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Management for Construction Materials and Control of Construction Waste in Construction Industry: A Review

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ABSTRACT
In recent treads a wide range of building materials is available for the construction of civil engineering structures. 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. Effective construction materials management is a key to success for a construction project. Construction waste is another serious problem in construction industry. A large and various types of construction waste with different characteristics are created at all the stages of construction. Construction industries have a larger part in contributing environmental problems. The economic and environmental benefits must be gained from construction waste minimization. This paper presents a review on systematically investigation of the management of construction materials and construction waste, material management techniques, control of construction waste and existing situation of construction management and construction waste in the industry.

Keywords **-** Material Management, Construction Waste, Management techniques, Economic relevance, Existing Situation.

I. INTRODUCTION

Construction industry is largest economic expenditure in India. According to eleventh five year plan, it is the second largest economic activity after agriculture. Materials management is an important element in project management. Effective construction materials management process is a key to success of a construction project. For many years it has evolved and changed with respect to the ever-growing complexity of projects. It is very important to understand the origin of materials management procedures and how these procedures differ from those of other industries. Materials constitute a major cost component for construction Industry. The total cost of materials may be 60% or more of the total cost incurred in construction project dependent upon the type of project and the extent of mechanisation and plant used (K V. Patel et al. 2011). Such a large investment requires considerable planning and control so as to minimize wastage which invariably affects the performance of the organization. Materials management is a coordinating function responsible for planning and controlling materials flow. One of the major problems in delaying construction projects is poor materials management. Ensuring a timely flow of materials is an important concern of material management. The management of procuring materials is critical as any materials surpluses or shortages will delay the project and put it at risk. This then affects the maintenance of a consistent flow of materials for production, thus affecting the overall project. Materials Management is simply the process by which an organization is supplied with the goods and services that it needs to achieve its objectives of buying, storage and movement of materials. Basically, material management is concerned with the planning, identification, procuring, storage, receiving, and distribution of materials. The purpose of material management is to assure that the right materials are in the right place, in the right quantities when needed. The increased economic growth as well as urbanization has led into extensive construction activities that generate large amounts of construction wastes. All round the world construction materials generate million tons of waste annually. Waste is one of the serious problems in construction industry. The term wastage refers to the variance, if any between the estimated and actual consumption of an individual item. Some hazardous materials may not be moved, before the authorities have ascertained that safety guidelines and restrictions have been followed. Hence proper management of waste materials from construction sites has now become very crucial. Managing waste means that eliminating waste wherever possible, minimizing waste wherever feasible and reusing materials which could otherwise become waste. A large and various types of waste with different characteristics are created at all the stages of construction right from site preparation, demolition of existing structures to final product. The exact quantity and composition of construction waste

generated throughout the projects are difficult to be identified as they are keep on changing due to the dynamic nature of the construction activities. A different stage of construction generates different types and composition of waste. However, the generation of construction waste is predictable based on the building design and procurement of the building materials. The nature of waste composition might be different at various construction stages. Thus waste generation throughout the construction stages needs to be identified and quantified to minimize the wastage.

II. MANAGEMENT OF CONSTRUCTION MATERIALS

An essential factor adversely affecting the performance of construction projects is the improper management of materials during site activities (N B. Kasim. 2008). Material is the main component in any of the construction projects. Therefore, if the material management in construction projects is not managed properly it will create a major project cost variance. The total cost of the project can be well controlled by taking corrective actions towards the cost variance occur in the project. (T. Phani Madhavi et al. 2013, Alin Veronika et al. 2006). Studies by the Construction Industry Institute (CII) have shown that materials and installed equipment can make up 50–60%of the total project cost and impact 80%of its schedule (C H. Caldas et al. 2014). During the last few years, enormous growth in infrastructure has been found, by wide range of diversity construction organization (S V. Desale et al. 2013). Fundamental Principles of Site Material Management enlightens the factors considered during site layout and planning for efficient material management. Ineffective material management practices are evident on many projects and cause considerable waste in time and money. (H. Randolph et al. 2005, Pauline Jeruto Keitany et al. 2014). For managing a productive and cost efficient site efficient material management is very essential. The materials management system in any project insure that the right quality of material and quantity of materials are appropriately selected, effectively purchased, properly delivered and safely handled on site in a timely manner and at a proper reasonable cost. (G.Kanimozhi et al, 2014, S. Donyavi et al. 2009). Any organizations need to put their effects for proper materials management techniques for the effectiveness of project execution. Material management involves storage, identification, retrieval, transport, and construction methods. Each of above is indelibly linked to ensure safety, productivity, and schedule performance. According to Kini (1999), materials management is an indispensable part of the project management which can be integrated with engineering to provide an end product that meets the client's requirements and is cost effective. Over the years, materials management in any construction project has become a critical component of successful project execution. (Carlos H. Caldas et al, 2014, C.K.Georgekutty et al. 2012). There should be a centralised material management team co-ordination between the site and the organization so that effective material management strategies can be applied and monitored. Construction materials management may present similarities at the conceptual level but the implementation details vary. Material planning considers materials in the order of requirement at site (S V. Desale et al. 2013). Material procurement and storage on construction sites need to be properly planned and executed to avoid the negative impacts of material shortage or excessive material inventory on-site deficiencies in the supply and flow of construction material were often cited as major causes of productivity degradation and financial losses (G.Kanimozhim et al. 2014). It is observed that construction materials are less homogeneous, less standardized, and more numerous than those of manufacturing, and that the characteristics of demand are different. Their should be awareness about material planning & scheduling at every stage of material management. (A R. Patil et al, 2013).

