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POTENTIALS OF READY MIX CONCRETE INTRODUCTION TO THE CITY OF BAHIR DAR

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February 2019

Bahir Dar, Ethiopia

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A thesis submitted to the school of Research and Graduate Studies of Bahir Dar Institute of Technology (BiT), BDU in partial fulfillment of the requirements for the degree of

Master of Science in the ***Construction Technology and Management*** in the Faculty of Civil and Water Resource Engineering.

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DECLARATION

I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have acknowledged all materials used in this work. I understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/ fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

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DEDICATION

To my beloved family: My father Ato Degu Mengesha, my mother Woy zero YelbieAysheshim, and my brothersand sisters. I would like to say "Thank you!!!" for all your support.

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ABSTRACT

The role the construction industry plays in socio-economic development is significant. In the whole effort concrete is one of the major construction materials which is produced from the three basic ingredients; namely, cement, aggregate and water. It is common in Ethiopia to build all the structural elements using conventional site mix concrete, where concrete is mixed on site and poured using manual labor. Now a day, Ready Mix Concrete (RMC) is one aspect of delivering fresh concrete to site in order to get the required quality and speed of construction which, of course needs considerable attention. Therefore, the principal objective of this research is determining the potentials form introduction to Bahir Dar from the view point of water availability, cement supply, aggregate quality and reliable source, the potential market demand of the product, leading to comparing and contrasting of the unit cost of RMC including transportation to the required site with that of the conventional Site Mix Concrete (SMC). In order to achieve the stated objective, literature review, face to face interview, questionnaire survey, examining aggregate test results and site observations were carried out. The results of the undertaken assessments show that more than 64% of the type of water being used in many projects doesn't fulfill the set standards and those stated in reviewed literatures' plant could not be starved from scarcity of cement. In general, the quality of both fine and coarse aggregates around Bahir Dar are within the acceptable limits of standards. However, about 68 percent of the fine aggregate and 71 percent of coarse aggregate sources couldn't satisfy graduation requirements which need treatment; like, blending of different sources of aggregates. The fine aggregate in and around Bahir Dar contains high amount of silt and clay content and needs proper source selection, and washing of fine aggregate. The conventional SMC in Bahir Dar is facing many problems; like, shortage of skilled laborers, appropriate space for storage and handling of raw materials, wastage of raw materials on construction sites is beyond the set limits, improper mixing of ingredient materials in concreting process, properly maintaining the water to cement ratio, and generally the productivity of concreting is very low and time taking. In Bahir Dar, the estimated market potential for RMC is huge, this indicates that investors can start their RMC plant and capture the uncontested opportunity. The new entrant of RMC Plant can have an estimated market share between 183,695 $m^3$and 222,504 m^3. In the Bahir Dar construction industry, the majority of the respondents of the construction sector are aware and satisfied.C-25 is used for cost comparison between RMC and SMC concrete. The average price for RMC is 3065.27ETB/m^3 which is 10% higher than the average conventional SMC that is 2780.96ETB/m^3. This might be compensated by the quality margin, reducing labor cost, reducing wastage of raw materials, reducing cement amount, material discount from suppliers through bulk purchase, and increase in fresh concrete productivity and supply. As the results obtained in this research have shown, the introduction of Ready-Mixed Concrete to the Bahir Dar construction industry will surely resolve the current problem of the poor concrete use forever. And it would also lead to the proper and economical use of resources in general.

Key words; Concrete raw materials, ready mix concrete demand, comparing unit cost, site mix concrete problems.

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LIST OF ABBREVATIONS

ACR	Alkali-Carbonate Reaction
AD	Air Dry
ANRS	Amhara National Regional State
ASR	Alkali-Silica Reaction
ASTM	American Society for Testing and Materials
BDU	Bahir Dar University
BiT	Bahir Dar Institute of Technology
BOQ	Bill of Quantity
BS	British Standard
CO_2	Carbon Dioxide
ES	Ethiopian Standards
ETB	Ethiopian Birr (currency)

FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross Domestic Product
GGBBS	Ground Granulated Blast Furnace Slag
GTP	Growth and Transformation Plan
IS	Indian Standard
JIT	Just In Time
Mt	Million tons
MPa	Mega Pascal
OPC	Ordinary Portland Cement
PFA	Pulverized Fly Ash
PPC	Portland Pozzolana Cement
QA	Quality Assurance
QC	Quality Control
RMC	Ready Mix Concrete
SMC	Site Mix Concrete
SSD	Saturated Surface Dry
UK	United Kingdom
USA	United States of America

1 INTRODUCTION

1.1 General

Concrete is one of the major construction materials in building construction industry and produced from three basic ingredients; namely, cement, aggregate and water. In addition, admixtures are sometimes used to improve some properties of concrete; like, workability and setting time. The ingredients of concrete should be of good quality that satisfy the requirements set in standards.

African cities have growth rates of up to 5% per year; which makes them the fastest growing urban units in the world which isn’t different for Ethiopia including Bahir Dar. For instance, Ethiopia will be confronted with a population increase of 45 million people in urban area over the next 15 years along with increased demand for basics; like food, water, safety, infrastructure and housing [1].

Recent study, Ethiopia is prioritizing a wealth of construction projects in order to stimulate its economy, reinvigorate its infrastructure and supply affordable housing and power to its population of close to 100 million. The construction industry in Ethiopia has been developing tremendously since 2001. The GDP contribution of the construction industry has been raised to 5.6% and approaches to the Sub-Saharan average of 6% [2].

Therefore, rapid urbanization is triggering unanticipated housing and infrastructure demand and the government is looking to invest heavily to fill the gap. To achieve the above, the required quality of building materials and speed of construction for which Ethiopia is aspiring for to upgrade the construction industry’s capabilities which needs a serious attention. With the exception of underdeveloped regions, Ready-Mix Concrete (RMC) is used throughout the world abundantly which is a better option by far.

1.2 Background of the Study

Many buildings in Ethiopia are predominantly made of reinforced concrete for which there is no exception in the case of Bahir Dar. It is common in Ethiopia to build all the structural elements using conventional Site Mix Concrete (SMC), where concrete is mixed on site and poured using manual labor.

According to Kibirit(2017), in in-situ contractors use an excess of cement in their concrete mix in order to ensure that the final concrete product has a strength that is equal to or more than the design value. Other times, contractors attempt to save expenses by using as little cement as possible. The amount of water used to mix concrete is rarely measured, which means the strength of the finished concrete is not known. There are abundances of irregularities regarding the quality of concrete structures in Ethiopia [3].

The Construction industry in Bahir Dar is traditionally labor oriented and the pace of mechanization is very low. Because of this the speed of construction is very low and managing many labors creating additional assignment or burden on the contractors.

Concrete ingredients on sites are batched mostly using volume batching. Volume batching, boxes of a given capacity are constructed manually on sites for coarse and fine aggregates per 50Kg or one sack of cement in accordance with the proportion specified in mix design which results in inaccuracy [4].

The quality of concrete is mostly dependent on the quality of composing ingredients, ways of batching, transporting, placing, compacting, and curing. It’s obvious that, the way of batching of SMC in Bahir Dar is usually in volumetric measurement which is a cause of inaccuracy. It’s very difficult to measure each ingredient of concrete accurately; especially, the amount of water added is random which affects the property of fresh and hardened concrete. The amount of water added is mainly dependent on wetness and dryness of fresh concrete not based on water cement ratio.

Generally, cost remains the driving factor in deciding the award of construction contracts and very little or no premium is placed on quality. As a result, many concrete making materials are wasted and the cost of this wastage increases the total project cost.

Another unavoidable issue with SMC is a problem of procuring and storing concrete making materials like cement, aggregate and reinforcement bar. It’s common to store these materials in an inappropriate place; like, aggregates on dust places, on the main street of Bahir Dar and storing cement on not moisture free area. This is a big hassle for contractors; especially, on crowded construction sites. Procuring and storing of materials, quality and consistency problems cannot be solved by relying on age-old techniques of constructing with the conventional McCone has to go out of the box and use RMC to avoid the mentioned challenges.

From the above discussion one can understand that RMC is one of the aspects of the construction industry which helps to get the required quality and speed of construction which highly demands considerable attention. However, since no previous local study has properly addressed the issue of Bahir Dar, this research is intended to fill the gap.

1.3 Statement of the Problem

As it is pin pointed out in the preceding part of this introductory section, the aim of the research is to undertake qualitative and quantitative assessment on the potentials of RMC plant introduction to the Bahir Dar construction industry.

One of the major problems of heavy reliance on labor intensive technique is the assurance of concrete quality. This is because SMC has serious limitations as far as quality of concrete and speed of construction is concerned. Generally, cost remains the driving factor in deciding the award of construction contracts and very little or no premium is placed on quality. As a result, many structures have shown premature deterioration and the cost of repairs and rehabilitation is proving prohibitive.

RMC has many advantages over SMC in terms of quality, speed of construction, cost efficiency, space usage, especially on crowded construction sites and congested public roads. For example, Dave et.al(n.d), regarding the overall benefits of RMC notes as; uniform and assured quality of concrete, durability of RMC, faster construction speed, storage needs at construction sites eliminated, addition of admixtures is easier, documentation of the mix design, reduction in wastage of materials, and eco-friendly [5].

The main factors that affect the existence of RMC plant are the availability of quality raw materials, the construction industry’s growth potential market demand, and finally the unit cost of RMC relative to SMC. Quality of RMC mainly depends on the ingredients of concrete. Especially, properties of aggregates playan enormous role for workable and durable concrete. Aggregates make up about 60% to 75% of the total volume of concrete, indicating the importance of their selection. Aggregates, like; fine and coarse production, storage and transporting has a direct relation with concrete quality. Like any other business entity, factors that influence the RMC industry is determined by both supply and demand of the market. Moreover, companies sell their products/services to their customers targeting affordability with a market of reasonable profit margin. Thus, estimating the price of RMC is very essential in the face of its competitor SMC.

1.4 Objectives of the Study

1.4.1 General Objective

The main objective of this research is to determine the potentials of RMC introduction to Bahir Dar by assessing assured supply of cement, good quality aggregate availability, the potential market demand for RMC, and determine the unit cost of RMC including transportation to the required construction site and compare it to its competitor the conventional SMC to arrive at an informed decision.

1.4.2 Specific Objectives

- ✓ Assess the availability of quality concrete making materials including water, cement, and aggregates in Bahir Dar for RMC.
- ✓ To identify the challenges faced in the use of conventional SMC.
- ✓ To assess the potential market demand for RMC; the level of awareness of the customers and the general construction industry of Bahir Dar.
- ✓ To compare and contrast the unit costs of SMC to that of RMC including delivery to site charges.

1.4.3 Research Questions

1. Do the quality of concrete making materials and their availability invite the setting up of RMC plant in Bahir Dar?
2. What are the challenges in the conventional SMC which are the major drivers to opt for RMC?

3. What are the market opportunities of RMC plant and the awareness level of builders?
4. How is the cost of RMC compared to that of SMC for market penetration?

1.5 Scope

The scope of the study is restricted to Bahir Dar City. The research mainly focuses on; availability of water on construction sites, assessment of cement supply, the availability quality aggregates, and compliance with standards for Misidentifying customers in the construction industry, awareness level and comparative unit cost of SMC with that of Simkin Bahir Dar.

1.6 Significance of the Study

RMC is an advanced technology, which involves a high degree of mechanization and automation. Therefore, it helps the construction industry to step upon terms of quality, speed and cost efficiency.

Quality of the final product is the most important aspect under consideration in the construction sector. Since factory manufactured products always take the lead in the quality of industrial out puts; there comes the importance of RMC while competing with SMC.

In light of the above, the study is concentrated on the potential of RMC use in the Bahir Dar construction industry. Based on the study outcome business entities can introduce RMC plant to Bahir Dar. To that end, the study will try to investigate the awareness level of contractors about RMC which will be helpful for the promotion of the product in the future. This study also deals with the challenges faced by the builders in SMC and their future expectations regarding the ideal RMC.

2 LITERATURE REVIEW

In order to address the research objectives, a comprehensive literature review has been conducted focusing on; quality requirements of ingredients for RMC plant, market condition for Rican possible target customers of the product leading to a relative cost comparison of RMC with that of the customary SMC.

2.1 General

Concrete is basically a mixture of two components: aggregates and paste. The paste, comprised of cement and water, binds the aggregates (usually sand and gravel or crushed stone) into a rocklike mass as the paste hardens because of the chemical reaction of the cement and water. Supplementary cementitious materials and chemical admixtures may also be included in the paste.

Concrete is one of the versatile and widely used building materials in the world construction industry. Concrete in its simplest basic form consists of a mixture of cement, sand,stone(coarse aggregate)andwater sometimes admixtures.Concrete is the most universal of all the construction and is frequently considered as the most economical one and is strong and durable material. In the same fashion, Jain, writes, concrete is the largest 'man made' material in the world and stands second to water in per capita consumption [6].In a like manner, Kumars wamy et.al,also explain concrete as, the premier construction material in the construction industry around the world which is a man-made product, mainly consisting of Portland cement and/or secondary cementitious materials (PFA, GGBS, Micro silicates.), aggregates, water and admixtures [7].

RMC is used nowadays almost in all the construction industry especially in developed countries, where the work is to be completed in short time and more effectively. Over80%ofsite-placed concrete in the UK is produced by the ready-mixed concrete industry and this accounts for about 45% of the total cement sales for all purposes. Similar figures apply to the industrialized countries they demonstrate the increasing tendency of contractors relay on the supply of a concrete from a RMC plant. For instance, Japan is the world's largest producer of RMC shipping 181.96 million m3 in 1992, followed by the USA, Korea, and Italy shipping 160, 96 and 70 million m^3 respectively [8].

Ready Mix Concrete is produced in a controlled environment in batching plant or in a transit truck mixer. Therefore, ingredients are standardized and well-proportioned to get the required quality of concrete. Similarly, RMC is manufactured in a factory or batching plant, according to a set recipe and then delivered to a work site by truck mounted in transit mixers and this result in a precise mixture, allowing specialty concrete mixtures to be developed and implemented on construction sites [9].

As time is directly equivalent to money, especially in the construction industry, there is a great demand for fast track construction which needs sophistication and advanced technology. RMC enables us mass concrete production work and timely completion of large construction sites. For instance, is an advanced technology, which involves a high degree of mechanization and automation is technologically superior to the SMC [7].

Racism generally superior in terms of quality, speed, life-cycle cost and eco-friendliness. Owing to these advantages, it is slowly replacing site mixed concrete. According to Yogesh, strengthen the advantage of RMC as the best alternative to SMC as it has advantages such as high quality, high speed, eco-friendliness, reduced life time cost and elimination of procurement and storage hassles. Material should satisfy the requirements for safety, structural performance, durability and appearances of the finished structures taking into account the environment to which it will be subjected [10].

2.1.1 Definition

Different literatures give almost the same meaning or definition for "Ready-Mix Concrete". For example, ASTM defineReady-mixed concrete, "concrete manufactured and delivered to a purchaser in a fresh state." [29].According to Yogesh, RMC is the concrete which is manufactured at the central batching plant and delivered at construction site with the use of truck mounted Transit Mixers (TM) [10].Similarly, RMC is a composite material which, like all well-designed composites, has resultant properties that combine the best qualities of the component materials [11]and, also RMC refers to concrete that is specifically manufactured for delivery to the customer's construction site by truck-mounted transit mixers in a freshly mixed and plastic or unhardened state [12].

Therefore, one can note that “Ready Mix Concrete” is the concrete which is well-designed composites, has resultant properties that combine the best qualities and specifically manufactured for delivery to the customer's construction site from the central batching plant using a truck mounted transporter.

2.1.2 Historical and Progressive Growth of RMC in Some Countries

Its long history of development extends way back when Germany was patented with the first production of RMC in 1903. The history of concrete in Britain dates back to Roman times, but it was not until the 1930s that concrete was supplied arm in the UK. The constituent materials come from the earth in bulk, so concrete is most economically produced by handling the materials in bulk and mixing them in bulk. Its main purpose, especially, was the advantages of scale and efficiency of mechanical mixing, plus improved control resulting from weighing the ingredients, that opened the way for the supply of RMC [11].

However, as Dewar noted, RMC was patented in Germany in 1903, but the means of transporting it had not developed sufficiently well to enable the concept to be exploited [11]. By the same analogy, Takeyam, had summarized the evolution of RMC to some selected countries in Europe and USA in Table 2.1 [8].

Table 2.1: Start of RMC production in Europe and USA [8]

Year	**Country**
1900s	Germany (1903)
1910s	Spain (1912) USA (1913) Holland (1918)
1920s	Denmark (1926)
1930s	UK, Norway (1930) Sweden (1932) France, Switzerland (1933)
1940s	Japan (1949)
1950s	Belgium (1956) Finland (1958)
1960s	Austria, Ireland (1961) Italy (1962) Israel (91963) Portugal (1966) Greece (1968)

Unlike the trend in Ethiopia where concrete is normally produced on site, in most developed and developing countries RMC production plants are responsible for the production of the major portion of the total concrete produced in their country. Today, RMC offers high-tech solutions to the needs of the construction industry. It allows building of ever longer bridges, ever higher buildings, tunnels, dams, etc. For instance, Denamo, observed in the German construction industry RMC constitutes about 87% of the total concrete produced excluding precast concrete and it consumes about 47% of the total cement consumed in the country. The following table shows production, production per capita, cement consumption and % of RMC in different countries in the world [13].

Table 2.2: Ready-mixed concrete production figures in different countries [13]

Country	Total Production X $10^6 m^3$	Production per Capita (m^3/capita)	Cement Consumption X 10^6 ton	% of cement for RMC production
USA	310.00	1.06	113.83	74.00
Spain	81.00	1.96	46.22	50.00
Italy	79.90	1.27	43.48	48.70
Germany	46.90	0.57	28.90	46.70
Russia	35.00	0.24	36.41	-
France	34.80	0.58	20.68	47.00
Turkey	28.2	0.40	28.11	30.00
United Kingdom	22.00	0.37	13.24	54.00

Kassahun, presented a general report on cement and concrete production in the Ethiopian construction industry. The growth potentials, challenges, and the RMC market were discussed in this report and it was finalized as it's time to introduce RMC. From the report, one can understand that the construction industry is very far away from the RMC technologies yet [14].

To date, there is no RMC plant in Bahir Dar so far for commercial purposes; except some companies who have their own RMC plants; like, MIDROC Ethiopia, though the construction industry growth is on a gradual rise.

2.1.3 Components of RMC Batching Operation

The work of Park et.al, elaborates components of RMC batching plant operation as follows. A typical RMC plant owns batching plant, cement silos, water storage tanks, ground hoppers, storage, weighing hoppers, and trucks. In Figure 2.1 below, the batching plant operation is conceptualized and a brief description of each component is provided.

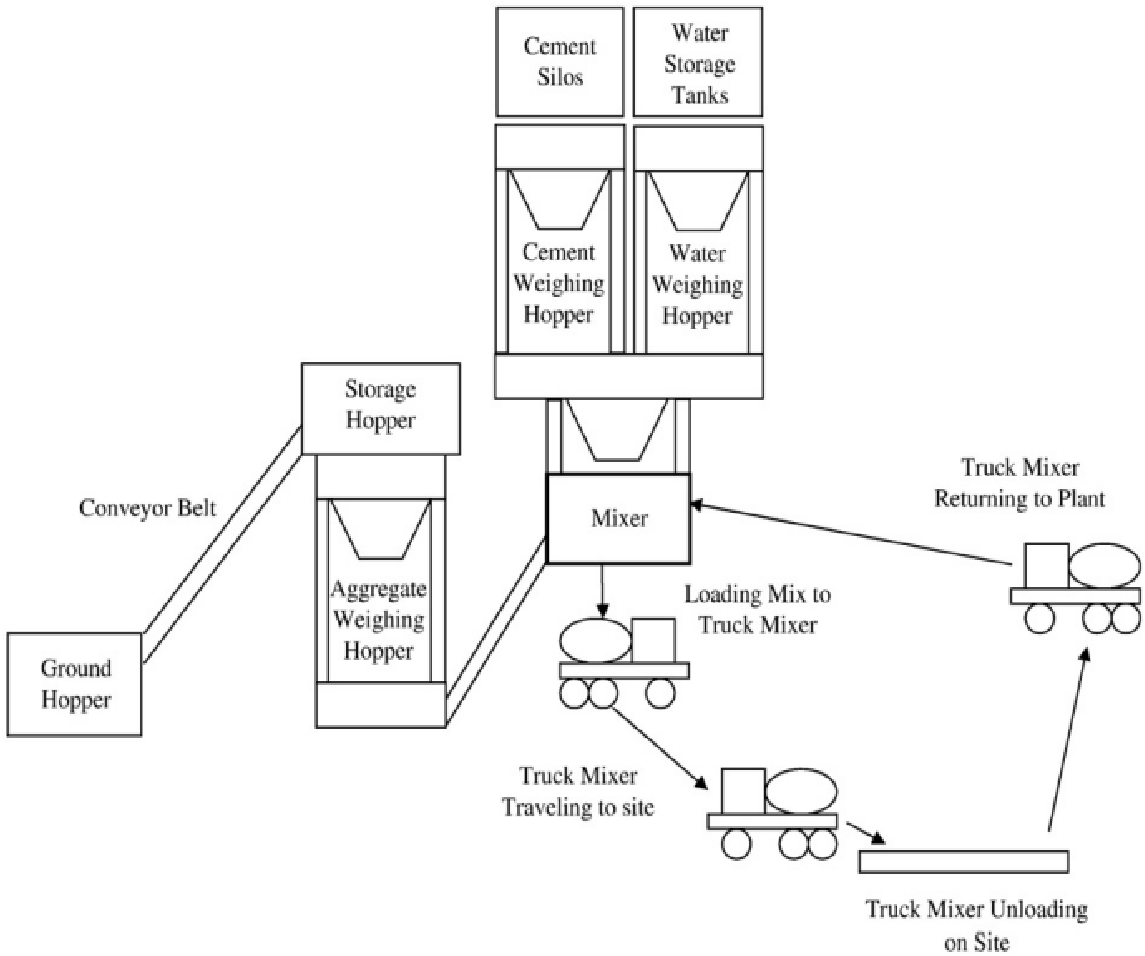


Figure 2.1: Batching plant and truck mixer cycles [15]

2.1.3.1 Ground Hopper

The hopper is located on the ground, and it is connected to the storage hopper by a conveyor belt. An operator drives the vehicle required to load sand and aggregates into the ground hopper. Then, the conveyer belt transports these materials to the storage hopper.

2.1.3.2 Storage Hopper

The storage hopper consists of compartments to store sand and aggregates, namely sand, 10 mm aggregates, and 20 mm aggregates. When released, materials are discharged into the aggregate weighing hopper, which is located directly below the storage hopper.

2.1.3.3 Cement Silo and Water Storage Tank

Cement silos and water storage tanks are located above the mixer. Cement is discharged into the cement weighing hopper, which measures its weight. Then, the cement is released into the mixer through gravity. Similarly, water is discharged into the mixer through the water weighing hopper.

2.1.3.4 Weighing Hopper

There are three types of weighing hoppers. The cement and water weighing hoppers are located below the cement silos and water tanks, and above the mixer. This design ensures that, after weighing, the cement and water are discharged directly into the mixer due to gravity. On the other hand, the aggregate weighing hopper weighs the sand and aggregates before allowing the conveyor belt to transport them to the mixer.

2.1.3.5 Mixer

The mixer receives all the components to batch the ready mixed concrete. By rotating constantly, the mixer ensures that the components are mixed evenly and thoroughly to the right workability. Using the amp-meter, the batch plant control room operator determines whether the mix is too dry or too wet, and he/she makes necessary adjustments before releasing it to the truck mixers.

2.1.3.6 Truck Mixer

The full carrying capacity of a truck mixer is 6 m^3but now a day there are truck mixers that can carry more. Truck mixer drivers are on standby to receive a work order, responding immediately if the plant runs out of truck mixers.

2.1.4 Batching Plant Performance

Batching plant operations is determined by the performance of the overall batching process i.e. Availability of materials on the stock, the processes of weighing of ingredient materials and discharge to the mixer. The loading of sand and aggregates from the ground hopper is independent of the other batching plant processes. However, the time taken to discharge cement and water into the mixer is insignificant because the discharge is immediate (due to free fall), which has a minimal effect on the batching process. The average time taken to confirm the weight of aggregates and to discharge the materials to the mixer is estimated as 6 min and 8 min; respectively.

2.1.5 Truck Mixer Performance

In general, the performance of truck mixers varies, depending on the type of concrete placement methods used on-site. Truck mixer drivers take an average of up to 5 min to position their truck mixers and to load them. Before leaving the plant, each batch of delivery must go through the slump test to ensure that the ready mixed concrete is of correct workability. The average duration of the slump test is 3 min.

When arriving at the site, truck mixers queue up for a certain time. The average time to unload concrete from the truck mixer is 20 min, ranging from direct pour to wheel barrow. As a result, it takes an average of 90 min to deliver one batch of RMC. In addition, a comparison of the average truck mixer dispatching interval and the average concrete unloading productivity indicates that the RMC operating manager must adjusts the truck mixer interval according to concrete work speed on-site [15].

2.1.6 Advantages and Disadvantages of Ready-Mix Concrete

According to literatures, RMC has many advantages over onsite mix concrete in terms of quality, speed of construction, cost efficiency, space usage especially on crowded construction sites and public roads. Though RMC concrete has many advantages that pave the road for concrete construction to step up, it has also some limitations in addition. The advantages and disadvantages of RMC are summarized in the table below.

Table 2.3: Advantages and disadvantages of RMC (Summary)

<table>
<tr><th>Subject</th><th>Author and year</th><th>Statement made</th></tr>
<tr><td rowspan="3">Advantage</td><td>Dave et.al (n.d) [5].</td><td>✓ Uniform and assured quality of concrete
✓ Durability of RMC
✓ Faster construction speed
✓ Storage needs at construction sites eliminated
✓ Addition of admixtures is easier
✓ Reduction in wastage of materials</td></tr>
<tr><td>Rajashe et.al, (2014) [17]</td><td>✓ Wastage minimization of materials on site
✓ Repeated shifting of the mixer location
✓ Faster construction speed
✓ Storage needs at construction sites eliminated
✓ Reduce supervision and labor cost
✓ Helps in controlling the water to cement ratio (w/c)</td></tr>
<tr><td>Amiyangshu et. al (2016) [9].</td><td>✓ Produce better quality concrete
✓ Elimination of storage space for basic materials at site
✓ Elimination of hiring of plant and machinery
✓ Avoiding wastage of basic materials
✓ Eliminate labors associated with production of concrete
✓ Reduce time required
✓ Noise and dust pollution at site is reduced</td></tr>
<tr><td rowspan="2">Disadvantage</td><td>Amiyangshu et. al (2016) [9].</td><td>limited time span between mixing and going-off</td></tr>
<tr><td>Al-Araidah, (2012) [12].</td><td>✓ Impact of traveling time on properties of concrete
✓ Load carrying capacity of roads and bridges and traffic conditions</td></tr>
</table>

2.2 Concrete Making Materials

Materials should satisfy the requirements for safety, structural performance, durability and appearances of the finished structures taking into account the environment to which it will be subjected. As technically, in most cases there is no difference between Rican site mixed concrete except pumpability of RMC to higher elevation. Thus, the specifications of materials which are applicable to Scare also applicable to RMC [16].

Generally, in order to ensure that the concrete produced is of the desired type, it is necessary that quality control is exercised at all the stages right from receipt of raw material to delivery of concrete at site, placing, compacting, and curing [4].

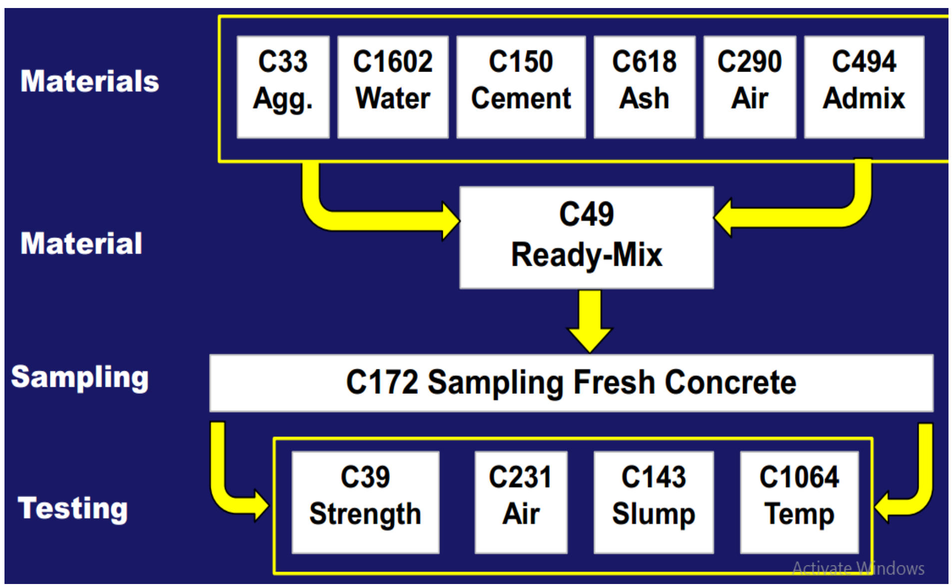


Figure 2.2: Requirement of RMC raw materials based on ASTM Standard [16]

The basis of purchase shall be a cubic yard or cubic meter of fresh concrete as discharged from the transportation unit.

Three options for ordering or specifying concrete are described in ASTM C 94:

1. **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.
2. **Option B;** is prescription based. The purchaser specifies mixture proportions, including cement, water and admixture contents.

3. **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.

2.2.1 Water

Almost any natural water that is drinkable and has no pronounced taste or odor can be used, as mixing water for making concrete. For instance, Neville mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions [19]. In addition, substances in water which, if present in large amounts, may be harmful are: salt, oil, industrial wastes, alkalis, sulphate, organic matter, silt, sewage etc. Tests by the sense of smell, sight or taste would reveal such impurities; however, water of doubtful quality should be submitted for laboratory analysis and tests [18].

The function of the water, other than enabling the chemical reactions that cause setting and hardening to proceed, is to lubricate the mixture of aggregates and cement in order to facilitate placing. Some standards stipulate that water fit for drinking is generally suitable for making concrete. Water quality is the most consistent of the constituents of concrete but water quantity, as it affects the free/water cement ratio, is most important for control of consistence, strength and durability [18, 19, 36].

Moreover, deleterious substances which affect the quality of both the fresh and hardened concrete that could possibly be found in impure water like silt, clay, acids, alkalis, algae, inorganic salts and sugars should be within the permissible limits so that concrete quality shouldn’t be adversely affected. Generally, the pH value of water that is suitable for concrete construction has to be in the range of 6to8.The water, which is fit for drinking purpose, is fit for concrete production [19].

A recent study by Ayalew, the Lake Tana basin, Bahir Dar is a major city which has the water supply from surface and groundwater sources. As the population and business activity of the town is growing at an alarming rate it is obvious, that more water will be needed in the future. This additional water demand can be supplied by either increasing the number of boreholes and/or utilizing surface water resources of the area based on detail hydro geological studies.

The field measurements of pH values of the Lake Tana basin ranges between 6 to 8.44 and therefore, values in the area can be considered as neutral [20]. This is suitable water for concrete making as far as the pH of water is considered because the suitable pH value of water for concrete is between 6 to 8 even as high as 9 [19].

2.2.2 Cement

Nowadays, after several important technical improvements, concrete made with Portland cement is probably the most used manmade material in the world. In a concrete mixture the function of the cement is to react with the water forming a plastic mass when the concrete is fresh and a solid mass when the concrete is hard. Since the most widely used cement is Portland cement, the discussion made in this paper is primarily on this cement type only [19]. According to Troxel, Portland cement is a finely powdered substance, usually gray or brownish grey, composed largely of artificial crystalline minerals, the most important of which are calcium and aluminum silicates [21].

As cement is the main constituent of concrete, therefore, quality and continuous supply of cement is quite important for production of quality concrete. For instance, Jain, pointed outthe growth of RMC in any country has a direct relation with the growth of its cement industry and consumption of cement by the construction industry [6]. Moreover, RMC technology could not be implemented as investors felt that Ready-Mix Concrete plant will starve due to non-availability of cement [22].

2.2.2.1 Cement Production in Ethiopia

It is believed that infrastructure is a key aspect towards the economic development of countries. Further, it is a known fact that it is impossible to think of infrastructure development without the development of the construction industry. In addition, cement consumption index can be used as an indicator of the development of the construction industry of countries [22].

Ethiopia has more than 16 cement plants (other than 2 new entrants). In terms of size and installed production capacity: four are large and integrated firms with more than 2 Mt (Million tons) installed cement production capacity; four are mid-sized cement plants with combined installed cement production capacity of 2.3 Mt. Import of cement except special cement and new investment has been temporarily halt by the government since March 2012.

Even though cement consumption in Ethiopia is significantly growing, evidences show that the country's production capacity has grown far more than the demand leading the industry to under capacity production. By 2014, the actual installed production capacities were 11.2 Mt but consumption was limited only at 5.47 Mt. This left the industry at only 49% capacity utilization rate. This shows that cement supply to Bahir Dar would be sufficient to support the construction industry [23].

2.2.2.2 Ordinary Portland and Portland Pozzolana Cement

There are various types of Portland cements. According to Abebe, the two cements namely; Ordinary (OPC) and Pozzolana Portland Cements (PPC) are cements which are commonly produced by the cement factories in Ethiopia and used for concrete production.

OPC is admirably suitable for use in general concrete construction when there is no exposure to sulphate in contacted soil or in ground water. However, in urban and near urban areas, underground water has higher tendency of getting spoiled with chemicals due to the possibility of percolation of wastes discharged from factories and various chemicals which are used for domestic purposes. Therefore, the placing of sub-structural reinforced concrete elements like footing, mats or piles needs special cement [4].

PPC is produced by partially replacing a certain percentage of the Portland cement by pozzolanic material obtained from volcanic ash. The Pozzolana added varies commonly between 10-30% even higher quantities. Additionally, pozzolanic cement has some resistance to sulfate attack and to attack by weak acids. [19]. According to Gambhir, Pozzolanas aren't reactive by themselves but becomes reactive when it gets in contact with Portland cement. It reacts with the calcium hydroxide liberated from Portland cement at ordinary temperatures to form compounds possessing cementitious properties. Portland pozzolanic cements gain strength slowly and require, therefore, curing over comparatively longer period, but their ultimate strength is approximately the same as that of ordinary Portland cement alone.

Low heat Portland cement such as PPC has approximately half the strength of ordinary Portland cement at 7 days, two-thirds at 28 days and is approximately equal in strength at 3 months.

Pozzolana cements are cheaper than the Portland ones, 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 [24].

2.2.3 Aggregates

Aggregates have two prime functions in concrete; providing concrete with a rigid skeletal structure, and reducing the void space to be filled by the cement paste. Aggregate may be defined as relatively inert mineral filler used in construction of concrete. This aggregate consists of uncrushed or crushed gravel, crushed stone, sand or rock, or artificially produced inorganic materials [36].

Rached et. al, clearly spelt out the purpose of aggregate in concrete. There are two main reasons for increasing the amount of aggregates in concrete. The first is that cement is more expensive than aggregate, so using more aggregate reduces the cost of producing concrete. The second is that, most of the durability problems, e.g. shrinkage, freezing and thawing of hardened concrete are caused by the presence of more cement paste in concrete. Generally, concrete shrinkage increases with increase in cement content; aggregates, on the other hand, reduce shrinkage and provide more volume stability. Furthermore, cement production is a key source of carbon dioxide (CO_2) emissions and reducing its usage should be a goal for concrete production [25].

The important characteristics of aggregates for concrete are; nominal maximum size, grading and mean size, silt, clay or fine dust content, shape and surface texture, water absorption, relative density, bulk density, moisture content [36].According to Troxel,other properties which have particular importance for some aggregates or for some special uses are: chloride content, susceptibility to alkali-silica reaction, deleterious materials content, moisture movement [21].

Mode of production of aggregates accounts for quality and cost of concrete. According to Abebe, it's important to understand its modes of production in an effort to produce the required quality of concrete at a minimum price. Finally, this would be directly related to the shape and surface texture of aggregates and other properties.

Generally, aggregates need to be chemically inert and physically strong and stable. Most natural rocks, whether massive or broken down by nature into gravel and sand, make first-class concreting aggregates. The essential requirement of an aggregate for concrete production is that, it remains stable within the concrete and in the particular environment throughout the design life of the concrete without adversely affecting the performance of concrete [26].

Moreover, aggregates represent the major proportion of concrete by volume. Hence, it has significant importance on the quality of concrete, especially on strength. This is because good aggregates are known to have better crushing strength and better resistance to impact. Not only that aggregates affect the strength of concrete, but also the properties of aggregates such as its size and shape affect the durability and structural performance of concrete [24]. Elongated and flaky particles can affect adversely the durability of concrete; because flaky particles tend to be oriented in one plane, with bleeding water and air voids forming underneath [19].

Attention should be given in choosing aggregate for use in a particular concrete, to three important requirements [18].

1. **Workability**-when fresh for which the size and gradation of the aggregate should be such that undue labor in mixing and placing will not be required.
2. **Strength and durability-**when hardened for which the aggregate should be:

   a. Be stronger than the required concrete strength
   b. Contain no impurities which adversely affect strength and durability
   c. Not go in to undesirable reaction with the cement
   d. Be resistant to weathering action
3. **Economy of the mixture**–meaning to say that the aggregate should be:
   a. Available from local and easily accessible deposit or quarry
   b. Well graded in order to minimize paste hence cement requirement

Pumpability depends on workability of freshly mixed concrete. To this end, Neville, workability determines the ease of placement and the resistance to segregation[19]. In addition, Mikyas,workability comprises at least three separate properties as follows.

1. ***Compactability:*** the ease with wich the concrere can be compacted and the air voids be removed.
2. ***Mobility:*** the ease with wich the concrere can flow through molds, pipes, around reinforced steel.
3. ***Stability:*** the ability of concrete to remain a stable coherent homogeneous mass during he handling and vibration without the constituents segregtion.

Workability and consistency of fresh concrete are principally affected by the materials that constitute concrete. Summarizing the basic influences of the constituent materials on the workability and consistency of concrete [18]:

1. Relative quantities of cement paste and aggregates.
2. Plasticity of the cement paste.
3. Grading of aggregates.
4. Shape and surface characteristics of aggregate particles.

2.2.3.1 Properties of Aggregates

The importance of using the right type and quality of aggregates cannot be overemphasized. The fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete’s freshly mixed and hardened properties, mixture proportions, and economy [36].

2.2.3.1.1 Physical Properties

The physical properties like; specific gravity, porosity, thermal and the chemical properties of an aggregate are attributed to the parent rock. However, the shape and surface texture of natural aggregates and the density in addition to shape and surface texture in artificial aggregates are attributed from the mode of production [13]. It is therefore, very important to give a due consideration to the source and mode of production of aggregates.

2.2.3.1.1.1 Aggregates Size, Shape and Surface Texture

The use of larger maximum size of aggregate affects the strength in several ways. First, since larger aggregates have less specific surface area and the aggregate–paste bond strength is less; aggregate fails along surfaces of aggregates resulting in reduced compressive strength of concrete; secondly, for a given volume of concrete using larger aggregate, results in a smaller volume of paste thereby providing more restraint to volume changes of the paste. This may induce additional stresses in the paste, creating microcracks prior to application of load, which maybe a critical factor in very high strength concretes [19]. Therefore, it makes sense that smaller size aggregates should be used to produce higher strength concrete.

The shape of the aggregate particles, influences paste demand placement characteristics, such as; workability and pumpability, strength and cost. Shape is related to sphericity, form, angularity, and roundness [25].

- ✓ The sphericity measures how nearly equal are the three-principal axis of the aggregate (length L, width W and height H). The sphericity increases as the three dimensions approach equal values.
- ✓ The form or the shape factor, describes the relative proportions of the three axes of a particle. It helps distinguish between particles that have the same sphericity
- ✓ The angularity describes the proportions of the average radius of curvature of corners and edges to the radius of maximum inscribed circle.
- ✓ The roundness describes the sharpness of the edges and corners particle shape can be classified by the following descriptions.

A classification sometimes used in the USA is as follows [19]:

- ✓ Well-rounded –no original faces left
- ✓ Rounded – faces almost gone
- ✓ Sub rounded- considerable wear faces reduced in area
- ✓ Sub angular-some wear but faces untouched
- ✓ Angular- little evidence of wear

The descriptions of angularity and roundness are illustrated in Figure 2.3 below

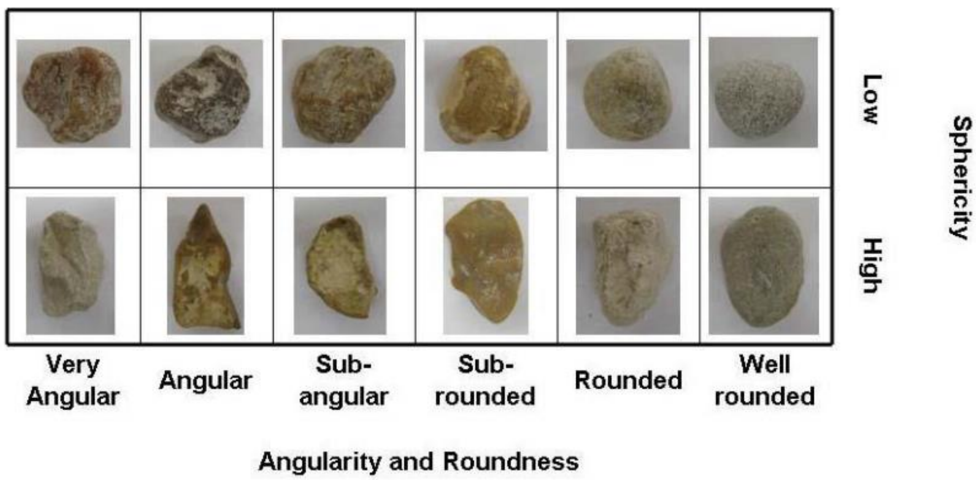


Figure 2.3:Aggregate particle shape [19]

In the case of crushed aggregate, the particle shape depends not only on the nature of the parent material but also on the type of crusher and its reduction ratio, i.e. the ratio of the size of material fed into the crusher to the size of the finished product [19].

