SSRG International Journal of Mechanical Engineering
ISSN: 2348 – 8360 / 10.14445/23488360/IJME-V6I5P105
Volume 6 Issue 5, 32-40, May 2019

Investigation of Mechanical Properties of Horse Hair and Glass Fiber Rein Forced Hybrid Polymer Composite

Mamaru wutabachew[1], Dr. Negash Alemu (Ass. Prof.)

[1]*Department of Mechanical Engineering, Addis Ababa Science and Technology University Addis Ababa, Ethiopia*
[2]*Department of Mechanical Engineering, deface university college of engineering Bishoftu, Ethiopia*

Abstract *- this paper assesses the mechanical properties of horse hair/epoxy resin, glass fiber /epoxy resin and horse hair/glass fiber/epoxy resin hybrid composite. The weight percentage and staking sequence (orientation) of fiber has impact on mechanical properties like tensile strength, compressive strength and flexural strength. Afterward testing the composite; it is clear that there is a basic effect of weight percentage and orientation in mechanical property of composite. The test out comes are drawn and conclusion are made with comparing the result of horse hair/epoxy and glass fiber /epoxy with hybrid of glass fiber and horse hair fiber. The result also shows the hybrid one is preferred.*

Keywords — *glass fibre, horse hair, hybrid, mechanical property.*

I. INTRODUCTION

Composite materials are emerged as new generation structural materials quenching the needs and demands of rapid growing industrial, automotive and aerospace sectors. Composites are created artificially by combining two or more materials of different characteristics. Composites are characterized by length, size, orientation, volume/weight fraction of fibres and properties comprised by both fibres and matrix.

To enhance the properties of the composites more than one fibre is used with single matrix, known as Hybrid Composites. Among various types of fibres used in the preparation of composites Natural fibres plays predominant role.[1]improved properties can be achieved by hybridizing natural fibre-based composites with glass fibres [2] Natural fibres are lighter and cheaper, but they have low mechanical properties than glass fibres. So, this paper provides overview of Natural (horse hair)-glass fibre reinforced polymers. The mechanical properties such as tensile strength, compressive strength and bending strength of horse hair/ epoxy, glass fibre/ epoxy and glass fibre/horse hair /epoxy hybrid composite is considered. The weight percentage increment is 20% and orientation of fibre is 0^0,90^0,0-90^0. The total weight percentage of fibre is 70% and epoxy is 30%. 13 differentcomposite material is made.

Three horse hair/epoxy, three glass fiber/epoxy and four glass fiber/horse hair/epoxy hybrid composite with different weight percentage and the remaining three is hybrid of two fibers with equal percentage fibers but, they have different orientation. For each 13 different composite materials three sample spacemen is prepared. After performing the test, the average value of the result is taken for each test andcomparative study is done.

II. LITERATURE SURVEY

Srinivas Nunna [2] this paper review Hybrid composites by combining two or more fibers in a single matrix. Hybrid composites can be made from artificial fibers, natural fibers and with a combination of both artificial and natural fibers. this review can be attributed to the significant aspects of natural fiber-based hybrid composites which are found to be predominantly affected by factors which include variation in fiber volume/weight fraction, variation in stacking sequence of fiber layers, fiber treatment and environmental conditions. Hybrid composites can help us to achieve a better combination of properties than fiber reinforced composites.

Hamidullah Naik and his colleagues **[**3**]** studies effect of horse hair on plain cement concrete on the basis of its compressive, crushing, flexural strength, cracking control and heat resistant to economize concrete and to reduce environmental problems. Experiments were conducted on concrete beams and cubes with various percentages of horse hair fiber i.e. 0%, 1%, and 2%, by weight of cement. For each combination of proportions of concrete one beam and three cubes are tested for their mechanical properties. By testing of cubes and beams we found that there is an increment in the various properties and strength of concrete by the addition of horse hair as fiber reinforcement and were tested for heat resistance.

Sanjay M Ra, Arpitha G Ra & B Yogeshaa [4] this review has been carried out to make use of natural fibers that is plant fiber (such as abaca, banana, bamboo, cotton, coir, hemp, jute, pineapple, sisal

etc.). the review is carried out Glass Fiber Reinforced Polymers are mixing with natural fibers to increase Engineering and Technology applications. So This paper presents a review on the mechanical properties of natural (plant fiber)-glass fiber reinforced polymer composites.

Somashekar S M, Manjunath V, Gowtham M J, Balasubramaniam N S [5**]**In this study untreated continuous Hemp Fiber-Bi directional woven E Glass fiber reinforced hybrid polymer matrix composite laminates are developed and tested for its mechanical properties such as tensile, compression and flexural as per ASTM standards by varying fibers proportions. The obtained results yield that natural fiber composites performed equally or more than synthetic fibers such as Glass fibers.

