Influence of Stone Quarry Dust and Jute Fibre on the Mechanical Properties of Concrete

Rohit Kotla, Vijay Kumar

Abstract-In the present era, concrete is one of the extensively used construction materials. Enormous efforts are made to improve the tensile strength of concrete due to its weakness in tension. In this paper, an attempt is made to enhance the tensile strength of concrete by introducing jute fiber in concrete. Waste from the crushing plants is used as a replacement of fine aggregates to achieve good compressive strength and jute fiber is added to enhance tensile strength. The length of the jute fiber used is 25mm and the percentage taken was 0.25%, 0.5% and 0.75% of the volume of concrete. Stone quarry dust is replaced as 10%, 20%, 30% and 40% of the weight of fine aggregates. The compressive test split tensile test and the flexural test is performed at 7, 14 and 28 days by casting cubes, cylinders, and beams for the respective tests. Experimental test under a controlled environment revealed that stone quarry dust raised 13% compressive strength at 28 days and jute fiber raised 21.15% tensile strength at 28 days. Further investigation is carried out by introducing both stone quarry dust and jute fiber into the concrete and optimal results are discussed. Final test exposed that amalgamation of jute fiber and stone quarry dust imposed a positive impact on compressive, split tensile and flexural strength of concrete.

Keywords: Jute fiber, Stone quarry dust, compressive strength, split tensile strength, flexural strength.

I. INTRODUCTION

Concrete is a versatile material in the construction field, which is used in the construction of buildings, bridges, dams, and roads. Due to its strength and durable properties, it became a long-lasting material. Cement is the binding material that has adhesive and cohesive properties with these properties it binds the other ingredients of concrete. Fine aggregate is a material which reduces the shrinkage of concrete and fill the voids present in between coarse aggregate. Coarse aggregate is a material that makes the concrete stronger and denser, water is used to mix all the ingredients of concrete. Water should be free from harmful contaminants of salts, alkalis, acids and organic materials and should have a pH value greater than 6.0. Generally, gaps present in between the coarse aggregate are filled with fine aggregate and fine gaps present in between the fine aggregate are filled by cement particles or other finer material by this the structure becomes durable.

The usage of concrete is more than steel, wood, aluminium, and plastic combined. Concrete is little different from mortar, concrete is used to build heavy structures.

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It can be molded into any desired shapes such as domes, vaults, and arches. We can make different types of blocks that are used for construction using concrete. There are different types of concrete available such as polymer concrete, asphalt concrete, pervious concrete, nano concrete, prestressed concrete, high-performance concrete, self-compacting concrete. Reinforced cement concrete and Plain cement concrete are mostly used for the construction purpose. Many different types of admixtures are also used for making concrete such as fly ash and gypsum. The strength of the concrete also depends upon the ratio of water-cement which is called as the water-cement ratio. Jute fiber is the largest produced fiber in the South Asian countries like India and Bangladesh. Jute fiber can be used in different fields such as textile Industries, construction fields and many more. The name Jute is derived from the plant used to make burlap. Jute contains plant materials such as cellulose and lignin. The specific properties of Jute fiber have been compared with many different fibers such as glass fiber and many different fibers. Jute fiber is 100% bio-degradable and thus it is environmentally friendly too. The jute fiber has a golden color and it is also known as Golden fiber. India is the largest producer of jute in the world. Jute fiber is used for making many different things such as clothes, bags and many other types of textile products. In the ancient times, the jute has been traded in a very large amount. India is the largest producer of jute in the world. The jute is a very strong and durable fiber it can be used in the place of many synthetic fibers. Past work revealed that performance of concrete with addition of jute fiber leads to upsurge in performance of concrete at 0.5% [1], 0.4% [2], 0.6% [3], 0.5% [4], 0.2% [5], and 0.5% [6] addition of jute fiber into the concrete. Stone quarry dust is the outcome of the stones in the crushing plants. In the places where a large number of stones are present there the quarrying of stones is done, that is the stones are been cut into different sizes and shapes. This is generally a waste product which is generated in the form of dust. We can use this dust in the form of fine aggregate in the concrete mix. The stone quarry dust has good compressive strength, the Stone quarry dust mainly consist of Silicon dioxide (SiO_2). We can use this stone quarry dust in different types of construction works such as construction of buildings, bridges, roads, etc. The main advantage of using stone quarry dust is, as it is economical than the normal sand and the easy availability of the stone quarry dust.

