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# Study on strength and initial surface absorption of concrete using recycled steel fiber

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## ABSTRACT

***Experimental investigation on Re-using Steel Wire from tyres for Fibre Reinforced concrete was carried out by researchers. Steel Fibres are most popular metallic fibers used for the production of Steel Fibre Reinforced Concrete particularly from the point of view of strength and ductility in the present experimental investigation, attempts are made to study on the various strength properties like compressive strength, split tensile strength, an also durability properties ISAT test was held on long-term durability properties of tire steel fiber. Experiments were conducted for both Ordinary Concrete and steel Fibre Concrete with different percentages. It was observed that as the addition of waste tyre steel fibers to concrete mix increases, the workability of the concrete mix was found to decrease as compared to control mix. At an optimum dosage of WTSF, the increase in compressive strength of glass fibre concrete mixes compared with control mix. The percentage increase of split tensile strength of WTSF concrete mixes compared with control mix by weight of the binder. The addition of waste tyre steel fibers into the concrete mixture marginally improves the compressive strength at 28 days. It is observed from the experimental results and its analysis, that the compressive strength of concrete, splitting tensile strength of concrete increases with the addition of 1% Percentage of waste tyre steel fibers.***

***Keywords—*** *Recycled steel fiber, Silica fume, Admixture, Workability, Compressive strength, ISAT*

## 1. INTRODUCTION

Waste tyres in INDIA are neither categorized as solid waste or hazardous waste has posed a health hazard since tyre piles are excellent breeding grounds for mosquitoes. Shape and impermeability of tyres help to hold water for long periods thus provide breeding sites for mosquitoes'. Waste tyres also pose a serious fire hazard since they are easy to ignite. However, once ignited tyres burn are very difficult to extinguish. This is due to the 75% void space present in the tyre, which makes it difficult to quench the tyres with water or to eliminate the oxygen supply. In addition, a large tyre fire can smoulder for several weeks or even months, sometimes with dramatic effect on the surrounding environment. These fibers are produced in the industries for special tasks of different sizes and shapes. These are available in markets with various weights of bags mostly in 10 kg bags. Steel fibers are being produced by the developers for the use in concrete to form a composite concrete mix for the improvement of weak parameters of concrete, but mostly the researchers have used industrially produced steel fibers for the improvement of these characteristics of concrete.

## 2 MATERIALS USED

### 2.1 Cement

Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests conforming to Indian Standard IS 1489-1991(Part-1). All the tests were carried out as per recommendations of IS: 4031-1988. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. The fineness of cement is obtained as 3%. Standard consistency is obtained to be 31%. Initial setting time is 65 minutes and final setting time is 315 minutes**.**

### 2.2 Course aggregate

Crushed angular granite from a local source was used as coarse aggregate. The specific gravity was 2.67, flakiness index of 4.58 percent and elongation index of 3.96

### 2.3 Fine aggregate

River sand was used as fine aggregate. The specific gravity and fineness modulus was 2.55 and 2.94 respectively and it belongs to zone II of grading.

 

**2.5 Steel fiber extracted from waste tyre**

Waste tyres in India are the low and economical price and in abundance available material. In India, the utilization of waste tyre is very rare, and it becomes a pollution problem. Therefore, the utilization of waste tyre is done in this research. In this study, the steel fibers taken out from waste tyres (Fig. 1) are used in the concrete mix to form a composite fibrous material. Steel fibers waste tyre are extracted from chips of waste tyres by the manual cutting process (Figs. 2 and 3) and cut to 1 inch (25.4 mm) length (Fig. 4), and an average diameter of the fiber is 0.28 mm keeping aspect ratio 90. As waste tyres steel fibers are uniformly and randomly distributed in different proportions from 0 - 1% with an increment of 0.25% by the volume of concrete to prepare the different concrete matrix. The chips of waste tyres are available in the local market; normally they sell those as scrap to scarp industry.

