Methods to Monitor Resources and Logistic Planning at Project Sites

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Abstract Construction projects are unique and complex in nature. Various resources such as men, material, plant and machinery, capital, information, space, time, and above all local infrastructure are involved in the construction activity. Hence, controlling and monitoring the flow of resources plays a vital role in the timely completion of the project contributing to reduced delays leading to time and cost optimization. Productivity analysis of transit mixer, workmen have been done through data collected from a commercial project and suggestions to improve the same have been proposed. Logistics of two different sites one with onsite storage and other with offsite storage have been studied and recommendations to improve the logistics are provided. Some of the methods to monitor the resources on site have been proposed, which can be used without any hindrances at the construction project sites. Further, based on planned resources, a simplified logistics planning template and labour productivity monitoring data sheet which can be updated based on project's progress is developed that can be used with ease at project site considering all the necessary factors.

Keywords Resources · Productivity · Monitoring · Logistics · Transit mixer

1 Introduction

Managing construction projects requires an integrated process to ensure that they are completed on time, on budget and within the contract specifications. Various resources that are used must be effectively managed, controlled in order to complete the project on time. Resources can be broadly classified as men, material, plant and

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B. B. Das and N. Neithalath (eds.), *Sustainable Construction and Building Materials*, Lecture Notes in Civil Engineering 25,
https://doi.org/10.1007/978-981-13-3317-0_71

machinery. Men include all manpower that involves directly or indirectly in the project consisting of two teams namely management and workforce. Material includes all the materials utilized in the project namely consumables that are actually consumed in the project such as concrete, steel and facilitating materials that are used to facilitate the progress of an activity such as formwork materials. Plant and machinery include the equipment and machines comprising of production machinery namely batching plant and bar bending setup and versatile machinery such as tower crane, boom placer, concrete pump, etc.

In this paper, the productivity of labour and transit mixer is analyzed by a case study of a commercial project. Factors affecting productivity are determined through direct observations by a visit to the project site and recommendations to improve the same have been proposed. Site logistics plan is studied, factors influencing the reinforcement and formwork logistics are observed. Based on observations, recommendations to make a better logistic plan are proposed in the form of logistic planning templates.

2 Literature Review

2.1 Labour Productivity

There are six factors affecting labour productivity namely workforce (skill and experience), management and control, financial, external, project, material and equipment (planning and availability). According to Structural Equation Modelling, management and control are found to be the most significant factor affecting labour productivity [1].

Productivity usually refers to labor productivity in the construction industry. Some of the construction management practices that have the potential to improve labor productivity are material management, equipment and tools management, preconstruction phase management, management practices related to construction methods and human resource management [2].

Lack of proper material management leads to craft foremen spending almost 20% of their time hunting for materials. According to [3], poor material management increased the project duration by 50–130%.

Proper control and management of materials can increase productivity by 6% or more. Some of the technologies include barcode, RFID, GPS and GIS. A time-dependent material supply must be used. Two costs are to be minimized namely direct crew cost investment due to delayed delivery of materials, material inventory cost in connection with double handling and storage as a result of early material supply [4].

2.2 Methods to Monitor Materials Onsite

Collection of construction resource information is an essential task for construction engineers and managers. A majority of construction projects rely on manual observation to obtain construction resource information. Datasheet is the most commonly used method to track various construction materials on site. Barcode is another method used to identify various materials on site which involves contact with the materials. RFID technology is a contactless object identification system that uses radio waves.

Various efforts to adopt new technologies have been made in order to expedite the resource monitoring process. Personal digital assistants (PDA) and closed-circuit television (CCTV) are two examples of these efforts. Construction engineers, who are visually observing construction sites, manually input the collected information into PDA devices [5]. The information is then uploaded to the main server of the on-site office either by direct wire connection or by a wireless local area network (WLAN) connection [6]. CCTV allows for remote monitoring of the construction site [7]. A system that integrates RFID, Bluetooth, and GPS technologies to track construction vehicles in urban areas and on construction sites are proposed [8].

