

A Review on Effect of Controlled Permeable Formwork (Cpf) Liner on Concrete

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ABSTRACT:Controlled permeable formwork (CPF) liner is an innovative material used to improve the quality of the concrete in the cover region, by allowing the air bubbles and mix-water to drain out from the surface of concrete whilst retaining cement and other fine particles. Accordingly, this not only minimises the porosity of the surface area of concrete, but it also helps towards improving or enriching the actual content. This paper aims to present the influence of CPF liner concerning the properties such as surface hardness and durability characteristics of CPF concrete. It was reported that there is significant improvement in strength, durability and near surface concrete quality improvement in CPF liner than that of impermeable formwork (IMF) liner.

KEYWORDS:Controlled permeable formwork (CPF), durability, Impermeable formwork (IMF), surface hardness, porosity.

I. INTRODUCTION

As per Construction Industry Research and Information Association (CIRIA) report, the controlled permeable formwork liner can be defined as “a manufactured formwork liner that allows the passage of water and entrapped air from the concrete, and through the formwork, whilst retaining cement and other fine solids” [Price 2000]. As conventional plywood, steel or plastic formwork is impermeable formwork (IMF), this mix water and

entrapped air normally gets trapped at the concrete/formwork interface. The mix water which reaches the interface increases the effective water/cement (w/c) ratio in the cover region. Visually, this may be evident on all concrete surfaces through the presence of blowholes and pin holes following formwork removal. The net result of this process would modify the surface zone of concrete with higher w/c ratio and lower cement content than that had originally been contemplated. In another words, the surface zone of concrete will be of poorer quality compared to the bulk/core concrete.

Controlled permeable formwork system consisted of a non-woven polypropylene fibre fabric liner affixed on conventional formwork as shown in Figure 1.1, allowing the mix water and entrapped air to drain out from the concrete surface whilst retaining cement and other fine particles. This enables to lower the w/c ratio (Figure 1.2) and enrich of cement content in the near surface zone of concrete. This action creates a uniform surface without blowholes, pinholes and surface blemishes. Further, surface zone of concrete hydrates to a high degree and makes dense surface skin as a CPF liner maintains sufficient moisture which is a conducive ambiance for effective cement hydration.

