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Experimental Study on Freeze & Thaw Resistance of Carbon Fibre Reinforced Concrete

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Abstract:-

Freeze and Thaw resistance is an important durability criterion of concrete in cool areas. To further improvement in freezing and thawing resistance of concrete, carbon Fibre was added into the concrete. Rehashed absorbing water will speed up the freeze-thaw harm of concrete, resulting in the declination in compressive strength of concrete.

Consequently, a repetitive Freeze-Thaw test, in which samples (Specimens) of carbon-Fibre-Reinforced concrete were frozen for 16h followed by 8h of thawing, was completed to gauge the relationship of the carbon Fibre and Freeze-Thaw resistance. The outcomes show that adding Carbon Fibre content upto optimum limit into concrete could diminish the rate of weight loss of the concrete during the Freeze-Thaw investigation. The increment in Fibre content into the concrete resulted in improvement in compressive strength (28 days) of concrete significantly. Compressive strength losses was 1.055%, 7.656%, 23.243% and weight losses were 0.114%, 0.552%, 1.333% at 10, 25 and 50 Freeze-Thaw cycles of Plain Cement Concrete.

The experimental results indicate that the Fibre Reinforced concrete made with carbon Fibre is suitable as construction material in cold regions when the optimal addition of amount of carbon Fibre is 1 % of the weight of the cement.

Keywords*: *Carbon Fibre Reinforced concrete, Carbon Fibre, Slump, Freeze-Thaw Resistance, Compressive strength.

Introduction

Concrete is a versatile widely utilized construction material. Since concrete has been laid out as a material for construction, investigators have been attempting to work on its quality improvement. As a brittle material, concrete is strong under compression and weak under tension as well as in Flexure. This issue might be lightened by the addition of short carbon Fibres.

About portion of substantial structures have various levels of freeze-thaw damage around the world. Worldwide, in cold areas, like Japan, Russia, Canada and United States, substantial designs have various levels of freeze-thaw damage, and the expense for upkeep and support is very huge. The financial misfortune brought about by the freeze-defrost harm of structures is much higher than the construction cost. Concrete structures are frequently exposed to freeze-thaw cycles, and their durability and mechanical properties will be decreased by different degrees or even harmed, particularly in a salt-rich climate. Subsequently, it is exceptionally important to study how to improve the freeze-thaw resistance of concrete.

Material

Cement: - Ordinary Portland cement grade of 43 (OPC-43)

Coarse Aggregate: - Crushed coarse aggregates size of 20mm.

Fine Aggregate:-

The coarse sand passing through 4.75 mm sieve and retained on 600 μm sieve, conforming to IS 383-1970.

Fig- 1 (Aggregate and coarse sand)

Carbon Fibre:-

Tensile Strength: 3.45 GPa

Tensile Modulus: 230 GPa

Resin Dia: 7µ

Fig- 2 (Carbon Fibre)

Design Mix: M35

Table-1

Mix	Cement in Kg	Coarse Aggregate	Fine Aggregate	Water	Carbon Fibre	Dispersant	Admixture
C1/0.00	390	1222	664	156	0.00	2.34	3.9
C2/0.25	390	1222	664	156	0.98	2.34	3.9
C3/0.50	390	1222	664	156	1.95	2.34	3.9
C4/0.75	390	1222	664	156	2.93	2.34	3.9
C5/1.00	390	1222	664	156	3.90	2.34	3.9
C6/1.25	390	1222	664	156	4.88	2.34	3.9

Preparation of Specimens

Each material was weighed as per design proportion of the Design Mix. Firstly carbon fibre was immersed in water upto marginal height with addition of dispersant and vibrated by the Oscillation machine for 15 min, to make carbon fibre solution.

Cement, Coarse aggregate, Fine aggregate, water-reducing agent (Admixture) was uniformly mixed by concrete mixture and then carbon fibre solution were mixed with it. Cube moulds of size 150x150x150mm were prepared and total 72 nos specimens was casted as per variability of carbon fibre content. The mould shall be of 150 mm size conforming to IS 10086: 1982. The specimens were kept under clean water for 28 days and water renewed at every 7 days interval.

Fig- 3 (Cube Specimens)

Testing of Specimens

To calculate the 28 days compressive strength of the specimens, 3 specimens from each type were taken out from the curing tank and kept at room temperature for 30 minutes prior to the test and same was tested for compressive strength and the results of specimen is given in Table- 3.

Specimen oven dried for 24 hrs and cooling at room temperature, the weight of specimens calculated. Cubes were placed in individual containers resting on ceramic tiles. And the containers were filled with 3% sodium chloride solution at a temperature of 27 ±2 ̊C for 24 hrs. The level of solution was kept 2mm above the surface of the specimen. Following the 24 hrs saturation period cubes were subjected to continuous freeze- thaw cycles.

Saturated cubes were kept in freezing chamber for 16 hrs at -15 ̊C temperature. After completion of 16hrs in freezing chamber cubes were placed in thawing chamber for 8 hrs to complete the one cycle of Freezing-Thawing. The same process of freezing and thawing were repeated for 10, 25 and 50 cycles.

After completion of freezing and thawing cycles, the specimens washed with 3% sodium chloride solution to remove all loose particles. These particles and spelled material washed and stained through a filter and dried to a constant weight. The residues weighted after 10, 25 and 50 cycles cumulatively.

The specimens were tested for compressive strength after 10, 25 and 50 cycles.

Results & Conclusions

Mechanical Properties of concrete decreases with increases in Freeze-Thaw Cycles in which the compressive strength is the most delegated parameter. The compressive strength test was conducted at room temperature according to IS: 516 as shown in fig- 4.

Fig- 4

Plain Cement Concrete (C1/0.00) has resulted value of compressive strength (28 days) was 41.20MPa. The Carbon Fibre Reinforced Concrete (C2/0.25) cubes have the compressive strength (28 days) 39.35MPa which is lowest value of compressive strength w.r.t. other specimens. When the carbon fibre resins were 0.25% of the weight of the cement used the compressive strength decreases with certain amount while the carbon fibre resins were 0.50% of the weight of the cement used the compressive strength starts increasing that is slightly more than the Plain Cement Concrete.

When amount of 2.93kg/m^3 carbon fibre (i.e. 0.75% weight of cement) added to concrete mix the compressive strength resulted 1.09 times higher than the Plain Cement Concrete. Carbon fibre Reinforced Concrete with carbon fibre content of 1% had the highest value of compressive strength i.e. 47.44Mpa. However fibre resins added more than 1% of weight of cement compressive strength starts decreasing. Cubes made with addition of Carbon content of 1.25% by weight resulted lower value of compressive strength as compared to C5/1.00 cubes strength.

After the completion of 50 Freeze-Thaw cycles the compressive strength of Cubes were calculated. The cube strength of Plain Cement Concrete was recorded 33.43 MPa. The result shows that when small amount (0.25% by weight of Cement) of carbon fibre added, the compressive strength was recorded 33.38 MPa but it is 99.85% of Plain Cement Concrete Cube Strength (after 50 Freeze-Thaw Cycle) while it reduces 17.885% as compare to its 28 days strength. The cubes made with 1.95Kg/m^3 (i.e 0.50% by weight of cement) had the compressive strength of 42.29MPa that is reduces by 1.182% to its 28 days strength. While specimens of C4/0.75 had the compressive strength of 44.59MPa and it is 0.695% lower than its 28 days strength. The compressive strength 47.26MPa resulted for C5/1.00 specimens and it is just only 0.381% lower than its 28 days compressive strength. The cubes made with more than 1% carbon fibre content resulted decreasing in compressive strength after completion of 50 Freeze-Thaw cycles. The value of compressive strength recorded was 37.22MPa i.e. Lowest value recorded as compare to other specimens and it is 11.741% lower than its 28 days strength.

Hence the outcomes showed that when a small quantity of carbon fibre was considered the compressive strength of the Carbon Fibre Reinforced Concrete (CFRC) was lower than that of Plain Cement Concrete and when the quantity added more than 0.5% by weight of cement, the compressive strength of Carbon Fibre Reinforced Concrete (CFRC) was more than that of Plain Cement Concrete. Thus optimum value of Carbon Fibre Resins is 1% by Weight of Cement (3.90Kg/m^3).

Freeze-Thaw Resistance of Carbon Fibre Reinforced Concrete:

In the Freeze-Thaw resistance test, impact of Carbon fibre resins on weight loss and compressive strength are shown in Table 2 & 3 and fig- 5 and 6 respectively. The cubes made with Plain Cement Concrete (C1/0.00) shown the maximum weight loss 1.333% after 50 cycles of freezing and thawing while (C5/1.00) shown the minimum weight loss 0.039%.

Table- 2

Mix	28 days Weight	% Loss after 10 Cycles	% Loss after 25 Cycles	% Loss after 50 Cycles
C1/0.00	8.451	-0.114	-0.552	-1.333
C2/0.25	8.452	-0.071	-0.083	-0.084
C3/0.50	8.488	-0.047	-0.051	-0.059
C4/0.75	8.518	-0.047	-0.051	-0.058
C5/1.00	8.609	-0.031	-0.031	-0.039
C6/1.25	8.482	-0.122	-0.601	-1.061

Table- 3

Mix	28 days Strength	% Loss after 10 Cycles	% Loss after 25 Cycles	% Loss after 50 Cycles
C1/0.00	41.20	-1.055	-7.656	-23.243
C2/0.25	39.35	-0.768	-4.321	-17.885
C3/0.50	42.79	-0.635	-0.825	-1.182
C4/0.75	44.9	-0.447	-0.582	-0.695
C5/1.00	47.44	-0.275	-0.296	-0.381
C6/1.25	41.59	-1.069	-1.563	-11.741

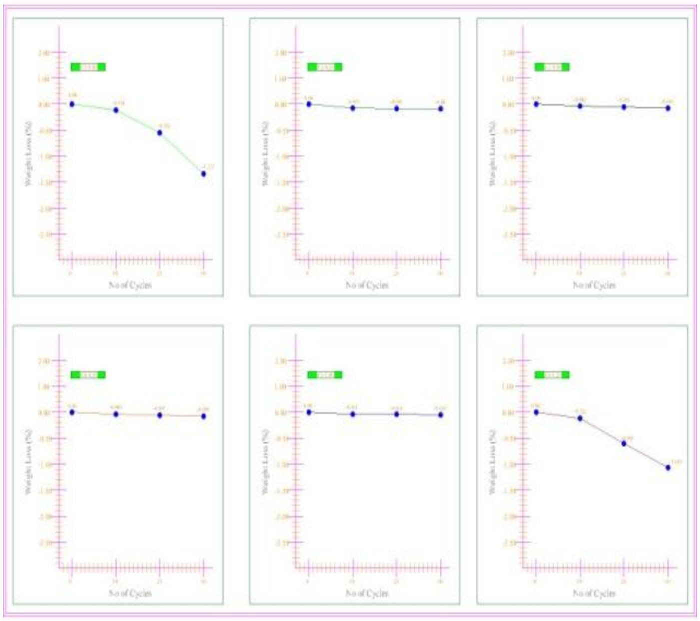

Fig- 5 (Weight Loss)

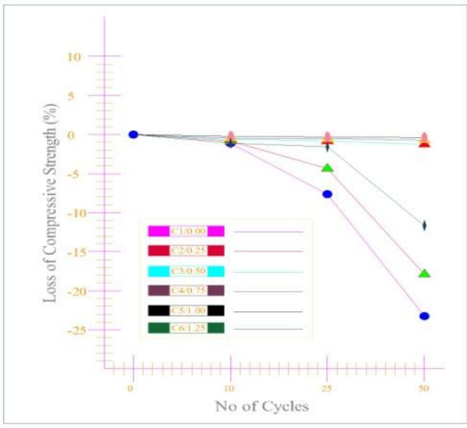

Fig- 6 Compressive strength loss

The frost resistance mark displayed on concrete cube in increasing pattern with increase in carbon fibre content before 1 % by weight of cement. When carbon fibre content increase more than 1% then, it shown not any further improvement in frost resistance in concrete. When the water present in pores experienced frost resistance its volume increased and which would cause of tensile stress development and microcracks forms. The improvement in frost resistance by using carbon fibre in concrete prevented the formation of microcracks. Therefore the addition of optimum carbon fibre content that is 1 % by weight of cement used can improve the frost resistance in concrete.

Conclusions:

- By increasing Carbon Fibre Content from 0% to 1.25% by weight of cement showing a decrease pattern in workability. Slump value decreases from 146mm to 78mm.
- The mixing of Carbon fibre into concrete could compressive strength decrease first and cause increase after that, the value of maximum compressive strength after 50 cycles reported is 47.26MPa which is just only 0.381% lower than its 28 days strength.
- The mixing of carbon fibre content into concrete can decrease the weight loss of the concrete.

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