International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Email:editorijoer@gmail.com http://www.ijoer.in

Vol.4., Issue.2., 2016
(Mar-Apr)

RESEARCH ARTICLE

ISSN: 2321-7758

EFFECT OF LENGTH, WIDTH & THICKNESS OF GFRP ON STRENGTHENING OF UNCRACKED REINFORCED LIGHT WEIGHT CONCRETE BEAM

SATISH S. KOTWAL[1], MAYUR.M.MORE[2], Dr.H.S.JADHAV[3]
[1,2]Assistance Professor, Bharati Vidyapeeth's College of Engineering, Kolhapur,
[3]Professor, Rajarambapu Institute of Technology Sakhrale, Islampur

ABSTRACT

Normal Reinforced Concrete has its unit weight about 25 to 26 KN/m^3. This increases size of structural member due to its self-weight, which is uneconomical. There are many ways to reduce self-weight of the structural member such as replacing normal aggregate by lightweight aggregate like pumice partially or fully. This paper is devoted towards experimental study of flexural strengthening of uncracked reinforced lightweight concrete beam. Total 36 nos of beams were studiedhavingsame size 100mmx150mmx1000mm. For study purpose various configuration of GFRP stripsare attached on tension face of the uncracked beam. The study includes different configuration of lengths, widths and thickness of GFRP strips. All beams were tested under flexural loading and comparison of result is carried out over reference beam and beams attached with GFRP strips with various configurations. It is observed that beam strengthened with GFRP strip not only exhibited relatively good ductile behavior but also as width of GFRP strip increases on the tension face of beam increases load carrying capacity of beam under flexure loading compared with reference beam.

Keywords: Uncracked, Lightweight, GFRP,Pumice, Ductility.

I. INTRODUCTION

Ample qualitative research has been conducted on a natural or artificial lightweight aggregate. The mix design of lightweight concrete used for structural purpose is more complicated because this lightweight aggregate are porous. So water absorption is more than normal aggregate. In present study pumice is used as lightweight natural aggregate instead of normal aggregate. This lightweight concrete may get damage due to overloading, faulty mix design, defective construction practices and there may be change in use, effective strengthening technique is needed to regain their structural capacity. The use of FRP for repair and retrofit is widely accepted practice. FRP is an excellent choice for strengthening due to its high strength and stiffness to weight ratio low installation and maintenance cost, high ductility, available in any length and can be moulded to any shape.

II. RESEARCH SIGNIFICANCE

To study the flexural behavior and mode of failure of reinforced uncracked lightweight concrete beam. When it is strengthen on tension side of beam by different configuration of length, width and thickness of GFRP strips.

III. EXPERIMENTAL WORK

A. Mix design for structural lightweight aggregate concrete

Experimental work consists of mix design for M20 grade concrete by using naturalpumice as coarse aggregate in concrete. Pumice aggregate size less than 20mm is usedwater absorption of pumice aggregate is more than 30% so, aggregates are pre-soaked.Locally available sand & 43-garde cement is used. Beams were cured for 28days in pure drinking water.

B. Details of beam specimen

The experimental work consisting of 36 rectangular under reinforced beams. Allbeams were having same size 100mmx150mmx1000mm. Reinforced with 2 no's of 8mm diameter bars were usedfor flexural reinforcement at bottom and 2 no's of 6mm at top of each beam. 6mm diameterbars used as stirrups spaced at 150 mm c/c for shear reinforcement. All beams casted with M20 gradeconcrete.

C. Preparation of test beams and Notations.

The beam specimens were divided into 13 groups as follows:

i. Type I-Reference beam RF,
ii. Type- II UncrackedBeam strengthened using triple layer GFRP strip (1000x100) UTD,
iii. Type III Uncracked Beam strengthened using double layer GFRP strip (1000x100) UDD,
iv. Type IV Uncracked Beam strengthened using single layer GFRP strip (1000x100) USD,
v. Type V Uncracked Beam strengthened using triple layer GFRP strip (500x100) UTB,
vi. Type VI Uncracked Beam strengthened using double layer GFRP strip (500x100) UDB,
vii. Type VII Uncracked Beam strengthened using single layer GFRP strip (500x100) USB,
viii. Type- VIII Uncracked Beam strengthened using triple layer GFRP strip (1000x50) UTC,
ix. Type IX Uncracked Beam strengthened using double layer GFRP strip (1000x50) UDC,
x. Type X Uncracked Beam strengthened using single layer GFRP strip (1000x50) USC,
xi. Type XI Uncracked Beam strengthened using triple layer GFRP strip (500x50) UTA,
xii. Type XII Uncracked Beam strengthened using double layer GFRP strip (500x50) UDA,
xiii. Type XIII Uncracked Beam strengthened using single layer GFRP strip (500x50) USA,

