ANALYSIS OF AIRCRAFT WING WITH DIFFERENT MATERIALS USING ANSYS SOFTWARE

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ABSTRACT: *An aircraft wing is a type of fin that produce lift, while moving through air or. As such, wings have efficient cross-sections that are subject to aerodynamic forces and act as an airfoils.*

In this thesis work, it is investigated how high-end CAD software's can be used in the early stages of an aircraft design process, especially for the design of an aircraft wing and its structural entities wing spars and wing ribs.

The finite element mesh is generated for the wing panels, wing spars and wing ribs. Furthermore, the finite element mesh is updated based on any changes in geometry and the shape of the wing panels, wing spars or wing ribs, and ensure that all the mesh elements are for all time properly attached at the nodes. The automated FE mesh generated can be used for performing the structural analysis on an aircraft wing.

1.INTRODUCTION:

Aircraft design is a complex and multi-disciplinary process that involves a large number of disciplines and expertise in aerodynamics, structures, propulsion, flight controls and systems amongst others. During the initial conceptual phase of an aircraft design process, a large number of alternative aircraft configurations are studied and analysed. Feasibility studies for different concepts and designs are carried out and the goal is to come up with a design concept that is able to best achieve the design objectives. One of the crucial studies in any aircraft design process is the conceptual design study of an aircraft wing. The aircraft wing is one of the most critical components of an aircraft not only from an aerodynamics point of view but also from a structural point of view. The aircraft wing is designed in such a way that it is able to provide the requisite lift while minimizing the drag.

1.1 Aim

The main aim of this thesis work is the development of a generic parameterized aircraft wing model that can employed from the early stages of an aircraft design process.

1.2 Motivation:

The generic aircraft wing model offers a series of advantages and thus provides a motivation for its development. Some of the advantages provided by a generic aircraft wing model are listed below,

1. Single model is able to represent different aircraft wing planform and configurations
2. Automated CAD geometry generation

1.3 Applications:

The generic wing model that is developed in this thesis work can not only be used for designing of the aircraft wing which is its primary application, but, also can be used for designing other types of wing shapes used in other applications. The structure of the model is made as general and generic as possible for enabling its use in different applications.

2 AIRCRAFT WING CONFIGURATION

Based on the type of mission requirements and the different flight regimes the aircraft will encounter be it subsonic, transonic, supersonic or even hypersonic, there are different wing configurations and plan form shapes that are available to the aircraft designer for the wings.

2.1 Rectangular Wing (Constant Chord)

The rectangular wing is the type of wing planform where, the root chord and the tip chord of the wing are of equal length. The rectangular or constant chord wing is normally found on low-subsonic aircrafts.

2.2 Tapered Wing

A tapered wing is the type of wing planform, where, the root and the tip chord of the wing are not of equal length. A tapered wing is chosen for aerodynamic reasons. A taper introduced to the wing will change the lift distribution. The ideal form of span-wise lift distribution is elliptical.

2.3 Elliptical Wing

An elliptical wing is the type of wing planform, where, the wing planform is in the shape of an ellipse and the edges of the wing turn inward to form a rounded tip. The ideal form of span-wise lift distribution is elliptical, which is one of the prime reasons for choosing an elliptical wing planform.

2.4 Reverse Tapered Wing

A reverse tapered wing is a type of wing planform, where, the root chord of the wing is smaller than the tip chord of the wing.

2.5 Compound Tapered Wing

A compound tapered wing is a type of wing planform, where, the taper ratio changes along the span. A compound tapered wing can be thought of as consisting of two trapezoidal wing panels.

2.6 Delta Wing

A delta wing has a triangular planform with a swept leading edge. A delta wing is typically found on supersonic jet aircrafts, where, it is aerodynamically efficient than a straight wing.

3. GENETIC AIRCRAFT WING CONCEPT

A generic aircraft wing model should constitute an external surface of the wing, and should also be comprised of structural elements of the wing which are spars and ribs.

3.1 Surface and Solid Model Integration

In the surface model, all the features of the wing (wing panels, spars and ribs) will be represented by a series of surfaces. As, the number of wing panels, spars or ribs are changed, the surfaces for each wing panels, spars and ribs will be connected together.

