USE OF BUILDING DEMOLISHED WASTE AS COARSE AGGREGATE IN POROUS CONCRETE

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Abstract
Titanic quantities of construction and demolition wastes are generated every year in developing countries like India. The disposal of this waste is a very serious problem because it requires huge space and very little demolished waste is recycled or reused. In this experimental study, the utilization of building demolished waste in the manufacturing of Porous concrete as a replacement of coarse aggregate. The mechanical properties of the concrete have been investigated for nominal mix and mix design as per the mix design codes IS 10262-2009 and IS12727:1989. Porous concrete is no fines concrete with desired degree of compressive strength with high porosity to allow permeability. Various proportions of cement, water and percentage of coarse aggregates and building demolition wastes are used. In this paper 40:60, 50:50 and 60:40 ratio of coarse aggregate and building demolition wastes are used with water cement ratio 0.4 to 0.48. 28 days cube compressive strength of average of three samples are determined. During the study, lesser density by weight and compressive strength from 5.22 MPa to 8.32 MPa are observed as per IS 12727: 1989 for the ratio 1:10 and 1:12 respectively. By the investigation it is found that the porous concrete results are encouraging to use as a porous material for the drainability and has been found to be comparable to the conventional concrete.

Keywords: Porous concrete, building demolished waste, cube compressive strength, coarse aggregate.

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1. INTRODUCTION

In recent years, the demolished waste is necessary to produce new product suitable for the environment. Infrastructure department is the second largest sector after agriculture in India. Concrete is the world's most widely used construction material. Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway, re-modelling 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 (Collins, R.J. 1994).

Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled aggregate can be used to make concrete for road construction and building material. The continuously growing demand for concrete to meet the "ejection" infrastructure development worldwide is not without any negative impacts on the environment and on our future capacity for development. The management of construction and demolition waste is a major concern due to increased quantities of demolition debris, the continuing shortage of dumping sites, increase in the cost of disposal and transportation and above all the concern about environmental degradation (Hansen, T.C. 1992).

The global construction industry uses billions tons of cement and billions tons of sand, gravel, and crushed rock every year. The use of waste materials as a source of aggregate in new construction materials has become more common in recent decades. The depletion of the existing landfills and the scarcity of natural resources for aggregates encourage the use of construction and demolition waste as a source of aggregates in the production of new concrete.

Due to tremendous development in infrastructure, major cities in India are getting covered with buildings and impermeable pavement. Concreting everywhere leads to environmental issues such as reduction in recharge of rainwater into the ground. Hence, constant fall of water table which makes the life miserable. One of the solutions is by installing pervious concrete pavement instead of impervious concrete for low traffic volume, tennis courts, drains & drain tiles, floors in greenhouses, patios, slope stabilization, swimming pools decks, zoo areas, parking lots, sidewalks, pathways, parks, shoulders, drains, noise barriers, friction course for highway pavements, etc. In this investigation, materials like Ordinary Portland cement 53 grade, BDWof uniform size and shall confirm to IS 383:1970 and water. The proportioning of ingredients in porous concrete is governed by performance of concrete in plastic & hardened states as per the mix design IS 10262-2009 and IS 12727:1989.

2. MATERIALS AND METHODS

2.1 Cementitious Materials

Portland cements and blended cements may be used in pervious concrete. Supplementary Cementitious Materials (SCMs) such as fly ash, pozzalona and blast-furnace slag may also be used. These added materials will affect the

performance, setting time, strength, porosity and permeability of the final product. The overall durability of the pervious concrete is increased with the use of silica fume, fly ash and blast-furnace slag due to the decrease in permeability and cracking. The mixtures containing higher cement paste resulted in higher compressive and flexural strength than other mixtures.

2.2 Aggregate

The size of the coarse aggregate used is kept fairly uniform in size (most common is size 89, or 3/8 inch) to minimize surface roughness and for a better aesthetic. The use of the pervious concrete will dictate the size of the aggregate used, and sizes can vary from ¼-inch to ½-inch (6.35mm-12.7mm) in size. Aggregate can be rounded like gravel or angular like crushed stone and still make for a good mixture.

2.3 Building Demolished Waste (BDW)

Recycled aggregates are composed of the rubble from the buildings, roads and other sources. The recycled aggregate concrete aggregate concrete elastic properties are significantly impacted by the proportion of recycled material in the mix.

2.4 Water

Potable water is used for mixing and curing. On addition of higher percentage of demolished waste, the requirement of water increases for the same workability. The specimens having 0% demolished waste, 40:60, 50:50 and 60:40 ratio has been used for the study. 0.6% superplasticizer is added to increase the workability of concrete.