III. MATERIAL MANAGEMENT TECHNIQUES

Materials management is categorized to 5 processes these processes are majorly followed on construction site they are namely 1.Planning, 2.Procurement, 3.Logistics, 4.Handling 5.Waste control processes. Materials planning include quantifying, ordering and scheduling. Companies may have two major levels in planning- micro and macro level. Procurement is described as the purchase of materials and services from outside organizations. (N. Kasim. 2011, C H. Caldas et al. 2014). Purchasing procedure can be described as Step 1 – Material Indent, Step 2 – Enquiry to Vendors, Step 3 – Vendor Comparison, Step 4 – Vendor Selection and Negotiations, Step 5 – Purchase Order, Step 6 – Vendor Evaluation. Receipt system can be divided into 1.Receipt from outside suppliers 2.Receipts from internal divisions. Inspection can happen in two ways 1. Pre- dispatch inspection 2. inspection on the site. There are three methods of inspection 1. Visual 2. Tactile 3. Statistical. Logistics is a concept that emphasizes movement of materials. Materials handling encompasses virtually all aspects of all movements of raw materials, work in process, or finished goods within a construction site. (G. Kanimozhi et al. 2014, K V. Patel et al. 2011). For effective material management the most important materials management functions are (I) Primary Functions is to meet the primary objectives, the primary functions of the materials management are

given as materials requirements planning (MRP), purchasing, inventory planning and control, ascertaining and maintaining the flow and supply of materials, quality control of materials, departmental efficiency. (II) Secondary functions are standardization and simplification, make and buy decisions, coding and classification of materials, forecasting and planning. (K V. Patel et al 2011). Some other functions in context to material management are: Project Acquisition Strategy, Subcontracting, Expediting, Supplier Quality Management .Site Materials Management, Materials Management for Operations and Maintenance, Implementing Materials Management Programs. (Carlos H. Caldas et al. 2014). For effective execution of material management following process can be followed first of all material need generated from site, then material ordered in store after that indent is generated, then check availability in the store after that check for the balance Items after that vendor selection from the approved list then Material Inspection from received stock at last issue of material to the department. (Ashwini R. Patil et al. 2013). Implementation of IT in materials management could facilitate the effective and efficient control of materials on site reducing the human efforts. Implementation of IT includes construction materials planning system, material handling equipment selection advisor, construction materials exchange, and bar-code system (N.B. Kasim et al.2005, 2014). Experimental methodologies which can also be adopted for management of construction materials are analysis of site and management, analysis on inventory controlling, analysis on purchasing procedures, analysis on procurement and tracking, analysis on costs. (T. Phani Madhavi et al. 2013.

