Jimma University

School of Graduate Studies

Jimma Institute of Technology

Faculty of Civil and Environmental Engineering

Construction Engineering and Management Chair

# ASSESSMENT OF CONCRETE PRODUCTION PROCESSES AND THE RATE OF CONCRETE QUALITY FOR BUILDING CONSTRUCTION IN THE CASE OF JIMMA TOWN

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

By:

WUBSHET GETAHUN MEKURIA

October, 2017

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CONSTRUCTION ENGINEERING AND MANAGEMENT STREAM

# ASSESSMENT OF CONCRETE PRODUCTION PROCESSES AND THE RATE OF CONCRETE QUALITY FOR BUILDING CONSTRUCTION IN THE CASE OF JIMMA TOWN

By

**Wubshet Getahun Mekuria**

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## DECLARATION

I, the undersigned, declare that this thesis entitled: "ASSESSMENT OF CONCRETE PRODUCTION PROCESSES AND THE RATE OF CONCRETE QUALITY FOR BUILDING CONSTRUCTION IN THE CASE OF JIMMA TOWN is my original work, and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for thesis have been duly acknowledged.

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As Master Research Advisors, we hereby certify that we have read and evaluated this MSc research prepared under our guidance, by Mr. WUBSHET GETAHUN MEKURIA, entitled: ASSESSMENT OF CONCRETE PRODUCTION PROCESSES AND THE RATE OF CONCRETE QUALITY FOR BUILDING CONSTRUCTION IN THE CASE OF JIMMA TOWN

We recommend that it can be submitted as fulfilling the MSc Thesis requirements.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AC | Absorption Capacity |
| ACI | American Concrete Institute |
| AD | Air Dry |
| ACV | Aggregate Crushing Value |
| ASTM | Americans Society for Testing of Materials |
| BS | British Standards |
| EA | Effective Absorption |
| EBCS | Ethiopian Building Codes of Standards |
| ES | Ethiopian Standard |
| OD | Oven Dry |
| OPC | Ordinary Portland Cement |
| PPC | Portland Pozolana Cement |
| QA | Quality Assurance or Quality Audit |
| QC | Quality Control |
| QMS | Quality Management System |
| SM | Surface Moisture |
| SSD | Saturated Surface Dry |

# ABSTRACT

*Concrete is a composite material composed of aggregates (fine and coarse) bonded together with fluid cement (hydraulic cement and water) that hardens over time. The production of concrete passed through various stages. These are batching, mixing, transporting, placing and compacting, finishing and curing. Concrete production is time-sensitive. Once the ingredients are mixed, workers must put the concrete in place before it hardens.*

*Inconsistency or variability of concrete production processes, which have significant impact on the quality of concrete, seen in the building construction projects.Lack or absense of detailed study conducted in Jimma town was the principal/driving factors to undertake this research on the area.*

*This paper focused on the assessments of concrete production processes and the rate of concrete quality in building construction projects. The assessment pointed on twenty five building project (private and government), which were under construction, found in Jimma town.*

*This paper conducted by distributing questionnaire to the contractors and consultant engineers and by carried out physical observation on the active projects. Statistical method used to analyze information gathered through primary and secondary sources.*

*Poor practice of concrete production processes observed and it have great gaps from the specified requirements and standard codes. It was found out that 52 percent of the projects contain defective lots as per the EBCS, as per the American Standard 24 percent have defective lots and as per British standard 40 percent have defective lots.*

*It's concluded that adequate concrete ingredient tests were not conducted. And also tests like soundness and chloride content not conducted at all. Analyses carried out on the investigated projects clearly showed us lower rate of concrete quality.*

*Not only improving the quality of workmanship but also non-intermittent concrete ingredient tests recommended for all projects. Hence, a great deal required from Jimma town construction office, contractors and consultants to improve quality of concrete in building construction.*



***Key words****: - Concrete, concrete grade, concrete ingredients, concrete production and compliance.*

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background

Concrete is composed of sand, crushed rock, or other aggregates held together by a hardened paste of hydraulic cement and water. The thoroughly mixed ingredients, when properly proportioned, make a plastic mass which can be cast or molded into a predetermined size and shape. Upon hydration of the cement by the water, concrete becomes stone like in strength and hardness and has utility for many purposes. In addition an admixture is sometimes used to improve some properties of concretes like workability and setting times. Concrete is one of the major construction materials in building construction industry (Zongjin, 2011).

Production of quality concrete requires not only good quality concrete ingredients but also thoroughly care exercised at every stage of manufacture of concrete. These various stages of concrete manufacture are batching, mixing, transporting, placing compacting, curing and finishing.

The production of uniform and economical concrete is largely dependent on inspection taken on the ingredients and different stages on concrete production process. Therefore, quality control measures by a contractor and assured by a consulting engineer play a central role in compliance with the specified requirements.

In order to ensure that concrete produced is of desired quality, it is necessary that quality control is practiced at all the stages right from receipt of raw material to production of concrete at site. The consultant should be ensured that contractors has adopted quality assurance program. Quality control is a process by which entities review the quality of all factors involved in production. Quality Assurance Program for concrete production can be broadly divided into three components i.e. Forward control, immediate control and retrospective control (NEVILLE, 2010).

Since, Jimma is a center for western part of Ethiopia and also a major coffee growing area of the country, observed that building constructions currently booming in Jimma town. And all of these building structures constructing from reinforced concrete, in which concrete have main percentages. The quality of concrete has also a very direct effect on the strength & durability of the structure as a whole.

There are many factors that can affect the quality of concrete, like differences in the quality of constituent materials, variation in mix proportions, deviation in the quality of operating and mixing equipment, workmanship and supervision quality at the site. Also, during transportation, placing, compacting and curing, variations may occur. These different factors causing variations in the quality should be taken into account, in order to avoid non quality or non-compliance that can appear at short or long term (Zongjin, 2011).

## 1.2 Statement of the problem

Concrete is used for many different building frames structures, bearing parts of a building, much more than any other construction material. The production of uniform and economical concrete is largely dependent on inspection taken; starting from the ingredient selection to various stages of concrete production process. Hence, quality control measures by a contractor and assured by a consulting engineer play a central role to achieve quality concrete product which satisfy the compliance of specified requirements.

Structural failure can occur from many types of problems, most of which are unique to different industries and structural types. However, most can be traced to one of five main causes.

> The first is that the structure is not strong and tough enough to support the load, due to its size, shape, or choice of material. If the structure or component is not strong enough, catastrophic failure can occur when the structure is stressed beyond its critical stress level (Zongjin, 2011).
>
> The second type of failure is from fatigue or corrosion, caused by instability in the structure's geometry, design or material properties. These failures usually begin when cracks form at stress points, such as squared corners or bolt holes too close to the material's edge. These cracks grow as the material is repeatedly stressed and unloaded (cyclic loading), eventually reaching a critical length and causing the structure to suddenly fail under normal loading conditions (Zongjin, 2011).
>
> The third type of failure is caused by manufacturing errors, including improper selection of materials, incorrect sizing, improper heat treating, failing to adhere to the design, or shoddy workmanship. This type of failure can occur at any time and is usually unpredictable (Zongjin, 2011).
>
> The fourth type of failure is from the use of defective materials. This type of failure is also unpredictable, since the material may have been improperly manufactured or damaged from prior to use(Zongjin, 2011).
>
> The fifth cause of failure is from lack of consideration of unexpected problems. This type of failure can be caused by events such as vandalism, sabotage, or natural disasters. It can also

occur if those who use and maintain the construction are not properly trained and overstress the structure (Zongjin, 2011).

Among the causes of structural failure mentioned above the third and fourth point would be the problems seen in our country and also here in Jimma town. Therefore, the two equally important activities directly related to the quality of concrete produced were the quality of ingredient used and the process involved in its production studied. Since, variability of concrete production processes seen in the town could be the principal driving factors to undertake this research. Hence, problems related to the practices of concrete production process and the projects' concrete quality rate identified and finally forward the ways of outstanding quality concrete.

## 1.3 Research question

i. How much the quality of concrete ingredients kept?
ii. Could the practice of concrete production process affect quality of concrete?
iii. How much the compressive strengths of concrete produced satisfy the standard codes?

## 1.4 Objective of the research

The objective of this research was to assess concrete production processes and the rate of concrete quality in building construction projects of Jimma town.

### 1.4.1Specific Objective

1. To investigate concrete ingredient quality control mechanisms
2. To investigate the practice concrete productions process
3. To investigate the rate of concrete compressive strengths compliances' as of the standard codes.

## 1.5 Significant of the study

This study compared the concrete production process to that of Ethiopian building codes standards and provides helpful information to the client, contractors, consultant and material supplier. Jimma town construction office could be benefited from the study as a source of information and foundation for the building construction follow up information. Owners, contractors and consultants will benefit from the study as a source of information. Other researchers will use the findings as a reference for further research on the areas of concrete quality.

## 1.6 Scope and limitations of the study

The scope of the study mainly concerns on the assessment of concrete production process and the rate of concrete quality in the case of Jimma town. And finally suggest the best practices to be applied to handle problems associated to the quality of concrete.

Lack of adequate finance, time restriction and unwillingness of some private contractors and government organization limits the study objectives.

## 1.7 Justification of the study

The rationale of conducting this study provided the bench mark under which the quality of (compressive strength) of concrete is improved. Facts are shown that; in Jimma town there are lots of defected concrete.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Definition of Concretes.

Portland cement concrete is a composite material made by combining cement, supplementary cementing materials, aggregates, water, and chemical admixtures in suitable proportions and allowing the resulting mixture to set and harden over time. Some of the basic constituents: cements, aggregates, water and chemical and/or mineral admixtures.

The constituent materials must be proportioned correctly, and the concrete must then be mixed, placed, and cured properly. In addition, there must be careful quality control of every part of the concrete-making process (Nawy, 2008).

### 2.1.1 Portland cement

Portland cement is by far the most important member of the family of hydraulic cements—that is, cements that harden through chemical interaction with water (Nawy, 2008).

According to the definition in ASTM C 219, Portland cement is hydraulic cement produced by pulverizing Portland cement clinker, and usually containing calcium sulfate

#### 2.1.1.1Tests of cement

Testing of cement can be brought under two categories:

a) Field testing
b) Laboratory testing

Field testing

It is sufficient to subject the cement to field tests when it is used for minor works. The following are the field tests (Abebe Dinku, 2002):

a. Open the bag and take a good look at the cement. There should not be any visible lumps. The color of the cement should normally be greenish grey
b. Thrust your hand into the cement bag. It must give you a cool feeling. There should not be any lump inside
c. Take a pinch of cement and feel-between the fingers. It should give a smooth and not a gritty feeling.

d. Take a handful of cement and throw it on a bucket full of water, the particles should float for some time before they sink.
e. Take about 100gmof cement and a small quantity of water and make a stiff paste. From the stiff paste, pat a cake with sharp edges. Put it on a glass plate and slowly take it under water in a bucket. After 24hours the cake should retains its original shape and at the same time it should also set and attain some strength.

If a sample of cement satisfies the above field tests it may be concluded that the cement is not bad. But the cement may go bad during transportation and storage prior to its use in works. The following tests are usually concluded in the laboratory (Zongjin, 2011).

a. Fineness test
b. Setting time test
c. Strength
d. Soundness test
e. Heat of hydration test
f. Chemical composition test

### 2.1.1.2 Ordinary Portland cement

Ordinary Portland cement is general-purpose cement suitable for all uses where the special properties of other types are not required. Its uses in concrete include pavements, floors, reinforced concrete buildings, bridges, tanks, reservoirs, pipe, masonry units, and precast concrete products (Zongjin, 2011)

### 2.1.1.3 Portland pozzolana cement

These cements are produced by inter-grinding or blending pozzolan with Portland cement. As a rule, Portland-pozzolan cements gain strength slowly and therefore require curing over a comparatively long period, but the long-term strength is high.

Portland-pozzolan cements are designated as Type IP or Type P. Type IP may be used for general construction and Type P is used in construction not requiring high early strengths. These cements are manufactured by intergrading Portland cement clinker with a suitable pozzolan, by blending Portland cement or Portland blast-furnace slag cement and a pozzolan or by a combination of intergrading and blending. The pozzolan content of these cements is between 15% and 40% by mass. Laboratory tests indicate that performance of concrete made with Type IP cement as a group is similar to that of Type I cement concrete. Type IP may be designated as air-entraining, moderate sulfate resistant or with moderate heat of hydration by adding the suffixes A, MS, or MH. Type P may be designated as low heat of hydration (LH), moderate sulfate resistant (MS), or air entraining (A).

Pozzolana was cheaper than Portland cement. Its slow hydration and the resulting slow rate of heat development make it important in mass concrete construction. It also shows good resistance to sulphate attack and to some other destructive agents. This is so because the pozzolanic reaction leaves less lime to be leached out and also reduces the permeability of concrete (Lamond and James, 2006).

#### 2.1.1.4 Transport, storage and Batching

The storage of cement is entirely a matter of keeping it dry, and it is necessary to stack the bags in a shed or under whatever cover is available. On small projects where storage without a shed is required for a few days, the cement should be placed on a raised platform and covered with transpaulins, polyethylene film (0.2mm thick) or water proof building paper

Even when stored under good conditions bagged cement may lose 20 percent of its strength after 2 months of storage, and 40 percent after 6 months of storage. Cement can be stored in air tight bins indefinitely without deteriorating in any way, but this is not practicable for site use. Cement which is 4 months old should be classified as "aged" and be retested for use air set cement results from storage in a damp atmosphere. This is due to the moisture present in the air being absorbed by the cement and causing a partial set. Preventing the movement of air in to the store as far as practicable reduces the absorption of moisture from a damp atmosphere. As a rough guide, lumpy cement, which cannot be easily crumbled in the fingers, is unsatisfactory for general use. Cement should be stacked in such a way that the cement first delivered can be used first (Lamond and James, 2006).

### 2.1.2. Aggregates

#### 2.1.2.1. General

Aggregates make up about 75% of the volume of concrete, so their properties have a large influence on the properties of the concrete. Aggregates are granular materials, most commonly natural gravels and sands or crushed stone, although occasionally synthetic materials such as slags or expanded clays or shale’s are used. Most aggregates have specific gravities in the range of 2.6 to 2.7, although both heavyweight and lightweight aggregates are sometimes used for special concretes. The role of the aggregate is to provide much better dimensional stability and wear resistance; without aggregates, large castings of neat cement paste would essentially self-destruct upon drying. Also, because they are less expensive than Portland cement, aggregates lead to the production of more economical concretes (Steven Kosmatka, 2003).

Aggregates which are less expensive than cements have significant portion of a concrete. In general, aggregates are much stronger than the cement paste, so their exact mechanical properties are not considered to be of much importance (except for very high-strength concretes). Similarly, they are also assumed to be completely inert in a cement matrix, although this is not always true, as will be seen in the discussion on the alkali–aggregate reaction. For ordinary concretes, the most important aggregate properties are the particle grading (or particle-size distribution), shape, and porosity, as well as possible reactivity with the cement. Of course, all aggregates should be clean that is, free of impurities such as salt, clay, dirt, or foreign matter.

As a matter of convenience, aggregates are generally divided into two size ranges: coarse aggregate, which is the fraction of material retained on a No. 4 (4.75-mm) sieve, and fine aggregate, which is the fraction passing the No. 4 sieve but retained on a No. 100 (0.15-mm) sieve(Nawy, 2008).

#### 2.1.2.2. Properties of Aggregates

The physical properties of aggregates such as size shape, texture, porosity, absorption, moisture content, bulking of fine materials, presence of deleterious substances etc affects significantly the resulting concrete quality produced as briefly explained here under (Abebe Dinku, 2002).

##### 2.1.2.2.1. Aggregate size, shape and texture

Ideally, to minimize the amount of cement paste required to provide adequate workability of the fresh concrete, aggregate particles for ordinary concrete should be roughly equal-dimensional with relatively smooth surfaces, such as most natural sands and gravels. Where natural sands and gravels are unavailable, crushed stone may be used. Crushed stone tends to have a rougher surface and to be more angular in shape. As a result, it tends to require rather more cement paste for workability. Whether using natural gravels or crushed stone, however, either flat or elongated particles should be avoided, as they will lead to workability and finishing problems (Nawy, 2008).

The Ethiopian standard has adopted the requirement set on the parts of the American standard (ASTM Standard, 1993). Classification of aggregates as British Standard (BS 882, 2002)

There are several reasons for specifying grading limits and nominal maximum aggregate size; they affect relative aggregate proportions as well as cement and water requirements, workability, pump ability, economy, porosity, shrinkage, and durability of concrete. Variations in grading can seriously affect the uniformity of concrete from batch to batch. Very fine sands are often uneconomical; very coarse sands and coarse aggregate can produce harsh, unworkable mixtures. In general, aggregates that do not have a large deficiency or excess of any size and give a smooth grading curve will produce the most satisfactory results (SHETTY, 2005).

#### 2.1.2.2.2. Absorption and surface moisture of Aggregate

The absorption and surface moisture of aggregates should be determined according to ASTM C 70, C 127, C 128, and C 566 (AASHTO T 255) so that the total water content of the concrete can be controlled and correct batch not contain water. The moisture conditions of aggregates classified as: -

1. Ovens dry (OD)—all moisture is removed by heating the aggregates in an oven at 105°C to constant weight.
2. Air dry(AD)—dry at the particle surface but containing some interior moisture, thus still somewhat absorbent.
3. Saturated surface dry (SSD) — All pores are full, but the surface is completely dry.
4. Damp or wet—all pores are full, and a water film is on the surface.

- The *absorption capacity* (AC) represents the maximum amount of water the aggregates can absorb. From Figure 1.10, this is the difference between the SSD and OD states, expressed as a percentage of the OD weight. It should be noted that, for most common aggregates, the absorption capacities are of the order of 0.5 to 2.0%. Absorption capacities greater than 2% are often an indication that the aggregates may have potential durability problems.

  $$AC = \left(\frac{WSSD - WOD}{WOD}\right) * 100\% \qquad 2.1$$

  Where *W* represents weight

- The *effective absorption* (EA) refers to the amount of water required for the aggregate to go from the AD to the SSD state:

  $$EA = \left(\frac{WSSD - WAD}{WSSD}\right) * 100\% \qquad 2.2$$

  To calculate the weight of the *water absorbed* ($W_{abs}$) by the aggregate in the concrete mix:

$$Wabs = (EA)Wagg \qquad 2.3$$

The *surface moisture* (SM) represents water in excess of the SSD state, held on the aggregate surface:

$$SM = \left(\frac{Wwet - WSSD}{WSSD}\right) * 100\% \qquad 2.4$$

Thus, the extra water added to the concrete from the wet aggregates will be:

$$Wadd = (SM)Wagg \qquad 2.5$$

Surface moisture on fine aggregate can cause considerable bulking; the amount varies with the amount of moisture and the aggregate grading. The amount of water added at the concrete batch plant must be adjusted for the moisture conditions of the aggregates in order to accurately meet the water requirement of the mix design. If the water content of the concrete mixture is not kept constant, the water-cement ratio will vary from batch to batch causing other properties, such as the compressive strength and workability to vary from batch to batch. Coarse and fine aggregate will generally have absorption levels (moisture contents at SSD) in the range of 0.2% to 4% and 0.2% to 2%, respectively. Free-water contents will usually range from 0.5% to 2% for coarse aggregate and 2% to 6% for fine aggregate. The maximum water content of drained coarse aggregate is usually less than that of fine aggregate. Most fine aggregates can maintain maximum drained moisture content of about 3% to 8% whereas coarse aggregates can maintain only about 1% to 6% (Nawy, 2008).

