APPLICATION OF INVENTORY MATERIAL MANAGEMENT TECHNIQUES IN CONSTRUCTION PROJECT- CASE STUDY

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Abstract—Construction materials consists more than 50% of the total cost of the project. Efficient materials management plays a key role in the successful completion of the project within estimated cost and time. In this research paper written to explore current practice of material management to construction project and Inventory control techniques such as ABC classification and EOQ analysis are performed to maintain the inventory in an optimum level and S curve Analysis performed to compare the Actual work performed cost and budgeted cost of work performed using Microsoft project software. By applying inventory control techniques such as ABC classification and EOQ analysis the stock out problems of some A-class materials can be avoided. After the application of ABC and EOQ analysis, the total cost of inventory will be reduced.

Index Terms: Material Management, Inventory Control, Cost Control

I. INTRODUCTION

The construction sector represents one of the most dynamic and complex industrial environments. In developing countries like India, construction industry plays a most important role in development and economic growth of the country. Successful completion of projects requires all resources to be effectively managed. Materials are the major element in any construction project. Construction material constitutes a major cost component in any construction project. The total cost of material may be 50-60% of the total project cost [8].

Material management is an approach for planning, organizing, and controlling all those activities principally concerned with the flow of materials into an organization. The goal of material management is to ensure that the materials are available at their point of use when needed hence, efficient procurement of material represents a key role in the successful completion of the work. [II]

Materials management is a critical component of the construction industry. As such, organizations need to understand the effects of proper materials management techniques on the effectiveness of project execution. Properly implemented materials management techniques can achieve the timely flow of materials and equipment to the jobsite, and thus facilitate improved work face planning, increased labor productivity, better schedules, and lower project costs. [III]

Material management is concerned with the planning, identification, procuring, storage, receiving and distribution of material. The responsibility of Material management department for the flow of material from the time the material is ordered, received, and stored until they are used is the basic responsibility of material management. Materials represent a major expense in construction, so minimizing procurement cost improves opportunities for reducing the overall project cost. [II] Material management is the process to deliver right material at right place at right time in right quantity so as to minimize the cost of project".

Success of any construction project strongly depends on the effective utilization of cash flow, material management to complete project in scheduled timeframe with required quality norms in optimized cost. Considering importance of project material management this project includes importance of material management for construction cost optimization with theoretical details & practical illustration of inventory control systems. [x]

Objective of Material Management

There are two types of objective of material management.

1) Primary Objective

- Low prices
- Reduction in inventory cost and high inventory turnover ratio
- Maintaining the flow of production.
- Maintaining Consistency of quality
- Cordial relationship with suppliers
- Good record keeping protects the purchase and stores from charge of corruption.
- Development of personnel in the material department

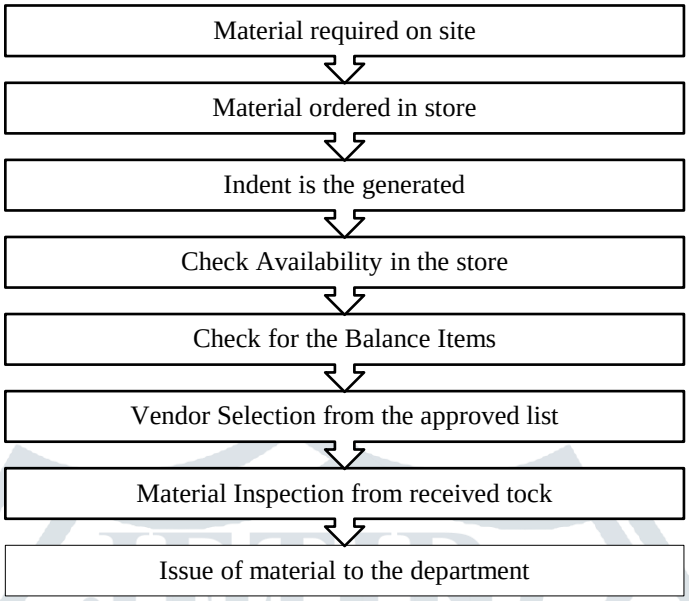
2) Secondary Objectives

- Promotion of Standardization with suppliers
- Development of reciprocal relations with customers
- Committees to decide on economic make or buy decisions
- Development of inter departmental relationships

