Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444
Volume 4, Issue 4, April - 2017

Mechanical and durability attributes of cementitious concrete incorporating polypropylene strapping roll fibers

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This paper deals with the consequences on inclusion of numerous proportions of polypropylene strapping roll fibers on compressive strength, split tensile strength, workability, and sorptivity for cementitious concrete. This research work aims to intuition the effects of such fibers on concrete by varying its aspect ratio by 10, 20, 30, 40, 50 and fiber content by 0%, 0.5%, 1%, 1.5%, 2% and 2.5% by overall volume of concrete and to figure out the optimum aspect ratio and fiber content. The test results evince that mechanical and durability properties rises while workability decreases with increase in aspect ratio and fiber content.

Keywords: *fibers; tensile strength; compressive strength; sorptivity; workability.*

1. INTRODUCTION

Concrete by its attribute is strong in compression but is brittle and weak in tension. Another vital frailty of cementitious concrete is cracks starts occur as the concrete is placed and before it gets properly hardened. These cracks are the main cause of shortcoming for cement concrete for large onsite applications resulting in subsequent failure and fracture and also lacking in durability [1]. This shortcoming of concrete in tension can be overwhelmed by the using conventional steel reinforcement and to some extent by the addition of an appropriate volume of short, discrete, and randomly oriented fibers. In this research work Polypropylene strapping roll fibers manually recycled from strapping rolls used for carton packaging have been introduced in conventional concrete with M25 grade to increase and observe its tensile properties.

Figure 1: PP Strapping Roll Fibers

Table 1: Properties of PP strapping roll fibers

Chemically inert
Density = 930 kg/m³
water demand = 0%
Tough
Flexible
Melting point = 160 to 166 °C
Fewer discrepancy in its density due to regular atomic arrangement there is
Tensile breaking load is 86kg
Elongation at break is 40%

The motivation and mechanism behind using such fibers is mainly due to the surface texture and roughness observed on strapping roll as shown in figure 2. Due to this roughness friction between concrete and fibers increases and when concrete starts to crack this randomly oriented fibers starts functioning and turn out to be bridging source between these micro cracks and doesn't permit cracks to become broaden. This way Polypropylene fiber reinforced concrete gives loftier results comparing to the conventional concrete by increasing strength and durability.

Figure 2: Surface texture and roughness observed on Polypropylene strapping rolls

Using such fibers in concrete not only boosts its mechanical and durability properties but also solves disposal problem of PP if the scrap of strapping roll is used.
The length of fiber recommended is normally tied to the nominal maximum size of aggregate in the mixture. Manufacturers indorse that the length of the fiber should be greater than two times the size of the aggregate. This depends on past experiences and with the current theories of fiber dispersion and bonding [2].

2. MATERIALS

The materials used for the concrete mixture comprises of the normal Ordinary Portland Cement confining IS: 12269-1987 was used with specific gravity 3.15. The sand used here is of specific gravity 2.605 according to IS 2386-3-1963, zone classification 2 confining to IS 383-1970 table 4.Similarly, coarse aggregate (20mm and 10mm) used are with specific gravity 2.88. Refer figure3, the type and properties of fibers used here are as discussed above.

Ultra-tech cement (OPC 53 grade)

Coarse aggregate (20 mm)

Fine aggregate

Coarse aggregate (10 mm)

Figure 3: Surface texture and roughness observed on Polypropylene strapping rolls

3. EXPERIMENTAL PROGRAM

Experimental program was been conducted to accomplish the objectives of this research work. At primary stage in a plastic testing laboratory the density for the particular type of fiber was found 930kg/m^3 .Then after the these tests were conducted : Slump test, Compression test, Split tensile test and Sorptivity test. For decision of optimum aspect ratio at first for all the test 1% fiber content by overall volume of concrete was fixed (proportion fixed from previous researches on PP FRC) and then aspect ratio were varied on M25 grade of concrete. After the decision of optimum aspect ratio of fibers the particular aspect ratio was fixed and fiber content were varied from 0% to 2.5% by overall volume of concrete.

