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"BEHAVIOUR OF CONCRETE CONFINED WITH CARBON FIBER REINFORCED POLYMER (CFRP) SHEET"

Akshay Kumar[1], Punit kumar[2], Dr. Shweta Nisha[3],

[1,]M.Tech Scholler, CIT Ranchi

2,3, Assistant Professor, Cambridge Institute of Technology Ranchi Jharkhand India

ABSTRACT -

The objective ofthisresearch is to investigate the effectiveness of carbon fibre wrapping for improving the compressive strength of concrete members. Compared with traditional methods, the reinforcement technology of carbon-wrapped columns has the least interference to structural members. Effective use of carbon Fiber reinforced concrete or polymers can significantly increase the life of the structure and minimize maintenance requirements. The columns wrapped in carbon fibres are corrosion resistant, so they are used for corrosion control and repair of reinforced concrete structures. Carbon Fiber reinforced concrete and carbon wrapped columns are also widely used to strengthen concrete structures. When building a floor higher than a stilt or adding a floor above the first floor/bungalow, reinforcement columns are necessary to be able to bear the weight of the new structure. Carbon Fiber cloth wrapped foundation columns is the most mature technology for strengthening concrete structure and buildings in high rise buildings. The results obtained clearly show the effectiveness of the hybrid confinement and partially confined concrete in improving the compressive strength and deformation of the concrete, so it is possible to replace CFRP total confinement by partially confined concrete with two CFRP layers or by a hybrid confinement with a CFRP layer in the central zone and GFRP layers on the top and bottom of the specimen.

Keyword Composite column, Fibre-reinforced polymer material, High performance concrete.

INTRODUCTION

Carbon Fiber Wrapping System is an answer for structural strengthening. Carbon Fiber has very excessive tensile power and is likewise very lightweight. When bonded to the outside of a concrete .column, beam, or slab, Structures are given tremendous strength by Carbon Fiber Wrapping Systems, which also protect against additional erosion and corrosion. In addition to being incredibly elastic, carbon Fiber is also quite light. When attached to the outside of a support segment, pillar, or piece, wrapping frameworks are created specifically for each project and use. Tensile strength increases, and air voids and water voids will be reduced. Since substitute of such poor factors of systems incurs a big quantity of public cash and time, strengthening has turn out to be the perfect manner of enhancing their load wearing potential and lengthening their provider lives. Infrastructure decay resulting from untimely deterioration of homes and systems has result in the research of numerous procedures for repairing or strengthening purposes. One of the demanding situations in strengthening of concrete systems is choice of a strengthening approach in order to decorate the electricity and serviceability of the shape at the same time as addressing boundaries which include constructability,

Carbon Manufacturing Process: Carbon Fiber is made of carbon atoms that are woven into filaments that are joined by polymer glue and heated under specific pressure. It is a thin, extremely spreadable substance. The filaments are heated below 400 c to create carbon Fiber. In order to remove the carbon impurities, the filaments are subjected to a carbonization process in which the Fibers are heated to around 800°C in an oxygen-free environment. When Fibers are graphitized, they are stretched between 50 and 100 percent of their original length and heated between 1100 and 3000 degrees Celsius,

Brief History of Carbon Fiber: Although carbon Fiber has been around for more than 150 years, it has only been through manufacturing process improvements in the last half century or so that its excellent strength-to-weight and stiffness-to-weight ratios have been achieved,

Benefits of Carbon Fiber Laminates: Any repair or rehabilitation project should be light on the pocket (low-cost). There should be a limited and predictable degree of changes with time and protection from premature deterioration throughout the structures course an life.

Installation of Carbon Fiber Wrapping System: Carbon Fiber Wrapping provides significant strength to structures and protects against further corrosion and erosion. The impervious material will protect a structure from moisture intrusion and further corrosion, reducing the need for ongoing maintenance work.

Concluding remarks: Fiber reinforced concrete composite has been commonly used in different kind of structures in earthquake prone areas as it is found suitable for heavy loaded structures in respect of strength and durability point of view. Objective, scope and methodology of SFRC have been highlighted. This work organized properly and its literature review has been discussed in next chapter

LITERATURE REVIEW

A. Joseph Wilson Swan; (1860): First created carbon Fiber in to use in an early incandescent light bulb. In 1879, Thomas Edison used cellulose-based carbon Fiber filaments in some of the first light bulbs to be heated by electricity. Their high heat tolerance made them ideal electrical conductors. These filaments were made of cotton or bamboo, as opposed to today's petroleum-based raw materials, this baking method, called "pyrolysis", is still used today. Pyrolysis is the process of thermally decomposing organic matter by heating it at high temperatures in an inert atmosphere. When tungsten became the light bulb filament of choice in the early 1900s, carbon fiber was rendered obsolete for the next 50 years or so.

