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Improvement in the Design Influence on the Dynamic Response of The Ailerons

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Abstract

In this papers we will study the effect frequencies on the important part of control surface in the aircraft is called for Ailerons, in order to get a good structure of Ailerons that bears strong vibrations and with weight is lower.

We will choose an Aileron in two cases , the first case with three ribs and the second case with four ribs every case is structured with skin from Aluminum ,ribs from Wood and shaft from Structural Steel in different designs of Ailerons .

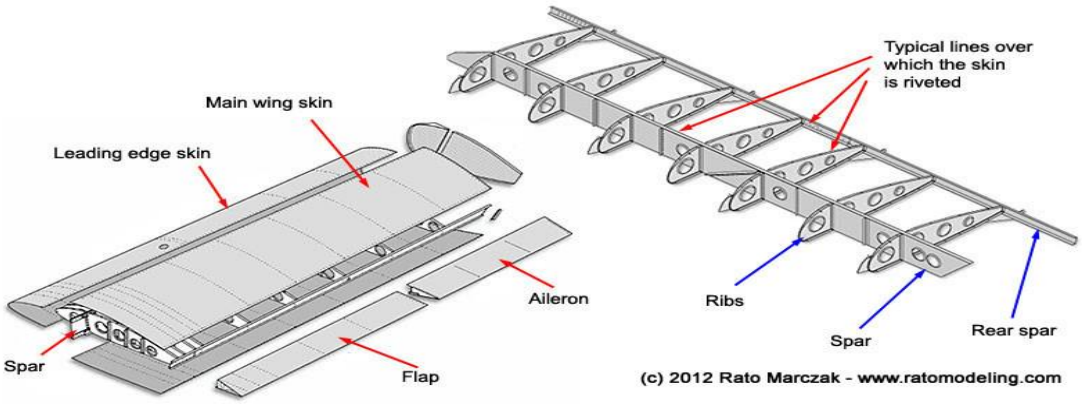
We will calculate the frequencies for Ailerons with Mesh (Normal, Coarser, Finer and Extra fine)in two cases (three and four Ribs), and use the number of elements and the value of frequencies we will get the plot for every case of mash.

After comparing between the results we will choose the perfect of Ailerons , by using the two program Matlab an Comsol.

1. Introduction

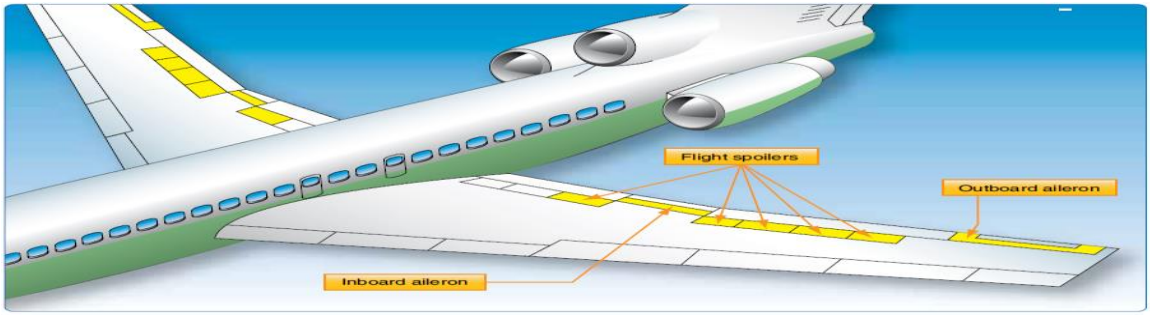
For getting safe and stable flight and in order to allowing the pilot to adjust and control the aircraft s flight attitude Because any problem occurs in any part of control surfaces leads to lack of control of the plane and crash directly, We chose the Ailerons for example of control surfaces for aircraft to apply and test the vibration motion , Let us take some information about the Ailerons and its function and the importance:

1.1. Ailerons function:[1],[2],[3],[4],[6],[11] It is to move the plane around the longitudinal axis and in other words the movement of ailerons in flight lead aircraft to roll .(Figure1)shows shape of aileron.



