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EFFECT OF DIHEDRAL AND ANHEDRAL ON LATERAL-DIRECTIONAL STABILITY OF A RECTANGULAR SWEPT BACK WING

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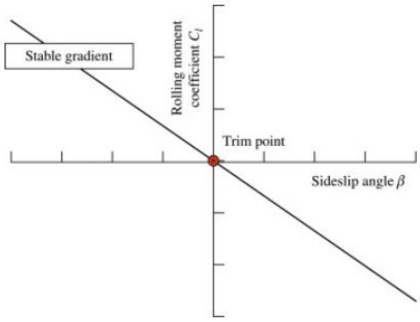
Abstract:

This paper investigates the probable effect a dihedral and an anhedral have on the Lateral-directional stability of an aircraft. In this paper we discuss the basic design of a rectangular swept back wing, designed in the XFLR5 software. We will apply different angles for both the dihedral and anhedral and analyse it using the XFLR5 Software. Our main goal would be to understand the stability criterion, mainly lateral-directional, of the airplane, analysing the graphs that help us understand lateral-directional static stability, compiling all the results and concluding our findings. Furthermore, we will be well-versed in the domain of static stability of an airplane with a rectangular plan form which has swept back wings. The design and analysis part of this paper will wholly be covered in the XFLR5 software and the theoretically knowledge of the concept to stability will covered separately in the coming sections

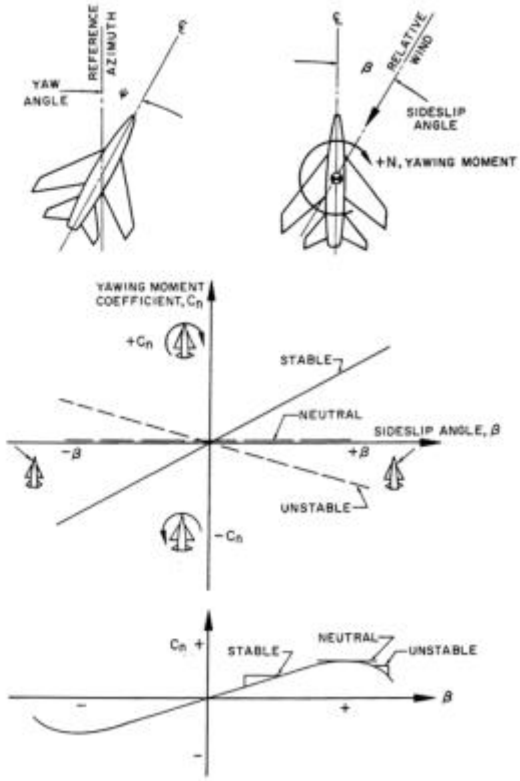
Keywords: Static stability, Lateral-directional stability, dihedral, anhedral, swept back wings.

1INTRODUCTION:

Static stability and its criterion: Static stability of an airplane is, it's inclination to return to its initial stage or stability after being displaced from its original state. We know that static stability of an airplane is essentially divided into three main categories, Longitudinal, Lateral or Roll stability and Directional stability. In this paper we will be mainly focusing on two kinds of stability i.e.; lateral stability and directional stability. For an airplane to be laterally stable, it needs to fulfil a set of conditions. These conditions help us determine the airplane's current stability state and also help us know the requirements for the airplane to become stable, if there is a destabilising effect. The conditions for an airplane to be laterally stable or to have roll stability is, it's Cl Vs β graph must have a negative slope. The following graph gives us a brief idea.



Similarly, for an airplane to possess directional stability or to be directionally stable, it's Cn Vs β graph must have a positive slope. The following graph represents the requirement for an airplane to be directionally stable.



2METHODOLOGY:

2.1 Design:

The rectangular wing plan form was designed using the XFLR5 software. We started by choosing the suitable NACA airfoil for the wing, elevator and fin designing. The airfoil chosen for the wing is the NACA 4412 and for the vertical and horizontal stabiliser we chose the NACA 4 0009 symmetric airfoil. After selecting these airfoils from the already present NACA airfoils in XFLR5 software. We then define the wing, elevator and fin.

