Application of time and motion study to increase the productivity and efficiency

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Abstract. The productivity and efficiency in any construction is always a challenge. Due to various factors the efficiency of men and machine gets reduced hampering the productivity. The purpose of this study is to highlight the benefits of time and motion study employed in construction sector. Time and motion study and work sampling has been employed to measure the productivity of the various construction activities and the paper discusses its application to the various phases of erection of steel structure such as installation of purlins, installation of primary beams and installation of secondary beams on the arrival slab of an airport. The parameters such as efficiency, productivity, tool time, support time and idle times are observed. Motion corrections and time corrections are applied. It is expected that employing lean concepts to construction will help in increasing productivity and reduce risks. After first week of observation and then employing time and motion study corrections, an increase of 37.95% is observed in terms of efficiency, an increase of 218.03% is observed in terms of productivity and an increase of 93.25% is observed in terms of tool time. The idle time showed a decrease of 40.24%. The results are highly promising and hence the management of construction industry need to consider the application of time and motion study not only from the point of view of enhancing efficiency and resource usage, but should also discuss the soft side of employee psychology.

1. Introduction

The construction industry is one of the largest industries in any economy. It makes a significant contribution to the national economy and provides employment to large number of people. In recent years India’s construction sector is witnessing massive investment in both public as well as in private enterprises. Multibillion Rupee investments made in constructing roads, ports, power plants, telecommunication sector, urban infrastructural developments etc. have paved the way for construction demands grow substantially. Although numerous approaches have been developed to improve efficiency and effectiveness of construction process, implementing statistical techniques offer the promise to minimize, if not eliminate non value- adding work. Labor productivity is a very important factor that affects the overall productivity of construction. Different labors show different level of productivity and affect the overall time and profit of construction. Time and motion study is also known as motion and time study. This scientific study searches one of the most efficient method of doing a task by conserving the resources. Time and motion study is related to the time period management of
activities to achieve higher productivity in construction industry. If the efficiency of doing work between labors is improved, higher productivity can be expected. A systematic view and relation between time and motion is made in method study and work study. Establishing standard time is chief goal of time study; whereas work methods are improved using motion study. The relation between two has been widely accepted. The effective use of resources may be made using time study and motion study which result in enhancement of performance and productivity. Method study is the systematic recording and critical examination of the existing and proposed method of executing the work. It helps in applying easier and more effective methods to reduce the cost and to increase the pace of the construction. It also provides better working conditions and environment for workers by avoiding unnecessary movement of man power. Time study is the application of techniques designed to establish the time for a qualified worker to carry out a specified job at defined level of performance. Time study helps in choosing the alternatives of the same work execution and also it helps in deciding the man power required for a specific work thus helping in manpower economy. It also helps in the plant and machinery procurement.

2. Literature review
Many researchers have done studies on importance of productivity, method study and time study in construction projects. The relevant research was made in detail and reviewed to identify the effective productivity in construction projects. Every individual paper has given the intense information about the effective productivity through work and time corrections in the construction industry. Nishant J. Khandve [1] carried out time and motion study to plastering work. He presented an overview on a new combined methodology for efficient improvement in productivity with the help of various work study methods in the construction field. Productivity improvement was studied using work study approach along with modern soft skills. Human effectiveness is assessed by improved planning to its employees using time motion study. He showed that the time required to do the work can effectively be reduced by 30 percent thus reducing the overrun of the project cost. Sneha Jamadagni and Birajdar B V [2] conducted questionnaire survey in the various constructions projects to study the factors affecting labor productivity of the Construction industry. It involved 38 factors spanning four groups. The groups involved were technological group, human/labour group and external management. For analyzing data, the relative importance technique (RII) was used and top fifteen factors affecting the labor productivity were ranked. Sivaraj S and Vidivelli B [3] tried to identify the factors reducing and increasing productivity in construction and to describe the effective productivity in construction through labor management. He adopted questionnaire survey with a total number of respondents at 122. The responses were analysed using SPSS software. From the descriptive statistical analysis result, factors on reducing and increasing productivity in construction through labour management are identified Attar A A et al.[4] studied the factors which affect productivity in small, medium and large construction companies and identified the ten most significant factors. The work is based on a survey made on project managers and experienced engineers of building projects in Sangli, Kolhapur & Pune districts. Respondents were required to rate using their experience how all factors affect productivity with respect to time, cost and quality. Cury P H and Saraiva J [5] Illustrates how to reduce non value added activities in production of organic lenses in multinational company located in Brazil by studying the cycle time of each activities. Time and motion studies were made to identify value-added, non-value-added activities and wastes in order to optimize operations. The aim of this study was to have a five-minute break every production hour without compromising with productivity and the operator’s workload. Doiphode M S and Phatak U J [6] employed time and motion study in the construction sector. The productivity measurement of various construction activities are made using method study, work measurement, work sampling and to establish regression equation using statistical analysis. Olanrewaju A L et al. [7] conducted the questionnaire survey on the poor performance of Malaysian construction sector due to poor communication among the various parties involved in construction. The study pointed out the absence of a shared language between superiors and workers, workplace stress, superiors, and colleagues’ attitude towards site workers, misinterpreting of instructions, and
poor communication skills among workers lead to poor performance. Soekiman A et al. [8] conducted survey on factors affecting productivity in Indonesian construction industry and rank them using relative importance index. The 113 factors identified from past researches were rated by the respondents. Totally 15 broad categories are made using these factors.