Process of Material Management

Material management process initiates from need generated from site then this information conveyed to store department and material is ordered in the store, indent is generated. Vendor selection is to be carried out for the least value and best items. Materials are received at store department and inspection is carried out. [III]

Figure 1 Process of material management



Benefits of material management

An effective material management system can bring many benefits. these benefits are:

- Reducing the overall costs of materials
- Better handling of materials
- Materials will be on site when needed and in the quantities required
- Quality control
- Better field material control
- Better relations with suppliers
- Reduce of materials surplus
- Reduce storage of materials on site
- Stock reduction
- Purchase savings
- Better cash flow management

II. LITERATURE REVIEW

Mr. Deepak M.D **(2015)** They analysed ABC analysis to classify the materials therefore a methodology is made to classify the materials and S-Curve analysis are taken up to measure the variations and also discussed, various project cost variance in terms of the material, equipment's, manpower, subcontractor, overhead cost, and general condition in construction project operation.

They conclude that if strictly followed the measures to handle the materials properly and efficiently for a construction project, it can reduce the total material cost of the project. The variation in cost among Class A materials is of prime importance and affects the overall cost of the project.

Ashwini R Patil (2013)this study explored current practice of Material Management on construction field is suitable analyzed using ABC & EOQ inventory control techniques and S curve analysis. They describe various problems of administrative causes, consultant's causes, contractor's faults, and unavailability of resources and also conclude that the total cost of material may be 50% of total cost. Administrative causes are 30% which affects directly on contractors rework, 5% reasons due to unavailability of material.

Aditya A. Pande (2015) They explored material management tracking system in the industry is satisfactory for proper management using techniques with the help of inventory tools and s curve analysis and concluded that the total cost of material may be 52% of total cost; so that it is important for contractor to consider that timely availability of material is potential cause of successful completion of project.The Total cost of inventory after adoption of EOQ analysis is less than without adopting EOQ.

Harsh Soni1 (2016) this study explored the current practice of Material Management in construction industry and analyzed using ABC, SDE, & EOQ inventory control technique. The purpose is to find out the ways of managing the inventory properly, so that there would be a little impact on the profits.They conclude that ABC analysis provides identifying those items that make the largest impact on a company's overall inventory cost performance. SDE analysis in very useful in knowing present day scarcity of materials, in lead time and deciding upon purchase strategies. EOQ maintains the sufficient material safety stock in period short supply and reduced material wastage. Economic Order Quantity total investment is reduced and no of order is more in a year. So, Rate of Interest is increasing in actual site ordered material.

III. RESEARCH OUTLINE

Aim of the Study

To study Present Practices of Material Management at Construction Site and by applying the inventory control technique to analyze the effect of material management on constructions projects and control cost of project.

Objective of the Study

- To study the conventional Practices of material management at Construction site.
- Comparison of planned and actual cost of construction material using S Curve Analysis with the help of Microsoft Project Software.
- Apply inventory control technique so as to minimize the total cost of inventory.

Study area Profile

The case study which is selected for this project is Residential Project under Gujarat state Electricity Corporation Pvt. Ltd. Company. Gujarat State Electricity Corporation Limited (GSECL) was incorporated in August 1993 and is registered under the Companies Act, 1956. Company have successfully executed en-number of construction projects and achieved recognition in the construction field. Company has various industrial projects going on Like Thermal Power station, Ukai dam and residential Project. Residential Project which has been selected as case study for this work.