## 2.1.2.2.3. Bulking of fine Aggregate

Bulking is the increase in total volume of moist fine aggregate over the same mass dry. Surface tension in the moisture holds the particles apart, causing an increase in volume. Bulking of a fine aggregate (such as sand) occurs when it is shoveled or otherwise moved in a damp condition, even though it may have been fully consolidated beforehand. Since most fine aggregates are delivered in a damp condition, wide variations can occur in batch quantities if batching is done by volume. For this reason, good practice has long favored weighing the aggregate and adjusting for moisture content when proportioning concrete (Zongjin, 2011).

## 2.1.2.2.4. Soundness of aggregates

Soundness refers to the ability of aggregates to withstand cyclic volume changes due to wetting and drying or freezing and thawing without deteriorating. Rocks that are susceptible to wetting and drying cycles are rare, so soundness generally refers to freeze–thaw resistance. Aggregates will deteriorate if high internal stresses are developed when water absorbed within the aggregate freezes. This deterioration, in turn, depends on the size, porosity, permeability, and degree of saturation of the aggregate. For most aggregates, the critical size above which unsoundness develops is greater than the maximum size normally used in concrete; however, for some sedimentary rocks (chert, gray wacke, sandstone, shale, and poorly consolidated limestone), the critical size can be less than 25 mm. The most susceptible rocks are those that have a relatively high absorption (porosity), greater than

2%, combined with a very fine pore structure (low permeability) so the freezing water cannot easily be expelled from the aggregate. If aggregates are unsound, this can lead to surface pop-outs and to D-cracking in pavements and slabs (Abebe Dinku, 2002).

### 2.1.2.2.5. Grading of Aggregates

The particle-size distribution in a sample of aggregate, referred to as the grading, is generally expressed in terms of the cumulative percentage of particles passing (or retained on) a specific series of sieves. These distributions are most commonly shown graphically as grading curves. Examples of such curves are given in Figure 1.9, which shows the usual North American grading limits for fine aggregate and for a particular maximum size (38.1 mm) of coarse aggregate. Such grading limits have been determined empirically. They are intended to provide a fairly dense packing of aggregate particles, again to minimize the cement paste requirement; however, no ideal aggregate grading exists that can be derived theoretically. In practice, one can provide good concrete with quite a range of aggregate grading. Although the continuous type of grading is the most common, other types of grading are sometimes used for special purposes; for example, gap grading refers to a grading in which one or more of the intermediate size fractions is omitted. This is sometimes convenient when it is necessary to blend different aggregates to achieve a suitable grading. Such concretes are also prone to segregation of the fresh concrete. No-fines concrete is a special case of gap-graded concrete in which the fine aggregate (<4.75 mm) is omitted entirely to produce a porous, lighter weight concrete that, for example, may allow water to drain through it. For fine aggregates, the particle-size distribution tends to be described by a single number, the fineness modulus (FM), which is defined as:

$$FM = \frac{\sum \ (cumulative \ \% retained \ on \ standard \ sieve)}{100} \qquad \text{......2.6}$$

where the standard sieve sizes are No. 100 (0.15-mm), No. 50 (0.30-mm), No. 30 (0.60-mm), No. 16 (1.18-mm), No. 8 (2.36-mm), and No. 4 (4.75-mm). Normally, the FM should fall between 2.3 and 3.1 (higher values imply a coarser material). The value of the FM is required for mix design purposes (Lamond and James, 2006).

### 2.1.2.2.6. Strength and shrinkage of aggregate

The strength of an aggregate is rarely tested and generally does not influence the strength of conventional concrete as much as the strength of the paste and the paste-aggregate bond. However, aggregate strength does become important in high-strength concrete. Aggregate stress levels in concrete are often much higher than the average stress over the entire cross section of the concrete. Aggregate tensile strengths range from 2 to 15 MPa (300 to 2300 psi) and compressive strengths from 65 to 270 MPa (10,000 to 40,000 psi).

Different aggregate types have different compressibility, modulus of elasticity, and moisture-related shrinkage characteristics that can influence the same properties in concrete. Aggregates with high absorption may have high shrinkage on drying. Quartz and feldspar aggregates, along with limestone, dolomite, and granite, are considered low shrinkage aggregates; while aggregates with sandstone, shale, slate, hornblende, and graywacke are often associated with high shrinkage in concrete(SHETTY, 2005).

## 2.1.2.2.7. Deleterious substances in Aggregates

There are three broad categories of deleterious substances that may be found in aggregate:

*Impurities* interfere with the process of hydration of cement. *Coatings* prevent the development of good bond between aggregate and the cement paste and certain individual particles are *weak or unsound* in them.

Organic impurities may delay setting and hardening of concrete, may reduce strength gain, and in unusual cases may cause deterioration. Organic impurities such as peat, humus, and organic loam may not be as detrimental but should be avoided.

Materials finer than the 75µ (No. 200) sieve, especially silt and clay, may be present as loose dust and may form a coating on the aggregate particles. Even thin coatings of silt or clay on gravel particles can be harmful because they may weaken the bond between the cement paste and aggregate. If certain types of silt or clay are present in excessive amounts, water requirements may increase significantly.

There is a tendency for some fine aggregates to degrade from the grinding action in a concrete mixer; this effect, which is measured using ASTM C 1137, may alter mixing water, entrained air and slump requirements.

Aggregates can occasionally contain particles of iron oxide and iron sulfide that result in unsightly stains on exposed concrete surfaces. The aggregate should meet the staining requirements of ASTM C 330 (AASHTO M 195) when tested according to ASTM C 641; the quarry face and aggregate stockpiles should not show evidence of staining (A M NEVILLE, 2010).

### 2.1.2.2.8. Alkali-silica Reaction

A large number of failures have resulted from expansions caused by reactions between certain types of siliceous aggregates and the alkalis ($K_2O$ and $Na_2O$) contained in the cement. The types of rocks that are likely to participate in these reactions include siliceous lime stones, cherts, shale, flint, volcanic glasses, opaline rocks, quartzite, sandstone, and some granites and schists. In some cases, these expansive reactions, which are first manifested by extensive surface cracking, occur within a few years after the concrete has been cast. In other cases, however, damage may not appear until 15 to 20 years after construction.

The factors that control the rate and extent of the alkali–aggregate reaction are

1. The nature of the reactive silica
2. The amount of reactive silica
3. The particle size of the reactive material
4. The amount of alkali available and
5. The amount of available moisture.

Regardless of the specifics of the cement and the aggregate, however, the alkali–silica reaction progresses through the steps indicated in Table 1.10. Step 1 is controlled by the alkali content of the cement. Any real control of the reaction potential must be taken at this step, either by avoiding reactive aggregates or by keeping the alkali content of the cement quite low ($Na_2O + 0.6K_2O \leq 0.60$). Step 2 depends on the exact form of the silica and determines the rate at which the reaction will take place. It is at Step 3 that the damage occurs as the alkali–silicate gel imbibes water and swells, cracking the matrix. Step 4 mostly produces the visible signs of the reaction.

It should be noted that Steps 3 and 4 will not occur if the concrete is kept dry.

**Table 2.1** the Alkali–Silica Reaction **(Zongjin, 2011)**

| Step | Reaction | Consequences |
|---|---|---|
| 1 | Release of alkali ions during cement hydration | Increased alkalinity of water in the pores (pore solution) |
| 2 | Initial hydrolysis of the reactive silicates in the alkaline pore solution: $K(Na)OH + SiO_2 \rightarrow K_2O(Na_2O){-}SiO_2{-}H_2O$, amorphous alkali silicate gel | Aggregate integrity destroyed |
| 3 | Swelling of alkali silicate gel as it imbibes water | Localized cracking |
| 4 | Liquefaction of alkali silicate gel as it imbibes more moisture | Liquid gel expelled through the cracks |

If low-alkali cements are not available in a particular region (because the raw materials used to produce the cement are themselves too high in alkali content), a useful strategy is often to replace some of the cement with a pozzolanic material (such as fly ash) that contains no alkalis at all, to reduce the total alkali content of the cementitious materials to an acceptable level. Although pozzolanic materials contain silica in a reactive form, the silica is very finely divided and reacts very quickly with the alkalis. Harmful expansions do not occur because the resulting alkali–silicate gel is distributed throughout the cementitious matrix, so the expansions are distributed. The worst case is to have relatively small volumes of reactive aggregates in large pieces scattered throughout the concrete; this localizes and concentrates the expansions, leading to severe cracking (Nawy, 2008).

## 2.1.2.2.9. Alkali-carbonate Reaction

Expansive reactions can also occur between the alkalis in the cement and certain dolomitic lime stones ($MgCO_3/CaCO_3$) that contain some clay. Not all dolomitic lime stones are subject to this reaction; those that are have the following features:

Very small crystals of $MgCO_3$

Presence of considerable fine grained calcite

Abundant interstitial clay and

Dolomite and calcite crystals uniformly distributed in the clay matrix.

The expansive reaction is:

CMC+NH (orKH) MH+CC+N……………………………..……………………………..…….2.7

Dolomite + from cement →brucite + calcite + soluble carbonates

This reaction is still not fully understood. The alkali–carbonate reaction can also be controlled by keeping the alkali content of the cementitious material very low (<0.40%). Unlike the case of the alkali–silica reaction, pozzolanic materials in this case cannot control the alkali–carbonate reaction (Nawy, 2008).

**Handling and storing Aggregates**

Aggregates should be handled and stored in a way that minimizes segregation and degradation and prevents contamination by deleterious substances. Stockpiles should be built up in thin layers of uniform thickness to minimize segregation. The most economical and acceptable method of forming aggregate stockpiles is the truck-dump method, which discharges the loads in a way that keeps them tightly joined. The aggregate is then reclaimed with a front-end loader. The loader should remove slices from the edges of the pile from bottom to top so that every slice will contain a portion of each horizontal layer (SHETTY, 2005).

## 2.1.3 Mixing and curing Water

Although the water itself is often not considered when dealing with materials that go into the production of concrete, it is an important ingredient. Typically, 150 to 200 kg/m3 of water is used. The old rule of thumb for water quality is "If you can drink it, you can use it in concrete," although good-quality concrete can be made with water that is not really potable. Indeed, more bad concrete is made by using too much drinkable water than by using the right amount of undrinkable water. The tolerable limits for various common impurities in mixing water are given in Table below. When in question, the suitability of the water is determined by comparing the strength of concrete made with the suspect water to the strength of concrete made with known acceptable water (SHETTY, 2005).

A pump provides the means to move the material to precise locations, multi-floor buildings, and other distance prohibitive locations. Buckets suspended from cranes are also used to place the concrete. The drum is traditionally made of steel but on some newer trucks as a weight reduction measure, fiberglass has been used (Zongjin, 2011).

**Table 2.2** Tolerable Levels of Some Impurities in Mixing Water **(Zongjin, 2011)**

| Impurity | Maximum Concentration (ppm) | Remarks |
|---|---|---|
| Suspended matter (turbidity) | 2000 | Silt, clay, organic matter |
| Algae | 500–1000 | Entrains air |
| Carbonates | 1000 | Decreases setting times |
| Bicarbonates | 400–1000 | 400 ppm for bicarbonates of Ca or Mg |
| Sodium sulfate | 10,000 | May increase early strength but reduce later strength |
| Magnesium sulfate | 40,000 | |
| Sodium chloride | 20,000 | Decreases setting times, increases early strength, |
| Calcium chloride | 50,000 | reduces ultimate strength, and may lead to corrosion of reinforcing steel |
| Magnesium chloride | 40,000 | |

### 2.1.3.1 Effects of certain impurities in mixing water on properties of concrete

*Carbonates and bicarbonates of sodium and potassium* have different effects on the setting times of different cements. Sodium carbonate can cause very rapid setting; bicarbonates can either accelerate or retard the set. In large concentrations, these salts can materially reduce concrete strength. When the sum of the dissolved salts exceeds 1000 ppm, tests for their effect on setting time and 28-day strength should be made. The possibility of aggravated alkali-aggregate reactions should also be considered (SHETTY, 2005).

Concern over *high chloride content* in mixing water is chiefly due to the possible adverse effect of chloride ions on the corrosion of reinforcing steel or pre-stressing strands. Chloride ions attack the protective oxide film formed on the steel by the highly alkaline (pH greater than 12.5) chemical environment present in concrete. The acid alkalis soluble chloride ion level at which steel reinforcement corrosion begins in concrete is about 0.2% to 0.4% by mass of cement (0.15% to 0.3% water soluble). Of the total chloride- ion content in concrete, only about 50% to 85% is water soluble; the rest becomes chemically combined in cement reactions (SHETTY, 2005).

Acceptance of acid mixing water should be based on the concentration (in parts per million) of acids in the water. Occasionally, *acceptance is based on the pH*, which is a measure of the hydrogen-ion concentration on a log scale. The pH value is an intensity index and is not the best measure of potential acid or base reactivity. The pH of neutral water is 7.0; values below 7.0 indicate acidity and those above 7.0 indicates alkalinity (a base).

Water *containing algae* is unsuited for making concrete because the algae can cause an excessive reduction in strength. Algae in water lead to lower strengths either by influencing cement hydration or by causing a large amount of air to be entrained in the concrete. Algae may also be present on aggregates, in which case the bond between the aggregate and cement paste is reduced. A maximum algae content of 1000 ppm is recommended (SHETTY, 2005).

### 2.1.4. Admixtures for concrete

Admixtures are those ingredients in concrete other than Portland cement, water, and aggregates that are added to the mixture immediately before or during mixing. Admixtures can be classified by function as follows:

*Air-entraining admixtures*

*Water-reducing admixtures*

*Plasticizers*

*Accelerating admixtures*

*Retarding admixtures*

*Hydration-control Admixtures*

*Corrosion inhibitors*

*Shrinkage reducers*

*Alkali-silica reactivity inhibitors*

Coloring admixture Miscellaneous admixtures such as workability, bonding, damp proofing, permeability reducing, grouting, gas-forming, anti-wash out, foaming, and pumping admixture concrete should be workable, finish able, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the selection of suitable materials rather than by resorting to admixtures (except air-entraining admixtures when needed).

The major reasons for using admixtures are: to reduce the cost of concrete construction, to achieve certain properties in concrete more effectively than by other means, to maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions to overcome certain emergencies during concrete operations.

Despite these considerations, it should be borne in mind that no admixture of any type or amount can be considered a substitute for good concreting practice.

The effectiveness of an admixture depends upon factors such as type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportions; mixing time; slump; and temperature of the concrete. The amount of admixture recommended by the manufacturer or the optimum amount determined by laboratory tests should be used (SHETTY, 2005).

## 2.3. Designing and Proportioning Normal Concrete Mixtures

The process of determining required and specifiable characteristics of a concrete mixture is called mix design. Characteristics can include: (1) fresh concrete properties; (2) required mechanical properties of hardened concrete such as strength and durability requirements; and (3) the inclusion, exclusion, or limits on specific ingredients. Mix design leads to the development of a concrete specification.

Mixture proportioning refers to the process of determining the quantities of concrete ingredients, using local materials, to achieve the specified characteristics of the concrete (Zongjin, 2011).

### 2.3.1 Selecting mix characteristics

Before a concrete mixture can be proportioned, mixture characteristics are selected based on the intended use of the concrete, the exposure conditions, the size and shape of building elements, and the physical properties of the concrete (such as frost resistance and strength) required for the structure. Once the characteristics are selected, the mixture can be proportioned from field or laboratory data (Zongjin, 2011).

### 2.3.2Water/Cement Ratio

Mix proportioning for normal-strength concretes is based, to a large extent, on the w/c ratio law articulated by D.A. Abrams in 1919: “For given materials, the strength depends only on one factor—the ratio of water to cement.” This can be expressed as:

$$fc = \frac{K1}{K2\left(\frac{w}{c}\right)} \qquad \text{2.8}$$

Where*K*1 and *K*2 are constants and *w*/*c* is the water/cement ratio by weight.

For a given cement and acceptable aggregates, the strength that may be developed by a workable, properly placed mixture of cement, aggregate, and water (under the same mixing, curing, and, testing conditions) is influenced by the: (a) ratio of cement to mixing water; (b) ratio of cement to aggregate; (c) grading, surface texture, shape, strength, and stiffness of aggregate particles; and (d) maximum size of aggregate.

For ordinary concretes, the w/c ratio law works well for a given set of raw materials, because the aggregate strength is generally much greater than the paste strength; however, the w/c ratio law is more problematic for high-strength concretes, in which the strength-limiting factor may be the aggregate strength or the strength of the interfacial zone between the cement and the aggregate. Although it is, of course, necessary to use very low w/c ratios to achieve very high strengths, the w/c ratio vs. strength relationship is not as straightforward as it is for normal concretes. Figure 1.8 shows a variety of water/ cementitious material vs. strength relationships obtained by a number of different investigators. A great deal of scatter can be seen in the results. In addition, the range of strengths for a given w/c ratio increases as the w/c ratio decreases, leading to the conclusion that, for these concretes, the w/c ratio is not by itself a very good predictor of strength; a different w/c ratio “law” must be determined for each different set of materials (Nawy, 2008).

## 2.4 Concrete production process

The specification, production, and delivery of concrete are achieved in different ways.

The basic processes and common techniques explained by ASTM C 94 provide standard specifications for the manufacture and delivery of freshly mixed concrete.

Three options for ordering or specifying concrete are:

Option A is performance based. It requires the purchaser to specify the compressive strength only, while the concrete producer selects the mixture proportions needed to obtain the required compressive strength.

Option B is prescription based. The purchaser specifies mixture proportions, including cement, water and admixture contents.

Option C is a mixed option. It requires the concrete producer to select the mix proportions with the minimum allowable cement content and compressive strength specified by the purchaser (SHETTY, 2005).

### 2.4.1. Batching

Batching is the process of measuring concrete mix ingredients by either *mass or volume*methodsand introducing them into the mixer.

Volume batching: - Volume batching is not a good method for proportioning the material because of the difficulty it offers to measure granular material in terms of volume. Volume of moist sand, in a loose condition, weights much less than the same volume of dry compacted sand.

Weight batching: - strictly speaking, weight batching is the correct method of measuring the materials. For important concrete, invariably, weight batching should be adopted. Use of weight systems in batching, facilitates accuracy, flexibility and simplicity. To produce concrete of uniform quality, the ingredients must be measured accurately for each batch(NEVILLE, 2010).

