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Strengthening of RC Column Using GFRP

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Abstract: In construction industry, engineers try to find new, better, economical material. Today there are several new techniques observed in the industry. In recent years, the construction industry has seen an increasing demand to reinstate, rejuvenate, strengthen and upgrade existing concrete structures. This may be attributed to various causes such as environment degradation, design inadequacies, poor construction practices, lack of regular maintenance, revision of codes of practice, increase in loads and seismic conditions etc. One of the technique used is the wrapping of damaged and newly constructed columns with GFRP. As GFRP has the properties like high strength, light weight, resistance towards chemicals and salt water, it can be moulded into complex shapes, requires low maintenance etc. The behaviour of fibre reinforced polymer on different shapes of column has been extensively studied, but much less is known about concrete in FRP confined damaged columns. In this project a total of 21 columns are casted, out of which 3 columns are conventional columns, 9 columns are damaged & 9 are newly constructed columns. The columns are wrapped with single, double and triple layer of GFRP. An average increase of 33.21% is observed in damaged single layer wrapped GFRP column and 51.64% in damaged double layer wrapped GFRP column and 62% in damaged triple layer wrapped GFRP column. Similarly, 46.93% of increase in newly constructed single layer wrapped GFRP column and 72.56% of increase in newly constructed double layer wrapped GFRP column and 90.23% of increase in newly constructed triple layer wrapped GFRP column.
Keywords: GFRP, damaged column, newly constructed column.

I. INTRODUCTION

The construction industry has seen an increasing demand to reinstate, rejuvenate, strengthen and upgrade existing concrete structures. From past many years engineers have used different methods and techniques to retrofit existing structures by providing external confining stresses. Externally applied jackets were used as a reinforcement to contain concrete for different reason. Engineers have used different materials such as steel, wood, concrete to confine and improve the structural behaviour of concrete. Fiber reinforced polymers (FRP) has emerged over the last decade as a new material to be used in structural engineering, due to its attractive mechanical properties. Fibre Reinforced Polymer (FRP) composite is defined as a polymer that is reinforced with fibre. It represents a class of materials that fall into a category referred to as composite materials. Composite materials are made by dispersing particles of one or more materials in another material, which forms a continuous network around them. The primary function of fibre reinforcement is to carry the load along the length of the fibre and to provide strength and stiffness in one direction. It replaces metallic materials in many structural applications where load-carrying capacity is important.

II. AIMS AND OBJECTIVES

The present work is aimed to study the strengthening of reinforced concrete columns using glass fiber reinforced polymer (GFRP) with the following objectives.

1) To investigate the effect of increase in layer of GFRP on strength of newly constructed column.
2) To explore the effect of increase in layer of GFRP on strength of damaged column.

III. MATERIALS AND METHODOLOGY

A. Materials

1) Sand - Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt.
2) GFRP fibre sheet - Glass fibres are basically made by mixing silica sand, limestone, folic acid and other minor ingredients.
3) Ordinary Portland cement (OPC) of 53 grade is used for experimental work.
4) Natural coarse aggregate of 10 mm and 20 mm were used for the preparation of concrete.
5) ISO Resin - ISO Resin is a medium viscosity, medium reactive polyester resin based on Isophthalic acid and superior glycols. It exhibits good mechanical and electrical properties together with good chemical

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B. Methodology

The experimental investigation was carried out in three phases. The first phase is to prepare a mix design of concrete as per the properties obtained and gradation of materials. Second phase of experimental investigation is to decide the size of column and column specimen to be tested under compression and also to find out the percentage of damage of column to be tested and treated using GFRP. Phase three mainly focuses casting of new column and taking damaged columns to be treated using application of GFRP sheets and also to test the above columns by using number of layers of GFRP to find the percent increase in the strength of column using GFRP.

