An Experimental Study on the Strength of Retrofitted Short Column

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Abstract:-
With the advancement of technology, the construction industry has witnessed enormous change in the production of concrete and construction materials. Such materials have helped the community to produce structures that consume less energy, environmentally friendly. However, old buildings that didn't follow the latest technology are no longer considered to have previous qualities. As a result, many researchers have continued to investigate different types of materials that can use in strengthening and rehabilitate ageing of concrete structures and render them safe from any type structural failure. Retrofitting is the process of addition of new features or modification to the old structures and bridges, i.e. it reduces the damage vulnerability of an existing structure due to seismic activities. It also improves the sustainability of the structure. Retrofit of columns is needed when the load carried by the column is increased due to either increase the number of floors or due to mistakes in the design. It is the best solution to strengthen such structures without replacing them. Fiber wrapping is also a type of retrofitting which gives encasement to the concrete which enhances the strength and ductility of concrete columns are generally used. From past extensive researches, I found that many scholars have done an experimental study as well as numerical study for strengthening of columns with help of various materials as well as various software.
In this paper, a new technique for the strengthening of concrete columns is adopted. The columns were wrapped by Glass Fibre reinforced polymer (GFRP) and Aramid fibre reinforced polymer (AFRP) with two rounds. The reference column were name as (C1) which is the initial column and are repaired columns by SCC and wrapped by Glass fabric and Aramid fabric, A total of twelve Short concrete column specimens have been cast. From that six columns were tested under failure and then repaired the dismantle column with Self Compacting Concrete (SCC), from that three columns were wrapped with Glass fiber fabric (GFRP) and rest of three were wrapped with Aramid fiber fabric (AFRP), and the six fresh columns were wrapped by GFRP and AFRP by epoxy .The core dimensions of all the columns are same which is 125 mm * 125 mm ***** 450 mm. The experimental results show that the compressive strength of the columns can increase by wrapping of fabrics which may imparts strength to the columns.

Keywords: - Self Compacting Concrete, Strengthening, Short column, Glass Fiber Fabric (GFRP), Aramid Fiber Fabric (AFRP), Wrapping.

INTRODUCTION:-

Columns are considered be the most important structural elements of any type of structure. It can carry only axial force i.e. Compression. The buckling Capacity of the column is depends upon its geometry, material used and effective length of column, which depends on the restraint condition at the top and bottom of the column. It helps to transfer the loads to the footings on the ground. In other words it can say that columns are leg of the structure. Columns are get destroyed or damaged by wrong design of building and it also get effect from the low quality of material. From past years various methods has been proposed to strengthen

the damaged column but few methods were applied, then advance techniques of repairing were formed or it may be used by many engineers to rehabilitate the structure.

Retrofitting is the process of addition of new features or modification to the old structures and bridges, i.e. it reduces the damage vulnerability of an existing structure due to seismic activities. Retrofit of columns were applied on those places were the design of structure may gone wrong and due to seismic activities. Nowadays retrofitting is expanding like a leg in the world. Many historical and public places can rehabilitate for long time duration. Retrofitting helps to increase the strength resistivity and improve overall life span of structure. It is required to repair the column to increase the loading capacity because replacement of the damaged columns cannot be possible, it can create high risk to other structural members Retrofit of column is needed when the load carrying capacity of the column is increased or no. of floors. Retrofit Can be done by various methods i.e. Glass fiber fabric (GFRP), Aramid fiber fabric (AFRP), Carbon fiber fabric (CFRP), Concrete jacketing, Steel Jacketing etc.

In this paper Glass fiber fabric (GFRP), and Aramid fiber fabric (AFRP) enhances the load carrying capacity or the external confinement increases the axial strength of the column. The FRP fabrics can be overlapped by two rounds on the columns from which it may take the ultimate load. These fabrics can withstand large axial loads and may withstand at environmental conditions. Glass fiber fabric (GFRP) can increase the axial load up to one layer of wrapping but later on it is needed to wrap two rounds which can improve the strength of column.[Shamim A. Sheikh, and Grace Yau]., Aramid fabric may improve the load capacity but no significant improved in ductility[Manuel A.G. Silva]. So, from last two decades various fabrics have been made to study for wrapping of deterioted columns.

