International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 04 - Issue 02 || February 2019 || PP. 109-118

Experimental Investigation on High Performance Concrete Using Carbon Black & Pet

R. Dheemadha Pragatha[1], V. Dass Mohan, M.E.,[2]
[1]*PG Scholar of Structural Engineering,*
Vickram College of Engineering, Enathi, Tamil Nadu, India
[2]*Head of department, Department of Civil Engineering,*
Vickram College of Engineering, Enathi, Tamil Nadu, India

Abstract: The current tendency in the world is to find new materials at lower cost which can guarantee better performances during their incorporations in the concrete. This study consist the development and high performance concrete with Carbon Black Powder and PET. Super Plasticizer used was CERAPLAST-300. Reuse of waste materials acts eco friendly also prevents exploitation of resource. Usage of such materials for construction purpose enhances the traditional methods of construction. In this project the PET as a partial replacement of fine aggregate and Carbon Black as a partial replacement of Cement.

In this paper an experimental investigation on the effect of PET (polyethylene terephthalate) on various strength properties was presented. The strength properties of M40 grade concrete are studied with 0 %, 5%, 10 %, 15%, 20 % and 25% of PET. The carbon black as a partial replaced by cement with 0%,5%,10%,15%, 20% and 25 %.. Concrete cubes and cylinders are cast depending on percentage ratio and it's effect is studied at different ages by performing tests on concrete specimens. A comparison is made with test results to conventional concrete only to arrive at valid conclusion.

Keywords: High Performance Concrete, Ceraplast-300, PET, Carbon Black Powder.

I. Introduction

Concrete is a mixture of naturally, cheaply and easily available ingredients as cement sand, aggregate and water. Cement is occupied second place as most used material in the world after water. The rapid production of cement creates big problems to environment. First environment problem is emission of co_2 during the production process of the cement. The co_2 emission is harmful which creates big changes in environment. According to the estimate, 1 tonne of carbon dioxide is released to the atmosphere when 1 tonne of ordinary Portland is manufactured. As there is no alternative building material which totally replace the cement. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environment impact. Substantial energy and cost savings can result when industrial by products are used as a partial replacement of cement. Super Plasticizer used was CERAPLAST-300. Fly ash, ground granulated blast furnace slag, rice husk ash, high reactive mera kaolin, silica fume are some of the pozzolonic materials which can be used in concrete as partial replacement of cement.

For developing concrete mix, it is important to select proper ingredients, evaluate their properties and understand the interaction among different materials. HPC will normally contain not only Portland cement, Aggregate and Water, but also Super plasticizers and Supplementary Cementing Materials. The ingredients used for this Dissertation work are same as that used for the normal concrete ordinary Portland cement, Coarse and Fine Aggregates, Water and Chemical Admixture – except for Fly ash which is generally not used in conventional concrete. This chapter provides a detailed description of the materials used in the experimental program and experimental methods used in this study.

II. Materials and Methods

2.1 Cement:

Cement is the most important constituent of concrete, in that it forms the binding medium for the discrete ingredients made out of naturally occurring raw materials and sometimes blended with industrial waste. The quantity required for this work was assessed and the entire quantity was purchased and stored properly in casting yard. The cement used in this experimental investigation is 53 grade OPC conforming to IS 12269:1987.

2.2 Fine Aggregate

The fine aggregate sample taken for study and physical properties of fine aggregate. Both river sand and crushed stones may be used. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in High Performance Concrete as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, etc. The sand particles should also pack to give minimum void ratio as the test results show that higher void content leads to requirement of more mixing water. Finally in this study river sand is used, Specific gravity of sand is 2.62.

2.3 Coarse Aggregate

The coarse aggregate sample taken for study and the physical properties of coarse aggregate. For coarse aggregate, crushed 12mm normal size graded aggregate was used. The specific gravity and water absorption of coarse aggregate were found to be 2.68 and 1.0%, respectively. The grading of coarse aggregate conforms to the requirement as per IS: 383 – 1970.The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete. By usage of mineral admixtures, the cement concrete becomes more homogeneous and there is marked enhancement in the strength properties as well as durability characteristics of concrete. The strength of High Performance Concrete may be controlled by the strength of the coarse aggregate, which is not normally the case with the conventional cement concrete.

