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Recycled Aggregates: A Sustainable Solution of Construction and Demolished Waste

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Abstract: *With the development and modernization of societies, lot of construction activities are seen everywhere. These construction activities are increasing at faster rate by large amount. Also, the destruction of existing structures, which have reached their service life, runs parallel to the construction activities. It is not essential that the structures need to be demolished only after when they have completed their service life, but also due to change in fashion and ongoing trend of reconstruction of even healthy structures just for creating more space in order to meet the present demand. All such activities are generating waste in bulk, and this waste is called the Construction and Demolition (C&D) waste. Disposal of such C&D waste in a sustainable manner is a hard nut to crack for the builders, developers and owners. While the disposal of C&D waste is a challenge, on the other hand there is a severe shortage of naturally available aggregates for construction of structures. Reduction of this demand in a small way is possible with the recycling or reusing of construction and demolition waste generated from the construction activities. Hence, the recycling of demolished waste is a sustainable solution of C& D waste.*

Keywords- *Construction & Demolished waste, Recycling, Service life, Sustainability, Waste management.*

I. Introduction

Concrete is the single most widely used construction material in the world, far exceeding other materials as production of the concrete required much less energy and had a lower net environmental impact . Humans have been using concrete in their pioneering architectural and structural feats for millennia. The global concrete industry will annually require 8 to12 billion tones of natural aggregates after the year 2010 (Keun-Hyeok et al., 2008). This huge demand of concrete seems to be increase at much faster rate in 2020 due to the modernization of cities, rehabilitation of old buildings, expansion of concrete pavements etc. Each construction material is manufactured from some combination of raw materials, and the basic ingredients of concrete are– sand and gravel (aggregate), a cement-like binder, and water out of these cement can be manufactured in industries but natural aggregates are usually obtained by mining cannot be manufactured in industries. As aggregates, raw material of concrete, are non-renewable and scarce therefore there is an urgent need to find the sustainable solution to get an alternative of natural aggregates.

On the other hand due to renovations and refurbishments for reasons such as deterioration, alteration of needs, or change in fashion, many concrete structure and its components are changed and thus resulting in Construction & Demolished wastes. These processes sometimes occur frequently. It is estimated that 30-50% of overall construction waste results from renovation activities (Construction and Demolition Waste Practices and Their Economic Impact-Report, 1999). Sometimes waste are generated due to the structural problems of individual buildings like collapse of a building, due to earthquakes, illegal structuring, and urban transformation processes etc. For example, in turkey 13 million tons of waste was generated due to the Marmara Earthquake of 1999. These wastes were left in empty spaces and fill areas and some of them were dumped at sea (Solid Waste Control Sub Commission Report –Ankara, 2000). As per report of Central Pollution Control Board (CPCB) Delhi, in India, 48million tons solid waste is produced out of which 14.5 million ton waste is produced from the construction waste sector, out of which only 3% waste is used for embankment.

India is currently the second fastest-growing economy in the world. Its construction industry plays a vital role in overall economic development of the country, with investment in construction accounting for approximately 11 percent of GDP and growth rates anticipated at 15 percent. India's development dictates the country needs to build suitable infrastructure to support the current economic growth and to attract continued inward investment. The public sector will continue to be a significant investor in the construction industry with suggested figures ranging from US$320bn to US$485bn to upgrade the nation's roads, railways, ports, airports and power stations. This data represents the increase in concrete demand at an alarming rate. New studies from The Freedonia Group, a market research firm, forecasts world demand for construction Aggregates to grow at a faster rate of 4.7 percent annually from 2011 to 26.8 billion metric tons. In addition, sales of construction aggregates in the Asia/Pacific region are forecast to climb 5.7 percent per annum to 32.6 billion metric tons in

2015, slowing from the torrid 2005-2010 paces but maintaining the regional market's position as the fastest growing worldwide.

The author strongly advocates that a strong commitment & investment by government bodies as well as private bodies make this necessary for sustainability. Some materials are reused for recycling such as plastic, glass etc. In the same way concrete can also be used continuously as long as the specification is right. Recycling solid waste materials for construction purposes becomes an increasingly important C&D waste management option, as it overcome the hurdles like more restrictive land use, depletion of natural aggregates reserves and environmental regulations. Conservation of natural resources, saving of energy and cost in production and transportation, and reduction of pollution are few of the advantages of recycling of concrete. In particular, concrete is a perfect construction material for recycling.

Table.1. World Construction Aggregates Demand (million metric tons) (The Freedonia Group, 2012*)*

II. Problems With C&D Waste

	2005	2010	2015	% Annual Growth	
				2005-2010	2010-2015
Construction Aggregates Demand	27300	33 7400	48 300	6.5	5.2
North America	3280	3 010	37 10	-1.7	4.3
Western Europe	2920	2 630	30 50	-2.1	3.0
Asia/Pacific	16000	2 4750	32 600	9.1	5.7
Other	5100	7 010	89 40	6.6	5.0

Presence of Construction & Demolition waste and other inert material (e.g. drain silt, dust and grit from road sweeping) is significant about a third of the total municipal solid waste generated. Construction & Demolition waste needs to be focused upon in view of:

- The potential to save natural resources (stone, river sand, soil etc.) and energy.
- Its bulk which is carried over long distances for just dumping.
- It is occupying significant space at landfill sites.
- Its presence spoiling processing of bio-degradable as well recyclable waste.

