Building Waste Management

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Abstract- *The most prominent and common issue that occurs in a construction industry is the huge waste liberation. These wastes are released at all stages of construction. Most of these are released during the demolition stage. Hence managing and controlling these wastes is of serious concern. This can be done by various methods. Introducing BIM in waste management is novel technique of handling and controlling the construction wastes. Usually waste management is done practically by monitoring and effective supervision. At present, there are insufficient design decision making tools to support effective construction waste minimization evaluation and implementation throughout all design stages. A limited but growing body of recent literature suggests that building information modeling has the potential to assist architects to minimize design waste on their projects. In this project construction and demolition waste management and minimization is done more effectively using BIM. This is done by analyzing the waste generation from different construction industries and then studying the nature of wastes. Most of the times, methods which are using for collection, demolition and recycling are not sophisticated and it accelerates the problems of environmental pollution, health impacts, etc. All these wastes are not just wastes some or many of it can be converted into useful products. After collecting the waste data it is analyzed and a suitable method is suggested to solve this problem. In this project waste generation data is collected using field surveys and is analyzed and compared. If proper methods are not implemented to control this waste it may threat the environment and the sustainable movement of the construction industry. C&D wastes generated in India in 2010 may be estimated as 24 million tones.*

Keywords- BIM (Building Information Modeling), C&D waste (Construction & Demolition), Waste Management, CWM (Construction Waste Management)

I. INTRODUCTION

Construction waste is anything that is generated as a result of construction works and is then abandoned, regardless of whether it has been processed or stockpiled. It comprises surplus materials from site clearance, excavation, construction, refurbishment, renovation, demolition and road works

Environmental Protection Agency (EPA) defines construction and demolition (C&D) waste as waste materials consist of the debris generated during the construction, renovation, and demolition of buildings, roads, and bridges. C&D waste often contain materials that include: concrete, asphalt, wood, metals, gypsum, plastics and salvaged building components. It is a daring and risky task to handle C&D waste because it is bulky, heavy and inert and also a combination of various materials of different characteristics. It is difficult too to choose a suitable disposal method to dispose and manage waste. For example, it cannot be disposed by incineration due to its high density and inertness. With the introduction of sustainable practices in the construction industry, C&D waste generation and managing issues have been in focus to attain the sustainable goals of waste management. Reduce, Reuse, Recycle (3Rs) philosophy is highly useful in controlling, regulating and handling of C&D waste. Even though recycling of construction wastes had already been implemented at the time of Second World War. During that time Germany reused most of the demolished concrete for construction purposes, yet many countries, especially developing countries are not fully aware of the capability and potential of 3Rs in regulating the waste. And hence they find land filling as the only method for C&D waste management. The better practice to regulate C&D waste is to minimize generation of C&D waste, but sometimes the minimization of waste is unavoidable due to various issues such as change-orders or demolition requirements for redevelopment.

Globally, building waste production is estimated at 2 to 3 billion tons per year. Out of this total liberation 30-40 % is concrete. C&D waste issues are more important for the developing countries. According to the annual report of Dubai municipality's Waste Management Department, a total of 27.7 million tones of construction waste were removed from various construction sites in the city in 2007, recording growth of 163 % in comparison to the waste generated in 2006, just 10.5 million tones. In their study, Vilas and Guilberto found that many countries in Asia do not have specific regulations designed for C&D wastes, although some countries include some sections in their solid waste management regulations and/or related policies. According to the study, developed countries generate 500 to 1000 kg per capita per year building & construction waste and waste in European Countries is estimated to be 175 million tonnes/year. It was also mentioned that very small percentage of waste from construction industry is reused or recycled, the majority being deposited or used as landfill. Like other developing countries, India is also enjoying construction boom. With the rapid growth in construction activities of India it is appropriate to link the generation of C&D waste with the growth of construction industry and related issues. It is also essential to study C&D waste generation and handling to develop accurate data and establish sustainable methods to manage construction waste. INDIAN CONSTRUCTION INDUSTRY According to 11th five year plan, in terms of magnitude construction industry is second only to agriculture.

