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Utilization of Construction & Demolition Waste in Road Sector

Shivam Gupta[1] and Rachit Khandelwal[2]

[1]Under Graduate Student, Department of Civil Engineering, Jaypee University of Engineering & Technology, Guna, M.P.
[2]Under Graduate Student, Department of Civil Engineering, Jaypee University of Engineering & Technology, Guna, M.P
E-mail: [1]shivam04june@gmail.com, [2]rachit611@gmail.com

Abstract—*Construction waste management is a quite important, economical and environmental deal for our societies. The need to manage construction and demolition waste (CDW) has led to environmentally-friendly actions that promote the reuse and recycling of this type of waste. In the last two decades, a variety of recycling methods for construction and demolition wastes (CDW) have been developed.It is estimated that the construction industry in India generates about 10-12 million tons of waste annually. Projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55,000 million cu.m. An additional 750 million cu.m. aggregates would be required for achieving the targets of the road sector. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sectors. The scarcity in the availability of aggregate for the production of concrete is one of the important problems facing by the construction industry. Appropriate use of the construction waste is a solution to the fast degradation of virgin raw materials in the construction industry. The aim of this study is to show the technical viability of using construction waste as material for the base pavement layers of road surfaces. Further, this paper shows that re-use of construction and demolition waste is very well possible and results in good quality materials which can be used to build durable and sustainable pavement structures. This paper also enlightens the importance of reduce, reuse and recycle (3R) concept for managing the construction waste in India.*

1. INTRODUCTION

Environmental Protection Agency (EPA) defines construction and demolition debris as the waste material produced in the process of construction, renovation or demolition of structures (both buildings and roads). In addition, it includes the materials generated as a result of natural disasters. Construction wastes are mainly leftovers from new construction materials like cut-offs, damaged materials, packaging waste, used materials during construction and all other wastes typical for activities for activities on a construction site. Demolition waste are mainly the collection of all construction materials from a building after removal of certain parts. Demolition wastes are much larger in volume than the construction wastes.

The concept of C& D waste management is new and it is essentially required to spread the education and informationin order to gain the public support. The present mindset of public and their attitude towards the waste generated fromconstruction and demolition sites is required to be changed which is possible only with the education in this field. It is required to sensitise not only the Engineers, but all stakeholders including regulatory authorities in constructionindustry. One must understand the reuse potential of C& D waste and existing practices in implementation andenforcement for achieving the aim with an ultimate motive of Environmental sustainability.

Recycling cost is influenced by transportation distance and amount of waste concrete to be recycled. CO2 emission isinfluenced by transportation distance. It is important to minimize C&D waste generation and maximizereuse/recycling as the construction industry is consumer of tremendous amount of natural resources and energy aswell as emitter of GHGs.

In future, recycled aggregates from C&D waste could act as substitutesfor primary aggregate extraction to a much greater extentthan the way they are currently being used. There is a potentialfor these materials to be crushed and used as recycled aggregates(RA) in applications such as road base and sub-base construction.To date only a small number of investigations have dealt withthe use of RA in hot mix asphalt (HMA). The performance of HMA with coarse RA is related totheir heavily crushed face, which contributes to the internalfriction for permanent deformation resistance. From this point of view, HMA made with coarse RA showed a better performance interms of permanent deformation and stiffness than HMA elaborated with only natural aggregates (NA).

2. COMPONENTS OF CONSTRUCTION AND DEMOLITION WASTE

In general, Construction and Demolition Waste may comprise the following materials:

2.1. Major components

- Cement concrete
- Bricks
- Cement plaster
- Steel (from RCC, door/window frames, roofing support, railings ofstaircase etc.)
- Rubble
- Stone (marble, granite, sand stone)
- Timber/wood (especially demolition of old buildings)

2.2. Minor components

- Conduits (iron, plastic)
- Pipes (GI, iron, plastic)
- Electrical fixtures (copper/aluminium wiring,bakelite/plastic switches, wire insulation)
- Panels (wooden, laminated)
- Others (glazed tiles, glass panes)

3. ISSUES IN MANAGING C&D WASTE

3.1. Lack of a Suitable C&D Waste Collection System

Mixed collection will enhance recycling cost and affect quality of recycling materials. On the one hand, large and advanced equipments to efficiently separate mixed waste must drive recycling cost increase. On the other hand, impurity caused by mixed waste incurs no quality assurance of recycled materials. Manual separation and outdated equipments also influence efficiency of collection. In addition, contractors consider environmental management as a non-profitable activity.

3.2. Lack of a suitable C&DWaste Recycling Approach

The recycling is restricted to those high scrap value recycling materials like steel, whereas other non-profitable will be sent to C&D landfills directly. The current recycling will speed the depletion of relevant resources and the saturation of limited landfill space. Several bottlenecks in recycling market have been identified like market of potential demand for recycled materials, regulations, Recyclers, Investment, Unspecific standards on recycled materials, Economic feasibility etc.

