Economic Evaluation of Reuse and Recycle of Construction Waste in India

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Abstract—History of Human evaluation indicates that the growth obtained since industrialization era to till date is with consumption of various resources and production of waste. The growth of human kind is conveniently considered as equivalent to the growth of construction industry, which is also the major source of waste. Approximately half of the wastes generated and landed in landfill are from Construction and Demolition waste (CDW). Materials ended as waste of CDW often consists high economic value as well as environmental threats. Since the concept of sustainable development, reuse and reuse of waste are in practice globally, it is now almost indispensable to reuse and recycle construction and demolition waste to utilize the resources utmost and gain economic benefits and to prevent environmental deterioration. This paper categorizes different types and sources of CDW. It also describes current scenario and model for economic evaluation of recycle and reuse.

Keywords: Reuse, Recycle, Construction and Demolition waste, Economic model.

I. INTRODUCTION

Construction, remodeling and demolition of buildings, roads, bridges, flyover, subways, factories and other similar establishments accompany developments of infrastructural facilities. The waste generated mainly consists of inert and non-biodegradable materials such as concrete, plaster, wood, metal, broken tiles, bricks, masonry, etc. These wastes are heavy, having high density, very often occupy considerable storage space either on roadsides or communal waste bin and valuable space in landfills. Such waste makes municipal waste heavy and unsuitable for further treatment like composting or energy recovery. Presently, awareness of resource –efficient construction practices are lacking in most of countries. Many European countries had made considerable achievements to utilize the construction waste. The countries like U.K., USA, France, Denmark, Germany and Japan have succeeded in developing economically feasible technologies for recycling up to 80-90 percent of C&D waste. However least effort has been reported for the utilization of construction waste in India. Each year millions of tons of construction wastes are discarded due to the construction and demolition practices. In production of such new materials an enormous amount of energy, resources and labor is used. The use of recycled products from construction and demolition debris has many advantages: Reducing carbon print of the original material, increasing the life cycle of a product, creation of a link between past, present and future in terms of material use, cost reduction, providing another work sector for recycling companies. The economic and environmental benefits to be gained from waste minimization and recycling are enormous (Gutherie, Woolveridge, & Patel, 1999), since it will benefit both the environment and the construction industry in terms of cost savings. Thus this paper aims to focus the problem of construction waste and its reuse and recyclability.

II. OVERVIEW OF CURRENT INDIAN PRACTICES

According to 11th five-year plan, construction industry is the second largest economic activity after agriculture. Based on an analysis of the forward and backward linkages of construction, the multiplier effect for construction on the economy is estimated to be significant (Srivastava & Chini, 2009).

The construction industry sets in motion the process of economic growth in the country. Construction accounts for nearly 65 per cent of the total investment in infrastructure and is expected to be the biggest beneficiary of the surge in infrastructure investment over the next five years. Investment in construction accounts for nearly 11 per cent of India’s Gross Domestic Product (GDP) (Market, 2009). This sector is likely to continue to record higher growth in the coming years due to the Government of India’s (GOI) recent initiative to allow 100 per cent foreign direct investment in real estate development projects (India(GOI), 2007). Technology Information, Forecasting and Assessment Council (TIFAC) study mentions that total construction work for five years during 2006-2011 is equivalent to $847 billion. The component of materials cost comprises nearly 40%-60%. Therefore material waste generation from construction activity is also huge in monetary terms.

III. CONSTITUENTS OF C&D WASTE

Fig. 1: Various constituents of construction waste (TIFAC, 2000)

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The chart and Table 1.1 shows Constituents and generation of construction and demolition waste in India in 2000. Constituent waste that consists considerable significance in waste generation is soil, sand, gravel, concrete, brick and masonry which are also of high value as for resource material.

IV. SOURCES OF C&D DEBRIS:

During different construction and demolition activity CDW are generated. Type of Waste generated varies with different activity. Different source of the waste material are as follows.