Suresha K V [6] In this study, natural hybrid reinforced composites panels are made with Hemp fabric/glass fabric/Epoxy and Hemp fabric/carbon fabric/Epoxy 3mm thickness and composites are fabricated using Simple hand layup technique. Appropriate test methods as per standards and guidelines are followed to analyze mechanical behavior of the composites. The physical and mechanical characteristics of the natural hybrid reinforced composites used for the fabrication of the sandwich panels are tested as per the ASTM standards. To characterize the tensile, compression and flexural properties of the natural composites, a series of tensile test, compression test and 3-point bending tests were conducted on the sandwich panels. A quantitative relationship between the Hemp fabric/glass fabric/Epoxy and Hemp fabric/carbon fabric/Epoxy has been established with varying thickness.

III. MATERIALS

Materials used in the current study include commercially available epoxy resin used as a matrix. The reinforcement materials used are commercially available horse hair/glass fiber Raw material suppliers from market.

Fig.1 horse hair

Fig.2 epoxy resin

Fig.3 uni-directional glass fibre

Hardener was used as a binder during the fabrication and Wax is used to safely remove the prepared spacemen from the mold.

Fig.4 hardener

Fig.5 wax

A. procedure for preparation of laminate experimental spacemen

- Each composite laminate consists of a well compound mixture of Epoxy, Natural fibers and E glass fibers. The Natural fibers, horse hair is used in this procedure are untreated and free from chemicals.
- An open mold made up of aluminum plate of dimension 300X300 mm is prepared and the prepared composite is cut for each test.
- Using rule of mixtures, the various Fiber weight proportions are calculated to achieve laminates with 0:100, 100:0, 80:20, 20:80, 60:40 and 40:60 ratios with former being the ratio of Fiber and the latter is natural fiber. the Natural fiber/s and E Glass fibers with the total weight of the composite the fiber contain 70%.
- The composite material has six layers. The orientation of fiber is[0],[90],[0/90].The layers of a laminate are usually bonded together by the same matrix material that is used in the individual lamina. Laminates can be composed of plates of different materials or, in the present context, layers of fiber-reinforced lamina.
- Natural fibers are cut in to required length of the mold.
- Based on the weight proportion calculations appropriate amount of Natural fibers, glass fiber and resin are weighed.
- based on weighed amount the fibers is placed inside the mold as a first layer.
- Epoxy resin LY501 and the hardener HY-951 are mixed with a ratio of 2:1 before impregnating the first layered fibers.
- Apply a mixture of resin and hardener over first layered fibers.
- Uni directional E glass of has cut into required mould size and placed over impregnated fibres.
- Again, suitable amount of resin and hardener mixture is applied over previously placed E glass fibre.
- Rest of the amount of natural fibres is placed over impregnated E glass fibre as a second layer and again mixture of resin and hardener is applied.
- The resin mixture is spread up around the corners uniformly by Manual layup.
- A dead weight is placed over the open mould and left for settlement.
- After sometime the laminate is extracted from the open mould and kept in suitable temperature oven for curing.
- The composite is dried for seven day

The spaceman is prepared with cutting the plat with required dimension of each test.

IV. MECHANICAL TEST

A. Tensile test

The most common specimen for ASTM D3039 is a constant rectangular cross section, 25 mm (1 in) wide, 250 mm (10 in) long and 4mm thickness.[7]

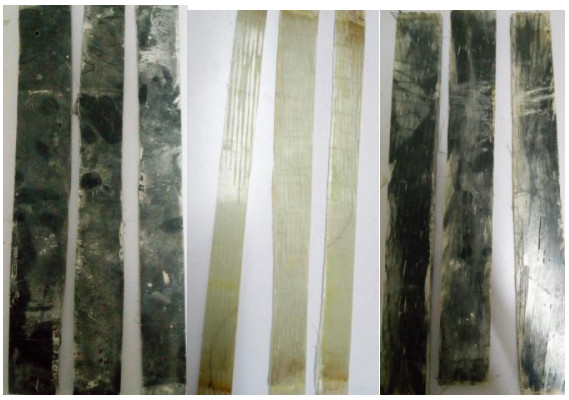


Fig. 6 spacemen for tensile test

ASTM D3039 tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress-strain diagram, which is used to determine tensile modulus.

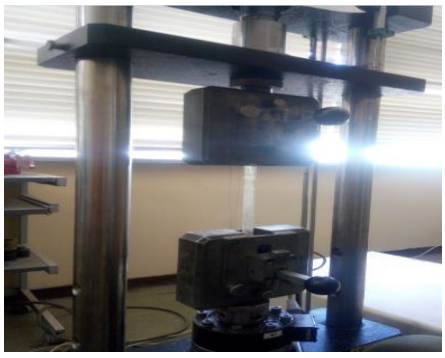


Fig.7 universal testing machine for tensile test

B. Compression test

All specimens were rectangular shape having length 50 mm width is 50 mm, thickness is 4mm. [1]

Fig.8 spacemen for compression test

The compression test was carried out in UTM machine in accordance with ASTM D 3410 to obtain the value of the compression strength of the composite materials.

