

Time and Motion Study of Construction Activities in Industrial Building

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Abstract - Time and motion studies of construction activities are process to find the time required to complete the task. Time study was developed by Fedrick W. Taylor in about 1880 which is the first person to use stopwatch to study and measure work content with his purpose to define "a fair day work". Motion study was developed by Frank B. Gilbreth and his wife Lillian developed and redefined the motion study in 1909. The main advantage of T&M study is to simplify the necessary operations make the job easier by analyzing the process in the order to improve it through elimination of unnecessary operations, rearrange the sequence and layout of operations it may results in reducing the operating time. The method is use in time and motion study is to identify problems, choose the appropriate activity, plan the activity, record the information by relevant method, analyze activity factor develop economic method, measure work and standard time, define new efficient method and maintain new standard. In this research work the stop watch method is use to determine respective operation of construction activity of industrial building by physical observation. By time and motion study we can increase our productivity by 20% that means saving of resources.

Key Words: Time and Motion Study (T&M), Construction Activity, Industrial Building, Construction Engineering and Management, Stop Watch Method, Mean Value Method, Industrial Building Construction, Activity Process Chart, Physical Observation.

1. INTRODUCTION

Time and motion study are a work measurement technique for recording the times of performing a certain specific job or its elements carried out under specified conditions. Time study is direct and continuous observation of a task, using a time measurement devices or physical observation.

The motion study was developed by Frank B. Gilbreth and Lillian M. Gilbreth and consists of a wide variety of procedures for the description, systematic analysis, and means of improving work methods. By the time being researches are carried out time and motion study to manage work by scientifically controlling.

Industrial buildings have complex, unique and challenging construction work. The scope of work and change in design impact is average of 35%. All of those projects will have a major change issues regarding productivity, shortage of time and work efficiency. Growth of Infrastructure and industrial project have been a key part of the Indian construction, government increased its investment 20.9% from ₹ 4.9 trillion to ₹ 6.0 trillion. Statistics over the period have shown that compared to other sectors, this sector of economic activity generally creates 4.7 times increase in incomes and 7.76 times increase in employment generation potentially.

By the time and motion study of industrial construction activity is done with physical observation, improve productivity and efficient work progress with desired quality. This research work is limited because big issue of global pandemic COVID-19 prevailing during the time of research.

1.1 NEED FOR STUDY

To know stability of various construction activities in industrial building and to know wastage of resource and reduced by work standardization.

1.2 OBJECTIVE AND SCOPE

The main objective of T&M study is to study planned time for each job which can be scientifically estimated. By the stop watch, calculate time required to complete the activity. To manage proper balancing of distribution of work. To develop efficient and standardized work method. The scope of the research work is limited to Ahmedabad city and to study construction activities on Industrial construction building with cost up to 100cr.

2. RESEARCH METHODOLOGY

Research methodology is the process to find out desire problem solution. This research includes following research procedure:

Literature review - Literature review is done after referring and study of 20 past research paper, reference books, past survey methods applied to Time and motion studies in industrial building, construction articles, detail discussion with expert and their opinion.

Data collection - Data collection has been carried out by physical observation of ongoing construction activities by stop watch method in industrial projects, inquire question regarding activity, discuss with experience person/project manager.

Data Analysis - Data analysis is done after collection of required data form data collection by mean value method.

3. LITERATURE REVIEW

The aim of literature review is to understand the scope of work, methodology for research work, current scenario of work and identify the problems in industry, it helps to formulating hypothesis or probable solutions, collecting, organizing and evaluating data. The main purpose of study is to discover answers to questions through application of scientific methods.

Time and motion study are the step by step examination method of the various construction task. This method is use to improve execution methodology by scientific management in any project. It helps to increase productivity by set the new standards and also improve design & planning at any phase of project.

Motion and time study are not confine only for construction industry; it is viable for any manufacturing industry who needs for efficient work improvisation.

4. DATA COLLECTION

Data collection is most essential, crucial and important part of research work. It will help in to achieve desire problem solution. Data is interpretation of what we think, what we explore, what we imagine, what we can write. It is needed to make new standard, to manage and to control what happenings in our civilization. In data collection researcher keep in mind what should he can observe? And how to be accurate data was collected? for desire goal.

4.1 METHODS FOR CONDUTING TIME AND MOTION STUDIES

The following methods is commonly use in T&M study:

- 1) Stop watch
- 2) Work sampling and historical data
- 3) MOST – Maynard Operation Sequence Technique
- 4) Vision based motion capture analysis
- 5) Standard time
- 6) Questionnaire surveys
- 7) Expert opinion
- 8) Daily work schedule
- 9) Activity Process Chart

Stop Watch Method

Stop watch study method is most commonly method used to determine performed task duration and efficiency of task. This survey is done through physical observation of ongoing construction activities and experience or qualified person who have enough knowledge about activities performance. If the actual observed time is above average, operation time must be increased, and the actual observed time is below average, it may result in decrease operation time.