India is sharing 5% of the world's total area book-keeping for 3,185,263sq.km of which 68% lives in countryside and 32% lives in built-up zones i.e. cities, towns, etc. According to the Indian Government estimates, India produces at present about 165-170 million tons (MT) of debris annually and as per estimates of the Union Ministry of Urban Development. Construction plays an important role in developing the infrastructure of the country. But the problem faced by the industry is the construction material waste. Construction activities generate more waste materials compared to other industries. All the materials used in the construction activities gets wasted, which in turn increases or boosting the cost of the project, reduces the profitability for contractor and gives a negative impact to the environment.

Although construction waste occurs during the actual construction activities, there is an understanding that it is caused by activities and actions at design, materials procurement handling and construction stages of project delivery processes. Construction industry is one of the highly growing economies in India. Accordingly, introduction of appropriate management and planning system in terms of construction materials and organizational set up may be beneficial to not only the construction companies but also the society and environment. Waste could be attributed to the constant uptake of construction, demolition and renovation activities during which villages are built into towns, towns into cities and cities into mega cities (Jaillon and Poon, 2014). To ensure the conservation of natural resources and to reduce the cost and impacts of waste disposal, effective waste management practices must be put in place. This will ensure the flow of construction material in a closed loop to minimize waste generation, preserve natural resources and reduce demand for landfills. Despite these opportunities to minimize CDW at the design stages, existing waste management tools are not, in reality, helpful to designers (Osmani et al., 2008). This is because they are completely detached from the design process and can only be used after the bill of quantities has been prepared. Although several studies in 2011 have identified that building information modeling (BIM) has potentials for designing out waste, none of the studies has provided clear instructions on how BIM could be used for this purpose.

Appropriate planning and construction management reduces wastage of construction materials substantially. Management is concerned with planning, procuring, receiving, stacking and distribution of construction materials at appropriate time and place. The main objective of material management and planning is to make available the right construction materials are in the right place, in the right quantities when needed.

Construction waste has been defined in various ways. As the different researcher defined waste is difference between materials ordered and those placed for fixing on building projects. In 1981 another definition emerged about waste stating that waste is any material apart from earth materials, which needed to be transported elsewhere from the construction site or used on the site itself. Construction wastes in any project are in the form of building debris from demolition activities, rubble, earth material, concrete wastes, steel wastes and timber etc.

The objective of the study is to analyze the potential application of Building Information Modeling (BIM) in construction waste minimization. This research aims in the assessment of waste developed in construction sites and the Implementation of BIM in waste management. Also it aims at developing a new technology in waste minimization by the optimization of waste produced in construction sites."This study assesses the expectations of stakeholders on how BIM could be employed for CDW management and also finds the limitations of existing CDW management tools, qualitative Focus Group Interviews (FGIs) were conducted with professionals who are familiar with the use of BIM to understand their expectations on the use of BIM for CDW management."(**Akinade A, Lukumon O. Oyedele A, Saheed O.**") Potential opportunities of BIM for efficient C&D waste management and minimization was done in this paper such as design review, 3D coordination, quantity take-off, phase planning, site utilization planning, construction system design, digital fabrication, and 3D control and planning. (**JongsungWon A, Jack C.P**.) "BIM's computational application is demystify to CWM. Computational BIM algorithms that can manipulate the information to facilitate decision-making for CWM are also identified. Finally, the operation of computational BIM is elaborated by relating it to various prevailing procurement models within which BIM applications are contextualized."(**Weisheng Lua, Chris**

Websterb, Ke Chena). **"**The first attempt to develop a design decision making framework for improving construction waste minimization performance through building information modeling. The questionnaire respondents were asked to rate the potential impact of BIM to address construction waste causes during building design, using a scale of 1–4 (1=no potential, 2=low potential, 3=significant potential, 4 = high potential). The results are shown in Table, which suggest that BIM can potentially have a high impact on addressing construction waste causes that are associated with design changes, design and detailing complexity, and ineffective coordination and communication at three levels: design team level, project level, and company level."(**Zhen Liu, Mohamed Osmani, Peter Demian).**

SOURCES OF MATERIAL WASTE IN CONSTRUCTION

Different factors contribute to the generation of material waste. These factors have been grouped under four categories:

(1) Design;
(2) Procurement;
(3) Handling of materials; and
(4) Operation

From these in formations it can be derived that the process of waste minimization must be started at the early stages of the project. The most frequent measures practiced to minimize and reduce material waste are staff training, adequate storage and just- in time delivery of materials are one of the most important.

