

ENHANCING PRODUCTIVITY IN CIVIL WORKS OF SUPER STRUCTURE IN MID-RISE RESIDENTIAL BUILDINGS

A Thesis

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Building Management

By

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**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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MAY 2022



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This is to certify that this Report is the bonafide work of **SUDHARSUN (40840016)** who carried out the Pre-Thesis entitled "**ENHANCING PRODUCTIVITY IN CIVIL WORKS OF SUPER STRUCTURE IN MID-RISE RESIDENTIAL BUILDING**" under our supervision from January 2022 to May 2022

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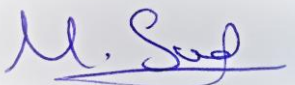
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DECLARATION

I **SUDHARSUN** hereby declare that the Pre-Thesis Report entitled “**ENHANCING PRODUCTIVITY IN CIVIL WORKS OF SUPER STRUCTURE IN MID-RISE RESIDENTIAL BUILDING**” done by me under the guidance of **Ar.Priyadharshini** (Internal) and **Mr. S. KAVIN KUMAR** (External) at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Master of Architecture degree in Building Management.

DATE: May 4th 2022

PLACE:

A handwritten signature in blue ink, appearing to read 'M. Sud', is centered within a light gray rectangular box.

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Proper management of resources in construction projects can yield substantial savings in time and cost. The profitability of most construction projects critically depends on construction productivity, which can lead to project cost overruns and schedule delays if not fully addressed. Inefficient management of construction resources can result in low productivity. Therefore, it is important for contractors and construction managers to be familiar with the methods leading to evaluate the productivity of the equipments and the laborers in different crafts.

To understand how productivity can yield cost and time saving in construction and what are the tools and techniques that are used to measure and improve productivity in construction.

Understand the basic principles of Productivity in construction. Study how Productivity can yield savings in cost, time and quality in construction industry. To study how productivity is measured in a construction. To study the techniques and tools used to improve productivity in construction. Analyze how these techniques are implicated in the construction project. To find out what impact does these techniques create in the Construction project

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CHAPTER-1

INTRODUCTION

1.1 AIM

To understand how productivity can yield cost and time saving in construction and what are the tools and techniques that are used to measure and improve productivity in construction.

1.2 OBJECTIVE

- Understand the basic principles of Productivity in construction. Study how Productivity can yield savings in cost, time and quality in construction industry.
- To study how productivity is measured in a construction.
- To study the techniques and tools used to improve productivity in construction. Analyze how these techniques are implicated in the construction project.
- To find out what impact does these techniques create in the Construction project.

1.3 RESEARCH METHODOLOGY

Stage-1: Identify various journals related to productivity in building construction.

Stage-2: From the journals identify the factors affecting the productivity in construction.

Stage-3: From the journals, study how the productivity is measured.

Stage-4: From the journals identify the tools and techniques to improve the productivity in construction.

Stage-5: Observe what impacts that has been caused in the construction by using these tools and techniques.

Stage-6: By using the gained from the study try and improve the productivity in the construction of a building and compare it with it benchmark.

CHAPTER-2

JOURNAL PAPERS

2.1 IDENTIFICATION OF CRITICAL FACTORS AFFECTING CONSTRUCTION LABOR PRODUCTIVITY IN INDIA USING AHP

2.1.1 Purpose of the Paper

The main aim of this study is to identify key factors affecting labor productivity in India and to give the ranking to those factors by Analytical hierarchy process.

2.1.2 Research Process

1. Critical review of literature on labor productivity.
2. To do a field survey to capture opinion of experts.
3. To identify the most critical factors associated with the labor productivity in construction projects with reference to Indian context.
4. To rank the critical factors by Analytical Hierarchy Process.
5. Conclusion and Inference.

2.1.3 Analytical Hierarchy Process (AHP)

- AHP is a decision-aiding method developed by Saaty (1980).
- It aims at quantifying relative priorities for a given set of alternatives on a ratio scale, based on the judgment of the decision maker.

2.1.4 Pair-Wise Comparison Scale for AHP Preferences

Table-1

Pair-Wise Comparison Scale for AHP Preferences	
Level of Importance	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance

7	Very strong or demonstrated importance
9	Absolute Importance
2,4,6,8	Intermediate values between adjacent scale values

**Statistical Data of Respondent of
Questionnaire used for study**

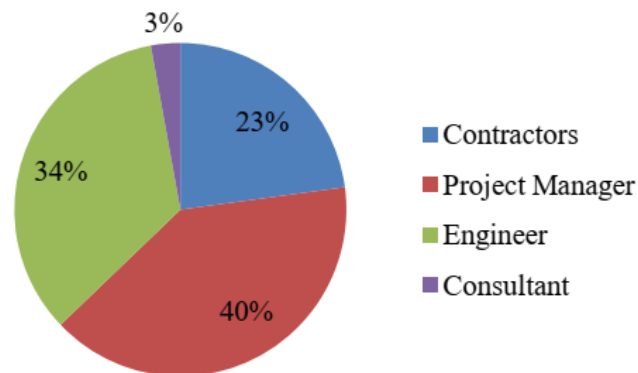


Fig-1

2.1.5 Factors Affecting Construction Labor Productivity

Productivity is the outcome of several interrelated factors. Twenty Five factors affecting Construction labor productivity are outlined with reference to Indian context by literature review, Field survey and expert opinion which are classified under the six primary groups.

Table-2

Factors Affecting Construction Labor Productivity					
Psychological factors group	Human/Labor factor group	Design factor group	Technological factor group	Managerial factor group	External factor group
-Stress - Job satisfaction -Fear of height -Personal clashes	-Level of skill -Lack of experience worker -Familiarity with job	-Design complexity level - Clarity of Technical specification - Degree of	-Construction methods - Site Layout -Unavailability of suitable tools	-Payment Delay -Shortage of Material -Work Planning and scheduling	-Weather conditions -Social-Economic Condition -Location of Project

	-Motivation	Quality control -The extent of variation/ Change orders during execution	-Rework	- Lack of Labour Supervisions -SHE (Safety, Health & Environment.)	-Project Nature
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2.1.6 Cumulative importance for factors affecting labor productivity

Table-3

Cumulative importance for factors affecting labor productivity					
SI.NO	Group Factors	Importance	factors	Importance	Cum. Importance
1	Psychological factor group	0.07754798	Stress	0.1926999	0.01494
			Job satisfaction	0.0890689	0.00691
			Fear of heights	0.3773012	0.02926
			Personal clashes	0.34093	0.02644
2	Human/Labor factor group	0.09603193	Level of skill	0.4675014	0.04490
			Lack of experience	0.1373595	0.01319
			Familiarity with job	0.1269337	0.01219
			Motivation	0.2682054	0.02576
3	DESIGN FACTOR GROUP	0.19059167	Design complexity level	0.2097289	0.03997

			Clarity of technical specification	0.3739128	0.07126
			Degree of quality control	0.2007692	0.03826
			The extent of variation/Change orders	0.2155891	0.04109
4	Technological factor group	0.19136814	Construction methods	0.2654221	0.05079
			Site layout	0.2692039	0.05152
			Unavailability of suitable tools	0.2117567	0.04052
			Rework	0.2536173	0.04853
5	Managerial factor group	0.26991924	Payment delay	0.2260462	0.06101
			Shortage of material	0.3293835	0.08891
			Work planning & scheduling	0.1579319	0.04263
			Lack of labor supervision	0.124136	0.03351
			SHE (safety, Health & Environment)	0.1625024	0.04386
6	External factor group	0.10293497	Weather conditions	0.4520822	0.04654
			Social economic conditions	0.2239937	0.02306

	Location of project	0.1555701	0.01601
	Project location	0.168354	0.01733

Table-4

Priority and Ranking vectors		
Criterion	Priority vector	Ranking Vector
Psychological factors	0.077548	0.287301
Human/Labor factors	0.096032	0.35578
Design factor	0.190592	0.706106
Technological factor	0.191368	0.708983
Managerial factor	0.269919	1
External factors	0.102935	0.381355
Consistency ratio	0.063944 < 0.1	
For The CR to be acceptable it should not exceed 0.1		

2.1.7 Conclusions

- From this study we can conclude that by using AHP for identifying and ranking the factors affecting the productivity in construction.
- Provide professionals and contractors guidance for focusing, acting upon and controlling the most significant factors perceived to influence the construction labor productivity (CLP) on site.

2.2 A REVIEW ON PRODUCTIVITY IMPROVEMENT IN CONSTRUCTION INDUSTRY

2.2.1 Purpose of the paper

This paper includes systematic literature reviews on productivity in construction industry the paper gives an review on different method which are used for measurement of construction productivity, factors affecting and theories on improvement of construction productivity such as labour factor, management factors and external factors, the paper further reviews on the different innovations which are made for improvement in construction productivity.

2.2.2 Research process

1. Classify workers activities in three groups (effective work, essential contributory work, and inefficient work)
2. Collection of data from field observation results in particular order.
3. Taking randomized observational result data.
4. Then checklist is created for the workers activity.
5. Add all checked workers activities and then percentages calculation.
6. Conclusion and inference.

2.2.3 Factors Affecting Productivity

Table-5

1.MANAGEMENT			
Management System	Design	Material	Variation order
•The Decision making on the site is as important of actual construction work. •So for high productivity proper decisions should be taken.	•Should concentrate on jobsite design, in which temporary facilities, construction equipment, material storage areas, workplaces, access roads,	Material management is a worldwide problem & research is going on which highlights effects on site productivity.	•The variation affects efficiency of workers by rework, disruption & presence due to change work. •William Ibbs (2012) had studied on variation order they collected the database from 226 projects

	site objects must be discusses.		
Oral mustada et al (2011) presented supervised vs. Supervised learning for crew& in supervised learning they used neural networks as decision making as 1) Feed forward back propagation (FFBP) 2) General regression neural networks (GRNN) 3) SOM.	They used rule thumb, approach & first come-first serve technique while designing they concentrated on contractor (39%), consultant (30%) & designer (26%).	David grau et al (2009) Studied on impact on productivity due to atomization in identifying & localizing the components on site. Using radio frequency identification (RFID) & global positioning system (GPS) They recorded the time taken for traditional site material tracking and the results proved very use full in managing materials,	• They recognize the average amount of change in projects was 8%. • They found that average PI was 0.82 meaning an 18% of total loss • Productivity which shows that small amount of change can cause worse cost change in schedule performance than budgeted.

Table-6

2 Labour		
Lack of Measurement	Motivation and Safety	Skills and Ability
• There are many labour factors that affects construction project. • For improvement of labour productivity the activities on site should be measured and record should be kept on regular basis and should always be compared with a standard acceptable benchmark. • This will give a proper baseline productivity of previous projects having same conditions.	The lack of motivation in workers will leads to take them in anti-work behaviors which leads to negligence of their duties, coming late to work, failures to meet deadlines, absentees, frustrations on job site which affects the labour productivity. Khan Ahsan Ali (2015) conducted a questioner survey in which they conducted four tests 1) Data reliability and validation. 2) Interpretation of	The personal attributes of workers contributes more of the factors that directly affect the productivity. The factors are as. 1) Worker skills, experience, training and qualification, 2) Physical and mental ability, 3) Use of both skills and ability for the production process. Laura florez (2016) collected the multiple Masons having different skills, personalities and

	motivational factor. 3) Shapiro willk test 4) Kruskal Wallis test And they found that many of organizations are not interested in motivating their workers, which affects their productivity and they conclude that the basic motivational facility should be provided for enhancing the labour productivity.	capabilities for a Complex masonry job. They were implied to do job for several days. And she got a conclusion as the different skills of workers balance the complexity characteristics of those jobs on site.
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Table-7

3 External issues
•There are some other issues than labour and management that harms productivity in high manner, such as social factor, economic factor, weather conditions, labour unions, legal issues etc. •Xiaodong li et al. (2016) had studied on high temperature stress on labour productivity. They collected data in two phases first in June for 27days and in July-August for 27 days by taking eight rebar workers for field measurements with grate Body Mass Index (BMI) •They found that period of 7:00 to 9:00 is safest time to work. 7:00 to 8:00 shows 3.57% hazards and 8:00 to 9:00 shows 7.14% hazards which are safe, but the period of 14:00 to 15:00 most hazardous and dangerous time which shows 57.14% of hazards. •Unsatisfactory working conditions as high noise level, high temperature result in productivity loss.

2.2.4 CONCLUSIONS

- From the above literature it is concluded that there are many methods of increasing productivity in construction industry.
- There is enormous study on the methods which improve the productivity which consists of material tracking, healthy and safe working condition and effective management systems.

2.3 Critical Factors Affecting Labour Productivity in Construction Projects: Case Study of South Gujarat Region of India

2.3.1 Purpose of the paper

- The Aim of this study is to find the critical factors affecting labour productivity by using AHP technique and RII technique
- And by doing so observe the difference between these techniques.

2.3.2 Research Process

1. Collecting relevant data for this investigation by a structured, close-ended questionnaire survey.
2. Classify workers activities in three groups (effective work, essential contributory work, and inefficient work).
3. Give the ranking to these factors by AHP (analytical hierarchy process) and RII (relative importance index) techniques.
4. Conclusion and Inference.

2.3.3 Data Collection and Calculation

On the basis of related previous studies on labor productivity and the input of local industry experts, professionals, and practitioners, 27 factors were identified which are having an influence on construction labor productivity in the Gujarat state of India.

2.3.3.1 AHP ranking method

- To obtain statistically representative sample size of the population following equation was used Where n, m and N = the sample size of limited, unlimited available population, respectively. m is estimated by following Equation:

$$\hat{n} = \frac{m}{1 + \frac{(m-1)}{N}} \quad m = \frac{z^2 * p * (1 - p)}{e^2}$$

- Where z=the statistic value for the confidence level used, i.e, 1.96, and 1.645 for 95% and 90% confidence level respectively; p=the value of the population that estimated and e=the sampling error to be estimated. Because the value of p is unknown sincich et al. (2002) suggest the value 0.50 to be used in sample size.

- Here confidence level is taken as 90%.Accordingly,for the total number of classified contractors, the sample size is 152.

$$m = \frac{1.645^2 * 0.50 * (1 - 0.50)}{(0.05)^2}$$

$$\approx 271$$

$$n = \frac{271}{1 + \frac{(271-1)}{344}}$$

$$\approx 152$$

2.3.3.2 RII ranking method:

- Relative Importance Index method helps to determine the relative importance of the various factors affecting on labour productivity. The four-point scale ranging from 1 (less important) to 4 (extremely important) is adopted and it is transformed to relative importance indices (RII) for each factor as follows:
- Where: n1, n2, n3, and n4, = the number of respondents who selected: 1, for no effect; 2, for little effect; 3, for moderate effect; 4, for strong effect;
- N is the weighting given to each factor by the respondents (ranging from 1 to 4), A is the highest weight (i.e. 4 in this case). The RII value had a range from 0 to 4 (0 not inclusive), Higher the value of RII, more important was the factors affecting on labour productivity.

$$RII (\%) = \frac{4(n4)+3(n3)+2(n2)+1 (n1)}{4 (n1+n2+n3+n4)} * 100$$

2.3.3.3 Ranking of factors affecting labour productivity by AHP & RII Technique

TABLE-8

Ranking of factors affecting labour productivity by AHP & RII Technique				
NO	CRITERIA	SUBCRITERIA	AHP RANK	RII RANK
1	TECHNOLOGICAL			
		Clarity of technical specification	10	3
		The extent of variation/change order During execution	16	15
		Coordination level among	13	21

		design disciplines		
		Design complexity level	14	12
		Rework	15	13
		Site lay out	9	18
		Inspection delay /stringent by the engineer	12	8
		Site restricted access	11	14
2	HUMAN/LABOUR			
		Motivation of labour	4	5
		Skill of labour	8	2
		Physical fatigue	5	7
		A shortage of experienced labour	6	9
3	MANAGEMENT			
		Construction managers lack of leadership	21	10
		Lack of labour supervision	27	23
		Working over time	26	25
		Crew size and composition	24	24
		Unsuitability of storage location	25	27
		Accidents as a result of poor	22	17

		site safety programme		
		TYPE B (MATERIAL)		
		Proportion of work subcontracted	17	20
		Unrealistic schedules and expectation of labour performance	23	11
		Shortage of materials	19	4
		Construction method	20	6
		Payment delay	18	1
4	EXTERNAL			
		High/low temperature	1	16
		High humidity	7	22
		High wind	3	26
		Rain	2	19

2.3.4 Conclusion

- Finding from this study reveals that there is a contradiction in critical factors ranking by two techniques. RII technique gave first rank to delay in payments while AHP technique gave first rank to high/low temperature.

2.3.5 Research summary

TABLE-9

RESEARCH SUMMARY				
SI.NO	RESEARCH PAPER	FINDINGS OF THE STUDY	METHODS AND TECHNIQUES USED	INFERENCE
1.	Identification of Critical Factors	AHP method is useful in	By distributing the questionnaire	Ranking of the factors affecting

	Affecting Construction Labor Productivity in India Using AHP	identifying and ranking the critical factors that reduce the productivity in construction. The questionnaire is based on the AHP pair wise comparison of critical factors	by handing over to the participants directly or mailing them	productivity in construction is made simple
2	A REVIEW ON PRODUCTIVITY IMPROVEMENT IN CONSTRUCTION INDUSTRY	The paper gives an review on different method which are used for measurement of construction productivity, factors affecting and theories on improvement of construction productivity	Qualitative and Quantitative data's were collected from various participants to identify and mitigate the factors that affect the productivity in construction	The factors affecting the productivity in construction are combined into 3 Groups and their mitigation process are discussed.
3	Critical Factors Affecting Labour Productivity In Construction Projects: Case Study Of South Gujarat Region Of India	Total 51 feedbacks were analyzed through the Analytic hierarchy process (AHP) and Relative Importance Index (RII) techniques.	By distributing the questionnaire by handing over to the participants directly or mailing them	RII technique gave first rank to delay in payments while AHP technique gave first rank to high/low temperature.

CHAPTER-3

NET CASE STUDY

3.1 BUILDING DETAILS

Building type-Multi-Storied Apartment building.

No.of floors-G+19

Location-Mumbai

No.of towers-2

3.2 CALCULATION OF PRODUCTIVITY

Productivity is generally ratio of output to input. In form of Equation it can be shown as follows:

Productivity = Output ÷ Input= Total output ÷ Total work hour.

- Different measures of productivity serve different purposes.
- Thomas et al.defined different aspects of measures as follows:
 - a) Economic Model: Total Factor Productivity (TFP)
(TFP) = Total Output/Labour +Material +Equipment+Energy +Capital.
 - b) Project Specific Model:
Productivity = Output/Labour +Material +Equipment.
 - c) Activity Oriented Model:
Labour Productivity = Output/Labour cost

3.3 DATA COLLECTION FROM QUESTIONIRE:

- Data required to carry out the research was collected by Questionnaire Survey.
- 24 factors were identified which are having influence on construction Labour productivity in Mumbai Region.

TABLE-10

DATA COLLECTION FROM QUESTIONIRE			
Sl.NO	Factors affecting	RII	Ranking

1	Skilled Labour	0.970	1
2	Availability of tools	0.955	2
3	Construction method	0.941	3
4	Communication between site management and labour	0.926	4
5	Scheduling of work	0.882	5
6	Numbers of labours on site	0.853	6
7	Motivation to labour	0.838	7
8	Meetings with labour contractor	0.823	8
9	Unscheduled extra work	0.808	9
10	Climatic condition	0.794	10

3.4 PRODUCTIVITY IN CONSTRUCTION CALCULATION

- For purpose of finding labour productivity, erection and binding of reinforcement of column has been selected for present study.
- Skilled labour and change in site layout are the two factors considered for calculating changes.
- Work study method was used for data collection.

- For research purpose it is considered reinforcement binding of column of building with nos. of floors: G + 19 and from varying sizes of column we took size of Column as 600mm x 600mm x 3000mm.

3.5 EFFECT OF CHANGES IN SITE LAYOUT

- It was seen that steel bars and stirrups are stacked away from the construction and also not properly placed.
- The steel bars and stirrups should be placed separately according to their diameter and size so that time required to finding the bar required can be minimized.

3.5.1 Result

Average time taken for erection and binding of reinforcement of column without changes = 200 min/column

TABLE-11

TIME TAKEN FOR ERECTION WITHOUT CHANGES IN SITE LAYOUT		
SI.NO	TIME TAKEN	NO.OF LABOUR
1	200 min/column	2

Average time taken for erection and binding of reinforcement of column with changes in site layout = 190 min/column.

TABLE-12

TIME TAKEN FOR ERECTION WITH CHANGES IN SITE LAYOUT		
SI.NO	TIME TAKEN	NO.OF LABOUR
1	190 min/column	2

Time saving = 10 min/column

3.5.2 Effect of Changes in Site Layout Along With Changing Semi Skilled Labour with Skilled Labour

- It was seen that labour used for preparation of column were semiskilled. This was resulting in compromising with quality of work and time consuming.

3.5.3 Effect of Changes in Site Layout Along With Changing Semi Skilled Labour with Skilled Labour

- It was seen that labour used for preparation of column were semiskilled. This was resulting in compromising with quality of work and time consuming.
- With use of two skilled labours instead of two semiskilled labours the time could be reduced and there was no need to compromise with quality of work
- Average time taken for erection and binding of reinforcement of column without changes = 200 min/column

TABLE-13

TIME CONSUMPTION OF CONSTRUCTION WITH SEMI-SKILLED LABOURS AND WITHOUT CHANGES IN SITE LAYOUT				
SI.NO	TIME TAKEN	NO.OF COLUMNS	LABOUR USED	WORKING HOURS
1	200 MIN/COLUMNS	2	2(SEMI-SKILLED)	8 HOURS/DAY

- Average time taken for erection and binding of reinforcement of column with changing of labours = 155 min/column

TABLE-14

TIME CONSUMPTION OF CONSTRUCTION WITH SKILLED LABOURS AND WITH CHANGES IN SITE LAYOUT				
SI.NO	TIME TAKEN	NO.OF COLUMNS	LABOUR USED	PRODUCTIVITY
1	155 MIN/COLUMNS	3	2(SKILLED)	8 HOURS/DAY

- Time saving = 45 min/column

- Since effect of change is considerable after applying changes in site layout along with changing semi-skilled labour with skilled labour; considering result of those changes data is analyzed for saving in cost and time per floor and from that for whole building.
- To find out the productivity we are using activity oriented model as $\text{Labour Productivity} = \frac{\text{Output}}{\text{Work hour}}$
- Before application of any changes on site number of columns completed per day are 2 which shows that 494.53 kg of steel reinforcement binding used to complete in 8 working hours. From this the productivity can be calculated as
- $\text{Productivity} = \frac{494.53}{8} = 61.81 \text{ kg/ work hour.}$

TABLE-15

PRODUCTIVITY OF CONSTRUCTION WITH SEMI-SKILLED LABOURS AND WITHOUT CHANGES IN SITE LAYOUT						
SI.NO	TIME TAKEN	NO.OF COLUMNS	LABOUR USED	STEEL USED	WORKING HOURS	PRODUCTIVITY
1	200 MIN/COLUMNS	2	2(SEMI-SKILLED)	494.53 KG	8 HOURS/DAY	61.81 kg/ work hour

- After application of changes it was seen that columns completed per day are 3 which shows that 741.8 kg of steel reinforcement binding used to complete in 8 working hours. From this the productivity can be calculated as
- $\text{Productivity} = \frac{741.8}{8} = 92.72 \text{ kg/ work hour}$

TABLE-16

PRODUCTIVITY OF CONSTRUCTION WITH SKILLED LABOURS AND WITH CHANGES IN SITE LAYOUT						
SI.NO	TIME TAKEN	NO.OF COLUMNS	LABOUR USED	STEEL USED	WORKING HOURS	PRODUCTIVITY
1	155 MIN/COLUMNS	3	2(SEMI-SKILLED)	741.8 kg	8 HOURS/DAY	92.72 kg/ work hour

- This shows 50% increase in reinforcement binding labour productivity. Increase in labour productivity also results in saving cost and time. It can be seen in following calculations.

3.5.4 Saving In Time and Cost Due To Changes Applied Per Floor

- Data collection using time study method showed considerable reduction in time after applying changes with site layout and labours which means considerable saving in time for the activity and which in turn means saving in cost as well.
- Calculations regarding saving in time and cost are shown as follows.

3.5.5 Consumption in Time (Prior To Changes)

- Number of columns of size 600 x 600 x 3000 per floor = 32.
- Number of columns completed prior to changes = 2 per day.
- Number of days to complete reinforcement of column = 16 days.
- Time for 32 columns without applying changes = $32 \times 200 = 6400$ mins.

3.5.6 Consumption In Time (After Changes)

- Time for 32 columns after changes in site layout and changing labour with skilled labour = $32 \times 155 = 4960$ min
- Time saving per floor = $(6400 - 4960) = 1440$ mins

3.5.7 Saving In Time (After Changes)

- This time is equivalent to $(1440/155 = 9.29 \approx 9)$ 9 extra columns.
- With time of 155 min per column and 8 hours of working day per labour number of columns completed per day = 3 column
- Time required to complete 32 columns = $10.6 \approx 11$ days
- Saving in time after changes applied = 5 days

3.4.8 Construction Cost (Prior To Changes With Semi-Skilled Labours)

- Wages paid to semi-skilled labour = Rs. 350/-
- Number of labours = 2

- Number of days required to complete 32 columns before applying any changes = 16 days
- Cost of semiskilled labours per floor when changes were not applied on site= 16 X350X2 = Rs. 11200/-

3.4.9 Saving In Cost (After Changes With Semi-Skilled Labours)

- Wages paid to skilled labour = Rs. 400/-
- Number of labours = 2
- Number of days required to complete 32 columns before applying any changes = 11 days
- Cost of skilled labours per floor when changes were not applied on site= 11 X400X2 = Rs. 8800/-
- Savings per Floor = 11200-8800 = Rs. 2400/-

3.4.10 Saving In Cost For Building

- Number of floors = G + 19 =20
- Savings per floor = Rs. 2400/-
- Net savings for entire building (1 tower) = 2400 x 20 =48000/-
- Changing the semi-skilled labour with skilled labour along with change in site layout helped increasing labour productivity for reinforcement binding by 50% and it also helped in reducing time by 5 days per floor and labour cost by Rs. 2400/- per floor which results in saving of Rs.48000/-for entire building. Using this technique it helped to reduce cost by 20% of labour cost per floor.

3.4.11 Conclusion

Despite of time consuming techniques Work study and work measurement are the techniques useful for data collection of labour and improvement in labour productivity.

CHAPTER-4

4. CASE STUDY

4.1. OBJECTIVE OF THE STUDY:

- To find out how productivity of the construction affects the cost and time of the project.
- To find out how to improve the productivity in the project by using various techniques.

4.2. STUDY PROCESS:

1. Selecting suitable activities for the study
2. By using work sampling technique Measure the work progress
3. By using value stream mapping identify value added and non- Value added activity
4. Identify the cause for these non-value added activities and
Rectify them to increase productivity
5. Inference and conclusion

4.3. WORK SAMPLING TECHNIQUE:

Work sampling is the statistical technique used for determining the proportion of time spent by workers in various defined categories of activity.

4.4. VALUE STREAM MAPPING:

Value stream mapping (VSM) is a tool used within the field of Project Management to visualize and improve the overall flow process of a product or service from raw material all the way to the customer.

(TABLE-17)

SELECTED ACTIVITIES		
• Bar bending for ring rods	• Plastering work	• Block work

4.5 CASE STUDY-1

BUILDING NAME-Celesta

LOCATION-PALLIKARANAI

PROJECT AREA: 134000 Sft

STATUS: UNDER CONSTRUCTION

NO. OF BLOCKS-6

NO. OF FLOORS-STILT+5

NO.OF UNITS PER FLOOR-4

TOTAL NUMBER OF

HOUSES-100

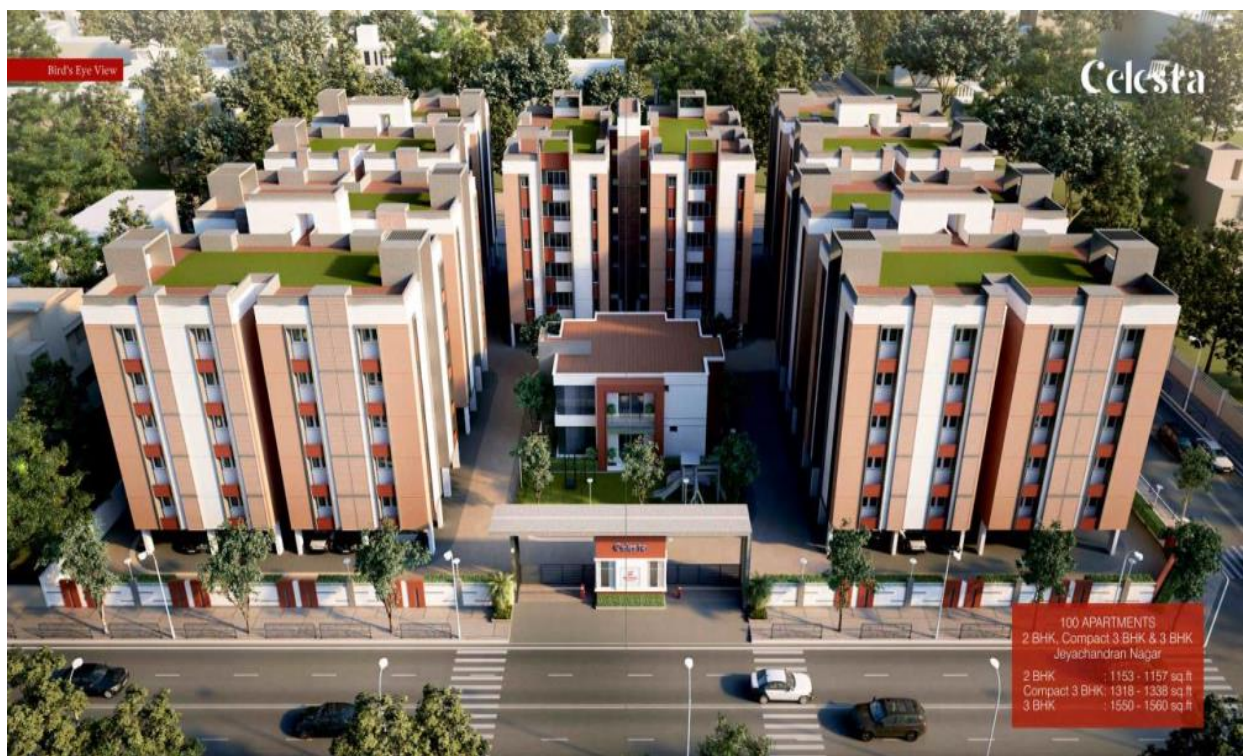


Fig-2

4.5 BAR BENDING ACTIVITY:

4.5.1 Area Of Study:

Bar bending activity for the steel required for 5th Floor Of block-5.

4.5.2 Limitation Of The Study:

Since I am measuring the bar bending activity I am limiting my study to bar bending of rings for beams and columns.

4.5.3 Process:

1. Shifting of steel from storage to workplace.
2. Straightening of U-shaped bars.
3. Cutting of steel before sending for bending Activity.
4. BarBending work.



Fig-3

4.5.4 Key Plan:

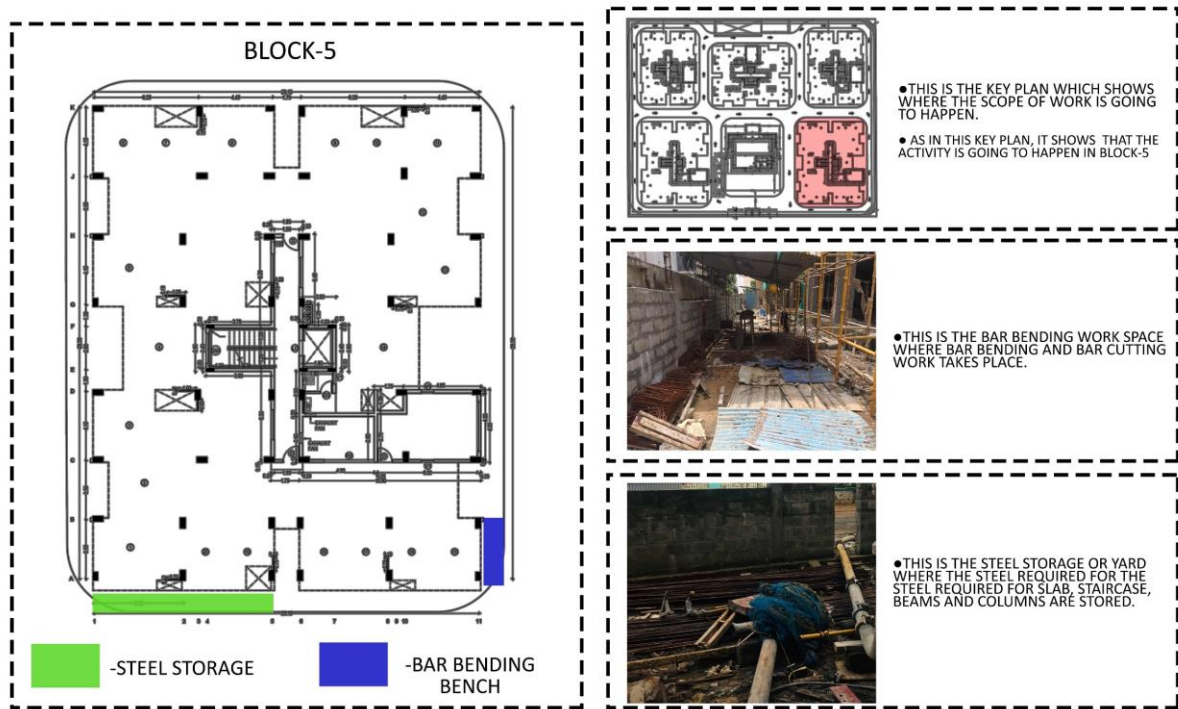


Fig-4

4.5.5 Data for Shifting Of Steel from Storage to Work Place:

(TABLE-18)

Data for Shifting Of Steel from Storage to Work Place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of steel bars moved per shift or cycle	5 bars
4	Distance traveled per shift or cycle	20m for shifting and 20m for returning to the storage
5	Total NO. of shifts or cycle	57
6	Time taken to complete 1 complete shift or cycle	75 seconds
7	Total time consumed for this activity(Overall Cycle time)	4275 seconds(71.2 minutes) (1.18 Hours)
8	Value Added Time	0

4.5.6 Data for Straightening Of Steel Bar:

(TABLE-19)

Data for Straightening Of Steel Bar		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of steel bars moved per shift or cycle	5 bars
5	Total NO. of shifts or cycle	57
6	Time taken to complete 1 complete shift or cycle	265 seconds(4 min 25 sec)
7	Total time consumed for this activity(Overall Cycle time)	15105 seconds(4.2 hours)
8	Value Added Time	0

4.5.7 Steel Cutting Details:

TABLE-20

Steel Cutting Details				
SI.NO	STRUCTURE	LENGTH OF RING	WEIGHT PER RING	TOTAL NO.OF RINGS REQUIRED
1	BEAM	1.3 METERS	0.51 KG	1736
2	COLIMN	1.5 METERS	0.60 KG	735
3	Total No.of Steal Bars Required • Steel Bars Required For TMT Rings In Beam-194 Bars • Steel Bars Required For TMT Rings In Column-92 Rings			286 8 mm TNT BARS (or) 1,430 KG OF 8 mm TNT BARS

4.5.8 Data For Cutting Of Steel Bars For Beam Rings:

TABLE-21

Data For Cutting Of Steel Bars For Beam Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of parts to be cut in a steel bar	9
4	Length of 1 ring	1.3 METERS
5	NO. of steel bars grouped per cycle	10

6	Total NO. of shifts or cycle	19
7	Time taken to completely cut 1 cycle	30 sec X 9=270 seconds
8	Time taken to realign the steel bar after every cut	20 sec X 9=180 seconds
9	Total time consumed for completing 1 cycle	270 + 180 = 450 seconds
10	Total time consumed for this activity(Overall Cycle time)	8,550 seconds(2.4 hours)
11	Value Added Time	5,130 seconds(1.4 hours)

4.5.9 Productivity Of Cutting Of Steel Bars For Beam Rings:

TABLE-22

Productivity Of Cutting Of Steel Bars For Beam Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Steel required	885.4 kg
2	Total time taken to complete the activity	2.4 hours
3	Productivity of cutting steel bars for beam rings	369 kg/hours

4.5.10 Data For Bar Bending Of Steel Bars for Beam and Column Rings:

TABLE-23

Data For Bar Bending Of Steel Bars for Beam and Column Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	2(1 Bar bender, 1 Fixer)
3	Total NO. of rings required for Beams and Columns	1736 + 735 = 2,471
4	Steel used	1,430 kg
5	Time taken to create 1 ring	38 Seconds
6	Time taken to realign a new bar for bending	5 Seconds
7	Total time consumed to complete all the rings(cycle time)	78.24 Hours +2 Hours = 80.24 Hours

8	Value Added Time	78.24 Hours
9	Necessary Non Value Added Time	2 Hours

4.5.11 Productivity Of Bar Bending Of Steel Bars For Beam And Column Rings:

TABLE-24

Productivity Of Bar Bending Of Steel Bars For Beam And Column Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Rings required	2471
2	Total time taken to complete the activity	80.24 Hours
3	Steel used	1430 kg
4	Productivity of bending of steel bars for beam and column rings	31 Rings/hours

4.5.12 Brief Summary of Barbending Work:

TABLE-25

Brief Summary of Barbending Work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Total Labours working in the crew	4 Labours -Bar bender -Fixer -Male helper-1 -Male helper-2
2	Total amount of steel used	1,430 kg

3	Total time consumed for this activity(Overall Cycle time)	89 Hours
4	Value Added Time	80.24 Hours
5	Non Value Added Time	8.76 hours

4.5.13 Current State Vsm For Bar Bending Activity:

- From the above collected data it is evident that there is a overall duration of 8.24 hours Non-Value Added Time taken place In the Bar Bending activity.
- To create the Current State VSM for bar bending activity these Non Value Added Activities should be noted and listed out.

