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Constraints on labour productivity-a case study

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ABSTRACT

Productivity always acts as a main factor influencing timely completion of the project and cost control in all construction projects. Proper evaluation of labour productivity and corrective measures taken to achieve the required level of productivity will always help to keep the project in track. In this research, observations were conducted in a construction site in Kerala by adopting work sampling technique which revealed that workers are engaged in unproductive activities during 30%-40% of the normal working time. The main factors which are negatively affecting productivity were observed and their frequencies were also noted. Normality tests were conducted to analyse the data. Baseline productivity measurement and variation coefficient indicates that there is a good variation in daily productivity and so productivity can be improved by controlling these costraints on labour productivity. It was observed that activities like being simply idle, unnecessary roaming, talking, waiting for materials and tools are the main reasons for unproductiveness. Lack of proper managerial efficiency is the basic reason for all these issues.

KEYWORDS: *labour productivity, work sampling, coefficient of variation*

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I. INTRODUCTION:

Understanding the various factors that affect labour productivity negatively or positively is very important to form a strategy that will help the construction companies to reduce costs and time delays and thus to improve overall project performance. Shehata and El-Gohary (2012) provides different definitions of labour productivity, aspects, measurements, factors affecting it, techniques used for measuring it and modeling techniques. The study focuses concentrates on baseline productivity which occurs when there are few or no disruptions In simple terms productivity can be defined as a relation between output generated from a system and input used to generate the output. Inputs generally are labour, materials, equipment etc which is brought into the system. Output can be goods and services produced using these inputs. Accurate determination of productivity is very important but productivity measurement in construction is a complex issue because of the interaction of labour, capital, materials and equipment and varying effect of various site conditions on productivity rates of most standard construction items. This paper covers data collection by work sampling method, determination of baseline productivity and various constraints to productivity with their frequencies, analysis of data, results and discussion and conclusion.

II. RESEARCH METHOD:

1.1 Methodology:

Work sampling method of evaluation has been recommended for measuring highly variable labor productivity in construction (Kumaraswamy and Chan 1998). Work sampling is an indirect measuring method that through instantaneous observations, allows to determine the amount of activity or inactivity in a production process. It makes a random and instantaneous number of observations of a group of machines, process (activity) or workers by the needs of each company. It is based on the fundamental law of probability: at any given time an event can be present or absent.

In this method works are classified into 3 groups namely

1. Productive work - the activities directly related with construction process and affects the output.
2. Contributory work - the activities that indirectly affects the output, but commonly needed in an operation.
3. Unproductive work - idle or doing activities that is not related with the job. For example: take a walk without bringing anything, doing activities which is out of procedures, chit chat, and so on.

This research aims to find the percentage productive time of various operations at the site, measuring the productive rates of these activities, identifying various factors that contribute to unproductiveness with their frequencies.

1.2 Data collection:

Data for this study is collected from a G+15 apartment building of a reputed builder in Kerala. Blockwork, plastering and other general works are the various activities from which data is collected. In these plastering works were given to subcontractors and payment were made on the basis of work done per day. The other two works, blockwork and general works were on a daily labour basis and payments were not based on quantity of work done per day.

To find the required number of observations in work sampling method, many construction and industrial engineering journals provide the following equation for determining sample size based on desired error, and anticipated category percentages (Groover, 2007; Picard, 2004; Stevens, 1969; Thomas Jr. et al., 1982)

$$N=\frac{Z^\wedge 2 * P * (1-P)}{L^\wedge 2} \qquad (1)$$

Where, N= no. of observations required

P= estimated probability of observing a worker doing a certain activity

L=limit(in percentage)of accuracy required

Z=standard normal variable depending on the level of confidence

For maximum N, $\frac{dN}{dP}=\frac{Z^2}{L^2}(1-P)=0$ (2)

If the anticipated percentage P is unknown, avalue of 50% (0.5) may be used as a worst case scenario ensuring the number of samples will be overestimated. Considering 95% confidence limits, corresponding Z value = 1.96, required sample size is

$$N=\frac{1.96^2 * 0.5 * 0.5}{0.05^\wedge 2}=385$$

So minimum number of observations required is 30 observations per day for 13 days. But 30 observations for 20 days were done for each activity. The purpose for large data set gathering is for accuracy.