3.3. Pollution by Simple Landfill Sites and illegal Dumping

Because in these simple landfills (without collection system of leachate and odour) only a negligible quantity of leachate is treated before being discharged into the groundwater, this situation will devalue the nearby land, pollute the water, land and air as well as endanger the health of people. For instance, chromated copper arsenate (CCA)-treated wood containing a lot of hazardous substances such as chromium and lead, can contribute to toxic and ecotoxic impact on groundwater and soil. Hydrogen sulfide (H2S) as a principal odorous component from C&D landfills enormously contributes to acidification of environment. Due to no compulsive regulation about collection of leachate and odour from C&D landfill as well as deficient investment on landfill, pollution from landfill is more and more serious with waste quantity increase.

4. RECYCLING OF C& 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. C and D waste management includes following steps.

4.1. Storage and Segregation

C and D wastes are best stored at sourcei.e. at the point of generation. If they arescattered around or thrown on the road, theynot only cause obstruction to traffic but alsoadd to the work load of the local body. A properscreen should be provided so that the wastedoes 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.

4.2. Collection and Transportation

If the C and D debris is stored in skips, then skip lifters fitted with hydraulic hoistsystem should be used for efficient and promptremoval. In case, trailers are used, then tractorsmay remove these. For handling very largevolumes, front-end loaders in combination withsturdy tipper trucks may be used so that thetime taken for loading and unloading is kept to the minimum.

4.3. Recycling and Reuse

C and D waste is bulky and heavy andis mostly unsuitable for the disposal byincineration/ composting. The growingpopulation and requirement of land for otheruses has reduced the availability of land forwaste disposal. Reutilization or recycling is animportant strategy for management of suchwaste. Apart from mounting problems of wastemanagement, other reasons which support adoption of reuse/recycling strategy are reduced extraction of raw materials, reducedtransportation cost, improved profits andreduced environmental impact. Above all, thefast depleting reserves of conventional naturalaggregate has necessitated the use of recycling/reuse technology, in order to be able toconserve the conventional natural aggregate for other important works.In the present context of increasingwaste production and growing public awareness of environmental problems, recycled materials from demolished concreteor masonry can be profitably used in differentways within the building industry. The major components of theC and D waste stream are excavation material, concrete, bricks and tiles, wood and metal.

4.4. Disposal

Being predominantly inert in nature, C and D waste does 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 landfills are sometimes created for inert waste, which are normally located in abandoned mines and quarries.

5. OPTIONS IN ROAD SECTOR

As part of the study, we analyzed the performance of a road surface course on the basis of the values obtained for the following variables: dry density, moisture, and deflections.

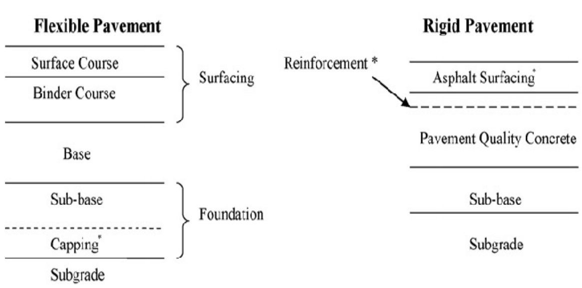

Fig 1: Structural layers of Flexible and Rigid pavements

The values obtained for a conventional road surface with a subbase of quarry aggregate were compared to the values obtained for a road surface composed of recycled aggregate. Our study consisted of the following phases:

5.1. Characterization of the MaterialsUsed for the BaseLayer of the Surface Course

The first step was to define the materials and establish their volume percentage in the mix. Three types of material were used: (1) concrete from building demolitions, test cylinders, factory surpluses, and slabs, (2) asphalt waste from pavement rehabilitation projects, and (3) ceramic waste from the demolition of partition walls and mezzanines.

5.2. Treatment of Materials for Their Use as the Base Layer of the Road Surface Course

The first step in the treatment process was to wash the materials manually and mechanically to eliminate impurities, e.g., plastic, paper, and wood. Afterwards, a track-mounted backhoe excavator with hydraulic pincers extracted metal from the waste, thus reducing the original size of the material. Once the material was clean of impurities, the backhoe excavator fed it into an impact mill. This mobile grinding unit had a prescreening unit that separated and stored the material whose diameter was less than 40 mm. The rest of the material underwent a reduction process. This phase of the process guaranteed the absence of plasticity in the finalproduct because it eliminated dirt and any extraneous substances.

The recycled artificial aggregate was thus composed only of concrete, asphalt, and ceramic. After the grinding, an electromagnet was used to capture and separate any metal that might have entered the mill. The rest of the material was transported on the conveyor belt to the entry of the mobile screening unit. Here, the material was classified, and the final product was obtained, recycled CDW aggregate (0–32 mm).