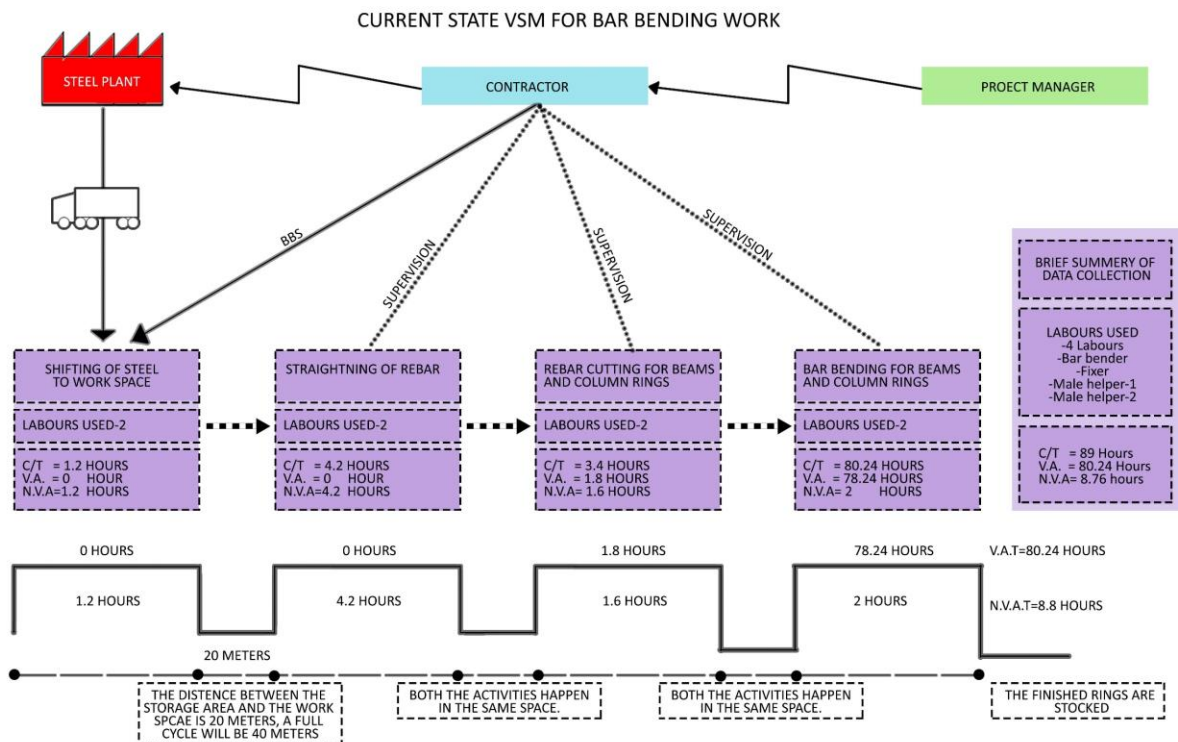


Fig-5

4.5.14 Improvements To The Current State Vsm For Bar Bending Activity:

- According to the current state VSM the Non Value Added activities are identified and ways to rectify the activities are discussed.

4.5.15 Rectifying Non Value Adding Activity-1 (Shifting Of Steel From Storage To Work Place):

- From the data gathered from site, the steel storage space was located relatively near to the entrance of the site itself due to convenience of offloading.
- The bar bending work space was located farther away from the storage space which seems to be an isolated spot.
- Because of this factor the shifting of the material to work space is adding up to the non-value added time.

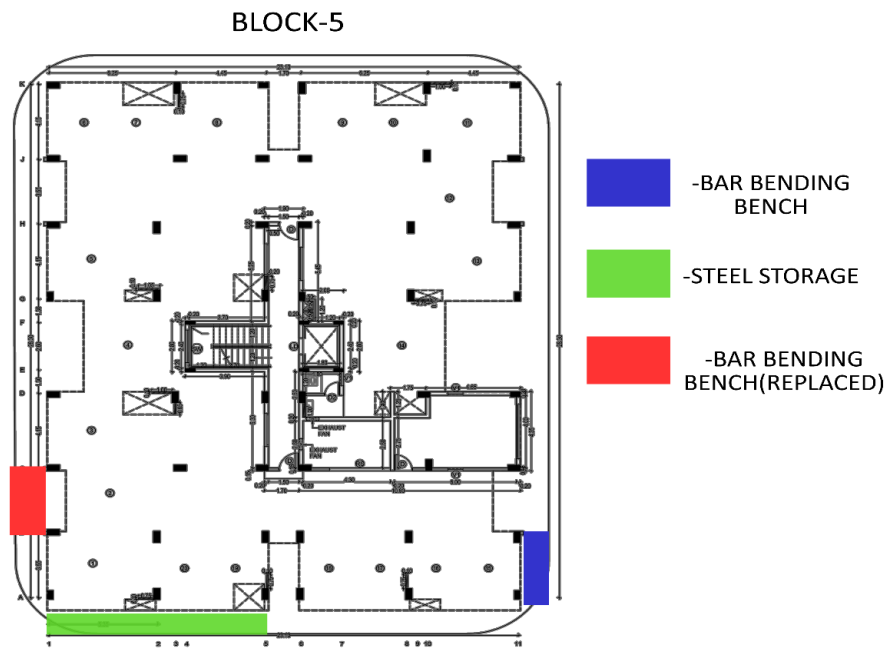


Fig-6

- To rectify this problem we can replace the bar bending work bench from its previous location to new place where it will be in a much closer proximity to the work space.
- By taking this action the material shifting task can be totally neglected since the work bench is located near to the storage space.
- A non-value added time of 1.2 hour can be saved from the overall time after this action.

4.5.16 Rectifying Non Value Adding Activity-2 (Straightening Of Steel Bar):

- Straightening of U-shaped TMT rod is a necessary activity which does not add any value to the Bar Bending process.
- This task requires 2 male helpers and consumes a non-value added time of 4.2 hours.
- This activity also can be fully neglected by ordering 12 meter straight TMT rod which can be transported using a trailer vehicle instead of the conventional U-shaped TMT rods.
- By taking this action a 4.2 hours of non-value added time can be saved from the overall time.

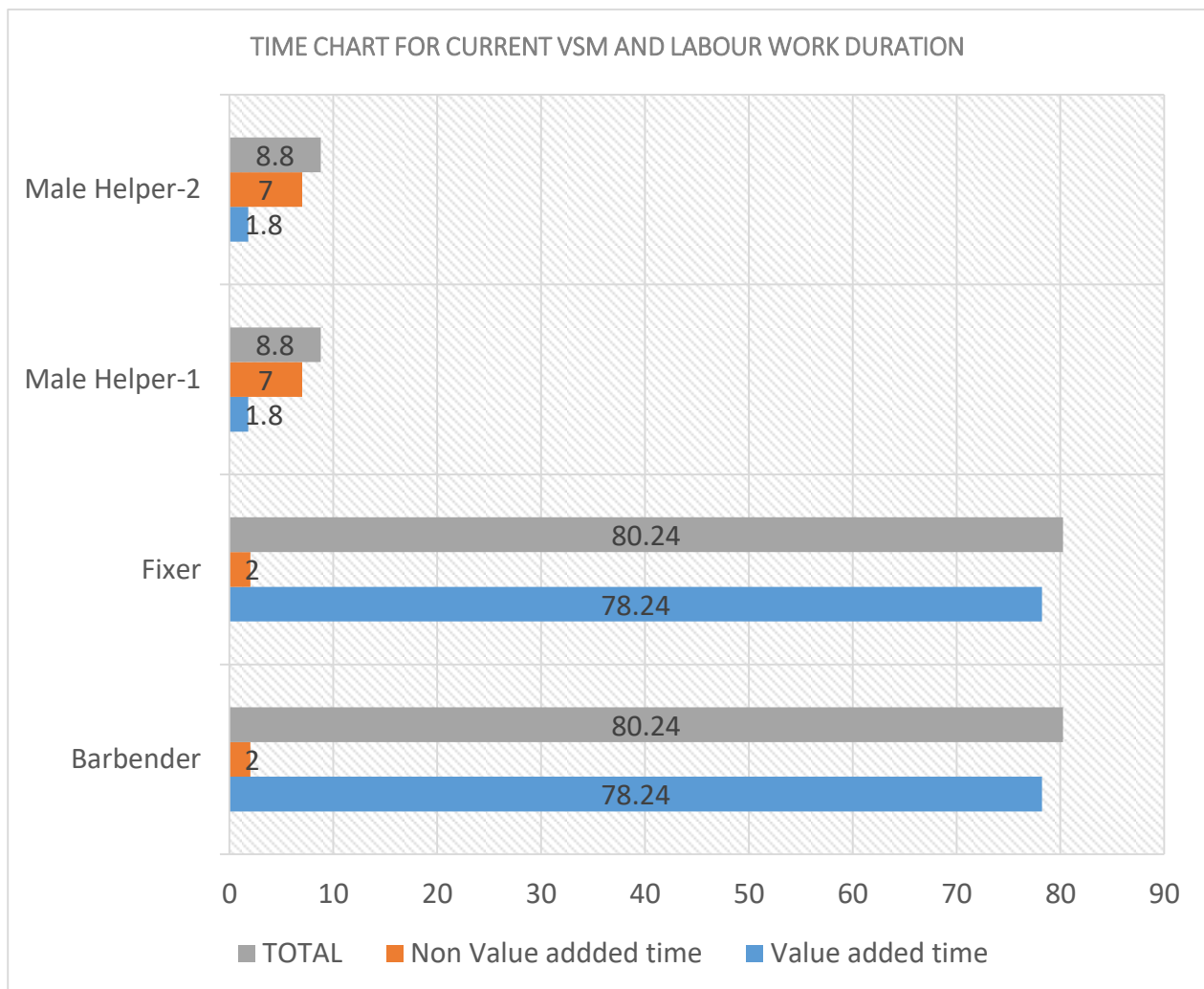


Fig-7

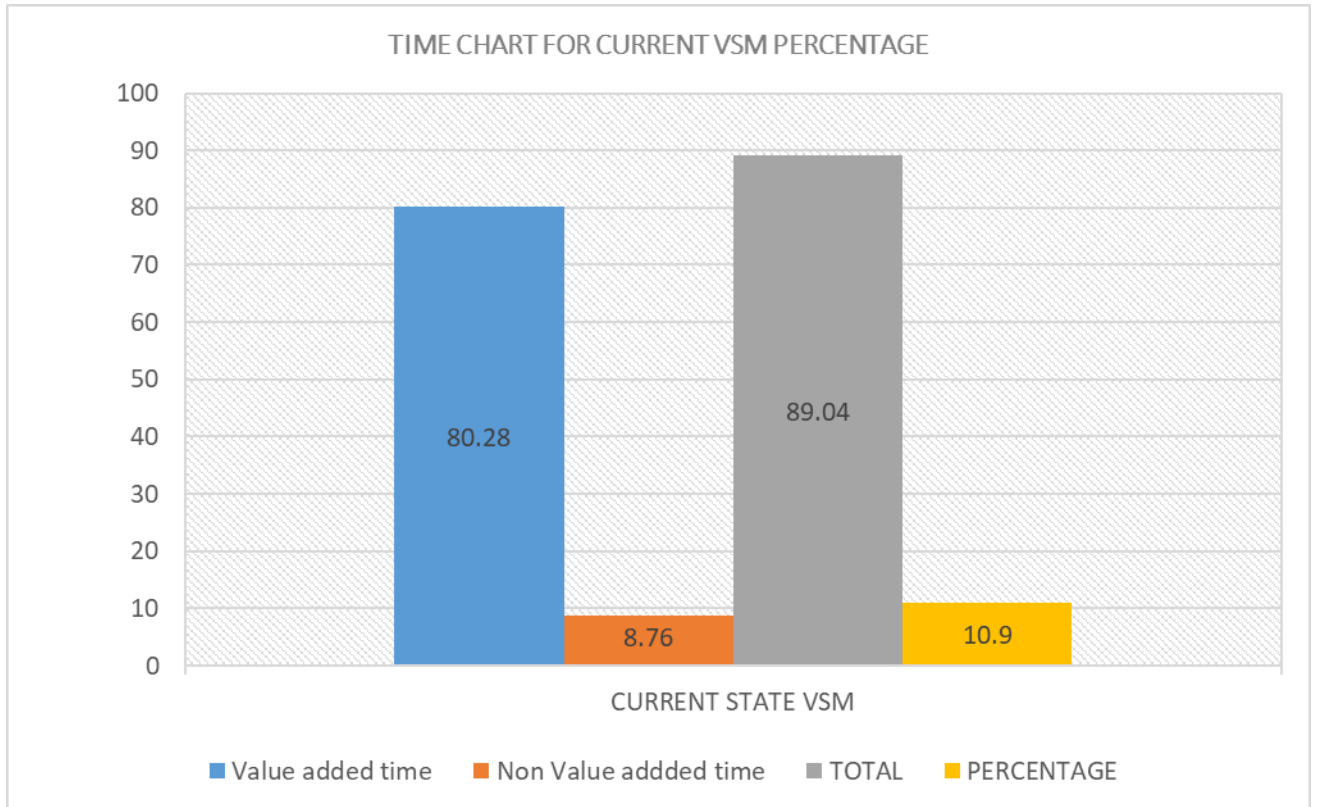


Fig-8

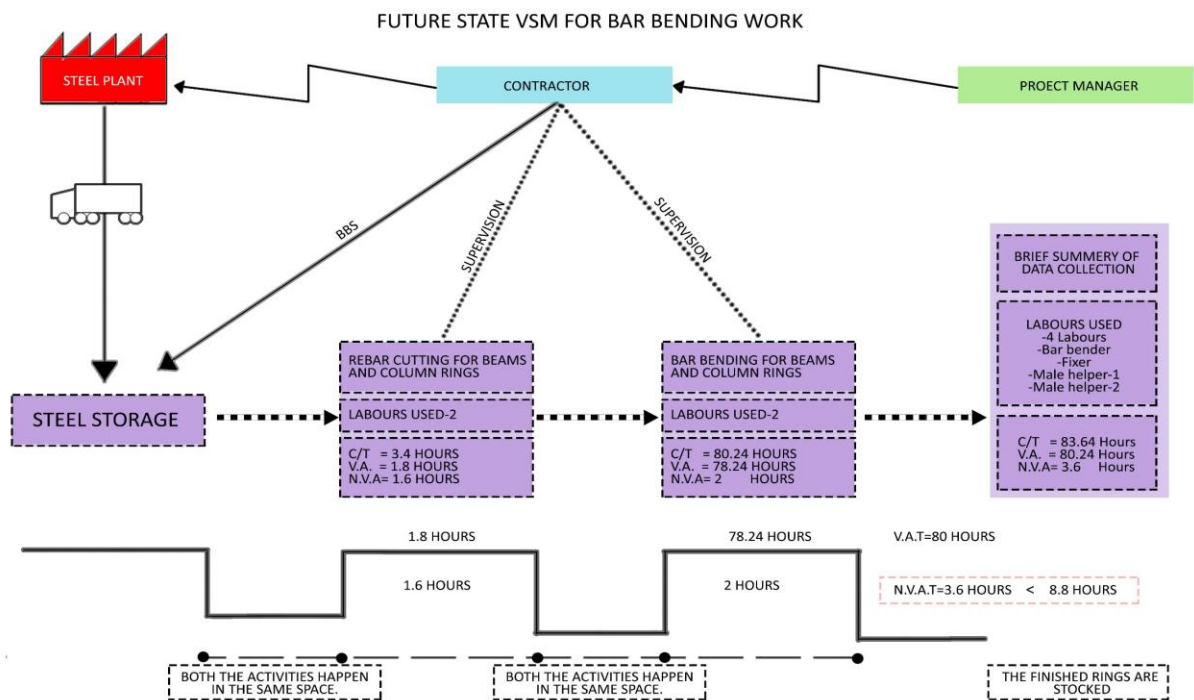
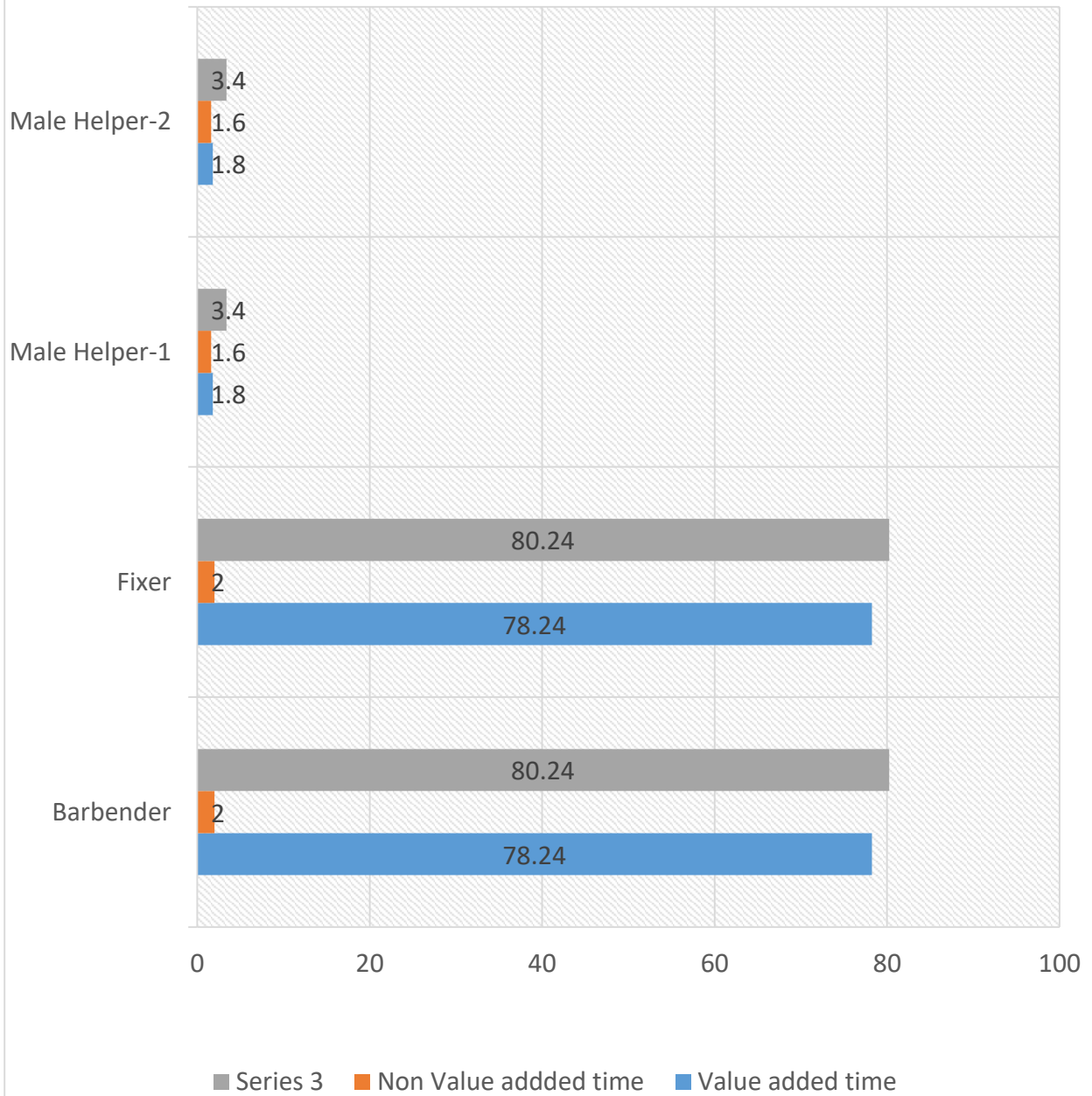


Fig-9

TIME CHART FOR FUTURE VSM AND LABOUR WORK DURATION
Fig-10



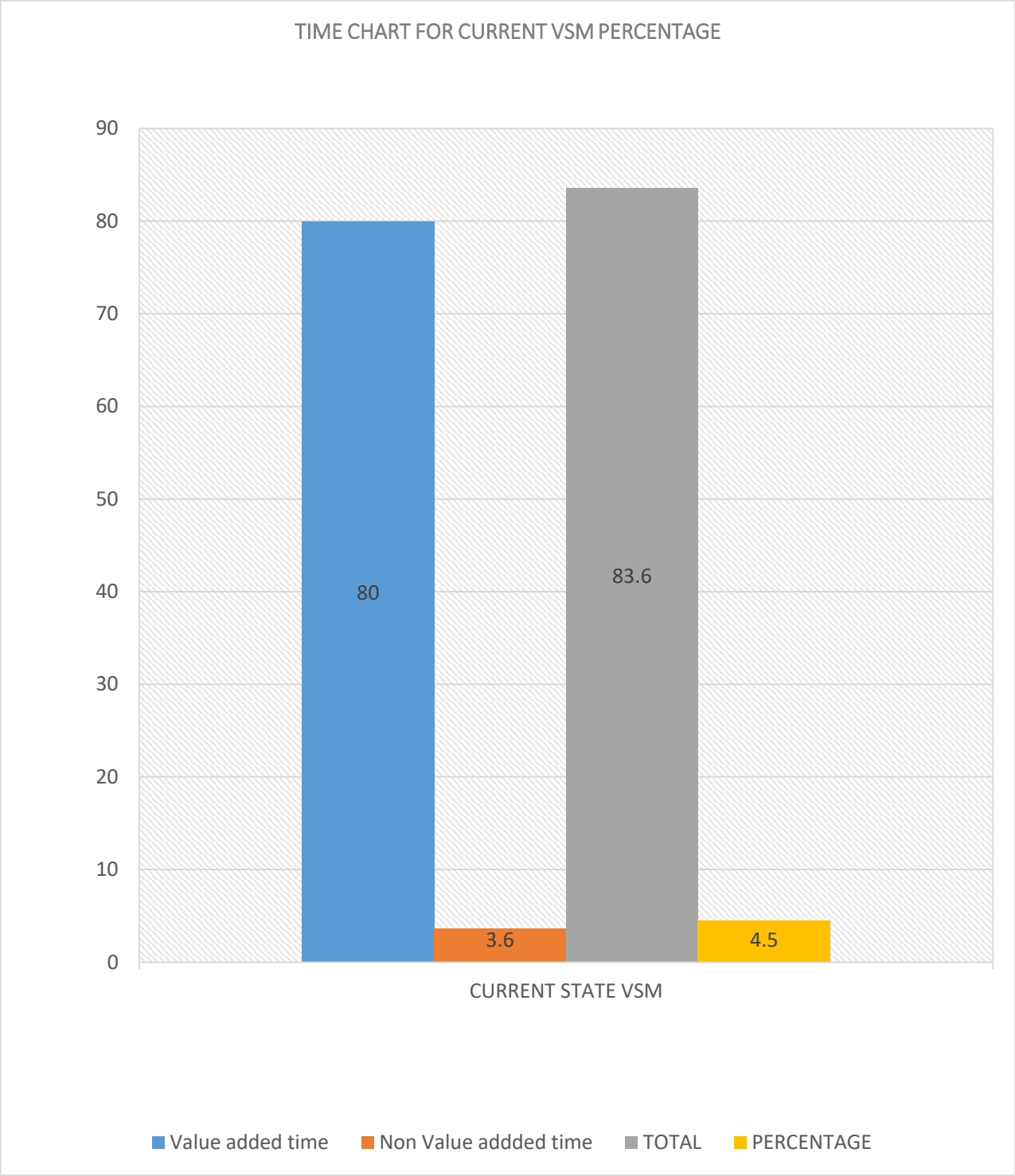


Fig-11

(TABLE-26)

COST ANALYSIS FOR BAR BENDING FOR CURRENT STATE AND FUTURE STATE VSM			
SI.NO	DESCRIPTION	CURRENT STATE	FUTURE STATE
1	NUMBER OF LABOURS USED	4 LABOURS BARBENDER-1 MALE HELPERS-3	4 LABOURS BARBENDER-1 MALE HELPERS-3
2	WAGES OF LABOURS	MASON-Rs 900/DAY MALE HELPER- Rs 700/DAY	MASON-Rs 900/DAY MALE HELPER- Rs 700/DAY
3	TIME TAKEN TO FINISH THE TASK	BARBENDER:10 DAYS MALE HELPER 1: 10 DAYS MALE HELPER (2,3): 1 DAY	BARBENDER: 10 DAYS MALE HELPER: 10 DAYS MALE HELPER (2,3): 1/2 DAY
4	COST OF LABOURS	$(1 \times 900 \times 10) + (1 \times 700 \times 10) + (2 \times 700 \times 1)$ =9000+7000+1400 =17,400	$(1 \times 900 \times 10) + (1 \times 700 \times 10) + (2 \times 700 \times 1/2)$ =9000+7000+700 =16,700

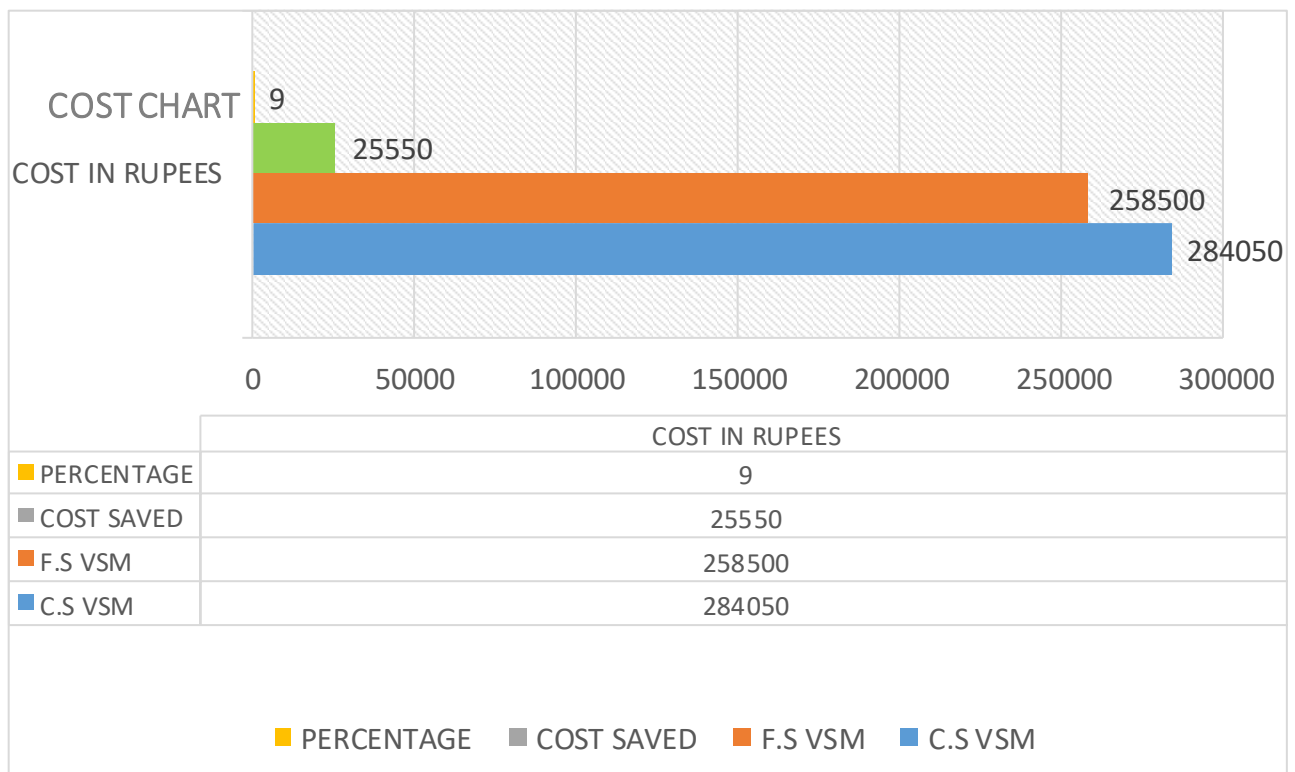
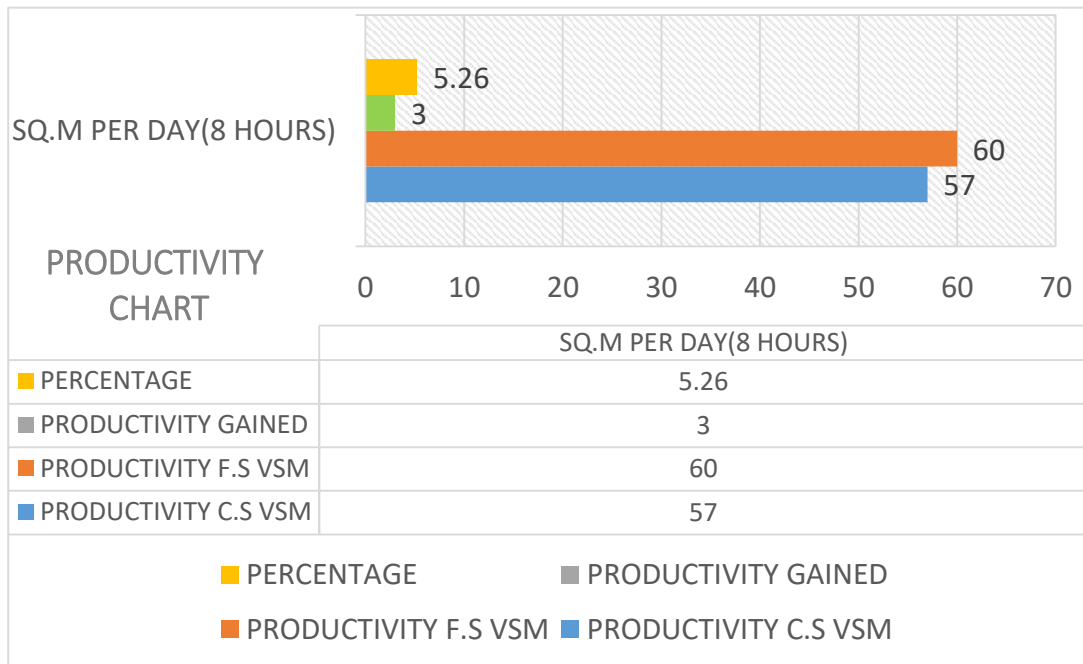


Fig-12

4.6 INTERNAL PLASTERING WORK:

4.6.1 Area of Study:

Internal wall plastering in 4th floor of block-1

4.6.2 Limitation of the Study:

Since I am measuring the internal wall plastering Activity I am limiting my study wall plastering for 4 units in 4th floor of block-1.

