MECHANICAL CHARACTERIZATION OF DIFFERENT ORIENTATION OF GLASS FIBRE REINFORCED POLYESTER MATRIX COMPOSITE

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Abstract

*The purpose of this study is to evaluation of the mechanical characterisation such as tensile, compression and bending test and to conduct wear test. This study focus on preparation and testing of Polyester resin using glass fibre for different orientation. The Mechanical properties of the polyester changes gradually by changing the layers of fibres and for different orientation of glass fibre the property differs. The laminate is prepared of size 300*300*4mm size and specimens are prepared as per ASTM standard, different layers of glass fibres are one, two and three layers and the orientation of glass fibre is 30^o, 60^o, and 90^o. The glass fibre used is in fabric form. From the results which were obtained we can observed that three layers glass fibre for 90^o orientation has improved tensile strength and the compressive strength is found to be more for 60^0orientation of glass fibre. And the wear rate is also less for three layer of glass fibre for 90^0 orientations.*

Keywords: *Glass Fibre/Polyesters Composites, Mechanical Characterisation of Polyester, Orientation of Glass Fibre.*

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1. INTRODUCTION

Composite material can be defined as the combination of two or more different materials which having dissimilar property. the composite materials the fibre which may be in the form of fabric which is reinforced in the material gives strength to the overall material and the matrix provides rigidity. Fibre glass which are reinforced in polymer are generally popular reinforced plastic material which are used in many industry. Depending upon the formation and their use, they may be fabricated into products which are light in weight, transparent, colourless or coloured, flat or shaped sheets with no limits on size of object can be made. The reinforcing fibre is available in different form, it may be in the form of fabric or long continuous or chopped fibres. Different types of fibres which are reinforced give different properties. The Properties are usually depending on how the fibre is lay into composites and which fibres are used. In this study we have used glass fibre in fabric form and it is known

II. OBJECTIVE AND METHODOLOGY

A. Objective: The main objective of this project is to know and evaluate the mechanical characteristics and to find wear of material.

B. Methodology: Following are the steps involved,

- Preparation of mould.
- Preparation of composite laminates for different orientations of glass fibre.
- Cutting the laminates.
- Conducting mechanical test.
- Conducting Pin-on-disc wear test

III. EXPERIMENTAL PROCEDURE

The hand layup method is one of the efficient processes for developing of PMC's products. The first step is to calculate the amount of material required in the preparation of laminate of required size. The calculated amount of polyester resin with additive ($caso_4$), catalyst and accelerator is mixed in a bowl. the laminate is prepared for 1 layer, 2 layers and 3 layers of glass fibre. The mixed materials is poured in a prepared mould and glass fibre is placed on the resin. For 1 layer laminate, only 1 layer of glass fibre is placed on the poured resin in the mould and the remaining resin is again poured over the glass fibre. The procedure will remain same for 2 layers and for 3 layers.

IV. SPECIMEN PREPARATION

A. Tensile test: Tensile test was performed to calculate the ultimate tensile strength. Specimen dimensions are 228mm in length, 25mm in width and 4mm thickness.

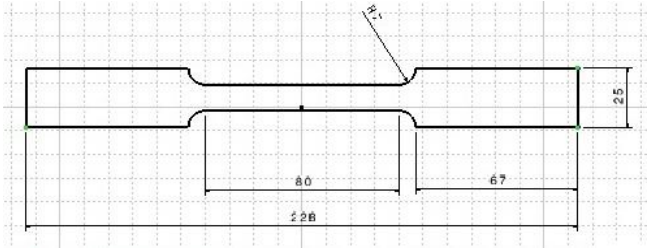

Figure 1: Tensile test specimen

Figure 2: Tensile test specimen for different layers of glass fibres.

A. Compression test: In this test the material is compressed till the material is able to withstand not causing fracture in the material. The specimen dimensions are 127mm in length, 10mm in width and 4mm in thickness.

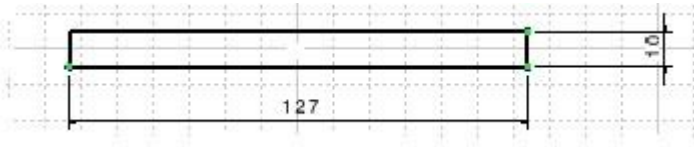

Figure 3: Compression test specimen.

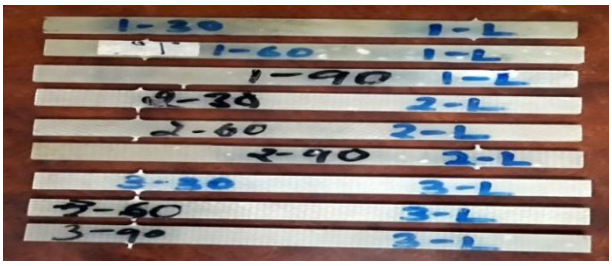

Figure 4: Compression test specimen for different layers of glass fibres.

B. Bending test: The specimen dimensions are 80mm in length, 20mm in width and 4mm in thickness.

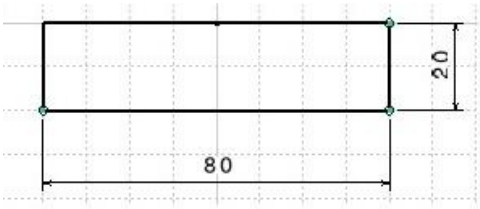

Figure 5: Bending test specimen.

Figure 6: Bending test specimen for different layers of glass fibres.

V. WEAR TEST

A. Pin-on-disc wear test: Wear is simply defined as contact of material surfaces which causes deformation of material. The wear testing was carried out at a constant revolving speed 200rpm with constant load 20N. The speed and load was kept constant but the time was shifting. The test was carried out for three trails for 2min, 4min and 6min. The figure below shows the specimen size.

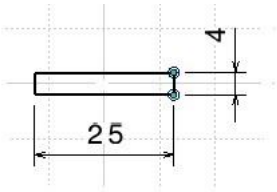

Figure 7: Wear test specimen.

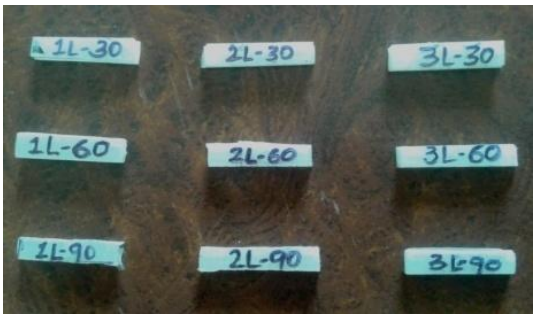

Figure 8: Wear test specimen fordifferent layers of glass fibres before testing.

