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Original Article

Potential for Reducing Green House Gas Emissions and Energy Consumption by Recycling the Construction Waste Materials

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ABSTRACT
The construction industry is defined as the sector which is engaged in preparation of land and the construction, alteration and repair of the buildings, structures and other real estate properties. Construction waste recycling is the separation and recycling of recoverable waste materials generated during construction and remodeling. If a large number of small green house gas sources within the construction industry were to adopt energy and climate conscious practices, aggregate emissions could be reduced significantly. During the construction of 200 m² home, 5000 kilograms of waste are typically thrown into the landfill. Production, mining and transportation of construction materials require huge amount of energy through burning of coal and oil, which in turn emit a large volume of green house gases. Reduction in these emissions through alternate practices and reuse of recycled materials will be beneficial to the problem of global warming. Recycling produces usable materials at much less environmental costs than materials from primary source. That is, in addition to conserve raw materials, recycling conserves energy and water also. It is estimated that 40% of the total building construction material is steel, concrete and glass which is recyclable. If only these can be recycled, enormous amount of primary energy can be saved. In general 90-95% of the total construction material waste can be recycled. The recycling of construction material can reduce the load on landfills which is around 25% of the total waste generated in India.
The present work provides insight of the construction and demolition waste materials and their recycling technologies in India both in terms of energy savings and environmental health.
Key words: *Construction materials, Recycling, Waste generation, Buildings and Roads.*

INTRODUCTION

As per the census of 2011, with an estimated population of 1.210 billion, India is the world's second most populated country after China [3]. The decadal population growth rate for urban India was 31.8%, while for rural India it was 12.2%. India added almost 2,800 towns in the last decade, both at places that have a municipal administration of some sort, or at places that have a population of at least 5,000, where the main occupation for adult males is not farming, and where the minimum population density is 400 people per square kilometer. Due to rapid pace of urbanization, rising energy prices, water scarcity and increasing attention to climate changes, the building and construction industries are facing an increasing pressure to bring a change and come out with innovative ideas so as to create materials with superior properties. Reusing and recycling the C&D (construction and demolition) waste is also very important in order to reduce the energy consumption and CO_2 emissions for a healthy environment. In almost all cases, the cost of the recycling is lower than the cost of the materials throwing away [4].
Construction activities lead to generation of solid wastes, which include sand, gravel, concrete, stone, bricks, wood, metal, glass, plastic, paper etc. The management of construction and demolition waste is a major concern for town planners and builders due to the increasing quantum of demolition's rubble, continuing shortage of dumping sites, increase in transportation and disposal costs and above all growing concern about pollution and environmental deterioration.

Present Status of Infrastructure Development in India

Since independence, construction activities in India are growing exponentially. Construction sector can be broadly classified into Real estate (Residential, Commercial and Industrial zones), which contributes around 24% to the construction GDP of India while Infrastructure segment (Transportation, Urban development, Utilities) contributes around 76% [2].Construction content as percentage of total development plan outlay in almost all the five year plans have been found more than 40%. The Construction sector in India is the second largest economic activity after agriculture and provides employment to about 33 million people.

Construction activities accounts for nearly 65 per cent of the total investment of infrastructure and has grown at a Compounded Annual Growth Rate (CAGR) of about 11.1% over the last eight years [1] as indicated in Fig. 1. In terms of construction materials India appear to be nearly self sufficient. In the year 2007, India was the second largest country in the world in production of cement (180 Million Tones) with US being the third largest (100 Million Tones). As such it can be deduced that India may also be the second largest in the world in consumption of cement and concrete. Construction activity in India is estimated at about Rs.700, 000 crores per annum.

In the 11th plan period 2007-12, the estimated annual outlay is around Rs.290, 000 crores only in infrastructure project. In the 12th plan period 2012-17, this estimated to be $1 trillion i.e. about Rs.45, 00,000 crores. If we add to this the construction in the real estate and other private projects, the figure become shocking. Compared to the manufacturing sector, the construction industry is almost unique where the project is sold before it is made. Construction activities are field and project oriented as such it requires different type of treatment than that of regular industry.

As far as human resources are concerned, India is producing largest number of civil engineers and diploma holders involved in construction industry. This industry involves construction of major irrigation projects, river valley projects, major and minor road projects, tall structures, offshore and ocean structures, major and minor bridges, railways, airports, nuclear structures and variety of other special and prestigious structures. There are cases that two to three generations have been working in this industry for last many years [5].