Equipment should be capable of measuring quantities within these tolerances for the smallest batch regularly used as well as for larger batches. The accuracy of scales and batching equipment should be checked periodically and adjusted when necessary.

Liquid chemical admixtures should be charged into the mixture as aqueous solutions. The volume of liquid, if significant, should be subtracted from the batched quantity of mixing water. Admixtures that cannot be added in solution can be either batched by mass or volume as directed by the manufacturer. Admixture dispensers should be checked frequently since errors in dispensing admixtures, particularly overdoses, can lead to serious problems in both fresh and hardened concrete(Shri Purvansh B Shah, 2015).

### 2.4.2. Mixing of concrete

Through mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency. There are two methods adopted for mixing concrete:

*Hand mixing:* -Hand mixing is practiced for small scale unimportant concrete works. As the mixing cannot be through and efficient, it is desirable to add 10percent more cement to cater for the inferior concrete produced by this method.

*Machine Mixing:* - Mixing of concrete is almost invariably carried out by machine, for reinforced concrete work and for medium or large scale mass concrete work.

Mixers should not be loaded above their rated capacities and should be operated at the mixing speed recommended by the manufacturer. Increased output should be obtained by using a larger mixer or additional mixers, rather than by speeding up or overloading the equipment on hand. If the blades of a mixer become worn or coated with hardened concrete, mixing action will be less efficient. These conditions should be corrected (SHETTY, 2005).

If concrete has been adequately mixed, samples taken from different portions of a batch will have essentially the same unit weight, air content, slump, and strength. Concrete is sometimes mixed at a jobsite in a stationary mixer or paving mixer; at other times, it is mixed in central mixers at ready-mix plants. Ready-mixed concrete can be manufactured by any of the following methods:

Centrally mixed concrete is completely mixed in a stationary mixer and then delivered in a truck agitator or in a truck mixer at agitating speed to the job site. Shrink-mixed concrete is partially mixed in a stationary mixer and completed in a truck mixer. Truck-mixed concrete is mixed completely in a truck mixer (Nawy, 2008).

The choice of mixer depends on the size, extent, and the nature of work. The choice between central and site mixing will be governed by factors such as accessibility, water supply, transport routes, availability of working space.

*Mixing time:* - mixing time is related to the capacity of mixer. The mixing time varies between 1.5 to 2.5 minutes. Bigger the capacity of drum more is the mixing time (SHETTY, 2005).

For high rise building with ground stationary mixer using admixture advised to overcome prior setting of concrete and to achieve desired workability. They can be charged with dry materials and water, with the mixing occurring during transport. They can also be loaded from a "central mix" plant, with this process the material has already been mixed prior to loading. The concrete mixing transport truck maintains the material's liquid state through agitation, or turning of the drum, until delivery. The interior of the drum on a concrete mixing truck is fitted with a spiral blade. In one rotational direction, the concrete is pushed deeper into the drum. This is the direction the drum is rotated while the concrete is being transported to the building site. This is known as "charging" the mixer. When the drum rotates in the other direction, the Archimedes' screw-type arrangement "discharges", or forces the concrete out of the drum. From there it may go onto chutes to guide the viscous concrete directly to the job site. If the truck cannot get close enough to the site to use the chutes, the concrete may be discharged into a concrete pump, connected to a flexible hose, or onto a conveyor belt which can be extended some distance (typically ten or more meters).

There is not recorded time when mixing concrete. It is done by default experience/knowledge of visual inspection at the mix. Too long mixing resulted for poor workability while too short mix results for improper blend of the ingredients. Quality of concrete greatly depends on the rpm (revolution per minute) of the mixer and duration of mixing time. In general, to produce good quality concrete someone, who is experienced or not, have keep record of every batch of mixing (Zongjin, 2011).

#### 2.4.2.1 Types of Concrete Mix Design

**1. Nominal Mixes**

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength (https://www.the constructor.org, 2017).

**2. Standard mixes**

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively (https://www.the constructor.org, 2017).

**3. Designed Mixes**

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance (https://www.the constructor.org, 2017).

### 2.4.3. Transport of Concrete mix

When concrete has been transported to a job site, it is conveyed by a variety of methods including: -

| | |
|---|---|
| Mortar pan | Chutes |
| Wheel barrow, hand cart | Skip and hoist |
| Crane, Bucket and Rope | Transit mixer |
| Truck mixer and Dumpers | Pump and pipe line |
| Belt conveyors | Helicopter |

Concrete should be conveyed in such a manner that it is not allowed drying out; it should not be delayed, and it should not be allowed to segregate before it is placed (Nawy, 2008).

**Choosing the Best Method: -** The first thing to look at is the type of job, its physical size, the total amount of concrete to be placed, and the time schedule. Studying the job details further will tell how much of the work is below, at, or above ground level. This aids in choosing the concrete handling equipment necessary for placing concrete at the required levels.

Concrete must be moved from the mixer to the point of placement as rapidly as possible without *segregation or loss of ingredients*. The transporting and handling equipment must have the capacity to move sufficient concrete so that cold joints are eliminated (SHETTY, 2005).

### 2.4.4. Placement of Concrete mix

Concrete should be deposited continuously as near as possible to its final position. Concrete should be placed in horizontal layers of uniform thickness, each layer being thoroughly consolidated before the next is placed. The rate of placement should be rapid enough that a layer of concrete is not yet set when a new layer is placed upon it. Drop shoots should be used to prevent segregation and spattering of mortar on reinforcement and forms in wall placements.

When the concrete has been placed in a form or layer, it should be consolidated or compacted into the mold so it forms in and around embedded items and reinforcement and removes entrapped air. Consolidation is usually accomplished by mechanical methods. Use of internal vibrators is the most common method of consolidating concrete. When concrete is vibrated, it behaves like a liquid; it settles in the forms by the action of gravity, and large entrapped air voids rise to the surface. Workers must be careful to make sure that the vibrator is inserted into the concrete at a uniform distribution within the radius of action of the vibrator to properly consolidate all of the concrete. Even highly fluid, plasticized mixes with slumps over 7-1/2 in. (190 mm) require some vibration for proper consolidation (Nawy, 2008).

## 2.4.5. Consolidating Concrete

Consolidation is the process of compacting fresh concrete; to mold it within the forms and around embedded items and reinforcement; and to eliminate stone pockets, honeycomb, and entrapped air. It should not remove significant amounts of intentionally entrained air in air-entrained concrete.

Consolidation is accomplished by hand or by mechanical methods. The method chosen depends on the consistency of the mixture and the placing conditions, such as complexity of the formwork and amount and spacing of reinforcement. Generally, mechanical methods using either internal or external vibration are the preferred methods of consolidation (Zongjin, 2011).

Workable, flowing mixtures can be consolidated by hand rodding, which is, thrusting a tamping rod or other suitable tool repeatedly into the concrete. The rod should be long enough to reach the bottom of the form or lift and thin enough to easily pass between the reinforcing steel and the forms. Low-slump concrete can be transformed into flowing concrete for easier consolidation through the use of super plasticizers without the addition of water to the concrete mixture.

Spading can be used to improve the appearance of formed surfaces. A flat spade like tool should be repeatedly inserted and withdrawn adjacent to the form. This forces the larger coarse aggregates away from the forms and assists entrapped air voids in their upward movement toward the top surface where they can escape. A mixture designed to be readily consolidated by hand methods should not be consolidated by mechanical methods; otherwise, the concrete is likely to segregate under intense mechanical action.

Even in highly reinforced elements, proper mechanical consolidation makes possible the placement of stiff mixtures with the low water-cementitious materials ratios and high coarse-aggregate contents associated with high quality concrete. Among the mechanical methods are centrifugation, used to consolidate moderate to- high-slump concrete in making pipes, poles, and piles; shock or drop tables, used to compact very stiff low-slump concrete in the manufacture of architectural precast units; and vibration—internal and external(SHETTY, 2005).

### 2.4.5.1. Vibration of Concrete

Vibration, either internal or external, is the most widely used method for consolidating concrete. When concrete is vibrated, the internal friction between the aggregate particles is temporarily destroyed and the concrete behaves like a liquid; it settles in the forms under the action of gravity and the large entrapped air voids rise more easily to the surface. Internal friction is reestablished as soon as vibration stops.

When vibration is used to consolidate concrete, a standby vibrator should be on hand at all times in the event of a mechanical breakdown.

**Internal Vibration: -** Internal or immersion-type vibrators, often called spud or poker vibrators are commonly used to consolidate concrete in walls, columns, beams, and slabs. Flexible-shaft vibrators consist of a vibrating head connected to a driving motor by a flexible shaft. Inside the head, an unbalanced weight connected to the shaft rotates at high speed, causing the head to revolve in a circular orbit. The motor can be powered by electricity, gasoline, or air. The vibrating head is usually cylindrical with a diameter ranging from 20 to 180 mm (3⁄4 to 7 in.). Some vibrators have an electric motor built right into the head, which is generally at least 50 mm (2 in.) in diameter. The dimensions of the vibrator head as well as its frequency and amplitude in conjunction with the workability of the mixture affect the performance of a vibrator.

Proper use of internal vibrators is important for best results. Vibrators should not be used to move concrete horizontally since this causes segregation. Whenever possible, the vibrator should be lowered vertically into the concrete at regularly spaced intervals and allowed to descend by gravity. It should penetrate to the bottom of the layer being placed and at least 150 mm (6 in.) into any previously placed layer. The height of each layer or lift should be about the length of the vibrator head or generally a maximum of 500 mm (20 in.) in regular formwork.

In thin slabs, the vibrator should be inserted at an angle or horizontally in order to keep the vibrator head completely immersed. However, the vibrator should not be dragged around randomly in the slab. For slabs on grade, the vibrator should not make contact with the sub-grade. The distance between insertions should be about 11⁄2 times the radius of action so that the area visibly affected by the vibrator overlaps the adjacent previously vibrated area by a few centimeters (inches). The vibrator should be held stationary until adequate consolidation is attained and then slowly withdrawn. An insertion time of 5 to 15 seconds will usually provide adequate consolidation. The concrete should move to fill the hole left by the vibrator on withdrawal. If the hole does not refill, reinsertion of the vibrator at a nearby point should solve the problem.

Re-vibration of previously compacted concrete can be done to both fresh concrete as well as any underlying layer that has partially hardened. Re-vibration is used to improve bond between concrete and reinforcing steel, release water trapped under horizontal reinforcing bars, and remove additional entrapped air voids. In general, if concrete becomes workable under re-vibration, the practice is not harmful and may be beneficial.

**External Vibration: -** External vibrators can be form vibrators, vibrating tables, or surface vibrators such as vibratory screeds, plate vibrators, vibratory roller screeds, or vibratory hand floats or trowels. Form vibrators, designed to be securely attached to the outside of the forms, are especially useful (1) for consolidating concrete in members that are very thin or congested with reinforcement, (2) to supplement internal vibration, and (3) for stiff mixes where internal vibrators cannot be used(SHETTY, 2005).

### 2.4.6 Curing Of Concrete

Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. The need for adequate curing of concrete cannot be overemphasized. Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing and deicers. Exposed slab surfaces are especially sensitive to curing as strength development and freeze-thaw resistance of the top surface of a slab can be reduced significantly when curing is defective.

When Portland cement is mixed with water, a chemical reaction called hydration takes place. The extent to which this reaction is completed influences the strength and durability of the concrete. Freshly mixed concrete normally contains more water than is required for hydration of the cement; however, excessive loss of water by evaporation can delay or prevent adequate hydration. The surface is particularly susceptible to insufficient hydration because it dries first. If temperatures are favorable, hydration is relatively rapid the first few days after concrete is placed; however, it is important for water to be retained in the concrete during this period, that is, for evaporation to be prevented or substantially reduced.

With proper curing, concrete becomes stronger, more impermeable, and more resistant to stress, abrasion, and freezing and thawing. The improvement is rapid at early ages but continues more slowly thereafter for an indefinite period (Zongjin, 2011).

### 2.4.6.1 Curing Methods and Materials

Concrete can be kept moist (and in some cases at a favorable temperature) by three curing methods: this method maintains the presence of mixing water in the concrete during the early hardening period. These include ponding or immersion, spraying or fogging, and saturated wet coverings. These methods afford some cooling through evaporation, which is beneficial in hot weather.

The methods that reduce the loss of mixing water from the surface of the concrete can be done by covering the concrete with impervious paper or plastic sheets, or by applying membrane-forming curing compounds.

Methods that accelerate strength gain by supplying heat and additional moisture to the concrete. This is usually accomplished with live steam, heating coils, or electrically heated forms or pads (Dr. Edward G. Nawy, 2008).

## 2.5. Concrete Quality control

### 2.5.1. General

Quality may be defined as the ability of a product or system to satisfy all the requirements it was designed to meet. The production of uniform and economical concrete is largely dependent on inspection at the batching and mixing plants ( MONTGOMERY, 2009).

Quality comprises a combination of actions and decisions taken in compliance with specifications and checks to ensure that these are satisfied. Quality control consists of two distinct, the researcher but interconnected parts, namely production control and compliance control.

Production Control: Comprises a combination of actions and decisions taken during production, to check the operation and to obtain a reasonable assurance that the specifications will be satisfied.

Compliance Control: Comprises a combination of actions and decisions, in accordance with compliance rules adopted in advance, to check the compliance of the product with the specifications.

Due to the various factors involved in concrete production, such as materials, proportioning and production process, the concrete obtained at the end has shown variability from batch to batch. Therefore, this variability in properties must be considered when preparing concrete specifications.

Factors that contribute to variability of concretes may be grouped in to the following three general categories ( MONTGOMERY, 2009).

Materials: - these include variability in the cement; in the grading, moisture content, mineral composition, physical properties, and particle shape of the aggregates; and in the admixture used.

Production: - this involves the type of batching plant and equipment, the method of transporting concrete to the site, and the procedures and workmanship used to produce and place the concrete.

Testing includes the sampling procedures, the making and curing of test specimens, and the test procedures used.

The variability in concrete properties due to the factors mentioned above makes significant the importance of quality control. Quality control is defined as an action and decisions taken to ensure the compliance of works with the specification. It contains two parts, namely, production control and compliance control. Production control is a measure taken during production to obtain a reasonable assurance that the specifications will be satisfied. And compliance control is a check made to ensure the compliance of the product with the specification.

Though quality control incurs extra cost, the advantage due to quality control offset the extra cost. Some of these advantages are: -

Quality control is used for the rational use of the available resources after testing their characteristics and for reducing the material cost.

In the absence of quality control at the site, the designer is tempted to over design, so as to minimize the risks. This adds to the overall costs.

Checks at every stage of the production of concrete and rectification of the faults at the right time expedite completion and reduces delay.

Quality control reduces the maintenance costs

In the absence of quality control there is no guarantee that overspending in one area will compensate for the weakness in another, e.g. an extra bag of cement will not compensate for incomplete compaction or inadequate curing. Proper control at all the stages is the only guarantee.

The variation observed in concrete which indicates the degree of quality control exercised during concrete production could be quantitatively computed from compressive strength test results with variability measuring statistical parameters like standard deviations and coefficient of variation as shown below ( MONTGOMERY, 2009).

## 2.5.2. Deviation Test Result Evaluation

It has been found that the distribution of concrete strengths can best be approximated by the normal or Gaussian distribution. Such a distribution is defined by two parameters; the mean $X$ and the standard deviation S.

The mean is given by:

$\bar{x} = \frac{\sum x}{n}$……………………………………………………………………………………………..2.9

And the standard deviation or the root-mean-square deviation, which is the measure of dispersion or variability of the values, is given by:

$s = \frac{\sqrt{\sum xi - \bar{x}}}{n-1}$………………………………………………..……………………………………..2.10

Where xi =is the values of strength of a given sample

n =is the number of samples tested

$\bar{x}$= Arithmetic mean strength of all the samples

The variation of results about the mean can also be expressed by the coefficient of variations which is a non-dimensional measure of variation and is given by:-

$V = \frac{s}{\bar{x}} *$

$100$…………………………………………...……………………………………2.11(ACI 214, 2002)

## 2.5.3. Uses of Deviation analyses

The above statistical parameters; namely, standard deviation and coefficient of variation are useful in the design and quality control of concrete assuming that variations in concrete properties is to be described by normal distribution.

Following the statistical normal distribution assumption a number of important implications are observed:-

We can't design on the basis of mean strength or average strength. If we did, this would mean that about one half of the concrete would have strengths that fall below the design value, which would be unacceptable. On the other hand, we cannot insist that all concrete strengths be above the design value; since concrete strengths are approximately normally distributed, this is impossibility. Therefore, we must arbitrarily decide what constitutes an acceptable percentage of specimens falling below the "minimum" design values. The Ethiopian building code and standards specifies a 5% defective or fall below the design values. Using this percentage, and knowing or assuming the standard deviation in strength that can be expected, we can then determine the required mean strength for which to design the concrete mix.

When carrying out tests on concrete, we are trying to evaluate the distribution in strength of all the concrete in the structure, based upon a limited sample size. Clearly enough test data must be collected so that the tests are truly representative of the concrete in the structure. However it has to be known that, the test results are only estimates of the strength of concrete in the structures.

Because variations in concrete strengths are due not only to mix variations, but also to sampling variations, there are two risks that must be balanced. The "producer's risk" that satisfactory concrete will be rejected and the "consumer's risk" that bad concrete will be accepted. This consumer's risk can be large indeed if insufficient testing is carried out.

There must be some plan of action that can be followed if the concrete is considered not to have complied with the specification. This is stated well in the succeeding section.

Depending on the quality of control measures taken in construction sites or in laboratories, there are values of standard deviation and coefficient of variation assigned to each class of activities (ACI 214) as shown in table below (ACI 214, 2002).

**Table 2.3 standard of concrete control (ACI 214)**

a. Based on standard deviation

| Over all variation (for $f_c$ less than or equal to 35Mpa(5000psi)) | | | | | |
|---|---|---|---|---|---|
| Class of Operation | Standard deviation for different control standards, MPa(psi) | | | | |
| | Excellent | Very good | Good | Fair | poor |
| General construction testing | Below 2.8 (below 400) | 2.8 to 3.4 (400 to 500) | 3.4 to 4.1 (500 to 600) | 4.1 to 4.8 (600 to 700) | Above 4.8 (above 700 |
| Laboratory trial batches | Below 1.4 (below 200) | 1.4 to 1.7 (220 to 250) | 1.7 to 2.1 (250 to 300) | 2.1-2.4 (300 to 350) | Above 2.4 (above 350) |

b. based on coefficient of variation

| Class of Operation overall variation | Coefficient of variations for different control standard % | | | |
|---|---|---|---|---|
| | Excellent | Very good | Good | Poor |
| General construction testing | Below 10 | 10 to 15 | 15 to 20 | Above 20 |
| Laboratory trial batches | Below 5 | 5 to 7 | 7 to 10 | Above 10 |

## 2.5.4. Compliance controls and acceptance of compressive strength

### 2.5.4.1 The American standard of ACI 318 criterion

For laboratory cured specimens of job concrete every arithmetic average of any three consecutive strength tests must equal or exceed fc`; and no individual tests (average of two cylinders) may fall below fc` by more than 3.5Mpa when fc` is less than or equal to 35Mpa or by more than o.1 fc` if fc` is greater than 35Mpa.

