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Use of Steel Fiber in Rigid Pavement

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ABSTRACT

This paper deals with Experimental investigation for M-20 grade of concrete to study the compressive strength, and tensile strength of steel fiber reinforced concrete (SFRC) containing fibers of 0.4% and 0.5% volume fraction of Crimped Steel fibers of 50 aspect ratio were used. A result data obtained has been analyzed and compared to each other. A relationship between Compressive strength vs. days, and flexural strength vs. days represented graphically. Result data clearly shows percentage increase in 7 and 28 days Compressive strength and Tensile strength for M-20 Grade of Concrete.

KEYWORDS: Steel Fiber, Compressive strength, flexural strength.

INTRODUCTION

As per IRC:SP:46–1997[1] steel fibres are generally 30–50 mm long, 0.5–1.0 mm in diameter and 50 to 100 mm aspect ratio. According to Gopalaratnam (1991)[2] for a given type of fibre, a higher volume fraction provides more energy absorption capacity or toughness as long as the fibres can properly be mixed and the composite can be cast and compacted properly. This result should be expected because more fibres provide more resistance, especially in the tension zone. For the given fibre geometry, longer fibres typically provide greater toughness. Balasubramanian et al. (1996) [3] have investigated the impact resistance of the specimens with 0.5%, 1.0%, 1.5%, and 2.0% for each of the three types of steel fibres (viz. straight, crimped and trough shaped) using Schrader's test Device. Addition of 0.5% of steel fibres resulted in 3.5 times increase in the number of blows required for failure. Further increase in fibre percentage increases the impact resistance of composites. Crimped fibres give consistently higher impact resistance.

N.Banthia(2002)[4] examines the two major issues related to impact loading on plain and fiber reinforced concrete. It was found that the machine parameters strongly influence the observed material response to impact. Results appear to be far less sensitive to the mass of the hammer than to the hammer drop height. Crimped polypropylene fiber is less effective than

Steel fiber at quasi state of loading but at higher stress rates, it performs better than steel fibre. Ravishankar (2006)[5] investigated the mix design aspects of steel fibre reinforced concrete and concluded that there is an increase of 42% in modulus of rupture due to addition of fibres in plain concrete. K.Shankar [6] investigated that the addition of scrap steel fibre beyond 1.5% decreases the flexural strength of the FRC.

OBJECTIV

The main objectives of this study are:

- To investigate the use of steel fiber in rigid pavement.
- Check out Flexural Strength of beams with flexural testing machine.
- Check out compressive strength of mixes with compression test carried out on cubes
- To find out the cost effective cross section of the pavement.

EXPERIMENTAL PROGRAMME MATERIAL USED

- In this experimental study, Cement, sand, coarse aggregate, water and steel fibers were used.
- Cement: Ordinary Portland cement of 53 grades was used.
- Sand: Locally available sand zone II with specific gravity 2.45, water absorption 2% and fineness modulus 2.92.
- Water: Potable water was used for the experimentation.
- Steel Fibers:-crimped steel fiber, 25 mm length and 0.5 mm Diameter (A/R 50).
- Concrete for M20 grade were prepared as per I.S.10262:2009 with w/c 0.5.Mix proportion for M20 grade concrete for tested material as follows:

Table 1: Concrete mix proportions

Material	Quantity
Cement	383 Kg/m^3
Sand	672 Kg/m^3
Coarse aggregate	1100 kg/m^3
Water	192 kg/m^3
Steel fiber	0.4 & 0.5 by volume of concrete
Slump	75-100 mm

SPECIMEN

The compression and flexural strength of the cube and beam specimens are tested respectively. From the experiment results optimum dosage of steel fiber used to get the maximum compressive as well as flexural strength is found out. No. of cubes (150 mm x 150 mm x 150 mm) prepared for Compression test = 12 No. of beam specimen (500 mm x 100 mm x 100 mm) prepared for Flexure test = 12.

