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Experimental investigation on properties of concrete containing manufactured sand and recycled aggregates

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ABSTRACT

An alternative source of raw material for concrete it the debris of concrete which can be recycled and reused. It has created an increasing interest by recycling of concrete debris and using it as aggregates. The solid waste pollution gets decrease by recycling and reuse of concrete debris. The term recycled aggregate (RA) is termed from reuse of concrete. The global usage of natural fine aggregate sand (FA) is very high, due to its extensive and enormous usage of concrete. This had led to the demand in naturally available sand in various developing nations to satisfy the rapid infrastructure growth. In this situation developing nations face shortage in the quality and quantity of natural sand hence manufactured sand (MA) or quarry dust has become the alternate.

This paper presents an study on the properties of binder cement, fine aggregate(FA), quarry dust or manufactured sand (MA), normal coarse aggregate (CA), recycled aggregate (RA) The fresh concrete properties and hardened concrete properties of concrete prepared with normal and recycled aggregates, river and manufactured sand were studied. Their influence on concrete's compressive strength was also investigated. Concrete mixes with a target strength of 25MPa were prepared by varying normal coarse aggregate and recycled aggregates in percentages from 45% to 55% of the total aggregate since it showed the peak strength in paper. W/C ratio was varied from 0.45 to 0.5. When river sand was replaced by m sand up to 50%, w/c ratio was 0.45 and for above percentages of replacement w/c ratio was 0.5, since the RA showed higher water absorption compared to CA. The target strength of cubes and cylinder, tensile strength test of cylinders and flexural test of beams were done. From the experimental studies, it was found that the compressive strength and tensile strength of concrete made with RA increased upto 50% replacement. The concrete of 40% to 50% replacement by recycled aggregate showed strength and with increase in percentage of RA above 50% the strength decreased.

Keywords: normal coarse aggregate (CA), recycled aggregates (RA), fine aggregate (FA), quarry dust or manufactured sand (MA)

INTRODUCTION

Concrete is the premier construction material across the world and the most widely used material in construction works. Concrete is a product made using binder cement, fine and coarse aggregates, water and admixture. Cement concrete is the one which is seemingly simple but actually a complex material. Hence each and every property of materials in concrete that are being used is studied thoroughly. Concrete with cement, coarse aggregate and fine aggregate (river sand) is being practiced throughout everywhere and the strengths are being determined.

The amount of concrete debris collected from demolished structures is huge. The amount of concrete waste has increased considerably over the last few decades. The research works on the recycling of waste construction materials is important since the materials waste is gradually increasing with the increase in population and increasing in urban development. This waste concrete could serve as recycled aggregate in another fresh concrete by crushing, washing and thereby drying. Recycling and reusing the concrete waste debris can now not only be reducing waste but also transform into fresh and new aggregate resources. In this paper the strength of concrete can be found when the coarse aggregate was replaced with recycled aggregate in different percentages. The nominal grade mixes of M25 concrete was studied and were compared with the 10% to 100% replacement of RA.

EXPERIMENNTAL STUDY

Material Properties:

Cement Properties: (OPC53 Grade): OPC of Grade 53 was used for the preparation of test specimens.
Test on Fineness (Air Permeability) Specific Surface= 278m^2/kg
Setting: (Vicat's)
Initial - setting time = 28 minutes
Final - Setting Time = 158 minutes
Test on Strength: Compressive Strength: Cement sand ratio of 1:3 and cubes of size 70.5mmx70.5mmx70.5mm are used in finding the strength of mortar cubes.
7 Days = 3.6 N/mm^2
14 Days = 18.4 N/mm^2
28 Days = 52.2 N/mm^2
Test on Soundness (Le-Chatelie) = 0.48mm

Specific gravity (Density Bottle) = 3.10

Coarse Aggregate Properties (CA): Crushed granite aggregates particles passing 20mm and retained by 12.5mm I.S sieve were used as natural coarse aggregates.

Specific gravity (Pycnometer) = 2.596
Water absorption (Density Bucket) = 1.26 %
Aggregate Bulking = 2.01%

Shape Test:

Flakiness (Thickness Gauge) = 23.89%
Elongation (Length Gauge) = 24.62%
Crushing Strength test (CTM) =23.82%
Impact test (Impact - Testing Machine) =18.32%
Soundness Test =1.52%
Abrasion Test (Los Angels - Abrasion) =17.04%
Aggregate Grading - Fineness Modulus = 6.32

Fine Aggregate Properties (FA): The fine aggregate used was natural river sand confirming to zone II.

