Jimma University

School of Graduate Studies

Jimma Institute of Technology

School of Civil and Environmental Engineering

Construction Engineering and Management Stream

ASSESMENT OF QUALITY IMPLEMENTATION OF CONCRETE INGREDIENTS USES FOR BUILDING CONSTRUCTION IN JIMMA TOWN

A thesis submitted to the School of Graduate Studies of Jimma University in Partial fulfillment of the requirements for the Degree of Master of Science in Civil Engineering (Construction Engineering and Management)

By: **_Biruk Hailu Eshete**

September, 2016

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BY

BIRUK HAILU

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ABBREVATION

ACI- American Concrete Institute

ASTM-American Society for Testing and Materials

AASHTO-American Association State Highways and Transportation Officials

AFM/AFT-Calcium monosulfoaluminate/ ettringite

BS-British Standard

C_3A-Tricalcium aluminate

C_3S-Tricalcium silicate

C_2S-Dicalcium silicate

C_4AF-Tetracalcium aluminoferrite

C-S-H-Calcium silicate hydroxide

CA $(OH)_2$-Calcium hydroxide

Cm^2-Centemeter square

ES-Ethiopian Standard

ERA-Ethiopian Road Authority

Eg.-Example

g- 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

no- Number

OPC-Ordinary Portland cement

QC-Quality Control

QA- Quality Assurance

SSD- Saturated Surface Dry

S.Gravity-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 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 and quality problems. Concrete being one of the important constituents of many of the construction projects, in addition to its subjectivity to variability, requires a close and thorough care and handling in construction projects.

Therefore, with this respect a research was carried out to assess the quality implementation of concrete ingredients and workmanship in Jimma town on building constructions with a special emphasis given to the concrete making aggregates. The objective of the research was to assess the quality implementation of concrete ingredients and workmanship in general and to give recommendation in line with the outcome of the results of the research.

The research is conducted through laboratory investigation and field observation which is found in Jimma town of concrete making ingredients. The findings of the conducted tests shown as sufficient tests on cement and aggregate on the laboratory but not include water. Those indicate to improve the concrete quality of the ingredients in building constructions.

From the observation made in construction sites the implementation of concrete ingredients in most projects are not up to the standards with respect to quality and implementation and handling of the ingredients on the sites. Another conclusion drawn from the research was that the concrete ingredients quality, the handling and storage of the materials should be upgrade in all aspects including expert training and introduction of standardization for the quality of the concrete ingredients.

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's had 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 [1].

Concrete has been the most common building material for many years. It is expected to remain so in the coming decades. Much of the developed world has infrastructures built with various forms of concrete. Mass concrete dams, reinforced concrete buildings, pre stressed concrete bridges, and precast concrete components are some typical examples. It is anticipated that the rest of the developing world will use these forms of construction in their future development of infrastructures [1].

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 [3].

In pre-historic times, some form of concrete using lime-based binder may have been used, but modern concrete using Portland cement, which sits under water, dates back to mid-eighteenth century and more importantly, with the patient by Joseph Aspdin in 1824. Traditionally, concrete is a composite consisting of the dispersed phase of aggregates (ranging from its maximum size coarse aggregates down to the fine sand particles) embedded in the matrix of cement paste. This is a Portland cement concrete with the four constituents of Portland cement, water, stone and sand. These basic components remain in current concrete, but other constituents are now often added to modify its fresh and hardened properties. This has broadened the scope in the design and construction of concrete structures. It has also introduced factors that designers should recognize in order to realize the desired performance in terms of structural adequacy, constructability, and required service life. These are translated into strength, workability and durability in relation to properties of concrete.

Implementation of quality control is the way of checking that concrete materials and through the production process in the specific requirements of the specified code of standards. A standard is a written form of a book which is designed by an authority or by a general consent of a comparison [1].

When we see the workmanship is also affecting the quality of concrete. It must be on the regarded with the stated standards. To have a good quality of concrete we must be controlled and have proper care in the selection and checking the ingredients and during the production process of concrete and control the workmanship defects, which also use to have some management system on the site and involve professionals in the construction industry.

In our country, there is a lot of building contractor and most of them have good experiences in the working quality implementation of their work, but some of our focus on the profit of what they get benefits from the stakeholders.

Any substance that bonds materials may be considered cement. There are many types of cements. In construction, however, the term cement generally refers to bonding agents that are mixed with water or other liquid, or both, to produce a cementing paste. Initially, a mass of particles coated with the paste is in a plastic state and may be formed, or molded, into various shapes. Such a mixture may be considered a cementation material because it can bond other materials together. After a time, due to chemical reactions, the paste sets and the mass harden. When the particles consist of fine aggregate (sand), mortar is formed. When the particles consist of fine and coarse aggregates concrete results [1].

1.2. Statement of the Problem

In order to make this selection intelligently, the selecting person should be able to asses' 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 [3].

Concrete work is important in all infrastructures to improve in building its useful life and strength of the structure. Especially in our country, most regions now have new infrastructures and its main thing to control the quality of the structures of their concrete works and improve the implementation on the concrete ingredients. In most places of our country do not implement this process properly. To better understand the implementation of the concrete and the workmanship performed to get constant quality standards from all local contractors.

This study needed for the necessary implementation concrete ingredients and workmanship, selection and handling of the ingredients and quality of the ingredients of concrete; its focus on commonly used in the construction preparation of a building in Jimma town. In the local contractor shows that there are problems regarded with the implementation and handling of the concrete ingredients on the construction sites.

1.3. Research Question

- What is the implementation of quality control like on the ingredients of concrete?
- What is the effective way to achieve good quality concrete ingredients and workmanship on building construction?
- Are the concrete ingredients get proper handling and stockpiling on project site?

1.4. Objectives

1.4.1. General objective

To investigate the quality implementation of concrete ingredients and workmanship on building construction

1.4.2. Specific Objectives

- To identify the affecting of the implementation of concrete ingredients and workmanship on site.
- To determine the Engineering properties of the concrete ingredients used for the concrete mix for building construction.
- To compare the result of concrete ingredients with Standard Specifications.

1.5. Significance of the study

This research is significant in that it may help the people engaged in the construction industry how they can controlling, managing and implementing the concrete ingredients on the site while they deliver and stored at construction site. In addition, this study intends to provide some of the supervision and consultancies on the concrete ingredients.

1.6. Scope and delimitation

Investigating on the quality implementation on concrete ingredients and workmanship in building construction is the optimum of the study including recommendation of mitigation measures. Even if there are so many areas where are prone to quality control in Ethiopia this research study will go on only on pre mentioned site.

The scope of the research was limited on the building construction projects in Jimma town concerning mainly on the quality implementation of concrete ingredients and workmanship. 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 some tests are not conducted because of the shortages and calibrated equipment's on the laboratory.

1.7. Organization of the study

The organization of the study is divided in different chapters, as follows:

Chapter 1 Introduction: this section provides a background of the topic researched in this study.

The main idea of this chapter is to explain the background of the problem, the objectives and the contribution made by this project.

Chapter 2 Literature Review: this chapter were provides information about the main subjects of this thesis; implementation and quality control of concrete ingredients on building construction projects and providing the practical suggestion and recommendations to upgrade the knowledge of controlling and managing the quality of the ingredients on building construction in jimma town. In addition it will provide theoretical foundation of some proposed scheme or plan for the research.

Chapter 3 Methodology:- this chapter provides the plan to explain of the strategies, approaches and sample collection methods. In this project, assessment made on to determine the out puts.

Chapter 4 Result and Discussion:- this section were provides the results from the laboratory, field observation and analysis to make a comparison with the existing literature.

In addition, the results are used to confirm or reject the hypothesis. Also provide a critical evaluation of this work including the limitation of the research.

Chapter 5 Conclusions and Recommendations:- this section will be summarizes the main issues of this long essay and it provides an overview of the main findings. Also it concludes if the project met the proposed objectives and the way in which the essay was useful to confirm or reject the hypothesis.

CHAPTER TWO

LITRATURE REVIEW

2.1. 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 [2].

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 [3].

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[3].

Concrete is a composite material that consists essentially of binding medium within which Are embedded particles or fragments of relatively inert mineral filler. In some cases, Admixtures may be added to give the concrete special properties. The usual concrete in use in Ethiopia and throughout the world is Portland cement concrete. In Portland cement concrete the binder or matrix, either in the plastic or in the hardened state, is a combination of Portland cement and water. The filler material, called "aggregate," is generally graded in size from fine sand to pebbles or fragments of stone which, in some concretes, may be several inches in diameter [4].

When these materials are mixed and placed in forms and allowed to cure the chemical reaction between the water and cement forms a hardened binding medium or cement paste which surrounds and holds the aggregates together.

There are three different ways of producing concrete:

1. On site mixing – concrete ingredients batched and mixed on site
2. Ready-mixed concrete – concrete is delivered for placing from a central plant
3. Precast concrete – both mixing and placing is done in a central plant

For practical, concrete mixes, the cement, water and aggregates should be so proportioned that the resulting concrete has the following properties [4]:

A. When freshly mixed it is workable enough for economical and easy uniform placement, but not excessively fluid.

B. When hardened it possess strength and durability adequate to the purpose for which it is intended.

C. It involves minimum cost consistent with acceptable quality [4].

2.2. Basic ingredients of concrete and their properties

2.2.1. Cement

Cement in a general sense is adhesive and cohesive materials which are capable of bonding together particles 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 [4].

Cements used in the construction industry may be classified as hydraulic and non-hydraulic. The latter does not set and harden in water, such as non-hydraulic lime or which are unstable in water, eg. Plaster of Paris; the hydraulic cement set and hardens in water and gives a product which is stable. Portland cement is one such [4].

Cement can be manufactured either from natural cement stones or artificially by using Calcareous and argillaceous materials. The examples of natural cements are Roman cement, Puzzolana cement and Medina cement and those of artificial cement are Portland cement and special cements [4].

Today cement finds extensive use in all types of construction works; in structures where high strength is required, e.g. bridge piers, lighthouses, lofty towers, and large structures such as bridges, silos, chimneys, And also in structures exposed to the action of water, e.g. reservoirs, dams, dockyards, etc. Cement mortar, concrete, reinforced brick work, artificial stones, plastering, pointing and partition walls are routinely used in buildings [4].

2.2.1.1. Portland cement

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 [4].

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 [4].

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 [5].

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 [5].

- 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 [6].
- 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 [6].
- 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 [6].

- Type IV, low-heat-of-hydration cement, has been developed for mass-concrete applications. If a Type I cement is used in large masses that cannot lose heat by radiation; it liberates enough heat during hydration to raise the temperature of the concrete as much as 50 or 60°F. This results in a relatively large increase in dimensions while the concrete is still plastic and later differential cooling after hardening causes shrinkage cracks to develop. Low heat of hydration in Type IV cement is achieved by limiting the compounds that make the greatest contribution to heat of hydration, C3A and C3S. Since these compounds also produce the early strength of cement paste, their limitation results in a paste that gains strength relatively slowly. The heat of hydration of Type IV cement usually is about 80% of that of Type II, 65% of that of Type I, and 55% of that of Type III after the first week of hydration. The percentages are slightly higher after about 1 year [6].
- Type V, sulfate-resisting cement, is specified where there is extensive exposure to sulfates. Typical applications include hydraulic structures exposed to water with high alkali content and structures subjected to seawater exposure. The sulfate resistance of Type V cement is achieved by reducing the C3A content to a minimum since that compound is most susceptible to sulfate attack [6].

Types IV and V are specialty cements not normally carried in dealer's stocks. They are usually obtainable for use on a large project if advance arrangements are made with a cement manufacturer [6].

2.2.1.2. Manufacturing Process of Portland cement

1. Crushing and Proportioning

Limestone rock is the principal raw material, the first step after quarrying in the processes is the primary crushing. Mountains of rock are fed through crushers capable of handling pieces as large as an oil drum. The first crushing reduces the rock to a maximum size of about 15 cm. The rock then goes to secondary crushers or hammer mills for reduction to about 7.5 cm or smaller [7].

2. Raw milling & Blending

The next step in the process is to grind the above particles to a size of 90 microns or less which is done in a raw mill, a closed circuit ball mill equipped with a high efficiency separator. After achieving the 90 micron size the fine grained material also known as raw meal is sent to the continuous blending silos for homogenization & extracted by means of a load cell hopper for the next step which is fed to the kiln pre heaters [7].

3. Pyro-processing

The raw material is heated to exceeding 1,450 °C (2,700 degrees F) in huge cylindrical steel rotary kilns lined with special firebrick. Kilns are frequently as much as 3.7 M in diameter, large enough to accommodate an automobile and longer in many instances than the height of a 40-story building [7].

Kilns are mounted with the axis inclined slightly from the horizontal. The finely ground raw material or the slurry is fed into the higher end. At the lower end is a roaring blast of flame, produced by precisely controlled burning of powdered coal, oil or gas under forced draft [7].

4. Burning and cooling

As the material moves through the kiln, certain elements are driven off in the form of gases. The remaining elements unite to form a new substance with new physical and chemical characteristics. The new substance, called clinker, is formed in pieces about the size of marbles [7].

Clinker is discharged red-hot from the lower end of the kiln and generally is brought down to handling temperature in various types of coolers. The heated air from the coolers is returned to the kilns, a process that saves fuel and increases burning efficiency [7].

5. Cement milling, Storage & Packing

Portland cement, the basic ingredient of concrete, is a closely controlled chemical combination of calcium, silicon, aluminum, iron and small amounts of other ingredients to which gypsum is added in the final grinding process to regulate the setting time of the concrete. Lime and silica make up about 85% of the mass. Common among the materials used in its manufacture are limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore [7].

2.2.1.3. 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 langbeinite is present, then it will provide both calcium and sulfate ions in solution, which are available for ettringite formation [8].

The supply of soluble calcium sulfate controls the C3A hydration, thus preventing a flash site. Ground clinker mixed with water without added calcium sulfate sets rapidly with heat evolution as a result of the uncontrolled hydration of C3A. The cement then enters a dormant period when the rate of loss of workability is relatively slow. It will be more rapid, however, at high ambient temperatures (above 25°C) [8].

Setting time is a function of clinker mineralogy (particularly free lime level), clinker chemistry and fineness. The finer the cement and the higher the free lime level, the shorter the setting time in general. Cement paste setting time is arbitrarily defined as the time when a pat of cement paste offers a certain resistance to penetration by a probe of standard cross-section and weight. The setting is largely due to the hydration of C3S and it represents the development of hydrate structure, which eventually results in compressive strength [8].

The C–S–H gel which forms around the larger C3S and C2S grains is formed in situ and has a rather dense and featureless appearance when viewed using an electron microscope.

This material is formed initially as reaction rims on the anhydrous material, but as hydration progresses the anhydrous material is progressively replaced and only the largest particles (larger than ~30 microns) will retain an unreacted core after several years' hydration. This dense hydrate is referred to as the 'inner product' [8].

The 'outer hydration product' is formed in what was originally a water-filled space and also the space occupied by the smaller cement grains and by interstitial material (C3A and C4AF). When viewed using an electron microscope this material can be seen to contain crystals of the CA (OH) 2, AFm/AFt and also C–S–H with a foil- or sheet like morphology [8].

The structure of the outer product is strongly influenced by the initial water-to-cement ratio, which in turn determines paste porosity and consequently strength development. The hydration of Portland cement involves exothermic reactions, i.e. they release heat. The progress of the reactions can be monitored using the technique of isothermal conduction calorimetric (Killoh, 1988) [8].

The heat release is advantageous in cold weather and in precast operations where the temperature rise accelerates strength development and speeds up the production process.

However, in large concrete pours the temperature rise, and in particular the temperature difference between the concrete core and the surface can generate stresses which result in 'thermal cracking' [8].

The temperature rise experienced depends on a number of factors, which include:

- Concrete is placed temperature
- Cement content
- Minimum pours dimensions
- Type of formwork
- Cement type (fineness, C3S and C3A contents)

Cement heat of hydration (during the first ~ 48 hours) is highest for finely ground cements with a high C3S content (>60%) and a high C3A content (>10%).

By 28 days a typical Portland cement cured at 20°C can be expected to be ~90% hydrated. The extent of hydration is strongly influenced by cement fineness and in particular the proportions of coarse particles in the cement. Cement grains, which are coarser than ~30 microns will probably never fully hydrate. Thus, cement particle size distribution has a strong influence on long-term compressive strength. Cement produced in an open- circuit mill with a 45 micron sieve residue of 20% may give a 28-day strength ~10% lower than that of a cement produced from the same clinker but ground in a closed-circuit mill with a 45 micron sieve residue of 3% (Moir, 1994) [8].

Elevated temperature curing, arising from either the semi-adiabatic conditions existing in large pours or from externally applied heat, is associated with reduced ultimate strength.

This is believed to be due to a combination of micro cracks induced by thermal stresses but also a less dense and 'well-formed' microstructure [8].

2.2.1.4. Test on Cement

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 [9].

Fineness of cement

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 [9].

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 [7].

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 [10].

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 [10].

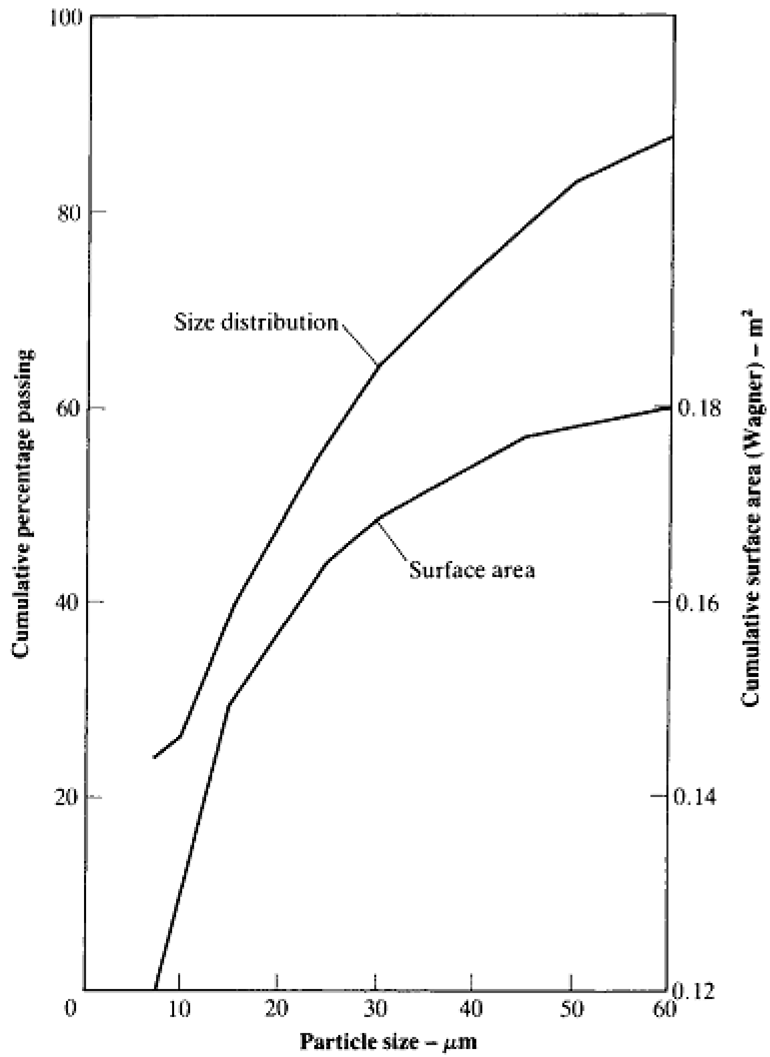

Figure 2.1 Example of particle size distribution and commutative surface area contributed by particles up to any size for 1 gram of cement

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 [9].
The minimum initial setting time specified by the standard is 45 minutes.

