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A Review on Waste Material Minimization in Construction Industry

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***Abstract*: Construction industry is one of the major consumers of resources and energy. Huge amount of waste is generated in the construction industry. It is important not only from the perspective of efficiency, but also concerns have been growing in recent years about the adverse effect of the waste of construction materials on the environment. More ever it has been revealed that construction sector producing unacceptable level of waste. This both waste generating activities result in increase in project cost, decrease in profit margin, create environmental management and the mission of sustainable development have exerted the pressure demanding for the adoption of proper methods to protect the environment across all industries including construction. Construction by nature is not an environmental-friendly activity.**

There is huge need for infrastructure and housing for meeting demands of increasing population, urbanization etc. it is increasing waste generation in construction industry. Hence waste minimization at source itself has prime importance. The construction industry cannot wait until the goals of sustainable development have been identified and tools to achieve them have proved practical. A proactive approach is needed in research and education, precursors for lowering environmental burdens while maintaining sustainable growth.

In order to achieve this, construction companies can adopt variety of materials and methods for reducing wastage of this materials using application of technology evolving innovative designs efficient construction management, efficient programming of work, improved skills of labour force, online monitoring etc. Some of the important aspects need to be considered while trying to minimize wastes are durability and design life of construction products i.e., longer life facilities may become functionally obsolete. Many issues arise like period of use of facilities, rate of obsolescence for our facilities, planning period for the economic analysis of construction products. Another aspect need to be considered is good planning. Designs should be based on standard sizes and materials should be accurately ordered in sufficient quantities. This approach can reduce the amount of material wastage and increases profitability reasonably by 1 to 2% of total project cost.

***Keywords*: Waste Material, Minimization Management, Construction Industry.**

1. Introduction

A. History of waste management

Construction industry is one of the major consumers of resources and energy. Waste in the construction industry is important not only from the perspective of efficiency, but also concerns have been growing in recent years about the adverse effect of the waste of construction materials on the environment. More ever it has been revealed that construction materials on the environment. More ever it has been revealed that construction sector producing unacceptable level of waste. Waste generated may be on-site or off-site. This both waste generating activities result in the increase in project cost, decrease in profit margin, create environmental management and the mission of sustainable development have exerted the pressure demanding for the adoption of proper methods to protect the environment across all industries including construction. Construction by nature is not an environmental-friendly activity.

Wyatt (1978) stressed the consequences of high levels of waste, both in reducing future availability of materials and energy and in creating unnecessary demand on the transportation system. In fact, some building materials and components use large amount of renewable energy, as well as resources that are in danger of depletion, such as timber, sand and crushed stone.

Indian economy is creating demand for residential and non-residential schemes as consumer demands more house production units and amenities. Rapid growth of population, mechanization and urbanization has resulted in generation of large quantity of waste every day. More ever growth in construction activities adds to be the waste generated. Hence waste minimization at source itself has prime importance. The construction industry cannot wait until the goals of sustainable development have been identified and tools to achieve them have proved practical. A proactive is needed in research and education, precursors for lowering environmental burdens while maintaining sustainable growth.

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arise like period of use of facilities, rate of obsolescence for our facilities, planning period for the economic analysis of construction products. Another aspect need to be considered is good planning. Designs should be based on standard sizes and materials should be accurately ordered in sufficient quantities. This approach can reduce the amount of material wastage and increases profitability reasonably by 1 to 2% of total project cost.

Effective waste management is of growing significance for the construction industry. Adding the cost of storing and transporting construction waste, along with the loss of revenue from not reclaiming waste materials, it makes financial sense for construction companies to take actions to minimize waste. The use of recycled aggregate derived from concrete rubble in the production of ready mixed concrete was demonstrated in the example of an office building, erected in Darmstadt, Germany. Generally, the economic interest in re-using or recycling building materials is governed by three factors listed below.

- The availability and thus the cost of natural or new materials.
- The availability of disposal space, the tipping charges and the taxes for dumping.
- The transportation cost.