Failure to satisfy either of the acceptance criteria requires changes in the mix proportions and construction procedures to increase concrete strength. Failure to meet the second criterion requires an investigation of the strength of the concrete in the structure (ACI 214, 2002).

### 2.5.4.2The British standard of (BS 5328, 1990) criterion

Compliance with the characteristics strength is based on groups of consecutive test results, as well as on single test results. Each result is the average of two cubes, made in the specified manner from concrete which is sampled at a prescribed rate, and normally tested at 28 days. Compliance is assumed if both of the following requirements are satisfied:

The mean strength determined from the first two, three or four consecutive test results or from any group of four consecutive results complies with the limits listed below.

No individual test result falls short of the specified characteristics strength by more than the value given in table below.

**Table 2.4** compliance requirements for compressive strength according to BS 5328: 1990

| Specific characteristics Strength(grade) [MPa] | Group of results | Minimum value by which the mean strength of the group of test results should exceed the grade strength [MPa] | Maximum value by which any individual test result falls short of the grade strength [Mpa] |
|---|---|---|---|
| 7.5 to 15 | First two | 0 | 2 |
| | First three | 1 | 2 |
| | Any consecutive four | 2 | 2 |
| 20 and above | First two | 1 | 3 |
| | First three | 2 | 3 |
| | Any consecutive four | 3 | 3 |

If only one result (average of two cubes) fails to meet the second requirement, we can assume that the result represents only the particular batch of concrete from which the cubes were made, provided that the average strength of the group satisfies the first requirement. If the average strength of any group of four consecutive test results fails to meet the first requirement, then all the concrete in all the batches represented by the test cubes is deemed not to comply with the strength requirements. In such a case, the mix proportions of subsequent batches of concrete should be modified to increase the strength (BS 1881 part-116, 2003).

### 2.5.4.3The Ethiopian (EBCS-2, 1995) Compliance control criterion

Two acceptance criteria are envisaged

**Criterion 1:** this criterion may be applied in all cases but is less suited to large scale sampling each lot is represented by three samples, the strength of which are $X1 < X2 < X3$.

The lot is accepted if the following conditions are satisfied simultaneously.

$m3 \geq fck + k1$.....................................................................................................................2.12

$\bar{x}1 \geq fck - k2$…………………..……………………………………………………………….…2.13

Where:

m3 is the mean value

Fck is the specified characteristic strength

K1&K2 are the margins of strength given in the table 3.1 below

$\bar{x}1$ is the average strength of the minimum strengths of the several lots

**Table 2.5** EBCS-2, 1995 margin of compliance

| Margin of strength | First two lots | Third and fourth lots | Fifth lot and above |
|---|---|---|---|
| K1 | 5 | 4 | 3 |
| K2 | 1 | 2 | 3 |

**Criterion 2**:- this criterion is suitable for large lots.

Each lot is represented by a lot less than 15 test specimens (n≥15).

The lot is accepted if the following conditions are satisfied simultaneously.

$\bar{m}n - \lambda Sn \geq$

$fck$…..........................................................................................................................2.14

Where:

$\bar{m}_n$ is the mean value

Sn is the standard deviation of the set of sample results.

Fck is the characteristics cylindrical strength.

$\Lambda$ is the coefficient (may be taken as 1.4)

K2 is the margin of strength (may be taken as 4MPa)

N is the member of specimens

If the test results do not satisfy the requirements of the selected acceptance criterion, measures specified below shall be taken

**Measures to be taken in case of non-compliance**

If the quality of the structure is found to be in doubt after an inspection or from the test results, then a special examination shall be made to verify the soundness of the information received and to assess the actual strength of the structure as constructed with possible recourse to more accurate methods of calculation (EBCS-2, 1995).

**Sequence of Measures**

The following sequential measures shall be taken where the results of compliance control tests or inspection are unsatisfactory:

The position of concrete which does not fulfill the compliance criterion shall be identified.

The structural safety shall be checked by appropriate calculations on the basis of the actual test results which did not comply. If safety is assured, the concrete can be accepted. If such structural safety or durability are not assured, then the strength of the concrete shall I be examined by taking drilled cores or by non-destructive methods. The results of such tests shall be assessed on the basis of the prescribed acceptance criterion, taking into account any differences in age.

If this new information shows that structural safety is assured, the concrete may be accepted after it has been decided whether repairs are necessary to ensure durability.

If the results of check tests by non-destructive methods (3) show that the quality of concrete is in adequate or show other defects, the engineer may require a loading test to be made which shall then be carried out.

If structural safety and durability are not assured, then the possibility of strengthening the structure must be investigated. If strengthening is not feasible, then the concrete shall be rejected, and the structure or member demolished or given a reduced structural grading by limiting its service rating, as appropriate (EBCS-2, Ethiopian Building code standard Structural Use of Concrete, 1995)

The lot could be defined as the quantity of concrete produced in the same essential conditions and subjected to individual assessment given hereunder.

No individual sampling can represent, on the average, more than 100 mixes or 100 $m^3$.

For each grade of concrete, at least one sample shall be taken every week.

For each grade of concrete, at least two lots shall be made.

If the test results do not satisfy the requirements of the above acceptance criteria, there are recommended measures to be taken. The measures includes checking the strength using non-destructive tests, rechecking the structural safety by making new calculation or design with the non-complying compressive strength and so on.

The non-destructive tests that could be used to check the quality of hardened in-situ concrete are like ultrasonic and Schmidt hammer test. However; those tests have their own drawbacks and hence accurate results are not expected. Schmidt hammer test is the very common test used, but it provides sufficient information only for a surface layer of concrete up to 30mm deep(Zongjin, 2011).

*Mechanical wave techniques (MWT):* These techniques take the mechanical waves as the working agency. The principle of these techniques is the generation and propagation of laws concerning mechanical waves. Ultrasonic waves, acoustic waves, and sub-acoustic waves are mechanical waves. A special feature of these waves is that they are directly related to the mechanical properties of the media they propagate through it. Hence, this is a remarkable advantage for determining the mechanical performance of the materials. Mechanical wave NDT techniques are widely used in NDT-CE, and are also some of the most popularly used conventional NDT techniques. They can be used in a wide range of objectives, as a tool for measurement, detection, and monitoring. They can meet most of the requirements for NDE in civil engineering. They are accurate in determining shape, size, and depth of the defective areas, with high sensitivity, deep penetration, low cost, and they are easy and fast to operate and convenient for in situ use. Mechanical waves are not harmful to the human body, which is an important advantage over radiation (Zongjin, 2011).

*Schmidt hammer test:* provides reliable result only at shallow depth on the surface of the structure up to around 30 mm. Mostly, hammer test satisfies the compliance criteria. But, it is difficult to determine with certainty the in-situ strength of deeper structural parts like MWT.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Description of study area

The study was conducted at Jimma Town, southwestern Ethiopia that is located 335km by road southwest of Addis Ababa. Its geographical coordinates are between 7° 13’- 8° 56N latitude and 35°49’-38°38’E longitude with an estimated area of 19,506.24. The town is found in an area of average altitude, of about 5400 ft. (1780 m) above sea level. It lies in the climatic zone locally known as Woyna Dega, which is considered ideal for agriculture as well as human settlement.

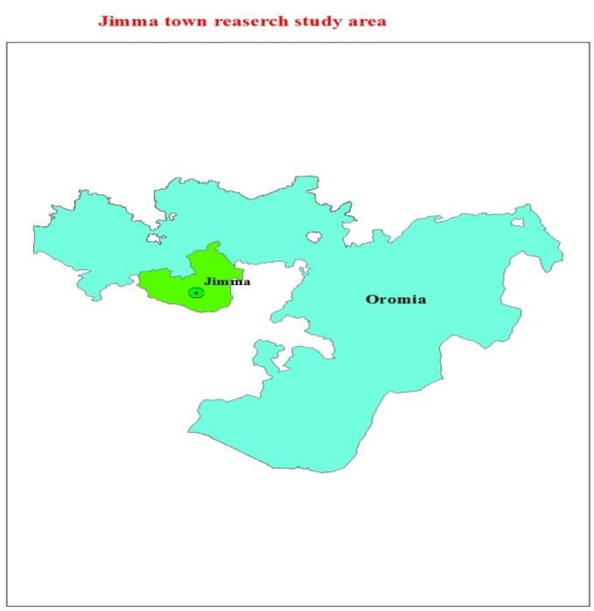



**Figure 1Jimma town area of the research study**

## 3.2 Research Design

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

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

## 3.3 Sampling techniques

Cluster sampling was used first to select representative samples from active construction, inactive construction and terminated building construction projects. Among the total population, building construction project, size of 115 active building construction projects 41 in numbers were selected. And the contractors and consultants participated on these projects selected for the collection of primary data.

After an in-depth review of literature, a questionnaire was designed and distributed to contractors and consultants to get their opinion based on their experience. Observation on active site activities also carried out altogether. Upon obtaining the desired data, checking and sorting of data has been done.

Descriptive questions which both open and closed ended having contents which mainly focus on the quality of material and concrete production process was used to collect data from selected construction site. Compressive strength of structural grade C-25 concrete collected from the laboratory test results recorded data.

## 3.4 Study variables

Dependent variables of this research would be *compressive strength of C-25 concrete grade* and *the rate of concrete quality*. And the independent variables could be *concrete production practices* and *contractors' workmanship quality*.

## 3.5 Methods of data analysis

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

The information gathered through questionnaire, site observations and compressive strength test results are briefly discussed here. The observed phases of concrete production process in the building construction discussed against the required specifications and different codes & standards. The quality of concrete making materials, workmanship and the level quality control thoroughly discussed. And the variability observed from various codes and standards analyzed altogether.

## 3.6 Ethical Considerations

The appropriate recommendation  paper taken from Jimma University as a permit to conduct this research and to obtain the required data from the selected company (individual).and to undertake field observation

## 3.7 Data Quality Assurance

In order to increase the quality of the data the researcher prepared a fieldwork manual to check every day progress. And also assistants are selected and trained to handle the data carefully. The collected data could also be checked for reliability and accuracy.

## 3.8 Limitations of the Study

In fact, with in this short period of time and budget it is very difficult to compare up all construction sites and detail investigation about the concrete production process and quality control. Therefore, if there are other financial providers, it will be further investigated and studied by conducting lab test.

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 Analyze the quality of concrete ingredients

The data and information gathered through questionnaires and observations on building construction sites analyzed. The total number of distributed questionnaires in this study contained forty one but collected responses were only twenty nine. Out of the returned questionnaires, four were rejected for the analysis due to negligently answered. And twenty five projects analyzed on this research.

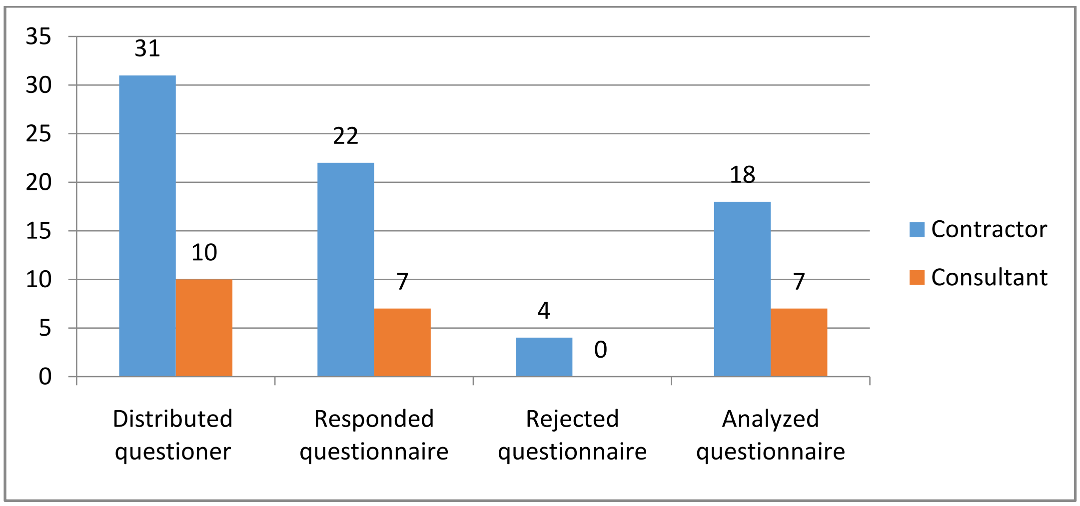



**Figure 2 chart shows questionnaire analyzed for the research**

### 4.1.1 Quality of aggregates

#### 4.1.1.1 Fine aggregates

Here for the investigated projects various river deposit natural sand, crushed fine aggregates and the mixture of two used as a sources fine aggregates. Aggregates are coming from different quarry sites namely Chora, Gambela, and Worabe.

The investigation undergoing shows 88 percent of the project natural sand was selected favorably causes of economical, timely and easily availability. The rest 12 percent of the project used mixed crushed fine aggregate and natural sand.  But the mineral contents of aggregates and the presence of other deleterious substances like salts and sulphate were not tested.

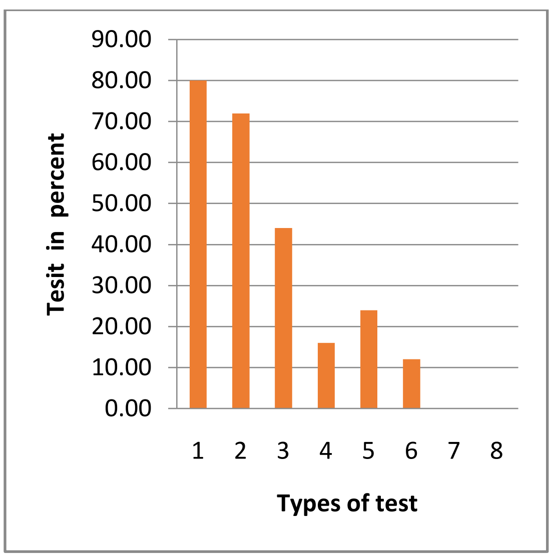
**Table 4.1** Percentage use of Fine aggregate sources

| No. | Sources of fine aggregates | Projects in percent (%) |
|---|---|---|
| 1 | Natural Sand only | 88 |
| 2 | Mixed crushed fine aggregate and natural sand | 12 |

The investigation undergoing shows 72 percent of the projects conducted silt and clay content test and organic impurity test conducted on 44percent of the projects. Therefore, strict gradation tests taken in all projects to comply the standards requirements.

The investigation undergoing shows that testes conducted on the projects were unit weight, specific gravity and water absorption percent would be 16%, 24% and 12% of the projects conduct respectively. These tests are having significant impact on the determination of mix-design, water to cement ratio proportioning and also to keep the desired concrete quality.

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




**Legend**

1- Sieve analysis

2- Silt and clay content

3- Organic impurity

4- Unit weight

5- Specific gravity

6- Water absorption

7- Soundness test

8- Chloride test

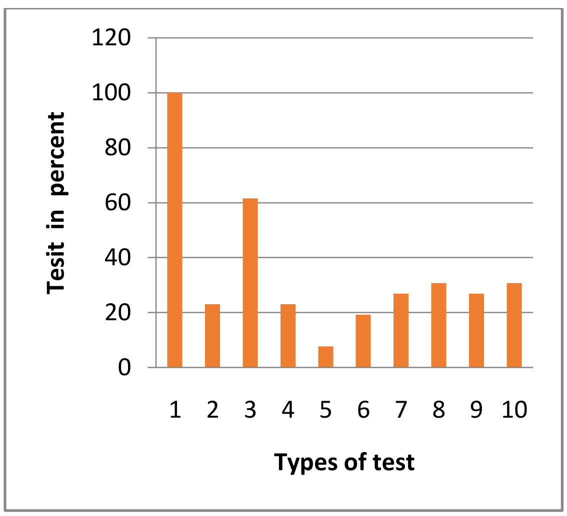
Figure 3 Rate of Projects conducting Different Tests on Fine Aggregates

### 4.1.1.2Quality of Coarse aggregates

Majority of the projects, which is about 88%, conducted sieve analysis, 56% conducts ACV test and only 20% of the projects conduct LA. This shows that unsatisfactory aggregate strength tests were done in the project. And in turn it raises question on the overall quality of concrete.

And those of 36% of the projects conduct flakiness index test. The presence flakiness aggregate paving the way for the formation of void in concretes, which results, for low compressive strength. This shows that most projects were not conduct test as per the standards requirements. And it results for the lower compressive strength of concrete.

Only 12% of the projects conduct clay lump & friable particles and dust content test. Organic impurities may delay setting and hardening of concrete, may reduce strength gain, and in unusual cases may cause deterioration. Organic impurities such as peat, humus, and organic loam may not be as detrimental but should be avoided.




**Legend**

Sieve analysis

ACV

LA

Flakiness index

Clay lump & friable particles

Dust content

Unit weight

Specific gravity

Water absorption

Soundness

Figure 4 Rate of Projects Doing Different Tests on Coarse Aggregates

Other testes collected on the projects were unit weight, specific gravity and water absorption percent would be 16%, 32% and 24% of the projects conduct respectively. These tests are having significant impact on the determination of mix-design, water to cement ratio proportioning and also to keep the desired concrete quality.

The grading for a given maximum-size coarse aggregate can be varied over a moderate range without appreciable effect on cement and water requirement of a mixture if the proportion of fine aggregate to total aggregate produces concrete of good workability. Mixture proportions should be changed to produce workable concrete if wide variations occur in the coarse-aggregate grading. Since variations are difficult to anticipate, it is often more economical to maintain uniformity in manufacturing and handling coarse aggregate than to reduce variations in gradation.

The maximum size of coarse aggregate used in concrete has a bearing on the economy of concrete. Usually more water and cement is required for small-size aggregates than for large sizes, due to an increase in total aggregate surface area.

On envisaged projects various tests undergone for the assessment of the load bearing capacity (strength) and to check weathering resistance.

None of the projects had conducted soundness and chloride test. The presence of these chlorides may affect the concrete by (1) altering the time of set, (2) increasing drying shrinkage, (3) significantly increasing the risk of corrosion of steel reinforcement, and (4) causing efflorescence. Generally, aggregates containing large amounts of chloride should not be used in reinforced concrete.

Materials finer than the 75µ (No. 200) sieve, especially silt and clay, may be present as loose dust and may form a coating on the aggregate particles. Even thin coatings of silt or clay on gravel particles can be harmful because they may weaken the bond between the cement paste and aggregate. If certain types of silt or clay are present in excessive amounts, water requirements may increase significantly (BATCODA, 1991)

#### 4.1.1.3 Source of aggregates

Here the investigated projects take samples of aggregates to be tested once only for sources are 24%.The rest 74% conduct tests once when it comes from the source and when defected quality observed. Tests made in the laboratory or on sites under the supervision of the consultant Engineer.

