Rapid Chloride Permeability Test Of Polypropylene And Glass Fiber Reinforced Concrete

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ABSTRACT

The main aim of this research is to study the effects of chloride penetration on the polypropylene and glass fiber reinforced concrete. The chloride permeability is vital check for the serviceability and life of concrete structures like buildings, bridges, dams etc. because this tends to the corrosion of reinforcing. The mechanical properties generally improved on the addition of polypropylene and glass fiber from the conventional concrete but it entirely depends upon the compaction effort. The mechanical properties like toughness, modulus of elasticity, compressive and flexural strength. In this paper the rapid chloride permeability tests were conducted for a period of 7 days,14 days,28 days and 56 days.

INTRODUCTION

Generally the normal concrete deteriorates by the chloride attack and which leads to the many problems like decrease in the strength, failure of concrete structures and corrosion of reinforcing rods in the structures. The main role of chloride permeability is in the hydraulic structures, where the concrete structure exposed to the chloride environment and causes the failure of concrete structures. The chemical actions of concrete ingredients with the chloride leads to the hydration and bleeding of the concrete. The penetration of chlorides into the concrete depends on the voids, which is affected by ingredients of concrete, construction practices, compaction and addition of secondary reinforcement. Cracks play important role while dealing with the chloride permeability test as they leads to concrete structures into permeable structures and with high risk of the corrosion. Cracks not only affects the quality of concrete but also make it aesthetically. The inclusion of fiber as secondary reinforcement arrests the crack and improves the durability of the concrete. [1] studied the effects of chloride and acid attack on the durability of the glass fiber reinforced concrete and concluded that the use of glass fiber reduces the penetration of

chloride in the concrete. [2] investigated the effects of glass fiber, steel fiber and polypropylene fiber in the concrete and concluded that the use of 0.1% steel fiber imparts better strength than the other two fibers. [3] demonstrated the addition of steel fiber in the concrete provide better resistance to chloride penetration than the normal concrete. [4] concluded that the chloride penetration is perplexing phenomena, it depends on the variation of temperature and repeatedly dry-wet cycles for the durability test. [5] examined the addition of glass fiber to the concrete decreases the crack and 0.1% addition of glass fiber decreases the chloride penetration. [6] contrived that the addition of polypropylene fibers caused delay in starting the degradation process by decreasing permeability, reducing the shrinkage and expansion of concrete. [7] studied the regression models made up of various fiber dosage and mortar composites have been used to explain the effect of concrete mix materials on the mechanical behavior and durability studies of a Fiber Reinforced High performance concrete using Polyolefin Macro-Monofilament Fibers.[8] concluded in their research studies that there has been marginal improvement in the compressive strength and flexural strength at first crack of fiber reinforced concrete cubes and deep beams respectively.[9]they found that no workability problem was encountered for the use of hooked fibers up to 1.5 percent in the concrete mix. [10] concluded that the ultimate residual strengths of RC beams containing polypropylene fibers are higher than the conventional concrete beams[11] studied the behaviour of concrete by the addition of steel and polypropylene fibers and concluded that the addition of fibers improves the mechanical behaviour of the concrete.

EXPERIMENTAL METHODOLOGY

The list of the materials and casting procedure used for this study are given below:-

A. Materials Used

The Ordinary Portland cement of 53 grade having 28 days compressive strength of 47.02 MPa, satisfying the requirements of IS: 12269–1987. The some of the physical properties of cement are presented in Table I. OPC 53 Grade Cement is a prime brand cement with the remarkably high C_3S (Tri Calcium Silicate) providing long-lasting durability and serviceability to concrete structures. River sand obtained from locally available in the nearby river bed, fine aggregate passing through IS sieve which satisfying the grading zone-II as per IS: 383-1970. The fineness modulus value is 2.96, specific gravity of 2.70 and water absorption of 0.68 % at 24 hours.

