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An Investigation of Effectiveness of Construction Practices for Material Management in Construction Project

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Abstract - *A building project involves several essential aspects such as planning, design, labour management, material management, quality control, cost control, and so on. It's been found that, around 50% of the budget is utilized by the materials used in project. Literature studied unveiled, material management, different methods, techniques and software are mainly studied and used for multi-storey projects. Although material management for small scale construction projects is not studied much. So in this project small residential houses have been studied. Firstly meeting with some engineers working on small scale residential projects was done, got to know their method of material management and after learning the similarities in all of them, and then a common method and its step were decided. After that one of the sites was selected and the management of the material was studied in detail. On that site, the management of the material observed how much and how it affected the cost and time, and studied how often the material is ordered and how much is used. It was later found that there was a difference of 6% between their estimated cost and actual cost, as well as the difference between the scheduled time and the actual time. Then a study was done to find out what percentage of the difference is due to the material. Also, their project was delayed 4 times due to material management. Then there are suggestions for material management to reduce the difference between delay and cost.*

Key Words: *Material, construction, Management, Cost, Time.*

1. INTRODUCTION

The management of materials in construction projects is an important function that significantly contributes to the success of a project. As projects grow in scale and complexity, materials management becomes more difficult, often requiring the use of appropriate tools and techniques to ensure, amongst other things, that materials are delivered on time, stock levels are well managed, the construction schedule is not compromised, and that wastage is minimized. Materials management is especially problematic for large and complex projects, where sophisticated tools and techniques are necessary. The management of materials should be considered from the phases of the construction process and throughout the construction period. Generally, construction materials are bulky, expensive and are supplied in large amounts to construction sites. Therefore, there is a need for an excellent management system for handling materials. In construction field, there are many techniques and methods which are developed for the management of the material. Research has been done for the proper and effective material management which can lead to minimize the delay, increases in cost of project and wastage of material. By using these management techniques, the material management can be done effectively. It is beneficial to minimize the overall cost of project, time and wastage of material. Although these techniques and methods are available for management of materials, it is observed that, the time delay in construction projects are caused due to delays in arrival of materials on site. Also it is found that there is lack of up-to-date information or unavailability of information regarding the status of the order of material. In some cases, materials which arrive on site do not match with the specifications in the purchase order. In that case delay can cause due to searching for the material and this can lead to the increase in total cost of project.

1.1. Gap Identification

The literature has suggested different techniques, methods and software for effective material management that can help to minimize the total cost of project, time and also wastage of material. So, it needs to study that these techniques are actually implemented or not or problems behind implementing these techniques.

1.2. Problem Statement

The various methods have been suggested by previous studies for effective material management. But still many construction projects are facing the problem related to delay in completion of project or increase in cost of project. So, it is necessary to find out that whether it is because of lack of awareness of material management techniques or limitations in implementation.

1.3 Objectives

1. To study the current practices of material management.
2. To identify the problem relates to material management.
3. To investigate the effectiveness of material management on construction project.
4. To suggest effective measures.

1.4 Methodology

PHASE 1-Through study the to study current practices in construction industry by using literature review
PHASE 2-Collection of data to identify the problems behind implementation of material management techniques.
PHASE 3-Analysis of data to identify the effectiveness of implementation of material management
PHASE 4-Result conclusion and suggestion of effective measure.

2. LITERATURE REVIEW

There are many techniques, methods and software for effective material management which are useful for effective material management so that delay of work due to material or transportation of material can be minimized. It can also help to minimize the total cost of project, time. Also it has seen that these techniques are mainly used for large scale projects. So, it needs to study the implementation of the techniques on small scale projects also.

3. COLLECTION OF DATA

After studying the literature related material management and problems related to it has seen that there is need to study material management for small scale projects. So, we selected 5 small scale construction project sites. After visiting and discussing with the particular site contractors and engineers it is found that the method used by them is nearly same for small scale residential building projects. After studying these methods a common material management steps are decided.

