International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION ON BEHAVIOUR OF SELF CURING HPC WITH BAMBOO FIBRE REINFORCEMENT AND STRENGTHENING USING HFRP

Achu A[1], Rakhi Ajayakumar[2], Prasoon P P[3]

[1]Mtech Scholar, Structural Engineering & Construction Management, CISAT, Ernakulam
[2]Asst.Professor, Dept of Civil Engineering, CISAT, Ernakulam
[3]Asst.Professor, Dept of Civil Engineering, College of Engineering Pathanapuram

---

Abstract - High Performance Concrete (HPC) provides a long lasting, durable concrete. Self-curing concrete helps to eliminate the problems of insufficient curing. The use of Polyethylene Glycol (PEG400) in HPC as self-curing agent helps better hydration by internal curing. Natural bamboo fibre can be used for the enhancement of characteristic strength of concrete and the optimum percentage of the fibre for M30 mix was obtained as 1.00% by varying its percentage in concrete by weight of cement from 0.25% to 1.50% with 0.25% intervals. Strengthening of concrete structures can improve the functional performance, the commonly used technology is Fibre Reinforced Polymer (FRP) wrapping and natural fibre will be a better option when pointing on the fact of sustainability and environment friendly concepts. It was found that strengthening using Hemp FRP shows great improvement in ultimate strength. The strengthening was done by three techniques U, strip and base wrapping. The ultimate strength of strengthened RCC beam shows an increase of 108.46%, 61.05% and 23.16% for U wrapping, strip wrapping and bottom wrapping respectively. Use of Self curing HPC with natural fibre reinforcement and strengthening with the use of HFRP in construction lead to durable structures.

***Key Words*: Self curing, PEG, Bamboo fibre, Hemp fibre reinforced polymer, high performance concrete**

1. INTRODUCTION

Concrete is the basic engineering material used in most of the civil engineering structures. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tones every year. Concrete is needed to be provided with moisture for a minimum period of 28 days for good hydration and to attain desired strength. Any laxity in curing will badly affect the strength and durability of concrete. Self-curing concrete helps to eliminate the problems of insufficient curing due to human negligence, unavailability of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of undesirable chemicals in water badly affect the characteristics of concrete. Most commonly used agents are Cera Polycure-W, Poly Vinyl Alcohol, and Polyethylene Glycol etc. In this paper Polyethylene Glycol 400 (PEG 400) was used. PEG 400 is a type of internal curing agent. The self-curing concrete is easily cracked under low tensile stress due to the weakness in resisting tensile forces. Addition of fibres into the concrete enhances the tensile strength, impact strength, durability, fracture toughness etc. also that will control the cracks due to both plastic and drying shrinkages. Bamboo fibre is a natural, abundantly available, high strength fibre that can be used to enhance the tensile behavior of self-curing concrete. The development of fibre reinforced polymer (FRP) materials in various forms such as non-woven, that is loose fibres, woven, that is braided fibres, textile or fabric, that is strongly braided along with a backing material such as latex backing or natural rubber backing, etc. and configurations offers an alternative design approach for the strengthening of new & existing structure.

1.1 Bamboo fibre

Bamboo is a multipurpose reserve categorized by large ratio of strength to weight and its ease of work with simple tools. It is one of the rapidly growing natural reserves also it is easily and locally available. Bamboo had been using for construction even from early times. It can be used as Technical and Non-Technical ways. For building the houses our forefathers used Bamboo as basic material. Because of its high strength to weight ratio, traditionally it has been used in varied living facility and tools. This property is due to the longitudinal alignment of fibres. Bamboo fibres have better modulus of elasticity than another natural material. The longer is the fibre the higher it gives the tensile strength. Addition of Bamboo fibres to the concrete elevates the mechanical strength and tensile strength. It has low specific weight too.

1.2 HFRP (Hemp Fibre Reinforced Polymer)

FRPs offer designers an excellent combination of properties not available from other materials and present a potential solution to civil infrastructure's crisis hence are suitable materials for structural retrofitting,. The advantages of FRP are many such as high strength to weight ratio, high specific tensile strength, good fatigue resistance, ease of installation

and corrosion resistance characteristics, ease of repairing, high strength in the required direction, and higher ultimate strength and lower density than steel, etc. are some of the properties which make FRPs ideal for strengthening applications. The widely used FRPs are artificial like carbon, glass etc. which are costly and non-ecofriendly. Natural fibres can be used instead of artificial FRPs which promises good strengthening. Hemp FRP is used in the work for strengthening.