The shape of natural aggregates depends on the strength, abrasion resistance and on the degree of wear to which they have been subjected in their depositional environment. Natural aggregates tend be more spherical and less angular. On the other hand, the shape of manufactured aggregate depends on the rock type and the crushing equipment. Manufactured aggregates are more angular when compared to natural aggregates.

Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular and elongated particles require more water to produce workable concrete than smooth, rounded and compact aggregate. Consequently, the cement content must also be increased to maintain the water-cement ratio. Generally, flat and elongated particles are avoided or are limited to about 15 percent by weight of the total aggregate. The essential requirement of an aggregate for concrete production is such that it remains stable within the concrete and in the particular environment throughout the design life of the concrete without adversely affecting the performance of concrete in either the fresh or hardened state.

On the other hand, it seems that the shape and surface texture of aggregate influence considerably the strength of concrete. The flexural strength is more affected than the compressive strength, and the effects of shape and texture are particularly significant in the case of high strength concrete. Possibly, a rougher texture results in a larger adhesive force between the particles and the cement matrix. Likewise, the larger surface area of angular aggregate means, which a larger adhesive force can be developed [19].

The rounded aggregate requires lesser amount of water and cement paste for a given workability [24]. The amount of mixing water could be reduced by 5 to 10% and the sand content by 3to 5 percent. On the other hand, the use of crushed aggregate may result in 10 to 20 percent higher compressive strength due to the development of stronger aggregate-mortar bond. This increase in strength may be due to the development of stronger aggregate-mortar bond. This increase in strength may be up to 38% for a concrete having a water-cement ratio below 0.4. The elongated and flaky particles, having a higher ratio of surface area to volume reduce the workability appreciably. These particles tend to be oriented in one plane with water and air voids underneath. An aggregate with a rough and porous texture is preferred to one with a smooth surface as the former can increase the aggregate-cement bond by 75%, which may increase the compressive and flexural strength up to 20% [19].

2.2.3.1.1.2 Surface Moisture, Porosity and Absorption

With regards of moisture content, the various states in which an aggregate may exist are:

1. Oven Dry (OD),
2. Air Dry (AD),
3. Saturated-Surface Dry (SSD) and

4. Damp or wet. In proportioning the materials for concrete, it is always taken for granted that the aggregates are saturated and surface dry.

It should be noted that, if the aggregates are dry, they absorb water from the mixing water and there by affect the workability and on the other hand, if the aggregates contain surface moisture, they contribute extra water to the mix and thereby increase the water/cement ratio. Both these conditions are harmful for the quality of concrete and they are undesirable [21].

According to the Chinese Construction Standard, the water absorption of coarse natural aggregate and coarse recycled aggregate shall not exceed 0.8% and 10%; respectively [58].

Some of the aggregates are porous and absorptive. Porosity and absorption of aggregate affect the water/cement ratio and hence the workability of concrete. The porosity of aggregate also affects the durability of concrete when the concrete is subjected to freezing and thawing and also when the concrete is subjected to chemically aggressive liquids [27].

In addition, due to the presence of air bubbles, which are entrapped in a rock during its formation or on account of the decomposition of certain constituent minerals by atmospheric action, minute holes and cavities, are formed in it that is commonly known as pores. Since aggregate constitutes about 75% by volume of concrete, the porosity and absorption affect the bond between aggregate and the cement paste, the resistance of concrete to freezing and thawing, chemical stability, resistance to abrasion, and the specific gravity of the aggregate [24].

2.2.3.1.2 Mechanical Properties

According to Shetty, both the shape and surface texture of aggregates influence the strength of concrete; especially, for high strength concrete. Generally, flexural strength is more affected than compressive strength. Rougher texture results in a greater adhesion or bond between the particles and cement matrix.

When bond is good, a crushed concrete specimen should contain some aggregate particles broken right through, in addition to the more numerous ones separated from the paste matrix. On the other hand, an excess of fractured particles suggest that the aggregate is too weak.

When cement paste of good quality is provided and its bond with the aggregate is satisfactory, then the mechanical properties of the rock or aggregate will influence the strength of the concrete. Therefore, it can be concluded that without strong aggregates cannot make strong concrete, for making strong concrete, strong aggregates are essential requirement [27].

It is generally understood that the compressive strength of concrete cannot significantly exceed that of the major part of the aggregate contained therein, although it is not easy to determine the crushing strength of the aggregate itself. The required information about the aggregate particles has to be obtained from indirect tests, such as crushing strength of prepared rock samples, crushing value of bulk aggregate and performance of aggregate in concrete. The aggregate crushing value (ACV) test is prescribed by different standards and is a useful guide when dea1ing with aggregates of unknown performance [26].

Toughness can be defined as the resistance of aggregate to fai1ure by impact and it is usual to determine the aggregate impact value of bulk aggregate based on ASTM standard. Toughness determined in this manner is related to the crushing value and can be used as an alternative test [29].

Hardness or resistance to wear is an important property of concrete used in roads and in floor surfaces subjected to heavy traffic. The aggregate abrasion value of the bulk aggregate is assessed using Los Angeles abrasion machine. The Los Angeles Abrasion test combines the processes of attrition and abrasion and gives results which show a good correlation not only with the actual wear of the aggregate in concrete but also with the compressive and flexural strength of concrete when made with the same aggregate.

Apart from testing aggregate with respect to its Crushing Value and impact resistance; testing the aggregate with respect to its resistance to wear is an important test for aggregate to be used for road constructions, ware house floors and pavement constructions [27].

2.2.3.1.3 Chemical Properties: Alkali-Aggregate Reactions

Alkali-aggregate reactions are chemical reactions in concrete involving certain active mineral constituents often present in some aggregates and the sodium and potassium alkali hydroxides from Portland cement paste. The reactions are potentially harmful only when they produce significant expansion and hence cracking of concrete, leading to loss of strength and elastic modulus.

Alkali-aggregate reactions occur in two forms: Alkali-Silica Reaction (ASR) and Alkali-Carbonate Reaction (ACR). ASR is the reaction between the alkali hydroxide in Portland cement and certain siliceous rocks and minerals present in the aggregates, such as opal, chert and chalcedony. The products of this reaction often result in significant expansion and cracking of the concrete and ultimately, failure of the concrete structure. Alkali-carbonate reaction on the other hand is the reaction between the cement hydroxides and certain dolomitic limestone aggregates which can also result in deleterious expansion. Alkali-silica reaction is of more concern than alkali-carbonate reaction because the occurrence of aggregates containing reactive silica minerals is more common. Alkali reactive carbonate aggregates have a specific composition whose occurrence is relatively rare. Since the occurrence of dolomitic limestone is very rare in Ethiopia, more emphasis should be given to alkali-silica reactions [26].

2.2.3.1.4 Deleterious Substances

According to Abebe (2005), there are three broad categories of deleterious substances that may be found in aggregates: impurities which interfere with the processes of hydration of cement, coatings preventing the development of good bond between aggregate and cement paste, and certain individual particles which are weak or unsound in themselves. These harmful effects are distinct from those due to the development of chemical reactions between the aggregate and the cement paste [26]. Aggregates may also contain sulphate or chloride salts that can be easily removed by washing in fresh water as otherwise it can have dangerous consequences in reinforced concrete structures resulting in corrosion of steel [19].

The concrete aggregate should be free from impurities and deleterious substances that are likely to interfere with the process of hydration and results in prevention of effective bond between the aggregate and matrix. These impurities sometimes reduce the durability of the aggregate. Generally, the fine aggregate obtained from natural sources is likely to contain organic impurities in the form of silt and clay [26].

Poor bond characteristics sometimes excessive silt and clay contained in the fine or coarse aggregates may result in increased shrinkage or increased permeability. The excessive silt and clay also necessitate greater water requirements for given workability, so undesirable. The quantity of clay, fine, silt and fine dust are determined by sedimentation method. To ascertain whether a sample of fine aggregate contains permissible quantity of organic impurities or not, a simple test known as colorimetric test is made [27].

Aggregates shall be free of injurious amounts of organic impurities. The amount of deleterious substance in coarse and fine aggregate according to Ethiopian, and ASTM standards shall not exceed the limits specified in the table below [29, 30].

Table 2.4:Permissible limits for deleterious substances in aggregates [27, 29, 30]

Standards	**ES-permissible**		**ASTM-limits**		**Shetty in (1982)**	
Deleterious substances	**Maximum %, by mass**					
Type of aggregate	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**coarse**
Friable particles clay or fine silt (passing 63 sieve) in fine	1.0	3.0	-	-	1.0	3.0
- Aggregate used for Concrete subject to abrasion	3.0	-	-	-	-	-
All other concrete	5.0	-	5.0	1.0	-	-
Coal and lignite	1.0	1.0	0.5	0.5	1.0	1.0
Clay lumps -		0.25	-	-	1.0	1.0
Material passing sieve 63μm						

including crusher dust	-	1.5	-	-	-	-
Chert as an impurity: Sever exposure: Mild exposure:	 - -	 - -	 - -	 1.0 5.0	 -	 -
Friable particles	-	-	3.0	0.25	-	-
Soft particles	-	-	3.0	5.0	-	-
Material finer than size 200 sieve	-	-	3.0	1.0	3.0	1.0

Note: *The sum of the percentage of all deleterious material shall not exceed five [27].*

By the same analogy, Blackledge advocated, aggregates should be clean and free from organic impurities; aggregate containing organic material makes poor concrete. The particles should also be free from coatings of dust of clay, as these prevent the proper bonding of the material. An excessive amount of fine dust or stone 'flour' may prevent the particles of stone from being properly coated with cement and thus lower the strength of the concrete.

On the other hand, gravels and sand are sometimes washed by the suppliers to remove excess fine (clay and silt, for example) and other impurities, which, if present in excessive amounts, result in a poor-quality concrete. Even though excessive washing can remove all fine material passing the 300µm sieve, this may result in a concrete mix lacking in cohesion and in particular, being unsuitable for placing by pump. Sand deficient in fines also tends to increase the bleeding characteristics of the concrete, which can result in poor vertical finishes due to water scour [28].

2.2.3.1.5 Soundness of Aggregates

Soundness is the resistance of aggregates change in volume as a result of changes in physical or environmental conditions such as freezing, and altering wetting and drying. For example, Neville, states the aggregate is said to be unsound when volume changes result in deterioration of the concrete. This may range from local scaling and so-called pop-outs to extensive surface cracking and to disintegration over a considerable depth, and can thus vary from no more than impaired appearance to structurally dangerous situation [19].

Therefore, aggregate used for concrete production are tested for its soundness and it should comply with the requirement set in specifications. For instance, the Ethiopian Standard (ES.C. D3.201) specifies on coarse aggregate: when subjected to five cycles of soundness test, shall not show loss in mass exceeding 12 percent when sodium sulphate solution is used or 18 per cent when magnesium sulphate solution is used. It specifies on fine aggregate; fine aggregate, when subjected to five cycles of soundness test, shall not show loss in mass exceeding 10 percent when sodium sulphate solution is used or 15 percent when magnesium solution is used [30].

Fine aggregate subjected to five cycles of the soundness test shall have a weighted average loss not greater than 10 % when sodium sulfate is used or 15 % when magnesium sulfate is used [29].

2.2.3.1.6 Grading of Aggregates

According to Gambhir, the grading of aggregates affects the workability, which, in turn, controls the water and cement requirements, segregation, and influence the placing, and finishing of concrete. These factors represent the placing and finishing of concrete and affect properties in the important characteristics of fresh concrete as well as properties in the hardened state. Therefore, aggregate has to conform to the grading requirement of standards specified on the technical specification.

The particle size distribution of an aggregate as determined by sieve analysis is termed grading of aggregate. If a concrete contains aggregate of uniform size; the compacted mass will contain a lot of voids. However, use of graded aggregate produces dense concrete and needs less quantity of fine aggregate. Therefore, a well-graded aggregate is required to produce quality concrete [24].

Coarse aggregate shall consist of gravel, crushed gravel, or crushed stone. The grading or particle size distribution of coarse and fine aggregate on ES and ASTM shall be within the limits specified in the tables below.

Table 2.5: ES- grading requirement for coarse aggregate [30]

Normal size of graded aggregate, mm	Percentage passing through test sieves having square Openings						
	75mm	63mm	37.5mm	19mm	13.2mm	9.5mm	4.75mm
37-5	100	-	95-100	30-70	-	5-10	0-5
19-5	-	-	100	95-100	-	25-55	0-10
13-5	-	-	-	100	90-100	40-85	0-10

According to the Ethiopian Standard (ES.C. D3.201) fine aggregate shall consist of natural sand obtained from the natural disintegration of rock or sand obtained from crushed stones. The grading or particle size distribution of fine aggregate shall be the limits specified in the table below. The Ethiopian Standard and the ASTM (1999), standard have the same grading requirements i.e. Ethiopian Standard might be adopted from ASTM, Standard. The fine aggregate shall not have more than 45 percent retained between any two consecutive sieves. The fineness modulus shall not be less than 2.0 or more than 3.5 with a tolerance of 0.2 [29]. However, according toast, the fineness modulus shall not be less than 2.3 or more than 3.1[30]. Hence, Ethiopian Standard (ES.C. D3.201) is locally adopted standard; this research is governed by Ethiopian Standard.

Table 2.6: ASTM and ES- grading requirement for fine aggregate [28, 29]

Sieve Size (mm)	**Percentage Passing**
9.5	100
4.75	90-100
2.36	80-100
1.18	50-85
600µm	25-60
300µm	10-30
150µm	2-10

2.2.3.2 Durability of Aggregates

According to Blackledge, aggregates make up the bulk of concrete, any lack of durability of the aggregate will have disastrous consequences for the concrete. If there are durability problems, special screening tests may be required, routinely to avoid problem aggregates or special measures must be taken to counter act the effects of undesirable aggregates.

Aggregates should be hard and should not contain materials that are likely to decompose or change in volume when exposed to weather. Examples of undesirable materials are lignite, coal, pyrite and lumps of clay [28].

2.2.3.3 Origin and Classification of Aggregates

Aggregates can be classified as natural or artificial depending on their sources. Natural aggregates are obtained from quarries by processing crushed rocks or from riverbeds while artificial aggregates are obtained from industrial by products such as blast furnaces lag. Natural aggregates are most commonly obtained and are relevant for the Ethiopian construction sector since artificial aggregates are hardly produced in the country [18, 26].

Physical and mechanical properties of aggregates are inherited from parent materials, while the properties of the parent material intern depend on its geological formation. Geologically rocks are classified into three major divisions based on their origin, namely Igneous, Sedimentary and Metamorphic. Igneous rocks are rocks formed from the solidification of molten matter (magma) either at or below the earth’s surface. Igneous rocks are divided into two: plutonic or intrusive, those having cooled slowly within the earth (e.g. granite, diorite, gabbro, etc.) and volcanic or extrusive, those which are formed from quick cooled lava (e.g. volcanic rock, volcanic glass, felsite, basalt, etc.). Plutonic rocks usually have grain sizes larger than 1mm and classified as coarse or medium grained while volcanic rocks have grain sizes less than 1mm and are classified as fine-grained. These grains are, however, not visible to the naked eyes [26].

The rocks in the vicinity of Lake Tana were studied mainly extrusive volcanic rocks representing three or more phases of volcanic activity. The Lake Tana sub-basin is formed by structural deformation, erosion and extrusions of volcanic rocks. It is surrounded by volcanic mountains, consisting primarily of basaltic lava flows associated with tuff, trachytic and rhyolitic rock types [31].

The study of Shetty reveals that, sedimentary rocks are formed as strata as a result of sedimentation from disintegrated products. They are stratified rocks usually laid down under water although they can also be formed by wind and glacial action. The sediments are cemented together or compacted during geologic time with varying degree. Typical examples are sand stone, limestone, and shale.

Metamorphic rocks are formed from pre-existing igneous, sedimentary or metamorphic rocks by the action of heat or pressure or both. The change may be textural, structural or mineralogical accompanied by changes in chemical composition. Typical examples are marble, meta-quartzite, and slate.

Most igneous rocks make highly satisfactory concrete aggregates because they are normally hard, tough and dense. Therefore, bulks of the concrete aggregates are derived from igneous rocks.

The most widespread of all the igneous rocks are basalts. Basalts are dark colored, fine-grained extrusive rocks. Most basalts are volcanic in origin and were formed by the rapid cooling and hardening of the lava flows. Some basalts are intrusive having cooled inside the Earth's interior.

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

The thickness of the stratification of sedimentary rock may vary from a fraction of a centimeter to many centimeters. If the stratification thickness of the parent rock is less it is likely to show up even in an individual aggregate and thereby it may impair the strength of the aggregate. Such rocks may also yield flaky aggregates. The degree of consolidation, the type of cementation, the thickness of layers and contamination, are all important factors in determining the suitability of sedimentary rock for concrete aggregates [27].

Table 2.7:Classification of rocks according to their mode of formation [18]

Igneous	**Sedimentary**	**Metamorphic**
Formed from the solidification of molten rock 1. Volcanic - Basalt - Trachyte 2. Plutonic - Granite	Formed as strata as a result of sedimentation from the disintegration products derived from rocks. - Sand stone - Lime stone - Shale	Either igneous or sedimentary that has been altered structurally and mineralogically by heat or pressure or both acting together.
They are very good concrete making materials.	If hard, sand stone and lime are good materials for concrete.	They are of minor interest for building purposes except marble

It was found in some literatures that, the type of rock normally used for concrete production in Ethiopia is igneous rock. For instance, Denamo states, especially, basalt and rhyolites are widely used. In addition to igneous rocks, sedimentary rocks such as black limestones are also used for concrete production [13].

2.2.3.4 Production of Aggregates

The mode of production of the aggregates differs depending on the type of aggregate produced. The two dominantly produced aggregates, lightweight namely scoria and normal weight basalt do have different modes of production. The light weight aggregate is produced from quarries by simple digging or bulldozing as itis a soft material and the different sizes produced mainly depend on digging or bulldozing. The normal weight aggregates, on the other hand, are drilled, blasted or dug with special mechanisms, fed to crushers, sieved and separated according to their sizes. In Ethiopia, the different sizes commonly known as: Fine01, 02, 03 and 04 are produced and stockpiled separately [13].

A research was carried out by Tigist(2002), as cited in Abebe, to test the potential use of local normal weight aggregates around Addis Ababa for the production of high strength concrete. The result confirmed that the locally available basalt stone can reasonably be used to produce concrete of higher strength. With the application of super plasticizers, concrete strength of 90MPa was obtained. This result was obtained by proper selection of aggregates (removing friable particles), limiting the maximum size of aggregates (higher strength can be attained with smaller maximum sizes) and washing (to remove material finer than No. 200 sieve) and using higher quantity of cement in combination with limiting the w/c ratio. Nevertheless, from this result it is possible to see that the widely used concrete class C-25 is a low grade as compared to the potential of producing higher strength concrete [26].

The production method of sand in Ethiopia is so primitive that the sand produced in this manner is exposed to the following situations; according to Denamo.

1) Since it is collected in a primitive manner by human labor using small hand tools, it is susceptible to a greater degree of non-uniformity; this non uniformity can be expressed by its gradation.
2) Since it is transported by donkey and collected somewhere in an unprepared ground, it is susceptible to contamination by deleterious substances.
3) There is no room for quality checkup.
4) There is no room for modern production of standardized product.
5) Most sand producers are local farmers who have no detail technical knowledge about the material they produce. The only knowledge they have doesn’t go far from what they are informally heard from their product customers.
6) The local producers are quite numerous in a single local area that it is difficult to get consistent supply from a specific area.
7) Since the sand itself is naturally available material it is quite difficult to get a consistent supply from same location even in hour’s interval.
8) There is wastage of material in the process.

Coarse aggregate is produced in Ethiopia using aggregate crushers and by crushing manually using human labor and small hand tools. Especially, in rural areas and in construction sites where the course aggregate demand is low manual crushing is normally experienced. In addition, the crusher plants vary in size and production quality [13].

2.2.3.5 Benefits of Standardization

According to Denamo, the important general benefits of standardization are as follows:

1) Standardization helps reduce inventory items on site.
2) It helps in evolving better means of communication about the material being considered.
3) It forms a base for further inventory analysis.
4) The specification of items can be more clearly spelled out, making quality control firm. By using national standards, it is easier to locate sources of supplies.

The importance of standardization in the construction industry especially for construction materials cannot be overemphasized. The industry has become increasingly interested in assessing its economic efficiency, and thus is more interested in the role of standardization. Systematic and reliable results can be attained on a common basis [13].

2.2.3.6 Researches Related to Aggregates

There was a thesis submitted to the school of graduate studies of Addis Ababa University by Denamo, under the title “handling of concrete making materials in the Ethiopian construction industry” to assess situation of handling of concrete making materials in the Ethiopian construction industry through collecting results of different tests done on concrete making materials from different parts of Ethiopia. The result showed that from the total number of tests carried out, 44% of the tests were not incompliance with the requirements of standards. This was an indication that more than 44% of the tests carried out on the aggregates supplied for concrete production in the country were not met by the concrete aggregates. Further, out of the 44% of the tests at which the aggregates failed to satisfy requirements, 71% of the tests attributed to the production property of the aggregates which was not related to the property of the parent rock. This shows aggregate production need close follow up to control the quality of aggregates [13].

There was a recent study by Abel, to assess the quality of sand sources, the effect on workability, compressive strength and cost of concrete in and around Bahir Darwinianly, questionnaires and interviews were made with stakeholders finally different natural sand samples were collected from 13 sand sources then; their physical and chemical properties were tested in the laboratory. The result revealed that stakeholders gave little attention for sand quality tests and the respondents have no satisfaction on the quality of sand. In this study, the test results obtained had shown that, all of the sand sources could not satisfy the graduation requirement. In addition, 84.62% were more on the coarser side and about 76.93% had non-acceptable fineness modulus whose value lies between 2.3 and 3.1 against ASTM C33-01 limit. It was also observed from the test results that, 92.31% by volume and 77% by weight failed to meet the silt and clay content limits set by standards. Silt and clay contents of as high as 24.69% by volume were observed from the Lake Tana sand sample. The sand samples were also subjected to organic impurity tests. The results had shown that, about 85% of the collected sand samples were within the organic limit set by standard requirements (AASHTO T21). On the other hand, about 92.3% had loose unit weights and 76.9% had compacted unit weight, which are not in the common ranges of unit weights of sand. The bulk specific gravity was found to be in the range of 2.54 to 2.74; while the water absorption was from 1.66 to 2.92.Soundness tests were also carried out on samples taken from the three top most common sand sources the values found were far above the maximum limit stated by standards (ASTM C-33) (i.e. 24.08, 23.40 and 25.14 for Arno, Tana and Tis-Abiy respectively [32]. The result shows that using fine aggregate without any treatment can affect the property of fresh and hardened concrete. For example, to get intended workability and strength of concrete is blending of different sources of natural sand was found to be a better option.

Another research conducted by Ebenezer assess the effect of partially replacing natural sand with crushed rock fine on the workability, compressive strength and cost of the produced concrete was carried out. To achieve the objective, natural and crushed rock fine sample to be used in the concrete mixes were collected from a specific source. The result of fresh concrete property showed that, partial or full replacement of natural sand with crushed rock fine has a negative (decreasing) effect on the workability of the fresh concrete; but this problem can be eliminated by using the suitable admixture (super plasticizer).In addition, a maximum increase in compressive strength by 14.13% was seen when natural sand was fully (100%) replaced by crushed fine rock without using admixture and 15.79% increase when a 1% super plasticizer is added to the mix. The outcome of the research recommended using crushed fine rock as a replacement of natural sand with proper admixture for the concrete construction works in and around Bahir Dortha result revealed that conventional natural sand can be potentially replaced by crushed fine rock using relevant admixture results better quality fine aggregate for intended quality concrete [33]. The researcher believes that, the use of partially replaced sand with crushed fine rock for concrete production is a better option.

There was a research by Habtamu, to find out the effect of silt and clay in sand on concrete workability, compressive strength, and to realize the stated objective of the study. The researcher assessed construction sites and carried out laboratory investigations. The mixes were designed to achieve a compressive strength of 25 MPa with a target mean strength of 33.5 MPa. According to the mix design, it was determined to use 364.56 kg of cement with a water to cement ratio (w/c) of 0.491 to get a fresh concrete with a slump of 25-50mm and a hardened concrete with 25 MPa compressive strength at 28 days.

Table 2.8 Slump test results of individual trial mix [34]

Silt and Clay Content (%)	**Workability (mm)**
0	50
3	48
5	45
7	40
10	31
15	20

The correlation between silt and clay in sand and workability of concrete was as shown in table above. It can be clearly observed that, the workability of concrete decreases with the increase in silt and clay content of sand.

Table 2.9: Compressive strength test results of all casted cubes [34]

Age of concrete cubes (days)	**Silt and clay content (%)**					
	0	3	5	7	10	15
	Compressive strength (MPa)					
3	17.10	15.20	14.30	12.50	10.58	10.50
7	26.70	24.60	22.30	18.40	17.10	14.20
14	31.50	27.10	25.80	20.70	18.80	15.80
28	33.68	29.30	27.10	22.10	21.10	17.20

The results showed that, the compressive strength decreased with an increase in silt and clay content. The table above indicated the strength development of the concrete trial mixes with 3, 7, 14- and 28-days age of testing. The mix was designed for a target mean strength of 33.5 MPa, but it was only the concrete mix with 0% silt content that has achieved the set strength requirement. The compressive strength decreased from 33.69 MPa to 29.3 MPa for 28-day strength due to the presence of 3% silt and clay particles in the sand. There was a 16.49 MPa loss in compressive strength of concrete because of 15% silt and clay addition to the concrete mix. A concrete cube with the age of 28 days casted with sand that contains 3% silt and clay content lost about 13% of its strength. The same concrete casted with sand that contains 15% loses its 49% strength due to the silt and clay incorporation. The effect of silt and clay content on fresh and hardened concrete is significant and remedial measures are needed either by adding more cement or washing the sand [34].

2.2.4 Admixtures

A material other than cement, aggregate, water and other additives like Pozzolana or slag added to the concrete batch immediately before or during the its mixing to modify one more of the properties of concrete in the plastic or harden state. The different types of admixture are as follows:

a) ***Accelerating admixtures:*** It accelerates setting of concrete. It is mainly used in cold weather concreting.

b) ***Retarding admixtures:*** It expands the setting time of concrete. It is mainly used in hot weather concreting.
c) ***Water reducing admixtures:*** This reduces the amount of water without affecting workability of concrete.
d) ***Air-entraining admixtures:*** It is mainly used in concrete exposed to freezing and thawing conditions.
e) ***Super plasticizing admixtures:*** it is used to significantly reduce the water content while maintaining workability and to gain high strength. Generally, admixture is used 0.5 -1.2 % of weight of total cementitious material (cement + fly ash + GGBS).

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 [36].

In RMC Plant admixtures mainly perform the following functions [35].

- ✓ Reducing water content and hence increasing strength.
- ✓ Increasing durability of concrete.
- ✓ Accelerating and decreasing setting time of concrete.
- ✓ Avoiding segregation and bleeding in concrete.
- ✓ Increasing pump ability of concrete.

2.2.5 Concrete production

Only a good concrete mix design isn’t sufficient in getting the intended concrete quality product, rather the concrete placed in a structure must be of uniform quality, free of voids and discontinuities, and adequately cured. Hence, the proper execution of the operations in the production process, namely, batching, mixing, transportation, placing, compaction, finishing and curing are important in attaining the desired quality. Concrete production is a scientific process that is based on some established principles and governs the properties of concrete mixes in fresh as well as in hardened state [19, 24].

The process of determining required and specifiable characteristics of a concrete mixture is called mix design. Characteristics can include [36].

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. A properly proportioned concrete mix should possess these qualities.

1. Acceptable workability of the freshly mixed concrete
2. Durability, strength, and uniform appearance of the hardened concrete
3. Economy

Strength (compressive or flexural) is the most universally used measure for concrete quality. Although it is an important characteristic, other properties such as durability, permeability, and wear resistance are now recognized as being equal and in some cases more important, especially when considering life-cycle design of structures. Within the normal range of strengths used in concrete construction, the compressive strength is inversely related to the water-cement ratio or water-cementing materials ratio. For fully compacted concrete made with clean, sound aggregates, the strength and other desirable properties of concrete under given job conditions are governed by the quantity of mixing water used per unit of cement or cementing materials [36].

During batching, quantities should be measured with a high degree of accuracy. For solid granular materials, such as aggregates and cements, batching is best done by weight. Only water and liquid admixtures can be measured accurately by volume. Batching by weight also follows rapid and convenient adjustments aggregates and water contents when changes in aggregates moisture contents occur [24].

Further, batching is the process of measuring concrete mix ingredients by either mass or volume and introducing them into the mixer. To produce concrete of uniform quality, the ingredients must be measured accurately for each batch. Most specifications require that batching be done by mass rather than by volume (ASTM C 94 or AASHTO M 157). Water and liquid admixtures can be measured accurately by either volume or mass.

Volumetric batching (ASTM C685 or AASHTO M 241) is used for concrete mixed in continuous mixers [29].

Careful attention should be paid to the required mixing time. Many specifications require a minimum mixing time of one minute plus 15 seconds for every cubic meter (yard), unless mixer performance tests demonstrate that shorter periods are acceptable and will provide a uniform concrete mixture. Short mixing times can result in nonhomogeneous mixtures, poor distribution of air voids (resulting in poor frost resistance), poor strength gain, and early stiffening problems. The mixing period should be measured from the time all cement and aggregates are in the mixer drum, provided all the water is added before one-fourth of the mixing time has elapsed [36].

There was a research carried out by Abebe, under the title *"Concrete Production and Quality Control in Building Construction Industry of Ethiopia"* through collecting sample compressive strength test result data and information on qualities of concrete ingredients and methods of concrete production using questionnaire and site observation. The findings of the investigation had shown that in most of the projects sufficient tests were not conducted both for the coarse and fine aggregate, 51.23 % of the projects` quality control is not good and more than half, 52.17% of the projects had got defective lots, which failed to satisfy the compliance requirement set on the Ethiopian building codes and standards. This indicates that a lot has to be done to improve concrete quality in the building construction industry [4].

2.2.6 Storage and Handling Construction Materials

Neville, notes the following: materials required in construction operations shall be stored, and handled in a manner to prevent deterioration and damage to the materials, ensure safety of workmen in handling operations and non-interference with public life including safety, prevention of damage to property and natural environment. Materials shall be stored and placed so as not to endanger the public, the workers or the adjoining property. Stairways, passageways and gangways shall not become obstructed by storage of building materials, tools or accumulated rubbish.

Materials shall be separated according to kind, size and length and placed in neat, orderly piles. High piles shall be staggered back at suitable intervals in height. Handling of aggregate is one vital recommendation should be mentioned: coarse aggregate should be split into size fractions approximately 5 to 10, 10 to 20, 20 to 40 mm.

Materials stored at site depending upon the individual characteristics shall be protected from atmospheric actions; such as rain, sun, winds and moisture to avoid deterioration. Improper handling of aggregates can result in contamination by other aggregate or by deleterious material [19].

A research was carried out by Yonas, to assess the current situation of handling and storage of concrete aggregates in and around Woodie construction sites. Towards achieving the research objectives, data were collected on qualities of concrete aggregates and method of handling and storage through observations, interviews, questionnaires and finally laboratory tests were conducted by collecting concrete aggregates from sources and selected active projects which were using the same sources. The results showed that the physical and mechanical properties such as, silt and clay content, moisture content and gradation indicated that the collected aggregates from sources and project sites do not satisfy the Ethiopian Standards. Sufficient tests were not conducted on ingredients used for the production of concrete. During the observations made, concrete making materials were not stored properly till the time of usage and beyond. They were placed in a place where they could be easily contaminated with dust and other pollutants. According to the obtained test results, 37.5% of coarse and 50% of fine aggregates samples from construction sites in the study area could not satisfy the requirements set by standards [59].

2.2.7 Identification and Causes of Material Wastage

2.2.7.1 Identification of Material Wastage

Building material wastage can be defined as the difference between the value of materials delivered and accepted on site and those properly used as specified and accurately measured in the work after deducting the cost saving of substituted materials transferred elsewhere in which unnecessary cost and time may be increased by the material wastage [37].

There are many ways through which causes of wastage can be identified. Identified two areas of responsibility where action can be exercised to control material wastage, namely, in the design stage and management on site [38]. Waste can be categorized according to its source namely, the stage in which the root causes of waste occur [39]. Waste may result from process preceding construction such as material manufacturing, design, material supply, and planning as well as the construction stage.

Wastage was divided into two types; the first is direct waste which is the loss of these materials, which were damaged and subsequently used or which were lost during the building process. The second is indirect waste which was distinguished from direct waste because it is a monetary loss and the materials were not lost physically [40].

2.2.7.2 Causes of Material Wastage

The main causes of waste were classified in construction into six sources, which are design, procurement, material handling, operation, residual, and others used the same six categories [41, 42].

Waste production on construction sites is often due to inadequate storage and protection, poor or multiple handling, poor site control, over ordering of material, bad stock control. The “Wrong and lack of space for storage of materials” was ranked in the fourth position with Importance Index of 50.75 [43]. This cause can result in many different ways. Similar studies concluded that inappropriate storage of material was one of the main causes of wastage on construction projects. For instance, a study by Muhwezi et.al, in (2012) classified materials wastage on building construction projects into 9 groups. These are design and documentations, site management and practices, procurement, materials handling, storage, transportation, operation, and environmental and other conditions [44].

Table 2.10:Direct causes of material wastage [41]

Source	**Cause**
Design	Error in contract document
	Poor design
	Contract document incomplete at commencement of construction
	Change to design
	Choices about specifications of products
	Choice of low-quality products
	Lack of attention paid to sizes of used products
	Designer is not familiar with possibilities of different products
	Lack of influence of contractors and lack of knowledge about construction
Procurement	Ordering error, over ordering, under ordering, and so on
	Lack of possibilities to order small quantities
	Use of products that do not fit
Material Handling	Damaged during transportation to site/on site
	Inappropriate storage leading to damage or deterioration
	Unpacked supply
	Throwaway packaging
Operation	Error by tradesperson or laborer
	Equipment malfunction
	Inclement weather
	Accidents
	Damage caused by subsequent trades
	Use of incorrect material, requiring replacement
	Required quantity of products unknown due to imperfect planning
Residual	Conversion waste from cutting uneconomical shapes
	Over mixing of materials for wet trades due to lack of knowledge of requirements
	Waste from application process
	Packaging
Others	Criminal waste due to damage or theft
	Lack of onsite materials control and waste management plans

According to Bat Coda (Building and Transport Construction Design Authority) the Standard limit for wastage in the Ethiopian construction industry are as shown in the following table.

Table 2.11:BaTCoDA standard limits for wastage [45]

Concrete Materials	**Wastage (%)**
Cement	5%
Sand	15%
Coarse aggregate	15%
Steel reinforcement	5%
Hollow Concrete Block	5%
Brick	5%

A research undertaken by Aristo assess the extent, causes and effects of construction materials waste on selected building construction projects, based on case studies and questionnaires survey in Bahir Darfur practical reasons, it was confined to five different construction materials; namely, cement, fine aggregate, coarse aggregate, HCB, and reinforcement bar. The research revealed that, the main causes of material waste were purchased materials that don't comply with specification; over ordering due to incorrect estimate; lack of attention paid to dimensions of products available in the market; lack of workers' awareness; and rework contrary to drawings and specifications. He also identified the wastage levels of the five major materials are as shown in table below [46]. Therefore, the wastage level of construction materials in Bahir Dar is above the Bat Coda specification limits.

Table 2.12: Wastage level of the five major materials in Bahir Dar [45]

No.	Material	Wastage in %
1	Cement	12.78%
2	Sand	17.68%
3	Coarse Aggregate	13.08%
4	HCB	12.94%
5	Reinforcement Bar	10.23%

2.2.7.3 Wastage Minimization in RMC Plant

According to Aynor et.al, concrete waste forms the major ingredient of the construction solid waste, accounting for 50% of the total construction and demolition waste generation. Although hardened concrete is not dangerous, fresh concrete can cause serious burns to human skin and damage soil and water as it is alkaline. Therefore, it is necessary to minimize or fully eliminate the disposal of fresh concrete waste. This can provide several benefits as follows.

- ✓ Reduction in the consumption of non-renewable natural resources,
- ✓ Reduction of areas destined for landfill,
- ✓ Reduction of the energy consumption,
- ✓ Reduction of pollution in the cement production.

The concrete returned to a batching plant can be divided into two types:

(i) **Over-ordered concrete**; of which frequency depends on the accuracy of the ordering and delivery practices and

(ii) **Leftover concrete**; which is always observed in a truck mixer after each delivery.

Aggregates can be reclaimed from the mud that results from washout and cleaning operations of truck mixer drums at the end of each working day to prevent the small amount of the fresh concrete residue from setting in the drum overnight. About 8-10 tons of the fresh concrete waste can be produced every day from a concrete batching plant with a daily output of 1000 m^3 of concrete, which typically corresponds to 0.4-0.5% of the total production. There is about 300-350 kg of mortar remaining or adhering to the inside of each truck mixer drum. These numerical values confirm that it represents a heavy burden for contractors, batching plants, and the environment [60].

Current methods of processing the returned concrete include the following opportunities and change with the type of the returned concrete is shown in the figure below.

Table 2.13: Methods of processing the returned concrete from construction sites [60]

Methods of processing	Description
a. Direct ingredient of new batches	✓ It can be used as a direct ingredient as partially hydrated cementitious materials (PHCMs) in the new concrete. ✓ PHCMs act as an effective setting and hardening accelerator without the need for the accelerating admixtures.
b. Discharging into settling basin	✓ This option is applied especially by small and medium-sized batching plants. ✓ A series of interconnected washout pits can be used to allow the progressive settlement of cement solids and other fines. ✓ The sufficiently drained solid sludge is either used as a fill material for detour roads or disposed in landfills.
c. Discharging onto ground	✓ Excess concrete material is discharged onto the ground at a particular location in the plant until hardened although this does not seem to be an environmentally friendly method. ✓ Hardened concrete is then dumped to a landfill or crushed to produce aggregates.
d. Pre-cast components	✓ Pre-cast concrete elements (e.g., blocks for breakwaters or retaining walls, pads, and bulkheads) are produced by the over-ordered concrete at the batching plant. ✓ However, this possibility can be very limited by local market conditions and opportunities.
e. Mechanical recyclers	✓ The coarser sand and aggregates can be reused as a replacement of natural fine aggregates for new construction works. ✓ About 42% can be recycled as coarse aggregate from concrete waste.

	✓ Concrete that contains 15-30% recycled fresh concrete waste aggregates is optimum for producing normal strength concrete.
f. Hardened slurry cake in concrete	✓ To replace natural aggregates, hardened slurry cake remained after coarse and fine aggregates in residual fresh concrete is recycled and taken. ✓ In case of the use of this waste in the new fresh concrete, some important physical properties are adversely affected. ✓ However, it is possible to match the designed compressive strength of concrete containing no more than 30% hardened slurry cake aggregate with that of the corresponding natural aggregate concrete. ✓ Therefore, hardened slurry cake can be used for non-structural concrete production.
g. Hardened slurry cake in partition wall blocks	Can also be used in the production of partition wall blocks. In this case, blocks produced with waste aggregates of 50% show the highest compressive strength.
h. Hydration stabilizer admixtures	✓ Recycling can be made by chemical systems based on the addition of extended set-control or hydration stabilizer admixtures (i.e., super-plasticizers). ✓ The concrete mix can be maintained in a deactivated state for maximum 3 days. ✓ Set-retarding admixtures do not adversely affect important mechanical parameters of concrete.
i. Superabsorbent polymer (SAP)	✓ Recycling efforts can be realized by chemical systems based on the addition of a non-toxic additive called SAP into the truck mixer drum without the need of any specific equipment. ✓ After its addition, a mixing process of 6-7 minutes takes place, followed by discharging and curing procedures. ✓ Thus, 1 m^3 returned concrete can be transformed into 2.4 tons of new aggregates.

Pre-cast concrete elements (e.g., blocks for breakwaters or retaining walls, pads, and bulkheads) are produced by the over-ordered concrete at the batching plant. However, this possibility can be very limited by local market conditions and opportunities [60].

2.3 The Nature of Supply and Demand for Ready-Mix Concrete

2.3.1 The Nature of Supply

This section discusses factors that influence the industry from the supply side: what individual plants look like, how industry firms are structured, technological change, and producer turnover.

2.3.1.1 A Typical Ready-Mixed Concrete Plant

According to Syverson, the manufacturing process for RMC can be crudely analogized to factories. They include facilities for handling raw materials, usually including steel cement silos (cement must be protected from moisture in the air, lest it harden prematurely), open piles of aggregate (sand, gravel and rock) sorted by size, a payloader and conveyor system for moving aggregate, and a water source. There is also often a structure with limited office space and rooms that house controls for the batcher the equipment that weighs and feeds the various ingredients into the mixing bin. The bin sits in an elevated structure to allow drivers to pull the mixer trucks, which are the other key pieces of capital equipment found at ready-mixed plants, underneath for loading.

