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Performance Analysis of Styrene Butadiene Rubber-Latex on Cement Concrete Mixes.

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ABSTRACT

To improve the performance of concrete, polymers are mixed with concrete. It has been observed that polymer-modified concrete (PMC) is more durable than conventional concrete due to superior strength and high durability. In this research, effect of Styrene-Butadiene Rubber (SBR) latex on compressive strength and flexural strength of concrete has been studied and also the optimum polymer (SBR-Latex) content for concrete is calculated. This research was carried out to establish the effects of polymer addition on compressive and flexural strength using concrete with mix design of constant water-cement ratio at local ambient temperature. The mixes were prepared with Styrene-Butadiene Rubber (SBR) latex -cement ratio of 0 %, 5%, 10%, 15% and 20%. Slump test was conducted on fresh concrete while compressive strength and flexural strength were determined at different age. A locally available Perma-Latex is used as SBR Latex. It has been observed that SBR latex has negative effect at early age while at 28 days, the addition of SBR latex in concrete results in enhancement of compressive strength and Flexural Strength. Based on the results of this study, latex modified concrete made using Perma-Latex may be recommended to be used with various types of concrete structures. However, for the mixes rich in cement, the dosage of SBR latex needs to be adjusted to maintain required workability of concrete.

Key words: Concrete; SBR Latex; slump; compressive strength; Flexural Strength.

I. INTRODUCTION

Concrete is the most extensively used construction material all over the world due to economy and easy availability of its constituents. To improve the durability of concrete structures, the internal structure of concrete must be improved to make it impervious. Due to the formation of three dimensional polymer network in the hardened cement based matrices, polymer cement concretes have high tensile strength, good ductile behavior, and high impact resistance capability (Sakai and Sugita, 1995). Consequently, the porosity is decreased and pore radius is refined because of the void filling effect of this network. In addition to this, improvement in the transition zone as a result of the adhesion of a polymer is also obtained (Silvaa et al. 2001; Ohama et al. 1991; Chandra and Flodin, 1987). In the last two decades, many research studies have been carried out on the use of different polymers suitable for admixing into fresh concrete to improve the mechanical properties, among them styrene butadiene rubber (SBR) latex has been widely used in the past (Joao and Marcos, 2002; Ru W. et al., 2006; Zhengxian Y. et al., 2009; Baoshan H. et al., 2010). Latex is a polymer system formed by the emulsion polymerization of monomers and it contains 50% solids by weight. Styrene butadiene, polyvinyl acetate, acrylic and natural rubbers are the best examples of polymers which are usually used in latex. Since mechanical properties, hydration process in cement and durability of concrete are highly dependent on the state of micro-structure, previous research studies have shown that the polymer as modifier is promising in improving micro-structure of concrete (Lewis and Lewis, 1990; Ohama, 1997).

Styrene butadiene rubber (SBR) latex is a type of high-polymer dispersion emulsion composed of butadiene, styrene and water and it can be successfully bonded to many materials. Due to its good intermiscibility with vinyl pyridine latex for fabric dipping, its major engineering application is in tire dip fabric industry. In civil engineering field, it is used to replace cement as binder to improve tensile, flexural and compressive strengths of concrete. SBR is white thick liquid in appearance; it has good viscosity with 52.7% water content (Baoshan H. et al., 2010).

In this present contribution, the effect of adding locally available SBR latex known as Perma-Latex on compressive and flexural strength of normal strength concrete has been investigated. In cement based composites, water absorption is an important parameter as it is a measure of resistance against carbonation migration. Water absorption value indirectly provides information about the porosity of concrete. Compressive strength and flexural strength development of the concrete in the presence of SBR latex was studied at 7, 14 and 28 days of age and compared to normal concrete mix.

II. MATERIALS AND METHODS

The cement used was Ordinary Portland Cement Grade 43 (OPC) supplied by A.C.C Manufacturing Company, which complies with IS 8112:2013. The cement is in dry powdery form with the good chemical compositions and physical characteristics. Locally available Narmada river sand and crushed stone were used as fine and coarse aggregates, respectively. The properties of fine and coarse aggregates are given in Table 1. Locally available polymer 'Perma-Latex' was investigated in this study. Perma-Latex is a type of Styrene butadiene rubber (SBR) latex. The composition of the Perma-Latex used as polymer is given in Table 2.