3.1 SLUMP TEST

The concrete slump test confining to IS 1199:1959 measures the consistency of fresh concrete before it setting and workability of freshly made concrete that is the ease with which concrete flows. It can also be used to indicate the appropriateness mixed batch.

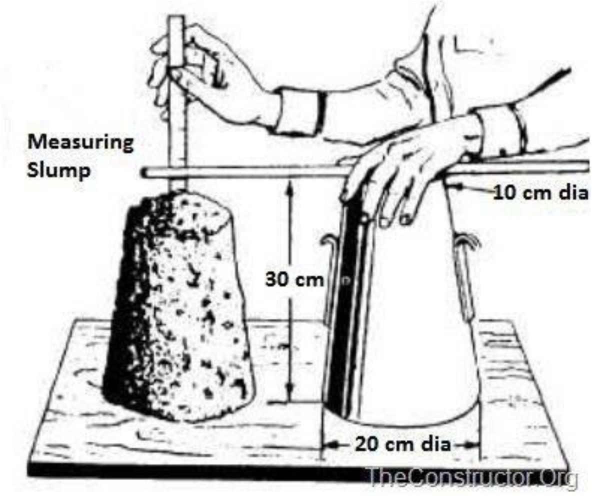

Figure 4: Concrete slump test and types of slump

3.2 COMPRESSIVE STRENGTH TEST

Compressive strength of concrete is the utmost significant characteristic of concrete, which is dignified by engineers in structure designing. The compression test displays the finest possible strength concrete can range in the best condition. The compression strength test measures concrete strength in its final hardened state. It is one of the most essential attribute of concrete and effects many other related properties of the concrete. The mean compressive strength are found at 7, 28 and 56 days of curing. Determining compressive strength by cube where size of cube specimen is 150 × 150 × 150 mm and this test was performed on a 2000 kN capacity compression testing machine. The compressive strength of cube specimen is found using the following formula:

$$\text{Compressive Strength} = P/A$$

Where, P = Failure load
A = Area of cross section in mm

Figure 5: Compressive strength test setup

3.3 SPLIT TENSILE TEST

One of the most common test for appraising the concrete tensile strength is the split tensile strength test according to IS: 5816-1999 where a 150 mm cylinder diameter and 300 mm cylinder height is subjected to compressive load along the two diametrically opposite axial lines. The load applied is continuous with constant rate within the splitting tension stress till the specimen fails with the occurrence of first crack. A transverse tensile stress is produced by this compression, which is uniform along the vertical diameter. Split tensile strength of concrete cylinder is dignified in N/mm^2.The split tensile strength of the cylinder specimen is calculated using the following formula:

$$\text{Split Tensile Strength} = \frac{2P}{\pi d L}$$

Split tensile strength fsp = N/mm^2 Where,

P = Failure load in N
L = Specimen length in mm (300 mm)
d = Specimen diameter in mm (150mm)

Figure 6: Split tensile test setup

3.4 SORPTIVITY TEST

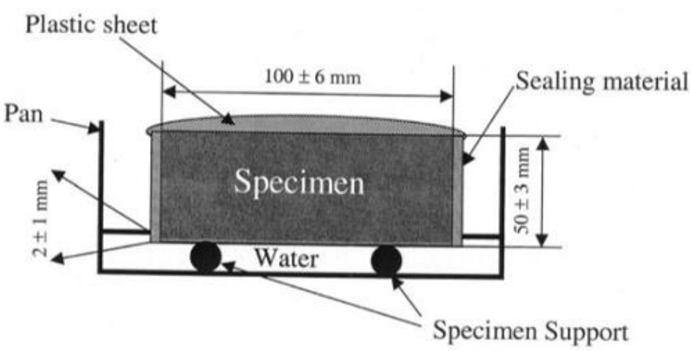

Figure 6: test setup for sorptivity

The test method confining to ASTM C 1585-04 is used to define sorptivity that is rate of water absorption (initial and secondary) of water by measuring the change in the mass of a specimen caused due to absorption of water as a function of time when only one surface of the specimen is exposed to water as shown in figure 6.

