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STUDY ON SUSTAINABLE HIGH PERFORMANCE CONCRETE COMPOSITE BY THE PARTIAL REPLACEMENT OF BINDING MATERIAL

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ABSTRACT

Concrete is one of the important cell in human civilization. Beginning with the origin of the earliest form of life habitat concrete has been the thick and thin of our growth. This effort focuses on the enhancement of vacuum condition in concrete by focusing on the surface area to volume ratio phenomenon to improve the impermeability of concrete and thereby improving its living standard in terms of workability, Compressive strength and durability. The foot was moved forward by doing an experimental work which is a proven mapping method with ground realities. The density of concrete was tested by inoculation of fly ash at the progressive interval of 5% and flyash combined with silica fume at a succeeding rate of 2.5%. From the observation it was inferred that the later combination gives a better picturesque in terms of allied standard durability indicators when comparing to the binary one.

Keywords: Durability, composites, High performance Concrete, Silica Fume, Fly ash.

I. INTRODUCTION

Composites are extremely versatile products. A composite material is a material made from two or more constituent materials with significantly different from the individual components. The new material may be preferred for many reasons: materials which are stronger, lighter, or less expensive when compared to traditional materials. Throughout history, composites have played a vital role and Humans have been using concrete in their pioneering architectural feats for millennia. Concrete is the single most widely used material in the world after water. Cement composite is the most popular and widely used building material, due to obtainability of the raw materials over the world, its ease for preparing and fabricating in all sorts of imaginable shapes. Conventional concrete structure has a problem with long life performance allied term with durability characteristics [1].

The adding of inorganic admixture in composite has vividly increased along with the development of concrete industry, due to the reflection of cost saving, energy saving, environmental protection and safeguarding of resources. About 1.5 tons of raw materials is needed in the production of every ton of PC, at the same time, about one ton of carbon dioxide (CO_2) is released into the environment during its production [3].However, environmental concerns both in terms of damage caused by the extraction of raw material and carbon dioxide emission during cement manufacture, have brought pressures to reduce cement consumption by the use of supplementary materials. In this work an effort has been made in a lab scale environment aligned with the production of concrete by injecting the mineral admixtures silica fume and fly ash as a partial occupancy for cement.

II. MATERIALS

Portland cement

Ordinary Portland cement (53 Grade), Dalmia Cements conforming to Indian standard code IS 8112-1995 was used.

Silica Fume

The Silica fume obtained from the M/s ELKEM south Asia (P) LTD, Mumbai confirming to ASTM C1240 was used for this experimentation, and its physical and chemical properties were given in Table 1.

Fly Ash:

Fly ash (Class F) was obtained from Thermal power plant at Mettur in Salem district, Tamil Nadu state, India confirming to IS: 3812-1981.Spcific gravity of Fly ash is 2.00 to 2.05 the physical and chemical properties of OPC, Silica Fume (SF) and Fly Ash are given in Table 1.

Table 1: Physical and Chemical Properties of Cement and Admixtures

Physical Properties			
Property/ Composition	**Cement**	**Fly Ash***	**Silica Fume****
Specific Gravity	3.15	2.00 to 2.05	2.2
Standard Consistency	30.00%	–	–
Initial Setting time (Min)	104	–	–
Final Setting Time (Min)	220	–	–
Physical Form	–	Powder form	Powder form
Class	–	F	–
Chemical Composition			
Silicon Dioxide (SIO2)	19.65%	54.92%	90-96 %
Aluminium Oxide (Al2O3)	5.65%	23.04%	0.5-0.8%
Ferric Oxide (Fe2O3)	5.40%	4.5-4.8%	0.2-0.8%
Calcium Oxide (CaO)	61.55%	3.84 %	0.1-0.5%
Magnesium Oxide (MgO)	0.91%	2.82 %	0.5-1.5%

Fly ash*: Mettur Thermal power plant

Silica Fume: ELKEM**

Aggregates:

Coarse aggregates crushed from igneous basalt rock of 12.5 mm and down size having specific gravity of 2.78, fineness Modulus of 4.03 and conforming to IS 383-1970 were used.

Fine aggregate, local sand having specific gravity of 2.56, fineness Modulus of 2.53 and conforming to grading zone II of IS: 383-1970 was used.

