiO_2$ or C_3S), dicalcium silicate ($2CaO.SiO_2$ or C_2S), tricalcium aluminate ($3CaO.Al_2O_3$ or C3A), and tricalciumaluminoferrite ($4CaO.Al_2O_3.Fe_2O_3$ or C_4AF).These compounds are different in rate of reaction, heat liberation and cementing value [37].

2.1.2.2 Types of Cement

Types of Portland cement can be varied by changing the relative proportions of its prominent chemical compounds, by the degree of fineness of the clinker grinding and/or by adding some pozzolanic materials. As a result, there are several types of cements for different purposes.

Some of them are: - Ordinary Portland Cement (OPC), Rapid Hardening Portland cement, Sulphate Resisting Portland Cement, Low heat Portland Cement, Portland Pozzolana Cement (PPC). But, only Ordinary Portland cement and Portland Pozzolana Cements are produced in Ethiopia. A pozzolan is defined in ASTM C 618 as “a siliceous or siliceous and aluminous material, which in itself possesses little or no cementations value but which will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementations properties.” They are composed of similar materials and react with the products of hydrating cement to create additional cementitious binder. Glassy non-crystalline forms of silica, alumina, and iron are principally responsible for the pozzolanic reaction with calcium hydroxide (lime). In concrete, lime results from the hydration of Portland cement. Pozzolanic material can be used to modify and improve plastic and hardened properties of concrete. There are calcite types and volcanic soil pozzolanic materials found in Ethiopia near Zeway and between Wolenchite and Metehara and their analyses and chemical compositions was done by researchers in laboratory [38].

AASHTO M 85, Specification for Portland cement, uses type designations I through V for Portland cement.

Type I Portland cement; is general-purpose cement suitable for all uses where the special properties of other types are not required. Its uses in concrete include pavements, floors, reinforced concrete buildings, bridges, tanks, reservoirs, pipe, masonry units, and precast concrete products [36].

Type II (Portland Pozzolana cement) Portland cement; is used where precaution against moderate sulfate attack is important. It is used in normal structures or elements exposed to soil or ground waters where sulfate concentrations are higher than normal but not unusually severe. Type II cement has moderate sulfate resistant properties because it contains no more than 8% tricalcium aluminates (C3A) [36].

Sulfates in moist soil or water may enter the concrete and react with the hydrated C3A, resulting in expansion, scaling, and cracking of concrete. Some sulfate compounds, such as magnesium sulfate, directly attack calcium silicate hydrate. Use of Type II cement in concrete must be accompanied by the use of a low water to cementitious materials ratio and low permeability to control sulfate attack. Concrete exposed to seawater is often made with Type II cement [36].

Type III Portland cement; provides strength at an early period, usually a week or less. It is chemically and physically similar to Type I cement, except that its particles have been ground finer. It is used when forms need to be removed as soon as possible or when the structure must be put into service quickly. In cold weather its use permits a reduction in the length of the curing period [36].

Type IV Portland cement; is used where the rate and amount of heat generated from hydration must be minimized. It develops strength at a slower rate than other cement types. Type IV cements is intended for use in massive concrete structures, such as large gravity dams, where the temperature rise resulting from heat generated during hardening must be minimized [36].

Type V Portland cement; is used in concrete exposed to severe sulfate action principally where soils or ground waters have high sulfate content. It gains strength more slowly than

Type I cement. The high sulfate resistance of Type V cement is attributed to low tricalcium aluminate content, not more than 5% [36].

2.1.3 Water

Water is needed for the hydration of cement but not all is used up for this purpose. Part of this added water is to provide workability during mixing and for placing. Almost any natural water that is drinkable and has no pronounced taste or odor can be used as mixing water for making concrete [39] (US Department of the Interior Bureau of Reclamation, 1988). ASTM C94 and BS 3148 both provide guidance on acceptance criteria for water of questionable quality in terms of strength and setting time. However, the two sets of recommendations have slightly different limits. Additional, optional chemical limits using wash water from mixer washout operations are also stated in ASTM C94. Seawater should not be used as mixing water for reinforced concrete due to the presence of chloride and its effect on corrosion of steel reinforcement [40].

2.2 Basic Properties of coarse Aggregate

2.2.1 Shape

The shape of the aggregate particles influences paste demand, placement characteristics such as workability, pump ability, strength, and cost [17]. Shape is related to sphericity, form, angularity, and roundness.

Round or nearly cubical shaped aggregates are desirable due to the ease in which they move in the mixing and handling process. However, aggregates can also contain flat or elongated shapes. Methods used to measure the shape of coarse aggregates are the elongation factor and flatness factor. A flat particle has a width-to-thickness ratio greater than or equal to 3, while an elongated particle has a length-to-width ratio greater or equal to 3. Specifications usually define limiting elongation ratios of 3:1 or 5:1 to describe undesirable shapes of aggregates. The shape can modify the strength of the concrete, as in the case where a thin, flat particle is oriented in the hardened concrete where outside stresses are introduced [12]. The shape of natural aggregates depends on the strength, abrasion resistance, and on the degree of wear to which they have been subjected in their depositional environment. Natural aggregates tend be more spherical and less angular. On the other hand, the shape of manufactured aggregate depends on the rock type (mineralogy) and the crushing equipment. Manufactured aggregates are more angular when compared to natural aggregates [12].

The shape of an aggregate influences the workability of the mixture as well as the void content and packing density. For the same amount of paste, a mixture with round or cubical shaped aggregate will have better workability than a mixture with flaky and elongated aggregates. Moreover, for the same mass of aggregates, round and cubical aggregates produce mixtures with higher packing, which results in a lower void content [11]. The decreased percentage of voids lowers the amount of cement paste required for that particular mixture. Some specifications, such as the Spanish and British standards [22], limit the percent of use of flaky and elongated particles, but ASTM (American Society for Testing and Materials) has set no limits. Some state departments of transportation (DOTs) have set limits on the percentage of flaky and elongated particles ranging from 8 to 20%.

The shape of fine aggregates affects concrete workability more than the shape of coarse aggregates [22]. Since fine aggregates are smaller than coarse aggregates, a larger volume of paste is needed to coat the fine aggregates. When poorly-shaped fine aggregates are used, the paste requirement to achieve the target workability becomes substantial [22]. This is one of the main reasons that poorly-shaped fine aggregates are not desirable in concrete. Unlike coarse aggregates, the shape of fine aggregates is not always directly evaluated. Indirect methods have been used to evaluate the shape of fine aggregate; such methods include ASTM D 3398 (standard method for Index of Aggregate of Particle Shape and Texture) and ASTM C 1252 (Standard Test Method for Uncompact Void Content of Fine aggregate as Influenced by Particle Shape, Surface Texture, and Grading). Both methods evaluate shape indirectly by measuring the packing density of a graded fine aggregate sample. Aggregates with better shape such as natural siliceous sands are expected to have higher packing density than the poorly-shaped manufactured sands [22].

Table2.3Article Shape Classification of Aggregates according to BS 812: Part 1: 1990;

Classification	description	Example
rounded	Fully water –worm or completely shaped by attraction	River or seashore gravel; desert seashore and wind-blown sand
Irregular	Naturally irregular , or partly shaped by attrition and having rounded edges	Other gravel; land or dug flint
Flaky	Material of which the thickness is small relative to the other two dimensions	Laminated rock
Angular	Possessing well-defined edges formed at the intersection of roughly planar faces	Crushed rocks of all types; crushed slag
Elongated	Material, usually angular, in which the other two dimension	
Flaky and elongated	Material having the length considerable larger than the width, and the width considerable larger than the thickness	

2.2.2 Texture

Surface texture is the degree to which the surface may be defined as either 1) being rough or smooth (referring to the height of asperities) or 2) coarse grained or fine grained (referring to the spacing between grains) [12]. The surface texture influences the workability, quantity of cement and bond between particles and the cement paste. Two independent geometric properties are the roughness (degree of surface relief) and the roughness factor (the amount of surface area per unit of dimensional or projected area) [12].

Natural aggregates have a smooth surface [12]. Natural gravel subject to transport mechanisms tends to be smoother than manufactured aggregates. For instance, gravel would have a surface smoother than crushed limestone. An improvement in the bond to the matrix is obtained as the surface roughness increases [3]. Rough-textured angular grains bond better with the cement paste to generate higher tensile strengths [17]. Although rougher textures lead to better bond between paste and aggregate, they also lead to harsher mixtures, as texture roughness increases, the internal friction increases between the aggregates, and therefore more paste is needed to achieve a given workability. There are no direct methods to measuring the texture of fine aggregates. ASTM D 3398 and ASTM C 1252 can be used to indirectly evaluate texture of fine aggregates (as well as shape).

Table2.4 Surface Texture Classification of Aggregates according to BS 812: Part 1: 1990

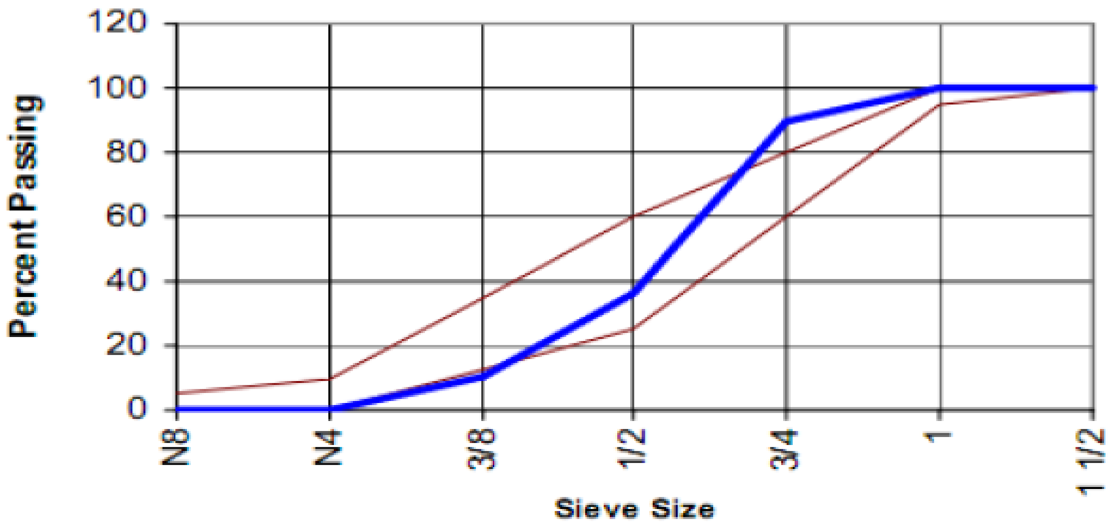
Group	Surface	Characteristics	Example
1	Glassy	Conchoidal fracture	Black flint, vitreous slag
2	Smooth	Water –worn, or smooth due to fracture of laminated or fine grained rock	Gravel, chert, slate, marble, some rhyolites
3	Granular	Fracture showing more or less uniform rounded grains	Sandstone, oolite
4	Rough	Rough fracture of fine or medium grained rock containing no easily visible crystalline constituents	Basalt, felsite, porphyry, limestone
5	Crystalline	Containing easily visible crystalline constituents	Granite, gabbro, gneiss
6	Honeycom bed	With visible pores and cavities	Brick, pumice, expanded clay

2.2.3 Water Absorption

Absorption is defined as the increase of mass due to presence of water in the pores of a material not including water adhering to the outside surface of a particle [ASTM C127; ASTM C128]. The absorption value may be regarded as an aggregate property that is a function of aggregate porosity and pore size [55]. It has been suggested that absorption might be a good indication of durability since it is a direct measure of accessible pore space in the aggregate [55]. However, this relationship has not been proven reliable. Quiroga and Fowler found that the strength of the bond between cement and aggregate increases as absorption increases, but the durability decreases with an absorption increase [22].

2.2.4. Grading

The gradation of an aggregate is defined as the frequency of a distribution of the particle sizes of a particular aggregate [12]. Grading limits are specified in ASTM C 33 section 6 [ASTM C 33].



(a) Natural River gravel from Indian

Figure2.3Grading of Coarse Aggregates [38]

Grading or particle size distribution affects significantly some characteristics of concrete like packing density, voids content, and, consequently, workability, segregation, durability and some other characteristics of concrete [53]. One of the physical properties of aggregate that influences the property of concrete is grading of aggregate. Maximum size of aggregate, MSA, influences workability, strength, shrinkage, and permeability. Mixtures with large maximum size of coarse aggregate tend to produce concrete with better workability, probably because of the decrease in specific surface [53].

- Aggregate grading can be divided into three categories:

1. Coarse aggregate: material retained by No. 4 sieve.

2. Fine aggregate: material passing No. 4 sieve and retained on No. 200 sieve.

3. Micro fines: material passing No. 200 sieve.

Gradation plays an important role in the workability, segregation, and pump-ability of the concrete. Grading changes are more prevalent than shape and surface texture in the case of coarse aggregates. For example, uniformly distributed aggregates require less paste which will also decrease bleeding, creep and shrinkage while producing better workability, more durable concrete and higher packing [22]. A graded aggregate, as opposed to a single-size aggregate, will have a greater packing density. The smaller aggregates will fill in the voids created by the larger aggregates [22]. Larger maximum sizes of coarse aggregates are beneficial for workability because they extend the range of aggregate sizes which improves grading [55]. Aggregate grading can be improved by combining two different grades of coarse aggregates.

Particles of irregular shape do not fit together perfectly and voids are created when these particles are assembled in a single container. The greater the void content, the more the paste required to fill these voids. The void content is affected by the particle size, shape, and grading. When a portion of two aggregates are combined and placed in a single container, the quantity of water (or paste) needed to fill the voids for the same volume decreases. Thus, combining aggregates of different size fractions reduce the void ratio [55].

Fine aggregate grading has a greater effect on workability of concrete than coarse aggregates [11]. Manufactured sands require more fines than natural sands to achieve the same level of workability; this is probably due to the angularity of the manufactured sands particles [22]. A decrease in the workability and durability of concrete are possible consequences of using an aggregate with either an excess or a lack of a particular size fraction [55]. One common method used for evaluating gradation of fine aggregates is by computing the fineness modulus (ASTM C 33). Fineness modulus is obtained by adding the total percentage of a fine aggregate sample retained on each of a specified series of sieves, and dividing the sum by 100. Various research studies have suggested that the fineness modulus is inadequate to differentiate between sands [22].

Research funded by ICAR has shown that good quality concrete can be produced using fine aggregate that does not meet ASTM C 33 standards [11]. Compared to the same aggregate and grading without micro fines, MFA with more than 17% micro fines can be used to produce quality concrete that has the same or higher compressive and flexural strength, lower permeability, and higher resistance to abrasion [28]. It should be noted that ASTM C 33 was developed for natural sands. The amount of micro fines allowed by specifications has been limited for three reasons:

1. Micro fines may reduce workability due to large surface areas that need to be wetted.

2. Micro fines may increase the water requirement, which increases the amount of cement, therefore increasing shrinkage.

3. Micro fines tend to adhere to larger particles, preventing proper bonding between paste and aggregate. Improper bonding promotes cracking and weakens concrete.

2.3. Physical Properties of aggregate (Engineering property)

2.3.1 Relative Density (Specific Gravity)

The specific gravity of an aggregate is used in mixture proportioning calculations to find the absolute volume that a given mass of material will occupy in the mixture. Absolute volume of an aggregate refers to the space occupied by the aggregate particles alone; that is the volume of solid matter and internal aggregate pores not including the voids between particles [30].

The bulk specific gravity is defined as the ratio of the weight in air of a given volume of a material at the standard temperature to the weight in air of equal volume of distilled water at the standard temperature. For use in the computation of concrete mixes the bulk specific gravity is always determined for saturated surface dry aggregates. The specific gravities of a number of commonly used aggregates fall within the range of 2.6 to 2.7, although there are satisfactory materials for which the specific gravity falls outside this range [31]. Test methods for finding specific gravity of aggregates are described in ASTM C127, ―Specific Gravity and Absorption of Coarse Aggregate, ―and ASTM C 128, ―Specific Gravity and Absorption of Fine Aggregate [32].

Four moisture conditions are defined for aggregates depending upon the amount of water held in the pores or on the surface of the particles. These conditions are shown in Figure 2.4 and described as follows:

1. Damp or wet: Aggregate in which the pores connected to the surface are filled with water and with free water also on the surface.

2. Saturated surface-dry: Aggregate in which the pores connected to the surface are filled with water but with no free water on the surface.

3. Air-dry: Aggregate that has a dry surface but contains some water in the pores.

4. Oven-dry: Aggregate that contains no water in the pores or on the surface.

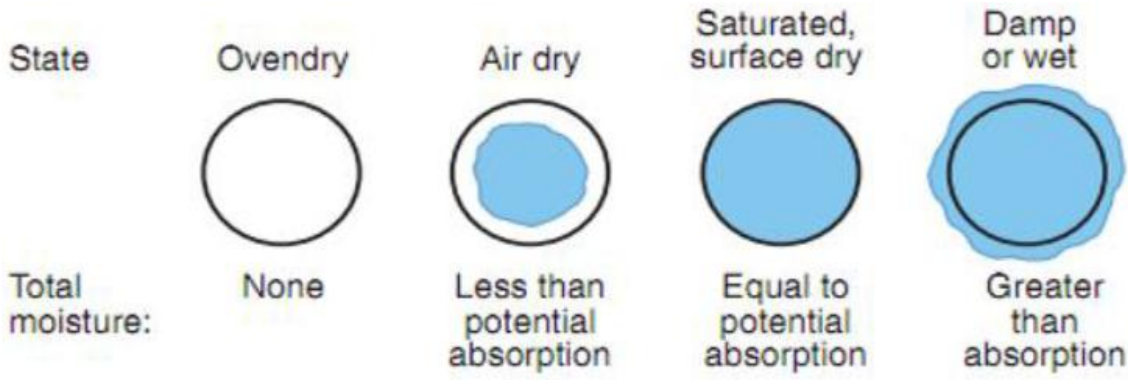


Figure2.4 Moisture conditions of aggregates [41]

2.3.2 Bulk Density (Unit Weight)

Bulk density measures the weight of the aggregate that fills a container of unit volume part of which is void because of loose packing of the particles. The bulk density is used to convert quantities by weight to quantities by volume for batching concrete. In general, for comparison of different aggregates and calculation of mix quantities the standard conditions are dry and compact (rodded) **[**28**].**

Figure2.5 The Cylindrical Metal Measures bulk density for the Fine and Coarse Aggregates [28]

Table2.5 the general range in unit weights of some fine and coarse aggregates are shown

	Material	Kg /m3
1	Sand (dry)	1520-1680
2	Gravel	1280-1440
3	Crushed stone	1250-1400

Sources*: Denamo Addissie 2005; table 2.13*

The bulk density (dry-rodded unit weight) of an aggregate is the mass of the aggregate divided by the volume of particles and the voids between particles. Methods for determining bulk density are given in ASTM C 29.

Bulk density= $\frac{Magg+Mcon-Mcon}{Vcon}$

The rodded bulk density of aggregates used for normal-weight concrete generally ranges from 1200 to 1760 kg/m3 (75 to 110 lb. /ft3 [32]. The bulk density or unit weight of an aggregate is the mass or weight of the aggregate required to fill a container of a specified unit volume. The volume referred to here is that occupied by both aggregates and the voids between aggregate particles. Void contents range from about 30% to 45% for coarse aggregates to about 40% to 50% for fine aggregate. Angularity increases void content while larger sizes of well-graded aggregate and improved grading decreases void content [33].

2.3.3 Water absorption

The absorption capacity is a measure of the porosity of an aggregate.

If the aggregate is dry, it absorbs water, which does not take part in the reactions and also in lubrication of particles. Thus workability is likely to be reduced and water-cement ratio is also altered. It is, therefore, always necessary to make allowance for water absorption while calculating total water to be added to the mixes [34].

2.3.4. Aggregate Crushing Value (ACV)

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied load. The standard aggregate crushing test shall be made on aggregate passing a 14 mm BS (12.5mm ASTM) test sieve and retained on a 10.0mm BS (10 mm ASTM) test sieve. [35]

2.4. Natural Fine Aggregate (sand)

Natural River sand: - is fine aggregate from the natural disintegration of rock and which has been deposit by streams or glacial agencies. It can be got from various source, river, run off, sand deposit etc. and most of the time contains high percentages of organic materials, chlorides, sulphates, silt and clay (i.e. sub 75µm) that adversely affect the strength and durability of concrete and reinforcing steel by reducing the life of structure [41]. Because of high percentages of sand in hardened concrete and have an impact on cost effectiveness of the concrete. That is why the materials for construction should be sampled, inspected, tested and acceptance for use or be given if they meet the established standards in all respects. Fine aggregates such as sand used in concrete production may contain excessive silt and clayey contents as well as organic impurities that impact negatively on the quality of hardened concrete.

Being an important component for concrete, obtaining good quality natural sand is critical. These easily available natural resources usually accompany gravels which basically imply the deposits may not have been laid uniformly, meaning a potential change in quality and size is possible. In some deposits, sand found below the water table differs in fines content and quality from that found above the water table, due to this subsurface drilling, sampling, and testing are necessary to know to what degree and where these differences occur [42].

A) Gambella sand sample; Gambella sand is one of the most commonly used river sand in Jimma town and its surrounded Regional state; it is extracted from “Baro” River which is found in Gambella Regional State that is 518 km. [43]

B) Worabe sand sample; Worabe sand is the second the most commonly used river sand in Jimma town and its surrounded Regional state, it is extracted from “Omo” River which is found in Worabe, Gurage Zone of the Southern Ethiopia which is 343 km [43].

C) Asendabo sand sample ;Asendabo sand is the third commonly used river sand in Jimma town and its surrounded Regional state, it is extracted from City of ‘Nada kela’ around Homo Nada area which is Asendabo, Jimma zone that is 54.3km. [43]

2.5 Negative effects of river sand mining

For thousands of years, sand has been used in the construction of roads and buildings. Today, demand for sand and gravel continues to increase. Excessive sand mining causes the degradation of rivers. Sand mining lowers the stream bottom, which may lead to bank erosion. Depletion of sand in the streambed and along coastal areas causes the deepening of rivers and estuaries, and the enlargement of river mouths and coastal inlets. It may also lead to saline-water intrusion from the nearby sea. The effect of mining is compounded by the effect of sea level rise. Any volume of sand exported from streambeds and coastal areas is a loss to the system [44].

Figure2.6 Sand harvesting along a river bank (source: Jin Mohamed, 2014)

Excessive stream sand mining is a threat to bridges, river banks and nearby structures. Sand mining also affects the adjoining groundwater system and the uses that local people make of the river.

2.6. Geological/physical Impact

As mentioned above, aggregate extraction has a physical impact on the aquatic environment. The sediment topography and type will change through the removal of material and resettlement of fine particles. If the human-induced physical disturbances continue, this could lead to continuous erosion and poverty [57].

Stability of Structures

Various researchers have pointed out that fine aggregate extraction that causes turbulence of basin movements and removal is the main cause of unstable banks. Moreover, it is generally accepted that increased sedimentation, turbidity, higher stream temperature, reduced dissolved oxygen, lowered water table, and decreased rainy seasons are some of the effects directly related to the extraction process [57].

Figure2.7 unstable sand structure in the mining site [57]

(a) (b)

Figure2.8 unstable sand structure in the mining site [57].

Figure2.9 sand extraction in site [57]

2.7. Manufactured sand

Aggregate content is a factor, which has direct and far-reaching effects on both the quality and cost of concrete. Unlike water and cement, which do not alter in any particular characteristic except in the quantity in which they are used, the aggregate component is infinitely variable in terms of shape and grading [45].

When it is required to construct a major structure, the supply of high quality aggregate for concrete, both coarse and fine, are of extreme importance. The growing shortage and price rise of the natural sand is also a question that a construction industry shall think about. Now looking for viable alternatives to natural sand is a must and not a necessity. Due to short of supply of natural sands and the increased activity in construction sector, the time has come, for manufactured sand to play a significant role as an ingredient in concrete [45].

2.8. Definition and functions of manufactured sand

The term-manufactured sand is used for aggregate materials having dimensions less than 5.0mm that are processed from crushed rock or gravel and intended for construction use. The term sand refers to relatively small particles and there are some variations of sand with regard to particle size [45].

The use of manufactured aggregates (crushed hard rock) in concrete has been known since the Roman time. In modern technology, natural aggregates have proved to be significantly economical in use, for which reason extensive use of manufactured aggregates has been concentrated to regions or projects where the availability of natural aggregates has been limited [45].

The growing problem of surplus fines from hard rock quarries has, however, in recent times encouraged a development towards more use of manufactured aggregates in many populated areas, and for several concrete applications [8]. Production of excess amounts of fines and depletion of natural aggregate resources are the main problems for aggregate producers.

Crushed /manufactured sand has rough surface texture and the particle size distribution curve can be adjusted in the manufacturing of the material.

Another advantage in manufactured sand is quarries can be kept in the near vicinity to its place of end use, therefore shortening transport distances, and increased employment opportunities for the locals. In the future it is expected that manufacturing of sand from rock will increase and production from natural deposits will decrease [45].

Manufactured sands are made by crushing aggregate to size appropriate for use as a fine aggregate (< 5.0mm). The crushing process caused the manufactured sand to have an irregular particle shape. These fine particles and irregular shape of the aggregate have detrimental effects on the workability and finish of the concrete. These negative effects have given manufactured sands a poor reputation in the construction industry. However this study reveals that in some other practical areas, these fine particles can be utilized to increase the compressive strength of the concrete [45].

2.9. Properties of Manufactured sand

The particle size distribution (PSD) curve of manufactured sand is more often than not tight and the particles are cubic, angular and their surface texture is rough. Properties of aggregates from natural sand and gravel deposits (natural aggregates) differ when compared to aggregates from crushed rock (crushed aggregates). Natural aggregates are weathered and their surface is often smooth and particles are sub angular to round. Crushed aggregates on the other hand have a rough surface texture, particles are angular and, if the production process is high quality, their shape is cubical. This difference in surface texture and shape properties indicates that natural and crushed aggregates are two different types of material and must be treated accordingly, i.e. different requirements apply to the two types. For instance regarding particle size distribution, knowledge and experience for natural aggregates can, for instance, not be used without suitable adjustments [45].

The particle size distribution curve (PSD), for manufactured sand is high in proportions of fines, as opposed to what is normal for natural sand. The best result is expected with a blend of natural and manufactured sand proportions depending on properties for specific production process.

Table2.6 Comparison between natural and manufactured sand [45]

Natural sand	Manufactured sand
• Has enough fine	• Has a lots of fine
• Has smooth surface	• Provide stable grain distribution
• Has good shape for concrete pumps	• Grains have shape edges and sometimes irregular
• Need less water for concrete pumps therefore less cement	• Needs more water
• Surface is smooth and weathered	Surface is rough
• Rounded to sub angular in shape	• Particles are angular

2.10. Technical and Environmental challenges of aggregate production

2.10.1 Technical challenges

One of the main challenges in aggregate production, especially when producing crushed aggregates from hard rock quarries is to obtain a satisfactory mass balance. Any excess fraction that has to be kept on stock or even more deposited will create an economic as well as an environmental problem [46].

From the data found from manufacturers of manufactured sand, the production of crushed aggregate gives a miss balance of particle sizes, as the relative quantity of the sand fraction (0- 4.75mm) in most cases exceeds what can be placed on the concrete to be casted. Unless special processing precautions are taken, the crushed sand will end up with a more or less uncontrolled fine content, far in excess of what can be tolerated if the end product is concrete [46].

The surplus fines have traditionally been considered as a waste material at most plants, and have caused considerable deposition costs for the producers as well as being a problem also from an environmental point of view. Besides, the sharp angular nature of the crushed materials along with a grading curve different from that of natural sand, calls for precautions in the mix design if the potentials of the material shall be taken to benefit. Table 2.6 shows the difference between natural and manufactured sand [46].

2.10.2 Environmental challenges

Aggregates are important construction materials, both for new constructions and maintenance. Aggregates are a valuable natural resource and it is our obligation to use it sensibly, in particular in highly populated areas where the demand is great and costs may increase due to long transportation distances. Good understanding of the basic material properties, usage possibilities and quality are significant for sensible use. It is further important for authorities to be up to date with locations and details of existing and potential quarries. In the developed world, the aggregate and concrete industry is presently facing a growing, public awareness relating to the environmental profile of their activities. Important areas of concern are [45]:

a) The non-renewable character of the natural resources, especially in regions facing a coming shortage of adequate local materials.

b) The environmental impact on neighborhood and society (noise, pollution, etc.) of the quarry and of the materials transport related to the quarrying activities.

c) Land use conflicts between quarries and e.g. agriculture, recreation, building sites, archaeology especially in densely populated regions.

d) A lack of sustainability in production, characterized by inferior mass balance. (I.e. A high percentage of e.g. surplus fines to be deposited) and a high energy consumption needed per ton of aggregate produced. This case might not fully apply in our country case.

e) The potential environmental or health impact of the very materials produced, due to e.g. leaching of heavy metals, radioactivity and to special minerals suspected to have hazardous health properties[45].

2.11. Production and use of Manufactured sand in Ethiopian construction industry.

Ethiopia has been abundantly supplied with natural aggregates resources for construction purposes due to geographical location of the country. Traditionally most concrete aggregates have been produced on the basis of glacio-fluvial sand /gravel deposits, which offer rich but unevenly distributed throughout a country characterized by large transport distances [46].

When conditions require using large quantities of high quality aggregate and sand and even if sufficient quantities of gravel and natural sand are available, concrete made with crushed aggregate and sand is preferred for this application due to its superior performance. The under construction bridge across the Blue Nile river (Abay bridge) is an example to this effect [46].

The use of manufactured sand for concrete production in Ethiopia started about a decade ago. This material is being used by foreign contractors for Asphalt and road structures. Extensive uses of manufactured sand have been used in areas where the availability of natural sand is limited. However, in using these materials the benefit of using manufactured sand economically is not yet proved [46].

2.12. Property of harden concrete

2.12.1 Compressive Strength of Concrete

The strength of a material is defined as the capability of the material to resist stress without failure [48]. The strength of hardened concrete is fundamental in structural design, and is widely used as an index to predict other concrete properties.

The compressive strength of concrete is one of the most important and useful properties of concrete. The primary purpose for design concrete is to resist compressive strength in structural members, in general is the characteristic material value for classification of concrete.

Strength of concrete is the commonly considered its most valuable property, although in many practical cases other characteristic ,such as durability and impermeability , may in fact be more. However, strength usually gives an overall picture of the quality of concrete because strength is directly related to the structure of the hardened cement paste [49]. In addition, it has a great practical and economic significance because the sections and sizes of the concrete structures are determined by it.

In addition to this, Strength is usually the basis for acceptance or rejection of the concrete in the structure. The specifications or code designate the strength (nearly always compressive) required of the concrete in the several parts of the structure. Because concrete is an excellent material for resisting compressive loading, it is used in dams, foundations , columns, arches and tunnel linings where the principal loading is in compression.

Strength is most of the time determined by means of test either cylinders and cubic test made of fresh concrete on the job and tested in compression at various ages. The requirement is certain strength at an age of 28 days or such earlier age as the concrete is to receive its full service load or maximum stress [47].

2.12.2 Flexural strength test

Flexural strength is one of the measures of tensile strength of concrete. It is a measure of the unreinforced concrete beam or slab to resist failure in bending. Although concrete is not normally designed to resist direct tension, the knowledge of tensile strength is of value in estimating the load under which the concrete will crack. The absence of cracking is of considerable importance in maintaining the continuity of a concrete structure and in many cases the prevention of corrosion of reinforcement. (Neville, 1981). The flexural strength is expressed as Modulus of Rupture (MR). It is determined by the third point loading or the Center Point loading. The MR determined by the Third Point Loading is less than that determined by the Center Point Loading, sometimes by as much as 15%. (National Ready Mix Concrete Association, CIP 16, 2000) [44].

2.13 Factors that affect the strength of concrete

There are a multitude of variables that affect the strength of concrete. The factors that are likely to influence the strength of concrete are:-

A) Porosity

All concrete is porous to some extent, primarily because of excess water in the concrete mix. More water is added to concrete than is necessary for hydration in order to achieve acceptable workability.

It is this excess water that remains unreacted in the concrete and results in pores [48]. Pores introduce flaws into the concrete matrix, whereby stress is not transferred through the pores but through the adjacent concrete. This results in localized areas of higher stress than the surrounding concrete. At high stress, failure starts at these localized areas of increased stress. Strength therefore decreases with increasing porosity [48].

B) Aggregates

Strength of concrete depends on the aggregate properties like strength of aggregate; shape and texture affect the concrete strength by the strength of aggregate, its effect on aggregate – cement paste bond and compaction.

C) Aggregate paste interface

The interface between the aggregate and the concrete has been found to be the weakest area in the concrete matrix [48].

A number of factors influence the strength of the aggregate-paste interface and therefore the overall strength of concrete [48].

D) Water-to-cement ratio: It has been found that at lower water-to-cement ratios, the strength of the aggregate-paste interface increases.

E) Age of concrete*:* The strength of the aggregate-paste interface has been found to increase with age, provided there is sufficient water.

F) Bleeding: Strength decreases with increased bleeding.

G) Ultra-fines in aggregates: It has been found that ultrafine material reduces bleeding and causes a fine filler effect at the aggregate-paste interface. Both of these effects will increase the strength of concrete.

H) Surface texture of aggregates: Strength has been found to increase with increasing roughness of aggregates.

2.14 Gradation of Aggregates:

The particle size distribution of the aggregates is called gradation. To obtain the gradation curve for aggregate, sieve analysis has to be conducted in accordance with ASTM C136. The gradations of aggregates are classified into three types, well graded, gap-graded, and uniformly graded, which are illustrated in Figure 2.10
[10].

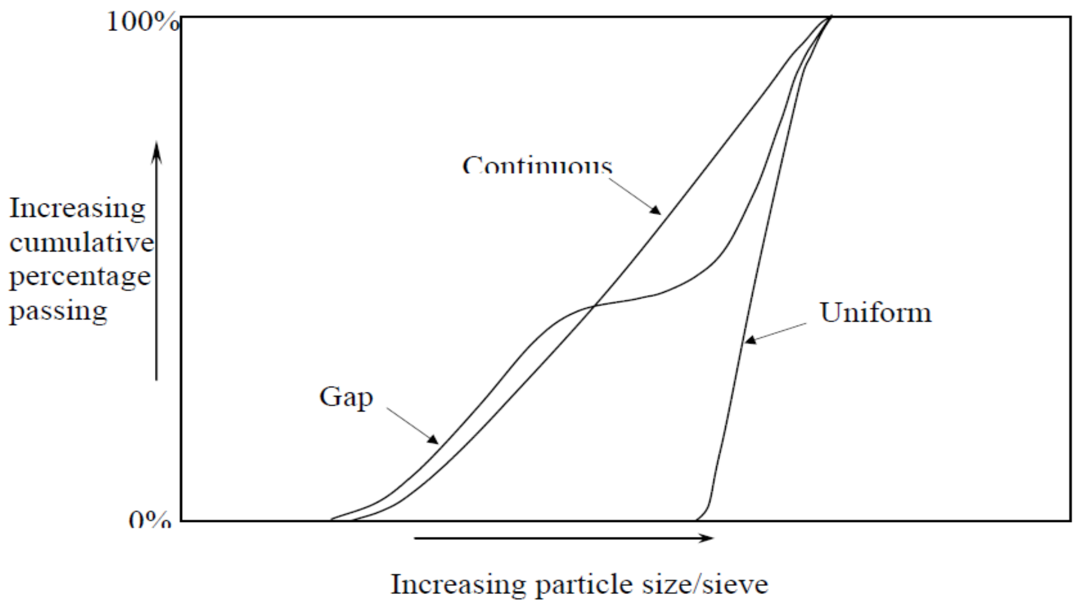


Figure2.10 Gradation of Aggregate [10]

In uniformly graded aggregate, only a few sizes dominate the bulk material and the aggregates are not effectively packed. The result is porous concrete requiring more cement paste. Gap graded aggregate is a kind of grading which lacks one or more intermediate sizes. This grading can make good concrete when the required workability is relatively low. When it is to be used in high workability mixes, segregation may become a problem. It would require higher amount of fines, would require more water, and would increase susceptibility to shrinkage. Well-graded aggregates are desirable for making concrete, as the space between larger particles is effectively filled by smaller particles to produce a well-packed structure, requiring lesser amount of cement paste. This gradation would reduce the need for excess water still maintains adequate workability. Achieving a better gradation may require the use of three or more different aggregate sizes. An optimized gradation is defined as one in which practical and economic constraints are combined with attempts to obtain and use a mix of aggregate particle sizes that will lead to improved workability, durability, and strength [10].

