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Inventory Management in Construction Industry

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Abstract. Inventory management is a critical part of construction Industry. Inventory Management system consist of different tasks like finding suitable materials, procurement process of those materials, transportation. Materials on construction site cost around 50-60% of the total cost of the project, so it becomes very crucial to handle the materials methodically. The main objective of this paper is to study the existing research on inventory management in Indian construction industry to observe the importance of inventory management and different costs associated with. Future scoop of this study will be how to conduct the projects smoothly and to find the flaw in the inventory management on construction site or the factors affecting the poor management of materials on site and also to find the research gap so that more reliable findings could be achieved. This article will contribute a lot to the research, society, new researchers and constructions.
Key words: Inventory, Construction, Materials, Projects, Management etc.

I. INTRODUCTION

Inventory management plays an important role in the completion of construction project successfully and on time. The role of inventory is to store the materials on site so that those material can be available in time of their use. Inventory not only holds the material required for construction but also store the finished products, spare parts and tools. It is very common in Indian construction industry that the project suffers from cost overrun and exceeding the deadline. The problems like this could be solved by the proper implementation of the inventory management. Which will increase the productivity on site and the progress of project will be consistent. Inventory management consist of many processes like selecting the materials and their procurement, cost involve in transporting them and storage of materials. Inventory management has its own budget which is used in different costs in maintaining and running the inventory at optimal level, those costs are-

Ordering cost; The essential cost incurred when a company placed an order.

Holding cost; The cost associated with the storing of materials before it is used on site.

Storage cost; The cost associated with storage of material. This cost could be direct or indirect which includes the cost of rent, electricity and etc.

If the project needs to be conducted smoothly then all factors need to be accomplished by good communication, making critical decision and keep an eye on inventory and manage it properly.

II. LITERATURE REVIEW

Singh and Singh (2013) studied the just in time (JIT) strategy. The authors also mentioned the elementary method of inventory control i.e., ABC analysis. Authors explained the philosophy behind the JIT strategy and mentioned that no activity should take place until the requirement of that activity. JIT also helps to eliminate the excess inventory by which the waste in inventory automatically reduces. It could be done by simplification of manufacturing process. Since quality become the necessity, with this there will be fewer defective items in the inventory. Which reduces work in process inventory. The authors concluded that JIT has potential and it could take the organization through this competitive market as well as from this dynamic environment of construction industry.

Mansour N. Jadid (2013) studied and developed a framework using an internet-based system which is in the material selection decision support system for projects that are under design or construction phase. This development could help various domains of civil engineering but the authors focused it architecture, engineering, construction and inventory management department. The authors focused on the problems like material approval, selection and information management. The authors mentioned that the main source for the input of data is from the previous or current projects. This paper discussed various criteria for material selection like maintainability, aesthetics, adaptability, durability, sustainability, cost efficiency and lack of toxicity which all support the officials to finalize decision on material selection.

Patil and Pataskar (2013) analysed the inventory management techniques. Authors focused on to find the present techniques in inventory management. This study was done in two phases, in first phase, the authors used the S curve analysis by using MSP tools to provide qualitative data and for second phase, the authors considered the ABC analysis and EOQ analysis to solve the problem of stock out. The authors collected data from tender documents, material requisition note, ledger register and interviews. The result says the unavailability of RCC drawing causes the problem to contractor to assess the project accurately. Uneven geographical feature could also impose delay or problem on projects. The authors recommended ABC and EOQ analysis should be done before the work starts and all the drawings should be completed or handed over to contractor to increase the efficiency of inventory management.

Jose V and Jayakumar (2013) studied different items from inventory and done the EOQ analysis and ABC analysis to find out which materials are important to project and their respective quantities. The authors collected the data of 40 materials from inventory and gathered the following data of each material like demand per year, re order cost, carrying cost and number of units ordered. Then the authors mentioned about safety stocks and how we can apply it in inventory management. Authors calculated the actual demand for a period of 1 year and lead time is taken 100 days maximum. The authors also segregated all 40 items into class A, B and C to do the ABC analysis. The authors found that the items with worth more than 100 rupees are consisted of 45% of total inventory, items with worth 25- 100 rupees are in 35% of total inventory and items with less than 25 rupees are only of 30%.

