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Study on properties of concrete with addition of SBR and Steel Fiber

Rajan L. Wankhade, Amarsinh B. Landage
Government College of Engineering, Karad-415124, India
Email: rajanw04@gmail.com, amarlandage@yahoo.co.in

Abstract*—Steel fibers are now days commonly used in concrete as due to addition of these fibers considerable strength is achieved. Fiber reinforced concrete possesses desirable properties like high compressive strength, stiffness and durability under usual environmental condition. In the present work, experimental test are carried out on SBR and steel fiber reinforced concrete to calculate flexural strength on beam, spilt tensile strength on cylinder. Casting of the specimen is done in laboratory using different % of polymer (styrene butadiene rubber) with varying the hooked end steel fiber. It is observed that by changing the % steel fibers and SBR concrete a strong cement hydrate- aggregate bond is developed. Also micro cracks are bridged by the polymer film on membranes which prevent cracks propagation. As observed flexural and bond strength of concrete is increased with the addition of steel fiber and SBR.

Keywords—High strength concrete, styrene butadiene rubber, steel fibers.

1. Introduction

Concrete is used as construction material as it is having several desirable properties like high compressive strength, stiffness and durability. Plain concrete has two deficiencies, low tensile strength and a low strain at fracture and hence addition of fibers is desirable. Reinforcement consists of continuous deformed steel bars or pre-stressing tendons. The advantage of reinforcing and pre-stressing technology utilizing steel reinforcement as high tensile steel wires have helps in improving the capacity of concrete in tension. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate (usually made from different types of sand and gravel), that is bonded together by cement and water.

The other major part of concrete besides the cement is the aggregate. Aggregates include sand, crushed stone, gravel, slag, ashes, burned shale, and burned clay. Fine aggregate (fine refers to the size of aggregate) is used in making concrete slabs and smooth surfaces. Kardon gives a brief review on Polymer-Modified Concrete. Rodwell further provided use of Synthetic Rubber Latexes for Polymer modified systems as advancements. Geist et al. Performed study of Polyvinyl acetate in Modified Polymer mortar. Dikeou and Cowan performed study on concrete polymer Materials. Shibazaki used properties of Masonry Cement Modified with water soluble Polymers for his work. Bing and Liu investigated mechanical properties of polymer-modified concrete which contains expanded polystyrene beads. Further Gengying et al performed work to study properties of polymer modified steel fiber-reinforced cement concretes. After Kurugo and Tanac calculated Youngȏs modulus of fiber-reinforced and polymer-modified lightweight concrete composites. Ribeiro et al provided Mix design process of polyester polymer mortars modified with recycled GFRP waste materials. In the present work flexure test and split tensile test are performed on concrete with SBR and steel fibers

2. Polymer Modified Concrete

Polymer modified concrete (PMC) has at times been called polymer Portland cement concrete (PPCC) and latex modified concrete (LMC). It is defined as Portland cement and aggregate combined at the time of mixing with organic polymer that are dispersed or re-dispersed in the water. As the cement are hydrate coalescence of the polymer occur resulting in the co-matrix of hydrated cement and polymer film throughout the concrete.
A wide variety of polymer type has been investigated for use in PMC, the major types in use todayȏs are as follows:

- Styrene-butadiene copolymer (S-B)
- Acrylic ester photopolymers (PAE) and copolymers, particular with styrene (S-A)
- Vinyl acetate copolymer (VAC)
- Vinyl acetate homo-polymers (PVAC)

The selection of the polymer depends on the service life requirements and cost. It should be noted that PVAC should not be used where the PMC will be exposed to moist condition. Essentially, mixing and handling of PMC is similar to conventional to Portland cement concrete (PCC). Short mixing time is recommended to ensure the acceptable air content and, because of good adhesion exhibits by PMC; prompt cleanup of mixing equipment is suggested. Curing of PMC is different from PCC in that extended moist curing is not required. In fact, moist curing beyond 24 to 48 hr. is not recommended because it slows the coalescence or formation of the polymer film retards the loss of water from concrete thus making it available for hydration of cement. Moist curing of PMC is required during the early stage of cure to prevent the occurrence of plastic-shrinkage cracks.

3. Experimental Results

The splt tensile strength and flexure strength of concrete is tested for normal concrete specimen and constant content of 15% polymer (styrene butadiene rubber) with different percentage of steel fiber from 1% to 10% by weight of cementThe tests are conducted on UTM and results are shown in table.

