Trade-Off Assessment between Environment and Economy for Demolition Waste in India

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Abstract

In India, the amount of Construction and Demolition waste (C&D) generated is found to be 25-30 million tons out of which it is estimated that 40-50 kg/cu.m. generated mainly from the construction and minor renovation works and 300-500 kg/cu.m.is generated from the demolition of buildings, in this 90% of demolition waste goes to landfill which makes that land unfeasible. In the current scenario, the world is moving towards a sustainable approach due to various climate change catastrophes, thus using recycled materials to construction could be a greater advantage as it minimizes the impact of depletion of natural resources. Through the literature review, the major recyclable waste constituents during the demolition phase of buildings are identified and also ways of recycling them are studied. Two live projects of different scales are taken as case studies and the revised prices of discovered material (i.e. recycled material instead of new material) are used in the analysis of rate, for calculating the overall cost of the whole material in both projects. Usage of recycled materials leads to a reduction in environmental impact along with an increased cost savings. Procedure for the usage of the found recyclable materials in the projects is discussed. Further, planned cost savings are achieved only by monitoring and controlling it, during execution. Cost savings are proved by comparing the derived price (i.e. a part of recycled materials is used instead of new materials) and the original price of the whole materials.

Keywords: *Demolition waste, Recycle, Cost analysis, Cost savings*

1. Introduction

Construction and demolition debris represent around 55 percent of all solid waste by weight as a major component of municipal solid waste. During the demolition of building the amount of waste generated is estimated as 300-500kg/cubm depending upon the scale of the project and also more than 90 percent of this waste is landfilled throughout India. The amount of demolition waste quantity is influenced by the ever increasing land use for new construction, renovation, demolition of old buildings, and road transport network reconstruction or expansion. [22] Despite the concern, our perception of the demolition waste stream is not as comprehensive as other municipal solid waste components. In India, the new approach of architects and contractors towards sustainability is to create green and environmentally sustainable buildings in a number of ways, such as minimizing the use of electricity, reducing the carbon footprint etc. Yet it is necessary to note that any building has a finite age or life cycle. [2]

Demolition waste is considered a harmless material that causes no problem at all. Nevertheless, these waste contain a large amount of resources and are sometimes dumped without thought, creating a great deal of confusion and allowing certain forms of waste and trash to be stored unlawfully, As a consequence, a major factor in waste production is the construction industry. Several problems are negatively affected due to growing volumes of demolition pollution, such as the lack of landfill space and the ever increasing construction costs. Demolition waste management is, therefore, a major objective, particularly in developing countries where often unregulated landfills happens frequently and cause a huge problem. In current times, different intensive initiatives to promote the reduction of building materials at source and reuse in India have failed to substantially increase the level of recovery and reuse. Recycling of materials is neither encouraged by the local municipalities nor granted by public attention. There is also heavy pressure on simply waste from landfill development. As a result, the amount of proposed landfill sites approved for demolition waste as well as some unauthorized or unchecked locations, is growing and existing landfills are almost approaching their full ability.[19]

2. Objective

- To study about current drawback in recycling of demolition waste from building, so that why it is not adopted can be analyzed.
- To obtain the major recyclable waste constituents during the demolition phase of buildings and also ways of recycling them are studied.
- To study about Indian standards in usage of recycled material in new construction
- To obtain cost savings from the 2 different scale live case study project

3. Methodology

In Literature study, the various data need to be collected are performed and analyzed for implementing in two live case study that is selected. Through literature review, the different material that constituents in the demolition phase of construction is found and various recycling factors in India like requirements for recycling demolition waste, general issues affecting recycling, potential uses, and limits of recycling demolition materials are discussed through various resources from the internet, around 20 research papers and Indian standard books related to recycling of demolition waste. Further, collected data is implemented in two different scale live case study and cost savings percentage is calculated to conclude that recycled material always give cost savings and not cost escalation in projects. This will fade away the thought that builders, architects, contractors have on usage of recycled materials and also motivate them to use it as it will considerably reduce the actual project cost.

4. Background study

4.1.Waste management planning

Management can be described as using a means judiciously to accomplish a goal. “An end” is the elimination of the rejected material from material flow. It is no longer valuable to the public and has poor inherent worth to the public. So it is destroyed, and if not properly treated, it would cause future issues to the public. A recyclability concept has to be implemented into the overall holistic urban planning strategy and waste management for better results. In-depth analysis of market requirements, with an evaluation of those needs which recycled materials may well fulfill, would promote recycling. The whole cycle of a product needs to be measured from the cost point of view, from start to finish, and in the end, we mean when it is rejected and will be disposed of. If this includes expenses for the community, it is simply part of the product's expense. Another thing which doesn't promote recycling is that raw materials, electricity and other manufacturing factors are extremely expensive in most situations. A revolutionary solution to the topic of cost is then necessary, with goods and packaging built to allow effective use of resources and minimizes wastes. [19] The core principle is to follow the structure of waste management to be of important: (1) Minimizing (source elimination, utilizing discarded goods and managing the content to eliminate final waste) (2) Reuse (3) Recycling (4) Incineration (energy recovery) (5) Safe disposal.**[19]**

