iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VII **Month of publication:** July 2017

DOI:

Experimental Study on Shear Strength of Reinforced Concrete Beam using Fiber Reinforced Polymer

Dr. Kaushal B.Parikh[1], Sudhirchandra B. Trivedi[2]
[1]Associate Professor & Head, [2]PG student Department of Applied Mechanics
Government Engineering College, Dahod-389151

Abstract: Reinforced Concrete (RC) is one of the common and widespread building material in the world. Most structures such as buildings, bridges etc. made up of reinforced concrete as a main construction material but during its entire life span, almost all engineering structures ranging from an industrial building, residential buildings to power stations and bridges faces degradation or deteriorations. Among all strengthening techniques, external application of Fiber Reinforced Polymer Sheet to such deficient structure becoming more and more popular. They are quickly becoming the popular over steel for reinforced concrete structures. So, there is lots of research work being carried out in all over world in this area. In this study strengthened with CFRP sheet beam were compared with the control beam and increment to sustain ultimate load observed. By using different configurations like U wrapping, Full wrapping on both faces & Half wrapping on both the faces, effective solution was determined.
Keywords: CFRP, Shear strengthening, RC beams, Retrofit methods, FRP strengthening.

I. INTRODUCTION

FRP composite materials are comprised of high strength continuous fibers, such as glass, carbon, or steel wires, embedded in a polymer matrix. The fibers provide the main reinforcing elements while the polymer matrix (epoxy resins) acts as a binder, protects the fibers, and transfers loads to and between the fibers

FRP systems have been successfully used to strengthen buildings, bridges, silos, tanks, tunnels, and underground pipes. The higher cost of FRP materials is offset by reduced costs of labour, use of equipment, and downtime during installation, making them more cost-effective than traditional strengthening techniques. There are different types of FRPs are available in industry amongst which mainly using in strengthening are Glass Fiber(GFRP), Kevlar Fiber (KFRP), Carbon Fiber(CFRP) and Aramid Fiber(AFRP).

Replacing deficient structures requires huge investments and is not a viable option, hence strengthening has become the appropriate way for improving the load carrying capacity and prolonging their service life.

II. REMARKS FROM LITERATURE REVIEW

A. The significant increase in the shear strength up to 50% can be achieved by bonding CFRP sheets to the sides of the RC beams.
B. FRP application leads to a variation of some of the significant structural aspects like the cracking pattern and deformation levels in shear reinforcing systems.
C. Diagonal shear cracks become steeper and post cracking stiffness also increases as the amount of longitudinal reinforcement ratio increases.
D. The result of this study shows that CFRP may be used to increase the strength and stiffness of beams without causing catastrophic brittle failures associated with this strengthening technique.
E. CFRP wrapped at tension side gives better strength as compared to CFRP wrapped at two parallel sides but gives less strength as compared to CFRP wrapped at three sides.
F. Due to low temperature resistance, the CFRP systems are not capable of safely and adequately enduring fire for any substantial period of time.
G. The FRP method triggers premature debonding failure at the mid-span leading to loss of sufficient ductility.
H. With increasing numbers of layers of CFRP sheets, there was increment in strength but in decreasing manner.
I. It is seen that the failure mode of debonding of CFRP, reduces the effectiveness of CFRP by not utilizing the strength of CFRP.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VII, July 2017- Available at www.ijraset.com

J. Overall, there is lack of comparison of different configuration other than full side wrapping and U- wrapping for beams strengthened in shear.
K. For the strengthened beam, the ultimate strength can have a significant increase in comparison with the normal beam.
L. Crack width decreases due to application of CFRP sheet.

III. MATERIALS & PROPERTIES

A. Cement
For OPC – 53 grade cement:

Table 1 Properties of Cement

Properties of cement as per IS:1489(part-1) 1991			
1	Sp. Gravity	3.15	--
2	Standard consistency	30	--
3	Initial setting time	135 min	30 min.
4	Final setting time	187 min	600 min.
5	Le-chetelier soundness	1.1 mm	10 m max

B. Aggregates
The sand used for the experiments was locally procured and conformed IS: 383 (1970). The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm, locally available coarse aggregates having the maximum size of 20 mm was used in the present work. Testing of fine and coarse aggregates were done as per IS: 383 (1970).