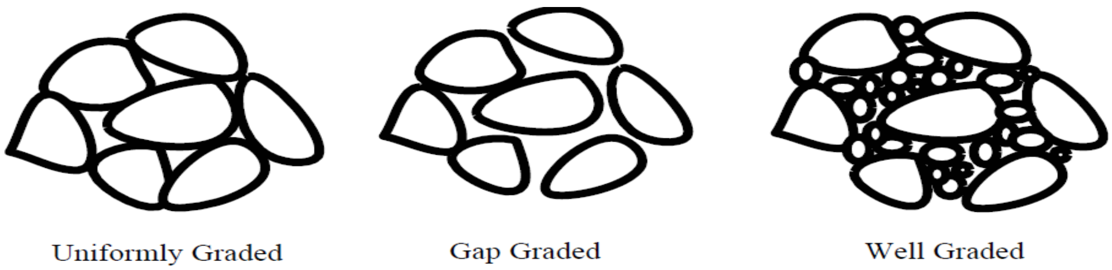


Fig2.11Grading of Aggregates [10]

2.14.1 Coarse-Aggregate Gradation

The grading for a given maximum-size coarse aggregate can be varied over a moderate range without appreciable effect on cement and water requirement of a mixture if the proportion of fine aggregate to total aggregate produces concrete of good workability. Mixture proportions should be changed to produce workable concrete if wide variations occur in the coarse-aggregate grading. Since variations are difficult to expect, it is often more economical to maintain uniformity in manufacturing and handling coarse aggregate than to reduce variations in gradation. The maximum size of coarse aggregate used in concrete has a bearing on the economy of concrete. Usually more water and cement is required for small-size aggregates than for large sizes, due to an increase in total aggregate surface area [39].

Table2.7Sieves commonly used for concrete coarse aggregate sieve analysis

Standard sieve designation		Nominal sieve size	
		mm	In
Coarse sieve size			
75mm	3in	75	3
63	2 1/2 in	63	2.5
50	2in	50	2
37.5	1 1/2	37.5	1.5
25mm	1in	25	1
19mm	3/4in	19	0.75
12.5mm	1/2in	12.5	0.5
9.5mm	3/8in	9.5	0.375

Sources: ACI Education Bulletin E1-99; Table 1 Aggregates for Concrete E1 3

2.14.2 Fine-Aggregate Gradation

The most desirable fine-aggregate grading depends on the type of work, the fruitfulness of the mixture, and the maximum size of coarse aggregate. In leaner mixtures, or when small-size coarse aggregates are used, a grading that approaches the maximum recommended percentage passing each sieve is desirable for workability. In general, if the water-cement ratio is kept constant and the ratio of fine-to-coarse aggregate is chosen correctly, a wide range in grading can be used without measurable effect on strength. However, the best economy will sometimes be achieved by adjusting the concrete mixture to suit the gradation of the local aggregates [39].

Fine aggregate grading has a greater effect on workability of concrete than coarse aggregates. Manufactured sands require more fines than natural sands to achieve the same level of workability, probably due to the angularity of the manufactured sands particles [41].

Table2.8 Fine aggregate grading limits (ASTM C 33/ AASHTO M 6) [56].

Sieve size	Percentage passing
9.50mm (3/8 in.)	100
4.75mm (No. 4)	95 – 100
2.36mm (No. 8)	80 – 100
1.18mm (No. 16)	50 – 85
600mm (No. 30)	25 – 60
300μm (No. 50)	5 – 30 (AASHTO 10 – 30)
150μm (No. 100)	0 – 10 (AASHTO 2 – 10)

Table2.9 BS and ASTM grading requirement for fine aggregate [49]

Standard Sieve Size		Percentage by weight passing sieves				
		BS 882:1992				ASTM
BS	ASTM No.	Grading Zone 1	Grading Zone 2	Grading Zone 3	Grading Zone 4	Standard C33-78
9.5mm	3/4 in	100	100	100	100	100
4.75mm	3/16in	90-100	90-100	90-100	95-100	95-100
2.36mm	8	60-95	75-100	85-100	95-100	80-100
1.18mm	16	30-70	55-90	75-100	90-100	50-85
600 μm	30	15-34	35-59	60-79	80-100	25-60
300 μm	50	5-20	8-30	12-40	15-50	10-30
150 μm	100	0-10	0-10	0-10	0-15	2-10

Sand falling in to any of the above zone can generally be used in concrete although under some circumstances the suitability of the given sand may depend on the grading and shape of coarse aggregate [49].

2.20. Effect of Fine Aggregates on Fresh Concrete Properties

Particle shape, texture, and grading have a great impact on the fresh properties of concrete. Mixtures containing high amounts of poorly shaped particles (like MFAs) tend to need a higher amount of paste content to achieve the same workability (compared to a mixture made with natural sands) [11]. Other properties such as finish ability, air content, bleeding, and segregation might also be affected by the use of MFA.

A) Workability

Fine aggregates have a higher impact on workability than coarse aggregates. One of the obstacles to using MFA in concrete is that manufactured sands are typically composed of sharp, angular particles with large numbers of flat and elongated particles [12]. Angular particles create a greater void volume within the aggregate. Additional paste (water and cement) is needed to fill those voids [24]. This can be offset, however, by using a higher dosage of admixture [11]. When using MFA in concrete mixtures, a water-reducing admixture may not be sufficient to achieve a slump of 2 in. [25]. Mid-range or high-range water-reducing admixtures (MRWRA and HRWRA) have a higher water reducing capacity.

Another aspect of MFA that affects workability is the presence of high amounts of micro fines. Micro fines are believed to have an adverse effect on the workability of concrete due to their small sizes (large surface area) and because they might contain deleterious materials (like clay and other organic materials). Research by ICAR on self-consolidating concrete found that micro fines can be successfully used and can lead to an improvement in the workability of concrete (when low amounts of deleterious materials such as clays are present) [14]. Furthermore, when micro fines are considered as part of the aggregates, higher dosages of admixture are needed to achieve the same workability as compared to mixtures where the micro fines are accounted for as part of the paste [11]. Both the angular nature of MFA and the presence of high amount of micro fines affect the workability of concrete. These negative impacts on workability can be counteracted by blending sands, using an admixture, or by the addition of fly ash [25]. Increasing the quantity of manufactured sand in a blend will reduce workability or will require a higher dosage of admixture [25].

2.21 Property of fresh concrete

A) Slump Test

The procedure used for measuring the slump of all mixes was in accordance with ASTM C 143 Standard Test Method for Slump of Hydraulic-Cement Concrete to characterize the consistency of the fresh concrete from all the mixes. The slump cone was filled with fresh concrete in 3 equivalent layers, and rodded 25 times after every layer. After the slump cone was filled, the excess concrete was struck off the top and removed from the area surrounding the base of the cone. Once the cone was removed, the distance between the displaced center of the sample's top surface and the top of the cone mold was recorded as the slump. All slump tests were performed and measurements made by the same individual to minimize the variance between results [53].

If the sample, once the cone was removed, showed falling away or shearing off behavior, as illustrated in Figure 2.12, the test was discounted and repeated using a new sample. However, if this behavior recurred on the subsequent test, the mix was deemed "unworkable" as it lacked proper consolidation and flow ability [53].

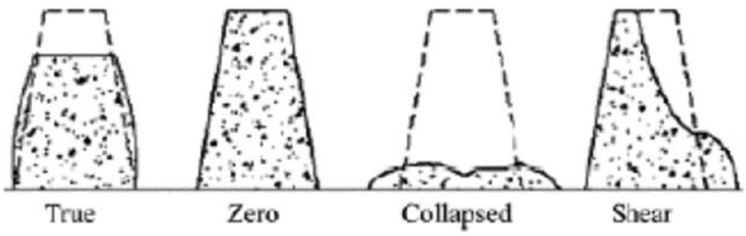


Fig2.12 Types of Slump Behavior (Koehler, 2009a)

Table2.10 Degree of Workability and Slump (Source: Neville & Brooks, 2010)

Degree of workability	Slump(mm)	**Application**
Very Low	0-25	Vibrated concrete in roads or other large sections.
Low	25-50	Mass concrete foundations without vibration. Simple reinforced section with vibration
Medium	50-100	Normal reinforced work without vibration and heavily reinforced sections with vibration
High	100-180	Sections with congested reinforcement. Not normally suitable for vibration

2.22 Methods of blending aggregate

The blending of aggregates is a process in which two, three, or more of aggregates, which have different types of sources and sizes, are mixed together to give a blend with a specified gradation.

The blending of aggregates is done because (4):

- ❖ There are no individual sources, sizes, and types of aggregates (natural or by product) that individually can supply aggregate of gradation to meet a specific or desired gradation.

- It is more economical to use some natural sands or rounded aggregates in addition to crushed or manufactured aggregates, and this process (mixing natural and crushed) cannot be held without using a blending operation.

There are different methods and techniques which can be employed to find percentage values. None of these should give a blend outside the specified grading. Obviously, there may be several acceptable combinations. An optimal combination is achieved when the blended or composite percentages match the original desired percentages [4].

Regardless of which method will be used, there are two important pieces of information that must be known before finding the proportion values. These are the sieve analysis of each material, and the limits of desired specifications. Following are the commonly used methods which are used to find blending values:

A) Trial-and-error method: Is the most common method of determining the proportions of aggregate which meets specification requirements [23]. The designer, who has plenty of experience, can estimate the percentage value of each aggregate contributes in the blend. He also can predict the first approximation value by interpreting the sieve analysis of each type and desired gradation. By repeating the trial process several times, the contribution of each one can be estimated.

B) Mathematical method: depending on the basic formula of this method which is true for any number of aggregates combined; [23]

$P=Aa+Bb$……………………………………………………………………..……Eq.2.1

a+b+c+⋯=1………………………………………………………………………Eq.2.2

Where:

P is the percentage of material passing through a given sieve for the combined aggregates A, B, C.

A, B, and C are the percentages of material passing a given sieve for aggregates A, B, C, respectively. a, b, and c are the proportions of aggregate A, B, and C used in the combination.

C) Graphical Methods: These techniques have been devised for determining combinations of aggregates to obtain a desired gradation. They are applied for early stage of construction and are still popular among engineers due to their simplicity and rapidity of use [18]. In these methods, only graph paper and simple engineering drawing tools are needed. However, as the number of aggregates to be combined is increased, the graphical method becomes increasingly complicated. [4].

CHAPTER THREE

MATERIALS AND METHODS OF RESEARCH

3.1. Study Area

The study area of this research was Jimma Town. It is one of the ancient and largest towns in the country which located 335km by road southwest of Addis Ababa. Its geographical coordinates are approximately 7°41'N latitude and 36°50'E longitude. The town is found in an area of average altitude, of about 5400ft (1780 m) above sea level. It is a special zone of the Oromia Region and is surrounded by Jimma Zone as shown in Figure 3.1.

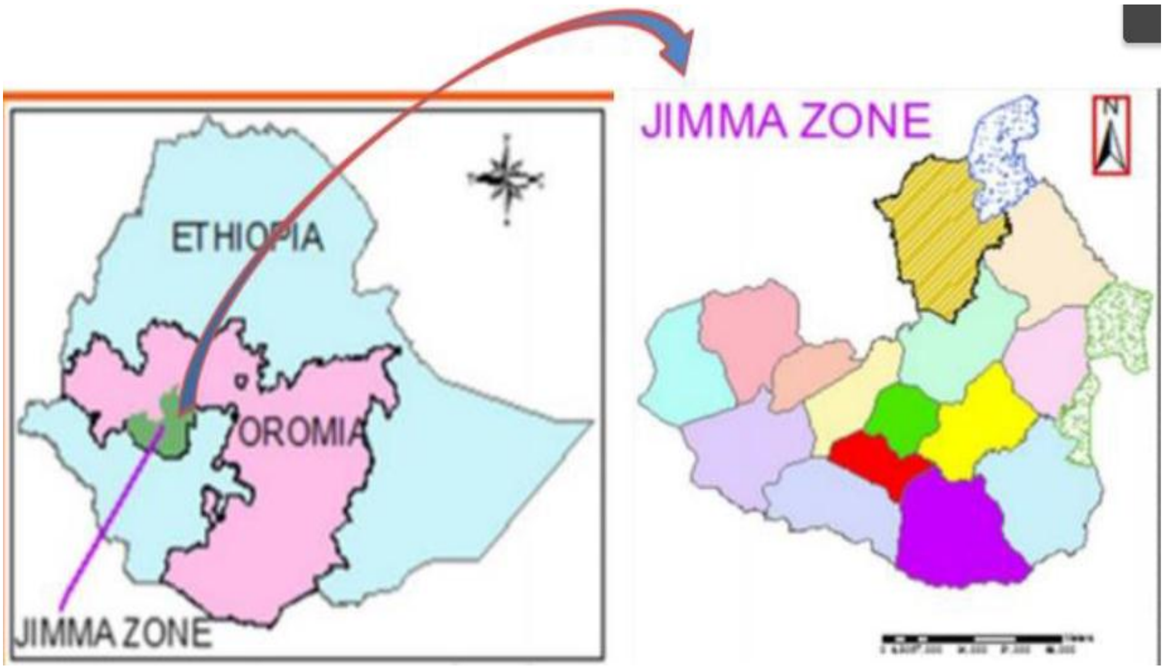


Figure3.1 Map of Jimma zone (Source: GIS, 2017).

3.2. Study Design and Methods

Laboratory experimental method was used for this research during the study period, in order to provide the most reliable proof by studied the quality of the raw material of concrete mainly quality of natural river fine aggregate, manufacturing sand, natural gravel, crushed coarse aggregate and identified their effects on the blended of natural river sand with manufacture sand and natural gravel with crushed coarse aggregate on concrete properties such as workability and mechanical strength of concrete mainly compressive strength and flexural strength of concrete. The research program was divided into two main phases:

Phase: 1

The aggregate was collected from their source and tested in the laboratory to determine its physical, mechanical and fresh concrete properties. The tests were carried out in accordance with the appropriate ASTM, AASHTO, ACI, ES and BS was applicable.

Phase: 2

In phase 2, the two coarse aggregate types (crushed coarse aggregate and uncrushed river gravel aggregate) and the two fine aggregate (natural sand and manufacture sand) were blended together using the mathematical method (P=Aa+Bb+Cc…Nn) to produce concrete.

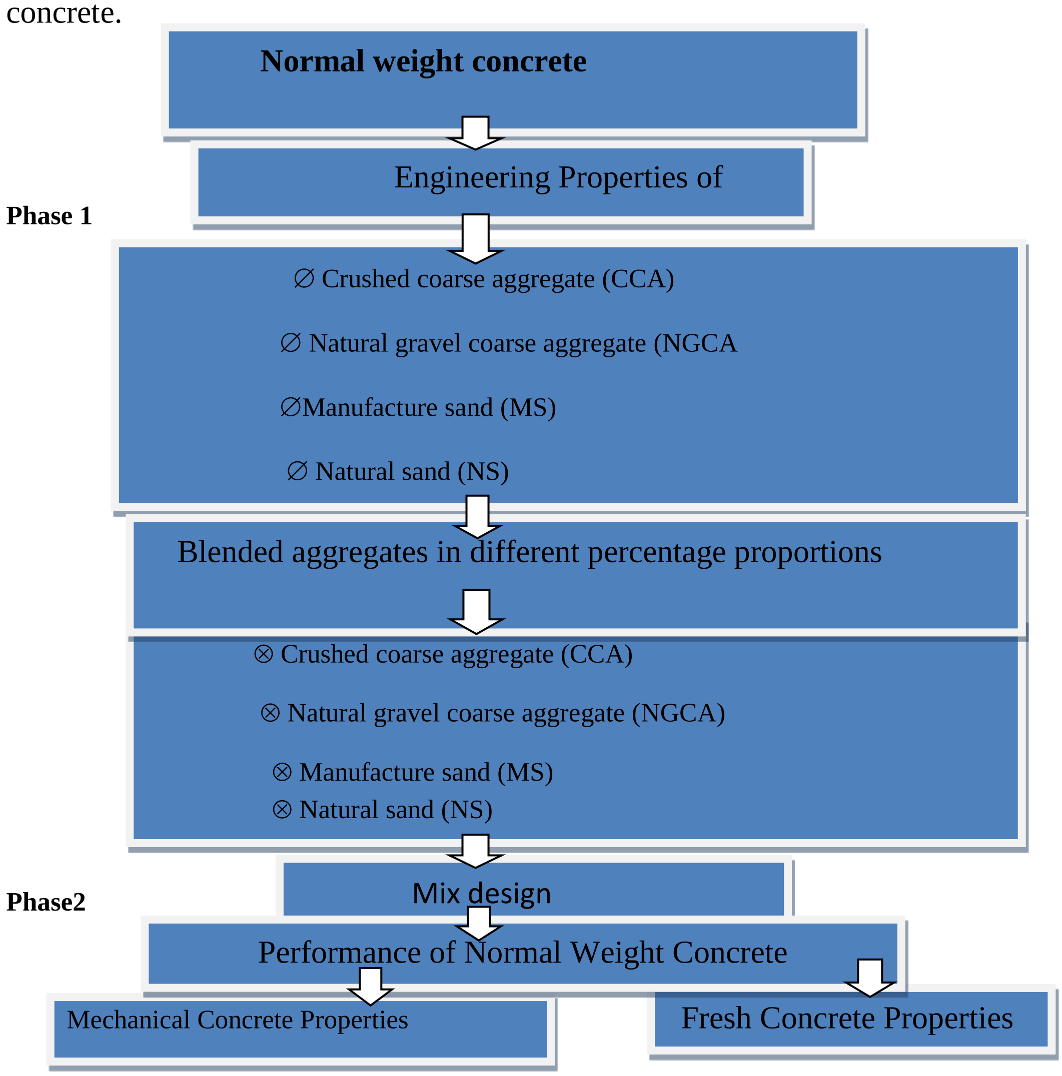


Figure3.2 Research program

3.3 Materials Supply for Laboratory Experimental Works

- **Cement:** Dangote Commercially available type I Ordinary Portland Cement was used for this purpose. This cement has a specific gravity of 3.15 and 42.5R grade.

Table 3.1 Properties of Ordinary Portland cement (OPC).

Type of test	Method of testing	Test result		AASHTO M-85 Specification
Determination of setting time	AASHTO T-128-97 (BS EN 196-3) vicat test	initial setting time	70	Min. 45 minute
		final setting time	185	Max. 375 Minute
Determination of Consistency	AASHTO T-131-01(BS EN 196-4)	9.3		
Determination of Fineness	AASHTO T-129-01-01(BS EN 196-6)	150 μm(No. 100)	99.3 %	-
		75μm (No 200)	92.4%	-

- **Coarse Aggregate**: two types of coarse aggregates; crushed basalt, and river gravel; were used. Crushed coarse aggregate collected from varnero crushing site whereas river graver coarse aggregate collected from Gibe River.
- **Fine aggregate**: two types of fine aggregates; manufacture sand, and river sand; were used. Manufacture sand collected from varnero plc. Crushing site whereas natural sand collected from Gambella Baro River.
- **Water:** Drinkable (potable) water was used from Jimma Institute of Technology Construction Materials Laboratory water supply.

Preliminary laboratory investigation was conducted to determine the suitability of using the aggregates for construction work.

3.4. Samples of the Research

The sample frame or target populations of this research were listed in Table 3.2

Table 3.2 Type and source of aggregate

No	Aggregate type	Source
1	Crushed coarse aggregate (CCA)	From Varnero crushing site
2	River gravel coarse aggregate (RGCA)	From Gibe river
3	Natural sand (NS)	From Gambella"Baro" Riversand
4	Manufacture sand (MS)	From Varnero crushing site

Figure3.3 CCA field sample

Crushed coarse aggregate and river gravel coarse aggregate with nominal maximum size of 25 mm, specific gravity of 2.62and complying with ASTM C-33 was used as crushed coarse aggregate in this study. While river bank gravel coarse aggregate was obtained from source and have a specific gravity of 2.64.

Figure3.4 RGCA field sample

3.5. Sampling Techniques

The sampling technique was used for this research was a purposive sampling technique which is the non-probability method and to accurate the sampling, the researcher used in the laboratory splitting method for all sample. This sampling technique was proposed based on the information that the researcher have and the aim or goal of the researcher to be achieved.

3.6. Study variables

1. Dependent variable

- fresh and harden properties of concrete

2. Independent variable

- Blended different percentage of crushed and natural aggregate in concrete mix.

3.7. Sources of Data

Both primary and secondary data sources were used. Secondary data needed for this research was collected from different journals, book, website etc. during the literature review and primary sources of data for this study were a laboratory experimental output.

3.8. Laboratory Experimental Works Procedure

Stage 1: Sampling preparation stage

3.8.1 Crushed Coarse Aggregate

Crushed Coarse aggregate sample was washed to minimize or remove the impurities of the coarse aggregate on the surface of material before using in concrete mix. And sun dried on a clean platform as shown in Figure 3.5. For all the concrete mixes, the same crushed coarse aggregate from varnero plc.Agaro crushing stone site was used. This aggregate is commonly used in the Jimma Town area and as such, is readily available and best simulates normal construction practice in the region.

Source: from researcher photo gallery during lab work 2017

Figure3.5 washing the crushed coarse aggregate sample and sun dried on a clean platform.

3.8.2. River gravel coarse aggregate

Using the same Procedure of CCA, River gravel coarse aggregate sample were washed to minimize or remove the impurities of aggregate on the surface of material before using in concrete mix. And sun dried on a clean platform as shown in Figure 3.5. For all the concrete mixes, the same river gravel coarse aggregate from Gibe river bed was used. This aggregate is commonly available material source around Jimma zone (like Gibe river, Seka river, Deniba river) well conserved material in the river bed area and due to different case it is not practicable for construction in the region.

Source: from researcher photo gallery during lab work 2017

Figure3.6 washing river gravel coarse aggregate sample and sun dried on a clean platform.

Fig3.7 Both Coarse Aggregate Sample preparations using riffling method for Laboratory Test.

After the sample was saturated surface dried, then both the sample crushed coarse aggregate and river gravel coarse aggregate was prepared to the laboratory experimental test by using Sample Splitter as shown in the above Figure 3.7 to representative for the entire sample in the experiment.

3.8.3. Fine Aggregate (Sand) and manufacturing sand

Both manufacture and river sand sample was sun dried in order to minimize the effect of impurity on concrete and Check the saturated surface dry of the sample by using small cone and tamper.

Stage 2: Laboratory tests on ingredient of concrete

- ❖ Tests on coarse aggregate according to ASTM Standard Procedures. (I.e. sieve analysis or gradation, water absorption, unit weight, specific gravity, moisture content)
- ❖ Tests on fine aggregate according to ASTM Standard Procedures. (I.e. sieve analysis or gradation, water absorption, unit weight, specific gravity, moisture content and Silt/Clay Test of Sand sample).
- ❖ Tests on cement (i.e. Consistency test, initial and final setting time test and fineness of cement test).
- ❖ **Silt content of sand**

This test conducted to determine the silt (finer than No.200 sieve) content in sand, because Sand is a product of natural or artificial disintegration of rocks and minerals.

Sand is obtained from glacial, river, lake, marine, residual and wind-blown (very fine sand) deposits. These deposits, however, do not provide pure sand. According to the Ethiopian Standard it is recommended to wash the sand or reject if the silt content exceeds a value of 6%. The testing procedure was done according to ASTM.

- **Sieve Analysis**

The grading is determined in accordance with ES C.D3. 201 Sieves or Screen Analysis of Fine and Coarse Aggregates. A sample of the aggregate is shaken through a series of sieves nested one above the other in order of size, with the sieve having the largest openings on top and the one having the smallest openings at the bottom. According to ASTM, the term coarse aggregate is used to describe particles larger than 4.75 mm (retained on No. 4 sieve), and the term fine aggregate is used for particles smaller than 4.75 mm.

The gradations of aggregate were selected by considering the ASTM C-33 standard coarse aggregate gradation specifications as shown in (appendix C). The gradation of the aggregate was selected primarily based on the lower, average and upper values of the percentage weight passing through the specific sieves. During this test; the laboratory sample was taken by reducing the filed sample with sample Riffling technique. A plot of the low, average and upper values of the gradation is shown in (appendix C). After this analysis is carried out, aggregates are described as well graded, poorly graded, uniformly graded, gap graded mainly depends on the quality of the concrete because Maximum size of aggregate is the smallest sieve that all of a particular aggregate must pass through and nominal maximum size of an aggregate: the smallest sieve size through which the major portion of the aggregate must pass ninety up to hundred percent. The testing procedure was done according to ASTM.

(A) Riffling sample (B) sieve sample (C) balancing
sample

Figure 3.8 Riffling samples and gradation coarse aggregate in the apparatus.

- **Specific Gravity & Absorption (ASTM C 127-01 and ASTM C 128-01)**

Test methods for finding specific gravity of aggregates are described in ASTM C 127&AASHTO T 85, ―Specific Gravity and Absorption of Coarse Aggregate, are the generally accepted test procedures.

Since aggregates generally contain pores, both permeable and impermeable, the meaning of the term specific gravity has to be carefully defined, and there are indeed different types of specific gravity, like: apparent specific gravity and bulk specific gravity. Bulk specific gravity refers to total volume of the solid including pores of the aggregate, and Apparent specific gravity refers to the volume of the solid is consider to include the impermeable pores but not the capillary ones whereas, absorption capacity of the aggregate is the ability of the aggregate to be absorb in the mixing water.

- The apparent specific gravity and bulk specific gravity SSD are calculated as follows;

- Bulk specific gravity (OD):

$$Bulk\ Spe.gra = \left[\frac{A}{(B - C)} \right] \quad \text{……………………Eq. 3.1}$$

- Bulk specific gravity (saturated surface dry basis)

- $Bulk\ Spe.gra = \left[\frac{B}{(B-C)} \right]$ ……………………………Eq. 3.2
- Apparent specific gravity= $\frac{A}{(A-C)}$ ………………………………………Eq. 3.3

$$Absorption\ Capacity = \left[\left[\frac{(B-A)}{A} \right] *100 \right]$$ ………...………Eq. 3.4

Where:

- Weight of oven dry sample in air (mass A)
- Weight of saturated surface dry sample in air (mass B)
- Weight of saturated sample in water (mass C)

❖ Moisture Content of fine Aggregates Test

The moisture content of fine aggregate was determined by Oven dry 2kg of fine aggregate (sand) for about 24hrs with a temperature of 110±5°C and waiting until to cool for an hour. Then, dividing the weight difference by oven dry weight and multiplying by hundred provide the moisture content.

❖ Bulk density (Rodded unit weight)

The bulk density of the aggregate was determined according to ASTM C29 & AASHTO T019. In the test, a test cylinder of known volume is used and the mass of aggregate required to fill the cylinder is determined from the difference in mass between filled and empty cylinder. The method most commonly used requires placing in three layers and rodding each layer 25 times with a tamping rod.

Figure3.9 Bulk Density of coarse Aggregate Test both river gravel and crushed coarse aggregate.

The mass of the container is subtracted to give the mass of the aggregate, and the bulk density is the aggregate mass divided by the volume of the container.

- Unit Weight (Kg/m3) $=\frac{A-B}{C}$ …………………………………………….Eq. 3.5

Where:

A = Mass of Container (Kg)

B = Mass of Container + Sample (Kg)

C= Volume of container (m^3)

- **Aggregate Impact Value**

The AIV test was done according to BS 812-112:1990. The AIV value gives a relative measure of the resistance of the aggregate to sudden shock or impact. This test has been designed to evaluate the toughness or the resistance of stones, aggregate to breaking down under repeated application of vertical impact.

The test samples are prepared by sieving coarse aggregates with sieve size 10 mm and 14 mm, and collecting samples passing through the 10 mm sieve and retained in the 14 mm sieve. The test specimen is then compacted, in a proper procedure, in an open steel cup. The specimen is then subjected to a number of standard impacts from a dropping weight as shown in figure 3.10 this action breaks the aggregate to a degree which is dependent on the impact resistance of the material. This degree is assessed for the amount of crushed aggregate passing through sieve size 2.35 mm and is taken as a measure of the aggregate crushing value (AIV).

Figure3.10 Aggregate Impact Value test

$$AIV=\frac{W2}{W1}*100 \text{ ....Eq.3.6}$$

Where W1 is the mass of oven-dried test specimen (in kg) and W2 is the mass of oven dried material passing the 2.35 mm test sieve (in kg).

- **Setting time of cement**

This method is used to determine the initial setting time and final setting time of cement paste with normal consistency. Cement forms a solid and hard mass (or change from fluid to a rigid state) when mixed with water upon hydration. This phenomenon is known as setting of cement. The duration of a cement paste requires undergo setting is its setting time. As setting is the consequence of hydration of cement, setting time is affected by the amount of water used to prepare cement paste, that its water to cement ratio. Cement pastes with different water to cement ratio will, generally, have different setting times. The setting time of cement paste with normal consistency that is referred to as the setting time of cement.

There are two types of setting time to determine in the laboratory, initial and final setting times. The initial setting time is the duration of cement paste related to 25mm penetration of the Vicat needle in to the paste in 30 seconds after it is released while the final setting time is that related to zero penetration of the Vicat needle in to the paste. The testing procedure was done according to ASTM.

Stage 3: Concrete Mix design

In this research work, the ACI Method of concrete mix design was used to design C-25 concrete grade having a 33.5 MPa target mean strength with 0.491 of water to cement ratio. In addition to this, the slump was in the minimum range of 25 to 50mm. On this base; 8 different types of mix-design was prepared based on percentage of blend show in the table 3.3. For all the concrete mixes, the same w/c ratio was used.

The quantity of concrete materials was calculated by using the physical properties of the materials and Table 3.11 shows the quantity of materials for one cubic meter for C-25 concrete grade. The Standard cast iron molds of size 15cmx15cmx15cm are used in the preparation of concrete cubes for compressive strength tests and 50cm×10cm×10cm for flexural strength.

Table 3.3 percentage proportion of Concrete Mix -Design for 1 m3 of concrete

Mix design	Percentage of blended material			
	MS (%)	NS (%)	RGCA (%)	CCA (%)
#1	0	100	0	100
#2	0	100	100	0
#3	100	0	0	100
#4	10	90	10	90
#5	20	80	20	80
#6	30	70	30	70
#7	40	60	40	60
#8	50	50	50	50

1. Properties of aggregates used in the analysis

Table 3.4 Physical Properties of aggregate samples used for the mix design

Engineering Properties of Aggregate Used in the research		River gravel coarse Aggregate	Crushed coarse aggregate	Fine aggregate		Standard Specification
		RGCA	CCA	MS	NS	
1	Specific Gravity (SSD)	2.64	2.62	------	------	ASTM C 127 2.4-2.9
2	Water Absorption (%) (SSD)	1.03	1.94	-------	-----	ASTM C 127 0.2% to 4%
3	Dry-Rodded Unit Weight (kg/m3)	1451.5	1636.5	-------	------	ASTM C 29M – 97 1200-1750
4	Aggregate Impact Value (%)	9.56	12.68	-------	------	BS812-112:1990 ≤45
1	Unit weight (kg/m3)	--------------------	-------------------			ASTM C -29 1520-1680

2	Fineness modulus	-----------------	------------------	3.00	2.85	ASTM C 136 2.2-3.1
3	Specific gravity	------------------	------------------	2.64	2.54	ASTM C128 2.3-2-9
4	Absorption, %	-----------------	-----------------	1.41	1.22	ASTM C128 0.2-2
5	moisture content, %	1.21	0.76	0.9	1.06	ASTM C70-79 2-6
6	Specific gr. Of Cement (O.P.C)	3.15				ASTM C 150

- **Combination specific gravity of CCA and RGCA (SSD) using Eq. (3) Formula.**

Sp.gr (SSD) =$\frac{1}{\frac{PCCA}{GCCA}+\frac{PRGCA}{RGCA}}$ ……………………………..………………….………….Eq.3.7

Where:

PCCA: Blending crushed coarse aggregate in percentage

PRGCA: blending river gravel coarse aggregate in percentage

GCCA: specific gravity of crushed coarse aggregate

GRGCA**:** specific gravity of river gravel coarse aggregate

Table 3.5 Combination specific gravity (SSD) of CCA & RGCA

Percentage of blended aggregate(CCA&RGCA)	Specific gravity before combined(blended)		Specific gravity after combined (blended) using the formula
	Sp.gr CCA	Sp.gr RGCA	
90%CCA + 10%RGCA	2.62	2.64	2.622
80%CCA + 20% RG	2.62	2.64	2.624
70%CCA + 30% RG	2.62	2.64	2.626
60%CCA + 40%RG	2.62	2.64	2.68
50%CCA + 50%RG	2.62	2.64	2.63
Average			**2.63**

- **Blended CCA&RGCA Absorption capacity calculation using Eq.3.8 formula.**

PA*absorption A + PB*Absorption B……………………..……….…………….Eq.3.8

Where: PA= percentage proportion of blend aggregate A (CCA)

PB=percentage proportion of blend aggregate B (RGCA)

90%CCA: 10%RG= 0.9*1.94 +0.1*1.03=1.85%

Table 3.6 Water absorption capacity of blended test result

Percentage of blended aggregate(CCA&RGCA)	Water absorption before combined the aggregate (%)		Water absorption after combined the aggregate (%)
	Absorption CCA (%)	Absorption RGCA (%)	
90%CCA + 10%RGCA	1.94	1.03	1.85
80%CCA + 20% RG	1.94	1.03	1.76
70%CCA + 30% RG	1.94	1.03	1.67
60%CCA + 40%RG	1.94	1.03	1.58
50%CCA + 50%RG	1.94	1.03	1.49
Average			**1.67**

- **Concrete mixing and Production Process**

The ingredients, such as; cement, fine aggregate (sand), coarse aggregate and water were measured to an accuracy of 0.1g balance. After that the weighted fine aggregate was first added on the large flat plat and the coarse aggregate was added after the fine aggregate and then the cement is added next to fine aggregate and dry mixed for a minute. Then, water was added to the dry mixed concrete ingredients mixture and thoroughly mixed for two more minute. Mixing of concrete by varying percentage of manufacture sand and river graver coarse aggregate content (0%, 10%, 20, 30%, 40% and 50%) and the mix cement and water are constant for all C-25 concrete mix.

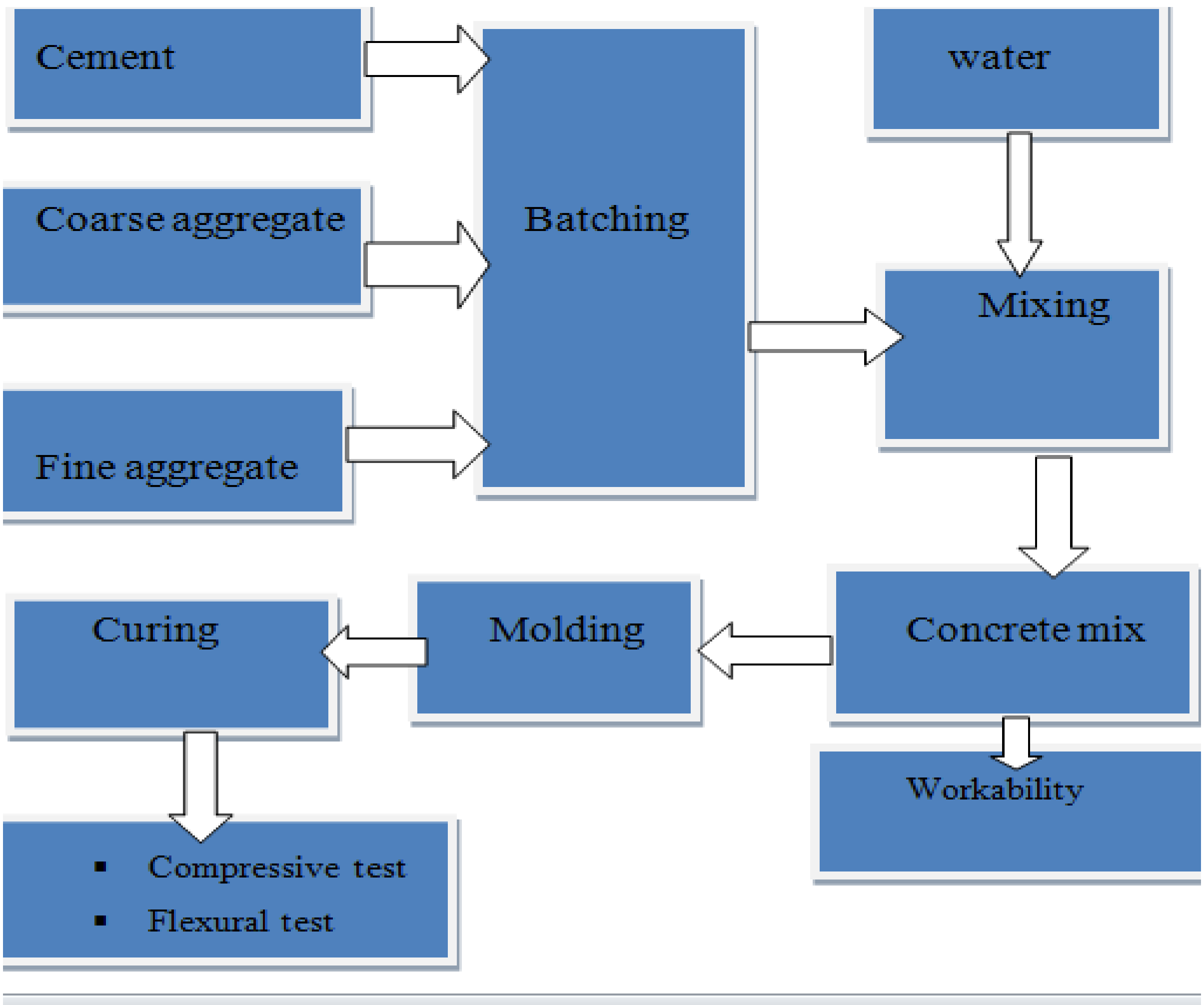


Figure3.11 Flow Chart represented work in the laboratory.