2. METHODOLOGY

Concept of self-curing concrete, fibre reinforced concrete and strengthening was conceived from various research studies and books. Based on studies of different literatures the usage of Polyethylene Glycol 400 as self-curing agent was studied and followed. The optimum percentage for self-curing agent was obtained from references and fixed as 1.00%. Various tests on fine, coarse aggregate, cement etc. are conducted and results are obtained which are confirming to Indian standards. To find the improvement of self-curing concrete with bamboo fibre reinforcement comparison is done with conventional concrete in various tests. M30 mix concrete was designed and used in the study. Different specimens are casted with varying percentage of bamboo fibre to the weight of cement. Different mixes are made by varying the percentage of bamboo fibre as 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, and 1.5%. The experimental program was aimed to study the effect of fibre content on the mechanical properties like compressive strength, split tensile strength and flexural strength of self-cured concrete. By analyzing the experimental result optimum percentage of bamboo fibre that can give better improvement in mechanical strength of self-curing concrete was obtained. Later beams are casted by the same mix and self-curing agent with the obtained optimum amount of bamboo fibre. The beams are strengthened by Hemp Fibre Reinforced Polymer by three techniques namely U wrapping, strip wrapping and base or bottom wrapping, then the beams are loaded by two point loading and ultimate load was found out. The results are studied to find the improvement in strength.

3. MATERIALS USED

3.1 Cement

Ordinary Portland cement of grade 43 confirming IS 8112:1989 is used.

3.2 Fine aggregate

The fine aggregate used was obtained from a nearby merchant and was conforming to zone II according to IS 383:1970

3.3 Coarse aggregate

Crushed stone was used as coarse aggregate which is confirming to IS: 383-1970 .The maximum coarse aggregate size used is 20 mm

3.4 Reinforcement steel

Here Fe 415 HYSD of 8 mm diameter, i.e. high yield strength, hot rolled deformed bars having characteristic strength of 415 N/mm^{2}were used for casting of the RC beams. Reinforcement details are given in Fig.1.

3.5 Polyethylene Glycol 400

The self-curing agent used for the study was PEG-400.It is a type of water soluble internal curing agent. Curing agent for the present study was obtained from Jay kay dyes and chemicals, Delhi.

3.6 Ceraplast 300

Ceraplast 300 was used as superplasticizer for creating high performance, which was purchased from Cera Chem Pvt. Ltd. The dosage of Ceraplast 300 was fixed as 3.5 percentage of weight of cement by conducting many trials and measuring the flow.

3.7 Bamboo fibre

Bamboo fibre was obtained from bamboo plant, its extracted from its stem which was rapidly growing and has better strength. Aspect ratio of fibre is 50.

Table-1: Properties of bamboo fibre

Properties of Bamboo fibre	
Tensile strength (N/mm^2)	140 - 230
Youngs modulus (N/mm^2)	11000 - 17000
Elongation at break (mm)	2
Density (gm/cm^2)	0.6 – 1.1

3.8 Epoxy

Epoxy is used for wrapping the hemp fibre reinforced polymer to the beam as part of strengthening. The epoxy used was obtained from Cera Chem Pvt. Ltd, Chemmai.

3.9 HFRP

Hemp fibre are interwoven to form a reinforced form like fabric. The reinforced layer with epoxy is used to strengthen the beam.

Table-2: Properties of HFRP

Properties of HFRP	
Tensile strength (N/mm^2)	165
Youngs modulus	17000

(N/mm^2)	
Flexural strength (N/mm^2)	180
Flexural modulus	9000
Impact strength (KJ/m^2)	15

3.10 Water

Distilled water was used for mixing only. Not used for curing except for conventional samples.

4 Mix design

Concrete mix design has been adopted as per IS10262:2009 for M30 grade concrete. Mix design details and mix designation of cast specimens are given in Table 3 and 4 respectively.

