JIMMA UNIVERSITY

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JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT

COMPARISON ON ENGINEERING PROPERTIES OF COARSE AND FINE AGGREGATE USED IN JIMMA TOWN CONSTRUCTION PROJECTS WITH DIFFERENT STANDARDS

A Thesis submitted to the School of Graduate Studies, Jimma University Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of Master of Science in Construction Engineering and Management

BY:-MULUGETA H/MARIAM

February,2020

JIMMA, ETHIOPIA

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Main Advisor: - Prof.Dr-Ing Esayas Alemayehu

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Internal Examiner	Signature	Date
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Chair	Signature	Date

DECLARATION

"I declare that this research report entitled "comparison on engineering properties of coarse and fine aggregate used in jimma town construction projects with different standards" is original work of my own, has not been presented for a degree of any other university and that all sources of material used for the thesis have been duly acknowledged."

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Date: February,2020

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Signature Date

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ACRONYMS AND ABBRIVATION

ACI-	American Concrete Institute
ASTM-	American Society for Testing and Materials
AASHTO-	American Association State Highways and Transportation Officials
BS-	British Standard
ES-	Ethiopian Standard
ERA-	Ethiopian Road Authority
gm-	Gram
hr-	Hour
in-	Inch
JIT-	Jimma Institute of Technology
KN-	Kilo newton
Kg-	Kilogram
MPa-	Mega Pascal
m^3 -	Meter cube
m^2 -	Meter square
min-	Minute
mm-	Millimeter
max –	Maximum
№-	Number
OPC-	Ordinary Portland Cement
SSD-	Saturated Surface Dry
S.G-	Specific Gravity

Ton-	Tone
W/C-	Water cement ratio
ºC-	Degree Centigrade
ºF-	Degree Faranite
µm-	Micro meter

Abstract

One of the building construction materials widely used in construction project is concrete. Concrete being one of the important constituents of the construction project and construction material produced from three main ingredients namely cement, aggregates and water. In order to get quality standard concrete product, which satisfies the strength, workability and durability requirement, great care has to be given for concrete work starting from the ingredients selection. The ingredient selected has to fulfill the requirement stated on standards. The constituents of concrete, which majority of them occur naturally, are subjected to a wide range of variability. Concrete being one of the important constituents of many of the construction projects, in addition to its subjectivity to variability, requires checking the fulfillment of standards.

Therefore, with this respect the research was carried out the comparison on concrete materials used in Jimma town construction projects with different standards. The objective of the research was to comparison the engineering properties of coarse and fine aggregate used in jimma town construction projects with different standards in general, to identify sources,to determine, to compare the results of the engineering properties of coarse and fine aggregates and to give recommendation in line with the outcome of the results of the research.

The study area of the research was Jimma town and the population was coarse aggregate and fine aggregate and the research has been conducted through laboratory investigation, interview and field observation which is found in Jimma town of construction projects. To conduct the laboratory investigation the sampling techniques used was porpusive sampling techniques and also both primary and secondary data collection method were used.

From the interview and observation made in construction sites, the sources of materials that the projects used are from various sources like Gambela, Worabe, Chewaka for sand and Agaro-suse, Dedo-Ofole, Agaro- Mohamed & miftah for coarse aggregates. To determine the engineering properties of the concrete making materials used in Jimma town construction projects. as obtained from laboratory investigations all sampled sand passes the gradation standard also except Dedo-Ofole all sampled aggregate passes gradation and except Gambela sand all fulfill the requirement for fineness modulus, also for unit weight and the rest results tabulated in chapter four. Therefore, as the result obtained from laboratory investigations conducted on engineering properties of concrete making material, the researcher conclude that the concrete making material used in Jimma town construction projects are not uniformly fulfill the requirement for ES, ASTM and BS standard. Based on the above conclusion; all responsible body recommended to maintain material quality standard.

Keywords: concrete, fine aggregate, coarse aggregate, cement, water

CHAPTER ONE

INTRODUCTION

1.1 Background

Recently in the construction industry, concrete is one of the major ingredients in building construction and it has three main ingredients these are; cement, aggregate and water. Sometimes in addition to that, they used admixtures to improve its workability and setting time. These components of concrete should satisfy the quality requirements sets in standards (McGraw, 1999).

Concrete has been the construction material used in the largest quantity for several decades. The reason for its popularity can be found in the excellent technical properties of concrete ingredients has a major influence on the fresh as well as hardened concrete. Therefore, the selection of concrete making materials for a given purpose is quite important (Popovics, 2001).

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and affect economy. Earlier aggregates were considered as chemically inert materials but now it has been recognized that some of the aggregates are chemically active and also that certain aggregates exhibit chemical bond at the interface of aggregate and paste. The mere fact that the aggregates occupy 70-80 percent of the volume of concrete, their impact on various characteristics and properties of concrete is undoubtedly considerable. To know more about the concrete it is very essential that one should know more about the aggregates which constitute major volume in concrete. Without the study of the aggregate in depth and range, the study of the concrete is incomplete. Cement is the only factory made standard component in concrete. Other ingredients, namely, water and aggregates are natural materials and can vary to any extent in many of their properties. The depth and range of studies that are required to be made in respect of aggregates to understand their widely varying effects and influence on the properties of concrete cannot be underrated. Concrete can be considered as two phase materials for convenience; paste phase and aggregate phase (Shetty M. , 2005).

In our country, there are a lot of contractors and some of them have good experiences in the selection of standard concrete making materials for their work, but most of them are not worry for the standards than focuses on how they can be more economical in order to be more profitable.

Aggregate is relatively inexpensive and does not en-ter into complex chemical reactions with water; it has been customary, therefore, to treat it as an inert filler in concrete. However, due to increasing awareness of the role played by aggregates in determining many important properties of concrete, the traditional view of the aggre-gate as an inert filler is being seriously questioned.

Aggregate characteristics that are significant to con-crete technology include porosity, grading or size distri-bution, moisture absorption, shape and surface texture,crushing strength, elastic modulus, and the type of delete-rious substances present (Monteiro, October 20, 2001).

The standard of aggregates are very important to concrete, because a standard aggregates will maximize the durability of concrete structure,minimize failurity,to avoide un necessary over cost and to be economical. For practical purpose it is adequate to follow standard limits specified by various organizations (like ES, BS Standards and ASTM), which are not only broad and therefore economically feasible, but are also based on practical experience.

Construction projects that are already built and those on going here in Jimma town use different concrete ingredients, sand and gravel. Standard implementation of the concrete making materials is a key aspect for the building construction projects materials.

It‘s found out from the test result the fine aggregates have silt more than the standard limit content the Chewaka and Worabe sands. For fine aggregate the gradation result shown that there is coarser than the finer parts of sand. In addition, since the supply aggregates vary widely from one to the other the contractors are always in problem to keep the standard limitation of concrete making materials.
The gradation on coarse aggregate shows that on quarry sites, unfortunatilly it‘s shows that under standard limits;And the reaming coarse aggregate tests not uniformly fulfill, but satisfy the requirements of the standard except the apparent specific gravity of coarse aggregate. However the coarse and fine aggregates are fulfill the quality test for making concrete,but it need washing and blending .

1.2. Statement of the Problem

In order to select concrete making material intelligently, the selecting person should be able to assess concrete making materials, and should know what to select, how to select it and why to select it in a particular way. In other words should be familiar with the available types of each of the concrete-making materials; the significance application of this type in practice; its concrete making qualities and the effect of certain factors on them; recommended sampling and handling procedures; the underlying principles of the more important test methods; and the principal points of the pertinent specifications along with the usual values of the technically important properties (Popovics, 2001).

Concrete work is important in all infrastructures to improve buildings useful life and strength of the structure. In our country, concrete is widely used for building; however there is a big questions with the standardization for sources of concrete making materials like course and fine aggregates. In case of Jimma town construction projects different sources of coarse and fine aggregets are observed but rather making laboratory investigations no one can’t talk about the fulfilled standards for these sources of material. To better understanding for the selection of concrete making material, needs to be familiar with different codes of standards regarding to concrete ingredients.

Therefore, this study conducted on the comparison of sources of coarse and fine aggregates observed in jimma town construction projects with different standards.

1.3 Objectives of the Study

1.3.1. General objective

To compare the Engineering properties of Coarse and Fine aggregate used in Jimma town construction projects with different standards.

1.3.2. Specific Objectives

i. To identify sources of Coarse and Fine aggregate used in Jimma town construction projects.
ii. To determine the engineering properties of the Coarse and Fine aggregate.
iii. To compare the results of the engineering properties of the Coarse and Fine aggregate used in Jimma town construction projects with different standards.

1.4 Research Question

i. where are the sources of Coarse and Fine aggregate used in Jimma town construction projects?

ii. What are the engineering properties of the Coarse and Fine aggregate used in Jimma town construction projects?

iii. Does engineering properties of the Coarse and Fine aggregate used in Jimma town construction projects fulfilled the requirements of different standards?

1.5 Significance of the Study

This study is significant for Jimma town generally in order to provide helpful information to clients, contractors, consultants and material suppliers and specifically it may help to the peoples engaged in the construction industry how they can manufacture, supply, purchase and select standard concrete ingredients. In addition, this study intends to provide the requirement of series supervision and consultancies on the concrete ingredients. Jimma town construction and design office could be benefited from the study as a source of information and foundation for the building construction follow up information. Owners, contractors and consultants will benefit from the study as a source of information. Other researchers will use the findings as a reference for further research on the areas of concrete making materials standards.

1.6 Scope and Limitation of the Study

The scope of the research was limited on the building construction projects in Jimma town concerning mainly on the comparison on engineering properties of Coarse and Fine aggregate used in Jimma town construction projects with different standards. The methods were used by field observation and by conducting laboratory investigation to make the result of the assessment. The main limitation of the research was the availability of some test equipment and chemicals of the ingredients. In this research cement test is not conducted because it is already standardized on Ethiopian standard 1177-1CEM1/42.5R.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Definition of Concrete and Concrete making materials properties.

2.1.1 Concrete

Concrete is made by mixing: cement, water, coarse and fine aggregates and admixtures (if required). The aim is to mix this material in measured amounts to make concrete that is easy to: transport, place, compact and finish. This will set, and harden, to give a strong and durable product. The relative amount of each material (i.e. Cement, water and aggregates) affects the properties of concrete (AUSTRALIA, 2010).

Concrete has been the construction material used in the largest quantity for several decades. The reason for its popularity can be found in the excellent technical properties of concrete as well as in the economy of this material. It is also characteristic that the properties of concrete ingredients have a major influence on the fresh as well as hardened concrete. Therefore, the selection of concrete -making materials for a given purpose is quite important (Popovics, 2001).

In order to make this selection intelligently, the selecting person should be able to assess Concrete-making materials, and should know what to select, how to select it, and why to select it in a particular way. In other words, he or she should be familiar with the available types of each of the concrete-making materials; the significance and application of this type in practice; its concrete-making qualities and the effect of certain factors on them; recommended sampling and handling procedures; the underlying principles of the more important test methods; and the principal points of the pertinent specifications along with the usual values of the technically important properties (Popovics, 2001).

One of the major disadvantages of concrete is that there are lots of factors that affect its strength. Factors such as type of fine aggregate, type and size of coarse aggregate, grading of aggregate (generally quality of aggregate), type of cement, water -cement ratio and aggregate ± cement ratio all come to play as far as the strength of concrete is concerned

2.2. Basic concrete making materials and their properties

2.2.1 Cement

Cement in a general sense is adhesive and cohesive materials which are capable of bonding together of solid matter into a compact durable mass.For civil engineering works, they are restricted to calcareous cements containing compounds of lime as their chief constituent, its primary function being to bind the fine (sand) and coarse (grits) aggregate particles together (Troxel, 1956).

2.2.1.1. Portland cement

Portland cement is by far the most important member of the family of hydraulic cements—that is,cements that harden through chemical interaction with water. The first patent for "Portland" cement was taken out in England in 1824 by Joseph Aspdin, though it was probably not a true Portland cement;the first true Portland cements were produced about 20 years later. Since then, many improvements have been made to cement production, leading to the sophisticated, though common, cements that are now so widely available.

Portland cement, by definition (ES C D5 201. 1990), is a cementing material that is obtained from

- ✓ Thoroughly mixing together calcareous or other lime bearing materials with, if required, argillaceous and/or other silica, alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the resulting clinker .

In addition, the Ethiopian Standard (ES C D5 201. 1990) states that Portland cement shall contain no additions after burning except as provided below:

- ✓ Water or calcium sulfate, or both, may be added in optimum amounts such that the requirements for chemical composition shall not be exceeded.
- ✓ Processing additions such as grinding aid may be used in the manufacture of the cement, provided that such materials shall not be harmful in the amounts used and shall comply with the requirements.
- ✓ Traces, of metallic substances which may result from the grinding process shall not be regarded as additions (Troxel, 1956).

Portland cements are hydraulic cements; that is, they set and harden by reacting with water. This reaction, called hydration, causes water and cement combine to form a stone like mass.

Portland cement was invented in 1824 by an English mason, Joseph Aspdin, who named his product Portland cement because it produced a concrete that was the same color as natural stone from the Isle of Portland in the English Channel. Portland cement is produced by combining appropriate proportions of lime, iron, silica, and alumina and heating them. These raw ingredients are fed into a kiln that heats the ingredients to temperatures from 2600 to 3000°F (1450 to 1650°C) and chemically changes the raw materials into cement clinker. The clinker is cooled and then pulverized. During this operation, a small amount of gypsum is added to control the setting of the cement. The finished pulverized product is Portland cement (Nawy, 2008).

Portland cement is essentially calcium silicate cement. Powdered coal, oil, natural gas, or other materials are used as fuel for the kiln. A detailed discussion of cements and their chemistry is given in Chapter 1 of this Handbook. The American Society for Testing and

Materials (ASTM) Standard C 150, Specification for Portland cement, defines the following

Types of Portland cement:

- ✓ Type I—general Portland cement
- ✓ Type II—moderate sulfate-resistant cement
- ✓ Type III—high-early-strength cement
- ✓ Type IV—low heat of hydration cement
- ✓ Type V—high sulfate-resistant cement

  Types I, II, and III may also be designated as being air entraining (Nawy, 2008)

- ✓ Type I, general-purpose cement, is the one commonly used for structural purposes when the special properties specified for the other four types of cement are not required (F. S. Merritt, 1999).
- ✓ Type II, modified general-purpose cement, is used where a moderate exposure to sulfate attack is anticipated or a moderate heat of hydration is required. These characteristics are attained by placing limitations on the C3A and C3S content of the cement. Type II cement gains strength a little more slowly than Type I but ultimately reaches equal strength. Type II cement, when optional chemical requirements are met may be used as low-alkali cement where alkali-reactive aggregates are present in the concrete (F. S. Merritt, 1999).
- ✓ Type III, high-early-strength cement, is designed for use when early strength is needed in a particular construction situation. Concrete made with
- ✓ Type III cement develops in 7 days the same strength that it takes 28 days to develop in concretes made with Types I or II cement. This high early strength is achieved by increasing the C3S and C3A content of the cement and by fine grinding. No minimum is placed upon the fineness by the specification, but a practical limit occurs when the particles are so small that minute amounts

of moisture will pre-hydrate the cement during handling and storage. Since it has high heat evolution, Type III cement should not be used in large masses. With 15% C3A, it has poor sulfate resistance. The C3A content may be limited to 8% to obtain moderate sulfate resistance or to 5% when high sulfate resistance is required (F. S. Merritt, 1999).

2.2.1.2. Hydration of Portland cement

The hydration of Portland cement is rather more complex than that of the individual constituent minerals described above. When cement is first mixed with water some of the added calcium sulfate (particularly if dehydrated forms are present and most of the alkali sulfates present, dissolve rapidly. If calcium lang beinite is present, then it will provide both calcium and sulfate ions in solution, which are available for ettringite formation (Newman, 2003).

The hydration reactions that take place between finely ground Portland cement and water are highly complex, because the individual cement grains vary in size and composition. As a consequence, the resulting hydration products are also not uniform; their chemical composition and microstructural characteristics vary not only with time but also with their location within the concrete. The basic characteristics of the hydration of Portland cement may be described as follows:

- ✓ As long as the individual cement grains remain separated from each other by water, the cement paste remains fluid.
- ✓ The products of the hydration reactions occupy a greater volume than that occupied by the original cement grains.
- ✓ As the hydration products begin to intergrow, setting occurs.
- ✓ As the hydration reactions continue, additional bonds are formed between the cement grains,leading to strengthening of the system (Nawy, 2008)

2.2.1.3. Test On Cement

Standards such as ES.C.D5.201.90 and ES.C.D8.490.90 specify requirements for the composition and manufacture of Portland cement, methods of sampling, testing for chemical composition and physical requirements. The standards are specified: 1) in recognition of the fact that Portland cement is industrially manufactured from naturally occurring raw materials and hence its mineral composition could vary depending on the proportions of the raw materials, their mineral compositions, and the methods applied in the manufacturing process, and 2) in order to detect inferior products that deviate from the standards (Abayneh, 1987).

Because the quality of cement is vital for the production of good concrete, the manufacture of cement requires stringent control. A number of tests are performed in the cement plant laboratory to ensure that the cement is of desire quality and that it conforms to the requirements of the relevant national standards. It is also desirable for the purchaser, or for an independent laboratory, to make periodic acceptance tests or to examine the properties of a cement to be used for some special purpose. Tests on chemical composition are beyond the scope of this book and the reader is referred to the bibliography or to the relevant standards: ASTM C 114-05 AND BS EN 196-2; 1995. Fineness tests and setting time tests as prescribed by ASTM and BS EN procedure will now be briefly described (A.M.NEVILLE, 2010).

2.2.1.3.1 Physical Tests

In addition to chemical composition, ES. C. D5. 201 1990 requires that Portland cement conforms to the relevant physical requirements for fineness, setting time, soundness and strength.

Fineness Of Cement

According to the standard, Portland cement when tested for fineness must have a specific surface of not less than 2250 cm^2/g when ordinary and not less than 3250 cm^2/g when rapid-hardening.

Since hydration starts at the surface of cement particles, it is the total surface area of cement that presents the material available for hydration. Thus, the rate of hydration depends on the fineness cement particles, and for a rapid development of strength a high fineness is necessary. However, the cost of grinding and the effect of fineness on other properties, e.g. gypsum requirement, workability of fresh concrete and long term behavior, must be born in mind (A.M.NEVILLE, 2010).

Fineness of cement is also important; it affects:

- ✓ Rate of hydration
- ✓ Rate of setting
- ✓ Rate of hardening
- ✓ Durability (ASR)
- ✓ Rate of carbonation during storage
- ✓ Cost

- ✓ Rate of gypsum addition
- ✓ Bleeding

However, later strength is not directly affected (Sidney Mindess S. Y., 2003).The median particle diameter of Type I or II Portland cement is typically about 10 to 20 µm, but particles ranges in size from a few tenths of a micrometer to 50 µm or more. Type III Portland cement is typically finer than Type I, and Types IV and V Portland cements are often coarser. Blended cements are also broad in their particle size distribution, may cover a somewhat different size range, and are often bimodal (Joseph F. Lamond J. H., 2006).

Fineness is included in most specifications for hydraulic cements. In C 150, a minimum specific surface value is specified for all types of Portland cement except III and IIIA: either 280 m2/kg by the air permeability test or 160 m2 /kg by the turbid meter test. In C 595 for blended cements, fineness (both the amount retained on the 45µm sieve and the specific surface by the air permeability method) is listed as a physical requirement and must be included if the purchaser requests certification, but no fineness limits are specified. In addition, in blended cements containing pozzolan, no more than 20.0 % of the pozzolan may be retained on a 45µm sieve. Similarly, in C 1157 for hydraulic cements, fineness must be reported but no limits are specified (Joseph F. Lamond J. H., 2006).

