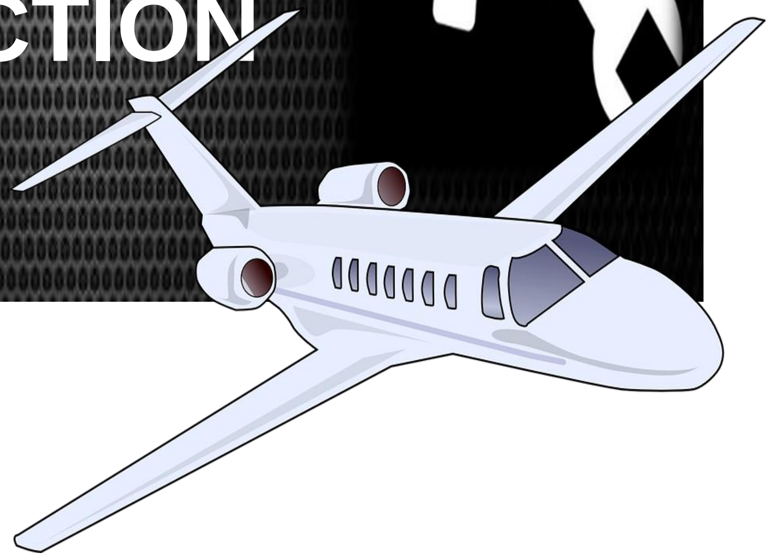
AMT 2106 –AIRCRAFT MATERIALS CONSTRUCTION AND REPAIR II (Composite)

PRELIM PERIOD

LABORATORY MODULE IV

BUILDING CORE MATERIALS: CONCEPT OF SANDWICH CONSTRUCTION



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General Plastics Manufacturing (march 2020) retrieved from https://www.azom.com/article.aspx?ArticleID=18971	**1**
A&P Technician Airframe Textbook - Jeppesen	**2**
Dr Damian Bannister, Chief Technical Officer, Gurit(2014)Citation An introduction to core materials: Part 1 – Designing sandwich structures retrieved from https://www.materialstoday.com/composite-processing/features/an-introduction-to-core-materials-part-1/	**3**

This laboratory module briefly discusses the importance of discussion to choose the right kind of composite core material that works as intended and offers the properties specified for users' applications. This module also set the criteria that have to be met by the material to help narrow down the decision-making process.

TIMEFRAME

You should be able to complete this module including all the self-assessments, research works, assignments, and other performance tasks within **3** hours.

LEARNING OUTCOMES

Course Learning Outcomes (CLO)

CLO 1. Explain the development of the composite structure and classify its element in terms of properties , advantages and characteristics of each elements

CLO 3. Produce clearly written, thorough and concise reports with well-founded analysis and conclusions, that explains the operation, applications of the composite structures to the aircraft

CLO 9. Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria, methods and techniques

Module Learning Outcome (MLO)

MLO 1. Explain and create understanding of facts and ideas of core being used in aircraft applications

MLO2. Developed a simple core materials in a concept of honeycomb core materials.

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Topic Learning Outcomes(TLO)

TLO 4. Construct and demonstration of core materials being used in aircraft applications and understand its concept and principle

As an introductory activity, you are encouraged to watch a short video entitled " Sandwich Core Materials ", using the following You Tube link: https://www.youtube.com/watch?v=DsQ8JGBhR-8 .

This shows an introductory part of Core Materials and samples of each types. Sandwich Core Materials are lightweight, structural layers that are embedded between laminate layers in order to build bulk and strength for a part—without adding significant weight. By employing sandwich core materials in your part or mold, you can achieve much higher flexural strength and flexural modulus than using skin laminates alone. Want to learn more about Sandwich Core? Pay special attention to the discussion 5 minutes after the introductory part using video presentation. We were starting discussion on laboratory how to choose composite materials defending on your applications, and creating a simple concept of sandwich construction as a part of laboratory activity

LABORATORY MODULE IV- CORE MATERIALS

HOW TO CHOOSE COMPOSITE CORE MATERIALS FOR YOUR APPLICATION

The function of engineered structures is completed by using composite core materials to make up for performance requirements or a specific type of design. The requirements may be reducing weight, adding stiffness, offering energy absorption, or providing impact resistance.