IV. RESEARCH METHODOLOGY

ABC Analysis

The ABC analysis classifies the material item based on the Annual Usage Value of items in order to determine its priority among plenty of material items. The ABC analysis is used to identifying material items that has a highest impact on overall inventory cost. In this method materials divided into three Groups. I.e. A, B and C Group. The grouping of all materials used in Construction into materials (A Class) which require the highest attention , materials (B Class) which require medium attention and materials (C Class) which require the least attention such that the control mechanism be focused on selective class of materials.

Methodology Adopted for ABC analysis:

1. List all the materials items used in the project along with unit price and quantity consumed annually.
2. Compute the Annual Usage Value (AUV) of each material item.
3. Arrange the items in the descending order of AUV and compute the cumulative percentage units consumed and cumulative percentage of AUV for each item.(Appendix C)
4. Graph is plotted between cumulative percentages of unit's vs. cumulative percentages of items.

S curve Analysis

S curve analysis is an important project management tool. This analysis is carried for comparison of planned and actual cost for material items. S-curve provides at a glance view of project performance in terms of cost and time. Analysis of S-curves allows project management team to quickly identify project growth, slippage, and potential problems that could adversely impact the project if no remedial action is taken. The deviations of the quantities is produced by the cumulative expenditure of certain parameters (Material cost) against time and it is the representation of project path.

S curve evaluated by using Microsoft project 13. Using s curve analysis Cost variance is calculated as difference between Budget costs for work performed (BCWP) and Actual cost for work performed (ACWP). Cost performance Index is calculated as ratio of Budget cost for work performed to Actual cost for work performed.

EOQ analysis

Economic order quantity (EOQ) is the order quantity of inventory that minimizes the total cost of inventory management. Two most important categories of inventory costs are ordering costs and carrying costs. Ordering costs are costs that are incurred on obtaining additional inventories. They include costs incurred on communicating the order, transportation cost, etc. Carrying costs represent the costs incurred on holding inventory in hand. They include the 1. Space, Electricity and other facilities 2. People for safety 3. Absolute items 4. Pilferage Items etc. At our site ordering cost includes transportation cost. Inventory cost includes Electricity and Cost of store keeper.

