Recyclability of Construction Left Over Materials

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Abstract: ***Due to rise in population there has been an immense need in increase of the infrastructure. Since most of the housing in India consists of concrete structures, the waste after demolition of these structures has been gathering. Every time a new structure is built by demolition of an existing one, it gives demolition waste. The amount of such wastes generated is increasing alarmingly and needs to be addressed. These wastes can be recycled and again be used in building new structures to minimize the wastage. It also has a positive effect on the environment. The urgent need for recycling these wastes can be seen in metropolitan cities where there is booming population and hence the need for new buildings. These new buildings shall be designed to accommodate more over a small area. Therefore, it shall contribute to the concrete wastes later on after completion of its life period. So, by every means, there is a need to control the wastes generated. The best effective method is recycling. The methodology used in this present study is recycling of the demolition waste and comparing the recycled material properties to naturally available material properties. Finally, the results will be projected to show that, use of recycled materials in normal construction works will be a solution to reduce the usage of natural resources and reduce the waste print in construction work.***

Index Terms: ***Demolition recycled concrete, urbanization, wastage.***

I. INTRODUCTION

Due to increase in construction activities, there has been a significant increase in the construction waste. This is being gathered only to form huge landfills. It should be seen as burying potentially and structurally nourished material. Preparing virgin concrete (the concrete prepared from purely manufactured cement and aggregates) impacts both the environment and current situation of landfills. The rate of generation of these wastes is also very high seeing the rate of growth of construction in India. The cost of the material can exceed 50% of that of the total cost of construction [1]. There is a need to reduce both the cost and the rate of waste generation. This process of reduction of construction waste is called as Construction Waste Management (CWM) [2].Approximately 40% of the waste generated globally originates from construction and demolition of buildings [3]. It is due to modernization that everyone prefers to move into concrete structures. Hence there is need for raw materials. raw material shortages and the environmental impacts due to illegal dumping [4]. Various sources contribute to the construction waste. They can be mainly divided into two categories those Bulk generators and Small generators[5].The bulk generators are demolished roads, bridges, Apartments, Malls, Offices etc., of higher capacity whereas the small generators are demolished houses and small buildings[6].In India, the construction waste is mostly concrete and it is large in number that it needs immediate attention[7]. Illegal disposing of environment wastes is the main cause for environmental degradation. It is prominent in major cities due to the amount of the waste generated. Such issues are rise in the water levels/flood levels due to dumping, illegal sand mining, release of harmful chemicals from the wastes into the water polluting the ground and surface water and finally the depletion of the resources [8]. The composition of this waste is mainly concrete and steel. Along with these, plastics, lime, wood, paints are also present. To accurately study the composition, three sites were selected namely; Site A, Site B, Site C. All of these sites have different type of construction. Site A was an old thatched roof construction. Site B was an old storage facility. Site C was an RCC building. The main components are wood and concrete others indicate various other things such as plastics, tubes, sheets, pipes and stoneware [9].

Waste Management

Waste management has been specified for aggregates, Asphalt, wood, gypsum, metals, glass and plastics. Figure I gives a detail about the construction wastes in India.

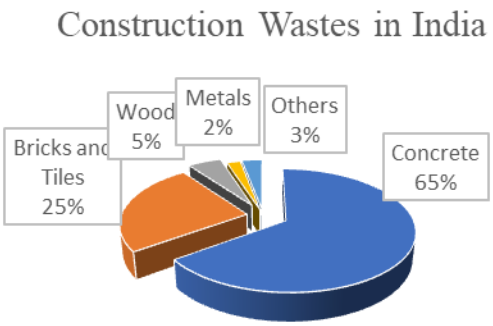

Figure I: Construction wastes in India (Source: Bhattacharya et al., 2016[8])

A. Aggregates

Aggregates are often mentioned while considering management of wastes. It is due to their abundance in demolition wastes. They can be easily used as loose fills in construction. However, using recycled aggregates shall reduce the use of minerals by up to 40% [2]. This is a very good often if considered. There will not be any exploitation of natural mineral resources and also aggregate waste will be managed. But in order to achieve complete recycling, all the aggregate waste has to be sorted first and then filtered to avoid any materials that might affect the strength adversely.