The use of stone quarry dust reduces the overall cost of construction. The stone quarry dust is finer than the normal Sand. Thus, attempts are going on the replacement of stone quarry dust as fine aggregate in concrete. Contrasting on the literature work there is an ample amount of work regarding stone quarry dust on the replacement with fine aggregates [7] [8] [9] and Jute fiber [1] [10] as an addition in the concrete.

Destructive tests on concrete as a replacement of fine aggregates with stone quarry dust revealed that there is an upsurge of compressive resilience by 6.7% [11], 10.56% [12], 22% [13], 22.76% [14], on the other hand, the tensile resiliency hiked by 7.78% [12], 13.47% [14]. The optimal percentages of stone quarry dust as per literature is at 30% [12], 40% [13,15] and 50% [14].

II. MATERIALS AND METHODOLOGY

2.1 Materials

Cement is the binding material that is used to bind the coarse aggregate and fine aggregate in the concrete. Cement used in the mix is conforming to IS 8112:2003[16]. The properties of the cement used in the experimental analysis is mentioned in Table 1.

Table 1 Properties 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 of cement	28 minutes
5	Final setting time of cement	620 minutes
6	Compressive strength	42.78

Fine aggregates are generally the materials that are used in the mortar and concrete mix. These fine aggregates can easily pass through 4.75 mm sieve. The fineness modulus of fine aggregates is 3.2 and has a 2.61 specific gravity of grade II. There are different types of fine aggregate available at different places depending upon the locality of the areas. Fine aggregate is a very important material in the concrete mix. Coarse aggregates selected for the experimental analysis having specific gravity 2.64 and 8.09 fineness modulus retaining on 4.75mm sieve. To achieve required workability and slump Tamcem 60R as a superplasticizer used in the experimental work. The corresponding properties of superplasticizer are shown in Table 2. The fine aggregates and coarse aggregates are conforming to IS 383:2016 [17] and the required admixture is conforming to IS 9103:1999 [18].

Table 2 Properties of Superplasticizer

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±1
6	Chloride content	<0.1

The Jute fiber is very strong and durable, it is used in the textile industries. The Jute is also used for making gunny bags and clothes. The density of the jute fiber used in the experimental analysis is 1.3 g/cm^3 with elongation of 1.5% to 1.8%. The tensile strength of jute fiber is 393-773 MPa and 26.5 GPa of Young modulus. Stone quarry dust is generally the outcome of the stones in the crushing plants. When the stones are crushed in the crushing plants then the dust is released which is generally a waste, this waste dust is called Stone quarry dust. Stone quarry dust is generally used as a replacement for the fine aggregate. The fineness modulus and specific gravity of stone quarry dust is 2.41 and 2.57. The nominal concrete cast is of grade M40. Later-on, stone quarry dust is replaced at the different percentages with fine aggregates and standard cubes, cylinders and beams are cast to investigate variation in compression, tensile, and flexural nature of concrete and testing at 7, 14 and 28 days is conducted. Similarly, jute fiber is added at a percentage of 0.25%, 0.5% and 0.75% of the volume of cement and similar testing is conducted. The optimum percentage of stone quarry dust was found at 10%. Further, after investigation of the sole performance of concrete with jute fiber and stone quarry dust at 0.5% and 10% respectively. Recasting of cubes, cylinders, and beams is carried out at mentioned optimal values to study the behavior of concrete when amalgamated with jute fiber and stone quarry dust. The casting of samples in accordance with

Table **3**

Table 3 Experimental data conforming to IS 10262:2019 [19] and IS 456:2000 [20]