2.4 Water

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrated cement gel. The requirement of water should be reduced to that required for chemical reaction of unhydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste in concrete. From High Performance Concrete mix design considerations, it is important to have the compatibility between the given cement and the chemical/mineral admixtures along with the water used for mixing.

2.5 Pet

PET in its natural state is a colorless, semi – crystalline resin. Based on how it is processed, PET can be semi – rigid to rigid, and it is very light weight. It makes a good gas and fair moisture barrier, as well as a good barrier to alcohol (requires additional "barrier" treatment) and solvents. It is strong and impact – resistant. PET becomes while when exposed to chloroform and also certain other chemicals such as toluene.

Figure .1 PET

2.6 Carbon Black Powder:

Carbon black is virtually pure element carbon in the form of colloidal particles that are produced by incomplete combustion or thermal decomposition of gaseous or liquid hydrocarbon under controlled conditions. Its physical appearance is that of a black, finely divided pellet or powder.

Figure .2 Carbon Black Powder

2.7 Ceraplast-300:

CERAPLAST 300 is a concrete plasticizer which reduces the amount of gauging water required and increases the workability, density and strength at the same cement content.

Figure.3 Ceraplast-300

2.7.1 Properties:

Supply form : Liquid
Colour : Brown
Specific gravity : 1.2 + .03
Chloride contents : Nil

2.7.2 Function:

CERAPLAST 300 disperses cement particles more rapidly in the concrete mix by reducing the surface tension of water and imparting repelling charges to the ions in solution. This makes the concrete highly workable and flow able even at lower water-cement ratios, resulting in increased strength.

III. Mix Design For M40 Grade Concrete

The mix design of M40 grade concrete is calculated using IS 456 – 2000 and IS 10262-2009. The material required as per design are given table 1 :

Table 1: Materials Required As Per Is Method of Design

W/C RATIO	QUANTITY OF MATERIALS (Kg/m^3)		
	CEMENT	FINE AGGREGATE	COURSE AGGREGATE
0.4	380	678	1235

The properties of materials used are

- Specific gravity of cement = 3.17
- Specific gravity of fine aggregate = 2.79
- Specific gravity of coarse aggregate = 2.5

3.1 Experimental Programme

The following tests were made after 28 days curing:

- ❖ Workability test
- ❖ Compressive strength test
- ❖ Split tensile strength test,
- ❖ Flexural strength test (for prism)
- ❖ Flexural strength test (for beam)

3.1.1 Workability test

3.1.1.1 Slump cone test

The concrete slump test is an empirical test that measures workability of fresh concrete. The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the case with test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformly for different batches of concrete under field conditions, and to ascertain the effects of plasticizers on their introduction. Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 100mm, and bottom internal diameter 200mm with a height of 300mm.

Fig 4: Slump test

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as the true slump, shear slump or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indicated of too wet a mix or that it is a high workability mix, for which the slump test is not appropriate. Very dry mixes having 10 -40mm are used for foundation with light reinforcement, medium workability mixes, 50 – 90 mm for normal reinforcement concrete placed with vibration , high workability concrete > 100mm.

3.1.2 Compressive strength test

This test method covers the deformation of cube compressive strength concrete specimen. The specimen is prepared by pouring freshly mixed concrete into lubricated cube moulds. Consolidation is done extremely over vibrating table for 1-2 minutes. After vibration and finishing, the moulds are kept at normal atmosphere conditions for 231/2 + ½ hours after which demoulding is done. The specimen are then cured in water tank.

Fig 5: Compressive Strength Testing Arrangement

The test is conducted at surface dry condition. The specimen is tested at the age for 28 days of curing under the compression testing machine.

$$\text{Compressive strength (N/mm2)} = \frac{\text{Maximum load at failure * 1000 N}}{\text{Loaded surface area (mm2)}}$$

The tests were carried out on a set of triplicate specimen and the average compressive strength values were taken.