Revised Manuscript Received on April 09, 2019.

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B. Asphalt

The major use of asphalt is in roads. There is a total of 54, 72,144 KM roads in India as of 2015[11]. Such enormous lengths of roads are reconstructed or topped every year. Therefore, the amount of asphalt waste generated can be seen to be drastically high. In order to extract recyclable asphalt, the waste is heated. This heat separates the aggregate and the asphalt. Such asphalt is sent to kilns where it will be treated to remove impurities.

C. Wood

Construction waste constitutes wood that is both damaged and rotten. The rotten wood cannot be used immediately but has to be treated in order to get the desired effects. The damaged wood though can be used as insulator, filling material, fuel etc. depending on the place of usage. It can also be made into panels. Panels can be used in furniture. If there is dry wood whose dimensions exceed that of the required, then it can be cut and be reused immediately just by chipping/sawing to the required dimension. However, if the wood is being used as fuel, then it has to be tested for contaminants before it is burnt. This shall prevent air pollution and its related side effects.

D. Metals

Metal recycling is of the highest value of all the materials. It is due to the methods adopted. The easiest way to recycle is by froth floatation. In this method, the metal is heated up till it reaches liquid state. All impurities are then segregated either from the top or from the bottom. This method gives a relatively good quality of metal which can further be molded to the required shape.

II. RESEARCH SIGNIFICANCE

In this present study is recycling of the demolition waste and comparing the recycled material properties to natural available material properties. The result will be projected to show that, use of recycled materials in construction works will be a solution to reduce the usage of natural resources and reduce the demolition waste.

III. DESCRIPTION OF WORK

A. Study Area

All the recycled concrete waste has been procured from Site, Site B and Site C, all of which are located in Thullur, Amaravati, Andhra Pradesh, because in Amaravati new constructions are going on so old buildings is collapsed. The waste after demolition of these structures has been gathering. These wastes can be recycled and again be used in building new structure to minimize the wastage.

B. Data Collection

Demolition waste collected from three different sites. All the sites are residential buildings which life period is an average of 30 years old. The grading and tests have been carried out at the Civil Department Laboratory. On demolition waste material tests are conducted as per Indian Standard code for natural aggregate and possibility.

C. Methodology

Figure II explains the methodology of the work.