VI. RESULTS AND GRAPHS

A. Tensile test:

Tensile test is conducted for the prepared specimens for 1 layer, 2 layers and for 3 layers glass fibres for different orientations. The test speed was 5mm/min and the graph generated is shown below,
For 1 layer of glass fibre

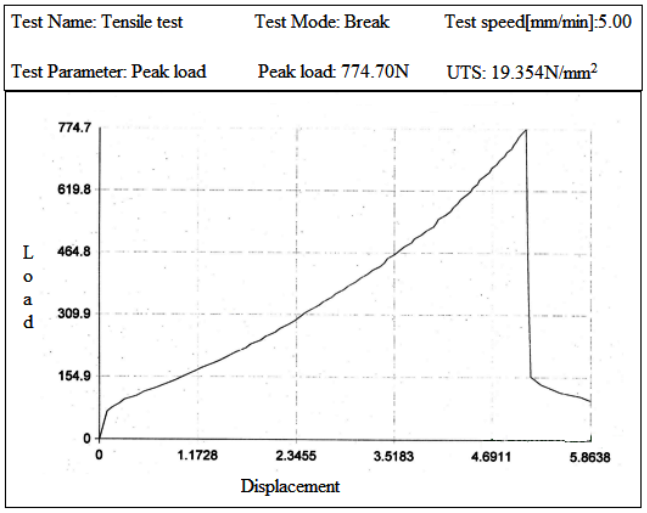

Figure 9: Tensile test graph for 1layer of glass fibre for 30^{o} orientation.

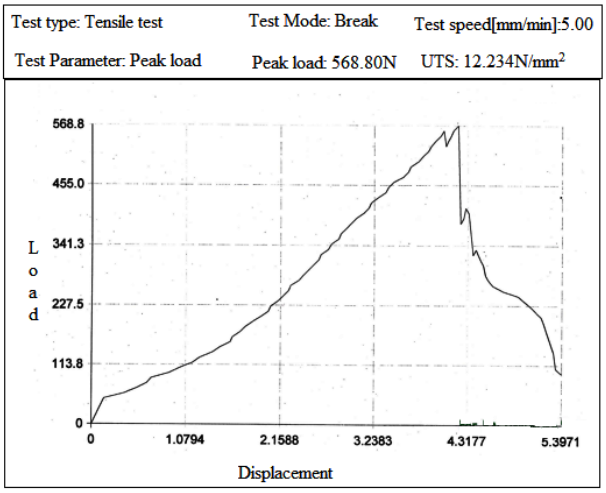

Figure 10: Tensile test graph for 1layer of glass fibre for 60^{o} orientation.

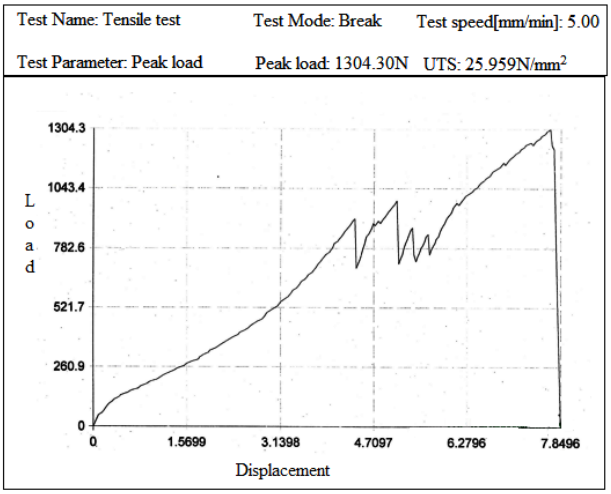

Figure 11: Tensile test graph for 1layer of glass fibre for 90^{o} orientation. For 2 layers of glass fibre.

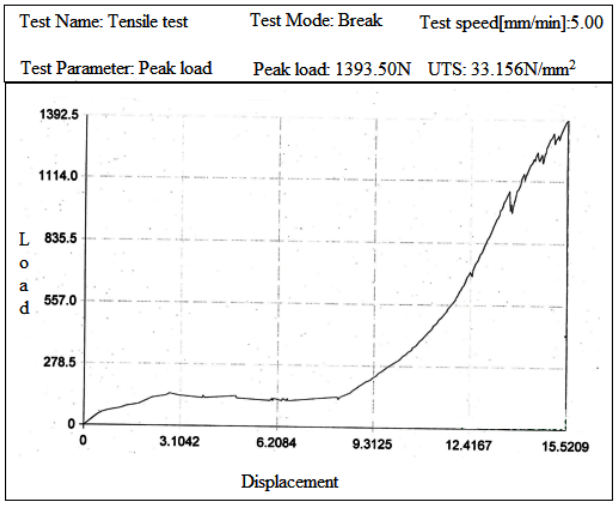

Figure 12: Tensile test graph for 2layer of glass fibre for 30^{o} orientation.

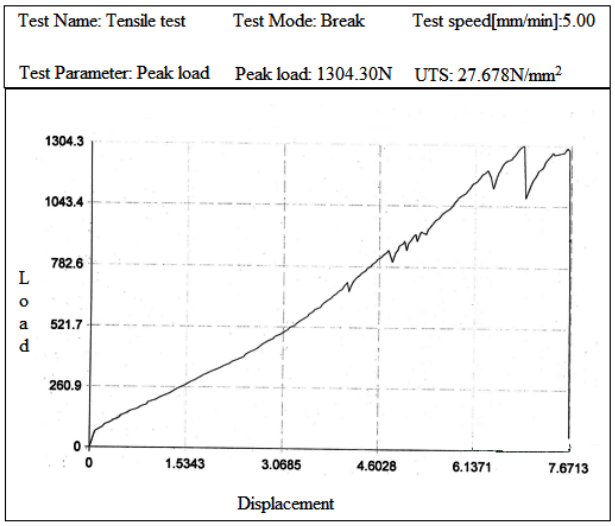

Figure 13: Tensile test graph for 2layer of glass fibre for 60^{o} orientation**.**

