Estimating Ready Mixed Concrete On-site Dispatch Time Using Concrete Slump and Volume: Case Study of a Construction Site in Nigeria[1]

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ABSTRACT

Ready mixed concrete is becoming common in the Nigeria construction industry as it reduces labour cost and other associated costs. This study was aimed at developing a model to predict ready mixed concrete on-site dispatch time using concrete slump and volume. Primary data was the only data source and it was obtained through site observation for two weeks. Thirty (30) ready mixed concrete transit trucks were studied. Hierarchical Multiple Linear Regression (HMLR) was employed for the analysis of data. The study revealed that concrete slump and volume have small impact on the dispatch time using concrete pump ($R = 0.366$; $R^2 = 0.134$; F-model = 1.676 [with $p > 0.05$]). It was thus concluded that concrete slump and volume have small effect on the dispatch time on ready mixed concrete. Hence, research should be carried out to identify these critical factors to improve productivity. It was thus recommended that ready mixed concrete companies should ensure that; the value of slump is kept at the acceptable value on arrival of concrete to construction sites, transit mixer pass through the best route to avoid delay as a result of traffic, and carry out daily checks on their equipment to assess its suitability for work and avoid technical breakdown.

Keywords: Dispatch time, Concrete Slump, Productivity, and Construction industry

1. INTRODUCTION

The construction industry is envisioned as the major driver of the economy with 5% increase in Gross Domestic Product (GDP) growth, other sectors like health, education, transportation and the likes depend heavily on the construction industry (Olanrewaju, 2017). However, the construction industry can be fractioned into three crucial parts which are the building industry,

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heavy and civil engineering works and specialist contractors who engage in the services of carpentry, plumbing, electrician, tiling and painting (Sanusi, 2008; Olanrewaju, *et al*. 2018). El-Rufai (2011) contended that infrastructure is essential to human and economic development and is the catalyst for magnetizing investment, for which Nigeria has requisite potentials. The rapid rate of urbanisation in Nigeria requires the use of ready mixed concrete so as to enhance productivity.

Ready mixed concrete (RMC) is an essential construction material consumed in all components of a building from the inception to completion, and therefore utilised in enormous quantities. Biruk (2015) revealed that 60-70% of all contemporary built structures are made of this material. Owning to increasing requirement for quality in concrete mix design aimed at achieving a quality product, it is manufactured in a fully controlled environment with the help of specialised batching plant. The mix is then delivered to construction sites where they are required by ready mixed concrete trucks so as to maintain its qualities (Biruk, 2015). Ready mixed concrete in Nigeria is becoming a very competitive business in a well-developed market. Companies are in search of economies in terms of dispatching ready mixed concrete so as to maximise profit and utilise their facilities optimally. This study therefore seeks to predict the ready mixed concrete pump dispatch time using concrete volume and slump with the view of developing a mathematical model to aid management of ready mixed concrete pump dispatch time on construction sites.

2. MAJOR PHASES OF READY MIXED CONCRETE PRODUCTION

According to Nellickal *et al*. (2015), the major phases of ready mixed concrete production can be divided into five phases. The phases include; Manufacturing of raw material, Transportation of raw materials, Operations at the RMC batching plant, Delivery of RMC using transit mixer trucks, and Construction operations at the site. This study focused on an integral part of "construction operations at the site" phase where ready mixed concrete is dispatched using concrete pump.

2.1 Manufacturing of raw materials

The raw materials required for RMC production include cement, sand, coarse aggregates, water, admixtures and flyash. Energy is utilised for the manufacture of cement at the cement plant for the extraction of raw materials, processing, clinker production, grinding and packaging. Coarse aggregates of sizes 20 mm and 12 / 10 mm are usually used for concrete production. Sand is mostly obtained from the riverbeds. Manufactured sand is used in cases when river sand is not available. Flyash is obtained as a by-product from thermal power plants. The admixtures are produced from a wide variety of chemicals. Water is usually obtained from a nearby natural source (Nellickal *et al*., 2015).

2.2 Transportation of raw materials to batching plant

The raw materials required for ready-mixed concrete production are transported from the supplier location to the batching plant by means of trucks. Cement and flyash are stored in large quantities in silos at the plant while the coarse and fine aggregates are stored in their respective storage yards. The admixtures are transported to the plant in cylindrical barrels which are usually directly connected to the batching plant mixer. Water is brought to the plant in tankers and are filled in the water tanks or is directly obtained from a natural source (Nellickal *et al*., 2015).