Materials, as one of the resources employed by the construction industry, pass through a number of processes before they are finally incorporated in construction. These processes bring about inadequacies of the materials such that the end not all the materials procured and - delivered to sites are used for the purposes for which they are ordered. This excessive loss in materials what is called Waste. Material wastage is any extra cost over and above the materials used, plus their handling as contained in the estimated price for the job.

B. Need of the study

Today, most of our building waste ends up in landfills increasing the burden on landfill loading and operation. The practice of minimizing and diverting construction waste, demolition debris, and land-clearing debris from disposal and redirecting recyclable resources

Back into the construction process is commonly referred to as construction waste management (CWM). Waste management affects carbon reduction efforts by impacting one or more of the following.

Energy consumption (specifically, combustion of fossil fuels) associated with manufacturing, transporting, using, and disposing the product or material that becomes a waste.

Non-energy-related manufacturing emissions, such as the release of carbon dioxide when limestone is converted to lime (which is needed for aluminum and steel manufacturing).

C. Objectives

The main objectives of the study are to achieve the following objectives with the help of case study for the selected construction materials namely cement; steel, coarse aggregates, fine aggregates and brick/concrete block which form the major part of the construction cost.

- To identify nature and amount of wastage.
- To establish the material wastage index for the selected materials.
- To find various causes of wastage.
- To establish effect of wastage.
- To reduce load of deposition of waste.
- To reduce demand for natural construction materials like sand, metal, bricks etc.

D. Scope of the study

Construction waste comes in various forms and thus can be discussed from many angles. Neo and Koh (1995) suggested that construction waste could be divided into three principal components: materials, labour and machinery wastes. With the advent of Just-In- Time philosophy in construction, material waste as well as time waste are referred to (Low and Tan, 1998). Although there are various forms of construction waste, the study focuses only on material wastage on site. The concentration is on material waste due to the fact that material waste has been recognized as a major problem in the construction industry that has important implications both for efficiency and for the environmental impact of construction projects.

This thesis focuses on the various waste minimization strategies the main contractor can adopt during the construction stage to curb the waste problem caused by subcontractors. Waste minimization involves design, operations, material-handling and procurement.

E. Method of research

The basic approaches are adopted in this study; mainly explanatory, descriptive and research

Explanatory research is used to clarify concepts and problems. This is used in the literature review whereby published works on a range of relevant theories and previous work on construction waste, its causes, management and minimization are looked into. The conceptual framework of waste minimization is then developed.

Descriptive research is used to provide an accurate profile of an event or situation with attempts to establish the waste minimization situation in the local construction industry.

Research seeks to explain a phenomenon, this study attempts to explain the causes and effects of construction waste generation in the local industry. The research strategy adopted for this thesis comprises the collection of secondary source data for model construction, collection of primary data for model testing and finally model validation through the use of case studies.

2. Literature review

Ohno focused for process improvement in the Toyota Production System in 1988. This study resulted in more dramatic performance improvements. Ohno (1988) divides the

movement (operations) of workers into waste and work. Waste is the movement that does not add value and is not needed. It is often called unproductive time. Work includes both nonvalue-adding and value-adding work. This definition assumes that some non-value-adding work is necessary in production systems, due to current working conditions-for example, walking to another location to remove parts, removing wrappers from parts, and so on. Womack and Jones (1996) describe waste as any human activity that absorbs resources but creates no value, such as mistakes that require rectification, production of items no one wants, process steps that are not needed, unnecessary movement of employees, and people waiting for the conclusion of upstream activities. Ohno (1988) presents seven categories of waste that were identified in the Toyota production system:

1. Unnecessary movement of people (including waste of human energy).
2. Waiting by employees for process equipment to finish its work or an upstream activity.
3. Defects in products.
4. Overproduction of goods not needed.
5. Inventories of goods awaiting further processing or consumption.
6. Unnecessary processing.
7. Unnecessary transport of goods.

The first two categories are related to operations (work by people) while the last five refer to the flow of materials (process). These are some of the conclusions derived from TPS and suitable measures are taken to improve performance in respective industry. Thus concept of Lean Production is developed and strengthened.