Table 2.1 Setting time standard [7]

	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. Aggregates

Aggregate in concrete occupies 65% to 80% of the volume of concrete, the remainder being in Portland cement. The aggregate must consist of different-size particles, referred to as size gradation. Proper gradation ensures that smaller particles fit within the voids created by larger particles, so that the entire mass of concrete is relatively dense [11].

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 [11].

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

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 [11].

Fine aggregate needs to be graded from a No. 4 sieve down to a No. 100 sieve.

Coarse aggregate is 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 [11].

2.2.2.1. Classification of natural aggregates

So far, we have considered only aggregate form 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 [12].

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 [12]

2.2.2.2. Properties of Aggregate

Internal Structure of Lightweight Aggregates has a low particle density because of the cellular structure. The cellular structure within the particles is normally developed by heating certain raw materials to incipient fusion, at which temperature gases are evolved within the pyro-plastic mass causing expansion that is retained upon cooling. Strong, durable, lightweight aggregates contain a uniformly distributed system of pores that have a size range of approximately 5 to 300 µm (0.000040 in.) and which are developed in a relatively crack-free, high-strength vitreous matrix [13].

There are many uses of Portland cement concrete in highway construction. Some of the major uses of aggregates are in rigid-pavement slabs, bridges, concrete barriers, sidewalks, curbs, slope walls, and other structures [13].

Aggregates in Portland cement concrete are required to always be physically and chemically stable. Other factors to be considered include:

1) The size, distribution, and interconnection of voids within individual particles

2) The surface character and texture of the particles

3) The gradation of the coarse and fine aggregates

4) The mineral composition of the particles

5) The particle shape

6) Soundness abrasion resistance

7) Water absorption [13]

Table 2.2 the major of the tests and characteristics listed on reference in ASTM C33

Characteristic	Significance	Test designation	Requirement or item reported
Resistance to abrasion and degradation	Index of aggregate quality; wear resistance of floors and pavements	ASTM C 131 (AASHTO T 96) ASTM C 535 ASTM C 779	Maximum percentage of weight loss. Depth of wear and time
Resistance to freezing and thawing	Surface scaling, roughness, loss of section, and aesthetics	ASTM C 666 (AASHTO T 161 ASTM C 682 (AASHTO T 103	Maximum number of cycles or period of frost immunity; durability factor
Resistance to disintegration by sulfates	Soundness against weathering action	ASTM C 88 (AASHTO T 104	Weight loss, particles exhibiting distress
Particle shape and surface texture	Workability of fresh concrete	ASTM C 295 ASTM D 3398	Maximum percentage of flat and elongated particles
Grading	Workability of fresh concrete; economy	ASTM C 117 (AASHTO T 11) ASTM C 136 (AASHTO T 27	Minimum and maximum percentage passing standard sieves
Fine aggregate degradation	Index of aggregate quality; Resistance to degradation during mixing	ASTM C 1137	Change in grading
Uncompact void content of fine aggregate	Workability of fresh concrete	ASTM C 1252 (AASHTO T 304	Uncompact voids and specific gravity values
Bulk density (unit weight)	Mix design calculations; classification	ASTM C 29 (AASHTO T 19)	Compact weight and loose weight
Relative density (specific gravity)	Mix design calculations	ASTM C 127 (AASHTO T 85) fine aggregate ASTM C 128 (AASHTO T 84) coarse aggregate	
Absorption and surface moisture	Control of concrete quality (water-cement ratio)	ASTM C 70 ASTM C 127 (AASHTO T 85) ASTM C 128 (AASHTO T 84) ASTM C 566 (AASHTO T 255	
Compressive and flexural strength	Acceptability of fine aggregate failing other tests	ASTM C 39 (AASHTO T 22) ASTM C 78 (AASHTO T 97)	Strength to exceed 95% of strength achieved with purified sand
Definitions of constituents	Clear understanding and communication	ASTM C 125 ASTM C 294	
Aggregate constituents	Determine amount of deleterious and organic materials	ASTM C 40 (AASHTO T 21) ASTM C 87 (AASHTO T 71 ASTM C 117 (AASHTO T 11) ASTM C 123 (AASHTO T 113) ASTM C 142 (AASHTO T 112) ASTM C 295	Maximum percentage allowed of individual constituents
Resistance to alkali reactivity and volume Change	Soundness against volume change	ASTM C 227 ASTM C 289 ASTM C 295 ASTM C 342 ASTM C 586 ASTM C 1260 (AASHTO T 303) ASTM C 1293	Maximum length change, constituents and amount of silica, and alkalinity

Particle Shape and Surface Texture

Depending on the source and the method of production, lightweight aggregates exhibit considerable differences in particle shape and texture. Shapes may be cubical, rounded, angular, or irregular. Textures may range from fine pore, relatively smooth skins to highly irregular surfaces with large exposed pores. Particle shape and surface texture directly influence workability, coarse-to-fine aggregate ratio, cement content requirements, and water demand in concrete mixtures, as well as other physical properties [10].

Flaky or elongated particles tend to be detrimental. Rounded particles tend to give better workability than crushed or angular particles. Producers can exercise some control over particle shape through the processing of the aggregate [8].

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 [8].

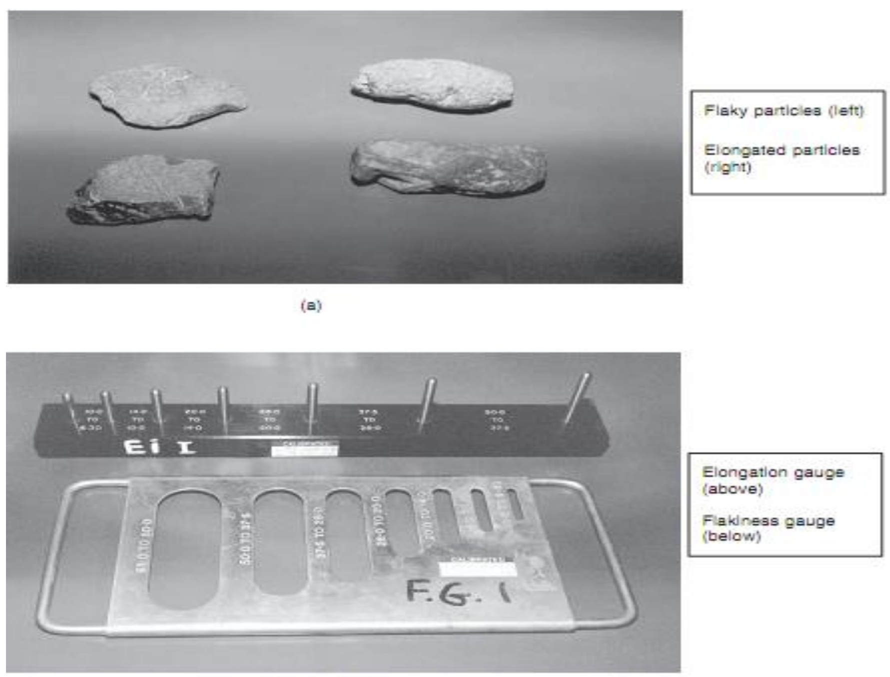

Figure 2.3 Flakiness and elongation [8]

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) [8].

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 [10].

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 [10].

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 [10].

Grading

Grading requirements are generally similar to those provided for normal-weight aggregate with the exception that lightweight aggregate particle size distribution permits a higher weight through smaller sieves. This modification recognizes the increase in relative density typical for the smaller particles of most lightweight aggregates, and that while standards are established by weights passing each sieve size, ideal formulations are developed through volumetric considerations [10].

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 that include coarse, intermediate, and fine grading's. By combining size fractions or by replacing some or the entire fine fraction with normal-weight sand, a wide range of concrete densities may be obtained. The aggregate producer is the best source of information for the proper aggregate combinations to meet fresh concrete density specifications and equilibrium density for dead load design considerations [10].

Table2.4 Grading requirements of coarse aggregate from ASTM Destination C: 33 [14]

Nominal sieve size	Amounts finer than sieve size, weight percent												
	100mm (4in.)	90mm (3.5in.)	75mm (3in.)	63mm (2.5in.)	50mm (2in.)	37.5mm (1.5in.)	25mm (1in.)	19mm (0.75in.)	12.5mm (0.5in.)	9.5mm(0.375in.)	4.75mm (No.4)	2.36mm (no.8)	1.16mm (no.16)
37.5-90mm (1.53.5in)	100	90-100		25-60		0-15		0-5					
37.5-63mm (1.5-2.5in)			100	90-100	35-70	0-15		0-5					
25-50mm (1-2in)				100	90-100	35-70	0-15		0-5				
4.75-50mm (no.4-2in)				100	95-100		35-70		10-30'		0-5		
19-37.5mm (0.75-1.5in)					100	90-100	20-55	0-15		0-5			
4.75-37.5mm (no.4-1.5in)					100	95-100		35-70		10-30'	0-5		
12.5-25mm (0.5-1in)						100	90-100	20-55	0-10	0-5			
9.5-25mm (0.375-1in)						100	90-100	40-85	10-40'	0-15	0-5		
4.75-25mm (no.4-1in)						100	95-100		25-60		0-10	0-5	
9.5-19mm (no.4-0.75in)							100	90-100	20-55	0-15	0-5		
4.75-19mm (no.4-0.75in)							100	90-100		20-55	0-10	0-5	
4.75-12.5mm (no.4-0.5in)								100	90-100	40-70	0-15	0-5	

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 sand 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 [15].

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 [15].

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 [15].

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 [15].

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 [16].

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 [17].

- 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)[17].

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 [18].

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 [12].

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 [12].

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 [19].

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 [12].

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 [12].

2.2.3. 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 [20].

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 [20].

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 [20].

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 [21].

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 [21].

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 [21].

2.3.1. Quality control

Control involves a universal sequence of steps as follows:

1. Choose the control subject, that is, choose what we intend to regulate.
2. Establish measurement.
3. Establish standard of performance, product goal, and process goals.
4. Measure actual performance.
5. Compare actual measured performance against standards.
6. Take action on the difference [22].

2.3.1.1. 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 [23].

2.3.1.2. 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 [20].

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 [20].

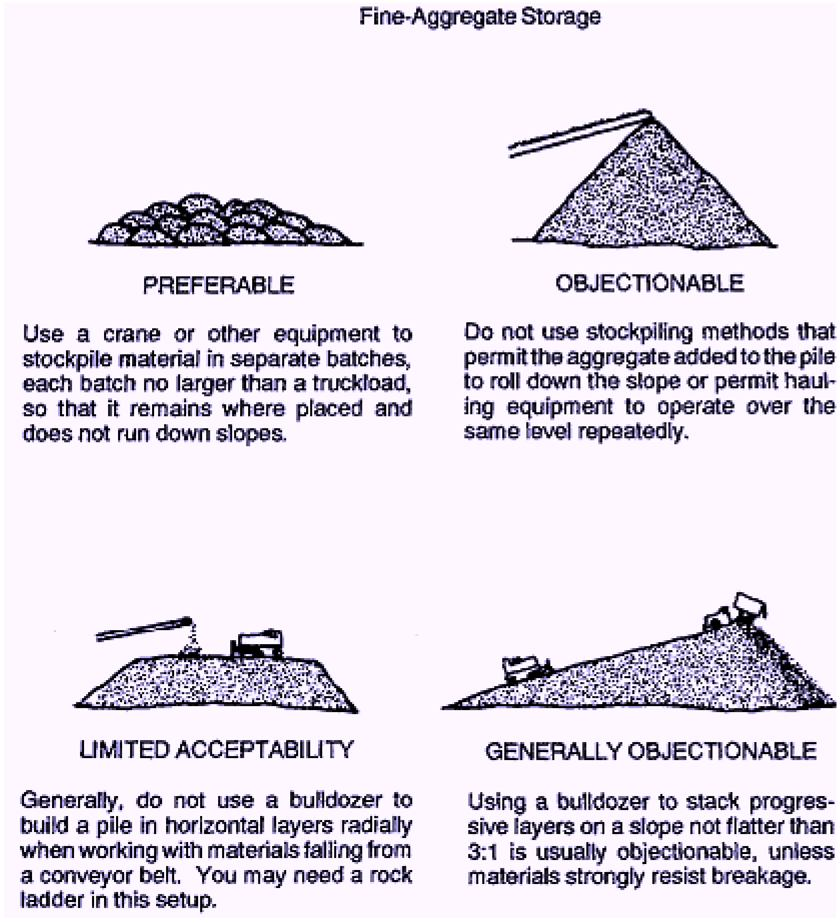

Figure 2.4 Correct and incorrect handling and storage of aggregate [20]

Crushed aggregates segregate less than rounded (gravel) aggregates and larger-size aggregates segregate more than smaller sizes. To avoid segregation of coarse aggregates, size fractions can be stockpiled and batched separately. Proper stockpiling procedures, however, should eliminate the need for this. Specifications provide a range in the amount of material permitted in any size fraction partly because of segregation in stockpiling and batching operations [20].

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 [19].

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 [24].

Cement

Portland cement is kept in sacks of 0.035 m3 (50 kg) capacity for local use. These are stored for a short period of time in an air tight room, avoiding moisture and dampness, at some distance from walls and at some height from floors. The stack should be covered with suitable coverings to avoid circulation of air through the stack and not more than ten bags should be stacked one over another [25].

Cement shall be transported and stored in clean containers and protected from moisture both in transit and during storage.

Provision shall be made to prevent accidental mixing of different types [24].

Cement is a moisture-sensitive material; if kept dry, it will retain its quality indefinitely. Cement stored in contact with damp air or moisture sets more slowly and has less strength than cement that is kept dry. At the cement plant, and at ready mixed concrete facilities, bulk cement is stored in silos. The relative humidity in a warehouse or sheds used to store bagged cement should be as low as possible. All cracks and openings in walls and roofs should be closed. Cement bags should not be stored on damp floors, but should rest on pallets. Bags should be stacked close together to reduce air circulation, but should never be stacked against outside walls. Bags to be stored for long periods should be covered with tarpaulins or other water- proof covering. Bags should be stored so that the first in are the first out [19].

On small jobs where a shed is not available, bags should be placed on raised wooden platforms (pallets) above the ground. Waterproof coverings should fit over the pile and extend over the edges of the platform to prevent rain from reaching the cement and the platform Rain-soaked platforms can damage the bottom bags of cement [19].

Cement stored for long periods may develop what is called warehouse pack. This can usually be corrected by rolling the bags on the floor. At the time of use, cement should be free-flowing and free of lumps. If lumps do not break up easily, the cement should be tested before it is used in important work. Standard strength tests or loss-on- ignition tests should be made whenever the quality of cement is doubtful [19].

CHAPTER THREE

MATERIALS AND METHODOLOGY

This section presents the methodologies adopted for the study in a process of collecting data from desk review, laboratory result and field observation to provide a solution to the objectives of the research. The scope of the research is limited to building constructions in Jimma town. It is intended to facts based on the research problem initiated mainly from observation and test results.

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.

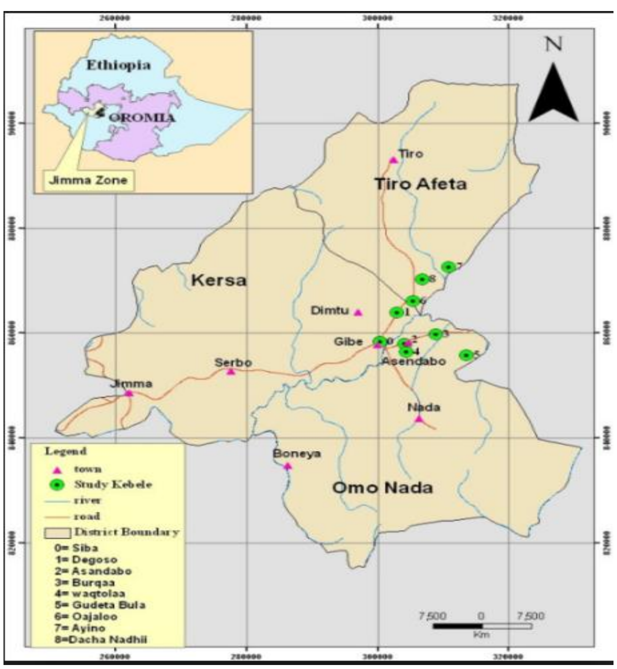

Figure 3.1 map of Jimma, Ethiopia (JIS)

3.2. Population

The population of the study include the ingredients of the concrete these are cement, aggregate and water; and building construction. In this study the populations are taken from three coarse aggregate, four fine aggregate (sand) and three cement was selected which are used on building construction 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 purposefully sampling method chosen for in order to extract the sample easily and to ensure the assessment was done to the research.

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

- For fine aggregate Asendabo (omo nada), Cewaka, Werabe, Gambella sand.
- For coarse aggregate from Seka site (afro-tsion crusher), Agaro site (Mohamed and miftah crusher) and around St Gabriel sites (dagem crusher).
- For cement National OPC cement, Derban OPC cement and Dangote OPC cement.

The field observation made through selecting ongoing construction in Jimma town which conducted in eight 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	Afro Tsion Construction	Inside Oromia road authority
2	Varnero Construction	Inside Jimma university main campus
3	Bifcon Construction	Inside Limat bank and inside municipal of Jimma town
4	Dawit and Mirafe construction	Merkato
5	Flinstones Construction	Inside Jimma university main campus
6	Bokra Construction	Beside honey land hotel
7	Wubcon Construction	Inside Jimma court and Merkato
8	Abiye construction	Merkato

3.4. Research Approach

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 ingredients of concrete, concrete production and workmanship, quality management and standards, specification and codes of practice.

B) The first objective was conducted as site observation and by taking photos of the factors that affect the implementation of the concrete ingredients and workmanship on the sites and the site visits involved observations where the researcher sought to find out how ingredients were stored and handled 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 quality tests on the material which is used as the concrete ingredients, these are cement and aggregate 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.

D) The samples take as purposefully which was used mostly on building construction in Jimma town. This is for fine aggregate Asendabo, Cewaka, Werabe, Gambella sand taken from the sites which mentioned on the table 3.1 And for coarse aggregate from Seka site (afro-tsion), Agaro site (Mohamed and miftah crusher) and around St Gabriel sites (dagem crusher) And for cement National OPC cement, Derban OPC cement and Dangote OPC cement which mostly used in the town. Most sites use water from fresh water so it was not concluded on the tests.

The laboratory test results are for cement setting time and fineness of cement; for the coarse aggregate sieve analysis, unit weight, specific gravity, absorption, flakiness index, aggregate impact value, aggregate crushing value, Los Angeles abrasion, soundness test; 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 quality 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. For the cement the samples taken from the suppliers and from the site which was mostly used for building purposes in Jimma town and each taken to ERA laboratory and by the quartering method by use mechanical splitter 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 ASTM, AASHTO, BS, ES, JIT laboratory and Abebe Denku manuals to determine the results.

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 quality assurances like AASHTO, 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 quality implementation on the concrete ingredients and workmanship was given.

3.5. Materials

In this section sees that the materials how was taken the samples to the laboratory room to conduct the tests.