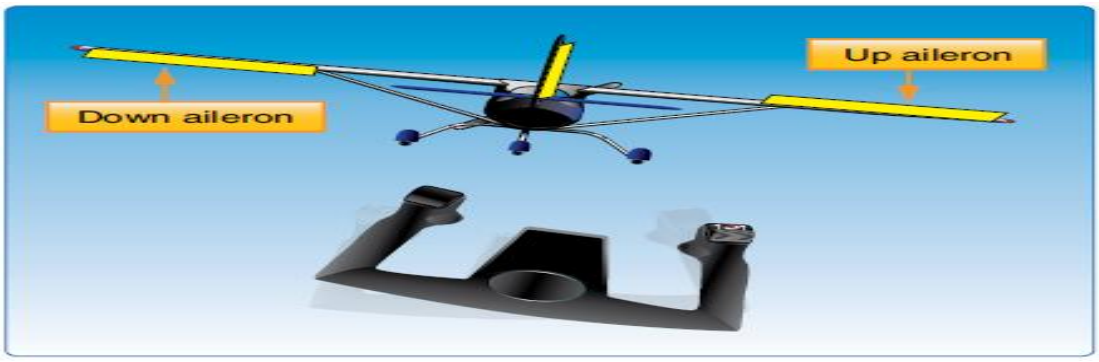
(Figure 1.Shape of aileron)

1.2. Location of Ailerons: [1],[2],[3],[4],[6],[11] Ailerons are usually located on the outboard trailing edge of each of the wings also they built on the wing and be counted as part of the wing space.(Figure 2)shows Ailerons located on kinds wing.



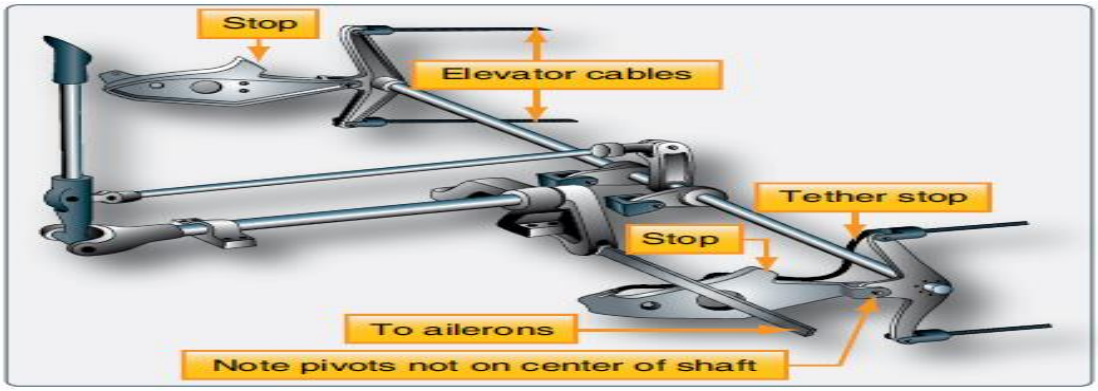
(Figure 2)shows Ailerons located on kinds wing.

1.3. The control of Ailerons: [1],[2],[3],[4],[6],[11] Ailerons are controlled by a side-to-side motion of the control stick in the cockpit or a rotation of the control yoke. The Ailerons are used to bank the aircraft to cause one wing tip to move up and the other wing tip to move down.(Figure 3)differential Aileron control movement. when one Aileron is moved down(lift is increased), the Aileron on the opposite wing is deflected upward(lift is decreased).



(Figure 3)differential Aileron control movement. when one Aileron is moved down(lift is increased), the Aileron on the opposite wing is deflected upward(lift is decreased).