Activity time observed by two method:

- A. Count overall time of activity performed from beginning to completion of work.
- B. Count each of operation time by lap/succeeding time deduction.

4.2 DATA COLLECTION PROCEDURE

Prepare planning of work, discussion with internal and external guide. Prepare observation sheet and process map for physical observation. Choose activity according to execution work.

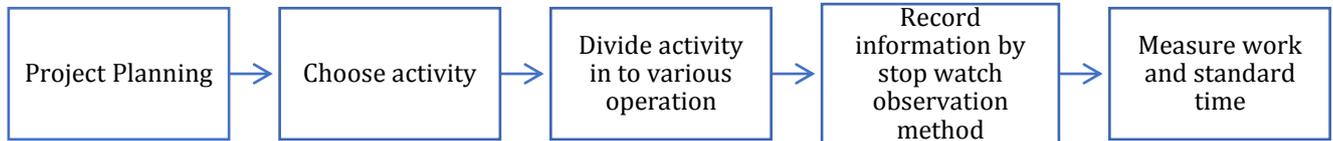


Fig - 4.1 Data collection Procedure

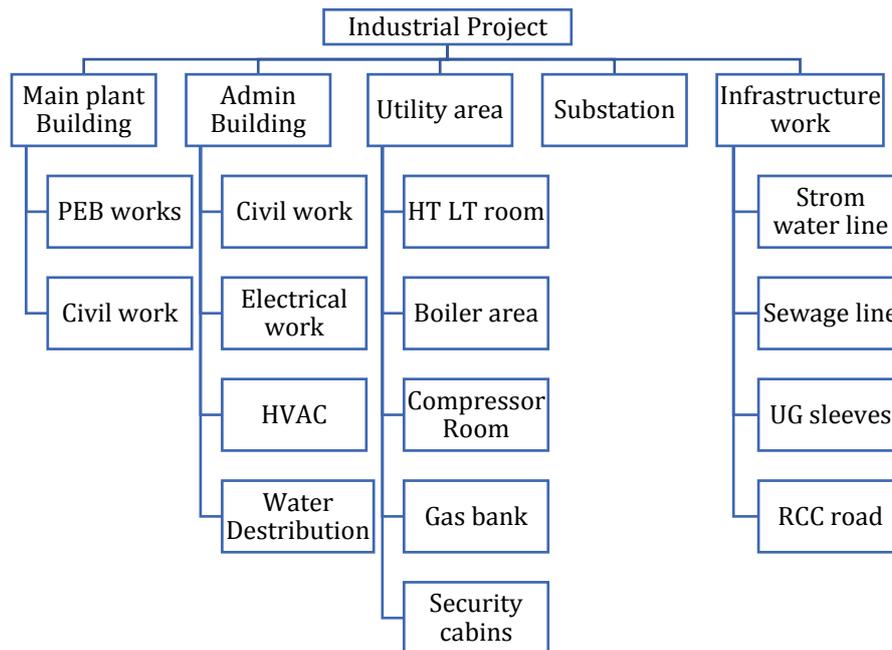
In data collection the observation is divided in to two parts 1) Make and follow process chart, 2) Fill data in to observation sheet. There is notation mention below is follow while physical construction activity observation.



Fig - 4.2 Notation follow while observation

4.2.1 ACTIVITY OBSERVED

The industrial project is divided in to 5 categories of work and the activity observed in various stage of building which is mention below. Total plot area and Total Construction area of industrial building is 10,272 m² and 6,505 m².



Activity mention in below table is observed resources and activity during research work. Resources helps in planning of activity, on time delivery of project and manage the defined work. Purpose of activity observation is to find how much time taken to completed the task.

Table 4.1 - List of Observed Activity

Sr. No.	Name of Activity	Resources		Name of Structure
		Labor	Equipment	
1.	Column Concrete work	Skilled, Unskilled	T.M., Material lift	Admin Building (1 st Floor)
2.	Steel Beam Erection	Skilled, Crane Operator	Mobile crane, Mobile lift, Bolt gun	Main Plant Building
3.	Brick Work	Skilled, Unskilled	-	Utility Area
4.	SSR (Standing Seam Roof) Roof sheeting	Skilled, Operator	Mobile crane, Screw gun	Main Plant Building

OBSERVATION SHEET

Observation sheet is the format to record data. It is form after discussion with expert and internal guide of research work.