1) Deciding the specifications of column under analysis.
2) New column specimens would be made with M20 grade concrete, Fe 500 grade will be used for longitudinal reinforcements and for tie members.
3) Actual Size of column is 300 X 600 X 3200.
4) Structural design relies essentially on tests made on column to estimate the probability of failures of prototype members, since full-scale testing of structures to determine strength is not feasible.
5) A prototype of the column would be cast and an axial load test would be carried out on the UTM machine.
6) The actual size of the prototype is reduced to 1/4th of its original size of column so that it could be tested on UTM machine.
7) The specimens would be jacketed with the required layers of GFRP (450 GSM).
8) Before jacketing the specimens with GFRP sheets, surface preparation will be carried out, which will include cleaning, forming one layer of epoxy-polyamine primer and one layer of epoxy putty, then epoxy adhesive will be used for bonding GFRP sheets on the specimens as shown in Figure 1.
9) After this axial loading test would be conducted on columns and results will be compared accordingly.

Experimental work includes casting, curing and testing of 21 columns. As shown in Table 1, out of these 21 columns, 3 columns were conventional columns, 9 damaged columns and 9 newly constructed columns. 9 damaged columns were damaged on universal testing machine until reverse loading. Out of these 9 damaged columns 3 columns were wrapped with single layer GFRP sheet and were tested under axial loading, other 3 columns were wrapped with double layer GFRP and were tested for axial loading and the remaining 3 columns were wrapped in three layers and tested under axial loading. 9 newly constructed columns were wrapped in single, double and triple layer respectively and were tested under axial loading.

Table 1: Nomenclature of specimens

SR NO.	NOMENCLATURE	DESCRIPTION
1	CC-1	Conventional column number 1.
2	CC-2	Conventional column number 1.
3	CC-3	Conventional column number 1.
4	DC-11	Damaged column number 1 with single layer GFRP sheet.
5	DC-21	Damaged column number 2 with single layer GFRP sheet.
6	DC-31	Damaged column number 3 with single layer GFRP sheet.
7	DC-12	Damaged column number 1 with double layer GFRP sheet.
8	DC-22	Damaged column number 2 with double layer GFRP sheet.
9	DC-32	Damaged column number 3 with double layer GFRP sheet.
10	DC-13	Damaged column number 1 with triple layer GFRP sheet.
11	DC-23	Damaged column number 2 with triple layer GFRP sheet.
12	DC-33	Damaged column number 3 with triple layer GFRP sheet.
13	NC-11	Newly constructed column number 1 with single layer GFRP sheet.
14	NC-21	Newly constructed column number 2 with single layer GFRP sheet.
15	NC-31	Newly constructed column number 3 with single layer GFRP sheet.
16	NC-12	Newly constructed column number 1 with double layer GFRP sheet.
17	NC-22	Newly constructed column number 2 with double layer GFRP sheet.
18	NC-32	Newly constructed column number 3 with double layer GFRP sheet.
19	NC-13	Newly constructed column number 1 with triple layer GFRP sheet.
20	NC-23	Newly constructed column number 2 with triple layer GFRP sheet.
21	NC-33	Newly constructed column number 3 with triple layer GFRP sheet.

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Figure 1.Application of GFRP

IV. RESULTS AND DISCUSSION

A. Results

Compression Test

The Compression load test was conducted on the column specimen and the results are shown in Table 2.

Table 2: Increase in compression strength of column after application of GFRP

Sr. No.	Column Type	Load (KN)		% increase in Strength
		Before application of GFRP	After application of GFRP	
1	CC1	140.02	-	-
2	CC2	139.67	-	-
3	CC3	140.83	-	-
4	DC11	138.36	179.63	29%
5	DC21	142.5	184.77	35.16%
6	DC31	139.8	186.58	35.49%
7	DC12	136.7	222.1	55.77%
8	DC22	133.85	203.58	52.09%
9	DC32	141.78	199.21	47.06%
10	DC13	137.7	220.8	57.97%
11	DC23	135.46	234.8	65.66%
12	DC33	139.71	227.7	62.38%
13	NC11	140.17	201.62	43.83%
14	NC21	140.17	212.58	51.65%
15	NC31	140.17	203.7	45.32%
16	NC12	140.17	234.28	67.13%
17	NC22	140.17	248.15	77.03%
18	NC32	140.17	243.26	73.54%
19	NC13	140.17	261.82	86.7%
20	NC23	140.17	269.77	92.4%
21	NC33	140.17	268.59	91.6%