5.3. Construction of a Test Road Section

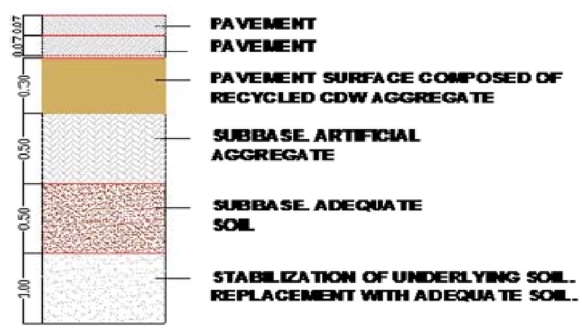

Fig 2. Pavement Section made of Recycled C&DWasteAggregate

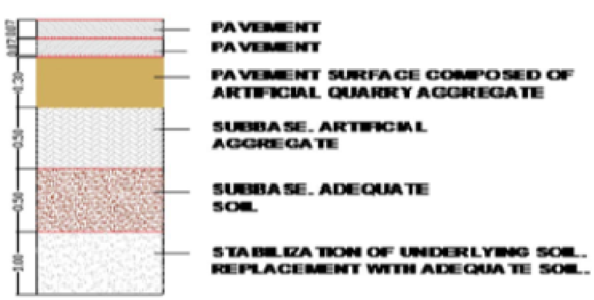

Fig. 3: Pavement made of Quarry aggregate from a mine

6. CURRENT SCENARIO IN ASIAN COUNTRIES

Globally, cities have employed the legal process to maximise reuse of C&D waste in construction.

6.1. Hong Kong

Hong Kong, which has serious land constraints and therefore cannot afford landfills, has very stringent controls over C&D waste. It imposes a construction waste charge on developers. The system has lowered the quantity of C&D waste needing disposal at landfills by 60 per cent. Also, rates have been structured to incentivize on-site recycling and reuse -100 per cent waste utilisation is charged at HKD $27 per tonne while more than 50 per cent waste needing landfill disposal is charged at HKD $125 per tonne. Revenue generated is used to maintain and subsidise C&D waste recycling centres. This has created incentives for reuse and also for very efficient construction practices that minimise the generation of construction debris. Instead of demolishing structures, Hong Kong dismantles systematically. It also offers tax concessions to C&D recycling centres.

6.2. Singapore

Singapore, yet another land constrained country, recycles 98 per cent of its C&D waste.

6.3. South Korea

South Korea has one of the most extensive and the oldest recycling policies for C&D waste. C&D waste management is part of its low carbon green growth strategy. The country has a law on Acceleration ofC&D Waste Reuse/Recycling 2005 that provides for step-by-step demolition, and utilisation of recycled aggregates. It has adopted separate building codes for recycled asphalt concrete aggregates, recycledconcrete aggregates, and road pavements. TheArchitectural Institute of Korea's Standard BuildingConstruction Specifications recommend increased use of recycled C&D material. The effectiverecycling rate in Korea is 36 per cent, with a target of increasing this to 45 per cent by 2016.

6.4. Japan

As per the basic philosophy followed in Japan, viewpoint of environmental conservation must be added to price and quality, selection making is based on diverse viewpoints, including formation of socio-economic system withenvironmentally sound material cycle and combating global warming, consideration is given to reducing environmental impact throughout the product lifecycle, from manufacture to disposal and a commitment to long-term use, correct utilization, and sorted disposal of procured goods. Aggregate, 70% by volume of concrete, anticipated as a recipient of waste and by-products from other industries.

7. CREATIVE STEPS IN INDIA

Even though legal reform is taking a long time in India,several architects have already taken steps to reusewaste in their buildings. There is the example of aschool building in Rajkot designed by Ahmedabad based architect Surya Kakani that has been built fromthe debris of Bhuj earthquake. The Institute of RuralResearch and Development (IRRAD) building inGurgaon has innovatively recycled and utilised its own construction waste in the building itself. But these arelimited steps and they will have to be encouraged with policy and fiscal support.

This is particularly relevant for the infrastructurenecessary for development such as roads, flyovers, pavements, etc. In fact, the attempt to use recycled material from the Buraricentre in New Delhi during the Commonwealth Games faced opposition as these materials are not backed bystandards as yet. This mindset will have to changeurgently. Globally, the strength of these materials hasbeen proven.

8. CONCLUSION

To optimize proper functioning and formulation of a project, C & D Waste Management Plan must start at the earliest possible stage of the project. The management of construction and demolition waste should be given due consideration throughout the duration of a project in order to promote an integrated approach. The waste management system should be planned and implemented which is holistic, integrated and sustainable. The plan should also target for waste diversion and recycling through implementation of new policies, information technologies, awareness and waste management facilities. Waste minimization, reuse and recycling should be managed project wise by nominated C & D waste manager. It is necessary to have more accurate and detailed data on C & D waste generation. Reduce, Reuse and Recycle [3R's] should be adopted to minimize C & D waste highly useful in handling of construction and demolition waste

Currently, existence of regional and national policies, laws and regulations governing 3R principlesfor C & D waste is minimal in Asia. However information compiled from some countries in differentsub-regions in Asia and different stages of development, presented in this paper, provides examplesand baseline data on current status in terms of policy and institutional, technological, and practicalaspects. This is expected to assist the policy and decision makers in the region by identifying challenges and opportunities in order todevelop specific strategies from the application of 3R principles based on specific conditions of Asian countries.

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