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# Steel Fibre Reinforced Latex Modified Concrete

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***Abstract*— Our paper documents the effects of using steel fibres in latex modified concrete. The study was carried out to record the different physical and mechanical properties of steel fibre reinforced latex modified concrete. Latex modified concrete is nothing but, conventional concrete made by replacing part of mixing water with latex. Polymer as an admixture can improve properties like higher strength and lower water permeability than the conventional concrete. Since, concrete is weak in tension, steel fibres have been added to concrete, to improve its characteristics in tension. The polymer concrete specimens with and without fibers were cast and tested to watch the improvement of certain mechanical and physical properties like compressive strengths, tensile strengths, and workability. Styrene Butadiene Rubber Latex polymer and hooked end steel fibres have been used for our study. 5% of SBR Latex and 0.5% of steel fibres have been used. The hardened properties of concrete were tested at 7th and 28th days. It was found that the given fibre dosage enhanced the early compressive strength of concrete but reduced the 28 days compressive strength. Steel fibers increase the tensile strength of concrete.**

***Keywords—Concrete, styrene butadiene rubber latex polymer, steel fibre, mechanical properties***

## I. INTRODUCTION

Conventional concrete generally constitutes cement, fine aggregates, coarse aggregates and water. As times change, there is a need to provide better concrete, in terms of its strength, durability, etc. Special concretes need to be designed which are task specific. Certain mineral and chemical admixtures, super plasticizers and polymers are used nowadays, to achieve the required concrete mixes.

To match the technical innovations in the construction industry in recent years, useful polymeric admixtures or polymer modified mortars and concretes have been developed. Polymer modified concrete, and latex modified concretes are promising construction materials for the future because of the good balance between their performance and cost compared to other concrete-polymer composites.

The concept of polymer hydraulic cement is not new, and in 1923, the first patent was issued to Cresson. He patented the concept of paving materials with natural rubber latexes, and cement was used as filler. The first patent with the present concept of the polymer latex modified systems was published by Lefebure in 1924. He was the first worker who intended to produce a latex-modified mortar and concrete using natural rubber latexes by a mix-proportioning method. A similar idea was patented by Kirkpatrick in 1925. For this study, Nitobond SBR Latex polymer has been used.

Egyptians used straw to reinforce mud bricks, but there is evidence that asbestos fiber was used to reinforce clay posts about 5000 years ago. Some ancient additives used in concrete were the hydraulic lime, volcanic ash, horse hair and blood. In both Roman and Egyptian times it was re-discovered that adding volcanic ash to the mix allowed it to set underwater. Similarly, the Romans added horse hair to concrete which made it less liable to crack while it hardened, and adding blood made it more frost-resistant.



Crack resistance of concrete improves when fibres are used in tension and during shrinkage. On addition of fibres, properties of concrete could be altered and a superior concrete mix could be achieved, thus overcoming certain drawbacks in conventional concrete practices, partially if not completely. Traditionally, steel reinforcement bars are used to improve the tensile strength in a particular direction, but steel fibres get distributed in three directions and helps concrete improve strength in any direction. This is one of the main reasons for using steel fibres for shotcreting in tunnels instead of a steel mesh. Less labour and less construction time are required in this process. Other places where steel fibres are mostly used are in industrial floorings and pavements.

Different types of fibres are available in the market like glass fibres, steel fibres, natural fibres, polypropylene fibres, nylon, polythene and polyester. Some steel fibres commonly used are hooked end steel fibres, crimped fibres, glued fibres, steel wool, etc. For our study, hooked end steel fibres have been used.

Since, river sand is becoming difficult to procure nowadays and the environmental laws restrict sand mining, we have to look for alternatives to river sand. One such alternative is the manufactured sand. Manufactured sand is obtained mainly from quarries where stones are crushed into different sizes for construction. The dust remaining after crushing, is refined and segregated to obtain manufactured sand or crushed sand. Hence, we have replaced river sand to manufactured sand for our study.

We have also used admixtures such as silicafume and super plasticizers in our concrete mix. Silica fume is added to portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. Addition of silica fume also reduces the permeability of concrete to chloride ions. Silica fume acts as filler in the voids and contributes largely to dense packing of concrete. The super plasticizer produces a homogeneous cohesive concrete generally without any tendency for segregation and bleeding. They are called high range water reducers. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. It is free of chloride & low alkali. It is compatible with all types of cements.

