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Durability Performance of Controlled Permeable Formwork on Self-Compacting Concrete

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***Abstract*-- Controlled Permeability Formwork (CPF) is one of the recently developed techniques for improving the cover zone of concrete. This technique is to drain the surface water and entrapped air from the near surface of fresh concrete by retaining the cement and fine particles. This ensures reduced water-cement ratio, decreased surface porosity and higher cement content near the cover zone. CPF action creates smooth surface free from blow holes, pinholes. By using CPF, the quality of near surface portion of concrete can be improved and the aggressive agencies can't find an easy entry in to the concrete to destroy concrete structures. Though CPF liner is proved to be effective in normal concrete an attempt has been made in the present work to check the effectiveness of CPF liner in self-compacting concrete (SCC).**

***Keyword*--Controlled permeability formwork · Strength · Durability.**

I. INTRODUCTION

The general perception about concrete is it is a permanent material. However, in recent times this perception has been proved mythical, particularly when concrete is reinforced with metal. Whilst functional requirements are very important, aesthetic value should not be ignored. Concrete in humid and extreme weather environment can take on external appearance that is visually unacceptable. Due to concrete's natural versatility, it finds wide spread application and yet in many situations finds it-self beleaguered by the environment in which it is put. A durable, efficient and effective infrastructure system is fundamental to economic prosperity, social justice, political stability and the quality of human life. However, sustainability in construction cannot be achieved if used materials and built structures cannot give durable service life. Durability of concrete structure in particular depends primarily on permeability of the concrete cover. Concrete cover has to protect reinforcement from environment and other forms of damages. The quality of the cover, that is the skin of any concrete structure is a crucial factor in determining the durability of any structure, The growing need to achieve durable service life performance may require considering additional protective measures which hinder corrosion and concrete degradation. It is well known that the durability of concrete is essentially dependent on the water-cement ratio.

The performance of the surface skin is significantly affected by the type of formwork used during the construction, together with curing applied to the concrete after removal of the formwork. The commonly used formwork made from impregnated plywood or steel are essentially impermeable to air and water. During the compaction process, it drives excess air and water within the cover zone towards the formwork. As conventional wood or steel is an impermeable formwork (IMF), the migration within in the mix ceases as the concrete/formwork interface is reached. Visually, this may be observed on all concrete surfaces through the presence of blowholes and pinholes when the specimens were de-moulded. The matrix within the core of any structural element is generally dense and of better quality compared to the surface as a direct result of the compaction. However, the concrete surface is more vulnerable to poor curing and compaction than the bulk of the concrete. Therefore for good durability a well compacted strong concrete surface zone is needed with low permeability, low diffusion and no surface porosity. CPF has been shown to improve the durability of concrete. The quality of surface concrete is improved by CPF as the bleed water and air escape whilst the cement particles are retained; this means that the water-cement ratio near the surface is reduced significantly creating a denser and less porous concrete surface and a reduction in the sensitivity of the concrete to poor curing.

Controlled Permeability Formwork (CPF):

The definition of CPF can be described as a manufactured formwork liner that allows the passage of water and entrapped air from the fresh concrete and through the formwork, whilst retaining cement and other fine solids. CPF liner is tensioned and attached to the internal face of formwork with staples or other fixing devices. Once attached, concreting is performed in the normal way. The release agents are not required as CPF liners easily de-bond from the concrete during formwork striking. Low w/c ratio alone with dense microstructure of concrete is achieved in the cover region of concrete. This creates a uniform surface relatively free from blowholes and other surface blemishes.

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In addition to enhancing the overall surface properties, these effects lead to an improved barrier to ingress of chlorides, giving reduced rates of transmission and thereby potential to extend service life.

Principle of CPF:

There are several CPF systems available worldwide but all of them share the same underlying general principles. The CPF system has three basic elements as shown in Fig.1

- A filter - which allows the passage of water and air away from the fresh concrete but retain cement and other fine solids.
- A drain - which transfers air and water from the filter to outside the formwork.
- A structural support - this is the formwork which supports the filter and drainage elements and also maintains the required formwork profile and resists the concrete pressure.