1.4. Mechanical movement of Aileron: [1],[2],[3],[4],[6],[11] The pilot s request for Aileron movement and roll are transmitted from the cockpit to the actual control surface in a many kinds of ways depending on the aircraft. A system of control cables and pulleys, push-pull tubes, hydraulics, electric, or a combination of these can be employed.(Figure 4).



(Figure 4)Mechanical movement of Aileron

1.5. Structure of Ailerons:[2],[6],[7],[12] The Ailerons are consist of three parts ;Spars, Rips, Skin.

1.5.1. Spars: are the main structure of the wing. They run parallel to the lateral axis of the aircraft. Spars are made of Metal or Wood or composite materials depending on the design of a private jet standards.

1.5.2. Wing Ribs: Ribs are forming elements of the structure of a wing, especially in traditional construction. They usually extend from the wing leading edge to the rear spar or to the trailing edge of the wing. Wing ribs are usually manufactured from either Wood or Metal(Wood ribs are usually manufactured from Spruce).

1.5.3. Wing Skin: The skin on a wing is deafness to carry part of the flight and ground loads in combination with the spars and ribs. The wing skin on an aircraft may from a wide range of materials such as Fabric, Wood or Aluminum.

2. **Theoretical Modeling: [8],[9],[10],[12],[13]**

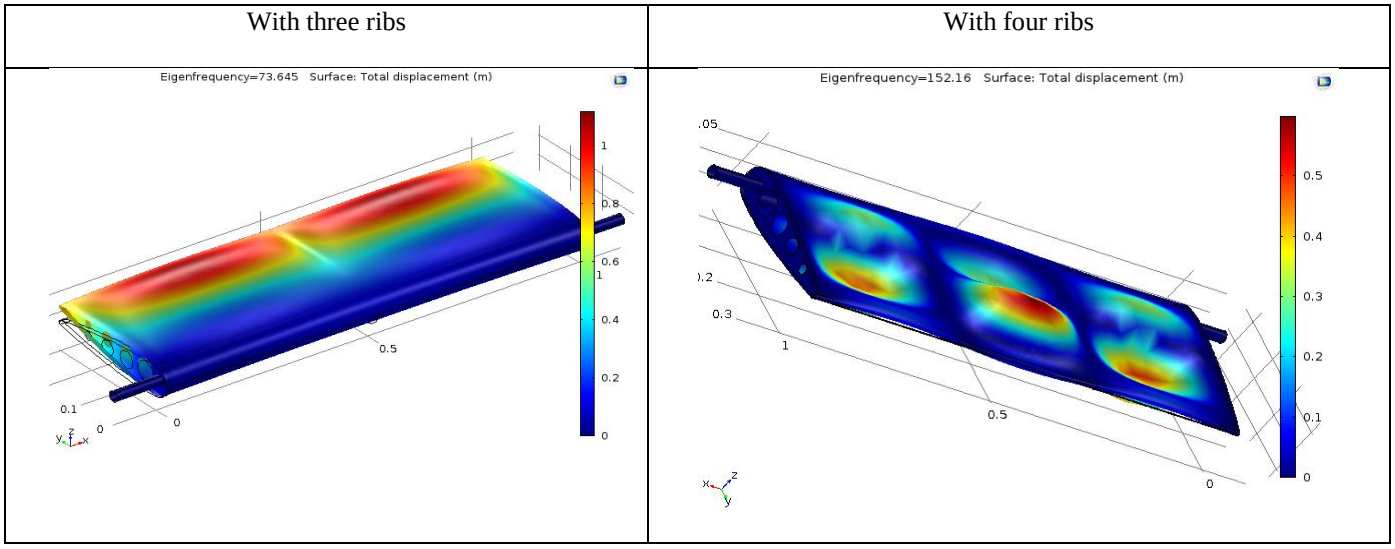
Mechanical properties of Aluminum, wood, and structural steel that will be used in the installation of the aileron structure are below in Table 1.

