"Construction waste reduction – A case study"

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Abstract:

This paper is aimed at knowing the sources and causes of construction waste occurrence. Construction waste contributes the large quantity of waste that is generated by construction industry every year. The waste generated on construction site has been found to result in financial losses i.e. the cost of transporting and disposing of site waste and material storage cost.

In this project the study of construction waste generation at different types of construction sites like commercial, residential and industrial sites was done and the data regarding waste generation sources and average waste generation i.e. 0.010457 m^3/Sq.m Also in this project route optimization for selected sites is carried out using GIS application. And suitable for Kolhapur region waste is classified in 3R (Reduce, Reuse, Recycle) principle and suggestion for reduction of waste generation is carried out; from which the waste can be minimized and cost of project can be saved.

Keywords:*construction waste, waste reduction, waste generation, 3R,GIS*

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Introduction:

The construction waste, now a day's, is a serious concern to the construction sector. So there is need to, reduce construction waste generation from construction site. The Indian construction industry also needs construction waste management due to its economic and environmental aspects. So there is need to increase awareness about waste reduction and implementation of construction waste management plan in India.

A construction site produces the large quantity of construction waste every year. The waste generated on construction site has been found to result in two types of losses i.e. the cost of transporting and disposing of site waste and material storage cost. This can have a negative impact on the profit margin of contractors. Reducing construction site waste can reduce both costs of raw material purchase and cost of disposing of the waste from the site.

In urban development, construction sector plays major role in its economy. Kolhapur city is now-a-day's one of the rapidly developing city in Maharashtra, India. The waste generation gives rise to several problems i.e. environmental problems as well as economical problem in recycle and reuse. So disposing the waste is better solution for it. The waste reduction will definitely save the economy involved in project. For the waste reduction 3R principle can be effectively used for all kinds of project.

Kolhapur is city with hilly area. The growth rate of Kolhapur city is also satisfactory. Construction industry in Kolhapur city is developing fast, as construction rate increases rate of waste produced on the site is also increase and one day it will become big concern. To avoid such situation the provision of suitable dumping station is necessary. Study includes providing suitable dumping station for Kolhapur city. It also focuses on reducing and recycling construction waste generated on sites.

The waste generation cannot be completely eliminated but with proper guidelines and following some waste reduction techniques it can be reduced to some extent. This is beneficial to both contractor and client of the project.

Motivation of the study:

During the literature survey/study, it is observed that in other countries there is good study and awareness about construction waste. They have done proper construction waste management and they have thought that it is very essential around development of construction industry, but in India there is lack of awareness regarding construction waste and construction waste management.

Indian construction industry is rapidly developing every year; this contributes large quantity of construction waste. The waste generated on construction site has been found to result in two types of financial losses i.e. the cost of transporting and disposing of site waste and material storage cost. The construction waste management is the only option to overcome the losses.

As late, Kolhapur is now-a-day's one of the rapid developing city in Maharashtra. Rate of construction in Kolhapur city is also very high, but no one uses waste reduction techniques in this city, Also in Kolhapur city there is no provision of dumping station for construction wastes.

Methodology:

For the study purpose literature survey about the techniques of waste reduction and disposal is done. The literature review of construction waste reduction and disposal is carried out through various journals and construction waste manuals.Data collection is carried out for the measurement of waste from construction sites. For this purpose various site visits is done and collection of weekly waste report is carried out.Usingthe collected data of construction waste, it is classified within 3R, and remedial suggestions are done for reuse and recycle of construction waste. Dump station is found out with the application of GIS.

Study of construction waste generation from various sites:

For data collection purpose quantitative method of data collection are adopted. For the measure of construction waste six sites are selected. In this there are two residential; two commercial and two industrial sites are selected. The site visit and data collection was done once in two weeks, quantities are worked out by onsite measurement .The reasons of waste generations are also found. The reasons are immediately taken from the present authority at the site. For these six sites, main construction waste is concrete, brick masonry, gypsum plaster; brick bats. Major component of construction waste from residential and commercial sites is gypsum plaster and for industrial sites is concrete, brick masonaryetc.