4.2.Demolition waste:

Studies show that there is approx. 300-500kg/cub.m. waste is generated in the demolition of a building in many of the developed countries. In this volume, many resources are capable of being reused or recycled goes wasted and these numbers are continuously increasing as we live in this emerging world. [22]

Demolition waste comprises concrete, masonry, limestone, sandstone, metal, and wood depending on the type of construction. In building waste, an optimum amount of paper, plastic, etc. is also expected due to packaging materials and the worked-out wood from formwork and scaffolding. This is all in addition to the substantial amounts of concrete, masonry and metal materials. The materials that comprise of demolition waste can be divided into separate groups. [19]

- Excavated materials such as underground wires, pipes which could be either contaminated or not.
- The site surrounding extraneous materials such as road asphalt and debris.
- Building material such as concrete, masonry, wood, plastic, metals.

In demolition, there is approximately 1-2 tons/m2 of waste is produced from constructed flooring of a building. [4]

4.3.Requirements of a recycling demolition waste

The use of the recycled material depends on the quality of the materials and the price it's available in the market to the people. So, the choice between the recycled material and virgin material comes down to the price and quality of the material. The recycled material will be preferred over natural material only if the price is considerably low and it fulfills the required specifications. [19]

Basic things need to be considered are listed below

- When there is a shortage of both war materials and suitable deposit sites. [19]
- A consistent supply of suitable recycled materials. [19]
- A proper organized way of collecting these materials. [19]
- Carefully sorting of the demolition waste either at the site or at the special treatment site. [19]
- Reprocessing of these materials into suitable raw materials and products. [19]
- Availability of markets for recycled materials and products produced from the recycled process. [19]

- The recycled product whose cost and quality are competitive with natural resources. [19]

There is a major influence of the economy whether all these basic requirements can be achieved at the same time. If failed to achieve even one of the requirements can result in the overall failure of the materials recycling. Some additional factors will also surely affect the efficiency of the recycling process. In the real world, a 100% recycling level is unlikely to be an optimal solution in waste management. [21]

In general, all waste related to concrete and masonry can be reused and recycled. To use the recycled material as a substitute for natural raw materials, it is necessary that the recycled material fulfills the given technical specifications and be economically competitive. [3]

In demolition waste, metals have the highest recycling rates among other materials. Due to its multiple uses and forms, its mechanical properties and its high value, it is highly recyclable. There are markets for steels, brass, copper, and steel that existed for many years. The Steel Recycling Institute estimates the recycling rate for demolition steel is approximately 85% in the United States. On the other hand, the waste produced from wood is partially recyclable. If the wood is cleaned and de-nailed, it still can be reused for new construction and uncontaminated wood can be shredded and used for farming, etc. However, the painted and waterproofed wood is not recyclable. They are considered as polluted waste because of the contents of paints and other chemicals and the risk of polluting the groundwater from leachate. [19]

4.4.General issues affecting recycling

Contamination - Contaminants present in the materials collected can act as a barrier to recycle it and making it unusable and degrading its physical properties furthermore limiting the range of application to lower value products than for primary materials. [21]

Collection and Transport – Economic acts as a barrier to effective collection and transportation. The major issue is to balance the cost and quality of the scrap that can be obtained from sites. [21]

Sorting, Transformation, and Disposing – the main hitch for the future of the demolition waste recycling is the cost of sorting, crushing and disposal. The costliest stages are sorting and crushing because they require a lot of manual labor. [21]

Standards – The recycled material needs to have the required specifications to compete with the virgin material. In current scenarios, to get a perceived output the specification of the product is quite stringent. They should be “fit for purpose” because of this perception, there will be increased adoption for the recycled material which will give an edge against the virgin raw materials as there is no technical barrier of the specifications. [19]

4.5.Potential uses and limits of recycled demolition waste materials

The recyclability of a material depends on the multiple factors such as purity of the material, the market for the recovered product, the monetary value of the material, the cost of collection, transport, and sorting, the cost of transformation into reusable material and the cost of disposing of any residual material to landfill or incineration. The selection for use of such material also depends on the effect they have on the environment, whether they are compatible enough. [21] The potential use of recycled demolition material are as follows:

- Concrete aggregate with lesser requirements (pure concrete chips, brick chips).
- Road construction.
- Paved or tiled areas.
- Water bound layers.
- Drainage material and backfill material.
- Production of cement blocks (using powdered concrete).