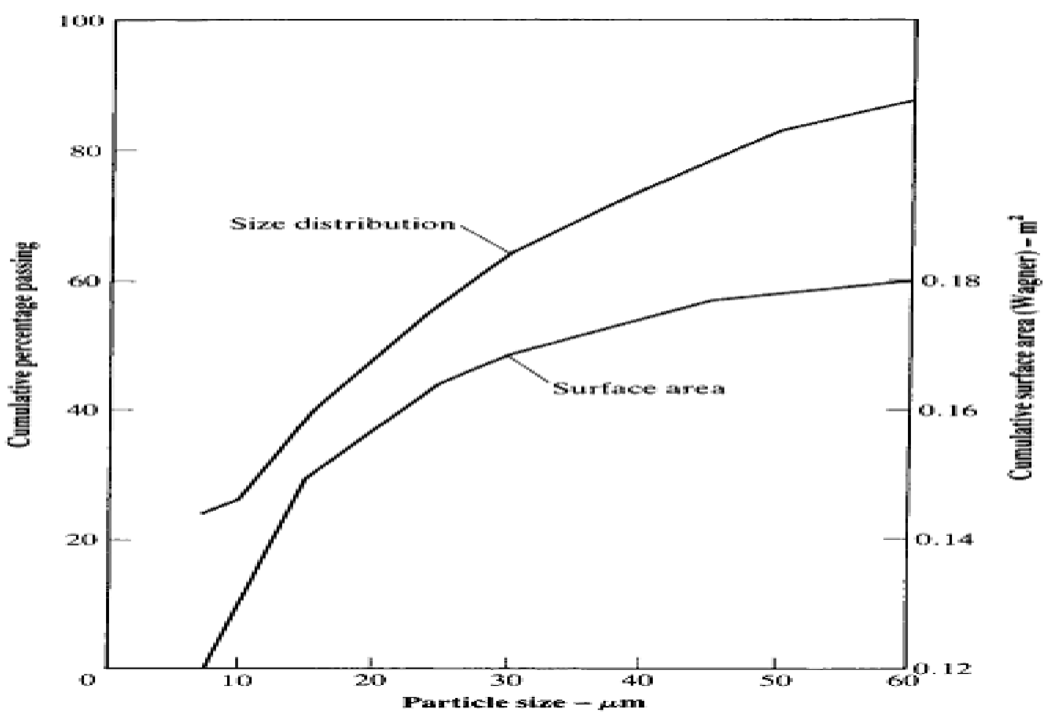

Figure 2.1 Example of particle size distribution and commutative surface area contributed by particles up to any size for 1 gram of cement

Setting Time

This is the term used to describe the stiffening of the cement paste. Broadly speaking, setting refers to a change from a fluid to a rigid state. The setting is mainly caused by a selective hydration of C3A and C3S and is accompanied by temperature rises in the cement paste; initial sets correspond to a rapid rise and final set correspond to the peak temperature (A.M.NEVILLE, 2010).

The minimum initial setting time specified by the standard is 45 minutes.

Table 2.1 Setting time standard

	Vicat needle	Gilmore needles
ASTM C 150 Portland Cement		
Initial sets, not less than (h:min) Final sets, not less than (h:min)	0:45 6:15	1:0 10:0
ASTM C 595 blended Cement		
Initial sets, not less than (h:min) Final sets, not less than (h:min)	0:45 7:0	
ASTM C 1157 hydraulic Cement		
Initial sets, not less than (h:min) Final sets, not less than (h:min)	0:45 7:0	

2.2.2 Water

The function of the water, other than enabling the chemical reactions that cause setting and hardening to proceed, is to lubricate the mixture of aggregates and cement in order to facilitate placing. Some standards stipulate that water fit for drinking is generally suitable for making concrete. Water quality is the most consistent of the constituents of concrete, but water quantity, as it affects the free/water cement ratio, is most important for control of consistence, strength and durability (Army, 1992).

Water used for concrete mixtures should contain no substance which can have an appreciable harmful effect on strength or upon the durability of the concrete in service. Substances in water which, if present in large amounts, may be harmful are: salt, oil, industrial wastes, alkalis, sulfates, organic matter, silt, sewage, etc. Tests by the sense of smell, sight or taste would reveal such impurities; however water of doubtful quality should be submitted for laboratory analysis and tests. Water should be avoided if it contains large quantities of suspended solids, excessive amounts of dissolved solids, or appreciable amounts of organic materials. In addition, the amount of water used should be the minimum necessary to ensure thorough compaction of the concrete (Army, 1992).

Unless tests or experience indicates that a particular water source is satisfactory, mixing water should be free from acids, alkalis, oils, and organic purities. The basic ratio of water to cement determines the strength of concrete. The less water in the mix as long as it is workable; and not too stiff, stronger, more durable and watertight the concrete. Too much water dilutes cement paste (binder), resulting in weak and porous concrete. Concrete quality varies widely, depending on the characteristics of its ingredients and the proportion of the mix (Army, 1992).

2.2.2.1 Test on Water

Asimple way of determining the suitability of water for mixing is to compare the setting time of cement and the strength of mortar cubes using the water in question with the corresponding results obtained using de-ionized or distilled water as prescribed by BS EN 1008: 2002,which requires the intial setting time to be not less than 1hour and to be within 25 per cent of the result with distilled water :final setting time shall not exceed 12 hours and also be within 25 per cent.The mean strength should be at least 90 per cent.Those requirements may be compared with BS3146:1980,which suggest a tolerance of 30 min in the intial setting time and recomendeds a tolerance of 10 per cent for setting time is from 1 hour 30min later,while strength has tobe at least 90 per cent.Wheather or not staining will occur due to impurities in the curing water cannot be determined on the basis of chemical analysis and should be checked by a performance test involving simulated wetting and evaporation. (A.M.NEVILLE, 2010).

2.2.3 Aggregates

Aggregates make up about 75% of the volume of concrete, so their properties have a large influence on the properties of the concrete (Alexander and Mindess, 2005). Aggregates are granular materials, most commonly natural gravels and sands or crushed stone, although occasionally synthetic materials such as slags or expanded clays or shale's are used. Most aggregates have specific gravities in the range of 2.6 to 2.7, although both heavyweight and lightweight aggregates are sometimes used for special concretes, as described later. The role of the aggregate is to provide much better dimensional stability and wear resistance; without aggregates, large castings of neat cement paste would essentially self-destruct upon drying. (Nawy, 2008)

A well-graded aggregate (implying that it consists of particles of various sizes) not only gives a stronger concrete, but also reduces the amount of Portland cement necessary to wrap the particles and fill spaces between them. An aggregate that consists of only one or two sizes of particles has a higher percentage of voids and, therefore, requires a much larger amount of Portland cement (Madan Mehta, 2009).

Because Portland cement is far more expensive than aggregates, this gives an uneconomical concrete. In general, therefore, the aggregate in a concrete mix consists of several sizes. However, the concrete industry divides the aggregate into two size groups:

- ✓ Fine aggregate
- ✓ Coarse aggregate

Figure 2.2 Range of particle sizes found in aggregate for use in concrete (Steven H. and Kosmatka B. K.).

Fine aggregate is generally sound, but more precisely it is that material of which 95% passes through a No. 4 sieve. A No. 4 sieve consists of a wire mesh with wires spaced at in. On center, because the wires have a certain standard thickness, the largest particle size of fine aggregate that can pass through a No. 4 sieve is slightly smaller than (Madan Mehta, 2009).

Fine aggregate needs to be graded from a No. 4 sieve down to a No. 100 sieve. Coarse aggregates that aggregate of which 95% is retained on a No. 4 sieve. It consists of either crushed stone or gravel. Gravel has several advantages over crushed stone, but crushed stone is commonly used because it is more economical (Madan Mehta, 2009).

Aggregate can be obtained from various sources; natural or manufactured. Natural aggregates are taken from natural deposits without change in their nature during production, with the exception of crushing, sizing grading, or during production. In this group, crushed stone, gravel, and sand are the most common.

2.2.3.1 Classification of natural aggregates

So far, we have considered only aggregate from naturally occurring materials, and the present chapter deals almost exclusively with this type of aggregate. Aggregate can, however, also be manufactured from industrial products: because these artificial aggregates are generally either heavier or lighter than ordinary aggregate (Neville, 2011).

ASTM Standard C 294-05 gives a description of some of the more common or important minerals found in aggregates. Mineralogical classification is of help in recognizing properties of aggregate, but cannot provide a basis for predicting its performance in concrete as there are no minerals universally desirable and few invariably un- desirable ones. The ASTM

Classification of minerals is summarized below:

Silica minerals (quartz, opal, chalcedony, tridymite, cristobalite)

- ✓ Feldspars
- ✓ Ferromagnesian minerals
- ✓ Micaceous minerals
- ✓ Clay minerals
- ✓ Zeolites
- ✓ Carbonate minerals
- ✓ Sulfate minerals
- ✓ Iron sulfide minerals

- ✓ Iron oxides

Based on this classification, this research generally focuses on coarse and fine aggregates, essentially, the engineering properties of coarse and fine aggregates comparison on different standard in Jimma town. And recommendations on their standards.

2.2.3.2 Aggregate Characteristics And Their Significance

A knowledge of certain aggregate characteristics (i.e., density, grading, and moisture state) is required for pro-portioning concrete mixtures (Chapter 9). Porosity or density, grading, shape, and surface texture determine the properties of plastic concrete mixtures. In addition to porosity, the mineralogical composition of aggregate affects its crushing strength, hardness, elastic modulus, and soundness, which in turn influence various properties of hardened concrete containing the aggregate. From a diagram illustrating the various interrelations it is evident that the aggregate characteristics significant to concrete technology are derived from microstructure of the material, prior exposure conditions, and processing factors. Generally, aggregate properties are discussed in two parts on the basis of properties affecting (1) mix proportions and (2) the behavior of fresh and hardened concrete. Due to a considerable overlap between the two, it is more appropriate to divide the properties into the following groups, which are based on microstructural and processing factors: (Monteiro, October 20, 2001).

1) Characteristics dependent on porosity

2) Characteristics dependent on prior exposure and processing factors

3) Characteristics dependent on chemical and mineralogical composition

4) Density and Apparent Specific Gravity

5) Absorption and Surface Moisture

6) Soundness abrasion resistance

7) Crushing Strength, Abrasion Resistance, and Elastic Modulus

8) Soundness

9) Size and Grading

10) Shape and Surface Texture (Monteiro, October 20, 2001).

The use of larger maximum size of aggregate affects the strength in several ways. First, since larger aggregates have less specific surface area and the aggregate-paste bond strength is less; aggregate fails along surfaces of aggregates resulting in reduced compressive strength of concrete. Secondly, for a given volume of concrete, using larger aggregate results in a smaller volume of paste, thereby providing more restraint to volume changes of the paste. This may induce additional stresses in the paste, creating micro cracks prior to application of load, which may be a critical factor in very high strength concretes (Akçaoglu, 2004;) . Therefore, it is the general consensus that smaller size aggregates should be used to produce higher strength concrete.

The surface texture of aggregate particles can range from glassy, through smooth, granular, rough and crystalline, to honeycombed. The texture is only really an issue where flexural strength is important, or for very high-strength concretes. In both cases, rougher textures give greater strengths, all other things being equal, because the aggregate cement paste bond is improved. The survey shows that the British Standard requirements of the maximum flakiness index 50 for increased gravel and 40 for crushed rock and crushed gravel are equivalent to European Standard categories of 50 and 35 respectively (Newman, 2003).

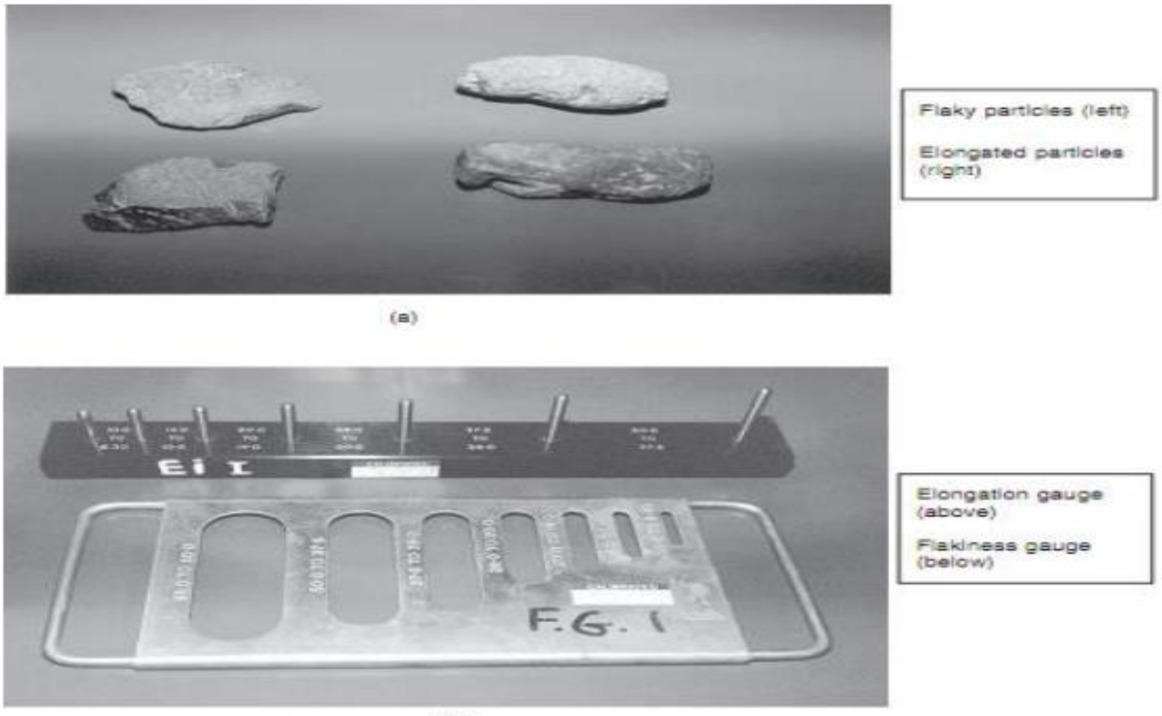

Figure 2.3 Flakiness and elongation (Newman, 2003)

The most common shape test is flakiness index. Coarse aggregate particles are presented to a special gauge. If a particle‘s least dimension is less than 60 per cent of its mean dimension, it passes through the gauge and is classed as flaky (BSI, 1989b). Flakiness index is defined as the percentage by mass of flaky particles in the sample. The European Standard flakiness test operates on a similar principle, using sieves with rectangular (rather than square) apertures. Confusingly, this test classes a particle as flaky if its least dimension is less than 50 per cent of its upper sieve size. A test survey has established an approximate relationship between the two indices (Eurochip, 1996) (Newman, 2003).

Relative Density

The relative density of an aggregate is the ratio between the mass of the material and the volume occupied by the individual particles contained in that sample. This volume includes the pores within the particles but does not include the voids between the particles. Relative density of individual particles depends both on the relative density of the pore less vitreous material and the pore volume within the particles, and generally increases when particle size decreases. The relative density of the pore-free vitreous material may be determined by pulverizing the lightweight aggregate in a jar mill and then following procedures used for determination of the relative density of cement (Joseph F. Lamond J. H., 2006).

Bulk Density

Aggregate bulk density is defined as the ratio of the mass of a given quantity of material and the total volume occupied by it. This volume includes the voids between, as well as the pores within, the particles. Bulk density is a function of particle shape, density, size, grading‘s and moisture content, as well as the method of packing the material (loose, vibrated, rodded), and varies not only for different materials, but for different sizes and gradations of a particular material.The maximum bulk density for lightweight aggregates listed in ASTM (C 330) and ASTM Specification for Lightweight Aggregates for Concrete Masonry Units (C 331). ASTM Standard Specification for Lightweight Aggregates for Insulating Concrete (C 332) provides minimum density requirements for perlite and vermiculite to limit over-expanded, weak particles that would break down in mixing (Joseph F. Lamond J. H., 2006).

Aggregate gradation

In practice, each fraction contains particles between specific limits, these being the openings of standard test sieves. That portion of an aggregate passing the 4.75 mm (No. 4) sieve and predominantly retained on the 75 mm (No. 200) sieve is called fine aggregate or sand, and larger aggregate is called coarse aggregate.

According to ACI E-701, Aggregate Grading refers to the distribution of particle sizes present in an aggregate. The grading is determined in accordance with ASTM C 136, “Sieve or Screen Analysis of Fine and Coarse Aggregates.” A sample of the aggregate is shaken through a series of wire-cloth sieves with square openings, nested one above the other in order of size, with the sieve having the largest openings on top, the one having the smallest openings at the bottom, and a pan underneath to catch material passing the finest sieve . The results of a sieve analysis are typically presented on a graph in the form of a grading curve with the log of the sieve aperture on the x-axis and the percentage of the total mass of aggregates which passes a particular sieve aperture on the y-axis.

Coarse and fine aggregates are generally sieved separately. That portion of an aggregate passing the 4.75 mm (No. 4) sieve and predominantly retained on the 75mm (No. 200) sieve is called fine aggregate or sand,

and larger aggregate is called coarse aggregate. 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 19mm (1-1/2 to 3/4 in) (ACI Educational Bulletin, 2007).

2.2.3.2 Fine aggregate grading

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

Table 2.3 Grading requirements for fine aggregate from ASTM Designation: C 33

Sieve size (specification E 11)	Percent passing
9.5mm (3/4 in.)	100
4.75 mm (no.4)	95-100
2.36mm (no.8)	80-100
1.16mm (no.16)	50-85
600µm (no.30)	25-60
300µm (no.50)	10-30
150µm (no.100)	2-10

Structural lightweight aggregate producers normally stock materials in several standard sizes

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 (Kosmatka, 2003).

Fineness Modulus

Using the sieve analysis results, a numerical index called the fineness modulus (FM) is often computed. The FM is the sum of the total percentages coarser than each of a specified series of sieves, divided by 100.

Source: (Donamo, 2005)

$$\text{Fineness modules} = \frac{\sum(\text{cum.of \% retain})}{100\%} \quad \text{…………………………………………….. Equation 2.1}$$

The specified sieves are 75.0, 37.5, 19.0, and 9.5 mm (3, 1.5, 3/4, and 3/8 in.) and 4.75 mm, 2.36 mm, 1.18 mm, 600µm, 300 µm, and 150 µm (No. 4, 8, 16, 30, 50, and 100).

Note that the lower limit of the specified series of sieves is the 150 µm (No. 100) sieve and that the actual size of the openings in each larger sieve is twice that of the sieve below. The coarser aggregate size, the higher the FM. for fine aggregate used in concrete, the FM generally ranges from 2.0 to 3.3 as per defined ACI E-701 and According to Ethiopian Standards ES C. D3. 201 the fineness modulus of fine aggregate in the range of 2.0-3.5 with tolerance of ±0.2.In addition to this SANS 1083:2006 specified the fineness modulus in the range of 1.2 to 3.5 for fine aggregates that use in concrete production.

It is used as an index to the fineness or coarseness and uniformity of aggregate supplied, but it is not an indication of grading since there could be an infinite number of grading which will produce a given fineness modulus. The following limits may be taken as guidance (Donamo, 2005).

Sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete (Donamo, 2005). However, it is clear that one parameter, the average, cannot be representative of a distribution: thus the same fineness modulus can represent an infinite number of totally different size distributions or grading curves. Therefore, the fineness modulus cannot be used as a description of a grading of an aggregate but it is valuable for measuring slight variations in the aggregate from the same source that is as a day to day check (NevilleA.3, 2011).

Unit weight of aggregates

Unit weight is the weight of a unit volume of aggregate, usually stated in kilo gram per cubic meter.

In estimating quantities of materials, and in mix computations when batching is done on a volumetric basis, it is necessary to know the conditions under which the aggregate volume is to be measured: (1) loose or compact, and (2) dry, damp, or inundated (Troxel, 1956).

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). However, for scheduling volumetric batch quantities, the unit weight in the loose, damp state should also be known (Shetty M. , 2005).

Specific Gravity (SG)

The density of the aggregate is required in mix proportioning to establish weight-volume relationships. The density is expressed as the specific gravity, which is a dimensionless ratio relating the density of the aggregate to that of water (Sidney, 2003).

SD= density of the aggregate /density of the water

Source (Sidney, 2003).

Because the aggregate mass varies with its moisture content, specific gravity is determined at fixed moisture content. According to ACI E-701 there are four moisture conditions are defined for aggregates depending on the amount of water held in the pores or on the surface of the particles.

Absorption and Surface Moisture

Various states of moisture absorption in which an aggregate particle can exist. When all the permeable pores are full and there is no water film on the surface, the aggregate is said to be in the saturated-surface dry condition (SSD); when the aggregate is saturated and there is also free moisture on the surface, the aggregate is in the wet or damp condition. In the oven-dry condition, all the evaporable water has been driven off by heating to 100◦C. Absorption capacity is defined as the total amount of moisture required to bring an aggregate from the oven-dry to the SSD condition; effective absorption is defined as the amount of moisture required to bring an aggregate from the air-dry to the SSD condition. The amount of water in excess of the water required for the SSD condition is referred to as the surface moisture. The absorption capacity, effective absorption, and surface moisture data are invariably needed for correcting the batch water and aggregate proportions in concrete mixtures made from stock materials. As a first approximation, the absorption capacity of an aggregate, which is easily determined, can be used as a measure of porosity and strength (P. Kumar Mehta, October 20, 2001).

Normally, moisture correction values for intrusive igneous rocks and dense sedimentary rocks are very low, but they can be quite high in the case of porous sedimentary rocks, lightweight aggregates, and damp sand. For example, typically, the effective absorption values of trap rock, porous sandstone, and expanded shale aggregates are 1/2, 5, and 10 percent, respectively .

Damp sands may suffer from a phenomenon known as bulking. Depending on the amount of moisture and aggregate grading, considerable increase in bulk volume of sand can occur because the surface tension in the moisture holds the particles apart. Since most sands are delivered at the job site in a damp condition, wide variations can occur in batch quantities if the batching is done by volume. For this reason, proportioning concrete mixture by weight has become the standard practice in most countries (P. Kumar Mehta, October 20, 2001).

