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A RATIONAL APPROACH FOR ASSESSMENT OF WASTE MANAGEMENT IN THE INDIAN CONSTRUCTION INDUSTRY USING SPSS-29.

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ABSTRACT: The construction industry in the world is growing rapidly, but waste generated during construction projects can negatively impact productivity and the environment. About 5% to 27% of materials procured for construction are wasted during execution, leading to unnecessary utilization of natural and human resources. Eliminating waste generation could lead to significant cost savings for companies. In India, construction waste generation is a serious concern due to increased activities, lack of resources, and limited funding. Limited studies have been conducted on waste types, composition, and quantities in construction projects. This research aims to study the current situation in India regarding construction waste generation

INTRODUCTION

The construction industry faces a significant problem of construction waste, which needs to be identified, quantified, and analyzed to improve productivity. This research focuses on identifying major causes of wastage in construction materials and proposing methods to minimize waste generation. The study focuses on identifying major causes of wastage in construction materials, focusing on buildings in various stages of completion. It suggests that human work should be the focus for waste prevention, as the value of materials depends on the work spent on them. The research proposes methods to minimize construction waste generation, including appropriate construction techniques and management checks. Data was analyzed using questionnaire surveys and statistical methods. Field observations were used to compile a compendium on wastage of key construction materials.

OBJECTIVES OF THE INVESTIGATION

This research aims to identify waste generation causes, identify waste minimization strategies for construction firms, and suggest recommendations for raising awareness to reduce construction waste and preserve natural resources.

LITERATURE REVIEW

Ekanayake & Ofori (2000) studied waste management in Malaysia's construction industry, focusing on source reduction and recycling. He identified waste sources and measures to minimize them by avoiding the design changes during construction. Also he identified ordering errors as the second highest contributor to material waste in procurement groups.

Jones & Greenwood (2001) highlighted the significant environmental impact of the construction industry, highlighting its significant resource consumption and waste production, influenced by construction stages, types, and site practices.

Harris & McCaffer (2001) suggest that construction companies prioritize labor control over materials control, but losses due to materials are often higher. He suggested some methods to improve material control, employ a reliable storekeeper, maintain a good bookkeeping system, double sign delivery notes, maintain a well-organized site, insist on palletized brick delivery, and thoroughly check deliveries.

Garas et al. (2001) and Alwi et al. (2002) found that untrained labour is one of the major contributors to material waste in Indonesian and Egyptian construction industries respectively.

Formoso et al. (2002) highlighted the importance of waste in the construction industry for efficiency and environmental impact. Controlling steel reinforcement use is challenging due to short, unusable pieces, poor structural design, and poor material handling, leading to large disorganized stocks and substitution with other materials.

Chen et al. (2002) compiled the data obtained from specialty contractors in USA, UK, China Mainland, Brazil, Korea and Hong Kong and compared the construction wastes generated from construction industries in these countries/regions.

Formoso et al. (2002) identified poor performance sites as contributing factors to brick and block waste. Issues

include delivery control, damage during unloading, poor handling and transportation, inadequate site layout planning, improper maintenance, and inadequate equipment use.

Shen et al. (2002) highlight the environmental impact of construction waste management, emphasizing the need for contractor responsibility, good environmental practices, and improved waste reduction to ensure construction activities align with environmental policies.

Alwi et al. 2002 identified Indonesian and Australian construction waste causes as design changes, lack of trade skill, slow decision-making, poor coordination, delayed material delivery, and inappropriate construction methods.

Shen et al. (2003) identified wastage in reinforcement steel, concrete, and timber formwork as main causes. Reinforcement steel wastage is primarily due to cutting, storage damage, and rusting. Concrete wastage is mainly due to mismatches in ready mix supply and aged timber boards. Timber formwork accounts for 30% of construction waste in Hong Kong. Timber's low durability and reusability contribute to high wastage. Bricks and blocks are commonly used for walls, but improper packing can increase wastage.

Poon (2004) found that 80% of construction work in Hong Kong is made from ready mixed concrete, with 3-5% wasted due to excessive material ordering, broken formwork, and poor concrete placement. Timber waste is primarily generated from formwork, with most being discarded after multiple reuses. Building contractors are required to use new timber formwork after every 8-15 floor cycle. Brick/block waste occurs at all stages of the construction process, including transportation, layering, and cutting due to lack of modular coordination in design.

