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Simulation of float of 19 passenger aircraft during landing on water surface

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Abstract. The 19-passenger plane was modified to land in the water by making a landing gear with a float. The floats used are imported products that have previously been used by similar aircraft. Float must be able to support the aircraft and can accept impact loads when landing. This study aims to determine the effect that occurs in float when making water surface landings. Stress and displacement are simulation outputs that are the focus of research. These parameters are obtained by numerical simulation methods based on Civil Aviation Safety Regulation (CASR) by varying input parameters such as: landing speed. From the results of the study it was found that the faster the velocity then the output of the stress and displacement response from the float becomes larger.

1. Introduction

The 19-passenger aircraft Amphibious aircraft that will be produced is a modified aircraft from the 19-passenger aircraft which is given a float to be able to take off and land in the waters. The floats used are imported products that have previously been used by similar aircraft. The use of floats is very beneficial to be applied to aircraft because it doesn't change the configuration of the airframe much, only the weight and design of the float shape must be adjusted so that the performance of the aircraft is not reduced. [1]

The impact load is one of the important factors to know because at the time of landing a large energy absorption process occurs from the surface of the water to the surface of the float. The impact between the water and the basic structure of the ship can cause critical loads or even result in structural damage [2].

Von Karman [3] was the first person to put forward a theory related to the analysis of amphibious aircraft landings. After that, many studies have been conducted regarding the effects of water impact. Numerical methods and experimental tests by dropping objects vertically have been done several times. The models that have been studied include: horizontal cylinders [4], wedges [5], cone 20^{o}, 45^{o} dan hemisphere [6], plate [7], boat [8], deformable sphere [9].

This 19-passenger aircraft float impact study was carried out using a static simulation method. Checking is needed to find out the strength of the imported float used on the 19-passenger aircraft. The float must be able to support the aircraft and can accept impact loads when landing in accordance with CASR (Civil Aviation Safety Regulation) Subpart C Water Load that issued by the Ministry of Transportation.

2. Methods

2.1 Float Specification

19 passenger aircraft Amphibian is a twin seaplane float. This float is located on both sides of the fuselage. The first series Amphibious 19 passenger aircraft float is an imported product made by a company from the United States specializing in float making for floatplane and amphibian, namely: WIPAIRE, Inc. This float is made of aluminium material, can float with a maximum load of 6,5 Tons each side and already used by Twin Otter 300 series.

Table 1. Float Dimension [10]

Float	Dimension
Length	9900 mm
Height Hull	1140 mm
Width Hull	1535 mm
Dead Rise	23^{o}

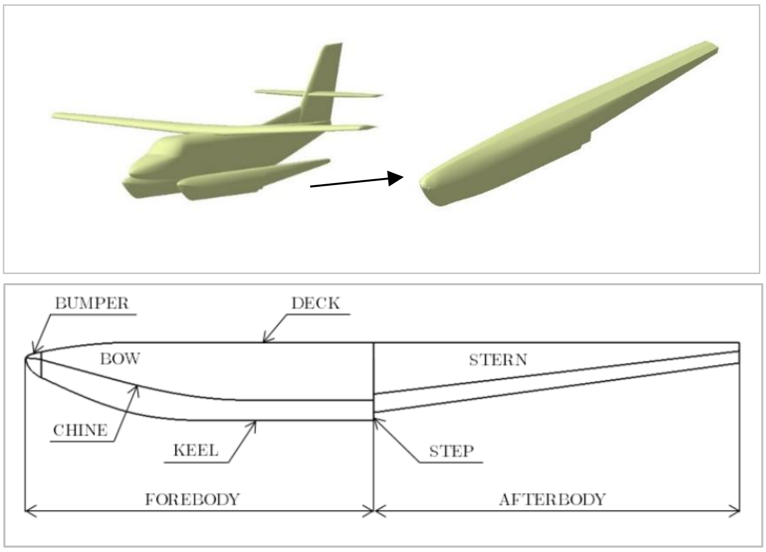

Figure 1. Illustration of Float 19 passenger aircraft Amphibian & Part of Float

Table 2. Sheet metal thickness Wipline13000 [10]

