Retrofitting of Reinforced Concrete Structure

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***Abstract*—**This paper shows the test result on durability of Carbon Fibre Reinforced Polymer (CFRP) composite wrapped specimens evaluated by using salt iron resistance test and temperature resistance test. The main aim of this study is to depict the durability of RCC end bearing piles retrofitted with CFRP. The specimens were wrapped with Carbon unidirectional fabric warp along with the circumference or hoop tension direction. 24 nos. of cube specimens were cast with and without CFRP wrapping to observe the fluctuation in compressive strength during salt iron and fire resistance tests. The salt iron resistance tests were carried out on specimens by using salt iron solution. The salt iron immersed specimens were tested for determination of compressive strength after curing for 7 days and 30 days. Similarly, the fire resistance tests were carried out by using hot air oven at 200□C for 1and 2 hours intervals. The comparison of the results between control specimens and CFRP wrapped specimens were made to evaluate the difference in compressive strength.

Index Terms - *salt iron resistance, Fire resistance, Compressive strength, Carbon Fibre*

I. INTRODUCTION

A. General

Generally, concrete is a durable material widely used in construction. Its durability is governed by concrete mix design, environmental conditions, age of building, chemical attack, atmospheric weather, carbonation, sub soil water table, sub soil condition, permeability, quality of materials & works, shape and size of members, cover thickness, cement contents, water cement ratio, chloride content, alkali-silica reaction, finishing and initial curing of water properties, etc. The strength of concrete has a direct relation with its durability. Hence, the concrete should possess the ability to resist weathering action, chemical attacks, abrasion, deterioration, etc. Durable concrete retains its the original form, quality and serviceability even when exposed to aggressive environments. Over recent years, concrete durability researches are being conducted by technologists for saving the structures from cited cause and for maintaining the sustainability of the world. Durability can be extended by using suitable methods of maintenance, repairing, rehabilitations and retrofitting or strengthening. Among the various methods of retrofitting, the FRP wrapping is one of the best methods. FRP supports in increasing the durability of concrete by reducing the permeability, resisting high temperature, resisting chemical attack, withstanding the fatigue action, sealing of micro pores, providing additional strength to the elements, etc. In this experiment, the carbon unidirectional fabric was used along the hoop direction that is along the perimeter.

Durability experimental tests were tested in concrete cube specimens in addition to retrofitting of RCC piles by using carbon fibre. Various experiments are used for measuring the durability performance previously against the RCC pile retrofitting works. Even now, the experiment tests were done for axial load, lateral load, impact load and skin friction performance after retrofitting with CFRP composites. Erdil et. al. carried out durability test in low strength concrete, by confining the same with carbon fibres under the temperature cycles of 200□C. and temperature change between -10°C to 50°C. Single layer wrapped specimens possess 3 times more strength and five times more resistance to strain while comparing with control specimens. Confined and unconfined concrete specimens exhibit increased strength, but strain decreased when subjected to temperature cycles and sustained loads.The CFRP specimens resist the chloride more than aramid and control specimen for a period of 6 months and one year in the direct field. Haider Al-Jelawy conducted durability test of CFRP wrapped beams by exposing to outdoor environment, sea water solution, leachate solution, UV radiation and dry heat the environment. In all the tests, the CFRP wrapped specimens are performed well while comparing with control specimens. Murugan et. al. determined the durability in cubes and cylinder by exposing to natural outdoor weather and water immersion condition with Glass and Carbon fibers Uni and Bi direction. Carbon unidirectional fibre confined cube and cylinder specimens were taken more compressive strength when compared with control specimens, bi-direction confined specimens and glass fibre confined specimens. This study measured the durability of CFRP wrapped cube specimens by using dry temperature test and salt iron solution test and compared with control specimens.

B. Objectives and scope

- To study the effect on environment condition such as salt water humidity and alkali solution on reinforced concrete structure by using FRP.
- To study the fire resistance and characteristics of FRP in reinforced concrete structure.
- To study the salt resistance and characteristics of FRP in reinforced concrete structure.

- To compare Salt resistance characteristics of conventional i.e. without FRP wrapped cube and FRP wrapped cube.
- To compare Fire resistance characteristics of conventional i.e. without FRP wrapped cube and FRP wrapped cube.
- Fiber reinforced polymer is composite material made up of polymer matrix reinforced with fiber.
- The polymer is usually an epoxy vinylestar for polyester thermosetting plastic and phenol form aldehyed resin are still in use.
- Composite material engineered or naturally occurring material made up of two or more constitute materials with significantly different physical and chemical properties.
- FRPs commonly used in construction industries.
- To study Strength can be extended by using suitable method maintenance, repairing, rehabilitation, retrofitting.

II.METHOD OF TESTING

A. Salt iron resistance test

The ingredients and preliminary tests were conducted an the single and double layer of CFRP wrapped specimens performances were found out. Based on that, author a paper was published in international journal [9]. For this salt iron resistance test, cube specimens of 24 nos. were cast using M30 grade concrete. After 28 days of water curing the specimens were dried in the atmosphere for 36 hours weighed (initial weight) and then kept immersed in 2% salt iron solution as per the Table I. Salt iron solution properties were shown in Table II.

Fig.1 - Cube casting

TABLE I
Details of experimental program

Description of Specimen	Specimens immersed in salt iron solution – Duration	
	7 Day	30 Day
Control or conventional specimens in nos.	3	3
CFRP wrapped specimens in nos.	3	3

TABLE II
Salt properties

Properties of salt iron (Salt iron strength 2%)	Value
PH Value	7
TDS	500 PPM

After the corresponding period of salt iron immersion, specimens were taken out of salt iron solution and weighed (Present weight). It is then tested for compressive load as per the IS code 516-1959. The test results were observed and compared with control & doubly CFRP wrapped specimens with respect to weight loss and strength loss.

Fig. 2 Cubes immersed in salt iron Solution

TABLE III
Salt iron resistance test result

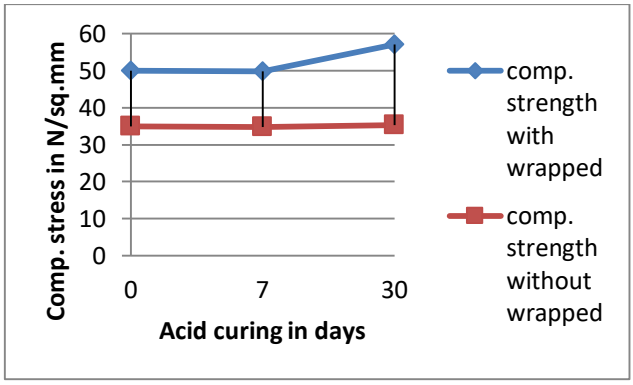

Fig. 3 - Average Compressive strength of salt iron immersed concrete cube

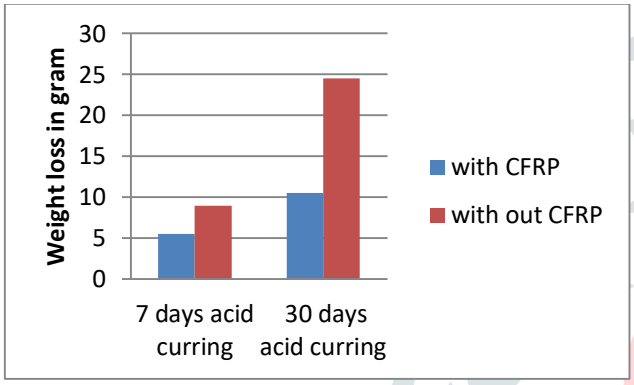

Fig. 4- Average weight loss of salt iron immersed concrete cube

B.Fire Resistance test.

Similarly, the specimens were weighed and kept in the hot air oven at 200˚C for duration of 1 and 2 hours. In this experiment, temperature is kept at constant 200°C where as the time varies in 1 hour interval upto three hours. The detailed data are given in below the Tables IV to V

Fig. 5- Cube kept in oven at 200˚C for 1Hr and 2Hr

Description		After 7 days		After 30 days	
Cube Specimen without wrapped	Cube	1	2	1	2
	Initial weight in gm	8650	8644	8850	8856
	Percent weight in gm	8642	8634	8826	8831
	Weight loss in gm	8	10	24	25
	Comp strength in KN	792	789	785	783
Cube Specimen with wrapped	Initial weight in gm	8638	8665	8773	8873
	Percent weight in gm	8633	8659	8765	8860
	Weight loss in gm	5	6	8	13
	Comp strength in KN	1150	1148	1132	1112

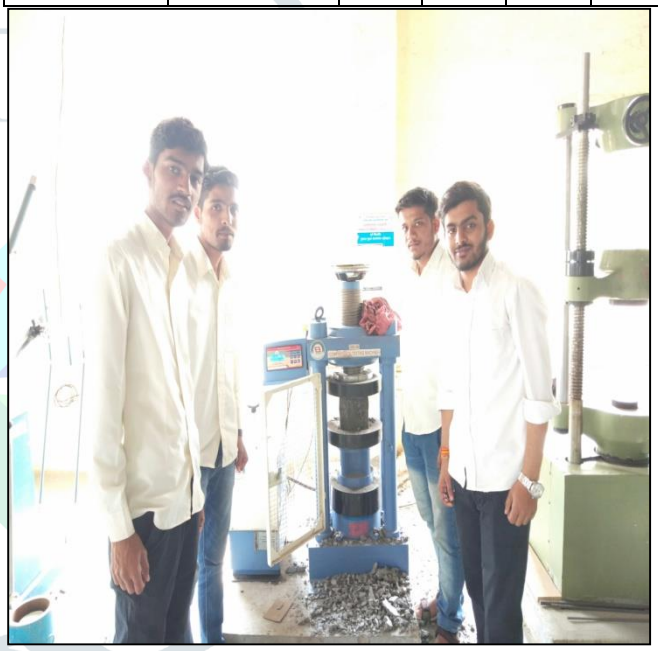

Fig 6 .compressive strength test on cube

TABLE IV
Fire resistance test at 200˚C – 1 hr.

Specimen Type	Initial Wt (gm.)	After Heating Wt (gm	Ultimate Load Carrying Capacity (KN	Comp Strength (N/mm^ 2)	Avg. Comp Stress
Without CFRP Wrap	8565	8554	795	35.33	35.57
	8495	8482	806	35.82	
With CFRP Wrap	8611	8605	1194	53.07	`53.15
	8590	8582	1198	53.24	

TABLE V
Fire resistance test at 200˚C – 2 hrs.

Specimen Type	Initial Wt (gm.)	After Heating Wt (gm	Ultimate Load Carrying Capacity (KN	Comp Strength (N/mm^ 2)	Avg. Comp Stress
Without CFRP Wrap	8592	8585	802	35.64	35.26
	8553	8539	785	34.88	
With CFRP Wrap	8605	8599	1198	53.24	53.04
	8595	8589	1189	52.84	

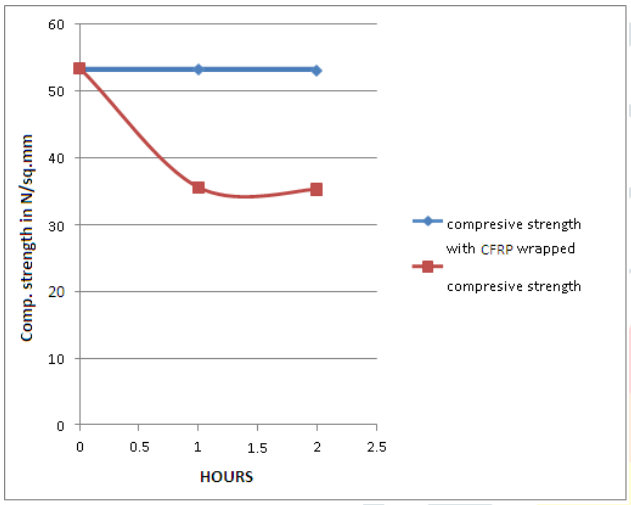

Fig. 7 Concrete cube compressive strength after dry temperature

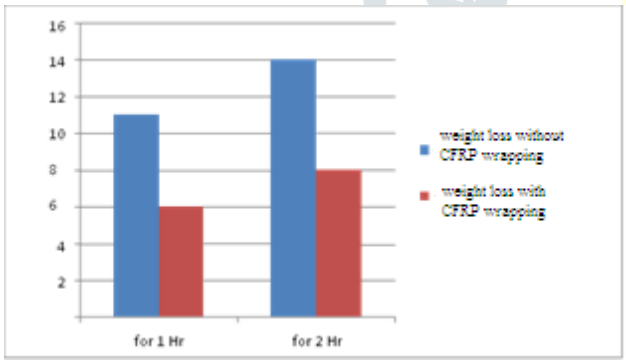

Fig. 8 Concrete cube weight loss due to temperature

IV.RESULT AND DISCUSSION

From those experiment ,the following inferences were made.

The CFRP wrapped specimen posess higher salt iron resistance than control concrete specimen

The decrement in compresive strength of control specimens after salt iron immersion for 7 days and 30 days are 35.7N/MM^2 and 35.24N/MM^2 as shown in fig

The decrement in compresive strength of CFRP wrapped specimen after salt iron immersion 7 days and 30 days are 53.77 N/MM^2 and 53.64 N/MM^2 as shown in fig

The CFRP wrapped concrete specimens are having high dry temprature resistance more than control concrete specimens

The decriment in compresive strength of control specimens after subjecting to dry temperature of 200^{0}C for 1 and 2 hrs are 35.7 N/MM^2 and 35.8 N/MM^2 as shown in fig

The decriment in compresive strength of CFRP wrapped specimens after subjecting to dry temperature of 200^{0}C for 1 and 2 hrs are 53.80 N/MM^2 and 53.46 N/MM^2 as shown in fig

V. CONCLUSIONS

From the research result it is concluded that CFRP wrapped cube specimens withstands more load carrying capacity after salt iron immersion and thermal effects than the conventional elements. purpose of the study is prove in this experimental. CFRP wrapping endures durability increase in the life of elements. Thus it can be concluded that CFRP wrapping can be used for retrofitting of RCC piles prevails.

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