



Evaluation of Compressive Strength and Water Absorption of Styrene Butadiene Rubber (SBR) Latex Modified Concrete

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ABSTRACT

In this research, effect of Styrene-Butadiene Rubber (SBR) latex on water absorption and compressive strength of concrete has been studied. A locally available "RIPSTAR-148" is used as SBR Latex.

It has been observed that SBR latex improves the internal structure of the latex modified concrete resulting in considerable reduction in the water absorption value at 28 days of age. However, at early age, the effect of SBR latex on water absorption is adverse. Same trend is noticed for the compressive strength; at 7 days of age, SBR latex has negative effect while at 28 days, the addition of SBR latex in concrete results in enhancement of compressive strength. Based on the results of this study, latex modified concrete made using "RIPSTAR-148" may be recommended to be used in RC structures in INDIA. However, for the mixes rich in cement, the dosage of "RIPSTAR-148" needs to be adjusted to maintain required workability of concrete.

Key words: Concrete; SBR Latex; slump; compressive strength; water absorption.

INTRODUCTION

Concrete is the most widely used construction material all over the world due to economy and easy availability of its constituents. To enhance 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 behaviour, and high impact resistance capability. 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 rubber 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 inter miscibility 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 “RIPSTAR”-148 on water absorption and compressive 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 development of the concrete in the presence of SBR latex was

studied at 7 and 28 days of age. Similarly, water absorption of Latex Modified Concrete (LMC) was also investigated at 7 and 28 days of age.

MATERIALS AND METHODS

Portland Pozzolana cement conforming to Indian Standards (IS:1489-1991) was used for this study. Locally available Manjara river sand and crushed stone (Quarry Crush) were used as fine and coarse aggregates, respectively. The properties of fine and coarse aggregates were determined as per specifications (IS 383-1970) and are given in Table 1. Locally available polymer “RIPSTAR”-148 latex was investigated in this study which is type of SBR latex. The composition of the “RIPSTAR”-148 used as polymer is given in Table 2.

Table 1: Properties of fine and coarse aggregates)

Properties	Fine Aggregate (River Sand)	Coarse Aggregate (Quarry crushed stone)
Fineness Modulus	3.75	7.13
Specific Gravity	2.63	2.68
Loose Bulk Density (kg/m ³)	1450	1350
Compacted Bulk Density(kg/m ³)	1710	1600
Water Absorption (%)	0.501	

Two different types of admixtures were used to improve the fresh and hardened properties of the latex modified concrete. First admixture used is named as ADDMIX 300, which is a new generation admixture based on modified poly

carboxylic ether. Second type of admixture was ADDMIX 345. It is a liquid admixture which acts on the cement particles in the mix combining the effect of a powerful plasticizer and deflocculating agent with controlled retardation.

Table 2: Polymer Latex used in this study

Type	Styrene butadiene rubber
Form	White Liquid
Density	1.08 kg/L at 25°C
Solid Content	45%
Hydrogen content (CHNS test)	8.68
PH value	8

Mix Design: The control concrete mixture was comprised of Portland cement, water, coarse (Quarry crush) and fine aggregates (Manjara sand). Control concrete Mixes with same aggregate

to cement ratios and w/c ratios were studied. The mix proportion of control mixes is presented in Table 3.

Table 3: Composition of Control Concretes

Concrete Constituent	Quantity (kg/m ³)
Cement	500
Fine Aggregate	640
Coarse Aggregate	980
Water	200

Latex Modified Concrete (LMC)

In this research, latex modified concrete compositions containing 10%, 15% and 20% SBR latex by weight of cement were prepared. Concrete cubes 100×100×100 mm were cast using these latex modified concrete to perform compressive strength and water absorption tests. Since the SBR latex used in this study contained 45% of water, the quantity of water required to be added in the concrete was accordingly adjusted to keep the water cement ratio 0.40 for Mix.

Sample Preparation: All concrete mixtures (Control concrete and Latex modified concrete) were prepared using a mechanical mixer. Concrete cube specimens of 100×100×100mm were cast. The specimens were cured in a curing room at 30°C temperature and 90% relative humidity. Both control and latex modified concretes were tested at 7 and 28 days of age to get compressive strength and water absorption values.

Compressive Strength: The compressive strength of concrete compositions was determined. The compressive strength tests were conducted on a compression testing machine. For each concrete composition three concrete cube specimens were tested. In this paper, average value of three samples has been reported.