Workers were observed 30 times a day and noted were they are involved in some productive or contributory work, or engaged in unproductive activities. If they are engaged in unproductive activities those unproductive activities and their frequencies were noted.

Data were collected in the prescribed format. Observation time is determined by random number, in order to no opportunity to have same time and also to guarantee the samples are taken by randomly (*Sutalaksana, 1979*). Random timings were generated using excel and used for these observations. Time for breakfast and lunch were excluded from the observations.

Table 1.Details of labours observed

Type of work	No. of labours observed	
	mason	helper
Blockwork	4	2
Plastering	12	6
General works	-	10

Thomas and Zavrski (1999a), 1999b) expressed the projects attributes in the following forms.

Cumulative productivity=$\frac{total\ \ quanity\ \ (m^3)}{total\ \ work\ \ hour\ (whr)}$ (3)

1.3 Baseline productivity:

Baseline productivity can be defined as the best performance a contractor can achieve, on a particular project or activity. To compute baseline productivity following steps were adopted. It is determined with respect to 10 % of the total workdays that have the highest daily output or production.

1. The number established in one above should be rounded off to the next highest odd number which should not be less than (5) five. This number, n, explains the size of the baseline division.
2. The contents of the baseline division are the n workdays that have the highest daily production or output.
3. The next step is to compute the summation of the work hours and quantities for these n workdays.
4. The baseline productivity can now be expressed as the ratio of work hours and the quantities contained in the baseline division.

Variability in productivity is a determinant of performance of a construction project. Well performing projects exhibit lower variability when compared to projects that perform poorly. Thomas et al. [10] emphasized the necessity to reduce variability in labour productivity to improve performance of construction projects. Variability in daily productivity is calculated using the following equation given by Thomas et al[1]:

Variation (V_j) =$\frac{\sum\sqrt{((dpij\ -baseline\ \ productivityj\ \ )^\wedge 2)}}{n}$ (4)

Where dp_{ij}= daily productivity (unit rate) for workday on project *j* and n = number of workdays on project *j*
The variation *Vj* for different projects cannot be compared directly unless the baseline productivity values are the same. Therefore, coefficient of variation is calculated for each project as follows:
Coefficient of Variation (CV_j) = $\frac{Vj*100}{baseline\ \ productivity\ \ j}$ (5)
Abdel – Razek *et al.* (2007) suggested that better labour and cost performance can be achieved by reducing variability.

III. RESULTS AND DISCUSSION:

Table 2. Chart showing percentage productive time and daily quantity in plastering

Sl.no	% productive time			Average % productive time	Total area plastered per day(M^2)	M^2/whr	Baseline productivity days
	Batch 1	Batch 2	Batch 3				
1	64.76	76.11	61.33	67.59	184.93	1.142	
2	72.38	71.67	64	69.82	184.97	1.142	
3	72.38	79.45	77.33	76.11	212.92	1.315	*
4	66.19	69.45	64	66.67	182.75	1.129	
5	78.57	81.11	68	71.85	197.43	1.219	
6	65.72	73.89	64	67.96	176.35	1.089	
7	78.09	83.89	69.34	77.59	214.24	1.323	*
8	80.48	78.89	70.67	77.22	197.66	1.221	
9	66.19	73.89	70	69.81	182.49	1.127	
10	71.43	72.22	66.66	70.37	192.28	1.187	
11	73.33	76.66	60	70.74	190.86	1.179	
12	67.61	68.89	64	67.04	190.72	1.178	
13	71.42	75.56	65.33	71.11	201.12	1.242	*
14	69.52	73.33	61.34	68.52	183.26	1.132	
15	67.14	68.89	66.67	67.6	195.42	1.207	
16	76.19	81.11	62.67	74.07	198.79	1.228	*
17	76.66	74.44	64.66	72.59	188.94	1.167	
18	72.86	75.56	67.34	72.22	198.02	1.223	*
19	61.9	61.67	58	60.74	165.76	1.024	
20	65.72	70.56	59.33	65.56	179.21	1.107	
Average	70.927	74.362	65.45	70.259	190.91	1.179	

Figure 1. Relation showing percentage of productive time and quantity of plastering work done