Arunprakash and Nandhini (2013) studied about the material control exercises adopted by different construction companies. For this, the authors designed the appropriate questionnaire and identified the companies. There was also a secondary mode of data collection where the authors go through the company's stock books. In this paper, the authors made some criteria and analysed it. Different criteria is kind of material stock, maintain stock for equipment spares, maintain stock for materials, stock for sand, brick, aggregate, steel rod, primer, cement, maintaining documents, reorder of stocks and stock management. The authors found that 50%-60% companies only focused on important materials like cement and steel. Rest of the materials and their availability on site decreased as they were less important for the companies and required lot of space to hold those materials.

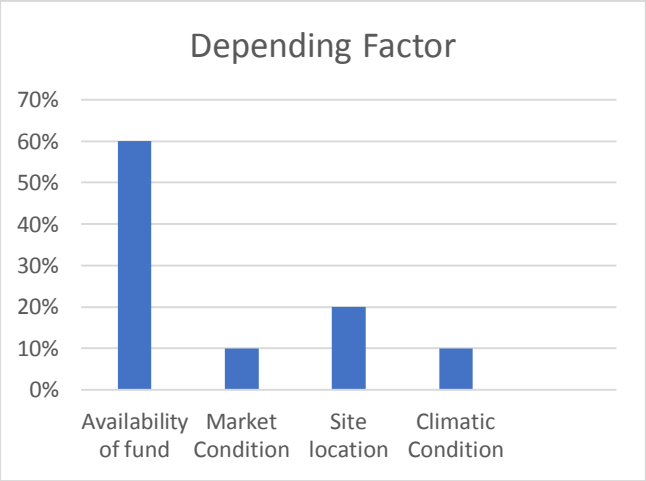

Fig 1: Depending factors for maintaining the Inventory
Source: Arunprakash and Nandhini (2013) [5]

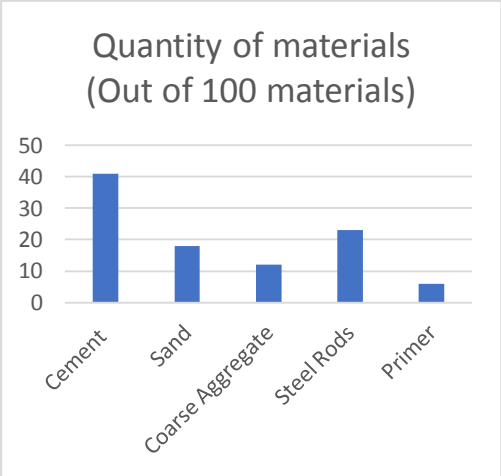

Fig 2: Different Materials in Inventory
Source: Arunprakash and Nandhini (2013) [5]

P. Lenin et al (2014) studied about the illegitimate inventory management and how it affects the cost of the construction project. For this the authors used the questionnaire and interview to collect the information and examined the practices of inventory management by the contracting companies. 26 factors were found to be most critical in this paper. This paper also aimed to rank the factors in accordance with their significance. The authors condensed the factors related to, design, client, contractor, site, labour and equipment, store, external, market condition and overall material mismanagement. The authors also ranked the factors with design related factors at top and client related factors given lower rank.

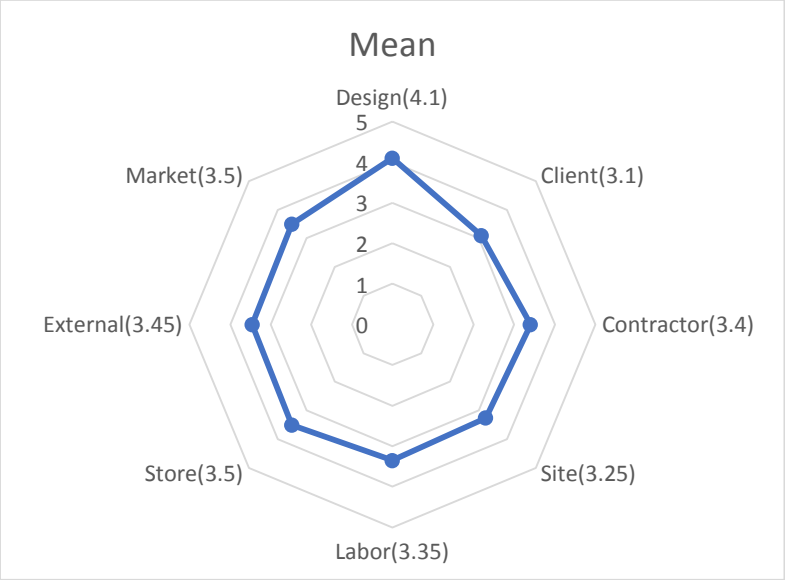

Fig 3: Factors effecting the Inventory Management
Source: P Lenin et al (2014) [6]

