Experimental Study on Partial Replacement of Fine Aggregate with Foundry Sand and Concrete Strengthened Using Basalt Fiber

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Abstract – *Concrete is an important material which is widely used for construction purposes. Due to the increase in cost of the concrete, the construction becomes very expensive. This project is conducted to reduce the cost of concrete thereby the cost of construction can be reduced and also increase the strength and durability of concrete. This can be done by partially replacing fine aggregate using some materials which are available at low cost or no cost. In this study foundry sand is used for the partial replacement of fine aggregate. Fine aggregate is replaced at different percentage, that is 10%, 20%, 30% & 40%. After all the test we found that the compression, flexural and tensile strength of the concrete is maximum at 20% of replacement of fine aggregate. The compressive strength has increased 12.64%, split tensile strength has increased 45.64% and the flexural strength has increased 83.33% than its original strength. The strength characteristics of concrete also studied in this project by adding basalt fiber to the optimum replacement of fine aggregate (20%). While adding 2.5% of basalt fiber by the weight of the cement the compressive strength has increased 7.86%, split tensile strength increased 27.27% and the flexural strength has increased 10.44% than its original strength.*

Key Words: Foundry sand, Basalt fiber, Compressive strength test, Split tensile strength test, Flexural strength test

1. INTRODUCTION

Concrete is a material which contain of sand, cement, aggregates, water and other essential materials for the construction. Sand is one of the major material used. These sand can be partially replaced using several materials. This will helps to reduce the cost of construction and improves the strength and durability of concrete. In this study foundry sand is used for partially replacing fine aggregate. Foundry sand is available in less cost or no cost and it is a light weight fine aggregate. Foundry sand is an industrial waste which are used for metal casting. Since it is available at low cost, the cost of construction can be reduced.

To increase the strength and durability of concrete, several fibrous materials are used such as steel fiber, copper fiber, basalt fiber etc… These will helps to strengthen the concrete. In this study, after partially replacinf fine aggregate using foundry sand, basalt fiber is added to strengthen the concrete. Basalt fiber is a fiber obtained from igneous rock which are available at the earth crust. These rocks are formed by the solidification of lava present in the earth surface. These rocks are excavated, washed and melted at high temperature and turned into thin fibers. These fibers can be used to strengthen the concrete.

2. MATERIALS USED

2.1 Cement

A cement is a material used for construction which helps to bind the other materials in concrete together. It helps to set and harden. The cement used in this study is Dalmia OPC, grade 53

2.2 Water

Water is one of the main substance in concrete. This is transparent, tasteless, odorless and nearly colorless.

2.3 Sand

Sand is a mixture of small particles of rock. The size ranging of sand is from 0.06mm to 2mm. the sand used in this study is M sand. The sand is finer size than coarse aggregate and coarser than silt.

2.4 Coarse Aggregate

Coarse aggregate is crushed stones, irregular and granular material which is used for making concrete.

2.5 Foundry sand

Foundry sand is an industrial waste which is used for metal casting. These sand is finer and uniformly sized. It is used in foundry casting process and is a high quality silica sand.

2.6 Basalt fiber

Basalt fiber is obtained from igneous rock. The igneous rocks are formed by the solidification of hot molten magma. These solid magma excavated from the earth's surface, washed and melted at high temperature up to 1500°C. Then these are turned into thin fibers. These fibers maybe continuous or fragmented and can be used for strengthening concrete.

3. METHODOLOGY

Mix design is done according to IS design method and numerous trial mixes were done to get the optimum M_{35} mix. When the optimum mix is obtained the fine aggregate in the concrete is partially replaced by using foundry sand at 10%, 20%, 30% and 40%. An optimum value of replacement obtained after performing the compressive strength test, split tensile strength test and flexural strength test. The strength after 7 and 28 days curing are evaluated. To the optimum percentage replacement of fine aggregate using foundry sand, basalt fiber is added to strengthen the concrete. The percentage of addition of basalt fiber is 2%, 2.5% & 3% by the weight of cement. Tests are conducted on the specimens after 7 and 28 days of curing to obtain the optimum percentage of adding basalt fiber. The percentage of increase in strength after replace fine aggregate using foundry sand and addition of basalt is compared to the original strength of M_{35} grade concrete.

