STUDY ON CONCRETE REPLACED WITH CRUSHED CONCRETE FINE AGGREGATE

Mrs. Roopa G Sindigi[1], Mr. Devaraja R [2], Mr. Paramesh G A[3]

[1] Associate Professor, Department of Civil Engineering, Islamiah Institute of technology, Bengaluru-560076
[2]Assistant Professor, Department of Civil Engineering, AMC Engineering College, Bengaluru-560083
[3]Assistant Professor, Department of Civil Engineering, APS College Engineering, Bengaluru-560082

---***---

Abstract - *Most of the solid waste production is used as landfill. Out of which Construction & Demolition (C&D) waste constitutes a major portion. In present study, utilization of construction and demolition waste in M20 grade concrete is investigated. The fine aggregate in the concrete is replaced with 25%, 50% and 100% recycled aggregate (crushed concrete). The fresh properties like the slump change for these mixes are analyzed. To check the change in compressive strength, split tensile strength and flexure strength, the specimens were tested at 3, 7 and 28 days.*

Key Words: Construction & Demolition; recycled aggregates; compressive strength; split tensile strength; flexure strength.

1. INTRODUCTION

Whenever any construction/demolition activity like construction of roads, bridges, fly over, subway, remodelling etc. takes place, the construction and demolition waste is generated. This waste mainly consists of inert and non – biodegradable material such as concrete, plaster, metal, wood, plastics etc. In India it is estimated that about 10-12 million tons of waste annually is generated by construction industry. Due to this availability of building material such as aggregates for housing and road construction in future is depleting. To cater the increasing demand recycling of aggregate material from construction and demolition waste for both housing and road construction sectors is the best possible way to reduce the environmental impact and also to fulfil the demand [1]. In India, a huge quantity of construction and demolition wastes is produced every year. These waste materials need a large place to dump and hence the disposal of wastes has become a severe social and environmental problem. On the other hand, scarcity of natural resources like river sand is another major problem which results in increasing the depth of river bed resulting in drafts and also changes in climatic conditions. This calls for protection and preservation of the depleting natural resources. The possibility of recycling demolition wastes in the construction industry is thus of increasing importance. In addition to the environmental benefits in reducing the demand of land for disposing the waste, the recycling of demolition wastes can also help to conserve natural materials and to reduce the cost of waste treatment prior to disposal [2]. The largest proportions of demolition waste are concrete rubbles. It has been shown that the crushed concrete rubble, after separated from other construction and demolition wastes and sieved, can be used as a substitute for natural coarse aggregates in concrete or as a sub-base or base layer in pavements [3, 4, 5 & 6]. Successful application of recycled aggregate in construction projects has been reported in some European and American countries [7]. Most of the work on using recycled aggregate in concrete has focused on replacing the coarse aggregate. Therefore, in the present study effect of replacing the fine aggregate (sand) with fine recycled aggregate on the properties of the concrete [8] is reported. many governments throughout the world have now introduced various measures aimed at reducing the use of primary aggregates and increasing reuse and recycling, where it is technically, economically, or environmentally acceptable. Number of policies has been introduced by UK government to encourage wider use of secondary and recycled concrete aggregate (RCA–defined as minimum of 95% crushed concrete) as an alternative to naturally occurring primary aggregates [1]. It was concluded by J.M. Khatib [8] that beyond 28 days of curing, the rate of strength development in concrete containing crushed concrete or crushed brick is higher than that of the control indicating further cementing action in the presence of fine recycled aggregate. An increase in CC content causes an increase in shrinkage and the expansion of concrete increases for concrete containing CC [8]. Amnon Katz [9] reported that concrete made with 100% recycled aggregates was weaker than concrete made with natural aggregates at the same water to cement ratio and the properties of aggregates made from recycled crushed concrete and the effect of the aggregates on the new concrete (strength, modulus of elasticity, etc.) resemble those of lightweight aggregate concrete. In addition, Salomon M. Levy et al. [10] reported that concrete made with recycled aggregates (20%, 50%, 100% replacement) from old masonry or old concrete can have the same fresh workability and can achieve the same compressive strength of concrete made by natural aggregates in the range of 20–40 MPa at 28 days. When the natural aggregate is replaced by 20% of the recycled aggregates from old concrete or old masonry, the resulting recycled concrete will likely present same, and sometimes better, behaviour than the reference concrete made with natural aggregates in terms of the properties suggested in their investigation.

