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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.*

I. 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 voidfilling 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 studieshave been carried out on the use of different polymerssuitable for admixing into fresh concrete to improve themechanical properties, among them styrene butadienerubber (SBR) latex has been widely used in the past (Joaoand Marcos, 2002; Ru W. et al., 2006; Zhengxian Y. etal., 2009; Baoshan H. et al., 2010). Latex is a polymersystem formed by the emulsion polymerization ofmonomers and it contains 50% solids by weight. Styrenebutadiene, polyvinyl acetate, acrylic and natural rubbersare the best examples of polymers which are usually usedin latex. Since mechanical properties, hydration processin cement and durability of concrete are highly dependenton the state of micro-structure, previous research studieshave shown that the polymer as modifier is promising inimproving micro-structure of concrete (Lewis and Lewis,1990; Ohama, 1997).Styrene butadiene rubber (SBR) latex is a typeof high-polymer dispersion emulsion composed ofbutadiene, styrene and water and it can be successfullybonded to many materials. Due to its goodintermiscibility with vinyl pyridine latex for fabricdipping, its major engineering application is in tire dipfabric industry. In civil engineering field, it is used toreplace cement as binder to improve tensile, flexural andcompressive strengths of concrete. SBR is white thickliquid 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.

II. Materials And Methods

Portland Pozzolana cement conforming to Indian Standards (IS:1489-1991) was used for this study. Locally availableManjara 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/m3)	1450	1350
Compacted Bulk Density(kg/m3)	1710	1600
Water Absorption (%)	0.50	1

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 polycarboxylic 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	Form
Styrene butadiene rubber	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 sameaggregate 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/m3)Cement	500
Fine Aggregate	640
Coarse Aggregate	980
Water	200

Latex Modified Concrete (LMC)

In this research, latexmodified concrete compositions containing 10%,15% and20% SBR latex by weight of cement were prepared.Concrete cubes 100×100×100 mm were cast using these latex modifiedconcrete 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 30ºC 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. Thecompressive strength tests were conducted on a compression testing machine. For each concrete composition three concretecube specimens were tested. In this paper, averagevalue of three samples has been reported.

Water absorption: For determination of waterabsorption of concrete specimen, wide variety of tests hasbeen developed in the world. In these tests, usuallyweight 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 Britishstandards [BS 1881-122].In this study, American standard testingprocedure [ASTM C 642] is followed to determine waterabsorption of latex modified concretes. In this test,concrete specimens are immersed in water for 48 hoursand after that water absorbed by the specimen ismeasured. ASTM C642 defines water absorption as ratioof the water absorbed to dry weight of test specimen. Theexpression to calculate water absorption is given in Equation 1.

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

where,

A = Dry weight of test specimen

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

III. 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 resultingconcrete will be affected adversely.

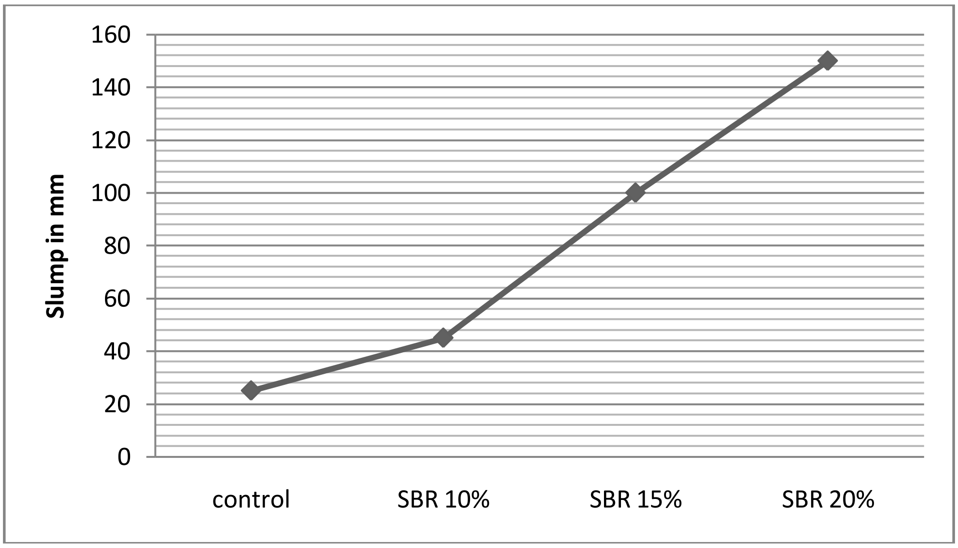

Figure1: Slump values of Control and Latex Modififide Concrete

Compressive Strength

The results of the compressive strength test performed as per ASTM C39 for Mixcontaining same percentage of SBR aregraphically 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 withage; this is the reason that at 28 days of age, increase incompressive strength is registered with the addition of "RIPSTAR"148-latex. However at 7 days, the development ofpolymer structure and cement hydration is in process offormation, consequently the effect of "RIPSTAR"148-latex additionon compressive strength is negative.