Hoe (2005) emphasized the debate on waste prevention in the construction industry, emphasizing local practices to minimize waste, benefiting all stakeholders and reducing costs in construction projects.

Begum (2007) stated that according to statistical data, construction and demolition debris frequently makes up 10 to 30% of the waste received at many landfill sites around the world.

Forsythe & Mate (2007) reported that the more re-stacking and barrowing of blocks the higher the expected breakages.

Alan (2009) reveals 30% of construction waste, low efficiency in labor, high accident costs, and 10% material waste, suggesting potential for increased productivity and sustainable construction.

Koshy & Apte (2012) define waste as inefficiency resulting in resource and energy losses, generating additional costs without adding value to the product. Waste minimization is necessary as it generates direct or indirect costs without adding value to the product.

Mehdi Rashid & Gholamreza Heravi (2012) suggested using lean management for waste identification and assessment in construction projects. They identified seven main waste groups, subdivided into 42 common ones, and identified three main reasons for waste: waiting and delay in funding, maps approval, and supplying construction materials.

Agyekum et al. (2012) observed that in Ghana, consultants prioritize purchasing sufficient raw materials, using materials before expiry dates, using efficient equipment, and good coordination to minimize waste. However, encouraging waste re-use, using low waste technology, and recycling are less effective and less practiced.

Ghanim A. Bekr's (2014) study found that frequent design changes, worker mistakes, poor contract documents, inadequate storage, poor waste minimization strategies, shortage of skilled workers, poor site conditions, transportation damage, theft, vandalism, and quantity surveying errors contribute to wastage on Jordanian construction sites.

Jawad Al-Rifai & Omar Amoudi (2016) pointed out that the impact of construction material waste on the environment is influenced by factors like design team lack of constructability consideration, management team awareness, and poor workers' skills. It can be classified into damage, construction process waste, and errors in construction

INFERENCE FROM THE LITERATURE

The literature study identifies over 94 causes of construction material waste generation, highlighting the lack of effective strategies. Most studies are conducted in residential and industrial construction sectors, mainly in foreign countries. The focus is on source reduction and recycling, but identifying root causes is missing. Construction companies focus on labor control rather than

materials, and some studies focus on lean management and just-in-time procurement.

METHODOLOGY

This research collected data through questionnaires and interaction with the project site team. Questionnaires are used for structured data acquisition and identify project execution processes. Designing and selecting complex questions is crucial for satisfaction with research objectives. Respondents were informed about the degree of treatment of answers, as this could significantly influence results accuracy.

STAGES OF RESEARCH

Figure 3.1 shows the various stages of the present study viz selection of projects, collection of data, analysis, model study etc.

Figure 3.1 Stages of research

DATA COLLECTION

Site Visit A detailed site visit plan was developed for residential building projects, involving direct interaction with project managers, construction managers, engineers, foremen, warehouse managers, and site detailing engineers. Interactive sessions were conducted to gather basic details and conduct practical surveys. A questionnaire was designed and distributed to the site team, identifying 48 major causes of material wastage, which are tabulated in Table 3.1

Table 3.1 Major causes for Waste Generation

Sl.	Major Causes
1	Delay in issuance of drawings
2	Change in design
3	Change in design specifications
4	Mistakes in design drawings
5	Non-clarity in details
6	Usage of superseded drawings
7	Non-delivery of Bill of quantities
8	Non continuity of data from one drawing to others
9	Influence of site conditions to modify the design
10	Non-usage of software for bar bending schedule
11	Ordering of specific length of reinforcement bars
12	Ordering of specific size of plates for pipe fabrication
13	Mistakes in shop drawings
14	Mistakes in bar bending schedule
15	Non availability of engineering team at site
16	Change in material specification
17	Lesser shelf life
18	Poor quality
19	Excess ordering of concrete
20	Change of source of basic materials
21	Delayed supply of basic materials
22	Non-compliance of testing procedures
23	Non availability of adequate plant and machinery
24	Improper storage of timber
25	Improper accounting of materials at site
26	Multiple handling of bricks
27	Deficiency in quantity received for bricks
28	Not having enough storage area