Description	Cement	Sand	Stone quarry dust	Coarse aggregates	Jute fiber	W/C ratio	Percentage of jute fiber	Percentage of stone quarry dust	Percentage of plasticizer
NOMINAL	1	1.47	0	2.83	0	0.36	0	0	1
10% S.Q,D	1	1.323	0.147	2.83	0	0.36	0	10	1
20% S.Q.D	1	1.176	0.294	2.83	0	0.36	0	20	1
30% S.Q.D	1	1.029	0.441	2.83	0	0.36	0	30	1
40% S.Q.D	1	0.882	0.588	2.83	0	0.36	0	40	1
0.25% JUTE FIBER	1	1.323	0.147	2.83	0.01325	0.36	0.25	10	1
0.5% JUTE FIBER	1	1.323	0.147	2.83	0.0265	0.36	0.5	10	1
0.75% JUTE FIBER	1	1.323	0.147	2.83	0.03975	0.36	0.75	10	1

2.2 Casting and testing of samples

Compression testing is performed in the compression testing machine available in the laboratory.

For the compression test, initially, nominal cubes of size 150 mm×150 mm×150 mm of grade M40 with no replacement shown in Figure 1 is cast and tested to obtain benchmark values for comparative analysis. Similarly, the concrete cylinders of diameter 150 mm and of length 300 mm are used for the split tensile strength test shown in

Figure **2** and the specimen of size 100 mm×100 mm×500 mm depicted in Figure 3 is used to determine the flexural strength of nominal concrete. Furthermore, fine aggregates are replaced with stone quarry dust at 10%, 20%, 30%, and 40% respectively and jute fiber is added to the concrete by volume of cement at 0.25%, 0.5%, and 0.75%. The mix proportion and design are all by IS 10262:2019 [19] and IS 456:2016 [20]. The Compression, tensile and Flexural testing of the concrete specimens is done at the 7, 14 and 28 days respectively as accordance with IS 516:1959 [21] and IS 5816:1999 [22]

III. RESULTS

Sufficient Experimental test revealed that on replacement of 10% stone quarry dust Figure 4 shows optimal value. Contrasting Figure 4 it is noticed that there is an increment of 13% compressive strength in 10% as compared to a nominal mix. Similarly comparing 10% replacement with 20%, 30% and 40% replacement of stone quarry dust, 10% replacement enhances compressive strength by 10.41%, 6.46%, and 4.42% respectively.

Figure 1 Casted Cubes

Figure 2 Casted Cylinders

Figure 3 Casted Beams

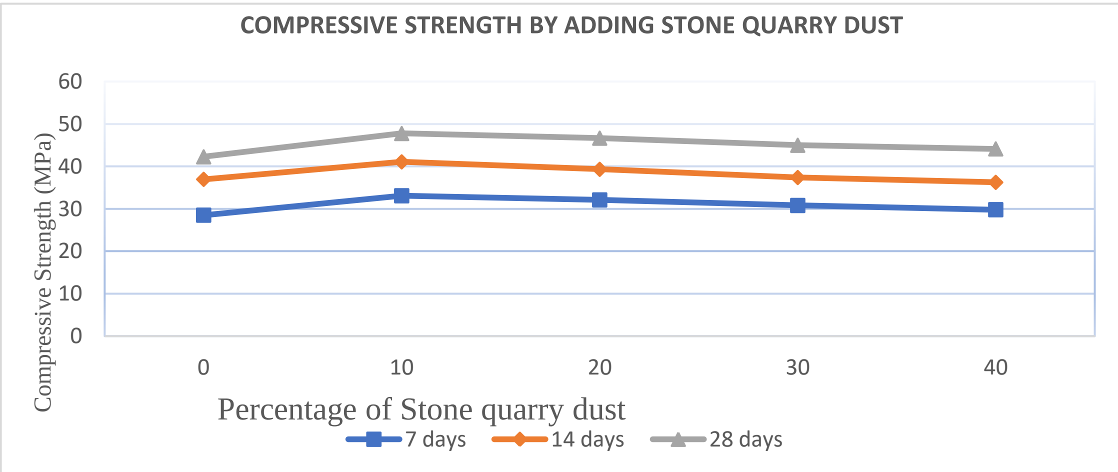

Figure 4 Compressive strength by adding stone quarry dust

The split tensile strength has found its optimal value at 10% replacement of stone quarry dust with fine aggregate as represented in Figure 5. Sufficient Experimental test revealed that on replacement of 10% stone quarry dust Figure 5 shows optimal value. Contrasting Figure 5 it is noticed that there is an increment of 9.57 % split tensile strength in 10% as compared to the nominal mix. Similarly comparing 10% replacement with 20%, 30%, and 40% replacement of stone quarry dust, 10% replacement enhances split tensile strength by 4.67%, 2%, and 0.22% respectively.

