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The Mechanical Properties of Steel Fibre Reinforced Concrete with Quarry Dust as a Partial Replacement of Fine Aggregate

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Abstract: ***This present work is an attempt to use Quarry Dust as partial replacement for Sand in concrete along with the steel fibres. Attempts have been made to study the properties of concrete and to investigate some properties of Quarry Dust reinforced with steel fibres; this article presents the compressive and split tensile strengths of Crimped steel fibre reinforced concrete with Quarry dust. In the experimental work natural Sand was replaced by Quarry dust in the proportion of 50% and 100%. The Crimped steel fibres (CSF) were used in the concrete by 1 and 1.5% volume fraction. After conduction of experiments on the cube and cylinder specimens, the results showed that, the incorporation of Crimped steel fibre reinforced concrete with 50% Quarry dust for M20 grade of concrete increases the mechanical properties of concrete.***
Keywords: Crimped steel fibre, quarry dust, compressive strength, split tensile strength, slump and compaction factor test.

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. In the last fifty years, there has been significant progress in concrete technology, the concrete without any fibre will develop the cracks due to plastic shrinkage, drying shrinkage and other reasons of changes in volume of concrete. the development of these micro-cracks causes elastic deformation of concrete. Plain concrete is a brittle material and having the values of modulus of rapture and strain capacity is low. The addition of fibres in the plain concrete will control the cracking due to shrinkage and also reduce the bleeding of water. Fibres help to improve the post peak ductility performance, pre crack tensile strength, fatigue strength, impact strength and eliminate temperature. Now a day's river erosion and other environmental issues have led to the scarcity of river sand So that excess river erosion is prevented and high strength concrete is obtained at lower cost. One such material is Quarry stone dust, Quarry dust is a sand replacing material by-product obtained during quarrying process. In concrete production quarry dust could be used as a partial or full replacement of natural sand. Besides, the utilization of quarry waste, which itself is a waste material, will reduce the cost of concrete production

II. LITERATURE REVIEW

A. Several Experimental work has to be Conducted on Steel Fibre reinforced conCrete some of Them are Given beLow

1) *Hanumesh B.M et. al. (2016),:* in his experimental shows that the compressive and split tensile strength of concrete increases and workability decreases with increase in the percentage of steel fibres
2) *Nitin Kumar et al (2015),: in* his study the addition of 1% 2% and 3% crimped steel fibres to the concrete with w/c ratio 0.35 and M40 grade of concrete shows increase strength toughness ductility and flexural strength of concret
3) *Elson John et. al. (2014),:* in his experimental study the addition of 0.5% and 1.0% crimped steel fibres to the concrete shows more compressive and split tensile strength than plain concrete
4) *Vikrant Vairagade et. al. (2012), :* "experimental investigation on mechanical properties of steel fibre reinforced concrete" with addition of 0% and 0.5% steel fibres it observed that for addition of 0.5% fibres shows slightly more compressive and tensile strength than normal concrete

Several experimental work has to be conducted on replacement of natural sand with quarry dust some of them given below

5) *P. Jagadeesh et. al. (2016), :* in his study he was partial replace the quarry dust with 20%,30%,40% and 50%, finally he was concluded that 50% replacement of sand with quarry dust shows an improvement in the compressive strength of the concrete.

6) *Ms. P. Sri Lakshmi Sai Teja et. al. (2013),* - partial Replacement of Sand with Quarry Dust in Concrete" shows an improved in the compressive strength of the concrete by replacing the sand with 50% of quarry dust
7) *Closure:* From the literature review it is observed that no work has been carried out on crimped steel fibre reinforced concrete with quarry dust as a partial replacement of fine aggregate. We are conducted the experiment on steel fibre reinforced concrete with quarry dust as a partial replacement of fine aggregate

III. OBJECTIVES OF THE STUDY

A. The Following are The Main Objectives of the Study

1) To find the effect of the addition of crimped steel fibre to the concrete with quarry dust as partial replacement of fine aggregate
2) To evaluate fresh properties of conventional concrete of M20 grade and concrete made with 1% and 1.5% addition of crimped steel fibre by volume of mould and quarry dust as a partially replacement of fine aggregate. For fresh properties, slump cone test and compaction factor tests are conducted.
3) To find out the compressive strength and split tensile strength of concrete made with 1% and 1.5% addition of crimped steel fibre by volume of mould with and without quarry dust at 28 days of curing.
4) To evaluate the optimum dosage of crimped steel fibre and quarry dust for M20 grade of concrete to increase the mechanical properties of concrete.
5) Comparison between reference/control concrete and concrete with crimped Steel fibre and quarry dust.

