JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT ON THE QUALITY OF THE AVAILABLE COARSEAGGREGATE WITH IN 50KM RADIUS OF JIMMA TOWN

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

By:

Ashenafi Asmamaw Mengistu

February, 2020

Jimma, Ethiopia

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Main Advisor: - Engr.Mamuye Busier (Assistant. Prof)

Co-Advisor: - Dr. Lucy Feleke (PHD)

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DECLARATION

I declare that this research entitled "**ASSESSMENT ON THE QUALITY OF THE AVAILABLE COARSE AGGREGATE WITH IN 50KM RADIUS OF JIMMA TOWN**" is my own original work, and has not been submitted as a requirement for the award of any degree in Jimma University or elsewhere.

Ashenafi Asmamaw Mengistu ________________ ________________

NAME SIGNATURE DATE

As research Adviser, I hereby certify that I have read and evaluated this thesis paper prepared under my guidance, By Ashenafi Asmamaw Mengistu entitled "**ASSESSMENT ON THE QUALITY OF THE AVAILABLE COURSE AGGREGATE WITH IN 50KM RADIUS OF JIMMA TOWN**" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

Advisor: Eng. Mamuye Busier (Assistant. Prof) ________________ ________________

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Co - Advisor: Dr. Lucy Feleke (PHD) ________________ ________________

NAME SIGNATURE DATE

ABSTRACT

The objective of this study is to assess the quality of the available aggregate material in Jimma zone. This study focused on the determination of the physical and mechanical properties of aggregate. To achieve the objective nine representative samples were collected from different crusher site of the zone for laboratory tests.

Five towns are found with crusher site in the zone; Jimma, Agaro, Haro, Offole and Seka. The laboratory tests were performed on aggregate samples through: moisture content, unit weight, specific gravity, Los Angeles abrasion resistance test, water absorption capacity test, impact value, sieve analysis and flakiness index.

Based on the results of this study, the specific gravity of the rock ranges from 2.67 to 2.87. The study shows that the natural moisture content varies from 0.79% to 1.83% and the water absorption value 0.64% to 2.1%. The water absorption and the moisture content are the nearest 1% that means very small void on a rock sample. While unit weight tests results range from 1.51-1.67KN/m^3*. The bulk density and the Voids between aggregate mixes are inversely proportional. Maximum Bulk density will make minimum voids so that there won't be much space for the cement paste. One way of identifying the strength of the rock sample is crushed value ranges from 11.61-16.83% according to crushed value the crushed value for cement concrete pavement shall not exceed 30% and the aggregate crushing value for wearing surface shall not exceed 45% so, the samples are compatible for both works. Identifying the hardness of the aggregate sample is Los Angeles abrasion value ranges from 15.67-21.8% and Aggregate impact value test correspond to the aggregate's toughness and its values below 10 are regarded as strong, and good for use in road surfaces. Results of impact value tests show that rocks of Jimma zone have ranges from 6.3-8.5%Comparison was made for standard specification in this study with laboratory test results. The comparison shows that the engineering performance of these rocks from the study area lie within the range given by different international standards and additional tests should be made on chemical property of aggregate to obtain more data points.*

Keywords*: -Aggregate,Crusher Plant, Concrete, Pavement,Quality, Quarry*

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ACRONYMS

AASHTO	American Association State Highway and Transportation Officials
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ASTM	American Society for Testing and Material
BS	British Standard
Gm	gram
GSI	Geological strength index
IS	Indian Standard
ISRM	International Society for Rock Mechanics
KN	Kilo Newton
LAAV	Los Angles Abrasion Value
MAS	Maximum Aggregate Size
mm	Millimeter
MPa	Mega Pascal
NMAS	Nominal Maximum Aggregate Size
VA	Voids of Air

CHAPTER ONE

INTRODUCTION

1.1. Background

Jimma is the largest city in south western Ethiopia, it has a latitude and longitude of 7'' 40' N and 36"50'E respectively with an elevation of 1,780m. And the town has a population more than 207,000 as counted in 2012[1].

In Jimma town it is expected that much more construction is going to be done in the future. The town, many buildings are constructed and being under construction without adequate and detailed aggregate quality investigation. It is required to determine properly the quality of aggregate. Since aggregate properties are essential for economic construction purposes. So, it is important to study aggregate properties in the zone [2].

There are many definitions stated by many scholars about Aggregates and most of them are similar in their content. Aggregates are "materials comprising of percentage required of gravel, crushed stone and natural sharp sand of their specific size of particle mixed together at a required ratio to form part of concrete mortar" [3].Construction aggregate is normally defined as being hard, granular materials which are suitable for use either on their own or with the addition of cement, lime or a bituminous binder in construction[4].

Aggregate used in construction basically comes in two different sizes-the bigger ones known to be coarse aggregate (grit) and the smaller one's fine aggregate (sand). The coarse aggregate forms the main matrix of concrete and the fine aggregate form the filler matrix between the coarse aggregate. Approximately 80 percent of the total volume of concrete consists of aggregate.

The physical properties like specific gravity, porosity, thermal behavior, and the chemical properties of an aggregate are attributed to the parent material. The shape, size and surface texture which are essential for concrete workability and bond characteristics between the aggregate and cement paste are, however, attributes of the mode of production. It is, therefore, essential to understand the mechanical, physical and chemical properties of aggregate and its modes of production in an effort to produce the required quality of concrete at a minimum price [5].

Aggregate characteristics significantly affect the performance of fresh and hardened concrete and have an impact on the cost effectiveness of concrete. Aggregate characteristics of shape, texture, sand grading influence workability, finish ability, bleeding, pump ability, and segregation of fresh concrete and affect strength, stiffness, shrinkage, creep, density, permeability, and durability of hardened concrete. Construction and durability problems have been reported due to poor mixture proportioning and variation on.

Aggregate constitutes the basic material for road construction and is quarried in the same way as aggregate for concrete. Because it forms the greater part of a road surface, aggregate has to bear the main stresses imposed by traffic, such as slow-crushing loads and rapid-impact loads, and has to resist wear. Therefore, the rock material used should be fresh and have high strength. The aggregate in blacktop should possess good adhesion properties with bituminous binders [6].

This research is intended to study the quality of aggregate from crusher sites in Jimma zone by conducting Crushing value test, Impact Value tests, Los Angeles Abrasion resistance test, Moisture content, Specific gravity, Unit weight, Water absorption capacity test, sieve analysis or gradation and Flakiness Index. These laboratory data are very important for construction works. And the study gives better understanding about some engineering behavior of the aggregate and factors affecting the quality of aggregate in Jimma.

Identifying the aggregate characteristic is essential to construct economically different types of civil engineering projects that will serve to the people for various purposes. The results of the study will be of great importance for the ever-growing building and road construction especially for those yet to be constructed in the area. It can be used as aggregate property manual as it will have a customized nature to meet the required rock information of the area with regard to the future development programs in the construction sector.

In this study to achieve the objectives, applying all the requirements procedural starting from literature review, sample collection, conducting relevant laboratory tests, distributing questioner and analysis of results obtained from input data, finally, comparison of the results with already available specification and then formulate a recommendation to who it concerns.

1.2 Statement of the Problem.

Jimma is one of the fastest growing cities in Ethiopia. Road construction projects, building construction projects, and industry projects are the major consumers of course aggregates. And also, there are many ongoing projects which are dependent on coarse aggregates.

The quality of coarse aggregate has a significant effect on the compressive strength of concrete as well as durability of asphalt pavement layers. Therefore, the available aggregate in jimma area should fulfill the required quality standards in order to build safe and sound structure

1.3 Research Questions

The questions that this research will answer are as follows:

1. What are the physical and mechanical properties of the available coarse aggregate materials with in 50 km radius of Jimma?
2. Identify the factors affecting the quality of course aggregates within 50 km radius of Jimma?
3. What are the factors that cause in sufficient supply of quality of course aggregate from crushing site?

1.4 Objectives

1.4.1 General Objective

The general objective of the study is to assess the quality of the available coarse aggregate within 50 km radius of Jimma.

1.4.2 Specific Objective

1. To investigate the physical and mechanical properties of the available coarse aggregate within 50km radius of Jimma.
2. To identify factors affecting the quality of course aggregates within 50km radius of Jimma.
3. To identify the factors that causes in sufficient supply of quality of course aggregate from crushing sites.

1.5 Scope and Limitation of the Study

The scope of research was to assessing of availability of quality of coarse aggregate in production site within the radius of 50km of Jimma city and the study was limited to conducting physical properties of coarse aggregate then compressive strength on hardening concrete, by using 9 different coarse aggregate from different sites considering C-25 grade of concrete. The findings of the research were limited to the physical properties of coarse aggregate. Test was conducted for aggregate properties used for building and highway projects.

1.6 Significance of the Study

This study could provide helpful information to various stake holders like town administration of Jimma will benefit from the study as a source of information and foundation for the construction industry that can help to improve and control qualities of the materials regarding to standard and specifications. For owners, contractors and consultants will benefit from the study as a source of information for building construction projects, in case of Jimma town. In addition, anyone who has the interest in the utilization of the engineering properties of aggregates surrounding Jimma town and other researchers will use the findings as a reference for further research on quality of aggregate.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition

Aggregate is a collective term for the mineral materials such as sand, gravel, and crushed stone that are used with a binding medium (such as water, bitumen, Portland cement, lime, etc.) to form compound materials (such as bituminous concrete and Portland cement concrete). By mass, aggregate generally accounts about 95 percent of Bituminous concrete and about 70 to 80 percent of Portland cement concrete.

2.2 Types of Aggregates

Aggregates can be classified to different categories Based on: -

- Sizes of aggregates
- Source and mineralogy
- Shape and texture

2.2.1. Size of Aggregates

Aggregate is usually described as either coarse aggregate (retained 4.75 mm) or fine aggregate (passing 4.75 mm). Aggregates generally make up about 95 percent of the total mass of hot mix asphalt mixtures and 80 percent by mass of concrete. Aggregate properties are, therefore, critical for quality hot-mix asphalt or concrete [7].

2.2.2 Source and Mineralogy

Aggregates are largely obtained from local supplies of natural rock. Among the natural rocks, three main types have been identified by geologists. They are as follows:

Igneous rocks: -are those which form as a result of cooling from the molten state. These are further classified as:

Intrusive: when the molten matter cools slowly under the earth’s surface, and results in the formation of large rocks with typically large crystals, e.g., Granite, gabbro, pegmatite.

Extrusive: when the molten matter cools rapidly on the earth's surface, resulting in the formation of rocks with smaller crystals, e.g., Basalt, andesite, rhyolite.

Pyroclastic: these are formed due to the cementation of extremely fine ash deposits which cool very rapidly resulting in an amorphous rock, e.g., volcanic tuff, pumice, breccia.

Sedimentary rocks: - are deposited in a fluid medium due to lithification of weathered sediments. Lithification can occur as a result of cementation (common cements being iron oxide, calcite, or quartz), crystallization, or compaction (due to the application of high temperature and pressure). Shale, sandstone, and limestone make up 46, 32, and 22 % of all sedimentary rocks, respectively.

Metamorphic rocks: - are formed when pre-existing rocks are subjected to heat and pressure. Re-crystallization often occurs, and the resulting rocks have typically large crystals with a well-defined cleavage. For example, marble, gneiss, schist, phyllite, slate, etc.

2.2.3. Gradation or Size Distribution (Shape and Texture)

The gradation of the aggregates used in bituminous and concrete materials is very important to developing the required engineering properties of the materials and for economical production.

Specifications generally permit a fairly broad range in gradation (gradation band) but a high degree of consistency is required during production for mix quality and uniformity. In concrete, the color and texture of the finished product is also largely a function of the aggregate and, particularly, the fine aggregate. The proportion of fine material produced in an aggregate operation depends on several factors, including the deposit geology and degree of crushing.

In fine aggregates, the gradation is one of the most important quality factors. If it is controlled, the material is usually acceptable. In coarse aggregate, the desired gradation can generally be controlled by appropriate processing (screening) and the degree of crushing, but many physical and chemical properties must also be satisfied.

Various deleterious materials, such as chert, shale and siltstone, may be present in a pit or quarry face, which may restrict or totally preclude the use of such materials. Specifications that do not permit the use of lower quality material result in higher prices. However, the cost of aggregate is usually considered to be a relatively small part of the total construction cost, and compromising the expected life of the finished product by using cheaper materials is rarely good practice.

2.3 Properties of Aggregate

This intent to familiarize the personnel responsible for aggregate testing with:

1. Physical Properties
2. Mechanical properties
3. Chemical Properties

Aggregate particles have certain physical and chemical properties which make the aggregate acceptable or unacceptable for specific uses and conditions.

1. Physical properties

The physical properties of aggregates include specific gravity, porosity, absorption capacity, moisture content, unsoundness due to volume changes and thermal properties and need a close scrutiny [5].

☞ **Specific gravity**

According to ASTM C 127-04, specific gravity is defined as the ratio of the density of material to the density of a material to the density of distilled water at a started temperature: hence, specific gravity is dimensionless. The absolute specific gravity and the particle density refer to the volume of the solid material excluding all pores [8]. It is used in certain computations for mixture proportioning and control, such as the volume occupied by the aggregate in the absolute volume method of mix design [9].

For the purpose of proportioning concrete mixtures, it is not necessary to determine the true specific gravity of an aggregate. Natural aggregates are porous; porosity values up to 2 percent are common for intrusive igneous rocks, up to 5 percent for dense sedimentary rocks, and 10 to 40 percent for very porous sandstones and limestone. For the purpose of mix proportioning, it is desired to know the space occupied by the aggregate particles, inclusive of the pores existing within the particles. Therefore, determination of the apparent specific gravity, which is defined as the density of the material including the internal pores, is sufficient. The apparent specific gravity for many commonly used rocks ranges between 2.6 and 2.7; typical values for granite, sandstone, and dense limestone are 2.69, 2.65, and 2.60, respectively [10].

☞ **Bulk density**

The bulk density or unit weight of an aggregate is the mass or weight of the aggregate required to fill a container of a specified unit volume. The volume referred to here is that occupied by both aggregates and the voids between aggregate particles [8].For mix proportioning, in addition to the apparent specific gravity, data are usually needed on bulk density, which is defined as the weight of the aggregate fragments that would fill a unit volume [10].

☞ **Porosity and absorption**

The porosity, permeability and absorption of aggregate influence the bond between it and the cement paste, the resistance of concrete to freezing and thawing. As well as chemical stability, resistance to abrasion and specific gravity [8].

Moisture content; -Since absorption represents the water contained in the aggregate in a saturated, surface-dry condition, we can define the moisture content as the water in excess of the saturated and surface-dry condition. Thus, the total water content of a moist aggregate is equal to the sum of absorption and moisture content [8].

Aggregates can hold water in two ways: Absorbed within the aggregate porosity or held on the particle surface as moisture content. Thus, depending on the relative humidity, recent weather conditions, and location within the aggregate stockpile, aggregate particles can have variable moisture content

i. Oven-dry (OD): All moisture is removed by heating the aggregates in an oven at 105°C to constant weight
ii. Air-dry (AD): No surface moisture is present, but the pores may be partially full.
iii. Saturated surface dry (SSD): All pores are full, but the surface is completely dry.
iv. Wet: All pores are full and a water film is on the surface of these four states, only two (OD and SSD) correspond to well-defined moisture conditions; either one can be used as a reference point for calculating the moisture contents (Edward, 2008).

☞ **Water permeability**

Is the capacity of a material to allow water to penetrate under pressure. Materials like glass, steel and bitumen are impervious [11].

- **Weathering resistance**

Is the ability of a material to endure alternate wet and dry conditions for a long period without considerable deformation and loss of mechanical strength [11].

2. Mechanical property

The behavior of solids is particular interest to construction engineers for the obvious reason that these are used to produce load-bearing structures (Peter D, 2010). Generally, flexural strength is more affected than compressive strength. Rougher texture results in a greater adhesion or bond between the particles and cement matrix. The required information about the aggregate particles has to be obtained from indirect tests, such as crushing strength of prepared rock samples, crushing value of bulk aggregate and performance of aggregate in concrete. The aggregate crushing value (ACV) test is prescribed by different standards and is a useful guide when dealing with aggregates of unknown performance [5].

- **Bond**

Both the shapes and the surface texture of aggregate influence considerably the strength of concrete, especially so for high strength concretes; flexural strength is more affected than compressive strength. A rougher adhesion or bond between the particles and the cement matrix [5].