It is important to choose the right kind of composite core material that works as intended and offers the properties specified for users' applications. However, there are many practical material options available, which make it important to first identify the criteria that have to be met by the material to help narrow down the decision-making process.

General Plastics covers the various factors that should be taken into consideration when choosing an appropriate composite core material. The company also specifically discusses material compatibility elements, significant processes, and application considerations.

Core Values

The main function of a composite core material is to offer stiffness, strength, and continuity across a structure without considerably increasing weight. Whether a core material is over-molded with self-skinning decorative cover/flexible foam or fixed between two composite skins to create a sandwich panel, it acts as the foundation or core member of a structure.

One of the main users of composite materials is the aerospace sector. Composite materials are often used as cargo liners, interior floor and ceiling panels, window surrounds, panels, overhead stowage bins, food and drink trolleys, lavatory modules, galleys, and bulkheads/class dividers.

However, composites are increasingly being used across other different industries such as medical, transportation, marine, etc. In 2019, the U.S. composite end products market was estimated at $26.7 billion and is predicted to increase at a compound annual growth rate (CAGR) of 3.8% in the next five years to reach $33.4 billion by 2025.

Composite core materials, often recognized for their excellent strength-to-weight ratio, have to be assessed for other properties and qualities like chemicals, moisture, resistance to corrosion, durability, and other environmental exposures. But these qualities rely on the type of material utilized, which makes it exceptionally significant to analyze and select an ideal core material to meet the structural demands. The selection of a core material starts with careful consideration of the manufacturing process, material qualities, and the preferred performance.

As we also mention to the lecture specifically on Module IV – Core materials, these are the common composite core materials as follows:

1. Balsa

The closed-cell structure of end-grain balsa features elongated, prismatic cells with a length (direction of the grain) measuring around 16 times the diameter. Balsa comes in a scrim-backed block arrangement that conforms to intricate curves, or in sheet form for flat panel construction.

2. Honeycomb

Honeycomb materials include aluminum, paper, polypropylene, phenolic resin impregnated fiberglass, and aramid fiber phenolic-treated paper. The physical characteristics differ to a large extent with the particular material and density. Extremely lightweight panels can be fabricated using honeycomb cores.

3. Foam Core

PVC Foam

Polyvinyl chloride, or PVC, foam cores are produced by integrating a polyvinyl copolymer with plasticizers, stabilizers, blowing agents, and cross-linking compounds. PVC foams provide an excellent combination of weight and strength with densities spanning from 4 to 30 lbs/ft^3.

Polyurethane Foam

Polyurethane (PU) foams are available in sheets, blocks, or other shapes. At times, PU foams are separately molded into discrete part-shapes. Based on formulation, the foams can be useful for temperatures ranging between 275 °F and 350 °F, and they still retain a significant amount of their toughness and strength. This feature enables them to be utilized in panel applications together with high-temperature curing prepregs, cured in autoclaves or ovens.

Image Credit: General Plastics Manufacturing

Factors to Consider

Generally, design engineers focus on the :

- core material's end cost,
- performance or design requirements,
- and property requirements needed to accommodate those demands.

For example, honeycomb is commonly used in composite core panel applications, has an excellent strength to weight ratio, but can be susceptible to moisture and is also on the expensive end of the spectrum

The first important step is to narrow down the properties that are particularly required for the application and assess the cost involved.