3.9. Concrete mix design

Mix design procedure used in this research as per ACI 211.1-91

I. Mix design using 100%CCA+100%NS (Control mix appendix C)

Table 3.7 Total concrete Ingredient Proportion mass before moisture adjusted.

Materials	**Proportion mass in (kg)**
Water	179
Cement	365
Fine aggregate/MS	702
Coarse aggregate/RGCA	1084
Total mass	2330

- **Estimated concrete density (using SSD aggregate)**
  - ✓ Ave. Absorption Capacity=1.94 %................................for Coarse Aggregate

- ✓ Ave. Water Absorption Capacity =1.03%......................for Fine Aggregate
- ✓ **Estimated concrete density (using SSD aggregate**)=179 + 365 + (1084 x 1.0194*) + (702x 1.01*) ≈2358.1 **kg/m3**
  - 1.94/100+1=**1.0194** and 1.03/100+1=**1.01**

❖ **Moisture correction**

Moisture: Corrections are needed to compensate for moisture in and on the aggregates. In practice, aggregates will contain some measurable amount of moisture. The dry-batch weights of aggregates, therefore, have to be increased to compensate for the moisture that is absorbed in and contained on the surface of each particle and between particles. The mixing water added to the batch must be reduced by the amount of free moisture contributed by the aggregates. From the laboratory Tests indicate that for the coarse-aggregate moisture content is 0.76% and fine-aggregate moisture content is 1.06%.

With the aggregate moisture contents (MC) indicated, the trial batch aggregate proportions become:

Coarse aggregate (0.76% MC) = 1084x 1.0076=**1092.24kg**

Fine aggregate (1.06% MC) = 702 x 1.0106 = **709.44kg**

Water absorbed by the aggregates does not become part of the mixing water and must be excluded from the water adjustment. Surface moisture contributed by the coarse aggregate amounts to 0.76% – 1.94% = -1.18%; that contributed by the fine aggregate is, 1.06%-1.22 %**%(MC-Absorption)** = - 0.16%. The estimated requirement for added water becomes

179 – (1084 x (-0.0118)) – (702 x (-0.0016)) = **192.9kg**

The estimated batch weights for one cubic meter of concrete are revised to include aggregate

Moisture as follows:

Table 3.8 revised proportion of ingredients of concrete

Materials	**Proportion mass in kg**
Water	192.9
Cement	365
Fine aggregate	709.44
Coarse aggregate	1092.24
Total mass	2359.58kg

II. Mix design using 100%RGCA+100%NS (appendix C)

Table 3.9 total concrete Ingredient Proportion mass before moisture adjusted.

Materials	Proportion mass in (kg)
Water	179
Cement	365
Fine aggregate/MS	828
Coarse aggregate/RGCA	961
Total mass	2333.1

- **Estimated concrete density (using SSD aggregate)**
  - ✓ Ave. Absorption Capacity=1.03 %..................for River Coarse Aggregate
  - ✓ Ave. Water Absorption Capacity =1.22%.......for Fine Aggregate
  - ✓ **Estimated concrete density (using SSD aggregate)**=179 + 365 + (961 x 1.0103*) + (828 x 1.0122*) ≈2353 **kg/m3**
    - 1.03/100+1=**1.0103** and 1.63/100+1=**1.0122**
  - **Moisture correction**

Coarse aggregate (1.21% MC) = 961x 1.012 =**972.53kg**

Fine aggregate (1.06% MC) = 828 x 1.0106 = **836.78kg**

Water absorbed by the aggregates does not become part of the mixing water and must be excluded from the water adjustment. Surface moisture contributed by the river coarse aggregate amounts to 1.21% – 1.03% = +0.18%; that contributed by the fine aggregate is, 1.06%-1.22 **%(MC-Absorption)** = - 0.16%. The estimated requirement for added water becomes

179 – (961 x (0.0018)) – (828x (-0.0016)) = **178.6kg**

The estimated batch weights for one cubic meter of concrete are revised to include aggregate

Moisture as follows:

Table 3.10 revised proportion of ingredients of concrete

Materials	**Proportion mass in kg**
Water	178.6
Cement	365
Fine aggregate	836.78
Coarse aggregate	972.53
Total mass	2352.9kg

- **Lab trial batching**

Table 3.11 Quantities of Materials for Lab Trial Batching for control Concrete Mix design.

Types of aggregate		Water (kg)	Cement (kg)	Coarse aggregate (kg)	Fine aggregate (kg)	Total (kg)
CCA	Quantity (per m3)	192.9	365	1092.24	709.44	2359.58
	Quantity (per 9 mold)	5.93	11.22	33.59	21.82	72.56
Ratio		0.53	1	2.994	1.945	≈1:2:3
RGCA	Quantity (m3)	178.6	365	972.53	836.78	2352.9
	Quantity (per 9 mold	5.5	11.22	29.91	25.73	72.36
Ratio		0.49	1	2.67	2.29	≈1:2:3
*=(0.15*0.15*0.15*9) =0.03075m3						

III. Mix design using the different blended proportion (appendix C).

Table: 11C total concrete Ingredient Proportion mass before moisture adjusted.

Materials	Proportion mass in (kg)
Water	179
Cement	365
Fine aggregate/MS	790
Coarse aggregate/RGCA	1025
Total mass	2359

Estimated concrete density (using SSD aggregate)

- ✓ Ave. Absorption Capacity=1.67 %................for blended Coarse Aggregate
- ✓ Ave. Water Absorption Capacity =1.28%.......for blended fine Aggregate
- ✓ **Estimated concrete density (using SSD aggregate**)=179 + 365 + (1025 x 1.0167*) + (790 x 1.0128*) ≈**2386.**kg/m3
    - 1.67/100+1=**1.0167** and 1.28/100+1=**1.0128**

❖ **Moisture correction**

Blended Coarse aggregate (0.95% MC) = 1025x 1.0095 =**1035kg**

Blended fine aggregate (0.95% MC) = 790 x 1.0095 = **798kg**

Water absorbed by the aggregates does not become part of the mixing water and must be excluded from the water adjustment. Surface moisture contributed by the blended coarse aggregate amounts to 0.95% – 1.67% = -0.72%; that contributed by the blended fine aggregate is, 0.95%-1.28 **%(MC-Absorption)** = - 0.33%. The estimated requirement for added water becomes

179 – (1025 x (-0.0072)) – (790x (-0.0033)) = **182.3kg**

The estimated batch weights for one cubic meter of concrete are revised to include aggregate Moisture as follows:

Table 12C revised proportion of ingredients of concrete

Materials	Proportion mass in kg
Water	182.3
Cement	365
Fine aggregate	798
Coarse aggregate	1035
Total mass	2380.3

Table 3.12 Quantities of Materials for Lab Trial Batching in different % of blended aggregate for Concrete Mix design by weight method.

Total mix Quantity per m3	W(kg)	C(kg)	CA(kg)		FA(kg)		Total
	182.3	365	1035		798		2380.3
Batching 1 in kg							
Blending Percentage	W	C	CCA	RGCA	NS	MS	Total
90%NS+10%MS & 90%CCA+10%RG	182.3	365	931.5	103.5	718.2	79.8	2360
Batching 2 in kg							
80%NS+20%MS & 80%CCA+20%RGCA	182.3	365	828	207	638.4	159.6	2380.3
Batching 3 in kg							
70%NS+30%MS & 70%CCA+30%RGCA	182.3	365	724.5	310.5	558.6	239.4	2380.3
Batching 4 in kg							
60%NS+40%MS & 60%CCA+40%RGCA	182.3	365	621	414	478.8	319.2	2380.3
Batching 5							
50%NS+50%MS & 50%CCA+50%RGCA	182.3	365	517.5	517.5	399	399	2380.3

Using the above mix proportions concrete 9 cubes for compressive and 9 beams for flexural strength were casted for each batching aggregate concrete. Workability of the mixes was measured by the standard slump test and the cubes and flexural beam were tested for their 7, 14 and 28 days compressive and flexural strength after curing them all in a tank full of water.

- **Concrete cube casting and slump testing**

The mixed concrete was checked for workability by filling the standard slump cone with three layers by rodding each layer with 25 times according to ASTM C143. Between each mix, the tool was cleaned using tap water and paint oil to ensure that there was no contamination between the mixes. After checked the slump the mixed concrete was placed in the mold and was well compacted in three layers with the help of a tape rode by rodding each layer with 25 times and as well as Side compaction of the molds was carried out by using tire hammer . For each mix, prepare 3 cubes molds having (15cmx15cmx15cm) and beam molds having (50cm×10cm×10cm) size and totally 63 cubes and 63 beam test samples were caste for compressive and flexural.

A) Wet concrete mix C) Cub casting D) Slump test

Figure 3.12 Caste of cube specimen

- **De-molding Specimen and coding (identification) of the sample concrete cubes**

The concrete mix was casted in the molds for the first 24 hours. After that, the concrete was removed from the molds but removing the cubic mold with a great care to prevent any damage, external and internal, to the specimen. After that, coding the concrete cube samples based on percentage of blending and day of curing.

- **Curing of the Concrete cube samples**

The concrete cubes were cured by immersion in water in the curing tank for 7, 14 and 28 days at a temperature of 23 ± 1^{o}C for curing to take place until the testing age was reached.

Figure3.13 Curing cube and flexural beam

Stage-4: Mechanical properties of concrete testing of molds

After 7, 14 and 28 days of curing period the concrete mold specimens was removed from the water tanker then placed in dry surface until the specimens was surface dried while weighted concrete cubes specimens in order to determine the unit weight of the concrete cube Finally, the specimens was tested by using "Wizaro Basic" a Digital readout Universal Testing Machine for compressive strength. Loading Rate for 15cmx15cmx15cm cube was 140 kg/cm2 per minute till the Specimens fails. The method of applying two point loads on a beam with simply supports is used to measure flexural strength of concrete. Loading should be without any inclination and the extension loads should intersect to the axes of the beam. The distance between point load and support should not be less than depth of the beam. The length of sample should be at least three times more than its depth.

A) Compression test apparatus B) two point load flexural test apparatus

Figure3.14 Mechanical test of harden concrete

❖ The calculation of compressive stress at failure is as follows:

Compressive stress (σ) = Force/Area

❖ The calculation of the flexural stress at failure is as follows:

C =D/2 cm; M=PL/3 N.m; I=bd3/12 m4

Flexural stress (σ) =Mc/I M………………………………………… [60].

Where:

P = Failure Load σ = Bending Strength

M = Maximum Moment

L = Span of Specimen

I = Moment of Inertia

D = Depth of specimen

C = Centroidal depth

CHAPTER FOUR

RESULTS AND DISCUSSIONS

This chapter contains tabulations of all data recorded during the tests conducted, a discussion of all quality tests, as well as outlines of the subsequent calculations needed to translate test results into the properties of the aggregates.

4.1. Physical property of Aggregates

The major constituents of ordinary concretes are crushed rocks used as coarse aggregates and sands used as fine aggregates. Materials used in concrete usually need to be processed for Engineering properties and conforming to the designated specifications. It follows, therefore, that concrete will only become a quality material for construction when the ingredients are properly sourced and selected as well as when it is manufactured under a regulated standard.

4.1.1 Coarse aggregate

This section objective was to determine the physical properties of Crushed and River Gravel Coarse Aggregate for the requirements of Conventional Concrete around the Jimma zone**.** This study obtained two different sources of coarse aggregate samples conforming to the designated specifications was used and thereafter conducted the following laboratory tests on some of their properties to determine their qualification for use in producing concrete with blended together .

In this study the physical properties of coarse aggregate test results, discussions and gradation chart are shown below in the Table and Figure.

Table 4.1 Summarized test results average physical (engineering) property of crushed Coarse Aggregate and uncrushed river gravel.

Physical property of aggregate		Uncrushed River gravel Coarse aggregate	Crushed Coarse Aggregate	Standard specification
		RGCA	CCA	
1	Bulk sp. Gravity (SSD)	2.64	2.62	ASTM C 127 2.4-2.9
2	Dry-Rodded Unit Weight (kg/m3)	1451.5	1636.5	ASTM C 29M -97 1200-1750
3	Water Absorption (%)	1.03	1.94	ASTM C 127 0.2% to 4%
4	Aggregate Impact Value (%)	9.6	12.68	BS812-112:1990 ≤45
5	Moisture Content (%)	1.21	0.76	ASTM C 127 0.2% to 4%

Table 4.1 showed that the test result of physical property of crushed coarse and uncrushed river gravel**.** From above table 4.1 the test result showed that all the physical property of the aggregate satisfied according to ASTM the standard specification. So the material can be ready to use for normal weight concrete.

4.1.2 Sieve analysis

Sieve analysis for fine and the coarse aggregates is based to ASTM C33 and ES C.D3201. The weight of aggregate percentages passing the sieves is measured and the percentages determined. The values are weighed for aggregates passing the sieves, expressed in percentage and recorded in the table as shown appendix B. A plot of the cumulative percentage passing against the sieves sizes done on a graph containing the sieve envelop, showed that the curve lied within the limits. This meant that if the curve lied between the upper and lower limit, the aggregates were good for use and no blending of the different sizes was needed.

4.1.3 Gradation of Samples (CCA before blend)

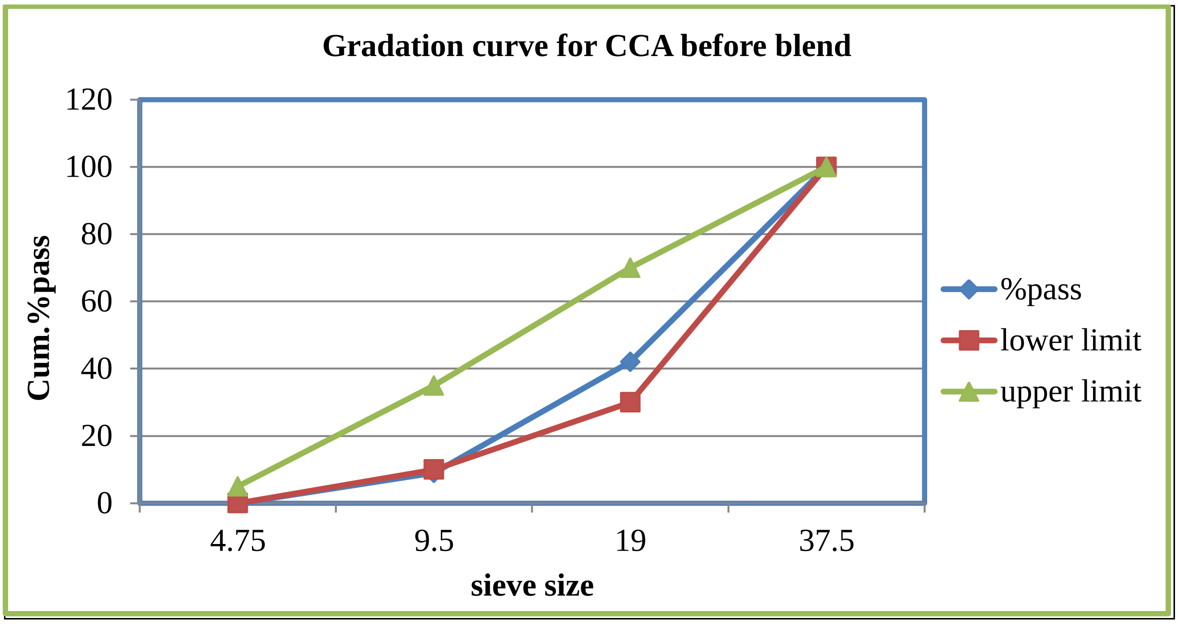


Figure4.1 Gradation curve for crushed coarse aggregate before blending using ES CD3.201Upper limit and lower limit

The results for average particle size distribution of crushed coarse aggregate are summarized and presented in Fig4.1.Figure 4.1. It was observed that the Crushed coarse aggregate were fall within the limits specified by ES CD3.201 standards. As shown in the Figure 4.1, the percentage passing sieve size 9.5mm through 4.75mm more closed to the lower limit and that indicates which the coarse aggregate was slightly coarser at that sieve size. Also from the Figure, 4.1 gradation results showed that the sieve size cumulative percentage pass of the coarse aggregate through sieve size of 19mm to 37.5mm was with the grade limit of the coarse aggregate based on the ES C.D3.201 limit standard. But through sieve size 9.5mm and 4.75mm Which showed that , the aggregate does not lie between the standard limit in some extent, which mean that the percentage pass of the Coarse aggregate is slightly overlap on the lower limit grading system and somewhat is not well graded.

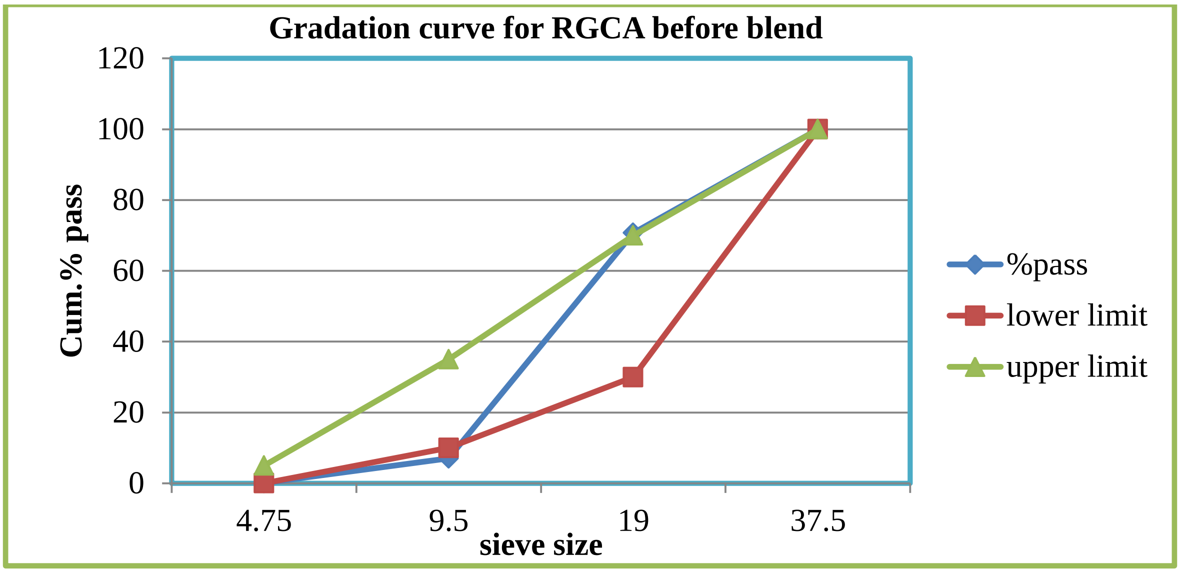


Figure4.2 Gradation curve for RGCA before blending using ES CD3.201Upper limit and lower limit

Figure 4.2 showed that the average test results for the sieve analysis of the river gravel coarse aggregate used. The above Fig 4.2 showed that the graphical representation of the RGCA gradation results. It was observed that the river gravel coarse aggregate from Gibe river bed were fall within the limits specified by ES CD3.201 standards except two sieve No (i.e. 9.5mm 7.04% and 19mm 70.7%). The result indicated that, the percentage passing on the sieve size of 19.0 mm was 70.7%, which is somewhat out of the upper limits and it seems 0.07% is finer material at this point. This is a common phenomenon with uncrushed gravel coarse aggregates both the mineralogical and parental properties of the sources. Also Figure 4.2 discloses the grading curve of the river gravel coarse aggregate displays insignificant fallout from the gradation lower limit requirement of 10% .But by the amount of 2.96% the curve is below the lower limit at 9.5 mm with the percentages passing of 7.04% which mean were somewhat it is coarser materials.

4.1.4 Gradation of blended coarse aggregate of CCA with RGCA

According to the literature (4) pass study, the main reasons for blending of fine as well as coarse aggregate are:

- Obtain desirable gradation
- Single natural or quarried material not enough
- Economical to combine natural and process materials

Based on the above three point of view consideration, this study was conducted to solve the cost problem and effective use of local available source.

❖ **Blended of 90%CCA and 10%RGCA**

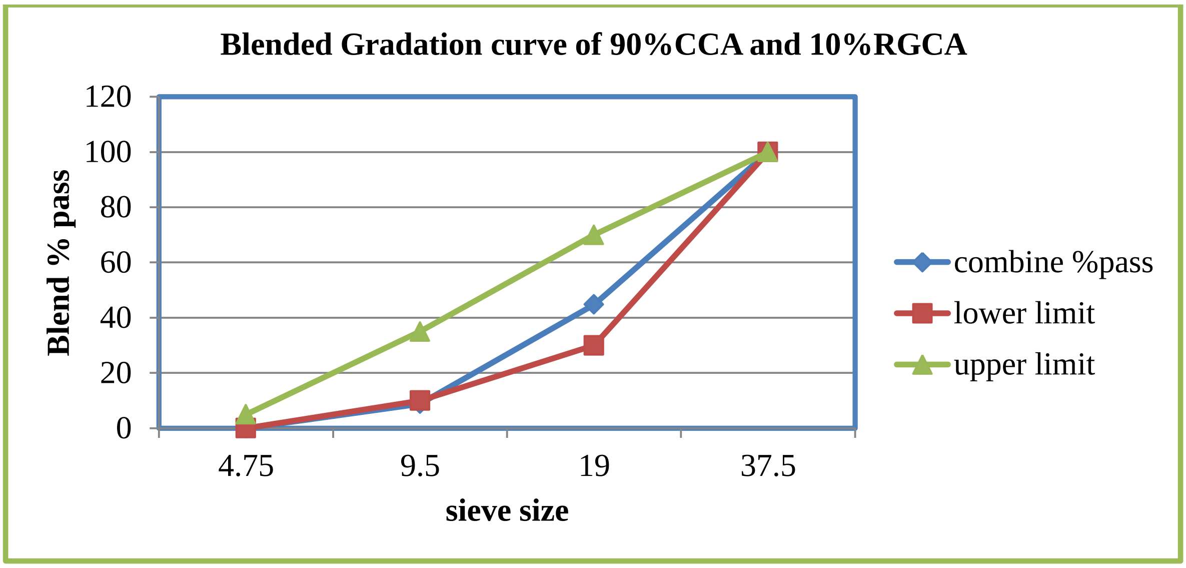


Figure4.3 Gradation curve for combined 90%CCA and 10%RGCA

From the above Fig 4.3 showed that the combination of 90%CCA and 10%RGCA almost fail between the lower and upper limit of Ethiopian standard specification but through sieve size of 9.5mm somewhat the % passing is slightly below the lower limit with percentage passing of 8.81% and this indicated that this is slightly coarser at this point by 1.11%. According to ES limit requirement, it is expected that the percent passing through the sieve size of 9.5 mm was 10 to 35 %.

❖ **Blended of 80%CCA and 20%RGCA**

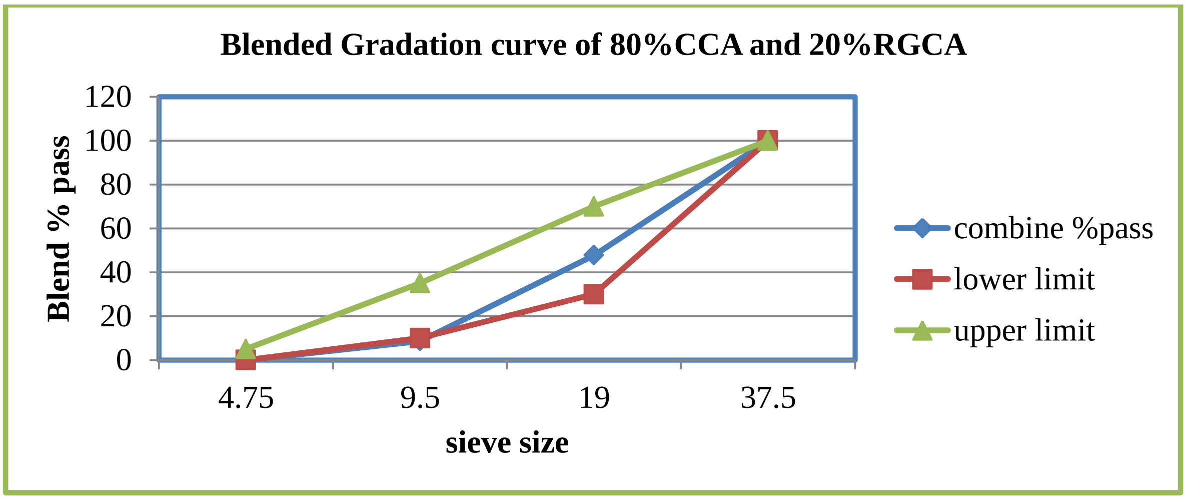


Figure4.4 Gradation curve for combined 80%CCA and 20%RGCA

From the above Figure 4.4 the combination of 80%CCA and 20%RGCA almost the same with gradation chart of Figure 4.3 the gradation that fails between the lower and upper limit of Ethiopian standard specification except in the sieve size of 9.5mm in somewhat the % passing is slightly below the lower limit with percent passing of 8.61% and this indicated that this is slightly coarser at this point by 1.39%. According to ES limit requirement, it is expected that the percent passing through the sieve size of 9.5 mm was 10 to 35 %.

- **Blended of 70%CCA and 30%RGCA**

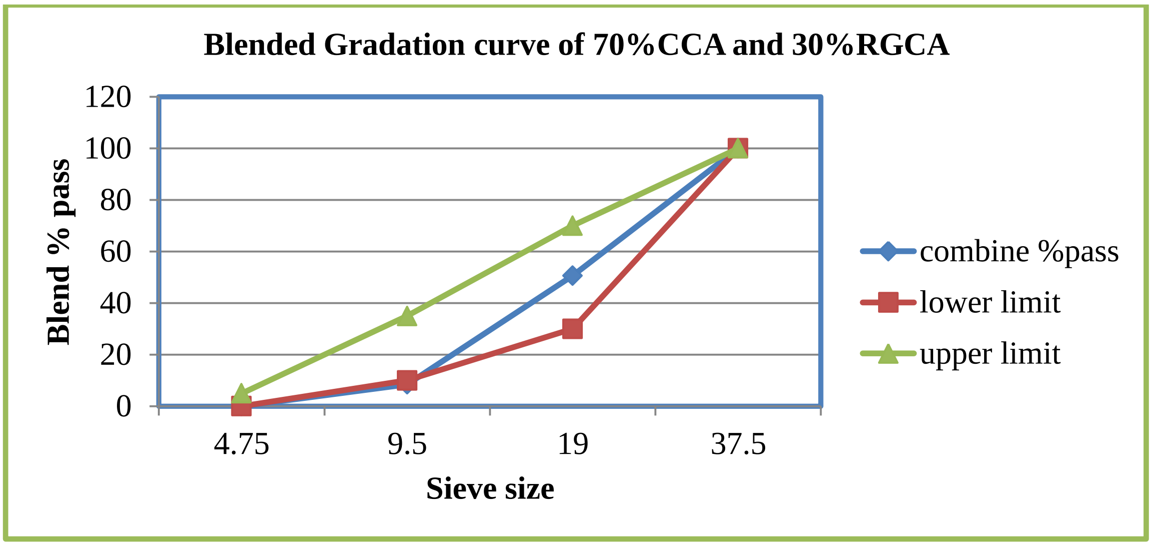


Figure4.5 Gradation chart for combined 70%CCA and 30%RGCA

From the above Figure 4.5 show that the combination of 70%CCA and 30%RGCA almost the same with gradation chart of Figure 4.3 and 4.4 the gradation that fails between the lower and upper limit of Ethiopian standard specification except in the sieve size of 9.5mm in somewhat the % passing is slightly below the lower limit with percent passing of 8.42% and this indicated that this is slightly coarser at this point by 1.58%. According to ES limit requirement, it is expected that the percent passing through the sieve size of 9.5 mm was 10 to 35 %.

❖ **Blended of 60%CCA and 40%RGCA**

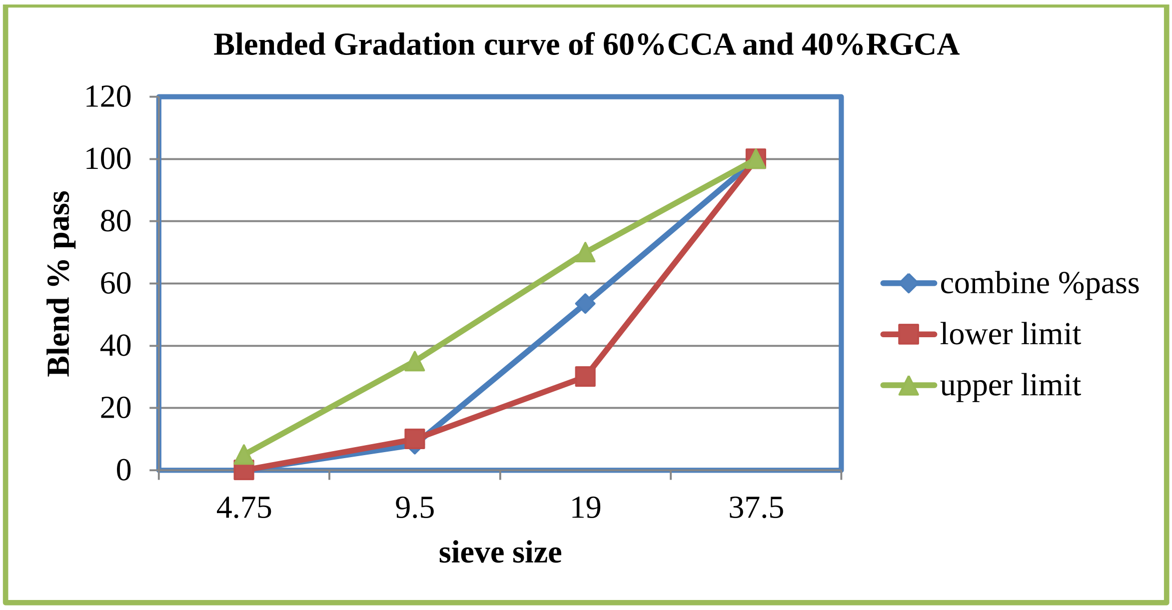


Figure4.6 Gradation curve for combined 60%CCA and 40%RGCA

From the above Figure 4.6 shows that the combination of 60%CCA and 20%RGCA almost the same with gradation chart of Figure 4.3, 4.4 and 4.5 the gradation that fails between the lower and upper limit of Ethiopian standard specification except in the sieve size of 9.5mm somewhat the %passing is slightly below the lower limit with percent passing of 8.22% and this indicated that this is slightly coarser at this point by 1.78%.According to ES limit requirement, it is expected that the percent passing through the sieve size of 9.5 mm was 10 to 35 %.

- **Blended of 50%CCA and 50%RGCA**

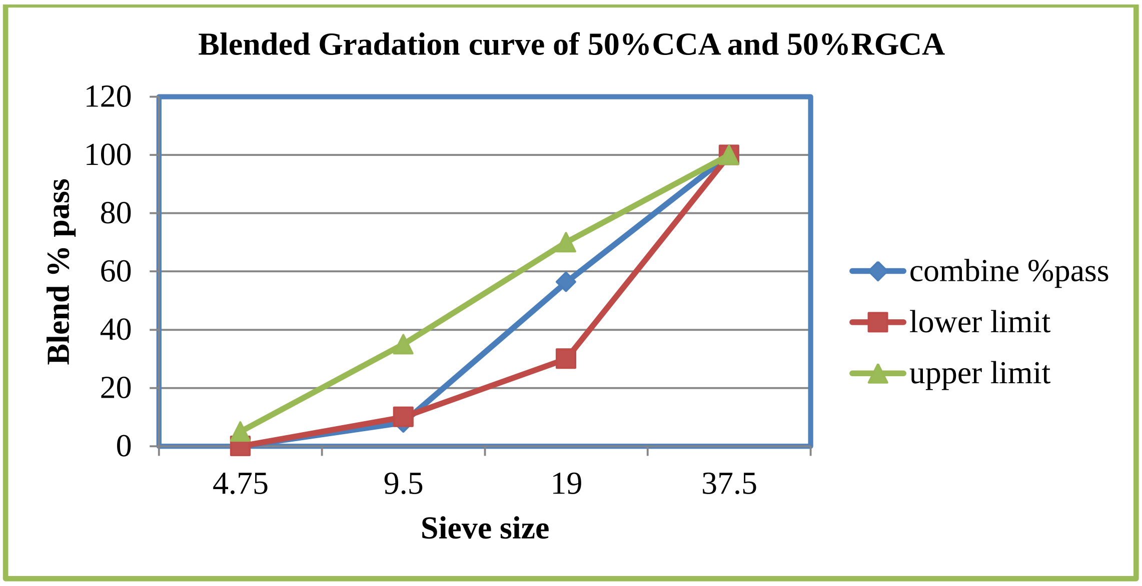


Figure4.7 Gradation curve for combined 50%CCA and 50%RGCA

From the above Figure 4.7 shows that the combination of 50%CCA and 50%RGCA blending percent of aggregate almost the same with gradation chart of Figure 4.3, 4.4, 4.5 and 4.6 the gradation that fails between the lower and upper limit of Ethiopian standard specification except in the sieve size of 9.5mm somewhat the %passing is slightly below the lower limit with percent passing of 8.1% and this indicated that this is slightly coarser at this point by 1.9%. According to ES limit requirement, it is expected that the percent passing through the sieve size of 9.5 mm was 10 to 35 %.

4.1.5 Relative Density (Specific Gravity) and Absorption of Coarse Aggregate

The specific gravity and absorption capacity of the coarse aggregates was determined using ASTM C 127 “Standard Test Method for Density, Relative Density (specific gravity), and Absorption of Coarse aggregates”. ASTM C 128 “Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate” was used to determine the specific gravity and absorption capacity of the fine aggregates.

Table 4.2 Average Absorption Capacity and Specific Gravity of coarse Aggregate

Crushed Coarse Aggregate (CCA) Sp.gr	Trial 1	Trial 2	Average result
Mass of Oven Dry Sample in Air kg (A)	1.985	1.996	1.991
Mass of Saturated Surface Dry Sample in Air kg(B)	2.032	2.026	2.029
Mass Sample in Water kg(C)	1.258	1.246	1.252
Bulk Specific Gravity(OD)	2.565	2.56	2.563
Bulk Specific Gravity (S.S.D basis)	2.63	2.6	2.62
Apparent Specific Gravity	2.73	2.66	2.695
Absorption capacity (%)	2.37	1.5	1.94
River Gravel Coarse Aggregate (RGCA)			
Mass of Oven Dry Sample in Air kg (A)	1.987	1.994	1.991
Mass of Saturated Surface Dry Sample in Air kg(B)	2.014	2.008	2.011
Mass Sample in Water kg(C)	1.26	1.238	1.249
Bulk Specific Gravity(OD)	2.64	2.59	2.62
Bulk Specific Gravity (S.S.D basis)	2.67	2.61	2.64
Apparent Specific Gravity	2.73	2.64	2.69
Absorption (%)	1.36	0.7	1.03

a. Specific Gravity

River gravel and crushed coarse aggregate were used as blend together for all concrete mixes.

Table 4.2 tells the values of the specific gravities and Absorption of coarse aggregate (Saturated Surface-Dry basis) used in the investigation in accordance with the specifications of ASTM C-127.

