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Fatigue behaviour of Polyurethane Core Sandwiched Glass Reinforced in Epoxy Matrix Composite Material

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Abstract: In this project flexural fatigue behaviour Polyurethane core sandwiched in glass/ epoxy composite laminate structures is studied. The effect of face sheet thickness and core thickness on the flexural fatigue is studied by testing the sandwich structures in computer controlled universal fatigue testing machine. The effect of core thickness and facesheet thickness on flexural strength of sandwich structures is also studied. From the experimental results of fatigue testing, it is observed that, Polyurethane core sandwiched in glass/ epoxy composite laminate structures have more than 2500000 cycles of fatigue life at 80 % of loading. The result of ANOVA on flexural strength reveals that, face sheet thickness is most significant parameter.

Keywords: E-glass fiber, epoxy resin, Sandwich structures, ANOVA, Fatigue life.

I. INTRODUCTION

Polymer matrix composite materials are finding its applications in the areas like aerospace for making wings of the plane, blades of the helicopter and in naval applications as boat hulls as a structural material. In civil engineering as a structural material, in automobiles they are used for making shafts, chassis for F1 cars, roofs, side panels. We must use, Because of similar mechanical and thermal properties as of metals with greater strength to weight ratio and high stiffness. One of the composite structures is of sandwich type. A sandwich panel is an uncommon form of a laminated shell structure including of three dissimilar layers which are joined together utilizing resin bonds to form a firm stiff load carrying assembly or simply the basic sandwiched structure consists of two face sheets between which a core material is sandwiched.

As these materials are used in various applications the damping behaviour and fatigue life of the material is prime importance of study for designers. The core structures like foam cores and honeycomb structures for composite materials have developed which have grater damping characteristics and improved fatigue life. The fatigue and damping behaviour of composite structures depends on the core density, face sheet thickness and core thickness. For specific applications optimization of these parameters of the materials is needed. So, in this project an effort is made to study the effect of face sheet thickness and core thickness on fatigue life of the Polyurethane core sandwiched in glass fiber reinforced in epoxy resin.

1] Specimen Preparation

The method that is used for manufacturing the laminated composite plates is HAND LAY UP technique as shown in Fig.1below, it is the oldest method used to get the composite materials. The type of glass fiber mat selected to make specimens is, E-glass of 300 GSM bidirectional woven roving.

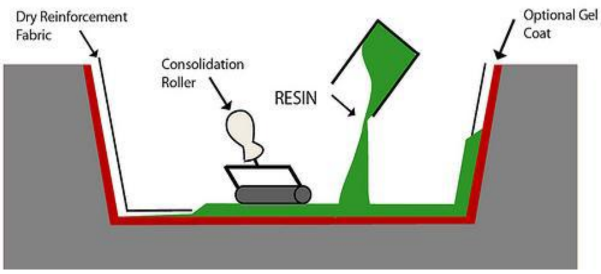

Fig.1HandLayUpTechnique
(source; www.netcomposites.com)

1.1] FABRICATION OF SANDWICH CORE:

The core material of sandwich structure is fabricated as follows: The polyurethane core is formed by the combination of Methyl di-isosynate (mdi) and polyol in proportion of 60:40. Both the liquids are mixed in jar, after two minutes of mixing the foam starts forming.

The oil is coated to the mould as a releasing agent for easy removal of core. The mixture is then poured in to the mould and placed in the press for 15-20 minutes. After that the mould is taken out and the foam core is removed from the mould.

1.2 FABRICATION OF SANDWICH STRUCTURE

The laminates of thickness 1, 2 and 3 mm are prepared on the PU foam core. The fiber layers are cut to the size of 40 X 40 cm, Weight of one ply is measured using electronic weighing machine. The hardener and resin are taken in a flask as per calculation and mixed.A layer of resin is

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applied on the surface of the core and then the lamina is placed on the applied resin, again a layer of resin is applied on the surface of the fiber again next layer is placed on the previous layer. The procedure is continued till the sandwich structure is built. The sandwich structures are cut as per ASTM standard C393.

