IJARSE
ISSN 2319 - 8354

DEVELOPMENT OF A BIO DEGRADABLE SANDWICH COMPOSITE PANELS FOR PARTITION WALLS

Thiyaneswaran. V[1], Dr. Gopalakrishnan. K. M[2],

Mr. M. Balaji[3]

[1]*PG Scholar, Department of Civil Engineering, Erode Sengunthar Engineering College, Erode- 638057.*

[2]*Professor, Department of Civil Engineering, Erode Sengunthar Engineering College, Erode – 638057*

[3]*Assistant Professor, Department of Civil Engineering, Erode Sengunthar Engineering College, Erode – 638057*

ABSTRACT

In the present state of affairs, the yearn for the composite sandwich structures in the construction sectors are emerging at a huge rate since composite sandwich wall panels are mainly preferred for light weight structures. This concept is appurtenant due to its extremely high strength to weight ratios. In spite of this, lack of structural freedom and high environmental and economic issues have retarded its wide range of application over these industries. Lately it has been proposed that improvement in specific mechanical behavior, economic and environment benefits could be achieved within realm of possibilityusing natural based composite structures comparing to prior sandwich structures.Therefore in our research work, flax is used as reinforcement and agglomerated cork as core material which has been proposed as a natural based composite sandwich. An experimental investigation was conducted to study the effect of sandwich panels with agglomerated cork on three different densities as a core material and the facing madeof(i) Glass, (ii) flax, (iii) hybrid and followed by separate campaign over face sheets on mechanical and environmental aspects.The objective of this investigation is to determine the mechanical behavior and failure mechanisms of sandwich structures using flat wise compression ASTM C 297 and edgewise compression ASTM C 364 and to compare their respective performance. The composite specimens were fabricated using vacuum assisted resin transfer molding process and tested in accordance with ASTM standards. Finally the study on the environmental aspects of a cork cored composite sandwich has been conducted using biodegradable test (soil burialtest).

The result elucidates that the specific strength of flax reinforced composite sandwich is higher than that of glass and hybrid reinforced composite sandwich, with a comparatively lesser load carrying capacity over other *sandwich structures. It is also observed that the increase in cork density increases the mechanical properties of the composite sandwich. The result of biodegradation test indicates that the biodegradability rate of a natural based composite sandwich is higher compared to the other sandwich structures.*

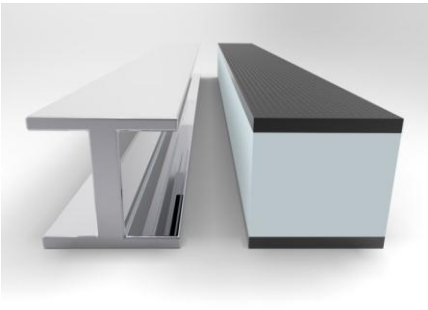
Keywords *— (i) Glass, (ii) flax, flat wise compression ASTM C 297, edgewise compression ASTM C 364, ASTM standards,biodegradable test (soil burialtest),sandwich structures.*

I.INTRODUCTION

In the modern rundown, the use of composite sandwich structures in construction, aerospace, automobile and marine applications has been increasing especially due to their extremely low weight that leads to reduction in the total weight and fuel consumption, high flexural and transverse shear stiffness [1]. Composite sandwich consists of low density core with stiff skins. It offers extensive potential for weight reduction in wide range of applications. In addition, these materials are capable of absorbing large amounts of energy under impact loads which results in high structural crashworthiness. A sandwich structure endeavors different mechanical properties with the use of different types of materials because the overall performance of sandwich structures depends on the properties of the constituents [2]. These sandwich structures becomes more copacetic in an assortment of fields, due to its high strength to weight ratio, faster construction, better thermal insulation, and electromagnetic properties, meanwhile, it has been proposed that the structural properties of the composite structure varies with core, facing and thickness of the sandwich structure. In a sandwich structure, generally the bending loads are carried by the force couple formed by the fact sheets whereas the shear loads are carried by the lightweight core material [3]. The face sheets are strong and stiff both in tension and compression as compared to the low density core material whose primary purpose is to maintain a high moment of inertia. Cores are the runt part of the composite sandwich but uphold the distance between two facing laminates, which provides compressive strength and withstands shear deformation of the sandwichstructure.

1.1 COMPOSITE SANDWICH

Sandwich structured composites are a special class of composite materials which have become very popular due to high specific strength and bending stiffness. Low density of these materials makes them especially suitable for use in aeronautical, space and marine applications.



.**Fig. 1.1 Sandwich analogous to I-beam**

1.1 RESEARCHOBJECTIVES

The following objectives are identified for this study:

- To investigatethe mechanical behavior and failure mechanisms of natural based sandwich structures using flatwise compression,and edgewise compression, and to compare their respective performance over synthetic compositesandwich.
- To study the interfacial bond on natural based composite sandwich using scanning electron microscopy.
- To investigatethe influence of cork density in the compositesandwich.
- To examinetherate of biodegradation of composite laminates and sandwich structures using soil burialtest.