3. **Objectives and Methodology**

3.1 **Objectives**

- To do work sampling for various construction activities
- To improve operational efficiency, productivity, tool time and support time and to decrease the idle time
- To find the productivity and hence to increase the productivity by ensuring the best possible use of human resource, machine and material and to achieve the best quality product

3.2 **Methodology**

- Identifying the job to conduct time and motion study (work sampling)
- Identifying improved procedure using method study approach and suggesting the motion corrections to obtain the effective methodology
- Select the workers and equipment's for the study
- To suggest the improved working procedure to the workers
- To prepare proper format in breaking the job into operations and operations into elements
- Record the observations on the time study form
- Determine the productivity, operational efficiency, tool time, support time and inefficient time

4. **Observations and corrections**

Below given Tables and Figures represent the one day observation of time and motion study of erection of steel structure on the arrival slab. Table 1 represents the observation of the 250 T crane working which comprises of assisting in structural member erection and shifting of these members with time taken to do the same

| Sl. No. | Start time | End time | Duration (Minutes) | Activities               |
|---------|------------|----------|--------------------|--------------------------|
| 1       | 8:00       | 8:32     | 0:32               | Idle                     |
| 2       | 8:32       | 9:09     | 0:37               | Displacement of Equipment|
| 3       | 9:09       | 9:35     | 0:26               | Shifting of tools from   |
| 4       | 9:35       | 9:47     | 0:12               | Idle                     |
| 5       | 9:47       | 10:11    | 0:24               | Shifting of purlins 4 nos|
| 6       | 10:11      | 10:20    | 0:09               | Shifting of wooden blocks|
| 7       | 10:20      | 10:42    | 1:00               | Shifting of purlins 6 nos|
| 8       | 10:42      | 11:03    | 0:21               | Shifting of secondary beam|
| 9       | 11:03      | 11:49    | 0:46               | Holding of secondary beam|
| 10      | 11:49      | 12:20    | 0:31               | Shifting of secondary beam|
| 11      | 12:20      | 12:55    | 0:35               | Holding of secondary beam|
| 12      | 12:55      | 1:55     | 1:00               | Break                    |
| 13      | 1:55       | 2:13     | 0:18               | Idle                     |
| 14      | 2:13       | 2:34     | 0:21               | Shifting of tools from   |
| 15      | 2:34       | 3:02     | 0:28               | Shifting of secondary beam|
| 16      | 3:02       | 3:44     | 0:42               | Holding of secondary beam|
| 17      | 3:44       | 4:10     | 0:26               | Idle                     |
Table 2 shows the 60T crane observations assisting in the structural steel erection.

**Table 2. Time and motion study of 60 T crane**

| Sl. No. | Start time | End time | Duration (hrs.) | Activities               |
|--------|------------|----------|-----------------|--------------------------|
| 1      | 10:18      | 12:13    | 1:55            | Installation of purlins  |
| 2      | 2:10       | 3:22     | 1:12            | Installation of primary beam |
| 3      | 3:52       | 5:12     | 1:20            | Installation of secondary beam |

Table 3 summarizes the erected structural members’ details like its components and their weights in metric tons.

**Table 3. Structural member details**

| Sl. No. | Structural member erected | Weight(MT) |
|---------|---------------------------|------------|
| 1       | Secondary                 | 3.11       |
| 2       | Secondary                 | 3.11       |
| 3       | Secondary                 | 3.06       |
| 4       | Secondary                 | 3.06       |
| 5       | primary                   | 2.44       |
| 6       | primary                   | 2.44       |
| 7       | Purlins 5 nos.            | 1.15       |
|         | Total                     | 18.37      |

Representation of the categorizing the time zones into tool time, support time and idle time are shown in Table 4, which helps in understanding the utilization of time. Figure 1 represents the categorizing the time zones through pie chart.

**Table 4. Classification of time zones**

| Tool time | Support time | Ineffective time |
|-----------|--------------|------------------|
| 3:47      | 3:21         | 2:36             |

**Figure 1. Representation of time zone in pie chart**
Table 5 represents the calculation of productivity and efficiency of the daily work. This work is carried out for fifteen days in order to calculate the productivity and efficiency.

| Duration assigned (minutes) | Duration utilized (minutes) | Efficiency (%) | Steel erected (MT) | No. of hours utilized (hr.) | Productivity (MT/hr.) |
|-----------------------------|-----------------------------|----------------|-------------------|----------------------------|------------------------|
| 660                         | 542                         | 82.12          | 18.37             | 11.00                      | 2.034330011            |

After seven days of observations following time and motion study corrections are made. Again observations are carried out in order to increase the efficiency and productivity of the work.

