Management of Construction and Demolition Waste for Sustainability

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Abstract **- Construction and Demolition (C&D) waste is a serious concern nowadays. In construction projects lot of waste is generated during the stage of demolition. The need for effective waste management arises as a result of the current dramatic, global, economic growth and development which cannot be sustained with the current construction, production and consumption patterns. Globally, we are extracting more resources to produce goods than the planet can replenish because the environmental impact from the construction, production and consumption of these goods, from final raw material extraction to last use and disposal is highly increasing daily. Some civilizations do seem to have been more profligate in their waste output than others the dramatic increase in waste for disposal led to the creation of the first incineration plants, in 1874. Waste management is intended to reduce these adverse effects of waste on health, the environment or aesthetics.**

Waste is said to be any substance(s) which is discarded after primary use, or it is worthless, defective and of no use. The Construction Waste Management practices are not uniform among countries. But the most common waste control practice is landfill, recycling, and Incineration etc. In most developed countries, domestic waste disposal is funded from a national or local tax which may be related to income, or notional house value, therefore Waste management is intended to reduce these adverse effects of waste on health, the environment or aesthetics. Optimizing utilization of demolition waste can reduce environmental impact and natural reserve can be saved. This project case study highlights the limitations regarding effective utilization of C&D waste. Construction and Demolition waste administration is advised to advance development for sustainability, aegis of ambiance and optimum use of accustomed resources in this research paper.

Index Terms **- Construction, Demolition and waste management.**

INTRODUCTION

The Indian construction industry generates a large quantity of construction and demolition [C&D] waste nowadays. Due to construction activities and structure demolition with the increase in population and the increase in housing, C&D waste are starting to grow and C&D waste are not new waste all over the world. In the developing countries like India, growth of population, increased construction and urbanization, on the one hand, and the absence of adequate landfill spaces, on the other, increase the need to manage recycling and reuse waste of C&D, even though much of the urban fabric of the countries is old and needs annihilation or restructuring. The disposal of Demolishing and landfilling the building waste has caused major environmental concerns as it incurs significant life-cycle expense to the Owner as landfill space is diminishing. Landfilling debris unnecessarily wastes both natural resources and valuable landfill space.

It is important to study and identifying the ways to provide a practical guidance for the professional in the building industry about waste management in construction site. Construction and demolition waste defined as a mixture of surplus materials arising from any excavation, civil or building construction, site clearance, demolition activities, road works and building renovation. Government sources indicate that there is an acute shortage of landfill space in India and the continuation of disposal of construction and demolition waste at landfills would risk to the strategic use of landfills for the disposal of the more demanding waste types such as domestic refuse and hazardous waste. Moreover, natural tragedies for instance alluvial sand hurricanes and earthquakes raise C&D waste. Waste management is a very challenging task because the characteristics of waste product are differing.

Significant research struggles have been made to study construction and demolition waste management (CDWM) in separate economies. Alternatives to demolition include recycling, recovery and deconstruction. Recycling includes diverting materials that are not reusable from the solid waste stream and using these extracted materials as feedstock for reprocessing into other useful products. Recovery includes the removal of materials or components from the solid waste stream in a manner that retains its original form and identity, for the purpose of reuse in the same or similar form as it was produced. Deconstruction means systematic dismantling of a building, preserving the integrity of the materials, with the goal of maximizing the recovery of salvageable materials for potential reuse and recycling. While these all sound very logical and simple, there is no "one size fits all" solution. Some options that will work for certain situations will not be feasible for others.

NEED OF STUDY

To effectively use the construction and demolition waste in the state by scientifically managing all the C&D waste of the state to achieve:

- Save Environment: Reduce air, water & noise pollution, health hazard etc.
- Save Energy: Energy consumed in the production of the construction material from natural resources.
- Enhance Economy: Potential high value of recycled material not tapped and gets buried in landfills or illegal dumps leading to economic loss. Reduce demand-supply gap in these sectors and save the natural resources. Reduce the valuable waste going to landfill.