Numbers from the 2002 Census of Manufactures as cited by Syverson (2004), the latest for which comprehensive data are available, offer a sense of the economic scale of a typical ready-mixed plant. The average value of raw materials inventory on hand at a plant was $81,000. The average book value of its capital stock (both structures and equipment) was $2.2 million, and mean annual sales were $3.9 million. This typical plant had 18 employees, 14 of whom were considered production workers (which include truck drivers).

2.3.1.2 Firm Structure

RMC plants, whether in single-plant firms or not, are usually highly specialized. Plants in the industry fabricate few precast concrete products; despite similarities in precast concrete's production process and that the ultimate buyers in the construction industry are often the same. Well over 90 percent of ready-mixed plants revenues come from ready-mixed sales, meaning single-plant firms in the industry derive the vast majority of their revenues from their primary product. Plants making prefabricated concrete products are similarly specialized in those products, with less than 10 percent of their revenues accounted for by ready-mixed sales.

Multi-plant firms with RMC operations tend to be more diversified, but their diversification comes through owning plants another industry. These can be prefabricated concrete operations, cement plants, or sand and gravel mines. For instance, in 1997, about half of the ready-mixed plants that were owned by multi-unit firms were owned by firms that also operated plants in other industries besides ready-mixed concrete. Thus, diversification among larger firms is not universal, since the other half of plants in multi-unit firms are owned by businesses that are ready-mixed specialists. This would greatly help the RMC plant in Bahir Dar to control quality of incoming concrete making materials, develop supply chain management, and reduce the unit volume cost RMC.

2.3.1.3 Technological Change

The basic process for making ready-mixed concrete has not changed for the past 60 years: dry raw materials are measured, loaded into a bin, mixed, placed into a truck, and water is added (sometimes the order of the last two steps is interchanged). However, the modest technological advances that have occurred in the industry have come in five areas such as the 1stchange is automated batching systems, the2nd change is the substantial increase in the capacity of concrete trucks, the 3rd change is a continuing expansion in the variety of chemical admixtures that can be added to a concrete batch to affect its properties in useful ways, the 4th change involves improvements in logistical coordination gained through the move toward centralized delivery dispatch and finally the 5thtechnological advance affected the concrete industry.

2.3.1.4 Environmental Concerns

Ready-mixed concrete plants can emit both waterborne and airborne pollutants. The former includes spilled oil or fuel, as well as fine and coarse particles of aggregates and cement, which can be inherently detrimental as well as raise the alkalinity of runoff water to toxic levels. Airborne emission concerns primarily involve dust from the concrete mixing process itself or from trucks driving on unpaved portions of plants. Plants typically monitor potential pollutants and control them as required. Runoff water is often captured in settling ponds that allow solids to be separated before the water is either discharged or recycled. Dust is controlled by hooding mixing facilities and either paving or occasionally spraying-down unpaved areas of the plant.

2.3.1.5 Producer Turnover

Now a day, RMC plants are making high profits. For example, Syverson by(2004) suggests that turnover rates would be even higher, given the volatility of construction demand for concrete [47].

2.3.2 The Nature of Demand for RMC

This section discusses factors that influence RMC demand: mainly depending on the customers' market need within the construction industry, the nature of the product, and its common substitutes. According to Syverson, elaborates the subject as follows.

2.3.2.1 Ties to Local Construction

The ready-mixed industry's fortunes are closely tied to the level of activity in the construction sector. The sector buys the vast majority of ready-mixed output. The basic demand conditions faced by ready-mixed producers in any given local market depend on how robust construction activity is in that same market, not elsewhere. Moreover, this variation in market demand is likely to be exogenous to the nature of competition among local ready-mixed concrete plants. This is because construction projects require intermediate materials from a wide array of industries, making the cost share of ready-mixed small.

2.3.2.2 Relationship Capital

Despite its physical uniformity, a source of non-spatial differentiation does exist in the industry. This entails the "relationship capital" built between specific suppliers and their customers. Long-run buyer-supplier ties, whether driven primarily by business or personal bonds, are common in the industry. While their influence is difficult to quantify, anecdotal evidence is plentiful. For example, a cement company president testified to the Federal Trade Commission that forward integrating into existing ready-mixed concrete firms was easier than building a business from scratch. His reasoning was, "The ready-mixed business, as we analyze, it is a very personal type of business and the operators develop personal relationships with contractors over many years. To go in and go through developing those relationships on the part of a newcomer would assure you that you are going to lose money for 3, 4, 5 years.

2.3.2.3 Substitutes

RMC faces potential competition from various substitute products. For example, Syverson, concluded in building construction, prefabricated concrete is the most likely outside option. Concrete block can be used for walls and pre-stressed structural concrete slabs (complete with embedded reinforcing bars) for floors. Recall that prefabricated concrete products are typically made at plants that do not also make ready-mixed, so such substitution does not simply imply buying a different product from the same producer. Another option is to use steel, wood, or stone as building materials. In road construction, asphalt is a popular alternative. Asphalt is physically akin to concrete; it is also comprised of aggregate mixed with a binding agent, except in asphalt the binder is bitumen, a product of petroleum refining, rather than the hydrated cement in concrete. However, most firms making either product do not make both but can Ready Plant can do [47].

2.3.3 Factors Affecting Future Growth of RMC

According to a research by Jain, in India, the followings are some of the factors, which are considered as critical in the future development of RMC [6].

- ✓ Consolidation of construction industry. The average size of individual civil contract would increase.
- ✓ Mechanization of construction and premium on mechanized construction in tender evaluation and awards.
- ✓ Changes in contract specifications and introducing separate rates for RMC and site mixed concrete. Recognizing RMC as a separate product than site mixed concrete.

- ✓ Changing codes and standards makes it mandatory for medium and major construction sites to use RMC. Similar changes in specification of major construction organization in government /Private Sectors.
- ✓ Availability of land in urban areas by local authorities on long-term lease at reasonable rates to RMC producers.
- ✓ Production of quality RMC equipment conforming to international standards to bring down initial cost of the project. Initiative has already been taken by reputed manufactures in this direction.
- ✓ Mindset of the construction professionals and the end consumers to value quality and long-term durability rather than economy
- ✓ Improvement in road network to reduce turnaround time of delivery vehicles.
- ✓ Judicious and equitable taxation policy on RMC by Central and State government.

According to Albany (2018), an increasing number of infrastructure projects including roads, bridges, dams coupled with rapid airport expansion works in emerging countries will fuel growth over the coming years. Furthermore, rising government spending on power plants, manufacturing facilities, construction infrastructure along with the growing population will augment industry expansion over the upcoming years. Growing population and rapid economic development in the coming years are expected to propel the demand for construction of commercial buildings such as shopping malls, schools, offices, colleges, banks, and hospitals.

Further key findings from the report suggest:

- ✓ Major government initiatives including the development of smart cities, revival of airports and Road Project are expected to create immense growth potential. Moreover, rising government spending for the development of government offices and buildings will augment the ready-mix concrete demand over the forecast period.
- ✓ Owing to rapid economic growth along with increasing construction of manufacturing plants and energy harnessing projects. Rising government efforts to promote solar power generation will spur product demand for construction purpose over the upcoming years.

In addition, various initiatives by governments regarding the development of smart cities will help drive the global ready-mix concrete market. The demand for wastage reduction, efficient utilization, and low inventory costs is leading to lowering of overall project expenditures and this will boost the demand for ready-mix concrete. Ready-mix concrete is extensively opted today, owing to the ease of use, high quality, better convenience, and better economy.

However, the handling of concrete from the mixer to various points of work is one of the key challenges faced by players or stakeholders operating in the global ready-mix concrete market. In addition to this, high initial investments for setting up manufacturing plants for ready-mix concrete will restrain the market.

On the other hand, it is expected that the introduction of new infrastructure construction projects will create a heightened demand for RMC. This will ensure a continued growth of the market in the coming years [48].

2.3.4 Need of Ready-Mix Concrete

Ready-Mix Concrete has following advantages over the site mix concrete [34]:

- ✓ RMC has better quality than the site mix concrete because of sophisticated equipment for batching and other process of making concrete.
- ✓ Use of RMC increases speed of construction. Typically, site mix concrete is produced at the rate of 4-5 m3 per hour, where a basic RMC plant can produce 60m3 per hour, with the larger plants producing much more.
- ✓ With the use of RMC, customers are not required to procure and store cement, aggregates, sand, water and admixtures at site. This is not only drastically reducing the space requirements at construction sites but also minimizes efforts on the part of customers to procure different materials, ensure their proper storage and check their quality parameters from time to time.
- ✓ Site-mixed concrete is a labor-intensive operation and managing large labor force is a big hassle for the customer. With the use of RMC, the labor requirements are minimized considerably, thus benefiting customers. Further, as RMC-India looks after the entire QA and QC needs, the customer’s manpower requirement for QA and QC operations is minimized. This is a saving for the customers.

- ✓ In site-mixed concrete job, wastage occurs in handling of all materials, including cement. The latter is generally of the order of about 2-3 kg per 50 kg bag of cement. All such wastages are considerably minimized at RMC facility.
- ✓ Use of Ready-Mix Concrete is also eco-friendly.

Research by Denamo under the title "Handling of Concrete Making Materials in the Ethiopian Construction "to assess of the current situation of handling of concrete making materials, finally to give recommendations with respect to handling of concrete making materials. With this sense, observation was made concerning RMC production and utilization in Germany compared to onsite mixed concrete, RMC had the following advantages:

A. Service

RMC provides consumers with good service quality. This advantage is due to the following reasons:

- ✓ The availability of concrete truck mixers allows delivery rates to be kept under control and optimized;
- ✓ Due to dense network of ready mixed plants it is always possible to get a ready-mixed plant near a work site;
- ✓ Special services for difficult work sites: pumps, conveyors, night deliveries etc.
- ✓ Availability of concrete of any grade according to the client's requirements;
- ✓ Durable and affordable;
- ✓ Environmentally friendly.

B. Quality

Ready mixed concrete guarantees quality due to the following reasons:

- ✓ The materials of which it is made are themselves subject to stringent quality requirements;
- ✓ Rigorous quality control is carried out thorough out the manufacturing and delivery process;
- ✓ The formulation and manufacturing of the concrete are covered by the numerous national quality standards.

C. The Delivery Solutions

Ready-mixed concrete meets a great variety of needs in terms of technical sophistication, ease of use and design due to the following reasons:

- ✓ The ability of test centers and laboratories to do research into and industrialize ever more innovative concrete that is in tune with trends in architecture and the construction industry
- ✓ The use of multiple combinations of cement aggregates and admixtures stored on production plant sites.

D. Benefit at site for the Customer/ Contractor

- ✓ Deliveries of ready-mixed concrete can be taken directly from the ready-mix plants or the concrete can be delivered to worksites by concrete mixer trucks;
- ✓ The use of ready-mixed concert keeps worksite nuisance (dirt, congestions, noise, etc.) to minimum levels;
- ✓ Elimination of procurement and hiring of plants and equipment;
- ✓ Wastage of materials as site is avoided;
- ✓ Labor and supervisory cost associated with production of concrete is lowered;
- ✓ Time required for concreting is greatly reduced;
- ✓ Noise and dust pollution at site are reduced;
- ✓ Organization at site is more streamlined;
- ✓ No storage space required either for raw materials or for the mix.

All the above-mentioned facts signify the advantage of using ready-mix concrete is the best option over conventional onsite concrete production. [13].

2.3.5 Potential Users of RMC

RMC is being increasingly used as a building material for residential, commercial buildings, manufacturing facilities, energy generation plants, roads and runways. Infrastructure developments in emerging economies coupled with increasing trend of urbanization are some of the key factors which are expected to drive industry growth over the future [48]. In the Bahir Dar construction industry, there would be a big potential for RMC users from the commercial, governmental, industrial projects and a little bit from residential projects following an awareness of its importance.

There was a study by Habtamu, to assess the viability of RMC in the Ethiopian construction industry: the case of Addis Ababa. Despite the comparative advantage of RMC with respect to the quality and economy of the produced concrete to that of the conventional site mixing, it is not applied in our construction industry even though; there are limited number of plants in Addis Ababa which are owned by contractors for their own purposes.

Based on the comparison made on the workability and compressive strength of C-25 concrete produced by an RMC supplier and conventional SMC on building projects the constancy of quality, it was found out that the variability of the test results of the SMC is twice than the corresponding results of the RMC, while the constituent materials were almost similar as shown in the table below.

Table 2.14: Statistical analysis results of measured slump and compressive strength at 28 day [61]

	Measured Slump (mm)		**Measured Strength @ 28 day (MPa)**	
Variable	**RMC**	**SMC**	**RMC**	**SMC**
Mean	56.5	53.27	27.06	31.22
Standard Deviation	10.63	19.54	5.36	9.59
Sample Variance	113.08	381.88	28.70	92.06
Skewness	0.01	0.07	-0.20	-0.44
Range	40.00	70.00	21.62	32.53
Minimum	40.00	20.00	14.67	12.79
Maximum	80.00	90.00	36.29	45.32
Confidence level	3.40	7.89	1.71	4.73

Taking the wide price fluctuation in Ethiopia and using the probabilistic approach of investment appraisal, the Net Present Value (NPW) of setting up RMC plant in Addis Ababa was 61.49 Million ETB and Internal Rate of Return (IRR) 8.86% for 15 years investment period. The risk analysis of the investment showed that there was 100% probability of getting a positive NPV from this investment. However, the RMC supplier should secure a minimum annual concrete sale of 10,000m^3 to cover the total annual expense for a break even. This was due to the 4 Million annual average owning cost of RMC Plant [61].

2.4 Quantification of Concrete Cost

2.4.1 Costs Associated with RMC

The work of Motrin, enumerate costs as: nearly every producer in the ready-mix concrete business has developed his own particular method for recording the various expenses associated with the operation. Consequently, each producer has either formally defined or by past experience devised a workable scheme for reporting these expenses.

The major objective of a ready-mix concrete business as well as any other business is to realize a profit. One of the most important factors in maximizing these profits is to control the cost of doing business. The control of costs depends on how well the management endeavors to actually pinpoint each individual cost. If each of the expenses are defined and a cost value determined, it is a relatively simple matter to discover the costs which are too high when compared with the costs of other producers in the concrete industry. This is the apparent reason for separating these costs into three divisions; namely, Production, Delivery, and General Administrative expenses [49].

2.4.1.1 Production Costs

The production phase in a ready-mix concrete company encompasses all of the activities needed to ready the raw materials for making concrete. This includes the purchasing and receiving of the cement, rock, sand, and other additives at the plant and the convey age of these ingredients into storage bins where they are then stored for immediate dispatch until an order has been received [49].

i. Purchase of Raw Materials

b. ***Cement -*** This should include the cost of cement and the freight charges. (Usually purchased by the barrel~ ton or carload, or 94-pound bags, in Ethiopia using 50kg bags.)

c. ***Rock -*** This should include the cost of rock and freight charges. (Purchased by the ton)

d. ***Sand*** **-** This should include the cost of the sand, plus the freight charges. (Purchased by the ton.)

e. ***Other Additives*** **-** This should include the cost of the additives and delivery charges, if any. (Purchased in various containers, such as 100-pound bags, barrels, etc.)

ii. Salaries (Production)

a. ***Batch-Man*** - The duties of this job includes the weighing of each ingredient that is dispatched from the storage bins directly into the mixers onto the trucks. The batch-man is informed by the dispatch clerk that an order has been received. He then dispatches the raw materials according to customer specifications.

b. ***Dozer Operator (Conveyor Operation)*** - The duties of the dozer operator consist of supplying the storage bins with rock and sand by use of a conveyor belt system.

c. ***Cement Unloaded (Railroad Cars)*** - Railroad cars must be unloaded by hand. The cement unloader stands on top of the car and uses a long-handled hoe to unload the cement through the bottom of the car onto a conveyor directly below the tracks. This conveyor transports the cement up into the cement storage bin. If the cement is hauled in trucks, the trucks are unloaded by an air operated device directly into the cement storage bins.

d. ***Crane Operator (Crane Operation)*** **-** The duties encompassed in this job consists of supplying the storage bins with rock and sand via a crane.

e. ***Other Yardmen*** - This category should include any other personnel employed in the production phase.

iii. Rentals

In the operation of a ready-mix plant, it is almost certain that at one time or another, it will be necessary to rent some type of equipment. In general, this equipment may be a dozer, tractor, dirt mover, etc.

iv. Utilities

The utilities include gas, lights, and water. The gas and lights used would be for heating and lighting the batch-man's office and the general offices. Water is, by far, the biggest expense of the utilities. Water is one of the major ingredients of concrete, and is used extensively for cleaning the mixer after each delivery.

v. Depreciation

Broadly speaking, depreciation is the lessening in value of physical assets with the passage of time. Depreciation in the production phase consists of the plant, the conveyor, and the tractor (dozer) or crane. Most of the producers interviewed employed a public accountant outside of the ready-mix plant to calculate depreciations. This is due largely to the ever-changing laws pertaining to depreciation.

vi. Insurance

The insurance in this division was on the plant building.

vii. Payroll Taxes

Employers' taxes for old age benefits and unemployment compensation represent additional costs to the business and should be considered a part of the cost of production. This also includes state and federal taxes as required by law.

viii. Other Taxes

This item would include all other taxes charged to the production phase of the ready-mix operation.

ix. Repairs

This category includes maintenance on the plant building, conveyor, tractor or crane, or any equipment used in the production phase.

x. Miscellaneous

This listing is designed as a "catchall" item to include any expenses which a producer might experience that would be related to the production aspect of a ready-mix operation.

2.4.1.2 Delivery Expenses

Delivery expenses in a RMC company operation consists of all expenses incurred on the equipment involved in deliveries, the salaries of all truck drivers and mechanics, depreciation and re-pairs on the equipment, insurance, truck licenses, i.e., any expense which occurs from the time that the raw materials (cement, rock, sand, and additives) are received from the storage bins into the mixers on trucks until the concrete is delivered to the customer location and un-loaded of its contents and truck is returned to the plant site to await further concrete orders. More simply, delivery expenses include all costs from the point of charging the batch or mix into the trucks to delivery of the concrete at the job site. In arm plant operation, a producer must define and analyze delivery expenses if an economical and efficient business is to be maintained. Economy of delivery expenses requires careful control of these costs to ensure that these expenditures are made as effectively as possible in achieving the purposes of the enterprise [49].

i. Salaries

The salaries relative to the delivery phase would include truck drivers and mechanics. The purchasing of manpower is one of the highest expenses in any business concern and this is particularly true of arm operation. One of the greatest problems a producer is confronted with is the utilization of manpower in the slack periods of the business. According to the author arm company must rely on customers to order concrete continually if it is to fully utilize the manpower it must maintain on the payroll at all times. If a producer is not fully utilizing his manpower and equipment, a larger sales force should be employed or other remedies sought.

ii. Depreciation

The depreciable amount of a truck and mixer should be spread in equal amounts over the life span of the asset; the amount is ordinarily expressed as a percent of cost. The most widely used method to figure this depreciation is the straight-line method.

In most cases, the mixer will remain in operative condition much longer than the truck. Therefore, the depreciation for the mixer and the truck should be calculated separately and adjusted accordingly. The straight-line method of depreciation assures that depreciation is equal each year of the life of the asset.

iii. Payroll Taxes

In some states, personal income taxes must be withheld from employee's pay by the employers. The same problem is presented in any withholding tax requirement, such as the various federal withholding taxes.

iv. Repairs and Maintenance (truck and mixer)

Maintenance and repair expenditures are costs of maintaining the trucks and mixers in efficient working condition without increasing the productive capacity or appreciably extending the life of assets beyond the span contemplated in setting depreciation rates. Unarm operation, this item is one of the largest problems of the producer. To maintain a constant maximum output, the producer must consistently employ ways and means to keep his ready-mix trucks in operation the full time. The responsibility of maintaining a full operating truck force should be shared by the truck drivers and the mechanics. The truck drivers should report any equipment on the truck or mixers which are not operating correctly. The mechanics should check and repair any inoperative functionary equipment on the trucks and mixers daily. The truck drivers should remain alert to any malfunction of the equipment and should be aware of the hazards and dangers involved to the equipment when making deliveries to congested or close quartered areas, such as building construction, highways, etc.

v. Gas, oils and Grease

These items are particularly expensive to delivery costs. However, it is the duty of the truck drivers and mechanics to ensure that the equipment is properly lubricated and a gas level maintained so that the truck will not run out of gas in the course of a delivery.

vi. Tires and Tubes

Another item which can be controlled to an extent is the tires on the trucks. Again, truck drivers should inspect the area of delivery and arrival to ensure that the area is free of any foreign materials which could cause a puncture. Needless to state, that one blow-out could affect the expected profits from the customer order.

vii. Repairs (tires and tubes)

This self-explanatory item includes the repairs of tires and tubes in the course of everyday delivery operation.

viii. Truck and Automobile Licenses

Plant automobiles and truck licenses are expenditures charged to prepaid accounts. In turn, they should be reduced to delivery expenses and prorated evenly over a one-year period.

ix. Two-Way Radio Control Unit

The repair and maintenance on radio control units is, in general, relatively small compared to the function the unit performs in everyday operations [49].

2.4.1.3 General Administrative Expenses

Complications involved in preparing the general administrative expense list are few and the area covered is generally well-known. General administrative expenses are based largely on the past experience of the RMC producer. The most important item to be included in this category is salary. The following is a proposed list to be included in the general administrative expense classification [49]:

i. Salaries

In most cases, the companies that were interviewed listed their administrative salaries in the following category:

A. Officers' Salaries
B. Sales Salaries
C. Other Salaries

ii. Depreciation

Depreciation in this particular instance includes the general office building, company automobiles, and office equipment. Depreciation for these items is generally handled by an accountant not employed by the firm.

iii. Payroll taxes

This expense should be the same for administrative personnel as was previously discussed in the production expense.

iv. Supplies

Supplies would be items such as customer order blanks, office stationery, pencils, etc. Also, the postage required to send monthly statements and any form of written communication with the exception of telegrams.

v. Travel and Entertainment

This should be an expense encompassing the entertainment of businessmen visiting the firm. Also, it would consist of any travel expenses by employees and officers in the line of duty, such as attending various ready-mix concrete association meetings, etc.

vi. Telephone and Telegrams

Any communication expense; such as telegrams long distance telephone calls and monthly telephone charge.

vii. Advertising

In advertising, the important item of cost relates to the advertising media used. The media most used by RMC companies are magazines, newspapers, and car cards. The amount designated for this item would depend on the size of the company involved.

viii. Automobile Expense

This would include gas, oil, tires, and maintenance of the company cars.

x. Bad Debts

This particular account can be handled in various ways. If an account is not paid at the end of the accounting period, it should be written off and charged to the account allowance for bad debts. If the customer pays this account at a later date, the account should be cleared to protect the customer's good name.

xi. Subscriptions and Dues

Subscriptions are capitalized if it represents a substantial amount. The capitalized amount is reduced to an expense item by equal annual and monthly expense charges. It includes industry journals, pamphlets, magazines, etc. The dues refer to the ready-mix concrete association fees.

xii. Legal and Auditing

Services rendered by attorneys in connection with purely organizational matters, or of a general character when not excessive, may be treated as regular administrative expense. The auditor's fee should be charged to administrative expenses. The auditor relies on the accounting system used and firm's files to validate his findings. His purpose is to protect the producer in any way deemed legal.

By the same analogy, Al- Araidah (2012), states to estimate the cost of a demanded volume of RMC, it is necessary to cost required materials, labor involved, fuel and maintenance needed, plant and ancillary equipment hired and depreciated, and delivery of RMC to customer site. There was a proposed cost model that subdivides the cost of RMC into [12];

1. On-floor cost, expenses related to all the costs (materials and labor) related to that floor.
2. Cost of delivery; includes delivery related costs.

According to Graham et. al, (2005b), the cost of concrete placement is significant for contractors and ways of reducing this cost should be examined. To this end, an investigation was undertaken to define the actual costs that a contractor incurs in placing concrete, based upon data from real construction projects where RMC was being supplied by an external batching plant. Graham et. alpresented the results of this investigation at ARCOM 2005 in a paper entitled ‘Cost of Concrete Placement for Contractors’. It was found that the main sources of contractor cost are: RMC material, plant hire, labor and plant idleness and a surcharge for truck mixer idleness (on site).

RMC is an important construction material and the cost of placing this material is significant for a contractor. The costs associated with RMC system which were identified through consultation with industrial practitioners like several managers of both RMC batch plants (in USA and UK) and contractors (in UK) that were as follows [50]:

RMC material costs; the price quoted by an RMC supplier absorbs a number of the supplier’s costs, including raw materials prices, overheads, transportation costs and suppliers’ profits. These prices can vary significantly according to the design mix.

Plants hire costs; the on-site plant required in the RMC system differs from pour to pour. However, in the studied projects there was some standard plant used in each pour, such as a concrete pump, vibrating poker units and mechanical trowels.

Plant operating costs; these costs are a function of pour duration, fuel prices, plant running during idle periods and repair costs.

Labor costs; RMC is placed by labor teams, often consisting of a ganger (or foreman), plant operator, placing personnel, general laborers and masonry specialists (for finishing) and they are usually paid at an hourly rate.

Truck mixer surcharge; The RMC supplier often has a tolerance for the length of time that a truck mixer may remain on a project site. This tolerance is roughly 5 minutes per cubic meter. For example, a truck mixer carrying a load of $8m^3$ of RMC would be permitted a time of 40 minutes on a site to wait.

Transport of material; this is a cost absorbed in the price of the material and is not directly applicable to the contractor, but could be useful in identifying ways to reduce the contractor’s costs.

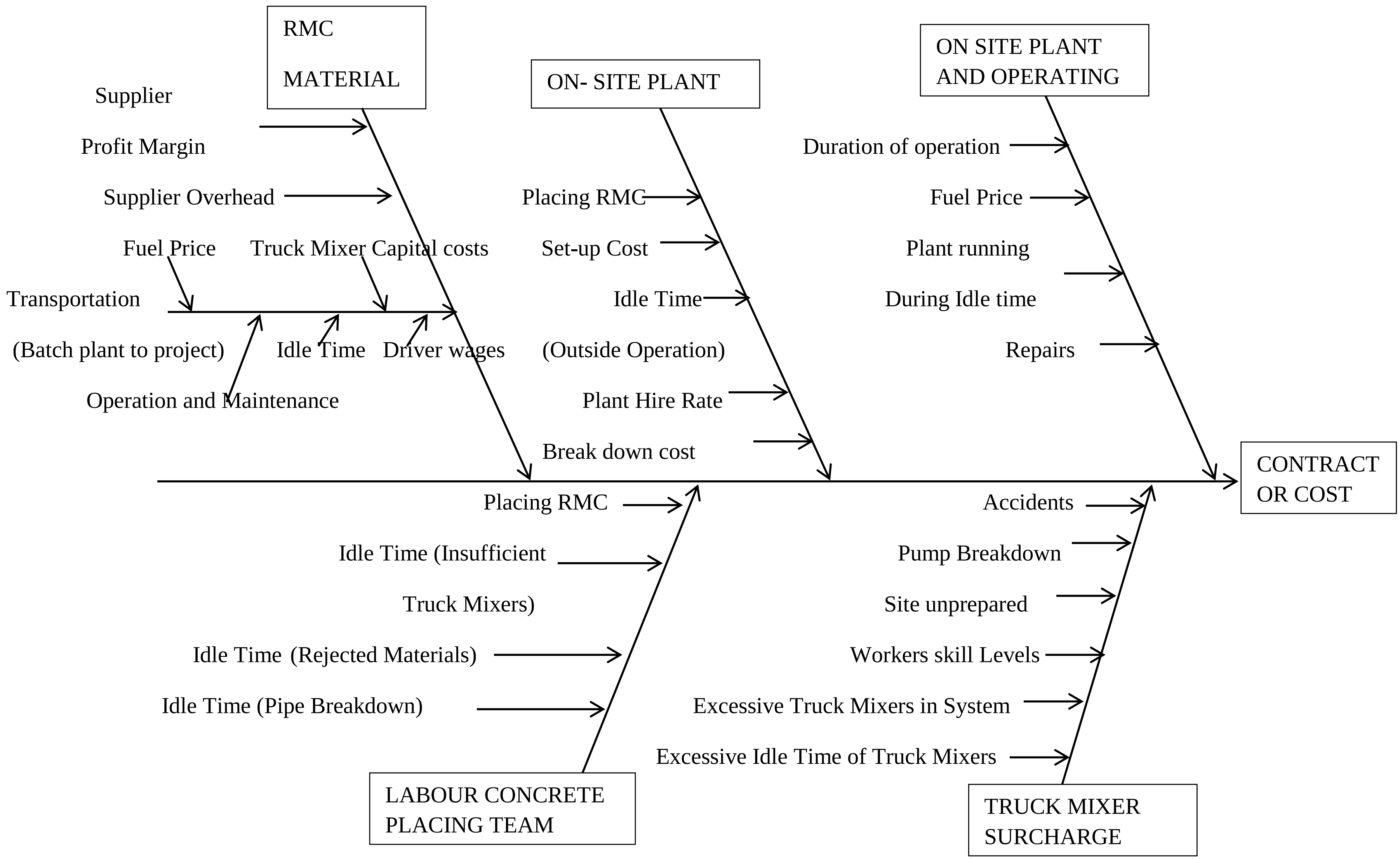


Figure 2.4: Ishikawa diagram of contractor costs in RMC system [50]

2.4.1.4 Quantification of Contractor Costs

According to Graham et. al, (2005b), the contractor costs in the RMC system was identified and these costs were calculated using the following formulae [50]:

Equation 1:RMC material costs (£) = Unit cost of RMC (£/m^3) X Pour volume (m^3)

Equation 2: Plant hire costs= Daily Hire Rate (£/day) X Days for Pour

Equation 3:Plant Operating Costs (£) = Unit Operating Cost (£/hr.) X Pour Duration (hrs.)

Equation 4: Labor Hire costs (£) = Duration (hrs.) X (No. of persons X Unit cost of Each Job (£/hr.))

Equation 5: Truck Mixer Surcharge (£)

Truck Mixer Surcharge (£) = [Tomtit Project (min) – Tolerance Threshold (min)] X £2/min If TMT > Tolerance

0 If TMT @ Project ≤ Tolerance

Where,

- ✓ TMT- Truck Mixer Time
- ✓ Tolerance Threshold = 5 minutes per cubic meter of RMC to be placed

Equation 6: Contractor Cost (£) = 1 + 2 + 3 + 4 + 5

Further,Graham et. Al (2005b),identified and quantified the cost contributors in the RMC systemto contractors as follows;The contributors to eachcost in the system are smmerized in the tableand figurebelow [50].

Table 2.15: Contributors of contractor and contributors to cost [50]

Cost breakdown	Percentage contribution
Material cost	
Raw material	54
Material transportation cost	5
Supplier overhead	12
Supplier profit	2
Total	**73**
Labor cost	
Cost placement for RMC	11
Idle labors	2
Total labor cost	**13**
Plant hire and operating cost	

Idle plant (outside pour) Set up cost Idle plant (operating cost) Plant hire (value adding) Plant operating cost (value adding)	3 1 1 5 2
Total plant operating cost	**12**
Truck mixer surcharge	2

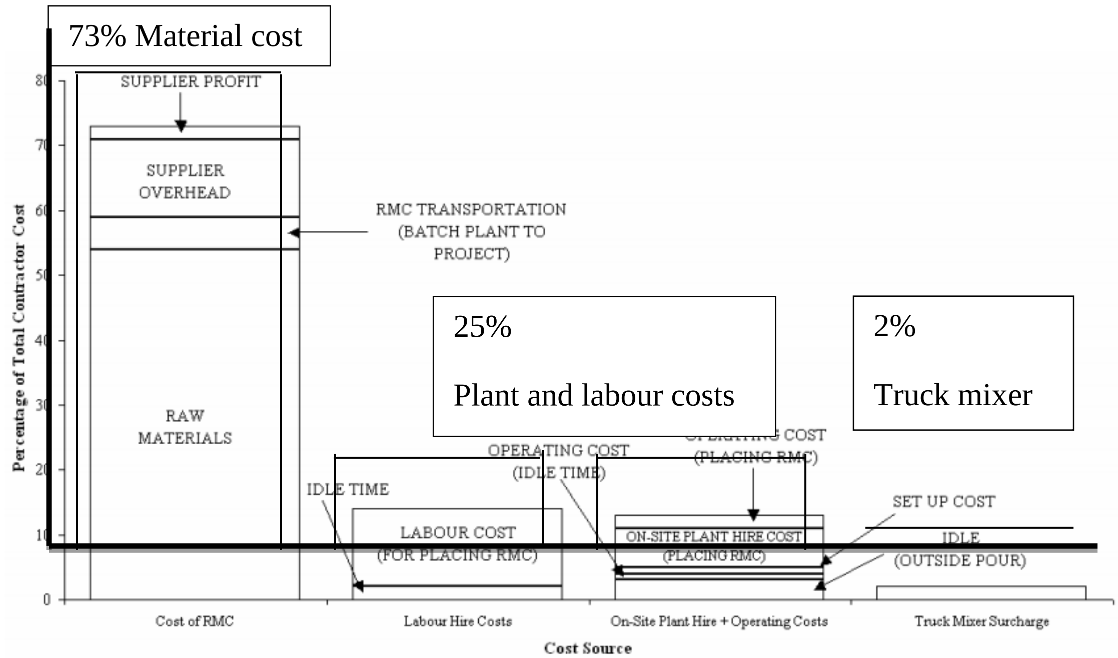


Figure 2.5: Contractor costs and contributors to cost in the observed small pours [50]

In summary , 73% of the contractor cost was topay for RMC material cost, 25% was due to plant and labour costs, while the remaining 2% accounted for truck mixer surcharges. On the other hand, research by Al-Araidah, today's RMC manufacturing environment, direct labor cost accounts for only 10% of the cost, whereas material accounts for 55% and overhead for 35% [12].

From the reviewed literatures the major cost is accounted for the material and related cost. This would be an advantage to minimize the unit cost of RMC through minimizing material cost of RMC and the difference of unit cost between RMC and conventional SMC can be possibly in insignificant. Genrally, the researcher believes that 73% of the contractor cost is relatedtoRMC material cost, 25% is due to plant and labour costs, while the remaining 2% is accounts for truck mixer surcharges.

2.4.1.5 Areas of Focus for RMC Cost Reduction Strategies

A number of costs and the contributors to cost could be focused upon to achieve a reduction in the total cost of placing RMC for a contractor. For instance, Graham et. al, (2005a) state,to achieve a minimum cost of RMC placement for a contractor a systemic solution to reduce costs should be applied. Such a solution would entail reducing all of the above costs as much as possible, with an obvious focus being placed upon the most significant source of cost. A possible solution is to follow the trend of aggregate producers and vertically integrate the resource (materials, plant, etc.) supply chain [51].

Furthermore, supplying RMC in an efficient and economical manner depends greatly on the distance between the batch plant and the construction site. Thus,RMC suppliers have to determine how to geographically distribute their plants and what production and delivery capacity each plant should have in order to handle the potential concrete demand within the coverage area. In addition, at the operational level, truck mixer scheduling and raw material logistics within the batch plant are critical to ensure timely and economical supply[52].

By same concept, using the Just-in-time (JIT) production philosophyattracted much attention by making operations faster, eliminating waste. For example JIT management of RMC is important because of the perishable nature of RMC. The implementation of JIT techniques in the RMC industry can help to improve product quality, eliminate waste, enhance overall productivity and increase customer satisfaction. JIT is to provide the right material, in the right quantities and quality, just intime for production [53].

2.4.2 Costs Associated with SMC

According to a research in India Mohd et.al, (2017), a typical site mixed concrete wastage of raw materials, wastage of concrete during placing, high supervision cost due to checks required at site on raw materials are unavoidable issues that maximizes the cost site mix concrete. In addition to this investment in material testing equipment on site to site basis are required and high overheads of longer project duration have serious commercial implication [54].

By the same analogy in site-mixed concrete job, wastage occurs in handling of all materials, including cement. The latter is generally of the order of about 2-3 kg per 50 kg bag of cement. All such wastages are considerably will be minimized at RMC [35].

On the other hand, use of RMC increases speed of construction. Typically, site mix concrete is producing at the rate of 4-5 m3 per hour, where a basic RMC plant can produce up to60m3 per hour, with the larger plants can produce much more. This reduces greatly the overhead cost of the customer or the contractor [35]. The average placing speed of all the observed concrete pours for the SMC was 26.4% of the RMC pours which clearly witnessed between the gaps in placing speed between the two production methods. The placing speed of the RMC pours showed an increase $2m^3$/hr. while on the SMC an average increase of $0.60m^3$/hr. for every extra $10m^3$ [61].

Cost comparison between RMC and SMC for C-25 structural concrete was carried out by Habtamu as shown in the Table 2.16. The prices of concrete making materials, labor and equipment were taken as the average in Addis Ababa and contractors' estimation.

Table 2.17: Resource utilization and direct cost of observed pours [61]

	RMC		**SMC**	
Item (Resource)	**Cost (ETB)**	**Resource time (Hr.)**	**Cost (ETB)**	**Resource time (Hr.)**
Labor	38.34	3.43	318.37	23.18
Equipment	351.85	0.84	518.50	2.82
Material	1170.53	-	1247.95	-
Total	1,560.72		2084.82	

The direct cost comparison on the concrete pours showed that there was a 1% cost increase in the purchasing RMC than producing it on site using the conventional SMC. The researcher recommended that further cost savings can be achieved, if the RMC delivery is made competitive with respect to the scheduling capability, since the cost is sensitive to transport costs, which in turn are highly affected by the coordination of the plant and the construction site.

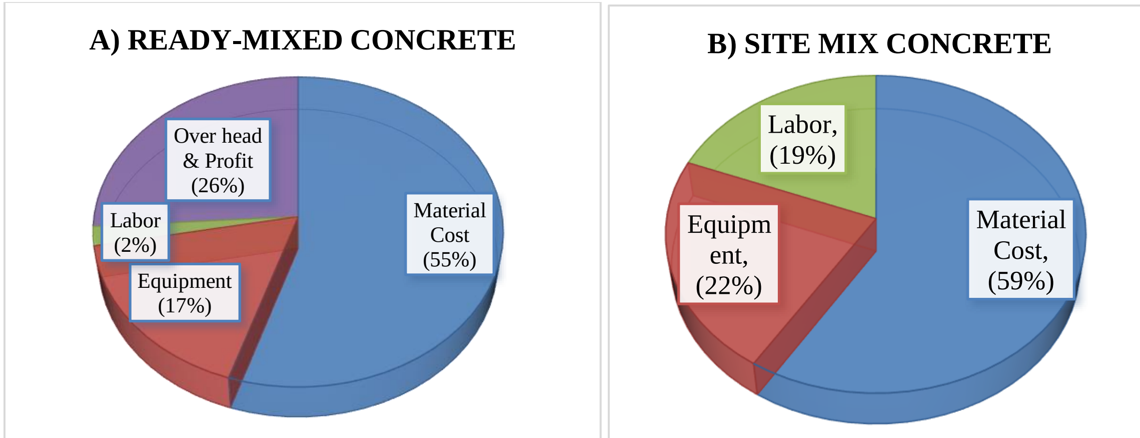


Figure 2.6: Proportion of direct concrete production cost components [61].

From the cost comparison it was concluded that the contribution of labor cost was insignificant in RMC 2% as compared to SMC 19%, while equipment costs contribute equally in both cases. The major cost component was a material cost composed of cement, aggregate, water and admixtures in some cases. It constitutes 59% and 55% in SMC and RMC respectively [61].

Site-mixed concrete is a labor-intensive operation and managing large labor force is a big hassle for the customer. With the use of RMC, the labor requirements are minimized considerably, thus benefit customers. Further, as RMC looks after the entire QA (Quality Assurance) and QC (Quality Control) needs, the customer's manpower requirement for QA and QC operations is minimized. This is a saving for the customers [35].

2.5 Legal Requirements of RMC Plant

According to the New Zealand Ecolabelling Trust,licencing criteria for RMC plant, the product must comply with the provisions of all relevant laws and regulations that are applicable during the product's life cycle. Ready-mixed concrete manufacture can potentially place a significant burden on the environment. The most important adverse impacts on the environment are related to quarrying of raw materials, potential nuisance impacts from dust discharges and discharges of high pH water to waterways.

Relevant laws and regulations could, for example, include those that relate to:

- ✓ Producing, sourcing, transporting, handling and storing raw materials and components for manufacture;
- ✓ Manufacturing processes;
- ✓ Handling, transporting and disposing of waste products arising from manufacturing;
- ✓ Transporting product or raw materials within and between countries; and
- ✓ Using and disposing of the product.

The documentation required may include, as appropriate:

- ✓ Procedures for approving and monitoring suppliers and supplies; and
- ✓ Information provided to customers and contractors regarding regulatory requirements.

It is not intended to require license holders to accept increased legal responsibility or liability for actions that are outside their control.

Based on the above criteria all industries enter to industry park should fulfill the following pre-condition

- ✓ All industries enter to investment should supply end product to customers.
- ✓ Should have ***management plans*** including any policies and management procedures to minimize adverse effects from the following potential impacts: noise, vibration, dust, and discharges to surface water, groundwater, oceans or land.
- ✓ A quarry restoration plan.
- ✓ **Hazardous Substances;** No substance shall be used in the production processes that are classified as toxic, carcinogenic, harmful to the reproductive system or genetically harmful (excluding cement).
- ✓ **Water and Water Re-use;** the ready mixed concrete manufacturer must have and implement effective water management policies and procedures and/or a water management programmed.
- ✓ **Waste Management;** The RMC manufacturer must have effective waste management policies and procedures and/or a waste management programmed covering manufacturing operations.