4.1 Corrections

4.1.1 Motion corrections

- Hydraulic hand pallets are replaced by trolleys
- Crane ropes were reduced from six ropes to four and hook was replaced to increase the pace
- Two spider boom lifters were introduced to pace up
- Passenger hoists was introduced to shift the tools and brackets from ground to slab
- Old belts were replaced with new one
- Two more mobile cranes (60T) were used to assist the erection
- Steel mat track were made for movement of mobile cranes on slab
- Two storage yard of steel components were setup near the peripheral region of the slab
- Walkie- talkies were introduced for better communication and coordination
- Forklifts are used to unload the structural components from the trailor

4.1.2 Time corrections

- Workers were asked to engage in the work for full duration assigned by the company
- Illegal breaks in between, by the workers was prohibited
- Workers were made to engage in supporting works during the stoppage of assigned work due to some reasons
- Discipline in workers was motivated
- Workers were advised to avoid rework as for as possible

5. Results and Discussions

This study is carried out for a period of fifteen days to draw the results of productivity, efficiency, tool time, support time and idle time. Table 6 shows the fifteen days observation of erection of steel structures using 250 T crane.

| Days | Efficiency (%) | Productivity (MT/hr.) | Tool time(hr.) | Support time (hr.) | Idle time (hr.) |
|------|----------------|------------------------|----------------|--------------------|-----------------|
| 1    | 78.48          | 1.235                  | 6:18           | 2:20               | 2:22            |
| 2    | 50.45          | 0.28                   | 1:19           | 4:14               | 5:27            |
| 3    | 37.95          | 0.48                   | 2:26           | 2:21               | 8:04            |
| 4    | 44.84          | 0.56                   | 2:06           | 2:50               | 6:04            |
| 5    | 63.78          | 1.50                   | 5:21           | 1:40               | 3:59            |
| 6    | 36.67          | 0.22                   | 1:32           | 2:30               | 6:58            |
| 7    | 56.36          | 0                      | 0:00           | 6:12               | 4:48            |
| 8    | 62.76          | 1.45                   | 4:56           | 1:58               | 4:06            |
If we plot the line graph of each parameter we can study their behavior easily. Figure 2 shows the line graph of efficiency v/s days. We can observe that the efficiency is in the range of 70 to 85 percent after applying time and motion study corrections where as it was below average in the beginning.

![Figure 2. Efficiency v/s Days](image)

The line graph of productivity v/s days is shown in Figure 3. It can be seen that the productivity is increasing after applying time and motion study corrections beyond 7 days which is an excellent sign for the construction firm.

![Figure 3. Productivity v/s Days](image)

The line graph of time v/s days graph is shown in Figure 4. It can be observed that the tool time is increasing and idle time is decreasing beyond 7 days, after applying time and motion study corrections. This is a good sign for the construction firm.

|   |   |   |   |   |
|---|---|---|---|---|
| 9 | 68.03 | 1.00 | 5:36 | 1:53 |
| 10 | 36.06 | 0.65 | 0:54 | 5:00 |
| 11 | 78.94 | 2.38 | 5:54 | 4:50 |
| 12 | 83.78 | 2.73 | 6:48 | 3:12 |
| 13 | 82.12 | 1.68 | 3:47 | 3:21 |
| 14 | 89.09 | 2.34 | 6:44 | 2:49 |
| 15 | 80.15 | 3.3  | 7:22 | 1:20 |
Parameters such as efficiency productivity, tool time, support time and idle time are shown in Table 7. It can be observed that there is a remarkable increase of efficiency, productivity and tool time after applying motion study corrections. The idle time has drastically come down.

### Table 7. Percentage increase after 1\textsuperscript{st} and 2\textsuperscript{nd} week of observation

| Parameter          | After 1 week | After 2 weeks | % Increase |
|--------------------|--------------|---------------|------------|
| Efficiency (%)     | 52.64        | 72.62         | 37.95      |
| Productivity (MT/hr.) | 0.61       | 1.94         | 218.03     |
| Tool time (hr.)    | 2:43         | 5:15          | 93.25      |
| Support time (hr.) | 3:10         | 3:03          | -3.68      |
| Idle time (hr.)    | 5:23         | 3:13          | -40.24     |

### 6. Conclusion

After First week of observation and then employing Time and Motion Study correction, we can observe the following:

- Efficiency got better from 52.62% (after 1st week) to 72.62% (after 2nd week), an increase of 37.95%.
- Productivity got better from 0.61MT/hr (after 1st week) to 1.94MT/hr (after 2nd week), an increase of 218.03%.
- Tool Time got better from 2hrs 43min (after 1st week) to 5hrs 15min (after 2nd week), an increase of 93.25%.
- Support time got better from 3hrs 10min (after 1st week) to 3hrs 03mins (after 2nd week), a decrease of 3.68%.
- Idle time got better from 5hrs 23min (after 1st week) to 3hrs 13min (after 2nd week), a decrease of 40.24%.

This method proves to be one of the efficient methods of monitoring and controlling. Result show that time and motion study can be employed to construction sector with promising results. One can optimize the work, standardize the work, proper distribution of human resources can be achieved which ultimately helps in man power economy.
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