International Conference on Innovative Research in Engineering, Management and Sciences
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2019 IJSRCSEIT | Volume 4 | Issue 9 | ISSN : 2456-3307

Reuse and Recycling of Construction and Demolition Waste

Geethu. V
Assistant Professor, Department of Civil Engineering, New Horizon College of Engineering, Outer Ring Road, Marathalli, Bengaluru, Karnataka, India

ABSTRACT

Due to rapid urbanization in India, environmental impacts from construction and demolition (C&D) waste are increasingly becoming a major issue in urban waste management. Construction and demolition waste is generated whenever any construction/demolition activity takes place. It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc. A major part of this waste comes to the municipal stream. This study aims to focus on the possibilities of reuse, recycling and renovation in reducing C&D waste. Various practices of reuse and recycling like renovation, concrete recycling, and deconstruction were studied. Along with reduction in C&D waste these practices can reduce the exploitation of virgin natural resources. Renovation of existing residential building for new requirements was done to reduce the demolition waste produced. It helped in the onsite reuse of functional parts of existing building for the new building. In this particular study we were able to save the entire foundation, roofing frame, flat slab and 73.84% of wall for superstructure.

Keywords : Construction & demolition waste, deconstruction, renovation, recycling, reuse, material recovery

I. INTRODUCTION

Parallel to rapid urbanization in India, environmental impacts from construction and demolition (C&D) waste are increasingly becoming a major issue in urban waste management. C&D waste management in India and other developing countries is relatively underdeveloped and emerging. Particularly in mega-cities, where rapid population growth and economic development is evident, an increasing growth of built environment is also manifested. This built environment includes the urban infrastructures, high rise commercial buildings and residential buildings, among others. Construction, renovation, and demolition activities of the built environment cause C&D waste contributing to one of the major environmental burdens. Furthermore, these environmental burdens of waste emission continue with current poor solid waste management and limited solid waste facilities which are evident in most of mega-urban centers. Apart from this construction Industry is the largest sector in respect of consumption of energy. It consumes around 2/5th of the total consumed energy throughout the world. Resource utilization in case of construction industry amounts to half of the total resource used all over the world.[1]

Construction and demolition waste is generated whenever any construction/demolition activity takes place. It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc. A part of this waste comes to the municipal stream. These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container. Waste from small generators like individual house construction or demolition, find its way into the nearby municipal bin/vat/waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. A large part of it from bulk generators goes to existing landfills, eating into their spaces. [1]

It is estimated that the construction industry in India generates about 10-12 million tons of waste annually. It constitutes about 10-20 % of the municipal solid waste (excluding large construction projects). While some of the items like bricks, tiles, wood, metal etc. are re-used and recycled, concrete and masonry, constituting about 50% of the C&D waste is not currently recycled in India. The fine dust like material (fines) from C&D waste is presently not being used and thus wasted.

C&D waste requires focus primarily in view of (i) its potential to save natural resources (stone, river sand, soil etc.) and energy (ii) its bulk, which is carried for long distances without any proportionate return (iii) the space it occupies at the sanitary landfill site unless the fines are used as landfill cover, (iv) its potential for spoiling processing of biodegradable as well as other recyclable waste. On the other hand it has potential use after processing and grading. There is a huge demand of aggregates in the housing and road sectors but there is significant gap in demand and supply, which can be reduced by recycling construction and demolition waste to certain specifications. Thus, its presence in terms of quantity as well as its importance is growing. So far in India there is very little effort to manage and utilize construction and demolition waste.[1]

CONSTRUCTION & DEMOLITION WASTE

Construction and demolition waste is generated whenever any
Construction/demolition activity takes place, such as, building roads, bridges, flyover, subway, remodeling etc. It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc. A part of this waste comes to the municipal stream.

These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container. It is not uncommon to see huge piles of such waste, which is heavy as well, stacked on roads especially in large projects, resulting in traffic congestion and disruption. Waste from small generators like individual house construction or demolition, find its way into the nearby municipal bin/vat/waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. Often it finds its way into surface drains, choking them. It constitutes about 10-20 % of the municipal solid waste (excluding large construction projects). [1]

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.[1]

While retrievable items such as bricks, wood, metal, titles 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.[1]

STORAGE OF CONSTRUCTION AND DEMOLITION WASTE

C&D wastes are best stored at source, i.e., at the point of generation. If they are scattered around or thrown on the road, they not only cause obstruction to traffic but also add to the workload of the local body. All attempts should be made to stick to the following measures:

1. All construction/demolition waste should be stored within the site itself. A proper screen should be provided so that the waste does not get scattered and does not become an eyesore.
2. Attempts should be made to keep the waste segregated into different heaps as far as possible so that their further gradation and reuse is facilitated.
3. Material, which can be reused at the same site for the purpose of construction, leveling, making road/pavement etc. should also be kept in separate heaps from those, which are to be sold or land filled.
4. The local body or a private company may arrange to provide appropriate number of skip containers/trolleys on hire which may be parked at the site and removed with skip lifters or tractors as the case may be.
5. Whenever a new streamlined system is introduced in a municipality, the local body may consider using its old vehicles, especially, tractors and trailers or old Lorries or tippers for this purpose.
6. For large projects involving construction of bridges, flyovers, subways etc., special provision should be made for storage of waste material. Depending on the storage capacity, movement of the waste has to be planned accordingly. Otherwise, it would result in job constraint as well as traffic bottlenecks.
7. This subject is often neglected in case of repair/maintenance of roads, water pipes, underground telephone and electric cables etc. It is not uncommon to see that after such work, the waste remains piled for months on the roads or pavements. The concerned departments and contractors must co-ordinate with the municipality for removal of the debris generated. The municipality while giving permission for such work should clearly sort out the issue of removal of the debris and should insist that immediately after the job is over, the road should be repaired and brought back to its normal shape. [1]

RECYCLING AND REUSE OF C&D WASTE

The use of these materials basically depends on their separation and condition of the separated material. A majority of these materials are durable and therefore, have a high potential of reuse. It would, however, be desirable to have quality standards for the recycled materials. Construction and demolition waste can be used in the following manner: [1]

1. Reuse (at site) of bricks, stone slabs, timber, conduits, piping railings etc. to the extent possible and depending upon their condition.

2. Sale / auction of material which cannot be used at the site due to design constraint or change in design.

3. Plastics, broken glass, scrap metal etc. can be used by recycling industries.

4. Rubble, brick bats, broken plaster/concrete pieces etc. can be used for building activity, such as, leveling, under coat of lanes where the traffic does not constitute of heavy moving loads.

5. Larger unusable pieces can be sent for filling up low-lying areas.

6. Fine material, such as, sand, dust etc. can be used as cover material over sanitary landfill.

Metropolitan and mega cities usually generate huge quantities of wastes because of large-scale building and other developmental activities. They may identify suitable sites where such waste can be temporarily stored and some physical treatment can be carried out. [1]

DISPOSAL OF C&D WASTE

Being predominantly inert in nature, construction and demolition waste does not create chemical or biochemical pollution. Hence maximum effort should be made to reuse and recycle them as indicated 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. The same can be attempted in our country also for cities, which are located near open mining quarries or mines where normally sand is used as the filling material. However, proper sampling of the material for its physical and chemical characteristics has to be done for evaluating its use under the given circumstances. [1]

CHALLENGES IN C&D WASTE RECYCLING

C&D waste is a major component of the solid waste stream, which should be recognized as a valuable resource as large quantities of it could either be reused or recycled. C&D waste has been mostly overlooked in the efforts to reduce waste sent to landfill, with the emphasis being placed on domestic reuse and recycling. With this view, Asian countries have a problem of disposal sites of which C&D waste largely account to it. Environmental issues such as increase in volume and type of waste, resource depletion, shortage of landfill and illegal dumping, among others are evident in countries in the region. Furthermore, the Asian countries have limited or no available data on C&D waste and the management aspects, particularly with regards to their C&D waste generation and composition; practices and policy, key actors and stakeholders' participation and available technology related to 3Rs. Most of the local governments do not recognize and include C&D waste in their waste management plan. [1]

CONCRETE RECYCLING

Concrete is a composite construction material composed primarily of aggregate, cement and water. Concrete is everywhere. Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Twice as much concrete is used in construction around the world than the total of all other building materials, including wood, steel, plastic and aluminium. Concrete is extremely durable and can last for hundreds of years in many applications. Concrete is an excellent material to make long-lasting and energy-efficient buildings. However, even with good design, human needs change so buildings will be demolished and thus potential waste will be generated. [6]

Concrete has fairly unique properties and its recovery often falls between standard definitions of reuse and recycle. Concrete is rarely able to be "reused" in the sense of being reused in its original whole form. Nor is it "recycled" back into its original input materials. Rather, concrete is broken down into smaller blocks or aggregate for use in a new life. So generally "recycled concrete" refers to concrete that has been diverted from waste streams and reused or recovered for use in a new product. Concrete recycling is a well established industry in many countries and most concrete can be crushed and reused as aggregate.[6]
Concrete can be recycled from:

- Returned concrete which is fresh (wet) from ready mix trucks
- Production waste from a pre-cast production facility
- Waste from construction and demolition

The most significant source is demolition waste.
It is a material that can last for a very long time, and most concrete waste is generated not because the concrete is worn out, but usually because the structure itself has become redundant with changing infrastructure needs and planning. In some countries near full recovery of concrete is achieved, in most parts of the world the potential to recover concrete is overlooked and it ends up as unnecessary waste in landfill. Extraction of materials for aggregates like broken stone, sand etc create significant environmental degradation, pollution and energy consumption. Recycling of concrete can replace a considerable amount of natural aggregate required

for the production of concrete and other purposes like road construction. [6]

DECONSTRUCTION

Deconstruction is a relatively recent practice in which buildings are carefully dismantled to salvage components for reuse and recycling. Its benefits include reducing the amount of construction and demolition (C&D) waste going to landfills, conserving resources through recycling, generating marketable products from salvage, providing job training to low and unskilled workers, and creating jobs. Deconstruction is a process of building disassembly in order to recover the maximum amount of materials for their highest and best re-use. Re-use is the preferred outcome because it requires less energy, raw materials, and pollution than recycling does in order to continue the life of the material. As a consequence of deconstruction, there are also many opportunities for recycling other materials along the way. [7]

Deconstruction combines the recovery of both quality and quantity of reusable and recyclable materials. The re-use of materials can serve a broad set of goals including the provision of low-cost building materials to a community, and the avoidance of demolition debris going to landfills. [7]

The deconstruction process roughly follows the reverse of the construction process. The premise is that materials which have been put on last will come off first. Variations occur for whole building sections, for example, an addition will be removed in its entirety separately from the rest of the building. The practice of focusing on each material type in a reverse order of the construction process is more efficient for separating materials for reuse, recycling, and disposal at the time of removal. Additions are an impediment to removing one type of material or whole sections of the original structure, but can provide a working surface for other parts of the building, and be structurally dependent on other parts of the building.

EPA ON DECONSTRUCTION

According to the Old Research Report on Recycling; Training Programs; Environmental Protection Department; Demolition EPA defines "deconstruction" as the disassembly of buildings to safely and efficiently maximize the reuse and recycling of their materials. While windows, doors and light fixtures are routinely salvaged as part of standard demolition practice, deconstruction also aims to save and reuse flooring, siding, roofing, and framing where these materials have retained their value. In some cases, EPA notes, deconstruction can save materials that are otherwise not available, such as old-growth Douglas fir and redwood lumber. [8]

EPA calls deconstruction a "grave-to-cradle" program that helps take care of the enormous stock of buildings reaching the end of their useful lives while simultaneously reducing the pressure to mine or harvest natural resources for new construction, reducing the need for landfill space, and creating new jobs. [8]

According to EPA, construction activities consume 60% of the total raw materials used in the U. S. economy. EPA estimates that 136 million tons of building-related C&D waste is generated annually, of which 92% is from renovation and demolition work. Only 20 to 30% of C&D waste is being recycled. [8]

Deconstruction provides the following environmental benefits:-

- Reducing the C&D waste stream, saving landfill space.
- Saving natural resources that would otherwise be used, reducing the need for, and environmental impacts of, mining and timber-cutting.
- Saving energy by reusing and recycling materials.

Reducing job site pollution from dust, airborne lead and asbestos

Deconstruction provides the following social benefits:

- Creates jobs because it requires more labour.
- Deconstruction's basic skills are easily learned, enabling unskilled and low-skilled workers to receive on-the-job training.

TYPICAL METHODS OF DECONSTRUCTION

Deconstruction is commonly separated into two categories; structural and non-structural. Non-structural deconstruction, also known as "soft-stripping", consists of reclaiming non-structural components, appliances non doors, windows, and finish materials. The reuse of these types of materials is commonplace and considered to be a mature market in many locales. [8]

Structural deconstruction involves dismantling the structural components of a building. Traditionally this had only been performed to reclaim expensive or rare materials such as used brick, dimension stone, and extinct wood. In antiquity, it was common to raze stone buildings and reuse the stone; it was also common to steal stones from a building that was not being totally demolished: this is the literal meaning of the word dilapidated. Used brick and dimension limestone in particular have a long tradition of reuse due to their durability and color changes over time. Recently, the rise of environmental awareness and sustainable building has made a much wider range of materials worthy of structural deconstruction. Low-end, commonplace materials such as dimensional lumber have become part of this newly emerging market. [8]