- ✓ **Dust Management Plan;** The RMC manufacturer must have and implement a dust management plan covering all areas of the operation including access ways, concrete plant and associated activities.
- ✓ **Truck Washing;** All RMC trucks shall be washed out at a location where all wash water and wash solids are collected and re-used or disposed of to a licensed facility.
- ✓ **Truck Driver Training;** The RMC manufacturer must ensure a training programmed is in place to ensure all drivers are knowledgeable of procedures to minimize impacts on the environment in the event of a spill or potential discharge.
- ✓ **Energy Management;** the RMC manufacturer must have effective energy management policies and procedures and/or an energy management programmed covering the RMC plant and delivery of ready mixed concrete [62].

2.6 Lessons Learnt from the Literature Review

"Ready Mix Concrete" is the concrete which is well-designed composites, has resultant properties that combine the best qualities and specifically manufactured for delivery to the customer's construction site from the central batching plant by using truck mounted transit mixer.

In general RMC has the following advantages over SMC.

- ❖ **Quality of concrete:** Ready-mix concrete uses sophisticated plant and equipment, which enables it to produce quality concrete. There is strict control on the quality of all ingredients through rigorous testing, applying stringent controls on process parameters, meticulously monitors key properties of concrete. In contrast, in atypical site-mixed concrete there is poor control on the quality of input materials, batching of ingredients and mixing of concrete, thus the resultant quality of concrete is poor, non-uniform and inconsistent.
- ❖ **Elimination of material procurement requirements and storage hassles:** With the use of RMC, customers are not required to procure and store cement, aggregates, sand, water and admixtures at site. This not only drastically reduces the space requirements at construction sites but also minimizes efforts on the part

of customers to procure different materials, ensure their proper storage and check their quality parameters from time to time.

- **Reduction in wastage:** In site-mixed concrete job, wastage occurs in handling of all materials, including cement. The latter is generally of the order of about 2-3 kg per 50 kg bag of cement. All such wastages are considerably minimized at RMC facility.
- **Improved life cycle cost:** Increased speed of construction coupled with reduction in labor cost and wastage results in considerable savings to customers. Further, the improved quality of concrete translates into enhanced long-term durability of concrete, thus minimizing the maintenance and repair costs. Overall, when one considers the life cycle costs, the use of RMC become cost-effective in the long run. The benefits directly accrue to the customers.
- **Speed of construction:** Mechanized operations at ready-mix plants ensure that construction activities are speeded up. While the production output from a typical site-mixed concrete operation using 8/12 mixer is around 4-5 m^3/hour, the output forms a 30-60-m^3/hour. Thus, there is nearly 10-foldincrease in the output which translates into direct savings to the customer.
- **Saving in labor requirement:** Site-mixed concrete is a labor-intensive operation and managing large labor force is a big hassle for the customer. With the use of RMC, the labor requirements are minimized considerably, thus benefiting customers.

From the review of the above different literatures, it can be understood that, the quality of concrete depends on the main ingredients of concrete which are cement, mineral aggregates and water. Among the ingredients, mineral aggregates are not factory produced, hence due attention should be given. The selection of ingredients greatly affects the quality of a concrete product; leading to the violation of both strength and durability requirements. Therefore, quality of concrete making materials should fulfill the requirements stated in standards.

In Ethiopia, most of the projects don’t conduct sufficient tests both for the coarse and fine aggregates. In addition, workmanship in concrete production doesn’t follow the proper procedure of standards. Waste production on construction sites is often due to inadequate storage and protection, poor site control, over ordering of material, bad stock control. Understanding the wastage level of materials on construction sites using SMC it would be obvious that embarking on RMC technology can greatly reduce the successive loss. This indicates that using RMC plant with fully equipped laboratory is going to be a great solution.

Conventional SMC has many problems; like, contractors are required to procure and store cement, aggregates, water and admixtures at construction sites, wastage occurs in handling of all raw materials, less speed of construction coupled with increase in labor cost, problem of managing large labor force and non-environmentally friendly activities.

It’s a well-established fact that the existence of RMC plant mainly depends on the influence of the industry from the supply side; what individual plants look like, how industry firms are structured, technological change, producer turnover and demand; potentials of the market should be enough to support establishing RMC plant, the nature of the product, and its common substitutes.

An increasing number of infrastructure projects including roads, bridges, dams coupled with rapid airport expansion works in emerging countries like Ethiopia, will fuel the growth of RMC plant over the coming years.

From the reviewed literatures, the major cost is that of the material and related items, like; material transportation, suppliers’ profit and overhead. This would an advantage to minimize the unit cost of RMC through reduction of material cost so that the difference in unit cost between RMC and the conventional SMC would possibly be insignificant or even lesser for the plant product.

3 RESEARCH DESIGN AND METHODOLGY

3.1 Introduction

This chapter describes the research method adopted for the study. It discusses the description of the study area, the design of the survey and the selection of sample respondents. The statistical tools for the data analysis are also discussed.

Tadesse, quoted Kumar (1999), "***research*** is defined as processes of collecting, analyzing and interpreting information to provide solution for question or problem." With this background research design and methodology is therefore a means which ties up all the research processes jointly and guides the researcher to achieve the aim of the study. That means it is a plan of constructing the research structure to show all the most important parts of the research together [55].

3.2 Research Design

Research design is the overall plan for obtaining answers to the questions raised and the subsequent handling of some of the difficulties encountered during the research process. It is an action plan for getting from "here" to "there", where here may be defined as the initial set of questions to be answered, and there is some set of conclusions (answers) to those questions. Between "here" and "there" there are a number of major steps, including the collection, interpretation and analysis of relevant data [56].

There are a variety of survey designs that can be used to accommodate different substantive needs and problems if those problems are anticipated in the planning of the survey. The structured questionnaire is probably the most widely used data collection technique for conducting surveys to find out facts, opinions, and views. Interviews can be classified according to the degree to which they are structured. In an unstructured or non-directive type of interview the interviewer asks questions as they come to mind. On the other hand, in the structured or directive interview the questions are specified in advance. In a quantitative study, the steps involved in conducting an investigation are fairly standard [56].

For this research; desk study, interviews, structured questionnaires, evaluating laboratory test results, and site visits were used in the gathering of data. The interviews were adapted to collect detailed information about respondent's experiences, governmental bodies about the legal requirements of RMC plant and to know the impressions of practitioners about the notion of RMC plant for Bahir Dar construction industry. The questionnaire survey was also adapted to get feedback on opinions of respondents about concrete production problems and wastage of building materials in the Bahir Dar building construction sites. The site visits involved observations, where the researcher sought to find out how materials were stored and handled, concrete production process and also to have a first-hand information on high waste generating building materials in the construction industry.

Towards achieving the research goal, a flow chart which shows the structure of the whole process was designed before starting the research work. The methodology flow chart presented in Figure 3.1 shows how the research work proceeds in a structured way so as to make the work effective. Site visits, structured questionnaires, interviews, collecting aggregate test results and relevant information from literature reviews related term production process were used as a data gathering tool. Statistical analysis was also carried out to analyze the collected data. Finally, conclusions and recommendations were drawn.

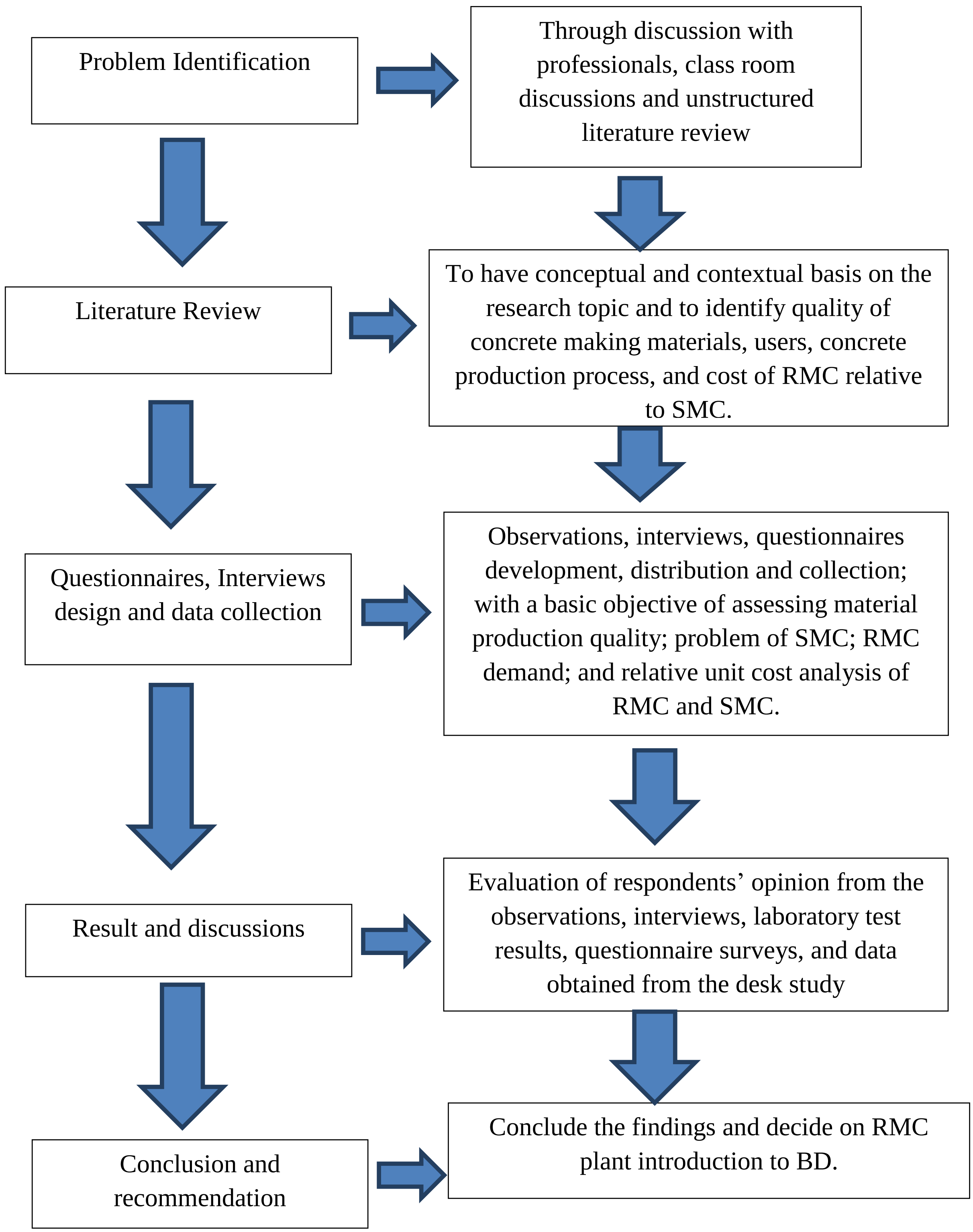


Figure 3.1:Research methodology flow chart

3.3 Sources of Data and Collection Approaches

The study depended on both primary and secondary data. Primary data were made up of first-hand inputs collected by the candidate through reviewing laboratory test results, questionnaires, interviews and site visits (observations). The secondary sources of data were obtained using relevant books, journals, magazines, web sites and research papers i.e., literatures.

To identify the potentials of RMC introduction to Bahir Carpinteria with construction practitioners, statutory bodies about the legal requirement of RMC plant, evaluate the perceptions of institutions and desk study approaches were carried out.

The purpose of the desk study was to obtain actual data from compiled laboratory test results of construction materials, type and amount of construction permit for the last five years, the quantity of average structural concrete on Bo documents and construction development trend in Bahir Dar and cost of SMC from bid documents.

The analysis of the gathered data was followed by a subjective assessment on the current quality standards of concrete making materials, the market potential of RMC in Bahir Dar and the relative cost of RMC with Simkin reference to the recommended scientific approaches learnt from the literatures reviewed and also to make a quantitative evaluation of the building construction sites of the investigated projects.

Conclusion and recommendation had been made from the analysis and discussion based on the compiled data of the questionnaires, interviews, laboratory test results, document review, and on-site observations.

3.4 Study Population

Based on the data from Bahir Dar City Administration, at the start of this research there were about 25 contractors and 10consultantsof Grade 1 and2 on active commercial and public projects with buildings of five story and above including industrial projects. Because these stakeholders use bulk volume of concrete which will be major users of RMC product. Since they are small in number, all contractors and consultants who are participating in the projects are the focal respondents.

3.5 Methods of Data Collection

A combination of both quantitative and qualitative data was considered in this study. Quantitative research is based on the measurement of quantity or amount. It is applicable to a phenomenon that can be expressed in terms of quantity. Qualitative research, on the other hand, is concerned with qualitative phenomenon, i.e., phenomenon related to or involving quality [57]. Therefore, the data collected by reviewing documents, from direct observation of the construction sites, individual interviews, aggregate test result documents; construction permits for the last five years, and bill of quantities were considered. The questionnaires covered information on the responsibility of the respondents, and experience in construction works.

3.5.1 Data Collection Method for Specific Objective One

The data collection method for specific objective one, which is to determine the quality requirements and availability of raw materials in Bahir Dar were acquired by referring the aggregate test result documents in the three laboratory centers. In addition, questionnaires were used to assess availability of cement and water on construction projects and their onsite material handling. Earlier findings were also used as comparative analysis to validate the results obtained.

3.5.2 Data Collection Method for Specific Objectives Three

To investigate the potentials of RMC in Bahir Dar construction industry;

1. The construction development trend for the last five years was analyzed from the document of ***Bahir Dar Building Officer*** referring construction permits of each year.
2. The volume of structural concrete per year, the contract periods were thoroughly examined. Based on this, most public and commercial construction contract periods are 2 years. By taking bill of quantities of some buildings and averaging structural concrete volume per floor and projection was made to cover others.
3. Questionnaires and interviews were also used to get perceptions of the practitioners of grade 1 and 2 contractors and consultants on active commercial, industrial and public projects.

4. In addition to the above techniques, different institutions like Bahir Dar University project office were consulted. Moreover, legislative bodies were interviewed on the legal requirements of RMC plant investment criteria and the presence of basic documents.

3.5.3 Data Collection Method for Specific Objectives Four

Basically, to compare the unit cost of RMC with SMC cost break down for C-25 concrete were made using current material, labor and machinery cost. In addition, the unit contract cost of SMC in Bahir Dar is collected in the form of questionnaires, interviews, and consultation of bid documents in May, 2018 including material wastage, productivity, quality of SMC production and material storage.

3.6 Respondents Composition

Professionals proposed to participate in the study as respondent were; project managers, resident engineers, office engineers, contractors, consultants, and the regulatory bodies. All the respondents have a direct involvement in the actual construction and management.

3.7 Triangulation

Different techniques are available to evaluate its validity and reliability. For example, Lee Cronbach in 1951 developed measures of reliability, or internal consistency test. Cronbach's alpha tests is used to see if multiple-question Likert scale surveys are reliable or not [64].

On the other hand, triangulations the use of multiple methods which raises the researcher above personal biases that stem from a single methodology. The use of multiple methods in the same study enables the researcher to overcome the deficiencies that flow from the use of one method [65]. In this research, in order to strengthen the validity and reliability of data collection and findings, the researcher tried to collect data through questionnaires, interviews and desk study triangulates the results obtained from different method.

4 RESULTS, ANALYSIS AND DISCUSSIONS

4.1 Introduction

In this chapter, results, analysis and discussion are carried out based on the data collected from the laboratory test results in Bahir Dar, information gathered through questionnaires, interviews, and observations on active building construction sites. The questionnaires are collected from Grade 1, 2 contractors and consultants of active building construction projects. While test results are obtained from three laboratory Material Testing Centers of namely; Amhara Design and Supervision Works Enterprise (ADSWE), Bahir Dar University (BDU) and Amhara Rural Road Authority (ARRA). Moreover, site observations on site material handling and current concrete production workmanship are conducted. The investigation is carried out in various parts of Bahir Dar and on various types of construction projects; i.e. public, commercial, real estate and industrial projects. Document review was also carried out. The names of the contractors, consultants, and projects are not given in order to keep the privacy of the sources.

As the quality of concrete is affected both by the quality of concrete making materials and workmanship in the production process, each concrete ingredient and every production process are thoroughly discussed. The test results are also analyzed and their compliance with the requirement of various codes and standards are evaluated. In addition to this, the comparative unit cost of RMC and the conventional SMC were compared with respect to productivity, concrete production quality and convenience to site management.

4.1.1 Classification of Respondents

Figure 4.1 shows the categorization of the respondents in the construction industry. The category of the firms consists of 65% contractors and 35% consultants. Due attention is given to contractors because they are the major stakeholders in the execution of construction projects.

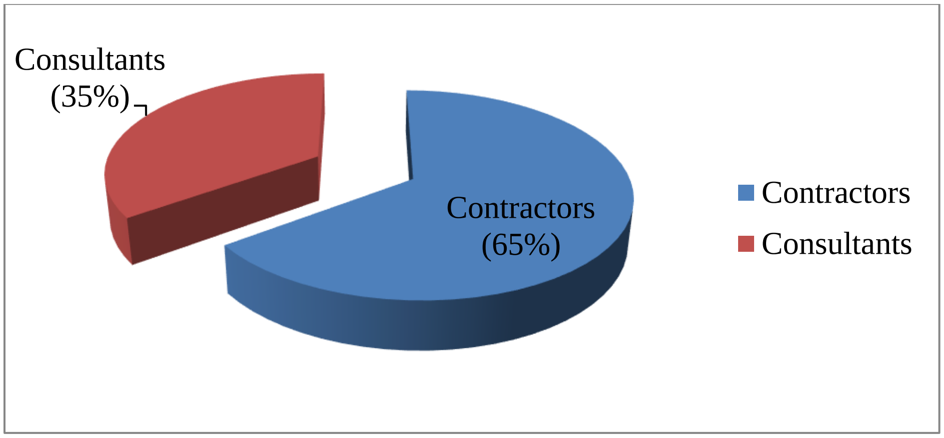


Figure 4.1: Category of respondents

In terms of permit registration,71% are at federal level and the remaining are at regional government certification office as shown in Figure 4.2.

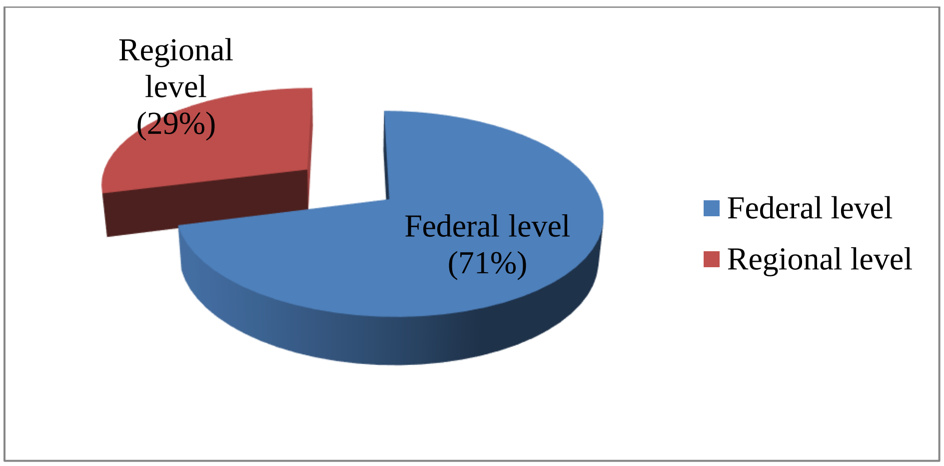


Figure 4.2: Registration of construction firms

The majority of the construction firms under this study; executed more than 15 projects in the last ten years. This indicates that they do have more experience on project execution and concrete production and use.

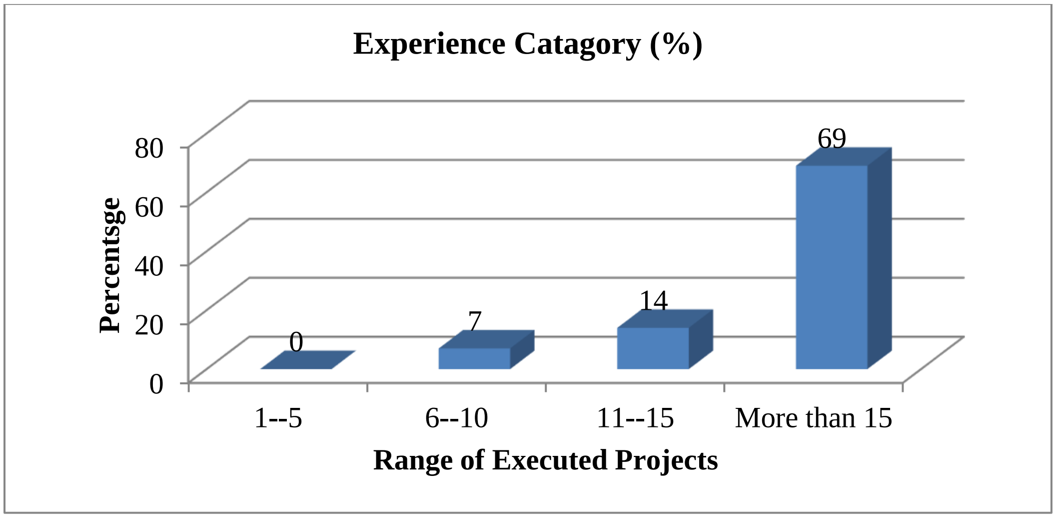


Figure 4.3:Number of projects executed by investigated firms

The respondents 'years of experience are minimum of 2 years and maximum of 48 years. Figure 4.4 shows the respondents' years of experience, in which86% of them have more than five years of experience. This gives an indication of high level of confidence in their responses.

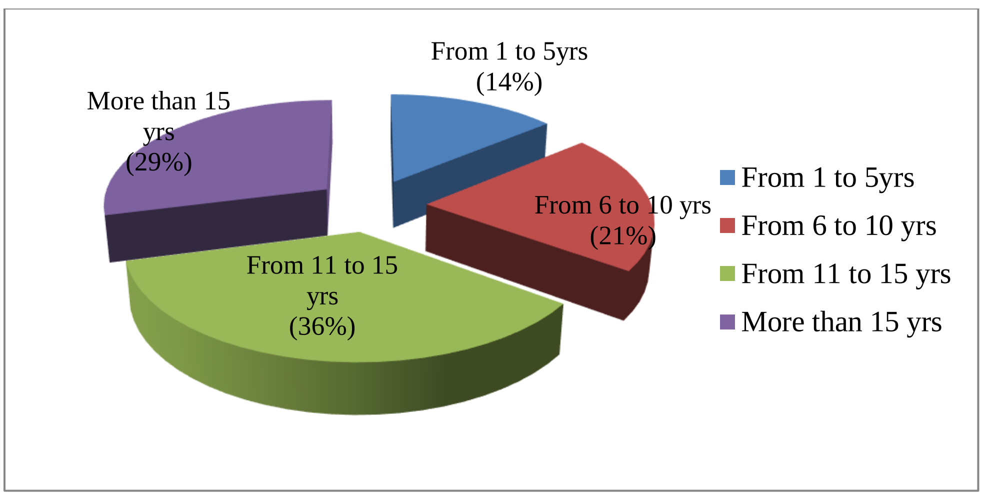


Figure 4.4: Respondents' experience

4.1.2 Response Rate

Initially, a total of 35 copies of the questionnaires were distributed for construction companies who were participating in the active construction projects. Out of the distributed questionnaires, 29 were returned; but two of the questionnaires were excluded from the analysis due to: incompleteness one (1) and illogical or incorrect responses one

(1). As a result, only 29 copies were duly filled and returned representing 82.8% response rate. These are from 21 contractors, and8 consultants.

Table 4.1: Questionnaire response rate

Companies Category	**Proposed No.**	**Correctly Responded**	**Response Rate (%)**	**Not Received**	**Invalid Response**
Contractor	25	21	84	3	1
Consultant	10	8	80	1	1
Total	35	29	83	4	2

Figure 4.5: shows the validated questionnaires. Around 83% of the questionnaires were correctly responded, 11% of the questionnaires weren't collected and the remaining 6% of the questionnaire were invalid; i.e. some were incomplete and the others were incorrect response.

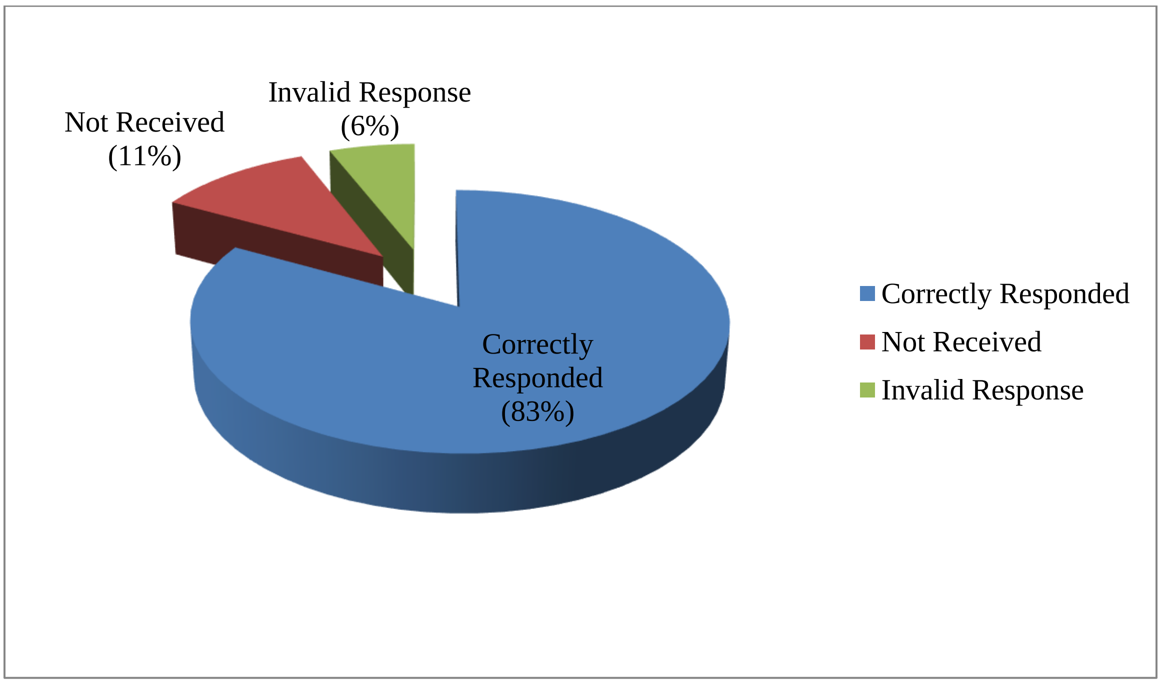


Figure 4.5: Questionnaire response rate percentage

4.2 Analysis and Discussion

4.2.1 Concrete Making Materials

4.2.1.1 Water

Lake water, river water, ground water under development, and tap water are commonly used for mixing water in most of the projects and the remaining use any of the sources; alternatively. Figure 4.6 below shows, that 23 percent of the projects use lake water and river water each (two groups), 18 percent use tap water and ground water under development each (two groups each), and the remaining 18 percent use all sources of water; alternatively. According to Atmore than 64% of the type of water being used in many projects isn't recommended or is undesirable in many literatures and standards. Therefore, this problem could be solved by RMC plant that can develop its own water supply source.

In all the projects studied, there is no test conducted for water except visual inspection on any type of water. In most cases drinking water could be used for mixing purpose without any test; however, when this water is brought from other sources like river, drilled well and lake it should be tested. Even drinkable water also should be checked for its chlorine content and other undesirable substances. Because non-visually observed dissolved salts and other impurities, which could possibly be present in it may have a negative impact on both fresh and hardened concrete quality [19, 29].

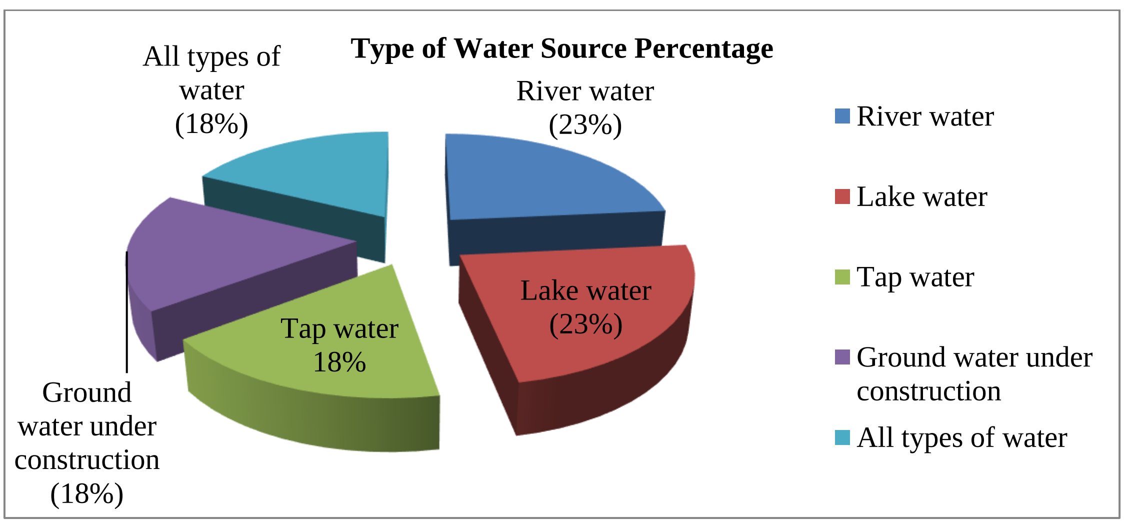


Figure 4.6: Source of water for construction projects

In urban and outskirt areas, the ground water under development has higher tendency to be polluted with domestic wastes and chemicals discharged out of factories. Even though this water is not mostly used as under mixing water, sub structures of buildings with reinforced concrete are with a higher possibility of getting in contact with such ground water. Such water bodies contain significant amount of deleterious substances like sulphate and other soluble salts that deteriorate concrete [19]. Therefore, use of RMC is highly recommended to solve such scarcity of tap water on construction sites to get the intended quality concrete from the plant. The water supply for RMC can be either from

1. Requesting additional water supply from the municipality.
2. Drilling ground water on its own as a source and test its suitability for concrete production.

4.2.1.2 Cement

As cement is the main constituent of concrete, therefore, quality and continuous supply of cement is quite important for production of quality concrete. The growth of RMC industry in any country has a direct relation with the growth of its cement industry and consumption of cement by the construction industry [6]. Moreover, RMC technology could not be implemented as investors felt that RMC plant will starve due to non-availability of cement [22].

The conducted survey indicated that,71 percent of the respondents answered, as, there is no scarcity of cement in the City of Bahir Dar. However, the remaining 29% of the respondents believe that there is scarcity of cement because there is escalation of cement price. Moreover, the price in Bahir Dar is almost the same with the Addis Ababa. The only reason to say there is a scarcity of cement; which inflates the cement price.

In addition, from interviews of stakeholders many cement companies can supply cement to the construction industry within the required time and current price. However, the researcher believes that the availability of cement is guaranteed from interviews of construction industry practitioners of Bahir Dar and document reviews.

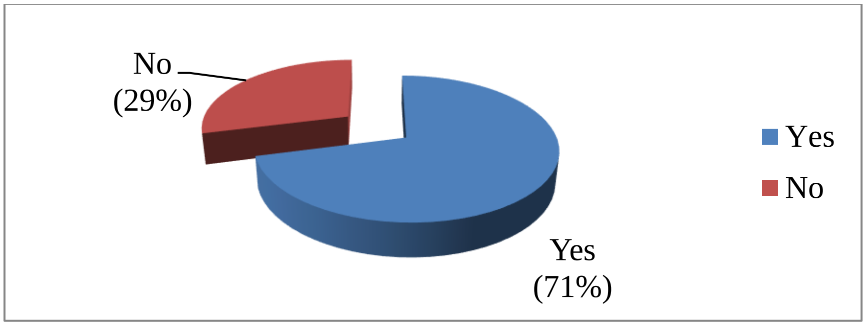


Figure 4.7: Availability of cement for the construction industry

Even though cement consumption in Ethiopia is significantly growing, evidences show that the country's production capacity has grown far more than the demand leading the industry to under capacity production. Accordingly, in 2015 as shown in the figure belowfrom2014 the cement production capacities are much higher than consumption or demand of cement in Ethiopia [23]. This shows that supply to Bahir Dar could be sufficiently assured and implementation of RMC plant is possible as long as the availability of cement is concerned.

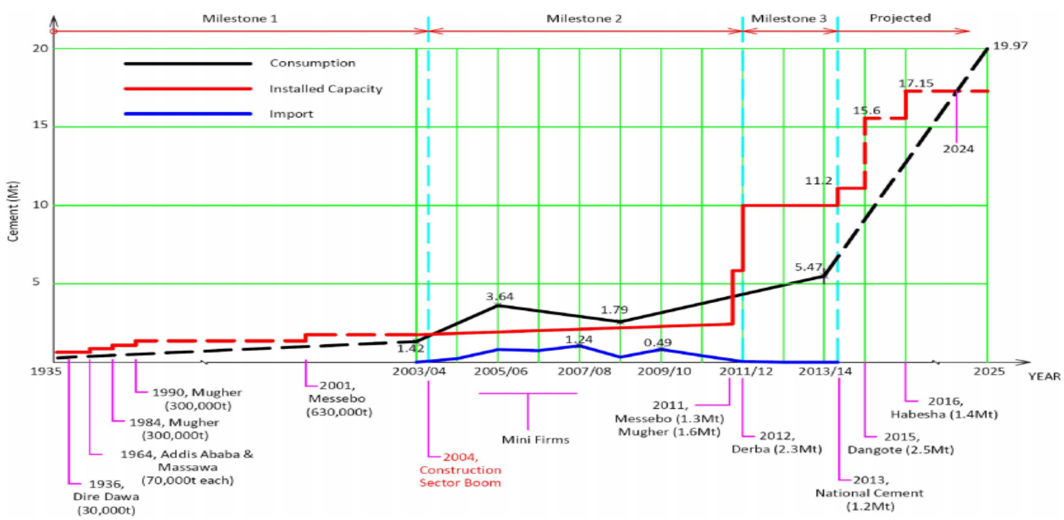


Figure 4.8: Summarized historical development and production capacity of the Ethiopian cement industry [22]

OPC and PPC cements are commonly used in construction projects of the study area. The supply sources are from the many factories located in different parts of the country. The major sources of cement for Bahir Dar are Mugger, Messe, Dangote, National, and Addis Ababa cement factories.

When the usage of OPC and PPC cements are examined, the figure below shows, OPC`s consumption rate is higher in which 57percent of the projects are using OPC for concrete production. Only 21.5 percent use PPC and the rest 21.5 percent of the projects are using both OPC and PPC cements alternatively; and as available.

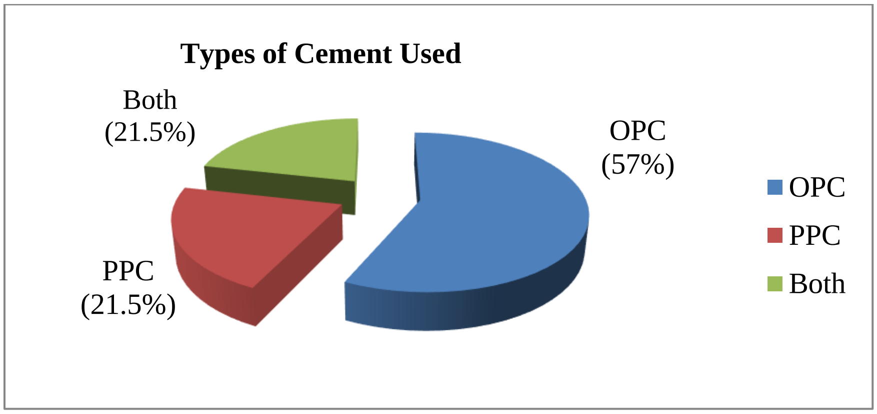


Figure 4.9: Usages of Portland cements on building constructions

Which cement is best? Which cement should be used for a given purpose? There is no simple answer to these questions but a rational approach will lead to satisfactory responses. First of all, no single cement is the best one under all circumstances. For instance, due to the higher calcium oxide content of OPC, which results in higher C3S content, the rate of strength gains or the rate of hydration is accelerated in the early ages of concretes containing this cement. However, there is an advantage obtained by using PPC cement. The Pozzolana in PPC undergoes pozzolanic reaction and leaves less free lime to be leached out which reduces the permeability of concrete and makes concrete resistant to attack against chemicals [19]. The reason for most projects using OPC cement as explained by resident engineers of the projects is the faster strength gain capability and the thought that, generally, concrete produced with OPC has faster speed of construction than PPC i.e., faster setting time. However, PPC is a better cement particularly when durability is of special interest. The only problem with the use of PPC is its lower rate of strength gain [4].

The majority of contractors prefer the brand of cement based on the delivery process easiness. Figure 4.10 below shows, that 64% respondents give the importance to the delivery of the product, 22% prefer the particular brand on the basis of price of the brand, the remaining 14% respondents use the brand due to both delivery and price. The majority of builders are delivery sensitive while preferring the brand. There are also respondents who pay attentions to more than one factor for selecting the brand.

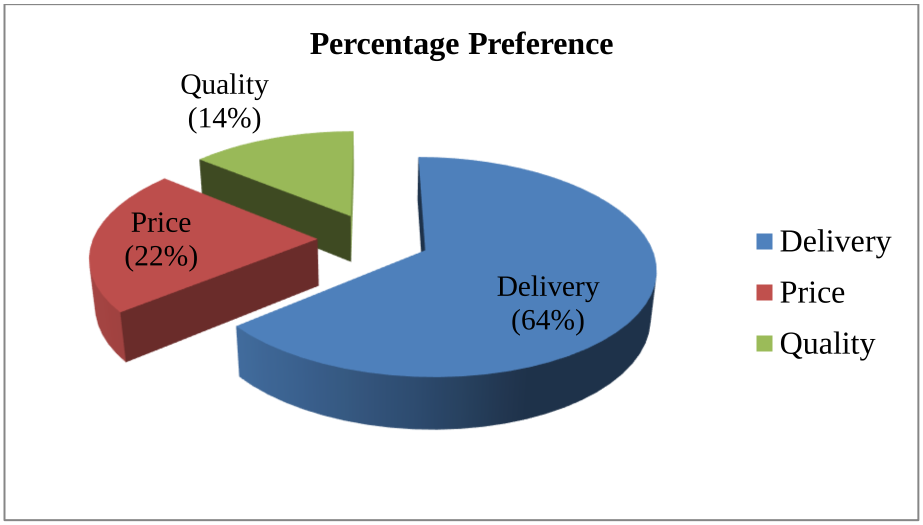


Figure 4.10: Reasons for using a particular brand of cement

Transport and storage of cements influences to a higher degree the quality of concrete. Hence, it requires proper care, otherwise there is a higher tendency that the cement may get moisture and consequently loose its significant amount of strength. Cement shall be stored at the work site in a building or a shed which is dry, leak proof and moisture proof. The building or shed shall have minimum number of windows and well-fitting doors which shall be kept closed at all times except during loading and unloading [19].

In Ethiopia, it is common that cements are transported a long distance by trucks and trailers that make them susceptible to moisture contact unless attention is given. The other serious problem is with the storage of cement. Cements after brought from factories are stored in places that are not properly constructed. Therefore, its impact on concrete quality is not given due attention. In addition, it's exposed to robbers, which is a consequent of wastage. To solve this serious problem RMC is highly recommended because cements are transported in bulk and stored in cement silos which are very secure from diverse external effects.

Some of the effects of poor handling and storage of cements are crack in cast concrete, reduction in quality, cement cakes and reduction in strength of concrete.   Since, cement has a higher tendency to attract moisture and as a consequence of which it loses its significant amount of strength [59].

Figure 4.11: Common type of cement storing culture in Bahir Dar

Among the surveyed projects, it was observed that no test was conducted to check the quality of cement used. Therefore, this is considered as one of the problems that could seriously affect the quality of concrete and responsible for cement wastage.

4.2.1.3 Aggregates

To investigate the quality and availability of suitable concrete making aggregates in Bahir Dar, test results of coarse and fine aggregates were collected from three prominent Construction Material Testing Laboratories. The test documents regathered from tests carried out between September 2017 and May 2018. In addition to this, the goal of questionnaire survey was to know the common aggregate sources that are supplied to the civil projects in and around Bahir Dar.

In this study, the sources of fine and coarse aggregates were identified from the very beginning of data collection through reviewing of researches done previously in Bahir Dar, questionnaires and interviews. The next step was collecting the test results from the laboratory centers mentioned above, and make analysis of these sources.

Recently a study was conducted by Abel (2016), on the assessment of quality of sand sources and the effect on the properties of concrete; the findings revealed that there were more than 13 sand sources but out of the 13 sand sources the most commonly purchased for concrete production are; Arno, Addis Zemen, Rib and Tana that are found in and around Bahir Dar. According to the researcher's justification, those sands which are coming afar are expensive and of good quality. The reason for this is transportation cost, in addition to the better quality of sand. For instance, sand sources those from Arbane, Lalibela and Arno are costly [32].

Figure 4.12: Main sand supply source locations found between Bahir Dar City and Gondar [32]

Figure 4.13: Main sand source locations along the route of Bahir Dar to Taskset [32]

(Goggle earth, March 2016)

By the same analogy a research by Habtamu (2015), showed that the major sources of coarse aggregate were from Benzema, Meshenti, Kinbaba (Adet), BikoloAbay, Wegelsa (Airport) and Addis Zemen; respectively. The sources of fine aggregates were also identified as Addis Zemen (Yifag), Ribb,Arno, Enfiranz and Keha were the top six sources. About 27 contractors out of 33 or 81.82% of the assessed population were using only natural sand from the quarry sites listed above [34].