B. Dr. Akio Shindo; (1960): of the Agency of Industrial Science and Technology in Japan, used polyacrylonitrile (PAN) as his precursor. PAN is a synthetic, semicrystalline organic polymer resin that allowed Shindo to create carbon Fibers that were ~55% carbon using a much more cost-effective production method.

C. British scientists W. Watt, L. N. Phillips, and W. Johnson; (1963): of the UK Ministry of Defence, patented a new carbon Fiber manufacturing process. This manufacturing process created a much stronger carbon Fiber product than previous processes yielded. The British National Research Development Corporation then licensed the process to Rolls Royce, Morganite, and Curtails. At the time, Rolls Royce was already manufacturing carbon fiber, and this new process allowed them to begin using carbon fiber in the design of their jet engine fan assemblies. They then broke into the US market with their RB-211 aero-engine with carbon fiber compressor blades. Unfortunately, bird impact proved to be a major vulnerability of the compressor blades, which led to major setbacks for Rolls Royce. Ultimately, Rolls Royce sold off their carbon fiber plant.

D. Xiao et al;(2005): proposed CFRP as a supplementary material for CFT columns in order to control the local buckling of the steel tube and to provide. The system consists of Carbon fibre that is made of thin, strong crystalline filaments of carbon that is used to strengthen

Fiber & Laminate Engineering Properties: The values for various engineering properties of carbon fiber and laminate are given below.

Table: 1 Carbon fiber sheet properties:

Carbon Fiber Sheet Properties	SI unit
TENSILE STRENGTH	4900MPa
TENSILE MODULUS	230000 MPa
ULTIMATE ELONGATION	2.1%
DENSITY	1.8 g/cm3

Table: 2 Carbon Fiber laminate properties.

Carbon Fiber Laminate Properties	SI unit
Tensile Strength	2750 MPa
Tensile Modulus	16500 MPa
Ultimate Elongation	1.7%
Density	1.3g/cm3

Table: .3: Carbon Fiber VS Glass Fiber

Technical data of fiber	Carbon fiber	Glass fiber
Modulus of elasticity	240 KN/ mm2	73 KN/mm2
Tensile strength	3800 N/mm2	3400 N/mm2
Total weight of the sheet	230 g/m2	900g/m2 in main direction
Thickness	0.117 mm	0.342 mm

Table: .4 :Properties of Primer Saturate.

Property	Primer	Saturant
DENSITY	2.00 g /cm2	1.12-1.16 g/cm3
Pot life	20 min @ **35 °C**	2 h @ **30 °C**
Full cure	7 days	5 days @ **30 °C**
Indicative coverage/coat	5-6 m2 per kg	2-3 m2 per kg
color	------	Pale yellow

Table 5.5: Technical Parameters.

Model	Specification	Strength Grade	Thickness
HM-20	200g/m2	High strength Grade I	0.111mm
HM-23	230g/m2	High strength Grade I	0.128mm
HM-30	300g/m2	High strength Grade I	0.167mm
HM-43	430g/m2	High strength Grade I	0.240mm
HM-45	450g/m2	High strength Grade I	0.250mm
HM-53	530g/m2	High strength Grade I	0.294mm
HN-60	600g/m2	High strength Grade I	0.333mm

- **Experimental investigation / Experimental methodology**: **Tensile Strength of carbon fiber:** The ultimate tensile strength (UTM) and young's modulus are generally determine by using ASTM(American society for testing and materials) which is bases on Universal testing machine.
- Tensile test can perform on a single fiber or a bundle of fiber.
- Single fiber test is time taken may not be realistic if fibers are not uniform.
- Testing fiber bundle pose difficulties to align all fibers along the direction of the load applied friction between fibers and twisting of fibers.

Test on Cement

Fineness test

- Fineness test perform to determine the practical size of the cement.
- More fineness will generate more heat of hydration.
- Finesse of cement is tested either by saving or by determination of specific surface using air probability apparatus.
- Increase in fineness of cement may lead to increase the drying shrinkage and cracking of the concrete.
- Reference. I as 4031 part 1 .1988.