As indicated from literature the standard specific gravity of Bulk specific gravity of normal weight aggregates used in concrete is ranges from 2.30 to 2.90. From the results of experiment conducted and presented in table 4.2, sample CCA and RGCA met the specified standard with specific gravity values of 2.62 and 2.64 respectively. From the laboratory result, the specific gravity of aggregates samples are within the ranges of the specific gravity of aggregates requirements according to ASTM C 33 are ranges from 2.4 to 2.9 for normal weight aggregates.

b. Water Absorption

The water absorption of the crushed coarse aggregate and river gravel coarse aggregate vary greatly as shown in the above Table 4.2 and Figure 4.8 from the results; the crushed coarse aggregate samples have higher water absorption capacity as compared to river gravel coarse aggregate.

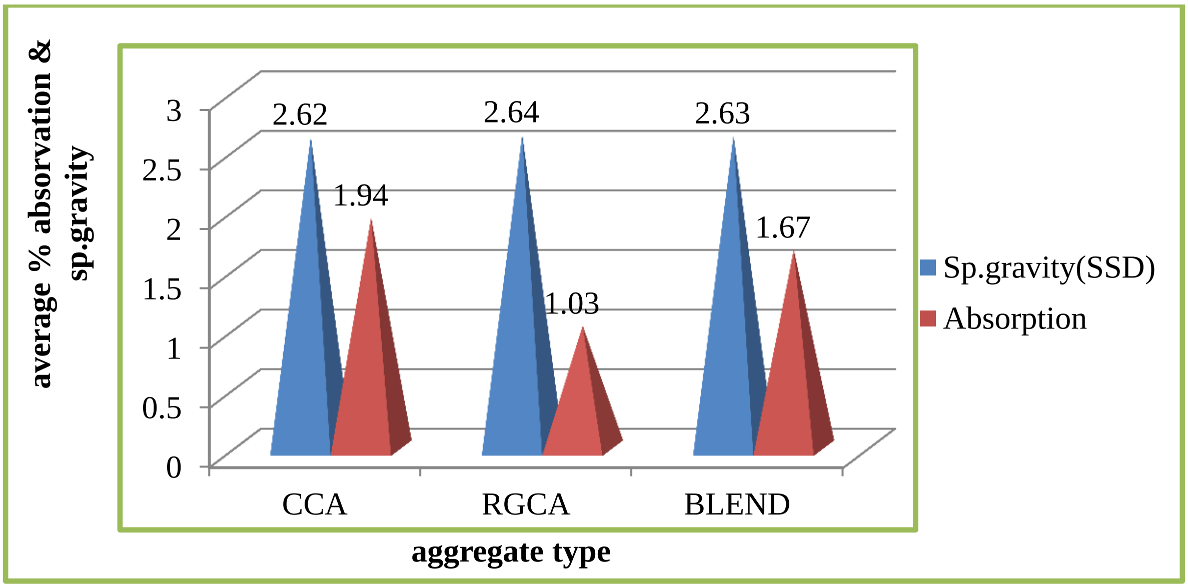


Figure4.8 Absorption capacity and specific gravity of CCA and RGCA relationship

Figure 4.8 shows as the relation between absorption capacity and specific gravity of the coarse aggregate. In somewhat RGCA has the higher specific gravity than CCA and the lower water absorption capacity. From this case the higher specific gravity were founded by river gravel coarse aggregate with values of 2.64 and 1.03% water absorption capacity which are less with compared to crushed coarse aggregate. This indicated that aggregate with the highest specific gravity have low water absorption capacity and aggregate with low specific gravity have high water absorption. While blending the two coarse aggregate, the water absorption capacity was reduced by 0.27% from CCA water absorption capacity and almost the same specific gravity.

- **4.1.6 Dry-Rodded (Unit Weight)**

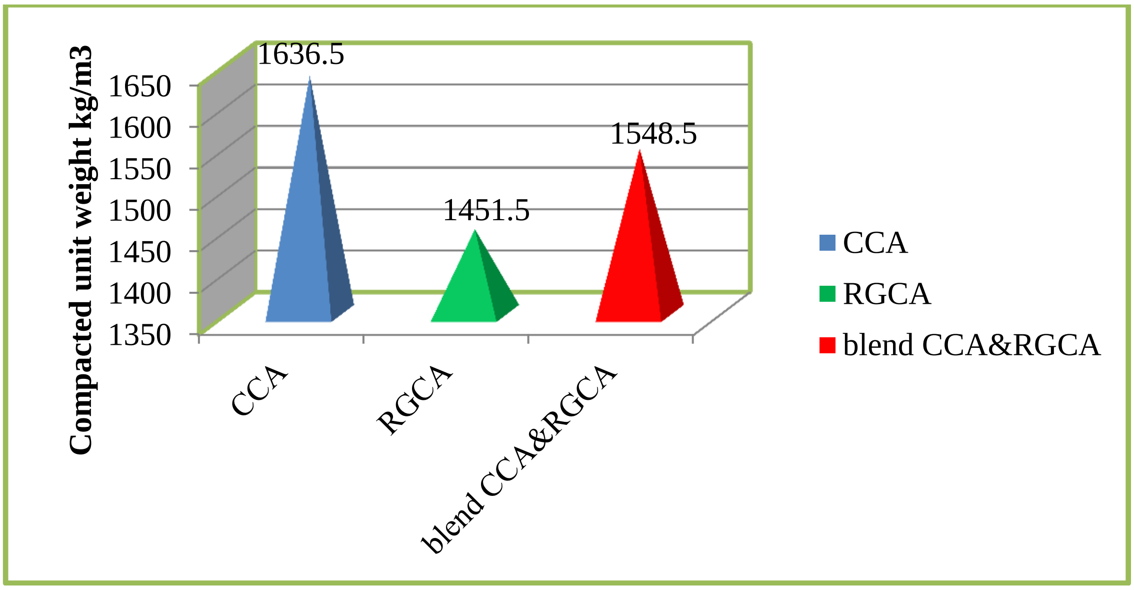


Figure4.9 average Compacted Density of CCA and RGCA

Figure 4.9 shows that all the two samples have satisfy the bulk density of aggregate commonly used in normal-weight concrete ranges from about 1200 to 1750 kg/m3 given in ASTM C29M-97. From the test result, the dry rodded unit weight of river gravel coarse aggregate was slightly lower as compared to crushed coarse aggregate. The reason could be the river gravel coarse aggregate has rounded shape and smooth texture surface and due to that case it has poor compactable and interlocking and made high void between the aggregate. Whereas crushed coarse aggregate has irregular shape and have good interlocking and minimum void between aggregate surfaces as compare river gravel coarse aggregate. However, from the Fig 4.9 shows that the blending of the two coarse aggregate has been well compacted unit weight of river gravel coarse aggregate and better reduce void between the aggregate.

4.1.7 Aggregate Impact Value (AIV)

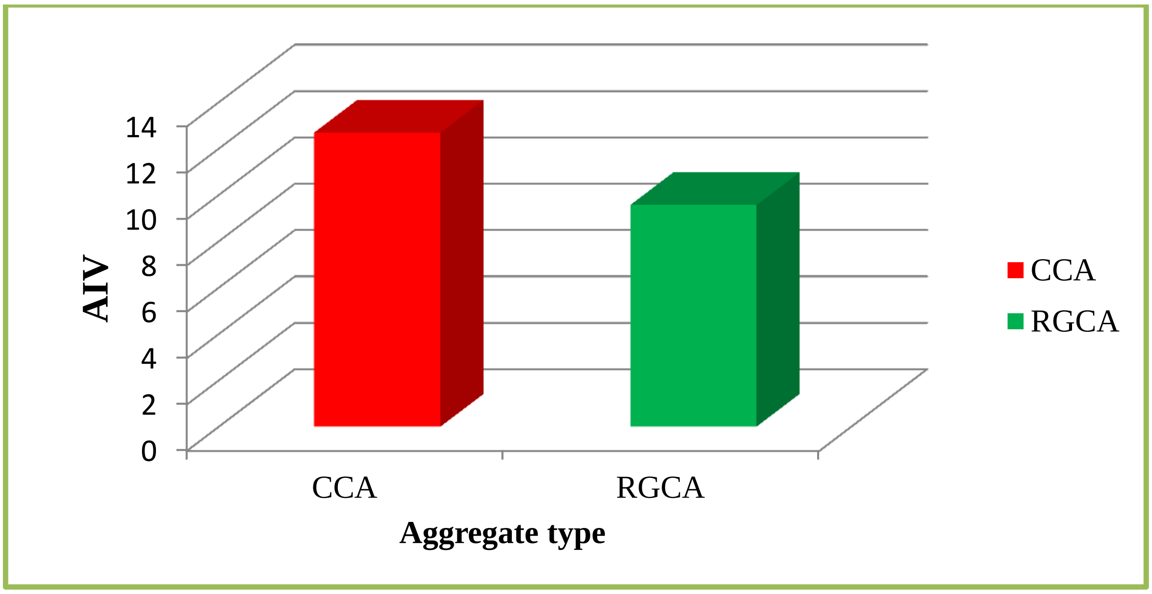


Figure4.10 Average AIV tests of CCA and RGCA coarse aggregate

AIV is a relative measure of resistance to crushing of an aggregate when it is subjected to repetitive and impact loads. ASTM and BS standards both specified that concrete constituent aggregates AIV value should be less than 45%. From Figure 4.10 shows that the quarry site crushed coarse aggregate samples AIV laboratory evaluation result is12.68% and 9.56% river gravel coarse aggregate respectively. From above results quarry site crushed aggregate AIV value are less than 45% so that sample crushed aggregates can be used as concrete ingredient for building construction.

However, the result showed that the River Gravel Coarse Aggregate will have slightly reduced impact load resistance as we compared with the Crushed Coarse Aggregate.

4.1.8 Fine Aggregates physical Property

The fine aggregate used in the concrete productions was natural river sands with blending of manufacture sand and they were dried to saturated and surface dry (SSD) state before any test was carried out. In addition to this, all fine aggregate which retain on 9.5mm sieve size were no longer relevant, and all the passing fine aggregate were used for experimentation. As the Figure 4-11**,** describes the sieve size, cumulative percentage pass of Gambella sand with grade limit for the fine aggregate based on ASTM limit standard.

4.1.8.1 Sieve Analysis Gambela natural sand

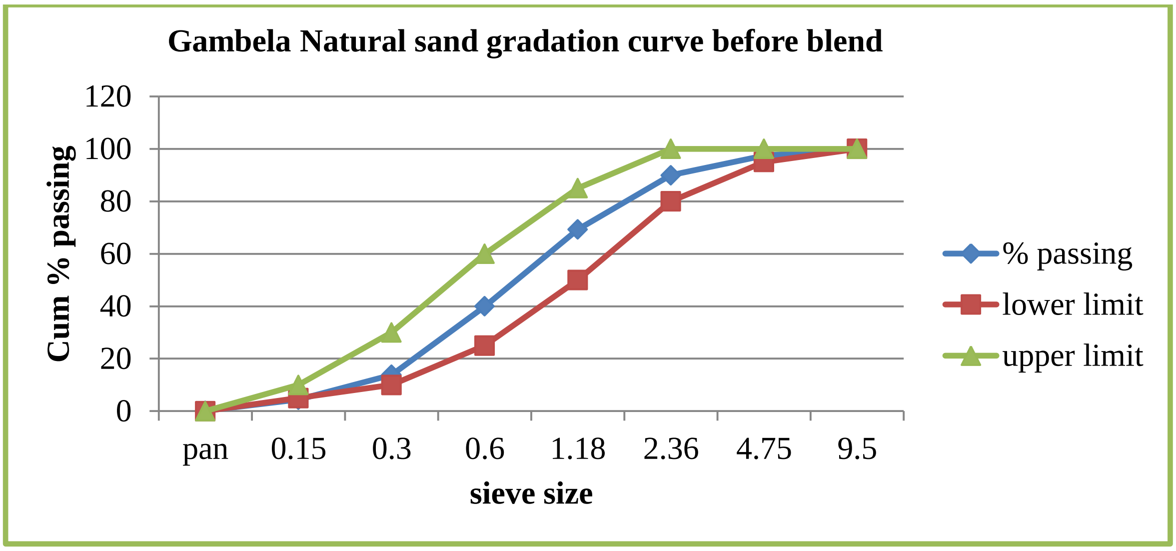


Figure4.11 Grading curve of Gambela NS before blending

The results for the sieve analysis test on the aggregates are shown in Fig 4.11. The grading curve for the natural sand aggregates falls within the lower and upper limit of the grading requirement for aggregate from natural sources according to ES C.D3 201. This implies that the fine aggregate has well grade and suitable for construction work. The results of the analysis are summarized (Appendix B).

4.1.8.2 Manufactured sand

For this research laboratory test the manufactured fine aggregates have been obtained from Varnero PLC, quarry site located at Agaro, about 42km from Jimma town. This manufactured sand was produced from crushing of basaltic stone where the contractors used for different structures.

4.1.8.3 Manufacture Sieve Analysis

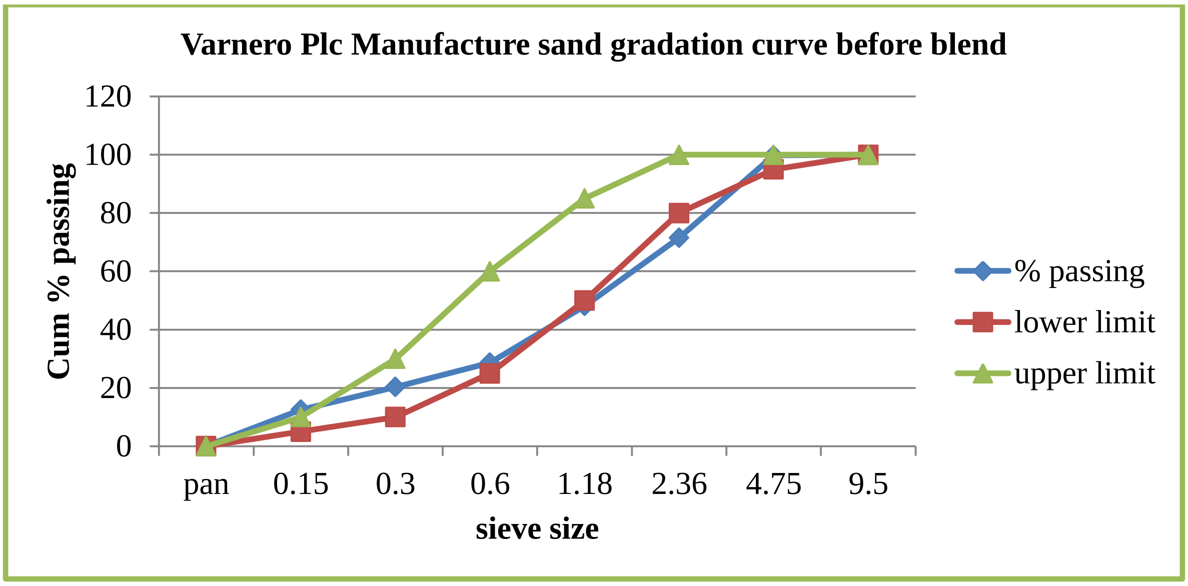


Figure4.12 Grading curve of MS before blending

Figure 4.12 shows that According to ES C.D3 201, the gradation result of the Varnero PLC MS sample was out of range on 0.15 mm, 1.18 mm and 2.36mm sieve size. From the above gradation Figure4.12 the result showed that the percentage passing on the sieve size of 0.15mm above the upper limit. So this indicated that sand is finer at that point and the percentage passing on the sieve size of 1.18mm and 2.36mm showed that the manufactured sand was below the lower limit. So this indicated that the sand is coarser material at this point. Generally, according to ES C.D3.201 grading requirements, the percentage passed of the Varnero manufactured sand as fine aggregate from the figure gradation curve indication was not well grade. therefore, to came up and satisfied the required gradation, the Gambela natural sand blending with the Varnero PLC manufactured sand is important for seeks of economical point of view and graduation requirement.

4.1.8.4 Blended gradation of manufacture sand with natural sand

- **Blended of 90%NS with 10%MS**

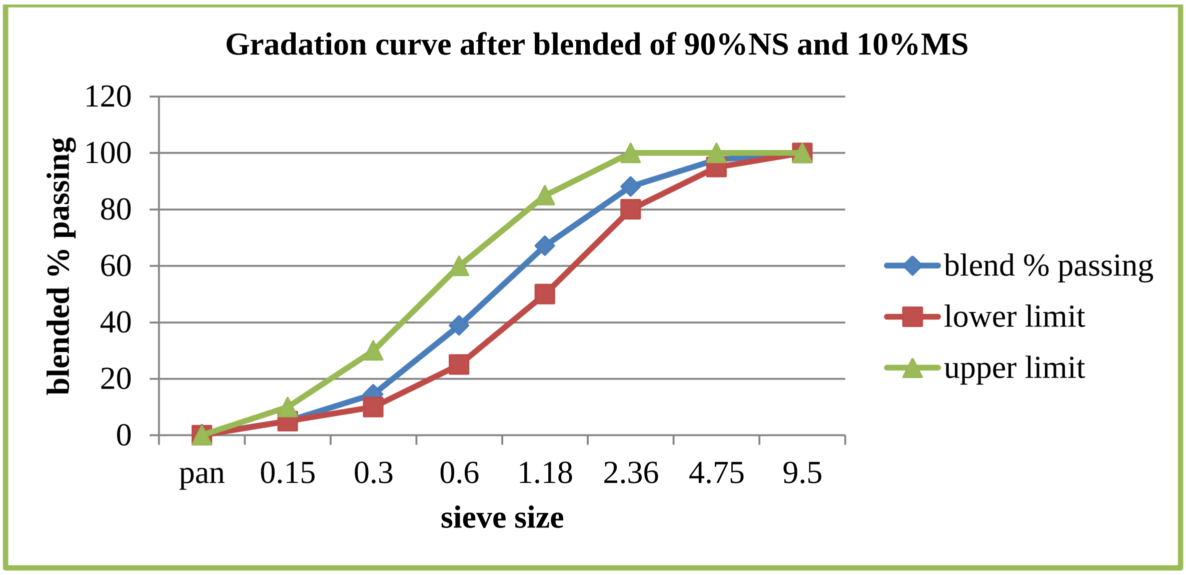


Figure4.13 gradation curve after blending of 90%NS and 10%MS

The results for the sieve analysis test on the blending of 90%NS and 10%MS fine aggregates are showed in the Figure 4.13. The grading curve for the fine aggregates falls within the lower and upper limit of the grading requirement for fine aggregate according to the standard specification of ES C.D3 201. This implies that the blended of 90%NS with 10%MS fine aggregates were satisfied and suitable for construction work.

- **Blended of 80%NS with 20%MS**

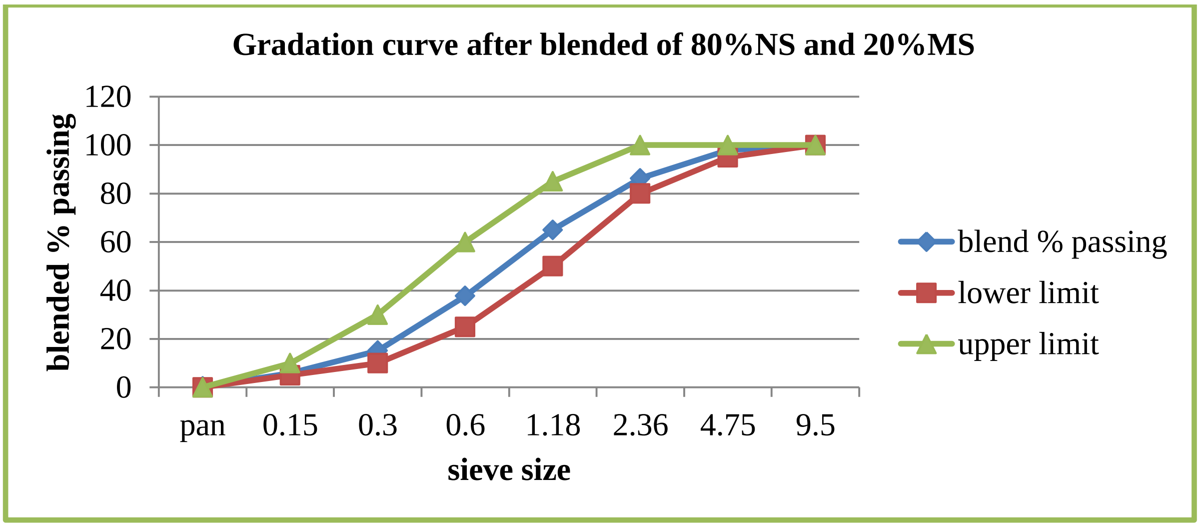


Figure4.14 gradation curve after blending of 80%NS and 20%MS

The results for the sieve analysis test on the blended of 80%NS and 20%MS fine aggregates are showed in the Figure 4.14. Also the grading curve for the fine aggregates falls within the lower and upper limit of the grading requirement for fine aggregate according to the standard specification of ES C.D3 201. The above Fig 4.14 suggests that the blended of the two fine aggregates gradation were fulfilled the standard specification and suitable for construction work.

- **Blended of 70%NS with 30%MS**

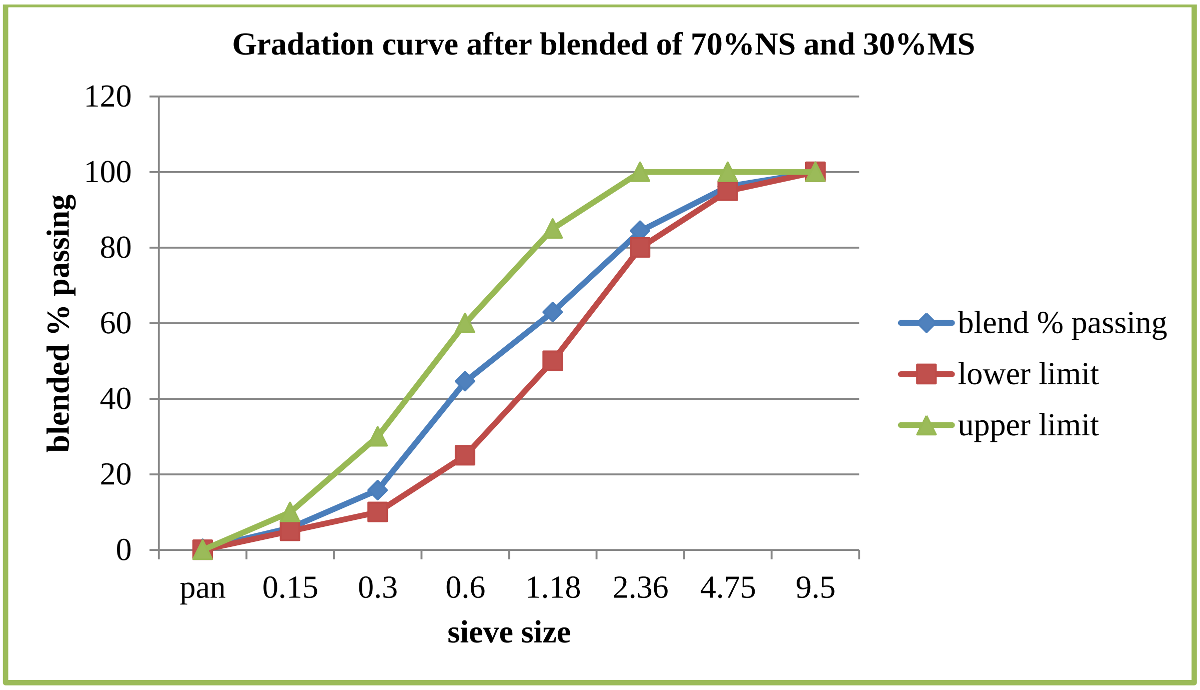


Figure4.15 Gradation curve after blending of 70%NS and 30%MS

The results for the sieve analysis test on the blending of 70%NS and 30%MS fine aggregates are shown in the Figure 4.15. The grading curve for the fine aggregates falls within the lower and upper limit of the grading requirement for fine aggregate according to the standard specification of ES C.D3 201. The gradation curve implies that the blended of 70%Gambel natural sand with the 30% of manufactured fine aggregates were fitted and suitable for construction work.

- **Blended of 60%NS with 40%MS**

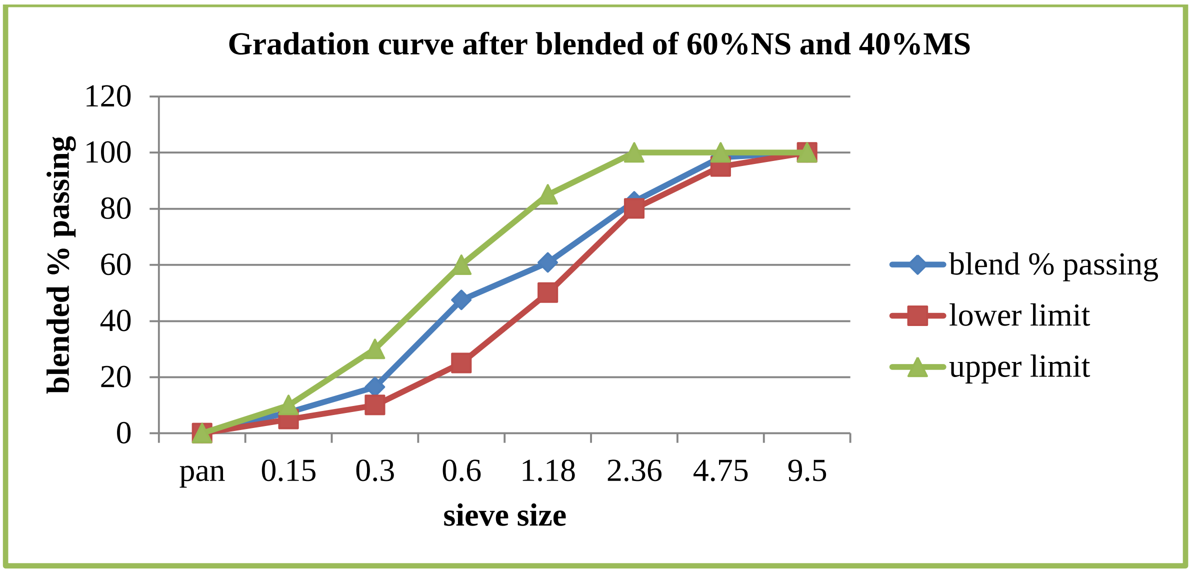


Figure4.16 Gradation curve after blending of 60%NS and 40%MS

The results for the sieve analysis test on the blending of 60%NS and 40%MS fine aggregates are showed in the Figure 4.16. The grading curve of the two blended fine aggregates falls within the lower and upper limit of the grading requirement for fine aggregate according to the standard specification of ES C.D3 201. The result implies that the blended fine aggregates were reasonable and suitable for construction work.

- **Blended of 50%NS with 50%MS**

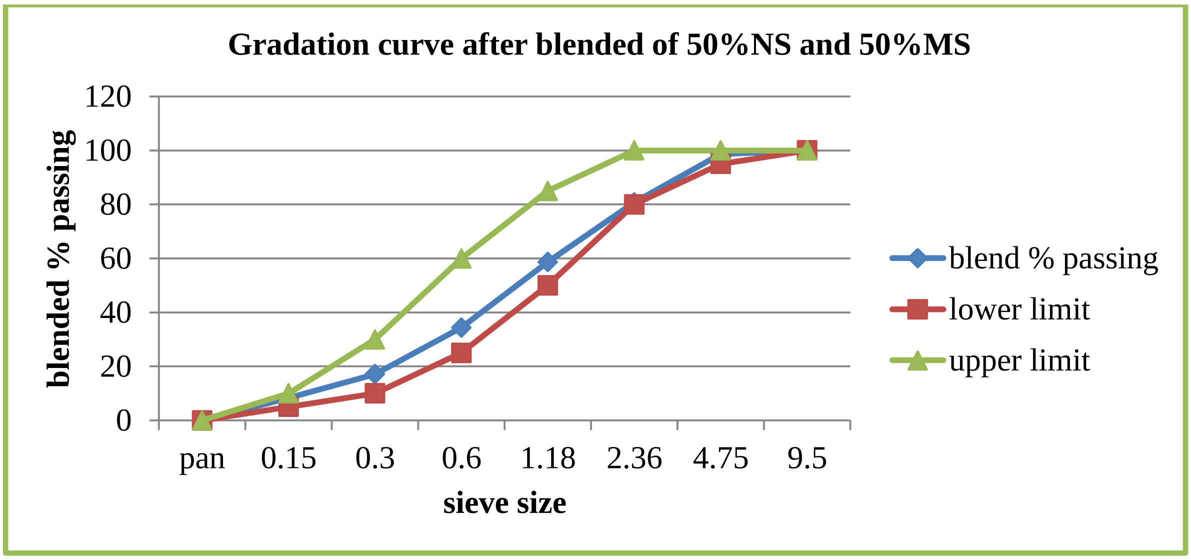


Figure4.17 Gradation curve after blending of 50%NS and 50%MS

From the above Figure 4.17 the combination of 50%NS and 50%MS almost fail between the lower and upper limit of Ethiopian standard specification but through sieve size of

2.36mm somewhat the %passing is slightly closer to the lower limit with result percentage passing of 80.74% and this indicated that while increased the percentage of manufactured sand blended with natural sand, the percentage passing on sieve size of 2.36mm become coarser by 0.74% from the expect of ES 80%-100%.

- **Blended of 40%NS with 60%MS**

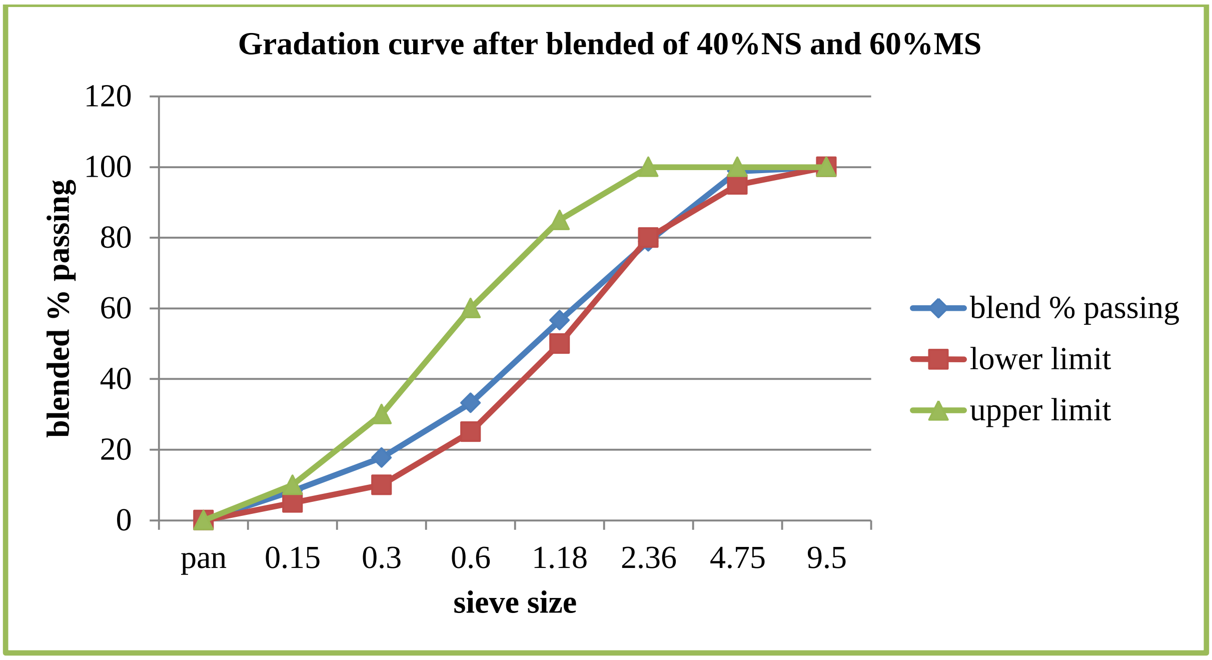


Figure4.18 Gradation curve after blending of 40%NS and 60%MS

Figure 4.18 showed that, the sieve analysis graphical representation of the blended 40% NS and 60%MS aggregate gradation results. It was observed that the two blending sand aggregate were fall within the limit specified by ES CD3.201 standards except one sieve No (i.e. 2.36mm 78.89%). As shown in Fig 4.18, the percentage passing on sieve 2.36 mm were 78.89%, which is somewhat out of the lower limits and it seems 1.11% is coarser material at this point with the expect percentage passing of 80%-100%. So from the this gradation curve result ,it indicated that in this gradation of fine aggregate the optimum blending material percentage of the sand is up to 50% and beyond 50%,insignificant fallout from the gradation limit

4.1.8.5. Specific Gravity and Water absorption results of NS and MS

Table 4.3 absorption capacity and Specific Gravity of Fine Aggregate Samples

Relative density (specific gravity)		Average result			ASTM C128
		NS	MS	blended	
1	Bulk Specific Gravity(OD)	2.51	2.62		2.30 to 2.90
	Bulk Specific Gravity (S.S.D basis	2.54	2.66	2.63	2.4 to 2.90
	Apparent Specific Gravity	2.59	2.71		2.4 to 2.90
2	Absorption	1.22	1.41	1.28	0.2% to 2%,

From above Table 4.3 the specific gravity of all sand samples collected from sites are within the limit of specification. The specification indicates that most natural aggregates have relative densities between 2.3 and 2.9. Laboratory data showed that the relative densities of the two sand samples are in between 2.4 and 2.9. These values are showed in Table 4.3 tells the relative density or specific gravity of the blended fine aggregates used in the investigation were 2.63, which indicates that the blended fine aggregate is stable for construction work. Also Table 4.3 tells the Absorption of Fine Aggregate in accordance with ASTM C 128-97, ―Standard Test Method for Specific Gravity and Absorption of Fine Aggregate. Natural, manufactured and the two blended sand used for the experiment was conforming ASTM C 128-97 standard with values 1.22%, 1.41% and1.28% respectively. Also the Table showed that, the manufactured sand higher water absorption capacity as compare to natural sand and the blended of natural with manufacture sand it was gives the value of 1.28%.

4.1.8.6 Compacted Unit Weight of sand

Table 4.4 The Value of the Compacted Bulk Density of Fine Aggregate.

	Natural sand	Manufacture sand	The blend
Average Unit weight kg/m3	1537.1kg/m3	1698.8kg/m3	1675.7kg/ m3
ASTM C29/C29M limit	1200kg/m3-1760kg/m3		

The compacted bulk density measures the volume that the aggregate will occupy in concrete. The result for the compacted bulk density is shown in Table 4.4. According to ASTM C-*33* the compacted bulk density of aggregates used for normal weight concrete generally ranges from 1200 to 1760kg/m3. The value of the compacted bulk density of fine aggregate is within the specified limit as shown in Table 4.4. This result indicates that the fine aggregate is stable for construction work. But manufacture fine aggregate has more bulk density than natural sand.

4.2 Fresh Concrete property Test

4.2.1 Workability Test

A concrete mix must be made of the right amount of cement, aggregates and water to make the concrete workable enough for easy compaction and placing and strong enough for good performance in resisting stresses after hardening. If the mix is too dry, then its compaction will be too difficult and if it is too wet, then the concrete is likely to be weak.

For instance, a load of aggregate may be wetter or drier than what is expected or there may be variations in the amount of water added to the mix. These all necessitate a check on the workability and strength of concrete after producing. Slump test is the simplest test for workability and are most widely used on construction sites. In the slump test, the distance that a cone full of concrete slumps down is measured when the cone is lifted from around the concrete.

The mold for the slump test is in the form of a frustum of a cone, which is placed on top of a metal plate. The mold is filled in three equal layers and each layer is tamped 25 times with tamping rod. Surplus concrete above the top edge of the mold is struck off with the tamping rod. The cone is immediately lifted vertically and the amount by which the concrete sample slumps is measured. The value of the slump is obtained from the distance between the underside of the round tamping bar and the highest point on the surface of the slumped concrete sample. The types of slump i.e. zero, true, shear or collapsed are then recorded. Table 4.5 shows the results of the slump test for all mixes.

The result workability of the concrete mix on the samples at 0%CCA, 0%RGCA,for control mix design and at 10%RGCA, 20%RGCA, 30%RGCA, 40%RGCA and 50%RGCA blend with crushed coarse aggregate and10%MS,20%MS,30%MS,40%MS and 50%MS blend with natural sand were shown.