From the questionnaires, interviews and document reviews the major suppliers of coarse aggregate of the studied projects are BikoloAbay Crushing Plant, Wegelsa (Airport)Crushing Plant, Meshenti Crushing Plant; Zen Zelma CrushingPlant, Kinbaba (Adet)Plant, Addis Zemen Crushing Plant, YibabCrushing Plant.

Through the same data collection technique, the major sources of fine aggregatesfor the projects are; natural sand fromTana, BeneshangulGumz (Bulen white sand) or GilgelBeles, Adis Zemen (Yifag), Gumara, Sendeta, Arbaya (Belessa), Enfranz, Ribb, Kehaand crushed aggregates from crushing plants around Bahir Dar.

Various aggregate source test results were examined from the documents collected from material testing centers. The indication is that, most of the projects are using materials from sources which are nearer to the location on their projects irrespective of quality.

The coarse and fine aggregates have passed through a number of laboratory tests. The tests conducted in all the three prominent Construction Materials Testing Laboratory Centers are: sieve analysis, aggregate crushing value, Los Angeles abrasion, silt and clay content, unit weight, specific gravity, water absorption, organic impurity, and soundness as listed in the following Table 4.2.

Table 4.2: Summary of the number of tests carried out on the collected aggregate samples

Type of test	Fine aggregate		Coarse aggregate	
	No.	**Percentage**	**No.**	**Percentage**
Gradation	26	44.00	14	31.80
Silt and clay content	26	44.00	-	-
Aggregate Crashing Value (%)	-	-	10	22.70
Specific Gravity and Water Absorption	1	0.02	8	18.18
Aggregate Crashing Value (%)	-	-	6	13.64
Soundness	2	0.03	2	4.55
Unit weight	4	0.08	-	-
Loss Angeles Value (%)	-		3	6.82
Elongation Index (%)	-		1	2.27

4.2.1.3.1 Aggregates Size, Shape and Surface Texture

Roundness measures the relative sharpness or angularity of the edges and corners of a particle. Roundness is controlled largely by the strength and abrasion resistance of the parent rock and by the amount of wear to which the particle has been subjected. In the case of crushed aggregate, the particle shape depends not only on the nature of the parent material but also on the type of crusher and its reduction ratio, i.e. the ratio of the size of material fed into the crusher to the size of the finished product [19].

The ***flakiness*** affects adversely the durability of concrete because flaky particles tend to be oriented in one plane, with bleeding water and air voids forming underneath. The mass of flaky particles expressed as a percentage of the mass of the sample is called the ***flakiness index.*** A maximum flakiness index value of 35% is stated in the ASTM for crushed concrete aggregate (ASTM C33). However, there is no requirement stated in the Ethiopian Standard. Accordingly, 90 percent of the flakiness indexes of the coarse aggregate samples are within the allowable limit and the remaining 10% deviate from the standard as shown the table below. This is an indication that most of the coarse aggregates around Bahir Dar are good for concrete as far as flakiness index is concerned.

The presence of elongated particles in excess of 10 to 15 percent of the mass of coarse aggregate is generally considered undesirable, but no recognized limits are laid down in Ethiopian standard. British Standard BS 882: 1992 limits the ***elongation index***of the coarse aggregate to 50% for natural gravel and to 40% for crushed or partially crushed coarse aggregate. However, for wearing surfaces, lower values are required. The results of the Elongation Index (EI) indicates a value of 21%; but only for one source. However, the maximum elongation index is limited to 15% according to British standard. Therefore, the aggregate isn't good as far as elongation index is concerned which needs adjusting or changing the aggregate crushing plant. Jaw crusher plants have a tendency to produce elongated aggregates [19].

The table below shows test results related to shape of coarse aggregates from the laboratory centers.

Table 4.3: Coarse aggregate test results on shape

Source of aggregates	**Date of tested**	**Flakiness Index**	**Elongation Index**
B/Dar	19/03/2018	7.90	-
B/Dar	19/10/2017	36.29	-
B/Dar	26/10/2017	30.42	-
B/Dar	10/11/2017	34.46	-
Yibab	13/10/20217	31.00	-
Meshenti	15/12/2017	33.00	21.00
Meshenti	07/11/2017	33.00	-
Meshenti	12/02/2018	30.00	-
Meshenti	07/11/2017	24.00	-
Requirement		**≤35.00**	**≤15.00**

Surface texture of the aggregate affects its bond to the cement paste and also influences the water demand of the mix, especially in the case of fine aggregates. Surface texture depends on the hardness, grain size and pore characteristics of the parent material (hard, dense and fine-grained rocks generally having smooth fracture surfaces) as well as on the degree to which forces acting on the particle surface have smoothed or roughened it. There is no recognized method of measuring the surface roughness. A rougher surface, such as that of crushed particles, results in a better bond due to mechanical interlocking; better bond is also usually obtained with softer, porous, and mineralogically heterogeneous particles [19].

- ✓ The shape and surface texture of fine aggregate have a significant effect on the water requirement of the mix made with the given aggregate i.e. the amount of water will increase with increase content.
- ✓ Flakiness and the shape of coarse aggregate in general have an appreciable effect on the work-ability of concrete.

4.2.1.3.2 Surface Moisture, Porosity and Absorption

Some of the aggregates are porous and absorptive. Porosity and absorption of aggregate affect the water/cement ratio and hence the workability of concrete. The porosity of aggregate also affects the durability of concrete when the concrete is subjected to freezing and thawing and also when the concrete is subjected to chemically aggressive liquids [27]. By the same argument the porosity of aggregate, affects its permeability, and absorption such properties of aggregate influence the bond between it and the hydrated cement paste, the resistance of concrete to freezing and thawing, as well as its chemical stability and resistance to abrasion [19].Generally, it is coarse rather than fine aggregate particles with higher porosity values and medium-sized pores (0.1 to 5 µm) that are easily saturated and cause concrete deterioration and popouts. Absorption and porosity or void is measured in terms of specific gravity and water absorption.

The following tables show that, the test results of specific gravity and water absorption of coarse and fine aggregates from different sources around Bahir Dar on the given date.

Table 4.4: Specific gravity and water absorption of the tested coarse aggregate samples

		Specific Gravity			Water Absorption (%)
Sample Source	**Date**	**Bulk**	**Bulk (SSD)**	**Apparent**	
B/Dar	12/10/2017	2.83	2.85	2.93	1.0
BikoloAbay	10/11/2017	2.81	2.84	2.91	1.2
Meshenti	15/12/2017	-	-	-	1.2
Sebatamit	20/12/2017	2.71	2.75	2.84	1.8
Sebatamit	07/01/2018	2.81	2.85	2.91	1.2
Meshenti	04/02/2018	-	-	-	1.0
Yibab	13/10/2017	2.83	2.85	2.91	1.0
B/Dar	06/01/2018	2.63	2.65	2.67	0.5
Requirement		**2.4-3.0**	**2.4-3.0**	**2.4-3.0**	**0.2-4.0**

Table 4.5: Specific gravity and water absorption of the tested fine aggregate samples

		Specific Gravity			Water Absorption (%)
Sample Source	**Date**	**Bulk**	**Bulk (SSD)**	**Apparent**	
B/Dar	06/01/2018		2.65	2.5	5.29
Requirement		**2.4-3.0**	**2.4-3.0**	**2.4-3.0**	**0.2-4.0**

There is no requirement concerning water absorption in the Ethiopian Standard. According to the requirement of ASTM the water absorption content of a concrete aggregate should lie in the range of 0.2 to 4 % (ASTM C127).89%of the specific gravity and water absorption of the coarse and fine aggregate samples are within the range i.e. 0.2- 4%. See Tables 4.4 and 4.5 above.

According to the Chinese Construction Standard (CS3, 2013), the water absorption course natural aggregate and coarse recycled aggregate shall not exceed 0.8% and 10%; respectively. However, coarse natural aggregates around Bahir Dar are beyond the standard requirement and there is no course recycled aggregate test result.

Bulking of Sand; 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 increasing volume [19]. 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 [36]. There are eight test results for coarse aggregate; all fulfill the requirement as far as moisture content is concerned. There is one test result for fine aggregate on moisture content which is short of the requirement that needs further test to be clarified.

A research by Abel(2016), on six major sand source sample tests were tested for specific gravity as detailed in ASTM C 128-01; aggregates less than 10mm diameter using the pycnometer glass vessel. Results showed that the bulk specific gravity in SSD lies between 2.44 and 2.66 while the water absorption is in the range of 1.66 to 2.92 [32]. This is also a good sign of aggregate as far as specific gravity is concerned; so, it can be taken as good input for the RMC plant if established in Bahir Dar.

4.2.1.3.3 Mechanical Properties

When cement paste of good quality is provided and its bond with the aggregate is satisfactory, then the mechanical properties of the rock or aggregate will influence the strength of the concrete. Therefore, for example, according to Shetty (1982), it can be concluded that without strong aggregates, one cannot make strong concrete, for making strong concrete, strong aggregates are essential [27].

On the other hand, 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) [36].

It is generally understood that the compressive strength of concrete cannot significantly exceed that of the major part of the aggregate contained therein, although it is not easy to determine the crushing strength of the aggregate itself. The required information about the aggregate particles has to be obtained from indirect tests, such as crushing strength of prepared rock samples, crushing value of bulk aggregate and performance of aggregate in concrete. The aggregate crushing value (ACV) test is prescribed by different standards and is a useful guide when dea1ing with aggregates of unknown performance.

The following table (Table 4.6) shows the results of mechanical properties of aggregates from the laboratory centers considered.

Table 4.6: Test results of mechanical properties of coarse aggregates

Sample Source	Test of Date	Loss Angeles Value (%)	Aggregate Crashing Value (%)	Aggregate Impact Value (%)
B/Dar	08/01/2018		18.1	19.89
Yibab	13/10/2017	17		
Meshenti	15/12/2017	17	10.0	
Meshenti	07/11/2017		11.0	
Meshenti	12/02/2018	14	9.6	8.40
Meshenti	07/11/2017		5.0	
Meshenti	12/02/2018		14.0	
Requirement		**≤50%**	**≤40%**	**≤45%**

Literatures state that, the aggregate crushing value of a course aggregate sample should be equal to or less than 40%. There are six aggregate crushing value test results ranging between 5.0%and 18.1% all indicating that the values are within the limit which is a good concrete aggregate as far as crushing value is concerned.

According to the Ethiopian Standard (ES C. D3. 201), the maximum loss in mass when coarse aggregate is subjected to abrasion test shall not exceed 50 percent. In addition, ASTM states that a range from 25 to 50% is acceptable for a good aggregate ASTM (C131 and C 535). Details of the test are prescribed in BS 812-112:1990 (2000), and BS 882: 1992 recommends the following maximum values: 25 percent when the aggregate is to be used in heavy duty floors; 30 percent when the aggregate is to be used in concrete for wearing surfaces; and 45 percent when it is to be used in other concrete. Table 4.6shows the summary of the Los Angeles value, aggregate crashing value, and aggregate impact value of the coarse aggregate samples of this study. There are five test results for Loss Angeles value and aggregate impact value all which satisfy the set requirements.

4.2.1.3.4 Chemical Properties: Alkali-Aggregate Reactions

There were no aggregate samples tested to assess their potential for alkaline- aggregate reaction. Referring to literatures, most concrete aggregates are derived from igneous origin. Among all the igneous rocks, basalts are most wide spread. Additionally, some siliceous sand stones and limestone also can yield good concrete aggregate. In Ethiopia, most locally available aggregates are volcanic origin. Among the most common of such volcanic rocks are; basalt, ignimbrite and tuffs [13]. Thus, Abel (2016), examined the three sand sources were having natural sands of basaltic rock origin which implies that they can be used for concrete production [32].

4.2.1.3.5 Deleterious Substances

The concrete aggregate should be free from impurities and deleterious substances that are likely to interfere with the process of hydration and results in prevention of effective bond between the aggregate and matrix. These impurities sometimes reduce the durability of the aggregate. Generally, the fine aggregate obtained from natural sources is likely to contain organic impurities in the form of silt and clay [27].

In the Ethiopian Standard nothing is stated concerning the limit of organic contents of fine aggregates. However, ASTM (C40 – 79) states that plate number 3 is the maximum value allowed for fine aggregates as far as their organic content is concerned. When a sample subjected toast (C40 – 79) a color darker than the standard color, or Organic Plate No. 3(Gardner Color Standard No. 11), the fine aggregate under test shall be considered to possibly contain injurious organic impurities.

In this research two organic impurity test results for fine aggregate were observed which are plate number 2 and 3 and all of the samples have acceptable value of organic impurity. In addition to this Abel (2016), indicated that, 85% of the collected samples were within the organic content limit as set in AASHTO T 21-00, indicating a failure rate of 15% [32]. This is a good indication that about the majority of the aggregates produced around Bahir Dar are good for concrete as far as their organic impurity is concerned.

The Ethiopian Standard stipulates that the silt and clay contents of a fine aggregate sample should be less than or equal to 5% for all type of normal concrete (ES. C. D3. 201); the silt and clay contents of the fine aggregate samples are shown in Table 4.7 below.

Table 4.7: Silt and clay contents of the fine aggregate samples from different sources and test dates

No	Sample Source	Type of sand	Date	Silt and Clay Content (%)
1	Arbaya	Natural sand	15/03/2018	1.74
2	Gumara	Natural sand	28/02/2018	3.26
3	Adiszemen	Natural sand	20/02/2018	8.92
4	BikoloAbay	Natural sand	11/12/2017	7.47
5	Enfranz	Natural sand	08/10/2017	1.35
6	Adiszemen	Natural sand	29/02/2018	7.99
7	Arbaya	Natural sand	03/09/2017	2.48
8	Bulen	Natural sand	09/02/2018	4.49
9	Arbaya	Natural sand	07/10/2017	2.46
10	Arbaya	Natural sand	27/11/2017	2.70
11	Pawi	Natural sand	10/04/2018	2.20
12	Sebatamit	Natural sand	18/11/2017	3.80
13	Beles	Natural sand	12/01/2018	2.80
14	Sebatamit	Natural sand	06/01/2018	2.50
15	Arbaya	Natural sand	12/10/2017	2.70
16	B/Dar	Natural sand	18/04/2018	4.50
17	B/Dar	Natural sand	18/10/2017	1.43
18	B/Dar	Natural sand	19/01/2018	1.84
19	B/Dar	Natural sand	15/02/2018	3.40
20	B/Dar	Natural sand	16/05/2018	3.47
21	B/Dar	Natural sand	16/05/2018	5.84
22	B/Dar	Natural sand	16/05/2018	3.92
23	B/Dar	Natural sand	16/05/2018	14.86
24	B/Dar	Natural sand	18/05/2018	20.14
25	B/Dar	Natural sand	10/10/2017	8.78
ES Requirement				**≤5.0%**

In this research 25 laboratory test results of fine aggregate on silt and clay contents were thoroughly examined. According to the Ethiopian Standard,28% of the samples had a silt and clay content which are beyond the limits of Ethiopian Standard requirements. This is a good indication that about 72% of the fine aggregates produced around Bahir Dar are good for concrete as far as their silt and clay content values are concerned. However, a recent research by Abel(2016), revealed that 92% failed to meet the limit set in the Ethiopian Standard [32]. In addition, Habtamu (2015), revealed that the fine aggregate in and around Bahir Dar contains high amount of silt and clay content in it [34]. This is in a complete contradiction with those results from the laboratory centers. The indication is that, the contractors may conduct laboratory tests after washing the fine aggregates.

However, the researcher believes that the results obtained by the above researchers are convincing because the researches are laboratory test based researches. Therefore, the selection of aggregates sources and needs washing of fine aggregates in some sources to be used in good quality concrete production for RMC plant.

4.2.1.3.6 Soundness of Aggregates

The soundness effect is a problem where the concrete is subjected to freezing and thawing. Soundness is the resistance of aggregates change in volume as a result of changes in physical or environmental conditions such as freezing, and altering wetting and drying. For example, Neville (2011), the aggregate is said to be unsound when volume changes result in deterioration of the concrete. This may range from local scaling and so-called pop-outs to extensive surface cracking and to disintegration over a considerable depth [19]. Therefore, aggregates used for concrete production are tested for its soundness and it should comply with the requirement set in specifications.

There are five test results observed to assess the soundness two on fine and three on coarse aggregate samples around Bahir Dortha summaries of soundness of fine and coarse aggregate sample test results are shown in the Table 4.8 below. Soundness was determined using Sodium Sulphate and the results obtained were 19.98, 11.00, 7.18, 7.72 and 6.50 % loss in weight.

Table 4.8: Soundness weight loss test results of aggregate using Sodium Sulphate

sample location	**Date**	**Coarse aggregate**	**Fine aggregate**
B/Dar	29/02/2010	19.98	6.50
Yabba	03/02/20210	11.00	-
B/Dar	28/04/2010	7.18	7.72
ES Requirement		**≤10%**	**≤10%**

However, the maximum loss stated in ASTM is 10%. This shows that the majority of both fine samples satisfy the requirement and but not coarse aggregate samples. The ES also states in fine aggregate, when subjected to five cycles of soundness test, shall not show loss in mass exceeding 10 percent when sodium sulphate solution is used or 15 percent when magnesium sulphate solution is used. Therefore, in both cases the majority of samples satisfy the requirement. However, according to Abel (2016), samples taken from only three sources failed to satisfy the requirement out of the 13 sources tested for soundness [32]. This is a good indication as far as soundness is concerned; suggesting aggregates within the vicinity of Bahir Dar can make a durable concrete structure.

4.2.1.3.7 Grading of Aggregates

Gradation of aggregates is one of the most important quality parameters that predominantly influence the properties of a concrete. The grading of aggregates affects the workability, which, in turn, controls the water and cement requirements, segregation, and influence the placing, and finishing of concrete [25]. Therefore, aggregate has to confirm to the grading requirement of standards specified in the technical specifications especially, for RMC production. The results of the analysis are summarized in the Table 4.9 below. See Appendix II for details.

Table 4.9:Summary of gradation distribution of fine and coarse aggregate samples

Condition		**Fine aggregate**		**Coarse aggregate**	
		No.	**Percentage**	**No.**	**Percentage**
Not complying	Coarser	2	7.7	3	21.4
	Finer	16	61.5	7	50.0
complying		8	30.8	4	28.6
Total		**26**	**100.0**	**14**	**100.0**

To see whether the results satisfy the graduation requirements set in the Ethiopian Standard, gradation charts are prepared and their gradations are checked in light of the given requirements. The gradations of the samples were characterized as coarser, finer and complying to the standard. Coarser samples had a percentage passing value below that stipulated in the standard and finer samples had a percentage passing value above that stipulated in the standard; at least in one sieve size.

There were 26 laboratory test results of gradation for fine aggregates. The results show that about 68percent of fine aggregate samples couldn't satisfy a graduation requirement which is 8 percent on the coarser side and 61 on the finer side. This has an implication that about 68% of fine aggregates supplied to the industry have quality problems as far as graduation requirements are concerned.

There were also 14 laboratory test results of gradation for coarse aggregates of nominal maximum size 37.5. However, the results show that about 71percent of coarse aggregate samples couldn't satisfy graduation requirements. This is also coarse aggregates supplied to the industry have quality problems as far as graduation requirements are concerned.

Moreover, a recent study by Abel (2016), proved that 100% of fine aggregate samples could not satisfy the set limits out of which 84.62% are more on the coarser side while 15.38% fall on to the finer sand. Based on the research outcome, blending of Addis-Zemen sand with that of Rib sand incurs the least cost, while at the same time fulfill requirements of fresh and hardened concrete.

The results show that, aggregates gradation properties of fine and coarse aggregate around Bahir Dar are far from ASTM and ES requirements. As a result, aggregates around Bahir Dar need treatment like blending different sources of aggregate [32]. This could be easy for the RMC Plant to order from different aggregate sources and blending with the required proportion.

Fineness Modulus (FM) is an important parameter influencing the properties of concrete significantly. In this research, 26 laboratory test results were thoroughly observed for fineness modulus of fine aggregates. According to the Ethiopian Standard, the fineness modulus shall not be less than 2.0 or more than 3.5and only about 16% of the samples have unacceptable value of fineness modulus of fine aggregates. However, the remaining 84% fineness moduli are within the range.

The physical and mechanical properties of aggregates are inherited from parent materials [13, 26]. As shown in the Table 4.10 below, out of91tests investigated for fine aggregate, the results of 70% of the tests satisfy the requirements of set standards. This is an indication that more than half of the tests carried out on fine aggregates supplied for concrete production in Bahir Dar have met the requirements needed for concrete aggregates. Further, out of those30% of the tests of which the fine aggregates fail to satisfy requirements,97% of the tests attribute to the property of the aggregate which is not related to the natural quality of the fine aggregates. This is an indication that only 3% of the failure of the aggregates is due to the natural quality of the aggregates.

However, if fine aggregate materials had been passed through some treatment to make it suitable for concrete work it wouldn't have failed to meet these standard requirements. Like; washing of fine aggregates from rivers to remove excessive silt and clay content, storing of aggregates in clean places and blending different sources of aggregates to attain a well- graded composition.

Table 4.10: Summary of collected test results on fine aggregate with the failed percent

Order	**Type of test**	**Number of tested samples**	**Percent of contribution**	**Percent failed**
1	Gradation Fineness modulus	26 26	29.0 29.0	16 5
2	Silt and clay content	26	29.0	8
3	Loose unit weight	4	4.4	0
4	Organic impurities	2	2.2	0
5	Soundness	2	2.2	
5	Compacted unit	1	1.1	0
6	Bulk specific gravity Bulk specific gravity (SSD) Water absorption	1 1 1 1	1.1 1.1 1.1 1.1	0 0 0 1
Total		**91**	**100**	**30**

As shown in the Table 4.11 below, out of 47 tests examined for coarse aggregate, the results of 80.6% of the tests satisfy the requirements of standards. This is also an indication that the majority of the tests carried out on coarse aggregates supplied for concrete production in Bahir Dar are within the allowable limits. In addition, out of this 19.4% of the tests at which the aggregates fail to satisfy requirements, 89% of the failures attribute to the production process of coarse aggregates.

Table 4.11:The summary of tests on the collected coarse aggregate and percentage failed

Type of test	**No. of tests collected**	**Percentage**	**Percentage failed**
Gradation	14	30.4	17.3
Elongation Index (%)	10	21.7	0

Specific Gravity and Water Absorption	8	17.4	0
Aggregate Crashing Value (%)	6	13.0	0
Loss Angeles Value (%)	3	6.4	0
Soundness	3	6.4	2.1
Aggregate Impact Value (%)	2	2.2	0
Elongation Index (%)	1	0.9	0
Total	**47**	**100**	**19.4**

4.2.1.4 Storage and Handling Practices

Materials required in construction operations shall be stored, and handled in a manner to prevent deterioration. For instance, Neville (2011) states, improper handling of aggregates can result in contamination by other aggregates or by deleterious materials [19]. It may also induce a quality problem.

It was observed on sites by Yonas (2018), that the aggregates were not stored properly. They were placed in a place where they easily get dust, kept under trees where leaves drop on the stockpiles. As a result, the amount of organic content of aggregates increases. In addition, there is no proper demarcation between fine and coarse aggregates. Such negligence in aggregate handling and storage affects or degrades its quality [59].

Many construction firms store their aggregates on main roads that obstruct the traffic movement as shown in the Figure 4.14 below. This problem will be greatly solved by using RMC.

Figure 4.14: Photos taken from construction projects to show how aggregates are stored

4.2.1.5 Concrete production Practices

In general, the proper execution of the operations in the production process, namely; batching, mixing, transportation, placing, compaction, finishing and curing are important in attaining the desired quality.

In all the construction projects under investigation concrete ingredients on sites are batched by volume. In volume batching, boxes of the given capacity are constructed manually on sites for coarse and fine aggregates. The Box sizes of {50 x 40 x (16, 18 20)} are decided per 50 Kg or 1 sack of cement for a given strength of structural concrete While measuring the given proportions during batching and mixing there is no accuracy because the boxes are either over or under filled. In addition to this, the amount of water added to the given volume of fresh concrete is by guess or not measured. Which means the water to cement ratio is ignored? They use simply the proportion (1:2:3) for the given strength of concrete using variable volume of box which isn't accurate. The proportioning, mixing, and placing in most case is as follows.

- ✓ One bag of cement, 50 kg
- ✓ Two boxes of sand, weight unknowns well as moisture content
- ✓ Three boxes of coarse aggregate, weight unknown
- ✓ Estimated quantity of water based on wetness and dryness of fresh concrete
- ✓ Estimated mixing time
- ✓ Finally, transporting long distance using labor force which in turn affects consistency.

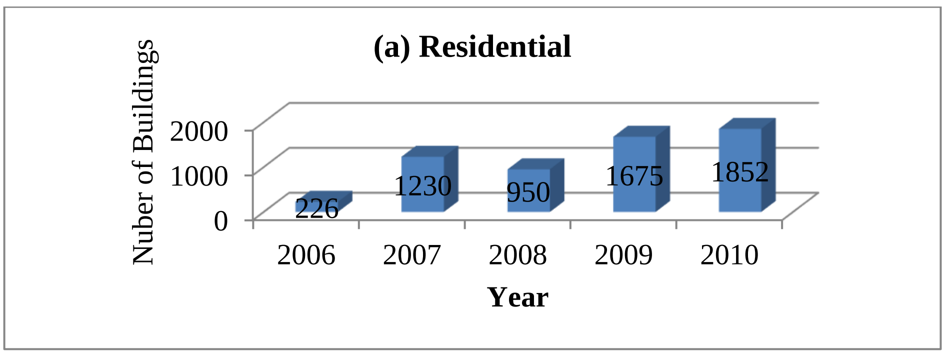
For fully compacted concrete made with clean, sound aggregates, the strength and other desirable properties of concrete under given job conditions are governed by the quantity of mixing water used per unit of cement or cementing materials [35].

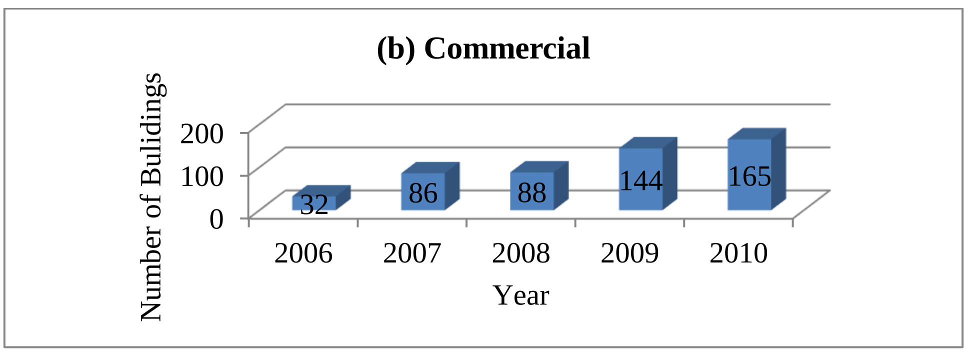
In all of the projects adopting volume-batching techniques do not make any water measurement and adjustments. This shows that, there is negligence on adjusting the quantities of aggregates on construction sites. Most of the time, the aggregates are left open outside; hence, during the rainy season, aggregates have excess water or free moisture on their surface and during dry season aggregates need additional water to be saturated. In volume batching, in addition to adjusting the amount of water, bulking of sand should also be considered [19].

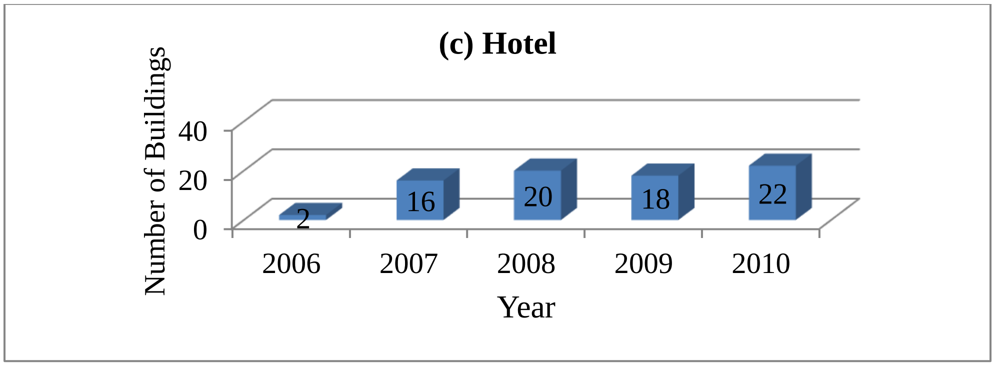
During batching, batching quantities should be measured with a high degree of accuracy. For solid granular materials, such as aggregates and cements, batching is best done by weight. Accordingly, water and liquid admixtures can be measured accurately by volume. Batching by weight also follows rapid and convenient adjustments on aggregates and water contents when changes in aggregates moisture contents occur [23].

4.2.2 The Nature of Demand for Ready Mix Concrete

The ready-mixed industry's fortunes are closely tied to the level of activity in the construction sector. The sector buys the vast majority of ready-mixed output. For instance, the basic demand conditions faced by ready-mixed producers in any given local market therefore depend on how robust the construction activity is in that same market, not elsewhere [47]. Therefore, as we can see the Figures 4.15 below the need for concrete construction in Bahir Darden to high need of residential, commercial, hotel, industrial and other buildings is increasing. Buildings are not only growing in number and size but also in their height and complexity. In this research, the data from "Construction Permit Office" of ***Bahir Dar Building Officer*** means a document verifying the permission given to a person to construct a building upon fulfillment of the necessary requirements. See Appendix III.







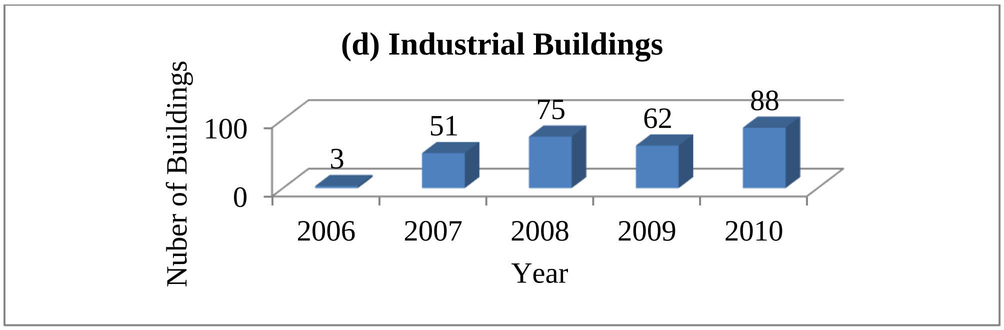


Figure 4.15: Gradual increments of construction projects

Estimating the market potential for a business is critical in evaluating its viability and provides an estimate of the maximum total sales potential for a given market. Once the estimated market potential has been calculated, it is possible to determine if the market is large enough to sustain your proposed business or sustain an additional competitor in the marketplace. It is important to remember that the estimated market potential sets an upper boundary on the market size and can be expressed in either units and/or sales. Unless there are no direct or indirect competitors, a business will capture a share of the total estimated market potential not all of it [57].

However, the RMC supplier should secure a minimum annual concrete sale of 10,000m^3 to cover the total annual expense for break even. This was due to the 4 Million annual average owning cost of RMC Plant [61]. The average total structural concrete volume usage per year in Bahir Dar City is about258,725m^3(see Appendix III). The major concrete goes to commercial projects, public projects, and industrial projects; respectively. This is a good indication as long as RMC plant supplier concerns annual concrete sale.

Table 4.12:The major structural concrete share by builders/contractors

Type of projects	**Annual usage (m^3)**	**Percentage (%)**
Commercial buildings	138,056	53.00
Public projects	71,119	27.00
Industrial buildings	49,550	20.00
Total	**258,725**	**100.00**

From the above table, the majority of the builders, i.e., 53.00% takes the commercial project followed by 27.00% builders take government project the remaining 20.00% belongs to industrial buildings. There is a big market for RMC from the commercial developers. There are few builders who undertake both public and industrial types of projects. Residential, real estate and low story less than G+5 types of projects aren't considered hear because mostly they aren't built by professionals. However, there is a possibility of potential RMC users within these construction sectors in the future.

In Bahir Dar, currently, RMC is not totally available. Therefore, the builders are using the SMC as shown in the figure below.

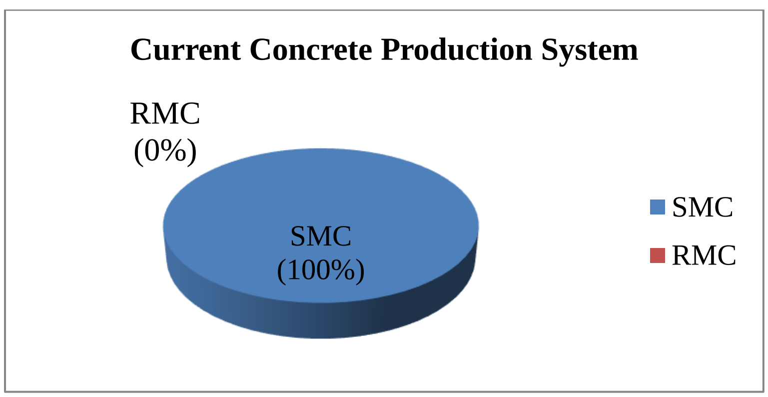


Figure 4.16: Chart showing type of current concrete production system

In the Bahir Dar construction industry, as shown in the figure below 86% of respondents are interested to use to the future, and among the 14% there is a lack of awareness and are not interested to use RMC because they are not comfortable with this new concept. This is a good indication because the majority of contractors have an idea about RMC even if it's a new technology.

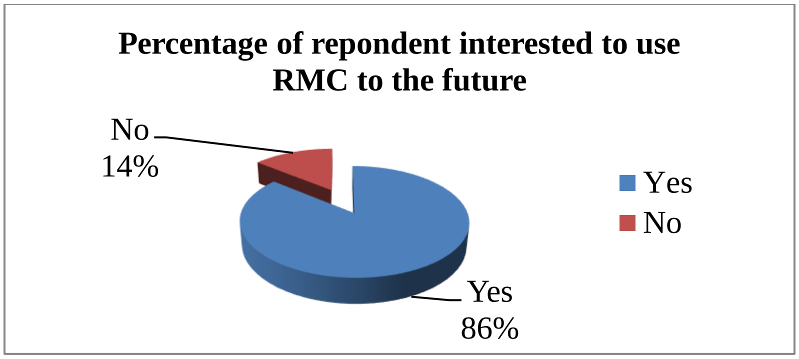


Figure 4.17: Chart showing the awareness and satisfaction of respondents about RMC

From the total volume of annual concrete demand in the Bahir Dar City, RMC can take more than half of market share. At least, federal level contractors share might be overtaken by the new entrant due to mobilization difficulty of their machinery to Bahir Dar, i.e., 71%. At most, all contractors who are aware and satisfied with RMC product, i.e., 86% of stakeholders can use the product in the future. Therefore, the minimum and maximum RMC share to the market can be determined as follows.

- ✓ Minimum market share = Percent of federal level stakeholders * Total volume of concrete demand per year = 0.71 * 258,725m^3 = 183,695 m^3
- ✓ Maximum market share = Percent aware and satisfied respondents * Total volume of concrete demand per year= 0.86 * 258,725m^3 = 222,504 m^3

From the above, it can be understood that the new entrant of RMC Plant can have an estimated market share between 183,695 $m^3$and 222,504 m^3.

Therefore, a conclusion can be made on the potentials of RMC introduction to the Bahir Dar construction industry. It's a viable new technology because the needs for buildings are increasing, the volume of structural concrete is large enough to support plant, and the respondents are aware and ready to use RMC in Bahir Dar.

There are different types of concrete mixing plants developed by different companies which are built to optimize the production efficiency, the quality of concrete mixture, and the return on investment. Equipped with different models of mixers, the batch plants have the capacity from 25-240 m^3/hr. which can satisfy various construction requirements whether for temporary installation of special projects or permanent facilities [63].

4.2.3 Cost Comparison of Scandrick

The major objectives of an RMC business as well as any other business are to realize a profit. The major costs of RMC are separated into three cost divisions; namely, Production, Delivery, and General Administrative expenses [49].

From interviews and researches done before, the two most common structural concrete grades observed on the targeted building projects are C-25 and C-30 concrete grade in the Ethiopian construction industry [4] and C-25 concrete grade for the case of Bahir Dar [34]. That is why here C-25 is used for cost comparison between RMC and SMC concrete.

The figure below shows that, 43% of the respondents are using different unit contract prices for C- 25 and C-30, the others 43% of respondents have unit bid price for only C-25 grade structural concrete, and the remaining 14% respondents use the same contract unit prices for C-25 and C-30 grade structural conventional SMC concrete.

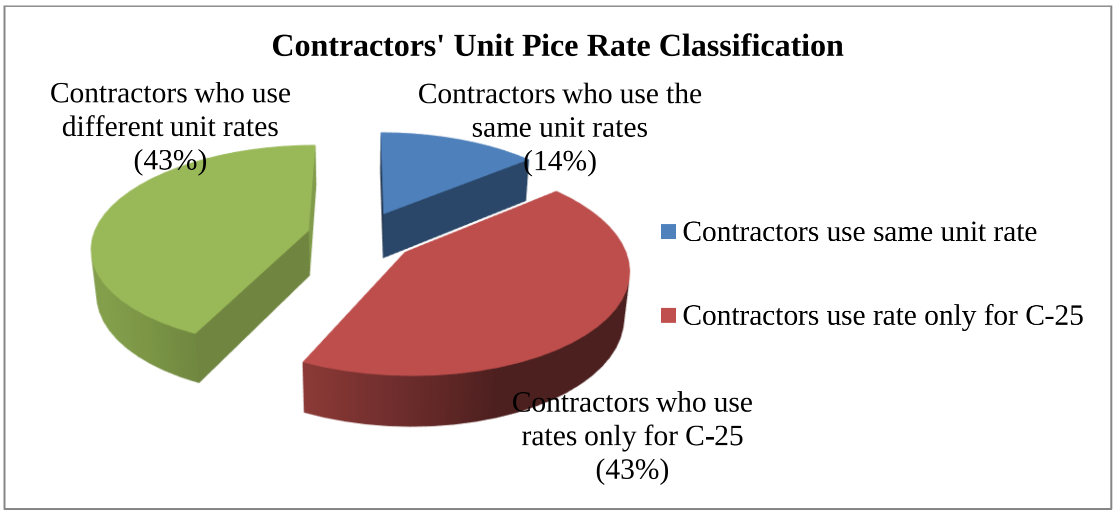


Figure 4.18: Contractors' current unit contract price classification in Bahir Dar

from questionnaire of active construction projects in Bahir Dar May 2018, for conventional SMC the contract price of C-25 ranges from 2000 to 3222ETB and for C-30 ranges from 2552 to 3500ETB, i.e., the average prices are 2,611 and 3,026ETB/m^3; respectively. This includes contractor's profit margin and overhead cost. Reinforced concrete quality C-25 price is 2648.43ETB for footings, foundation columns, grade beams, and floor slabs from Bureau of Urban Development and Construction (ANRS) in the 3rd quarter price estimation which supports the study.

On the other hand, both from the supplier and contractor side the price of C-25 ranges from 2350-2600 ETB and C-30 from 2600 to 2900 ETB in May of 2018 the same month. The cost variation mainly depends on the following excluding contractor's profit margin and overhead cost;

- ✓ The distance from the RMC plant to the intended construction site,
- ✓ The easiness of access to the construction site,
- ✓ The volume of concrete that the contractor can order, and
- ✓ The height of floor to which the concrete is going to be placed.

From the interviews, the cost of profit margin and overhead depend on the company's policy. Mostly, it ranges from 20–30% of the direct unit cost and the average is 25%. In this case the direct cost is the RMC supplier's unit cost including the transportation cost.

Table 13: Analysis sheet for direct and indirect unit costs

PROJECT: ***CONCRETE WORK***

LABOUR HOURLY OUTPUT: 5 m^3 / hr. placing

WORK ITEM: (3.5) C-25 Concrete (Mechanical Mix) 1:2:3

EQUIPEMENT: Mixer and Vibrator 24 m^3 / hr. production

TOTAL QUANTITY OF WORK ITEM: 1m^3

Sub structure Footing RESULT:

Material Cost (1:01)					Labor (1:02)					Equipment Cost (1:03)			
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labor by Trade	No.	UF	**Index Holy Cost	Hrly Cost	Type of Equipment	No.	11	Hourly Cost
Cement(OPC)	Qnt.	3.78	232.22	877.78	Foreman	1.00	1.00	20.00	20.00	Batching plant	1.00	713.80	713.80
Sand	m3	0.51	168.00	85.68	Plasterer	1.00	1.00	8.00	8.00				29.74
Gravel (02)	m^3	0.80	220.00	175.56	D/L	6.00	1.00	2.80	16.80	Vibrator	2.00	9.23	18.46
Water	m^3	0.23	3.00	0.68						Truck mixer	1.50	455.49	683.24
				0.00						Crane	1.00	618.83	618.83
				0.00					0.00	Dumper	0.25	**78.06**	19.52
										Tools	6.00	**0.5**	3.00
													1343.04
				0.00					0.00				245.87
Total (1:-01)				1139.70	**Total (1:02)**				44.80	**Total (1:03)**			275.61

A= Materials Unit Cost 1139.7 Birr/m^3

B=Manpower Unit Cost 8.20 Birr./m^3
Total of (1:02) / Hourly Output

C= Equipment Unit Cost : 275.61 Birr/m^3
Total of (1:03) / Hourly output:

Direct Cost of work item = A+B+C = 1423.51 Birr/m^3
Overhead Cost: 15% 213.53 "
Profit Cost: 15% 213.53 "

Total Unit Cost : 1850.56 Birr/m^3

Remark UF: UTILIZATION FACTOR
*: INCLUSIVE OF WASTAGE, TRANSPORTING, HANDLING, ETC.
**: INCLUSIVE OF BENEFITS, TRAVEL SUBSIDES AND COST OF OVERTIME RELATED TO TARGETED OUTPUT.

