Application of Time and Motion study for Brickwork activity in Residential building

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ABSTRACT. Construction industry is one of the largest industries in any economy whether gauged in currency volume or workforce quantity but still it is not attentive in appealing it. Human resource plays a vital role in increasing economy and enhancing productivity. Labor productivity is the key driving factor in burgeoning thrift. Various labors possess distinct productivity levels, thus ultimately affects time and profit of construction. Construction activities performed by workers are usually repetitive and demands physical attention, which can be examined by time and motion study followed by evaluation through statistical analysis. A time and motion study are a work measurement technique that involves recording the time spent on a specific job. A time keeping system can be used to record time, while a motion study can be used to eliminate waste. In this research work, a total of seven residential building sites were selected for performing time and motion study considering brick masonry work as main domain where vision-based approach is followed to collect data, i.e., video record study followed by statistical analysis applied to the observed and collected data on site to determine the time parameters, work efficiency and labor productivity construing to the hassles and its reasons. This study focused on only residential buildings limiting the crew designation to mason and helpers aged 25-35 years with 10-16 years of work experience working under traditional method with conditioned tools like hand trowel, mason square, spirit level, plumb rule, etc.

Keywords: Brick Masonry Work, Time and Motion Study, Efficiency, Productivity and Statistical Analysis.

1. INTRODUCTION

Construction industry significantly contributes to national economy providing employment to large number of people in any nation. In the past few years, Indian construction sector is spreading wings in terms of investment.[1] As per statistics, Indian construction sector has an increment of 4.7 times in income and 7.76 times in employment generation and 20.9% in investment.[2] The construction industry completely relies on four major resources namely, men, material, machinery and money i.e. 4M’s. Among those men is the exuberant resource which plays key role in every stage of construction. The effective use of this resource enhances the performance and productivity. In many nations labor cost comprises 30-50% of project cost, which reflects its influence on economic success. As construction is a labor effective industry, it can be strongly stated that efficiency in construction productivity is mainly dependent on labor power, i.e. human effort and performance.[3] The level of productivity, overall time parameters, cost and profits of a project depend on act on labors and workers.[4] Despite of development of various methods in improving efficiency and effectiveness of construction process, it is still a
challenge due to various factors.[1] In order to achieve high level of quality in construction industry and improve the performance, feasibility and suitability of a construction projects, Productivity is the most frequently used performance indicators to measure success of a construction project because of its importance and flexibility. [5] Hence, labor productivity analysis is captivating method as it affects overall productivity of construction.[6]

To improve the work efficiency and effectiveness of labor productivity, time and motion study is opted. It is a step by step method of examining various construction tasks, where each factor has impact on project despite of being small or large, positive or negative. [2] It is very useful to identify the ineffective time and reasons for that. [4] Time study is a direct and constant observation of a task in an activity using a time measurement device to record and note the completion time. Motion studies are carried out to eliminate waste with a wide range of techniques for defining, evaluating and developing work methods.[7] Time and motion study optimizes work; standardize work and supports in proper distribution of human resources which ultimately leads to man power economy.[1]

2. LITERATURE REVIEW

Many researchers are carried out so far on importance of productivity, method study, time study, labor planning etc. Every paper discussed in this research has given its optimum and intense information regarding efficiency and effective productivity by means of time and work corrections. M.A.R. Shinde and R.R. Salgude gathered information on brick material handling and conducted statistical research and discovered that usage of work sampling and skilled workers eliminates rework and ensures that the right numbers of people are on the job.[6] The residential building was chosen by N.J.Khandve for project completion, and the concrete work was done in two sections over the course of one day. It was noticed that human efforts were limited, and that the rework, seasoned staff, was a result of the work scheduling technique.[8] J.H.Balar et al prepared time study and collected data through personal site visits, and excel sheeted the activities of concreting and masonry and discovered that improvements were effective in achieving project goals and objectives, as well as a decrease in human effort and exhaustion.[7] R.Patel et al selected a residential building and carried out two methods of workability; the traditional method (using on-site mortar) and the improved method (Using ready-available mortar i.e. dry mortar). The data from both methods were analyzed statistically and causes for time delay were identified.[9] C.Prakash et al tried to establish the factors responsible for change in construction productivity and also tried to explain efficient construction productivity through labor management. A questionnaire survey is carried out and received a total of 122 responses which were analyzed by SPSS software and concluded with a result of factors for reducing and increasing productivity in construction by labor management.[1]

3. METHODOLOGY

In this research, total seven sites were chosen considering brick work as main activity.