Koskela incorporated concept of Lean Production to construction industry. According to Koskela (1992), to implement the concepts of the Lean Thinking in the Civil Construction is necessary, initially, understand the existing concepts, and then implement them in the new environment. Koskela (1992) also presents eleven principles for flow process design and improvement.

1) Reduce activities that do not add value

According to Koskela (1992) value adding and non-value-adding activities can be classified as follows: value - adding is the activity that transforms material and/or information in what is required by the customer and non-value adding activity also called waste is the one that takes time, resources or space but does not add value.

2) Increase output value through systematic consideration of customer requirements

This principle establishes that the necessities of the external and internal clients must be identified clearly and this information must be considered in the project of the product and the production management.

3) Reduce variability

Longer is the cycle time greater will be the amount of activities that do not add value to the end item. Koskela (1992) affirms that a possible form to reduce the variability consists of working with standardized activities.

4) Reduce cycle times

One of the objectives in LC is to compress the cycle time, which forces the reduction of inspection, move and wait time. According to Koskela (1992) progression of cycle time reduction is done through successive process such elimination of the WIP (Work in Process), reduction of the batch size, changing plant layout so that moving distances are minimized, synchronizing the flows, reduction of variability, changing activities from sequential order to parallel order, isolating the main value adding sequence from support work.

5) Simplify by minimizing the number of steps and parts

According to Koskela (1997) simplification can be understood as reducing of the amount of components in a product or reducing of the amount of steps in a material or information flow. Koskela (1997) also affirms that simplification can be done, on the one hand, by excluding non-value-adding activities from the production process, and on the other hand by reconfiguring value adding parts or steps.

6) Increase output flexibility

At first glance, increase of output flexibility seems to be contradictory to simplification. However, many companies have succeeded in realizing both goals simultaneously.

According to Isato et- al (2000), the increase on the output flexibility is related to the process concept as value-adding, and refers on the possibility to modify the outputs characteristics without substantially increase the cost of the product.

7) Increase process transparency.

The increase process transparency makes the identification of errors in the production system easier (Koskela, 1992). The transparency of planning makes possible the evaluation of the interference of the productivity of the teams.

8) Focus control on the complete process.

The control of the complete process is very important, and someone in the team must be responsible for that control. Depending on the complexity of the project, may be necessary to involve not only the company but also the entire productive chain on this effort. For inter organizational flows, long term co-operation with suppliers and team building have been established with the objective of getting mutual benefits from a better total flow (Koskela, l992).

9) Build continuous improvement into the process

The effort to minimize waste and maximize value of the product is an internal, incremental, and repetitive activity that must be carried out always (Koskela, 1992). It is necessary to analyze possible divergence in each party of the process.

10) Balance flow improvement with conversion improvement

According to Koskela 0992) there is a great potential of improvements in activities of flow considering that generally in construction these activities tends to be neglected. Koskela (1992) affirms that bigger is the complexity of the process of production, higher is the impact of the improvements in the activities of flow and if the waste is inherent to the production

process, the improvements will bring better resulted if is directed to the activities of flow.

11) Benchmark

The process of benchmarking does not have to be considered only as stimulation for better performance, but also as a mechanism that contributes to the learning of the company, because it induces the company to collect data and to analyse its own processes and its competitors and leaders on the market as well.

According to Koskela (2000), the most important principles for flow process design and improvement are divided into three types. The first and principal is theory rained.

Reduce the share of non-value adding activities

- The second is composed of two principles that derive from the theory.
- Reduce lead time
- Reduce variability

3. Case study

A. Introduction

The brief view of the case is, for any country its infrastructure development is the matter of pride, Indian infrastructure sector is also at the level today with the good initiatives in the areas of roadways, railways, airports and other smart city projects. In the last five years the phenomenal changes in this sector has been done. Due to the increase in the economic growth after development and redevelopment projects in the Country and subsequent increase in the Urbanization in the Cities has made Construction sector to increase drastically, but also Environmental impacts from Construction waste are increasingly becoming a major issue for Construction waste management. In this review paper the today's construction waste generation rate as well as the management practice scenario is explained with some of the suggestions which will be helpful to deal at site and helps to handling. It also covers various rules and regulations currently in practice in India and how it gets bifurcated from the solid waste management.