Soundness

Aggregate soundness is measured by ASTM C88,

Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.‘‘ This test measures the amount of aggregate degradation when exposed to alternating cycles of wetting and drying in a sulfate solution (Frederick S. Merritt, 2000).

Aggregate is considered unsound when volume changes in the aggregate induced by weather, such as alternate cycles of wetting and drying or freezing and thawing; result in concrete deterioration (Quarter, 2015).

- ✓ Depends on: porosity, flaws and contaminants.
- ✓ Pumice (10% absorption) - no problem with freezing and thawing.
- ✓ Limestone - breaks: use smaller aggregates (critical size)
  (Critical aggregate size: size below which high internal stresses capable of cracking the particle will not occur) (Quarter, 2015).

Aggregate impact value

With respect to concrete aggregates, toughness is usually considered the resistance of the material to failure by impact. Several attempts to develop a method of test for aggregate impact value have been made. The most successful is the one which a sample standard aggregate kept in a mold is subjected to fifteen blows of a metal hammer of weight 14 kg falling from a height of 38cm. The quantity of finer material (passing through 2.36 mm) resulting from pounding will indicate the toughness of the aggregate sample (Shetty M. , 2005).

Aggregate Los Angeles Abrasion test

An American test combining attrition and abrasion is the Los Angeles test; it is quite frequently used in other countries, too, because its results show good correlation, not only with the actual wear of aggregate when used in concrete but also with the compressive and flexural strengths of concrete made with the given aggregate. In this test, aggregate of specified grading is placed in a cylindrical drum, mounted horizontally, with a shelf inside. A charge of steel balls is added, and the drum is rotated a specified number of revolutions. The tumbling and dropping of the aggregate and the ball results in abrasion and attrition of the aggregate, and this is measured in the same way as in the attrition test (Neville, 2011).

The Los Angeles test can be performed on aggregates of different sizes, the same wear being obtained by an appropriate mass of the sample and of the charge of steel balls, and by a suitable number of revolutions. The various quantities are prescribed by ASTM C 131-06. The Los Angeles test is, however, not very suitable for the assessment of the behavior of fine aggregate when subjected to attrition on prolonged mixing; lime- stone fine aggregate is probably one of the more common materials to undergo this degradation (Neville, 2011).

The abrasion resistance of an aggregate is often used as a general index of its quality. Abrasion resistance is essential when the aggregate is to be used in concrete subject to abrasion, as in heavy-duty floors or pavements. Low abrasion resistance of an aggregate may increase the quantity of fines in the concrete during mixing; consequently, this may increase the water requirement and require an adjustment in the water-cement ratio (Steven H. and Kosmatka B. K.).

Aggregate crushing value

The crushing value is a useful guide when dealing with aggregates of unknown performance, particularly when lower strength may be suspected. There is no obvious physical relation between this crushing value and the compressive strength, but the results of the two tests are usually in agreement (Neville, 2011).

The material to be tested for crushing value should pass a 14.0 mm (1/2 in.) test sieve and be retained on a 10.0 mm (3/8 in.) sieve. When, however, this size is not available, particles of other sizes may be used, but those larger than standard will in general give a higher crushing value, and the smaller ones a lower value, than would be obtained with the same rock of standard size. The sample to be tested should be dried in an oven at 100 to 110 °C (212 to 230 °F) for four hours, and then placed in a cylindrical mold and tamped in a prescribed manner. A plunger is put on top of the aggregate and the whole assembly is placed in a compression testing machine and subjected to a load of 400 KN (40 ton) (pressure of 22.1 MPa (3200 psi)) over the gross area of the plunger, the load being increased gradually over a period of 10 minutes. After the load has been released, the aggregate is removed and sieved on a 2.36 mm (No. 8 ASTM*) test sieve in the case of a sample of the 14.0 to 10.0 mm (1/2 to 3/8in.) standard size; for aggregates of other sizes, the sieve size is prescribed in BS 812: 110: 1990. The ratio of mass of the material passing the smaller sieve to the total mass of the sample is called the aggregate crushing value (Neville, 2011).

2.3 Quality implementation and managements

The quality management of work on the construction site takes place in three phases:

1. Planning what is to be done.

2. Controlling the execution of the plan.

3. Providing verification that the work has been carried out according to plan.

Let us consider the requirements of a quality system in the context of these phases (Ashford, 1930).

Planning

The steps to be taken to ensure that specified standards are met need to be planned in a systematic fashion and they have to be taken into account when overall work plans are being prepared. Design plans, construction plans, cost plans, and so on, are part of everyday site management. So, too, should be quality plans (Ashford, 1930).

Further advises that quality plans should define:

1. The quality objectives to be attained;
2. The specific allocation of responsibility and authority during the different phases of the project;
3. The specific procedures, methods and work instructions to be applied;

4. Suitable testing, inspection, examination and audit programs at appropriate stages (e.g. Design and development);

5. A method for changes and modifications in a quality plan as projects proceed;

6. Other measures necessary to meet objectives (Ashford, 1930).

2.3.1 Quality controls on concrete ingredients

Fine Aggregate:

A. Source name and port number.

B. Method of transport & handling from pit to mixer.

C. Sampling locations.

D. Sampling and testing frequency and control tolerance.

E. Action to be initiated when samples exceed control limits.

Coarse Aggregate:

A. Source name, pit number and grade number.

B. Method of transport and handling from pit to mixer.

C. Sampling locations.

D. Sampling and testing frequency and control tolerance.

E. Action to be initiated when samples exceed control limits.

Water

Description of water source and method of specification compliance assurance

Cement:

A. Source and type to be used (by class of concrete). Where special requirements exist, a testing plan to assure compliance must be described.

B. Method of transport, storage, handling and introduction into mixer (L.B.Shastri Marg, 2007).

2.3.1.1 Quality control on storing concrete ingredients

Aggregates

Aggregates should be handled and stored in a way that minimizes segregation and degradation and prevents contamination by deleterious substances. Stockpiles should be built up in thin layers of uniform thickness to minimize segregation. The most economical and acceptable method of forming aggregate stockpiles is the truck-dump method, which discharges the loads in a way that keeps them tightly joined. The aggregate is then reclaimed with a front-end loader. The loader should remove the slices from the edges of the pile from bottom to top so that every slice will contain a portion of each horizontal layer (Army, 1992).

When aggregates are not delivered by truck, acceptable and inexpensive results can be obtained by forming the stock pile in layers with a clamshell bucket (cast-and-spread method); in the case of aggregates not subject to degradation, spreading the aggregates with a rubber-tire dozer and reclaiming with a front-end loader can be used. By spreading the material in thin layers, segregation is minimized. Whether aggregates are handled by truck, bucket loader, clamshell, or conveyor belt, stockpiles should not be built up in high, cone-shaped piles since this result in segregation. However, if circumstances necessitate construction of a conical pile, or if a stockpile has segregated, gradation variations can be minimized when the pile is reclaimed; in such cases, aggregates should be loaded by continually moving around the circumference of the pile to blend sizes rather than by starting on one side and working straight through the pile (Army, 1992).

Washed aggregates should be stockpiled in sufficient time before use so that they can drain to uniform moisture content. Damp fine material has fewer tendencies to segregate than dry material. When dry, fine aggregate is dropped from buckets or conveyors, wind can blow away the fines; this should be avoided if possible (Steven H. and Kosmatka B. K.).

Aggregates shall be handled and stored so as to minimize segregation and contamination with undesirable constituents. Separate storage facilities with adequate provision for drainage shall be provided for each different nominal size of aggregate used. (Ethiopian Patent No. EBCS 2, 1995)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Study Area

Jimma is the largest city in southwestern Ethiopia. Located in the Jimma Zone of the Oromia Region, this city has a latitude and longitude of 7°40′N 36°50′E / 7.667°N 36.833°E / 7.667; 36.833. It was the capital of Kaffa Province until the province was dissolved. Oromia regional states are the biggest regional state in the country of the Oromia regional state that was and still is engaged in the implementation of building construction and infrastructures. This study therefore is carried out in Jimma town and focuses on the quality implementation of concrete ingredients on building construction.

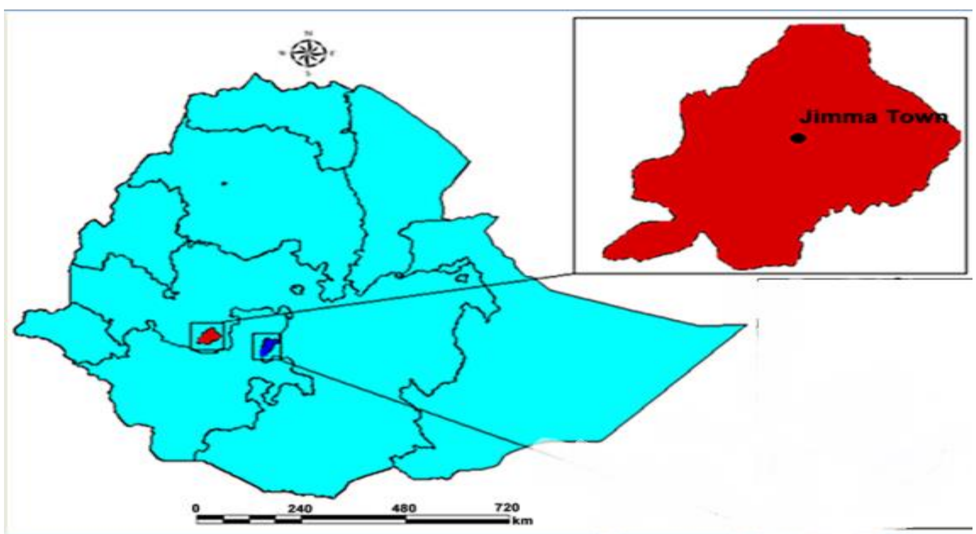

Figure 3.1 Map of Jimma, Ethiopia

3.2. Population

The population of the study include the ingredients of the concrete these are Corse aggregate and Fine aggregate. In this study the populations are taken from three sources of coarse aggregate three sources of fine aggregate (sand) and water was selected directly from observed building construction site in Jimma town. And also observe on the construction sites.

3.3. Sampling Technique and Sample Size

The objective of sampling was to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provides a good representation of the population; that is the sample was representative. Since the population information is available for this research the preferable sampling technique is from non-probability sampling technique which is purposive sampling method chosen in order to extract the sample easily and to ensure the assessment was done to the research.

In this research purposively selected the material samples which are mostly used in building construction in Jimma town this are:

- ✓ For fine aggregate Chewaka, Werabe and Gambella sand.
- ✓ For coarse aggregate from Agaro – Suse (tuba crusher) & Mohamed Miftah sites and Jimma site; on dedo road Worakolobo sites (Abdulesemed Crasher).
- ✓ For water; from observed construction site.

The field observation made through selecting ongoing construction in Jimma town which conducted in seven building project contractors were as listed in the table below

Table 3.1 Building contractors location and names for field investigation

Building/ contractor names	Location of the projects
1 Yasin Building	Around Yasin Garage
2 Nuumera Construction	In front of ERA /Ajip/
3 Abey construction	In front of Yetebaberut Fuel station
4 Hermata mentina market building	In merkato (near to hermata CBE)
5 Wolda Mura Market Center	In merkato (near to Ajip Taxi station)
6 Rama Construction	Jimma University (Agaro Branch)
7 Tana miseso Markete Center	In merkato (near to CBE of Main Brnch)

3.4 Study Design

The data collected was by using both primary and secondary sources. The primary data was obtained through interview directed to contractors ,consultants and Engineers involved in active building projects. The secondary data was obtained from code of standards, internet, journals and books. The secondary data was used to get an understanding of the problem and was used as criteria for developing and analyzing the primary data.

The research was both qualitative and quantitative type. Some of the data collected was in descriptive form while some of the data was in numerical form.

3.5. Procedure

In order to achieve the objective of the study and adequately information was gathered through review of literature, site observation and by conducting laboratory result. The study was attended through the following research approaches categorized into phases.

A) The literature survey includes the basic materials of concrete, and standards, specification and codes of practice.

B) The first objective was conducted as site observation and by taking photos of the ingredients used in construction projects on the sites and the site visits involved observations where the researcher sought to find out how ingredients were selected and concrete ingredients are conducted were located on a Jimma town building construction which was selected non-probability sampling techniques in this sampling technique for this research the preferable one was purposefully sampling method which on those taken ongoing construction projects.

C) The second objective was conducted at the ERA laboratory by work the standard tests on the material which is used as the concrete ingredients, these are aggregates tests which is found in Jimma town for uses of building construction. Since this research is mainly focused on concrete making aggregates, the discussion made concerning water is not detailed; cement is fabrics product, it is already standardized so have not laboratory tests only compare Ethiopian standard with others.

D) The samples take as purposefully which was used mostly on building construction in Jimma town. This is for fine aggregate Cewaka, Werabe, Gambella sand taken from the sites which mentioned on the table 3.1 And for coarse aggregate from Agaro-suse site, Dedo-worakolobo sites (Abdulsemed crusher) and Agaro (Mohamed and miftah crusher) site and And for cement Muger OPC cement, Derban OPC cement and Dangote OPC cement which mostly used in the town and it was not conclude on tests which is already standardized in production factory by Ethiopia standard. Most sites use water from fresh water (Tap water) so it was not concluded on the tests.

The laboratory test results are for the coarse aggregate sieve analysis, unit weight, specific gravity, absorption, for fine aggregate (sand), unit weight, apparent specific gravity, bulk specific gravity, bulk specific gravity (SSD), water absorption and silt content are done in the laboratory to determine their properties and for the standard assurance of the ingredients for making concrete.

The sample of each fine aggregate was taken from the sites of the projects. For the coarse aggregate the samples were taken from the quarry sites and the construction projects and each taken to ERA laboratory and by the quartering method for coarse aggregate; for fine aggregate by the riffle box and take the samples of each to do the trial tests by using references of ES, ASTM, BS, laboratory and Abebe Denku manuals to determine the results. For the cement is packed & standardized in factory, so the cement was not take test, only compare the Ethiopia standard to other standards.

E) The third objective was conducted as desk review by comparing the results with the standards that uses on the laboratory manual and building materials standard assurances like ASTM, BS, EBCS and ES.

F) Analysis made from the site observations, from desk review and from the laboratory results carried out a subjective assessment of the quality implementation of concrete ingredients and workmanship in Jimma town building constructions. The field observation, analysis was made on the quality implementation of the concrete ingredients and storages of the ingredients on the sites of ongoing building construction in Jimma town.

G) A conclusion made from the analysis made through the gathered the laboratory results and field observation on the sites.

H) Recommendation for the standard implementation on the concrete making materials given.

3.6 Study Variables

3.6.1 Dependent variables

- ✓ Quality standard of coarse and fine aggregates

3.6.2 Independent variables

- ✓ Sourse of the materials
- ✓ Engineering properties of materials
- ✓ Code of standards

3.7 Methods of data analysis

Statistical method used to analyze information gathered through primary and secondary sources. Then make a subjective assessment on the current sources of concrete materials with respect to building code standards.

The information gathered through interview, site observations and engineering properties test results are briefly discussed here. The observed phases of concrete materials in the building construction discussed against the required specifications and different codes & standards. And the variability observed from various codes and standards analyzed altogether.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 General

To compare the concrete material used in Jimma town construction projects with different standards field observation, interviews and test results of coarse aggregate and fine aggregate samples were collected from quarry sites and ongoing projects.

The first objective was to identify sources of coarse and fine aggregates used in Jimma town construction projects. In this research to obtain the objective the visual observation and interview was conduct on seven selected projects of building construction.

Figure 4.1 Stockpiling of the Materials on the observed sites (Around Bus Station sites)

The coarse aggregates are supplied from different quarry site located in Agaro-suse, Dedo-Ofole,Agaro-Mohamed & miftah and the fine aggregates are supplied from Chewaka, Werabe and Gamble.

- ✓ Authentically, in some small projects there was also used fine and coarse aggregate produced in another quarry site like Yedi, Assendabo, Nada Kela and Gibe for fine aggregate and Beda Buna and Gidi Lulesa for coarse aggregate respectively. As the information gathered through interview from consultant, project engineers, contractors and clients, the reasons that they provided why they was not used fine aggregates brought from another site like Yedi, Assendabo, Nada Kela and Gibe are:

1. It has much silt content, in necked eye observation
2. After concrete casting, serious structural crack will observed
3. The consultants and clients are refused
4. For the restriction of contract document and specification
5. For the appearance of compression failure on the structure

During on the field observation, the above reasons were obtained on the selected building construction projects.

- ✓ For Coarse aggregates the reason was:

1. Luck of enough production
2. Not fulfill gradation requirement
3. Luck workability
4. Appearance of void space between particles
5. Appearance of segregation
6. Because of flakiness

The second objective was to determine the engineering properties of the coarse and fine aggregates used in Jimma town construction projects. The determination was conducted through laboratory investigation of the ingredients like fine aggregate and coarse aggregate as follows:

4.1.1 Fine aggregate

The fine aggregate samples are purposefully collected from the sites which were commonly used in Jimma town construction projects for the production of concrete. These aggregates are obtained from Werabe, Chewaka and Gambella quarry sites.The samples are taken as the ASTM D75, as AASHTO T2 reference and also as Abebe Dinku Laboratory manuals. After that the sample minimization of the aggregates for every samples are taken by the riffle box for each tests of the aggregate.

4.1.1.1. Test result for Chewaka sand

The Chewaka sand laboratory test results are summarized on table 4.1 and the procedure is in the Annex A:

Table 4.1 Results for Chewaka sand

Material type	Type of test	Test result		
		Sieve size (mm)		% Passing
		12.5		
Fine aggregate (Chewaka)		9.5		100.00
		4.75		97.55
		2.36		91.84
		1.18		78.34
		0.6		43.64
		0.3		11.26
		0.15		1.58
		0.075		0.04
	Fineness Modules	2.76		
	Unit Weight	Roded	1639.31Kg/m^3	
		Loose	1527.73Kg/ m^3	
	Bulk Specific Gravity	2.65		
	Saturated-Surface-Dry Bases	2.66		
	Absorption Capacity (%)	0.19		
	Apparent Specific Gravity	2.67		
	Silt Content	6.702		
	Natural Moisture Content	0.27		

As shown the above results of Chewaka fine aggregate (snad) Gradiation were discussed in the graph, which is between the upper and lower limit as ES.C.D3.201:1990. And the Remaing Chewaka snad test results were between the standard limits,except the silt content.

4.1.1.2. Test result for Gambela sand

The Gambela sand laboratory test results are summarized on table 4.2 and the procedure is in the Annex A:

Table 4.2 Results for Gambela sand

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
		12.5	100
Fine aggregate (Gambela)		9.5	99.63
		4.75	96.71
		2.36	90.47
		1.18	75.94
		0.6	47.79
		0.3	16.49
		0.15	2.93
		0.075	0.30
	Fineness Modules	2.7	
	Unit Weight	Roded	1621.76 Kg/m^3
		Loose	1494.24 Kg/ m^3
	Bulk Specific Gravity	2.54	
	Saturated-Surface-Dry Bases	2.55	
	Absorption Capacity (%)	0.26	
	Apparent Specific Gravity	2.56	
	Silt Content	2.88	
	Natural Moisture Content	0.35	

As shown the above results of Gambela sand Gradiation were discussed in the graph, which is between the upper and lower limit as ES.C.D3.201:1990. And the Remaing Gambela sand test results were between the standard limits,except the Fineness Modules.

4.1.1.3. Test Result for Werabe Sand

The samples for the test result were taken by quartering method by using by riffle box. The results are summarized as table 4.3 and the procedures are in the Annex A as follow:

Table 4.3 Result of Werabe sand

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
		12.5	100
Fine aggregate (Werabe)		9.5	100.00
		4.75	94.84
		2.36	81.54
		1.18	59.82
		0.6	34.21
		0.3	10.44
		0.15	1.93
		0.075	0.08
	Fineness Modules	3.17	
	Unit Weight	Roded	1684.56Kg/m^3
		Loose	1588.20Kg/ m^3
	Bulk Specific Gravity	2.55	
	Saturated-Surface-Dry Bases	2.57	
	Absorption Capacity (%)	0.72	
	Apparent Specific Gravity	2.60	
	Silt Content	6.96	
	Natural Moisture Content	0.45	

As shown the above results of Werabe sand Gradiation were discussed in the graph, which is between the upper and lower limit as ES.C.D3.201:1990. And the Remaing Werabe sand test results were between the standard limits,except the Silt Content.

4.1.2 Coarse Aggregates Result

The coarse aggregate sample was purposefully collected from the quarry sites were mostly used in Jimma town for the purpose of concrete production these are from Dedo-Werakolobo, Agaro-Chedero suse and Agaro Mohamed Miftah quarry sites. These aggregates laboratory tests were conducted in the (Ethiopian Constructions Works Corporation Transport Infrastructure Construction) ERA laboratory.

