Cost Optimization of The Project by Construction Waste Management

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Abstract - *Construction industry consume substantial amount of raw materials in the process and the output is obviously the product and most importantly the waste material. Other than that, construction industry is well known as one of the worst environmental polluters. This study is to determine the use of waste minimization technique in creating sustainable waste management in order to identify the technique which has the most capabilities to reduce waste on-site. The objective is to assess the waste minimization techniques taken from the 4R concept which is reduce, reuse and recycle technique in minimizing the waste in construction waste management. Questionnaire has been distributed randomly across the district of Ahmedabad and the data has been analyzed to determine whether the output meet its original objective. The most used waste minimization technique found in 3R concept would be the waste reduction. This shows that local construction industry has the awareness to plan out the waste management planning but the implementation is still far from satisfying.*

***Key Words*: construction waste.wastemanagement,4R, reduce, reuse, recycle , waste minimization, cost reduction model**

1. INTRODUCTION

The Indian construction industry is characterized by challenges such as low productivity, lack of skilled labor, time and cost overruns, etc. These are associated with considerable waste present in the construction sites.

There is no Indian policy document which examines waste as part of a cycle of production consumption-recovery or perceives waste through a prism of overall sustainability. In fact, interventions have been fragmented and are often contradictory. The new municipal solid waste management rules 2000, which came into effect from January 2004, fail, even to manage waste in a cyclic process. Waste management still is a liner system of collection and disposal, creating health and environment hazards.

Urban Indian is likely to face a massive waste disposal problem in the coming years. Until now, the problem of waste has been seen as one of cleaning and disposing as rubbish. But a closer look at the current and future scenario reveals that waste needs to be treated holistically, recognizing is natural resource roots as well as health impacts.

Waste can be health wealth, which has tremendous potential not only for generating livelihoods for the urban poor but can also enrich the earth through composting recycling rather than spreading pollution as has been the case. Increasing urban migration and a high density of population will make management a difficult issue to handle in the near future, if a new paradigm for approaching is not created.

As a prerequisite to implementing modern construction principles, in which a major focus is on elimination of waste, it is important to understand and quantify the amount of waste actually present in Indian construction sites. This study aims to investigate the incidence of waste in Indian construction industry.

1.1 Construction Waste Scenario around the World

Mazumdar (2009), In **Scotland,** about 63% of waste was recycled in 2000; remaining 37% was being disposed in landfill and exempt sites. The Government over there is working out specifications and code of practice for waste management. Attempts are being made for establishing links with the planning system, computerizing transfer note system to facilitate data analysis and for facilitating dialogue between agencies for adoption of secondary aggregates by consultants and contractors.

According to the **Danish Environment Protection Agency** (DEPA), in 2003, 30% of the total waste generated was construction waste. According to DEPA around 70-75%, waste is generated from demolition activity, 20-25% from renovation and the remaining 5-10% from new building developments. Because of constraints of landfills site, recycling is a key issue for Denmark. Statutory orders, action plan and voluntary agreements have been carried out, e.g., reuse of asphalt (1985), sorting of construction waste (1995) etc.

Mazumdar (2009) stated that more than 40 million construction waste is being generated of which 80% is brick and concrete. Number of initiatives taken since 1993, such as prevention of waste, stimulate recycling, promoting building material which have a longer life, products which can be easily disassembled, separation at source and prohibition of construction waste at landfills. Factors which led to high recycling rates are as follows:

1. Separation at source
2. Good market for recycled products
3. Ban on landfills
4. Guidelines for using construction waste in place of fresh aggregates

As per Mazumdar (2009), construction waste accounts for about 22% of the total waste generated in the country. Reuse and recycling of construction waste is one component of a larger holistic practice called sustainable or green building practice. Green building construction practices may include salvaging dimensional lumber, using reclaimed aggregates from crushed concrete, grinding drywall scraps for use as soil amendment at the site promoting 'deconstruction' instead of 'demolition'. Deconstruction means planned breaking of a building with reuse of materials being the main motive.

Much of the R&D in **Japan** is focused on materials which can withstand earthquake and prefabrication. Concrete and composite materials constitute the main construction materials. 85 million tons of construction waste was generated in 2000, of which 95% of concrete was crushed and reused as road. Bed and backfilling material, 98% of asphalt + concrete and 35% sludge was recycled (Mazumdar, 2009).