Sheet metal 6061-T6		Thickness (inch)
Top Skins	Forward & Aft	0.04
	Centre	0.063
Side Skins	Forward & Aft	0.04
	Centre	0.063
Bottom Skins	Bow to Wheel Well	0.063
	Afterbody	0.032
	All Remaining	0.05
Bulkhead	Nose	0.1
	Aft Wheel Well	0.063
	All Remaining	0.04

Float is made of 6061-T6 series aluminium material. (Mg and Si alloy). This type of aluminium has very good corrosion resistance and excellent seepage despite reducing the strength in the welding zone [11]. To restore its strength can be done by reheat treatment and artificially aging [12]. This type of aluminium has medium fatigue strength. In addition, this type of aluminium has excellent joining characteristics and acceptance of good coating applications.

Table 3. Al 6061-T6 Mechanical Properties [13]

Properties	
Density	2,7 g/cm3
Ultimate tensile strength (24°C)	310 MPa
Modulus of Elasticity	68,9 GPa
Poisson's Ratio	0,33
Shear Modulus	26 GPa
Shear Strength	207 MPa

2.2 Water Loads

In NAS 807 [14] (National Aerospace Standard) which is the standard specification for twin seaplane float, it is stated that two seaplane floats must have 80% more buoyancy needed to support the maximum weight of the aircraft in water. Strength requirements are specified in terms of limit load and ultimate load. Limit load is the maximum load that occurs during operation. Ultimate load is the same as the limit load multiplied by the safety factor. Safety factor used 1.5.

Based on CASR 23.525 Application of Load (b) In applying the loads may be distributed over the hull or main float bottom using pressures not less than those prescribed in 23.533(c). [15]

The following pressure distributions shall be used for the design of the frames, keel and chine structure. These pressures shall be applied simultaneously over the entire float bottom and their distributions shall be uniform.

The magnitudes of the symmetrically distributed pressures in psi shall be given by.

$$P = \frac{C_4 K_2 V_{so}^2}{\tan\beta} \quad (1)$$

Where:

P : Pressure (psi)
C_4 : $0{,}078C_1$ (C1 = 0.012)
K_2 : Float station weighing factor (figure 2.)
V_{so} : Stalling speed (knots) (Vs = 59 knots, Vso = 45.4 knots)
β : Angle of dead rise. (β = 23°)

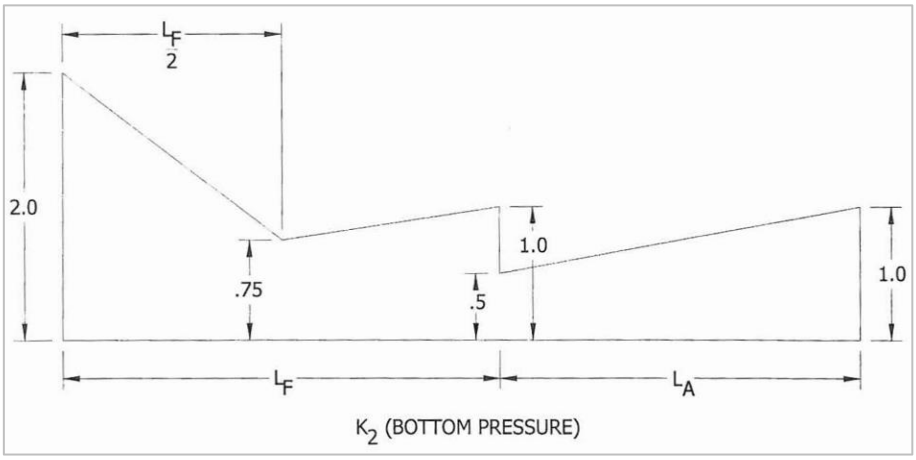

Figure 2. Float Station Weighing Factor

2.3 Numerical Modelling

The float model is designed in CATIA-V5 Software. The designed model is shown below.

