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Augmentation of Batching Plant Productivity without Affecting the Quality of Concrete

Sudeshna Wawhal

Imperial College of Engineering and Research, Wagholi, Pune, Maharashtra

sudeshnawaw@gmail.com

Abstract: Ready mixed concrete (RMC) is the prime material required for buildings and Government & Non-Government infrastructure work, and it is exponentially growing industry in India. RMC is produced to meet client's/customer's requirements and its deliveries must be conventional to construction site. Therefore, due to technological operating constraints – the material cannot be prepared in advance and stored. To operate effectively the concrete production scheduling & truck dispatching are always handled by experienced staffs. This paper represents the constructive and unconstructive impacts due to geographical, political and regulatory differences. Also, various other factor like controlled and uncontrolled delays which occurs during preparation, transportation and utilization of RMC plants in India. Also, paper focuses on delay factors effecting batching plant by with stochastic mathematical models. The main objectives are (1) Identifying the sources of delay in concrete batching plant (CBP) (2) assessing their impact on production, time, cost and efficiency (3) how each factor can affect the rate cost of CBP in unit price. Researched data were collected for different batching plant sites to verify the designated model.

Keywords: Ready Mix Concrete, Stochastic Models, Operating Constraints, Truck Dispatching.

1.1 INTRODUCTION

Productivity measurement at construction site level enables companies to monitor their own performance against their site performance. Construction productivity at construction site level can be grouped under various departments likes, productivity in concrete, steel work and shuttering.Computer modelling and analysis of construction processes have gained importance in recent years because of an increase in the complexity of construction processes. Petri nets provide a modelling and analysis approach that can be used to effectively study, understand, analyze, and improve construction processes.[2] This paper highlights the advanced features of Petri nets and describes their utilization as a process modelling and analysis tool for the study of a ready-mix concrete plant. Usually, process modelling and analysis are performed by initially developing a graphical portrayal of the process and then dynamically studying the response of the process to external and internal factors. A Petri net is a formal graphical modelling tool that can be efficiently utilized as a process modelling and analysis tool because it can graphically portray and dynamically analyze a process in an integrated manner. The paper contributes significantly in the area of computer-based decision making and provides value to practicing schedulers, estimators, and project managers who deal with the complex in construction processes. In this paper stochastic mathematical models are used for assessing and analyzing concrete batching plant.

1.1.1 Sources of delay

Factors influence the concrete batching plant production (CBP); labor crew skills placing methods, organizational and management factors, site access conditions, the number of truck mixers available, site congestion, materials delivery system, weather conditions, de-monetization and mechanical problems. The aforementioned factors are responsible in reducing productivity and increases delays with different percentages. Latest research categorizes delays into two most important categories. First, uncontrolled delays (UD), delays due to factors that are out of plant management control. The other category includes controlled delays (CD), delays due to factors which can be controlled by plant management.

- Uncontrolled Delays: The major elements of the UD are as followed:

1. Weather conditions
2. No work available for the CBP
3. Delays due to pouring of concrete
4. De-monetization

- Controlled Delays

5. Management conditions: delays because of numbers of truck mixers are not convenient, pouring crew skills, and site conditions.
6. Mechanical Problems
7. Due to cement problems & aggregated delivery problems.

The future scope of this dissertation is to increase economy of the related plant, by the reduction of unnecessary route for transportation of material (cement)

1.2 OBJECTIVES

- To step up the procurement of quality raw materials such as cement, sand, aggregates, water etc.
- To achieve better productivity by regular maintenance of machinery required in batching plant. For example Cleaning of extra deposits of concrete from silos, and other equipment batching plant.
- To audit continuous review of various batching plants sites for the factors which could affect the output of subject batching plant and recognizing and troubleshooting of such factors in time.
- To calculate how these factors influence on production, efficiency, time and cost.

1.3 SCOPE

Ready mixed concrete (RMC) is the leading material required for infrastructure work.

Increasing Batching Plant Productivity will assuage the buildability and quality of buildings by avoiding prolonged in constructions.

1.4 METHODOLOGY

1.4.1 CONCRETE BATCHING PLANT STOCHASTIC MATHEMATICAL MODEL

The Concrete batching plant (CBP) expenses per unit can be segregated into batch plant expenses (BPE) and transporting expenses (TE).[7] The BPE considers the expenses of batch plant and services provided by the equipment and tools, whereas the TE considers truck mixers expenses. The total expenses of the construction equipment have two categorizations ownership expenses (OE) and operating expenses. As, the CBP and its truck mixers are both equipment's, it safe to categorized their expenses as OE & PE. The OE always includes depreciation i.e. the value decreases with the usages, maintenance, and repairs (M&R); and spares parts and tools. The PE includes fuel, grease, oils, salaries, wages and others. Therefore, the total equipment expenses (TTE) can be determined using following model (1)

Total Equipment Expenses (TEE) $=\sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij}$ (Rs/m^3) (1)

To analyze the probability of frequent arrivals of delays, it can be measured, the number of occurrences divided the total of observations.