COMPOSITION OF CONSTRUCTION WASTE

Category of waste is complex in nature as different types of building materials are being used but in general may comprise the following materials:

1. Bricks
2. Cement Concrete
3. Cement Plaster
4. Steel (from RCC, door/ window frames, roofing support, railing of stair cases etc.)
5. Rubble
6. Stone (Marble, granite, sand stone)
7. Timber/wood

In addition to this, conduits (iron, plastics), Pipes (GI, Iron, Plastic), electrical fixtures, panels (wooden, laminated) etc. are termed as minor components of waste as shown in Fig. 2. Construction and Demolition waste for new residential and commercial construction is mostly made up of bricks, stone, concrete, steel, metal, wood and cardboard. When organic materials like wood and cardboard wind up in landfills, over the time they break down and produce methane, a greenhouse gas 23 times more potent than carbon dioxide [7].

The total quantum of C&D waste in India is estimated to be about 12 to 14.7 million tons per annum. Quantity of different constituents of waste that arise from construction industries in India are estimated as shown in Fig 3. Some amount of this construction waste is being recycled as building material [9].

The source of building materials and recycling and reuse of C&D waste and CO_2 emission from building materials is presented in Table 1.

Reusing or recycling wood and cardboard instead of land filling them puts a big dent in the amount of methane coming out of landfills. And when C&D debris like wood, cardboard, metal, steel and concrete are reused or recycled into new products, a lot less energy is needed compared to making new products. New products require raw materials to be extracted from the earth which require burning of fossil fuels – one of the main causes of global warming [8].

RECYCLING AND REUSE OF C&D WASTE

In order to ensure that C&D materials are reused or recycled instead of land filled, reduce the carbon footprint from the buildings. Almost all construction and demolition waste is capable of being recycled, providing the waste is segregated and separated. Retrievable items such as bricks, wood, metal, concrete are recycled, the concrete and masonry waste, accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India.

Recycling of concrete and masonry waste is, however being done abroad in countries like U.K., USA, France, Denmark, Germany and Japan [9].

A certain portion of the materials from construction and demolition projects are toxic or classified as hazardous waste that may require special handling and that include latex paint, chemical solvents and adhesives. The materials should be managed according to local regulations.

The recycled materials can then be used for things like landscaping and in road construction. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in housing and road sectors in some extent.

CO_2 EMISSIONS FROM CONSTRUCTION MATERIALS PRODUCTION

The major part of India's emissions comes from fossil fuel-related CO2 emissions. Production of ordinary and readily available construction materials requires huge amounts of energy through burning of coal and oil, which in turn emit a large volume of GHGs [6].

In India, the main ingredients of building construction are steel, cement, concrete, sand and brick. Emissions from crude steel production in sophisticated plants is about 3.00 t per t. Cement production is another high energy consuming process and it has been found that about 0.9 t of CO_2 is produced for 1 t of cement. CO_2 emissions associated with concrete production can be calculated based on the fuels used for the three major concrete operations, quarrying, blending, and transportation. Sand is a natural product obtained from river beds, which does not consume any energy, except during transport. Brick is one of the principal construction materials and the brick production industry is large in most Asian countries. In a study by GEF in Bangladesh (where the method of brick is the same as in India), an emission of 38 t of CO_2 has been noted per lakh of brick production [7].

The construction industry is one of the major sources of pollution. Construction-related activities account for quite a large portion of CO_2 emissions. Contribution of the building industry to global warming can no longer be ignored. The reuse and recycling of C&D material technologies help in the reduction of CO_2 emissions and therefore in the preservation of the environment. Production energy of recycled materials is considerably less than the energy used to produce and transport primary construction materials [10].

REDUCTION OF ENVIRONMENTAL DEGRADATION

Illegal dumping of C&D waste and excessive extraction of natural resources has negative environmental effects. Reusing building materials prevents environmental impacts by reducing the need for virgin natural resources to be mined and harvested, while saving forests and natural areas from further degradation. Reusing waste is efficient, as it does not require further processing, thereby not requiring further energy use. Efficiency can be improved further by reusing materials on site, eliminating the need for transportation [11].

Reduction of health hazards generated by illegal deposits can be reduced if C&D waste is reduced, reused, recycled and minimal quantities are deposited on controlled landfills. Improvement of air quality due to production and uncontrolled disposal or burning of C&D waste is also reduced.

STRATEGIC TO ENERGY SAVING BY CONSTRUCTION TECHNOLOGY

Green building: Construction technology can play a major role in reduction of GHG emission. The design of other improved alternate technologies like bamboo panels, concrete with bamboo reinforced, masonry stub foundation, etc. can contribute significantly in reducing the CO2 emission and construction cost. In rural areas, the very poor will continue for a long time to come to depend on traditional building materials which largely comprise mud, stone and biomass.

Building materials: Successful building materials are those which; cut down cost by eliminating some of the cost components such as transportation, energy use, skilled labour, self help construction and use of local resources and are amenable to local manufacture (12).