3.1.3 Split tensile strength test

Splitting tensile strength test was conducted on concrete cylinders to determine the tensile nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimensions of the specimen was noted. The cylinder specimen was placed on compression testing machine. The local was applied continuously without shock at a constant rate. The breaking load (p) was noted.

$$\text{Splitting tensile strength test} = \frac{\text{2 * breaking load (N/mm2)}}{\Pi \text{ * dia. of cylinder * length of cylinder}}$$

Fig 6: Split Tensile Strength Testing Arrangement

3.1.4 Flexural strength (prism):

Flexural strength test was conducted on concrete prism to determine the flexural nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimension of the specimen was noted. The load was applied continuously without shock at a constant rate. The breaking load (p) was noted.

Flexural strength (N/mm2) = PL / BD^2

Fig 7. Flexural strength test

3.1.5 Flexural strength (beam):

Flexural strength test was conducted on concrete beam to determine the flexural nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimensions of the specimen was noted. The load was applied continuously without shock at a constant rate. The breaking load (p) was noted.

Flexural strength (N/mm2) = PL/BD^2

3.1.6 Permeability Test

Permeability testis used to find the durability of concrete with the help of water and air. It is done by using Concrete Permeability test Apparatus. Since permeability affects the destructiveness of saturated freezing this test is done. It is 3 cell apparatus, in which cubes of 100mm can be placed. Pressure gauge is placed to find the pressure applied in the apparatus; nearly 1.25 kg f/cm^2 air pressure is applied. Cell assembly is filled with water.

Permeability test of all the cubes after 28 days is shown in Table 6.By measuring the water and time, coefficient of permeability is found. Depending upon the quantity of water and time of flow, permeability varies for the concrete. It is determined by using the following formula

$$k = \frac{QL}{tAh}$$

Where, k = Darcy Coefficient of Permeability (m/s)
Q = Volume of water in m^3
L = Length of the test sample in metres, to the nearest 0.001m
t = Elapsed time in seconds
h = Applied pressure head in metres of water
A = Area of the test sample in m^2

Fig 8: Permeability Testing Arrangement

IV. Result and Discussion

4.1 Experimental Results
Fresh concrete properties:

The required quantities of all the ingredients were taken by weight batching with appropriate coarse aggregate fractions and mineral admixtures. Mixing of the ingredients was done in a pan mixer as per the standard procedure. A reference mix was prepared using a water-binder ratio of 0.31 and suitable super plasticizer content (by weight of cement) in order to get desired workability. The workability of the concrete was studied by conducting slump and compaction factor tests as per the standard procedure. All the HPC mixes were prepared with same water-binder ratio and super plasticizer dosage and tested for workability and strength properties of HPC mixes. It was observed that the super plasticizer had significant role in the workability of concrete with a w/c of 0.31.

4.1.1 Slump test

From the slump test results the slump value for conventional concrete is found to be 72mm.Based on the test results, it is found that the workability is better for addition levels of CB and PET by weight of cement compared to replacement levels and conventional concretes. The slump values for the replacement of CB and PET is tabulated in table 4.1

Table 4.1: Slump test results on replacement of CB and PET

Sl. No	Mix Designation	CB and PET by weight of cement	Water cement ratio	Super plasticizer	Slump in mm
1	CB & P 0	0	0.31	0.8% by weight of cement	64.5
2	CB & P 5	5%			65
3	CB & P 10	10%			65.5
4	CB & P 15	15%			66
5	CB & P 20	20%			66.5
6	CB & P 25	25%			67

4.1.2 Compaction factor Test

From the compaction factor test results the value for conventional concrete is found to be 72mm.Based on the test results, it is found that the workability is better for addition levels of CB & P by weight of cement compared to replacement levels and conventional concretes. The compaction factor values for the replacement of CB & P is tabulated in table 4.2.

