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Strengthening Of Reinforced Concrete Rectangular Columns by using Frp Sheets

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Abstract— ***Strengthening of columns is needed now a days because of various reasons. Upgrading existing strength of columns, rectifying inadequacies due to poor construction practices or due to degradation or due to environmental effects are may be some reasons.***

In the present study the strength behavior of RC short axially loaded columns(100x00x500) strengthened with FRP sheet strips and the effect of edge rounding (sharp edges are made round) on load carrying capacity are studied. The Column is wrapped with strips of different FRP sheets at different spacings of constant FRP sheet material area. Columns are reinforced with 4#10mm diameter steel bars. The columns are designatedas CC,SG83.33,SG50,SB83.33,SB50,SC83.33,SC50,RG83.33,RG50, RB83.33,RB50,RC83.33,RB50. Here CC column is of control column without FRP sheet sticked S stands for sharp edge columns. R stands for rounded edge columns .G,B and C stands for Glass, Basalt, Carbon FRP sheets respectively. Here numerical indicates the width of the FRP strips in mm. The percentage increase in the capacity (load) of FRP strengthened columns compared with control column(CC) For SG83.33 is 20.7% ,for SG50 is 49.1% , for SB83.33 is 6.7% , for SB50 is 13.3%, for SC83.33 is 29.49% ,for SC50 is 65% , for RG83.33 is 43.1% , for RG50 is 63.33% ,for RB83.33 is 24.9% ,for RB50 is 40.3%, for RC83.33 is 54.85% ,for RC50 is 67.26%.

Keywords- FRP, CC Column, Strengthening, Number of Wrap.

I. INTRODUCTION

The maintenance and rehabilitation by means of strengthening of the existing structures is one of the major problem of present day civil engineering practices. This is because, many structures which were constructed earlier with then design codes throughout the world are structurally not safe when checked with the present code of practices. Since the replacement of the structural members which are not safe involves a lot of economy and time. So retrofitting of the structural members by means of strengthening the existing members is the best way of improving the capacity (load) and the service life of the structure. Infrastructural damage of the structure by the premature deteriorations resulted in the initiation of the investigation of several repairing and strengthening processes of the existing structures. Strengthening of concrete structures put upon a challenge in selecting the appropriate method which will enhance the strength and service life of the structure with limitations of constructability, type of building operations and the economy involved. Improving the strength of the structure is required depending on the situation and the need for instance, additional strength may be needed to increase the capacity of structure in terms of load. This is generally required when there is change in purpose of the structure or higher capacity(load) is required. This change in purpose of a structure comes into play when additional mechanical equipment, construction equipment are required to place on the structure. Strengthening of a structure is required when there is a need to resist additional imposed loads that were not considered in actual design. This is possible when a structure a subjected to some unexpected loads like wind load, earthquake force etc., which act in the lateral direction with very high intensities, in such situations strengthening is required. Additional Strength is required as there is deficiency in the structure to carry the design loads. The possible deficiencies include the deterioration of members by corrosion, spalling of the concrete, damage due to the vehicular impact, excessive loading, fire, damage caused by the errors in building without following the actual proposed design. Natural disasters like earthquakes, tsunamis, cyclones, etc., resulting a lot of disturbance to the infrastructural design and the service life of the structures. The majority of the reinforced concrete buildings and bridges constructed in India before 1970s typically does not have the required capacity (load) to resist the such above disasters. In order ensure the the structural safety efficient methods to be developed for structural repair and strengthing. For this FRP strengthening is one of the essential requirement among different strengthening techniques.

1.1 Strengthening Techniques For Rc Columns

- Jacketing of Concrete
- Jacketing using Steel
- Concrete Jacketing (Precast)
- External Pre-stressing
- Wrapping a column with a high strength fibre reinforced polymer(FRP) composites

1.2 Introduction To Fiber Reinforced Polymers (Frp)

Fiber Reinforced Plastics (FRP)is well known generic term, which is used to define a versatile composites family which is being used in all types of industries like chemical

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Plants, power plants, luxury power boats etc. The structure of the FRP is very typical which consists of an unsaturated Polyester resign used on a mould with the grouping of reinforcement like glass fibers, to outline a durable and low weight-rigid part. FRP gives an uncompared combination of properties:

- Design freedom
- High strength-to-weight ratio (kilo-for-kilo it's stronger than steel)
- Light weight
- Increase in stiffness levels
- Resistance against chemical attack
- Superior insulator for electricity
- Preservation of dimensional stability with variable ranges of temperature

1.3 Srengthening using Frp Composites

Mostly the usage of FRP materials for increasing the strength was increased rapidly in recent years. With the versatile properties of the FRP like light weight and high strength,corrosion resistance, speedy and easy application, and in-situ preparation of moulds into desired shapes made the FRP to be very flexible to choose it as the regular material for strengthening of the structures. The RC(reinforced concrete) structures are strengthened by adopting composite materials (FRP) instead of classical methods. This is the most commonly used technique by using externally bonded FRP sheets and strips for strengthening of concrete structures.

