A CRITICAL LITERATURE REVIEW ON THE IMPACT OF MATERIAL MANAGEMENT ON CONSTRUCTION PROJECT DELIVERY

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***ABSTRACT*:** In a construction project, the cost of construction material may range from 60-70 % of total construction cost. The main aim of this research paper is to examine the current material management practice and its impact on the delivery of building construction projects. A questionnaire survey administered to a purposive sample of main contractors and sub-contractors, eliciting current material management practices through semi-structured interview and obtaining their perception root causes of ineffective material management toward 34 causes that were extracted from an extensive literature review. Moreover, the relationship between different material management practices and project delivery in terms of cost overrun and delay were acquired from this questionnaire. There are three distinguish material management practices that were followed. The top three most common root causes of ineffective material management identified were matching price to competitor's price; time spent investigating non-qualified suppliers and unavailability of material.

Index Terms **- Construction projects, Material management, Cost overrun, Delay, Main contractor, Sub contractor.**

I. INTRODUCTION

The main reason for construction material to be so leading in a construction project is that the cost for material handling may range from 60 – 80 % of total construction cost. Therefore, ineffective material management can cause unavoidable loss for a construction project. Material management can be considered as a prime uncertainty in a construction project. Materials management functions which include planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory and material distribution. As material management is interrelated to other processes and stages of the construction project and is dependent over various other factors it has high uncertainty. Especially the nature of construction project being fragment basis with unstructured communication and no clear responsibility between the parties, increase the challenge of implementing effective material management. Although material management problems highly affect the construction professionals all over the world, they are more critical for construction professionals.

II. CRITICAL LITERATURE REVIEW

The following are the previous research review based on impact of material management on construction project.

Kasim Anumba Dainty et al. (2005) described a key factor adversely affecting project performance is the improper handling and management of materials on site. This paper reports on the early stages of research, which is developing a new ICT-based approach to managing materials on fast-track schemes. They concluded that, it is clearly important to manage all materials from the design stage to the construction stage. Poor handling of construction materials affects the overall performance of construction projects in terms of time, budget (cost), quality and productivity. The wastage of materials should also be minimised during construction in order to avoid loss of profit for construction companies. There is a need to develop new approaches to materials management in fast-track construction projects in order to improve the efficacy of the production process. **(17)**

Hemsworth Martinez-Lorente Clavel et al. (2006) stated that Standardization of materials is one important purchasing department decision. The primary objective of this study is to examine empirically the impact of standardization of materials and purchasing procedures on purchasing and business performance. The results of this research indicate that standardization in purchasing has a significant positive effect on both purchasing and business performance. They gave some points for a better understanding of how standardization in purchasing, operationalized as standardization of materials and purchasing procedures, can impact a firm's purchasing and business performance. Thus, standardizing materials and purchasing procedures is important and may help firms to meet their materials expenditure targets, and increase the quality of materials, on-time delivery from suppliers, and inventory performance. **(10)**

Kasim et al. (2007) stated that Materials management is made problematic by materials shortages, delays in supply, price fluctuations, damage and wastage, and lack of storage space. Thus, they reported on the early stages of research which is developing a new ICT-based approach to managing materials on construction projects. This was followed by exploring the ICT tools and techniques currently being employ on construction projects. Poor handling of construction materials affects the

overall performance of construction projects in terms of time, budget (cost), quality and productivity. The wastage of materials should also be minimised during construction in order to avoid loss of profit for construction companies. There is a need to develop new approaches to materials management in construction projects in order to improve the efficacy of the production process. **(18)**

Donyavi Flanagan et al. (2009) stated that Small and medium sized enterprises (SMEs) represent a large part of the construction sector. Large companies have the capacity and capability to use sophisticated information technology and management technology to control the labour and materials on projects. Materials can represent up to 70% of the project construction cost, hence any ways to reduce wastage and improve productivity will have major cost and time benefits. Now technologies can help in the management of materials flow and benefit contractors with lower costs and clients lower prices. They concluded that how SMEs can improve their performance in materials management, to reduce their costs, and to improve the project delivery. **(4)**

Patel Vyas et al. (2011) stated that a void created by the absence of proper materials management on construction sites. Research has shown that construction materials and equipment may constitute more than 70% of the total cost for a typical construction project. One of the major problems in delaying construction projects is poor materials and equipment management. They concluded that there should be a centralised material management team co-ordination between the site and the organization, Proper control, tracking and monitoring of the system is required, Awareness and accountability should be created within the organization. **(28)**