Standard types of composite core applications can be divided into two main groups — **sandwich panels and shaped cores.**

Sandwich Panels

Sandwich panels are utilized in many different applications in a variety of markets, including automotive and aerospace markets. A standard sandwich panel contains lower and upper skins that have a relatively thicker core in the center. The key purpose of the core in the middle of the sandwich panel is to provide as much spacing as possible between the two skins to produce the panel stiffness, introducing as little weight as possible, while simultaneously resisting the forces generated upon loading the structure.

Important Core Material Properties to Consider

Compressive Strength. The compressive strength of a material describes the extent of force that is sustained by a material before it succumbs to the force and breaks or deforms. Certain materials break down at their compressive strength limit, while others deform irreversibly. Therefore, a specified amount of deformation could be regarded as the limit for a compressive load.

Flexural Strength. Flexural strength is the stress sustained by a material just before it yields in a flexure test. Also called bend strength, flexural strength helps to quantify the level of a material's rigidity

Flexural Modulus. Flexural modulus is the ratio of stress to strain in flexural deformation, or the tendency of a material to resist bending. It is a crucial calculation since it corresponds to a panel's resistance to deflect when utilized as a structural member.

Shear Strength. Shear strength quantifies the highest amount of stress that can be tolerated by a material before it breaks or tears following the shifting and sliding of layers.

Shear Modulus. Shear modulus is the ratio of shear stress to the shear strain. This feature informs in advance of the level of resistance shown by a material to shearing deformation. If a material is highly resistant to attempted shearing, then it will spread the shear energy very rapidly.

Peel Strength. Peel strength is utilized to quantify the adhesive strength of two or more materials that have been adhered together, like the core material and two-face sheets inside a sandwich panel.

Application Environment Considerations

Will the panel come in contact with moisture? What kind of environment will it be subjected to? While mechanical properties are crucial, there are important environmental design parameters that can create a problem with the life expectancy of a core material, if not dealt with.

Moisture Resistance. Any panel subjected to high amounts of humidity/condensation and outdoor elements requires a water-resistant core material to prevent rot, saturation, swelling, softening, or bowing of the core. For example, balsa and other kinds of wood core materials may ultimately degrade, swell, or rot with prolonged exposure. It is equally significant to choose a core material that does not support the growth of fungi.

Thermal Conductivity. Thermal conductivity quantifies how a material resists or conducts heat transfer, which is crucial to assess whether the panel has to provide insulating properties or a thermal break.

Chemical and Corrosion Resistance. A material may be exposed to industrial chemicals, solvents, or cleaners, and hence, it is better to look for a material that is resistant to predicted conditions. It should not attract insects and rodents or support fungus.

Flammability. Sandwich panels are often utilized for aircraft interiors, and thus fulfilling the rigorous standards of aerospace for heat release and flame, smoke, and toxicity (FST) is crucial. If a panel is likely to be exposed to fire, it is required to fulfill several requirements to ensure that it will not spread a fire upon potential exposure to a flame.

Is the material self-extinguishing and flame-retardant? Does it have the ability to intumesce to produce a protective carbonaceous char layer that insulates, assists self-extinguishment, and safeguards the material from constant burning?

Weight.In automotive and aerospace markets, the concept of lightweight has become more and more significant to Tier 1 suppliers, Tier 2 suppliers, and OEMs. Manufacturers are forced to develop new products that fulfill the growing requirements of these industries as well as new government standards. It is important to know the right kind of lightweight core material that also does not compromise the other required performance properties.

Shaped Core. Shaped core — the second group of core applications — utilizes a core material as the base structure that is further covered or over-molded with a performance-enhancing material or cosmetic. Usually, the core material is machined or molded into the required geometry or shape needed by the application. Some examples of shaped core applications are automobile bumpers, winglets, car dashboards, crash pads, glare shields, automotive seatbacks, and headliners.

Image Credit: General Plastics Manufacturing

Process. Strengthening a bulletproof design and choosing the perfect materials are important to a project's success. But choosing the right processing technique for certain materials can impact costs, time-to-market, overall product quality, and users' bottom line.