Table 1: Properties of fine and coarse aggregates.

Properties	Fine Aggregates	Coarse Aggregate
Specific Gravity	2.60	2.70
Water Absorption	1.50	0.50
Specific Gravity of cement	3.15	
Free Surface Moisture	2	1

Table 2: Polymer Latex used in this study

Type	Styrene Butadiene Rubber
Form	White Liquid
Density	1Kg/L at 25^0
Solid Content	50%
Chloride Content	50%

III. Mix Design

The desired characteristic strength of 30 N/mm^2 at 28 days was used in this study. IS 456 method was applied in designing the mix. A total of 45 cubes and 30 beams were prepared for this study in 5 sets. All set were prepared in control mix in w/c = 0.42. 3 samples from each set of the mix were tested at the age of 7, 14, and 28 days for compressive strength and 7 and 28 days for flexural strength.

Latex Modified Concrete (LMC):

In this research, latex modified concrete compositions containing 5%, 10%, 15% and 20% SBR latex by weight of cement were prepared. Concrete cubes and beams were cast using these latex modified concrete to perform compressive strength and flexural strength tests. Since the SBR latex used in this study contained 50% of water, the slump cone test is also performed to calculate the workability of each mix.

Sample Preparation:

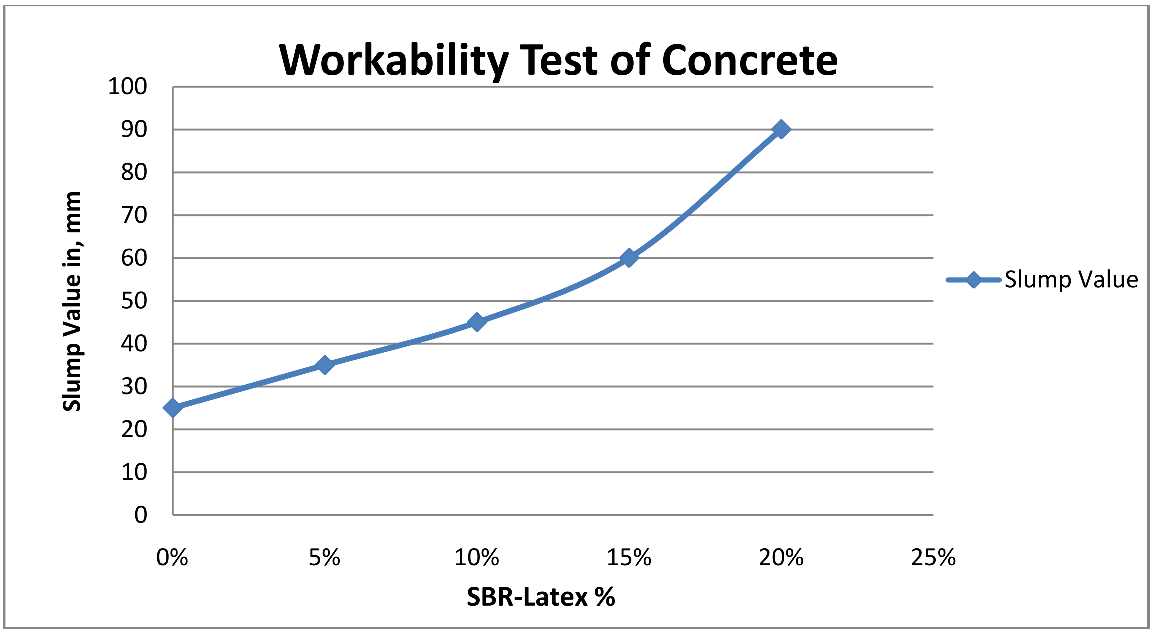
All concrete mixes were prepared using a mechanical mixer. Cube specimens of 15 ×15×15 cms and Beam specimen of 10×10×50 cms were cast. The specimens were cured in a curing room at 30ºC temperature and 90% relative humidity. Latex modified concretes were tested at 7, 14 and 28 days of age to get compressive strength and 7 and 14 days for flexural strength values.