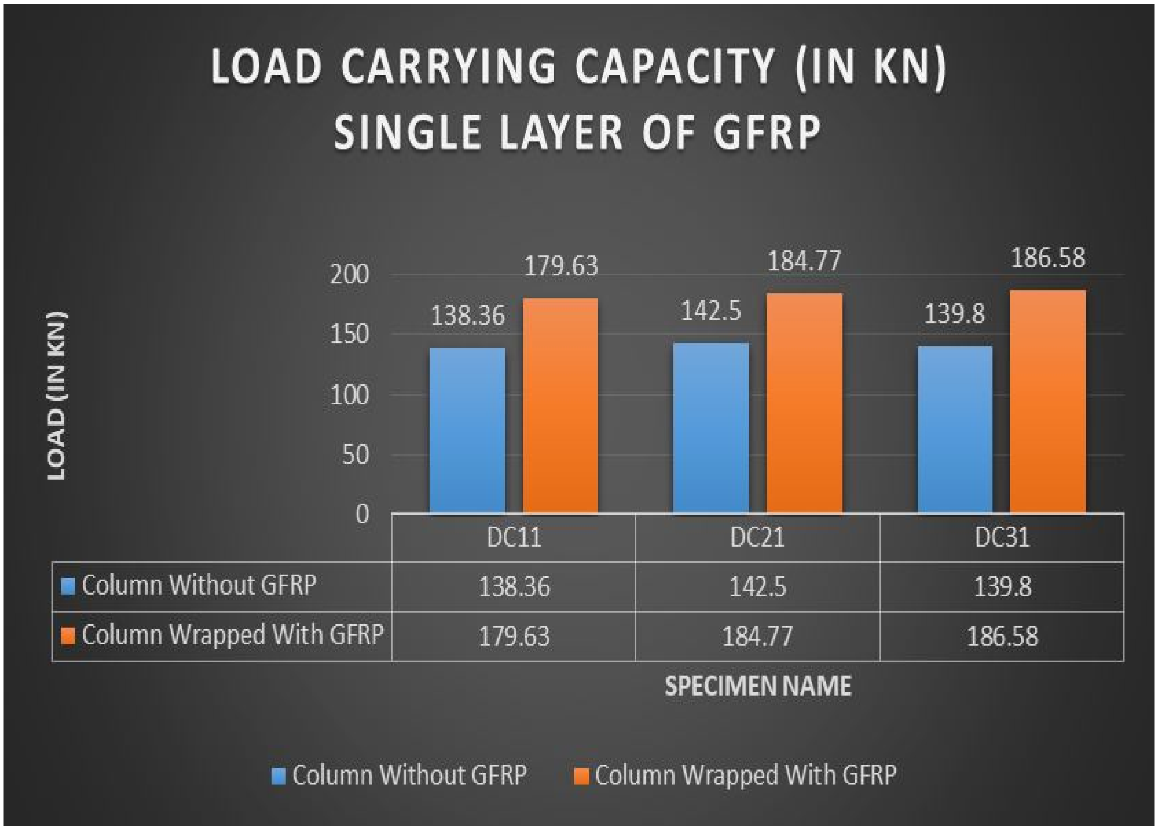

Figure 2. Results of single layer GFRP wrapped damaged column tested on UTM.