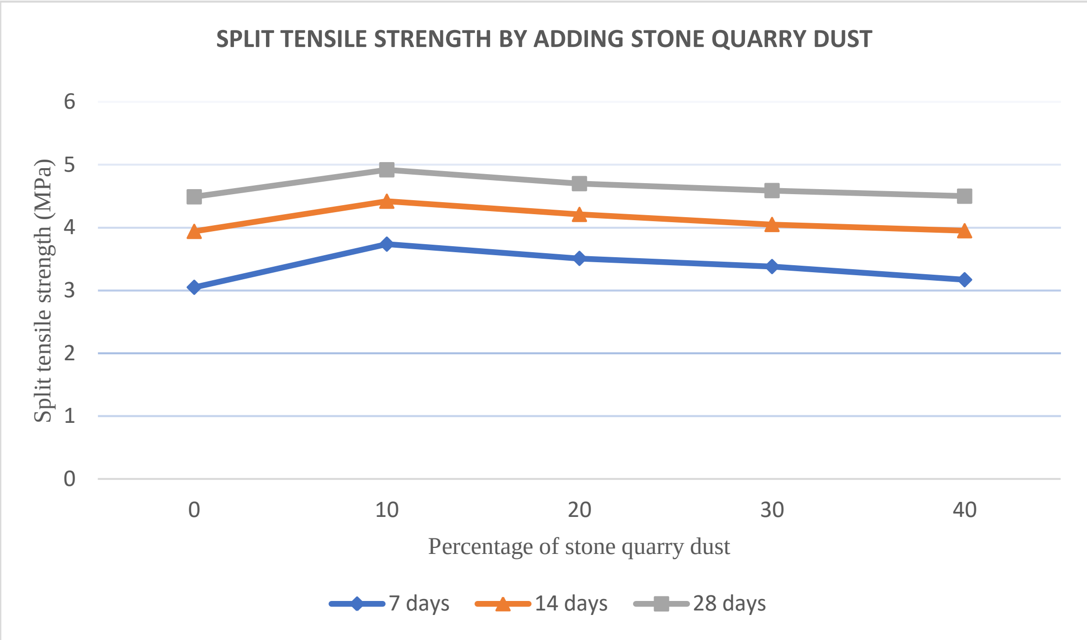

Figure 5 Split tensile strength by adding stone quarry dust

Flexural strength has found its optimal value at 10% replacement of stone quarry dust with fine aggregate shown in Figure 6. Sufficient Experimental test revealed that on replacement of 10% stone quarry dust Figure 6 shows optimal value. Contrasting Figure 6 it is noticed that there is an increment of 9.16% flexural strength in 10% as compared to the nominal mix. Similarly comparing 10% replacement with 20%, 30%, and 40% replacement of stone quarry dust, 10% replacement enhances flexural strength by 5.65%, 4.48%, and 0.1% respectively.

