CONSTRUCTION WASTE MANAGEMENT THROUGH THE APPLICATIONS OF BIM

Prachi Walmikey[1], Prof. Purva Kulkarni[2]

[1]*PG Student, Department of Civil Engineering, TSSM's PVPIT, Bavdhan, Pune, (India)*

[2]*Asst. Professor, Department of Civil Engineering, TSSM's PVPIT, Bavdhan Pune, (India)*

ABSTRACT

Construction firms has a major impact on the environment in terms of waste production. The construction industry is responsible for producing different onsite wastes; the amount and type of which depends on factors such as the stage of construction, type of construction work, changes in design and practices throughout the project lifecycle. A variety of construction waste minimisation (CWM) techniques and tools are currently available to divert waste away from landfill. However, literature survey reveals that there are insufficient techniques and tools for reducing construction waste during the design and procurement stages. Many cases show that design validation based on building information modeling (BIM) is an efficient means to reduce the amount of construction waste since construction waste is mainly caused due to improper design and unexpected changes in the design and construction phases. This paper focuses on causes of construction material waste and their impact on the project through questionnaire survey, current waste management practices, and applications of BIM to design out waste.

Keywords: Construction Waste, Construction Waste Minimization, Building Information Modeling (BIM)

I. INTRODUCTION

During the last few years, huge increase in infrastructure has been found by wide range of diversity construction organization. Construction firms in India create a large range of different waste .Different types of waste are created at all the phases of construction right from site preparation to final product. Minimizing the waste and optimizing the enhancing profitability is possible by reducing cost of material with proper planning, scheduling, purchasing, procurement, receiving, inspecting, handling, storing. BIM is a maturing modelling philosophy, which has been applied to considerable building-related activities such as visualising designs, automating quantity takeoffs, checking compliance with regulations governance, and organizing construction processes. The causes of Construction waste can be resolved through integrated building design and better construction planning and management, which could be facilitated by building information modelling (BIM). BIM provides the basis for improved planning and scheduling.

II. LITERATURE REVIEW

According to N. S. Chougule (2015), Construction sector is second largest firms contributing to the Indian economy. Increasingly, large construction companies in sector such as hotels and airports are starting to implement BIM in India with some benefits but at a very high cost. Indian industry has unwillingness to accept new technology immediately. Survey done by Indian built environment sector, RICS school of built environment and KPMG found that 22% of respondent currently use BIM, 27% respondent reported that they are aware and actively considering BIM usage. Surprisingly 43% respondents claimed to be aware of BIM but are not sure about implementing it in their organisation near future. Additionally 8% respondents are not aware of BIM . The main reason for not using BIM here is the lack of technical expertise, the professional who has heard about this doesn't know how to use it, and most of them are not even aware of this methodology.

III. CAUSES OF CONSTRUCTION MATERIAL WASTE

In general there are various categories of waste on construction sites such as waste of energy, time, manpower and material etc. However, excess utilization and waste of material is the main factor of construction waste with regards to increased cost. The sources of large amounts of waste are related to design changes, leftover material scraps, design or detailing errors and poor weather. A study conducted on the attitudes of architects and contractors toward the sources of construction waste analyzes that construction material waste is due to design, site operation, procurement routes, material handling and subcontractor's practices. Following are the general causes of material waste which is mostly found on the sites.

Table 1: General Causes of Material Waste

Sr. No	Group I- Design and Documentation
1	Lack of information while preparing construction drawings
2	Errors in contract document and design
3	Waiting for design documents and drawings
4	Changes in design
5	Incomplete contract documents during the commencement of project

Sr. No	Group 2- Material
1.	Damage to the materials on the site
2	Damage to the material due to improper loading and unloading techniques
3	Use of excessive quantities of materials than required
4	Lack of onsite material management plans

5	Damage to the material due to improper packing
6	Improper handling of material on site
7	Improper storage of materials while execution which leads to damage and deterioration
8	Inadequate space for storage of materials
9	Changes in design
10	Theft of materials
Sr. No	Group 3- Execution of project
1	Damage to the equipment which leads to rework
2	Using untrained and unskilled labour
3	Poor workmanship which leads to rework
4	Unfriendly labour attitudes
5	Using wrong construction method
6	Using wrong equipment
7	Unavailability of equipment which lead to carry out the work without equipment
8	Severe weather conditions
Sr. NO	Group 4- Site Management
1	Lack of waste management plans
2	Lack of quality management system
3	Improper material management on the site
4	Improper planning and scheduling of project
5	Poor communication and coordination in between the parties involved in the project
6	Accidents caused due to negligence
7	Decision making problem
8	Lack of supervision and delays in inspection

IV. RESULT AND DATA ANALYSIS

From the above list of general causes of material waste a questionnaire is prepared and this questionnaire was sent out to a total of 10 site engineers requesting them to rank the identified waste causes using an ordinal scale. A total of 7 site engineers filled out and returned the questionnaire. The response rate is 70% which is a good rate.

The impact of the each factor of the general causes of material waste is ranked by the measurement of the importance index. The below formula is used to rank them based on the level of importance as identified by the participants.

Importance Index (IMP.I) = $\sum a\,(n/N)/5$

where, a = The constant expressing weighting given to each response (ranges from 1 for very low impact up to 5 for very high impact) n = The frequency of the responses N = Total number of responses

V. EXISTING WASTE MANAGEMENT PRACTICES

Many studies have been provided in attempt to reduce material waste on construction sites but building a way to prevent waste at design and pre-construction phase still requires consideration. There is no reliable strategy and tool to estimate the quantity of construction waste before projects commence on site. On the hand, the analysis of sources of waste indicated that other a large quantity of material waste is due to flow activities, such as material delivery, inventories, and transportation and handling.