C. Water
Here, ordinary clean tap water is used to make concrete mix.

D. Concrete
Ultimate strength of concrete also depends on mixing technique, design constituents, placement and curing methods which are used. After 7 and 28 days compression test of cube was performed to final and validate mix design of concrete. In this research work M25 grade concrete used.
From results of mix design finalized mix design for this research work is:

VOLUME OF CEMENT	CEMENT (kg)	WATER (kg)	FINE AGGREGATE (kg)	COARCE AGGREGATE (20 mm) (kg)
1 m^3	380	178	672.4	1193.37
	1	**0.47**	**1.71**	**3.14**

E. Reinforcement Steel
In this research, TMT (Thermo Mechanically Treated) bars used.

F. Fiber Reinforced Polymer (FRP)
Here, Goldbond 1893 CF unidirectional Carbon Fiber Sheet is used and its properties are:

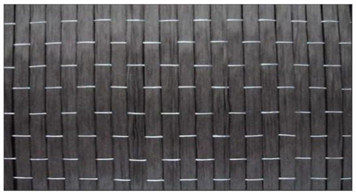

Figure 1 CFRP sheet

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
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Table 2 Properties of CFRP

Thickness	0.57 mm
Density	1.80 gm/cm3
Elongation at Break	1.7%
Tensile Modulus	240 Gpa
Tensile strength	3.8 Gpa

G. Epoxy Resin

Properties of epoxy resin used in this research are:

Table 3 Properties of Epoxy

Properties	Goldbond® 1893-Primer	Goldbond® 1893-Saturant
Base	Epoxide Resin	Epoxide Resin
Mix Proportion (By Weight)	Part A(base): Part B (Curing agent) = 1:1	Part A(base): Part B (Curing agent) = 1:1
Colour	Pale Yellow / Clear	Dark
Theoretical Coverage (on smooth concrete) For Carbon Fiber	4-6 sq.mt/ kg	1.5-2.0 sq.mt/ kg
Recommended No. of Coats	1	2
Cast epoxy material Properties		
Compressive Strength	70 Mpa	
Tensile Strength	50 Mpa	
Flexural Strength	>40 Mpa	
Elongation at Break	4 %	

IV. METHODOLOGY

The procedure followed for applying the CFRP sheets to the beam was as following.

A. Preparing the surface of the specimen Surface of the specimen should be cleaned with the help of glass paper to obtain smooth and even surface.

B. Application epoxy resin.

Epoxy resin will apply to the specimen in two stages

1) Primer

2) *Saturant:* Goldbond® 1893 is a 2-part specialty system comprising of a primer part and a saturant part. Goldbond® 1893 Primer is comprised of a base and curing agent. Goldbond® 1893 Saturant is also comprised of a base and curing agent. First of all, Primer will be applied to the beam surface. Then after 10 to 15 minutes Saturant will be applied on surface.

C. Application of CFRP

After applying Saturant CFRP sheet will be placed as per configuration of specimen. CFRP strips/sheets were cut beforehand into prescribed sizes using appropriate scissors. Then one layer of saturant will be applied.

All CFRP strips/sheets used in strengthening were of Uni-directional. After strengthening, the specimens were left undisturbed in the laboratory for 1 day before testing to make sure that the epoxy had enough time to cure.

Here 3 different configurations of CFRP sheet is shown:

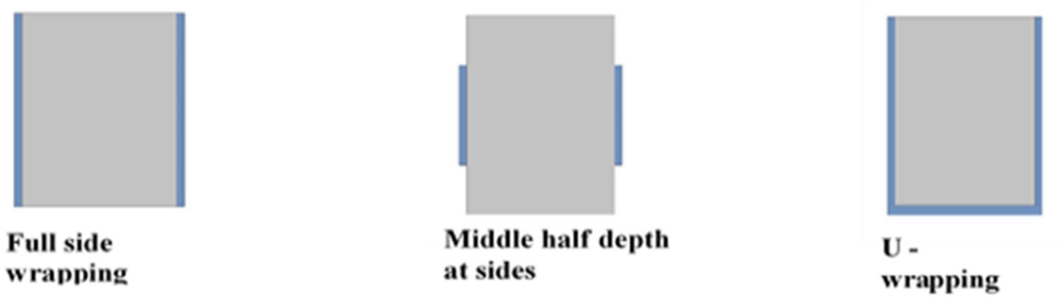


Figure 2 Full side wrapping

Figure 3 Half side wrapping

Figure 4 U wrapping

V. RESULTS & DISCUSSION

Beams were tested under Universal Testing Machine (U.T.M). The testing procedure for all the specimen was same. Supports were arranged at distance of 50 mm from the end of the beam. Clear span of the beam is 600 mm. Two-point loading was applied at the centre of the beam. Displacement at the mid-span was measured by dial gauge. Beams were placed at this U.T.M. and gradually increased load was applied. First crack load was measured and reading were taken at interval until beam failed. The load was applied at the rate of 140 kg/cm^{2}as per IS 516:1959.

In this research work beams of size 150 mm × 150 mm × 700 mm were tested.