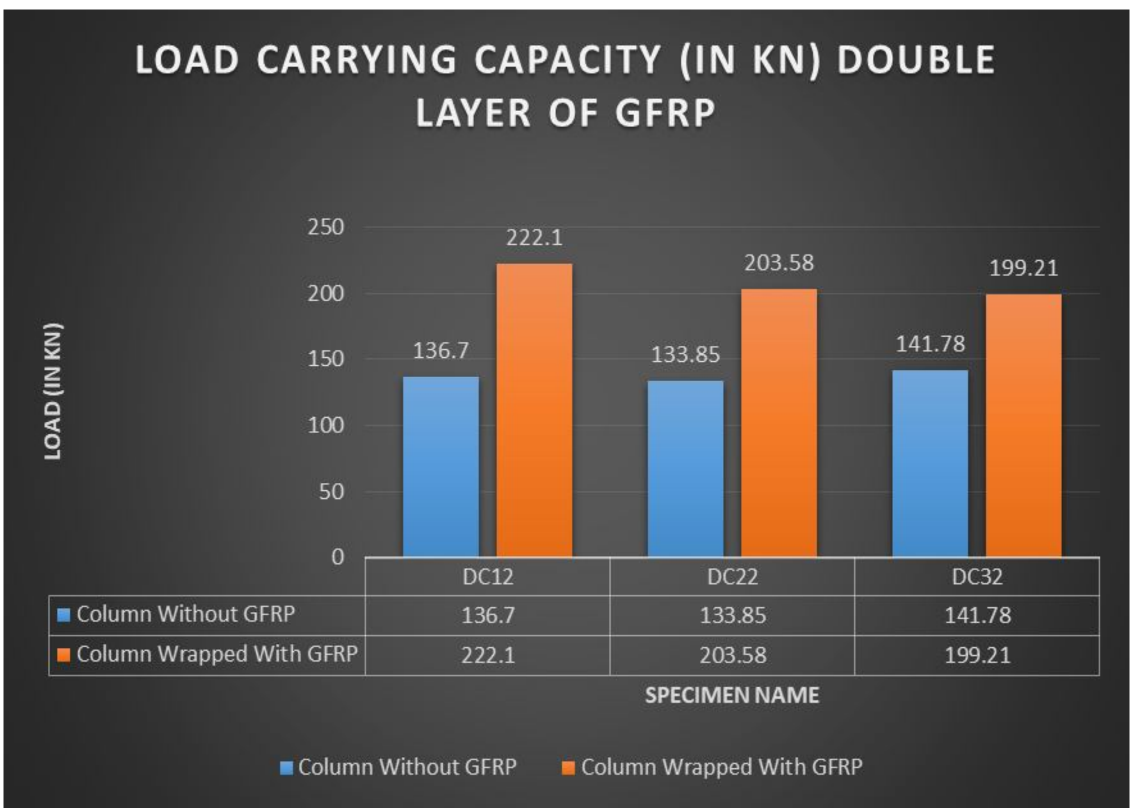

Figure 3. Results of double layer GFRP wrapped damaged column tested on UTM.