<table>
<thead>
<tr>
<th>Waste Material</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>Roads, bridges, parking lots, roofing material, flooring material</td>
</tr>
<tr>
<td>Brick</td>
<td>Masonry building equipment white good</td>
</tr>
<tr>
<td>Ceramics/Clay</td>
<td>Plumbing fixtures, tile</td>
</tr>
<tr>
<td>Concrete</td>
<td>Foundation, reinforced concrete frame, sidewalks, parking lots</td>
</tr>
<tr>
<td>Contaminants</td>
<td>Lead based paint, asbestos insulation, fiberglass, fuel tank</td>
</tr>
<tr>
<td>Fiber-Based</td>
<td>Ceiling system material, Insulation</td>
</tr>
<tr>
<td>Glass</td>
<td>Windows, Doors</td>
</tr>
<tr>
<td>Gypsum/Plaster</td>
<td>Wall board, Interior partitions</td>
</tr>
<tr>
<td>Metals, Ferrous</td>
<td>Structural steel, pipes roofing, flashing, iron</td>
</tr>
<tr>
<td>Plastics</td>
<td>Vinyl siding, Doors, Windows, Plumbing</td>
</tr>
<tr>
<td>Soil</td>
<td>Site Clearance</td>
</tr>
<tr>
<td>Wood Treated</td>
<td>Plywood: Pressure or creosote treated, Laminates</td>
</tr>
<tr>
<td>Wood Untreated</td>
<td>Framing, Scraps, Stumps, Tops, Limbs</td>
</tr>
</tbody>
</table>

Table 2: Source of C&D debris

V. TYPES OF C&D WASTE

According to Walter (2008) the materials found in the C&DW that can be of use are classified as:

Reusable materials: These are materials recovered in good shape, for instance high quality wood or structural steel, and manufactured pieces like bricks, concrete blocks, and tiles (roof, floor). Also excavation material or demolished concrete, free of impurities that can be used directly as sub-base material in the construction of roads. Recyclable materials: These materials (metal, glasses, plastics, etc) can be reincorporated into the recycling market, as long as they are free from impurities, and can be used to produce the same or similar products that created the waste.

Materials used for the generation of secondary products: Besides the glass, plastic, and metals which can also be used for this purpose; they are mainly materials of stone, ceramics, concretes the ones that can be used for manufacturing secondary products. A graphic and insert it into the text after your paper is styled.

C&D waste can be categorized majorly into four different types in context of recycle and reusability.

TYPE 1: Reusable Items

Items that are directly usable after removal with or without an overhaul e.g. window frames, doors, wooden logs, roof tiles, lamp sockets, roof boards, galss panes etc

TYPE 2: Recyclable Materials

Waste that can be reused after processing the material is type 2 waste. E.g. Reinforced Steel, Copper wires, Ferrous and non-ferrous metal

TYPE 3: Mineral Components

This type accumulates on the demolition site in the course of demolition activities. The material is undefined in its composition and therefore of minor value. E.g. concrete, cement mortar, tiles, bricks

TYPE 4: Non-reusable/ recyclable Waste

This fraction is devoid of any obvious monetary value. It is either disposed of along with municipal waste, on separate landfills or sometimes goes along with type 3 waste. E.g. municipal waste, wrappings, Plastics

VI. RECYCLE AND/OR REUSE OF C&D DEBRIS

Different waste generated from various stages of construction and demolition process consists different characteristics. Each different waste can be reused or recycled either after treating or without any requirement of treatment. Current practice globally to reuse and recycle different material from C&D waste is as followed.

1) Aggregates: Aggregates are used as binding material with cement to make concrete. Aggregates can be recycled into fill for roads an buildings. Also recycled concrete can be used as aggregate in production of new concrete.

2) Asphalt Shingles: Research on reusing of asphalt shingles are currently ongoing, although it can be recycled in asphalt pavement and other road construction application.

3) Wood: Clean wood can be reused in architectural woodwork whereas heavy timbers and floorings can often be reused. Wood which cannot be recycled can be used as fuel, mulch or compost additive. Treated wood due to long life span has potential for reusing.

4) Gypsum Board: It can be reused if undamaged during its previous use. Damaged gypsum board can be recycled in production of new board or cement. Gypsum can also be recycled as a soil amendment.

5) Metals: Structural steel and aluminum products can be reused if dismantled properly. Most metal waste is valued high so it is often first material targeted for recycling.