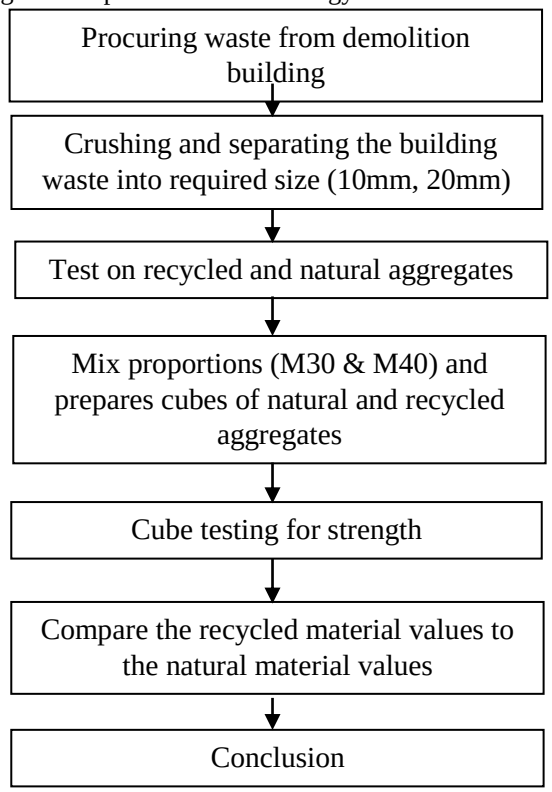

Figure I: Methodology flow chart

The waste was collected from the demolition site or dumps and was brought to the recycling facility. The collected waste was gathered at one place and it was crushed and divided as per required size. The size of the waste material was separated by the sieve analysis. Conducted tests on recycled aggregates as per Indian standards [12] [13] [14] for natural aggregate ex: water absorption, crushing strength, specific gravity, impact value and bulk density. The residues of the recycled material obtained from the above tests were used as coarse aggregate. The mix proportion used in this research was M30 and M40and tested for 7 days and 28 days. Cubes were cast as per mix proportion with partially replacement to natural aggregate with percentages of0%, 10%, 20% and 30%. In this mix 0% has totally natural aggregate used as a coarse aggregate. 24 cubes of each for M30 and M40 and tested for 7 days and 28 days. The standard cube size is 15x15x15cm. Compression test was conducted for 7 days and 28 days on and the results were noted. Repeat the procedure for flexural strength test. At last compare the flexural strength and compressive strength values of recycled aggregate and natural aggregate.

IV. RESULTS AND DISCUSSION

A. Particle Size Distribution

As per the Indian Standard IS 2386 [12], sieve analysis is carried out. The standard specifies the practice to be used while carrying gradation of aggregates. The volume of materials less than 4.75mm after completion of recycle process is approximately *7-24%* of the original aggregate used in the process. The crushing has been done in three

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stages. The primary stage, secondary stage and the tertiary stage. This 3-stage process is necessary to ensure that the aggregate endures the strength tests. It is debated that only 2-stage process is sufficient but, in this experiment, 3-stage process of gradation has been done to get greater accuracy. Therefore, the recycled aggregate meets all the requirements and aggregate in building material should possess.

B. Water Absorption Test

The recycled aggregate consists of old stone with mortar adhesive to it. When measured, Water absorption shall not be more than 0.6 per unit by weight. Such a percentage is generous when compared to the natural aggregates. Table I gives the water absorption values of natural aggregates and recycled aggregates.

Table I: Water absorption of natural aggregate and recycled aggregate

S.No	Description	Natural Aggregates			Recycled Aggregates		
		Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1	**Weight of saturated drain sample(grams)**	3210	3380	3582	2540	2385	2495
2	**Weight of oven dried sample(grams)**	3205	3375	3577	2535	2380	2490
3	**Water Absorption (%)** $=\frac{1-2}{2}$x100	0.156	0.148	0.139	0.197	0.210	0.200
Average value of water absorption (%)		0.1470			0.2023		

The difference in the water absorption values of the two is 0.20-0.14=0.60. Therefore, it is suitable to be used as an aggregate in construction.

C. Crushing Strength and Impact Strength Test

It is obvious that the recycled aggregate shall be weaker than the natural aggregate. It is due to the service it has provided. If it has to be used as a building material, then it should possess a minimum strength. To calculate the crushing and impact strength values, the IS 2386 Part IV [13] has been referred to. According to the IS 2386 Part IV, the crushing and impact values for concrete should not go beyond 40% for exhausting surfaces and beyond 50% for surfaces other than wearing surfaces. Table II provides the values of crushing and impact strength.

Table II: Crushing strength and Impact strength values

S.No	Test	Natural Aggregate	Recycled Aggregate
1	Crushing strength (%)	20.2	38.4
2	Impact strength (%)	19.3	35.6

The above values of crushing strength and impact strength are satisfactory and can be used for surfaces other than exhausting surfaces.

D. Specific Gravity Test

Specific gravity should not be less than 2.4. If it is less, then it may lead to early yield and also honey combing after removal of shuttering. Table III gives the values for specific gravity of the natural aggregate and recycled aggregate.

Table III: Specific Gravity of the aggregates

S.No	Test	Natural Aggregates		Recycled Aggregates	
		20mm	10mm	20mm	10mm
1	**Specific Gravity**	2.4	2.5	2.7	2.65

From the above table, it is evident that the recycled aggregates have specific gravity values less than that of natural ones. But the value is greater than 2.4 for both 20mm and 10 mm. therefore; they can be good building materials in terms of specific gravity.

