Experimental Investigation of SBR- Latex modified Steel Fiber Reinforced Concrete

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Abstract

The present investigation is aimed to study the behaviour of convectional concrete (M25 Grade of concrete), SBR-latex modified convectional concrete (SBR-latex combined with M25 Grade of concrete), steel fiber reinforced concrete (steel fibers combined with M25 Grade of concrete) and SBR-latex modified steel fiber reinforced concrete (SBR-latex and steel fibers combined with M25 Grade of concrete). The experimental study has been made to obtain strength characteristics of above said matrix in compressive strength, split tensile strength and flexural strength.

From the above study it is observed that the concrete added with fiber and latex behaved much better with regards to higher first crack load and ultimate load and also lesser deflection . This is due to compactness achieved due to latex and fiber filling in concrete matrix.

Keywords:SBR-Latex reinforcedconcrete, *compressive strenth, flexural strength, split tensile strength,silica fumes,steel fibers.*

1. Introduction

In reviewing technology advances through the centuries, it is evident that material development plays a key role. Considerable efforts are still being made in every part of the world to develop new construction materials. In the construction industry, concrete technology is heading towards entirely new era by way of using polymers and fibers along with Super plasticizer in concrete. Increasing interest is being shown in the area of new materials in the past decade. This is quite understandable because, it is slowly, but increasingly being recognized that economic progress in construction depends more on an intelligent use of the materials and constant improvement of available materials than on extreme refinements of structural analysis.

Concrete is probably the most widely used material in the world in view of its strength, structural stability, durability, economic considerations and low level maintenance and Portland cement, probably the most important constituent of concrete, is a versatile and relatively low cost material. With the extensive use of cement for widely varying conditions, technologists catered to the needs of the construction industries for specific purposes. Some of the admixtures presently being used include pozzolanas, retarders, accelerators etc.

Concrete is usually characterized by its compressive strength. It has been observed that microstructure is very important for the macro performance. The versatility of concrete as a building material pushed the research into improving rather old material, the demand for taller reinforced concrete structures which increase the quest for higher concrete strength. This was facilitated by the introduction of super plasticizers along with the use of admixtures the most significant of these properties is to increase the compressive strength of concrete.

Further, high performance concrete structures, unlike steel structures, tend to fracture or fail in a relatively brittle fashion, as the ductility or deformation capacity of concrete is limited. In such structures the brittle failure as a result of inelastic deformation can be avoided only if the concrete is made to behave in a ductile manner so that the member can absorb and dissipate large amount of energy.

Hence, many studies have been carried out to explore the mechanical properties and strength characteristics of fiber reinforced concrete. The primary role of fibers in hardened concrete is to modify the cracking mechanism. By modifying the cracking mechanism, the macro cracking becomes micro cracking. The cracks are smaller in width thus reducing the permeability of concrete and the ultimate cracking strain of the concrete is enhanced. The fibers are capable of carrying a load across the crack. A major advantage of using fiber reinforced concrete (FRC) besides reducing permeability and increasing fatigue strength is that fiber addition improves the toughness and load carrying ability after the first crack in flexure behavior.

1.1 Fiber Reinforced Concrete

Fiber reinforced concrete is the concrete made of hydraulic cement, containing fine or fine and coarse aggregate and discontinuous discrete fibers. Mainly steel fiber is currently being used as concrete reinforcement in present investigation. Inclusion of randomly distributed steel fibers has been found to enhance the tensile strength and fracture toughness of cementatious materials significantly these improvements can be attributed to the arrest of micro cracks by fibers and also to the restraint against widening of cracks provided by the fibers bridging these cracks.

1.2. Polymer (Latex) Concrete Composites

Polymer (Styrene Butane Rubber –SBR) Latex modification is governed by both cement hydration and polymer film formation processes in their binder phase, a co-matrix is formed by both processes. Although, the inclusion of polymers especially in latex form improve the consistency of the composite in fresh state. In the hardened state, mortars and concrete show a noticeable increase in flexural strength, adhesion, extensibility, water proofness and bond strength, impermeability and durability, ductility and vibration damping capacity of concrete member as compared to ordinary cement ,therefore polymer admixtures produce effects in fresh and hardened state properties.

1.3 Latex Modified Steel Reinforced Concrete

In recent years latex modified mortars and concrete have been used widely as construction materials because of their improved properties of high strength, extensibility, adhesion, water proofness and durability. In general latex modified concrete show noticeable increase in tensile strength, adhesion, bond strength, impermeability and durability, etc. Latex modified steel fiber reinforced concrete is made of hydraulic cement, containing fine and coarse aggregate, discontinuous discrete fibers and polymer (SBR-latex).