WORKING METHOD

- In order to meet the proposed objectives, the research was developed through two stages: literature review and field research.
- In addition to the literature review, carried out in that study, an analysis was carried out on the legislation on civil construction waste and on the possibilities of its correct management in Ahmedabad, Gujarat. Three construction companies, located in the city, were willing to cooperate with this work.
- Construction sites were visited with special attention to the application of new construction technologies and waste management practices.
- During the research, a photographic record of machinery and equipment was made, as well as the construction and waste management practices at the construction sites.

TYPE OF C&D WASTE PRODUCTS PROPOSED UNDER RULES

The C & D wastes products suggested under the Construction and Demolition (C & D) Waste Management Rules, 2016 are as follows:

- Provision for giving incentives for use of material made out of construction and demolition waste in the construction activity including in non-structural concrete, paving blocks, lower layers of road pavements, colony and rural roads.
- Construction and demolition waste shall be utilized in sanitary landfill for municipal solid waste of the city or region.
- Procurement of materials made from construction and demolition waste shall be made mandatory to a certain percentage (say 10-20%) in municipal and Government contracts subject to strict quality control.

TABLE 01: POTENTIAL USE OF C&D WASTE

C & D waste	Potential use of C & D wastes
Concrete	The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. Opportunity: The enormous quantities of demolished concrete can easily be recycled as aggregate and used in concrete. Research & Development activities have been taken up all over the world for proving its feasibility, economic viability and cost effectiveness. Work on recycled concrete has been carried out at few places in India by CBRI and CRRI, but waste and quality of raw material produced being site specific, tremendous inputs are necessary if recycled material has to be used in construction for producing high grade concrete.

Bricks	If deconstructed properly, bricks can be reused after removal of mortar. Broken bricks can be used for refilling or for manufacturing debris paver blocks or debris blocks.
Stone	Stone can be reused for plinth formation, masonry construction, landscape purpose, ledges, platforms, window sills, coping etc. depending upon the form of available stones.
Timber	Timber elements from deconstructed building may have aesthetic and antique value. Opportunity: Whole timber arising from construction and demolition works can be utilized easily and directly for reused in other construction projects after cleaning, de-nailing and sizing.
Plywood and other timber based boards	Plywood and other timber based boards can be either reused for interior works in new construction or it can be recycled for manufacturing of timber based boards.
Gypsum	In India, over 10 about of waste gypsum such as phosphor-gypsum, fluro-gypsum etc., are being generated annually. Opportunity: Plaster developed from this waste gypsum has showed improved engineering properties without any harmful effect. Phosphor-gypsum and lime sludge can be recycled for manufacture of Portland cement, masonry cement, sand lime bricks, partition walls, flooring tiles, blocks, gypsum plaster, fibrous gypsum boards, and super-sulphate cement.
Metals & metal alloys	Ferrous Metals are the most profitable and recyclable material. Scrap steel is almost totally recycled and allowed repeated recycling. Structural steel can be reused as well as 100% steel can be recycled to avoid wastage at construction site. Advantage: Generally sold to a scrap metal dealer at a specified price. Metals like scrap iron can be mixed with the virgin metal in the foundry. In India more than 80% scrap arising is recycled.
Non-ferrous metal	The main non-ferrous metal collected from construction and demolition sites are aluminum, copper, lead and zinc. Opportunity : In India aluminum and copper are recycled and are valuable resources
Debris	Construction debris can be recycled to manufacture paver blocks which can be used in light traffic areas and masonry blocks. Other uses of processed debris include use in lean concrete for leveling purpose, as mortar for masonry, as bedding mortar for pavement tiles and used for land filling materials is comparable with new materials. Opportunity: Market potential on an average in Pune city estimates about 40 crores of bricks in a year.
Composite materials	The plastic wastes are best for recycling if these materials are collected separately and cleaned. Recycling is difficult if plastic wastes are mixed with other plastics or contaminants. Plastic may be recycled and used in products specifically designed for the utilization of recycled plastic, such as street furniture, roof and floor, PVC window noise barrier, cable ducting, panel. Constraint: The third largest consumer of composite materials is construction sector, automobile and aeronautics being first two largest consumers. Composite materials like thermoplastics are not only using non-renewable resources, they are non-biodegradable products. Thermoplastics (Polycarbonate, polyethylene, polypropylene, PVC etc.) can be recycled, but recycling involves high costs, whereas thermosets (Epoxy adhesives) are difficult to recycle. The lack of adequate markets, high recycling cost, and lower quality of the recyclates are the major commercialization barriers in recycling of composite materials. PVC-U sourced mostly from window and door fabricators is being recycled into wiring accessories and cable management systems including skirting and trucking. Composite materials can be down-cycled.