## II. METHODOLOGY

### A. Cement

OPC Birla Super 53 grade cement has been used for our experimental work. All the properties for cement have been tested as per the code IS 12269: 1987, for 53 grade ordinary Portland cement. The specific gravity of cement is 3.15. The initial and final setting time of cement was found to be 70 minutes and 220 minutes respectively. The fineness and standard consistency of cement were found to be 1.5% and 30%.

### B. Fine aggregate

Manufactured sand has been procured from M/s. Robo Silicon. From sieve analysis conducted on the sample of fine aggregates, manufactured sand conformed to zone II. The specific gravity of manufactured sand is 2.66. Loose bulk density and dense rodded bulk density are found to be 1422Kg/m$^3$ and 1600Kg/m$^3$. 40% of voids ratio and fineness modulus of 2.64 has been noted.

### C. Coarse aggregate

Coarse aggregates have been procured from M/s. Robo Silicon. Two types of coarse aggregates have been used which are 20mm and 10mm in size. The basic tests conducted on coarse aggregate are as per IS Standards, IS: 2386-1963. Specific gravity of coarse aggregates is 2.67. The value of fineness modulus is 6.2. The abrasion value and impact value for coarse aggregates are 13% and 16%.

### D. Silica fume

Micro silica 920-D, a dry powder available in densified form as supplied by Elkem India Pvt. Ltd, Navi Mumbai, is used. The particle size of silica fume is less than 1 µm. Specific gravity of silica fume is 2.2. The densified bulk density of silica fume is 600-700 kg/m3 and the procured bulk density being 200-350 kg/m3. The specific surface value is 15,000 - 30,000 m$^2$/kg.

### E. Chemical admixture

Master Glenium SKY 8630 super plasticizer is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. It is free of chloride & low alkali. It is compatible with all types of cements. The physical characteristics Master Glenium Sky as provided by the manufacturer are as follows,

TABLE I. Physical characteristics of super plasticizer

| ***Description*** | ***Value*** |
|---|---|
| Aspect | Light Brown Liquid |
| Relative density | 1.08 at 25°C |
| pH | > 6 at 25°C |
| Relative ion content | < 0.2% |
| Specific Gravity | 1.10 |

### F. Polymer

Nitobond® SBR Latex from FOSROC has been used in this project. Nitobond SBR (Latex) is modified styrene butadiene emulsion. The addition of Nitobond SBR (Latex) to cement mortars reduces permeability and therefore helps reduce the rate of attack by aggressive chemicals. The physical characteristics of SBR Latex are as follows as provided by the manufacturer,

TABLE II. Physical characteristics of SBR Latex polymer

| ***Description*** | ***Value*** |
|---|---|
| Specific Gravity | 1.015 to 1.040 @ 270C |
| Compressive strength (N/mm2)<br>3 days<br>7 days<br>28 days | <br>12.5<br>14.5<br>24.0 |
| Tensile Strength, 28 days (N/mm2) | 3.5 |
| Flexural Strength, 28 days (N/mm2) | 6.5 |

### G. Fibre

Hooked end steel fibres have been used for our experimental study and its physical characteristics are as mentioned below,

TABLE III. Physical characteristics of steel fibres

| ***Description*** | ***Value*** |
|---|---|
| Cross Section | Hooked end |
| Diameter | 0.6 mm |
| Length | 30 mm |
| Aspect Ratio | 50 |
| Density | 7900 kg/m3 |

## III. RESULTS AND DISCUSSION

### *A. Compressive Strength*

The compressive strength test results for latex modified concrete with and without steel fibres are as shown below in the Table IV. Figure I represents pictorially the 7 day and 28 day compressive strength values. It has been observed that the 7 day compressive strength value for latex modified concrete is more compared to SFRC and SFLMC. The compressive strength values for 28 days obtained for SFRC and SFLMC are less than conventional concrete. Even though SFRC value is less than CC, it is only marginally less.