Currently, countries in Asia have their own definition of C & D waste in terms of the components of C & D waste in the construction industry. In some countries particularly in urban setting, the 3R principles have already been practiced in most construction waste management. Such countries are Japan, Hong Kong, Special Administrative Region (SAR), India, Sri Lanka, Singapore, and Malaysia, among others. Also, awareness rising on C & D waste management is being practiced in some of these countries.

1.2 Construction Waste Scenario In India

Poon (2007), Presence of construction waste and other insert material (e.g. drain silt, dust and grit from road sweeping) is significant about a third of the total municipal solid waste generated in India. There are mainly two types of generators bulk generator and retail or small generator.
Infrastructure sector (construction/repair of roads, bridges, flyovers etc.), real estate (especially demolition and major renovation work) demolition of unauthorized structure etc. are sources of bulk generation. Households and small commercial enterprises are the small generators. The total of all activities comes to large figures.

1.3 Possibilities of Construction Waste Management in India

According to, Poon (2007), Possibilities of construction waste management in India can be laid as follows

With its growing quantum a comprehensive management plan for construction waste is essential comprising (a) hierarchy and (b) plan.

Hierarchy – the principle of '3R' – reduction, reuse and recycle is applicable for construction waste.

Plan –with a good plan during construction or demolition, it is possible to minimize waste generation by reducing wastage (reduction), followed by reuse or salvage of the materials or even some items like door/window frame, panes and shutters etc.

The last in the list of priority – recycle – is possible by way of segregation of the components, crushing the large aggregates and using the different size grades

Experiments by CRRI has shown that it is possible to use construction waste for road and embankment construction – embankment and sub-grade, sub-base, stabilized base course, rigid pavement etc.
CPWD already has recommendations for salvage value (salvage content)

Recycling of black-top road has already been tried successfully (e.g. Mohali – Badarpur Road in Delhi done recently and Dashbandhu Gupta Road in Delhi about 20 years ago)

Systematic collection is crucial for success of the construction waste management system.

Table -1: Percentage Cost Distribution in Construction Industry

	Materials %	Construction equipment %	Lsabour %	Finance %	Enabling Expenses %	Admin Expenses %	Surplus %
Building	58-60	4-5	11-13	7-8	5.5-6.5	3.5-4.5	5-6
Roads	42-45	21-23	10-12	7-8	5.5-6.5	3.4-4.5	5-6
Bridges	46-48	16-18	11-13	7-8	5.5-6.5	3.5-4.6	5-6
Dams,etc	42-46	21-23	10-12	7-8	5.5-6.5	3.4-4.6	5-6
Power	41-43	21-24	10-12	7-8	5.5-6.5	3.5-4.7	5-6
Railway	51-53	6-8	16-18	7-8	5.5-6.5	3.4-4.7	5-6
Mineral plant	41-44	20-22	12-14	7-8	5.5-6.5	3.5-4.8	5-6
Transmission	49-51	5-7	19-21	7-8	5.5-6.5	3.4-4.8	5-6

1.4.Components Of Construction & Demolition Waste In India

Table -1: Quantity of various constituents generated per year (Ekanayake, 2004)

Constituent	Million tones/yr.
Soil, sand and gravel	4.20 to 5.14
Brick and masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

2.SOURCE IDENTIFICATION FOR CONSTRUCTION WASTE

The following is a conceptual framework that organizes the sources of construction waste into six categories.

1. Design
   - Blueprint error
   - Detail error
   - Design changes

2. Procurement
   - Shipping error
   - Ordering error

3. Handling of materials:
   - Improper storage/deterioration

- Improper handling (Off-site and on-site)

4. Operation:
- Human error (by craftsmen or other laborers)
- Equipment malfunction
- Acts of God (catastrophes, accidents, and weather)

5. Residual
- Leftover scrap
- Irreclaimable non consumables

Not all the listed errors will lead to construction wastes. Damaged or surplus materials can often be salvaged and reused or simply resold to the materials vendor.

3. DETAILS OF CASE STUDY

1) Godrej Garden city
- **Type of Project:** Residential Township
- **Project Location:** Nr. S.G. Highway, Ahmedabad.
- **Client**: M/s Godrej Properties Limited, Mumbai
- **Contractor/**s L&T-EDRC
- **Consultant:** M/s STUP consultant Pvt. Ltd, Mumbai
- **Architecture/s** P G Patki architect-Mumbai
- **Total Project Cost:** 132.06 cr

3.2 Assume & Permissible vs. Actual waste of different company

Chart-1 Permissible and Actual waste percentage of GGC

3.3 Quantity and Rates of the material from the Questionnaire

The following data got from the questionnaire survey and BOQ or quantity sheet of particular project. The rate of material gives the idea about the market price of material for particular project which help us for rate analysis ahead.