3.2 Concept for Wing Panels

The entire wing panels of the aircraft wing should be properly connected, which means that all the wing panels should be connected in such a way so as to yield a continuous surface of the wing.
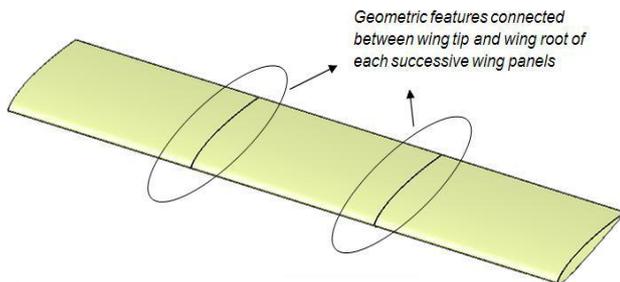

Fig-a: Genetic aircraft wing

3.3 Concept for Wing Spars

As far as the wing spars are concerned, the wing spar position will be defined by "point values on curve" along the root and tip of the tip of the wing. The point values on curve will range between 0 and 1. 0 means that the spar position

will start at the leading edge while, means that the spar position will start at the trailing edge.

3.4 Concept for Wing Ribs

Similar to the case of the spars, the wing rib positions will be defined by "point values on curve" along the span of the wing (front and aft curve of the wing).

4. DESIGN CONSIDERATIONS OF AIRCRAFT WING:

The primary hindrance is the structural and vibration considerations due to the unsteady nature of the airflow during the flight. The preliminary construction was tested in the low speed subsonic wind tunnel and as such based upon the tunnel dimension (width – 36 inches, height – 24 inches and length – 72 inches) the maximum semi-wingspan of the wing was limited to 30 inches to avoid the wall effects of the wind tunnel.
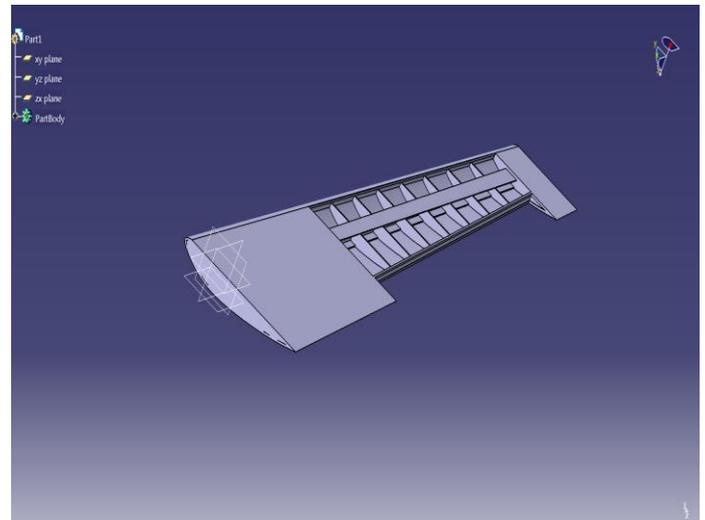

Fig-b: Catia file

Table-4.1:Change in model weight depending on the change in aspect ratio for un-extended wing

Span (S_{UE}) inch	Aspect Ratio (AR_{UE})	Chord Length (c) inch	Wing Area (A_{UE}) sq. inch.	Wing Loading (WL_{UE}) oz./sq. ft.	Model Weight (W) oz.
40	4.45	8.99	359.99	20	49.99
40	5	8	320	20	44.44
40	6	6.67	266.67	20	37.03
40	7	5.71	228.57	20	31.74