Material management has been of concern in the construction industry. According to a survey, the cost of material can exceed 50% of the cost of construction, depending on the type of construction. Due to the increase in the economic growth after development and redevelopment projects in the Country and subsequent increase in the Urbanization in the Cities has made Construction sector to increase drastically, but also Environmental impacts from Construction waste are increasingly becoming a major issue for Construction waste management. Nevertheless, practice of CWM and application of low-waste management technologies in the Indian Construction sector are still at a lower level compared to those of some advanced Countries, such as USA, UK and Australia. The poor management of Construction waste in India can be attributable to various aspects. For example, there is a lack of precise and detailed CWM related regulations that all technical persons (Owner, Engineer, Contractor) involved can actually follow. Consideration for Environmental management issues including CWM is not a priority when undertaking Construction projects. Industry stakeholders generally less awareness about construction waste minimization or environmental protection. Most of Indian construction projects do not have detailed waste management plans at the project level. Construction waste generated on-site is huge but management is poor. Furthermore, the local government does not launch long-term schemes with respect to construction waste disposal. All these problems demonstrate a pressing appeal for need to ameliorate current CWM practices in order to minimize construction waste in India.

B. Waste Generation in Construction Industry

All over the world, the construction industry has gained very rapid growth in recent decades. Due to the increase in infrastructures & industrializations the generation of waste also increased drastically. In general, there are two source of generation of construction waste materials, namely bulk generators &retail or small generators. The Infrastructure development sector involves bridges, flyovers, roads etc. Similarly, real estate sector involves industrial, commercial & housing building constructions, which are considered as bulk generators. While small commercial enterprises and individual house building teams are considered as retail or small generators. The construction projects must be well planned and must be properly executed to minimize the construction wastes.

The composition of construction waste depends on type of structure. For example, if the construction is flyover or bridge structures the composition will be usually concrete or steel. On the other hand, if the residential structure is built the composition will be in verity, it consists of concrete, steel, wood, pipes, plastics, paints etc.

Table 1
List of Waste

Components of construction wastes	TIFAC (%)	MCD Survey (%)	Survey IL & FS (%)
Soil; gravel	36	43	31.5
Bitumen	2	-	-
Metals	5	-	0.4
Concrete	23	35	-
Wood	2	2	1.5
Others	1	1	7.6

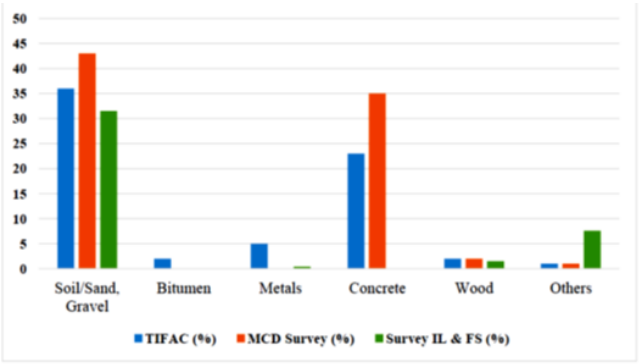

Fig. 1. Typical composition of Indian construction waste

C. Overview of Construction Waste Management

In India, at the beginning it is said that there is no adequate data for accessing construction wastes. Construction waste has become a one of the major issue, because of no separate rules & regulations for construction wastes in India, as it is considered as a sub category of municipal solid waste management. Because of which it is becoming difficult to handle the construction waste management. As per the estimates of Centre for Science and Environment (CSE), since 2005, India has newly constructed 5.75 billion sq. m of additional floor space with almost one billion sq. m in 2013 itself. A report from Ministry of Environment and Forest shows that it is estimated that in 2008- 0.53 million tons/day of waste is generated in the country. On this basis we can say that 210 million tons of waste is produced yearly.