2.4.1 Method

Compression test is the most common test conducted on hardened concrete, because it is easy to perform and most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

The compressive strength test is done on $150 \times 150 \times 150$ mm cubes. The procedure is carried out as per the guidelines of IS: 516-1959. All the cubes are wet cured up to the day of testing. The cubes are subjected to axial compressive load until crushing. The crushing load divided by the surface area of load application gives the compressive stress that the concrete can resist. This gives measure of the strength and its confirmation with acceptance criteria.

Table 1: Properties of Coarse aggregate and demolished waste

Parameters	Coarse aggregate	Demolished waste
Specific gravity	2.65	2.51
Water absorption	0.3%	4.54%
Sieve analysis	Conforming to table-2 of IS 383-1970	Conforming to table-2 of IS 383-1970
Crushing value	22%	35.25%
Impact value	25%	27.42%

2.4.2 Nominal Mix Proportions

Table 2: Nominal mix proportions

Sl no.	C:A	W/C	Designation	% of CA:BDW	Wt. of cement, kg	Wt. Of agg., Kg	Wt. of CA, Kg	Wt. of BDW, kg	Water, ml.
1.	1:8	0.40	M1	40:60	1	8	3.2	4.8	400
2.	1:8	0.40	M2	50:50	1	8	4.0	4.0	400
3.	1:8	0.40	M3	60:40	1	8	4.8	3.2	400
4.	1:9	0.42	M4	40:60	1	9	3.6	5.4	420
5.	1:9	0.42	M5	50:50	1	9	4.5	4.5	420
6.	1:9	0.42	M6	60:40	1	9	5.4	3.6	420
7.	1:10	0.45	M7	40:60	1	10	4.0	6.0	450
8.	1:10	0.45	M8	50:50	1	10	5.0	5.0	450
9.	1:10	0.45	M9	60:40	1	10	6.0	4.0	450
10.	1:12	0.48	M10	40:60	1	12	4.8	7.2	480
11.	1:12	0.48	M11	50:50	1	12	6.0	6.0	480
12.	1:12	0.48	M12	60:40	1	12	7.2	4.8	480

2.4.3 Mix Proportions

Table 3: Mix Design Proportions

Trial .no	W/C Ratio	Proportion		Weight in kg /m³ (for 1 m³)					Mix Proportion
		CA	BDW	Cement	Water	CA	BDW	Superplasticiser	
1	0.40	40	60	350	140.0	787.58	1118.9	2.10	1:1.25:3.197
2	0.40	50	50	350	140.0	984.47	932.4	2.10	1:2.81:2.66
3	0.40	60	40	350	140.0	1181.3	745.9	2.10	1:3.37:2.13
4	0.45	40	60	311.1	140.0	802.40	1140.0	1.86	1:2.57:3.66
5	0.45	50	50	311.1	140.0	1003.0	950.0	1.86	1:3.22:3.05
6	0.45	60	40	311.1	140.0	1203.6	760.0	1.86	1:3.86:2.45
7	0.50	40	60	280.0	140.0	813.0	1155.1	1.68	1:2.90:4.12
8	0.50	50	50	280.0	140.0	1016.2	962.5	1.68	1:3.62:3.43
9	0.50	60	40	280.0	140.0	1219.5	770.0	1.68	1:4.35:2.75
10	0.60	40	60	233.3	140.0	828.9	1177.6	1.39	1:3.55:5.05
11	0.60	50	50	233.3	140.0	1036.1	981.4	1.39	1:4.44:4.20
12	0.60	60	40	233.3	140.0	1243.3	785.1	1.39	1:5.34:3.36

Note: CA = Coarse Aggregate,
BDW = Building Demolished Waste

3. RESULTS AND DISCUSSION

The interpretation made during the examination of cubes are summarized as mixed proportion and compressive strength are presented in Table 2 and Table 3. Three specimens each having 40:60, 50:50 and 60:40 in the ratio of demolished waste as coarse aggregate and tested after 28 days in order to have a comparative study. Table 4 and 5 shows the variation of Density for nominal mix and mix design and table 6 and 7 shows the variations of compressive strength for nominal mix and mix design for demolished waste mixes. Cubical specimens were cast for the determination of compressive strength and these observations are presented as compressive strength values (Table 6 and 7, Figure 1 and 2). Cubes up to 40 - 60% of coarse aggregate was replaced by demolished waste which gave strength closer to the strength of plain concrete cubes and strength retention was recorded in the range of 60% for demolished wasteconcrete mix.