Flexible buildings: The effects of climate change and unpredictable demographics could lead to a generation of buildings that are better equipped to change e.g. heating to cooling, home to office space. This would be beneficial in terms of waste reduction. The absence of adaptable buildings will increase construction activity to provide change of use/performance. This would in turn increase waste (13).

Fig.1: Industry size and growth of Construction GDP at constant price (` billion)

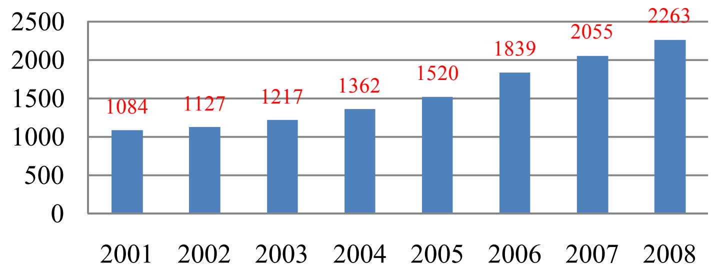

Fig 2: Construction and Demolition Waste (a) Brick debris (b) Steel (c) Ceramics and (d) Wood

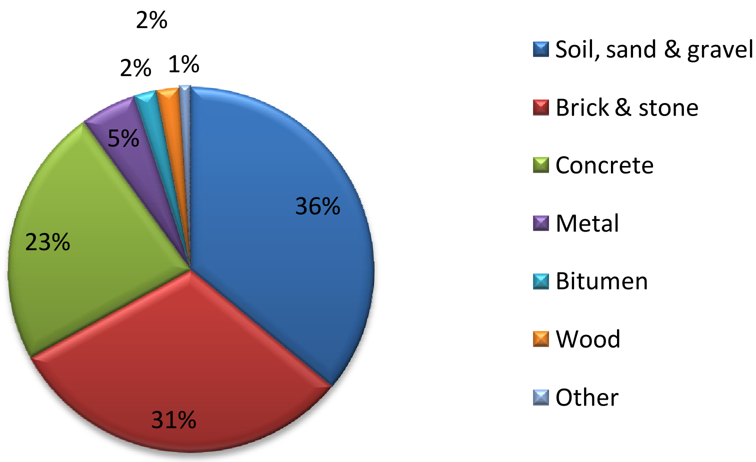

Fig 3: Composition of C&D Waste in India

Table 1: Source of building materials and CO2 emission

Material	**Description of Sources and Generation**	**Recycling Process and Reuse**	**CO_2 emission in kg from building materials**
Brick	Largely from demolition and renovation. Limited waste from new construction.	Used in aggregate production Commonly crushed to form filling materials.	380 kg/ 1000 bricks
Concrete	Largely from demolition and renovation. Limited waste from new construction	Concrete typically must be separated from brick, block, and concrete used in aggregate production	
Cement	Largely from demolition of old buildings	Reuse of cement is only for filling.	900 kg/t
Sand	Sand is a natural product obtained from river beds, which does not consume any		

	energy, except during transport.		
Stone	Largely from demolition of old buildings	Reused for construction	Stone is a natural product, energy consumed during quarrying, dressing and transportation
Asphalt Pavement	Almost exclusively from parking areas. Limited waste from new construction.	Typically recycled separately from other materials. Used in production of new asphalt.	
Steel	Structural and framing steel from demolition. Framing scrap from new construction and renovation. Typically very little structural steel from new construction or renovation.	Scrap markets; used in production of new steel.	3000 kg/t
Metals, Non-Ferrous	Aluminum, copper, brass and alloys from electric, plumbing, and HVAC. Often significant scrap in new construction.	Scrap markets. Highest value if separated by metal at point of generation. Can be mixed and marketed with ferrous metals.	
Wood	From new construction and renovation. Whole boards from renovation and demolition. Pre-fabbed walls and trusses greatly reduce waste.	Reused markets available in most areas for whole boards. Scrap goes primarily to mulch and boiler fuel.	

CONCLUSION

Thus we see that, waste reduction, reuse and recycling are important components of sustainable building. Construction and demolition waste (C&D) includes materials generated from building a structure (construction) and those created during the wrecking of a building (demolition debris).

Construction process of a structure that is environmentally sound and resource-efficient throughout the building's life is known as green construction. Green construction implements a recyclable aspect throughout the entirety of the building's lifecycle, meaning the project will utilize renewable resources or efficient forms of alternative energy sources. The building will use energy, water and dispose of waste in an efficient manner from design to construction subsequent operation, maintenance, renovation and finally its demolition.

It is very important that National authorities and construction practitioners understand the benefits of the deconstruction process and look at it as an advantageous way to improve waste management, thus following other countries' practices.

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