Specific gravity Test (Density Bucket) = 2.56
Water absorption Test (Density Bucket) = 3.42%
Bulking =5.02%
Grading: Fineness Modulus: = 2.52

Manufactured sand Properties (MA):

Specific gravity of MA (Density Bucket) = 2.326
Water absorption of MA (Density Bucket) = 2.45%
Bulkingof MA =3.26%
Grading of MA aggregate - Fineness Modulus = 3.47

Recycled - coarse Aggregate Properties (RA): Crushed aggregate of concrete waste passing 20mm and retained on 12mm IS sieve was used as RA aggregate. RA obtained from site near Schemmencherry, Tamil Nadu, India.

Specific gravity (Pycnometer Test) = 2.78
Water absorption Test (Density Bucket) = 5.93 %
Soundness Test =1.42%

Shape Test:

Flakiness - Thickness Gauge = 26.12%
Elongation - Length Gauge =27.38%
Bulking - Aggregate = 6.24%
Crushing Strength(CTM) =21.98%
Grading of aggregate - Fineness Modulus = 7.11
Impact Test(Impact Testing- Machine) =18.41%
Abrasion Value (Los Angels - ATM) =21.01%

Water: Portable water in lab was used

Test Specimen: Specimens of M25 Grade of concrete were made by varying percentages of aggregates CA, RA and RA, MA as listed Table 1. The variation in w/c ratio is 0.45% for 0% - 30% replacement in natural fine aggregate by manufactured sand and the variation increase to 0.5% from 40% - 60% replacement since the water absorption properties of recycled aggregates gets increased.

Table.1.Specimens Description

Specimen	Coarse Aggregate		Fine Aggregate		Number of Specimens			Water Cement Ratio
	Normal Coarse Aggregate (CA)	Recycled Aggregate (RA)	Fine Aggregate/River Sand (FA)	Manufactured Sand(MA)	Cube	Cylinder	Prism	
A - 0% (Control Specimen)	100%	0%	100%	0%	9	18	9	0.45%
MA - 10%	45%	55%	90%	10%	6	12	6	0.45%
MA - 20%	45%	55%	80%	20%	6	12	6	0.45%
MA - 30%	45%	55%	70%	30%	6	12	6	0.45%
MA - 40%	45%	55%	60%	40%	6	12	6	0.50%
MA - 50%	45%	55%	50%	50%	6	12	6	0.50%
MA - 60%	45%	55%	40%	60%	6	12	6	0.50%

Test on Fresh Concrete: Fresh concrete properties of M25 grade of concrete were studied.

Table.2.Properties of Fresh Concrete

SPECIMEN		A-0%	MA-10%	MA-20%	MA-30%	MA-40%	MA-50%	MA-60%
w/c ratio		0.45	0.45	0.45	0.45	0.50	0.50	0.500
Slump Test	Slump Value	18mm	13mm	11mm	6mm	12mm	11mm	9mm
Flow Table	Flow %	13%	10%	7%	6%	13%	10%	8%
Compaction Factor	Compaction Factor	0.92	0.73	0.74	0.72	0.76	0.73	0.79

Test on Hardened concrete: Cube moulds size 150mmx150mmx150mm, cylinder mould of height 300mm and diameter 150mm and prism moulds of length 500 mm and c/s100mmx100mm were used. After proper compaction moulds were allowed to set. Then the specimens were cured for specified days. The testing was done in CTM for compression and Flexural Testing Machine in case of bending test. The crushing loads were found and compressive strength average and flexural strength average was determined.

Figure.1.Mixing of Concrete

Figure.2.Batching of Concrete

Figure.3.Vibrating Table

Compressive Strength Test: Compressive strength for concrete was done using CTM of 1000kN capacity. The strength of cube and cylinder were determined from collapse load.

Split Tensile Strength Test: The splitting tests are used in determining the tensile strength of concrete. The specimens were loaded and collapse load were determined. From collapse load and cross sectional area of loading, Split Tensile Strength was calculated in the corresponding specimen for 3, 7 and 28 days.

Flexural Strength Test: Flexural strength is a measure of beam or slab to resist failure in bending. Measured by 100mmx100mm concrete beams with a span length of at least three times the depth. The flexural strength is expressed as Modulus of Rupture (MPa) and is determined by standard third-point loading.

Figure.4.Cube Tested CTM

Figure.5.Cylinder TestedCTM

Figure.6.Split Tensile Test CTM

Figure.7.Split Tensile Test CTM

Figure.8.Flexural Test Beams

Figure.9.Flexural Test Beams

RESULTS

The mean compressive strength of cylinder and cube was calculated based on the collapse load. The graphs show the compressive strength 45% of CA and 55 % of RA for cubes. Target compressive strength increases rapidly for 10% replacement to 50% replacement and then decreases. It shows the significant change from 50% to 60% of replacement of FA with MA. When plotted in a smooth graph it shows the significant peak increase around equal percentage variation.