3.5.1. Aggregate

The aggregates sample is selected from the project sites of the selected contractors and quarry sites were taken as the sampling procedure on AASHTO T2 which is identical to ASTM D75 as follows:

- Avoid sampling coarse or combined aggregate from stockpiles and transportation units whenever possible, especially when the sample taken is intended to determine characteristics dependent upon the grading of the sample. It is very difficult to ensure unbiased samples, due to the segregation which often occurs when material is stockpiled, with the coarser particles rolling to the outside base of the pile.
- A flat board shoved vertically into the pile just above the sampling point aids in preventing further segregation by holding the material above the location in place.
- A minimum of three increments must be obtained, one from the top third, one from the midpoint, and one from the bottom third of the pile. If necessary to determine the degree of variability existing within the pile, separate samples should be drawn from separate areas of the pile.
- The shovel should be held at an approximate ninety degree angle to the vertical face and inserted into the fine aggregate approximately 50 mm (2 in.). The aggregate should be in a damp condition to use this method.
- When sampling a unit of fine aggregate, select at least three areas to obtain the individual increments, that when combined, will make up the field sample. The mass

of the field sample must be large enough to provide enough material for each test to be performed on the aggregate.

3.5.2. Cement

Cement sample were taken from the contractors sites and for each sample one bag cement is taken.as ASTM D75 refers that:

- The major problem sampling schemes for cementitious materials must overcome is manufacturing variation. Standards covering these materials typically give rather specific instructions on when and where grab samples can be taken, on how many grab samples can be composited for a test sample, and also relatively specific instructions on the number of test samples required to adequately represent a lot of production. Segregation is not heavily covered, but many standards do caution about sampling from the surface of a storage or transportation unit because of the layer of fine cementitious dust that can settle there as a result of the loading or transfer process. The procedure is typically to remove several inches of material before taking a grab sample.
- Cementitious materials are sometimes carried in trucks or rail cars used for hauling other materials. Small residues of these other materials may reside in the bottom of these containers. This may constitute a relatively minor contamination considering the amount of material in the load, but this relatively minor contamination may show up as a significant contamination if a grab sample is taken from the first material taken from the container. A common result of such a sample (due to, for example, fly ash and cement being transported in the same trucks or stored in close proximity such that contamination can occur) is that the insoluble residue of the cement will exceed normal levels or fail to meet requirements.

Three standard sampling procedures are allowed:

1. From bulk storage at point of discharge, from rail cars, and from trucks (road tankers);

2. from bags;

3. from conveyor delivering to bulk storage.

From this standards for this research the samples taken from bags for every trial of the test.

3.6. Preparation of Materials

In the preparation of the material after the materials sample selected it's transported to the ERA laboratory room and place them on preferable storage. Then the aggregates put on the tray until a saturated surface dry of the samples for the preparation of the test conducted on the materials. And each sample was in weighing balance as the every test required on the procedures as shown in the annex.

Each samples of the aggregates after delivered on the laboratory each sample are dried by using saturated surface dry and prepared for the tests of aggregate because the aggregates had come with wet state so it should had dry.

Table 3.2 Summary of fine aggregate samples

Type materials	Sample sites	size of samples	test conducted	Trials	Standards for the test
Fine aggregate (sand)	Asendabo (omo nada)	1 m^3 for each sites	Gradation Fineness modulus Specific gravity Silt content Unit weight Water absorption	2 for each tests	ES.C.D3.201
	Chewaka sand				ES.C.D3.201
	Werabe sand				ES.C.D3.201
	Gambella sand				ES.C.D3.201 and ASTM
					ASTM C29
					ASTM C127

Table 3.3 Summary of coarse aggregate sample

Type materials	Sample sites	size of samples	test conducted	Trials	Standards for the test
Coarse aggregate	St. Gabriel(dagem crusher)	1 m^3 for each sites	Gradation Flakiness index Specific gravity Aggregate crushing value Unit weight Water absorption Soundness by sodium sulfate Aggregate impact value	2 for each test	ESC.D3.201
					ASTM C33
	Seka (afro-tsion)				ESC.D3.201
					BS812
					ASTM C29
	Agaro (Mohamed and miftah crusher)				ASTM C127
					ASTM C88
					BS812

Table 3.4 Summary of cement sample

Type materials	Sample sites	size of samples	test conducted	Trials	Standards for the test
OPC Cement	Derban	1bag for each sample	Setting time of cement Fineness of cement	2 trials for each test	ES.D5.201
	Dangote				ES.D5.201
	National				

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 General Results

To assess the quality implementation on concrete ingredients and workmanship on building construction in Jimma town field observation and test results of coarse aggregate, fine aggregate and cement samples were collected from the suppliers, ongoing projects and quarry site.

The first objective finding was on that affect the implementation of concrete ingredients and workmanship on the sites. In this research to obtain the objective it conduct on eight selected projects of building construction and observe on the site that some problems that affect the ingredients before the mix. These are:

- When the materials were transported from quarry sites to the project sites.
- Improper handling the ingredients on the sites.
- Due to stocking problem on the construction site of the ingredients
- Absence of material engineer on the project site.
- The practice of quality control is too loose even in some constructions; it is not stated in the contract documents.

Figure 4.1 Stockpiling of the ingredient on the observed sites (merkato sites)

Figure 4.2 Storage of cement on the construction sites (varnero site)

- The aggregates are contaminated to the surface which combine with dust particles and have more moisture content.
- Most sites on the storage of cements are placed on the contaminated with surface.

This is some effects obtained during on the field observation on the selected building projects were conducted on the concrete ingredients.

The second objective was the results conducted in the laboratory of the ingredients, fine aggregate, coarse aggregate and cement tests as follow:

4.1.1 Fine aggregate results

The fine aggregate samples are purposefully collected from the sites which were mostly used in building construction projects in Jimma town. These aggregates are from Werabe, Gambella, Chewaka and Asendabo this fine aggregates are mainly used on building construction projects in the town.

The samples are taken as the ASTM D75 and as AASHTO T2 refer. 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 Asendabo (omo nada) sand

The results are summarized as table 4.1 and the procedure in the Annex A:

Table 4.1 summarizes results for Asendabo sand

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
		12.5	100
Fine aggregate (Asendabo sand)	Gradation	9.5	96.3
		4.75	88.1
		2.36	78.1
		1.18	65.8
		0.6	47.6
		0.3	20.2
		0.15	5.8
		0.075	0.4
	Fineness modules	2.94	
	Unit weight	Compacted =1401. 19kg/m3	
		Loose =1334. 167kg/m3	
	Bulk specific gravity	2.60%	
	Bulk specific gravity (SSD)	2.60%	
	Apparent specific gravity	2.76%	
	Water Absorption	2.78%	
	Silt content	13.72%	

4.1.1.2. Test result for Chewaka sand

The Chewaka sand results are summarized as table 4.2 and the procedure in the Annex A:

Table 4.2 Summarizes results for Chewaka

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
		12.5	100
Fine aggregate (Chewaka sand)	Gradation	9.5	96.9
		4.75	94.6
		2.36	91.3
		1.18	85.1
		0.6	73.4
		0.3	45.7
		0.15	13.4
		0.075	0.7
	Fineness modules	2.94	
	Unit weight	Compacted =1478.26kg/m3	Loose =1357.97kg/m3
	Bulk specific gravity	2.5%	
	Bulk specific gravity (SSD)	2.6%	
	Apparent S. Gravity	2.650%	
	Water Absorption	2.030%	
	Silt content	15.32%	

4.1.1.3. Test Result for Werabe Sand

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

Table 4.3 Summery result of Werabe sand

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
Fine aggregate (Werabe sand)	Gradation	12.5	100
		9.5	96.5
		4.75	93.1
		2.36	85.4
		1.18	73.3
		0.6	55.7
		0.3	30.5
		0.15	6.4
		0.075	0.3
	Fineness modules	2.56	
	Unit weight	Compacted =1401.78	Loose =1345.47
	S. Gravity SSD	2.600%	
	Water Absorption	2.160%	
	Bulk specific gravity	2.690%	
	Bulk specific gravity (SSD)	2.750%	
	Silt content	5.09%	

4.1.1.4. Test Result for Gambella Sand

The samples for the test result were taken by quartering method where the quartering was used by riffle box. The results are summarized as table 4.4 and the procedure in the Annex A are shown:

Table 4.4 Summery result of Gambella sand

Material type	Type of test	Test result	
		Sieve size (mm)	% Passing
Fine aggregate (Gambella sand)	Gradation	12.5	100.0
		9.5	97.6
		4.75	94.0
		2.36	86.1
		1.18	73.2
		0.6	56.0
		0.3	30.1
		0.15	6.8
		0.075	2.3
	Fineness modules	2.54	
	Unit weight	Compacted =1416.54	Loose =1350.35
	Apparent S. Gravity	2.680%	
	Water Absorption	1.240%	
	Bulk specific gravity	2.590%	
	Bulk specific gravity (SSD)	2.630%	
	Silt content	3.45%	

4.1.2 Coarse Aggregates Result

The coarse aggregate sample was purposefully collected from the quarry sites were mostly used in Jimma town for building purpose these are from St. Gabriel, Seka and Agaro quarry sites. These aggregates were conducted in the ERA laboratory to identify their quality.

The samples of all coarse aggregate are depend on ASTM D75 and AASHTO T2 procedure of sampling method. This is taken from the stockpiling of the quarries site. And the results are listed below:

4.1.2.1 Test Result for St. Gabriel Quarry Site (dagem crusher)

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 4.5 below and the procedures are in the Annex B:

Table 4.5 Summery of St. Gabriel site result of coarse aggregate

Type of test	**Test result**	
	Sieve size (mm)	**% Passing**
Gradation	37.5	100.0
	25	93.5
	19	42.3
	12.5	9.8
	9.5	2.2
	4.75	0.6
Flakiness Index	26	
Unit weight	Compacted = 1432.1 kg/m3	Loose =1291.8 kg/m3
ACV	20.3%	
bulk specific gravity	2.8%	
bulk specific gravity(ssd)	2.8%	
S. Gravity SSD	2.91%	
Water Absorption	1.91%	
LAA	15.5%	
bulk specific gravity	2.81%	
bulk specific gravity (ssd)	2.84%	
Soundness by sodium sulfate	2.4%	
AIV	12.95%	

4.1.2.2 Test Result for Seka Quarry Site (afro-tsion crusher)

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 4.6 Summery result of Seka quarry site

Type of test	Test result	
	Sieve size (mm)	**% Passing**
Gradation	37.5	100.0
	25	91.4
	19	46.0
	12.5	17.9
	9.5	6.2
	4.75	0.8
Flakiness Index	26%	
Unit weight	Compacted = 1588.18 kg/m3	Loose =1406.78 kg/m3
ACV	17.4%	
S.Gravity SSD	2.92%	
Water Absorption	0.9%	
LAA	19.04%	
bulk specific gravity	2.84%	
bulk specific gravity (ssd)	2.87%	
Soundness by sodium sulfate	2.2%	
AIV	15.77%	

4.1.2.3 Test Result for Agaro Quarry Site (Mohamed and miftah crusher)

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 shows in the Annex B

Table 4.7 Summery result for Agaro quarry site

Type of test	**Test result**	
	Sieve size (mm)	**% Passing**
Gradation	37.5	100.0
	25	89.1
	19	45.7
	12.5	9.2
	9.5	1.9
	4.75	0.3
Flakiness Index	25	
Unit weight	Compacted = 1522.42kg/m3	Loose =1470.27kg/m3
ACV	14.2%	
Apparent S. Gravity	2.36%	
Water Absorption	1.11%	
LAA	17.6%	
Bulk specific gravity	2.3%	
Bulk specific gravity (SSD)	2.32%	
Soundness by sodium sulfate	2.3%	
AIV	10.57	

4.1.3. Test results in cement

The cement samples are collected from the suppliers purposefully, which mostly used in Jimma town building constructions. These are Derban, Dangote and National cement.

The cement samples were taken for each test according to the recommended laboratory manual book. And the tasted cement on the laboratory is the fineness and setting time of cement for the selected samples. The samples are taken from as the standard sampling method of ASTM D75 AND AASHTO T2 refers. For each sample of the tests were taken from the bags.

4.1.3.1. Test result for Derban OPC cement

The results are summarized as table 4.8 and the procedure are shown in the Annex C

Table 4.8 Summery test results in Derban OPC cement

Material Type	***Type of test***	***Test result***	
Derban OPC cement	Determination of setting time	Initial setting time	76
		Final setting time	175
	Determination of Fineness	150 µm(No. 100)	99.5%
		75µm (No 200)	95.6%

4.1.3.2. Dangote OPC cement test result

The procedure and the results on the Annex C and on table 4.9. As shown below

Table 4.9 Summery test results for Dangote OPC cement

Material Type	***Type of test***	***Test result***	
Dangote OPC cement	Determination of setting time	Initial setting time	87
		Final setting time	148
	Determination of Fineness	150 µm (No. 100)	99.9%
		75µm (No 200)	98.7%

4.1.3.3. Test Result for National OPC Cement

On the cement test the samples are taken from one bag cement is 500 g in every one trial of the tests and conducted as the procedure in the Annex C and the result as shown on the following table 4.10.

Table 4.10 Summary of national OPC cement result

Material Type	***Type of test***	***Test result***	
National OPC cement	Determination of setting time	Initial setting time	83
		Final setting time	193
	Determination of Fineness	150 µm (No. 100)	99.3%
		75µm (No 200)	99.1%

4.2. Analysis and Discussion

In this section the findings on field observation and the laboratory results are discussed as the quality implementation on the concrete ingredients and workmanship the test results compare to various standards and literatures to evaluate the quality 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 investigation and the laboratory result as the following below:

4.2.1. Implementation on concrete ingredient on site

Concrete ingredients 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 cement

On the field observation most sites are not properly implementing on the delivery and storage of cement on the site due to that it affects the cement property. Cement should be kept properly on the site and as discussed below:

Cement is a moisture-sensitive material; if kept dry, it will retain its quality indefinitely. Cement stored in contact with damp air or moisture sets more slowly and has less strength than is kept dry [19].

At all stages up to the time of use, cement must be kept dry so as to prevent or minimize deterioration from the effects of moisture, atmospheric humidity and carbonation. Air tight drums and internally coated bulk silos are ideal storages. Cement in multi-wall paper bags should be stored in a waterproof building with close-fitting doors which should be kept closed as much as possible. The floor should be placed well above the ground and incorporate a vapor proof membrane so as to keep it dry. If this is not possible, the bagged cement must be stacked on pallets or on a dry board platform, some 150mm clear of the surface. The roof should be pitched as a slope of 1 in 3, so that condensation drips will not fall. In regions of high relative humidity, insulation and a storage temperature of 45ºc are advisable [4].

Bags of cement should be stacked close together, so as to restrict the circulation of air around them. The stakes should be kept 150 - 300 mm clear of the walls (with access ways 900 mm wide). Stacks that are more than eight bags high should be placed in the header and stretcher formation, so as to increase their stability when laid up to the maximum height (for economic handling) of 4.2 m. Tall stacks are stepping back for stability when cement is being withdrawn [4].

The cement which is 4 months old should be classified as "aged" and be retested before use. The capacity of bulk-storage containers should excess the requirements of cement for 1 week and they should be cleared out at least once each 4 months. For full strength development, the cement should be used within 3 months [4].

Ethiopian standard [ES 1177-1:2005] limit 8 bags high and protected by waterproof structure. On the other hand ACI 2009 recommended 14 and 7 layers depends on their storage period in stock of less than or greater 60 days by providing proper air circulation [4].

4.2.1.2. Implementation on aggregate

Aggregates are used 60 to 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 [4].

Stockpiles should be as large as possible, as this helps to ensure uniformity of moisture content. Ideally, stockpiled sand should be allowed to stand for 12 hours before use so that, apart from the lower part of the stockpile, the moisture content will be reasonably uniform at about 5 -7 %. When sand is very wet the moisture content can be as high as 12 - 15%. Unless adjustments are made to the water added at the mixer, excessive variations in workability, strength and durability will result [4].

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.

4.2.1.3. Implementation of water

The purpose of water with the ingredients for hydration acts as a lubricant cement, fine and coarse aggregates to produce workable and economical concrete mix.

In most sites water used from fresh water and portable water and it’s free from other organic impurities. In all building projects, there is no test conducted for water except visual inspection of non-drinking water. Of course, drinking water could be used for mixing purposes without any test; however, when this water is brought from other sources like rivers and drilled well off the ground, it should be tested. Because non-visually observed dissolved salts and other impurities, which could possibly be present in it, have a negative impact on both fresh and hardened concrete quality [26].

4.2.1.4. Quality control and assurance of concrete ingredients

The performance of implementing quality control and assurance of concrete ingredients on building construction in Jimma town is too loose from material delivery up to the ingredients tests on the field. Most sites do not test the quality of ingredients before concrete mix they used the test for the compressive strength of the concrete after the mix with regard that the quality of the ingredients are necessary for the achievement of its strength and workability.

Responsible for the quality control and assurance in the projects are the site engineers, material engineers, Forman's and supervisors. QC and QA should be properly implemented on the construction sites as discussed below:

QA consists of all the activities conducted by the owner, agent, or its representatives in order to confirm that the delivered pavement product meets specifications. QC refers to all activities conducted by the contractor (such as batching, placing, and finishing) to ensure that the product will meet or exceed QA specifications.

QA and QC test methods do not necessarily correlate for two reasons:

- Not all performance specifications are directly measurable.
- Not all laboratory tests can be completed in the field.

Also, the contractor may require different and/or more frequent tests than those specified to ensure quality control.

Repeatability and reproducibility of results are critical for both QC and QA functions. To support consistency, the following criteria should be met:

- QA and QC personnel are adequately trained and certified.
- Testing facilities are certified by AASHTO, ASTM, or other qualifying organization.

Still, the nature of the materials and the tests is such that test results are only estimates of actual pavement properties. All tests have different built-in levels of precision and variability that must be accounted for.

Proper documentation is necessary for accurate interpretation of QA and QC testing data. A good recordkeeping system usually includes the following elements:

- Clear, consistent labeling of samples.
- Accurate recording of sample locations and/or times.
- Legible handwriting on testing worksheets.
- Organized filing system.

Control charts, used primarily for process control, are useful for identifying and analyzing statistical shifts in concrete materials and processes. Their visual format provides a simple and effective means for interpreting acceptable and unacceptable levels of test result variability. Statistical control charts can also be used to show when a specific process is trending out of limits [27].

4.2.2. Standardization of concrete ingredients

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. 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 [19].

