International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 09 | Sep 2019 www.irjet.net p-ISSN: 2395-0072

Assessment of CFRP Strengthening Method for R.C. Column in Marine Environment

Mrs. Ramatai Somwanshi[1], Manoj Gadge [2], Saurab Borvadkar[3], Rahul Dumbre[4], Shripad Palkar[5]

[1]Assistant Professor, Dr. D.Y. Patil Institute of Technology, Pimpri, Pune, Maharashtra, India
[2,3,4,5]UG Student, Dr. D.Y. Patil Institute of Technology, Primpri Maharashtra, India

---***---

Abstract - ***An experimental investigation of the utilization of carbon fiber reinforced polymer (CFRP) to concrete marine structures. The study involved testing reinforced concrete (RC) columns. A total of 24 specimens were grouped and investigated to evaluate the performance of CFRP wrapped RC circular columns in a marine environment. The specimens were immersed for different periods in natural water and seawater, which are common conditions for marine structures. The specimens were identical and had a diameter of 150 mm and an overall height of 500 mm. Period of immersion was the main test parameter and the investigation focused on the performance of the columns wrapped with CFRP in terms of load capacity, deformation and ductility. The test results showed that the ultimate load capacity of the RC columns wrapped with CFRP was not noticeably affected by immersion in natural water and seawater. However, there was a significant reduction in ultimate axial displacement and radial strain. Hence, there was a significant negative effect of immersion in natural water and seawater on the ductility of RC columnsconfined with CFRP.***

Key Words: Fibre Reinforced Polymer (FRP), Reinforced concrete columns, Marine Environment, Strengthening,

1. Introduction

In the past few decades, many types of materials have been developed for the repair or strengthening of reinforced concrete (RC) structures, driven by the demands of the construction industry arising from the existence of concrete problems, such as deterioration and the need for post-strengthening of structures to ensure their safety and serviceability. Among these materials, fibre reinforced polymer (FRP) has been widely used in construction engineering because of its tensile strength, corrosion resistance and easier handling, in addition to the economic advantages. Many studies have investigated RC strengthened using FRP. In this experimental investigation we will cover aspects of FRP-wrapped RC columns, including mechanical properties like strength capacity, ductility and durability. The main goal of this experiment is to investigate the effect of the marine environment on the behavior of RC strengthened with CFRP sheets in the short term. The purpose is to evaluate the aggressiveness of seawater on the performance of RC columns wrapped with CFRP and those unwrapped for the same period of exposure. However, the main focus is on the effect of immersion in seawater on CFRP-wrapped columns. [5]

Fiber-reinforced polymer (FRP) have been widely used for strengthening and retrofitting of concrete structures. Despite widespread use of FRP composites in civil structures, mostly their tensile load carrying capacity has been considered in civil applications.[4]

In this experimental work we evaluate the aggressiveness of seawater on the performance of RC columns wrapped with CFRP and those unwrapped for the same period of exposure. The effects of the marine environment on RC, especially cracking and deterioration, are very harsh and more notable than in other environment.

Table 1: Comparison of Typical Properties of Materials

Property	Materls			
	Steel	GFRP	CFRP	AFRP
Tensile Strength (MPa)	483-690	517-1207	1200-2410	1200-2068
Yield Strength (MPa)	276-414	N/A	N/A	N/A
Elastic Modulus (GPa)	200	30-55	147-165	50-74
Specific Gravity	7.9	1.5-2.0	1.5-1.6	1.25

Table 2: Qualitative Comparison of The Three Main Types of FRPs

Criterion	Fibre Type		
	Carbon	Aramid	Glass
Tensile Strength	Excellent	Very Good	Good
Modulus of Elasticity	Excellent	Good	Adequate
Long Term Behaviour	Very Good	Good	Adequate
Fatigue Behaviour	Excellent	Good	Adequate
Bulk Density	Good	Excellent	Adequate
Alkaline Resistance	Very Good	Good	Adequate
Cost	High	Adequate	Adequate

Table 3: The Final Mix Proportions of M45 Grade of Concrete

Water	Cement	FA	CA
180.42	360.0	584	1223.8

2. Results and Discussions

2.1 Results:

Table 4: Result of The Compression Test on Unwrapped and Wrapped Columns immerse in Sea water.

Sr. No	Shape Of Column	Size	Wrapping Condition
1	Circular	150 mm Dia. X 500 mm Length	Unwrapped
2	Circular	150 mm Dia. x 500 mm Length	Wrapped

Table 5: Result of The Compression Test on Unwrapped and Wrapped Columns immerse in Potable water.

Sr. No	Shape Of Column	Size	Wrapping Condition
1	Circular	150 mm Dia. X 500 mm Length	Unwrapped
2	Circular	150 mm Dia. x 500 mm Length	Wrapped

2.2 Result analysis: (Effect of Sea Water)

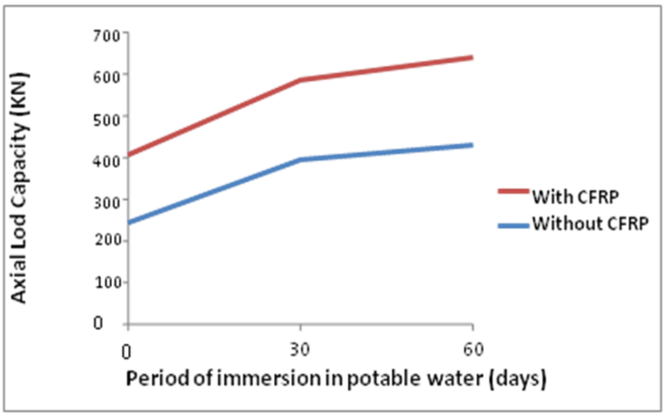
The results of compressive load tests for all columns, with and without CFRP wrapping, that were immersed in Sea water for different periods are presented in below graphs

The ultimate load capacity of each column (with CFRP) was compared with control specimen (without CFRP) immersed in Sea water. It can be seen that the capacity of CFRP-wrapped columns were not affected and that was a slight increase in capacity.

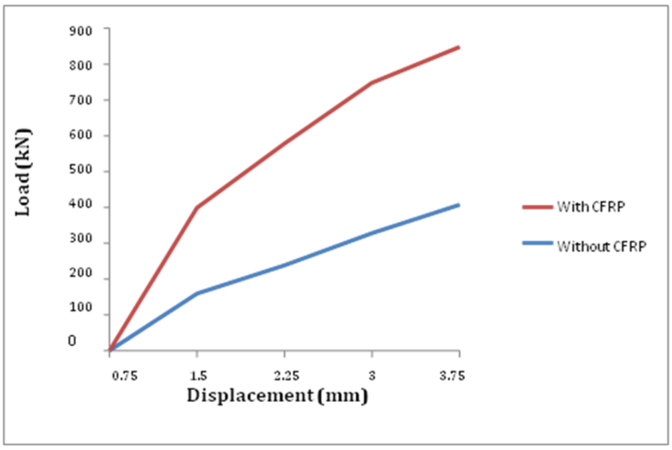
The ultimate deformations of columns wrapped with CFRP and immersed in Sea for different period, shows the relationship between the axial displacement and axial load for specimens wrapped with CFRP. It can be seen that the ultimate axial displacements decreased due to immersion in Sea.

The radial stress-strain curves of the tested columns wrapped with CFRP and immersed in Sea. It is clear that the ultimate radial strain decreased with the period of immersion in Sea.

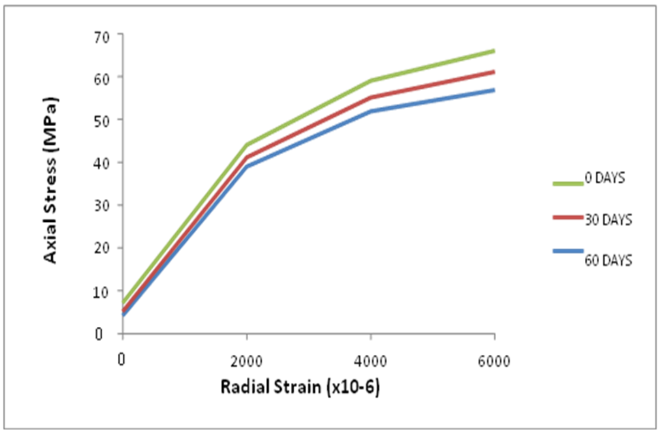
Result Analysis of CFRP Wrapped and Unwrapped Circular RCC Columns immerse in Sea water.



Graph No. 1 period of immersion Vs Axial Load Capacity



Graph No. 2 Displacement Vs Load



Graph No. 3 Radial Strain Vs Axial Stress

Table 6: Summary of result tested specimens in Sea water:

Specimen	Axial load (KN)	Axial displacement (mm)	Radial strain	Axial stress (MPa)
S-0d-CFRP	629	3.96	6113	38.3
S-30d-CFRP	689	3.1	3989	47.7
S-60d-CFRP	723	1.53	3543	63.2

2.3 Result analysis: (Effect of Potable Water)

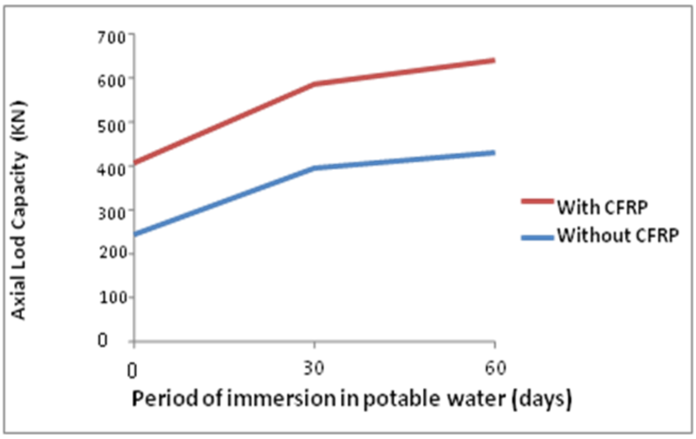
The results of compressive load tests for all columns, with and without CFRP wrapping, that were immersed in Potable water for different periods are presented in below graphs.

The ultimate axial load capacity of each column (with CFRP) was compared with control specimen (without CFRP) immersed in Potable water. It can be seen that the capacity of CFRP-wrapped columns were not affected and that was a slight increase in capacity.

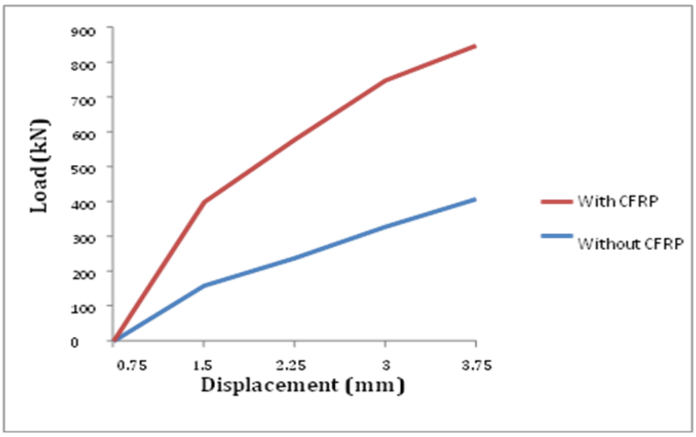
The ultimate deformations of columns wrapped with CFRP and immersed in potable for different period, shows the relationship between the axial displacement and axial load for specimens wrapped with CFRP. It can be seen that the ultimate axial displacements decreased due to immersion in potable.

The radial stress-strain curves of the tested columns wrapped with CFRP and immersed in potable. It is clear that the ultimate radial strain decreased with the period of immersion in potable.

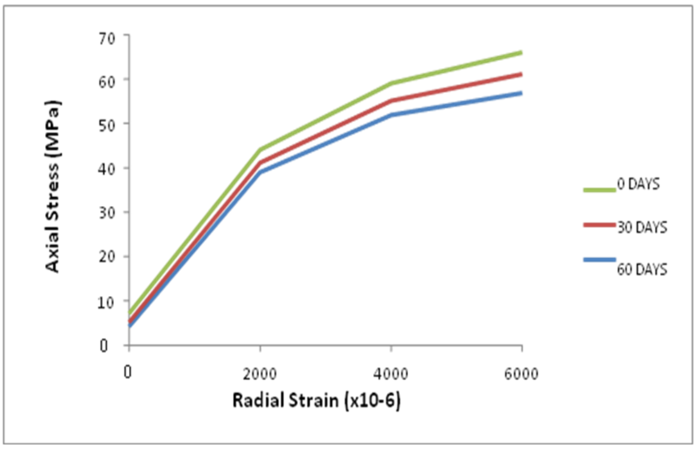
Result Analysis of CFRP Wrapped and Unwrapped Circular RCC Columns immerse in Potable Water.



Graph No. 4 period of immersion Vs Axial Load Capacity



Graph No. 5 Displacement Vs Load



Graph No. 6 Radial Strain Vs Axial Stress

Table 7: Summary of result of tested specimens in potable water

Specimen	Axial	Axial displacement (mm)	Radial strain	Axial stress (MPa)
S-0d-CFRP	405	9.31	6101	69.7
S-30d-CFRP	585	3.43	3890	72.3
S-60d-CFRP	640	1.92	2243	85.6

Our test results shows that the increase in strength of RCC member is more than 50 % of conventional method. For retrofitting of structures this is an useful and successive technique we achieve.

3. Conclusions

➢ We can increase the strength of RCC structures successfully by using CFRP. Our test results shows that the increase in strength of RCC member is more than 50 % of conventional method.

➢ There was a significant reduction in the load capacity of the control columns (without CFRP) due to immersion in seawater.

➢ Noticeable decreases in the ultimate axial displacement of the CFRP-wrapped columns were observed after immersion in sea water.

➢ Noticeable decreases in the radial strain of CFRP-wrapped columns were observed after immersion in seawater.

➢ All tested specimens wrapped with CFRP and immersed in seawater for different periods were governed by an explosive and sudden failure type after reaching the maximum tensile strength of the CFRP sheet.

4. Reference

1) M. Long, C. Djelal, S.kesteloot "**durability of cfrp-concrete bonding in a marine environment",** ECCM15-June2012.

2) M. H. Kabir, S. Fawzia, T.H.T. Chan **"durability study of cfrp strengthened steel circular hollow section n members under marine environment"** 23rd Australasian Conference on the Mechanics of Structures and Materials (ACMSM23) Byron Bay, Australia, 9-12 December 2014.

3) Davood Mostofinejad, Niloufar Moshiri **"Compressive Strength of CFRP Composites Used for Strengthening of RC Columns: Comparative Evaluation of EBR and Grooving Method".** DOI: 10.1061/(ASCE)CC.1943-5614.0000545.© 2014 American Society of Civil Engineers.

4) Davood Mostofinejad, Ala torabian**, "Experimental Study of Circular RC Columns Strengthened with Longitudinal CFRP Composites under Eccentric Loading: Comparative Evaluation of EBR and EBROG Methods**", DOI: 10.1061/(ASCE)CC.1943-5614© 2015 American Society of Civil Engineers.

5) Alaa Alsaada, Gulan Hassanb **"Utilization of CFRP for strengthening RC columns in marine environment"** Case Studies in Construction Materials Vol- 7 (2016) 30–35, journal homepage.

6) Hong Hao, F.ASCE1, Zhong-Xian Li, M.Asce, Yanchao Shi **"Reliability Analysis of RC Columns and Frame with FRP Strengthening Subjected to Explosive Loads"** DOI: 10.1061/(ASCE)CF.1943-5509.0000748. © 2016American Society of Civil Engineers.

7) Vikrant S Vairagade, Dr. Shrikrishna Dhale, Dr. Patel Rakesh **"Analysis of Reinforced Concrete Column using FRP composite".** International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869 (O) 2454-4698 (P), Volume-4, Issue-2, February 2017.

8) Ning Zhuang, Yujue Zhou, Yeming Ma, Yingdi Liao and Da Chen **"Corrosion Activity on CFRP-Strengthened RC Piles of High-Pile Wharf in a Simulated Marine Environment".**Coastaland Offshore Engineering, Hohai University, Nanjing ,China Published February 2017.

9) Civil engineering database-ASCE

10) http://cedb.asce.org/CEDBsearch/#.