Super plasticizers

CONPLAST SP 430 was used obtained from **Fosrac** chemicals pvt Ltd, Bangalore. as a high range water reducing admixture. Super plasticizer based on sulphonated naphthalene formaldehyde was used to impart additional desired properties to the high performance concrete. The dosage of super plasticizer was 1% by weight of cement.

Water

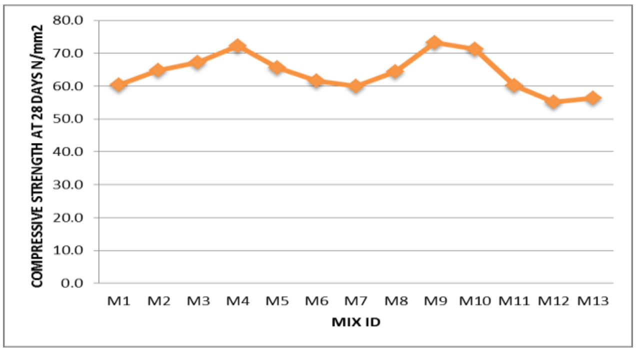
The water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities when present may have adverse effect on the strength of concrete Potable water with PH value of 8.2 was determined using pH meter confirming to IS 456-2000 was used for making concrete and curing this specimen as well.

III. RESULTS

1. Compressive strength of HPC

Compressive strength of SF and FA blended cement HPC cube was determined as per IS 9013-1997 after 28 days of moisture curing. The specimens were tested by using a standard compression testing machine as shown in figure 1. The results of the test were graphically represented in figure 2.

Fig 1: Testing of cube specimen using Compression Testing Machine



y = -0.4787x + 67.401

Fig 2: Compressive strength at 28 days v/s HPC Mix

The HPC with mix ID M4 and M9 shows higher compressive strength. The results of all the mixes showed improved strength.

2. Saturated Water Absorption:

Saturated water absorption (SWA) tests were carried out on 100mm cube specimen at the age of 28 and 90 days curing as per ASTM C 642. The specimens were weighed before drying. The drying was carried out in a hot air oven at a temperature of 105°C.The dried specimens were cooled at room temperature and immersed in water. The specimens were taken out at regular interval of time, surface dried using a clean cloth and weighed. This process was continued till the weights became constant. The difference between the measured water saturated mass and oven dried mass expressed as % of oven dry mass gives the SWA.

The water absorption was calculated as % of water absorbed = (W_s-W_d)x $100/W_d$

Where,

W_s = weight of specimen at fully saturated condition ; W_d = weight of oven dry specimen

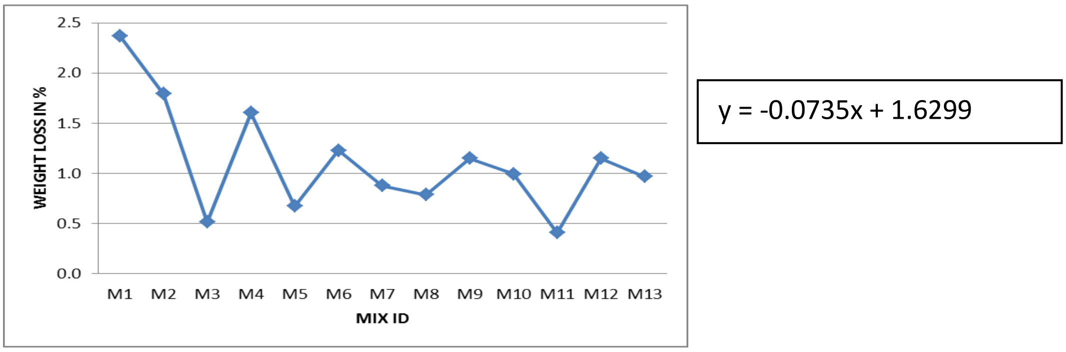


Fig 3: % of water absorption v/s Mix ID

The results of water absorption results are represented in figure 3. The HPC mix CSF and CSFF shows less water absorption characteristics. The test results indicate that with the addition of silica and fly ash, the water absorption of concrete become less compared to conventional concrete.