2.0 EXPERIMENTAL PROGRAM

The present study aims at casing and testing of concrete specimens for compressive strength, tensile strength and flexural strength that consists of four mixes mix 1, mix 2,mix 3 and mix 4. M20 grade concrete was designed and to that fine aggregate was replaced with 25%, 50% and 100% by crushed concrete recycled aggregate. The effect of replacement of natural fine aggregate with recycled aggregate on the fresh concrete properties like the slump was also studied in units

2.1 Material specifications

In the present experimental study ordinary Portland cement of grade 43 was used. Tests were conducted in accordance to iIS-12269:1987 to determine the physical characteristics of the cement. Fine aggregate used was river sand conforming to Zone II as per IS 383:1970. For recycled concrete aggregate (RCA), construction and demolition waste from locally situated building was used. The construction waste so obtained was crushed to fines that pass IS 4.75 mm sieve. The coarse aggregate used in the work is 20mm downsize and 16mm retaining conforming to IS 383:1970. The tests were conducted to ascertain the physical properties of the coarse aggregate in accordance with IS 2386:1963.

Table 2.1: Test Results of Materials Used

Parameters	**Results**
Standard consistency	34%
Specific gravity of cement	3.2
Specific gravity of fine aggregate	2.43
Fineness modulus of fine aggregate	4.73
Optimum bulkage of fine aggregate	7.86%
Bulk density of fine aggregate	1250 kg/m^3
Water absorption	0.22%
Specific gravity of RCA	2.3
Fineness modulus of RCA	6.42
Optimum bulkage of RCA	2.22%
Bulk density of RCA	1320 kg/m^3
Water absorption RCA	0.31%
Specific gravity of coarse aggregate	2.65
Water absorption	0.20%
Fineness modulus of coarse aggregate	8.16
Bulk density of coarse aggregate	1470 kg/m^3

2.2 Mix Proportion

Four different mixes of grade M20 including one control mix were designed to examine the influence of replacing the natural fine aggregate with recycled concrete aggregate on the properties on concrete (both fresh and hardened properties). The mix was designed as per the IS 10626:2009. The water cement ratio for all the mixes was 0.6. In mixes CC25, CC50 and CC100, the natural fine aggregate was replaced with 25%, 50% and 100% crushed concrete aggregate respectively. No admixtures were used. The details of the mix used in the present investigation are summarized in the table 2.2.

Table 2.2: Mix Proportion

Mixes	**Cement (kg/m^3)**	**FA (kg/m^3)**	**CA (kg/m^3)**	**Recycled aggregate (kg/m^3)**	**Water (kg/m^3)**
CM	328	716	1078	0	197
CC25	328	537	1078	179	197
CC50	328	358	1078	358	197
CC100	328	0	1078	716	197

2.3 Test Specimens

For each mix, cubes of 150mm, cylinders of 150mm dia. And 300mm height and prisms of size 100mm X 100mm X 500mm were cast. The total number of test specimens casted is summarized in the table 2.3

Table 2.3: Total Number of Test Specimens

Test Specimens	Total Number Casted
Cubes	36
Cylinders	36
Prisms	36

2.3 Casting of Specimens

The quantities of all the ingredients were weighed to an accuracy of 0.1% of total weight of the batch. The mix was done by hand mixing method. All the ingredients were thoroughly dry mixed on a non-absorbent platform and the water was added. The batch was mixed thoroughly until homogenous mix with desired consistency was obtained. Each batch of concrete was tested for slump immediately after mixing using slump cone apparatus. Care was taken in preparation of test specimens to maintain the standards by proper mixing, adequately compacting the concrete, and by properly curing the prepared test specimens.

3. Testing Methodology

In the present experimental study, both the fresh and the hardened strength of the concrete were investigated. Slump was checked for each batch to know the consistency of the fresh concrete. The hardened properties like compressive strength, split tensile strength and the flexural strength of all the mixes were tested at 1 day, 7 days and at 28 days. The test procedure for determination of the above parameters were in accordance with IS 516:1959.

4. Results and Discussions

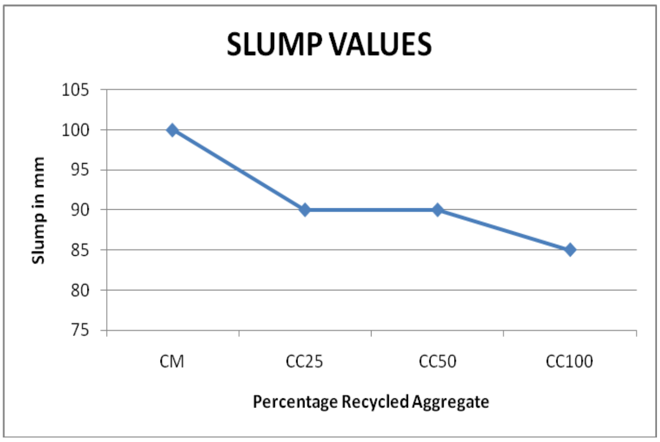
The test results so obtained for different mixes are summarized in the following tables and graphs.

