Effect of partial replacement of coarse aggregate by recycled aggregate using basalt fiber

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Abstract- *This paper presents the comparative study of effect of basalt fibre and recycled aggregate on compressive, tensile and flexure strength of M25 grade concrete. The basalt fibre was mixed in concrete by 0.5% and 1% of its total weight of cement and coarse aggregate was replaced by recycled aggregate with 0%,20%,40% and 60% in concrete. Results indicated that the strength increases with increase of recycled content up to 40% beyond that there is a reduction in strength on increasing recycled aggregate. The results show that the concrete specimen with 1.0% of basalt fibre gives better performance when it compared with 0.5% basalt fibre mix in concrete specimens.*

Keywords- Basalt fiber,Recycled aggreagtes, Compressive Strength, Split tensile strength, Flexural strength.

I. INTRODUCTION

In the world of construction, concrete like other materials is playing an important role in development. concrete is a composite material which is a mixture of cement, fine aggregate , coarse aggregate and water .The major constituents of which is natural aggregate such as gravel, sand, Alternatively, artificial aggregates such manufactured sand furnace slag, fly ash, expanded clay, broken bricks and steel may be used where appropriate. It possesses many advantages including low cost, general availability of raw material, adaptability, low energy requirement and utilization under different environmental conditions.

The debris is also a major problem for municipal authorities to dispose of at particular location. It is most common practice in all over the world that most of the materials (paper, plastic, rubber, wood, concrete, etc) are being recycled to save the natural resources and environment. Concrete is such a costly material but Now a day's waste concrete is only being used as a landfill material instead of recycling the concrete as a recycled concrete aggregate (RCA) to use for the construction purposes.

Basalt rock is volcanic igneous rock it's a excellent presentation in terms of strength, durability and high temperature range. Basalt is quarried, crushed and washed and then melted at high temperature (15000 C) and rapidly drawn into a continuous fiber. Continuous fiber can be chopped into different lengths. Basalt fiber color varies between brown, gold or gray. Basalt rocks are melted into Junker's technology in the form of basalt fiber. It's give the superior tensile strength as compared to E-glass, good resistance to chemical attack, take impact load and fire resistance. Since because of mineralogical and chemical properties, basalt are widely used in building materials. Some of journal paper research and adopt the fibers are added to improve the performance of concrete. For example steel fiber, asbestos fiber, glass fiber, carbon fiber, etc. now a day introduces the basalt fiber for better result of concrete. Fibers are normally used in concrete, it controls the cracks due to plastic and to drying shrinkage. They also permeability of concrete is reduce and thus reduce bleeding of water.

II. MATERIAL PROPERTIES

A. Material Used

1) Cement:

Cement is a binder, a substance that sets and hardens and can bind other materials together. Though all cement conforming to various IS code is suitable, selection of cement should be based on their compressive strength, fineness and compatibility with other ingredients.

Table 1. Physical Properties of Cement

Sr. No.	Physical Properties of OPC 53 Grade Cement	Value
1	Specific Gravity	3.15
2	Grade of cement	OPC(53)
3	Fineness Test	7.5%
4	Normal consistency	35%
5	Initial Setting Time	30min
6	Final Setting Time	600min

2) Corse Aggregate:

Coarse aggregate was crushed stone which was available locally. Maximum size chosen was 10mm down. Tests are conducted to find the properties of coarse aggregate and the results are tabulated in Table 2

Table 2.Physical Properties of Coarse Aggregate

Sr. No.	Properties	Values
1	Specific Gravity	2.68
2	Size Of Aggregates	20mm down
3	Fineness Modulus	5.96
4	Water absorption	2.0%
5	Impact Test	15.2%
6	Crushing Test	22.5%

3) Fine Aggregate:

Locally available river sand was used as fine aggregate. Tests are conducted to find the properties of fine aggregate and test results are tabulated in table 3

Table 3. Physical Properties of Fine Aggregate

Sr.No	Tests	Values
1	Specific gravity	2.65
2	Water absorption	1.5%
3	Fineness modulus	2.25

4) Recycled aggregate:

Construction materials are increasingly judged by their ecological characteristics. Concrete recycling gains importance because it protects natural resources and eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete or other applications. The states that do use recycled concrete aggregate (RCA) in new concrete report that concrete with RCA performs equal to concrete with natural aggregates. Most agencies specify using the material directly in the project that is being reconstructed. Recycling of concrete is a relatively simple process. It involves breaking, removing, and crushing existing concrete into a material with a specified size and quality.