Meghani Vyas Hingu Bhavsar et al. (2011) stated that in Construction, 4-M (Material, Manpower, Money, Machine) play crucial role. This paper describes the main results of research studies carried out in Anand (Gujatrat) India that investigated the occurrence of material waste at five building sites located in different location of the Anand in India. Most of this waste can be avoided by strict supervision and control of material. Even after some extent of wastage rate allowable in each project, this limit extended beyond the allowable limit, which ultimately effect on project profit or return on investment (ROI). To compare the material wastage on different construction of project at Anand and give the necessary suggestion for reduce waste at site. **(24)**

Georgekutty Georgemathew et al. (2012) found that Construction project implementation in India is still facing challenges. Generally projects taken up for implementation will never complete, in time or complete at a later stage leaving cost and time overrun. Researchers are trying to find out the reasons why projects could not complete in time. They concluded that the fact that very few project are well planned before implementation and projects are always affected time overrun due to several reasons. Materials contribute more than 60% of the total project cost. So material management and control is a serious issue. This research work is an attempt to find a method to control the procurement and carrying cost in construction projects. **(8)**

Phani Mathew Sasidharan et al. (2013) obtained that the objective of the present study is to understand about all the problems occurring in the company because of improper application of material management. The results obtained show that the main problem of procurement is related to schedule delays and lack of specified quality for the project. To prevent this situation it is often necessary to dedicate important resources like money, personnel, time, etc. After studied all problems they gave some conclusions, analysis on the work site was done with the previous knowledge of the material management, and new methodologies were implemented at work site, based on the current construction scenario. **(21)**

Liwan Kasim Rozlin et al. (2013) stated that Inventory is important especially in construction project, as the proper amount of inventory will ensure that all construction activities will be able to carry out according to the planned schedules. The main problems within Malaysian construction projects regarding material tracking practices are excessive paper-based report, lack of up-to-date information regarding the status of materials, theft and labour intensive processes. Thus, there is a need for the application of sophisticated technology such as RFID to improve materials tracking practices for the purpose of inventory management in construction projects. Thus, they concluded that contractors should start implement emerging technologies such as bar-coding, RFID and wireless technology to automate material tracking practices. It is important to shift from manual to automated materials tracking using technology as it can facilitate material tracking for inventory management processes. **(34)**

Sindhu Nirmalkumar Krishnamoorthy et al. (2014) stated that Inventory management system involves procurement, storage, identification, retrieval, transport and construction methods. The first part based on conducting questionnaire survey in various construction companies. In second part, analysing those results by using Statistical Package for Social Sciences SPSS. ABC analysis is one of the conventionally used approaches to classify the inventories and the case study of a company is collected. They were focused some points mainly in Construction Industries: Involvement of contractor in material management, Need for stock management, managing stock in growth of company, Importance to stock comparing other works, Maintaining safety in storing. **(30)**

Lenin Kumar et al. (2014) stated that a void created by the absence of proper materials management on construction sites. Research has shown that construction materials accounts for 60-70% of the total cost in construction projects. Material mismanagement decrease the contractor's profit leading to huge losses, and leaving the project in big troubles, therefore the proper management of this single largest component can improve the productivity and cost efficiency of a project and help ensure its timely completion. The results obtained from the ranking factors shows that the top five major is causes of cost overruns are design issues, market condition, store issues, contractor issues and external issues. They obtained conclusions are given: Identifying variables influencing construction time and cost overruns shows that, design issues, client issues, contractor issues, site issues, labour and equipment issues, store issues, external issues, market condition issues are responsible for cost overrun of building construction projects are described. **(19)**

Keitany Wanyoike Salome et al. (2014) stated that Materials management is a tool to optimize performance in meeting customer service requirements at the same time adding to profitability by minimizing costs and making the best use of available resources. The main objective of the study was to assess the role of materials management on organizational performance. Specifically, the study intended to assess how inventory control systems and lead-time affect organizational performance. The ratings showed that inventory control systems played a vital role in organizational performance, and as such, organizations must

ensure that inventory control system be highly involved in material management activities hence achieving higher organizational performance. The results also showed that the coefficient correlation between inventory control systems and organizational performance is 0.884. **(16)**

Ashokkumar et al. (2014) stated that the development of construction industry depends on the quality of construction projects. Quality is one of the critical factors in the success of construction projects. This project mainly focuses the importance and factors that affects the quality management in the execution (construction) phase. He concluded that the main factors, which affect the construction quality and increase in cost of construction due to quality defect. This study will create the quality management awareness to all level construction companies' especially small-scale companies. He get the major factors and issues which affects the construction quality and that create a chance for find out the remedial measure. This thesis is useful for minimize the material wastage, workmanship wastage, time wastage and indirect cost. **(7)**

