CONSTRUCTION AND DEMOLITION WASTE RECYCLING FOR SUSTAINABLE GROWTH AND DEVELOPMENT

Hemalatha B.R\textsuperscript{1}, Nagendra Prasad\textsuperscript{2}, B.V. Venkata Subramanya\textsuperscript{3}

1. Civil Department, RLJIT, Dodaballapur, Bangalore (INDIA)
2. Environment Department, P.E.S.C.E, Mandya, Karnataka (INDIA)
3. Civil Department, MSRIT, Bangalore (INDIA)

*E-mail : hemabrenv@gmail.com

Received November 7, 2007 Accepted April 13, 2008

ABSTRACT

Construction and demolition (C and D) waste is defined as the solid waste generated by the construction, remodeling, renovation, repair, alteration or demolition of residential, commercial, government or institutional buildings, industrial, commercial facilities and infrastructures such as roads, bridges, dams, tunnels, railways and airports. Construction and demolition waste is considered as high volume, low risk. It is commonly understood that this waste can be considered a resource, either for reuse in its original form or for recycling or energy recovery. Because of increasing waste production and public concerns about the environment, it is desirable to recycle materials from building demolition. If suitably selected, ground, cleaned and sieved in appropriate industrial crushing plants, these materials can be profitably used in concrete. Despite this, most Construction and Demolition waste ends up in landfills. This paper highlights the composition of Construction and Demolition waste, the need for its recycling and options that can be implemented for its efficient use in the field of concrete technology in general.

Key Words : Recycling, Concrete, Sustainable, Hazardous components, Mobile plant

INTRODUCTION

Construction and demolition (C and D) waste constitutes a major portion of total solid waste production in the world. C and D waste is generated whenever any construction / demolition activity takes place, such as building, roads, bridges, flyover, subway, remodeling etc. these wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin. It is not uncommon to see huge piles of such waste, which is heavy as well, stacked on roads especially in large projects, resulting in traffic congestion and disruption. It constitutes 10-20\% of the municipal solid waste (excluding large construction projects). Hence appropriate management of this waste is required.

With an enormous increase in the quantity of disposable materials on one hand and a continuing shortage of dumping sites on the other, the waste disposal problems is assuming serious and at times, even alarming proportions.
Preservation of the environment and conservation of the rapidly diminishing natural resources should be the essence of sustainable development. Continuous industrial development poses serious problems of construction and demolition waste disposal.\(^1\)

Whereas on the other hand, there is critical shortage of natural aggregate for production of new concrete, on the another, the enormous amounts of demolished concrete produced from deteriorated and obsolete structures creates severe ecological and environmental problem.\(^2\) Recycling of aggregate materials from construction and demolition waste may reduce the demand – supply gap in both these sectors.

Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled aggregate can be used to make concrete for road construction and building material.

According to a study commissioned by Technology Information Forecasting and Assessment Council (TIFAC), New Delhi, 70% of the construction industry is not aware of recycling techniques. The study recommends establishment of quality standards of recycled aggregate materials and recycled aggregate concrete. This would help in setting up a target product quality for producer and assure the user of a minimum quality requirement, thus encouraging him to use it.

**Characteristics**

This category of waste is complex due to the different types of building materials being used, but in general may comprise the following materials:

<table>
<thead>
<tr>
<th>Major Components</th>
<th>Minor Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Concrete</td>
<td>Pipes (GI, Iron, plastics)</td>
</tr>
<tr>
<td>Bricks</td>
<td>Electrical fixtures (Copper/aluminium wiring, wooden baton, bakelites/plastic switches, wire insulation)</td>
</tr>
<tr>
<td>Cement plaster</td>
<td>Panels (wooden, laminated)</td>
</tr>
<tr>
<td>Steel (from R.C.C, door / window frames, roofing supports, railings of staircase etc)</td>
<td>Others (glazed tiles, glass panes, and paints)</td>
</tr>
<tr>
<td>Rubble</td>
<td></td>
</tr>
<tr>
<td>Stone (marble, granite, sand stone)</td>
<td></td>
</tr>
<tr>
<td>Wood/Timber (especially demolition of old buildings)</td>
<td></td>
</tr>
</tbody>
</table>

The EPA report regrouped C and D waste into the 6 categories shown in Fig. 1.

**Fig. 1** : Source: Characterization of Building-related C and D waste in USEPA 530-R-98-010, June, 1998
Effects of Environment

Construction of any infrastructure make a considerable environmental impact through extraction of raw materials, the use of energy in production processes and transport, production of masses by byproduct waste, and the damage to environment and health in all phases of the life cycle of hazardous components.

The disposal of C and D wastes has become a major concern in recent year. Some building owners, waste haulers and demolition contractors are disposing of this waste improperly and illegally in order to avoid transportation costs and tipping fees at waste disposal facilities. Illegal disposal sites have been discovered in gravel pits and ground water recharge areas, on farm land, and prime residential property, and in borrow pits and low lying areas.