Water Absorption: For determination of water absorption of concrete specimen, wide variety of

tests has been developed in the world. In these tests, usually weight gain of test specimen, volume of water entering the test specimen, depth of water penetration from surface or a combination of two is measured. Standard testing procedures to determine water absorption of hardened concrete have been developed in the world, for example, American standards [ASTM C 642] and British standards [BS 1881-122]. In this study, American standard testing procedure [ASTM C 642] is followed to determine water absorption of latex modified concretes. In this test, concrete specimens are immersed in water for 48 hours and after that water absorbed by the specimen is measured. ASTM C642 defines water absorption as ratio of the water absorbed to dry weight of test specimen. The expression to calculate water absorption is given in Equation 1.

$$\text{Water Absorption} = [(B-A)/A] \times 100 \text{ Eq.1}$$

where,

A = Dry weight of test specimen

B = Wet weight of test specimen after immersion in water for 48hrs

RESULTS AND DISCUSSION

Slump Tests: Slump tests were performed on both control and latex modified concretes and the results are presented in Fig.1. It is obvious in this

figure 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. It was observed during the slump test that Mix containing 20% SBR latex collapsed and it was

not possible to measure slump. 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.

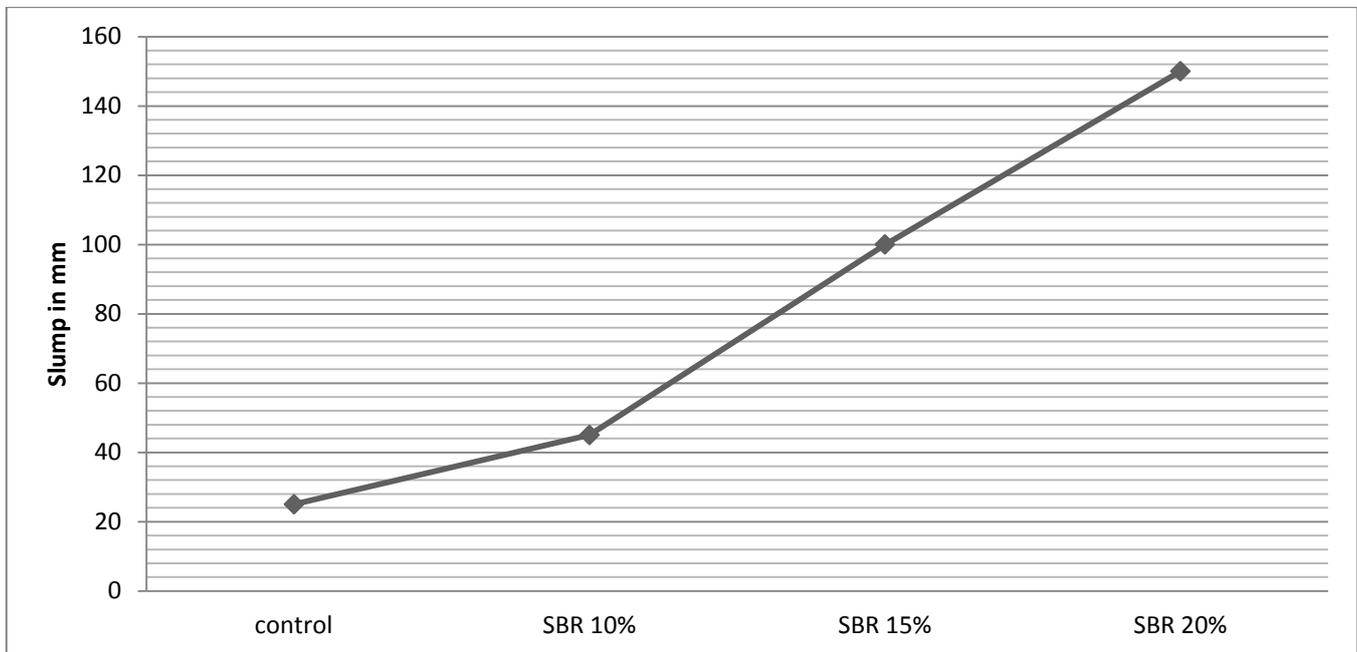


Figure1:Slump values of Control and Latex Modified Concrete

Compressive Strength: The results of the compressive strength test performed as per ASTM C39 for Mix containing same percentage of SBR are graphically represented in Fig.2 along with values of control concrete. It is observed that in case of LMC made using Mix with aggregate to cement ratio 3.25, compressive strength is decreased with the addition of “RIPSTAR”148-latex at 7 days of age. On the contrary, compressive strength of concrete is increased at 28 days of age with the addition of “RIPSTAR”148-Latex.

