International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 23 (2015) pp 43659-43662

Rate Of Chloride Penetration In Polymer Modified Concrete Embedded With Crimped Polypropylene Fibres

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Abstract

The present study focused on the chloride impregnation and permeability behaviour of SBR polymer crimped fibre concrete. Polymers are highly resistance to external environmental effect due to their polymer film formation around the cement aggregate matrix and provides strong bond between the cement and aggregate phase by filling the pores and micro pores in the concrete matrix. Trails were conducted with concrete materials with SBR combination and 8 mixes were arrived. Polypropylene fibre is added in a volume fraction of 0. 1% and 0. 3% to the volume of concrete and dosage of SBR is kept constant as 8% to the weight of total binder. In this paper, a systematic study on RCPT and accelerated permeability were made with all the mixes. The study on the chloride penetration shows that addition of SBR latex has high resistance towards chloride migration than plain concrete mix. Under accelerated permeability condition subjected to 40% of compression with respect to the ultimate load has recorded lower permeability values than plain concrete which evidently proves the arresting of micro crack by addition of polypropylene to the concrete mix.

Keywords: RCPT; Accelerated permeability; SBR latex; Polypropylene fibre.

Introduction

Polymer Impregnation in ordinary Portland cement mortars and concrete enhances the usage in Portland cement mortars and concrete leading to the high density concrete by filling pores and also improves the strength and durability of concrete. Polymers are easily dispersed in cement and aggregate phase providing high workability at fresh state and exhibit early hardening of concrete [1]. Polymer latex addition to concrete shows good bond strength, resistant to freezing-and thawing effect, impact resistance, flexural strength, Acid resistance, resistance to dissolved salts and shrinkage resistance [2-3]. Usage of polymers in concrete shows minimum need of water for curing and attains strength without moist condition. [4-5] Polypropylene fibres in addition with silica fume and fly ash decrease the length flow of water permeability in concrete. Polypropylene fibre provides resistance to bleeding and segregation in concrete and also reduces the micro cracks in the matrix preventing the water to percolates between the cracks and improves the permeability resistance of concrete [6]. Dry shrinkage strain of the concrete decreases with increase in the dosage of polypropylene fibres. It also observed that polypropylene fibres in addition with fly ash and silica fume shows higher resistance to drying shrinkage [7-9] Compressive strength increases with addition of class C fly ash than class F fly ash for the constant cement and fly ash content. Addition of class C and class F with cement content shows increase in chloride resistance compared to plain concrete without fly ash. [10-11] Addition of SBR latex polymer in cement mortar enhances the resistance to chloride permeability and provides resistance to the movement of ionic compound in the matrix. It also improvises the density and overall microstructure arrangement of the cement mortar. SBR latex in mortar increases the formation of calcium aluminate trisulfate in the hydrated phase and expedites the binding of chlorides in mortar. [12-16] Polypropylene fibres in concrete shows reduction in the capillary pores by arresting the micro cracks in concrete and reduces the penetration of chloride ions in concrete. Workability of concrete is highly reduced with increase in the dosage of fibres in concrete. It shows decrease in compressive strength in addition to the dosage of polypropylene fibres.

Materials Used

The details of materials used in the present experimental investigation are as follows.

Ordinary Portland cement of 53 grade having 28 days compressive strength of 47. 5 MPa, satisfying the requirements of IS: 12269-1987 was used in the present study. The specific gravity of cement was found to be 3. 15. River sand obtained from locally available source passing through 4. 75mm IS sieve, conforming to grading zone-II of IS: 383-1978 was used with fineness modulus of 2. 46 and specific gravity of 2. 65. Machine crushed well graded angular blue granite stone with 12. 5 mm maximum size, conforming to IS: 383-1978 was used. The specific gravity and fineness modulus was found to be 2. 71 and 6. 8 respectively. Crimped polypropylene fibres imported from Korea supplied by Onward Chemicals Pvt. Ltd, were used in the present study. The PP fibres used in the investigation was a low elastic modulus fibre which has a hydrophobic surface; and the balling effect of fibres were prevented by dry mixing in concrete. The property of the polypropylene fibres is shown in **Table 1.** Styrene-butadiene rubber latex is a synthetic rubber having milky white appearance with low viscosity. The property of SBR latex is shown in **Table 1**. A polycarboxylate ether based super-plasticizer condensate was used with specific gravity of 1. 16. The class F fly ash used in the study was pozzolanic in nature, and contains less than 10% lime (CaO). The glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. The properties of class F fly ash are given in **Table 1.**