4.6.3 Process:

1. Shifting of sand from storage to workplace.
2. Shifting of cement bags to work place.
3. Internal plastering work.



Fig-13

4.6.4 Key Plan:

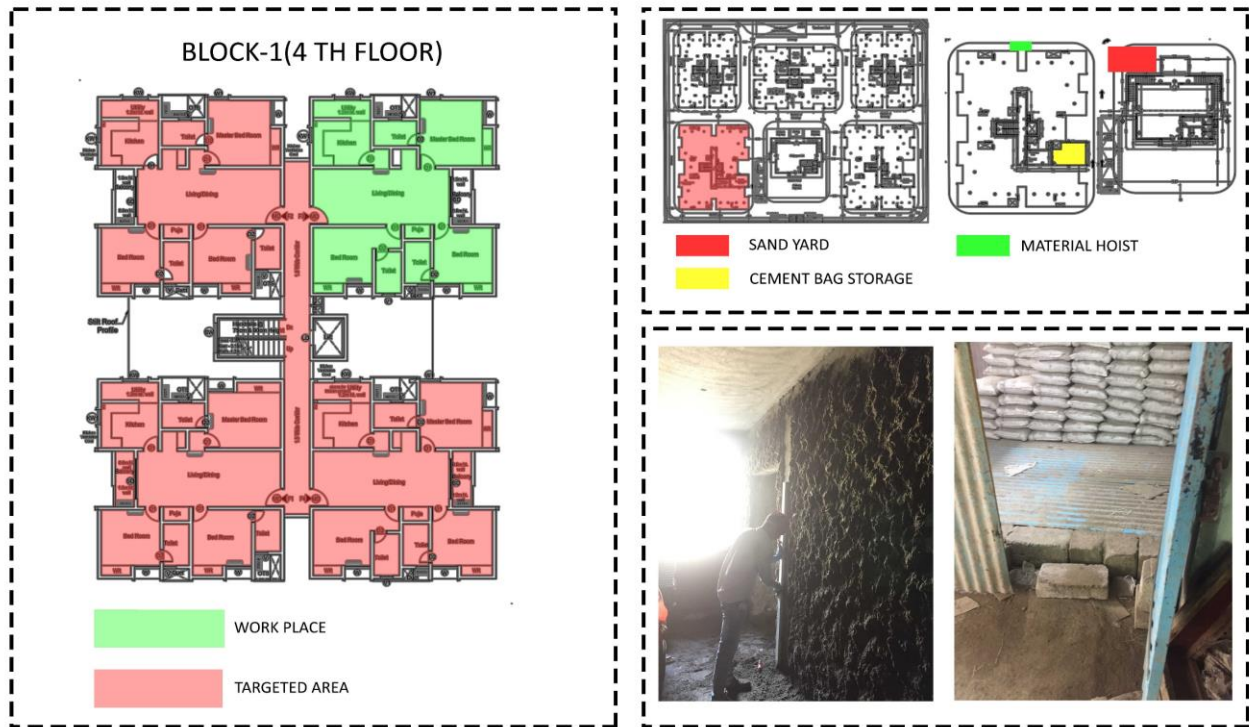


Fig-14

4.6.5 Data For Shifting Of Sand From Storage To Work Place:

(TABLE-27)

Data For Shifting Of Sand From Storage To Work Place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	Volume of sand required to be moved	16 Cu.m
4	Volume of sand moved per shift or cycle	0.1 Cu.m
5	Distance traveled per shift or cycle	Horizontal distance of 30 meters and vertical distance

		of 12 meters.
6	Time taken to complete 1 shift or cycle	191 seconds
7	Total NO. of shifts or cycle required	160
8	Total time consumed for this activity(Overall Cycle time)	30,560 seconds(509.3 minutes) (8.5 Hours)
9	Value Added Time	0

4.6.6 Data for Shifting Of Cement from Storage to Work Place:

(TABLE-28)

Data for Shifting Of Cement from Storage to Work Place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of cement bags moved per shift or cycle	3 bags
4	Total NO. of shifts or cycle	24
5	Time taken to complete 1 shift or cycle	145 Seconds
6	Distance traveled per shift or cycle	Horizontal distance of 32 meters vertical distance of 12 meters
7	Total time consumed for this activity(Overall Cycle time)	3,480 seconds nearly 1 hour
8	Value Added Time	0

4.6.7 Data For Plastering Work:

TABLE-29

Data For Plastering Work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	7(4 masons, 3 male helpers)
3	Wall area plastered per day(8 hours)	33.6 Sq.m
4	Sand used per day	0.5 Cu.m
5	Cement used per day	2 Bags
6	Total area targeted (4 th floor)	1195 Sq.m
7	Time taken to install raised support for plastering higher wall	150 Seconds
8	Time taken to install raised support for plastering for all higher walls	200 minutes (3.3 Hours)
9	Time taken to finish the target(4 th floor)(cycle time)	284.5 Hours + 20 hours +3.3 hours = 308 hours
10	Value added time	284.5 hours
11	Non value added time	24 hours

4.6.8 Productivity of Plastering Work:

TABLE-30

Productivity of Plastering Work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Wall area to be plastered	1195 Sq.m

2	Total time taken to complete the activity	304.5 hours (38 days)
3	Productivity of work	8.4 SQ.M / day / Mason
4	Productivity of the team (4 masons + 3 male helpers)	33.6 SQ.M//DAY
5	Total productivity of the team (4 masons + 3 male helpers)	4.2 SQ.M /hour

4.6.9 Brief Summary of Internal Plastering Work:

TABLE-31

Brief Summary of Internal Plastering Work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Total Labours working in the crew	7 Labours-4 masons,3 male helpers
2	Wall area to be plastered	1195 Sq.m
3	Time taken to finish the target(4 th floor)(cycle time)	317.5 Hours
4	Value added time	284.5 hours
5	Non value added time	33.5 hours

4.6.10 Productivity of Plastering Work:

TABLE-32

Productivity of Plastering Work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Wall area to be plastered	1195 Sq.m
2	Total time taken to complete the activity	317.5 Hours(40 days)

3	Productivity of work	8.4 SQ.M / day / Mason
5	Productivity of the team(4 masons + 3 male helpers)	30 SQ.M//DAY

4.6.11 Current State Vsm for Internal Plastering Activity:

- From the above collected data it is evident that there is an overall duration of 33.5 hours Non-Value Added Time taken place in the internal plastering work.
- To create the Current State VSM for internal plastering activity these Non-Value Added Activities should be noted and listed out.

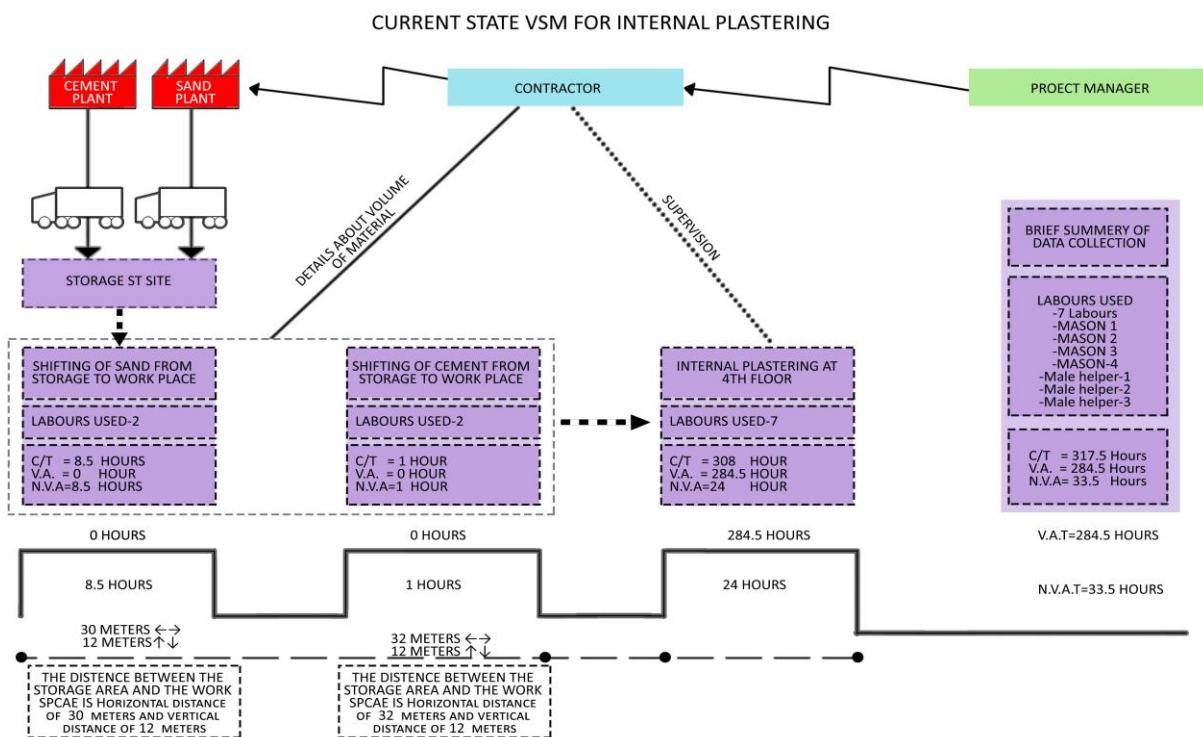


Fig-15

4.6.12 Improvements to the Current State Vsm for Material Shifting Activity:

- According to the current state VSM the Non Value Added activities are identified and ways to rectify the activities are discussed.

4.6.13 Rectifying Non Value Adding Activity-1 (Shifting Of Materials From Storage To Work Space):

- Material shifting from storage to workspace is necessary for any activity but it does not necessarily add any value to the activity as a whole.
- Yet this process is necessary and it consumes time and cost. Even though it cannot be fully neglected it can be minimized.
- Adding an additional hoist lift for the block will speed up the shifting process.
- Also by splitting the sand storage into two and providing one adjacent to each hoist will be more convenient for the shifting process.

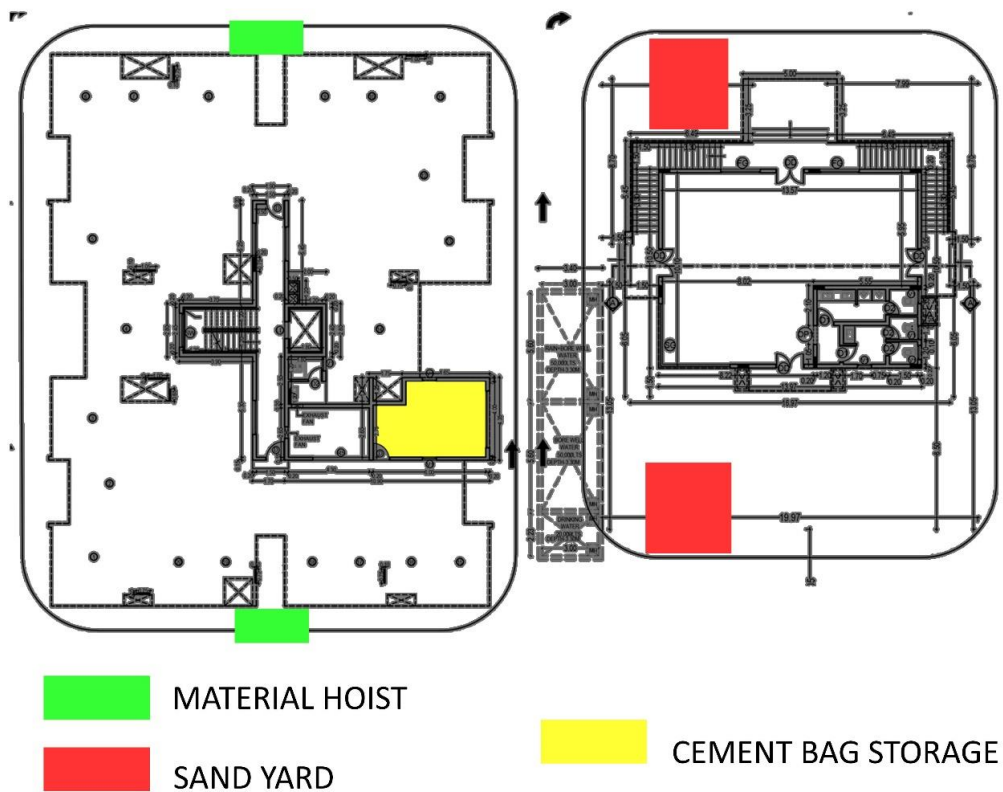


Fig-16

4.6.14 Rectifying Non Value Adding Activity-2 (Time Taken To Install

4.6.14.1 Raised Support For Plastering For Higher Walls):

- For plastering of higher wall they were using one or more wooden planks which have been supported on steel drums on either side.
- By using a proper plastering hop ups we can completely avoid the Non Value added time of 3.3 hours that has being consumed by setting up the temporary work bench for plastering higher walls.



Fig-16.1

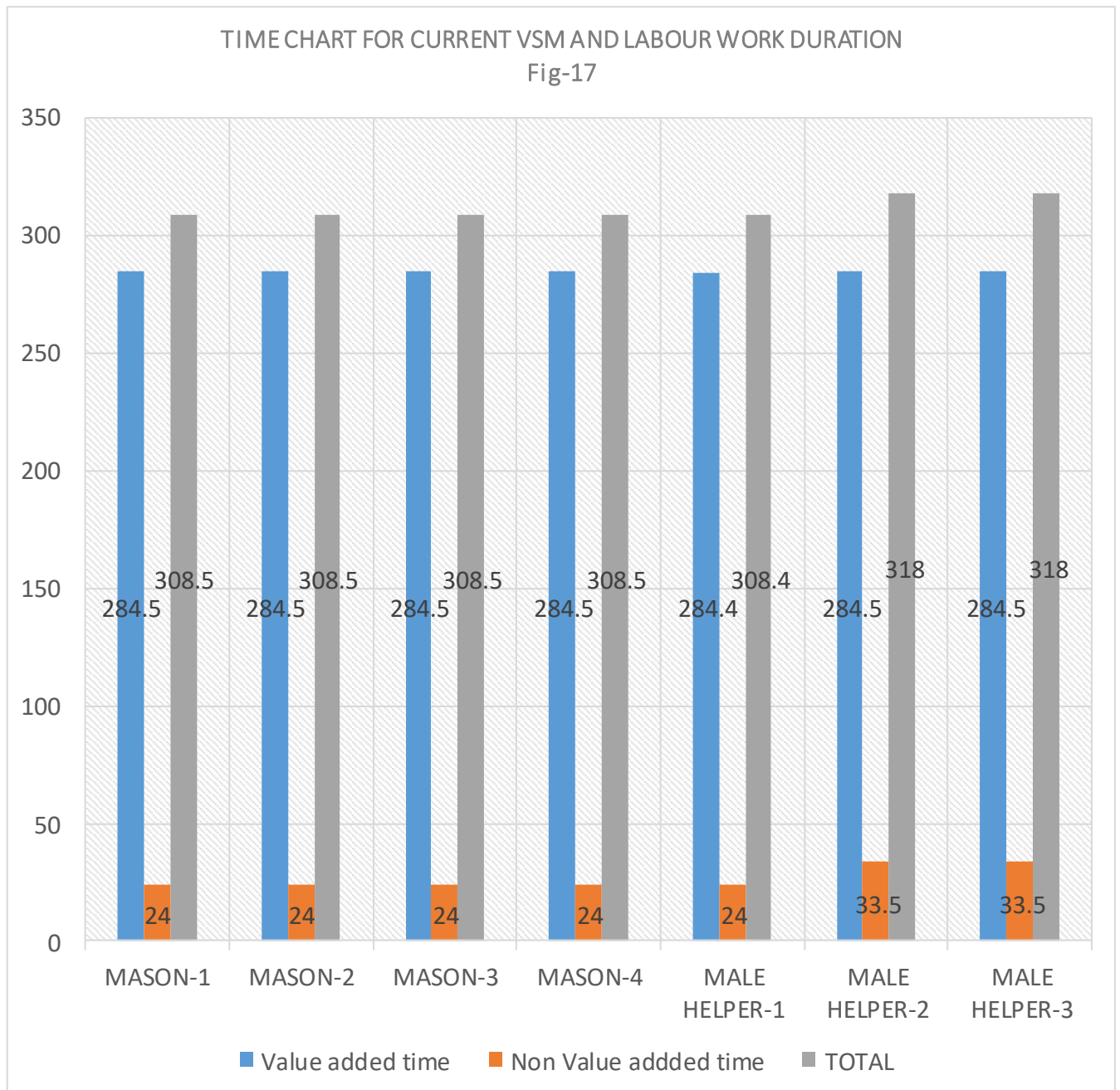
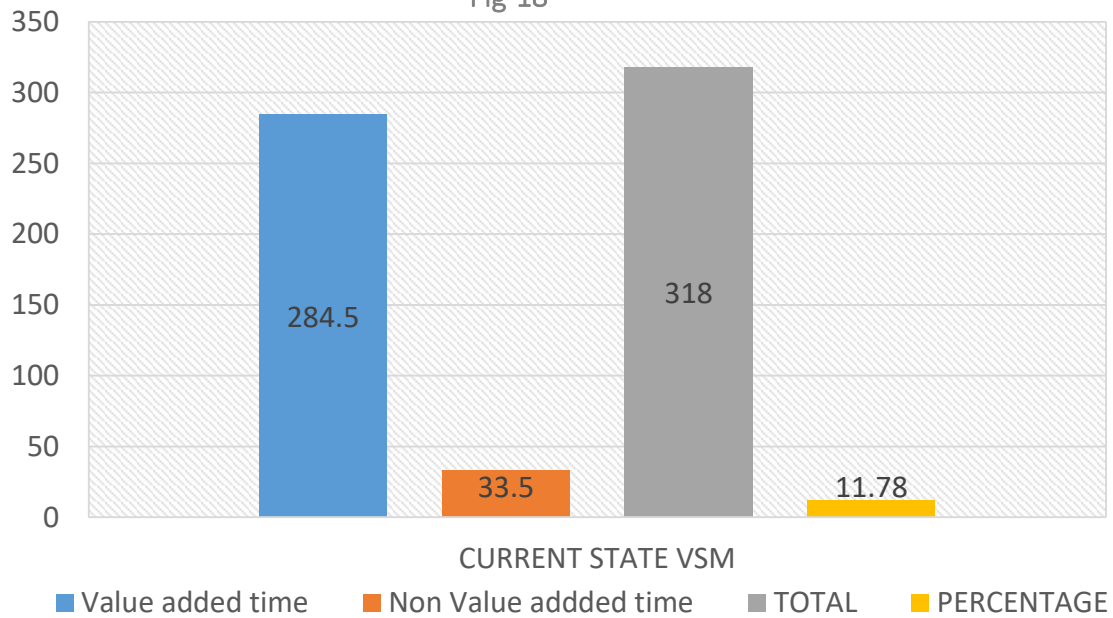


Fig-17

TIME CHART FOR CURRENT VSM AND LABOUR WORK PERCENTAGE

Fig-18



FUTURE STATE VSM FOR INTERNAL PLASTERING

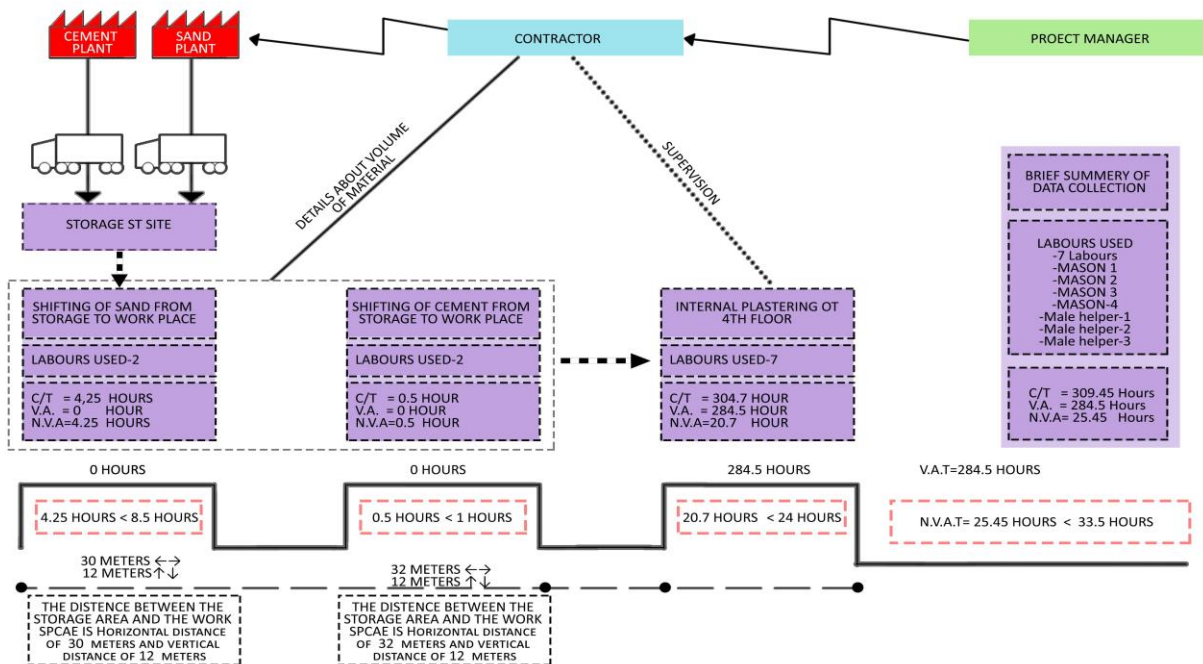


Fig-19

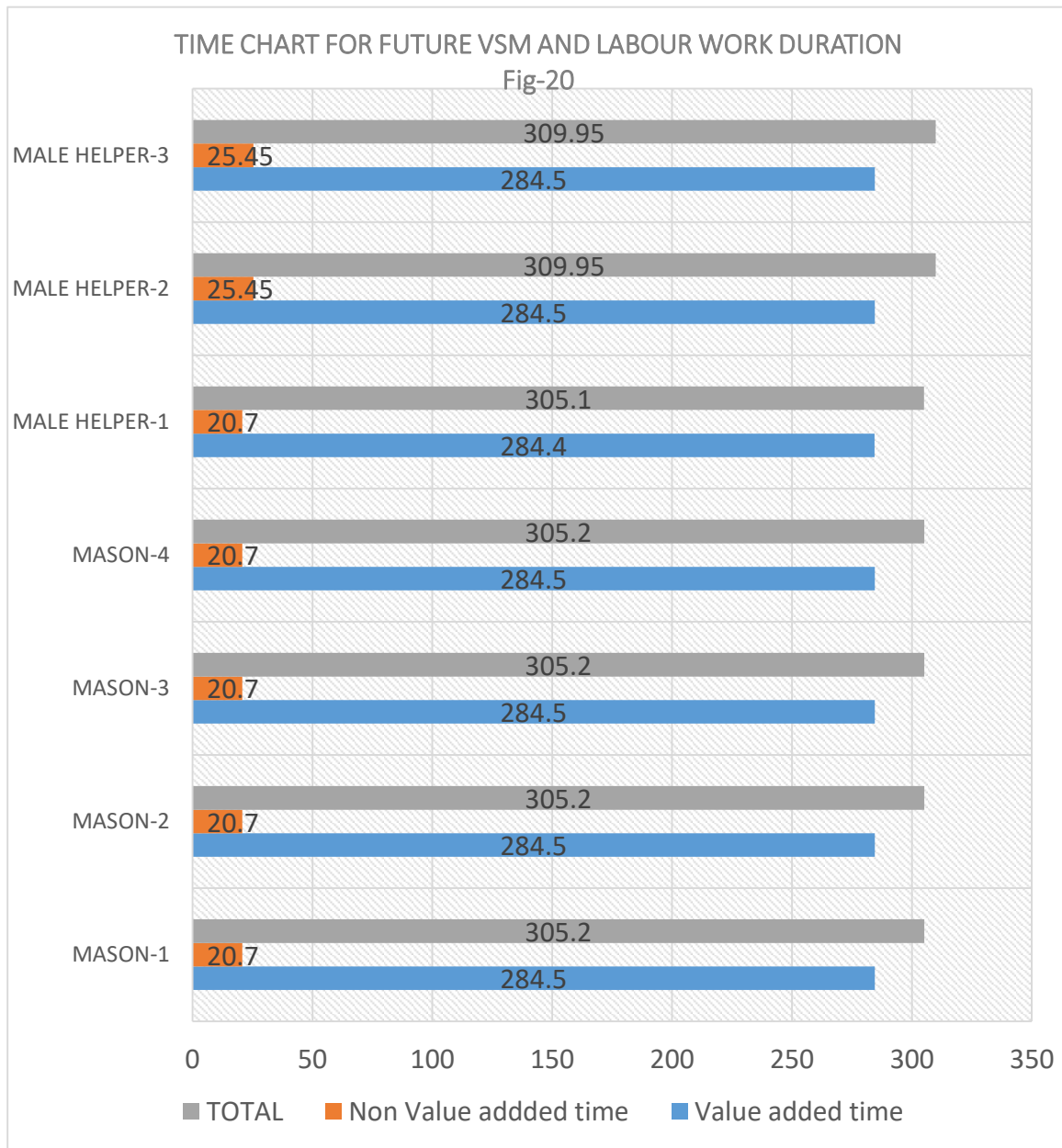


Fig-20

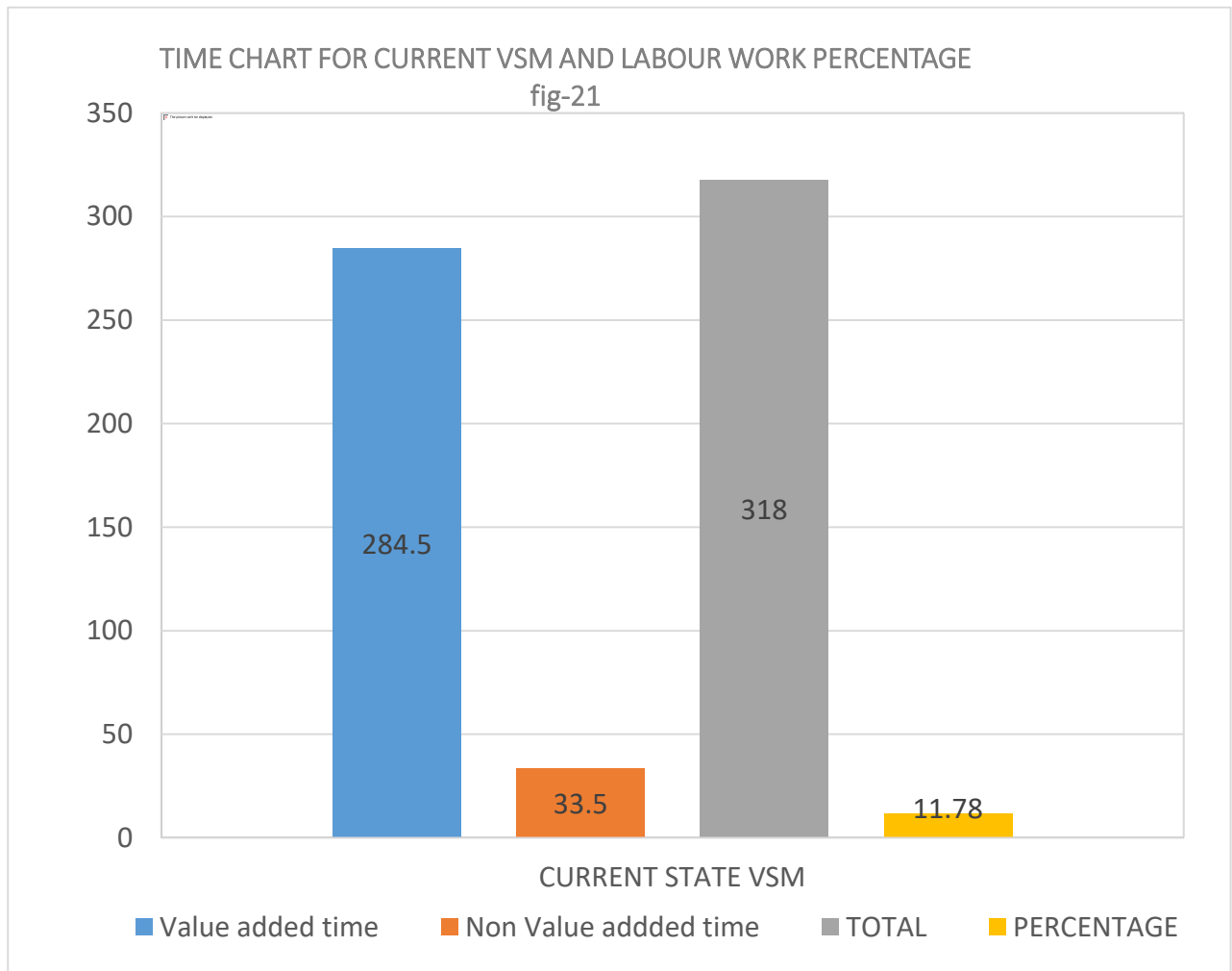


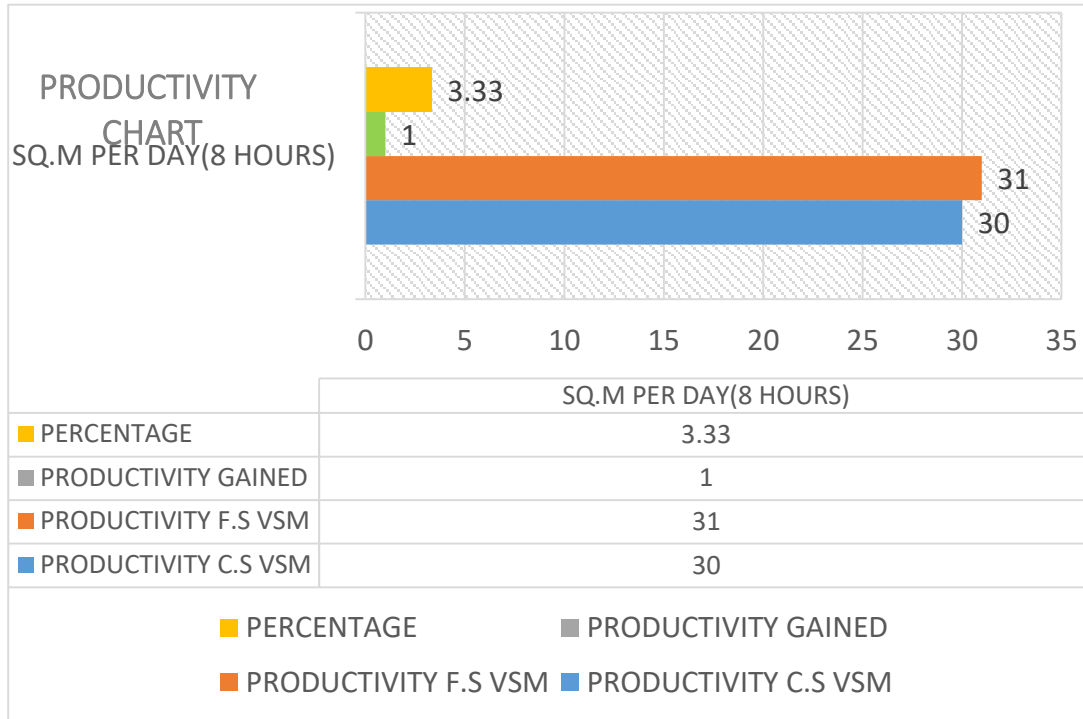
Fig-21

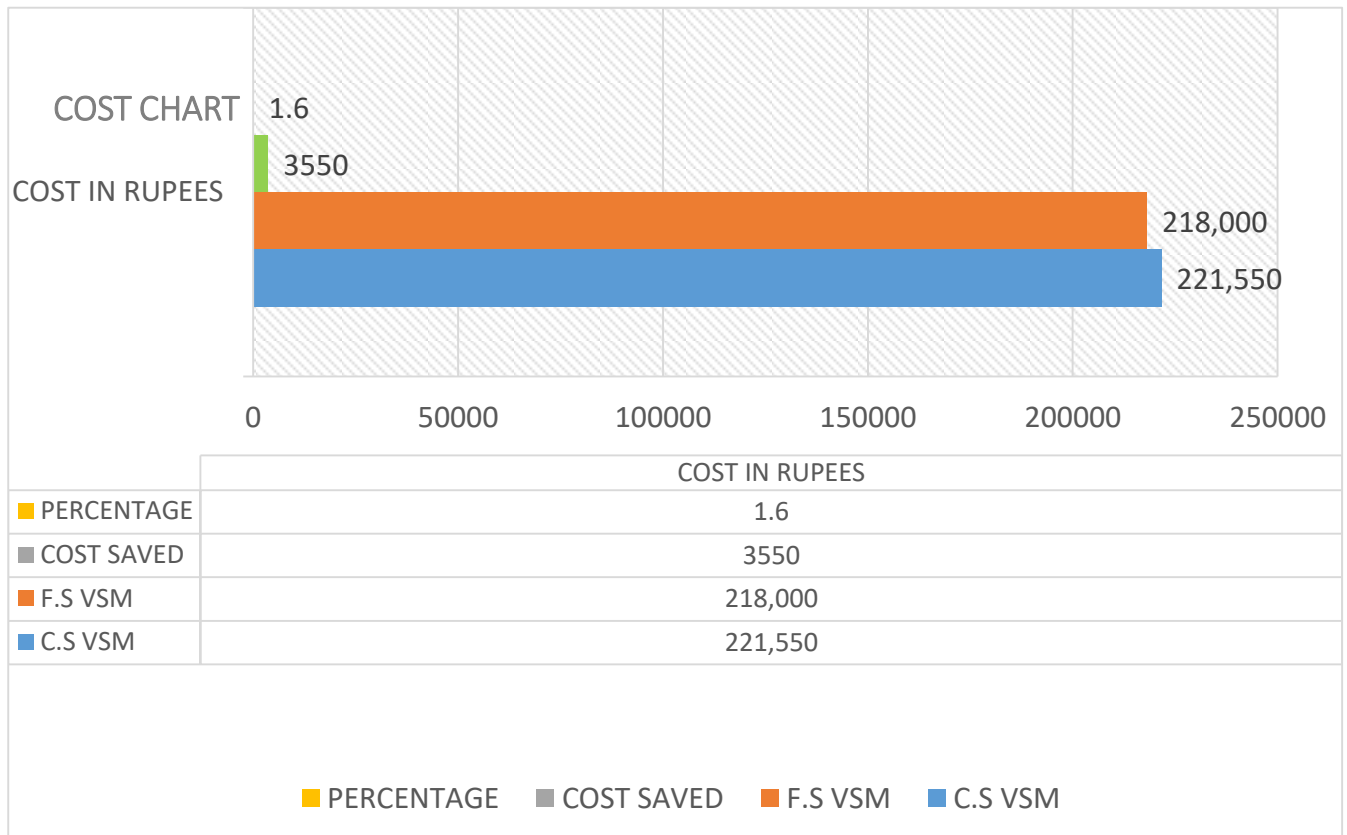
4.6.15 Cost Analysis for Internal Plastering for Current State and Future State Vsm:

(TABLE-33)

COST ANALYSIS FOR INTERNAL PLASTERING FOR CURRENT STATE AND FUTURE STATE VSM			
SI.NO	DESCRIPTION	CURRENT STATE	FUTURE STATE

1	Number Of Labours Used	7 Labours Masons-4 Male Helpers-3	7 Labours Masons-4 Male Helpers-3
2	Wages Of Labours	Mason-Rs 900/DAY MALE HELPER- Rs 700/DAY	Mason-Rs 900/DAY MALE HELPER- Rs 700/DAY
3	Time Taken To Finish The Task	Mason(1-4):38.5 Days Male Helper 1: 38.5 Days Male Helper (2,3): 40 Day	Mason(1-4):38 Days Male Helper1: 38 Days Male Helper (2,3): 39 Day
4	Cost Of Labours	$(4 \times 900 \times 38.5) + (1 \times 700 \times 38.5) + (2 \times 700 \times 40)$ =138,600+26,950+56,000 =221,550	$(4 \times 900 \times 38) + (1 \times 700 \times 38) + (2 \times 700 \times 39)$ =136,800+26,600+700+54,600 =218,000





4.7 BLOCK WORK ACTIVITY:

4.7.1 Area of Study:

Block work activity happening in 5th Floor Of block-1.

4.7.2 Limitation of the Study:

Since I am measuring the block work activity I am limiting my study to measure all the sub- Activities that are happening along with block work.

4.7.3 Sub-Activities:

1. Shifting of sand from storage to work place.
2. Shifting of cement from storage to work place
3. Shifting of solid blocks from storage to work place
4. Block work.