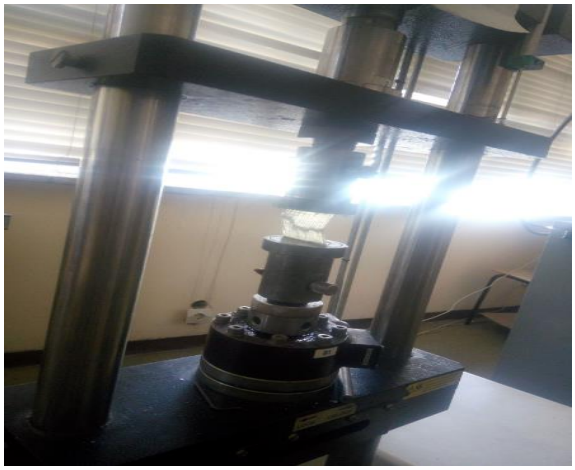


Fig.9 universal testing machine for compression test

C. Flexural test

3-Point bend flexural test is one of the simple bending tests used to determine flexural strength of a material. The specimens are prepared according to ASTM D790.[8] All the specimens (composites) were of rectangular shape having length is 150 mm, 20 mm is width and thickness of 4 mm. maintaining 100mm of span length. [1]

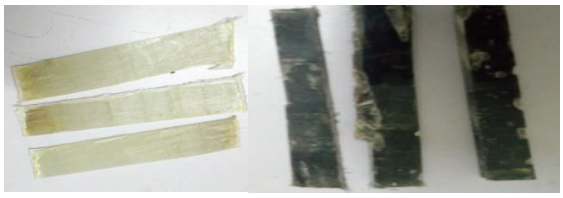


Fig.10 spacemen flexural test

Fig.11 universal testing machine for flexural test.

V. RESULT AND DISSECTION

The result of 13 different composite material with three sample for each in orientation and weight percentage is summarized in the table below.

Table:1 maximum tensile strength of three sample and its average value

NO.	Tensile strength (Mpa)	Sample 1	Sample 2	Sample 3	average	figure
1	70% pure glass fiber	157.6	252	252.8	220.8	
2	42% pure glass fiber	114	164.6	190.5	156.4	12
3	14% pure glass fiber	94.7	115.2	142.3	117.4	
4	70 pure horse hair	43.4	30.9	93.02	55.773	
5	42% pure horse hair	50	30.2	23	34.4	13
6	14% pure horse hair	24.2	26.3	20.1	23.533	
7	0-degree hybrid	146.7	107.1	127.7	127.2	
8	90-degree hybrid	3.4	6.8	4.3	4.833	15
9	0-90-degree hybrid	82.1	37.7	148.7	89.5	
10	14% glass hybrids	33.72	64.3	48.6	48.87	
11	28% glass hybrids	135.9	72.6	72.6	93.7	14
12	42% glass hybrids	205.4	108.9	140.9	151.733	
13	56%glass hybrids	306.2	254.2	288.5	282.97	

The graph of each individual one is shown below. fig.12 below shows the stress-strain diagram of glass fiber and epoxy composite. The result shows that the weight percentage of glass fiber is increasing the tensile strength of the composite is also increase. The martial property which is constant is called modules of elasticity is also increase since, modules of elasticity is the slop of stress- strain curve.

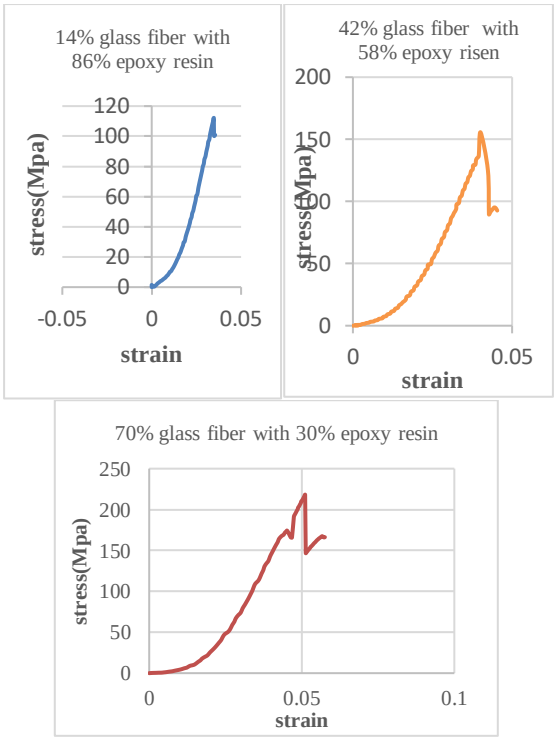


Fig.12 glass fibre epoxy composite

Figure 13 show the stress-strain diagram of horse hair with epoxy resin composite. As the weight percentage of horse hair fiber increase the tensile strength of the martial is also increase.

