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DESIGN AND ANALYSIS OF HONEY COMB STRUCTURES

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ABSTRACT:

In most modern aircrafts, the skin plays an important role in carrying loads. Sheet metals can usually only support tension. But if the sheet is folded, it suddenly does have the ability to carry compressive loads. Stiffeners are used for that. A section of skin, combined with stiffeners, called stringers, is termed a thin-walled structure.

On aircraft with stressed-skin wing design, honeycomb structured wing panels are often used as skin. A honeycomb structure is built up from a core material resembling a bee hive's honeycomb which is laminated or sandwiched between thin outer skin sheets. Panels formed like this are lightweight and very strong. They have a variety of uses on the aircraft, such as floor panels, bulkheads, and control surfaces, as well as wing skin panels. These honeycomb structures are used in the locations of construction of wing panels on a jet transport aircraft. Sandwich structures have been used for many years in aerospace structures due to their high stiffness compared to their density. The basic philosophy of their design is the use of a relatively thick core that carries the shear loads whereas the thin faces carry the bending loads. The capability of the core material to undergo large plastic deformations under constant nominal stress makes sandwich structures preferable also for energy absorption applications. Regarding aeronautical structures, sandwich composite materials are used in areas such as cabin floor, cabin stowage bins, rudders and the range of applications is expected to become wider. CATIA and ANSYS software's are used for modelling and determining analysis results.

INTRODUCTION

What is a honeycomb structure?

Honeycomb structures are natural or man-made structures that have the geometry of a honeycomb to allow the minimization of the amount of used material to reach minimal weight and minimal material cost. The geometry of honeycomb structures can vary widely but the common feature of all such structures is an array of hollow cells formed between thin vertical walls. The cells are often columnar and hexagonal in shape. A honeycomb shaped structure provides a material with minimal density and relative high out-of-plane compression properties and out-of-plane shear properties

Man-made honeycomb structural materials are commonly made by layering a honeycomb material between two thin layers that provide strength in tension. This forms a plate-like assembly.

Honeycomb materials are widely used where flat or slightly curved surfaces are needed and their high strength is valuable. They are widely used in the aerospace industry for this reason, and honeycomb materials in aluminium, fibreglass and advanced composite materials have been featured in aircraft and rockets since the 1950s. They can also be found in many other fields, from packaging materials in the form of paper-based honeycomb cardboard, to sporting goods like skis and snowboards.

The main use of honeycomb is in structural applications. The standard hexagonal honeycomb is the basic and most common cellular honeycomb configuration.

LITERATURE REVIEW:

AIRCRAFT wings, especially wings can significantly improve system performance over an aircraft's nominal operational envelope, allow a single aircraft to perform multiple missions effectively and efficiently, and even expand its operating envelope. The morphing concepts that have been considered have included a wide spectrum of shape adaptations such as variations in camber, twist, span, sweep, and planform area. From the 1980s onward there have been a number of major morphing aircraft development and demonstration programs in the United States. These include the Mission Adaptive Wing Program (Hall, 1989), the Active Aeroelastic Wing Program (Pendleton et al., 2000), the Smart Wing Program (Kudva, 2004; Bartley-Cho et al., 2004), and most recently, the Morphing Aircraft Structures Program (Andersen et al., 2007; Bowman et al., 2007; Love et al., 2007). The Air Force/NASA/Boeing Mission Adaptive Wing program (19791988) investigated the use of smoothly varying leading- and trailing-edge camber over three span-wise segments on an F-111 aircraft for improved cruise and maneuver performance,Wings increased range and reduced loads. The Air Force/NASA/Boeing Active Aero-elastic Wing Program, starting in 1983, employed leading- and trailing-edge control surfaces and a torsionally softened wing, to control the wing twist and aerodynamic shape for improved roll performance. Attractive features of this concept were the use of aerodynamic forces to help induce the shape change and the reduced wing weight (more efficient structural design) associated with a more flexible wing.