When a detailed set of instructions are followed based on technological and organizational procedures, the efficiency of the recycling waste material can be increased. This can be accomplished by certain strategies listed below that can help in promoting the increase in demolition waste recycling rate. [11]

- There should be maximum efforts in providing the sorted material to the recycling facility
- A greater emphasis by public agencies on contracts specifying secondary construction materials and greater acceptance of these products from the private sector.
- Proof of using recycled construction materials and prior quantification of mass flow rate.
- Development of separation technology to remove contaminants that influence the quality of alternative construction materials.
- Assuring the quality of secondary construction materials through coordinated processing technologies and generally accepted quality control.

Creating markets for problematic large-volume materials, e.g., bricks and wood, as well as greater usage of existing market [19]

4.6.Marketing recycled products

The recycling cost of a material is the combination of collected recyclable material, pre- treatment operations and recycling operation itself. The promotion of recycling behavior will not be easy if the term economic incentive is not brought into practice. As long as cheap disposal of demolition waste is available, there is very minimum economic incentive to recycle or find alternative uses or even to reduce waste. It is challenging to get contractors, builders and demolition people to avoid waste when it can be disposed of cheaply. Therefore, it is essential to apply the concept of polluter pays principle when dealing with recycling and waste management. This concept helps in the legal basis for assigning the financial responsibility for pollution. This strategy provides an incentive to the manufacturers who practice or use their products to reduce the impact on the environment and promotes the concept of design for recycling. Hence, it's obvious that the marketing of products from recycling facilities shows the weakest link in the raw material cycle. The public sector rarely markets a product professionally or if sometimes it does by using that material in its projects. There is a little bright scope of marketing the recyclable material by manufacturing industries, the retail sector, consumers and the public sectors.[18] The manufacturing industry can contribute to marketing by expanding the existing marketing operations of recycled products simultaneously developing the recycling technologies. The retail sector can contribute to marketing by favoring the price for recycled products. The consumer plays a major role as there should be increased demand for goods and products by consumers which are made of recyclable materials in their projects or works. This will help in the marketing and selling of the products. The public sector can help with a wide range of options such as encouraging research and development ventures, providing tax incentives, changing national quality standards and requirements and creating a demand to use these products or conducting greater public relations outreach efforts to use and market these secondary products. [19]

5. Indian scenario

Large housing, manufacturing, and infrastructure development projects are very common throughout the world. Developing economic zone, constructing roads, restoration of the old building contribute to the amount of demolition waste.

The municipalities are formulating strict legislation but compliance has its limits. Private contractors extract this waste for a price on private property, low lying areas or more generally, dispose of it illegally along roads or public areas. Demolition waste from individual households finds its way into nearby municipal reservoirs which render municipal waste heavy and degrade its quality for treatments such as composting or energy recovery. Demolition waste management, recycling, and reuse practices have been energized since demolition waste management has been released.

The constituents of the produced demolition waste their respective quantity differ regionally and even within the region. The indicative C&D waste in northern plains urban areas will typically consist of dirt, sand, and gravel (26%), Brick & masonry (32%), concrete (28%), metal (6%), wood (3%), and other (5%). Recycled materials are bricks, tiles, woods, and iron metal. The rest of the materials usually taken for landfill dump yard. [11]

Government, local bodies and industry are now very proactive and involved in the demolition waste management sector. The project to create demolition waste collection facilities has been undertaken by more than ten municipal corporations.

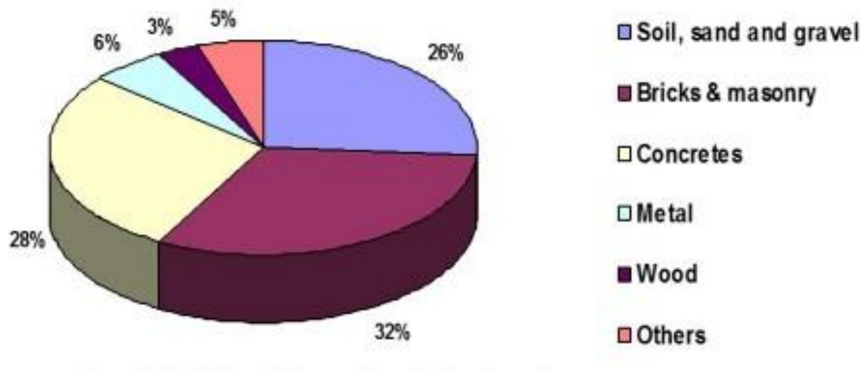
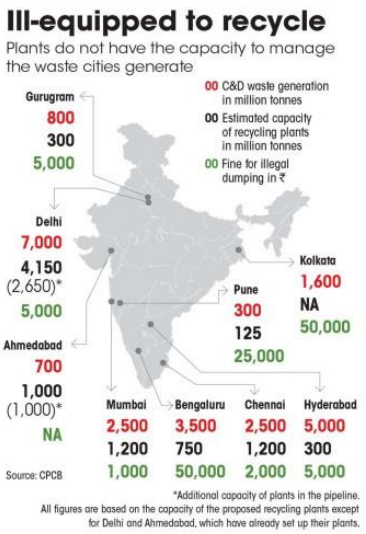