Bottom surfaces ofthese beams were cleaned to assure a good bond between GFRP strip and concretesurface. Cracked and pre cracked were externally bonded with GFRP strip and epoxyat bottom face of beam as per the procedure laid down by the manufacture.

D. *Testprocedure*

All beam specimens were instrumented and loaded simply supported. The load was applied through UTM (600 KN). All beams were tested under twopoint loading. They were statically tested to failure at equal 5KN increment of load.During loading the mid span deflection was measured by using dial gauge. Load &deflection readings were recorded for each stage. The results of all beam tests were summarised in fig.1 to 13. Cracks formed on the surfaces were marked and identified,load and deflection characteristics.

IV. RESULTS AND DISUSSIONS

A. Width Comparison

In width Comparison study of uncracked beams attached with GFRP strips with single, double and triple layers having 50 mm and 100mm width of GFRP strip with constant length of 1000mm is carried out.

i. Comparison of uncracked beam strengthened using single layer GFRP strip (1000x100) USDand uncracked beam strengthened using single layer GFRP strip (1000x50) USC

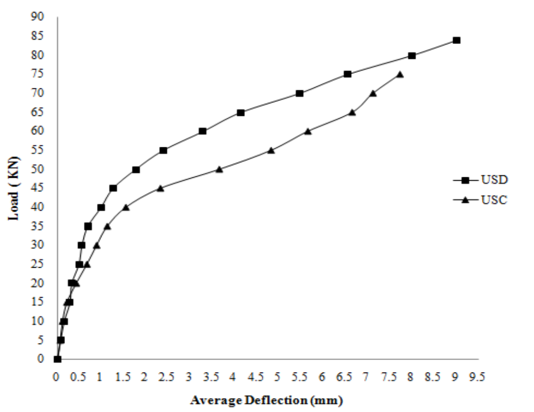

Figure:-1 Load Vs Avg. Deflection curve USC, USD

Above beam were strengthened with 50mm and 100mm wide GFRP strip the bottom of beam having same length 1000mm from figure 1 it isobserved that as width of strip increases beam ductility increases. For 100mm wide strip ultimate load is increased by 12% as compared to 50mm width strip.

ii. Comparison of uncracked beam strengthened using double layer GFRP strip (1000x50) UDC and uncracked beam strengthened using double layer GFRP strip (1000x100) UDD

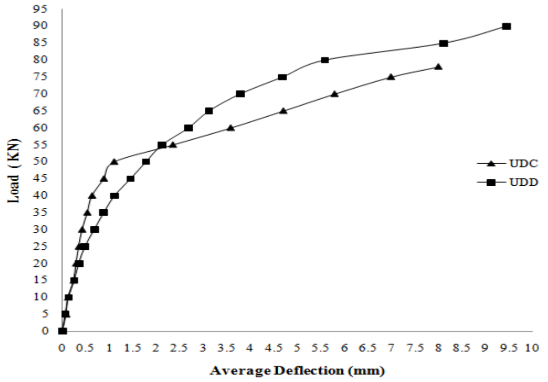

Figure:-2 Load Vs Avg. Deflection curve UDC, UDD.