IV. EXISTING SITUATION OF MATERIAL MANAGEMENT

Research has shown that construction materials and equipment may constitute more than 70% of the total cost for a typical construction project (K V. Patel et al. 2011, Pauline Jeruto Keitany et al. 2014). In Indian construction industry currently manual materials management practices and control procedures are unsatisfactory as they are labour intensive, inaccurate and error prone. All these reasons leads to waste and surplus of construction materials, delays in construction projects, decrease in labour productivity and lack of up-to-date and real-time information of the project. An initial assessment of the tools and techniques currently in use in materials management suggests that most of them are under development with a few being used on a commercial basis. (N.B. Kasim et al. 2012). New emerging technologies such as wireless communication system, bar-coding readers and Radio Frequency Identification (RFID) are being adequately used on site to overcome human error and are well integrated with project management systems on construction projects to make the tracking and management of construction materials easier and faster. (T. P. Madhavi et al. 2013, N. Kasim et al. 2013). It has found that scheduling delays occurred in 70%, 40% and 50% of government contracted construction projects in the United Kingdom, India, and United Arab Emirates (UAE) respectively due to improper material management (G.Kanimozhi et al. 2014). Currently all over the globe the main reason in cost variance and problematic management of material are due to overstocked materials because of improper planning, damaged materials due to logistics, handling or in application, loss of materials because of improper supervision, waiting of the materials to arrive in location due to improper tracking systems, frequent moving of materials due to improper site layout, inflation, material changes in buying/purchasing situation starting from the prepared cost estimation, bulk construction material, the shortages and changes of construction materials quantity required, materials inefficiency on site, stealing and loss of construction materials, material shipment, work repairing, delay in updating/posting storage system on site, inaccurate measurement of work locationon construction projects, material off-take, inaccurate estimation of shipment quantity of materials, uneconomic order quantity of materials, poor shipping time, inadequate tools/equipment needed on site, increasing transportation cost of materials, material over usage in location of project, choosing the wrong materials for construction, the increasing storage cost of materials, the poor buying ability of managers, delay of payment for materials, and the poor policy in purchasing the materials (Alin Veronika et al. 2006, N. Kasim et al. 2013). It is found out that administrative causes are 30% which affects directly and 5% reasons due to unavailability of material for faulty material management. “A” category consists of 10% of total material involved in construction but that cost 70% of the total cost. (T. Phani Madhavi et al. 2013). Research has shown that construction materials and handling equipment may constitute more than 50% to 70% of the total cost for a typical construction project. Firms employing proper material management system are seen to have increased their overall efficiency by 35%. (K V. Patel et al. 2011).

V. CONSTRUCTION WASTE MANAGEMENT

Construction waste consists of unwanted material produced directly or incidentally by the construction or industries. Construction and demolition waste is generated whenever any construction/demolition activity takes place (A.Harikumar et al. 2014).

Construction wastes in any project are in the form of building debris form demolition process, rubble, earth material, concrete waste, steel waste, timber waste, and mixed site clearance construction materials, arising from different construction activities of project including land excavation or formation on site, civil and building construction materials, site clearance waste, demolition activities waste, roadwork waste, and building renovation waste. The management of construction wastes is a global environmental issue experienced by countries all over the world (L. Y. Shen et al. 2004, C. S. Poon et al. 2013, Siti Akhtar Mahayuddin et al. 2013). Vigorous literature review identified 81 factors for causing construction waste and clustered in 7 groups of factors namely design of project, handling of construction materials and equipment, construction workers, project management, site condition and procurement of materials and external items (Ismail Abdul Rahmana et al. 2013). The term "wastage" refers to the variance if any between the estimated and actual consumption of an individual item and total factor consumption of all inputs in a construction project. Material waste has been recognized as a major problem in the construction industry that has important implications both for the efficiency of the industry and for the environmental impact of construction projects. (S V. Desale et al. 2013, Jing Zhang et al. 2005). For managing the waste their must be efficient waste management system which can control the waste at source and manage the waste at every stage or phase of construction project (M D. Meghani et al. 2011, K R. Kareem et al. 2013). Moreover, waste measurement plays an important role in the management of production systems since it is an effective way to assess their performance. The increasing awareness of environmental impacts from construction wastes has led to the development of waste management as an important function of construction project management (Carlos T. Formoso et al. 2002). Waste management in construction activities has been promoted for the aim of protecting the environment in line with the recognition that the wastes from construction works contributes significantly to the polluted environment (L. Y. Shen et al. 2004). Various approaches for managing construction wastes have been developed in the existing research works and simultaneously practices, and these project works can be grouped largely into three areas mainly classification of waste, management strategies for waste and disposal technologies for waste. Construction activities generally have negative effects on the environment, which includes the exploitation of natural land and other resources for development and the generation of waste and various forms of pollution (Tam et al. 2005, 2006, Carlos T. Formoso et al. 2002, S. Nagapan et al. 2012). Other negative impacts to the environment are generation of waste, ecological imbalance, changes in living environment, sewage, reduction in environmental resources and energy usage (Siti Akhtar Mahayuddin et al. 2013). To reduce this impact on environment construction practitioners need to determine significant contributory factors of waste generation before engaging with construction works (Ismail Abdul Rahmana et al. 2013).