Mechanically crushed well graded angular blue granite stone of size 20 mm and 12.5 mm were used, for different size of sieve used as per standard , which is maintained with different proportion of coarse aggregate and conforming to IS: 383-1970. The specific gravity was found to be 2.74, fineness modulus is 7.21 and water absorption is 0.61 % at 24 hours. Polycarboxylate ether based super-plasticizer condensate as high range water reducing admixture (HRWR) to maintain a satisfactory of workability for different mixes with constant w/b ratio throughout the experimental works. The specific gravity value of 1.17; pH value of 5.6 and solids content of 41%. The glass fibers used was of the Cem-FIL Anti-Crack HD with modulus of elasticity 70 GPa, Filament diameter 13 microns, specific gravity 2.67, length 13 mm. The crimped polypropylene fiber was used in the study, polypropylene is derived from monomeric C_3H_6 which is purely hydrocarbon. The properties of polypropylene fibers are given in Table II and Figure 1 shows the snapshot of polypropylene fibers.

Table I. Properties of cement

S. No.	Test	Value
1	Consistency	33%
2	Initial setting time	155 minutes
3	Final setting time	485 minutes
4	Specific Gravity	3.21
5	Fineness	2%
6	Soundness	3 mm
7	Compressive Strength 7 day 28 day	 26.3 N/mm^2 48.5 N/mm^2

Table II. Properties of Polypropylene Fibers

Material	Polypropylene
Appearance	Crimped white fiber
Relative Density	0.91
Length	48 mm

l/d ratio	80
Thickness	0.6 mm
Width	1.1 mm
Tensile strength	450 MPa
Failure strain	15%

Fig 1. Snap shot of polypropylene fibers

B. Concrete Mixture Proportions and Casting of specimens

The concrete mixture proportions used in the study are given in Table III. A total of 12 different concrete mixtures were proportioned based on water to binder ratio (w/b) 0.35 and fine to coarse aggregate ratio (F/C) 0.6. The concrete mixtures were mixed using a 30 liters capacity of container with tilting drum type mixer and specimens were casted using steel mould, cylinders (100 mm diameter X 200 mm height) and then cutting is done as per requirements.These specimens were tested as per IS 516 and 1199.The fresh concrete mixtures in moulds were compacted using table vibrator and the specimens were demoulded after 24 hours after casting and water cured at 27 ± 3^{o}C until the age of testing at 7days,14days,28days and 56 days.

Table III. Concrete Mixture Proportions

Mix Id	Cement	Fine Aggregate	Coarse Aggregate	Water	F/C	w/b	Polypropylene fiber (%)	Glass Fiber(%)
	Kg/m^3							
M1	425	676	1127	149	0.6	0.35	0	0
M2	425	676	1127	149	0.6	0.35	0.01	0
M3	425	676	1127	149	0.6	0.35	0.02	0
M4	425	676	1127	149	0.6	0.35	0.03	0
M5	425	676	1127	149	0.6	0.35	0	0.02
M6	425	676	1127	149	0.6	0.35	0.01	0.02
M7	425	676	1127	149	0.6	0.35	0.02	0.02
M8	425	676	1127	149	0.6	0.35	0.03	0.02
M9	425	676	1127	149	0.6	0.35	0	0.04
M10	425	676	1127	149	0.6	0.35	0.01	0.04
M11	425	676	1127	149	0.6	0.35	0.02	0.04
M12	425	676	1127	149	0.6	0.35	0.03	0.04

C. Rapid chloride permeability test

According to ASTM C1202 test, water-saturated, 50 mm thick, 100 mm thick diameter concrete specimen is subjected to applied DC voltage of 60 V for 6 hours. In one container 3.0% NaC1 solution and in the other container 0.3 M NaOH solution. The total charge passed from the fiber reinforced concrete is determined and rate the fiber reinforced concrete according to the criteria included as Table IV. The variation of charge passed for various mix proportions are shown in Figure 2, Figure3,Figure 4.

Table IV. RCPT ratings as per ASTM C1202.