The samples of all coarse aggregate are depend on ASTM D75 and AASHTO T2 procedure of sampling method. And the results are listed below:

4.1.2.1 Test Result for Agaro-Chedero Suse Quarry Site (Tuba Crasher)

The samples for the test result were taken by quartering method where the quartering was a mechanical splitter. The results are summarized as table 4.5 below and the procedures are in the Annex A:

Table 4.4 Agaro-Chedero Suse quarry site result of coarse aggregate

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
Coarse aggregate (Agaro-Chedero Suse)		37.5	100
		19	32.23
		13.2	4.34
		9.5	1.25
		4.75	0.78
	Unit Weight	Roded	1647.86Kg/m^3
		Loose	1560.56Kg/ m^3
	Bulk Specific Gravity	2.92	
	Saturated-Surface-Dry Bases	2.97	
	Absorption Capacity (%)	1.06	
	Apparent Specific Gravity	3.01	

As shown the above results of Agaro-Chedero Suse Coarse aggregate Gradiation were discussed in the graph, which is out of the upper and lower limit as ES.C.D3.201:1990. And the Remaing Coarse aggregate test results were between the standard limits,but the Apparent Specific Gravity and Saturated-Surface-Dry Bases of the standard limit ASTM,Bulk Specific Gravity were out of BS & ASTM and Absorption Capacity was out of BS.

4.1.2.2 Test Result for Dedo-Werakolobo Quarry Site (Abdulsemed crasher)

The samples for the test result were taken by quartering method where the quartering was used by mechanical splitter. The results are summarized as table 4.6 and the procedures in the Annex B

Table 4.5 Result of Dedo-Werakolobo quarry site

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
Coarse aggregate (Dedo-Werakolobo)		37.5	100
		19	39.88
		13.2	1.43
		9.5	0.13
		4.75	0.07
	Unit Weight	Roded	1642.34Kg/m^3
		Loose	1519.98Kg/ m^3
	Bulk Specific Gravity	2.93	
	Saturated-Surface-Dry Bases	2.98	
	Absorption Capacity (%)	1.85	
	Apparent Specific Gravity	3.10	

As shown the above results of Dedo-Werakolobo Coarse aggregate Gradiation were discussed in the graph, which is out of the upper and lower limit as ES.C.D3.201:1990. And the Remaing Coarse aggregate test results were between the standard limits,but the Apparent Specific Gravity and Saturated-Surface-Dry Bases out of the standard limit ASTM, Bulk Specific Gravity were out of BS & ASTM and Absorption Capacity was out of BS.

4.1.2.3 Test Result for Agaro Quarry Site (Mohamed miftah crasher)

The samples for the test result were taken by quartering method where the quartering was used by mechanical splitter. The results are summarized as table 4.7 and the procedure shown in the Annex B

Table 4.6 Result for Agaro -Mohamed miftah quarry site

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
Coarse aggregate (Agaro -Mohamed miftah crasher)	Gradation	37.5	100
		19	42.02
		13.2	4.82
		9.5	1.42
		4.75	0.06
	Unit Weight	Roded	1591.07Kg/m^3
		Loose	1546.26Kg/ m^3
	Bulk Specific Gravity	2.91	
	Saturated-Surface-Dry Bases	2.96	
	Absorption Capacity (%)	1.56	
	Apparent Specific Gravity	3.05	

As shown the above results of Agaro -Mohamed miftah crasher Coarse aggregate Gradiation were discussed in the graph, which is out of the upper and lower limit as ES.C.D3.201:1990. And the Remaing Coarse aggregate test results were between the standard limits,but the Apparent Specific Gravity and Saturated-Surface-Dry Bases out of the standard limit ASTM, Bulk Specific Gravity were out of BS & ASTM and Absorption Capacity was out of BS.

The third objective was to compare the results of the engineering properties of the concrete making materials used in Jimma town construction projects with different standards. The difference is tabulated below:

4.2. Analysis and Discussion

In this section the findings on field observation and the laboratory results are discussed as the concrete materials used in Jimma town construction projects test results compare to various standards to evaluate the standard fulfillment of the selected samples which is used as concrete ingredients on building constructions in Jimma town. The discussions are made up on the results which are found in the field observation and the laboratory results as the following below:

4.2.1. Implementation on concrete ingredient on site

Concrete ingredients coarse and fine aggregates are delivered to the site in many forms; some will be in bulk or even bagged, while others are created, packaged or in pellet form. Obviously this affects distribution and storage on site, and while large quantities in bulk or loose. Quality control of concrete should start with a visual inspection of the ingredients as they deliver on site, combined with some quick, simple testing on the site. The concrete ingredient should be kept on their preferable stockpile on the construction site.

4.2.1.1 Implementation on aggregate

Aggregates are used about 75% of the concrete volume and there should be proper implementation on delivery and stockpiling on site; most sites are not implementing the proper method on the field. Aggregate should keep properly on the site on delivery and stockpiling as discussed below:

Aggregates should be stored so that they are kept as uniform as possible in grading and moisture content, and protected from intermingling and contamination by other materials. If clean, hard base is not provided, the bottom 300 mm of each aggregate pile should not be used, since dirt and water can accumulate there. It is essential to provide substantial partitions to separate the different aggregate sizes and to prevent spillage from one bay to another (Troxel, 1956).

Indian standard recommended to stock fine aggregate and coarse aggregate separately on hard, dry and level pitch of ground if such surface is not available a platform of planks or old corrugated iron sheets or floor of bricks or thin layer of lean concrete shall be made to prevent the admixture of clay, dust and vegetables or other vegetable matter specially fine aggregates must stocks in a place where loss due to the effect of wind is minimized.

4.2.2 Standardization of concrete Materials

In this section the laboratory result of the concrete ingredients which are found and mostly used in Jimma town building construction would be compare and discuss with the standards of ASTM, AASHTO, BS and ES as follows:

4.2.2.1 Aggregate

4.2.2.1.1. Gradation

A) For Fine Aggregate

As shown on the results of each fine aggregate were discussed in the graph which has the upper and lower limit as the following using Ethiopian standard

ES.C.D3.201:1990. (Standard E., Gradation Fine aggregate, 1990)

Grading is the particle-size distribution of an aggregate as determined by a sieve analysis (ASTM C 136 or AASHTO T 27). The aggregate particle size is determined by using wire-mesh sieves with square openings. The seven standard ASTM C 33 (AASHTO M 6/M 80) sieves for fine aggregate have openings ranging from 150 µm to 9.5 mm (No. 100 sieve to 3⁄8 in.). Other requirements of ASTM C 33 (AASTHO M 6) are:

1. The fine aggregate must not have more than 45% retained between any two consecutive standard sieves.
2. The fineness modulus must be not less than 2.3 nor more than 3.1, nor vary more than 0.2 from the typical value of the aggregate source. If this value is exceeded, the fine aggregate should be rejected unless suitable adjustments are made in proportions of fine and coarse aggregate (Steven H. and Kosmatka B. K.).

There are several reasons for specifying grading limits and nominal maximum aggregate size; they affect relative aggregate proportions as well as cement and water requirements, workability, pump ability, economy, porosity, shrinkage, and durability of concrete.

Variations in grading can seriously affect the uniformity of concrete from batch to batch. Very fine sands are often uneconomical; very coarse sands and coarse aggregate can produce harsh, unworkable mixtures. In general, aggregates that do not have a large deficiency or excess of any size and give a smooth grading curve will produce the most satisfactory results (Steven H. and Kosmatka B. K.).

Fine aggregate grading has a much greater effect on workability of concrete than does coarse aggregate grading. Along with the water and cement (and, in some cases, other mineral admixtures), the fine aggregate comprises the matrix in which the coarse aggregate resides. This matrix needs to coat the coarse aggregate particles and retain sufficient fluidity for placement purposes. Thus, the fine aggregate cannot be too coarse or harshness, bleeding, and segregation may occur. At the same time, if it is too fine, the additional surface area will require additional water and also may result in segregation. The grading in

ASTM C 33 is usually satisfactory, but as previously mentioned; deviations are permitted because certain areas do not have native material containing these sizes (Joseph F. Lamond J. H., 2006).

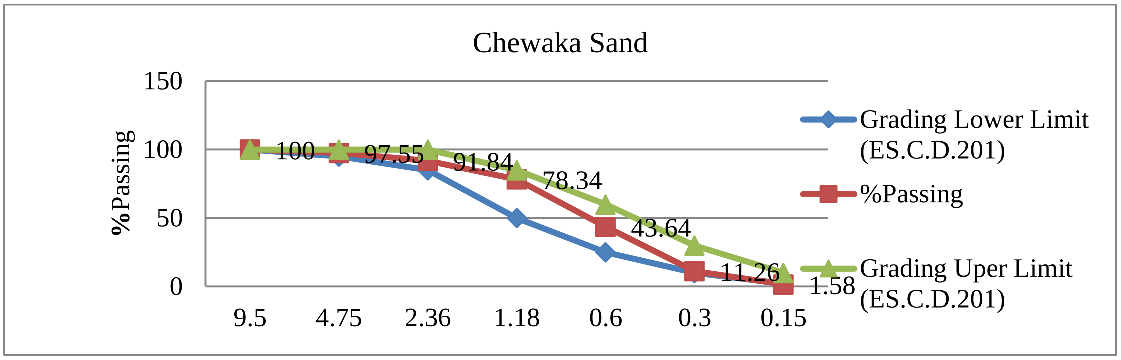

Figure 4.3 Chewaka Sand from Oromia region

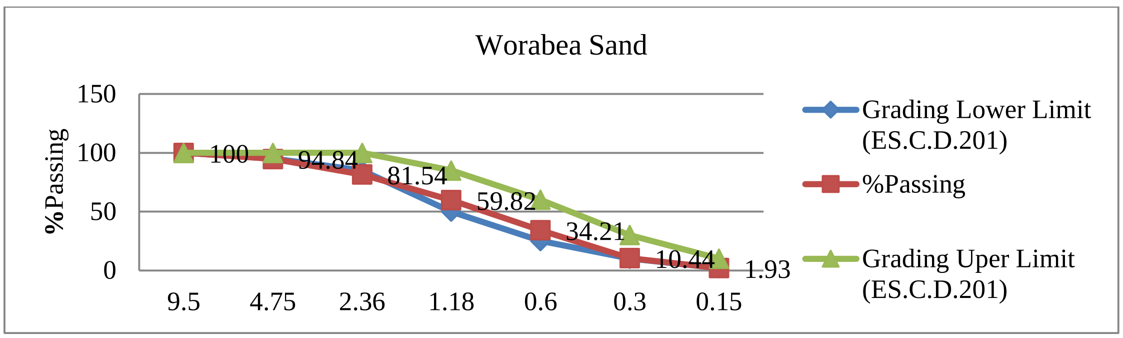

Figure 4.4 Worabea Sand form south region

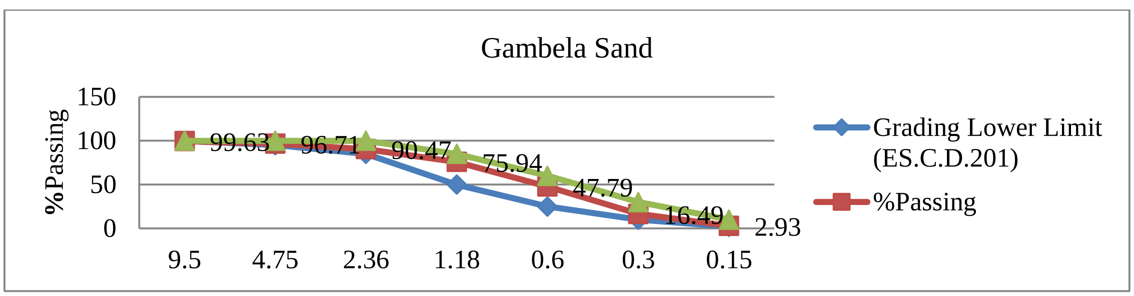

Figure 4.5 Gambela Sand from Gambela region

B) For Coarse Aggregate

To see the results satisfy the requirement set by Ethiopian standard (ESC.D3.201) and on ASTM C 33 (AASHTO M 80) permit a wide range. Gradation charts were prepared below for all results of coarse aggregates. (Standard E. S., Gradiation of Coarse aggregate, 201)

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 (Steven H. and Kosmatka B. K.).

As shown on the charts the coarse aggregates are well graded there have good interlock between the grading. It means that there is low permeability on the aggregate.

There are several reasons for specifying both grading limits and maximum aggregate size. Aggregates having a smooth grading curve and neither a deficiency nor an excess of any one particle size generally produce mixtures with fewer voids between particles. Because cement costs more than aggregate and the cement paste requirement for concrete increases with the increasing void content of the combined aggregate, 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 cement paste. Such 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 uneconomical concretes because of the larger surface area of finer particles, which requires additional cement (American Concrete Institute Supersedes, 2007).

One of the most important characteristics of the fine aggregate grading is the amount of material passing the 300 and 150 µm (No. 50 and 100) sieves. Inadequate amounts of materials in these size ranges can cause excessive bleeding, difficulties in pumping concrete, and difficulties in obtaining smooth troweled surfaces. Most specifications allow 10 to 30% to pass the 300 µm (No. 50) sieve, and 2 to 10% to pass the 150 µm (No. 100) sieve. ASTM C 33 permits the lower limits for percent passing the 300 and 150 µm (No. 50 and 100) sieves to be reduced to 5 and 0, respectively. A precautionary note in ASTM C 33 states that to alleviate potential problems with decreased fines, one can add entrained air, additional cement, or a supplementary cementitious material to supply the deficiency fines.

Many specifications permit a relatively wide range of grading for both fine and coarse aggregates. ASTM C 33, for example, states that fine aggregate failing to meet the sieve analysis requirements may be accepted if it is demonstrated that concrete made with the fine aggregate under consideration will have relevant properties at least equal to those of similar concrete containing a fine aggregate that conforms to the specification requirements and that is selected from a source having an acceptable performance record in similar concrete construction. Once a specific grading is selected, close control should be exercised to minimize variation. If wide variations in coarse aggregate grading occur on a given project, it may be necessary to adjust mixture proportions to produce workable concrete (American Concrete Institute Supersedes, 2007).

When the aggregate surface area increases, if the cement paste content is left constant, the thinner layers of paste surrounding the aggregate particles result in a stiffer concrete that is harder to place and compact. If the paste is made more fluid by adding water, the concrete strength and durability will suffer, while if more cement and water are added, the cost of the concrete increases. Consequently, it is best to avoid adding too much fine aggregate to a concrete mixture, and to avoid using extremely fine sand unless an intermediate aggregate is used in the batch proportions to fill in some of the missing sizes (Taylor, 2006).

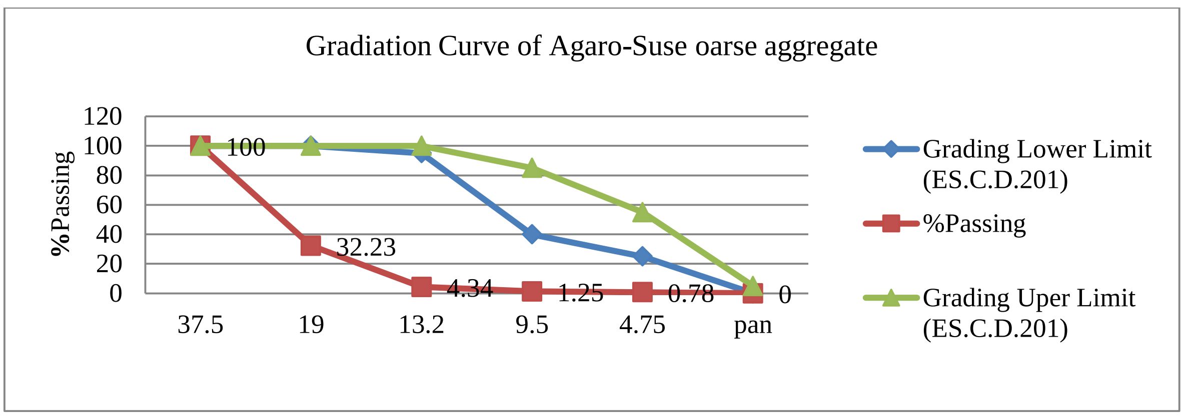

Figure 4.6 Gradiation Curve of Agaro-Suse oarse aggregate

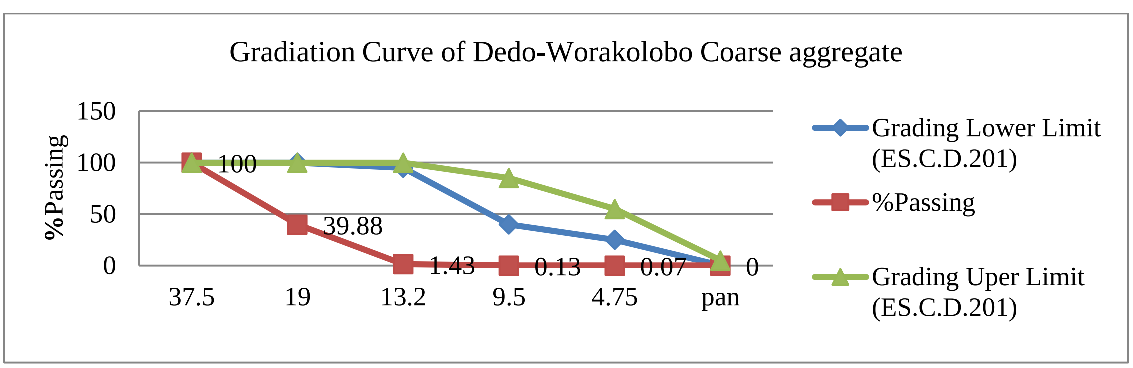

Figure 4.7 Gradiation Curve of Dedo-Worakolobo Coarse aggregate

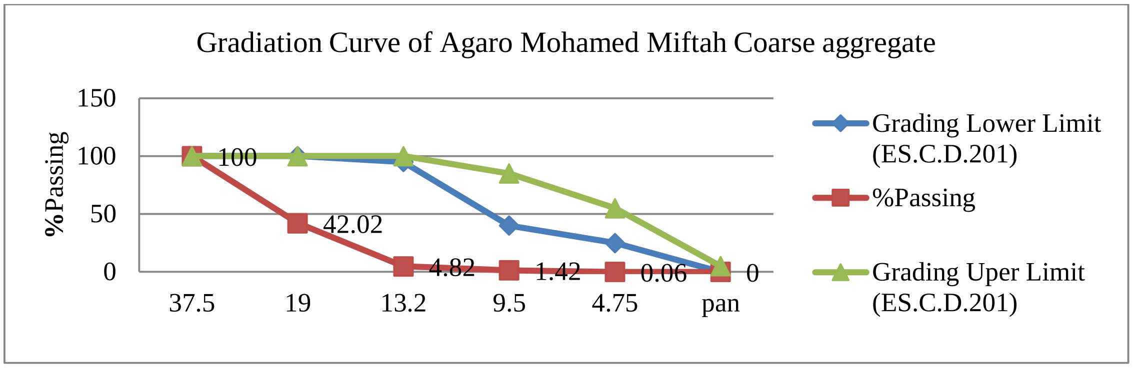

Figure 4.8 Gradiation Curve of Agaro Mohamed Miftah Coarse aggregate

4.2.2.1.2. Fineness modulus

A) For Fine Aggregate

The fineness modulus in Ethiopian standards stated as from 2.0 - 3.5 with the tolerance of ±0.2 and the results of the sands were investigated in the laboratory which are mostly used in Jimma town building constructions are full fill the requirements of the Ethiopian standard. (Ethiopian Standard, 1990)

Table 4.7 Fineness modulus

Types of test	Typ es of material	Test result	Standard limit (ESC.D3.201:1990)	Remark
Fineness modulus	Chewaka	2.4	Between 2.0-3.5	Between the standard limit
	Werabe	2.63		Between the standard limit
	Gambella	4.72		Out of the standard limit

If the base fineness modulus differs from that used in selecting proportions of the concrete, suitable adjustments must be made in the proportions of fine and coarse aggregate. As the fineness modulus of the fine aggregate decreases (aggregate becomes finer), a lower percentage of sand in the total aggregate will be required or the amount of coarse aggregate that may be used increases. It is often more economical to maintain uniformity in producing and handling aggregates than to adjust proportions for variations in grading (American Concrete Institute Supersedes, 2007).

4.2.2.1.3. Unit weight

A) For fine aggregate

In the Ethiopian standards and other standards, there is no limit for the compacted and loose unit weight. However, ASTM refers as good compacted unit weight ranges between 1450 and 1750 kg/m3 (ASTM C29) (Sidney Mindess U. o.-2.). So the entire tested fine aggregate the result is shown as it is in the range of the ASTM standard requirements. It fulfills the requirements of the unit weight.