Figure-1: Mixing of Aggregates

Figure-2: Slump cone test (workability)

Details of specimens used for mix design proportion of 1:1.27:2.83 with constant water cement ratio:
1. 150mm x 150mm x 150mm Cube specimens for Compressive strength.
2. 100mm x 100mm x 500mm Beam specimens are used for Flexural Strength test.

Cube Specimen				Beam Specimen				Slump Value (mm)
S.No	**Cube Sample name**	**% of SBR Latex**	**Weight of SBR latex in mix (gm)**	**S.No**	**Beam Samplez name**	**% of SBR Latex**	**Weight of SBR latex in mix (gm)**	
1	P 0	0	0	1	B 0	0	0	**25**
2	P 5	5	80	2	B 5	5	117	**35**
3	P 10	10	160	3	B 10	10	234	**45**
4	P 15	15	240	4	B 15	15	351	**60**
5	P 20	20	320	5	B 20	20	468	**90**



Graph – 1: Workability test of concrete mix with different percentage of SBR-Latex

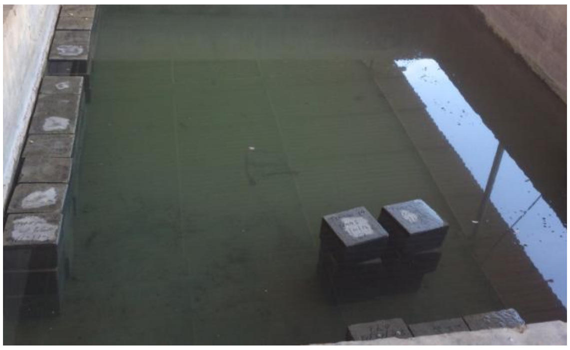


Figure-3: Curing of Specimens

Figure-4: Specimen Prepared for test

Testing methodology (Compressive & Flexural strength):

The compressive strength and flexural strength of all concrete compositions was determined following Indian standard testing procedure [IS 516:1959]. The compressive strength tests were conducted on a Compression testing machine and flexural strength was carried on third point loading machine. For each concrete composition three cube specimens were tested for compressive strength and three beams specimen where tested for flexural strength. In this paper, average value of samples has been reported.

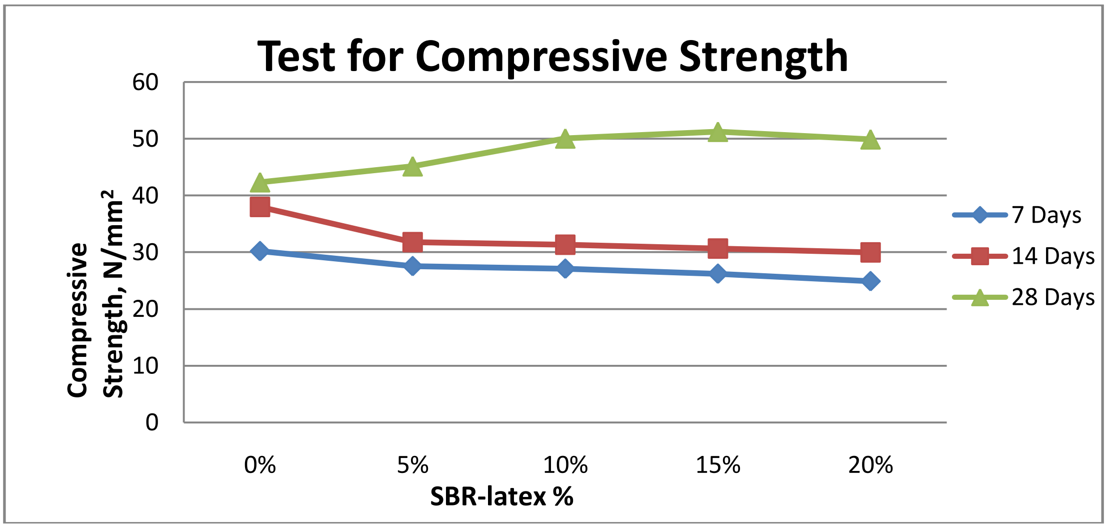
Figure-5: Beam Specimen Third point loading arrangement. (Flexural strength test).

Figure-6: Cube Specimen compressive strength test.