Under the DARPA/AFRL/NASA Smart Wing program, a team led by Northrop-Grumman Corporation used smart materials based technologies to produce smoothly varying leading- and trailing-edge camber in place of standard hinged control surfaces, for improved performance of military aircraft. A limitation of the Phase 1 effort (19951999) was the low bandwidth achievable with Shape Memory Alloy-based actuation But in Phase 2 (19972001) a hingeless, smoothly contoured, structurally compliant, trailing edge control surface actuated using high-bandwidth piezoelectric motors was tested in the wind-tunnel. Span-wise and chord-wise shape control was demonstrated and performance improvements in terms of increased rolling and pitching moments for lower control surface deflections were quantified. The most recent DARPA/AFRL Morphing Aircraft Structures Program was also the most ambitious, by far. Under this program, NextGen Aeronautics developed a wing capable of changingaspect ratio by 200%, area by 70%, and span by 40% using a system that allows continuous morphing and independent control of sweep and area. A second Lockheed Martin team developed an aircraft wing that can fold and be locked in two positions. In Germany, starting in the mid-1990s, a consortium headed by the German Aerospace Center (DLR) undertook the Adaptive Wing Project whose objective was to achieve a variable wing camber and an adaptive 'bump' to alleviate shock, by applying adaptive structural systems (Bein et al., 2000; Campanile and Sachau, 2000; Campanile et al. 2004). These technologies were meant to improve the aerodynamic performance of transonic wings of civilian aircraft over variations in altitude, Mach number, and aircraft weight. The major demonstration programs listed above as well as numerous smaller efforts by various research groups have led to a good understanding of the critical issues associated with aircraft morphing. For example, the challenge of designing structures that are sufficiently rigid to carry the aerodynamic loads yet compliant enough so the actuation force requirements are not unreasonably high, is clearly appreciated. Considerable experience has been gained in the use of distributed and optimally placed actuators, based on smart materials. Similarly, the community has developed insight on issues such as integration of actuation mechanisms into the wing structure, power efficiency, weight efficiency and control system design. Asignificant issue, that perhaps did not receive quite a smuch attention during this period, is the development offlexible skins for morphing wings. Gandhi and Anusonti - Inthra (2007) systematically brought into focus several design considerations for flexible skins. It is now understood that the skins must display a high degree of anisotropy with low in-plane stiffness to minimize actuation energy but high out-of-plane stiffness to carry the aerodynamic pressure loads. The skin is also required to have high strain capability. The actual requirement is dependent on the specific morphing application, with strains of the order of 23% generally considered adequate for airfoil camber type applications while larger strains of the order of 50100% may be required for gross morphing applications involving span, chord, and plan form area change. The flexible skins used in some of the major programs mentioned above were designed using a somewhat ad hoc and sometimes iterative process. In the Smart Wing Program a flexible silicone skin was used on the variable camber wing, supported underneath by a through-the-thickness honeycomb flexcore (Kudva, 2004; Bartley-Cho, 2004). The requirements for the flexible skins in the Smart Wing program (indeed, for camber morphing in general) were not as challenging as some other applications as the strains in the skin are modest, and the aerodynamic pressure loads at the trailing-edge are small. In the Morphing Aircraft Structures program the NextGen Aeronautics concept required the skin to undergo very large shear strain. Once again the skin was of an elastomeric silicone material, but was supported with an underlying metallic ribbon structure to provide out-of-plane stiffness to withstand airloads (Andersen et al., 2007). Other efforts by various researchers focused on flexible skins over the last few years are described below. Kikuta (2003) examined a number of readily available materials such as polyurethane, co-polyester, shape and memory polymers for morphing aircraft flexible skins applications and identified some of them to be promising candidates. Perkins et al. (2004) and Reed et al. (2005) considered the use of shape memory polymers for flexible skins in wing chord morphing applications, while Keihl et al. (2005) experimentally tested shape memory polymers under uniaxial and shear loading for morphing applications. However, there are many challenges associated with the use of shape memory polymers as morphing skins including practical thermal activation, heat losses, brittleness of the material, thermal fatigue issues, etc. Another approach considered by Yokozeki et al. (2006) and Thill et al. (2007) considered corrugated composites with a flexible face-sheet to create a smooth aerodynamic surface for flexible skins for 1D morphing applications. Murray et al. (2007) examined the use of flexible matrix composites as a skin material for 1D morphing applications. The fibers, aligned along the non-morphing direction, allowed the skin to be subjected to large pre-tension in that direction which increased its ability to carry outof- plane loads. The flexible, high-strain capable matrix, on the other hand, allowed morphing at low actuation cost. Reich et al. (2007) use topology optimization to determine the distribution of stiff and soft material to create a multi-phase skin that has specific stiffness characteristics in specific directions. However, they do not consider the in-plane strain-capability of such a skin. Topology optimization for flexible skin design was also used by Olympio and Gandhi (2008). Olympio (2006) first suggested the idea of flexible skins comprising of a cellular honeycomb core covered with a compliant face-sheet (Figure 1) for morphing applications. The present paper is, in fact, based on work originating in Olympio (2006). Olympio and Gandhi (2007) then extended the work by designing zero Poisson's ratio honeycombs suited for 1D morphing applications. Bubert et al. (2008) fabricated a skin for 1D morphing applications with a zero Poisson's ratio honeycomb core similar to the designs of Olympio and Gandhi (2007), covered by a flexible matrix composite face-sheet.

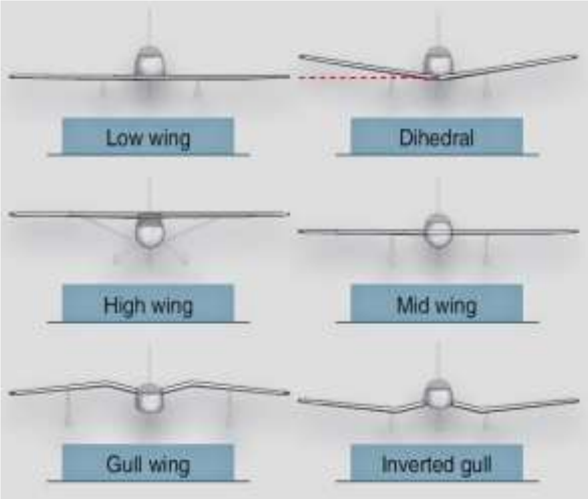
PROPOSED FLEXIBLE SKIN CONCEPT WITH CELLULAR CORE