Above beam were strengthened with 50mm and 100mm wide GFRP strip the bottom of beam having same length 1000mm. Figure 2 it isobserved that, as width of strip increases beam ductility increases. For 100mm wide strip ultimate load is increased by 15% as compared to 50mm width strip.

iii. Comparison of uncracked beam strengthened using triple layer GFRP strip (1000x50) UTC and uncracked beam strengthened using triple layer GFRP strip (1000x100) UTD

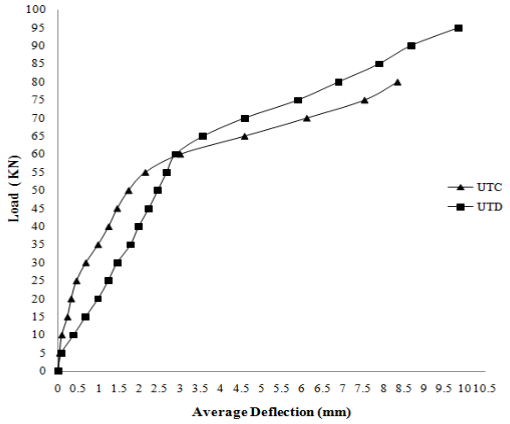

Figure:-3 Load Vs Avg. Deflection curve UTC, UTD

Above beam were strengthened with 50mm and 100mm wide GFRP strip the bottom of beam having same length 1000mm. Figure 3 it isobserved that as width of strip increases beam ductility increases. For 100mm wide strip ultimate load is increased by 18% as compared to 50mm width strip.

B. Length Comparison

In lengthComparison study of uncracked beams attached with GFRP strips with single, double and triple layers having 500mm and 1000mm length of GFRP strip with 50mm and 100mm widthis carried out.

i. Comparison of uncracked beam strengthened using single layer GFRP strip (500x50) USA and uncracked beam strengthened using single layer GFRP strip (1000x50) USC

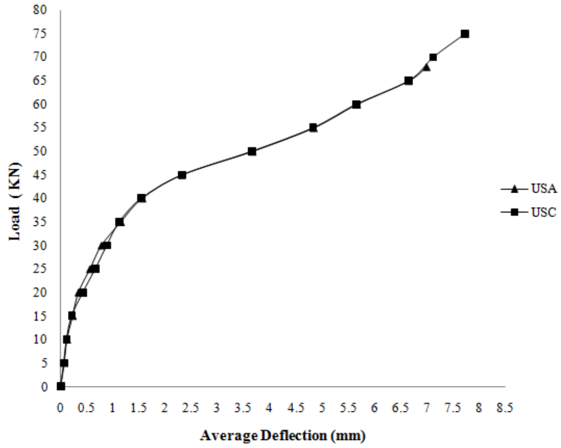

Figure:-4 Load Vs Avg. Deflection curve USA, USC

Figure 4 shows load Vs deflection curve at mid span beam strengthened with GFRP strips in single layer with constant width 50mm and varying length 500mm and 1000mm.

All strengthened beam specimen responded in the same manner, varying only at points of failure. As length of GFRP strip increases load carrying capacity and deflection increases. Compared 1000mm length strip with 500mm length strip load is increased by 10 %.

ii. Comparison of uncracked beam strengthened using double layer GFRP strip (500x50) UDA and uncracked beam strengthened using double layer GFRP strip (1000x50) UDC

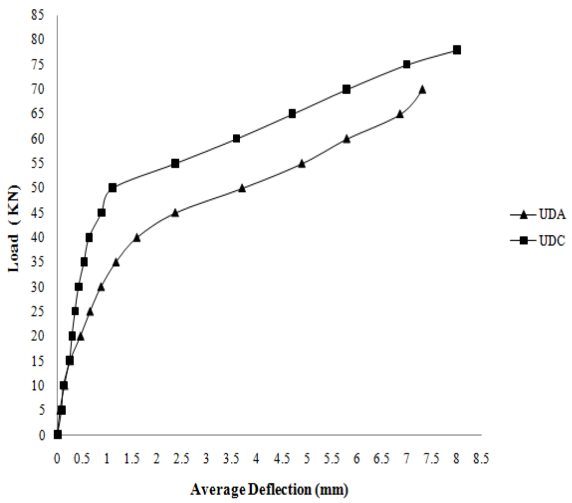

Figure:- 5 Load Vs Avg. Deflection curve UDA, UDC

Figure 5 shows load Vs deflection curve at mid span beam strengthened with GFRP strips in double layer with constant width 50mm and varying length 500mm and 1000mm.