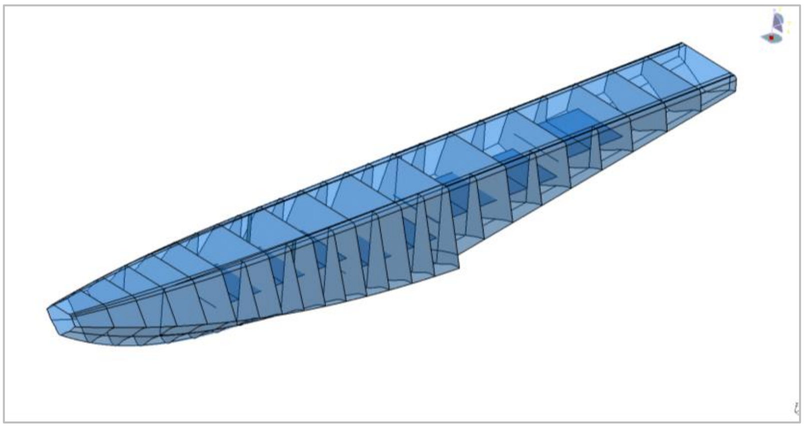

Figure 3. Float Model

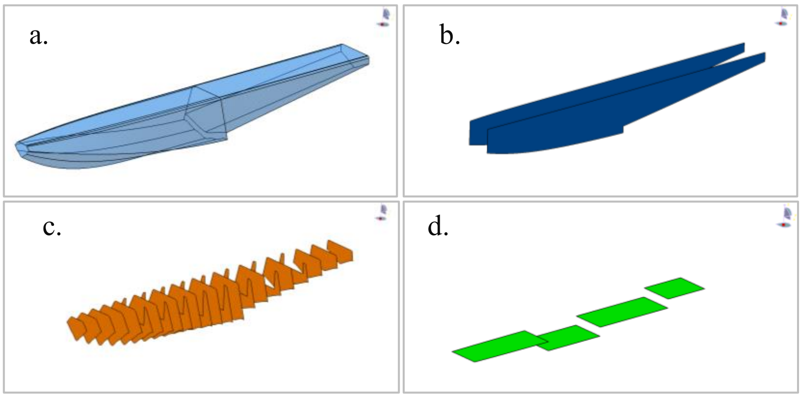

Figure 4. Parts of Float (a. Skin; b. Frame; c. Bulkhead; d. Floor)

The results of the Catia software image are then imported for further analysis. Design analysis is done using Abaqus software.

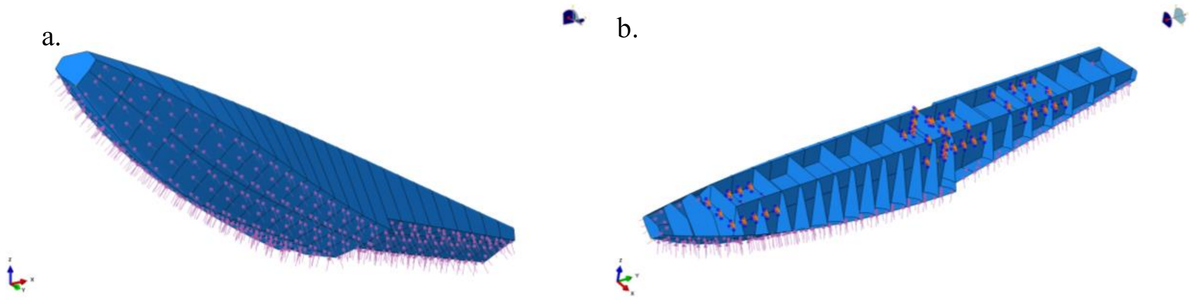

Figure 5. a. Load Distribution; b. Boundary Condition

Load distribution is given to all the lower surfaces of the float. Boundary conditions are placed on the floor inside the float, this is because in that part the landing gear strut is attached. The mesh used in the simulation is a quad type.