Site selection:

This case study is related with Kolhapur city therefore four sites is selected in this city and two sites are selected near the city. Construction waste generation from residential, commercial and industrial sites is different, therefore two residential; two commercial and two industrial sites are selected to find out quantity of construction waste.

On site data collection:

Data related to construction waste is collected from 6 different sites in Kolhapur city. Quantities are worked out by manual onsite measurement technique. The site visit and data collection was done once in a week, and the waste quantities are carried out. The measurement of site waste is done by following criteria:

1. The waste should be only through construction operation waste.
2. The measurement is done weekly basis.
3. The waste is measured in volumetric methods.
4. The manufacturing defect material is not considered as construction waste.

The weekly data is collected for following purpose:

1. To know the sources of waste generation.
2. To know the quantities of waste generated at the time of construction.

This collected data is further used for analysis purpose. In this the waste is categorized in their sources of generation like handling error, rework etc. and the data is used for categorization of waste in 3R principles (Reduce, Reuse, Recycle). Also from the collected data it is possible to come to know the average waste generation per sq. meter by the different types of construction sites i.e. residential, commercial, and industrial. And it is also useful to work out the amount of waste generation for next ten years and regarding this data the suitable dumping area can be suggested for the Kolhapur region.

Tabulated result of area and waste generated from respective sites:

The area and waste generated quantity are tabulated as shown in table no. 1. Here, from which we understood the tendency of waste generated from different types of sites. From this it has to know that, as area of construction increased the quantity of waste generation also increase. In this

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maximum construction waste generated from commercial a site which is 117.12 m3.

Table No 1. Data collection

Name of Site	Area of construction (Sq.m)	Total wastage on site (m^3)
i) GhatgePatil industry	Core Shop = 4000	26.85
	Molding shop= 12800	38.77
ii) Indocount Textile industry	923.21	6.768
iii) Palm grove	7686.80	85.36
iv) Rajlaxmi Empire, Rajarampuri	673.13	1.672
v) Revolution commercial complex	4456	117.12
vi) Dr.Joshi nursing home	886	10.31

Average waste generation at selected sites:

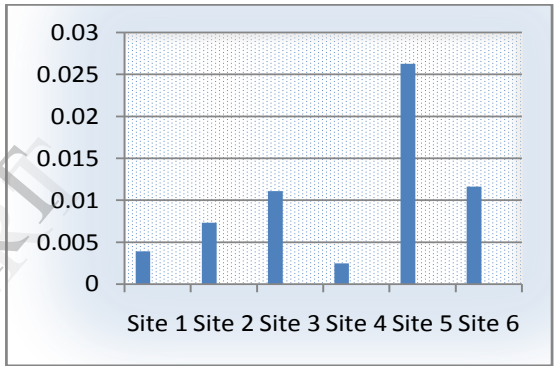
Table No 2. Average waste generated on selected sites

Name and Type of Site	Average waste generation (m3/ Sq.m)
i) GhatgePatil industry (Core Shop)	0.006713
(Molding shop)	0.003029
ii) Indocount Textile industry	0.007331
iii) Palm grove (Bedekar Builder)	0.011105
iv) Rajlaxmi Empire, Rajarampuri	0.002484
v) Revolution commercial complex	0.026284
vi) Dr.Joshi nursing home	0.011637

Table no 2 shows average waste generation from selected construction sites. From above data it can be shown that how much average waste is generated from construction sites. Site no. 3 is residential which generated maximum average waste and site no. 2 has generated minimum average waste. From overall observation it is seen that commercial construction sites generated maximum average construction waste. This average waste generation data has been used to find out how much waste is generated in Kolhapur city after 10 years by using forecasting method.

Comparison matrix of average waste generation from different types of construction sites:

Graph No 1 shows comparison between average wastes generated from selected construction sites. Average waste generation from selected sites is different. Maximum average waste generated from site no 5 and it is minimum from site no 4.During the execution of work wastages has occurred at site which was in mass quantity. On site no 5 gypsum plaster waste generation was more in quantity than any other material. Reason behind large amount of waste is unfriendly attitude of laborers, slow work process of plastering etc. From above graph it is concluded that average waste generation from commercial sides is maximum with compare to sites. This average waste generation data further used to finding out quantity of construction waste to dump for 10years.