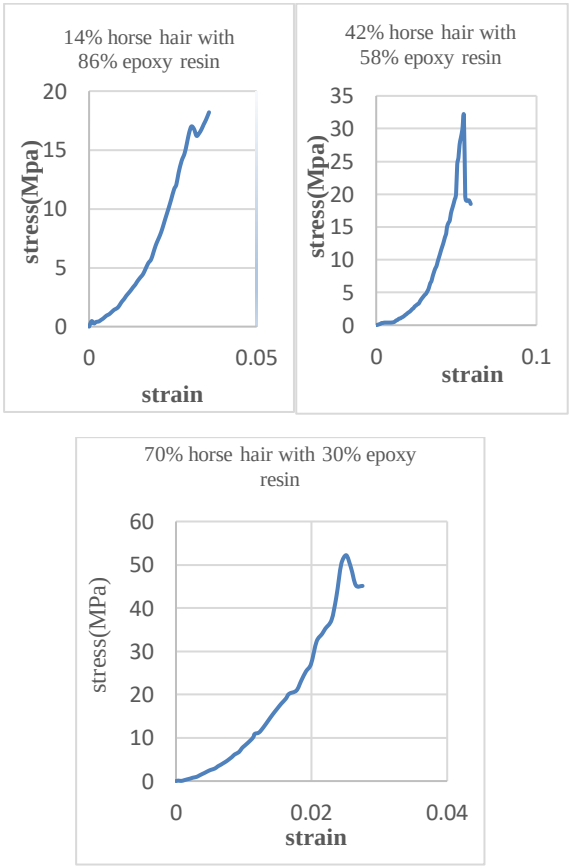


Fig.13horse hair epoxy composite

Figure 14 shows the strain-strain diagram of glass fiber and horse hair used as a reinforcement and epoxy resin as a matrix. The composite martial is hybrid. In this case the orientation is the same 0^0 but the weight percentage of fiber is changed. As shown the figure below the weight percentage of glass fiber increase the tensile strength is also increase.

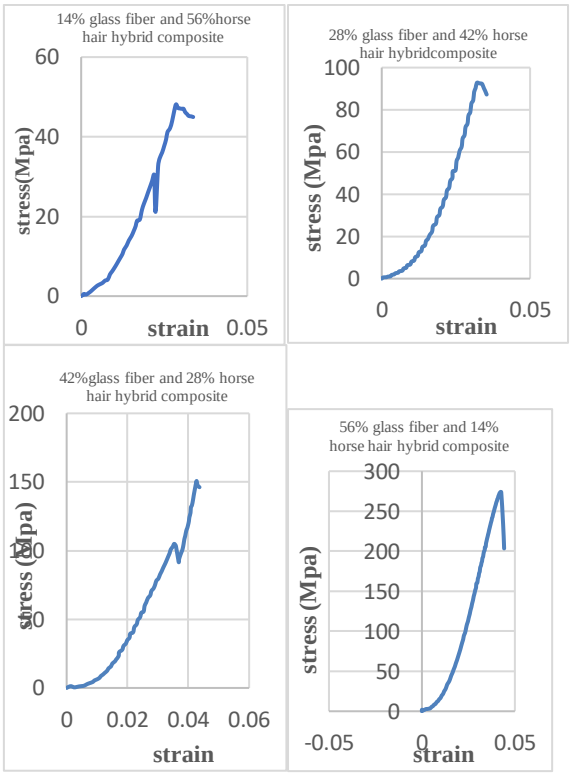
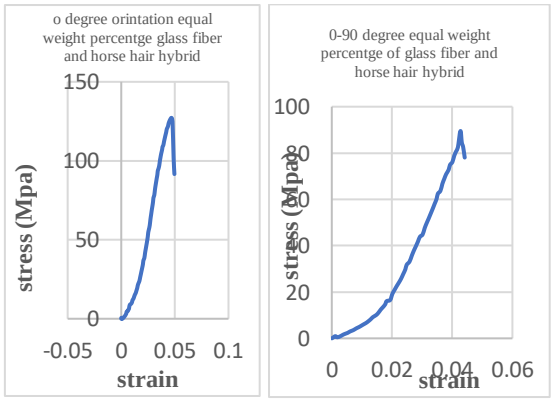


Fig.14 glass fiber horse hair epoxy hybrid composite

Figure 15 shows the stress-strain diagram of horse hair, glass fiber hybrid composite.in this case the weight percentage of the two fiber is equal but the orientation of fiber is different. The result shows the orientation angle increase the tensile strength is decrease.