Table-3: Details of mix

Designed mix proportion	1: 1.97: 2.67
Cement content	400 kg/m^3
Fine aggregate content	795 kg/m^3
Coarse aggregate content	1080 kg/m^3
Water cement ratio	0.4

Table-4: Mix designation for specimen

Xn	Conventional curing
XnS	Self cured concrete
XnS25	Self cured with 0.25% bamboo fibre
XnS50	Self cured with 0.50% bamboo fibre
XnS75	Self cured with 0.75% bamboo fibre
XnS100	Self cured with 1.00% bamboo fibre
XnS125	Self cured with 1.25% bamboo fibre
XnS150	Self cured with 1.50% bamboo fibre

5 EXPERIMENTAL INVESTIGATION AND RESULTS

Experimental investigation are done by conducting compressive, split tensile and flexural strength tests for self-cured PCC with different percentage of bamboo fibre and ultimate load for self-curing RCC with optimum percentage of bamboo fibre.

5.1 Compressive Strength

Preparation of specimens and testing was done as per IS: 516-1959. The compression test was carried out on a cubical specimen of size 150mm in a compression testing machine of capacity 2000kN at a loading rate of $14N/mm^2$ per minute. The maximum load taken by the specimen was noted and the compressive strength was obtained by dividing maximum load by area of the cross section of specimen.

Table-5: Compressive strength

Designation	28 day Compressive strength N/mm^2
Xn	40
XnS	41.59
XnS25	43.40
XnS50	43.84
XnS75	43.98
XnS100	45.13
XnS125	44.39
XnS150	43.55

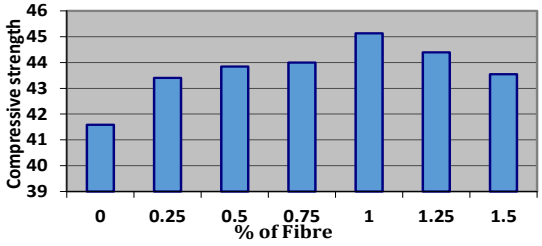

Chart 1. 28 days Compressive strength

5.2 Split tensile strength

Cylindrical specimen of diameter 150mm and height 300mm were tested for determining the splitting tensile strength as per IS 5816:1999 specification. The test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load was applied continuously without shock at the rate of $1.2N/mm^2/min$ to $2.4N/mm^2/min$ specimen splits in to two along the vertical diameter.

Table-6: Split tensile strength

Designation	28 day Split tensile strength N/mm²
Xn	2.94
XnS	3.25
XnS25	3.46
XnS50	3.60
XnS75	3.74
XnS100	3.82
XnS125	3.66
XnS150	3.43

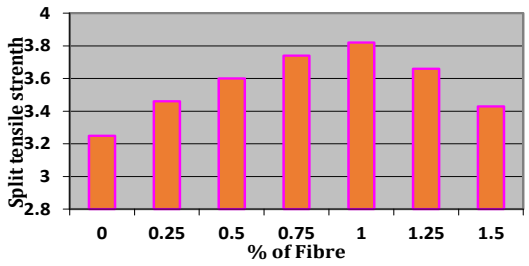

Chart 2. 28 days Split tensile strength

5.3 Flexural Strength

Beam specimen of size 100mm×100mm×500mm was tested for determining the flexural strength as per IS 516:1959 specifications. Centre and one third distance from either supports were marked on the specimen. The specimens were placed on the steel rollers resting on the bed of the testing machine. The load was then applied at the rate of 1.8kN per minute without shock. The breaking load and appearance of the fractured faces of concrete were noted. The fracture took place within the middle third of the span.

Table-7: Flexural strength

Designation	28 day Flexural strength N/mm²
Xn	11.64
XnS	12.20
XnS25	13.12
XnS50	13.54
XnS75	14.20
XnS100	15.42
XnS125	14.30
XnS150	14.00

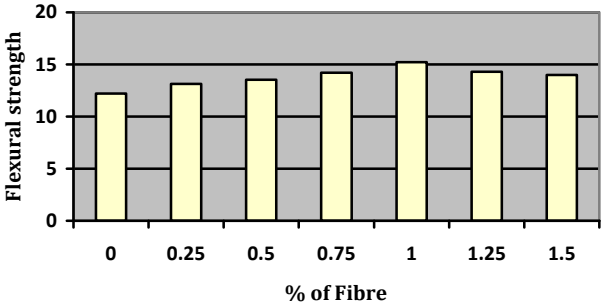

Chart 3. 28 days Flexural strength

Chart -1: Name of the chart

The experimental investigation showed that there is considerable improvement in mechanical properties of concrete with the addition of bamboo fibre. The maximum of mechanical properties where observed for mix designation having 1% of bamboo fibre.