CONSTRUCTION & DEMOLITION WASTE IN INDIA

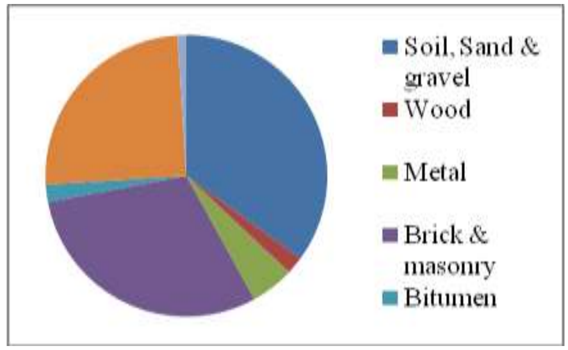
In India C&D waste has two components:

MAJOR COMPONENTS

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

MINOR COMPONENTS

Conduits (iron, plastic), Pipes (GI, iron, plastic), Electrical fixtures (copper/ aluminum wiring, wooden baton, switches, wire insulation), Panels (wooden, laminated) and others (glazed tiles, glass panes).



The existing tools can be categorized under five broad groups, which are: (i) waste management plan templates and guides; (ii) waste data collection and audit tools; (iii) waste estimation tools; (iv) environmental assessment tools and (v) waste Geographic Information System (GIS) tools. (Olugbenga O. Akinade a,) and also after an exhaustive review, five main limitations that impede the effectiveness and usability of existing construction waste management tools were identified. These limitations can be summarized thus:

(i) Existing tools are completely detached from the design Process,
(ii)Existing CDW management tools lack interoperability Capabilities,
(iii) Construction and demolition waste data are not sufficient,
(iv)Waste management responsibilities are not clear, and
(v)Lifecycle assessment of waste performance is not available.

The existing waste management tools can be categorized under five broad groups and it is shown in the Table 1 as per the report of (Olugbenga O. Akinade a,) in 2018. Also they reports that the expectation of industry stakeholders for BIM- based CDW management were revealed by conducting a focus group discussion. Each of the expectation factors and how the expectation could be achieved are discussed under these factors

1. BIM based collaboration for waste management
2. Waste driven design process and solutions
3. Waste throughout the building lifecycle
4. Innovative technologies for waste intelligence and analytics

Improved documentation for waste management

In a summarized discussion, this study presents dual contributions:

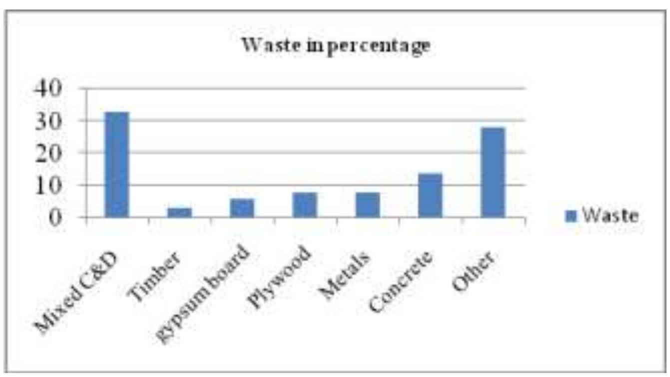
The results improve the understanding of BIM functionalities and how they could be employed to improve the effectiveness of existing CDW management tools and the understanding of the industry expectation on the use of BIM for CDW management will improve the implementation of BIM-based software prototypes for CDW management. In addition, the study revealed that harnessing current technological capabilities into BIM would help to achieve unprecedented CDW analysis performance.

The results highlight the current potentials of BIM in driving effective design-out-waste process and providing a basis for the development of BIM-based CDW management tools.