5 MATERIAL PROPERTIES

Properties of Aluminum 7075-T6

Density= 2.71 g/cc
Poisson's Ratio=0.33`
Young's Modulus=7e10 Pa

Properties of Carbon Epoxy

Density=1.6g/cc
Poisson's Ratio=0.25
Young's Modulus=7e10 Pa

Properties of Steel

Density=7.85g/cc
Poisson's Ratio=0.3
Young's Modulus=2e11 Pa

6. ANALYSIS OF AIRCRAFT WING:

6.1 STATIC ANALYSIS:

6.1.1 SATATIC ANALYSIS FOR ALUMINIUM:
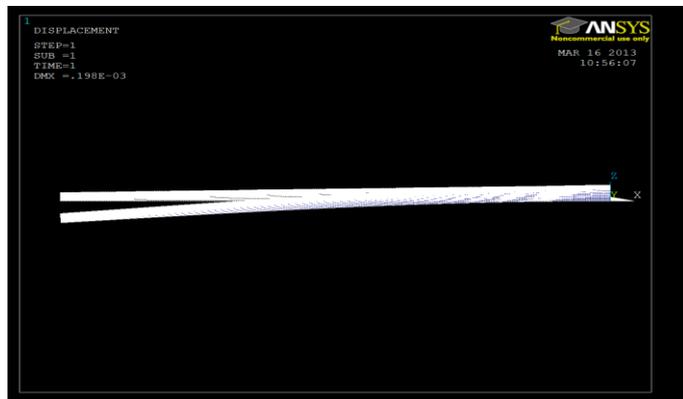
**Fig-c: Deformed +un-deformed shapes for Aluminum 7075-T6**
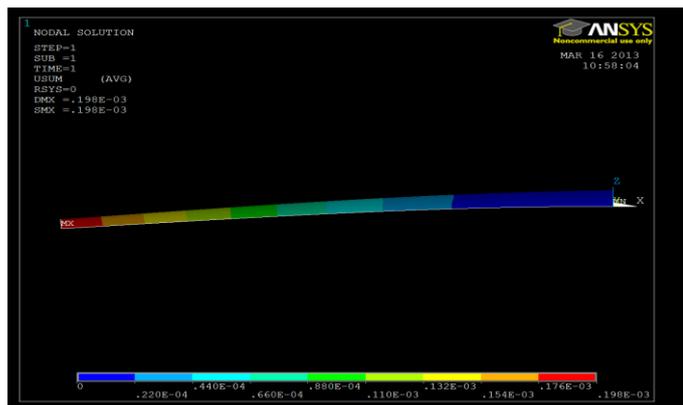
Fig-d: Displacement vector sum for Aluminum 7075-T6

list results of displacement vector sum for aluminium 7075-t6:

Node No.	UX	UY	UZ	USUM
1	0.14000E-05	0.63366E-05	-0.19758E	-0.19688E-03
2	0.25296E-05	0.63382E-05	-0.19687E	0.19698E-03
3	0.34616E-06	0.63088E-05	-0.19750E	0.19760E-03
4	0.93970E-06	0.63022E-05	-0.19691E-03	0.19701E-03
5	0.31906E-05	0.63543E-05	-0.19688E-03	0.19701E-03