RENOVATION

Renovation is the process of modifying an existing structure to suit the modern requirements of users. This is an existing practice locally but not widely practiced and it can enable the reuse of building materials producing material savings. Buildings are usually demolished not because they are completely damaged and become useless, but usually because the building itself has become redundant with changing needs and lifestyle. Therefore instead of demolishing the existing building and constructing a new building, existing building can be modified to suit the current needs. This can considerably reduce the amount of demolition waste generated. This is an alternative that should be considered before the demolition of any building.

CASE STUDY

In order to make an assessment of the renovation process in material savings we have done a case study on a renovated building. It is a residential building in, Kollam, Kerala, India.

DETAILS OF OLD BUILDING

Total area : 196.98m^2 (excluding porch)
Roof : Sloping tiled roof, RCC flat roof 10cm thick
Floor : Mosaic floor
Plastering : Cement Plastering.
Walls : 20 cm thick laterite wall.

Existed old building had various issues like:

- Inadequate ventilation
- Insufficient daylight
- Outdated fashion
- Outdated function
- Inadequate living space

In order to overcome the above mentioned difficulties and to satisfy the requirements of the residents the house had been renovated. We compared both the buildings with available data on both like building drawings and data collected during the site visit and documentation of the renovated building by our project team.

DETAILS OF RENOVATED BUILDING

Total area : 196.98m^2 (excluding porch)
Roof : Sloping tiled roof, RCC flat roof 10cm thick

Floor : Vitrified tiles
Plastering : Cement Plastering
Walls : 20 cm thick laterite wall

FOUNDATION

Foundation of the old building did not have any settlement or weakness, therefore existed foundation is completely retained for the renovated building. 5.12m of new wall is constructed to make minor changes in the plan new foundation is given for this much length.

According to this almost entire foundation for the renovated building is retained from the old building. This means the saving of 71.13m^3 of foundation material which was needed to provide foundation for the new building. Currently demolition waste from random rubble masonry is not recycled or reused except for usable rubble after demolition in some cases. So retaining effectively reduced the demolition waste. This can be considered as the reuse of existed foundation in the renovated building which leads to the saving of material and reduction in waste production.

WALLS

The major issue that was addressed in the renovated building is lack adequate space for living and dining areas and ventilation and lighting in the interior parts of the building. For this purpose some of the interior walls of the building were removed some small partition walls are added. This was one of the major restructuring processes in the renovation of this building. Changes in the superstructure have lead to the removal and addition of considerable amount of brick work. Walls of the old building were of laterite and the newly added partitions and walls were of brick masonry.

According to the calculations is 26.16% (17.09m^3) of laterite wall is removed and 17.22% (11.25m^3) of brick wall is added in the renovation of the building. This means 73.84% of laterite wall in the old building is retained in the renovated building. This saved 48.24m^3 of brick masonry needed for the construction of the building if the old building was completely demolished. It also reduced the amount of demolition waste from the superstructure by about 74% and reuse of the same amount of material in the new building.

Table1: Total quantity of wall of superstructure

SL No.	Description	Numbers	Length (m)	Breadth (m)	Height (m)	Quantity (m^3)
1	Laterite wall 20cm thick	1	133.26	0.2	3	79.9
	Deductions					
2	Door 1	17	1	0.2	2	6.8
3	Door 2	15	0.9	0.2	2	1.44
4	Opening	1	2	0.2	3	1.2
5	Window 1	5	1.5	0.2	1.5	2.25
6	Window 2	9	1	0.2	1.5	2.7
8	Ventilator	3	0.9	0.2	0.5	0.24
	Total Deduction					14.63
	Total					65.33

Table 2: Total quantity of wall removed

SL No.	Description	Numbers	Length (m)	Breadth (m)	Height (m)	Quantity m^3
1	Laterite Wall 20cm thick	1	31.82	0.2	3	19.09
	Deductions					
2	Door 1	1	1	0.2	2	0.4
3	Door 2	4	0.9	0.2	2	1.6
	Total Deduction					2
	Total					17.09

Table 3: Quantity of wall added

SL No.	Description	Numbers	Length (m)	Breadth (m)	Height (m)	Quantity (m^3)
1	10cm wall	1	5.99	0.1	3	1.797
2	20cm wall	1	15.75	0.2	3	9.45
	Total					11.25