Table 4.8 Unit weight

Type of test	Type of material	Test result	Standard limit (ASTM C29)	Remark
Compacted unit weight	Chewaka	1639.31kg/m^3	1450 – 1750kg/m^3	Between the standard limit
	Werabe	1684.56 kg/m3		
	Gambella	1621.76 kg/m3		
Loose unit weight	Chewaka	1527.73 kg/m3	1450 – 1750kg/m^3	
	Werabe	1588.20 kg/m3		
	Gambella	1494.24 kg/m3		

B) For coarse aggregate

For the compacted and loose unit weight nothing stated in the Ethiopian standard. However, ASTM refers as good compacted unit weight ranges between 1450 – 1750 kg / m^3 (ASTM C29) (Sidney Mindess U. o.-2.).In the conducted coarse aggregate tests all the results satisfy the requirement of ASTM C29 and it's preferable to use in the mix.

Table 4.9 Unit weight for coarse aggregate

Type of test	Type of material	Test result	Standard limit (ASTM C29)	Remark
Compacted unit weight	Agaro_suse	1647.86 kg/m^3	1450 – 1750kg/m3	Between the standard limit
	Dedo-Worakolobolobo	1642.34 kg/m3		
	Agaro.mohamed mifitah	1591.07 kg/m3		
Loose unit weight	Agaro_suse	1560.56 kg/m3	1450 – 1750kg/m3	
	Dedo-Worakolobolobo	1519.98 kg/m3		
	Agaro.mohamed mifitah	1546.26 kg/m3		

Bulk density depends on the moisture content of the aggregate. For coarse aggregate, increasing moisture content increases the bulk density; for fine aggregate, however, increasing moisture content beyond the saturated surface-dry condition can decrease the bulk density. This is because thin films of water on the sand particles cause them to stick together so that they are not as easily compacted. The resulting increase in volume decreases the bulk density. This phenomenon, called ―bulking, is of little importance if the aggregates for a concrete mixture are batched by mass, but must be taken into account if volumetric batching is used and moisture content varies.

Other properties that affect the bulk density of an aggregate include grading, specific gravity, surface texture, shape, and angularity of particles. Aggregates having neither a deficiency nor an excess of any one size usually have a higher bulk density than those with a preponderance of one particle size. Higher specific gravity of the particles results in higher bulk density for a particular grading, and smooth rounded aggregates generally have a higher bulk density than rough angular particles of the same mineralogical composition and grading (American Concrete Institute Supersedes, 2007).

4.2.2.1.4. Specific Gravity

A) For Fine Aggregate

The requirement of specific gravity for fine aggregate in Ethiopian standard (ES.C.D3.201:1990) refers that it should be in the range of between 2.4 and 3.The results of fine aggregate were the samples taken for specific gravity are all in the requirements of the Ethiopian standard. (Ethiopian, 1990)

Table4.10 Bulk Specific Gravity and Saturated-Surface-Dry Bases (SSD)

Type of test	Type of material	Test result	Standard limit (ES.C.D3.201)	ASTM C117	BS BSEN1097-3	Remark
Bulk Sp. Gr'ty	Chewaka	2.65	2.4 - 3	2.4 - 2.9	2.0-2.6	B/n standard limits; ES,BS & ASTM
	Werabe	2.55				
	Gambella	2.54				
Saturated-Surface-Dry Bases	Chewaka	2.66	2.4 - 3	2.4 - 2.9	2.6-2.7	B/n standard limits; ES,BS & ASTM
	Werabe	2.57				
	Gambella	2.55				

Table 4.11 Absorption Capacity (%) and Apparent Specific Gravity

Type of test	Type of material	Test result	Standard limit ES	ASTM C127	BS BS 812-2	Remark
Absorption Capacity (%)	Chewaka	0.19	no std'd limit	0.2 - 4%	2-7%	B/n standard limit of ASTM, but out of ES
	Werabe	0.72				
	Gambella	0.26				
Apparent S.Gr'y			ES.C.D3.201	ASTM C33	BS 812-2	
	Chewaka	2.67	2.4 - 3	2.4 - 2.9	2.6-2.7	B/n standard limits, ASTM,BS,ES
	Werabe	2.60				
	Gambella	2.56				

4.2.2.1.5. Silt content

For Fine Aggregate

In the Ethiopian standards (ESC.D3.201) the allowable limit for silt/clay content is recommended not to exceed a value of 5%. (Standard E. , Silt/Clay Content, 201).And in the ASTM C117 states that the allowable limit is maximum 5%.

Table 4.12 Silt content

Types of test	Types of material	Test result	Standard limit			Remark
			(ES. C.D3.201)	ASTM C117	BS BS 812-103	
Silt content	Chewaka	6.702	5%	Max 5%	≤ 2%	Out of the max. standard limit
	Werabe	6.96				Out of the max. standard limit
	Gambella	2.88				In the standard limit

B) For Coarse Aggregate

The Ethiopian standard requires for the specific gravity of the coarse aggregate should be in the range of between2.4-3. (Ethiopian, 1990)

Table 4.13 Bulk Specific Gravity and Saturated-Surface-Dry Bases (SSD)

Type of test	Type of material	Test result	Standard limit ES.C.D3.201	ASTM C117	BS	Remark
Bulk Sp. Gr’ty	Agarosuse	2.94	2.4 - 3	2.4-2.9	2.0-2.6	B/n ES standard limit, out of BS & ASTM
	Dedo	2.97				
	Agaro-Mohamed miftah	2.91				
Saturated -Surface-Dry Bases	Agarosuse	2.97	2.4 - 3	2.4-2.9	> 2.6	Out of the standard limit ASTM, But B/n ES & BS standard limits
	Dedo	3.02				
	Agaro-Mohamed miftah	2.97				
Apparent S.Gr’y				ASTOMC127-04	BS812-102-1995	
	Agarosuse	3.01	2.4 - 3	2.4-2.9	> 2.6	Out of the standard limit of ES & ASTM, But fulfill BS
	Dedo	3.10				
	Agaro-Mohamed miftah	3.05				

Each aggregate particle is made up of solid matter and voids that may or may not contain water. Because the aggregate mass varies with its moisture content, specific gravity is determined at fixed moisture content. Four moisture conditions are defined for aggregates depending on the amount of water held in the pores or on the surface of the particles.

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, excluding the voids between particles.

In a given concrete mixture, substituting one aggregate with another of a different specific gravity will cause the volume of concrete (yield) to change for the same batch mass. Because concrete is often sold by volume, this change means either that the purchaser is receiving less concrete than ordered or the producer is supplying more concrete than purchased. Changes in the aggregate specific gravity also cause the concrete density to change. This is undesirable if a minimum density is specified, for example, in heavyweight concrete for nuclear-radiation shielding. While the specific gravity of an aggregate is not a measure of aggregate quality, a variation in the specific gravity may indicate a change in the aggregate characteristics (American Concrete Institute Supersedes, 2007)

4.2.2.1.6. Water Absorption

A) For Fine Aggregate

For the water absorption there is no requirement on Ethiopian standard. However, ASTM states that the range of water absorption of fine aggregate is between 0.2 and 4% with respect to ASTM C 127. So all the results of fine aggregate were conducted have the range of ASTM states. (ASTM, Water Absorption)

Table 4.14 Water absorption of fine aggregate

Type of test	Type of material	Test result %	Standard limit ES	Standard limit (ASTM C127)	BS	Remark
Water Absorption	Chewaka	0.19	No standard limit	0.2 - 4%	1-2%	B/n standard limits of ASTM, But Under BS
	Werabe	0.72				
	Gambella	0.26				

B) For Coarse Aggregate

For the water absorption according to ASTM standard should lie in the range of between 0.2 and 4% (ASTM C127). For the coarse aggregate which conducted for water absorption all the results satisfy the requirement of ASTM standard. (ASTM, Water Absorption)

Table 4.15 Water absorption of Coarse Aggregate

Type of test	Type of material	Test result %	Standard limit ES	Standard limit (ASTM C127)	BS 812-2	Remark
Water Absorption	Agaro-suse	1.06	No limit	0.2 - 4%	0.5-1%	B/n the standard limits ASTM, But out of BS
	Dedo-worakolobo	1.85				
	Agaro-Mohamed miftah	1.56				

Aggregates stockpiled on the job are seldom in either of these states. They usually carry some free or surface moisture that becomes part of the mixing water. Freshly washed coarse aggregates contain free water, but because they dry quickly, they are sometimes in an air-dry state when used, and they absorb some of the mixing water.

At this point, it is necessary to define the terms ―mixing water and ―w/cm. the mixing water in a batch of concrete is all the water present in the concrete, with the exception of absorbed water within aggregate particles. Absorption is a measure of the total pore volume accessible to water, and is usually calculated using the results from a specific gravity determination (ASTM C 127 and C 128) (American Concrete Institute Supersedes, 2007).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

In this research some of the problems associated with Standard, implementing of coarse and fine aggregates in Jimma town building constructions investigated in the field and laboratory to show the standard implementation on the coarse and fine aggregates. The following conclusion and recommendation are drawn out from the assessments undertaken on the building construction projects which are found in Jimma town.

5.1Conclusion

Standard implementation of the coarse and fine aggregate is a key aspect for the building construction projects materials. It is a known fact that, the coarse and fine aggregates should have keep standard limitation, it‘s one of the most important aspects of standard controlling in the building construction projects.

It‘s found out from the test result the fine aggregates have silt more than the standard limit content the Chewaka and Worabe sands and Fineness modulus of Gambella sand was out of the standard limit . For fine aggregate the gradation result shown that there is coarser than the finer parts of sand. In addition, since the supply aggregates vary widely from one to the other the contractors are always in problem to keep the standard limitation of concrete making materials and producing concrete which satisfies the standard grade requirements with washing the Chewaka and Worabe sands .

The gradation on coarse aggregate shows that on quarry sites, unfortunatilly it‘s shows that under standard limits. And the reaming coarse aggregates tests,not uniformly fulfill, but satisfy the requirements of the standard except the apparent specific gravity of coarse aggregate. However the coarse aggregate are fulfill the quality test for making concrete,but it need blending .

All most all of the observed construction projects are used tap water for the concrete mixing, and there is no any difficulty in concrete mixing water.

5.2 Recommendation

The following recommendations have been made to improve the standard of coarse and fine aggregates at Jimma town construction projects. First of all there should be co-related on the client, contractor and consultant for both parties responsible for standard control and assurance of the coarse and fine aggregates on the projects. Generally the following recommendations are the major add ups by this study.

Jimm town administration should create awareness about to keep quality standards of Coarse and Fine aggredates.

Government Construction control Desk

- ✓ Should give inspection and standards on every delivery of the materials on site
- ✓ Should ask and control the contractor to prepare and submit the results of every test of the materials and evaluate.

Contractors

- ✓ The coarse and fine aggregates should be check and test the standards on the production sites and on every delivery of the materials before in the uses of mixing on construction sites.
- ✓ It should be check physical condition of the dump materials before use concrete work.

Consultants

- ✓ On the construction sites there should be proper control the standard of delivery of the concrete materials.
- ✓ Should give inspection for every delivery of the concrete materials standard limits and check the stockpile and storage of the materials standard limitation.
- ✓ Should assign material engineers to control and check materials standards in production sites and the construction projects.

Recommendation for further study

This research studied some of the basic concrete making material standard limits in Jimma town, due to shortage of budget and time, however there some points that needs a further study concrete making materials standard.

- ✓ It studies the source standard coarse and fine aggregates position.

- ✓ It is necessary to repeat this research periodically to observe the engineering properties of the coarse and fine aggregates and standard limitation.

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7 ANNEX

ANNEX-A

PROCEDURE OF FINE AGGREGATE

EXPERIMENT – 1

GRAIN SIZE A OF FINE AGGREGATE / TESTING OF AGGREGATES

Objective

NALYSIS

This test used to determine the particle size distribution of fine aggregates.

Theory

Aggregates make up 65% to 75% of the volume of concrete. Therefore the quality of concrete produced is very much influenced by the properties of its aggregates. Sieve analysis is a procedure to determine the particle size distribution of aggregates using a series of square or round opening starting with the largest. It is used to determine the grading or aggregates and the fineness modulus, an index to the fineness and the coarseness and uniformity of aggregates. After this analysis is carried out, aggregates are described as well graded, poorly graded, uniformly graded, gap graded, etc. Each of the above aggregates categories has close association with a range of quality of concrete produced using the aggregate.

Apparatus

Balance, Series of sieves, Shovel, Sieve brush, and Sieve Shaker

II. Procedure for grading fine aggregates

1. Taking 2 kg of sample of fine aggregates
2. Quartering the sample using riffle box
3. From the quartered sample we have taken 500g
4. Place the pan to the bottom of the sieve shaker and put the other sieves into the pan with increasing opening seizes of the sieves
5. Placing 500g of the sample on the top of sieve (having large opening size)
6. Shaking the sample about two minutes in the sieve
7. Weighing the aggregate retained on each sieve
8. Calculating the percentage of the weight retained on each sieve
9. Fill in the gradation chart and calculate the fineness modules

Test results
Chewaka Sand
Table A1

Trial 1 Sample-wet weight – 540.4 gm. Dry weight- 513.13 gm.					
Sieve size, mm.	Weight retained (gm.)	% retained (gm.)	cum % pass	Cumulative % of Retained	% Passing
12.5	0.00	0.00	0.00	0.00	0.00
9.5	10.10	0.99	100.00	1.97	100.00
4.75	29.40	2.88	98.03	7.69	98.03
2.36	83.90	8.23	92.31	24.02	92.31
1.18	175.30	17.19	75.98	58.14	75.98
0.6	158.70	15.56	41.86	89.02	41.86
0.3	48.60	4.77	10.98	98.48	10.98
0.15	7.60			279.31	1.52
0.075	0.20				279.31
	513.8				
Fineness Modulus				2.79	

Trial 2 Sample-wet weight – 532.1 gm. Dry weight- 512.4 gm.					
Sieve size, mm.	Weight retained (gm.)	% retained (gm.)	cum % pass	Cumulative % of Retained	% Passing
12.5	0	0.00	0.00	0.00	100.00
9.5	15.6	100.00	0.00	3.05	100.00
4.75	27	96.91	3.09	8.32	96.95
2.36	69.8	91.35	8.65	21.95	91.68
1.18	164.3	77.79	22.21	54.03	78.05
0.6	173.9	44.31	55.69	87.99	45.97
0.3	52.3	10.67	89.33	98.20	12.01
0.15	9.1	2.41	97.59	273.54	1.80
0.075	0.1		276.56		
	512.1				
Fineness Modulus				2.74	

Table A2

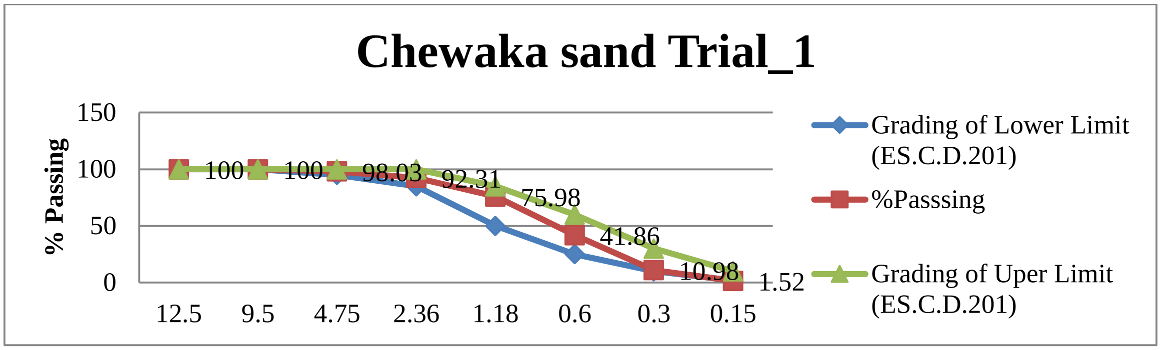

Figure A 1

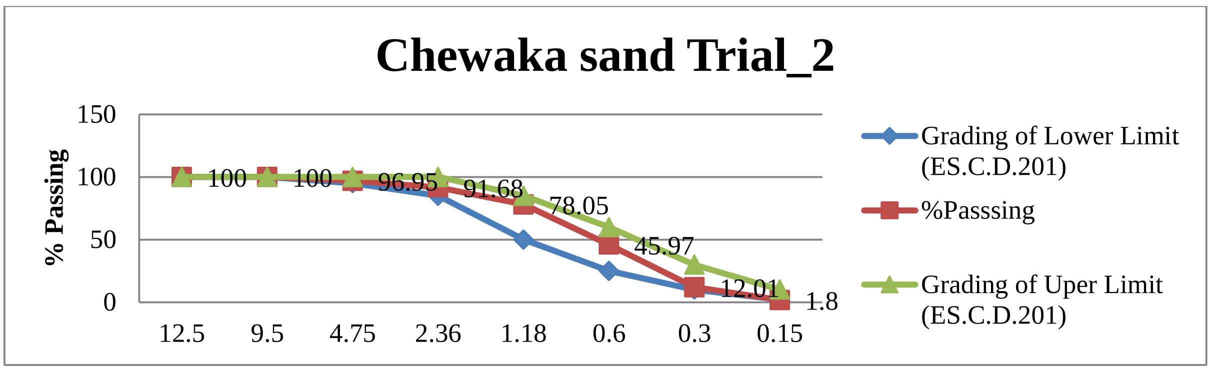

Figure A2

Table A3

Trial 3 Sample-wet weight – 542.5 gm. Dry weight- 523.93 gm.					
Sieve size, mm	Weight retained, gm.	% retained (gm.)	cum % pass	Cummulative % of Retained	% Passing
12.5	0.00	0.00	0.00	0.00	100.00
9.5	12.30	1.19	1.19	2.35	100.00
4.75	32.10	3.11	4.31	8.47	97.65
2.36	55.60	5.40	9.70	19.07	91.53
1.18	198.40	19.25	28.96	56.89	80.93
0.6	169.50	16.45	45.41	89.21	43.11
0.3	49.10	4.76	50.17	98.57	10.79
0.15	7.20	0.70	50.87	274.55	1.43
0.075	0.30	0.03	50.90		
	524.5		241.50		

Fineness Modulus		2.75

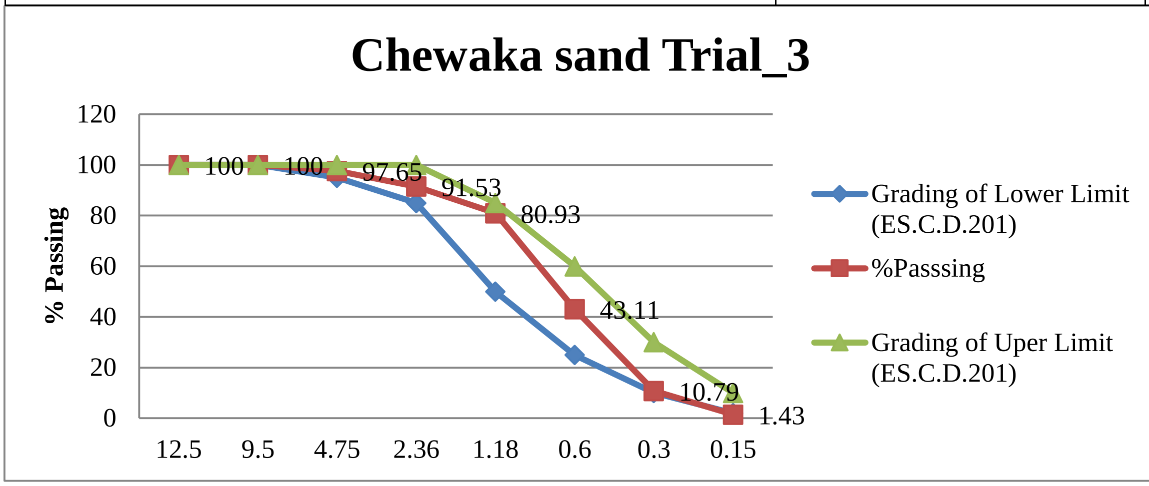

Figure A3

Werabe Sand

Table A4

Trial 1 Sample-wet weight – 556.4 gm. Dry weight- 535.0 gm.					
Sieve size, mm.	Weight retained (gm.)	% retained (gm.)	cum % pass	Cumulative % of Retained	% Passing
12.5	0.00	0.00	0.00	0.00	100.00
9.5	36.80	3.54	3.54	6.89	93.11
4.75	71.70	6.89	10.43	20.32	79.68
2.36	102.60	9.87	20.30	39.53	60.47
1.18	136.60	13.13	33.43	65.11	34.89
0.6	121.50	11.68	45.12	87.87	12.13
0.3	52.40	5.04	50.15	97.68	2.32
0.15	11.80	1.13	51.29	317.40	100.00
0.075	0.60	0.06	51.35		48.65
pan	534		265.6		
Fineness Modulus				3.17	