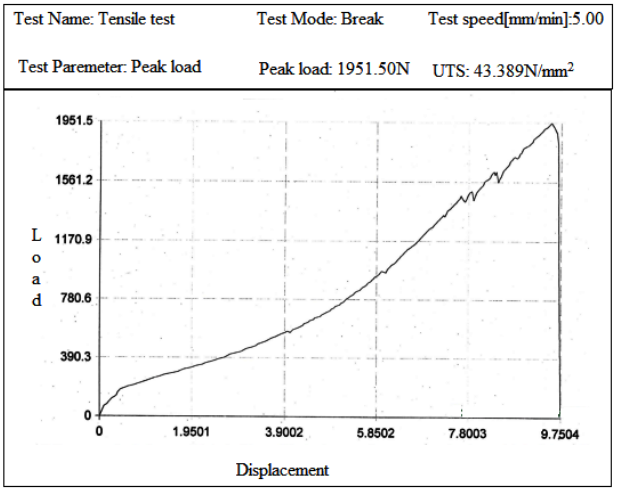

Figure 14: Tensile test graph for 2layer of glass fibre for 90^{o} orientation. For 3 layers of glass fibre.

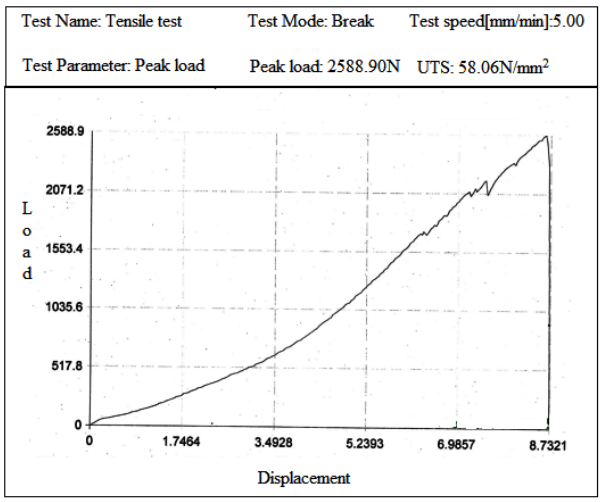

Figure 15: Tensile test graph for 3layer of glass fibre for 30^{o} orientation.

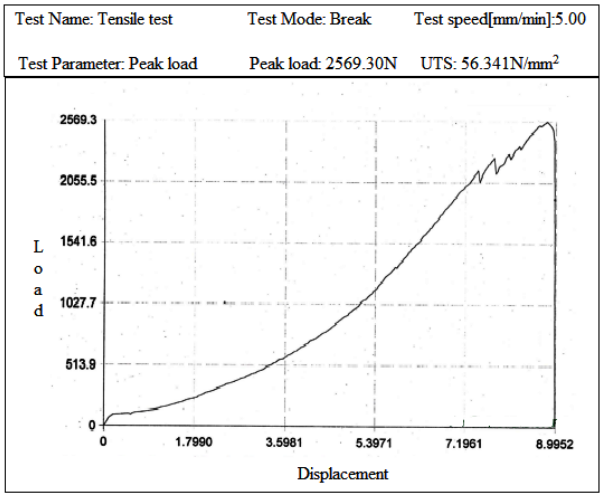

Figure 16: Tensile test graph for 3layer of glass fibre for 60° orientation.

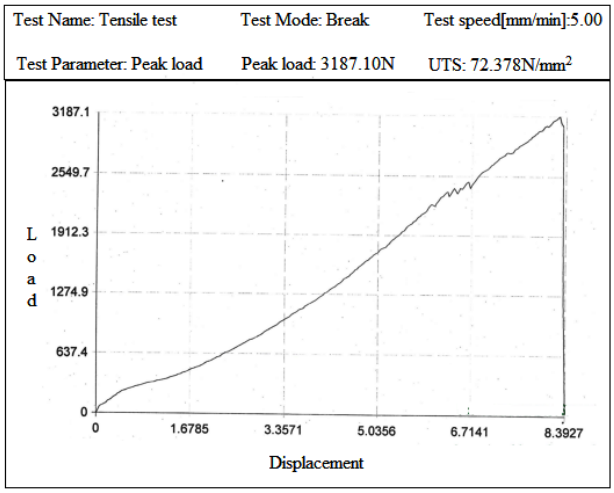

Figure 17: Tensile test graph for 3layer of glass fibre for 90° orientation

Table 1: Tensile test results

	Peak Load In N	UTS In N/mm^2
For 1Layer- 30°	774.700	19.354
60°	568.800	12.234
90°	1304.300	25.959
For 2Layers- 30°	1392.500	33.156
60°	1304.300	27.678
90°	1951.500	43.389
For 3Layers- 30°	2588.950	58.06
60°	2569.300	56.341
90°	3187.100	72.378

B. Compression Test:

Compression test is conducted for the prepared specimens for 1 layer, 2 layers and for 3 layers glass fibres for different orientations. The graphs are shown below
For 1 layer of glass fibre.

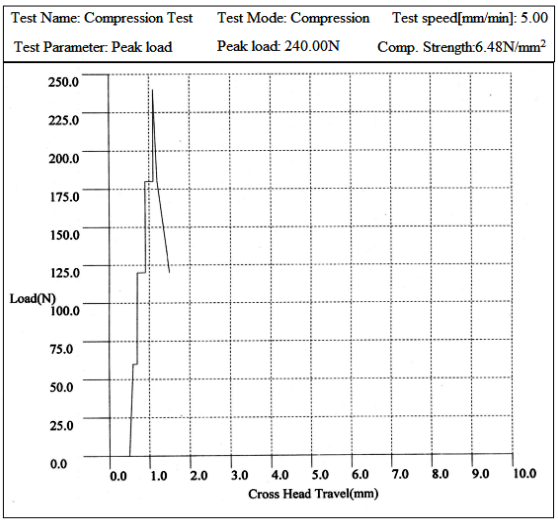

Figure 18: Compression test graph for 1layer of glass fibre for 30° orientation.