IV. Test Results & Discussion

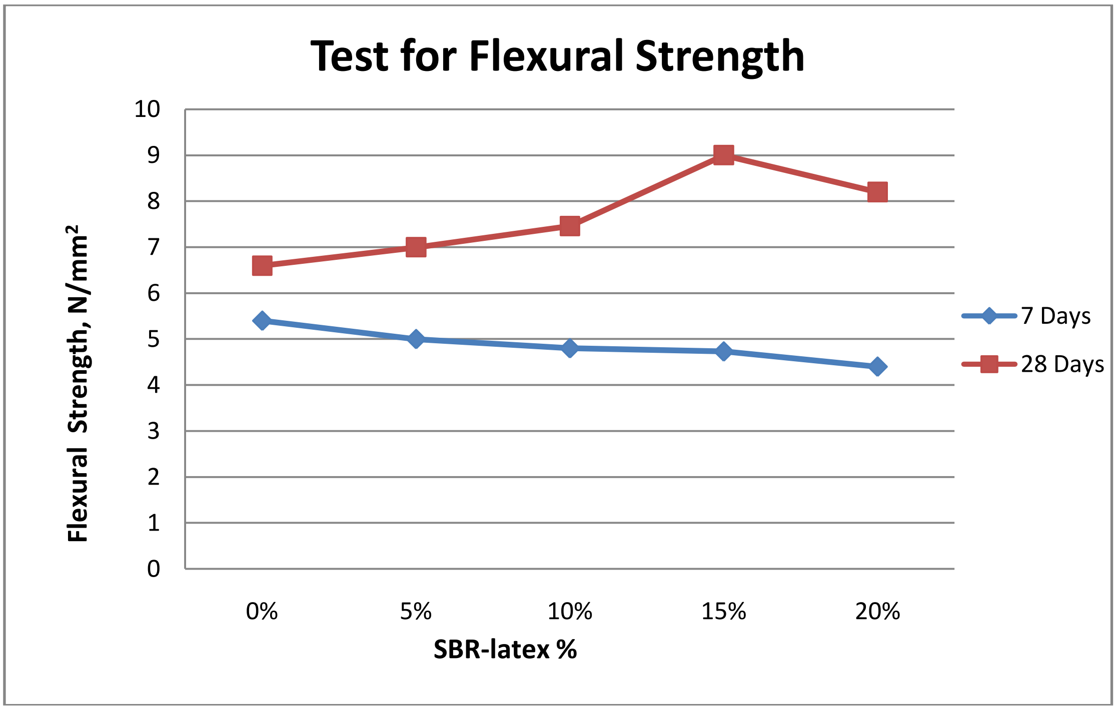
Slump tests were performed on each concretes mixes and the results are presented in Graph.1. It is obvious in this Graph that, the addition of SBR Latex increases slump value of concrete. This shows that SBR latex has plasticizing effect due to which workability of concrete is increased. In some cases, higher value of slump is not desirable as it will result in segregation. Consequently, mechanical properties of resulting concrete will be affected adversely.

The results of the compressive strength test performed as per IS 516: 1959 for Mix containing different percentage of SBR are graphically represented in Graph.2. It is observed that in case of Latex modified concrete strength is decreased with the addition of Latex at early age. On the contrary, strength of concrete is increased at 28 days of age with the addition of SBR latex. Same case is observed in flexural strength at early stage the strength is decreased on the converse, strength of concrete is increased at 28 days of age with the addition of SBR latex. The flexural strength improvement percentage is more in compared to the compressive strength by adding SBR latex.



Graph – 2: Compressive strength test of concrete mix with different percentage of SBR-Latex.

