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Experimental Investigation of Increasing the Strength of Pervious Concrete by Partially using Flyash as A Replacement Material of Cement

Varatharajaperumal Thangavel[1]*, Karthickraja, G.[2], Ajith, N.[3] and Mohamed Shameem K.[4]

Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu,
[2,3,4]Civil Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, Karthickraja

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ABSTRACT

Being at the core of construction pervious concrete has gravitate curiosity of many passionate researchers towards itself. They studied and experimented with different composition to evaluate efficiency of pervious concrete. Such explorations lead to conquering many hurdles and lead ultimately to sustainable development, a very important aspect of research in the 21st century. The main objective of the work is to investigate the experimental investigation of pervious concrete with special admixture fly ash and super plasticizer permaplast. In this work, a brief literature review has been carried out on previous concrete, fly ash and permaplast. The size of the cubes 150 mm were used to assess the compressive strength of porous concrete. The percentage of Fly ash is varying like 5%, 10%, 15%, 20% was used in this study for replacement of cement. From this comparison of different flyash percentage will make the economic as well as the strength benefits. The pervious concrete are also eco-friendly for the ground water recharge activities. From this cost analysis we can conclude that 5% of fly ash saves the cost of 71 rupees when compared with 100% of cement and also the strength of the pervious concrete mix with fly ash and permaplast nearly attain to the pervious concrete but not get increased.

Keywords: *Concrete, Replacement, Flyash, Permaplast, Cost Analysis.*

Introduction

Pervious concrete or porous concrete is a unique and effective means to meet growing environmental demands. By capturing rainwater and allowing it to seep into the ground, pervious concrete is instrumental in recharging groundwater, reducing storm water runoff. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swales, and other storm water management devices. In doing so, pervious concrete has the ability to lower overall project costs on a first cost basis. In pervious concrete, carefully controlled amounts of water and cement materials are used to create a paste that forms a thick coating around aggregate particles. Using sufficient pastes to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly. This paper provides the review of improving the mechanical properties of pervious concrete through different factors i.e, using additives, using different type and size of aggregates, different w/x ratios, without considerable effect on permeability (ACI 552). It is clear that by using

[1]Assistant Professor, [2,3,4] IV Year B.E

waste material by partially replacement of cement in pervious concrete, overall cost of making of concrete can reduce. It can reduce the disposal problems of waste materials and also consume the cement used for making of pervious concrete. When cement is replaced by various industrial waste compressive (Bassuonl and Sonebi, 2010). Research has shown that the major factors that affect pervious concrete strength include the concrete porosity, water-to-cement material ratio (w/cm), paste characteristic, and size and volume content of coarse aggregates. The mechanical properties of pervious concrete can be greatly improved by using proper concrete materials and mix proportions. The addition of polymer (styrene butadiene rubber) could improve pervious concrete workability, strength and permeability as well as freeze–thaw resistance (Ferguson, 2004). The water- cement ratio needs to be kept low, 0.31- 0.5, to ensure the cement paste coats the aggregates and does not run off (Ferguson, 2006).

Methodology

The main objective of the project is to investigate the experimental investigation of pervious concrete with special admixture fly ash and super plasticizer permaplast the methodology of work is given below in the Figure 1.