Table1

The Materials	**E= Young modulus in (n/m^2)**	**Density in (kg/m^3)**	**v=Poisson coefficient**
Aluminum	**69e9**	**2700**	0.3
Wood(Ash, black)	11e9	526	0.3
Structural steel	200e9	7850	0.33

2.1. Ailerons Structure: [2],[6]

We will calculate the frequencies for two ailerons everyone is structured of skin from Aluminum, ribs from Wood and shaft from Structural Steel.



(Figure 5)Kinds of ailerons

2.2. Properties of Ailerons with 3 ribs that we be used in in this test at below in table 2: [2],[6],[7]

Table 2

Name	Expression	Value	Description
R_le	35 [mm]	0.035 m	Leading edge radius
R_te	5 [mm]	0.005 m	Trailing edge radius
chord	300 [mm]	0.3 m	Chord
length	1000 [mm]	1 m	Aileron length
R_rib	25 [mm]	0.025 m	Hole in ribs – radius
H	100 [mm]	0.1 m	Max profile thickness
no_ribs	3	3	
rib_thick	2 [mm]	0.002 m	Rib thickness
skin	0.5[mm]	5E−4 m	Skin thickness
shaft_thick	3 [mm]	0.003 m	Shaft thickness

2.3. Mesh in Comsol

We will use Mesh to test the accuracy of vibrations results on ailerons with four kinds of mesh by Comsol and by Matlab programs.