OBSERVATION SHEET															
TIME AND MOTION STUDY OF INDUSTRIAL BUILDING															
Project Name:											Date:				
Project Location:											Note:	Time must be fill in 24hrs format			
Work Time:						Break Time:				Sheet No:			Structure Name:		
Sr. No.	Activity ID	Activity Description	Process Type	Actual QTY of Work	Unit	Resource Type		Resource Name	Productivity of work	Time		Time Observed	Unnecessary Time	Total Time Observed	Remarks
						Labor	Equipment			(R/O T)	Time (Stop Watch) Start Finish				
1.															
2.															

ACTIVITY PROCESS FLOW CHART

Process flow chart shows the sequence to do execution work. It includes detail work break down of work task execution.

Name of Activity: - Column Concreting

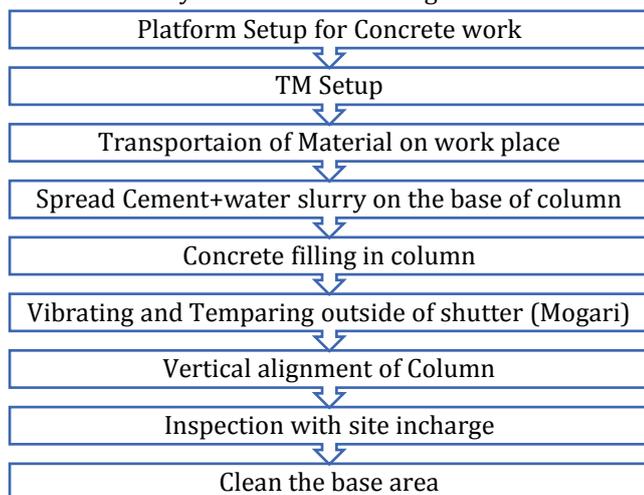


Fig. - 4.3 Flow chart for column concreting

Name of Activity: - Steel beam erection

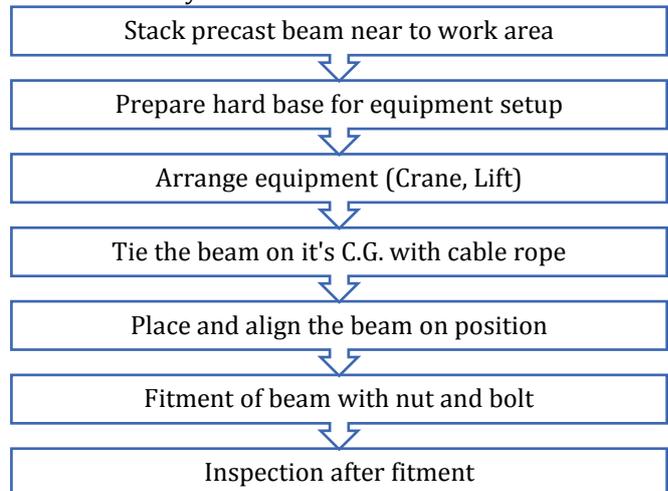