Figure 1. C&D waste composition: Indian urban area

6. Reusing and recycling potential of different materials

The volume of C&D waste in India was estimated at 10-12 million tons per year and the proportion of concrete was estimated at 23-35% of total waste. Assuming 30% of demolition waste as concrete of 12million tons and 50% of concrete as coarse aggregate, the estimated usable recycled concrete aggregate in India is 1.8 million tons each year. [9]

Figure 2. Waste generated and recycling capacity in Indian urban areas



6.1.Concrete

Concrete is mainly a mixture of cement, coarse aggregates, fine aggregates, and water, refined further by incorporating industry products/products to improve strength. The chemical reaction of coarse and fine aggregate, water with cement is a major factor that engineers depend on obtaining the required strength there is demand rising on these naturally available materials, so potential options need to be investigated. Portable water is highly recommended even wastewater can be used after proper treatment. Recycled concrete aggregates (RCA) are one of the main alternative of coarse aggregates produced from the recycled waste of demolition. The demolished concrete waste is transported to a recycling plant during and after the demolition of every concrete construction and crushed into necessary sizes called Recycled concrete aggregates (RCA). [3] Often during demolition, good-sized precast components are collected which can be reused or otherwise, these are then crushed and turned into recycled aggregates. Recycled aggregates have their limitations. Therefore the full utilization for recycled aggregate is not possible and only a certain percentage is possible which is tabulated below under various circumstances. [9]

Table 1. Demolition Waste Produced Utilization Weightage

Type of aggregate	Max. utilization		
	Plain conc. %	RCC %	Lean conc.(<M15 grade) %
COARSE AGGREGATE			
Recycled conc. Aggregate	25	30	100
Recycled aggregate	Nil	Nil	100
FINE AGGREGATE			
Recycled conc. aggregate	25	30	100

Source: BMPTC – As per IS383 (2016)

Table 2. Replacement of Natural fine aggregate by the recycled fine aggregate in concrete

Replacement (%)	Compressive strength as per IS 516 (Mpa)			
	07 days	28 days	56 days	90 days
0	25.93	38.98	46.41	52
25	31.84	42.90	51.16	58.80
50	34.27	46.14	53.87	61.82
75	30.55	39.87	47.15	53.62
100	24.77	37.97	44.42	51.30

Source: Nikhil kaushik, V.V.Arora and P.N.Ojha, National council for cement and building materials, India

Table 3. Replacement of nature fine aggregate by the recycled coarse aggregate in concrete

Replacement (%)	Compressive strength as per IS 516 (Mpa)			
	07 days	28 days	56 days	90 days
0	25.93	38.98	46.41	52
25	26.28	44.48	51.59	55.29
50	25.36	38.56	45.05	51.31
75	22.80	36.42	41.54	45.50
100	21.60	32.99	37.18	41.62

Source: Nikhil kaushik, V.V.Arora and P.N.Ojha, National council for cement and building materials, India

6.2.Brick

Bricks are significant construction products and major constituent in demolition waste for both residential and non-residential structures. Bricks are mostly viewed as wasted when lost or destroyed from the brick manufacturing line or the building site due to inadequate internal management and unnecessary cutting. Brick is a maintenance free structural element that lasts for the entire service life of the house. The brick durability makes it eco-friendly in the sense that it can be reused after the demolition of building so that leftover quantity which is non-reusable is used for certain beneficial purposes. Bricks are stacked during the demolition phase of the building for future usage in the original stage after removing the mortar and ready for reuse or recycle, if not reusable. Demolished debris composed of bricks can be processed into concrete aggregate by various recycling process and then can be used as pavement base material by correctly combining cement and fly ash amounts. Concrete manufactured from broken brick aggregate has good engineering and also better thermal properties, but has a higher shrinkage than ordinary concrete. Often, during the processing of bricks, due to insufficient burning or sometimes due to over-burning, the whole lot is transformed into construction waste. [9]

Table 4. Comparison of cost from DSR 2015 and equivalent item using demolition waste

MATERIAL	UNIT	DSR 2015	COST OF EQUIVALENT ITEM USING DEMOLITION WASTE
Fine aggregate	m^3	700	665
stone dust	m^3	1100	950
brick mix aggregate	m^3	600	465
Stone aggregate 20mm	m^3	1175	900
Stone aggregate 10mm	m^3	1175	900

Source: IRC 121-2017

7. Case study – cost considerations

7.1.Project 1 – Office Building (Lb+Ub+G +4)

