Comparative Analysis of Mechanical Properties of Ordinary Concrete and Light Weight Aggregate Presaturated Polymer Emulsion Concrete

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Abstract - **This experiment is going to compare a non-conventional concrete to conventional concrete in aspects of mechanical properties. Also results are shown in the form of graph for grades of M25 and M30. In addition to comparing this experimental study aimed to design a concrete mixture with recycled bottle crush as an alternative to fine aggregates. In this research, effect of Styrene-Butadiene Rubber (SBR) latex on mechanical parameters such as compressive and flexural strength of concrete has been studied and also the best suitable polymer (Nitoband SBR-Latex) content for concrete is calculated. Before the experimental testing the aggregates were saturated in a polymer emulsion of styrene butadiene rubber (SBR). The mixes were prepared with Nitoband SBR latex - cement proportion 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. Observations from the tests performed were conducted in the laboratory where accurate data was determined and completely analyzed. It was determined from the following research that in the initial stage the compressive strength was less than conventional while at its final stage the strength goes above the strength of conventional concrete.**

Keywords: Concrete, fine aggregate, recycled bottles, Styrene butadiene rubber (SBR), compressive strength

I. INTRODUCTION

Concrete has been the most widely and best material used construction material for about 20 years all over the world because of its availability and ease of use. To improve concrete structure's durability, the internal structure of concrete should be improved so as to increase its resistance to permeability and to make it impervious. Due to the formation of polymer network in the hardened cement based matrices, polymer emulsion incorporated cement concretes have high tensile strength, good ductile behavior, and high impact resistance capability. Consequently, the porosity is decreased and pore radius varies because of the void acquiring effect of this network. In addition to this, as a result of the adhesion of a polymer an improvement in the transition zone is also obtained. In the last three decades, a lot of researches studies have been carried out on the optimum use of different polymers suitable for admixing into conventional concrete to improve the mechanical parameters, among them styrene butadiene rubber (SBR) latex has been widely used in the past. Latex is a polymer that is formed by the emulsion polymerization of monomers. Styrene butadiene, polyvinyl acetate, acrylic and natural rubbers are the best examples of polymers which are usually used in latex. Since mechanical properties and durability of concrete are highly dependent on the state of micro-structure, previous researches shows that the polymer as modifying admixture is promising in improving micro-structure of concrete. Styrene butadiene rubber (SBR) latex is a type of high-polymer dispersion emulsion composed of butadiene, styrene and water and it can make bonds successfully to many materials. In civil engineering field, it is used to replace cement as binder and 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. Concrete polymers composite are environment conscious and confirm to concerns saving of that natural resources, the longevity of infrastructure and environmental protection.

In this present contribution, the effect of adding SBR latex on mechanical properties of normal strength concrete has been determined. In cement based composites, water absorption is an important parameter as it is the measure of resistance against carbonation migration. Water absorption parameter 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 and 28 days of age and compared to normal concrete mix.

In addition to Nitoband SBR latex, an alternative of light weight aggregate is incorporated in the experiment to make is economical and light weight as much as possible and an optimum mix is proposed for it.

II. LITERATURE REVIEW

Sivakumar.M.V.N (2011) study states the comparative effect of different polymers on structural properties of concrete. In this study a mechanical and flexural properties of polymer modified concrete were observed. Two different types of the polymers latex-styrene butadiene and styrene acrylic were used for varying dosages (0-20%) to modify concrete composites individually in each case[1]. A graphical comparison of results were carried out for 7th day as well as 28th day. A significance of this experiment was wet curing process was carried up to testing date. It was also observe that the dosages of polymer in both the cases is optimal for 15% polymer. While justifying potence of each polymer it was interpreted that Acrylic styrene was proved superior over latex polymer because of its fine particle size and relatively less viscosity.

Z.A. Siddiqui et.al. (2013) in his research states the effects of addition of polymer SBR latex in concrete in terms of compressive strength and water absorption. And observation is made that SBR latex improves the internal structure of latex modified concrete resulting in great reduction in the water absorption value at 28 days. A comparison was observed between SBR modified concrete in controlled concrete. From results it is concluded that enhancement in compressive strength and reduction in water absorption was observed on 28 days while on 7th day the early compressive strength shows negative effects and at early age water absorption was adverse. Specimens are varied from 5%, 10%, and 20% of polymer dosages. Modification of concrete by polymer leads to increase workability in comparison to control concrete max increase in compressive strength was observed to 72% as well reduction in water absorption was observed at 30%. It’s concluded that thin polymeric film restored the water by hydration process and helps in reduction in water absorption.

Batayneh et al investigated the effect of pulverised plastic on the slump of concrete. Concrete mixtures of about 20% of plastic particles are proportioned to partially replace the fine aggregates. It was observed that there is a decrease in the slump value with the increase in the plastic crush content. For a 20% replacement of fine aggregates, the slump has decreased to 25% of the original slump value with 0% plastic crush content. Soroushian et al., 1995: reported reduction in slump value with the use of recycled plastic in concrete. Ismail and Hashmi, 2008: have also found that the slump is liable to decreasing sharply with increasing the waste plastic ratio. Al-Manaseer and Dalal, 1997: investigated the effect of plastic aggregates on the bulk density of concrete. They concluded that the bulk density of concrete decreased with the increase in plastic bottle crush content.