6.1.2 STATIC ANALYSIS FOR CARBON EPOXY:
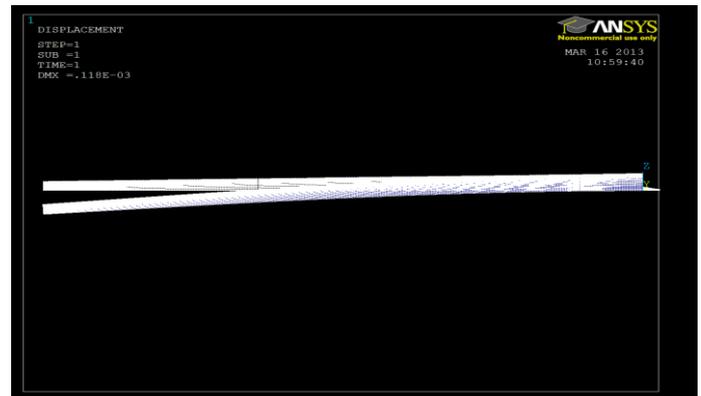

Fig-e: deformed+undeformed shape for carbon epoxy
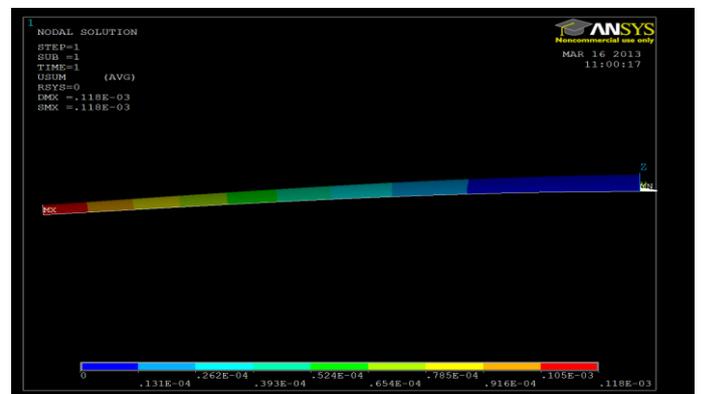
Fig-f: displacement vector sum for carbon epoxy

List results for displacement vector sum for carbon epoxy:

NODE	UX	UY	UZ	USUM
1	-0.49840E-06	-0.24307E-05	0.70840E-04	0.70883E-04
2	-0.10125E-05	-0.24290E-05	0.70739E-04	0.70788E-04
3	-0.47955E-07	-0.24264E-05	0.70828E-04	0.70869E-04
4	-0.32642E-06	0.24241E-05	0.70745E-04	0.70788E-04
5	-0.12965E-05	-0.24311E-05	0.70741E-04	0.70795E-04

6.1.3 STATIC ANALYSIS FOR STEEL:
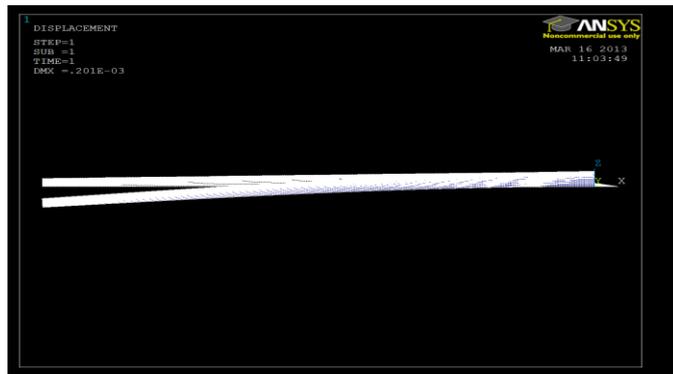
**Fig-g: deformed+Undeformed shape for steel**
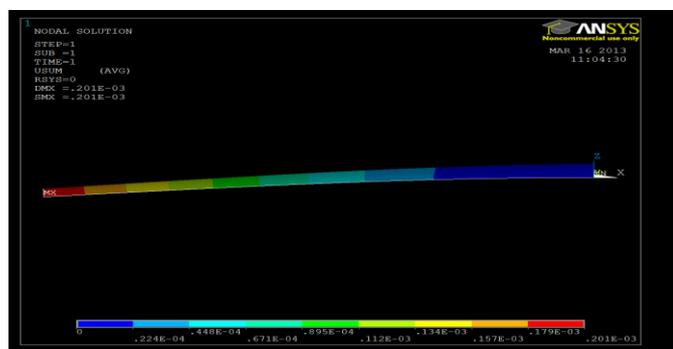
Fig-h: displacement vector sum for steel

List results for displacement vector sum for Steel

NODE	UX	UY	UZ	USUM
1	0.14239E-05	0.64438E-05	-0.20096E-03	0.20107E-03
2	0.25719E-05	0.64453E-05	-0.20026E-03	0.20038E-03
3	0.35286E-06	0.64166E-05	-0.20088E-03	0.20098E-03
4	0.95615E-06	0.64102E-05	-0.20030E-03	0.20041E-03
5	0.32437E-05	0.64610E-05	-0.20028E-03	0.20041E-03

6.2 MODAL ANALYSIS

### 6.2.1 MODAL ANALYSIS FOR ALLUMINIUM:
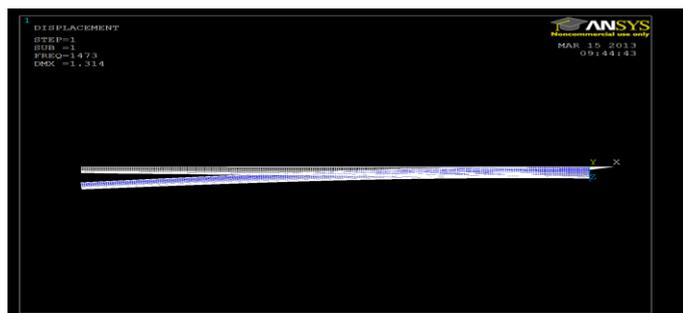
Fig-i: Deformed+undeformed shape for frequency minimum.