3.1 Pilot study

Pilot study was done in order to identify the tasks and sub tasks involved in brick masonry work and identified as mortar mixing, mortar placing, brick slicing, brick placing, leveling, joint work and finishing.
3.2 Time and Motion study

Time-Motion study was carried out and observed workers, Total observation time, non-productive value-added time, unproductive time, productive time.

3.3 Statistical analysis

Later statistical analysis is applied to the observed and recorded field data with respect to the time parameters to find out a work efficiency and labor productivity.

4. RESULTS AND DISCUSSIONS

4.1 Data collection

Time study is carried out for the ongoing activity of brickwork for the identified seven sites at Vijayawada, Guntur and Visakhapatnam region during its execution stage and recorded in MS excel. The below given Table1 to Table7 represents the total observation time, non-productive valued added time and unproductive time recorded for the crew (i.e., mason and helper individually) at each site.

| Table 1. Data recorded for various sub tasks in Brickwork Activity at Site No.1. |
|-----------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| **Observation:** 1               | **Activity:** Brick masonry                   | **Unit of measurement:** hh:mm:ss              |
| **Type of material:** AAC        | **Crew:** 2                                   | **Area:** 27.05 Sq.m.                          |
| **Time:** 01:03:00               | **Date:** 19-02-2021                          |                                               |
| **S. No.** | Laborer     | Total observation time | Nonproductive value added time | Unproductive time | **S. No.** | Laborer     | Total observation time | Nonproductive value added time | Unproductive time |
| 1        | Mason       | 01:03:00               | 0:11:02                                    | 0:03:23                |
| 2        | Helper1     | 01:03:00               | 0:00:00                                    | 0:30:21                |

| Table 2. Data recorded for various sub tasks in Brickwork Activity at Site No.2. |
|-----------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| **Observation:** 2               | **Activity:** Brick masonry                   | **Unit of measurement:** hh:mm:ss              |
| **Type of material:** AAC        | **Crew:** 4                                   | **Area:** 56.58 Sq.m.                          |
| **Time:** 01:55:09               | **Date:** 21-02-2021                          |                                               |
| **S. No.** | Laborer     | Total observation time | Nonproductive value added time | Unproductive time | **S. No.** | Laborer     | Total observation time | Nonproductive value added time | Unproductive time |
| 1        | Mason1      | 01:55:09               | 0:03:07                                    | 0:28:41                |
| 2        | Mason2      | 01:55:09               | 0:01:54                                    | 0:05:50                |
| 3        | Helper1     | 01:55:09               | 0:00:00                                    | 0:42:09                |
| 4        | Helper2     | 01:55:09               | 0:00:00                                    | 0:15:23                |
### Table 3. Data recorded for various sub tasks in Brickwork Activity at Site No.3.

| S. No. | Laborer  | Total observation time | Nonproductive value added time | Unproductive time |
|--------|----------|------------------------|-------------------------------|-------------------|
| 1      | Mason1   | 01:06:21               | 0:06:12                       | 0:02:38           |
| 2      | Mason2   | 01:06:21               | 0:01:31                       | 0:00:46           |
| 3      | Helper1  | 01:06:21               | 0:03:18                       | 0:15:14           |

### Table 4. Data recorded for various sub tasks in Brickwork Activity at Site No.4.

| S. No. | Laborer  | Total observation time | Nonproductive value added time | Unproductive time |
|--------|----------|------------------------|-------------------------------|-------------------|
| 1      | Mason    | 01:08:00               | 0:04:40                       | 0:14:33           |
| 2      | Helper1  | 01:08:00               | 0:00:00                       | 0:36:46           |

### Table 5. Data recorded for various sub tasks in Brickwork Activity at Site No.5.

| S. No. | Laborer  | Total observation time | Nonproductive value added time | Unproductive time |
|--------|----------|------------------------|-------------------------------|-------------------|
| 1      | Mason    | 01:20:00               | 0:11:55                       | 0:01:55           |
| 2      | Helper1  | 01:20:00               | 0:00:00                       | 0:43:24           |

### Table 6. Data recorded for various sub tasks in Brickwork Activity at Site No.6.

| S. No. | Laborer  | Total observation time | Nonproductive value added time | Unproductive time |
|--------|----------|------------------------|-------------------------------|-------------------|
| 1      | Mason    | 0:58:52                | 0:08:09                       | 0:04:03           |
| 2      | Helper1  | 0:58:52                | 0:04:47                       | 0:29:06           |
Table 7. Data recorded for various sub tasks in Brickwork Activity at Site No.7.

| S. No. | Laborer | Total observation time | Nonproductive value-added time | Unproductive time |
|--------|---------|------------------------|-------------------------------|------------------|
| 1      | Mason   | 01:25:02               | 0:03:08                       | 0:00:24          |
| 2      | Helper1 | 01:25:02               | 0:00:00                       | 0:34:07          |

4.2 Data analysis

After time study, motion study is carried out for brickwork activity for the identified seven sites to analyze the productive time in each site. Table 8 represents the output data for each site with respect to total observation time, nonproductive value-added time, unproductive time, productive time, and brickwork wall area. Later, Statistical analysis is carried out for the observed and recorded data of time parameters to analyze the work efficiency and labor productivity at each site (refer to table 9).