The flexible skin is conceived to be a multi-layered composite, comprising of a thin, high-strain capable, low-modulus face sheet (of rubber, silicone or some other similar synthetic polymer) covering a cellular honeycomb core (Figure 1). The face-sheet material modulus is considerably lower than the modulus of the honeycomb material. For a honeycomb made of Aluminum, the face-sheet material's Young modulus could be in the 0.110MPa range (many siliconerubber membranes can be found in that range). The function of the face-sheet is simply to provide a smooth aerodynamic surface. It is thus a requirement on the outer surface, but may or may not be used on the inner surface. The overall mechanical properties of the skin are then largely governed by the properties of the cellular core layer. The cellular core supports the face-sheet and provides the required out-of-plane stiffness of the composite skin. Simultaneously, its in-plane stiffness must be low and it must be capable of deforming to the required strain levels. The cellular cores considered in this paper include both a conventional honeycomb coreas well as an auxetic core, with re-entrant hexagonal.

Wing Configurations

Wings are airfoils that, when moved rapidly through the air, create lift. They are built in many shapes and sizes. Wing design can vary to provide certain desirable flight characteristics. Control at various operating speeds, the amount of lift generated, balance, and stability all change as the shape of the wing is altered. Both the leading edge and the trailing edge of the wing may be straight or curved, or one edge may be straight and the other curved. One or both edges may be tapered so that the wing is narrower at the tip than at the root where it joins the fuselage. The wing tip may be square, rounded, or even pointed. Figure 1 shows a number of typical wing leading and trailing edge shapes.

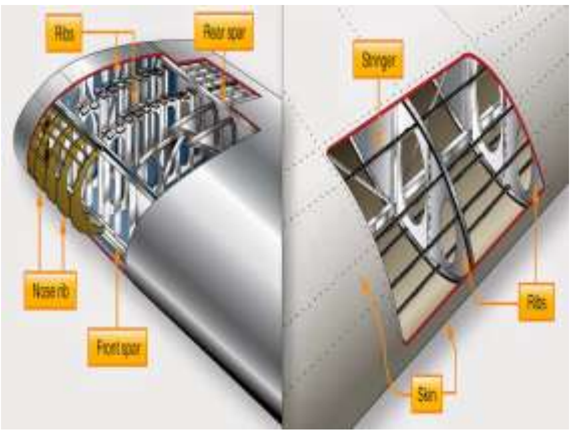
The wings of an aircraft can be attached to the fuselage at the top, mid-fuselage, or at the bottom. They may extend perpendicular to the horizontal plain of the fuselage or can angle up or down slightly. This angle is known as the wing dihedral. The dihedral angle affects the lateral stability of the aircraft. Figure 2 shows some common wing attach points and dihedral angle.



The wings of an aircraft are designed to lift it into the air. Their particular design for any given aircraft depends on a number of factors, such as size, weight, use of the aircraft, desired speed in flight and at landing, and desired rate of climb. The wings of aircraft are designated left and right, corresponding to the left and right sides of the operator when seated in the cockpit.

Often wings are of full cantilever design. This means they are built so that no external bracing is needed. They are supported internally by structural members assisted by the skin of the aircraft. Other aircraft wings use external struts or wires to assist in supporting the wing and carrying the aerodynamic and landing loads. Wing support cables and struts are generally made from steel. Many struts and their attach fittings have fairings to reduce drag. Short, nearly vertical supports called jury struts are found on struts that attach to the wings a great distance from the fuselage. This serves to subdue strut movement and oscillation caused by the air flowing around the strut in flight. Figure 4 shows samples of wings using external bracing, also known as semi cantilever wings. Cantilever wings built with no external bracing are also shown.

Aluminum is the most common material from which to construct wings, but they can be wood covered with fabric, and occasionally a magnesim alloy has been used. Moreover, modern aircraft are tending toward lighter and stronger materials throughout the airframe and in wing construction. Wings made entirely of carbon fiber or other composite materials exist, as well as wings made of a combination of materials for maximum strength to weight performance. The internal structures of most wings are made up of spars and stringers running spanwise and ribs and formers or bulkheads running chordwise (leading edge to trailing edge). The spars are the principle structural members of a wing. They support all distributed loads, as well as concentrated weights such as the fuselage, landing gear, and engines. The skin, which is attached to the wing structure, carries part of the loads imposed during flight. It also transfers the stresses to the wing ribs. The ribs, in turn, transfer the loads to the wing spars.



In general, wing construction is based on one of three fundamental designs:

1. Monospar
2. Multispar
3. Box beam

Modification of these basic designs may be adopted by various manufacturers.