- **Strength**

Is a measure of the amount of stress required to fail a material? The working stress theory for concrete design considers concrete as mostly suitable forbearing compressive load [10]. The compressive strength of concrete cannot significantly exceed that of the major part of the aggregate contained therein, although it is not easy to determine the crushing strength of the aggregate itself. A few weak particles can certainly be tolerated; after all, air voids can be viewed as aggregate particles of zero strength [8].

- **Elasticity**

Is the ability of a material to restore its initial form and dimensions after the load is removed. Within the limits of elasticity of solid bodies, the deformation is proportional to the stress. Ratio of unit stress to unit deformation is termed as modulus of elasticity. A large value of it represents a material with very small deformation [11].

- **Toughness**

It can be defined as the resistance of aggregate to failure by impact, and it is usual to determine the aggregate impact value of bulk aggregate (Neville A, 2010). The term toughness issued as a measure of this energy. The contrast between toughness and strength should be noted; the former is a measure of energy, whereas the latter is a measure of the stress required to fracture the material [10].

- **Hardness**

Hardness, or resistance to wear, is an important property of concrete used in roads and in floor surfaces Subjected to heavy traffic [8].

3. Chemical Properties

The chemical properties of aggregates have to do with the molecular structure of the minerals in the aggregate particles. The chemical composition of a mineral usually dictates the chemical properties of that mineral or aggregate. Surface chemistry of an aggregate is very important because it affects the strength and durability of the bond between the aggregate and asphalt. This property is more important in the presence of moisture. Some aggregates appear to have a greater affinity for water than for asphalt cement. If the aggregate's affinity for water is higher than its affinity for asphalt, the asphalt film on these aggregate particles may become detached or stripped after exposure to water. Most siliceous aggregates become negatively charged in the presence of water, whereas calcareous aggregates carry a positive charge in the presence of water. The aggregates that have a tendency to be hydrophilic are usually acidic in nature. On the other hand, aggregates having more affinity for asphalt are basic in nature and are called hydrophobic [12].

2.4 General Characteristics

Aggregates have three primary uses in construction:

1. As compacted aggregates in bases, sub-bases and shoulders
2. As ingredients in hot mix asphalt
3. As ingredients in Portland cement concrete. Aggregates may also be used as special backfill material, riprap, mineral filler, and other less significant uses.

Compacted Aggregates

Compacted aggregates without the addition of a cementing material may be used as a base or sub base for hot mix asphalt and Portland cement concrete pavements. Portland cement concrete pavements are rigid pavements. For these types of pavements, the purpose of the base may be to improve drainage, to prevent pumping, or to cover a material that is highly susceptible to frost. Consequently, gradation and soundness are the primary considerations in selecting or evaluating aggregates for bases under rigid pavements. The load-carrying capacity is a primary factor in the selection of aggregates for hot mix asphalt pavements. A hot mix asphalt pavement does not carry the load; help from the underlying base courses is required. In addition to graduation requirements, the aggregates are required to also possess the strength to carry and transmit the applied loads. Aggregates are sometimes used to make up the entire pavement structure. In this type of pavement, aggregates are placed on the natural soil to serve as a base course and surface course. Again, the primary requirement is the gradation. In many instances, compacted aggregates are also used to construct roadway shoulders and berms. In these applications, gradation and stability are very important.

2.5 Effects of Using Different Type of Aggregates on Concrete Strength

Since up to approximately 80 percent of the total volume of concrete consists of aggregate, aggregate characteristics significantly affect the performance of fresh and hardened concrete and have an impact on the cost effectiveness of concrete [13]. Aggregate characteristics of shape, texture, and grading influence workability, finish-ability, bleeding, pump-ability, and segregation of fresh concrete and affect strength, stiffness, shrinkage, creep, density, permeability, and durability of hardened concrete. Construction and durability problems have been reported due to poor mixture proportioning and variation on grading [14].

Maximum size, Specific gravity or relative density, Soundness and Toughness. An excess of poorly shaped particles could reduce the strength of concrete through the increase of water demand. In addition, flat particles can be oriented in such a way that they could impair the strength and the durability of concrete [15].

The properties of aggregates and their processing and handling influence the properties of both plastic and hardened concrete. The effectiveness of processing, stockpiling, and aggregate quality control procedures will have an effect on batch-to-batch and day-to-day variation in the properties of concrete ASTM, So that to proportion suitable concrete mixes, certain properties of aggregate which influence the paste requirement of fresh concrete such as shape and texture, size graduation, moisture content, specific gravity and bulk unit weight must be known[9].

Aggregates shall be stockpiled on clear hard surface to prevent contamination by other material and to avoid segregation. Different grades of aggregate shall be stocked independently, sufficient distance being maintained, to avoid mixing during unloading and use (BACTON).

2.6 Road Aggregate

Aggregate constitutes the basic material for road construction and is quarried in the same way as aggregate for concrete. Because it forms the greater part of a road surface, aggregate has to bear the main stresses imposed by traffic, such as slow-crushing loads and rapid-impact loads, and has to resist wear. Therefore, the rock material used should be fresh and have high strength. The aggregate in blacktop should possess good adhesion properties with bituminous binders [6].

Aggregate used as road metal must, in addition to having high strength, have high resistance to impact and abrasion, polishing and skidding, and frost action. It must also be impermeable, chemically inert and possess a low coefficient of expansion. The principal tests carried out in order to assess the value of a road stone are the aggregate crushing test, the aggregate impact test, the aggregate abrasion test and the test for the assessment of the polished stone value. Other tests of consequence are those for water absorption, specific gravity and density, and the aggregate shape tests [16].

The properties of an aggregate are related to the texture and mineralogical composition of the rock from which it was derived. Most igneous and contact metamorphic rocks meet the requirements demanded of good road stone. On the other hand, many rocks of regional metamorphic origin are either cleaved or schistose and are therefore unsuitable for road stone. This is because they tend to produce flaky particles when crushed. Such particles do not achieve good interlock and, consequently, impair the development of dense mixtures for surface dressing [6].

The way in which alteration develops can influence road stone durability. Weathering may reduce the bonding strength between grains to such an extent that they are plucked out easily from the stone. Chemical alteration is not always detrimental to road stone performance; indeed, a small amount of alteration may improve the resistance of a rock to polishing

CHAPTER THREE

RESEARCH METHODOLOGY AND MATERIALS

3.1 Study Area

This study was conducted within 50 km radius of Jimma Town, Western Ethiopia which is located 258 km by road west Addis Ababa. Its geographical coordinates are between7°40′N latitude and 36°50′E and longitude.

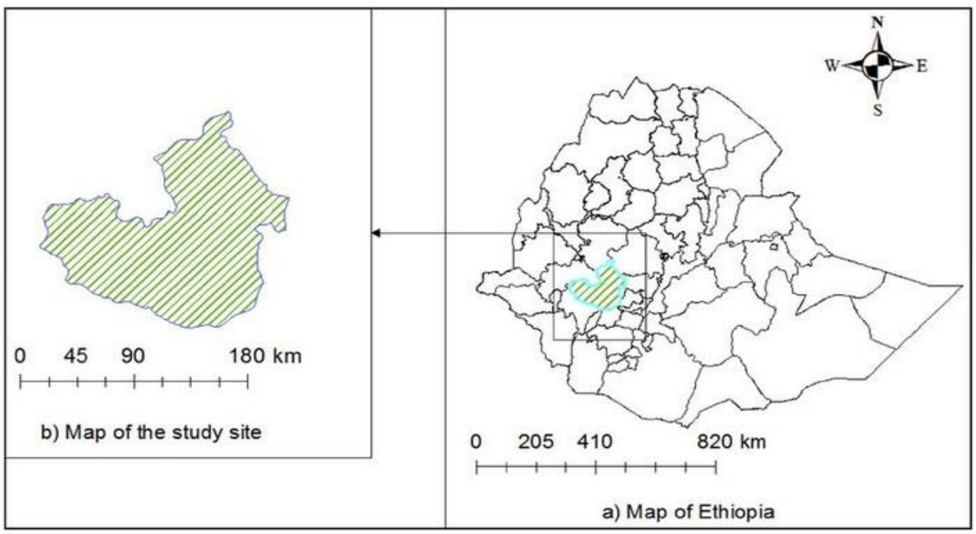

Figure 3. 1 Map of Jimma Zone

3.2 Study Variable

Dependent Variable

Quality of course aggregate

Independent Variable

-Moisture content - Los Angeles abrasion -Flakiness Index

- Impact value - Unit weight

- Specific gravity - Absorption capacity

- Crushed value -Gradation

3.3 Study Design

A study design/frame is the process that guides researchers on how to collect, analyze, and interpret observations. Therefore, the objective of the research will be achieved under the methodology outlined below.

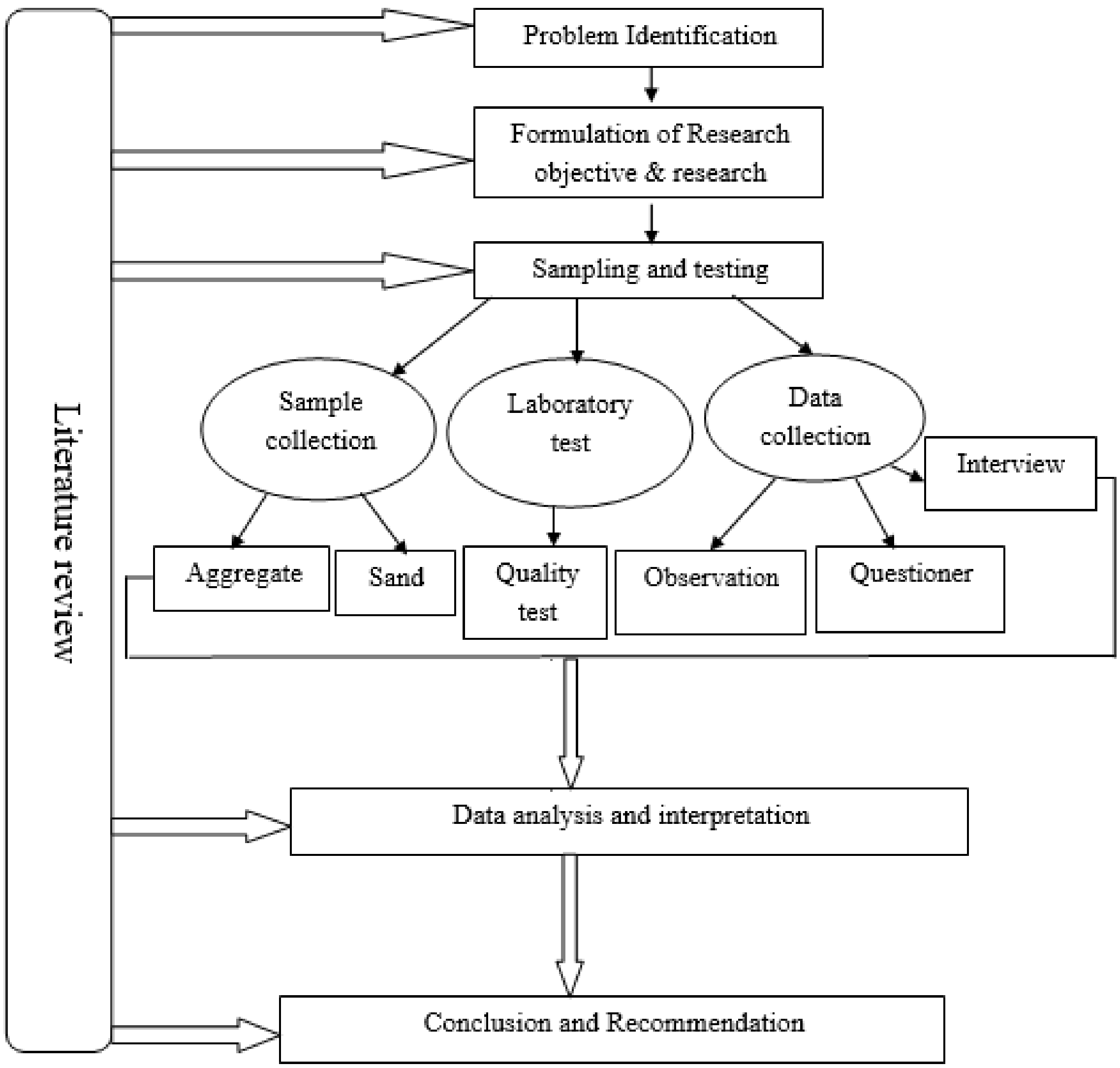

Figure 3. 2 Research Methodology Chart

3.4 Population

The population under the study is nine crusher sites. Namely, Agaro1, Agaro2, Agaro3, Agaro4, Agaro5, Haro, Gidilulesa (Jimma), Offole, and Seka. In this study the researcher has assess the quality of aggregate around the above listed population in the engineering performance of aggregate using Crushing value test, Impact Value tests, Los Angeles abrasion resistance test, moisture content specific gravity, Water absorption capacity test, sieve analysis and flakiness index test.

3.5 Sample Size &Sampling procedure

The samples for aggregate were taken in 50km radius around Jimma city and sample for aggregate was 9 form different crushing sites aggregate. Using total population in radius to assess the factors that reduce the quality of aggregate 45 questionnaires was distributed 5 for each 9 crushing sites. To know which aggregate type, have quality than other compressive strength test was done and cube was used with size of 150mm*150mm*150mm a total of 54 cube with testing age of 7^{th} and 28^{th} day. The procedure was accomplished according to ASTM, ACI and Ethiopian standard.

3.6 Data Collection Process

Data was collected through sample tests by using standard laboratory procedures (both descriptive and analytical) was obtained and the Field Survey was consisted of only looking for where the aggregate production companies are available. The survey helps to get information about the sources of data that the researcher was perform the laboratory tests.

3.7 Data Processing and Analysis

Qualities of aggregate have to be performed in laboratory tests. In processing all the design and analysis, identify literature review of research, and data gathered to be evaluated to come up with the research output. Then Compare the output with the available international design and specification. Finally present the results of analysis according to the research objectives.

3.8 Data Quality Assurance

The quality of the data was assured through replicate the samples by using standard operating procedures. To check the accuracy and validity of data instrument calibration and verification was checked. Laboratory test and field work manual was prepared in order to avoid error of data. And also given attention during data collected and recorded carefully.

3.9 Experimental Work and Procedure

General

The Laboratory tests were conducted by ASTM procedure. But the results are categorized and calculated in accordance with ASTM, ACI, BS and South Africa national standard to analyze the obtained results.

The aggregate samples for this study were collected from crusher sites in Jimma Zone. Prior to sampling, visual site investigations and information from residents and construction firms were collected to investigate aggregate site available in Jimma zone. Accordingly, five towns with different crushing site were found from the zone. Samples were collected for this work and taken to laboratory for testing.

The Laboratory test was from the results of experimental procedures at laboratory and record with proper format the data would become an input for the analytical analysis and the result will till as some out puts of the findings.

3.9.1 Crushing Value Test:

The principal mechanical properties required in stones are

i. Satisfactory resistance to crushing under the roller during construction and
ii. Adequate resistance to surface abrasion under traffic

Aggregate Crushing value is a measure of the strength of the aggregate. The strength of concrete largely depends upon the strength of aggregate. The aggregate should therefore have minimum crushing value. The aggregate crushing value test is a useful guide when dealing with aggregates of unknown performance, particularly when lower strength is suspected.

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. In aggregate crushing test, if aggregate crushing value is less than 10, it signifies an exceptionally strong aggregate. While aggregate crushing value above 35 would normally be considered as weak aggregates. The standard aggregate crushing test shall be made on aggregate passing a 14.0-mm BS (12.5-mm ASTM) test sieve and retained on a 10.0-mm BS (10-mm ASTM) test sieve.

The crushed aggregate (W_2) is expressed as % of the total weight of sample (W_1), which is the crushing value of the aggregate.

Aggregate crushing value = $(w_1/w_2)*100$ ……………………………………………..…..Equation 1

3.9.2 Impact Value Tests

The property of a material to resist impact is known as toughness. Due to the movement of vehicles on the road, the aggregates are subjected to impact. It results in their breaking down into smaller pieces. Therefore, the aggregates should have sufficient toughness to resist their disintegration due to the impact. This distinctive property is measured by impact value test. The aggregate impact test value is a measure of resistance to sudden impact or shock, which may vary from its resistance to gradually applied compressive load.