Table 4: Density of Nominal Mix

Mix	Mix Proportion (C:A)	W/CRatio	CementKg	Waterml	CA %	BDW %	Density (Kg/m³)				% reduction of weight
							S1	S2	S3	Avg.	
M1					40	60	18.13	17.46	17.63	17.73	26.12
M2	1:8	0.40	1.0	400	50	50	18.23	17.43	17.70	17.78	25.92
M3					60	40	18.25	18.45	18.25	18.25	23.96
M4					40	60	17.46	17.57	17.54	17.52	27.00
M5	1:9	0.42	1.0	420	50	50	17.59	17.33	17.42	17.44	27.33
M6					60	40	16.97	16.89	16.92	16.90	29.58
M7					40	60	16.91	17.00	16.98	16.96	29.33
M8	1:10	0.45	1.0	450	50	50	19.09	16.56	17.40	17.68	26.33
M9					60	40	18.34	18.57	18.51	18.47	23.04
M10					40	60	18.37	18.96	18.81	18.71	22.04
M11	1:12	0.48	1.0	480	50	50	16.14	16.37	16.31	16.27	23.87
M12					60	40	15.56	16.30	16.11	16.00	33.33

Note: C = Cement, A = Aggregate, CA = Coarse Aggregate,
BDW = Building Demolished Waste
S1 = Sample 1, S2 = Sample 2, S3 = Sample

Table 5: Density of Mix Design

Mix	Mix Proportion (C:A)	W/CRatio	CementKg	Waterml	CA %	BDW %	Density (Kg/m^3)			
							S1	S2	S3	Avg.
M1	1:5.54				40	60	16.48	18.35	17.88	17.57
M2	1:5.47	0.40	350	140	50	50	18.51	18.42	18.40	18.44
M3	1:5.50				60	40	16.48	17.50	17.24	17.07
M4	1:6.23				40	60	17.10	17.85	17.66	17.53
M5	1:6.27	0.45	311.11	140	50	50	15.69	16.52	16.31	16.17
M6	1:6.31				60	40	15.34	16.23	16.00	15.86
M7	1:7.02				40	60	18.20	18.51	18.40	18.37
M8	1:7.05	0.50	280	140	50	50	18.35	17.88	17.66	17.96
M9	1:7.10				60	40	15.21	16.25	16.00	15.81
M10	1:8.60				40	60	15.14	16.31	16.52	16.00
M11	1:8.64	0.60	233.33	140	50	50	15.27	16.23	16.05	15.85
M12	1:8.70				60	40	15.50	16.45	16.21	16.05

Table 6: Compression Test for Nominal Mix

Mix	Mix Proportion (C:A)	W/CRatio	Cement Kg	Waterml	CA %	BDW %	Compressive Strength (f_{ck}) in MPa			
							S1	S2	S3	Avg.
M1					40	60	5.33	5.44	5.88	5.55
M2	1:8	0.40	1.0	400	50	50	5.88	5.77	5.32	5.65
M3					60	40	5.33	6.22	5.99	5.84
M4					40	60	5.33	5.33	5.33	5.33
M5	1:9	0.42	1.0	420	50	50	5.33	7.55	6.44	6.62
M6					60	40	5.33	5.77	5.99	5.70
M7					40	60	5.00	5.88	5.44	5.44
M8	1:10	0.45	1.0	450	50	50	5.33	7.11	5.72	6.05
M9					60	40	7.55	8.88	8.54	8.32
M10					40	60	5.00	5.44	5.22	5.22
M11	1:12	0.48	1.0	480	50	50	5.22	5.77	5.60	5.53
M12					60	40	5.33	5.77	5.88	5.66