Table -1: Optimum mix preparation

Materials	Water (L)	Cement (Kg)	Coarse Aggregate (Kg)	Fine Aggregate (Kg)	Super Plasticizer (L)
Quantity of 1 m^3 of concrete	197.16	438.13	1119.85	730.50	2.5
Mix Ratio	0.45	1	2.6	1.6	0.006

4. TEST RESULTS

4.1 Tests on Concrete by Replacing FA with FS

Table -2: Details of Replaced Concrete Specimen

Percentage of Replacement (%)	Cement (Kg)	FA (Kg)	CA (Kg)	Foundry Sand (Kg)
0	18	28.8	46.8	0
10	18	25.92	46.8	2.88
20	18	23.04	46.8	5.76
30	18	20.16	46.8	8.64
40	18	17.28	46.8	11.52

4.1.1 Compressive Strength

Compressive strength test is conducted to measure the maximum amount of compressive load a material can bear before fracturing. The test is conducted on a cube of size 15×15×15 cm. the specimen is placed in the compression testing machine and gradually load is applied. The load before cracking the specimen is noted. This test is allotted as per the rule given in IS 3495-1992. The test is conducted in a Compression Testing Machine. This test is then carried out on the 7th and 28th day from the day of casting.

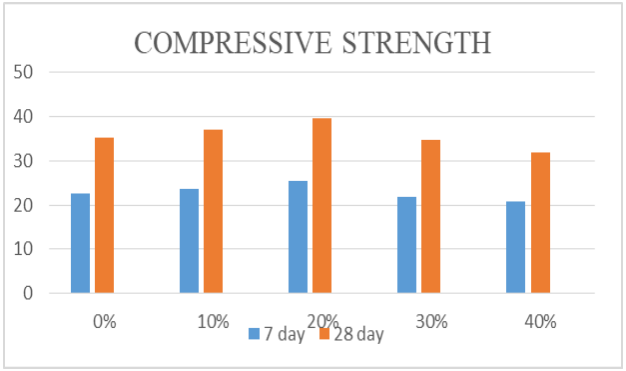
Fig-1: Compression testing Machine

Table-3: Compressive Strength Test Results

SL No.	Percentage of Replacement (%)	7 Day Test (N/mm^2)	28 Day Tests (N/mm^2)
1	0	22.67	35.11
2	10	23.55	37.11
3	**20**	**25.33**	**39.55**
4	30	21.77	34.66
5	40	20.88	32

From the results obtained, the compressive strength at the replacement of 10% and 20% the increase in strength is 5.69% and 12.64%. At the replacement of 30% and 40% the strength is decreasing 1.28% and 8.85% respectively from its original strength. From these results optimum percentage replacement of fine aggregate with waste foundry sand is **20%.** The maximum compressive strength obtained at the replacement of 20% and the percentage of increase in strength is 12.64%.

Graph-1: Compressive strength



4.1.2 Flexural Strength Test

Flexural strength test is used to measure the resistance to bending of the concrete. The test is conducted on a non reinforced concrete beam of size 50×10×10 cm after 7 and 28 day of curing.

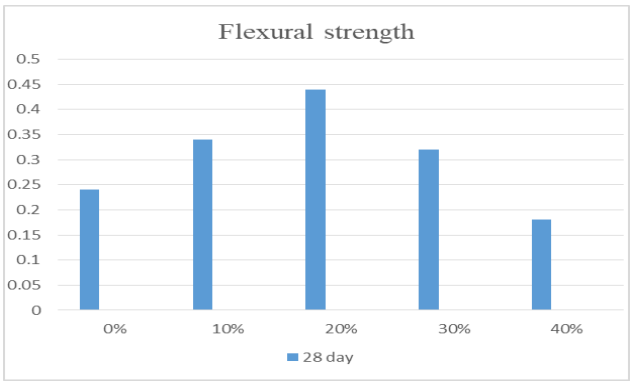
Fig 2: Flexural strength testing Machine

Table-4: Flexural Strength Test Results

SL No.	Percentage of Replacement (%)	28 Day Test (N/mm²)
1	0	0.24
2	10	0.34
3	**20**	**0.44**
4	30	0.32
5	40	0.18

From the results obtained, the flexural strength at the replacement of 10%, 20% and 30% the percentage of increase in strength is 41.66%, 83.33% and 33.33% respectively from its original strength. At the replacement of 40% the strength is decreasing 54.16%. From these results optimum percentage replacement of fine aggregate with waste foundry sand is **20%.** The maximum flexural strength obtained at the replacement of 20% and the percentage of increase in strength is 83.33%.