Fig. 1 Aramid Fiber Fabric

Fig. 2 Glass Fiber fabric

OBJECTIVE OF THE STUDY

In this Experimental work AFRP and GFRP have been used for retrofitting of columns, Hence the experimental work will be performed to study the following objectives:-

- To evaluate the performance of Short Column by different Retrofitting (wrapping) techniques.(Aramid Fibre Reinforced Polymer, Glass Fibre Reinforced Polymer)
- To repair the dismantle column with a latex modified concrete and strengthen by retrofitting (Wrapping) techniques.

EXPERIMENTAL PROGRAMME:-

In this experimental study a total 12 column were casted Using M25 grade of concrete after the mix design of trial mixes then we get the optimum ratio 1:2.34:2.06 with a water cement ratio of 0.46 and grade of steel is Fe 450 are tested on Compression testing machine (CTM). The size of column can be taken as core dimension (125mmx125mmx450mm) with two layers of reinforcement i.e. Outer layered reinforcement and Inner layered reinforcement, the cross sectional area of outer layered is (125x125mm^2) and for inner layered reinforcement is (65x65mm^2) and clear cover of 15mm. The total no. of bars used in outer reinforcement is 8 bars of 8 mm and inner reinforcement 4 bars of 8mm, the spacing between the outer and inner reinforcement is 6mm@45mmc/c , the column is in square shape. We give double layered of reinforcement

to provide higher strength to the column specimen. The specimens are casted on the wooden formwork in the laboratory.

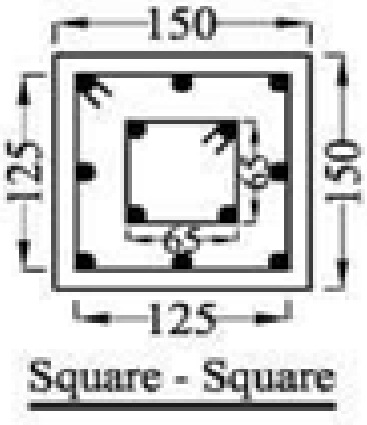

Fig. 3 – Reinforcement Detailing

Using Ordinary Portland Cement, sand, and aggregate of size 10mm, tap water and Super plasticizer (Poly Carboxylic Ether) is adopted. The characteristics compressive strength of cube after 28 days is 34 MPa on that mix design we used to cast the column specimen. In the casting of columns we use self compacting concrete because it may cover the difficult portion as compared to normal concrete, this type of concrete do not require tempering and vibrators.

The Compression Testing Machine is used to test the Concrete Specimens; it is fully automatic machine and digital display. The rate of loading for the specimens (150x150mm) is 5.0kn/sec. For different dimension the rate of loading were also different. The distance between upper platen and lower platen is 900mm. The ram stroke of the machine is 100mm.

Fig.- 4 Compression Testing Machine

There are 12 short concrete columns from that six columns were tested after 28 days of curing on CTM machine and other specimens are retrofitted with Glass fiber fabric (GFRP) and Aramid fiber fabric (AFRP). The dismantle columns were repair by Self compacting concrete in which a SBR latex is also used which makes a bond between old concrete and new concrete, latex makes the concrete should be impermeable to liquid[Er. Kapil Soni and Dr. Y.P Joshi] and it improves the flexural strength of concrete and shrinkage cracks were reduced. From that six columns were tested under failure and then repaired the dismantle column with Self Compacting Concrete (SCC), from that three columns were wrapped with Glass fiber fabric (GFRP) and rest of three were wrapped with Aramid fiber fabric (AFRP), and the six fresh

columns were also wrapped by GFRP and AFRP, to compare the compressive strength of repaired columns and wrapped columns.