RANGE OF FREQUENCY SUMMARY:

SET	TIME/FREQ	NODE NUMBERS	FREQUENCING	CUMULATIVE
1	1473.4	1	1473.4	1
2	6610.7	2	6610.7	2
3	10036	3	10036	3
4	14321	4	14321	4
5	16540	5	16540	5

6.2.2 MODAL ANALYSIS FOR CARBON EPOXY:
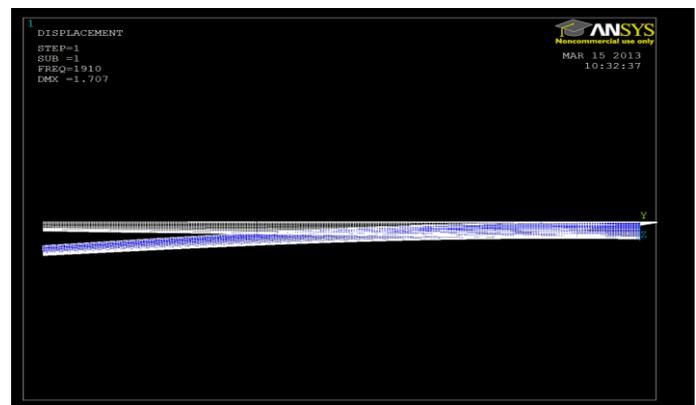
**Fig-j: Deformed & UN deformed shape for frequency min.**

RANGE OF FREQUENCY SUMMARY:

| SET	TIME/FREQ	NODE NUMBER	FREQUECING	CUMULATIVE
1	1910.3	1	1910.3	1
2	8577.0	2	8577.0	2
3	13060.	3	13060	3
4	19186.	4	19186	4
5	21497	5	21497	5

6.2.3 MODAL ANALYSIS FOR STEEL
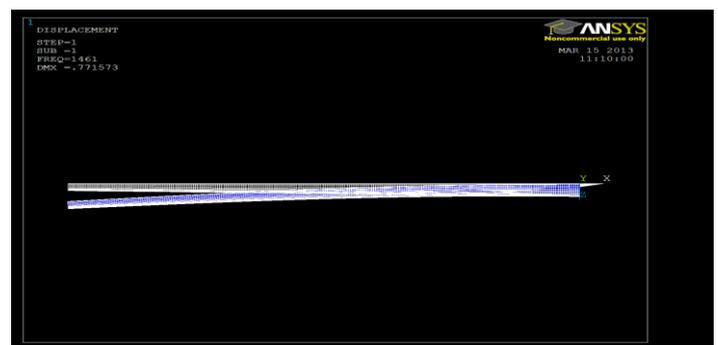
Fig-k: Deformed+undeformed shapes of frequency at min.

RANGE OF FREQUENCY SUMMARY:

SET	TIME/FREQ	NODE NUMBERS	FREQUECING	CUMULATIVE
1	1461.0	1	1461.0	1
2	6556.6	2	6556.6	2
3	9966.4	3	9966.4	3
4	14375.	4	14375	4
5	16415.	5	16415	5

6.3 HARMONIC ANALYSIS

6.3.1 HARMONIC ANALYSIS FOR ALLUMINIUM:
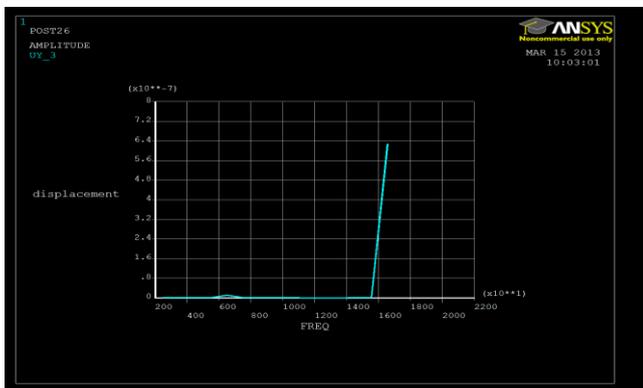
Fig-l: Graph for y-displacement(6533)

List results for y-displacement graph.