4.1 Result of Slump Test

The slump was checked for every mix of concrete mix batch. The results are tabulated below in the table 4.1

Table 4.1: Slump Values

Sl.No.	Concrete Mixes	Slump In mm
1	CM	100
2	CC25	90
3	CC50	90
4	CC100	85



Graph 1: Slump Values of Different Concrete Mixes

The slump values indicate that all concrete mixes exhibit good workability. There is systematic decrease in the slump value with increase in the recycled aggregate percentage in the mix.

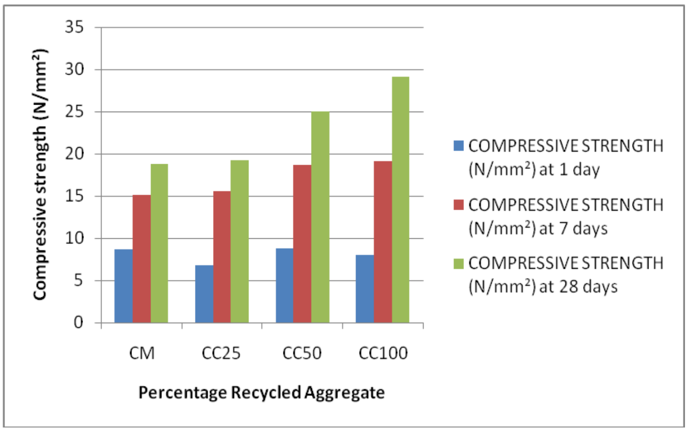
4.2 Compressive Strength Results

The capacity of the material or the structure to withstand loads. This is the main criteria for the design of structures. To determine the compressive strength of the material the material is subjected to uniaxial compression. In the present study the cubes of 150mm size cured at 1,7 and 28 days were subjected to the testing. The test results are tabulated below.

Table 4.2: Compressive Strength of Different Mixes.

Sl.No.	CONCRETE TYPE	COMPRESSIVE STRENGTH (N/mm^2)		
		1 day	7 days	28 days
1	CM	8.67	15.18	18.81
2	CC25	6.82	15.55	19.26
3	CC50	8.74	18.67	25.04
4	CC100	8	19.11	29.18

A graphical representation of increase in compressive strength for different mixes at various days of curing is as shown in the graph below.



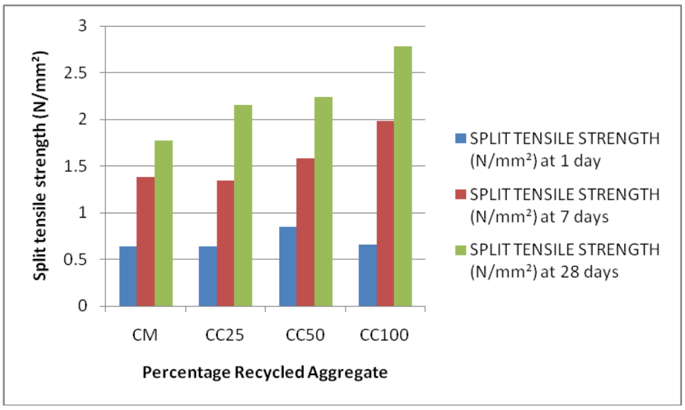
Graph 2: Effect of Recycled Aggregate on Compressive Strength

4.3 Split Tensile Strength Results

Split tensile test is a standard test to determine the tensile strength of the concrete in an indirect way. A standard test cylinder of concrete specimen of 150mm dia. and 300mm height is placed horizontally between the loading surfaces of compression testing machine. To allow the uniform distribution of load and to reduce the magnitude of the high compressive stresses near the point of application of the load, plywood strips are placed between the specimen a testing machine. The split tensile strength for all mixes at 1,7and 28 days is presented in the table 4.3.

Table 4.3: Split Tensile Strength

Sl.No.	CONCRETE TYPE	SPLIT TENSILE STRENGTH (N/mm^2)		
		1 day	7 days	28 days
1	CM	0.64	1.38	1.77
2	CC25	0.64	1.34	2.15
3	CC50	0.85	1.58	2.24
4	CC100	0.66	1.98	2.78