EXPERIMENTAL RESULTS

1) Compressive Strength Test:

The compressive strength test is consider the most suitable method of evaluating the behavior of steel fiber reinforced concrete for underground construction at an early age, because in many cases such as in tunnels, steel fiber reinforced concrete is mainly subjected to compression [7] Results of Compressive strength for M-20 grade of concrete on cube specimen with 0.4% and 0.5% steel fibers for aspect ratio 50 is shown in table and graph below:

Table2: Results of Compressive strength using cubes specimen

Days	Average Compressive strength(N/mm^2)	
	0.4 %	0.5 %
7	23.15	25.57
28	32.83	34.18

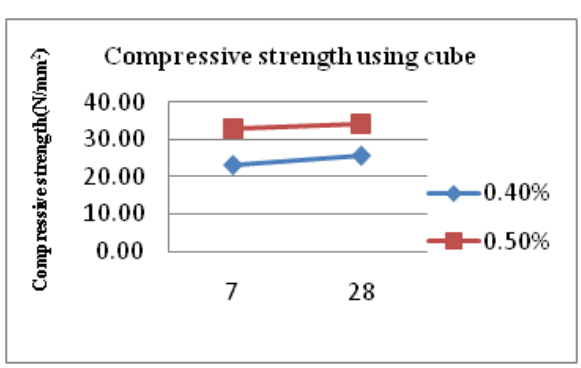

Figure 1: Compressive strength using cube

Figure.1 indicates the comparison of result of compressive strength using cube specimen of M20 grade of concrete. It is observed that for addition of fiber give higher compressive strength.

2) Flexural strength:

The specimens (500 mm x 100 mm x 100 mm) are loaded and tested in accordance with the ASTM Test Method C 78. Results of flexural strength for M-20 grade of concrete on beam specimen with 0.4% and 0.5% steel fibers for aspect ratio 50 is shown in table and graph below:

Table3: Results of Compressive strength using cubes specimen

Days	Average flexural strength(N/mm^2)	
	0.4 %	0.5 %
7	3.73	4.10
28	4.69	4.82

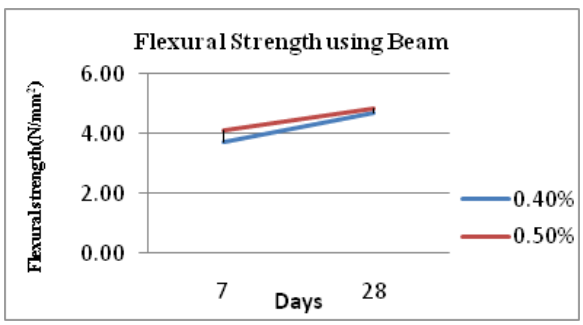

Figure 2: Flexural strength using beam

It is evident from Table 3 and Figure 2 that the rate of gain of flexural strength of steel fiber concrete is increase with percentage of steel fiber. It is seen that the flexural strength obtained experimentally is more than the flexural strength calculated theoretically.

PAVEMENT DESIGN AND ANALYSIS

Pavement slab is designed as per IRC 58:2002[7]. The flexural strength is directly taken from the beam flexural test. The design details are tabulated in Table 4. The Axle load spectrum is taken from IRC: 58 -2002 and other data used in this design is given below:

- Elastic modulus of concrete = 3 x 10^{-5} N/mm2
- Tyre pressure = 8 kg/cm^2
- Spacing of contraction joints = 4.5m
- Design life = 20 years
- Poisson' ratio = 0.15
- Rate of traffic increase = 0.075
- Present traffic =1000 cvpd
- Elastic Modulus of Sub grade
- Reaction of the DLC sub-base = 8 kg/cm^3
- Coefficient of thermal Expansion of concrete = 10x 10-6 /^{o}C.

Table 4: Variation in the Thickness in the Concrete cube

Grade of concrete	Flexural strength(kg/cm^3)	Slab thickness	Fatigue life consumed ratio	Corner stress in kg/cm^3
M20	46.9	31	0.533	17.18
	48.2	29	0.75	19.5

From Table 3, it is clear that the addition of small amount of fiber will also reduce the thickness of the pavement slab. For M20 Concrete thickness saved in construction with Steel fiber concrete is 23%.

CONCLUTION

From the experimental studies and subsequent pavement analysis carried out as per IRC: 58-2002, it is concluded that the compressive strength of Steel fiber concrete increased when compared to plain cement concrete. Addition of steel fiber increases the flexural strength of Steel fiber concrete to great extent.

Addition of steel fiber in concrete, the pavement thickness is decreased by 23% and which is economical when compared to plain cement concrete slab.

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