A. Shear Beam Control 1 (BSC1)

Control beam was tested for flexure strength under Universal Testing Machine (UTM). Flexural strength and displacement at mid-span was measured. The load increment was applied as per IS 516:1959. It has been seen that first crack was developed at 73.1 kN. As load increases, shear cracks in the shear region developed along with minor cracks in the middle flexure region. Further load increased more crack widen in shear region & finally the beam failed at 135.7 kN and that stage maximum deflection noted as 3.2 mm.

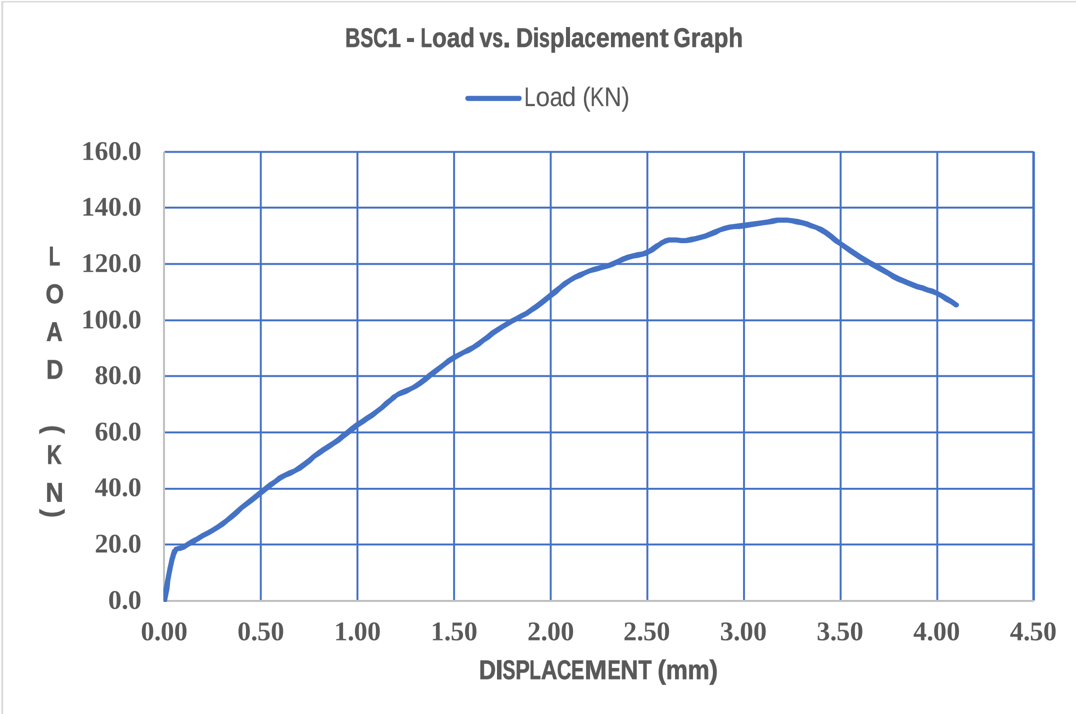


Figure 5 Load vs. Displacement curve for BSC1

B. Shear Beam Full Side of CFRP with Initially Strengthened (BSFS20)

This beam BSFS20 is wrapped with CFRP sheet at its both the faces. It was tested for two-point loading by UTM. Beam was finally failed at 174.9 kN load and at that time, displacement at mid span was noted 1.80 mm. Here, graph is showing beam & load vs. deflection behavior respectively for this beam compare to BSC1 (control beam).