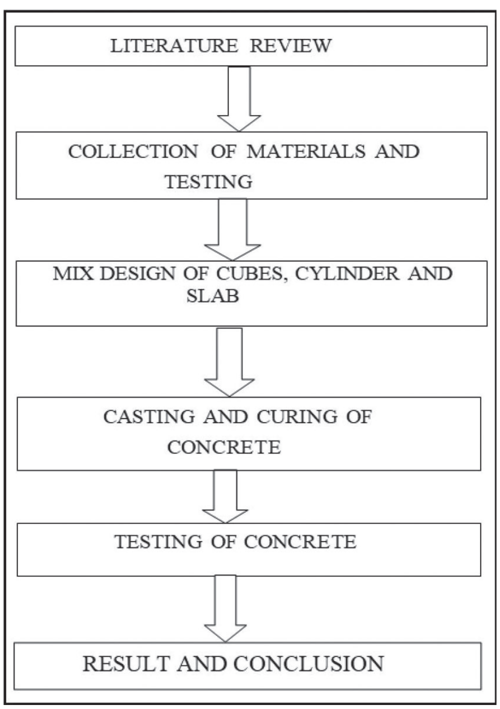

Fig. 1. Flow Chart representation of the work

Materials used and Mix Design

Cement is used as a binding material and setting of concrete to attain strength. The Portland Pozzolana Cement (PPC) is used in a grade of 53 as per IS 12269:1987. The coarse aggregate which was used for the concrete is angular in shape and the size is 20 mm. Specific gravity of cement is 3.16. Fineness test is used to check the proper grinding of cement Average percentage of residue cement is 2.8% (The percentage of residue less than 10% therefore this cement can be used for test.). These twists done through the vicat's plunger apparatus as per IS:4031(PART-4) The percentage of water required for obtaining cement parts of standard consistency is 36%. Initial setting time of cement 30 minutes (as per IS 269, the initial setting time of cement should be less than or equal to 30 minutes, therefore it can be used for test.) The test for the specific gravity we have conducted by using pycnometer as per IS 2386-3 (1963) code book. Specific gravity of coarse aggregate is 2.77. Specific Gravity of fly ash is 2.00 and the Bulk Density of flyash is 881 kg/m^3. To determine the fineness of fly ash by dry sieving as per IS: 4031 (Part 1) 1996 is 8%.

(a) Mix design

(i) Cube

Volume of the cube = Area x Length
= 0.15 × 0.15 x 0.15 m
= 3.375 × 10-3 m^3
Total weight = Unit weight of concrete x volume of cube
= 1900 × 3.375 × 10^{-3} = 6.413 kg
Total weight of Cement and fly ash
= 1/9 x 6.413 = 0.713 kg
Weight of flyash (5% replacing)
= 5/100 x 0.713 = 0.035 kg = 35g
Weight of cement (95% replacing)
= 95/100 x 0.713 = 0.677kg
Weight of coarse aggregate (12mm)
= 8/9 x 6.413 = 5.7kg
Water cement ratio = 0.36 27
Water content = 0.36 *0.677 = 0.243 liter = 243 ml

(ii) Cylinder

Volume of the cylinder = Area x Length
= 3.14 x 0.15*0.15/ 4 x 0.3 m = 0.0053m3
Total weight of = Unit weight of concrete X volume of cylinder
= 1900 x 5.3x10^3

= 10.067 kg

Total weight of Cement and fly ash

= 1/9 x 10.067 = 1.12 kg

Weight of flyash (5% replacing)

= 5/100 x 1.12 = 0.05 x 1.12 = 0.06 kg

60 g Weight of cement (95% replacing)

= 95/100 x 1.12 = 0.95 x 1.12 = 1.064 kg

Weight of coarse aggregate (12mm)

= 8/9 x 10.067 = 8.95 kg

Water cement ratio = 0.36 Water content = 0.36 x 1.064

= 0.385 litre = 385 ml

(iii) Slab

Size of the slab mould = 1 x 1 x 0.5 feet

= 0.3048 x 0.3048 x 0.1524 m

= 0.014 m^3

Total Weight = Density of concrete x volume of slab

= 1900 x 0.014 = 26.6kg

Total weight of cement and fly ash

= 1/9 x 26.6 =2.95kg

Weight of flyash (5% replacing)

=0.05 x 2.95

=0.150kg = 150g

Weight of cement (95% replacing)

= 0.95 x 2.95

= 2.8kg

Weight of coarse aggregate (12mm)

= 8/9 x 26.6

= 23.64 kg

Water cement ratio = 0.36

Water content = 0.36 x 2.95 = 1.062 liter

Results and Discussion

Compression Test

Cubes of size 150 mm were cast for finding compressive strength of porous concrete. Fly ash of varying percentage of 5%, 10%, 15%, 20% was used in this study for replacement of cement. Concrete is allowed to be cured for 28 days and the strength of concrete was tested for 7 days and 28 days. Compression strength test on concrete was carried out in a universal testing machine It is a mechanical test measuring the maximum amount of compressive load of material which it can with stand before fracturing. The concrete used to test can be made in cube, prism or cylinder shaped by using its respective mould and is compressed between platens of a compression testing machine by gradually applied load and it is shown in Fig. 2. The cubes are made up for 7 days and 28 days. These cubes are made three for both 7 days and 28 days and finally the average is taken.