Note: C = Cement, A = Aggregate, CA = Coarse Aggregate,
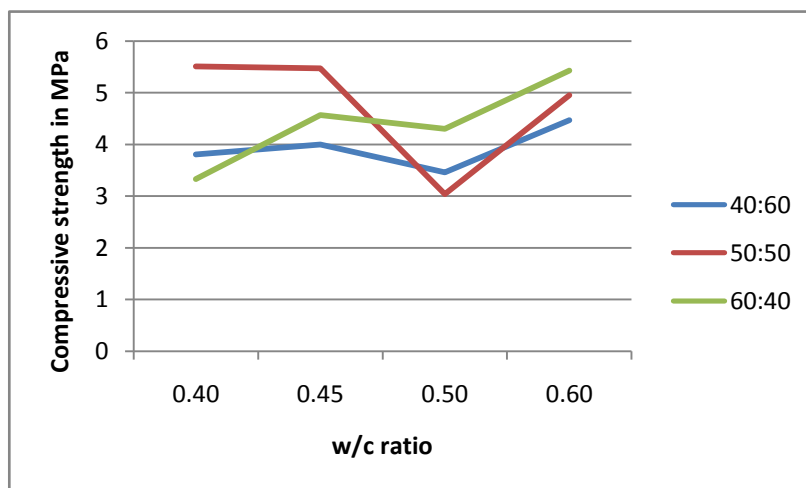BDW = Building Demolished Waste
S1 = Sample 1, S2 = Sample 2, S3 = Sample 3
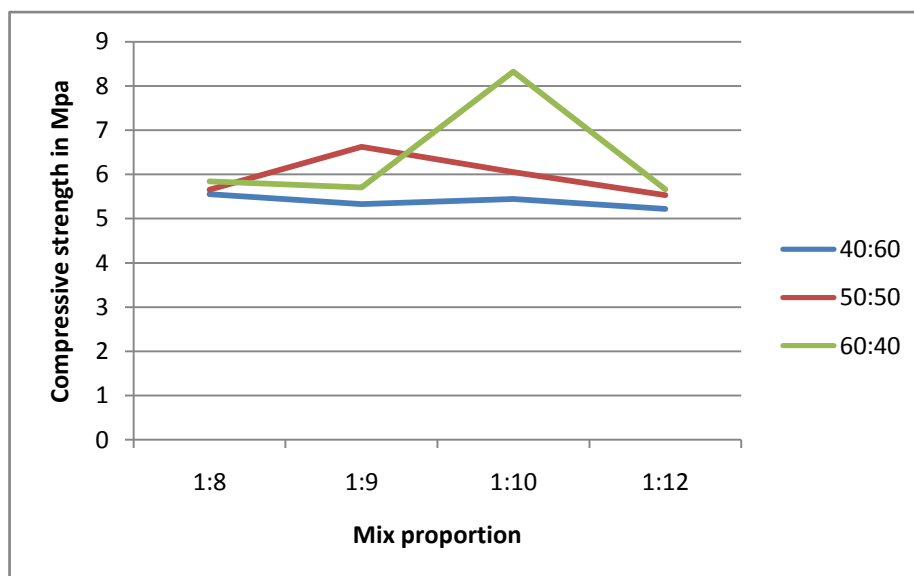
Fig 1: Different Types of Concrete Mix v/s Compressive Strength

Table 7: Compression Test of Mix Design

Mix	Mix Proportion (C:A)	W/C Ratio	Cement Kg	Water ml	CA %	BDW %	Compression Strength in MPa			
							S1	S2	S3	Avg.
M1	1:5.54				40	60	3.55	4.00	3.88	3.81
M2	1:5.47	0.40	350	140	50	50	5.77	5.33	5.44	5.51
M3	1:5.5				60	40	3.11	3.50	3.40	3.33
M4	1:6.23				40	60	4.00	4.00	4.00	4.00
M5	1:6.27	0.45	311.11	140	50	50	5.33	5.55	5.55	5.47
M6	1:6.31				60	40	4.44	4.67	4.61	4.57
M7	1:7.02				40	60	3.56	3.44	3.44	3.46
M8	1:7.05	0.50	280	140	50	50	3.11	3.00	3.02	3.04
M9	1:7.10				60	40	4.00	4.50	4.37	4.30
M10	1:8.60				40	60	4.44	4.50	4.48	4.47
M11	1:8.64	0.60	233.33	140	50	50	4.89	5.00	4.97	4.95
M12	1:8.70				60	40	5.33	5.50	5.45	5.43

Note: C = Cement, A = Aggregate, CA = Coarse Aggregate,
BDW = Building Demolished Waste
S1 = Sample 1, S2 = Sample 2, S3 = Sample 3

Fig 2: Different Types of Concrete Mix Compressive Strength v/sW/C ratio

4. CONCLUSIONS

Research on the usage of Building demolished waste is very important because, demolished waste is gradually increasing with the increase in population and increasing urban developments. The reason that many investigations and analysis had been made on recycled aggregate is because, it is easy to obtain and the cost is cheaper than natural aggregate. Natural aggregates need to extract but recycled aggregate can ignore this process.

The following conclusions are drawn from the experimental study.

1. Porous concretemay be an alternative to the conventional concrete because of low density and high porosity.
2. The average 28 days cube compressive strength are satisfying the requirements of the values given in table-1 of IS 12727-1989. Hence porous concrete can be suggested for intentional use.
3. Aggregate ratio of 1:8 with 50 % of CA and 50% of BDW is recommended for low traffic volume.Similarly mix design with w/c ratio of 0.40 and 0.45 with 50% of CA and 50% of BDW is suitable for intended use.

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