With aggregate of aggregate impact value higher than 30 the result may be anomalous. Also, aggregate sizes larger than 14 mm BS are not appropriate to the aggregate impact test.

Aggregate Impact Value below 10 is regarded as exceptionally strong and AIV's above 35 would normally be regarded as too weak for use in road surfaces. Aggregate Impact values and Aggregate crushing values are often numerically very similar, and indicate similar aggregate strength properties. Classification of aggregate using Impact value is as given below [17].

Aggregate Impact Value Classification

- <10% = Exceptionally strong
- 10- 20% = Strong
- 20-30% = Satisfactory for road surfacing
- >35% = Weak for road surfacing

The standard aggregate impact test shall be made on aggregate passing a 14.0-mm BS test sieve and retained on a 10.0 mm BS test sieve. If required, or if the standard size is not available, smaller sizes may be tested but owing to the non-homogeneity of aggregates the results are not likely to be the same as those obtained from the standard size. 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.

An impact value is measured as % of aggregates passed through the 2.36mm sieve (W_2) to the total weight of the sample (W_1).

Aggregate impact value = $(w_1/w_2)*100$……………………….………………………Equation 2

3.9.3 Los Angeles Abrasion Resistance Test

Los Angeles Abrasion Test can be executed to test the hardness property of aggregates and to decide whether they are suitable either for concrete, road construction or pavement construction. There are 3 tests commonly used to test aggregates for its abrasion resistance. (a) Deval Abrasion Test (b) Dorry Abrasion Test (c) Los Angeles Abrasion Test.

Los Angeles abrasion test gives the best realistic results of hardness property. This test gives a measure of the resistance of aggregate to surface wears by abrasion. Where aggregate sample is placed in a 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. Soft aggregates are quickly ground to dust while hard aggregates lose little mass.

The maximum Los Angeles abrasion value should not be more than 30% for the use of wearing surface and not more than 50% for the use of concrete.

The aggregate abrasion value is measured the material is sieved through 1.7 mm. the difference between the original weight (W_1) and the final weight (W_2) (sieved through 1.7mm) is expressed as % of the original weight of the sample aggregate (W_1).

Los Angeles abrasion value = $(w_1-w_2)/w_1$……………………………………...…. Equation3

3.9.4 Moisture Content

It is well known to engineers that water-cement ratio affects the workability and strength of concrete specimens. A design water-cement ratio is usually specified based on the assumption that aggregates are inert (neither absorb nor give water to the mixture). But in most cases aggregates from different sources do not comply with this i.e. wet aggregate give water to the mix and drier aggregates (those with below saturation level moisture content) take water from the mix affecting, in both cases, the design water-cement ratio and therefore workability and strength of the mix. In order to correct for these discrepancies, the moisture content of aggregates has to be determined.

The moisture content test is one of the simplest and least expensive laboratory tests to perform. Moisture content is defined as the ratio of the mass of the water in aggregate specimen to the dry mass of the specimen.

Moisture content can be tested in a number of different ways including: (1) a drying oven (ASTM D 2216); (2) a microwave oven (ASTM D 4643). The radiation heating induced by the microwave oven and the excessive temperature induced by the field stove may release water entrapped in the rock structure that would normally not be released at 110^{o}C.

Field measurements of moisture content often rely on a field stove or microwave, due to the speed of testing. When dealing with compacted material, it is common to use a nuclear gauge (ASTM D 3017) in the field to rapidly assess moisture contents. Results from these techniques should be “calibrated” or confirmed using the drying oven (ASTM D 2216).

Sampling, handling, and storage may alter the in-situ moisture content tests. Because the top end of the sample tube may contain water or collapse material from the samples. Also, as storage time increases, moisture will migrate within a specimen and lead to altered moisture content values.

The aggregate moisture content is the difference between the air-dried rock sample (W_1) and the oven dried sample (W_2) is expressed as % of the oven dried sample (W_2).

Moisture content = $(w_1-w_2)/w_2$…………………………………………………..……..Equation 4

3.9.5 Specific Gravity and Water Absorption Capacity Test

Specific Gravity: Specific Gravity is the ratio of the density of the stone to the density of water or the specific gravity of a substance is the ratio between the weight of the substance and that of the same volume of water. This definition assumes that the substance is solid throughout. Aggregates, however, have pores that are both permeable and impermeable; whose structure (size, number, and continuity pattern) affects water absorption, permeability, and specific gravity of the aggregates.

The Bulk Specific Gravity is the weight of oven dry sample in air (W_1) per the difference between the weight of saturated surface dry sample in air (W_2) and saturated sample in water (W_3).

Bulk Specific Gravity $= w_1/(w_2 - w_3)$……………………………………………...………Equation 5

Water Absorption: Water absorption is a measure of the porosity of a stone and can be an indicator of its susceptibility to damage during freezing. A stone that has greater water absorption will also tend to absorb liquid stains more readily. In general, the lowest water absorption is desired. The absorption is expressed as the percent weight change due to absorbed water. The maximum allowable water absorption for each type of stone is prescribed in the standard specifications for that specific stone.

Water absorption is determined by measuring the decrease in mass of a saturated surface dry sample after oven drying for 24 hours. The ration of the decrease in mass to the mass of the dry sample expressed as a percentage is termed absorption.

The Absorption capacity is the difference between the weight of saturated surface dry sample in air (W_1) and weight of oven dry sample (W_2) is expressed as % of the weight of oven dry sample (W2).

Absorption Capacity (%) $= (w_1 - w_2)/w_2$…………………………….……………………Equation 6

3.9.6 Unit Weight

Unit weight can be defined as the weight of a given volume of graded aggregate. It is thus a density measurement and is also known as bulk density. But this alternative term is similar to bulk specific gravity, which is quite a different quantity, and perhaps is not a good choice. 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 between them.

The unit weight is simply measured by filling a container of known volume and weighing it. Clearly, however, the degree of compaction will change the amount of void space, and hence the value of the unit weight. Since the weight of the aggregate is dependent on the moisture content of the aggregate, constant moisture content is required. Dry aggregate is used in this test.

The density of the stone indicates the unit weight of the stone, which is necessary for the Architect or Engineer who is designing the structure to support the stone. Generally, a higher-density stone is probably harder, less porous, and stronger, but this is not always the case. Note that there is no density for slate specified in ASTM C629, although it could be determined, if desired, using the procedure of ASTM C97.

Table 3. 1 Ranges in physical properties for normal-weight aggregates used in concrete

Property		Typical ranges
Fineness modulus of fine aggregate (defined in the following)		2.0 to 3.3
Nominal maximum size of coarse aggregate		9.5 to 37.5 mm
Absorption		0.5 to 4%
Bulk specific gravity (relative density)		2.30 to 2.90
Dry-rodded bulk density*of coarse aggregate		1280 to 1920 kg/m3
Surface moisture content	Coarse aggregate	0 to 2%
	Fine aggregate	0 to 10%

Source: ACI E701. (2007).

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 General

Nine crusher companies were selected around Jimma zone. From each of crusher sites three representative's samples were taken for laboratory testing. The nine crusher sites namely Temiseajida (Agaro1), Koye tije (Agaro2), Kela (Agaro3), Koye (Agaro 4), Kalid shifa (Agaro 5), Haro, Offole, Seka and Gidi Lullesa (Jimma). In order to determine the quality of the materials, laboratory tests were carried out. The tests involved aggregate physical and mechanical properties.

In this section the experimental data are examined statistically among the various aggregate properties are given. The difficulties encountered in measuring some of the properties and the bases for the interpretation of the test data are discussed.

Table 4. 1 Distance by km of the crusher sites from Jimma city

Sample code	Locality Name	Distance (km)
A	Agaro	46.2
H	Haro	30.5
O	Offole	23.2
S	Seka	21

4.2 Factors that Causes insufficient Supply of Quality of Course Aggregate from Crushing Sites

Coarse aggregates supply for construction sites should be quality with good suppliers. In this study the main drawbacks insufficient supply of quality of course aggregate was identified and the main reasons were access to the main road, production capacity of the crusher plant, method of blasting, shortage of electricity, working hours (working shifts), and periodic maintenance.

☞ **Access to the Main Road**

Suppliers should make the road from the main to the crusher site for smooth movement of dump trucks even on rainy season. In all the five Agaro sites and Seka sites it has short distance and good access to the main road where as in Haro, Offole and Gidi Lulesa the road is too long and uncomfortable to dump trucks.

☞ **Production Capacity of the Crusher Plant**

It is known that the more efficient crusher plant produces quality of coarser aggregate with enough supplied. In all site the plant daily produce limited volume in a range $48m^3$ to $96m^3$.

☞ **Method of Blasting**

Blasting of the parent can be either by explosive or manual in which explosives blast a huge amount whereas manually blasted will produce a little amount. In all sites except Seka uses manually by jack hammer loaded on excavator. In Seka dynamite is used mostly.

☞ **Shortage of electricity**

All plant sites use Diesel Generator which will limit their supply. In all agaro sites and Gidi Lulesa they are waiting the government to deliver electric power.

☞ **Working Hours (working shifts)**

All the sites use eight working hours and six days a week. It implies that least production will affect least supply of course aggregate.

☞ **Periodic Maintenance**

All the sites don't have chief mechanic crew which is permanent on the sites. Even most of them bring them from Addis Ababa when the plant stops working. Therefore, no periodic maintenance is done in all sites which will affect the supply of course aggregate.

4.3 Laboratory Result & Discussion

4.3.1 Unit weight

The bulk unit weight (the total unit weight) is the natural in situ unit weight of the rock; therefore, it should only be obtained from rock specimens. The first step in the laboratory is to determine the Dry-rodded bulk density using sample. Laboratory unit weight measurements were made for dry conditions, with the gradation of sample being as nearly as possible representative of the field sample. The laboratory measurements were made in accordance to ASTM C-29.

Table 4. 2 Unit weight of coarse aggregate

Study area	Sample 1 g/cm^3	Sample 2 g/cm^3	Sample 3 g/cm^3	Average (g/cm^3)
Agaro 1	1.51	1.51	1.52	1.51
Agaro 2	1.59	1.59	1.59	1.59
Agaro 3	1.58	1.58	1.58	1.58
Agaro 4	1.52	1.52	1.52	1.52
Agaro 5	1.59	1.59	1.6	1.59
Haro	1.57	1.63	1.62	1.61
Offole	1.56	1.57	1.56	1.56
Seka	1.67	1.67	1.68	1.67
Jimma	1.59	1.59	1.6	1.60

Results of data are presented in table 4.2 and the unit weight in the study sample is in range of 1.51 to 1.67 g/cm^3.The data shows that the highest (1.67g/cm^3) unit weight value for Seka, while minimum 1.51g/cm^3 for Agaro 1 sample and According to ACI E-701. (2007). the unit weight average (1.28-1.92 g/cm^3). So, all the samples lie within the range and all the samples are compatible for concrete works.

4.3.2 Moisture Content

Moisture content of the specimen to the nearest 1% or 0.1% according to ASTM D2216-98 as appropriate based on minimum sample used. Results of data are presented in table 4.3 and the moisture content in the studied sample is in the range of 1.83 to 0.79%. The data showing that the highest (1.83%) moisture content value for Agaro 3, while minimum (0.79%) for Jimma sample and all the samples are the nearest 1% and that means very small void on an aggregate sample.

Table 4. 3 Moisture content value

Study area	Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Average (%)
Agaro 1	1.43	1.3	1.43	1.38
Agaro 2	1.2	1.03	1.65	1.29
Agaro 3	1.7	2.03	1.78	1.83
Agaro 4	1.53	1.5	1.7	1.58
Agaro 5	1.4	1.48	1.75	1.54
Haro	1.25	1.1	1.15	1.17
Offole	1.15	1.35	1	1.17
Seka	0.95	1.05	0.75	0.92
Jimma	0.98	0.85	0.55	0.79

4.3.3 Specific Gravity

The specific gravity is also determining in the studied sample and presented in table 4.4. It is in the range of 2.67 to 2.87, with rocks of Agaro 3 and Offole and Jimma sample respectively. The result shows highest value is Offole and Jimma and the specific Gravity the type of rock is Basalt and the lowest value is Agaro 3 and the type of rock lies Greywacke type of rock the other samples are the nearest 2.81 and the type of rock is Hornfels [6].

Table 4. 4 Specific Gravity of the samples

Study area	Sample 1	Sample 2	Sample 3	Net Average SG
Agaro 1	2.68	2.7	2.71	2.69
Agaro 2	2.8	2.8	2.80	2.80

Agaro 3	2.66	2.67	2.68	2.67
Agaro 4	2.83	2.84	2.82	2.83
Agaro 5	2.8	2.9	2.82	2.80
Haro	2.8	2.81	2.81	2.80
Offole	2.86	2.87	2.88	2.87
Seka	2.78	2.81	2.79	2.79
Jimma	2.87	2.84	2.90	2.87

4.3.4 Water Absorption Capacity

Water absorption is the ability of water to take-up, assimilation or incorporation in to the aggregate. As mentioned earlier water absorption was determined in these sample by the method as derived by ASTEM (1993). Results of data are presented in table 4.5. In General water absorption in the studied samples is in the range of 0.64 to 2.10 %. This data shows that highest (2.1%) water absorption value for Agaro 3, while minimum (0.64%) for Jimma sample. In ASTM C 127-88 (1993) the absorption result to the nearest 1% so all the sample except for the sample from A1, A2, A3 and Offole are compact and show no water absorption problem.

Table 4. 5 Water absorption values

Study area	Sample1	Sample2	Sample3	Net Average Abs.c (%)
Agaro 1	1.83	1.57	1.65	1.68
Agaro 2	1.78	1.5	1.65	1.64
Agaro 3	2.27	2.09	2	2.1
Agaro 4	0.76	0.53	0.8	0.69
Agaro 5	1.29	1.29	1.11	1.23
Haro	1.3	1.21	1.61	1.23
Offole	1.93	1.3	1.6	1.62
Seka	0.5	0.6	0.93	0.76
Jimma	0.73	0.63	0.55	0.64

4.3.5 Aggregate Impact Value

Aggregate impact value test corresponds to the aggregates toughness to resist breaking into smaller pieces and are carried out according to [18]. Results of data are presented in table 4.6

and the Aggregate impact values in the studied sample are in the range of 6.3 to 8.5%. The data showing that the highest (8.5%) for Agaro 5, while minimum (6.3%) for Agaro 1. Aggregate Impact value below 10 are regarded as strong so in this study all samples are below 10 this shows the sample in the study area are strong [18] and The value < 10 are exceptionally strong, so all the samples have good technical values and it's good to use in road surfaces [17].

Table 4. 6 Aggregate impact value

Study area	Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Average (%)
Agaro 1	7	5.8	6	6.3
Agaro 2	7.3	8	7	7.6
Agaro 3	7.4	7.3	6.8	7.4
Agaro 4	8.2	7.9	8.4	8.2
Agaro 5	8.4	8.4	8.5	8.5
Haro	8.1	7.8	8.4	8.1
Offole	7.9	7.5	6.9	7.5
Seka	6	7	6.8	6.6
Jimma	7.2	6.9	6.9	7.0

4.3.6 Los Angeles Abrasion Resistance Test

The abrasion hardness tests exhibited the largest variations of all the physical tests conducted. Result of Los Angeles abrasion resistance test data are presented in table 4.7 and Los Angeles abrasion resistance test in studies sample is in the range of 15.67 to 21.8%. The data shows that the highest 21.8% for Agaro 1. While the minimum (15.67%) for Jimma sample. In ASTM C-131 the abrasion value limited to 10 to 45%. The maximum los angles abrasion value should not be more than 30 % for use of wearing surface and not more than 45% for the use of concrete. In this study all the sample is compatible to both activities.

Table 4. 7 Los Angeles Abrasion value

Study area	Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Average (%)
Agaro 1	21.4	20.6	23.4	21.80
Agaro 2	16.82	17.2	17.1	17.04
Agaro 3	15.46	15.6	16	15.69

Agaro 4	20.52	20.4	22	20.97
Agaro 5	18.1	17.84	17.88	17.97
Haro	20.07	17.96	16.26	18,09
Offole	20.82	20.24	20.66	20.57
Seka	16.88	16.76	16.52	16.71
Jimma	15.44	16.14	15.42	15.67

4.3.7 Aggregate Crushing Value

Aggregate crushing value is to evaluate the resistance of aggregates against a gradually applied load. Results of Aggregate Crushing Value data are presented in table 4.8 and Aggregate crushing value in the studied sample is in the range of 11.61 to 16.83%. The data shows that the highest (16.82%) for Agaro 2 while the minimum (11.61%) for Agaro 4 sample. To achieve a high quality of pavement, aggregate possessing low aggregate crushing value should be preferred.