All strengthened beam specimen responded in the same manner, varying only at points of failure. As length of GFRP strip increases load carrying capacity and deflection increases. Compared 1000mm length strip with 500mm length strip load is increased by 11 %.

iii. Comparison of uncracked beam strengthened using triple layer GFRP strip (500x50) UTA and uncracked beam strengthened using triple layer GFRP strip (1000x50) UTC

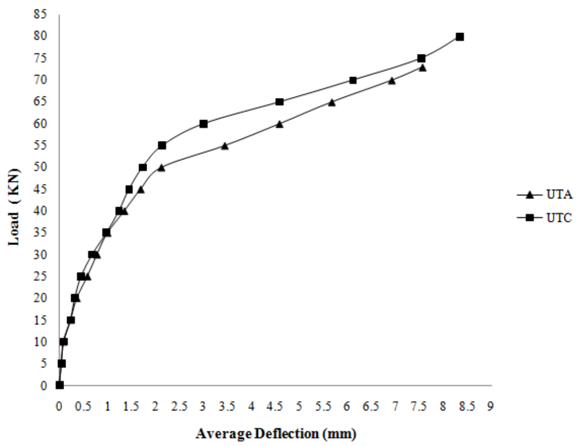

Figure:- 6 Load Vs Avg. Deflection curve UTA, UTC

Figure 6 shows load Vs deflection curve at mid span beam strengthened with GFRP strips in triple layer with constant width 50mm and varying length 500mm and 1000mm.

All strengthened beam specimen responded in the same manner, varying only at points of failure. As length of GFRP strip increases load carrying capacity and deflection increases. Compared 1000mm length strip with 500mm length strip load is increased by 8%.

iv. Comparison of uncracked Beam strengthened using single layer GFRP strip (1000x100) USD and uncracked beam strengthened using single layer GFRP strip (500x100) USB

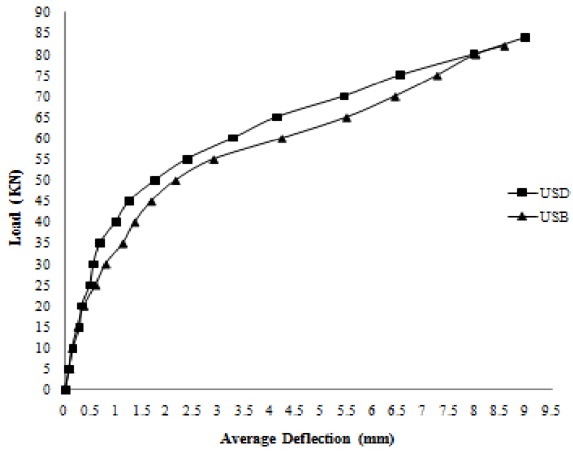

Figure:-7 Load Vs Avg. Deflection curve USB, USD.

Figure 7 shows load Vs deflection curve at mid span beam strengthened with GFRP strips in single layer with constant width 100mm and varying length 500mm and 1000mm.

All strengthened beam specimen responded in the same manner, varying only at points of failure. As length of GFRP strip increases load carrying capacity and deflection increases. Compared 1000mm length strip with 500mm length strip load is increased by 2%.

v. Comparison of uncracked beam strengthened using double layer GFRP strip (500x100) UDB and uncracked beam strengthened using double layer GFRP strip (1000x100) UDD

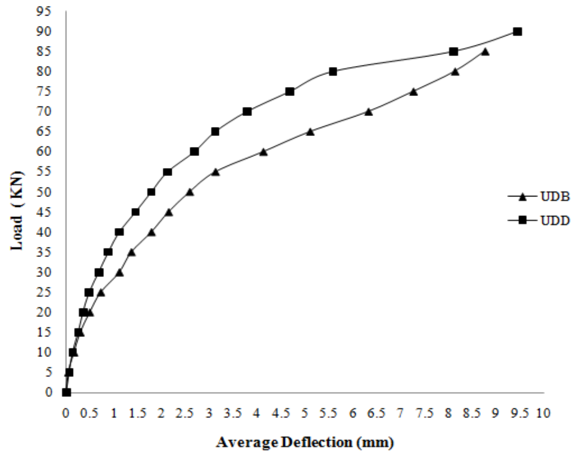

Figure:-8 Load Vs Avg. Deflection curve UDB, UDD

Figure 8 shows load Vs deflection curve at mid span beam strengthened with GFRP strips in double layer with constant width 100mm and varying length 500mm and 1000mm.