24 percent of projects responds automatically reject defective aggregates. While 64 percent of the projects taken are habilitation measures by mixing with other aggregates and the rest 12 percent by washing separately the defected aggregate. For the sake of economy aggregates that are out of specification limit used for lower grade concrete (like lean concrete). Generally, to be both economical and keep the quality blending aggregates for mix-design recommended.

**Table 4.2** Projects Conducting Tests on the Aggregate Coming from Source

| Testing frequencies | Projects in percent |
|---|---|
| Only once when it comes from the source | 24 |
| Once when it comes from the source and then depending on the visually observed quality defects | 76 |

Most of the projects prefer natural sand aggregate sourced from Worabe and Gambela. Because of it's a consistently good quality, attain required grading, non-stop potentially supplied and good quality control taken by the supplier at the production sites.

Marine aggregates, aggregates which con not be used for reinforced concrete, can be an appreciable source of chlorides. Selecting the right source of aggregate is the primary duty of resident and consultant Engineer. The frequency tests made on the source improves the quality of concrete greatly.

#### 4.1.1.4 Storage and Handling

As it was observed aggregates dumped from truck out of the project right of area/property. There is not site cleaning and proper handling. As far as, the source test quality is good but the dust coated and organic impurity mixed at job site have a significant impact on the quality of concrete produced.

### 4.1.2 Cements used

As concluded from the observations, tabulated below, majority of the project 72% used OPC, 12 used PPC and the rest 16% used both OPC and PPC for trial mix proportioning. Engineers prefer OPC more than PPC cause of its fast strength attainment. In fact PPC has lower strength development and good for sulphate attack which promotes durability of the concrete.

Generally, the cement types used by the entire project are categorized in to OPC and/or PPC. And sole suppliers of this cement to the projects were Dangote cement; Derba cement and Muger cement factories.

All the projects investigated there is no test conducted to check the quality of cement. But there is not long storage accumulation of cement in average two months of storage time observed. This is taken positively to keep quality of concrete produced with factory property of cement.

Even if all the projects have minimum cement content specified in the contract document, but the contractors used more cement than specified. They do so to compensate poor production process and loss of workmanship. These resulted from poor construction management.

Cement storage had also major problems; cements are simply stored on small stores made of mostly earth (cement screed) floor, CIS wall and roof. Since, cement is sensitive to environmental conditions easily lose its required properties. Generally, poor management of cement resulted for lower concrete quality.

### 4.1.3 Water for concrete mixing

Most of the projects used drinking water for mixing and curing concrete and few projects used groundwater when there is shortage of drinking water. Table below shows 92 percent of the projects use only drinking water for concrete mixing and curing the rest 8 percent used groundwater.

**Table 4.3** Mixing Water Used

| Type of water | Percent of Projects using the specified water type for mixing purposes |
|---|---|
| Drinking water | 92.00 |
| Drinking &well water | 8.00 |

Almost any natural water, that is, drinkable and has no pronounced taste or odor can be used as mixing water for making concrete. However, some waters that are not fit for drinking may be suitable for use in concrete (SHETTY, 2005).

Ground water had a tendency of easily diluted with waters carrying sanitary sewage. Those resulted for the development of organic acids, such as tannic acid, can have a significant effect on strength at higher concentrations and soluble salts which deteriorate concrete. And also ground water could be the source of algae. An alga in water leads to lower strengths either by influencing cement hydration or by causing a large amount of air to be entrained in the concrete. Algae may also be present on aggregates, in which case the bond between the aggregate and cement paste is reduced. A maximum algae content of 1000 ppm is recommended (BATCODA, 1991)

### 4.1.4 Admixtures

Only 16 percent of the project used an accelerating chemical admixture. The rest of the projects don't used admixtures. Accelerating chemical admixture used to accelerate the rate of hydration (setting) and strength development of concrete at an early age. Strictly understanding and implementing the manufacturer guidelines/usage manual of the admixture recommended.

## 4.2 The practice of concrete production process

### 4.2.1Batching of concretes

Among the investigated projects 92 percent used volume batch method and the rest 8 percent used weight batch method. Volume batching is not a good method for proportioning the material because of the difficulty it offers to measure granular material in terms of volume. Volume of moist sand in a loose condition weights less than the same volume of dry compacted sand (Zongjin, 2011).

Observed also any adjustment measures were not taken to compensate bulking. The presence of water in aggregates, if not adjusted, have a significant impact on the properties of fresh concrete and finally resulted for poor quality of concrete/lower compressive strength. Therefore, adjusting excess water required to adjust water to cement (w/c) ratio adjustment in mix design

### 4.2.2 Mixing of concretes

All the investigated projects use on-site stationary mixers and truck mixers. Out of 92 percent of observed projects used on-site stationary mixers the rest 8 percent used truck mixer .On site stationary mixer have the capacity ranging from 200L to 750L Mixer. Truck mixer 3.5 $m^3$ used, special concrete transport trucks (in–transit mixers) are made to transport and mix concrete up to the construction site.

As investigated from the projects to achieve the desired slump they used to add water or reduce water. This is done when the slump harden add water to achieve its flow ability and when it is flows too add aggregates and cement. This totally out the mix design water to cement ratio specified.

First the supervisor/consultant engineer has a responsibility to check the right ingredient proportioned and batching procedure. In general, a great deal of care is taken to develop the proportions of the concrete mixtures to achieve desired performance characteristics such as compressive strength and resistance to damage from freezing and thawing, exposure to sulfates, and corrosion. It is critical to understand that these performance characteristics may become vulnerable with additions of water above the design limitations.

### 4.2.3 Placing, Compaction and curing

Incomplete compaction in the investigated projects resulted for the loss concrete strength. All the projects used immersion vibrators referred to as 'poker' or 'needle' vibrators. 80 percent of the investigated project don't keep it vertical, inclined & drag it in the concrete and remove it by experience when the slump flows around the poker. And 20 percent of the project random insertions, which likely, leave areas of the concrete un-compacted. This practice is the main cause for not adequately expel entrapped air.

As responded from investigated projects there is not separate curing period undertaken for OPC & PPC cement manufactured concrete. 80 percent of the projects cure for 7 days while the rest 20percent cure for 7 to 21 days. 100 percent of the projects used Sprinkling. Using a fine spray or fog of water can be an efficient method of supplying additional moisture for curing and, during hot weather, helps to reduce the temperature of the concrete.

Generally, Water curing is carried out by supplying water to the surface of concrete in a way that ensures that it is kept continuously moist.

The water used for this purpose should not be more than about 5°C cooler than the concrete surface. Spraying warm concrete with cold water may give rise to 'thermal shock' that may cause or contribute to cracking. Alternate wetting and drying of the concrete must also been avoided as this causes volume changes that may also contribute to surface crazing and cracking.

Without an adequate supply of moisture, the cementitious materials in concrete cannot react to form a quality product. Drying may remove the water needed for this chemical reaction called hydration and the concrete will not achieve its potential properties (Jack C McCormac, 2014).

The methods used in placing concrete in its final position have an important effect on its homogeneity, density and behavior in service. The same care which has been used to secure homogeneity in mixing the avoidance of segregation in transporting must be exercised to preserve homogeneity in placing. To secure good concrete it is necessary to make certain preparations before placing. The forms must be examined for correct alignment and adequate rigidity to withstand the weight of concrete, impact loads during construction without undue deformation.

**Figure 5 Uncovered reinforcing bar seen under the beam caused by poor (under vibration) compaction.**

**Figure 6 Segregation under the slab caused by over vibration compaction.**

Finishing is screeding, floating or trowelling the concrete surface to compact and further compact the surface of concrete, as well as giving it the look you want. This step is to take into consideration before curing concrete. Investigated projects had concrete surface finish by floating, trowelling, edging the concrete. Trowelling leaves a dense, hard, smooth and durable surface. The surface should be trowelled twice.

Curing is the maintaining of an adequate moisture content and temperature in concrete at early ages so that it can develop properties the mixture was designed to achieve. Curing begins immediately after placement and finishing so that the concrete may develop the desired strength and durability.

## 4.3 Compliance of concrete quality as per EBCS–2, ACI 318 and BS 5328

Analyses of the compressive strength test results indicated in table 4.9, shows 52 % of the projects contain defective lots as per the Ethiopian building codes and standards. On the other hand, as per the American Standard (ACI 318) 24% and British standard (BS) 40% of the projects contain defective lots respectively.

The magnitude of variations in the strength of concrete test specimens is a direct result of the degree of control exerted over the constituent materials, the concrete production and transportation process, and the sampling, specimen preparation, curing and testing procedures.

Different statistical analysis parameters were used for the analyses of compressive strength data. The standard deviation, coefficient of variance, skew and arithmetic mean or average values were calculated for the purpose of analysis. Strength test results vary.

Variations in measured strength may originate from any of the following sources:

Batch-to-batch variations of the proportions and characteristics of the constituent materials in the concrete, the production, delivery, and handling process, and climatic conditions; and Variations in the sampling, specimen preparation, curing and testing procedures (within-test).

Conclusions regarding the strength of concrete can only be derived from a series of tests. The characteristics of concrete strength can be estimated with reasonable accuracy only when an adequate number of tests are conducted, strictly in accordance with standard practices and test methods (ACI 214, 2002).

## **Table 4.4**Analysis of compressive strength test result

| No. | Name of projects investigated & grade of concrete | Total mean compressive strength | Sample Standard Deviation in M.pa (cubic strength) | Sample Standard Deviation in M.pa (cylindrical strength) | Coefficient of Variation | Ethiopian Standard (EBCS-2,1995) | | | American Standard (ACI 318) | | | British Standard (BS 5328:1990) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Number of defective lots | Number of Non-defective lots | % of defective lots | Number of defective lots | Number of Non-defective lots | % of defective lots | Number of defective lots | Number of non-defective lots | % of defective lots |
| 1 | Abdu Kemal | 30.74 | 2.09 | 1.67 | 6.79 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 2 | Abdulwahid Sharif | 28.60 | 1.08 | 0.86 | 3.77 | 1.00 | 5.00 | 16.67 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 3 | Ahmed A/Biyya | 35.61 | 5.58 | 4.47 | 15.68 | 1.00 | 5.00 | 16.67 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 4 | Ahmedin Danur | 31.38 | 3.56 | 2.85 | 11.33 | 1.00 | 5.00 | 16.67 | 0.00 | 6.00 | 0.00 | 1.00 | 6.00 | 14.29 |
| 5 | Awigcho Birhanu | 33.10 | 5.64 | 4.51 | 17.03 | 1.00 | 5.00 | 16.67 | 1.00 | 6.00 | 14.29 | 1.00 | 6.00 | 14.29 |
| 6 | Biya Abameca | 33.57 | 6.28 | 5.02 | 18.70 | 1.00 | 5.00 | 16.67 | 1.00 | 6.00 | 14.29 | 1.00 | 6.00 | 14.29 |
| 7 | Christian W/berhan | 30.42 | 3.19 | 2.55 | 10.47 | 0.00 | 5.00 | 0.00 | 1.00 | 6.00 | 14.29 | 1.00 | 6.00 | 14.29 |
| 8 | Dejochisayizegu | 35.37 | 5.08 | 4.07 | 14.37 | 1.00 | 5.00 | 16.67 | 1.00 | 6.00 | 14.29 | 1.00 | 6.00 | 14.29 |
| 9 | Dirre Industry | 30.89 | 4.42 | 3.53 | 14.30 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 10 | Gashew Abebe Building | 28.51 | 2.16 | 1.73 | 7.59 | 2.00 | 5.00 | 28.57 | 0.00 | 6.00 | 0.00 | 1.00 | 6.00 | 14.29 |
| 11 | Gizachew Dibaba | 30.02 | 1.44 | 1.15 | 4.78 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 12 | Hermata Minch plc | 30.64 | 3.21 | 2.57 | 10.49 | 0.00 | 5.00 | 0.00 | 1.00 | 6.00 | 14.29 | 1.00 | 6.00 | 14.29 |
| 13 | Jimma Town Health Center | 29.69 | 1.72 | 1.38 | 5.80 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 14 | Jimma University Fuel station | 39.21 | 3.52 | 2.81 | 8.97 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 15 | Jimma University Hotel & tourism | 40.47 | 3.30 | 2.64 | 8.14 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 16 | Meka Abdulkadir | 36.36 | 5.97 | 4.78 | 16.42 | 1.00 | 5.00 | 16.67 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 17 | Mohammed Bikiltu | 36.88 | 6.17 | 4.94 | 16.74 | 1.00 | 5.00 | 16.67 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 18 | Nejat Ibrahim | 29.84 | 2.41 | 1.92 | 8.06 | 1.00 | 5.00 | 16.67 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 19 | Niguisie W/gabriel | 29.27 | 3.10 | 2.48 | 10.59 | 2.00 | 5.00 | 28.57 | 0.00 | 6.00 | 0.00 | 1.00 | 6.00 | 14.29 |
| 20 | Tokuma Mixed Use Building plc | 28.36 | 4.06 | 3.25 | 14.33 | 2.00 | 5.00 | 28.57 | 2.00 | 6.00 | 25.00 | 2.00 | 6.00 | 25.00 |
| 21 | Tsinat Yegebeya Maekel plc | 32.68 | 4.30 | 3.44 | 13.17 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 22 | W/ro kristian W/Birhan | 31.86 | 2.39 | 1.91 | 7.50 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 23 | Walda kanisa | 32.51 | 3.92 | 3.13 | 12.05 | 1.00 | 5.00 | 16.67 | 0.00 | 6.00 | 0.00 | 1.00 | 6.00 | 14.29 |
| 24 | Yerango Yebu | 30.67 | 3.06 | 2.45 | 9.97 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |
| 25 | Yetana Misoso plc | 33.68 | 4.48 | 3.58 | 13.30 | 0.00 | 5.00 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 6.00 | 0.00 |

Concrete gains strength with time after casting. It takes much time for concrete to gain 100% strength and the time for same is still unknown. The rate of gain of concrete compressive strength in higher during the first 28 days of casting and then it slows down.
The table below shows the compressive strength gained by concrete after 1, 3, 7, 14 and 28 days with respect to the grade of concrete we use.

From above table, we see that, concrete gains 16 percent strength in one day, 40 percent in 3 days, 65% in 7 days, 90% in 14 days and 99% strength in 28 days.

Thus, it is clear that concrete gains its strength rapidly in the initial days after casting, i.e. 90% in only 14 days. When, its strength have reached 99% in 28 days, still concrete continues to gain strength after that period, but that rate of gain in compressive strength is very less compared to that in 28 days.

After 14 days of casting concrete, concrete gains only 9% in next 14 days. So, rate of gain of strength decreases. We have no clear idea up to when the concrete gains the strength, 1 year or 2 year, but it is assumed that concrete may gain its final strength after 1 year.

So, since the concrete strength is 99% at 28 days, it's almost close to its final strength, thus the researcher rely upon the results of compressive strength test after 28 days and use this strength as the base for analysis evaluation.

Though there are also some rapid method of testing concrete compressive strength which gives relation between rapid test methods and 28 day strength. This rapid test is done where time is limited for construction and strength of structural member must be known to carry out further construction work (https://www.the constructor.org, 2017).
Therefore, the overall variations have two component variations, the within-test s1, and batch-to-batch s2 variations. The sample variance—the square of the sample standard deviation—is the sum of the sample within-test and sample batch-to-batch variances. The variation used/described here under was the integral of overall variation.
The data should be derived from samples obtained by means of a random sampling plan designed to reduce the possibility that selection will be exercised by the sampler. In random sampling that each possible sample has an equal chance of being selected. To ensure this condition, the selection should be made by some objective mechanism such as a table of random numbers.

A Compressive strength tests result was a reflection of the overall qualities of structural elements of a building. Therefore, tests made for each lot of concrete casted prove the quality of ingredients used, production process, level of quality control and testing methods.

Ethiopian Building codes of Standards, American standard ACI 214 and British Standard were the tools used for the analyses of compressive strength test result of the same age (28 days).

In case of Ethiopian Building codes of Standards equation 2.12 and 2.13 used simultaneously, since sampling used were not large scale.

In case of American standard ACI 214 equation 2.9, 2.10 and 2.11 simultaneously together with ACI 318 criterions. Conversion factor of 0.8 is used to convert cylindrical strength to cubic strength (cylindrical strength = 0.8* cubic strength)

In case of British Standard BS 5328 criterions was applied. Hence, the compliance of sample test results analyzed as per the above three standards requirements.

Defective lots further tasted by non-destructive testing method. Non-destructive testing obtains the information without destroying the integrity of the materials or structures.

Investigated projects commonly used *Mechanical wave techniques (MWT)* and *Rebound hammer test*.

Observed variability of test result, in accordance of ACI 214, measured by statistical control parameters. These are standard deviation and coefficient of variation. Classification of the level of quality control, based on standard deviation and coefficient of variation, shown on table 4.11 respectively. The level quality control of twenty-five projects whose test results are analyzed shown below in pie chart.

**Table 4.5** Assessment of the level of quality control

- a. Classification of the level of quality control based on standard deviation

| No. | Standard deviation | No of projects & grade of concrete | Percentage of projects | Control standards |
|---|---|---|---|---|
| 1 | Below 2.8 | 7.00 | 28.00 | Excellent |
| 2 | 2.8 - 3.4 | 5.00 | 20.00 | Very good |
| 3 | 3.4 - 4.1 | 4.00 | 16.00 | Good |
| 4 | 4.1 - 4.8 | 3.00 | 12.00 | Fair |
| 5 | Above 4.8 | 6.00 | 24.00 | Poor |
| | Total | 25.00 | 100.00 | |

b. Classification of the level of quality control based on Coefficient of variations

| No. | Coefficient of variation | No of projects & grade of concrete | Percentage of projects | Control standards |
|---|---|---|---|---|
| 1 | Below 10 | 10.00 | 40.00 | Excellent |
| 2 | 10 to 15 | 10.00 | 40.00 | Good |
| 3 | 15 to 20 | 5.00 | 20.00 | Fair |
| 4 | Above 20 | 0.00 | 0.00 | Poor |
| | **Total** | **25** | **100.00** | |

In the instigated projects where there are defective lots, mostly rechecking test is found to satisfy the compliance criteria. And rarely non-destructive test, Schmidt hammer test, ordered for compliance check.

Since, defective concrete have a significant impact on structure of the building design strength have a safety factor to overcome this drawback. But concrete structures are designed with higher safety factors. For a C-25 concrete is assumed to have design strength of 11.33MPa. That is, Fcd = 0.85*(Fck/1.5). For a C-30 concrete is assumed to have design strength of 13.6MPa (EBCS-2, 1995).