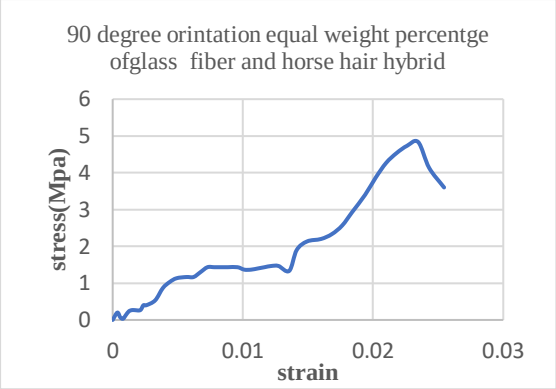


Fig.15 glass fiber horse hair epoxy hybrid with different orientation

As shown the overall graph in figure 16 below the hybrid composite have maximum tensile strength than Indusial fibre composite. The orientation also has less significance in tensile strength of material.

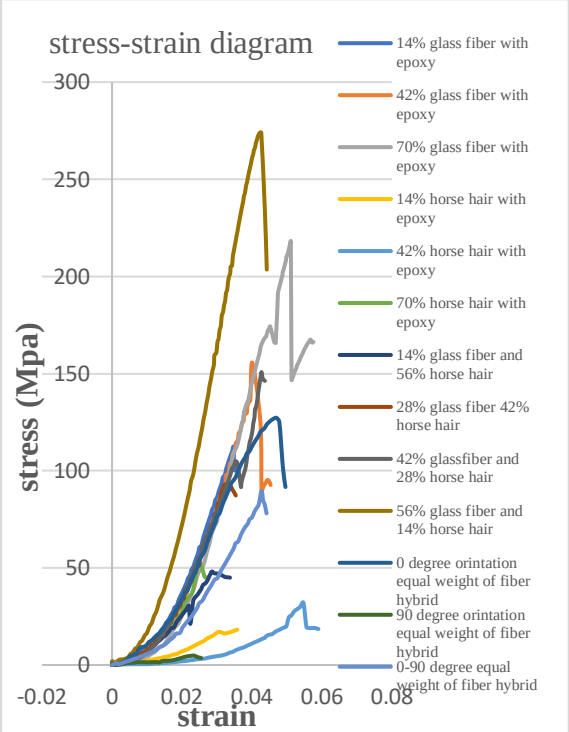


Fig.16 the overall stress-strain diagram of 13 different composite

B. Compression test

The compressive strength of 13 different composite with three sample spacemen and the average value of the compressive strength of the three sample is shown in the table below

Table.2 maximum compressive strength of three sample and its average value

NO.	compressive strength (MPa)	Sample 1	Sample 2	Sample 3	average	figure
1	70% pure glass fiber	36.3	38.45	36.95	37.23	
2	42% pure glass fiber	34.25	28.35	35.15	32.58	
3	14% pure glass fiber	35.2	26.65	27.55	29.8	4.8
4	70 pure horse hair	20.73	25.55	12.8	19.69	
5	42% pure horse hair	18.35	9.55	5.45	11.12	
6	14% pure horse hair	13.55	9.4	8.1	10.35	4.9
7	0-degree hybrid	21.95	15.55	22.6	20.033	
8	90-degree hybrid	9.1	7.85	11.5	9.48	
9	0-90-degree hybrid	31.35	25.35	35.1	30.6	4.10
10	14% glass hybrids	30.45	28.85	36.8	32.03	
11	28% glass hybrids	50.05	46	36.65	44.2	
12	42% glass hybrids	46.85	36.1	51.45	44.8	4.11
13	56%glass hybrids	57.75	43.5	43.7	48.32	

The figure below also shows the average compressive strength of 13 different composite martial. Figure:17 shows the stress-strain diagram of glass fiber/epoxy composite. the result shows the compressive strength of the composite increase when the weight percentage of fiber increase.

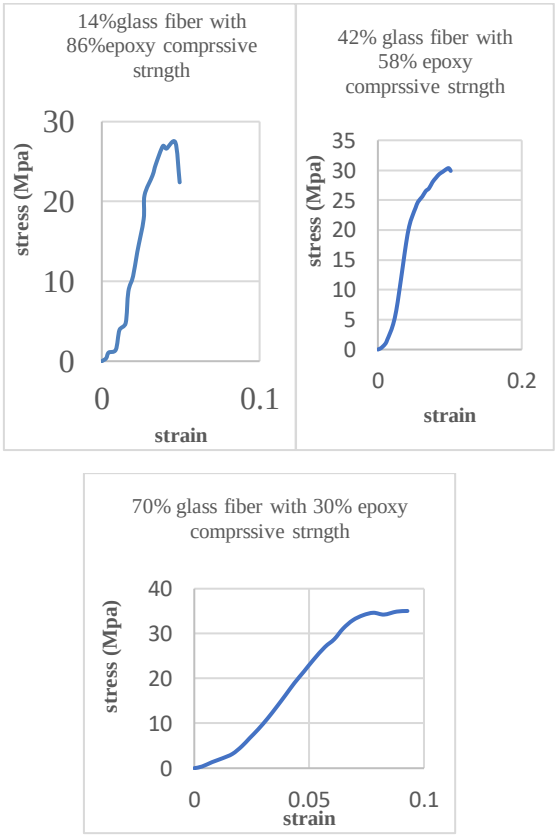


Fig:17compressive strength of glass fiber/epoxy with different weight percentage

Figure 18 shows the stress-strain diagram of horse hair/epoxy composite. The result shows the

compressive strength is increasing with increasing weight of fiber.