Fig-22

4.7.4 Key Plan:

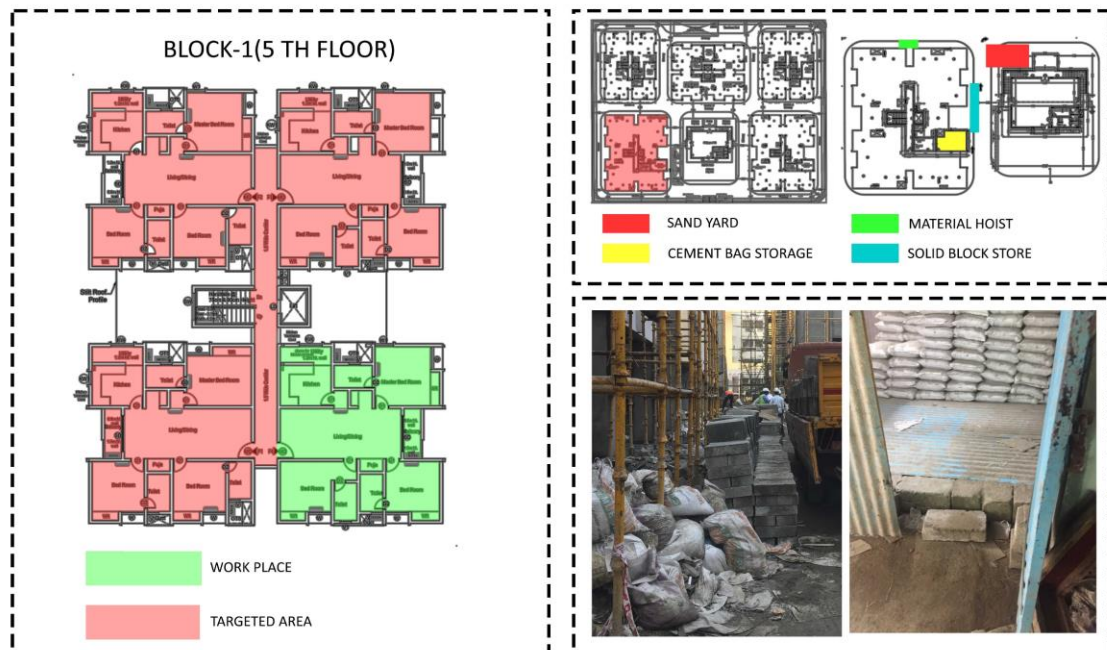


Fig-23

4.7.5 Data for Shifting Of Sand from Storage to Work Place:

TABLE-34

Data for Shifting Of Sand from Storage to Work Place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	Volume of sand required to be moved	45.6 Cu.m
4	Volume of sand moved per shift or cycle	0.1 Cu.m
5	Distance traveled per shift or cycle	Horizontal distance of 30 meters and vertical distance of 15 meters.
6	Time taken to complete 1 shift or cycle	191 seconds
7	Total NO. of shifts or cycle required	456
8	Total time consumed for this activity(Overall Cycle time)	87,096 seconds(1,451.6 minutes) (24.2 Hours)
9	Value Added Time	0

4.7.6 Data for Shifting Of Cement from Storage to Work Place:

TABLE-35

data for shifting of cement from storage to work place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added

2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of cement bags moved per shift or cycle	3 bags
4	Total NO. of shifts or cycle	73
5	Time taken to complete 1 shift or cycle	145 Seconds
6	Distance traveled per shift or cycle	Horizontal distance of 32 meters vertical distance of 15 meters
7	Total time consumed for this activity(Overall Cycle time)	10,585 seconds(176.4 minutes) (Nearly 3 hour)
8	Value Added Time	0

4.7.7 Data for Shifting Of Solid Block from Storage to Work Place:

TABLE-36

Data for Shifting Of Solid Block from Storage to Work Place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	Number of solid block required to be moved	13211
4	Number of sand moved per shift or cycle	14 solid blocks
5	Distance traveled per shift or cycle	Horizontal distance of 33 meters and vertical distance of 15 meters.
6	Time taken to complete 1 shift or cycle	217 seconds
7	Total NO. of shifts or cycle required	944

8	Total time consumed for this activity(Overall Cycle time)	2,04,848 seconds(3,414 minutes) (57 Hours)
9	Value Added Time	0

4.7.8 Data For Block Work:

TABLE-37

SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	8(4 masons, 4 male helpers)
3	Block work completed per day(8 hours)	42 Sq.m
4	Sand used per day	1.6 Cu.m
5	Cement used per day	8 Bags
6	Total area targeted (5 th floor)	1195 Sq.m
7	Time taken to install raised support for plastering higher wall	150 Seconds
8	Time taken to install raised support for plastering for all higher walls	200 minutes (3.3 Hours)
9	Time taken to finish the target(5 th floor)(cycle time)	227.6 Hours + 20 hours +3.3 hours = 251 hours
10	Value added time	227.6 hours
11	Non value added time	23.3 hours

4.7.9 Productivity of Block Work:

TABLE-38

Productivity of Block Work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Targeted work to be completed	1195 Sq.m
2	Total time taken to complete the activity	251 hours Hours(31 days)
3	Productivity of work	10.5 SQ.M / day / Mason + Helper
4	Productivity of the team(4 masons + 4 male helpers)	42 SQ.M/DAY
5	Total productivity of the team(4 masons + 4 male helpers)	5.25 SQ.M /Hour

4.7.10 Brief Summary of Block Work:

TABLE-39

Brief Summary of Block Work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Total Labours working in the crew	8 Labours -4 masons -4 male helpers
2	Wall area to be plastered	1195 Sq.m
3	Time taken to finish the target(5 th floor)(cycle time)	335 Hours
4	Value added time	227.6 hours

5	Non value added time	107.4 hours
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4.7.11 Productivity Of Whole Activity:

TABLE-40

productivity of whole activity		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Targeted work to be completed	1195 Sq.m
2	Total time taken to complete the activity	335 hours Hours(42 days)
3	Productivity of work	10.5 SQ.M / day / Mason + Helper
4	Productivity of the team(4 masons + 4 male helpers)	28.5 SQ.M//DAY
5	Total productivity of the team(4 masons + 4 male helpers)	3.56 SQ.M /Hour

4.7.12 current state vsm for block work activity:

- From the above collected data it is evident that there is an overall duration of 107.4 hours Non-Value Added Time taken place in the block work.
- To create the Current State VSM for block work activity these Non-Value Added Activities should be noted and listed out.

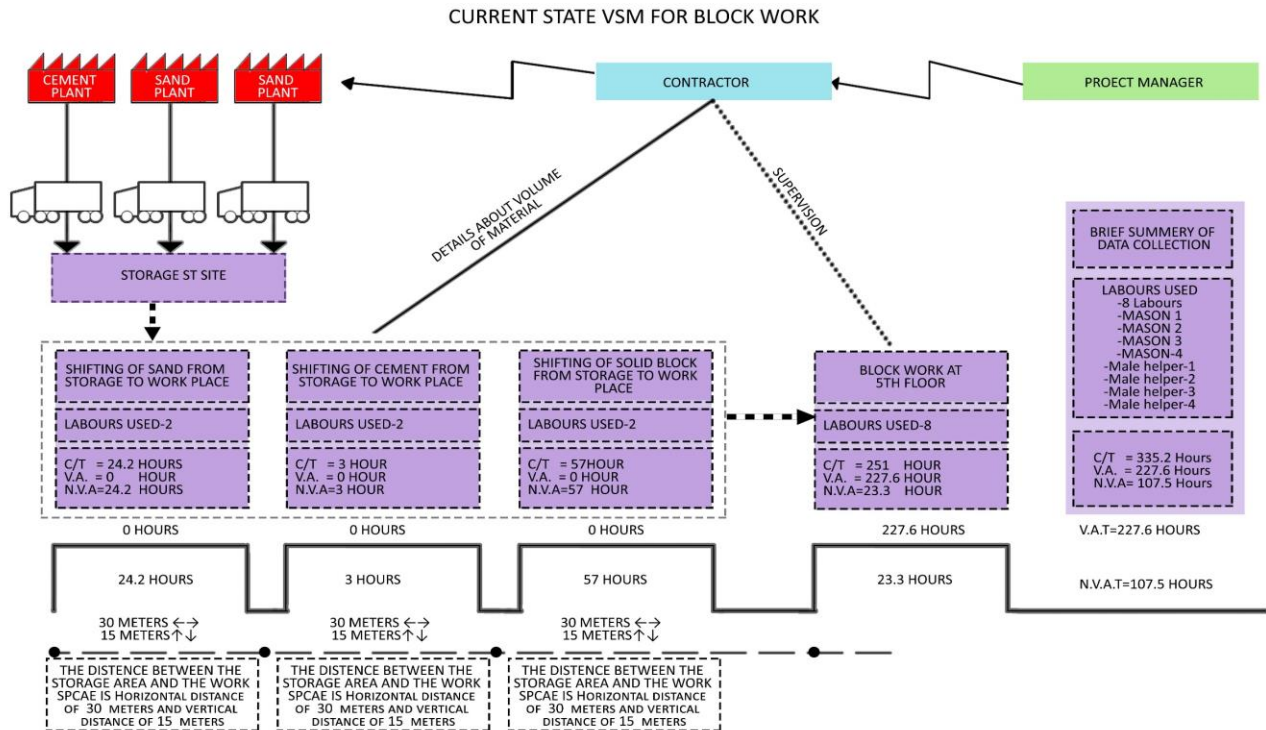


Fig-24

4.7.13 Improvements to the current state vsm for material shifting activity:

- According to the current state VSM the Non Value Added activities are identified and ways to rectify the activities are discussed.

4.7.14 rectifying non value adding activity-1 (shifting of materials from storage to work space):

- Material shifting from storage to workspace is necessary for any activity but it does not necessarily add any value to the activity as a whole.
- Yet this process is necessary and it consumes time and cost. Even though it cannot be fully neglected it can be minimized.
- Adding an additional hoist lift for the block will speed up the shifting process.
- Also by splitting the sand storage into two and providing one adjacent to each hoist will be more convenient for the shifting process.

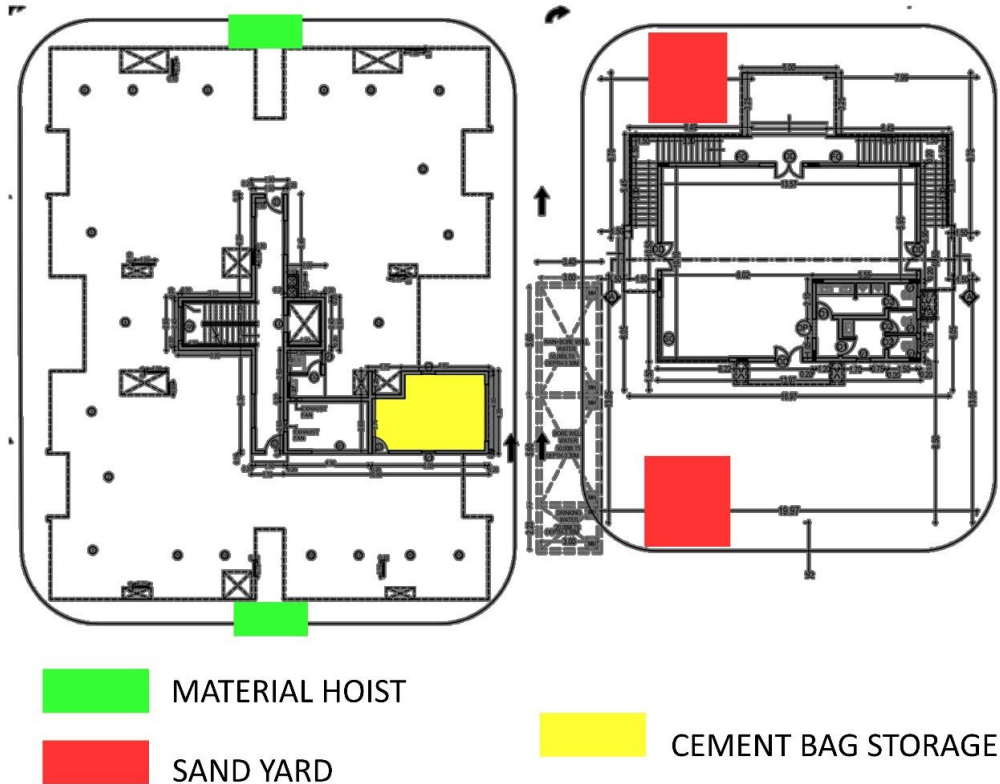


Fig-25

4.7.15 rectifying non value adding activity-2 (time taken to install :

4.7.16 RAISED SUPPORT FOR BLOCK WORK) :

- For plastering of higher wall they were using one or more wooden planks which have been supported on steel drums on either side.
- By using a proper plastering hop ups we can completely avoid the Non Value added time of 3.3 hours that has being consumed by setting up the temporary work bench for plastering higher walls.

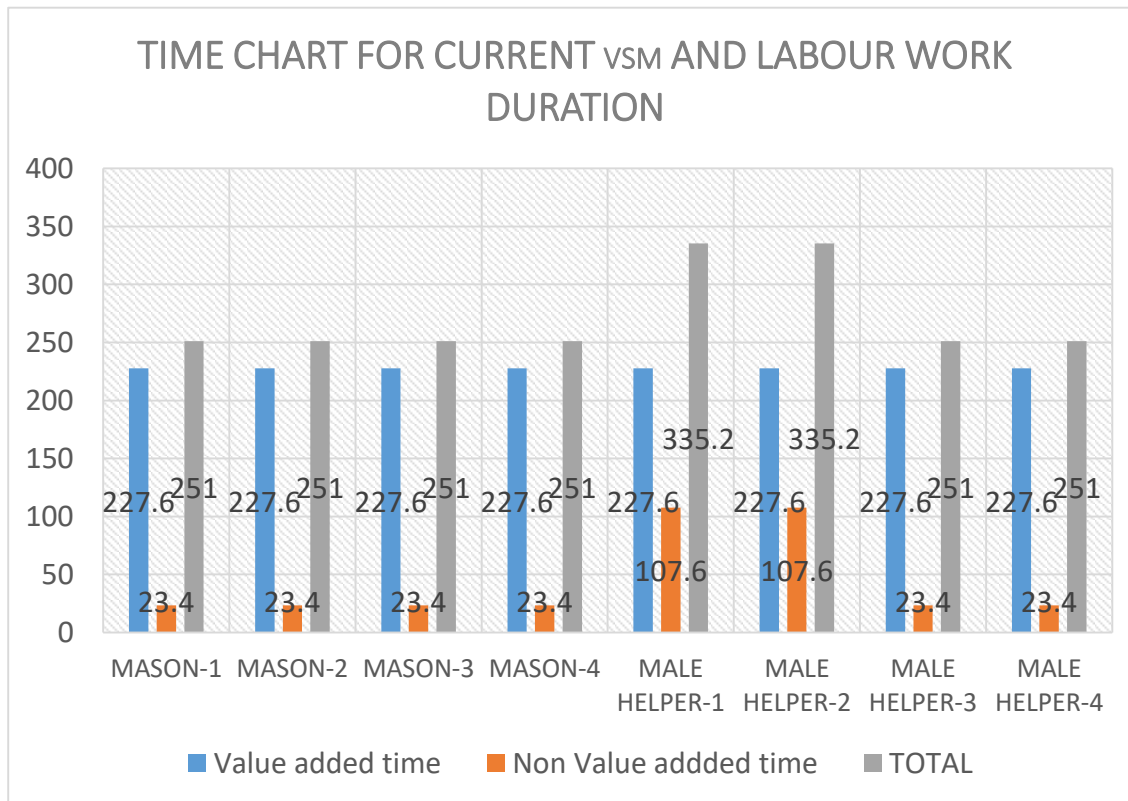


Fig-26

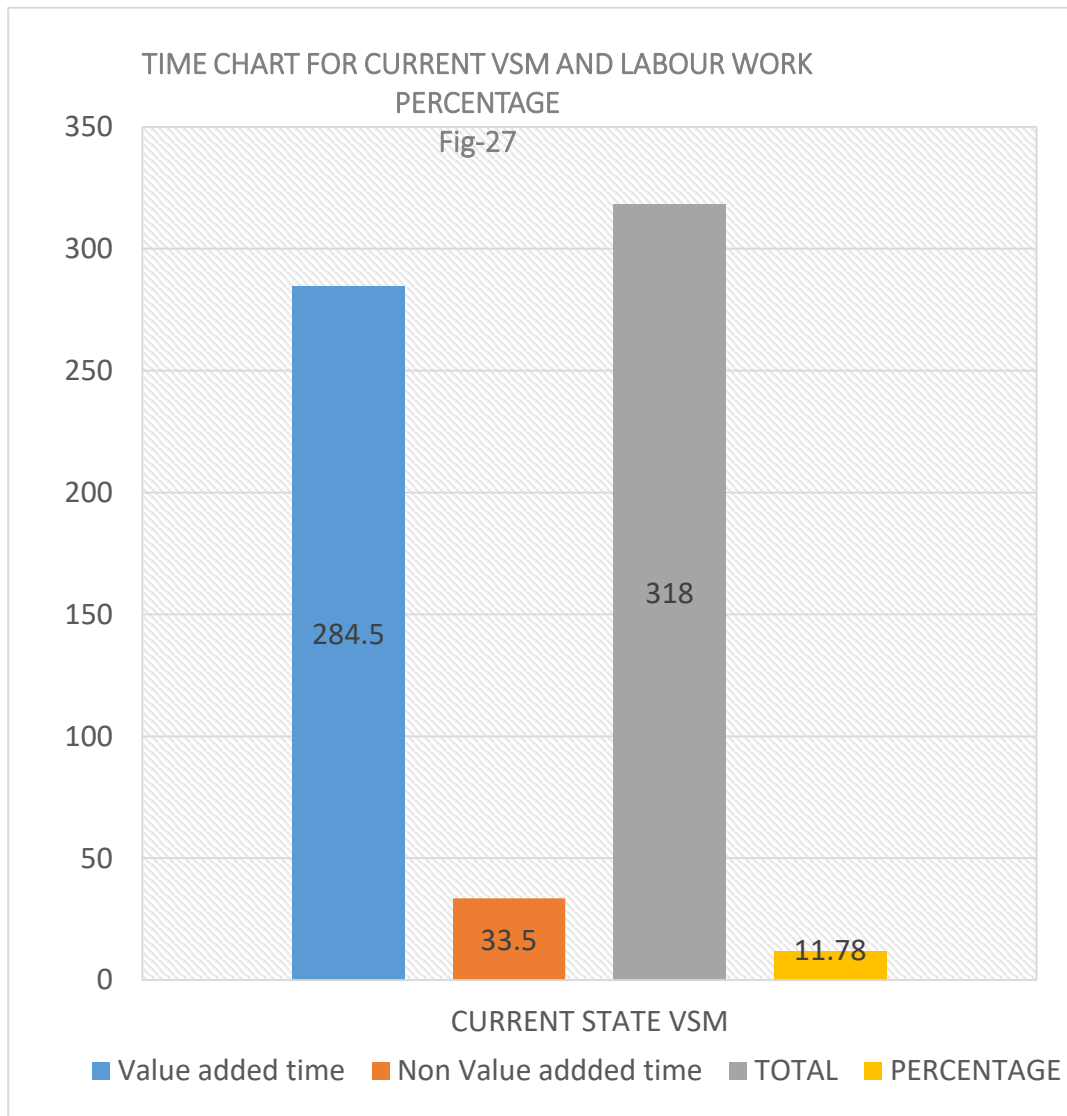


Fig-27

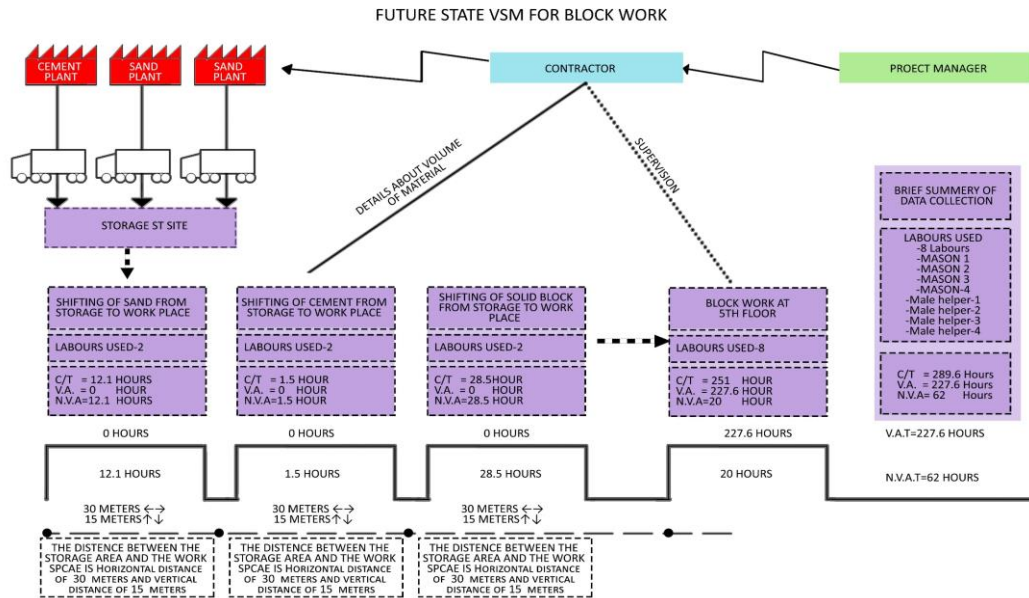


Fig-28

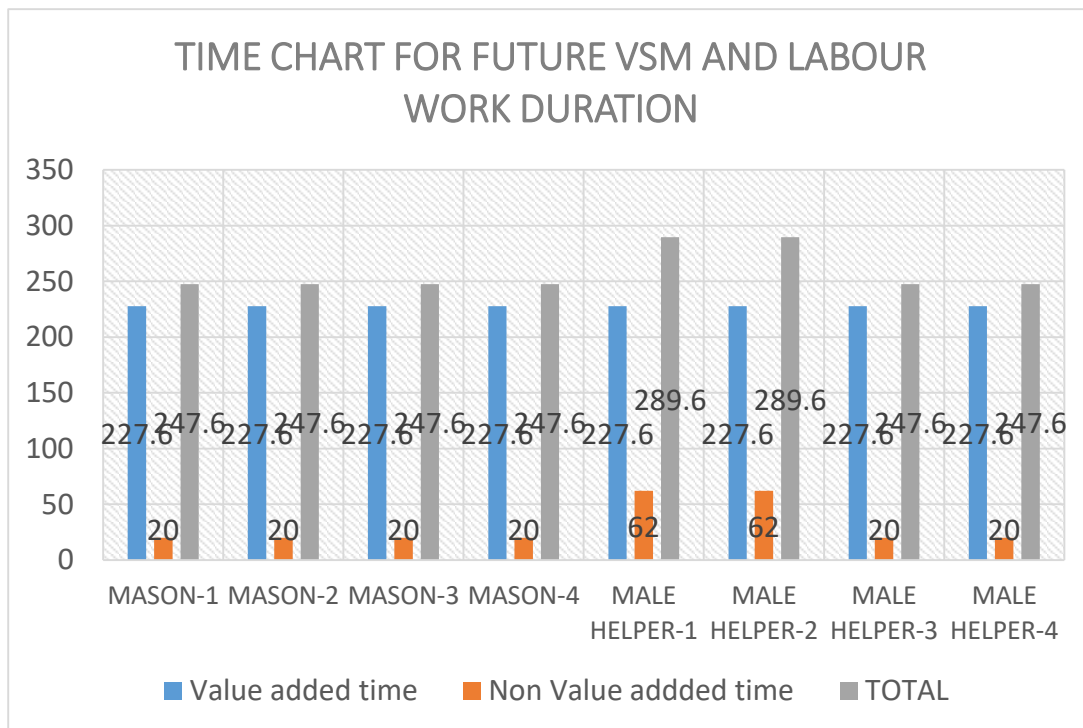
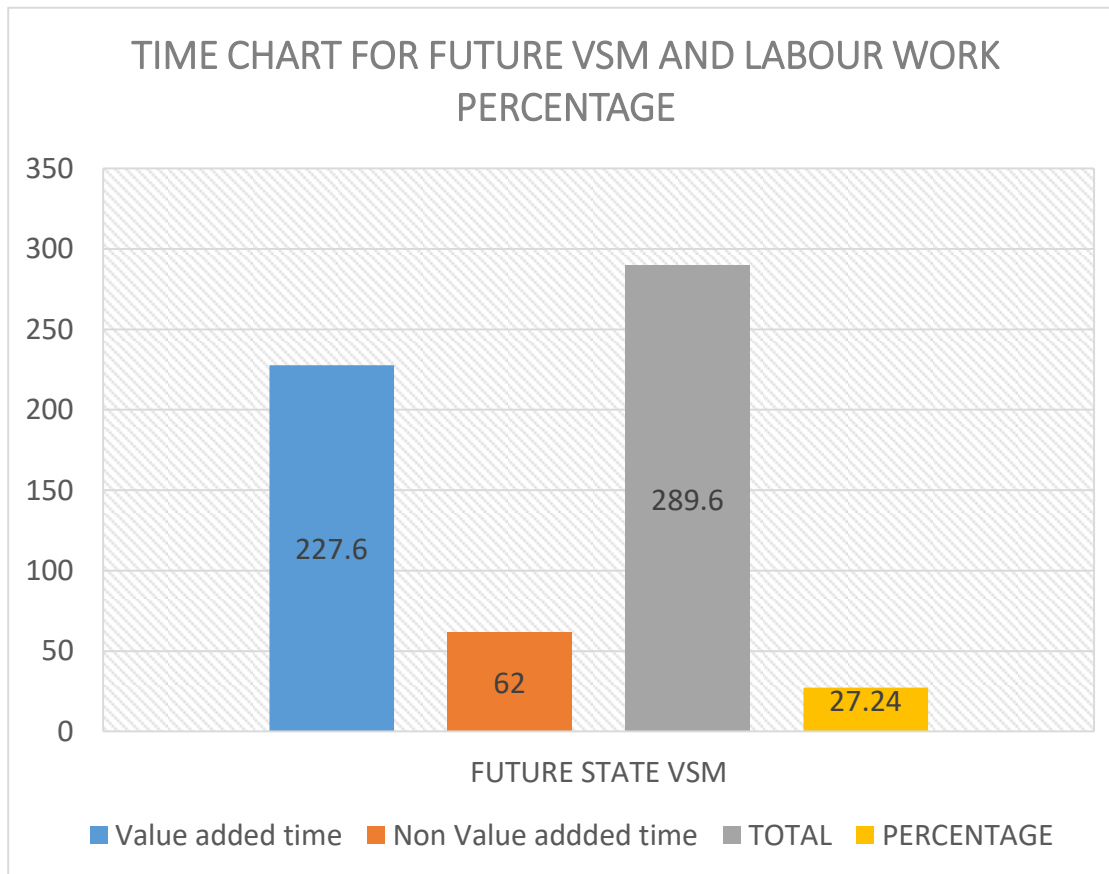


Fig-29

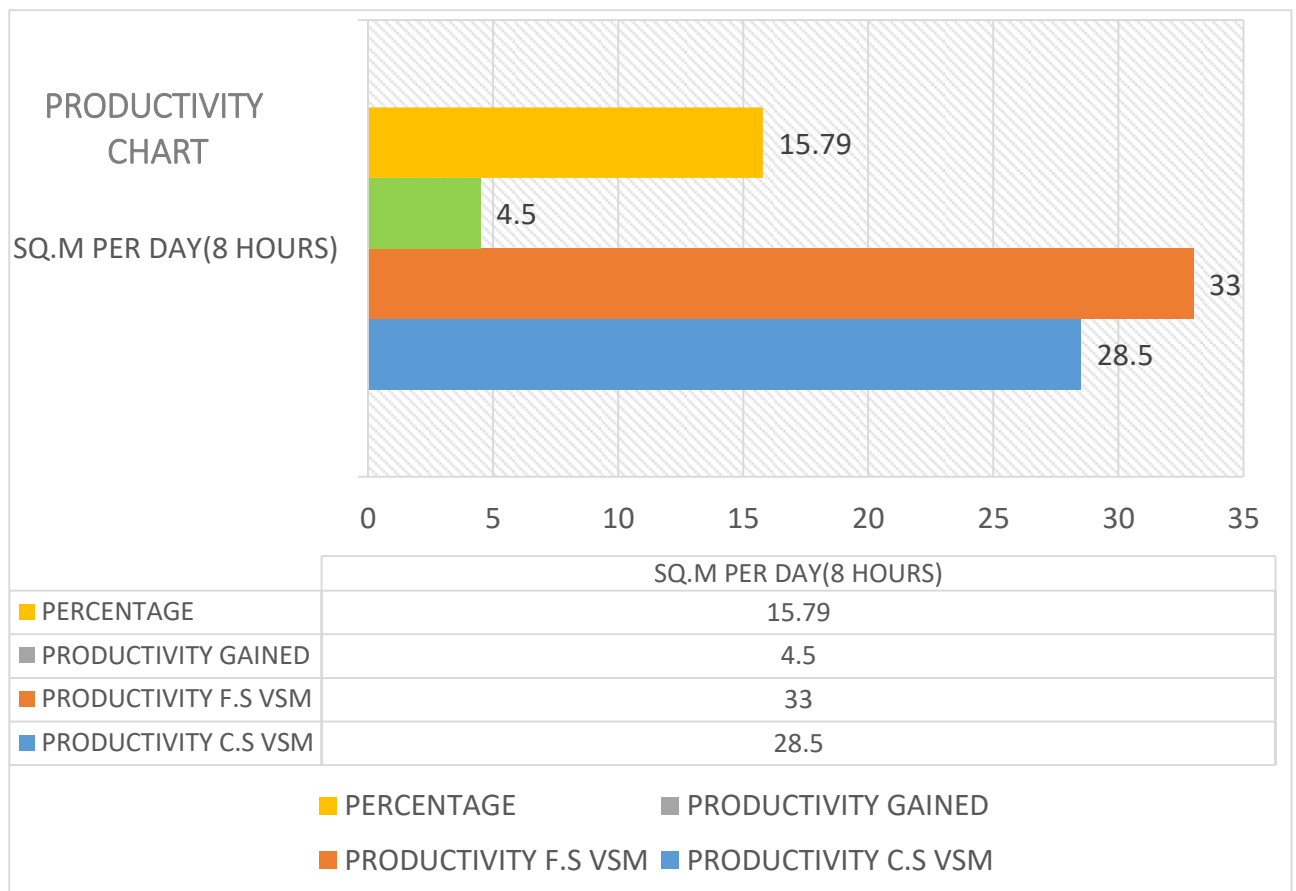


4.7.17 Cost Analysis Of Block Work For Current State And Future State Vsm:

(TABLE-41)

COST ANALYSIS OF BLOCK WORK FOR CURRENT STATE AND FUTURE STATE VSM			
SI.NO	DESCRIPTION	CURRENT STATE	FUTURE STATE
1	Number Of Labours Used	8 Labours Masons-4 Male Helpers-4	8 Labours Masons-4 Male Helpers-4

2	Wages Of Labours	Mason-Rs 900/DAY MALE HELPER- Rs 700/DAY	Mason-Rs 900/DAY MALE HELPER- Rs 700/DAY
3	Time Taken To Finish The Task	Mason(1-4):31 Days Male Helper(3,4): 31 Days Male Helper (1,2): 42 Day	Mason(1-4):31 Days Male Helper: 31 Days Male Helper (2,3): 36 Day
4	Cost Of Labours	$(4 \times 900 \times 31) + (2 \times 700 \times 31) + (2 \times 700 \times 36)$ $= 1,11,600 + 43,400 + 57,400$ $= 212,400$	$(4 \times 900 \times 31) + (2 \times 700 \times 31) + (2 \times 700 \times 36)$ $= 1,11,600 + 43,400 + 50,400$ $= 2,05,400$



CASE STUDY-2

Building Name- Ocean Dew

(Phase-2)

Location- Pallikaranai

Project Area: 19,894.5 Sq.m

Status: Under Construction

No. Of Blocks – 2 (block- 4 and 5)

No. Of Floors: Block 4- Stilt + 10

Block 5- Stilt + 11

Total Number of Houses -234



Fig-30

4.8 BAR BENDING ACTIVITY:

4.8.1 Area of Study:

For the Bar bending activity the 3RD Floor Of block-4 is selected.

4.8.2 Limitation of the Study:

Since I am measuring the bar bending activity I am limiting my study to bar bending of rings for beams and columns.

4.8.3 Process:

1. Cutting of steel before sending for bending

Activity.

2. BarBending work.



Fig-31

4.8.4 Key Plan:

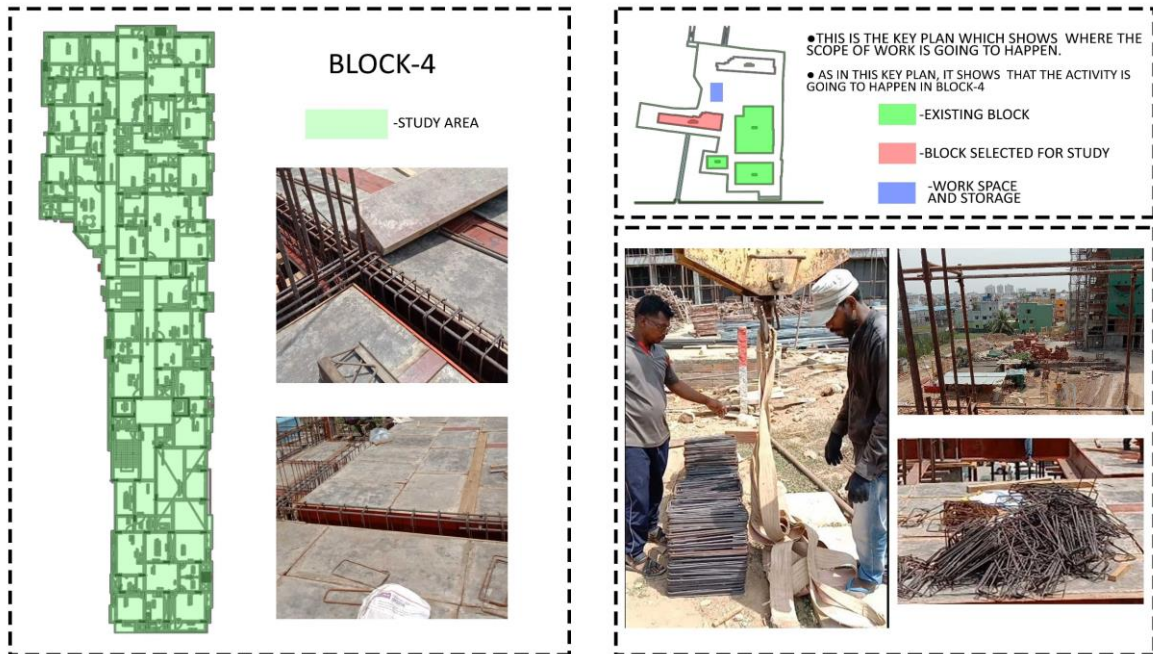


Fig-32

4.8.5 Steel Cutting Details:

TABLE-42

Steel Cutting Details					
SI.NO	STRUCTURE	LENGTH OF RING	WEIGHT OF ROD PER METER	WEIGHT PER RING	TOTAL NO.OF RINGS REQUIRED
1	BEAM	1.5 METERS	0.395 kg/meter	0.6 KG	8,155
2	COLIMN	1.7 METERS	0.395 kg/mete	0. 67 KG	3,591
3	Total No.of Steal Bars Required • Steel Bars Required For TMT Rings In Beam-1,020 Bars • Steel Bars Required For TMT Rings In Column-509 bars				1,529 (8 mm) TNT BARS (or) 7,187 KG OF 8 mm TNT BARS

4.8.6 Data For Cutting Of Steel Bars For Beam Rings:

TABLE-43

Data For Cutting Of Steel Bars For Beam Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of parts to be cut in a steel bar	8
4	Length of 1 ring	1.5 METERS
5	NO. of steel bars grouped per cycle	10
6	Total NO. of shifts or cycle	102
7	Time taken to completely cut 1 cycle	22 sec X 8 =176 seconds
8	Time taken to realign the steel bar after every cut	35 sec X 8=280 seconds
9	Total time consumed for completing 1 cycle	176 + 280 = 456 seconds
10	Total time consumed for this activity(Overall Cycle time)	46,512 seconds(13 hours)
11	Value Added Time	17,952 seconds(5 hours)



Fig-33



Fig-34

4.8.7 Productivity Of Cutting Of Steel Bars For Beam Rings:

TABLE-44

Productivity Of Cutting Of Steel Bars For Beam Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Steel required	4,893 kg
2	Total time taken to complete the activity	13 hours
3	Productivity of cutting steel bars for beam rings	376 kg/hours

4.8.8 Data For Cutting Of Steel Bars For Column Rings:

TABLE-45

Data For Cutting Of Steel Bars For Column Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of parts to be cut in a steel bar	7
4	Length of 1 ring	1.7 METERS
5	NO. of steel bars grouped per cycle	10
6	Total NO. of shifts or cycle	51
7	Time taken to completely finish 1 cycle	22 seconds X 7 =154 seconds
8	Time taken to realign the steel bar after every cut	35 seconds X 7 =245 seconds
9	Total time consumed for completing 1 cycle	154 + 245 =399 seconds

10	Total time consumed for this activity(Overall Cycle time)	20,349 seconds(5.6 hours)
11	Value Added Time	7,854 seconds(2.1 hours)
12	Necessary Non Value Added Time	12,495 Seconds(3.5 hours)

4.8.9 Productivity Of Cutting Of Steel Bars For Column Rings:

TABLE-46

Productivity Of Cutting Of Steel Bars For Column Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Steel required	2,406 kg
2	Total time taken to complete the activity	5.6 hours
3	Productivity of cutting steel bars for beam rings	430 kg/hours

4.8.10 Data For Bar Bending Of Steel Bars for Beam and Column Rings:

TABLE-47

Data For Bar Bending Of Steel Bars for Beam and Column Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	2(1 Bar bender, 1 Fixer)
3	Total NO. of rings required for Beams and Columns	8155 + 3591 = 11,746
4	Steel used	7,187 kg

5	Time taken to create 1 ring	36 Seconds
6	Time taken to realign a new bar for bending	3 Seconds
7	Total time consumed to complete all the rings(cycle time)	117.46 Hours +9.78 Hours = 127.25 Hours
8	Value Added Time	117.5 Hours
9	Necessary Non Value Added Time	9.78 Hours (10 hours)

4.8.11 Productivity Of Bar Bending Of Steel Bars For Beam And Column Rings:

TABLE-48

Productivity Of Bar Bending Of Steel Bars For Beam And Column Rings		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Rings required	11,746
2	Total time taken to complete the activity	127.25 Hours
3	Steel used	7,187 kg
4	Productivity of bending of steel bars for beam and column rings	39 Rings/hour

4.8.12 Brief Summary of Barbending Activity:

TABLE-49

Brief Summary of Barbending Activity		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Total Labours working in the crew	4 Labours -Bar bender -Fixer

		-Male helper-1 -Male helper-2
2	Total amount of steel used	7,187 kg
3	Total time consumed for this activity (Overall Cycle time)	145.85 Hours
4	Value Added Time	124.56 Hours
5	Non Value Added Time	21.28 hours

4.8.13 Current State Vsm For Bar Bending Activity:

- From the above collected data it is evident that there is an overall duration of 21.28 hours Non-Value Added Time taken place In the Bar Bending activity.
- To create the Current State VSM for bar bending activity these Non-Value Added Activities should be noted and listed out.