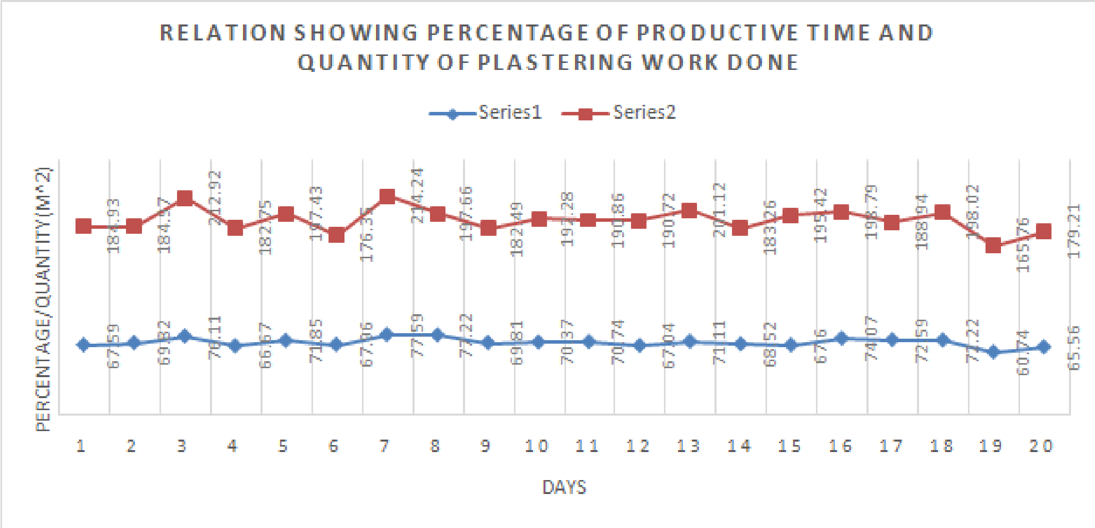


Table 3. Chart showing percentage productive time and daily quantity in blockwork

Sl.No	average % productive time	quantity of work done each day (m^3)	M^3/whr	Baseline productivity days
1	55.45	1.45	0.027	
2	58.52	1.55	0.029	
3	60.95	1.8	0.034	
4	62.47	2.12	0.04	
5	61.24	2.2	0.041	*
6	64.85	2.25	0.042	*
7	63.25	2.2	0.041	*
8	65.75	2.7	0.05	*
9	61.22	2.1	0.039	
10	60.28	2.2	0.041	
11	63.36	2.18	0.041	
12	64.2	2.5	0.047	*
13	60.55	1.95	0.037	
14	62.82	2.08	0.039	
15	61.26	2.15	0.04	
16	62	2.04	0.038	
17	60.48	1.85	0.035	
18	62.64	2.06	0.039	
19	59.85	1.6	0.03	
20	60.42	1.96	0.037	