2.3 Operations at the RMC batching plant

The batching plant is fully automated and is run by diesel, electricity or both. The major sources of energy consumption at the plant include the diesel generator, site office operations, loader used for handling aggregates from the storage yard to automated belt conveyor, and the company vehicles. The batching plant is able to produce different grades and types of concrete. The mix proportions are already stored in the automated control systems of the batching plant. The plant uses either a pan mixer or a twin-shaft mixer of specific capacity (Nellickal *et al*., 2015).

2.4 Delivery of RMC using transit mixer trucks

The batched concrete is then fed into the transit mixer trucks which is transported to the respective customer sites. These are special types of trucks in which the final mixing of the concrete is performed in their rotating drums. For the best properties of concrete to be maintained, the concrete should reach the site within a time limit of 1 to 1.5 hours from the time of batching. This is hindered by heavy traffic on several occasions, especially in the major cities (Nellickal *et al*., 2015). One of the major problems associated with this stage is heavy traffic in major cities in which Lagos is not left out.

2.5 Construction operations at the site

Once the transit mixer reaches the customer site, the concrete is pumped to the required location by means of concrete pump. The placed concrete is further levelled and compacted. The surface is then given the final finish using appropriate tools in order to get an even surface of the concrete placed, prior to its curing (Nellickal *et al*., 2015).

3. RESEARCH METHOD

This research undertakes an extensive literature review and site observation to provide the required background information on the processes of ready mixed concrete (RMC). A quantitative research method was employed by using checklist to obtain data at various processes as shown in Figure 1. The RMC parameters obtained on site were dispatch time, slump and, quantity of concrete. The dispatch time was measured using stopwatch while quantity of concrete was extracted from RMC way-bill, and slump was measured onsite using the slump measuring tools (slump measuring cone and ruler). The data was collected over a period of two weeks. During this period, thirty (30) trucks came to the site to dispatching concrete while casting slab. The statistical tools used for this research was Hierarchical Multiple Linear Regression (HMLR). IBM SPSS version 23 and Microsoft Excel 2016 were the software packages used for analysis and presentation.

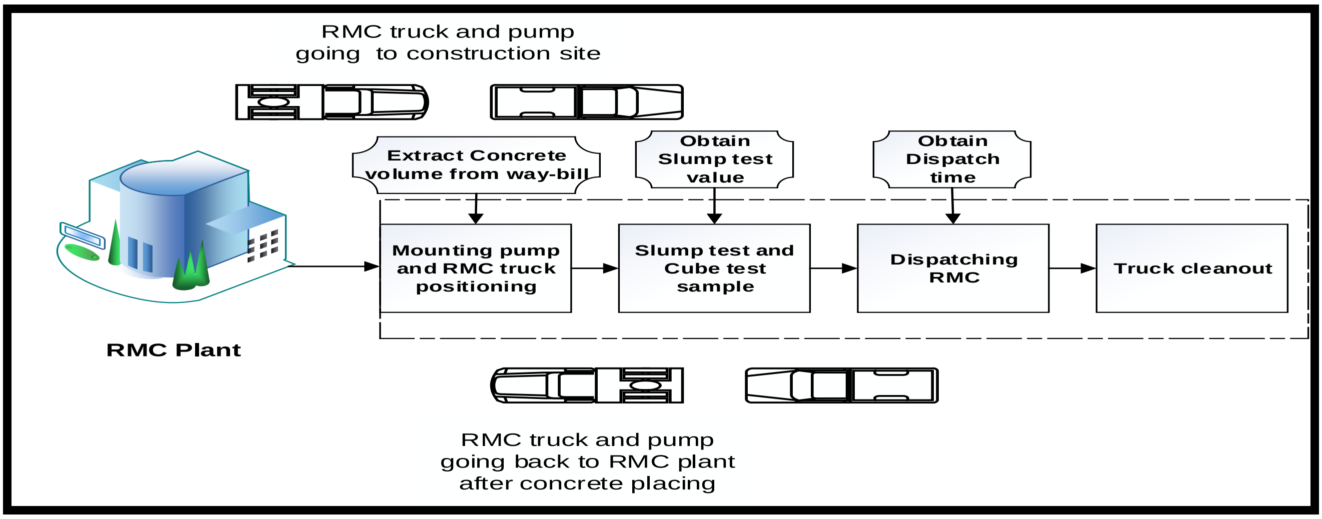

Figure 1: Ready Mixed Concrete On-site Processes and Data Collection Approach

4. DATA PRESENTATION

Table 1 shows the data obtained from site observation. The data include; dispatch time, concrete volume, flow rate, and slump value.