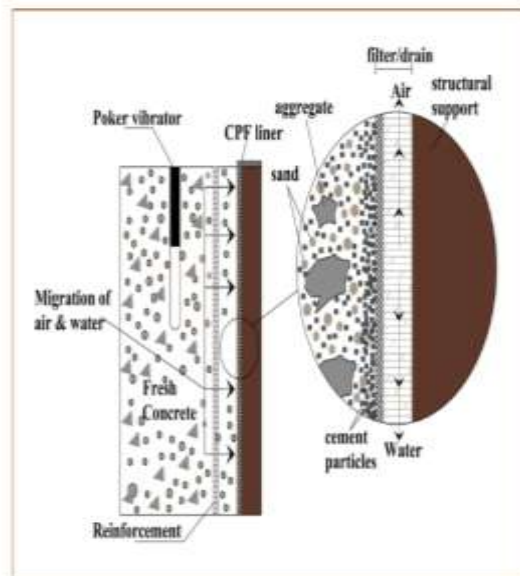


Fig 1.1 Controlled permeable formwork

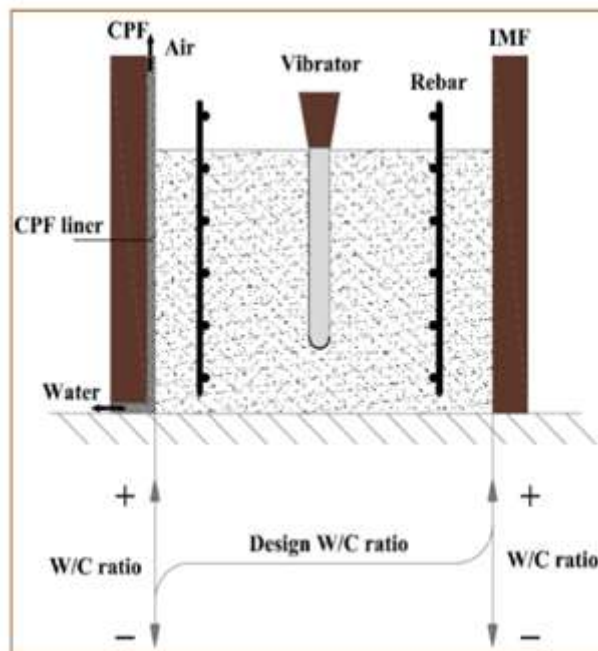


Fig 1.2 Basic concept of CPF

II. LITERATURE REVIEW

Kandasamy Selvaraj et al. (2021) demonstrated the effect of CPF liner with respect to the durability properties and service life of reinforced strengthened concrete. In this study experimental tests were then conducted at different stages to determine rapid chloride penetration, chloride ingress, chloride diffusion, and accelerated rebar corrosion. They found that the CPF concrete

acquired excellent resistance against the ingress of chloride ions ranging between 47% and 80%. Furthermore, the results showed that the service life of concrete cast against CPF liner was extended by around 2.1 times compared to IMF concrete.

S.Kandasamy et al. (2020) investigated the influence of CPF liner concerning the durability properties and the service life of reinforced/strengthened self-compacting concrete

(SCC). They conducted the experiments at different stages in order to examine accelerated rebar corrosion, rapid chloride penetration, chloride ingress, chloride diffusion and the experimental investigations revealed that CPF concrete acquired excellent resistance against the ingress of chloride ions ranging between 54 and 75%. Furthermore, the results showed that the service life of self-compacting concrete cast against CPF liner was extended by around 1.5 times as compared to IMF concrete.

Sahil Garg et al. (2019) studied the properties of near surface concrete (NSC) by the use of a commercially available CPF liner, and comparing the performance of more easily available and cheaper alternatives to CPF liner used. They performed the tests such as rapid chloride permeability test, AgNO₃ colorimetry test, initial surface absorption test and pull off test to study durability properties of near surface concrete (NSC). The results showed that commercially manufactured CPF produces better surface than the particle board and gunny bag, the improvement in NSC properties by use of gunny bag is also noteworthy.

S. Kandasamy et al. (2020) studied the influence of CPF liner concerning the resilience of surface quality properties of self-compacting concrete (SCC). The experimental tests were then conducted at different stages in order to determine rebound number, dynamic hardness number, superficial Rockwell hardness number, wear resistance and abrasion resistance. They found that the CPF concrete acquired excellent resistance against the abrasion resistance ranging between 46% and 60% and the results showed that by the application of CPF liner, the cover concrete (thickness: 20 mm) turned harder, when compared to core concrete. The cover concrete (thickness: 15-mm) turned softer than core concrete in conventional cast concrete.

S. Kothandaraman et al. (2016) investigated the effect of CPF liner on the surface hardness and wear of concretes. They prepared the suitable size specimens were cast against CPF liner and (impermeable) steel formwork (IMF) and tested at various ages. In this study, the results revealed that the surface quality/hardness of CPF concretes enhanced by 14% - 58% and it was ascertained that due to CPF liner, 20 mm thick cover concrete was found to be harder than the core concrete. In conventionally cast concrete, 15 mm thick cover concrete was found to be softer than the core concrete. This change in the quality of cover concrete was found to be consistent over the w/c ratio of 0.31 to 0.48.

S. Kothandaraman et al. (2016) investigated the influence of CPF liner on the strength and certain mechanical properties of concrete with three different water-cement (w-c) ratios. In this study, the specimens were prepared against CPF liner and impermeable steel formwork (IMF) and tested at various ages starting from 7 to 365 days. They conducted the various tests to assess the surface quality; compressive, split tensile and flexural strengths, rebound hammer and abrasion resistance of concrete. The results indicated that CPF concrete performed better than IMF concrete in all aspects. They found that the use of CPF liner has significantly improved the tensile strength (say, 20 %) of concrete and the abrasion resistance has been enhanced to a remarkable level (50-80 %). Further, the surface quality is very essential to assess the cube strength of concrete and the existing testing method slightly underestimates the cube strength.