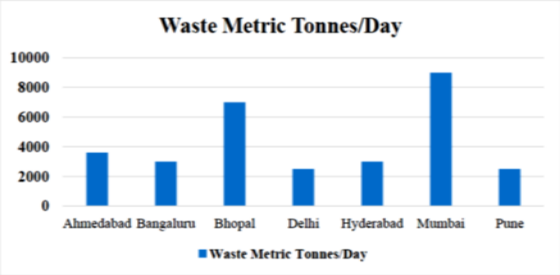

Fig. 2. Waste generated in Indian cities

D. Relevant Rules & Guidelines and Present Practices for Waste Disposal

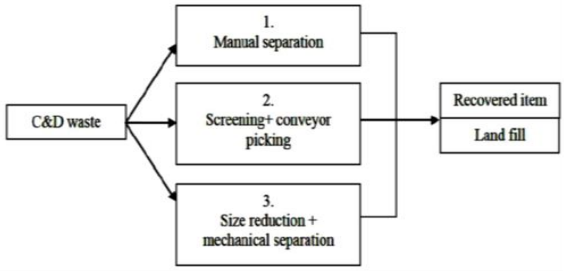

Fig. 3. Construction waste treatment methods

Construction waste is briefly included in the "Municipal Solid Waste (Management and Handling) Rules, 2000" but there is no detail except a brief mention in schedule II of the rule for its separate collection. This brief mention does not appear to be sufficient in view of its growing quantum and the way it affects the overall management of municipal solid waste. Greater details and more teeth is required for,

a) Controlling the situation.
b) Management of construction waste in a comprehensive manner which is likely to have significantly positive impact on the overall scenario of waste management and cleanliness.

The present waste management practices adopted by the construction industry in India are,

- Landfill tax is not imposed by the municipality.
- No penal action is taken against violators.
- Items recovered during construction /demolition is sold in the market at a discount rates.
- The feasibility of recycling is not even considered seriously in most cases. Items that cannot be re-used are used for filling the land.
- The waste is disposed without segregation.

E. Technical & Regulatory Requirements

Policy is required for mandating the following:

- Each urban local bodies should keep track of construction activity and generate data regarding quantity and characteristics continuously for at least one year and then once in 3 years.
- This data should be collated by the Nodal Agency (may be urban development bodies/ Municipal Administrative Department of the concerned state government).
- Expert organizations/institutions should analyze the data and evolve ways to use the material in the best possible way.
- Pilot demonstration projects in each state.
- Change in the relevant regulations and by-laws etc.
- There should be charges for disposal in landfills, which should be sufficiently high to encourage processing and recycling of construction wastes.
- For new constructions, permission from municipalities should include a clear waste management strategy, including use of recyclable building materials. The emphasis will be on reduction of wastes and deconstruction instead of demolition.

From the above paper we understood that, proper and detailed rules & regulations needed to handle the huge mass of construction waste and detail guidelines for the management of various type of construction waste which helps to deal with the quantum of waste, which is nowadays unutilized and partially utilizing in some of the areas.

All the stockholders who are directly dealing with the sites and handling the material they should have detailed legislations and information, so in future optimal utilization can be done and saving rate also increase.

It also helps to increase sustainability and helps to develop market for recycled products.

4. Recommendations

After identifying the prime causes and their ranking, next step is to stay aloof from such causes by paying heed to the following recommended solution. This potential recommended solution might help in reducing the wastage of construction material to a great extent, thus augmenting the profit margin and avoid the project delay. As natural construction materials are on the verge of depletion, this solution will help in preventing the depletion of natural resources.

A. Ways to Control Wastage of Cement at Site

These solutions have been ranked according to the ranking given to the respective causes.