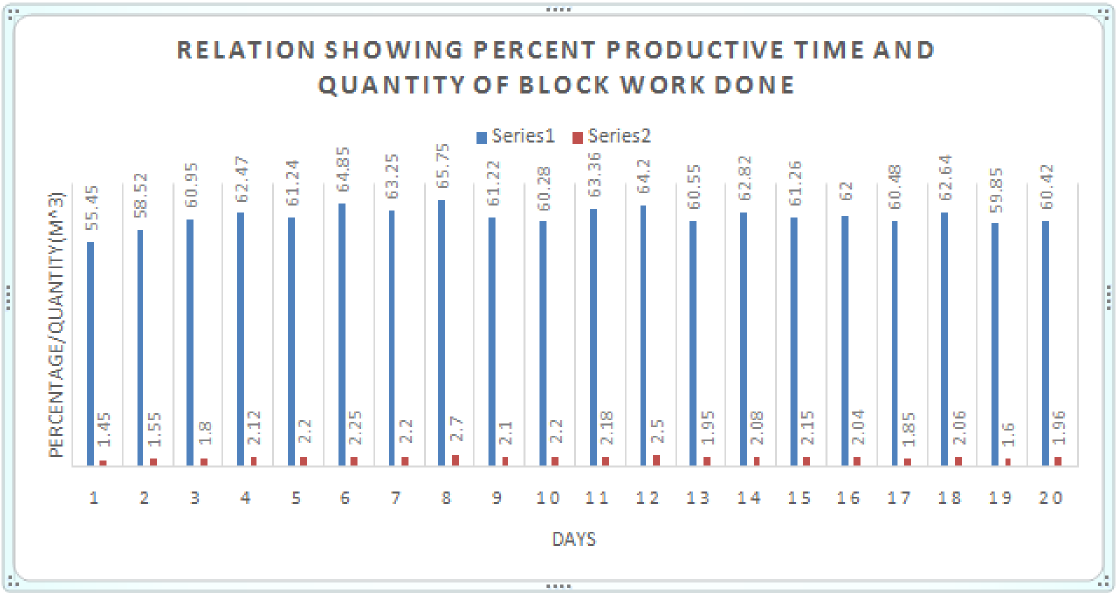


Figure 2. Relation showing percentage of productive time and quantity of block work done

Table 4. Chart showing percentage productive time during general works

Sl.No.	Average % productive time
1	64.67
2	63.67
3	65.33
4	65.33
5	65.67
6	63
7	66
8	62.67
9	62
10	62.67
11	63
12	60
13	60.33
14	62.33
15	66.67
16	61.33
17	57.33
18	59
19	64.33
20	60.5

Figure 3. Average percentage productive time during general works

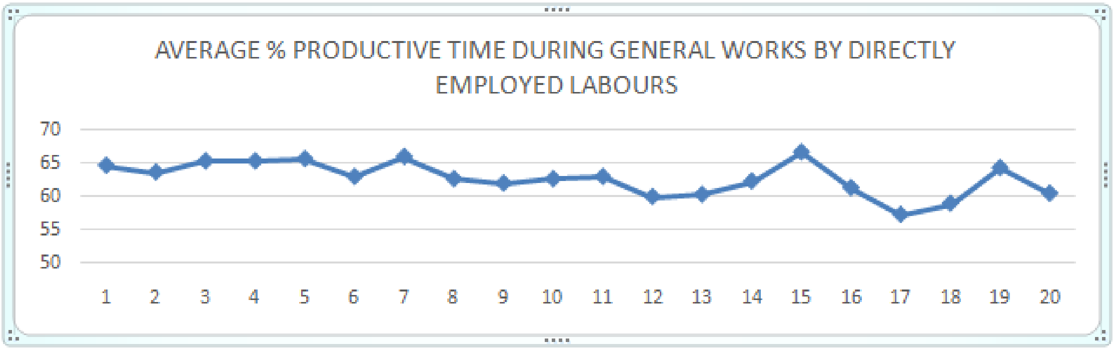


Table 5. Average % productive time of various activities

Nature of work	Average % productive time
Blockwork	61.58
Plastering	70.26
General works	62.79
Average % productive time	64.88

From the data obtained and graphs plotted it is clear that there exists some relation between average % productive time measured and quantity of work done. It can be noticed that in most cases the quantity of work done increases when there is an increase in the observed percentage of productive time. The values show that around 30%-40% of the time, workers are engaged in unproductive activities. This is a major contribution to cost overrun and project delays. Results shows that, considering the 3 works observed, the average percentage productive time is only 64.88% which means the labours were spending 35.12% of their time for non-productive activities. Among these the subcontract works have more percentage of productive time compared to works carried out using labours directly employed. This is because the subcontract works were paid according to the quantity of work done and the more the quantity of work they can finish, the more payment they will receive.

Table 6. Performance measures:

Type of work	Cumulative productivity	Baseline productivity	Mean	median	Variation(V_j)	Coefficient of Variation(CVj)
Blockwork	0.038	0.04	0.0384	0.039	0.0065	14.88
Plastering	1.179	1.266	1.1791	1.1785	0.097	7.71