Table -2: Quantity and Rates of the material from the questionnaire

Sr.No	Description	Unit	GGC	GALA
A	**Quantity Based Questions**			
1	Concrete	cum	49724	3211
2	Reinforcement	MT	4264	524
3	Brick Masonry	cum	27599	16332
4	Formwork	sqm	554299	16000
B	**Rate Based Questions**			
5	1 cub m Concrete	Rs	4679	4200
6	1 tone reinforcement	Rs	42000	45000
7	1 brick	Rs	2.5	3
8	1sq m formwork	Rs	218	190

4. PRICE AND QUANTITY OF MATERIAL (L&T):

From the rate analysis calculation and input all the material and labour charge in rate analysis format we got price of cement, brick ,reinforcement and formwork as follow:

CEMENT:
M10:3234/- PER CUM
M15: 3309/- per cum
M20: 3556/- per cum
M25: 3857/- per cum
M30:4253/- per cum
BRICK MASONRY
2440/- per cum
REINFORCEMENT:
59/- per kg
FORMWORK:
162/- per sqm

For the further calculation we have total quantity of cement, brick, reinforcement and formwork as follow: (From the Annexure BOQ of L&T)

CEMENT:
M10: 0 CUM
M15: 0 cum
M20: 0 cum
M25: 42550 cum
M30: 7174 cum
BRICK MASONRY
27599 cum
REINFORCEMENT:
4264000 kg
FORMWORK:
554299 sqm

4.1Quantity and waste cost calculation GGC by L&T:

Table 3. Quantity and waste cost calculation by L&T

1	2	3	4	5	6	7	8	9	10	11
					Permissible Waste		Actual Waste			Difference
CONCRETE	Rate (Rs/Cum)	Total Quantity	Total cost(Rs)	%	Quantity	Cost(Rs)	%	Quantity	Cost(Rs)	Actual-Permissible
M10	3234	0	0	2	0	0	4	0	0	0
M15	3309	0	0	2	0	0	4	0	0	0
M20	3556	0	0	2	0	0	4	0	0	0
M25	3857	42550	164115350	2	851	3282307	4	1702	6564614	3282307
M30	4253	7171	30511022	2	143.48	610220.44	4	286.96	1220441	610220
		49724	194626372		994.48	3892527.44		1988.96	7785055	3892527.44

				Permissible Waste			Actual Waste			Difference
BRICK	Rate (Rs/cum)	Total Quantity	Total Cost(Rs)	%	Quantity	Cost(Rs)	%	Quantity	Cost(Rs)	Actual-permissible
	2440	27599	67341560	3	827.97	2020246.8	5	1379.95	3367078	1346831.2

				Permissible Waste			Actual Waste			Difference
FORMWORK	Rate (Rs/cum)	Total Quantity	Total Cost(Rs)	%	Quantity	Cost(Rs)	%	Quantity	Cost(Rs)	Actual-permissible
	162	554299	89796438	2	11085.98	1795928.76	3	16628.97	2693893	897964.38

				Permissible Waste			Actual Waste			Difference
FORMWORK	Rate (Rs/cum)	Total Quantity	Total Cost(Rs)	%	Quantity	Cost(Rs)	%	Quantity	Cost(Rs)	Actual-permissible
	162	554299	89796438	2	11085.98	1795928.76	3	16628.97	2693893	897964.38

5. OPTIMIZATION MODEL THROUGH WASTE MANAGEMENT

Now we have all type of data which we need in making of cost optimization model from the data we calculate the benefit or saving money through waste management. In this model we use the best option to reduce, reuse and reuse the waste quantity of concrete, bricks, reinforcement and formwork.

From this model we realized that from the total waste occur in the project we optimize the cost of waste. In concrete we decrease cost of concrete waste 7.65%,in reinforcement we decrease reinforcement waste 25.36%,in brick we decrease cost of brick waste 15.18% and for formwork we found that for the wastage which occurs in formwork is in accessory mostly and in the plate cutting scrap which is nominal.so there is no reuse of that type of waste only things is to be doing is carefully fitting and removing the formwork. Use the rebound type of shuttering chemical for increase the life of formwork and number of repetition can be increase. The cost optimization model and explanation of this model is described below.