Site area: 4050 Sq.m

Build up area: 8400 Sq.m

Bricks and concretes are concluded as major constituents after the demolition of building from the literature review. A cost that impacts the project after the considerations of these materials in construction is calculated and compared with the DSR price to get the cost savings in the project. The following are DSR 2019 code taken for analysis of its rate with recycled concrete aggregates – Nos.6.1, 6.4, 6.12, 6.13 which is Full brick and half brick below and above plinth level respectively added to that No.3.9 - 1:4 cement mortar with coarse aggregate is considered, No.5.33 for reinforced concrete and last No.16.43.1 concrete road work is considered. Replacing the natural aggregate with 30 % recycled aggregate and AOR is done. Using cost index value the found equivalent item rate is converted to the current market rate and used in the analysis of rate.

Material 1: Brick & Cement mortar

Activity: Brick masonry

Table below describes how the rate has been calculated for one cubft of the wall so that it’s easy to calculate for many cubft.

RATE ANALYSIS OF FULL BRICK (9" THICK)					
DSR CODE	DESCRIPTION	QUANTITY	UNIT	RATE	AMOUNT
6.4	Brick work with common burnt clay F.P.S. (non modular) bricks of class designation 7.5 in superstructure above plinth level up to floor V level in all shapes and sizes in :				
6.4.1	Cement mortar 1:4 (1 cement : 4 coarse sand)	1259.3	Cu.m	7797.874	9819862.761
ANALYSIS					
6.4.1	Details of cost for 1 cum				
	MATERIAL				
1	Common burnt clay F.P.S. (non modular) bricks classdesignation 7.5	0.494	1000nos	4500	2223
2	Carriage of Bricks	0.494	1000nos	276.72	136.69968
3	Cement mortar 1 : 4 (1 cement :4 coarse sand) - 70%	0.175	Cu.m	4010.35	701.81125
4	Cement mortar 1 : 4 (1 cement :4 coarse sand) - 30%	0.075	Cu.m	3896.775	292.258125
4	sundries	2.73	L.S	2	5.46
6.4.1	LABOUR				
	Mason (brick layer) 1st class	0.47	day	738	346.86
	Mason (brick layer) 2nd class	0.47	day	679	319.13
	Coolie	1.8	day	558	1004.4
	Bhisti	0.2	day	617	123.4
3	Scaffolding	22.36	L.S	2	44.72
	Coolie	1.13	day	558	630.54
6.4.1	**sub total -1**	-			5828.279055
	Add 1 % Water charges	58.28279055			
	sub total - 2	5886.561846			
	Add GST	827.0619393			
	sub total - 3	6713.623785			
	Add 15% CPOH	1007.043568			
	sub total - 4	7720.667353			
	Add Cess @ 1%	77.20667353			
	sub total - 5	7797.874026			
	Cost of 1 Cum.	7797.874026			
	Cost of 1 Cuft.	220.8403859			

Figure 3. Rate analysis of Full Brick

Table 5. (6.1) Full brick (Below Brick level)

DSR price	797669
AOR price	796243
Cost savings	1426.2

Table 7. (6.1) Half brick (Below Brick level)

DSR price	21820.03
AOR price	21784.05
Cost savings	35.97

Table 6. (6.1) Full brick (Above Brick level)

DSR price	9834188.5
AOR price	9819862.76
Cost savings	14325.76

Table 8. (6.1) Half brick (Above Brick level)

DSR price	2256241.26
AOR price	2253155.57
Cost savings	3085.69

The pie chart shown in figure 6 has the Cost savings percentage in which its clear that full brick wall above plinth level has more cost savings