Where:

Fck is the cylindrical characteristic compressive strength and

Fcd is the design strength

Durability is directly related to strength of concrete. Durability is most likely to relate to long-term serviceability of concrete and concrete structures. Serviceability refers to the capability of the structure to perform the functions for which it has been designed and constructed after exposure to a specific environment. Hence, slight deviations from the compliance requirement don’t have much impact.

In the investigated projects, which have higher variability, have higher standard deviation and coefficient of variation. These indicate that the unsatisfactory quality control.

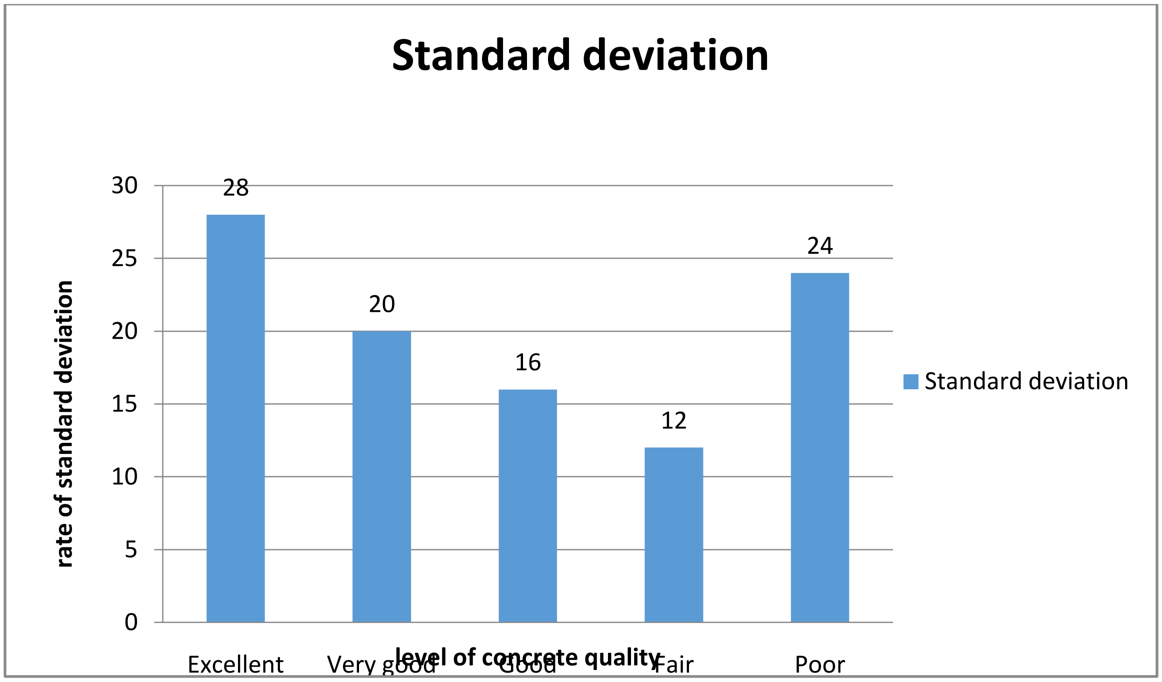



**Figure 7** Level of quality control of projects based on standard deviation

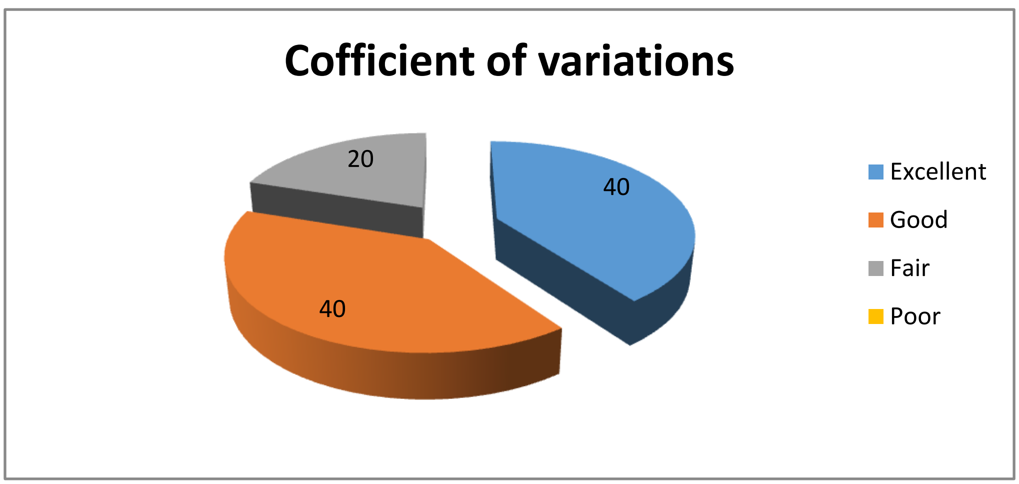



**Figure 8** Level of quality control of projects based on coefficient of variations

In the investigated project cubic mean compressive strength test result of C-25 structural concrete found was 35.61MPa with a standard deviation of 5.58Mpa indicates that there is poor quality control practice.

However, on the project of Jimma University Hotel & tourism, with the same concrete grade, cubic mean compressive strength test result was 40.47MPa with a standard deviation of 3.30Mpawhich displays excellent concrete quality control practice.

Concrete with higher variability is designed to attain higher required mean strength than a concrete with lower variability for the same concrete grade. In turn, it results for the consumption of more cement; it's to be uneconomical concrete production practice.

Certain investigated projects used mix with a very high compressive strength to counterbalance of defects related to concrete quality. Not only higher compressive strength concrete said to be quality concrete but also durability is also vital to determine quality. Higher compressive strength consumes much cement, which is, uneconomical.

Since, the higher cement content of concrete may show higher compressive strength due to the lower w/c ratio at the early age of the structure. Therefore, strict follow up of concrete production process assure the quality of concrete produced.

Concrete sample testing time of instigated project shows that 32% of the projects were not tested on time. Table below shows projects having lots test of above $28^{th}$ day.

**Table 4.6** Projects having lots tested above $28^{th}$ day

| No. | Name of projects investigated projects | Number of lots tested | Number of lots tested on 28 days | 28 - 40 days | Above 40 days | % of lots tested above 28 days | Maximum observed testing time in days |
|---|---|---|---|---|---|---|---|
| 1 | Abdulwahid Sharif | 30.00 | 10.00 | 10.00 | 10.00 | 66.67 | 45.00 |
| 2 | Christian W/berhan | 36.00 | 9.00 | 12.00 | 15.00 | 75.00 | 45.00 |
| 3 | Dirre Industry | 18.00 | 9.00 | 5.00 | 4.00 | 50.00 | 45.00 |
| 4 | Gizachew Dibaba | 24.00 | 6.00 | 10.00 | 8.00 | 75.00 | 45.00 |
| 5 | Hermata Minch plc | 22.00 | 7.00 | 10.00 | 5.00 | 68.18 | 45.00 |
| 6 | Tokuma Mixed Use Building Plc | 30.00 | 10.00 | 10.00 | 10.00 | 66.67 | 45.00 |
| 7 | Tsinat Yegebeya Maekel plc | 28.00 | 7.00 | 8.00 | 13.00 | 75.00 | 45.00 |
| 8 | Yerango Yebu | 20.00 | 10.00 | 5.00 | 5.00 | 50.00 | 45.00 |

On some projects that are listed on table 4.12, Samples which are intended to be tested on $28^{th}$ day were sometimes observed to stay up to forty five days.

Since, the concrete strength is 99% at 28 days; it's almost close to its final strength. Thus, I rely upon the results of compressive strength test after 28 days and use this strength as the base for the analysis evaluation. If it doesn't satisfy specified requirements, the in-situ strength is rechecked with non-destructive tests. Finally, decision given on defected lots whether take rehabilitation measures or demolish all.

If demolishing would be the final decision, it might have a possibility of damaging the erected superstructure over it.

If defects parts are not resolved on time and construction work continues as it is, brought damage to the overall structures. It leads to not only higher maintenance cost (cost overrun) but also delayed (unscheduled) project. To overcome this problem early, $7^{th}$ and $14^{th}$, day test forecast late $28^{th}$ day strength which helps to attain specified quality, accomplish on schedule and avoid cost overrun.

In general, quality of concrete assessed quantitatively by analyzing test result of sample concrete, onsite inspection of the project and by analyzing properly answered questionnaire

# CHAPTER FIVE

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

### 5.1.1 Find out on the quality of concrete ingredients

It's concluded that adequate tests specified on the contract documents and Ethiopian building codes standard were not carried out in most of the investigated projects. Because tests carried out for coarse aggregate; mostly aggregate crushing value (ACV), Losangeles Abrasion test (LAV) tests which is not enough to check the strength of aggregate; and for fine aggregate only sieve analysis and silt & clay content tests are conducted in a vast number of the projects (on 80.00%).There is no project that conducts test for presence of chloride and Soundness test on both of the fine and coarse aggregate.

In all of the investigated projects there is not any adjustment measure taken to compensate bulking of sand. Bulking of sand have a great influence on the concrete mix design. Water to cement ration adjustment considered if the amount of bulk known in sand. And also attentions were not given for the moisture contents of aggregates.

Its good observations which satisfy the requirement of cement handling. Most of the investigated projects used cements immediately up to a month and a maximum of three month storage time recorded.

### 5.1.2 Investigated practice of concrete production process

Over vibration and under vibration is the major problem observed on the investigated projects. Clearly visible segregation caused by over vibration seen on most of the projects. And also due to an adequate vibration even parts of bare reinforced bar seen on the slab.

On the investigated projects contractors blame the client for late delivery of materials. Because in most projects the contract agreement made between a clients and contractors were a labor contract and supply of material could be the responsibility of a client.

In most of the private project par timer site engineer hired as a super visor and some project contractors carry out dual responsibility, which is not ethical. Almost all (92%) of the investigated project don't have a separate contract agreement with consulting engineer.

### 5.1.3 Verified rate of concrete quality (compliance of compressive strengths)

Here is the rate of concrete compliance as per the building standard codes of Ethiopia, America and British elaborated.

The statistical analyses carried on the rate of concrete quality as per the Ethiopian building codes Standard (EBCS-2, 1995) proved 52% of the projects have defective lots.

The statistical analyses carried on the rate of concrete quality as per the British Standard (BS 5328:1990) proved 40% of the projects have defective lots.

As shown in the statistical analyses the rate of concrete quality as per the American Standard (ACI 318) proved 24% of the projects have defective lots. And also by the classification of ACI 214, the standard deviation of 36 % of the projects compressive strength has shown that the quality control is not good from which 12% fall in the “fair” classification range and 24% in the “poor” range; and the coefficient of variation of 20% of the projects compressive strength has shown that the quality control is not good.

And also thirty two percent (32%) of the investigated projects don’t conducted strength test on time (on 28th day).

## 5.2 Recommendations

### 5.2.1 How to improve the quality of concrete ingredients

All the tests specified in the contract documents and Ethiopian standard conducted to identify the quality and properties of concrete ingredients.

Responsible government bodies have the responsibility to identify the potential sources, test/study the mineral contents, grading the source and certify sole supplier.

Coordinated efforts of a client, contractor, consultant, concerned government officials and material supplier required to achieve the desired quality level.

### 5.2.2 Upgrade the practice of concrete production processes

Since, slump test is the preliminary indication concrete quality rigorously taking sample and test for every lot mix taken as a mandatory. And when the slump test fails instead of simply adjusting (adding or reducing) water content; point out why it failed and took adequate remedial measure.

Start vibration when the vibrator rod is submerged into the new concrete vertically and quickly (i.e., about 1-foot per second), then withdraw slowly (i.e., about 3sec per foot); and (Afework Achalu, 2017),

Put the stinger into each portion of new concrete. When fresh concrete poured in layers, place the stinger about 6 inches in the previous layer, then stop vibration when the surface becomes shiny, and there are no more breaking air bubbles (Afework Achalu, 2017).

### 5.2.3 Optimize the rate of concrete quality

Before giving a construction permit Jimma Town construction office have to check and confirm the contract agreement signed between a client and contractor and also between a client and a consultant.

Instead of only labor contract agreement, the causes for late delivery of materials which hinders the critical activities of concrete production, full (supply & built) contract agreement recommend avoiding problems arising on this aspect.

The critical activities concrete production processes have to be identified and its quality implementation plan settled.

This research also opens for the next extension researcher on the area of; the contract management, impacts of formwork on the quality of concrete, and quality & mineralogy content of aggregate source used in the building construction and its influence on quality of concrete.

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## Appendix A Questionnaire Distributed for Data Gathering

Please put an `X` mark at your choice on the rectangles shown for questions having your choices and or writing on the space provided.

1. Your project has the structural grade of concrete C-25 and/or C-30?

- ☐ **Yes**
- ☐ **No**

If it have C-25 structural grade of concrete please cooperate me to fill below listed questions.

## Aggregate

2. Where is the source(s) of your coarse and fine aggregate?

Coarse aggregate:

- ☐ Crushed
- ☐ River sand

Fine aggregate:

- ☐ Gambela
- ☐ Worabe
- ☐ Chewaqa
- ☐ blend of the two or three above aggregates
- ☐ Nada/local which is more silt

3. What kind of fine aggregate do you use for concrete production?

- ☐ Natural sand
- ☐ Crushed aggregate

4. Which testsare conducted for coarse aggregates?

Physical tests:

- ☐ Specific gravity
- ☐ Natural moisture content of aggregate
- ☐ Water absorption
- ☐ Gradation used to measure FM
- ☐ Aggregate crushing value ACV
- ☐ Flakiness index
- ☐ Clay lump and friable particles

- ☐ Dust content
- ☐ Unit weight

Chemical tests:

- ☐ Soundness

5. Which tests are conducted **for fine aggregates**?

Physical tests:

- ☐ Bulk of sand
- ☐ Silt and clay content
- ☐ Organic impurity
- ☐ Specific gravity
- ☐ Natural moisture content of aggregate
- ☐ Water absorption
- ☐ Chloride test
- ☐ Unit weight
- ☐ Gradation used to measure FM

Chemical tests:

- ☐ Soundness

6. How frequent do you take samples when testing aggregates?

- ☐ Only once for one source
- ☐ For every fleet of a dump truck came from the source
- ☐ When the aggregate seems defective test ordered

7. Are you satisfied with the quality of aggregate?

- ☐ Yes
- ☐ No

What would you do if test result fails?

- ☐ Mix aggregates
- ☐ Wash aggregates

8. What would you do with the aggregates if it doesn’t satisfy the requirement on the specification?

- ☐ Order to wash to remove a higher content of silt
- ☐ Mix with the aggregates which satisfy the test result

☐ Not used for C-25 concrete but it used for lower grade concrete

☐ Reject it at all

## Cement

9. What type of cement do you use for the concrete production?

☐ OPC

☐ PPC

☐ If any other, please specify ___________________________

10. Where is the source of cement used in concrete production?

☐ Dangote Cement

☐ Derba cement

☐ Muger cement

☐ Capital cement

☐ Mesebo Cement

☐ National cement

☐ Habesha cement

11. What is the minimum cement content specified in the specification of the contract document of this specific contract?

☐ From concrete mix ration: ______

☐ ______ $kg/m^3$ of concrete

12. Is there any test made for the cement that you are using? If any, please specify.

☐ Color test

☐ Presence of lumps

☐ Adulteration test

☐ Temperature test

☐ Float tests

☐ Strength test

☐ Setting test

☐ Date of packing

☐ Fines of cement

- ☐ Consistency of cement
- ☐ None of them

13. On average how long it last the cement until casting date? Starting from date of packaging/production date and including transportation and storage time

- ☐ Less than a month
- ☐ One month
- ☐ Two month
- ☐ Three month
- ☐ Above three month

## Water

14. What quality of water do you use for concrete mixing?

- ☐ Drinking water
- ☐ If non-drinking water;
- ☐ From river
- ☐ Ground water from drilled well

15. Is there any test that was made for the water? If any, please specify

- ☐ Salt content test
- ☐ Test for the presence of algae
- ☐ PH of water

## Admixture

16. Do you use admixture in concrete production?

- ☐ Yes
- ☐ No

If it is yes, please specify the type and dosage the admixture.

- ☐ Accelerator admixtures
- ☐ Retarder admixtures
- ☐ Water-reducing admixtures
- ☐ Air-entraining admixtures
- ☐ Super plasticizing admixtures

## Workmanship

## Mixing

17. What kind of concrete mixing procedures do you follow?

- ☐ Designed mixes
- ☐ Prescribed mixes
- ☐ Standard (or nominal) mixes

18. In case when you aren't able to get the type of cement specified on the specification of the contract document, for instance if OPC is specified and PPCis the only cement available on the market, what adjustments do you make?

- ☐ Mix cements
- ☐ Increase the cement content
- ☐ Waiting for the market to have the required cement
- ☐ Ignore the market and continue with any cement I found
- ☐ If any other specify here, ________________________________________

19. Which batching techniques do you use?

- ☐ By weight
- ☐ By volume

20. What are the adjustments that you make to ingredients when using;

a) Weight batching:

- ☐ Water to cement ratio adjustment
- ☐ Gradation adjustment of aggregates

b) Volume batching:

- ☐ Water to cement ratio adjustment
- ☐ Gradation adjustment of aggregates

21. How do you mix your concrete?

- ☐ Manually
- ☐ Using mixing plant
- ☐ Both of them (both manually and using mixing plant)

22. If you are using mixing plant, what type of mixing plant do you use?

- ☐ On site mixing
- ☐ Ready mix; mixing out of the construction site and transported to the site bytrucks.