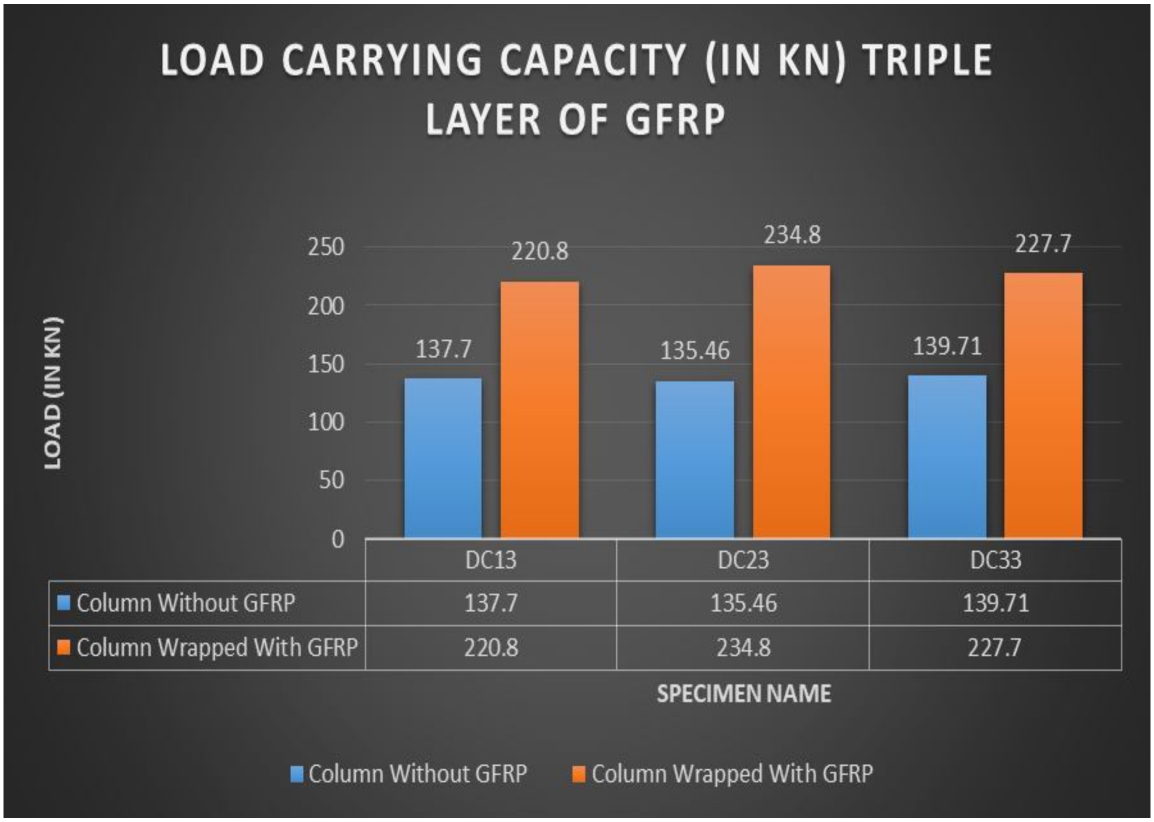

Figure 4. Results of triple layer GFRP wrapped damaged column tested on UTM.

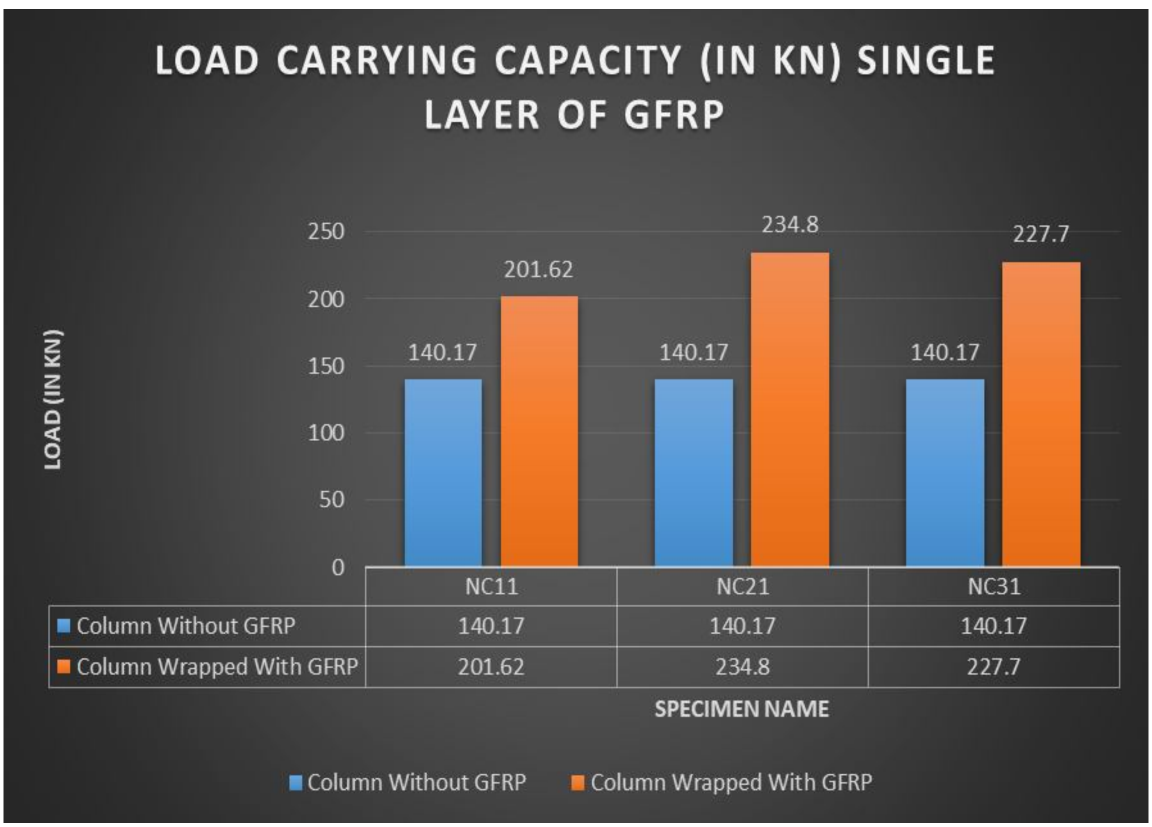

Figure 5. Results of GFRP wrapped new column tested on UTM.