II. WASTE DATA ANALYSIS

Waste Generation Data for BUILDING A

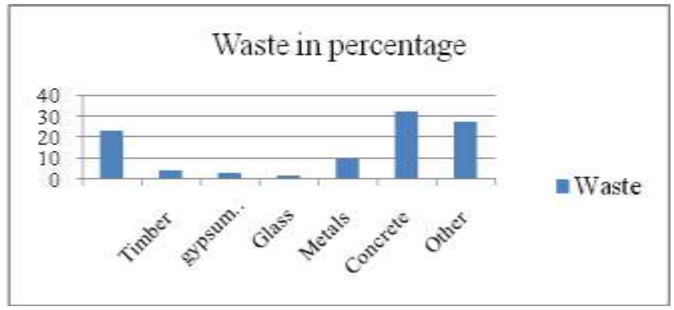
Waste Type	Tonnes	Reuse/Recovery		Recycle			
		%	Tonnes	%	Tonnes		Tonnes
Mixed C&D	0.6	10	0.06	0	0	90	0.54
Timber	0.05	40	0.02	55	0.0275	5	0.0025
gypsum board	0.1	0	0	60	0.06	40	0.04
Plywood	0.15	30	0.045	60	0.09	10	0.015
glass	0.06	75	0.045	25	0.015	0	0
Metals	0.15	5	0.0075	80	0.12	15	0.0225
Concrete	0.25	0	0	0	0	100	0.25
Other	0.5	20	0.1	60	0.3	20	0.1
Total	1.86		0.2775		0.6125		0.97



From the waste data analysis done on Building A, it can be concluded as:-

1. Construction and demolition waste is mostly liberated in this building when comparing to other wastes.
2. Next prominent waste that is generated in Building A is the concrete wastes.
3. From these two results it is clear that the wastes generated in Building A are the recyclable ones that can be reused for other purposes.
4. The best method to control such wastes is to collect, recycle and then reuse.
5. Recycling of these wastes can be done in many ways. The concrete which is the mixture of aggregates, cement and water can be broken and then used.
6. Also the individual constituents in the concrete can also be recycled and then used.

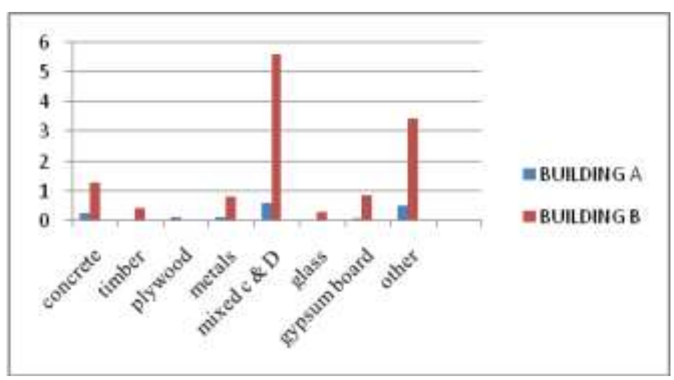
Waste Generation Data for BUILDING B



From the waste data analysis done on Building A, it can be concluded as:-

1. Concrete waste is mostly liberated in this building when comparing to other wastes.
2. Next prominent waste that is generated in Building B is the construction and demolition wastes.
3. From these two results it is clear that the wastes generated in Building B are the recyclable ones that can be reused for other purposes.

COMPARISON BETWEEN BUILDING A AND BUILDING B



From the comparison between Building A and Building B it can be concluded that Construction and demolition waste and concrete waste are mostly liberated.

Waste Type	Tonnes	Reuse /Recovery		Recycle		Disposal	
		%	Tonnes	%	Tonnes		Tonnes
Mixed C&D	0.43	10	0.06	0	0	90	0.387
Timber	0.082	40	0.0328	55	0.0451	5	0.0041
gypsum board	0.05	0	0	60	0.03	40	0.02
Glass	0.03	75	0.0225	25	0.0075	0	0
Metals	0.18	5	0.009	80	0.144	15	0.027
Concrete	0.6	0	0	0	0	100	0.6
Other	0.5	20	0.1	60	0.3	20	0.1
Total	1.872		0.2243		0.5266		1.1381

III. WASTE RECYCLING PROCESS

The ability to reuse and recycle materials salvaged from demolition and building sites for reuse and recycling depends on:

1. Local recycling facilities
2. Market demand
3. Quality and condition of materials and components
4. Time available for salvage
5. Emphasis put on reuse and recycling.