6) Plastics: PVC window and doorframes can be easily reused. Currently market for recycling plastic is being developed.

7) Ceiling Tiles: It can be easily reused if undamaged. Broken tiles can be recycled in production of new tiles.

8) Synthetic carpeting: Undamaged carpeting can be reused whereas often be recycled for use in new carpet components and other synthetic products.
9) Whole Structures: In Europe and USA, whole structures occasionally moved. The concept of moving whole structure is comparatively new to India.

VII. PRESENT C & D WASTE HANDLING IN INDIA.

Clients, contractors, architects and the Government should play an important role in improving construction site waste management techniques and approach in India. According to TIFAC (2000) study, following are the present waste handling measures adopted by the industry at various levels.

- Items recovered during construction /demolition is sold in the market at a discount with respect to price of new material.
- Items that cannot be re-used are disposed to landfill site.
- Municipal corporations allow C&D waste in their landfills. No landfill tax is imposed.
- Different constituents of waste are not segregated prior to disposal.
- Builders/ owners bear the cost of transportation, which at present, ranges between 350-700 Indian rupees/truckload depending on the distance of demolition site from landfill area.

Though directives exist for disposal of waste to landfill areas, presently penal action against violators is practically not taken. The above study indicate the attempts made to handle C&D waste in the industry but still majority of it is not implemented in an appropriate manner. This shows lack of awareness in the industry concerning the possibilities of cost savings from proper handling of C&D waste. Managing building material waste can in fact achieve higher construction productivity, save in time and improvement in safety (Chan & Ma, 1998) while disposal of extra waste takes extra time and resources that may slow down the progress of construction.

VIII. FACTORS INFLUENCING RECYCLING

1) As a recycling is challenging problem, factors influencing decision for recycling construction waste are extracted as follows.
2) Law enforcement: To ensure all project stakeholders share commitment in waste control, developing law enforcement by the government is needed (Tam et al., 2007)
3) Labors required: According to Wang et al. (2008), the processes of C&D waste management require a decent number of labors.
4) Specific machine: Specific machine is needed to effectively sort construction waste (Tam et al., 2007).
5) Skilled Labor: Kofoworola and Gheewala (2009) claimed that one of the problems of construction waste recycling in Thailand is the lack of skilled labors in waste collection and disposal.
6) Supported regulation: Supported regulation from government encourages contractors to recycle the C&D waste (Leigh et al., 2004).
7) Amount of landfills: The limitation of landfill spaces forces construction companies to search for other techniques to manage C&D waste (Pitt, 2005).
8) Environmental impact: Air and water pollution is one of the causes that force construction companies to recycle construction waste (Leigh et al., 2004).

9) Transportation cost: According to Shakantu et al. (2008), high transportation cost of waste disposal forces companies to consider waste recycling.
10) Value of the recycled materials: Value of recycled materials is important to the benefit of the company (Kofoworola and Gheewala, 2009).
11) Amount of waste generated: According to Tam et al. (2007), the increase of C&D waste requires more landfills to dispose of; this could be a problem for small country with limited space.
13) Reduction of virgin materials: The use of recycled materials helps reducing the need of virgin materials. (Merino et al., 2009).
14) Lack of market: Lack of a mature market for trading recycled C&D waste results in only small part of waste recycled and used in the construction processes (Yuan et al., 2011).
15) Company’s image: Implementing waste management as a part of company policy allows the company to enhance its public images as an environmental-friendly company (Hwang and Yeo, 2011).
16) Complication of recycling processes: The complication of recycling processes may increase the cost (Tam et al., 2007)
17) Limited site space: Limited site space can greatly affect the implementation of on-site construction and demolition waste management activities (Yuan et al., 2011).
18) Standard of the recycled waste: According to Richardson et al. (2010), if the standard of the recycled waste is not up to the standard, the contractors may not consider use it.
19) Time constraint: Time constraint may limit the implementation of C&D waste recycling (Lawson et al., 2001).
20) Intense competition: Intense competition in the construction industry may reduce the attention to recycle the C&D waste (Yuan et al., 2011).
21) Government’s financial support: According to Leigh et al. (2004), government support is crucial in a successful waste-recycling program.