In according to (IS:2386- Part-4) The aggregate crushing value for cement concrete pavement shall not exceeded 30% and for wearing surface shall not exceed 45%. All the samples are compatible for both concrete pavement and wearing surface works.

Table 4. 8 Aggregate crushing value

Study area	Sample 1	Sample 2	Sample 3	Average
Agaro 1	17	16.29	16.97	16.73
Agaro 2	16.35	17.28	16.87	16.83
Agaro 3	13.48	13.95	13.68	13.70
Agaro 4	11.87	11.33	11.63	11.61
Agaro 5	16.64	16.57	16.58	16.59
Haro	15.85	16.57	16.24	16.30
Offole	13.87	13.11	14.06	13.68
Seka	12.21	12.60	12.57	12.46
Jimma	13.69	13.97	13.85	13.87

4.3.8 Sieve Analysis or Gradation

In this section size distribution of aggregate is discussed and presented both in tabular form and using S-curve, and the tables show the size distribution of coarse aggregate from each aggregate production site, It shows percent of passing and percent of retained of each sieve size, as well as their mass of pass and retained, this table also shows the Nominal Maximum Aggregate Sizes (NMAS) and Maximum Aggregate Sizes (MAS) .The result is evaluated according to(ES C. D3.201) &ASTM C- 33

Table 4. 9 Sieve analysis for coarse aggregate from Agaro 1

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	145.3	2.9125824	2.9125824	97.087418	100
28	1058.7	21.221962	24.134544	75.865456	90-100
20	2130.7	42.710526	66.84507	33.15493	40-85
14	1164.2	23.336741	90.181811	9.8181891	0-40
10	473.8	9.4974643	99.679275	0.3207248	0-15
4.75	16	0.3207248	100	0	0-5
Pan	18.3				
Sum	4988.7		383.75328		
FM			3.8375328		

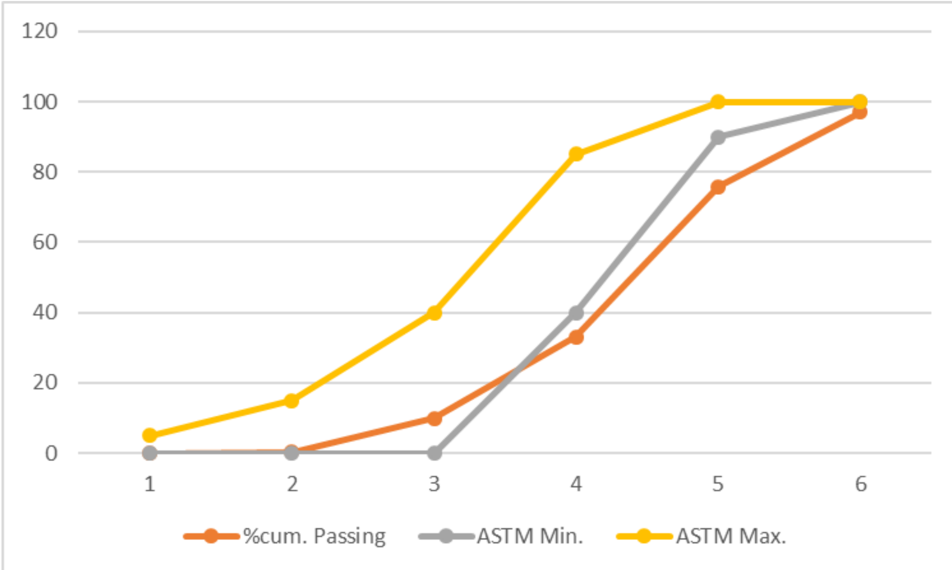

Figure 4. 1 Average Sieve Analysis Agaro 1

Table 4. 10 Sieve analysis for coarse aggregate from Agaro 2

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	63	1.26308	1.26308	98.7369	100
28	649.8	13.0278	14.2909	85.7091	90-100
20	2405.3	48.2237	62.5145	37.4855	40-85
14	1354.7	27.1603	89.6748	10.3252	0-40
10	505	10.1247	99.7995	0.20049	0-15
4.75	10	0.20049	100	0	0-5
Pan	12.7				
Sum	4987.8		367.543		
FM			3.67543		

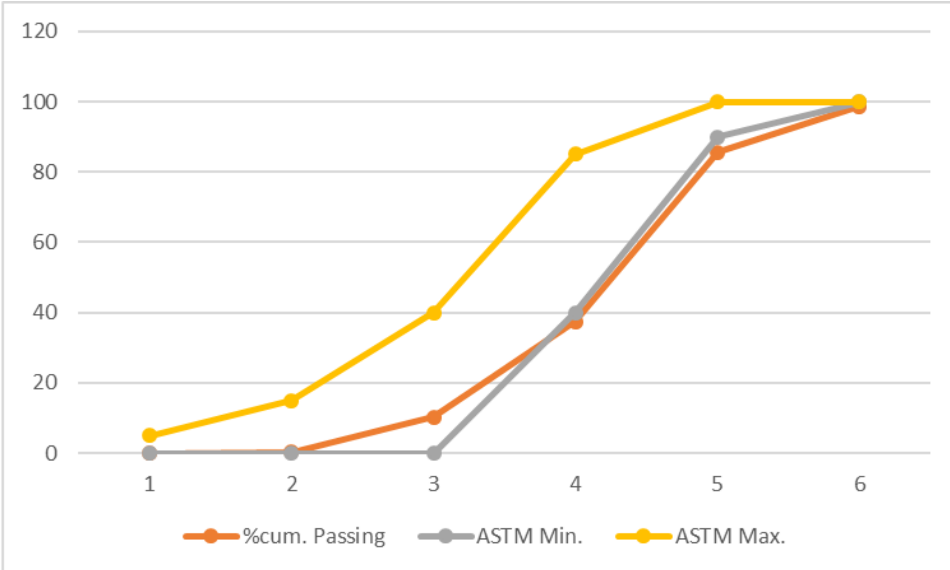

Figure 4. 2 Average Sieve Analysis Agaro 2

Table 4. 11 Sieve analysis for coarse aggregate from Agaro 3

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	0	0	0	100	100
28	107	2.1624	2.1624	97.8376	90-100
20	1117	22.5739	24.7363	75.2637	40-85
14	1707.3	34.5035	59.2397	40.7603	0-40
10	1973.2	39.8771	99.1169	0.88315	0-15
4.75	43.7	0.88315	100	0	0-5
Pan	52				
Sum	4948.2		285.255		
FM			2.85255		

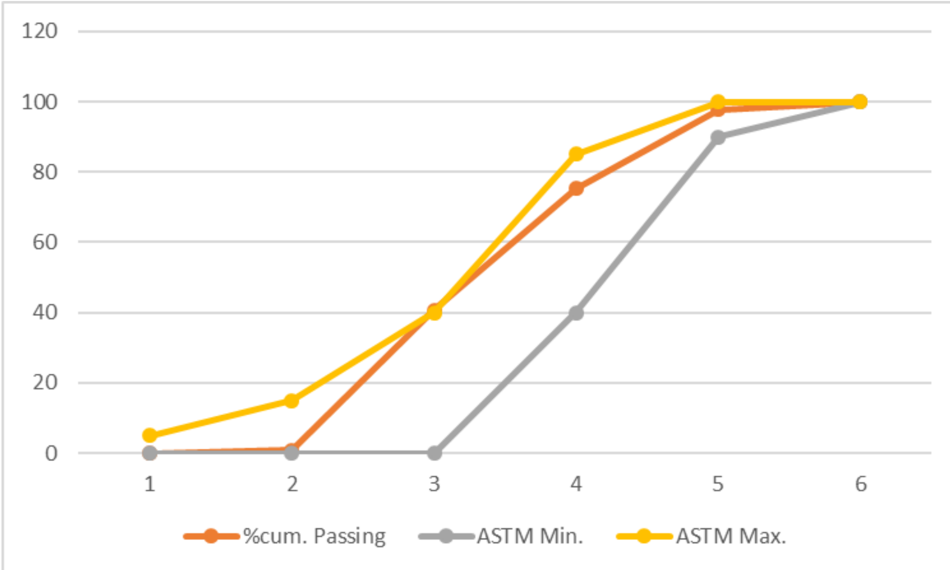

Figure 4. 3 Average Sieve Analysis Agaro 3

Table 4. 12 Sieve analysis for coarse aggregate from Agaro 4

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	0	0	0	100	100
28	230.7	4.62696	4.62696	95.373	90-100
20	2298	46.089	50.716	49.284	40-85
14	1892.3	37.9523	88.6683	11.3317	0-40
10	560	11.2314	99.8997	0.10028	0-15
4.75	5	0.10028	100	0	0-5
Pan	14.3				
Sum	4986		343.911		
FM			3.43911		

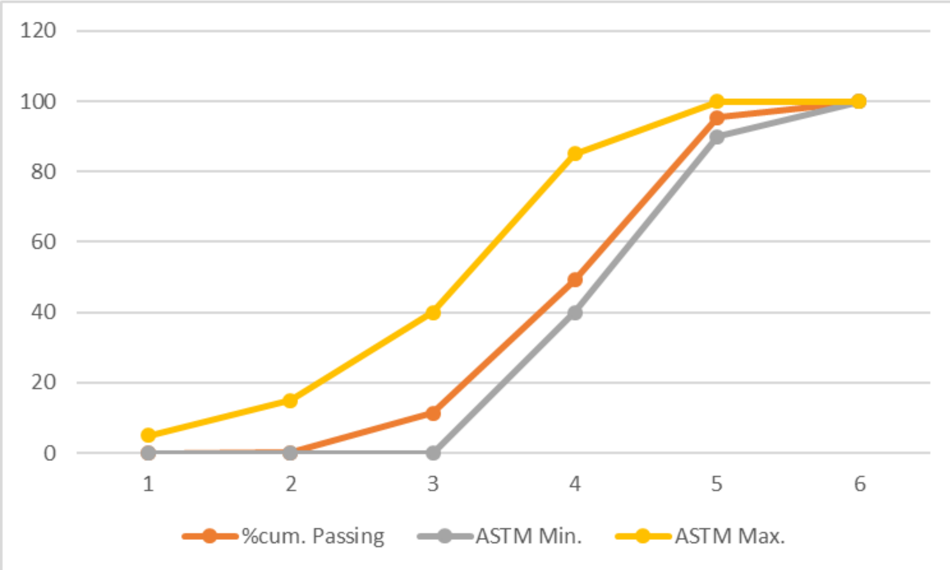

Figure 4. 4 Average Sieve Analysis Agaro 4

Table 4. 13 Sieve analysis for coarse aggregate from Agaro 5

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	0	0	0	100	100
28	936.7	18.7968	18.7968	81.2032	90-100
20	2688.2	53.9442	72.741	27.259	40-85
14	1170.7	23.4925	96.2334	3.76658	0-40
10	176.7	3.54584	99.7793	0.22074	0-15
4.75	11	0.22074	100	0	0-5
Pan	16.8				
Sum	4983.3		387.55		
FM			3.8755		

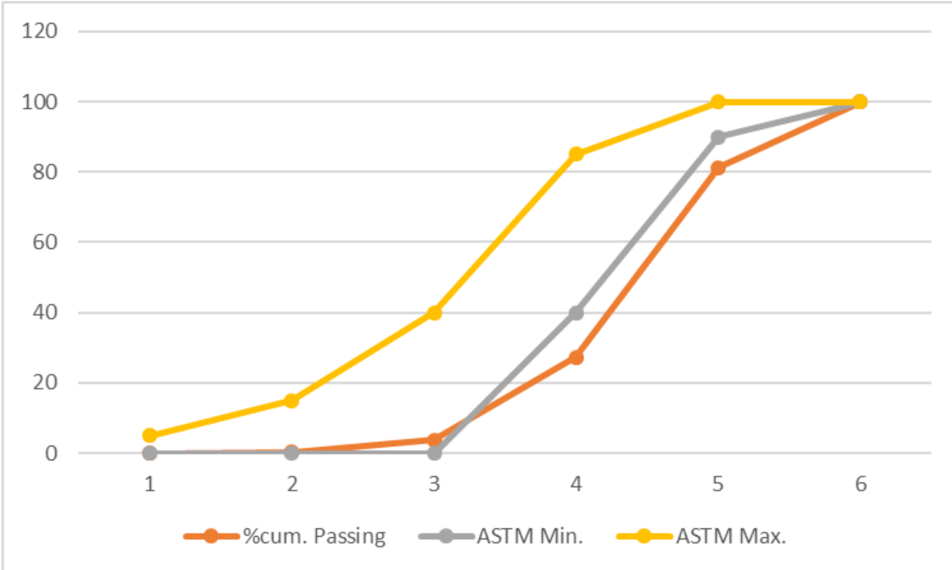

Figure 4. 5 Average Sieve Analysis Agaro 5

Table 4. 14 Sieve analysis for coarse aggregate from Haro

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	39	0.78141	0.78141	99.2186	100
28	750.7	15.0411	15.8225	84.1775	90-100
20	2032.2	40.7173	56.5398	43.4602	40-85
14	2009.8	40.2685	96.8083	3.19175	0-40
10	144	2.88519	99.6934	0.30655	0-15
4.75	15.3	0.30655	100	0	0-5
Pan	9.8				
Sum	4991		369.645		
FM			3.69645		

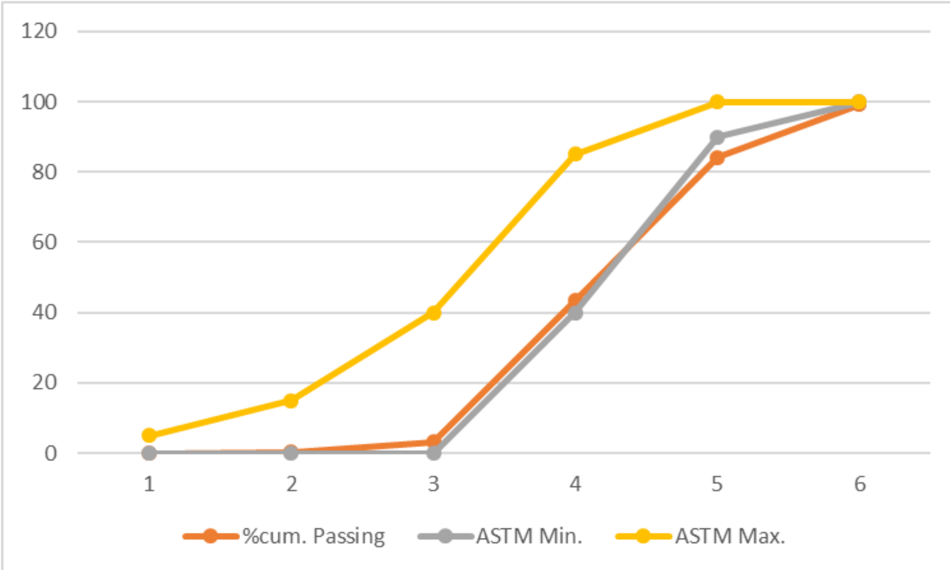

Figure 4. 6 Average Sieve Analysis Haro

Table 4. 15 Sieve analysis for coarse aggregate from Seka

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	0	0	0	100	100
28	665.5	13.3311	13.3311	86.6689	90-100
20	3133.5	62.7692	76.1002	23.8998	40-85
14	1021.3	20.4583	96.5586	3.44144	0-40
10	163.3	3.27117	99.8297	0.17027	0-15
4.75	8.5	0.17027	100	0	0-5
Pan	8				
Sum	4992.1		385.82		
FM			3.8582		