The design-oriented stress-strain models for FRP concrete confined in rectangular columns has gained a significant importance. The studies projected a new design oriented stress-strain models for FRP confined concrete which is wrapped with fibers particularly in the hoop direction based on existing observations and test data. The model is reduced directly to idealized stress-strain curves in prevailing design codes for unconfined concrete. Whereas, the compressive behavior of a short concrete member reinforced with fiber reinforced polymers with rectangular sections up to the failure is investigated and was analyzed using simplified elastic model. A theoretical model of short compressed column externally wrapped with FRP sheets with a rectangular cross sections and sharp or round corners were analyzed for predicting the maximum strength and strain capacities. Generally the columns are strengthened widely by using FRP jacketing. The FRP is fully confined which to be proved as effective method for improving axial load and failure strain of columns (concrete), to resist early buckling and to reduce use of required lap length of bars against corrosion. While partial wrapping resulted in better utilization of the existing steel reinforcement while it may be provided for higher axial strain of concrete at failure and higher strain at failure of the straps in some instances of circular columns than full reinforcement. Analytical prediction of axial stress-strain behavior of partially confined FRP concrete which are based on proposals of semi-empirical or empirical models.

Previous studies published the behavior of FRP wrapped RC columns. This paper investigates the behavior of plain concrete columns. Vertical FRP straps are selected to apply on the columncircumferentially. All the columns are tested up to the failure by applying axial compressive eccentric load. The test results of columns indicated that the FRP shafts were very worthwhile in increasing the higher load carrying capacity and ductility compared with conventional RC columns.

Additional Strengthening may be required in unpredicted loads cases like seismic, wind and blast loads which shows a great impact on structures which were not designed for, So FRP Wraps are considered in this study to counter them.

II. EXPERIMENTAL PROGRAME

2.1 Objective Of The Study

By observing the literature available, studies are limited to full wrapping of FRP sheet around the columns. Also studies using FRP strips are very meager.

Therefore it is interesting in studying the strength of short axially loaded columns strengthened with FRP sheet strips, also the effect of edge rounding (sharp edge are made round).

2.2 Materials

Ordinary Portland cement with a specific gravity of 3.15 , river sand having fineness modulus of 3.718 and with specific gravity of 2.6 and coarse aggregate with crushed granite of 10 mm maximum size which is having specific gravity of 2.7 and fineness modulus of 4.31 has been used in casting. Water is checked to have the properties which are conformed with the requirements as per IS: 456–2000 was used throughout. The 28-days compressive strength of cubes (concrete) was 30 MPa with a mix ratio 1:1.595:3.268 and water 0.45. The longitudinal reinforcements used were bars of 10mm dia (high-yield strength deformed). The lateral ties of6mm diameter bar of mild steel were used. The average proof stress at 0.2% strain of 10mm diameter bars was 437 N/mm2 and that of 6mm diameter bars is 260 N/mm2. Concrete column specimens were confined by wrapping them with fiber sheets of glass FRP, basalt FRP, carbon FRP having a thickness of 0.11mm,0.1mm,0.11mm and tensile strength 32358 MPa, 2100 MPa, 3500 MPa. The resin system used in this work was Nitobond EP ultimate tensile strength = 30 N/mm2.

Experimental Procedure

2.3 Description Of Specimens

For this study, columns of size 100mmx200mmx500mm were prepared. Steel reinforcement cage consists of 4#10 mm diameter bars used as longitudinal reinforcement and 6mm diameter bars as lateral ties. Steel grade used is of Fe 500.

FRP sheets were sticked in following ways. The area of FRP strips is kept constant.

1.Glass FRP -

83.33mm wide strips were sticked @ 125mm spacing,
50.00mm strips were sticked @ 62.5mm spacing,

2.Basalt FRP-

83.33mm wide strips were sticked @ 125mm spacing,
50.00mm strips were sticked @ 62.5mm spacing,

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3. Carbon FRP-
   83.33mm wide strips were sticked @ 125mm spacing
   50.00mm strips were sticked @ 62.5mm spacing

Testing Of Sharp Edged Columns With Frp

2.4 Instrumentation and testing procedure

All the seven specimens of the columns were tested in a UTM to the failure under compression (axial). A dial gauge to measure axial deformations is placed along the length of the section and other dial gauge to measure transverse deformations is placed along the width. Loads is increased in regular intervals. At every increment the behavior of columns were observed and dial gauge readings are noted down. Test set up is as shown in figures below.

Fig 1:Testing of SC83.33

Fig 2:Failure of SG83.33

Fig 3:Testing of SC50

Fig 4:Failure of SG50

III. TEST RSULTS

The failure loads and displacements at failure of the columns were noted and tabulated as below.