Table 4. Physical properties of recycled aggregate

Properties	Values
Specific Gravity	2.37
Size Of Aggregates	20mm
Fineness Modulus	6.05
Water absorption	2.50%
Impact Test	19.2%
Crushing Test	32.5%

5) Basalt fibre:

Physical Properties:

1. Color: It is available in golden brown in color.
2. Diameter: It is available in different diameter like 5.8 micron. Length:- Available in 6mm,8mm,12mm etc.
3. Density: density of basalt fiber is 2.75 g/cm^3
4. Coefficient of friction: The coefficient of friction may be between 0.42 to 0.50.

Chemical Properties:

a) Basalts are more stable in strong alkalis.
b) Weight loss in boiling water, Alkali and acid is also significantly lower.
c) Basalt fibers have very good resistance against alkaline environment, with the capability to withstand pH up to 13-14. It also has good acid and salt resistance

6) Water:

The water available in laboratory which satisfies the potable water standards was used casting of concrete specimen and its subsequent curing.

III. METHODOLOGY

The aim of the experiment was to assess the properties of concrete made with Recycled Aggregate and Basalt Fibre and to study the various important aspects such as compressive strength and flexural strength of concrete prepared by using Recycled Aggregate and Basalt Fibre and with different percentage of replacements with Coarse Aggregate and Addition with cement respectively. The studies were carried out for mix design of Grade of concrete-M25 and Design-IS 456:2000 & IS 10262:2009. In this study, a total 63 numbers of concrete specimens were casted. In those 42 numbers of cubes and 21 numbers of beams respectively. All the values are the average of the three trails in each case in the testing program of this study.

Table 5. Specimens used

Type of test	Type of Specimen	Dimensions(mm)
Compression test	Cube	150x150x150

Split tensile test	Cylinder	150 diax300 height
Flexural strength test	Beam	750x150x150

According to IS 456:2000 & IS 10262:2009. Mix proportion of M25 Grade becomes

Table 6. Mix proportion

Water (Litres)	Cement(kg)	Fine aggregate(kg)	Coarse aggregate(kg)
186	405	613	1160
0.46	**1**	**1.527**	**2.86**

IV. TEST RESULTS AND DISCUSSIONS

1. Compressive Strength:

Table 7. Compressive strength of concrete for Different percentage of Recycled Aggregate and 0.5% of Basalt Fiber constant for 7 curing days.

Sr.No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average Compressive Strength in N/mm^2
1	00	00	13.23	17.58
			21.18	
			18.24	
2	0.5	20	23.24	19.90
			18.53	
			17.95	
3	0.5	40	22.20	22.24
			24.57	
			19.97	
4	0.5	60	14.58	20.22
			25.10	
			20.97	

Table 8. Compressive strength of concrete for Different percentage of Recycled Aggregate and 0.5% of Basalt Fiber constant for 28 curing days.

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average Compressive Strength in N/mm^2
1	00	00	32.10	25.28
			15.66	
			28.08	
2	0.5	20	28.88	26.67
			27.81	
			23.92	
3	0.5	40	28.48	27.46
			29.86	
			24.04	
4	0.5	60	22.29	26.27
			33.15	
			23.52	

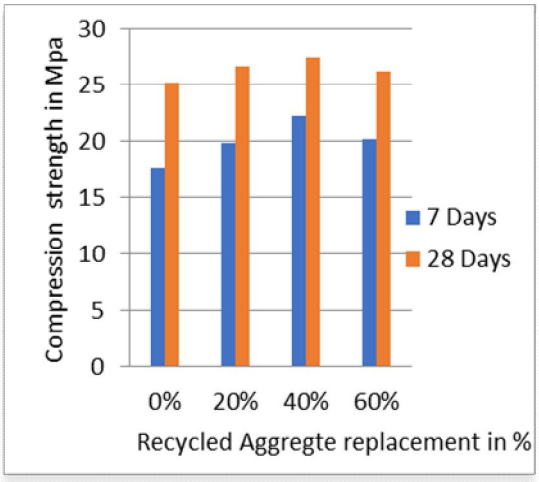

Figure 1. Graph % Replacement of recycled aggregate vs compressive strength(mpa)