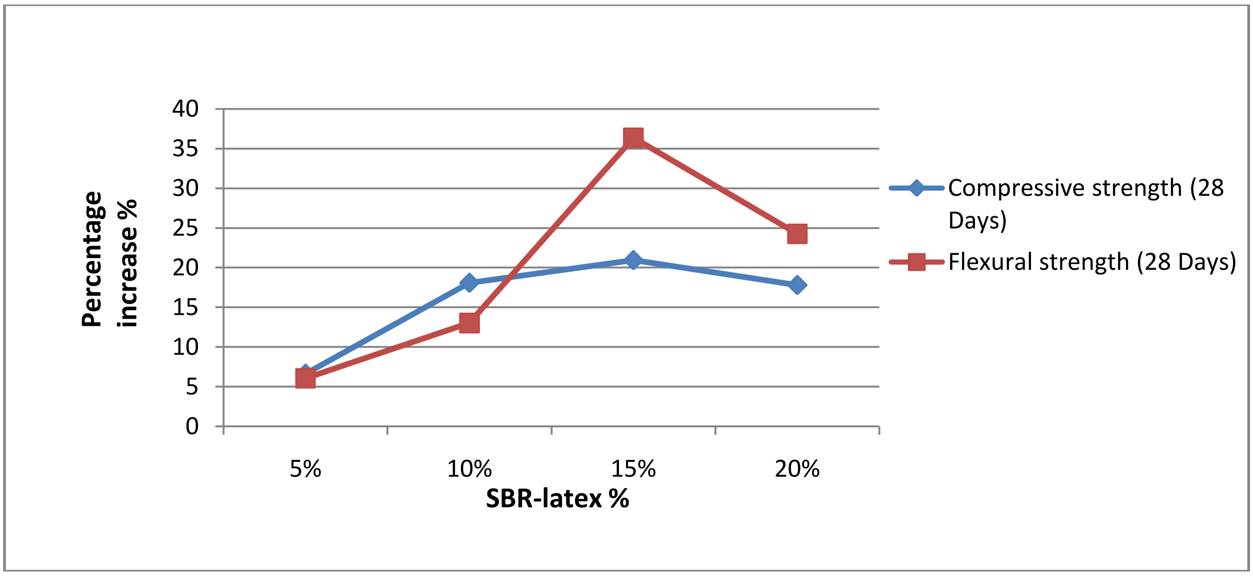
S.No	Cube Sample name	SBR latex %	7 Days strength, N/mm^2	14 Days strength, N/mm^2	28 Days strength, N/mm^2
			Average of 3 samples		
1	P0	0	30.21	37.99	42.37
2	P 5	5	27.55	31.77	45.18
3	P 10	10	27.10	31.33	50.07
4	P 15	15	26.21	30.66	51.25
5	P 20	20	24.88	29.99	49.92



Graph – 3: Flexural strength test of concrete mix with different percentage of SBR-Latex.

S.No	Beam Sample name	SBR latex %	7 Days strength, N/mm^2	28 Days strength, N/mm^2
			Average of 3 samples	
1	B0	0	5.4	6.6
2	B 5	5	5.0	7.0
3	B 10	10	4.8	7.46
4	B 15	15	4.73	9.0
5	B 20	20	4.4	8.2

Decrease and increase in the strength is due to the development of polymer film on the surface that retains the internal pressure for continuing cement hydration. In addition to this, polymers require time for the progress of polymer structure and formation of cement matrix. This polymer film matures with age; this is the reason that at 28 days of age, increase in compressive and flexural strength is registered with the addition of SBR latex. However at Early age, the development of polymer structure and cement hydration is in process of formation, consequently the effect of SBR latex addition on strength is negative.



Graph – 4: 28 Days percentage increase of strength with different percentage of SBR-Latex.

V. Conclusions

Based on the results and observations made in this experimental research study, the following conclusions are drawn:

1. By the addition of SBR latex, there is an increase in the workability of concrete as the polymer content increased.
2. The presence of SBR-Latex is proved to be effective to reduce the ingress of water in concrete. However, for the mixes rich in cement, the dosage of SBR-Latex should be so adjusted that the workability of concrete should remain in controlled limits to avoid the highly flowable concrete due to plasticizing effect of SBR latex.
3. There is an improvement in the strength of concrete as the polymer content increased in the mix of various percentage of SBR latex of concretes tested in this investigation.
4. The maximum increase in compressive strength at 15 % SBR latex content for concretes is 20.95%. However, the maximum increase in flexural strength is 36.35%.
5. It has been observed from the test results that the optimum content of SBR latex for cement concrete mix is 15% by weight of cement.
6. Due to the increase in compressive and flexural strength by mixing SBR latex, the thickness requirement of pavement should be comparatively less as compared to normal mix in same traffic conditions. Hence, the construction by SBR latex mix concrete can be more Economical.

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