General steps used for the material management on small scale material management site are

STEP 1. Material Planning: Determining the total Quantity of material requirement for activity.
STEP 2. Material Purchase: Locating and developing sources of supply, market research for purchasing, selection of suppliers, negotiations, contracting and Issuing of purchase orders.
STEP 3. Store Keeping: Material Handling, Damage Control.
STEP 4. Inventory Control: Locating, storing and recording of goods, Availability of material as per requirement, Maintenance of stock.
STEP 5. Quality Control and Inspection: Inspection consists of comparing the actual products against previously laid down standards and specifications.
STEP 6. Material Handling: Inspection in the storage and issue for use, materials should be handled in such a way so as to cause minimum damage.
STEP 7. Disposal of Surplus, Obsolete and Scrap stock: If surplus, obsolete and scrap stock is held in possession, this involves inventory carrying, storage and security costs.

3.1 Collection of data

The basic data about site is collected which is listed below:
1. Plan of building
2. Estimation of building
3. Planned and actual date of activities

3.2 Schedule of activities

Activity No.	Activity	Planned date of start of activity	Days to complete	Actual date of start of activity
1	Mobilization	3 Sep 2018	1	3 Sep 2018
2	Topographic survey Plot preparation	4 Sep 2018	2	4 Sep 2018
3	Excavation	6 Sep 2018	3	6 Sep 2018
4	PCC in Foundation10 Sep 2018	10 Sep 2018	3	12 Sep 2018
5	Footing13 Sep 2018	13 Sep 2018	4	15 Sep 2018
6	Plinnth beam	18 Sep 2018	12	20 Sep 2018
7	Column	2 Oct 2018	14	8 Oct 2018
8	Plinth Filling	18 Oct 2018	4	24 Oct 2018
9	Beam	23 Oct 2018	21	6 Nov 2018
10	slab	23 Oct 2018	21	6 Nov 2018
11	Staircase	23 Oct 2018	21	6 Nov 2018
12	pardi	16 Nov 2018	7	30 Nov 2018
13	Brickwork (230mm)	24 Nov 2018	12	13 Dec 2018
14	Brickwork (150mm)	8 Dec 2018	12	31 Dec 2018
15	Ext Plaster	22 Dec 2018	15	15 Jan 2018
16	Internal Plastering	5 Jan 2019	15	1 Feb 2019
17	Vitrified tiles	19 Jan 2019	12	22 Feb 2019
18	Skirting	2 Feb 2019	2	8 Mar 2019
19	Ceramic Tile	5 Feb 2019	4	12 Mar 2019
20	Dado	9 Feb 2019	3	14 Mar 2019
21	Polished quota stone	13 Feb 2019	2	18 Mar 2019
22	Aluminium Window and Doors	15 Feb 2019	3	22 Mar 2019
23	Column	19 Feb 2019	14	26 Mar 2019
24	Brickwork (230mm)	7 Mar 2019	4	13 Apr 2019
25	Ext Plaster	12 Mar 2019	4	18 Apr 2019
26	Oil Bond	16 Mar 2019	5	23 Apr 2019
27	Waterproof Cement paint	23 Mar 2019	8	2 May 2019

One example of an activity is explained below which is collected to study the material management of each activity on the site.
Example 1 - Total quantity for RCC in Footing is 4 m^3.

Table 1: *Planned date, Actual date and Delay in activity 5: RCC in Footing*

Activity	Planned date of start of activity	Days to complete	Actual date of start of activity	Actual days to complete activity	Idle days before activity starts	Delay	Reason for delay
Footing	13 Sep 2018	4	15 Sep 2018	4	0	0	

Table 2: *Material and other charges for activity 5: RCC in Footing*

Description	Material								
	Cement (In Bags)	Rate	Sand (In Brass)	Rate	Aggregate (In Brass)	Rate	Steel (In Ton)	Rate	Amount
Material Required	32.00	₹250.00	0.60	₹5,500.00	1.19	₹2,200.00	0.38	₹38,000.00	₹28,414.35