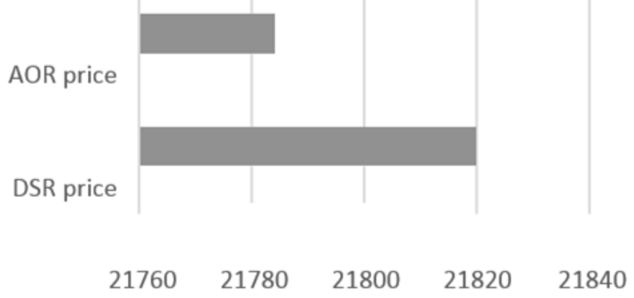


Figure 4. AOR vs. DSR price for half brick wall – Below plinth lvl

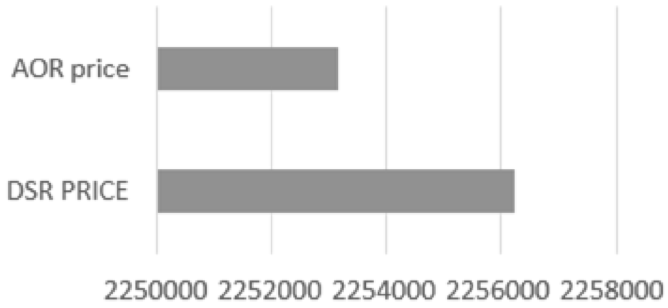


Figure 5. AOR vs. DSR price for half brick wall –Above plinth lvl

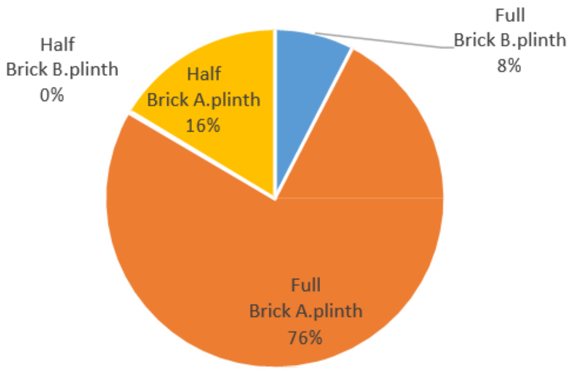


Figure 6. Brick masonry cost savings in percentage

Similarly, the AOR is done for all the DSR code no. 6.1, 6.12, and 6.13.Total cost savings from this brick masonry is Rs.1887

Material 2: Concrete (Cement: Coarse aggregate: Stone aggregate (20 and 40mm)
Activity: Batch plant concrete pouring

Table 9. (5.33.1) RCC (Below Brick level)

DSR price	14298880.9
AOR price	13849699.3
Cost savings	449181.58

Table 10. (5.33.2) RCC (Above Brick level)

DSR price	28609780.9
AOR price	27553008.1
Cost savings	1056772.82

Material Calculation for 1cu.m. of Beam Concrete					
5.33.1	Description	Total Quantity	Unit	Rate	Amount
	Cement(1/4)	0.33	ton	4940	1630.2
	Carriage of Cement	0.33	ton	92.24	30.4392
	RiverSand(1/4) - 70%	0.2975	cu.m.	1350	401.625
	Carriage of River Sand	0.2975	cu.m.	103.77	30.871575
	RiverSand(1/4) - 30%	0.1275	cu.m.	1100	140.25
	Aggregate(2/4) 20mm -70%	0.399	cu.m.	1350	538.65
	Aggregate(2/4) 10mm - 70%	0.196	cu.m.	1350	264.6
	Aggregate(2/4) 20mm - 30%	0.171	cu.m.	1100	188.1
	Aggregate(2/4) 10mm -30%	0.084	cu.m.	1100	92.4
	Carriage of Aggregate of 20mm	0.595	cu.m.	103.77	61.74315
	Total				**3378.878925**
	Per Cubic Feet Cost (35.3147)				95.679
Labor Calculation for 1cu.m. of Column Concrete					
5.33.1	Description	Quantity (Productivity)	Unit	Rate	Amount
	Skilled labor x 1no	0.17	day	709	120.53
	Unskilled labor x 2 nos	2	day	558	1116
	Unskilled labor x 2 nos	0.9	day	617	555.3
	Machine				
	Vibrator	0.07	day	370	25.9
	Batch Plant	1	day	350	350
	Pumping (Includes Hire Charges)	1	day	210	210
	Total				**2377.73**
	Total Cost(Material + Labor Concrete)				**5756.608925**
	Add 1 % Water charges on "W"				57.56608925
	TOTAL				5814.175014
	Add GST on "X" (multiplying factor 0.1405)				816.8915895
	TOTAL				6631.066604
	Add 15% CPOH on "Y"				994.6599906
	TOTAL				7625.726594
	Add Cess @ 1% on "Z"				76.25726594
	Cost of 1 cum.				**7701.98386**
	Per Cubic Feet Cost (35.3147)				218.096

Figure 7. Rate analysis of RCC with derived price

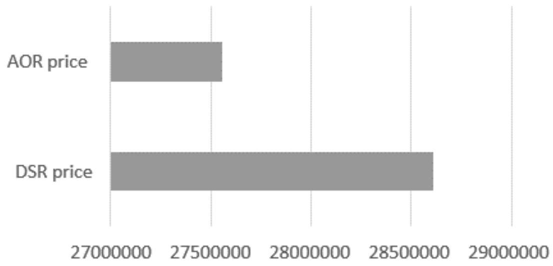


Figure 8. AOR vs. DSR price for RCC – Below plinth lvl

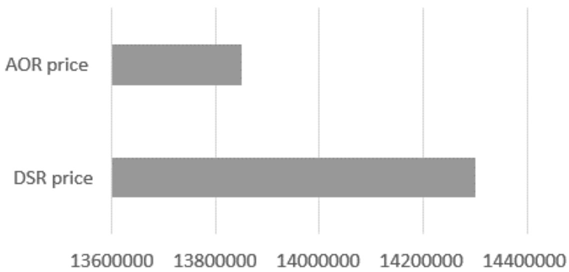


Figure 9. AOR vs. DSR price for RCC–Above plinth lvl

In this project it’s clearly visible that RCC that is used above the plinth level has major impact in savings cost wise than the RCC below the plinth level