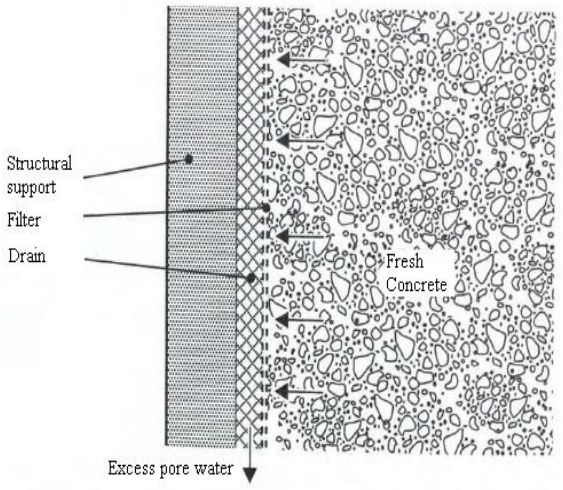

Fig.1-Functioning Of CPF

The basic function of CPF is to drain water and air from the near surface of fresh concrete during compaction while retaining cement and other fine particles. To drain water and air from the surface of fresh concrete through the CPF filter some form of driving force is required. Two mechanisms are possible to generate the driving force. They are the vibrator pressure and hydrostatic pressure. CPF liners are essentially non-absorptive materials. Therefore they do not facilitate to absorb and transmit water. Vibrator pressure and hydrostatic pressure are the main factors involved in forcing water through the CPF liner. When fresh concrete is subject to vibration from an internal poker vibrator the concrete generally behaves as a liquid and a succession of rapidly recurring circular compression waves are generated within the fluid concrete.

The action of the vibrator causes the fluid concrete to be repeatedly compressed against the internal faces of the form resulting in a high dynamic pressure. This dynamic pressure (i.e. increased pore water pressure) causes excess water and air to be expelled through the CPF filter. In-order to observe how the CPF performs on concrete where the vibratory pressure do not act, Self-compacting concrete was chosen and used throughout this study.

Experimental work:

Materials

Cement

Ordinary Portland Cement (OPC) of 43 grade conforming to IS: 8112 (1989) with specific gravity of 3.12 was used throughout the investigation.

Fine Aggregate

Locally available river sand conforming to zone II as per IS: 383 (1987) with specific gravity of 2.6and fineness modulus of 2.54 was used for this study.

Coarse Aggregate

Crushed natural rock stone aggregate conforming to IS: 383 (1987) with specific gravity of 2.79 and fineness modulus of 7.8 was used for this study.

Water

Normal tap water available in the concrete laboratory was used for both concreting and curing in this study.

Admixture

Super plasticizer SupafloPC which is a polycarboxylate based polymer, conforming to IS 9103-1999 was used in this work. The specific gravity of the SP is 1.01 and solid content is 40%. Viscosity Modifying Agent of specific gravity 1.0 has been used.

Fly ash

Fly ash of class F produced from Ennore thermal power station(Chennai) with specific gravity of 2.05 was used in this study.

CPF

In this study, the CPF liner used was type II. It is a single layer system . The inner face (concrete side) acts as filter and the outer face (formwork side) acts as drain.

Self-compacting concrete (SCC) mix proportion:

In this study SCC with 40 MPa strength was targeted. Nan Su method was considered for the mix proportioning. After a number of trials on flow characteristics the final proportion was arrived . The final design proportion is tabulated below in Table.

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SL. No	MATERIALS	QUANTITY
1	Cement	435 kg/m^3
2	Fly ash	100 kg/m^3
3	Sand	875kg/m^3
4	Coarse aggregate(20mm)	430kg/m^3
5	Coarse aggregate(12.5mm)	430kg/m^3
6	Water	210kg/m^3
7	Super plasticizer	5.4l/m^3
8	Viscosity modifying agent	1 l/m^3

Preparation and curing of specimens:

Steel moulds were used to cast reference test specimens. CPF liner was affixed to the side plates of moulds and specimens were cast . The concrete specimens cast using steel moulds were identified as "IMF" specimens and those made steel moulds affixed with CPF liner as "CPF" specimens. The concrete mixes were prepared in a drum mixer of capacity 55 litre. The moulds were filled with concrete and demoulded after 24 hours. The cast specimens were water cured till the date of test.