REUSE/RECYCLING FROM CONSTRUCTION SITES

Materials that can generally be recycled from construction sites include:

1. Steel from reinforcing, wire, containers, and so on
2. Concrete, which can be broken down and recycled as base course in driveways and footpaths
3. Aluminum
4. Plastics – grades 1 and 2
5. Paper and cardboard
6. Untreated timber, which can be used as firewood or mulched topsoil
7. Paint. A number of manufacturers/retailers take back unwanted paint and paint containers.

REUSE/RECYCLING FROM DECONSTRUCTION OR DEMOLITION SITES

Materials that can generally be recycled from deconstruction/demolition sites include:

1. Site works and vegetation – asphalt paving, chain link fencing,
2. Timber fencing, trees
3. Concrete – in situ and precast concrete
4. Masonry – concrete blocks and decorative concrete, paving stones, bricks,
5. Metals – reinforcing steel (rebar), structural steel, steel roofing including flashings and spouting, zinc roofing, interior metal wall studs, cast iron, aluminum, copper etc.
6. Timber – hardwood flooring, laminated beams, truss joists, treated and untreated timbers/posts, joinery, and untreated timber generally, engineered timber panels, terracotta tiles, electrical wiring, wool carpet and Plastics – high density polyethylene water pipes, PVC, polystyrene (resin codes 1–6).

Components that can readily be reused include:

1. timber – hardwood flooring, weatherboards, laminated beams, truss joists, treated and untreated framing, timbers/posts, and New Zealand native timber components
2. thermal insulation – fiberglass, wool and polyester insulation, 3 polystyrene sheets
3. carpet and carpet tiles
4. plumbing fixtures – baths, sinks, toilets, taps, service equipment, hot water heaters
5. electrical fittings – light fittings, switches, thermostats
6. Linings and finishing – architraves, skirting, wood paneling, specialty wood fittings, joinery
7. doors and windows – metal and timber doors, mechanical closures, panic hardware, aluminum windows, steel windows, sealed glass units, unframed glass mirrors, store fronts, skylights, glass from windows and doors, timber and metal from frames, clay and concrete roof tiles, metal wall and roof claddings and PVC and metal spouting.

Hazardous materials

Hazardous materials must be disposed of appropriately. Check the requirements for removal and disposal of hazardous waste for your local area.

Hazardous wastes from the demolition of buildings may include:

1. Fluorescent light ballasts manufactured before 1978 – contain PCBs
2. Fluorescent lamps – contain mercury

3. Refrigeration and air conditioning equipment – contain refrigerants made using CFCs
4. Batteries – contain lead, mercury and acid
1. roof and wall claddings, pipe insulation, some vinyl flooring, textured ceilings and roofing membrane sheets containing asbestos fibers
5. Lead or materials that contain lead such as flashings, paint, bath and basin wastes.

Requirements for recycled or reused materials

Factors include the:

1. Cost of transport
2. Cost of skip hire
3. Value of material
4. Weight/amount of material
5. Amount of contaminants.

Every market has its own specifications for recycled or reusable materials. Obtain specifications from the recycling operators before starting deconstruction so you know what to save and how to save it. You should find out: material type, acceptable and unacceptable levels of contamination, acceptable and unacceptable levels of damage quantities accepted, transportation requirements required documentation including waste tracking forms sorting and handling requirements for each material type.

Things to check for concrete:-

Types of concrete and rubble accepted.

1. Size of concrete pieces.
2. Amount of preprocessing.
3. Acceptable levels of bricks and tiles.
4. Acceptable amount of contamination from materials such as glass, metal, soil.

Some concretes products are too hard-wearing on crushing machines and some concretes are too soft to meet reuse specifications after crushing, so will not be accepted by operators.

Things to check for metal:-

1. Types of metal accepted.
2. Contamination tolerances from materials such as plastics and leftover product in containers.

Things to check for plasterboard:-

1. Whether demolition board is acceptable.
2. Minimum and maximum sizes of chip or powder particles.
3. Contamination tolerances from materials such as screws, nails, paint and glues.
4. Moisture tolerances.
5. Minimum and maximum quantities.