1) Improper storage and issuance of cement

Probable measures to minimize wastage of cement due to these causes are as follows:

- The cement should be used on first come first used basis.
- Materials reconciliation should be done on monthly basis and not to left to be done at the end of the project.
- Proper inventory management of cement. Make use of Just in time order technique.
- During monsoon season cement bags should be covered with polythene.
- The cement bags should be kept close together to reduce air circulation.
- The cement bags should not be hand stitched.
- Do not purchase cement bags which are partially set due to moisture.
- Do not purchase if there are small lumps in the bags.
- Cement should be stacked in a shed, which should be dry, leak proofand moisture proof.
- Cement should be placed on dry brick floors, on wooden crates or on the planks.
- Cement from different manufacturers should be stacked separately.

2) Because of not considering necessary adjustment to made before actual mixing of ingredients of concrete/mortar (e.g. bulkage, water absorption/moisture content).

Probable measures to curtail wastage of cement due to these causes are as follows.

- Bulking of sand should be taken into account when volumetric proportioning of the aggregate is adopted. Otherwise less quantity of concrete per bag of cement will be produced, which naturally will increase the cost of concrete.

3) Inefficient or improper construction method (like outdated calibration of mixer, choking of pump)

Some of the recommendations to reduce wastage are given bellow.

- For high quality in work the mixing of different types of materials should be done by weighing the materials.
- Ensure that all types of cement concrete shall be done with mechanical mixer and Vibrator.
- Make use of concrete mixer which is calibrated periodically.
- It has been established that if driver, operator &maintenance crew are skilled personnel and the project manager did the proper selection of equipment, the wastage could be brought to negligible.
- It is important to select correct diameter of pipeline with adequate wall thickness of the pipeline to match the pump and required placing rate.
- A carefully laid pipeline is the prerequisite for trouble free pumping operation.
- Concrete which is made pass through pipeline should be designed as pumpable concrete to avoid blockage in the lines.
- Pipeline should be immediately cleaned after the concreting to avoid concrete sticking to the inner surface of pipeline and creating the blockage for passage of concrete.

4) Due to extra work than the theoretical (e.g. increase in slab thickness, filling the Column with concrete to a height more the required)

Probable measures to curtail wastage of cement due to these causes are as follows.

- Proper study of drawings and specifications before starting of actual execution of work.
- Employment of skilled mason on site for finishing work.
- Stringent supervision at the time of execution.
- Make use of leveling instrument while doing finishing work to achieve desired thickness as per drawing.
- Strong support to formwork to avoid sagging of structural members in order to avoid wastage.
- Required quantity of materials should be planned and ordered as per schedule. No extra order should be given then required, if not avoidable work should be properly planned to achieve minimum wastage of material.

5) Due to poor site supervision (like bulging, shuttering sides getting moved due to pressure of concrete)

Probable measures to curtail wastage of cement due to these causes are as follows.

- Employment of skilled carpenter to provide strong support and proper alignment to shuttering material as per drawing.
- Proper design of shuttering schemes to avoid bulging, bursting of shuttering materials.
- Proper selection of suitable shuttering material.
- Avoid giving wrong instruction to labours.
- Provide proper training to carpenters regarding proper use of shuttering materials. Joints of formwork should be properly sealed to avoid leakage of cement slurry.
- Stringent supervision at the time of execution to take timely action to avoid bulging, collapse of formwork & movement of sides of formwork.

6) Poor handling (hook used while unloading from truck) of cement at site

Probable measures to curtail wastage of cement due to this causes are as follows.

- Lay importance on minimum use of hooks while loading and unloading of cement from trucks.
- Preferably order cement in bilkers to avoid wastage due to this cause.
- Order cement bags which are packed in paper bags.
- Make sure of weigh bridge before and after unloading to account for wastage due to this cause.

7) Due to faulty and/or repair work

Probable measures to curtail wastage of cement due to this cause are as follows:

- Try to finish the work in line with the principle of "Right work in first time".
- Proper study of drawings and specifications before starting of actual execution of work.
- Stringent supervision at the time of execution to avoid dismantling of the newly cast structures.
- Avoid defective work causing rejects and redoing.
- Proper mixing, transportation, laying & compaction of concrete to avoid honeycombing and rough in order to avoid repair to the same.
- It has been observed at many sites that concrete is filled to an excess height then required and then chipping of that excess concrete is done.

