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FABRICATION AND TESTING OF FLEXURALPROPERTIESOFGLASSFIBRE EPOXYSKIN PIR 250 RIGID FOAM CORE SANDWICHCOMPOSITE MATERIAL

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ABSTRACT:-*The aim of this research paper is to study the flexural and shear properties of foam based sandwich composites. Polyisocyanurate foam is used as the core of composite and glass fabric reinforced epoxy based laminates are used as the skin of the sandwich, the density of polyisocyanurate foam is 250kg/m^3. Skin to core weight ratio of 2:1 and 1:1 are maintained for the panels fabricated separately with the vacuum bagging technique.Specimen with varying span length to depth ratio of 21:1, 16:1and varying skin to core weight ratio of 2:1 and 1:1 are tested using an UTM machine. The three point bending tests are carried out for finding maximum bending stress maximum deflection shear stress and bending strength and other flexural properties.The testing results are compared and analysed in depth to find the influence of the core density and span to depth ratio on the flexural and shear properties of the sandwich composite structure.*

1. INTRODUCTION

Composite materials are those materials which are chemically distinct and physically separable .Composite materials have high strength to weight ratio as compared to metal alloy.
Defining a composite materials needs following parameters

1. Matrix material
2.Reinforcing material
3. Structure: laminated or sandwich

1.1 Sandwich Structural Composite

Amongst all possible design concepts in composite structures, the idea of sandwich construction has become increasingly popular because of the development of manmade cellular material as core materials. Sandwich structure consist of

1. A pair of thin, stiff, strong skins (faces, facing or covers)
2. A thick, light weight core to separate the skins and to carry the load from one skin to other
3. An adhesive attachment which is capable of transmitting shear and axial loads to and from the core.

The separation of the skins by the core increases the moment of inertia of panel with little increase in weight, producing an efficient structure for resisting bending and buckling loads.
The sandwich panel is popular in high performing application where weight must be kept to a minimum, for example aeronautical structure, high speed marine craft and racing cars. In the most weight critical applications, composite materials are used for skins.

1.3 Theoretical Consideration

The flexural rigidity of the sandwich composite is the addition of flexural rigidities of the core and skin measured about centroid axis of structure.

For 2:1 sandwich composite
Skin weight=2*core weight
For 1:1 sandwich composite
Skin weight= 1*core weight
The maximum bending strength is obtained when
Core weight = total weight of skins
In this experiment design is done by using maximum flexural rigidity criteria and properties are evaluated in three point bending test.

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2. EXPERIMENTAL DETAILS

Matrix material:
The matrix material is made up of epoxy resin and hardener in the ratio 2:1. The epoxy resin used is of the grade is GY257 with ARADUR(140) as a hardener. The density of resin is 1.2gm/cc

Properties of Core And Skin

Sr.no	Skin to Core weight ratio	Glass fabric (gsm)	No. of layers
1	2:1	280	8
2	1:1	280	4

Glass Table 1: fabric layers vs skin to core weigh ratio

Sr. no	**Properties**	**Core**	**Skin**
1	Elastic modulus	11 MPa	11500 MPa
2	Shear modulus	4.18 MPa	-----
3	Poisson's ratio	0.312	0.32

Table 2: The PIR used is of 250kg/m^3 , dimension of core= 500x500x10 mm^3

3. SANDWICH COMPOSITE FABRICATION

3.1Pre- fabrication

1. Initially, the core thickness was non-uniform throughout. It was made uniform of thickness 10mm by polishing with the use of rough & fine emery papers.
2.The glass fabric was cut of dimension 480*480mm^2

3.2 Fabrication

1. The tool caul plate is placed initially on table; over it bleeder cloth and nylon peel ply is placed.

2. Now, we spray silicon spray over the nylon peel ply so that it doesn't stick to sandwich composite and it is fixed at corners using clip.