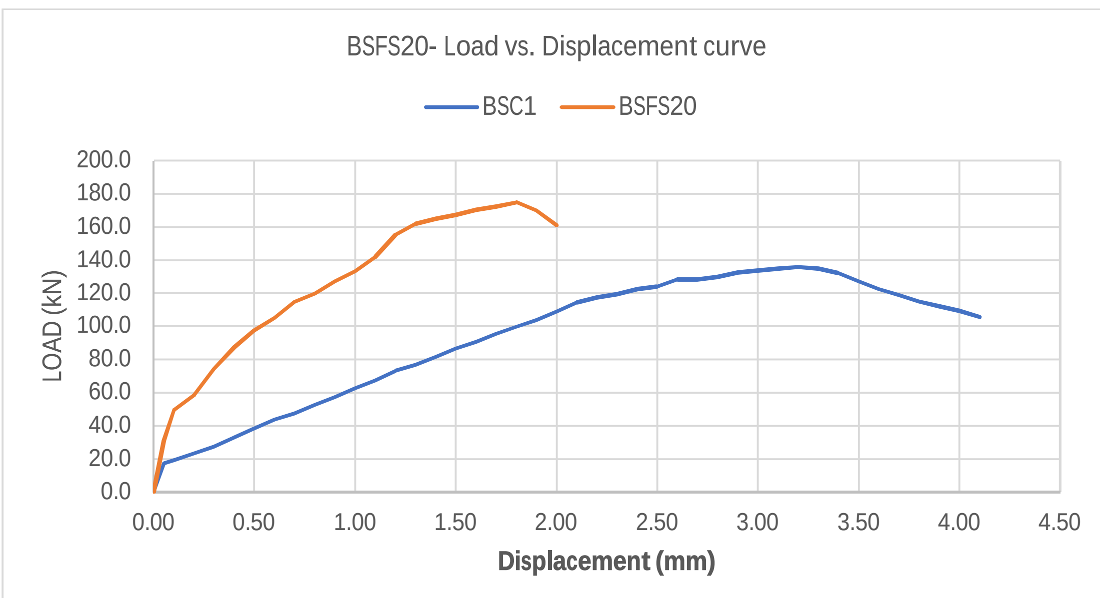


Figure 6 Load vs. Displacement curve for BSFS20

C. Shear Beam Half Side of CFRP with Initially Strengthened (BSHS30)

This beam BSHS30 is wrapped with CFRP sheet on its both face at middle portion. It was tested for two-point loading by UTM. Beam was finally failed at 159.1 kN load and at that time, displacement at mid span was noted 2.0 mm. Here, following Table, photograph & graph is showing beam & load vs. deflection behavior respectively for this beam compare to BSC1 (control beam).

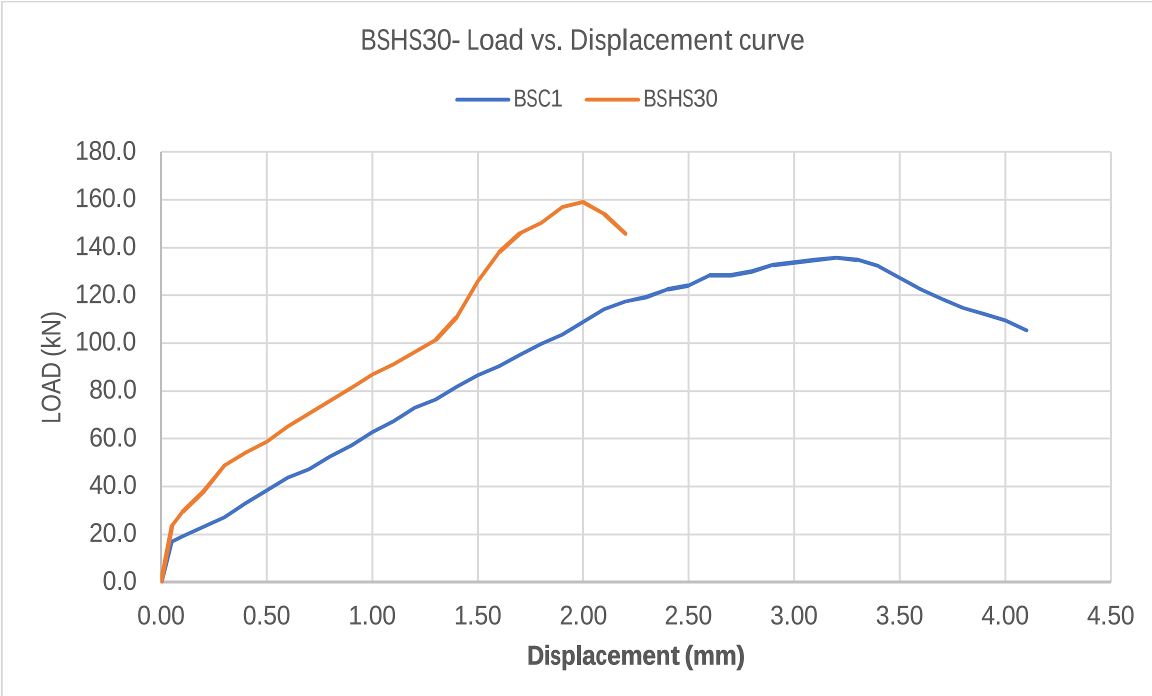


Figure 7 Load vs. Displacement curve for BSHS30

D. Shear Beam U shape of CFRP with Initially Strengthened (BSU40)

This beam BSU40 was wrapped with CFRP sheet in U shape. It was tested for two-point loading by UTM. Beam was finally failed at 206.8 kN load and at that time, displacement at mid span was noted 2.8 mm. Here, following graph is showing beam & load vs. deflection behavior respectively for this beam compare to BSC1 (control beam).