Graph-2: Flexural Strength



4.1.3 Split Tensile Strength Test

The split tensile strength test on concrete is conducted to measure the resistance tensile force when stress is applied. A cylindrical specimen is used for the test. The tensile strength of concrete is measured by the unit of force per cross sectional area. The most common machine used is universal testing machine.

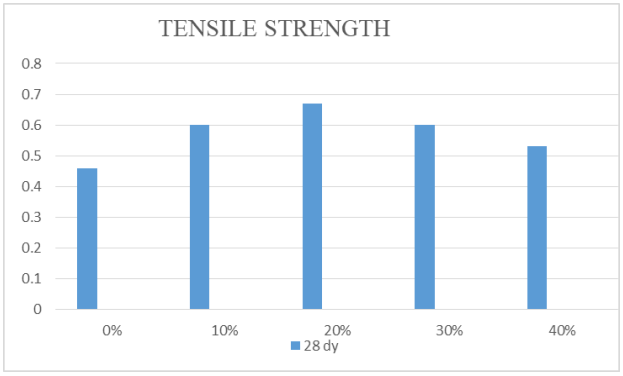
Fig 3: Split Tensile Strength Testing Machine

Table -5: Split Tensile Strength Test Results

SI No.	Percentage of Replacement (%)	28 Day Test (N/mm²)
1	0	0.46
2	10	0.60
3	**20**	**0.67**
4	30	0.60
5	40	0.53

From the results obtained, the split tensile strength at the replacement of 10%, 20%, 30% and 40% the increase in strength is 30.43%, 45.65%, 30.43% and 15.21% respectively from its original strength. From these results optimum percentage replacement of fine aggregate with waste foundry sand is **20%.** The maximum split tensile strength obtained at the replacement of 20% and the percentage of increase in strength is 45.65%.

Graph-3 : Split Tensile Strength



4.2 Tests on Concrete by Adding Basalt Fiber to the Optimum Percentage Replaced FA with FS

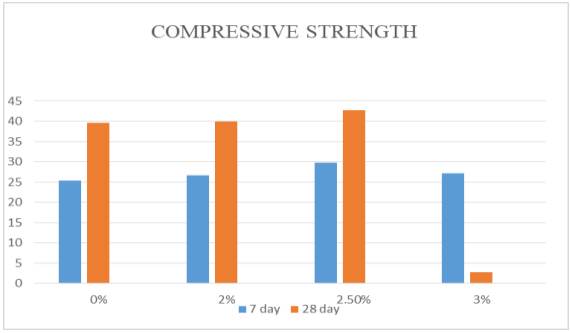
4.2.1 Compressive Strength Test

Table-6: Compressive Strength Test

SI No.	Percentage of Adding (%)	7 Day Test (N/mm²)	28 Day Test (N/mm²)
1	0	25.33	39.55
2	2	26.66	40
3	2.5	**29.77**	**42.66**
4	3	27.11	39.11

From the results obtained, the compressive strength at the addition of 2% and 2.5% the increase in strength is 1.13% and 7.86% respectively than its original strength. At the addition of 3% the split tensile strength is decreasing 1.11%. From these results optimum percentage addition of basalt fiber to the concrete by the weight of cement is **2.5%.** The maximum compressive strength obtained at the addition of 2.5% and the percentage of increase in strength is 45.65%.

Graph-4: Compressive Strength Test



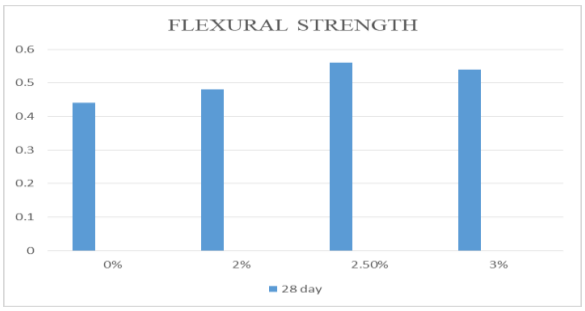
4.2.2 Flexural Strength Test

Table-7: Flexural Strength Test

SI No.	Percentage of Adding (%)	28 Day Test (N/mm²)
1	0	0.44
2	2	0.48
3	**2.5**	**0.56**
4	3	0.54

From the results obtained, the flexural strength at the addition of 2%, 2.5% and 3% the increase in strength is 9.09%, 27.27% and 22.72% respectively than its original strength. From these results the optimum percentage addition of basalt fiber to the concrete by the weight of cement is **2.5%.** The maximum flexural strength obtained at the addition of 2.5% and the percentage of increase in strength is 27.27%.