III. MATERIALS AND METHODS

The cement used here was Ordinary Portland Cement Grade 43 (OPC) which complies with IS 8112:2013. The cement is in dry powdery form with the good chemical compositions and physical characteristics. Locally available and crushed stone were used as fine and coarse aggregates, respectively. The fine and coarse aggregates were tested as per IS: 383-1970 and 2386-1963 (Part I, II and III) specifications [12, 13]. The other type of fine aggregate that was used in this research is plastic bottle crush. The properties of fine and coarse aggregates are given in Table 1. Locally available polymer ‘Nitobond-Latex’ was investigated in this study. Nitobond-Latex is a type of Styrene butadiene rubber (SBR) latex.

Nitobond SBR is a polymer bonding aid and mortar additive. Supplied as a ready to use white liquid, it is designed to improve the quantities of site-batched cementitious mortars and slurries. Being resistant to hydrolysis, it is ideal for internal and external applications in conjunction with cement. It improves cohesion and workability and also it improves mortars to produce waterproof repairs, renders and toppings which are highly resistant to freeze/thaw cycling. The tensile and flexural properties are also improved that allow thin applications. It provides excellent bonding to concrete, masonry, stonework, plaster and block work. And it can be applied to damp substrates.

The composition of the Nitobond-Latex used as polymer is given in Table 2.

Plastic Bottle Crush: The consumed Plastic bottle crush was obtained from a nearby located plastic crushing plant “MAPPLE INDUSTRIES”. The size of aggregates used was 3mm-4mm.

The properties of plastics are then analyzed by performing density, specific gravity & sieve analysis tests. Density of the material is determined by determining the weight and volume of a specified material.

TABLE 1. PROPERTIES OF AGGREGATES

Properties	Fine Aggregate	Bottle Crush	Coarse Aggregate
Max size of aggregate	4mm	4mm	20mm
Specific gravity	2.53	.53	2.85
Bulk Density	1718.5 kg/cu.m	760 kg/cu.m	1564.2 kg/cu.m
Fineness Modulus	2.65	-	7.63
Water Absorption	1.2%	0.0%	1.15%

Nitobond SBR latex has compressive strength of 14.5 N/mm² and 24 N/mm² at 7 days and 28 days respectively. It has tensile and flexural strength of 3.5 N/mm² and 6.5 N/mm² respectively at 28 days.

The ordinary Portland cement of grade 43 was used whose initial setting time was 52 minutes and final setting time was 436 minutes. The specific gravity of cement was 3.15.

IV. EXPERIMENTAL DETAILS

a. Mix Design

In this researcha comparison is carried out on two concrete grades that are M25 snd M30. The desired characteristic strength of 25 N/mm² and 30N/mm² at 28 days was used in this study. IS 10232:2009 method was applied in designing the mixture. A total of 60 cubes and 20 beams were prepared for this study in 10 sets. A w/c ratio of 0.55 is taken for control mix. Samples from each set of the mix were tested at the age of 7 and 28 days for compressive strength and 28 days for flexural strength.

The fine aggregates in this research is replaced by bottle crush up to 50%. So the ratio of fine aggregate to the plastic bottle crush is 1:1.

In this research, latex modified concrete compositions containing 0%, 5%, 10%, 15% and 20% SBR latex by weight of cement were prepared[2]. Concrete cubes and beams were cast using these latex modified concrete to perform compressive strength and flexural strength tests. The aggregates were rinsed in latex for 24 hours before preparing mixes.

Fig 1:Rinsing of Aggregates

The above image shows the rinsing of aggregates and latex modified concretes were tested at 7 and 28 days of age to get compressive strength and same for flexural strength value.

Sample Preparation: All concrete mixes were prepared using a mechanical mixer. Cube specimens of 15 × 15 × 15 cms and Beam specimen of 15 × 15 × 75 cms were cast. The specimens were cured in a curing room at 30ºC temperature and 90% relative humidity.

Details of specimens used for mix design proportion of 1:1:2 with constant water cement ratio:

150mm x 150mm x 150mm Cube specimens for Compressive strength.

150mm x 150mm x 750mm Beam specimens are used for Flexural Strength test.