Graph No 1. Average quantity in m^3/Sq.m

Site No.1) GhatgePatil industry (Industrial)
Site No.2) Indocount Textile industry (Industrial)
Site No.3) Palm grove, Bedekar Builder (Residential)
Site No.4) Rajlaxmi Empire (Residential)
Site No.5) Revolution commercial complex (Commercial)
Site No.6) Dr.Joshi nursing home (Commercial)

Data analysis:

Collected data is further used for analysis purpose. In this the waste is categorized in their sources of generation like handling error, rework etc. and the data is also used for categorization of waste in 3R principles (Reduce, Reuse, Recycle). Also from the collected data it is possible to come to know the average waste generation per sq. meter from the different types of construction sites i.e. residential, commercial, and industrial. And it is also useful to work out the amount of waste generation for next ten years and regarding this data the suitable dumping area can be suggested for the Kolhapur region.

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Sources and causes waste generation:

From the selected sites, to collect data questionnaires were formed and they were given to engineer, supervisor and labours. Each questionnaire had 5 questionsrelated to causes of waste generation. Suggestions to reduce waste were obtained from engineers on site through interview. After analysis of the answered questionnaire it was found that many factors contribute to construction waste at site. Waste may occurs due to one or a combination of various causes. The factors which cause construction waste on site can be grouped infour main reasons which is 1) Design 2) Operational 3) Material handling 4) Procurement

1. Design:

i) Changes made in design while construction is in progress. ii)Designer's is inexperience in method and construction.iii)Lack of attention paid to standard sizes available in market.v) Complexity of detailing in the drawing.vi) Selection of low quality of product.

2. Operational:

i) Errors by laborers. ii) Accident's due to carelessness.iii) Equipment malfunctioning.iv)Delays of passing information to the contractor on types and sizes of products to be used. v) Use of incorrect material, thus requiring replacement. vi)Required quantity unclear due to improper planning.

3. Material handling:

i) Damage during transportation. ii)Unsuitable storage leading to damage. iii) Material supplied in loose form.iv) Unfriendly attitude of laborers.

4. Procurement:

i) Ordering errors ii) Lack of possibilities to order small quantities.

From our study it observed that maximum waste is generated due to frequent changes in design or related issues. Minimum waste generated from procurement.

Suggestion to reduce waste on the site:

a) The provision of appropriate plans saves much waste generation on site, it minimizes rework.

b) Provide skilled labour force where risk of waste generation is higher.

c) Provision of weekly accounts of waste collection and use it to appropriate purpose in succeeding tasks.

d) The awareness about waste minimization in labour should be carried out by once in three month.

e) Order materials accurately and as needed, to minimize the risk of waste formation.

f) There should be regular waste audit once in year.

g) Protect materials from multi-handling process, weather conditions, theft, and damage from other construction activities. For this purpose proper storage units should be adopted

h) Reuse materials on site, if approved by the Architect. Possibilities include covering from land-clearing, debris, or aggregate from the crushed rock of excavation.

i) Select suppliers that take back packaging, unused or scrap materials

j) Give penalties to supervisor for wrong work.

k) Increase communication between owner, architect and RCC consultant.

l) Use of skill operator for equipment's onsite.

m) Equipment should be well maintained to give high performance.

n) Storage facility should be appropriate.

o) Loading and unloading of material should be done appropriately.

Safe waste disposal in city:

To calculate total waste generated in next ten years from Kolhapur city, use future forecasting method to calculate future construction area using arithmetical increase method.

Future forecasting area by using arithmetical increase method:

The prediction of future construction area based on present construction area and construction rate is known as future forecasting.

In this past and present data about construction work under construction per year is used to forecast the area under construction after 10 years. The total area of construction under construction after 10 years are worked out and multiplying by average waste generated it will give appropriate amount of waste quantity after 10 years. It will helpful to choose the appropriate dump zone to Kolhapur city for next 10 year.