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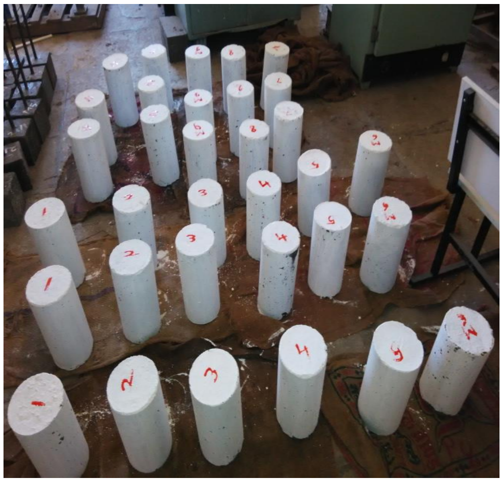

(a)

(b)

(c)

Figure 1. Split Tensile test

(a)

(b)

(c)

Figure 2. Flexure test on Beam

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Table 1. Stress and Strain (b)

Sr. No	Stress	Strain	Stress	Strai	Stress	Strain	Stress	Strai
	15%P+3%S		15%P+4%S		15%P+5%S		15%P+6%S	
1	4.36	0.0035	4.36	0.0041	4.36	0.005	4.36	0.0052
2	8.72	0.0053	8.72	0.0064	8.72	0.0074	8.72	0.0080
3	13.08	0.0068	13.08	0.0080	13.08	0.0088	13.08	0.0096
4	17.44	0.0084	17.44	0.0094	17.44	0.0104	17.44	0.0114
5	21.8	0.0098	21.8	0.0111	21.8	0.0117	21.8	0.0131
6	26.16	0.0114	26.16	0.0126	26.16	0.0132	26.16	0.0156
7	30.52	0.0131	30.52	0.0156	30.52	0.0146	30.52	0.0175
8	34.88	0.0143	34.88	0.0171	34.88	0.0164	34.88	0.0201
9	39.24	0.0160	39.24	0.0181	39.24	0.0191	37.64	0.0215
10	40.838	0.0181	39.385	0.0182	41.12	0.0207	34.88	0.0217
11	39.24	0.0183	39.24	0.0184	39.24	0.0213	30.52	0.0218
12	34.88	0.019	34.88	0.0185	34.88	0.0233	26.16	0.0220
13	30.52	0.0209	30.52	0.0188	30.52	0.0243	21.8	0.0226
14	26.16	0.0221	26.16	0.0196	26.16	0.0247	17.44	0.0237
15	21.8	0.0232	21.8	0.0215	21.8	0.0253	13.08	0.025
16	17.44	0.0248	17.44	0.0229	17.44	0.0261	8.72	0.0262
17	13.08	0.0268	13.08	0.0244	13.08	0.0272	4.36	0.0280
18	8.72	0.0282	8.72	0.0270	8.72	0.0292	0	0.0306
19	4.36	0.0291	4.36	0.0279	4.36	0.0306		
20	0	0.0309	0	0.0293	0	0.0321		

Table 2. Stress and Strain table no 4.5 (c).

Sr. No	Stress	Strain	Stress	Strain	Stress	Strain	Stress	Strain
	15%P+7%S		15%P+8%S		15%P+9%S		15%P+10%S	
1	4.36	0.0033	4.36	0.0046	4.36	0.0061	4.36	0.0066
2	8.72	0.0056	8.72	0.0068	8.72	0.0077	8.72	0.0080
3	13.08	0.0081	13.08	0.0090	13.08	0.0092	13.08	0.0108
4	17.44	0.0108	17.44	0.0108	17.44	0.0106	17.44	0.0108
5	21.8	0.0132	21.8	0.0132	21.8	0.012	21.8	0.0128
6	26.16	0.0156	26.16	0.0157	26.16	0.0137	26.16	0.0149
7	30.52	0.0188	30.52	0.0194	30.52	0.0154	30.52	0.0171
8	34.88	0.0226	34.88	0.0231	34.88	0.0195	34.73	0.0208
9	36.91	0.0232	36.188	0.0234	35.45	0.0198	30.52	0.0216
10	34.88	0.0237	34.88	0.0237	34.88	0.0204	26.16	0.0226
11	30.52	0.0254	30.52	0.0246	30.52	0.0207	21.8	0.0234
12	26.16	0.0266	26.16	0.0248	26.16	0.0222	17.44	0.0245
13	21.8	0.0288	21.8	0.0256	21.8	0.0232	13.08	0.0258
14	17.44	0.0304	17.44	0.0267	17.44	0.0243	8.72	0.0273
15	13.08	0.0316	13.08	0.0282	13.08	0.0254	4.36	0.0298
16	8.72	0.0338	8.72	0.0296	8.72	0.0268	0	0.0317
17	4.36	0.0347	4.36	0.0329	4.36	0.0277		
18	0	0.0358	0	0.0349	0	0.0286		