It can be seen that all construction phases directly or indirectly devoted to onsite waste generation. However, the level and severity of waste production varied from phases to phases depending on a number of variables that include type of procurement, project brief, stakeholders' engagement and commitment, etc. There are several measures that can be considered to avoid and reduce the impact of causes of wastage. Some of these causes of waste and their corrective actions have been discussed in table.

Table II. Causes of waste and Corrective actions

Sr. No	Causes of Waste	Corrective Actions
1	Changes in design	Try to reduce the changes in design by making correct design
2	Waiting for design drawings	Set a time limit for completion of design drawings
3	Improper handling of material on site	Carefully handle fragile material and consider a secure method for unloading
4	Theft of materials	Provide security guard, barricade the construction area
5	Using untrained and unskilled labour	Train and employ the workers
6	Severe weather conditions	Avoid placing washable materials at sleep slope, built proper shelter
7	Lack of quality management system	Provide checklist before execution of any project
8	Accidents caused due to negligence	Make compulsory to use safety props
9	Lack of waste management plans	Boost the companies to

		accept waste management plans
10	Irrelevant cutting of bars instead of using short pieces	Avoid excessive cutting of bars

VI. APPLICATIONS OF BIM

This recent technology provides correct visualization for all members involve in the project to have a better perspective of material and equipment layout, activity procedure, conflicts between building elements. Design information modeling is investigated that prefabrication and pre-cast is the options to reduce construction waste in high rise residential buildings.BIM provides a good platform for establishing the analysis of construction waste and the implications of design decisions. BIM provides a design team with a tool to calculate the impact of the design decisions on the overall construction process with the backing of Virtual Prototyping. It is widely acknowledged that associating BIM with the development and application of 3D virtual building modeling techniques and technologies can yield very productive results. The BIM solutions for waste reduction are as follow:

A. Conflict, Interference and Collision detection- BIM inspects all interferences, clashes and collision by visual technology and thus reduce conflicts. This ability enables BIM to act as an advisor tool for designers and engineers. The models can be rigorously analyzed, simulations can be performed quickly and performance benchmarked. There is better communication and understanding from 3D visualization. Minimum design changes after construction allow project finishes during logical time and eliminate loss of extra cost.

B. Construction Sequencing and Planning- BIM can be used to create an effective schedule of material ordering, fabrication, and delivery of all building components. Accurate program scheduling enables just-in time delivery of materials and equipment, reducing potential for damages. Application of BIM for automated fabrication of equipment and components enables more efficient materials handling recovery.

C. Reducing Rework -The design problems are solved early in the design and hence there will be less controversial problems in the plans and less damages. Any changes in design entered to the building model are automatically updated. Hence, there will be less rework due to possible drawing errors.

D. Synchronizing Design and site layout -By connecting the 3D objects in the design model to the construction plan the clear procedure of activities are developed and hence it is possible to show how the building and the site would look at any point in time. By BIM 4D modeling the layout of equipment and material are exactly considered and everyone in each part of the project knows where the material should be placed. This ability will reduce the number of additional handling, unnecessary moving and the loss of material lost.

E. Detection of errors and omissions (Clash detection)- This is the most rated way by which owners save time and money using BIM. In 2D drawings, any changes in one drawing are not updated in other related drawings. This leads to many inconsistency and hence lots of errors and omissions. A lot of these errors are detected only after the work has started at the site, which might lead to many site conflicts, legal disputes and change orders. However, use of BIM eliminates these issues. Conflicts are identified before they are detected at site and hence co-ordination between the designers and the contractors are enhanced. Detection of errors speeds the construction process, reduces costs, minimizes legal disputes and provides a better project process.

F. Accurate Quantity take- off – Accurate quantity take-off means that materials are not over ordered. This technology gives an accurate forecasting to planners and engineers for having correct order of material. Thus, extra materials won't be existing on site which would be deployed by poor weather or movement.

VII. CONCLUSION

The generation of construction waste also contributes to the depletion of raw materials used in the construction industry hence leading to shortage of raw materials.

The thirteen factors causing material wastes are shown in following Bar chart.

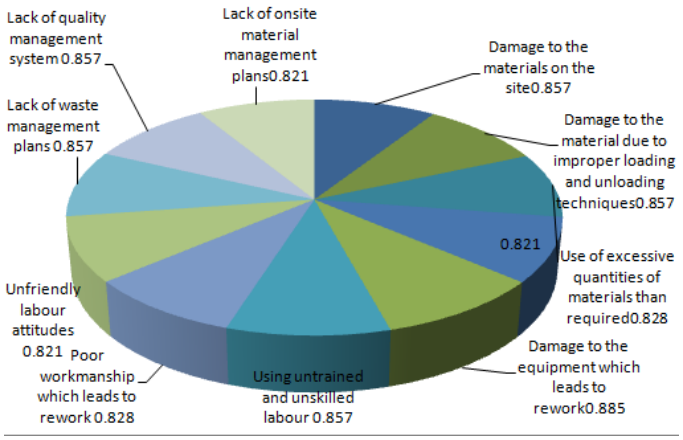

Fig 1. Showing causes of material waste having high importance index

Building information modelling acts as a coordination tool to support individuals to perform their objectives by a more efficient and sustainable vision. The cost of construction material is increasing significantly and every amount of material waste has an irreversible effect on cost and project earnings. Using BIM applications in every stage of project, particularly during design and construction phase can help to evaluate probable amount of construction waste.

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