$$I = m_t / a * d$$

Where,
I = absorption (mm)
m_t = change in specimen mass at particular time interval (gm)
a = the exposed area of the specimen (mm^2) i.e.7853.98mm^2
d = density of the water (g/mm^3) i.e.0.001 g/mm^3

4. RESULTS AND DISCUSSION

4.1 SLUMP TEST

As show in figure 7 and 8 slump values for different aspect ratio and fiber content are shown. It is observed that slump value for aspect ratio 60 is very low and hence concrete was not workable so aspect ratio up to 50 was used for various testing and research work. Workability was found to decrease with increase in aspect ratio and fiber content gradually.

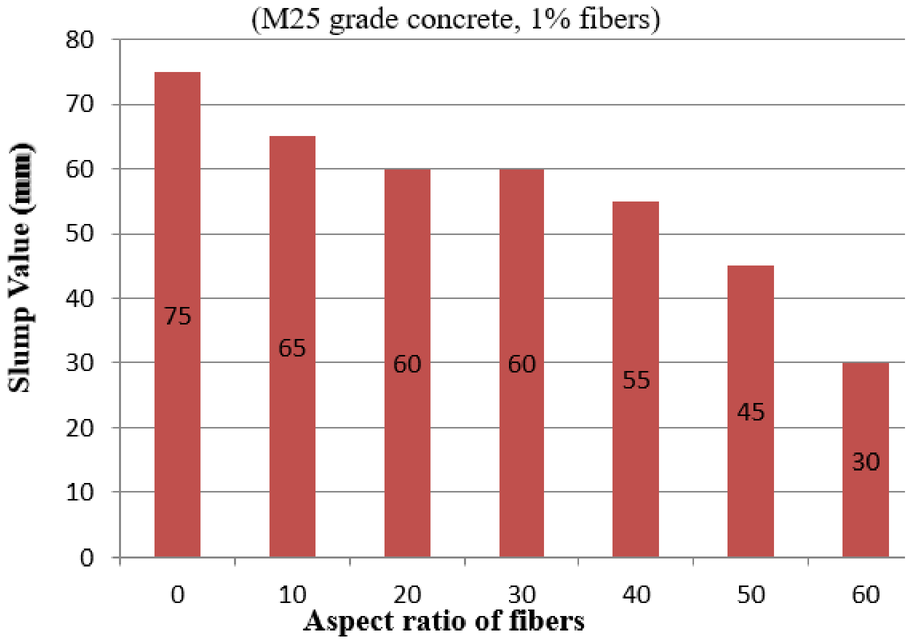

Figure 7: Slump values for different aspect ratio

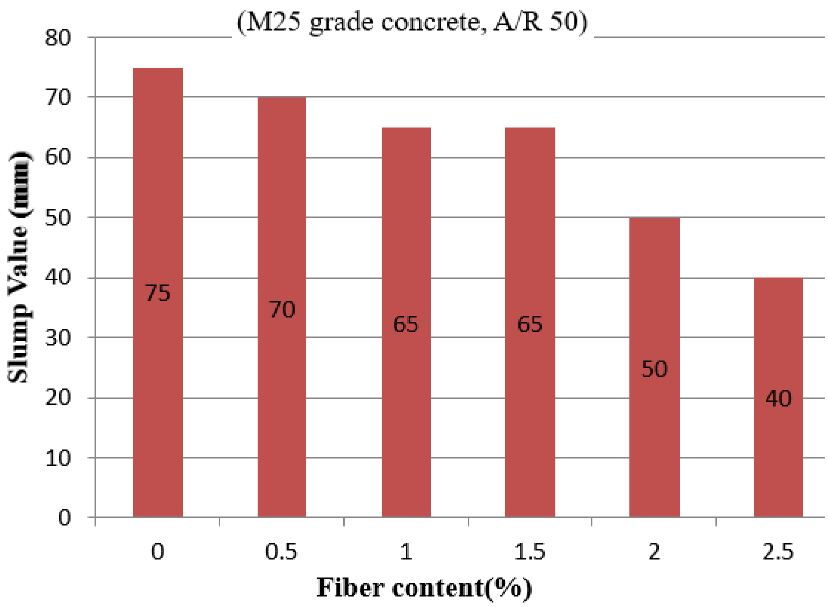

Figure 8: Slump values for different fiber content

4.2 COMPRESSIVE STRENGTH TEST

As shown in figure 9 and 10 results for compressive strength has been displayed. Figure 9 shows the optimum aspect ratio which is 50 and figure 10 gives optimum fiber content which is 1% by overall volume of concrete.