Previous Stock	35.00	₹250.00	2.10	₹5,500.00	1.70	₹2,200.00	3.00	₹38,000.00	₹1,38,040.00
Material Ordered	0.00	₹250.00	0.00	₹5,500.00	0.00	₹2,200.00	0.00	₹38,000.00	₹0.00
Actual Consumption	33.00	₹250.00	0.65	₹5,500.00	1.20	₹2,200.00	0.40	₹38,000.00	₹29,665.00
Remaining Stock	2.00	₹250.00	1.45	₹5,500.00	0.50	₹2,200.00	2.60	₹38,000.00	₹1,08,375.00

Table 3: *Labour charges required for activity 5: RCC in Footing*

Labour	Quantity	Rate	Days Of Work	Amount	Total Amount
Mason	3	550	3	₹4,950.00	₹9,750.00
Male Mazdoor	4	400	3	₹4,800.00	₹4,800.00

4. ANALYSIS OF DATA

4.1 Delay Report

For analysis of delay due to material it is necessary to study details related to actual dates, planned dates and delay. Following table shows the details related to activity with their planned date, Actual date, Idle days before activity starts and total delay caused for the particular activity with their reasons.

Table 4*: Delay Report*

Activity No.	Activity	Planned date of start of activity	Days to complete	Actual date of start of activity	Actual days to complete activity	Idle days before activity starts	Delay	Reason for delay
1	Mobilization	Sep 3, 2018	1	Sep 3, 2018	1	0	0	
2	Topographic survey Plot preparation	Sep 4, 2018	2	Sep 4, 2018	2	0	0	
3	Excavation	Sep 6, 2018	3	Sep 6, 2018	3	0	0	
4	PCC in Foundation	Sep 10, 2018	3	Sep 12, 2018	3	2	2	Labour availability
5	Footing	Sep 13, 2018	4	Sep 15, 2018	4	0	0	
6	Plinth beam	Sep 18, 2018	12	Sep 20, 2018	13	1	2	Slow work
7	Column	Oct 2, 2018	14	Oct 8, 2018	14	2	2	Labour absence
8	Plinth Filling	Oct 18, 2018	4	Oct 24, 2018	4	0	0	
9	Beam	Oct 23, 2018	21	Nov 6, 2018	21	7	7	Arrangement of material and labour
10	Slab	Oct 23, 2018	21	Nov 6, 2018	21	7	7	Arrangement of material and labour
11	Staircase	Oct 23, 2018	21	Nov 6, 2018	21	7	7	Arrangement of material and labour
12	Pardi	Nov 16, 2018	7	Nov 30, 2018	7	0	0	

Activity No.	Activity	Planned date of start of activity	Days to complete	Actual date of start of activity	Actual days to complete activity	Idle days before activity starts	Delay	Reason for delay
13	Brickwork (230mm)	Nov 24, 2018	12	Dec 13, 2018	15	4	7	Labour unavailability
14	Brickwork (150mm)	Dec 8, 2018	12	Dec 31, 2018	13	0	1	Slow work
15	Ext Plaster	Dec 22, 2018	15	Jan 15, 2018	15	0	0	
16	Internal Plastering	Jan 5, 2019	15	Feb 1, 2019	15	0	0	
17	Vitrified tiles	Jan 19, 2019	12	Feb 22, 2019	12	3	3	Material unavailability
18	Skirting	Feb 2, 2019	2	Mar 8, 2019	3	1	2	Material unavailability
19	Ceramic Tile	Feb 5, 2019	4	Mar 12, 2019	4	0	0	
20	Dado	Feb 9, 2019	3	Mar 14, 2019	3	0	0	
21	Polished quota stone	Feb 13, 2019	2	Mar 18, 2019	2	0	0	
22	Aluminium Window and Doors	Feb 15, 2019	3	Mar 22, 2019	3	2	2	Material unavailability
23	Column	Feb 19, 2019	14	Mar 26, 2019	14	0	0	
24	Brickwork (230mm)	Mar 7, 2019	4	Apr 13, 2019	4	2	2	Labour unavailability
25	Ext Plaster	Mar 12, 2019	4	Apr 18, 2019	4	0	0	
26	Oil Bond	Mar 16, 2019	5	Apr 23, 2019	8	0	3	Slow work
27	Waterproof Cement paint	Mar 22, 2019	8	May 2, 2019	10	0	2	Slow work