S. Kothandaraman et al. (2016) conducted an experimental study to verify the performance and efficiency of CPF liner against self-compacting concrete (SCC). In this study, suitable size specimens were prepared using impermeable formwork (IMF) and CPF liner as well. They carried out the tests to check compressive, split tensile strength and flexural strength; ultrasonic pulse velocity and rebound hammer; abrasion resistance, sorptivity and water absorption. They found that CPF liner performs equally well with SCC. Vibration/hydrostatic pressure may not play significant role in draining the interface water through CPF liner.

Wael A. Megid et al. (2018) evaluated the effect of rheology of self-consolidating concrete and super workable concrete on formed surface quality. In this study a total 31 mixtures with different 12 workability and rheological properties were cast in a specially designed Z-shaped column without any mechanical consolidation. They evaluated the surface defects, including surface air voids, signs of bleeding, segregation, and low filling ability using a proposed image analysis methodology. They found that surface defects resulting from segregation with flowable concrete with plastic viscosity lower than 10 Pa.s and yield stress lower than 100 Pa.

Wael A. Megid et al. (2020) evaluated the effect of the forming materials on surface quality of the self-consolidating and highly workable concretes. In this study, mixtures were placed in a Z-shaped mould and no mechanical consolidation was applied at all. The sides of the mould were built up using plywood, PVC, steel, and permeable formwork liner using a polyester filter. They found that the permeable lined formwork was shown to provide an effective way for the entrapped air/water

bubbles and the bleed water to escape. The maximum surface dimension of the voids found on the concrete surfaces was limited to 3, 6, 7, and 10 mm for the mixtures cast using the permeable liner, steel, PVC, and plywood formwork materials, respectively.

Jiaping Liu et al. (2013) studied the effect of CPF on the water adsorption property of concrete. In this study, surface appearance, meso-surface morphology and microstructures of concrete blocks were characterized to analyze the affecting mechanism of CPF on concrete adsorption. It was found that, by applying CPF, concrete permeability was markedly reduced due to the improved surface and microstructures. In addition, the surface structure of the CPF liner was studied by SEM. It was indicated that the CPF was a beneficial and promising material for the improvement of concrete performances.

Helena Figueiras et al. (2009) investigated the full size precast elements with both self-compacting concrete (SCC) and conventional vibrated concrete (CC) using controlled permeability formwork (CPF). In this study, they compared the performance of two different CPF systems and also assess the combined effect of using CPF on SCC compared to CC.

P.J. Schubel et al. (2008) investigated the influence of concrete mixes and commonly used mineral additions and their effects on the near surface performance of vertically cast concrete against controlled permeable formwork (CPF). They found that the surface quality was dramatically improved in each case and changes to surface colour through densification were quantified. Near surface performance studies indicated a significant improvement for all systems studied.

J. Sousa Coutinho (2003) presented a laboratory study of controlled permeability formwork (CPF) applied to concrete where cement was partially replaced (10%, 15% and 20%) with Portuguese rice husk ash (RHA). They carried out the various tests to evaluate the durability of

concrete made with RHA at 10%, 15% and 20% replacement of cement by weight and cast with both the usual formwork and CPF. They found that the results lead to the conclusion that CPF enhances concrete performance even further when using partial cement replacement by RHA.

III. ELEMENTS OF CPF SYSTEM

The CPF system has three basic elements

- Filter - that allows the passage of air and water out from the fresh concrete but retains cement and other fine particles.
- Drainage system - that transfers the air and water filtered from fresh concrete to outside the formwork.
- Structural support - that supports the filter and drainage elements and also maintains the required formwork profile and resists the concrete pressure.