II. EXPERIMENTAL SET UP

The following tests were conducted in desertion work;

- Flexural test,
- Fatigue test,

The tests were conducted using calibrated Servo Hydraulic Fatigue Testing machine as shown in fig.2 below,

Fig.2 Servo Hydraulic Fatigue Testing machine
(Source: www. http://en.kejian-tech.com)

The experimental plan according to L9 array is shown in table number 1:

Table No.1: Experimental Plan.

Experiment no.	Facesheet thickness, mm	Core thickness, mm
1	1	10
2	1	20
3	1	30
4	2	10
5	2	20
6	2	30
7	3	10
8	3	20
9	3	30

III.CALCULATIONS

3.1] FOR FOAM DENSITY

PU foam used in the preparation of sandwich structure is considered constant at 80 kg\m3 density for 10mm, 20mm and 30mm core thickness. For example, PU FOAM WITH 10MM THICKNESS:

Volume of foam= 0.4×0.4×0.01mm
Mass of di-isosynate and polyol= density of foam ×volum
= 80×0.4×0.4×0.01
= 0.128 kg
Mass of di-isosynate= 0.6×0.128
= 0.0768 kg
Mass of polyol = 0.4×0.128
= 0.0512 kg

3.2] FOR LAMINATE PREPARATION

In the preparation of face sheet glass fiber is reinforced in epoxy resin. To prepare face sheet bidirectional e-glass of 300GSM and epoxy resin is used of thickness 1mm, 2mm, 3mm.For example, GLASS\EPOXY LAMINATES OF 1MM THICKNESS:

Number of plies of glass fiber to be combined with matrix material
ṕf =2.54g/cc ṕresin =1.15g/cc
Wff= 65% Wfr= 35%
Density of laminate = (ṕf × wff) + (ṕresin × wfr)
=(2.54×0.65) + (1.15×0.35)
= 2.053g/cc
Weight of laminate = ṕlaminate × Vlaminate
=2.053×0.1×40×40
= 328.48 g
Weight of resin = Wfr × Wlaminate
= 0.35 ×328.48
= 114.968 g
Weight of fiber = Wff × Wlaminate
= 0.65×328.48
= 213.512 g
Weight of hardner = Wresin × 11/111
= 114.968 × 11/111
= 11.39 g
Weight of one ply =43 gms
No. Of layers required = Wfiber / Wfiber one ply
= 213.512 /43
= 5 layers

IV.RESULT & DISCUSSION

4.1] EFFECT OF FACESHEET THICKNESS ON FLEXURAL STRENGTH

Effect of face sheet thickness on the flexural strength of polyurethane glass epoxy sandwich composite material is shown in figure.3. The graph plotted show, as the face sheet thickness increases flexural strength increases. The flexural strength is directly proportional to the face sheet thickness. The maximum flexural strength is obtained for 3mm Face sheet thickness of 10mm core thickness. The maximum strength is 45.85Mpa.

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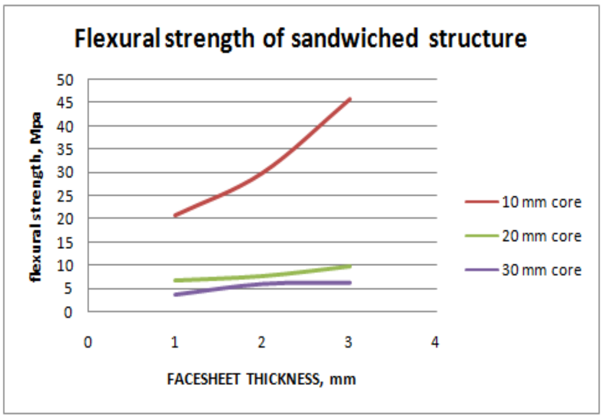