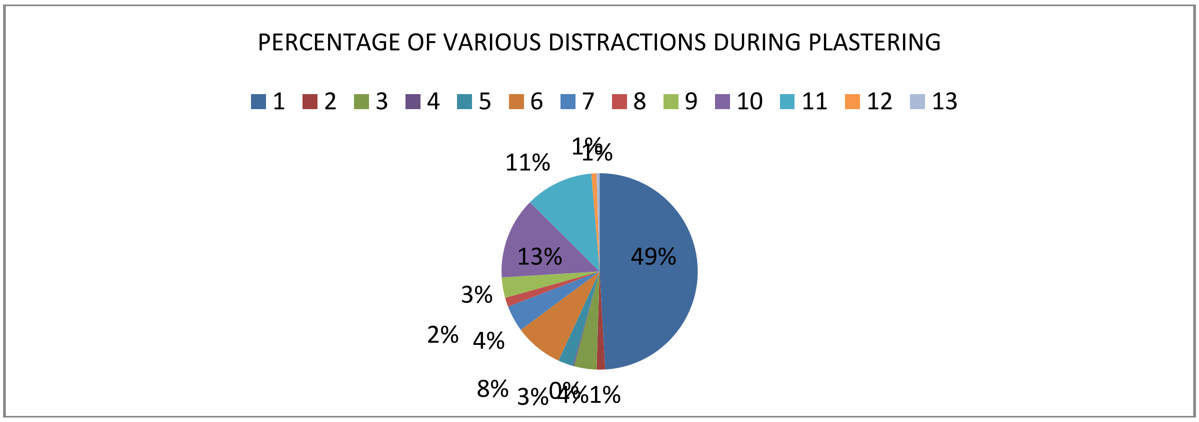
The cumulative productivity, variation and coefficients of productivity variation were calculated as per equations (3), (4) and (5) and the values are presented in table. These values shows that coefficient of variation is 14.88 in block laying and 7.71 in plastering. This suggests that there is still room for improvement of productivity. Reducing variability will bring about improvement in labour performance. From the percentage productive time observations it is noticed that 30-40% time workers are engaged in unproductive activities. While considering all these factors it is evident that there aa lot of spaces for improvement in productivity.

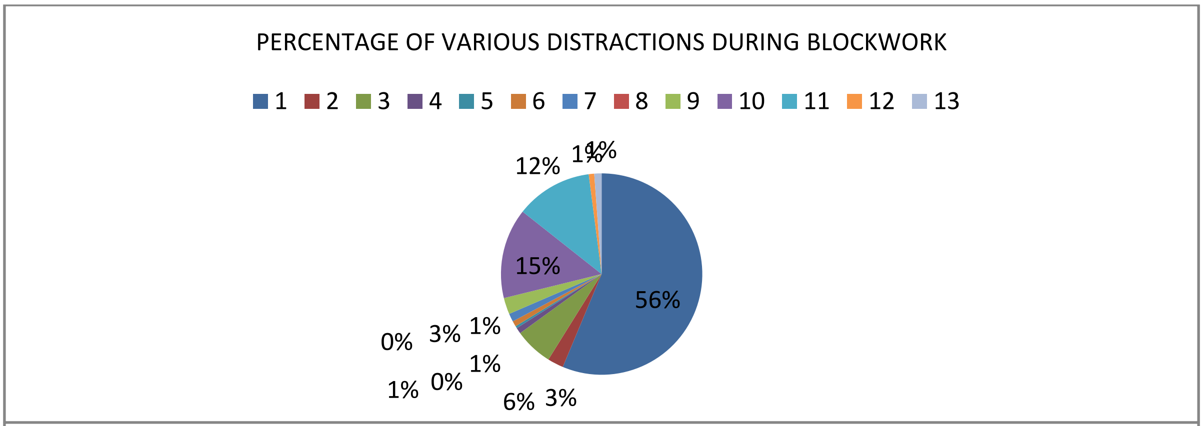
Normality test was conducted on the productivity data and observed that for plastering, the mean of the estimate was higher than the median. This indicates that the frequency distribution is not symmetrical. It is a skewed distribution. The analysis further indicates that the distribution is positively skewed having a skewness value of 0.124 and standard deviation of 0.411.