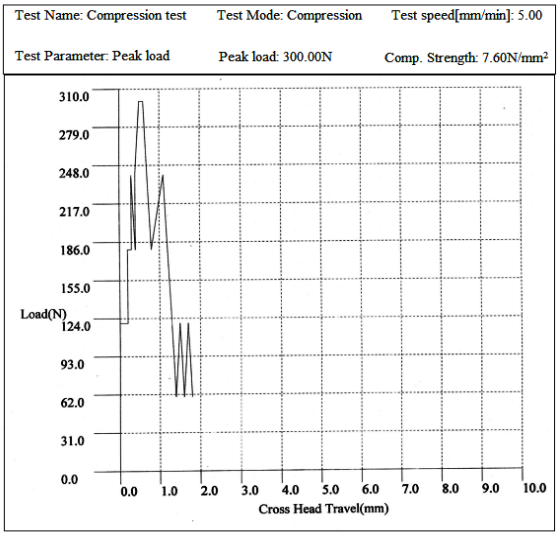

Figure 19: Compression test graph for 1layer of glass fibre for 60° orientation.

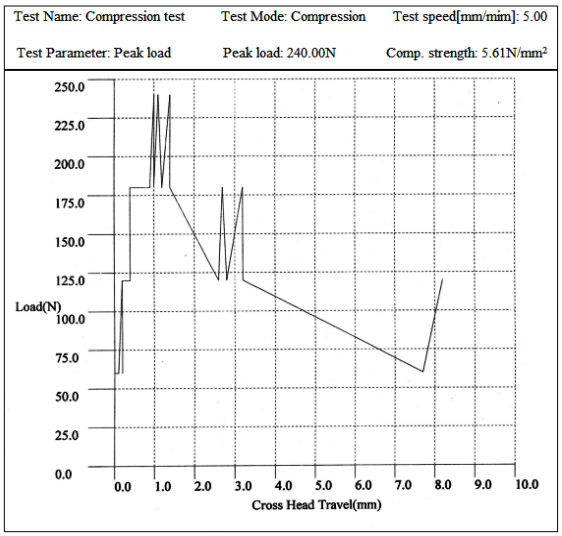

Figure 20: Compression test graph for 1layer of glass fibre for 90° orientation.

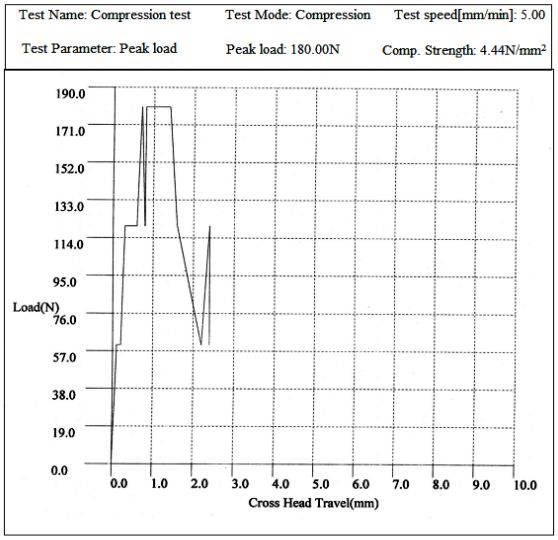

Figure 21: Compression test graph for 2layer of glass fibre for 30° orientation**.**

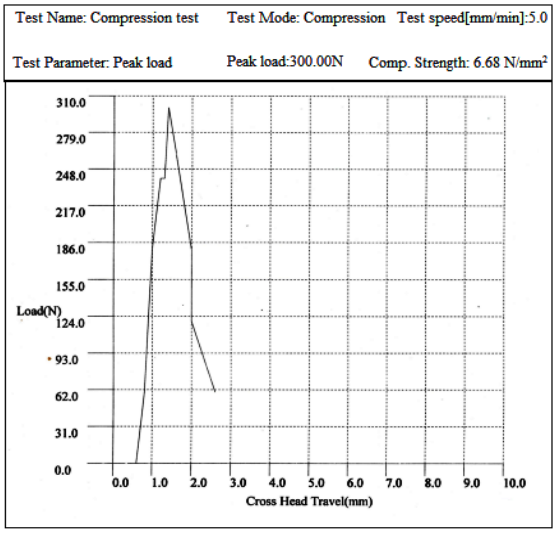

Figure 21: Compression test graph for 2layer of glass fibre for 60° orientation.

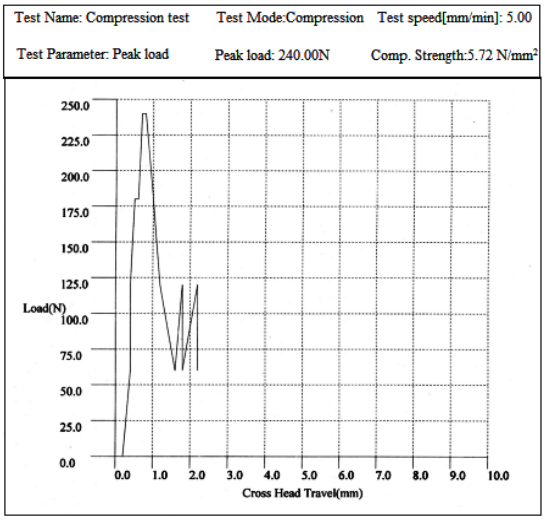

Figure 22: Compression test graph for 2layer of glass fibre for 90° orientation.

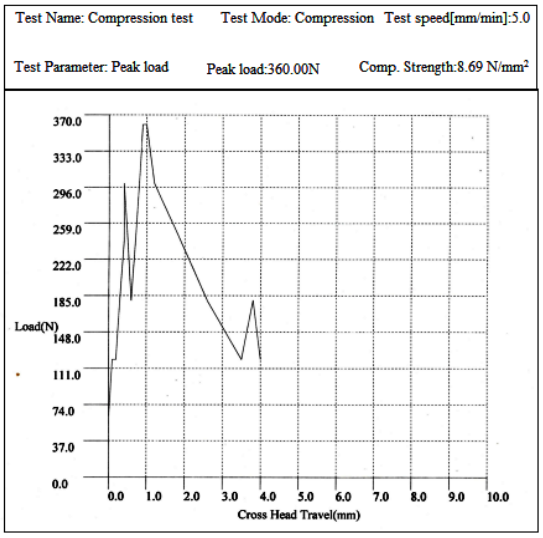

Figure 23: Compression test graph for 3layer of glass fibre for 30° orientation.