Consistency test

- It taste is conducted 2 calculate the amount of water to be added to the cement to get a paste of standard consistency which is defined as that consistency which will permit then we get plunger to penetrate 5 to 7MM from the bottom of the vicat mould.
- This experiment is done with the help of
  - Vicat apparatus.
- The time taken between adding of water to the cement and filling of mould of vicat apparatus is called as gauging time which should be between 3 to 5 minutes.
- Reference: Is 4031 (part -4): 1988

Setting time

- When the cement mix with water forms slurry which gradually becomes lesser and lesser plastic and lastly forms a hard mass.
- After certain time a stage is obtained When cement paste can easily sustain a small amount of pressure.
- The time taken by the cement paste to resist some pressure it is called initial setting Time.
- Reference: IS 4031 (part-1):1988

Specific gravity

- It is defined as the ratio of weight of a given volume of material and weight of an equal volume of water.
- Specific gravity of cement can be determined by Le Chatelier flask.
- To determining the Specific gravity of cement we use kerosene, because kerosene does not react with cement.
- Reference: IS 4031 (part -11): 1988.

Compressive strength

- Compressive strength is very important.
- When any important structure has been built the bye compressive strength.
- Compressive strength tests generally not performed on plain cement due to excess shrinkage and cracking of plain cement paste.
- Reference: IS 4031-1988 (part 6)

Soundness of cement

- The ability of cement to maintain a constant volume is known as the soundness of cement.
- Soundness of cement is ensured Bye limiting the quantity of free line magnesia and sulphate as these compounds undergo a large change in volume.
- This test is carried out with the help of 'Le Chatelier's apparatus'.
- Reference: IS 4031 (part-3):1988

Sieve Analysis of Course and Fine Aggregate

- dispersed throughout the cement paste so as the produced a large volume of concrete.
- they constitute more than 3/4 of volume of concrete.

- we can see they provide body to concrete it prevent shrinkage and make it durabl.
- The aggregates are classified in two categories first fine aggregates and second one is coarse aggregate.
- the size of fine aggregate is limited to a maximum of 4.75 mm,beyond which known as course aggregate.
- IS 383:1970 Specifies four grading zone of fine aggregates. These four grading zones become progressively finer from grading zone 1 to grading zone 4.
- Reference: IS 383-1970.

specific gravity and water absorption of fine aggregate

- It is defined as the ratio of the mass of solid in a given volume of sample to the mass of equal volume of water at 4 degrees Celsius.
- Usually water absorption of course aggregate is about .5%by weight whereas water absorption of fine aggregate is about 2% by weight.
- the value of water absorption are used to calculate the change in the weight of aggregate while proportioning and mixing of concrete.
- Reference: IS 2386 (part -3) -1963

Plasticizers

- It is also called water inducer agent hence known as water reducing admixture.
- Plasticizer are used to improve the workability of concrete at low water cement ratio.
- Normal plasticizer range are 0.1 to 0.4 %.
- Some plasticizer entrain air too, but it is limited to 1-2%.

Water

- We know that water reacts chemically with cement and it is called hydration of cement.
- It lubricates the mix and give it the workability required to place and compact it properly.
- As per IS456:2000 Water should be portable quality and its pH value should not be less than 6.

Slump

- A concrete is said to be workable if it can give me mixed placed compacted and finished.
- A workable concrete should do not saw any segregation or bleeding.
- Segregation is said to occur when course aggregate tries to separate out from the final material and a concentration of course aggregate at one place occur.
- it gives an idea of water content needed for concrete to be used for different works.
- To measure the slump value the taste fresh concrete is filled into a mould of specified shape and dimension and the settlement or slump is measured when supporting mould is removed.

RESULT AND DISCUSSION

Presents a summary of the experimental test results, to wit, the compressive strength, corresponding strain, and elastic modulus of all the concrete specimens. We note that the compressive strength is from 29 to 47Mpa; the corresponding strain varies from 1.35 to 5.8‰; and the elastic modulus is from30 to 36GPa. For all the confinement variants of the specimens, the ratios are always significant; they present values superior to one, which shows the effectiveness of the confinement of the concrete by the different composite materials in the improvement of the mechanical properties, whatever the geometry of the confinement.