Table 4.2: Compaction factor test results on replacement of CB & P

Sl. No	Mix Designation	CB & P by weight of cement	Water cement ratio	Super plasticizer	Compaction factor
1	CB & P 0	0	0.31	0.8% by weight of cement	0.75
2	CB & P 5	5%			0.775
3	CB & P 10	10%			0.78
4	CB & P 15	15%			0.79
5	CB & P 20	20%			0.795
6	CB & P 25	25%			0.805

4.1.3 Compressive strength on replacement of CB & P

The 7 days, 14 days and 28days compressive strength of the HPC mixes with Carbon black powder and PET replacement levels ranging from 0 to 25% were illustrated in figure 4.1.Replacing cement by carbon black and fine aggregate by PET up to 15% increased the compressive strength of concrete at all ages of testing (7, 14 and 28 days). Further increase in the replacement level does not increase the strength. The improvement in compressive strength at 7, 14 and 28 days are 33%, 10% and 16%, respectively. At the age of 7 days, the gain in compressive strength is higher compared to the gain in compressive strength at 14 and 28 days. This shows that the carbon black and PET plays a significant role in the development of strength of concrete at the early age.

Sl. No	Mix Designation	CB & P by weight of cement	Compressive strength in Mpa		
			7 Days	14 Days	28 Days
1	CB & P 0	0	29.25	32.86	41.58
2	CB & P 5	5%	35.55	46.65	54.22
3	CB & P 10	10%	42.67	52.89	59.44
4	CB & P 15	15%	46.05	58.87	68.22
5	CB & P 20	20%	50.78	54.86	64.21
6	CB & P 25	25%	48.89	51.56	60.86

Table 4.3: Compressive strength test results on replacement of CB & P

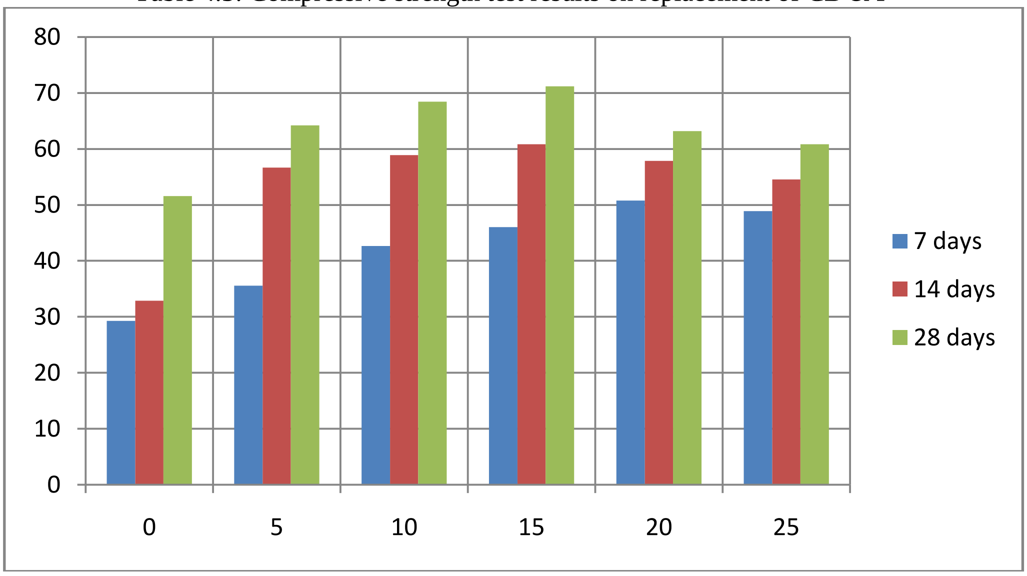

Fig 4.1: Compressive strength on replacement of CB &PET

4.1.4 Split tensile Strength on replacement of CB & P

The splitting tensile strength test results are illustrated in figure 4.2.It was observed that, at all ages of testing, the tensile strength of concrete increased with replacement of cement by carbon black and fine aggregate by PET up to 15%. Further increase in replacement level does not increase the tensile strength at all ages. The improvement in tensile strength at 7, 14 and 28 days are 105%, 40% and 11%, respectively. The gain in tensile strength is higher at 7 days than at 14 and 28 days. This again shows that the carbon black and PET plays a vital role in the development of strength of concrete at the early age.