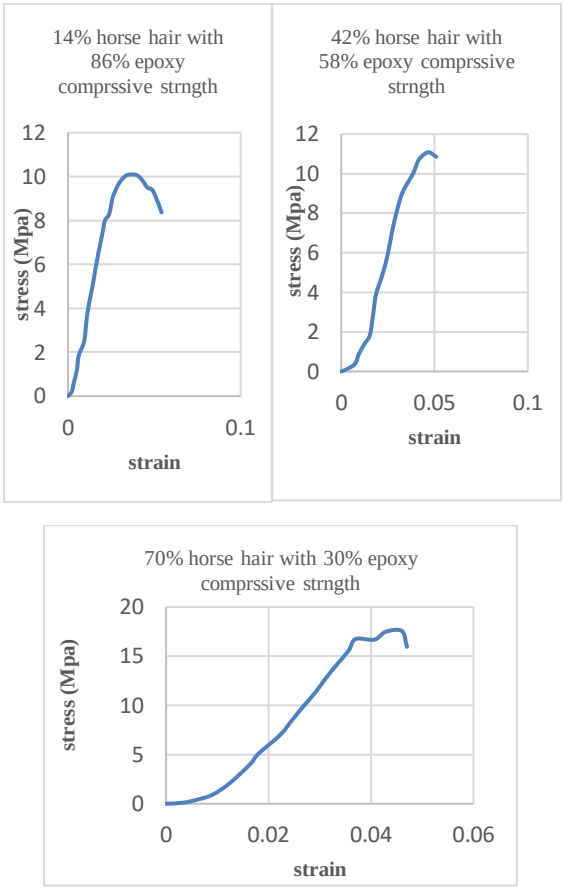
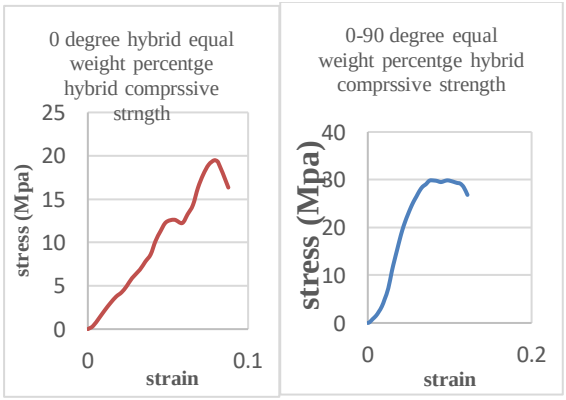


Fig .18compressive strength of horse hair fiber/epoxy with different weight percentage

Figure 19 shows the stress-strain diagram of glass fiber/horse hair/epoxy hybrid composite. The weight percentage of each fiber is equal but the orientation of the fiber is different. The result shows orientation of fiber has high significant in compressive strength so that the maximum compressive strength is in 0-90^0



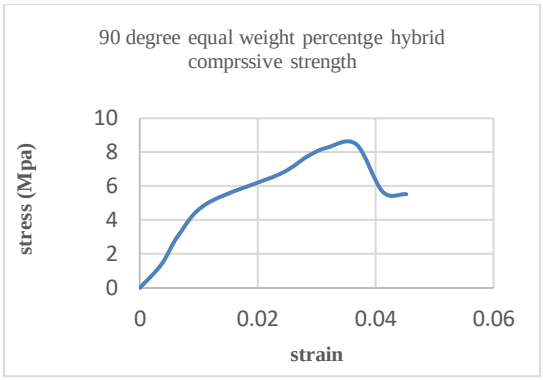


Fig. 19 compressive strength of horse hair fiber/glass fiber/epoxy with different orientation

Fig.20 shows the compressive strength of glass fibre/horse hair/epoxy hybrid composite. In this case the orientation is the same but the weight percentage of each fibre is different. The result shows the weight percentage of glass fibre increase the cross ponding compressive strength increase