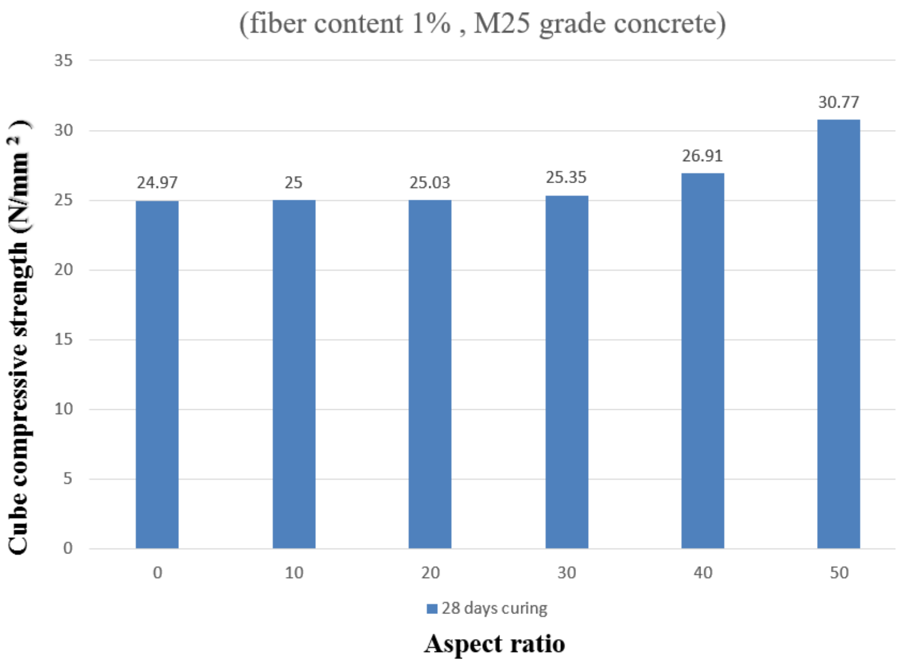

Figure 9: Decision of optimum aspect ratio

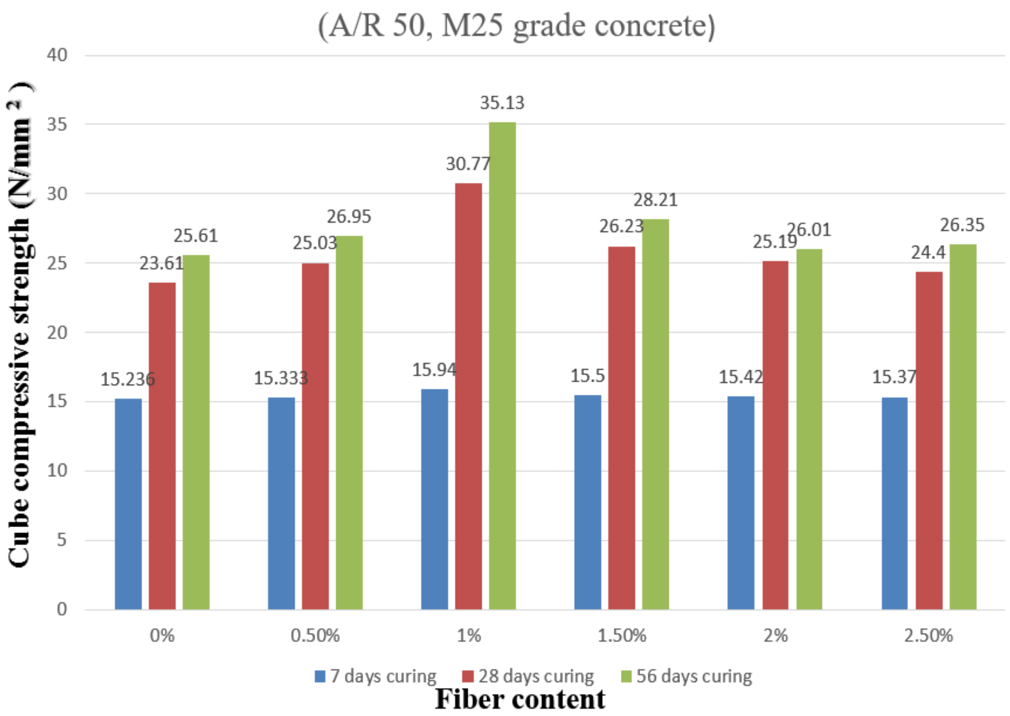

Figure 10: Decision of optimum fiber content

4.3 SPLIT TENSILE TEST

As shown in figure 11 and 12 results for split tensile strength has been displayed. Figure 11 shows the optimum aspect ratio which is 50 and figure 12 gives optimum fiber content which is 1.5% by overall volume of concrete.