Table A5

Trial 2 Sample-wet weight -543.3 gm. Dry weight-522.1 gm.					
Sieve size, mm.	Weight retained (gm.)	% retained (gm.)	Cum % pass	Cum % Retained	% Passing
12.5	0.00	0.00	0.00	0.00	100.00
9.5	22.70	2.21	2.21	4.35	95.65
4.75	70.50	6.86	9.07	17.88	82.12
2.36	107.90	10.50	19.58	38.58	61.42
1.18	143.00	13.92	33.50	66.01	33.99
0.6	111.60	10.86	44.36	87.42	12.58
0.3	52.80	5.14	49.50	97.54	2.46
0.15	12.20	1.19	50.69	311.78	0.12
0.075	0.60	0.06	50.74		
pan	521.3		259.64		
Fineness Modulus				3.12	

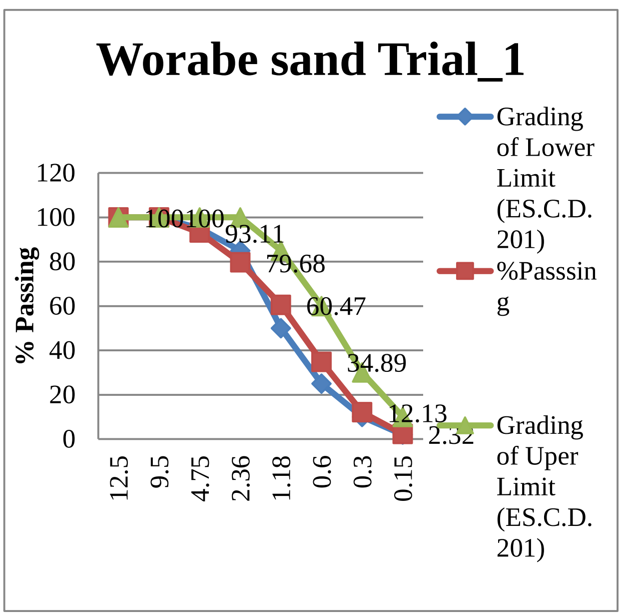

Figure A 4

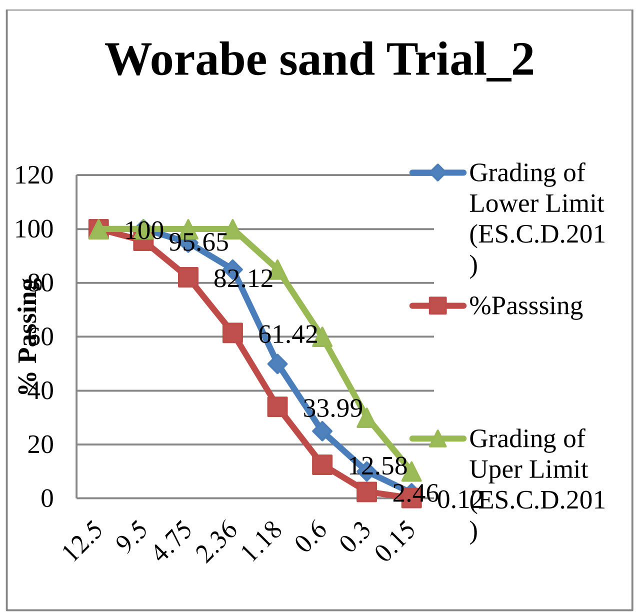

Figure A 5

Table A6

Trial 3 Sample-wet weight -538 gm.			Dry weight-517.1 gm.		
Sieve size, mm.	Weight retained (gm.)	% retained (gm.)	cum % pass	Cumulative % of Retained	% Passing
12.5	0.00	0.00	0.00		100.00
9.5	21.50	2.10	2.10	0.00	100.00
4.75	66.80	6.54	8.64	4.17	95.83
2.36	130.80	12.80	21.44	17.12	82.88
1.18	122.70	12.01	33.45	42.48	57.52
0.6	140.30	13.73	47.18	66.27	33.73
0.3	28.50	2.79	49.97	93.47	6.53
0.15	5.10	0.50	50.47	98.99	1.01
0.075	0.10	0.01	50.48	322.49	
pan	515.84		263.74		
Fineness Modulus				3.22	

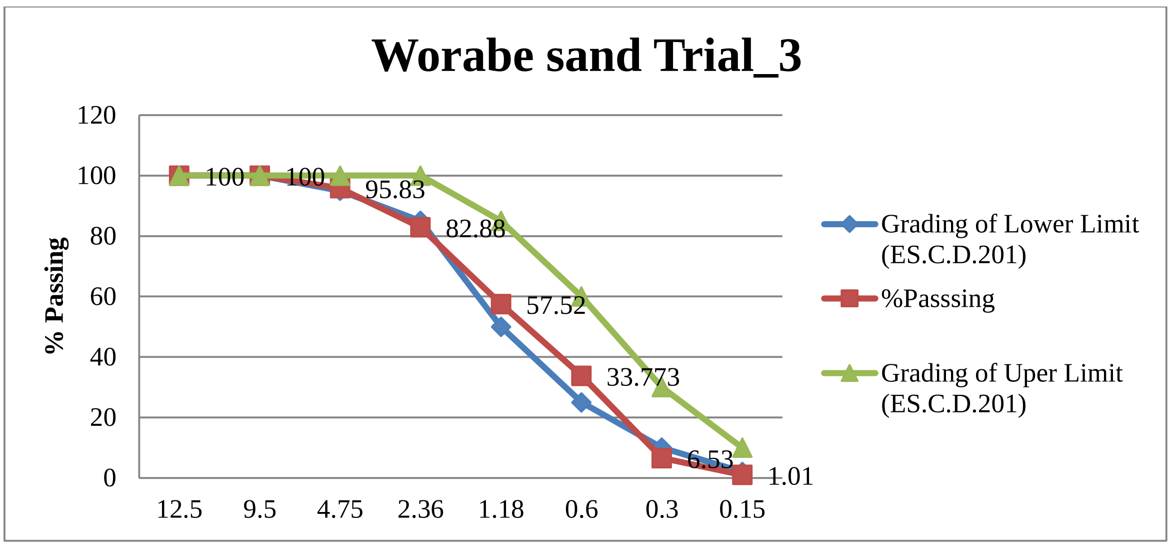

Figure A 6

Gambela Sand

Table A7

Trial 1 Sample-wet weight – 521.5 gm. Dry weight-541.3 gm.					
Sieve size, mm.	Weight retained (gm.)	% retained (gm.)	cum % pass	Cummulative % of Retained	% Passing
12.5	0.00	0.00	0.00		100.00
9.5	0.00	0.00	0.00	0.00	100.00
4.75	10.10	1.97	1.97	1.97	98.03
2.36	29.40	5.72	7.69	7.69	92.31
1.18	83.90	16.33	24.02	24.02	75.98
0.6	175.30	34.12	58.14	58.14	41.86
0.3	158.70	30.89	89.02	89.02	10.98
0.15	48.60	9.46	98.48	98.48	1.52
0.075	7.60	1.48	99.96	279.31	0.04
pan	0.20	0.04	100.00		0.00
	513.80		455.25		
Fineness Modulus				2.79	

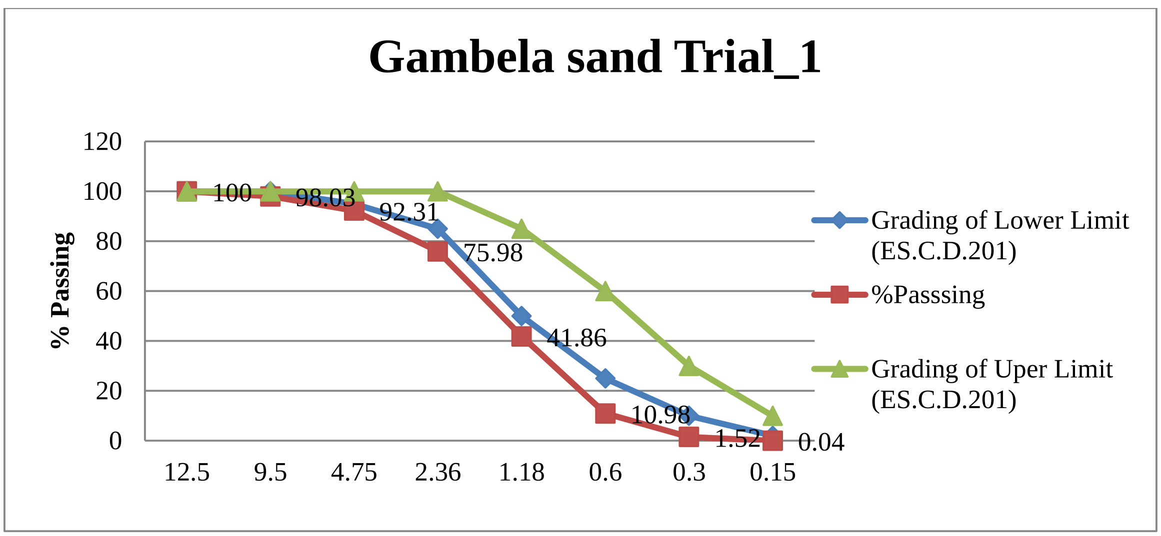

Figure A 7

Table A8

Trial 2 Sample-wet weight – 522.7 gm. Dry weight- 515.4 gm.					
Sieve size, mm	Weight retained (gm.)	% retained (gm.)	cum % pass	Cumulative % of Retained	% Passing
12.5	0.00	0.00	0.00		100.00
9.5	0.00	0.00	0.00	0.00	100.00
4.75	15.90	3.09	3.09	3.09	96.91
2.36	28.60	5.56	8.65	8.65	91.35
1.18	69.80	13.56	22.21	22.21	77.79
0.6	172.30	33.48	55.69	55.69	44.31
0.3	173.10	33.64	89.33	89.33	10.67
0.15	42.50	8.26	97.59	97.59	2.41
0.075	9.90	1.92	99.51	276.56	0.49
pan	2.50	0.49	100.00		0.00
	514.60		476.08		
Fineness Modulus				2.77	

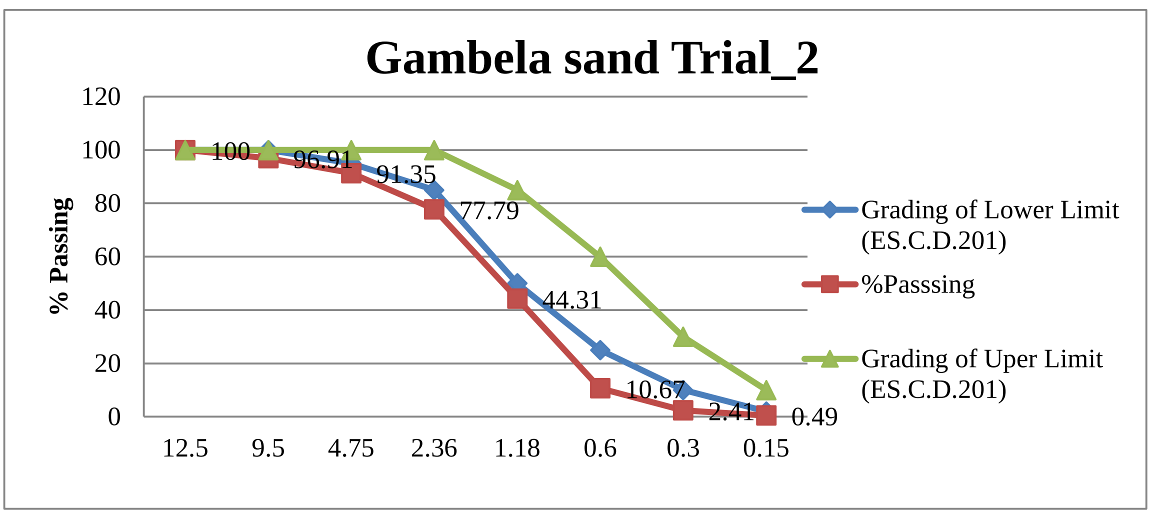

Figure A 8

Table A9

Trial 3 Sample-wet weight –538.4gm. Dry weight- 530.6gm.					
Sieve size, mm	Weight retained (gm.)	% retained (gm.)	cum % pass	Cumulative % of Retained	% Passing
12.5	0.00	0.00	100		100
9.5	5.70	1.08	1.08	1.08	98.92
4.75	19.50	3.68	4.76	4.76	95.24
2.36	39.20	7.41	12.17	12.17	87.83
1.18	72.70	13.74	25.90	25.90	74.10
0.6	90.80	17.15	43.06	43.06	56.94
0.3	155.80	29.44	72.49	72.49	27.51
0.15	120.10	22.69	95.18	95.18	4.82
0.075	23.60	4.46	99.64	254.64	0.36
Pan	1.90	0.36	100.00		0.00
	529.30		454.28		
Fineness Modulus				2.55	

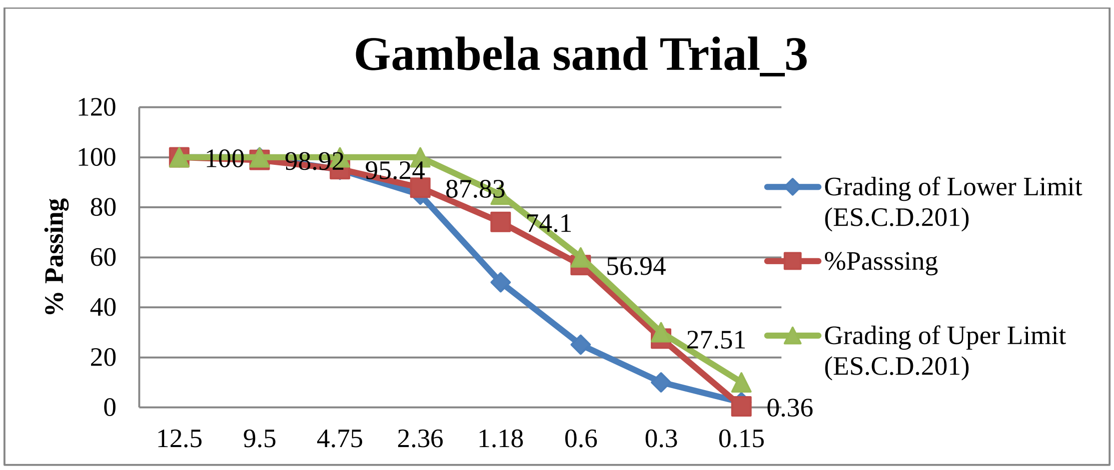

Figure A9

Experment-1

Gradation With Different Standards

Comparison Of Chewaka, Worabe And Gambela Sands With Standards

Table A 10 Comparison of Chewaka sand with standards

Material Type	Types Test	Result		EBCS-2, 1995	ES ES C.D3.201	ASTM C-33-02a	BS 882:1992
		Sieve size (mm)	% Passing	% Passing Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	% Passing	% Passing	% Passing
Chewaka Sand	Gradation	9.5	100		100	100	100
		4.75	98.76		95-100	95-100	89-100
		2.36	98.88		80-100	80-100	60-100
		1.18	89.06		50-85	50-85	30-100
		0.6µm	71.52		25-60	25-60	15-100
		0.3 µm	55.16		10-30	5-30	5-70
		0.15 µm	50.27		2-10	0-10	0-15

Comparison of Chewaka sand with standards

Table A 11

Material Type	Types Test	Result		EBCS-2, 1995	ES	ASTM	BS
Chewaka Sand	Fineness Modules	2.40		Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates. ES there is no limit ES there is no limit ES	ESC.D3.201:1990	ASTM C-33-01	BS 812
					2.0-3.5	2.3-3.1	2.20-2.60
	Unit Weight	Loose	1639.31Kg/m^3		ASTM117	ASTM117	*ASTM117*
					1520 – 1680	1520 – 1680	1320-1680
		Roded	1527.73Kg/ m^3		1520 – 1680	1520 – 1680	1520 – 1680
	Bulk Sp. Gr'ty	2.65			ES. C. D3. 201	ASTM C128	BSEN1097-3
					2.4 - 3	2.4 - 2.9	2.0– 2.60
	Saturated-Surface-Dry Bases	2.66			(ES. C. D3. 201).	ASTM C 127	BS 812-2
					2.4 - 3	2.4 - 2.9 %	> 2.6
	Absorption Capacity (%)	0.19			ES	ASTM C127	BS 812-2
					No req't, ES	0.2 - 4%	< 2%
	Apparent S.Gr'y	2.67			(ES. C. D3. 201).	ASTM C 33	BS 812-2
					2.4 - 3	2.4 - 2.9	> 2.6
	Silt Content	6.702			ES. C. D3. 201	(ASTM C 117)	BS 812-103
					5%	Max 5%	≤ 2%
	Natural Moisture Content	0.27			ES	ASTM C56	BS 812-109
						2% to 6%	1–3%

Comparison of worabe sand with standards

Annex Table A 12

Material Type	Types Test	Result		EBCS-2, 1995	ES	ASTM	BS
		Sieve size (mm)	% Passing	% Passing	% Passing	% Passing	% Passing
worabe sand	Gradation	9.5	100	Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	100	100	100
		4.75	97.38		95-100	95-100	89-100
		2.36	90.61		80-100	80-100	60-100
		1.18	79.56		50-85	50-85	30-100
		0.6µm	66.54		25-60	25-60	15-100
		0.3 µm	54.45		10-30	5-30	5-70
		0.15 µm	50.12		2-10	0-10	0-15

Comparison of worabe sand with standards

Table A 13

Material Type	Types Test	Result		EBCS-2, 1995	ES	ASTM	BS
worabe sand	Fineness Modules	2.63		Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	ESC.D3.201:1990	ASTM C-33-01	BS 812
					2.0-3.5	2.3-3.1	2.20-2.60
	Unit Weight	Loose	1639.31Kg/m³		*ASTM C29*	ASTM117	*ASTM117*
					1245-1825	1520 – 1680	1320-1680
		Roded	1527.73Kg/ m³		1245-1825	1520 – 1680	1520 – 1680
	Bulk Sp. Gr'ty	2.65			ES. C. D3. 201	ASTM C143	BSEN1097-3
					2.4 - 3	2.6-2.7	2.0– 2.60
	Saturated-Surface-Dry Bases	2.66			(ES. C. D3. 201).	ASTM C 127	BS 812-2
					2.22– 2.78	2-6%	> 2.6
	Absorption Capacity (%)	0.19			ES	ASTM C127	BS 812-2
					No req't, ES	0.2 - 4%	< 2%
	Apparent S.Gr'y	2.67			(ES. C. D3. 201).	ASTM C 33	BS 812-2
					2.56 – 2.89	2.64	> 2.6
					ES. C. D3. 201	(ASTM C 117)	BS 812-103
	Silt Content	6.702			5%	Max 5%	≤ 2%

	Natural Moisture Content	0.27		ES	ASTM C56	BS 812-109
					2% to 6%	1–3%

Comparison of Gambela sand with standards

Table A 13

Material Type	Types Test	Result		EBCS-2, 1995	ES ES C.D3.201	ASTM C-33-02a/ C33M-13	BS 882:1992 BS812-103
Chewaka Sand	Gradation	Sieve size (mm)	% Passing	% Passing	% Passing	% Passing	% Passing
		9.5	98.18	Art.8.2.2.2 aggregates (1) Ingeneral aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	100	100	100
		4.75	96.30		95-100	95-100	89-100
		2.36	90.06		80-100	80-100	60-100
		1.18	75.73		50-85	50-85	30-100
		0.6µm	47.59		25-60	25-60	15-100
		0.3 µm	16.27		10-30	5-30	5-70
		0.15 µm	2.92		2-10	0-10	0-20

Comparison of Gambela sand with standards

Table A14

Material Type	Types Test	Result		EBCS-2, 1995	ES	ASTM	BS
Gambela Sand	Fineness Modules	4.72		Art.8.2.2.2 aggregates (1) Ingeneral aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	ESC.D3.201:1990	ASTM C-33-01	BS 812
					2.0-3.5	2.3-3.1	2.20-2.60
	Unit Weight	Loose	1494.24Kg/m^3		ASTM117	*ASTM C29*	*ASTM C29*
					1520 – 1680	1520 – 1680	1320-1680
		Roded	1621.76Kg/ m^3		1520 – 1680	1520 – 1680	1520 – 1680
	Bulk Sp. Gr'ty	2.54			ES. C. D3. 201	ASTM C127	BSEN1097-3
					2.4 - 3	2.4-2.9	2.0 – 2.60
	Saturated-Surface-Dry Bases	2.55			(ES. C. D3. 201).	ASTM C127	BS 812-2
					2.22– 2.78	2.4-2.9	> 2.6
	Absorption Capacity (%)	0.26			ES	ASTM C127	BS 812-2
					No req't, ES	0.2 - 4%	≤ 2%
	Apparent S.Gr'y	2.56			(ES. C. D3. 201).	ASTM C127	BS 812-2
					2.56 – 2.89	2.4-2.9	> 2.6
	Silt Content	2.88			ES. C. D3. 201	(ASTM C 117)	BS 812-103
					5%	Max 5%	≤ 2%
	Natural Moisture Content	0.35			ES	ASTM C56	BS 812-109
						2% to 6%	1–3%

EXPERIMENT-2

Unit Weight Of Aggregates

Objective

This method is used to determine the unit weight of fine aggregates

Theory

Unit weight can be defined as the weight of a given volume of graded aggregate. It is thus a density measurement and also known as bulk density. The unit weight effectively measures the volume that the graded aggregate will occupy in concrete and includes both the solid aggregate particles and the voids b/n them.

