MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE

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ABSTRACT

Waste materials are common problem in modern living. Waste accumulates from number of sources including domestic, industrial, commercial, construction and demolition activity. A significant portion of municipality waste is construction related. Proper management of construction and demolition waste is important or else it will get mixed with municipal waste. This type of mixing leads to cutting off the recycling options for C and D waste and also reduces the efficiency of further municipal waste processing. Land disposal of C and D waste presents a threat of ground water contamination because of trace amount of hazardous constituents, which are some times encountered. In this article possibilities of C and D waste recycling options are discussed, which includes recycling of concrete aggregate; their properties and constrains in reusing of C and D waste concrete. This also highlights the possible use of recycled aggregate in which further research is necessary.

Key Words: Municipal waste, C and D waste, Recycling, Strength, Recycled aggregate.

INTRODUCTION

Waste generates from all human activities. These waste materials have to be eventually disposed off in ways that do not endanger human health. In light of this, waste minimization is increasingly seen as an ecologically sustainable strategy for alleviating the need to dispose of waste materials, which is often costly, time and space consuming, and can also have significant detrimental impacts on the natural environment.1

Enormous growth in construction activities increases the amount of construction waste. Recycling of construction waste is an important component of environmentally responsible construction, as it reduces the amount of waste directed to landfills. A significant portion of municipality waste is construction related, so its reduction becomes important. Construction
companies benefit by reducing the waste generation in number of ways, including reducing transportation and landfill deposition costs, and purchasing costs of virgin materials.  

**Construction and Demolition (C and D) waste**

Construction and demolition (C and D) debris produced when new structures are built and when existing structures are renovated or demolished. Many definitions of C and D debris also include trees, stumps, earth, and rock from the clearing of construction sites. Construction and demolition debris means uncontaminated solid waste resulting from the construction, remodeling, repair and demolition of utilities, structures and roads and uncontaminated solid waste resulting from land clearing.

When buildings are demolished, large quantities of waste will be produced in a relatively shorter period of time, depending on the demolition technique used. On a per building basis, demolition waste quantities may be 20 to 30 times as much as construction debris. Ordinary concrete typically contains about 12% cement and 80% aggregate by mass. This means that globally, for concrete making, we are consuming sand, gravel, and crushed rock at the rate of 10 to 11 billion tones every year. Mining, processing, and transport operations involving such large quantities of aggregate consume considerable amounts of energy, and adversely affect the ecology of forested areas and riverbeds.  

![Generation of Construction and Demolition debris from buildings.](image)

**Fig. 1:** Generation of Construction and Demolition debris from buildings.

**Characteristics of C and D Waste : The Indian scenario**

The idea of recycling concrete waste as coarse aggregates for new construction is gaining importance on the international scale. In India very few attempts have been made to use recycled aggregates on large scale. Estimated waste generation during construction and renovation work is 40-60 and 40- 50 kg/m² respectively. The highest contribution to waste generation is from demolition of buildings, which yields 300-500 kg/m² of waste. Recycling technology for C and D waste has to be established on a pilot scale in India and is recommended that application of recycled aggregates in different construction activities are to be demonstrated. Central road research Institute
Table 1: Estimation of Quantity of different constituents of waste that arise from construction industry in India is estimated as follows.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Constituent</th>
<th>Quantity generated in Million tones / Annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soil, Sand and Gravel</td>
<td>4.2 – 5.14</td>
</tr>
<tr>
<td>2</td>
<td>Bricks and Masonry</td>
<td>3.6 – 4.4</td>
</tr>
<tr>
<td>3</td>
<td>Concrete</td>
<td>2.4 – 3.67</td>
</tr>
<tr>
<td>4</td>
<td>Metals</td>
<td>0.6 – 0.73</td>
</tr>
<tr>
<td>5</td>
<td>Bitumen</td>
<td>0.25 – 0.3</td>
</tr>
<tr>
<td>6</td>
<td>Wood</td>
<td>0.25 – 0.3</td>
</tr>
<tr>
<td>7</td>
<td>Others</td>
<td>0.1 – 0.15</td>
</tr>
</tbody>
</table>


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. In India concept of recycling is not so popular compare to other countries because,

1. Acceptability of recycled materials is hampered due to the poor image associated with recycling activity in India.
2. Low dumping cost prevalent in India acts as a barrier for recycling activity. Imposition of considerable charge on sanitary landfill can induce builders and owners to divert the waste for recycling.
3. Non awareness of recycling possibilities is one of the main barrier due to which waste is disposed only in landfills.
4. There is lack of government support and commitment towards development of recycling industry. Development of policy supported by proper regulatory framework is necessary
5. Development of proper standards, specifications for recycled materials would provide producers a targets and users an assurance in quality of material.

Effects of C and D waste on environment:
Disposal of C and D waste has become a major concern in recent years. Some building owners, waste haulers and demolition contractors are disposing this waste improperly and illegally in order to avoid transportation cost and tipping fee, at waste disposal facilities. Illegal disposal sites have discovered in gravel pits and ground water recharging areas, on farm land and prime residential property and low lying areas. Potential ground water contamination results from small amount of hazardous materials such as organic compounds, heavy metals that may be present in the substances that have been applied to construction materials, or by improper disposal of residues or bulk chemicals in the waste stream. Degradation of ground water quality may also results 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, when land filled. Therefore we can say that,
improper disposal of C and D waste does pose a threat to ground water quality.