Samuel and Ondiek (2014) studied the inventory management automation and the performance of supermarkets with consideration of some automated systems like Material Requirement Planning (MRP), Electronic Point of sale (E-POS), Enterprise Resource Planning (ERP), Vendor Managed Inventory (VMI), E-procurement and Radio frequency identification (RFID). For this, the authors used descriptive survey design and collected data from 12 supermarkets. The authors recommended that decentralized management structure is more effective to make decision as it provide the low-level manager to make a decision. Supermarkets should take initiative to collect the information to know how to precisely determine the demand of the customers.

Pande and Sabihuddin (2015) studied about the implementation of the inventory management techniques and how it will affect the management of the items on construction site. The authors adopted quantitative and qualitative methodologies. For the qualitative analysis, the authors used the MSP (Microsoft project) software to study the actual cost and planned cost of the items in the inventory. For quantitative analysis, the authors used the ABC analysis and EOQ analysis. The authors also mentioned about the how often have different materials been ordered on site. The authors found that by using the EOQ analysis, he managed to solve the issue to stock out of cement bags. He showed the result of S-curve Analysis and identified the problem of variations in planned cost and actual cost of the material like problem with availability of RCC drawings and procurement of materials.

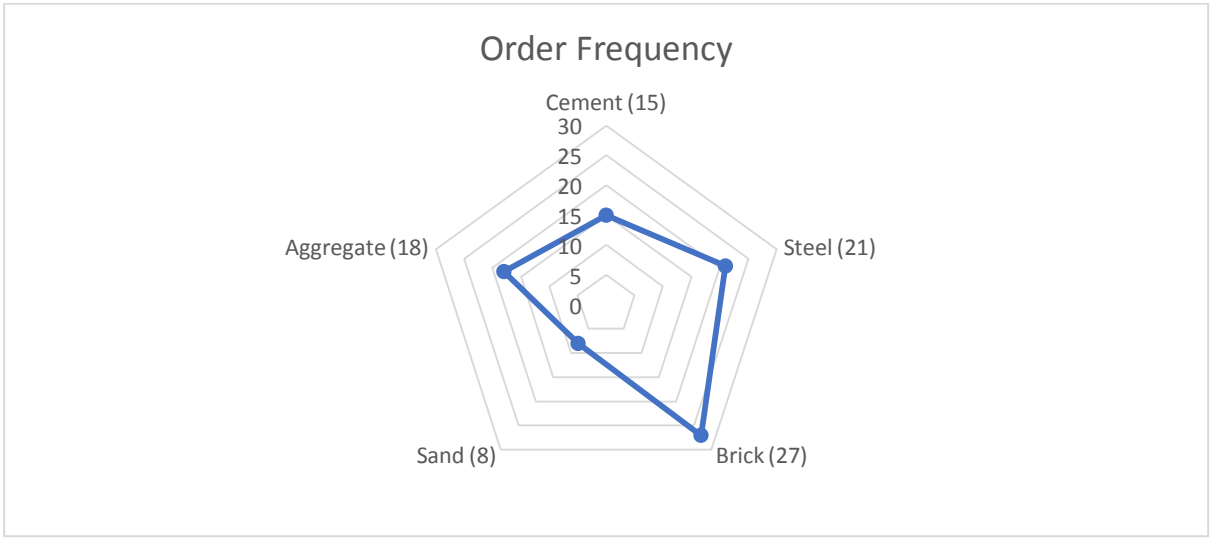

Fig 4: Frequency of Orders
Source: Pande and Sabihuddin (2015) [8]

Rohit S. Agawane et al (2015) studied about the effective ways to manage the procurement and with this, to optimise the quality, cost and duration for the project. The authors also researched about the different modern techniques which can be used in project management like Microsoft Project, Primavera and Enterprise Resource Planning. For this the authors collected the data from questionnaire from a purchase manager in Pune. The authors found that factors affecting the procurement management process like the effect of location, availability of equipment, availability of raw material etc. He also mentioned the data required for procurement management i.e., Planning, estimation, Records of spend, Lead time analysis and ABC analysis. The authors also ranked the modern methods of procurement management.