TABLE IV. Compressive strength test values

| TYPE OF MIX | 7 DAYS | 28 DAYS |
|---|---|---|
| CC | 48.58 | 60.30 |
| LMC | 51.96 | 57.56 |
| SFRC | 47.42 | 59.81 |
| SFLMC | 43.24 | 57.56 |

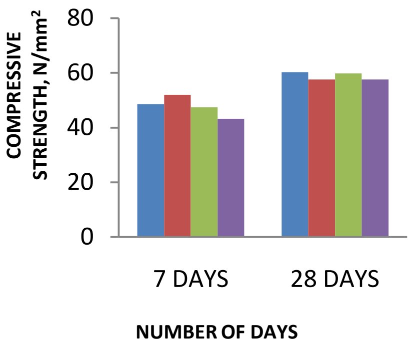


FIGURE I. Compressive strength values Vs number of days

### *B. Split Tensile Strength*

The split tensile strength test result for latex modified concrete with and without steel fibres are as shown below in the Table V. Figure II, depicts pictorially the values of split tensile testing. It has been observed from the values below that there is a marginal difference in values for the four castings. A value of 4.01 N/mm$^2$ has been obtained for 28 day tensile test for SFLMC. From this we can infer that the steel fibres with latex give good results for split tensile testing.

TABLE V. Split tensile strength test values

| TYPE OF MIX | 7 DAYS | 28 DAYS |
|---|---|---|
| CC | 3.30 | 3.60 |
| LMC | 3.50 | 3.38 |
| SFRC | 3.30 | 3.90 |
| SFLMC | 3.36 | 4.01 |

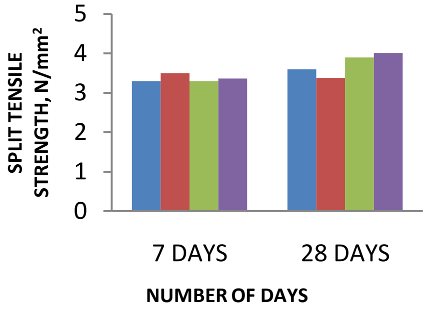


FIGURE II. Split tensile strength values Vs number of days



### *C. Flexural Strength*

The flexural strength test results for latex modified concrete with and without steel fibres are as shown below in the Table VI.

Figure III, shows a pictorial representation of the flexural strength test result values so obtained. From the following values it has been observed that the 7 day test values of flexural strength for SFRC and SFLMC are lesser than that obtained for LMC. This shows that latex helps in the early gain of strength in concrete. But it can also be seen that the flexural strength value of SFLMC for 28$^{th}$ day is 9.16 N/mm$^2$, which, is the highest value obtained for all the castings.

TABLE VI. Flexural strength test values

| TYPE OF MIX | 7 DAYS | 28 DAYS |
|---|---|---|
| CC | 6.04 | 7.86 |
| LMC | 7.01 | 8.00 |
| SFRC | 6.22 | 7.11 |
| SFLMC | 5.78 | 9.16 |

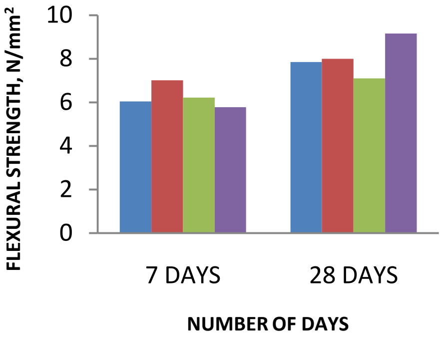


FIGURE III. Flexural strength values Vs number of days

## IV. DISCUSSION

From the above test results, the following observations have been made,

(i) The addition of latex helps in achieving the highest values for 7 days testing of specimens for compression, tension and flexure.
(ii) It can be said that, latex helps in increasing the early strength of concrete.
(iii) A good workability has been achieved for SFLMC. This has been achieved due to the super plasticizer Glenium, the usage of latex and steel fibres.
(iv) It can also be seen clearly that, latex and steel fibres help in achieving a good strength when tested for tension and flexure.
(v) Also the addition of silica fume improves microstructure of concrete which is also helpful to enhance all the properties along with its durability.
(vi) It was also observed during testing that the specimens did not fail suddenly. Very few cracks were observed on the specimens.

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