Charge Passing (Coulombs)	**Chloride Ion Permeability**
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very Low
<100	Negligible

EXPERIMENTAL RESULTS AND DISCUSSION

The durability of fiber reinforced concrete that is resistance to chloride penetration is studied. Rapid chloride ion penetrability tests were for fiber reinforced specimens, an electrical current recorded at 1 minute intervals over the 6 hour time, resulting in the total charge passed in coulombs is shown in Table IV and Table V shows chloride permeability as per ASTM C 1202. The testing of specimen were done at 7 days,14days,28days and 56 days.

Table IV. RCPT values for different mix proportions.

MIX ID	7 DAYS	14 DAYS	28 DAYS	56 DAYS
M1	3754	3421	3148	2978
M2	3526	3209	2910	2765
M3	3346	3096	2874	2671
M4	3275	3005	2814	2553
M5	3123	2908	2785	2489
M6	3055	2870	2649	2431
M7	2989	2766	2563	2349
M8	2761	2654	2488	2219
M9	2692	2430	2317	2174
M10	2578	2397	2271	2160
M11	2496	2306	2215	1927
M12	2452	2296	1843	1685

Figure 2. Variation of charge passed for M1,M2,M3,M4

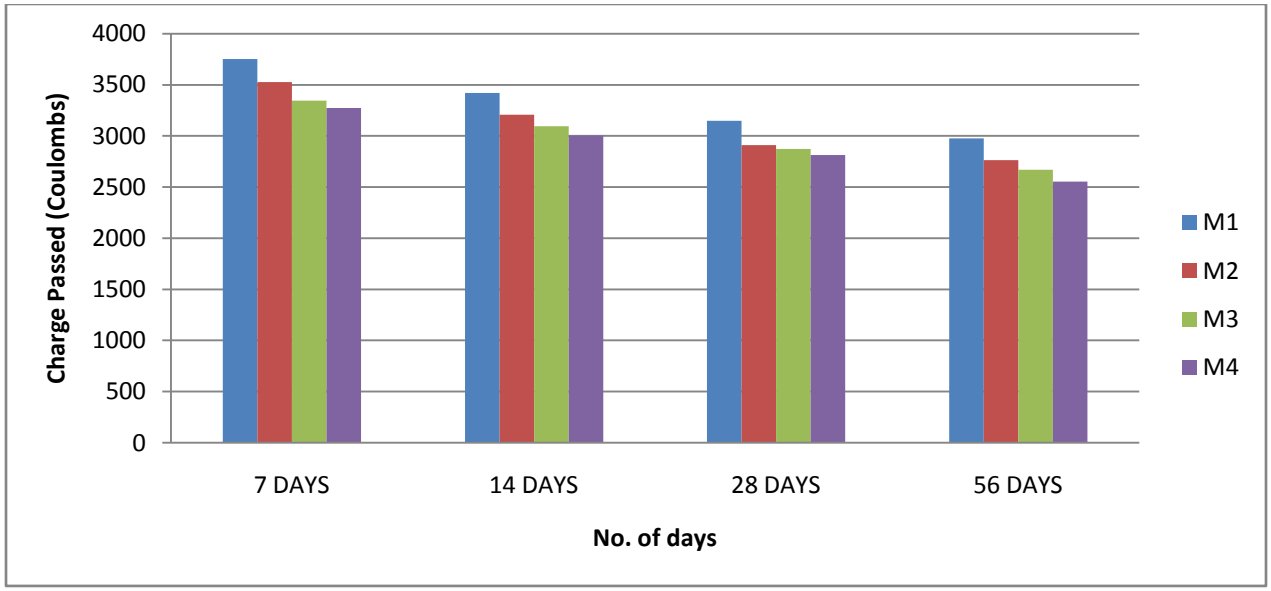

Figure 3. Variation of charge passed for M5,M6,M7,M8

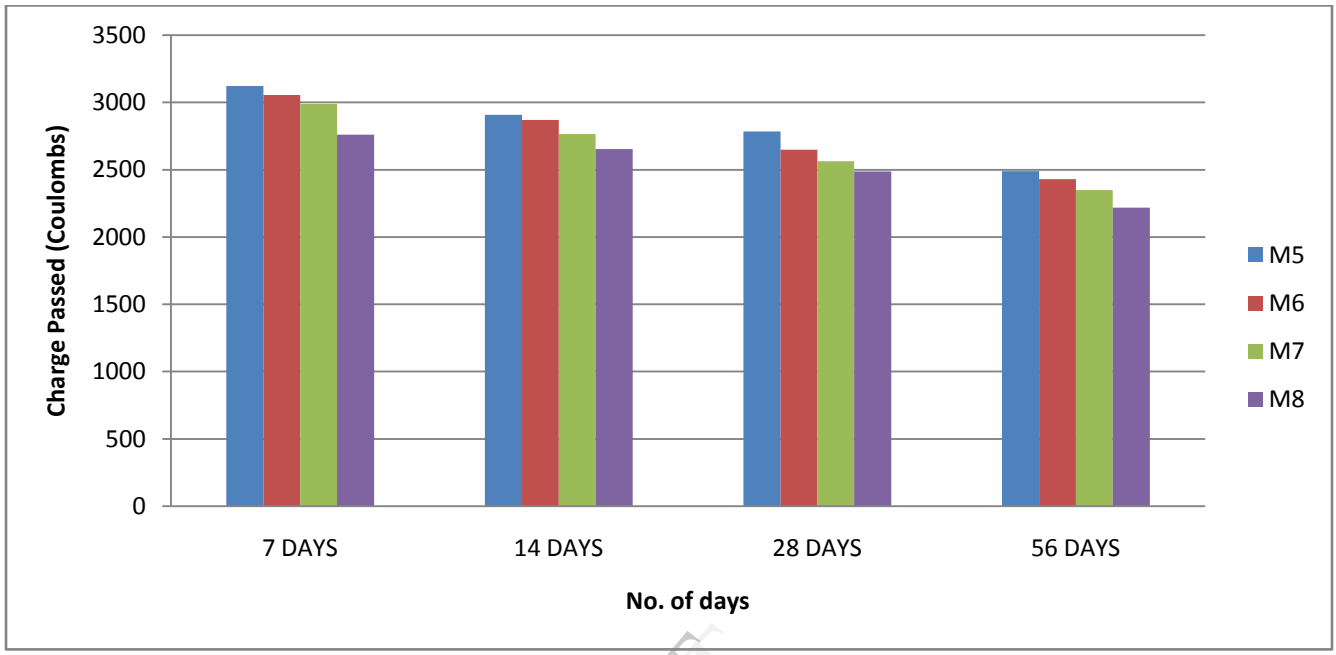

Figure 4. Variation of charge passed for M9,M10,M11,M12

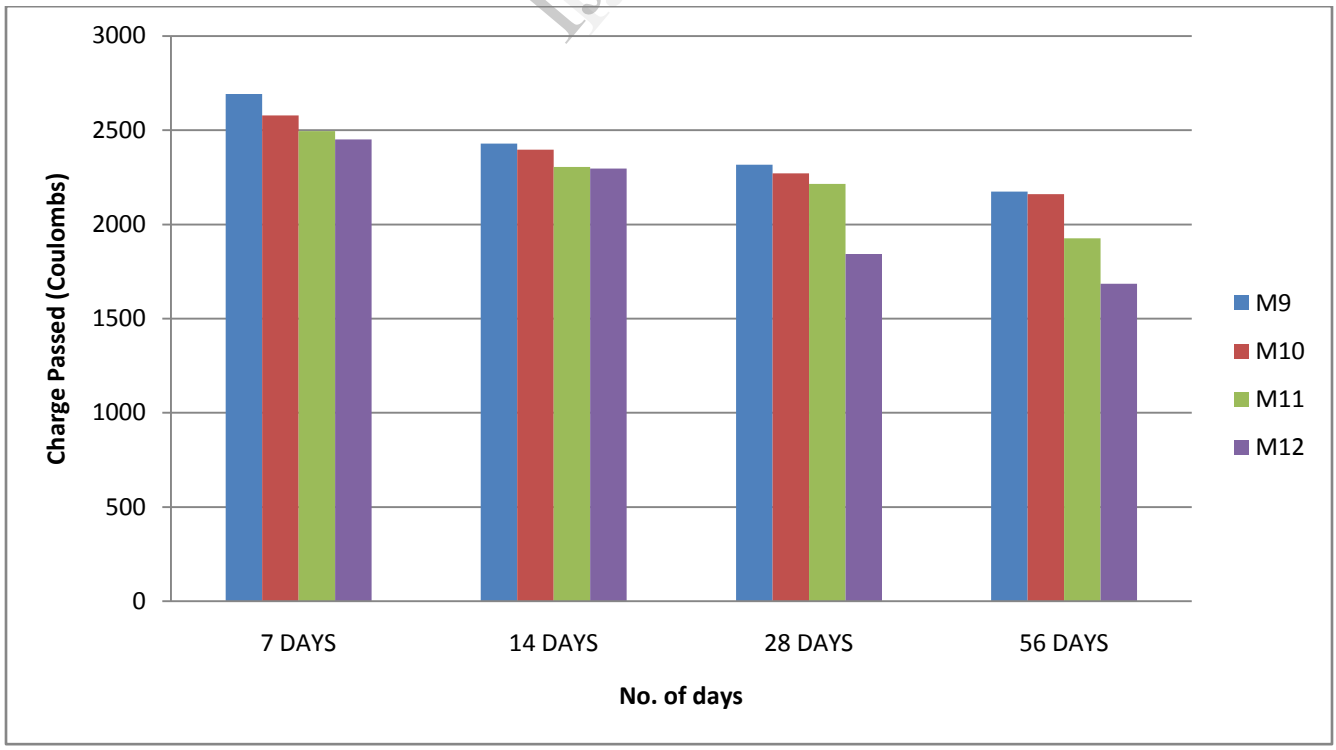

Table V. Chloride Permeability as per ASTM C 1202

MIX ID	7 DAYS	14 DAYS	28 DAYS	56 DAYS
M1	MODERATE	MODERATE	MODERATE	MODERATE
M2	MODERATE	MODERATE	MODERATE	MODERATE
M3	MODERATE	MODERATE	MODERATE	MODERATE
M4	MODERATE	MODERATE	MODERATE	MODERATE
M5	MODERATE	MODERATE	MODERATE	MODERATE
M6	MODERATE	MODERATE	MODERATE	MODERATE
M7	MODERATE	MODERATE	MODERATE	MODERATE
M8	MODERATE	MODERATE	MODERATE	MODERATE
M9	MODERATE	MODERATE	MODERATE	MODERATE
M10	MODERATE	MODERATE	MODERATE	MODERATE
M11	MODERATE	MODERATE	MODERATE	LOW
M12	MODERATE	MODERATE	LOW	LOW

CONCLUSIONS

The performance behavior of polypropylene and glass fiber reinforced concrete increased with regards to durability. The following conclusions are drawn from this investigation:-

a) Chloride permeability of polypropylene and glass fiber reinforced concrete shows less penetration of chlorides into the concrete, compared with reference concrete i.e. 0% fiber.

b) The polypropylene and glass fiber reduces the cracks which makes the interconnecting voids to be minimum;

c) Due to the addition of 0.04% of glass fibers and 0.03% of polypropylene fibers there was decrease in chloride permeability at 7,14,28 and 56 days.

d) The failure of plain concrete specimens were restraint with volumetric bulging because of the presence of the glass fibers and polypropylene fibers which anticipated the gradual release of fracture energy.

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