**2.6. Admixtures**

In this study Master, Glenium SKY 51 was used as a Superplasticizer to improve the workability of concrete. It is polycarboxylic ether based, high range water reducing new second generation super plasticizer concrete admixture. It meets the requirements of TS EN 934-2, ASTM C 494 Type F and IS 9103: 1999. Optimum dosage of Master Glenium SKY 51 should be determined with trial mixes. The technical data related to the superplasticizer provided by the manufacturer are presented in Table 3.11.

## 3. RESULT AND DISCUSSION ON EXPERIMENTAL TESTS

**3.1 Workability of concrete mixes**

The workability of concrete mixes was found out by slump test as per procedure is given in chapter 3. w/b ratio was kept constant 0.4 for all the concrete mixes. Super-plasticizer SP 430 was used to maintain the required slump. The dosage of super-plasticizer was varied from 1.0% to 1.25% by weight of binder depending upon the type of mix. The workability results of different concrete mixes were shown in Table 1.

**Table 1: Workability values for different concrete mixes**

| Mix no. | Description | Superplasticizer (%) by weight of the binder | Slump (mm) |
|---|---|---|---|
| 1 | 85%OPC+15%SF+0%SF | 1.00 | 120 |
| 2 | 85%OPC+15%SF+0.25%SF | 1.00 | 115 |
| 3 | 85%OPC+15%SF+0.50%SF | 1.00 | 112 |
| 4 | 85%OPC+15%SF+0.75%SF | 1.00 | 110 |
| 5 | 85%OPC+15%SF+1.0%SF | 1.00 | 105 |
| 6 | 85%OPC+15%SF+1.5%SF | 1.00 | 99 |
| 7 | 85%OPC+15%SF+2.0%SF | 1.25 | 95 |

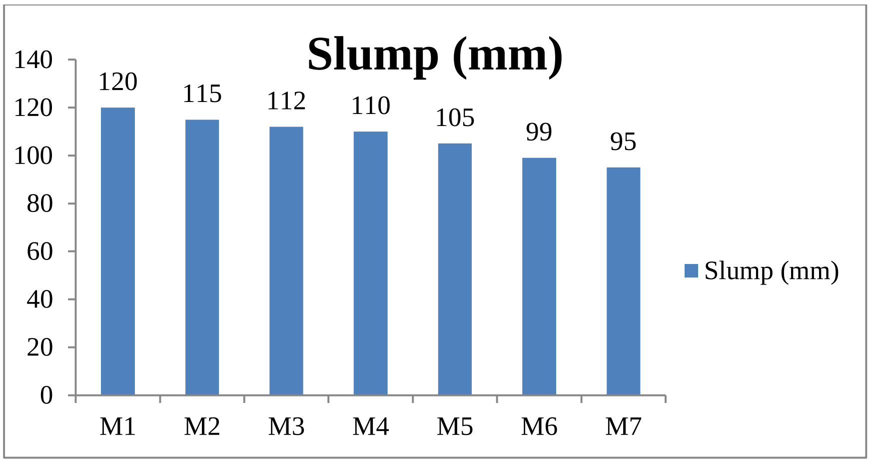


**Fig. 1: Slump test results**

Table 1 shows that as the addition of steel fibres to concrete mix increases, the workability of the concrete mix was found to decrease as compared to the control mix. The addition of steel fibres into the concrete mix further decreases the workability. To achieve the required slump super plasticizer was added to the concrete mix. As a percentage of fibres increases the quantity of super plasticizer was increased. The lowest value of slump was obtained with mix M7 and the highest value was obtained with M1. There is a decrease in workability of concrete with an increase in steel fibre content

**3.2 Compressive Strength**

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test was conducted at curing ages of 7, 14, 28, 56 and 90 days.