23. What is the capacity of your mixing plant?

☐ _______ m3/liter

24. For how long do you mix the ingredients of one batch?

☐ _______min

25. If the concrete is mixed out of the site, how long is taken for the concrete tobe placed on the forms? (The time between the start of mixing and placing)

☐ _______min

26. What is the corrective measure that you take in case when slump collapsed/failed due to high water to cement ratio?

☐ Adjust w/c ratio

☐ Use admixture

☐ Retest of slump

Shear of slump (incomplete slump):

27. What is the corrective measure that you take in case when slump sheared due to incomplete slump?

☐ Adjust w/c ratio and mix again

☐ Use admixture

☐ Retest of slump

## Placing

28. How you control segregation caused by poor placing of concrete?

☐ Insert pump discharge hoses in to the forms

☐ Minimize free fall from conveyor/cart/other poring equipment

☐ If you have other method please specify here, __________________________

## Compaction

29. How do you compact concrete?

☐ Using hand compaction (Roding)

☐ Using mechanical vibration

☐ If any other, please specify _____________________

30. When you are using internal Vibrator (spude or poker)

a) How long time (in second) keep in specific station

☐ 5 to 15 seconds

☐ Above 15 seconds

☐ Varying depending on the vibrator capacity

b) In case of compacting thicker concrete sections,
What is the maximum compaction depth that you use? _______ mm

31. What would you do to prevent formation of cold joint, honey comb and sand streaks?

- ☐ Vibrate adequately
- ☐ Above 15 seconds

## Curing

32. After casting your concrete, for how long do you cure?

- ☐ 3 days
- ☐ 7 days
- ☐ Extend up to 21 days

33. What methods do you use to cure your concrete?

a) To prevent moisture loss

- ☐ Curing compounds
- ☐ Plastic sheeting
- ☐ Leaving formwork in place

b) To supply supplemental moisture

- ☐ Water ponding
- ☐ Water sprinkling
- ☐ Wet burlap, Geotextile and coated paper

34. What precautionary methods used in fresh or immature concrete to prevent injurious degradation due to adverse weather conditions such as wind, precipitation and extreme temperatures? Especially for drying condition

- ☐ Restore surface humidity by using fog spray
- ☐ Using evaporation retarder films
- ☐ Wind breaker

35. Please fill the table below compressive strength test results of your project

| Assigned personnel | Concrete Grade | Lot number | Age of test | | | | |
|---|---|---|---|---|---|---|---|
| | | | 3(three) days | 7 ( seven) days | 14 (fourteen) days | 21 (twenty one) days | 28 (twenty eight) days |
| 1. Civil Engineer (M.Sc)<br>o Experienced<br>o Non-experienced<br>2. Civil Engineer (B.sc)<br>o Experienced<br>o Non-experienced<br>3. Advance diploma C. Eng.<br>o Experienced<br>o Non-experienced | **C-25** | 1 | | | | | |
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| | **C-30** | 1 | | | | | |
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| | **If you have a test above 28th day, please specify here under. _________days, _______days, _______days __________days** | | | | | | |

Project name: ______________________________________________________

Are you a contractor or consultant?

☐ Consultant or supervisor

☐ Contractor or sub-contractor

# Appendix B Compressive strength test results analyses

28th day concrete compressive strength test results and there analyses based on EBCS-2; 1995, American ACI 318 and British Standard BS 5328:1990

| No. | Project number and concrete grade | Compressive strength in Mpa | Mean compressive strength | mean of minimum strength of several lots | mean strength of each lot | standard deviation | coefficient of variation | Compliance of compressive strength to the various standards | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Ethiopian standard | American standard | British standard |
| 1 | Abdu Kemal | 28.50 | 30.74 | 30.67 | 28.33 | 2.09 | 6.79 | Complied | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 28.50 | | | | | | | Complied | Complied |
| | | 33.00 | | | 32.83 | | | Complied | Complied | Complied |
| | | 33.50 | | | | | | | Complied | Complied |
| | | 32.00 | | | | | | | Complied | Complied |
| | | 27.50 | | | 28.13 | | | Complied | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 28.90 | | | | | | | Complied | Complied |
| | | 34.00 | | | 32.50 | | | Complied | Complied | Complied |
| | | 32.00 | | | | | | | Complied | Complied |
| | | 31.50 | | | | | | | Complied | Complied |
| | | 30.00 | | | 30.50 | | | Complied | Complied | Complied |
| | | 30.50 | | | | | | | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
| | | 33.00 | | | 32.17 | | | Complied | Complied | Complied |
| | | 32.00 | | | | | | | Complied | Complied |
| | | 31.50 | | | | | | | Complied | Complied |
| 2 | Abdulwahid Sharif | 26.50 | 28.60 | 28.68 | 27.33 | 1.08 | 3.77 | Failed | Complied | Complied |
| | | 27.50 | | | | | | | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 28.00 | | | 28.30 | | | Complied | Complied | Complied |
| | | 28.50 | | | | | | | Complied | Complied |
| | | 28.40 | | | | | | | Complied | Complied |

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| | | 28.60 | | | 28.40 | | | Complied | Complied | Complied |
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| | | 28.20 | | | | | | | Complied | Complied |
| | | 30.00 | | | 30.50 | | | Complied | Complied | Complied |
| | | 30.50 | | | | | | | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
| | | 28.00 | | | 28.83 | | | Complied | Complied | Complied |
| | | 29.00 | | | | | | | Complied | Complied |
| | | 29.50 | | | | | | | Complied | Complied |
| | | 28.20 | | | 28.23 | | | Complied | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 28.50 | | | | | | | Complied | Complied |
| 3 | Ahmed A/Biyya | 32.00 | 35.61 | 35.83 | 29.53 | 5.58 | 15.68 | Complied | Complied | Complied |
| | | 25.60 | | | | | | | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
| | | 33.50 | | | 31.17 | | | Complied | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 27.00 | | | | | | | Complied | Complied |
| | | 32.00 | | | 32.30 | | | Complied | Complied | Complied |
| | | 32.50 | | | | | | | Complied | Complied |
| | | 32.40 | | | | | | | Complied | Complied |
| | | 44.00 | | | 42.00 | | | Complied | Complied | Complied |
| | | 42.00 | | | | | | | Complied | Complied |
| | | 40.00 | | | | | | | Complied | Complied |
| | | 38.00 | | | 36.33 | | | Complied | Complied | Complied |
| | | 36.00 | | | | | | | Complied | Complied |
| | | 35.00 | | | | | | | Complied | Complied |
| | | 44.00 | | | 42.33 | | | Complied | Complied | Complied |
| | | 42.00 | | | | | | | Complied | Complied |
| | | 41.00 | | | | | | | Complied | Complied |

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| 4 | Ahmedin Danur | 27.00 | 31.38 | 31.03 | 26.50 | 3.56 | 11.33 | Failed | Complied | Failed |
| | | 26.50 | | | | | | | Complied | Failed |
| | | 26.00 | | | | | | | Complied | Failed |
| | | 33.60 | | | 33.27 | | | Complied | Complied | Complied |
| | | 33.20 | | | | | | | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 30.50 | | | 30.50 | | | Complied | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
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| | | 28.00 | | | | | | | Complied | Complied |
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| | | 38.00 | | | 36.00 | | | Complied | Complied | Complied |
| | | 36.00 | | | | | | | Complied | Complied |
| | | 34.00 | | | | | | | Complied | Complied |
| | | 34.00 | | | 34.00 | | | Complied | Complied | Complied |
| | | 34.50 | | | | | | | Complied | Complied |
| | | 33.50 | | | | | | | Complied | Complied |
| 5 | Awigcho Birhanu | 30.00 | 33.10 | 33.08 | 30.50 | 5.64 | 17.03 | Complied | Complied | Complied |
| | | 30.50 | | | | | | | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
| | | 21.00 | | | 28.33 | | | Complied | Failed | Failed |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 34.00 | | | | | | | Complied | Complied |
| | | 26.00 | | | 27.10 | | | Failed | Complied | Complied |
| | | 26.80 | | | | | | | Complied | Complied |
| | | 28.50 | | | | | | | Complied | Complied |
| | | 34.00 | | | 34.50 | | | Complied | Complied | Complied |
| | | 34.50 | | | | | | | Complied | Complied |
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| | | 40.00 | | | 41.17 | | | Complied | Complied | Complied |
| | | 41.50 | | | | | | | Complied | Complied |
| | | 42.00 | | | | | | | Complied | Complied |
| | | 38.00 | | | 37.00 | | | Complied | Complied | Complied |
| | | 37.00 | | | | | | | Complied | Complied |
| | | 36.00 | | | | | | | Complied | Complied |
| 6 | Biya Abameca | 26.00 | 33.57 | 34.15 | 27.40 | 6.28 | 18.70 | Failed | Complied | Complied |
| | | 28.20 | | | | | | | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 33.00 | | | 33.10 | | | Complied | Complied | Complied |
| | | 33.10 | | | | | | | Complied | Complied |
| | | 33.20 | | | | | | | Complied | Complied |
| | | 30.80 | | | 30.43 | | | Complied | Complied | Complied |
| | | 30.50 | | | | | | | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 39.00 | | | 38.47 | | | Complied | Complied | Complied |
| | | 38.00 | | | | | | | Complied | Complied |
| | | 38.40 | | | | | | | Complied | Complied |
| | | 21.00 | | | 28.67 | | | Complied | Failed | Failed |
| | | 32.00 | | | | | | | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 44.00 | | | 43.33 | | | Complied | Complied | Complied |
| | | 42.00 | | | | | | | Complied | Complied |
| | | 44.00 | | | | | | | Complied | Complied |
| 7 | Christian W/berhan | 30.15 | 30.42 | 29.53 | 28.35 | 3.19 | 10.47 | Complied | Complied | Complied |
| | | 27.50 | | | | | | | Complied | Complied |
| | | 27.40 | | | | | | | Complied | Complied |
| | | 33.60 | | | 33.27 | | | Complied | Complied | Complied |
| | | 33.20 | | | | | | | Complied | Complied |
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| | | 21.00 | | | 28.20 | | | Complied | Failed | Failed |
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| | | 34.00 | | | 33.53 | | | Complied | Complied | Complied |
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| | | 33.60 | | | | | | | Complied | Complied |
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| | | 30.20 | | | | | | | Complied | Complied |
| | | 30.80 | | | | | | | Complied | Complied |
| 8 | Dejochis Ayizegu | 42.00 | 35.37 | 34.30 | 41.20 | 5.08 | 14.37 | Complied | Complied | Complied |
| | | 41.60 | | | | | | | Complied | Complied |
| | | 40.00 | | | | | | | Complied | Complied |
| | | 39.00 | | | 38.53 | | | Complied | Complied | Complied |
| | | 38.60 | | | | | | | Complied | Complied |
| | | 38.00 | | | | | | | Complied | Complied |
| | | 36.00 | | | 35.73 | | | Complied | Complied | Complied |
| | | 36.20 | | | | | | | Complied | Complied |
| | | 35.00 | | | | | | | Complied | Complied |
| | | 34.00 | | | 34.27 | | | Complied | Complied | Complied |
| | | 34.20 | | | | | | | Complied | Complied |
| | | 34.60 | | | | | | | Complied | Complied |
| | | 34.00 | | | 27.00 | | | Failed | Complied | Complied |
| | | 26.00 | | | | | | | Complied | Complied |
| | | 21.00 | | | | | | | Failed | Failed |
| | | 36.00 | | | 35.47 | | | Complied | Complied | Complied |
| | | 36.40 | | | | | | | Complied | Complied |
| | | 34.00 | | | | | | | Complied | Complied |

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| 9 | Dirre Industry | 26.60 | 30.89 | 30.70 | 28.03 | 4.42 | 14.30 | Complied | Complied | Complied |
| | | 29.30 | | | | | | | Complied | Complied |
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| | | 40.40 | | | | | | | Complied | Complied |
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| 10 | Gashew Abebe Building | 28.00 | 28.51 | 28.77 | 27.63 | 2.16 | 7.59 | Failed | Complied | Complied |
| | | 28.50 | | | | | | | Complied | Complied |
| | | 26.40 | | | | | | | Complied | Complied |
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| | | 28.00 | | | | | | | Complied | Complied |
| | | 27.50 | | | 29.23 | | | Complied | Complied | Complied |
| | | 30.20 | | | | | | | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 21.80 | | | 25.77 | | | Failed | Complied | Failed |
| | | 27.50 | | | | | | | Complied | Failed |
| | | 28.00 | | | | | | | Complied | Failed |

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| | | 30.00 | | | 31.00 | | | Complied | Complied | Complied |
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| | | 29.00 | | | 29.20 | | | Complied | Complied | Complied |
| | | 29.40 | | | | | | | Complied | Complied |
| | | 29.20 | | | | | | | Complied | Complied |
| 11 | Gizachew Dibaba | 28.00 | 30.02 | 30.23 | 28.17 | 1.44 | 4.78 | Complied | Complied | Complied |
| | | 28.40 | | | | | | | Complied | Complied |
| | | 28.10 | | | | | | | Complied | Complied |
| | | 29.00 | | | 29.13 | | | Complied | Complied | Complied |
| | | 29.40 | | | | | | | Complied | Complied |
| | | 29.00 | | | | | | | Complied | Complied |
| | | 31.00 | | | 30.43 | | | Complied | Complied | Complied |
| | | 30.10 | | | | | | | Complied | Complied |
| | | 30.20 | | | | | | | Complied | Complied |
| | | 33.00 | | | 32.00 | | | Complied | Complied | Complied |
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| | | 31.00 | | | | | | | Complied | Complied |
| | | 28.50 | | | 29.20 | | | Complied | Complied | Complied |
| | | 29.10 | | | | | | | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 31.20 | | | 31.20 | | | Complied | Complied | Complied |
| | | 31.40 | | | | | | | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
| 12 | Hermata Minch plc | 27.40 | 30.64 | 29.25 | 28.10 | 3.21 | 10.49 | Complied | Complied | Complied |
| | | 27.50 | | | | | | | Complied | Complied |
| | | 29.40 | | | | | | | Complied | Complied |
| | | 33.00 | | | 32.73 | | | Complied | Complied | Complied |
| | | 32.80 | | | | | | | Complied | Complied |
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| | | 21.00 | | | 28.67 | | | Complied | Failed | Failed |
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| | | 29.00 | | | 29.37 | | | Complied | Complied | Complied |
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| | | 29.80 | | | | | | | Complied | Complied |
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| | | 31.50 | | | | | | | Complied | Complied |
| | | 32.00 | | | | | | | Complied | Complied |
| | | 34.00 | | | 33.83 | | | Complied | Complied | Complied |
| | | 34.50 | | | | | | | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| 13 | Jimma Town Health Center | 28.40 | 29.69 | 29.88 | 28.20 | 1.72 | 5.80 | Complied | Complied | Complied |
| | | 28.20 | | | | | | | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 30.00 | | | 30.00 | | | Complied | Complied | Complied |
| | | 30.20 | | | | | | | Complied | Complied |
| | | 29.80 | | | | | | | Complied | Complied |
| | | 30.00 | | | 31.00 | | | Complied | Complied | Complied |
| | | 31.20 | | | | | | | Complied | Complied |
| | | 31.80 | | | | | | | Complied | Complied |
| | | 29.00 | | | 28.17 | | | Complied | Complied | Complied |
| | | 28.30 | | | | | | | Complied | Complied |
| | | 27.20 | | | | | | | Complied | Complied |
| | | 32.00 | | | 32.20 | | | Complied | Complied | Complied |
| | | 32.20 | | | | | | | Complied | Complied |
| | | 32.40 | | | | | | | Complied | Complied |
| | | 26.80 | | | 28.60 | | | Complied | Complied | Complied |
| | | 29.00 | | | | | | | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |

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| 14 | Jimma University Fuel station | 42.00 | 39.21 | 39.17 | 41.87 | 3.52 | 8.97 | Complied | Complied | Complied |
| | | 41.60 | | | | | | | Complied | Complied |
| | | 42.00 | | | | | | | Complied | Complied |
| | | 44.00 | | | 44.20 | | | Complied | Complied | Complied |
| | | 44.20 | | | | | | | Complied | Complied |
| | | 44.40 | | | | | | | Complied | Complied |
| | | 40.00 | | | 40.23 | | | Complied | Complied | Complied |
| | | 40.30 | | | | | | | Complied | Complied |
| | | 40.40 | | | | | | | Complied | Complied |
| | | 39.00 | | | 38.70 | | | Complied | Complied | Complied |
| | | 38.60 | | | | | | | Complied | Complied |
| | | 38.50 | | | | | | | Complied | Complied |
| | | 36.20 | | | 36.33 | | | Complied | Complied | Complied |
| | | 35.80 | | | | | | | Complied | Complied |
| | | 37.00 | | | | | | | Complied | Complied |
| | | 34.00 | | | 33.93 | | | Complied | Complied | Complied |
| | | 34.60 | | | | | | | Complied | Complied |
| | | 33.20 | | | | | | | Complied | Complied |
| 15 | Jimma University Hotel & tourism | 42.10 | 40.47 | 40.52 | 41.80 | 3.30 | 8.14 | Complied | Complied | Complied |
| | | 42.30 | | | | | | | Complied | Complied |
| | | 41.00 | | | | | | | Complied | Complied |
| | | 42.00 | | | 43.10 | | | Complied | Complied | Complied |
| | | 43.20 | | | | | | | Complied | Complied |
| | | 44.10 | | | | | | | Complied | Complied |
| | | 39.00 | | | 38.63 | | | Complied | Complied | Complied |
| | | 38.50 | | | | | | | Complied | Complied |
| | | 38.40 | | | | | | | Complied | Complied |
| | | 43.10 | | | 43.53 | | | Complied | Complied | Complied |
| | | 43.80 | | | | | | | Complied | Complied |
| | | 43.70 | | | | | | | Complied | Complied |