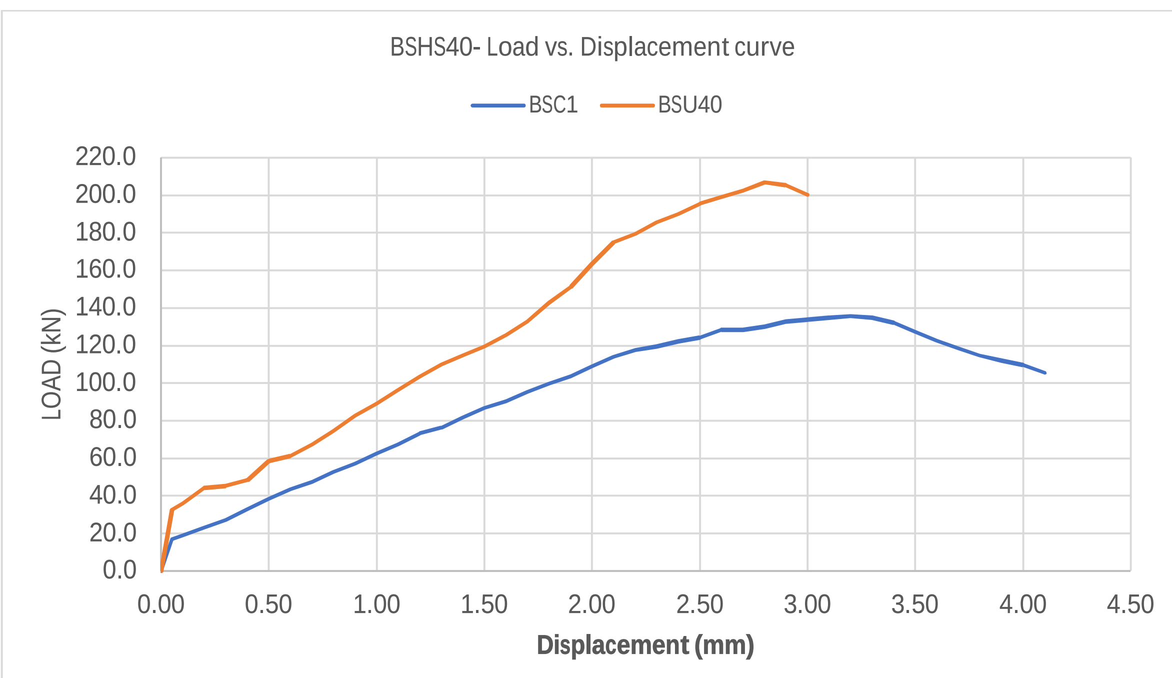


Figure 8Load vs. Displacement curve for BSU40

1) *Behaviour of Initially Strengthened Beams:* Here, all initially strengthened beam were compared to Control beam BSC1. Highest ultimate load was achieved in U-shape and lowest ultimate load achieved in half side wrapped beam at middle on

both the faces of the beam.

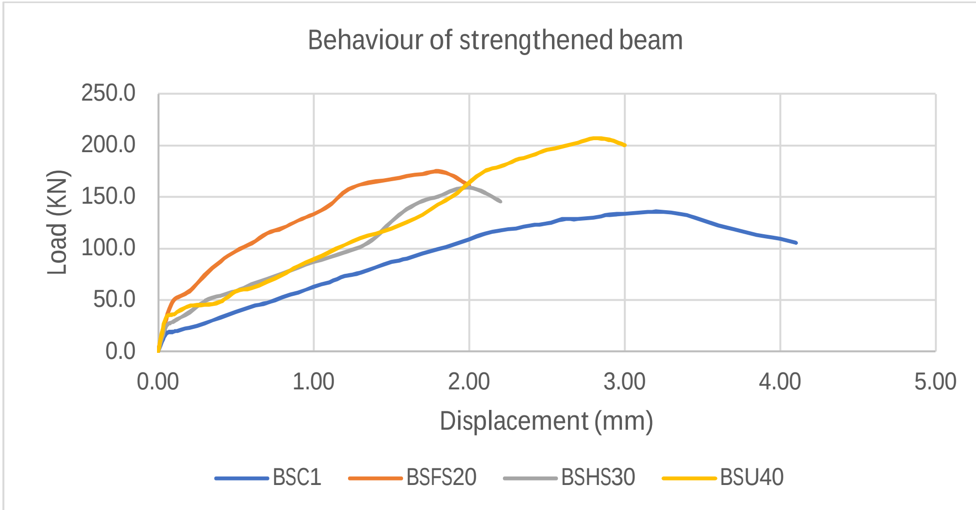


Figure 9 Behaviour of strengthened beam

2) *Comparison of Ultimate Load:* From the results, it was clear that after strengthening with CFRP sheet ultimate load capacity of beam was increased. Here in table the results are shown. Highest strength was achieved in U wrapping.