3. Results

3.1 Loads

By using equations (1) and divide the float into sections based on the position of the bulkhead, then the load obtained in the form of pressure at the bottom of the float as follows:

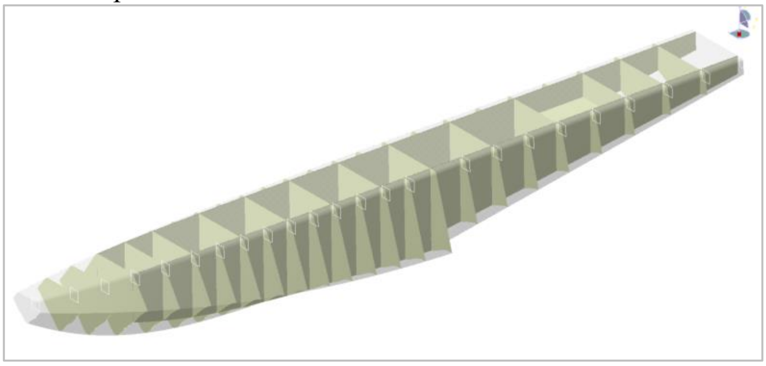

Figure 6. Section of Float Based on Bulkhead Position

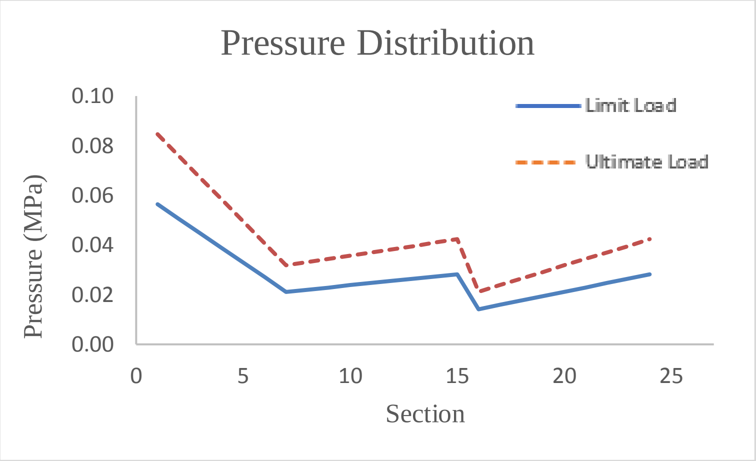

Figure 7. Pressure Distribution Under the Float

3.2 Mesh Convergence

Six mesh sizes were selected (70, 60, 50, 40, 30 and 20) for the float simulation. These meshes are simulated to obtain convergent points of the simulated model mesh size.

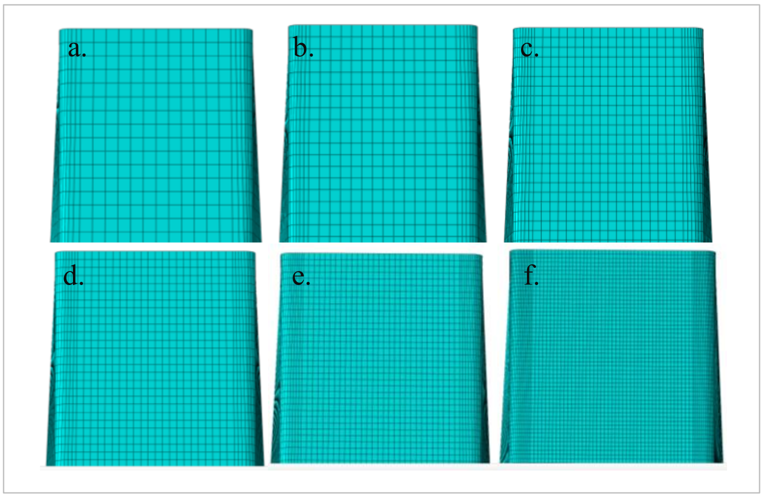

Figure 8. Mesh size (a. 70; b. 60; c. 50; d. 40; e. 30 and f. 20)

Based on the simulation results, it is found that with reduced mesh size, the stress produced is getting smaller. Convergent points occur when entering mesh size 40 and stable up to size 20. With this result, for the next modeling, a mesh with a size of 40 will be used.