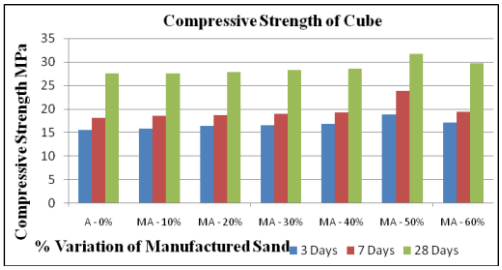

Figure 10. Compressive Strength of Cube

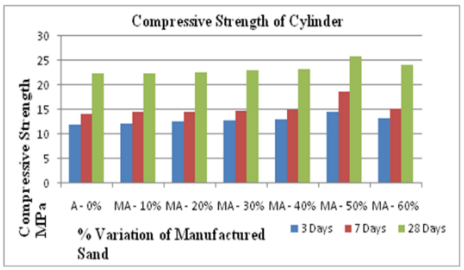

Figure 11. Compressive Strength of Cylinder

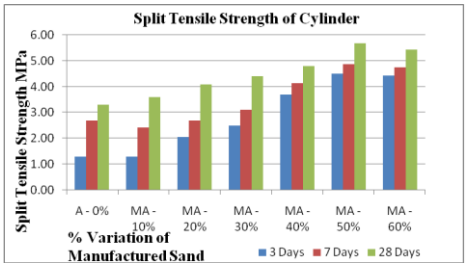

Figure 12. Split Tensile Strength of Cylinder

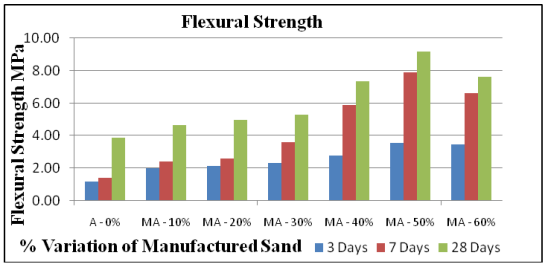

Figure 12. Split Tensile Strength of Cylinder

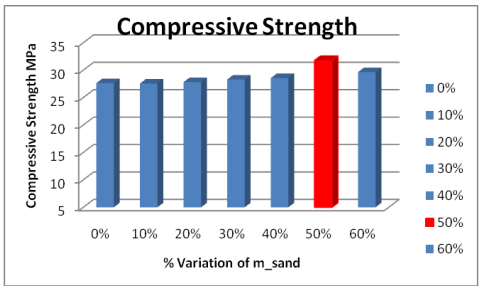

Figure.14.Variation of Compressive Strength

CONCLUSION

This paper has discussed properties of RA and effects of the RA use on concrete material properties, and the large scale impact of RA on member properties and strength.

1. Specific gravity of RA was high when compared with specific gravity CA.
2. Water absorption was high for RA and hence the w/c ratio of 0.05% was increased for increase in RA content above 50% replacement with CA. Although recycled aggregate can be applied in the high strength structure, one issue must not be neglected that increase in recycled aggregate with reduce water content would have low workability. Whenever recycled aggregate is applied, water content in the concrete mix has to be monitored carefully as the water absorption capacity of recycled aggregate will vary.
3. With the same w/c ratio, the slump value decreases if percentage of RA was increased.
4. With the same w/c ratio, the flow percentage decreases when percentage of RA was increased.
5. With the same w/c ratio, the compaction factor increases when percentage of RA was increased.
6. The effect in the use of recycled aggregate on mean compressive strength depends on the % of coarse aggregate. In case of low % of substitution, influence is neglected. Compressive strength gradually increased form 10% to 50%.
7. When CA was replaced by RA the compressive strength decreases gradually form 60%. For higher percentages of substitution the compressive strength of concrete decreased with an increase in the recycled aggregate content. Replacing CA in concrete with RA decreases the compressive strength above 60% replacement.
8. When the replacement was 50% - 60% target strength remains almost equal or the percentage variation was less. The maximum mean compressive strength was achieved for various variation.
9. Split-tensile strength is equivalent and at times superior. Split tensile strength showed marginal for 3 and 7 days test but gradually varied for 28 days test.

REFERENCES

Desai SB and Limbachiya MC, Coarse Recycled Aggregate – A Sustainable Concrete Solution, The Indian Concrete Journal: 17–23. ACC Limited, Maharashtra, India.

Katrina Mcneil and Thomas Kang HK, Recycled Concrete Aggregates: A Review", International Journal of Concrete Structures and Materials, 7(1), 2013, 61–69.

N.Sivakumar, S.Muthukumar, Experimental Studies On High Strength Concrete By Using Recycled Coarse Aggregate, International Journal Of Engineering And Science, 4(1), 2014, 27-36.

Parekh DN and Modhera CD, Assessment Of Recycled Aggregate Concrete, Journal of Engineering Research, 2(1), 2011.

Pauline T, Ashok V, Experimental Studies on Concrete with Recycled Aggregates, Journal of Chemical and Pharmaceutical Sciences, JCHPS, Special Issue 1: March 2015, 42-47.