Table 1: Failure loads and Displacements of Sharp and Rounded Edge columns

Description of Column	Failure load and Displacement of Sharp edged columns			Failure load and displacement of Rounded edged columns		
	Load (KN)	Displacement (mm)	Designation	Load (KN)	Displacement (mm)	Designation
Control column	419.1	6.8	CC	419.1	6.8	CC
Glass 83.33mm strip	506.1	7.7	SG83.33	599.85	7.1	RG83.33
Glass 50mm strip	625.25	8.1	SG50	684.53	9.7	RG50
Basalt 83.33mm strip	447.2	6.8	SB83.33	523.75	8.3	RB83.33
Basalt 50mm strip	475.2	7.7	SB50	588.2	7.9	RB50
Carbon 83.33mm strip	542.7	8	SC83.33	649.0	7.5	RC83.33
Carbon 50mm strip	691.7	7.4	SC50	701.0	7.5	RC50

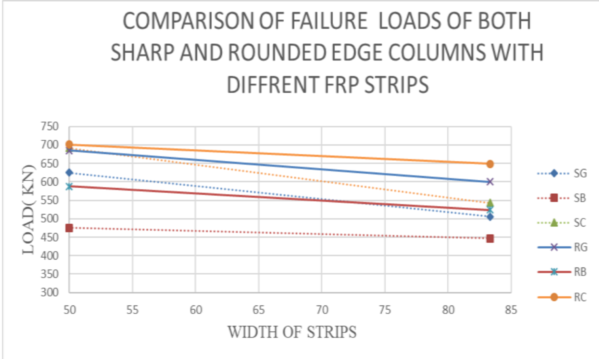

Fig 5:Comparison of failure loads of both sharp and rounded edge columns with different FRP strips

Table 2:% increase load carrying capacity

Column designation	%increase in load carrying capacity of Sharp edged columns (%)	%increase in load carrying capacity of Rounded edged columns (%)
Control column	0	0
Glass 83.33mm STRIP	20.7	43.1
Glass 50mm STRIP	49.1	63.33
Basalt 83.33mm strip	6.7	24.9
Basalt 50mm strip	13.3	40.3
Carbon 83.33mm strip	29.49	54.85
Carbon 50mm strip	65	67.26

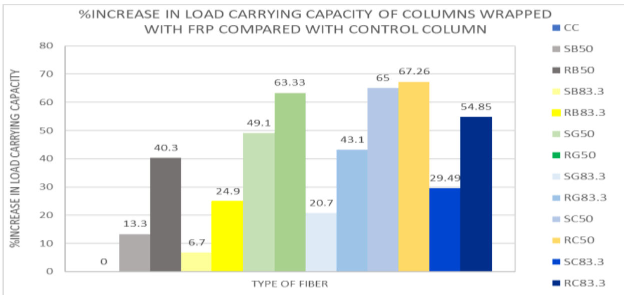

Fig 6:Displacement at failure of the columns

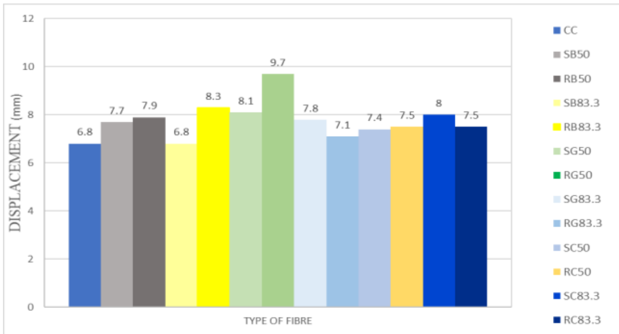

Fig 7:increased % in load carrying capacity of columns wrapped with FRP compared with control column

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IV. CONCLUSION

- The percentage increase in load carrying capacity of FRP strengthened columns compared withcontrol column(CC) for SG83.33 is 20.7% ,for SG50 is 49.1% , for SB83.33 is 6.7% , for SB50 is 13.3%, for SC83.33 is 29.49% ,for SC50 is 65% , for RG83.33 is 43.1% , for RG50 is 63.33% ,for RB83.33 is 24.9% ,for RB50 is 40.3%, for RC83.33 is 54.85% ,for RC50 is 67.26% .
- Among all strengthened columns,RC50(rounded edge column with 50mm carbon strip) load carrying capacity is more(701KN) and also the percentage increase in load carrying capacity compared with control column(CC) is 67.26% .
- The load carrying capacity of columns with 50mm strip is more than the columns with 83.33mm strips.
- By observing the deflections at maximum load, more ductile failure is observed in case of FRP wrapped columns as all FRP strengthened columns deflections are more than the control column.
- Further the load carrying capacity is more if the sharp edges are made round.

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