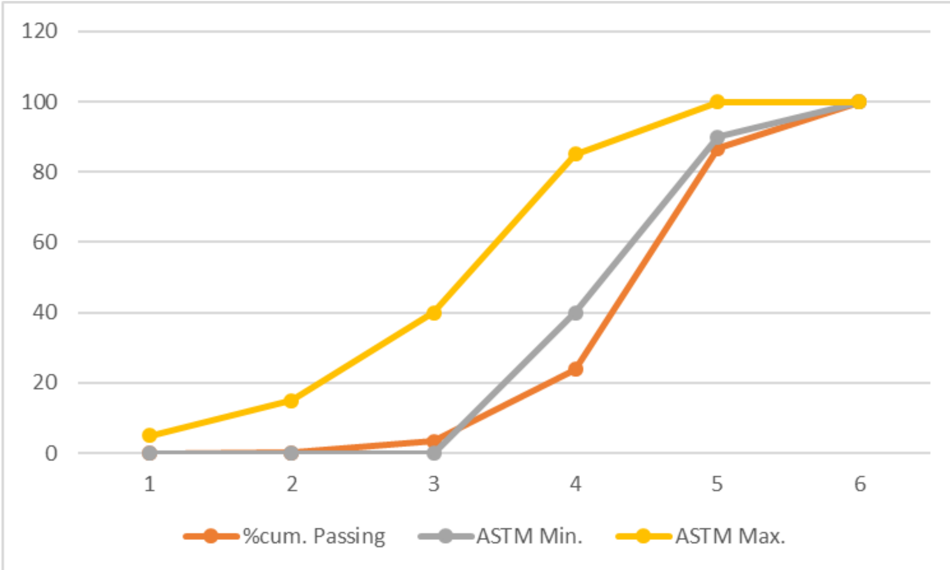

Figure 4. 7 Average Sieve Analysis Seka

Table 4. 16 Sieve analysis for coarse aggregate from Offole

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	0	0	0	100	100
28	160.8	3.21645	3.21645	96.7835	90-100
20	2368	47.3666	50.5831	49.4169	40-85
14	2326.7	46.5405	97.1236	2.8764	0-40
10	143.8	2.8764	100	0	0-15
4.75	0	0	100	0	0-5
Pan	0				
Sum	4999.3		350.923		
FM			3.50923		

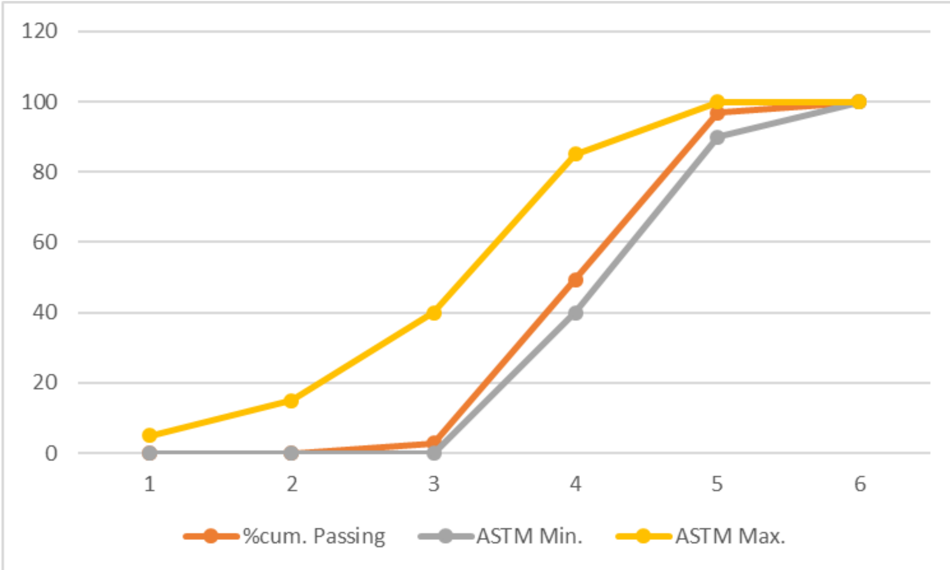

Figure 4. 8 Average Sieve Analysis Offole

Table 4. 17 Sieve analysis for coarse aggregate from Gidi lulesa

Sieve Size	Average Mass of retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	100	100
63*	0	0	0	100	100
37.5	112.2	2.24548	2.24548	97.7545	100
28	1874.5	37.5148	39.7602	60.2398	90-100
20	2224.5	44.5194	84.2796	15.7204	40-85
14	638	12.7684	97.0481	2.95195	0-40
10	139.7	2.79585	99.8439	0.1561	0-15
4.75	7.8	0.1561	100	0	0-5
Pan	4				
Sum	4996.7		423.177		
FM			4.23177		

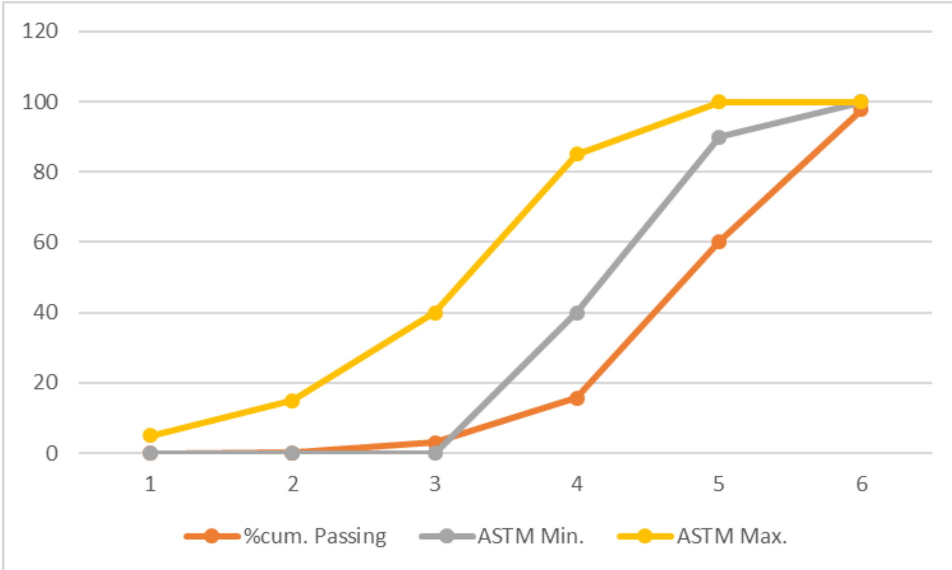

Figure 4. 9 Average Sieve Analysis Gidi Lulesa

4.3.9 Flakiness Index

Table 4. 18 Flakiness Index for Agaro 1 site

Sample	Retain	% Retain	Pass	% Pass
Sample 1	3535.5	75	1166	25
Sample 2	3542.5	75	1150.5	25
Sample 3	3526.5	76	1142.5	24

4.4 Effect of Aggregate on C-25 concrete

Concrete ingredients test result

I. Cement

Dangote OPC cement is taken as a representative sample because it is widely used in the sector.

Table 4. 19 Properties of ordinary Portland cement

property	Average value of OPC from experiment	Standard value of OPC
Consistency (%)	30	26-33%
Initial setting time (min)	90	>45
Final setting time (min)	145	<600

As shown in the table the result gained from consistency, initial and final setting time tests was in the range of standard.

II. River Sand

Sand sample is taken from Werabe because river sand quality in the area is so poor.

Sieve analysis

Table 4. 20 Sieve analysis results of River Sand

ASTM sieve designaction	Sieve size (mm)	Weight retained (gm)			Retained (%)	Cumulative retained (%)	Cumulative passing (%)	Specification % passing (ESC.D3.20)
		Sample 1	Sample 2	Sample 3				
3/8	9.5							100
No. 4	4.75	66.5	65	60	3.19	3.19	96.81	95-100
No. 8	2.36	147.5	149	147	7.39	10.58	89.42	80-100
No. 16	1.18	306.5	305	309	15.34	25.93	74.08	50-85
No. 30	600	742	743.5	741.5	37.12	63.04	36.96	25-60
No. 50	300	515.5	509	514	25.64	88.68	11.32	0-15
No. 100	150	176	185.5	180.5	9.03	97.72	2.28	0-10
No. 200	0.75	0			0.00	97.72	2.28	
Pan		46	43	48	2.28	100.00	0.00	
Sum		2000	2000	2000	100	486.86	313.14	

FM=Σ cumulative retained (%)/100 =486.86/100=4.87

The FM result shows that in the range of allowable amount based on ASTM C33/C33M (ASTMC33/C33M, 2011).

Water absorption and specific gravity

The test conduct on fine aggregate water absorption and specific gravity general process indicate on Appendix B. But the result gained designate below

Table 4. 21 Test result on Water absorption

No	Test conducts	Result
1	Bulk specific gravity (SSD basis)	2.63
2	Apparent specific gravity	2.69
3	Water absorption, dry weight	1.47

From ASTMC33/C33M (2011), absorption capacity ranges from 0.2 to 2 % for fine aggregates. As a result, the fine aggregate is in the limitation of ASTM.

Unit weight

The stroked bulk density of aggregates used for normal weight concrete generally ranges from 1200 to 1760 kg/m3 (ACI318M, 2011). The average unit weight of the fine aggregate samples results of loss and compacted unit weight was 1344 and 1622 kg/m3 respectively that is near in the range. Detail result is discussed on Appendix E.

Moisture content

Sand graded for use in concrete will have an average moisture content of 0.2-2 % ASTM C566-89

The result of moisture content was: -

- Moisture content Sample1= ((500-488.5)/488.5) *100=2.35%
- Moisture content Sample1= ((500-490.5)/490.5) *100=1.94%
- Average=2.46%
- Moisture content Sample1= ((500-485)/485) *100=3.09%

Silt content

Ethiopian standard for silt content restricts the silt content not exceed 6 % and the organic impurity limit is 13. If it exceeds this maximum value, the standard recommends washing or rejecting the sand. But in this study the result gained was in the allowable range that was 4.6% and also the organic impurity laid on no. 1.

General properties of fine aggregate gain from laboratory test indicate on the next table

Table 4. 22 General properties of fine aggregate

No	Property	Fine aggregate
1	Fineness modulus	2.69
2	Water absorption (%)	1.47
3	Bulk density (kg/m3)	2.63
4	Loose unit weight (kg/m3)	1344
5	Compacted unit weight (kg/m3)	1622
6	Moisture content (%)	2.46
	Silt content (%)	4.6

Results and Discussion on Harden concrete properties Compressive strength test

Compressive strength test of samples was done at the age of 7 and 28. The 7th age results are indicated on the following tables. C-25 concrete is taken for test purpose because it the most commonly concrete strength used in jimma area. Therefore, compressive test is only conducted.

Table 4. 23 The 7th day's Average compressive strength values of concrete summery

Aggregate	Maximum load (KN)	Compressive strength (Mpa)
Agaro 1	447.82	19.91
Agaro 2	425.39	18.91
Agaro 3	450.05	20.0
Agaro 4	447.75	19.9
Agaro 5	411.85	18.3
Haroo	468.65	20.84
Jimma	483.83	21.62
Offole	391.29	17.39
Seka	482.38	21.44

Compressive strength of concrete at the age of 7days result shows that all aggregate can be used for concrete.

Table 4. 24 The 28th days compression test and the corresponding compressive stress

Aggregate	Maximum load (KN)	Compressive stress (Mpa)
Agaro 1	643.25	28.59
Agaro 2	712.71	31.68
Agaro 3	733.65	32.62
Agaro 4	672.89	29.79
Agaro 5	643.87	28.62
Haroo	689.56	30.65
Jimma	658.77	29.28
Offole	605.28	26.9
Seka	748.68	33.28

Compressive strength of concrete at the age of 28 days result shows that all aggregate is good for concrete.

4.5 Comparison of the laboratory test result with standard specification

The following table shows tests taken to investigate the quality of aggregate, results of the tests and limit standards.

Table 4. 25 Laboratory results and different international standards

Parameter	This study Result	Limit standard	Type of standard	Remark
Unit weight (g/m3)	1.51-1.67	1.28-1.92	ACI E-701. (2007).	With standard
Los Angeles abrasion resistance (%)	15.67-21.8	10 – 45	ASTM C 131	With standard
Aggregate crushing value (%)	11.6-16.83	not exceed 45	(IS: 2386 PART- 4)	Wearing surface
		not exceed 30		concrete pavement
		Mean value 16	BS 812	Igneous rock

Aggregate impact value (%)	6.3-8.5	Below 10 strong Above 35 poor	SANS 6239:2012	With standard
Moisture Content (%)	0.79-1.83	Nearest 1or 0.1	ASTM D 2216	
Specific gravity	2.67-2.87		AASHTO T 85	
Water absorption capacity (%	0.64-1.68		AASHTO T 85	

4.6 Factor affecting Aggregate Quality

The questionnaires are designed to collect data regarding the major factors affecting the quality of aggregate in Jimma zone and analyzed in following section.

4.6.1 Response rate

All 45 were received respondents solicited as shown in the table 4.52below.

Table 4. 26 Response rate

Crusher Site	Distributed Questionnaires	Collected Questionnaires	Rate of Return (%)
Agaro 1	5	5	100
Agaro 2	5	5	100
Agaro 3	5	5	100
Agaro 4	5	5	100
Agaro 5	5	5	100
Haro	5	5	100
Gidi Lulesa	5	5	100
Offole	5	5	100
Seka	5	5	100
Total	45	45	100

Totally about 45 Questionnaire was distributed for 9 crusher sites around Jimma andfor each project 5 Questionnaire was distributed. These respondents were Managers, Machine operator, skilled labor, whohave a practical experience in the crushing site. Their sufficientexperiences are a suitable indication to find out factors affecting aggregate properties.

Table 4. 27 General Information of respondents

		Frequency	Percentage
Sex	Male	12	26.67
	Female	33	73.33
	Total	5	60.00
Education Level	12	27	20.00
	10	9	20.00
	<10	9	20.00
Experience	1-5	22	48.89
	6-10	14	31.11
	11-20	9	20.00
	>20		
Marital status	Married	36	80.00
	Unmarried	9	20.00
Age	<20		
	20-30	9	20.00
	30-40	18	40.00
	40-50	4	8.89
	>50	14	31.11

Source: From survey data, 2019

4.6.2 Analysis Related to factor affecting quality of aggregate

Table 4. 28 Tendency of Factor Affecting the Quality of aggregate

Question	Response	Frequency	Percentage (%)
From your experience, which of the following activity will affect the quality of aggregate in your site?	Age of the crushing plant	36	80%
	Type of Rock	45	100%
	Skill of worker	27	60%
	Type of mining	5	11.11%
	Management	41	91.11%
	Storage	32	71.11%
	Area of the site	45	100%

Hint; the respondents given a chance of choosing above 1 tendency from the following.

According to the data in the above table 4.54, 100% of the respondents believed that Type of Rock and catchment area of the site will affect the quality of aggregate, while 91.11% of the respondents understand that the management system have effect on the quality of aggregate produced and 71.11%of the respondents believed as type of storage have its own effect on aggregate quality. In addition, skill of workers is 60% and type of mining is 11.11%.

Table 4. 29 Tendency of Challenges in the crushing site

Question	Response	Frequency	Percentage (%)
What are the challenges in your working environment?	Weather Condition	45	100
	Investor problem	0	0
	Lack of political stability	14	31.11
	Poor Planning	5	11.11
	Rock Type	41	91.11
	Lack of Labor force	41	91.11
	Poor monitoring and control	0	0
	Poor Communication	0	0
	Weak labor productivity	27	60
	Electricity	45	100

Hint; the respondents given a chance of choosing above 1 tendency from the following. The above data in table 4.55 shows 100% Weather condition and Electricity is challenge in the site, while 91.11% of the respondents mention lack of labor force is a challenge in the site and the other 60,31.11 and11.1 percent of respondent agree that Weak labor productivity, lack of political stability and poor planning respectively are challenges in the aggregate production site.

Table 4. 30 Factor affecting quality of aggregate as Perceived by the Respondents

No	Issues	Frequency				
		1	**2**	**3**	**4**	**5**
Aggregate Quality Control						
Production of Aggregate is as standard		0	0	0	0	45
The Company works to improve the quality of the aggregate		0	5	18	22	0
Testing aggregate quality is frequently done		5	5	23	12	0
Means of storage of produced aggregate affects the quality		0	0	5	9	31
Means of blasting or downgrading the rock affects the quality of the aggregate		0	0	8	5	32
Capacity of Investor						
Weak investor's technical and financial capacity will affect aggregate quality		0	0	5	9	31
Type of the crusher plant affects the quality of the aggregate		9	0	9	18	9
The available human resources affect the quality of the aggregate		9	0	9	22	5
Management system of the quarry site affects the quality of aggregate		0	0	5	5	35

Hint:1=Strongly Disagree, 2=Disagree, 3=Neutral,4=agree,5=strongly agree.

All the participants (100%) agreed that production of aggregate as per standard affects the quality of aggregate; while 48.9% of them believed that the quality of aggregate depends on the company works to improve the quality of aggregate.88.9% of respondents strongly agree that means of storage and investor's capacity affects the quality.