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Fig - 5 Aramid fiber wrapping (AFRP)

Fig- 6 Glass Fiber Wrapping (GFRP)

MATERIAL PROPERTIES:-

Different materials used in Concrete columns were given below-

1. Cement:-

Ordinary Portland cement conforming to IS 8112- 2013 and 43 grade cement were used. The standard Consistency of cement is 36.67 and the initial setting time of cement is 127 minutes or final setting time of cement is 425 minutes.

2. Fine aggregate

The fine aggregate used in this experiment was a clean sand, whose maximum size is 4.75 mm, conforming to grading zone II. The sand was air dried, and sieved.

3. Coarse aggregate

10 mm size aggregates were used in this experimental study. The shape of the coarse aggregates chosen from as per IS 2386 Part 1 (1963). The surface texture characteristics as per IS 383:1970.

4. Superplasicizer (Poly Carboxylic Ether)

It gives very high workability and allows the particles to be more workable where it enable working with low water-cement ratio. Enhances the hydration process and increase strength, eliminate concrete segregation & allow good dispersion of cement particles in water and accelerating the rate of hydration.

5. Styrene Butadiene Rubber (SBR) LATEX

(i) It provides an excellent bond to the existing Substrate.
(ii) It makes the structure impermeable to liquid.
(iii) It improves chemical, abrasion and impact resistance.
(iv) It has improved flexural strength and hence avoids cracking.
(v) Shrinkage cracks are reduced.

6. Glass Fiber Reinforced Polymer (GFRP):-

It is a woven glass fabric of thickness 0.20mm and it is low in weight, strong ad less brittle. It has ability to get molded into complex shapes. The glass fiber is in the form of flattened sheets or in a woven fabric. The following properties and types of glass fabric are given below:
(i) High Tensile Strength
(ii) Dimensional Stability
(iii) High heat Resistance
(iv) Fire Resistance
(v) Good Chemical Resistance
(vi) Durability
(vii) Economical

7. Types of Fiber Glass

A-Glass:-It is a alkali glass and resistant to chemicals
C-Glass:-It offers a very good resistance to chemical impact, so it is also called chemical glass.
E-Glass:- It is also known as electrical glass and it is good for insulator.
AE-Glass:- This glass is alkali resistant glass.
S-Glass:- It is also called a structural glass and it is good for mechanical properties.

8. Aramid fiber reinforced polymer (AFRP):- Aramid fabric is also known as kevlar it belongs to the family of synthetic, the strength of aramid fiber is five times stronger than steel. Aramid are high strength and low in weight The Following properties are given below:-
(i) High Strength
(ii) Resistance to Absorption
(iii) Good Chemical Resistance
(iv) It has low flammability
(v) Higher heat Resistance
(vi) It is not cut easily
(vii) Sensitive to UV rays and chemicals

ANALYSIS OF TEST RESULTS:-

In this experimental study, the load carrying capacity of reference column and retrofitted column were tested until the column was totally failed. C1- Initial Column, C2- Strength regain after retrofit by wrapping

with GFRP, C3- Strength regain after retrofit by wrapping with AFRP, C4- Reference Column, C5- Strength after retrofit by Glass Fiber, C6- Strength after retrofit by Aramid Fibre.