II. MATERIALS AND FABRICATION PROCESS

In the present state of affairs, the development of high-performance composites sandwich made from natural resources has been increasing worldwide due to environmental and sustainability concerns. The natural constituents can be used as reinforcing elements (normally in the form of fibers), biopolymers or both. The reinforcing fibers have a significant impact in the overall mechanical behaviour of composites which has been searched out on considering the significant number of scientific literature dedicated to natural fibers.

2.1 MATERIAL SELECTION:

There are several criterions that have to be contemplated in the material selection. Some of these criterionsare:

- Structuralfreedom,
- Fabricationconstraint,
- Economicand
- Environmentalaspects.

2.1.1 Selection ofReinforcement

Figure 3.1 summarizes the main categories of the natural fibers grouped according with their extraction sources.

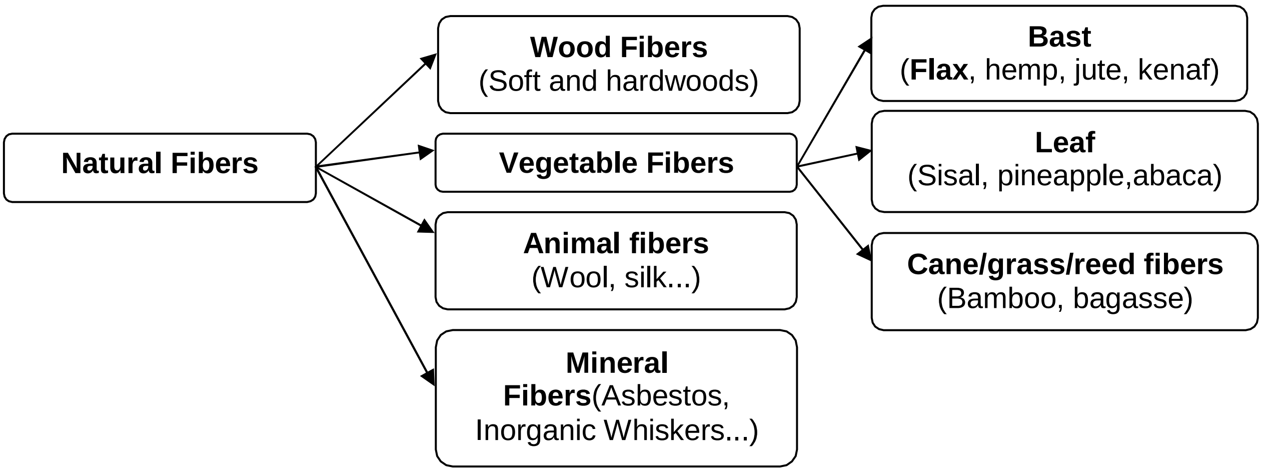


Fig.2.1Main categories of the natural fibers

IJARSE
ISSN 2319 - 8354

.