1. Find out the Q (Economic Order Quantity)

$$Q = \sqrt{\frac{(2 * Co * D)}{Cc}}$$

- Co= Ordering Cost
- D= Total Consumption
- Cc =Inventory carrying Cost

2. Find out the number of orders per year.
   No of orders = (ordering cost)/ (Cost per order)

3. Find out the total cost.

V. ANALYSIS AND RESULTS

ABC Analysis

Table 1 ABC Analysis

Sr. No (1)	ITEM NAME (2)	UNIT OF MEASUREMENT (3)	ANNUAL UASGE (4)	COST PER UNIT ITEM (5)	PERCENTAGE ITEM USED (6) =(4)/∑(4)	CUMM PER ITEM USED (7)=	ANNUAL USAGE VALUE (Rs) (8)= (4)x(5)	PERCENTAGE OF ANNUAL USAGE (9)	CUMM ANNUAL USAGE PERCENTAGE (%) (10)	RANK (11)
1	PPC Cement	Bag	3273	310	3	3	1014630	25.5	25	A
2	Rebar Steel TMT FE450	Kg	16823	35	13	16	588805	14.8	40	A
3	Mosaic Tiles (30cmx30cm)	box	1578	300	1	17	473400	11.9	52	A
4	Ceramic Tiles(300mmx300mm)	Nos	2208	145	2	19	320160	8.0	60	A
5	Fly Ash Bricks	Nos	97661	3.2	76	94	312515	7.8	68	A
6	Sand	Cum	289	900	0	95	260100	6.5	74	A
7	MS Rail	M	842	260	1	95	218938	5.5	80	B
8	Aggregate	Cum	198	800	0	95	158400	4.0	84	B
9	Vetrified Tiles (600mmx600mm)	Nos	983	120	1	96	117960	3.0	87	B
10	Teak wood Door	nos	36	2500	0	96	90000	2.3	89	B
11	Kota Stone	Nos	373	116	0	97	43268	1.1	90	B
12	Distember with premier	kg	720	50	1	97	36000	0.9	91	C
13	Emulsion paint with premier	litre	195	173	0	97	33735	0.8	92	C
14	Chicken mesh jali	Sq.m	341	98	0	97	33418	0.8	93	C
15	150mm long handles	Nos	184	150	0	98	27600	0.7	94	C
16	Pin type lamp 60 Watt.	Nos	60	350	0	98	21000	0.5	94	C
17	Ceiling Fan	Nos	12	1500	0	98	18000	0.5	95	C
18	Aluminium Sliding Window	Sq.m	4	4000	0	98	16600	0.4	95	C
19	15mm.dia.brass C.P. Screw down bib cock	Nos	30	550	0	98	16500	0.4	95	C
20	Mains (2 wire 2.5 sq mm)	m	720	20	1	98	14400	0.4	96	C
21	Granite Stone (600x450)	Nos	10	1417	0	98	14170	0.4	96	C
22	Plastic paint with premier	litre	102	135	0	98	13770	0.3	96	C
23	pvc pipe 150mm dia	m	217	60	0	99	13020	0.3	97	C
24	White porcelain rectangular wash hand basin size 550X450mm	Nos	6	2000	0	99	12000	0.3	97	C
25	pvc pipe wiring	m	360	32	0	99	11520	0.3	97	C
26	50mm dia Distribution Pipeline pvc	m	198	50	0	99	9900	0.2	98	C
27	P.V.C. water tight storage tank -1500 Lit.	Nos	2	4800	0	99	9600	0.2	98	C
28	300 mm. lock 16 mm. dia aldrop Stainless steel	Nos	78	110	0	99	8580	0.2	98	C
29	75mm dia Filter pipe line	m	132	60	0	99	7920	0.2	98	C
30	RCCBO	Nos	6	1200	0	99	7200	0.2	98	C
31	FRP door	Nos	12	500	0	99	6000	0.2	99	C
32	1 phase 12 way D.B	Nos	6	850	0	99	5100	0.1	99	C
33	450 mm long& 20 mm. dia. towel rod.	Nos	6	799	0	99	4794	0.1	99	C
34	300 mm. long flat latch/aldrop	Nos	66	65	0	99	4290	0.1	99	C
35	150 mm. long butt hinges	Nos	428	10	0	100	4280	0.1	99	C
36	Switch board	Nos	42	100	0	100	4200	0.1	99	C
37	Door catchers/magnet	Nos	132	30	0	100	3960	0.1	99	C
38	25 mm dia. chromium plated brass half turn flush cock	Nos	6	594	0	100	3564	0.1	99	C
39	Orissa TYPE porcelain W.C. SEAT of 580mm. size	Nos	6	535	0	100	3210	0.1	99	C
40	300 mm dia RCC pipe	m	15	200	0	100	3000	0.1	99	C
41	250mm dia RCC pipe	m	15	180	0	100	2700	0.1	100	C
42	Holdfasts	Nos	108	22	0	100	2376	0.1	100	C
43	900 mm. long & 20 mm. dia. Aluminum anodized towel rod with brackets etc.	Nos	6	389	0	100	2334	0.1	100	C
44	MS 40mm dia Pipe	M	44.07	52	0	100	2292	0.1	100	C
45	150mm dia RCC pipe	m	12	160	0	100	1920	0.0	100	C
46	Tube Light	Nos	6	260	0	100	1560	0.0	100	C
47	Energy meter qty	Nos	6	250	0	100	1500	0.0	100	C
48	call bell	Nos	6	200	0	100	1200	0.0	100	C
49	32 Amp MCB double pole	Nos	12	96	0	100	1152	0.0	100	C
50	Fan regulator	Nos	12	60	0	100	720	0.0	100	C
51	40 Amp MCB double pole	Nos	7	95	0	100	665	0.0	100	C
52	Brass C.P. shower rose with 15mm.dia. C.P. Stop cock	Nos	6	110	0	100	660	0.0	100	C
53	150 mm. long tower bolts	Nos	94	5	0	100	470	0.0	100	C
54	150 mm. hook eye or stopper of	Nos	28	15	0	100	420	0.0	100	C
55	150X100mm stone ware gully trap	Nos	6	65	0	100	390	0.0	100	C
56	tinted float Glass 5mm	Sq.m	0.2	1150	0	100	248	0.0	100	C
57	16 Amp switch	Nos	12	15	0	100	180	0.0	100	C
			128741				3986294			