Ngwu Okolie Ezeokonkwo et al. (2015) identified the key areas where material management is deficient so that improvement could be made in order to increase productivity. The data collected formed the background of the structured questionnaires for proper analysis and recommendations. Eighty-seven out of ninety questionnaires launched to the sites were properly completed and returned. The material schedule would further assist in material scheduling – identifying materials required and making deliveries at scheduled times and dates. Since the problem areas have been identified, measures should be taken by contracting organizations to upgrade their performance. This could be achieved by engaging full time estimators or Quantity Surveyors and material controllers. **(5)**

Abhilin Vishak et al. (2015) described the main objective of the study was to assess the role of materials management on construction projects. ABC analysis is one of the conventionally used approaches to classify the inventories and case study of company is collected. By using ICT technique, exact consumption of material, stocked material, and location of material can be obtained. However, most contractors did not actually apply some tools and techniques of construction materials management, such as: Creating data for materials categories, local suppliers, international suppliers, and materials cost, Updating data for local suppliers, international suppliers, materials cost when change, and using internet for knowing the new materials and its prices, Providing a list of materials in project. **(1)**

Gulghane Khandve et al. (2015) stated that the total cost of materials may be up to 60% or more of the total cost incurred in construction project dependent upon the type of project. This give light to the fact that pre-planning and material procurement are equally important in controlling the total project cost. It reveals that the minimization of materials wastage during the construction phases is important in order to avoid loss of profits. It is observed that considerable research has been conducted to investigate individual construction waste management strategies at a specific stage of a construction project. **(9)**

Kwadwo et al. (2015) given the important contributions of the manufacturing sector to the Ghanaian economy, this research deems it necessary to evaluate the impact of efficient inventory management on the profitability of manufacturing firms in Ghana. The Ordinary Least Squares (OLS) stated in the form of a multiple regression model was applied in the analysis. From the results of the study, he can be realized that raw materials inventory management is a major variable that has significant positive relationship on the profitability of the manufacturing firms in Ghana. Management of raw materials is therefore an important factor to be considered in enhancing or boosting the performance of manufacturers in Ghana. **(14)**

R. Lakshmi et al. (2015) evaluated the use of Quality Function Deployment (QFD) as a management tool to benefit project managers. The project manager has primary responsibility within the construction, to ensure the design both fulfils user's requirements and is prepared correctly, and that quality control/assurance procedures are correctly administered. He found out that there is a positive and significant relationship between materials management problems and the frequent breakdown of the plant. This can be expected since the existence of materials management problems result in the breakdown of the plant. Out of stock and lack of spare parts interrupts production and hinder profitability. He shown how profitability can be achieved through effective management of materials with particular attention to sourcing, receiving, storing and issuing materials. **(33)**

Mallawaarachchi Senaratne et al. (2015) stated that Construction projects are always expected to create a balance between cost, time and quality. It is possible to have high quality and low cost, but at the expense of time, and conversely to have high quality and a fast project, but at a cost. Therefore, the purpose of this research is to investigate the importance of quality for construction project success. Moreover, poor quality could lead to unnecessary cost to the organization where it could create costs due to failure, appraisal and prevention. Implementing proper quality management plan is important at the project inception where, quality drawings, quality standards and constructability of design may lead to enhance the project quality. **(11)**

Mat Kasim et al. (2016) stated that Material management is an important element in project management as materials contribute a major portion to total project cost. It also plays a key role because of the successes of every construction project rely on having proper resources. Therefore, the aim of this paper is to identify the effects factors of material management on project performance. They gave conclusion: - The availability and sufficient materials and equipment have effect on time, quality, productivity and performance. Appropriate quality material has effect on time, cost and quality performance. Reasonable changes has effect on time performance. Efficient material controlling has effect on waste performance. **(13)**

Shet Sayali, Narwade Raju (2016) stated that the average material cost is 60-80 % of total project cost. The cost, quality & time are important objective of material management. This can be achieved by using material management techniques. The ABC analysis, VED analysis and SDE analysis are different techniques of material management. ABC analysis is based on inventory value of material. VED analysis gives Priority to utility of material whereas SDE analysis gives availability of material in market. They give some points that should be consider while ordering material. I) Scheduling of activities II) Quantity of material required. III) Transportation capacity & time required to reach the site. IV) Supplier previous records, location. The 23.07 % of material have 67.30 % of total project cost. The 30.76% of material have 25.01% cost. The 46.17% of material have 7.69% of total project cost. ABC analysis gives less interest charges as compare to other techniques. It shows that ABC analysis is more economical than any other method. **(27)**

