Analyzing Inventory Control Techniques of Material Management in Construction Projects

Ambrin.B[1] Dr.Arulselvan.S[2]
[1]PG Student [2]Associate Professor
[1,2]Department of Civil Engineering
[1,2]Coimbatore Institute of Technology, Coimbatore, India

Abstract— Construction materials account for more than 50% of the total cost of the project. Efficient materials management plays a major role in the successful completion of the project within estimated cost and time. This study mainly focuses on Materials planning and Inventory control as these are the major aspects of materials management. S-curve analysis is performed to measure the deviation in planned materials cost and actual materials cost. S-curve analysis is performed for 5construction projects in which 3 projects are for commercial purpose and 2 projects are for residential purpose. The result of the S-curve analysis show that the actual materials cost is higher than the planned materials cost in any type of construction. The major reasons for cost variance are identified and corrective actions are suggested. Inventory control techniques such as ABC classification and EOQ analysis are performed to maintain the inventory in an optimum level. Inventory control techniques are applied for a construction in ongoing status. By applying inventory control techniques such as ABC classification and EOQ analysis the stock out problems of some A-class materials can be avoided. EOQ analysis also helps to save some substantial amount of money if price hike in materials is predicted in advance and this savings can be utilized for other purposes related with the project. After the application of ABC and EOQ analysis, the total cost of inventory will be reduced.

Key words: Materials Management, Jobsite, Labour Productivity, Procurement, Inventory

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.

Materials constitute a major cost component of construction Industry. The total cost of materials may be 60% or more of the total cost is not-ocurred in construction project dependents upon the type of project and the extent of mechanisation and plant used. Hence materials management plays a vital role in construction project management.

Effective construction materials management process is a key for success of a construction project. Materials management is defined as the process of providing right quantity and right quality of right materials at right place in right time. The management of procuring materials is critical as any materials surpluses or shortages will delay the project and put it at risk and then affects the maintenance to consistent flow of the materials for production of thus affecting the overall project.

Often construction projects suffer from cost overrun and time overrun. These issues can be avoided by properly implemented materials management which ensure the timely flow of materials to the jobsite which in turn increase the labour productivity and thus reducing the costs of the project. As materials represent the major portion of the project cost, the overall cost of the project can be controlled by the materials overall cost. Materials Management is simple the process by which an organization was supplied with the goods and services that it needs to achieve its objectives of buying, storage and movement of materials. Materials management is considered as a means to achieve better productivity, which should be translated into cost reduction.

Efficient materials management in construction project environment calls for an integrated approach covering various functions such as materials planning, purchasing, inventory control, store-keeping and warehousing, handling and transportation, codification and standardization and the disposal of surpluses. When these functions are not properly managed, materials shortages, surpluses, and cash flow problems are likely to occur. Costly labour delays result when the required quantity or quality of materials is not available when needed and it increases the project cost and time.

Effective materials management undoubtedly has the positive impacts on project overall cost, schedule, safety, and quality. Ultimately, materials management most effectively leverages value and should be involved as early as possible in the project life cycle.

II. LITERATURE SURVEY

Damodara U. Kini (1999) discussed how materials management is essential for a successful project management in construction industry. In this paper he stratified construction project management in seven stages and explained the role of materials management in each stage. The seven stages in construction project management according to the author were planning, preliminary design, final design, procurement, vendor control, construction and closeout. In the planning stage project management team should be formed which consist a materials manager. The materials manager should have the authority to deal with subcontractors, buyers and expediters and materials manager should directly report to project manager. During preliminary design stage, a materials management focus requirement of a concentrated effort on the all definition of material and equipment while minimizing the cost of design. During the final design stage, materials manager prepares the specifications and other required data for the procurement of materials and equipments. During the procurement stage, materials manager should go for

competitive bidding process in order to achieve best value for the price. The materials management objective during the vendor control stage is to minimize the time spent on vendor drawing review and to ensure that all required submittals are received from the vendors in a timely manner. The objective during construction is to properly account for the equipment and materials delivered to the site and locate it within the ware house so that it is readily available when needed by construction. During the closeout stage, materials manager should dispose the surplus materials properly.