Among the results stated, the most influencing factors for India are Law enforcement, Lack of skilled labor, and Government’s financial support.

IX. CAUSES OF PROBLEM IN THE INDUSTRY

In India, construction industry is unable to take appropriate economic benefits through cost savings. The setbacks behind the inability are discussed below.

Barriers for widespread adoption of waste management (Reduce, reuse and recycle) system as stated by (Wildermuth, 2008) are the following:
1) Lack of Awareness in the Industry: The major barrier in the industry is the lack of awareness among local contractors, construction labor and architects about waste management techniques and approach. Usually most of the waste that is produced during the
the construction process is the result of poor handling and techniques.

2) Lack of interest from clients: Another main reason for an ignorant industry is lack of importance given by clients in imposing waste reduction and management practices into the projects. Clients do not support those activities which do not offer tangible benefits to them. Potential of significant cost saving is not yet voluntarily implemented in projects and timing is given major preference.

3) Lack of proper training and education: Lack of contractor’s federations and professional institutes in the country which could significantly raise awareness among the clients and contractors about the possible economic benefits and its social consequences.

4) Lack of skilled labor: Major portion of construction labor in the industry is unskilled. Due to which proper waste handling methods are not adopted. Thus it is very important that contractors and sub-contractors should develop awareness and skills in labors.

5) Lack of market competition: The above mentioned barriers make the industry as a whole to be fragmented and fail to extract benefits from the much evident aspects. This leads to lack of competition among contractors, for e.g. if one contractor makes good cost savings from a project and increases their profit margins. Eventually this should then incentivize other contractors to get involved with waste minimization and management techniques. But mostly from a contractor’s viewpoint, taking up waste minimization and management is more of ex ante issue where risks are associated with the contractor to bear the cost implications. This will become widespread only after taking project initiative and then benefiting from them.

6) Lack of Government Interventions: Government regional, national policies and regulations are limited and are not implemented appropriately. Regulations like landfill tax or tax incentives to incorporate this approach in the project might enforce industry to explore cost savings seriously.

7) Lack of waste reduction approach by architects: Usually architects do not give preference to waste minimization approach during design and planning stage. Designing as per standard minimum sizes will eliminate wastage on sites.

X. ECONOMIC THEORY/MODEL

This theory/model will evaluate the economic feasibility in terms of cost saving by recycling and reusing waste. This will also help in examining how proper waste handling can economically benefit a project.

Generally, economic feasibility is carried out by standard measures of profitability, which is cost- benefit analysis. According to the US EPA (2002), waste management makes good economic and business sense and at the same time it can improve production efficiency, product quality and environmental performance. We evaluate project cost and waste management using a cost function to estimate overall, input specific and marginal production cost of waste reduction.

Net benefits can be expressed by eq. (1), which is by subtracting total benefits by total costs.

\[ \text{Net benefits} = \text{Total Benefits} - \text{Total Costs} \]...(1)

Now considering the terms which should be included in total benefits are as following

1) Purchasing cost savings \((P_C)\) by reusing construction waste materials. Company can save money by reusing and buying recycled materials instead of buying virgin materials from the market. (Cost savings from market price = Average market price /unit x total amount of reused and recycled individual material – Cost of purchasing reused and recycled material at lower cost).

This is estimated to be 25% less than virgin materials. (Begum & Siwar, (2006)), Denoted as \(P_C\)

2) Revenue from selling of construction waste materials, Denoted as \(R_S\)

3) Waste collection and transportation cost savings from disposing less material to landfill, Denoted as \(W_{ST}\)

4) Cost savings from landfill charges by reusing and recycling of construction waste materials, Denoted as \(L_C\)

5) Intangible Benefits, Denoted as \(A^*\).

Therefore,

\[ \text{Total Benefits (TB)} = \text{PC} + \text{RS} + \text{WST} + \text{LC} + \text{A*} \]...(2)

Total costs are all incremental costs associated with the reusing and recycling of construction waste materials. This is sum of all direct, indirect and intangible costs. Followings are the terms included in total costs.