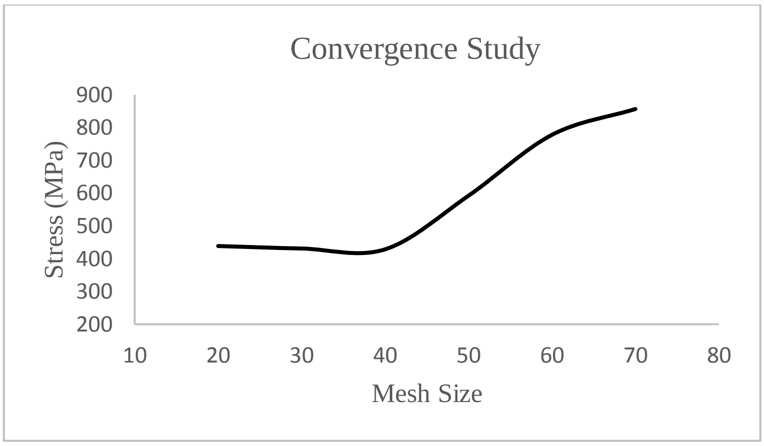

Figure 9. Mesh Convergence Study

3.3 Numerical results

The results of the simulation with the distribution pressure limit load on the float with aluminum float thickness of 2.5 mm on the entire surface produce von misses stress of 236 MPa. Whereas in the loading of the ultimate load (1.5 times the limit load) von misses stress that occurs on the float is 353 MPa. If the float only gets a limit load, the float structure can still withstand the pressure received because the stress received is smaller than the allowable stress Al 6016-T6 but when the float receives the ultimate load, the float structure will fail.

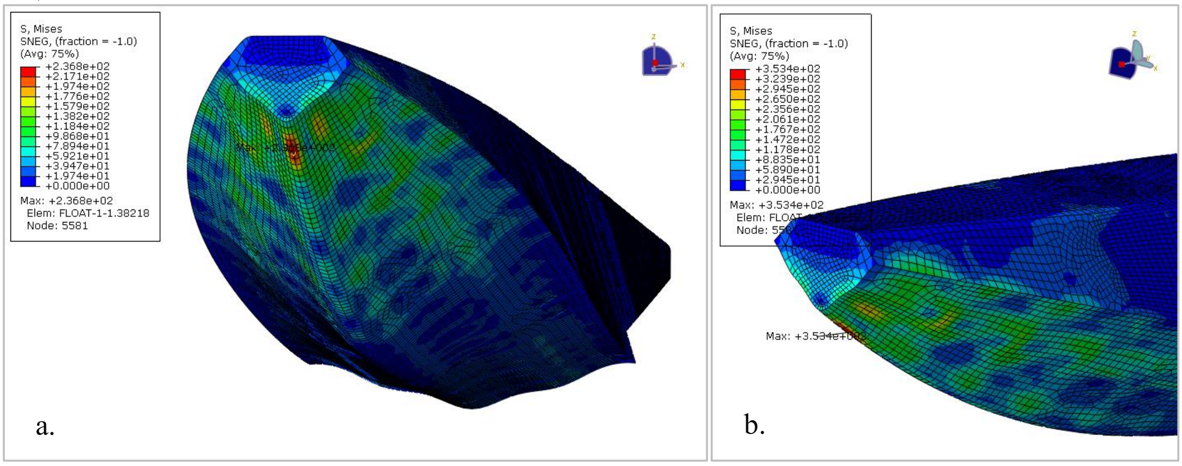

Figure 10. Simulation Results with A Thickness Of 2.5 mm (a. Limit Load; b. Ultimate Load)

From Figure 10 it can be seen that max stress occurs in the first section of the bottom skin float. It is understandable because in that part according to Figure 2, float station weighting factor in that position has the biggest K factor. other than that, in that section there are only skins supported by bulkhead without additional support from the frame and floor. See figure 11.