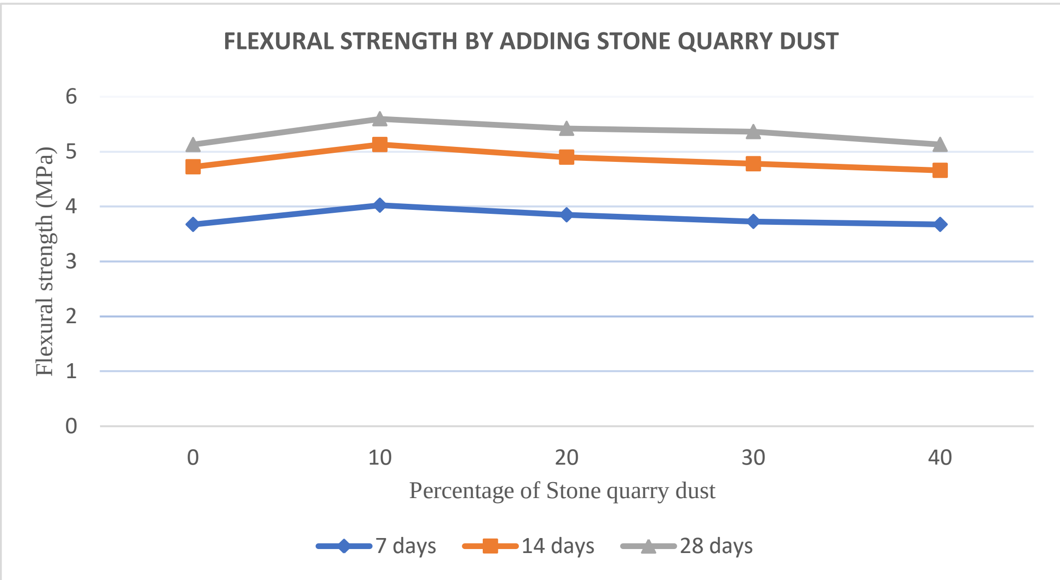

Figure 6 Flexural strength by adding stone quarry dust

The compressive strength was found maximum at 10% replacement of stone quarry dust and the addition of 0.5% of jute fiber by the volume of concrete depicted in Figure 7. Sufficient Experimental test revealed that on replacement of 10% stone quarry dust and the addition of 0.5% jute fiber by volume of concrete Figure 7 shows optimal value. Contrasting Figure 7 it is noticed that there is an increment of 18.14% of compressive strength by replacement of 10% of stone quarry dust and addition of 0.5% of jute fiber as compared to the nominal mix. Similarly comparing 10% replacement of stone quarry dust with fine aggregate and addition of jute fiber by 0.25% enhances compressive strength by 15.45%, 11.92% respectively.

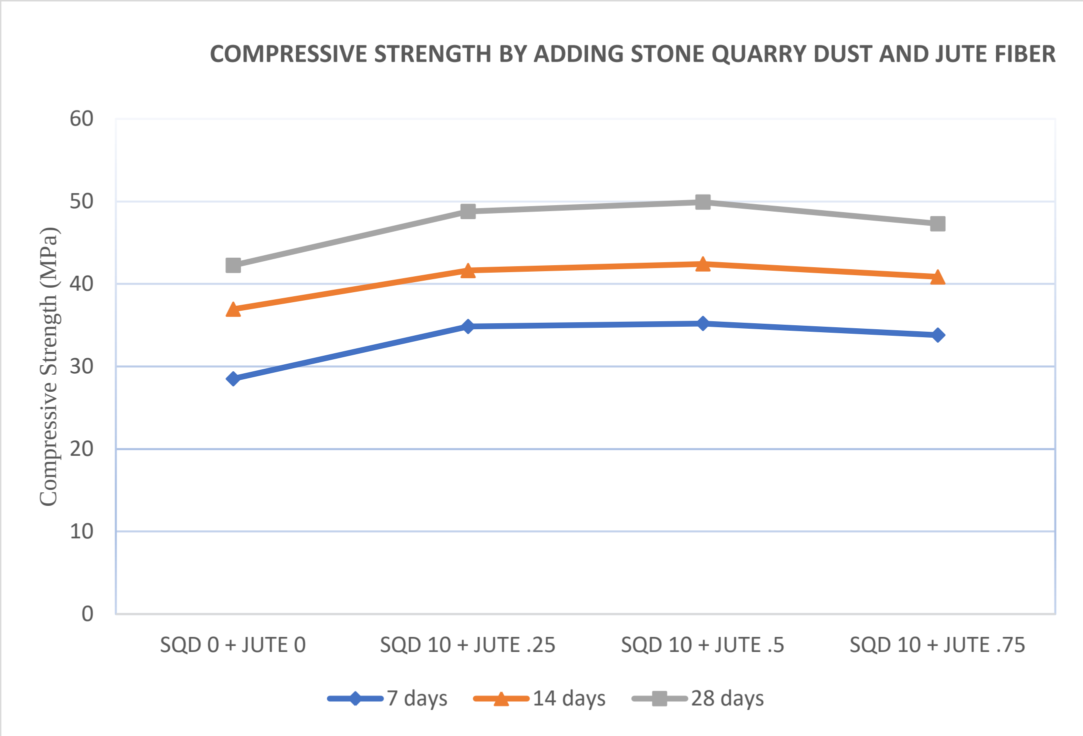

Figure 7 Compressive strength by adding stone quarry dust

The split tensile strength was found maximum at 10% replacement of stone quarry dust and the addition of 0.5% of jute fiber by the volume of concrete depicted in Figure 8.

