EXPERIMENTAL INVESTIGATIONS ON STRENGTH ASPECTS OF HIGH PERFORMANCE CONCRETE AND SBR LATEX MODIFIED CONCRETE

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Abstract

Gradually the conventional concrete is being replaced by High Performance Concrete (HPC) in major and heavy constructions, this is due to constant evolution in the field of concrete technology wherein a more efficient form of concrete has been developed like High Performance Concrete (M-60) which possesses excellent strength and durability properties. HPC contains mineral and chemical admixtures which increases the strength and durability of the concrete. Whereas inclusion of SBR latex in HPC enhances the flexural strength. This research includes experimental studies on compression, split tensile and flexure tests on HPC and Styrene Butadiene Rubber (SBR) latex modified concrete (M60+SBR).The test specimens are cubes, cylinders and prisms as per IS 456:2000 and are tested for compression, split tensile and flexure strength respectively. The results show that the flexure strength is significantly increased with integration of SBR latex modified concrete(M60+SBR.)

Keywords: *High Performance Concrete (HPC); Styrene Butadiene Rubber (SBR) Latex Concrete; Compressive Strength; Split Tensile Strength; Flexure Strength.*

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1. INTRODUCTION

In reviewing technology advances through the centuries, it is evident that material development plays a key role. Considerable efforts are still being made in every part of the world to develop new construction materials. Concrete technology is achieving new milestones in the way of using polymers with super plasticizers in concrete. Increasing interests is being shown in the area of new materials in the past decades. This is quite understandable because, it is slowly, but increasingly being recognized that economic progress in the construction depends more on intelligent use of materials and constant improvement of available materials than on extreme reinforcement of structure.

High performance concrete is a logical development resulting from advancement in cement concrete technology wherein the strength and durability of conventional concrete has been improved by addition of chemical and mineral admixtures.

HPC possesses higher strength and higher durability compared to conventional concrete.**[1]** HPC contains more than one of the cementations materials like Silica fumes, Fly Ash, GGBS and Metakaolin etc. is accompanied by a super plasticizer.**[2,3]** The term 'high performance' is important because the unique feature of that type of concrete is that it's proportions are specifically chosen so as to have appropriate mechanical properties in the expected use of the structural member like high strength with low permeability.**[2,3]** HPC contains the same materials as that of the regular concrete but the only difference are the use of many chemical and mineral admixtures along with High Range Water Reducers (HRWR) to enhance its strength, workability, durability and quality to a very high extent.**[4, 5]**

Polymer-Modified SBR latex Concrete or Polymer-Portland Cement Concrete is modified cement concrete where the part of cementations binder is changed by synthetic organic polymer such as Styrene Butadiene Rubber latex into ordinary Portland cement concrete**[6,7,8]**

Though concrete is the most widely used construction material, it suffers from three major weakness- low tensile strength, high porosity and susceptibility to chemical and environmental attack. By using polymer concrete composite, most of these disadvantages found in ordinary structural concrete can be removed. Polymer concrete composite are relatively a new development and are extensively used in many structural applications. They possess very high ductility and are more durable and resistant to most of the chemical and acids.

Ordinary concrete's ingredients are same when compared with HPC, except that HPC contains both pozzolonaic and chemical admixtures **[9,10]**

ASTM type I, II, III Portland cement and in Indian concrete 43 and 53 grade Portland cement have been successfully employed in the production of HPC.There is now almost universal use of blended cements for cast-in place HPC. The most common type is a type 10 cement plus silica fume **[11, 12]**

Polymer composites due to their lightweight, chemical and corrosion resistance as well as heterogeneous composition provide unlimited possibilities of deriving any characteristic material behaviour. Polymers are chemically inert materials which have higher compressive and tensile strength than the regular concrete. However, polymers have low modulus of elasticity, a higher creep, and degraded by heat, oxidizing substances, ultra violet light, chemical substances and micro-organisms. Also, certain organic solvents may cause stress cracking. Many of these disadvantages can be overcome by choosing a suitable polymer and by adding substances to the polymer, which suppress the harmful effects

There are different types of polymer and are being used in cement concrete construction. They are aqueous polymer, powder emulsion, water-soluble polymer, liquid polymers etc. Rubber latex comes under aqueous polymer category. Recent studies indicate that both natural and synthetic rubber latex improve the engineering properties of concrete markedly.SBR Latex is Styrene Butadiene Rubber polymer, designed to use the latex for the modifying the cement composites. The adding of SBR Latex in cement improves the chemical and physical properties such as:

- Increased flexural strength and compressive strength
- Improving of bonding to the substrates and ductility of the structure
- Improvement of resistance to any moisture content
- Improvement of resistance to any chemical attacks

Among all major polymer composites, Styrene Butadiene Rubber Latex is performing well in the augmentation of the mechanical behaviour of the ordinary cement concrete. The technology of polymer concrete is still, to a large extent, in the experimental stage. Extensive work is being done presently in different parts of the world to arrive at practically acceptable technologies and optimum concrete polymer combinations suitable for convenient commercial applications. More practical application and their performance studies is still more confidence for field applications of these materials. Hence an attempt has been made in the present investigation to study the mechanical properties of concrete such as compressive strength, split tensile strength and flexural strength of High Performance Concrete (M60) and SBR latex combined with High Performance Concrete (M60+SBR).

2. EXPERIMENTAL PROGRAM

In this research investigation, mechanical properties of concrete like compressive, split tensile and flexural strength of High performance concrete (M60) with and without SBR-Latex matrices are studied. Total 27 specimens having 150mm cubes, 150mm diameter and 300mm height cylinders and prisms of 100×100×500mm were casted and tested for compression, split tensile and flexural strength for 3, 7 and 28 days respectively as per IS-456 :2000 specifications.

The results obtained from these experiments are tabulated and relevant graphs are plotted. These graphs include compressive strength v/s age, split tensile strength v/s age, flexural strength v/s age and comparison graphs comparing results of HPC matrix and HPC+SBR matrix.

3. MATERIALS USED IN THE PRESENT STUDY

In the present work, the concrete used in the experiments consists of 53 grade Portland cement, crushed granite with maximum nominal size of 20mm down size coarse aggregate, fine aggregate satisfying the requirement of zone II, portable water, Silica fume/micro silica (NUSIL-50,concrete admixture) supplied by M/S NUCHEMS, Ground Granulated Blast furnace Slag (GGBS) supplied by Nandi Cements Pvt. Ltd, Super plasticiser (BASF Gleniam 8233) a high range water reducer and Styrene Butadiene Rubber emulsion (SBR)-latex FosrocNitobond SBR latex (Polymer latex bonding aid) as per optimum percentages subject to the required workability were used. Detailed properties of materials used are shown in table 1.

Table 1. Properties of the materials used

Materials used	Specifications
Specific gravity of cement	3.11
Specific gravity of fine aggregate	2.635
Fineness modulus of fine aggregate	3.14
Dry rodded density of Fine aggregate	1659.21 kg/m³
Specific gravity of Coarse aggregate	2.53
Fineness modulus of Coarse aggregate	6.6
Dry rodded density of Coarse aggregate	1629.7 kg/m³
Specific Gravity of Silica Fume	2.26
Specific gravity of GGBS	2.32
Percentage solids of SBR	46.50
Polymer type	Styrene Butadiene 68 ± 4% Styrene 32 ± 4% Butadiene
pH of Water	6.8

To determine the mix proportions for M60 grade of concrete (HPC), tests on trial mixes were carried out and was finally selected with required workability of 25-50mm. 8% of silica fume is replaced by weight of the cement, 10% of SBR latex, 20% of GGBS and 0.7% of Super Plasticiser by weight of cementations materials were used in the concrete mix in the present investigation.[12]. Final mix proportions for the matrix (1:0.27:0.78) used in the investigation are shown in the table 2

Table 2. Mix Proportion Selected for Study

Mix	Units	HPC	HPC+SBR
Cement	kg/m³	513.5	513.5
Fine Aggregate	kg/m³	375.1	375.1
Coarse Aggregate	kg/m³	1146	1146
W/b		0.36	0.36
Water	l/m³	141.3	141.3
SBR	l/m³		66.68
Super plasticiser	l/m³	4.0	4.0
Silica fume	kg/m³	53.3	53.3
GGBS	kg/m³	133.4	133.4

4. METHODOLOGY OF TEST

In the present investigation compressive strength, split tensile strength and flexural strength are taken to account. The experimental setup, casting, curing of the specimen and the testing procedure is in accordance with IS 456-2000 and 516:1959 *Clause 5.1 up to 5.6* for the determination of compressive, split tensile and flexural strength respectively.