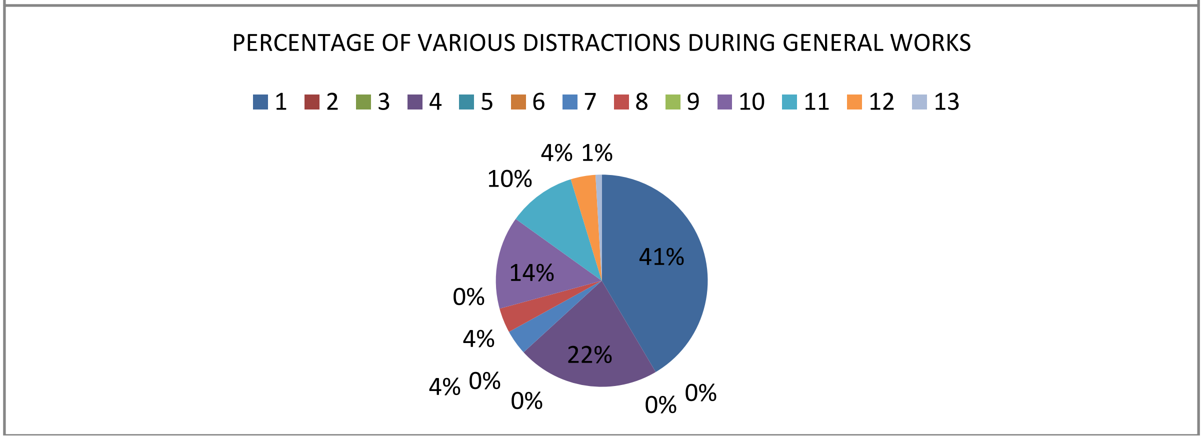
For blockwork mean of the estimate was lower than median. This also indicates that the frequency distribution is not symmetrical. The distribution is negatively skewed having a skewness value of -0.218 and standard deviation of 0.668.

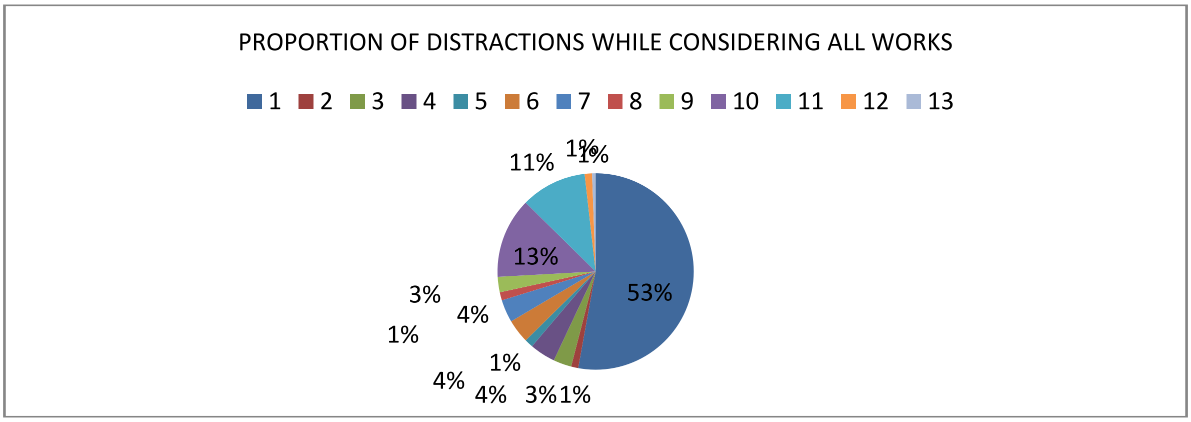
Table 7. No.of observations for eachunproductive acitivity

Sl. No.	Description of distraction	Frequency of distractions							
		Blockwork		Plastering		General works		Total	
		No.	%	No.	%	No.	%	No.	%
1	Simply idle	769	56.3	1535	49.09	1238	56.02	3542	52.85
2	From stockyard	35	2.56	44	1.41	0	0	79	1.18
3	Waiting for materials from helpers	84	6.15	116	3.71	0	0	200	2.99
4	Waiting for tools from store	13	0.95	6	0.2	264	11.95	283	4.23
5	Waiting for materials from other workers	5	0.36	78	2.5	11	0.5	94	1.41
6	Rework	12	0.88	249	7.97	0	0	261	3.9
7	Waiting for instructions/ inspection	18	1.32	135	4.32	97	4.39	250	3.73
8	Waiting for co-workers	0	0	47	1.51	43	1.95	90	1.35
9	Using mobile phone	36	2.63	105	3.36	29	1.32	170	2.54
10	Roaming	198	14.5	419	13.4	270	12.22	887	13.24
11	Talking with co-workers	168	12.3	351	11.23	208	9.42	727	10.85
12	Drinking water	12	0.88	26	0.84	43	1.95	81	1.21
13	Personal hygiene	16	1.17	16	0.52	7	0.32	39	0.59
Total		1366	100	3127	100	2210	100	6703	100









Among the various unproductive activities, it is observed that being idle is the main reason for loss in productivity while considering all the three works viz, blockwork, plastering and general works.