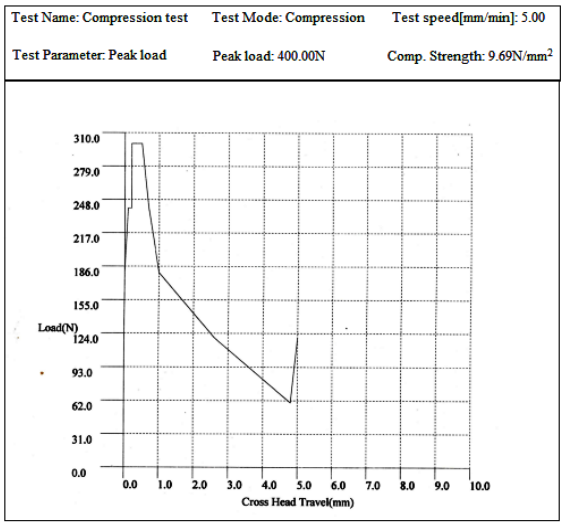

Figure 24: Compression test graph for 3layer of glass fibre for 60° orientation.

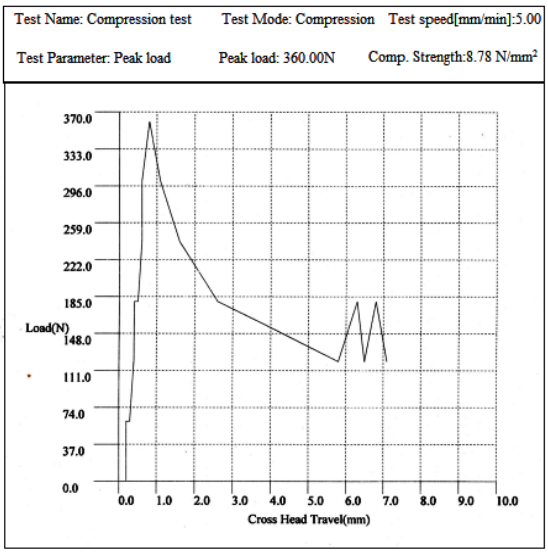

Figure 25: Compression test graph for 3layer of glass fibre for 90° orientation.

Table 2: Compression test results

	Peak Load In N	Comp. Strength In N/mm^2
For 1Layer-30^o	240.00	6.48
60^o	300.00	7.60
90^o	240.00	5.61
For 2Layers-30^o	180.00	4.44
60^o	300.00	6.68
90^o	240.00	5.72
For 3Layers-30^o	360.00	8.69
60^o	400.00	9.69
90^o	360.00	8.78

C. Bending Test:

Bending test is conducted for the prepared specimens for 1 layer, 2 layers and for 3 layers glass fibres for different orientations. The test speed was 5mm/min and the graph generated is shown below

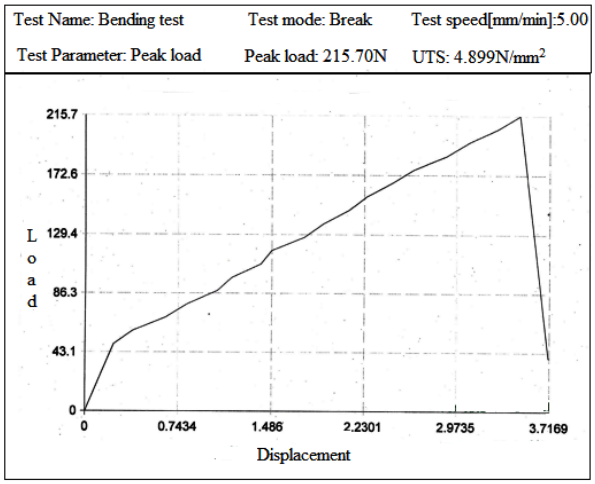

Figure 26: Bending test graph for 1layer of glass fibre for 30^o orientation.

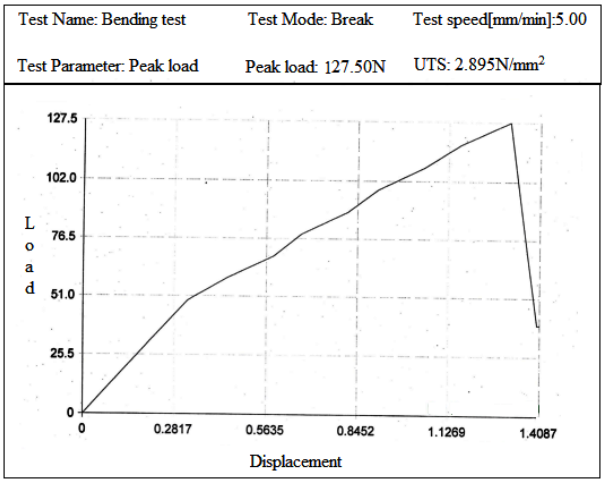

Figure 27: Bending test graph for 1layer of glass fibre for 60^o orientation.

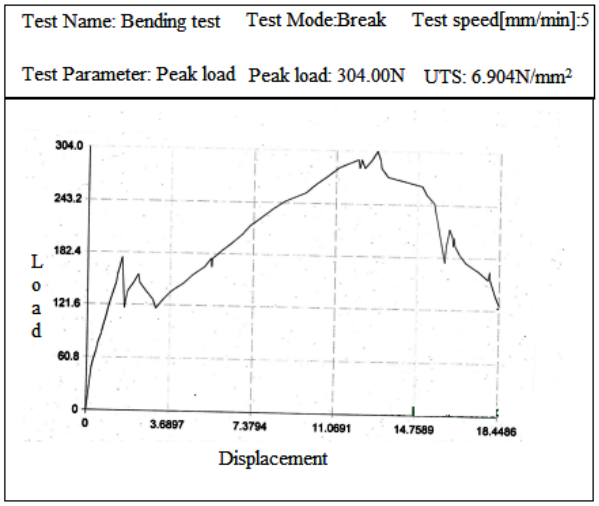

Figure 27: Bending test graph for 1layer of glass fibre for 90^o orientation.