- Compression test: Cubes of size 150mm are tested in 200T capacity compressive testing machine cured for 3, 7 and 28 days to get the compressive strength.
- Split tensile test: test is conducted on cylindrical specimens of 150mm diameter and 300mm height. The tensile strength of concrete can be obtained indirectly, by subjecting a concrete cylinder to the action of a compressive force along two opposite ends of a base plate of compression testing machine.
- Flexure test: Test is conducted on prisms of size 100×100×500mm. Two point loading condition having pure bending criteria with bending in 1/3rd span is considered and modulus of rupture is obtained.

5. RESULTS AND DISCUSSIONS.

5.1 Compressive Strength

Concrete compressive strength in particular is widely used in specifying, controlling and evaluating concrete quality. The compressive strength of concrete defines the overall picture of quality of concrete. The compressive strength of concrete depends on numbers of factors like water cement ratio, curing methods, degree of hydration, rate of loading etc. The minimum compressive strength for 28 days curing for HPC is 60N/mm². The compressive strength values obtained for HPC and HPC+SBR concrete specimens at 3, 7, 28 days curing are tabulated in table 3 and table 4 respectively. The graphs showing the comparison of compressive strength for HPC and HPC+SBR concrete specimens are shown in Figure 1 and 2.

Table 3. Compressive strength of HPC Cube specimens

Days	HPC Strength in N/mm^2			
	1	2	3	Aver age
3	23	25	26	24.67
7	39	40	40	39.67
28	66	68	68	67.33

Table 4 Compressive strength of HPC+SBR Cube specimens

Days	HPC+SBR Strength in N/mm^2			
	1	2	3	Aver age
3	21	22.0	21.5	21.5
7	38	38.0	38.0	38.0
28	63	62.5	62.5	62.7

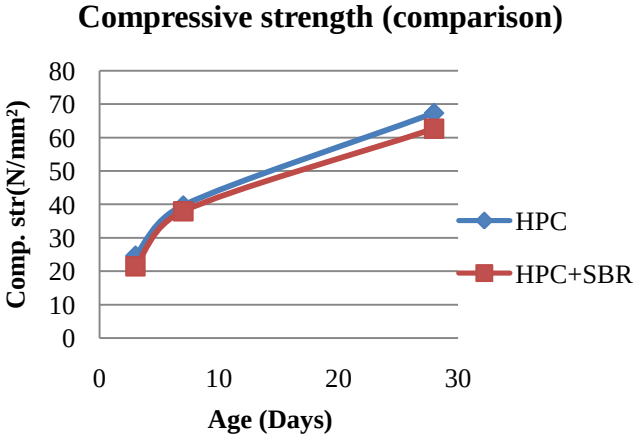

Fig 1 Compressive strength comparison for HPC and HPC+SBR concrete specimens

5.2 Split Tensile Strength

The tensile strength of concrete governs the cracking behavior and affects other properties such as stiffness, toughness, damping action, bond to embedded steel, and durability of concrete. It is also of importance with regard to the behavior of concrete under shear loads. The tensile strength is determined either by direct tensile tests or by indirect tensile tests such as split tensile test. The split tensile strength values obtained experimentally for HPC and HPC+SBR concrete specimens at 3, 7, 28 days curing are tabulated in table 5and table 6. The graphs showing the comparison of split tensile strength are shown in Figure 3 and figure 4 respectively.

Table 5. Split tensile strength of HPC specimens

Days	HPC Strength in N/mm^2			
	1	2	3	Average
3	1.55	1.60	1.78	1.64
7	2.46	2.59	2.50	2.52
28	3.10	3.47	3.05	3.20

Table 6. Split tensile strength of HPC+SBR specimens

Days	HPC+SBR Strength in N/mm^2			
	1	2	3	Aver age
3	1.24	1.3	1.29	1.27
7	1.99	1.92	1.85	1.92
28	3.06	3.14	3.12	3.10