The cost break down of RMC above is taken from MIDROC Ethiopia Plc. during Bahir Dar international stadium construction using onsite RMC plant. From the cost break down, 62% of the contractor cost is to pay for RMC material, 15% accont to plant including truck mixer and labour costs, while the remaining 23% goes to overhead and profit marigin cost. Literatures note that, also 73% of the contractor's cost is topay for RMC material, 25% is due to plant and labour costs, while the remaining 2% is due to truck mixer surcharges [50]. In addition, direct labor accounts for only 10% of the cost, whereas material accounts for 55% and overhead for 35% [12].

C-25 grade concrete is used for cost break down comparison between RMC and SMC by using current prices of material, labor and equipment costs. Because the cost difference of other concrete grades are insignificant almost only material proportion change [61]. From the cost components, it can be concluded that the contribution of labor cost is insignificant in RMC (2%) as compared to SMC (17%) while equipment costs are higher in RMC. The major cost component is the material cost composed of cement, sand,and coarse aggregate in addition admixtures are used when required. It constitutes 46.55% and 49.50% in RMC and SMC; respectively(Appendix IV).

Table 4.13:Unit cost comparison between RMC and SMC

Item	**Cost contribution in RMC**		**Cost contribution in SMC**	
	Cost (ETB)	**Percentage**	**Cost (ETB)**	**Percent**
Material	1426.80	46.55	1376.80	49.50
Equipment	637.78	20.80	350.88	12.62
Labor	49.40	1.60	497.09	17.87
0ver head and profit	951.29	31.10	556.19	20.00
Unit cost	3065.27	100.00	2780.96	100.00

Any decision for a construction manager the contractor or any customer in need of concrete, for choosing from RMC and SMC, the cost of purchasing should incorporate the profit and overhead of the supplier in the quotation of the supplier.

Considering the common practices of the contractors and the estimated costs of the RMC plant under consideration a comparison was made with the site mix concrete. Taking an average value of 45% (20% for RMC Plant and 25 % for contractor) overhead cost and profit margin, the average price of RMC is 3065.27ETB/m3 which is 10% higher than the average conventional SMC as shown in the above table. Considering advantages discussed in Chapter 2, a cost increase of 10% in RMC relative to SMC is not significant.

The cost of RMC can be minimized further applying different techniques [51, 52, 53, 61].

- ✓ Using reasonable overhead and profit margin.
- ✓ Applying the trend of aggregate producers and vertically integrate the resource (materials, plant, etc.) supply chain.
- ✓ Reducing the distance between the batch plant and the construction site. In addition, at the operational level, truck mixer scheduling and raw material logistics within the batch plant are critical to ensure timely and economical supply.
- ✓ JIT techniques in the RMC industry can help to improve product quality, eliminate waste, enhance overall productivity and increase customer satisfaction.

The speed of concreting in Bahir Dar construction industry hourly productivity ranges between 2.5m^3 and 7m^3 with average of 3.5m^3on the investigated construction sites. This makes the indirect cost of project high, i.e., overhead cost of the project. This is because the site overhead of the project is the same whether concrete is purchased or mixed on site.

From interviews and questionnaires, it was very difficult to quantify wastage of different concrete making materials. However, many respondents estimate the wastage level of concrete making materials accounts 5-15% the unit bid price. Accordingly, a research was conducted by Addis (2016), on assessment of extent, causes and effects of construction materials wastage in selected building construction projects Bahir Dar. The result revealed that the wastage levels of the five major materials had beyond the wastage limits of BaTCoDA as shown in the Table 4.15 [46].

Table 4.14: Wastage level of the five major construction materials in Bahir Dar [45, 46]

No.	**Material**	**limits of BaTCoDA**	**Wastage in %**
1	Cement	5%	12.78%
2	Sand	15%	17.68%
3	Coarse Aggregate	15%	13.08%
4	HCB	5%	12.94%
5	Reinforcement Bar	5%	10.23%

The wastage level of cement, HCB, and reinforcement bar were two fold above the standard limit stated in BaTCoDA. In addition, the causes of wastage of concrete and concrete making materials were discussed as follows [46].

- ✓ Poor performance leads to reworking and redoing due to poor concrete placement quality. Inadequate use of vibration leads to problems in concrete such as honeycomb leading.
- ✓ Far distance between place of mixing and casting is another problem in the transportation of the fresh concrete which increases the wastage rate.
- ✓ "Excessive quantities of cement during mixing more than the required “and other factors have great contribution for occurrence of cement waste. Especially “Poor performance causing reworking” and “Mixing of quantities greater than the required" take the first and second ranks; respectively. This is additional cost for site mix concrete.
- ✓ The major causes which can be pointed out for sand waste are poor quality of sand and lose of unaccounted for quantity at washing, poor storage and the actual volume of sand not properly measured during purchase.
- ✓ Three main causes can be pointed out for coarse aggregate waste: wrong handling, volume of aggregate not properly measured during purchase and mixing quantities greater than the required.

Therefore, the increase speeds of concreting and reducing wastage means increase the saving for the project. From the above discussions, the unit contract price of RMC is slightly costly. Moreover, the cost of ready-mixed concrete, since it is a bought commodity, may be somewhat higher than that of site-mixed concrete, but this is often offset by savings in site organization, in supervisory staff, and in cement content. The later arises from better control so that a smaller allowance need be made for chance variations [13].

The overall comparative analysis of RMC and conventional SMC is shown below.

Table 4.15: Comparative analysis between RMC and SMC

No.	**Comparative criteria**	**Grade of concrete**	**RMC**	**SMC**
1	From cost break down	C-25	3061.27 ETB	2780.96 ETB
2	Average concrete productivity per hour		Up to 240m^3/hr.	3.5m^3
3	Wastage generation		Low	High
4	Batching ingredients of concrete		By weight	By volume
5	System of concrete production		Machine intensive	Labor intensive
6	Procurement of materials and storage on construction sites		No need	Mandatory
7	Material discount from suppliers like cement and aggregates		High	Low to medium
8	Cement consumption		Relatively low	Relatively high
9	Initial capital for setting up		High	Low
10	Mobilization of site mixers		No	Yes
11	Cement protection from the environment		Good	Not good
12	Material quality control		There's laboratory.	No laboratory.

4.2.4 Legal Requirements of RMC Plant

Interview is made with legal bodies to know the requirements to establish RMC plant in Bahir Dar. Having in mind the need of investment on RMC plant in Bahir Dortha following criteria of Table 4.17 should be satisfied.

Table 4.16:Local evaluation criteria of RMC industry in ANRS

No.	Evaluation criteria	Result (%)
1.	Companies that export more than 40% of their product	20
2.	Job opportunity create more than 100 person	13
3.	Investment capital amount for more than 60,000,000	25
4.	Industry that local material more than 75%	15
5.	Technology development contribution whether it's new or not if it's is in best quality, quantity, best in production process, use local trained labor, use local material, high productivity, energy efficient, that shouldn't oppose local custom, low environmental impact, etc.	12
6.	Economy linkage between supplier and customer	15
	Total evaluation result	**100**

From the above table RMC plant can fulfill all evaluation except companies should export more than 40% of their product because the product is only used as an input to the construction industry in Bahir Dar. As a result, RMC plant can be established by satisfying the legal requirements of Bahir Dar City.

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The ready-mix concrete industry is an important winning tool in today's construction business environment. This industry provides the required quality of concrete used in construction works. The production of this concrete has many different operational components and it is highly essential to satisfy all the desired quality in actual practice.

The constituents of concrete which most of them are naturally occurring materials are subjected to a wide range of variability. The first constituent, water, is a relatively non variable and usually available in a condition to be used for concrete readily. The second constituent, cement, is also a factory product that it is relatively easy to control its production process and its quality. However, the third constituents of concrete, which are coarse and fine aggregates, are usually naturally occurring and are subjected to a wide range of variability.

- ✓ More than 64% of the type of water being used in Bahir Dar projects falls short of set limits in many standards and reviewed literatures, even though no attempt were made for quality test.
- ✓ The availability of cement for Bahir Dar is guaranteed.
- ✓ The major of tests conducted on fine aggregates are acceptable but gradation, and silt and clay content results of the aggregates deviate from standard limits. This could be easily treated through selecting good sources, blending of different sources, and washing of fine aggregates.
- ✓ The majority of coarse aggregate properties are within limits. However, gradation is not as good as to requirements which rather need blending of different sources.

The challenges faced by the conventional SMC in Bahir Dar are found to be:

- ✓ The basic ingredients, like; water, cement and aggregates aren't checked for their quality before use.
- ✓ While measuring the ingredients during batching and mixing, accuracy is compromised.
- ✓ The amount of water added to the given volume of fresh concrete is not measured; rather done arbitrarily.

- ✓ The concrete making materials are not stored and handled properly.

To overcome the mentioned challenges in the use of SMC the construction industry of Bahir Dar has to switch to RMC products whose advantages are:

- ✓ The basic ingredients could be checked periodically through an organized laboratory.
- ✓ Batching and mixing shall remain accurate.
- ✓ The amount of water and admixture added to a given volume of fresh concrete is measured accurately.
- ✓ The plant can have quality assured and continuous water supply from own source.
- ✓ The plant can have crashed fine aggregate unit to avoid using natural sources.
- ✓ There is no need of procuring and storing ingredients on construction sites.
- ✓ The concrete making materials can be stored properly according to the requirements in RMC plants accordingly to the industry requirements.

The existence of RMC plant can be assured from demand perspective because of the following reasons;

- ✓ The average structural concrete volume of demand per year in Bahir Dar city is about 258,725 m^3out of which the new entrant can take between 183,695 m^3and222,504 m^3. This is more than enough to support RMC plant.
- ✓ The majority of respondents., about 86% are aware and interested to use RMC product to the future.
- ✓ The need for concrete construction in Bahir Dar is increasing.

To justify the potential of introducing RMC plant to the Bahir Dar construction industry cost- benefit analysis between SMC and RMC are done leading to the following findings.

- ✓ The major costs are material costs in both cases, i.e., for SMC 49.50%, and RMC 46.55% followed by overhead costs 20.00% and 31.10%; respectively.
- ✓ The average price of RMC is 3065.27ETB/m^3 which is 10% higher than the average conventional SMC that is 2780.96ETB/m^3.
- ✓ Thus his/her cost for RMC can be offset taking the advantage; quality, reduced labor cost, eliminating wastage of materials, reduced cement quantity, avoiding need of material storage space on site, material discount from suppliers due to bulk purchase and increased productivity of concrete.

Overall, the ingredients are available and can be improved easily to produce good quality concrete, the conventional SMC is full of many problems, the need for concrete construction in Bahir Dar is increasing from time to time, though RMC is slightly cost; the introduction of ready-mix concrete plant to the Bahir Dar construction industry is viable. In addition, the use of RMC would help towards the proper utilization of naturally available raw resources.

5.2 Recommendation

- ✓ The fine aggregates need great attention during production and selection of sources; especially, some should be washed to remove clay and silt content and blended to get the required gradation i.e. to make good quality and economical concrete.
- ✓ RMC plant is advised to have its own manufactured sand production plant, so that it can produce a good quality sand.
- ✓ The coarse aggregate should be given due consideration during selection of quarry sites, types of aggregate crashing plants and different aggregate sizes should be separated during storage.
- ✓ The earlier researches recommend, that replacing natural sandwich crushed rock fine with proper admixture for concrete construction works in and around Bahir Dar.
- ✓ The RMC Company is strongly advised to make an effective and efficient material procurement method i.e. the "five rights"; these are the right quality, the right quantity, the right cost / price, the right counterpart and the right time thus can ensure minimize the unit cost of RMC and increase the number of customers.
- ✓ A more reliable detail investment analysis with respect to the demand distribution of concrete, selection of location, type and capacity of plant and the traffic condition of the area to be served needs assessment before deciding on investing in RMC Plant.
- ✓ Designers, specifiers and contractors need to appreciate the quality and economical advantage of adopting RMC plant rather than be scared by looking at high investment cost of RMC Plant.

- ✓ Ethiopia should have updated standard documents, guidelines, quality control schemes and specifications that provides detailed criteria of plant, machineries, testing facilities, intensify control on the properties of concrete ingredients and the final product, technical manpower, etc.; which any RMC plant, irrespective of its size and capacity which must be fulfilled to qualify for plant certification.

5.3 Areas for Future Researches

Further researches are proposed in the following areas;

- ✓ Assess the quality and availability of concrete ingredient materials for high strength and light weight concrete aggregates.
- ✓ Carry out an Environmental Impact Assessment (EIA) of RMC batching plant in Bahir Dar.

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APPENDICES

Appendix – I

Questionnaire

QUESTIONNAIRE SURVEY ONTITLE:-

POTENTIALS OF READY MIX CONCRTE INTRODUCTION TO THE CITY OF BAHIR DAR CONSTRUCTION INDUSTRY

Objective of the Study

The main objective of this research is determining the potentials of RMC introduction to the City of Bahir Dar construction industry in terms of cement supply, aggregate production quality and availability, assessing demand, and comparing the unit cost of RMC including transportation to the pouring site with site mix concrete.

Definition; ***RMC*** is the concrete which is manufactured at the central batching plant and delivered at construction site with the use of truck mounted Transit Mixers (TM).

Purpose of the Survey

1. *This questionnaire serves as a tool in identifying the gap between the theory and the local practice.*
2. *To determine the potentials of RMC introduction to the city of Bahir Dar in terms of cement supply, assessing demand, aggregate production quality and availability, the potential market demand of RMC and the unit cost of concrete including transportation to the required site.*
3. *To serve as a data source for this study.*
   For any further information the researcher can be reached through the following address
   AtoTilksew Degu 0918001643

- *The information that you will provide us will be kept confidential and the results obtained from this survey are intended to serve only for academic purposes.*
- *Finally we would like to thank you in advance for your willingness and cooperation.*

NOTE:-

- *You Can SkipTo Answer The Questions That Do Not Concern You.*
- *If Necessary You Can Give More Than One Answer.*

Part I; General Information

Company Profile

a. Name of the Company...

b. Year of Establishment...

c. Category of the firm as major stake holder :-

☐ *Consultant*

☐ *Contractor*

Client ☐

Other ☐

d. Ownership of the Firm :-

☐ *Private* *Public* ☐

e. Registration of the Firm:-

☐ *Federal* ☐ *Regional*

f. How many projects have your firm undertaken for the past ten years.

☐ *1-3* ☐ *4-6*

☐ *7-9* ☐ *10-12*

☐ *13-15* ☐ *more than 15*

g. What is your position in your firm?...

h. Years of experience...

Part II

Please give your response to the following questions either by putting an “X” mark at your choice for questions by writing your answers in the space provided.

1. What type of water do you use for concrete mixing?
   i. ________Tap water
   ii. ________River water
   iii. ________Drilled well (deep ground water)
2. Is there any scarcity of tap water in Bahir Dar construction sites?Yes or no?_______
3. If the water used was not tap water, is there any test that was made for the water?Yes or no?_______
   (if any, please specify)_________________________________
4. Do you measure the amount of water during concrete production? Yes or no?_______

   If yes, how
   ____
   ____
5. What type of cement do you use for concrete production including 32.5 and 42.5?
   i. ________OPC
   ii. ________PPC
   iii. Other (please specify)_________________________________
6. How do you store cement?
   ____
   ____
7. Do you think cement is available at any time with the market price? Yes or no?_______
8. What type of Cement brand are you using for concrete production?

____

____

9. What is your Reason for using a particular brand of cement?
   i. ________Price
   ii. ________Quality
   iii. ________Delivery
   iv. (if any, please specify)________________________________
10. Where is the source(s) of your coarse and fine aggregate? place
    i. Coarse aggregate:
       ____
       ____
       ____
    ii. Fine aggregate:
       ____
       ____
       ____
11. Which standard specification of aggregate is used in the specification of your contract document?
    i. ________ES (Ethiopian standard)
    ii. ________BS (British standard)
    iii. ________ASTM (American standard)
    iv. Other (Please specify)________________________
12. What kind of course aggregate do you use for concrete production?
    i. ________Natural gravel
    ii. ________Crushed aggregate
    iii. ________Both natural and crushed aggregate
    iv. Other (please specify)________________________________
13. What kind of fine aggregate do you use for concrete production?
    i. ________Natural sand
    ii. ________Crushed sand
    iii. ________Both natural and crushed

iv. Other (please specify) ________________________________

14. Which laboratory tests were conducted for coarse aggregates? Please enclose the corresponding test results. If any.
    i. Physical and Mechanical tests:
       ________Los Angeles Value
       ________Aggregate Impact Value
       ________Particle density or Unit weight
       ________Water Absorption
       ________Soundness
       ________Gradation
       Specify if any other tests;
       ____
       ____
    ii. Chemical tests:
       ________Alkali-silica reaction (ASR)
       ________Alkali-carbonate reaction(ACR)
15. Which laboratory tests were conducted for fine aggregates? Please enclose the corresponding test results. If any.
    i. Physical test:
       ________Silt content
       ________Particle density or Unit weight
       Specify if any other tests;
       ____
       ____
    ii. Chemical test:
       ____
       ____
    iii. Specify if any other tests;
       ____
       ____
16. How frequent do you take samples for testing aggregate?

i. Only once for one source
ii. Once when it came from the source and then after depending on conditions (that is when the aggregate seems defective, test may be ordered).

If any other sampling procedure is to be followed, please specify?

____

____

17. Are you satisfied with the quality of aggregate? Yes or no?

Reason,

____

____

18. What would you do with the aggregate if it doesn't satisfy the requirement on the specification?

____

____

19. What do you propose to maintain the quality of aggregate?

____

____

20. How would you handle and store aggregates on the construction site?

____

____

21. Do you have enough space on site to store concrete materials like aggregate and cement?

____

____

22. How do you mix your concrete?

________Manually

________Using mixer machine

________Both of them (both manually and mixing plant)

23. What types of projects you are undertaken?

i. ________Residential housing

ii. ________Commercial building

iii. ________Governmental projects

iv. ________Industrial buildings

24. Do you think the size and complexity of construction projects are increasing in Bahir Dar? Yes or no? _______
25. What type of concrete production system currently you are using for concrete?
    i. ________SMC (Site Mix Concrete)
    ii. ________RMC (Ready Mix Concrete)
26. Are you aware about RMC (Ready Mix Concrete)? Yes or no?_______
27. Do you appreciate the concept of ready-mix concrete in Bahir Dar? Yes or no? _______
28. Are you interested to use RMC in future? Yes or no? _______
29. How much is the bid price in ETB per unit volume of concrete in your contract document?
    i. C-25________
    ii. C-30 ________
30. The costs associated with Site Mix Concrete System (the average tender price) ________
    i. ________ (%) Wastage of raw materials,
    ii. ________ (%) Wastage of concrete during placing,
    iii. ________ (%) supervision cost due to checks required at construction sites on raw materials and tests
    iv. Specify if any other cost;

        ____

        ____
31. The average productivity of concrete production per hour on your construction site. ________________________
32. Which batching techniques do you use?
    i. ________By weight
    ii. ________By volume
33. Are you satisfied with the quality of your concrete produced? Yes or no? _______

THANK YOU!!!

Appendix – II

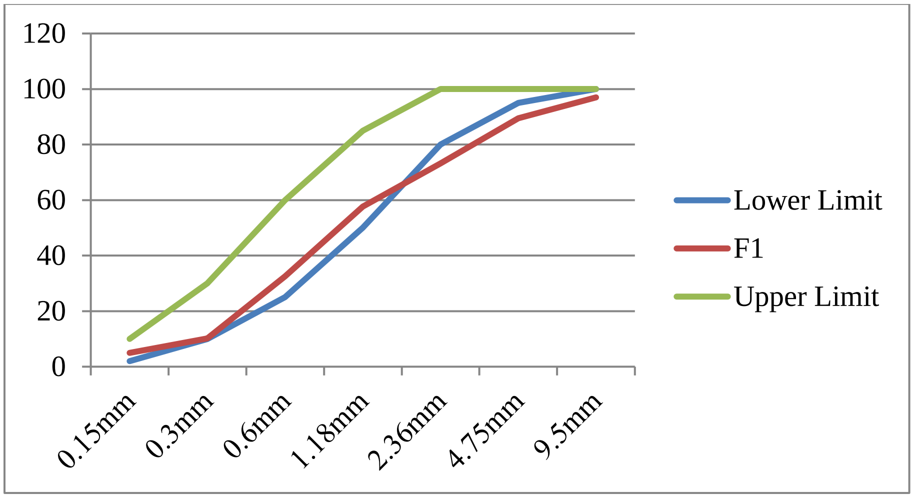
Gradation Tables and Charts

The gradation results are collected from the prominent laboratory centers between September and May 2018. These results summarized in the following table-based ES graduation requirement. Final, gradation charts are prepared for each source of aggregate test result to evaluate gradation curves as shown in tables and gradation curves below for fine and coarse aggregates respectively.

Sieve analysis result of fine aggregate samples from different source and date

				Percentage Passing							
Source		**Type of Sand**	**Date tested**	**9.5mm**	**4.75mm**	**2.36mm**	**1.18mm**	**0.6mm**	**0.3mm**	**0.15mm**	**F.M**
Tana	F1	Natural sand	01/11/2017	96.99	89.51	73.17	57.71	32.52	10.17	4.98	3.96
Arbaya	F2	Natural sand	13/09/2017	99.33	88.33	71	45.67	21	9	6.17	3.4
Arbaya	F3	Natural sand	13/10/2017	100	85.25	68.33	53	25.59	5.46	1.22	3.6
Enfranze	F4	Natural sand	09/10/2017	92.36	87.09	79.34	60.34	29.64	8.85	2.53	3.39
Bikolo -abay	F5	Natural sand	13/01/2018	100	97.5	91.62	75.25	35.13	6.99	1.4	2.92
Bulen	F6	Natural sand	10/02/2018	100	98.45	84.47	56.52	24.22	10.25	4.19	3.22
Abay	F7	Natural sand	21/02/2018	100	96.08	83.51	62.89	36.29	11.13	3.29	3.06
Addis zemen	F8	Natural sand	21/02/2018	100	98.36	92.29	74.07	38.08	14.49	8.18	2.75
Gumara, sendeka	F9	Natural sand	29/02/2018	100	99.15	97.45	91.51	66.88	28.66	17.83	1.98
Arbaya	F10	Natural sand	17/03/2018	100	95.15	87.07	69.28	36.03	12.93	6.47	2.93
Tana Beles	F11	Crashed sand	22/04/2018	98.49	93.72	84.42	64.82	33.84	9.38	2.6	3.12