Table 4.5 Results of workability tests

Mix design	Percentage of blended material				w/c	Slump(mm)
	MS (%)	NS (%)	RGCA (%)	CCA (%)		
#1	0	100	0	100	0.491	52
#2	0	100	100	0	0.491	58
#3	100	0	0	100	0.491	5
#4	10	90	10	90	0.491	46
#5	20	80	20	80	0.491	40
#6	30	70	30	70	0.491	32
#7	40	60	40	60	0.491	24
#8	50	50	50	50	0.491	20

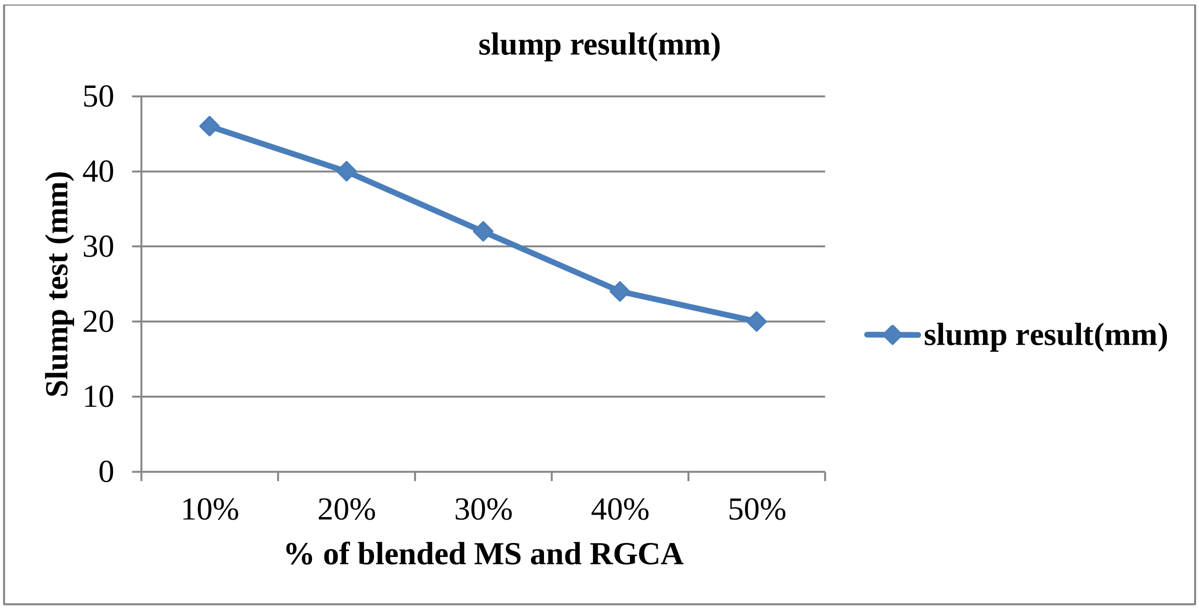


Figure4.19 Slump test result in different blended percentage of MS and RGCA

From Table 4.5 the result showed that the mix design using 100%NS+100%RGCA has higher workability than from the mix of conventional concrete (100%NS+100%CCA) with the slump result of 58mm.Main research study and literatures showed that because of the round and smooth surface of textures, the river gravel aggregates has well and suitable for the workability in the hydraulic cement concrete. Also from table 4.5 workability result in the mixing concrete of 100%MS+100%CCA the slump test result was very low with value of 5mm and below the standard specification. This indicated that because of rough texture and the angular shape of the crushed basaltic aggregate and higher finer material in the manufacture sand was thought to be the main reason for low slump. Generally, from the slump test result showed that the percentage of the sand with manufactured sand increases the workability of the concrete was decreased due to the absorption of the water by the manufactured finer material. Also from Table 4.5 it shows that the slump results value in the blended percentage of 40%MS and 50%MS fail from the limit specification with value of 24mm and 20mm respectively. This result indicates that there was a problem for the placement and compaction of fresh concrete and needed high water demand or admixture to make the concrete workable.

4.3. Mechanical Properties of Hardened Concrete

4.3.1 Compressive strength test results

In this part, the results of compressive strength experiments on the C-25 concrete different percentage of blending natural sand with manufactured sand and crushed coarse aggregate with river gravel coarse aggregate are showed in the form of Table and Fig. Compressive strengths were measured at different ages of 7, 14 and 28 days. For each age of each concrete mixture, three concrete specimens were tested.

Table 4.6 Average Compressive Strength Test of control mix

	Proportion of material				**w/c**	Slump(mm**)**
Mix # 1	NS (%)	MS (%)	CCA (%)	RGCA (%)	0.491	40mm
	100	0	100	0		
Age (days)				7^{th}	14^{th}	28^{th}
Average Compressive strength (MPa)				24.35	28.29	31.91
Rate of achievement of strength in %				97.4	113.16	127.64
Percentage of 28th day strength attends at 7^{th} and 14th day.						
Ratio 7/28 day				76.31%		
Ratio 14/28 day				88.66%		

From the above Table4.6 showed that the concrete test specimens using 100%CCA+100%NS for control mix the strength achieved about 97.4% at 7^{th} day, 113.16% at 14^{th} day and 127.64% at 28th day. Also the result showed that percentage of 28^{th} day strength attends at 7^{th}day was 76.31% and 88.66% at 14^{th}day.

Table 4.7 Average Compressive Strength Test at Various ages in the proportion mixes#2

	Proportion of material				**w/c**	Slump(mm**)**
Mix # 2	NS (%)	MS (%)	CCA (%)	RGCA (%)	0.491	48mm
	100	0	0	100		
Age (days)				7^{th}	14^{th}	28^{th}
Average Compressive strength (MPa)				17.93	20.93	25.71
Rate of achievement of strength (%)				71.72	83.72	102.48
Percentage of 28th day strength attends at 7^{th} and 14th day.						
Ratio 7/28 day				67.74%		
Ratio 14/28 day				81.4%		

From the above Table 4.7 shown that the compressive strength at 7^{th}, 14^{th} and 28^{th} day curing time using 100%RGCA +100%NS was 17.93Mpa, 20.93Mpa and 25.71Mpa respectively. And Table 4.7 shown that at 7^{th}, 14^{th} and 28^{th} day curing time 71.72%, 83.72% and 102.48% respectively the compressive strength achieved.

Table 4.8 Average Compressive Strength Test at Various ages in the proportion mixes #3

	Proportion of material				w/c	Slump(mm)
Mix # 3	NS (%)	MS (%)	CCA (%)	RGCA (%)	0.491	5mm
	0	100	100	0		
Age (days)				7^{th}	14^{th}	28^{th}
Average Compressive strength (MPa)				18.73	25.61	26.93
Rate of achievement of strength in %				74.92	102.44	107.72
Percentage of 28th day strength attends at 7^{th} and 14th day.						
Ratio 7/28 day				69.6%		
Ratio 14/28 day				95.1%		

From the above the above Table 4.8 shown that the compressive strength at 7th, 14th and 28th day curing time using 100%CCA +100%MS was 18.73Mpa, 25.61Mpa and 26.93Mpa respectively. And Table 4.8 shown that at 7th, 14th and 28th day curing time 74.92%, 102.44% and 107.72% respectively the compressive strength achieved.

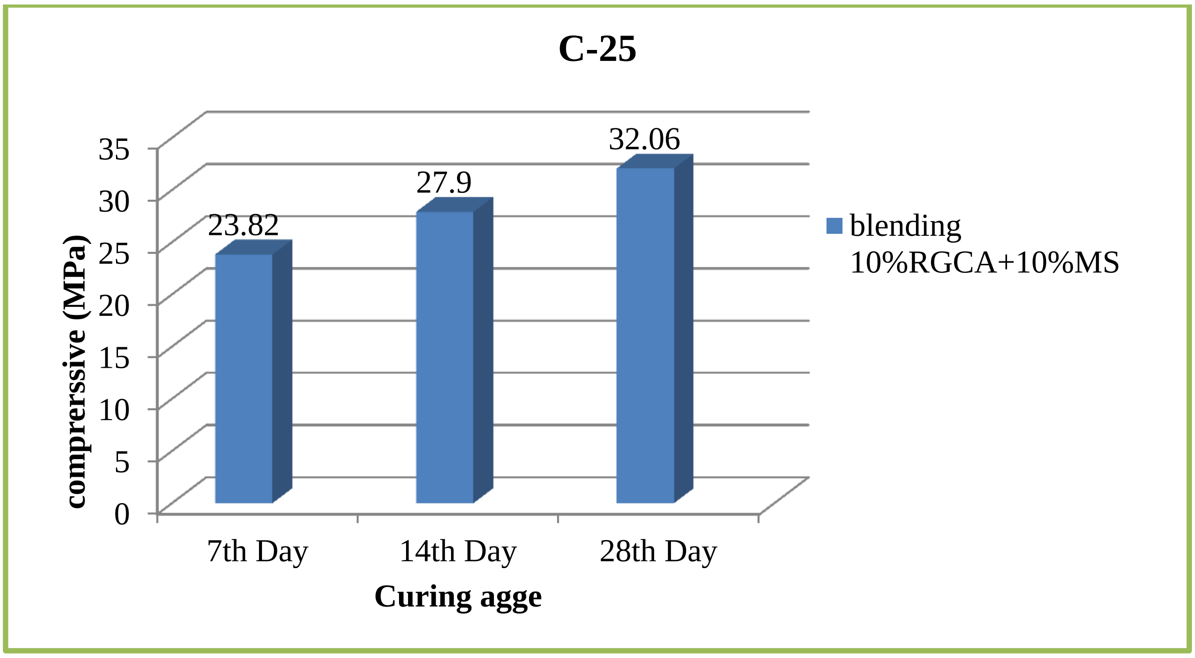


Figure4.20 Average compressive strength blending 10%RGCA+10%MS mix4

Figure 4.20 shows the rate of strength development graphically. From the above Table 4.6 indicated that the concrete test specimens using 100%CCA+100%NS for control mix, it achieved about 31.91MPa strength at 28th day, and Table 4.7 showed that using 100%RGCA+100%NS mix it achieved 25.71MPa strength at 28th day and Table 4.8 shows that using 100%CCA+100%MS it achieved 26.93MPa strength at 28th day. But from Fig 4.20 shows that the blended 90%CCA with 10%RGCA and 90%NS with10%MS, it achieved 32.06MPa strength at 28th day. This indicated that the blended material using 90%CCA with 10%RGCA and 90%NS with 10%MS increased strength by 0.15MPa (0.47%) from the control mix using 100%CCA+100%NS and100%RGCA+100%NS and 100%CCA+100%MS increased by, 6.35MPa (19.84%) and 5.13MPa (16%) respectively.

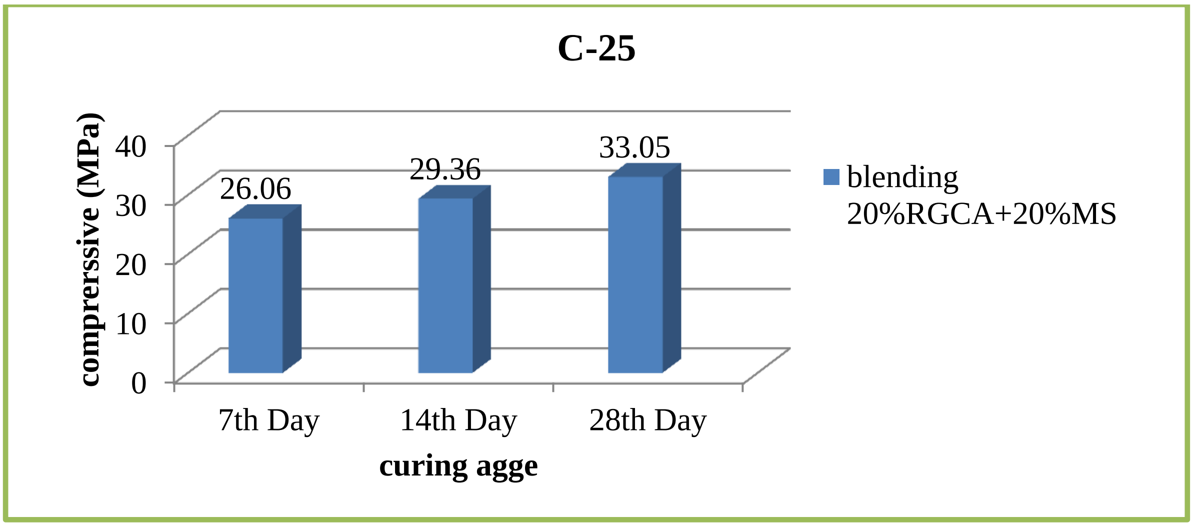


Figure4.21 Average Compressive Strength Test blending 20%RGCA+20%MS mix5

Figure 4.21 shows that the rate of strength development graphically. From the above Table 4.6 showed that the concrete test specimens using 100%CCA+100%NS for control mix it achieved 31.91MPa strength at 28th day, Table 4.7 showed that using 100%RGCA+100%NS for control mix it achieved 25.71MPa strength at 28th day and Table 4.8 shows that using 100%CCA+100%MS achieved 26.93MPa strength at 28th day. But Fig 4.21 shows that the blended 80%CCA with 20%RGCA and 80%NS with 20%MS, it achieved 33.05MPa strength at 28th day. This indicated that the blended material using 80%CCA with 20%RGCA and 80%NS with 20%MS increased strength from the control mix using 100%CCA+100%NS, 100%RGCA+100%NS and 100%CCA+100%MS by 1.14MPa (3.45%), 7.34MPa (22.21%) and 6.12MPa (18.52%) respectively.

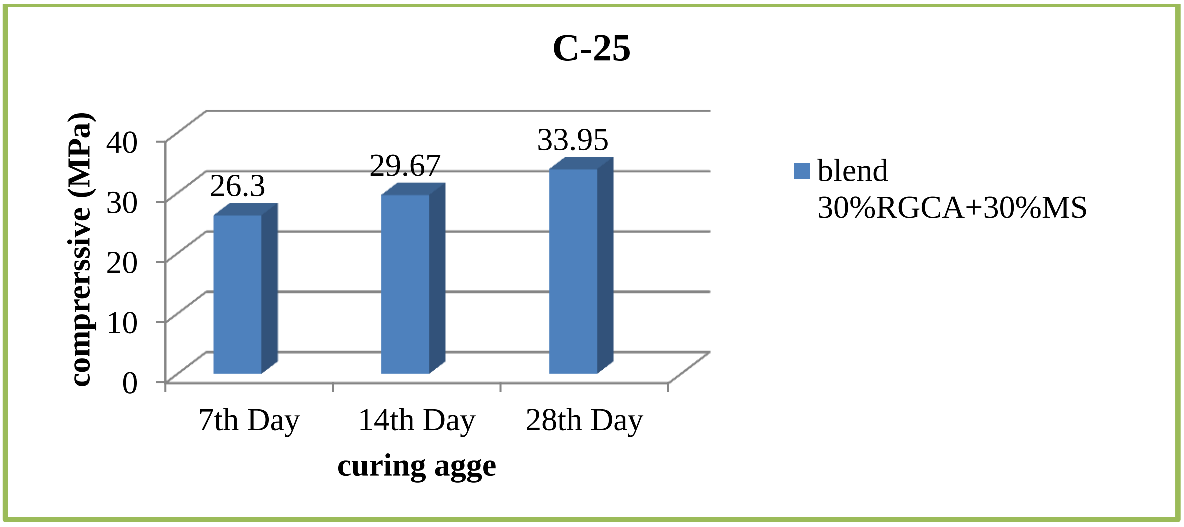


Figure4.22 Average Compressive Strength Test blending 30%RGCA+30%MS mix6

Figure 4.22 shows the rate of strength development graphically. From the above Table 4.6 showed that the concrete test specimens using 100%CCA+100%NS for control mix it achieved about 31.91MPa strength at 28th curing day, Table 4.7 showed that using 100%RGCA+100%NS it achieved 25.71MPa strength at 28th day and Fig 4.22 shows that using 100%CCA+100%MS achieved 26.93MPa strength at 28th curing day. But Fig 4.22 showed that the blended of 70%CCA with 30%RGCA and 70%NS with 30%MS, was achieved 33.95MPa strength at 28th curing day. This indicated that still the blended material using 70%CCA with 30%RGCA and 70%NS with 30%MS increased the strength by 2.04MPa from the control mix of using 100%CCA+100%NS.

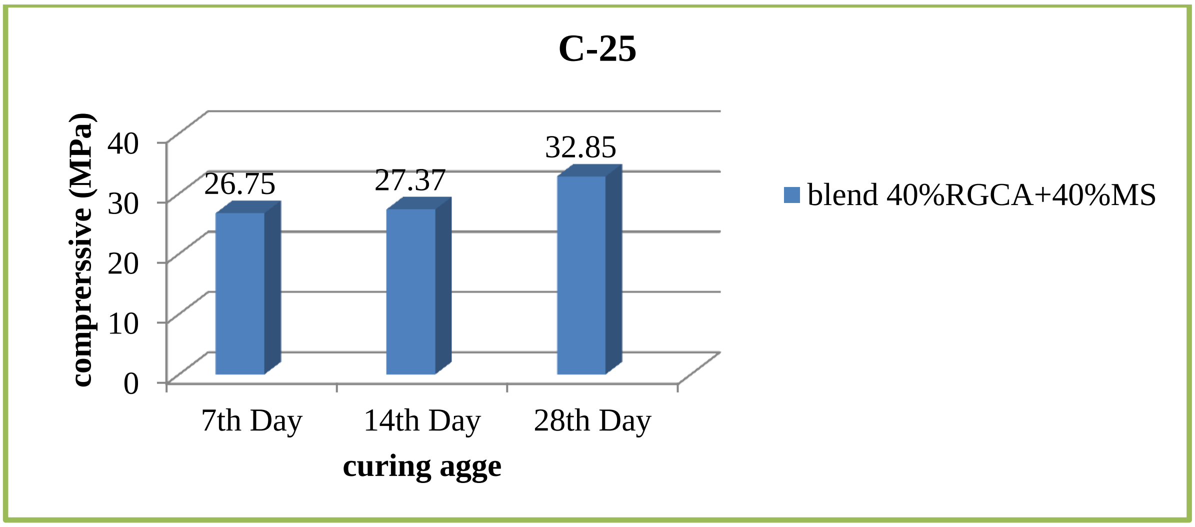


Figure4.23 Average Compressive Strength Test blended 40%RGCA+40%MS mix7

Figure 4.23 showed the rate of strength development graphically. Table 4.6 showed that the concrete test specimens using 100%CCA+100%NS for control mix was achieved 31.91MPa strength at 28th curing day, Table 4.7 shows that using 100%RGCA+100%NS mix achieved 25.71MPa strength at 28th curing day and Table 4.8 shows that using 100%CCA+100%MS was achieved 26.93MPa strength at 28th curing day. But Fig 4.23 showed that the blended 60%CCA with 40%RGCA and 60%NS with 40%MS, was achieved 32.85MPa strength at 28th curing day. This indicated that still the blended material used 60%CCA with 40%RGCA and 60%NS with 40%MS increased strength by 0.94MPa (2.86%), from the control mix. However, the percentage of blended 40% of river gravel coarse aggregate and 40% of manufacture sand has to be reduced the compressive strength by1.1MPa (3.35%) at 28th curing day as compared with blended of 30% aggregate.

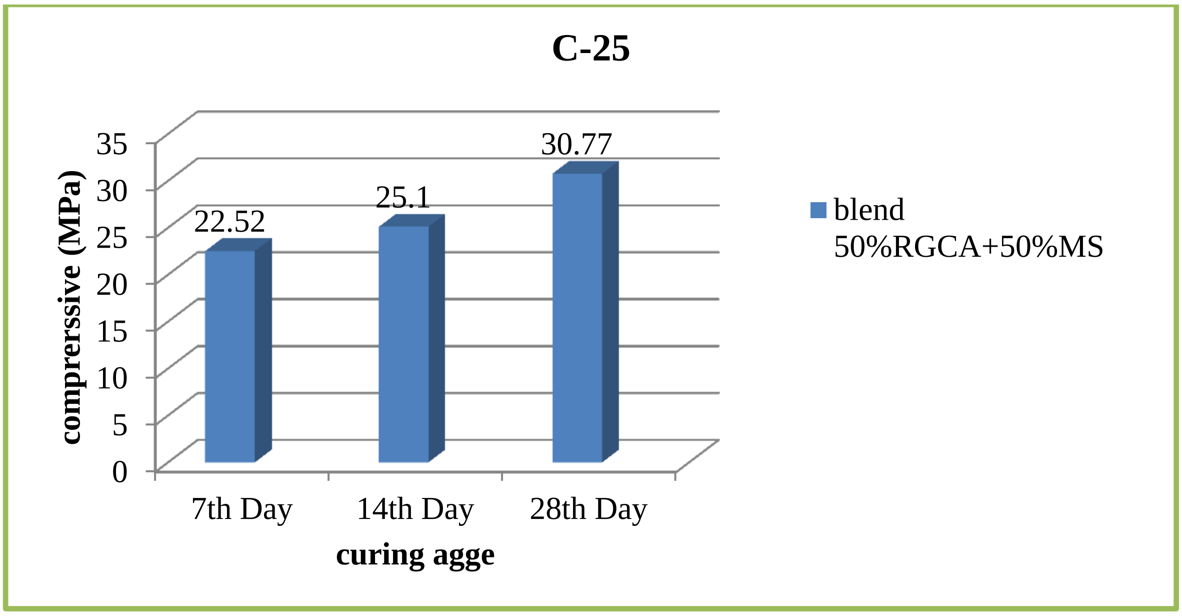


Figure4.24 Average Compressive Strength Test blending 50%RGCA+50%MS

Figure 4.24 showed that the rate of strength development graphically. Table 4.6 showed that the concrete test specimens using 100%CCA+100%NS for control mix was achieved 31.91MPa strength at 28th curing day, Table 4.7 shows that using 100%RGCA+100%NS for control mix achieved 25.71MPa strength at 28th day and Table 4.8 shows that using 100%CCA+100%MS achieved 26.93MPa strength at 28th day. But Fig 4.24 shows that the blended 50%CCA with 50%RGCA and 50%NS with 50%MS, was achieved 30.77MPa strength at 28th day. This indicated that the blended material using 50%CCA with 50%RGCA and 50%NS with 50%MS decreased the compressive strength by 1.14MPa (3.7%) from the control mix (i.e100%CCA+100%NS).

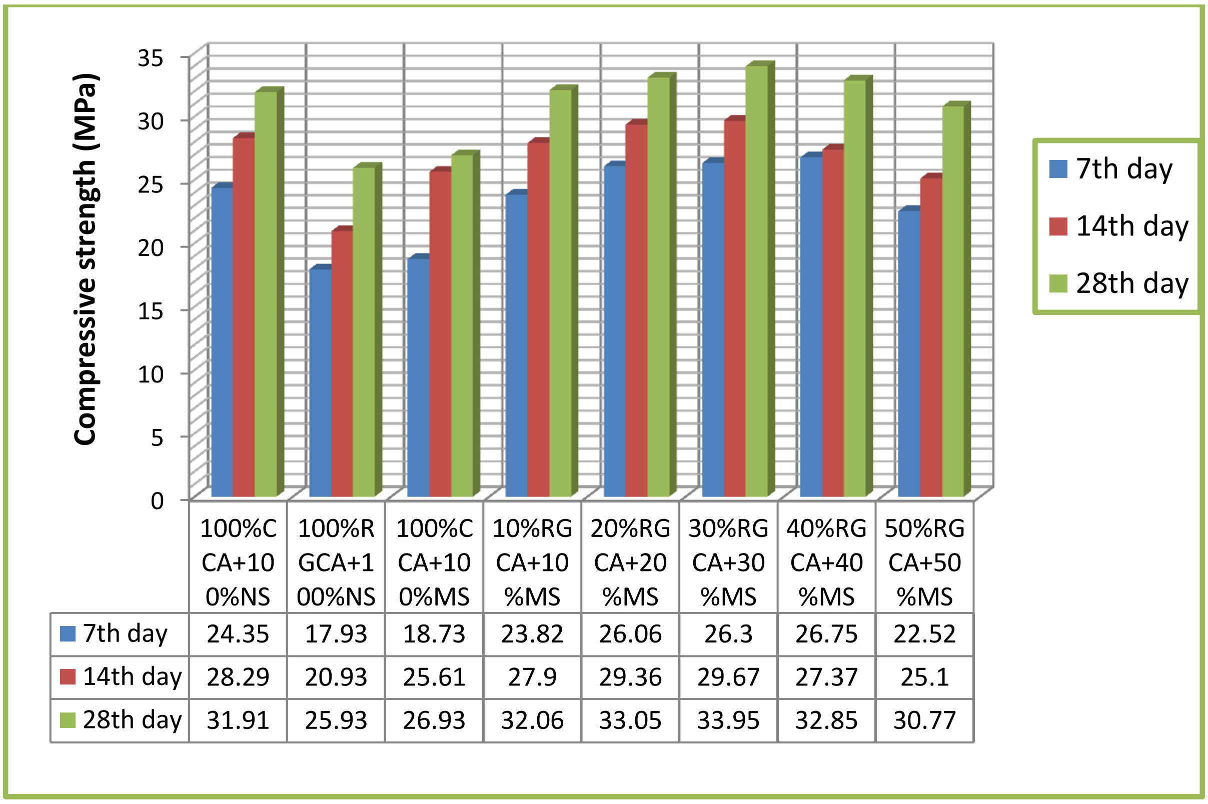


Figure4.25 Summarized Average Compressive Strength Test of concrete in different mix

Fig4.24 showed that, the different concrete mixes with two coarse aggregate and two fine blended aggregates proportions (i.e., for coarse 90%CCA +10%RGCA, 80%CCA +20%RGCA, 70% + 30%RGCA, 60%CCA + 40%RGCA and 50%CCA + 50%RGCA, for fine aggregate 90%NS +10%MS, 80%NS +20%MS, 70%NS + 30%MS, 60%NS + 40%MS and 50%NS + 50%MS) which impart a positive effect on the compressive strength of the produced concrete. While increase the percentage of blended material it also increase the compressive strength from the control mix up to 40% but slightly decrease its strength from the control at 50%. This indicated that the maximum compressive strength possibility of blended for this research was up to 30% which mean 33.95Mpa. But the results have shown in Fig4.25 all the concrete mixes with different blended proportions were achieved the strength requirements. From this indication, we can conclude that using blended RGCA with CCA and MS with NS of the available sources with specified proportions can improve the compressive strength of the produced concrete.

4.3.2 Effect of MS blended with NS and RGCA blended with CCA on compressive strength

To quantify influences of MS blended with NS and RGCA blended with CCA material on compressive strength of concretes, "Strength Coefficient Index" is defined in this study as below:

Strength Coefficient Index: SCI (%) = (A/B) × 100

Where:

A = average compressive strength of test concrete mixtures containing MS and RGCA MPa

B = average compressive strength of control mixtures without MS and RGCA, MPa

Table 4.9 Strength coefficient index at different curing age

Percent of blended MS and RGCA mix	SCI (%) at 7th day	SCI (%) at 14th day	SCI (%) at 28th day
0% of MS and 0% of RGCA	**Control mix**	**Control mix**	**Control mix**
100%NS and 100%RGCA	73.63%	73.98%	81.26%
100%MS and 100%CCA	76.92%	90.53%	84.39%
10% MS and 10% RGCA	97.82%	98.62%	100.47%
20% MS and 20% RGCA	107.02%	103.78%	103.57%
30% MS and 30% RGCA	108%	104.88%	106.39%
40% MS and 40% RGCA	109.86%	96.75%	102.95%
50% MS and 50% RGCA	92.48%	88.72%	96.43%

Table 4.9 the Strength coefficient index curing at age 28th day with blended of 10%, 20%, 30%, 40% and 50% was 100.47%, 103.57, 106.39%, 102.95% and 96.43% respectively of the compressive strength of the control mix. The result showed that the blended 10% - 30% respectively the compressive strength increase from the control mix. But at the blended percentage of 40%-50% the compressive strength decrease. Table 4.10 showed the strength coefficient index comparing to control mix.

Table 4.10 percent of loss and gain compressive strength of concrete at 7days

Percent of blended MS and RGCA mix	Average Compressive Strength (Mpa) at 7^{th} day	Percent of strength loss and strength gain
0% of MS and 0% of RGCA	24.35	Control mix
100%NS and 100%RGCA	17.93	26.37% loss
100%MS and 100%CCA	18.73	23.08% loss
10% MS and 10% RGCA	23.82	2.18% loss
20% MS and 20% RGCA	26.06	7.02% gain
30% MS and 30% RGCA	26.3	8% gain
40% MS and 40% RGCA	26.75	9.86% gain
50% MS and 50% RGCA	22.52	7.52% loss

From the above Table 4.10 showed that in the blended of 100%NS: 100%RGCA and 100%MS: 100%CCA mix at 7^{th} day curing time, 26.37% and 23.08% respectively loss its strength from the control mix. And in the blending mix percentage of 20, 30 and 40 (%) gain strengths by 7.02%, 8% and 9.86% respectively from the control mix. But in the percentage of 10% and 50%, the compressive strength loss by 2.18% and 7.52% respectively from the control mix.

Table 4.11 percent of loss and gain compressive strength of concrete at 14th days

Percent of blended MS and RGCA mix	Average Compressive Strength (Mpa) at 14^{th} day	Percent of strength loss and strength gain
0% of MS and 0% of RGCA	28.29	Control mix
100%NS and 100%RGCA	20.93	26.02% loss
100%MS and 100%CCA	25.61	9.47% loss
10% MS and 10% RGCA	27.9	1.38% loss
20% MS and 20% RGCA	29.36	4.88% gain
30% MS and 30% RGCA	29.67	4.78% gain
40% MS and 40% RGCA	27.37	3.25% loss
50% MS and 50% RGCA	25.1	11.3% loss

Table 4.12 percent of loss and gain compressive strength of concrete at 28th days.

Percentage of blended MS and RGCA mix	Average Compressive Strength (Mpa) at 28th day	Percent of strength loss and strength gain
0% of MS and 0% of RGCA	31.91	Control mix
100%NS and 100%RGCA	25.93	18.74% loss
100%MS and 100%CCA	26.93	15.67% loss
10% MS and 10% RGCA	32.06	0.47% gain
20% MS and 20% RGCA	33.05	3.57% gain
30% MS and 30% RGCA	33.95	6.39% gain
40% MS and 40% RGCA	32.85	2.95% gain
50% MS and 50% RGCA	30.77	3.57% loss

Table 4.12 showed that using 100%NS:100%RGCA and 100%MS:100%CCA mix at 28th day curing time, 18.74% and 15.67% respectively loss its strength from the control mix. And in the blended mix percentage of 10, 20, 30 and 40 (%) improvement strengths by 0.47%, 3.57%, 6.39 and 2.95% respectively from the control mix. But in the blended percentage of 50%, the compressive strength loss by 3.57% from the control mix.

4.3.3 Comparison of compressive strength with characteristics of compressive strength

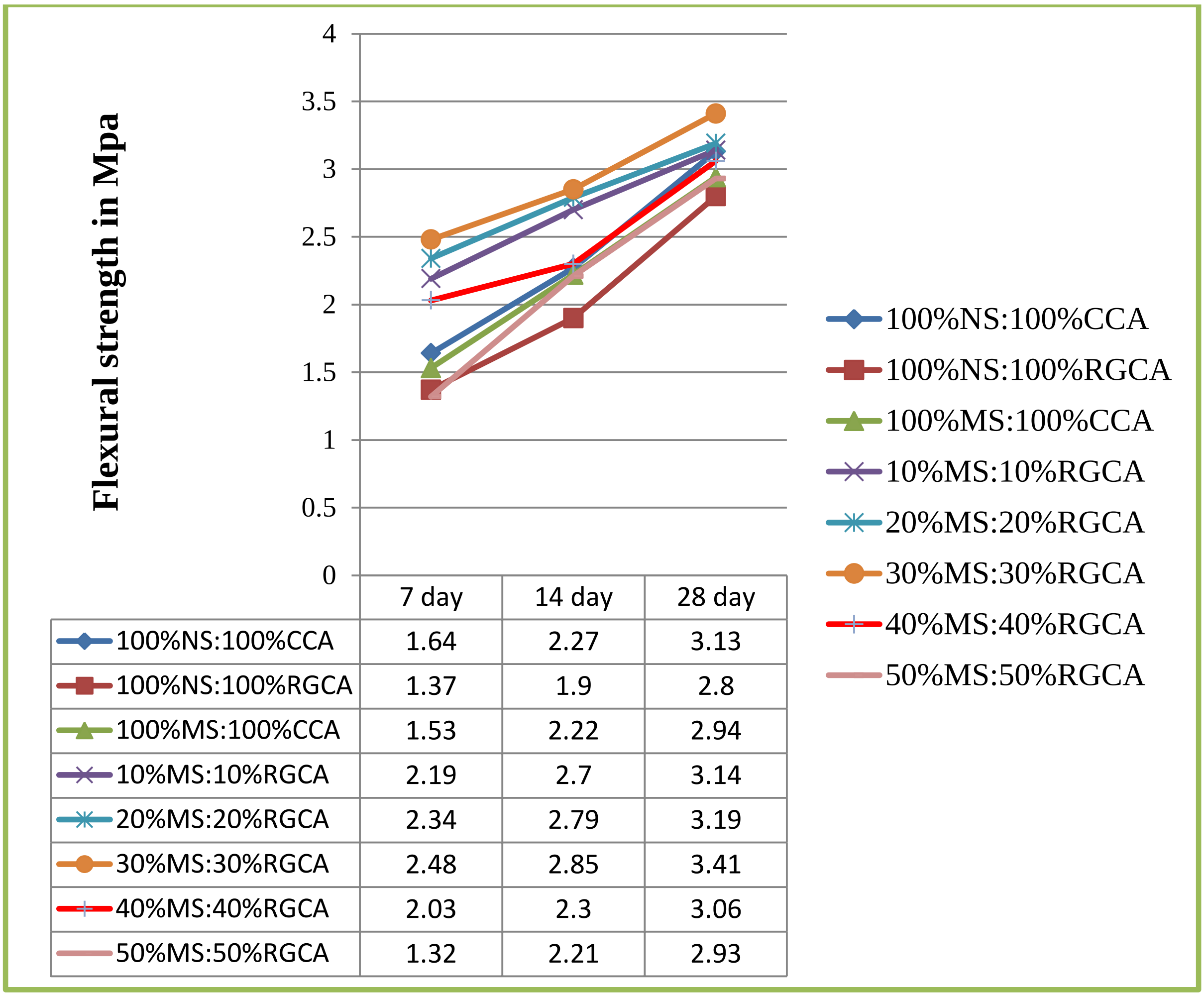
It is known the compressive strength at 7th day the concrete should attained ≥65% of the characteristics of the compressive strength. In this research the characteristics compressive strength is C-25. so the results of the average compressive strength shown Figure 4.25 at 7th day at 0%,10%,20%,30%,40% and 50% blended of natural with manufactured sand and crushed coarse with river coarse aggregate attained 97.4%, 95.28%,104.24,105.2%,107 and 90.08% respectively. And also the compressive strength at 28th day the concrete should attained 99% of the characteristics compressive strength or specified strength so the result of the average compressive strength at 28th day of curing at 0%, 10%, 20%, 30%, 40% and 50% blended of natural with manufacture sand and crushed coarse with river coarse aggregate attained beyond the specified compressive strength showed Figure 4.25. In this research it is allowed to blending up to 50% of natural sand with manufacture and river gravel Coarse with crushed Coarse aggregate.

4.3.2 Flexural strength

In this part, the results of flexural experiments on the concrete C-25 different percentage of blended crushed Coarse with river gravel Coarse aggregate and crushed fine aggregate with natural sand are showed.

Table 4.13 average flexural strength

Percentage of blended MS & RGCA	Average Flexural strength (Mpa)		
100%NS:100%CCA	7th day	14th day	28th day
100%NS:100%RGCA	1.64	2.27	3.13
100%MS:100%CCA	1.37	1.9	2.8
10%MS:10%RGCA	1.53	2.22	2.94
20%MS:20%RGCA	2.19	2.7	3.14
30%MS:30%RGCA	2.48	2.85	3.41
40%MS:40%RGCA	2.03	2.3	3.03
50%MS:50%RGCA	1.32	2.21	2.93



	7 day	14 day	28 day
100%NS:100%CCA	1.64	2.27	3.13
100%NS:100%RGCA	1.37	1.9	2.8
100%MS:100%CCA	1.53	2.22	2.94
10%MS:10%RGCA	2.19	2.7	3.14
20%MS:20%RGCA	2.34	2.79	3.19
30%MS:30%RGCA	2.48	2.85	3.41
40%MS:40%RGCA	2.03	2.3	3.06
50%MS:50%RGCA	1.32	2.21	2.93

Figure4.26 Average flexural strength at different mix proportion

4.3.3 Effect of blended river gravel with crushed Coarse and manufacture with natural sand on flexural strength

In this part, the results of flexural experiments on the concrete C-25 different percentage of blending river gravel with crushed coarse and natural sand with manufacture sand are shown.