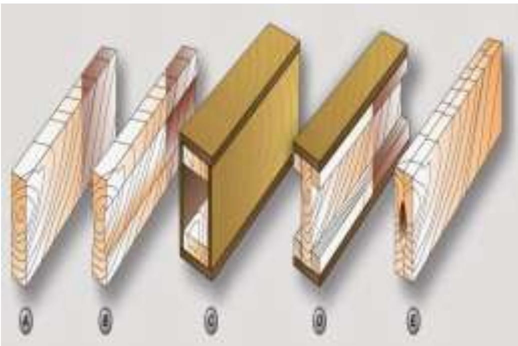
The monospar wing incorporates only one main spanwise or longitudinal member in its construction. Ribs or bulkheads supply the necessary contour or shape to the airfoil. Although the strict monospar wing is not common, this type of design modified by the addition of false spars or light shear webs along the trailing edge for support of control surfaces is sometimes used. The multispar wing incorporates more than one main longitudinal member in its construction. To give the wing contour, ribs or bulkheads are often included.

The box beam type of wing construction uses two main longitudinal members with connecting bulkheads to furnish additional strength and to give contour to the wing. A corrugated sheet may be placed between the bulkheads and the smooth outer skin so that the wing can better carry tension and compression loads. In some cases, heavy longitudinal stiffeners are substituted for the corrugated sheets. A combination of corrugated sheets on the upper surface of the wing and stiffeners on the lower surface is sometimes used. Air transport category aircraft often utilize box beam wing construction.

Wing Spars

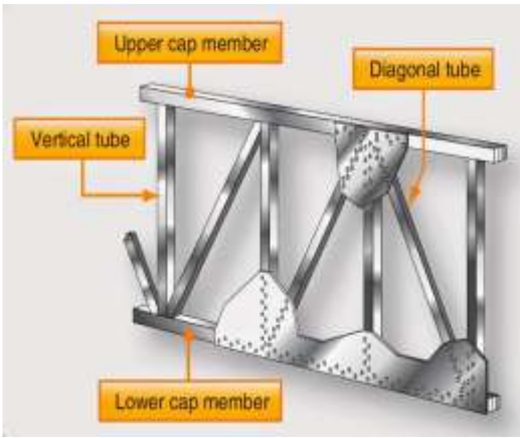
Spars are the principal structural members of the wing. They correspond to the longerons of the fuselage. They run parallel to the lateral axis of the aircraft, from the fuselage toward the tip of the wing, and are usually attached to the fuselage by wing fittings, plain beams, or a truss.

Spars may be made of metal, wood, or composite materials depending on the design criteria of a specific aircraft. Wooden spars are usually made from spruce. They can be generally classified into four different types by their crosssectional configuration. As shown in Figure 7, they may be (A) solid, (B) box shaped, (C) partly hollow, or (D) in the form of an I-beam. Lamination of solid wood spars is often used to increase strength. Laminated wood can also be found in box shaped spars. The spar in Figure 7E has had material removed to reduce weight but retains the strength of a rectangular spar. As can be seen, most wing spars are basically rectangular in shape with the long dimension of the cross-section oriented up and down in the wing

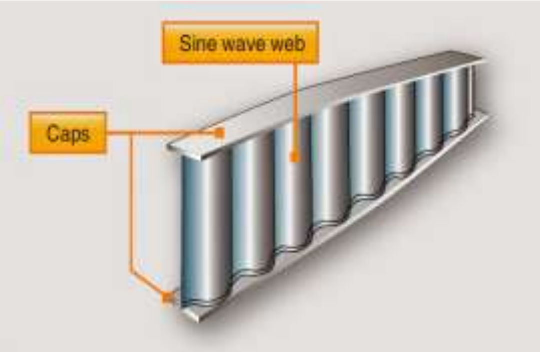


Currently, most manufactured aircraft have wing spars made of solid extruded aluminum or aluminum extrusions riveted together to form the spar. The increased use of composites and the combining of materials should make airmen vigilant for wings spars made from a variety of materials. Figure 8 shows examples of metal wing spar cross-sections.

In an I–beam spar, the top and bottom of the I–beam are called the caps and the vertical section is called the web. The entire spar can be extruded from one piece of metal but often it is built up from multiple extrusions or formed angles. The web forms the principal depth portion of the spar and the cap strips (extrusions, formed angles, or milled sections) are attached to it. Together, these members carry the loads caused by wing bending, with the caps providing a foundation for attaching the skin. Although the spar shapes in Figure 8 are typical, actual wing spar configurations assume many forms. For example, the web of a spar may be a plate or a truss as shown in Figure 9. It could be built up from light weight materials with vertical stiffeners employed for strength.



It could also have no stiffeners but might contain flanged holes for reducing weight but maintaining strength. Some metal and composite wing spars retain the I-beam concept but use a sine wave web.



Additionally, fail-safe spar web design exists. Fail-safe means that should one member of a complex structure fail, some other part of the structure assumes the load of the failed member and permits continued operation. A spar with failsafe construction is shown in Figure. This spar is made in two sections. The top section consists of a cap riveted to the upper web plate. The lower section is a single extrusion consisting of the lower cap and web plate. These two sections are spliced together to form the spar. If either section of this type of spar breaks, the other section can still carry the load. This is the fail-safe feature.