P.Lenin et al. (2014) describes the effects of improper materials management on construction project cost. This paper aims to fill a void created by the absence of proper materials management on construction sites. The study was exclusively assessed through questionnaire survey, interviews, field visits and discussion with the concerned authorities. 26 factors were selected for the proper assessment of most critical factors. From the results, the top causes that contribute for cost overrun are 1. Design related issues which include improper material availability study, inflated specifications, and inadequate pre construction survey 2.Client related issues which include delay in contractor payment and poor cooperation of owner 3.Contractor related issues such as lack of supervision, insufficient handling instructions, lack of labour skill and fraudulent activities of subcontractor 4.Site related issues such as unforeseen conditions, improper or lack of proper waste control techniques and existence of unnecessary materials and equipments 5.Labour and equipment related issues which include unsuitable equipment and materials, price fluctuation and materials scarcity 6.Store related factors which include improper procurement policy and inefficient inventory control 7. External factors include weather condition and natural disaster.

Carlos H. Caldas et al. (2014) identifies the current and emerging material management techniques in the construction industry. Surveys, interviews, and case studies involving 54 organizations were used to identify the techniques. For the purpose of this study, the authors considered materials management as an overarching process, embracing many different vertical functions such as the materials requirements to planning, the project acquisition strategies, purchased and subcontracting, expediting, supplier quality management, transportation and logistics, site material management, and overall materials planning operations and maintenance turnover. The result shows that the use of technology has been increased in the field of materials management, organizations involve their materials management team in front end planning and supplier relationship was given much importance. The current and foreseen issues affecting global procurement and materials management were identified to be defects, non conformances and lack of interoperability of different systems that uses IT. The authors suggest that the materials management system be fully automated and highly integrated.

Ismail Abdul Rahman et al. (2013) discuss about the relationship between factors of construction resources affecting project cost. This study focuses to identifying significant resource factors are causes construction cost over rush and also assess the relationship between these two factors. Data collection was carried out through a structured questionnaire survey consisting of 25 factors to be identified through the comprehensive literature review. Data was analyzed using statistical software package SPSS. The Cranach's alpha of the data was 0.910 which means that the collected data was highly reliable. The data shows that 11.32% of projects face cost overrun above 15%, where normal range of cost overrun is 0 to 15%. The factors were ranked through mean rank approach and it was found that 3 most significant factors are fluctuation of prices of materials, cash flow the financial difficulties focused by contractors and shortage of materials. Cash flows and financial difficulty focused by contract has strong correlation with the financial difficulties of owner. While the least significantly factors are in causing cost overall run are insufficient numbers of equipment, relationship between management and labour and labour absenteeism. The result of Spearman test indicates that cash flow and financial difficulties focused by contractors and constructions with financial effects of owner correlate strongly at a significant level of 0.752. Financial problems of contractors also fluency the procurements of equipments and arrangement of number of material and equipment. This affects labour productivity. Resolving this issue plays an important role in achieving successful projects.

Dinesh Dhoka (2013) explores the use of ABC classification for optimizing the inventory. This study mainly focuses to check whether some assumptions of ABC analysis are taken for granted. Several different strategies need to be applied appropriately for Integrating Inventory Classification and Policy Selection so that it benefits the entire Supply Chain and not only individual entities of the Supply Chain Weight. Data from an OEM Company dealing in Automotive Plastics is considered for this Study. The period of analysis has a large impact on ABC analysis. So the study was carried out for 1 month, 2 months, 3 months, 4 months, 5 months and 6 months. It is found that improperly done ABC analysis lead to serious inventory management issues.

III. RESEARCH MODULE

This research work mainly focuses on materials planning and inventory control as they are the two important measures as per as materials management is concerned. Material planning is the first stage in materials management. The determination of right quality and right quantity of materials is very essential for a successful project.This research work is carried out in two phases where the first phase deals with materials planning while the second phase deals with inventory control. To accomplish this, following objectives have to been adopted.