Table 5: Color coding

Chart colour coding	
	Planned Activity
	Actual execution of activity
	Sunday (Holiday)

Chart 1: Planned and actual activities

Activity no.	Activity
1	Mobilization
2	Topographic survey plot preparation
3	Excavation
4	PCC in foundation
5	Footing
6	Plinth beam
7	Column

Chart 2: Planned and actual activities

Activity no.	Activity
8	Plinth filling
9	Beam
10	Slab
11	Staircase
12	Pardi

Chart 3: Planned and actual activities

Activity no.	Activity

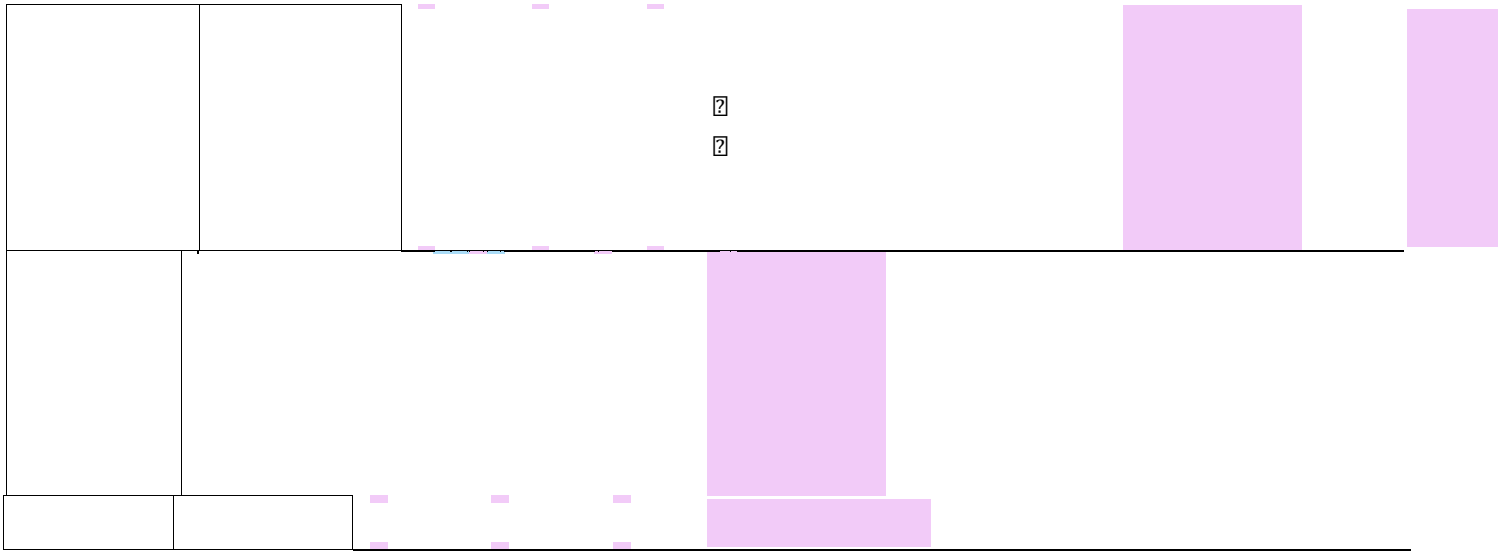


Chart 4: Planned and actual activities

Activity no.	Activity

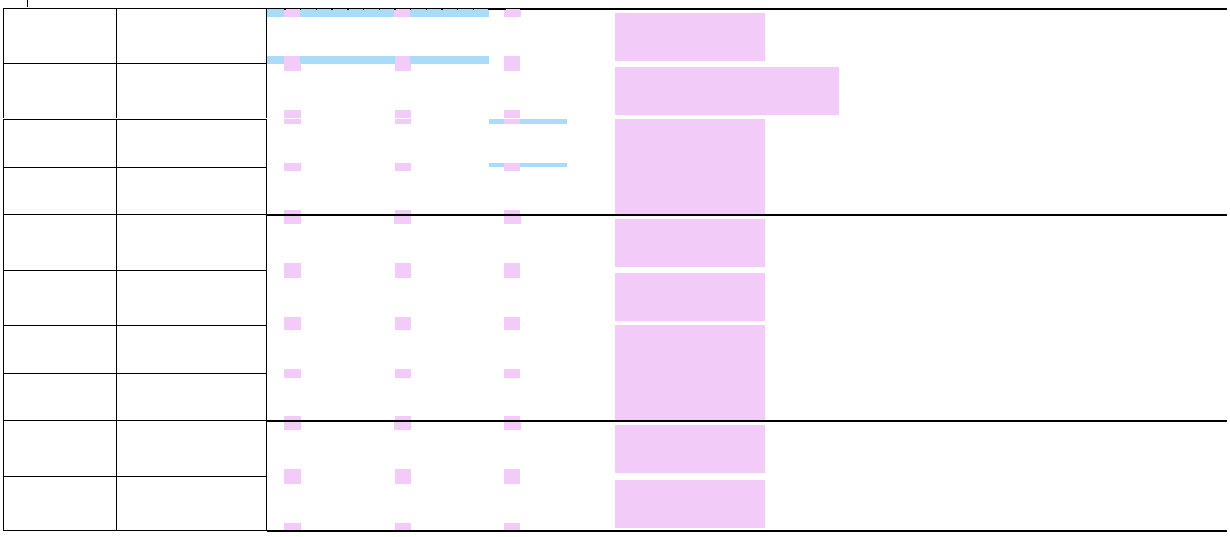


Chart 5: Planned and actual activities

Activity no.	Activity
21	Polished quota stone
22	Aluminium window and doors
23	Column

