Ready Mix Concrete: Its Proliferation Opportunities to Regions of Ethiopia and Far Beyond

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ABSTRACT

As the pace of infrastructure development is growing vigorously the world over, the dominance of concrete as the pillar of critical input construction material is technologically breaking the limits of the challenging barriers. In doing so, the concrete industry was embarking on various innovative and game changing initiatives in ingredient materials production, economical use, enhanced concrete making technique and delivery. Accordingly, resurgence of Ready Mix Concrete (RMC) in the face of onsite batched concrete was studied to introduce the well-controlled plant product in the construction industry of Bahir Dar City of Amhara National Regional State. The aim was to expand RMC use far and beyond the capital Addis Ababa and its vicinity to unify infrastructure construction quality nation-wide. Therefore, the principal objective of this research is determining the potential of RMC proliferation from the point of raw material quality and reliable source, potential market demand; finally, comparing and contrasting of the unit cost of RMC with Site Mix Concrete (SMC) including transportation to the required site. Results show that more than 64% of the type of water being used doesn't fulfill the standards and entrants have to look options. The coarse aggregate properties are within the acceptable limits of standards. However, 56% of fine aggregate sources couldn't satisfy gradation requirements which need treatment; like, blending of different sources. Fine aggregate sources contain high amount of silt and clay which needs proper source selection and washing. Moreover, majority of respondents of the construction sector are aware and satisfied with the RMC introduction which is a good indication of acceptance. The unit prices of RMC for C-25 and C-30 show that 13.3% and 12.5% price increase, respectively; relative to the corresponding SMC. This might be compensated by the quality margin, reduced labor cost, reduced wastage of raw materials, reduced cement amount, material discount from suppliers through bulk purchase, and increase in fresh concrete productivity and supply. As the results obtained have shown, introduction of RMC to Bahir Dar will change the current problem of poor concrete use for now and forever. It would also lead to the proper and economical use of resources.

Key Words: Ready mix concrete, Material availability, Cost comparison, Concrete demand, Proliferation

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1. Introduction

Many buildings in Ethiopia are predominantly constructed 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), contractors use in-situ concrete with excess of cement in their 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 irregularities regarding the quality of concrete structures in Ethiopia.

Concrete ingredients on sites are batched mostly using volume batching. A study by Abebe (2005), 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.

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 dusty places, on the main streets of Bahir Dar and cement in non-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 SMC. One has to go out of the box and exercise other options to avoid the mentioned sorts of challenges.

1.1 Statement of Problems

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 (year unspecified), presents the overall benefits of RMC as: uniform and assured quality of concrete, durability of RMC, faster construction speed, storage needs at construction sites elimination, easier addition of admixtures, documentation of the mix design, reduction in wastage of materials, and eco-friendliness.

The main factors that affect the existence of RMC plant are the availability of quality raw materials, the construction industry 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 play an 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. Aggregate of fine and coarse; production, storage and transporting have a direct relation with concrete quality. Like any other business entity, factors that influence the RMC industry are 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.

1.2 Objectives of the Study

The main objective of this study 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.

1.3 Literature Review

1.3.1 General

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. Over 80% of site-placed concrete in the UK is produced by the ready-mix concrete industry and these accounts

for about 45% of the total cement sales for all purposes. Similar figures apply to other industrialized countries and they demonstrate the increasing tendency of contractor solely on the supply of a concrete from RMC plant. For instance, Japan is the world's largest producer of RMC shipping 181.96 million m^3 in 1992, followed by the USA, Korea, and Italy shipping 160, 96 and 70 million m^3; respectively Takeyam (1996).
RMC is 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 (2016), 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. 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.

Different literature sources give almost the same meaning or definition for "Ready Mix Concrete". For example, ASTM defines RMC as, "concrete manufactured and delivered to a purchaser". According to Yogesh (2016), RMC is the concrete which is manufactured at the central batching plant and delivered to construction site with the use of truck mounted Transit Mixers (TM). Similarly, RMC is a composite material which, like all well-designed composites, has resultant properties that combine the best qualities of the component materials as defined by Dewar (1992). Also Al-Araidah (2012), refers RMC as a type of 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.

1.3.2 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. Technically, in most cases there is no difference between RMC and SMC except pumpability of RMC to higher elevation. Thus the specifications of materials which are applicable for SMC are also applicable to RMC Szecsy (2014).