All strengthened beam specimen responded in the same manner, varying only at points of failure. As length of GFRP strip increases load carrying capacity and deflection increases. Compared 1000mm length strip with 500mm length strip load is increased by 5%.

vi. Comparison of uncracked beam strengthened using triple layer GFRP strip (500x100) UTB and uncracked beam strengthened using triple layer GFRP strip (1000x100) UTD

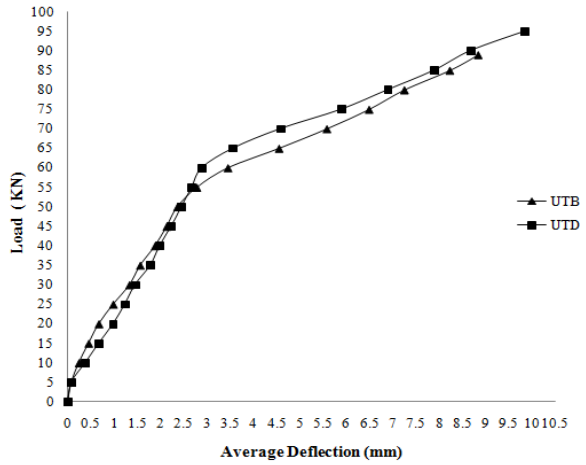

Figure:-9 Load Vs Avg. Deflection curve UTB, UTD

Figure 9 shows load Vs deflection curve at mid span beam strengthened with GFRP strips in triple layer with constant width 100mm and varying length 500mm and 1000mm.

All strengthened beam specimen responded in the same manner, varying only at points of failure. As length of GFRP strip increases load carrying capacity and deflection increases. Compared 1000mm length strip with 500mm length strip load is increased by 6%.

C. Comparison of thickness

In thickness comparison study of uncracked beams attached with GFRP strips with single, double and triple layers having same width and length are compared with reference beam.

i. Comparison of uncracked beam strengthened using single layer GFRP strip (500x50) USA and uncracked beam strengthened using double layer GFRP strip (500x50) UDA and uncracked beam strengthened using triple layer GFRP strip (500x50) UTA and reference beam RF

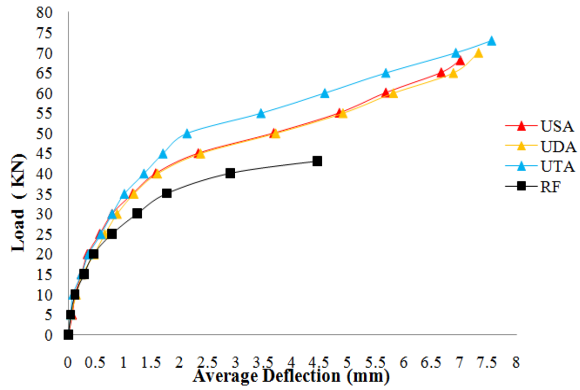

Figure:-10 Load Vs Avg. Deflection curve RF, USA, UDA, UTA

From figure 10 it is observed that initial load Vs deflection is linear up to 40 KN than slightly curved and deflection rate is increased as load increases. It is observed that ultimate load is increased as numbers of layers are increased. Ultimate load of triple layer is increased by 4%, 7%, and 69% respectively as compared with double layer, single layer and reference beam.

ii. Comparison of uncrackedbeam strengthened using single layer GFRP strip (500x100) USB and uncracked beam strengthened using double layer GFRP strip (500x100) UDB and uncracked Beam strengthened using triple layer GFRP strip (500x100) UTB and reference beam RF.