Apparatus

Balances, Tamping rods, Buckets, and Teenier

Capacity, (lit)	Inside diameter,[mm]	Inside height,[mm]	Minimum thickness of metal,[mm]		Maximum nominal of aggregate (mm)[a]
			Bottom	Wall	
3	155±2	160±2	5.0	2.5	12.5
10	205±2	305±2	5.0	2.5	25
15	255±2	295±2	5.0	3.0	37.5
30	355±2	305±2	5.0	3.0	100

I. Compact weight determinations coarse and fine aggregates

Rodding procedure:

1. We have filled the measure one third full and level the surface with our fingers. Rodding the Layer of aggregate with 25 strokes of the tamping rod evenly distributed over the surface.

Fill the measure to overflowing and again rod as above.

2. Level the surface of the aggregate with fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregates approximately balance the larger voids in the surface below the top of the measure.

3. In rodding the first layer, do not allow the rod to strike the bottom of the measure forcibly. In rodding the second and third layers, use only enough force to cause the tamping rod to penetrate the previous layers of aggregate.

4. Weigh the measure and its contents and record the net weigh of the aggregate. Divide this

Weigh by the volume of the measure. The result is the Compact weight of the aggregate.

II. Lose weight determinations of coarse and fine aggregates

Shoveling procedure (applicable to aggregate having maximum size of 100mm or less)

1. Fill the measure to over flowing by means of shovel or scoop; discharge the aggregate from a height not exceeding 50 mm above the top of the measure.

2. Level the surface of the aggregate with fingers or straight edge as in the above Procedures.

3. Weigh the measure and its content and record the net weigh of the aggregate. Divide this weight by the volume of the measure to get the loss unit weight.

Test results

Chewaka Sand

Table A 15

1. Compacted Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.9403	2.9403	2.9403	2.9403
Mass of Container + Sample	B	Kg	7.0006	6.9916	7.003	6.9984
	B-A	Kg	4.0603	4.0513	4.0627	4.0581
	C	m3	0.0024755	0.0024755	0.0024755	0.0024755
	(B - A) / C	Kg/m3	1640.19	1636.56	1641.16	1639.31

Table A 16

2. Loose Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.9403	2.9403	2.9403	2.9403
Mass of Container + Sample	B	Kg	6.7007	6.7438	6.7221	6.7222
	B-A	Kg	3.7604	3.8035	3.7818	3.7819
	C	m3	0.0024755	0.0024755	0.0024755	0.0024755
	(B - A) / C	Kg/m3	1519.05	1536.46	1527.69	1527.73

Worabe Sand

Table A 17

1. Compacted Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.9403	2.9403	2.9403	2.9403
Mass of Container + Sample	B	Kg	7.0977	7.0829	7.1507	7.110433
	B-A	Kg	4.1574	4.1426	4.2104	4.170133
	C	m3	0.0024755	0.0024755	0.0024755	0.0024755

	(B - A) / C	Kg/m3	1679.42	1673.44	1700.83	1684.56

Table A 18

2. Loose Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.9403	2.9403	2.9403	2.9403
Mass of Container + Sample	B	Kg	6.8799	6.8542	6.8816	6.8719
	B-A	Kg	3.9396	3.9139	3.9413	3.9316
	C	m3	0.0024755	0.0024755	0.002476	0.002476
	(B - A) / C	Kg/m3	1591.44	1581.05	1592.12	1588.2

Gambela Sand

Table A 19

1. Compacted Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.9403	2.9403	2.9403	2.9403
Mass of Container + Sample	B	Kg	6.9662	6.9543	6.9444	6.9444
	B-A	Kg	4.014	4.014	4.0627	4.0041
	C	m3	0.0024755	0.0024755	0.0024755	0.0024755
	(B - A) / C	Kg/m3	1626.30	1621.49	1617.49	1621.76

Table A 20

2. Loose Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.9403	2.9403	2.9403	2.9403
Mass of Container + Sample	B	Kg	6.6425	6.6373	6.6381	6.6393
	B-A	Kg	3.7022	3.697	3.6978	3.699
	C	m3	0.002476	0.002476	0.002476	0.002476
	(B - A) / C	Kg/m3	1495.54	1493.76	1493.76	1494.24

EXPERIMENT-3

SPECIFIC GRAVITY AND ABSORPTION CAPACITY OF FINE AGGREGATES

Objective

To determine bulk and apparent Specific gravity and absorption fine aggregates

Theory

Specific gravity of a substance is the ratio between the weight of the substance and that of the same volume of water. Aggregates, however, have pores that are both preamble and impermeable, whose structure (size, number, and continuity pattern) affects water absorption, Permeability and Specific gravity aggregates.
Apparatus

Balance, Pycnometer, Mold and Tamper

Procedure

1. Immediately introduce into the pycnometer 500g of the fine aggregate sample prepared and fill with water approximately 90% of the capacity

2. Roll, invert and agitate the pycnometer to eliminate all air bubbles.

3. Determine the total weigh of the pycnometer, sample and water.

4. Remove the fine aggregate from the pycnometer dry to constant weigh at a temperature of

105±5C0, cool in air at room temperature for ½ to 1 ½ hrs. And weigh 5. Determine the weight of pycnometer filled to its calibration capacity with water at 23±1.7C0

Test results

Chewaka Sand

Table A21

	Trial 1	Trial 2	Trial 3
Mass of saturated surface-dry specimen S	500 g	500 g	500 g
Mass of pycnometer filled with water B	731.8 g	730	728.2
Mass of pycnometer + specimen + water C	1046.6 g	1043.5	1035.59
Mass of container Wc	g		G
Mass of container + oven-dry specimen W1	g		G

Mass of oven-dry specimen A = W1 - Wc	498.51g	499.41	499.2 g

Table A 22

	Trial 1	Trial 2	Trial 3
Bulk Specific Gravity (A / (B + S - C))	2.691738661	2.677801609	2.591765744
Saturated - Surface - Dry Basis(S / (B + S - C))	2.699784017	2.680965147	2.595919215
Absorption Capacity (%) ((S - A) / A) x 100%	0.298890694	0.118139404	0.16025641
Apparent Specific Gravity A/(A+B-C)	2.71357030	2.686299822	2.602575465

Table A 23

	Trial 1	Trial 2	Trial 3
Mass of saturated surface-dry specimen S	500 g	500 g	500 g
Mass of pycnometer filled with water B	731.4	728.2	731
Mass of pycnometer + specimen + water C	1036.7	1035.1	1035.6
Mass of container Wc	g		G
Mass of container + oven-dry specimen W1	g		G
Mass of oven-dry specimen A = W1 - Wc	496.3 g	496	497 g

Worabe Sand

Table A 24

	Trial 1	Trial 2	Trial 3
Bulk Specific Gravity (A / (B + S - C))	2.543500512	2.568617297	2.543500512
Saturated - Surface - Dry Basis(S / (B + S - C))	2.558853634	2.589331952	2.558853634
Absorption Capacity (%) ((S - A) / A) x 100%	0.60362173	0.806451613	0.60362173
Apparent Specific Gravity A/(A+B-C)	2.583160083	2.62295082	2.583160083

Gambela Sand

Table A 25

	Trial 1	Trial 2	Trial 3
Mass of saturated surface-dry specimen S	500 g	500 g	500 g
Mass of pycnometer filled with water B	731.4	728.2	731
Mass of pycnometer + specimen + water C	1036.7	1035.1	1035.59
Mass of container Wc	g		G
Mass of container + oven-dry specimen W1	g		G
Mass of oven-dry specimen A = W1 - Wc	496.3 g	496	498.71 g

Table A 26

	Trial 1	Trial 2	Trial 3
Bulk Specific Gravity (A / (B + S - C))	2.552847194	2.515735324	2.552121181
Saturated - Surface - Dry Basis(S / (B + S - C))	2.560426055	2.521686504	2.558722686
Absorption Capacity (%) ((S - A) / A) x 100%	0.296878761	0.236558278	0.258667362
Apparent Specific Gravity A/(A+B-C)	2.572342621	2.53079655	2.569080981

EXPERIMENT-4

SILT CONTENT OF FINE AGGREGATE

Objective

To determine the silt and clay content of sand

Theory

Sand used for construction should be clan, free from dust, clay and vegetable matter. Silt is unnecessary part of sand with a diameter less than 75µm. if there is too much silt the aggregate will have less adhesive property with cement resulting in weaker bond strength with a probability of porosity. Moreover, it decreases workability by absorbing water.

If the silt is greater than 6% of the total mass of sand should not be used for construction unless and otherwise should be washed.

Apparatus

- 75µm size sieve
- Balance
- A pan or vessel
- Oven
- Tray

Procedure

1. Dry the test sample at temperature should not exceed 110ºc, and weigh to the nearest 0.1% of the mass sample. (Record as mass 1)
2. After being dried and weighed, place it in a vessel and add sufficient washing water to cover it.
3. Agitate the content of the vessel vigorously so as to bring the fine aggregate to suspension.
4. The washing water shall turn on be carefully poured over the sieves using care of coarse particles do not fall from the vessel. The agitation shall be continued until the washing water is clear.

5. Collect all material retain on the sieve and dry in a temperature should not exceed 110ºc to constant mass and weigh to the nearest to 0.1%. (Record as mass 2)

Table A 27

For Chewaka sand	Trial 1	Trial 2	Trial 3	Average
B=Amount of clean sand	93.5	94	6	6.33
A=Amount of silt deposited above the sand	6.5	6.5	96	94.5
Silt Content (%)=A/BX100	6.952	6.915	6.25	6.702
For Werabe sand				
B=Amount of clean sand	95.6	96.6	97	6.733
A=Amount of silt deposited above the sand	6.7	7.0	6.5	96.70
Silt Content (%)=A/BX100	6.943	7.25	6.701	6.963
For Gambela sand				
B=Amount of clean sand	95	89	94	94.5
A=Amount of silt deposited above the sand	3	2.5	2.5	2.67
Silt Content (%)=A/BX100	3.16	2.89	2.66	2.88

EXPERIMENT-1

GRAIN SIZE ANALYSIS OF AGGREGATE / TESTING OF AGGREGATES

Objective

This test used to determine the particle size distribution of coarse aggregates.

Theory

Aggregates make up about 75% of the volume of concrete, so their properties have a large influence on the properties of the concrete (Alexander and Mindess, 2005).

Sieve analysis is a procedure to determine the particle size distribution of aggregates using a series of square or round opening starting with the largest. It is used to determine the grading or aggregates and the fineness modulus, an index to the fineness and the coarseness and uniformity of aggregates. After this analysis is carried out, aggregates are described as well graded, poorly graded, uniformly graded, gap graded, etc. Each of the above aggregates categories has close association with a range of quality of concrete produced using the aggregate.

Apparatus

Balance, Series of sieves, Shovel, Sieve brush, and Sieve Shaker

I. Procedure for grading coarse aggregates

1. Taking20 kg of sample of coarse aggregates
2. Select a representative sample by quartering
3. From the quartered sample, we have taken 5 kg = 5000gm of coarse aggregates
4. Placing the 5 kg of sample on the top sieve (having large opening size)
5. Shaking the sample about 15 minutes in sieve shaker i.e. electrical shaker
6. Weighing the aggregate retained on each sieve
7. Calculating percentage of the weight retained on each sieve
8. Fill in the gradation chart

TEST RESULTS

Sieve Analysis and Fineness Modulus of Coarse Aggregate- Agaro-Suse

Table A 28

Gradation for caorse aggregate								
sieve size	trial-1	% retained	cum % retained	cum % pass	trial-2	% retained	cum % retained	cum % pass
37.50	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00
19.00	3656.40	66.13	66.13	33.87	3727.40	71.00	71.00	29.00
13.20	1646.10	29.77	95.90	4.10	1296.30	24.69	95.69	4.31
9.50	164.60	2.98	98.88	1.12	160.80	3.06	98.75	1.25
4.75	20.10	0.36	99.24	0.76	20.90	0.40	99.15	0.85
Pan	42.10	0.76	100.00	0.00	44.80	0.85	100.00	0.00
	5529.30		460.14		5250.20		464.58	
		Fineness Modulus		4.6		Fineness Modulus		4.65

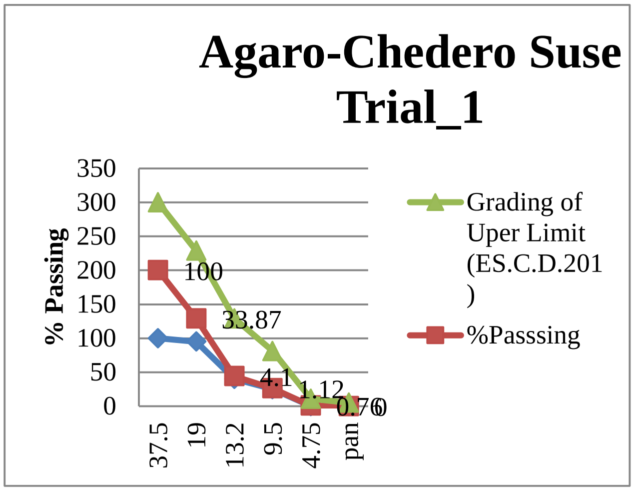

Figure A 10

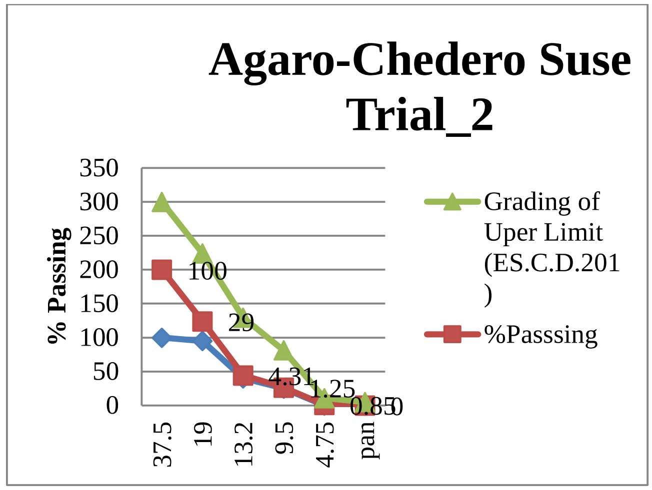

Figure A 11

Table A 29

sieve size	trial-3	% retained	cum % retained	cum % pass
37.50	0.00	0.00	0.00	100.00
19.00	3630.50	66.33	66.33	33.67
13.20	1590.70	29.06	95.40	4.60
9.50	175.90	3.21	98.61	1.39
4.75	35.40	0.65	99.26	0.74
Pan	40.50	0.74	100.00	0.00
	5473.00		459.61	
		Fineness Modulus		4.6

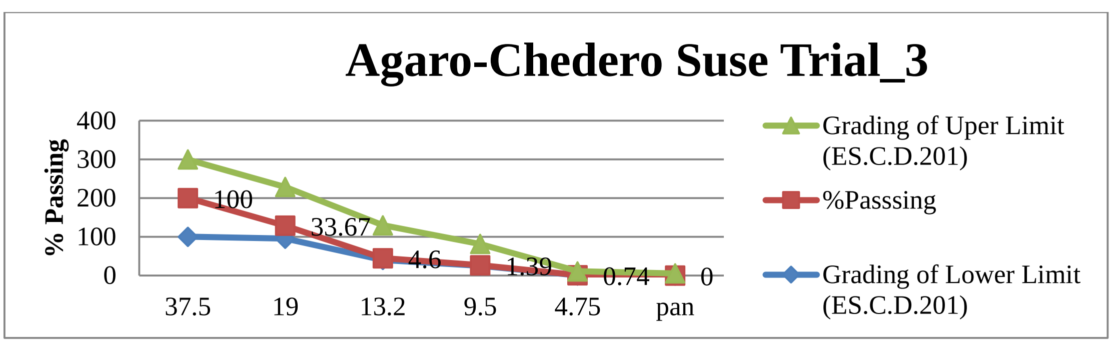

Figure A 12

Sieve Analysis and Fineness Modulus of Coarse Aggregate-
Dedo Table A 30

Gradation for caorse aggregate – in gm.								
sieve size	trial-1	% retained	cum % retained	cum % pass	trial-2	% retained	cum % retained	cum % pass
37.50	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00
19.00	3285.20	62.34	62.34	37.66	3055.20	57.85	57.85	42.15
13.20	1922.60	36.48	98.83	1.17	2134.90	40.42	98.27	1.73
9.50	57.00	1.08	99.91	0.09	83.60	1.58	99.85	0.15
4.75	2.50	0.05	99.96	0.04	3.90	0.07	99.92	0.08
Pan	2.30	0.04	100.00	0.00	4.00	0.08	100.00	0.00
	5269.60		461.03		5281.60		455.89	
					4.61	Fineness Modulus		4.56

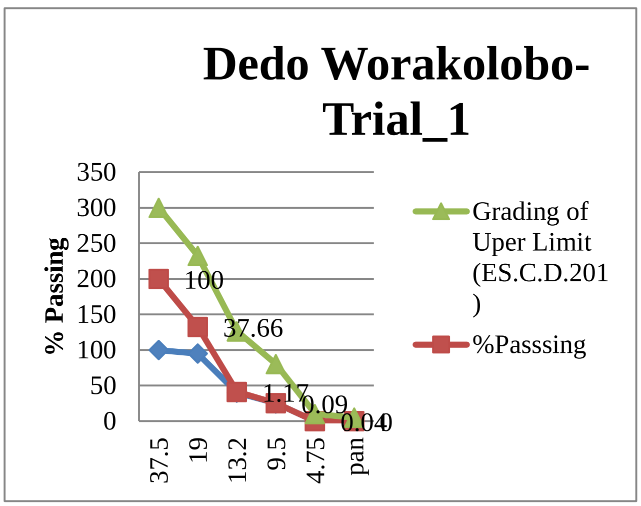

Figure A 13

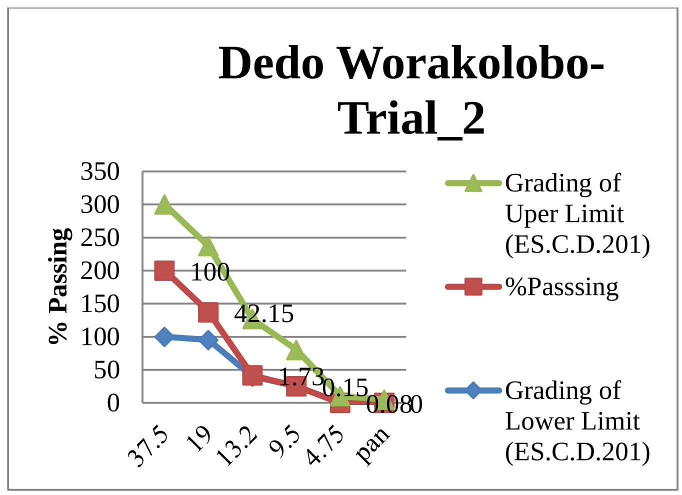

Figure A 14

Table A 32

sieve size	trial-3	% retained	cum % retained	cum % pass
37.50	0.00	0.00	0.00	100.00
19.00	3185.70	60.18	60.18	39.82
13.20	2035.10	38.44	98.62	1.38
9.50	65.40	1.24	99.86	0.14
4.75	3.50	0.07	99.92	0.08
pan	4.00	0.08	100.00	0.00

	5293.70		458.58	
		Fineness Modulus		4.59

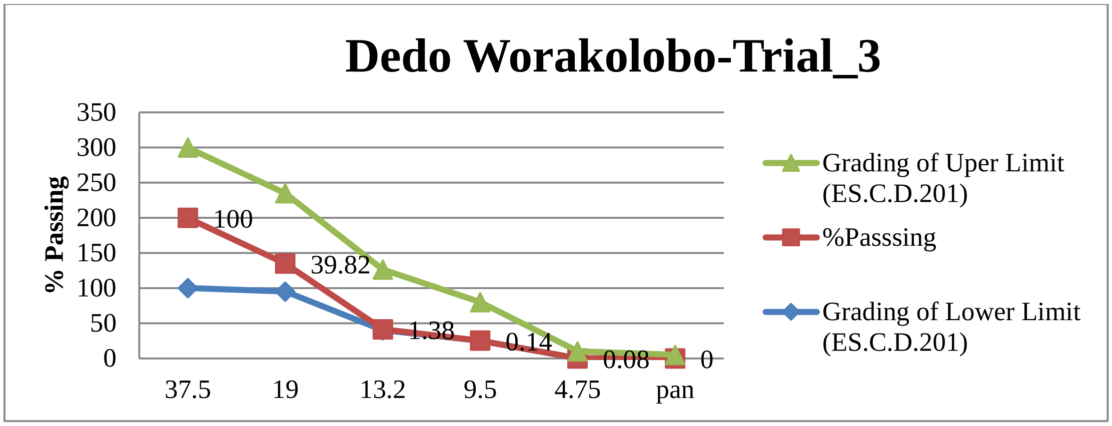

Figure A 15

Sieve Analysis and Fineness Modulus of Coarse Aggregate- Agaro-Mohamed Miftah crasher