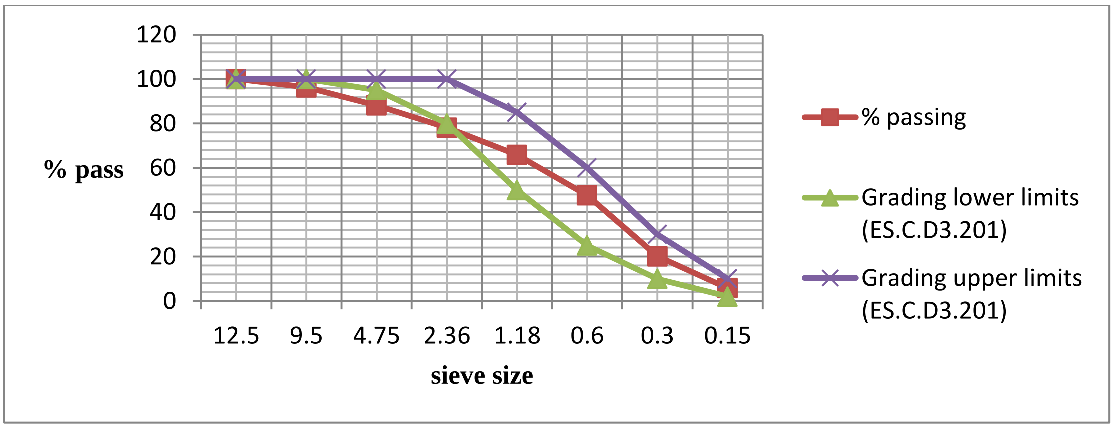

Figure 4.3 Gradation curve of Asendabo (omo nada) sand

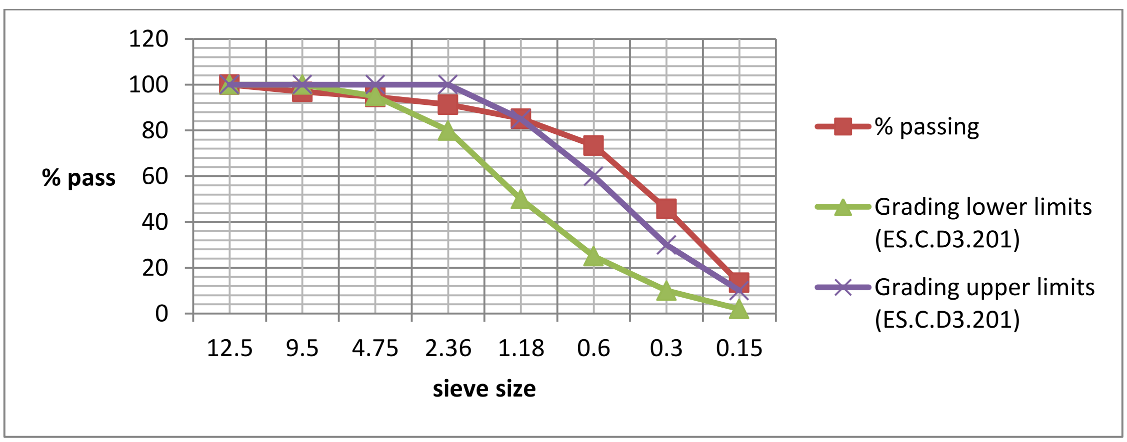

Figure 4.4 Gradation curve of Chewaka sand

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 [19].

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 [10].

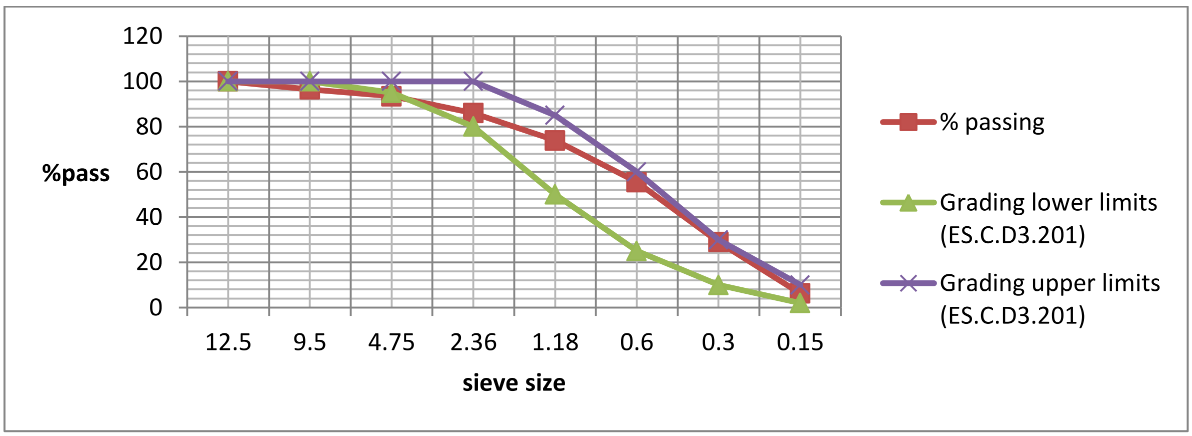

Figure 4.5 Gradation curve of Werabe sand

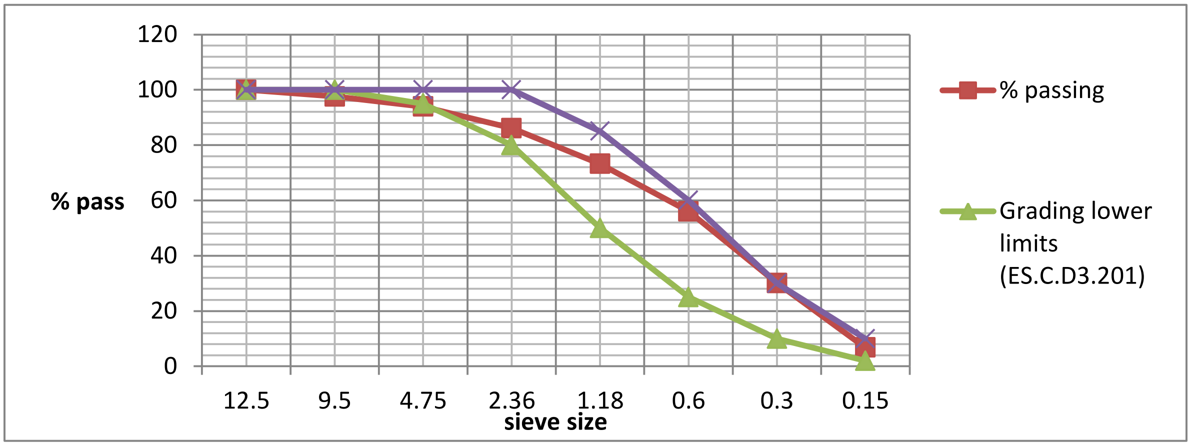

Figure 4.6 Gradation curve of Gambella sand

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.

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 [19].

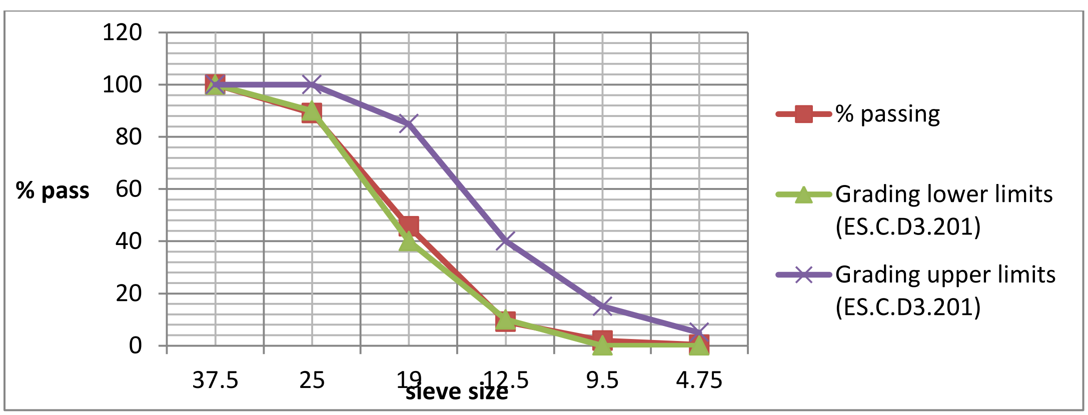

Figure 4.7 Gradation curve of Agaro quarry site (Mohamed and miftah crusher) result

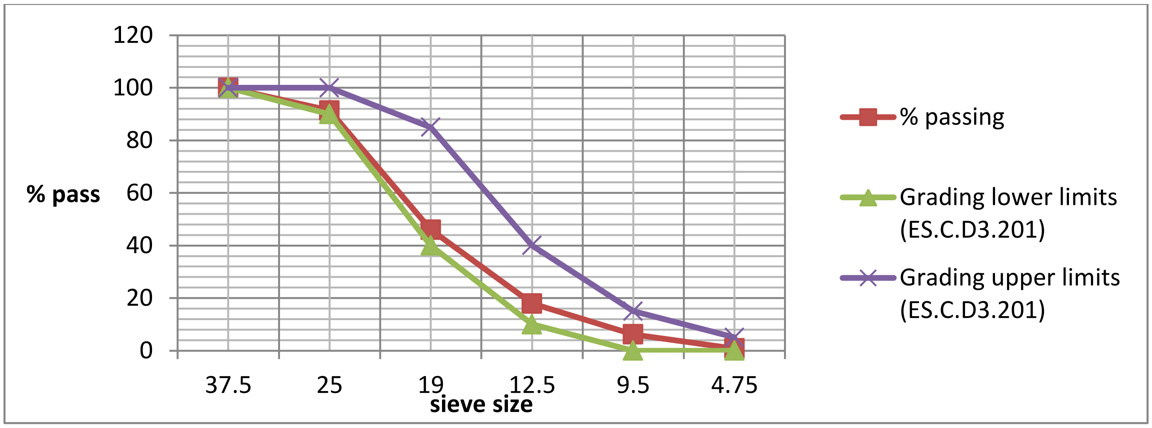

Figure 4.8 Gradation curve of Seka (afro-tsion crusher) quarry site result

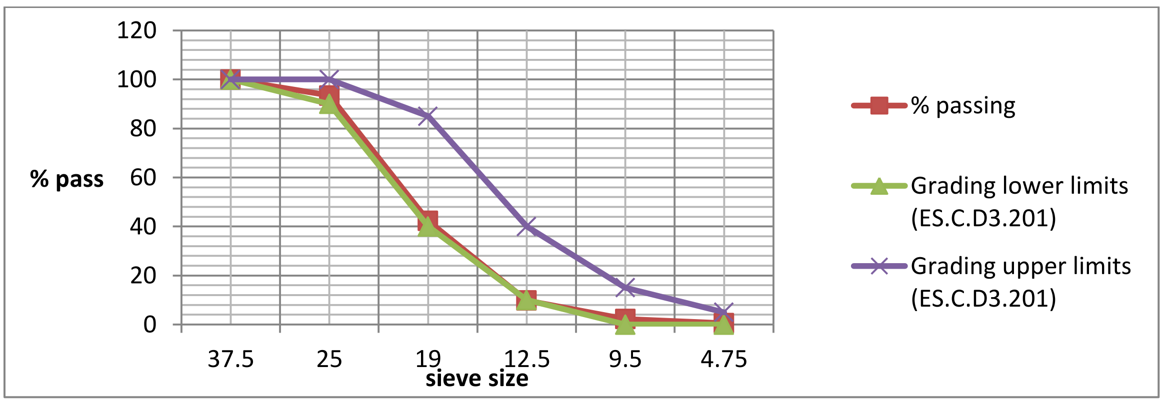

Figure 4.9 Gradation curve of St. Gabriel site (dagem crusher)

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 [28].

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 [28].

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 [29].

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.

Table 4.18 Summary of fineness modulus

Types of test	Types of material	Test result	Standard limit (ESC.D3.201:1990)	Remark
Fineness modulus	Asendabo (omo nada)	2.94	Between 2.0-3.5	It's between the limit
	Chewaka	1.97		Without the limit
	Werabe	2.56		It's between the limit
	Gambella	2.54		It's between the 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 [28].

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 1245 and 1825 kg/m3 (ASTM C29).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 4.19 Summary of unit weight

Type of test	Type of material	Test result	Standard limit (ASTM C29)	Remark
Compacted unit weight	Asendabo (omo nada)	1401.19kg/m^3	1245 – 1825kg/m^3	Within the limit
	Chewaka	1478.26kg/m^3		Within the limit
	Werabe	1461.78kg/m^3		Within the limit
	Gambella	1416.54kg/m^3		Within the limit
Loose unit weight	Asendabo	1334.18kg/m^3	1245 – 1825kg/m^3	Within the limit
	Chewaka	1357.97kg/m^3		Within the limit
	Werabe	1345.47kg/m^3		Within the limit
	Gambella	1334.35kg/m^3		Within the limit

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 1245 and 1825 kg/m3 (ASTM C29).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 4.20 Summary of unit weight for coarse aggregate

Type of test	Type of material	Test result	Standard limit (ASTM C29)	Remark
Compacted unit weight	St. Gabriel	1432.1kg/m^3	1245 – 1825kg/m^3	Within the limit
	Agaro	1522.42kg/m^3		Within the limit
	Seka	1588.18kg/m^3		Within the limit
Loose unit weight	St. Gabriel	1291.8kg/m^3	1245 – 1825kg/m^3	Within the limit
	Agaro	1470.27kg/m^3		Within the limit
	Seka	1406.78kg/m^3		Within the limit

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 [28].

4.2.2.1.4. Silt content

A) 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 6% and in the ASTM C117 states that the allowable limit is maximum 5%.

Table 4.21 Summary of silt content

Types of test	Types of material	Test result	Standard limit (ESC.D3.201) and ASTM C117	Remark
Silt content	Asendabo	13.72%	≤ 6%	Without the limit
	Chewaka	15.03%		Without the limit
	Werabe	5.09%		Within the limit
	Gambella	3.45%		Within the limit

Silt is unnecessary part of sand, 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.

4.2.2.1.5. 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.

Table 4.22 Summary of bulk and apparent specific gravity

Type of test	Type of material	Test result	Standard limit (ES.C.D3.201)	Remark
Apparent specific gravity	Asendabo	2.76%	2.4 – 3	Within the limit
	Chewaka	2.65%		Within the limit
	Werabe	2.6%		Within the limit
	Gambella	2.68%		Within the limit
Bulk specific gravity	Asendabo	2.6%	2.4 – 3	Within the limit
	Chewaka	2.5%		Within the limit
	Werabe	2.69%		Within the limit
	Gambella	2.68%		Within the limit

Table 4.23 Summary of bulk specific gravity (SSD)

Types of test	Types of material	Test result	Standard limit (ESC.D3.201)	Remark
Bulk specific gravity (SSD)	Asendabo	2.6%	2.4 – 3	Within the limit
	Chewaka	2.6%		Within the limit
	Werabe	2.75%		Within the limit
	Gambella	2.63%		Within the limit

B) For Coarse Aggregate

The Ethiopian standard requires for the specific gravity of the coarse aggregate should be in the range of between 2.4 and 3. In the investigated result all are satisfied the requirement of the Ethiopian standard except the coarse aggregate which came from Agaro quarry sites.

Table 4.24 Summary of specific gravity for coarse aggregate

Type of test	Type of material	Test result	Standard limit (ES.C.D3.201)	Remark
Apparent specific gravity	St. Gabriel	2.91	2.4 – 3	It's within the limit
	Agaro	2.36		Without the limit
	Seka	2.92		It's within the limit
Bulk specific gravity	St. Gabriel	2.81	2.4 – 3	It's within the limit
	Agaro	2.3		Without the limit
	Seka	2.84		It's within the limit
Bulk specific gravity (SSD)	St. Gabriel	2.84	2.4 – 3	It's within the limit
	Agaro	2.32		Without the limit
	Seka	2.87		It's within the limit

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 [28].

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.

Table 4.25 Summary of water absorption of fine aggregate

Types of test	Types of material	Test result	Standard limit (ASTM C127)	Remark
Water absorption	Asendabo	2.78%	0.2 – 4	Within the limit
	Chewaka	2.03%		Within the limit
	Werabe	2.16%		Within the limit
	Gambella	1.24%		Within the limit

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.

Table 4.26 Summary of water absorption of coarse aggregate

Type of test	Type of material quarry sites	Test result	Standard limit (ASTM C127)	Remark
Water absorption	St. Gabriel	1.91%	0.2 – 4%	It's within the limit
	Agaro	1.11%		It's within the limit
	Seka	0.9%		It's within the limit

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) [28].

4.2.2.1.7. Flakiness Index of coarse aggregate

According to the requirement of British standard (BS812) should lie in the range of the maximum of 35%.

All the conducted tests for the coarse aggregate are less than the allowable limit of British standard requirements. It's preferable to use on the concrete mix.

Table 4.27 Summary of flakiness index of coarse aggregate

Type of test	Type of material quarry sites	Test result	Standard limit (BS812)	Remark
Flakiness index	St. Gabriel	26	Maximum 35%	It's within the limit
	Agaro	25		It's within the limit
	Seka	21		It's within the limit

Surface texture refers to the degree of roughness or irregularity of the aggregate particle surface. Surface texture is usually described qualitatively using terms such as rough, granular, crystalline, smooth, or glassy rather than being described quantitatively. Smooth particles require less mixing water and therefore less cementitious material at a fixed w/cm to produce concrete with a given workability, but also have less surface area than rougher particles to bond with the cement paste [28].

Considering all of the factors that have an effect on concrete strength, the following appear to be most important:

1. The surface area available for bond to the cement paste. Here, the shape and texture of the largest particles is most important.

2. The surface texture of the largest pieces, which affects the bond strength per unit of surface area. The mineralogy and crystal structure of these largest pieces affects bond strength per unit area as well.

3. The relative rigidity of the aggregate particles compared with the surrounding paste or mortar. The closer the deformation characteristics of the aggregate are to that of the surrounding media, the lower are the stresses developed at particle surfaces.

4. Maximum size of the aggregate. For a given w/cm, as the size of the larger particles is increased, the likelihood of bond failure between paste and aggregate increases because stresses at the interface are higher than those for smaller particles [28].

4.2.2.1.8. Los Angeles Abrasion Test for coarse aggregate

According to the ASTM standard (ASTM C 131) require that the range should lie on maximum 50 % and also the Ethiopian standard (ESC. D3. 201 :) of coarse aggregate recommend not exceeding 50%.

Table 4.28 Summary of Los Angeles abrasion test of coarse aggregate

Type of test	Type of material quarry sites	Test result	Standard limit (ESC. D3.201)	Remark
Los Angeles abrasion	St. Gabriel	15.5%	Maximum 50%	It's within the limit
	Agaro	17.6%		It's within the limit
	Seka	19.04%		It's within the limit

All the tests of the coarse aggregate results show that falls on the allowable limit of the Ethiopian standards and recommends using in the mix.

The Los Angeles test is a measure of degradation of mineral aggregates of standard grading's resulting from combination of actions including abrasion or attrition, impact and grinding in a rotating steel spheres, the number depending up on the grading of the test sample.

The Los Angeles test has been widely used as an indicator of the relative quantity or competence of various sources of aggregate having similar mineral compositions [30].

4.2.2.1.9. Aggregate Crushing Value for coarse aggregate

On the British standard (BS812) it requires for the aggregate crushing value should be equal or less than 45%.

Table 4.29 Summary of aggregate crushing value of coarse aggregate

Type of test	Type of material quarry sites	Test result	Standard limit (BS812)	Remark
Aggregate crushing value	St. Gabriel	20.3%	≤ 45%	It's within the limit
	Agaro	14.2%		It's within the limit
	Seka	17.4%		It's within the limit

All the tasted coarse aggregate for crushing value have acceptable ranges as referred to British standard.

4.2.2.1.10. Soundness by Sodium Sulfate for coarse aggregate

According to ASTM standard (ASTM C88) the requirement of soundness by sodium sulfate shall not exceed 12%.

Table 4.30 Summary of soundness by sodium sulfate of coarse aggregate

Type of test	Type of material quarry sites	Test result	Standard limit (BS812)	Remark
Soundness by sodium sulfate	St. Gabriel	2.4%	< 12%	It's within the limit
	Agaro	2.3%		It's within the limit
	Seka	2.2%		It's within the limit

The range of the tasted all coarse aggregate results for soundness by sodium sulfate satisfies the requirements of the ASTM standards.

