Use of Steel Fiber Reinforced Concrete (SFRC) over Plain Concrete for Shotcrete in Underground Tunneling

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***ABSTRACT**-After drilling and blasting, it be comes very important to choose the right material for shot crete in underground tunneling. Over the years,SFRC has been frequently used for shotcrete. This paper focuses attention to the advantages coming from the use of SFRC over plain concrete in terms of compressive strength and flexural strength*

***Keywords** –Compressive strength,Flexural strength ,Shocrete,SFRC,plain concrete*

1. INTRODUCTION

Application of Fibre Reinforced Concrete(FRC) is continuously growing in various application fields.FRC is widely used in structures. Due to the property that fibre enhances toughness of concrete, FRC is used on large scale for structural purposes. It improves fatigue resistance, makes crack pattern distributed.[1] By making crack pattern distributed, it is meant that it decreases the crack width.

Underground tunneling has a very vast and profound application of SFRC and there is growing interest in SFRC as compared to plain concrete. Rehabilitation of conventional rokbolt and wire mesh support can be very disruptive and expensive. The excavations being shotcreted immediately are increasing. The incorporation of steel fibre reinforcement into the shot crete is an important factor in this escalating use,since it minimizes labour intensive process of wire mesg installation. Trials and observations suggest that shot crete can provide effective support in mild rock burst conditions[2].

In the present paper advantages of SFRC over plain concrete in underground tunneling over properties like compressive strength and flexural strength are discussed with some experiments performed and collective data on the samples of SFRC and plain concrete

[1]

2. EXPERIMENT METHODOLOGY

2.1 COMPRESSIVE STRENGTH

Three different types of steel fibres are used in the experiment with aspect ratios of 50.1,53.87 & 62.50.Two cube specimen of dimensions 150x150x150 mm and cylindrical specimen of length 200mm and diameter 100mm are used. The concrete that is used for csasting is M25 grade concrete. One mould is filled with plain comcrete(0% fiber) and other with 0.5% steel fiber. Table vibrators were used for vibration. Specimens are demoulded and then transferred to curing tank. In curing tank, they are used for 7 and 28 days with strengths being noted at 7th and 28th day. Testing of cube and cylinder is done under digital compression testing machine. The testing is stopped where the cube is failed or when failure load is approached. The behaviour of plain concrete and SFRC is shown graphically in the compressive stress strain curves in "Fig." 1 in Figures and Tables.

Formula for calculating compressive strength is:
Failure Load/Cross Section Area

2.2 FLEXURAL STRENGTH

Steel fibres are generally found to have much greater effect on flexural strength than on compressive or tensile strength. Increase in the flexural strength is not only affected by volume of fibres but also by aspect ratio of the fibres with larger aspect ratio leading to greater flexural strength. "Fig." 2 in the Figures and Tables shows the fibre effect in terms of combined parameter W*l/d*,where *l/d* is the aspect ratio and W is the weight of fibres.It should be noted that for W*l/d*>600,the mix characterstics tends to be quite unsatisfactory.Deformed fibres show the same type of increase at lower volumes,because of their improved bond characterstics.[3]In order to check the sample for flexural strength,two point loading test is implemented which is discussed below:

Normal concrete beam of size (700x150x150)mm is casted in mould and it is cured for 24 hours.After that it is unmoulded and kept in water for 28 days.After that it would be tested for flexural strength by Two Point Loading method. "Fig." 3 in the Figures and Tables shows the arrangement of Two Point Loading method.The bed on which the specimen is to be supported is provided with two steel rollers which is of 38mm in diameter.The bearing surface of the supporting and the loading roller should be wiped clean and any other material should be removed.The load is transmitted to through a load cell and spherical seating on to a spreader beam.The test member is supported on the roller bearings acting on similar spreader plate.The loading frame should be strong enough to carry the test load without major distortions.Aspace of 50mm is left on the end of the beam and the specimen is placed over two steel rollers.The remaining space of 600mm is divided into three parts of 200mm each.A hydraulic jack of capacity 600 kN does the loading.For recording the deflection of beams,one dial gauge at the centre is placed.The load should be applied such that it is increased continuously at a rate of 7 kg/sq.cm/min that is at the rate of loading of 400 kg/min for 15cm specimen and at a rate of 180 kg/min for 10cm specimen[4].The load is applied until the specimen fails and the load at which it fails is recorded.Any unusual features such as appearance of flexural faces should be noted.