3 Methodology

The research method that is used is a qualitative method where the primary data has been collected through direct observations by visiting the construction site. The main source for secondary data is the theory and data collected through literature review and past research. Another source is existing data and information from the construction site. Interacted with the supervisor, obtained the labour count. Counted the number of work hours and calculate the total amount of work done.

Data of four transit mixers have been collected such as time taken for transport to and fro, loading, unloading, waiting time. Logistics of reinforcement yard are observed by visiting the reinforcement yard periodically. Vehicular logistics are recorded by constant site visits for about 15 days. Movement of transit mixer, trailer and other such machinery are recorded.

After the data is collected, evaluation and analysis of available information have been done. Then conclusions have been drawn based on theory, data, evaluation and analysis. Based on the labour data collected, productivity analysis has been done. The cycle time of transit mixer is calculated based on data collected. Recommendations to improve the logistics based on data collected have been proposed.

4 Data Collection and Analysis

4.1 General

Data is collected through direct observations by visiting the construction site. Wipro IT SEZ, Bengaluru which is a commercial project has been chosen as a case study for this paper. Project details are as presented in Table 1 and the site details are shown in Fig. 1.

Table 1 Project details

Project name	Wipro IT SEZ
Project location	Kodathi, Sarjapur road, Bengaluru
Project owner	Wipro
Project management consultant	Tata Consulting Engineers
Project architect	Venkataramanan Associates
Project structural consultant	M/s. Prasad Consultants
Project contractor	L&T Construction
Project duration	30 months
Project scope	Structural works of all the blocks + finishing works of elevator area + NSC coordination
Project value	Rupees 980 crores
Total built up area	4.05 lakh sq. m
Type of contract	Lump sum

Sl.	Description	BUA (Sqm)	Details
1	Block B1	86,689	2 Podium + 13 Floors
2	Block B2	50,323	2 Podium + 13 Floors
3	Block B3	66,223	2 Podium + 2 Dining + 10 Floors
4	Block B4	63,179	2 Podium + 2 Dining + 10 Floors
5	Block B5 (DC)	9,290	G + 2 (2 lvlstie beam below GL)
6	Common Basement	121,570	3 Basements
7	Utility Block	7,997	GF

Fig. 1 Site details

4.2 Labour Productivity

Workmen at the project site have been divided into various gangs based on the type of activity performed. Rebar gang, shuttering gang, housekeeping, etc. are some of the common gangs at the site. A rebar gang has been considered, work status as of 9:30 am is shown in Table 2 and daily productivity is analyzed by closely monitoring them for the whole day and observations are presented in Table 3. Work hours considered per man day are 8 h, work done by 25 man days being 1.85 MT gives productivity as 73.96 kg per man day which is calculated using the formula shown in Eq. 1 below given by Durdyev [9].

$$\text{Productivity} = \frac{\text{Quantity of Output}}{\text{Resource Input}} \quad (1)$$

In general, the average productivity of reinforcement gang is assumed to be 80–100 kg per man day. Productivity obtained through constant monitoring is observed to be a little less than average value. Some of the potential reasons for the decrease in labour productivity are 7 workmen were idle for 10 min from 9:30 to 9:40, 5 workmen were idle for 15 min from 10:25 to 10:40 (water), 30 workmen were idle for 50 min during lunch, total time wasted is 1645 min (27 h), total man days wasted are 3.38.

Recommendations to improve labour productivity are lunchtime of each gang has to be monitored by the respective supervisor by maintaining a data sheet shown in Table 5. Daily targets imposed on gang are to be strictly adhered to.