Tana Beles	F12	Natural sand	21/12/2017	98.02	93.62	78.66	11.03	4.45	1.73	0.33	3.1
Sebatamit	F13	Natural sand	21/12/2017	98.9	92	79.78	64.86	32.34	5.25	1.27	3.3
Sebatamit	F14	Natural sand	07/01/2018	100	95.8	85.1	68.8	36	13.5	4	3
B/Dar	F15	Natural sand	17/01/2018	94.86	85.4	66.94	43.77	25.03	14.8	10.35	3.59
B/Dar	F16	Natural sand	12/10/2017	100	96.8	84	68.9	35.4	11.9	3.9	3
B/Dar	F17	Natural sand	25/12/2017	96.58	93.35	89.18	80.54	61.13	37.55	25.6	2.16
Arbaya	F18	Natural sand	08/10/2017	95.15	87.06	75.37	55.38	24.05	7.01	3.17	3.52
Bulen	F19	Natural sand	10/02/2018	95.33	93.44	89.29	76.16	44.27	16.25	6.75	3.74
Arbaya	F20	Natural sand	13/09/2017	91.39	82.63	71.83	52.15	12.3	5.6	2.94	3.81
Addis zemen	F21	Natural sand	01/02/2018	99.3	98.44	93.79	80.58	36.1	15.08	9.33	2.67
Enfranze	F22	Natural sand	09/10/2017	93.29	85.33	75.06	47.21	13.38	4.67	2.64	3.78
Bikolo -abay	F23	Natural sand	13/01/2018	99.28	95.34	80.1	39.91	19.18	10.3	8.16	3.47
Addis zemen	F24	Natural sand	10/08/2018	99.05	97.95	94.49	84.9	48.59	14.6	8.77	2.48
Gumara, sendeka	F25	Natural sand	01/02/2018	100	100	96.57	84.82	25.71	7.18	4.12	2.82
Arbaya	F26	Natural sand	16/03/2018	98.52	94.52	86.35	54.76	15.52	4.55	2.38	3.43
ES Requirement			Date tested	100	95-100	80-100	50-85	25-60	10_30	2_10	2-3.5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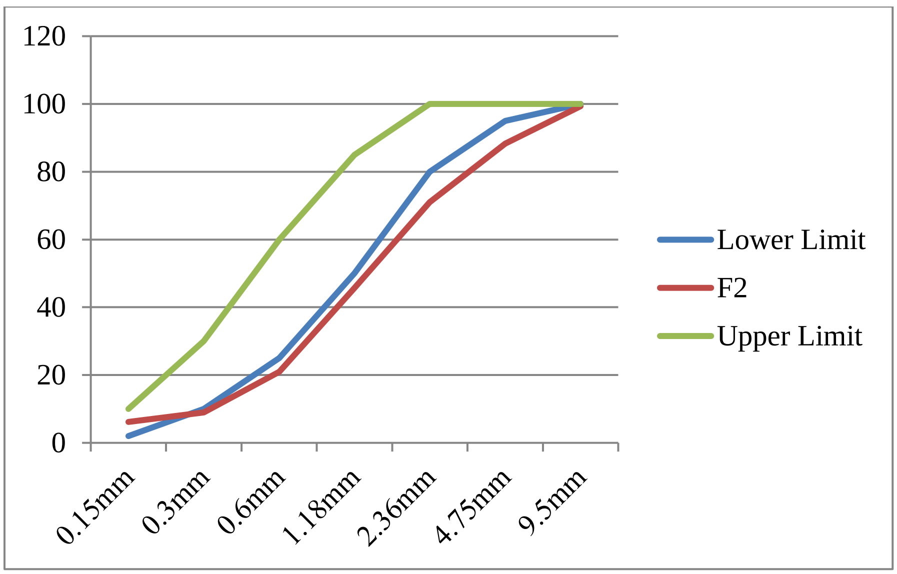
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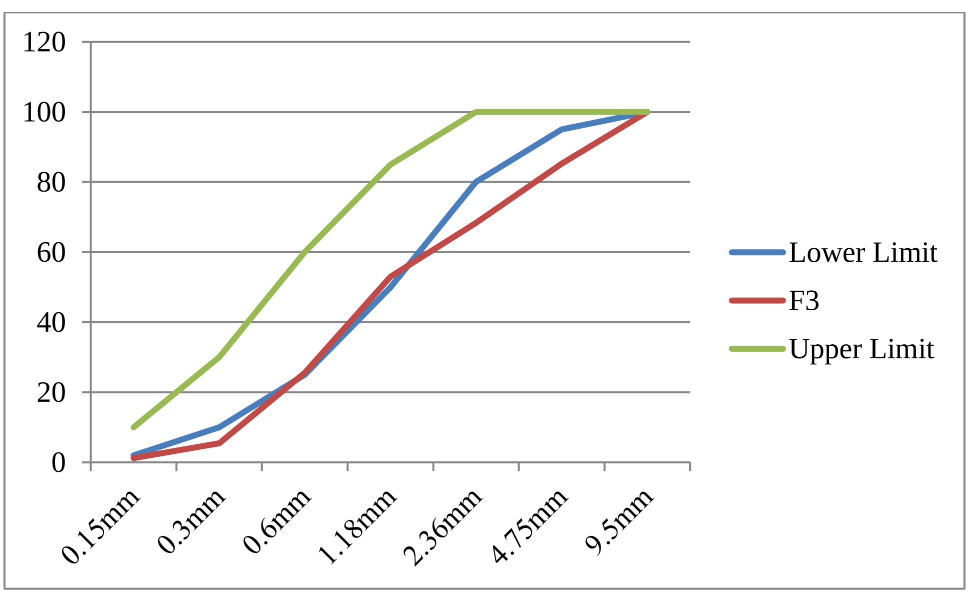
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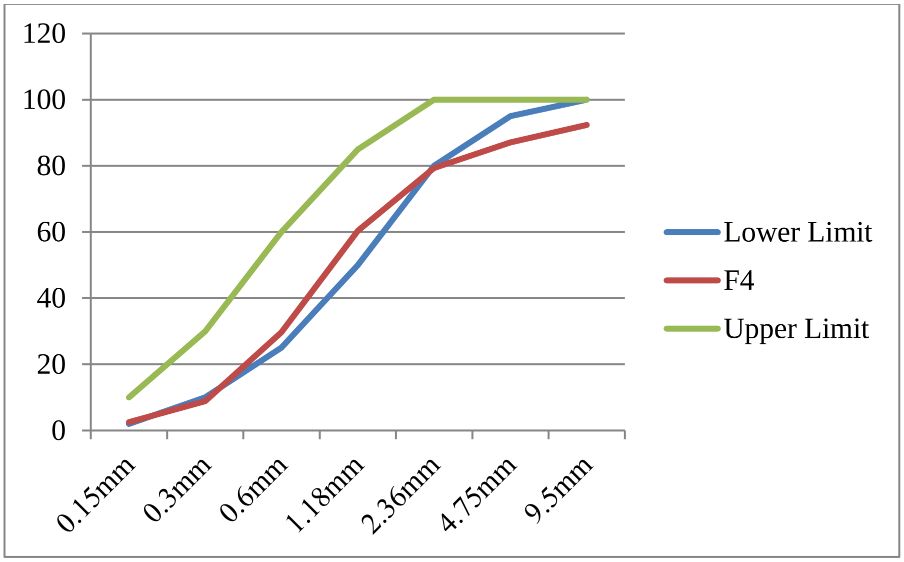
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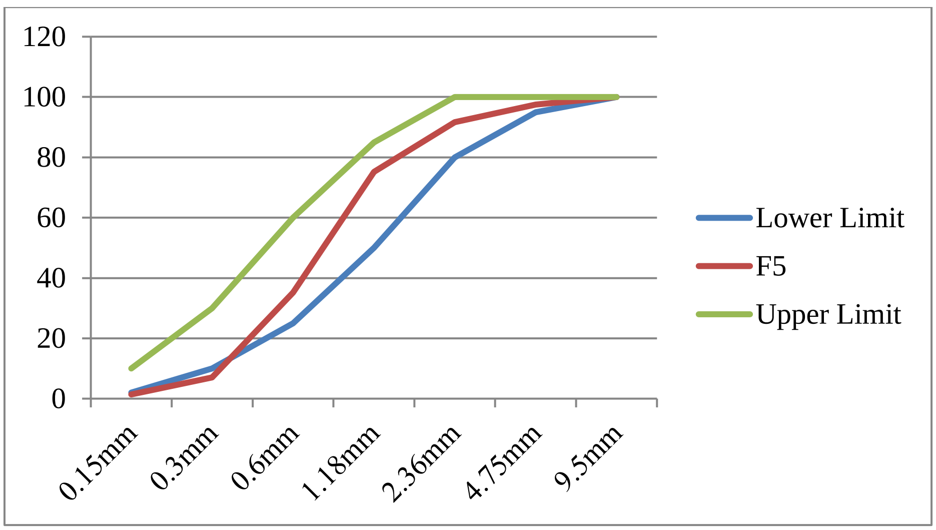
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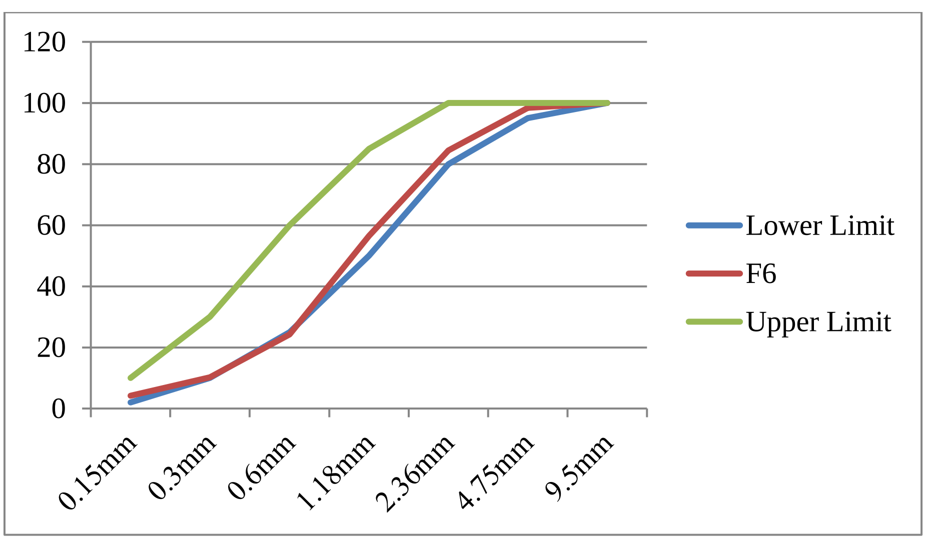
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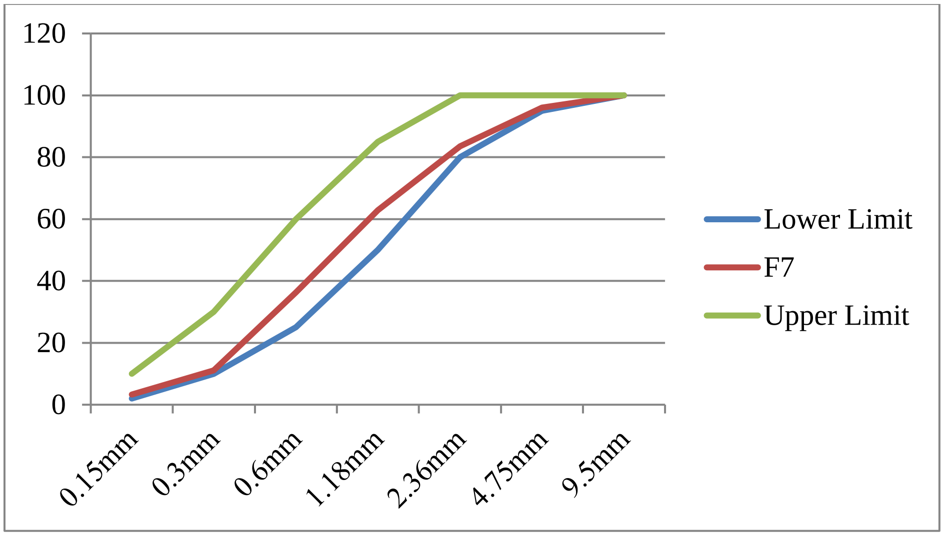
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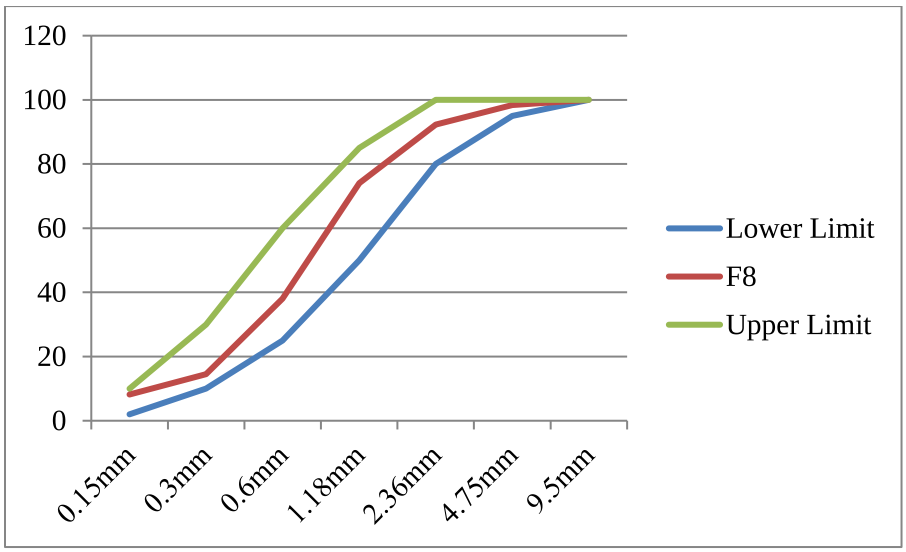
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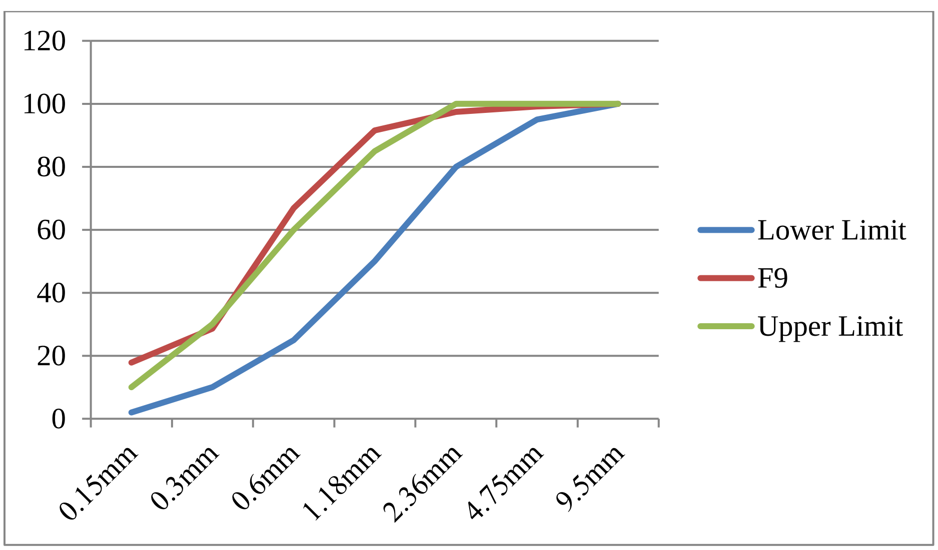
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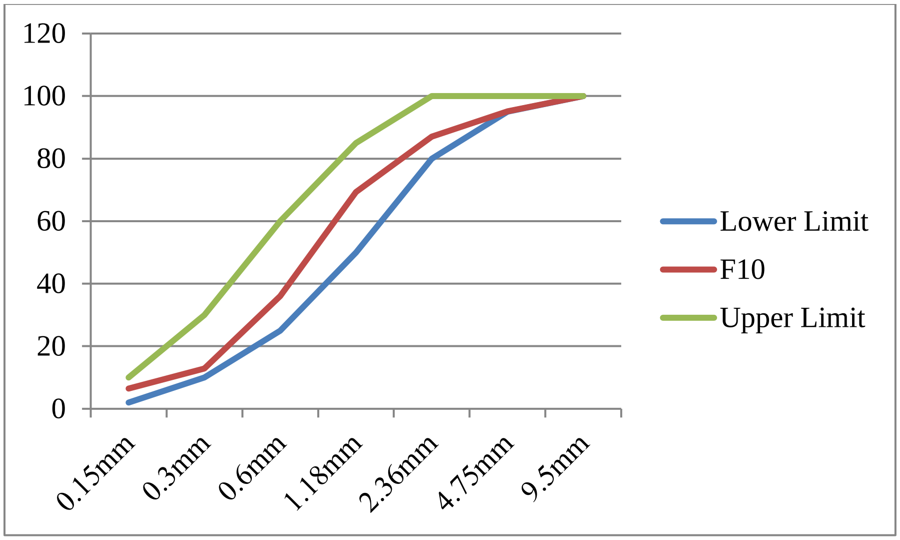
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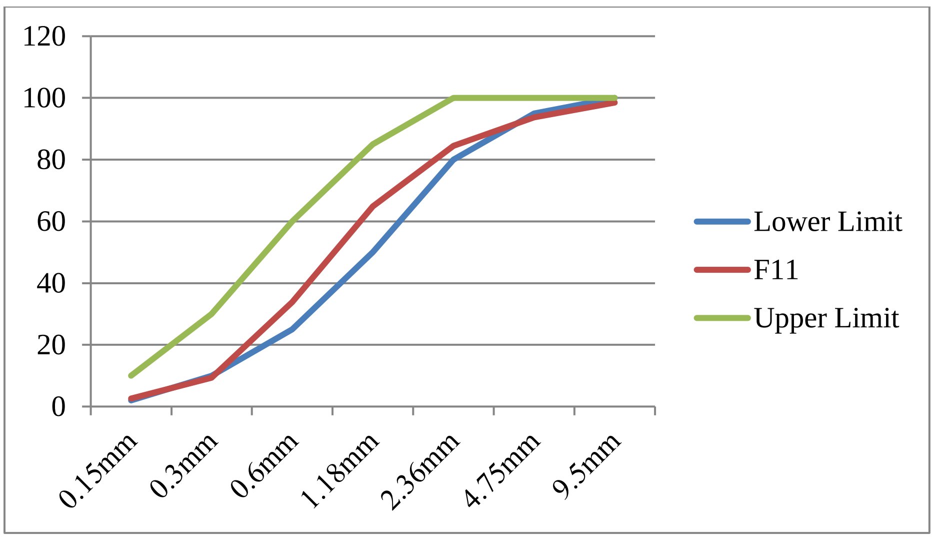
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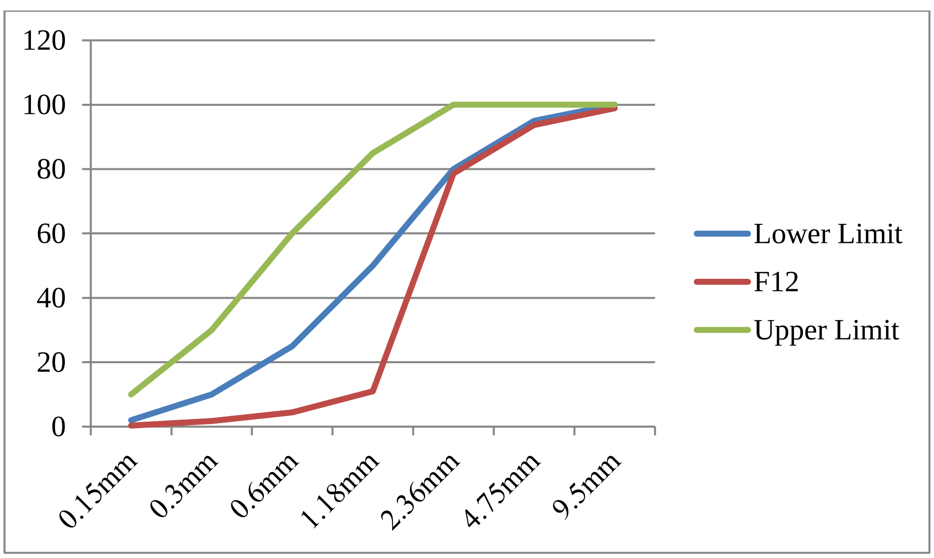
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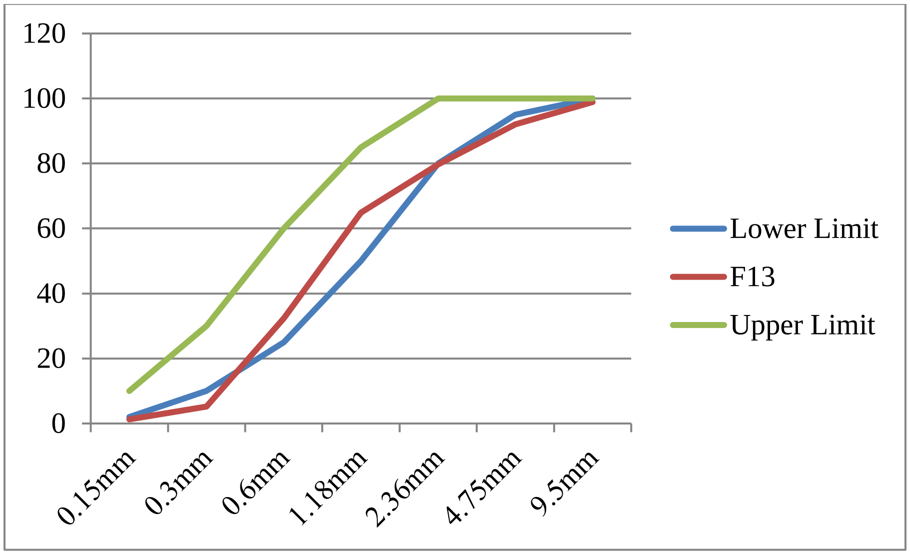
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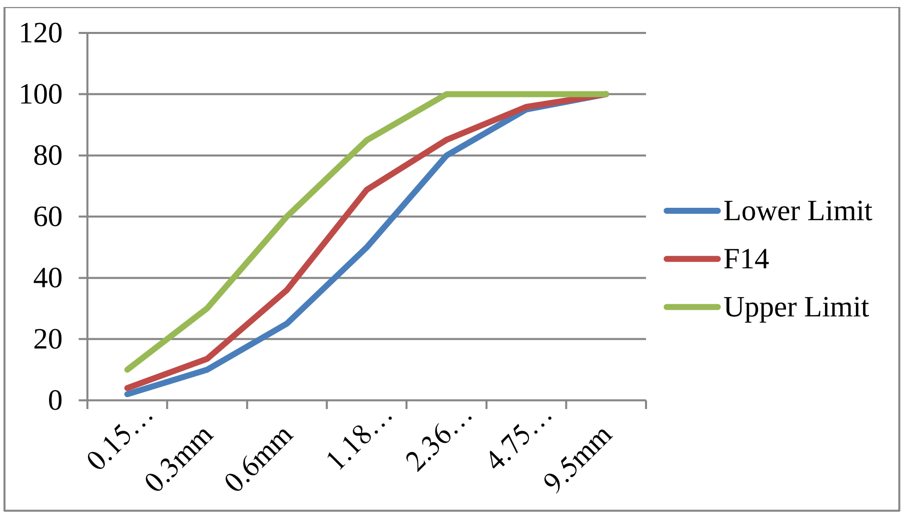
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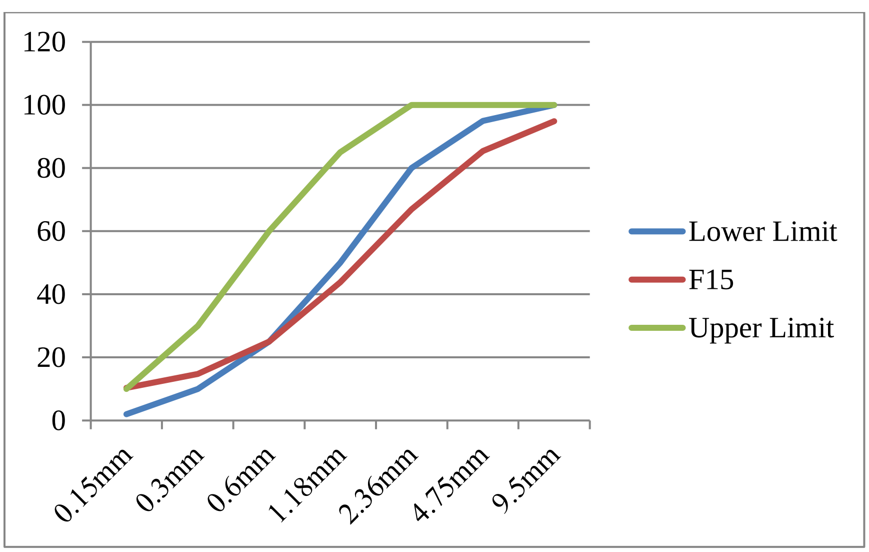
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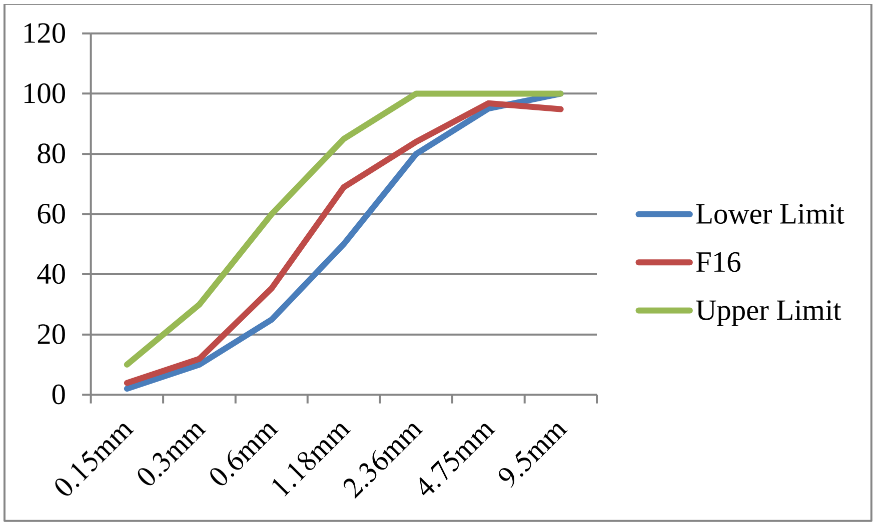
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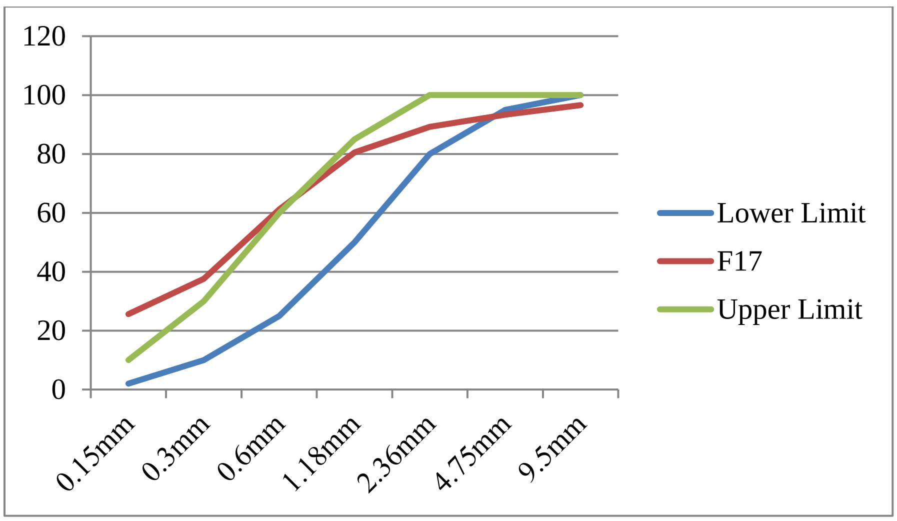
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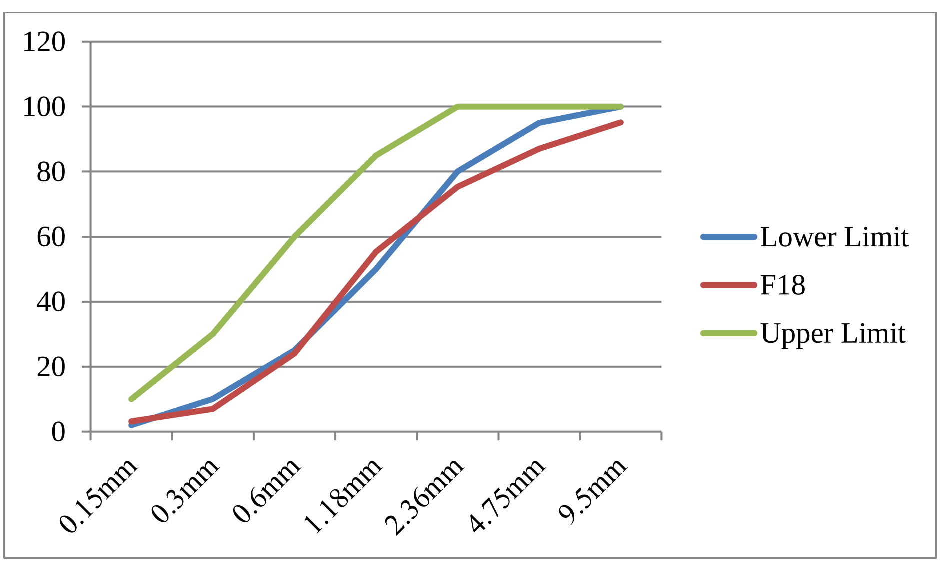
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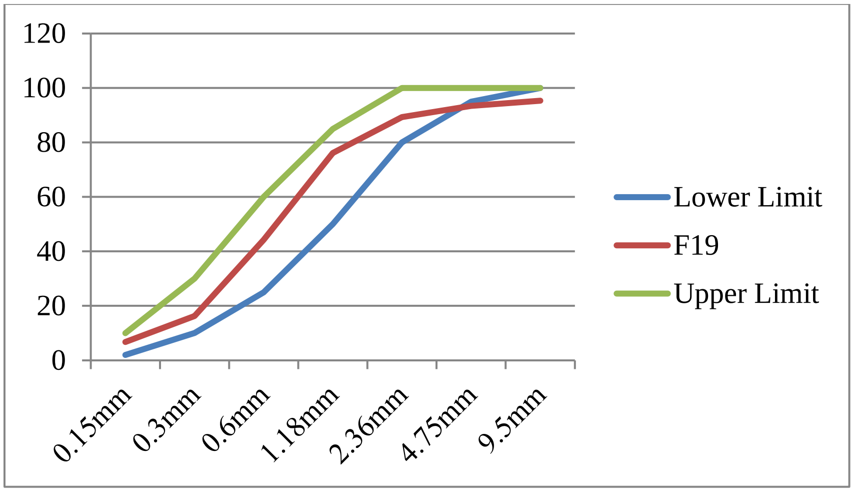
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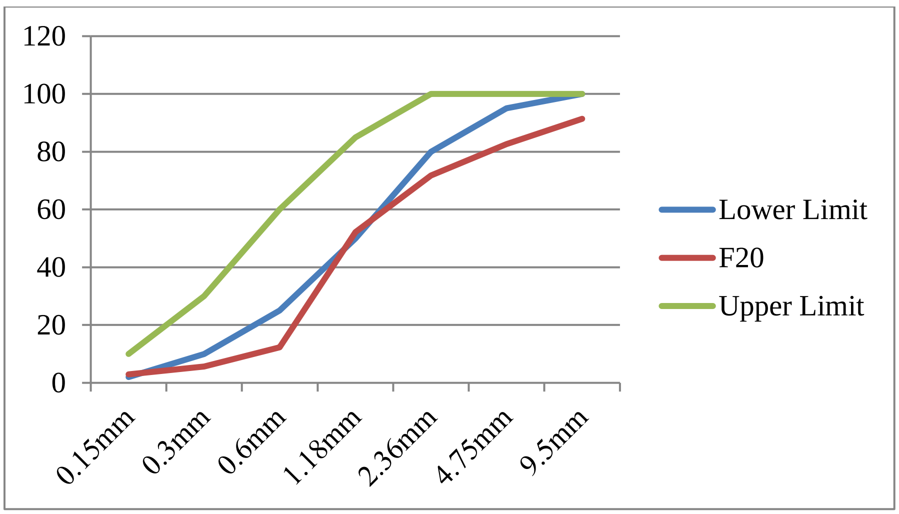
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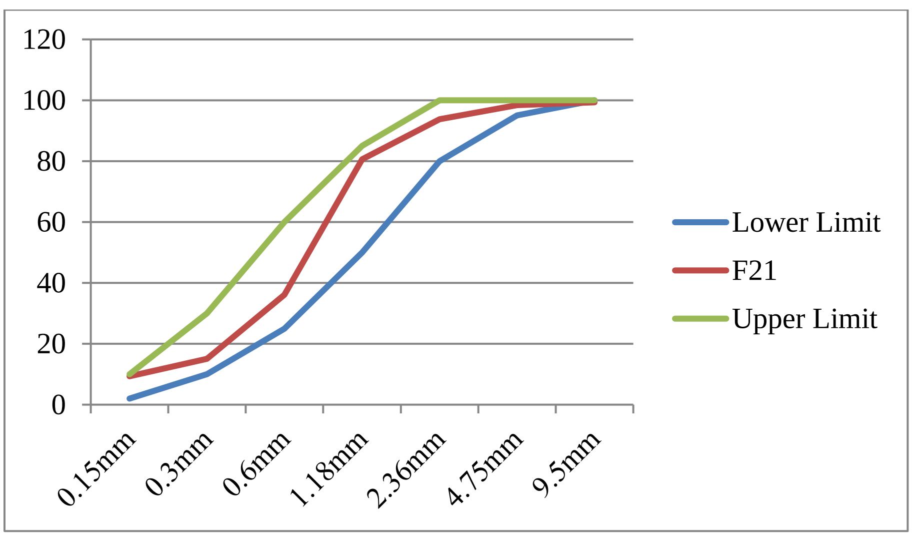
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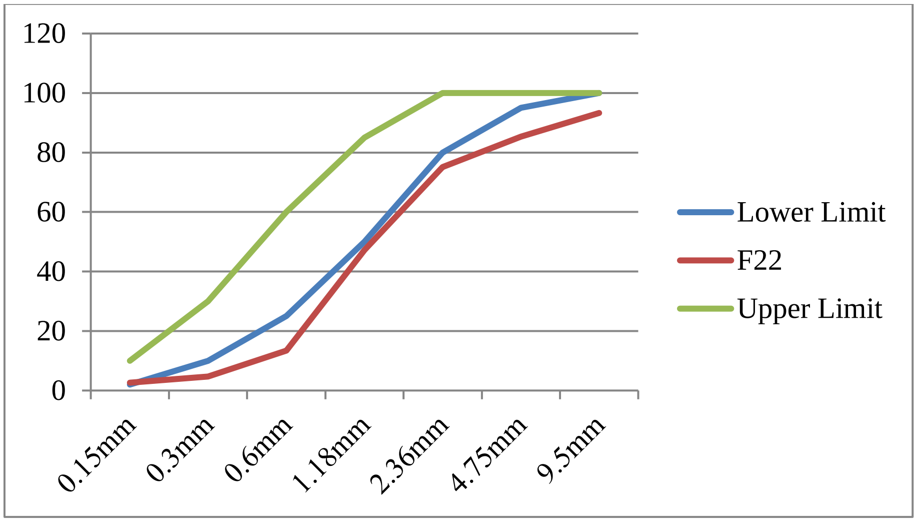
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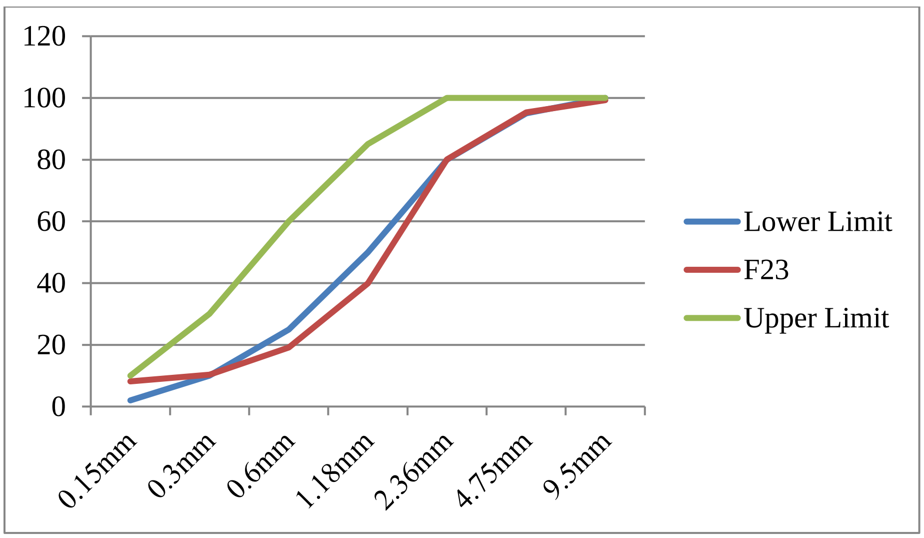
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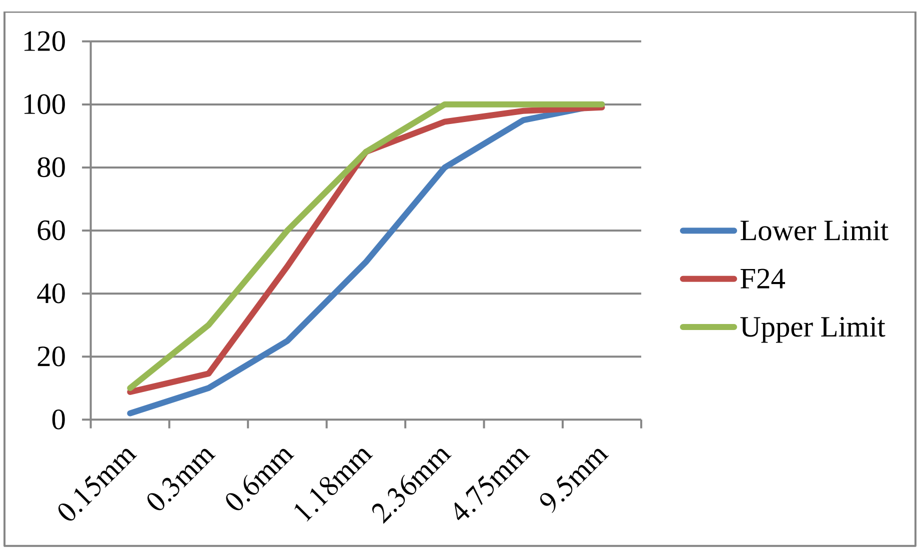
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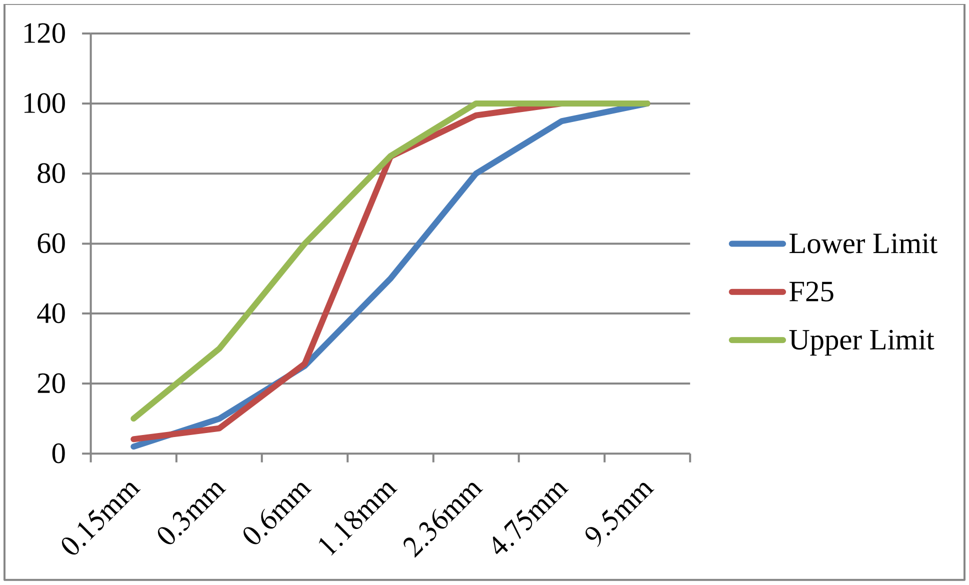
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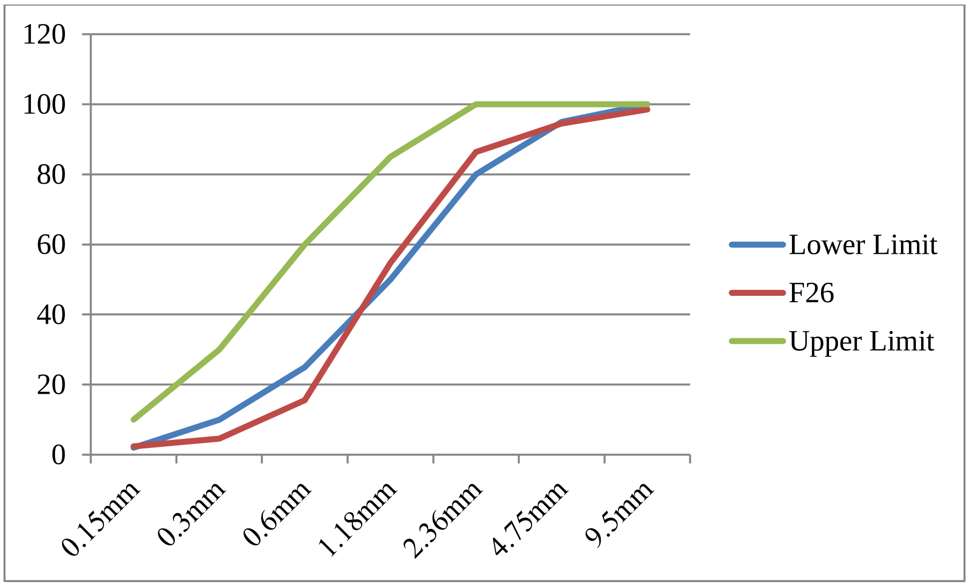
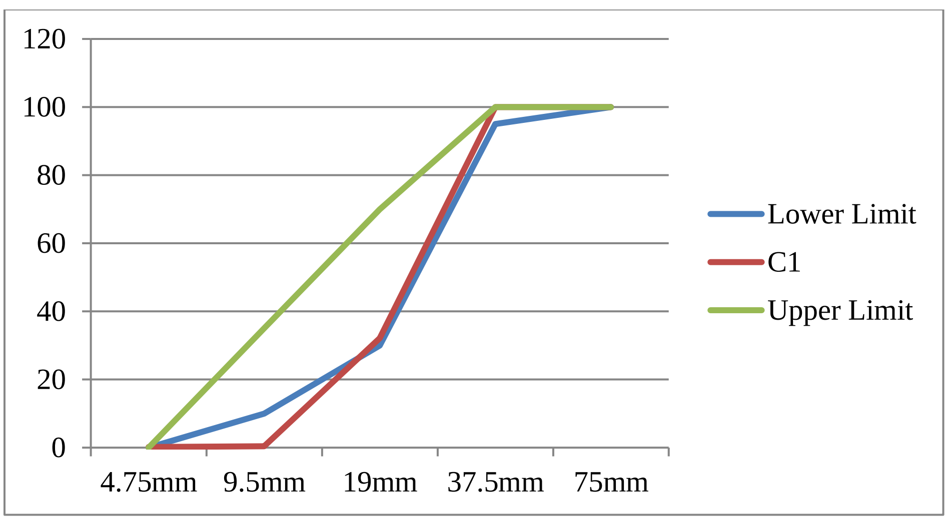
F25
Upper Limit

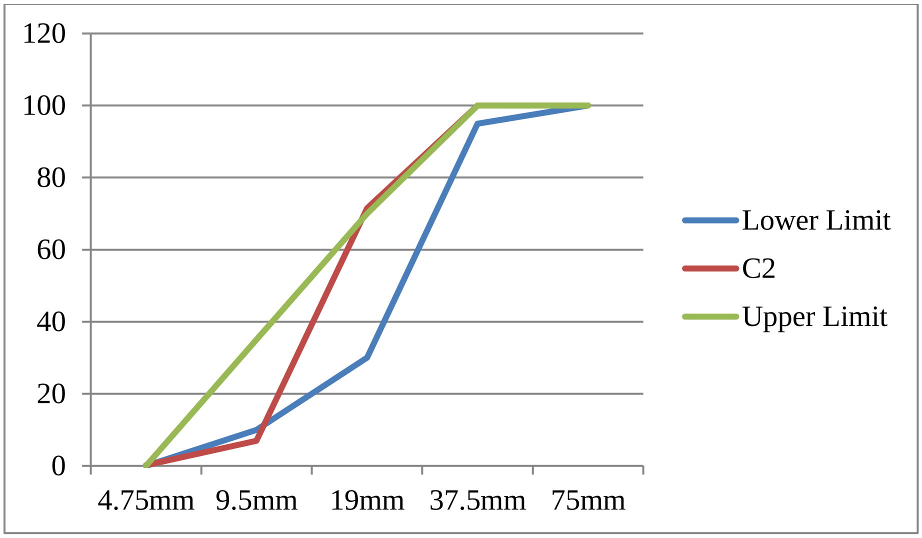

120
100
80
60
40
20
0
0.15mm
0.3mm
0.6mm
1.18mm
2.36mm
4.75mm
9.5mm
Lower Limit
F26
Upper Limit

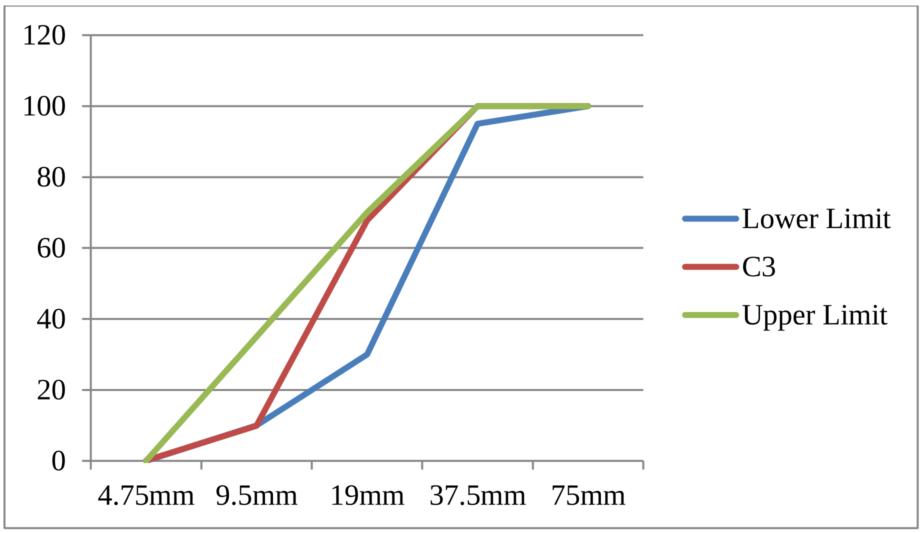
Sieve analysis results of the coarse aggregate samples of nominal maximum size of 37-5 aggregate from different sources and date.

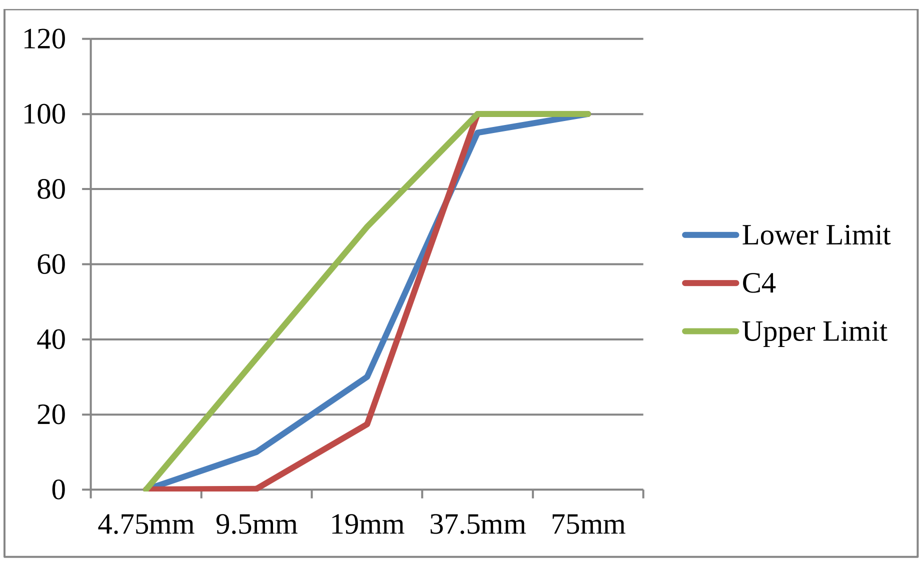
Sample Source			Sieve Sizes and Percentage Passing				
	Tested date	**Sample Code**	**75**	**37.5**	**19**	**9.5**	**4.75**
B/Dar	19/10/2017	C1	100	100	32.18	0.36	0.18
B/Dar	26/10/2017	C2	100	100	71.56	6.92	0.18
Yibab	10/06/2018	C3	100	100	67.8	9.9	0.1
Durbete	10/11/2017	C4	100	100	17.42	0.18	0.05
Sebatamit	20/12/2017	C5	100	100	58.4	8.9	0.9
Meshenti	27/12/2017	C6	100	100	58	10	2.2
Meshenti	09/11/2017	C7	100	100	39	20	12
Kinbaba	17/01/2018	C8	100	100	52.8	4.6	0.2
Meshenti	06/02/2018	C9	100	100	60.1	29.2	26.4
Meshenti	05/03/2018	C10	100	100	66.1	43.1	21.5
Meshenti	08/11/2017	C11	100	100	48	2.5	1.9
Meshenti	06/02/2018	C12	100	100	53	3	0
Adiss Zemen	20/10/2017	C13	100	100	26.78	0.11	0.06
Yibab	13/10/2017	C14	100	100	60.37	8.84	0.05
ES Requirement			100	95-100	30-70	10-35	0-5

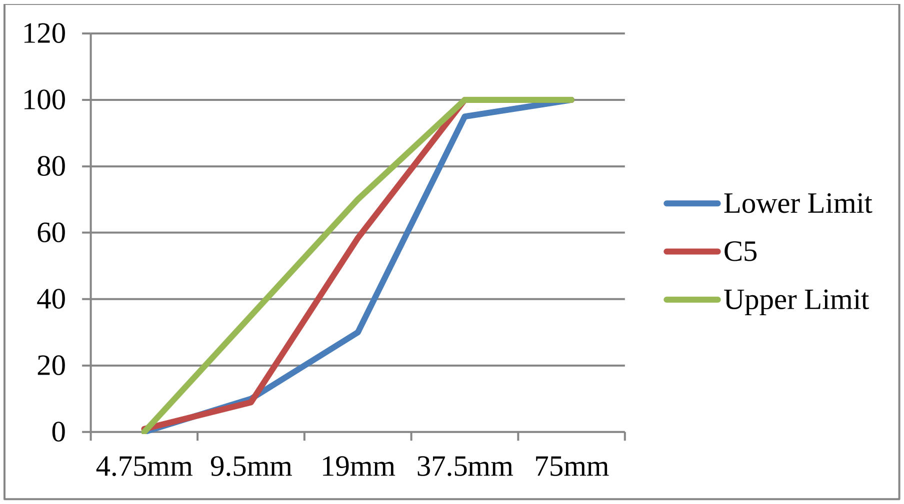
Gradation charts prepared based on the sample codes given in theabove table

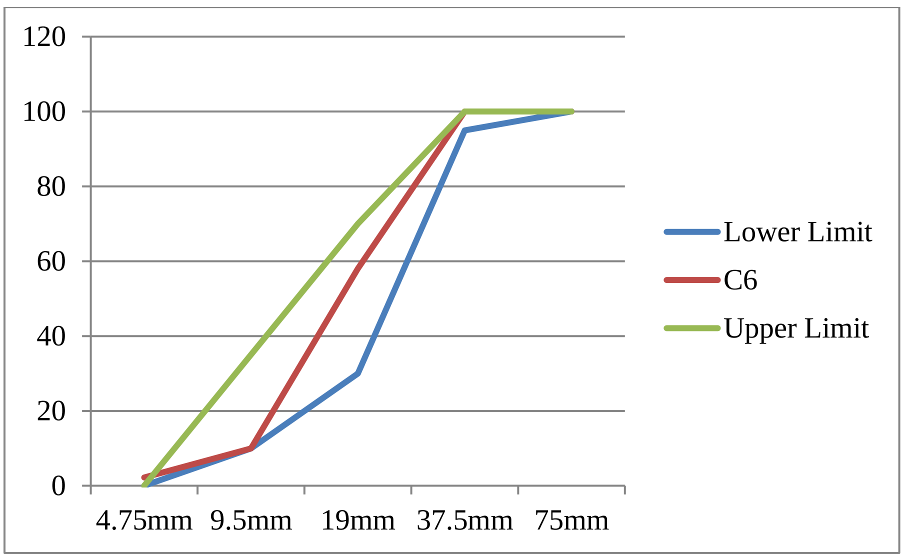



120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C2
Upper Limit


120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C3
Upper Limit


120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C4
Upper Limit


120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C5
Upper Limit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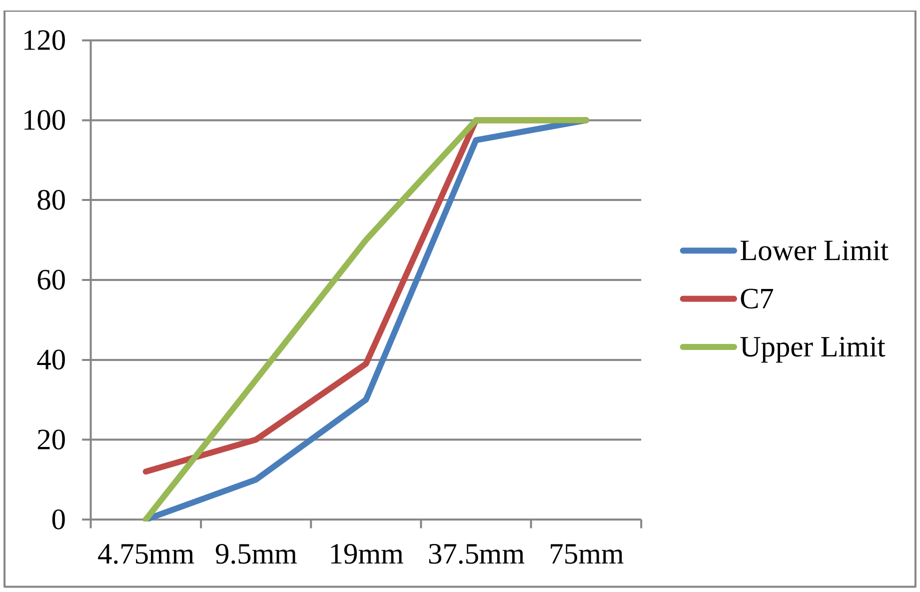
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C6
Upper Limit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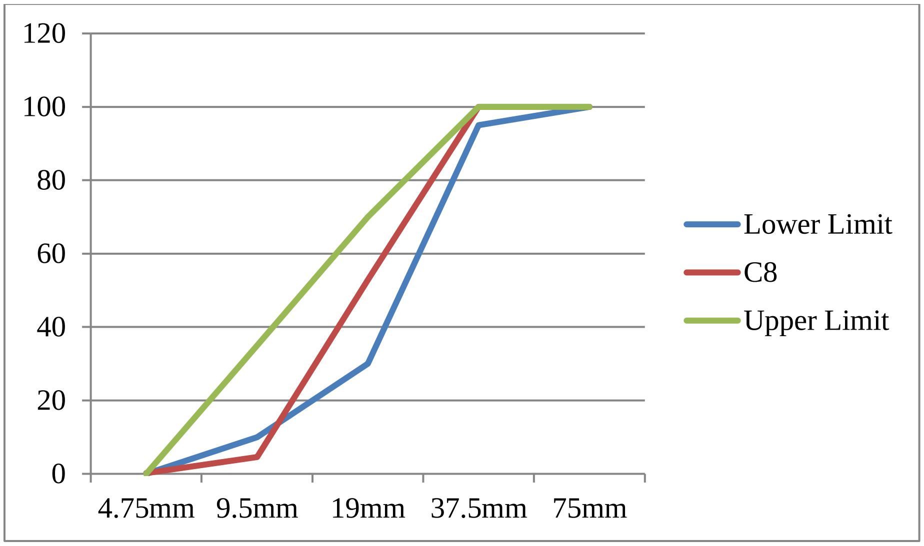
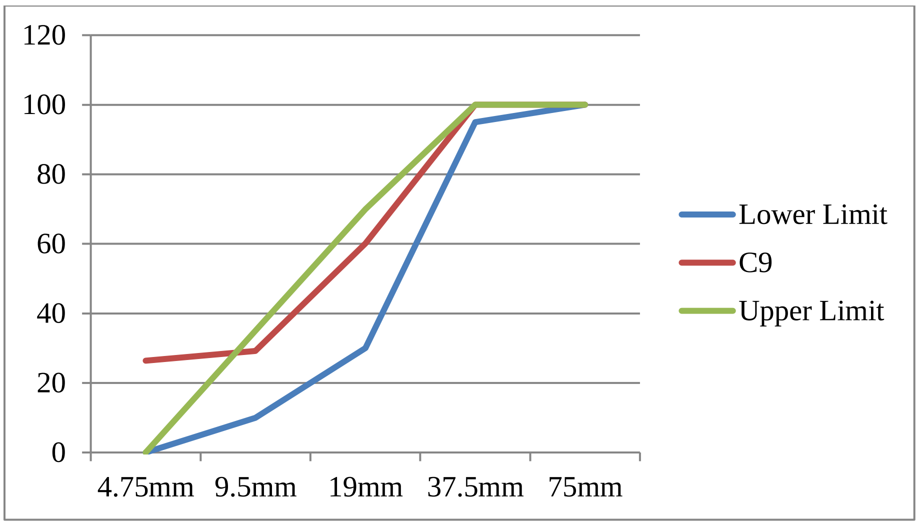
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C7
Upper Limit