29	Improper handling of materials by not using proper equipment
30	Non-calibration of equipment
31	Non-maintenance of equipment
32	Non-cleaning of equipment
33	Unexpected breakdown of machinery
34	Improper operation of equipment
35	Non-cooperation of crew
36	Measurement of materials for concrete
37	Rolling margin of reinforcement bars
38	Re-use of scraps
39	Improper co-ordination in delivery of products
40	Lack of inter site co-ordination
41	Non-involvement of skilled workmen
42	Bad workmanship
43	Improper supervision of works
44	Incorrectness in ordering of concrete quantity
45	Fabrication of major pipes and embedded parts at site
46	Idling of equipment
47	Delay in decisions
48	Lack of co-ordination

METHOD OF DATA COLLECTION

According to the Center for Strategy Research (2006), the minimum sample size required to accurately estimate the reality in a questionnaire survey is 30 or more. However, according to Majumdar (1991), the minimum sample size of 20 is required to satisfy the condition of large sample statistics.

Convenience Sampling

Convenience sampling is a specific type of non-probability sampling method that relies on data collection from members who are conveniently available to participate in study. Subsequently internal organization survey was made to identify the on-going and completed residential building projects in India.

Structured Questionnaire

The material wastage is the difference between the value of materials delivered and accepted on site and those properly used as specified and accurately measured in the work after deducting the cost saving of substituted materials transferred elsewhere in which unnecessary cost and time may be increased. This waste generation causes are grouped into two stages where the design phase are procurement, material storage, material usage etc., and in management phase are planning and executing the scheduled activities in construction. Each of the causes has been grouped into particular category. Out of the 94 causes listed above, 58 causes of occurrences have been chosen which are relevant to the research scope and they further grouped into 15 categories. The 15 categories have been grouped again into 2 stages. Hence, the survey questionnaire was also formulated based on two facets namely the planning and execution stage and the procurement and storage stage.

Questionnaire 1 is designed in such a way that respondents need not have to spend much time to answer. It is also designed to identify and understand the most common waste categories pertaining to two stages, which ultimately generate waste and affect the cost of the Residential building projects. The range of occurrences is scaled with 5-point scale similar to Likert's method.

METHOD OF DATA ANALYSIS

Statistical method is used to analyze the data collected in this research work. It is challenging to operate with many variables (internal and external) simultaneously. Among them, the important variables or dominating factors were identified and distinguished. Factors having similar characteristics were identified. Factors having an interconnection with each other and those remain independent were also identified. Statistical analysis is a tool in the process of decision making using the data obtained. All research activities involve an analysis of data. Statistical approach would provide a scientific approach for the future events also. Statistical methods are systematic and built by several experts on firmly established theories and consequently they would enable a researcher to overcome the uncertainties associated with future occasions. However,statistical tools have their shortcomings too. The limitations do not reflect on the subject. Rather they shall be traced to the methods of data collection and recording of data. In any practical problem, it has to be ensured whether the assumptions are reasonable or not, whether the data represents a wide spectrum, whether the data is adequate, whether all the

conditions for the statistical tests have been fulfilled, etc. If these aspects are taken care, it would be possible to arrive at better alternatives and more reliable solutions. A researcher should have a proper experience of the statistical theories and practical knowledge and shall always strive for a holistic approach. Statistical Package for the Social Sciences (SPSS) is a data management and statistical analysis tool with a very versatile data processing capability. This software was used to process the data collected for the following reasons

- It is capable of handling large amounts of data
- It can perform many data processing and statistical tests.
- It can handle data inputs from other software's like MicrosoftExcel.
- It can generate routine descriptive statistical data for questionresponses
- It can create graphical representations of questionnaire datafor reporting, presentations or publications.
- It can explore relationships between responses and differentquestions.

The data collected from the respondents were keyed in Microsoft Excel sheet which were then converted to SPSS data format.

CONCLUSION

This chapter summarizes the conclusions of the study. An extensive literature survey was carried out, and the information was used for the questionnaire preparation. The questionnaire was provided to the stakeholders of the construction industry, and their views will be collected and to be use for analysis. Based on the analysis, suitable suggestions are to be provide (Construction companies).

WORKS TO BE CARRY IN PHASE -II PROJECT

- Data Collection from various Construction Companies
- Data Analysis (SPSS Software)
- Ranking the factors
- Results and Discussions
- Suggestions to the Companies and Conclusions