Normal

Coarser

Finer

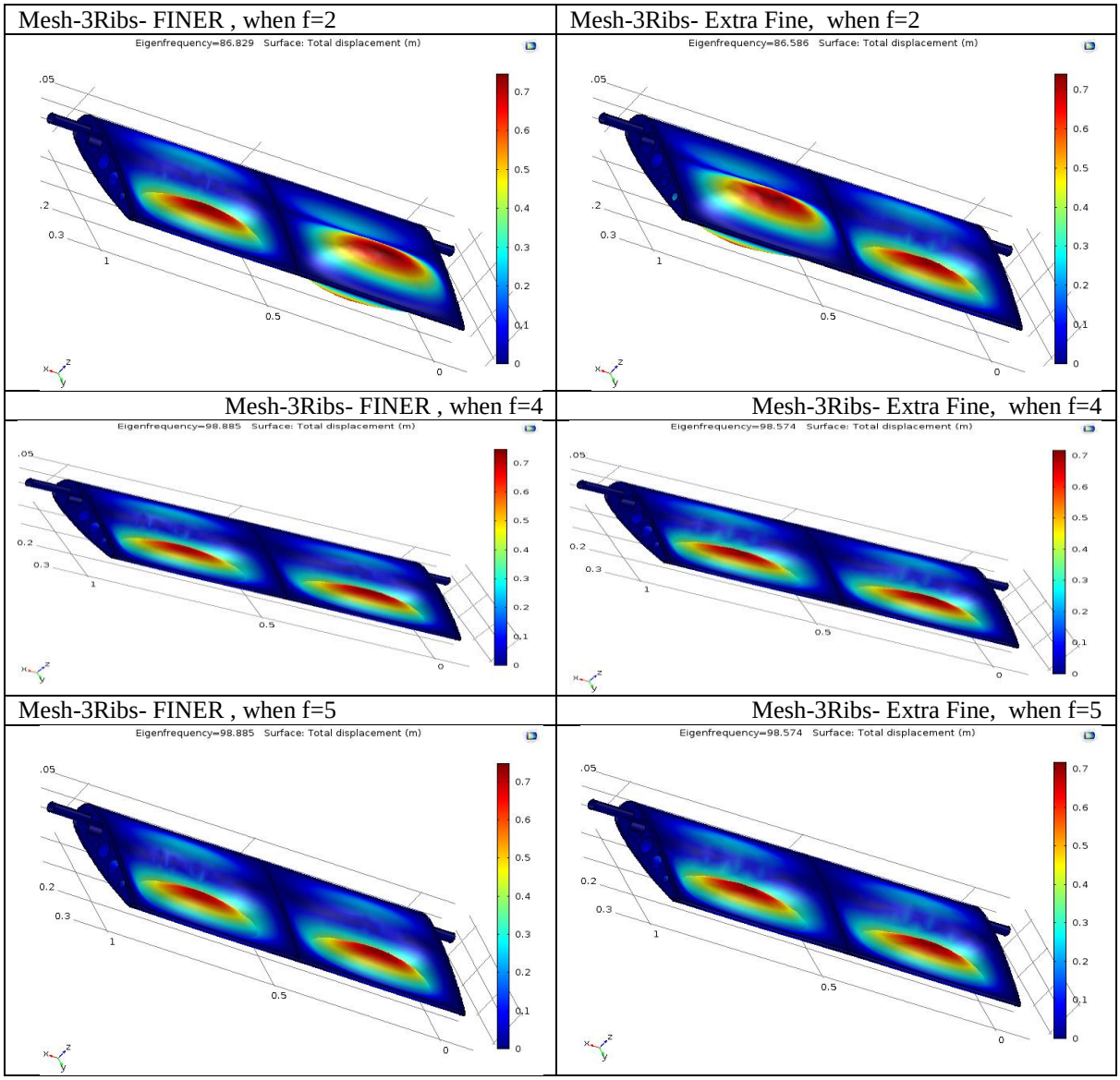
Extra Fine

2.4. The results of frequencies in (rad/s) for ailerons with three ribs after applying the deflections at below in table 3.

Table 3

MESH MODE 3	NORMAL	COARSER	FINER	EXTRA FINE
NO OF ELEMENTS	3558	1140	19430	45236
FREQUNCY1	73.963	0.00017863	73.847	73.74
FREQUNCY2	88.018	0.0077754	86.829	86.586
FREQUNCY3	98.306	0.015645	97.031	96.522
FREQUNCY4	100.09	0.028156	98.885	98.574
FREQUNCY5	114.62	0.034376	112.56	112.05
FREQUNCY6	120.04	0.03697	118.44	117.78

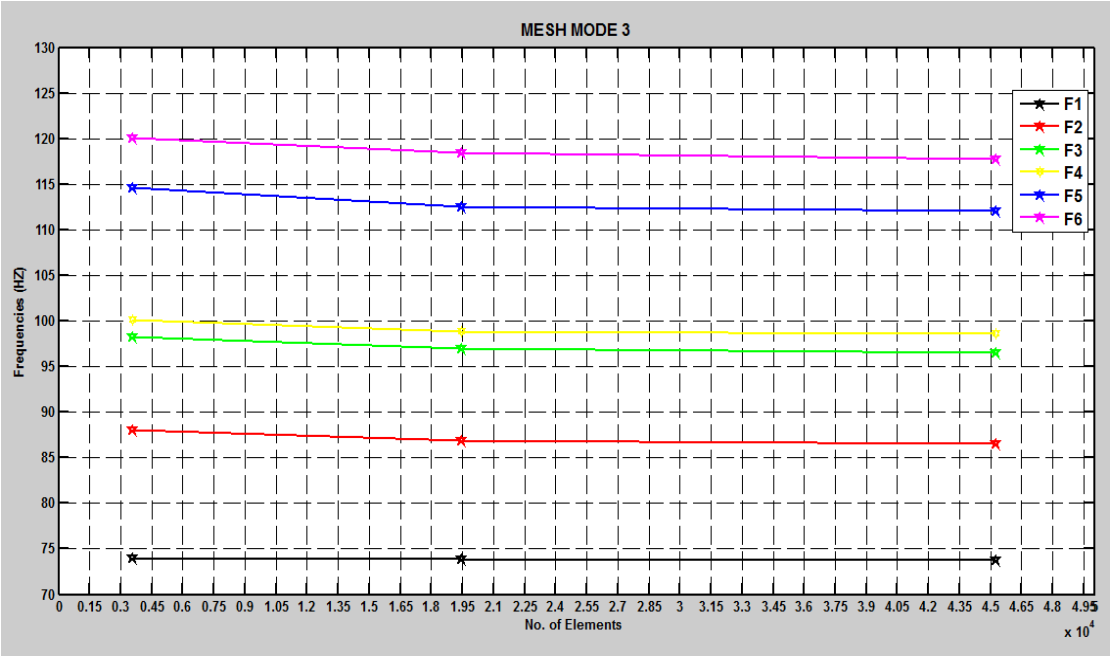
2.5. Examples of deflections in ailerons with three ribs in figure 6.



