Quality and durability of concrete structures through CPF

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Summary

A study of two CPF Controlled Permeability Formwork systems was carried out at Oporto University to ascertain the benefits of CPF compared to traditional Portuguese formwork. Several types of tests were undergone on concrete cast with CPF and traditional formwork, such as surface hardness, absorption, water penetration, mercury porosity tests including assessment of pore size distribution curves, carbonation, abrasion and chloride ion diffusion tests. The study lead to the conclusion that quality and durability of a concrete structure may be drastically enhanced by the use of CPF.

1. Introduction

Quality and consequently durability of concrete structures have turned into outstanding issues in the last 20 years as engineers have become aware of the leaping maintenance and repair costs for concrete structures.

The now classical approach to durability of a concrete structure, is already implied in Standards throughout the world (for example, in Europe - ENV 206) in which durability of a concrete structure depends on a good protective outer concrete cover over the reinforcement able to resist the environmental actions on the structure, throughout its design life. The quality of this cover is mainly achieved by considering simplicity in the design phase, an adequate mix with a low water-binder ratio, adequate binder, and efficient compaction and curing.

Quality and durability may be drastically enhanced by the use of Controlled Permeability Formwork (CPF), which consists of using a textile liner on the formwork. This liner acts as a filter/drain, allowing air bubbles and surplus water to drain out but retaining cement particles which are flushed out of the bulk of the concrete, mainly during compaction (*Fig. 1*).

When concrete is cast, the first particles in contact with the liner cannot proceed their way through and as compaction is carried out, more and more particles are retained further and further to the inside of the surface layer of the concrete. At the same time water and air bubbles manage their way out easily.

All this process leads to a very dense outer concrete layer with a very low water/cement ratio where it is most needed - the outer layer. This is, where concrete is usually of poorer quality. If the CPF formwork is not stripped off too soon, the liner will also induce hydration as the filter makes enough water available at the right time.

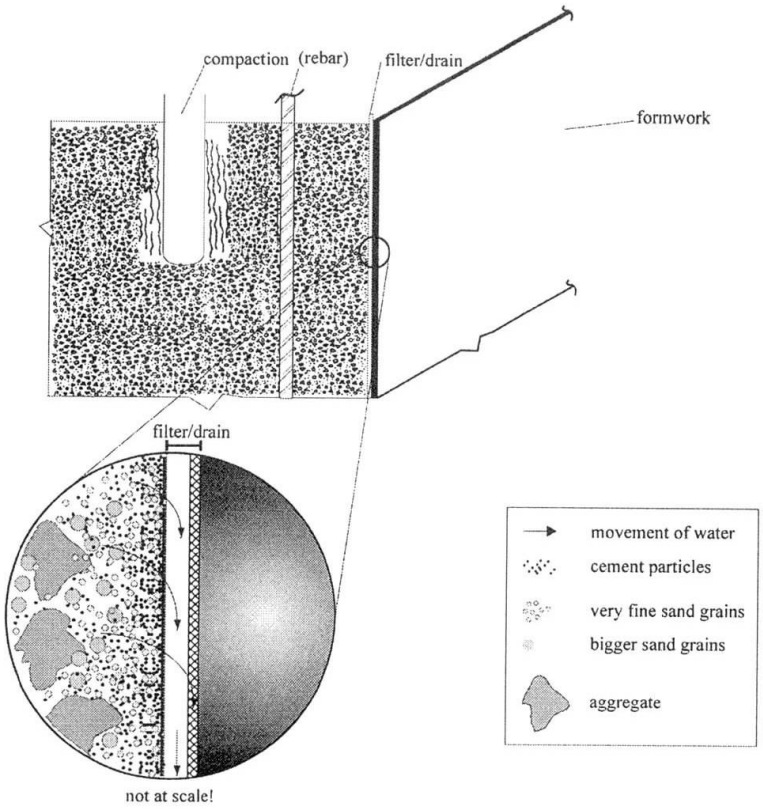

Fig. 1 - Controlled Permeability Formwork - a schematic representation.

2. Research Programme and Results

Test-walls 100 x 100 x 20 cm^3 of two concrete brands were cast using a form made of pine boards attached to each other (traditional Portuguese formwork) previously divided into vertical strips, each corresponding to different formwork types: untreated (control), CPF-T and CPF-Z. CPF-T was obtained from perforated Portuguese formwork over which was tensioned and attached a pp and pe liner, prior to casting. CPF-Z corresponds to Portuguese formwork over which was placed - no tensioning needed, Zemdrain MD1 specially engineered by DuPont for this purpose.

The surface hardness of the concrete was evaluated (EN/ISO 8045), 28 days after casting. Later, cores were drilled out and submitted to several tests. For each experimental test the outcome for cores of the same concrete but corresponding to different formwork types, was compared. This paper presents some of the results, with a special focus on the absorption by cappillarity tests.

The increase on surface hardness in CPF concrete was over 59% compared to the same concrete cast with the control formwork. As to other tests, the absorption coefficient decreased over 62%, permeability (water penetration) decreased over 49%, porosity (Mercury intrusion) decreased over 32%, carbonation decreased over 67% and concerning chloride penetration the Diffusion coefficient decreased over 38%.

3. Discussion

All these results confirm the aim of this study: CPF applied to Portuguese formwork does enhance durability. Although actual results have not been displayed it is interesting to verify that a C12/15 concrete cast with CPF-Z performed better in every test compared to a C30/37 concrete cast traditionally.