The flexural strength of samples, tested in the ages of 7,14 and 28 days of curing with different values of (0%, 10%, 20% ,30%,40% and 50%) blended river grave coarse with crushed coarse aggregate and natural sand with manufacture sand for concrete C-25.

Strength Coefficient Index: SCI (%) = (A/B) × 100

Where:

A = average compressive strength of test concrete mixtures containing MS and RGCA MPa

B = average compressive strength of control mixtures without MS and RGCA, MPa

Table4.14 Strength coefficient index

Percentage of blended MS and RGCA mix	SCI (%) at 7th day	SCI (%) at 14th day	SCI (%) at 28th day
0% of MS and 0% of RGCA	Control mix	Control mix	Control mix
100%NS and 100%RGCA	83.54%	83.7%	89.46%
100%MS and 100%CCA	93.3%	97.79%	93.93%
10% MS and 10% RGCA	133.54%	118.94%	100.32%
20% MS and 20% RGCA	142.68%	122.91%	101.92%
30% MS and 30% RGCA	151.22%	125.55%	108.95%
40% MS and 40% RGCA	123.78%	101.32%	97.76%
50% MS and 50% RGCA	80.49%	97.36%	93.61%

Table 4.14 the result of flexural strength at 7th day,14th day and 28th day curing time with 100%NS: 100%RGCA mix was 83.54% ,83.7% and 89.46% of the flexural strength of the control mix respectively was achieved. And the mix of 100%MS:100%CCA concrete at 7th ,14th and 28th day the flexural strength was achieved 93.3%,97.79% and 93.93% respectively.10%MS:10%RGCA,20%MS:20RGCA,30%MS:30%,40%MS:40%RGCA and 50%MS:50%RGCA mix concrete at 28th day is 100.32%, 101.92%,108.95%,97.76% and 93.61% respectively the flexural strength of the control mix achieved.

Table 4.15 percent of loss and gain compressive strength of concrete at 7days.

Percentage of blended MS and RGCA mix	Average flexural Strength (Mpa) at 7th day	Percent of strength loss and strength gain
0% of MS and 0% of RGCA	1.64	Control mix
100%NS and 100%RGCA	1.37	16.46%
100%MS and 100%CCA	1.53	6.7%
10% MS and 10% RGCA	2.19	33.54% gain
20% MS and 20% RGCA	2.34	42.68% gain
30% MS and 30% RGCA	2.48	51.22%gain
40% MS and 40% RGCA	2.03	23.78%gain
50% MS and 50% RGCA	1.32	19.51%

Table 4.16 percentage of loss and gain compressive strength of concrete at 14th days.

Percentage of blended MS and RGCA mix	Average flexural Strength (Mpa) at 14^{th} day	Percent of strength loss and strength gain
0% of MS and 0% of RGCA	2.27	Control mix
100%NS and 100%RGCA	1.9	16.3%
100%MS and 100%CCA	2.22	2.21%
10% MS and 10% RGCA	2.27	18.94%gain
20% MS and 20% RGCA	2.79	22.91%gain
30% MS and 30% RGCA	2.85	25.55% gain
40% MS and 40% RGCA	2.3	1.32%gain
50% MS and 50% RGCA	2.21	2.64%

Table 4.17 percentage of loss and gain compressive strength of concrete at 28th days.

Percent of blended MS and RGCA mix	Average flexural Strength (Mpa) at 28^{th} day	Percent of strength loss and strength gain
0% of MS and 0% of RGCA	3.13	Control mix
100%NS and 100%RGCA	2.8	10.54% loss
100%MS and 100%CCA	2.94	6.07% loss
10% MS and 10% RGCA	3.14	0.32%gain
20% MS and 20% RGCA	3.19	1.92%gain
30% MS and 30% RGCA	3.41	8.95%gain
40% MS and 40% RGCA	3.06	2.24% loss
50% MS and 50% RGCA	2.93	6.39% loss

From the above Table 4.17 it shows that using 100%NS: 100%RGCA and 100%MS: 100%CCA mix at 28^{th} day curing time, 10.54% and 6.07% respectively loss its flexural strength from the control mix. And in the blending mix percentage of 10, 20, and 30 (%) gain strengths by 0.32%, 1.92%, and 8.95% respectively from the control mix. But in the blended percentage of 40% and 50%, the flexural strength loss by 2.24% and 6.39% respectively from the control mix.

4.4 The maximum compressive, flexural strength of the blended aggregates and the amount of aggregate to be blended.

Fig 4.26 showed that the blended aggregates at the percentage of 30% CCA with 30%RGCA and 30% NS with 30%MS the compressive strength and flexural strength was achieved with the result of 33.95Mpa and 3.41Mpa respectively. This indicated that the maximum compressive strength and flexural strength were achieved at the percentage of 30%. From the gradation curve of coarse aggregate Figure4.3 up to Fig 4.7 the gradation result showed that the blended coarse aggregate was achieved up to the possibility blended percentage of 50%. This indicated that the river gravel gab grade coarse aggregate can be blended with the crushed coarse aggregate to satisfy the required gradation. But beyond 50% blend the material was started fail out slightly from the standard limit. Also the gab grade of Varnero crushed fine aggregate can be blended with Gambela natural sand up to 50% and satisfied the required limit. But the gradation curve showed that the Varnero fine aggregate blended beyond 50% was started somewhat failed out of the limit.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the results of this investigation, which have been discussed, the following conclusions were drawn:

1) The result shows that the gradation curve of crushed coarse aggregate was fall within the gradation specifications for ES C.D3 201/C 33M grading requirements for coarse aggregates designation. Whereas the river gravel coarse aggregate was in some sizes was above the upper limits and below lower limit gradation line. In action the gradations of coarse aggregates was affected the workability of fresh concrete; for this case, in river gravel aggregate is more smooth and partially smoothed textures were minimized the opportunities of affects the workability of fresh concrete and from the test result indication, the workability of the river gravel slump value higher than crushed coarse aggregate slump value. Also While blended both the crushed coarse aggregate with river gravel coarse aggregate up to the percentage of 50% the gradation was more closed to the required specification. So it is concluded that the gradations of both the blended crushed coarse aggregate and river gravel coarse aggregates suitable for use in normal or conventional concrete as a coarse aggregate.
2) From the test result, the river gravel coarse aggregate is higher in specific gravity and lower dry-rodded unit weight and lower in absorption as compared to crushed coarse aggregate. On the other hand the crushed coarse aggregate had high value of the dry rodded Unit Weight and higher in water absorption. Also the result showed that the AIV of river gravel was higher than crushed coarse aggregate but for all the two samples was satisfied with Aggregate Impact Value. From this result we can conclude that the river gravel has high resistance of AIV but has high void or low dry roded unit weight than crushed coarse aggregate.
3) According to the result, the slump obtained for the crushed coarse aggregate mix was lesser than and river gravel aggregate mix. Therefore, we can conclude that the river gravel coarse aggregate has good workability than crushed coarse aggregate due to its smooth surface textures and rounded shape. The slump test shown that while increase the percentage of manufacture sand it decrease the

slump value; for this reason the manufactured sand has more fine material and needed more water to made suitable workability. And also because of the round shape and smooth surface texture of natural sand reduces the inter particle friction in the fine aggregate component so that the workability was higher in natural sand. Manufactured sand particles are angular in shape and their rough surface texture improves the internal friction in the mix. Therefore, Because of the problem of the workability point of view using manufactured sand without blend is difficult to produce normal concrete.

4) The Varnero PLC manufactured sand gradation curve showed that, the sand sources did not satisfy the grade requirements. In some sieve size is more on coarser side and in some sieve size was on the finer side. However, the trail done on blended among the manufacture sand sources and natural sand shown that the grade requirement was achieved the gradation. From this indication we can conclude that the varnero PLC crushed fine aggregate cannot use without blend.
5) From the test result MS has low workability. To overcome this problem blending natural sand aggregate is important. Manufactured sand offers a viable alternative to the natural sand if the problems associated with the workability of the concrete mix can be resolved by using super plasticizer. The addition of super plasticizer to a concrete mix with manufactured sand allows the mix to have a better workability.
6) From the test result with the blended percentages of 10%MS: 10%RGCA, 20%MS: 20%RGCA, 30%MS: 30%RGCA, 40%MS: 40%RGCA and 50%MS: 50%RGCA the compressive strength at 28th curing age day was achieved 32.06Mpa, 33.05Mpa, 33.95Mpa, 32.85Mpa and 30.77Mpa respectively. From this result we can conclude that the maximum compressive strength possibility of blended in this research was up to 30% of crushed sand as fine aggregate and 30% of river gravel as crushed coarse aggregate with compressive strength of 33.95Mpa.
7) From the test result with the blended percentages of 10%MS: 10%RGCA, 20%MS: 20%RGCA, 30%MS: 30%RGCA, 40%MS: 40%RGCA and 50%MS: 50%RGCA the flexural strength at 28th curing age was achieved 3.14Mpa, 3.19Mpa, 3.41Mpa, 3.06Mpa and 2.93, Mpa, respectively. From this result we can conclude that at the possibility of blended percentage of 30% the maximum

flexural strength was achieved 3.41Mpa use 30% crushed sand as fine aggregate and 30% river gravel as crushed coarse aggregate.

5.2 Recommendations

1. Since natural sand aggregate is limited resource we have to use it wisely by making standardizing and blending with manufactured sand for the specified work. High strength concrete production is possible by using standardized aggregate and following the literature recommendation during proportioning the mix.
2. The fact that this study concluded the river gravel aggregates are qualified with the engineering property test and recommended based from the combined result of the comparison with crushed coarse aggregates for the use of conventional concrete in Jimma Zone. But some procedure needed proper attentions in order to use river gravel as a coarse aggregate (like manual removals of over graded stone, impurities, and others).
3. From the gradation curve result, Varnero PLC Quarry crushed sand was not satisfied the standard specification. So, use as fine aggregates in concrete production without blend was difficult to use in concrete because of gap grade and poor workability. Results from this research and other works indicate that also 100% replacement of sand with quarry crushed stone sand is possible as showed the strength tests but it should be check by the approval the quality, workability treatment and check all physical property of sand before use. Also trial casting with the proposed crushed should be carried out to achieve the most suitable water content and mix proportions to suit the required workability levels and strength requirements.

Further research is proposed in the following areas.

1. The effects that have on digging for natural sand on environment shall be studied.
2. More research and investigations need to be carried out to assess the scope for saving through optimization of both natural and manufactured sand.
3. Researcher will conduct using admixture on the effect of strength
4. More research and investigation need on the concrete material cost analysis of crushed fine and natural sand around Jimma zone.

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Appendix

Appendix A

Applicable standard and required specifications for the study

Table1A.The appropriate ASTM, AASHTO, ACI, Ethiopian and British Standards

Aggregate properties & requirements	standards	CODE	types of aggregate	
			Coarse aggregate	sand
			specifications	
*Sieve Analysis; Graduation Requirements % Passing	ASTM	C136, C117,		
	AASHTO	T-11		
	ES	C. D3. 201		
Flakiness index % maxim	ASTM	C-33		
	BS	05.1:1989	≤30%	
fineness modulus	ASTM			
	ES	C. D3. 201		2 to 3.5
loose unit weight kg/m3	ASTM	C-29	1245 and 1825	1520 – 1680
Abrasion and Impact in the Los Angeles Machine % maxim	ASTM		25 to 50%	
	ES	C. D3. 201	50%	
Absorption (moisture contents at SSD)	ASTM	C-127, C-128,	0.2% to 4%	0.2% to 2%,
Specific Gravity Apparent Specific Gravity Bulk Specific Gravity Bulk Specific Gravity (S.S.D basis)	ASTM	C127, C128,	*2.30 to 2.90	*2.30 to 2.90
	ES	C. D3. 201	2.4 to 3.0	2.4 to 3.0
Bulk density (dry-rodded unit weight) kg/m3	ASTM	C -29	1200 to 1760 kg/m3	1520 – 1680
Aggregate Impact Value (AIV	BS	812112:1990	≤ 30%	

Appendix B

1. Material quality Test Results

1.1. Tests for Coarse Aggregate

I. Determination of gradation of coarse aggregate

Objective:

This test method covers the determination of particle size distribution of coarse aggregates by the sieve analysis method.

Theory:

According to ASTM C136, the term coarse aggregate is used to describe particles larger than 4.75 mm (retained on No. 4 sieve).

Apparatus:

- Balance – Digital balance with an accuracy of 0.1gm.
- Sieves – ASTM standard sieve size of 37.5 mm, 25 mm, 19.0 mm, mm; 9.5mm, 4.75mm, 2.36 mm and pan.

Sampling:

The samples of (5kg before blending and 5kg after blending) were prepared with quartering method and riffle box as appropriate.

Procedure:

- The air-dry sample was weighed and sieved successively on the appropriate sieves starting with the largest size sieve. Care was taken to ensure that the sieves were clean before use.
- Sieving was carried out with a nest of sieves on a sieve shaker for a period of at least 10 mins.
- The retained materials on each successive sieve were weighed and recorded.

Observation and Calculation: Crushed coarse aggregate before blending

Table 1B Sieve analysis test result for CCA

Sieve size	Wt.Rt (kg)	Wt. %RT	Cum.%Rt	Cum.%pass	ES C.D3. 201 limit		Remark
					Lower	Upper	
37.5	0	0	0	100	100	100	Ok
25	0.950	37	37	63			
19	0.548	21	58	42	30	70	Ok
12.5	0.651	25	83	17			
9.5	0.201	8	91	9	10	35	Ok
4.75	0.236	9	100	0	0	5	Ok
2.26	0	0	100	0	0	0	
Pan	0	0	100	0			

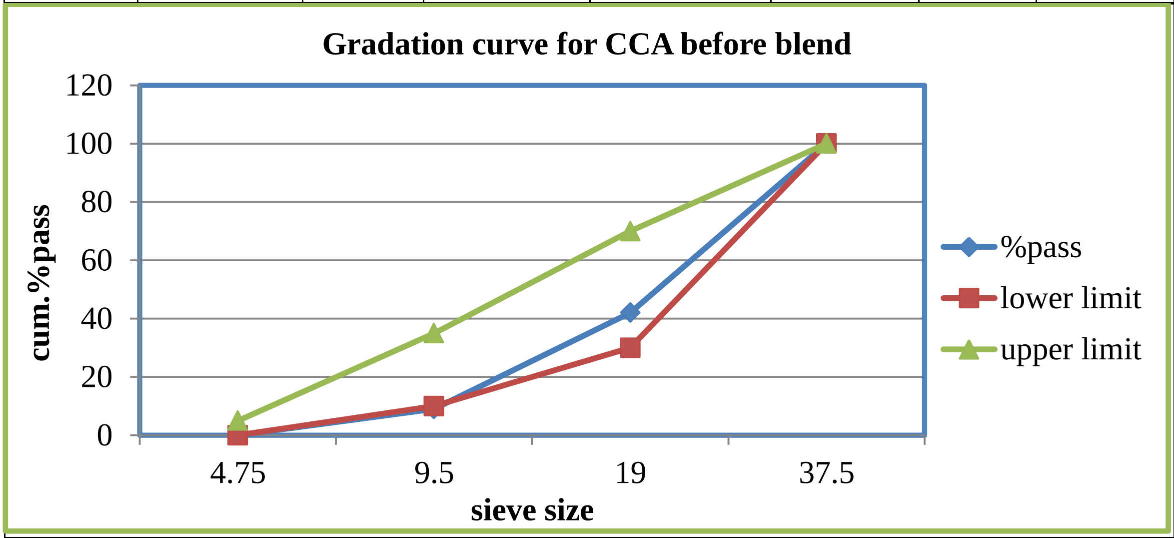

Fig 1B: Gradation curve for crushed coarse aggregate before blending

Observation and Calculation: River gravel coarse aggregate gradation before blending

Table2B Average Particle size distribution of RGCA before blend

Sieve size	Wt. Rt	Wt. %RT	Cum.%Rt	Cum. %pass	ES C.D3. 201 limit		
					Lower	Upper	Remark
37.5	0	0	0	100	100	100	Ok
25	0.145	2.9	2.9	97.1			
19	1.32	26.4	29.3	70.7	30	70	**No**
12.5	1.363	27.26	56.56	43.44			
9.5	1.82	36.4	92.96	7.04	10	35	**No**
4.75	0.35	7	99.96	0.04	0	5	Ok
2.36	0.002	0.04	100	0	0		
pan							

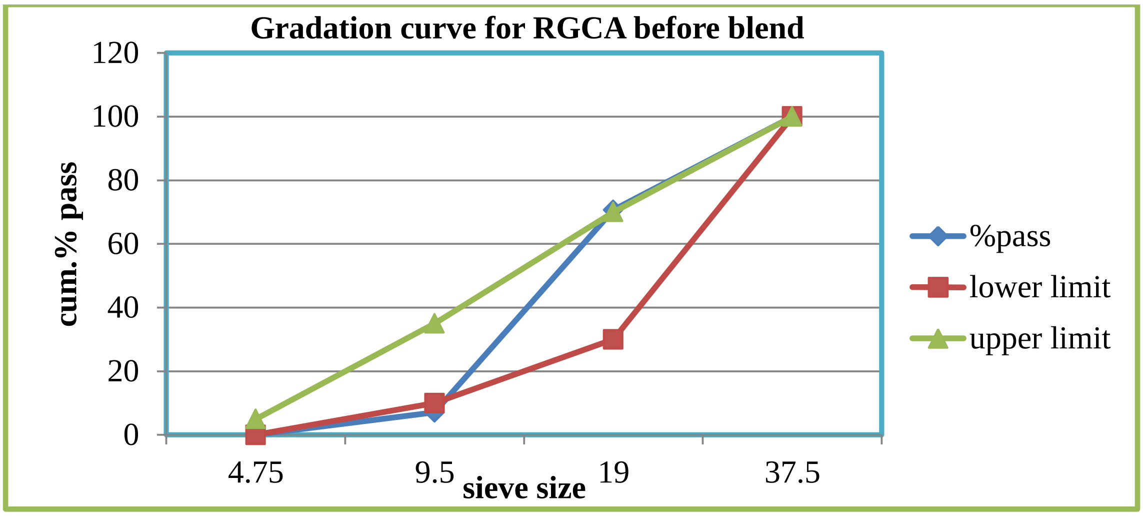

Fig 2B: Gradation curve for RGCA before blending

After blending coarse aggregate of CCA and RGCA

Using P=Aa+Bb+Cc……formula

Where:
P is the percentage of material passing through a given sieve for the combined aggregates **A,**
B, C.
A, B, and C are the percentages of material passing a given sieve for aggregates A, B, C, respectively. a, b, and c are the proportions of aggregate A, B, and C used in the combination.

4 Blending of 90%CCA and 10%RGCA

Table 3B Combined particle distribution of 90%CCA and 10%RGCA

Crushed coarse			River gravel coarse		blend	Standard Specification (ES CD3.201)	
	%passing	a = 90%	%passing	b =10%			
Sieve size		% batch		% batch		Lower limit	Upper limit
37.5	100	90	100	10	100		100
25	63		97.1				
19	42	37.8	70.7	7.07	44.87	30	70
12.5	17		43.44				
9.5	9	8.1	7.04	0.704	8.81	10	35
4.75	0	0	0.04	0.004	0.004	0	5
2.36	0		0	0	0		

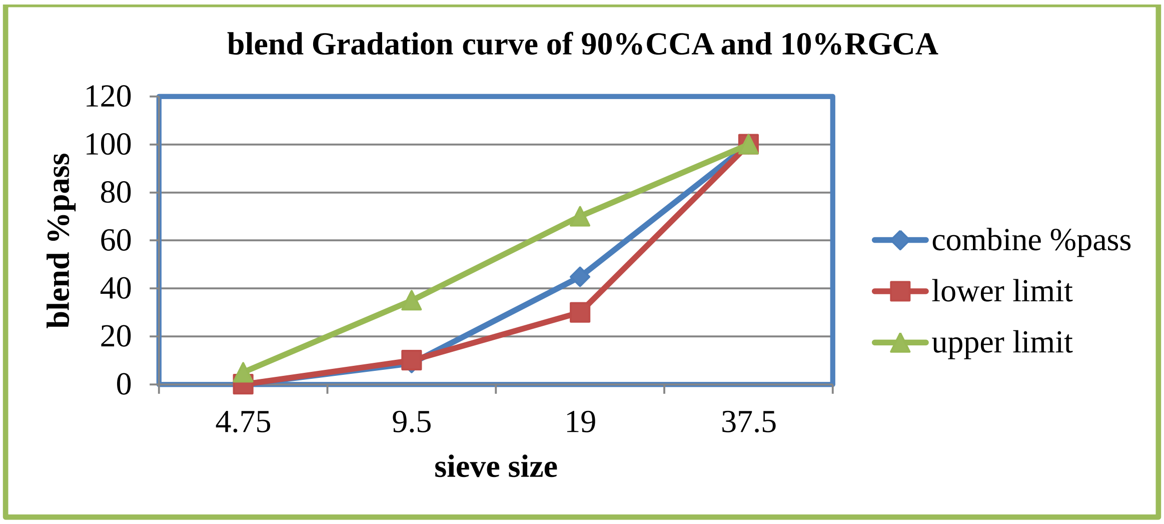

Fig3B Gradation curve for combined 90%CCA and 10%RGCA

5 Blending of 80%CCA and 20%RGCA

Table 4B Combined particle distribution of 80%CCA and 20%RGCA

Crushed coarse			River gravel coarse		blend	Standard Specification (ES CD3.201)	
	%passing	a = 80%	%passing	b =20%			
Sieve size		% batch		% batch		Lower limit	Upper limit
37.5	100	80	100	20	100		100
25	63	50.4	97.1	19.42			
19	42	33.6	70.7	14.14	47.74	30	70
12.5	17	13.6	43.44	8.89			
9.5	9	7.2	7.04	1.41	8.61	10	35
4.75	0	0	0.04	0.008	0.008	0	5
2.36	0	0	0	0	0		

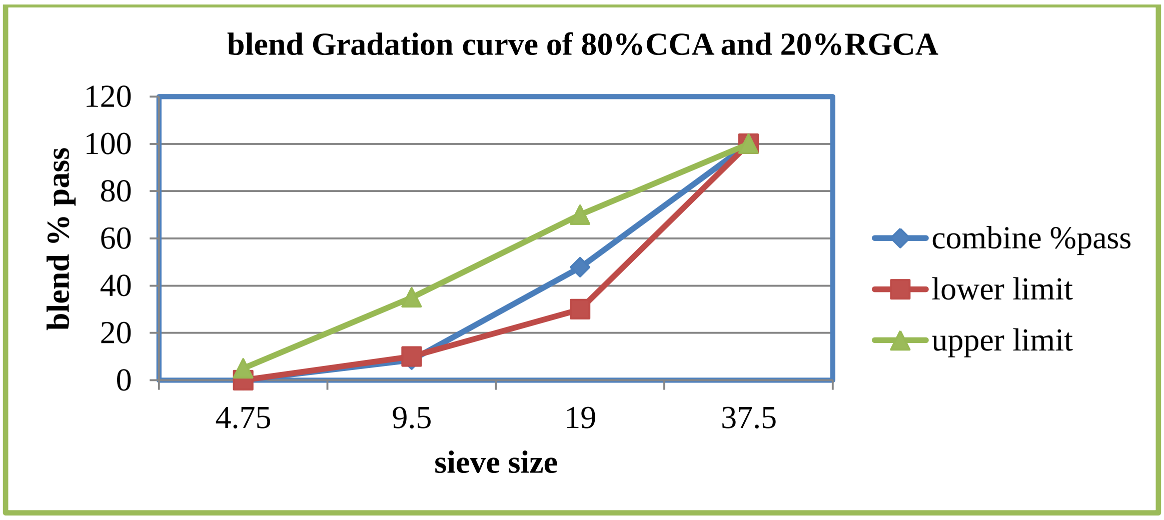

Fig4B Gradation curve for combined 80%CCA and 20%RGCA

6 Blending of 70%CCA and 30%RGCA

Table 5B Combined particle distribution of 70%CCA and 30%RGCA

Crushed coarse			River gravel coarse		blend	Standard Specification (ES CD3.201)	
Sieve size	%passing	a = 70%	%passing	b =30%			
		% batch		% batch		Lower limit	Upper limit
37.5	100	70	100	30	100		100
25	63	44.1	97.1	29.13	73.23		
19	42	29.4	70.7	21.21	50.61	30	70
12.5	17	11.9	43.44	13.03	24.93		
9.5	9	6.3	7.04	2.12	8.42	10	35
4.75	0	0	0.04	0.012	0.012	0	5
2.36	0	0	0	0	0		

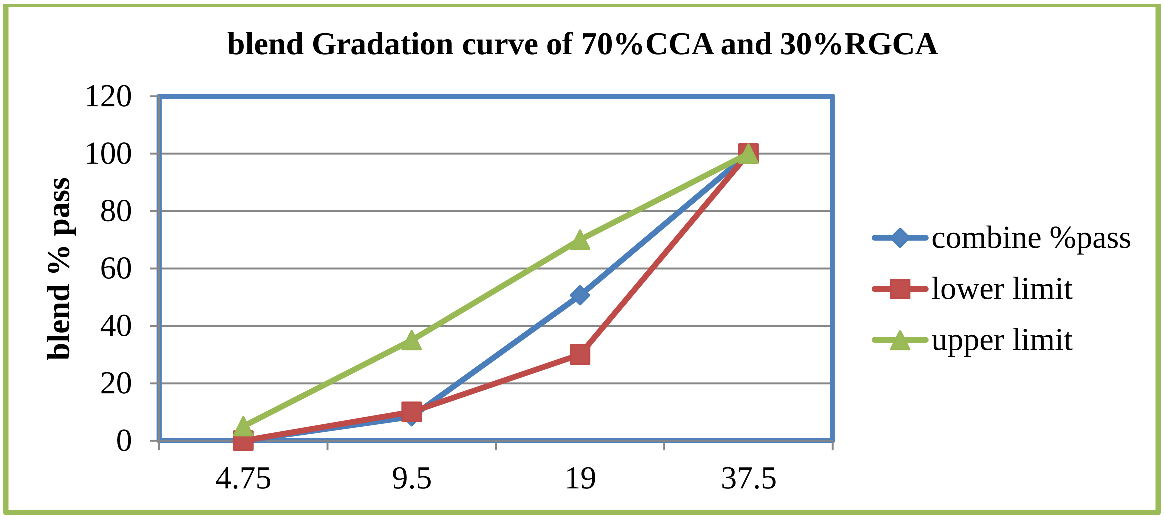

Fig.5B Gradation curve for combined 70%CCA and 30%RGCA

7 Blending of 60%CCA and 40%RGCA

Table 6B Combined particle distribution of 60%CCA and 40%RGCA

Crushed coarse			River gravel coarse		blend	Standard Specification (ES CD3.201)	
Sieve size	%passing	a = 60%	%passing	b =40%			
		% batch		% batch		Lower limit	Upper limit
37.5	100	60	100	40	100		100
25	63	37.8	97.1	38.84	76.14		
19	42	25.2	70.7	28.28	53.48	30	70
12.5	17	10.2	43.44	17.38	27.58		
9.5	9	5.4	7.04	2.81	8.22	10	35
4.75	0	0	0.04	0.016	0.016	0	5
2.36	0	0	0	0	0		

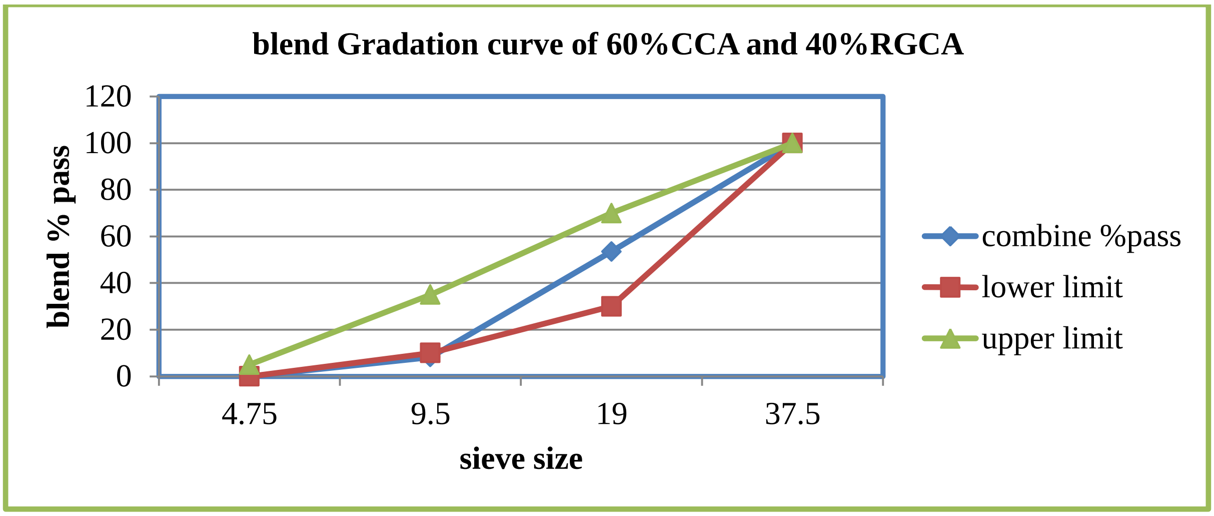

Fig.6B Gradation curve for combined 60%CCA and 40%RGCA

8 Blending of 50%CCA and 50%RGCA

Table 7B Combined particle distribution of 60%CCA and 40%RGCA

Crushed coarse			River gravel coarse		blend	Standard Specification (ES CD3.201)	
Sieve size	%passing	a = 50% % batch	%passing	b =50% % batch		Lower limit	Upper limit
37.5	100	50	100	50	100		100
25	63	31.5	97.1	48.55	80.05		
19	42	21	70.7	35.35	56.35	30	70
12.5	17	8.5	43.44	21.72	30.22		
9.5	9	4.5	7.04	3.52	8.1	10	35
4.75	0	0	0.04	0.02	0.02	0	5
2.36	0	0	0	0	0		

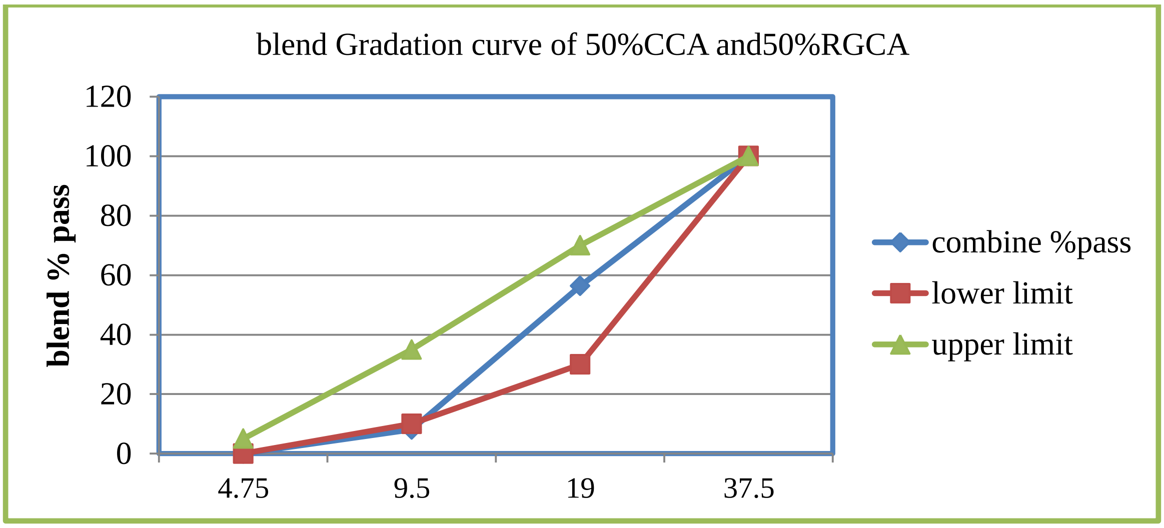

Fig7B Gradation curve for combined 50%CCA and 50%RGCA

II. Determination of bulk unit weight of coarse aggregate

Objective:

This test method covers the determination of compact weight of coarse aggregate.

Theory:

Unit weight can be defined as the weight of a given volume of graded aggregate. It is a density measurement and also known as bulk density. It includes the aggregates and the void between them.

Apparatus:

- Balance
- Tamping rod
- Cylindrical metal container with a capacity of 0.01m3

Procedure:

First, fill the container about one third full with the thoroughly mixed coarse aggregate by means of a shovel.

Then, compact it with a tamping rod (25 times), each blow being given by allowing the tamping rod to fall freely from a height of 50 mm above the surface of the aggregate; the blows being evenly distributed over the surface. Then add a further similar quantity of aggregate in the same manner and give the same number of blows.

Finally, fill the container to over flowing, tamp it again with the same number of blows, and remove the surplus aggregate by rolling the tamping rod across and in contact with the top of the container; any aggregate, which impedes its progress being removed by hand, and add the aggregate to fill any obvious depressions. Finally, determine the mass of the aggregate in the container.

- **Calculation and Observation from sample test:**

1. **Unit weight of CCA**

$$Bulkunitweight=\frac{B-A}{C}$$

Where:
A= Weight of container
B= Weight of aggregate plus container
C= volume of container

Area container= $\frac{\Pi D2}{4}$

Where: D=diameter of container =0.235m

Height of container =0.235m

Trial one and two
Table: 8B unit weight test of the blended Coarse aggregate

Description	Trial 1	Trial 2
Weight of container, Kg(A)	1.53	1.53
Weight of aggregate plus container, Kg(B)	18.25	17.54
Volume of the container, m3(C)	0.01	0.01

a) **Trial one**

$Bulkunitweight = \frac{18.25-1.53}{0.01}$=**1672kg/m3**

b) **Trial two**
$Bulkunitweight = \frac{17.54-1.53}{0.01}$=**1601kg/m3**

- Take the average of the two=**1636.5kg/m3**

2. **Unit weight of RGCA**

$Bulkunitweight = \frac{B-A}{C}$

Area container= $\frac{\Pi D2}{4}$

Where: D=diameter of container =0.235m

Height of container =0.235m

Trial one and two
Table: 9B unit weight test of the blended coarse aggregate (trial 1)

Description	Trial 1	Trial 2
Weight of container, Kg(A)	1.53	1.53
Weight of aggregate plus container, Kg(B)	15.2	16.89
Volume of the container, m3(C)	0.01	0.01

a) **Trial one**

$Bulkunitweight = \frac{15.2-1.53}{0.01}$=**1367kg/m3**

a) **Trial two**

$Bulkunitweight = \frac{16.89-1.53}{0.01}$=**1536kg/m3**

- Average of the two=**<u>1451.5kg/m3</u>**

3. **Blend unit weight of CCA and RGCA**

Take 20kg sample (i.e10kg CCA and 10kg) RGCA using riffling and quartering method

$Bulkunitweight = \frac{B-A}{C}$

Area container= $\frac{\Pi D2}{4}$

Where: D=diameter of container =0.235m

Height of container =0.235m

Trial one and two

Table: 10B unit weight test of the blended Coarse aggregate

Description	Trial 1	Trial 2
Weight of container, Kg(A)	1.53	1.53
Weight of aggregate plus container, Kg(B)	15.69	18.34
Volume of the container, m3(C)	0.01	0.01

a) **Trial one**

$Bulkunitweight = \frac{15.69-1.53}{0.01}$=**1416kg/m3**

b) **Trial two**

$Bulkunitweight = \frac{18.34-1.53}{0.01}$=**1681kg/m3**

- Average of the two=**<u>1548.5kg/m3</u>**

III. Determination of moisture content of coarse aggregate

Objective:

This method covers the determination of moisture content of coarse aggregate by oven-dry method. This method is sufficiently accurate for usual purpose such as for adjusting batch weights of concrete.

Definition:

Moisture content is the total amount of water present in the aggregate; i.e., both internally (inside the pores) and externally at the surface.

Apparatus:

- Balance of suitable capacity, readable with an accuracy of 0.1gm. Container
- Oven-well ventilated, thermostatically controlled to maintain a temperature of 110±5oc.
- Metal tray for use in quartering and riffle box.