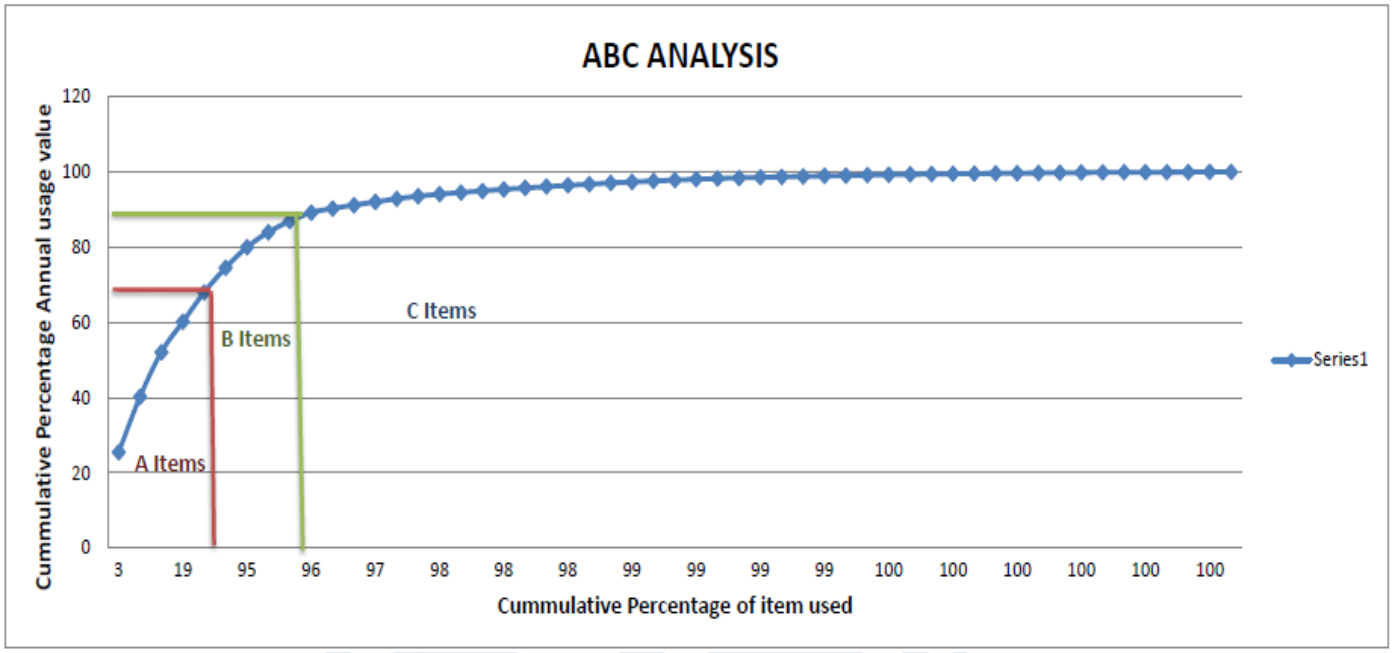


Figure 2 ABC analysis

From the ABC analysis following conclusions can be made,

- Class A materials – 6 items (70% of AUV)
- Class B materials – 5 items (20% of AUV)
- Class C materials – 46 items (10% of AUV)

S curve Analysis

S curve Analysis carried out using MSP (Microsoft Project)Software.