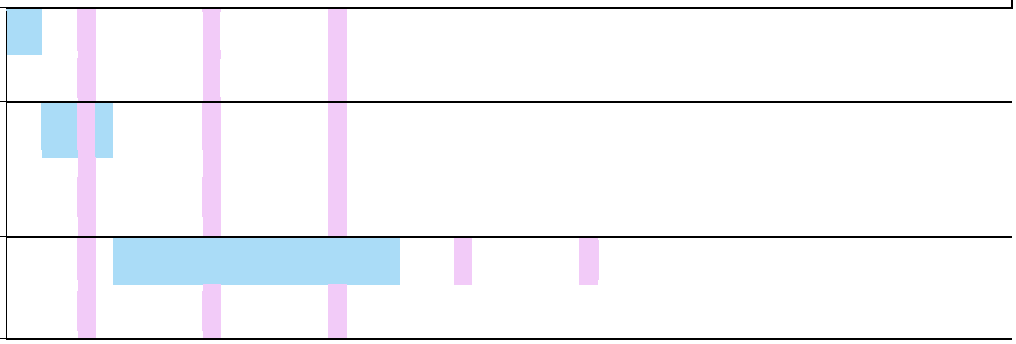
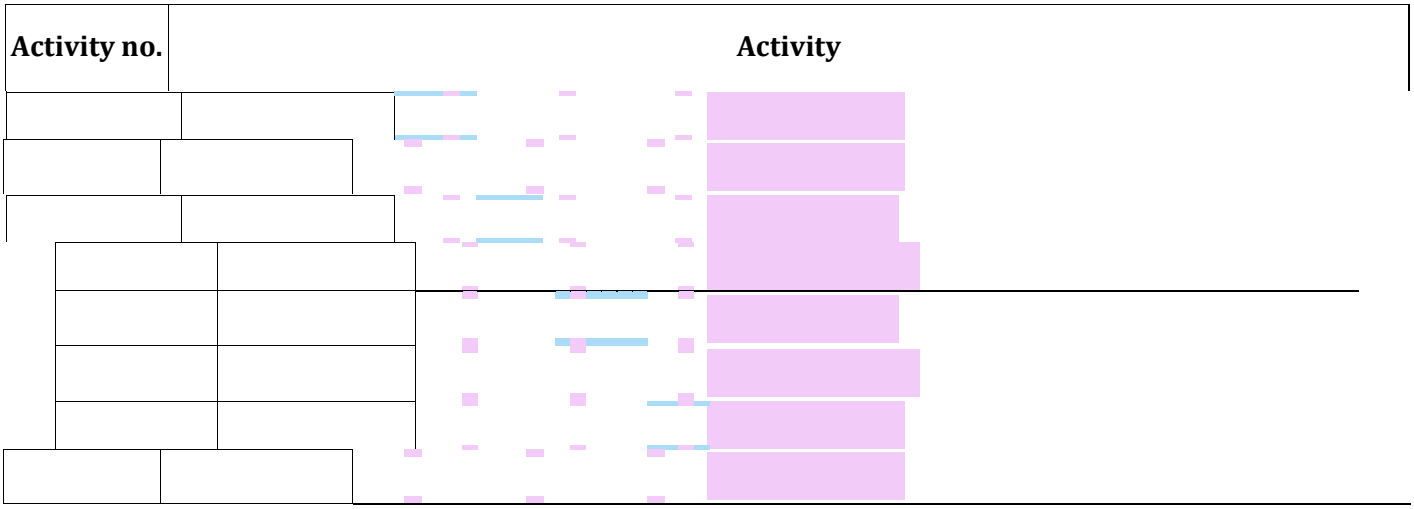


Chart 6: Planned and actual activities


Activity no.
Activity

4.2 Frequency of ordering material, delay and reasons for delay

Table 6: *Frequency of ordering materials*

Sr. No.	Activity	Material	Qty.	Rate	Amount	Total	Delay due to materials	Reason for delay
1	PCC in Foundation	Cement	50	₹250.00	₹12,500.00	**₹1,45,750.00**		
		Sand	2.5	₹5,500.00	₹13,750.00			
		Aggregate	2.5	₹2,200.00	₹5,500.00			
		Steel	3	₹38,000.00	₹1,14,000.00			
2	Plinth Beam	Cement	100	₹260.00	₹26,000.00	**₹50,750.00**		
		Sand	2.5	₹5,500.00	₹13,750.00			
		Aggregate	5	₹2,200.00	₹11,000.00			
3	Column	Murrum	67	₹500.00	₹33,500.00	**₹33,500.00**		
4	Plinth Filling	Cement	250	₹270.00	₹67,500.00	**₹2,99,300.00**	7 days	Selection of Suppliers and Negotiations
		Sand	5	₹10,000.00	₹50,000.00			
		Aggregate	6	₹1,800.00	₹10,800.00			
		Steel	4.5	₹38,000.00	₹1,71,000.00			
5	Pardi	Cement	100	₹255.00	₹25,500.00	**₹63,500.00**		
		Aggregate	1.5	₹2,000.00	₹3,000.00			