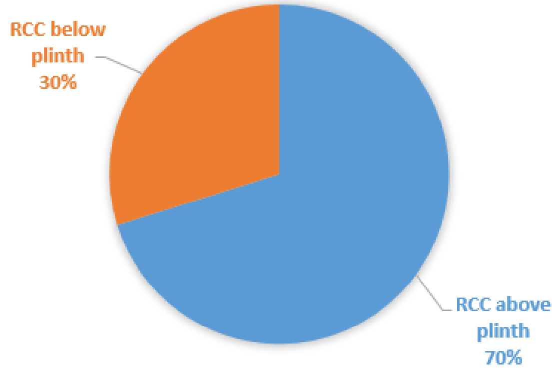


Figure 10. RCC cost savings in percentage

7.2.Project 2 – Residential Building (Lb+Ub+G + 9)

Site area: 27 acres
Build up area: 140600sq.m
Tower: 9nos.

Material 1: Concrete (Cement: Coarse aggregate: Stone aggregate (20 and 40mm)
Activity: Batch plant concrete pouring

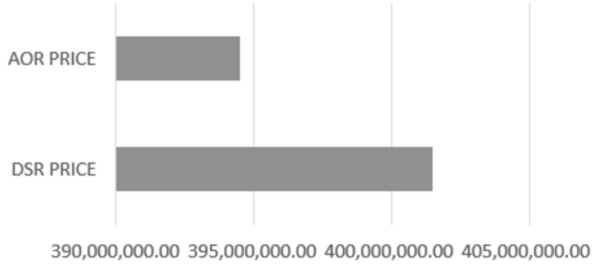


Figure 11. AOR vs. DSR price for RCC – below plinth lvl

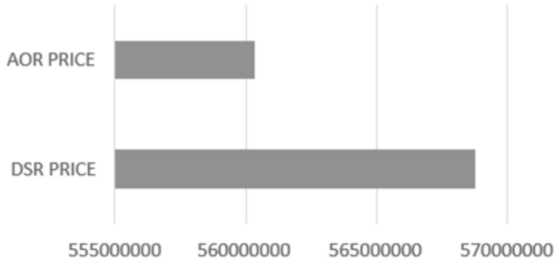


Figure 12. AOR vs. DSR price for RCC–Above plinth lvl

Table 11. (5.33.1) RCC (Below Brick level)

DSR price	401468319.9
AOR price	394498378.8
Cost savings	6969941.1

Table 12. (5.33.2) RCC (Above Brick level)

DSR price	568781477
AOR price	560320720.5
Cost savings	8460756.5

RCC Work Batching Plant					
CODE	DESCRIPTION	UNIT	QUANTITY	RATE ₹	AMOUNT ₹
5.37.1	Providing and laying in position machine batched and machine mixed design mix M-25 grade cement concrete for reinforced cement concrete work, using cement content as per approved design mix, including pumping of concrete to site of laying but excluding the cost of centering, shuttering, finishing and reinforcement, including admixtures in recommended proportions as per IS: 9103 to accelerate, retard setting of concrete, improve workability without impairing strength and durability as per direction of Engineer-in-charge. (Note :- Cement content considered in this item is @ 330 kg/cum. Excess/ less cement used as per design mix is payable/recoverable separately).	m³	1		
	MATERIAL				
	Stone Aggregate (20 mm nominal size) 70% natural material	m³	0.39	1350	526.50
	stone aggregate (20 mm nominal size) 30% recycled material		0.171	1100	188.10
	Stone Aggregate (10 mm nominal size) 70% natural material		0.196	1350	264.60
	stone aggregate (10 mm nominal size) 30% recycled material		0.084	1100	92.40
	Carriage of Coarse aggregate below 40 mm nominal size	m³	0.85	103.77	88.20
	Coarse Sand (Zone III) 70% natural material	m³	0.297	1350	400.95
5.37.1	Coarse Sand (Zone III) 30% recycled material		0.127	1100	139.70
	Carriage of Coarse Sand	m³	0.425	103.77	44.10
	Portland Cement	tonne	0.33	4940	1630.20
	Carriage of Cement	tonne	0.33	92.24	30.44
	Plastisizer/super plasticizer 0.5% of cement Production cost, pumping to respective floors and laying in position	kg	1.65	36	59.40
	Production cost of concrete by batch mix plant	m³	1	350	350.00
	carriage of concrete by transit mix	km/cum	10	30	300.00
	Pumping charges of concrete including Hire charges of pump, piping work & accessories etc.	m³	1	210	210.00
	LABOUR				
	Labour for pouring, consolidating & curing				
	Mason (average)	day	0.17	709	120.53
	Beldar	day	2	558	1116.00
	Bhisti	day	0.9	617	555.30
	Vibrator (needle type 40mm)	day	0.07	370	25.90
	Sundries	L.S	13	2	26.00
	TOTAL (W)				6168.33
5.37.1	Add 1% Water charges on W				61.68
	TOTAL (X)				6230.01
	Add GST on "X" (multiplying factor of 0.1405)				875.32
	TOTAL (Y)				7105.33
	Add 15% CPOH on "Y"				1065.80
	TOTAL (Z)				8171.12
	Add Cess @ 1% on "Z"				81.71
	Cost of 1 unit				8252.84