Graph-5: Flexural Strength Test



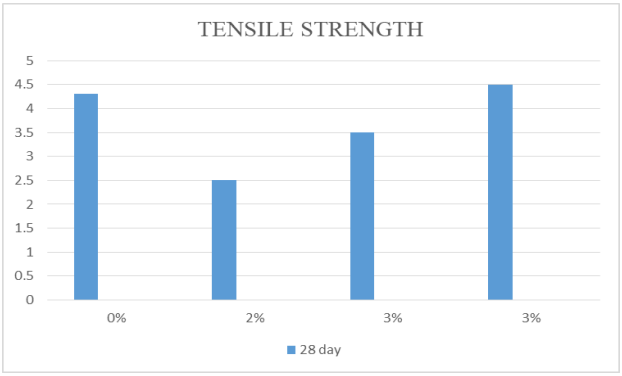
4.2.3 Split Tensile Strength Test

Table-8: Split Tensile Strength Test

SI No.	Percentage of Adding (%)	28 Day Test (N/mm²)
1	0	0.67
2	2	0.67
3	**2.5**	**0.74**
4	3	0.71

From the results obtained, the split tensile strength at the addition of 2% there is no increase in strength. At the addition of 2.5% and 3% the increase in strength is 10.44% and 5.97% respectively than its original strength. From these results optimum percentage addition of basalt fiber to the concrete by the weight of cement is **2.5%.** The maximum split tensile strength obtained at the addition of 2.5% and the percentage of increase in strength is 10.44%.

Graph-6: Split Tensile Strength Test



5. CONCLUSIONS

- In this study the mechanical properties of the concrete by partial replacement of fine aggregate with foundry sand by 10%, 20%, 30% & 40% were investigated.

- The compressive strength at 10% replacement of fine aggregate with waste foundry sand shows 5.69% of increase and at the replacement of 20%, the percentage of increase is 12.64%.The compressive strength of 30% and 40% replacement shows 1.28% and 8.85% of decrease than its original strength. So as per compressive strength test, the optimum percentage replacement obtained for compressive strength test is 20%.

- The Flexural strength at 10%, 20% and 30% replacement of fine aggregate with waste foundry sand shows 41.66%, 83.33% and 33.33% of increase in strength respectively. At 40 % replacement shows 54.16% decrease in strength than its original strength. So as per flexural strength test, the optimum percentage replacement obtained for flexural strength test is 20%.

- The Split tensile strength at 10%, 20%, 30% and 40% replacement of fine aggregate with waste foundry sand shows 30.43%, 45.65%, 30.43% and 15.21% of increase in strength than its original strength respectively. So as per Split tensile strength test, the optimum percentage replacement obtained for split tensile strength test is 20%.

- The strength characteristics of concrete also studied in this project by adding basalt fiber to the optimum replacement of FA using WFS(20%).

- The compressive strength at the addition of 2% and 2.5% of basalt fiber by the weight of cement shows 1.13% and 7.86% of increase in strength than its original strength. At the addition of 3%, the strength is decreasing 1.11% than the original strength. So the optimum percentage addition of basalt fiber obtained for compressive strength test is 2.5%.

- The Flexural strength at the addition of 2%, 2.5% and 3% of basalt fiber by the weight of cement shows 9.09%, 27.27% and 22.72% of increase in strength than its original strength. So the optimum percentage addition of basalt fiber obtained for flexural strength test is 2.5%.

- The Split tensile strength at the addition of 2%, 2.5% and 3% of basalt fiber by the weight of cement shows 0%, 10.44% and 5.92% of increase in strength than its original strength. So the optimum percentage addition of basalt fiber obtained for split tensile strength test is 2.5%.

- From the results the optimum percentage replacement of fine aggregate with waste foundry sand and strengthening of concrete using 2.5% of basalt fiber by the weight of cement shows 21.50% of increase in strength than its original strength on M35 mix.

- The addition of basalt fiber improves the mechanical properties.

- Basalt fiber increases durability and reduces workability of concrete.

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