Fig. - 4.4 Flow chart for steel beam erection

Name of Activity: - Brick work

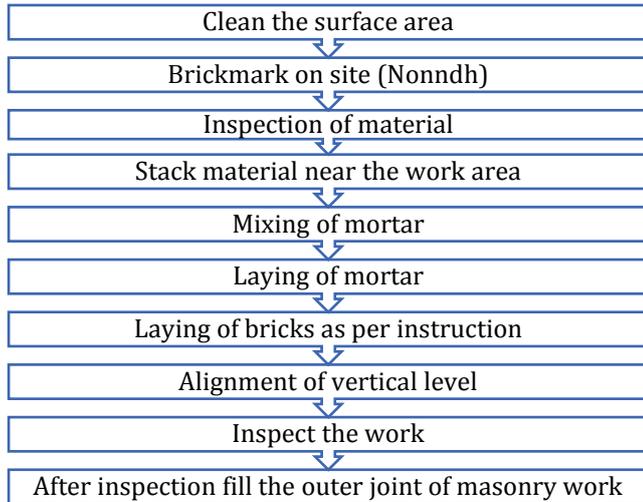


Fig. – 4.5 Flow chart for Brickwork

Name of Activity: - SSR Roof sheeting

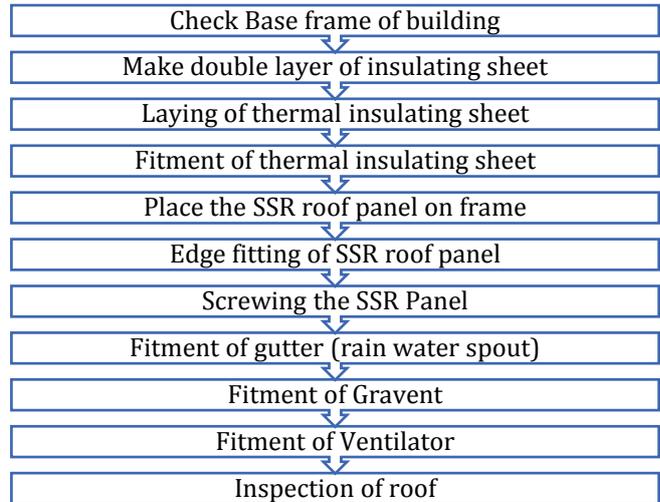
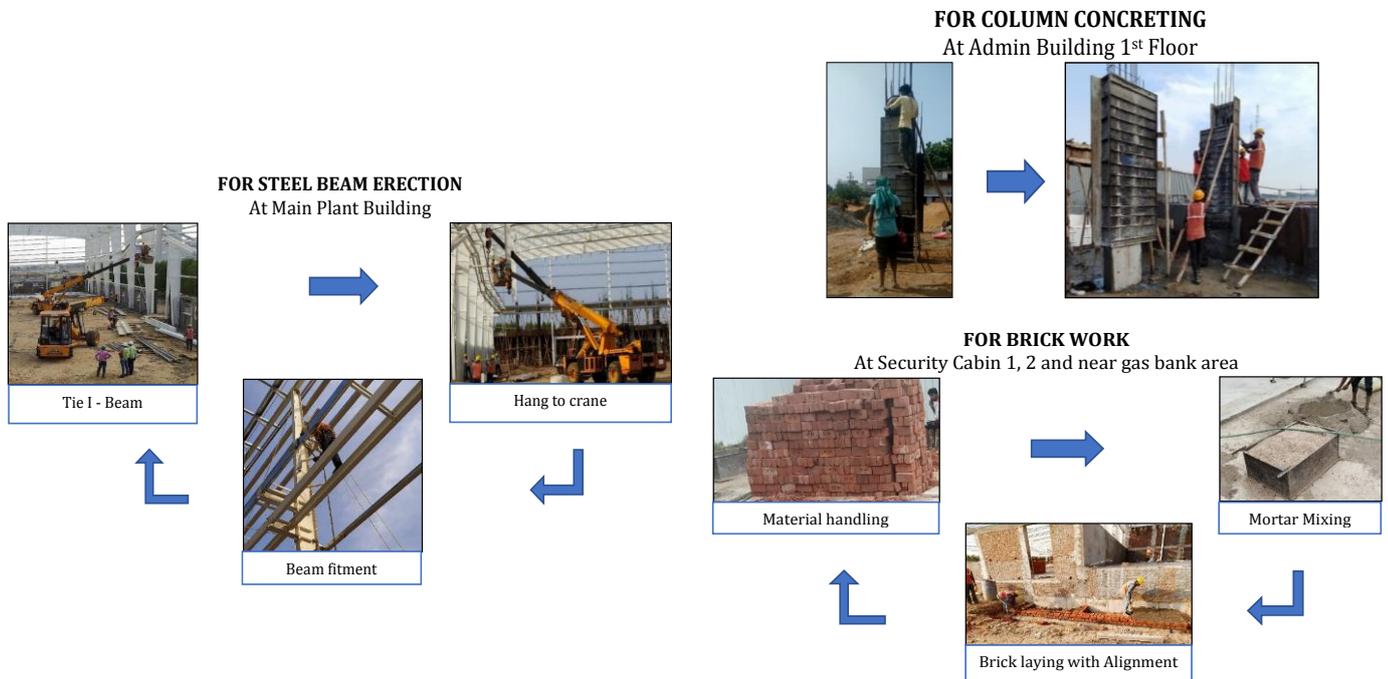


Fig. – 4.6 Flow chart for SSR Roof sheeting

Table 4.2 – Total activity observed time

ACTIVITY	TOT (In Hour)
Column concreting	09:31:10
Steel Beam erection (Phase - 1,2)	16:17:45
Brickwork (Phase - 1,2)	16:51:59
SSR Roofing	08:45:40

CYCLE OBSERVED WHILE PHYSICAL OBSERVATION



5.DATA ANALYSIS

Data analysis is scientific process to find out result and outcome from valid collected data. It is a process of segregation of operational value, inspection of data collection and evaluate the data with appropriate method. By precise data analysis it will helpful in decision making process and set up a new standard.