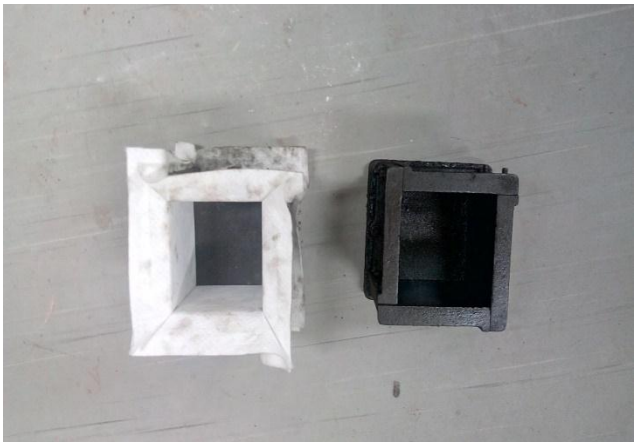

FIG.2- IMF & CPF Moulds.

Test programme:

Compressive strength was carried out using 100 mm size cube specimen, whereas chloride ingress and Rapid chloride penetration test were carried out on circular specimens (with 100mm diameter and 50 mm long). Two sets of moulds were kept ready for specimen preparation i.e regular steel mould (impermeable formwork) and CPF liner attached steel mould (Controlled permeable formwork). The relevant tests were carried out for 7, 14, 28 and 60 days.

II. Results And Discussion

Compressive Strength Test:

The compressive strength results of CPF and IMF specimen are plotted in the graph below. Even though the compressive strength of CPF and IMF cast specimens increased with age, there was only a small improvement of CPF concrete strength over the IMF concrete. This is because any improvement made over the surface level may not significantly improve the compressive strength

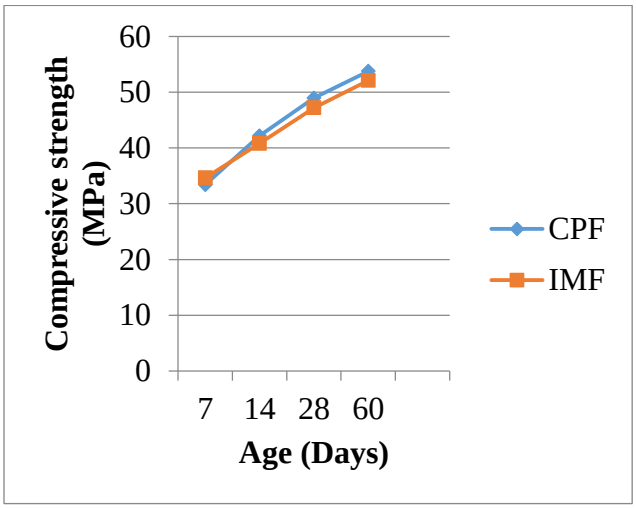

FIG.3- Compressive Strength Test

Rapid chloride penetration test:

The Rcpt results of CPF and IMF specimen are plotted in the graph below. It was observed that the charge passed through IMF specimens is relatively more when compared with specimens casted with CPF liner