3. Acid Resistance

The acid resistance tests were carried out on 150 mm size cube specimens at the age of 28 days curing. The cube specimens were weighed and immersed in water diluted with one percent by weight of sulfuric acid for 45 days continuously. Then the specimens were taken out from the acid water and the surfaces of the cubes were cleaned. Next the weight and the compressive strengths of the specimens were found out and the average percentage of loss of weight and compressive strengths were calculated.

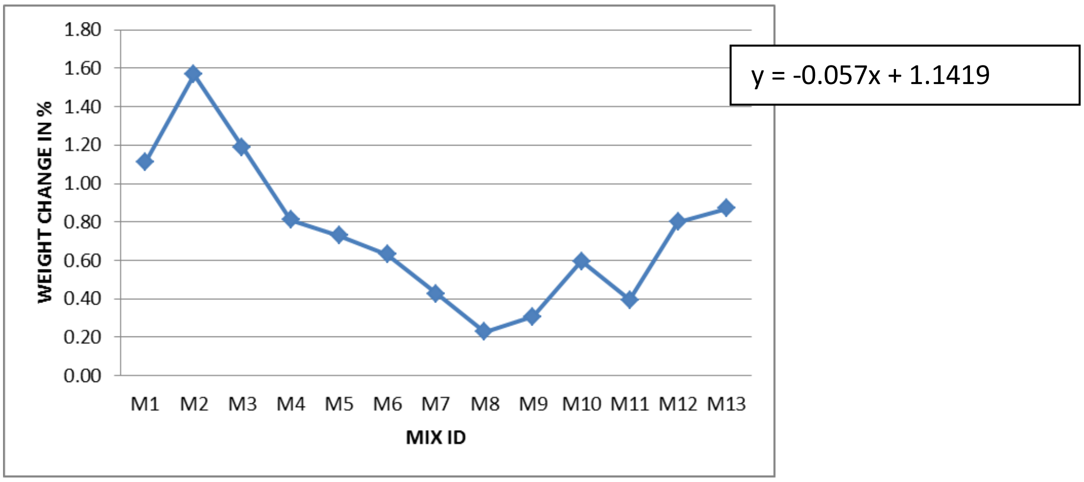


Fig. 4: % of weigth change v/s Mix ID

The results are represented graphically in figure 4. The mixM8, M9 and M11 shows less reduction in weight compared to other mixes. With the increase in additive amount, the HPC show improved results in acid resistance.

4. Rapid chloride penetration test

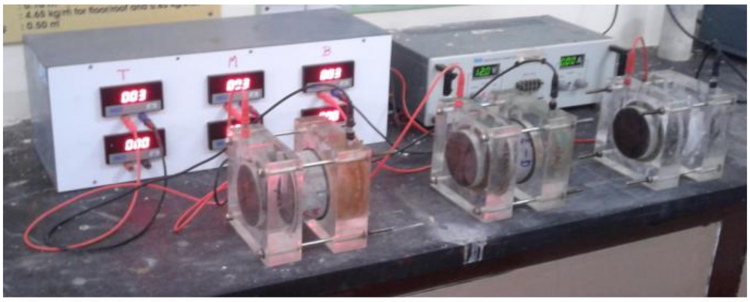


Fig. 5: Rapid Chloride Penetration Test Setup

Rapid Chloride ion Penetration Test (RCPT) is a measure of electrical conductivity of concrete which depends on pore structure characteristics. Chloride diffusion causes corrosion of steel reinforcement inside concrete. Corrosion of reinforcing steel because of chloride ion penetration is one of the most common environmental attacks that lead to the decline in durability of concrete structures. Therefore it is necessary to study concrete for its chloride ion permeability, since it primarily affects the durability characteristics of concrete. The RCPT is performed by monitoring the amount of electrical current that passes through a sample 50 mm thick by 100 mm in diameter in 6 hours. The results are graphically represented in figure 6.