Fig.3 Results for Flexural Strength

4.2] FATIGUE BEHAVIOR OF SANDWICH STRUCTURE

Table No.2 Flexural strength and endurance limit

Material	Peak load in N	Flexural strength in N/mm²	Endurance limit
Sandwich specimen (1mm Facesheet and10mmcore thickness)	900	20.625	16.11
Sandwich specimen (1mm Facesheet and20mmcore thickness)	525	6.833	3.4
Sandwich specimen (1mm Facesheet and30mmcore thickness)	400	3.63	1.5
Sandwich specimen (2mm Facesheet and10mmcore thickness)	1625	29.84	22.1
Sandwich specimen (2mm Facesheet and20mmcore thickness)	675	7.734	4.5
Sandwich specimen (2mm Facesheet and30mmcore thickness)	725	6.020	3.3
Sandwich specimen (3mm Facesheet and10mmcore thickness)	3010	45.855	34.7
Sandwich specimen (3mm Facesheet and20mmcore thickness)	725	9.696	6.1
Sandwich specimen (3mm Facesheet and30mmcore thickness)	825	6.302	3.4

The fatigue behaviour of sandwich structures of different Facesheet thickness and core thickness is studied at 80% flexural loading condition. The flexural strength verses number of cycles is plotted for all the nine specimens. From the graphs, the fatigue life of the sandwich structures is more than 225000 cycles.

The Flexural strength and endurance limit for all the specimens is shown in table 2. From the table, the maximum endurance limit is 34.7 for 3mm Facesheet and 10 mm core sandwich structure.

V. CONCLUSION

From the experimental results of flexural and fatigue life of PU core sandwiched in glass/epoxy laminates, the following conclusions are drawn;

1. The flexural strength is directly proportional to the Face sheet thickness of sandwich structure.
2. The flexural strength is inversely proportional to the thickness of the core material at constant density of core.
3. The fatigue life of PU core sandwiched in glass/epoxy laminates, is found to be infinite and is more than 225000 cycles at 80 % of flexural loading.
4. The endurance limit is maximum for greater thickness values of face sheet of sandwich structure.
5. The most significant factor for fatigue life is face sheet thickness.

REFERENCES

[1] Krishnan Kanny, Hassan Mahfuz, Leif A. Carlsson, Tonnia Thomas, Shaik Jeelani, “Dynamic mechanical analyses and flexural fatigue of PVC foams”, Elsevier, composite structures 58, 2002M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, “High resolution fiber distributed measurements with coherent OFDR,” in Proc. ECOC’00, 2000, paper 11.3.4, p. 109.
[2] Mohammad Mynul Hossain, Kunigal Shivakumar, “Compression fatigue performance of a fire resistant syntactic foam”, Elsevier, composite structures 94, 2011. (2002) The IEEE website. [Online]. Available: http://www.ieee.org/
[3] Nitin Kulkarni, Hassan Mahfuz, Shaik Jeelani, Leif A. Carlsson, “Fatigue crack growth and life prediction of foam core sandwich composites under flexural loading”, Elsevier, composite structures 59, 2003FLEXChip Signal Processor (MC68175/D), Motorola, 1996.
[4] R.Vijayalakshmi Rao, Manujesh B J, “Behavior of sandwich composites under flexural and fatigue loading: Effect of variation of core density”, IJEST, ISSN: 0975-5462, Vol.3 No.10 October 2011.
[5] A. M. Harte, N. A. Fleck, M. F. Ashby, “Fatigue failure of an open cell and a closed cell Aluminium alloy foam”, Pergamon, Acta mater. Vol. 47, No.8, pp. 2511-2524, 1999.
[6] E. E.Theotokoglou, D. Hortis, L. A. Carlsson, H. Mahfuz, “Numerical study of fractured sandwich composites under flexural loading”, SAGE, Journal of sandwich structures and materials, Vol. 10 Jan (2008) 75.
[7] Dan Zenkert, Magnus Burman, “Tension, compression and shear fatigue of a closed cell polymer foam”, Elsevier, Composites science and technology, 2008.

BIOGRAPHIES

Pavan B Bagali presently working as Asst. Prof. In CMR Engineering College, Hyderabad.He had 1 year of teaching experience. Completed B.E degree in Mechanical Engg. at GNDEC, Bidar (2013) and done Masters in Computer Integrated Manufacturing at GNDEC, Bidar (2015).

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