Sl. No	Mix Designation	CB & P by weight of cement	Splitting tensile strength in Mpa		
			7 Days	14 Days	28 Days
1	CB & P 0	0	2.41	3.48	5.62
2	CB & P 5	5%	2.85	3.03	5.80
3	CB & P 10	10%	3.98	3.11	5.97
4	CB & P 15	15%	4.96	4.24	6.22
5	CB & P 20	20%	4.75	5.08	5.54
6	CB & P 25	25%	4.35	4.76	5.11

Table 4.4: Split tensile strength test results on replacement of CB & P

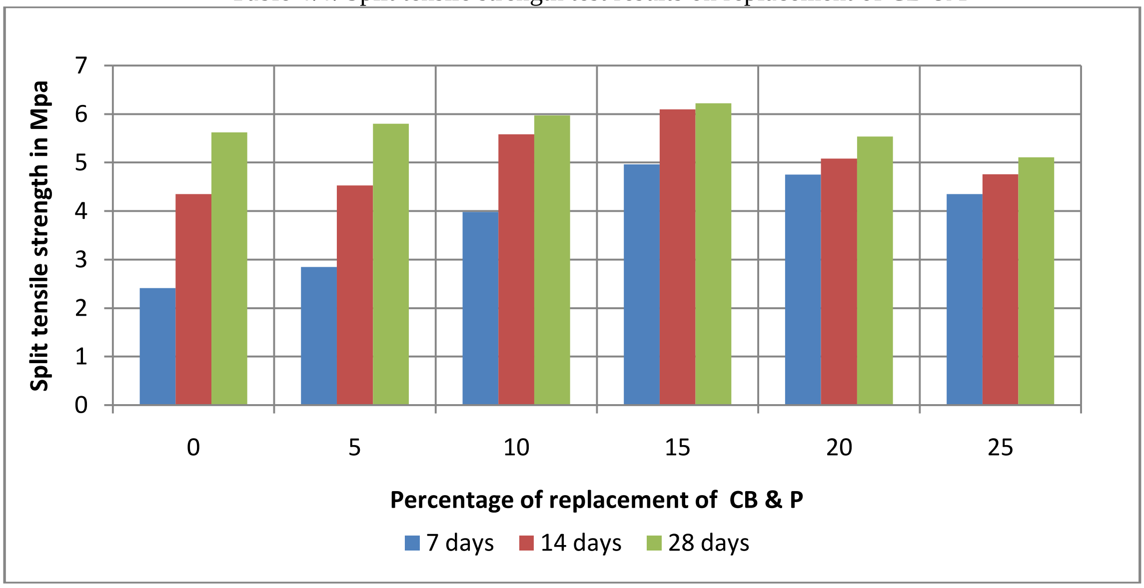

Fig 4.2: Split tensile strength on replacement of CB & P

4.1.5 Flexural strength on replacement of CB & P

The 7 days, 14 days and 28days flexural strength of the HPC mixes with carbon black and PET replacement levels ranging from 0 to 25% were illustrated in figure 4.3.Replacing cement by carbon black and fine aggregate by PET up to 15%increased the flexural strength of concrete at all ages of testing (7, 14 and 28 days). Further increase in the replacement level does not increase the strength. The improvement in flexural strength at 7, 14 and 28 days are 20%, 7% and 8%, respectively. At the age of 7 days, the gain in flexural strength is higher compared to the gain in flexural strength at 14 and 28 days. This shows that the carbon black and PET plays a significant role in the development of strength of concrete at the early age.