Sufficient Experimental test revealed that on replacement of 10% stone quarry dust and the addition of 0.5% jute fiber by volume of concrete Figure 8 shows optimal value.

Contrasting Figure 8 it is noticed that there is an increment of 21.15% of split tensile strength by replacement of 10% of stone quarry dust and addition of 0.5% of jute fiber as compared to the nominal mix.

Similarly comparing 10% replacement of stone quarry dust with fine aggregate and addition of jute fiber by 0.25% enhances split tensile strength by 15.81%, 15.59% respectively.

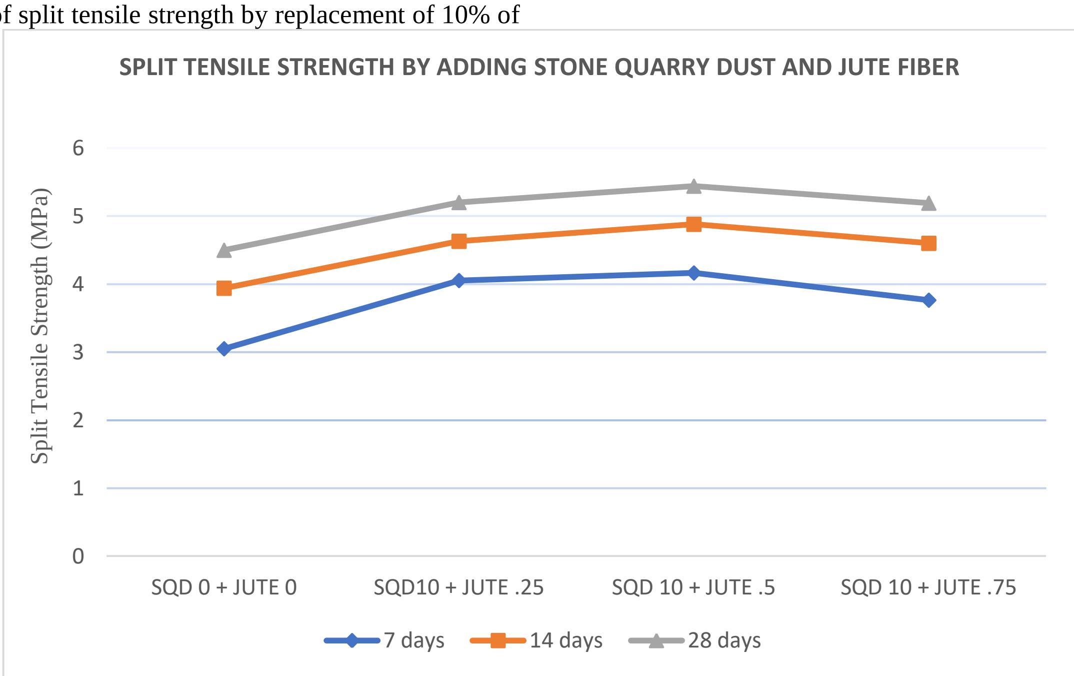

Figure 8 Split tensile strength by adding stone quarry dust and Jute fiber

The Flexural strength was found maximum at 10% replacement of stone quarry dust and the addition of 0.5% of jute fiber by the volume of concrete depicted in Figure 9. Sufficient Experimental test revealed that on replacement of 10% stone quarry dust and the addition of 0.5% jute fiber by volume of concrete Figure 9 shows optimal value. Contrasting Figure 9, it is noticed that there is an increment of 23.78% of flexural strength by replacement of 10% of stone quarry dust and addition of 0.5% of jute fiber as compared to the nominal mix. Similarly comparing 10% replacement of stone quarry dust with fine aggregate and .5% of jute fiber with 0.25% and 0.75%, 0.5% addition of jute fiber enhances flexural strength by 18.12% and 12.47% respectively.