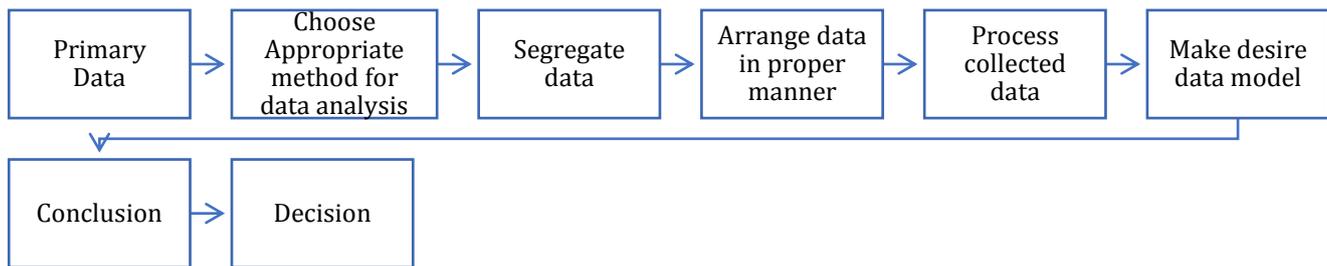


Fig - 5.1 Data analysis Procedure

In T&M study various method is use to defined new standards of work process, which is regression equation analysis, mean value analysis, Cumulative data analysis, Questionnaire survey analysis, factor weightage analysis.

Mean Value Method

Mean or average is the mid value of a whole operational value. It is a set of number of operation time taken to perform the task divided by the number of cycles for observation. It is most efficient tool to determine average performance of particular activity.

$$Mean\ hour\ of\ work\ (\bar{x}) = \frac{\sum T_i}{n} = \frac{T_1 + T_2 + T_3 + \dots + T_n}{n}$$

Where, \bar{x} = Average value of observed time

T_i = Observation time $T_1, T_2, T_3, T_n \dots$

n. = Total number of cycles

Σ = Symbol of Summation

Another table abbreviation

R = Regular Time

U = Unnecessary Time

Total Productive Time (TPT) = Total Observation Time (TOT) – Total Unnecessary Time

MHW = Mean Hour of Work

The data analysis is divided in to two parts:

- A. **Essential Function** – A function must be following to perform the operation is known as essential function. The activity should not be completed without required operation.
- B. **Supportive Function** – A function is required while essential operation is active is known as supportive function.

Name of Activity: - Column Concreting

Table 5.1 – Column Conc. Essential function analysis

LOCATION – ADMIN BUILDING						
ESSENTIAL OPERATIONS						
Particular	Concrete filling and vibrating		Column Alignment		Cube Casting	
	Time		Time		Time	
	R	U	R	U	R	U
TOT	06:26:12	00:26:07	02:16:25	00:04:21	00:21:24	00:00:00
TPT	06:00:05		02:12:04		00:12:24	
MHW	00:21:11		00:07:46		00:12:24	

Table 5.2 – Column Conc. Supportive function analysis

LOCATION – ADMIN BUILDING						
SUPPORTIVE OPERATIONS						
Particular	Arrangement of Conc. Platform		TM Set up		Change Transportation Set up (Khapeda)	
	Time		Time		Time	
	R	U	R	U	R	U
TOT	00:25:33	00:08:26	00:04:29	00:00:00	00:06:07	00:00:00
TPT	00:17:07		00:04:29		00:06:07	
MHW	00:17:07		00:04:29		00:06:07	

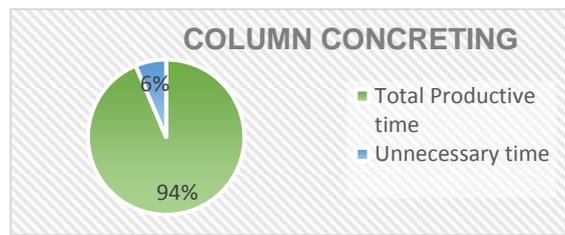


Chart – 5.1 Col. Conc. Graphical Representation

Name of Activity: - Steel Beam Erection

In Steel beam Erection data analysis is done by 2 phase and have Different unnecessary time.

Table 5.3 – Steel Beam Erection Essential function analysis Phase-1

LOCATION – MAIN PLANT BUILDING						
ESSENTIAL OPERATIONS						
Particular	Tie I- Beam		Hang to crane with all adjustment		Alignment, Bolting and inspection	
	Time		Time		Time	
	R	U	R	U	R	U
TOT	02:20:21	00:03:10	02:34:40	00:09:59	02:57:30	00:20:46
TPT	02:17:11		02:24:41		02:36:44	
MHW	00:09:48		00:10:20		00:11:12	

Table 5.4 – Steel Beam Erection Supportive function analysis Phase-1

LOCATION – MAIN PLANT BUILDING				
SUPPORTIVE OPERATIONS				
Particular	Equipment set up		Change orientation of Lift & crane	
	Time		Time	
	R	U	R	U
TOT	00:19:23	00:00:00	00:15:47	00:00:00
TPT	00:19:23		00:15:47	
MHW	00:19:23		00:15:47	