C&D WASTE GENERATION IN NINE CITIES OF INDIA:

CITY	AREA (METROPOLITAN REGION KM^2)	POPULATION	NO. OF WARDS/ZONES	ULB	C&D GENERATION (TONNES PER DAY)
Ahmedabad	-	6,063,047	64/6	Ahmedabad Municipal Corporation (As per discussions with AMC officials)	700

Mumbai	4,355	12,442,373	24/6	Municipal Corporation of Greater Mumbai (www.mcgm.gov.in)	2,500
Chennai	1,189	6,500,000	200/15	Chennai Municipal Corporation (As per discussions with IITMadras)	2,500
Bengaluru	-	8,443,675	198/5	Greater Bengaluru Municipal Corporation (BBMP)(TIFAC, 2001)	875
Patna	99.45	2,514,590	72/4	Patna Municipal Corporation (TIFAC, 2001)	250
Jaipur	-	3,471,847	91/8	Jaipur Municipal Corporation (TIFAC, 2001)	200
Bhopal	-	1,917,051	70/14	Bhopal Municipal Corporation (TIFAC, 2001)	50
Coimbatore	-	2,618,940	100/5	Coimbatore City Municipal Corporation (CCMC, 2015)	92
Kolkata	-	4,496,694	144/-	Kolkata Municipal Corporation (As per discussions with KMC)	1,600

REDUCTION, REUSE AND RECYCLING PROCESS:

The Preference should be given to the non-generation of waste, and then work is done on the reduction, reuse, recycling, treatment and proper final disposal of the waste. Thus, reduce, reuse and recycle are the main concepts to be emphasized, forming what is known as 3 R's.

REDUCTION:

In order to reduce waste, adequate planning is required for each stage of the work, from the acquisition of materials to internal distribution. Building efficiently implies directly in a lean production that, in turn, implies savings, both for the consumption of material and for the use of financial resources. For the reduction to happen, some factors must be observed and avoided, such as: choice of technology, which will influence the higher or lower generation of losses; design failures; lack of standardization in the execution of services; inadequate storage and transport of materials at the construction site.

REUSE:

Careful use of reusable materials provides economic and environmental advantages. The absence of the practice of reuse and recycling of materials can be considered as the main cause of waste generation. The possibility of reuse and the economic viability of waste recycling should receive special attention, since costs with acquisition of new materials, removal and disposal can be avoided if an appropriate waste treatment system is applied.

RECYCLING:

Based on the principle of sustainability, the practice of recycling implies a reduction in the consumption of natural resources and the maintenance of raw materials, avoiding unnecessary extraction and preserving the environment. Many advantages can be obtained through the practice of recycling which are as under:

- Preservation of natural resources with the replacement of these by transformed aggregates
- Reduction of landfill areas due to the decrease in the volume of waste to be deposited
- Reduction in energy expenditure and generation of employment and income.

DISPOSAL OF WASTE:

Civil construction companies face a serious problem when it comes to the destination of C&D. The lack of legislation addressing the issue drives generators to dispose of waste in an inappropriate or irregular manner. Improper disposal is responsible for generating problems of degradation and

contamination, as well as generating costs. It is worth mentioning that the responsibility for waste is the responsibility of the generator. Some factors are essential for waste disposal solutions, and there must be a combination of environmental commitment and economic viability, in order to ensure sustainability.

WASTE MANAGEMENT ON THE CONSTRUCTION SITE CONSTRUCTION TECHNOLOGIES

The use of pre-molded constructive elements allows a great reduction in the generation of waste, since other materials do not need to be used, such as wires, wood and nails. It is worth mentioning that for the option of pre-molding in places other than the construction site, the transportation of the elements deserves special care, because if transported improperly, the possibility of damage should be considered.