2. Tensile strength for cube:

Table 9. Split tensile strength of concrete for cube for Different percentage of Recycled Aggregate and 0.5% of Basalt Fiber constant for 7 curing days

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average tensile strength for 28 days(mpa
1	00	00	8.49	11.26
			13.59	
			11.71	
2	0.5	20	14.92	12.78
			11.90	
			11.52	
3	0.5	40	9.36	15.58
			17.70	
			20.52	

4	0.5	60	11.58 16.70 15.51	14.69

Table 9. Split tensile strength of concrete for cube for Different percentage of Recycled Aggregate and 0.5% of Basalt Fiber constant for 28 curing days

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average tensile strength for 28 days(mpa
1	00	00	20.60 10.05 18.03	16.22
2	0.5	20	18.15 17.85 15.36	17.12
3	0.5	40	18.28 19.17 15.43	17.62
4	0.5	60	14.31 21.28 14.95	16.84

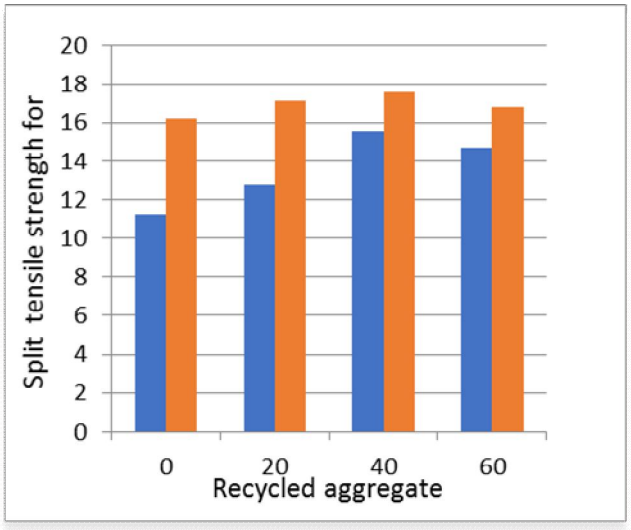

Figure 2. Graph % Replacement of recycled aggregate vs tensile strength

3. Flexural Strength:

Table 10. Flexural Strength of concrete for Different percentage of Recycled Aggregate and 0.5% of Basalt Fiber constant for 28 curing days.

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Flexural strength(mpa) for 28 days	Average Flexural Strength in N/mm^2
1	00	00	6.22 6.35 7.46	6.67
2	0.5	20	5.86 6.93 7.64	6.81
3	0.5	40	8.00 8.44 7.28	7.90
4	0.5	60	6.57 6.75 6.35	7.22

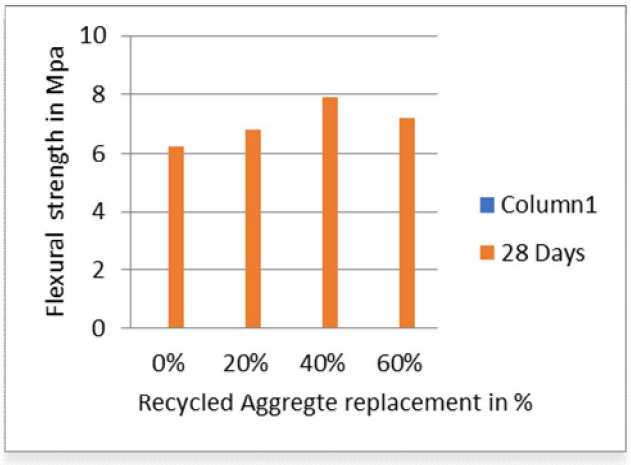

Figure 3. Graph % Replacement of recycled aggreagte vs flexural strength in mpa

4. Compressive Strength:

Table 11. Compressive strength of concrete for Different percentage of Recycled Aggregate and 1 % of Basalt Fiber constant for 7 curing days.