Beam	Ultimate load (kN)	% Increase (Compare to BSC1)
BSC1	135.7	-
BFSF20	174.9	28.89%
BSHS30	159.1	17.24%
BSU40	206.8	52.39%

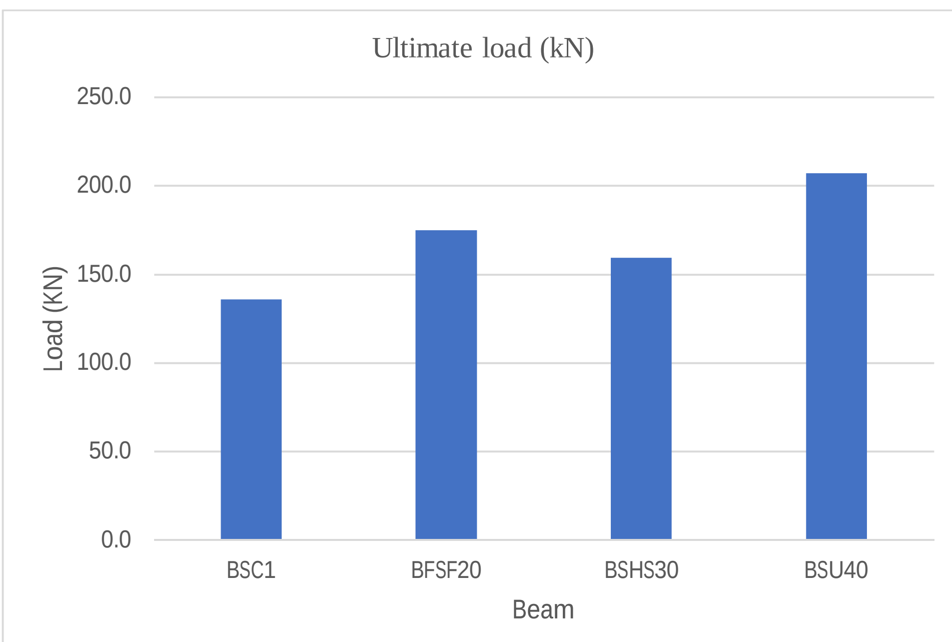


Figure 10 Comparison of ultimate load

3) *Comparison of Ultimate displacement:* From the results, it was clear that after strengthening with CFRP sheet ultimate displacement of beam was decreased. Here in table the results are shown. From graph, highest 43.75% displacement was decreased in full side wrapping.

Beam	Ultimate Displacement (mm)	% Decrease (Compare to BSC1)
BSC1	3.2	-
BFSF20	1.80	43.75%
BSHS30	2.00	37.50%
BSU40	2.80	12.50%

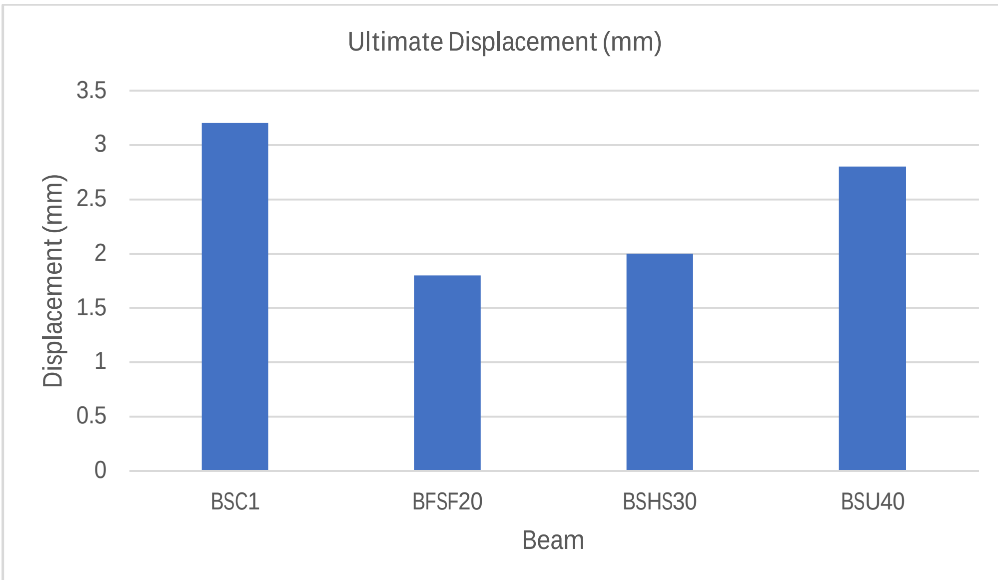


Figure 11 Comparison of Ultimate Displacement

VI. CONCLUSION

Following critical remarks observed from this research work was;