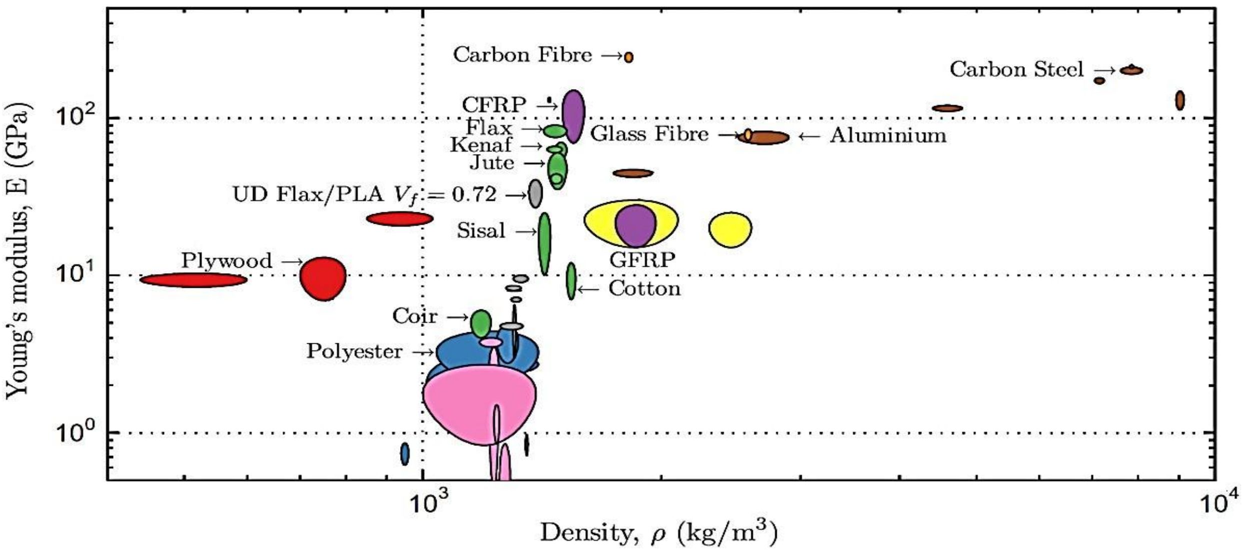
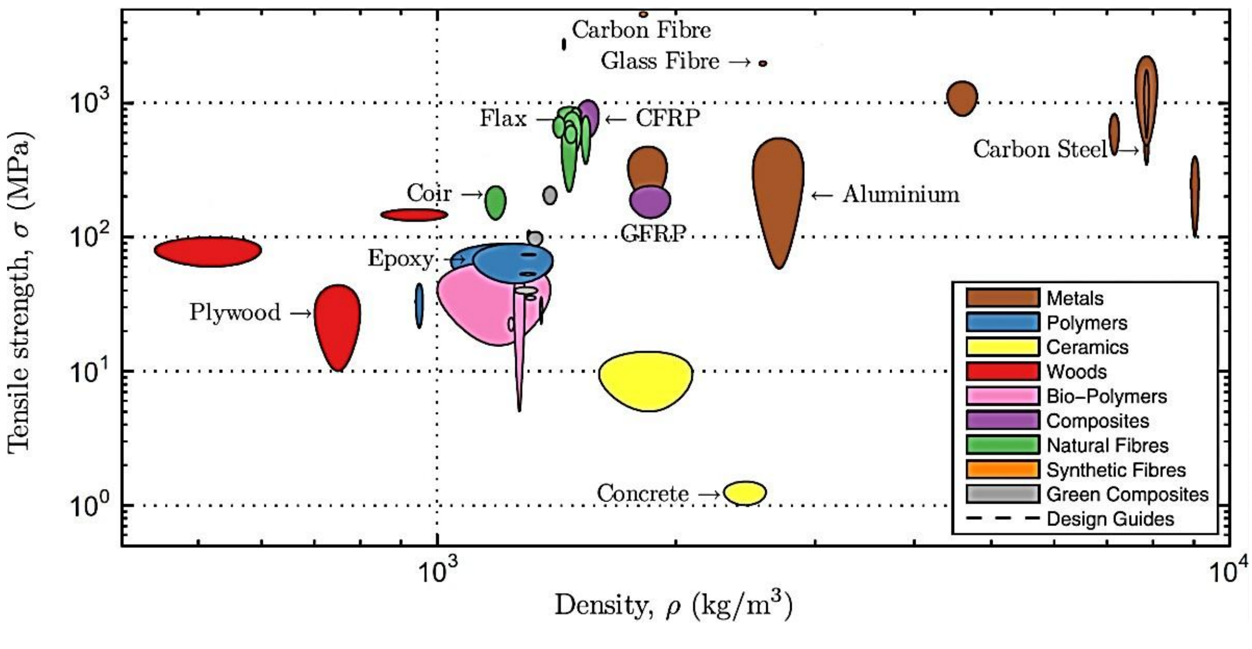


Fig.2.2 Ashby plots on themodulus and strength properties of a wide range of materials[21]



Amongst this natural fiber shown in Fig.3.1, vegetable fibers have taken a leading position in the research and production of green-composites over the last decade. The attractiveness of modern agricultural techniques ensuring a high production yield together with very interesting mechanical properties are the key reason for this choice[20].Several works evinced that there might be some cases where the strength (or stiffness) to weight ratios of some natural fibers are in the same range or even higher than some synthetic fibers, namely E-glassfibers.

Global trends towards sustainable development have brought to light natural, renewable; biodegradable raw materials on several applications, among them flax fibers are predominant.In order to outline the general characteristics of naturally occurring materials in terms of mechanical strength and stiffness, it is useful to refer to the two Ashby plots in Fig.3.2.