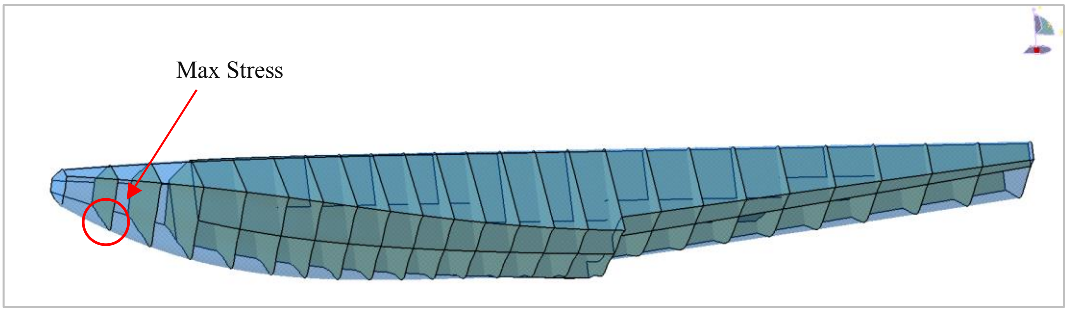

Figure 11. Max Stress Location Without Frame and Floor Support

To resolve this problem can be done by extending the frame to the front or adding an extra floor between the front bulkhead to bulkhead behind and one more solution that can be done is to increase the thickness of the bottom surface that receives max stress.

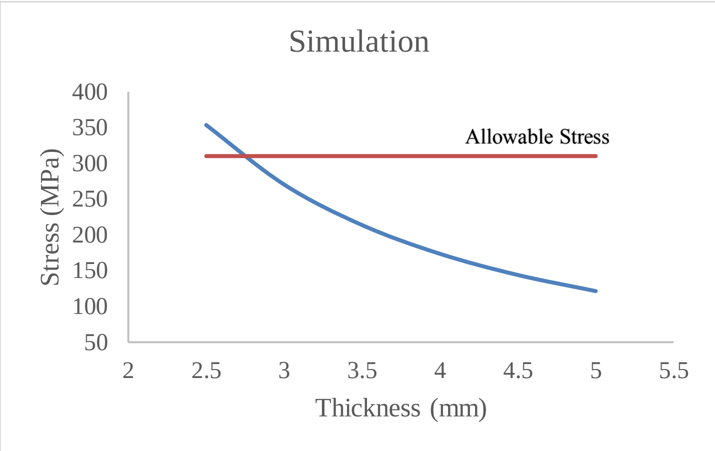

Figure 12. Simulation Result After Increasing The Thickness

Figure 12 shows that with an increase in float surface thickness the stress will be reduced. At 3mm thickness the stress on the float surface becomes 207.3 MPa so that the float will be safe when receiving pressure.