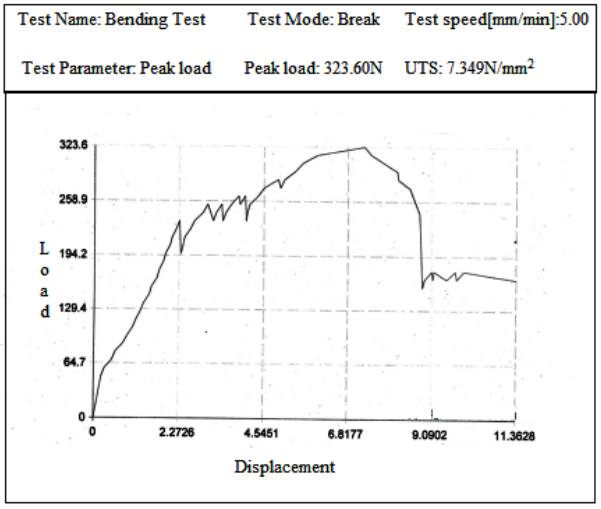

Figure 28: Bending test graph for 2layer of glass fibre for 30^o orientation.

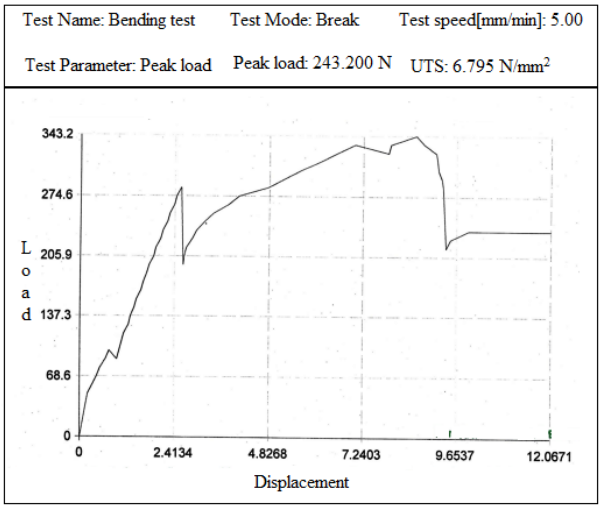

Figure 29: Bending test graph for 2layer of glass fibre for 60^o orientation.

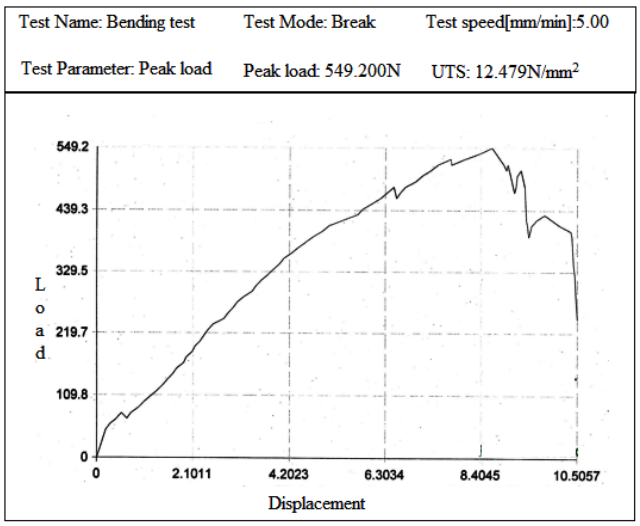

Figure 30: Bending test graph for 2layer of glass fibre for 90^o orientation.

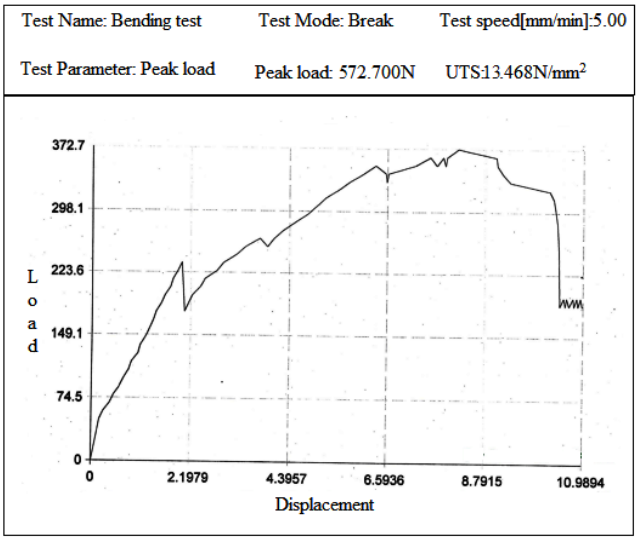

Figure 31: Bending test graph for 3layer of glass fibre for 30^o orientation**.**

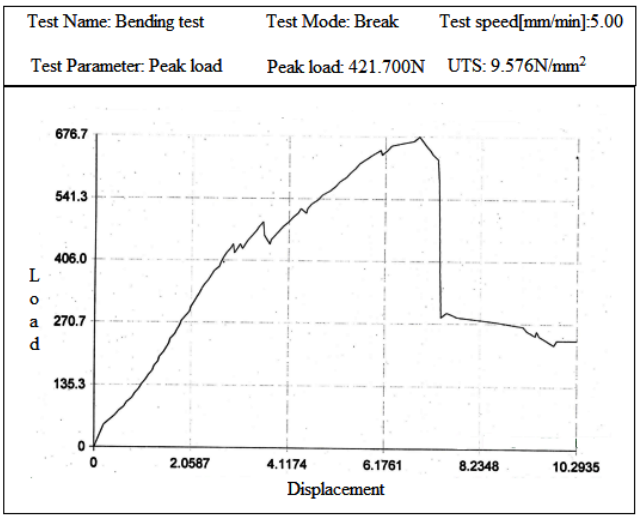

Figure 32: Bending test graph for 3layer of glass fibre for 60^o orientation.

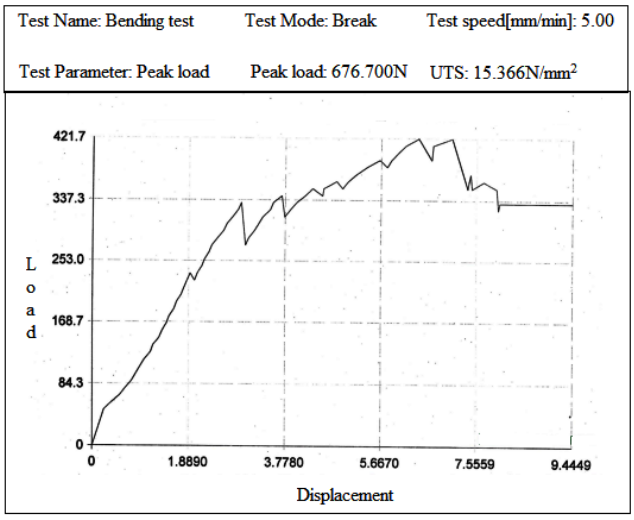

Figure 33: Bending test graph for 3layer of glass fibre for 90^o orientation.