2.2Specifications: WING

Wing span= 2.00m

Area=0.36m2

Projected area=0.35m2

Projected span=1.97m

Mean geometric chord=0.18

Mean aerodynamic chord=0.18

Aspect ratio=11.11

Taper ratio=1.00

Root to tip sweep=10.04 degrees

Dihedral= 5 degree, 10 degrees, -5 degrees, -10 degrees

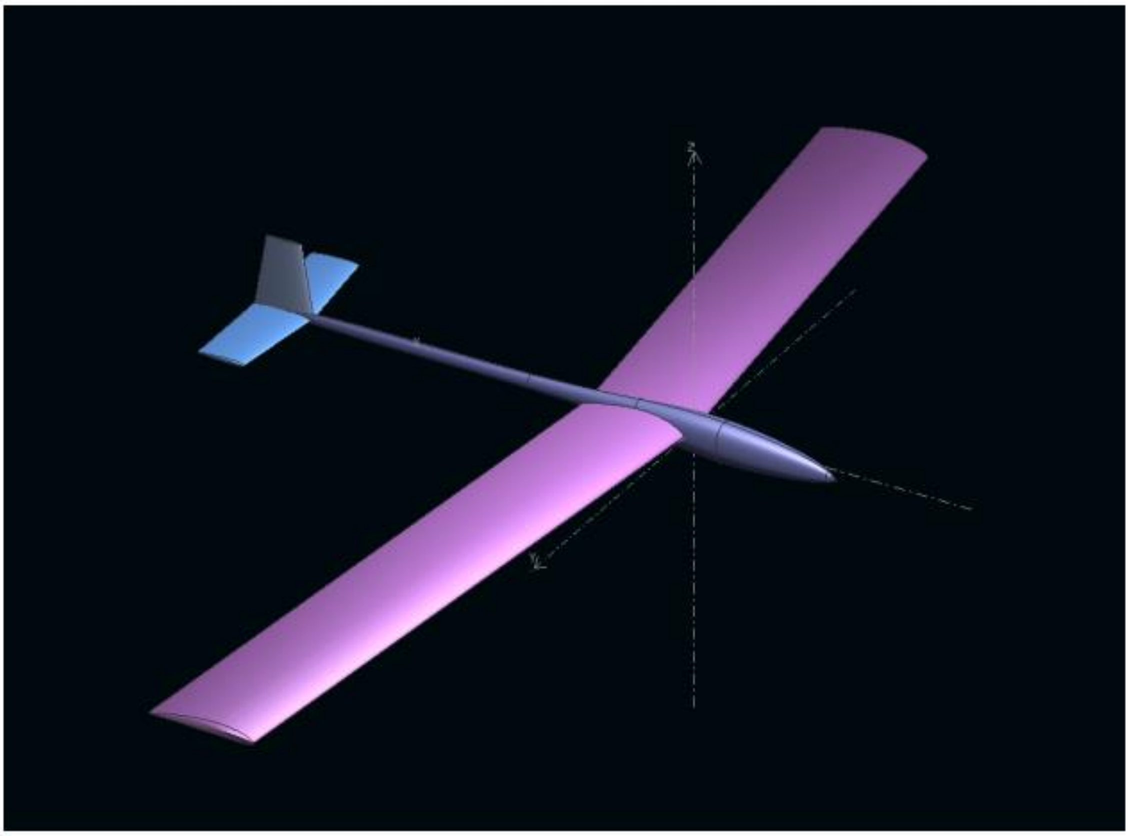


FIG 1 Dihedral angle of 5 degrees

2.3Analysis:

We start the stability analysis by defining an analysis to our specified wing. We use the Type 5 (Beta range) Polar, as we are only concerned with the lateral and directional stability of the airplane. We take the free stream velocity (constant) at V=60m/s, Kinematic viscosity=1.5e-05m2/s and density= 1.225kg/m3. We perform the Ring Vortex (VLM2) Analysis method as it is most suitable for stability analysis. As we are only considering the aerodynamic implications on our airplane, we shall not consider the wing loading criteria. We run iterations for both the anhedral and dihedral, at 5 degrees and 10 degrees.

