Experimental Examination on Mechanical Properties of Polypropylene Fiber Blended Concrete as Partial Replacement of Sand as Stone Quarry Dust

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Abstract: Concrete is recognized as a quite breakable material when exposed to impact loading and normal stresses. Concrete tensile strength is nearly one-tenth of its compressive strength. As a result of which concrete members are not able to support such stresses and loads which mainly occurs in most concrete structures. So, we mainly reinforce it with such materials which help it to increase its tensile and flexural strength. Fibers are the material which helps to increase the toughness and durability of concrete and reduce plastic and drying shrinkage. As we know cement, sand and aggregate are three basic construction materials. Due to the huge demand for these materials, their deposits are scarce. So, we need to find the material which can replace them partially and fully. Stone quarry dust is material that may be used to replace sand partially and fully. In this study, the casting of moulds for various percentage of stone quarry dust (5%, 10%, 20%, 30%, 40%, and 50%) is carried and maximum value for stone quarry dust is obtained. After obtaining the max value of stone quarry dust at 10% it is replaced with various percentages of polypropylene fiber (0%, 0.1%, 0.2% and 0.3%). This study aims to investigate the limit up to which stone quarry can be replaced with sand for M35 grade of concrete and to investigate the combined effect of stone quarry dust (10%) and polypropylene fiber with varying percentage (0%, 0.1%, 0.2%, and 0.3%).

Keywords: Conventional concrete; Admixtures; Stone quarry dust and Polypropylene fiber.

I. IINTRODUCTION

Concrete is one of the most adaptable structural materials in the construction industry because it is economical in nature. It tends to be cast to fit any basic shape from a round hollow water storing tank to a rectangular bar or section in a tall structure. The benefits of concrete are having high compressive strength, great resistance to fire, water-resistant, and long service life. Concrete also comes with some of its disadvantages like weak in tensile strength, curing time is high to regain its desired strength and tends to crack. When crack or pores occur in concrete then air and moisture get enter and water gets seep which tends to corrosion in the reinforcement of the structure which leads to a decrease in the service life of the structure.

Fiber Reinforced Concrete can be characterized as a composite material comprising blends of cement, sand, aggregate and irregular, discrete, uniformly oriented and randomly scattered fibers. As we know concrete is brittle in nature, the insertion of fibers in concrete helps us to improve the tensile strength, toughness, and durability of concrete, decrease cracking and reduce plastic and drying shrinkage. Fibers also help us to modify and increase the mechanical properties of concrete. When we add fibers in concrete, we must ensure that each fiber gets cement coating. Fibers can be round and flat in shapes. Polypropylene fibers were introduced to the textile arena in the 1970s and now polypropylene has become one of an important member of quickly developing synthetic fibers. Today polypropylene fiber has the fourth greatest volume after the three fibers, i.e. acrylic, polyester, and polyamide. Polypropylene fiber has many advantages in concrete such as it doesn't react with acids, a high melting point (upto165°C), water requirement is nil, can be used to increase tensile strength.

As we know construction is increasing at a very fast rate all over the world which leads to the deficiency of construction materials. Sand is a conventional material used in the construction industry as a fine aggregate. The huge demand for sand makes river sand deposits very costly and scarce. So, we need to find the materials which can replace sand partially and fully. Stone quarry dust is the material which may be used as partial and full replacement of sand. In this study, we are studying the possibility of replacing the locally accessible stone quarry dust without sacrificing the workability and strength of concrete. The resources need to be used in control to improve environmental footprints. Here we are trying to deal with a large amount of waste generated in the form of quarry dust. The advantages of using stone quarry dust help to protect the environment, cost-effective, easily accessible, and can be effectively used as a replacement of sand.

II. MATERIALS

To accomplish the objectives of research program, a test examination has been completed on stone quarry dust in varying percentages (5%, 10%, 20%, 30%, 40%, and 50%). Beams, cylinders and cubes have been casted with varying percentages of fibers (0%, 0.1%, 0.2%, and 0.3%) keeping stone quarry dust 10% fix.