3. The epoxy resin mixture is prepared as follows:
   FOR 2:1 sandwich composite: (8 layers of 280gsm)
   The total volume of resin mixture =475 cc
   The volume of hardener =1/3* Total resin mixture volume= 158.33cc
   The volume of Epoxy resin=2/3* Total resin mixture volume=316.66cc

FOR 1:1 sandwich composite
4layers 280gsm
Volume of the resin mixture =259.26 cc
Volume of the hardener =1/3* Total resin mixture volume= 86.42cc
Volume of epoxy resin =2/3* Total resin mixture volume=172.84cc
The epoxy resin is measured and poured in the required amount and then it is stirred continuously mic the both epoxy and hardener.
The epoxy resin should be applied to the nylon peal ply and the glass fabric is placed over it and rolled so that no air bubble remains and there is maximum impregnation. In this way, half the glass fabric layers are pasted on one side and the remaining on other side of the core, thus we get the composite sandwich panel.

3.3 Post Fabrication:

1. Now, the composite sandwich panel is placed inside the vacuum bag, properly sealed and connected to vacuum pump.

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2. The vacuum pump is switched on for 45 minutes. The atmospheric air pressure acts on the panel. The composite is kept within the bag for a day for complete curing of resin. The overhang is cut with the help of powered jigsaw and weight is measured.
3. As per ASTM standards, the specimen should be as per follows:

Width of specimen= 2* average thickness of sandwich panel
Length of specimen=16* average thickness of sandwich panel
According to above calculations, the sandwich panel is cut into 4 specimens.

Figure 1: Samples for flexural testing

4. FLEXURE TEST

Flexural properties are determined as per ASTM standards.Three point bending tests were performed on UTM.
Parameters like Maximum Bending stress, Flexural rigidity, Bending stiffness, shear strength in core, Bending strength, normal stress, bending shape factor were calculated for both 2:1 and 1:1 weight ratios and are SHOWN IN Tabular data form.

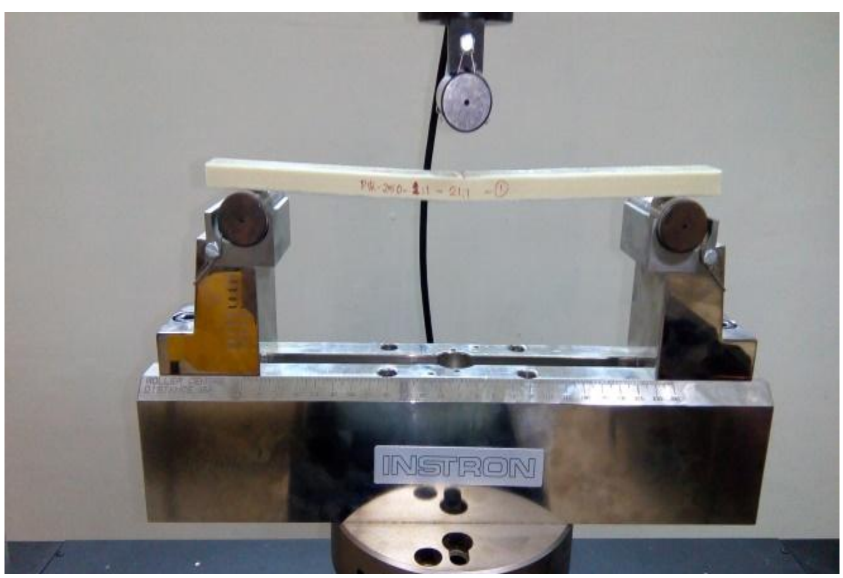

Figure 2: Three point bending testing macchine (ASTM)

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4.1 Results For Three Point Bending Test

Skin to core weight ratio	Maximum bending stress	Mean of bending stress(MPa)	Flexural rigidity(Nmm*2)
2:1(21:1)	188.92	151.5	14983624.53
2:1(16:1)	148.5	124.875	14983624.53
1:1(21:1)	163.64	156.8	7588577.455
1:1(16:1)	148.32	142.40	7588577.455