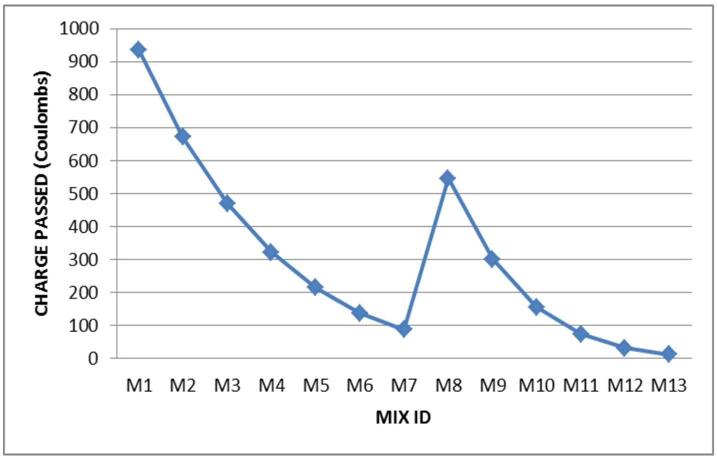


Fig. 6: Total charges passed v/s Mix ID

The results showed less chloride penetration for HPC mix M7 and M13. From the results, it was clear that as the amount of additive increases the concrete shows high resistance against chloride ion penetration.

5. Scanning Electron Microscopy (SEM)

A JEOL 5410LV SEM equipped with the Oxford Instruments Imquant image analysis package was employed. The images were collected by a bse detector in low vacuum (9Pa) mode. The accelerating voltage was 20 kV and the spot size was 12. Forty to fifty images were automatically collected for each specimen. The microstructure of the reference mortar (0%) and of the composites containing added different percentage of mineral additives were analyzed by scanning electron microscopy after 28 days of curing to check the dispersion of sand and waste particles in the matrix.

Fig. 6: Scanning electron microscope

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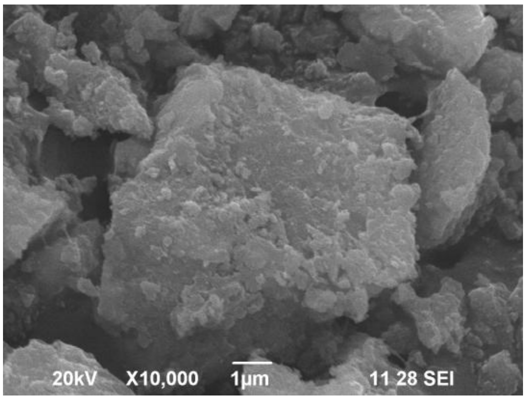

Fig. 7a: SEM Image of M1 (Only OPC)

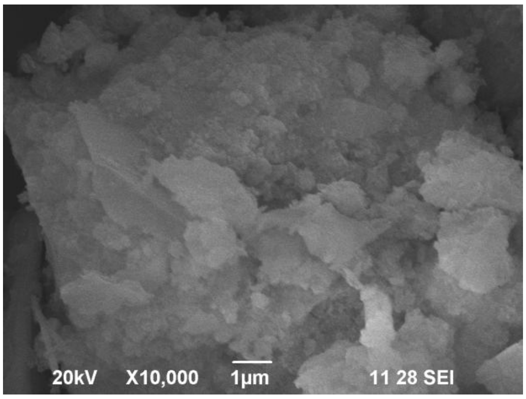

Fig. 7b: SEM Image of M2 2.5 % SF

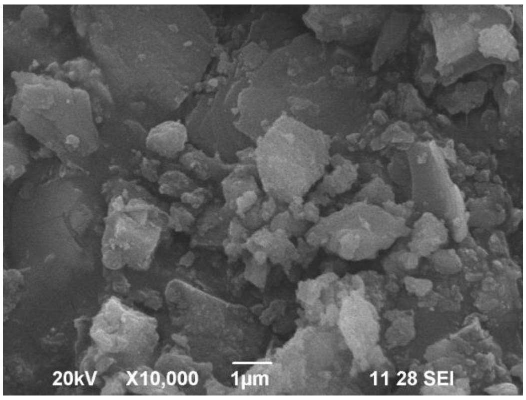

Fig. 7c: SEM Image of M3 (5 % SF)

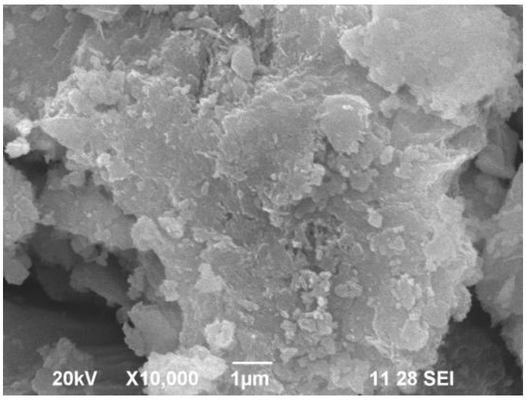

Fig. 7d: SEM Image of M4 (7.5 % SF)