Formula for calculating flexural strength:

a) Shorter breaking distance more or equal to 200mm:
   F = [(WxL)/(BxD2)]
b) Shorter breaking distance less than 200mm:
   F = [(3WxP)/(BxD2)]
   W - Total load applied
   P - Shorter breaking distance(0 to 200mm)
   L – Centre to centre distance between two supports=600mm
   B – Width of beam=150mm
   D – Depth of beam=150mm

3. EXPERIMENTAL RESULTS

3.1 Compressive Strength

In many underground construction works,such as in tunnels,steel fiber reinforced concrete is subjected to compression.Therefore compressive strength test is considered the most suitable method for evaluating the behaviour of steel fiber reinforced concrete[5]

Results of compressive strength of M-25 grade of concrete on cube and cylinder 0%(plain concrete) fiber and 0.5%(I), 0.5%(II), 0.5%(III) is shown in table 1 and "Fig." 4 in Figures and Tables.

3.2 Flexural Strength

"Fig." 5 and table 2 in Figures and Tables shows the results and verification of the fact that SFRC has greater flexural strength than plain concrete.

4. FIGURES AND TABLES

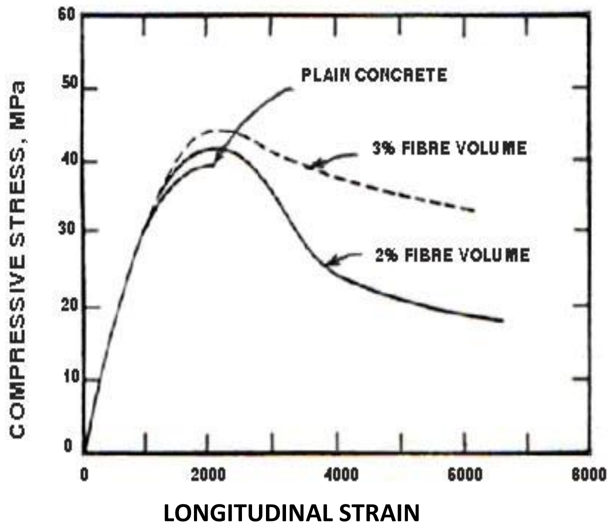

Figure 1 Relation between stress-strain in compression for plain concrete and SFRC[6]

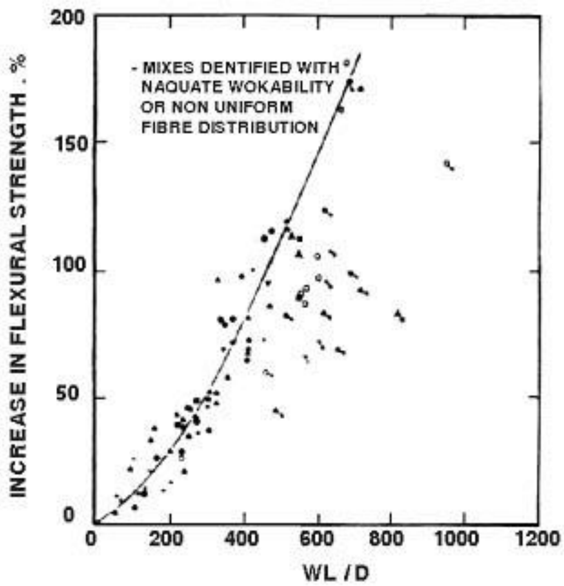

Figure 2 Effect of W*l*/*d* ratio on the flexural strength of concrete[6]