Vignesh Shanmugapriya et al. (2016) stated that it is important to improve the decision making process in supply chain process. However, they do not know how to improve the decision-making in supply chain process in relation to the needs of the organization. Analytical Hierarchy process (AHP), a multi attribute decision analysis method is used with a view to providing solutions for two issues. First to find out the importance of factors which affect the decision making process in construction supply chain process. Second, based on the factors importance, which Performance measures need to be account for accurate decision making during material management process can be found out. In this study critical factors which cause great impact in the specific decision was found, this provide not only the most cost effective solution, but the solution could better serve the contractor needs at that particular instant. **(33)**

Krishna Satyanarayana Rao et al. (2017) stated that Materials are basic core organs of any product it occupies around 60 to 70% of total cost of production. Materials management will attempt resolve the issues viz., materials shortages, delays in supply, price fluctuations, damage and wastage, and lack of storage space. After analysis, they concluded that the materials are managed in a series of stages such as procurement, transportation, Shipping, grading, storage, warehouse maintenance, supplying to production centres Etc. Minimising the risk at all the above levels give management not only better utilization of resources but also serves as competitive advantage. **(20)**

Antony Roger Navodaya et al. (2017) studied that even though the materials and components used in construction costs more than 60% of the project cost in total, methods that exists for managing them totally depends on human skills. In this methodology, they said that the combination of Near Field Communication (NFC) and Global Positioning System (GPS) technologies are used which can facilitate low cost, easy to implement solutions to identify and track materials and components. This system is fully automatic and provides effective identification and tracking in all phases like production (offsite), en-route (transportation), construction site (onsite). This technology helps in obtaining real time and accurate information about the construction resources. It also helps in sharing the information with all the players of the project immediately. This approach uses the combination of NFC and GPS as a powerful portable tool which enables to collect, store, share and reuse of field data accurately, completely and almost instantaneously. **(2)**

Kulkarni Sharma Hote et al. (2017) they worked on the analysis of factors affecting effective materials management in building construction projects. They studied on nine different small, large & medium firms in Maharashtra. By studying gathered data, factors were found out affecting material management. They concluded that the large firms are good & capable enough in applying material management techniques on construction sites. Medium firms have some technical as well as some seasonal problems as they do not use any software. Small firms lack behind in material management as compared to medium & large firms due to lack of knowledge about material management. Use of software like MSP, PRIMAVERA, ERP, SAP, etc. should be done to avoid manual errors in material management. Before placing any order, every construction firm should apply EOQ technique to reduce project cost overrun. **(15)**

Patil Sarode et al. (2017) stated that Construction industry now a day is very progressive and innovative industry as compare to other industries in the world. At every construction industry for financial profit, need of people, owner various fast track techniques are used for completion of the construction work. They analysed the Correlation coefficient between cost of project and cost on material management of 15 building sites by using following methods of correlation with results on SPSS statistical software,

- Pearson correlation – 0.921
  +1 > 0.921 > 0 - the correlation between the two variables is said to be perfect and positive
- Kendall tau – b – 0.543
  +1 >0.543> 0 - the correlation between the two variables is said to be perfect and positive
- Spearman rho – 0.688
  +1 >0.688> 0 - the correlation between the two variables is said to be perfect and positive. Hence, data analysis of total cost of project and the material management cost on project is perfect and gives positive results of correlation; data is useful for future survey work. **(5)**

III. MAJOR FINDINGS FROM THE LITERATURE REVIEW:

1. There are three distinctive material management process types practicing in Surat building projects.
2. There is a significant relationship between these material management process types and project value.
3. Top three root causes of ineffective material management were identified as matching price to competitor's price; time spent investigating non-qualified suppliers and availability of material.
4. The identified top root causes of ineffective material management are consequences of existing problems in Surat construction industry such as depending on imported construction material, few suppliers in market and lack of skilled workers.
5. Storage issues have been a well-known problem among the construction professionals that it is no longer categorized as a threat as they are well prepared and mitigated from this problem.
6. There is a significant relationship between material management process type and project delivery in terms of delay and cost overrun.
7. Material management type one, phase-by-phase delivery suffered severe cost overrun compared to the other types and material management type 3 depending on local supplier shops experienced worst delay problems.