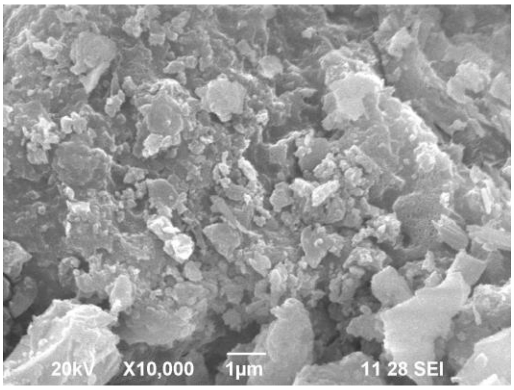

Fig. 7e: SEM Image of M5 (10 % SF)

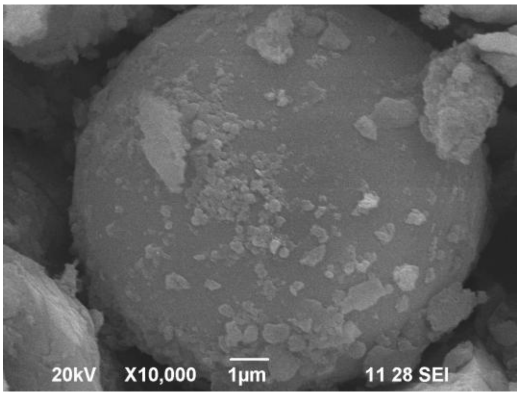

Fig. 7f: SEM Image of M6 (12.5 % SF)

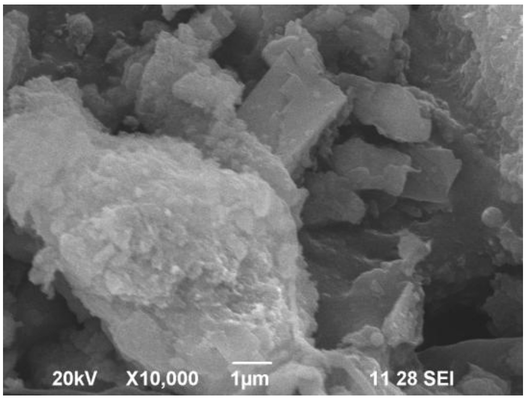

Fig. 7g: SEM Image of M7 (15 % SF)

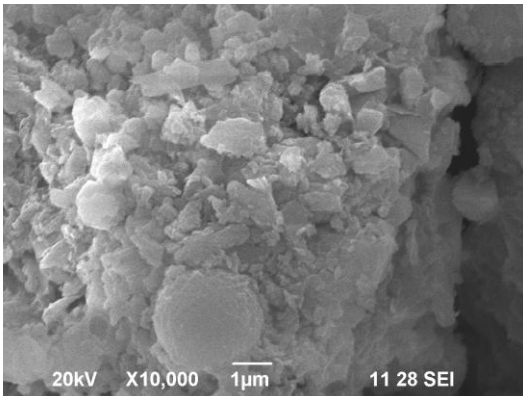

Fig.7h: SEM Image of M8 (2.5 % SF+5 % FA)

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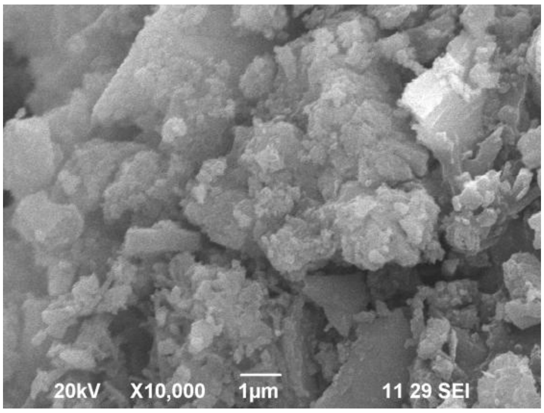

Fig. 7i: SEM Image of M9 (5% SF+10% FA)

