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Experimental investigation on Controlled Permeable Formwork Liner in steel fibre reinforced concrete

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Abstract

The current experimental work is carried out to observe the effect of CPF liner on mechanical properties of M20 grade concretes with the varying percentages (0%, 1%, and 2%) of steel fibres. The samples were created with CPF liner and impermeable steel formwork and conducted test at 28 days. Different tests like compressive strength, split tensile strength, rebound hammer and ultrasonic pulse velocity tests were done on the normal and CPF-lined concrete. From the test result the performance of CPF-lined concrete is high at various percentage of steel fibre reinforced concrete as compared to normal concrete. At last, the uses of CPF liner in the M20 grade of concrete are effective in both compression and tension with adding of steel fibres in the concrete.

1. Introduction

The durability of reinforced concrete is significantly based on the quality of the cover zone. The cover zone serves as the first line defense against deterioration due to physical or chemical factors. Aggressive substances enter the concrete through its surface area; as a result, the transport characteristics of this zone will control the rate of penetration into the concrete's core and, ultimately, how long it will last [1]. However, compared to the concrete in the section's centre, the concrete on the surface is more vulnerable to improper curing and compaction. Therefore, for durable concrete, a well-compacted, thick, hard, and strong concrete surface zone with low permeability and low diffusivity is recommended. Air bubbles and water can drain from the surface of the concrete with controlled permeable formwork, but the cement and fine particles are kept in place. This assures a decrease in the w-c ratio and raises the cement content in the concrete's surface zone. A homogeneous, denser, and less porous concrete surface is produced through CPF lining [2].

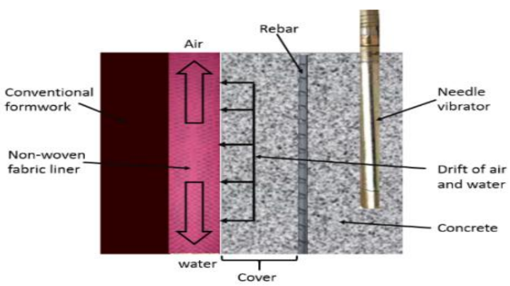

Fig.1 Controlled permeable formwork schematic representation [3]

2. Literature review

In 2016, Kothandaraman & Kandasamy [4] investigated the effect of compressive strength on CPF and impermeable steel form work. They found that controlled permeable form work samples produced compressive strengths that were consistently greater (2–5%) than those of standard concrete. surface scratching. The rebound hammer test was carried out to gauge how much harder the surface became after using CPF liner.

According to Chen, C. Liu, and J. Cui [5], the concrete surface of CPF had significantly different pore structure from the control sample. The 0-3mm slice's porosity decreased from 10.48 percent of the Specimen to 7.04 percent of the CPF sample. In Control samples, there were a lot of big pores with a diameter of 10–100 um, but CPF could get rid of them.

The effects of non-woven fabric on the mechanical characteristics of concretes of grades M20, M30, and M40 were investigated by Krishnan T, Telkar, etal. [3]. The study found that using locally accessible non-woven fabric liner in concrete grades M20, M30, and M40 produced strong, dense cover concrete for long-lasting reinforced concrete structures.

Steel fibres can be utilized as an additional kind of structural reinforcement and improve concrete's ability to resist cracking. Workability and slump are greatly influenced by steel fibre.

This paper further shows the behavior of steel fiber added to the different grades of concrete in percentage of (0%, 1%, and 2%) and shows the changes in CPF concrete and normal concrete. By doing compression test, rebound hammer, split tensile and ultrasonic pulse velocity it shows the steel fiber behavior on samples shown in results.

3. Experimental program

3.1Materials used

3.1.1. Cement

Portland Pozzolana Cement (PPC) is a type of environmentally friendly cement that is produced using pozzolanic ingredients and common hydraulic cement clinkers (such as fly ash, calcite clay, etc.). In Portland pozzolana cement, pozzolanic elements typically make up 10 to 25 percent of the total mass.