Soundness of an aggregate refers to its ability in concrete to withstand aggressive exposure, particularly due to weather. In areas with severe or moderate winters, a major cause of aggregate deterioration in exposed concrete is freezing and thawing. If an aggregate particle absorbs so much water that its pores are nearly completely filled, it may not accommodate the expansion that occurs when water turns to ice. As ice forms, the resulting expansion pushes unfrozen water through the aggregate pores and the resistance to this flow results in pressures that may be high enough to crack the particle. These pressures may crack the aggregate particle, and, in concrete, the surrounding concrete as well. This is known as "D-cracking." The developed pressure depends on the rate of freezing and the particle size above which the particle will fail if completely saturated. This critical size depends on the porosity, pore size, and total pore volume of the aggregate; the permeability or rate of discharge of water flowing through the aggregate; and the tensile strength of the particle [28].

4.2.2.1.11. Aggregate Impact Value for coarse aggregate

In the British standard (BS812: part 112:1190) refers the requirement of the aggregate impact is shall be in the range of maximum 30%.

All the conducted aggregate for building purposes are within the required range of British standard, so it's accepted for the standard.

Table 4.31 Summary of aggregate impact value of coarse aggregate

Type of test	Type of material quarry sites	Test result	Standard limit (BS812)	Remark
Aggregate crushing value	St. Gabriel	12.95%	Maximum 30%	It's within the limit
	Agaro	10.57%		It's within the limit
	Seka	15.77%		It's within the limit

The abrasion and impact resistance of an aggregate is its ability to resist being worn away by rubbing and friction or shattering upon impact. It is a general measure of aggregate quality and resistance to degradation due to handling, stockpiling, or mixing [28].

4.2.2.2. Cement

One of the ingredients of the concrete is cement. Most of the time in building construction OPC cement is preferable. In Jimma town most of the building projects are used OPC cement in the factory made, especially Dangote, Derban and National OPC cement.

As shown in the result the test conducted on setting time and fines of cement, these results are discussed below:

4.2.2.2.1. Setting time

According to the requirements of Ethiopian standard (ES D5. 201:1990) and on AASTHO T-131 is recommended that the range is the initial setting time should be minimum 45 minutes and final setting time should be maximum of 375 minutes.

Table 4.32 Summary of setting time of cement

Type of test	Type of material	Test result		Standard limit (ES. D5. 201)	Remark
		Initial setting time	Final setting time		
Setting time of cement	Dangote	87	148		It's within the limit
	Derban	76	175		It's within the limit
	National cement	83	193		It's within the limit

With regard to the Ethiopian standard all the tested cement fulfills the requirement of the Ethiopian standard, so it's preferable to use in the mix.

It is very important to predict and control setting time during concrete processing so concrete remains workable for a sufficient time that it can be placed and consolidated, but not for such a long time that finishing or form removal is excessively delayed. It is particularly important to prevent premature stiffening of the concrete due to false set or flash set. Because concrete set is controlled by reactions of the cement and water, perhaps modified by admixtures, it is expected that setting times of concrete may be measured using cement paste or mortar. The tests are used to ensure that the cement does not produce abnormal setting times or to test the response of a particular combination of cement and chemical admixture. Limits in setting time of paste and mortar also help assure overall concrete performance [10].

4.2.2.2.2. Fineness of cement

The Ethiopian standard (ES D5. 201:1990) and AASHTO T-128 requires for the fineness of cement should be no residue 10%.

Table 4.33 Summary of fineness of cement

Type of test	Type of material	Test result		Standard limit (ES. D5. 201)	Remark
		150µm (no.100) sieve	75µm (no.200) sieve		
Fineness of cement	Dangote	99.9%	98.7	< 10%	It's within the limit
	Derban	99.5%	95.6%		It's within the limit
	National cement	99.3%	99.1%		It's within the limit

According to the Ethiopian standard all the conducted cements achieve the requirements. So it's preferable for uses in the mix.

Fineness is a very important physical property for cement. Hydration rate is a function of fineness, so setting time, strength, shrinkage, heat of hydration, and permeability are all influenced by fineness. Increasing the fineness substantially increases the rate of hydration, thereby shortening the setting time, speeding up the strength gain, and speeding up the permeability reduction that accompanies hydration. Increasing fineness is a common strategy for meeting the faster strength gain specified for Type III Portland cement. Finer cements adsorb chemical admixtures more rapidly, often requiring higher admixture dosages. Finer cements also generate higher temperatures during hydration. Effects of fineness on performance properties were discussed by Bentz et al.

Fineness also affects consistency of fresh cementitious mixtures (paste, mortar, and concrete). The particle size distribution controls the density with which cement particles pack, therefore influencing the fluidity (viscosity) and, indirectly, the strength. With increased fineness generally come a higher proportion of submicron-sized particles, which are prone to flocculate. Unless prevented through the use of dispersing admixtures (water-reducers or super plasticizers), flocculation substantially increases the water demand of the cement, either reducing slump or, if a higher water content is used, reducing strength [10].

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

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

5.1. Conclusion

Quality implementation of the concrete ingredients and workmanship is a key aspect for the construction projects. It is a known fact that, the concrete ingredients should have proper management and handling, it’s one of the most important aspects of quality controlling in the building construction projects.

It was observed in this research that the concrete ingredients are not properly stockpiled in the sites as delivered to the project place. Most of the projects do not have large and preferable place for the concrete ingredients stockpiled on the site. In few projects the ingredients of concrete are not tested on the laboratory and on the field when delivered on site before mixing the concrete ingredient more than one in a time.

On the observed sites 75% of project sites do not fulfill the standard requirements of implementing and storing of aggregates with regard that it affects the quality of aggregate. This can be concluded that there is poor workmanship implanting and storing aggregate. It was observed that in most sites the quality control and assurance on the concrete ingredients, it’s too loose.

There was a shortage of aggregates suppliers in Jimma town due to that there was mixed one quarry aggregate to another aggregate on the site this affect the quality of concrete. Among the observed projects, most of them used tap water for the concrete mixing. When investigated in the field the consumption of the cement of OPC cement is higher than the need of PPC cement for concrete production for building purpose.

It’s found out from the result the fine aggregates have more silt content specially the Chewaka and Asendabo sands. For fine aggregate the gradation result shown that there is coarser than the finer parts of sand. In addition, since the supply of coarse and fine aggregates vary widely from one to the other the contractors are always in problem of producing concrete which satisfies especially, strength requirements.

The gradation on coarse aggregate shows that in sieve size 25mm (1 in.) and 12.5 mm (0.5 in.) on Agaro quarry site, also sieve size 12.5 mm (0.5 in.) on St. Gabriel quarry site it’s shows that under limit. All coarse aggregates satisfy the requirements of the standard except the specific gravity test observed on Agaro quarry site. However the coarse aggregate are fulfill the quality test for making concrete.

The cement is satisfying its requirement because of its produced in the factory with respect to the quality of standards. With respect to standardization of concrete making materials, the requirements set in the Ethiopian standard are not sufficient enough and also the quality requirements of contract documents and work supervisors in construction projects are quite loose.

The ingredients of concrete are found mostly in naturally occurring materials. However, their quality control is too loose when they are in the production before getting on the sites except cement because it’s a factory product. In addition, responsible authorities and construction supervisors make all the necessary check up on the quality of the materials.

5.2. Recommendation

The following recommendations have been made to improve the implementation of concrete ingredients and workmanship at Jimma town building construction site. First of all there should be co-related on the client, contractor and consultant for both parties responsible for the selection, quality control and assurance of the concrete ingredients on the projects.

5.2.1. Contractors

- The construction sites should have large and suitable place for the ingredients of concrete.
- Aggregates should be stockpiled on pallet or clear place free from moistures and clay materials.
- When aggregates deliver on the site there should be stockpiled by their gradation size on the preferable place.
- Cement should be kept dry storage. Cement which is 4 month old should be retested before use.
- The concrete ingredients should be tested quality tastes on sites and on every delivery of the ingredients before in the uses of mixing.
- Sand should be washed on the site before use and adjustment should be made on the water content in the sand on the building projects.
- Every building contractor should have check list manual of the concrete ingredients on the projects.
- When the ingredients used to mix, there should be on flat pellet or free from silt and moisture content and should not out more than the required amount of cement on the preferable mixing place.

5.2.2. Client

- Should give inspection on every delivery of the ingredients on site
- Should ask the contractor to prepare and submit the results of every test of the ingredients.

5.2.3. Consultants

- On the construction sites there should be proper control on delivery of the ingredients of concrete.

- Should review the specification of the concrete ingredients and the test results made on every concrete work.
- Should give inspection for every delivery of the concrete ingredients and check the stockpile and storage of the ingredients.
- Should assign material engineers to the construction projects.

5.2.4. Recommendation for future studies

- It is necessary to repeat this research every three years to observe the trends of the contractors.
- It is needed to develop the study concerning on the quality implementation of the concrete ingredients and workmanships in all towns of Ethiopia.

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ANNEX – A

PROCEDURE OF FINE AGGREGATE

EXPERIMENT – 1 GRAIN SIZE ANALYSIS OF AGGREGATE / TESTING OF AGGREGATES

Objective

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

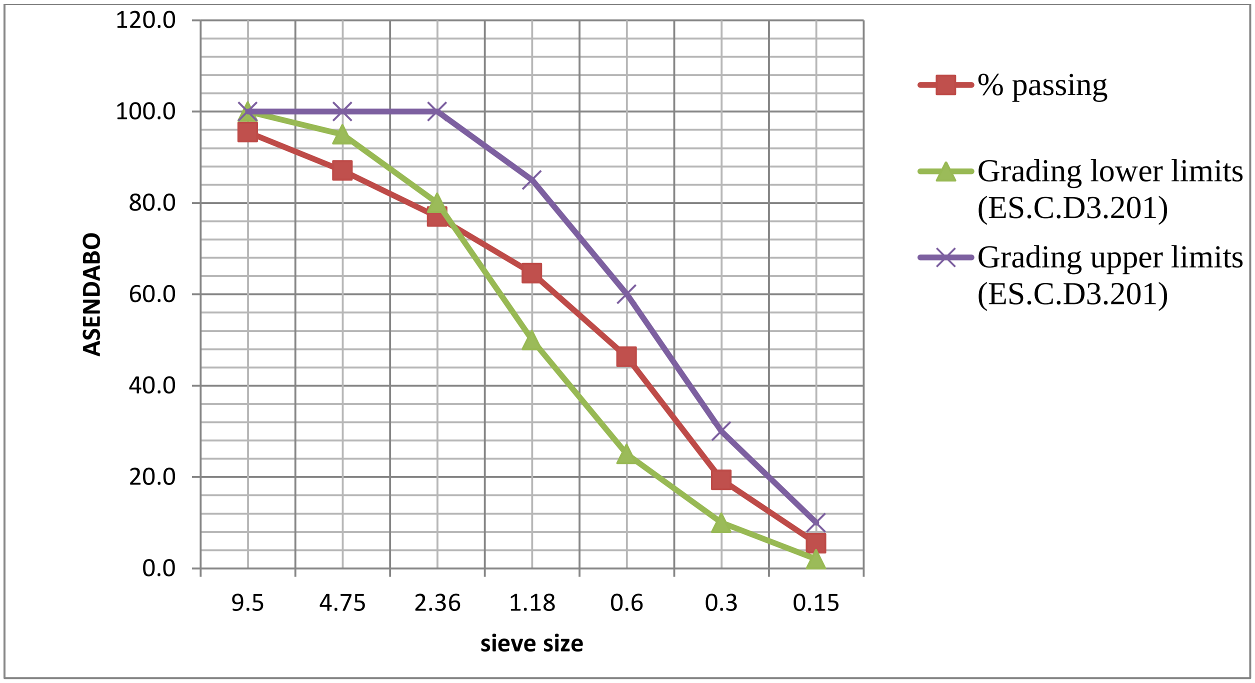
1. Taking 2 kg of sample of fine aggregates
2. Quartering the sample using riffle box
3. From the quartered sample we have taken 500g
4. Place the pan to the bottom of the sieve shaker and put the other sieves into the pan with Increasing opening seizes of the sieves
5. Placing 500g of the sample on 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

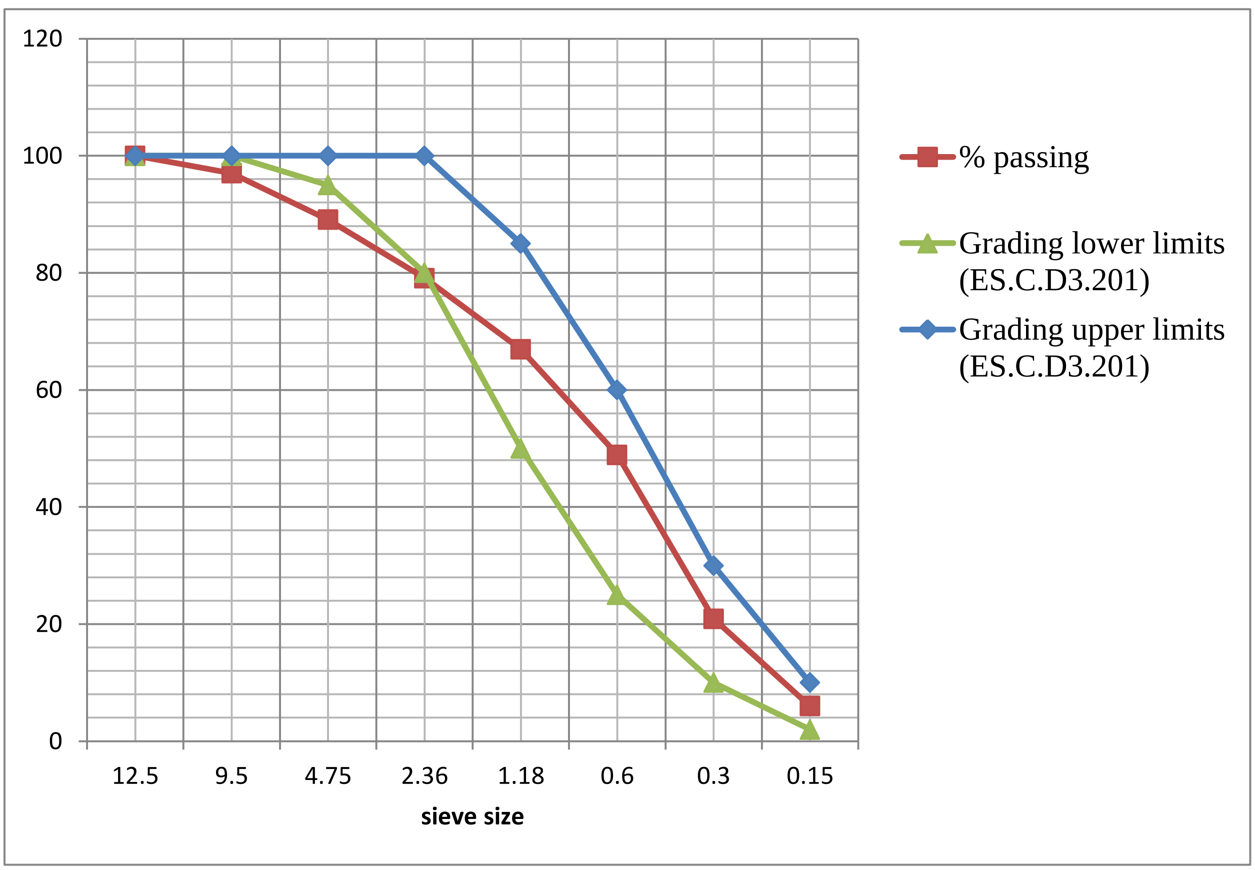
For Asendabo sand

Trial 1 **Sample-wet weight - 500.6 g** **Dry weight- 437.4 g**			
Sieve size, mm.	Weight retained(gm)	% Retained	% Passing
12.5	0	0	100
9.5	19.7	4.5	95.5
4.75	36.8	8.4	87.1
2.36	44.1	10.1	77.0
1.18	54.1	12.4	64.6
0.6	80.2	18.3	46.3
0.3	117.7	26.9	19.4
0.15	60.7	13.9	5.5
0.075	22.5	5.1	0.4
Pan	1.6		

Trial 2 Sample – wet weight= 508.2 g Dry weight=455.0 g			
sieve size, mm.	weight retained(gm)	% Retained	% Passing
12.5	0	0	100
9.5	13.6	3.0	97.0
4.75	36.0	7.9	89.1
2.36	45.5	10.0	79.1
1.18	55.3	12.2	66.9
0.6	82.0	18.0	48.9
0.3	127.5	28.0	20.9
0.15	67.7	14.9	6.0
0.075	25.5	5.6	0.4
pan	1.9		



Trial-1

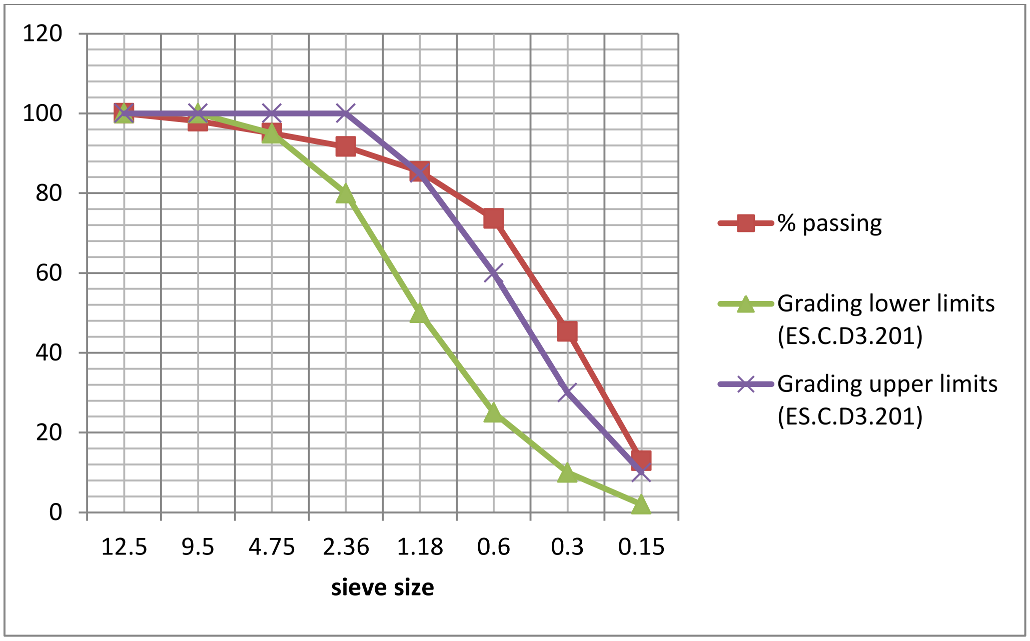


Trial-2

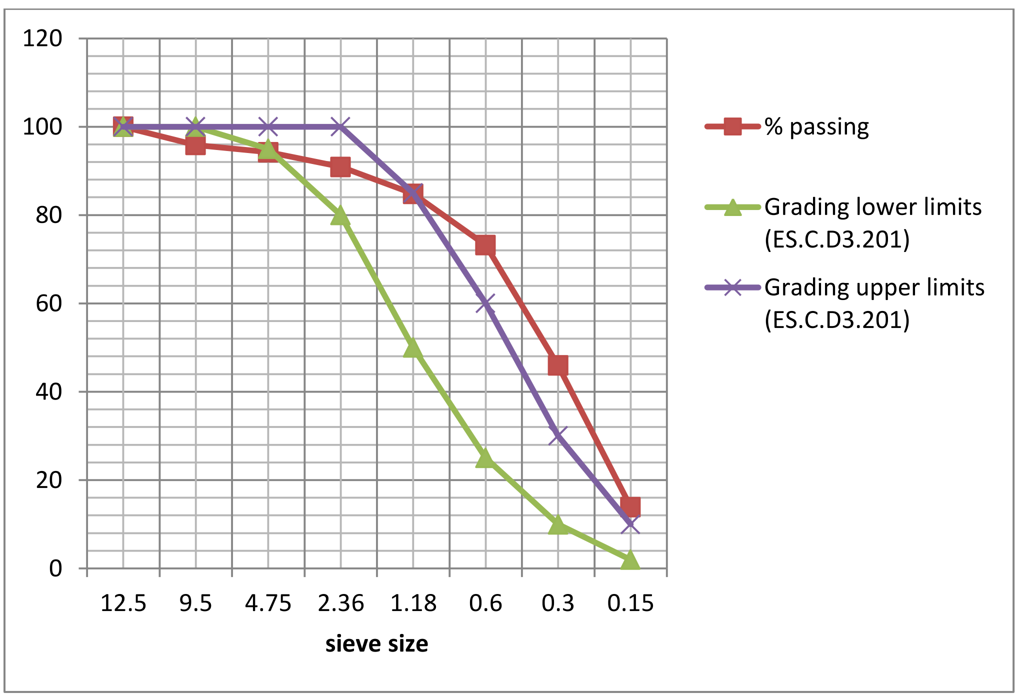
For Chewaka sand

Trial -1 Sample- wet weight =576.4 g Dry weight=436.8 g			
size, mm.	retained(gm)	Retained	Passing
12.5	0	0	100
9.5	8.6	2.0	98.0
4.75	13.1	3.0	95.0
2.36	14.7	3.4	91.7
1.18	27.1	6.2	85.5
0.6	51.8	11.9	73.6
0.3	123.4	28.3	45.4
0.15	141.8	32.5	12.9
0.075	53.4	12.2	0.7
pan	2.9		