IV. MATERIALS

A. Cement

In this experimental work, Ordinary Portland Cement (OPC) 43 grade conform to IS: 8112-1989 was used for casting cubes and cylinders for all concrete mixes. The specific gravity of cement was noticed as 3.1. The initial and final setting time was 30min and 510min respectively. The compressive strength of cement was found 46.28MPa at 28days.

B. Natural Sand

Locally available river sand confirming to zone II of IS 383-1970 was used for the project work. The specific gravity of sand was observed as 2.64. The sieve analysis results are as shown in Fig 1.

C. Quarry Dust

In concrete production quarry dust could be used as a partial or full replacement of natural sand obtained during quarrying process. The specific gravity of quarry dust was observed as 2.86. the typical properties and particle size distribution of quarry dust and natural sand as shown in Table 1 and Fig 1 respectively.

Table 1
The typical chemical properties of quarry dust and natural sand (Ref: P.Jagadeesh et.al)

Constituents	Quarry Dust (%)	Natural Sand (%)	Test method
SiO2	62.48	80.78	IS 4032-1968
Al2O3	18.72	10.52	
Fe2O3	6.54	1.75	
CaO	4.83	3.21	
MgO	2.56	0.77	
Na2O	Nil	1.37	
K2O	3.18	1.23	
TiO2	1.21	Nil	
Loss of ignition	0.48	0.37	

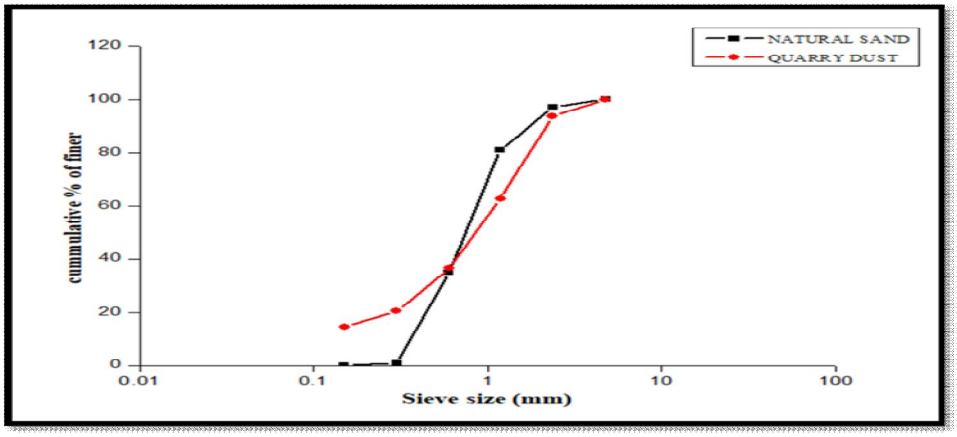

Fig 1 The particle size distribution of natural sand and quarry dust

D. Coarse aggregate

Crushed natural granite aggregate from local crusher has been used and which has maximum size of 20 mm. The specific gravity of coarse aggregate was observed as 2.78.

E. Crimped steel fibre

It is a one of the most commonly used fibre. In this project round crimped steel fibres are used. The diameter is 1mm. and length will be 50mm. crimped steel fibres are likely to get rusted and lose some of its strengths. But investigations have shown that the rusting of the fibres take place only at the surface. The physical properties of crimped steel fibre as shown in Table 2, and Fig 2 shows the types of steel fibres.