Standard Modulus Carbon Fiber
Fiber Properties

PROPERTY	METRIC
Tensile Strength	3,530 MPa
Tensile Modulus	230 GPa
Strain at Failure	1.5%
Density	1.76 g/cm3
Filament Diameter	7 µm
Yield	198 g /1000m

Composite Properties

PROPERTY	METRIC
Tensile Strength*	1,820 MPa
Tensile Modulus*	140 GPa
Tensile Strain	1.26%
Compressive Strength*	1,470 MPa
Flexural Strength*	1,790 MPa
Flexural Modulus*	123 GPa
ILSS	94.1 MPa
In Plain Shear Strength	95 MPa
90° Tensile Strength	76 MPa

Cement Test Deta

Fineness:

Objective: Determination of fineness of cement by dry sieving.
Reference: IS 4031 (Part-1):1988.
Type/grade of cement-OPC 53
Brand of cement- Ultratech
Apparatus: IS-90-micron sieve conforming to IS: 460 (Part 1-3)-1985; Weighing balance; Gauging trowel; Brush. Material: Ordinary Portland cement

Procedure:

1. Weigh accurately 100 g of cement to the nearest 0.01 g and place it on a standard 90 micron IS sieve.
2. Break down any air-set lumps in the cement sample with fingers.
3. Agitate the sieve by giving swirling, planetary and linear movements for a period of 10 minutes or until no more fine material passes through it.
4. Collect the residue left on the sieve, using brush if necessary, and weigh the residue.
5. Express the residue as a percentage of the quantity first placed on the sieve to the nearest 0.1 percent.
6. Repeat the whole procedures two more times each using fresh 100 g sample. 2

Observations:

Sl. No.	Weight of sample taken (W) (in g.)	Weight of residue retain on 90 micron (R) (in g.)	%age of residue =(R/w)*100	Average % of residue
1	100	3.40	3.40	3.39
2	100	3.38	3.38	
3	100	3.39	3.39	

Result: The Avg. % of residue is less than 10 % hence cement is good. (As per IS 4031-part 1-1996).

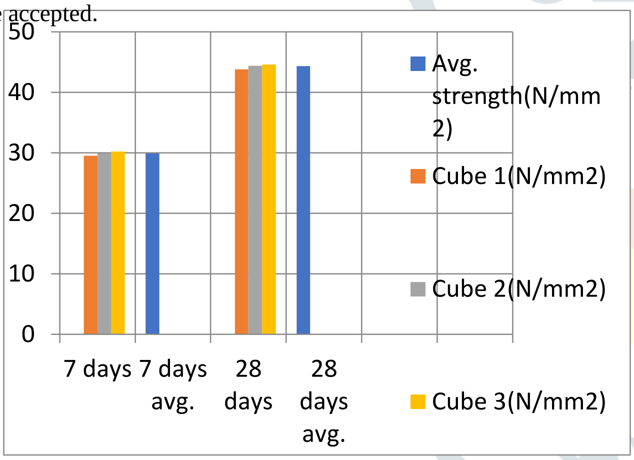
CONCLUSIONS

Conventional concrete and CFRP Wrapped concrete materials were tested and respective results are tabulated and corresponding charts were plotted based on the results found, the following conclusions are deduced:

- The compressive strength increases from 20 - 45 % in CFRP wrapped concrete compared to conventional concrete due to usage of CFRP material which enhanced the strength.
- The split tensile strength of CFRP concrete enhanced from 20 to48% compared to conventional concrete
- The Flexural strength increased from 15 to 30% in CFRP wrapped concrete compared to conventional concrete.
- Main reason is that, they have higher ultimate strength and lower density compared to steel. CFRP is used because of its easy applications. Use of CFRP enhances the bond property between fibers and the matrix.
- CFRP Wrapped concrete is progressively increases the compressive strength split tensile strength and flexural strength of concrete, hence it is advisable to use for repairs and rehabilitation of distressed concrete structures.

•	7 Days				28 Days			
	Failure load (Kn)	**Comp. strength (N/mm2)**	**Avg. strength (N/mm2)**	**min. strength (N/mm2)**	**Failure load (Kn)**	**Comp. strength (N/mm2)**	**Avg. strength (N/mm2)**	**min. strength (N/mm2)**
Trial 1	753.36	33.5	**34.0**	33.5	1103.4	49.0	**50.6**	49.0
	768.7	34.2			1134.3	50.4		
	771.2	34.3			1179.1	52.4		
Trial 2	663.9	29.5	**29.9**	29.5	985.7	43.8	**44.3**	43.8
	673.2	29.9			999.7	44.4		
	680.4	30.2			1003.5	44.6		
Trial 3	555.3	24.7	**25.3**	24.7	885.4	39.4	**40.8**	39.4
	573.2	25.5			923.7	41.1		
	581.4	25.8			943.8	41.9		

Recommendation- Based on 7 days and 28 days result trial Mix II may be accepted.



Test graph b/w compressive load and days

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