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EVALUATION OF STRENGTH PARAMETERS ON DIFFERENT GRADES OF RECYCLED AGGREGATE CONCRETE

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Abstract - In developing countries like India, the generation of construction and demolition (C &D) waste is increasing day by day. On the other hand, the reuse of construction waste is highly essential the to preserve natural resources. Using the demolished concrete debris as recycled concrete aggregate conserves natural aggregates, reduces the impact on landfills, decreases energy consumption and can provide cost savings. The use of recycled aggregates in concrete results in significant economical and environmental benefits. In the present work, attempts have been made to assess the effect of recycled concrete aggregate on the strength of ordinary concrete. A study has been made on the properties of recycled aggregate which is to be used as coarse aggregate for four different grades of concrete M25, M30, M35 and M40 grade of Concrete. The percentage of recycled aggregate that partially replaced natural aggregate by weight was 0%, 20%, 40%, 60%, 80% and 100%. Concrete cubes, cylinders and prisms were casted and tested in laboratories. Properties of aggregate and comparison of recycled aggregate concrete against natural aggregate concrete is performed according to requirements as such for its workability, Compressive strength test, Split Tensile test and Flexural test.

***Key Words*:** compressive strength, flexural strength, split tensile strength, recycled aggregate.

1. INTRODUCTION

There is severe shortage of infrastructural facilities like houses, hospitals, roads etc. in India and large quantities of construction materials for creating these facilities are needed. Rapid infrastructural development such as highways, airports etc. and growing demand for housing has led to scarcity & rise in cost of construction materials Dumping of wastes on land is causing shortage of dumping place in urban areas. Therefore, it is necessary to start recycling and re-use of demolition concrete waste to save environment, cost and energy. Therefore, it is necessary to evaluate the strength properties of concrete.

2. LITERATURE REVIEW

[1] Mehul Kumawat and S.D Thanvi, (2020), "A Study on Use of Recycled Concrete Aggregate (RCA) in M-25 Grade Concrete":

In this study RCA has been added in concrete which varies from 0% to 100% at interval of 25% by total weight of coarse aggregate. A total of four mixes were prepared for M 25 grade concrete. This study investigated the performance of concrete mixture in terms of Compressive, Spilt and Flexure strength for 7days and 28 days and durability against acid and alkali attack. Finally they concluded that, 25 % replacement of natural coarse aggregate with recycled coarse aggregate provide desirable compressive strength of 25 N/mm^2. After increasing the percentage of recycled coarse aggregate in fresh concrete, compressive strength decreases. At higher percentage of recycled coarse aggregate i.e. 50% & 100% slump and compaction factor is also low, which shows poor workability.

[2] Abdulsamee M. Halahla (2019), "Utilization of demolished waste as coarse aggregate in concrete":

In this research, the old concrete was crushed and used as aggregates to obtain new concrete. Different mechanical tests were carried out to measure and characterize the new recycled aggregate concrete. All the mechanical tests showed that recycled aggregate concrete has slightly lower values than the natural aggregate concrete. The old crushed concrete can be a good alternative to be used as an aggregate in new concrete.

[3] Jagdish Kanungo, Dr. Hemant Sood (2018),"Effect of Use of Recycled Coarse Aggregate in Concrete":

In this study a comparative analysis of the experimental results of the properties of Natural Aggregate Concrete and different replacement ratios of natural aggregates with recycled coarse aggregates is presented. Recycled aggregate was made by crushing the waste concrete of laboratory test cubes. Four type of concrete mixtures were tested: concrete made entirely with natural coarse aggregate as a controlled concrete and three types of concrete made with different replacement ratios of natural coarse aggregates with recycled coarse aggregate (10%, 30% and 50% replacement with recycled aggregates).They finally concluded that use of recycled aggregate upto 30% does not effect the fictional requirements of structure.