Eventhough a portion of idle observations can be considered as rest during the works, but a good portion of idleness can be accounted to spend time without doing anything productive. It can be noticed that more than half(52.85%) of the total unproductive observations accounts for being simply idle. These values are exclusive of time spend for breakfast and lunch time. The second main reason for unproductiveness is unwanted roaming which accounts for about 13.24% of the total unproductive observations. The other main reason for unproductiveness is chatting with co-workers. It accounts for about 10.85% of the total unproductive observations. This shows the workers negative attitude to work. The limited number of site engineers/supervisors makes it difficult to supervise all activities when the work is carried out in many floors.

The other reason is waiting for materials at job site from stock yard. This is mainly because there was only one hoist for shifting materials to all the 15 floors and this hoist will be always busy due to shifting of civil, electrical and plumbing materials to different contractors and labours at different floors and because of these, there will be a long queue to shift materials near the hoist mostly at mornings. The company personnel tried to arrange materials to all contractors by shifting materials during times other than normal working time but it was not effective always.

The masons before starting plastering will be idle for some time at morning till their workplace is cleaned and getting their mortar ready from the helpers. From the observations it is noticed that if there are no sufficient number of helpers, the masons will be idle for more time. It is evident from the plastering activities in which work is carried out by 3 teams comprising of different number of mason helper combination. In team A, there were 5 masons and 2 helpers, in team B, there were 4 masons and 2 helpers and in team C, there were 3 masons and 2 helpers. The team A masons took more time to start their work at morning because of the improper crew composition. It was noticed that the helpers were more engaged in contributory activities to satisfy the requirements of masons and in many times masons were idle due to unavailability of mortar or tools. But at the same time, team 3 having 3 helpers for 2 masons were also not a good combination because the helpers were idle for more time as they have no work.

Workers waiting for tools were one of the main reasons for loss of productivity. It was because of the delay in issuing tools to the labours. The daily work planning and deployment of labours for various works which is done at morning takes some time. Also there was shortage of tools which makes the site engineers to re-allot the labours to other works. All these are time consuming and will result in wastage of productive time.

The other issue is waiting for instructions or inspection. The direct employed labours will be waiting for instructions from the site supervisors while doing general works like shifting materials, cleaning, chipping and cutting etc. This may happen because of the poor communication problems between supervisors and labours and also due to the different activities they are doing in different days. The labours mainly from other states may not understand the instructions clearly even though the instructions were given in hindi as many labours know their own local language only. Sometimes labours will be waiting for inspection from site supervisors or engineers after completing the whole work or part of it. This is because the workers may not be sure about the quality of work they have done and so a green signal from the engineers/supervisors will give confidence for them to proceed the work.

Waiting for co-workers is other issue which arise due to the mistakes in labour allotment for various works. Some works cannot be done individually and so labours will be waiting for their co-workers. Also when working as a pair, one person will go for his hygiene requirements or drinking water or will be using mobile phone which makes the other person idle. The solution to this problem is to provide sources of drinking water in different floors of building. Also providing toilet facilities in 2 or 3 floors of the entire building will help to save time for these purposes.

Rework was another hurdle for the progress of the work. Time taken for rework varies between 30-45 minutes per mason per day. Eventhough many factors contributed to rework, poor condition of tools, delay in inspection or delay in giving instructions are the main causes of rework.

IV. CONCLUSION:

The study showing losses in productivity clearly indicates the improper management of a construction project. Only 60-70 % of time the labours found working. Even by closing the gap between baseline productivity and normal productivity rates, performance can be improved.

Improper material planning and insufficient number of tools and equipment contributed a lot to the loss of productivity.

Lack of proper supervision due to insufficient number of supervisors and engineers also contributed mainly to the productivity losses. All these factors mainly confirm to the managerial inefficiencies in most cases.

As labourwages are high, labour productivity can be improved by raising human performance and by reducing non value-added activities.Labour productivity improvement will automatically upgrade the level of value added activities and thereby reduces the chances for cost overrun and time delays.

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