120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C8
Upper Limit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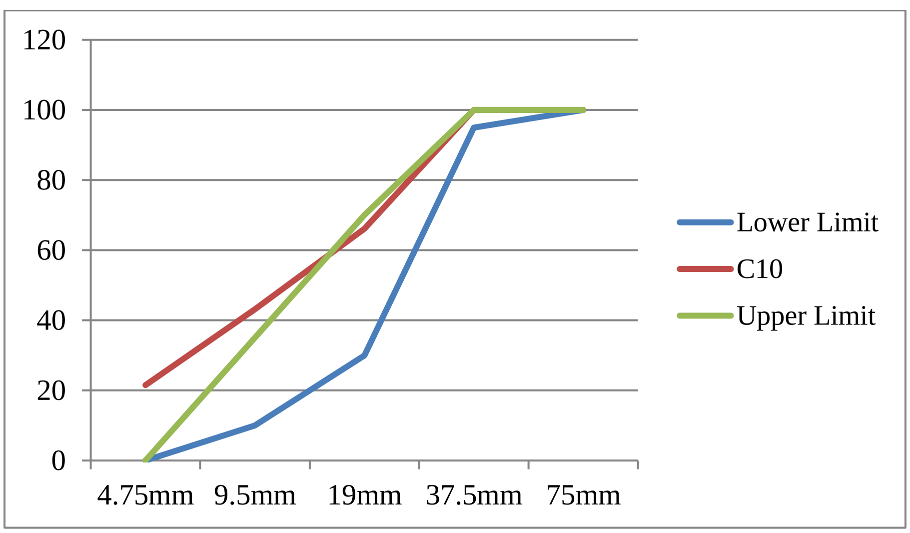
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C9
Upper Limit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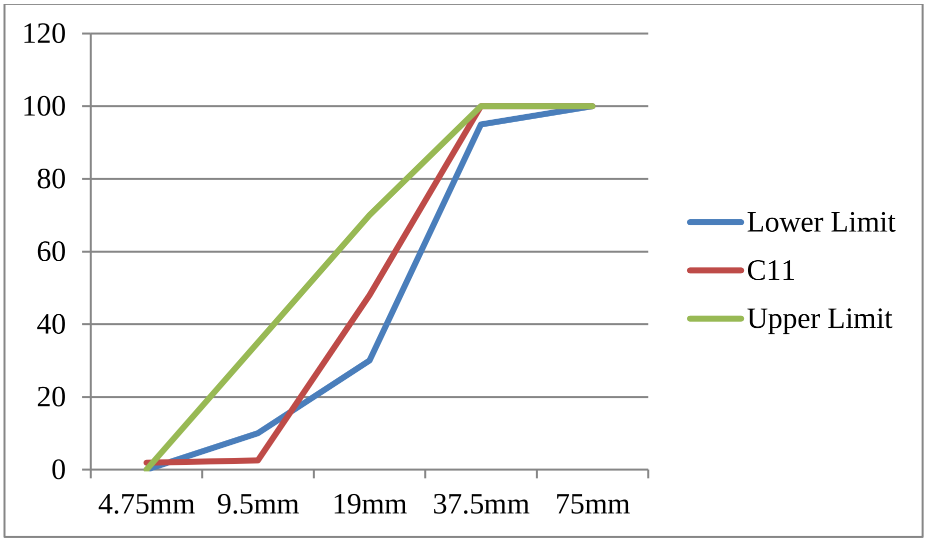
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C10
Upper Limit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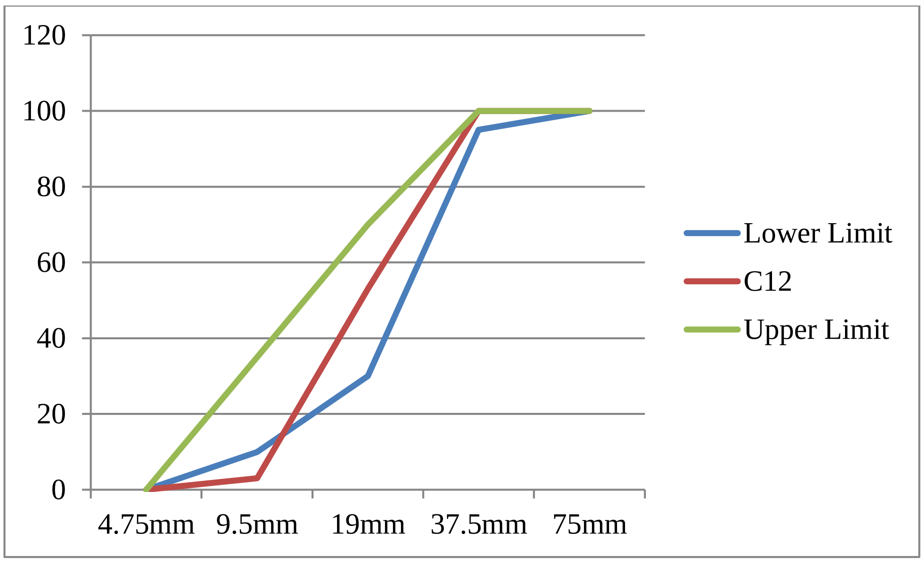
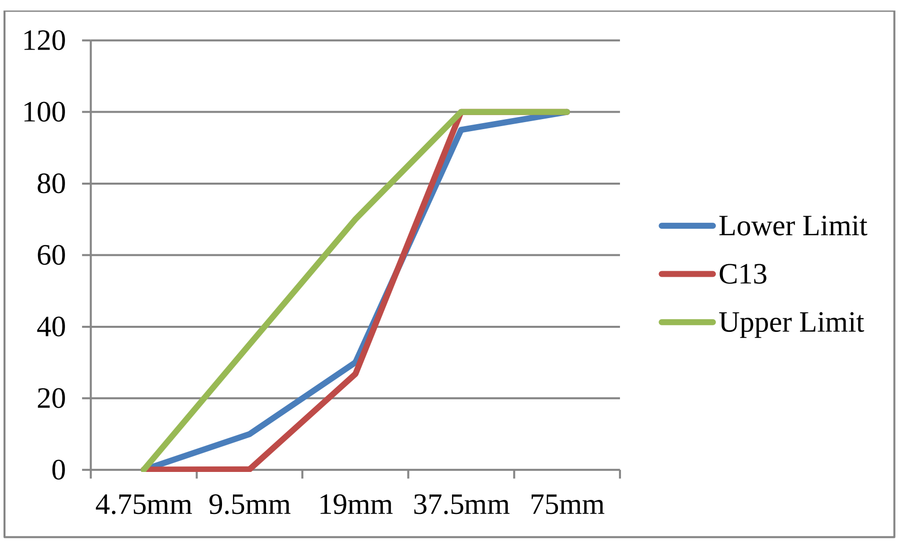
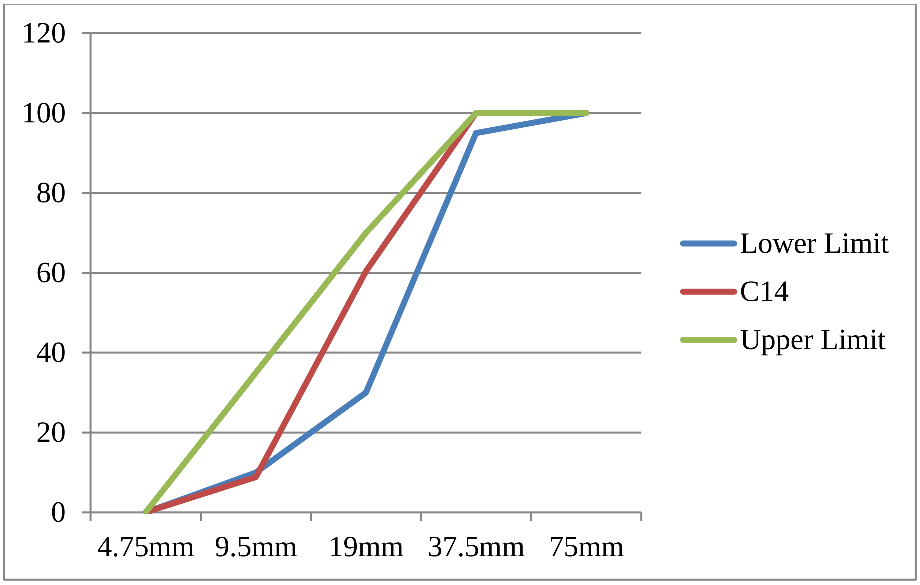
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C11
Upper Limit


120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C12
Upper Limit


120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C13
Upper Limit


120
100
80
60
40
20
0
4.75mm
9.5mm
19mm
37.5mm
75mm
Lower Limit
C14
Upper Limit

Appendix – III

Data Used to Estimate the Development of RMC Plant for Construction of Bahir Dar

The table below shows the list of permits which the **Bahir Dar Building Officer** hasgiven construction buildings, like; residential, commercial, hotel, real estate and othertypes of service buildings for the last five years.

The table below shows typical residential, real state, commerial and industrial buildings permits from the **Buiding Officer**in Bahir Dar.

በባህር ዳር ከተማ አስተዳደር ህንፃ ሹም ፀድቀው ወደሥራ የተገባባቸው ህንፃዎች ዝርዝር መረጃ መሰብሰቢያ

ተ.ቁ	የቦታው ባለቤት ስም	ጾታ	ካርታ ቁጥር	አድራሻ	የቦታው ስፋ	ህንፃው የሚሰጠው አገልግሎት	የህንፃው ከፍታ	በግንባታ የተሸፈነ ቦታ ስፋት	የህንፃው ምድብ	የግንባታው ወጪ	ዲዛይኑ ፀድቆ የወጣበት ቀን	የግንባታ ማብቂያ ጊዜ	አዲስ	ፋይል ቁጥር	ስልክ ቁጥር	የአገልግሎት
1	ደረጀ ዘውዱ መንጌ	ወ	ሀ11/4178/2010	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	1025282.64	18/5/2010	18/5/2011	አዲስ	ፋ.ቁ 5472	ስ.ቁ 0918706457	
2	እያሱ አበረ ገበየሁ	ወ	ግ/20/ክ/ከ/1000/07	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	932451.77	18/5/2010	18/5/2011	አዲስ	ፋ.ቁ 2681	ስ.ቁ 0930317450	
3	አስራት አያሌው ተገኝ	ወ	ሀ11/3085/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	1324043.58	21/5/2010	21/5/2011	አዲስ	ፋ.ቁ 4366	ስ.ቁ 0911630599	
4	መሰፍንት አያሌው አስናቀ	ወ	ሀ11/3100/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	972356.3	8/5/2010	8/5/2011	አዲስ	ፋ.ቁ 4383	ስ.ቁ 0918728363	
5	አምሳሉ ሞላ መንግስቴ	ወ	ሀ11/2872/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	1109723.55	16/5/2010	16/5/2011	አዲስ	ፋ.ቁ 4155	ስ.ቁ 0918515151	
6	መላኩ ስማቸው ንጋቴ	ወ	ሀ11/2932/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	980989.8	17/5/2010	17/5/2011	አዲስ	ፋ.ቁ 4211	ስ.ቁ 0975092652	
7	አምሳል ሙሉጌታ መስፍን	ሴ	ሀ11/2755/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	1284349.51	16/5/2010	16/5/2011	አዲስ	ፋ.ቁ 4039	ስ.ቁ 0918766693	
8	ዘርትሁን ዋጋው ወርቁ	ሴ	ሀ11/3287/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	1330491.48	15/5/2010	15/5/2011	አዲስ	ፋ.ቁ 4581	ስ.ቁ 0918801273	
9	ማቲያስ ሰለሞን ማሞ	ወ	ግ/20/ክ/ከ/918/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1387708.39	15/5/2010	15/5/2011	አዲስ	ፋ.ቁ 3062	ስ.ቁ 9008257468	
10	አየነው አድማስ አስማረ	ወ	ግ/20/ክ/ከ/1429/10	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1556706.57	15/5/2010	15/5/2011	አዲስ	ፋ.ቁ 3360	ስ.ቁ 0932271050	
11	አንዱአለም መንጌ መኮነን	ወ	ሀ11/3461/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	1552835.71	17/5/2010	17/5/2011	አዲስ	ፋ.ቁ 4745	ስ.ቁ 0935982562	
12	ልጥገበው ደታይሀ ገላው	ወ	ግ/20/ክ/ከ/979/10	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1638016.82	15/5/2010	8/5/2011	አዲስ	ፋ.ቁ 3315	ስ.ቁ 0918702023	
13	አሰፌ ጌታሁን አድማሱ	ወ	ግ/20/ክ/ከ/215/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1687693.59	22/5/2010	21/5/2011	አዲስ	ፋ.ቁ 2931	ስ.ቁ 0918705357	
14	ቶፊቅ እንድሪስ ሀሰን	ወ	ግ/20/ክ/ከ/355/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	22/5/2010	21/5/2011	አዲስ	ፋ.ቁ 2412	ስ.ቁ 0969029090	
15	ሰድያ አባስ ኡመር	ሴ	ግ/20/ክ/ከ/353/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	22/5/2010	21/5/2011	አዲስ	ፋ.ቁ 2408	ስ.ቁ 0923426761	
16	ጥሩ እንድሪስ ሀሰን	ሴ	ግ/20/ክ/ከ/350/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	22/5/2010	21/5/2011	አዲስ	ፋ.ቁ 2406	ስ.ቁ 0918716298	
17	ሽኩር እንድሪስ ሀሰን	ወ	ግ/20/ክ/ከ/358/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	22/5/2010	21/5/2011	አዲስ	ፋ.ቁ 2414	ስ.ቁ 0918705871	
18	ንጉሴ አደመ ይግዛው	ወ	ግ/20/ክ/ከ/359/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	22/5/2010	21/5/2011	አዲስ	ፋ.ቁ 2415	ስ.ቁ 0918012580	
19	ያሲን ጋሹ አህመድ	ወ	ግ/20/ክ/ከ/1036/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	24/5/2010	23/5/2011	አዲስ	ፋ.ቁ 2702	ስ.ቁ 0918800733	
20	መርድያ ጅብሪል ሁሴን	ሴ	ግ/20/ክ/ከ/349/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	23/5/2010	23/5/2011	አዲስ	ፋ.ቁ 2404	ስ.ቁ 0918024300	
21	ሞሚና ሙሀመድ አሊ	ሴ	ግ/20/ክ/ከ/351/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	23/5/2010	23/5/2011	አዲስ	ፋ.ቁ 2407	ስ.ቁ 0921279062	
22	መሀመድ ይማም እንድሪስ	ሴ	ግ/20/ክ/ከ/352/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	23/5/2010	23/5/2011	አዲስ	ፋ.ቁ 2409	ስ.ቁ 0918180605	
23	እስማኤል ረጋሳ ገዳ	ወ	ግ/20/ክ/ከ/347/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1564799.59	23/5/2010	23/5/2011	አዲስ	ፋ.ቁ 2402	ስ.ቁ 0918006464	
24	አድና አለባቸው እጅጉ	ሴ	ሀ11/2110/09	ሀዳር11	150	መኖሪያ /የማህበር	G+1		ሀ	1053606.96	24/5/2010	24/5/2011	አዲስ	ፋ.ቁ 3405	ስ.ቁ 0920252245	
25	አማረ መኳንንት ተባባል	ወ	ግ/20/ክ/ከ/1084/09	ግንቦት 20	150	መኖሪያ /የማህበር	G+1		ሀ	1353490.24	23/5/2010	22/5/2011	አዲስ	ፋ.ቁ 3329	ስ.ቁ 0913484111	
26	ስለናት ብርሀን ገበየሁ	ሴ	34056	ግንቦት 20	250	መኖሪያ /የሊዝ ይዞ	G+1		ሀ	1327059.96	23/5/2010	22/5/2012	አዲስ	ፋ.ቁ 42754	ስ.ቁ 0911874875	
27	ጥላሁን ባየ እስረስ	ወ	34067	ግንቦት 20	250	መኖሪያ /የሊዝ ይዞ	G+1		ሀ	1327059.96	23/5/2010	22/5/2012	አዲስ	ፋ.ቁ 42765	ስ.ቁ 0918769934	
28	ጥበቡ በላይ በለጠ	ወ	928/2008	ጣና	246	መኖሪያ /የሊዝ ይዞ	G+1		ሀ	1676431.95	23/5/2010	22/5/2012	አዲስ	ፋ.ቁ 906	ስ.ቁ 0910034572	

በባህር ዳር ከተማ አስተዳደር ህንፃ ሹም ፀድቀው ወደሥራ የተገበ

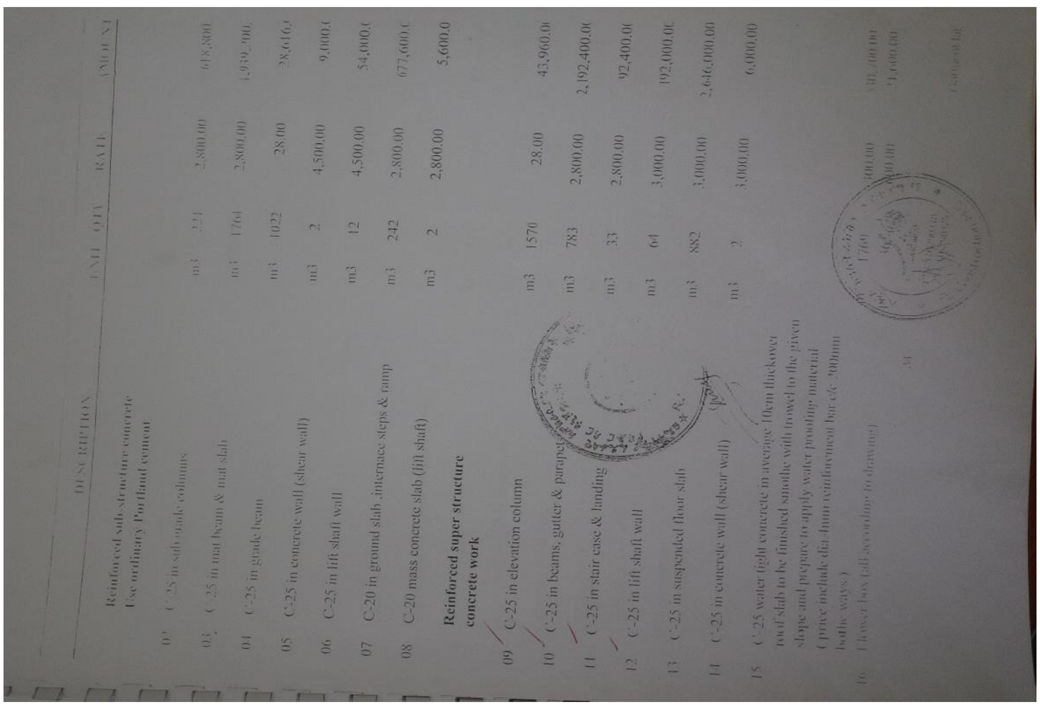
ተ.ቁ	የቦታው ባለቤት ስም	ጾታ	ካርታ ቁጥር	አድራሻ	የቦታው ስፋት	ህንፃው የሚሰጠው አገልግሎት	የህንፃው ከፍታ	በግንባታ የተሸፈ ቦታ ስፋት
1	ተሾመ አንተነህ	ወ	ባህኢፓ/0053/09	ግንቦት20	7000	ለኢንዱስትሪ/አኩሪ አተር ማቀነባበረ	G+0	
2	አባይነህ ነጋሽ	ወ	ባህኢፓ/0077/09	ግንቦት20	6000	ለኢንዱስትሪ/የቆዳ ውጤቶች ማምረ	G+0	
3	ባህራን ትሬዲንግ ሀ/የተ/የግ/ማህበር		33539/09	ግንቦት20	20000	ኢንዱስትሪ/ ምግብ ዘይት ፋብሪካ/	G+0	
4	ባህራን ትሬዲንግ ሀ/የተ/የግ/ማህበር		33538/09	ግንቦት20	10000	ኢንዱስትሪ/ ካርቶን ፋብሪካ/	G+0	
5	ብሩሀንስ ሁለገብ የውበት ስራና ማሰልጠኛ ማዕከል ኃ/የተ/የግ/ማ		28290/03	ሰፈነሰላም	310	ለንግድ/የሊዝ ይዞታ/	B+G+8	
6	ሂክማ ኃ/የተ/የግ/ማህበር		ባህኢፓ/0076/09	ግንቦት20	6000	ኢንዱስትሪ/የፕላስቲክ ውጤቶች/	G+0	
7	ሰለሞን ጌታቸው	ወ	ባህኢፓ/0038/09	ግንቦት20	4000	ኢንዱስትሪ/ፍሮማካና ፕላይውድ ማ	G+0	
8	የአማራ ክልል ፖሊስ ኮሚሽን		28458/03	ጣና	19876	ለማርሽ ባንድ	G+0	
9	አበራ እጅጉ አሰሜ	ወ	33931	ጣና	10000	ለኢንዱስትሪ/ሲረንጅና ግላቭ ፋብሪካ	G+0	
10	ጀማል ሙሀመድ አሊ	ወ	33703/09	ግንቦት20	22000	ለኢንዱስትሪ/ቆርቆሮ ፋብሪካ/	G+0	
11	አብድልቃድር ሲራጅ ሙሀመድ	ወ	43373/10	ግንቦት20	3500	ለኢንዱስትሪ/ጤፍ ዱቄትና ብስኩት	G+0	
12	የኢት.7ኛቀንአድቪንቲስት ቤ/ክርሲቲያን			ህዳር11		ለአምልኮ	G+0	
13	ሞላ ቢተው እረዳት	ወ	33717/09	ጣና	15000	ለአኢንዱስትሪ/ኮምፖልሳቶ ማምረቻ	G+0	
14	ሙሉአለም አንማው ሰውነት አስመጪና ላኪ ሃ/የተ/	ወ	ባህኢፓ/0006/09	ጣና	7000	ለኢንዱስትሪ/ፍራፍሬ ማቀነባበረ ፋ	G+0	
15	ኢ. ደብሊው ትሬዲንግ ሃ/የተ/የግ/ማህበር		34240/09	ግንቦት20	3000	ለኢንዱስትሪ/የአትክልት ዘይት ፋብሪ	G+0	
16	የሻረግ ካሳ ፈረደ	ሴ	9577/92	ሰፈነሰላም	249	ለንግድ/የይዞታ/	G+0	
17	አሉላ አለሙ ካሳዬ	ወ	33722/09	ግንቦት20	3000	ለኢንዱስትሪ/ጥራጥሬ ማበጠርና ማ	G+0	
18	አንለይ አድማስ	ወ	ባህኢፓ/0019/09	ጣና	15000	ለኢንዱስትሪ/ጣጥ ማዳመጫናየጥጥ	G+0	

Sample buildings structural concrete BoQsareused to esstimate structural concrete quantities per each buliding.

To determine the volume of structural concrete,

1. Sample buildings are selected which can represent buildings in Bahir Dar and summed up their structural concrete from BoQs.
2. The total number of projects are collected within the last two years to average the structural concrete usage per year because most public, government and industrial projects are two years contract periods in Bahir Dar.
3. Finally, the total volume of concrete for commercial, public and industrial active projects are estimated based on sample buildings structural concretes calculated above.

1. BoQ Sample for public projects (for 1 Building)



	DESCRIPTION	UNIT	QTY	RATE	AMOUNT
	Reinforced sub-structure concrete Use ordinary Portland cement				
02	C-25 in sub grade columns	m3	221	2,800.00	618,800
03	C-25 in mat beam & mat slab	m3	1764	2,800.00	4,939,200
04	C-25 in grade beam	m3	1022	28.00	28,616
05	C-25 in concrete wall (shear wall)	m3	2	4,500.00	9,000
06	C-25 in lift shaft wall	m3	12	4,500.00	54,000
07	C-20 in ground slab, intermediate steps & ramp	m3	242	2,800.00	677,600
08	C-20 mass concrete slab (lift shaft)	m3	2	2,800.00	5,600.0
	Reinforced super structure concrete work				
09	C-25 in elevation column	m3	1570	28.00	43,960.00
10	C-25 in beams, gutter & parapet	m3	783	2,800.00	2,192,400.00
11	C-25 in stair case & landing	m3	33	2,800.00	92,400.00
12	C-25 in lift shaft wall	m3	64	3,000.00	192,000.00
13	C-25 in suspended floor slab	m3	882	3,000.00	2,646,000.00
14	C-25 in concrete wall (shear wall)	m3	2	3,000.00	6,000.00
15	C-25 water tight concrete in average 10cm thick over roof slab to be finished smothe with trowel to the given slope and prepare to apply water proofing material (price include dia 6mm reinforcement bar c/c 200mm both ways)	[illegible]	[illegible]	[illegible]	[illegible]
16	Flower box (all according to drawing)	[illegible]	[illegible]	[illegible]	[illegible]

The total number and quantity of active public projects are estimated two folds of BDU projects. Based on this, the total numbers of active BDU projects and their BoQs are taken from **BDU Project Office**. BDUs' active projects of structural concrete are given in the table below.

Active projects of BDU

Contractor name	Under construction buildings	Amount concrete (m^3)
Samson G	Bill no. 1	1,648
	Bill no. 2	
Gad Construction	Bill no. 1	11,184
	Bill no. 2	
	Bill no. 3	
FE construction	Bill no. 1	22,675.1
	Bill no. 2	
	Bill no. 3	
	Bill no. 4	
	Bill no. 5	
	Bill no. 6	
ETETE construction	Bill no. 1	2,184
	Bill no. 2	
Esubalew Dessie	Bill no. 1	693.8
	Bill no. 2	
Orbit Engineering	Bill no. 1	18
	Bill no.2	
	Bill no. 3	
Afro Tsion		4,420
Yotek Construction	Bill no. 1	6,283.4
	Bill no. 2	
	Bill no. 3	
	Bill no. 4	
	Bill no. 5	
	Bill no. 6	
	Bill no. 7	
	Bill no. 8	
	Bill no. 9	
Yen comadconstructuion	Bill no. 1	7,423.6
	Bill no. 2	
	Bill no. 3	

TACON	Bill no. 1	8,123.4
	Bill no.2	
Total concrete		**64,654.00**
Wastage (10%)		**6,465.00**
Total amount of concrete including wastage		**71,119.00**

2. Sample structural concrete work (BoQ) for a commercial building

PROJECT: 2B+G+4 MIXED USE BUILDING
LOCATION: Bahir Dar
DATE: MAY, 2018

No.	In situ concrete	Unit	Quantity
01	Plain blinding concrete C-5	m^3	10.50
	Use ordinary Portland cement		
	Reinforced sub structure concrete		
02	C-25 in footing	m^3	294
03	C-25 in foundation column	m^3	34.7
04	C-25 in grade beam	m^3	73.73
05	C-25 in basementsolid slab	m^3	537
06	C-20 in slab including entrance steps	m^3	88.54
	Reinforced Super-Structure Conc.		
07	C-25 in elevation column	m^3	456
08	C-25 in beam and lintels	m^3	474.34
09	C-30 in beams	m^3	522.3
10	C-25 in Solid floor slab Basement one to fourth floor	m^3	692
11	In 200mm thick shear wall	m^3	99
11	C-30 in Solid roof slab	m^3	74.80
12	C-25 in Stair case and landing	m^3	79.00
13	C-30 in Concrete Gutter and parapet	m^3	18.78
14	C-25 in Sun breaker	m^3	37.14

15	C-25 in concrete element	m^3	21.9
16	C-25 in stair case baluster	m^3	5.00
17	C-25 water tight concrete in average 10cm thick over roof	m^2	108.16
Total		$\mathbf{m^3}$	**3690**
Average concrete per floor			**615**

3. **Estimated commercial buildings structural concrete volume based on the sample**

Type Of Building	**Story**	**Area (m2)**	**quantity**
ቢ.ዲ.አርሁለገብየገበያማዕከል	B+G+8	2000	6,395.25
እባቡደምሴፈታአምላክ	B+G+6	5000	4950.75
ብሩሀንስሁለገብየውበትስራ	B+G+8		6395.25
ዘላለምዘበናይባለህ	B+G+5	232	3690
በቀለቸኡርጋ	B+G+8	994	6395.25
ሽልልትፏፏቴሁለ/የገ/ማዕከል	G+6 እና G+7	11000	7995
ኢትዩጵያንግድ	2B+G+12	4190	11531.25
ኢ.ኤስፅናትለልማትሁ/ የገ/ማዕከል	B+G+7	4540	5658
አለሙተገኘይርዳው	B+G+6	18000	4950.75
ጌታቸውመኳንንትአማረ	G+6	2500	3690
ዋለልኚኤሌውተገኘ	G+6	2399.4	3690
ሮቢትኢንተርናሽናቢዝነስግሩኘ	G+8	1565	5658
አዝዋንግድአክሲዩንማህበር	G+7	855	4950.75
አራጋውይመር	G+6	8603	3690
ደሳለኝገበየሁ	G+7	2352	4950.75
ኤምቲአሁለገብየገበያማዕከል	G+6	1500	3690
ህይወትድጋፊ	G+6	312	3690
መገናኛሁለገብየንግድማዕከል	G+6	750	3690
አዝመራአሰፋandየሽማጫሽአያልነህ	G+6	236	3690
ፒኮልአባይኢ/ቢ/ሃ/የተ/የግ/ማህበር	G+17	8088	13068.75
ዳኛውጌትነት	G+5	1096	3075
ራዕይየገበያማዕከል	G+6	2000	3690
ሀሽምሁሴንያሲን	G+6	1096	3690
ሙሉጌታጋሪመርጋ	G+6	1470	3690
አሳብላየአጠናንግድአ/ማህበር	G+7	2270	4950.75
ቢዋይየንግድማዕከልአ.ማ	G+5	1224	3075
ደጌቢተው	G+4 እና G+6	2000	6150
አባይደሳለኝእናጓደኞቻቸው	G+8	2710	5658
መስታየገ/ማ/አ/ማህበር	G+6	1373	3690
ሸርደምሁለገብየገ/አ/ማህበር	G+6	3600	3690

ሰንደቅየገበያማዕከልአ/ማህበር	G+6	1349	3690
እንዘግድምኮንስትራክሽንእቃዎችማመላለሻ	G+6	1473	3690
አባይነህድንቁምህረቴ	G+7	2000	4950.75
ተመስገንጌጡ	G+6	6000	3690
ሀብታሙይሁኔ	G+8	3690	5658
ጋሻውዳንኤልቸኮል	G+6	600	3690
ፈለንሁለገብየገበያማእከልአ/ማህበር	G+8	4760	5658
ደረበወርቁጥሩነህ	G+10	1000	7687.5
ያሚአብጠቅላላንግድሀ/የተ/የገ/ማህበር	G+7	286	4950.75
ዘመነዋለመኮነን	G+6	795	3690
ዘላለምስፋየእናጓደኞቹ	G+6	268	3690
ፀዳይጌታቸውበላይ	G+6	3600	3690
ለምለሙብዙአለምእንዳሌ	G+5	1096	3075
ዉባንቾደምሴአየለ	G+6	600	3690
ሊቦተራራሁለገብየገ/ማዕ/አክ/ማህበር	G+8 እና G+10	3000	13345.5
መስኮየዱቄትመኮረኒ፣ፓስታናብስኩትማቀነባበሪአ/ማ	G+8	3800	5658
እፅገነት፣ሳባነሽእነጓደኞቻቸውህ/ሽ/ማ	G+6	1250	3690
አስምረት፣ሙሉእመቤትናእናጓደኞቻቸውህ/ሽ/ማ	G+6	1250	3690
ወንድወሰንአስፋውበላይ	G+6	675	3690
አባይነህድንቁምህረቴ	G+8	2000	5658
Total structural Concrete			**251,010.00**
Wastage of concrete (10%)			**25,101.00**
Total structural Concrete needed			**276,111.00**

2. Estimated industrial buildings structural concrete

Industrial Buildings	Area	Quantity
ሀይለእሱስልዕል	5000	1000
ሬድስታርኢንተርናሽናል	6000	1000
ሃይማኖትችሎታው	6447	1000
ዮሐንስክንፈተክለ	500	1000
ግርማዘለቀአያሉ	5000	1000
ዳኛነሽክንዴአለሙ	500	1000
አየነውንጋቱናጓደኞቹ	500	1000
አያሌውሙሃመድኑሩ	5000	1000
አንዋርታከለሁሴን	7000	1000
ደርሰህአሰፋናጓደኞቹ	500	1000
አበበውለታውደሴ	4500	1000
TBF industrial P.L.C	3000	1000
ሙላትአሰፋው	18300	1000
ጤናውየኔአለምፓስታናመኩረኒማቀነባበሪያፋብሪካ	7763	1000
የአብክመብረታብረትኢንዱስትሪማሽንቴክኖሎጅልማትኢንተርፕራይዝ	100000	1000

መርዕድጌታቸውተክሉ	500	1000
ፍሌቨርትሬዲንግ PLC	6000	1000
ባህሩአዘነሙሀመድ	10000	1000
ባዩካሳኡመር	10000	1000
ጣናኢንተርቴመንት	5000	1000
አብዩዋሴወንድምአገኝ	1118	1000
ኃይለማርያምዘመነ	500	1000
አምባቸውሙሉጌታአየለ	5400	1000
ኑሩአደምእንድሪስ	5000	1000
አለማየሁብርሀኔበየነ	10000	1000
መስፍንመንግስቴዉድነሀ	3000	1000
ቤአኤካጠ/ንግድኋ/የተ/የግ/ማህበር	10000	1000
ጀሀድአሊምትኩ	3000	1000
ኑርሁሴንሙሃመድ	4000	1000
አማጋዝዲስተርቢተር	5000	1000
ምናቬኢንዱስትሪኋ/የተ/የግ/ማህበር	3000	1000
ጌታሰውአያሌውዋሲሁን	3000	1000
ቋረትአግሮኢንዱስትሪሀ/የተ/የግ/ማህበር	3000	1000
ወርቁመሀመድሞሳ	5000	1000
መዳኒአጠቃላንግድሀ/የተ/የግ/ማህበር	15000	1000
ናይልኢንዱስትሪናኮመርሻልሃ/የተተ/የግ/ማህበር	10000	1000
አንየውአዳሙካሴ	1122	1000
ምስጋናሀ/የተ/የግ/ ማህበር	10000	1000
ሰይድሙሀመድአሊ	10000	1000
ሀብታሙይሁኔመንግስቴ	5400	1000
ኑርልኝአወቀ	7000	1000
መስየምግብማቀነባበሪያሃ/የተ/የግ/ማህበር	4000	1000
ኤምዋይቢትሬዲንግሃ/የተ/የግ/ማህበር	8000	1000
ንጉስአንማውቦጋለ	8000	1000
ሀቢሆቴልሃ/የተ/የግ/ማ	10000	1000
ኤኤስጅየመጋዝንናየገበያማዕከልሃ/የተ/የግ/ማ	10000	1000
ፀዳሉአለሜምልክት	6000	1000
ሙሉጌታቻሌናጓደኞቹየህ/ሽማ	5000	1000
ሙሉጌታቻሌናጓደኞቹየህ/ሽማ	6000	1000
አድባርአግሮኢንዱስትሪሃ/የተ/የግ/ማህበር	7000	1000
ዲዋይአግሮፕሮሰሲንግሃ/የተ/የግ/ማህበር	5000	1000
ተገኘግዛቸውአያሌው	8000	1000
ጤናውየኔአለምተመስገን	7763	1000
ፍሬህይወትማተቤከበደ	4500	1000
ኤ.ኤም.ኤፍትሬዲንግሃ/የተ/የግ/ማህበር	7000	1000
ገላውየጁብ	8000	1000

ኡመርወርቁ	6000	1000
AFTA ኢንድስትሪያልናትሬዲንግሃ/የተ/የግ/ማ	10000	1000
ገደፋውይስማውባይሌ	5000	1000
ያማረትሬዲንግሃ/የተ/የግ/ማህበር	3000	1000
ኢብራሂምአህመድ	6000	1000
M.Z.G.H ፕላስቲክኢንዱስትሪያልኃ/የተ/የግ/ማህበር	3000	1000
ይርጋመኮነንእናቤተሰቦቹሃ/የተ/የግ/ማህበር	15000	1000
አህመድሙሀመድሰይድ	8000	1000
ቋሪትአግሮኢንዱስትሪሀ/የተ/የግ/ማህበር	7000	1000
ቢኒያስኢንዱስትሪያልሀ/የተ/የግ/ማህበር	3000	1000
የሻምበልእያዩናቤተሰቦቹሃ/የተ/የግ/ማህበር	8000	1000
ገገርፕላስቲክናየፕላስቲክውጤቶችማምረቻ	6000	1000
አቡበክርኡስማንእናወንድሞቹየህ/ሽ/ማህበር	10000	1000
ሙሉአለምክንዱፈንታ	4000	1000
ደረጀኢንዱስትሪልናትሬዲንግሃ/የተ/የግ/ማህበር	10000	1000
ወራሚትአትክልትናፍራፍሬምርመራስልጣን	71958	1000
ምንባለመንግስቱአማኑ	12000	1000
ጤናውአለ¢ኝ	10000	1000
መላኩጌቴሙሉ	7000	1000
በለጠአባስኡመር	5000	1000
ኑሩሀሰንሙሀመድ	5000	1000
ደሴትሁ/የገ/ማዕ/አክማህበር	3400	1000
ደሳለውመንግስቱአማኑ	7000	1000
ዋልያፕላስቲክእናየፕላስቲክውጤቶች	13000	1000
ጌታሰውአያሌውዋሲሁን	5000	1000
ኤች.ኤም.ጅትሬዲንግኢንዱስትሪሀ/የተ/የግ/ማህበር	3000	1000
አለማየሁብርሀኔበየነ	10000	1000
ኤም. ኢ.ኤንንግድሃ/የተ/የግ/ማ	5000	1000
ሲሳይምኳንንትአማረ	4000	1000
ደረጀመኳንንትአማረ	6000	1000
ቤአኤካጠ/ንግድኃ/የተ/የግ/ማ	5600	1000
ካሳሁንእውነቴ	6000	1000
ሀይለእየሱስልዑልዘላለም	5000	1000
አምሳልዳኛቸውብርሀኑ	10000	1000
ዴቭኢምፔክስኢንተርፕራይዝባ/ዳርቆዳፋብሪካሃ/የተ/የግ/ማ	8940	1000
Total		**91,000.00**
Wastage		**9,100.00**
Total structural concrete including wastage		**99,100.00**

Appendix IV

Cost Break down Analysis Sheets for RMC and SMC

ANALYSIS SHEET FOR RMC DIRECT and INDIRECT UNIT COSTS

PROJECT: **CONCRETE WORK** LABOUR HOURLY OUTPUT: $5m^3$ / hr. placing
WORK ITEM: C-25 RMC WEIGHT BATCH EQUIPEMENT: Mixer and Vibrator 30m^3 / hr. production
TOTAL QUANTITY OF WORK ITEM: $1m^3$ Super Structure (Slab) RESULT:

Material Cost (1:01)					Labour (1:02)					Equipment Cost (1:03)			
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labour by Trade	No.	UF	** Indexed Hourly Cost	Hourly Cost	Type of Equipment	No.	11	Hourly Cost
Cement(OPC)	Qnt.	3.78	232.22	877.78	Foreman	1.00	2.00	40.00	80.00	Batching plant	1.00	1413.80	1413.80
Sand	m3	0.51	442.00	225.42	Plant operator	1.00	1.00	40.00	40.00				47.13
Gravel (02)	m^3	0.80	342.00	272.92	D/L	6.00	1.00	24.00	144.00	Vibrator	2.00	25.23	50.46
Water	m^3	0.23	3.00	0.68						Truck mixer	1.50	550.00	825.00
Admixture	Lit.	0.50	100.00	50.00						Pumper	1.00	1618.83	1618.83
				0.00					0.00	Loader	1.00	650	650.00
										Tools	6.00	2	12.00
													3156.29
				0.00					0.00				590.65
Total (1:-01)				1426.80	**Total (1:02)**				264.00	**Total (1:03)**			637.78

A= Materials Unit Cost: 1426.80 Birr/m^3 B=Manpower Unit Cost: 49.40 Br./m^3 C= Equipment Unit Cost : 637.78 Br./m^3

Total of (1:02) / Hourly Output — Total of (1:03) / Hourly output:

Direct Cost of work item = A+B+C =		2113.98	Birr/m^3
Overhead Cost:	10%	211.40	"
Profit Cost:	35%	739.89	"
Total Unit Cost :		3065.27	Birr/m^3

Remark ____

UF: UTILIZATION FACTOR
*: INCLUSIVE OF WASTAGE, TRANSPORTING, HANDLING, ETC.
**: INCLUSIVE OF BENEFITS, TRAVEL SUBSIDES AND COST OF OVERTIME RELATED TO TARGETED OUTPUT.

ANALYSIS SHEET FOR SITE MIX CONCRETE DIRECT and INDIRECT UNIT COSTS

PROJECT: **CONCRETE WORK** LABOUR HOURLY OUTPUT: 2.5 m^3/ hr. placing

WORK ITEM: C-25 Concrete (SMC) 1:2:3 EQUIPEMENT: Mixer and Vibrator 4 m^3 / hr. production

TOTAL QUANTITY OF WORK ITEM :1 m^3 Super structure: (Slab) RESULT:

Material Cost (1:01)					Labour (1:02)					Equipment Cost (1:03)			
Type of Material	Unit	Qty *	Rate	Cost per Unit	Labour by Trade	No.	UF	** Indexed Hourly Cost	Hourly Cost	Type of Equipment	No.	11	Hourly Cost
Cement(OPC)	Qnt.	3.78	232.22	877.78	Foreman	1.00	1.00	20.00	20.00	Mixer	1.00	150.00	150.00
Sand	m3	0.51	442.00	225.42	Mixer operator	1.00	1.00	20.00	20.00	Vibrator	2.00	25.23	50.46
Gravel (02)	m^3	0.80	342.00	272.92	D/L	25.00	1.00	16.00	400.00	Tools	6.00	3.00	18.00
Water	m^3	0.23	3.00	0.68	Mason	1.00	1.00	30.00	30.00	Crane	1.00	900.00	900.00
					B. bender	1.00	1.00	30.00	30.00				
					Mixer Operator	1.00	1.00	24.00	24.00				
													1118.46
													372.82
Total (1:-01)				1376.80	**Total (1:02)**				500.00	**Total (1:03)**			1491.28

A= Materials Unit Cost 1376.80Birr/m^3B=Manpower Unit Cost 350.88 Br./m^3C= Equipment Unit Cost : 497.09 Br./m^3

Total of (1:02) / Hourly Output - - Total of (1:03) / Hourly output: -

Direct Cost of work item = A+B+C = - 2224.77 Birr/m^3

Overhead Cost:	15%	333.72	"
Profit Cost:	10%	222.48	"
Total Unit Cost :		2780.96	Birr/m^3

Remark ____

UF: UTILIZATION FACTOR

*: INCLUSIVE OF WASTAGE, TRANSPORTING, HANDLING, ETC.

**: INCLUSIVE OF BENEFITS, TRAVEL SUBSIDES AND COST OF OVERTIME RELATED TO TARGETED OUTPUT