The land disposal of C and D waste presents a threat of ground water contamination because of trace amounts of hazardous constituents, which are sometimes encountered. The potential for ground water contamination results from small amounts of hazardous materials, such as organic compounds or heavy metals that may be present in substances that have been applied to construction materials, or by the improper disposal of residues or bulk chemicals in the waste stream. Degradation of ground water quality may also result from larger amount of generally non-toxic chemicals, such as Chloride, Sodium, Sulphate, and Ammonia that may be present in leachate generated from C and D waste materials (Ex: wood, concrete, metal, drywall, asphalt) when land filled. Therefore the improper disposal of C and D waste does pose a threat to ground water quality.

An illegal disposal site may also attract the illegal disposal of other types of waste, including conventional municipal waste, industrial waste and hazardous waste this would further impact the site and increase the future cost for cleaning up an impacted or contaminated site. The open burning of demolition material is a major concern and is prohibited. Plastic material, insulation foam, painted or treated wood, etc. will give off toxic fumes when burnt. Demolition material from ware housing buildings, industrial and agricultural facilities may be contaminated with chemicals some spillage or from their normal operation. Leachate from the ashes may impact the ground water. Health Canada advises that “burning any form of treated wood represents a health hazard and should be avoided”.

Recycling of C and D Waste

C and D waste management may be defined as the discipline associated with the proper storage, collection and transportation, recovery and recycling, processing, reusing and disposal of C and D wastes in a manner that is in accord with the best principles of human health, economic, engineering, aesthetics and other environmental considerations. The management approaches are different from one country to another, as are the levels of environmental protection. Most of the C and D management systems reviewed on the following basis:

C and D waste management includes following steps.
1. Storage and segregation.
2. Collection and transportation.
3. Recycling and reuse.
4. Disposal.

Storage and Segregation

C and D wastes are best stored at source i.e. at the point of generation. If they are scattered around or thrown on the road, they not only cause obstruction to traffic but also add to the work load of the local body. A proper screen should be provided so that the waste does not get scattered and does not become an eyesore.

Segregation can be carried out at source during C and D activities or can be achieved by processing the mixed material to remove the foreign materials. Segregation at source is most efficient in terms of energy utilization,
economics and time. Gross segregation of C and D wastes into road work materials, structural building materials, salvaged building parts and site clearance waste is necessary. Additional segregation is required to facilitate reuse/recycling of materials like wood, glass, cabling, plastic, plaster board and so on before demolition in order to produce recycled aggregate that will meet the specification.

Collection and Transportation

If the C and D debris is stored in skips, then skip lifters fitted with hydraulic hoist system should be used for efficient and prompt removal. In case, trailers are used, then tractors may remove these. For handling very large volumes, front-end loaders in combination with sturdy tipper trucks may be used so that the time taken for loading and unloading is kept to the minimum.

Recycling and Reuse

C and D waste is bulky and heavy and is mostly unsuitable for the disposal by incineration/ composting. The growing population and requirement of land for other uses has reduced the availability of land for waste disposal. Reutilization or recycling is an important strategy for management of such waste. Apart from mounting problems of waste management, other reasons which support adoption of reuse/recycling strategy are reduced extraction of raw materials, reduced transportation cost, improved profits and reduced environmental impact. Above all, the fast depleting reserves of conventional natural aggregate has necessitated the use of recycling/reuse technology, in order to be able to conserve the conventional natural aggregate for other important works.

In the present context of increasing waste production and growing public awareness of environmental problems, recycled materials from demolished concrete or masonry can be profitably used in different ways within the building industry. The study survey indicates the major components of the C and D waste stream are excavation material, concrete, bricks and tiles, wood and metal.

Concrete

Concrete appears in two forms in the waste. Structural elements of building have reinforced concrete, while foundations have mass non-reinforced concrete. Excavations produce top soil, clay, sand and gravel.

Excavation materials may be either
reused as filler at the same site after completion of work, in road construction or in stone, gravel and sand mines, land fill construction, structural fill in low lying areas to assist in future development, in garden and land scaping.

Concrete and masonry constitute more than 50% of waste generated. It can be reused in block/slab form. 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 industry. 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 differentiated 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. The plant is transported to the demolition site itself and is 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. End product quality is better than that of a mobile plant.

Above plants are not capable to process a source of mixed demolishing waste containing foreign matter like metal, wood, plastic, etc. Stationary plants are equipped for carrying out crushing, screening as well as purification to separate the contaminants. Issues necessary to be considered for erection offer stationary plant are: Plant location, road infrastructure, availability of land space, provision of Weigh Bridge, provision for storage area etc.

Different types of crushers are used in recycling plant namely jaw-crusher, impact crusher, impeller-impact crusher4.

**Applications**

Recycled aggregate can be used as general bulk fill, sub base material in road construction, canal lining, play ground, fills in drainage projects and for making new concrete to less extent. While using recycled aggregate for filler application, care must be taken that it is free of contaminants to avoid risk of ground
water pollution use of recycled aggregate are sub-base for road construction is widely accepted in most of countries.