Table 3: Bending test results

	Peak Load In N	UTS In N/mm^2
For 1Layer- 30^o	215.700	4.89
60^o	127.500	2.895
90^o	304.00	6.904
For 2Layers- 30^o	383.600	8.349
60^o	343.200	7.795
90^o	549.200	12.471
For 3Layers-30^o	572.700	13.468
60^o	421.700	9.576
90^o	676.700	15.366

VII. DISCUSSION

A. Tensile test: The tensile strength for the different orientation has been depicted in the form of graph below,

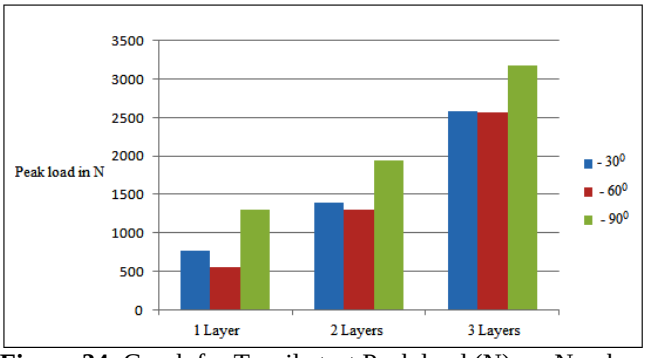

Figure 34: Graph for Tensile test Peak load (N) vs. Number of layers of Glass fibre.

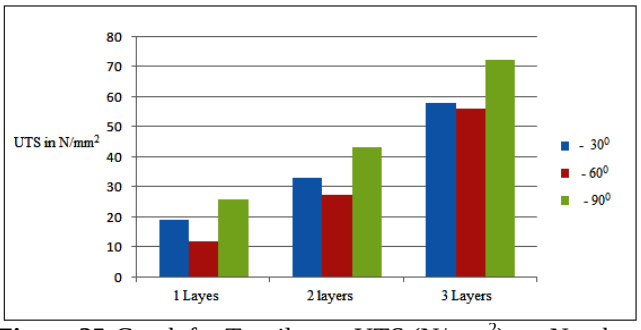

Figure 35: Graph for Tensile test UTS (N/mm^2) vs. Number of layers of Glass fibre.

- The results obtained from the tensile test carried on 1, 2 and 3 layers of glass fibre for 30^0, 60^0 and 90^0 orientation, it is observed from the graph that the peak load is more for 30^0 and 90^0 orientations. And while comparing for 30^0 and 90^0, the peak load and Ultimate tensile strength is maximum for 90^0 orientation.
- Comparing all the layers of glass fibres for 30^0, 60^0 and 90^0 orientation it is observed that the 3 layer glass fibre for 90^0 orientation withstand maximum peak load and Ultimate tensile strength than the rest of the samples.

B. Compression test**:** The compression strength for the different orientation has been depicted in the form of graph below,

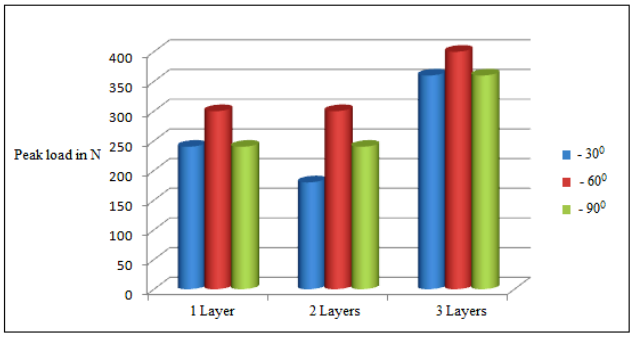

Figure 36 : Graph for Compression test Peak load (N) vs. Number of layers of Glass fibre

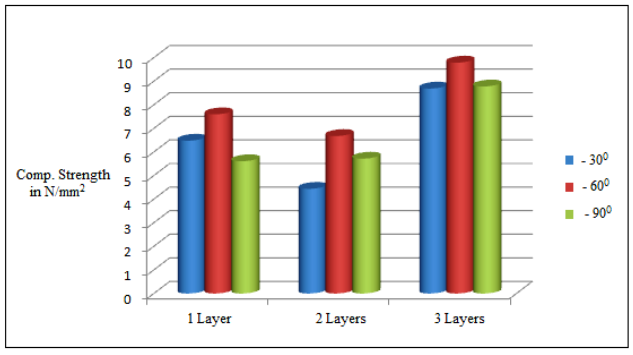

Figure 37 : Chart for Compressive strength in UTS (N/mm^2) vs. Number of layers of Glass fibre

- The results shows that Compression test carried on 1, 2 and 3 layers of glass fibre for 30^0, 60^0 and 90^0 orientations, it is observed that the peak load and compressive strength is more for 60^0 orientation than 30^0 and 90^0 orientations.
- Comparing all the layers of glass fibres for 30^0, 60^0 and 90^0 orientation it is observed that the 3 layer glass fibre for 60^0 orientation withstand maximum peak load and Compressive strength than the rest of the samples.

C. Bending test: The bending strength for the different orientation has been depicted in the form of graph below,

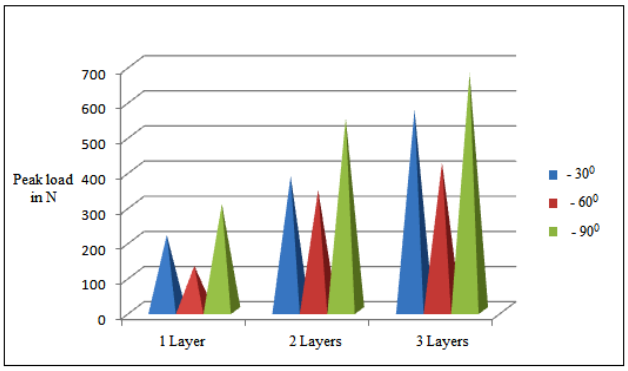

Figure 38: Graph for bending test Peak load (N) vs. Number of layers of Glass fibre