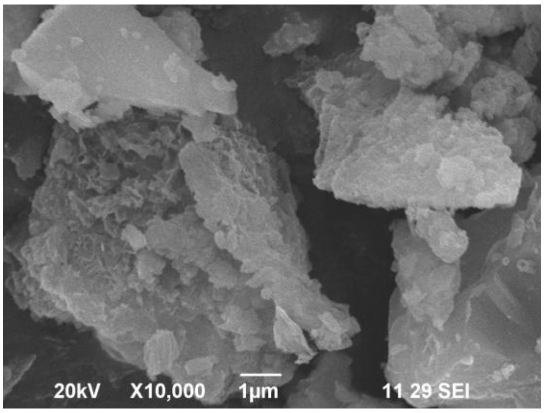

Fig. 7j: SEM Image of M10(7.5 % SF+15 % FA)

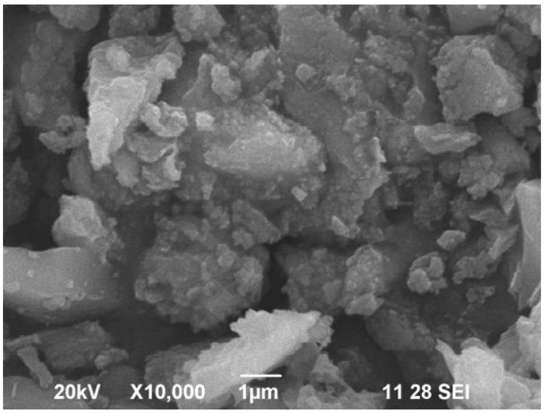

Fig. 7k: SEM Image of M11(10 % SF+20% FA)

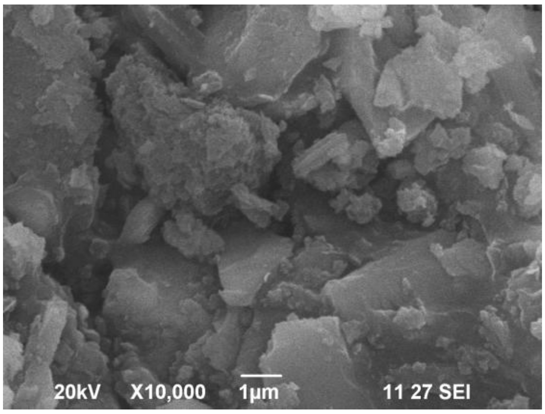

Fig. 7l: SEM Image of M12(12.5 % SF+25% FA)

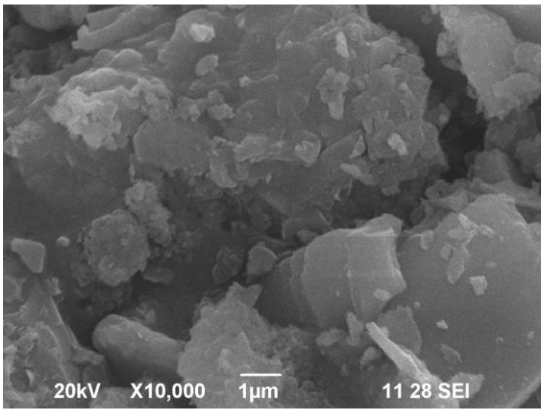

Fig. 7m: SEM Image of M13 (15 % SF+30% FA)

IV. CONCLUSION

The Based on the above tests the following conclusions can be drawn: Water demand of concretes containing PC +SF was similar to that of the concretes with only PC and Water demands of PC + SF + FA blends were higher than those of PC + SF binary blends. Incorporation of SF in binary mixtures improved the compressive strengths at all ages. Ternary blends almost made it possible to obtain higher strengths than PC + SF mixtures at all ages provided that the replacement level by FA was chosen properly. Substitution of SF or FA under certain conditions has been shown to increase the chemical resistance of such concrete mixers over those made with plain Portland cement. Concrete were relatively little affected by 1% hydrochloric acid, The results of the strength and durability related tests have demonstrated superior strength and durability characteristics of HPC mixes containing SF. This is due to the improvement in the microstructure due to pozzolanic action and filler effects of SF, resulting in fine and discontinuous pore structure. In RCPT, as the amount of fine particles, that is SF and FA increases, chloride permeability decreases. This is due to the fact that the pores in concrete structure get filled with fine materials, which in turn decreases the permeability.

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