Procedure:

- First, clean the container, dry, weigh and tare it. Weigh the collected wet sample and denote as A.
- Place the container with the test specimen in the oven and leave it to dry at a temperature 110±5oC. In addition, maintain this temperature until the test specimen has reached a constant mass for 24hrs.
- Remove the container, test specimen from the oven, and allow it to cool until it is possible to handle and weigh; after which, weigh the sample on another tarred container and denote as B.

Observation and Calculation:

a) CCA moisture content

A=wt. of original air dry sample=2kg
B=wt. of oven dry sample=1.985kg

MC%=$\frac{A-B}{B}$X100=$\frac{2-1.985X}{1.985}X100 = \mathbf{0.76}\%$

b) RGCA moisture content

A=wt. of original air dry sample=2kg

B=wt. of oven dry sample=1.976kg

MC%=$\frac{A-B}{B}$X100 = $\frac{2-1.976}{1.976}X100 = \mathbf{1.21}\%$

***VI.* Determination of specific gravity and absorption capacity of coarse aggregate**

Objective:

This test method covers the determination of specific gravity and absorption capacity of coarse aggregate. The specific gravity may be expressed as bulk specific gravity or apparent specific gravity.

Theory:

- **Absorption–** the increase in the weight of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as percentage of the dry weight.

- **Specific gravity–** the ratio of the mass (or weight in air) of a unit volume of material of the mass of the same volume of water at stated temperature.

- **Apparent specific gravity–** the ratio of the weight in air of unit volume of the impermeable portion of the aggregate at a stated temperature to the weight in air of an equal volume of gas free distilled water at a stated temperature.
- **Bulk specific gravity (at Saturated-Surface-Dry)** – the ratio of the weight in air of a unit volume of aggregate, including the weight of water with in the voids filled to the extent achieved by submerging in water for approximately 24 hrs. (But not including the voids between particles) at a stated temperature; compared to the weight in air of an equal volume of gas free distilled water at a stated temperature.
- **Bulk specific gravity**– the ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight in air of equal volume of gas free distilled water at a stated temperature. For mix design, this parameter is used.

Apparatus:

- Balance– A weighing device that is sensitive, readable, and with accuracy of 0.1gm.

- Sample container– A wire basket of 3.35mm or finer mesh, or a bucket of approximately equal breadth and height.

- Water tank– A watertight tank in to which the sample container may be placed while suspended underneath the balance.

Procedure:

- The sample is soaked in water for 24hrs.

- The test sample was removed from the water and rolled in a large absorbent cloth until all visible films of water removed. The larger particles were wiped individually. To avoid evaporation of water from aggregate pores during the surface dry operation the sample was covered. The test sample was in the saturated surface dry (SSD) condition and the weight was recorded to the nearest 0.1gm.

- A wire mesh basket, which is hanged from the balance, was immersed in the container and the weight was tarred.

- Then, immediately the SSD test sample was put in the basket and immersed in the container and the weight is recorded at room temperature.
- The test sample was dried to a constant temperature of 110 ±5^{o}C for 24hrs, and cooled until the aggregate is cool enough to handle and weigh.

Calculations and Observations from the sample test:

a) CCA

Trial 1

Bulk.sg (OD) =$\frac{A}{B-C}$=$\frac{1.985}{2.032-1.258kg}$=**2.56**

Bulk.gr (SSD) =$\frac{B}{B-C} = \frac{2.032}{2.032-1.258} = \mathbf{2.63}$

Apparent sp. Gr =$\frac{A}{A-C} = \frac{1.985}{1.985-1.258}$=**2.73**

Absorption =$\frac{2.032-1.985}{1.985}$X100=**2.37%**

Trial 2

Bulk.sg (OD) =$\frac{A}{B-C}$=$\frac{1.996}{2.026-1.246kg}$=**2.56**

Bulk.sg (SSD) =$\frac{B}{B-C} = \frac{2.026}{2.026-1.246} = \mathbf{2.6}$

Apparent sp.gr=$\frac{A}{A-C} = \frac{1.996}{1.996-1.246}$=**2.66**

Absorption $=\frac{B-A}{A}=\frac{2.026-1.996}{1.996}$X100=**1.5%**

Table 11B water absorption capacity and specific gravity test result of CCA

Sample for test 2kg			
Specific gravity CCA	Trial 1	Trial 2	Average
Mass of Oven Dry Sample in Air kg (A)	1.985	1.996	
Mass of Saturated Surface Dry Sample in Air kg(B)	2.032	2.026	
Mass Sample in Water kg(C)	1.258	1.246	
Bulk Specific Gravity (OD)	2.565	2.56	2.563
Bulk Specific Gravity (S.S.D basis)	2.63	2.6	**2.62**
Apparent Specific Gravity	2.73	2.66	2.695
Absorption (%)	2.37	1.5	1.94

b) RGCA

Bulk.sg (OD) $=\frac{A}{B-C}$

Bulk.sg (SSD) $=\frac{B}{B-C}$

Apparent sp.gr$=\frac{A}{A-C}$

Absorption capacity $=\frac{B-A}{A}$

Table 12Bwater absorption capacity and specific gravity test result of RGCA

Sample 2kg			
Specific gravity RGCA	Trial 1	Trial 2	Average
Mass of Oven Dry Sample in Air kg (A)	1.987	1.994	
Mass of Saturated Surface Dry Sample in Air kg(B)	2.014	2.008	
Mass Sample in Water kg(C)	1.26	1.238	

Bulk Specific Gravity (OD)	2.64	2.59	2.62
Bulk Specific Gravity (S.S.D basis)	2.67	2.61	**2.64**
Apparent Specific Gravity	2.73	2.64	2.69
Absorption (%)	1.36	0.7	1.03

C) Combination sp.gr of CCA and RGCA (SSD) calculation

Sp.gr (SSD) $=\frac{1}{\frac{PCCA}{GCCA}+\frac{PRGCA}{RGCA}}$

Where:

PCCA: Blending crushed coarse aggregate in percentage

PRGCA: blending river gravel coarse aggregate in percentage

GCCA: specific gravity of crushed coarse aggregate

GRGCA: specific gravity of river gravel coarse aggregate

A) GCCA= 2.6

B) GRGCA=2.64

A) 90%CCA + 10%RGCA=2.622

B) 80%CCA + 20% RG = 2.624

C) 70%CCA + 30% RG= 2.626

D) 60%CCA + 40%RG =2.628

E) 50%CCA + 50%RG =2.63

Average = 13.13/5= 2.63

D) Combined water absorption of CCA and RGCA

Absorption = PA*absorption CCA + PB*Absorption RGCA

Where: PA= percentage blending CCA

PB=percentage blending RGCA

⇒90%CCA: 10%RG= 0.9*1.94 +0.1*1.03=1.85%

⇒80%CCA: 20%RG=0.8*1.94+0.2*1.03=1.76%

⇒70%CCA: 30%RG=0.7*1.94+0.3*1.03 =1.67%

⇒60%CCA: 40%RG=0.6*1.94+0.4*1.03=1.58%

⇒50%CCA: 50%RG=0.5*1.94+0.5*1.03=1.49%

Average = 1.67

Table 13B combined specific gravity and absorption capacity of CCA and RGCA.

Percentage of blending sand (%)=CCA:RGCA	90%:10%	80%:20%	70%:30%	60%:40%	50%:50%
Blended bulk sp.gr(**SSD**)	2.622	2.624	2.626	2.628	2.63
Average =2.63					
Absorption capacity (%)	1.85	1.76	1.67	1.58	1.49
Average =1.67					

Table 14B aggregate impact value of CCA

Aggregate Impact value					Total AIV
No	Wt .of cylinder(kg) ….a	Wt. of cylinder plus aggregate(kg) …..b	Aggregate weight (kg) (A) b-a	Fraction passing on 2.36mm(kg) (B)	AIV=$\frac{B}{A}*$ 100
1	2.82	3.53	0.71	0.09	
2	2.82	3.56	0.74	0.07	
Average (%)					12.68%

Table 15B aggregate impact value of RGCA

Aggregate Impact value					Total AIV
No	Wt .of cylinder(kg) ….a	Wt. of cylinder plus aggregate(kg) …..b	Aggregate weight (kg) (A) b-a	Fraction passing on 2.36mm(kg) (B)	AIV=$\frac{B}{A}*$ 100
1	2.82	3.5	0.68	0.065	
2	2.82	3.48	0.66	0.07	
Average (%)					9.56%

2. QUALITY TEST OF FINE AGGREGATE

I. Determination gradation of fine aggregate

Objective:

This test method covers the determination of particle size distribution of coarse and all-in aggregates by sieving.

Theory:

According to ASTM C136, the term fine aggregate is used for particles smaller than 4.75 mm.

Apparatus:

- Balance – Digital balance with an accuracy of 0.1gm.
- Sieves – ASTM standard sieve size 9.5mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 μm, 300 μm, 150 μm, 75 μm.

Sampling method:

The samples were prepared with quartering method and riffle box as appropriate.

Procedure:

- The air-dry sample was weighed and sieved successively on the appropriate sieves starting with the largest size sieve. Care was taken to ensure that the sieves were clean before use.
- Sieving was carried out with a nest of sieves on a sieve shaker for a period of at least 10 mins.
- The retained materials on each successive sieve were weighed together with the sieve and recorded.

Observation and Calculation from the test result:

a) Natural Sand before blending

Taken sample size (2kg)

Table 16B: Gradation of natural sand before blending

Sieve size	Wt.Rt(gm)	Wt. %RT	Cum.%Rt	Cum.%pass	Upper and lower limit	Remark
9.5	0	0	0	100	100	Ok
4.75	12.75	2.55	2.55	97.45	95-100	Ok
2.36	37.34	7.46	10.01	89.98	80-100	Ok
1.18	103.5	20.8	30.81	69.28	50-85	Ok
0.6	145.75	29.2	60.01	40	25-60	Ok
0.3	131.25	26.25	86.26	13.88	10-30	Ok
0.15	47.35	9.48	95.74	4.41	2-10	Ok
pan	21.5	4.3	100			
Total			285.4			

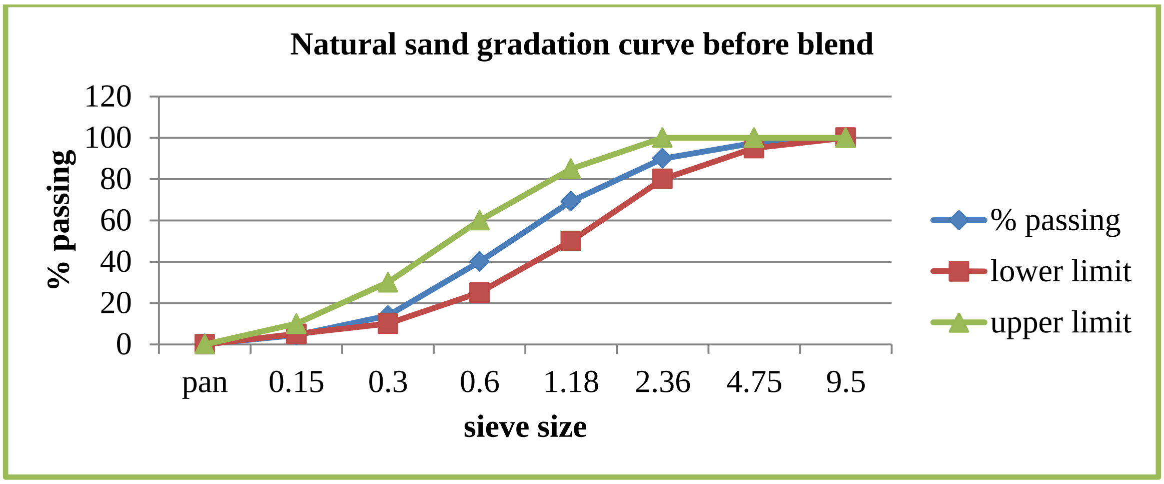

Fig. 8B Gradation curve of NS before blending

b). Manufacture sand before blend

Table 17B Grain Size Analysis of manufacture Fine Aggregate Samples

Sieve size	Wt.Rt	Wt. %RT	Cum.% Rt	Cum.% pass	Upper and lower limit	Remark
9.5	0	0	0	100	100	Ok
4.75	0.005	0.25	0.25	99.75	95-100	Ok
2.36	0.565	28.25	28.5	71.5	80-100	No
1.18	0.468	23.4	51.9	48.1	50-85	No
0.6	0.389	19.45	71.35	28.65	25-60	Ok
0.3	0.167	8.35	79.7	20.3	10-30	Ok
0.15	0.155	7.75	87.45	12.55	2-10	No
pan	0.245	12.25	99.7			
Total		99.65				

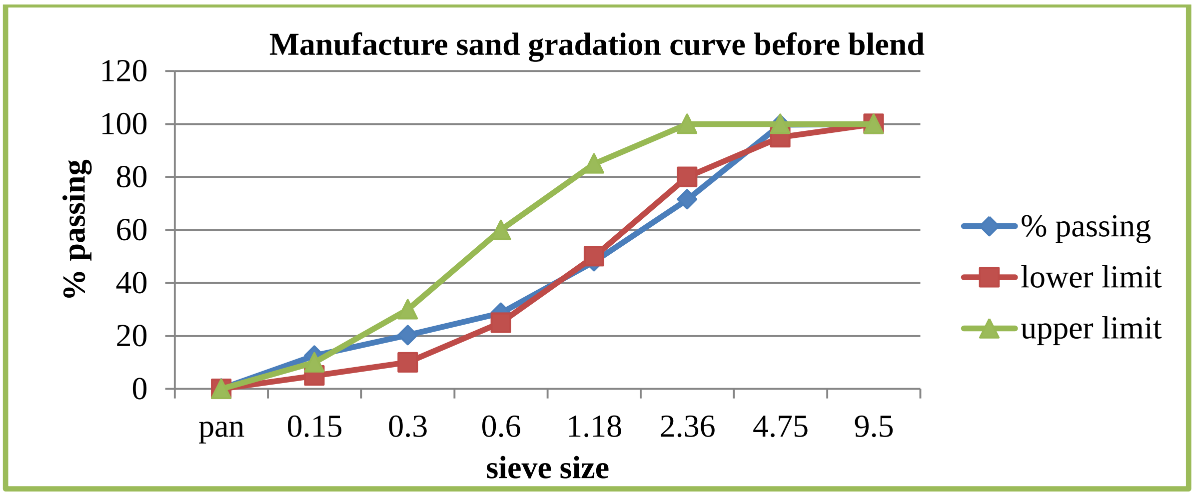

Fig. 9B Gradation curve of MS before blending

C). after blending of MS and NS gradation in different percentage

Using P=Aa+Bb+Cc……formula

Where:
P is the percentage of material passing through a given sieve for the combined aggregates **A,**
B, C.
A, B, and C are the percentages of material passing a given sieve for aggregates A, B, C, respectively. a, b, and c are the proportions of aggregate A, B, and C used in the combination.

9 Blending of 90%NS and 10%MS

Table 18B Combined particle distribution of 90%NS and 10%MS

	Manufacture sand		Natural sand		blend	Specification	Remark
	cum%passing	a = 10%	cu% passing	b =90%		Upper and lower limit	
Sieve size		% batch		% batch			
9.5	100	10	100	90	100	100	Ok
4.75	99.75	9.98	97.45	87.71	97.69	95-100	Ok
2.36	71.5	7.15	89.98	80.98	88.13	80-100	Ok
1.18	48.1	4.81	69.28	62.35	67.16	50-85	Ok
0.6	28.65	2.87	40	36	38.87	25-60	Ok
0.3	20.3	2.03	13.88	12.49	14.52	10-30	Ok
0.15	12.55	1.26	4.12	3.71	4.97	2-10	Ok
Pan							

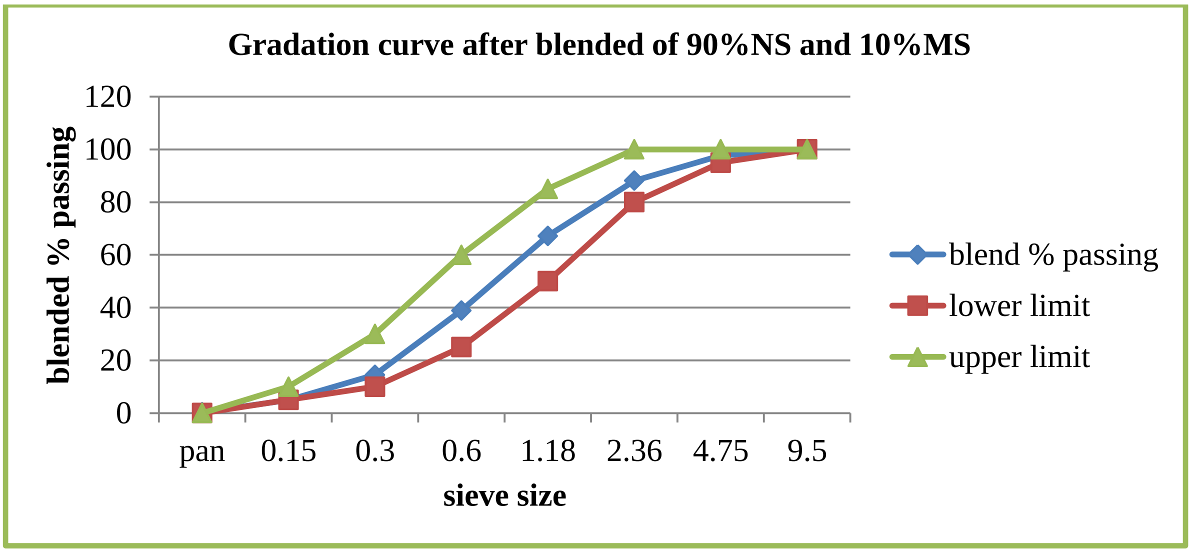

Fig 10B gradation curve after blending of 90%NS and 10%MS

10 Blending of 80%NS and 20%MS

Table 19B Combined particle distribution of 80%NS and 20%MS

	Crushed sand		Natural sand		blend	Specification Upper and lower limit	Remark
	cum%passing	a = 20%	cu%passing	b =80%			
Sieve size		% batch		% batch			
9.5	100	20	100	80	100	100	Ok
4.75	99.75	19.95	97.45	77.96	97.9	95-100	Ok
2.36	71.5	14.3	89.98	71.98	86.28	80-100	Ok
1.18	48.1	9.62	69.28	55.42	65.04	50-85	Ok
0.6	28.65	5.73	40	32	37.73	25-60	Ok
0.3	20.3	4.06	13.88	11.1	15.16	10-30	Ok
0.15	12.55	2.51	4.12	3.30	5.81	2-10	Ok
Pan							

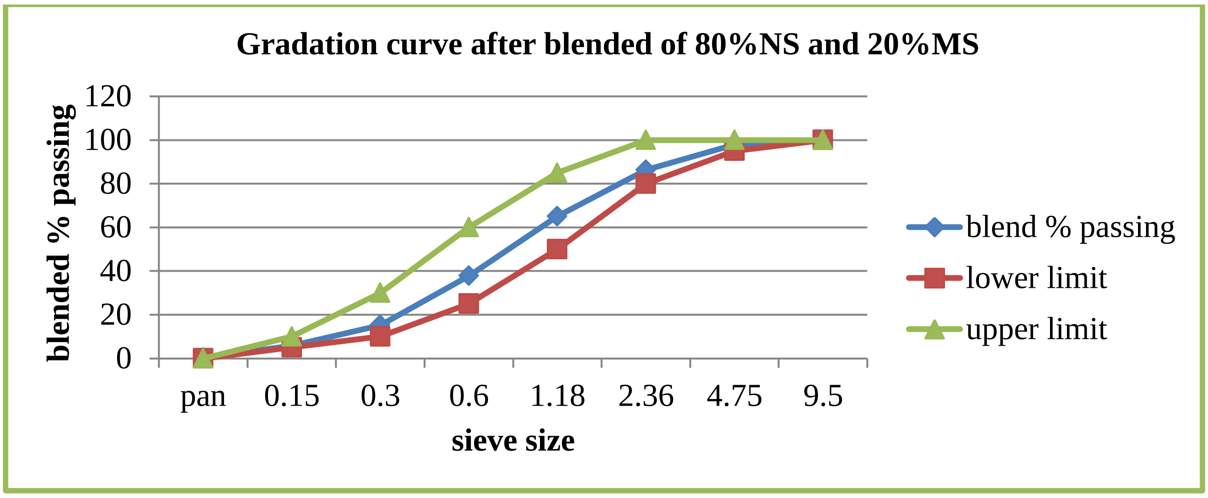

Fig 11B gradation curve after blending of 80%NS and 20%MS

11 Blending of 70%NS and 30%MS

Table 20B Combined particle distribution of 70%NS and 30%MS

	Crushed sand		Natural sand		blend	Specification Upper and lower limit	Remark
	cum%passing	a = 30%	cu%passing	b =70%			
Sieve size		% batch		% batch			
9.5	100	30	100	70	100	100	Ok
4.75	99.75	27.93	97.45	68.22	96.15	95-100	Ok
2.36	71.5	21.45	89.98	62.99	84.44	80-100	Ok
1.18	48.1	14.43	69.28	48.50	62.93	50-85	Ok
0.6	28.65	8.60	40	36	44.6	25-60	Ok
0.3	20.3	6.09	13.88	9.72	15.81	10-30	Ok
0.15	12.55	3.77	4.12	2.88	6.65	2-10	Ok
Pan							

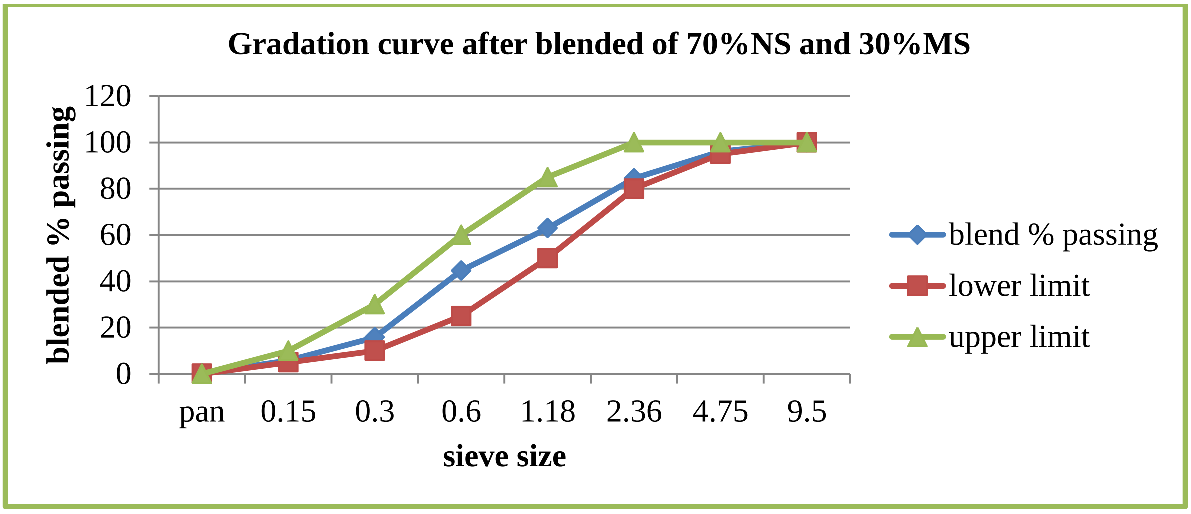

Fig 12Bgradation curve after blending of 70%NS and 30%MS

12 Blending of 60%NS and 40%MS

Table21B Combined particle distribution of 60%NS and 40%MS

	Crushed sand		Natural sand		blend	Specification	Remark
	cum%passing	a = 40%	cu%passing	b =60%		Upper and lower limit(ES)	
Sieve size		% batch		% batch			
9.5	100	40	100	60	100	100	Ok
4.75	99.75	39.9	97.45	58.5	98.37	95-100	Ok
2.36	71.5	28.6	89.98	53.99	82.59	80-100	Ok
1.18	48.1	19.24	69.28	41.57	60.81	50-85	Ok
0.6	28.65	11.46	40	36	47.46	25-60	Ok
0.3	20.3	8.12	13.88	8.33	16.45	10-30	Ok
0.15	12.55	5.02	4.12	2.47	7.49	2-10	Ok
Pan							

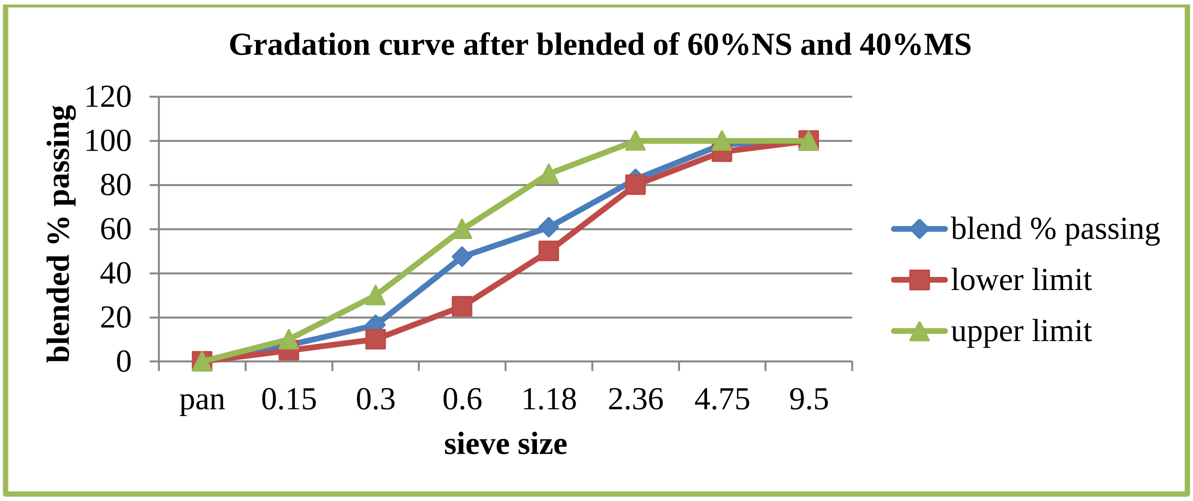

Fig 13Bgradation curve after blending of 60%NS and 40%MS

13 Blending of 50%NS and 50%MS

Table 22B Combined particle distribution of 50%NS and 50%MS

	Crushed sand		Natural sand		blend	Specification Upper and lower limit(ES)	Remark
	cum%passing	a = 50%	cu%passing	b =50%			
Sieve size		% batch		% batch			
9.5	100	50	100	50	100	100	Ok
4.75	99.75	49.88	97.45	48.73	98.61	95-100	Ok
2.36	71.5	35.75	89.98	44.99	80.74	80-100	Ok
1.18	48.1	24.05	69.28	34.64	58.69	50-85	Ok
0.6	28.65	14.33	40	20	34.33	25-60	Ok
0.3	20.3	10.15	13.88	6.94	17.09	10-30	Ok
0.15	12.55	6.28	4.12	2.06	8.34	2-10	Ok
Pan							

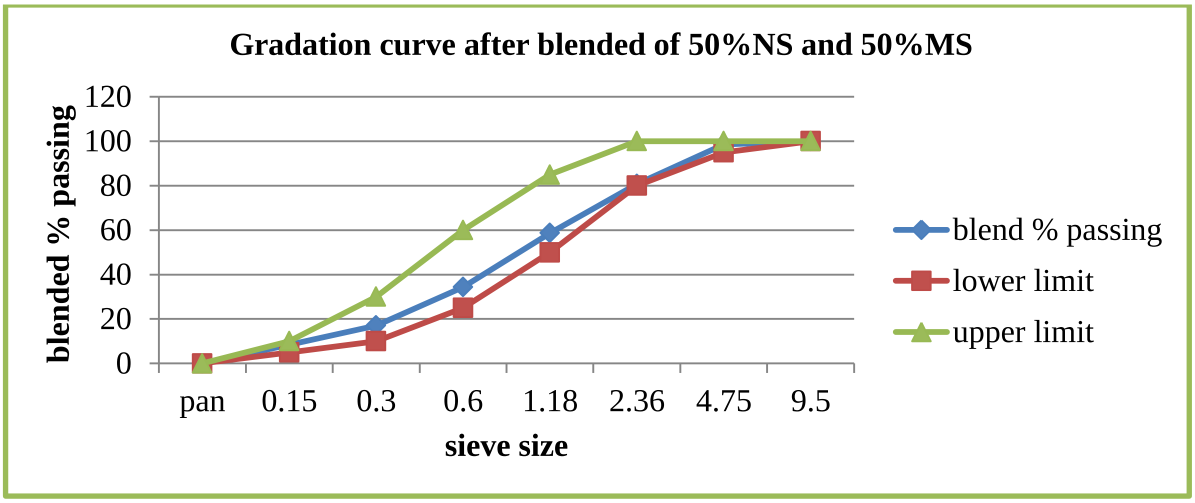

Fig 14Bgradation curve after blending of 50%NS and 50%MS

II. Determination of bulk unit weight of fine aggregate

Theory:

The bulk density or unit weight of a fine aggregate is the mass of the aggregate divided by the volume of particles and the voids between particles. It is measured by weighing a container of known volume filled with aggregate. The mass of the container is subtracted to give the mass of the aggregate, and the bulk density is the aggregate mass divided by the volume of the container. The value will clearly depend on the grading, which will govern how well the particles fit together, and on how well the aggregate is compacted.

The unit weight effectively measures the volume that the graded aggregate will occupy in concrete and includes both the solid aggregate particles and voids between them. Since the weight of the aggregate is dependent on the moisture content of the aggregate, constant moisture content is required.

Apparatus:

- Cylindrical metal container of known volume
- Balance with accuracy of 0.1gm and adequate capacity

Procedure:

First, measure the weight of an empty container having a volume of 0.00498m3. Then, the container is filled in three layers, each layer being tamped with 25 blows with standard tamping rod. Finally, the excess layer is trimmed off and weighed.

a) Natural sand unit weight

Table23B bulk unit weight of natural sand

Compacted unit weight	**Trial 1**	**Trial 2**	**ASTM C33**
Wt. of container (kg)	1.06	1.06	1200kg/m3-1760kg/m3
Wt. of container + wt. sand	9.23	8.22	
Wt. of sand (kg)	**8.17**	**7.16**	
Volume of container (m3)	0.00498	0.00498	
Rodded unit weight (kg/m3)	**1640.6**	**1437.8**	
Average rodded unit weight	**1537.2kg/m3**		

b) Manufacture sand unit weight

Table24B bulk unit weight of manufacture sand

Compacted unit weight	**Trial 1**	**Trial 2**	**ASTM C33**
Wt. of container (kg)	1.06	1.06	1200kg/m3-1760kg/m3
Wt. of container + wt. sand	9.58	9.46	
Wt. of sand (kg)	**8.52**	**8.4**	
Volume of container (m3)	0.00498	0.00498	
Rodded unit weight (kg/m3)	**1710.8**	**1686.75**	
Average rodded unit weight	**1698.8kg/m3**		

C) **Blending unit weight of NS and MS**

Take sample 20kg (10kg NS and 10MS) using riffling and quartering method

Table25B bulk unit weight of blended manufacture and natural sand

Compacted unit weight	**Trial 1**	**Trial 2**	**ASTM C33**
Wt. of container (kg)	1.06	1.06	1200kg/m3-1760kg/m3
Wt. of container + wt. sand	9.62	9.19	
Wt. of sand (kg)	**8.56**	**8.13**	
Volume of container (m3)	0.00498	0.00498	
Rodded unit weight (kg/m3)	**1718.9**	**1632.53**	
Average rodded unit weight	**1675.7kg/m3**		

III. Determination of specific gravity of fine aggregate

Theory:

The specific gravity of a substance is the ratio of the mass (or weight) in air of a unit volume of the material to the mass of the same volume of water at stated temperature. Values are dimensionless.

Bulk specific gravity (at Saturated-surface-dry) – Is the ratio of the weight in air of a unit volume of aggregate, including the weight of water with in the voids filled to the extent achieved by submerging in water for approximately 24 hrs. (But not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of gas free distilled water at a stated temperature.

Apparatus:

- **Balance** –A device for determining mass; that is sensitive, readable, and has an accuracy of 0.1gm.
- **Water tank** – A watertight tank in to which the sample container may be placed while suspended underneath the balance.
- **Pycnometer**– a flask or other suitable container into which the fine aggregate test sample can readily be placed.

Preparation of test sample:

The test sample was obtained by use of sample splitter (riffle box) and quartering method as appropriate. Using a suitable pan the sample was dried in an oven. Then the dried sample was covered with water for about 15 hrs. After cooling the sample approaches to free-flowing condition, it was spread on a flat surface and was exposed to gently moving warm air. Next, the partially dried sample was placed loosely in to the mold and tamped 25 times with tamper. Finally, the mold was lifted vertically. The drying process was repeated until the sample partially flows when the mold is lifted vertically. This indicates that the sample has reached a surface dry condition.

Procedure:

1. 500 g of fine aggregate sample was added in to the pycnometer and filled with water to approximately 90% of its capacity.

2. In order to eliminate all air bubbles the pycnometer was rolled, inverted and agitated. Finally, the level of water was brought to the calibrated capacity of the pycnometer.

3. Then the total weight of the pycnometer, the sample and water was determined and recorded.

4. The fine aggregate was removed from the pycnometer; dried in an oven, cooled at a room temperature for about an hour and then weighed.

Observation and Calculation from the sample result:

a) Natural sand

Sample 500g

Bulk sp.gr= $\frac{A}{B-(D-C)}$

sp.gr (SSD) = $\frac{B}{B-(D-C)}$

Apparent sp.gr= $\frac{A}{A-(D-C)}$

Absorption= $\frac{B-A}{A}$*100

Table 26B Specific Gravity of the Natural Fine Aggregate Samples

Description	Trial 1	Trial 2	Average	ASTM
Mass of Oven Dry ample in Air kg (A)	0.492	0.496		
Mass of Saturated Surface Dry Sample in Air kg (B)	0.5	0.5		

Mass of pycnometer + Water kg (C)	1.465	1.477		
Mass of pycnometer + Water + Sample kg (D)	1.765	1.783		
Absorption (%)	1.63	0.81	**1.22**	
Bulk Specific Gravity (OD)	2.46	2.56	2.51	
Bulk Specific Gravity (S.S.D basis)	2.5	2.58	**2.54**	
Apparent Specific Gravity	2.56	2.61	2.59	

III. Moisture content of natural sand

$$\mathbf{MC\% = \frac{A-B}{B} X100}$$

Table 27B moisture content of natural sand

Moisture content of natural sand	**Test 1**	**Test 2**	Average
A=original sample(kg)	1	1	
B=Oven dry sample(kg)	0.987	0.992	
MC%	1.32	0.8	**1.06**

b) Manufacture specific gravity

Table 28B water absorption and specific gravity of manufacture sand

Description	Trial 1	Trial 2	Average	ASTM
Mass of Oven Dry Sample in Air kg (A)	0.491	0.495		
Mass of Saturated Surface Dry Sample in Air kg (B)	0.5	0.5		
Mass of pycnometer + Water kg (C)	1.68	1.676		
Mass of pycnometer + Water + Sample kg (D)	1.992	1.987		

Absorption (%)	1.8	1	**1.41**	0.2% to 2%,
Bulk Specific Gravity (OD)	2.61	2.62	2.615	2.30 to 2.90
Bulk Specific Gravity (S.S.D basis)	2.66	2.65	**2.655**	2.4 to 2.90
Apparent Specific Gravity	2.74	2.68	2.71	a. to 2.90

IV. Moisture content of Manufacture sand

Table 29B moisture content of manufacture

Moisture content of Manufacture sand	Test 1	Test 2	Average
A=original sample(kg)	1	1	
B=Oven dry sample(kg)	0.989	0.993	
MC%	1.1	0.705	**0.9**

C). Combination sp.gr of NS and MS (SSD) calculation

Sp.gr (SSD) $=\frac{1}{\frac{PNS}{GNS}+\frac{PMS}{GMS}}$

Where:

PNS: Blending natural sand in percentage

PMS: blending manufacture sand in percentage

GNS (SSD): specific gravity of natural sand

GMS (SSD): specific gravity of manufacture sand

GNS = 2.66
GMS =2.54

D) 90%NS + 10%MS=2.65

E) 80%NS+ 20% MS = 2.64

F) 70%NS + 30% MS= 2.624

G) 60%NS + 40%MS =2.612

H) 50%NS + 50%MS =2.6

Average = 13.13/5= 2.63

- **Combined water absorption of NS and MS**

  Absorption = PA*absorption NS + PB*Absorption MS

Where: PA= percentage blending NS

PB=percentage blending MS

⇒90%NS**:** 10%MS = 0.9*1.22 +0.1*1.41 =1.24%

⇒80%NS**:** 20%MS =0.8*1.22+0.2*1.41 =1.26%

⇒70%NS**:** 30%MS =0.7*1.22+0.3*1.41 =1.28%

⇒60%NS**:** 40%MS =0.6*1.22+0.4*1.41 =1.3%

⇒50%NS**:** 50%MS =0.5*1.22+0.5*1.41 =1.32%

Average = 1.28

Table 30B combined specific gravity and absorption capacity of NS and MS.

