FABRICATION AND TENSILE PROPERTY ANALYSIS OF A COMPOSITE LAMINATE WITH DIFFERENT DIAMETER HOLES

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Abstract

Composites play a vital role in aerospace, land transportation and consumer goods due to their high specific strength and stiffness leading to reduction in the mass of moving objects. Some of the important aerospace hardware such as rocket motor casing makes extensive use of carbon fiber reinforced polymer(CFRP). In this present investigation E-Glass epoxy laminates were used. The tensile properties for various Diameter holes were determined and compared with the actual strength of the material without any hole. Results indicate that because of the increase in diameter of the hole the tensile strength of the material is decreasing.

Keywords: *CFRP, E-Glass, Epoxy, Tensile strength.*

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1. INTRODUCTION

In the field of mechanical & aerospace composites are widely used because of the high specific strength and low density of composites. Composites are widely used because of their tailorability of properties to the required direction or strength. In the field of aerospace, for the sake of pressure vessels like rocket motor casings composites will result in high strength as well as low weight. Weight is a major factor of any flying object whenever we discuss about trade off ratios. So for the sake of reduced weight and increased FOS composites are emerging materials now days.

Mechanical performance of fibrous composites will depends on the following aspects

1. Surface treatment of the fiber
2. Percemtage elongation of the fiber & matrix
3. Chemistry of the resin dictated by functionality, addition of toughening agent, curing agents and curing conditions.

2. LAMINATE PREPARATION

E-glass/epoxy resin laminates were prepared by drum winding process. E-glass fibres are passed through a resin bath containing epoxy resin mixed with 10%by weight of hardener HY 5200.The traction for pulling resin wetted fibres which pass through a pay-out eye attached to the longitudinal slide (tool post), is provided by rotating cylindrical mandrel. The resin bath is equipped with in-built servo controlled heating system and the temperature of resin mix is maintained at 40^0c, in order to bring the resin viscosity to around 1000-1500cpa.This enables the volume fraction of fibres to be at around 60%.The cylindrical drum on which fibres are deposited is rotated at a low speed of 15rpm. Prior to winding, it is covered with a thick HDPE film without any wrinkles what so ever. After the winding is completed, the mandrel kept under rotation for about an hour to ensure that there is no resin collection at the bottom due to gravity. The punch plate is then assemble to it and clamped with bolts & nuts. The clamping bolts are torqued to a value of 30N-m with the help of a torque wrench. The assembly is placed in a curing oven and the composite was cured. as per the following general cure cycle.

Variations were made to suit the resin systems as recommended by the manufacturer.
Room temperature to 70oC **-** 3omin
Hold at 70oC – 120 min
Ramp to 150oC – 30min
Hold at 150oC – 240min

Thereafter remove the composite laminate from mouldand trim the edges.

To prepare the laminate, the following process parameters were used

SNo	Parameter/Material	Details
1	Resin/Hardener	LY-556/HY 5200
3	Tool	Cylindrical/Rectangular Mandrel
4	Process	a)Drum winding
5	Band width	3.0mm
6	Fibre Tension	0.9kg
7	Distance between Resin bath and mandrel	1.66m
8	Number of processes	1

9	Mandrel RPM	15 RPM
10	Resin temperature	45°C
11	Volume fraction	60%

Specimen Preparation: Specimens were prepared from composite laminated plates according to ASTM specifications

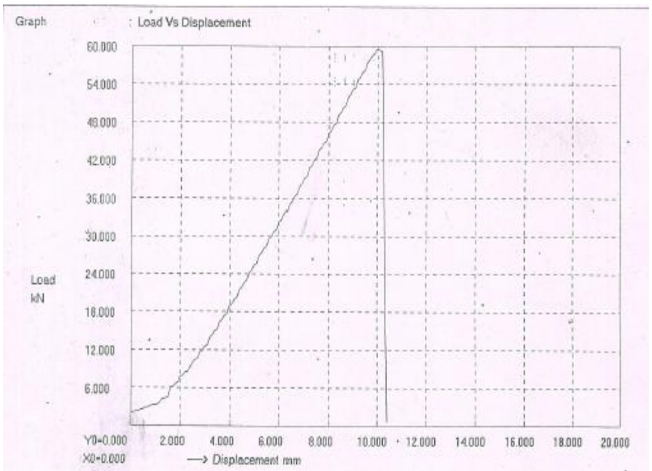
ASTM Specifications: Specimens were prepared from composite laminated plates; the manufacturing process is described under the heading "material preparation". The specimens conform to the requirements lead down in the relevant ASTM specifications listed below