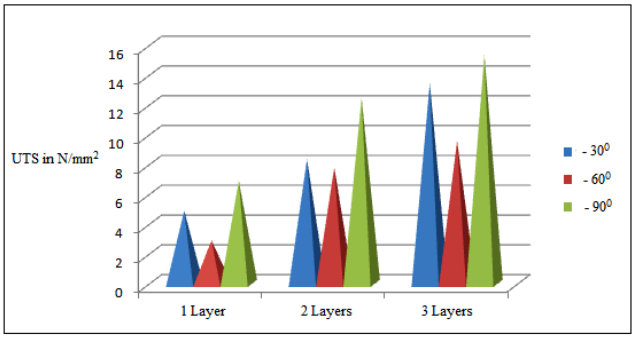

Figure 39: Graph for bending test UTS (N/mm^2) vs. Number of layers of Glass fibre

The Results obtained from the Bending test carried on 30^0, 60^0 and 90^0 orientation of glass fibre using polyester resin we observed that,

- The results obtained from the Bending test carried on 1, 2 and 3 layers of glass fibre for 30^0, 60^0 and 90^0 orientation, it is observed from the graph that the peak load and UTS is more for 30^0 and 90^0 orientations. And while comparing for 30^0 and 90^0, the peak load and UTS is maximum for 90^0 orientation for 1 layer glass fibre.
- Comparing all the layers of glass fibres for 30^0, 60^0 and 90^0 orientation it is observed that the 3 layer glass fibre for 90^0 orientation withstand maximum peak load and UTS than the rest of the samples.

Pin-on-disc wear test: For 1 Layer glass fibre for different orientation the wear is,

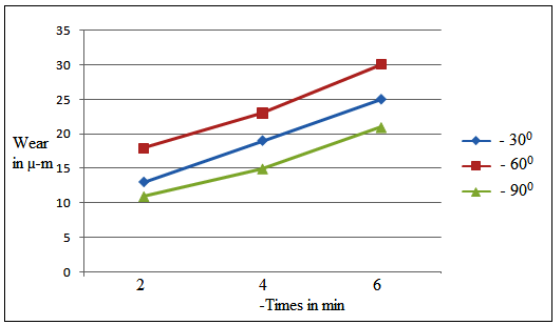

Figure 40: Graph for wear vs. Time for 1 layer of glass fibre for different orientation.

By considering the above graph it is seen that the wear for 1 layer glass fibre for different orientations increases as the time increases. As the tensile strength is more for 30^0 and 90^0 orientations, the wear is less as shown in the above figure. As the tensile strength is less for 60^0 orientation, the wear is comparatively more. The tensile strength is more for 90^0 orientations as compare to 30^0 and 60^0 hence the wear rate is less for 90^0 as compare to 30^0 and 60^0.

For 2 Layers glass fibre for different orientation the wear is,

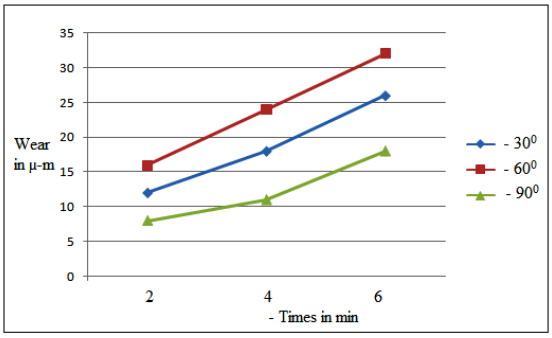

Figure 41: Graph for wear vs. Time for 2 layer of glass fibre for different orientation.

By considering the above graph it is seen that the wear for 2 layers glass fibre for different orientations increases as the time increases. As the tensile strength is more for 30^0 and 90^0 orientations, the wear is less as shown in the above figure. As the tensile strength is less for 60^0 orientation, the wear is comparatively more. The tensile strength is more for 90^0 orientation as compare to 30^0 and 60^0 hence the wear rate is less for 90^0 as compare to 30^0 and 60^0.

For 3 Layers glass fibre for different orientation the wear rate and Frictional force are:

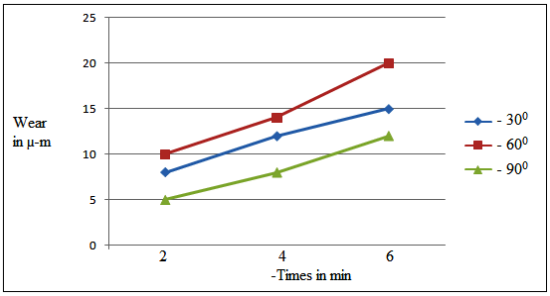

Figure 43: Graph for wear vs. Time for 3 layer of glass fibre for different orientation.

By considering the above graph it is seen that the wear for 3 layers glass fibre for different orientations increases as the time increases. As the tensile strength is more for 30^0 and 90^0 orientations, the wear is less as shown in the above figure. As the tensile strength is less for 60^0 orientation, the wear is comparatively more. The tensile strength is more for 90^0 orientation as compare to 30^0 and 60^0 hence the wear rate is less for 90^0 as compare to 30^0 and 60^0.

VIII. CONCLUSION

A. TENSILE:

❖ We consider 1, 2 and 3 Layers of Glass fibre laminate composite for the orientation of 30^0, 60^0 and 90^0 angles reinforced in polyester matrix composite for tensile experimental test and the results shows that the Peak load and Ultimate Tensile strength is maximum for 3 layers of glass fibre for 90^0 orientation.

B. COMPRESSION:

❖ We consider 1, 2 and 3 Layers of Glass fibre laminate composite for the orientation of 30^0, 60^0 and 90^0 angles reinforced in polyester matrix composite for Compression experimental test and the results shows that the peak load and Compressive strength is more for 60^0 orientation for 3 layers of the glass fibre.

C. BENDING:

❖ We consider 1, 2 and 3 Layers of Glass fibre laminate composite for the orientation of 30^0, 60^0 and 90^0 angles reinforced in polyester matrix composite for bending experimental test and the results shows that the Peak load and UTS is maximum 3 layers of glass fibre for 90^0 orientations.

D. PIN-ON-DISC WEAR TEST:

❖ We consider 1, 2 and 3 Layers of Glass fibre laminate composite for the orientation of 30^0, 60^0 and 90^0 angles reinforced in polyester matrix composite for wear test and by considering the results it is seen that the wear rate increases as the time increases and as the tensile strength is more for 30^0 and 90^0 orientation, for all the layers of glass fibres wear rate is less as compare to 60^0 orientation.

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