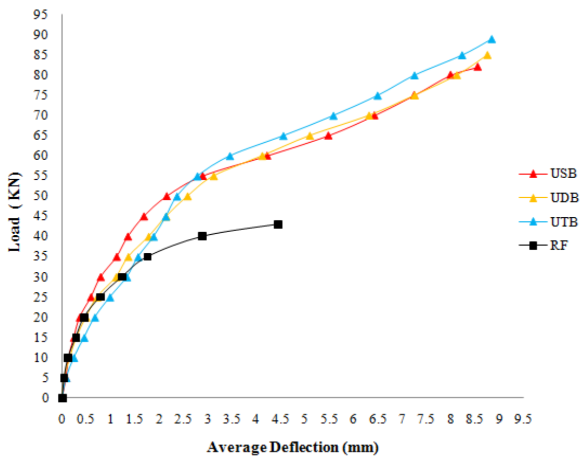

Figure:-11 Load Vs Avg. Deflection curve RF, USB, UDB, UTB

From figure 11 it is observed that initial load Vs deflection is linear up to 45 KN than slightly curved and deflection rate is increased as load increases. It is observed that ultimate load is increased as numbers of layers are increased. Ultimate load of triple layer is increased by 4%, 8%, and 106% respectively as compared with double layer, single layer and reference beam.

iii. Comparison of uncrackedbeam strengthened using single layer GFRP strip (1000x50) USC and uncracked beam strengthened using double layer GFRP strip (1000x50) UDC and uncracked beam strengthened using triple layer GFRP strip (1000x50) UTC and reference beam RF.

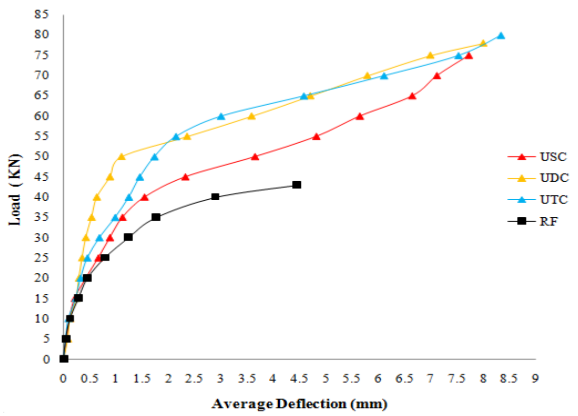

Figure:-12 Load Vs Avg. Deflection curve RF, USC, UDC, UTC

From figure 12 it is observed that initial load Vs deflection is linear up to 35 KN than slightly curved and deflection rate is increased as load increases. It is observed that ultimate load is increased as numbers of layers are increased. Ultimate load of triple layer is increased by 2%, 6%, and 86% respectively as compared with double layer, single layer and reference beam.

iv. Comparison of uncracked beam strengthened using single layer GFRP strip (1000x100) USD and uncracked beam strengthened using double layer GFRP strip (1000x100) UDD and uncracked beam strengthened using triple layer GFRP strip (1000x100) UTD and reference beam RF

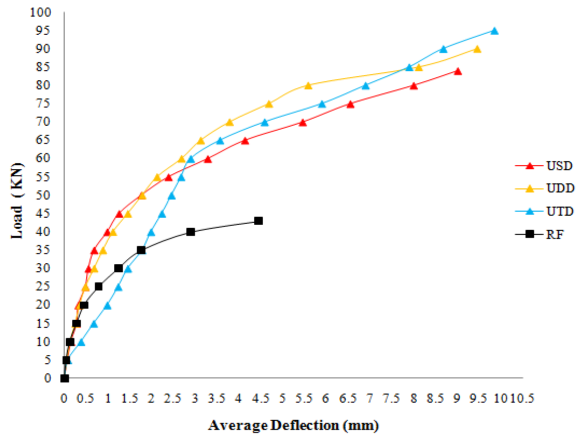

Figure 13 Load Vs Avg. Deflection curve RF, USD, UDD, UTD

From figure 13 it is observed that initial load Vs deflection is linear up to 45 KN than slightly curved and deflection rate is increased as load increases. It is observed that ultimate load is increased as numbers of layers are increased. Ultimate load of triple layer is increased by 5%, 13%, and 120% respectively as compared with double layer, single layer and reference beam.

V. CONCLUSIONS

From the above experimental study following conclusions are drawn,

- Compressive strength of lightweight concrete using Pumice as coarse aggregate is observed to be 17.55 N/mm^2 to 18 N/mm^2 with the corresponding density of 1733 kg/m^3 to 1868 kg/m^3.
- As width of GFRP strip increases on the tension face of beam, increases load carrying capacity of beam as compared with Reference beam.