[4] AnaghaKalpavalli (2015) "Use of demolished concrete waste as coarse aggregate in high strength concrete production":

In this research, various tests were done on concrete with replacement of natural coarse aggregates and on conventional concrete. The demolished waste was crushed to required size manually by using rammers and thoroughly washed to remove adhere present in the aggregate. Then soaked in the water for 24 hrs to reduce the water absorption in concrete. Due to this, no additional water is required while mixing. It shows that the concrete replaced with more recycled aggregates will develop the least strength compared to the lesser replacement ratio

concrete. But, it can be seen that up to 30% replacement gives better results. Beyond this replacement, the strength acquired reduces gradually and does not cross the required tensile strength. Further, this also concludes that split tensile strength follows same trend.

[5] Manjunath M, Prakash K B., (2015),"Effect of replacement of natural aggregates by recycled aggregates derived from field demolished concrete on the workability and strength characteristics of concrete":

This paper presents an experimental investigation on the effect of replacing natural coarse aggregate by recycled aggregate obtained by processing field demolished concrete on the properties of recycled aggregate concrete. The natural coarse aggregate (NA) in concrete was replaced by recycled coarse aggregate (RA) at different percentages. Workability tests and strength tests such as compressive test, tensile test, flexural test and impact test are conducted to study the effect of replacing NA by RA. Test results show that for different percentage replacements of natural coarse aggregates by recycled aggregates there is a reduction in strength of concrete with the increase in the percentage of replacement. For replacement of natural aggregates by recycled aggregates up to 20%, the reduction in strength was marginal.

3. MATERIALS USED

(a) Cement

Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together.

(b) Fine Aggregate

Fineaggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed stone particles that are ¼" or smaller.

(c) Coarse Aggregate

Coarse aggregate are generally obtained by blasting in stone quarries or by breaking them by hand or by crushers. machine – crushed stones consist of stones of various sizes whereas hand – broken aggregates consist of only ingle size stones.

(d) Recycled Aggregate

Recycled Aggregates is a term that describe crushed cement concrete from construction debris that is reused in other building projects. Recycled aggregates to be produced from aged concrete that has been demolished and removed from foundations, pavements, bridges or buildings, is crushed and processed into various size fractions.

(e) Water

Potable water free from impurities and deleterious materials was used for mixing and curing in this thesis.

4. METHODOLOGY

The aim of this investigation is to compare the basic properties of control concrete (concrete made with natural aggregate) and the properties of concrete made with different percentages of recycled aggregate for different grades of concrete (M_{25}, M_{30}, M_{35}, M_{40}).

Six concrete types were tested for each grade of concrete mix. The type and quantity of coarse aggregate were replaced with recycled aggregate in the following way:

(a) The first concrete sample had 100% of Natural Coarse Aggregate (R0), control mixture.
(b) The second concrete sample had 80% of Natural Coarse Aggregate (NCA) and 20% of Recycled Coarse Aggregate (RCA), (R20).
(c) The third concrete sample had 60% of Natural Coarse Aggregate (NCA) and 40% of Recycled Coarse Aggregate (RCA), (R40).
(d) The fourth concrete sample had 40% of Natural Coarse Aggregate (NCA) and 60% of Recycled Coarse Aggregate (RCA), (R60).
(e) The fifth concrete sample had 20% of Natural Coarse Aggregate (NCA) and 80% of Recycled Coarse Aggregate (RCA), (R80).
(f) The sixth concrete sample had 100% of Recycled Coarse Aggregate (RCA), (R100).

As all the other variables were kept constant, this research enabled us to determine the influence of the coarse recycled aggregate amount (0%, 20%, 40%, 60%, 80% and 100%) on tested concrete properties. The experimental investigation was done on different grades of concrete (M_{25}, M_{30}, M_{35}, M_{40}).

Experimental investigation of the present study mainly divided in to the following methods.

1. Procurement and retrieval of recycled coarse aggregate from construction and demolition waste.
2. Testing the physical properties of untreated aggregates.
3. Adopting four treatment methods to improve the surface properties of RCA.
4. Investigating fresh and hardened properties of concrete made with natural and recycled coarse aggregates.