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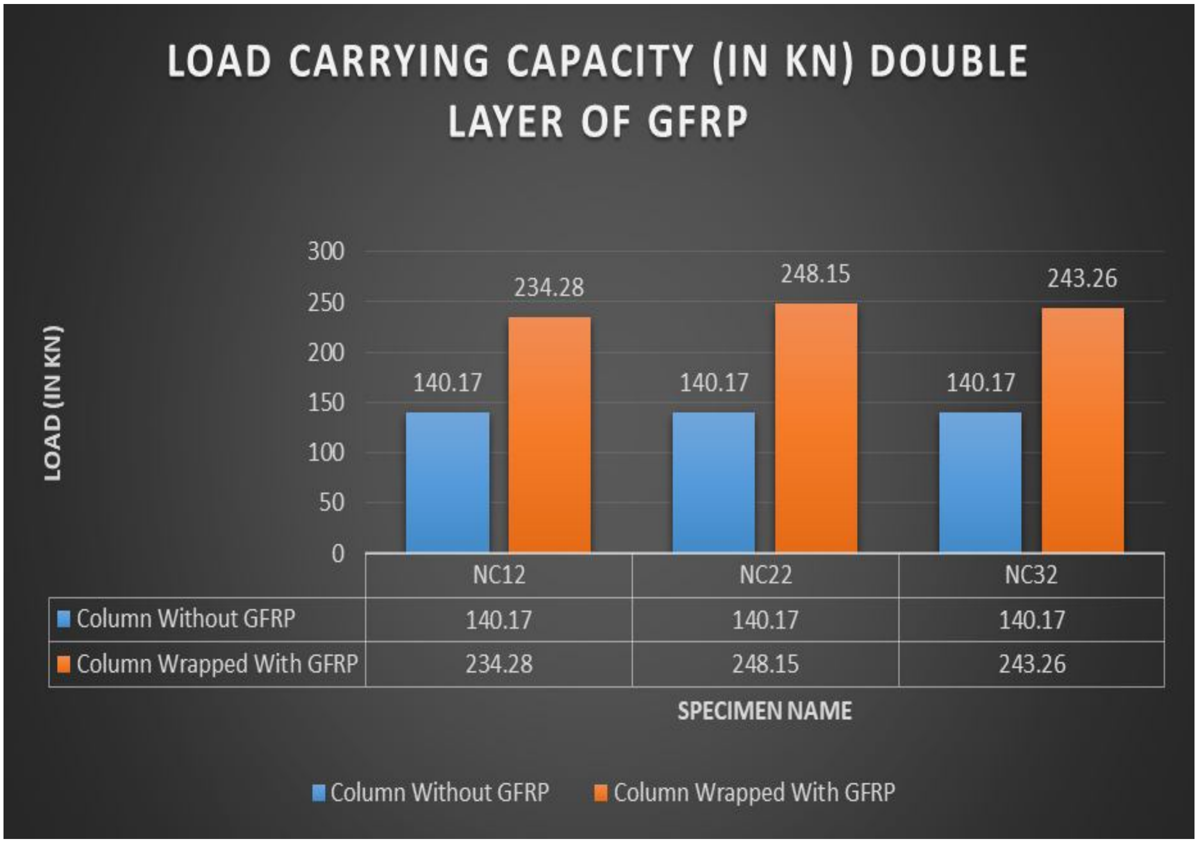

Figure 6. Results of double layer GFRP wrapped damaged column tested on UTM.