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A. Cement

Cement is the binding material of concrete when we combine cement with water as the process of hydration it turns into hard mass and helps to make bond between materials. OPC-43 grade of cement was used for this study. Locally available cement OPC-43 grade conforming to IS 8112-1989 was used for investigation.

Table 1Properties of cement

S.NO.	Description	Results
1	Specific gravity of cement	3.3
2	Normal consistency of cement	30.5%
3	Fineness of cement	2.27
4	Initial setting time	28 minutes
5	Final setting time	232 minutes
6	Compressive strength	42.78

B. Fine Aggregates

Fine aggregates are used to fill the voids in coarse aggregate and it also work as workability agent. Locally available sand is used for this study, tests on sands are performed as per recommendations given by IS 383-1970.

Table 2Properties of Fine Aggregates

S.NO.	Description	Results
1	Fineness modules	3.22
2	Specific gravity	2.61
3	Grade zone	2

C. Coarse Aggregates

Aggregate in concrete is basic filler, yet its job is a higher importance than what that basic explanation infers. Aggregate possesses the greater part of the concrete volume. The arrangement, shape, and size of the aggregate all have huge effect on the shrinkage of concrete, strength, durability, workability, weight. Tests performed on coarse aggregates are as per recommendations given by IS 383-1970.

Table 3Properties of Coarse Aggregates

S.NO.	Description	Results
1	Fineness modules	8.09
2	Specific gravity	2.64

D. Stone quarry dust

Stone quarry dust is by product left during crushing process of boulders into small pieces. Stone quarry dust can be used as fine aggregates and its color is grey.

Table 4Properties of Stone Quarry Dust

S.NO.	Description	Results
1	Fineness modules	2.41
2	Specific gravity	2.57

E. Polypropylene Fibers

Polypropylene is the synthetic fiber which is commonly used to reinforce to improve its toughness, durability, plastic and drying shrinkage and help to reduce the crack areas. Polypropylene fiber is to be added by weight of cement.

Table 5Properties of Polypropylene fiber

S.No.	Description	Results
1	Length(mm)	6 and 12
2	Diameter(mm)	0.078
3	Aspect ratio(l/d)	76.2 and 153.84
4	Melting point	162˚C
5	Specific gravity	0.91
6	Moisture content	0%

F. Water

Cement solidifies as a result of hydration which is unimaginable without water. Water also gives workability to concrete. Drinkable water is used for mixing and curing. IS456-2000 specifications have been used for this study.

G. Super Plasticizer

Superplasticizer is used to reduce the amount of water in concrete and addition of superplasticizer do not affect the strength properties of concrete. In this study 1% of superplasticizer is used by weight of cement. In this study TamCem 60R superplasticizer is used.

Table 6Properties of Super Plasticizer

S.NO.	Description	Result
1	Form	Liquid
2	Colour	Thick brown
3	Density (g/cm^3)	1.07±0.02
4	Solid content (%)	27.00±1.30
5	Ph	5.0±1.0
6	Chloride content	< 0.1

III. EXPERIMENTAL PROGRAM

To carry out this experimental program 3 cubes, 3 cylinders, 3 beams has been casted for 7, 28 for stone quarry dust in various percentage of replacement (5%, 10%, 20%, 30%, 40%, and 50%) with sand. Maximum strength is found in 10% of replacement. After keeping stone quarry dust constant at 10% it is being replaced with various percentage of polypropylene fiber (0%, 0.1%, 0.2%, and 0.3%) for 7, 28 and 56 days.