Brick and masonry arise as waste during demolition. These are generally mixed with cement, mortar or lime. It is used in the construction of road base and drainage layer, and mechanical soil stabilizers due to its inertness after crushing and separation.

Tile materials recycling are almost identical to bricks. Tile is often mixed with brick in final recycled product.

Metal waste is generated during demolition in the form of pipes, light sheet material used in ventilation system, wires and sanitary fittings and as reinforcement in the concrete. Metals are recovered and recycle by re-melting. The metals involved onsite separation by manual sorting or magnetic sorting. Aluminium can be recovered without contamination, the material can be directly sold to an recycler.

Wood recovered in good condition from beams, window frames, doors, partitions and other fittings is reused. However wood used in construction is often treated with chemicals to prevent termite infestation and warrants special care during disposal other problems associated to wood waste are inclusion of jointing, nails, screws and fixings.

Infact wood members have a high market value for special reuses (furniture, cabinets, and floorings). Lower quality waste wood can be recycled/burned for energy recovery. Scrap wood is shredded in-site/in a centralized plant. Shredded wood is magnetically sorted for scrap metal. Wood chips are stored so as to remain dry and can be used as fuel. Also it is used in the production of various press boards and fiber boards and used for animal bedding.

Bituminous material arises from road construction, breaking and diggng of roads for services and utilities. Recycling of Bituminous material can be carried out by hot or cold mixing techniques. Recycling of waste either at location or at a central asphalt mixing plant it offers benefits like saving in use of asphalt, saving of energy, reduction in aggregate requirement etc.

Other miscellaneous materials that arise as waste include glass, plastic, paper etc. can be recovered and reused.

**Disposal**

Being predominantly inert in nature, C and D waste dose not create chemical or Bio-chemical pollution. Hence maximum effort should make to reuse and recycle them as explained above. The material can be used for filling/leveling of low-lying areas. In the industrialized countries, special land fills are some times created for inert waste, which are normally located in abandoned mines and quarries.

**The Indian Scenario**

Indian construction industry is highly employment intensive and accounts for approximately 50% of the capital out lay in successive 5-year plans of our country. The projected development in the building sector continues to show a growing trend. Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons/annum of which waste from construction industry accounts for 25%. The total quantum of waste from construction industry is estimated to be 12 to 14.7 million tons per annum. Quantity of different constituents of waste that arise from construction industry in India is estimated as follows:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Quantity generated in million tons/annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil, Sand, Gravel</td>
<td>4.20 – 5.14</td>
</tr>
<tr>
<td>Bricks and Masonry</td>
<td>3.60 – 4.40</td>
</tr>
<tr>
<td>Concrete</td>
<td>2.40 – 3.67</td>
</tr>
<tr>
<td>Metals</td>
<td>0.60 – 0.73</td>
</tr>
<tr>
<td>Bitumen</td>
<td>0.25 – 0.30</td>
</tr>
<tr>
<td>Wood</td>
<td>0.25 – 0.30</td>
</tr>
</tbody>
</table>
The recycled technology for C and D waste has to be established on a pilot scale in India. It is recommended that pilot scale plant for producing recycled aggregates is established and application of recycled aggregates in different construction activities is demonstrated. Central Road Research Institute or Central Building Research Institute may be involved to put up a pilot plant and establish use of recycled aggregate in road and building construction.

CONCLUSION

There should be a proper institutional mechanism to take care of the collection, transportation, intermediate storage (if necessary), utilization and disposal of the C&D waste. In number of municipalities, the sanitary department or the Health Department is responsible for garbage whereas the Engineering or the planning Department is responsible for C and D waste. Under such circumstances, it is extremely important that either the Solid Waste Management department is made responsible for collection of C and D waste or these departments work in close coordination. It is essential that proper accountability is fixed and official information is readily available regarding day to day situation.

The civic authority should consider the following points and after deliberations get them approved by the competent authority, except those which already exist in their municipal act.

- The civic authority should notify that no person should dispose of C and D waste on the streets/pavements/storm drainage/open land belonging to the municipality or the government. In case such waste is dumped on a private land, the owner of such land would be accountable for the act and would be held responsible for any degradation of the surrounding environment or causing of any pollution.
- Such waste should be stored within the premises till they are removed from the site to a place notified/permited by the body.
- In case of new construction, the advance is to be deposited with the application for sanction of the building plan. The charges would be notified by the civic authority and would be refundable after due deductions in case of compliance of the stipulated laws. In case of any default, the whole amount would be confiscated.
- These rules/notifications would also be valid for Government, Semi-Government and Public Sector Departments.

REFERENCES

2. Elisabeth Schachermayer et al., Assessment of Two different separate techniques for Building wastes, Waste management & Research, 18, 16-24, (2000).
5. Kumar Mehta P. and Paulo J.M. Monteiro, Concrete, Microstructure, Properties and materials, Indian Concrete Institute, Chennai (2005).