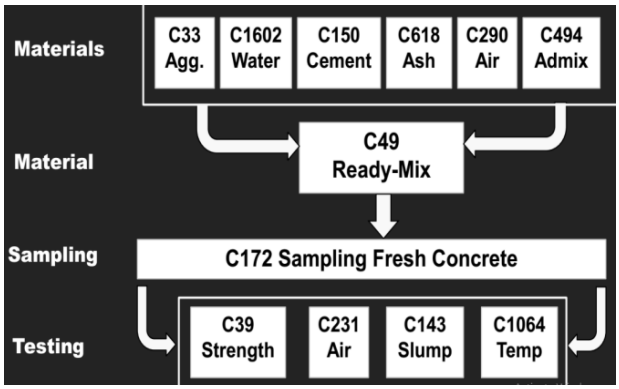


Figure 1.1: Requirement of RMC raw materials based on ASTM Standard (Szecsy, (2014))

Cement is the main constituent of concrete, quality and continuous supply of cement is quite important for the 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 Jain (2013). Moreover, RMC technology could not be implemented as investors felt that RMC plant will starve due to non-availability of cement Vilas (2011).

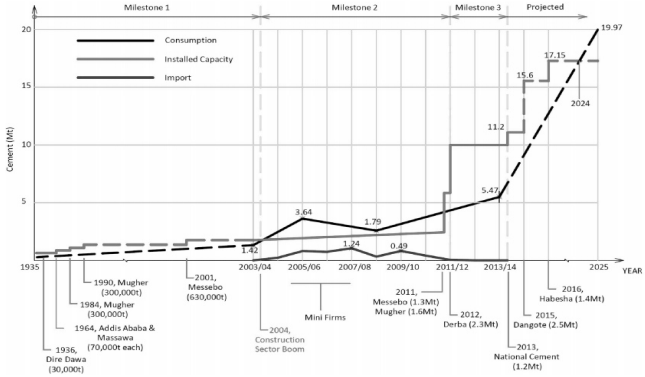


Figure 1.2: Summarized historical development and production capacity of the Ethiopian cement industry (FDRE Ministry of Industry (2015))

1.3.3 The Nature of Demand for Ready-Mix Concrete

The ready mix concrete industry's fortunes are closely tied to the level of activity in the construction sector. The sector buys the vast majority of ready mix output. The basic demand conditions faced by ready mix producers in any

given local market depend on how robust the construction activity is in that same market, not elsewhere Syverson (2004). 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.

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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 determined, it is possible to figure out if the market is large enough to sustain a proposed business or sustain an additional competitor in the market place Vilas (2011).

1.3.4 Quantification of Concrete Cost

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.al (2005a), presented the results of this investigation at ARCOM 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).

Further, Graham et.al (2005b), identified and quantified the cost contributors in the RMC system to contractors as follows. The contributors to each cost in the system are summarized in the table below.

Table 1.1: Contractor cost and contributors to unit cost (Graham et.al (2005b))

Cost Breakdown	Percentage Contribution
Material cost	
Raw material	54
Material transportation cost	5
Supplier overhead	12
Supplier profit	2
Total material cost	**73**
Labor cost	
Cost placement for RMC	11
Idle labors	2
Total labor cost	**13**
Plant hire & operating cost	
Idle plant (outside pour)	3
Set up cost	1
Idle plant (operating cost)	1
Plant hire (value adding)	5
Plant operating cost (value adding)	2
Total plant operating cost	**12**
Truck mixer surcharge	2

In summary, 73% of the contractor's cost was to pay for RMC material cost, 25% was due to plant and labour costs, while the remaining 2% accounted for truck mixer surcharges Graham et.al (2005b). On the other hand a research by Al-Araidah (2012), noted, in today's RMC manufacturing environment, direct labor cost accounts for only 10%; whereas, materials accounts for 55% and overhead for 35%.

Cost comparison between RMC and SMC for C-25 structural concrete was carried out by Haftamu (2010) considering; the common practice of the contractor's and the estimated costs of the RMC plant under consideration. Taking an average value of 10% profit margin and 25% overhead costs for RMC Plant, the average price of RMC for construction project site located at an average distance of 18km is 2,106.97 Birr/m^3, which is 1% higher than the average cost of SMC as shown in Table 1.2 which is 2084.83 Birr/m^3. The prices of concrete making materials, labor and equipment

were taken as the average in Addis Ababa and contractors' estimation.