Table 3: PIR250,skin to core weight ratio(1:1), span to thickness ratio(16:1)

Sr. no	Maximum Bending stress (MPa)	Deviation in bending stress (MPa)	Maximum shear stress in core(MPa)	Shear strain
1	148.32	-5.92	0.6386	0.0313
2	140	2.4	0.603	0.02959
3	140	2.4	0.6029	0.02959
4	141.3	1.1	0.60	0.02985

Table 4: PIR250,skin to core weight ratio(2:1), span to thickness ratio(21:1)

Sr. No	Maximum Bending stress (MPa)	Deviation in bending stress(MPa)	Maximum shear stress in core(MPa)	Shear strain
1	131.76	19.74	0.86	0.03542
2	130.25	21.25	0.85	0.0349
3	163.84	-12.3	1.0807	0.044
4	143.47	8.034	0.946	0.03857
5	188.92	-37.416	1.24669	0.0507

Table 5: PIR 250,SKIN TO CORE WEIGHT RATIO 2:1 AND SPAN TO THICKNESS RATIO(16:1)

Sr. no	Maximum bendinding stress (MPa)	Deviation in bending stress(MPa)	Maximum shear stress in core(MPa)	Shear strain
1	163.64	-6.84	0.59	0.026
2	161.55	-4.75	0.58	0.02735
3	156	0.8	0.48	0.02635
4	147.69	9.11	0.51	0.02564
5	155.1	1.7	0.52	0.02607

Table 6: PIR250, Skin to core weight ratio (1:1), span to thickness ratio 21:1

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SKIN TO CORE WEIGHT RATIO (2:1)	Properties for different skin to core weight ratio	21:1(SPAN TO THICKNESS RATIO)	16:1(SPAN TO THICKNESS RATIO)
	Maximum Bending Stress Range (N/mm^2)	188.32	148.5
	Flexural Rigidity Per unit width ($N\text{-}mm^2/mm$)	633557	633557
	Max Bending strength Per unit width range (N/mm)	868	683
	Max shear stress in core	1.24669	1.286
	Max shear strain	0.0507	0.0524
	Bending shape factor for stiffness	10.1759	10.175

Table 7: Flexural results results for 2:1 specimen

SKIN CORE WEIGHT RATIO (1:1)	Properties for different skin to core weight ratio	21:1S(SPAN TO THICKNESS RATIO)	16:1(SPAN TO THICKNESS RATIO)
	maximum bending stress (MPa)	163.64	148.32
	Flexural rigidity per unit width	345563.61	345563.61
	Max bending strength per unit width (N)	402	364.17
	Max shear stress in core (MPa)	0.59	0.6386
	Max shear strain	0.02735	0.0313
	Bending shape factor for stiffness	17.59	17.59

Table 8: Flexural results for 1:1 specimen

5. CONCLUSION

Three-point bending test on PIR foam glass/epoxy sandwich composites are carried out by varying spans and plotted the relevant graphs for determining the flexural behaviour. Specimens were expected to be failed by laminate shear failure, compressive core crushing, laminate core interface failure, tensile and compressive yielding. Majority of specimens failed by laminate shear, while only a few number of specimens undergone failure by laminate-core interface shear failure which can be due to desired failure mode for optimization. The laminate-core shear interface failure was found only in two specimens of $250kg/m^3$ density 2:1 and 1:1 skin to core weight ratio, with span to depth ratios16:1 and 21:1. From the plots, flexural rigidity of specimens with span to depth ratio 21:1 is lower than 16:1. This could be due to the variation in the Elastic modulus for shorter span specimens. The bending strength increases with increase in span almost linearly. With increase in skin to core weight ratio flexural rigidity and bending strength increases but variation is not exactly linear. There is no particular trend in the variation of bending stiffness with weight ratio as it gives a zigzag plot. This may be due to the increase in the sandwich panel thickness, which increases the distance from neutral axis giving more normal stress bearing capacity to the specimen and thereby increasing the flexural rigidity and bending strength.

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