S.No	Type of test	Relevant ASTM	Number of specimens	Specimen size(mm)
1	UD-Tensile	D-3039	5	250x15x1.0
2	Transverse tensile	D-3039	5	175x25x2.0
3	Flexural	D-790	5	50X25X1.6
4	ILSS	D-2344	5	24X12X6.0
5	In plane shear	D-3518	5	300x25x3.0

Tensile test specimen

Tensile Properties without a hole

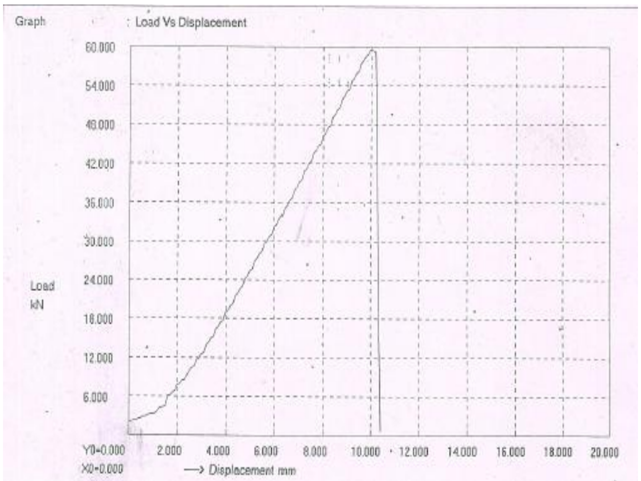
S.No	Geometry (mm)	BreakingLoad(KN)	σ(MPa)
1.	300 x 27.27 x 3.8	59.6	575.14
2.	300 x 27.8 x 3.9	58.5	539.56
3.	300 x 27.8 x 5.1	80.5	567.78



Graph 1

Tensile Properties with 3mm centre hole:

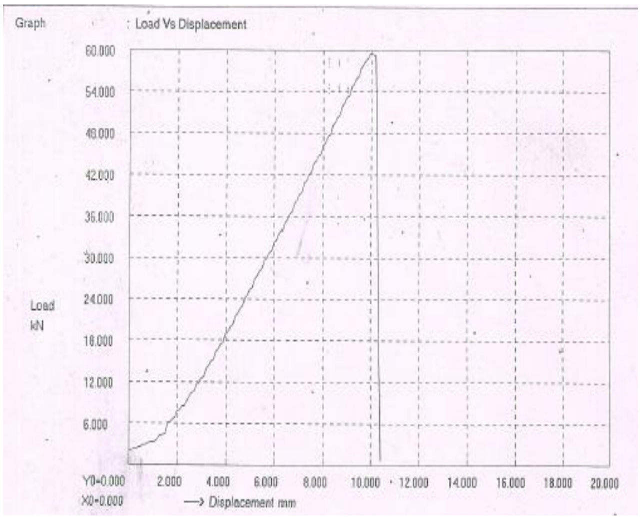
S.No	Geometry (mm)	BreakingLoad(KN)	σ(MPa)
1.	300 x 26.5 x 3.8	40.5	402.18
2.	300 x 28.5 x 4.0	47.0	412.28
3.	300 x 26.6 x 5.15	61.46	448.64



Graph 2

Tensile Properties with 3mm offset hole

S.No	Geometry (mm)	BreakingLoad(KN)	σ(MPa)
1.	300 x 26.4 x 3.8	35.0	348.88
2.	300 x 28.0 x 4.0	46.0	410.71
3.	300 x 26.0 x 5.1	61.4	463.04