The following table represent that major factors of the research paper,

TABLE: 1

REPRESENTATIVE REFERENCES	FACTORS
Kasim Anumba Dainty et al. (2005)	The early stages of research that is developing a new ICT-based approach to managing materials on fast-track schemes.
Hemsworth Martinez-Lorente Clavel et al. (2006)	To examine empirically the impact of standardization of materials and purchasing procedures on purchasing and business performance.
Kasim et al. (2007)	Materials management is made problematic by materials shortages, delays in supply, price fluctuations, damage and wastage, and lack of storage space.
Donyavi Flanagan et al. (2009)	Small and medium sized enterprises (SMEs) represent a large part of the construction sector.
Patel Vyas et al. (2011)	Void created by the absence of proper materials management on construction sites. Delaying construction projects is poor materials and equipment management.
Meghani Vyas Hingu Bhavsar et al. (2011)	Construction, 4-M (Material, Manpower, Money, Machine) play crucial role.
Georgekutty Georgemathew et al. (2012)	Generally projects taken up for implementation will never complete, in time or complete at a later stage leaving cost and time overrun.
Phani Mathew Sasidharan et al. (2013)	The main problem of procurement is related to schedule delays and lack of specified quality for the project. To prevent this situation it is often necessary to dedicate important resources like money, personnel, time, etc.
Liwan Kasim Rozlin et al. (2013)	Inventory is important especially in construction project, as the proper amount of inventory will ensure that all construction activities will be able to carry out according to the planned schedules.
Sindhu Nirmalkumar Krishnamoorthy et al. (2014)	Inventory management system involves procurement, storage, identification, retrieval, transport and construction methods.
Lenin Kumar et al. (2014)	Void created by the absence of proper materials management on construction sites.
Keitany Wanyoike Salome et al. (2014)	Materials management is a tool to optimize performance in meeting customer service requirements at the same time adding to profitability by minimizing costs and making the best use of available resources
Ashokkumar et al. (2014)	The development of construction industry depends on the quality of construction projects.
Ngwu Okolie Ezeokonkwo et al. (2015)	The key areas where material management is deficient so that improvement could be made in order to increase productivity.
Abhilin Vishak et al. (2015)	To assess the role of materials management on construction projects. ABC analysis is one of the conventionally used approaches to classify the inventories and case study of company is collected.

Khandve et al. (2015)	The fact that pre-planning and material procurement are equally important in controlling the total project cost.
Kwadwo et al. (2015)	The impact of efficient inventory management on the profitability of manufacturing firms in Ghana.
Lakshmi et al. (2015)	The use of Quality Function Deployment (QFD) as a management tool to benefit project managers.
Mallawaarachchi et al. (2015)	Construction projects are always expected to create a balance between cost, time and quality.
Mat, Narimah et al. (2016)	to identify the effects factors of material management on project performance
Vignesh, Shanmugapriya et al. (2016)	It is important to improve the decision making process in supply chain process.
Krishna Satyanarayana Rao et al. (2017)	Materials are basic core organs of any product it occupies around 60 to 70% of total cost of production
Antony Navodaya et al. (2017)	Near Field Communication (NFC) and Global Positioning System (GPS) technologies are used which can facilitate low cost, easy to implement solutions to identify and track materials and components.
Kulkarni Sharma Hote et al. (2017)	The analysis of factors affecting effective materials management in building construction projects.
Patil Sarode et al. (2017)	The Correlation coefficient between cost of project and cost on material management of 15 building sites by using following methods of correlation with results on SPSS statistical software

IV. CONCLUSION

From the above literature review, we can conclude the following things:

1. In the present case study, analysis on the work site was done with the previous knowledge of the material management, and new methodologies were implemented at work site, based on the current construction scenario.
2. Following aspects were taken into consideration, the original site layout was redesigned, then the proper management was bought in and a completely new concept was derived.
3. Understanding of the problems that occur at the work site due to, inventory, purchasing and on how materials are being handled at the work site were taken into consideration.
4. On how, materials are being procured was done with questionnaires and weight ages were given to each. On further these problems were tackled with cause effect and diagram and how materials can be properly procured with the help of proper flow charts.
5. Importance on how materials are properly procured at the site was also taken into consideration and new appropriate technological implications were introduced like RFID, PDA, which helped us in a proper scheduling and financial control for proper scheduling and based on the materials importance, and on how they have to be released, ABC analysis.
6. From the above concepts, new theories which help us in proper material management at worksite were identified and prime importance was given to them.

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