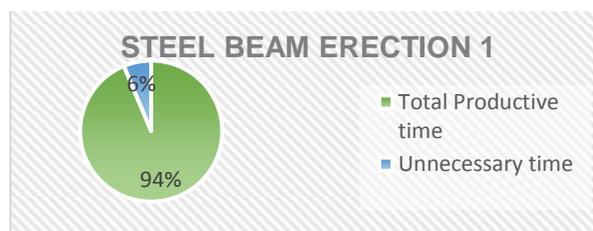


Chart – 5.2 Steel Beam Erection Phase 1 Graphical Representation

Table 5.5 – Steel Beam Erection Essential function analysis Phase-2

LOCATION – MAIN PLANT BUILDING						
ESSENTIAL OPERATIONS						
Particular	Tie I- Beam		Hang to crane with all adjustment		Alignment, Bolting and inspection	
	Time		Time		Time	
	R	U	R	U	R	U
TOT	02:14:26	00:19:36	02:40:20	00:32:13	02:03:31	00:00:00
TPT	01:54:50		02:08:07		02:03:31	
MHW	00:09:34		00:10:41		00:10:18	

Table 5.6 – Steel Beam Erection Supportive function analysis Phase-2

LOCATION – MAIN PLANT BUILDING				
SUPPORTIVE OPERATIONS				

Particular	Equipment set up		Change orientation of Lift & crane	
	Time		Time	
	R	U	R	U
TOT	00:33:41	00:11:54	00:18:06	00:00:00
TPT	00:21:47		00:18:06	
MHW	00:21:47		00:09:03	

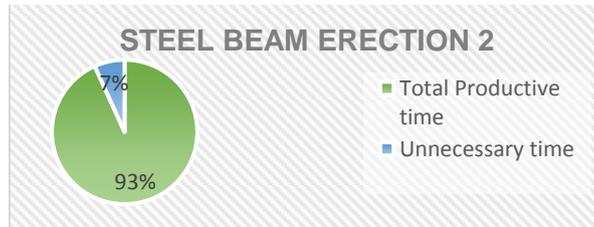


Chart – 5.3 Steel Beam Erection Phase 2 Graphical Representation

Name of Activity: - Brickwork

In Brick work data analysis is done by 2 phase and have Different unnecessary time.

Table 5.7 – Brickwork Essential function analysis Phase-1

LOCATION – SCURITY CABIN 1 – 2								
ESSENTIAL OPERATIONS								
Particular	Brick mark				Material Handling		Brick laying	
	Material Handling		Marking		Time		Time	
	Time		Time		Time		Time	
	R	U	R	U	R	U	R	U
TOT	00:28:21	00:06:34	00:44:35	00:09:27	02:58:52	00:05:43	03:36:48	00:40:44
TPT	00:21:47		00:35:08		02:53:09		02:56:04	
MHW	00:21:47		00:35:08		00:24:44		00:25:09	

Table 5.7 – Brickwork Supportive function analysis Phase-1

LOCATION – SCURITY CABIN 1 – 2						
SUPPORTIVE OPERATIONS						
Particular	Inspection		Vatta		Arrange Platform	
	Time		Time		Time	
	R	U	R	U	R	U
TOT	00:34:25	00:10:26	00:48:06	00:03:52	00:08:15	00:00:00
TPT	00:23:59		00:44:14		00:08:15	
MHW	00:12:00		00:22:07		00:08:15	

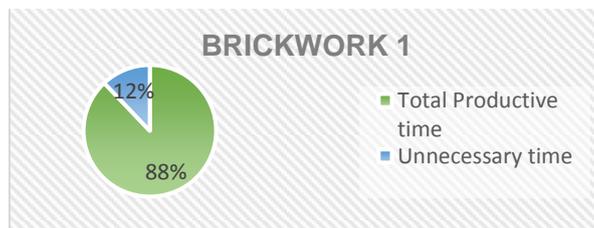


Chart – 5.4 Brickwork Phase 1 Graphical Representation

Table 5.8 – Brickwork Essential function analysis Phase-2

LOCATION – SCURITY CABIN 1 & NR. GAS BANK AREA				
ESSENTIAL OPERATIONS				
Particular	Brick mark		Material Handling	Brick laying
	Material Handling	Marking		
	Time		Time	Time

	R	U	R	U	R	U	R	U
TOT	00:18:57	00:06:34	00:36:44	00:09:27	02:22:58	00:05:19	03:05:20	00:18:52
TPT	00:12:23		00:27:17		02:17:39		02:46:28	
MHW	00:12:23		00:27:17		00:19:40		00:23:47	