Table 2
Physical properties of crimped steel fibres (Ref: Elson john et al)

S.NO	Property	Description
1	Equivalent dia (mm)	1.0
2	Specific gravity (kg/m^3)	7850
3	Tensile strength (Mpa)	1100
4	Young's Modulus (Gpa)	200
5	Ultimate elongation (%)	4-10
6	Thermal conductivity (1%)	2.74
7	Aspect ratio	50

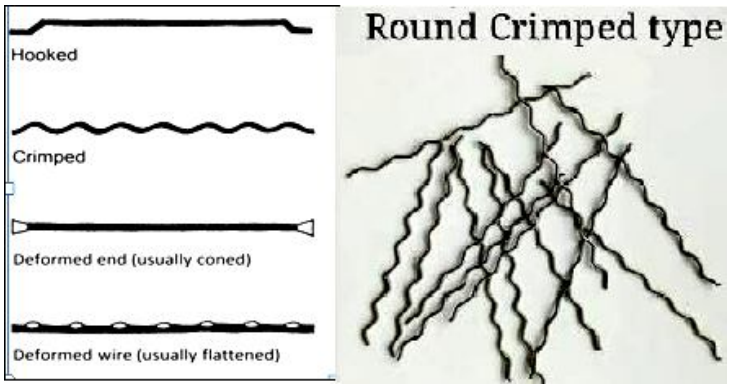

Fig. 2 Types of steel fibres

F. Water

Locally available portable water is used for making concrete and curing specimens.

V. MIX-DESIGN AND CASTING

The cubes of inner dimensions 150x150x150 mm were cast to find out the compression strength of mixes. To evaluate the split tensile strength, cylinders of 150 mm diameter with 300 mm height were cast. The various trial mixes are done to observe 100 mm slump by changing w/c ratio, the 100mm slump was observed at 0.53 w/c ratio, the mixes are designed for M20 grade concrete. Here in the IS code procedure was adopted with target strength as 26.6 N/mm^2 . the obtained mix proportion as shown in Table 3, and mix-description as shown in Table 4

All materials were weighed as per mix design separately. The cement, natural sand, coarse aggregate, quarry dust and crimped steel fibre were dry mixed in pan mixer thoroughly till uniform mix is achieved. Required quantity of water is added to the dry mix. The fresh concrete was placed in the mould and the compaction was adopted by mechanical vibrator. The specimens were removed from moulds after 24 h and placed in water tank for 28 days curing. After a period of 28 days the specimens were taken out and allowed to dry under shade, later the specimens are allowed for testing.

Table 3
Mix proportion

W/C Ratio	Water (kg/m^3)	Cement (kg/m3)	FA (kg/m3)	CA (kg/m3)	Mix Ratio (C:FA:CA)
0.53	234.08	372	678.43	1154.13	1:1.82:3.10

Table 4
Mix descriptions

Mix designation	Descriptions
M0	Conventional concrete of grade M20
M1	1% of Crimped steel fibre
M2	1.5% Crimped steel fibre
M3	50% quarry dust
M4	50% quarry dust and 1% of Crimped steel fibre
M5	50% quarry dust and 1.5% of Crimped steel fibre
M6	100% quarry dust
M7	100% quarry dust and 1% of Crimped steel fibre
M8	100% quarry dust and 1.5% of Crimped steel fibre

VI. EXPERRIMENTAL RESULTS

A. Study on fresh Properties of Crimped steel Fibre Reinforced Concrete With Quarry Dust.

The concrete mixes were prepared based on the mix proportions of Table 4, workability of all mixes were observed in terms of slump and compaction factor. These results are reported in Table 5. And variation in slump for different mixes as shown in Fig 3

Table 5
Workability Properties of Concrete

Mix Designation	Slump in mm	Compaction factor
M0	110	0.9
M1	103	0.88
M2	95	0.86
M3	96	0.92
M4	90	0.90
M5	86	0.89
M6	89	0.88
M7	83	0.87
M8	78	0.84