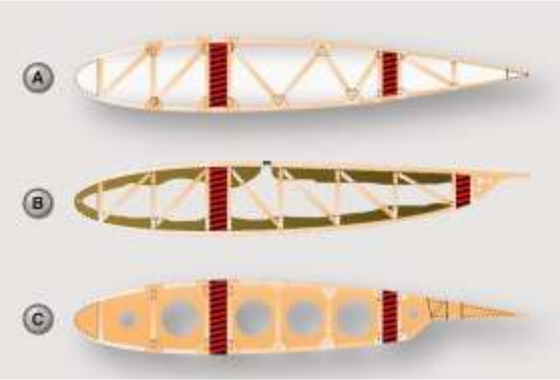
False spars are commonly used in wing design. They are longitudinal members like spars but do not extend the entire spanwise length of the wing. Often, they are used as hinge attaches points for control surfaces, such as an aileron spar.

Wing Ribs

Ribs are the structural crosspieces that combine with spars and stringers to make up the framework of the wing. They usually extend from the wing leading edge to the rear spar or to the trailing edge of the wing. The ribs give the wing its cambered shape and transmit the load from the skin and stringers to the spars. Similar ribs are also used in ailerons, elevators, rudders, and stabilizers.

Wing ribs are usually manufactured from either wood or metal. Aircraft with wood wing spars may have wood or metal ribs while most aircraft with metal spars have metal ribs. Wood ribs are usually manufactured from spruce. The three most common types of wooden ribs are the plywood web, the lightened plywood web, and the truss types. Of these three, the truss type is the most efficient because it is strong and lightweight, but it is also the most complex to construct.

Figure shows wood truss web ribs and a lightened plywood web rib. Wood ribs have a rib cap or cap strip fastened around the entire perimeter of the rib. It is usually made of the same material as the rib itself. The rib cap stiffens and strengthens the rib and provides an attaching surface for the wing covering. In Figure 13A, the cross-section of a wing rib with a truss-type web is illustrated. The dark rectangular sections are the front and rear wing spars. Note that to reinforce the truss, gussets are used. In a truss web rib is shown with a continuous gusset. It provides greater support throughout the entire rib with very little additional weight. A continuous gusset stiffens the cap strip in the plane of the rib. This aids in preventing buckling and helps to obtain better rib/skin joints where nailgluing is used. Such a rib can resist the driving force of nails better than the other types.



Continuous gussets are also more easily handled than the many small separate gussets otherwise required. Figure 13C shows a rib with a lighten plywood web. It also contains gussets to support the web/cap strip interface. The cap strip is usually laminated to the web, especially at the leading edge.

A wing rib may also be referred to as a plain rib or a main rib. Wing ribs with specialized locations or functions are given names that reflect their uniqueness. For example, ribs that are located entirely forward of the front spar that are used to shape and strengthen the wing leading edge are called nose ribs or false ribs. False ribs are ribs that do not span the entire wing chord, which is the distance from the leading edge to the trailing edge of the wing. Wing butt ribs may be found at the inboard edge of the wing where the wing attaches to the fuselage. Depending on its location and method of attachment, a butt rib may also be called a bulkhead rib or a compression rib if it is designed to receive compression loads that tend to force the wing spars together.

Since the ribs are laterally weak, they are strengthened in some wings by tapes that are woven above and below rib sections to prevent sidewise bending of the ribs. Drag and anti-drag wires may also be found in a wing. In Figure 14, they are shown crisscrossed between the spars to form a truss to resist forces acting on the wing in the direction of the wing chord. These tension wires are also referred to as tie rods. The wire designed to resist the backward forces is called a drag wire; the anti-drag wire resists the forward forces in the chord direction. Figure 14 illustrates the structural components of a basic wood wing.

At the inboard end of the wing spars is some form of wing attach fitting as illustrated in Figure 14. These provide a strong and secure method for attaching the wing to the fuselage. The interface between the wing and fuselage is often covered with a fairing to achieve smooth airflow in this area. The fairing(s) can be removed for access to the wing attach fittings.

The wing tip is often a removable unit, bolted to the outboard end of the wing panel. One reason for this is the vulnerability of the wing tips to damage, especially during ground handling and taxiing. Figure 16 shows a removable wing tip for a large aircraft wing. Others are different. The wing tip assembly is of aluminum alloy construction. The wing tip cap is secured to the tip with countersunk screws and is secured to the interspar structure at four points with ¼-inch diameter bolts. To prevent ice from forming on the leading edge of the wings of large aircraft, hot air from an engine is often channeled through the leading edge from wing root to wing tip. A louver on the top surface of the wingtip allows this warm air to be exhausted overboard. Wing position lights are located at the center of the tip and are not directly visible from the cockpit. As an indication that the wing tip light is operating, some wing tips are equipped with a Lucite rod to transmit the light to the leading edge.

Wing Skin

Often, the skin on a wing is designed to carry part of the flight and ground loads in combination with the spars and ribs. This is known as a stressed-skin design. The all-metal, full cantilever wing section illustrated in Figure 17 shows the structure of one such design. The lack of extra internal or external bracing requires that the skin share some of the load. Notice the skin is stiffened to aid with this function.