Table 4.5: Flexural strength test results on replacement of CB & P

Sl. No	**Mix Designation**	**CB & P by weight of cement**	**Flexural strength in Mpa**		
			7 Days	**14 Days**	**28 Days**
1	CB & P 0	0	4.95	5.82	6.24
2	CB & P 5	5%	5.66	6.19	6.64
3	CB & P 10	10%	6.03	6.29	6.91
4	CB & P 15	15%	5.82	6.14	6.57
5	CB & P 20	20%	5.54	6.04	6.42
6	CB & P 25	25%	5.33	5.96	6.27

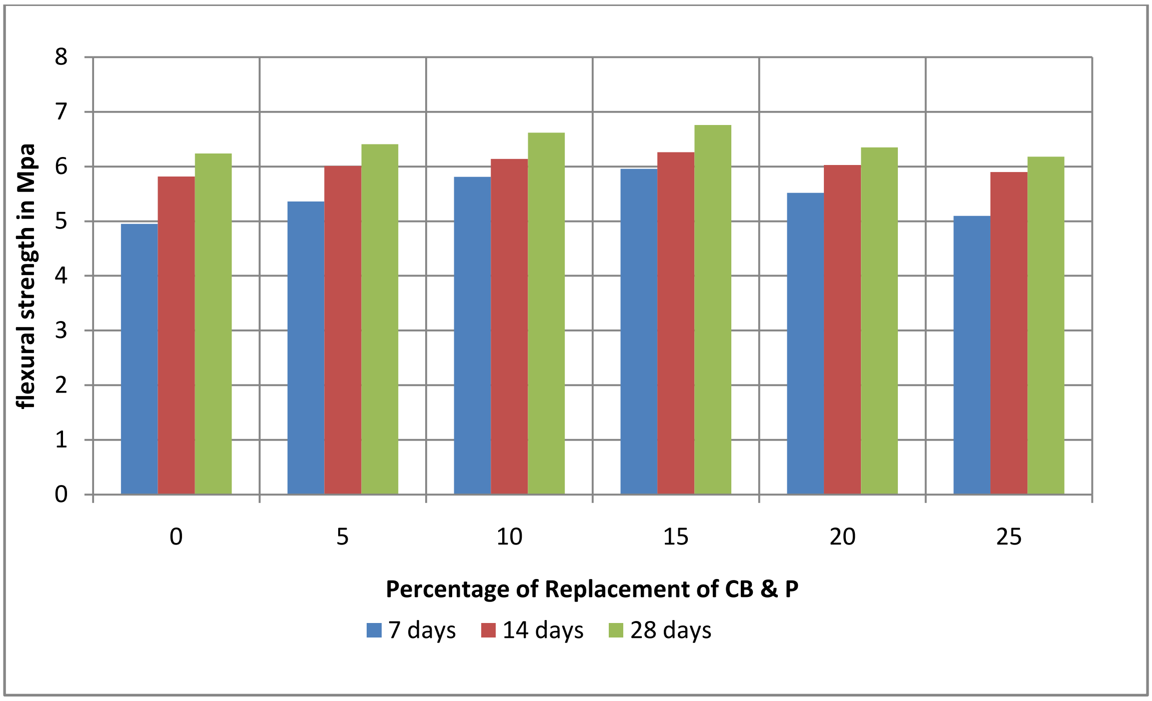

Fig 4.3: Flexural strength on replacement of CB & P

4.1.6 Permeability test on replacement of CB & P :

The results of various proportions of replacement of cement by CB and fine aggregate by PET from the permeability test is tabulated in table 4.6 and necessary graph the loss of weight and strength are illustrated in fig 4.4 Permeability test results identifies that there is very less voids present in HPC with CB & P at 15% replacement.

Table 4.6: Permeability test results on Replacement of CB & P

Sl. No	**Mix Designation**	**CB & P by weight of cement**	**Co-efficient of Permeability (k)x10^{-12} in m/sec**
1	CB & P 0	0	6.53
2	CB & P 5	5%	6.22
3	CB & P 10	10%	5.34
4	CB & P 15	15%	3.89
5	CB & P 20	20%	4.12
6	CB & P 25	25%	5.45