(Figure 6) Examples of deflections in ailerons with three ribs

2.6. . Explains Natural Frequencies curve paths for ailerons with three ribs in chart 1.

Chart 1.



Discussion the results in chart 1 we see

1- The frequency is correct when its value gets stabilized that is going to stable value.
2- We look at frequency 1 is a horizontal for the beginning and is good for any mesh.
3- Frequency 2 has a certain value and very little change make it not very good.
4- Frequency 3 is acceptable because it goes for horizontal and the value has stabilized.
5- Frequency 4 relatively is good.
6- Frequency 5 isn't very good.
7- Frequency 6 I think maybe need improvement because the slop is go down and I need more number of elements and that need more computing time.

2.7. Properties of Ailerons with 4 Ribs that we be used in this test at below in table 4.

Table4

Name	Expression	Value	Description
R_le	35 [mm]	0.035 m	Leading edge radius
R_te	5 [mm]	0.005 m	Trailing edge radius
chord	300 [mm]	0.3 m	Chord
length	1000 [mm]	1 m	Aileron length
R_rib	25 [mm]	0.025 m	Hole in ribs - radius
H	100 [mm]	0.1 m	Max profile thickness
no_ribs	4	4	
rib_thick	2 [mm]	0.002 m	Rib thickness
skin	0.5[mm]	5E−4 m	Skin thickness
shaft_thick	3 [mm]	0.003 m	Shaft thickness

2.8. Mesh in Comsol

We will use Mesh to test the accuracy of vibrations results on ailerons with four kinds of mesh by Comsol and by Matlab programs.