Trial -2 Sample-wet dry=510.8 g Dry weight=489.9 g			
Sieve size, mm.	Weight retained(gm)	% retained	% Passing
12.5	0	0	100
9.5	20.2	4.1	95.9
4.75	8.1	1.7	94.2
2.36	16.3	3.3	90.9
1.18	29.8	6.1	84.8
0.6	57.0	11.6	73.2
0.3	133.4	27.2	45.9
0.15	157.0	32.0	13.9
0.075	64.5	13.2	0.7
Pan	3.6		



Trial-1

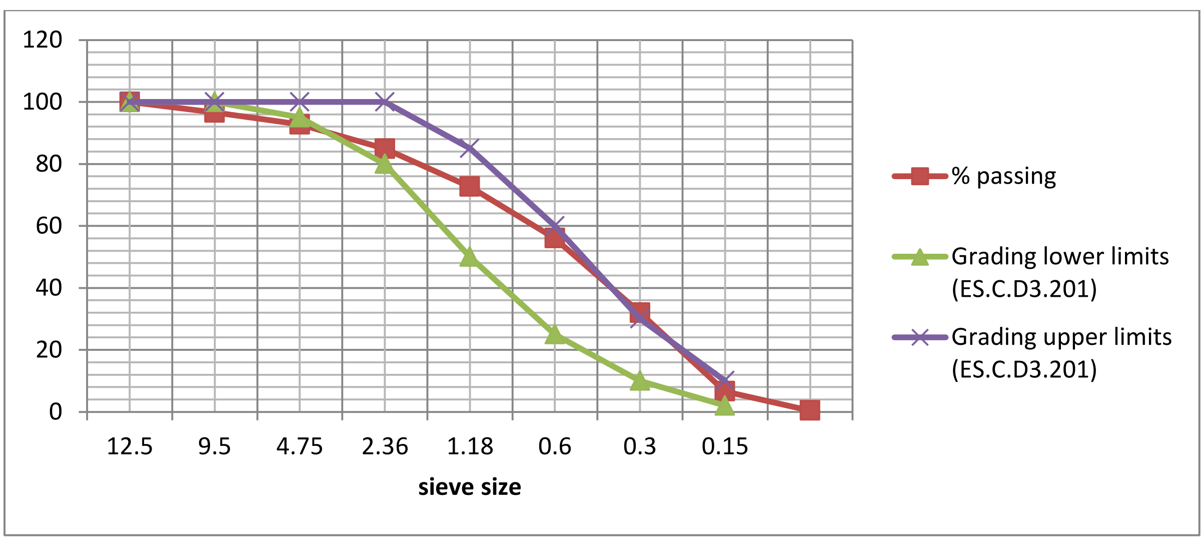


Trial-2

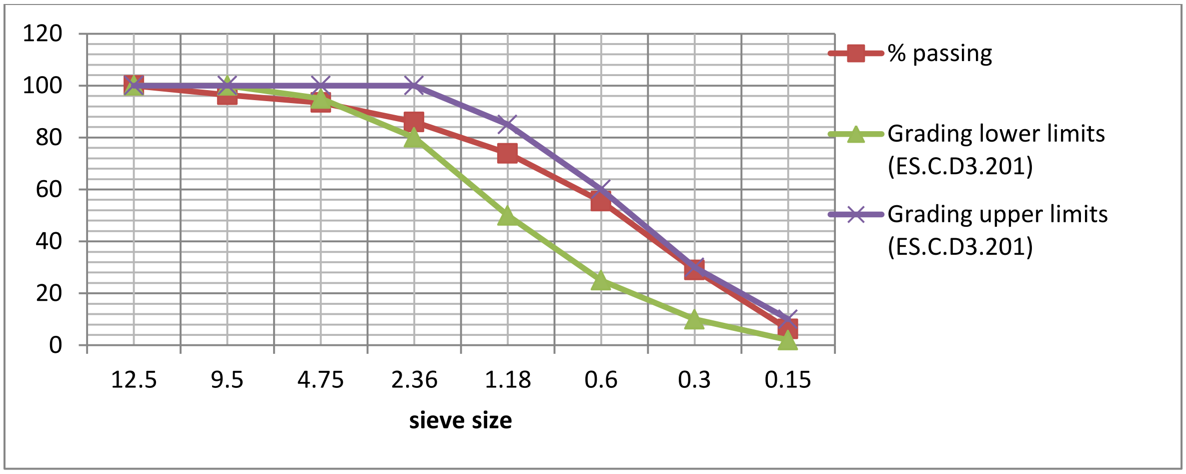
For Werabe sand

Trial 1 Sample-wet weight=550.4 g - Dry weight=534.1 g			
sieve size, mm.	weight retained(gm)	% retained	% passing
12.5	0	0	100
9.5	18.4	3.4	96.6
4.75	20.3	3.8	92.8
2.36	42.1	7.9	84.9
1.18	65.2	12.2	72.7
0.6	89.1	16.7	56.0
0.3	128.1	24.0	32.0
0.15	135.6	25.4	6.6
0.075	33.2	6.2	0.4
pan	2.1		

Trial 2 Sample-wet weight=550.2 g Dry weight=541.1 g			
sieve size, mm.	Weight retained(gm)	% retained	% passing
12.5	0	0	100
9.5	19.3	3.6	96.4
4.75	16.3	3.0	93.4
2.36	40.3	7.4	86.0
1.18	65.3	12.1	73.9
0.6	99.7	18.4	55.5
0.3	143.2	26.5	29.0
0.15	123.1	22.7	6.3
0.075	32.9	6.1	0.2
pan	1.0		



Trial-1

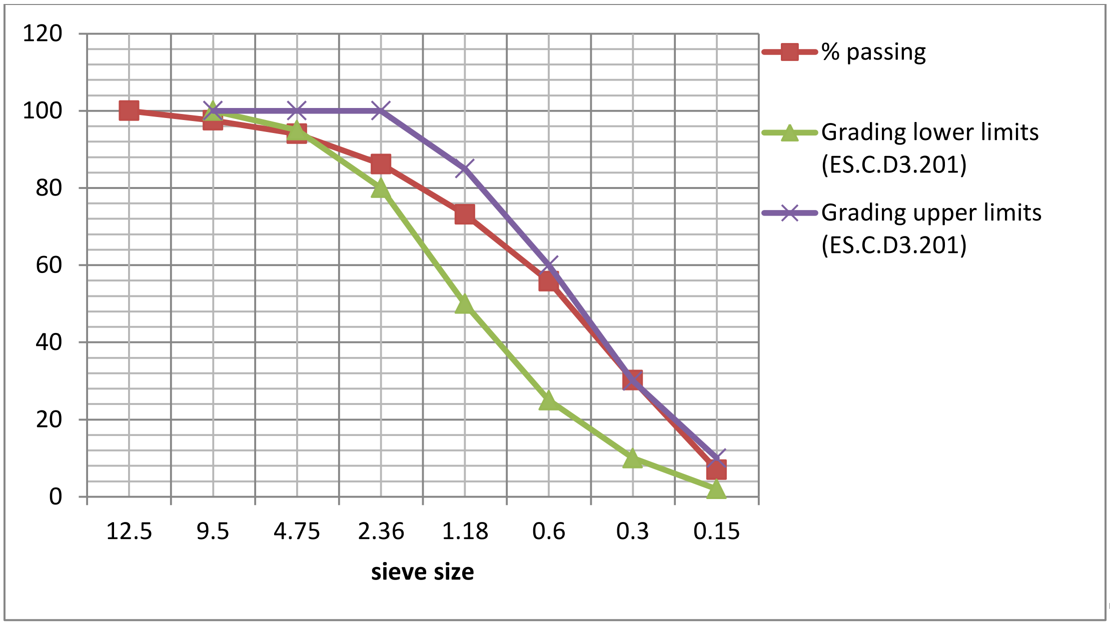


Trial-2

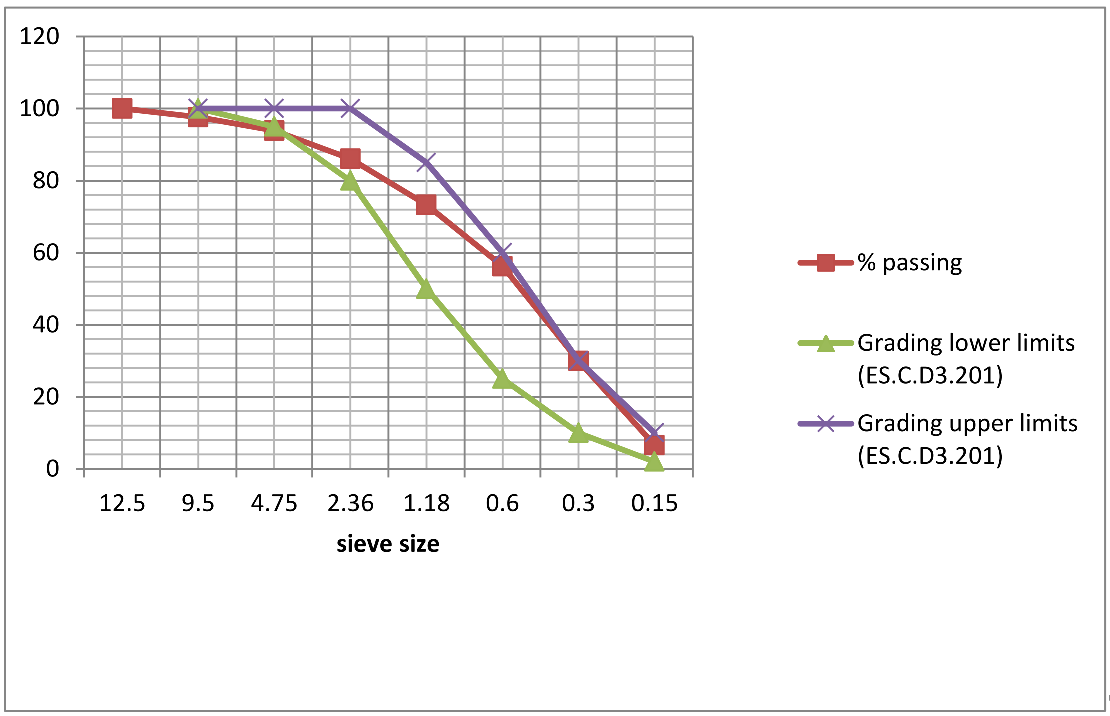
For Gambella sand

Trial 1 Sample size- wet weight=535.4 g Dry weight=527.3 g			
sieve size, mm.	weight retained(gm)	% retained	% passing
12.5	0	0	100
9.5	13.2	2.5	97.5
4.75	18.2	3.5	94.0
2.36	41.4	7.9	86.2
1.18	68.6	13.0	73.2
0.6	91.3	17.3	55.9
0.3	135.2	25.6	30.2
0.15	122.6	23.3	7.0
0.075	35.3	6.7	0.3
Pan	1.5		

Trial 2 Sample size- wet weight=525.3 g Dry weight= 518.0 g			
sieve size, mm.	Weight retained(gm)	% retained	% Passing
12.5	0	0	100
9.5	12.4	2.4	97.6
4.75	19.4	3.7	93.9
2.36	40.4	7.8	86.1
1.18	66.2	12.8	73.3
0.6	88.4	17.1	56.2
0.3	136.1	26.3	29.9
0.15	121.2	23.4	6.5
0.075	32.9	6.4	0.2
pan	1.0		



Trial-1



Trial-2

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. Loose 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

For Asendabo sand

1. Compacted Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.814	2.814	2.814	
Mass of Container + Sample	B	Kg	6.987	6.618	6.607	
Mass of Sample	B – A	Kg	4.173	3.804	3.793	
Volume of Container	C	m3	0.0028	0.0028	0.0028	
Unit Weight	(B - A) / C	Kg/m3	1490.357	1358.571	1354.643	1401.190

2. Loose Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	2.814	2.814	2.814	
Mass of Container + Sample	B Kg	6.613	6.538	6.498	
Mass of Sample	B – A Kg	3.799	3.724	3.684	
Volume of Container	C m3	0.0028	0.0028	0.0028	
Unit Weight	(B - A) / C Kg/m3	1356.786	1330.000	1315.714	1334.167

For Chewaka Sand

1. Compacted Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.814	2.814	2.814	
Mass of Container + Sample	B	Kg	7.245	6.678	6.642	
Mass of Sample	B – A	Kg	4.431	3.864	3.828	
Volume of Container	C	m3	0.0028	0.0028	0.0026	
Unit Weight	(B - A) / C	Kg/m3	1582.500	1380.000	1472.308	1478.269
2. Loose Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.814	2.814	2.814	
Mass of Container + Sample	B	Kg	6.813	6.538	6.498	
Mass of Sample	B – A	Kg	3.999	3.724	3.684	
Volume of Container	C	m3	0.0028	0.0028	0.0028	
Unit Weight	(B - A) / C Kg/m3		1428.214	1330.000	1315.714	1357.976

For Werabe sand

1. Compacted Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.814	2.814	2.814	
Mass of Container + Sample	B	Kg	7	6.743	6.735	
Mass of Sample	B – A	Kg	3.925	3.929	3.921	
Volume of Container	C	m3	0.0028	0.0028	0.0028	
Unit Weight	(B - A) / C	Kg/m3	1401.786	1403.214	1400.357	1401.786
2. Loose Density						

Trial No		1	2	3	Average
Mass of Container	A Kg	2.814	2.814	2.814	
Mass of Container + Sample	B Kg	6.601	6.605	6.538	
Mass of Sample	B – A Kg	3.787	3.791	3.724	
Volume of Container	C m3	0.0028	0.0028	0.0028	
Unit Weight	(B - A) / C Kg/m3	1352.500	1353.929	1330.000	1345.476

For Gambella sand

1. Compacted Density						
Trial No			1	2	3	Average
Mass of Container	A	Kg	2.814	2.814	2.814	
Mass of Container + Sample	B	Kg	6.776	6.796	6.769	
Mass of Sample	B - A	Kg	3.962	3.982	3.955	
Volume of Container	C	m3	0.0028	0.0028	0.0028	
Unit Weight	(B - A) / C	Kg/m3	1415.000	1422.143	1412.500	1416.548

2. Loose Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	2.814	2.814	2.814	
Mass of Container + Sample	B Kg	6.613	6.634	6.538	
Mass of Sample	B – A Kg	3.799	3.82	3.724	
Volume of Container	C m3	0.0028	0.0028	0.0028	
Unit Weight	(B - A) / C Kg/m3	1356.786	1364.286	1330.000	1350.357

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

For Asendabo sand

		Trial 1		Trial 2	
Mass of saturated surface-dry specimen	S	501.5	g	502.4	g
Mass of pycnometer filled with water	B	729.4	g	729.4	g
Mass of pycnometer + specimen + water	C	1041.2	g	1040.7	g
Mass of container	W_c		g		G
Mass of container + oven-dry specimen	W_1		g		G
Mass of oven-dry specimen	$A = W_1 - W_c$	487.4	g	489.2	g

Bulk Specific Gravity **(Dry Basis)**
A / (B + S - C) = **trial 1=2.5**

Trial 2=2.55

Bulk Specific Gravity
(Saturated Surface-Dry Basis)

S / (B + S - C) =**trial 1= 2.64**

Trial 2 =2.62

Absorption
[(S - A) / A] x 100% **trial 1= 2.89 %**

Trial 2=2.69

Apparent Specific Gravity
A/(A+B-C) **trial 1= 2.77 %**

Trial 2=2.74

For Chewaka sand

		Trial 1		Trial 2	
Mass of saturated surface-dry specimen	S	500.2	g	501.7	g
Mass of pycnometer filled with water	B	726.1	g	726.1	g
Mass of pycnometer + specimen + water	C	1031.6	g	1032.3	g
Mass of container	W_c		G		G
Mass of container + oven-dry specimen	W_1		G		G
Mass of oven-dry specimen	$A = W_1 - W_c$	490.6	g	491.2	g

Bulk Specific Gravity (Dry Basis)

A / (B + S - C) trial 1= <u>2.51</u>
Trial 2=2.51

Bulk Specific Gravity (Saturated Surface-Dry Basis)

S / (B + S - C) trial 1=<u>2.56</u>
Trial 2=2.56

Absorption
[(S - A) / A] x 100% **trial 1= <u>1.95 %</u>**

Trial 2=2.13

Apparent Specific Gravity
A/(A+B-C) **trial 1=2.51 %**

Trial 2=2.65

For Werabe sand

	Trial 1	Trial 2
Mass of saturated surface-dry specimen	510.5g	508.5
Mass of pycnometer filled with water	728.9g	728.9
Mass of pycnometer + specimen + water	1043.5g	1041.8
Mass of container	g	
Mass of container + oven-dry specimen	g	
Mass of oven-dry specimen A = W_1	499.8g	497.6

Bulk Specific Gravity
(Dry Basis)

A / (B + S - C) **Trial 1 = 2.55**

Trial 2= 2.54

Bulk Specific Gravity
(Saturated Surface-Dry Basis)

S / (B + S - C) **Trial 1 = 2.60**

Trial 2 =2.59

Absorption
[(S - A) / A] x 100% **Trial1 = 2.14 %**

Trial 2 = 2.19

Apparent Specific Gravity
A/(A+B-C) **Trial 1 = 2.57%**

Trial 2=2.67

For Gambella sand

Weigh to 0.1g

		Trial 1	Trial 2
Mass of saturated surface-dry specimen	S	503.2g	502.1g
Mass of pycnometer filled with water	B	728.9g	731.5g
Mass of pycnometer + specimen + water	C	1040.8g	1042.7g
Mass of container	W_c	g	G
Mass of container + oven-dry specimen	W_1	g	
Mass of oven-dry specimen	$A = W_1 - W_c$	497g	495.8g