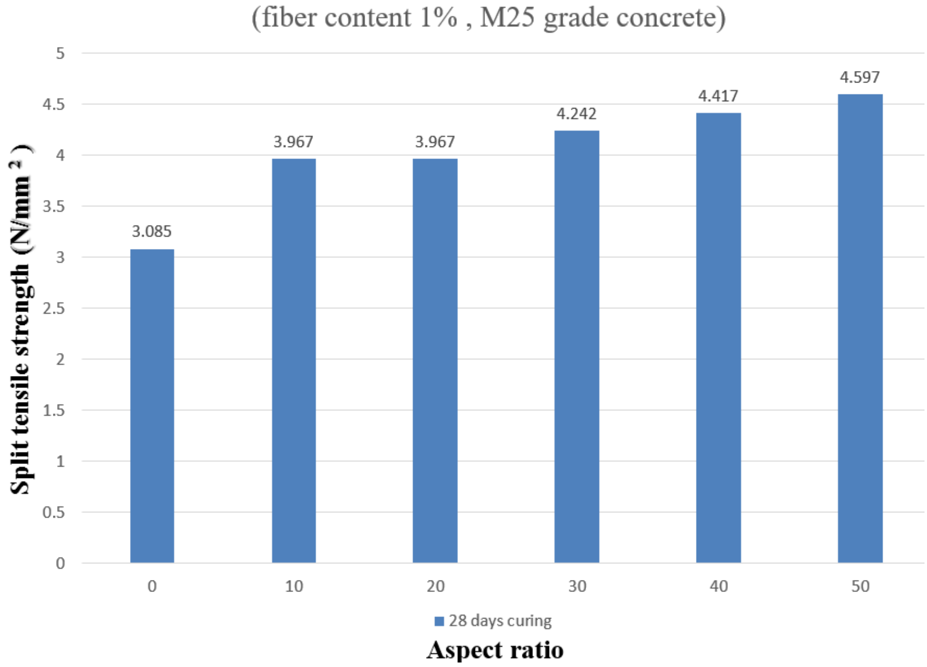

Figure 11: Decision of optimum aspect ratio

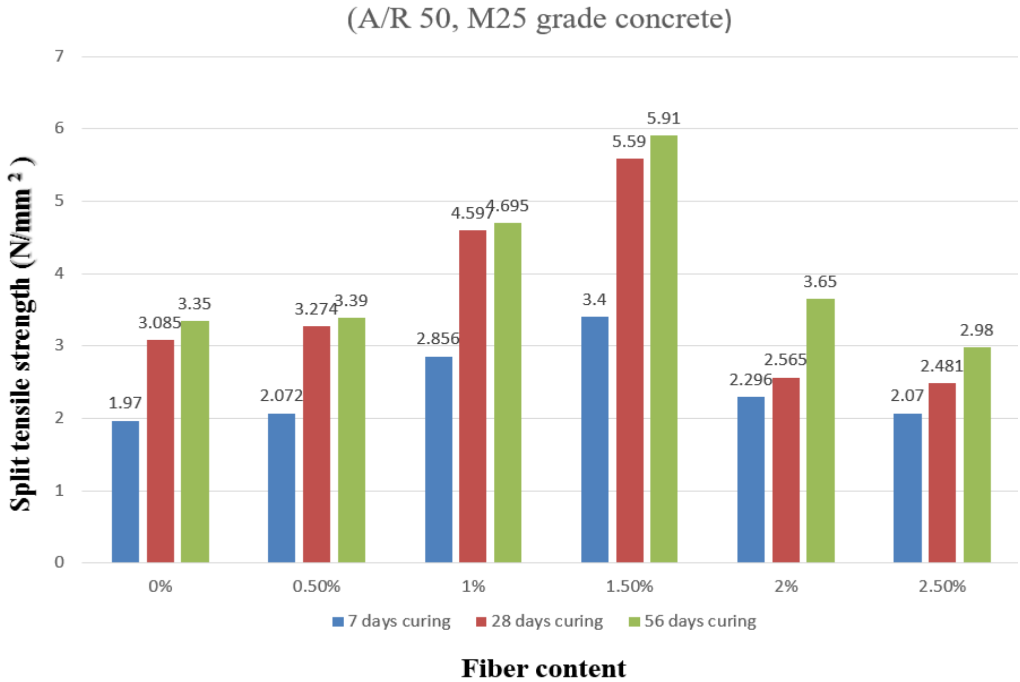

Figure 12: Decision of optimum fiber content

4.4 SORPTIVITY TEST

The results for sorptivity for different aspect ratio and fiber content are shown below in figure 13 and 14. It is observed from figure 13 that with increase in aspect ratio initial rate of water absorption (sorptivity up to 6 hours) decreases gradually while secondary rate of water absorption (sorptivity from 6 hours to 9 days) is having negligible changes. And from figure 14 it is observed that optimum fiber content for sorptivity is found to be 2% by overall volume of concrete.