Graph 3

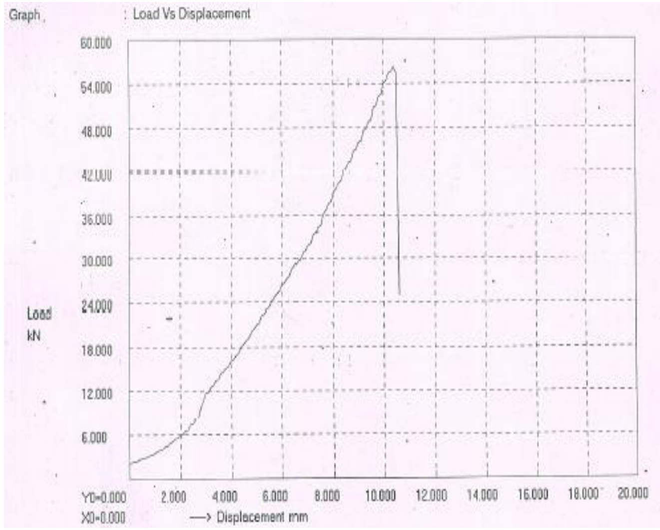
Tensile Properties with 5mm centrehole:

S.No	Geometry (mm)	BreakingLoad(KN)	σ(MPa)
1.	300 x 26.0 x 3.68	34.5	360.57
2.	300 x 28.0 x 3.85	39.5	366.42
3.	300 x 26.75 x 5.15	58.92	427.69

Graph 4

Tensile Properties with 5mm offset hole:

S.No	Geometry (mm)	BreakingLoad(KN)	σ(MPa)
1.	300 x 26.25 x 3.8	33.5	335.84
2.	300 x 27.32 x 3.8	34.0	327.5
3.	300 x 26.75 x 5.1	56.24	412.24



Graph 5

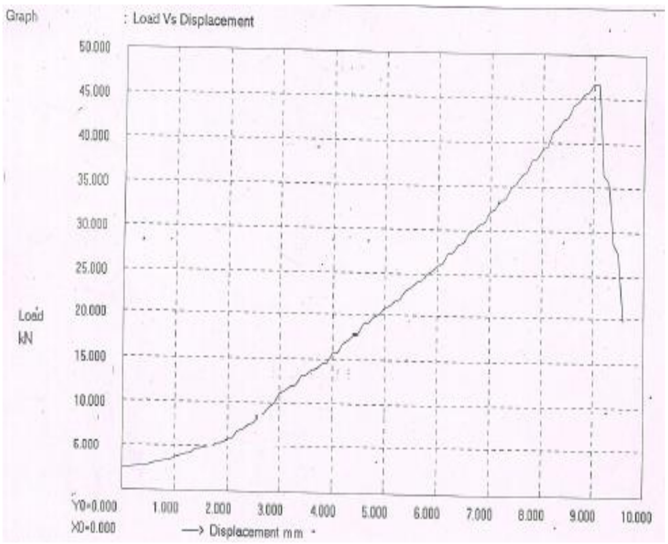
Tensile Properties with 7mm centre hole:

S.No	Geometry (mm)	BreakingLoad(KN)	σ(MPa)
1.	300 x 27.0 x 3.8	32.5	316.76
2.	300 x 27.8 x 4.0	33.5	301.26
3.	300 x 26.2 x 5.1	47.22	353.39

Graph 6

Tensile Properties with 7mm offset hole:

S.No	Geometry (mm)	BreakingLoad(KN)	σ(MPa)
1.	300 x 26.3 x 3.85	29.4	290.35
2.	300 x 27.0 x 4.0	30.82	285.37
3.	300 x 27.2 x 5.1	46.7	336.65



Graph 7

3. RESULTS & CONCLUSION

1. Tensile strength of samples without hole=560.82 MPa
2. Tensile strength of samples with 3mm hole at center=421.03 MPa
3. Tensile strength of samples with 3mm hole at 5mm offset from the center=407.54 MPa
4. Average Tensile strength of samples with 5mm hole at center=384.89 MPa
5. Average Tensile strength of samples with 5mm hole at 5mm offset from the center=358.52 MPa
6. Average Tensile strength of samples with 7mm hole at center=323.80 MPa.

The Tensile strength of the specimen is inversely proportional to the Diameter of the hole.The Tensile strength is lower for specimen having hole at offset from the centre compared to specimen with hole at the centre.

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