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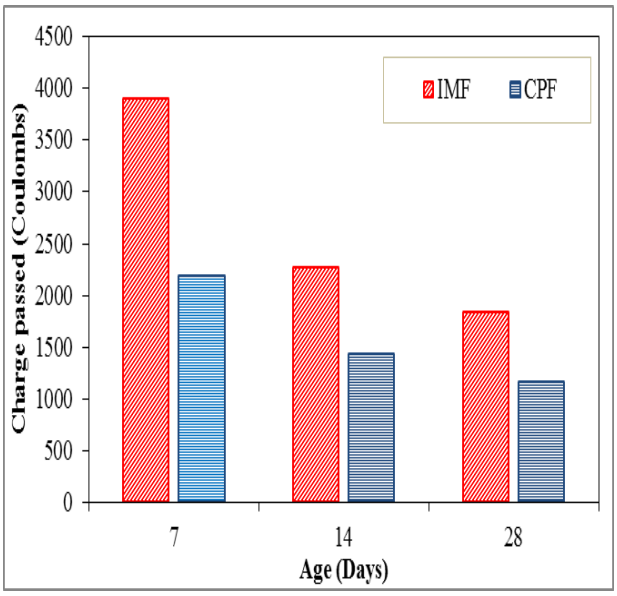

FIG.4-Rapid Chloride Penetration test

Chloride ingress Test:

The chloride ingress results of CPF and IMF specimen are plotted in the graph below i.e Fig 5. It was observed that the depth of penetration of chloride in IMF specimens is more when compared with CPF specimens .

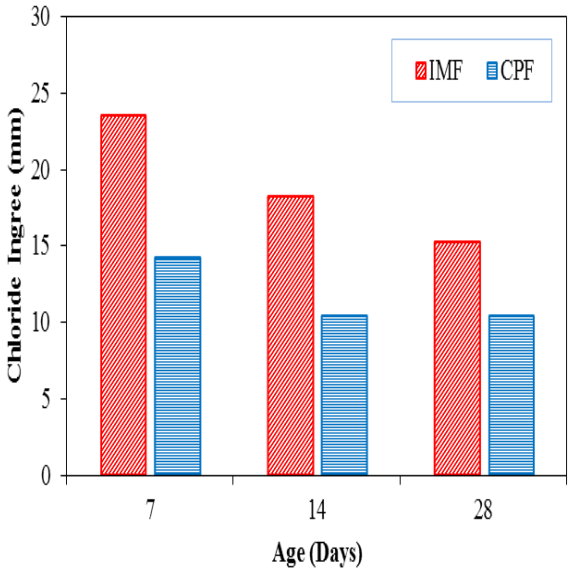

FIG.5-Chloride Ingress Test

We can also obtain the Non steady state migration coefficient values from the ingress test. It is observed that the coefficient values of IMF is more than the CPF specimens as shown in the fig.6.

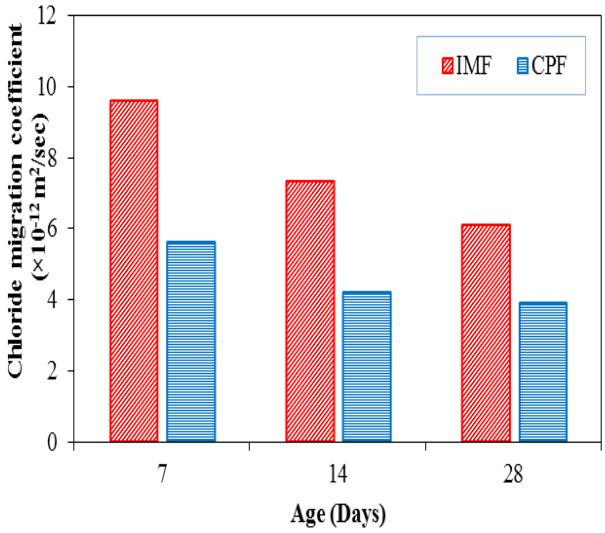

FIG.6- Chloride Migration Co efficent

III. Conclusion

1. CPF liner performs equally well on Self compacting concrete also. In spite of no vibration being carried out CPF liner had drained out water from the surface of concrete to improve its surface quality.
2. Surface hardness has also improved by the use of CPF liner . In short, the durability of concrete will be improved by the use of CPF liner
3. Overall, the improved performance shown by the CPF lined SCC specimens indicate that the CPF liner performs by itself to a great extent and the effect of vibration may have a little effect, which needs further study.

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