- To compare planned material cost vs. actual material cost using S-curve analysis
- To identify the causes of deviation in planned materials cost and actual materials cost
- The methodology adopted for this research work has been represented in the form of flow chart.

A. Data Collection

Cost of each material used in the construction project is required to carry out this research work. Quantity of each material should be known to calculate the individual cost of a material. For this purpose, plan and detailed estimate of 5

construction projects were obtained from different engineers. Out of these 5 projects, 3 projects are for commercial purpose and the other 2 projects are for residential purpose. The actual cost incurred on some materials like cement, steel and bricks were also collected from the engineers.

B. S-Curve Analysistera

The curve illustrates the side by side comparisons of the actual time and expenditure components vs. the estimated costs and time allocations of specific resources. It is used as a tracking tool to monitor the progress or growth of the project. Analyses of S-curves allow project managers to quick to identify project improvements, slippage, and potential effects that could adversely impact the project if no remedial action is taken. S-curve helps to analyze baseline is to be design or improved work, and baseline, design or actual costs. One of the primary uses carried of the S-Curve is to comparative any two or all three of these costs or work values at once. For example

C. Reasons For Cost Variance

The purpose of project cost control is to get the early detection of any possibility of cost variance from the budget (cost overrun) so that corrective actions can be taken as anticipation. Cost overrun can effected to the total project cost and minimize the profit. Material cost is one of the five important components of the project cost. It is the main factor in project overall cost control, and holed to an important role in project development & productivity, which the materials control consist of the relation between quality and quantity of the materials, shipping, scheduling and overall and overrun cost.

Based on a research, the material cost control covers the control of ten main steps in materials management, which are: planning & scheduling, organization & personal, procured, delivery, and quality vary assistance/quality control (QA/QC), storage and storage facilities, usage, change order, watch ,monitor and control, and other external factors. Material control covers related factors i.e.; quality, quantity, acquainted, schedule and overall cost. In material control, there are many things required to considerate: material purchase, items check, stock overall control, material storage and keep, material ship, and quality assurance/quality of material control. In control process, the first thing that needs to be done is to monitor the project cost report and to analyze the cost variance.

D. ABC Analysis

An important aspect of managing inventory is to have a link to an classify it is based on its importance thing. All items in the supply chain are not of equal importance. Some are very important while others are less important. The first step in manage and inventory is to classify invent based to its degree of importance to manage it properly. Classifying inventory based on degree of importance allows giving priority to most important inventory items and managing those with extra care. It also prevents from wasting resources on managing items that are of less value and importance. The grouping of all materials used in production into materials which require the highest attention, materials which require medium attention and materials which require the least attention such that the control mechanism be focused on selective companies of materials are called selective inventory control. Literally, thousands of items are kept in inventory. Periodic reviews of inventories of items have to be taken under for effective inventory control.. Material classification with reference to a particular function under examination is the solution. Among all the methods that are available to the purpose of categories, ABC analysis is simple yet effective tool. This method is very well suited for the construction industry and is also being used widely.
In ABC classification, the materials are classified as

- A class materials – 20% materials accounts for 70% of money value
- B class materials – 30% materials accounts for 20% of money value
- C class materials – 50% materials accounts for 10% of money value

E. EOQ Analysis

It is necessary to reduce the inventory cost in order to reduce the total cost of the project. The most important categories of inventory costs are ordering costs and holding costs. Ordering costs are the costs that are incurred on obtaining inventory items. It includes costs incurred on communicating the order, transportation costs, costs for supplier selection etc. Holding costs represent the costs incurred on holding the inventory. It includes storage costs, spoilage costs, insurance, taxes etc. Ordering costs and carrying costs are exactly opposite to each other. In order to minimize the carrying costs small orders should be placed but that in turn increase the ordering costs. In order to minimize the ordering costs few orders should be placed that is in larger size which in turn increases the carrying costs. EOQ model just helps to minimize the total inventory costs. The economic order quantity (EOQ) is defined as an inventory related model that is used to determine the optimal quantity that can be purchased to minimize the cost of both the carrying inventory and the processing of purchase orders.