8) Any other reason (miscellaneous cause)

Some ways to reduce down wastage caused by such reasons are as follows:

- No change should be allowed in drawings and specifications after work has commenced.
- Proper planning for storage and. procurement during rainy seasons
- Because of suspension and stoppage of work.
- Use of cement in temporary and labour colony construction by labours.
- Use of cement in temporary and labour colony construction by labours.

*9) **Construction flaws (like structures not in line and level, larger mortar joint & bed thickness in case of brick work)***

Probable measures to curtail wastage of cement due to these causes are as follows.

- If the joints of brickwork and bed thickness are more than specified it would lead to wastage of material. So adhere to minimum thickness as specified in specifications.
- Make use of mortar which falls down while doing brickwork by keeping jute bags adjacent to wall to carry such mortar.
- Provide proper thickness of cement plaster to walls by constructing masonry wall in Plumb.
- Taking bulking of sand into account to avoid wastage of cement.

*10) **Due to theft or pilferage from site***

Probable measures to curtail wastage of cement due to these causes are as follows:

- Make use of security personnel to curb the wastage of cement due to pilferages.
- Proper barricading of sites.
- Less number of access gates to sites.
- Proper checking of background of labours before allowing to work on site by contractor.
- Proper inventory management.

B. Ways to Control Wastage of Fine Aggregate

These solutions have been ranked according to the ranking given to the respective causes.

1) Improper storage of sand

Probable measures to curtail wastage of sand due to this causes are as follows.

- Proper storage yard for fine aggregate should be provided on well prepared concrete base with proper bonding on all sides to avoid wastage due to wash away along with runoff.
- Equipment or vehicles at site should not be allowed to ply near storage place.
- Loading and unloading of sand should be done with the help of mechanization to limit the wastages.

2) Due to improper means of transportation and placing of concrete

Probable measures to curtail wastage of sand due to this causes are as follows.

- For important works various mechanical devices such as dumpers, truck mixers, buckets, chutes, belt conveyors, pumps, hoist etc. may be used.
- The concrete should be transported in such a way that there is no segregation of the aggregates and minimum spillage of concrete.
- It is desirable to deposit concrete as near as practicable to its final position.
- Large quantities should not be deposited at a time.
- Proper planning and provision should be made for the construction & contraction joints.
- Make use of proper techniques to fill the thin structural members like plinth and tie beams, shear walls etc. to minimize wastage.

3) Due high silt content. (Washing of sand before use)

Probable measures to curtail wastage of sand due to this causes are as follows.

- Limit the silt content of incoming sand to about 8%. Reject the sand not satisfying the above criteria.
- Avoid unloading of sand at site containing lumps of clay.
- If washed sand is used at site certain percentage of wastage because of silt content in sand should be considered at the time of estimating by the quantity surveyor.

4) Due to extra work than the theoretical (e.g. increase in slab thickness, filling the column with concrete to a height more the required)

Probable measures to curtail wastage of sand due to this causes are as follows.

- Proper study of drawings and specifications before starting of actual execution of work. Employment of skilled mason on site for finishing work.
- Stringent supervision at the time of execution.
- Make use of levelling instrument while doing finishing work to achieve desired thickness as per drawing.

- Strong support to formwork to avoid sagging of structural members in order to avoid wastage.
- Required quantity of materials should be planned and ordered as per schedule. No extra order should be given then required, if not avoidable work should be properly planned to achieve minimum wastage of material.

5) Due to faulty and/or repair work

Probable measures to curtail wastage of sand due to these causes are as follows.

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- Avoid defective work causing rejects and redoing.
- Proper mixing, transportation, laying & compaction of concrete to avoid honeycombing and rough in order to avoid repair to the same.
- It has been observed at many sites that concrete is filled to an excess height then required and then chipping of that excess concrete is done.

