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Replacement of Recycled Aggregate in Concrete

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Abstract—*The use of recycled aggregates from construction and demolition wastes is showing prospective application in construction as alternative to natural aggregates. It conserves natural resources and reduces the space required for the landfill disposal. There is also a public will to reduce the use of primary aggregates in construction, including concrete. Use of recycled aggregate in concrete can be described in environmental protection and economical terms. The application of recycled aggregate to use in construction activities have been practice by developed European countries and also of some Asian countries. Recycled aggregates have evolved towards a worthy alternative for natural aggregates. Energy efficiency, sustainable construction and the use of recycled resources together with renewable energy sources are becoming priorities of contemporary construction process. In order to achieve the best ecology-to-quality ratio considering materials, appropriate selections should be made. This is a research paper based on proportion of coarse aggregates replacement. The study represents the several mechanical properties as compressive and tensile strengths. The study shows a good correlation between aggregates replacement percentage and concrete properties.*

1. INTRODUCTION

The use of construction waste as a source of aggregate for the production of new concrete has become more common in the recent decade. The increasing charges for landfill, on the one hand, and the scarcity of natural resources for aggregate, on the other hand, encourage the use of waste from construction sites as a source for aggregates.

The applications of recycled aggregate in construction have started since end of World War II by demolished concrete pavement as recycled aggregate in stabilizing the base course for road construction. The advantages of using recycle aggregate concrete in construction industry are of economic values and environmental issues. The wastes from construction and demolition works are of large volume and increasing in time. To overcome this issue, sustainable concrete construction is one of the strategies to be considered by the construction industry. One way of achieving these is to introduce recycled aggregates from these wastes of construction and demolition works into the production of concrete

Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and by products in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. In that case, the aggregates considered are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, red mud, burnt clay, sawdust, combustor ash and foundry sand. The enormous quantities of demolished concrete are available at various construction sites, which are now posing a serious problem of disposal in urban areas. This can easily be recycled as aggregate and used in concrete. Research & Development activities have been taken up all over the world for proving its feasibility, economic viability and cost effectiveness.

An investigation conducted by the environmental resources ltd. (1979) for European Environmental commission (EEC) envisages that there will be enormous increase in the available quantities of construction and demolition concrete waste from 55 million tons in 1980 to 302 million tons by the year 2020 in the EEC member countries. As a whole, the safety and environment regulations are becoming stringent, demand for improvement in techniques & efficiency of the past demolition methods is getting pronounced. Special rules and regulations concerning the demolition have already been introduced in several countries like U.K., Holland and Japan.

Fig 1: Construction & Demolition Waste

2. MATERIAL USED

2.1.Cement

Portland Pozzolana Cement was used. Its physical properties are as given Table 1.

Table 1: Physical Properties of PPC Cement

Physical Property	Results Obtained
Fineness (Blaine's)	346 m^2/Kg
Normal Consistency	30.5%
Vicat initial setting time (minutes)	185
Vicat final setting time (minutes)	245
Compressive strength 3-days (MPa)	16.3
Compressive strength 7-days (MPa)	22.8
Specific gravity	2.82

2.2.Fly ash

Fly ash which was obtained from Chhabra Thermal Plant, Rajasthan was used.

Table 2: Chemical Properties of Fly Ash

S. No	Constituents	Percentage
1.	Silica (SiO_2)	62.96
2.	Alumina (Al_2O_3)	19.38
3.	Iron Oxide (Fe_2O_3)	8.10
4.	Loss Of Ignition	0.89

2.3.Aggregate

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight. Both fine aggregate and coarse aggregate conformed to Indian Standard Specifications IS: 383-1970. The physical properties of the coarse and fine aggregates are as under:

Table 3: Physical Properties of Coarse Aggregate & Recycled Coarse Aggregate

Physical tests	Coarse aggregate	Recycled Coarse aggregate
Specific gravity	2.70	2.55
Bulk density (kg/m^3)	1650	1405
Water Absorption (%)	0.3	2.41

Table 4: Physical Properties of Fine Aggregate

Physical tests	Fine Aggregate
Specific gravity	2.6
Fineness modulus	2.7
Bulk density (kg/m^3)	1460
Water Absorption (%)	0.16

3. TEST METHODS

The samples for Recycled Coarse Aggregate (RCA) was obtained from the crushing facility where it undergoes a threefold process of Dumping, Crushing and Screening .Dumping was facilitated by Hopper then the Jaw crusher executed the crushing process followed with Rotary Screening where the sample is separated in different heaps of aggregate upto 4.75 mm, 10mm and 20mm.The sample used was the one passing through 4.75 mm sieve.