2.1.1.1 Flax:

Table 2.1Physical and tensile properties of flax fibers by different authors

Diameter (μm)	Density (g/cm^3)	Tensile strength (MPa)	Elastic modulus (GPa)	Strain at failure (%)	References
12-600	1.4 – 1.5	343-2000	27.6-103	1.2-3.3	Dittenber&GangaRao,
17.8 ± 5.8	1.53	1339 -486	58 - 15	3.27 - 0.4	Baley, 2002
12.9 ± 3.3	-	1111 – 544	71.7 - 23.3	1.7 - 0.6	Andersons et al., 2006
15.8 ± 4.1	-	733 – 271	49.5 - 3.2	1.7 - 0.6	Andersons et al., 2006
15.6 ± 2.3	-	741 – 400	45.6 - 16.7	1.7 - 0.6	Andersons et al., 2006
21.2 ± 6.6	-	863 – 447	48.0 - 20.3	2.1 - 0.8	Andersons et al., 2006
15 ± 0.6	1.53	1381 – 419	71 - 25	2.1 - 0.8	Charlet et al., 2006

Fig.2.3 Glass fiber and Flax fiber

This research work substantially focused on flax as reinforcement with aconcern of coinciding the functional requirements, cost attractiveness and less environmental burdens. The work also focused on glass and hybrid reinforcement for the purpose of comparison. Table 3.1 describes the physical and tensile properties of a flax fiber suggested by different authors and Table 3.2 shows the comparison of physical and tensile properties of natural fibers and glassfibers.

Table 3.2Comparison on physical and tensile properties of natural fibers and glass fibers

Fiber type	Density (g/cm^3)	Tensile strength (MPa)	Elastic modulus (GPa)	Specific modulus (GPa cm^3/g)	Elongation at failure (%)
E-glass	2.5-2.6	2000-3500	70-76	29	1.8-4.8
Bamboo	0.6-1.1	40-800	11-32	25	2.5-3.7
Banana	1.35	500	12	9	1.5-9
Coir	1.15-1.46	95-230	2.8-6	4	15-51.4
Cotton	1.5-1.6	287-800	5.5-12.6	6	3-10
Flax	**1.4-1.5**	**343-2000**	**27.6-103**	**45**	**1.2-3.3**
Hemp	1.4-1.5	270-900	23.5-90	40	1-3.5
Sisal	1.33-1.5	363-700	9.0-38	17	2.0-7.0

2.1.2 Selection of CoreMaterial

The main common impediment involved in the existing core material is lack of structural freedom. These core materials are fabricated in the form of flat panels with variance in thickness, which constraints their versatile use. Balsa wood can be alleged as 'natural honeycomb', because it has a similar hexagonal structure of a synthetic honeycomb. However it has a limitation over the size of cross section in order to cover a huge plane of structure with vertically aligned grains. In contempt of low density and excellent thermal property, mechanical aspect and environmental benefits of foam is lower than other core materials. Honeycomb structures are light and strong against compression but its structural limitation, high cost and a fabrication difficulty retards its wide range of use. Henceagglomerated Cork is used as a core material due to its low density, reduced thermal conductivity and enhanced corrosive resistance[16].

2.1.2.1 Agglomerated Cork:

Cork is a natural, renewable, sustainable material extracted from the bark of the oak (*Quercussuber L.*) which is periodically harvested from the tree, usually every 9–12 years. The most intensive cork production is located around the Mediterranean basin and China. Microscopically, cork may be described as a homogeneous tissue of thin-walled cells, regularly arranged without intercellular space lying under an alveolar structure, analogous to that of ahoneycomb.

2.2 PROCESS SELECTION:

The fabrication of composites is a convoluted process and it requires simultaneous consideration of various parameters such as component geometry, production volume, reinforcement & matrix types, tooling requirements, and process and market economics. The multitude of tasks involved in the manufacturing of composite laminates can be categorized into two phases: (1)

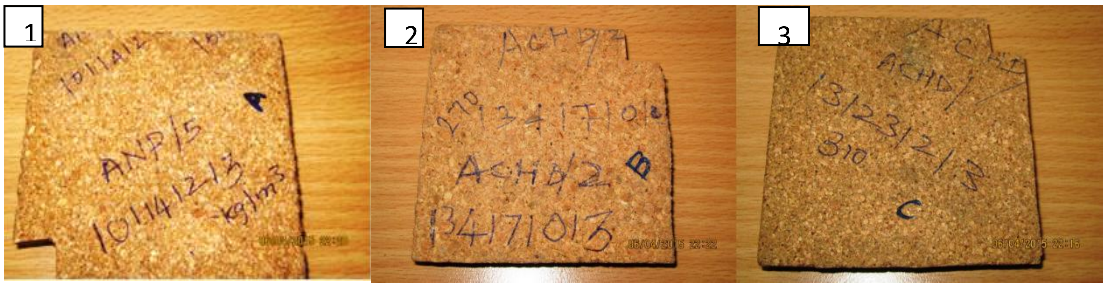


Fig.2.4: Agglomerated cork with density: 240kg/m^3, 280 kg/m^3 and 400 kg/m^3.

Composite materials can be fabricated by many techniques like,

2.2.1 Open MoldingProcess,

2.2.2 Vacuum BagMolding,

2.2.3 Auto-clave,

2.2.4 Compressionmolding,

2.2.5 Vacuum Assisted Resin Transfer Moldingand

2.2.6Injection Molding,etc.