**Table 2: Compressive strength (MPa) results of all mixes at different curing ages**

| Mix no. | Description | 7 days | 14 days | 28 days | 56 days | 90 days |
|---|---|---|---|---|---|---|
| 1 | 85%OPC+15%SF+0%SF | 32.02 | 36.25 | 38.02 | 40.15 | 43.31 |
| 2 | 85%OPC+15%SF+0.25%SF | 39.13 | 41.11 | 43.60 | 45.90 | 48.91 |
| 3 | 85%OPC+15%SF+0.50%SF | 39.30 | 42.40 | 44.20 | 46.60 | 49.52 |
| 4 | 85%OPC+15%SF+0.75%SF | 38.29 | 41.74 | 43.10 | 45.65 | 49.24 |
| 5 | 85%OPC+15%SF+1.0%SF | 37.15 | 39.86 | 41.50 | 43.35 | 47.10 |
| 6 | 85%OPC+15%SF+1.5%SF | 35.26 | 38.23 | 39.50 | 42.51 | 45.60 |
| 7 | 85%OPC+15%SF+2.0%SF | 33.30 | 35.41 | 37.20 | 40.11 | 42.40 |

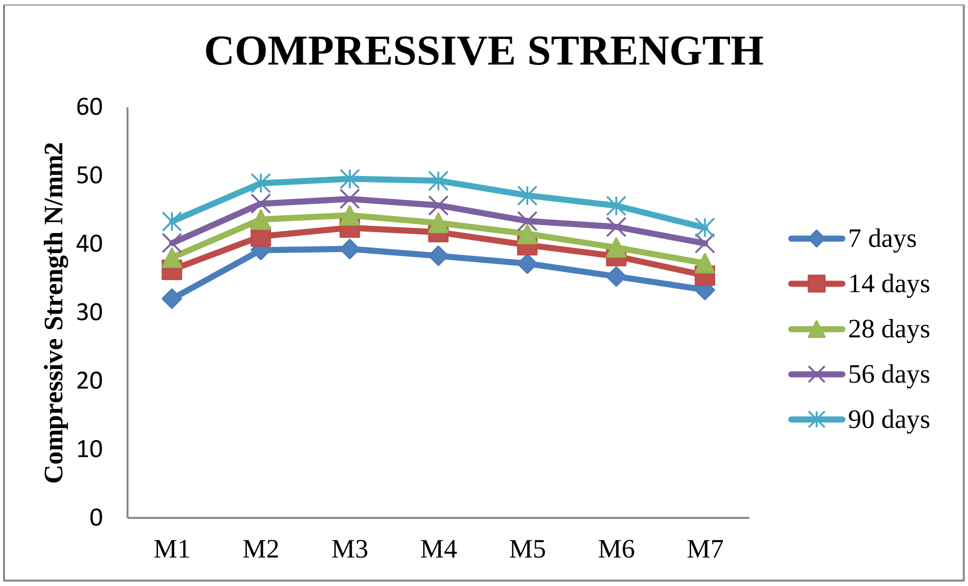


**Fig. 2: Compressive strength results**

Table 2 shows that the addition of waste recycled steel fiber in concrete to increasing strength compare to the control mix. Maximum compressive strength obtained from the mix. M3 is 44.20 MPa and minimum 37.20 MPa at 28 days respectively. Finally, we observed that increasing percentage of steel fiber in concrete to increasing strength as compare to control mix M1 and Represents the details of compressive strength of steel fiber concrete.

### 3.3 Split tensile strength test results

**Table 3: Splitting tensile strength (MPa) results of all mixes at different curing ages**

| Mix no. | Description | 7 days | 14 days | 28 days | 56 days | 90 days |
|---|---|---|---|---|---|---|
| 1 | 85%OPC+15%SF+0%SF | 4.11 | 4.50 | 4.61 | 4.98 | 5.32 |
| 2 | 85%OPC+15%SF+0.25%SF | 4.71 | 5.65 | 5.98 | 6.10 | 6.30 |
| 3 | 85%OPC+15%SF+0.50%SF | 4.50 | 5.78 | 5.88 | 6.15 | 6.35 |
| 4 | 85%OPC+15%SF+0.75%SF | 4.71 | 5.75 | 5.81 | 6.28 | 6.12 |
| 5 | 85%OPC+15%SF+1.0%SF | 4.68 | 5.75 | 5.92 | 6.00 | 6.71 |
| 6 | 85%OPC+15%SF+1.5%SF | 3.61 | 4.80 | 5.00 | 5.10 | 5.63 |
| 7 | 85%OPC+15%SF+2.0%SF | 3.50 | 4.16 | 4.76 | 4.83 | 5.22 |