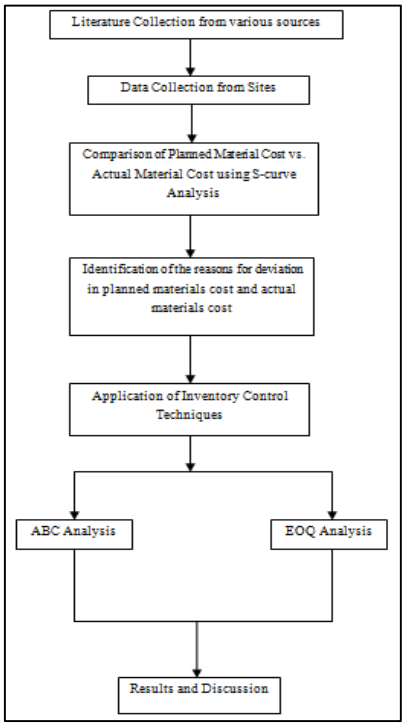

Fig. 1: represent the methodology adopted

Sample 1 Commercial Building (3537 Sqft) - Cost Estimate				
Material Description	Cost (Rs)	% of Total Cost	Rank	Class
Cement	12,108,161	57.26	1	A
Steel	5,984,000	28.30	2	A
Bricks	926,768	4.38	3	A
Sand	1,317,007	6.23	4	B
Aggregates	1,193,164	5.64	5	B
Ceramic Tiles	764,975	3.62	6	B
Emulsion Paint	757,698	3.58	7	B
Country Wood	721,064	3.41	8	B
Glazed Tiles	591,231	2.80	9	B
Teak wood Doors	280,000	1.32	10	B
Electrical holders and Fittings	459,813	2.17	11	B
PVC pipes and accessories	419,997	1.99	12	B
European Water Closet	312,556	1.48	13	C
Paver Blocks	285,600	1.35	14	C
Enamel Paint	271,309	1.28	15	C
Wash Basin	243,058	1.15	16	C
Staircase Handrail	214,461	1.01	17	C
White wash	210,398	1.00	18	C
Flexible Cables	116,573	0.55	19	C
Switches	112,236	0.53	20	C
Kitchen Accessories	97,648	0.46	21	C
PVC Conduits and accessories	96,389	0.46	22	C
Socket Outlets	93,817	0.44	23	C
GI Pipes & Fittings	85,261	0.40	24	C
Screws	54,736	0.26	25	C
Cudapah Slabs	38,315	0.18	26	C
Electric Cable	25,726	0.12	27	C
Dense tape	11,057	0.05	28	C
Teflon Tape	9,550.75	0.05	29	C
Total Cost of Materials	27,802,568.16			

Table 1: ABC analysis

Sl.no	Material	Planned Cost (Rs)	Actual Cost (Rs)	Cost Variance (Rs)	Cost performance Index
1	Cement	12,108,160/-	19,397,966/-	7289805/-	0.624
2	Steel	5,984,000/-	9,924,541/-	3940541/-	0.603
3	Bricks	926,767/-	2,255,577/-	1328809/-	0.411