Graph 2: Effect of Recycled Aggregate on Split Tensile Strength

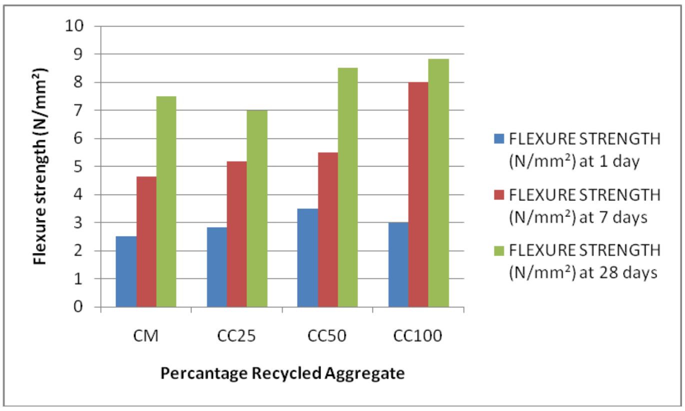
4.4 Flexural Strength Results

Design of the highway pavements is based on the flexural strength of concrete. It is also known as Modulus of Rupture, fracture or bending strength is a mechanical parameter of the material that defines the ability of material to resist maximum tensile or compressive stress at its moment of rupture. Flexural strength of concrete is evaluated by conducting bending test on a beam specimen of size 100X100X500mm. The flexure strength for all mixes is presented in Table 4.4.

Table 4.4: Flexural Strength of Different Mixes

Sl.No.	CONCRETE TYPE	FLEXURE STRENGTH (N/mm^2) at		
		1 day	7 days	28 days
1	CM	2.5	4.64	7.5
2	CC25	2.83	5.17	7
3	CC50	3.5	5.5	8.5
4	CC100	3	8	8.83

Graphical representation of increase in flexural strength of different mixes at various curing days is as shown in graph below.



Graph 3: Effect of Recycled Aggregate on Flexural Strength

5. SUMMARY AND CONCLUSION

In the present experimental program, the strength variation of M20 grade concrete when replaced with recycled aggregates in various proportions is documented. Four different mixes (including the control concrete) with different replacement percentage were tested for compression strength, split tension strength and flexural strength respectively.

The following conclusions were made based on the test results.

- The rate of gain of early compressive strength is less compare to that of control concrete.
- The rate of gain of 7days and 28 days compressive strength had increased.
- The split tensile strength shows alternate increase and decrease in early strength for various percentages of replacement, whereas the 7days strength 50%and 100% replacement of fine aggregate with crushed concrete has shown increment in strength than that of control concrete.
- The flexural strength shows considerable increment in the strength for 1day and 7days but, for 28days a decrease in strength is observed for 25% replacement concert mix.

From the present experimental investigation, it is observed that there is possibility to replace fine aggregates in concrete to percentage up to 50% to 100% for lower grade concrete.

REFERENCES

[1] Limbachiya M.C., "PERFORMANCE OF RECYCLED AGGREGATE CONCRETE", RILEM International Symposium on Environment-Conscious Materials and Systems for Sustainable Development, Pg. no 127-136, April 2004.

[2] Kumutha R., et al, "STRENGTH OF CONCRETE INCORPORATING AGGREGATES RECYCLED FROM DEMOLITION WASTE", ARPN Journal of Engineering and Applied Sciences, Volume 5, Number 5, Pg. no 64-71, May 2010.

[3] Hansen T.C., "RECYCLING OF DEMOLISHED CONCRETE AND MASONRY", RIELM, Report No. 6, E and FN Spon, U.K., 1992.

[4] Mehta P.K, et al, "CONCRETE: STRUCTURES, PROPERTIES AND MATERIALS", New Jersey, Prentice Hall, 1993.

[5] Collins R.J, "THE USE OF RECYCLED AGGREGATES IN CONCRETE", BRE Report, Building Research Establishment, U.K., May 1994.

[6] Sherwood P.T, "ALTERNATIVE MATERIALS IN ROAD CONSTRUCTION", Thomas Telford, London, 1995.

[7] Desmyster J, et al, "USE OF RECYCLED MATERIALS AS AGGREGATES IN CONSTRUCTION INDUSTRY", Proceedings of the 1st ETNRecy, net/RIELM Workshop, ETNRecy, Paris, 2000.

[8] Khatib J.M., "PROPERTIES OF CONCRETE INCORPORATING FINE RECYCLED AGGREGATE", Cement and Concrete Research, Volume 35, Number 4,

[9] Amnon Katz, "PROPERTIES OF CONCRETE MADE WITH FINE RECYCLED AGGREGATE FROM PARTIALLY HYDRATED OLD CONCRETE", Cement and Concrete Research, Volume 33, Number 5, Pg no 703-711, May 2003.Pg no 763-769, April 2005.

[10] Salomon M. Levy, et al, "DURABILITY OF RECYCLED AGGREGATES CONCRETE: A SAFE WAY TO SUSTAINABLE DEVELOPMENT", Cement and Concrete Research, Volume 34, Number 11, Pg no 1975-1980, November 2004.