		Bricks	5000	₹7.00	₹35,000.00			
6	Brickwork	Sand	5	₹9,000.00	₹45,000.00	**₹45,000.00**		
7	Brickwork (Internal)	Cement	50	₹250.00	₹12,500.00	**₹12,500.00**		
8	Ext Plaster	Sand	5	₹9,000.00	₹45,000.00	**₹45,000.00**		
9	Internal Plaster	Cement	25	₹270.00	₹6,750.00	**₹6,750.00**		
10	Vitrified Tiles	Tiles	1422	₹25.00	₹35,550.00	**₹35,550.00**	3 Days	Market research for purchasing
11	Ceramic Tiles	Tiles	66	₹25.00	₹1,650.00	**₹1,650.00**		
12	Polished Quota Stone	Tiles	65	₹35.00	₹2,275.00	**₹14,275.00**		
		Sand	1.5	₹8,000.00	₹12,000.00			
13	Aluminium windows and doors	Aluminium Window	193.6	₹200.00	₹38,720.00	**₹76,220.00**	2 Days	Delay in delivery by vendor
		Doors	10	₹3,000.00	₹30,000.00			
		Flush Doors	3	₹2,500.00	₹7,500.00			
14	Column	Sand	5	₹8,000.00	₹40,000.00	**₹42,000.00**		
		Aggregate	1	₹2,000.00	₹2,000.00			
15	Oil Bond	Oil Bond	10	₹1,700.00	₹17,000.00	**₹27,800.00**		
		Putty	18	₹600.00	₹10,800.00			
16	Waterproof Paint	Paint	6	₹2,300.00	₹13,800.00	**₹13,800.00**		