VI. CONTROL OF CONSTRUCTION WASTE

Reduction of waste can be done by practicing attitude towards Zero wastage, proper decisions at design stage, site management, proper standardization of construction materials, and Codification of the same (S. Sanmath 2011). Construction waste can also be reduced by using waste management system on project. The project activities are to be planned at every stage by every construction personnel, who are involved, in minimizing the overall waste generation at project (J. Thomas et al. 2013). Waste rate estimation method can be used to improve the handling material, reduce the waste rate, and improve productivity (A. Al-Hajj et al. 2011, M D. Meghani et al. 2011). Concept of 3R and 4R can be also beneficial to reduce the wastage of construction materials, which includes reduce, reuse, recycle, and recovery. These can be applied to the entire lifecycles of products and services (K R. Kareem et al. 2013, J. Thomas et al. 2013, Nitish Bagdi et al. 2013). The free-flow mapping presentation technique can be adopted in the study for investigating the waste flow practice on construction sites. The technique has been considered advantageous in presenting flows of processes logically, clearly, and in the simplest way (L. Y. Shen et al. 2004). The prediction of waste flow can be modelled through the building elements at the construction stages (Siti Akhtar Mahayuddin et al. 2013). For effective reduction of material waste management strategy for construction waste can be used such as reduce waste generation, maximize reusing, and recycling, reduce the intake of mixed construction waste at landfills. The use of environmental friendly construction methods has been encouraged, such as using a large panel system on any project site, applying prefabrication components for effectivity, and reducing the application of wet trade (L. Y. Shen et al. 2004). A management strategy for construction waste also involves the maintenance of a well-managed public filling programme with sufficient facilities and access. Sort mixed construction waste and not just dispose of it in any single place, reuse and recycle as of materials as far as possible, design better and construct more efficiently to minimize waste etc. (A.Harikumar et al. 2014). Various strategies for Construction and Demolition waste reduction also include standardization of design, stock control for

minimization of over ordering, environmental education to workforce etc. (N. Bagdi et al. 2013). Government implemented construction waste disposal charging scheme (CWDCS) can provide financial incentives to C&D waste generators to reduce waste and encourage reuse and recycling. Government's interventions like Landfill tax, higher tax for using virgin construction materials, tax credits for recycling etc can be used on construction site for waste minimization (C. S. Poon et al. 2013, Mansi Jain 2012).

VII. EXISTING SITUATION OF CONSTRUCTION WASTE

Due to least priority given to appropriate site waste minimization and management systems in Indian construction industry leads to generation of huge quantities of material waste every year. Presently, awareness of resource-efficient construction practices is lacking in most countries (J. Thomas et al. 2013). Currently, existence of national policies as well as the regional policies, laws and regulations governing reuse and recycle principles for construction waste is minimal as far as India is consent (Mansi Jain. 2012). At present, private contractors remove this waste to privately owned site, low-lying land for a price purpose, or more commonly dumping it in unauthorized manner along roads or other public land or the region (A.Harikumar et al. 2014). Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons per annum of which waste from Construction Industry accounts for 25% (A.Harikumar et al. 2014, B.Prakash Rao et al. 2014). Recent studies as in pointed out the waste generated in China are around 40% and 39.27 million tons in Spain. Malaysia and Singapore is facing the problem of illegal dumping and the issue has become more serious recently throughout the country. According to government statistics, in Hong Kong, soft inert materials (such as soil, earth, and slurry) account for approximately 70% of all C&D waste, which can only be reused as fill materials in reclamation and earth filling works (C. S. Poon et al. 2013). Investment in construction accounts for nearly 11 per cent of India‟s Gross Domestic Product (GDP) (Market, 2009). Technology Information, Forecasting and Assessment Council (TIFAC) study mentions that total construction work for five years during 2006-2011 is equivalent to $847 billion. Therefore material waste generation from construction activity is also huge in monetary terms. Statistical data shows, construction, and demolition (C&D) debris frequently makes up to 30% of the waste received at many landfill sites around the world. (Mansi Jain, 2012). According to European Topic Centre on Resource and Waste Management (EIONET, 2006) construction and demolition waste represents around 25% of all waste generated. Indian buildings in 2013 must have generated more than 53 million tonnes. Demolitions of buildings generate 300-500 kg per sq meter (TIFAC. 2013). Considerable research has been carried out in country like United States of America, Japan, United Kingdom, France, Germany, and Denmark etc. for recycling of waste concrete from site, masonry, and bricks, bituminous and other constituents of waste from Construction Industry. These studies have shown possibility of using construction waste to substitute new materials of recycling. Today, in most European countries, it is economically feasible to recycle up to 80–90% of the total amount of construction waste and most demolition and recycling technologies are generally easy to implement and control (J. Thomas et al. 2013, M. Jain. 2012).

VIII. CONCLUSION

The systematic literature review identified that Materials management processes require a transformation to improve the overall 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 cost, time, quality, and productivity. From the literature review it is understood that this area require further research to find some feasible solutions to control the total project cost. There is no proper system for procurement of construction materials. 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. Currently, the majority of research efforts have been given to the material loss in construction activities rather than the non-value-adding work as an intangible waste. Waste Generation Rate is an effective indicator for measuring construction waste and benchmarking construction waste management performance.

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