The molding of construction elements on site is another important factor regarding the generation of waste on construction sites. This practice enables the reduction of waste generation, since damage caused by external logistics can be avoided. For internal transport, the equipment must be specific to each operation.

FIGURE 01: Preparation of forms for molding inspection boxes.

The Figure shows the preparation of shapes for molding inspection boxes. It should be noted, however, that the molding sites are not far from the application sites of the molded elements on site.

FIGURE 02: Miscellaneous inspection boxes molded in situ.

FIGURE 03: Covers for inspection boxes molded in situ.

FIGURE 04: Covers for inspection boxes molded in situ.

In figures 02 and 03, it is obtained molded parts in loco. Figure 04 shows the molding of paving blocks molded in situ.

STORAGE OF MATERIALS

The correct storage of materials provides verification, stock control and facilitates their use, avoiding loss and, subsequently, the generation of waste. In order to determine the correct storage of materials, it is necessary to observe basic criteria. Among the criteria, the frequency of use; maximum stacking and distance between places where the material is applied. Even though the storage spaces are smaller, it is possible to carry out the correct storage. For this, it is necessary to identify the intensity of use and maintain the preservation of operational spaces. As an example of material storage, the following figure 05 and 06 portrays this activity.

FIGURE 5: Proper storage of tubes and steel bars.

FIGURE 06: Proper storage of building blocks.

WASTE CONDITIONING ON CONSTRUCTION SITES

The waste, when generated, should receive adequate treatment with respect to the flow at the construction site. Initially, they should be conditioned as close as possible to the generation points, as shown in figure given below.

FIGURE 07: Initial Conditioning of Waste.

The collection and transportation of waste on construction sites should be the responsibility of employees. For internal transport, employees should use trolleys, as shown in figure 16, for horizontal transport. An alternative for the vertical transport of waste is the installation of ducts along the floors.

FIGURE 08: Carriage of Waste.

The temporary disposal must be done. The residues must be separated in bays and by class, as can be seen in figure below.

FIGURE 09: Waste conditioning bays.

Thinking about the reduction of waste generation, it is recommended the use of equipment that allows the non-occurrence of rework. In addition to providing productive gains and well-being to employees, the use of equipment such as trenchers (figure 10) and mortar projectors (figure 11) allows precision in the execution of work avoiding the need to rework.

FIGURE 10: Trencher

FIGURE 11: Mortar Projection

WASTE FOR REUSE ON CONSTRUCTION SITE

The correct handling of waste inside the construction site allows the identification of reusable materials, which generate savings both by dispensing with the purchase of new materials and by avoiding their identification as waste and generating removal costs. Correct sorting enables the reuse of waste for the transformation of aggregates with the use, for example, for instance, concrete and ceramic waste crushers, as can be seen in figure 19.

However, for the transformation of waste to be viable, the following aspects must be examined:

- Possible applications for recycled aggregates on site.
- Technological control over the aggregates produced.
- Cost of natural aggregates and cost of waste removal.

Only after analyzing the economic feasibility of the aspects listed above, the decision to recycle waste at the construction site can be concluded.

Figure 12: Waste Shredder for Aggregate Transformation.

TRANSPORT DESTINATION OF C&D WASTE GENERATED AT THE CONSTRUCTION SITE

When the waste generated cannot be reused, it must be transported by collecting companies, through appropriate equipment. The residues generated are still of responsibility of the generators, however, the transporters are also responsible for the destination and management of the residues. The final destination chosen will depend on each type of waste. The variables commonly evaluated in the definition of the final destination of waste are as follows:

- Type of waste
- Classification of waste
- Quantity of waste and Costs of treatment or disposal methods.

The carrier shall have a document that specifies the origin and destination of the waste to be presented to the inspection, if necessary. The company or the person responsible for the work must file a copy of the document. The solutions for the disposal of the waste must combine environmental commitment and economic viability, ensuring sustainability and the conditions for the reproduction of the methodology by the builders.