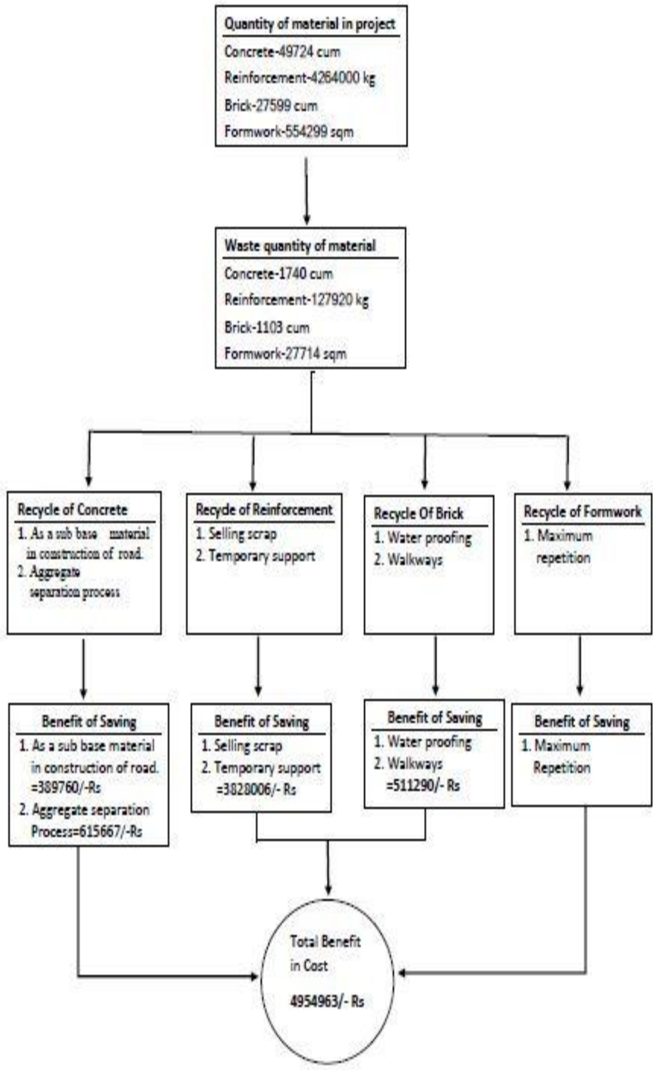

Chart -2:Cost Optimization Model of GGC

5.1Explanation of Cost of Model:

CONCRETE

1) If we use recycle concrete waste in sub base of road construction.

- From the survey and information we knew that we get only 70% concrete waste from total waste
- 1989 X 0.7=1392 cum
- Now rate of sub base material is 280/- per cum
- **1392 X 280 = 389760/-**

2) If we separation of aggregate from waste of concrete,

- In this process we get 65% aggregate back from the total quantity which we have as a Waste concrete
- As per rate analysis in 1 cum concrete there is 0.65 cum 20mm and 0.47 cum 10mm in it.
- So.
- 1392 X 0.65 X 0.65 = 588.12 cum 20 mm
- 1392 X 0.47 X 0.65 = 425.25 cum 10 mm
- Price of 20mm and 10mm aggregate are 660 Rs. and 535 Rs. per cum. So,

- 588.12 X 660 = 388159 Rs
- 425.25 X 535 = 227508 Rs
- Total = **615667** Rs

BRICK:

1) Total quantity of wastage in brick is 1380 cum. As per rate analysis in 1 cum there are 494 bricks

- So we have,
- 1380 x 494 = 681720 bricks as s brickbats.
- Assume we get ***75%*** brickbats out of total.
- 681720 x 0.75 =511290 brickbats
- Assume 1/- per brickbats
- **511290 X 1= 511290 Rs**

REINFORCEMENT:

1) From the survey and information we knew that 95% reinforcement we get back out of total waste.