Standard manufacturing techniques that are used when producing shaped core parts or sandwich panels include:

- **Machining/Shaping** — In this process, numerous machining methods like CNC machining, cutting, sawing, turning, routing, carving, filing, sanding, etc. are performed. Computer software is used by CNC machining to manage machine tools that cut intricate two-dimensional (2D) and three-dimensional (3D) shapes out of blocks of material. Generally, a CAD drawing or other digital representation of the required part is developed, and the drawing is subsequently translated into instructions (for example, coordination, locations, and speeds) for the CNC machine.

- **Bonding** — During this procedure, the following features should be taken into consideration: temperature resistance, open cell content, contact surface area, and resin compatibility. Also, materials not designed to operate at high temperatures for long durations may still be capable of withstanding the heat from resin exotherm or short term high-temperature exposure, so don't mistakenly eliminate materials because of this.

- **Resin-Infusion** — Resin-infusion is a process in which the layers in an evacuated stack-up of porous materials are infused with a liquid resin. As the resin solidifies, the solid resin matrix attaches the material assembly into a unified stiff composite. This process is very useful to reinforce the core of a sandwich panel. Furthermore, selecting the right kind of resin could considerably enhance the fire resistance of the panel.

- **Crush Core** — Crush core is a rapid and low-cost process performed at high pressure and temperature, where a cored laminate is positioned in a large press and crushed down to a predefined thickness. Such a process is often used to produce the preferred contour and thickness in a panel.

- **Vacuum Bagging** — Vacuum bagging is a clamping technique that holds the resin- or adhesive-coated components of a lamination in place using atmospheric pressure. The components are held in place until the adhesive cures. Another method is to add skins or layers to a core material.

- **Over molding** — In the over molding method, a molded or pre-machined core is placed inside a mold, forming or molding an extra covering around the core to finish the completed part. Shaped core parts that are created in this way can be selectively strengthened where required with hard mounting points, fasteners, backing plates, etc.

An introduction to core materials: Part 1 – Designing sandwich structures

The second link provided in this laboratory module, shows and present simple process how to make a sandwich construction using a nomex honeycomb material with a carbon fiber .

This is the link https://www.youtube.com/watch?v=YRpu3pb2b3U, entitled "Light Carbon Fiber on 9mm Nomex - Vacuum Bagged Epoxy Wet-layup". This is where the Laminate Library begins - not for any logical reason - just that doing some experiments, a video about a basic but unusual type of test panel. It seemed like a useful format and figured it would us a chance to show the simplest kind of part across a wide variety of materials and processes. Being able to compare weights is useful too.

A sandwich structure consists of two high strength composite skins separated by a core material. Various core materials are available, including balsa, PVC, and PET. There are various core materials available for composite sandwich structures, including PET, PVC, balsa and SAN. (Source: Gurit.)

Single skin composite laminates, made from glass, carbon or other fibres, may be strong but they lack stiffness due to their relative low thickness. Traditionally the stiffness has been increased by the addition of multiple frames and stiffeners, adding weight and construction complexity.

A sandwich construction consists of two high strength skins separated by a core material. Inserting a core into the laminate is a way of increasing its thickness without incurring the weight penalty. A variety of core materials are used in composite sandwich structures .

In effect the core acts like the web in an I-beam, where the web provides the lightweight separator between the load-bearing flanges. In an I-beam the flanges carry the main tensile and compressive loads and so the web can be relatively lightweight. Core materials in a sandwich structure are similarly low in weight compared to the materials in the skin laminates.

Engineering theory shows that the flexural stiffness of a solid laminate is proportional to the cube of its thickness; for sandwich laminates it is approximately proportional to the square of its thickness. The purpose of a core in a composite material is therefore to increase the laminate's thickness by effectively thickening it with a low-density core material. This will result in a dramatic increase of stiffness for very little additional weight.