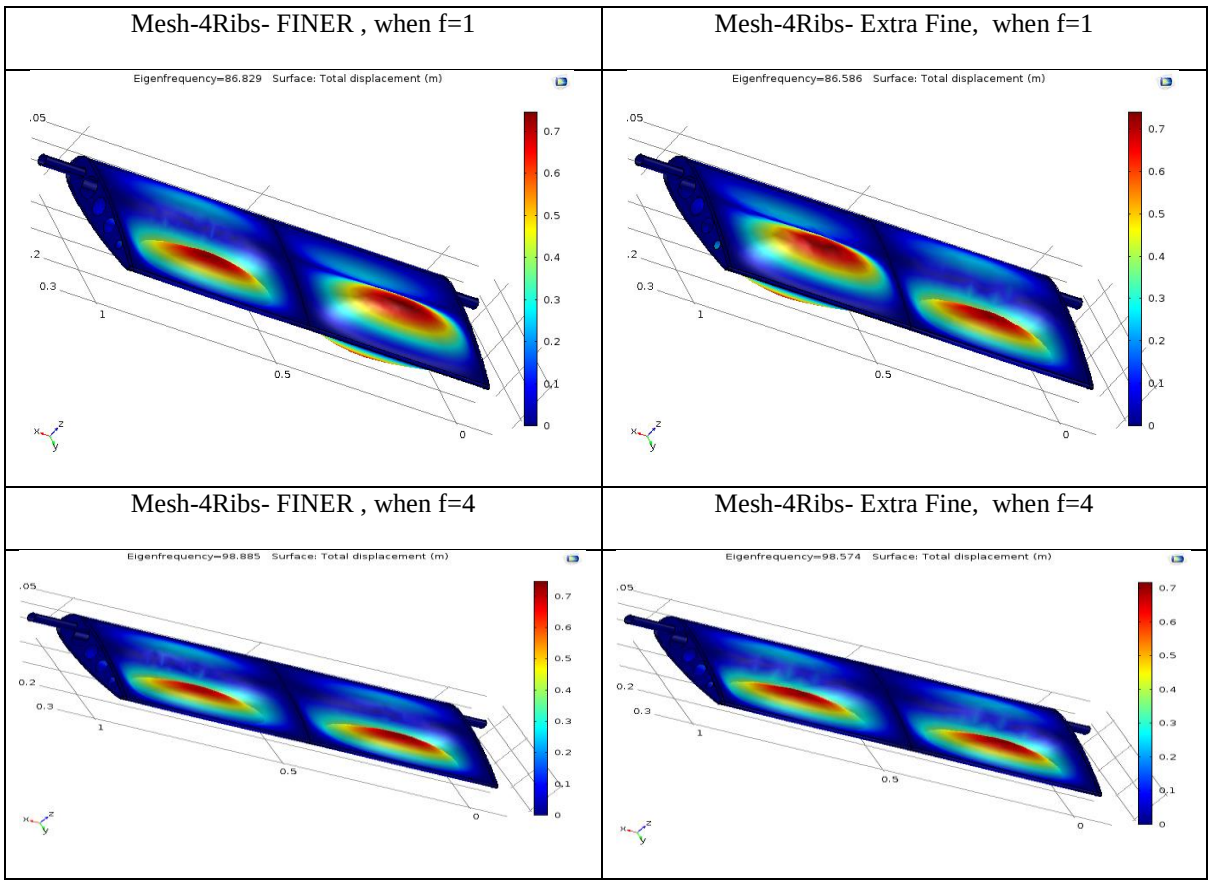
Normal
Coarser
Finer
Extra Fine

2.9. The results of frequencies in (rad/s) for ailerons with three ribs after the deflections at below in table 5.

Table 5.

MESH MODE 4	NORMAL	COARSER	FINER	EXTRA FINE
NO OF ELEMENTS	3912		20323	46982
FREQUNCY1	79,016	0.00007734	78.948	78.898
FREQUNCY2	129,7	0.00033498	127.93	127.8
FREQUNCY3	136,59	0.0015006	134.58	134.41
FREQUNCY4	149,18	0.021899	147.28	147.17
FREQUNCY5	152,72	0.032287	149.42	149.05
FREQUNCY6	154,46	0.038167	152.28	152.16