Table A 33

Gradation for coarse aggregate in gm.								
sieve size	trial-1	% retained	cum % retained	cum % pass	trial-2	% retained	cum % retained	cum % pass
37.50	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00
19.00	3012.50	59.23	59.23	40.77	2975.60	56.59	56.59	43.41
13.20	1904.20	37.44	96.66	3.34	2071.80	39.40	96.00	4.00
9.50	151.40	2.98	99.64	0.36	185.40	3.53	99.52	0.48
4.75	16.30	0.32	99.96	0.04	22.10	0.42	99.94	0.06
Pan	2.10	0.04	100.00	0.00	2.90	0.06	100.00	0.00
	5086.50		455.48		5257.80		452.06	
		Fineness Modulus		4.56	4.61	Fineness Modulus		4.52

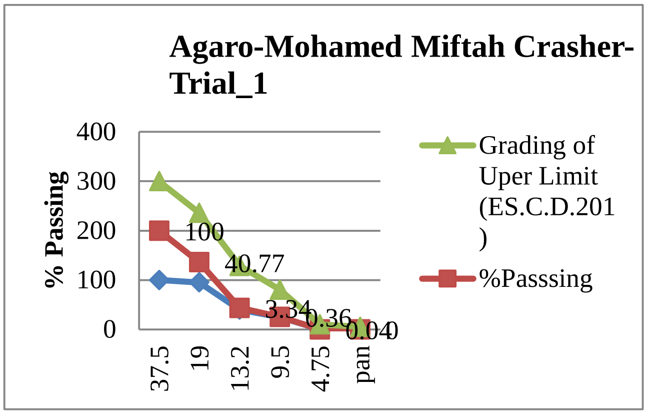

Figure A 16

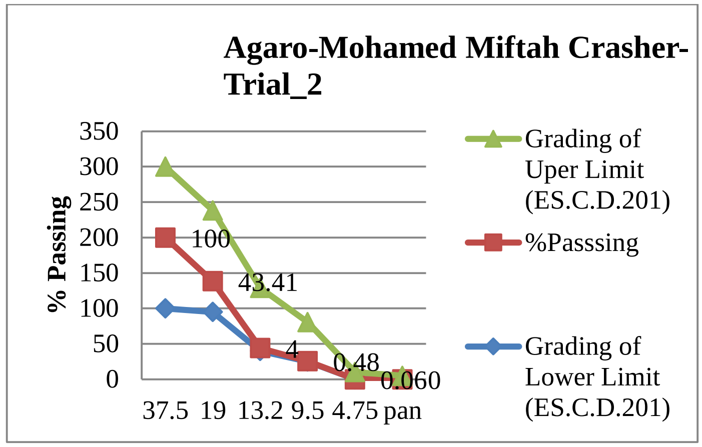

Figure A 17

Table A 34

sieve size	trial-3	% retained	cum % retained	cum % pass
37.50	0.00	0.00	0.00	100.00
19.00	3105.90	58.15	58.15	41.85
13.20	1859.90	34.82	92.97	7.03
9.50	195.50	3.66	96.63	3.37
4.75	175.60	3.29	99.92	0.08
Pan	4.20	0.08	100.00	0.00
	5341.10		447.68	
		Fineness Modulus		4.48

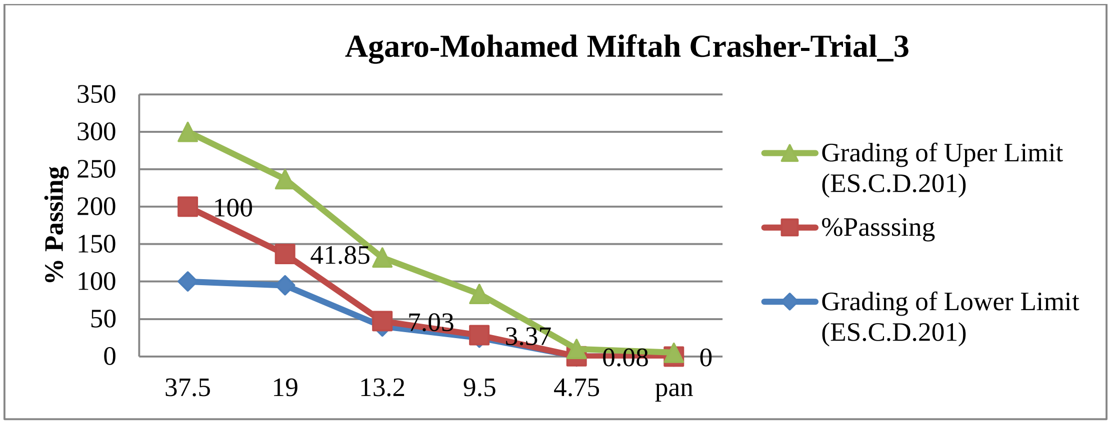
Agaro-Mohamed Miftah Crasher-Trial_3
% Passing
350
300
250
200
150
100
50
0
100
41.85
7.03
3.37
0.08
0
37.5
19
13.2
9.5
4.75
pan
Grading of Uper Limit (ES.C.D.201)
%Passsing
Grading of Lower Limit (ES.C.D.201)

Figure A 18

EXPERIMENT-1

Gradation with different Standards

Comparison of Agaro-Suse,Dedo-Worakolobo and Agaro-Mohamed Miftah Coarse aggregate with standards.

Table A 35 Comparison of Agaro-Suse Coarse Aggregate with standards

Material type	Types Test	Result		EBCS-2, 1995	ES C.D3.201	ASTM C-637	BS 812-103
		Sieve size mm	% Passing	% Passing	% Passing	% Passing	% Passing
Agaro-Suse Coarse Aggregate	Gradation	37	100.00	Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	95-100	95-100	100
		19	32.23		30-70	40-80	90-100
		13.2	4.34		-	20-45	40-80
		9.5	1.25		10-35	0-10	30-60
		4.75	0.78		0-5	0-2	0-10
	Fineness Modulus	4.61			ES	ASTM (CRD & CRD-C 104)	BS 812-111
					Nothing is stated; CRD& CRD-C 104, falls 5.5-8.5	5.5-8	5.5-8.0
	Unit Weight	Loose	1560.56 Kg/m3		ES	ASTM C29	BS 882
					there is no limit	1450-1750	1450-1750
		Roded	1647.86 Kg/m^3		there is no limit	1450-1750	1450-1750

Comparison of Agaro-Suse Coarse Aggregate with standards

Table A 36

Material Type	Types Test	Result	EBCS-2, 1995	ES	ASTM	BS
Agaro-Suse Coarse	Bulk Sp. Gr'ty	2.92	Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	ES.C.D3.201	ASTM C127-04	BS 812-2
				2.4 – 3.0	2.4-2.9	2.60 – 2.70
	Saturated-Surface-Dry Bases	2.95		ES. C. D3. 201	ASTM	BS 812-2
				2.4 – 3.0	2.4-2.9	> 2.6
	Absorption Capacity (%)	1.06		ES	ASTM C127	BS 812-2
				there is no req'nt, refer ASTM	0.2-4	0.5 – 1
	Apparent S.Gr'y	3.01		ES. C. D3. 201	ASTOM C127-04	*BS812-102-1995*
				2.4 – 3.0	2.4-2.9	> 2.6
	Natural Moisture Content	0.35		ES /No stated/	ASTM C127	BS 812-109
				1-6%	1-6%	To be allowed for in concrete mixing

Comparison of Dedo-Werakolobo Coarse Aggregate with standards

Table A 37

Material Type	Types Test	Result		EBCS-2, 1995	ES ES C.D3.201	ASTM ASTM C-637	BS BS 812-103
Dedo-Werakolobo Coarse Aggregate	Gradation	Sieve size (mm)	% Passing	% Passing	% Passing	% Passing	% Passing
		37	100.00	Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	95-100	95-100	100
		19	39.88		30-70	40-80	90-100
		13.2	1.43		-	20-45	40-80
		9.5	0.13		10-35	0-10	30-60
		4.75	0.07		0-5	0-2	0-10
	Fineness Modulus	4.59			ES	ASTM (CRD& CRD-C 104)	BS 812-111
					Nothing is stated; CRD& CRD-C 104, falls 5.5-8.5	5.5-8	5.5-8.0
	Unit Weight	Loose	1519.98 Kg/m3		ES	ASTM C29	BS 882
					there is no limit	1450-1750	1250- 1460
		Roded	1642.34 Kg/m^3		there is no limit	1450-1750	

Comparison of Dedo-Werakolobo Coarse Aggregate with standards

Table A 38

Material Type	Types Test	Result	EBCS-2, 1995	ES	ASTM	BS
Dedo-WerakoloboCoarse	Bulk Sp. Gr'ty	2.93	Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	ES.C.D3.201	ASTM C127-04	BS 812-2
				2.4 – 3.0		2.60 – 2.70
	Saturated-Surface-Dry Bases	2.98		ES. C. D3. 201	ASTM	BS 812-2
				2.22– 2.78	0.5-2	> 2.6
	Absorption Capacity (%)	1.85		ES	ASTM C127	BS 812-2
				there is no req'nt	0.2-4	0.5 – 1
	Apparent S.Gr'y	3.01		ES. C. D3. 201	ASTOM C127-04	*BS812-102-1995*
				2.56 – 2.89	2.6-2.7	> 2.6
	Natural Moisture Content	0.35		ES	ASTM C127	BS 812-109
				there is no limit	1-6%	To be allowed for in concrete mixing

Comparison of Agaro-Mohamed Miftah CrasherCoarse Aggregate with standards

Table A 39

Material Type	Types Test	Result		EBCS-2, 1995	ES ES C.D3.201	ASTM ASTM C-637	BS BS 812-103
Agaro-Mohamed Miftah Crasher Coarse Aggregate	Gradation	Sieve size (mm)	% Passing	% Passing	% Passing	% Passing	% Passing
		37	100.00	Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	95-100	95-100	100
		19	42.02		30-70	40-80	90-100
		13.2	4.82		-	20-45	40-80
		9.5	1.42		10-35	0-10	30-60
		4.75	0.06		0-5	0-2	0-10
	Fineness Modulus	4.52			ES	ASTM (CRD& CRD-C 104)	BS 812-111
					Nothing is stated; CRD& CRD-C 104, falls 5.5-8.5	5.5-8	5.5-8.0
	Unit Weight	Loose	1546.26 Kg/m3		ES	ASTM C29	BS 882
					there is no limit	1450-1750	1250- 1460
		Roded	1591.07 Kg/m^3		there is no limit	1450-1750	

Comparison of Agaro-Mohamed Miftah Crasher Coarse Aggregate with standards

Table A 41

Material Type	Types Test	Result	EBCS-2, 1995	ES	ASTM	BS
Agaro-Mohamed Miftah Crasher Coarse	Bulk Sp. Gr'ty	2.91	Art.8.2.2.2 aggregates (1) In general aggregates shall comply with the requirements of the latest Ethiopian Standards for Aggregates.	ES.C.D3.201	ASTM C127-04	BS 812-2
				2.4 – 3.0		2.60 – 2.70
	Saturated-Surface-Dry Bases	2.96		ES. C. D3. 201	ASTM	BS 812-2
				2.22– 2.78	0.5-2	> 2.6
	Absorption Capacity (%)	1.56		ES	ASTM C127	BS 812-2
				there is no req'nt	0.2-4	0.5 – 1
	Apparent S.Gr'y	3.05		ES. C. D3. 201	ASTOM C127-04	*BS812-102-1995*
				2.56 – 2.89	2.6-2.7	> 2.6
	Natural Moisture Content			ES	ASTM C127	BS 812-109
				there is no limit	1-6%	To be allowed for in concrete mixing

EXPERIMENT-2
Unit Weight Of Aggregates

Objective

This method is used to determine the unit weight of coarse aggregates

Theory

Unit weight can be defined as the weight of a given volume of graded aggregate. It is thus a density measurement and also known as bulk density. The unit weight effectively measures the volume that the graded aggregate will occupy in concrete and includes both the solid aggregate particles and the voids b/n them.

Apparatus

Balances, Tamping rods, Buckets, and Teenier

Table A 42

Capacity, (lit)	Inside diameter,[mm]	Inside height,[mm]	Minimum thickness of metal,(mm)		Maximum nominal of aggregate (mm)[a]
			Bottom	Wall	
3	155±2	160±2	5.0	2.5	12.5
10	205±2	305±2	5.0	2.5	25
15	255±2	295±2	5.0	3.0	37.5
30	355±2	305±2	5.0	3.0	100

I. Compact weight determinations coarse aggregates

Rodding procedure:

1. We have filled the measure one third full and level the surface with our fingers. Rodding the

Layer of aggregate with 25 strokes of the tamping rod evenly distributed over the surface.

Fill the measure to overflowing and again rod as above.

2. Level the surface of the aggregate with fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregates approximately balance the larger voids in the surface below the top of the measure.

3. In rodding the first layer, do not allow the rod to strike the bottom of the measure forcibly. In rodding the second and third layers, use only enough force to cause the tamping rod to penetrate the
- previous layers of aggregate.

4. Weigh the measure and its contents and record the net weigh of the aggregate. Divide this Weigh by the volume of the measure. The result is the Compact weight of the aggregate.

II. Lose weight determinations of coarse aggregates
Shoveling procedure (applicable to aggregate having maximum size of 100mm or less)

1. Fill the measure to over flowing by means of shovel or scoop; discharge the aggregate from a height not exceeding 50 mm above the top of the measure.

2. Level the surface of the aggregate with fingers or straight edge as in the above Procedures.

3. Weigh the measure and its content and record the net weigh of the aggregate. Divide this weight by the volume of the measure to get the loss unit weight.

Test Results
For Agaro Suse

Table 43

1. Compacted Density					
Trial No		1	2	3	Average
Weight of Mold	A Kg	6.2612			
Weight of Mold & Sample	B Kg	19.295	19.155	19.16	19.16
Weight of Material	B–A Kg	13.0338	12.8938	12.8988	12.8988
Volume of Mold	C m^3	0.0078539	0.0078539	0.0078539	0.0078539
Unit Weight	(B-A)/C Kg/m3	1659.53	1641.71	1642.34	1642.34

Table A 44

2. Loose Density					
Trial No		1	2	3	Average
Weight of Mold	A Kg	6.2612	6.2612	6.2612	6.2612
Weight of Mold & Sample	B Kg	18.451	18.605	18.497	18.51766667
Weight of Material	B–A Kg	12.1898	12.3438	12.2358	12.25646667
Volume of Mold	C m^3	0.0078539	0.0078539	0.0078539	0.0078539
Unit Weight	(B-A)/C Kg/m3	1552.07	1571.68	1557.93	1560.56

For Dedo

Table A 45

1. Compacted Density					
Trial No		1	2	3	Average
Weight of Mold	A Kg	6.2612	6.2612	6.2612	6.2612
Weight of Mold & Sample	B Kg	19.1	19.095	18.9	19.16
Weight of Material	B–A Kg	12.8388	12.8338	12.6388	12.8988
Volume of Mold	C m^3	0.0078539	0.0078539	0.0078539	0.0078539
Unit Weight	(B-A)/C Kg/m3	1634.70	1634.07	1609.24	1642.34

Table 46

1. 2. Loose Density					
Trial No		1	2	3	Average
Weight of Mold	A Kg	6.2612	6.2612	6.2612	6.2612
Weight of Mold & Sample	B Kg	18.05	18.052	18.495	18.199
Weight of Material	B–A Kg	11.7888	11.7908	12.2338	11.9378
Volume of Mold	C m^3	0.0078539	0.0078539	0.0078539	0.0078539
Unit Weight	(B-A)/C Kg/m3	1501.01	1501.27	1557.67	1519.98

For Agaro-Mohamed Miftah Crasher

Table 47

1. Compacted Density					
Trial No		1	2	3	Average
Weight of Mold	A Kg	6.2612	6.2612	6.2612	6.2612
Weight of Mold & Sample	B Kg	19.075	19.102	18.095	18.75733333
Weight of Material	B–A Kg	12.8138	12.8408	11.8338	12.49613333
Volume of Mold	C m^3	0.0078539	0.0078539	0.0078539	0.0078539
Unit Weight	(B-A)/C Kg/m3	1631.52	1634.96	1506.74	1591.07

Table 48

1. 2. Loose Density					
Trial No		1	2	3	Average
Weight of Mold	A Kg	6.2612	6.2612	6.2612	6.2612
Weight of Mold & Sample	B Kg	19.018	18.141	18.057	18.40533333
Weight of Material	B–A Kg	12.7568	11.8798	11.7958	12.14413333
Volume of Mold	C m^3	0.0078539	0.0078539	0.0078539	0.0078539
Unit Weight	(B-A)/C Kg/m3	1624.26	1512.60	1501.90	1546.26

EXPERIMENT-3

Specific Gravity And Absorption Capacity Of Coarse Aggregates

Objective

To determine bulk and apparent Specific gravity and absorption of coarse aggregates

Theory

Specific gravity of a substance is the ratio between the weight of the substance and that of the same volume of water. Aggregates, however, have pores that are both preamble and impermeable, whose structure (size, number, and continuity pattern) affects water absorption, permeability and Specific gravity of aggregates.

Apparatus

Buoyance balance , Sample container
Suitable apparatus for suspending the sample container in water from the center of the Scale pan or balance.
Sample SSD coarse aggregates , Wire basket, and Sieve

Procedure

1. Thoroughly washing the sample aggregate

2. Weigh the sample in the SSD condition (B)

3. Immediately place SSD sample in the sample container and determine its weigh in water at room temperature (Mw)

4. Dry the sample to constant weigh at temperature of 110±5C0, cool in air at room temperature and 1 to 3hrs, and weigh (MD)

Test results

For Agaro-Chedero Suse (Tuba Chrasher) site

Table A 49

Description	Test 1	Test 2	Test 3	Average
A. Weight of Oven Dry Sample in Air g	2492.20	2475.30	2483.50	2483.67
B. Weight of Saturated Surface Dry Sample in Air g	2508.60	2511.70	2509.90	2510.07
C. Weight Sample in Water g	1652.00	1658.00	1665.17	1658.39
Test temperature ,Co				
Bulk Specific Gravity A/B - C	2.91	2.9	2.94	2.92
Bulk Specific Gravity (S.S.D basis) B/B - C	2.93	2.94	2.97	2.95
Absorption (B - A)/ A *100	0.66	1.47	1.06	1.06
Apparent Specific Gravity A/A - C	2.97	3.03	2.94	3.01

For Dedo-Werakolobo (Abdulsemed Crasher) site
Table A50

Description	Test 1	Test 2	Test 3	Average
A. Weight of Oven Dry Sample in Air g	2448.20	2476.50	2460.00	2461.57
B. Weight of Saturated Surface Dry Sample in Air g	2510.10	2511.70	2499.60	2507.13
C. Weight Sample in Water g	1665.00	1665.00	1671.20	1667.07
Test temperature ,Co				
Bulk Specific Gravity A/B – C	2.90	2.92	2.94	2.93
Bulk Specific Gravity (S.S.D basis) B/B - C	2.97	2.97	3.02	2.98
Absorption (B - A)/ A *100	2.53	1.42	1.61	1.85

Apparent Specific Gravity A/A – C	3.13	3.05	3.12	3.10

For Agaro-Mohamed Miftah Crasher site

Table A 51

Description	Test 1	Test 2	Test 3	Average
A. Weight of Oven Dry Sample in Air g	2473.40	2479.10	2467.40	2473.30
B. Weight of Saturated Surface Dry Sample in Air g	2509.50	2511.60	2514.23	2511.78
C. Weight Sample in Water g	1657.00	1663.00	1667.03	1662.34
Test temperature ,Co				
Bulk Specific Gravity A/B – C	2.90	2.92	2.91	2.91
Bulk Specific Gravity (S.S.D basis) B/B - C	2.94	2.96	2.97	2.96
Absorption (B - A)/ A *100	1.46	1.31	1.90	1.56
Apparent Specific Gravity A/A – C	3.03	3.04	3.08	3.05

ANNEX – B

Laboratory Photos

LABORATORY INVESTIGATION