Construction & Demolition waste has potential use after processing and grading. Utilization of Construction & Demolition waste is quite common in industrialized countries but in India so far no organized effort has been made.

III. Production Of Concrete Aggregate From Demolished Waste

Recycled aggregates to be produced from aged concrete that has been demolished and removed from foundations, pavements, bridges or buildings, is crushed and processed into various size fractions. Reinforcing steel and other embedded items, if any, are removed and care is taken to prevent contamination by dirt or other waste building materials such as plaster or gypsum. It is prudent to store old concrete separately to other demolition materials to help avoid contamination. Records of the history of the demolition concrete – strength, mix designs etc. –would seldom be available, but if available these are useful in determining the potential of the recycled aggregate concrete. Fig 1 shows the flow chart of concrete recycling method.

Fig.1. Flow chart of the concrete recycling method.

Most recyclers use a jaw crusher for primary crushing because it can handle large pieces of concrete and residual reinforcement. Impact crushers are preferred for secondary crushing as they produce a higher percentage of aggregate without adhered mortar.
Most recycling plants have both primary and secondary crushers. The primary crusher usually reduces material down to 60-80 mm which is fed into a secondary crusher. The material from the secondary crushing then passes through two screens that separate the aggregate into sizes greater than 19 mm, between 19 mm and 7 mm, with the material finer than 7 mm being removed (and used as road metal). The plus 19 mm material is fed back into the secondary crusher. The 7-19 mm fraction is screened to produce coarse aggregate.

IV. Benefits Of Recycling Of Construction And Demolished Waste

- Reducing environmental effects of obtaining further raw materials, their transportation and processing,
- Reducing the dependence on natural resources,
- Reducing emission rates related to production and transportation of building materials,
- Reducing costs associated with new material purchases,
- Reducing the need for disposal sites for C&D wastes,
- Reducing the negative effects on environment through removal and disposal processes,
- Creating a source for the sector by recycling C&D materials to secondary salvaged materials,
- Creating new employment fields.

V. Simple Guidelines To Be Followed In Recycling Of Demolition Waste

The different agencies responsible for generation of wastes should separate the generated wastes having potential for reuse/recycling in future. The Engineer-in-charge will select structure's type and materials that are suitable for reuse/recycling, use recycled aggregates, and ensure proper treatment of wastes generated from such development. The waste generation from construction should not only be minimized, but should also minimize the hazardous effect from the generated wastes.

1.1 Agencies

Various agencies or sub-contractors to be involved are to be linked up with the steps in this process of C&D waste recycling and reuse. These few steps are waste collection and transportation, intermediate waste treatment i.e. receiving the waste, its segregation and further suitable comprehensive treatment before putting into the use. There are important duties to be either assigned or, he may be establishing himself like a dutiful contractor, he should establish step-by-step demolition plans. He should report expected amount of wastes by type and treatment plan at the beginning of construction. There should be effective utilization of recycled aggregates and Safe treatment of hazardous waste like asbestos. Contractor may be asked to submit Environmental Management Plan during Construction.

1.2 C&D waste information on web

All C&D waste information by contractor and by those involved in its treatment waste treatment companies are to be put on public domain in order to improve the rate of use of demolished concrete for e.g. application of recycled aggregates. This will help in reduction on the amount of wastes and promotion of recycling or reusing the C&D waste.

1.3 Demolition Plan

It is required to adopt a systematic approach while demolishing a building in order to minimize the waste and its best use. A recommended approach can be to follow a sequence of segregation of household waste as first step followed by mechanical and electrical equipment, interior and exterior finishing materials, water-proofing materials and roof finishing, then structure as a last resort. Demolished debris need to be brought out of field immediately or temporarily stored in a designated area for the C&D wastes.

VI. First Commercial Scale Pilot Project For C&D Waste Management In India

C&D waste recycling unit have been made functional in Delhi through Public Private Partnership between Municipal Corporation of Delhi (MCD) and Infrastructure Leasing and Financial Services Ltd (IL&FS) at Burari, with an installed capacity of 500 TPD of C&D waste. The plant produces pavement blocks, Kerb Stones from C&D waste through recycling process. The waste material after recycling process is also used for road construction in sub base preparation which has been certified by Central Road Research Institute (CRRI). (IL &FS Waste Management and Urban Services Ltd Presentation on PPP in Waste Management in India.)