IV. TYPES OF CPF SYSTEM

The CPF material is produced in three general classifications

- Type I: Two-layer filter fabric systems that are fixed over a structural support and tensioned in-situ. These systems are reusable (3-5 times) with careful cleaning between uses.
- Type II: A single-layer filter fabric system that is fixed over a structural support and tensioned in-situ. These systems are generally single-use products.
- Type III: A two-layer system combining a filter fabric bonded to a backing grid. This type of CPF is fixed onto a structural support, but does not need tensioning because the filter fabric is pre-tensioned in the manufacturing process and the tension is maintained by the backing grid. This type can be used more than once. With regard to the drainage capacity, performance of this system is better than the other two types. The comparative statement of these three types of CPF system.

V. PROPERTIES OF CPF LINER

S.NO	Characteristics	Values
1	Thickness at 2 kPa (mm)	1.2
2	Mean pore size (µm)	<30
3	Unit weight (g/m ²)	250
4	Tear strength in longitudinal (N)	250
5	Tear strength in transverse (N)	200

6	Air permeability at 800 Pa (l/s/m ²)	250
7	Composition	100% polypropylene

VI. SURFACE HARDNESS OF CPF CONCRETE

Rebound Number

Rebound number is a measure of hardness of the surface zone of concrete. A number of researchers had indicated that this number would increase substantially due to the refinement achieved by CPF liner. It is also learnt that the increase in rebound number is in the range of 11% - 23%.

Pull-off Strength

The pull-off strength is also one of the measures the hardness of surface zone of concrete. In this test, a greater depth of concrete is influenced compared to rebound test. In all the studies conducted by various researchers it was reported that the pull-off strength of CPF concrete has been increased than that of IMF concrete and it was in the range of 20% - 47%.

Abrasion Resistance

Abrasion resistance of concrete can be considered as one of the measures of its durability. Deterioration of concrete surface may occur due to abrasion. It was reported that the CPF concrete specimens had better abrasion resistance when compared to IMF concrete specimens and the improvement was about 90%. In another study on CPF concrete the depth of abrasion was reduced by about 36% compared to IMF concrete specimens.

VII. DURABILITY CHARACTERISTICS OF CPF CONCRETE

Water Permeability

In general, the term permeability indicates, the property of concrete to allow the ingress of substances. Studies conducted by various researchers reported that by use of CPF liner the permeability of concrete was reduced significantly when compared to IMF concrete.

Air Permeability

The air permeability is determined by measuring the flow of air under pressure through a concrete specimen. In all the studies conducted by various researchers it was reported that the air permeability of CPF concrete reduced when compared to IMF concrete and it was in the range of 56% - 74%.

Water Absorption

The water absorption is related to permeability and in turn durability of concrete. Studies conducted by various researchers reported that CPF concrete showed lesser water absorption than that of IMF concrete and it was in the range of 29% - 50%.

Sorptivity

This test method is used to measure the rate of water absorption both the concrete surface and interior concrete. In all the studies conducted by various researchers, it was reported that CPF concrete specimens showed lesser sorptivity than that of IMF concrete specimen and it was in the range of 76% - 78%.

VIII. CONCLUSION

The following conclusions are made by reviewing the literature

- CPF concrete specimens exhibited smooth and even surface with almost free of pin and blowholes.
- The combined effect of CPF liner, reduction in w/c ratio, removal of entrapped air and enrichment of cement content, produces a very dense with less porous surface zone in concrete cast against CPF.
- The porosity within this zone increases towards the cast surface when impermeable formwork is used, whereas in CPF concrete the porosity decreases towards the cast surface. The study reported that 50-70 per cent reduction in the pore volume in the surface zone.
- It is obvious that the porosity, especially near the surface, is remarkably reduced by using CPF liner, which means that the water dissipation through the CPF liner made the surface of concrete with very fine microstructure.
- The available limited research findings confirm that by using CPF liner the performance of concrete, in particular the durability of concrete could be enhanced substantially.

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