ID NO.	DETAIL OF MIX (Ratio)					%age of S.Q.D	%age of PP	W/C ratio	%age of plasticizer
	Cement	Sand	S.Q.D.	Coarse aggregates	Poly propylene				
RTAOO	1	1.6	0	2.92	0	0	0	.38	1
RTAO.5	1	1.52	0.08	2.92	0	5	0	.38	1
RTA01	1	1.44	0.16	2.92	0	10	0	.38	1
RTA02	1	1.28	0.32	2.92	0	20	0	.38	1
RTAO3	1	1.12	0.48	2.92	0	30	0	.38	1
RTA04	1	0.96	0.64	2.92	0	40	0	.38	1
RTA05	1	0.8	0.8	2.92	0	50	0	.38	1
RSP10	1	1.44	0.16	2.92	0	10	0	.38	1
RSP11	1	1.44	0.16	2.92	0.001	10	.1	.38	1
RSP12	1	1.44	0.16	2.92	0.002	10	.2	.38	1
RSP13	1	1.44	0.16	2.92	0.003	10	.3	.38	1

IV. TESTING DETAILS

The tests carried out are summarized as below

- Compressive strength
- Split tensile strength
- Flexural strength

Compressive Strength Test

In concrete, the compression strength test is a very significant factor as it helps to decide other factors like flexure and tension. So, it's very necessary to perform the test carefully on a predetermined testing machine. For compression strength test the dimension of moulds used are 150×150×150. The castings of cubes were done as per mix design. The casting of cubes for various percentages of stone quarry dust (5%, 10%, 20%, 30%, 40%, and 50%) was carried out for 7 and 28 days to determine the maximum value of stone quarry dust. The casting of cube combining stone quarry dust (10%) and polypropylene fiber (0%, 0.1%, 0.2%, and 0.3%) were carried out for 7, 28 and 56 days. After the removal of specimens from the curing tank, they were cleaned and dried. The compression machine surface was cleaned and the specimen was positioned at the center of the compression machine and the load was applied without shocks, uniformly and continuously, the compression tests were performed on the CTM machine. The compression strength is determined by using formula

$$\text{Compressive strength} = \frac{P}{A}\ \text{N/mm}^2$$

P = Compression load
A = cross section area of cube

Split Tensile Strength Test

In concrete, the split tensile strength is one of the significant and basic properties which affect the size and extent of cracking in structure. For studying the effect of split tensile strength, the cylinders of 150×300mm were cast as per mix design. The casting of the cylinder for various percentages of stone quarry dust (5%, 10%, 20%, 30%, 40%, and 50%) was taken place for 7 and 28 days to determine the maximum value of stone quarry dust. The casting of cylinders combining stone quarry dust (10%) and polypropylene fiber (0%, 0.1%, 0.2% and 0.3%) are carried out for 7, 28 and 56 days. The test of split tensile strength is carried out in the CTM machine along its diameter plane. Failure occurs along the load plane in the cylinders. The load applied along the diameter plane is uniform, continuous and without shocks. The split tensile is determined by using formula

$$\text{Split tensile strength} = \frac{2P}{\pi DL}\ \text{N/mm}^2$$

P = Maximum load applied shown by testing machine
D = Diameter of Specimen
L = Length of Specimen

Flexural Strength Test

The flexural strength test is performed to evaluate the tensile strength of the unreinforced concrete beam indirectly. In flexural members, reinforcement is provided to take the tension, yet it is necessary to have knowledge of the unreinforced concrete beam to determine the first crack load. As we know when cracks occur in structure it allows environment agents to penetrate it which leads to corrosion in reinforcement. For studying the effect of flexural strength in the unreinforced beam, beams of 100×100×500mm beams were cast as per mix design. The casting of beams for various percentages of stone quarry dust (5%, 10%, 20%, 30%, 40%, and 50%) are taken place for 7 and 28 days to determine the maximum value of stone quarry dust. The casting of beams combining stone quarry dust (10%) and polypropylene fiber (0%, 0.1%, 0.2% and 0.3%) are carried out for 7, 28, and 56 days. The flexural strength is determined by using formula

$$\text{Flexural strength} = \frac{PL}{BD^2}\ \text{N/mm}^2$$

P = ultimate load applied shown by testing machine
L = length of span
B = width of specimen
D = depth of specimen