1. The collection and separation costs of construction waste materials, Denoted as \(CS_C\)

2. The storage cost of waste material, Denoted as \(SC\)

3. The transportation cost of disposing waste to landfill, Denoted as \(TC\)

4. The intangible costs, Denoted as \(A^*\)

Therefore,

\[ \text{Total Costs (TC)} = \text{CSS} + \text{SC} + \text{TC} + \text{A*} \]...(3)

Net Benefits = Total Benefits > Total Costs…(4)

Costs are the key main determinants for decisions and choices for waste management technologies and practices. Financial constraint is the main reason for low priority for waste management. In fact the cost of implementing waste management practices is given more preference than benefits. Quantifying all the associated benefits and the costs in monetary value and also considering the intangible costs and benefits can give a clear picture of the economic benefits of reusing and recycling of construction waste.

Although Begum & Siwar, (2006) suggests that practices that induce waste reduction from the beginning through proper planning, designing etc should be encouraged. This would not only ensure reduced quantity of waste production on site but also less quantity of waste material to be reused and recycled and thereby reducing the cost implications associated with waste management. Following section shall discuss the strategies to mitigate this problem and its economic relevance.

XI. EVALUATING PRACTICAL RELEVANCE

Strategies to mitigate the problem of recycling and reuse at industry level will require government intervention to initiate the waste minimization and management system. The high costs of landfill charges and high taxes of using...
virgin materials along with various institutions and organization initiatives can create a derived demand – supply dynamics in the industry.

Demand from the clients will initiate contractors to develop and experiment various methods of waste minimization and extract possible cost savings from various projects. Benefits from cost savings will encourage more contractors to adopt and compete in the market to outbid the other. This will initiate market competition to evolve in the industry, which will soon appear at significant level.

As a result of the Government incentives on using recycled material instead of virgin ones, will increase the demand for recycled materials in the industry. The whole process will also make construction material manufacturing firms to actively participate and change their production process. Waste decisions by manufacturing firms in the context of production costs, and thus in terms of their impacts on input use, output production, and efficiency will be considered. A primary goal of firms is the maximization of output production while minimizing private costs. Minimizing environmental costs may also be a key target, if there is sufficient market or social incentives (Chapple, Morrison, & Harris, 2005). Reaching these objectives involves making choices about waste generation, in combination with other production decisions.

As a result of this lack of appropriate handling of waste in the industry coupled by waste in economic terms can be dealt with in significantly creating a demand in the industry.

Thus the above strategies will contribute in creating a demand – supply dynamics once its economic implications are widely understood and implemented. Demand from clients will initiate a supply side of system from contractors, which in turn will demand appropriate materials from manufacturers and also provide them with raw materials to recycle from the waste. Recycle and reuse of construction material waste can also help the economy through the creation of jobs related to salvaging and recycling of construction waste. New products create jobs through the manufacture of recycled content materials.

XII. CONCLUSION

Due to least priority given to the reuse and recycle of waste, current practice adopted in India is backward in comparison with developed countries. As a developing country it is of immense important that proper priority and focus should be drawn to reuse and recycling of waste for the economics and environmental benefits achieved from it. The huge quantities of waste generated every year not only detrimental at environmental level as most of it disposed of in landfill but also in economic terms as waste material have their specific economic value before getting discarded.

Examining various reasons for the problem, lack of awareness among clients and contractors, lack of skilled labor, lack of proper training and education, minimal Government interventions etc. are few of the many reasons that significantly affect the Industry as a whole.

First step toward mitigating the problem would be government’s interventions like landfill tax, higher cost of virgin materials, tax credit for recycling and use of recycled material etc. can act as an initial momentum towards seeking adequate recycling and reusing. Institution and local organization can create awareness among clients and contractors that will initiate demand for reuse and recycling.

These steps can create a market driven mechanism in the industry, with demand and supply factor and market competition, which will help to mitigate this problem that will both, benefit the economy and the environment.

XIII. RECOMMENDATIONS

Waste reuse and recycle system may also have its limitations. Proper market for recycling and reusing of waste will require an aggressive and intense marketing effort to locate markets to sell waste material to be recycled and then processed recycled material to be sold at appropriate prices. The current scenario in India market for recycle and reuse requires significant time and money to ensure its feasibility. Also skills and technology requires for recycle and reuse must be developed with context to Indian need.

REFERENCES