Reducing environmental impacts should be an objective to be achieved by engineering. For this, simple solutions must be studied and implemented.

Among these solutions, the following stand out:

- Alteration of the project aiming at reducing the consumption of resources in the use phase.
- Replacement of disposable equipment by others of greater durability.
- Recycling and reuse of generated waste.
- Product design and planning of production systems aiming at avoiding losses.

A construction becomes sustainable, from the environmental point of view, when it is based on the prevention and reduction of waste generated through the application of clean production methodologies.

RESULT STUDIED FROM THE WASTE MANAGEMENT FROM CONSTRUCTION SITE

From the three companies evaluated, it was observed that only one company correctly practiced the disposal of waste, while the other two did not know the laws and obligations regarding the correct management. It was observed that, concerning waste management, the

company correctly practicing the disposal of waste showed a constant concern of managers in properly disposing of waste, separating it, performing sorting and allocating it in bays for temporary storage, facilitating the possibility of transformation and reuse, as well as the disposal to companies specialized in waste treatment and recycling as shown in the figure below

FIGURE 13: Management of Residues of Company correctly practicing the disposal of waste.

INITIATIVES BY URBAN LOCAL BODY (ULB) OF AHMEDABAD MUNICIPAL CORPORATION (AMC) IN THE C&D WASTE MANAGEMENT

M/s DNP Infrastructure Pvt. Ltd. has been awarded operations of a 300 TPD C & D waste processing plant 5 acres of land on PPP mode for 30 years. It is operational from October, 2013, involved in collection & transportation of such waste from 24 designated locations. Ahmedabad Enviro Projects Pvt. Ltd. (AEPL) has commenced 100 tons per hour capacity plant located at Pirana, Ahmedabad for recycling of C&D waste in phase wise from December, 2013, fully operational since June, 2014. AMC has designated 16 spots around the city where citizen will have to bring the C&D waste at their own cost.

CONCLUSION OF THE RESEARCH

The impacts caused by inadequate management of C&D waste highlight the construction sector, often classifying it as the largest generator of waste. In conclusion waste management strategies are desirability in terms of waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste; The waste hierarchy is represented as a pyramid because the basic premise is for policy to take action first and prevent the generation of waste. The next step or preferred action is to reduce the generation of waste i.e. by re-use. The next is recycling which would include composting. The correct management of construction and demolition waste is a constant effort in the application of the 3 (three) R's: Reduce, Reuse and Recycle. Following this step is material recovery and waste-to-energy. Energy can be recovered from processes i.e. landfill and combustion, at this level of the hierarchy. The final action is disposal, in landfills or through incineration without energy recovery. This last step is the final resort for waste which has not been prevented, diverted or recovered. The waste hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management. The hierarchy represents the latter parts of the life-cycle for each product. Waste hierarchy remains the cornerstone of most waste management. However, it is emphasized that the objective of the builder is not to generate waste, which, consequently, implies changes in the constructive culture adopted by most of the builders

During the preparation of this work, it was sought to identify practices adopted by construction companies aiming at the correct management of C&D Wastes with regard to the reduction of generation and adequate final disposal. In the companies visited, it was observed that the application of construction techniques, different from conventional techniques, is a constant practice. The application of pre-molded or molded construction elements in the construction site and the use of equipment that allows the non-generation of C&D waste is applied, resulting in the reduction of the C&D Waste generation index. Regarding management, there was a concern of managers to properly dispose of waste, separating it, performing sorting and allocating it in bays for temporary storage, facilitating the possibility of transformation and reuse, as well as the disposal to companies specialized in waste treatment and recycling.

In general, the objectives were achieved, considering that the companies show continuous interest in the application of new construction techniques and waste management practices. However, much remains to be done to ensure that C&D Waste is managed correctly, especially for DEMOLISION waste.

RECOMMENDATION

It could be recommended that for effective Waste, minimization, reuse and recycling can best be managed operationally by nominating a "Construction and Demolition Waste Manager" in the construction site for the smooth progress of the project and as well The Polluter pays principle should be undertaken, where the polluting party pays for the impact caused to the environment and health. With respect to waste management, this generally refers to the requirement.

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