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| | | 36.50 | | | 34.50 | | | Complied | Complied | Complied |
| | | 34.00 | | | | | | | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 40.30 | | | 41.23 | | | Complied | Complied | Complied |
| | | 41.40 | | | | | | | Complied | Complied |
| | | 42.00 | | | | | | | Complied | Complied |
| 16 | Meka Abdulkadir | 27.40 | 36.36 | 35.60 | 27.73 | 5.97 | 16.42 | Failed | Complied | Complied |
| | | 27.60 | | | | | | | Complied | Complied |
| | | 28.20 | | | | | | | Complied | Complied |
| | | 33.90 | | | 33.70 | | | Complied | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 34.20 | | | | | | | Complied | Complied |
| | | 32.20 | | | 31.93 | | | Complied | Complied | Complied |
| | | 32.00 | | | | | | | Complied | Complied |
| | | 31.60 | | | | | | | Complied | Complied |
| | | 44.30 | | | 44.30 | | | Complied | Complied | Complied |
| | | 43.90 | | | | | | | Complied | Complied |
| | | 44.70 | | | | | | | Complied | Complied |
| | | 40.50 | | | 39.07 | | | Complied | Complied | Complied |
| | | 40.60 | | | | | | | Complied | Complied |
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| | | 41.20 | | | | | | | Complied | Complied |
| | | 41.00 | | | | | | | Complied | Complied |
| 17 | Mohammed Bikiltu | 27.50 | 36.88 | 35.80 | 27.90 | 6.17 | 16.74 | Failed | Complied | Complied |
| | | 27.80 | | | | | | | Complied | Complied |
| | | 28.40 | | | | | | | Complied | Complied |
| | | 33.80 | | | 33.70 | | | Complied | Complied | Complied |
| | | 33.10 | | | | | | | Complied | Complied |
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|---|---|---|---|---|---|---|---|---|---|---|
| | | 31.00 | | | 32.89 | | | Complied | Complied | Complied |
| | | 34.12 | | | | | | | Complied | Complied |
| | | 33.56 | | | | | | | Complied | Complied |
| | | 44.30 | | | 44.30 | | | Complied | Complied | Complied |
| | | 43.90 | | | | | | | Complied | Complied |
| | | 44.70 | | | | | | | Complied | Complied |
| | | 40.50 | | | 39.07 | | | Complied | Complied | Complied |
| | | 40.60 | | | | | | | Complied | Complied |
| | | 36.10 | | | | | | | Complied | Complied |
| | | 44.00 | | | 43.40 | | | Complied | Complied | Complied |
| | | 43.00 | | | | | | | Complied | Complied |
| | | 43.20 | | | | | | | Complied | Complied |
| 18 | Nejat Ibrahim | 26.15 | 29.84 | 29.77 | 27.05 | 2.41 | 8.06 | Failed | Complied | Complied |
| | | 27.00 | | | | | | | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 33.20 | | | 32.10 | | | Complied | Complied | Complied |
| | | 32.10 | | | | | | | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
| | | 31.12 | | | 30.51 | | | Complied | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 30.40 | | | | | | | Complied | Complied |
| | | 27.20 | | | 28.14 | | | Complied | Complied | Complied |
| | | 28.12 | | | | | | | Complied | Complied |
| | | 29.10 | | | | | | | Complied | Complied |
| | | 34.20 | | | 33.00 | | | Complied | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 31.80 | | | | | | | Complied | Complied |
| | | 27.10 | | | 28.22 | | | Complied | Complied | Complied |
| | | 28.25 | | | | | | | Complied | Complied |
| | | 29.30 | | | | | | | Complied | Complied |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 19 | Niguisie W/gabriel | 27.20 | 29.27 | 28.75 | 28.17 | 3.10 | 10.59 | Complied | Complied | Complied |
| | | 28.30 | | | | | | | Complied | Complied |
| | | 29.00 | | | | | | | Complied | Complied |
| | | 28.30 | | | 26.47 | | | Failed | Complied | Failed |
| | | 23.50 | | | | | | | Complied | Failed |
| | | 27.60 | | | | | | | Complied | Failed |
| | | 31.10 | | | 30.20 | | | Complied | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 29.50 | | | | | | | Complied | Complied |
| | | 34.00 | | | 34.17 | | | Complied | Complied | Complied |
| | | 34.20 | | | | | | | Complied | Complied |
| | | 34.30 | | | | | | | Complied | Complied |
| | | 28.50 | | | 29.60 | | | Complied | Complied | Complied |
| | | 33.20 | | | | | | | Complied | Complied |
| | | 27.10 | | | | | | | Complied | Complied |
| | | 25.20 | | | 27.03 | | | Failed | Complied | Complied |
| | | 26.50 | | | | | | | Complied | Complied |
| | | 29.40 | | | | | | | Complied | Complied |
| 20 | Tokuma Mixed Use Building Plc | 21.00 | 28.36 | 28.91 | 24.90 | 4.06 | 14.33 | Failed | Failed | Failed |
| | | 26.20 | | | | | | | Failed | Failed |
| | | 27.50 | | | | | | | Failed | Failed |
| | | 22.00 | | | 27.53 | | | Failed | Complied | Complied |
| | | 33.10 | | | | | | | Complied | Complied |
| | | 27.50 | | | | | | | Complied | Complied |
| | | 28.25 | | | 28.32 | | | Complied | Complied | Complied |
| | | 27.60 | | | | | | | Complied | Complied |
| | | 29.10 | | | | | | | Complied | Complied |
| | | 21.00 | | | 28.00 | | | Complied | Failed | Failed |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 34.00 | | | 33.10 | | | Complied | Complied | Complied |
| | | 34.20 | | | | | | | Complied | Complied |
| | | 31.10 | | | | | | | Complied | Complied |
| | | 27.10 | | | 28.30 | | | Complied | Complied | Complied |
| | | 27.80 | | | | | | | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| 21 | Tsinat Yegebeya Maekel plc | 28.50 | 32.68 | 31.63 | 28.90 | 4.30 | 13.17 | Complied | Complied | Complied |
| | | 29.00 | | | | | | | Complied | Complied |
| | | 29.20 | | | | | | | Complied | Complied |
| | | 30.10 | | | 28.20 | | | Complied | Complied | Complied |
| | | 27.50 | | | | | | | Complied | Complied |
| | | 27.00 | | | | | | | Complied | Complied |
| | | 31.00 | | | 32.83 | | | Complied | Complied | Complied |
| | | 34.00 | | | | | | | Complied | Complied |
| | | 33.50 | | | | | | | Complied | Complied |
| | | 38.25 | | | 40.02 | | | Complied | Complied | Complied |
| | | 42.20 | | | | | | | Complied | Complied |
| | | 39.60 | | | | | | | Complied | Complied |
| | | 36.00 | | | 33.10 | | | Complied | Complied | Complied |
| | | 34.20 | | | | | | | Complied | Complied |
| | | 29.10 | | | | | | | Complied | Complied |
| | | 34.60 | | | 33.03 | | | Complied | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 31.50 | | | | | | | Complied | Complied |
| 22 | W/ro kristian W/Birhan | 34.00 | 31.86 | 32.13 | 33.50 | 2.39 | 7.50 | Complied | Complied | Complied |
| | | 33.10 | | | | | | | Complied | Complied |
| | | 33.40 | | | | | | | Complied | Complied |
| | | 33.80 | | | 33.97 | | | Complied | Complied | Complied |
| | | 34.00 | | | | | | | Complied | Complied |
| | | 34.10 | | | | | | | Complied | Complied |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 31.00 | | | 31.20 | | | Complied | Complied | Complied |
| | | 31.10 | | | | | | | Complied | Complied |
| | | 31.50 | | | | | | | Complied | Complied |
| | | 34.00 | | | 34.27 | | | Complied | Complied | Complied |
| | | 34.60 | | | | | | | Complied | Complied |
| | | 34.20 | | | | | | | Complied | Complied |
| | | 29.00 | | | 28.83 | | | Complied | Complied | Complied |
| | | 29.50 | | | | | | | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 27.00 | | | 29.40 | | | Complied | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 31.20 | | | | | | | Complied | Complied |
| 23 | Walda kanisa | 27.70 | 32.51 | 32.81 | 27.93 | 3.92 | 12.05 | Failed | Complied | Complied |
| | | 27.80 | | | | | | | Complied | Complied |
| | | 28.30 | | | | | | | Complied | Complied |
| | | 33.60 | | | 33.63 | | | Complied | Complied | Complied |
| | | 33.00 | | | | | | | Complied | Complied |
| | | 34.30 | | | | | | | Complied | Complied |
| | | 31.15 | | | 32.95 | | | Complied | Complied | Complied |
| | | 34.10 | | | | | | | Complied | Complied |
| | | 33.60 | | | | | | | Complied | Complied |
| | | 34.00 | | | 34.50 | | | Complied | Complied | Complied |
| | | 35.00 | | | | | | | Complied | Complied |
| | | 34.50 | | | | | | | Complied | Complied |
| | | 38.00 | | | 36.07 | | | Complied | Complied | Complied |
| | | 36.00 | | | | | | | Complied | Complied |
| | | 34.20 | | | | | | | Complied | Complied |
| | | 21.60 | | | 29.97 | | | Complied | Complied | Failed |
| | | 32.50 | | | | | | | Complied | Complied |
| | | 35.80 | | | | | | | Complied | Complied |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Yerango Yebu | 25.60 | 30.67 | 30.38 | 28.03 | 3.06 | 9.97 | Complied | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 30.50 | | | | | | | Complied | Complied |
| | | 28.00 | | | 28.17 | | | Complied | Complied | Complied |
| | | 28.20 | | | | | | | Complied | Complied |
| | | 28.30 | | | | | | | Complied | Complied |
| | | 29.00 | | | 29.60 | | | Complied | Complied | Complied |
| | | 29.80 | | | | | | | Complied | Complied |
| | | 30.00 | | | | | | | Complied | Complied |
| | | 31.00 | | | 31.40 | | | Complied | Complied | Complied |
| | | 31.50 | | | | | | | Complied | Complied |
| | | 31.70 | | | | | | | Complied | Complied |
| | | 36.15 | | | 36.45 | | | Complied | Complied | Complied |
| | | 36.20 | | | | | | | Complied | Complied |
| | | 37.00 | | | | | | | Complied | Complied |
| | | 30.00 | | | 30.38 | | | Complied | Complied | Complied |
| | | 30.15 | | | | | | | Complied | Complied |
| | | 31.00 | | | | | | | Complied | Complied |
| 25 | Yetana Misoso plc | 28.30 | 33.68 | 33.82 | 28.47 | 4.48 | 13.30 | Complied | Complied | Complied |
| | | 29.10 | | | | | | | Complied | Complied |
| | | 28.00 | | | | | | | Complied | Complied |
| | | 28.50 | | | 28.93 | | | Complied | Complied | Complied |
| | | 29.00 | | | | | | | Complied | Complied |
| | | 29.30 | | | | | | | Complied | Complied |
| | | 30.00 | | | 31.23 | | | Complied | Complied | Complied |
| | | 30.60 | | | | | | | Complied | Complied |
| | | 33.10 | | | | | | | Complied | Complied |
| | | 36.00 | | | 36.50 | | | Complied | Complied | Complied |
| | | 36.50 | | | | | | | Complied | Complied |
| | | 37.00 | | | | | | | Complied | Complied |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 38.00 | | | 38.53 | | | Complied | Complied | Complied |
| | | 38.60 | | | | | | | Complied | Complied |
| | | 39.00 | | | | | | | Complied | Complied |
| | | 37.20 | | | 38.43 | | | Complied | Complied | Complied |
| | | 38.00 | | | | | | | Complied | Complied |
| | | 40.10 | | | | | | | Complied | Complied |

## Appendix C List of active building projects found from town investment office

**Figure 10 350liter Stationary concrete mixer used**

Bulchiinsa Magaala Jimmaatti Wajjiraa Invastimentii office

የጂማ ከተማ አስተዳደር ኢንቨስትመንት ጽ/ቤት

Jimma city Administrions Investemant

Bulchiinsa Magaalaa Jimmaati Wajjira Invastimantii Magaalaa Jimmaa

Lakk WIMJ- 1174/2010
ቁጥር
Guyyaa- 22/1/2010
ቀን

**Qaama dhimmi ilaalatuu Hundaaf**

Namni maqaa isaa **Wubisheet Geetahuun** jedhamu yeroo amma kana dhimma ijaarsaa irratti qorannoo gaggeessa waan jiranuuf karaa keessan atooma barbaachisu akka gootan gaafaacha, atooma keessaniif galanni keenya guddaa dha.

Bulchiinsa Magaalaa Jimmaati Wajjira Invastimantii Magaalaa Jimmaa

Nagaa wajjin

Hussen Zinab
ሁሴን ዘይናብ
Itti G/W/ra Invastimantii
የኢንቨስትመንት ጽ/ቤት ኃላፊ

✉203 ☎0472110539 Fax 047111 59 64

Jimma University 19/[illegible]/2010

## ❖Pirojektoota Ijaarsa irra kan jiranu Haaromfame 2009

| S.No | Promoter(s) Name | Kebele (pl) | Sectorial type | Sub-sector | Investment Activity | Approved land area in (ha) | Date of agreement signed | Budget year | Proposed Capital (000) | Permanent /M/ | Permanent (F) | temporary (M) | Temporary (F) | Sadarkaa Pirojektii |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Galib A/jabal | Ginjo-Guduru | Trade | Trade | Trade center | 0.6000 | 17/10/96 | 1996 | 1,000,000.00 | 5 | 9 | 11 | 19 | Under construction |
| 2 | Jihad Mohammed | Ginjo - Guduru | Hotel and Tourism | Hotel and Tourism | Motel | 0.0154 | 3/7/2002 | 2002 | 4,000,000.00 | 10 | 9 | 15 | 16 | Under construction |
| 3 | Abduwahid Sherif | Ginjo-Guduru | Trade | Trade | Rental office | 0.1500 | 4/4/1997 | 1997 | 1,589,300.00 | 8 | 8 | 12 | 15 | Under construction |
| 4 | Sultan Adem | Ginjo-Guduru | Manufacturing | Machinairy /Equipment | Work shop | 0.0800 | 7/7/1998 | 1998 | 827,225.00 | 10 | 9 | 15 | 16 | Under construction |
| 5 | Taye Caka | Ginjo-Guduru | Hotel and Tourism | Hotel and Tourism | Pensiyon | 0.1600 | 18/4/1998 | 1998 | 541,000.00 | 12 | 12 | `14 | 17 | Under construction |
| 6 | Biyya Aba-Mecha | Becho Bore | Health | Health | Clinic | 0.3600 | 27/10/99 | 1999 | 1,700,000.00 | 10 | 9 | 10 | 16 | Under construction |
| 7 | Jimma University | Becho-Bore | Hotel and Tourism | Hotel and Tourism | Turisim Hotel | 1.0000 | 12/12/2003 | 2003 | 120,000,000.00 | 39 | 23 | 180 | 130 | Under construction |

Buchiinsa Magaalaa Jimmaa Invastimantii Magaalaa Jimmaa

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Umer Abdella | Becho Bore | Trade | Trade | Mixed Use Building( Expansio n) | 0.0266 | 22/5/2005 | 2005 | 6,660,000.00 | 9 | 4 | 17 | 15 | Under construction |
| 9 | Tayser Business PLC | Awetu Mendera | Trade | Trade | Mixed use building G +3 | 0.0332 | 26/7/2005 | 2005 | 5,000,000.00 | 3 | 6 | 15 | 18 | Under construction |
| 10 | Nejat Ibrahim | Hermata Merakato | Trade | Trade | Mixed use | 0.0180 | 27/10/1999 | 1999 | 1,907,705.00 | 1 | 1 | 58 | 18 | Under construction |
| 11 | Dirre Industry | Hermata Merkato | Trade | Trade | Mixed use | 0.0750 | 4/16/2001 | 2001 | 3,000,000.00 | 2 | 1 | 24 | 20 | Under construction |
| 12 | Tokuma Mixed use Building PLC | Hermata Merkato | Trade | Trade | Market center | 0.1104 | 24/8/2004 | 2004 | 12,521,000.00 | 1 | 2 | 12 | 17 | Under construction |
| 13 | yetana misoso PLC | Hermata merkato | Trade | mixed use | Mixed use | 0.4200 | 23/3/2005 | 2005 | 1,600,000.00 | 5 | 5 | 24 | 21 | Under construction |
| 14 | Hamid Yasin & Sitina Husen | Kochi-Mender | Trade | Trade | Trade center | 0.0600 | 5/9/1998 | 1998 | 300,000.00 | 1 | 2 | 18 | 18 | Under construction |
| 15 | Shimelis Indale | Mendera Kochi | Manuf acturin g | Non Metallic Mineral Industry | Bolocket factory | 0.0160 | 6/22/1995 | 2000 | 1,600,000.00 | 13 | 6 | 8 | 20 | Under construction |
| 16 | Hadas G/medin | Ginjo | Trade | Trade | Mixed use | 0.0465 | 7/7/19998 | 1998 | 500,000.00 | 1 | 1 | 16 | 17 | Under construction |
| 17 | Jimma University | Ginjo | Trade | Trade | Fuel Station | 0.6000 | 6/22/1995 | 2000 | 100,000,000.00 | 23 | 16 | 10 | 20 | Under construction |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Jifar PLC | Hermata | Trade | Trade | Mixed use | 0.0366 | 3/9/2001 | 2001 | 1,842,394.00 | 1 | 1 | 33 | 21 | Under construction |
| 19 | Chiristian W/Berhan | Hermata | Trade | Trade | Mixed use | 0.0264 | 6/24/1995 | 2002 | 3,000,000.00 | 1 | 1 | 22 | 21 | Under construction |
| 20 | Mekia Abdulkadir | Hermata | Trade | Trade | Mixed use | 0.0250 | 6/24/1995 | 2002 | 800,219.00 | 1 | 1 | 12 | 13 | Under construction |
| 21 | Tsinat Yegebeya Maekel PLC | Hermata | Trade | Trade | Mixed Use building | 0.1270 | 8/7/2004 | 2004 | 12,000,000.00 | 9 | 7 | 14 | 021 | Under construction |
| 22 | Hafiz A/Mecha | Hermata Mentina | Trade | Trade | Mixed use | 0.1490 | 13/7/2004 | 2004 | 6,253,000.00 | 5 | 2 | 13 | 12 | Under construction |
| 23 | Awigcho Birhanuu | G\G | Trade | Trade | Mixed use | 0.4320 | 6/28/1905 | 2006 | 10,00,000.00 | 2 | 3 | 10 | 12 | Under construction |
| 24 | Yerango Yebo | G\G | Trade | Trade | Mixed use | 0.0400 | 2002 | 2002 | 4,000,000.00 | 1 | 2 | 9 | 10 | Under construction |
| 25 | Wonde Diriver | B\Booree | Education | Education | Kollej. | 1.0888 | 2008 | 2008 | 10,000,000.00 | 2 | 2 | 4 | 2 | Under construction |
| 26 | Fireyot Galayee | G\Gud. | Hotel and Tourism | Hotel and Tourism | Hotel | 0.0200 | 2006 | 2006 | 10,000,000.00 | 2 | 3 | 11 | 11 | Under construction |
| 27 | Abdulsemed Husen | Ginjo - Guduru | Trade | Trade | Mixed use | 0.0500 | 5/2\2007 | 2007 | 1,500,000.00 | 2 | 1 | 19 | 19 | Under construction |
| 28 | Nigusee W/Gabrii'eel | Hermaata a | Trade | Trade | Mixed use | 0.0270 | 1999 | 1999 | 5,000,000 | 6 | 3 | 5 | 4 | Under construction |
| 29 | Sulxaan Shukur | Hermata Merkato | Trade | Trade | Mixed use | 0.0129 | 16/3/97 | 1997 | 200,000.00 | 1 | 0 | 8 | 7 | Under construction |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | Gizachew Dibaba | Ginjo | Trade | Trade | Commercial Building | 0.0201 | 8/5/2004 | 2004 | 480,000.00 | 1 | 0 | 9 | 6 | Under construction |
| 31 | Ahmedin Danur | Becho-Bore | Hotel and Tourism | Hotel and Tourism | caffee & Hotel | 0.0300 | 6/17/1905 | 1995 | 1,500,000.00 | 0 | 1 | 0 | 0 | Under construction |
| 32 | G/Gala Gabaa hermaataa | Hermata Merkato | Trade | Trade | Mixed use | 0.1800 | | | 20,000,000 | 2 | 1 | 18 | 19 | Under construction |
| 33 | Waldaa Kanniisaa | H/ Markaato o | Trade | Trade | M/use | 0.0400 | 2005 | 2005 | 10,000,000 | 2 | 1 | 14 | 13 | Under construction |
| 34 | Tawaabech Bantii | Hermata Merkato | Trade | Trade | Mixed use | 0.0490 | 2002 | 2007 | 10,000,000 | 2 | 1 | 19 | 21 | Under construction |
| 35 | Ahimad A/Biyyaa | G/Guduru u | | Hoteela | Hoteela | 0.1800 | 1998 | 1998 | 3,000,000 | 10 | 9 | 6 | 5 | Under construction |
| 36 | Abduu Kamaal | A/Mandara a | Hotel and Tourism | Hotel and Tourism | Hotel | 0.0784 | 22/5/1998 | 1998 | 3,000,000,.00 | 2 | 5 | 13 | 13 | Under construction |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |