International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June-2018 www.irjet.net p-ISSN: 2395-0072

CFRP APPLICATION IN RETROFITTING OF RCC COLUMN

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Abstract - *Strengthening reinforced concrete structural member is through external wrapping with high strength fibre composites. In this paper to study the behaviour of RC columns wrapped fibre sheets. The experiment consist total 54 columns includes 18 circular columns, 18 square columns and 18 rectangular columns. In circular column, 3 columns for 7th day testing, 3 columns for standard column, 3 columns for 1 week deterioration, 3 columns for 4 week deterioration, 3 columns wrapped with 1 layer of CFRP, 3 degraded columns wrapped with CFRP sheet.*

In square column, 3 columns for 7th day testing, 3 columns for standard column, 3 columns for 1 week deterioration, 3 columns for 5 week deterioration, 3 columns wrapped with 1 layer of CFRP, 3 degraded columns wrapped with CFRP sheet . In rectangular column, 3 columns for 7th day testing, 3 columns for standard column, 3 columns for 1 week deterioration, 3 columns for 4 week deterioration, 3 columns wrapped with 1 layer of CFRP, 3 degraded columns wrapped with CFRP sheet. Effectiveness FRP sheet to confine RC columns are investigated. The entire test specimens loaded to fail in axial compression and the ultimate load carrying capacity, and failure or crack patterns are investigated and the test results are compared .

***Key Words*: CFRP, CaCl2, ETABS, RCC Column, Deterioration.**

1. INTRODUCTION

Natural disasters such as hurricanes, tornadoes, tsunamis, and earthquakes and accidental impacts can damage or destroy deficient structures in a matter of seconds. On the other hand, saltwater, deicing chemicals, and freeze-thaw cycles can cause structural deterioration over a longer period of time. The majority of older buildings and bridges were constructed according to older design codes. These structures are vulnerable during extreme events and need to be retrofitted to meet the current codes and standards. Traditional retrofit techniques include concrete and steel jacketing. These methods are time consuming and labor intensive. They also increase the cross-sectional area of the structural column member. Another more recent method of repair is the use of fiber reinforced polymers (FRP) because of their excellent mechanical properties, corrosion resistance, durability, light weight, ease of application, reduced construction time, efficiency, and low life cycle cost.

Interesting in the use of flexible fiber reinforced plastic (FRP) sheets for the external wrapping of concrete compressed members is today a very popular theme, especially as regards estimating the effectiveness of this reinforcing technique in increasing the strength and ductility of members in seismic areas.

1.1 Proposed Work

This study is focused on effects of CFRP wrapping for standard and deteriorated RC column with and without CFRP. The scope of study is to compare the load carrying Capacity of standard column wrapped with CFRP and deteriorated column wrapped with CFRP. To investigate the Failure Patterns for same member. All the column are designed as per limit state method of design, axially loading test was conducted as per ASTM D6272.

2. EXPERIMENTAL PROGRAMME

To evaluate the performance of existing building, the existing building was modeled and analyzed by considering the existing design. The same new building was modeled as per the present code requirement to compare the performance of new building with the existing.

2.1 Existing building properties

Table 1.Existing Building Properties

Types of Structure	G+2 RCC Frame			
Plan Dimension	53.53 m X 6 m			
Story Height	3m			
Grade of Concrete	M15			
Grade of Steel	Fe250			
Column Size	Col. 185X575	Col. 300X400		Col. 330X480
Beam Size Beam	Beam 230X375	Beam 250X500	Beam 270X652	Beam 300X450
Wall Size	450mm	300mm		100mm
Slab Thickness	125mm			

Table 1 New Building Properties

Types of Structure	G+2 RCC Frame			
Plan Dimension	53.53 m X 6 m			
Story Height	3m			
Grade of Concrete	M20			
Grade of Steel	Fe415			
Column Size	Col. 185X575	Col. 300X400		Col. 330X480
Beam Size Beam	Beam 230X375	Beam 250X500	Beam 270X652	Beam 300X450
Wall Size	450mm	300mm		100mm
Slab Thickness	125mm			

From this new properties building is modeled in ETABS and from this results column are designed for maximum axial load.

2.3 Modeling of building in ETABS

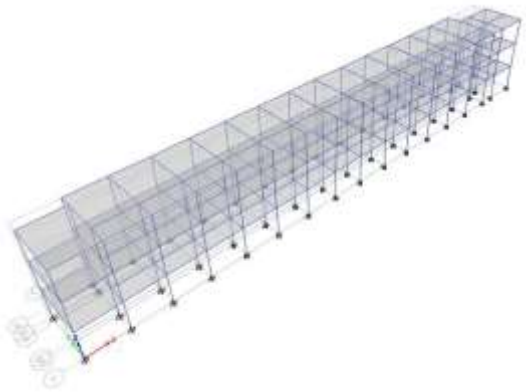

Fig. 1 3D Model of Building

2.4 Design of prototype column:

Columns are analyzed by using Limit State Method of Design as per IS 456-2000.

length = 3 m = 3000 mm

Load = 320kN

Width = 330 mm

Depth = 480mm

Effective cover = 40mm

AREA OD STEEL= 960mm^2

Use16 mm Φ bars

Number of Bars: 6

Ast provided = 1206.36 mm^2

Shear reinforcement: Use 2 L-8mm stirrups @ 250mm

2.5 Design of model column:

Assuming Scale Factor 3

Span = 1000 mm

Load = 107kN

Width = 110 mm

Depth = 160mm

In this paper to study the three shapes of column

1. Circular column, D=150.

2. Square column, W=133, D=133.

3. Rectangular column, W=110, D=160.

Effective cover = 25mm

AREA OF STEEL= 140.8mm^2

Use 8 mm Φ bars

Number of Bars: 4

Ast provided = 201.04 mm^2

Shear reinforcement: Use 2 L-6mm stirrups @ 150mm

Cross sectional area of all column is same.

2.6 Design of CFRP for model column

Table 3 FRP System Properties

Thickness per ply	t_f	1.02mm
Ultimate tensile strength	f^*_{fu}	621N/mm^2
Rupture Strain	ε^*_{fu}	0.015mm/mm
Modulus of elasticity of FRP laminates	E_f	37000N/mm^2
Environment factor	C_E	0.95

Number of Ply: 1

Type of Wrap: Wrap CFRP

3. GEOMETRY OF COLUMN

The geometry of all columns are 1000mm overall length.

In this paper to study the three shapes of column

1. Circular column, D=150.

2. Square column, W=133, D=133.

3. Rectangular column, W=110, D=160.

with varying reinforcement as per design. The dimensions of all columns are kept same throughout the experiment. All the column are initially designed as per limit state method of design, axially loaded column . Experiments are conducted to study the axial load carrying capacity of RC column with and without FRP using local available materials. All the columns are gradually loaded up to failure. Total 54 numbers of specimens were constructed.

3.1. Deterioration of Concrete

Concrete specimens were exposed to weekly cycles of wetting and drying in water and in solutions of calcium chloride (CaCl2) with 3 molal ion concentrations, equivalent in ion concentration solution CaCl2.Nine Specimens were used to deterioration.

The specimens were submerged in solution for 7 days. After 7 days, they were removed from the solution and dried in air. Cycles were repeated for 4weeks.

3.2. Experimental set up for testing of column

All the specimens are tested in loading frame of the Applied Mechanics Laboratory, Walchand College of Engineering, Sangli.

The testing procedures for all specimens are same. After curing for 7 days and 28 days, control columns and deteriorated columns were tested one by one applying load slowly up to failure. In the testing arrangement, axial load are applied on all the columns and gradually increased up to failure. The column is placed as shown in Fig.2.

3.3 Loading Pattern

The Fig.2 given below shows the typical test arrangement under the axial loads applied on all the columns in the structural laboratory. The geometry of all column is given as above.

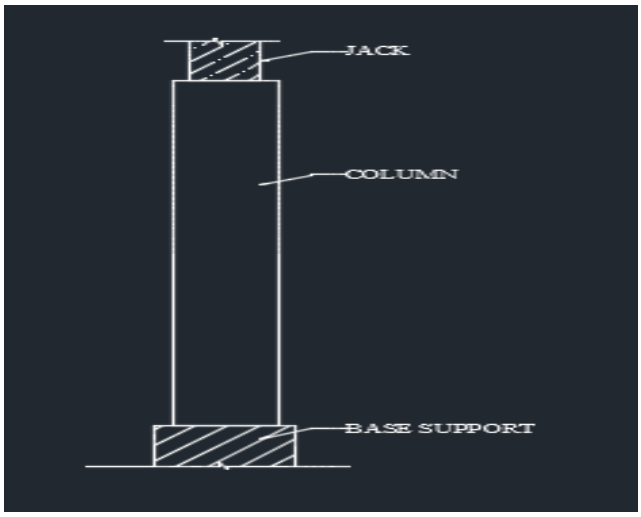

Fig. 2 Test setup

4 TEST RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter interprets the results obtained from the experimental investigation which Comprises of testing of 54 RC columns. The behavior of the RC columns with respect to ultimate load carrying capacity, crack pattern is studied throughout the test and their failure modes are described.

4.2 Standard Column

To understand the behaviour of RC columns wrapped with FRP sheets structural parameters like ultimate load carrying capacity, axial deformations and failure patterns were evaluated for standard/ control and FRP wrapped columns, respectively.

Table 4 Test Result of Standard column for 28th Days

Specimen type	Circular	Square	Rectangular
1	15	14.5	13.5
2	16	13.5	13
3	15.5	14	14
FAILURE AVERAGE LOAD IN TONNE	15.5	14	13.5

4.3 Deteriorated Column

The columns are deteriorated by using in solutions of calcium chloride (CaCl2) with 3 molal ion concentrations as explain in previous chapter. The testing of column are same as above.

Table 5 Test Result of Deteriorated Column for 28th Days

Specimen type	Circular	Square	Rectangular
1	14	12.5	12.5
2	14.5	14	13
3	14.5	12.5	12
FAILURE AVERAGE LOAD IN TONNE	14.33	13	12.5

4.4 Standard Column with CFRP Wrapping

The std column is strengthened with CFRP composites to study the behavior of the column under the axial load. The column are strengthened with bidirectional woven CFRP of 1 layer bonded to the both end portions with 2strips of equal width of 200 mm and spacing between the strips is 600 mm. The testing of column are same as above.

Table 6 Test Result of Std Column with CFRP Wrapping

Specimen type	Circular	Square	Rectangular
1	22.5	20	18.5
2	21.5	19.5	19
3	22	19	19
FAILURE AVERAGE LOAD IN TONNE	22	19.5	18.83

4.5 Deteriorated column with CFRP wrapping

The deteriorated column is strengthened with CFRP composites to study the behavior of column under axial loading. The column are strengthened with bidirectional woven CFRP strips of 1 layer bonded to the both end portions with 2 strips of equal width of 200 mm and spacing between the strips is 600 mm.

Table 7 Test Result of deteriorated Column with CFRP Wrapping

Specimen type	Circular	Square	Rectangular
1	20.5	18.5	17.5
2	20	19	18
3	20.5	17.5	17
FAILURE AVERAGE LOAD IN TONNE	20.33	18.33	17.5

4.6 Comparison of load for std column with CFRP wrap std column.

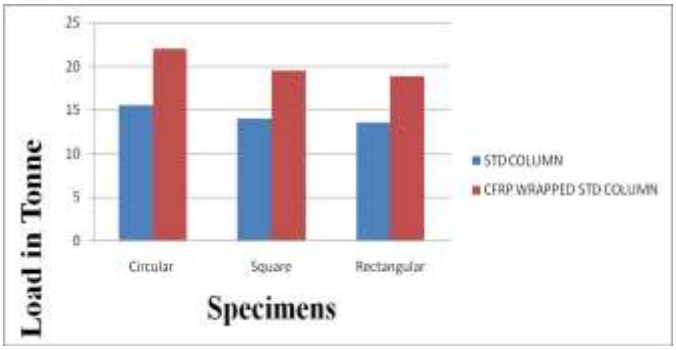

Fig. 3 Comparison of load

4.7 Comparison of load for deteriorated column with CFRP wrap deteriorated column.

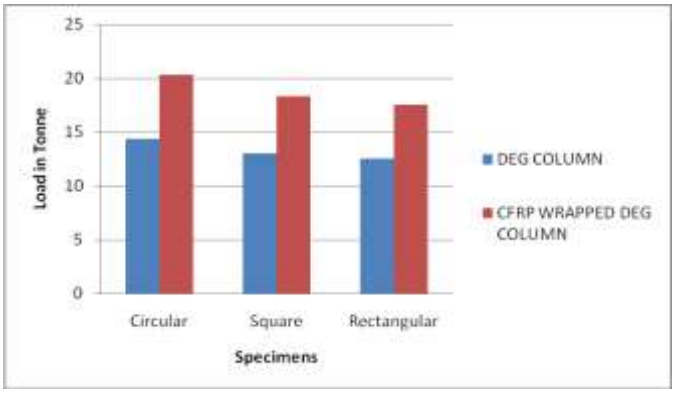

Fig. 4 Comparison of load

4.8 Failure patterns of column (Fig. 5 To Fig. 10)

Fig. 5 Circular Column

Fig. 6 Rectangular Column

Fig. 7 Square Column

Fig. 8 Circular column with CFRP

Fig. 9 Rectangular column with CFRP

Fig. 10 Square column with CFRP

5. CONCLUSIONS

- From the CFRP design it seems that by confining column ,we can achieve the required strength.
- From the test results load carrying capacity of degraded column is decreased by 7.55% .
- From the test results load carrying capacity of CFRP wrapped circular, square and rectangular std column increases by 41.90%, 39.20% and 39.00% respectively.
- Small cracks appeared on wrapped CFRP.
- CFRP wrapping used for improving the load carrying capacity of STD and DEG columns.

ACKNOWLEDGEMENT

The authors can acknowledge any person/authorities in this section. This is not mandatory.

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