S.NO	TIME	AMPLITUDE
1	2478.3	0.568910E-09
2	3482.5	0.239938E-09
3	4486.8	0.632267E-09
4	5491.1	0.123536E-08
5	6495.3	0.105695E-07

6.3.2 HARMONIC ANALYSIS FOR CARBON EPOXY:
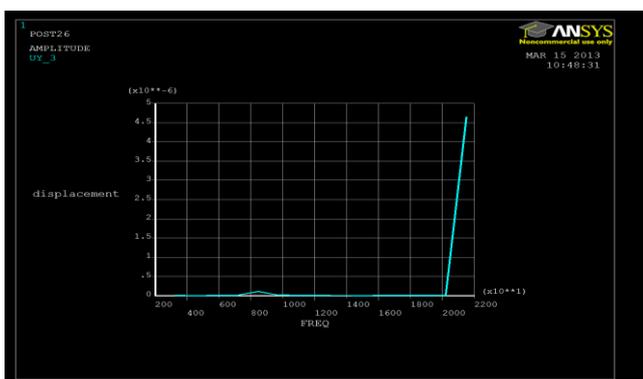
Fig-m: Graph for y-displacement(Node-6888)

List results for y displacement

S.NO	TIME	AMPLITUDE	NODE NUMBERS
1	3216.6	0.730140E-08	1
2	4522.2	0.110317E-08	2
3	5827.8	0.502036E-08	3
4	7133.4	0.108818E-07	4
5	8439.0	0.109608E-06	5

6.3.3 HARMONIC ANALYSIS FOR STEEL:
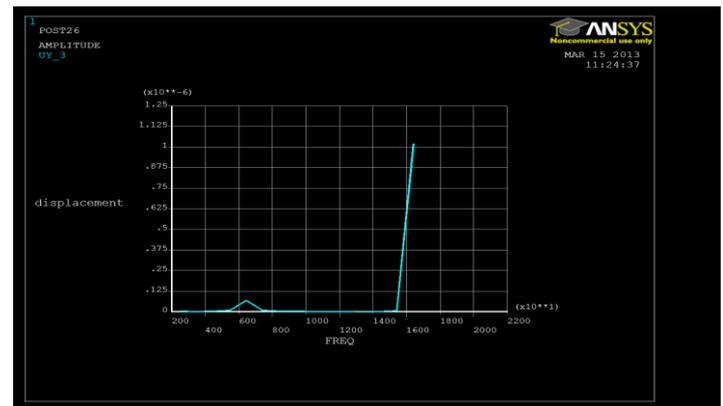
Fig-n: Graph for y-displacement(7856)

List results for y-displacement.

S.NO	TIME	AMPLITUDE
1	2459.5	0.377555E-08
2	3455.9	0.115328E-08
3	4452.4	0.354849E-08
4	5448.9	0.729735E-08
5	6445.3	0.683971E-07

7.CONCLUSION

The main objective of the project was to design and analysis of trapezoidal wing structure with three different materials (Aluminium, Carbon epoxy and steel).Finally i conclude the project by saying that the material suitable for the aircraft wing is found as Aluminium 7075-T6.When compare to other two materials (carbon epoxy and steel) aluminium is having less deformation whenever there is self-weight is acting on it. Finally aluminium is the efficient material for the aircraft wing.

8.FUTURE WORK

As future work to this thesis, the following recommendations are presented.

1. The methodology presented in this thesis work for the creation of the generic model for the aircraft wing can also be used to create a generic model for the aircraft fuselage.
2. Wing Flaps, ailerons and slats can be incorporated in the generic model for the wing.

3. Wing stringers can be incorporated into the generic model, in addition to the wing panel skin, wing spars and wing ribs already included in the generic model.

4. The wing spars can be designed in such a way to have different sections e.g.a T-section etc. Wing Ribs can also be designed to have holes and cutouts in them.

9. REFERENCES

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