Table 5.9 – Brickwork Supportive function analysis Phase-2

LOCATION – SCURITY CABIN 1 & NR. GAS BANK AREA						
SUPPORTIVE OPERATIONS						
Particular	Inspection		Vatta		Arrange Platform	
	Time		Time		Time	
	R	U	R	U	R	U
TOT	00:13:31	00:00:00	00:42:45	00:08:42	00:12:32	00:00:00
TPT	00:13:31		00:34:03		00:12:32	
MHW	00:13:31		00:17:02		00:12:32	

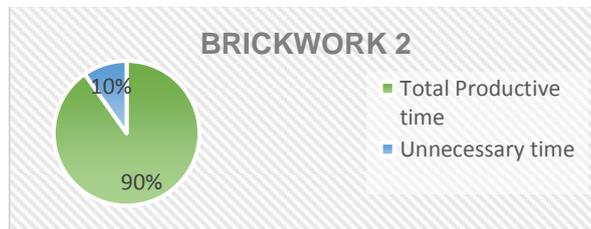


Chart – 5.5 Brickwork Phase 2 Graphical Representation

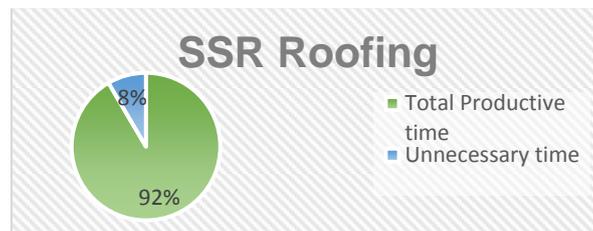
Name of Activity: - SSR Roof Sheeting

Table 5.10 –SSR Roof Sheeting Essential function analysis

LOCATION – MAIN PLANT BUILDING						
ESSENTIAL OPERATIONS						
Particular	Insulation Work		Erection of roof sheet		SSR Fitment	
	Time		Time		Time	
	R	U	R	U	R	U
TOT	02:53:58	00:24:09	02:50:30	00:22:50	01:46:48	00:00:00
TPT	02:29:49		02:27:40		01:46:48	
MHW	02:29:49		00:24:37		00:17:48	

Table 5.11 –SSR Roof Sheeting Supportive function analysis

LOCATION – MAIN PLANT BUILDING				
SUPPORTIVE OPERATIONS				
Particular	Hang to crane including collection of roof sheeting		Inspection	
	Time		Time	
	R	U	R	U
TOT	00:54:56	00:01:14	00:19:28	00:00:00
TPT	00:53:42		00:19:28	
MHW	00:08:57		00:19:28	


Chart - 5.6 SSR Roofing Graphical Representation
Table 5.12 - Total Time Analysis of Activity Observed

ACTIVITY	TOTAL OBSERVED TIME	TOTAL UNNECESSARY TIME	TOTAL PRODUCTIVE TIME
Column concreting	09:31:10	00:38:54	08:52:16
Steel Beam erection 1	08:27:41	00:33:55	07:53:46
Steel Beam erection 2	07:50:04	00:33:55	07:16:09
Brick Work 1	09:19:22	01:16:46	08:02:36
Brick Work 2	07:32:47	00:48:54	06:43:53
SSR Roof Sheeting	08:45:40	00:48:13	07:57:27

6. CONCLUSIONS

T&M study gives actual pictures to perform construction activity. The essential operation has more time loss as compare to supportive task. It can directly affect to our planned schedule, budgeted cost and result in project delay, declining in S-curve, project cost overrun or increase in overhead charges.

General factor is observed while study are as follows:

Design and planning procedure of work, Material handling, Precession of work, Capacity and productivity of equipment, spacing between two equipment, Lead of operational work, Absence of ideology of work, Frequent breaks, Operator's proficiency, Work permission procedure, Internal happiness of worker, Appreciation for workforce, Change in job plan of projects. In T&M study of industrial construction activity, each factor has small and larger impact on project it may be positive or negative.

Process flow chart and cycle chart give idea about how to do activity operation. That will helpful to decide standard operational time.

In research work of time and motion studies on industrial project 4 physical activity analysis is done by stop watch method and conclude the unnecessary time of operational task is average 6-12% while execution of activities.

Efficient performance cannot be achieved as per schedule due to unproductive work hours. If unnecessary time using in to productive working hours it may increase resource productivity and reduce material wastage. It will help to make guideline to do work operation, risk management plan, resource management plan, budget plan for future project.

7. FUTURE SCOPE

This study mainly focuses on how activity can perform and how much time to complete the activity. It involves only few activities observations due Covid-19 pandemic situation but by this research procedure we can find out remaining other activity average completion time and compare with traditional method to improved method (Defining Standard time). If labor and resource data will be calculated then it forms a regression equation with two or more variable. It will helpful to generate efficient productivity model. Based on all aspect of T&M study find project cost overrun.