E. Bulk Density

If bulk density is less, then the mix will have an imbalance in the strength properties. Table IV gives the values of Bulk density of the aggregates. Since the bulk density value of the recycled aggregates is less than that of natural aggregate.

Table IV: Bulk density of natural and recycled aggregates

S.No	Particulars	Values	
		Natural aggregate	**Recycled aggregate**
1	**Bulk density**	1786.5kN/m^3	1537.4kN/m^3

F. Compressive Strength Test on Cubes

As per IS 516 [14], standard cubes were cast and loaded onto a Universal Testing Machine (UTM). The ages at the time of testing were 7 days and 28 days respectively. M30 and M40 grades have been used to carry out the experiment. The values have been given in Table V.

Table V: Compressive Strength values

Grade of concrete	Duration of curing	Natural Aggregate	Replacement of natural aggregate with recycled aggregate		
		0%	10%	20%	30%
M30	7 days	33.13 N/mm^2	23.83 N/mm^2	31.90 N/mm^2	28.05 N/mm^2
	28 days	39.00 N/mm^2	38.28 N/mm^2	37.90 N/mm^2	37.05 N/mm^2

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M40	7 days	50.67 N/mm^2	50.00 N/mm^2	49.50 N/mm^2	49.38 N/mm^2
	28 days	61.00 N/mm^2	58.23 N/mm^2	56.22 N/mm^2	54.22 N/mm^2

From Table V, it is evident that recycled aggregate can be used as a building material. Because it shows considerable strength when compared to that of natural aggregate.

G. Flexural Strength Test

Table VI gives the Flexural strength values of the specimen used. Tests were conducted at 7 days and 28 days. After the28 days period, there is a considerable increase in the flexure strength of the concrete with recycled aggregates. Therefore, it is suitable to be used as a building material. Table VI gives the flexural strength of specimen.

Table VI: Flexural Strength of specimen

Grade of concrete	Duration	Natural Aggregate	Replacement of natural aggregate		
		0%	10%	20%	30%
M30	7 days	3.13 N/mm^2	3.83 N/mm^2	3.93 N/mm^2	3.05 N/mm^2
	28 days	4.30 N/mm^2	4.80 N/mm^2	4.90 N/mm^2	4.70 N/mm^2
M40	7 days	4.68 N/mm^2	4.87 N/mm^2	4.43 N/mm^2	4.20 N/mm^2
	28 days	5.14 N/mm^2	5.45/mm^2	5.26 N/mm^2	5.10 N/mm^2

V. INFERENCE

From the tables, it can be deduced that M30 and M40 grade *with* 10%, 20%, 30% recycled aggregate satisfy the results. Out of M30 and M40, M30 should be preferred relatively as M40 shows less change in the results. Lot of construction waste is generated and has to be tackled daily to prevent the losses caused. These losses might not be significant at this point of time, but in the future; there will definitely be an urgent need to see to it.

VI. CONCLUSIONS

Many tests conducted on recycled aggregate and comparing the recycled aggregate properties to naturally available material properties show that it can be used to replace natural aggregate. As per IS 2386, all the values for the recycled aggregate are satisfactory and can be used as a building material. If recycled concrete is made, then there will be less environmental impact and less pollution since manufacture of concrete emits a lot of CO_2into the atmosphere. The use of recycled aggregate up to 30% is recommended and will definitely help prevent the side effects. It has generally seen that the use of construction and demolition waste is restricted for use in green buildings because which require certification. The results to show that, use of recycled material in normal construction works will be a solution to reduce the usage of natural resources and reduce the waste print in construction work. Finally, it is concluded that the problem of construction and demolition waste utilization can be managed easily and society should come forth to protect the environment for the future generation.

VII.ACKNOWLEDGEMENT

The authors gratefully acknowledge the support of the Head of the Department and Koneru Lakshmaiah Education Foundation (Deemed to be University) for collaboration and funding the research.

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