Decrease and increase in the compressive strength at 7 and 28 days, respectively, is due to the

formation of polymer film on the surface that retain the internal pressure for continuing cement hydration. In addition to this, polymers require time for the development of polymer structure and formation of Portland cement matrix. This polymer film matures with age; this is the reason that at 28 days of age, increase in compressive strength is registered with the addition of “RIPSTAR”148-latex. However at 7 days, the development of polymer structure and cement hydration is in process of formation, consequently the effect of “RIPSTAR”148-latex addition on compressive strength is negative.

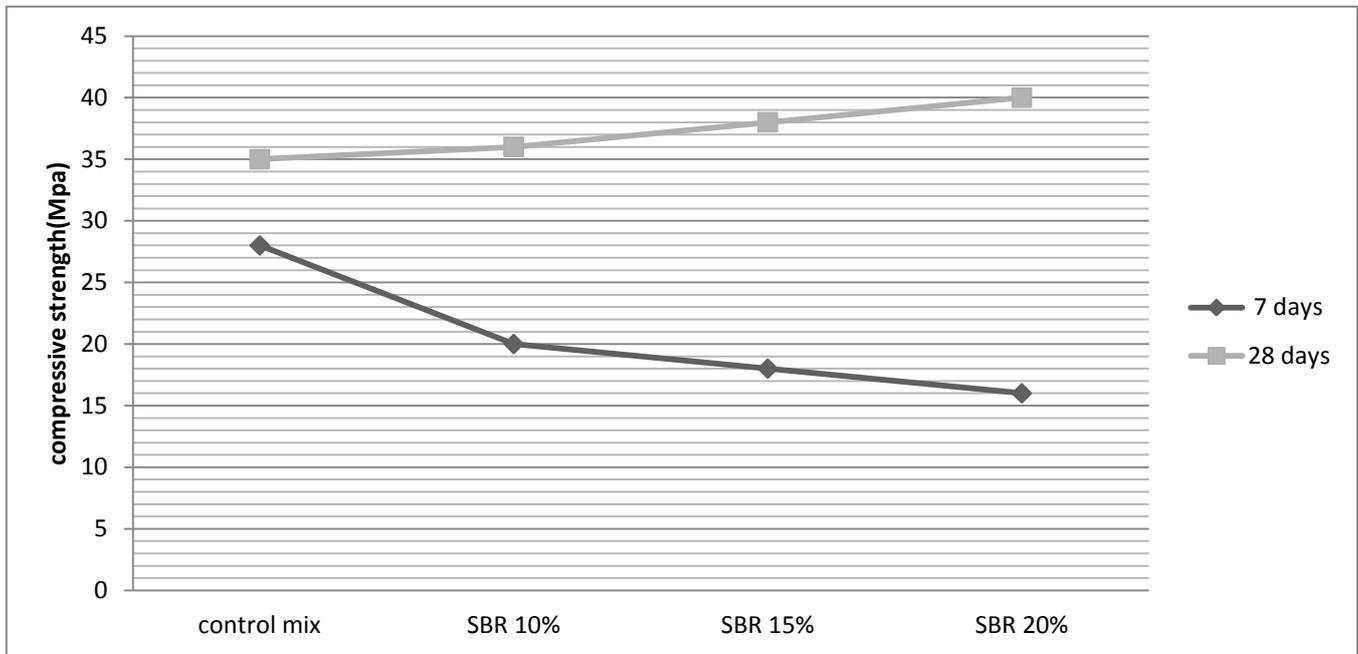


Figure 2: Compressive Strength of Mix containing same percentage of “RIPSTAR”148-latex

Water Absorption: Water absorption values of Mix with different dosages of SBR Latex are shown in Fig.3 along with values of control mixes. In such Mixes, water absorption of LMC was more at 7 days of age. However, at 28 days of age, all three latex modified concretes (i.e., Mix - 10% SBR, and Mix-20% SBR) showed water absorption values lesser than the value obtained with control mix. The decrease in water absorption of latex modified concrete containing

10%,15% and 20% “RIPSTAR 148”-latex at 28 days is due to the formation of polymer film which makes the concrete water tight.