Table 1.2: Resource utilization and direct cost of observed pours (Haftamu (2010))

Item	RMC		SMC	
(Resource)	Cost (Birr)	Resource time (Hr.)	Cost (Birr)	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**	**-**
Sub total	**1,560.72**		**2084.82**	
Profit and overhead for RMC's Plant (35%)	**546.25**		**-**	
Total	**2,106.97**		**2084.82**	

The cost comparison discussed didn't include idle cost when there was no concreting activity which is unavoidable due to owning cost of equipment and idle permanent employees engaged in the production activity. 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 Haftamu (2010).

Likewise, Kassahun (2017) reinforced the above by stating: "The results of a quick survey into the active four RMC local suppliers cost for a C-25 class of concrete including a pumping service for pouring is Birr 3,263.67/m^3. The cost of such a C-25 concrete as batched in-situ traditionally is Birr 2,952.18/m3 including direct and indirect expenses. The difference in cost of Birr 311.49 makes the RMC product charge higher by such a margin. The hastily compiled of a C-25 concrete cost for the conventional and RMC comparison has indicated that, the RMC product is expensive. This is in a sharp contrast to the world trend that embarking on RMC technology is meant for cheaper concrete; in monetary terms".

2. Research Methodology

According to Kofi (2012), the structured questionnaire is probably the most widely used data collection technique for conducting surveys to find out facts, opinions, and views. The other means for data gathering is interview. 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 Al-Moghany (2011). 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 adopted to collect detailed information about respondents, and to know the impressions of practitioners about the notion of RMC plant for Bahir Dar construction industry. The questionnaire survey was also adopted to get feedback on opinions of respondents on 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.

Based on the data from Bahir Dar City Administration, at the start of this research there were about 25 contractors and 10 consultants of Grade 1 and 2 on active commercial and public projects with buildings of five story and above including industrial projects. These projects were the target population to get the sample size because the volume of concrete to be used by these contractors is expected to be high in volume. Contractors and consultants who are participating in the selected projects were required to be focal respondents. Professionals proposed to participate in the study as

respondent were; project managers, resident engineers, office engineers, contractors, consultants, and the regulatory body. All the respondents have a direct involvement in the actual construction and management of the sites.

2 RESULTS AND DISCUSSIONS

2.1 Concrete Making Materials

More than 64% of the type of water being used in many projects isn't recommended or desirable according to many literature sources and set standards. It is the opinion of the researcher that such problem can be solved by the RMC plant which can set its borehole water supply system for sustainability.

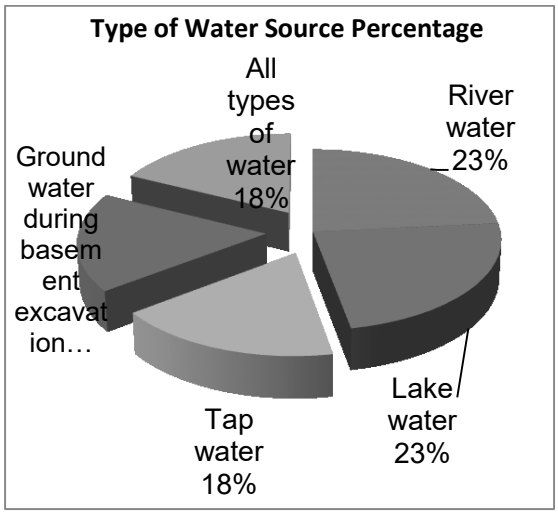


Figure 3.1: Sources of water for construction projects

Note; In urban and outskirt area, the ground water has higher tendency to be polluted with domestic wastes and chemicals discharged out of factories. Such water bodies contain significant amount of deleterious substances; like, sulphate and other soluble salts that deteriorate concrete Neville (2011). Therefore, for RMC it is highly recommended to solve such scarcity of tap water on construction sites with the following two possibilities.

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

From interviews, many cement companies may supply cement to the construction industry within the required time and current price.

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

Through the same data collection technique, the major sources of fine aggregates for the projects are; natural sand from Tana, Beneshangul Gumz (Bulen white sand) or Gilgel Beles, Adis Zemen (Yifag), Gumara, Sendeta, Arbaya (Belessa), Enfranz, Arbaye, Ribb, Keha and crushed aggregates from crushing plants around Bahir Dar.

Table 3.1: 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	44.07	14	31.82
Silt and clay content	26	44.07	-	-
Aggregate Crashing Value (%)	-	-	10	22.70
Specific Gravity and Water Absorption	1	1.69	8	18.20
Aggregate Crashing Value (%)	-	-	6	13.64
Soundness	2	3.39	2	4.55
Unit weight	4	6.78	-	-
Loss Angeles Value (%)	-		3	6.82
Elongation Index (%)	-		1	2.27
Total	**59**	**100**	**44**	**100**

Various aggregate source test results were examined from the documents of material testing. The tests conducted in all 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. Among these tests gradation and silt and clay content tests are the major ones.