When fibers and polymer are added to conventional concrete they improve mechanical properties of conventional concrete significantly. Recent test on polymer modified steel fiber concrete indicate that they are more durable.

2. Experimental investigation

A series of specimens are chosen for the investigation and all are having a unique nominal sectional dimensions for cubes 150 X 150 mm, cylinders 150 mm dia. and 300mm height and prisms 100 X 100 X 500mm respectively.

Plain cement concrete (M25 grade of concrete).

Plain cement concrete with Styrene butadiene Rubber latex (M25 + SBR-latex).

Plain cement concrete with Steel fibers (M25 + Steel fibers).

Plain cement concrete with steel fibers and Styrene Butadiene Rubber Latex (M25 + steel fibers + SBR-latex).

The details of experimental studies including characterization are presented below.

2.1. Materials used

Ordinary Portland Cement (OPC) was used for all the test specimens.Silica is added to reduce the dosage of chemical admixtures needed to get required slump. 12 mm nominal maximum aggregate is used as coarse aggregate and fine aggregate is the natural sand free from impurities.

The properties of steel fibers are shown in table 1.

Table 1: Properties of Steel Fibers

Type	Crimped round
Length	36mm
Diameter	0.45mm
Aspect ratio	80

The properties of the SBR Latex are given in the table 2.

Table 2: properties of the SBR Latex

Polymer Type	Styrene Butadiene 68 ± 3% Styrene 32 ± 3% Butadiene
Average Polymer Particle Size	1500 to 2500 Angstroms
Emulsion Stabilizers	Anionic and non-ionic surfactants
Percent Solids	46.20
Weight per liter, Kg at 25°C	1.005 to 1.039
Ph	9.5 to 10.50
Color	White

3. Mix Proportioning

A concrete mix grade of M25 is aimed, the designed mix proportion is obtained by IS method of mix design. Then to the target strength of designed mix obtained, the steel fiber and latex are added. Various trial mixes were carried out to obtain optimum dosage of super plasticizer, silica fume and steel fiber with regards to get required workability. A detailed study on mix proportion has been carried. For SBR+M25 the mix ratio adopted is 1: 1.21: 2.07 with w/b ratio of 0.44., and 10% SBR-latex by weight of binder was added to the mix. For SF+M25, the suitable mix ratio adopted is 1: 1.21: 2.07 with w/b ratio of 0.44, and steel fiber content was 0.75% by volume is incorporated. For SBR+SF+M25, the suitable mix ratio adopted is 1: 1.21: 2.07 with w/b ratio of 0.44., 15% SBR-latex by weight of binder was added to the mix and steel fiber content was 0.75% by volume is incorporated and in all above mixes 7% of silica fume was added as a partial replacement for cement to mix super plasticizer (Glenium-51) was added in the ratio of 1% of binder.

4. Significance And Kind Of Strength

In engineering practice the strength of hardened concrete are Compressive strength, Split tensile strength and Flexural strength
Among all, the compressive strength is generally considered as most important property of concrete and gives overall picture of quality of concrete.
In the present study Compressive strength, Split tensile strength & flexural strength are taken in to account.

4.1 Compressive Strength:

Most concrete structures all designed under all assumption that the concrete develops compressive stresses but not tensile stresses. The compressive strength is the main criteria for the purpose of structural design, the compression tests are relatively easy to carry out.
The test for determining compressive strength for concrete employs a cube specimen of 150mm size and cured for 3, 7, and 28 days which is subjected to uniaxial compression in a compression testing machine.

4.2 Splitting Tension:

This is an indirect test for tensile strength of concrete. The tensile strength of concrete can be obtained indirectly by subjecting the concrete cylinder to the action of a compressive force along two opposite ends of base plate of compression testing machine. Due to the compressive force the cylinder is subjected to a large magnitude of compressive stress near the loading region. The large portion corresponding to a depth of about 87% and length of the cylinder is subjected to a uniform tensile stress acting horizontally. The specimen is a 150Φx300mm cylinder made and cured in the same manner as similar to compressive test. The tensile strength computed in this manner is apparently about 15% higher than that determined by direct tension tests.