Designing sandwich structures

The use of sandwich panels in composite applications is well understood from an engineering perspective, allowing design of very lightweight stiff structures.

At a fundamental level the main purpose of the core in the centre of the sandwich is to provide as much spacing between the two skins as possible to create the panel stiffness, adding as little weight as possible, whilst resisting the shear forces created when the structure is loaded. But whilst shear properties are a prerequisite for a structural core that is only the first variable of many when designing a composite structure.

Mechanical performance

Depending on how the sandwich structure is loaded the core may also require good compressive or tensile properties or even good impact toughness. These requirements can be easily met by a range of structural core materials but the price and density invariably narrow the options.

The primary selection criterion of the core has to balance properties, density and total manufacturing cost.

Most composite structures are selected over more conventional materials due to their lightweight properties and the resulting lower loads a composite component will exert on the rest of the assembly. However, the balance of light weight life cycle performance vs cost of manufacture has to be considered to make the composite approach viable. Therefore, the primary selection criterion of the core has to balance properties, density and total manufacturing cost.

Due to the inherent variability in many of the core manufacturing processes the mechanical properties of a core used for design are often determined using statistical analysis. As the density of polymeric foams varies from one batch to another the properties are often plotted against a range of nominal densities to form a linear regression through the average values at the nominal density (*see Figure 1*). A second regression is then drawn two standard deviations below the average values to give the minimum properties for design at the nominal core density.

Although this design value gives high confidence that a core will meet its design requirements a more conservative approach is often used where the minimum value at the minimum density is used.

Having selected the most likely candidates for the design the secondary requirements then have to be considered. Due to the many varied applications of composites there is an extensive list of possible design parameters which include but are not limited to the following:

- thermal resistance;
- chemical resistance;
- thermal conductivity;
- acoustic insulation;
- electrical conductivity;
- vibrational damping;
- moisture resistance;
- recyclability; and
- sustainability.

Once all of the mechanical and physical properties of the core have been considered, the design for manufacture is the final step in the preliminary design of a component. Each core material has its own specific processing characteristics which can be broken down into a couple of categories:

- formability; and
- laminate skin compatibility/stability during the curing step.

PRELIM LABORATORY ACTIVITY 4

Name			**Instructor**		
Section		**GROUP NO.**		**Date:**	
				Rating:	

MODULE IV- BUILDING A CORE MATERIALS: CONCEPT OF SADWICHCONSTRUCTION

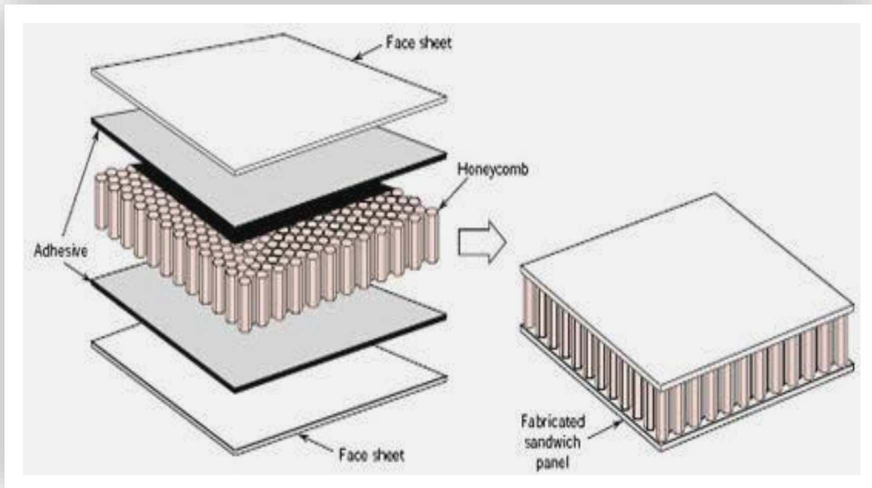
LABORATORY OBJECTIVE:

- The student was able construct and demonstration of core materials being used in aircraft applications and understand its concept and principle.
- The student will also develop simple sandwich materials that demonstrate the principle and concept of core materials in the structure.

