ISSN (Online): 2456-5717

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3 Issue.12 December 2017

An Investigation on Strength and Durability Properties of Polymer Modified Cement Concrete

[1]Muthukumaran.S, [2]Muralimohan.N, [3]Sudha.P
Assistant Professor, Department of Civil Engineering, Mother Teresa College of Engineering, Pudukottai[1]
Associate Professor, Department of Civil Engineering, K.S.R College of Engineering, Erode[2, 3]

***Abstract* – Polymer as one of the best admixture can improve the property of concrete than the conventional concrete. In this project 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 the properties of 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 M20 grade conventional concrete is used and both the polymers are mixed from 0% to 10% were used. The results obtained from literature studies are encouraging for partial addition of polymer with conventional cement concrete up to 10% which enhances the strength of concrete.**

***Keywords* – Polymer modified cement concrete, strength, durability, High Density Poly-Ethylene (HDPE), Poly-Propylene (PP).**

I. INTRODUCTION

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.

Therefore, process 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.

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. The mechanical properties of polymer concrete are very important in many of its applications. In Polymer modified concrete, the material properties can vary considerably in function of material composition; therefore each type of polymer modified concrete can be characterized by its special individual properties. The strength and

physical characteristics of polymer modified concrete primarily depend on the types of binder and admixture.

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 mortar or concrete to old concrete. Concrete polymer composites are Environment conscious and confirm to concerns of saving of natural resources, the long life of infrastructures and the environmental protection. Adding high density virgin polymer and poly propylene virgin polymer in the fresh concrete mix makes polymer modification of concrete.

II. STUDY ABOUT POLYMER

Polymer is a Greek word (*Poly* refers to Many, *mer* refers to Parts) i.e.) Large molecules or macro molecules composed of many repeated sub units. Molecule whose structure composed of many repeated sub units. Polymerization is the process of converting monomer or mixture of monomer into polymer.

High Density Polyethylene

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. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. High-density polyethylene, unlike polypropylene, cannot withstand normally required autoclaving conditions.

Fig.1 HDPE

Poly-Propylene

Poly-Propylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids. Most commercial polypropylene is isotactic and has an intermediate level of crystallinity between that of low-density polyethylene (LDPE) and high-density polyethylene (HDPE). Polypropylene is normally tough and flexible, 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. Polypropylene has good resistance to fatigue.

Fig.2 PP

III. METHODOLOGY

Infrastructure development is raising its pace. Many reinforced concrete and masonry buildings are constructed annually around the globe. With this, there are large numbers of them which deteriorate or become unsafe to use because of changes in use, changes in loading, change in design configuration, inferior building material used or natural calamities. Thus repairing and retrofitting these structures for safe usage of these structures has a great market. There are several situations in which a civil structure would require strengthening or rehabilitation due to lack of strength, stiffness, ductility and durability.

In this project all kind of concrete making material tests (Cement tests, Aggregate tests and water tests) to be carried out. From the test results the concrete mix design to be prepared as per IS 10262-1982.The selected polymers are from two different groups. Both the high density polyethylene and polypropylene polymers (by w/w cement) are added separately into the conventional concrete by the dosages.0 %, 2.5 %, 5.0 %, and 10.0 %.The behavior of this polymer modified 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. Finally recommendations are made based on the experimental investigations.

Properties of Polymer

TABLE I PROPERTIES OF CARBON FIBER

Tests	High density Polyethylene(Injection type) Virgin polymer	Polypropylene(Injection type) Virgin polymer
Composition	Milky white, Non polar material	White, Rigid material
Density	0.935 g/cm^3	0.946 g/cm^3
Mean particle size	1.2 mm	3.05 mm
Tensile strength	16.0 N/mm^2	14.35 N/mm^2
Crystallanity	50 %	80 %

Poisson Ratio	0.46	0.45
Water Absorption	< 0.01 %	0.01 %

Compressive Strength Test

Compression test is the most common test conducted on hardened concrete, partly because it is easy to perform, the partly because most of the desirable characteristics properties of concrete are qualitatively related to its compressive strength. The compression strength is carried out on a cube specimen of the size 150x150x150mm of 42 concrete cubes 7 groups, 6 cubes for each of the mixes with different dosage of HDPE and PP along with controlled concrete as 1 group having 6 cubes. The compressive strength of the cubes was tested at the ages of 7 and 28 days. In the 100 ton capacity compressive testing machine the smooth surfaces of the specimen were placed between the plates of compression testing machine, subjected to gradual loading and the ultimate load at failure was noted.