Table 1 Physical property of Class F Fly ash, PP fibres and SBR latex

Class F fly ash composition (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Cl	Loss on ignition	Insoluble residue	Moisture content
	59.30	34.60	5.87	1.02	0.38	0.10	1.28	0.01	0.49	1.90	-	0.73
PP fibres	Length (mm)		Diameter (mm)		Tensile strength (MPa)			Aspect ratio (L/d)			Density (Kg/ m^3)	
	47		0.60		450			80			910	

Conceptual Mix Design

In this study, the concrete mixtures adopted for the study were designed by conceptual mix design procedure and a total of 8 different concrete mixture proportions were prepared which consisted of four reference mix (without SBR latex and PP fibres) and four mixes with SBR latex and Polypropylene fibres. The mix proportions were arrived based on fine aggregate to coarse aggregate ratio of 0. 6 and 0. 8 with, different volume fraction of polypropylene fibres 0. 1 and 0. 3% volume fraction and water to binder ratio of 0. 3 was kept constant for all the studies. The mix proportions details were presented in **Table 2.**

Table 2 Mix proportions adopted for experimental study

Mix ID	Water+ Polymer composition					Binder + Aggregate composition				
	w/b ratio	F/c ratio	SBR Latex %	PP fibres (V_f) %	Super plasticizer %	Cement (Kg/m^3)	Fly ash (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Water (litres/m^3)
S1	0.3	0.6	0	0	1.5	400	100	713	1188	120
S2	0.3	0.6	0	0	1.5	400	200	675	1125	120
S3	0.3	0.8	0	0	1.5	400	200	800	1000	120
S4	0.3	0.8	0	0	1.5	400	100	844	1056	120
MS1	0.3	0.6	8	0.1	1.5	400	100	713	1188	120
MS2	0.3	0.6	8	0.3	1.5	400	200	675	1125	120
MS3	0.3	0.8	8	0.1	1.5	400	200	800	1000	120
MS4	0.3	0.8	8	0.3	1.5	400	100	844	1056	120

Casting of specimen

The cement, aggregates and fly ash were mixed first in a pan type concrete mixer of capacity 40 Kg for a period of 3 minutes, then super plasticizer was added with 1. 5% fixed throughout the experiment for various mixture proportions. Polypropylene fibres and SBR latex were added later and mixed thoroughly in the pan mixer for 2 minutes and circular concrete disc specimen of 100mm diameter x 50mm casted. The surface finishing was done very carefully to obtain a uniform smooth surface.

Curing Condition

In this research study, different types of curing regime were adopted for all specimens. SBR latex fibre concrete after demoulding was cured under wet, dry and hot water condition. The specimen were wet and dry cured separately for each mix proportions for 28 days. In this study another curing regime followed for latex fibre specimen is water curing for 6 days and then kept air dried for 22 days in room temperature, where as reference concrete is normal water cured. The Tests were performed at 28 day for all curing condition.

Experimental test setup:

Rapid chloride Permeability test

Rapid chloride permeability test were conducted as specified by code (**ASTM C 1202**). In the experimental study circular concrete disc specimen of 100mm diameter x 50mm thick were used to determine the quantity of chloride ions penetration in the disc specimen. The specimen is water sealed in the RCPT disc and provided with Nacl solution at one side of the disc and NaoH on the other side. The specimen is charged with a constant current voltage of 60 volts and reading are noted for every 30 minutes to a time period of 6 hours. The details of the RCPT test setup were shown in **Figure 1**.