3 RESULTS AND DISCUSSIONS:

The below given figures show the anhedral and dihedral angles on the wing planform:

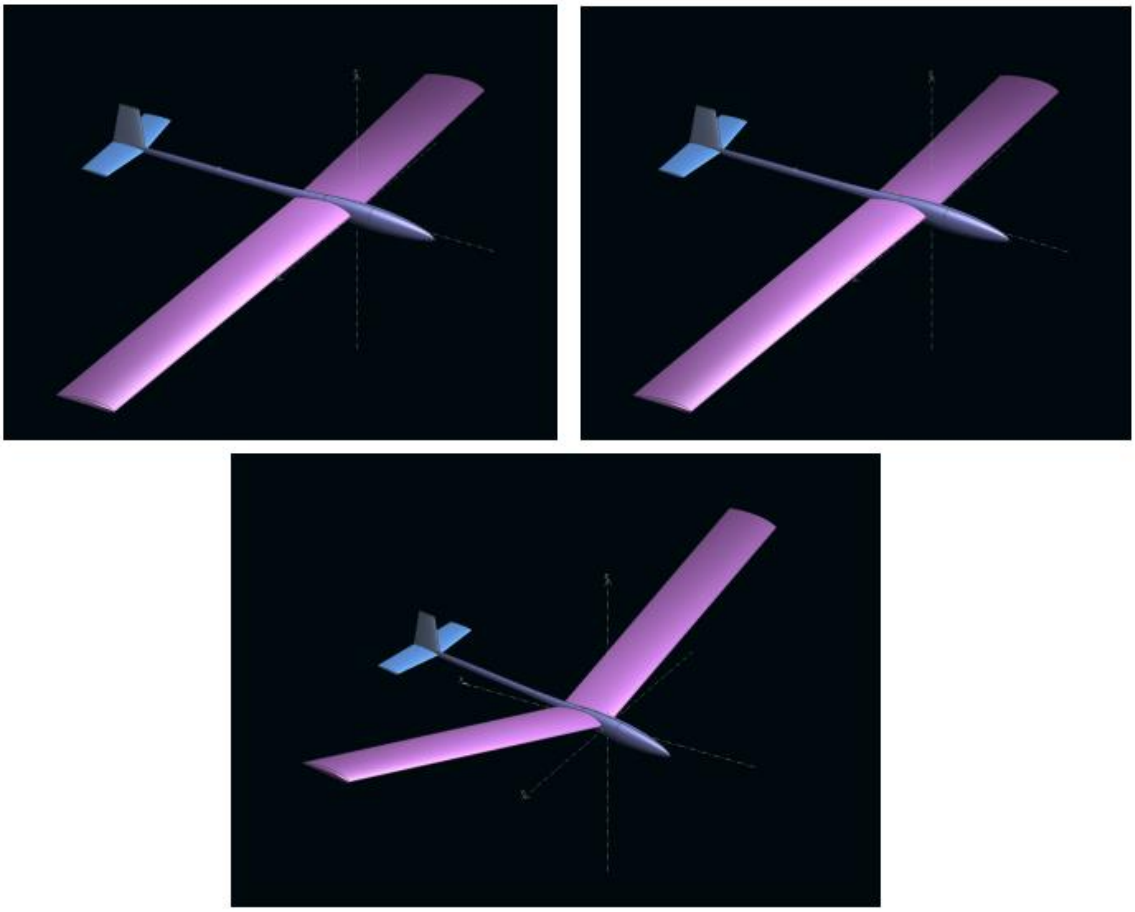
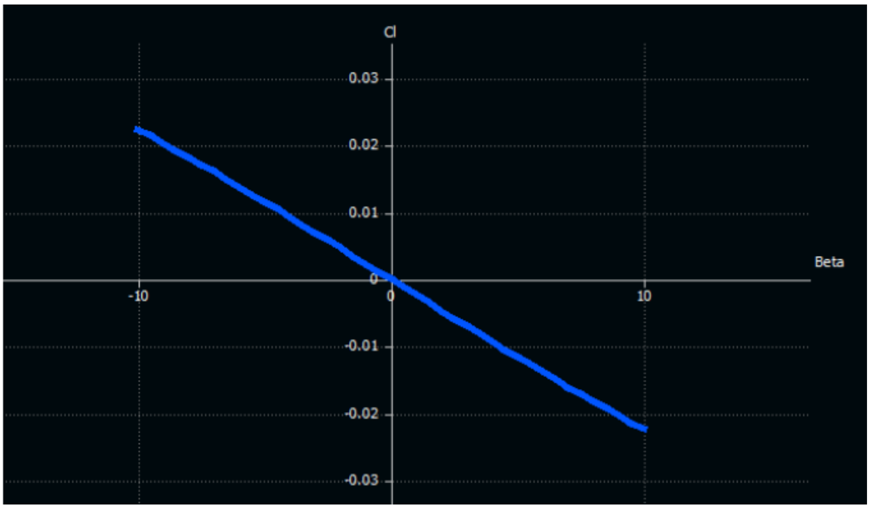
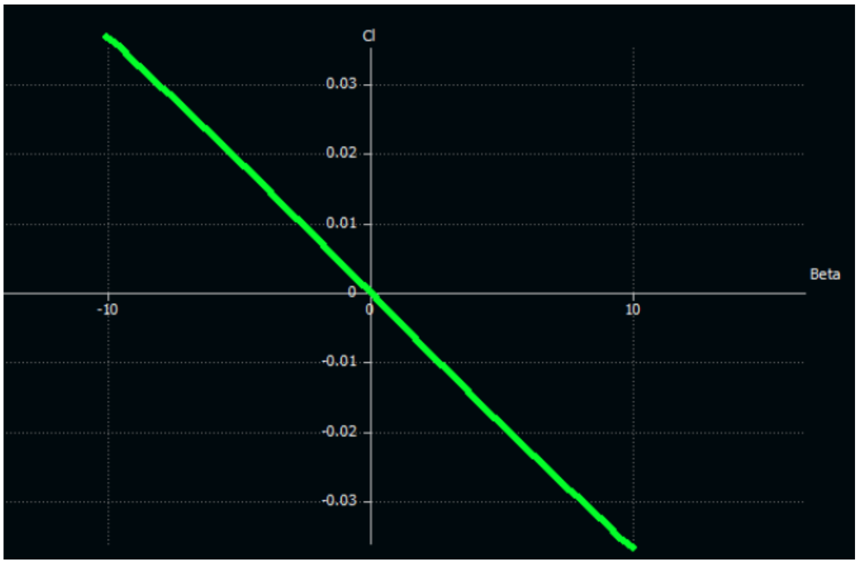