Split Tensile Strength Test

The test has to be carried out by placing a cylindrical specimen horizontally between the loading surface of compression -testing machine and load is applied failure of the cylinder, along the diameter. The split tensile strength test will be carried out on a cylinder specimen of 300mmx150mm of 42 concrete cylinders of 7 groups, 6 cylinders for each of the mixes with different dosage of HDPE and PP along with controlled concrete as 1 group having 6 cylinders for which the split tensile strength of the cylinder is to be tested at the ages of 7 and 28 days.

Flexural Behavior Strength for Beam

After the curing period the specimen is taken out from the curing tank and wiped clean. The dimensions of the specimens should be noted. The testing machine should be provided with two rollers of 38 mm diameter on which the specimens are placed and the rollers are spaced such the distance between two rollers the load is to be applied trough two similar rollers mounted at 1/3 rd points away from the supports. The load should be divided equally between two loading rollers and the rollers are mounted in such manner that the load is applied axially and without subjecting specimen to any torsion stress. A schematic test set up used to carrying out the flexural test on a beam shown in figure. A load cell has to be attached and at every loading cracks appearing on the surfaces were marked. The beams were loaded up to ultimate failure. The load has to be increased until the specimen fails and the maximum load applied to the specimen during the test is to be recorded. Data to be collected includes:

a) Ultimate strength of the beams at failure

b) Load versus deflection characteristics of beams

IV. EVALUATION

The basic problem is to introduce a sufficient volume of HDPE and polypropylene polymer to be uniformly dispersed in the mix to achieve the desired improvements in mechanical behavior, while retaining sufficient workability in the fresh mix to permit proper mixing, compacting, placing and finishing. Polypropylene has a property of evenly distributed in concrete. Concrete mixing process of HDPE and polypropylene polymers need

to be done carefully to ensure the polymer will be distributed uniformly in the concrete matrix.

TABLE II SPECIMEN DETAILS

Sl no	Grade of Concrete	Replacement % of cement	No of Cubes	No of Cylinders	No of Beams	No of cubes for durablity
1	M 20	0.0%	6	6	6	6
2	M 20	2.5% HDPE	6	6	6	6
3	M 20	5.0% HDPE	6	6	6	6
4	M 20	10.0% HDPE	6	6	6	6
5	M 20	2.5% PP	6	6	6	6
6	M 20	5.0% PP	6	6	6	6
7	M 20	10.0% PP	6	6	6	6

HDPE – High Density Poly-Ethylene; PP – Poly-Propylene

V. CONCLUSION

Based on the experimental test results, following conclusions were drawn:

(i) The results of the primary tests conducted in the laboratory reported that the use of Polymer modified concrete is rich in specific applications. However, with the increasing demand being made on concrete technology to serve the needs of society, experts are responding positively by proposing new formulations using other materials. Hence it is understood that, incorporating polymer materials into the concrete has, to some extent, contributed to this demand.

(ii) The properties of materials used like Cement, Coarse aggregate, Fine aggregate were tested and presented.

(iii) Proportions of polymer for cement replacement decided as 2.5%, 5.0%, 10.0% weight of cement.

(iv) It is observed that, Compressive strength, split tensile strength and flexural strength were increased with increasing amount of polymer.

(v) Adding 10% of HDPE&PP, the following improvement are observed.

(vi) The Compressive strength of concrete increases up to 26% for 28 days when compared with the conventional concrete.