Among them, vacuum assisted resin transfer molding process is predominant due to its low cost tooling,scalability to very large structures andreduced lay-up time which makes the fabrication process more reproducible, consistent and less dependent upon operator skills.

Table3.3Comparison onfabrication process.

S.no	Manufacturing process	Equipment Cost	Rate of production	Part strength
1	Vacuum assisted Resin transfer	Low	Medium	
	moulding	High	High	-
	Compression moulding			
2				-
3	Hand layup	Low	Medium	Medium
4	Vacuum bagging	Low	Medium	Low

III. FABRICATION OF COMPOSITE AND SANDWICH STRUCTURES USING VARTM PROCESS

3.1 INTRODUCTION

Vacuum Assisted Resin Transfer Molding (VARTM) has been developed as a variant of the traditional RTM process to reduce the cost and design difficulties. In VARTM, the upper half of a conventional mold is replaced by a vacuum bag. This eliminates the need for making a precise matched metal mold as in the conventional RTM process. Fig.5.1 shows a generalized schematic diagram of the VARTM process.

IJARSE
ISSN 2319 - 8354

This process is a low cost composite fabrication technique, differing from prepreg laminated composites, the resin is infused into dry fabric formed on a mold near product shape under vacuum pressure and cured in an oven. This process has already been utilized in the manufacture of commercial products such as windmills.The process increases the component mechanical properties and fiber content by reducing void percentage, when compared to other large-part manufacturing processes, such as hand lay-up.

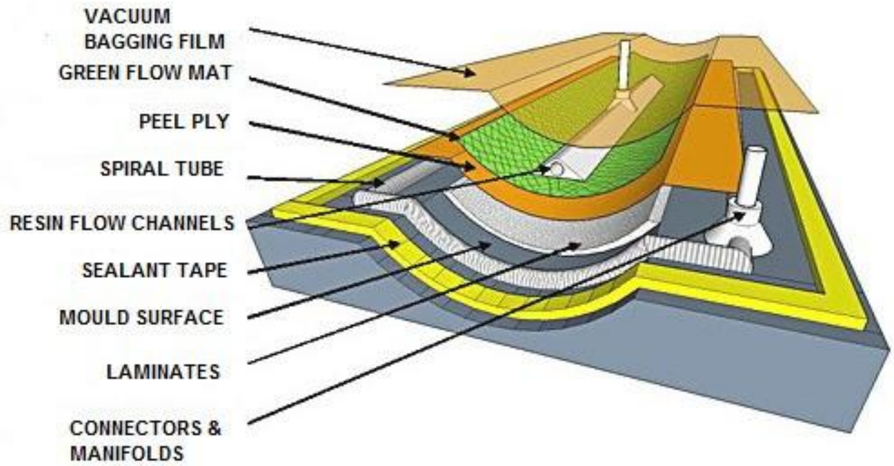
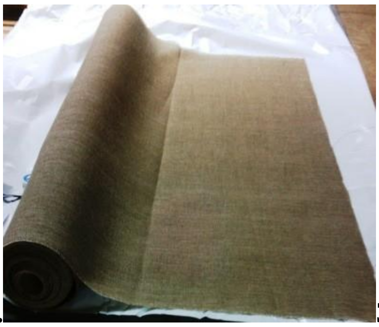


Fig.5.1 Vacuum Assisted Resin Transfer Molding (VARTM) process

3.2 STEPS INVOLVED IN FABRICATIONPROCESS

The step by step procedure involved in manufacturing process is as follows:

1.  **2.**  **3.** 

4.

Fig 5.2Steps involved in Vacuum assisted resin transfer molding (VARTM) process.