4. MIX DESIGN

Indian Standard Recommended Method of Concrete Mix Design (IS 10262 – 2009)

Table 5: Mix design for M30 and M40

Parameter	M30	M40
W.C Ratio	0.45	0.37
Mix Ratio	1:1.53:2.84	1:1.43:2.66
Cement	400.0kg	432.43kg
Fine Agg.	612.52 kg	621.27 kg
Coarse Agg.	1137.55 kg	1153.80 kg
Water	180kg	160kg

The Experimental Program was carried out by testing the under mentioned properties of M30 and M40 concrete mix and this was put along the replacement mixes starting from the Standard to the 50% replacement mix with the interval of 10% in each mix. The replacement was done partially replacing the Coarse Aggregate with the Recycle Aggregate obtained from the Construction and Demolition Waste.

Table 6: Batch Volumes Per m^3 Of Concrete for M30

Specimen	A00	A10	A20	A30	A40	A50
Cement	400	400	400	400	400	400
F. A.	612.52	612.52	612.52	612.52	612.52	612.52
RCA	0	113.75	227.51	341.25	455.00	568.75
C. A.	1137.55	1023.80	910.05	796.30	682.55	568.80
Water	180	180	180	180	180	180

Table 7: Batch Volumes Per m^3 Of Concrete for M40

Specimen	B00	B10	B20	B30	B40	B50
Cement	432.43	432.43	432.43	432.43	432.43	432.43
F. A.	621	621.	621.	621.	621.	621

	.27	27	27	27	27	.27
RCA	0	115. 38	230. 76	346. 14	461. 52	576 .90
C. A.	115 3.8 0	1038 .42	923. 04	807. 66	692. 28	576 .90
Water	160	160	160	160	160	160

5. TEST RESULTS

5.1.Workability Result

Table 8: Slump Test of Concrete for M30

MIX	SLUMP (mm)
A00	83
A10	80
A20	78
A30	75
A40	72
A50	68

Table 9. Slump Test of Concrete for M40

MIX	SLUMP (mm)
B00	76
B10	74
B20	71
B30	67
B40	65
B50	61

5.2.Compressive Strength Result

Table 10: Compressive strengthresult Of Concrete for M30

Mix	Compressive Strength (MPa)		
	7 days	28 days	90 days
A00	32.70	39.80	42.30
A10	34.31	48.19	51.64
A20	33.68	47.36	50.76
A30	32.94	42.10	44.95
A40	31.07	35.42	37.65
A50	29.10	33.03	35.11

Table 11. Compressive strength result Of Concrete for M40

Mix	**Compressive Strength (MPa)**		
	7 days	**28 days**	**90 days**
B00	43.90	49.20	53.20
B10	46.50	59.57	64.95
B20	45.12	58.64	64.91
B30	44.63	52.09	63.87
B40	41.67	43.84	47.35
B50	39.27	40.89	44.26

5.3. Flexure Strength Result

Table 12. Flexure strength result Of Concrete for M30

Mix	Flexure Strength (MPa)		
	7 days	28 days	90 days
A00	4.00	4.41	4.63
A10	3.91	4.32	4.61
A20	3.78	4.15	4.39
A30	3.66	3.98	4.21
A40	3.52	3.90	4.17
A50	3.42	3.82	4.05

Table 13: Flexure strength result Of Concrete for M40

Mix	Flexure Strength (MPa)		
	7 days	28 days	90 days
B00	4.63	4.90	5.14
B10	4.52	4.84	5.02
B20	4.43	4.73	4.93
B30	4.34	4.58	4.74
B40	4.20	4.43	4.63
B50	4.16	4.38	4.58

6. RESULT ANALYSIS

a) The value of slump shows a decreasing trend as the percent replacement of coarse aggregate with recycled coarse aggregate was increased by 10 % .The pattern obtained maybe due to higher water absorption of RCA in comparison to virgin coarse aggregate.
b) The compressive strength was observed to be increase both in M30 and M40 with the increment of RCA upto 30%, the compressive strength increase upto 20%. After increasing the percentage of RCA above 30% the compressive strength decreases.
c) The flexure strength was observed to be decrease both in M30 and M40 with the increment of RCA, the flexure strength decrease upto 15%.

7. CONCLUSION

Recycling and reuse of building wastes have been found to be an appropriate solution to the problems of dumping hundreds of thousands tons of debris accompanied with shortage of natural aggregates. The quality of recycled aggregate directly depends on the quality and composition of C&D waste. Composition and quality of construction and demolition waste have influence on thequality of recycled aggregate produced from waste. The use of recycled aggregates in concrete proves to be a valuable building material in technical, environment and economical respect.

Based on the test results it was found that the strength of the concrete mix was increasing with the increase in replacement percentages of coarse aggregate by recycled coarse aggregate when replacement is upto 30%. It can be inferred from the study that, compressive strength of both M30 and M40 grades of concrete has been observed upto the 30% replacement of coarse aggregate with recycled coarse aggregate. Recycled coarse aggregate has porous structure and high water absorption which resulted in loss of workability at high percent replacements .This property maybe due to the presence of adhered mortar on the surface of recycled coarse aggregate. Therefore the use of recycled coarse aggregate upto 30% of coarse aggregate is recommendable in concrete mixes.

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