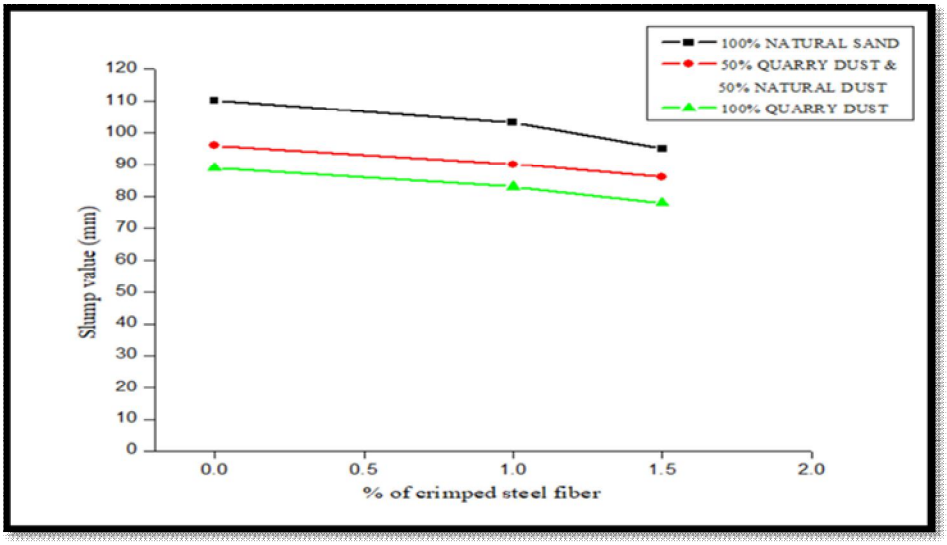

Fig 3 variation in slump for different mixes

B. Study on Strength Properties of Crimped Steel Fibre Reinforced Concrete with Quarry dust (Compressive Strength Test)

The cubes and cylinders were tested as per IS 516-1959 and IS 5816-1999 to obtain compressive and split tensile strengths respectively. The specimen was tested with manual operated compression testing machine of capacity 1000kN. The tested specimens can be viewed in figure 4, The compressive strength test results are shown in Table 6 and in Fig 5.

Fig 4 Testing of cube and cylinder specimens in CTM

Table 6
Compressive Strength and Split tensile Strength at 28 Days

Mix Designation	Compressive strength (N/mm^2)	Split tensile strength (N/mm^2)
M0	21.94	9.43
M1	23.22	11.47
M2	25.28	12.38
M3	23.10	11.28
M4	25.86	12.10
M5	27.64	13.31
M6	19.62	8.88
M7	20.05	10.35
M8	20.78	11.09

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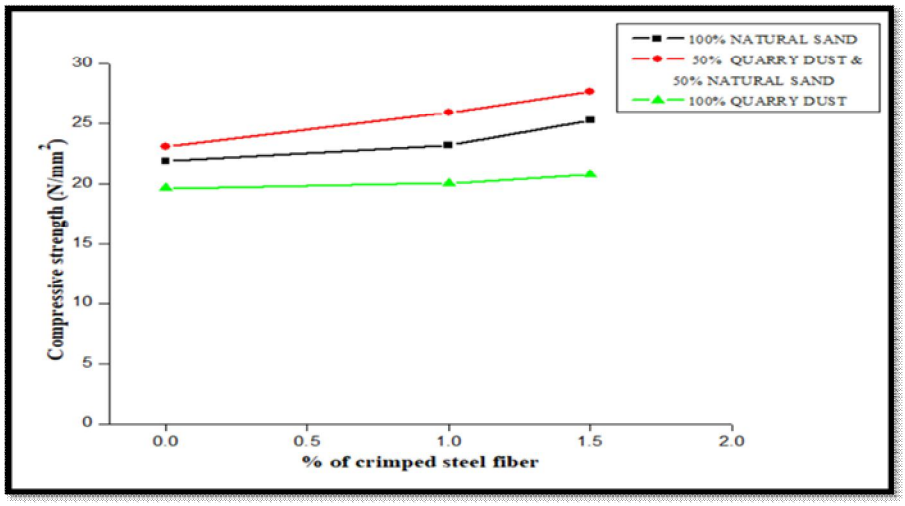

Fig 5 Compressive strength result for 28days curing period

C. Split Tensile Strength Test

For each concrete mix, the split tensile strength is determined on three150mm diameter and 300mm height cylinders at 28 days of curing. Following Table 6 and Fig 6 give the split tensile strength test results of conventional concrete and steel fibre reinforced concrete with quarry dust.