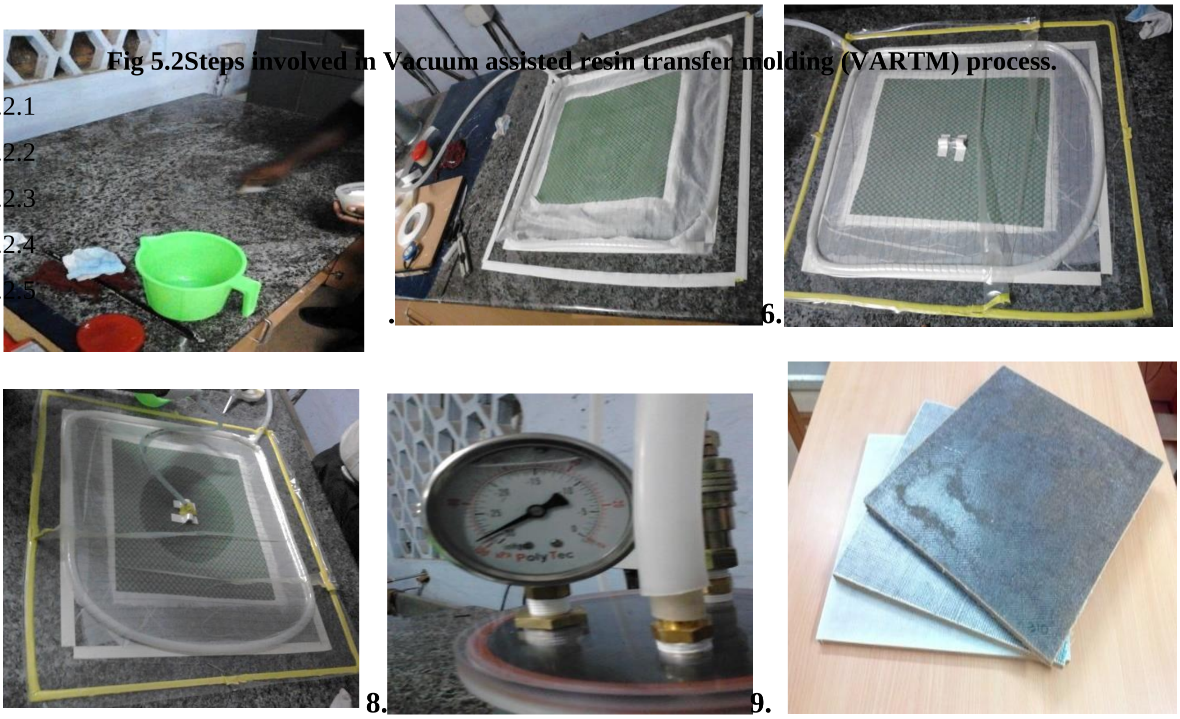
3.2.1

3.2.2

3.2.3

3.2.4

3.2.5



. 6. 8. 9.

3.2.6 Core material, Reinforcement – 2. Flax fibre and 3.Glass fibre, 4. PVAcoating,5. Placement of spiral tube, 6.Vacuum bagging, 7.Resin impregnation on preform8. Pressure gauge and resin collector, 9.Sandwich panels

- The surface of the mold has been cleaned using acetone, and coated with mold release i.e. PVA coating for easy removal of the preform from moldsurface.
- The preform of sandwich structure consists of required amount of the fiber layers that has been coveredoverandbeneaththecorkinequalproportionasafacesheetandplacedoverthecoatedsurface (The amount of layers can be sorted out as per the requirement on the thickness of the structure). Whereas for laminates, a stack of fibers were alone placed over the coated surface.
- The top and bottom of preform was covered using peel ply for easy removal of the preform from mold surface.
- Distributor and green flow mate was placed over peel ply for proportional resindistribution.
- A vacuum sealant tape was placed around the perimeter of the mold surface and vacuum bagging film was used to cover the stacked preform to create a sealedmold.
- A vacuum pump has been used to evacuate the sealed mold. After evacuating the preform,

the vacuum is incepted into the setup with a help of vacuum pump which causes the resin to surge and impregnate over the preform (before surging, the resin was mixed with the hardener in the pre-calculated percentages and the mixture was degassed).The resin supply was sealed once the preform was thoroughly wetted. After resin gelation the vacuum port wassealed.

- The preform was allowed to cure overnight at room temperature (26°C) and then removed from vacuum baggingfilm.

5.1 PROCEDURES:

The procedures to be followed in the biodegradable test under soil environment are as follows:

- Take a vessel for testing compost containing residual plastic material (capacity of600-700ml).
- Fill the three fourth (approx. 500g) vesselswith the wetland soil.The soil used in this test should be natural and fertile collected from the surface layers of fields and forests. It is advisable to avoid soil that has been exposed to pollutants that cause significant perturbations of the microbial population. The soils are preferably used fresh from the field to assure activemicrobial.
- Initial analysis and measurement should be done before testing the known quantity of the substrate.
- Organic chemicals like potassium, nitrogen, calcium and sulphur, followed by 20% of cow dungis mixed with the fertile soil. The potassium is obtained from super phosphate, Nitrogen from Urea and sulphur is obtained from thepotash.
- Moisture of 50% in the fertile soil should bemaintained.
- Once the initial analysis is completed, the known quantity of the substrate is weighted and impregnated into the fertilesoil.
- The known quantity of the substrate which is impregnated in the fertile soil should be weighted and recordedregularly.
- Proper investigation analysis should be made once in every 15days.

5.2 SPECIMENDETAILS:

The types of specimens subjected to biodegradability analysis were as follows: Sandwich structure with cork density 240 kg/m^3

5.2.1 Glass + Epoxy +Cork.
5.2.2 Flax + Epoxy +Cork.
5.2.3 Hybrid + Epoxy+ Cork. Sandwich structure with cork density 280kg/m^{3}Glass + Epoxy +Cork.
5.4.4Flax + Epoxy +Cork.
5.2.4 Hybrid + Epoxy+ Cork.Sandwich structure with cork density 400kg/m^3
5.2.5 Glass + Epoxy +Cork.
5.2.6 Flax + Epoxy +Cork.
5.2.7 Hybrid + Epoxy+Cork.