Table 1: Site Observation Data on RMC Dispatch Time

S/N	Dispatch Time (Minutes)	Concrete Volume (m3)	Flow Rate (m3/min.)	Slump Value (m)		S/N	Dispatch Time (Minutes)	Concrete Volume (m3)	Flow Rate (m3/min.)	Slump Value (m)
1	9.00	9	1.00	0.15		**16**	28.00	9	0.32	0.16
2	7.00	9	1.29	0.17		**17**	40.00	9	0.23	0.13
3	8.00	9	1.13	0.14		**18**	28.00	9	0.32	0.13
4	11.00	9	0.82	0.17		**19**	45.00	9	0.20	0.11
5	9.00	9	1.00	0.13		**20**	9.00	9	1.00	0.16
6	11.00	9	0.82	0.16		**21**	15.00	9	0.60	0.18
7	11.00	9	0.82	0.18		**22**	13.00	9	0.69	0.17
8	8.00	9	1.13	0.20		**23**	9.00	9	1.00	0.14
9	12.00	9	0.75	0.11		**24**	8.00	9	1.13	0.11
10	17.00	9	0.53	0.13		**25**	8.00	9	1.13	0.19
11	11.00	9	0.82	0.19		**26**	10.00	4	0.40	0.11
12	10.00	4	0.40	0.11		**27**	9.00	9	1.00	0.17
13	8.00	9	1.13	0.17		**28**	11.00	9	0.82	0.14
14	11.00	9	0.82	0.14		**29**	12.00	9	0.75	0.11
15	12.00	9	0.75	0.11		**30**	16.00	9	0.56	0.15

5. ANALYSIS AND DISCUSSION OF RESULTS

Hierarchical multiple linear regression (HMLR) analysis technique was applied also for predicting dispatch time. A regression analysis formula can be considered an easy expression to follow and implement, despite its inadequacy in representing nonlinear behaviors for real-world systems (Jassim, *et al*., 2017). The formula was modeled as a HMLR function of concrete volume and slump value for predicting dispatch time per cubic of concrete. Hierarchical multiple linear regression explored the relationship between dispatch time and some selected variables (Concrete volume and Slump value). The models are presented in Table 2. The first hierarchy which is model 1 seek to test the degree to which slump value predicted dispatch time, the model has a very poor predictive ability of 8.1% (R = 0.284; R^2 = 0.739; F-model = 2.454 [with $p > 0.05$]). The results of model show that slump value had negative insignificant relationship with dispatch time. Similarly, model 2 has a predictive reliability of 13.4% (R = 0.366; R^2 = 0.134; F-model = 1.676 [with $p > 0.05$]).

The results of hierarchical regression analysis between dispatch time and the selected variables. It indicates that there exists an insignificant relationship between dispatch time and the selected variables (Concrete volume and Slump value). Furthermore, the coefficient of determination (R^2) value observed was 13.4% indicating a weak relationship and the correlation coefficient (R) observed was 36.6% also indicated weak degree of association between the variables. The correlation observed between the variables indicates a tendency that an increase in the selected variables will be followed by a corresponding increase in the dispatch time and vice versa. The value of the R^2 implies that 36.6% increase in dispatch time is accounted for by changes in the value of the selected variables while 63.4% is as a result of other factors not considered in this study. The mathematical model below was generated;

$$\boldsymbol{\gamma(DT) = \beta_0^{DT} + \beta_{CV}^{DT}(CV) + \beta_{SV}^{DT}(SV)}$$

Where; DT = Dispatch time, CV = Concrete volume, and SV = Slump value

Table 2: Relationship Between RMC Dispatch Time and Selected Variables

Independent Variables	**Dependent Variable**	
	Dispatch Time (Mins.)	
	Model 1	**Model 2**
Slump Value (m)	-0.284	-0.374*
Concrete Volume (m3)		0.249
R	0.284	0.366
R^2	0.081	0.134
Δ F	2.454	1.676
Note: *p<0.1		

6. CONCLUSION

Ready mixed concrete is becoming very common in the Nigerian construction industry and there is need to study the parameters that influence on-site dispatch time of ready mixed concrete using concrete pump as it affects the productivity and profitability of ready mixed concrete companies. This research revealed that concrete slump value has more impact on dispatch time than the volume of concrete. Thus, it can be concluded that concrete slump and concrete volume have little impact on the dispatch time of concrete. Hence, research should be carried out to identify the critical factors that influence the dispatch time of ready mixed concrete. This study thereby recommends the following;

1. Ready mixed concrete companies should ensure that the value of slump is kept at the acceptable value on arrival of concrete to construction sites.
2. Ready mixed concrete companies should ensure that the transit mixer pass through the best route to avoid delay as a result of traffic.
3. Ready mixed concrete companies should ensure that they carry out daily checks on their equipment to assess its suitability for work and avoid technical breakdown.

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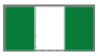

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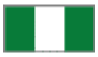

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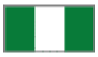

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