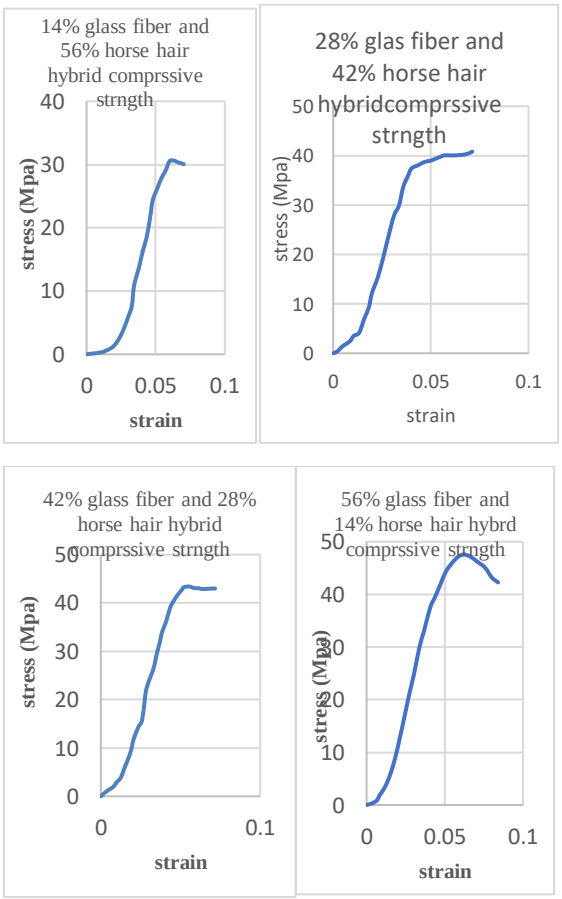


Fig.20 compressive strength of horse hair fibre/glass fibre/epoxy with different weight percentage

As shown in the figure 21 hybrid composite martial has high compressive strength than glass fiber/epoxy and horse hair/epoxy. The orientation of fiber is also having high influence compressive strength. So,

consideration of orientation of fiber in compressive strength is important.

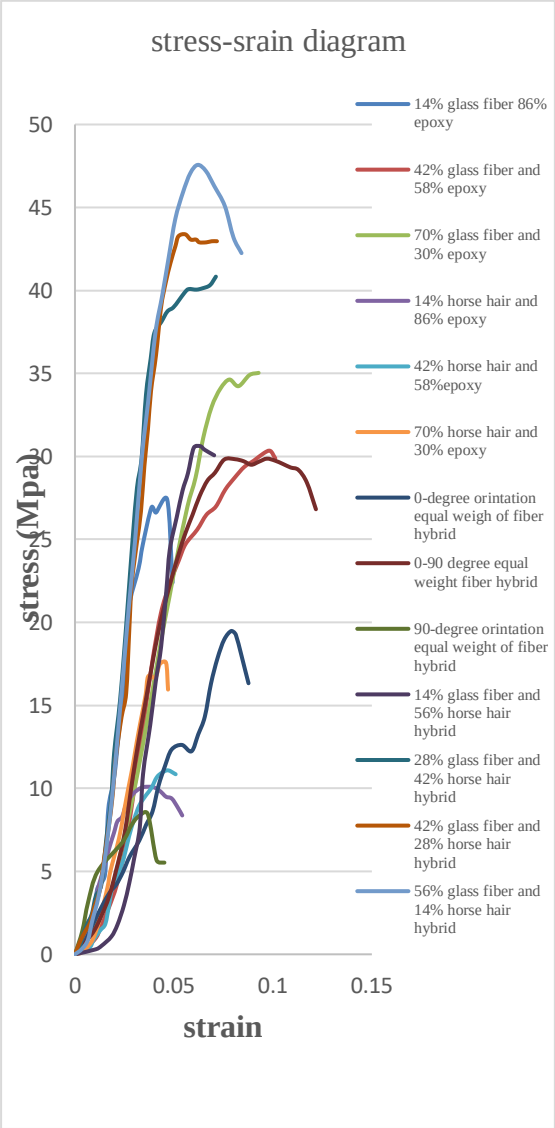


Fig.21 summarized average compressive strength 13 different composite

C. *Flexural test*

Each different composite has three sample spacemen. the maximum bending strength of each sample spacemen and average value of three sample spacemen for 13 different composite material is listed in the table below.

Table:3 flexural strength of different composite material

NO.	flexural strength (Mpa)	Sample 1	Sample 2	Sample 3	average
1	70% pure glass fiber	243.75	188.91	262.03	231.563
2	42% pure glass fiber	170.63	121.88	121.88	138.13
3	14% pure glass fiber	70.08	121.88	140.16	110.71
4	70 pure horse hair	42.66	54.84	67.03	54.84
5	42% pure horse hair	54.84	30.47	60.94	48.75
6	14% pure horse hair	42.66	42.66	42.66	42.66
7	0-degree hybrid	73.13	54.84	60.94	62.97
8	90-degree hybrid	12.19	12.19	24.38	16.49
9	0-90-degree hybrid	219.38	219.38	241.88	226.88
10	14% glass hybrids	121.88	134.06	188.91	148.28
11	28% glass hybrids	243.75	219.38	249.84	237.66
12	42% glass hybrids	237.66	292.5	341.25	290.47
13	56%glass hybrids	322.97	365.63	280.31	322.97