An illegal disposal site may also attract, illegal disposal of other types of waste including conventional municipal waste, industrial waste and hazardous waste. These would further impact the site and increase further cost for cleaning up the contaminated site. Open burning of demolition material is a major concern. Plastic material, insulation foam, painted wood will give toxic fumes when burnt. Leachate from ashes impact the ground water quality.

RESULTS AND DISCUSSION

Recycling of construction and demolition waste for the production of concrete is not new. It is well known that, this was successfully used previously in various forms of construction during Second World War. Europe utilized the recycled aggregates in its reconstruction on a large scale.

Test results of Poon et.al., shows that, replacement of coarse and fine natural aggregates by recycled aggregates at the levels of 25 and 50% had little effect on the compressive strength of the bricks and blocks, but higher levels of replacement reduced the compressive strength. However, the transverse strength of the specimens increased as the percentage of the replacement increased. Using recycled aggregates as replacement for natural aggregates at the level of up to 100%, concrete paving blocks with a 28-day compressive strength of not less than 49 MPa can be produced without incorporation of fly ash, while paving blocks for footway uses with a lower compressive strength of 30 MPa and masonry bricks can be produced with the incorporation of fly ashes. Performance of bricks and blocks are also satisfactory in the shrinkage and skid resistance tests.

Recent study at Hong Kong Polytechnic University aims to develop a technique for using recycled aggregates in molded concrete bricks and paving blocks. The bricks are expected to achieve a 28-day compressive strength of not less than 7 MPa according to the requirement of BS 6073 for masonry units. The paving blocks are expected to achieve either a 28-day compressive strength of not less than 49 MPa according to requirement of BS 6717. Laboratory trials were carried out to prepare the molded specimens with the dimension of 225×105×75 mm, with up to 100% by weight of the natural aggregates (both coarse and fine) replaced by recycled aggregates. Attempts were also made to incorporate fly ashes into the bricks and blocks. Density, compressive strength, transverse strength, shrinkage and skid resistance of the specimens were determined. In addition to the laboratory trials, a plant trial was conducted to test the feasibility of using recycled aggregates in producing molded paving blocks in real industrial production conditions.

Successful application of recycled aggregate in construction projects has been reported in some European and American countries, as reviewed by Desmyster and Vyncke. While this type of material has been used in a large amount in non-structural concretes or used as road bases, its use in structural concrete is limited. Only a few cases have been reported on the use of recycled aggregates in structural concrete, and the amount of recycled aggregate used has generally been limited to a low level of replacement of the total weight of coarse aggregate. An example is a viaduct and a marine lock project in the Netherlands in 1988, and an office building
in the UK in 1999. In the first case, a total of 11,000 m$^3$ of concrete in which 20% of the coarse aggregates were replaced by recycled aggregates were used in all parts of the structures. Another reported case involved the use of 4000 m$^3$ of ready mixed concrete, which were prepared with recycled aggregates obtained from crushed concrete railway sleepers to replace 40% of the coarse aggregates. It should be noted that in these cases recycled aggregates were used only to replace the coarse natural aggregates.$^{13-15}$

Limited use of recycled aggregate in structural concrete is due to the inherent deficiency of this type of material. In comparison with natural normal weight aggregates, recycled aggregates are weaker, more porous and have higher values of water absorption. Results of research studies show that, when recycled aggregates obtained from crushed concrete are used to replace up to 20% by weight of the coarse natural aggregate in concrete, little effect on the properties of concrete is noticed. However, when used at a higher level of replacement, the high water absorption ability of recycled aggregate results in a higher total water demand. This renders control of the free water-to-cement ratio (w/c) and the workability of fresh concrete difficult and, results in a higher shrinkage and creep of the hardened concrete when compared with the concrete prepared with natural aggregates. The extent to which the properties of concrete are affected by the use of recycled aggregate depends on the water absorption, crushing value and soundness of the recycled aggregate. Recycled-concrete aggregate, particularly the recycled masonry aggregate, has a higher porosity than natural aggregate. Therefore, with a given workability, the water requirement for making fresh concrete tends to be high and mechanical properties of hardened concrete are adversely affected. The problem can be resolved by using blends of recycled and natural aggregate or by using water-reducing admixtures and fly ash in concrete.$^{16-20}$

However, the disadvantages of using recycled aggregates in structural concrete can be avoided in concrete mixtures for mechanized molded concrete bricks and blocks. This is because in manufacturing concrete bricks and blocks using a mechanized molding machine, the mixed materials are molded under a combined vibrating and compacting action. The requirement for maintaining a workable mix is not so important. Only a minimal amount of water is needed to make the mixture fluid enough to be fed into the molding machine. This reduces the difficulties of controlling the w/c ratio and workability. Also, the low water content of the concrete mixtures for the molded bricks and blocks significantly reduces the creep and shrinkage of the hardened products. An attempt has been made by Collins et al to use recycled aggregates in making blocks for a beam and block floor system. The blocks were 440×215×100 mm in dimension and were produced at a block factory. Recycled aggregates were used to replace 25 to 75% by weight of the natural aggregate (including coarse and fine aggregates). A compressive strength of 6.75 MPa and a transverse strength of 1.23 MPa were reported for the blocks with 75% of the natural aggregates replaced by recycled aggregates.