From the above table it is observed that as the percentage of steel fiber with 15 % of constant polymer content concrete, the compression strength is more than that of polymer concrete and as the percentage of steel fiber (from 1% to 10 %).

4. Flexure Strength

The specimens are casted as normal concrete and constant content of 15% polymer with variation in steel percentage (1% to 10%) by weight of cement, tests are conducted on UTM and result is shown in table.

The strength is calculated using following relation

$$\text{Flexure strength } (\mathring{u}) = \frac{PL}{bd^2}$$

Where,

ů = Compression strength
P = Maximum load at which beam is failed, in N
b = width of beam in mm
d = depth of beam in mm
l = span of beam

Table 3. Flexure strength

Sr. No	Mix Proportion	Load (KN)	Flexure strength (N/mm^2)
1	NC	18.5	7.4
2	NC+15%Polymer	19.87	7.94
3	NC+15%Polymer +1% Steel fiber	20.3	8.2
4	NC+15%Polymer +2% Steel fiber	20.70	8.28
5	NC+15%Polymer +3% Steel fiber	21.53	8.61
6	NC+15%Polymer +4% Steel fiber	21.70	8.69
7	NC+15%Polymer +5% Steel fiber	22.4	8.96
8	NC+15%Polymer +6% Steel fiber	22.61	9.04
9	NC+15%Polymer +7% Steel fiber	23.43	9.37
10	NC+15%Polymer +8% Steel fiber	24.3	9.72
11	NC+15%Polymer +9% Steel fiber	24.93	9.97
12	NC+15%Polymer +10% Steel fiber	25.97	10.39

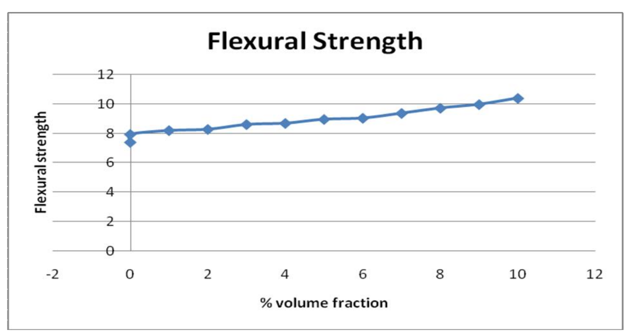

Figure 3 : Flexural strength for different % volume fraction

Enhancement in the compressive strength of the concrete is observed after addition of steel fiber up to 2%. After another

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From above graph and table it is observed that with addition of polymer there will be increase in the tensile strength as compare to normal concrete. After addition of the steelfiber content (from 1% to 10 %). in polymerconcrete there is increase in the tensile strength

5. Split Tensile Strength

The test are conducted on C.T.M the concrete is casted of 15% constant polymer with various percentage of steel fiber (1% to 10%) and normal concrete specimen, result are shown in table and calculated from following equation,

$$\text{Tensile strength } (ů) = \frac{2P}{\pi DL}$$

Where,

ů = Tensile strength in N/mm^2

P = Compressive Line Load at failure in N.

L = Length of cylinder in mm.

D= Diameter of cylinder in mm.