TABLE 2. AMOUNT OF LATEX IN CUBES

Cube Specimen			
S.No	Cube Denotation(M25)	Cube Denotations(M30)	% of SBR latex
1	C1	C6	0
2	C2	C7	5
3	C3	C8	10
4	C4	C9	15
5	C5	C10	20

TABLE 3. AMOUNT OF LATEX IN BEAMS

Beam Specimen			
S.No	Beam Denotation(M25)	Beam Denotations(M30)	% of SBR latex
1	B1	B6	0
2	B2	B7	5
3	B3	B8	10
4	B4	B9	15
5	B5	B10	20

The above two tables shows the % amount of latex or the SBR latex present in the different Denotations of the M25 and M30 beams as represented.

a. Testing Methodology:

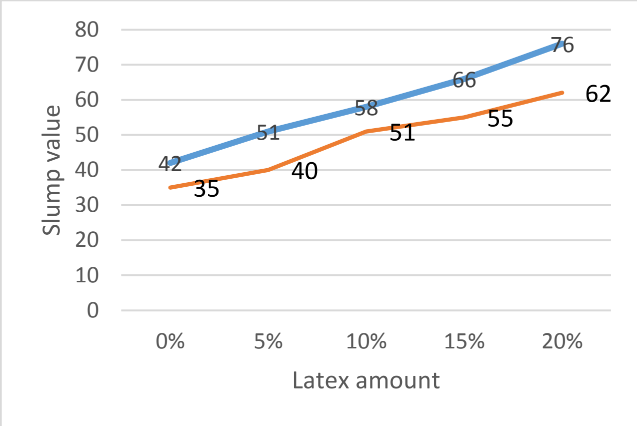

Fig 2. Workability graph for different compositions and the latex amount

b. The compression strength and flexural strength tests were conducted. These tests are conducted to determine the ultimate load that a concrete specimen can bear before failure. For every composition 3 cubes were tested for compressive strength after 7 days and 28 days and 10 beams were tested, two for each composition for flexural strength after 7 days and 28 days. Compressive strength tests were conducted in compression testing machine and flexural strength test were conducted in 3 point loading machine[3].

V. RESULTS AND DISCUSSION

A. Slump Test

Slump test was performed to determine the workability of each concrete composition. It is tested for the fresh concrete at the time of mixing and before casting of cubes and beam. This graph shows the slump values of all compositions as per the workability analysis. variation of the latex composition is also mentioned accordingly.

Compressive strength test& Flexural Strength:

Compressive strength test is carried out to determine the ultimate load that a specimen can resist safely in axial direction. The results of compressive strength tests for both grades are shown in table 5 and 6.

Flexural strength is carried out to determine the ultimate load that a specimen can resist safely in bending. The results are shown in table 7 and 8.

TABLE 4:COMPRESSIVE STRENGTH OF MODIFIED CONCRETE(M30)

S.No.	Cube No.	7 Days (N/mm²)	28 Days (N/mm²)
1	C6	18.13	31.25
2	C7	18.56	32.22
3	C8	18.89	32.52
4	C9	19.29	33.85
5	C10	20.34	34.29

For different cubes the compressive strength of the M30 modified concrete after 7 and 28 days is shown.

TABLE 5. FLEXURAL STRENGTH OF MODIFIED CONCRETE (M25)

S.No	Beam No.	7 Days (N/mm²)	28 Days (N/mm²)
1	B1	6.13	7.09
2	B2	6.33	7.22
3	B3	6.69	7.32
4	B4	7.00	7.42
5	B5	7.10	7.55

TABLE 6: FLEXURAL STRENGTH OF MODIFIED CONCRETE (M30)

S.No	Beam No.	7 Days (N/mm²)	28 Days (N/mm²)
1	B6	6..68	7.23
2	B7	7.25	7.88
3	B8	7.30	7.99
4	B9	7.33	8.20
5	B10	7.40	8.38

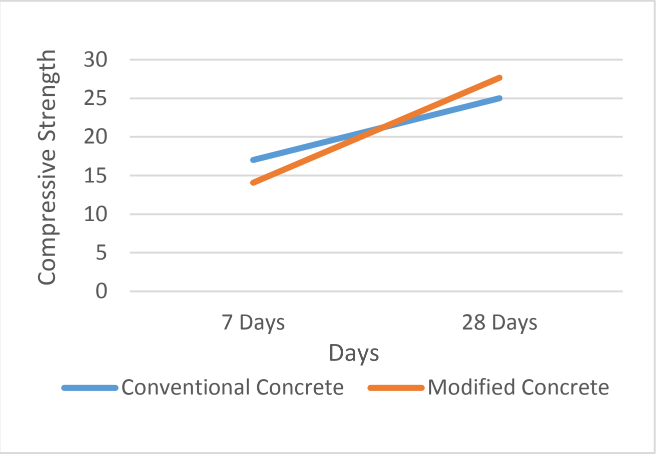

Fig 3. graph shows the comparison of modified and conventional concrete (M25)

The above two tables indicate the flexural strengths for the M25 and M30 concrete.

VI. CONCLUSION

1) It was observed that with the incorporation of latex, it improves the mechanical properties of concrete. Also, replacing the conventional fine aggregate with the plastic bottle crush does not make much effect on the strength of concrete but instead it makes it light weight[4].
2) It was observed during experiment that the normal concrete cube splits into two pieces suddenly but the modified concrete was more ductile and shows fractures before complete failure.
3) It was found that with increase in amount of latex the strength of modified concrete after 7 days lacks behind the conventional concrete but after 28 days it was more than the strength of conventional concrete.

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