- So we get.
- 255840 x 0.95 = 243048 kg
- Out of 243048 kg we reuse 25% in serviceable steel ***or*** in temporary support
- 243048 x 0.25 = 60762 kg
- Now we have,
- 243048-60762=182286 kg
- Now we sell it 20/- down market price
- 182286X21=**3828006/-Rs**

6. REDUCE, RECYCLE AND REUSE

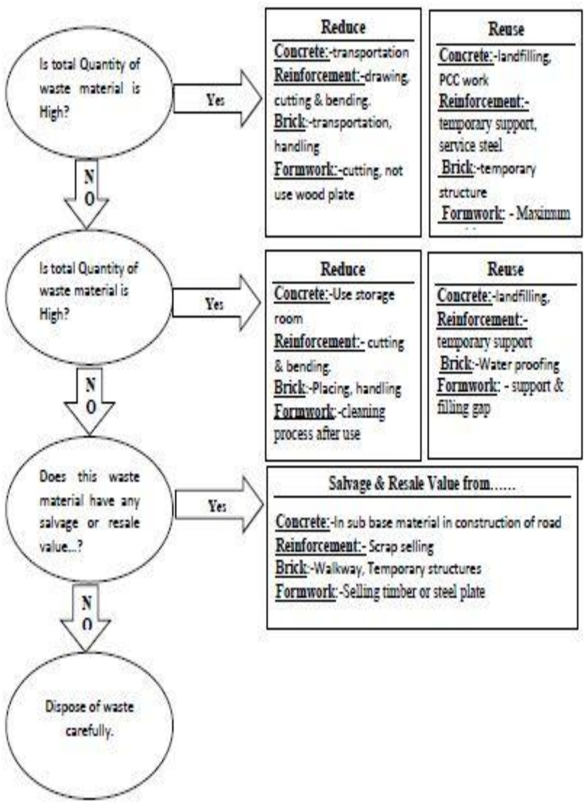

Chart -3: Reduce, Recycle and Reuse Model

6.1 Reduce

Segregation of waste:

Segregation of waste on site makes it far easier to pinpoint areas of work. Where excessive quantities are being generated and therefore where improvement can be made. Segregation of waste should not be limited to large volume of wastes, but small volumes of wastes, but small volumes of wastes which have an economic value when they are reused or recycle, should also be segregated.

Better storage

It is seen that as much as 10% of deliveries are lost as a result of poor storage.it is important to store materials correctly to avoid damaging them. If materials are damaged by poor storage, they may not meet the specification and therefore become waste. Also, by storing materials in a secure area theft, vandalism and pollution can be checked.

Appoint a site waste manager:

A specialized Waste manager should be employed at the site. This will result in overall efficiency of the system. The role of site waste manager will include:

- Co-ordinate reduction, reuse and recycling initiatives in site
- Co-ordinate waste management on site, maintain efficiency, gather data about waste on site, keep accurate records on waste movement on and off site.
- Ensure all site personnel know their responsibilities for site waste management.
- Take responsibility for making sure that all waste storage containers are accurately labeled to show site workers where to deposit specific materials.
- Obtain a list of potential buyers/sellers of used or recycled materials in the location of the site
- Wherever possible, try to reuse and recycle waste available on site before bringing in materials from other sites
- Conduct a survey of waste likely to be generated on site and keep a record of them. This will enable forward planning.

Mechanization:

Mechanization of construction is one of the least waste producing factors. That is, lesser the dependency on labor, more efficient the project can be.Also,mechanization in building industry would increase employment of semi-skilled and skilled workers, reduce time of construction and increase on investment.

6.2 Reuse

REUSE is to use a construction or demolition waste material again on-site without processing. Some materials can be reused on site itself. For e.g.

- Brick and concrete waste can be used on site under walkways or driveways.

- Reuse any timber as support for shuttering on construction sites nearby.
- Sell steel scrap from site.
- Reuse concrete waste in land filling and PCC work.
- Reuse reinforcement waste by lapping and welding.
- Use brickbats in waterproofing.

6.3 Recycle

RECYCLE WASTE is to process the material and use the product. Recycling of demolition waste was first carried out after the Second World War in Germany to tackle the problem of disposing large amount of demolition waste caused by the war and simultaneously generate raw material for construction industry is “Not aware of the recycling technique”. No respondent in the survey conducted showed awareness to any of recycling techniques.

Recycling Requirement:

- Quality standards codes of Practice regarding various aspects of product control and acceptance criteria for use of recycled aggregate in recycled aggregate concrete and other works should be formulated. This would help in setting a target product quality for producers and assure the user of a minimum quality requirement, thus encouraging him to use it.
- The present framework for disposal of waste needs to be strengthened and improved .In this approach, all the demolition and construction wastes have to be accounted in terms of re-use, recycling and disposal.
- To take care of the problem of noise and dust emission associated with recycling, suitable measure like erection of acoustic screening around the equipment, use of mufflers/silencers and water spraying equipment should be made mandatory in a recycling unit. Equipment manufacturers should ensure incorporation of these features in their machines.