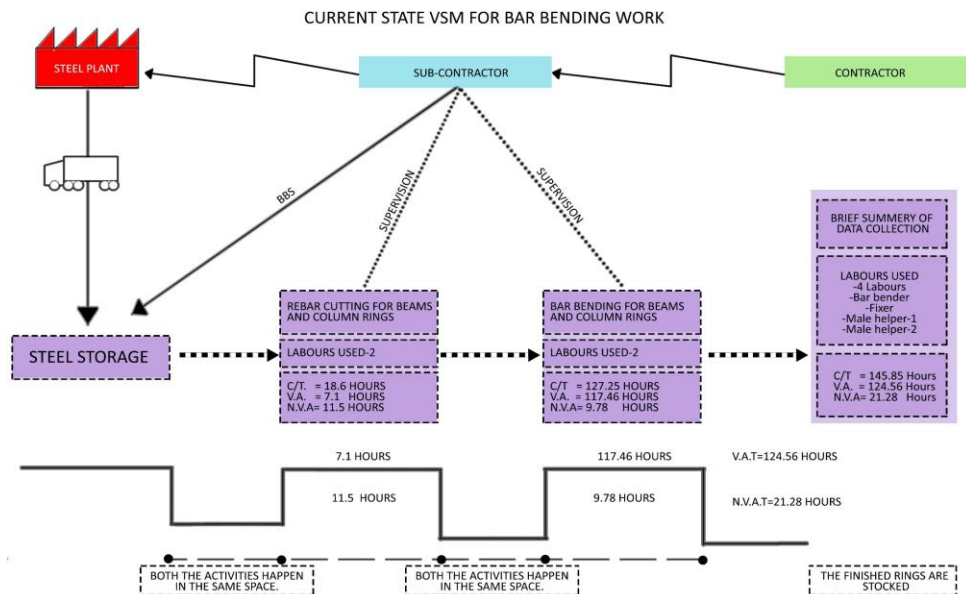


Fig-35

4.8.14 Improvements To The Current State Vsm For Bar Bending Activity:

- According to the current state VSM the Non Value Added activities are identified and ways to rectify the activities are discussed.

4.8.14.1 Improving The Value Adding Activity-1 (Machine Cutting Of Tmt Rods):

- The rod cutting activity was perfectly fine in terms of productivity, but they can improve the speed by using the hydraulic Press cutting machine which they already have at site which is being used to cut thicker rods.
- By using this already available hydraulic cutting machine the time taken for the cutting activity can be reduced.



Fig-36

4.8.14.2 Improving Value Adding Activity-2 (Bar Bending Of Tmt Rod):

- The productivity bar bending activity was measured to be 187 kg of steel/day were the standard productivity rate is 100 kg of steel per day.
- This activity can be even more improved by using the bar bending machine which is already available in the site and being used for bending thicker rods as 16mm rods which are easier to bend in machine than manual.

- By using this machine to bend 8mm rods, more numbers of rings can be produced in lesser time.



Fig-37

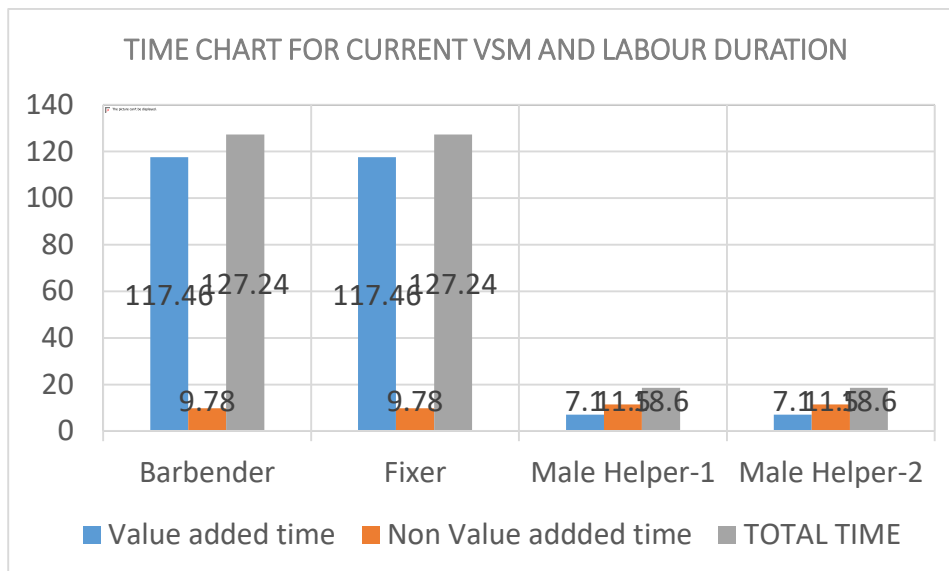


Fig-38

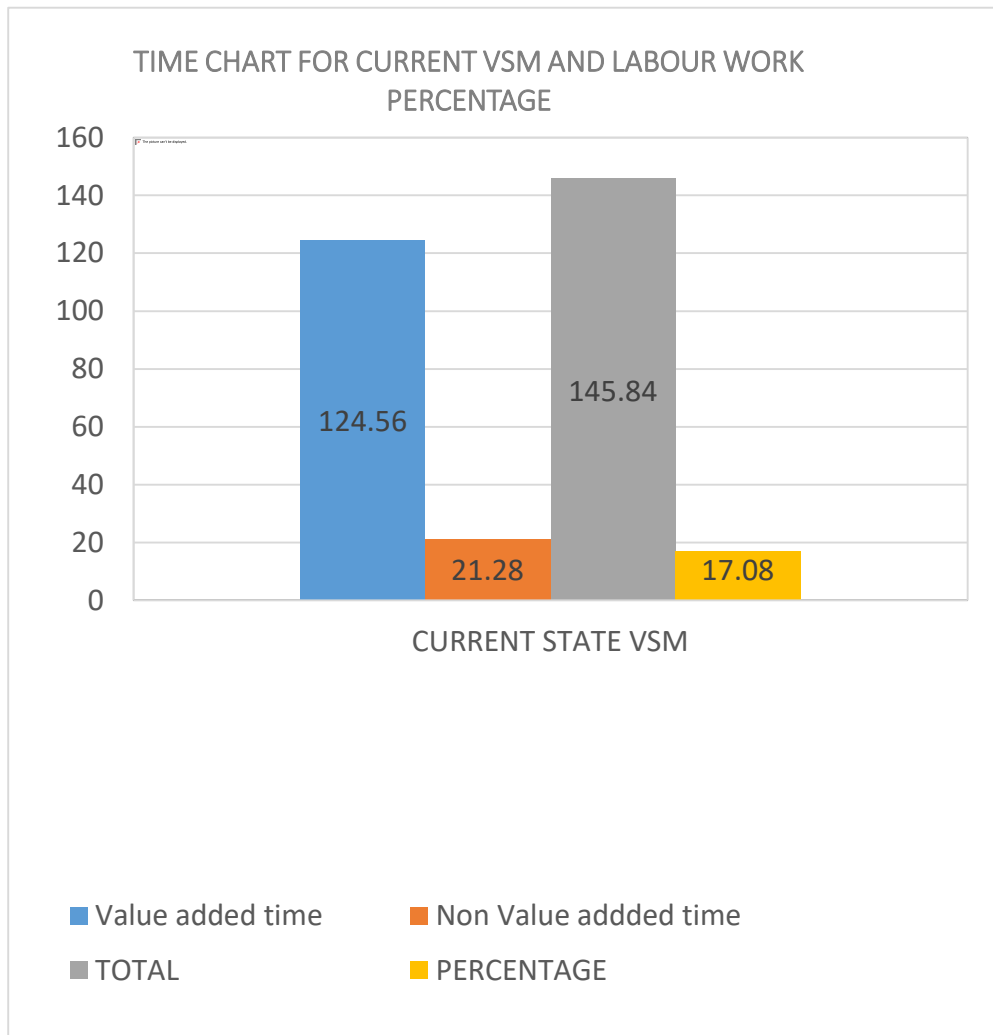


Fig-39

4.8.15 Data For Cutting Of Steel Bars For Beam Rings (Future State):

TABLE-50

data for cutting of steel bars for beam rings (future state)		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of parts to be cut in a steel bar	8
4	Length of 1 ring	1.5 METERS
5	NO. of steel bars grouped per cycle	10
6	Total NO. of shifts or cycle	102
7	Time taken to completely cut 1 cycle	1 sec X 8 =8 seconds
8	Time taken to realign the steel bar after every cut	35 sec X 8=280 seconds
9	Total time consumed for completing 1 cycle	8 + 280 = 288 seconds
10	Total time consumed for this activity(Overall Cycle time)	29,376 seconds(8.16 hours)
11	Value Added Time	816 seconds(13.6 minutes)

4.8.16 Data For Cutting Of Steel Bars For Column Rings (Future State):

TABLE-51

Data For Cutting Of Steel Bars For Column Rings (Future State)		
SI.NO	DESCRIPTION	UNIT/TYPE

1	Type of activity	Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of parts to be cut in a steel bar	7
4	Length of 1 ring	1.7 METERS
5	NO. of steel bars grouped per cycle	10
6	Total NO. of shifts or cycle	51
7	Time taken to completely finish 1 cycle	1 seconds X 7 =7 seconds
8	Time taken to realign the steel bar after every cut	35 seconds X 7 =245 seconds
9	Total time consumed for completing 1 cycle	7 + 245 =252 seconds
10	Total time consumed for this activity(Overall Cycle time)	12,852 seconds(3.57 hours)
11	Value Added Time	357 seconds(5.95 minutes)
12	Necessary Non Value Added Time	12,495 Seconds(3.5 hours)

4.8.17 Productivity Of Cutting Of Steel Bars For Rings (Future State):

TABLE-52

Productivity Of Cutting Of Steel Bars For Rings (Future State)		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Steel required	7187 kg
2	Total time taken to complete the activity	11.7 hours
3	Productivity of cutting steel bars for beam rings	614.3 kg/hours

4.8.18 Data For Bar Bending Of Steel Bars For Beam And Column Rings (Future State):

TABLE-53

Data For Bar Bending Of Steel Bars For Beam And Column Rings (Future State)		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	2(1 Bar bender, 1 Fixer)
3	Total NO. of rings required for Beams and Columns	8155 + 3591 = 11,746
4	Steel used	7,187 kg
5	Time taken to create 10 ring	30 Seconds
6	Time taken to realign a new set of bars for bending	3 Seconds
7	Total time consumed to complete the activity (cycle time)	9.8 Hours +1 Hours = 10.8 Hours
8	Value Added Time	9.8 Hours
9	Necessary Non Value Added Time	1 Hours (10 hours)

4.8.19 Productivity Of Bar Bending Of Steel Bars For Beam And Column Rings (Future State):

TABLE-54

Productivity Of Bar Bending Of Steel Bars For Beam And Column Rings (Future State)		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Rings required	11,746
2	Total time taken to complete the activity	10.8 Hours
3	Steel used	7,187 kg

4	Productivity of bending of steel bars for beam and column rings	665.5 kg/hour
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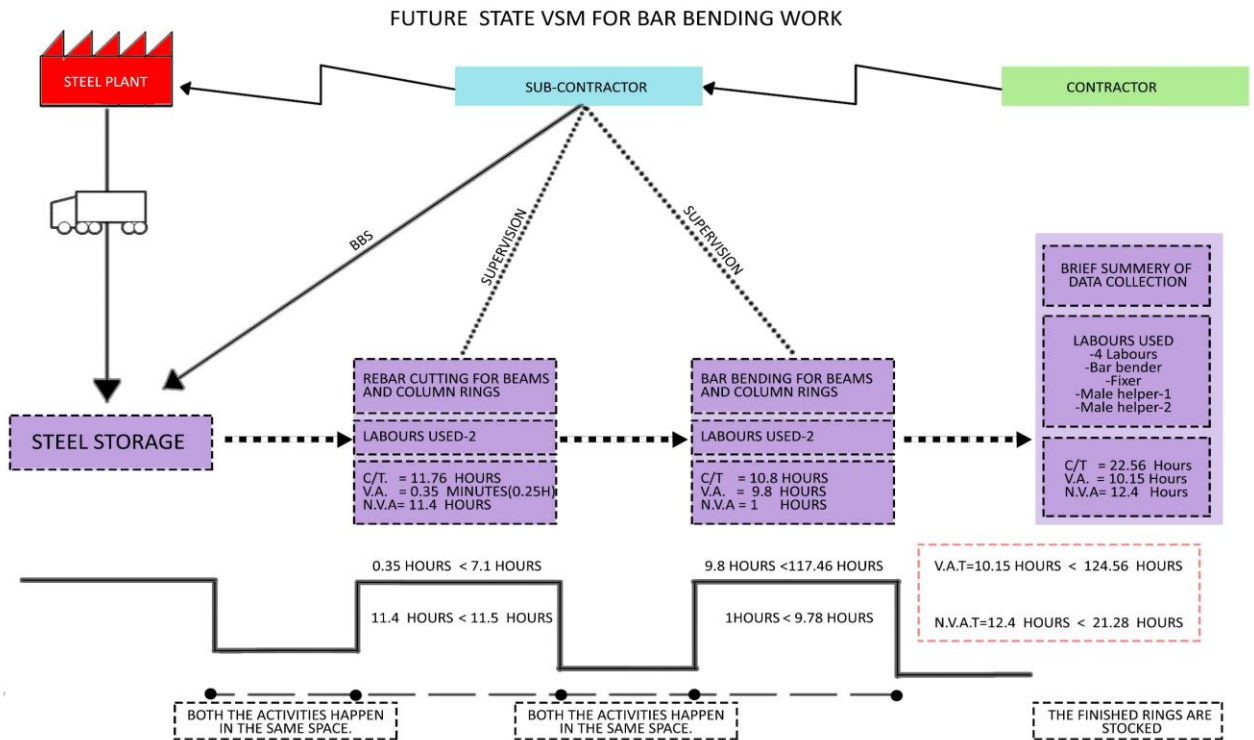


Fig-40

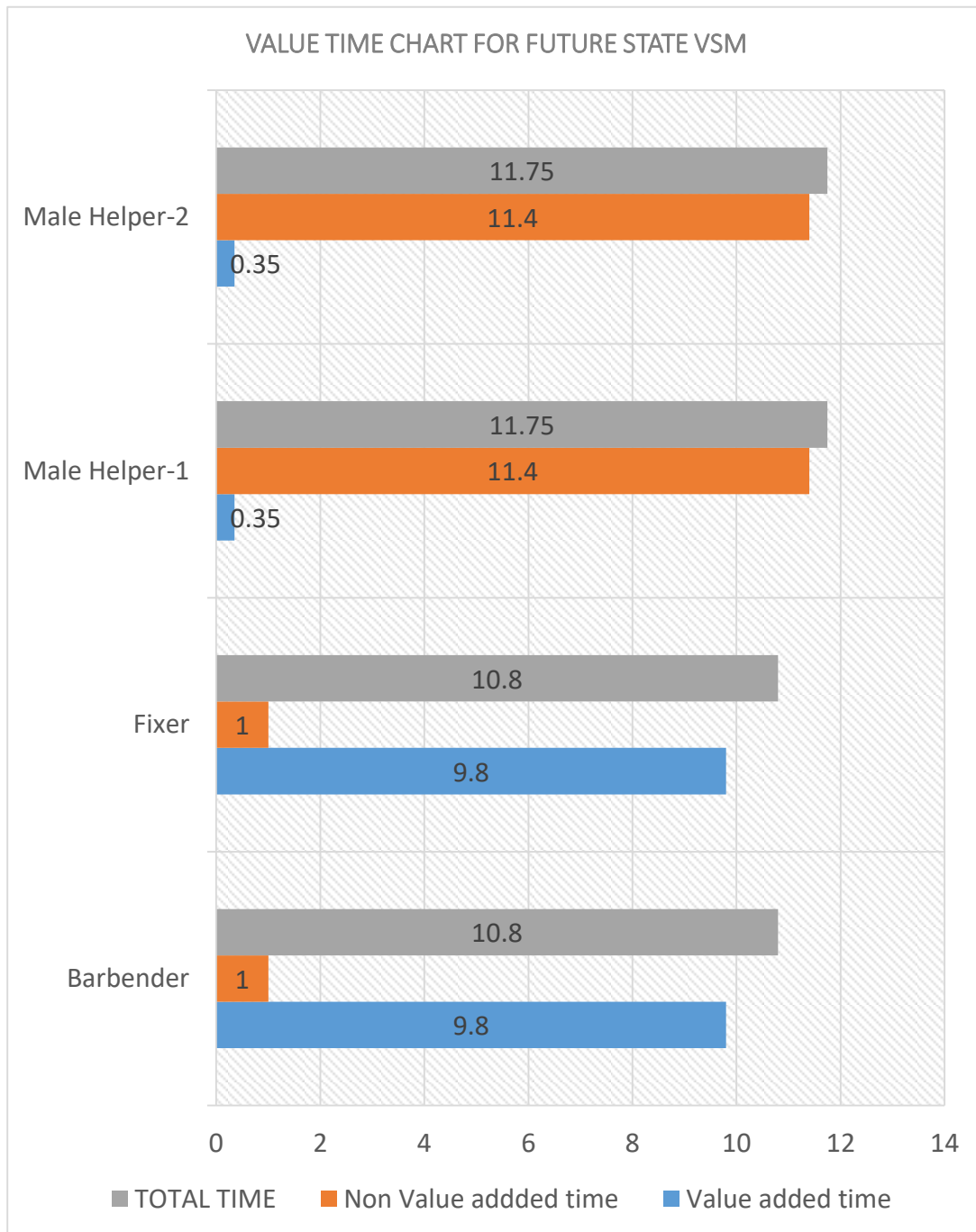


Fig-41

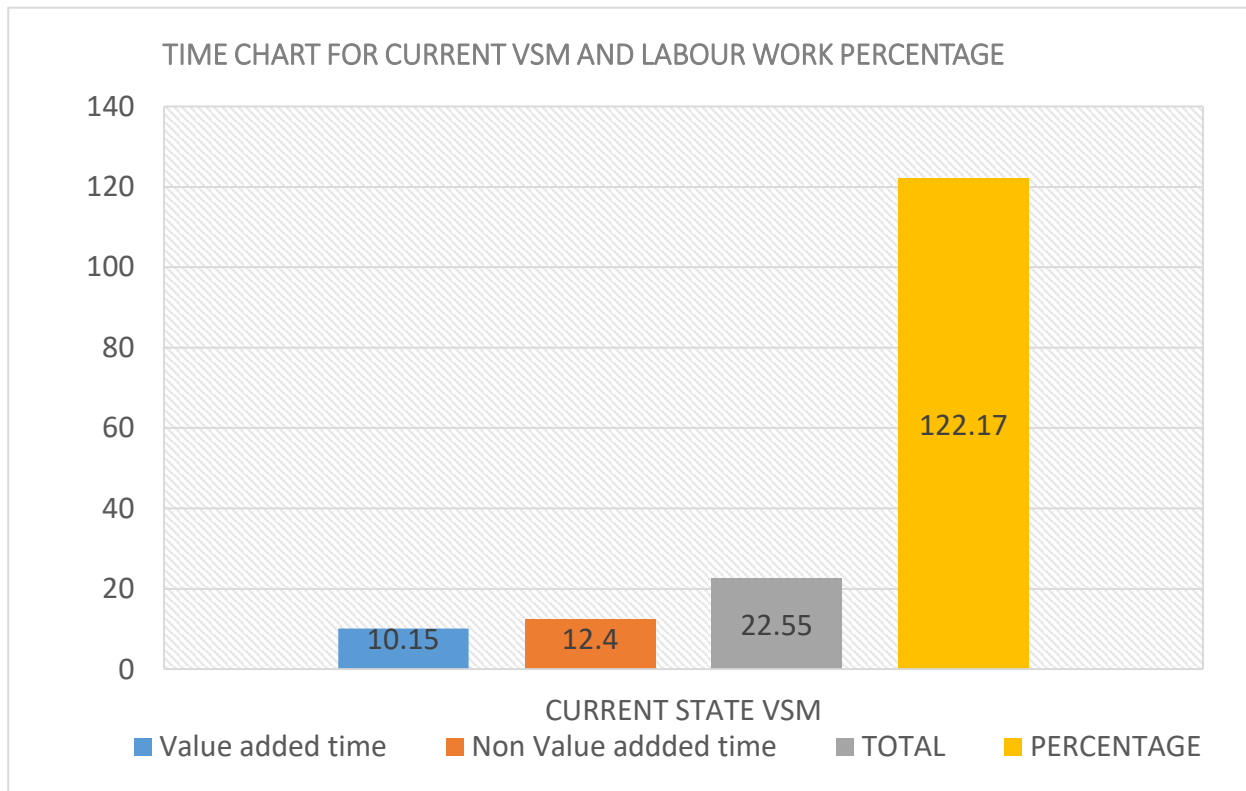


Fig-42

4.8.20 cost analysis for bar bending for current state and future state vsm

(TABLE-55)

COST ANALYSIS FOR BAR BENDING FOR CURRENT STATE AND FUTURE STATE VSM			
SI.NO	DESCRIPTION	CURRENT STATE	FUTURE STATE
1	Number Of Labours Used	4 Labours Barbender-1 Fixer-1 Male Helper-1 Male Helper-2	4 Labours Barbender-1 Fixer-1 Male Helper-1 Male Helper-2

2	Wages Of Labours	Bar bender-Rs 750/DAY Fixer-600/DAY MALE HELPER- Rs 600/DAY	Mason-Rs 750/DAY Fixer-600/DAY MALE HELPER- Rs 600/DAY
3	Time Taken To Finish The Task	Barbender:16 Days Fixer : 16 Days Male Helper (1,2): 2.5 Days	Barbender:1.5 Days Fixer : 1.5 Days Male Helper (1,2): 1.5 Days
4	Cost Of Labours	$(1 \times 750 \times 16) + (1 \times 600 \times 16) + (2 \times 600 \times 2.5)$ $= 12,000 + 9,600 + 3,000$ $= 24,600$	$(1 \times 750 \times 1.5) + (1 \times 600 \times 1.5) + (2 \times 600 \times 1.5)$ $= 1,125 + 900 + 1,800$ $= 3,825$

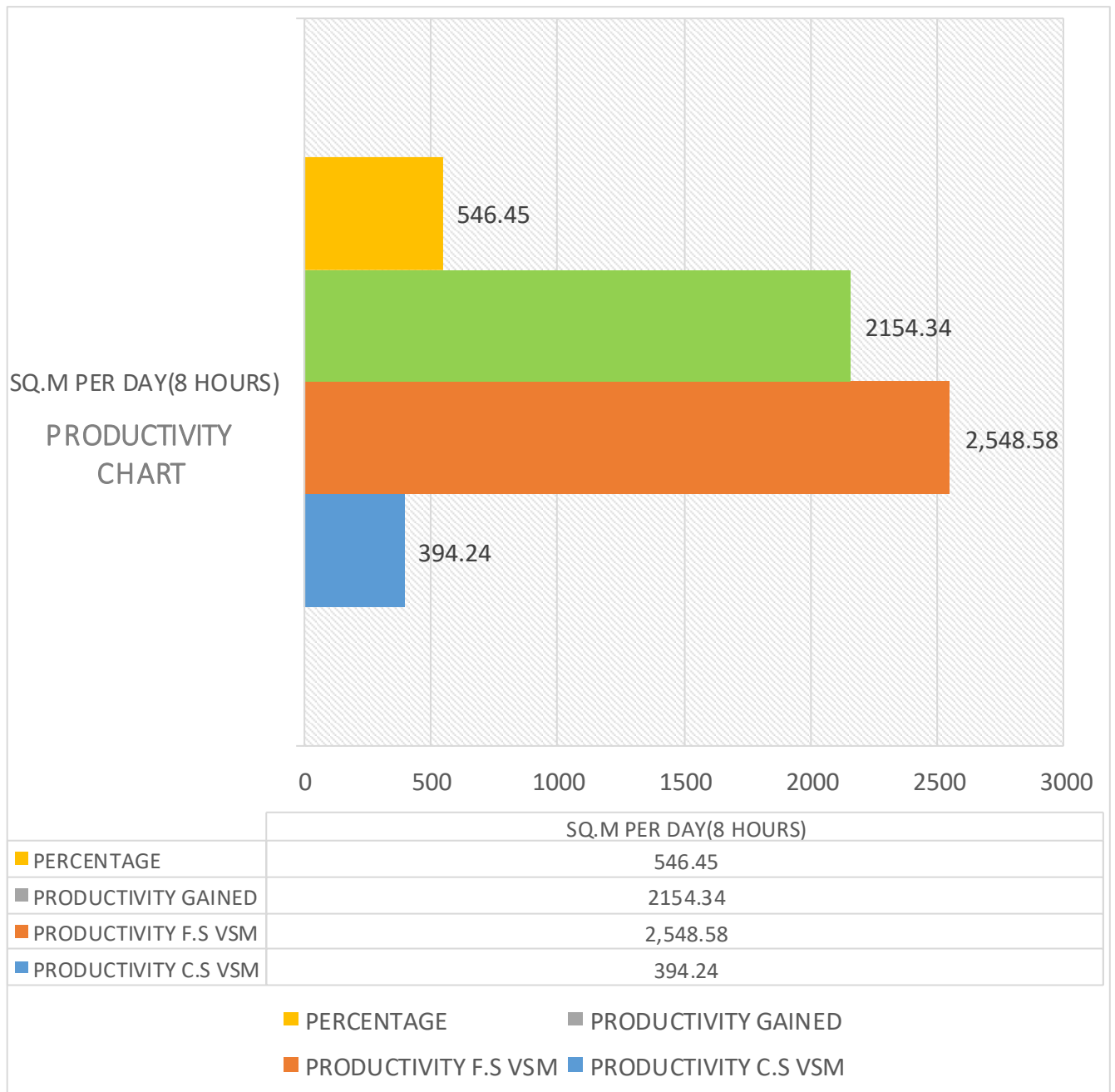


Fig-43

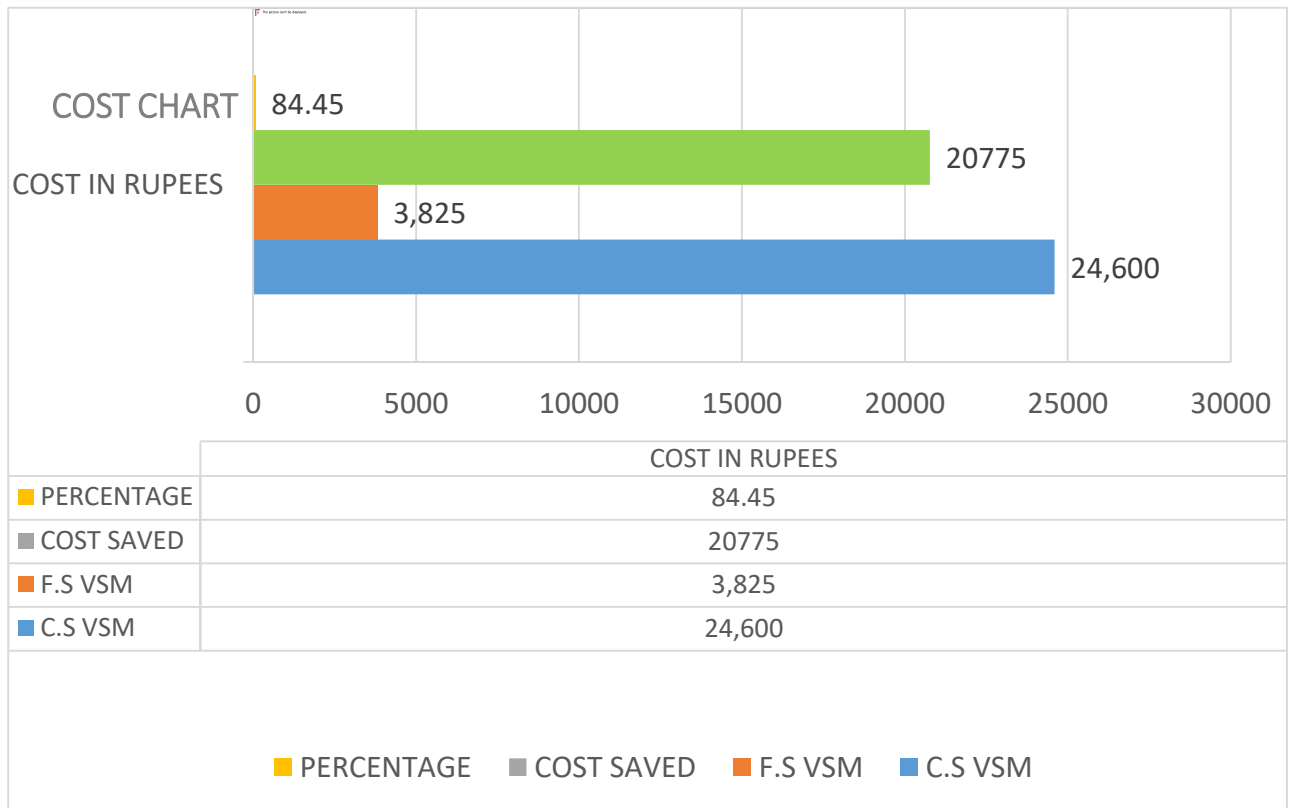


Fig-44

4.9 INTERNAL PLASTERING:

4.9.1 Area of study:

Internal wall plastering in 7th floor of block-5

4.9.2 Limitation of the study:

Since I am measuring the internal wall plastering Activity I am limiting my study wall plastering for the units in 7th floor of block-5

4.9.3 Process:

1. Shifting of sand from storage to workplace.
2. Shifting of cement bags to work place.
3. Internal plastering work.



Fig-45

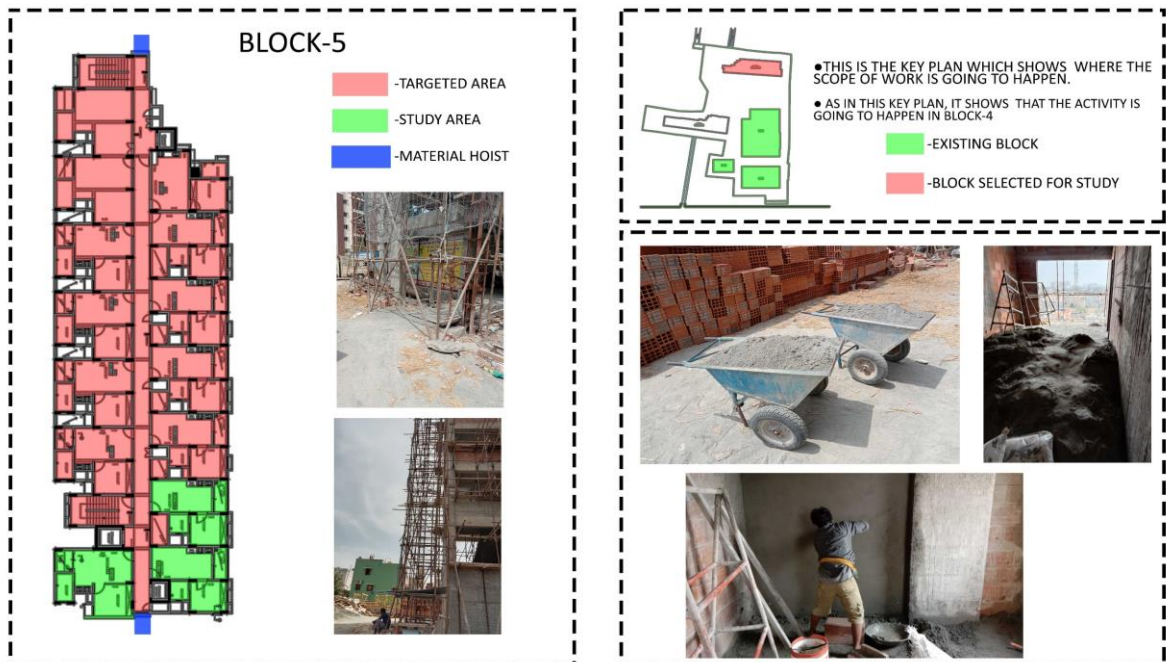


Fig-46

4.9.4 Data for shifting of sand from storage to work place:

TABLE-56

Data for shifting of sand from storage to work place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	(Male helper-1, Male helper-2)
3	Volume of sand required to be moved	23 Cu.m
4	Volume of sand moved per shift or cycle	0.2 Cu.m
5	Distance traveled per shift or cycle	Horizontal distance of 17 meters and vertical distance of 21 meters.
6	Time taken to complete 1 shift or cycle	400 seconds(6 Minutes 40 Seconds)
7	Total NO. of shifts or cycle required	115
8	Total time consumed for this activity(Overall Cycle time)	46,000 seconds(766.66 minutes) (12.8 Hours)
9	Value Added Time	0

4.9.5 Data for shifting of cement from storage to work place:

(TABLE-57)

Data for shifting of cement from storage to work place		
SI.NO	DESCRIPTION	UNIT/TYPE

1	Type of activity	Necessary Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of cement bags moved per shift or cycle	6 bags
4	Total NO. of shifts or cycle	18
5	Time taken to complete 1 shift or cycle	322 Seconds
6	Distance traveled per shift or cycle	Horizontal distance of 25 meters vertical distance of 21 meters
7	Total time consumed for this activity(Overall Cycle time)	5,796 seconds (1.6 hour)
8	Value Added Time	0

4.9.6 Data for plastering work:

TABLE-58

Data for plastering work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	10(6 masons, 4 male helpers)
3	Wall area plastered per day(8 hours)	45 Sq.m
4	Sand used per day	0.6 Cu.m
5	Cement used per day	3Bags

6	Total area targeted (4 th floor)	1730 Sq.m
7	Time taken to install raised support for plastering of higher walls	125 Seconds
8	Time taken to install raised support for plastering of higher walls	350 minutes (5.8 Hours)
9	Time taken to finish the target(4 th floor)(cycle time)	307.5+ 30 hours +5.8 hours = 343.3 hours
10	Value added time	307.5 hours
11	Non value added time	35.8 hours(Nearly 1 ½ day)

4.9.6 Productivity of plastering work:

TABLE-59

Productivity of plastering work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Wall area to be plastered	1730 Sq.m
2	Total time taken to complete the activity	343.3 hours (42.9 days)
3	Productivity of work	7.5 SQ.M / day / Mason
	Productivity of the team(6 masons + 4 male helpers)	45 SQ.M//DAY
4	Total productivity of the team(6 masons + 4 male helpers)	5.6 SQ.M /hour

4.9.7 Brief summary of internal plastering:

TABLE-60

Brief summary of internal plastering		
SI.NO	DESCRIPTION	UNIT/TYPE

1	Total Labours working in the crew	10 Labours -6 masons -4 male helpers
2	Wall area to be plastered	1730 Sq.m
3	Time taken to finish the target(7 th floor)(cycle time)	357.7 Hours
4	Value added time	307.5 hours
5	Non value added time	50.2 hours

4.9.8 Current state vsm for internal plastering activity:

- From the above collected data it is evident that there is a overall duration of 50.2 hours Non-Value Added Time taken place In the internal plastering work.
- To create the Current State VSM for bar bending activity these Non-Value Added Activities should be noted and listed out.