Fuel is often carried inside the wings of a stressed-skin aircraft. The joints in the wing can be sealed with a special fuel resistant sealant enabling fuel to be stored directly inside the structure. This is known as wet wing design. Alternately, a fuel-carrying bladder or tank can be fitted inside a wing. Figure 18 shows a wing section with a box beam structural design such as one that might be found in a transport category aircraft. This structure increases strength while reducing weight. Proper sealing of the structure allows fuel to be stored in the box sections of the wing.

METHODOLOGY

MECHANICAL PROPERTIES AND MAXIMUM GLOBAL STRAINS OF CELLULAR CORES

Gibson and Ashby (1997) derived analytical expressions for the linear mechanical properties of ellular cores, based on the assumptions that the cell walls could be modeled as shear deformable beam-rod elements and the boundary effects are negligible. For a cellular core with material properties Ec (Young's modulus) and v (Poisson's ratio), and cell parameters

$$E_x = E_c \frac{\beta^3 \cos\theta}{(\alpha+\sin\theta)\sin^2\theta} \frac{1}{1+(K+\cot^2\theta)\beta^2}, \quad (1)$$

$$E_y = E_c \frac{\beta^3(\alpha+\sin\theta)}{\cos^3\theta} \frac{1}{1+(K+\tan^2\theta+2\alpha/(\eta\cos^2\theta))\beta^2}, \quad (2)$$

$$\nu_{xy} = \frac{\cos^2\theta}{(\alpha+\sin\theta)\sin\theta} \frac{1+(K-1)\beta^2}{1+(K+\cot^2\theta)\beta^2}, \quad (3)$$

$$\nu_{yx} = \frac{\sin\theta(\alpha+\sin\theta)}{\cos^2\theta} \frac{1+(K-1)\beta^2}{1+(K+\tan^2\theta+2\alpha/(\eta\cos^2\theta))\beta^2}, \quad (4)$$

$$G_{xy} = E_c \frac{\beta^3(\alpha+\sin\theta)}{\alpha^2\cos\theta} \times \frac{1}{\left\{ \begin{array}{l} 1+2(\alpha/\eta^3)+(\beta^2/\alpha^2)\left[\alpha K(2/\eta+\alpha+\sin\theta)\right. \\ \left. +(\alpha+\sin\theta)\left[(\alpha+\sin\theta)\tan^2\theta+\sin\theta\right]\right] \end{array} \right\}}, \quad (5)$$

where K is a coefficient accounting for the shear deformation of the beam. A typical value, used by Gibson and Ashby (1997), is K =2.4+1.5v

Gibson and Ashby (1997) also provide expressions for the maximum global strains that the cellular cores can tolerate when subjected to loading along the principal directions and loading in shear. These strains correspond to plastic deformation where the local stresses in the cell walls reach the elastic limit, For morphing applications where the goal is to realize large deformation, the max global strain then determines the feasibility of a particular honeycomb in meeting morphing strain specifications. It should be noted that Gibson and Ashby's analytical expressions for the maximum global strains were based on the assumption that the cell walls undergo pure bending, without axial deformation. However, for, loading in the x-direction would result in deformation only through extension of the inclined (now 'horizontal') walls of length l. If the axial deformation is not considered in the calculation of the local stresses, then the local stresses will remain zero and never reach the elastic limit stress, and the maximum global strain would be predicted to be infinite.

$$\varepsilon_{xx-\max}=\frac{\sigma^{\lim}}{E_c}\frac{|\sin\theta|}{3\beta\cos\theta}\frac{1+(K+\cot^2\theta)\beta^2}{1+(\beta/3)|\cot\theta|},$$

$$\varepsilon_{yy-\max}=\frac{\sigma^{\lim}}{E_c}\times\frac{\cos^2\theta}{\beta(\alpha+\sin\theta)}\frac{1+(K+\tan^2\theta+2\alpha/(\eta\cos^2\theta))\beta^2}{\max\{2\beta/\eta;3\cos\theta+\beta|\sin\theta|\}},$$

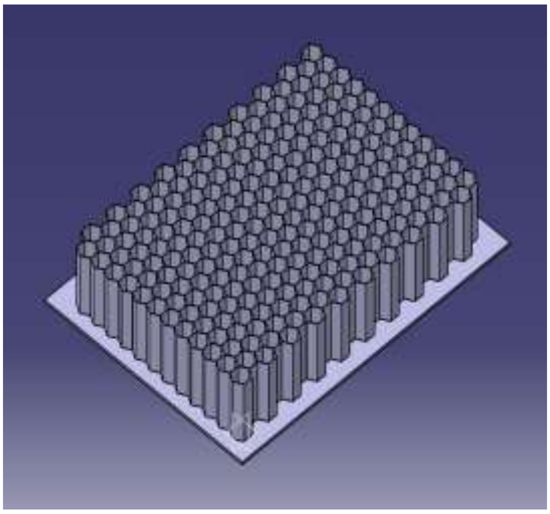
$$\gamma_{xy-\max}=\frac{\sigma^{\lim}}{E_c}\frac{\alpha}{3\beta}\frac{1}{\max\{2/\eta^2;1+(\beta/3)|\tan\theta|\}}\times\left\{1+2\frac{\alpha}{\eta^3}+\frac{\beta^2}{\alpha^2}\left[\alpha K\left(\frac{2}{\eta}+\alpha+\sin\theta\right)+(\alpha+\sin\theta)\times((\alpha+\sin\theta)\tan^2\theta+\sin\theta)\right]\right\}.$$