Note: Each category consists of four specimens to its name. The measurement and investigation analysis of a specimens belonging to their category are considered as a whole.

Fig 5.2Sandwich structures with cork density 240kg/m^3

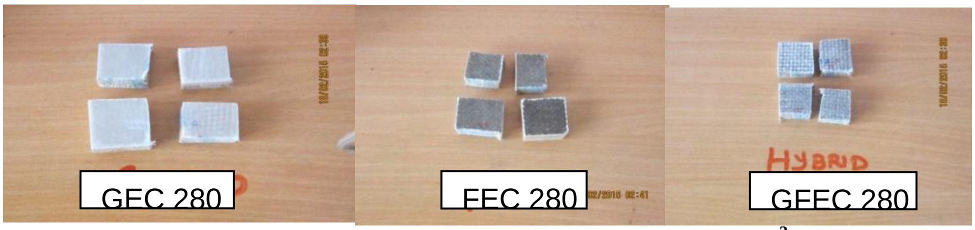


Fig 5.3Sandwich structures with cork density 280kg/m^3

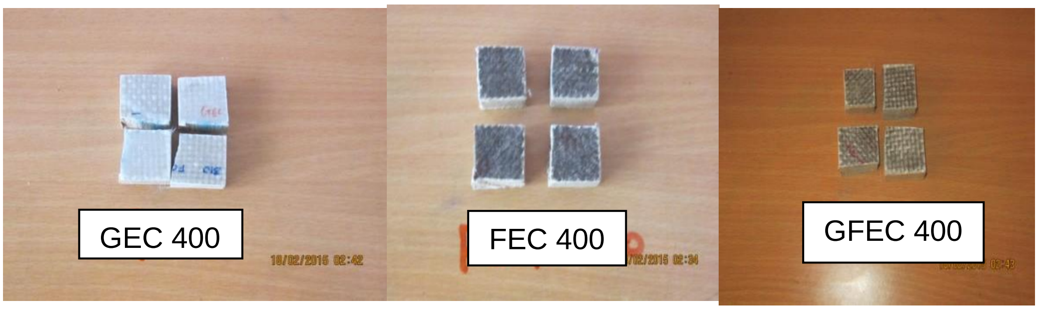


Fig 5.4Sandwich structures with cork density 400kg/m^3

VI RESULTS AND DISCUSSIONS

6.1 DENSITY OF COMPOSITE ANDSANDWICHES:

In the flatwise compression test, failure occurs due to flat wise compression causes crack propagation at the center of the core which leads to the crushing of the core resulting in bulging at the edges of the sandwich. Similar type of failure is observed in all the specimens. As the load increases, the thickness of the sandwich reduces due to compression. The maximum average compressive load withstand by the cork cored sandwich specimen with cork density 240 kg/m^3 under flat wise compression is 41.77kN for GEC 240, 40.27kN for FEC 240 and, 41.13kN for GFEC 240 and for the cork cored sandwich specimen with cork density 280 kg/m^3, it is observed that the maximum compressive load is 49.51kN for GEC 280, 40.53kN for FEC 280 and, 50.62kN for GFEC 280. Similarly for the case of cork cored sandwich specimen with cork density 400 kg/m^3, 58.18kN for GEC 400, 51.53kN for FEC 400 and, 53.03kN for GFEC 400.It was observed that up to the maximum load level a linear load-deformationrelation took place. The load continued to increase with a small slope afterthe initial drop.From the observation, it is found that maximum compressive strength of the flax sandwich is lower than that of glass and hybrid.The key ultrastructure features that affect the compressive properties of the flax composite sandwich are as follows:

6.1.1.1 Lumen Size: fiber compressive properties are proportional to the cell wall cross-sectional area. The larger the relative lumen size, lowers the stiffness and strength of thefibers.

6.1.1.2 Cellulose content: An increase in the cellulose content of the fibers was found to be well correlatedwithanincreaseoftheirstiffnessandstrength.Inaddition,thecellulosecrystallinityand the crystallite aspect ratio are known to affect the stiffness of the cell wall in the micro fibril direction.

6.1.1.3 Micro fibril Angle: The low micro fibril angle of flax fibers makes them highly anisotropic and this leads to relatively low comparativestrength

VII CONCLUSION

In the above project we had find that bio degradability of Wall Panels using composite made by Natural fibre materials and the results shows that the wall panels are environmental friendly by the above bio degradabilitytests.

