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STRENGTH AND DURABILITY OF HIGH STRENGTH POLYMER CONCRETE

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Abstract: Polymer as one of the best admixture can improve the property of concrete than the conventional concrete. In this paper High Density Poly-Ethylene (HDPE) and Poly-Propylene (PP) virgin polymers were used with cement composites. These two varieties of polymers are used in concrete as an admixture to increase compressive strength of the concrete. The objective of the present study is to investigate the behavior of polymer mixed cement concrete in both fresh and hardened state. For this experimental study the M60 grade concrete is used and both the polymers are mixed from 0 % to 10 % were used. The mechanical property like workability and compressive strength of concrete has been tested. The slump value of fresh polymer modified concrete (both HDPE and PP) is gradually reduced as the percentage of polymer increases and also the compressive strength of hardened High Strength polymer concrete (both HDPE and PP) at 7 days and 28 days result is gradually increased as the percentage of polymer increases. The compressive strength at 7 days and 28 days of M60 grade of concrete increased as the percentage of polymer increases. The maximum compressive strength obtained at 10 % High Density Poly-Ethylene and Poly-Propylene. The Compressive strength of PP virgin polymer concrete values is slightly increased than the HD virgin polymer concrete values.

Keywords: High Density Poly-Ethylene (HDPE), Poly-Propylene (PP), High Strength polymer concrete, compressive strength.

1. INTRODUCTION

The High Strength Polymer Concrete is to reduce the inherent porosity of the concrete, to improve the strength and other properties of concrete. The concrete is porous in nature. The porosity is due to air-voids, water voids or due to the inherent porosity of gel structure itself. On account of the porosity, strength of concrete is naturally reduced. The reduction of porosity results in increase of the strength of concrete. Concrete is one of the fundamental materials in civil engineering especially structural industries *[1].* Conventional concrete has many favorable advantages such as low material cost and simple application. However, it has some disadvantages like low tensile strength, weak flexural strength, poor resistance to freeze-thaw phenomena and destruction by sulfate and acid attack etc. In the constructions industry new building materials with improved properties are required for satisfying the new utilization domains for modern construction or for repair works. The application of polymer on concrete has significantly progressed in the last 30 years.

In order to improve concrete properties, continuous research carried out by concrete technologists to understand, improve and develop the properties of concrete has resulted in a new type of concrete known as "Polymer Concrete". We know that the concrete is porous. The porosity is due to air-voids, water voids or due to the inherent porosity of gel structure itself. On account of the porosity, strength of concrete is naturally reduced. It is conceived by many research workers that reduction of porosity results in increase of the strength of concrete. The processes like vibration, pressure application spinning etc., have been practiced mainly to reduce the porosity.

All of these methods have been found to be helpful to great extent, but none of these methods could really help to reduce the water voids and the inherent porosity of gel, which is estimated to be about 28 %. The impregnation of monomer and subsequent polymerization is the latest technique adopted to reduce the inherent porosity of the concrete, to improve the strength and other properties of concrete.

Polymers are either incorporated in a cement-aggregate mix or used as single binder. The composites made by using polymer along with cement and aggregates are called *polymer-modified concrete*, while composites made with polymer and aggregates are called *polymer* concrete *[4].* Simply, the addition of a minor amount of some kind of polymer to a cement concrete mix can significantly enhance the properties of the resulting material, which is known as polymer–modified cement concrete. These additives known as admixtures can be in the form of polymer particles or liquids *[7].*

The mechanical properties of polymer concrete are very important in many of its applications. This Polymer modification is a frequently used technique to overcome some of the shortcomings of conventional

concretes such as poor tensile and impact strength, limited resistance to corrosion, poor behavior under severe conditions and poor adhesion of fresh concrete to old concrete.

In this paper presents a comparative performance of two different polymers on conventional concrete. The selected polymers are from two different groups. The modification is brought by adding different dosages of polymers (by cement) to the conventional concrete *[9].*

The behavior of concrete is studied with respect to its mechanical properties by varying the two polymer dosages. Finally recommendations are made based on the experimental investigations. The main objective of the present study is to investigate the behavior of polymer mixed cement concrete in both fresh and hardened state *[10].*

2. MATERIALS

In general, concrete is a mixture of cement, fine aggregate, coarse aggregate and water. For modifying the properties of concrete, admixtures are added during the preparation of concrete. In this project work, OPC 53 (IS 8112:1989) grade cement is used for preparing the concrete. Fine Aggregates size will be between 150 microns to 4.75 mm. Size of coarse aggregates 10 mm and 20 mm are taken from sieve analysis test for preparing the concrete *[2]*. Potable water is generally considered satisfactory for mixing concrete. But PH value of 7 will be preferred for all kind of works *[8].*

High-density polyethylene (HDPE) or polyethylene high-density (PEHD) is a polyethylene thermoplastic made from petroleum. Known for its large strength to density ratio, HDPE is commonly used in the production of plastic bottles, corrosion-resistant piping, geo membranes, and plastic lumber. HDPE is known for its large strength to density ratio. The mass density of high-density polyethylene can range from 0.93 to 0.97 g/cm^3.