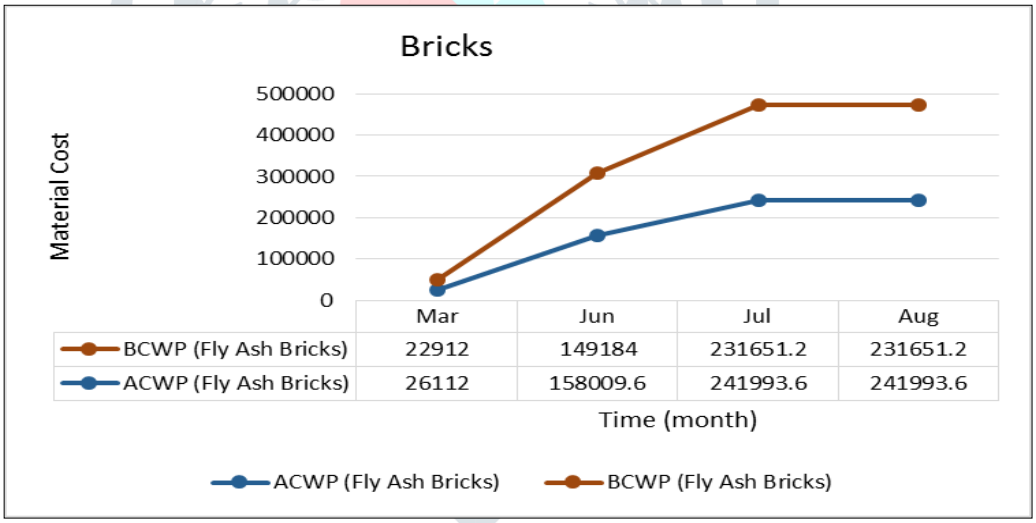


Figure 3 S curve for Bricks

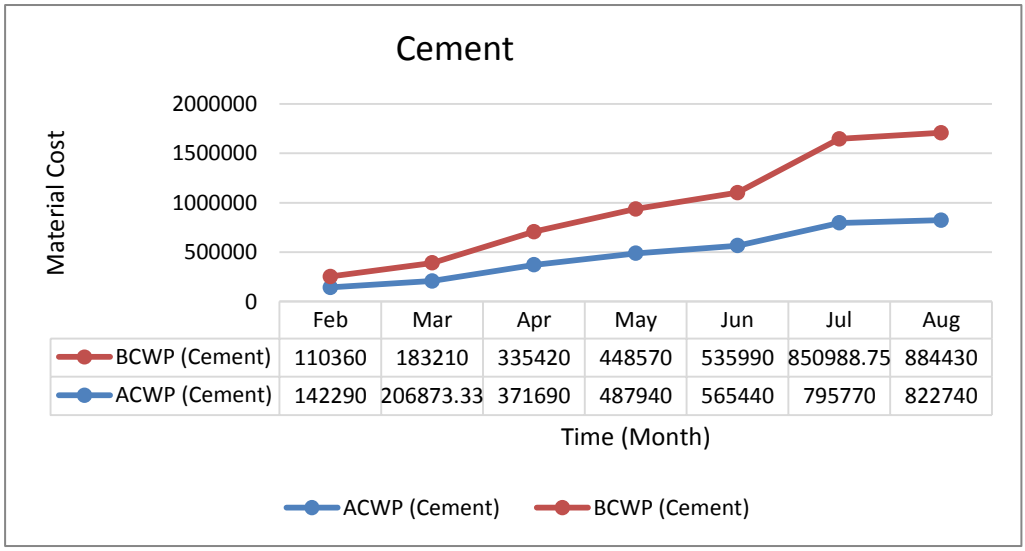


Figure 4 S curves for Cement

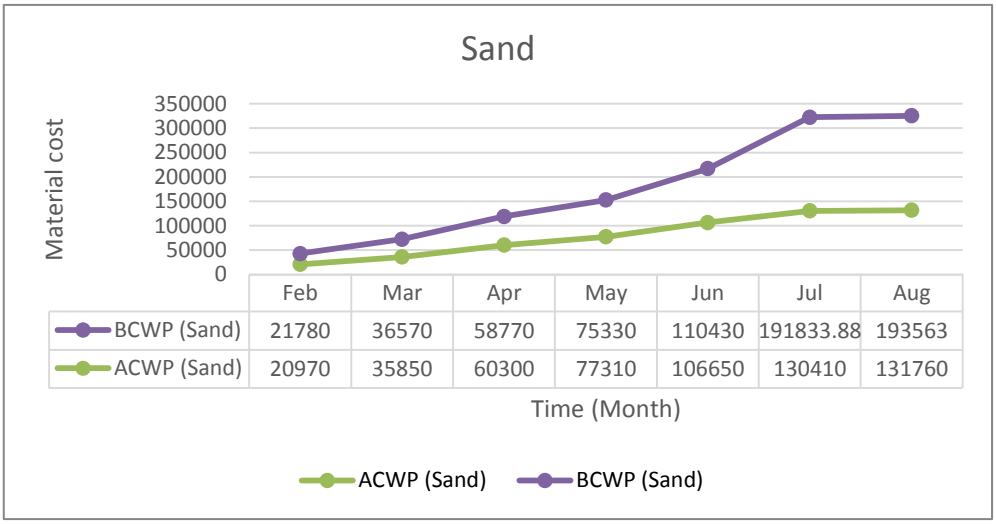


Figure 5 S Curve for Sand

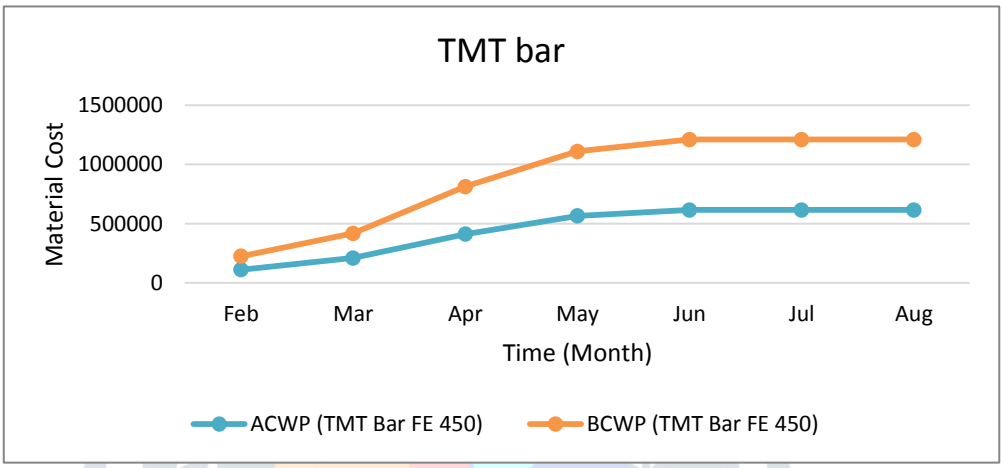


Figure 6 S Curve For Tmt Bar

Table 2 Cost performance index and Cost variance of material

Name	ACWP (Rs.)	BCWP (Rs.)	CV (Rs.)	CPI
Cement	8,22,740.00	8,84,430.00	61,690.00	1.1
Sand	1,31,760.00	1,93,563.00	61,803.00	1.5
TMT Bar FE 450	6,15,650.00	5,94,195.00	21,455.00	1.0
Fly Ash Bricks	2,41,993.60	2,31,651.20	10,342.40	1.0