Probability (P_{kh}) = t/N (%) (2)

However, the challenge that faces this straightforward application is the weight of each occurrence (delay time). The delay time is not always equal for each time occurrence; therefore, the straightforward application to conclude the probability is not sufficient. For example, cement delivery delay takes 10, 15, 25 minutes in the 1st, 2nd and 3rd occurrences respectively. However, the determining only the probability of occurrence is not effective, the delay time of each occurrence should be considered to calculate the delay percent for a specific delay type. Therefore, the model to calculate

Delay Percent (DP) = $[\sum_{k=1}^{r}\sum_{h=1}^{l} D_{kh}] * P_{kh} / Z$ (%) (3)

Production Efficiency for the concrete batching plant can be calculated by using

Efficiency = 100 – DP (%) (4)

By substituting the value of DP from the model (3) in (4)

Efficiency = 100 - [$\sum_{k=1}^{r}\sum_{h=1}^{l} D_{kh}$] * P_{kh} / Z (%) (5)

The expenses are increased due to delays; therefore the effective and extra expenses can be calculated in the stochastic models (6)

Effective Expenses (EE) = (100 * Total Expenses (Rs/m^3) / Efficiency (%))

EE= 100 * $\sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij}$ / 100 - [$\sum_{k=1}^{r}\sum_{h=1}^{l} D_{kh}$] * P_{kh} / Z) (Rs/m^3) (6)

The values indicate:

C_{ij} = Equipment Expenses per cubic meter of concrete for i expenses categories and their j expenses sub categories (Rs/m^3).

n = Maximum number of expenses breakdown types.

m = a maximum number of expenses sub – categories and their element.

t= Total number of occurrences of each delay types.

N= Total number of observation during the studies period.

D_{kh}= Delays percent for k delay types and h elements of different types.

P_{kh} = Probability of delay types K and its element h.

r = Maximum number of delay types.

l = The maximum number of elements in each delay type.

Z= Number of Plant sites.

Subscripts and Superscripts

i = expenses breakdown types BPE or TE.

j = expenses sub- categories OE and PE and their elements.

k = number of delay types UD and CD.

h = number of delay types element.

1.5 CASE STUDY- I

Construction of Multipurpose Building Including Community Center at Sec-3-A, Plot No.08, C.B.D., Navi Mumbai.The probability of occurrence for each delay type is determined using model 2 as shown in Figure 1. It shows that delay due to management problems has the highest probability of 30%. On the other hand, delay due to weather delay has the lowest probability of occurrence (1.0%).The percentage of each type is determined based upon weighted average technique as a model (3). The summation of all delays represents 8.27% of the CBP operation time. The result shows that CBP is working with an efficiency of 91.73% using model (5) as shown in figure 3. Based upon the discussion, the owner's management could have reduced controlled delays (7.75%) to enhance the efficiency to be 99.48%. The relative percent for each delay factor is shown in figure 2. Now, it is clear that the controlled delays have major delay share, which can be improved by enhancing cement delivery & measurement of the CBP. As shown in Figure 3, delays increase the total CBP expenses from Rs. 35 / m3 to Rs. 38.16 / m3.