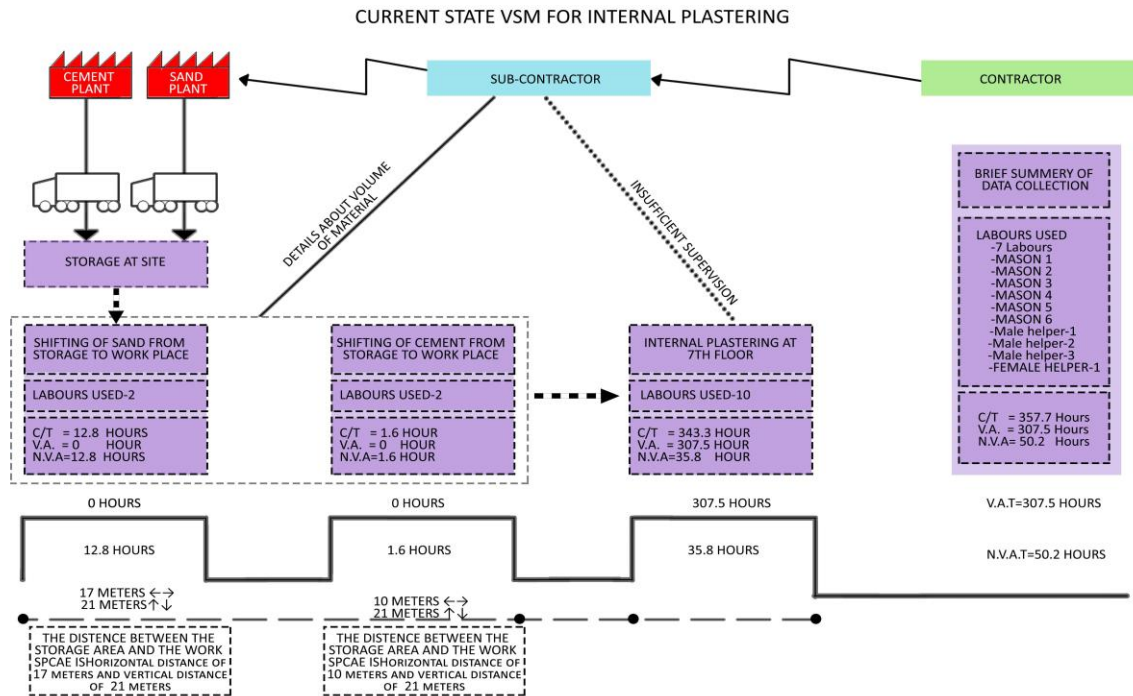


Fig-47

4.9.9 Improvements to the current state vsm for bar bending activity:

- According to the current state VSM the Non Value Added activities are identified and ways to rectify the activities are discussed.

4.9.9.1 Rectifying non value adding activity-1 (shifting of materials from storage to work space):

- Material shifting from storage to workspace is necessary for any activity but it does not necessarily add any value to the activity as a whole.
- Yet this process is necessary and it consumes time and cost. Even though it cannot be fully neglected it can be minimized.
- While measuring the material shifting process I noticed that even though there are two hoist lifts one on each side of the Building only one of the hoist lifts were used at a time to shift the materials.

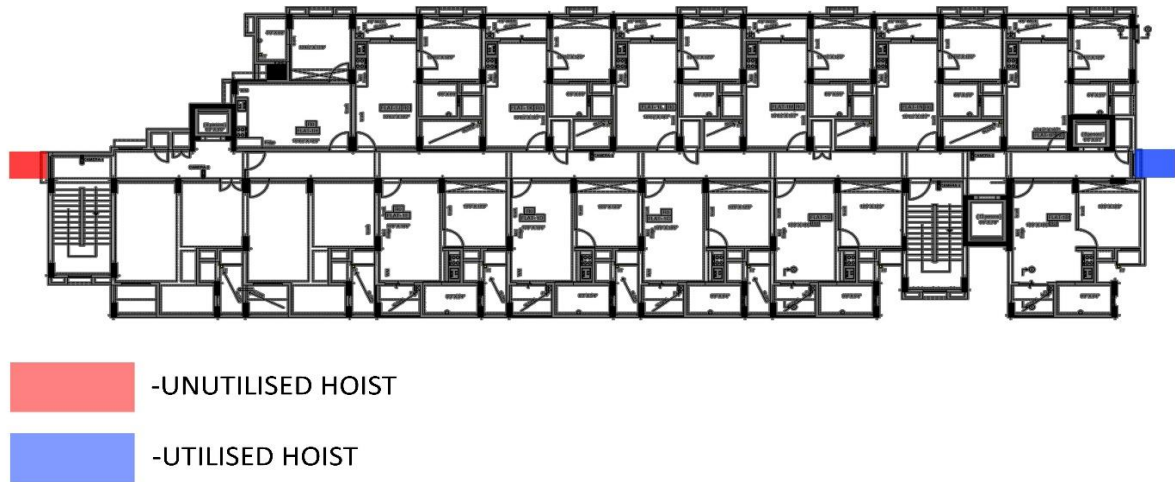


Fig-48



Fig-49



Fig-50

- By utilizing the second hoist the material shifting process can boost up ultimately reducing the time taken to complete the process by half.

4.9.9.2 Rectifying non value adding activity-2 (internal plastering work):

- While measuring the internal plastering work I could notice that the work was affected by longer breaks after finishing each wall.
- Due to insufficient supervision the labours were less motivated and the productivity rate measured was little bit lesser (7.5 Sq.m/day/mason) than the standard rate (8 Sq.m/day/mason).
- This was due to the parallel activity which was the block work happening in the 10th floor which required supervision as well.
- Allocating addition supervision for this activities we can expect a productivity improvement of atleast the standard rate that is 8 Sq.m /day/mason).

4.9.9.3 Rectifying non value adding activity-3 (time taken to install raised support for plastering for higher walls):

- For plastering of higher wall they were using one or more wooden planks which have been supported on steel drums on either side.



Fig-51



Fig-52

- By using a proper plastering hop ups we can completely avoid the Non Value added time of 5.8 hours that has being consumed by setting up the temporary work bench for plastering higher walls.

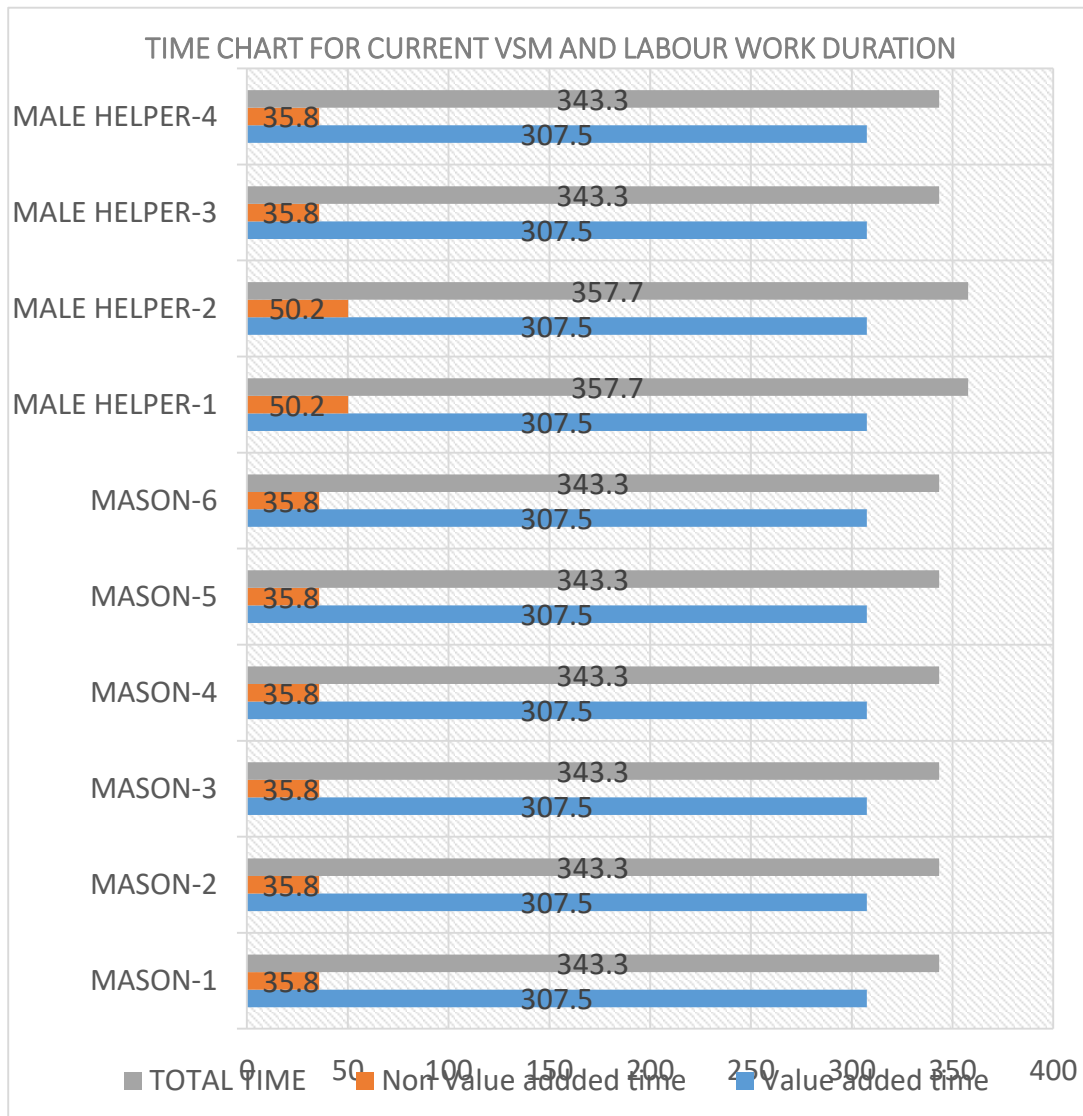


Fig-53

TIME CHART FOR CURRENT VSM AND LABOUR WORK PERCENTAGE

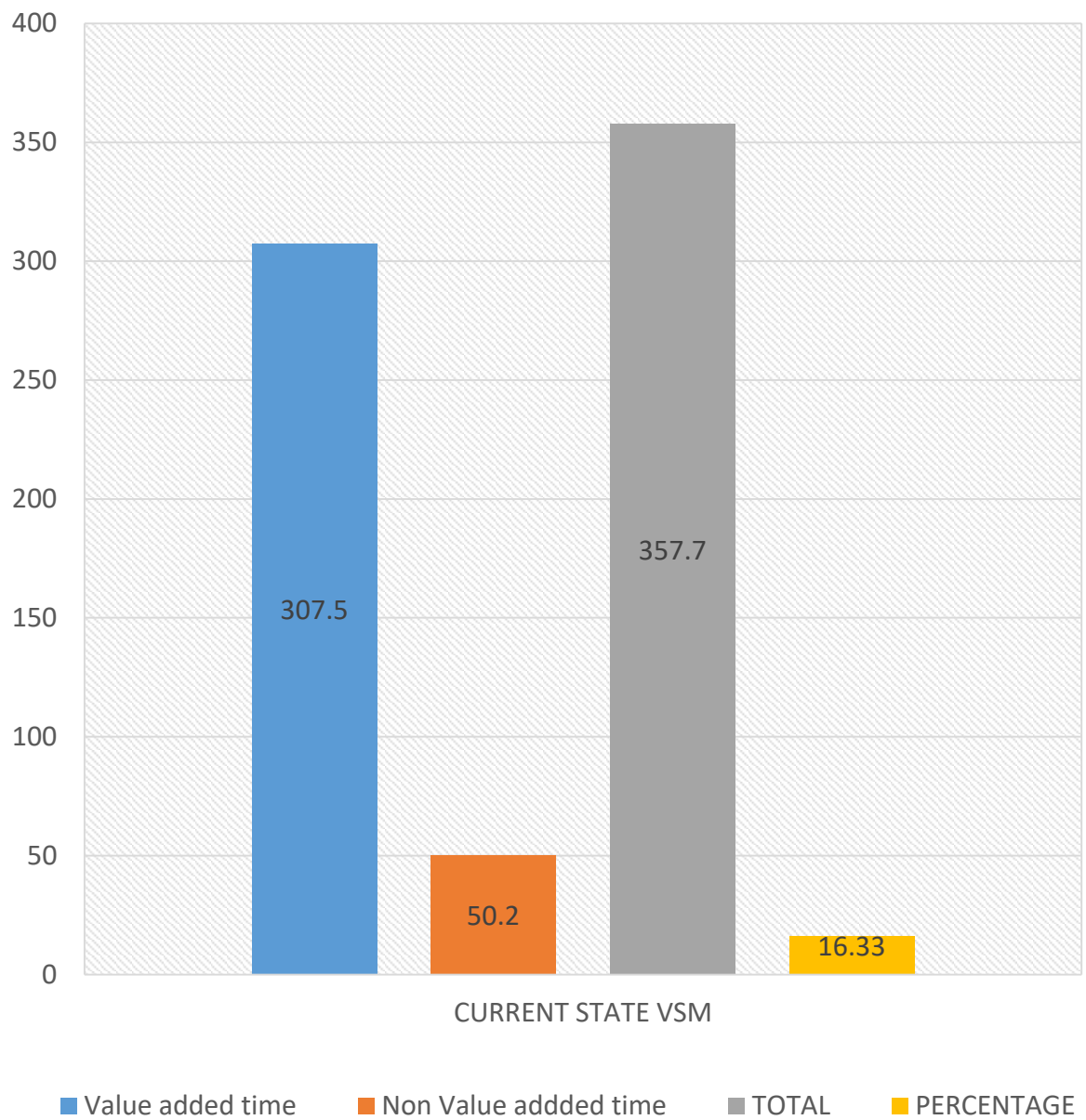


Fig-54

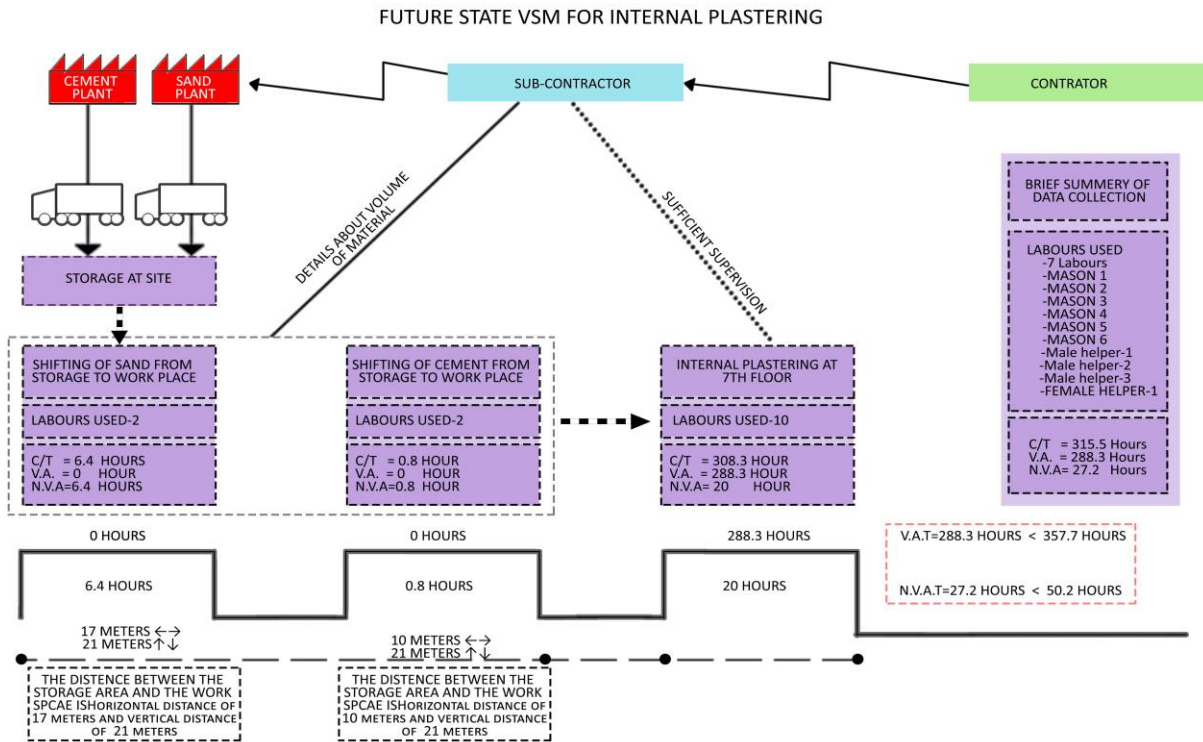


Fig-55

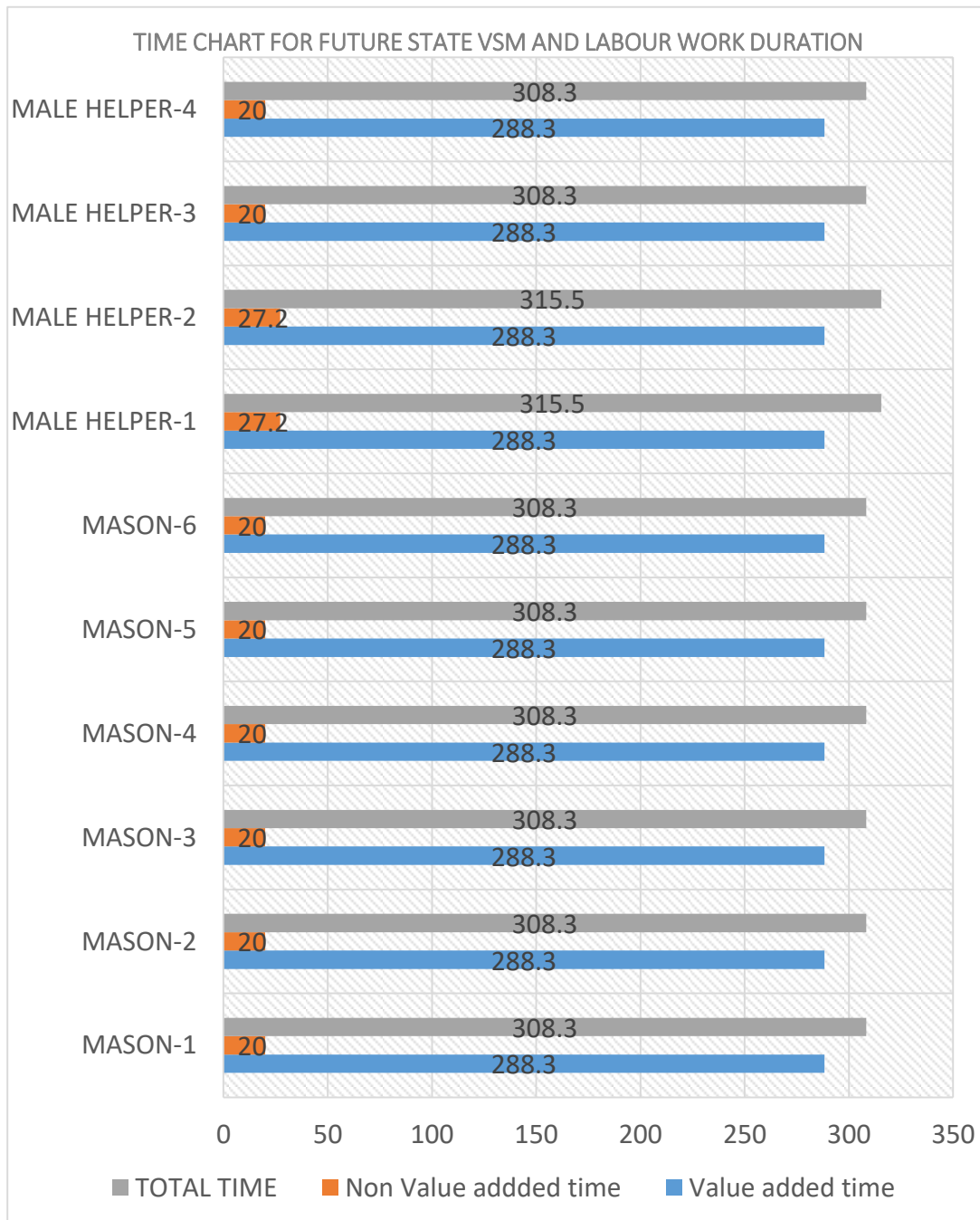


Fig-56

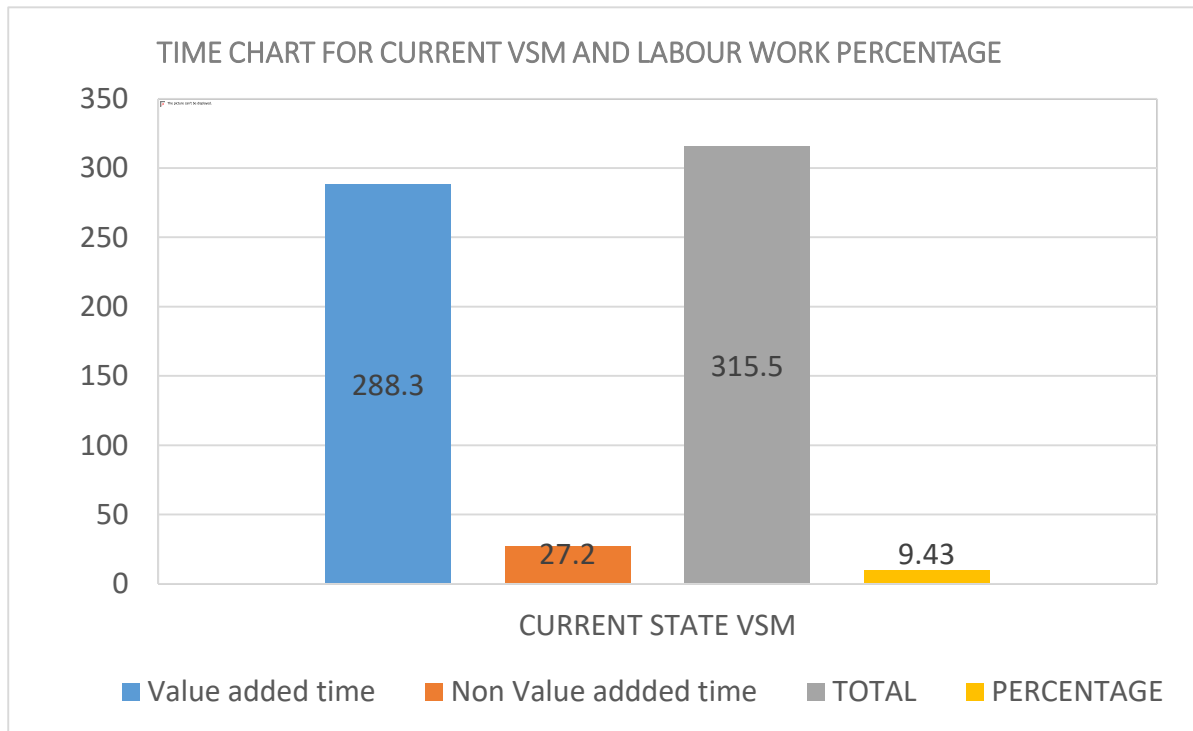


Fig-57

4.9.10 cost analysis for internal plastering for current state and future state vsm:

(TABLE-61)

COST ANALYSIS FOR INTERNAL PLASTERING FOR CURRENT STATE AND FUTURE STATE VSM			
SI.NO	DESCRIPTION	CURRENT STATE	FUTURE STATE
1	Number Of Labours Used	10 Labours Masons-6 Male Helpers-4	10 Labours Masons-6 Male Helpers-4

2	Wages Of Labours	Mason-Rs 750/DAY MALE HELPER- Rs 600/DAY	Mason-Rs 750/DAY MALE HELPER- Rs 600/DAY
3	Time Taken To Finish The Task	Mason(1-6):43 Days Male Helper (3,4): 43 Days Male Helper (1,2): 45 Day	Mason(1-4):38.5 Days Male Helper: 38.5 Days Male Helper (2,3): 39.5 Day
4	Cost Of Labours	$(6 \times 750 \times 43) + (2 \times 600 \times 43) + (2 \times 600 \times 45)$ =193,500+ 51,600+ 54,000 =299,100	$(6 \times 750 \times 38.5) + (2 \times 600 \times 38.5) + (2 \times 600 \times 39.5)$ =173,250 + 46,200 + 47,400 =266,850

4.10 BLOCK WORK ACTIVITY:

4.10.1 Area of study:

Block work activity happening in 10th Floor Of block-5.

4.10.2 Limitation of the study:

Since I am measuring the block work activity I am limiting my study measure all the sub-Activities that are happening along with block work.

4.10.3 Process:

1. Shifting of sand from storage to work place.
2. Shifting of cement from storage to work place
3. Shifting of solid blocks from storage to work place
4. Block work.



Fig-58



Fig-59

4.10.4 Data for shifting of sand from storage to work place:

TABLE-62

Data for shifting of sand from storage to work place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	3(Male helper-1,2,3)
3	Volume of sand required to be moved	62.7 Cu.m
4	Volume of sand moved per shift or cycle	0.2 Cu.m
5	Distance traveled per shift or cycle	Horizontal distance of 17 meters and vertical distance of 30 meters.
6	Time taken to complete 1 shift or cycle	430 seconds (7.16 minutes)
7	Total NO. of shifts or cycle required	314
8	Total time consumed for this activity(Overall Cycle time)	141,300 seconds(2,355 minutes) (39.25 Hours)
9	Value Added Time	0

4.10.5 Data for shifting of cement from storage to work place:

TABLE-63

Data for shifting of cement from storage to work place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added

2	Labour required	3(Male helper-1,2,3)
3	NO. of cement bags moved per shift or cycle	6 bags
4	Total NO. of shifts or cycle	50
5	Time taken to complete 1 shift or cycle	352 Seconds
6	Distance traveled per shift or cycle	Horizontal distance of 25 meters vertical distance of 30 meters
7	Total time consumed for this activity(Overall Cycle time)	17,600 seconds (293.3 minutes) (Nearly 5 hour)
8	Value Added Time	0

4.10.6 Data for shifting of solid block from storage to work place:

TABLE-64

Data for shifting of solid block from storage to work place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	3(Male helper-1,2,3)
3	Number of solid block required to be moved	18,200
4	Number of sand moved per shift or cycle	28 Porotherm blocks
5	Distance traveled per shift or cycle	Horizontal distance of 10 meters and vertical distance of 30

		meters.
6	Time taken to complete 1 shift or cycle	390 seconds
7	Total NO. of shifts or cycle required	650
8	Total time consumed for this activity(Overall Cycle time)	2,53,500 seconds(4,225 minutes) (70.4 Hours)
9	Value Added Time	0

4.10.7 Data for block work:

TABLE-65

Data for block work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	12(6 masons, 4 male helpers,2 female helpers)
3	Block work completed per day(8 hours)	57 Sq.m
4	Sand used per day	2 Cu.m
5	Cement used per day	10 Bags
6	Total area targeted (5 th floor)	1730 Sq.m
7	Time taken to install raised support for block work	125 Seconds
8	Time taken to install raised support for plastering for all higher walls	350 minutes (5.8 Hours)
9	Time taken to finish the target(10 th floor)(cycle time)	242.8 Hours + 20 hours +5.8 hours = 268.6 hours

10	Value added time	242.8 hours
11	Non value added time	25.8 hours (more or less 1 day)

4.10.8 Productivity of block work:

TABLE-66

Productivity of block work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Targeted work to be completed	1730 Sq.m
2	Total time taken to complete the activity	383.25 hours Hours(48 days)
3	Productivity of work	9.5 SQ.M / day / Mason + Helper
4	Productivity of the team(4 masons + 4 male helpers)	57 SQ.M//DAY
5	Total productivity of the team(4 masons + 4 male helpers)	5.7 SQ.M /Hour

4.10.9 Brief summary of block work:

TABLE-67

Brief summary of block work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Total Labours working in the crew	12 Labours -6 masons -4 male helpers -2 female helpers

2	Wall area to be plastered	1730 Sq.m
3	Time taken to finish the target(10 th floor)(cycle time)	383.25 Hours
4	Value added time	242.8 hours
5	Non value added time	140.45 hours

4.10.10 current state vsm for block work activity:

- From the above collected data it is evident that there is an overall duration of 140.45 hours Non-Value Added Time taken place in the block work.
- To create the Current State VSM for block work activity these Non-Value Added Activities should be noted and listed out.

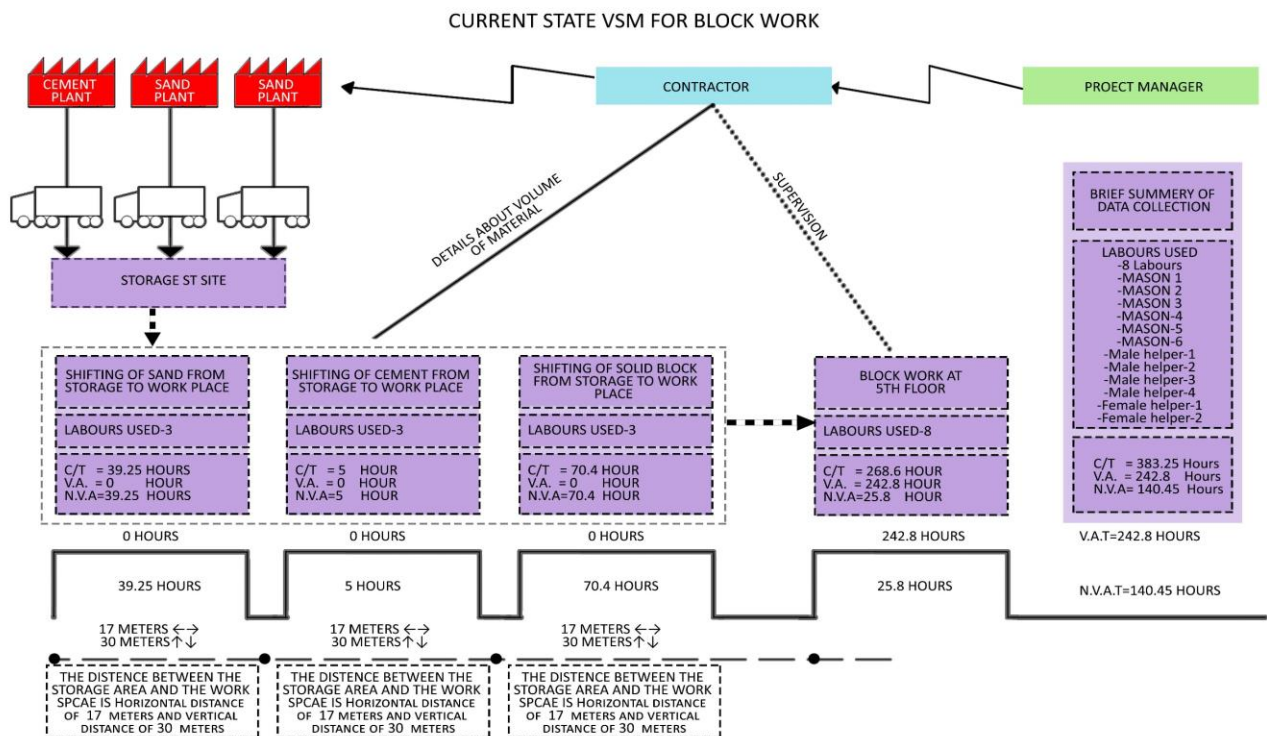


Fig-60

4.10.11 improvements to the current state vsm for bar bending activity:

- According to the current state VSM the Non Value Added activities are identified and ways to rectify the activities are discussed.

4.10.11.1 Rectifying non value adding activity-1 (shifting of materials from storage to work space):

- Material shifting from storage to workspace is necessary for any activity but it does not necessarily add any value to the activity as a whole.
- Yet this process is necessary and it consumes time and cost. Even though it cannot be fully neglected it can be minimized.
- While measuring the material shifting process I noticed that even though there are two hoist lifts one on each side of the building only one of the hoist lifts were used at a time to shift the materials.