5.4 Ultimate load and deflection

Ultimate load was found out for reinforced concrete beams which was casted by self-curing technique and having optimum percentage of bamboo fibre obtained from previous tests. The beam is 100mm×100mm×500mm. The control beam was fixed as self-cured beam with optimum fibre casted in same mix design. The beams are strengthened by HFRP in three different techniques. Two-point loading was applied to the beams until failure occurs. The test results of self-cured beam with fibre are compared with those beams which are strengthened.

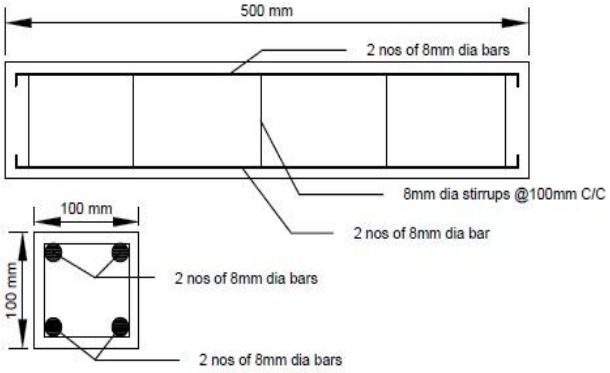

Fig 1. Reinforcement details of RCC beam

The beams casted as detailed above are then strengthened using HFRP by wrapping a layer of woven hemp fibre to the

beam by the use of epoxy. The beams are strengthened in three different ways, first method is by wrapping three sides of the beams which is known as U wrapping. The second technique is wrapping three sides of beam by strips of HFRP which are cut to desired size, i.e. 25mm strips which are placed 50mm C/C and a clearance of 12.5mm at two edges. There are three beams in each set. The beams are then loaded by two point loading system till failure occurs. The ultimate load and deflection of beams are then observed.

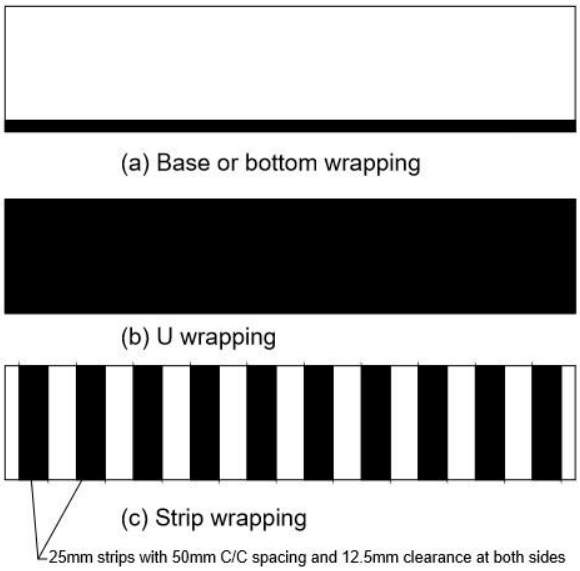

Fig 2. Strengthening using HFRP

Specimen (RCC beam)	Ultimate load (KN)	Percentage increase	Deflection (mm)
XnS	67.8	-	4.26
XnS100	84.8	-	6.4
XnS100 (Base wrapping)	104.44	23.16%	8.4
XnS100 (Strip wrapping)	136.52	61.03%	12.5
XnS100 (U wrapping)	176.78	108.46%	17.84

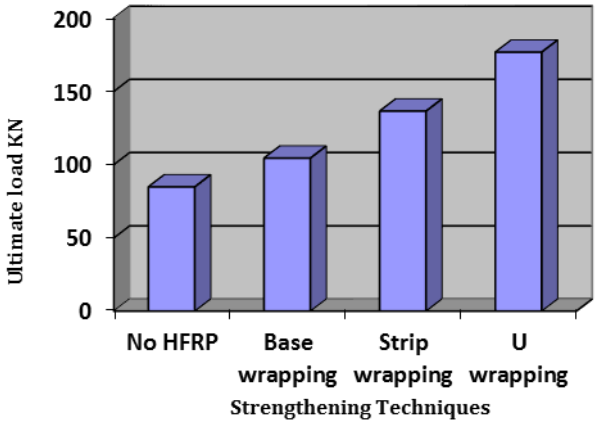

Chart 4. Ultimate load of RCC beams

6. CONCLUSIONS

Concrete which is a major component of construction industry need to attain desired strength by 28 days proper moisture content. The deficiencies in conventional curing can be avoided by introducing the concept of self-curing. Self-cured concrete shows improvement in mechanical properties of concrete and ensure sustainable development. To enhance the tensile performance of normal concrete natural bamboo fibre can be added and this increases the mechanical properties like compressive, split tensile, flexural strengths.