Table 4.1 Strength regain in dismantle column after retrofit by GFRP and AFRP

Specimen no.	Core dimension (mm)	Initial strength of column (C1) (KN)	Strength regain after retrofit by wrapping with GFRP (C2) (KN)	Strength regain after retrofit by wrapping with AFRP (C3) (KN	Percentage Strength regain after retrofitting	Average percentage
C1C2	125x125x450	1268	1049	-	82.8	**78.00**
C1C2		1239	900	-	72.82	
C1C2		1261	980	-	77.84	
C1C3		1289	-	1120	86.63	**85.54**
C1C3		1249	-	1102	88.16	
C1C3		1343	-	1100	81.85	
	Average =	**1274.8**				

Table 4.2 Comparison between Reference Column and Retrofitted by GFRP

Specimen no.	Core dimension (mm)	Reference Column (C4) (KN)	Strength after retrofit by Glass Fibre(C5) (KN)	Percentage Increase	Average percentage
C4C5	125X125X450	1274	1502	17.89	19.17
C4C5			1511	18.60	
C4C5			1542	21.03	

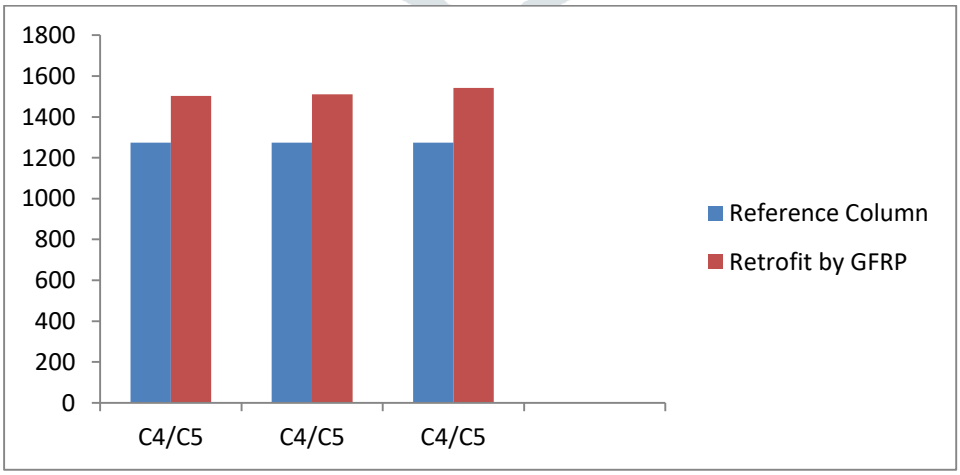

Chart-1 Comparison between Reference Column and Retrofitted by GFRP

Table 4.3 Comparison between Reference Column and Retrofitted by AFRP

Specimen no.	Core dimension (mm)	Reference Column (C4) (KN)	Strength after retrofit by AFRP (C6) (KN)	Percentage Increase	Average percentage
C4C6	125X125X450	1274	1656	31.29	28.1
C4C6		1274	1660	28.04	
C4C6		1274	1600	24.97	