Table 2: Cost Performance Index

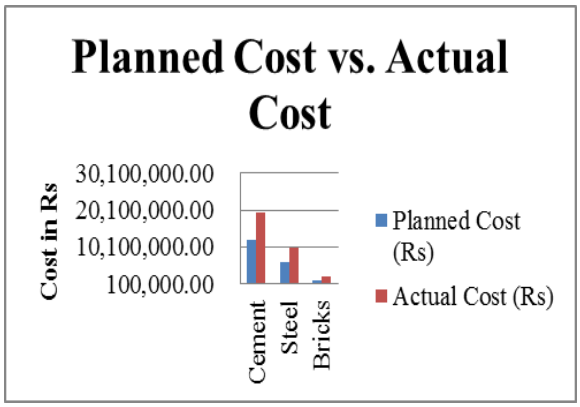

Fig. 2: Bar chart for Sample

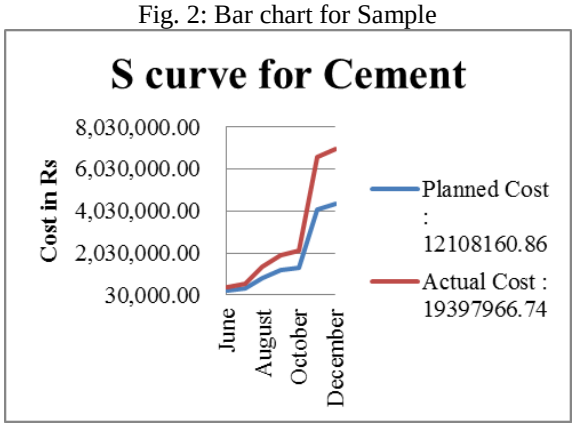

Fig. 4: S-Curve of Cement

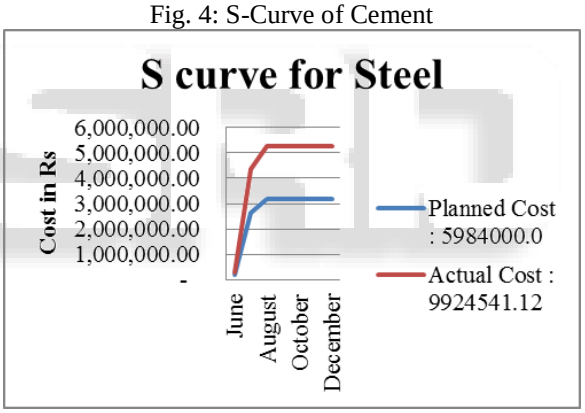

Fig. 3: S-Curve of Steel

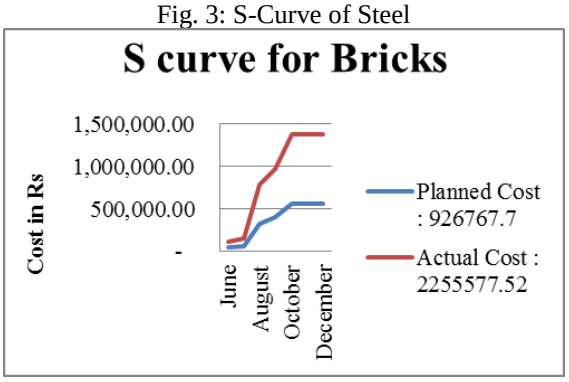

Fig. 5: S-Curves of Bricks 1

IV. RESULTS AND DISCUSSION

The results of the S-Curve analysis prove that there is a deviation in planned materials cost and actual materials cost for any type of construction whether it is small or big budgeted project. From the graphs it is clear that the actual materials cost is higher than the planned materials cost. Cost performance index is calculated for each material and it

supports the results of S-curve analysis by clearly stating that the cost performance index is less than 1, which means the project is under cost overrun.

The major reasons for deviation in planned materials cost and actual materials cost are found to be poor scheduling and estimation, poor prediction of market and field conditions, scarcity of materials, damages during transportation and storage, quality issues, improper material utilization, client intervention, changes in legal and economic conditions.