A. The ultimate load was enhanced for BSFS20 28.89% in comparison with control beam BSC1, but displacement 43.75% reduced.
B. The ultimate load was enhanced for BSHS30 17.24% in comparison with control beam BSC1, but displacement 37.50% reduced.
C. The ultimate load was enhanced for BSU40 52.39% in comparison with control beam BSC1, but displacement 12.50% reduced.
D. So, to obtain maximum strength U wrap is better than another Configurations. We can provide more than 50% shear strength to beams by using U wrapping method.
E. Also, we can reduce the displacement in beam by using CFRP sheet which gives more stiffness to beam**.**

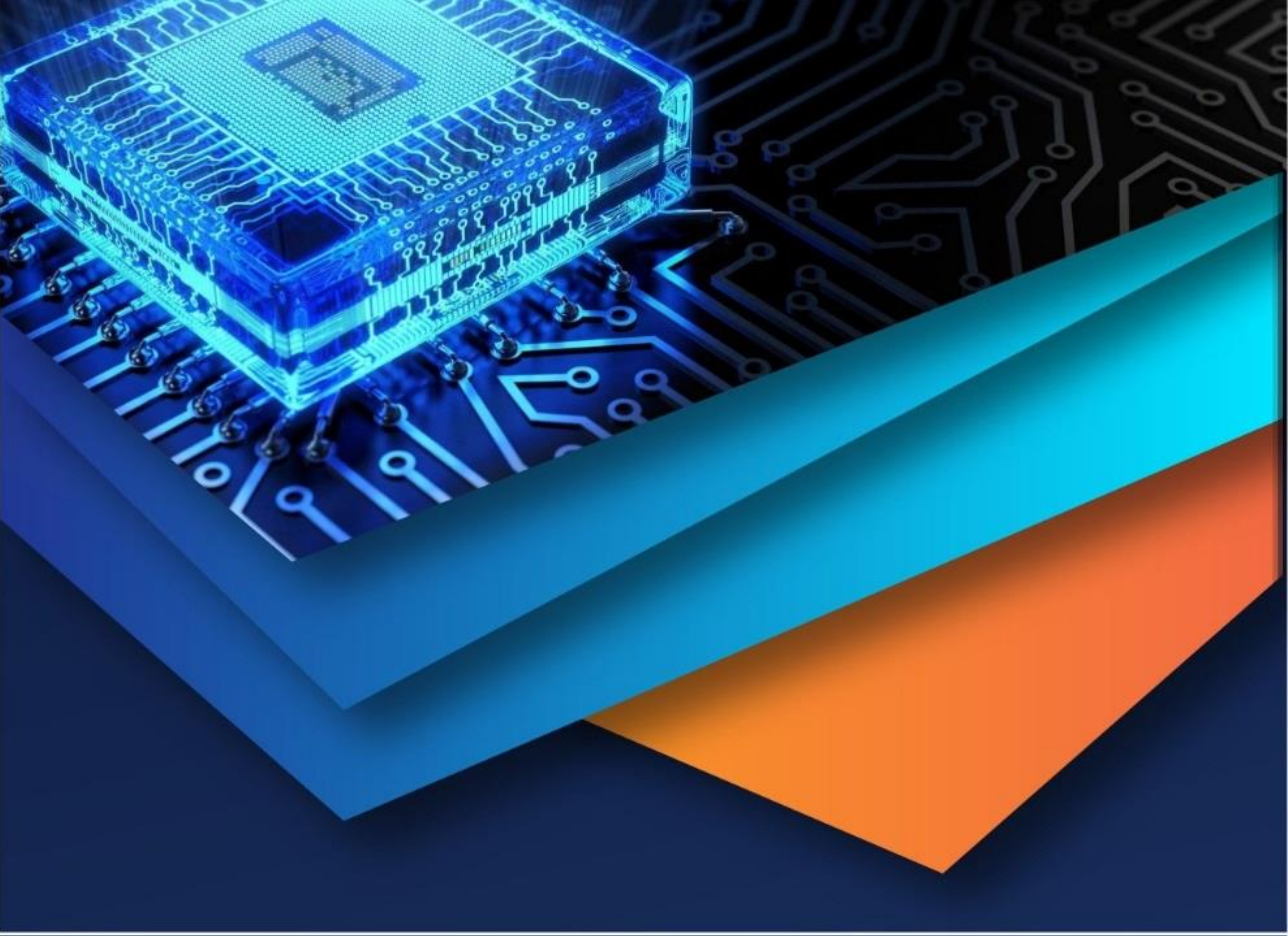
VII. ACKNOWLEDGEMENT

Research reported in this research was supported by Gujarat Council of Science and Technology (GUJCOST), Department of science and technology, Government of India. This support is greatly acknowledged.