Table no 4.7

Sr. No	Mix Proportion	Load (KN)	Tensile strength (N/mm^2)
1	NC	23.67	3.283
2	NC+15%Polymer	28	3.8836
3	NC+15%Polymer +1% Steel fiber	29.67	4.115
4	NC+15%Polymer +2% Steel fiber	30.67	4.254
5	NC+15%Polymer +3% Steel fiber	31.33	4.345
6	NC+15%Polymer +4% Steel fiber	32.33	4.484
7	NC+15%Polymer +5% Steel fiber	33.67	4.6233
8	NC+15%Polymer +6% Steel fiber	34	4.7158
9	NC+15%Polymer +7% Steel fiber	34.33	4.808
10	NC+15%Polymer +8% Steel fiber	35.33	4.9
11	NC+15%Polymer +9% Steel fiber	35.67	4.947
12	NC+15%Polymer +10% Steel fiber	36.33	5.0389

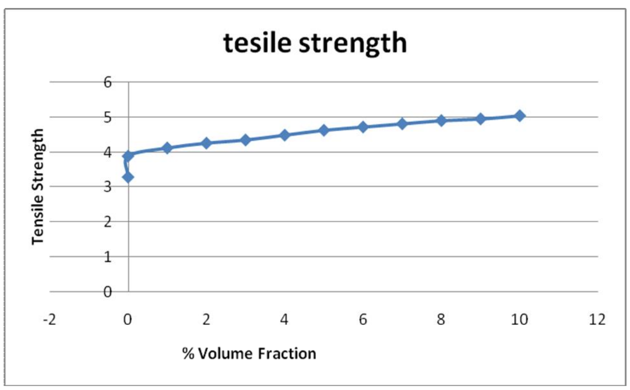

Figure 4. Tensile strength

From graphs and table it is observed that tensile strength of normal concrete is less. With addition of polymer and steel fiber from 1% to 10% there is increase in tensile strength.

6 Bond Strength

The specimen are casted for normal concrete and 15% polymer with various steel fiber percentage (1% to 10%)and test is conducted on U.T.M and. test results are shown in table and strength is calculated on the basis of following equation,

$$\text{Bond strength } (ů) = \frac{P}{\pi DL}$$

Where,

ů = Bond strength in N/mm^2

P = Pull out Load at failure in N.

L = Embedded length of bar in concrete, mm.

D= Diameter of bar in mm.

Table no 4.8

Sr. No	Mix Proportion	Load (KN)	Bond strength (N/mm^2)	Pull-out length (mm)
1	NC	71.33	9.45	7.7
2	NC+15%Polymer	82.67	10.96	10.6
3	NC+15%Polymer +1% Steel fiber	77.33	10.25	8
4	NC+15%Polymer +2% Steel fiber	84.33	11.18	8.3
5	NC+15%Polymer +3% Steel fiber	87.33	11.57	8.7
6	NC+15%Polymer +4% Steel fiber	96.33	12.64	8.2
7	NC+15%Polymer +5% Steel fiber	98.66	13.08	8.8
8	NC+15%Polymer +6% Steel fiber	101.33	13.43	11.2
9	NC+15%Polymer +7% Steel fiber	97.67	12.95	8.5
10	NC+15%Polymer +8% Steel fiber	90.67	12.02	6.3
11	NC+15%Polymer +9% Steel fiber	86.33	11.45	6.7
12	NC+15%Polymer +10% Steel fiber	79.33	10.52	6.6

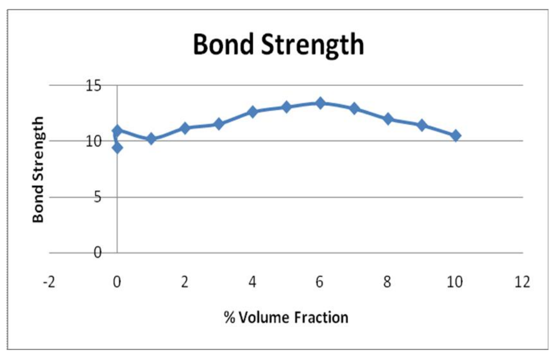

Figure 5. Bond Strength

From above graph and table it is observed that with addition of polymer there will be increase in the bond strength as compare to normal concrete. There is decrease in bond strength with addition of 1% of steel fiber content as compare to polymer concrete. There is enhancement in the bond strength of the concrete after addition of steel fiber from 2% to up to 6%. After another increase in the steel fiber from 7% to 10% there will be decrease in bond strength.

7. Conclusion

It is observed that with the percentage of steel fiber as 15 % of constant polymer content concrete, the compression strength is more than that of polymer concrete and as the percentage of steel fiber (from 1% to 10 %). With addition of polymer there will be increase in the tensile strength as compare to normal concrete. There is decrease in bond strength with addition of 1% of steel fiber content as compare to polymer concrete. There is enhancement in the bond strength of the concrete after addition of steel fiber from 2% to up to 6%. After another increase in the steel fiber from 7% to 10% there will be decrease in bond strength.

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