TOOLS NEEDED:

- Activity sheet
- Pen
- 5x5 thin sheet (illustration/folder or any materials that serves as thin sheets)
- Foam/honeycomb/balsawood (or any light materials readily available in the near areas that serves as your core)
- Adhesives

Time Limit: 30-45 minutes



Instructions:

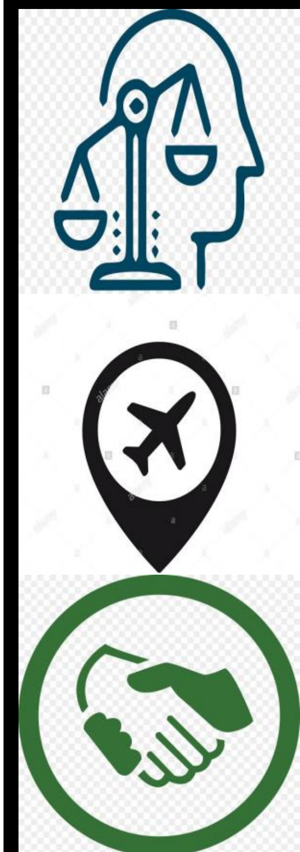
1. Create a simple sandwich construction using the available lightweight materials, using the 2 5x5 inches thin sheets, place it to the outer side of the sandwich constructions , and place the core in the inner part using the adhesives to make it fabricated .

2. To assess your individual projects, using online face to face,.. take note you need to prove that you material is light weight (send picture what is the weight of your structure). Using your weight you need to step on you structure to test the strength of the materials, creativity are also evaluated. See rubrics below.

Rubrics for ACTIVITY III

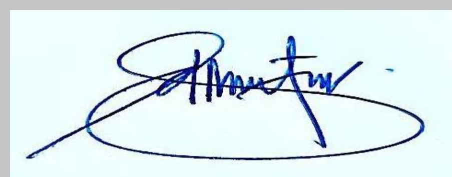
These basic rubric examples ensure that all parts of the activity are present. They help students keep track of each element of activity. Checklists also let teachers see whether a student fully participated in activity.

CRITERIA	INADEQUATE (Below Standard) 65%-74%	ADEQUATE (Meets Standard) 75%-84%	ABOVE AVERAGE (Exceeds Standard) 85%-92%	EXEMPLARY (Far Exceeds Standard) 93%-100%	SCORE
WEIGHT REQUIREMENTS	Several required elements are missing from the project	Missing one or more of the required elements as stated in the directions/instructions	Goes over and above all the required elements stated in the directions & instructions	Includes all of the required elements as stated in the directions/instructions	
LEVEL OF DESIGN (CREATIVITY)	Shows little creativity, originality and/or effort in understanding the material	A few original touches enhance the project to show some understanding of the material	Thoughtfully and uniquely presented; clever at times in showing understanding of the material	. Exceptionally clever and unique in showing deep understanding	
NEATNESS AND ATTRACTIVESS	Distractingly messy or very poorly designed. Does not show pride in work	Acceptably attractive but may be messy at times and/or show lack of organization	Attractive and neat in design and layout	Exceptionally attractive and particularly neat in design and layout	
COMPRESSION AND TENSIONAL TEST	Project is easily collapse when pressure is applied and totally damage.	Project is slightly collapsed and slightly damage	Project is somewhat stand the applied pressure and resist damage	Project is engagingly organized and presents material that is captivating the concept of corematerials , stand the applied pressure and resist impact and damage	
				GRADE (score/4)	



HONESTY CLAUSE

My signature below constitutes my pledge that all of my writing is my own work, with the exceptions of those portions which are properly documented



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Subject Instructor

Student Signature

Parent Signature