REFERENCES

[1] A.Ramezanianp, Mahdi khani, Ahmadibeni, “The effect of rice husk ash on mechanical properties and durability of sustainable concretes”, International journalnof civil engineering, Vol.7, no. 2, june 2009
[2] Ade Sri Wahyuni, FepySupriani, Elhusna, Agustin Gunawan, “The performance of concrete with rice husk ash, sea shell ash and bamboo fiber addition”Procedia Engineering 95 (2014) 473 – 478.
[3] A. E. Abalaka, “Strength and some durability properties of concrete containing ricehusk ash produced in a charcoal incinerator at low specific surface”,

international journal of concrete structures and materials vol.7, no.4, pp.287– 293, December 2013.
[4] Anju maryealias, Rajeena a p, Sivadutt s, asst. Prof. Life john, asst. Prof.Anjupaul, "Improvement of strength of concrete with partial replacement of course aggregate with coconut shell and coir fibres", iOS journal of mechanical and civil engineering (iosr-jmce), volume 11, issue 3 ver. Ii (may- jun.2014), pp 16-24.
[5] Chao-Lung Hwang a, Vu-An Tran, Jhih-Wei Hong and You-Chuan Hsieh, "Effects of short coconut fiber on the mechanical properties, plastic cracking behavior, and impact resistance of cementitious composites" Construction and Building Materials 127 (2016) 984–992.
[6] C. Mathiraja, "A study on concrete using bottom ash, manufacturing sand and hybrid steel and coir fibres" iosr journal of mechanical and civil engineering (iosr-jmce), volume 10, issue 1 (nov. - Dec. 2013), pp 55-57.
[7] DivyaChopra, Rafat Siddique, Kunal, "Strength, permeability and microstructure of self-compacting concrete containing rice husk ash", Bio Systems Engineering 130 (2015) 72-80.
[8] Hwang Chao-Lung, Bui Le Anh-Tuan, Chen Chun-Tsun, "Effect of rice husk ash on the strength and durability characteristics of concrete", Construction and Building Materials 25 (2011) 3768–3772.
[9] KhusbuRajhans, Proff.C.R.Sharma,"Studies on concrete characteristic strength using fly ash and rice husk ash", int. Journal of engineering research and applications, vol. 4, issue 2(version5), February 2014, pp 40-44
[10] Majid Ali, Anthony Liu, HouSou and NawawiChouw, "Mechanical and dynamic properties of coconut fibre reinforced concrete", Construction and Buildingn Materials 30 (2012) 814–825.
[11] M. Jamil, A.B.M.A. Kaish, S.N. Raman, M.F.M. Zain, "Pozzolanic contribution of rice husk ash in cementitious system", Construction and Building Materials 47 (2013) 588–593.
[12] M. Sivarajas. Kandasamy, "Potential reuse of waste rice husk as fibre composites in concrete", asian journal of civil engineering (building and housing) vol. 12, no. 2 (2011) pages 205-217.
[13] pravin v domke, "Improvement in the strength of concrete by using industrial and agricultural wast", iosr journal of engineering apr.2012, vol. 2(4) pp:755-759.
[14] Pravin v domke,Sandesh d deshmukh,Satish d kene,R.S.Deotale, "Study of various characteristic of concrete with rice husk ash as a partial replacement ofcement with natural fibers (coir)", international journal of engineering research and applications, vol. 1, issue 3, pp.554-562
[15] SaeidHesami, Saeed Ahmadi, Mahdi Nematzadeh, "Effects of rice husk ash and fiber on mechanical properties of pervious concrete pavement", Construction and Building Materials 53 (2014) 680–691
[16] Sandesh D.Deshmukh, Pravin v.Domke, Satish d. Kene, R. S. Deotale,"Experiment al study on strength of concrete by using artificial fibers with rice husk ash", international journal of engineering research and applications (ijera), vol.1, issue 3, pp.571-581
[17] S.N. Raman, T. Ngo, P. Mendis, H.B. Mahmud,"High-strength rice husk ash concrete incorporating quarry dust as a partial substitute for sand", Construction and Building Materials 25 (2011) 3123–3130
[18] Satish d.Kene,Pravin.V.Domke,Sandesh d.Deshmukh,R.S.Deotale,"Assessment of concrete strength using flyash and rice husk ash",international journal of engineering research and applications(ijera), vol.1, issue 3, pp.524-53.



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