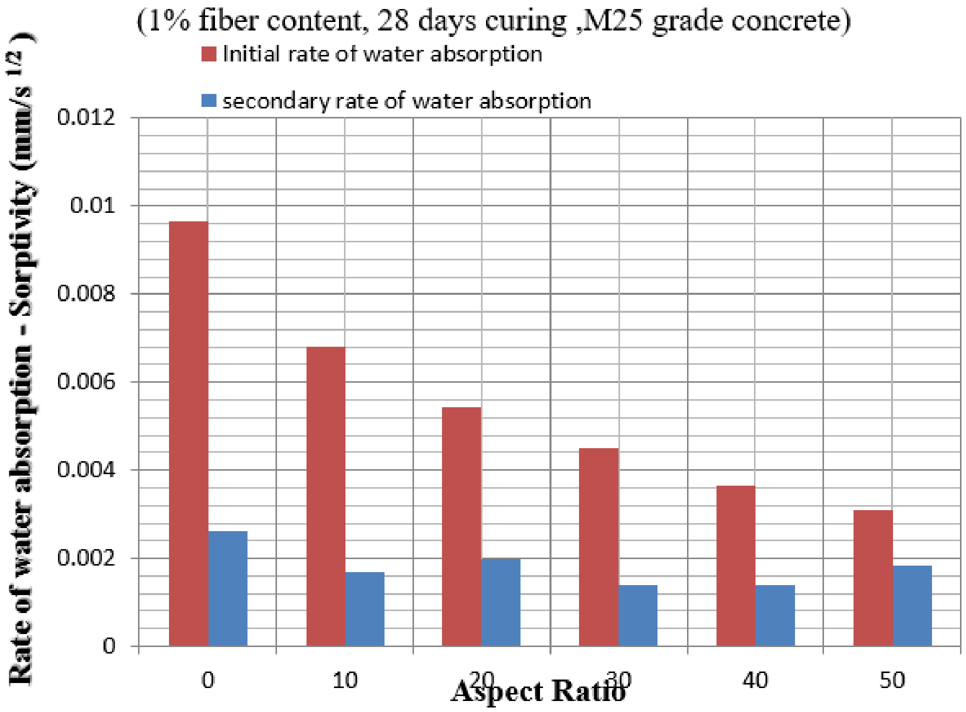

Figure 13: Decision of optimum aspect ratio

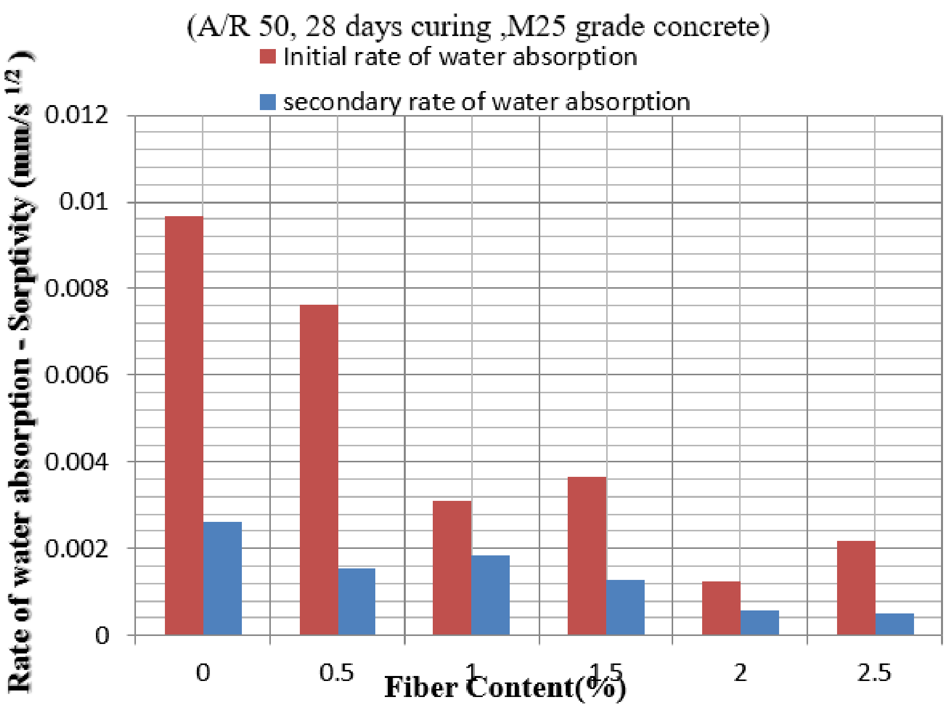

Figure 14: Decision of optimum fiber content

5. CONCLUSION

In summary the following points were concluded from this study:

1. The Compressive strength, Split tensile strength, Sorptivity of concrete with PP strapping roll fibers yields better result compared to conventional concrete.
2. Increasing aspect ratio and fiber content gradually decreases workability of concrete Aspect ratio of fiber more than 50 gives very less workability
3. Optimum aspect ratio and fiber content for the split tensile strength, Compressive strength test and sorptivity test are found to be 50 and 1%, 50 and 1.5% and 50 and 2%.
4. Using this type of fibers in concrete not only enhances its mechanical and durability properties but also solves disposal problem of PP up to some extent if its scrap is used.

6. ACKNOWLEDGMENTS

The authors gratefully acknowledge Marwadi Education Foundation Group of Institutions for supporting and facilitating this research work.

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