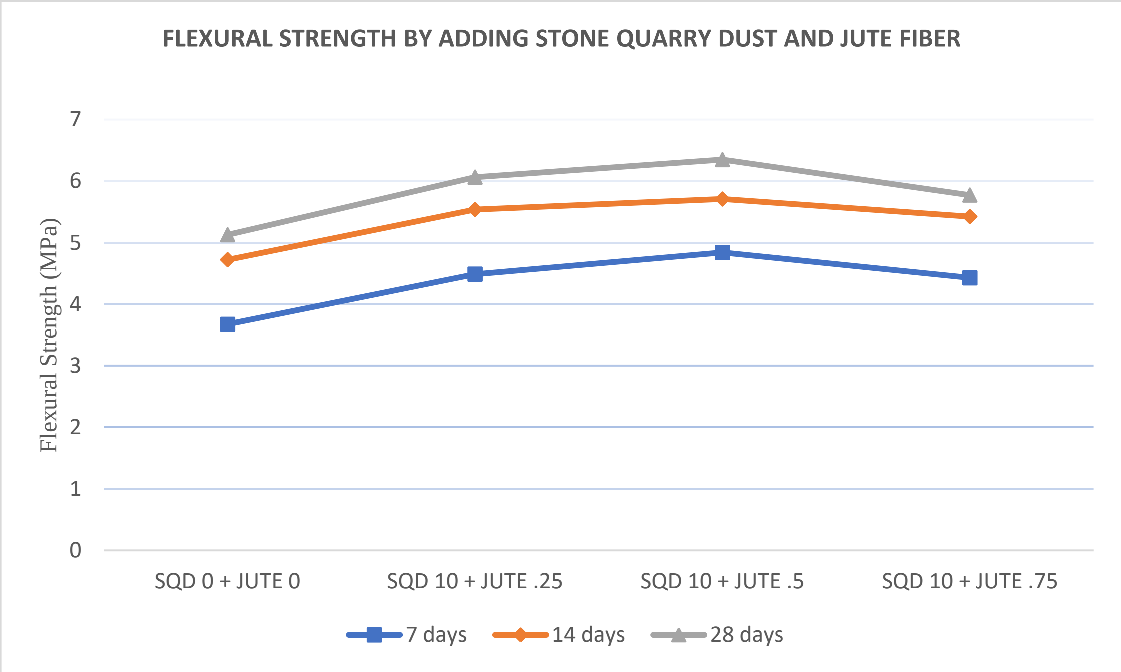

Figure 9 Flexural strength by adding stone quarry dust and Jute fiber

IV. CONCLUSIONS

- By replacing stone quarry dust by 10%, 20%, 30% and 40% it has been founded that the maximum increase in compression strength is shown in 10% replacement of sand with stone quarry dust after that there is a gradual decrease in compression strength of concrete.
- The maximum increase in split tensile strength is shown by 10% replacement of sand with stone quarry dust after that there is a gradual decrease in the split strength of concrete.
- By replacing the stone quarry dust by 10%, 20%, 30% and 40% it has been founded that the maximum increase in flexural strength is shown in 10% replacement of sand with stone quarry dust.
- By the addition of jute fiber with different percentages of 0.25%, 0.50% and 0.75% respectively by volume of concrete and replacement of stone quarry dust by 10% of fine aggregate it has been found that there is the increase in compressive strength by 15.45%, 18.14% and 11.92% respectively for normal concrete.
- By the addition of jute fiber (0.25%, 0.50%, and 0.75%) by volume of concrete and replacement of stone quarry dust (10%) by the fine aggregate, it has been found that there is 15.81% increase in split tensile strength by 0.25% replacement of jute fiber, 0.5% replacement show 21.15% increase in split tensile strength and 0.75% replacement show 15.59% increase in split tensile strength concerning normal concrete.
- The addition of 0.25% of jute fiber and 10% replacement of stone quarry dust showed an increase of 18.12% in flexural strength of the concrete, whereas addition of 0.5% and 0.75% with 10% replacement of sand by stone quarry dust showed an increase of flexural strength by 23.78% and 12.47% respectively concerning normal concrete.

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