The results about water absorption of control and LMCs clearly depict that at an early age, addition of locally available “RIPSTAR 148”-latex has adverse effects. However, with increase of age, polymer film is formed which results in reduction of water absorption of concrete.

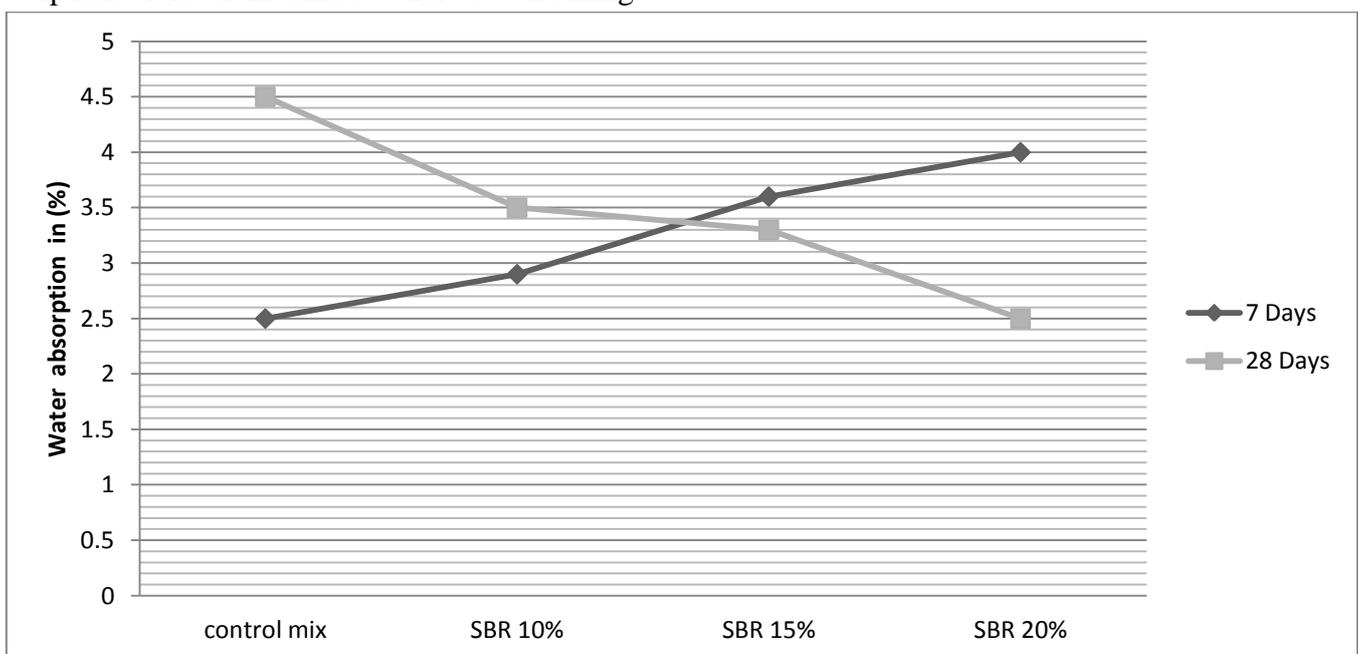


Figure 3: Water Absorption of Mix containing same percentages of “RIPSTAR 148”-latex

CONCLUSIONS

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

1. By the addition of locally available SBR latex ("RIPSTAR 148"-latex) the slump of the concrete is increased.
2. The presence of "RIPSTAR 148"-latex is proved to be effective to reduce the ingress of water in concrete. However, for the mixes rich in cement, the dosage of "RIPSTAR 148"-latex should be so adjusted that the workability of concrete should remain in controlled limits to avoid the highly flow able concrete due to plasticizing effect of "RIPSTAR 148"-latex.
3. Early age compressive strength of the concrete is reduced by the addition of "RIPSTAR 148"-latex. However, the strength is increased at 28 days of age. In comparison to control concrete, maximum increase at 28 days was 14% with the addition of 20% "RIPSTAR 148"-latex in concrete mix having w/c ratio 0.4 and aggregate to cement ratio 3.25.
4. The "RIPSTAR 148"-latex contributes significantly to the reduction of water absorption of concrete at 28 days of age. On the contrary, it is seen that "RIPSTAR 148"-latex causes increase in the water absorption of concrete at early age. Maximum decrease in the water absorption of LMC with 20% "RIPSTAR 148"-latex w/c ratio 0.4 and aggregate to cement ratio 3.25 was 44% compared to control mix.

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