5. Conclusion

Material waste has been recognized as a major problem in the construction industry that has important implications both for the efficiency of industry and for the environmental impact of construction projects. Moreover, waste measurement plays an important role in the management of construction projects since it is an effective way to assess their performance, allowing areas of potential improvement to be pointed out.

Construction industry produces more amount of the construction waste every year. Companies related to the various construction project concentrate on the increasing profit by adopting improved productivity and compressing scheduled of the project without concentrating on management of construction waste. This is also observed that not only the cost of the project gets increased due the construction waste material but also significant amount of valuable land is got occupied with waste generated by construction industry which have negative impact on our environment.

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. This problem is not only detrimental at environmental level as most of the waste is disposed off in landfills but also in economic terms as waste materials have their specific economic values before getting mishandled. Examining various reasons for the problem, lack of awareness among clients and contractors, lack of skilled labour, lack of proper training and education, minimal Government interventions etc. are few of the many reasons that significantly affect the Industry as a whole. Proper site waste management reveal that it is economically viable to do significant cost savings from the whole process. In which total benefits exceeds totals cost by incorporating appropriate methods. And widespread adoption can significantly save huge amount of money which otherwise goes into landfills in form of waste materials. First step towards mitigating this problem would be the Government's interventions like Landfill tax, higher tax for using virgin materials, tax credits for recycling etc. can act as an initial momentum towards seeking various other cost saving measures through waste minimization at source and appropriately managing it on site. Institutions and local organization can create awareness among clients and contractors which will initiate the demand for material waste minimization from clients and voluntarily from contractors.

Several challenges, opportunities and strategies are identified to increase the building waste management. Recycling and reuse of building waste is a sustainable approach which reduced cost, environmental pollution, energy demand, and conservation of natural resources. The various factors listed above will serve as guidance for engineers and material scientists to develop standards and specifications for alternate building materials utilising building waste. This study emphasizes the need to plan and develop waste management strategies for construction projects. Further research is needed on environmentally-friendly and energy efficient recycling methods and new reuse applications in infrastructure projects.

In this project the study of construction waste generation at different types of construction sites like commercial, residential and industrial sites was studied and the data regarding waste generation sources and average waste generation was done. Waste is classified in 3R (Reduce, Reuse, Recycle) principle due to this we can minimize cost of project.

The sources of waste generation are found out like Design, Operational, Material handling, and Procurement. Classifying construction waste material within 3R principal. This guidance provides a summary for construction clients, design teams and main contractors for achieving good practice WMM on their construction projects. This will help reduce the amount of construction waste sent to landfill, thus demonstrating a contribution to sustainable development and reducing project costs.

The main conclusions of the study so far are presented below,

- The lack of perception from managers of variability in production and productivity rates.
- The need of a prior definition of the type of control to be used (event-driven or period-driven).
- The lack of integration of waste control with the planning and control process, and the need for not only verifying but also monitoring the efficiency of construction processes.
- In the next stage of this project the research team intends to integrate the described tools with short and medium term production planning, through the use and discussion of data on work flows and material flows in production planning meetings.

Construction waste minimization can be viewed as a threat requiring ever-increasing expenditure on end of pipe recycling tools and technologies to meet ever-increasing legislation, or as an opportunity to cut cost and improve. The choice should be obvious but there is a need for a culture change. Rethinking waste management in construction requires adopting 'cyclic' rather than 'linear' approach to design and construction. This requires Engineering current practice to contribute to a cleaner environment through efficient and cost effective sustainable waste minimization to be effective and self-sustaining, it is important that all stakeholders along the construction supply chain embrace a more proactive approach in dealing with waste. In recognition of the responsibility of the architectural profession, through its leading role in project management and a key player in the construction industry, architects should move beyond the concept of 'eco-friendly' through bolt-on environmental strategies and strive to adopt 'eco-effective' practices by implementing a holistic approach to design out waste, which will be reinforced in tender documents and implemented during the construction stage, in addition to the capture and dissemination of lessons learnt to inform construction waste reduction baselines and benchmarking in future projects.

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