As per census of India, there are approximately 2.45 million properties in Delhi of which roughly 0.9 million are appraised properties. Even by a conservative estimate, using Technology Information Forecasting and Assessment Council (TIFAC), Dept of Science & Technology averages, Delhi should be producing C&D waste to the extent of 4600 tons. Post recycling, the available quantity should be of the order of 3300 tons. However, in effect the average daily estimate as MCD's record is about 1000-1200 tons. Daily average, as per log sheets at Landfills for a 15-month period ending May 2005, varies from a high of 2,877 tons in July to 446 and 442 tons in August - September. Average for the period is 879 tones per day. The higher quantum during July is due to removal of silt from drains.

Typical construction waste consists of Concrete (23%), Soil and sand (36%) and bricks and masonry (31%). As on date, C&D waste is used as a landfill to a large extent and the quantity that cannot be absorbed by the market reaches the landfills of MCD. To improve debris collection, treatment and disposal, MCD proposes to hire private operators to collect, transfer and treat C&D waste.

The capital investment for this plant has been estimated taking into consideration the latest manufacturing cost and the cost of the equipment and materials. IEISL's commitment to the project is $3.32 million out of which $2.21 million has already been spent. Fig 2 shows the composition of C & D waste.

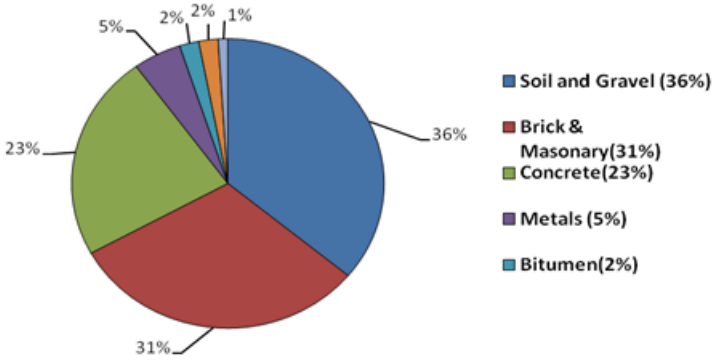

Fig.2. Typical Composition of Indian C&D waste

VII. Government And Ulb Initiatives

M. Sankarnarayana et al.(2009) presented the Government and ULB initiatives towards the management of construction and demolished waste in India.

- The SWM Cell of the Govt. of Maharashtra has given a prominent place to C&D waste in their action plan.
- Action point 1 states 'Separate collection of debris and Action point 1 states 'Separate collection of debris and bulk waste. Each city needs to have its own mechanism for collection and disposal of waste from bulk waste producers and construction debris' (prescribed time –30th November, 2006).
- Municipal Corporation of Greater Mumbai has notified Municipal Corporation of Greater Mumbai has notified the 'Construction and Demolition and Desilting Waste (Management and Handling) Rules, 2006'
- C&D waste along with silt was used as cover material in the closure project of old dump-site at Gorai in Mumbai.
- The bulk of C&D waste generated in Delhi does not get into the municipal solid waste stream as MCD has certain intermediate points for C&D waste but proper disposal is a problem because the debris is dumped in the existing landfills, eating into their space.
- MCD was instrumental in getting a feasibility study done MCD was instrumental in getting a feasibility study done in collaboration with IL&FS. The study "Feasibility study in collaboration with IL&FS. The study "Feasibility study on use of C&D waste in road works" was carried out by the CRRI
- The study found potential feasibility for application in (a) The study found potential feasibility for application in (a) embankment and sub-grade construction, (b) sub-base construction, (c) stabilized base course construction and (d) rigid pavement construction
- MCD has allocated a DBOT project for proper storage and collection of 500 TPD C&D waste from 3 MCD zones, transportation to an identified site where the material would be processed and utilized. The rejects would be landfilled at the same site
- The DBOT partner – IL&FS Waste Management and Urban Services Ltd. would also build a 'test' road using Urban Services Ltd. would also build a 'test' road using processed C&D waste with technical assistance of CRRI which would then be monitored for more than a year Efforts would be made for market development of processed C&D waste.

VIII. Guidelines For Successful C&D Waste Management

- Issue an office order to all the government organisations like Development Authorities, PWD etc. notifying them about the new proposed facility and pay the necessary tipping fee of C&D waste at the disposal facility.
- Issue a Notice to inform citizens about the new C&D waste collection and disposal system and the Container locations and direct the citizens to dispose the C&D waste in the listed container locations only or directly to the C&D facility side.
- Mandating submission of a C&D Waste management plan by large generators (> 400 sq m of Construction)
- Provision of adequate information to public at the time of application for building permission on web site and other media including display at the zonal offices on the protocol and details of the C&D operator in the area.

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IX. Conclusion

Natural resources are limited in nature and will be depleted with time. In order to conserve the natural resources, unnecessary wasting of natural resources should be restricted and regulated. Formulation and implementation of proper waste management plan throughout the life cycle of the projects can minimize C&D waste. With an integrated resource management scheme, most of the construction and demolition material can be recycled or reuse and more natural resources can be conserved for our next generations. The success of recycling requires promotion by means of education and information, in addition to judicial rules from the concerned governing body.

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