Generally, the highest percentage of the respondents(greater than 80%) responded that the quality of aggregate depends on other factors such as, means of storage of produced aggregate, means of blasting or downgrading the rock, weak investor's technical and financial capacity, type of crusher plant, available human resource, and management system of the quarry site.

Give your opinion to the following questions based on your last experience

Question

What actions should be taken to increase the quality of the aggregate during production?

Opinion collected from respondents

- Changing the mining Method
- Maintaining crusher Plant
- Using Quality rock
- Giving awareness for the workers

Question

What measures should be taken to fulfill aggregate demand without affecting the quality

Opinion collected from respondents

- Increasing labor force
- Developing work culture in the environment
- Add machinery and equipment
- Changing the location of the site near to the source of the rock

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusions

This study investigates the quality of available coarse aggregate within 50km of Jimma town. The study was done though experimental investigation and data collection process. The following conclusion is concluded from the result.

There are five towns found as a source for construction aggregate around Jimma city within 50km.This are, Jimma, Agaro, Haro, Offole and Seka. All samples of aggregate collected from the production site are compatible for concrete and for road surface.

Coarse aggregate available around Jimma town are in a good quality and can be used for concrete and on road projects. But there are common challenges faced in the crusher site such as, weather condition, lack of labor force and electricity problem were as from the data collected mining method used in the zone is cultural, there is no enough machinery in the crusher site, the crusher sites are far from quarry site.

The main drawbacks in the coarse aggregate supply are identified that as access to the main road, efficiency of the crusher plant, method of blasting, shortage of electric power and periodic maintenance of the plant. The government should give attention to the suppliers so that they will increase their supply.

Compressive strength results showed that aggregate from Seka has highest compressive strength than others rank as the findings Seka, Agaro 3 and Agaro 2 have good compressive strength than the rest with 28^{th} day result of 33.28MPa, 32.62MPa and 31.68MPa respectively.

Therefore, there are crusher sites around Jimma which have quality aggregate and preferable for both concrete structure and road project.

5.2 Recommendations

Based on findings the following recommendations are made:

To Client

It is important to review the aggregates quality periodical to as per quality specification to protect building and road projects from an early deteriorate and to maintenance extra cost.

To Contractor

Aggregate quality around Jimma city meets the requirement and can be used for concrete and road project. The researcher recommends for contractors to use aggregate which can attain maximum compressive strength like aggregates from Seka, Agaro 3 and Agaro 2 crushing sites.

To Consultant

As the one who work for the client, consultants should determine any material quality related activities, in accordance with the intention of client without compromise, in professional way.

For Future Studies

Location and quality of aggregate have been investigated in this study, the researcher recommend to study on increasing the production of course aggregate and on supply and demand

- ☞ Study on the type of stone used in Jimma zone for production of different types of aggregates
- ☞ Study on relationship between demand and supply of quality aggregate in Jimma zone
- ☞ Study on chemical properties of aggregate available in Jimma zone

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APENDIX-A

Moisture Content of coarse aggregate

Moisture Content of coarse aggregate from Temisea Jida (Agaro1)

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1971.5	1.43
2	2000	1974	1.30
3	2000	1971.5	1.43

Average=1.38%

Moisture Content of coarse aggregate from Koye Tije (Agaro 2)

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1976	1.2
2	2000	1979.5	1.03
3	2000	1967	1.65

Average=1.29%

Moisture Content of coarse aggregate from kela (Agaro 3)

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1966	1.7
2	2000	1959.5	2.03
3	2000	1964.5	1.78

Average=1.83%

Moisture Content of coarse aggregate from Koye (Agaro 4)

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)

1	2000	1969.5	1.53
2	2000	1970	1.5
3	2000	1966	1.7

Average=1.58%

Moisture Content of coarse aggregate Kalid Shifa (Agaro 5)

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1972	1.4
2	2000	1970.5	1.48
3	2000	1965	1.75

Average=1.54%

Moisture Content of coarse aggregate from Haro

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1975	1.25
2	2000	1978	1.1
3	2000	1977	1.15

Average=1.17%

Moisture Content of coarse aggregate from Jemila (offole)

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1977	1.15
2	2000	1973	1.35
3	2000	1980	1

Average=1.17%

Moisture Content of coarse aggregate from Seka

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1981	0.95
2	2000	1979	1.05
3	2000	1985	0.75

Average=0.92%

Moisture Content of coarse aggregate from Gidi lulesa(Jimma)

Trial	Weight of original sample (gm)	Weight of oven dry sample (gm)	% Moisture content (w)
1	2000	1980.5	0.98
2	2000	1983	0.85
3	2000	1989	0.55

Average=0.79%

APENDIX-B

Specific Gravity and Absorption Capacity of coarse aggregate

Specific Gravity and Absorption Capacity of coarse aggregate from Temisea Jida (Agaro 1)

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample 3
M_W=Wt of sample in water	1268.5	1270.5	1275
M_{SSD}=Wt of sample in air	2001.5	2001	2001.5
M_D=Wt of sample after oven	1965.5	1970	1969
Bulk specific gravity=$M_D(M_{SSD}-M_W)$	2.68	2.7	2.71
Absorption capacity $(M_{SSD}-M_D)/M_D)$ *100	1.83	1.57	1.65

Average Bulk S. G=2.69

Average Abs.Capacity=1.68

Specific Gravity and Absorption Capacity of coarse aggregate from koye Tije (Agaro 2) sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample
Mw=Wt of sample in water	1304	1298.5	1300
MssD=Wt of sample in air	2002	2000.5	2001.5
MD=Wt of sample after oven	1967	1971	1969
Bulk specific gravity=MD(MssD-Mw)	2.8	2.8	2.8
Absorption capacity (MssD-MD)/MD) *100	1.78	1.5	1.65

Average bulk S. G=2.8

Average abs.capacity=1.64

Specific Gravity and Absorption Capacity of coarse aggregate from Kela(Agaro 3) sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample 3
Mw=Wt of sample in water	1264	1267	1270
MssD=Wt of sample in air	2000.5	2001	2001.5
MD=Wt of sample after oven	1956	1960	1962
Bulk specific gravity=MD(MssD-Mw)	2.66	2.67	2.68
Absorption capacity (MssD-MD)/MD) *100	2.27	2.09	2

Average bulk S. G=2.67

Average abs.capacity=2.1

Specific Gravity and Absorption Capacity of coarse aggregate from Koye (Agaro 4) sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample
Mw=Wt of sample in water	1299	1301	1297

M_{SSD}=Wt of sample in air	2001	2000.5	2001
M_D=Wt of sample after oven	1986	1990	1985
Bulk specific gravity=M_D(M_{SSD}-Mw)	2.83	2.84	2.82
Absorption capacity (M_{SSD}-M_D)/M_D) *100	0.76	0.53	0.8

Average bulk S. G=2.83

Average abs.capacity=0.69

Specific Gravity and Absorption Capacity of coarse aggregate Kalid Shifa (Agaro 5) sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample
Mw=Wt of sample in water	1297.5	1295	1299
M_{SSD}=Wt of sample in air	2001.5	2000.5	2001
M_D=Wt of sample after oven	1976	1975	1979
Bulk specific gravity=M_D(M_{SSD}-Mw)	2.8	2.9	2.82
Absorption capacity (M_{SSD}-M_D)/M_D) *100	1.29	1.29	1.11

Average bulk S. G=2.8

Average abs.capacity=1.23

Specific Gravity and Absorption Capacity of coarse aggregate from Haro sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample 3
Mw=Wt of sample in water	1295	1296.5	1298
M_{SSD}=Wt of sample in air	2000	2001	2001
M_D=Wt of sample after oven	1974	1977	1978
Bulk specific gravity=M_D(M_{SSD}-Mw)	2.8	2.81	2.81
Absorption capacity (M_{SSD}-M_D)/M_D) *100	1.3	1.21	1.16

Average bulk S.G=2.8

Average abs. Capacity=1.23

Specific Gravity and Absorption Capacity of coarse aggregate from offole sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample 3
Mw=Wt of sample in water	1316	1312	1318
MssD=Wt of sample in air	2003	2001	2002
MD=Wt of sample after oven	1965	1975	1970
Bulk specific gravity=MD(MssD-Mw)	2.86	2.87	2.88
Absorption capacity (MssD-MD)/MD) *100	1.93	1.3	1.6

Average bulk S. G=2.87

Average abs. Capacity=1.62

Specific Gravity and Absorption Capacity of coarse aggregate from seka sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample 3
Mw=Wt of sample in water	1286	1295	1291
MssD=Wt of sample in air	2000	2001	2001.5
MD=Wt of sample after oven	1985	1989	1983
Bulk specific gravity=MD(MssD-Mw)	2.78	2.81	2.79
Absorption capacity (MssD-MD)/MD) *100	0.75	0.6	0.93

Average bulk S. G=2.79

Average abs. Capacity=0.76

Specific Gravity and Absorption Capacity of coarse aggregate from Gidi lulesa (jimma) sample

Description	Sample weight in (kg)		
	Sample 1	Sample 2	Sample 3
Mw=Wt of sample in water	1310	1300	1315
MssD=Wt of sample in air	2001.5	2000.5	2000
MD=Wt of sample after oven	1987	1988	1989
Bulk specific gravity=MD(MssD-Mw)	2.87	2.84	2.9

Absorption capacity (M_{SSD}-M_D)/M_D) *100	0.73	0.63	0.55

Average bulk S. G=2.87

Average abs. Capacity=0.64

APPENDIX-C

Aggregate Impact Value

Impact value of coarse aggregate from Temisea Jida (Agaro1) sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3508	3600.5	3590
After AIV	2817	2817	2751
After AIV passing sieve size 2.36	48.5	45.6	50.5
Calc. =	7	5.8	6

AVERAGE=6.3

Impact value of coarse aggregate from Koye Tije (Agaro 2) sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3490	3501	3480
After AIV	2751	2817	2751
After AIV passing sieve size 2.36	54	56.5	52.5
Calc. =	7.3	8	7

AVERAGE=7.6

Impact value of coarse aggregate from Kela (Agaro 3) sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3493.5	3495.5	3553
After AIV	2751	2817	2817
After AIV passing sieve size 2.36	55.5	53.5	50.5
Calc. =	7.4	7.8	6.8

AVERAGE=7.4

Impact value of coarse aggregate from Koye (Agaro 4) sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3458.5	3460.5	3450
After AIV	2751	2751	2751
After AIV passing sieve size 2.36	58	56.5	59
Calc. =	8.2	7.9	8.4

AVERAGE=8.2

Impact value of coarse aggregate Kalid Shifa (Agaro 5) sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3462.5	3460	3465
After AIV	2751	2751	2751
After AIV passing sieve size 2.36	60	59.5	61
Calc. =	8.4	8.4	8.5

AVERAGE=8.5

Impact value of coarse aggregate from Haro sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3460	3454.5	3459
After AIV	2751	2751	2751
After AIV passing sieve size 2.36	57.5	55	59.5
Calc. =	8.1	7.8	8.4

AVERAGE=8.1

Impact value of coarse aggregate from Offole sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3493	3488	3491
After AIV	2817	2827	2751
After AIV passing sieve size 2.36	54	50	51
Calc. =	7.9	7.5	6.9

AVERAGE=7.5

Impact value of coarse aggregate from seka sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3485	3479	3481
After AIV	2751	2817	2751
After AIV passing sieve size 2.36	44	47	50
Calc. =	6	7	6.8

AVERAGE=6.6

Impact value of coarse aggregate from Gidi lulesa sample

Description	Sample		
	Sample 1	Sample 2	Sample 3
Wt of sample	3500	3490	3501
After AIV	2817	2817	2751
After AIV passing sieve size 2.36	49	46.4	52
Calc. =	7.2	6.9	6.9

AVERAGE=7

APPENDIX-D

Los Angeles Abrasion Value

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Temisea Jida (Agaro 1) Sample1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3930	1070
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =21.4

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Temisea Jida (Agaro 1) Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3970	1030
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =20.6

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Temisea Jida (Agaro 1) Sample 3

	Fraction and mass		Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve

Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3830	1170
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =23.4

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Koye Tije (Agaro 2) Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4159	841
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 +	1250 + 10	1250			

	12.5					
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =16.82

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Koye Tije (Agaro 2) Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4140	860
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =17.2

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Koye Tije (Agaro 2) Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4145	855
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =17.1

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 kela (Agaro 3) Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4222	778
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =15.46

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 kela (Agaro 3) Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10	(g)	(g)	(g)

			(g)			
A	- 37.5 + 25.0	1250 + 25	1250	5000	4220	780
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =15.6

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 kela (Agaro 3) Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4200	800
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =16

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Koye (Agaro 4) Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3974	1026
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =20.52

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Koye (Agaro 4) Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)

A	- 37.5 + 25.0	1250 + 25	1250	5000	3980	1020
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =20.4

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Koye (Agaro 4) Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3900	1100
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =22

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Kalid Shifa (Agaro 5) Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4095	905
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =18.1

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131Kalid Shifa(Agaro 5) Sample 2

	Fraction and mass		Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve	
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10	(g)	(g)	(g)

			(g)			
A	- 37.5 + 25.0	1250 + 25	1250	5000	4108	892
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =17.84

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131Kalid Shifa(Agaro 5) Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4107	893
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =17.86

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Haro Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3998	1002
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =20.07

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Haro Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10	(g)	(g)	(g)

			(g)			
A	- 37.5 + 25.0	1250 + 25	1250	5000	4102	898
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =17.96

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Haro Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4187	813
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =16.26

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Offole Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3959	1041
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =20.82

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Offole Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10	(g)	(g)	(g)

			(g)			
A	- 37.5 + 25.0	1250 + 25	1250	5000	3988	1012
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =20.24

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Offole Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	3967	1033
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =20.66

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Seka Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4157	843
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =16.86

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Seka Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)

A	- 37.5 + 25.0	1250 + 25	1250	5000	4162	838
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =16.76

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Seka Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4174	826
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =16.52

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Gidi lulesa Sample 1

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4228	772
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =15.44

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Gidi lulesa Sample 2

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10	(g)	(g)	(g)

			(g)			
A	- 37.5 + 25.0	1250 + 25	1250	5000	4193	807
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =16.14

Los Angeles Abrasion Value AASHTO T96 / ASTM C 131 Gidi lulesa Sample 3

	Fraction and mass			Total Mass used	Mass of Sample Retained on 1.70 mm Sieve (dry	Loss through 1.70 mm Sieve
Grading of test sample	Fraction	Mass	Total mass used	A	B	C=A-B
	(mm)	(gm)	5000 + 10 (g)	(g)	(g)	(g)
A	- 37.5 + 25.0	1250 + 25	1250	5000	4229	771
	- 25.0 + 19.0	1250 + 25	1250			
	- 19.0 + 12.5	1250 + 10	1250			
	- 12.5 + 10	1250 + 10	1250			

(Los Angeles Abrasion Value) L.A.A.V: C/A*100 =15.42

APPENDIX-E

Unit weight of coarse Aggregate test

Unit weight of coarse aggregate from Temisea Jida sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	15,102.5	15.1
2	1000	15,112	15.11
3	1000	15,108.5	15.12

AVERAGE=15.12

Unit weight of coarse aggregate from Koye Tije sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	15,921.5	15.92
2	1000	15,918	15.92
3	1000	15,930	15.93

AVERAGE=15.92

Unit weight of coarse aggregate from kela sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	15,819	15.82
2	1000	15,825	15.83
3	1000	15,807	15.81

AVERAGE=15.82

Unit weight of coarse aggregate from Koye sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate(kg)	Unit weight (kg/m3)

1	1000	15,224	15.22
2	1000	15,248	15.23
3	1000	15,214	15.21

AVERAGE=15.23

Unit weight of coarse aggregate from Kalid Shifa sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	15,984.5	15.98
2	1000	15,975	15.97
3	1000	16,000	16

AVERAGE=15.98

Unit weight of coarse aggregate from Haro sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	15736	15.74
2	1000	16281.5	16.28
3	1000	16174	16.17

AVERAGE=16.06

Unit weight of coarse aggregate from Offole sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	15546.5	15.55
2	1000	15687	15.69
3	1000	15603.5	15.6

AVERAGE=15.61

Unit weight of coarse aggregate from Seka sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	16728	16.73
2	1000	16737	16.74
3	1000	16756	16.76