The total inventory cost is given by the sum of inventory carrying cost and ordering cost

Total cost = Ordering cost + Carrying cost

$$EOQ = \sqrt{(2 * Order\ cost * Demand)/Inventory\ carrying\ cost}$$

Sample No	Description	Total Demand	Annual Demand (A)	Ordering Cost (O)	Carrying Cost (C)	EOQ	Number of orders	Remarks
1	Cement	37,838.0	64865	500.0	83.2	883	43	1 Bag = 320/-
2	Steel	93.5	160	1700.0	16640.0	5.7	16	1 Ton = 64000/-
3	Bricks	154,461.0	264790	500.0	1.6	13028	12	1 Brick = 6/-

Table 3: EOQ analysis

EOQ analysis also helps to save some substantial amount of money if price hike in materials is predicted in advance and this savings can be utilized for other purposes related with the project. For example, the construction project taken for EOQ analysis is in its ongoing status and analysts have predicted a price hike in steel and sand in the month of April – May. According to analysts price hike will be around 4% - 5% per ton. EOQ analysis helps to determine the material requirement on monthly basis as frequency of ordering is known. The engineer or contractor can order two to five months requirement in advance according to their inventory capacity. If the engineer orders 6.5T(two months requirement) of steel in advance i.e., before the price hike, around Rs.13000 can be saved. Analysts predicted that there will be 10% - 15% hike in sand price. Sand requirement for two months in this construction project is found to be 5000Cu.ft. Extra amount of money needed to be spent on 5000Cu.ft of sand due to price hike will be around Rs.7000. The savings obtained from the steel can be utilized to compensate the price hike in sand as it is difficult to store large quantity of sand for a longer period. After the application of ABC classification and EOQ analysis, the stock out problems of some A and B class materials can be avoided.The total cost of inventory will be less after the application ABC and EOQ analysis.

V. Conclusion

Overall efficiency of the project can be increased by 35% by adopting proper materials management. For efficient materials management some simple tools are proposed in this project work. 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. Corrective actions to reduce materials cost variance have been suggested. inventory cost and to save some substantial amount of money when the price hike is predicted in advance. From this Work we can observe that if there in help of Economic Order Quantity material can reduce wastageon 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, Rate of Interest is increasing in actual site ordered material and as per EOQ rate of interest is decreased. So, after all saving the cost to use the other investment of material, other beneficial activity and reduce the thief the material. Instead of using costly software for inventory management, the engineers and contractors may use these simple inventory control techniques which are equally beneficial and economical.

References

[1] Damodara U. Kini, P.E. 1999. Materials Management: The Key to Successful Project Management. Journal of Management in Engineering, ASCE, 15(1), 30-34.
[2] P.Lenin, L.Krishnaraj, D.Narendra Prasad , V.R Prasath Kumar. 2014.Analysis of Improper Material Management Affecting Cost in Construction Projects.International Journal for Research in Applied Science and Engineering Technology, 2(5), 486-492.
[3] Carlos H. Caldas, Cindy L. Menches, Pedro M. Reyes, Laure Navarro, Daniel M. Vargas. 2015. Materials Management Practices in the Construction Industry. Practice Periodical on Structural Design and Construction, ASCE, 20(3), 1-8.
[4] Nann Lwin Phu, Aye Mya Cho. 2014. Factors Affecting Material Management in Building Construction Projects. International Journal of Scientific Engineering and Technology research, 03(10), 2133-2137.
[5] H. Randolph Thomas, David R. Riley, John I. Messner. 2005. Fundamental Principles of Site Material Management. Journal of Construction Engineering and Management, 131(7), 808-815.
[6] Narimah Kasim. 2011. ICT Implementation for Materials Management in Construction Projects: Case Studies. KICEM Journal of Construction Engineering and Project Management, 1(1), 31-36.
[7] NawajKalim Hannure, Sushma Shekhar Kulkarni. 2014. Comparative Study of Traditional Material Management and Material Management with ICT Application. Current Trends in Technology and Science, 3(4), 301-307.
[8] Ismail Abdul Rahman, Aftab Hameed Memon, Ahmad Tarmizi Abd. Karim. 2013. Relationship between Factors of construction Resources Affecting Project Cost. Modern Applied Science, 7(1), 67-75.
[9] Dinesh Dhoka, Dr.Y.Lokeswara Choudary. 2013. ABC Classification for Inventory Optimization.IOSR Journal of Business and Management, 15(1), 38-41.
[10] Kerridge, A. F. (1987). Manage Materials Effectively, Hydrocarbon Processing.