Patil and Patil (2015) researched about the accomplishment of the Just in Time inventory control technique on highway construction. The authors did the case study of a company doing a highway construction in Solapur district of Maharashtra. In this paper, the authors calculated equipment's productivity and monthly consumption of each material and suggested the JIT method for the construction of highway. The authors mentioned problem related to the project. Authors found that JIT method could save 5% cost of highway construction. Different equipment used could be less if JIT method was used.

Matsebatlela et al (2015) developed the framework for inventory management. The authors focused his study on raw materials and components to develop the framework for inventory management where he specifically focused on the reasons for excessive inventory. He collected the data from Enterprise Resources Planning system (ERP). Afterward, he has done the quantitative analysis. The authors concluded his study as the factors that affect the inventory are lack of collaboration between supply chain, lack of replenishment of inventory in a proper way and lack of guidelines in inventory management system of an organization. After he suggested the replenishment strategies for MTO-MTS system better now as push pull strategy. He also mentioned to analyse and use the Radio frequency identification of materials to increase the efficiency of inventory management framework.

Hansan et al (2015) studied the inefficient measures taken by the officers of inventory and the shopkeeper, the authors also mentioned the factors like inexperience and how absent workers impact the productivity. The authors used the purposive sampling to select the samples, Simple random sampling is used to reduce the biasedness of purposive sampling. This paper is based on the practices used in the inventory management of an organization. Thereafter, authors have mentioned different inventory classification models like ABC analysis and Critical value analysis. The factors involved in poor inventory management by the authors are- large quantities of obsolete items, high customer turnover rate, increasing number of back orders, examination of returned goods procedures, lead time analysis and etc. Authors also mentioned the advantages and disadvantages of Just in Time Inventory management (JIT). The authors found the 3 points which could ensure the inventory lean and clean.

Shet and Narwade (2016) studied the inventory management of industrial building by using different techniques. The main objectives of authors in this study are to find the effective item cost from the total cost, to determine the causes of lacune in inventory management, to list out the various techniques in Indian construction industry. For this the authors have to go through various stages to collect the data for the study like literature reviews and in it different techniques like ABC analysis and S curve analysis are used. The authors pointed out some factors as a result. First of all, the authors focused on ordering of materials should be done by consider the following points like quantity of items required and their scheduling activities, transportation capacity and time needed to reach the site and etc. After that, the authors mentioned the handling of Class A, B and C materials should be taken into account during the whole project.

Tundura and Wanyoike (2016) researched about the effect of inventory management strategies. The authors focused on three strategies of inventory control; Computerized inventory accuracy, cycle counting and inventory coding. The objective of this paper to find the effect of computerized inventory management on inventory record accuracy, to find the effect of cycle counting on inventory management. There after the authors mentioned the effects of cycle counting, inventory coding and computerized inventory on inventory record accuracy by using literature reviews. The authors used the Pearson correlation to establish the relation between the three strategies and as a result, authors recommend that cycle counting is a good determinant in accuracy. The authors also mentioned which organization or what type of work could use these three strategies.

Deepak and Kumar (2016) studied the material stored in the inventory of project and the amount in which they are stored, He also studied whether the material on site is in excessive amount which will increase the holding cost. He mentioned that there are 2 types of inventory decisions-1The item in inventory is empty and have to fill it again, 2To filling the item again, how much of that item need to be ordered. He studied the residential project's drawing and examine the situation on site and he did the quantity calculation by using Microsoft Project software. He found that quantities can be calculated from the drawing and the inventory chart preparation can be done effectively by considering the factors like site conditions and interlocking activities, with all this the holding cost of the inventory can be controlled and the over dumping of material cannot happen on site.