5.1.1 Figures and Tables

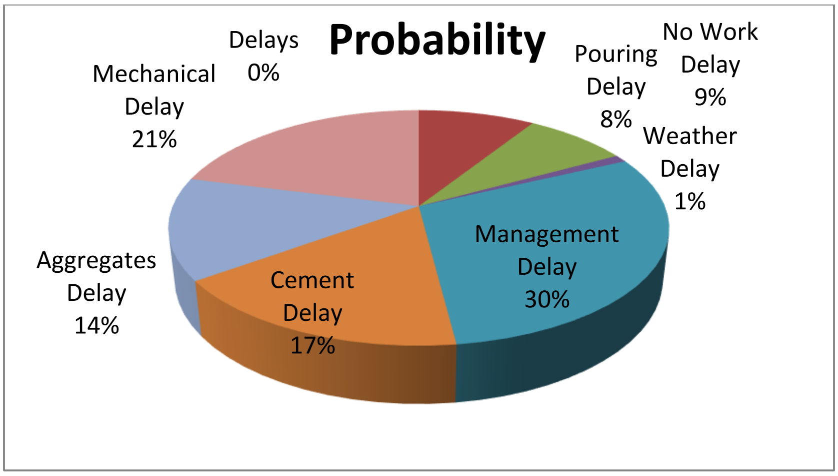

Fig.1 Delays Probabilities

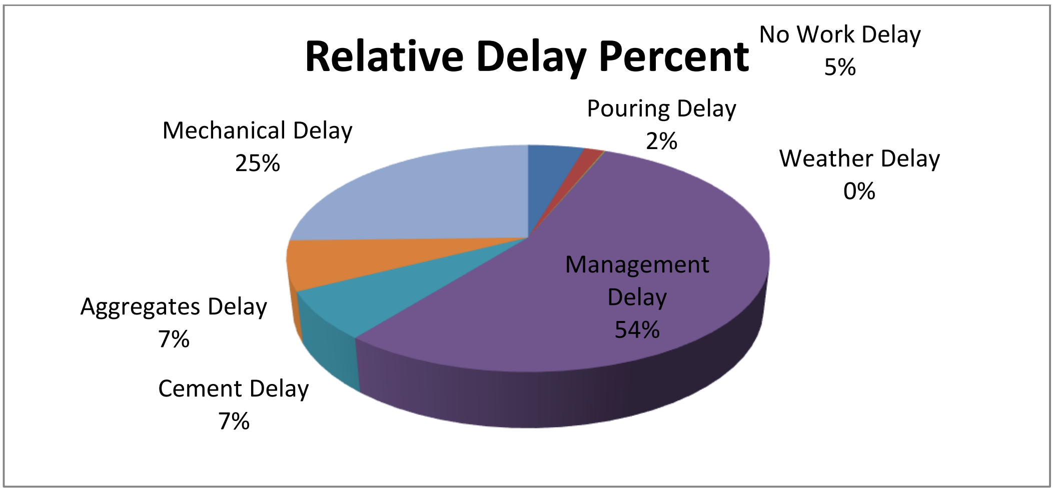

Fig .2 Relative Percent for Delay factors

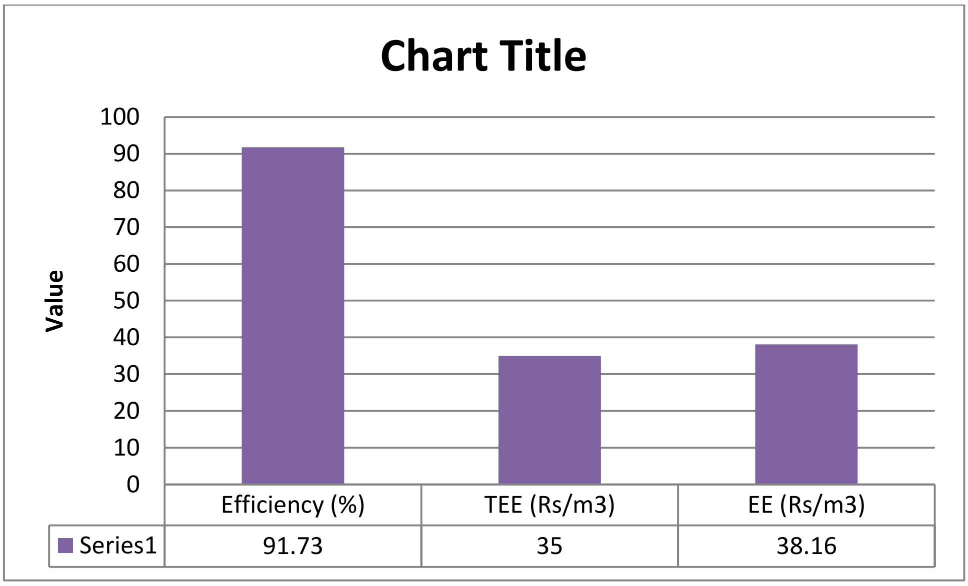

Fig.3 CBP Efficiency, TEE, and EE

Fig .4 Table represent delays (Site I)

Plant	**Total Study Time (Hrs)**	**Uncontrolled Delays Time and Percent**						**Controlled Delays Time and Percent**							
		No Work Delay		**Pouring Delay**		**Weather Delay**		**Management Delay**		**Cement Delay**		**Aggregates Delay**		**Mechanical Delay**	
		Time	**%**	**Time**	**%**	**Time**	**%**	**Time**	**%**	**Time**	**%**	**Time**	**%**	**Time**	**%**
2	120	5	4.2	2	1.7	1	0.8	18	15.0	4	3.3	5	4.2	12	10.0
Total	**120**	**5**	**4.2**	**2**	**1.7**	**1**	**0.8**	**18**	**15.0**	**4**	**3.3**	**5**	**4.2**	**12**	**10.0**
Probability			0.09		0.08		0.01		0.3		0.17		0.14		0.21
Delay Percent			**0.38**		**0.13**		**0.01**		**4.50**		**0.57**		**0.58**		**2.10**

CONCLUSION

Factors that affect delay in the concrete batching plant operation are identified and analyzed. Based upon these identified factors, several cost management models have been developed to assess concrete batching plant efficiency and effective expenses. The result shows for site I that management delay condition has the highest probability of occurrence, delay percent, and relative delay percent. This delay increases the concrete batching plant expenses by, Rs. 3.16 / m3 site. Also, efficient RMC truck dispatching is a critical task for batch plant managers. They must generate dispatching schedules quickly in order to balance operation batch plant production with construction site needs. This project is highlighting the study of Batching plant productivity without affecting the quality of concrete by prolonged recapitulation of various batching plants sites for the factors which could affect the output of subject batching plant and descry and predicament shooting of such factors in time. The study summarizes the main causes of delay that affect construction project.

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