Here are some recycling opportunities for construction debris.

Concrete and Masonry

Concrete and masonry constitute more than 50% of waste generated by the construction industry. Recycling of this waste by converting it to aggregate offer dual benefit of saving landfill space and reduction in extraction of natural raw material for new construction activity.

- Basic method of recycling of concrete and masonry waste is to crush the debris to produce a granular product of given particle size. Plants for processing of demolition waste are differential based on mobility, type of crusher and process of separation.
- There are three types of recycling plants Viz. Mobile, semi-mobile and stationary plant.in the mobile plant, the material is crushed and screened and ferrous impurities are separated through, magnetic separation suited to process only non-contaminated concrete or masonry waste. In the semi-mobile plant, removal of contaminants is carried out by hand and the end product is also screened. Magnetic separation, for removal of ferrous material is carried out.
- Above plants are not capable to process a source of mixed demolition waste containing foreign matter like metal, wood, plastic, hardbound etc.
- Density of recycled aggregate is tower and water absorption is higher than that of original aggregate. Recycled aggregate can be used as general bulk fill, sub-base material in road construction, fills in drainage projects and for making new concrete.Upto 30% of natural coarse aggregate can be substituted ,by coarse recycled aggregate any impact on the quality of concrete.
- The most common application of recycled aggregate in other countries is its usage as sub-base material in construction of road .At first recycles aggregate should be tried for this application.
- Concrete made from recycled aggregate has lower compressive strength caused by the bond characteristic of recycled aggregate and the fresh mortar. Fraction of less than 2mm of recycled aggregate bring about the largest reduction in strength of recycled aggregate concrete (RAC).Workability of concrete decreases with increased portion of demolition waste.

7. CONCLUSION

The work can be seen as an attempt to provide the waste management interested part of society with a construction waste management .hence, to a certain extent, the present work presents a pioneering attempt in that it is a proposal for a shift of waste management views. The results of study have confirmed that the level of material waste in the construction industry a fairly high and that much of this waste is predictable and avoidable.

The paper discusses the main results of study, aimed of measuring of materials in building projects and at identifying its main causes. The paper suggests that the level of material waste is very high, but that improving the preference of the industry in this respect does not demand much investment from the companies. Some general strategies for reducing waste are proposed .In general, companies need to improve their systems so that their waste becomes apparent and easier to eliminate.

The fact that most companies were unaware of the magnitude of waste at their sites indicate a lack of transparency in the performance of their production system. Indeed, very few of the sites had organized records on the actual delivery, storage and consumption of materials. The analysis of sources of waste indicated that a large proportion of material waste occurs because of flow activities, such as material delivery, inventories, transportation and handling, are often neglected by site management. This is probably result of the conceptual model of production currently used by the industry , which encourages the management effort to be focused on the conversion activities.It must be pointed out that the waste of other resources such increase the amount of non-value-adding activities and thereby the waste of other resources such as labour and equipment time. For instance, the excess of material that needs to be purchased tends to increase stocks, the demand of the transportation system, and the effort necessary to remove debris from site. These problems might also negatively affect health and safety conditions.

Finally, cost of materials when compared to the total cost of project may well be over 50% hence materials should be judiciously utilized and handle. Giving incentives to workers for handling of materials greatly minimizes waste on construction site as well as trying to male workers have a sense of belonging the firm. And most effective way of minimization waste on sites is to have experts to supervise the work and appoint a site waste manager.

Recommendation:

From the above conclusion, the following are recommended:

Construction waste recycling and reusing is visible option in construction waste management and from further studies or research laboratory experiments can be performed on some construction waste broken aggregates or demolished concrete to establish the feasibility of this option. It would be worthwhile extending the investigation to other building material like brick, timber, iron-mangery, broken-glass, sanitary wares and similar items.

To use of computer software like ERP should be adopted for storing records on construction site and for construction planning.

There should be awareness programs for all construction companies on construction waste management through reuse and recycle .Also formal education should be given to storekeepers and the foremen on effective material handling system.

The government should come up with a policy on construction waste management which may include introduction of heavy tipping charges on construction waste and taxes for dumping or disposing waste carelessly

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