5. MATERIAL PROPERTIES

Table 1: Physical Properties Of Cement

S.No.	Property of Cement	Values obtained
1.	Standard Consistency	29%
2.	Initial Setting Time	42 minutes
3.	Final Setting Time	480 minutes
4.	Fineness	8%
5.	Specific Gravity	3.15

Table 2: Properties of Fine Aggregate

S.No.	Property of Fine Aggregate	Values obtained
1.	Specific Gravity	2.71
2.	Fineness Modulus	2.89
3.	Grading Zone	III
4.	Water Absorption (%)	1.5

Table 3: Properties of Coarse Aggregate

S.No.	Property of Coarse Aggregate	Values obtained
1.	Specific Gravity	2.75
2.	Fineness Modulus	8.79
3.	Water Absorption (%)	0.5
4.	Bulk Density (kg/m^3)	1510
5.	Aggregate Crushing Value (%)	18.4
6.	Aggregate Impact Value (%)	17.65

Table 4: Properties of Recycled Aggregate

S.No.	Property of Recycled Aggregate	Values obtained
1.	Specific Gravity	2.58
2.	Fineness Modulus	7.78
3.	Water Absorption (%)	0.3
4.	Bulk Density (kg/m^3)	1650
5.	Aggregate Crushing Value (%)	36.3
6.	Aggregate Impact Value (%)	35.2

6. EXPERIMENTAL WORK

In present experimental work, various concrete mix batches have been prepared such as, normal concrete i.e. 0% replacement, 20% replacement, 40% replacement, 60% replacement, 80% replacement and 100% replacement. The testing of mechanical properties were conducted on Universal Testing machine for 3 days, 7 days and 28 days.

(a) Evaluation of Compressive Strength:

Compressive strength is the most common test conducted on hardened concrete, partly because itis an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. To evaluate the compressive strength cubes of size 150 mm x 150 mm x 150 mm were casted using C.I. mould.

(b) Evaluation of Split Tensile Strength:

Generally the split tensile strength will be predicted by using cylinders of diameter 150mm and depth or height of 300m placing longitudinally and applying force by machine. This work is carried out for grades of M40 & M60 at 3days, 7days and 28 days.

(c) Evaluation of Flexural Strength:

Modulus of rupture was tested by prisms with dimension of (100x100x500) mm. When tested the prisms we put the load in two points on them (two point load).

7. RESULTS & DISCUSSIONS

Table 5: Compressive Strength for varying % of RCA for M_{25} Grade Concrete

S.No	Recycled Aggregate (%)	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1.	0	10.30	16.80	26.20
2.	20	10.11	16.67	25.56
3.	40	10.06	16.61	25.30
4.	60	9.980	16.55	25.00
5.	80	9.910	16.01	24.70
6.	100	9.670	15.54	23.80

Table 6: Compressive Strength for varying % of RCA for M_{30} Grade Concrete

S.No	Recycled Aggregate (%)	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1.	0	12.10	22.48	32.89
2.	20	12.01	22.10	32.05
3.	40	11.89	21.78	31.86
4.	60	11.09	21.00	30.16
5.	80	10.89	20.56	29.36
6.	100	10.10	19.89	28.69

Table 7: Compressive Strength for varying % of RCA for M_{35} Grade Concrete

S.No	Recycled Aggregate (%)	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1.	0	14.19	23.56	37.45
2.	20	14.03	23.12	37.02
3.	40	13.89	23.01	36.78
4.	60	13.65	22.89	36.12
5.	80	13.35	22.67	34.95
6.	100	12.98	22.12	33.89

Table 8: Compressive Strength for varying % of RCA for M_{40} Grade Concrete

S.No	Recycled Aggregate (%)	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1.	0	16.45	28.34	42.56
2.	20	16.09	28.00	41.65
3.	40	16.01	27.40	40.89
4.	60	15.78	27.05	40.10
5.	80	15.18	26.35	37.98
6.	100	14.56	25.90	36.89