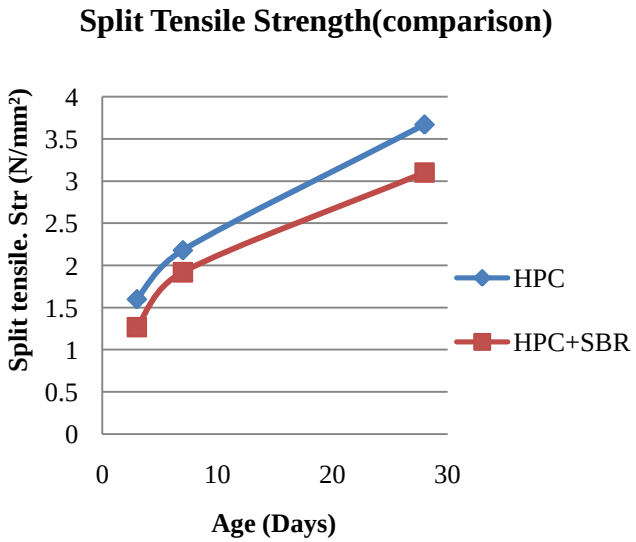

Fig 2. Split tensile strength comparison for HPC and HPC+SBR concrete specimens

5.3 Flexural Strength

Flexure test on concrete is mainly conducted to determine the ductility or the brittleness of the concrete. Prisms are casted and tested which are cured for 3, 7 and 28 days. The flexural strength values obtained for HPC and HPC+SBR concrete test specimens are tabulated in table 5 and table 6 respectively. The graphs showing the comparison of flexural strength between HPC and HPC+SBR concrete specimens are shown in Fig 7 and 8.

Table 7. Flexural strength of HPC specimens

Days	HPC Strength in N/mm^2			
	1	2	3	Average
3	1.56	1.64	1.60	1.60
7	2.15	2.36	2.05	2.18
28	3.59	3.68	3.74	3.67

Table 8. Flexural strength of HPC+SBR specimens

Days	HPC+SBR Strength in N/mm^2			
	1	2	3	Average
3	2.45	2.36	2.58	2.46
7	2.94	2.75	2.86	2.88
28	3.59	3.68	3.20	3.57

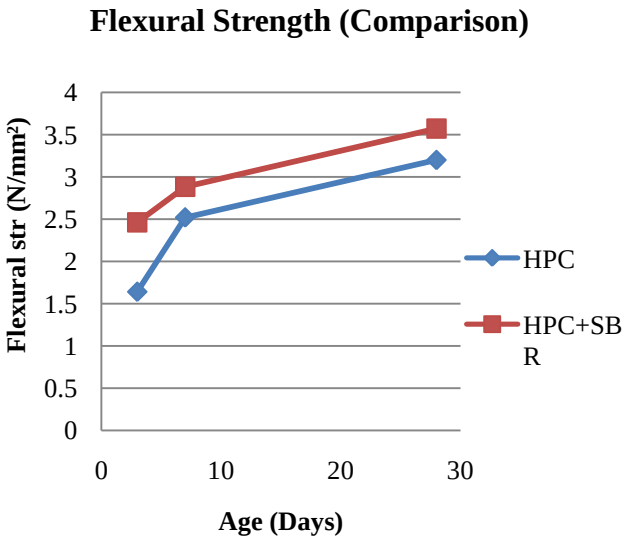

Fig 3. Flexure strength comparison for HPC and HPC+SBR concrete specimens

6. SUMMARY AND CONCLUSIONS

This experimental study deals with compression, split tensile and flexure tests on HPC and Styrene Butadiene Rubber latex modified HPC (M60+SBR). A concrete mix of grade M60 was designed for HPC and to which SBR latex was added. A total of 9 cubes for compression test, 9 cylinders for split-tensile test and 9 prisms for flexure test were casted. From the analysis of experiments conducted, following conclusions are reported.

- Compressive strength for 28 days of HPC and SBR-Latex modified HPC are 67.33 MPa and 62.7 MPa respectively. The compressive strength is lower in case of SBR Latex Modified HPC because of the low density of SBR latex with regards to matrix-density (mortar rheology).
- Split Tensile strength for 28 days of HPC and SBR-Latex modified HPC are 3.67 N/mm^2 and 3.1 N/mm^2. The Split Tensile strength is lower in case of SBR Latex Modified HPC.
- Flexure strength for 28 days of HPC and SBR-Latex modified HPC are 3.57 N/mm^2 and 3.2 N/mm^2. Flexure strength is higher in case of SBR Latex Modified HPC. This is due to compactness (filling of voids in cement, sand, aggregate matrix) achieved due to latex filling in the concrete matrix.
- Among the both mixes HPC is highly brittle and SBR Latex modified is found to be more ductile.

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