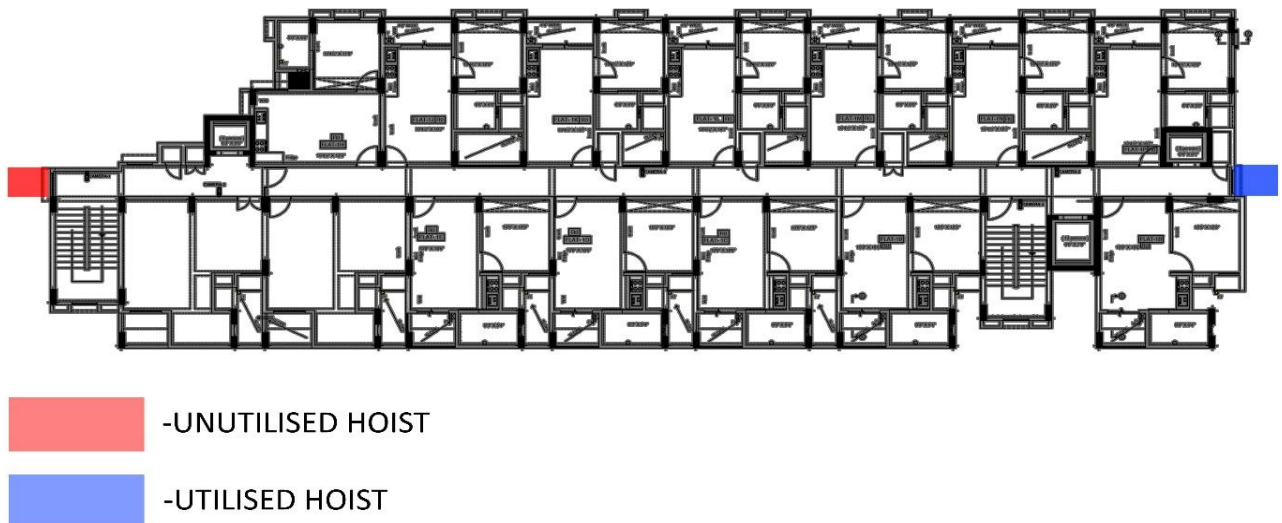


Fig-61



Fig-62



Fig-63

- By utilizing the second hoist the material shifting process can boost up ultimately reducing the time taken to complete the process by half.

4.10.11.2 Rectifying non value adding activity-2 (block work):

- While measuring the block work I could notice that the work was affected by longer breaks after finishing each wall.
- Due to insufficient supervision the labours were less motivated and the productivity rate measured was little bit lesser (9.5 Sq.m/day/mason+ helper) than the standard rate (8 Sq.m/day/mason + helper).
- This was due to the parallel activity which was the internal plastering happening in the 7th floor which required supervision as well.
- Allocating addition supervision for this activities we can expect a productivity improvement of atleast the standard rate that is 10 Sq.m /day/mason + helper).

4.10.11.3 Rectifying non value adding activity-3 (time taken to install raised support for finishing the block work upto the ceiling):

- For plastering of higher wall they were using one or more wooden planks which have been supported on steel drums on either side.



Fig-64



Fig-65

- By using a proper hop ups we can completely avoid the Non Value added time of 5.8 hours that has being consumed by setting up the temporary work bench for plastering higher walls.

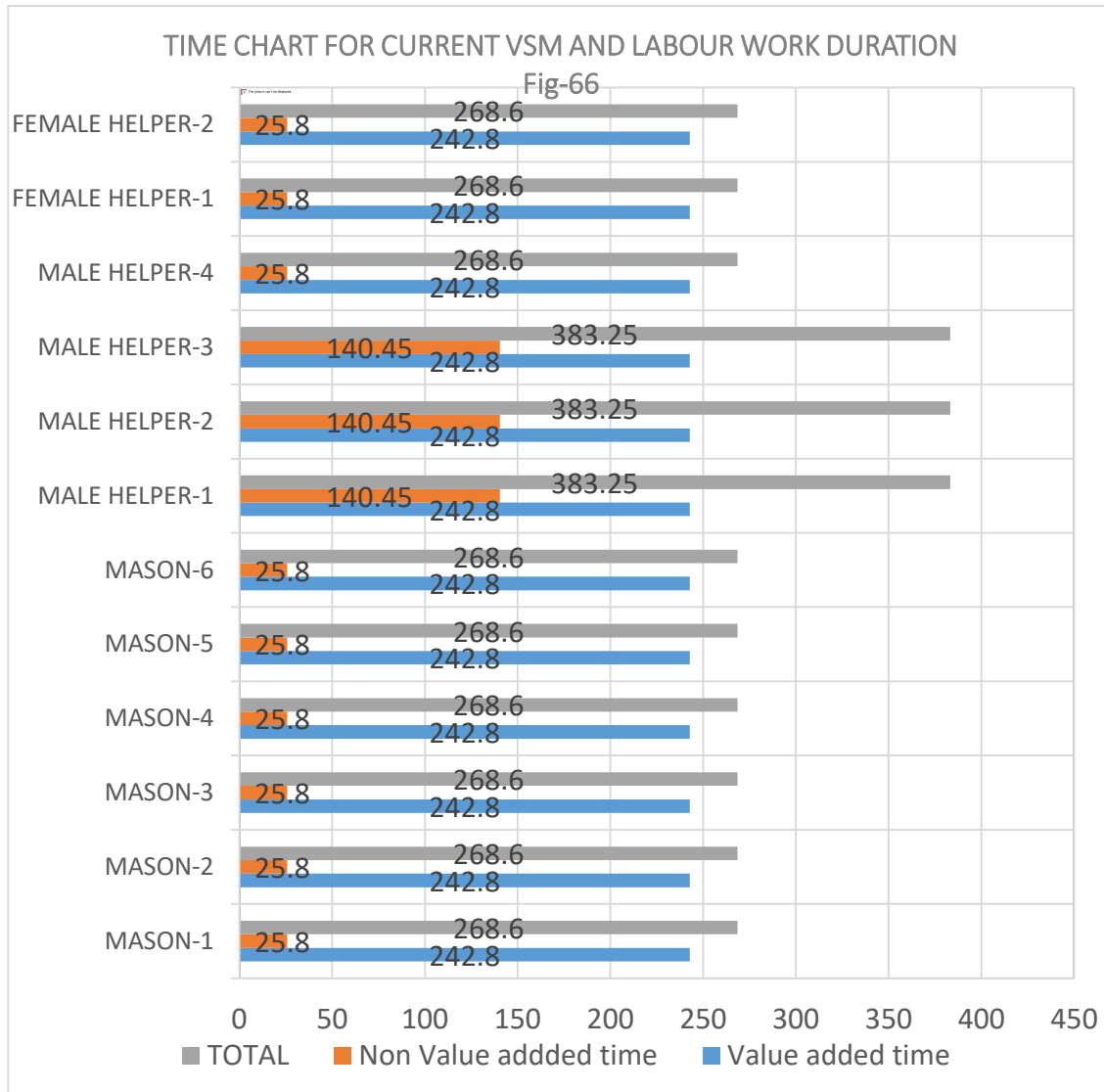


Fig-66

TIME CHART FOR CURRENT VSM PERCENTAGE

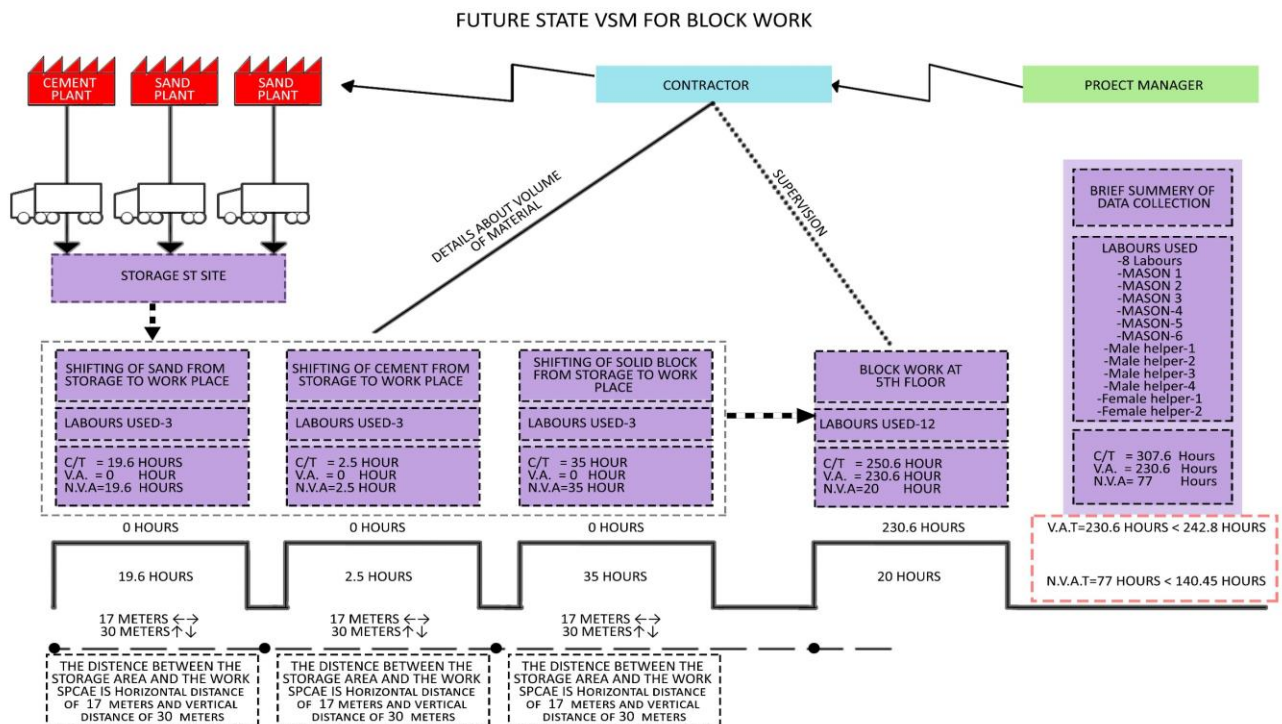
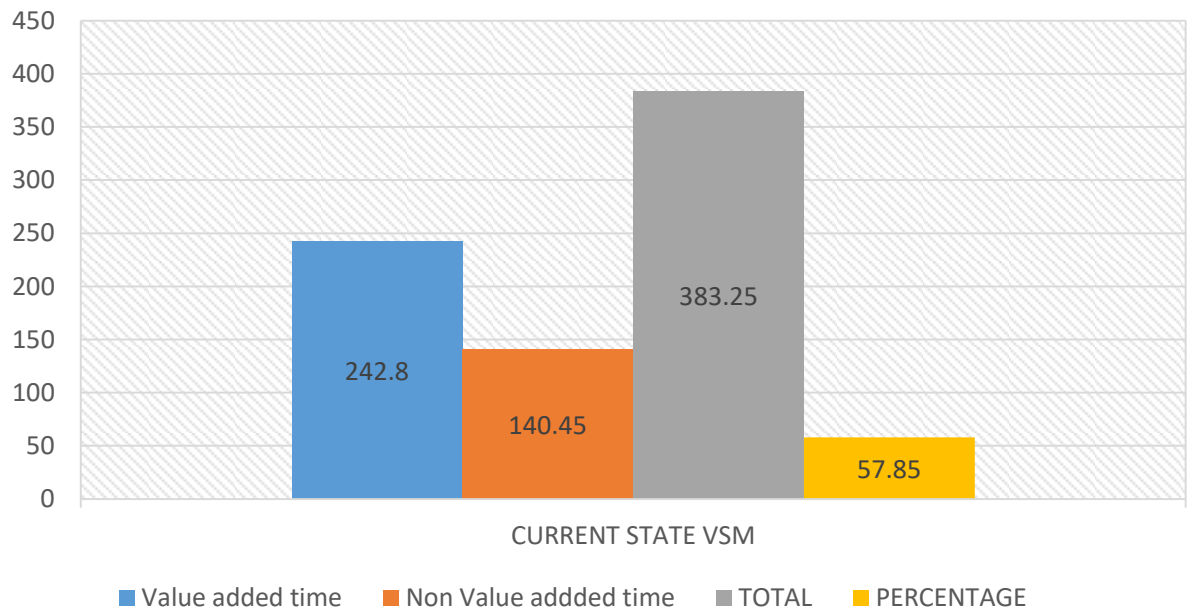


Fig-67

TIME CHART FOR FUTURE VSM AND LABOUR WORK DURATION

Fig-68

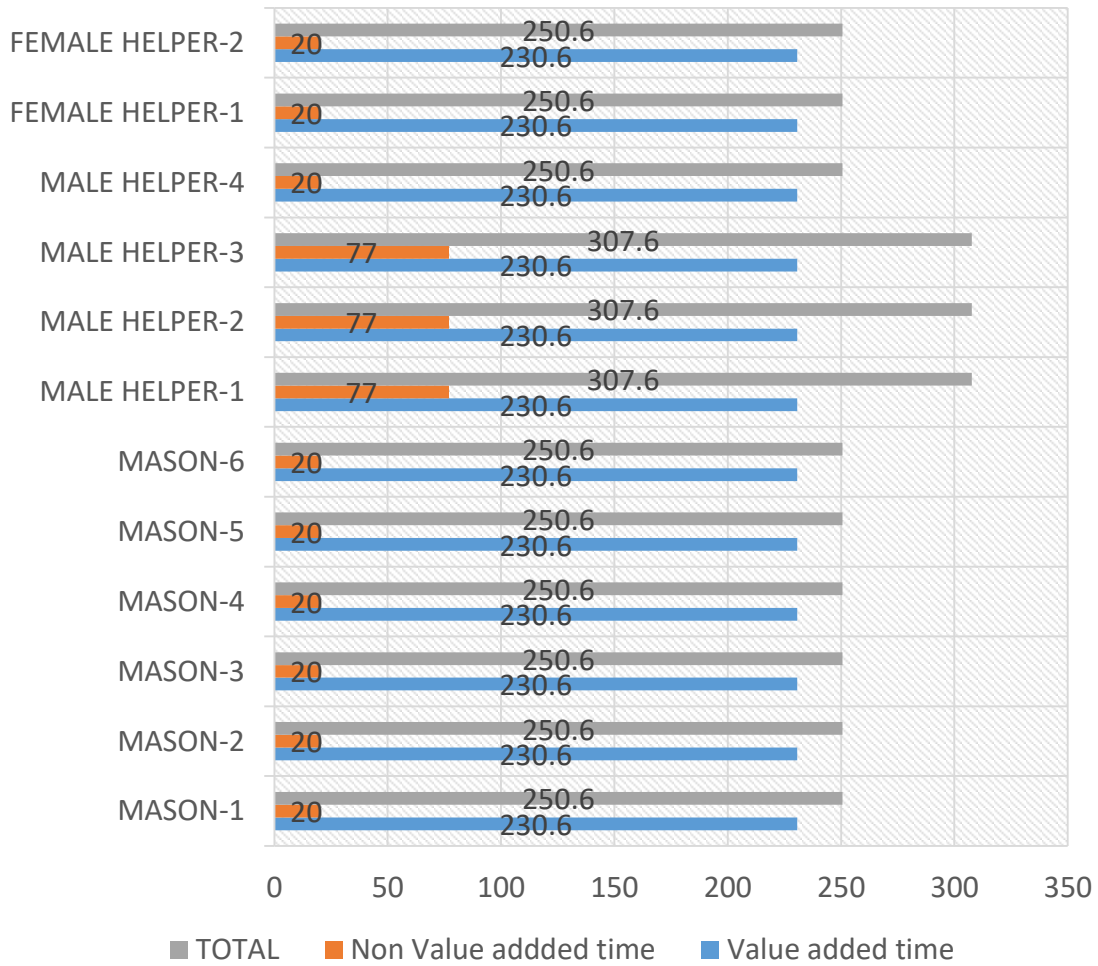


Fig-68

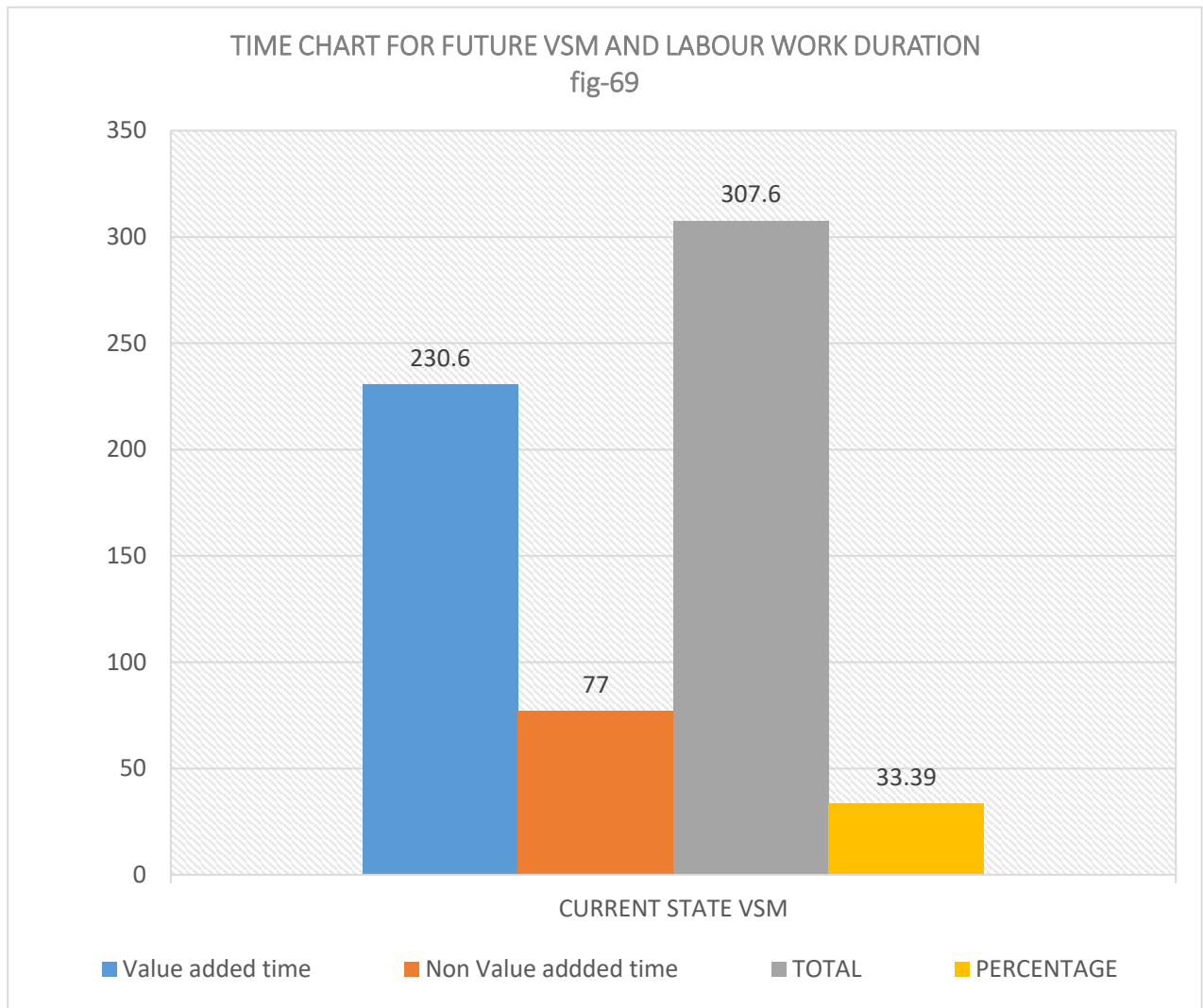
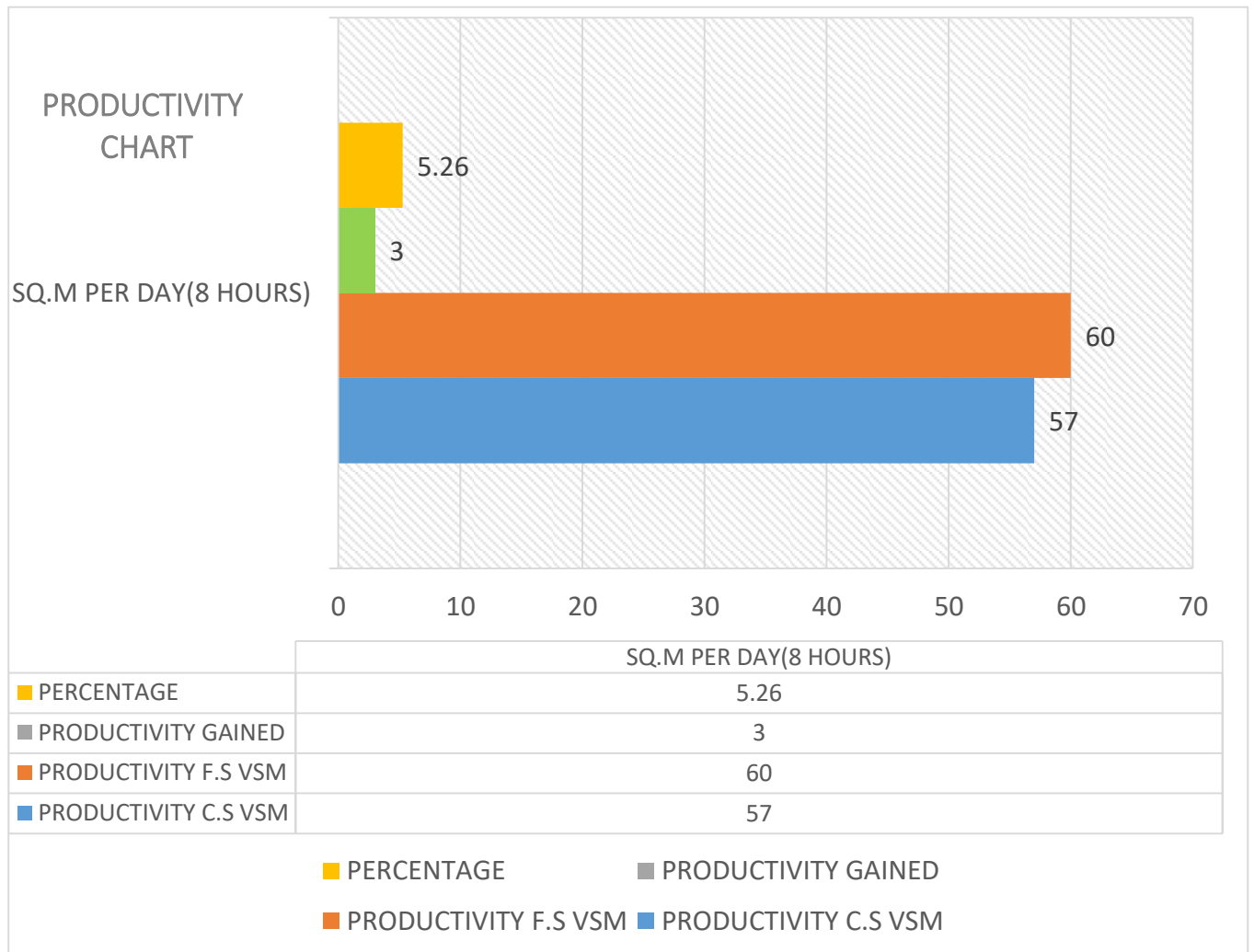


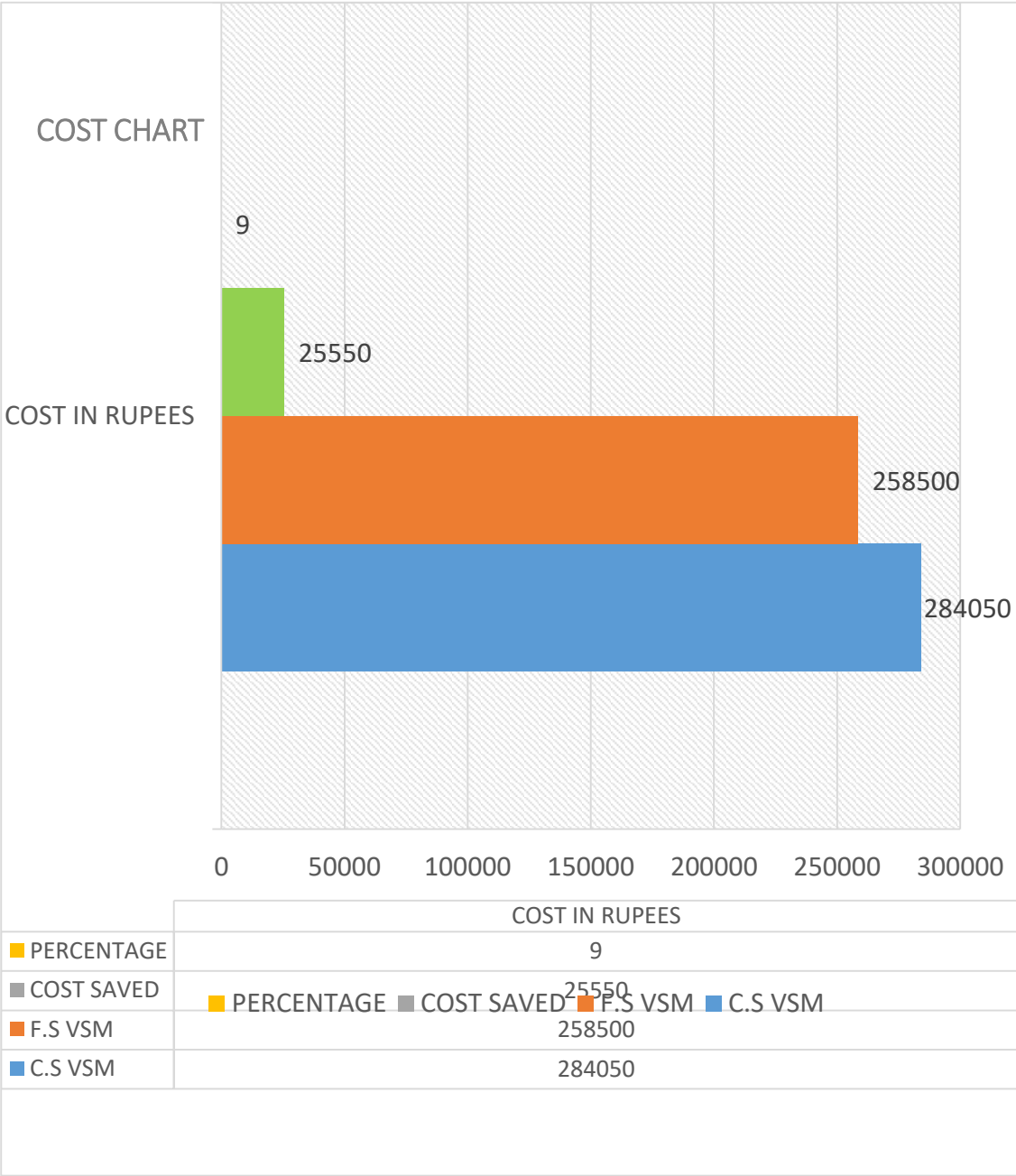
Fig-69

4.10.12 cost analysis of block work for current state and future state vsm:

COST ANALYSIS OF BLOCK WORK FOR CURRENT STATE AND FUTURE STATE VSM(TABLE-68)			
SI.NO	DESCRIPTION	CURRENT STATE	FUTURE STATE

1	Number Of Labours Used	12 Labours Masons-6 Male Helpers-4 Female Helpers-2	12 Labours Masons-6 Male Helpers-4 Female Helpers-2
2	Wages Of Labours	Mason-Rs 750/DAY MALE HELPER- Rs 600/DAY FEMALE HELPER-Rs 400/DAY	Mason-Rs 750/DAY MALE HELPER- Rs 600/DAY FEMALE HELPER-Rs 400/DAY
3	Time Taken To Finish The Task	Mason(1-6):33.5 Days Male Helper(1,2,3): 48 Days Male Helper (4): 33.5 Days Female Helper (1,2):33.5 Days	Mason(1-6):31 Days Male Helper(1,2,3): 42 Days Male Helper (4): 31 Days Female Helper (1,2): 31 Days
4	Cost Of Labours	$(6 \times 750 \times 33.5) + (3 \times 600 \times 48) + (1 \times 600 \times 33.5) + (2 \times 400 \times 33.5)$ =1,50,750 + 86,400 + 20,100 + 26,800 =2,84,050	$(6 \times 750 \times 31) + (3 \times 600 \times 42) + (1 \times 600 \times 31) + (2 \times 400 \times 31)$ =1,39,500 + 75,600 + 18,600 + 24,800 =2,58,500





4.11 Inducing Machineries For Improving Productivity In Construction:

4.12 Machine Plastering For The Future State Vsm Of Case Study-1:



4.12.1 Block work activity:

4.12.2 Area of study:

Automatic / machine plastering of 4th floor of Block-1 for internal plastering

4.12.3 Limitation of the study:

Since I am measuring the internal plastering activity I am limiting my study measure all the sub-Activities that are happening along with plastering work

4.12.4 Process:

1. Shifting sand from storage to the plaster machine in the ground level.
2. Shifting cement bag from storage to the plaster machine in the ground level
3. Automatic mixing of the mortar for plastering



Fig-70

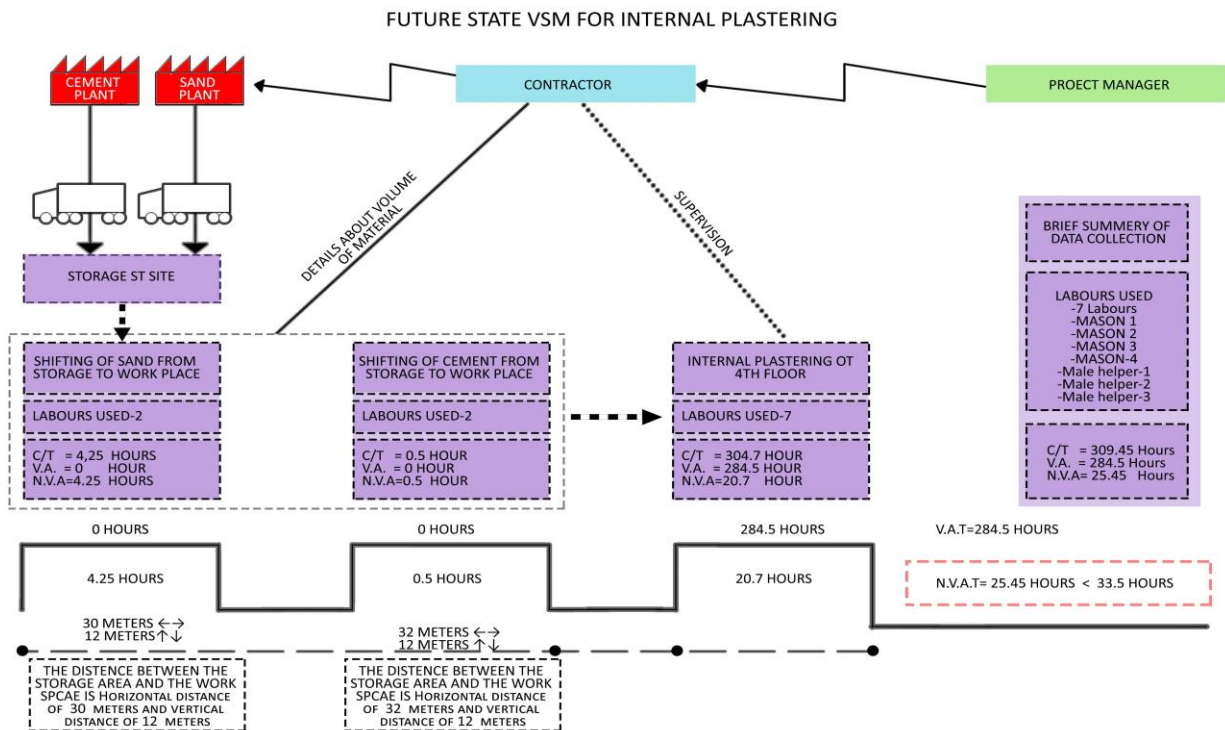


Fig-71

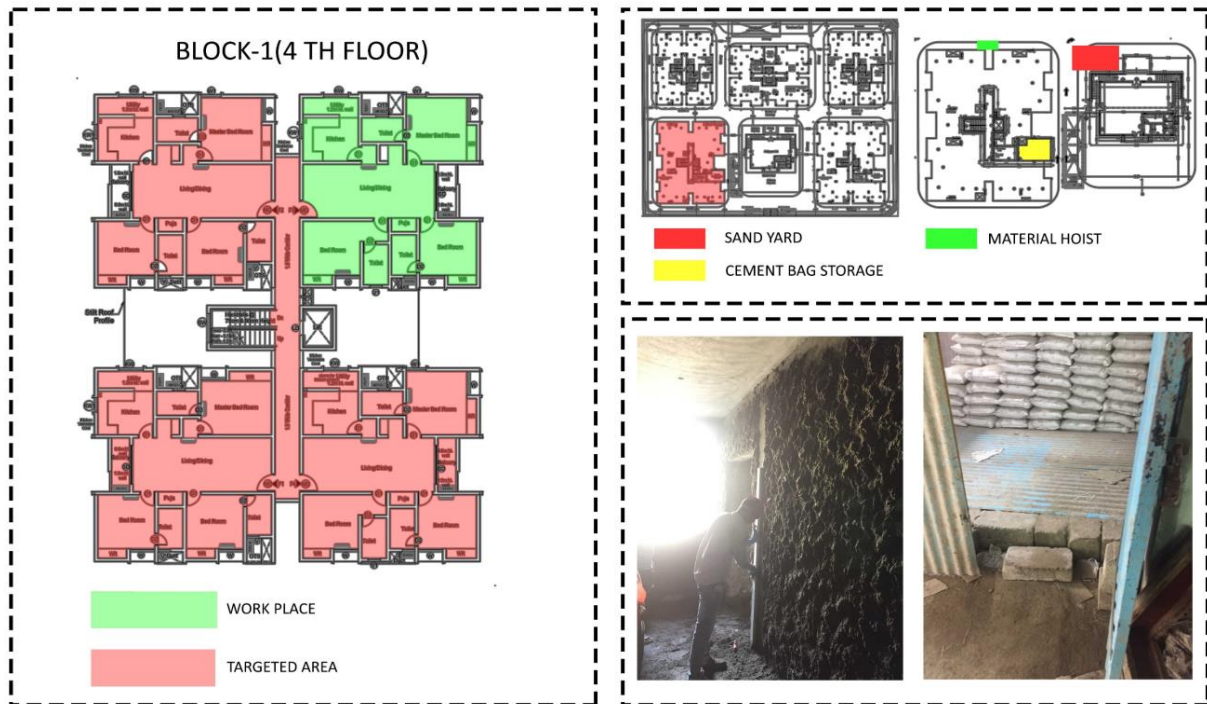


Fig-72

4.12.5 Data for Shifting Of Sand from Storage to Work Place:

TABLE-69

Data for Shifting Of Sand from Storage to Work Place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	(Male helper-1, Male helper-2)
3	Volume of sand required to be moved	16 Cu.m
4	Volume of sand moved per shift or cycle	0.1 Cu.m
5	Distance traveled per shift or cycle	Horizontal distance of 30 meters.