- Length of GFRP strip increases, there is increase in load carrying capacity of strengthened beam as compared with Reference beam. But there is no significant increase in load and deflection when compared with different length of GFRP strips.
- Thickness of GFRP strip increase load carrying capacity when compared triple layer GFRP of various configuration with Reference beam there is tremendous increase in load carrying capacity and deflection. But when compared triple, double and single layer GFRP of various configuration there is no significant increase in load carrying capacity and deflection.
- Beam strengthened with GFRP strip exhibited relatively good ductile behavior. All beam exhibited ductile failure modes.
- The number of cracks and their widths were experimentally reduced as the beam strengthened by varying lengths, widths and thickness of GFRP strip.

VI. REFERENCE

[1]. Sivakumar and Gomathi(2012) , "Pelletized Fly Ash Lightweight Aggregate Concrete: A Promising Material," Journal of Civil Engineering and Construction Technology, Vol.3(2).pp 42-48.

[2]. By H. Saadatmanesh and M. R. Ehsani(2012), "Fibre Composite Plates can Strengthen Beams," Concrete International, March. Pp 65-70.

[3]. Delsye C. L. Teo, Md. Abdul Mannan and John V. Kurian(2006), "Flexural Behaviour of Reinforced Lightweight Concrete Beams made with Oil Palm Shell(OPS),"Journal of Advanced Concrete Technology, Vol. 4, Oct. pp 459-467.

[4]. Fadia s. Kallak(2009), "Use of Crushed Bricks as Coarse Aggregate in Concrete," Tikrit Journal of Engg Science, Vol.(16) Sep.pp 64-69.

[5]. Haider M. Al-Baghdadi(2011), "Using local Materials Wastes for Development of High Strength Lightweight Concrete,"Pure and Applied Sciences,Vol.(19).

[6]. IS 10262:2009, Bureau of Indian Standard-Concrete Mix Proportioning Guidelines(First Revision)

[7]. IS 456:2000, Bureau of Indian Standard-Plain and Reinforced Concrete-Code of Practice(Fourth Revision)

[8]. IS 516:1969, Bureau of Indian Standard-Methods of Test for Strength of Concrete

[9]. KsenijaJankovic, DraganBojovic, DraganNikolic, LjiljanaLoncar and ZoranRomakov(2010), " Frost Resistance of Concrete with Crushed Brick as Aggregate, "Architecture and Civil Engineering, Vol. (8) Nov. pp 155-162.

[10]. MahyuddinRamli and EetharThanoonDawood(2010) , "Effects of Palm Fibre on The Mechanical Properties of Lightweight Concrete Crushed Bricks, "American Journal of Engineering and Applied Sciences, Vol. 3(2). pp 489-493.

[11]. Mix Design Manual, Durocrete Engineering Services Pvt. Ltd.

[12]. N. ShivlingaRao, Y. RadhaRatnaKumari, V. Bhaskar Desai, and B. L. P. Swami(2013) , "Fibre Reinforced Lightweight Aggregate (Natural Pumice Stone) Concrete, "International Journal of Scientific and Engineering Research, Vol.(4)May. pp 158-161.

[13]. Samuel Green, Nicholas Brooke, Leonard Mcsaveney and Jason M. Ingham(2011), "Mixture Design Development and Performance Verification of Structural Lightweight Pumice Aggregate Concrete, "Journal of Materials in Civil Engineering, Aug. pp 1211-1219.

[14]. Samuel Green, Nicholas Brooke and Len Mcsaveney(2008) , "Pumice Aggregates for Structural Lightweight and Internally Cured Concretes,"

[15]. Vishwanath K. G, D. S. Prakash and K. B. Prakash (2008), "The Flexural Behaviour of Hybrid Fibre Reinforced Concrete Beams with GFRP Wrappings," The Indian Concrete Journal, Oct. pp 11-17.

[16]. Manguriu Geoffrey N, Mutku Raphael. N, Oyawa Walter. O and AbuodhaSilvester O.(2012), "Properties of Pumice Lightweight Aggregate,"IISTE, Vol.(2). pp 58-67.