Bulk Specific Gravity (Dry Basis)

A / (B + S - C) trial 1= 2.59

Trial 2=2.59

Bulk Specific Gravity(Saturated Surface-Dry Basis)

S / (B + S - C) trial 1= 2.63
Trial 2=2.63

Absorption

[(S - A) / A] x 100% trial1=1.24 %
Trial 2=1.27

Apparent Specific Gravity
A/(A+B-C) trial 1= 2.685 %
Trial 2=2.68

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 110^{o}c, 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)

Test results

For Asendabo sand	Trial 1	Trial 2	Average
Weight of the original sample (M1)	508.2	506.1	
weight of oven Dry sample(M2)	446.1	429.1	
Silt content $x = \frac{M1-M2}{M1} * 100$	12.22	15.21	13.72
For Chewaka sand	Trial 1	Trial 2	Average
Weight of the original sample (M1)	576.4	510.8	
weight of oven Dry sample(M2)	486.4	434	
Silt content $x = \frac{M1-M2}{M1} * 100$	15.61	15.04	15.32
For Werabe sand	Trial 1	Trial 2	Average
Weight of the original sample (M1)	525.4	540.3	
weight of oven Dry sample(M2)	498.3	513.2	
Silt content $x = \frac{M1-M2}{M1} * 100$	5.16	5.02	5.09
For Gambella sand	Trial 1	Trial 2	Average
Weight of the original sample (M1)	520.8	544.8	
weight of oven Dry sample(M2)	502.9	525.9	
Silt content $x = \frac{M1-M2}{M1} * 100$	3.44	3.47	3.45

ANNEX- B

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 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

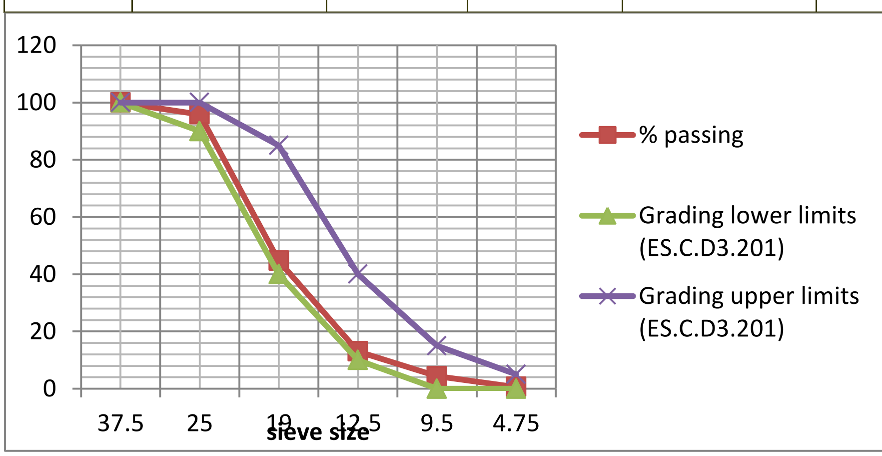
I. Procedure for grading coarse aggregates

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

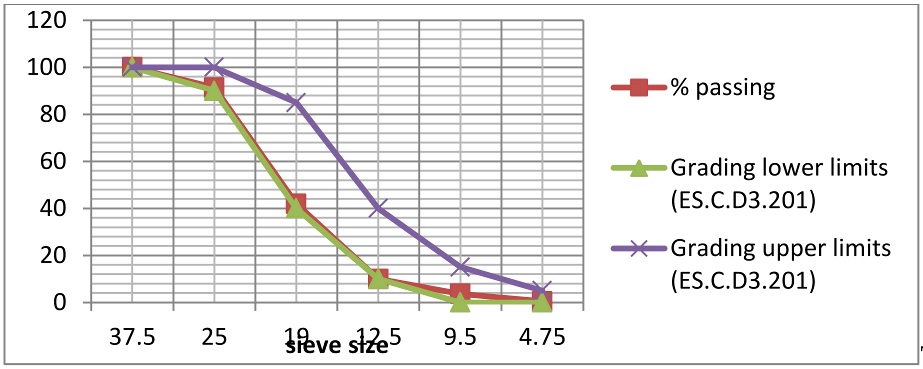
TEST RESULTS

For St. Gabriel site

	Trial 1			Trial 2		
sieve size, mm.	Weight retained(gm)	% retained	% passing	weight retained(gm)	% retained	% Passing
37.5	0	0	100	0	0	100
25	209.4	4.14	95.86	439.45	8.64	91.36
19	2588	51.18	44.68	2512.3	49.41	41.95
12.5	1601.2	31.67	13.01	1626.4	31.98	9.97
9.5	439.0	8.7	4.33	320.2	6.3	3.67
4.75	188.9	3.7	0.6	161.3	3.2	0.5
2.36	12.2	0.2	0.4	10.1	0.2	0.3
1.18	4.8	0.1	0.3	4.4	0.1	0.2
0.6	2.9	0.1	0.2	2.3	0.0	0.2
0.3	2.3	0.0	0.2	1.2	0.0	0.1
0.15	2.4	0.0	0.1	1.9	0.0	0.1
0.075	2.3	0.0	0.1	2.2	0.0	0.1
Pan	3.2			3.2		



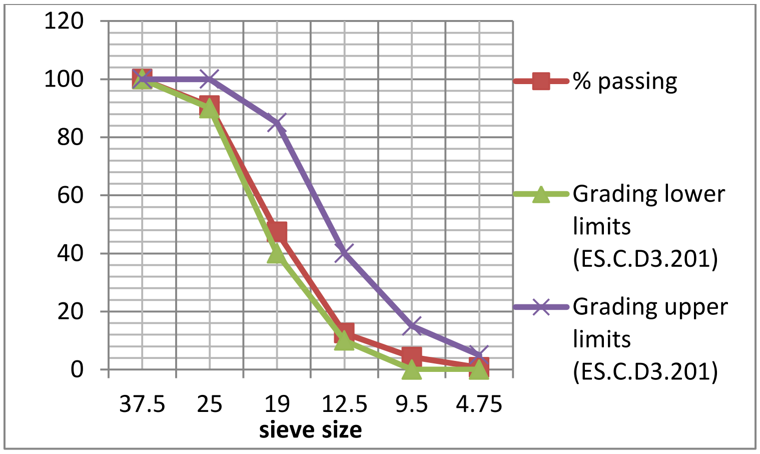
Trial-1



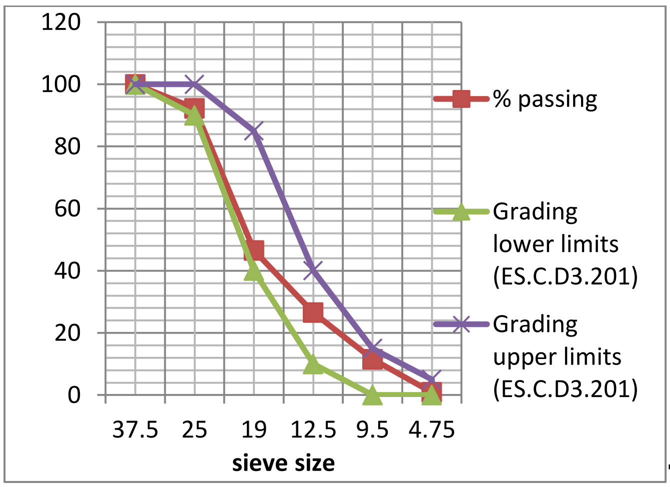
Trial-2

For Seka site

	Trial-1			Trial-2		
sieve size, mm.	weight retained(gm)	% retained	% passing	weight retained(gm)	% retained	% Passing
37.5	0	0	100	0	0	100
25	487.3	9.16	90.84	395.2	7.74	92.26
19	2314.3	43.48	47.36	2334.1	45.70	46.57
12.5	1854.2	34.84	12.52	1023.4	20.04	26.53
9.5	438.2	8.2	4.29	765.3	15.0	11.55
4.75	188.9	3.5	0.7	545.1	10.7	0.9
2.36	18.7	0.4	0.4	29.5	0.6	0.3
1.18	5.8	0.1	0.3	4.4	0.1	0.2
0.6	3.4	0.1	0.2	2.3	0.0	0.2
0.3	3.1	0.1	0.2	1.2	0.0	0.1
0.15	3.2	0.1	0.1	1.9	0.0	0.1
0.075	2.8	0.1	0.0	2.2	0.0	0.1
pan	2.4			3.2		

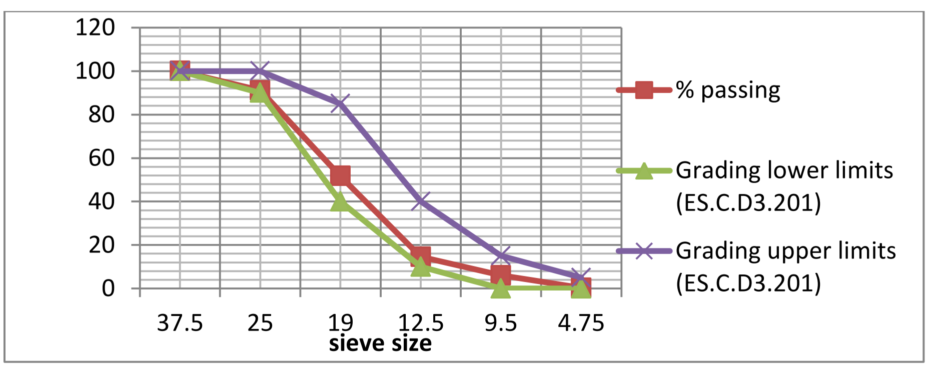


Trial-1

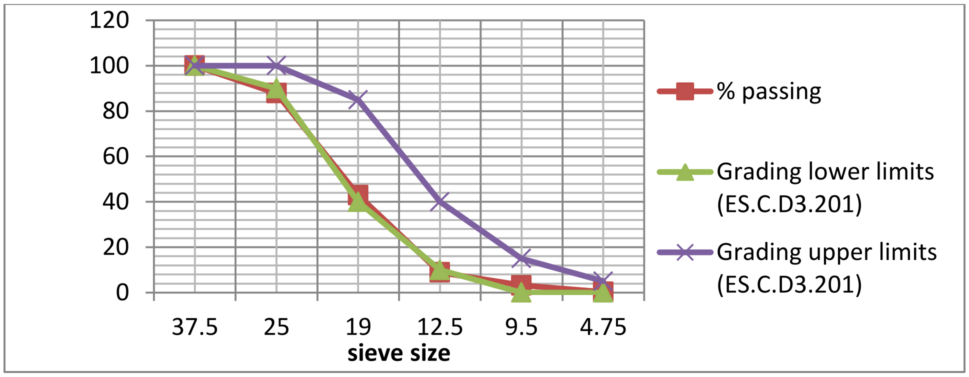


Trial-2

For Agaro site



Trial-1



Trial-2

	Trial-1			Trial-2		
sieve size, mm.	Weight retained(gm)	% retained	% passing	weight retained(gm)	% retained	% Passing
37.5	0	0	100	0	0	100
25	457.4	8.92	91.08	678.5	12.13	87.87
19	2016.3	39.34	51.74	2512.3	44.91	42.96
12.5	1905.1	37.17	14.57	1905.1	34.06	8.90
9.5	439.0	8.6	6.00	320.2	5.7	3.18
4.75	294.8	5.8	0.2	161.3	2.9	0.3
2.36	2.9	0.1	0.2	3.4	0.1	0.2
1.18	1.8	0.0	0.2	2.4	0.0	0.2
0.6	1.9	0.0	0.1	2.1	0.0	0.2
0.3	1.3	0.0	0.1	1.2	0.0	0.1
0.15	1.4	0.0	0.1	1.9	0.0	0.1
0.075	1.3	0.0	0.0	2.2	0.0	0.1
pan	2.2			3.2		

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

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. Loose 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 St. Gabriel

1. Compacted Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	9.987	9.987	9.987	
Mass of Container +Sample	B Kg	31.95	31.65	30.83	
Mass of Sample	B–A Kg	20.65	21.663	20.843	
Volume of Container	C m3	0.0147	0.0147	0.0147	
Unit Weight	(B-A)/C Kg/m3	1404.762	1473.673	1417.891	1432.109

2. Loose Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	9.987	9.987	9.987	
Mass of Container + Sample	B Kg	29.57	28.93	28.43	
Mass of Sample	B – A Kg	19.583	18.943	18.443	
Volume of Container	C m3	0.0147	0.0147	0.0147	
Unit Weight	(B- A) / C Kg/m3	1332.177	1288.639	1254.626	1291.814

For Seka site

1. Compacted Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	9.987	9.987	9.987	
Mass of Container +Sample	B Kg	35	34	31	
Mass of Sample	B–A Kg	25.013	24.013	21.013	
Volume of Container	C m3	0.0147	0.0147	0.0147	
Unit Weight	(B- A) / C Kg/m3	1701.565	1633.537	1429.456	1588.186
2. Loose Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	9.987	9.987	9.987	
Mass of Container + Sample	B Kg	32	30	30	
Mass of Sample	B – A Kg	22.013	20.013	20.013	
Volume of Container	C m3	0.0147	0.0147	0.0147	
Unit Weight	(B- A) / C Kg/m3	1497.483	1361.429	1361.429	1406.780

For Agaro site

1. Compacted Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	9.987	9.987	9.987	
Mass of Container +Sample	B Kg	32.6	32	32.5	
Mass of Sample	B – A Kg	22.613	22.013	22.513	
Volume of Container	C m3	0.0147	0.0147	0.0147	
Unit Weight	(B -A) / C Kg/m3	1538.299	1497.483	1531.497	1522.426
2. Loose Density					
Trial No		1	2	3	Average
Mass of Container	A Kg	9.987	9.987	9.987	
Mass of Container + Sample	B Kg	31.8	31.6	31.4	
Mass of Sample	B – A Kg	21.813	21.613	21.413	
Volume of Container	C m3	0.0147	0.0147	0.0147	
Unit Weight	(B-A) / C Kg/m3	1483.878	1470.272	1456.667	1470.272

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 St. Gabriel

Description	Test 1	Test 2	Average
A. Mass of Oven Dry Sample in Air g	2522.6	2497.2	
B. Mass of Saturated Surface Dry Sample in Air g	2553.8	2528.9	
C. Mass Sample in Water g	1649.9	1645.5	
Absorption (B - A)/ A *100	1.24	1.27	1.25
Test temperature ,^{o}C			
Apparent Specific Gravity A/A - C	2.890	2.930	2.91
Bulk Specific Gravity A/B - C	2.790	2.820	2.81
Bulk Specific Gravity (S.S.D basis) B/B - C	2.820	2.860	2.84

For Seka

Description		Test 1	Test 2	Average
A. Mass of Oven Dry Sample in Air	g	2500.0	2600.0	
B. Mass of Saturated Surface Dry Sample in Air	g	2522.8	2623.1	
C. Mass Sample in Water	g	1650.6	1704.3	
Test temperature ,^{o}C				
Absorption (B - A)/ A *100		0.91	0.88	0.90
Apparent Specific Gravity A/A - C		□□□□	□□□□	□□□□
Bulk Specific Gravity A/B - C		2.94	2.90	2.92
Bulk Specific Gravity (S.S.D basis) B/B - C		2.89	2.85	2.87

For Agaro site

Description		Test 1	Test 2	Average
A. Mass of Oven Dry Sample in Air	g	3260.5	3205.5	
B. Mass of Saturated Surface Dry Sample in Air	g	3302.1	3235.6	
C. Mass Sample in Water	g	1867.6	1856.3	
Test temperature ,^{o}C				
Absorption (B - A)/ A *100		□□□□	□□□□	□□□□
Apparent Specific Gravity A/A - C		2.341	2.376	2.36
Bulk Specific Gravity A/B - C		2.273	2.324	2.30
Bulk Specific Gravity (S.S.D basis) B/B - C		2.273	2.324	2.273

EXPERIMENT-4 Determination of aggregate impact value

Objective

To evaluate the resistance of aggregates to sudden impact loading

Theory

The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differ from its resistance to a slowly applied compressive load. With aggregate of aggregate impact value higher than 30 the result may be anomalous. Also aggregate sizes larger than 12.5 mm ASTM are not appropriate to the aggregate impact test. The standard aggregate impact test shall be made on aggregate passing a 12.5 mm ASTM test sieve and retained on a 10.0mm ASTM test sieve. If required, or if the standard size not available, smaller sizes may be tested but owing to the non-homogeneity of aggregates the result are not likely to be the same as those obtained from the standard sizes. In general, the smaller sizes of aggregate will give a lower impact value but the relationship between the values obtained with different sizes may vary from one aggregate to another.

Apparatus

- Impact testing machine
- Sieves
- Straight metal tamping rod
- Balance accurate to 0.1g

Procedure

1. Place the whole of the test sample in the impact machine.
2. Adjust the hammer so that its lower face is 380mm ASTM above the upper surface of aggregate in the cup and then allow it to fall freely on to the aggregate. Subject the sample to a total of 20 ASTM such blows.

   Note: weight of hammer is 14 kg ASTM.

3. Then remove the crushed aggregate, by holding the cup and hammering on the outside, in to a clean tray.
4. Sieve the whole sample in the tray on the 2.36 mm ASTM test sieve until no further significant amount passes in 1min.
5. Weigh the fractions passing and retained on the sieve to an accuracy of 1.0 g.(mass B and mass C respectively), and if the total mass B + C is less than initial mass(mass A) by more than 1g, discard the result and make a fresh test.

Test results

For St. Gabriel

Trial. No.	weight of measure (gm.) --a	weight of measure plus aggregates sample (gm.)------b	Net weight of aggregates in the measure in g (A) =b-a	The fraction passing through 2.36mm ASTM Sieve in g (B)	The fraction retained on 2.36 mm ASTM Sieve in g (C)	Aggregate impact value= **AIV=$\frac{B}{A}$*100**
1	783.2	1155.6	372.4	38.5	333.9	10.34
2	783.2	1148	364.8	56.6	308.2	15.52
Average value (%)						**12.927**

For Seka site

Trial. No.	weight of measure (gm.) --a	weight of measure plus aggregates sample (gm.)------b	Net weight of aggregates in the measure in g (A) =b-a	The fraction passing through 2.36mm ASTM Sieve in g (B)	The fraction retained on 2.36 mm ASTM Sieve in g (C)	Aggregate impact value= **AIV=$\frac{B}{A}$*100**
1	783.2	1152.0	368.8	55.2	313.6	14.97
2	783.2	1149.3	366.1	60.7	305.4	16.58
Average value (%)						**15.774**

For Agaro site

Trial. No.	weight of measure(gm.) -- a	weight of measure plus aggregates sample (gm.)------b	Net weight of aggregates in the measure in g (A) =b-a	The fraction passing through 2.36mm ASTM Sieve in g (B)	The fraction retained on 2.36 mm ASTM Sieve in g (C)	Aggregate impact value= **AIV=$\frac{B}{A}$*100**
1	783.2	1153.2	370	28.8	341.2	7.78
2	783.2	1146.2	363	48.5	314.5	13.36
Average value (%)						**10.572**

EXPERIMENT -5 Determination of aggregate crushing value

Objective

To evaluate the resistance of aggregates against a gradually applied load

Theory

The aggregate crushing value gives a relative measure of the resistance of an aggregate of an aggregate to crushing under a gradually applied compressive load. With aggregate of an aggregate crushing value higher than 30 the result may be anomalous, and in such cases the ten percent fines value should be determined instead. The standard aggregate crushing test shall be made on aggregate passing a 12.5 mm ASTM test sieve and retained on 10mm ASTM test sieve. If required, or if the standard size of aggregate is not available, the test shall be made according to table 1.