(vii) The split tensile strength of concrete increases up to 20% for 28 days when compared with the conventional concrete.

(viii) The flexural strength of concrete increases up to 31% for 28 days when compared with the conventional concrete.

REFERENCES

[1] M. Golestaneh, G. Amini, G.D. Najafpour and M.A. Beygi, “Evaluation of Mechanical Strength of Epoxy Polymer Concrete with Silica Powder as Filler”, World Applied Sciences Journal 9 (2): 216-220, 2010.

[2] I.M.Ibrahim,N.F.Ghaly.M,EL-Shafie and A.M.M.Abd El Rahman(2014), "*Effect of some polymers and asphalt emulsion on the deterioration of cement mortar and concrete*", in Life science journal 2014:11(10),Egyptian petroleum research institute ,Nasr City,Cairo,Egypt.

[3] V.Bhikshma, K. Jagannath Rao and B. Balaji, "An experimental study on behavior of polymer cement concrete", Asian Journal Of Civil Engineering (Building And Housing) Vol. 11, No. 5 (2010), Pages 563-573.

[4] Kim, J.H., Robertson, R. E. and Naaman, A. E. (1995), "Structure and properties of poly (vinyl alcohol) modified mortar and concrete", Journal of Cement and Concrete research, 29, 407-415.

[5] Sivakumar.M.V.N, 1996, "Effect of Polymer modification on mechanical and structural properties of concrete – An experimental investigation", International Journal of Civil and Structural Engineering, Volume 1, No 4, 2011, Pages 732-740.

[6] OrsolyaIlona Nemeth, "*Strength characteristics of polymer concrete in function of time and production conditions*", in the Conference of Junior Researchers in Civil Engineering, 150-157.

[7] Moetaz.M.El.Hawary, Ali Abdul-Jaleel, Thamer Al-Yaqoub (2004) "*Corrosion and durability of polymer modified concrete:" 29th conference on our world in concrete and structures, Singapore.*

[8] V.M.Karbhari, J.W.Chin, D.Hunston, B.Benmokarane, T.Juska, R.Morgan, J.J.LeskU.Sorathia and D.Reynaud (2010), "*Durability Gap analysis for Fiber reinforced polymer composites in civil engineering*", in Journal of composites for construction, 7(3) ,238-247,2003.

[9] Baoshan Huang, Hao Wu, Xiang Shu, Ewin G.Burdette (2009), "*Laboratory evaluation of permeability and strength of polymer modified pervious concrete*", in Journal of concrete building materials.2009.10.025, DOI 10.1016.

[10] Gorninski, J.P., D.C. Dal Molin C.S. Kazmierczak, 2004. "Study of the modulus of elasticity of polymer concrete compounds and comparative assessment of polymer concrete and Portland cement concrete", Cement and Concrete Res., 34(11): 2091-2095.

[11] Afridi MUK, Ohama Y, Demura K, Iqbal MZ (2001), "*A note on the comparison of crack resistance of Ca(OH)2 crystals of unmodified and polymer-modified mortars in carbonated atmosphere*", in Journal of Cement and Concrete Research, No. 11, Pages 1643-5,10.016/S0008-8846(01)00600-7.

[12] Afridi MUK, Ohama Y, Demura K, Iqbal MZ. "Development of polymer films by the coalescence of polymer particles in powdered and aqueous polymer modified mortars", Cement and Concrete Research, No. 11, 33(2003) 1715-21.

[13] Varghese, K.T. and B.K. Chaturvedi, 1996. "Fly ash as fine aggregate in polyester based polymer concrete", Cement and Concrete Composites, 18(2): 105-108.

[14] Jo BW, Park SK, Kim CH.,"Mechanical Properties of polyester polymer concrete using recycled polyethylene terephthalate", ACI Materials Journal, Mar/Apr 2006.

[15] Mandel, J. A. and Said, S. (1990), "Effect of the addition of an acrylic polymer on the mechanical properties of mortar", ACI Materials journal, 87(1), 54-61.