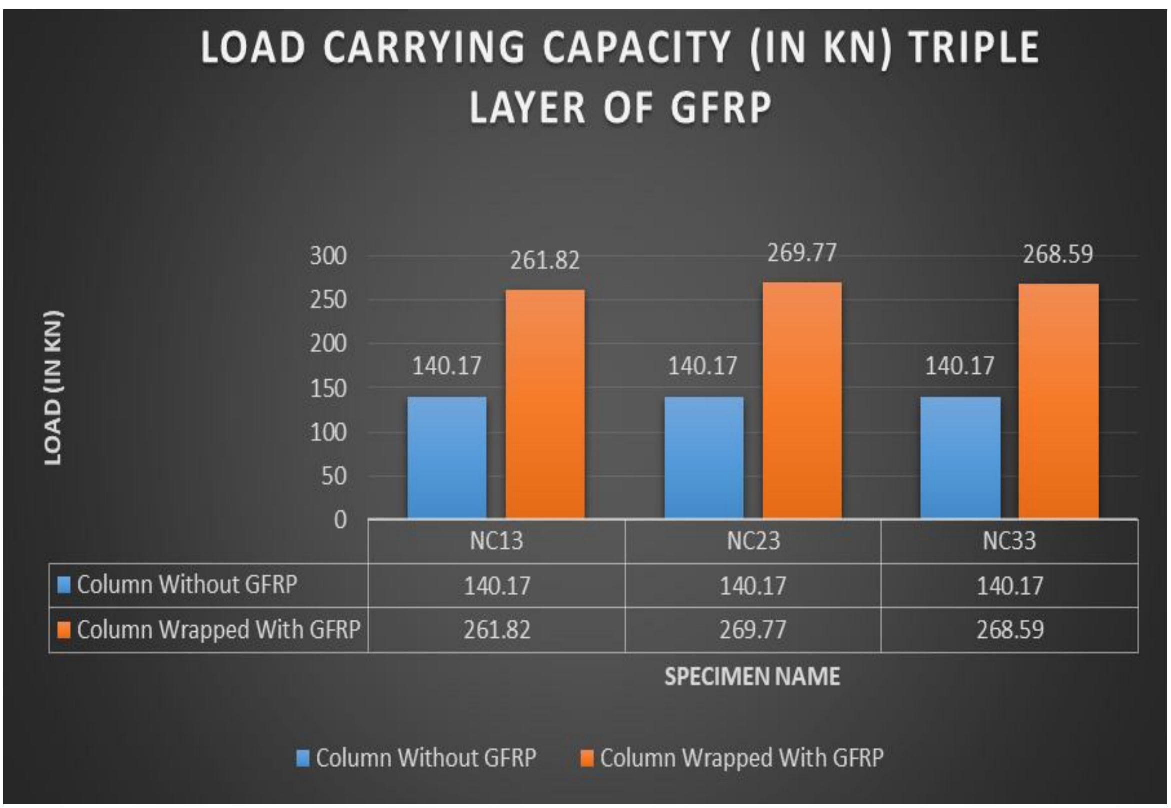

Figure 7. Results of triple layer GFRP wrapped newly column tested on UTM.

B. Results

From the tests conducted on columns, it has been observed from the graphs (from Figure 2 to Figure 7) that on the application of GFRP layers, there is a tremendous increase in the load carrying capacity of the column. Also, during the t,ests it was found that, proper method of application of GFRP layers and proper mixing of resin and hardener is of utmost importance as it shows the difference in results. With increase in the number of layers of GFRP, the load-carrying capacity has been found to be increased. This is due to the superior properties of FRP composites such as lightweight, high strength, corrosion resistance, and large creep strain, high fatigue resistance, less weight comparing to steel repairs and ease in installation. FRP wrapping systems has been found an attractive and easy retrofitting technique that can significantly enhance the strength of concrete columns and also the confinement of concrete for the newly constructed column is good so the load-taking capacity more as compared with damaged column. Because in the case of the damaged column the column is first damaged, because of which the confinement of concrete reduces in the case of the damaged column and so the load-carrying capacity also reduces in comparison with the newly constructed column.

V. CONCLUSION

A. In the case of damaged columns the column specimens were wrapped with single, double & triple layer of GFRP sheets shows an average increase of 33.21%, 51.64% & 62%.
B. And in the case of newly constructed columns the column specimens were wrapped with single, double & triple layer of GFRP sheets shows an average increase of 43.93%, 72.56%, 90.23%.
C. Column specimen wrapped with triple layer of GFRP shows the highest load taking capacity.
D. To sum up, GFRP has proved to be ideally suited method for retrofitting because of its improved strength, ease of application and many such other advantages as compared to other methods of retrofitting.

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