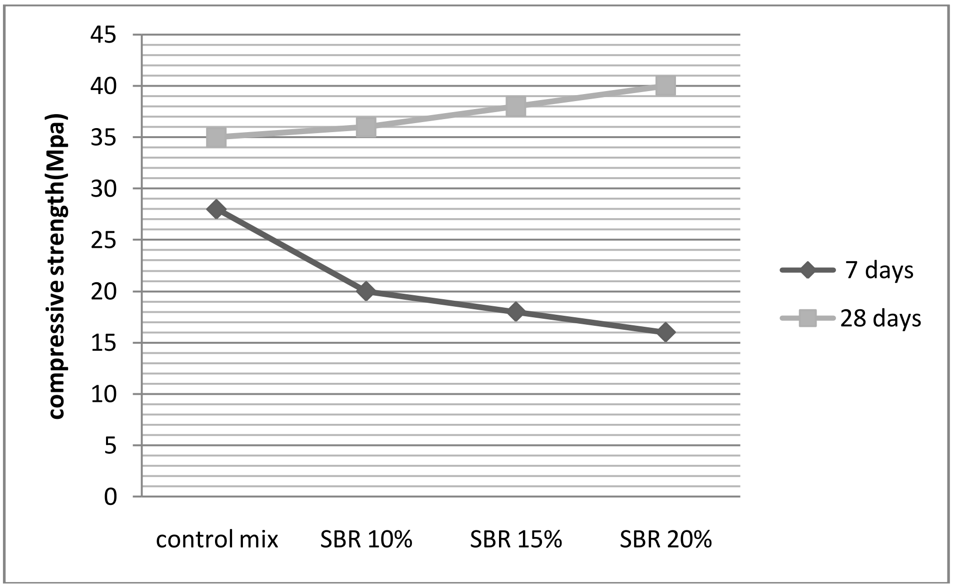

Figure 2: Compressive Strength of Mix containing same percentage of "RIPSTAR"148-latex

Water Absorption

Water absorption values of Mix with different dosages of SBR Latex areshown in Fig.3 along with valuesof control mixes. In such Mixes , waterabsorption 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 valueobtained with control mix.The decrease in waterabsorption of latex modified concrete containing 10%,15% and 20% "RIPSTAR 148"-latex at 28 days is due to theformation of polymer film which makes the concretewater tight.

The results about water absorption of controland LMCs clearly depict that at an early age, addition oflocally available "RIPSTAR 148"-latex has adverse effects.However, with increase of age, polymer film is formed which results in reduction of water absorption ofconcrete.

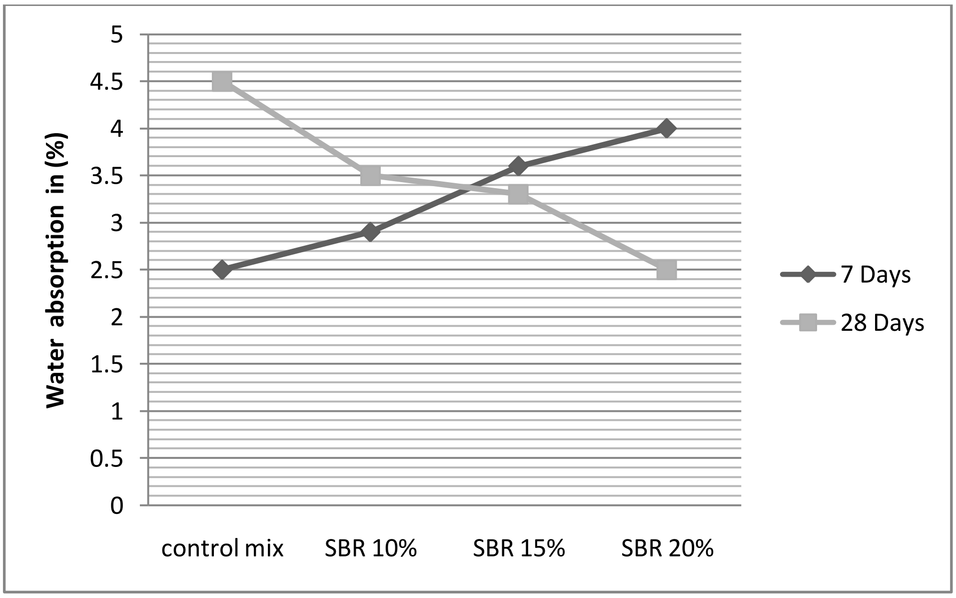

Figure 3: Water Absorption of Mix containing same percentages of "RIPSTAR 148"-latex

IV. Conclusions

Based on the results and observations madein this experimental research study, the followingconclusions 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 effectiveto reduce the ingress of water in concrete. However, forthe mixes rich in cement, the dosage of "RIPSTAR 148"-latex shouldbe so adjusted that the workability of concrete shouldremain in controlled limits to avoid the highly flowableconcrete due to plasticizing effect of "RIPSTAR 148"-latex.
3. Early age compressive strength of the concrete isreduced by the addition of "RIPSTAR 148"-latex.However, thestrength is increased at 28 days of age. In comparison tocontrol concrete, maximum increase at 28 days was 14%with the addition of 20%"RIPSTAR 148"-latex in concrete mixhaving w/c ratio 0.4 and aggregate to cement ratio 3.25.
4. The"RIPSTAR 148"-latex contributes significantly to thereduction of water absorption of concrete at 28 days ofage. On the contrary, it is seen that"RIPSTAR 148"-latex causesincrease in the water absorption of concrete at early age.Maximum decrease in the water absorption of LMC with20% "RIPSTAR 148"-latex w/c ratio 0.4 and aggregate to cementratio 3.25 was 44%compared to control mix.

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