Vikram Kulkarni et al (2017) studied the factors of inventory management that affects the construction site. Authors focused on to study the various procedures of inventory management and to provide the remedial measures to reduce or eliminate factors affecting the inventory management on construction site. Later in this paper, authors explained the benefits of this study in 13 points and provided a theoretical framework. The authors divided the factors affecting the inventory management in three firms, large, medium and small firms. The result of this study was that large firms followed the protocols and use software to manage the inventory whereas medium and small firms do not use these techniques, they are depended on conventional techniques of inventory management. The authors suggested to use the software like MSP, ERP, and etc.

T. Subramani et al (2017) studied about the adoption of the inventory management control and the productive use of inventory in construction projects. He used structured and purposive methods like framing questionnaires, review collection of literature in inventory management and use ABC analysis. The authors discussed about the techniques of Inventory Control like; Setting up various stock levels, maintaining perpetual inventory System, Reordering level, Maximum level. The authors found that contractor should involve itself in inventory management and also maintain the stock list and material usage and the storage of material safely, contractor need to check these things in order to improve the inventory management. So the Inventory management system is known to be very important for an organization, for company's project to finish on time.

Patel and Patel (2017) have done a case study, where he paid attention to the ways in which the materials were managed and how the project used the techniques like ABC classification and EOQ analysis to balance the materials in inventory. After that the authors discussed the type of objective of material management, primary objective which consist of low price, maintaining consistency of quality, maintaining flow of output etc. Then there was secondary objective like committees to decide what to buy, development of inter department relations etc. The authors used ABC analysis, specifically he computed the annual usage value of each item. Authors analysed 57 different materials from the inventory. Authors observed from his study that EOQ technique can help to reduce the wastage of materials on construction site. The result from S-curve analysis shows that the contractor can find the causes for the deviation in actual materials cost and planned material cost. The authors also emphasized on the importance of handling the materials from the design stage to construction stage.

Kameshwar and Saravanan (2017) studied about the effective system of inventory management present in the construction industry. The objective of this paper is reducing the total cost of inventory and achieve the optimum quantities of items for the construction at right time. The authors analgised 41 different materials from different work in construction, for example safety helmets, PVC cover block, measure tape, Shovel, mortar and etc. The authors suggested that inventory management team should replenish multi-item jointly to reduce the ordering cost. The authors also suggested 7 points explaining different techniques that can be used and what materials are important, are in continuous use throughout the project.

V. Rathinakumar et al (2018) studied material planning and inventory control, the role that material management plays in the efficient management of the project. He studied the case study of residential apartment of stilt+4 building and interviewing engineers and contractors. The authors analyse the cost performance of cement, steel and bricks through S curve analysis which resulted in all the 3 materials have the cost performance index value less than 1. The paper mentioned the cause for the variance of cost that are; changes have been made in material condition during transportation, Anticipation of market was poorly executed, Materials got damaged during storage, The material was utilize ineffectively. In this research Sensitivity analysis is also done to find how the change in value of demand and holding cost effect the EOQ's output value. He found that the sensitivity is 0.3 for 10 percent change in demand and for 25 percent change in holding cost of inventory, the sensitivity was 0.42. Furthermore, the authors found that the actual cost of the material is higher than the planned material cost which implies that the project is running under overrun of cost. The research indicated that the efficiency of project could increase by 35 percent if proper implementation of inventory management is there in project.

Nazar Sohail (2018) studied the connection between the company's performance and the material management. He studied the case study of small industry who is manufacturing steel. He found that performance of the company based on inventory days and return on Asset analysis. The author gathered data through different interface and through structured and unstructured interviews. He considered the annual reports and magazines articles. He found that the company should order their material regularly instead of ordering in bulk, he also suggested that despite managing inventory well, company should also use the modern technology to get the better hold onto its inventory.

Praveen and Suresh (2019) studied the different material management methods on construction project. The authors collected data from a construction project in Devanahali in Bengaluru and analysed 78 different items in inventory with methods like ABC analysis, VED analysis, HML analysis and EOQ model analysis. They authors found the categories of all 78 items in ABC analysis, further more they combined it with VED and HML analysis to understand and to get the accuracy during the procurement of the items. The Author also found the Planned cost of each floor of the building and compared it with the actual cost for each floor. With EOQ

model analysis, the authors showed and suggested the optimal quantities of different items required in the inventory.