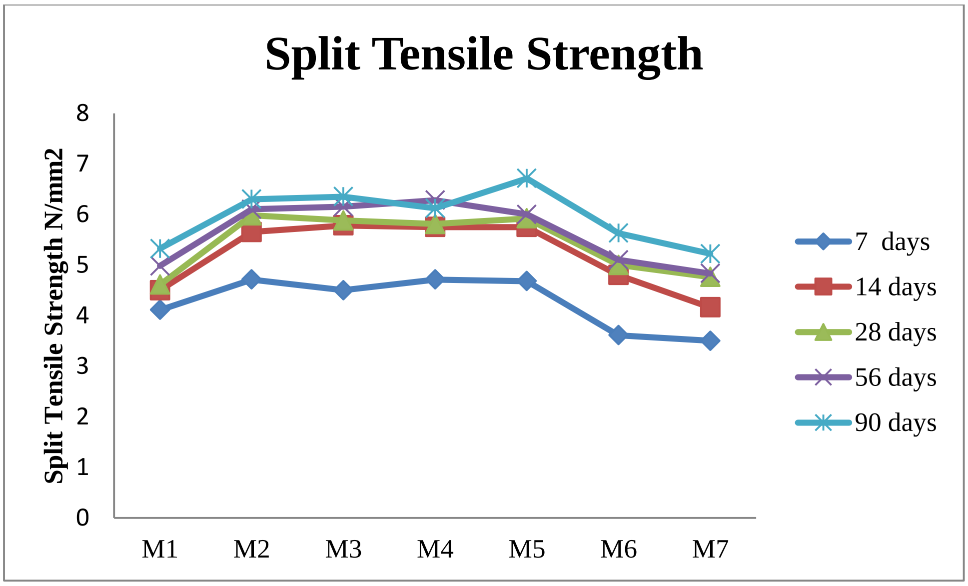


**Fig. 3: Variation of split tensile strength of concrete with age**

Show the variation of split tensile strength figure 3 maximum strength obtained in the mix. M2 and similar strength to obtained in mixM5 value 5.98 MPa and 5.92 MPa at 28 days respectively.

## 4. INITIAL SURFACE ABSORPTION TEST RESULTS (ISAT)

The ISAT was performed to have an idea about the water permeation of concrete, particularly at the concrete surface. The concrete cover is the weakest, most permeable and absorptive part of the concrete matrix as compared to the internal microstructure. The near surface concrete is highly heterogeneous in nature, due to the relative movement of cement paste and aggregates during the compaction of fresh concrete and bleeding of mix water in the early stages of cement hydration. As a result, there is a porosity gradient in the near surface concrete, where the porosity of near surface is higher than that of the internal part of the concrete. For a particular curing age, the absorption was measured at 3 different time periods i.e. 10, 30 and 60 minutes. The absorption of water or flow of water decreased with time.

**Table 4: Initial Surface Absorption values in [ml/(m$^2$.Sec)] at 10 min**

| Mix no. | Description | Initial Surface Absorption [ml/(m$^2$.Sec)] at 10 min | |
|---|---|---|---|
| | | 56 days | 90 days |
| 1 | 85%OPC+15%SF+0%SF | 0.310 | 0.296 |
| 2 | 85%OPC+15%SF+0.25%SF | 0.266 | 0.221 |
| 3 | 85%OPC+15%SF+0.50%SF | 0.239 | 0.205 |
| 4 | 85%OPC+15%SF+0.75%SF | 0.229 | 0.198 |
| 5 | 85%OPC+15%SF+1.0%SF | 0.281 | 0.238 |
| 6 | 85%OPC+15%SF+1.5%SF | 0.329 | 0.288 |
| 7 | 85%OPC+15%SF+2.0%SF | 0.391 | 0.320 |