AVERAGE=16.74

Unit weight of coarse aggregate from Gidi lulesa sample

Trial	Volume of a cylindrical metal measure (m3)	The net weight of aggregate (kg)	Unit weight (kg/m3)
1	1000	15996.5	15.99
2	1000	15975.5	15.98
3	1000	16005.5	16

AVERAGE=15.99

APPENDIX-F

Sieve Analysis of course aggregate

FM=Σ cumulative retained (%)/100

Sieve analysis for coarse aggregate from Agaro 1 Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	144.5	2.90131513	2.90131513	97.11	100
28	1054.5	21.172573	24.0738882	76.02	90-100
20	2129.5	42.7567513	66.8306395	33.42	40-85
14	1168	23.4514607	90.2821002	10.05	10-50
10	474	9.51711676	99.7992169	0.57	0-15
4.75	10	0.20078305	100	0.37	0-5

Pan	18.5				
Sum	4980.5		383.88716		
FM			3.8388716		

Sieve analysis for coarse aggregate from Agaro 1 Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	140	2.80870699	2.80870699	97.11	100
28	1065	21.3662353	24.1749423	76.02	90-100
20	2126	42.6522219	66.8271642	33.42	40-85
14	1164.5	23.3624235	90.1895877	10.05	10-50
10	463.5	9.29882636	99.4884141	0.57	0-15
4.75	25.5	0.51158592	100	0.37	0-5
Pan	20.5				
Sum	4984.5		383.488815		
FM			3.83488815		

Sieve analysis for coarse aggregate from Agaro 1 Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	151.5	3.02939412	3.02939412	97.11	100
28	1056.5	21.1257748	24.155169	76.02	90-100
20	2136.5	42.7214557	66.8766247	33.42	40-85
14	1160	23.1953609	90.0719856	10.05	10-50
10	484	9.67806439	99.75005	0.57	0-15
4.75	12.5	0.24995001	100	0.37	0-5
Pan	16				
Sum	5001		383.883223		
FM			3.83883223		

Sieve analysis for coarse aggregate from Agaro 2 Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	70	1.40336808	1.40336808	97.11	100
28	644.5	12.9210104	14.3243785	76.02	90-100
20	2403	48.1756215	62.5	33.42	40-85
14	1356.5	27.1952686	89.6952686	10.05	10-50
10	504.5	10.1142743	99.8095429	0.57	0-15
4.75	9.5	0.1904571	100	0.37	0-5
Pan	13				
Sum	4988		367.732558		
FM			3.67732558		

Sieve analysis for coarse aggregate from Agaro 2 Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	55	1.10242534	1.10242534	97.11	100
28	652	13.0687513	14.1711766	76.02	90-100
20	2412.5	48.356384	62.5275606	33.42	40-85
14	1350.5	27.069553	89.5971137	10.05	10-50
10	506.5	10.1523351	99.7494488	0.57	0-15
4.75	12.5	0.25055121	100	0.37	0-5
Pan	11				
Sum	4989		367.147725		
FM			3.67147725		

Sieve analysis for coarse aggregate from Agaro 2 Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	64	1.28346536	1.28346536	97.11	100
28	653	13.0953575	14.3788228	76.02	90-100
20	2400.5	48.1399779	62.5188008	33.42	40-85
14	1357	27.2134764	89.7322771	10.05	10-50
10	504	10.1072897	99.8395668	0.57	0-15
4.75	8	0.16043317	100	0.37	0-5
Pan	14				
Sum	4986.5		367.752933		
FM			3.67752933		

Sieve analysis for coarse aggregate from Agaro 3 Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	107	2.16445838	2.16445838	76.02	90-100
20	784	15.8592091	18.0236674	33.42	40-85
14	1710	34.5908769	52.6145444	10.05	10-50
10	2302	46.566198	99.1807424	0.57	0-15
4.75	40.5	0.81925761	100	0.37	0-5
Pan	57				
Sum	4943.5		271.983413		
FM			2.71983413		

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0		0	
63*	0	0		0	
37.5	0	0.00	0.00	100.00	100
28	107	2.14	2.14	97.86	90-100
20	784	15.68	17.82	82.18	40-85
14	1710	34.20	52.01	47.99	10-50
10	2302	46.04	98.05	1.95	0-15
4.75	40.5	0.81	98.86	1.14	0-5
Pan	57	1.14	100	0.00	
Sum	5000.5	100	368.88	331.12	

Sieve analysis for coarse aggregate from Agaro 3 Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	104	2.09740849	2.09740849	76.02	90-100
20	787	15.8717354	17.9691439	33.42	40-85
14	1712	34.5265705	52.4957144	10.05	10-50
10	2305.5	46.4959161	98.9916305	0.57	0-15
4.75	50	1.00836947	100	0.37	0-5
Pan	41				
Sum	4958.5		271.553897		
FM			2.71553897		

Sieve analysis for coarse aggregate from Agaro 3 Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	

37.5	0	0	0	97.11	100
28	110	2.22559433	2.22559433	76.02	90-100
20	1780	36.0141629	38.2397572	33.42	40-85
14	1700	34.3955488	72.635306	10.05	10-50
10	1312	26.5452706	99.1805766	0.57	0-15
4.75	40.5	0.81942337	100	0.37	0-5
Pan	58				
Sum	4942.5		312.281234		
FM			3.12281234		

Sieve analysis for coarse aggregate from Agaro 4 Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	247	4.95387084	4.95387084	76.02	90-100
20	2294.5	46.0188528	50.9727236	33.42	40-85
14	1885	37.8058564	88.77858	10.05	10-50
10	558	11.1913357	99.9699158	0.57	0-15
4.75	1.5	0.03008424	100	0.37	0-5
Pan	15				
Sum	4986		344.67509		
FM			3.4467509		

Sieve analysis for coarse aggregate from Agaro 4 Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	215	4.31380417	4.31380417	76.02	90-100
20	2295	46.0473515	50.3611557	33.42	40-85
14	1900	38.1219904	88.4831461	10.05	10-50

10	566	11.3563403	99.8394864	0.57	0-15
4.75	8	0.16051364	100	0.37	0-5
Pan	16				
Sum	4984		342.997592		
FM			3.42997592		

Sieve analysis for coarse aggregate from Agaro 4 Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	230	4.61106656	4.61106656	76.02	90-100
20	2304.5	46.2008821	50.8119487	33.42	40-85
14	1892	37.9310345	88.7429832	10.05	10-50
10	556	11.1467522	99.8897354	0.57	0-15
4.75	5.5	0.11026464	100	0.37	0-5
Pan	12				
Sum	4988		344.055734		
FM			3.44055734		

Sieve analysis for coarse aggregate from Agaro 5 Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	939.5	18.8616744	18.8616744	76.02	90-100
20	2688.5	53.9751054	72.8367798	33.42	40-85
14	1157	23.2282674	96.0650472	10.05	10-50
10	181	3.63380847	99.6988557	0.57	0-15
4.75	15	0.30114435	100	0.37	0-5
Pan	19.5				
Sum	4981		387.462357		

FM			3.87462357		

Sieve analysis for coarse aggregate from Agaro 5 Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	927.5	18.6207589	18.6207589	76.02	90-100
20	2690	54.0052198	72.6259787	33.42	40-85
14	1182.5	23.7402128	96.3661915	10.05	10-50
10	174.5	3.50331259	99.8695041	0.57	0-15
4.75	6.5	0.13049588	100	0.37	0-5
Pan	18				
Sum	4981		387.482433		
FM			3.87482433		

Sieve analysis for coarse aggregate from Agaro 5 Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	943	18.9072682	18.9072682	76.02	90-100
20	2686	53.8546366	72.7619048	33.42	40-85
14	1172.5	23.5087719	96.2706767	10.05	10-50
10	174.5	3.49874687	99.7694236	0.57	0-15
4.75	11.5	0.23057644	100	0.37	0-5
Pan	13				
Sum	4987.5		387.709273		
FM			3.87709273		

Sieve analysis for coarse aggregate from Haro Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	117	2.34939759	2.34939759	97.11	100
28	1976	39.6787149	42.0281124	76.02	90-100
20	2408	48.3534137	90.3815261	33.42	40-85
14	342	6.86746988	97.248996	10.05	10-50
10	120	2.40963855	99.6586345	0.57	0-15
4.75	17	0.34136546	100	0.37	0-5
Pan	21				
Sum	4980		431.666667		
FM			4.31666667		

Sieve analysis for coarse aggregate from Haro Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	142	2.84198939	2.84198939	76.02	90-100
20	1899.5	38.0166116	40.858601	33.42	40-85
14	2787	55.7790453	96.6376464	10.05	10-50
10	150	3.00210147	99.6397478	0.57	0-15
4.75	18	0.36025218	100	0.37	0-5
Pan	5				
Sum	4996.5		339.977985		
FM			3.39977985		

Sieve analysis for coarse aggregate from Haro Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing

75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	134	2.68187731	2.68187731	76.02	90-100
20	1789	35.8050635	38.4869409	33.42	40-85
14	2900.5	58.0506354	96.5375763	10.05	10-50
10	162	3.24226959	99.7798459	0.57	0-15
4.75	11	0.22015411	100	0.37	0-5
Pan	3.5				
Sum	4996.5		337.48624		
FM			3.3748624		

Sieve analysis for coarse aggregate from Seka Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	669.5	13.419523	13.419523	76.02	90-100
20	3138.5	62.9083985	76.3279214	33.42	40-85
14	1012	20.2846262	96.6125476	10.05	10-50
10	161	3.22709962	99.8396472	0.57	0-15
4.75	8	0.16035278	100	0.37	0-5
Pan	11				
Sum	4989		386.199639		
FM			3.86199639		

Sieve analysis for coarse aggregate from Seka Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	667	13.3640553	13.3640553	76.02	90-100

20	3130	62.7128832	76.0769385	33.42	40-85
14	1022	20.4768583	96.5537968	10.05	10-50
10	162	3.24584252	99.7996394	0.57	0-15
4.75	10	0.20036065	100	0.37	0-5
Pan	9				
Sum	4991		385.79443		
FM			3.8579443		

Sieve analysis for coarse aggregate from Seka Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	660	13.2092465	13.2092465	76.02	90-100
20	3132	62.6838787	75.8931252	33.42	40-85
14	1030	20.6144301	96.5075553	10.05	10-50
10	167	3.34233964	99.8498949	0.57	0-15
4.75	7.5	0.15010507	100	0.37	0-5
Pan	4				
Sum	4996.5		385.459822		
FM			3.85459822		

Sieve analysis for coarse aggregate from Offole Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	161.5	3.23258607	3.23258607	76.02	90-100
20	2366	47.3578863	50.5904724	33.42	40-85
14	2327	46.5772618	97.1677342	10.05	10-50
10	141.5	2.83226581	100	0.57	0-15
4.75	0	0	100	0.37	0-5

Pan	0				
Sum	4996		350.990793		
FM			3.50990793		

Sieve analysis for coarse aggregate from Offole Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	160	3.19936013	3.19936013	76.02	90-100
20	2370	47.3905219	50.589882	33.42	40-85
14	2328	46.5506899	97.1405719	10.05	10-50
10	143	2.85942811	100	0.57	0-15
4.75	0	0	100	0.37	0-5
Pan	0				
Sum	5001		350.929814		
FM			3.50929814		

Sieve analysis for coarse aggregate from Offole Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	0	0	0	97.11	100
28	161	3.21935613	3.21935613	76.02	90-100
20	2368	47.3505299	50.569886	33.42	40-85
14	2325	46.4907019	97.0605879	10.05	10-50
10	147	2.93941212	100	0.57	0-15
4.75	0	0	100	0.37	0-5
Pan	0				
Sum	5001		350.84983		
FM			3.5084983		

Sieve analysis for coarse aggregate from Gidi lulesa Sample 1

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	114.5	2.29137482	2.29137482	97.11	100
28	1874.5	37.5125075	39.8038823	76.02	90-100
20	2223	44.486692	84.2905743	33.42	40-85
14	637.5	12.7576546	97.0482289	10.05	10-50
10	139.5	2.79167501	99.8399039	0.57	0-15
4.75	8	0.16009606	100	0.37	0-5
Pan	4				
Sum	4997		423.273964		
FM			4.23273964		

Sieve analysis for coarse aggregate from Gidi lulesa Sample 2

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing
75	0	0	0	0	
63*	0	0	0	0	
37.5	109.5	2.19153407	2.19153407	97.11	100
28	1876	37.5462824	39.7378165	76.02	90-100
20	2224.5	44.5211648	84.2589813	33.42	40-85
14	639	12.7889523	97.0479336	10.05	10-50
10	137.5	2.75192635	99.7998599	0.57	0-15
4.75	10	0.2001401	100	0.37	0-5
Pan	4				
Sum	4996.5		423.036125		
FM			4.23036125		

Sieve analysis for coarse aggregate from Gidi lulesa Sample 3

Sieve Size	Mass retained	%age retained	Cumulative % retained	Cumulative % passing	Specification % passing

75	0	0	0	0	
63*	0	0	0	0	
37.5	112.5	2.2515761	2.2515761	97.11	100
28	1873	37.4862404	39.7378165	76.02	90-100
20	2226	44.5511858	84.2890023	33.42	40-85
14	637.5	12.7589313	97.0479336	10.05	10-50
10	142	2.84198939	99.8899229	0.57	0-15
4.75	5.5	0.11007705	100	0.37	0-5
Pan	4				
Sum	4996.5		423.216251		
FM			4.23216251		

APPENDIX-G

Flakiness Index

Flakiness Index for Agaro 1 site

Sample	Retain	% Retain	Pass	% Pass
Sample 1	3535.5	75	1166	25
Sample 2	3542.5	75	1150.5	25
Sample 3	3526.5	76	1142.5	24

APPENDIX-H

Aggregate Crushed value

Crushing value of coarse aggregate from Agaro 1

	Sample 1	Sample 2	Sample 3
wt of sample	2675.9	2664.8	2669.4
After ACV	2221.1	2230.6	2229.2
After ACV passing sieve size 2.36	454.8	434.2	453.2
Calc. =	17%	16.29%	16.97%

Average =16.75%

Crushing value of coarse aggregate from Agaro 2

	Sample 1	Sample 2	Sample 3
wt of sample	2776	2674.8	2734.3
After ACV	2322.1	2212.6	2311
After ACV passing sieve size 2.36	453.9	462.2	461.4
Calc. =	16.35	17.28	16.87

Average =16.83

Crushing value of coarse aggregate from Agaro 3

	Sample 1	Sample 2	Sample 3
wt of sample	2965	2901	2934.6
After ACV	2565.2	2496.2	2545.7
After ACV passing sieve size 2.36	399.8	404.8	401.6
Calc. =	13.48%	13.95%	13.68

Average =13.7

Crushing value of coarse aggregate from Agaro 4

	Sample 1	Sample 2	Sample 3
wt of sample	2928.6	2922.4	2925.7
After ACV	2581	2591.2	2596.1
After ACV passing sieve size 2.36	347.6	331.2	340.3
Calc. =	11.87%	11.33%	11.63

Average =11.61%

Crushing value of coarse aggregate from Agaro 5

	Sample 1	Sample 2	Sample 3
wt of sample	2587.2	2632.4	2612.5
After ACV	2156.6	2196.2	2167.4
After ACV passing sieve size 2.36	430.6	436.2	433.3
Calc. =	16.64%	16.57%	16.58

Average =16.59%

Crushing value of coarse aggregate from Haro

	Sample 1	Sample 2	Sample 3
wt of sample	2970.6	2632.4	2867.1
After ACV	2499.9	2196.2	2347.6
After ACV passing sieve size 2.36	470.7	436.2	467.4
Calc. =	15.85%	16.57%	16.24

Average =16.3%

Crushing value of coarse aggregate from Offole

	Sample 1	Sample 2	Sample 3
wt of sample	2903.2	2924.2	2933.4
After ACV	2500.5	2540.8	2551.1
After ACV passing sieve size 2.36	402.7	383.4	412.4
Calc. =	13.87%	13.11%	14.06

Average =13.68%

Crushing value of coarse aggregate from Seka

	Sample 1	Sample 2	Sample 3
wt of sample	2913.90	2889.4	2924
After ACV	2558	2525.3	2561.9
After ACV passing sieve size 2.36	355.90	364.1	367.8
Calc. =	12.21%	12.60%	12.57

Average =12.46%

Crushing value of coarse aggregate from Gidi Lulesa

	Sample 1	Sample 2	Sample 3
wt of sample	2930.1	2952.4	2946.3
After ACV	2500.5	2540.8	2534.5
After ACV passing sieve size 2.36	401.2	412.5	408.2
Calc. =	13.69%	13.97%	13.85