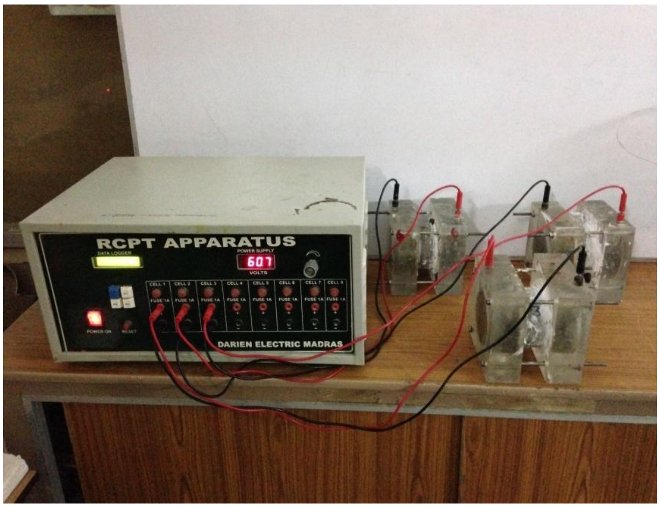

Figure 1 Rapid Chloride Permeability test

Results and Discussion

Rapid chloride permeability test:

The chloride penetration of polymer fibre concrete is higher compared to plain concrete and it’s observed for all polymer mix proportions. Resistance to diffusion of chloride ions in concrete is highly dominated by SBR latex polymer forming a thin layer of polymer flim around the cement particle and fills the micro pores formed in the concrete. It is observed that increase of dosage of fibres from 0. 1% to 0. 3% increases the penetration of chloride ions in the concrete mainly due to formation of micro pores by polypropylene fibres in the concrete matrix.

Polymer fibre concrete shows higher resistance of 289 coulombs for mix F/C 0. 6, fly ash 25%, PP 0. 1% compared to plain concrete of 1010 coulombs for mix F/C 0. 6, fly ash 25%. It is observed for all mix proportions that RCPT value decrease marginally with increase in the days of curing. Replacement of cement by 25% fly ash had shown better resistance to chloride ion penetration compared to 50% replacement of cement by fly ash. The details of the Rapid chloride permeability test for different mix proportions is shown in **Table 3** and graphical representation is shown in values are shown in **Figure 2**

Table 3 RCPT values for different mix proportions

S. NO	Mix Id	Flyash	F/C	PP %	SBR %	28 DAYS	56 DAYS	90 DAYS
1	S1	25	0. 6	0	0	1135	1025	1010
2	S2	50	0. 6	0	0	1357	1297	1287
3	S3	50	0. 8	0	0	1409	1386	1295
4	S4	25	0. 8	0	0	1268	1156	1078
5	MS1	25	0. 6	0. 1	8	310	289	271
6	MS2	50	0. 6	0. 3	8	404	397	390
7	MS3	50	0. 8	0. 1	8	340	330	323
8	MS4	25	0. 8	0. 3	8	464	449	432

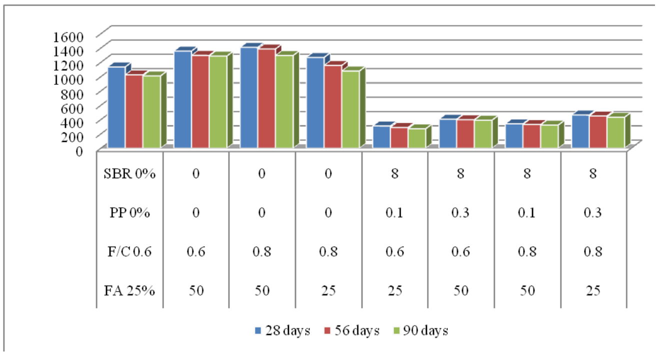

Figure 2 Rapid chloride penetration value for different mix proportions

Conclusion

Some of the salient features of the experimental test results are presented as given below.

- It can be concluded that fibre concrete shows a comparatively less penetration than control concrete mixes.
- Fibre concrete mix MS1 and MS3 consisting 0. 1% of polypropylene fibre has recorded a very low penetration than other mixes.
- The application of polypropylene fibres and SBR latex controls the penetration of chloride into the concrete matrix and thereby increasing its durability correspondingly.
- Mix MS1 consisting 8% of SBR latex and 0. 1% of crimped polypropylene fibres shows a very less penetration than any other mixes.
- The rate of penetration is also reduces significantly in mix MS1 as the days of observation increases.
- This experimentation proves the application of SBR with PP fibres shows a significant reduction in rate of chloride penetration than all the control concrete mixes.

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