VII REFERENCES

1. ASM International Metals Park, 1987, Engineered Materials Handbook, Vol.1.
2. Davies G.A.O, Hitchings D, Besant T, Clarke A, and C. Morgan, "*Compression after impact strength of composite sandwich panels*",2005, CompositeStructures. Vol. 63: pp.1–9.
3. Nguyen M.Q, Jacombs S.S, Thomso R.S, Hachenberg D, and M.L. Scott, "*Simulation of impact on sandwich structures*". 2005, Composite Structures, Vol.67:pp.217-227.
4. GencGarip, El Hafidi Ali, and Gning Papa Birame, "*Comparison of the mechanical properties of flax and glass fiber composite materials*", 2012, Journal of Vibro engineering, Vol. 14:pp.572- 579.
5. Mohamed. A. torabizadeh,"*Tensile, compressive and shear properties of unidirectional glass/epoxy composites subjected to mechanical loading and low temperature services*", 2013, Journal of Emergency Medical Services, Vol.20: pp.299-309
6. PreetiLodha, Anil N Netravali, "*Characterization of interfacial and mechanical properties of "green" composites with soy protein isolate and ramie fiber*", 2002, Journal of materials science, Vol. 37(17),pp.3657-3665.
7. Georgios Koronis, Arlindo Silva, MihailFontul, "*Green composites: A review of adequate materials for automotive applications*", 2013, Composites: Part B, Vol.44,pp.120-127.
8. M.M. Kabir, H. Wang, K.T. Lau, F. Cardona, T. Aravinthan, "*Mechanical properties of chemically-treated hemp fibre reinforced sandwich composites*", 2012, Composites: Part B, Vol. 43, pp.159–169.
9. Jose M. Silva, Roberto Sabatini, Alessandro Gardi, "*Opportunities Offered by Naturally Occurring Materials in Lightweight Aero structures Design*", 2014, Engineering Australia conventions.

10. Sabnis, 1979, G. M. Handbook of Composite Construction Engineering, Van Nostrand Reinhold Company, New York.
11. Enrico Papa and Alberto Corigliano, "*Mechanical behaviour of a syntactic foam/glass fiber composite sandwich: experimental results*", 2001, Structural Engineering and Mechanics, Vol. 12(2),pp.169-188.
12. Frostig Y, and Thomsen O. T, "*Non-linear behaviour of delaminated unidirectional sandwich panels with partial contact and a transversely flexible core*.", 2005, International Journal of Non- Linear Mechanics, Vol. 40, pp. 633 –651.
13. James Berthelot and Enlolive, "*Non-Linear Behaviour of Foam Cores and Sandwich Materials, Part 1: Materials and Modeling*", 2002, Journal of Sandwich Structures and Materials; Vol.4(3), pp.219-247.
14. Joseph Morlier, Amir Shahdin, Laurent Mezeix, Christophe Bouvet, Yves Gourinat, "*Fabrication And Mechanical Testing Of Glass Fiber Entangled Sandwich Beams: A Comparison With Honeycomb and Foam Sandwich Beams*", 2009, Composite Structures, Vol. 90, pp. 404–412.
15. YichengDua, Ning Yan, Mark T. Kortschot, "*Light-weight honeycomb core sandwich panels containing biofiber-reinforced thermoset polymer composite skins: Fabrication and evaluation",*2012, Composites: Part B, Vol.43, pp.2875–2882.
16. James Sargianis, Hyung-ick Kim and Jonghwan Suhr, "*Natural Cork Agglomerate Employed as an Environmentally Friendly Solution for Quiet Sandwich Composites*", 2012, scientificreport: Nature publishing group, pp.1-8.
17. A. Mir, B. Bezzazi, R. Zitoune, and F. Collombet, "*Study of mechanical and hygrothermal properties of agglomerated cork*", 2012, Mechanika, Vol. 18(1), pp.40-45.
18. Kannan R, and Paramananthan B, "*Studies on Biodegradability of Rice Husk/ E-Glass/ Polypropyne Hybrid Composites", 2014,* Global Engineers and Technologists Review, Vol. 4(3), pp.1-5.
19. A.A.A. Rashdi1, S.M. Sapuan1, M.M.H.M. Ahmad2 and A. Khalina1, *" Combined Effects of Water Absorption Due To Water Immersion, Soil Buried And Natural Weather On Mechanical Properties Of Kenaf Fiber Unsaturated Polyester Composites (KFUPC)***",** 2010, International Journal of Mechanical and Materials Engineering (IJMME), Vol. 5(1), pp.11-17.
20. Dicker M.P.M, Duckworth P.F, Baker A.B, Francois. G, Hazzard M.K and Weaver, "*Green composites: A review of material attributes and complementary applications*", *Composites Part A: Applied Science and Manufacturing*, vol. 56, pp.280-289