Apparatus

- An open ended steel cylinder
- A straight metal tamping rod of a circular cross-section 16mm diameter
- A balance of at least 3kg capacity and accurate to 1g
- ASTM standard sieves size 12.5mm,10mm, and 2.36mm

- A compression testing machine capable of applying a force of 400KN

Procedure

1. Place the apparatus, with the test sample and plunger in position, and load it as uniform a rate as possible so that the required force is reached in 10min. the required force shall be 400KN.
2. Release the load and remove the crushed material by holding the cylinder over a clean tray and hammering out side.
3. Sieve the whole of the sample on the tray on the 2.36mm ASTM test sieve until no further significant amount passes in 1 min.
4. Weigh the fraction passing the sieve (mass B)
   Note: take care in all this operations to avoid loss of the fines

Test results

For St. Gabriel

Trial No.	**1**	**2**
Size of aggregate, mm.	**10 - 14**	**10 – 14**
Maximum load applied, KN	**400.6**	**400**
Duration of testing, min.	**7.4**	**10**
Weight of sample tested, gm.	2631.7	2703.3
Weight of sample retained on 2.36 mm sieve size, gm.	2140.8	2110.1
Aggregate Crushing Value, %	18.7	21.9
AVERAGE AGG. CRUSHING VALUE, %	**20.3**	

For Seka site

Trial No.	**1**	**2**
Size of aggregate, mm.	**10 - 14**	**10 - 14**
Maximum load applied, KN	**400.6**	**400**
Duration of testing, min.	**7.4**	**10**
Weight of sample tested, gm.	2899	2788
Weight of sample retained on 2.36 mm sieve size, gm.	2389.9	2306.4
Aggregate Crushing Value, %	17.6	17.3
AVERAGE AGG. CRUSHING VALUE, %	**17.4**	

For Agaro site

Trial No.	**1**	**2**
Size of aggregate, mm.	**10 - 14**	**10 – 14**
Maximum load applied, KN	**400.6**	**400**
Duration of testing, min.	**7.4**	**10**
Weight of sample tested, gm.	2899	2788
Weight of sample retained on 2.36 mm sieve size, gm.	2389.9	2306.4
Aggregate Crushing Value, %	17.6	17.3
AVERAGE AGG. CRUSHING VALUE, %	**17.4**	

EXPERIMENT-6 Los Angeles Abrasion test

Objective

To evaluate how the aggregate is sufficiently hard to resist the abrasion effect.

Theory

This test give a measure of the resistance of aggregate to surface wears abrasion. The most widely used abrasion test is the Los Angeles abrasion test. Where aggregate sample is placed in steel drum with a number of steel balls of 4.8mm diameter and the drum is set to rotate a specified number of times at a specified speed. The Los Angeles abrasion value is the percentage of fines passing the 1.7mm ASTM sieve that gives the abrasion resistance of the aggregate. Soft aggregates are quickly ground to dust while hard aggregates lose little mass.

Apparatus

- Abrasion machine
- Sieves
- Balance(accurate to 0.1 gram)
- Brushes
- Well ventilated oven

Procedure

1. Wash, dry, and obtain mass of the sample.
2. Place in abrasion machine.
3. Add 12 standard balls.
4. Rotate the drum 500 revolutions at 28-30 rpm.
5. Remove the sample, sieve on 1.7mm ASTM sieve.
6. Wash the sample retained.
7. Oven-dry at 105ºc to 110ºc to subsequent constant mass, and weigh to the nearest 1g.

Test results

For St. Gabriel

Sieve Size (Square Openings)		Mass of Indicated Sizes, g			
Passing	**Retained on**	Grading			
		A	B	C	D
37.5 mm (11⁄2 in.)	25.0 mm (1 in.)	**1 250 ± 25**			
25.0 mm (1 in.)	19.0 mm (3⁄4 in.)	**1250 ± 25**			
19.0 mm (3⁄4 in.)	12.5 mm (1⁄2 in)	**1250 ± 10**	2500 ± 10		
12.5 mm (1⁄2 in.)	9.5 mm (3⁄8 in.)	**1250 ± 10**	2500 ± 10		
9.5 mm (3⁄8 in.)	6.3 mm (1⁄4 in.)			2500 ± 10	
6.3 mm (1⁄4 in.)	4.75-mm (No. 4)			2500 ± 10	
4.75-mm (No. 4)	2.36-mm (No. 8)				5000 ± 10
Total		5 000 ± 10	5 000 ± 10	5 000 ± 10	5 000 ± 10
Number of Revolution		**500**			
Number of Steel Balls		12	11	8	6

Sieve		Weight of the sample before test ;(gm.)	Weight of retained On sieve 1.7mm (#12)gm.	Weight of passing on sieve 1.7mm (#12) gm.	Percent loss %
Passing	**Retained on**				
37.5 mm (11⁄2 in.)	25.0 mm (1 in.)	1253.6	**4235.7**	**777.4**	**15.50%**
25.0 mm (1 in.)	19.0 mm (3⁄4 in.)	1252.8			
19.0 mm (3⁄4 in.)	12.5 mm (1⁄2 in)	1253.4			
12.5 mm (1⁄2 in.)	9.5 mm (3⁄8 in.)	1253.3			
9.5 mm (3⁄8 in.)	6.3 mm (1⁄4 in.)	-	-	-	-
6.3 mm (1⁄4 in.)	4.75-mm (No. 4)	-	-	-	-
4.75-mm (No. 4)	2.36-mm (No. 8)	-	-	-	-
Total		**5013.1**			
Calculate the loss (difference between the original mass and the final mass of the test sample) as a percentage of the original mass of the test sample.					

For Seka site

Sieve		Weight of the sample before test ;(gm.)	Weight of retained	Weight of passing on sieve 1.7mm (#12) gm.	Percent loss
Passing	**Retained on**		On sieve 1.7mm (#12)gm.		%
37.5 mm (1 1⁄2 in.)	25.0 mm (1 in.)	1254.5	**4055.6**	777.4	**<u>19.04%</u>**
25.0 mm (1 in.)	19.0 mm (3⁄4 in.)	1251.6			
19.0 mm (3⁄4 in.)	12.5 mm (1⁄2 in)	1253.2			
12.5 mm (1⁄2 in.)	9.5 mm (3⁄8 in.)	1250.3			
9.5 mm (3⁄8 in.)	6.3 mm (1⁄4 in.)	-	-	-	-
6.3 mm (1⁄4 in.)	4.75-mm (No. 4)	-	-	-	-
4.75-mm (No. 4)	2.36-mm (No. 8)	-	-	-	-
Total		**5009.6**			
Calculate the loss (difference between the original mass and the final mass of the test sample) as a percentage of the original mass of the test sample.					

For Agaro site

Sieve		Weight of the sample before test ;(gm.)	Weight of retained	Weight of passing on sieve 1.7mm (#12) gm.	Percent loss
Passing	**Retained on**		On sieve 1.7mm (#12)gm.		%
37.5 mm (11⁄2 in.)	25.0 mm (1 in.)	1249.0	**4120.4**	878.6	**17.6 %**
25.0 mm (1 in.)	19.0 mm (3⁄4 in.)	1250.3			
19.0 mm (3⁄4 in.)	12.5 mm (1⁄2 in)	1249.3			
12.5 mm (1⁄2 in.)	9.5 mm (3⁄8 in.)	1250.4			
9.5 mm (3⁄8 in.)	6.3 mm (1⁄4 in.)	-	-	-	-
6.3 mm (1⁄4 in.)	4.75-mm (No. 4)	-	-	-	-
4.75-mm (No. 4)	2.36-mm (No. 8)	-	-	-	-
Total		**4999.0**			

EXPERIMENT-7 Soundness by Sodium Sulfate

Objective

The objective of the test is to provide a procedure for making a preliminary estimate of the soundness of aggregates subject to weathering action for use in concrete and road pavements.

Theory

The soundness test by use of sodium sulfate covers the testing of aggregates to estimate their soundness when subjected to weathering. This is accomplished by repeated immersion in saturated solution of sodium sulfate followed by oven drying to partially or completely dehydrated the salt precipitated in permeable pore spaces. The internal expansive forces derived from the rehydration of the salt upon re-immersion, stimulates the expansion of water freezing. The test method furnishes information is not available from service records of the material exposed to actual weathering conditions.

Apparatus

- Sieves
- Oven
- Balance
- Containers
-

Procedures

1. Immerse the samples in the prepared solution of sodium sulfate for 16-18 hrs., in such a manner that the solution covers them to a depth at least 15mm. the temperature of the solution should be kept at 21±1 ºc.
2. After the immersion period, remove the aggregate sample from the solution, permit to drain for 15 ± 5min., and place in the drying oven.
3. Dry the samples at temperature of 110 ± 5ºc until constant mass has been achived.
4. After constant mass has been achived, allow the samples to cool to room temperature, when they shall again be immersed in the prepared solution.
5. Repeat the process alternative immersion and drying until the required number of cycles is obtained.

Test results

For St. Gabriel

Sieve Size(mm)		Weight of Test Fraction, g	Grading of original sample(%)	Mass of Test Fraction(gm)		% Passing Sieve used to Determine Loss	Weighted Average (Corrected % Loss)
Passing	Retained			Before	After		
Coarse Aggregate							
63.5	37.5	**5000 ± 300**	----	----			
37.5	19.5	**1500 ± 50**	53.65	1506	1484	1.5	0.78
19.5	9.5	**1000 ± 10**	35.66	1001	972	2.9	1.03
9.5	4.75	**300 ± 5**	10.69	300	283	5.7	0.61
Total			100	2807	2739		2.4

For Seka site

Sieve Size(mm)		Weight of Test Fraction, g	Grading of original sample(%)	Mass of Test Fraction(gm)		% Passing Sieve used to Determine Loss	Weighted Average (Corrected % Loss)
Passing	Retained			Before	After		
Coarse Aggregate							
63.5	37.5	**5000 ± 300**	----	----			
37.5	19.5	**1500 ± 50**	53.65	1506	1484.8	1.4	0.76
19.5	9.5	**1000 ± 10**	35.66	1001	973.4	2.8	0.98
9.5	4.75	**300 ± 5**	10.69	300	287.2	4.3	0.46
Total			100	2807	2745.2		2.2

For Agaro site

Sieve Size(mm)		Weight of Test Fraction, g	Grading of original sample(%)	Mass of Test Fraction(gm)		% Passing Sieve used to Determine Loss	Weighted Average (Corrected % Loss)
Passing	Retained			Before	After		
Coarse Aggregate							
63.5	37.5	**5000 ± 300**	----	----			
37.5	19.5	**1500 ± 50**	53.6	1510.1	1487.6	1.5	0.80
19.5	9.5	**1000 ± 10**	35.68	1005.4	982.1	2.3	0.83
9.5	4.75	**300 ± 5**	10.72	302	284.3	5.9	0.63
Total			100	2817.5	2754		2.3

ANNEX - C

EXPERIMENT NO.-1 SETTING TIME OF HYDRAULIC CEMENT

Objective

Objective of this test is to determine the initial setting time and final setting time of cement paste with normal consistency.

Theory

Cement forms a solid and hard mass (or change from fluid to a rigid state) when mixed with water upon hydration. This phenomenon is known as setting of cement. The duration of a cement paste requires undergo setting is its setting time. As setting is the consequence of hydration of cement, setting time is affected by the amount of water used to prepare cement paste, i.e. its water-cement ratio. Cement pastes with different water _ cement ratio will, generally, have different setting times. Therefore it seems confusing at first, which setting time to use. As a convention, it is the setting time of cement paste with normal consistency that is referred to as the setting time of cement.

Generally there are two types of setting time to determine in the laboratory, *initial and final setting times*. The initial setting time is the duration of cement paste related to 25mm penetration of the Vicat needle in to the paste in 30 seconds after it is released while the final setting time is that related to zero penetration of the Vicat needle in to the paste.

Apparatus

- Vicat apparatus (consisting of (1mm diameter needle (for initial time setting needle with annular collar (for final setting time), Vicat Mold, Glass Plate) , Glove
- Weighs and weighting device, Measuring cylinder, Mixing dish/Tray, Trowel, and Stopwatch

Procedure

1. Preparing cement paste of normal consistency 85%.
2. Inserting the paste in to the larger end of the conical ring.
3. Removing the excess at the larger end by a single movement of sharpened trowels.
4. Inverting the large ring on the glass plate and slice off the excess paste on the smaller end at a single oblique stroke by a sharpened trowel held at a slight angle

with the top of the ring. During the operation of cutting and smoothing took care not to compress the paste.

5. Immediately after molding, have placed the test specimen in the moist room and allow it to remain there except when determination of setting is being made. The specimen remains in the conical mold supported by the glass throughout the test period.
6. Allowed the specimen to remain in the moist cabinet for 30 minutes after molding without disturbing. Lower the needle until it reset on the surface of the specimen.
7. Taking the initial reading by tightening the screw and setting the indicator at the upper end of the scale. Release the rod quickly and allow the needle to settle for 30 seconds. No penetration is made closer than 10mm from any previous penetration and 10mm from the inside of the mold (ASTM 95)
8. Determining the penetration of the 1mm (diameter) needle at this time and every 10min thereafter until a penetration of 25mm or less is obtained and we have recorded the results of all penetration tests as show below:

Test result

Determination of setting Time of Hydraulic Cement by Vicat needle of Dangote

Description	**unit**	**Initial setting time**		**Final setting time**	
		Test result	Limit	Test result	Limit
Record of time from zero is	hrs.	14:28pm	**-**	14:28pm	**-**
record of time from zero at which the distance between the needle and the base plate (4±1)mm is	hrs.	15:55pm	**-**	16:56pm	
record of time from zero at which the distance between the needle and the base plate (4±1)mm is depth of penetration plunger is 5mm	mm	4	**(4±1)**	0.5	**0.5**
Setting time	Min.	87	(Min.)45	148	(Max.)375
Temperature of water bath	^{o}c	20	20±1	20	20±1

Determination of setting Time of Hydraulic Cement by Vicat needle of Derban

Description	unit	**Initial setting time**		**Final setting time**	
		Test result	Limit	Test result	Limit
Record of time from zero is	**hrs.**	1:40pm	**-**	1:40pm	**-**
record of time from zero at which the distance between the needle and the base plate (4±1)mm is	**hrs.**	2:56pm	**-**	4:35pm	**-**
record of time from zero at which the distance between the needle and the base plate (4±1)mm is depth of penetration plunger is 5mm	**mm**	4	**(4±1)**	0.5	**0.5**
Setting time	Min.	76	(Min.)45	175	(Max.)375
Temperature of water bath	^{o}c	21	20±1	20	20±1

Determination of setting Time of Hydraulic Cement by Vicat needle of National cement

Description	unit	**Initial setting time**		**Final setting time**	
		Test result	Limit	Test result	Limit
Record of time from zero is	**hrs**	10:02 AM	**-**	10:02 AM	**-**
record of time from zero at which the distance between the needle and the base plate (4±1)mm is	**hrs**	11:25:00 AM	**-**	7:15	**-**
depth of penetration plunger is 5mm	**mm**	4	**(4±1)**	0.5	**0.5**
Setting time	Min.	83	(Min.)45	193	(Max.)375
Temperature of water bath	^{o}c	20	20±1	20	20±1

EXPEREMIENT-2 FINENESS OF CEMENT

Objective

To determine the fineness of cement by sieving through sieve (standard size no. 100 and no. 200 sieves)

Theory

The degree of fineness of cement is a measure of the mean size of rains in cement. Finer cement will increase the rate of hydration. This leads to higher rate of heat evolution and strength gain. Finer cement the will decrease the amount of bleeding but it increase gypsum requirement which control proper setting and water requirement for workability which leads to higher drying shrinkage and cracking. Therefore, the fineness of cement has to be balanced with amount of coarseness in the cement. Finer cement decreases amount of bleeding. The test is used to check proper grinding of cement. And it can be determined by different methods, among then we use sieve methods (150µm (No. 100) or 75µm (no. 200) sieves).

Material used

- Sample of cement (100gm)

Apparatus used

- Sieves- 150µm (No. 100) or 75µm (no. 200)
- Weighing balance
- Sieve shaker
- Brush

Procedure:-

1. Place a 100g sample of the cement on the clean, dry 150µm (No. 100) or 75µm (No.200) sieve with the pan attached.
2. While holding the sieve and uncovered pan in both hands, sieve with a gentle wrist motion until most of the fine material has passed through and residue looks fairly clean. This operation usually requires only 3 or 4 min.

3. When the residue appears clean, place the cover on the sieve and remove the pan. Then, with the handle of the brush used for cleaning the sieve. Dust adhering to the sieve will thus be dislodged and the underside of the sieve may then be swept clean.
4. Empty the pan and thoroughly wipe it out with a cloth or waste, replace the sieve in the pan, and carefully remove the cover. Return any coarser material that has been caught in the cover during the taping to the sieve.
5. Continue the sieving without the cover as described above for 5 or 10 min, depending on the condition of the cement. Continuously rotate the sieve throughout the sieving. This open sieving may usually be continued safely for 9 min or more, but take care that it is not continued too long.
6. Then replace the cover and clean, following the same process as above. If the cement is in proper condition, there should now be no appreciable dust in the remaining residue nor adhering to the sieve or pan.
7. Make 1 min test as follows: hold the sieve, with the pan and cover attached, in one hand in a slightly inclined position and move it forward and backward in the plane of inclination, at the same time gently strike the side about 150 times/min against the palm of the other hand on the up stroke. Perform the sieving over a white paper. Return any material escaping from the sieve or pan collecting on the paper to the sieve. After every 25 strokes, turn the sieve about one sixth of a revolution, in the same direction. Continue the sieving operation until not more than 0.05g of the material passes through in 1 min of continuous sieving.
8. Transfer the residue on the sieve to the balance pan, taking care to brush the sieve cloth thoroughly from both sides to ensure the removal of the entire residue from the sieve.

Test results

Test result for Derban

Description	**150μm(100)**		**75μm (200)**		**Limit**
Residue weight, (gm.)	0.254	0.197	2.167	2.253	Not residue greater than 10%
total weight (gm.)	50	50	50	50	
% of fineness (100-(0.457*100)/50gm	99.5	99.6	95.7	95.5	
Average	**99.5**		**95.6**		

Test result for Dangote

Description	**150μm(100)**		**75μm (200)**		**Limit**
Residue weight, (gm.)	0.031	0.029	0.61	0.71	Not residue greater than 10%
total weight (gm.)	50	50	50	50	
% of fineness (100-(0.457*100)/50gm	99.9	99.9	98.8	98.6	
Average	**99.9**		**98.7**		

Test result for National cement

Description	**150μm(100)**		**75μm (200)**		**Limit**
Residue weight, (gm.)	0.336	0.366	0.432	0.421	Not residue greater than 10%
total weight (gm.)	50	50	50	50	
% of fineness (100-(0.457*100)/50gm	99.3	99.3	99.1	99.2	
Average	**99.3**		**99.1**		

ANNEX- D

Laboratory photos