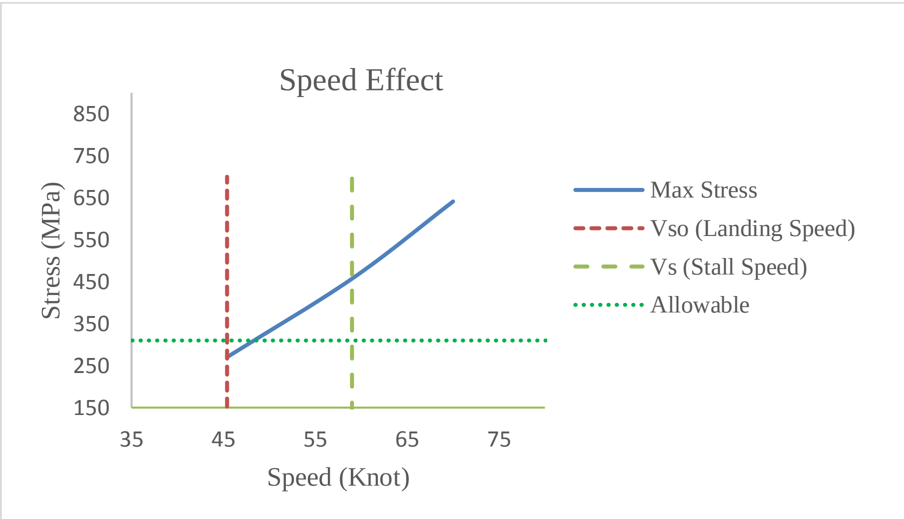

Figure 13. Simulation Results Based On Speed Effect

The effect of increasing speed on stress received by float can be seen in Figure 13. At landing speed (V_{SO}) the stress received was 207.3 MPa, with increasing speed becoming the stall speed (V_S) stress received to 457.1 MPa. and when it reaches a speed of 70 knots the stress it receives becomes even greater, which is 641.1 MPa. Based on equation 1 it can be seen that the speed variable has a large influence on pressure. Velocity has a quadratic function in the pressure distribution equation. so rising speed has a very large effect on increasing the pressure and stress received by float.

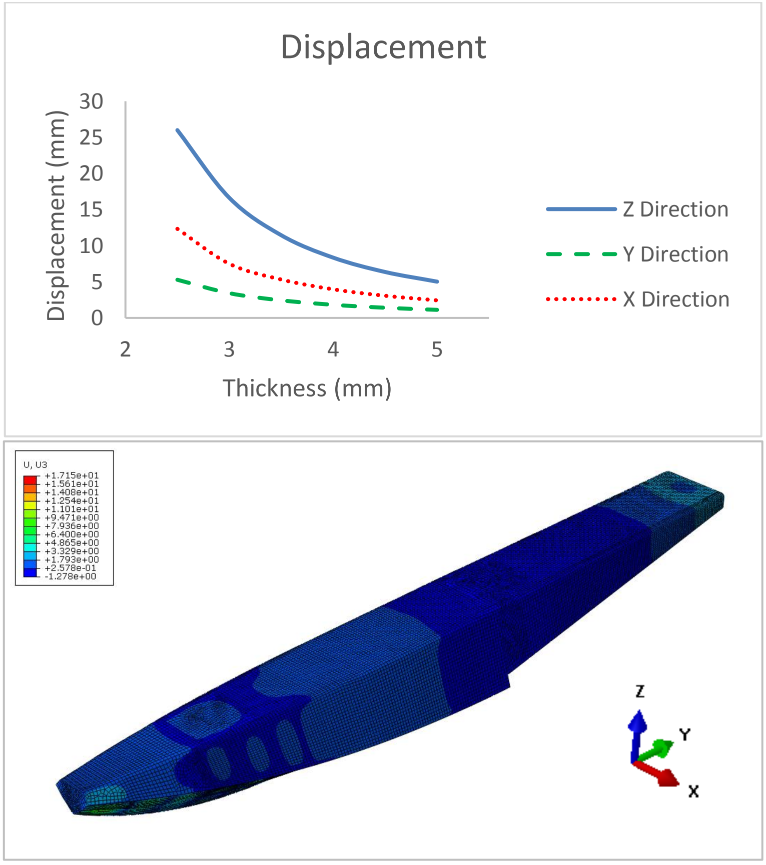

Figure 14. Displacement on Float & Axis Information

When the float receives pressure on the lower surface, the float will be displaced along with the stress received. From the simulation results in Figure 14. it can be seen that the greatest displacement occurs towards the z direction, because in this direction it is in the direction of the pressure received by the float. greatest displacement is on the front and rear of the float. this is because this point is the farthest point from the boundary so that the moment obtained is greater and the displacement is even greater.

4. Conlusions

In this paper we have discussed float design and analysis. The float is analyzed using simulation software for stresses and displacements. It was observed that the stress experienced by the float decreased with increasing surface thickness and stress increases with increasing aircraft speed when landing. The results show that with a thickness of 3mm, the float can accept impact loads based on CASR 23. For future work is to do dynamic simulations on float to get closer to the actual conditions and get more accurate results.

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