As shown in the table 3 above as well as the bar graph in fig.22 below the flexural strength of hybrid composite increases with increasing weight of glass fibre. for glass fibre/epoxy and horse hair/epoxy the compressive strength increase with increasing the weight percentage of each fibre. For equal weight percentage of fibre in hybrid composite the orientation have great impact. The flexural strength also has influenced by orientation like compressive strength. The figure below shows the flexural strength of 13 different composite martial

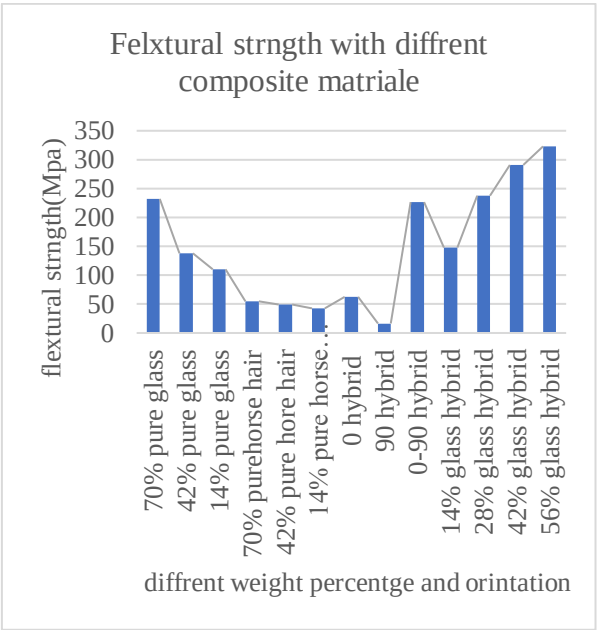


Fig. 22 the average flexural strength of 13 different composite

VI. CONCLUSION

- composites is highly influenced by the weight percentage of fiber and orientation of fiber.

- In different weight percentage;
  - For glass fiber/epoxy and horse hair/epoxy composite material the mechanical properties such as, tensile strength, compressive strength and bending strength is increase with increasing weight percentage of each fiber
  - For hybrid composite the mechanical property is increase with increasing weight percentage of glass fiber

- In equal weight percentage;

In this case the material is hybrid and there well consider orientation. the orientation of the fiber is significantly influencing the tensile strength but, it has highly influenced the compressive and bending strength.

ACKNOWLEDGEMENT

The authors acknowledge the valuable suggestion ministry of education

- The mechanical properties of the composites such as tensile strength, flexural strength and compressive strength of the

REFERENCES

[1] Somashekar S M, Manjunath V, Gowtham M J, Balasubramanian N S, Investigation on Mechanical Properties of Hemp–E Glass Fiber Reinforced Polymer Composites. International Journal of Mechanical Engineering and Technology, vol. 7, no. 3, pp. 182–192, 2016

[2] Srinivas Nunna, P Ravi Chandra, Sharad Shrivastava and AK Jalan, "A review on mechanical behavior of natural fiber based hybrid composites," Journal of Reinforced Plastics, vol. 31, no. 11, p. 759–769, 2016.

[3] Hamidullah Naik1, Nissar Ahmad Naikoo2, Sahil Ayoub Dar3, Mir Showket4, Sheikh Abbas Muhamm5, "Use of horse hair as fiber reinforcement in concrete," international journal, vol. Volume 3, no. Issue 6, pp. 1569-1572, 2015

[4] Sanjay M Ra*, Arpitha G Ra & B Yogeshaa, "Study on Mechanical Properties of Natural - Glass Fibre Reinforced Polymer Hybrid Composites: A Review," in Elsevier Ltd., Belgavi Karnataka, 2015.

[5] Somashekar S M, Manjunath V, Gowtham M J, Balasubramaniam N S, Investigation on Mechanical Properties of Hemp–E Glass Fiber Reinforced Polymer Composites. International Journal of Mechanical Engineering and Technology, vol. 7, no. 3, pp. 182–192, 2016

[6] 1Suresha K V, 2 Dr.Sumana B G, 3 Dr H K Shivanand, 4Mahesha, "Tensile, Compression and Flexural Behavior of Hybrid Fiber (Hemp, Glass, Carbon) Reinforced Composites," International Journal of Engineering Development and Research, vol. 5, no. 4, pp. 688-698, 2017.

[7] T.karthikeyan1, S.K.Aravindhkumar2, P.Sreepathi3, N. Shanmuga Prakash4, "Analysis of Mechanical Properties of Hybrid Composites Experimentally," *International Journal of Engineering Trends and Technology*, vol. 35, no. 8, pp. 391-396, 2016.

[8] R.Sakthivela*, D.Rajendranb, "Experimental Investigation and Analysis a Mechanical Properties of Hybrid Polymer Composite Plates," *International Journal of Engineering Trends and Technology*, vol. 9, no. 8, pp. 407-414, 2014