Permeability test

Permeability test was carried out on the specimen. Specimen in Permeability test. measures the permeability of pervious concrete by applying a constant water head on the surface of the sample and by weighting the water volume flowing through the sample at a designed time interval Permeability of pervious concrete is defined as the property that controls the rate of flow of fluids into a porous solid. It largely depends on the size of pores, connectivity of pores, and how tortuous the path is for the permeating fluid.

Fig. 2. Compressive Strength Test for Pervious Concrete Specimen

Table 1. Compressive strength of concrete with Permaplast

Concrete mix	7th day compression test value		Average compression test value for 7th day	28^{th} day compression test value		Average compression test value for
	Load	N/mm^2		load	N/mm^2	
Conventional	289.12	12.84		445.5	19.8	
Pervious concrete	293.24	13.12	13.05	433.3	19.26	20.78
mix With Permaplast	297.31	13.3		490	21.78	

Table 2. Compressive strength of concrete with (5% of fly ash) on 7th day

Concrete mix	Compressive strength of cube on 7th day (N/mm^2)			Average compressive Strength (N/mm^2)
	Trial 1	Trial 2	Trial 3	
Pervious concrete with (5% of fly ash)	6.81	7.12	6.63	6.85
(5% of fly ash) with mix of permaplast	11.84	12.41	12.72	12.32

Table 3. Compressive strength of concrete with (5% of fly ash) on 28th day

Concrete mix	Compressive strength of cube on 28th day (N/mm^2)			Average compressive Strength (N/mm^2)
	Trail 1	Trail 2	Trail 3	
Pervious concrete with (5% of fly ash)	10.92	10.86	11.36	11.04
(5% of fly ash) with mix of permaplast	17.98	19.54	19.25	18.92

Table 4 Compressive strength of concrete with (10% of fly ash) on 7th day

Concrete mix	Compressive strength of cube on 7th day (N/mm^2)			Average compressive Strength (N/mm^2)
	Trail 1	Trail 2	Trail 3	
Pervious concrete with (10 % of fly ash)	5.23	4.91	5.47	5.20
(10% of fly ash) with mix of permaplast	9.34	10.11	10.83	10.09

Table 5. Compressive strength of concrete with (10% of fly ash) on 28th day

Concrete mix	Compressive strength of cube on 28th day (N/mm^2)			Average compressive Strength (N/mm^2)
	Trail 1	Trail 2	Trail 3	
Pervious concrete with (10 % of fly ash)	9.68	9.47	8.74	9.29
(10% of fly ash) with mix of permaplast	15.80	16.49	16.58	16.25

Table 6. Compressive strength of concrete with (15% of fly ash) on 7th day

Concrete mix	Compressive strength of cube on 7th day (N/mm^2)			Average Compressive Strength (N/mm^2)
	Trail 1	Trail 2	Trail 3	
Pervious concrete with (15% of fly ash)	4.38	4.73	3.89	4.33
(15% of fly ash) with mix of permaplast	6.95	7.48	7.37	7.26

Fig. 3. Pervious Concrete Sample Specimen

Table 7. Compressive strength of concrete with (15% of fly ash) on 28th day

Concrete mix	Compressive strength of cube on 28th day (N/mm²)			Average compressive Strength (N/mm²)
	Trail 1	Trail 2	Trail 3	
Pervious concrete with (15% of fly ash)	7.73	7.28	6.97	7.32
(15% of fly ash) with mix of permaplast	12.91	13.52	13.84	13.42

Fig. 4. Permeability Test on Slab

Table 8. Permeability test Result of slab

Percentage of fly Ash	Rate of Permeability (ml/l)		Average Permeability (ml/l)
	Trail 1	Trail 2	
5%	912 ml	934 ml	923 ml
10%	879 ml	884 ml	881.5 ml
15%	852 ml	867 ml	859.5 ml

Conclusion

From this cost analysis we can conclude that 5% of fly ash saves the cost of 71 rupees when compared with 100% of cement and also the strength of the pervious concrete mix with fly ash and permaplast is nearly attain to the pervious concrete but not get increased.

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Department of Civil Engineering, Sri Ramakrishna Engineering College, Coimbatore Tamil Nadu, India

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Table 9. Cost Analysis

Sl. No	5% of flyash	100% of cement
1.	Cement cost 1604/-	Cement cost 1688/-
2.	Coarse aggregate cost 574.226/-	Coarse aggregate cost 574.226/-
3.	Cost of permaplast 175/-	Cost of permaplast 175/-
4.	Total cost 2368/-	Total cost 2438/-

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