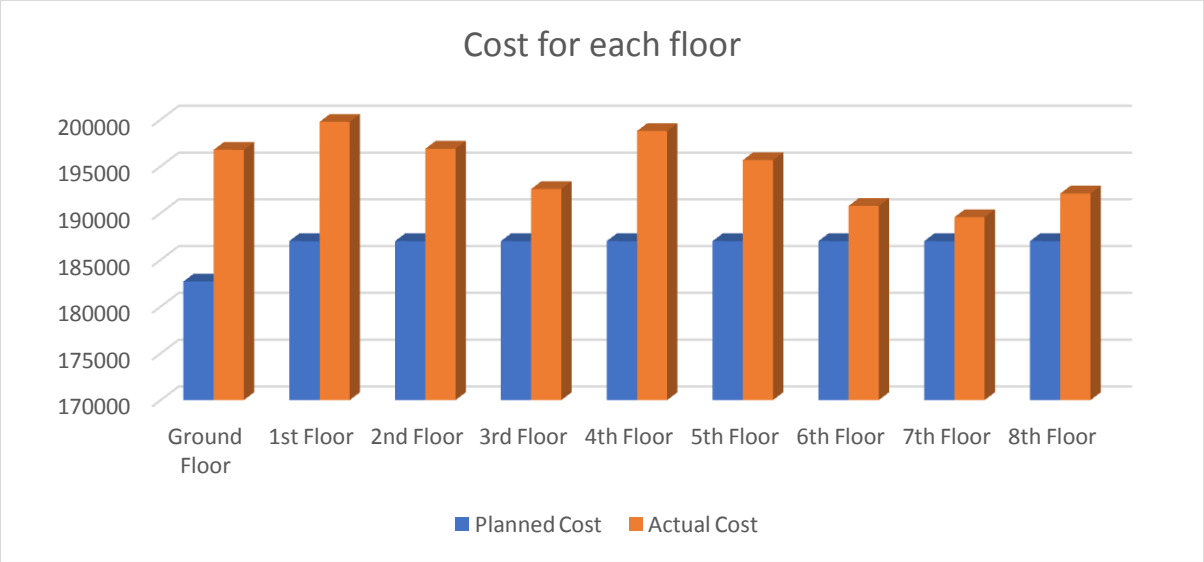

Fig 5: Planned and Actual cost of each floor
Source: Praveen and Suresh (2019) [22]

Rashmi Ranjan Panigrahi et al (2019) studied to pick out how different organization use the inventory management techniques to operate their inventory at optimal level. Authors' objective of this study was to find the various advanced inventory management accepted by the manufacturer of steel and to find the link between the efficiency of manufacturing industry and advanced inventory management. For this, the authors collected data from questionnaire that was send to officials of manufacturing industry. Authors found from the study that recently services, cost quality, flexibility in performance and innovation have a huge impact to make good inventory management. The factors like reduction of wastage, improvement in production, minimizing manufacturing downtime, reduce number of scraps and rejects can be solved by the techniques in advanced inventory management. The researchers suggested that if the advanced techniques are used then output performance of the industry will increase.

Gaviyaa and Kumar (2020) studied and showed the disadvantages of single criterion classifier (low price vendors) and gives optimal multi criterion model to analyse the inventory material which gives cost advantageous material management system. The authors used two methods; Single Criteria Model (SCM) results using single factor like cost or ageing. And the second one; Multi criteria model (MCM) which gives result by considering multiple factors like; ageing, cost, lead time, annual expenditure in rupees. Authors studied about 100 real project inventories, the authors collected data from it and analysed in SCM and MCM. He found that only 8 items out of 100 are found to be under same category (A, B or C categories) which shows that each factor has different priorities for the same item. The single criterion model needs the inventory items to be homogenous to get the most out of it but in multi criterion model we can use different types of inventory items.

Udaya and Philominal (2020) studied the going practices for material management in construction project and inventory control techniques like ABC classification, EOQ analysis and SPSS software. Authors analysed data collected from residential project and some literature review as well. And found that the supervision was inefficient, poor communication between the team which overall lead to improper and frequent moving of material on construction site. All these lead to cost increased not only in project but also in holding or storing of the inventory materials that all finally delays the completion of the project.