Percentage of blending sand (%)=NS:MS	90%:10	80%:20%	70%:30%	60%:40%	50%:50%
Blended bulk sp.gr(**SSD**)	2.65	2.64	2.62	2.61	2.6
Average =2.63					
Absorption capacity (%)	1.24	1.26	1.28	1.3	1.32
Average =1.28					

- **Blended moisture content of NS and MS**

Take sample 1kg (0.5kgNS and 0.5kgMS) using rifling and quartering screening method

Table 31B blended moisture content of natural and manufacture sand

Blended Moisture content of NS and MS	**Test 1**	**Test 2**	Average
A=original sample(kg)	1	1	
B=Oven dry sample(kg)	0.994	0.987	
MC%	0.6	1.3	**0.95**

Appendix-C

1. MIX DESIGN TABLE

Table 1C Recommended slumps for various types of construction

Concrete construction	Slump, mm (in.)	
	Maximum*	Minimum
Reinforced foundation walls and footings	75 (3)	25 (1)
Plain footings, caissons, and substructure walls	75 (3)	25 (1)
Beams and reinforced walls	100 (4)	25 (1)
Building columns	**100 (4)**	**25 (1)**
Pavements and slabs	75 (3)	25 (1)
Mass concrete	75 (3)	25 (1)

Sources: ACI 211-1-91 pp-211.1-7 Table 6.3.1

Table 2C Required Average Compressive Strength When Data Are Not Available To Establish a Sample Standard Deviation

Specified compressive strength, f' c, Mpa	Required average compressive strength, f'cr, MPa	Adapted from ACI 318.
Less than 21	f' c + 7.0	**f'cr,= f' c + 8.5**
21 to 35	f' c + 8.5	f'cr, =25+8.5=33.5MPa
Over 35	1.10 f' c + 5.0	

Sources: ACI-318M; Table 5.3.2.2 pp-68

Table 3C Relationship between water cement or water-cementitious materials ratio and compressive strength of concrete

Compressive Strength at 28 days, MPa	Water-cementitious materials ratio by mass
	Non-air-entrained Concrete
45	0.38
40	0.42
35	0.47
30	0.54
25	0.61
20	0.69
15	0.79

Source: ACI 211.1-91; Table A1.5.3.4 (a) PP- 211 .1-22

Table; 4C: approximate mixing water and air content requirements for different slumps and nominal maximum sizes of aggregates (SI)

Water, Kg/m3 of concrete for indicated nominal maximum sizes of aggregate								
Slump, (mm)	Aggregate size(mm)							
	9.5	12.5	19.0	25	37.5	50	75	150
25 to 50	207	199	190	179	166	154	130	113
75 to 100	228	216	205	193	181	169	145	`124
150 to 175	243	228	216	202	190	178	160	
Approximate amount of entrapped air in non-air-entrained concrete, percent	3	2.5	2	1.5	1	0.5	0.3	0.2

Source: ACI 211.1-91; Table; a1.5.3.3 PP- 211 .1-22

Table 5C Volume of coarse aggregate per unit of volume of concrete

Nominal maximum size of aggregate, in.	Volume of oven-dry-rodded coarse aggregate* per unit volume of concrete for different fineness moduli of fine aggregate			
`	2.4	2.6	2.8	3
(3/8 in.)	0.5	0.48	0.46	0.44
(1/2 in.)	0.59	0.57	0.55	0.53
(3/4in.)	0.66	0.64	0.62	0.6
1	0.71	0.69	0.67	0.65
(1 1/2 in.)	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.8	0.78	0.76
6	0.87	0.85	0.83	0.81

Sources: (ACI 211.1-91 Table 6.3.6 pp. - 211.1-12)

V. **Mix Design Calculations Using 100CCA+100%NS**

The data from test results, for mix design are:

- Properties of crushed coarse aggregate from the test results in Appendix A.
- Nominal maximum size =25mm
- Unit weight =1636.5 kg/m3
- Specific gravity =2.62
- Absorption =1.94%
- Moisture content =0.76%
- Properties of fine aggregate from the test results in Appendix A.
- Unit weight =1537.2kg/m3
- Fineness modulus =2.85
- Specific gravity =2.54
- Absorption =1.22%

- Moisture content =1.06%

Step 1: Slump

Range of 25 - 50mm (minimum slump possible) is selected.

Step 2: Maximum size of aggregate

Nominal maximum size is fixed to be 25 mm

Step 3: Target mean strength calculation

When no test data is available, 8.5MPa shall be added to get mean strength.

fmc=25+8.5=33.5MPa

Step 4: W/C ratio

For 27.6 MPa W/C ratio is 0.57 and for 34.5 MPa W/C ratio is 0.48. The W/C ratio for 33.5 MPa can be found by interpolation as follows:

$$\frac{W}{c} = \frac{0.54-0.47}{35-30}(35\text{-}33.5) + 0.47 = 0.491$$

Step 5: Mixing water amount

For nominal maximum size of aggregate of 25 mm, slump 25 to 50mm (minimum range) and non-air entrained concrete the mixing water requirement is; $mixingwater$=179 $kg/m3$ $entrapedair$=1.5 %

Step 6: Cement amount

Cement content = 179/0.491= 365 *kg/m3*

Step 7: Coarse aggregate amount

For nominal maximum size aggregate of 25 mm and sand fineness modulus of 2.85, the dry bulk volume can be interpolated between fineness modulus of 2.85 and 3 as:=0.662

Coarse aggregate amount = 1637 X 0.662 = **1083.7Kg≈1084kg**

Step 8: Fine aggregate amount

Water $\frac{179}{1\times1000}$ = $0.179m^3$

Cement $\frac{365}{3.15\times1000}$ = $0.116m^3$

Air $\frac{1.5}{100}$ = $0.015m^3$

Coarse aggregate $\frac{1084}{2.62\times1000}$ = $\underline{0.414m^3}$

Total volume of ingredients **$0.724m^3$**

Step 8: Fine aggregate amount

The calculated absolute volume of fine aggregate is then 1 – 0.724 = **0.276m3**

The mass of dry fine aggregate is 0.276 x 2.54 x 1000 = **701.7kg**

Table: 7C total concrete Ingredient Proportion mass before moisture adjusted.

Materials	**Proportion mass in (kg)**
Water	179
Cement	365
Fine aggregate/MS	702
Coarse aggregate/RGCA	1084
Total mass	2330

14 **Estimated concrete density (using SSD aggregate**)

- ✓ Ave. Absorption Capacity=1.94 %..................for Coarse Aggregate
- ✓ Ave. Water Absorption Capacity =1.03%.......for Fine Aggregate
- ✓ **Estimated concrete density (using SSD aggregate**)=179 + 365 + (1084 x 1.0194*) + (702x 1.01*) ≈2358.1 **kg/m3**
  - ▪ 1.94/100+1=**1.0194** and 1.03/100+1=**1.01**

Step 9: Moisture correction

Moisture: Corrections are needed to compensate for moisture in and on the aggregates. In practice, aggregates will contain some measurable amount of moisture. The dry-batch weights of aggregates, therefore, have to be increased to compensate for the moisture that is absorbed in and contained on the surface of each particle and between particles. The mixing water added to the batch must be reduced by the amount of free moisture contributed by the aggregates. From the laboratory Tests indicate that for the coarse-aggregate moisture content is 0.76% and fine-aggregate moisture content is 1.06%.

With the aggregate moisture contents (MC) indicated, the trial batch aggregate proportions become:

Coarse aggregate (0.76% MC) = 1084x 1.0076 =**1092.24kg**

Fine aggregate (1.06% MC) = 702 x 1.0106 = **709.44kg**

Water absorbed by the aggregates does not become part of the mixing water and must be excluded from the water adjustment. Surface moisture contributed by the coarse aggregate amounts to 0.76% – 1.94% = -1.18%; that contributed by the fine aggregate is, 1.06%-1.22% **%(MC-Absorption)** = - 0.16%. The estimated requirement for added water becomes

179 – (1084 x (-0.0118)) – (702 x (-0.0016)) = **192.9kg**

The estimated batch weights for one cubic meter of concrete are revised to include aggregate

Moisture as follows:

Table 8C revised proportion of ingredients of concrete

Materials	**Proportion mass in kg**
Water	192.9
Cement	365
Fine aggregate	709.44
Coarse aggregate	1092.24
Total mass	2359.58kg

VI. Mix design using 100%RGCA+100%NS

The data from test results, for mix design are:

- Properties of river gravel coarse aggregate from the test results in Appendix A.
- Nominal maximum size =25mm
- Unit weight =1451.5 kg/m3
- Specific gravity =2.64
- Absorption =1.03%
- Moisture content =1.21%
- Properties of natural fine aggregate from the test results in Appendix A.
- Unit weight =1537.2kg/m3
- Fineness modulus =2.85
- Specific gravity =2.54
- Absorption =1.22%
- Moisture content =1.06%

Step 1: Slump

Range of 25 - 50mm (minimum slump possible) is selected.

Step 2: Maximum size of aggregate

Nominal maximum size is fixed to be 25 mm

Step 3: Target mean strength calculation

When no test data is available, 8.5MPa shall be added to get mean strength.

fmc=25+8.5=33.5MPa

Step 4: W/C ratio

For 27.6 MPa W/C ratio is 0.57 and for 34.5 MPa W/C ratio is 0.48. The W/C ratio for 33.5 MPa can be found by interpolation as follows:

$$\frac{W}{c}= \frac{0.54-0.47}{35-30}(35\text{-}33.5) +0.47=0.491$$

Step 5: Mixing water amount

For nominal maximum size of aggregate of 25 mm, slump 25 to 50mm (minimum range) and non-air entrained concrete the mixing water requirement is; $mixingwater$=179 kg/m3 $entrapedair$=1.5 %

Step 6: Cement amount

Cement content = 179/0.491= 365 *kg/m3*

Step 7: Coarse aggregate amount

For nominal maximum size aggregate of 25 mm and sand fineness modulus of 2.85, the dry bulk volume can be interpolated between fineness modulus of 2.85 and 3 as:=0.662

Coarse aggregate amount= 1451.5X 0.662 = = **960.9Kg≈961kg**

River Coarse aggregate $\frac{961}{2.64\times1000}$ = $\underline{0.364m^3}$

Total volume of ingredients = 0.674m3

Step 8: Fine aggregate amount

The calculated absolute volume of fine aggregate is then 1 – 0.674 = 0.326m3

The mass of dry fine aggregate is 0.326 x 2.54 x 1000 = **828kg**

The mixture then has the following proportions before trial mixing for one cubic meter of concrete:

Table: 9C total concrete Ingredient Proportion mass before moisture adjusted.

Materials	Proportion mass in (kg)
Water	179
Cement	365
Fine aggregate/MS	828
Coarse aggregate/RGCA	961
Total mass	2333.1

15 **Estimated concrete density (using SSD aggregate**)

- ✓ Ave. Absorption Capacity=1.03 %..................for River Coarse Aggregate
- ✓ Ave. Water Absorption Capacity =1.22%.......for Fine Aggregate
- ✓ **Estimated concrete density (using SSD aggregate**)=179 + 365 + (961 x 1.0103*) + (828 x 1.0122*) ≈2353 **kg/m$_3$**
  - 1.03/100+1=**1.0103** and 1.63/100+1=**1.0122**

Step 9: Moisture correction

Coarse aggregate (1.21% MC) = 961x 1.012 =**972.53kg**

Fine aggregate (1.06% MC) = 828 x 1.0106 = **836.78kg**

Water absorbed by the aggregates does not become part of the mixing water and must be excluded from the water adjustment. Surface moisture contributed by the river coarse aggregate amounts to 1.21% – 1.03% = +0.18%; that contributed by the fine aggregate is, 1.06%-1.22 **%(MC-Absorption)** = **-** 0.16%. The estimated requirement for added water becomes

179 – (961 x (0.0018)) – (828x (-0.0016)) = **178.6kg**

The estimated batch weights for one cubic meter of concrete are revised to include aggregate Moisture as follows:

Table 10C revised proportion of ingredients of concrete

Materials	**Proportion mass in kg**
Water	178.6
Cement	365
Fine aggregate	836.78
Coarse aggregate	972.53
Total mass	2352.9kg

Table 11C Quantities of Materials for Lab Trial Batching for control Concrete Mix design.

Types of aggregate		Water (kg)	Cement (kg)	Coarse aggregate (kg)	Fine aggregate (kg)	Total (kg)
CCA	Quantity (per m3)	192.9	365	1092.24	709.44	2359.58
	Quantity (per 9 mold)	5.93	11.22	33.59	21.82	72.56
Ratio		0.53	1	2.994	1.945	≈1:2:3
RGCA	Quantity (m3)	178.6	365	972.53	836.78	2352.9
	Quantity (per 9 mold	5.5	11.22	29.91	25.73	72.36
Ratio		0.49	1	2.67	2.29	≈1:2:3
*=(0.15*0.15*0.15*9) =0.03075m3						

VII. Mix design using the different blended proportion.

The data from test results, for mix design are:

- Properties of the blended coarse aggregate from the test results in Appendix A.
  - Nominal maximum size =25mm
  - Unit weight =1548.5 kg/m3
  - Specific gravity =2.63
  - Absorption =1.67%

- Moisture content =0.95%

- Properties of the blended fine aggregate from the test results in Appendix A.
  - Unit weight =1675.7kg/m3
  - Average fineness modulus =2.85
  - Specific gravity =2.63
  - Absorption =1.28%
  - Moisture content =0.95%

Step 1: Slump

Range of 25 - 50mm (minimum slump possible) is selected.

Step 2: Maximum size of aggregate

Nominal maximum size is fixed to be 25 mm

Step 3: Target mean strength calculation

When no test data is available, 8.5MPa shall be added to get mean strength.

fmc=25+8.5=33.5MPa

Step 4: W/C ratio

For 27.6 MPa W/C ratio is 0.57 and for 34.5 MPa W/C ratio is 0.48. The W/C ratio for 33.5 MPa can be found by interpolation as follows:

$$\frac{W}{c} = \frac{0.54-0.47}{35-30}(35\text{-}33.5) + 0.47 = 0.491$$

Step 5: Mixing water amount

For nominal maximum size of aggregate of 25 mm, slump 25 to 50mm (minimum range) and non-air entrained concrete the mixing water requirement is; $mixingwater$=179 kg/m3 $entrapedair$=1.5 %

Step 6: Cement amount

Cement content = 179/0.491= 365 *kg/m3*

Step 7: Coarse aggregate amount

For nominal maximum size aggregate of 25 mm and sand fineness modulus of 2.85, the dry bulk volume can be interpolated between fineness modulus of 2.85 and 3 as:=0.662

Coarse aggregate amount= 1548.5X 0.662 = = **1025kg**

Step 8: Fine aggregate amount

Water $\frac{179}{1\times1000}$ = $0.179m^3$

Cement $\frac{365}{3.15\times1000}$ = $0.116m^3$

Air $\frac{1.5}{100}$ = $0.015m^3$

Blended Coarse aggregate volume = $\frac{1025}{2.63\times1000}$ = $\underline{0.39m^3}$

Total volume of ingredients $\mathbf{0.7m^3}$

Step 8: Fine aggregate amount

The calculated absolute volume of fine aggregate is then 1 – 0.7 = 0.3m3

The mass of dry fine aggregate is 0.3 x 2.63 x 1000 = **790kg**

The mixture then has the following proportions before trial mixing for one cubic meter of concrete:

Table: 11C total concrete Ingredient Proportion mass before moisture adjusted.

Materials	**Proportion mass in (kg)**
Water	179
Cement	365
Fine aggregate/MS	790
Coarse aggregate/RGCA	1025
Total mass	2359

16 **Estimated concrete density (using SSD aggregate**)

- ✓ Ave. Absorption Capacity=1.67 %...............for blended Coarse Aggregate
- ✓ Ave. Water Absorption Capacity =1.28%.......for blended fine Aggregate
- ✓ **Estimated concrete density (using SSD aggregate**)=179 + 365 + (1025 x 1.0167*) + (790 x 1.0128*) ≈**2386.**kg/m3
  - 1.67/100+1=**1.0167** and 1.28/100+1=**1.0128**

Step 9: Moisture correction

Blended Coarse aggregate (0.95% MC) = 1025x 1.0095 =**1035kg**

Blended fine aggregate (0.95% MC) = 790 x 1.0095 = **798kg**

Water absorbed by the aggregates does not become part of the mixing water and must be excluded from the water adjustment. Surface moisture contributed by the blended coarse aggregate amounts to 0.95% – 1.67% = -0.72%; that contributed by the blended fine aggregate is, 0.95%-1.28 **%(MC-Absorption)** = - 0.33%. The estimated requirement for added water becomes

179 – (1025 x (-0.0072)) – (790x (-0.0033)) = **182.3kg**

The estimated batch weights for one cubic meter of concrete are revised to include aggregate

Moisture as follows:

Table 12C revised proportion of ingredients of concrete

Materials	**Proportion mass in kg**
Water	182.3
Cement	365
Fine aggregate	798
Coarse aggregate	1035
Total mass	2380.3

Table 13C Quantities of Materials for Lab Trial Batching in different % of blended aggregate for Concrete Mix design by weight method.

Total mix Quantity per m3	W(kg)	C(kg)	CA(kg)		FA(kg)		Total
	182.3	365	1035		798		2380.3
Batching 1 in kg							
Blending Percentage	**W**	**C**	**CCA**	**RGCA**	**NS**	**MS**	**Total**
90%NS+10%MS & 90%CCA+10%RG	182.3	365	931.5	103.5	718.2	79.8	2360
Batching 2 in kg							
80%NS+20%MS & 80%CCA+20%RGCA	182.3	365	828	207	638.4	159.6	2380.3
Batching 3 in kg							
70%NS+30%MS & 70%CCA+30%RGCA	182.3	365	724.5	310.5	558.6	239.4	2380.3
Batching 4 in kg							
60%NS+40%MS & 60%CCA+40%RGCA	182.3	365	621	414	478.8	319.2	2380.3
Batching 5							
50%NS+50%MS & 50%CCA+50%RGCA	182.3	365	517.5	517.5	399	399	2380.3

Appendix D

1. Compressive Strength Test Results

Table: 1D Control mix design compressive strength at 7th day curing result using 100%CCA+100%NS

(%) of CCA+NS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	8.17	0.0034	547.7	24.34
	2	15	15	15	8.29	0.0034	564.4	25.08
	3	15	15	15	8.03	0.0034	531.66	23.63
	Mean						**547.92**	**24.35**

Table: 2D Control mix design compressive strength at 14th day curing result using 100%CCA+100%NS

(%) of CCA+NS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	8.79	0.0034	648.5	28.82
	2	15	15	15	8.25	0.0034	653.4	29.04
	3	15	15	15	8.67	0.0034	607.7	27.01
	Mean						**636.53**	**28.29**

Table: 3D Control mix design compressive strength at 28th day curing result using 100%CCA+100%NS.

(%) of CCA+NS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	8.49	0.0034	739.4	32.86
	2	15	15	15	8.32	0.0034	711.15	31.61
	3	15	15	15	8.37	0.0034	703.63	31.27
	Mean						**718.06**	**31.91**

Table: 4D Control mix design compressive strength at 7th day curing result using 100%RGCA+100%NS

(%) of RG+NS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	7.23	0.0034	357.8	15.9
	2	15	15	15	6.7	0.0034	466.6	20.74
	3	15	15	15	6.83	0.0034	385.8	17.15
	Mean							**17.93**

Table: 5D Control mix design compressive strength at 14th day curing result using 100%RGCA+100%NS

(%) of RG+NS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	7.21	0.0034	467.8	20.79
	2	15	15	15	7.665	0.0034	432.3	19.21
	3	15	15	15	7.19	0.0034	512.9	22.8
	Mean							**20.93**

Table: 6D Control mix design compressive strength at 28th day curing result using 100%RGCA+100%NS

(%) of RG+NS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	7.975	0.0034	584.27	25.97
	2	15	15	15	8.05	0.0034	596.4	26.5
	3	15	15	15	8.23	0.0034	554.9	24.66
	Mean							**25.71**

Table: 7D Control mix design compressive strength at 7th day curing result using 100%CCA+100%MS

(%) of CCA+MS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	8.11	0.0034	471	20.94
	2	15	15	15	7.69	0.0034	386.1	17.16
	3	15	15	15	7.43	0.0034	398.17	18.1
	Mean							**18.73**

Table: 8D Control mix design compressive strength at 14th day curing result using 100%CCA+100%MS

(%) of CCA+MS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	8.31	0.0034	569.9	25.33
	2	15	15	15	7.23	0.0034	580.5	25.8
	3	15	15	15	8.18	0.0034	578.2	25.7
	Mean							**25.61**

Table: 9D Control mix design compressive strength at 28th day curing result using 100%CCA+100%MS.

(%) of CCA+MS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
100%+100%	1	15	15	15	7.17	0.0034	574.2	25.52
	2	15	15	15	8.61	0.0034	681.4	30.28
	3	15	15	15	7.53	0.0034	562.31	24.99
	Mean						**605.97**	**26.93**

Table 10D: Compressive strength at **7th** days test results

(%) of RG+MS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
10%+10%	1	15	15	15	7.67	0.0034	526.6	23.41
	2	15	15	15	7.015	0.0034	548.6	24.38
	3	15	15	15	7.31	0.0034	532.8	23.68
	Mean						**536**	**23.82**
20%+20%	1	15	15	15	7.8	0.0034	552.9	24.57
	2	15	15	15	7.46	0.0034	614.88	27.23
	3	15	15	15	7.523	0.0034	593.5	26.38
	Mean						**587.09**	**26.06**
30%+30%	1	15	15	15	7.52	0.0034	616.4	27.39
	2	15	15	15	8.26	0.0034	586.3	26.06
	3				7.76	0.0034	572.4	25.44
	Mean						**591.7**	**26.297**
40%+40%	1	15	15	15	8.23	0.0034	672.0	29.87
	2	15	15	15	8.10	0.0034	576.3	25.61
	3	15	15	15	7.29	0.0034	557.4	24.77
	Mean						**601.9**	**26.75**
50%+50%	1	15	15	15	8.285	0.0034	493.8	21.95
	2	15	15	15	8.31	0.0034	509.8	22.66
	3	15	15	15	7.06	0.0034	516.3	22.95
	Mean						**506.63**	**22.52**

Table 11D Compressive strength at **14**thdays test results

(%) of RG+MS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cub (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
10%+10%	1	15	15	15	8.28	0.0034	655.3	29.13
	2	15	15	15	8.40	0.0034	605.1	26.86
	3	15	15	15	8.16	0.0034	623.2	27.698
	Mean						**627.9**	**27.9**
20%+20%	1	15	15	15	7.381	0.0034	639.1	28.4
	2	15	15	15	7.965	0.0034	714.4	31.75
	3	15	15	15	7.45	0.0034	628.67	27.94
	Mean						**660.72**	**29.36**
30%+30%	1	15	15	15	6.74	0.0034	669.8	29.77
	2	15	15	15	7.34	0.0034	656.2	29.16
	3				8.24	0.0034	675.9	30.04
	Mean						**667.3**	**29.67**
40%+40%	1	15	15	15	8.36	0.0034	644.3	28.64
	2	15	15	15	8.28	0.0034	618.3	27.48
	3	15	15	15	7.88	0.0034	584.85	25.99
	Mean						**615.82**	**27.37**
50%+50%	1	15	15	15	6.73	0.0034	577.6	25.67
	2	15	15	15	6.77	0.0034	544.4	24.2
	3	15	15	15	7.13	0.0034	572.4	25.44
	Mean						**564.8**	**25.1**

Table 12D Compressive strength at 28th days test results

(%) of RG+MS	No of Samples	Dimensions of cubical mold (cm)			Sample Weight (kg)	Volume of cube (m3)	Failure Load (KN)	Compressive Strength(MPa)
		L	W	H				
10%+10%	1	15	15	15	8.72	0.0034	797.3	35.44
	2	15	15	15	8.36	0.0034	677.2	30.1
	3	15	15	15	8.41	0.0034	689.3	30.64
	Mean						**721.27**	**32.06**
20%+20%	1	15	15	15	8.18	0.0034	731.1	32.49
	2	15	15	15	8.16	0.0034	737.5	32.78
	3	15	15	15	8.23	0.0034	762.2	33.88
	Mean						**743.6**	**33.05**
30%+30%	1	15	15	15	8.16	0.0034	844.5	37.53
	2	15	15	15	8.28	0.0034	713.79	31.72
	3	15	15	15	8.45	0.0034	733.4	32.6
	Mean						**763.9**	**33.95**
40%+40%	1	15	15	15	8.28	0.0034	750.75	33.37
	2	15	15	15	8.09	0.0034	750.28	33.35
	3	15	15	15	7.98	0.0034	716.22	31.83
	Mean						**739.08**	**32.85**
50%+50%	1	15	15	15	7.13	0.0034	749.91	33.33
	2	15	15	15	8.045	0.0034	694.77	30.88
	3	15	15	15	7.67	0.0034	632.15	28.1
	Mean						**692.28**	**30.77**

2. Flexural strength result

- The calculation of the flexural stress at failure is as follows:

C =D/2 cm; M=PL/3 N.m; I=bd3/12 m4;

Flexural stress (σ) =Mc/I M……………. [60].

Where:

P = Failure Load σ = Bending Strength

M = Maximum Moment L = Span of Specimen

I = Moment of Inertia D = Depth of specimen

C = Centroidal depth

Table 13D control flexural strength at7th day

% NS:CCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	1.68	280	8.3333E-06	5.00	1.68
	2	50	10	10	1.44	240	8.3333E-06	5.00	1.44
	3	50	10	10	1.8	300	8.3333E-06	5.00	1.8
	Mean				**1.64**	**273.33**			**1.64**

Table 14D control flexural strength at 14th day

%NS :CCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	2.1	350	8.3333E-06	5.00	2.1
	2	50	10	10	2.32	386.7	8.3333E-06	5.00	2.32
	3	50	10	10	2.4	400	8.3333E-06	5.00	2.4
	Mean				**2.27**	**378.9**			**2.27**

Table 15D control flexural strength at 28th day

% NS :CCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	3.33	555	8.3333E-06	5.00	3.33
	2	50	10	10	3.1	516.7	8.3333E-06	5.00	3.1
	3	50	10	10	2.95	491.7	8.3333E-06	5.00	2.95
	Mean				**3.13**	**521.13**			**3.13**

Table 16D flexural strength at7th day using 100%NS+100%RGCA

%NS: RGCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	1.37	228.33	8.3333E-06	5.00	1.37
	2	50	10	10	1.51	251.7	8.3333E-06	5.00	1.51
	3	50	10	10	1.22	203.33	8.3333E-06	5.00	1.22
	Mean				**1.37**	**227.8**			**1.37**

Table 17D flexural strength at14th day using 100%NS+100%RGCA

%NS: RGCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	$I[m^4]$	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	1.84	306.7	8.3333E-06	5.00	1.84
	2	50	10	10	2.12	353.33	8.3333E-06	5.00	2.12
	3	50	10	10	1.79	298.33	8.3333E-06	5.00	1.79
	Mean				**1.9**	**319.45**			**1.9**

Table 17D flexural strength at28th day using 100%NS+100%RGCA

%NS: RGCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	$I[m^4]$	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	2.99	498.33	8.3333E-06	5.00	2.99
	2	50	10	10	2.67	445	8.3333E-06	5.00	2.67
	3	50	10	10	2.73	455	8.3333E-06	5.00	2.73
	Mean				**2.8**	**466.11**			**2.8**

Table 18D flexural strength at7th day using 100%MS+100%CCA

%MS: CCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	$I[m^4]$	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	1.67	278.33	8.3333E-06	5.00	1.67
	2	50	10	10	1.33	221.7	8.3333E-06	5.00	1.33
	3	50	10	10	1.59	265	8.3333E-06	5.00	1.59
	Mean				**1.53**	**255.01**			**1.53**

Table 19D flexural strength at14th day using 100%MS+100%CCA

% MS: CCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	$I[m^4]$	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	2.44	406.7	8.3333E-06	5.00	2.44
	2	50	10	10	2.23	371.7	8.3333E-06	5.00	2.23
	3	50	10	10	1.98	330	8.3333E-06	5.00	1.98
	Mean				**2.22**	**369.47**			**2.22**

Table 20D flexural strength at28th day using 100%MS+100%CCA

% MS: CCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	Stress [Mpa]
		L	B	D					
100%	1	50	10	10	2.82	470	8.3333E-06	5.00	2.82
	2	50	10	10	2.89	481.7	8.3333E-06	5.00	2.89
	3	50	10	10	3.11	518.33	8.3333E-06	5.00	3.11
	Mean				**2.94**	**490.01**			**2.94**

Table Flexural strength at 7th day of curing test results

%MS: RGCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	Stress [Mpa]
		L	B	D					
10%	1	50	10	10	1.97	328.33	8.3333E-06	5.00	1.97
	2	50	10	10	2.18	363.33	8.3333E-06	5.00	2.18
	3	50	10	10	2.41	401.7	8.3333E-06	5.00	2.41
	Mean				**2.19**	**364.45**			**2.19**
20%	1	50	10	10	2.32	386.7	8.3333E-06	5.00	2.32
	2	50	10	10	2.57	428.33	8.3333E-06	5.00	2.57
	3	50	10	10	2.14	356.7	8.3333E-06	5.00	2.14
	Mean				**2.34**	**390.58**			**2.34**
30%	1	50	10	10	2.69	448.33	8.3333E-06	5.00	2.69
	2	50	10	10	2.46	410	8.3333E-06	5.00	2.46
	3	50	10	10	2.29	381.7	8.3333E-06	5.00	2.29
	Mean				**2.48**	**413.34**			**2.48**
40%	1	50	10	10	1.97	328.33	8.3333E-06	5.00	1.97
	2	50	10	10	1.78	296.7	8.3333E-06	5.00	1.78
	3	50	10	10	2.33	388.33	8.3333E-06	5.00	2.33
	Mean				**2.03**	**337.79**			**2.03**
50%	1	50	10	10	1.43	**238.33**	8.3333E-06	5.00	1.43
	2	50	10	10	1.17	**195**	8.3333E-06	5.00	1.17
	3	50	10	10	1.35	**225**	8.3333E-06	5.00	1.35
	Mean				**1.32**	**219.44**			**1.32**

Table Flexural strength at 14^{th} day of curing test results

%MS: RGCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	**Stress [Mpa]**
		L	B	D					
10%		50	10	10	2.64	440	8.3333E-06	5.00	2.64
		50	10	10	2.59	431.7	8.3333E-06	5.00	2.59
		50	10	10	2.87	478.33	8.3333E-06	5.00	2.87
	Mean				**2.7**	**450.01**			**2.7**
20%		50	10	10	2.77	461.7	8.3333E-06	5.00	2.77
		50	10	10	2.62	436.7	8.3333E-06	5.00	2.62
		50	10	10	2.98	496.7	8.3333E-06	5.00	2.98
	Mean				**2.79**	**465.03**			**2.79**
30%		50	10	10	2.83	471.7	8.3333E-06	5.00	2.83
		50	10	10	2.97	495	8.3333E-06	5.00	2.97
		50	10	10	2.76	460	8.3333E-06	5.00	2.76
	Mean				**2.85**	**475.5**			**2.85**
40%		50	10	10	2.08	346.7	8.3333E-06	500	2.08
		50	10	10	2.37	395	8.3333E-06	5.00	2.37
		50	10	10	2.46	410	8.3333E-06	5.00	2.46
	Mean				**2.3**	**383.9**		5.00	**2.3**
50%	1	50	10	10	2.27	378.33	8.3333E-06	500	2.27
	2	50	10	10	2.43	405	8.3333E-06	5.00	2.43
	3	50	10	10	1.94	323.33	8.3333E-06	5.00	1.94
	Mean				**2.21**	**368.89**			**2.21**

Table Flexural strength at 28^{th} day of curing test results

%MS: RGCA	Sample no	Dimension[cm]			P[kN]	M[N.m]	I[m^4]	C[cm]	**Stress [Mpa]**
		L	B	D					
10%		50	10	10	2.89	481.7	8.3333E-06	5.00	2.89
		50	10	10	3.04	506.7	8.3333E-06	5.00	3.04
		50	10	10	3.48	580	8.3333E-06	5.00	3.48
	Mean				**3.14**	**522.8**			**3.14**
20%		50	10	10	3.06	510	8.3333E-06	5.00	3.06
		50	10	10	3.12	520	8.3333E-06	5.00	3.12
		50	10	10	3.39	565	8.3333E-06	5.00	3.39
	Mean				**3.19**	**531.7**			**3.19**
30%		50	10	10	3.16	526.7	8.3333E-06	5.00	3.16
		50	10	10	3.35	558.33	8.3333E-06	5.00	3.35
		50	10	10	3.71	618.33	8.3333E-06	5.00	3.71
	Mean				**3.41**	**567.79**			**3.41**
40%		50	10	10	3.21	535	8.3333E-06	500	3.21
		50	10	10	2.96	493.33	8.3333E-06	5.00	2.96
		50	10	10	3.02	503.33	8.3333E-06	5.00	3.02
	Mean				**3.06**	**510.55**		5.00	**3.06**
50%	1	50	10	10	2.92	486.7	8.3333E-06	5.00	2.92
	2	50	10	10	2.79	465	8.3333E-06	5.00	2.79
	3	50	10	10	3.09	515	8.3333E-06	5.00	3.09
	Mean				**2.93**	**488.9**			**2.93**

APPENDIX E

❖ Gallery photo during laboratory work

- Crushed aggregate field sample

Figure 1: Crushed coarse and fine aggregate field sample from varnero aggregate crusher site

Fig 2 Washing river gravel aggregate

Fig 2 Collect River gravel coarse aggregate field sample from Gibe river bed

Figure 4: splitter or reducing aggregate field sample to test size of river gravel and crushed coarse aggregate

Figure 5: Sieve Analysis; Gradation coarse aggregate

Figure 6: Specific Gravity (SSD) and Water Absorption test for river and crushed coarse aggregate

Figure 7: Dry-Rodded Unit Weight test of fine and coarse aggregate

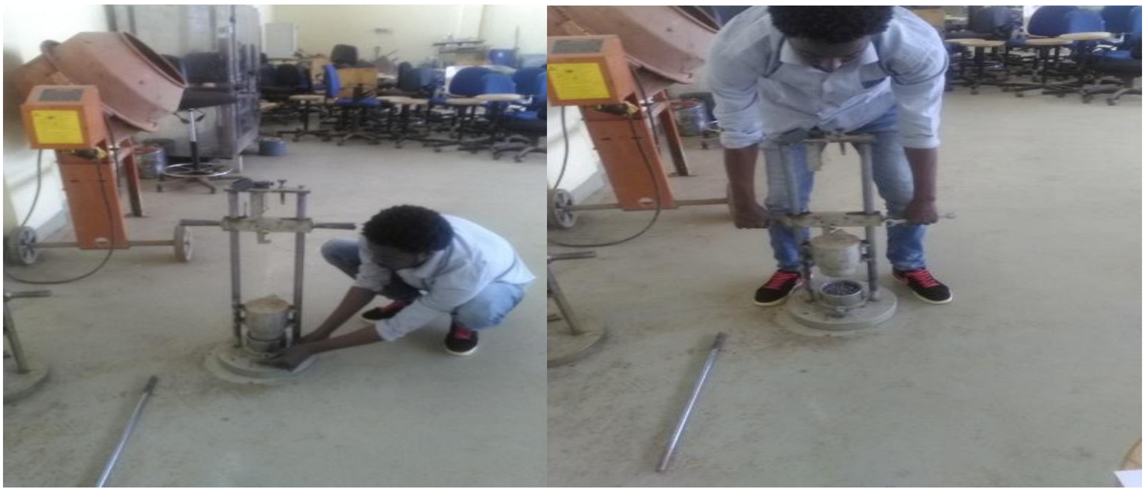

Figure 9: Aggregate Impact Value test for natural gravel and crushed coarse aggregate

Fig 12 silt content test of sand

Fig 13 specific gravity test for manufactured and natural sand

Fig 13 blended material in different percentage

Fig 14 casting cubes and slump test

Fig 15 curing of cubes and beams at different age

Fig 16 compressive and flexural strength test