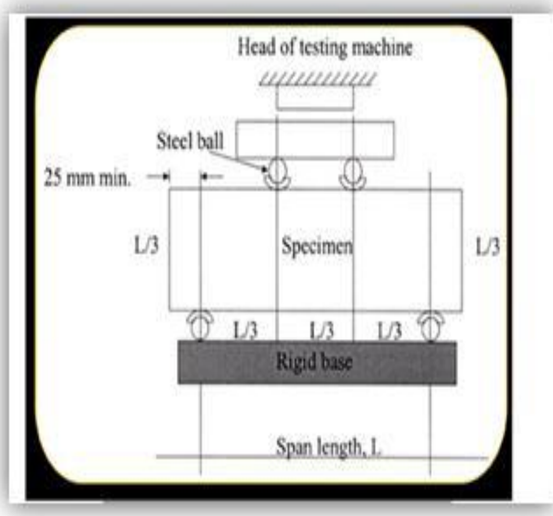

Figure 3 Two Point loading test apparatus setup for flexural strength

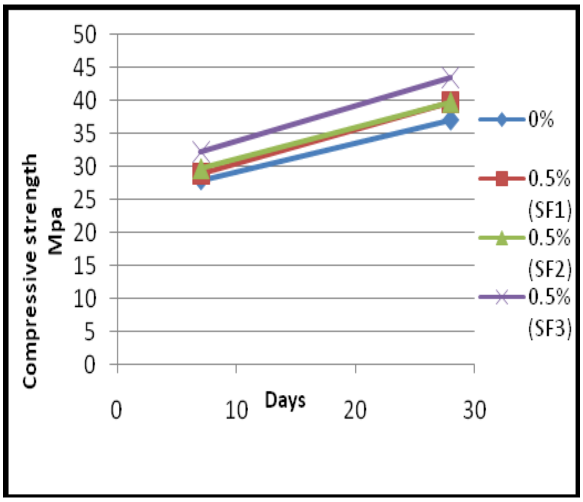

Figure 4 Compressive strength test results

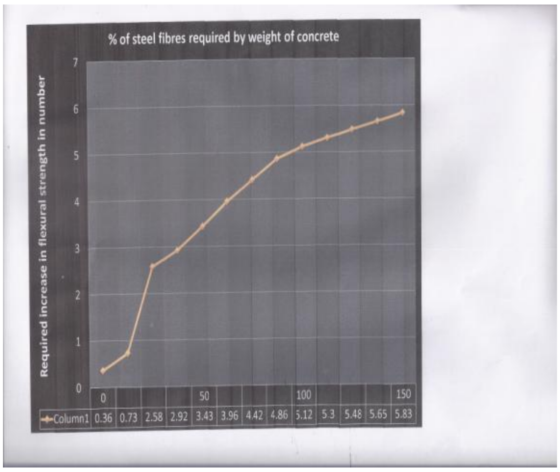

Figure 5 Percentage of steel fibres w.r.t desired increase in flexural strength

Table 1 Results of Compressive strength test

Day s	Average Compressive Strength(Mpa)			
	0%(plain concrete)	0.5%(SF 1)	0.5%(SF 2)	0.5%(SF 3)
7	26.72	28.83	29.87	33.12
28	35.42	37.57	40.24	44.53

Table 2 Test Results for Flexural Strength

S.no	% of steel fibers	Slump in mm	Average load in kN	ASBD in mm	FS in N/mm2
1	0.00	30	31.23	247.33	5.34
2	0.75	25	36.03	239.00	6.43
3	1.00	25	32.08	258.35	5.94
4	1.25	25	30.12	263.01	5.42
5	1.5	25	36.44	271.56	6.73
6	1.75	25	37.28	266.42	6.68

ASBD-Average Shorter Breaking Distance
FS-Flexural Strength

CONCLUSION

Underground tunneling requires a very strong support for the tunnel not to do any sort of lateral movement.Though plain concrete provides support in various structures but when it comes to underground tunnels, SFRC provides much strength as compared to plain concrete. With the above experiments and results, it is thus proved that SFRC has greater compressive and flexural strength as compared to plain concrete.

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