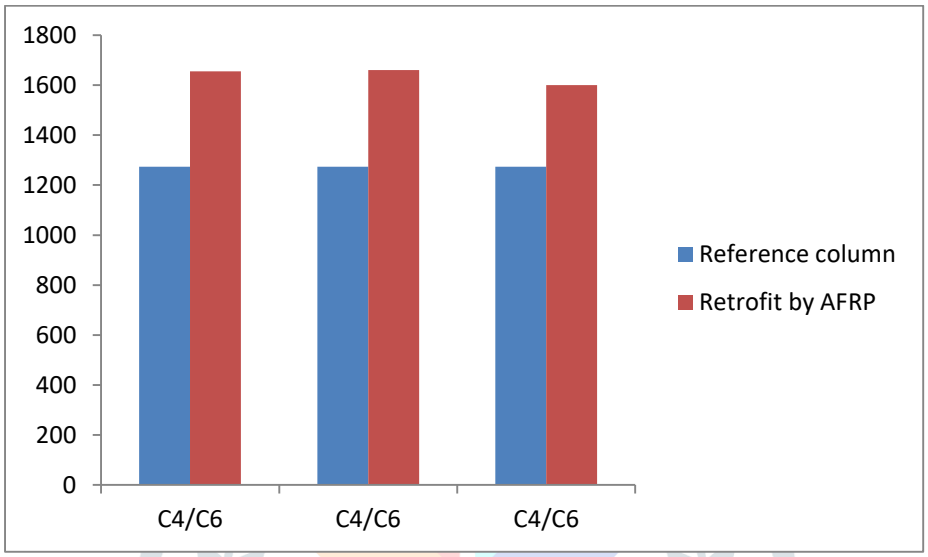

Chart-2 Comparison between Reference Column and Retrofitted by AFRP

Table 4.4 Comparison between Retrofitted by Aramid and Retrofitted by Glass

Specimen no.	Core dimension (mm)	Strength after retrofit by Aramid Fibre(C6) average	Strength after retrofit by Glass average fibre(C5)
C6C5	125X125X450	1656	1502
C6C5		1660	1511
C6C5		1600	1542

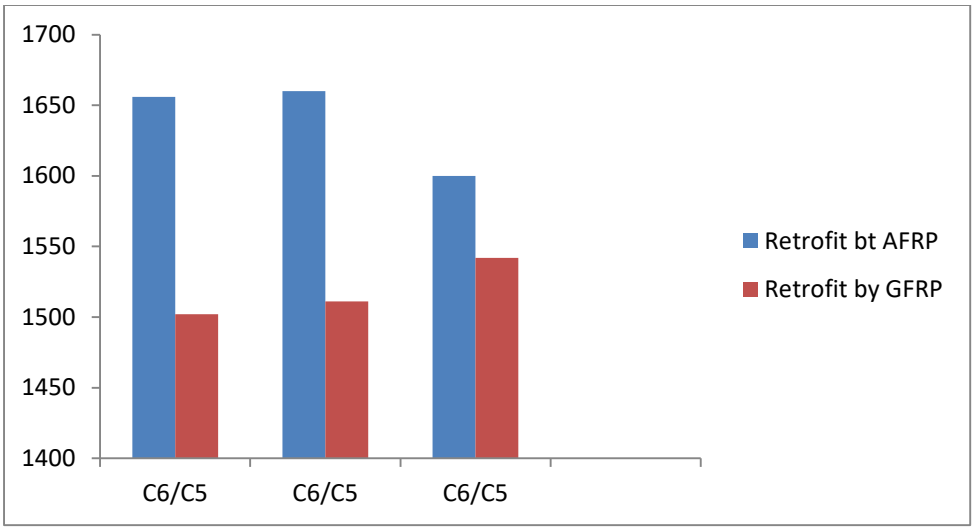

Chart-3 Comparison between Retrofitted by Aramid and Retrofitted by Glass

CONCLUSIONS:-

A total 12 columns were cast of core dimension (125x125x450mm) from them six columns were taken as reference column (C1) and the columns were tested until failure after 28 days. Then this dismantles columns were wrapped by GFRP and AFRP... From that three of them are wrapped by Glass fiber fabric (GFRP) and three are wrapped with Aramid fiber fabric (AFRP).and the other six column who were not dismantle (Fresh Column) were also retrofit by GFRP and AFRP. The following conclusion is drawn:-

(a) It is found that wrapping Aramid fiber reinforced polymer (AFRP) gives better strength then Glass fiber reinforced polymer (GFRP).

(b) It is found that when reference column is retrofitted by Glass fiber fabric the strength is increased by 19.17%.

(c) It is found that when reference column is retrofitted by Aramid fiber fabric the strength is increased by 28.1%.

(d) When damaged column is repaired with Self compacting and Wrapped with Glass fiber reinforced polymer (GFRP),.the strength regain by 78.00%.

(e) When damaged column is repaired with Self compacting and Wrapped with Aramid fiber reinforced polymer (AFRP), the strength regain by 85.54%.

(f) It is also found that Glass fiber reinforced polymer (GFRP) tears of at the edges of the columns. So it is recommended that GFRP is suited for columns without sharp edges such as circular and elliptical.

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