Table 8. Data of time parameters for brick work activity at identified sites.

| Area (Sq.m) | Total observation time (hh:mm:ss) | Nonproductive value-added time (hh:mm:ss) | Unproductive time (hh:mm:ss) | Productive time (hh:mm:ss) |
|-------------|----------------------------------|------------------------------------------|-------------------------------|----------------------------|
| Site1       | 27.05                            | 1:03:00                                  | 0:11:02                       | 0:17:07                    | 0:45:53                    |
| Site2       | 56.58                            | 1:55:00                                  | 0:15:19                       | 0:12:49                    | 1:42:11                    |
| Site3       | 32.32                            | 1:06:21                                  | 0:03:40                       | 0:06:19                    | 1:00:02                    |
| Site4       | 18.80                            | 1:08:00                                  | 0:04:40                       | 0:25:45                    | 0:42:15                    |
| Site5       | 30.15                            | 1:20:02                                  | 0:11:55                       | 0:22:39                    | 0:57:23                    |
| Site6       | 41.00                            | 0:58:52                                  | 0:05:13                       | 0:13:09                    | 0:45:43                    |
| Site7       | 19.50                            | 1:25:02                                  | 0:03:08                       | 0:17:15                    | 1:07:47                    |
Table 9. Work efficiency and Labor productivity at identified sites.

| Area (m²) | Total observation time (hr) | Nonproductive value added time (hr) | Unproductive time (hr) | Productive time (hr) | Efficiency (%) | Productivity (m²/hr) |
|-----------|----------------------------|-------------------------------------|------------------------|----------------------|----------------|----------------------|
| Site1     | 27.05                      | 1.05                                | 0.18                   | 0.28                 | 72.90          | 35.59                |
| Site2     | 56.58                      | 1.92                                | 0.25                   | 0.21                 | 89.14          | 33.08                |
| Site3     | 32.32                      | 1.10                                | 0.06                   | 0.10                 | 90.62          | 32.32                |
| Site4     | 18.80                      | 1.13                                | 0.07                   | 0.42                 | 62.57          | 26.48                |
| Site5     | 30.15                      | 1.34                                | 0.19                   | 0.37                 | 72.08          | 31.40                |
| Site6     | 41.00                      | 0.98                                | 0.09                   | 0.22                 | 77.63          | 53.94                |
| Site7     | 19.50                      | 1.42                                | 0.05                   | 0.29                 | 79.82          | 17.26                |

The plotted column graph of work efficiency v/s identified sites is shown in figure1. It can be illustrated that efficiencies are varying in the range of 60-90%. The reasons for these variations are found to be,
- Lack of work targets to complete the tasks
- Poor work planning
- Improper monitoring of workers
- Lack of precise and accurate control over labor tasks, etc.

The plotted column graph of Labor productivity v/s identified sites is shown in figure2. It can be illustrated that productivity is varying in the range of 15-60 m²/hr. A drastic variation is observed in the productivity and causes were,
- Lack of skilled labor and training for workers
- Lack of work experience
- Conflicts and misunderstandings i.e., no work ethics
- Material and equipment shortage, etc.
The column graph of various time parameters for identified sites is shown in figure 3. It can be observed that productive time, nonproductive value-added time, and unproductive time is varying from site to site.

Figure 1. Graph representing Work Efficiency for various identified sites.

Figure 2. Graph representing Labor Productivity for various identified sites.

Figure 3. Graph representing Non-Productive Value-Added Time (NPVT), Unproductive Time (UPT) and Productive Time (PT) of identified seven sites.
5. CONCLUSION

Conceptually efficient performance cannot be achieved as per planned schedule due to unproductive work hours and methods. This research presented real-time case studies of seven working construction site considering brickwork activity. Various tasks involved in brickwork activity are categorized to mortar works, bricks handling and finishing works for which time-motion study is carried to observe the various time parameters during which some common delays were observed like, Poor site management, Target less work environment, Material shortage, Miscommunications, Issues related to electricity, Equipment breakdown, etc. It had an overall effect on work efficiency and labor productivity. By considering the above stated problems and upgrading worker efficiency by training as per requirement, along with work sampling enhances efficiency, reduces the rework, time, economy and create a baseline to evaluate ergonomics side of workers.

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