Average =12.84%

APPENDIX-I

Effect of aggregate on compressive strength of C25 concrete

Compressive strength for c-25 concrete

Table Compressive Strength Test Result for 7th day

No	Site	Test day	Dimension (cm)			Weight (gm)	Volume (cm3)	Failure load (KN)	Unit weight (gm/cm3)	Comp. Strength (MPa)	Comp. Strength (MPa) Avrage.
			L	W	H						
1	A1	7th	15	15	15	8237	3.37	392.35	2.37	17.44	19.91

2			15	15	15	8145	3.37	472.41	2.37	21.01	
3			15	15	15	8138	3.37	478.69	2.37	21.29	
							Average	**447.82**		**19.91**	
1	A2	7th	15	15	15	8467	3.37	454.87	2.37	20.22	18.91
2			15	15	15	8452	3.37	462.24	2.37	20.55	
3			15	15	15	8659	3.37	359.06	2.37	15.96	
							Average	**425.39**		**18.91**	
1	A3	7th	15	15	15	8759	3.37	471.79	2.37	20.97	20
2			15	15	15	8794.5	3.37	481.69	2.37	21.41	
3			15	15	15	8489	3.37	396.66	2.37	17.63	
							Average	**450.05**		**20**	
1	A4	7th	15	15	15	8735	3.37	458.87	2.37	20.4	19.9
2			15	15	15	8720	3.37	470.36	2.37	20.91	
3			15	15	15	8792	3.37	414.02	2.37	18.41	
							Average	**447.75**		**19.9**	
1	A5	7th	15	15	15	8227	3.37	387.69	2.37	17.23	18.3
2			15	15	15	8362	3.37	434.82	2.37	19.33	

3			15	15	15	8300	3.37	413.05	2.37	18.36	
							Average	**411.85**		**18.3**	
1	Haro	7th	15	15	15	8145	3.37	472.41	2.37	21.01	20.14
2			15	15	15	8138	3.37	478.69	2.37	21.29	
3			15	15	15	8467	3.37	454.87	2.37	20.22	
							Average	**468.65**		**20.84**	
1	Offole	7th	15	15	15	8747	3.37	490.71	2.37	21.81	21.62
2			15	15	15	8643	3.37	478.94	2.37	21.62	
3			15	15	15	8534	3.37	481.85	2.37	21.42	
							Average	**483.83**		**21.62**	
1	Seka	7th	15	15	15	8169	3.37	369.79	2.37	16.44	17.39
2			15	15	15	8140.5	3.37	384.9	2.37	17.11	
3			15	15	15	8076	3.37	419.18	2.37	18.63	
							Average	**391.29**		**17.39**	
1	Gidi	7th	15	15	15	8265	3.37	481.69	2.37	21.41	21.44
2			15	15	15	8110.6	3.37	487.91	2.37	21.68	
3			15	15	15	8368	3.37	477.54	2.37	21.23	

Average	**482.38**		**21.44**	

Table C.2- Compressive Strength Test Result for 28th day

No	Site	Test day	Dimension (cm)			Weight (gm)	Volume (cm3)	Failure load (KN)	Unit weight (gm/cm3)	Comp. Strength (MPa)	Comp. Strength (MPa) Avrage.
			L	W	H						
1	A1	28^{th}	15	15	15	8267	3.37	625.16	2.37	27.79	28.59
2			15	15	15	8165.7	3.37	648.12	2.37	28.81	
3			15	15	15	8129	3.37	656.46	2.37	29.18	
							Average	**643.25**		**28.59**	
1	A2	28^{th}	15	15	15	8369	3.37	764.09	2.37	33.97	31.68
2			15	15	15	8366.4	3.37	743.19	2.37	33.04	
3			15	15	15	8352.5	3.37	630.85	2.37	28.04	
							Average	**712.71**		**31.68**	
1	A3	28^{th}	15	15	15	9034	3.37	764.39	2.37	33.98	32.62
2			15	15	15	7938	3.37	748.38	2.37	33.27	
3			15	15	15	8316.5	3.37	688.17	2.37	30.60	

Average								**733.65**		**32.62**	
1	A4	28th	15	15	15	8525	3.37	641.98	2.37	28.54	29.79
2			15	15	15	8571.8	3.37	683.16	2.37	30.01	
3			15	15	15	8598	3.37	693.53	2.37	30.83	
Average								**672.89**		**29.79**	
1	A5	28th	15	15	15	8507	3.37	623.15	2.37	27.7	28.62
2			15	15	15	8630.4	3.37	654.79	2.37	29.11	
3			15	15	15	8626	3.37	653.67	2.37	29.06	
Average								**643.87**		**28.62**	
1	Haro	28th	15	15	15	8165.7	3.37	648.12	2.37	28.81	30.65
2			15	15	15	8129	3.37	656.46	2.37	29.18	
3			15	15	15	8369	3.37	764.09	2.37	33.97	
Average								**689.56**		**30.65**	
1	Offole	28th	15	15	15	8533	3.37	705.81	2.37	31.37	29.28
2			15	15	15	8528.2	3.37	697.01	2.37	30.98	
3			15	15	15	8460.5	3.37	573.49	2.37	25.5	
Average								**658.77**		**29.28**	
1	Seka	28th	1	1	1	8602.	3.37	491.63	2.37	21.86	26.9

			5	5	5	5					
2			15	15	15	8685	3.37	660.08	2.37	29.34	
3			15	15	15	8687	3.37	664.14	2.37	29.52	
							Average	**605.28**		**26.9**	
1	Gidi	28th	15	15	15	8688	3.37	764.46	2.37	33.98	33.28
2			15	15	15	8641.3	3.37	751.89	2.37	33.42	
3			15	15	15	8559.5	3.37	729.7	2.37	32.44	
							Average	**748.68**		**33.28**	

APPENDIX-J

Laboratory Procedure

Crushing Value

Procedure

1. Place the apparatus, with the test sample and plunger in position, and load it at as uniform a rate as possible so that the required force is reached in 10 min. 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 on the outside

3. Sieve the whole of the sample on the tray on the 2.36mm BS (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 operation to avoid loss of the fines

Impact Value Tests

Procedure

1. Place the whole of the test sample in the impact machine

2. Adjust the hammer so that its lower face is 380±5mm BS (380mm ASTM) above the upper surface of the aggregate in the cup and then allow it to fall freely on to the aggregate. Subject the sample to a total of 15 BS such blows. Note: weight of the hammer is 13.5-14 kg BS (14kg 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 of the sample in the tray on the 2.36mm BS (ASTM) test sieve until no further significant amount passes in 1 min.

5. Weigh the fractions passing and retained on the sieve to an accuracy of 0.l gm. (Mass B and mass C respectively), and if the total mass B + C is less than the initial mass (mass A) by more than 1g, discard the result and make a fresh test.

Los Angeles Abrasion Resistance Test

Procedure

1. Wash, dry, and obtain mass of the sample.

2. Place in the abrasion machine.

3. Add 12 standard balls.

4. Rotate the drum 500 revolutions at 28-30 rpm.

5. Remove the sample, sieve on a 1.18mm BS (1.7mm ASTM sieve).

6. Wash the sample retained.

7. Oven-dry at 105°c to 110 °C to subsequent constant mass, and weigh to the nearest 1g.

Moisture Content

Procedure

1. Weigh a sample of 2kg coarse aggregate (A).

2. Oven dry the samples for about 24hrs with a temperature of 105 °c-110 °c.

3. Remove the samples from the oven and place them on the desiccator for about an hour in order to cool without absorbing water from the atmosphere.

4. Weigh the aggregates (oven dry weight, B).

5. Calculate the moisture content of the aggregates

Specific Gravity and Water Absorption Capacity Test

Specific Gravity:

Procedure

1. After thoroughly washing to remove dust from the surface of the particles, dry the sample to constant weight at a temperature of 11 0±5°C, cool in air at room temperature for 1 to 3 hrs. And then immerse in water at room temperature for a period of 24 ± 4 hrs.

2. Remove the sample from the water and roll in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. Take care to avoid evaporation of water from aggregate pores during the operation of surface-drying.

3. Weigh the sample in the saturated-surface-dry condition and record (B).

4. Immediately place the saturated-surface-dry sample in the sample container and determine its weight in water at room temperature. Take care to remove all entrapped air by shaking the container while immersed and fully immerse the test sample before weighing (C).

5. Dry the sample to constant weight at a temperature of 110±5°C, cool in air at room temperature and 1 to 3hrs, and weigh (A)

Unit Weight

Roding Procedure

1. Fill the measure one-third full and level the surface with the fingers. Rod the layer of aggregate with 25 strokes of the tamping rod evenly distributed over the surface. Fill the measure two-thirds full and again level and rod as above. Finally, 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 rod ding 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 weight of the aggregate. Divide this weight by the volume of the measure. The result is the compact unit weight of the aggregate.

Sieve analysis and gradation

Procedure:

Metal cylinder is calibrated by determining the weight of water at 27°C required to fill it, so that no meniscers is present above the rim of the container.

The sample of single size aggregate retained between the specified pair of sieves is dried in an oven at a temperature 100°C to 110°C for 24 hours and cooled prior to testing.

The aggregates are placed in the cylinder and subjected to 100 blows of the tamping rod at a rate of about 2 blows per second. Each blow is applied by holding the rod vertically with its rounded end 5cms above the surface of the aggregates and releasing it so that it falls vertically and no force is applied to the rod.

The process of filling and tamping is repeated exactly as described above with a second and third
layer of aggregate.

After the third layer is tamped, the cylinder is filled to over flowing and the aggregates are struck off level with the top using a tamping rod as a straight edge.

The aggregate with cylinder is then weighed accurately.

All the above steps are repeated on another sample and averages of two are represented.

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The angularity number is calculated from the formula, *Loow* AngularIty Number = 67 - -- where, CG W = Mean weight of aggregates in the cylinder, gm. C = Weight of water required in the cylinder, gm. G = Specific gravity of aggregate.

Flakiness Index

Procedure:
~The sample is sieved with the sieves mentioned in the table.

~A minimum of 200 pieces of each fraction to be tested are taken and weighed (wlgm).

~ In order to separate flaky materials, each fraction is then gauged for thickness on thickness gauge, or in bulk on sieve having elongated slots as specified in the table.
~ Then the amount of flaky material passing the gauge is weighed to an accuracy of at least 0.1 % of test sample.

~ Let the weight of the flaky materials passing the gauge be wlgm. Similarly, the weights of the fractions passing and retained on the specified sieves be wI, w2, w3, etc. are weighed and the total weight wI +w2+w3+ .... = wg is found. Also, the weights of the materials passing each of the specified thickness gauge are found = WI, W2, W3 ... and the total weight of the material passing the different thickness gauges = WI+W2+W3+ .... =Wg is found.

~ Then the flakiness index is the total weight of the flaky material passing the various thickness gauges expressed as a percentage of the total weight of the sample gauged

C-25 MIX DESIGN

PROCEDURES

The mix design for C-25 non-air entrained normal strength concrete was done as per ACI 211.1. Mix design procedure manual.

Step-1: Choice of slump: consistent to the method of placement the slump was set to be 25 - 50 mm (minimum slump possible) is selected

Step-2: **Maximum size of aggregate:** Maximum size was fixed to be 20 mm. **Step 3: Target mean strength calculation** From ACI 301 table 4.2.3.3C seen below for a 28-day compressive strength, when no test data is available, 8.5 MPa shall be added to get mean strength. As a result, for 25 MPa characteristic strength, the target compressive strength will be = 25+8.5=33.3 MPa

Step-4: Mixing water requirement: Based on the ACI table.3.8 seen below for the slump rang of 25-50 mm and a maximum size of 20 mm aggregates; the required mixing water is 180 kg. Therefore, for the first trial mix the mixing water required was 180 kg of water.

Step 5: water to cement (W/C) ratio for 30 MPa W/C ratio is 0.55 and for 35 MPa W/C ratio is 0.48. The W/C ratio can be found by interpolation as follows from table 3.1 of ACI 211.1.81:

Step-6: Determining Cement content: From this ratio the amount of cement required will be about 360KGs (180/0.5).

***Step-7: Estimation of Coarse aggregate content*:** The dry mass of coarse-aggregate required for a cubic meter of concrete is equal to the value from ACI 211-Table 3.11 multiplied by the dry-rodded unit mass of the aggregate in kilograms per cubic meter. In sieve analysis, it was found that the fines modulus of fine aggregate was 2.83. The unit weight of the dry rodded coarse aggregates is 1585KG/m3. From the table the percentage by volume of coarse aggregate with a nominal maximum size of 25 mm is about 67%. This intern gives a mass of 1064.63 (0.67*1585) Kg of coarse aggregates.

Step-8: Fine aggregate content: it is clear that the estimated weight of the fresh Non air entrained concrete is 2375 KG. Deducting the weight of all the known ingredients gives the weight of the sand 770.37 Kg (2375- 180-360-1064.63).

Step 9: Adjustments for moisture

APPENDIX – K

QUESTIONNAIRE

JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT

Dear Respondents;

The aim of this questionnaire is to assess the quality of the available aggregate material in Jimma city.It is designed for academic purpose only and it is hoped that it helps to high light the problem area of the point under the study. You are kindly requested to be honest and frank in responding all questionnaires. Your response will be kept confidential and used for the intended purpose only.

Thank you for your Cooperation!!!

The researcher can be contacted using 0911429507 (Ashenafi Asmamaw)

Instruction I: Background Information	
Name of organization	________________
Your Education Level	________________
Field of Study	________________
Experience	________________
Sex	________________
Marital Status	________________
Age	________________

—

Instruction II: Give your opinion to the following questions based on your experience in the last five years by putting tick mark (√) to the appropriate choice(s). You can select more than one choice whenever necessary.

1. From your experience, which of the following activity will affect the quality of aggregate in your site?
   ( ) Age of the crushing plant ( ) Management
   ( ) Type of the rock ( ) Storage
   () Skill of worker ( ) area of the site
   ( ) Type of mining ( ) Others,________________________

2. What are the challenges in your working environment?

   ( ) Lack of government support ( ) lack of labor force
   ( ) Investor problem ( ) Poor monitoring and control
   ( ) Lack of political stability ( ) Poor communication
   ( ) Poor designing and planning ( ) weak labor productivity
   ( ) Weather conduction ( ) Rock type
   ( ) Others,________________________

Instruction III: Indicate your level of agreement to the following items that are stated in the table. Express your opinion by putting tick mark in the appropriate number. 1= strongly disagree, 2= disagree, 3 = Neutral, 4 = Agree, 5 = strongly agree

Aggregate quality control	5	4	3	2	1
1. Production of the aggregate is as per the standard					
2. The company works to improve the quality of the aggregate					
3. Testing aggregate quality is frequently done on site					
4. The size of the crushed stone checked by sieve analysis					
5. Those crushed stones which do not pass through sieve will be crushed and sized again					
6. Means of storage of produced aggregates affects the quality					
Capacity of investor					
1. Weak investor's technical and financial capacity will affect the quality of aggregate					
2. Is there enough Machineries and trucks on the quarry site					
3. Type of the crusher plant affects the quality the aggregate					
4. Number of human resources available affects the quality of the					

aggregate					
5. Means of blasting or downgrading the rock affects the quality of the aggregate.					
6. Means of management of the quarry site affects the quality of the aggregate					

Instruction IV: Human & Equipment

HUMAN RESOURCE

Sr.no	Description	NO
1	Manager	
2	Engineer	
3	Commercial staff	
4	Machine operators	
5	Administration and finance staff	
6	Technical staff	
7	Skilled worker	
8	Unskilled worker	

Others: - ______________________________

MACHINERY AND EQUIPMENT

Sr.no	Description	Qty
1	Bull Dozer	
2	Excavator	
3	Loader	

4	Dump truck	
5	Compressor and power tools	
6	Crushing plant	

Tools used: - ________________________________

____

Instruction V: Give your opinion to the following questions based on your last five years' experience

1. What actions should be taken to increase the quality of the aggregate during production?

   ____

   ____

2. What measures should be taken to fulfill aggregate demand without affecting the quality?

   ____

   ____

3. Land holding of the site ____
4. Type of mining ____
5. Means of Storage____
6. Type of rock used ____

Pleas list out your additional opinion about factors affecting the quality of aggregate

____

____

____

____

____

Thank you for your contribution

APPENDIX – K

Sample Photo Gallery Taken During the Research


UTEST