- The compressive strength shows an increases with the increase of fibre up to 1.00% and there after shows a decrease. There is an increase of 12.82% in compressive strength than conventional concrete.
- The split tensile strength shows an increase of 29.93% than conventional concrete when 1.00% of bamboo fibre was added and a decrease was observed on further increase of fibre.
- The flexural strength showed an improvement of 32.474% by adding 1.00% of bamboo fibre than conventional concrete.
- Bamboo fibre reinforced self-cured concrete shows better characteristic strength than conventional ones and the optimum dosage of fibre was investigated as 1.00%.

- Strengthening of beams can be attained by using Hemp Fibre Reinforced Polymer (HFRP) and good results are obtained while comparing with beams without strengthening.
- The strengthened beam shows an increase of 23.16%, 61.03% and 108.46% in ultimate load for base, strip and U wrapping respectively.

ACKNOWLEDGEMENT

I thank my dad for his immense support that kept me motivated.

REFERENCES

[1] Basil M Joseph,"Studies On Properties Of Self Curing Concrete Using Polyethylene Glycol", IOSR Journal Of Mechanical And Civil Engineering (IOSR-JMCE) e-ISSN:2278-1684,2016

[2] Handbook on repair and rehabilitation of RCC buildings, Central Public Works Department New Delhi

[3] IS 4031:1996 Part I, "Methods Of Physical Tests For Hydraulic Cement", Bureau of Indian Standards New Delhi

[4] IS 4031:1988 Part 6, "Methods Of Test For Aggregates For Concrete" ,Bureau of Indian Standards New Delhi

[5] IS 2386:1963 Part I, "Methods Of Test For Aggregates For Concrete", Bureau of Indian Standards New Delhi

[6] IS 2386:1963 Part III, "Methods Of Test For Aggregates For Concrete", Bureau of Indian Standards New Delhi

[7] IS 10262: 2009, "Guidelines For Concrete Mix Design Proportioning", Bureau of Indian Standards New Delhi

[8] IS 516: 1959, "Methods Of Tests For Strength Of Concrete", Bureau of Indian Standards New Delhi

[9] IS 5816: 1999, "Split Tensile Strength Of Concrete - Method Of Test", Bureau of Indian Standards New Delhi

[10] J Saran Kumar,"A Comparative Study Of Mechanical Properties Of M25 Grade Self –Curing Concrete (Using PEG-400) With Conventional Concrete", International Journal Of Applied Research 2015;1(10):655-65950

[11] K.L. Pickering, M.G Aruan Efendy & T.M. Le ,"A review of recent developments in natural fibre composites and their mechanical performance", SCIENCE DIRECT Applied Science and Manufacturing, Vol.83:98–112. 2016

[12] Magda.I.Mousa, "Physical Properties Of Self-curing Concrete, Production and hosting", ELSEVIER on behalf of Housing and Building National Research Centre,2014.

[13] Mahesh S M and Kavitha S "Evaluation Of Aspect Ratio (L/D) Of Bamboo Fibre As A Reinforcement Material In Concrete", International Journal Of Research In Engineering And Technology,EISSN:2319-1163,Volume 05,Special Issue 14, 2016.

[14] Parnia Zakhikhani et.al "Extraction And Preparation Of Bamboo Fibre –Reinforced Composites", ELSEVIER, Materials and design 63(2014) 820-828

[15] **S**.Sreenivasulu, Dr.A.Chennakeshava.Reddy "Mechanical Properties Evalution of Bamboo Fiber Reinforced Composite Materials", International Journal of Engineering Research, Volume No.3 Issue No: Special 1, pp: 187-194

[16] Tara Sen & H N Jagannadha Reddy, "Flexural strengthgening of RC beams using natural sisal and artificial carbon and glass fabric reinforced composite system", ELSEVIER, Sustainable Cities and Society 10.195–206, 2014.