Chart 1: Compressive Strength for varying % of RCA for M_{25} Grade Concrete

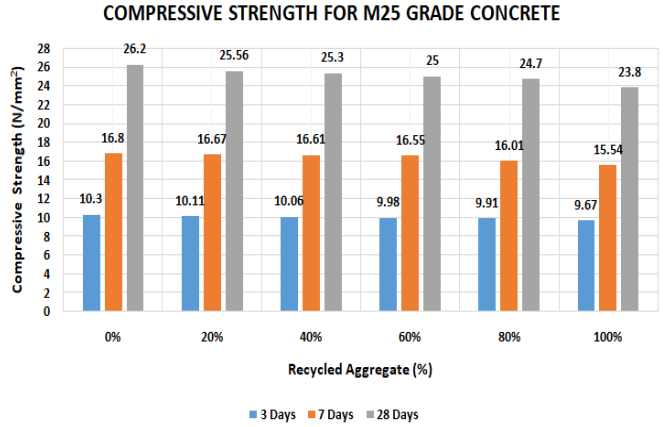

Chart 2: Compressive Strength for varying % of RCA for M_{30} Grade Concrete

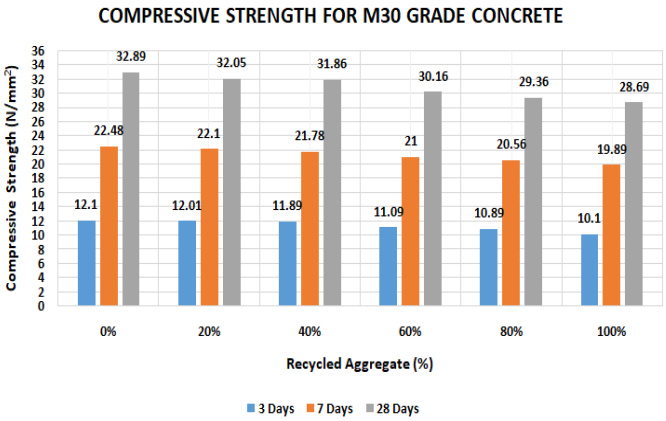

Chart 3: Compressive Strength for varying % of RCA for M_{35} Grade Concrete

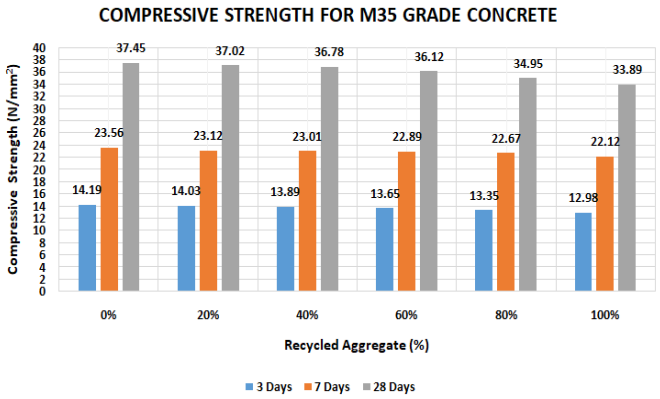

Chart 4: Compressive Strength for varying % of RCA for M_{40} Grade Concrete

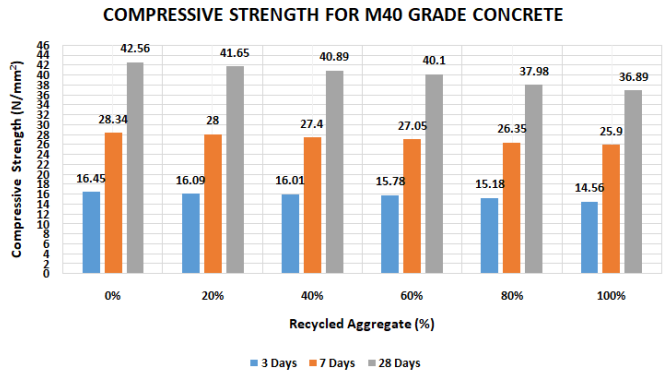

Table 9: Split Tensile Strength for varying % of RCA for M_{25} Grade Concrete

S.No	Recycled Aggregate (%)	Split Tensile Strength (N/mm^2)	
		7 Days	28 Days
1.	0	3.34	4.38
2.	20	3.01	4.11
3.	40	2.92	3.89
4.	60	2.82	3.62
5.	80	2.56	3.45
6.	100	2.34	3.32

Table 10: Split Tensile Strength for varying % of RCA for M_{30} Grade Concrete

S.No	Recycled Aggregate (%)	Split Tensile Strength (N/mm^2)	
		7 Days	28 Days
1.	0	3.60	4.53
2.	20	3.45	4.34
3.	40	3.30	4.12
4.	60	3.07	3.98
5.	80	2.84	3.80
6.	100	2.61	3.67

Table 11: Split Tensile Strength for varying % of RCA for M_{35} Grade Concrete

S.No	Recycled Aggregate (%)	Split Tensile Strength (N/mm^2)	
		7 Days	28 Days
1.	0	3.85	4.63
2.	20	3.66	4.54
3.	40	3.48	4.43
4.	60	3.34	4.25
5.	80	3.18	4.15
6.	100	3.00	4.02

Table 12: Split Tensile Strength for varying % of RCA for M_{40} Grade Concrete

S.No	Recycled Aggregate (%)	Split Tensile Strength (N/mm^2)	
		7 Days	28 Days
1.	0	3.96	4.70
2.	20	3.80	4.58
3.	40	3.67	4.42
4.	60	3.43	4.34
5.	80	3.20	4.05
6.	100	3.08	3.89