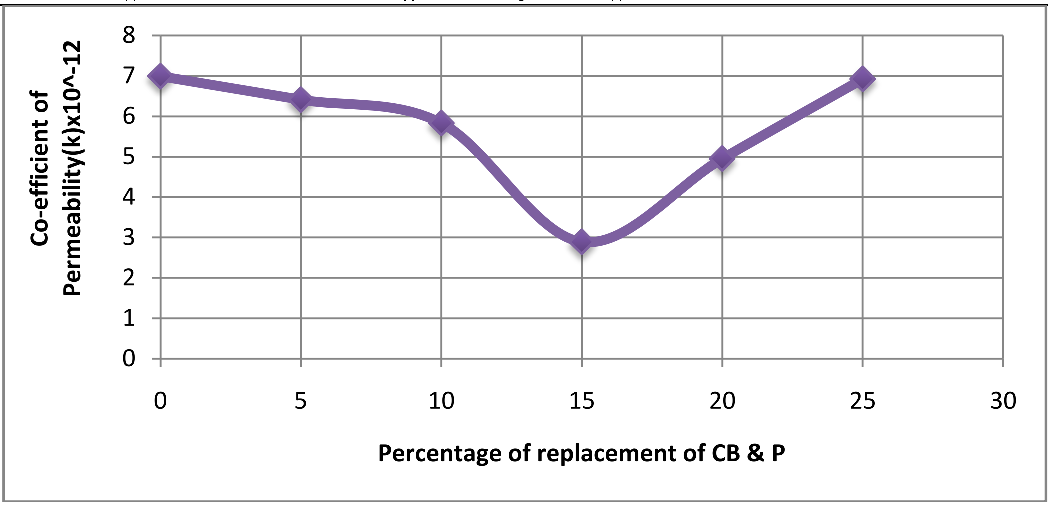

Fig 4.4: Permeability value on replacement of CB & P

V. Conclusions

Based on the findings of this work, the following conclusions shall be drawn:

1. HPC can even be made with help of carbon black powder and PET mineral admixture by replacing considerable amount of cement and fine aggregate. As such, utilization of lesser amount of cement in concrete reduces heat of hydration and shrinkage, and environmental problems considerably.
2. The compressive, tensile and flexural strengths of concrete increased up to 15% replacement level of cement by carbon black and fine aggregate by PET. Further increase in replacement level does not increase the aforesaid strength at all ages.
3. The improvement in compressive strength at 7, 14 and 28 days are 43%, 15% and 16%, respectively for the replacement of cement by carbon black and fine aggregate by PET.
4. The improvements in tensile strength at 7, 14 and 28 days are is 96%, 40% and 11%, respectively replacement of cement by carbon black and fine aggregate by PET.
5. The improvements in flexural strength at 7, 14 and 28 days are is 20%, 7% and 8%, respectively for the replacement of cement by carbon black and fine aggregate by PET.
6. The gain in compressive, tensile and flexural is higher at 7 days than gain in strength at 14 and 28 days. This shows that the carbon black and PET plays a vital role in the development of strength of concrete at the early age. Hence it shall be recommended for structures which are to be concreted continuously by using slip forms.
7. Permeability test results identifies that there is very less permeable present in HPC with carbon black at 15% replacement of cement by carbon black and fine aggregate by PET. It is prevent hope of the investigator that future project in this topic can be done in all other left out areas.

References

[1]. Mohammed Jalaluddin, 'Use of plastic waste in civil construction and innovative decorative material (eco – friendly)' Mahabubnagar, India.
[2]. IS 10262 – 2009. Recommended guidelines for concrete mix design, bureau of Indian standards, New Delhi, India.
[3]. Sami masadeh, 'The effect of added carbon black to concrete mix on corrosion of steel in concrete', Journal of minerals and materials characterization and engineering, 2015.
[4]. Ms.k.Ramadevi, Ms. R.Manju, 'experimental investigation on the properties of concrete with plastic PET fibres as fine aggregate'. International journal of emerging technology and advanced engineering (2012).
[5]. B.Harini, K.V.Ramana 'Use of recycled plastic waste as partial replacement for aggregate in concrete'. International journal of innovative research in science and technology (2015).
[6]. R.N.Nibudey, P.B.Nagarnaik, A.M.Pande, compressive strength and sorptivity properties of PET fibre reinforced concrete' international journal of advances in engineering and technology (2014).
[7]. Dora foti 'preliminary analysis of concrete reinforced with waste bottles PET fibres', construction and building materials (2011).