Table 2 Work status as of 9:30 am

Element	No's	Finished (%)	Actual MT	Finished MT
Columns	11	70	4.863	3.4041
SW	3	15	3.9	0.585

Table 3 Workmen datasheet

Time	No. of labour	Activity				MT	Remarks
		Columns		SW			
		%	MT	%	MT		
9:30–12:40	30	20	0.9726	5	0.195	1.1676	10 number of labour worked for half man day
12:40–14:30	30	0	0	0	0	0	
14:30–17:30	20	10	0.4863	5	0.195	0.6813	20 number of labour worked for full man day

Proper division of work is to be done as some labour stay idle due to lack of work. Material required to perform the work must be available whenever required.

4.3 Transit Mixer—Cycle Time Analysis

Transit mixer is one of the key machineries used for the internal movement of concrete in the current project site. Hence, control of cycle time of TM is an important activity which helps in monitoring the utilization of transit mixer. Four transit mixers have been considered for analysis and data collected is presented in Table 4. TM stands for Transit Mixer, BP stands for Batching Plant and TMC stands for Truck Mounted Crane. Based on data collected from direct observations, average cycle time of transit mixer is calculated, factors influencing the cycle time are determined, recommendations to optimize cycle time are proposed.

From all the above observations, Average Cycle Time of a Transit Mixer is determined as 66.5 min. It is assumed theoretically that the average cycle time of a transit mixer must be in the range of 40–50 min. But, as the machine is monitored practically at the site and the recorded values indicate that the cycle time of transit mixer is more than average.

Table 4 Cycle time of transit mixer

Vehicle number	3172		3174		3168		3163	
Activity	Time (min)	Remarks	Time (min)	Remarks	Time (min)	Remarks	Time (min)	Remarks
Waiting time at BP	10		20	Another TM was loading	15	Another TM was loading	10	Another TM was loading
Time for loading at BP	8		10		10		9	
BP to destination	8		8		7		14	TMC obstructed the way
Waiting time at destination	10	Another TM was unloading	25	Another TM was unloading	13	Another TM was unloading	5	Connecting to pump
Time for unloading at BP	20	Pumping is done gradually	20	Pumping is done gradually	10		12	
Destination to BP	8		8		3		3	
Total time	64		91		58		53	

Some of the factors influencing the cycle time of transit mixer as observed on site are to reach block-1 from Batching Plant, Transit Mixer has to move around the project site; Instead, it can move directly through block-4 to block-1 thus reducing the time for hauling of concrete to the destination; Transit Mixer is kept waiting at the destination due to poor coordination between the quality department and the supervisor who requires concrete; Only 4–5 transit mixers are used efficiently, remaining all the transit mixers are idle because of less demand of concrete.

Some of the recommendations to optimize the cycle time of Transit Mixer are Transit Mixer can move directly through B-4 to B-1, thus reducing the time required for hauling of concrete from batching plant to the destination; proper co-ordination is to be ensured between Batching Plant, Quality department and respective site engineer to reduce the waiting time of Transit Mixer at the destination; space is to be provided for waiting of Transit Mixer at site, so that it does not block the way for other vehicles that are supposed to move on the road.

4.4 Logistics of Reinforcement Yard

Some of the observations made by visiting the reinforcement yard in the site are tagged and are given based on diameter and quantity, no specific block-wise allocation, space available is insufficient for storage, division of space and signboards are inappropriate, manual handling of reinforcement material from full-length storage to cutting area and signboards are unavailable for individual sizes in case of stirrups prompting us to check for each and every tag for the required material.

Some recommendations to improve logistics of reinforcement yard are signboards must be placed for each individual sizes of cut pieces or stirrups, space available has to be well organized, location is to be fixed for blockwise storage, space allotted for each block has to be altered based on requirement of respective block, sign boards are to be kept for blockwise storage and reinforcement bars can be unloaded directly to the work location through tower cranes by bringing them on Just In Time basis instead of using trailers to bring them to the location.

4.5 Formwork Logistics

Some of the general observations have been made in relation to formwork logistics through site visit such as de shuttered material form 1st floor is brought to ground through tower crane, unloaded onto the ground and then placed manually in Truck by 7 workmen for 2 h leading to wastage of 14 h of labour work. Instead, material can be unloaded directly into the truck through tower crane rather than to place it on the ground and then load into the truck.