Chart 5: Split Tensile Strength for varying % of RCA for M_{25} Grade Concrete

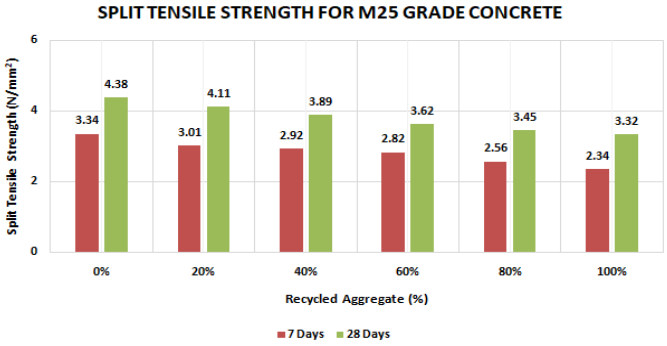

Chart 6: Split Tensile Strength for varying % of RCA for M_{30} Grade Concrete

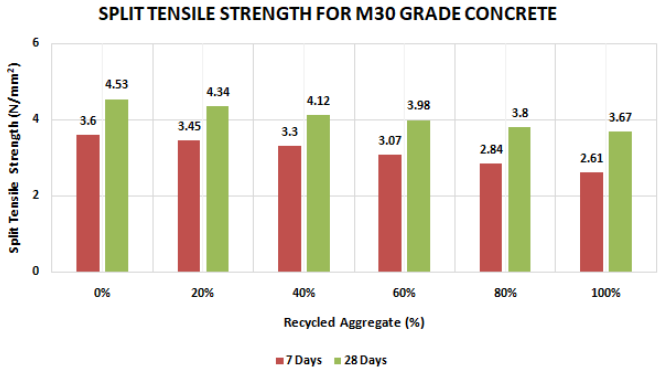

Chart 7: Split Tensile Strength for varying % of RCA for M_{35} Grade Concrete

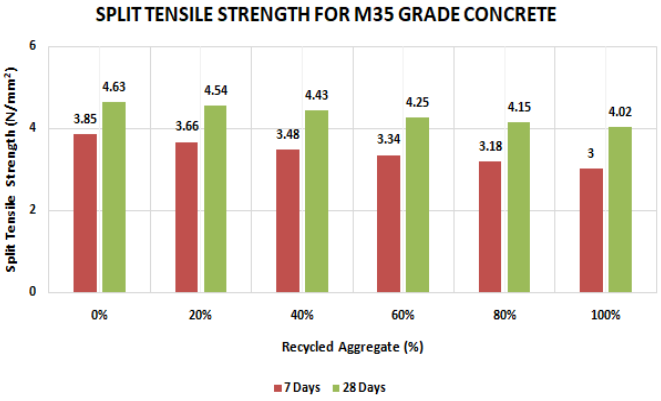

Chart 8: Split Tensile Strength for varying % of RCA for M_{40} Grade Concrete

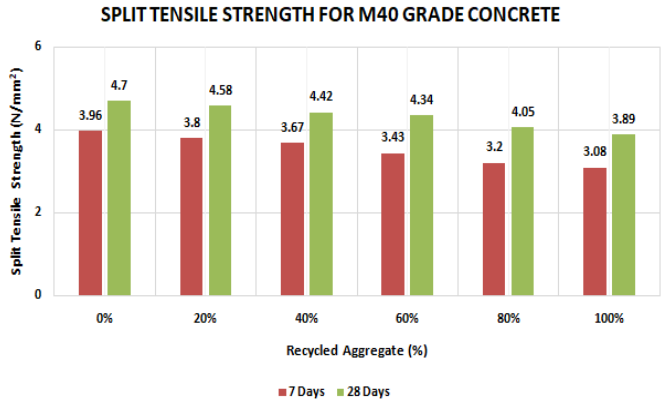

Table 13: Flexural Strength for varying % of RCA for M_{25} Grade Concrete

S.No	Recycled Aggregate (%)	Flexural Strength (N/mm^2)	
		7 days	28 days
1.	0	2.37	3.55
2.	20	2.31	3.49
3.	40	2.28	3.41
4.	60	2.21	3.35
5.	80	2.01	3.27
6.	100	1.92	3.18

Table 14: Flexural Strength for varying % of RCA for M_{30} Grade Concrete

S.No	Recycled Aggregate (%)	Flexural Strength (N/mm^2)	
		7 days	28 days
1.	0	2.56	3.83
2.	20	2.49	3.81
3.	40	2.42	3.76
4.	60	2.37	3.70
5.	80	2.30	3.61
6.	100	2.21	3.49

Table 15: Flexural Strength for varying % of RCA for M_{35} Grade Concrete

S.No	Recycled Aggregate (%)	Flexural Strength (N/mm^2)	
		7 days	28 days
1.	0	2.78	4.20
2.	20	2.72	4.11
3.	40	2.65	4.07
4.	60	2.59	4.00
5.	80	2.49	3.93
6.	100	2.41	3.82

Table 16: Flexural Strength for varying % of RCA for M_{40} Grade Concrete

S.No	Recycled Aggregate (%)	Flexural Strength (N/mm^2)	
		7 days	28 days
1.	0	2.97	4.45
2.	20	2.93	4.39
3.	40	2.88	4.33
4.	60	2.80	4.24
5.	80	2.73	4.16
6.	100	2.65	4.08