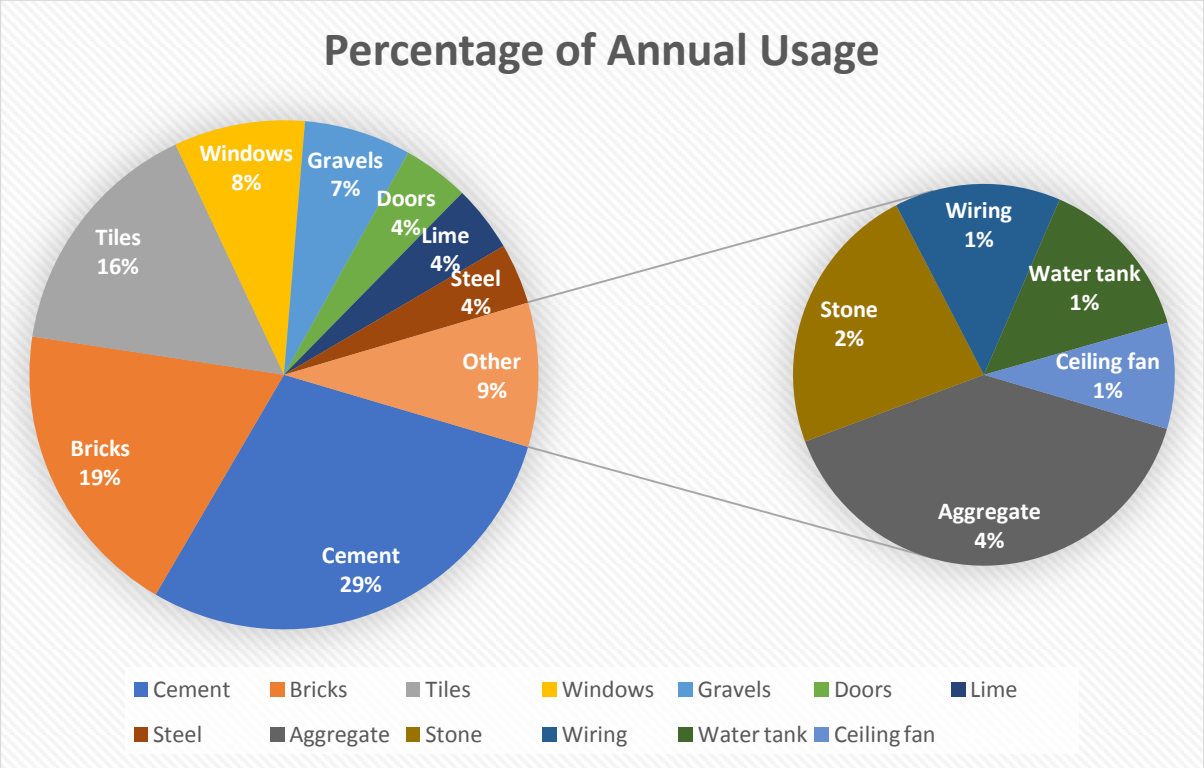

Fig 6: Percentage of Annual usage of materials
Source: Udaya and Philominal (2020) [25]

III. CONCLUSION

From this theoretical study, different problems with inventory management have been found. The factors that affect the inventory on construction site have also been found. Considering these factors, many techniques are recognized like use of SPSS software to test and find the reliability factor, EOQ analysis to find the optimal quantity of materials that need to be stored in inventory, ABC analysis to categorize the different materials on site according to their importance, VED analysis is one more step to ABC analysis in which it categorized the A, B, and C materials into Vital, Essential and Desirable categories. This paper also provides the information of where we can implement the automated technology like Material Requirement Planning (MRP), Electronic Point of sale (E-POS), Enterprise Resource Planning (ERP), Vendor Managed Inventory (VMI), E-procurement and Radio frequency identification (RFID). This paper contributes to questionnaire formation for site engineers or construction engineers. Also contributes different ways of finding data. Most of the authors collected data from interview and questionnaire. So, there is an urgent need to find on field situation of the inventory management and different factors associated throughout the project to make it a grand succuss.

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