Polypropylene (PP**)**, also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles, stationery, plastic parts and reusable containers, laboratory equipment, loudspeakers, automotive components.

Polypropylene is normally tough and flexible; also it has good resistance to fatigue especially when copolymerized with ethylene. Polypropylene is reasonably economical, and can be made translucent when uncolored but is not as readily made transparent as polystyrene, acrylic, or certain other plastics. It is often opaque or colored using pigments. These above two polymers are used as admixture in this present study *[6].*

Table 2.1: Basic details of these polymers

S. No	Type of Polymer	Marketed by	Model No
1	High Density Polyethylene virgin Polymer	*MARLEX*	*55180*
2	Polypropylene virgin Polymer	*RELIANCE*	*110 MA*

3. METHODOLOGY

In this project all kind of concrete making material tests to be carried out. From the test results the M60 grade concrete (design mixed) to be prepared as per ACI Method. Both the HDPE and PP polymers (by cement) are added separately into the conventional concrete by the dosages 0 %, 2.5 %, 5.0 % and 10.0 % The behaviour of this High Strength polymer concrete to be studied both fresh and hardened state. The compressive strength of polymer modified concrete is to be studied at 7 and 28 days and compared with the conventional concrete *[3].* Finally recommendations are made based on the experimental investigations.

4. RESULTS

Table 4.1: Details of Cement tests

S. No	Tests	Result	Permissible Values	Remarks
1	Specific Gravity	3.147	<3.15	Type of Cement: OPC 53 grade (IS 4031 -1998)
2	Fineness (%)	6	<10	
3	Initial Setting time (minutes)	30	<30	
4	Final Setting time (minutes)	598	<600	

Table 4.2: Details of Aggregates Tests

S No	Tests	Fine Aggregate		Coarse Aggregate	
		Result	Perm Value	Result	Perm Value
1	Specific Gravity	2.58	2.55	2.62	< 2.7
2	Fineness modulus	4.193	< 5	5.54	< 7
3	Density (kg/m^3)	1297	---	1646	---
4	Water absorption (%)	1	< 2 %	0.51	< 2 %

Table 4.3: Polymer Property Test details

S No	Tests	High density Polyethylene (Injection type) Virgin polymer	Polypropylene (Injection type) Virgin polymer
1	Composition	Milky white, Non polar material	White, Rigid material
2	Density	0.935 g/cm^3	0.946 g/cm^3
3	Mean particle size	1.2 mm	3.05 mm
4	Tensile strength	16.0 N/mm^2	14.35 N/mm^2
5	Crystallanity	50 %	80 %
6	Poisson Ratio	0.46	0.45
7	Water Absorption	< 0.01 %	0.01 %

Table 4.4: Details of Fresh Concrete tests

S. No	% of Polymer	Avg. Slump value (mm)		Avg. Compaction factor value		Avg. Consistency value (Seconds)	
		HDPE	PP	HDPE	PP	HDPE	PP
1	Without polymer	155	152	0.93	0.93	11	11
2	2.50 %	150	149	0.935	0.935	12	13
3	5.00 %	142	140	0.96	0.95	13	14
4	10.00 %	130	129	0.962	0.962	14	15

Table 4.5: Compression test after 7 days

S. No	% of Polymer	Avg. Compressive Strength value at 7 days (N/mm^2)	
		HDPE	PP
1	Without polymer	41.33	40.22
2	2.50%	43.33	42.66
3	5.00%	45.55	45.77
4	10.00 %	47.11	47.33

Table 4.6: Compression test after 28 days

S. No	% of Polymer	Avg. Compressive Strength value at 7 days (N/mm^2)	
		HDPE	PP
1	Without polymer	63.77	67.55
2	2.50%	66.22	68.88
3	5.00%	69.11	70.44
4	10.00 %	71.33	71.33

5. CONCLUSION

High Density Poly-Ethylene and Poly-Propylene mix shows a slight increase in the compressive strength as compared with the High Strength. The compressive strength at 7 days and 28 days of M60 grade of concrete increased as the percentage of polymer increases.

The maximum compressive strength obtained at 10% High Density Poly-Ethylene and Poly-Propylene. The Compressive strength of PP virgin polymer concrete values is slightly increased than the HD virgin polymer concrete values. The study is in process for tensile strength, flexural strength and durability characteristics.

Use polymer in the concrete industry as a replacement for cement has the benefits of reducing the costs of disposal and helps protecting the environment.

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