ROOFING

The roof provided in the old structure was a combination of both flat roof and tiled sloping roof. The tiled sloping roof in the rear half of the building and the front half of the building was RCC flat roof. The roof frame of tiled roof had no considerable damage and the flat roof had leaking problems which had to be addressed to retain it. In the renovated building the entire roof frame is retained to provide roofing for the rear half of the building. The roofing tiles were replaced with GI sheets in order to reduce the load on the structure. The purlins provided earlier where not in the same level, thus replacement of the tiles with GI sheet was affected. The GI sheets would bend along the unlevelled purlins. New purlins of rectangular steel tubes were provided at 2m distance to hold the sheets. Old timber purlins were retained as removing them was an unnecessary operation. The flat roof at the front portion of the building had leakage problems which had to be solved at minimum cost. Demolition and reconstruction of the flat roof was not economical. The best solution was to erect steel trusses and lay GI sheets over them. This provided uniformity in the structure which was a boost to its aesthetics.

In this renovation adopted for roofing entire roof frame and flat slab is reused in the renovated building, which saved the materials to provide new roofing for the new building. The removed roofing tiles have an existing market where they are sold for reuse. Retaining of the flat roof by addressing the leaking problem by providing a sloping GI sheet roof not only reduced the demolition concrete waste, which is not currently recycled in India, but also prevented the difficult process of demolition of flat slab which can damage the walls it is supported on.

DOORS AND WINDOWS

The doors and windows initially used were not of standard size and their placement and size according to the renovated design was different to provide adequate lighting and ventilation. Therefore the entire frames and shutters of doors and windows were replaced by new ones .Number of windows in the old building was increased due to insufficient lighting.

The doors and windows removed from old building can be reused and there is an existing market for them where they are sold for reuse or they are used to make components for new timber products.

FLOORING

Initially the flooring provided was mosaic. It had minor damages and low aesthetic appeal. New flooring was provided using vitrified tiles over the existing floor to improve its aesthetic appearance.

Conclusion

According to our assessment this renovation process has achieved considerable material savings. The amount of demolition waste produced is reduced to a great extend. Renovation provides an opportunity to reuse the functional parts of the old building in the renovated building as such for the same function or with necessary modification by retaining them in the renovated building. In this particular study we were able to save the entire foundation, roofing frame, flat slab and 73.84% of wall for superstructure. Renovation also promotes deconstruction instead of demolition in order to prevent damage to parts of building which is to be retained, which can increase the amount of reusable material extracted from the building. Possibilities of renovation should always be considered before the demolition of any building.

II. REFERENCES

[1]. Solid Waste Management Manual, Ministry of Urban Development, Govt. of India, 2000

[2]. Report of the Committee to Evolve Road Map on Management of Wastes in India, 2010

[3]. Report on Reduce, Reuse and Recycle (3R) Practices in Construction and Demolition Waste Management in Asia by Asian Institute of Technology School of Environment, Resources and Development, Thailand, 2008

[4]. Shima, Tateyashiki, Matsuhashi, Yoshida, An Advanced Concrete Recycling Technology and its Applicability Assessment through Input-Output Analysis, January 2005

[5]. Macozoma, 2000, cited in UNEP, 2002: 249

[6]. The Cement Sustainability Initiative (CSI) final report, 2009

[7]. Bradley Guy, Eleanor M. Gibeau, A Guide to Deconstruction, January 2003

[8]. Paul Frisman, Old Research Report on Recycling; Training Programs; Environmental Protection Department; Demolition; December 2004

[9]. Management of construction and demolition waste in India, Working Sub-Group on construction and demolition waste, April 2009

[10]. Y. Dosho, Development of a sustainable concrete waste recycling system: Application of recycled aggregate concrete produced by aggregate replacing method, 2006

[11]. Concrete Waste Management, California Stormwater BMP Handbook, January 2003 12Deconstruction - Building Disassembly and Material Salvage: The Riverdale Case Study, NAHB Research Center, June 1997

[12]. RCRA in focus: Construction, Demolition and Renovation, United States Environmental Protection Agency, September 2004

[13]. Utilization of Waste from Construction Industry, Technology Information Forecasting and Assessment Council (TIFAC), 2001

[14]. Patrick J. Dolan, Richard G. Lampo, and Jacqueline C. Dearborn, Concepts for Reuse and Recycling of Construction and Demolition Waste, June 1999