REFERENCES

1. **Acedamia**. <http://www.academia.pdu>. [Online] Academia. [Cited: 24 February 2020.] <http://www.academia.pdu>.
2. **Google**. Google Scholar. <https://scholar.google.com/>. [Online] [Cited: 05 March 2020.] <https://scholar.google.com/>.
3. **Researchgate**, Researchgate. <https://www.researchgate.net/>. [Online] [Cited: 25 March 2020.] <https://www.researchgate.net/>.

4. Enhance Labour Productivity Through Application of Work Study Principles. **Mayuri Sanjay Doipode, Prof. Uday J. Phatak**. 5, May 2017, International Journal of Engineering Sciences & Research Technology, Vol. 6, pp. 48-54.
5. An Impact Time Motion Study in the Automation Process. **Ariffin, Abdul Talib Bon & Aliza**. 1, 2012, Journal of Noval Applied Sciences, Vol. 1, pp. 17-24.
6. **Takashi YAMAGUCHI, Hiroshi YAMAMOTO**. Motion Anlysis of Hydraulic in Excavation and Loading Work for autonomus Control. Tsukuba, Japan : Public Works Research Institute, 2006.
7. Effective Time and Motion Study on Construction Project: "A case study of surat city". **Mr. Jigar H. Balar, Mr. Hiren A. Rathod, Mr. Rushabh Shah**. 3, 2018, International Journal of Scientific Research & Developlment, Vol. 6, pp. 31-34.
8. Time and Motion Study of Residential Site. **Miss. Rajshri Shrishimal, Prof. R. R. Salgue**. 6, 2015, International Journal of Innovative and Emerging Research in Engineering, Vol. 2, pp. 5-10.
9. Application of Work Study in Construction Project. **Rohit More, Pranali Mundale, Pritam Patil, Dhanasri Shirguppe, Nitish Patil**. 4, 2019, International Research Journal of Engineering and Technology, Vol. 6, pp. 1415-1417.
10. Time and Motion Study for flooring Activity of a Residential Building. **Ronak Patel, Chinmay Acharekar, Ajay Chiraboina, Rajatkumar Bejankiwar, Prof. Vikrant Kothari**. 3, March 2019, International Journal for Research in Applied Science & Engineering Technology, Vol. 7, pp. 1383-1388.
11. Time Implication and Measurement on Construction Industry. **Ghanfourian, Kamyar Kabirifar and kambiz**. 5, 2014, Indian Journal Science, Vol. 4.
12. Time Analysis with MOST Technique. **J. Senthil, G. Haripriya**. 2, 2016, Int. J. Chem. Sci, Vol. 14, pp. 519-526.
13. **Abdul Talib, Aliza Ariffin**. An Impact Time and Motion Study on Small Medium Enterprise Organization. Johor, Malaysia : Universiti Tun Hussein Onn, Malaysia.
14. A Productivity Model Utilising a Work Study Approach for Performamce Measurement. **Hassanali, Kevin N**. 1, April/may 2011, The Journal of the Association of Proffessional Engineers of Trinidad and Tobago, Vol. 40, pp. 13-25.
15. **Abdul Talib Bon, Daiyanni Daim**. Time and Motion Study in Determination of Time Standard in Mnapower Process. Malaysia : 3rd Engineering Conferrence 2010, 2010.
16. Vision-based Motion Detection for Safety Behavior Analysis in Construction. **SangUK Han, SangHyun Lee and Feniosky Pena-Mora**. 2012, Construction Reserach Congress (ASCE-American Society for Civil Engineers), pp. 1032-1041.
17. Application of Maynard Operaion Sequence Technique (M.O.S.T.) at Tata Motors and Adithya Automotive Applicationn Pvt Ltd. Lucknow for Enh. **Mr. Ankit Mishra, Mr. Vivek Agnihotri & Prof. D.V. mahindru**. 2, 2014, Global Journal of Reserachs in Rngineering, Vol. 14, pp. 1-8.
18. **Xingzhou Guo, Alireza Golabchi, SangUK Han, Jim Kanerva**. 3D Modelling of Workplaces for Time and Motion Study of Construction Labor. Alberta, canada : Department of Civil and Environmental Engineering, University of Alberta.
19. Time Standardization for Building Maintenance Tasks. **Mr. Nikhil A. Shete and Prof. Dhananjay S. Patil**. 7, 2013, Interantional Journal of Engineering Reasearch & Technology, Vol. 2, pp. 1527-1534.
20. **C R Kothari, and Gaurav Garg**. Reserach Methodology - Methods and Techniques. s.l. : New Age International Publishers, 2019.
21. **Frederick, Winsom Taylor**. THE PRINCIPLES OF SCEINTIFIC MANAGEMENT. New York & London : Herper & Brothers Publishers, 1911. pp. 1-144.