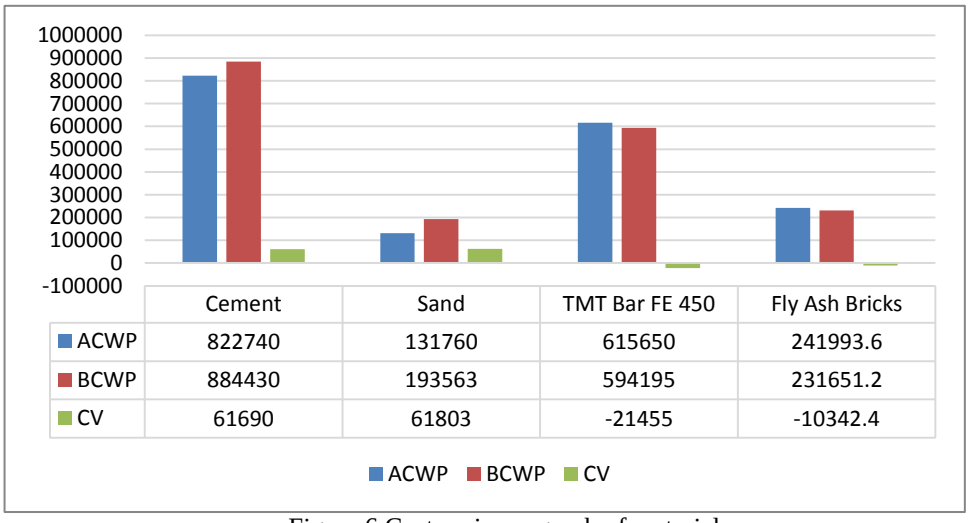


Figure 6 Cost variance graph of material

The Above Graph Show that Cost Variance of Cement and Sand is Positive that means Project run for cement and sand under budgeted cost. But cost variance of TMT Bar FE 450 and Fly Ash Bricks have negative that means project run for this Material over the budgeted cost. Cost performance index for A Class Material (cement, sand, steel and bricks) is one or Greater than one indicates a Favorable Performance. The Major Reasons For Deviation In Planned Materials Cost And Actual Materials Cost Are Found To Damages During Transportation And Storage, Quality Issues, Improper Material Utilization, Unskilled Labour, Changes In Legal And Economic Conditions.

EOQ Analysis

Item	Cost per order	Total Demand for 11 Month	Total Demand per year	Inventory carrying Cost	EOQ	No of Order	Order Cycle Time	Total Cost
Cement (Bag)	500	3273	3637	4.54	895	4	3	4,062
Steel (Kg)	350	16823	18692	0.88	3850	5	2	3,399
Sand (Cum)	600	289	321	51.39	87	4	3	4,450
Bricks (Nos)	450	97661	108512	0.15	25340	4	3	3,854
Aggregate (Cum)	500	198	220	75.02	54	4	3	4,062

VI. CONCLUSION

The study clearly shows the importance to manage all materials from the design stage to the construction stage. The systematic literature review identifies that materials management processes require a transformation to improve the overall process in handling of materials for more efficiency and effectiveness on the construction site. This is because poor handling of construction materials affects the overall performance of construction projects in terms of time, budget (cost), quality and productivity. The total cost of material may be 54% of total cost; so that it is important for contractor to consider that timely availability of material is potential cause of successful completion of project.

From the above study made, we can conclude that materials for the project, which is a very important resource if properly managed and handled, can vary the cost of the project to a large extent, especially Class A material items. If strictly followed the measures to handle the materials properly for a construction project, it can reduce the total material cost of the project. Suggested Material classification has to be done or followed in the site practices to identify the materials based on the importance during the project plan period

S-curve analysis is used to show the deviation in planned materials cost and actual materials cost and the main causes for this deviation are identified. By focusing on these causes the contractors and engineers can improve their material planning and keep overall project cost under control. The Cost Performance Index values for Class A materials are greater than or equal to 1 indicating a favourable performance of the material in the project. Corrective actions to reduce materials cost variance have been suggested.

From this Work we can observe that if there in help of Economic Order Quantity material can reduce wastage on construction site. Economic Order Quantity maintains the sufficient material safety stock in period short supply and reduced material wastage. It also helps in the But with using the Economic Order Quantity total investment are reduced and nub order is more in a year. So, Inventory carrying cost is increasing in actual site ordered material and as per EOQ rate of interest is decreased.

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