Research on environmental impacts of building materials or sustainable construction is also being carried out in, for example, Germany, Austria, US, Japan and Australia.
Suitability of recycled aggregate in construction: Only part of C and D waste recycled aggregate is suitable for use in non-structural concrete. The C and D waste visual sorting, crushing, and sieving approach is insufficient to produce recycled raw material for use in structural concrete. Nevertheless, there is variability in C and D waste aggregate composition and other physical properties such as bulk specific gravity and water absorption, which interfere in concrete and mortar performances.

Therefore, fast and reliable characterization techniques must be developed in order to classify C and D waste according to their possible uses. Furthermore, this variability demands C and D waste quality control and technological approach to both concrete and mortar applications. Analyzing the specifications of recycled coarse aggregate for concrete, the sink-float products with specific gravity above 2.3 g/cm³, equivalent to more than 70% (w/w), would present physical qualities to be used in structural concrete, which market is essentially dominated by conventional natural aggregates. Based on physical properties of the attained products a size classification followed by gravity concentration would allow producing an aggregate for use in structural concrete as well as high strength concretes.

The end-use of the aggregate recovered from concrete waste depends on its cleanliness and soundness, which are controlled by the source of origin of the rubble and the processing technology. Aggregate recovered from surplus fresh concrete in pre-casting yards and ready-mixed concrete plants are generally clean and similar in properties to the virgin aggregate. Concrete rubble from demolition of road pavements and hydraulic structures requires screening to remove the fines. Many laboratory and field studies have shown that the size fraction of the concrete rubble corresponding to coarse aggregate can be satisfactorily used as a substitute for natural aggregate. A comparison of properties of concrete from natural aggregate and the recycled concrete aggregate shows that the latter would give at least two-thirds of the compressive strength and the elastic modulus of natural aggregate.

CONCLUSION
In addition to environmental protection, conservation of natural aggregate resources, shortage of waste disposal land, and increasing cost of waste treatment prior to disposal are the principal factors responsible for growing interest in recycling concrete waste as aggregate. Masonry and bricks can be crushed and used in place of gravel, as aggregate in low grade concrete, as unbound base course material or for low grade fill material. High quality bricks can be cleaned and reused whole. Apart from reconstruction, construction demolition, debris also results from natural calamities. Depletion in the supply of quality aggregates has lead to the use of recycled aggregates. Prevention of the environment and conservation of rapidly diminishing natural resources should be the essence of sustainable development. There is critical shortage of natural aggregate for the production of new concrete on the other hand enormous quantity of demolished concrete produced from deteriorated and obsolete structures, creates ecological and environmental problems. Recycling of aggregate materials from construction and demolition waste may reduce the demand supply gap in both the sectors. C and D wastes are normally composed of concrete rubbles,
bricks and tiles, sand and dust, timber, plastics, cardboard and paper, and metals. Concrete rubbles usually constitute the largest proportion of the C and D waste. It has been shown that the crushed concrete rubble, after separated from other C and D wastes and sieved, can be used as a substitute for natural coarse aggregates in concrete or as a sub-base or base layer in pavements. This type of recycled material is called recycled aggregate. Construction and demolition waste consists of masonry and old concrete rubble. This presents a great opportunity for the concrete industry to improve its resource productivity by using coarse aggregate derived from construction and demolition wastes. In many parts of the world, dredged sands and mining wastes can be processed for use as fine aggregate. Recycling these wastes in spite of some processing cost is becoming economical, particularly in countries where land is scarce and waste disposal costs are very high. In addition, virgin aggregate deposits have already been depleted in many areas, and hauling aggregates over long distances can be much more expensive than using a free or a low-cost source of local recycled aggregate. Recycled concrete, in some cases, is being used as a road fill, which is better than landfill but it is “down-cycling” in the sense that virgin aggregate continues to be used for making new concrete.

Increased reuse and recycling can therefore be encouraged by the use of economic instruments and can contribute to a more sustainable construction industries. However, recycling has its own share of impacts arising from transport and processing that should be considered in the decision-making process and the Best Practicable Environment Option (BPEO) for a particular construction waste stream will vary depending on local circumstances.\(^27\)

In general, the recycled products are civil construction aggregates mostly used in pavement activities. However, this use is not sufficient to consume all produced Construction and Demolition Waste. There is demand to develop other uses such as mortar and concrete aggregates.\(^28\)

The ability to design and build structural members that last for 500 years or more instead of 50 will in the long run increase the concrete industry’s resource productivity by tenfold. Meanwhile, by substituting recycled materials for natural materials, as described in this article, it should be possible to substantially improve the resource productivity of the concrete industry immediately.

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