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average Compressive Strength in N/mm^2
1	0	00	13.23 21.18	17.58

			18.24	
2	1	20	22.17 10.67 23.56	18.80
3	1	40	18.51 26.02 24.16	22.89
4	1	60	27.56 21.35 19.62	19.62

Table 12. Compressive strength of concrete for Different percentage of Recycled Aggregate and 1% of Basalt Fiber constant for 28 curing days.

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average Compressive Strength in N/mm^2
1	0	00	32.10 15.66 28.08	25.28
2	1	20	23.97 19.70 27.30	23.65
3	1	40	24.63 33.09 28.02	28.58
4	1	60	24.13 31.18 24.16	26.49

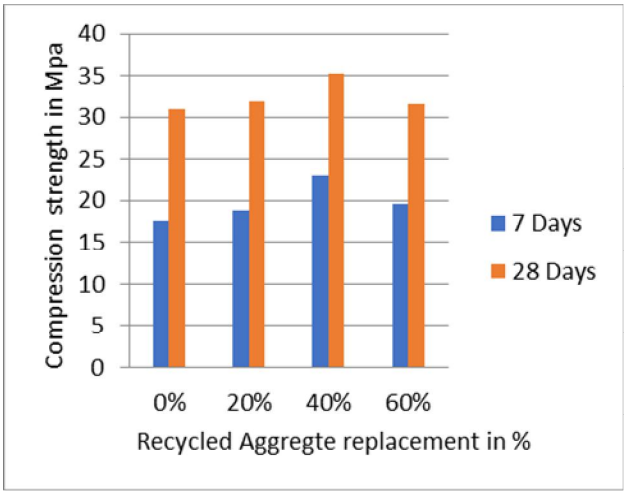

Figure 4. Graph % Replacement of recycled aggregate vs compresive strength in mpa

5. Tensile strength for cube:

Table 13. Split tensile strength of concrete for cube for Different percentage of Recycled Aggregate and 1% of Basalt Fiber constant for 7 curing days

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average tensile strength for 28 days(mpa
1	00	00	8.49 13.59 11.71	11.26
2	0.5	20	14.23 6.85 15.12	12.06
3	0.5	40	14.69 19.82 16.03	16.84
4	0.5	60	14.48 13.71 9.61	12.6

Table 14. Split tensile strength of concrete for cube for Different percentage of Recycled Aggregate and 1% of Basalt Fiber constant for 28 curing days

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Compressive strength(mpa) for 7 days	Average tensile strength for 28 days(mpa
1	00	00	20.60 10.05 18.03	16.22
2	0.5	20	15.38 12.65 17.53	15.18
3	0.5	40	15.81 21.24 17.99	18.34
4	0.5	60	15.49 20.02 15.51	17.06

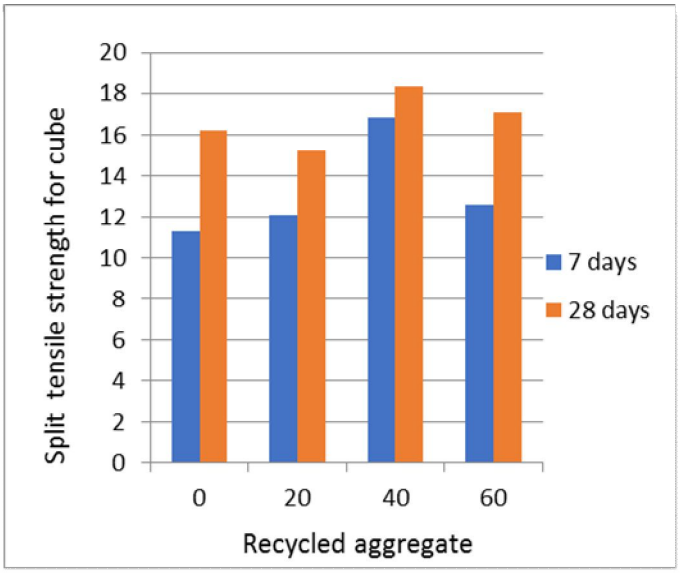

Figure 5. Graph replacement of recycled aggreagte vs tensile strength for cube in mpa

6. Flexural Strength:

Table no.-4.10: Flexural Strength of concrete for Different percentage of Recycled Aggregate and 1% of Basalt Fiber constant for 28 curing days.

Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Flexural strength(mpa) for 28 days	Average Flexural Strength in N/mm^2
1	00	00	6.22	6.67
			6.35	
			7.46	
2	0.5	20	6.93	7.40
			7.46	
			7.82	
3	0.5	40	8.00	8.02
			8.17	
			9.71	
4	0.5	60	7.11	7.09
			7.25	
			6.93	
Sr. No	Percentage of Basalt Fiber	Replacement of Coarse Agg. With Recycled Agg.	Flexural strength(mpa) for 28 days	Average Flexural Strength in N/mm^2
1	00	00	6.22	6.67
			6.35	
			7.46	
			6.93	
2	0.5	20	7.46	7.40
			7.82	
3	0.5	40	8.00	8.02
			8.17	
			9.71	
4	0.5	60	7.11	7.09
			7.25	
			6.93	

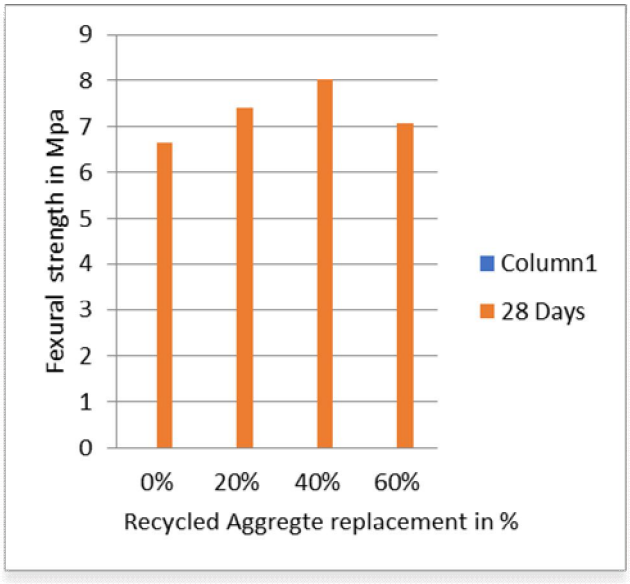

Figure 6. Graph Replacement of recycled aggregate va flexural strength in mpa

V. CONCLUSION

Experiments were performed to predict the behaviour of recycled coarse aggregate Based Basalt Fiber M25 grade of concrete. Following conclusions were drawn based on the results.

1. The recycled coarse aggregate based Basalt Fiber concrete gives higher Compressive and Flexural Strength than conventional concrete.
2. The compression test result indicates an increasing trend of compressive strength in the early age of the concrete specimens with 60% recycled aggregates. However, it shows that the strength of recycled aggregate specimens were gradually increase up to 40% replacement of recycled aggregate after 28 days. The target strength for M25 grade is 31.60MPa that are achieved for all the specimens tested in the study. The results also show that the concrete specimens with 40% replacement of recycled aggregate and 1 % Basalt Fiber get the highest strength when compared to the concrete specimens with different percentage of recycled aggregate. From the obtained

result, it is possible to use 40% recycled aggregate and 1% Basalt Fiber for higher strength of concretes.

3. The Compressive Strength is increased by 26.51% for 0.5% of basalt fibre and 30.2% for 1% of basalt fibre at 7 days and 8.62% for 0.5% of basalt fibre and 13.05% for 1% of basalt fibre at 28 days curing with the use of 40% replacement of coarse aggregate with recycled aggregate. Further increases percentage there is decreases in strength by using water cement ratio 0.46 and aggregate cement ratio 4.38
4. The flexural strength of beam is increased by 18.45% for 0.5% of basalt fibre and 20.24% for 1% of basalt fibre at 28 days curing with 40% replacement of coarse aggregate with recycled aggregate.
5. The Physical and Chemical properties of Basalt Fibre are satisfied the requirement of code provisions. The other strength and durability test conducted shows that the basalt fibre is fit to be used in concrete mix.

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