5 Discussion

5.1 Labour Productivity Data Sheet

Labour productivity can be improved by continuous monitoring of movement of labor on site through the data sheet provided as presented in Table 5.

5.2 Material Logistic Planning Template

Wastage includes both design waste and construction process wastage. Design wastage includes offcuts. Construction process wastage includes over-ordering, design changes and damages. These wastages are usually expressed in percentages. Templates are prepared consisting of the material requirement logistic plan, material management and material handling as presented in Tables 6, 7 and 8, respectively.

Table 5 Labour productivity datasheet

Name of Contractor/ Subcontractor: Name of Supervisor: Type of Work:							
S. No	**Name of Labour**	**Entry Time**	**Lunch Time**	**Exit time**	**Work Done**	**Working time**	**Comments**

Table 6 Material requirement logistic plan

Project Stage	Expected Duration	Material	Quantity	Delivery Method	Delivery Timings	Wastage	Justification of wastage	Supply Route

Table 7 Material management

S. No	Material	Receiving Location	Storage Location	Guidelines for Management	Procedure for Material Handling	Comments

Table 8 Material handling

Material	Site staff required	Site plant required	Site Equipment required	Availability	Comments

6 Conclusions

Various resources utilized in a construction project are identified among which men and transit mixer have been chosen as primary resources. Productivity analysis of chosen resources is carried out and some of the recommendations to optimize productivity are proposed. Various methods of resource monitoring have been studied. Labour productivity data sheet is prepared to monitor all the activities of workmen including lunch timings as it is found to be a major factor impairing productivity. Logistic planning templates are drafted to monitor material requirement, material management, and material handling. Labour productivity can be optimized by the usage of data sheet created and proper division of work among labour. A logistics manager is to be employed to monitor and track resources on site through the usage of logistics templates. The benefit of adopting this method of research is that it is very feasible to adopt it on-site through the use of templates.

Acknowledgements The authors are very thankful to Wipro IT SEZ, Bengaluru for providing appropriate data for carrying out this study.

References

1. Durdyev, S., Ismail, S., & Kandymov, N. (2018). *Structural equation model of the factors affecting construction labor productivity*. ASCE. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001452.

2. Gurmu, A. T. (2018). Construction materials management practices enhancing labour productivity in multi-storey building projects. *International Journal of Construction Management*. https://doi.org/10.1080/15623599.2018.1462447.
3. Thomas, H. R., & Sanvido, V. E. (2000). Role of fabricator in labor productivity. *Journal of Construction Engineering and Management, 126*(5), 358–365.
4. Choure, S. R., & Apte, M. R. (2015). On-site material management. *International Journal of Engineering Sciences & Research Technology*. ISSN: 2277-9655.
5. Navarrete, G. (1999). In the palm of your hand: Digital assistant aid in data collection. *Journal of Management Engineering, 15*(4), 43–45.
6. Ward, M. J., Thorpe, A., & Price, A. D. F. (2003). SHERPA: Mobile wireless data capture for piling works. *Computer Aided Civil and Infrastructure Engineering, 18*(4), 299–312.
7. Leung, S.-W., Mak, S., & Lee, B. L. P. (2008). Using a real-time integrated communication system to monitor the progress and quality of construction works. *Automation in Construction, 17*(6), 749–757.
8. Kim, C., Kim, H., Ryu, J., & Kim, C. (2011). Ubiquitous sensor network for construction material monitoring. *Journal of Construction Engineering and Management*. ASCE. https://doi.org/10.1061/_asce_co.1943-7862.0000257.
9. Durdyev, S., & Mbachu, J. (2011). On-site labor productivity of New Zealand construction industry: Key constraints and improvement measures. *Australasian Journal of Construction Economics and Building, 11*(3), 18–33.