Figure 13. Rate analysis of RCC with derived price

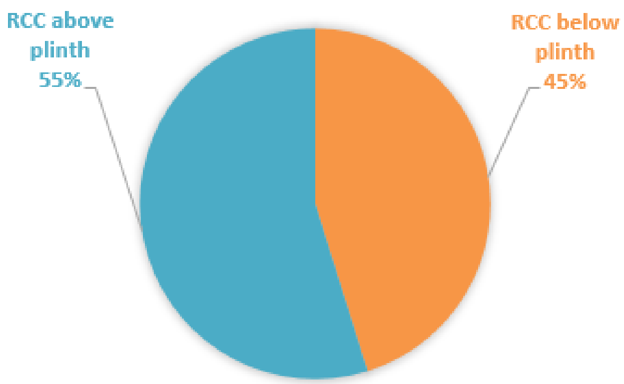


Figure 14. RCC cost savings in percentage

In the above pie chart it's clearly visible that the RCC from the above the plinth level and below plinth level has quite a similar impact. Yet the RCC used in above the plinth level has major savings compared to RCC below plinth level
This is a big scale project comparatively and the material here considered is RCC only. Masonry is not considered in this project as this has different binding material instead of cement mortar which sounds economically feasible.
Similarly, the AOR is done for the other DSR code no.5.37.2The Total cost savings from this material is Rs.15430697.6.Due to this activity, there is a huge amount of savings in this project.

8. Conclusion

The results from the above case studies taken indicate that the use of recycled material helps in reducing the cost of the project and also reducing the overall quantity of the demolition waste in India. In the first case study, 30% of the coarse aggregate is composed of recycled material in the mortar for placing the brick masonry. There is about Rs.18874 (0.2%) of cost difference in the brick masonry although there is no change in the compressive strength of the recycled material compared to the natural material. Similarly, in the case of the reinforced concrete, the aggregate used is stone and coarse aggregate with a ratio of 70% natural material and 30% recycled material. There is 4 percent (Rs.1524828) of the cost difference in the reinforced concrete with no effect on the compressive strength of the material.

In case study 2, by looking at the design of the project there is an immense use of concrete in the structure as the whole structure is standing on shear walls and the cost of concrete is about 66% of the whole project. So, the coarse aggregate used in this project is stone aggregate and coarse aggregate with a ratio of again maintaining 70% and 30% natural and recycled material respectively. The cost difference came out to be (15430697.6)1.5%. Even though the percentage in both studies is less but the amount its saves is high.

The waste management plan and the feasibility study of a recycled demolition waste facility presented in this paper is a gateway for implementing economically efficient and environmentally safe steps towards controlling the Demolition waste. Whether the building and construction waste originate from clearing up after natural disasters (e.g., earthquakes and tornadoes) or from human-controlled activities, (e.g., demolition, renovation, and new construction), its utilization through recycling will provide opportunities for saving land, energy, time, resources, and money. Therefore, architects, contractors, and developers play a major role in the growth and bringing forward such material into the regular practice of such material in upcoming projects. There should be a clause to incorporate the use of recycled products in their tenders. Many governments have issued advisories that mandate 2% and 10% use of recycled products in buildings and road works respectively.

Recycling has proven to be a great investment for future generations. Therefore, potential recycling efforts should continue and expand to cover most types of solid waste such as municipal, household waste, industrial, tires, etc. There is a need for more recycling plants to be set up across India so that the waste generated can be utilized legally and doesn't go waste or to be dumped into the sanitary landfills. A look into further development is always a key to achieving higher goals towards saving the environment.

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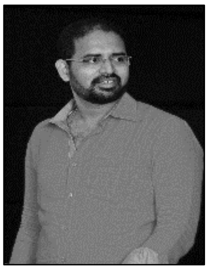

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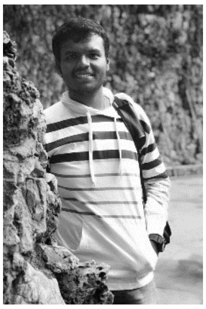

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