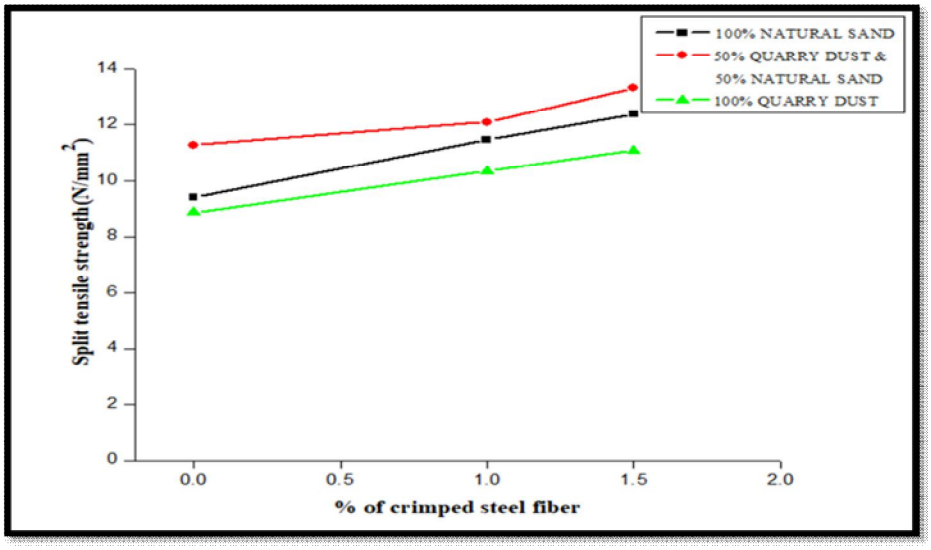

Fig 6 Split Tensile strength result for 28days curing period

VII. OBSERVATIONS AND DISCUSSIONS

A. From the experimental results and graphs the following observations are made

1) The slump of reference mix M0 is 110mm. As the percentage of fibre is increased in the mix the slump value still decreased. Further when the natural sand is replaced with quarry dust decrease in the value of slump can be observed.

2) The compaction factor of reference mix M0 is 0.9. As the percentage of fibre is increased in the mix the compaction factor values decreased. Further when the natural sand is replaced with quarry dust, compaction factor values got increased.

3) The compressive strength of concrete mix with only natural sand as fine aggregate without addition of crimped steel fibres is 21.94 N/mm2. The compressive strength of the concrete mix with addition of 1% and 1.5% crimped steel fibres with only natural sand is increased by 5.83% and 15.22% respectively.

4) The compressive strength of concrete mix with 50% natural sand and 50% quarry dust without addition of crimped steel fibres is 23.10 N/mm2. The compressive strength of concrete mix with 50% natural sand and 50% quarry dust addition with 1% and 1.5% of crimped steel fibres is increased by 11.94% and 19.65% respectively.

5) The compressive strength of concrete mix with only quarry dust as fine aggregate without addition of crimped steel fibres is 19.62 N/mm2. The compressive strength of the concrete mix with addition of 1% and 1.5% crimped steel fibres with only quarry dust is decrease by 2.91% and 5.91% respectively.

6) The Split tensile strength of concrete mix with only natural sand as fine aggregate without addition of crimped steel fibres is 9.43 N/mm2. The Split tensile strength of the concrete mix with addition of 1% and 1.5% crimped steel fibres with only natural sand is increased by 21.63% and 31.28% respectively.

7) The Split tensile strength of concrete mix with 50% natural sand and 50% quarry dust without addition of crimped steel fibres is 11.28 N/mm2. The Split tensile strength of concrete mix with 50% natural sand and 50% quarry dust addition with 1% and 1.5% of crimped steel fibres is increased by 28.31% and 41.14% respectively.

8) The Split tensile strength of concrete mix with only quarry dust as fine aggregate without addition of crimped steel fibres is 8.88 N/mm2. The Split tensile strength of the concrete mix with addition of 1% and 1.5% crimped steel fibres with only quarry dust is decrease by 9.65% and 17.6% respectively.

VIII. CONCLUSIONS

A. Use of quarry dust partial replacement of sand decreases the slump value. Hence decreasing the workability of the concrete. Also as the fibre volume in the concrete increases, the workability in the concrete decreases.

B. As the quarry dust content in the concrete increased up to 50% increase in the compressive strength is observed. Further increasing in the quarry dust content beyond 50% as replacement for natural sand compressive strength of concrete decreases.

C. As the percentage of the steel fibre in the concrete is increased compressive strength is also increased.

D. As the quarry dust content in the concrete increased up to 50% increase in the split tensile strength is observed. Further increasing in the quarry dust content beyond 50% as replacement for natural sand split tensile strength of concrete decreases.

E. As the percentage of the steel fibre in the concrete is increased split tensile is also increased.

F. From the studies it is observed that, as the natural sand is replaced with quarry dust, increase in the values of compressive strength and split tensile strength can be observed only up to 50% replacement. 50% is the optimum dosage of quarry dust for natural sand.

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