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Arithmetical increase method:

It will give low result than actual value. In this method the average increase in construction area per year is calculated from the past survey reports. This increase is added to the present construction area to find out the construction area of the next year. Thus, it is assumed that the construction area is increasing at constant rate.

Hence, dP/dt = C i.e. rate of change of construction area with respect to time is constant.

Therefore, construction area after n^{th} year will be

Pn= P + n.C

Where,

Pn=construction area after n years.

n = No of years.

P = present construction area

For calculation of 'p' the data of present construction area was collected from town planning department of Kolhapur Municipal Corporation which is shown in table no 3.

Table No 3.Average Increment of area

Year	Construction Area (Sq.m)	Increment (Sq.m)
2010-2011	6,47,591	-
2011-2012	6,81,941	34,350
2012-2013	7,30,566	48,625
Average Increment = 41,487.50 (Sq.m)		

Total construction for 10years = 95, 87,472.50 Sq.m

Average construction waste = 0.010457m^3/ Sq.m

Total quantity of construction waste generation in 10 years=Total construction for 10 years**x**Average construction waste= 9587472.50 x 0.010457

=100264.19m^3

Area calculation of suggested dumping station:

For dumping of construction waste Takala quarry is selected as a dumping site for Kolhapur city. The purpose for selecting this site is that, it is located within the city and it is under Kolhapur municipal authority. The generated waste can be easily dumped at that site. To know the capacity of Takala quarry the area calculation is done as below.

Using Google map area calculator tool, area for Takala quarry is calculated.

Total area of Takala quarry = 21362.34 Sq.m

Average height of Takala quarry is estimated = 8 m

Total capacity of Takala quarry=170898.72 m^3

Remote sensing & GIS:

Remote sensing:

Remote sensing can be broadly defined as the collection and interpretation of information about an object, area, or event without being in physical contact with the object. The capacity of remote sensing to identify and monitor land surfaces and environmental conditions has expanded greatly over the last few years and remotely sensed data will be an essential tool in natural resource management.

For this research purpose in application of GIS the GPS (Global Positioning System) technique of remote sensing is used to locate the co-ordinates of various reference points on the map i.e. Longitude and Latitude. It is just because for Geo-referencing of map by which exact measurement of road can be calculated.

Geographic information system (GIS):

A geographic information system (GIS) is a computer-based tool for mapping and analyzes geographic phenomenon that exists, and events that occur on earth. GIS technologies integrate common data base operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes and planning strategies. Map making and geographic analysis are not new, but a GIS performs these faster and with more sophistication than do traditional manual methods.

In this project GIS is used for route optimization is carried out through Quantum GIS software. For this purpose geological map of Kolhapur city is taken from Kolhapur Municipal Corporation and geo-referencing of map was done by using Quantum GIS software. With help of various tools from software the lengths of roads are find out. Finally the optimum route for transportation of construction waste from selected

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site to dumping site is found out. It is done to reduce the transportation cost of generated construction waste and also it provides shortest possible route from sites to the dumping station.

Site Name	Route Length (Km)
i) Palm grove (Bedekar Builder)	6.17
ii) Bedekar Builder Rajarampuri	1.48
iii) Revolution commercial complex	1.61
iv) Dr. Joshi nursing home	4.91
i) Indocount Textile industry	17.97
ii) GhatgePatil industry	20.11

Table No 3. Optimized route length

These lengths are of optimum route length from Takala quarry to selected sites.

Conclusion:

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

1 The sources of waste generation are found out like Design, Operational, Material handling, and Procurement.

2 Classifying construction waste material within 3R principal.

3 From collected data it can be concluded that approximate average waste generated from residential site is 0.006795m^3/Sq.m. and for commercial site that is 0.018961m^3/Sq.m, and that is for industrial type of construction the value is 0.005791m^3/Sq.m.

4 The total average waste generation from all three types of sites is 0.010457m^3/Sq.m.

5 Appropriate dumping station at TAKALA for generated waste is suggested for Kolhapur city.

6 The GIS technique is used for finding the optimum route from selected sites to dumping station.

7 From the results and analysis of questionnaire the various suggestions are given to reduce the construction waste on site.

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