Table 7: *Frequency of ordering material*

Sr. No.	Material	Frequency of ordering material	Delay in days	Percentage delay
1	Steel(Tonne)	2	0	-
2	Sand (Brass)	7	3	25%
3	Cement (in Bags)	6	4	33%
4	Bricks (No)	1	0	-
5	Tiles	3	3	25%
6	Aluminium Windows	1	2	17%
7	Door	1	0	-
8	Murum (Brass)	1	0	-
9	Aggregate(Brass)	5	0	-
10	White cement	1	0	-
11	Oil Bond	1	0	-
12	Paint	1	0	-
13	Putti	1	0	-
	Total Delay	-	**12**	-

4.3 Analysis of data

The study was related to material management in small scale building projects. For that the details related to material management on site was collected. From the collected data delay in activities, reasons behind delay in activities, material ordering frequencies are studied. Form that study, delay happened in activities due to material, that activities are separated and studied. Following are the details of activities that were delayed due to material.

Delay in activity No. 9, 10 and 11 (i.e. Beam, Slab and Staircase) Material- Cement, Sand.

Activity no 9, 10 and 11 was carried out at the same time. The Quantity of material required for these combined activities was high. So that it consumed more time for selection and negotiations with vendors and it results in delay in activity with 7 days.

Reasons for delaying - Reason for delay can be categorized through steps of material management.

Step No. 2 - Material Purchase

i. Selection of Suppliers

ii. Negotiations

iii. Delay in Delivery

Vendor Analysis –

For Cement

Cement	Vendor 1	Vendor 2	Vendor 3
Rates(in)	280.00	290.00	270.00

Delay happened because of delay in negotiations with vendors

Delay in activity No. 17-(Vitrified Tiles)

Material-Vitrified Tiles

Delay in this activity was caused due to unavailability of stock of particular material to the vendor.

Reasons for delaying- Reason for delay can be categorized through steps of material management.

Step No. 2- Material Purchase

i. Selection of Suppliers

Delay in activity No. 22-(Aluminium Doors and Windows)

Material- Aluminium Doors and Windows

Delay in this activity was cause due to delay in delivery of material by vendor. It can also be categorized as delay caused due to delay of delivery of material.

Reasons for delaying- Reason for delay can be categorized through steps of material management.

Step No. 2- Material Purchase

i. Selection of Suppliers

5. RESULT AND SUGGESTIONS

5.1 Results

1. After the completion of project it was found that there was a difference between the estimated cost and the actual cost. Actual cost of project was 6.78% higher than estimated cost.