6	Time taken to complete 1 shift or cycle	120 seconds
7	Total NO. of shifts or cycle required	160
8	Total time consumed for this activity(Overall Cycle time)	19,200 seconds(320 minutes) (5.3 Hours)
9	Value Added Time	0

4.12.6 Data for shifting of cement from storage to work place:

TABLE-70

Data for shifting of cement from storage to work place		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Necessary Non Value Added
2	Labour required	2(Male helper-1, Male helper-2)
3	NO. of cement bags moved per shift or cycle	3 bags
4	Total NO. of shifts or cycle	25
5	Time taken to complete 1 shift or cycle	65 Seconds
6	Distance traveled per shift or cycle	Horizontal distance of 32 meters
7	Total time consumed for this activity(Overall Cycle time)	1,625 seconds (27 minutes) (1/2 hour)
8	Value Added Time	0

4.12.7 Data for plastering:

TABLE-71

Data for plastering		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Type of activity	Value Added
2	Labour required	4 (masan-1,masan-2,male helper-1, male helper-2)
3	Capacity of the mixer	0.27 Cu.m
4	Capacity of the hopper	0.29 Cu.m
5	Time taken to dumping and mixing of materials in the mixer and transferring to the hopper(1 cycle/shift)	360 seconds(6 minutes)
6	Total number of cycle or shifts required	60
7	Total time required to finish the mixing of mortar	21,600 seconds(6 hours)
8	Wall area plastered per day(8 hours)	120 Sq.m
9	Time taken for waiting while refilling the hopper with mortar	6 minutes
10	Total Time taken for waiting while refilling the hopper with mortar	6 hours(60 shifts)
11	Targeted area	1195 Sq.m

12	Total time taken for plastering the targeted area	80 hours
13	Total time taken to complete the task	80 + 6 = 86 hours

4.12.8 Productivity of plastering work:

TABLE-72

Productivity of plastering work		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Wall area to be plastered	1195 Sq.m
2	Total time taken to complete the activity	86 hours (11 days)
3	Productivity of the team (3 masons + 2 male helpers)	120 SQ.M//day
4	Total productivity of the team (3 masons + 2 male helpers)	15 SQ.M /hour

4.12.9 BRIEF SUMMARY OF INTERNAL PLASTERING:

TABLE-73

BRIEF SUMMERY OF INTERNAL PLASTERING		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Total Labours working in the crew	7 Labours -3 masons -4 male helpers
2	Wall area to be plastered	1195 Sq.m
3	Time taken to finish the target(4 th floor)(cycle time)	92 Hours

4	Value added time	80 hours
5	Non value added time	12 hours

4.12.10 PRODUCTIVITY OF THE ENTIRE ACTIVITY:

TABLE-74

PRODUCTIVITY OF THE ENTIRE ACTIVITY		
SI.NO	DESCRIPTION	UNIT/TYPE
1	Wall area to be plastered	1195 Sq.m
2	Total time taken to complete the activity	91.8 hours (11.5 days)
3	Productivity of the team (3 masons + 2 male helpers)	104 SQ.M//day
4	Total productivity of the team (3 masons + 2 male helpers)	13 SQ.M /hour

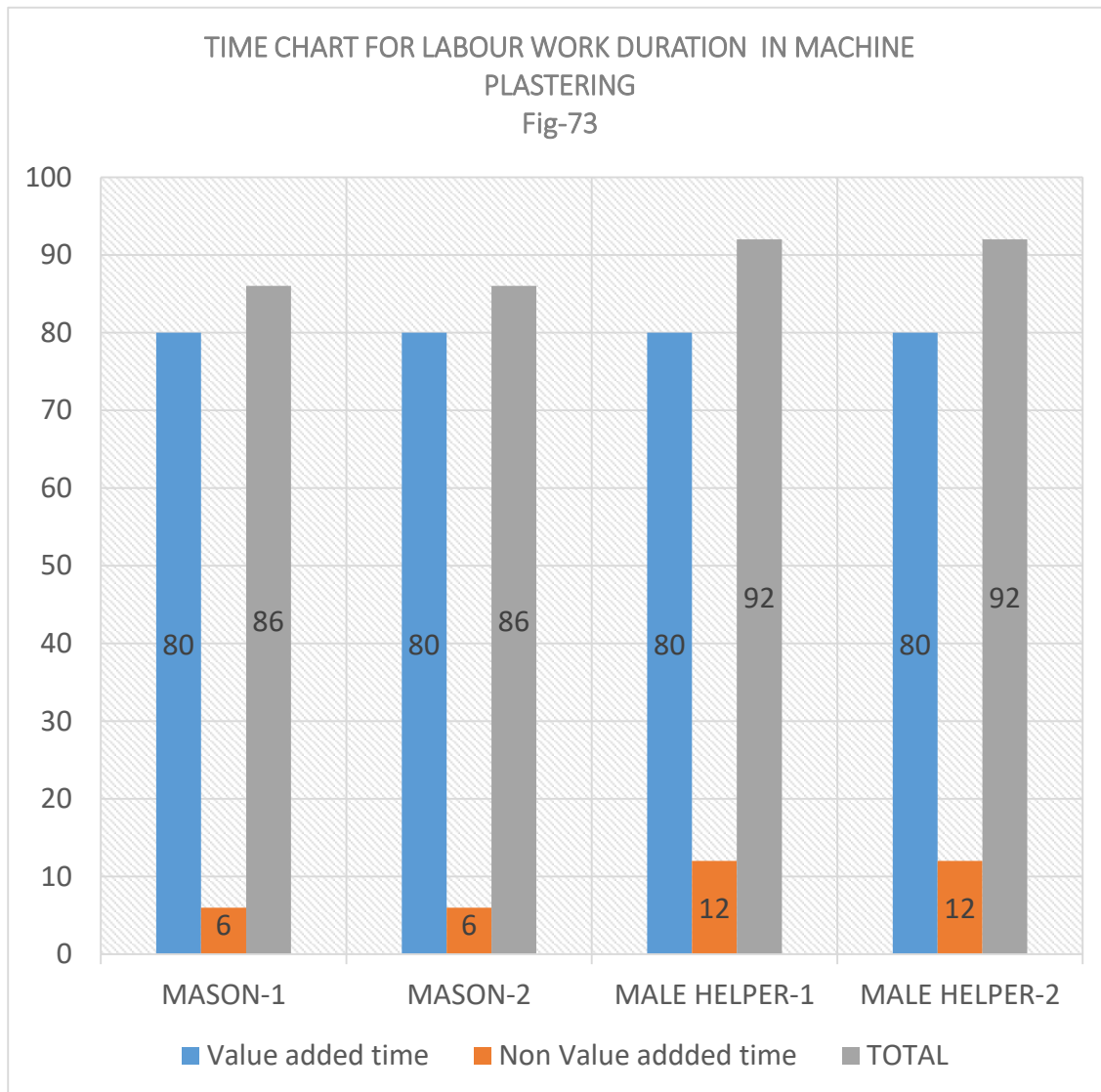


Fig-73

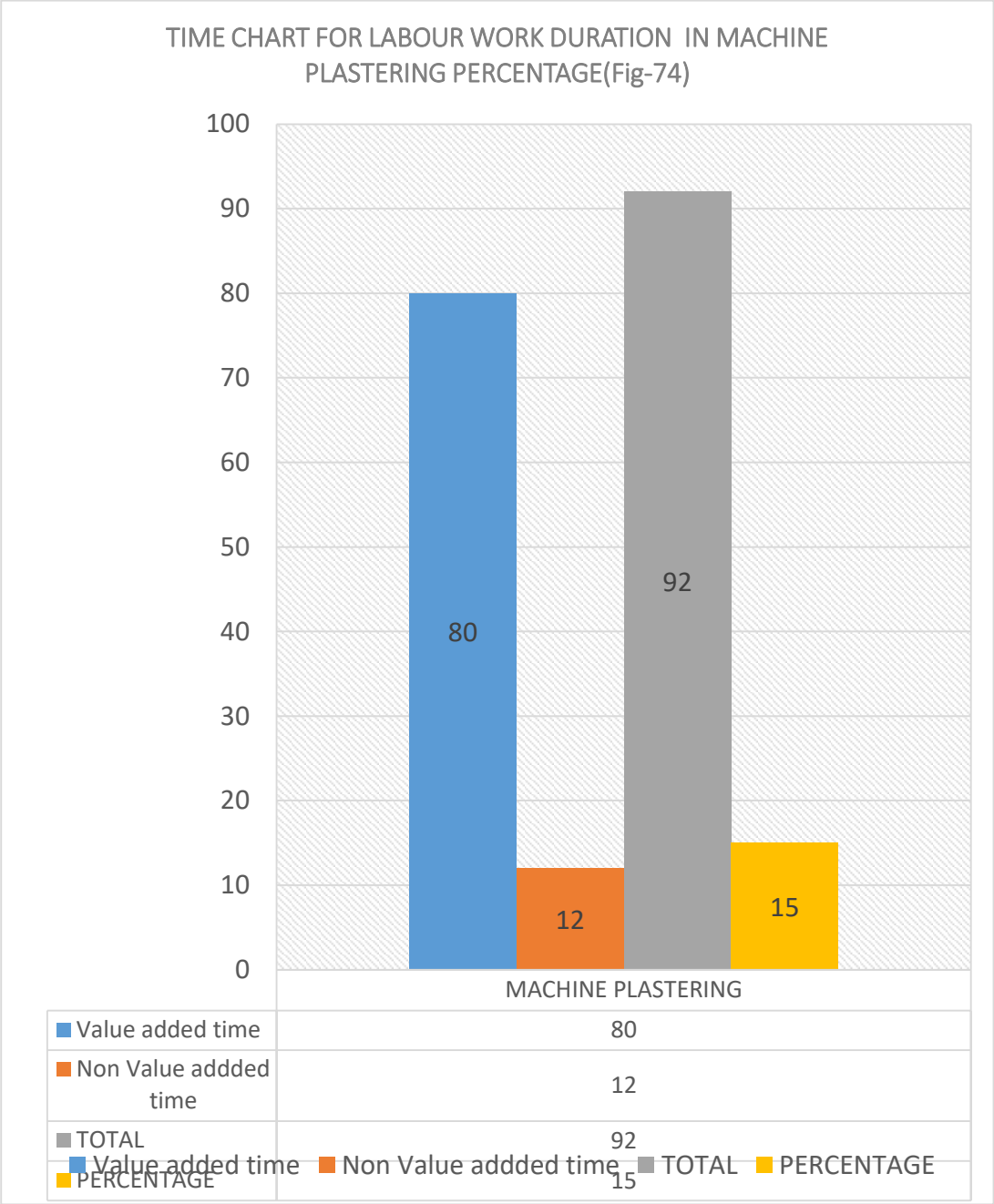


Fig-74

TIME CHART FOR FUTURE VSM AND LABOUR WORK DURATION
MANUAL PLASTERING(Fig-75

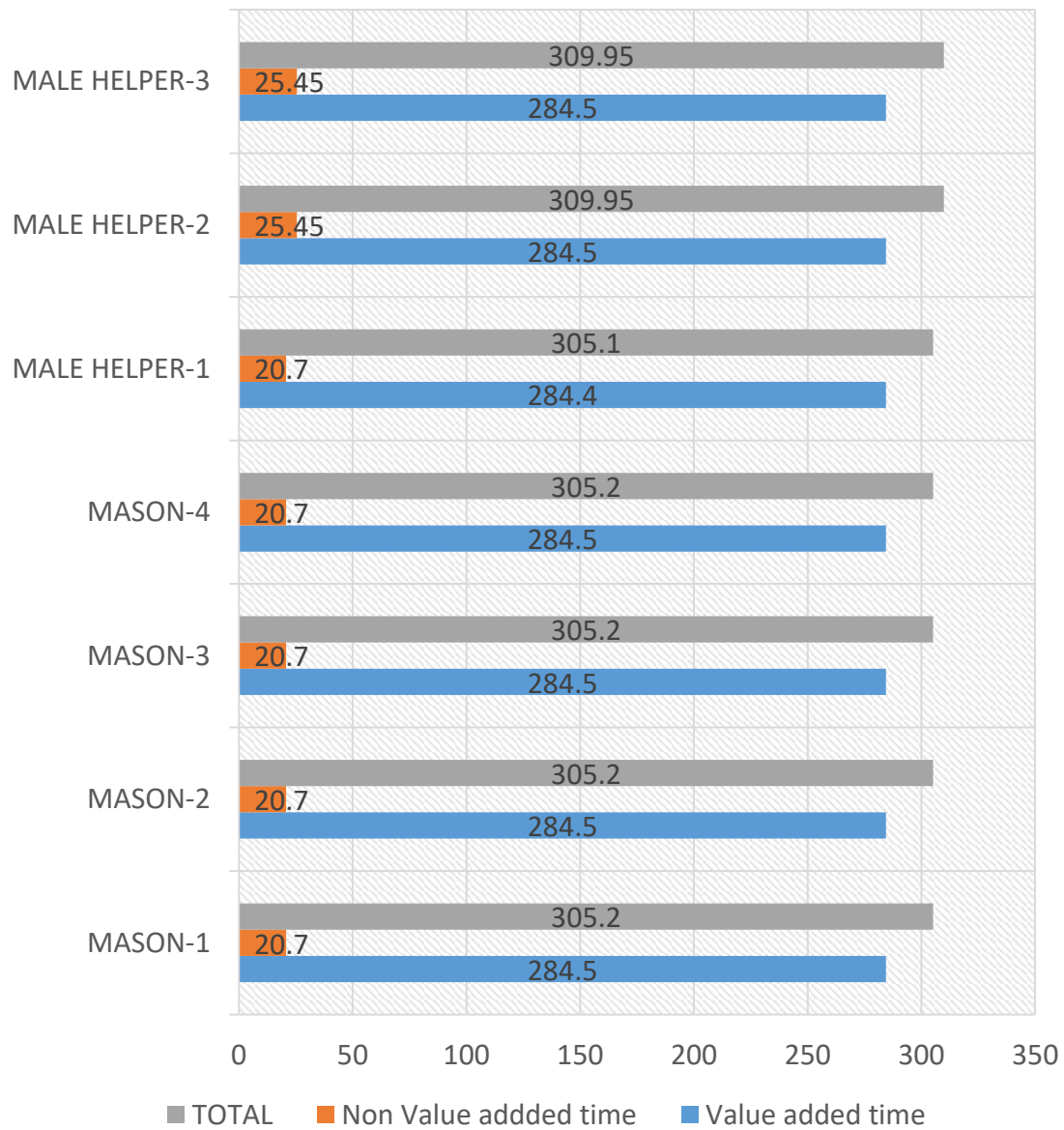


Fig-75

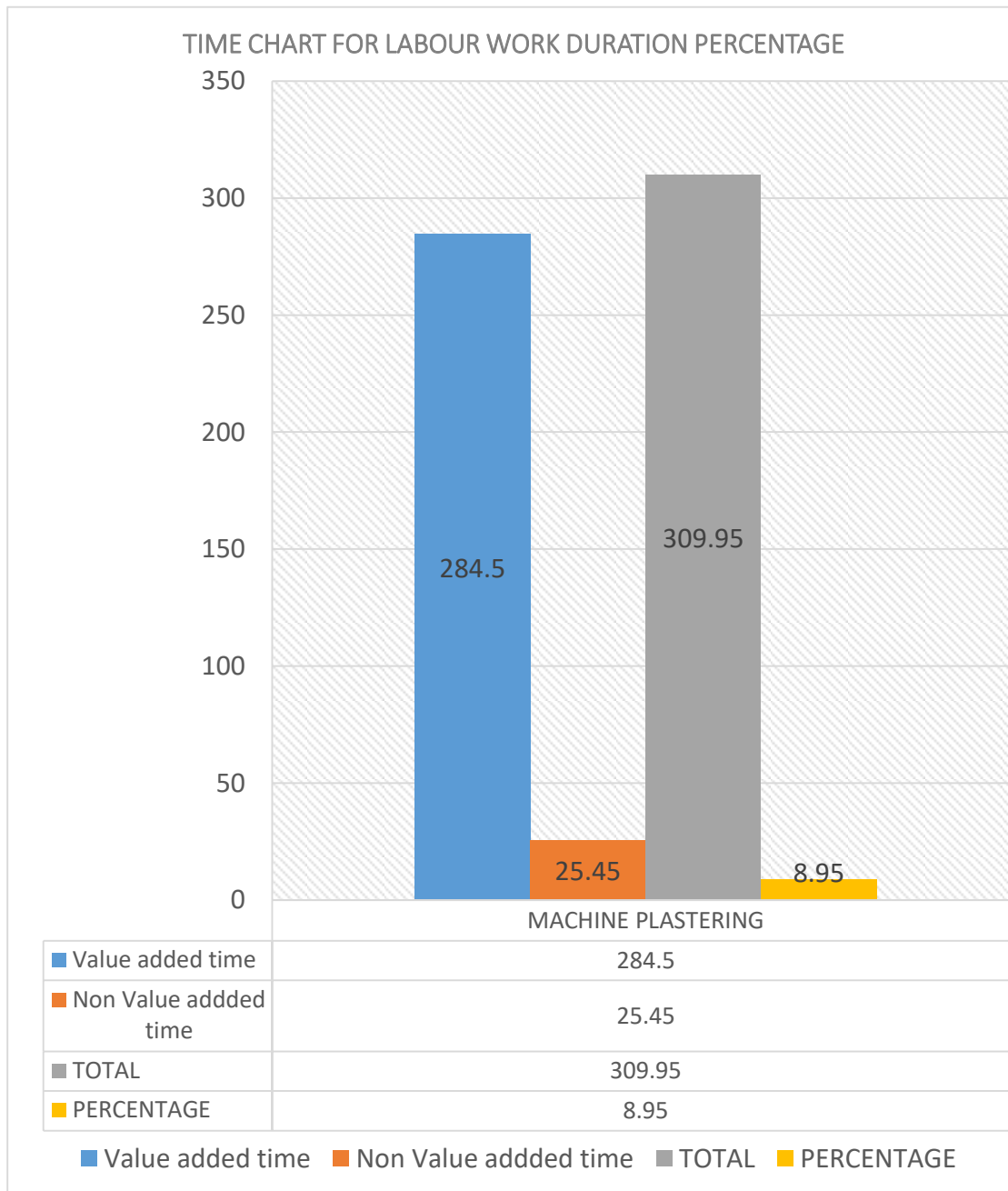
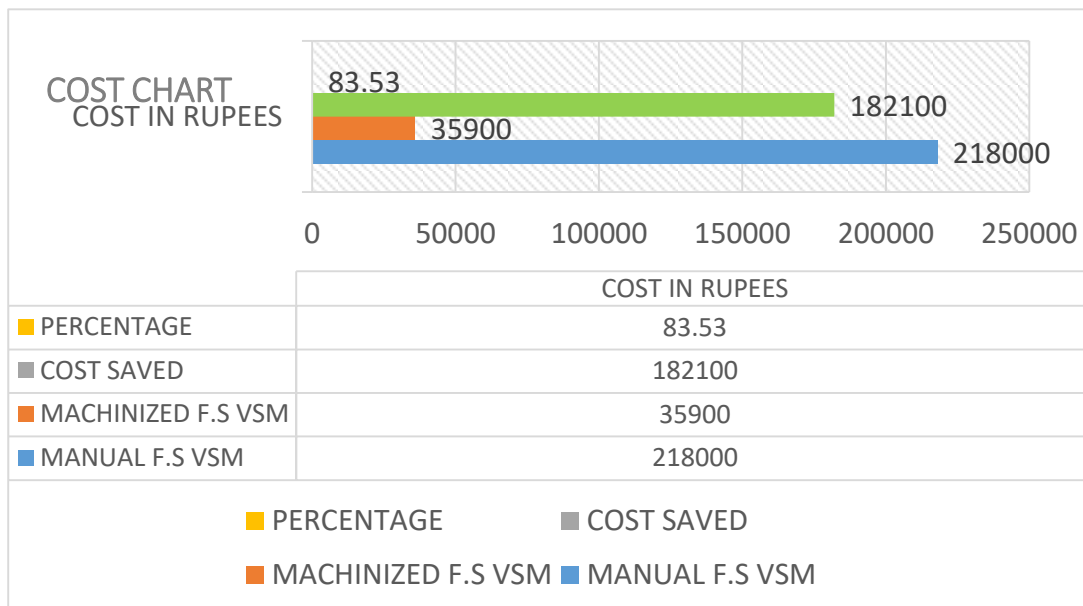
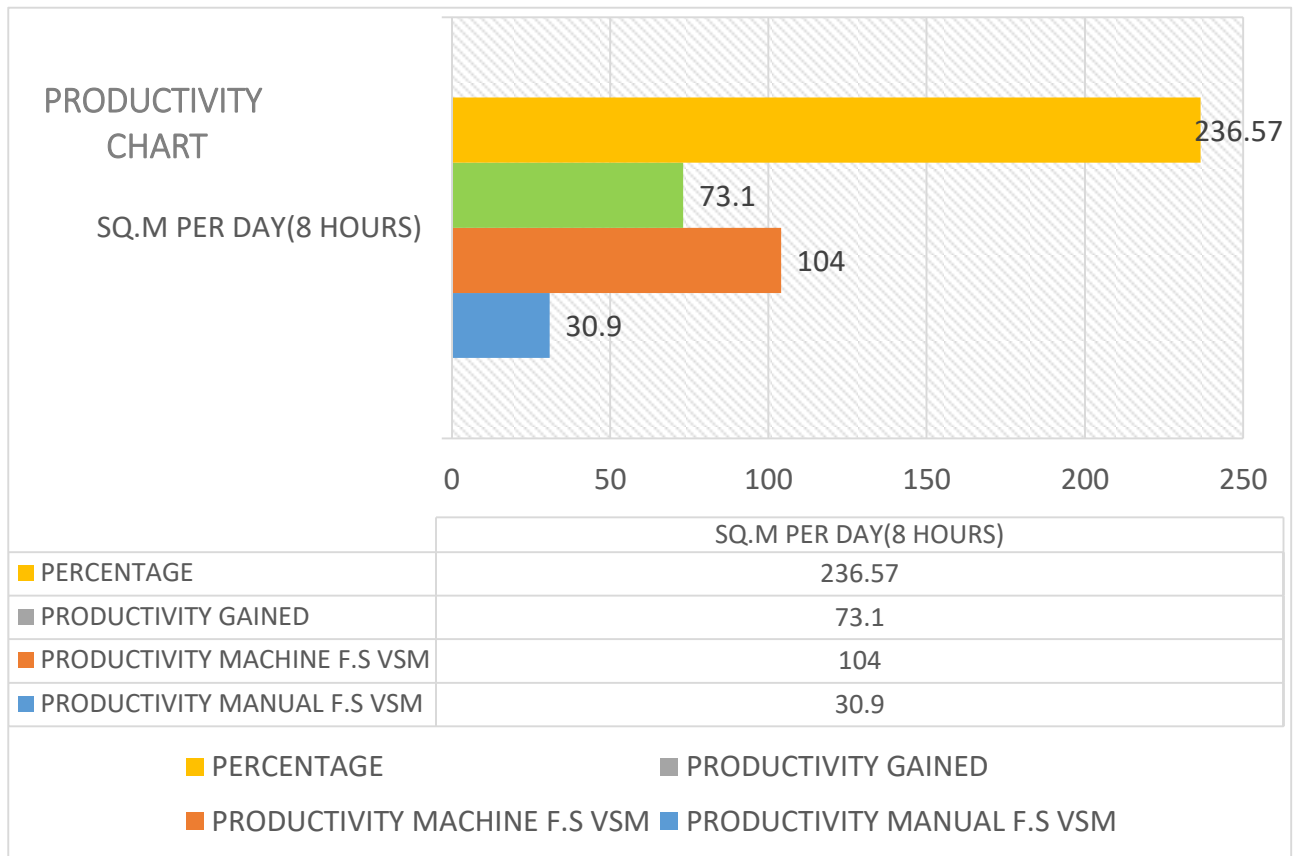


Fig-76

4.12.11 COST ANALYSIS OF MANUAL AND MACHINE INTERNAL PLASTERING:

(TABLE-75)

COST ANALYSIS OF MANUAL AND MACHINE INTERNAL PLASTERING			
SI.NO	DESCRIPTION	MANUAL(FUTURE STATE)	MACHINE(FUTURE STATE)
1	Number Of Labours Used	7 Labours -4 masons -3 male helpers	4 Labours Masons-2 Male Helpers-2
2	Wages Of Labours	Mason-Rs 900/DAY MALE HELPER- Rs 700/DAY	Mason-Rs 900/DAY MALE HELPER- Rs 700/DAY
3	Time Taken To Finish The Task	Mason(1-4):38 Days Male Helper 1: 38 Days Male Helper (2,3): 39 Day	Mason(1, 2)-11 days Male helper(1, 2)-11.5
4	Cost Of Labours	$(4 \times 900 \times 38) + (1 \times 700 \times 38) + (2 \times 700 \times 39)$ =136,800+26,600+700+54,600 =218,000	$(2 \times 900 \times 11) + (2 \times 700 \times 11.5)$ =19,800 + 16,100 =35,900



4.12.12 Brief Summary of The Analysis:

(TABLE-76)

BRIEF SUMMERY OF THE ANALYSIS			
		BUILDING	
		Celesta	Ramaniyam Ocean Dew
1	INTERNAL PLASTERING	- The labour productivity was good due to strict supervision at workplace, it can be even more improved by using proper equipments such as “hop-on” instead of using temporary setup. - Shifting of materials to the workplace from storage can be speeded up by installing additional hoist lift.	- The labour productivity was relatively lower due to insufficient supervision at workplace, it can be improved by providing a proper supervision. - It can be even more improved by using proper equipments such as “hop-on” instead of using temporary setup. - Shifting of materials can be speeded up if both the hoist lifts are utilized instead of one.
2	FACTORS IDENTIFIED	Insufficient equipments	- Underutilizing of equipments - Insufficient supervision.

(TABLE-76)

BRIEF SUMMERY OF THE ANALYSIS			
		BUILDING	
		Celesta	Ramaniyam Ocean Dew
1	BARBENDING OF 8mm TMT RING BARS FOR BEAMS AND COLUMNS	The labour productivity was good due to strict supervision at workplace. The shifting of steel bars from storage to work place is a non-value added activity which can be avoided by changing the work bench nearer to the storage space. Straightening of the 12 meters U-shaped bars can be avoided by ordering 12 meter straight rods in a trolley vehicle in a bulk order.	The labour productivity was relatively good due to strict supervision at workplace. The productivity can be even more developed by using the already available equipments in site itself.
2	FACTORS IDENTIFIED	Improper layout Improper material planning	Underutilizing of equipments.

(TABLE-76)

BRIEF SUMMERY OF THE ANALYSIS		
		BUILDING

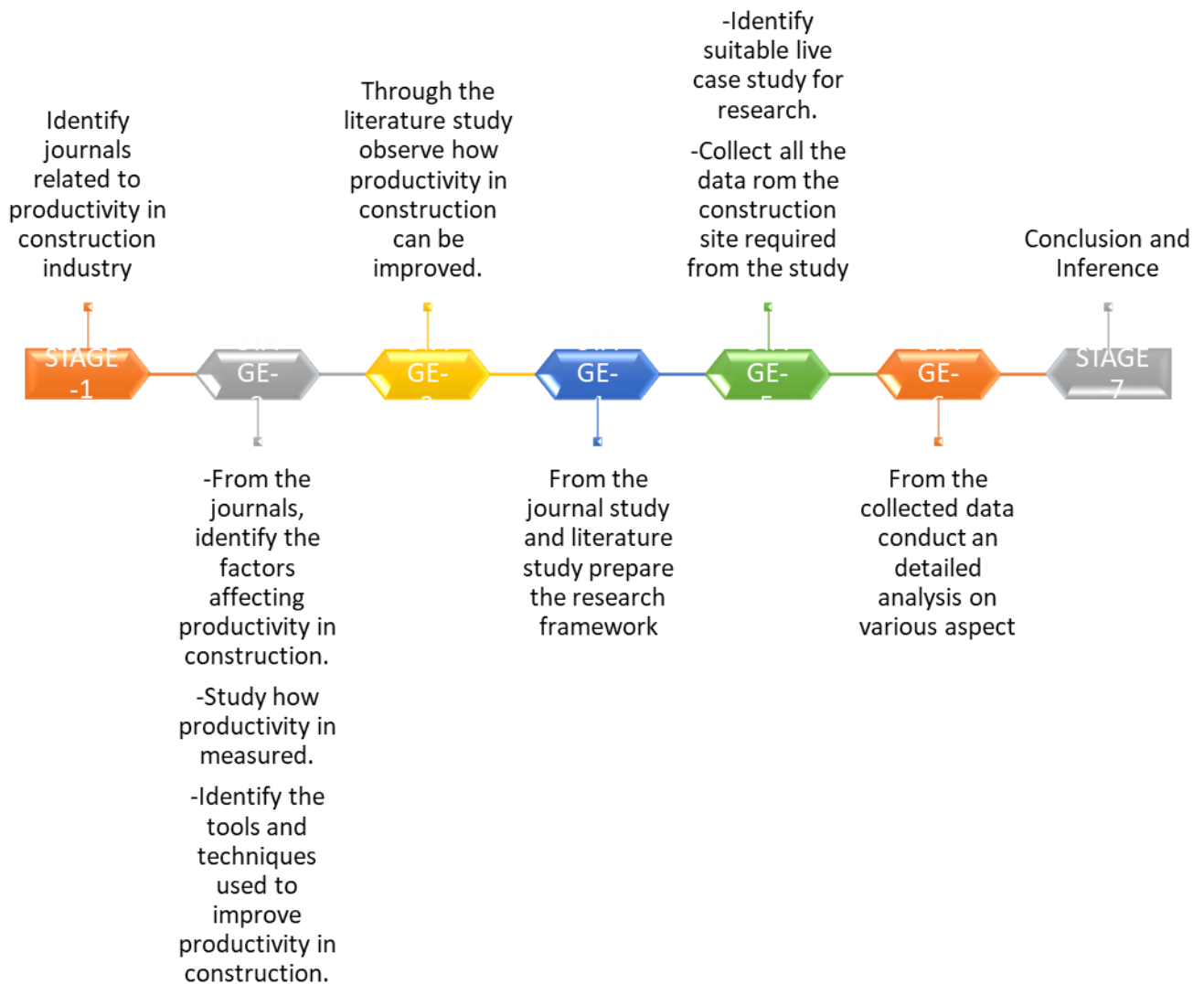
		Celesta	Ramaniyam Ocean Dew
1	BLOCK WORK	- The labour productivity was good due to strict supervision at workplace, it can be even more improved by using proper equipments such as “hop-on” instead of using temporary setup. - Shifting of materials to the workplace from storage can be speeded up by installing additional hoist lift.	- The labour productivity was relatively lower due to insufficient supervision at workplace, it can be improved by providing a proper supervision. - It can be even more improved by using proper equipments such as “hop-on” instead of using temporary setup. - Shifting of materials can be speeded up if both the hoist lifts are utilized instead of one.
2	FACTORS IDENTIFIED	Insufficient equipments	- Underutilizing of equipments - Insufficient supervision.

CHAPTER-5

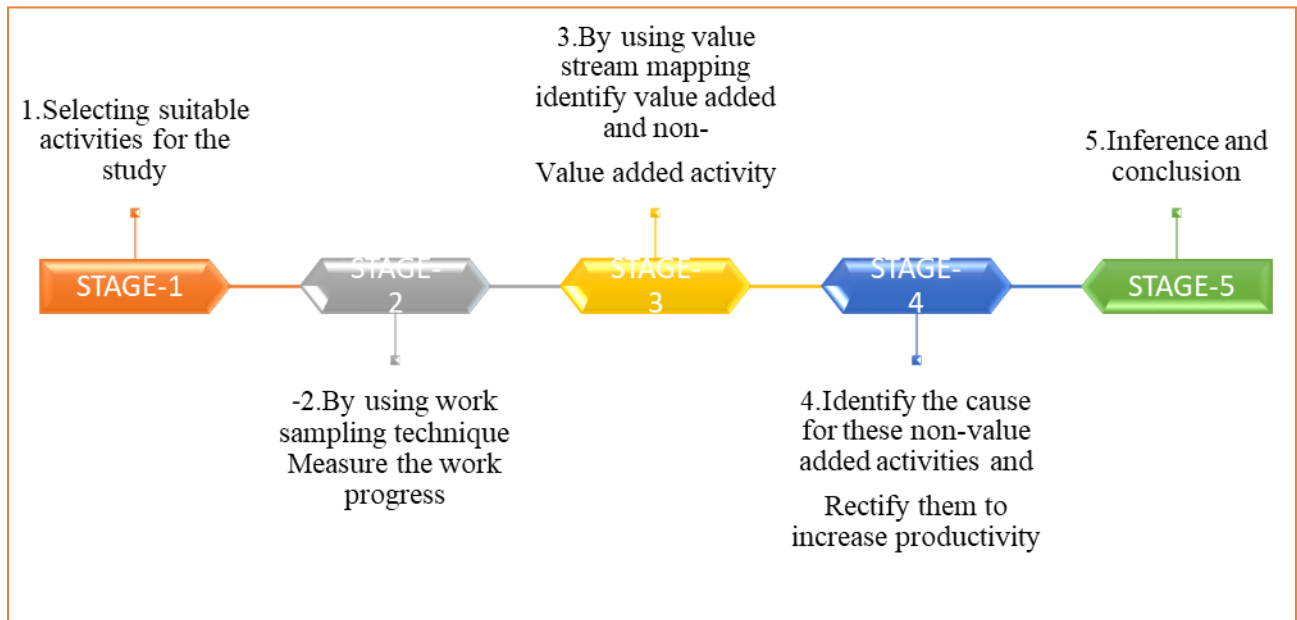
5. CONCLUSION

5.1 DISCUSSION

- This research aims to study and analyze how the productivity in construction can be identified and improves using different tools.
- This research was started by setting up the aim and research objectives for this study which concentrates on studying and understanding the basics of productivity in construction, techniques, implication process and its impact in construction field.
- Furthermore the research methodology was framed which briefs about step by step process of this research, which are as follows;



- Suitable journal papers were identified related to my research and were reviewed, and from the journals the types of data's to be collected and the theoretical frame work required to undertake surveys , data collection and Analysis for a project is observed.
- Furthermore a net case study was done to observe how the theoretical frame work is practically incorporated into the project and by doing so we had a better understanding on the process of productivity enhancement.
- Since this research is studying on residential building I have selected two apartment building my live case study. The study process for this study is going to be as follows;



5.2 LIMITATIONS FOR THE STUDY:

As this research mainly aims in studying the creditability and practicality of improving the productivity in construction I Have limited my study to the below mentioned activities.

TABLE-77

LIMITATIONS FOR THE STUDY	
SELECTED ACTIVITIES	TOOLS USED

• Bar bending of ring bars for beams and columns • Internal Plastering for walls • Block work / Masonry work	1. VSM (Value Stream Mapping) 2. Work Sampling.
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5.3 ANALYSIS:

- To start off with my studies I used the VSM (Value Stream Mapping) tool to measure the productivity of work and distinguish the value added and non-value added activities in it , and by doing so I could track the origin of the non-value added activities then try and eliminate or suppress the Cause of the delay.
- For this I visually recorded each and every activity along with the sub-activities to measure the work using a digital camera.
- The next stage of the study was to observe and identify the factors that cause the delay and visualize the activity as current state VSM and after rectifying these factors then again visualize the activity for future state VSM.
- By following this procedure for all the activities within the scope and I was able to identify various factors that affected the productivity and rectified it to some extent.
- I have also tried to increase the productivity of the activity whose VSM was already improved by introducing machine or automatic plastering machine in its future state VSM after which I could notice that productivity rate of the machine plastering was way ahead of than that of the productivity of the manual plastering.
- And finally I would like to conclude my research by saying that the productivity of construction works can be easily improved by following theses five simple steps that is **"1.Observing, 2.Measuring,**

3. Identifying, 4.Visualising and 5.Rectifying".

5.4 RECOMMENDATION FOR FUTURE STUDIES:

- In This research paper the study area was limited because the aim was to explore the credibility of the using various tools and techniques to improve productivity in the construction industry.
- This research has established that by using VSM (Value Stream Mapping) as an tool, it is easy to identify and visualize the non-value added activities from value added activities and by doing so we can track the origin of the delay and try and eliminate them or at the least

reduce them so that the time consumption for the overall process can be reduced ultimately resulting in cost reduction.

- In the future studies, with the help of lean tools such as **Bottleneck Analysis, Overall Equipment Effectiveness and Root Cause Analysis** I can explore the different aspect of enhancing the productivity in construction industry.

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