Fig.2 Portland Pozzolona Cement

3.1.2. Coarse aggregates

As per IS 456 (2000). The coarse aggregates, smashed stones with a 20 mm diameter were used. Typically, coarse combination is combined with smaller aggregates to fill in the gaps between the large objects and to "bind" the large objects along (such as sand). As a result, less cement paste is used, and there may be less shrinkage [10].

Fig.3 coarse aggregates

3.1.3. Fine Aggregates

The fine aggregate which is passed through a 4.75 mm sieve size is used in this experiment. Fine aggregates contain natural sand and crushed stone particles. The zone of fine aggregate is Zone-II as per IS 456 (2000) [10].

Fig.4 Fine aggregates

3.1.4. Controlled permeable formwork

The moulds are glued and attached with single CPF liner each side of the cubes (150*150*150) as shown in fig.5 The GSM of CPF lining is 150

Fig.5 controlled permeable formwork

3.1.5. Steel fibre

The material utilised was hooked steel fibre with a density of 7850 kg/m3. A metal reinforcement could be steel fibre. Short, unique lengths of steel fibres with a side magnitude relation (ratio of length to diameter) between twenty and one hundred are what are represented by steel fibre when it comes to reinforcing concrete. A precise amount of steel fibre will result in qualitative changes in the physical characteristics of concrete, considerably enhancing resistance to cracking, impact, fatigue, bending, tenacity, and durability.

Fig.6 Steel fibres

3.2 Mix proportion

IS 10262:2019 code was followed for the proportioning of the concrete for M20 grade of concrete. The exposure condition was considered as severe. The quantity of ingredients are shown in Table1 [11].

Table 1: Mix proportion

MATERIAL	QUANTITY (Kg/m³)
Cement	330
Water	198
Coarse aggregates	1122
Fine aggregates	723
Steel fiber (0.5%)	1.65
Steel fiber (1%)	3.3

3.3 Preparation and curing of specimens

The moulds are glued and attached with CPF liners shown in (fig.7) and make mixing in the drum capacity of 50kg. Mixing proportions are shown in (Table.1), as per the mixing ratio mix the mixture and cast in the moulds as shown (fig.7) after one day remove the moulds and place the samples in a curing water tank for 28 days, and take samples for the testing after 28 days.

Fig. 7 casting of specimens with CPF liner

4. Testing of specimens

4.1 Compressive strength test

After 28 days of curing, all of the mixes underwent a compressive strength test in accordance with IS 516 (1991). Cast and tested were three cube samples measuring 150 mm x 150 mm. When the highest load applied to the sample is divided by its cross-sectional area, the compressive strength of concrete can be computed [6].

4.2 Split tensile strength

After 28 days of curing, all of the mixes' test specimens underwent a splitting tensile strength test in accordance with IS 5816. (1999). For each age and each mix, three 100 mm x 200 mm cylinder specimens were cast and evaluated. When specimens fail, the highest load applied was recorded.

4.3 Rebound Hammer test

Cubes have undergone a rebound hammer test in accordance with IS-13311 (Part 2):1992. (Reaffirmed-May 2013). The rebound hammer has been held perpendicular to the concrete member's surface in order to take a measurement. The cube's vertical surfaces are suitable for conducting the test horizontally. On each observation point on every one of specimen's accessible faces, a rebound hammer test is performed [9].

Fig.8 Rebound hammer

4.4 Ultrasonic pulse velocity test

In order to conduct this test, an ultrasonic pulse is passed through the concrete to be tested, and the time it takes for the pulse to pass through the structure is recorded. by positioning the transducers on the material's opposing surfaces. A pulse generation circuit, which consists of an electronic circuit for generating pulses and a transducer for turning an electronic pulse into a mechanical pulse with an oscillation frequency in the range of 40 kHz to 50 kHz, is part of the ultrasonic pulse velocity apparatus (Fig. 9), along with a pulse reception circuit that receives the signal. This test reveals concrete cracks and faults [8].