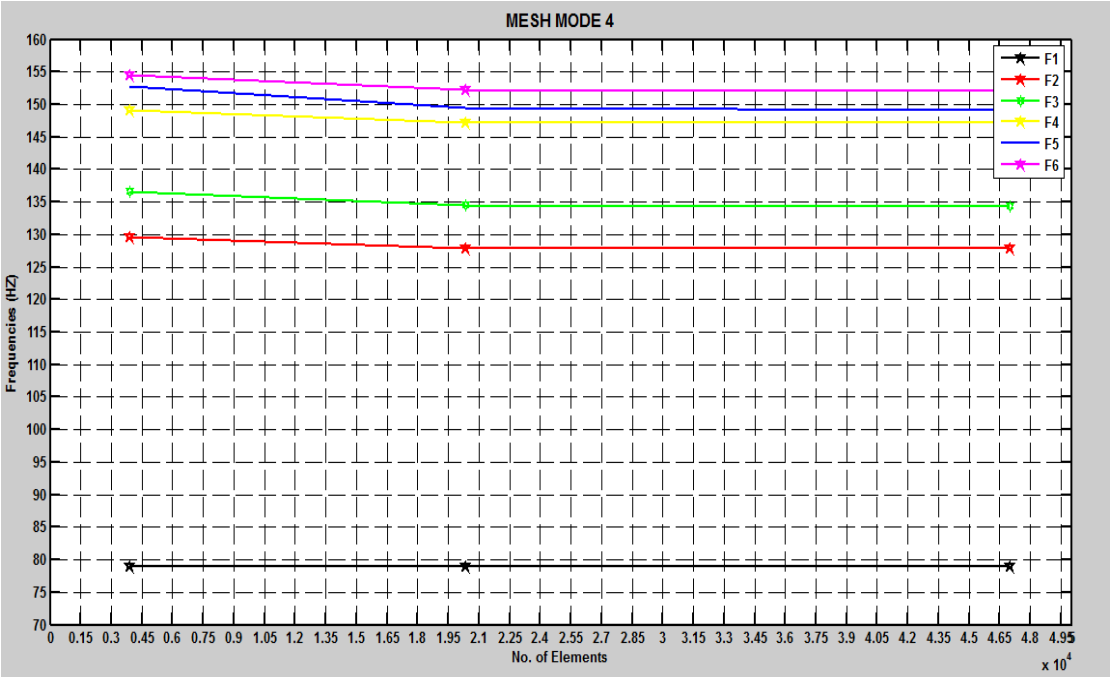
2.10. Examples of deflec1tions in ailerons with four ribs.



(Figure 7) Examples of deflections in ailerons with four ribs

2.11. Explains Natural Frequencies curve paths for ailerons with four ribs in chart 2

Chart 2.



Discussion the results In chart(2)we see

All frequencies are very good and correct and have a maximum accuracy because the curves of frequencies are stabilized and go to horizontal with number of elements as compare with the values of frequencies in the ailerons with 3 ribs .

2. Conclusions

From the results of frequencies we conclude :

1- The frequencies of ailerons with 4 ribs more better as compare with theirs of ailerons with 3 ribs.
2- Ailerons with 4 ribs responsive with the vibrations and gave a good and accurate frequencies.
3- From the results of frequencies we can limit the quality of control surfaces and their efficiency.
4- If the ailerons not responsive with the vibrations (they get a worse frequencies)that means wrong in the ailerons may be problem in the manufacturing or isn't so strong connected .
5- In future we need to study the elasticity of the mechanism of the control surfaces because the structure of the ailerons may be need to damper with the system to stop the vibrations or need to other mechanism for getting the ailerons or control surfaces more safe and economic.

References

1- https://www.grc.nasa.gov/www/k-12/airplane/alr.html.
2- https://www.faa.gov/regulations%20policies/handbooks%20manuals/aircraft/amt%20airframe%20handboo;/media/ama%20ch01.pdf.
3- http://streaming4.us/watch-movie/boeing-747-400heavy-aileron-use-during-landing.htm./
4- https://www.q-files.com/technology/aircraft/how-a-plane-flies/.
5- Https://www.comsol.com/video/design-model-with-livelink-for-solid-edge.
6- http://faculty.dwc.edu/sadraey/Aileron%20Deign.pdf./
7- https://www.google.ro/search?q=how+to+design+ailerons&tbm=isch&tbo=u&source=univ&biw=1366&bih=640#imgrc=ORGEXWMB0gkNRM%3A.
8- https://en.wikipedia.org/wiki/Young%27s modulus
9- http://www.acpsales.com/upload/Mechanical-Properties-of-Carbon-Fiber-Composite-Materials.pdf.
10- https://en.wikipedia.org/wiki/Specific modulus.
11- https://www.faa.gov/regulations policies/handbooks manuals/aircraft/amt airframe handbook/media/ama Ch06.pdf.
12- http://www.conradfp.com/pdf/ch4-Mechanical-Properties-of-Wood.pdf.
13- http://www.engineeringtoolbox.com/wood-density-d 40.html./