:

In the above expressions, rlim/Ec represents the maximum local strain (elim) up to which the material is in the linear elastic range. Then e_{xx}^{-max}/e_{lim}, $^{Eyy-max}/e_{lim}$, and _xy-max/elim epresent the strain-amplification (or the global strains the cellular honeycomb can be subjected to fore the linear elastic limit is reached in any of the walls) possible with the cellular honey comb with geometric properties at should be noted that the above expressions for in-plane moduli (Equations (1), (2), (5)), Poisson's ratios (Equations (3) and (4)), and maximum global strains (Equations (6) and (8)) of a cellular honeycomb core do not account for material or geometric non-linearities and are therefore strictly applicable only for small to moderate deformations. Thus, they provide an indication of what geometries might be most advantageous for Different types of morphing (from a low stiffness, high strain-capability standpoint), rather than determining the actual force requirement to morph the cellular honeycomb to higher strains. Although some figures provided in this article are available in the literature (Gibson and Ashby, 1997; Scarpa et al., 2000), they are presented here to examine how variations in cell geometric parameters would simultaneously affect the in-plane stiffnesses, outof- plane deflections, and the maximum strain capability. This allows determination of honeycomb geometries most suitable for morphing applications.

RESULTS AND DISCUSSIONS

First level or preliminary analysis of design uses tools that have to be simple to design the Hexagonal cell structure and then extrude. After that Assembly of group of Hexagonal cells will be generated for some cases for analysis Second level is level of design of panel of the rectangle .Computer codes are based on finite difference methods or finite element methods, with 1D, 2D or 3D models of physical phenomena (internal ballistics, fluid dynamics, continuum mechanics structural analysis). They allow precise calculations, or optimization up to defining final geometry



Model images

Material Selection

On the key design of the structure we are analyzed with different type of material like Aluminum, structural steel and have a clear over view on all categories and make an clear results

Ansys Analysis

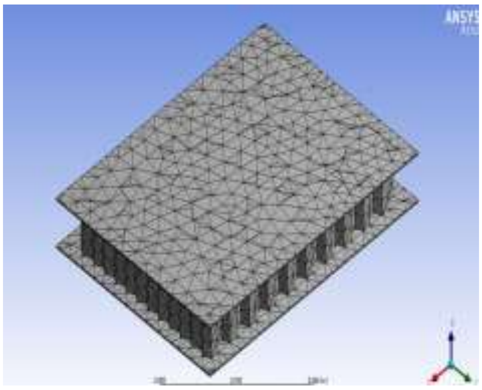
ANSYS is engineering simulation software (computer-aided engineering, or CAE). The company was founded in 1970 by Dr. John A. Swanson as **Swanson Analysis Systems, Inc.** SASI. Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static (stationary), dynamic (moving) and thermal (heat transfer) problems.

ANSYS is a general-purpose finite-element modelling package for numerically solving a wide variety of mechanical problems. These problems include static/dynamic, structural analysis (both linear and nonlinear), heat transfer, and fluid problems, as well as acoustic and electromagnetic problems.

In general, a finite-element solution may be broken into the following three stages.

(1) **Pre-processing**: defining the problem

The major steps in pre-processing are (i) Define key points/lines/areas/volumes, (ii) Define element type and material/geometric properties, and (iii) mesh lines/areas/ volumes as required. The amount of detail required will depend on the dimensionality of the analysis, i.e., 1D, 2D, axisymmetric, and 3D.



Mesh image

(2) **Solution**: assigning loads, constraints, and solving Here, it is necessary to specify the loads (point or pressure), constraints (translational and rotational), and finally solve the resulting set of equations.

(3) **Post processing**: further processing and viewing of the results in this stage one may wish to see (i) lists of nodal displacements, (ii) element forces and moments, (iii) deflection plots, and (iv) stress contour diagrams ortemperature

maps.

Honeycomb structural analysis:

The structural analysis will be done in 2 different material cases, in every case we consider deformation, stress and strain (Von Mises's). Also, we are comparing the deflection values between aluminium and structural steel.

CASE-1:

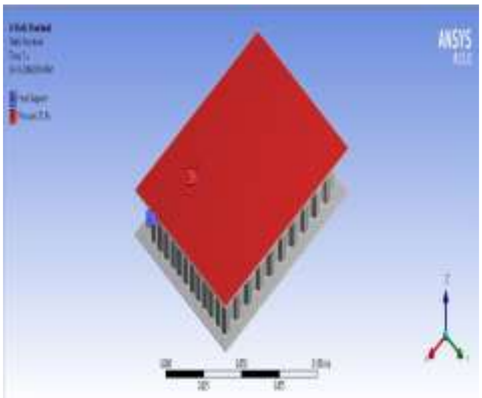
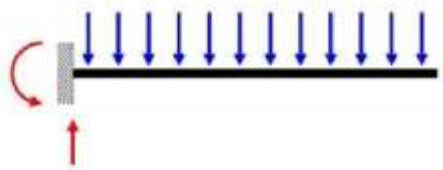