Estimated cost	-	14,39,465/- 14,68,254/-(including water and electricity charges)
Actual total cost	-	15,75,140/-
Difference in cost	-	1,06,886/-
Difference in cost (in percentage)	-	6.78%

2. The whole project was delay to some extent due to various reasons but the incident of delay due to material was 3 times.

3. It was found that 36% of days of the total project delays were due to material.

Table 8: *Percentage of delay*

Factors	Material	Labour	Equipment or other reason
Delay(in days)	12 days	14 days	7 days
Percentage	36%	42%	21%

4. The delay in materials was due to the following steps of material management

i. Selection of Supplies ii. Negotiation

5.2 Suggestions

Suggestion 1

Using material management technique or method i. e. ABC Analysis

It has become an indispensable part of a business and the ABC analysis is widely used for unfinished good, manufactured products, spare parts, components, finished items and assembly items.

This method of management divides the items into three categories A, B and C; where A is the most important item and C the least valuable.

This method can be used for the material management, from this A type of material can be focused and the delay can be minimized.

"A" types of materials are subjected to strict inventory control and are given highly secured areas in terms of storage. These goods have a better forecast for sales. These are also the items that require frequent reorders on a daily or a weekly basis. They are kept as a priority item and efforts are made to avoid unavailability or stock-out of these items. Following table shows the cost of "A" type of materials.

Table 9: *Costs of A type of materials*

Item	Quantity	Amount
Steel(Tonne)	8.03	₹3,05,140.00
Sand (Brass)	25.55	₹2,00,025.00
Cement (in Bags)	561	₹1,41,610.00
Bricks (No)	10,450	₹73,150.00
	Total	**₹7,19,925.00**

In the ABC model of inventory control, items categorized under A are goods that register the highest value in terms of annual consumption. It is interesting to note that the top 70 to 80 percent of the yearly consumption value of the company

comes from only about 10 to 20 percent of the total inventory items. Hence, it is crucial to prioritize these items. If ABC analysis is used and "A" type material ordered at the beginning for avoiding delay and increase in cost then following table shows the cost of "A" type of materials.

Table 10: *Cost of "A" type of materials if ordered at the beginning*

Item	Quantity	Rate/Unit	Amount	Transportation	Amount
Steel(Tonne)	8.03	₹38,000.00	3,05,140.00	₹3,000.00	₹3,08,140.00
Sand (Brass)	25.55	₹5,500.00	1,40,525.00	₹6,000.00	₹1,46,525.00
Cement (in Bags)	561	₹250.00	1,40,250.00	₹4,000.00	₹1,44,250.00
Bricks (No)	10450	₹7.00	73,150.00	₹1,000.00	₹74,150.00
				Total	**₹6,73,065.00**
				Difference in total cost	**₹46,860.00**
				Percentage difference	**6%**

If ABC analysis is used, the "A" type of material can be concentrated and delay happened due to these material can be minimized and increase in cost also controlled. If ABC analysis is used here then delay happened due to cement in activities could be minimized.

Suggestion2

One type of contact is made in this type of company project. It has a fixed range of rate for one thousand cement bags at a time. This rate is slightly lower than the market rate. And this rate range remains the same until the project is completed.

Advantages-

1. There is no need to find supplier and negotiation every time.
2. No delay in delivery
3. Rate can be limited within decided range

Disadvantages-

1. One time payment should be done.
2. Minimum 200 bags should be taken at one time.

In this project, if the contract of this method could be applied for the contract. If this method of contract had been applied in this project, it could have been contracted for 500 bags of cement. 500 bags of cement (250-260) would have been purchased in a fixed range and the remaining bags would have been bought at market rates. This method can properly manage this type of material and reduce costs and delays.

Suggestion 3

In this project, it has been seen that the delay in Activity No. 17 (vitrified tile) and No. 22 aluminum doors and windows is mainly due to the two activities material purchase step.

So pre-planning and ordering is important to reduce such delays, as well as selection of the right vendor. Compensation for delay should also be decided while vendor selection. A vendor who can deliver at the right time should be selected.

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