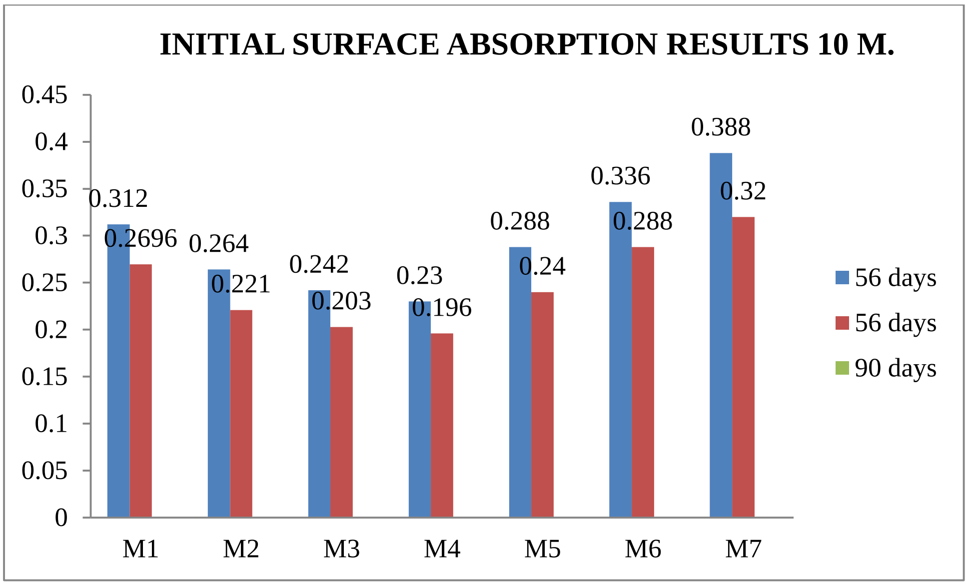


**Fig. 4: Initial surface absorption test results**

Table 4 shows the ISAT values (10 min, 30 min, and 60 min) of concrete mixes at different curing ages. Figure 4 also shows the variation in ISAT values of mixes at 10, 30 and 60 minutes for curing age of 56 and 90 days. The lowest values of ISAT-10 i.e. 0.230 and 0.196 ml/(m$^2$.Sec) at curing period of 56 and 90 days respectively are observed for a concrete mix containing 90%OPC+10%SF+0.75% SF, whereas, the highest values of ISAT-10 are observed as 0.406 and 0.344 ml/(m$^2$.Sec) at 56 and 90 days of curing for a concrete mix containing 90%OPC+10%SF+2%SF, whereas, the highest values of ISAT-10 are observed as 0.406 and 0.344 ml/(m$^2$.Sec) at 56 and 90 days of curing for a concrete mix containing 90%OPC+10%SF+2%SF.Further, the ISAT-10 values for control mix i.e. 90%OPC+10%SF+0%SF, are 0.312 and 0.269 ml/(m$^2$.Sec) at 56 and 90 days of curing, respectively. It was observed that less water absorption with the addition of steel fiber is less compare to normal concreter.

## 5. CONCLUSIONS

- It was observed that increasing percentage of recycled steel fiber in the concrete to the workability of concrete decreases with increasing mix compare to normal concrete.
- It is found that increasing the percentage of steel fiber in concrete with increasing compressive strength of concrete the maximum value of 4.42 MPa at 28 days.
- It was observed that increasing of tensile strength with increasing percentage of WSF in concrete with compare to normal concrete and the maximum spilt tensile strength value shown on the mix. 85%OPC+15%SF+0.50%SF respectively.
- The concrete containing 0.50% and 0.75% GF by weight of binder shows the lesser value of initial surface absorption.
- Finally, we observed that increasing the percentage of steel fiber in concrete with increasing compressive strength as well as tensile strength and less water absorption in all mix with compare to normal mix.

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