Things to check for timber:-

1. Types of timber acceptable (for example, treated, native, and untreated).
2. Minimum and maximum sizes of board and lengths of timber.
3. Minimum and maximum quantities.
   Contamination tolerances from materials such as nails, paint, concrete.
4. Any preprocessing requirements such as sorting or grading.

How timber is to be received (for example, loose, stacked in containers or on pallets).

RECYCLING OF BRICKS

Recycled brick can be crushed and used for a number of different applications. Companies often purchase it instead of aggregate (such as gravel) for construction projects. Bricks can be chipped and used in landscapes. Like the parent material, the chips look nice and will hold up well even in very cold, windy or rainy climates. If the bricks are broken down to a very fine material they can be used in place of sand or even go into new bricks. Sioux City Brick in Iowa makes a fine brick powder that can be used in baseball diamonds or running tracks.

RECYCLING OF CONCRETE

Recycling of concrete pavement is a relatively simple process. It involves breaking, removing and crushing concrete from an existing pavement into a material with a specified size and quality.

Crushed concrete may be reused as an aggregate in new Portland cement concrete or any other structural layer. Generally it is combined with a virgin aggregate when used in new concrete. However, recycled concrete is more often used as aggregate in a sub-base layer.

There are no restrictions on the types of concrete pavements that can be recycled. Successful and economical recycling projects have included jointed plain pavement, jointed reinforced pavement, continuously reinforced pavement and even airport pavement over 17 inches thick.

Arrangements can be made to haul concrete from a demolition site to the recycling plant, or, in some cases, recyclers are able to move portable recycling machinery to the plant site.

RECYCLING OF TIMBER OR LUMBER:

Most types of timber can be recycled. Waste wood can come in a variety of forms from medium density fiberboard (MDF) to tree branches.

The main causes of wood waste are:

1. Pallets
2. Crates
3. Beams
4. Window and doorframes
5. Doors
6. Floorboards
7. Shuttering
8. Fencing
9. Panels, such as chipboard.

POTENTIAL END USES FOR RECLAIMED WOOD

Reclaimed wood can be used in applications and materials including:

1. Chipboard, oriented strand board and fiberboard manufacture
2. Bedding products for animals play surfaces and pathways
3. Architectural components
4. Landscaping and commercial products - eg logs, fuel chips
5. Liquid fuel (ethanol and methanol)

RECYCLING OF GLASS:

Most glass waste is produced by demolition projects and the replacement of windows in refurbishment projects (flat glass). It also comes from:

1. Fluorescent lighting
2. PC monitors and TV screens
3. Structural glass - eg in modern office blocks

The main causes of glass wastage are:

1. Over ordering of materials
2. Breakages during installation
3. Damage during storage

Recycling options for glass

You can recycle waste glass produced on your construction site by:

1. Crushing
2. Screening to remove contamination
3. Air classification

IV. CONCLUSION

From this study it can be concluded that

1. On-site construction waste management is an integral part of construction industry and it plays a significant role in a project's sustainability.
2. However, success of the waste management program is only possible when proper planning and scheduling of construction waste is done as other construction activities.
3. Analysis of waste generated in different buildings shows different results and proper method should be adopted to regulate this waste.
4. Best way to control the waste generation is by recycling the waste liberated in various methods
5. By adopting proper ways, recycling of wastes will reduce the construction cost

This technique can be adopted very easily and hence the wastes can be managed.

REFERENCES

[1] Raimar J. Scherer, Peter Katranuschkov Institute of Construction Informatics, TU Dresden, Germany

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[13] Roshna Takim, ,Mohd Harris in Building Information Modelling (2013, pg 23-32 Social and behavioral Sciences).
[14] Abukhazam M and Leo A(2010), Workforce Attitude on technology Adoption and Diffusion.
[15] Shuratman Z, Building Information Modelling in Local Construction Industry (2012)
[16] Weygant R.S., BIM content development,standards, strategies and best practice. (2011)
[17] national Building information Modeling standard version 2, (2005) in NIST
[18] C.Eastman, R sacks BIM hand book, (2010)
[19] Wikipedia