Chart 9: Flexural Strength for varying % of RCA for M_{25} Grade Concrete

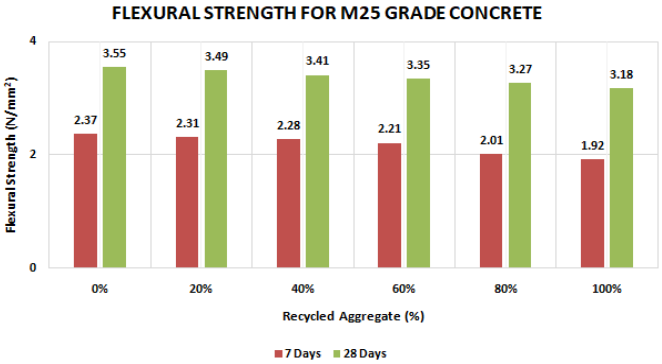

Chart 10: Flexural Strength for varying % of RCA for M_{30} Grade Concrete

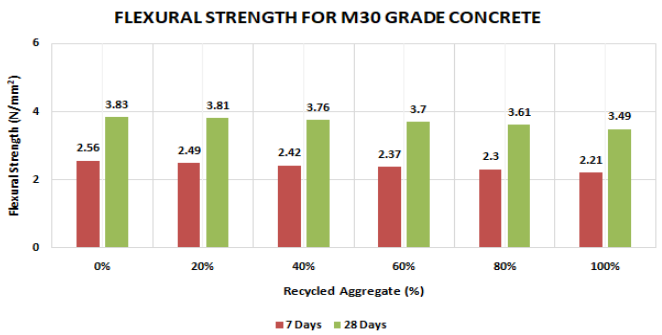

Chart 11: Flexural Strength for varying % of RCA for M_{35} Grade Concrete

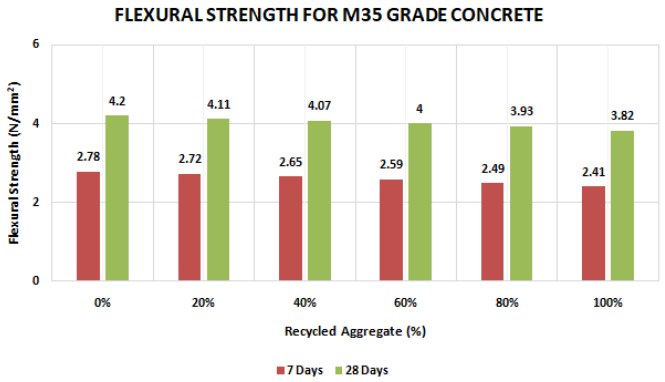

Chart 12: Flexural Strength for varying % of RCA for M_{40} Grade Concrete

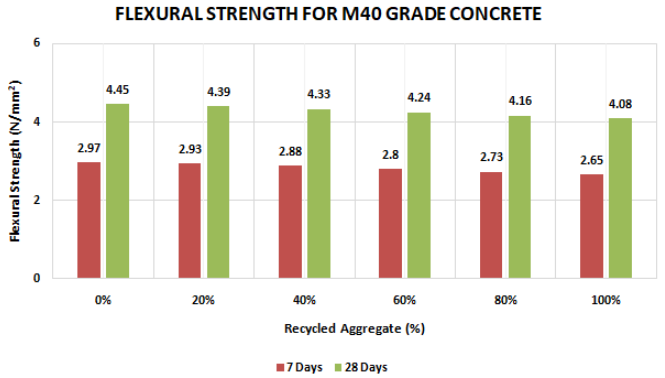

Table 17: Slump Values for varying % of RCA

S.No.	Recycled Aggregate(%)	Slump Value (mm)
1.	0%	96
2.	20%	88
3.	40%	82
4.	60%	80
5.	80%	78
6.	100%	75

CONCLUSIONS

In this study, recycled aggregate is used in different percentages varying from 0% to 100% at an interval of 20% in replacement of coarse aggregate for different grades of concrete.
The following conclusions were obtained from this study:

1) The Compressive Strength of Concrete is decreasing with increase in percentage of Recycled Aggregate.
2) The Split Tensile Strength of Concrete is decreasing with increase in percentage of Recycled Aggregate.
3) The Flexural Strength of Concrete is decreasing with increase in percentage of Recycled Aggregate.
4) The workability of concrete decreases with increasing in percentage of Recycled Aggregate.
5) The optimum percentage of Recycled Aggregate was found to be 60% replacement of Coarse Aggregate with Recycled Aggregate.

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BIOGRAPHIES

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