V. GRAPHS

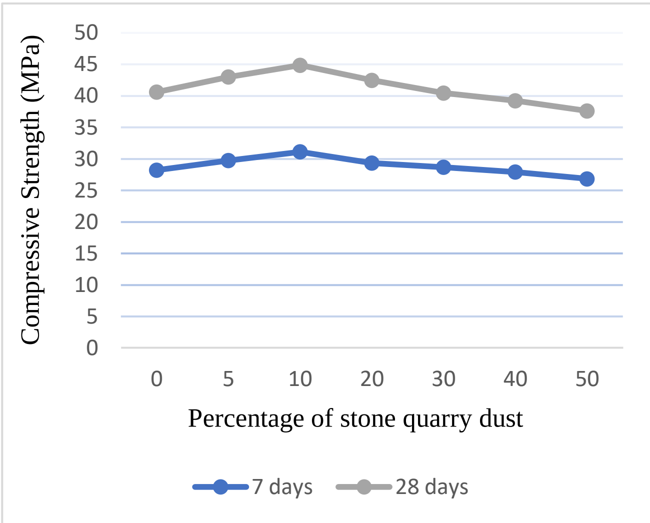

Figure 1Graphical Representation of Compressive Strength

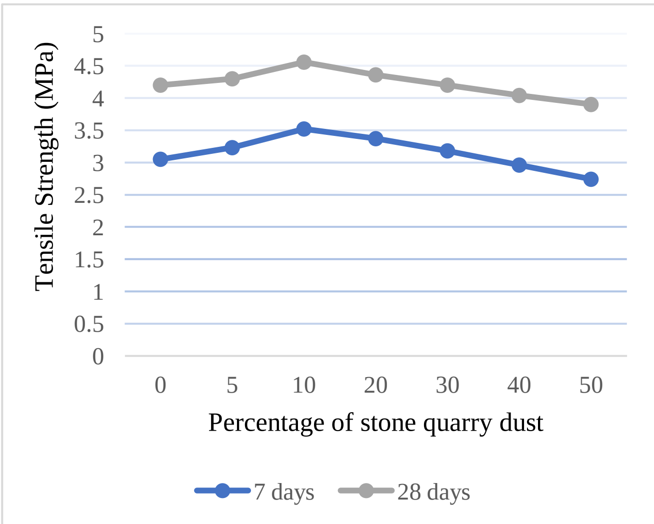

Figure 2Graphical Representation of Split Tensile Strength

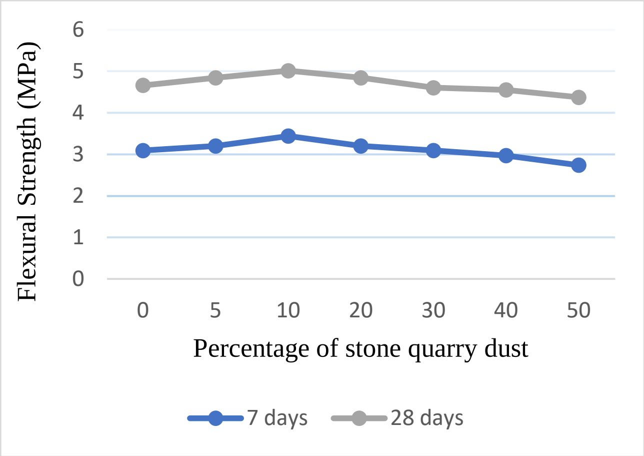

Figure 3Graphical Representation of Flexural Strength

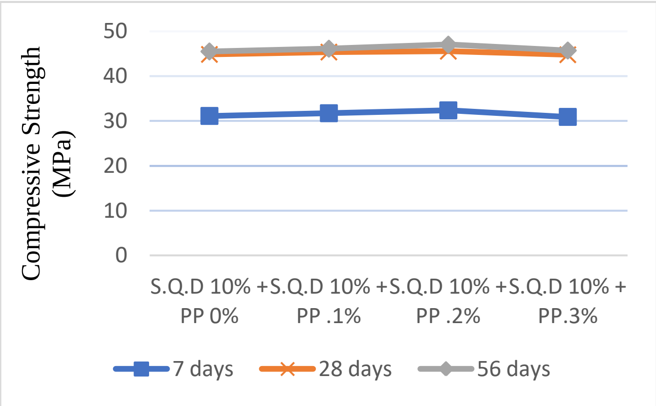

Figure 4Graphical Representation of Compressive Strength

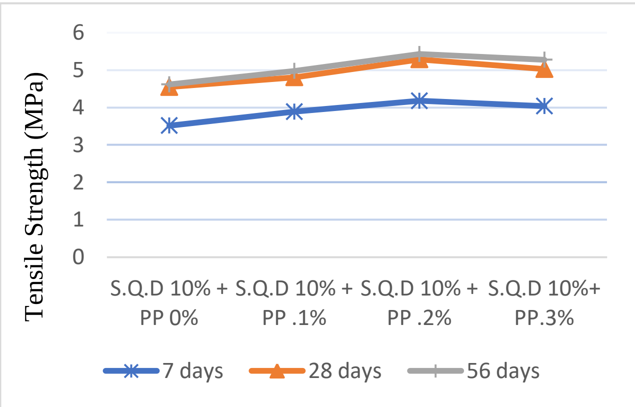

Figure 5Graphical Representation of Split Tensile Strength

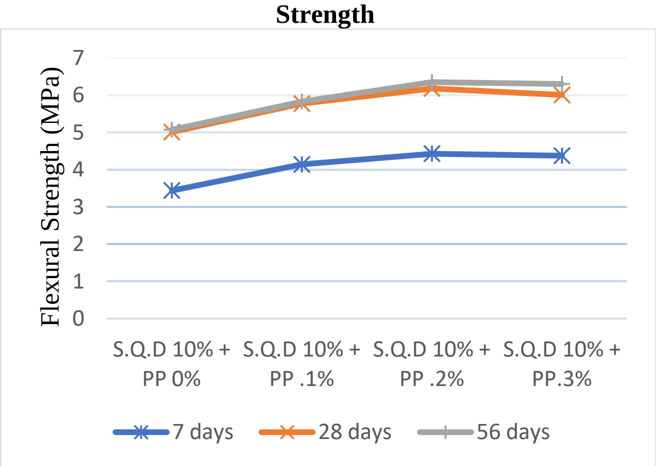

Figure 6Graphical Representation of Flexural Strength

VI. RESULT AND DISCUSSION

It has been noted that increasing the stone quarry dust content decreases the workability of concrete. An increase in the content of stone quarry dust water permeability of concrete decreases. The stone quarry can be replaced successively up to 50%. Increasing the content of stone quarry dust shows a gradual decrease in strength properties. It has been noted that increasing the fiber content there is not much increase in the compressive strength of concrete and show good increase in tensile and flexural strength of concrete.

VII. CONCLUSIONS

1. The slump value gets decreased as the stone quarry dust percentage get increased.
2. The compressive strength of concrete is increased most up to 10% replacement of stone quarry dust. Exceeding the stone quarry dust than 10% the compressive strength decreases gradually.
3. The split tensile strength of concrete is increased most up to 10% replacement of stone quarry dust. However, increasing the stone quarry dust more than 10% it shows the gradual decrease in split tensile strength.
4. The flexural strength of concrete increased most up to 10% replacement of stone quarry dust. Increasing the stone quarry dust more than 10% shows a gradual decrease in flexural strength.
5. Adding 0.1%, 0.2 and 0.3% polypropylene fiber there is very slight increase in compressive strength with respect to stone quarry dust at 10% replacement.
6. The addition of polypropylene fiber 0.1%, 0.2% and 0.3% increase the split tensile strength of concrete. For 0.1% there is an increase shown up to 7.79% and for 0.2% the increase is shown up to 17.53% and for 0.3% increase is 14.28% with respect to stone quarry dust at 10% replacement.
7. The addition of polypropylene fiber 0.1%, 0.2% and 0.3% increases the flexural strength of concrete. For 0.1% the increase is noted up to 14.75 and for 0.2% increase is shown up to 25.12% and for 0.3% the increase is 19.86% with respect to stone quarry dust at 10% replacement.

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