Fig .9 Ultrasonic pulse velocity equipment

4.5 Water absorption test

Take the specimens in the curing tank after 28 days and note the wet weight of the samples and keep the samples in the oven for 1hr at 100 degrees centigrade temperature. After 1hr take the samples and note the dry weight of the sample.

5. Results and Discussions

5.1 Compressive strength

In Fig.10 the compressive strength properties of conventional cement and Controlled Permeable Form work liner concrete at different steel fibre percentages is presented. The compressive strength of CPF liner concrete improved by 3.6 percent, 6.7 percent, and 2.3 percent for (0%, 0.5%, and 1%), respectively, as compared to the compressive strength of regular concrete.

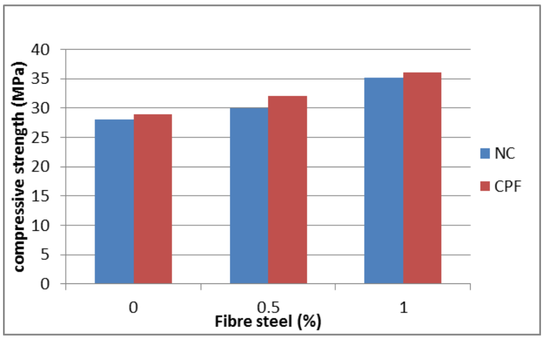

Fig.10 compressive strength vs. %steel fibre

5.2 Split tensile strength

In Fig.11 the split tensile strengths of conventional concrete and Controlled Permeable Form work liner concrete at different steel fibre percent is presented . When compared to ordinary concrete, CPF liner concrete's split tensile strength increased by 1.0 percent, 4.5 percent, and 7.8 percent for (0 %, 0.5%, and 1%) percent, respectively..

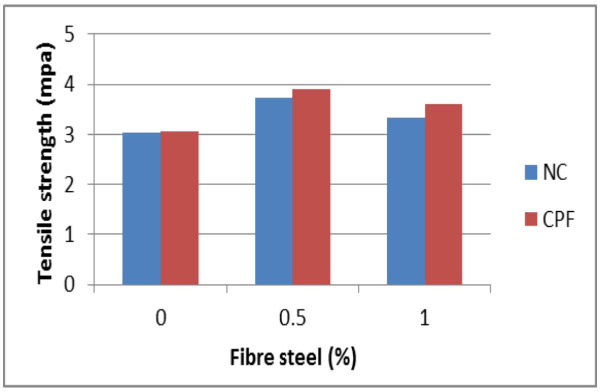

Fig.11 Tensile strength

5.3 Rebound hammer

In Fig.12, the rebound hammer of conventional concrete and CPF lining concrete at different steel fibre percentages is presented. When compared to the Rebound hammer of conventional concrete, its Rebound hammer of Controlled Permeable Formwork liner concrete increased by 6.9%, 8.2%, and 10.3% for (0%, 0.5%, and 1%), respectively.

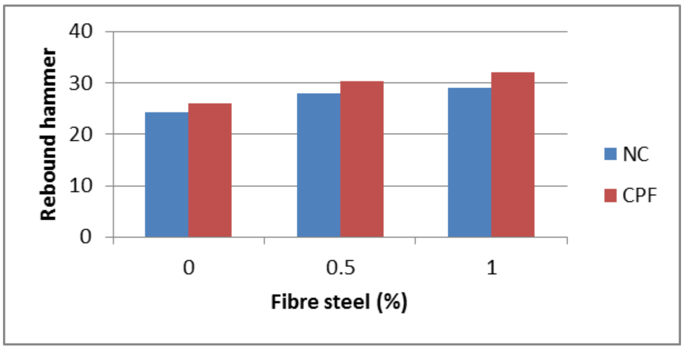

Fig.12 Rebound hammer

5.4 Ultrasonic pulse velocity

In Fig.13, the ultrasonic pulse velocities of normal concrete and CPF liner concrete at various steel fibre percentages are presented. When compared to conventional concrete, CPF liner concrete's ultrasonic pulse velocity increased by 0.6 percent, 1.0 percent, and 0.5 percent for (0%, 0.5% percent, and 1%), respectively.

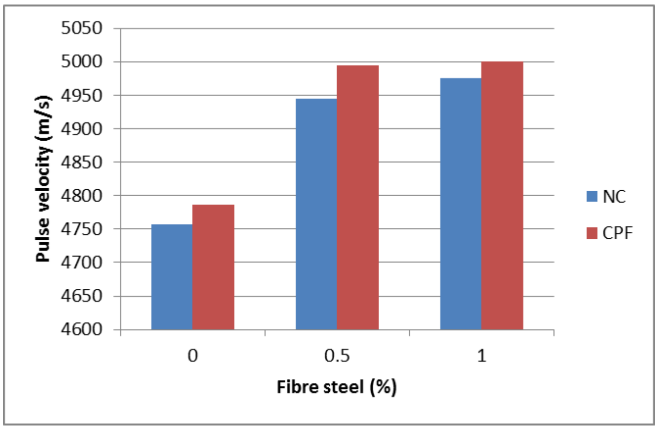

Fig.13 UPV (m/s)

5.5 Water absorption

In Fig. 14, the water absorption of normal concrete and CPF liner concrete at various steel fibre percentages is presented. When compared to regular concrete, CPF liner concrete's water absorption decreased by 11.1 percent, 8.7 percent, and 13.6 percent for (0%, 0.5%, and 1%), respectively.

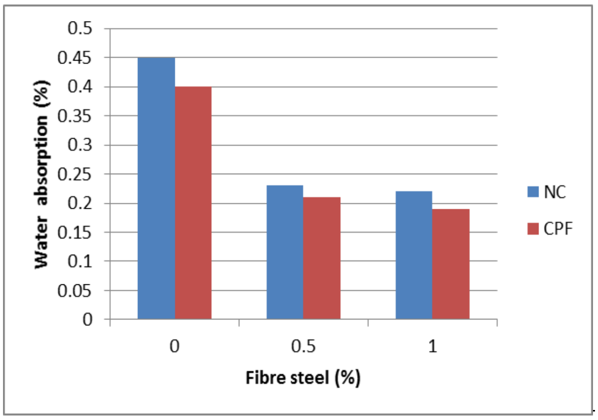

Fig.14 Water absorption

5.6 Visual Inspection

The surface of the concrete is shown in Figure 15. The CPF liner does not have any air voids and its surface looks clear compared to normal concrete have more voids and surface finishing also not good.

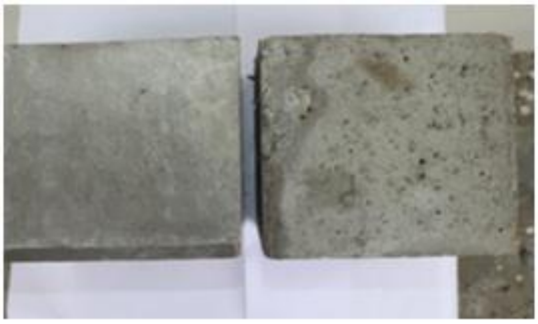

Fig.15 comparison for CPF and NC

Conclusions

The results of a study on the impact of Control Permeable Formwork liner with varying percentages of steel fibres (0%, 0.50%, and 1%) of M20 grade were mentioned below:

1. The non-woven fabric material used as the CPF liner. It allows water and air to escape from the concrete's cover zone.

2. The CPF liner concrete's compressive strength was slightly improved by the adding of more steel fibres.

3. The tensile strength of the CPF liner concrete was improved when the percentage of steel fibres is increased.

4. The Control Permeable Formwork liner concrete's surface was uniformly clear and free of blowholes.

5. The water absorption of CPF liner concrete is reduced as compare to the normal concrete at adding of different percentages of steel fibres.

With the addition of steel fibres to the concrete, CPF liner concrete for M20 grade concrete is generally effective in both compression and tension.

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