The quality of coarse aggregates in size, shape and surface texture around Bahir Dar are within the acceptable limits of standards. However, about 56 percent of the fine aggregate sources couldn't satisfy graduation requirements which need treatments; like, blending of different sources of aggregates. The fine aggregates in and around Bahir Dar contain high amount of silt and clay which needs proper source selection and washing.

2.2 The Nature of Demand for Ready Mix Concrete.

The need for concrete construction in Bahir Dar due to high need of residential, commercial, hotel, industrial and other buildings is increasing as the reality on the ground shows. The average total structural concrete volume usage per year in Bahir Dar City is about 258,725m^3. From this, the majority of the builders, i.e. 53% takes the commercial project followed by 27.00% builders take government project the remaining 20% belongs to industrial buildings. 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 of annual concrete sales.

From the above, 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.

2.3 Cost Comparison of RMC and SMC

From interviews and researches done earlier, the two most common structural concrete grades observed on the targeted building projects are C-25 and C-30 concrete in Bahir Dar and Ethiopia Abebe (2005) and Habtamu (2015). These structural grade concretes are also mostly produced by RMC suppliers in Addis Ababa which currently focus on C-25 and C-30 as its main products with 50% and 28.0% sales mix; respectively, out of their total planned concrete production Kassahun (2017). Therefore, C-25 and C-30 structural concrete grades are taken for cost comparison.

From interviews, for conventional SMC the price of C-25 ranges from 3800 to 4000 Birr/m^3 and for C-30 ranges from 4000 to 4400 Birr/m^3, i.e., the average prices are 3800 and 4200 Birr/m^3; respectively. On the other hand, the price of C-25 RMC product ranges from 4400-4600 Birr/m^3 and C-30 from 4700 to 4900 Birr/m^3. The unit prices of RMC for C-25 and C-30 show that 13.3% and 12.5% price increase relative to the corresponding SMC in Bahir Dar. Considering advantages, the cost increase observed of RMC relative to SMC is not significant; if those intrinsic gains are converted to monetary units.

3. Conclusion and Recommendation

3.1. Conclusion

The constituents of concrete which most of them are naturally occurring materials are subjected to a wide range of variability. From the constituents, water, is a relatively less variable and usually available in a condition to be used for concrete readily but it may face scarcity of clean tap water. The second constituent, cement, is also a factory product that it is relatively easy to control its production process and there by its quality. However, the remaining constituents, which are coarse and fine aggregates, are usually naturally occurring and are subjected to a wide range of variability. Thus, at times they need special enhancing treatment.

Results show that the need for concrete consumption in Bahir Dar is on the rise due to high demand for residential, commercial, hotel, industrial and other buildings. The estimated

market potential can be considered as an attractive future for RMC Plant competitive advantage. This is derived from the average total structural concrete volume usage per year of about 258,725 cubic meter of the City's construction industry.

C-25 and C-30 are used for cost comparison between RMC and SMC concrete. The unit prices of RMC for C-25 and C-30 show that 13.3% and 12.5% price increase relative to the corresponding SMC in Bahir Dar. This could be compensated by good quality of the product, reduced labor cost, reduced wastage of raw materials, reduced cement quantity, bulk purchase of materials at a discount cost from suppliers and increased productivity at construction sites leading to savings in time plus cost of construction.

As the results obtained so far have shown, the introduction of RMC to the Bahir Dar construction industry improves the current problem of concrete producers' inability to deliver a good quality product which could satisfy applicable standard requirements. In addition, the use of RMC would improve the quality of concrete produced and help towards the proper utilization of naturally available raw materials.

4. Recommendation

- ✓ The aggregates need focused attention during production and selection of sources; especially, selection of quarry sites and types of aggregate crashing plants, some should be washed to remove deleterious substances and blended to get the required gradation; i.e., to make good quality and economical concrete.
- ✓ The RMC Company is strongly advised to make an effective and efficient material procurement method.
- ✓ Ethiopia should have updated standard document, guideline, quality control schemes and specification that provides detailed criteria of plant, machineries, testing facilities, control on the properties of concrete ingredients and the final product, technical manpower, etc.; which any RMC plant, irrespective of their size and capacity, to fulfill standard requirements to qualify for the certification.

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