Fig Pressure applying on the panel, by keeping other side DOF as zero

In case-1, consider whole structure as cantilever beam and we know that cantilever beam have one fixed end and one free end. In this case apply pressure uniformly by keeping other side DOF as zero. And as results we have generated the results of deformation of aluminium and structural , Von misses stresses, strain's for aluminium and structural steel and analysed the stress and strain and strength of the component and make view that which have capable Here we have step by step process, how to do the structural analysis (for aluminium, structural steel)

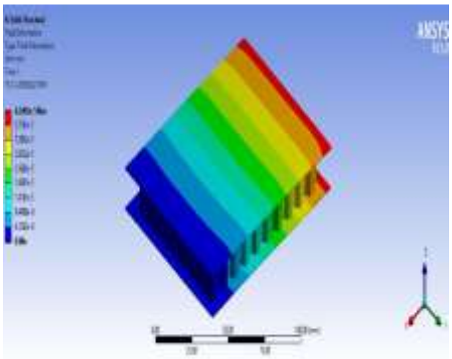
Case 1:

Consider the whole structure as cantilever beam, now apply the load uniformly.

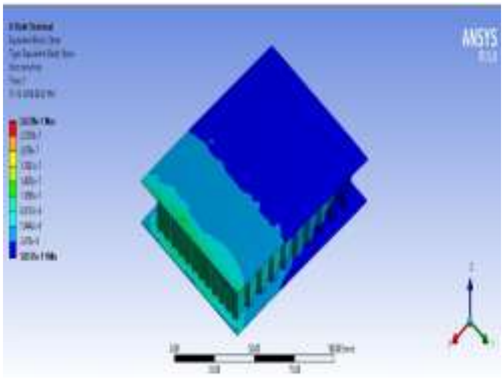


Cantilever beam with UDL

The result shows that aluminium has the less deformation compared to steel.



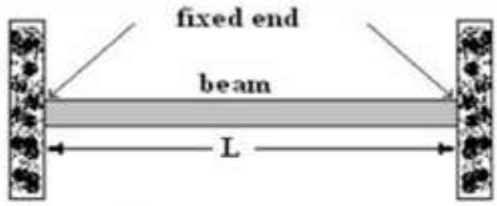
Deformation for steel



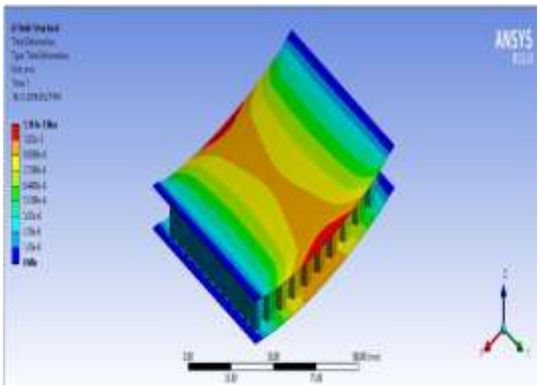
Equivalent elastic strain for steel

CASE-2

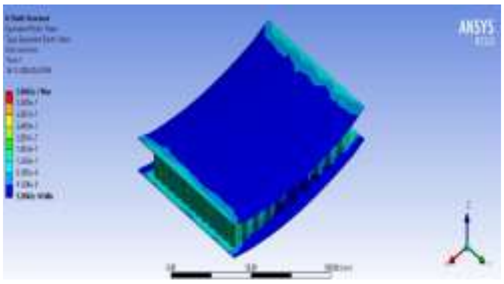
In this case, consider whole structure as simply supported beam. Same boundary conditions are taken which we used in case-1. Here below are the results for steel and aluminium.



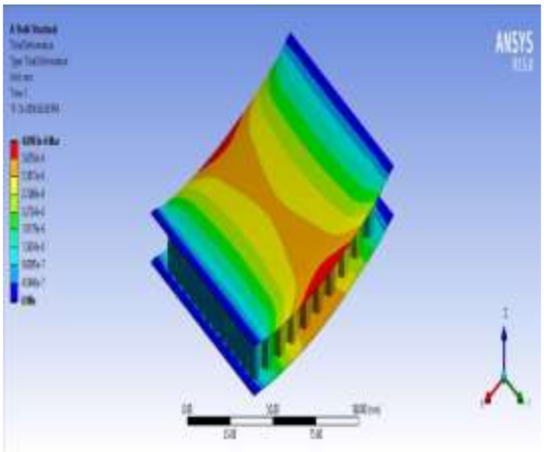
Simply supported beam



Total deformation for aluminium



Equivalent elastic strain for aluminium



Total deformation for steel

CONCLUSIONS

From the analysis, aluminium honey comb structure has less deformation as compared to steel material in both cantilever and simply supported beam Equivalent elastic strain results are lesser in steel as compared to aluminium. Aluminium is weight less and cost also expensive. Structural steel has high density so it is not recommended in aerospace industries. Other than structural steel is recommended. Also as a result honeycomb is a preferred core material that is advantageous because of:

- High strength to weight ratio
- Good compressive strength
- Lightweight

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