4.3 Flexural Strength:

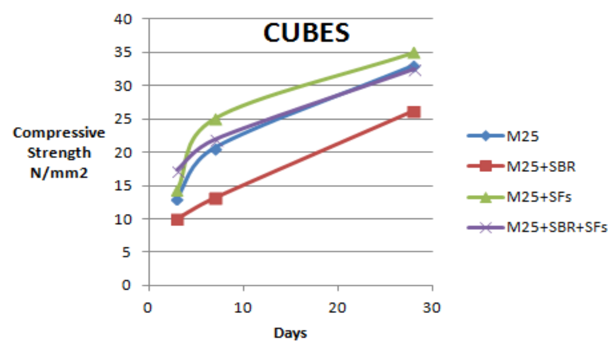
When concrete is subjected to bending, tensile and compressive stresses in many cases direct shearing stresses occur. The most common example of concrete structure subjected to flexure are highway pavements and the strength of concrete for pavements is commonly evaluated by means of bending tests on 100x100x500mm beam specimens. Flexural strength is expressed in terms of "Modulus of rupture" which is the maximum tensile (or compressive) stress at rupture.

5. Casting and testing of specimens

Total 108 specimens(cubes, cylinders and prisms) were casted and tested after 3, 7 and 28 days.
The primary variables considered for the study are
(i) Plain cement concrete (M25 grade of concrete).
(ii)Plain cement concrete with Styrene butadiene Rubber latex (M25 + SBR-latex).
(iii)Plain cement concrete with Steel fibers (M25 + Steel fibers).
(iv)Plain cement concrete with steel fibers and Styrene Butadiene Rubber Latex (M25 + steel fibers + SBR-latex).

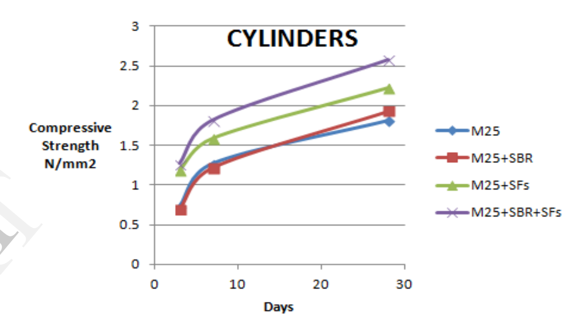
Fig 1:Ttesting of cube

Fig 2: Testing of cylinder

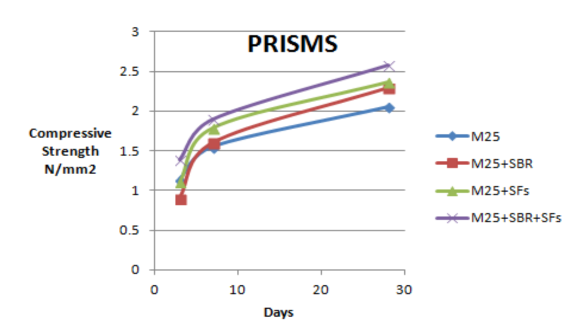


Graph 1: Variation of compressive strength with age

Fig 3: Testing of cylinder



Graph 2: Variation of split tensile strength with age



Graph 3: Variation of flexural strength with age

5.1 Test Readings Of Specimen

The average test readings of the soecimens for 3, 7 and 28 days are shown in table **3.**

Table 3:test results of the specimens

Properties	Age	M25	M25+SBR	M25+SFs	M25+SBR+SFs
Compressive strength (N/mm^2)	3 days	13.13	10	14.33	17.3
	7 days	20.66	13.16	25.1	21.9
	28 days	33	26.16	35	32.5
Split tensile strength (N/mm^2)	3 days	0.73	0.69	1.19	1.27
	7 days	1.27	1.22	1.59	1.82
	28 days	1.81	1.93	2.22	2.58
Flexural strength (N/mm^2)	3 days	1.14	0.9	1.11	1.39
	7 days	1.55	1.6	1.79	1.9
	28 days	2.05	2.29	2.36	2.58

6. Conclusions

1. A number of variables can cause changes in the physical and mechanical behavior of concrete. These include the composition of concrete mix, type of aggregate and their shape, admixtures and addition of fibers and other complementary reinforcement.
2. Among the four mixes in the present investigation namely M25, SBR+M25, SF+M25 and SBR+SF+M25, the compressive strength obtained at 28 days are 33Mpa, 26.16Mpa, 35 Mpa and 32Mpa respectively. In case of SBR-latex modified concrete there is decrease in compressive strength. This is due to lower density of latex with regards to matrix density (mortar rheology). Moreover the combination of SBR-latex and steel fiber showed an increase in compressive strength.
3. It is experimentally observed that the SBR+SF+M25`has considerable amount of increased in flexural strength as compared to other matrix used. This is because due to the compactness that is filling of voids in the matrix achieved due to latex and fiber filling in the concrete matrix.

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