Fig 1 Describes the design made using XFLR5, with different dihedral angles

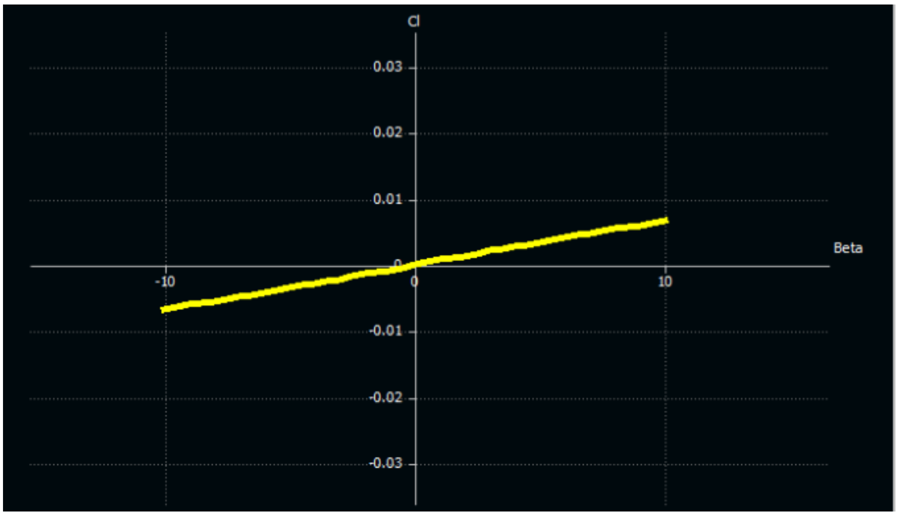
The following graphs are obtained after the analysis was completed: Cl Vs β (side slip angle) graphs:



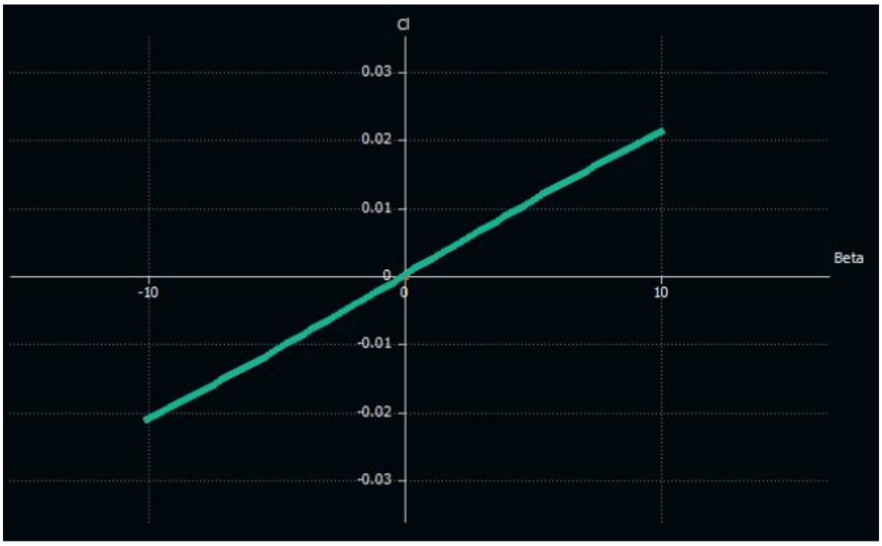
5-degree dihedral



10-degree dihedral

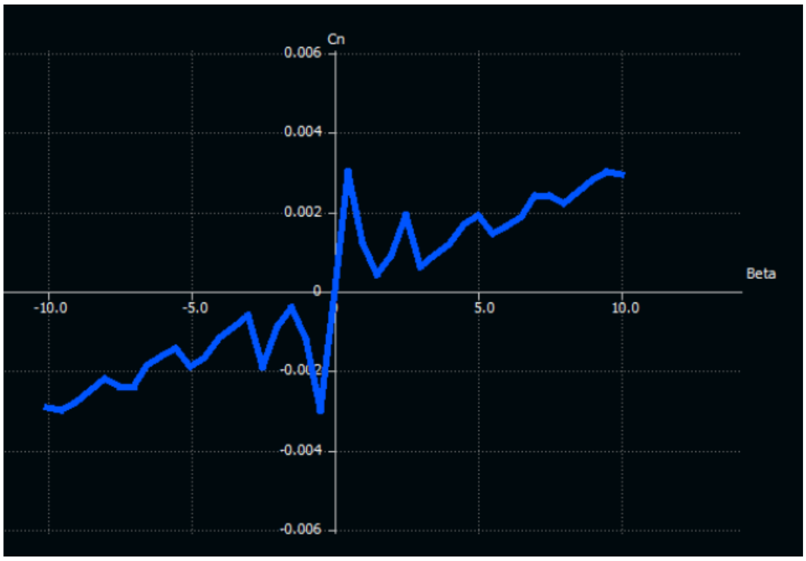


5-degree anhedral

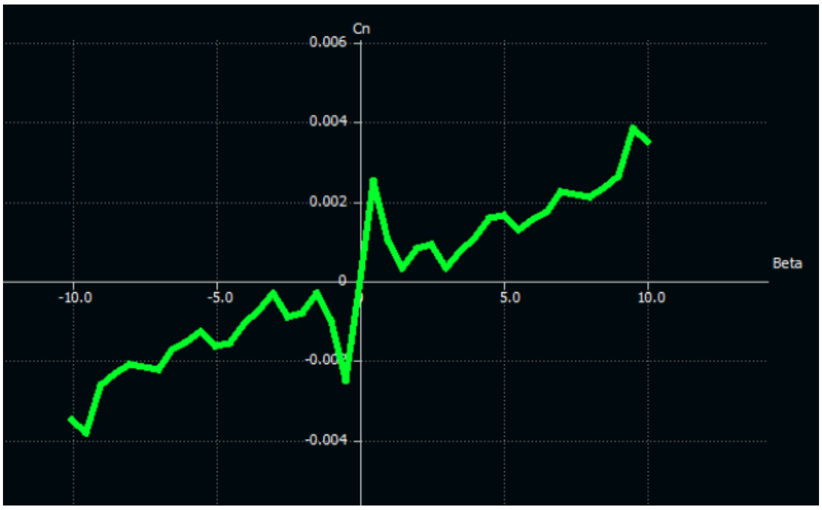


10-degree anhedral

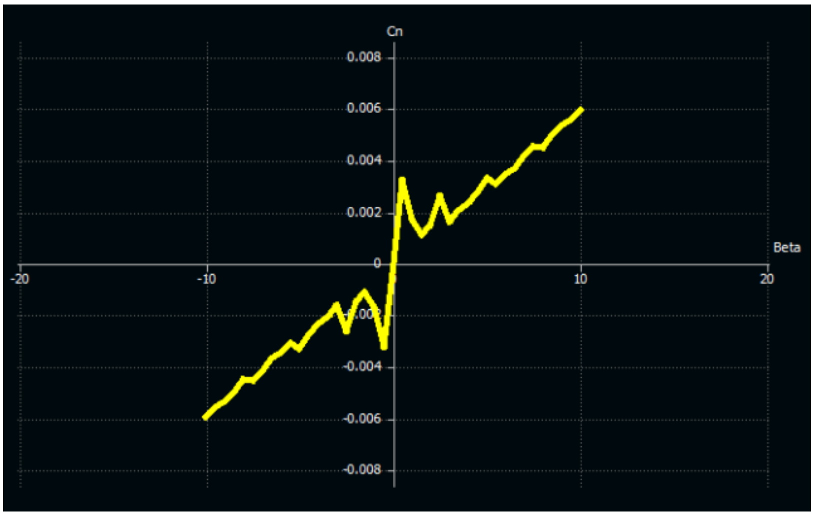
Cn Vs β (side slip angle) graphs:



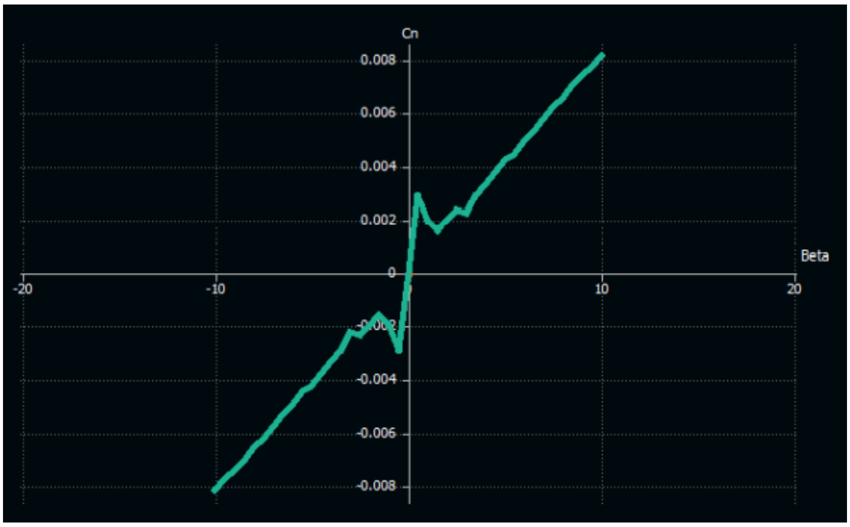
5-degree dihedral



10-degree dihedral



5-degree anhedral



10-degree anhedral

4 CONCLUSION:

- We can observe that a Dihedral has a Laterally stabilising effect on the airplane, obtaining a negative slope in the Cl Vs β graphs.
- We observe that an anhedral has a Laterally destabilising effect on the airplane, obtaining a positive slope. Hence, we can say that adding an anhedral to this wing plan form does not help with achieving lateral stability. An anhedral is mostly seen to increase roll instability and high manoeuvrability.
- An anhedral is useful for fighter airplanes where-in we require high manoeuvrability and low stability.

- We can see a positive slope being achieved in the Cn Vs β graphs for both Dihedral and anhedral, which results in Directional stability but there is also a down side to this as there are irregularities in the slope obtained. This results in the aircraft taking a lot of cycles to achieve stability, directionally. Directional Stability in this plan form will not help us achieve high manoeuvrability.
- These irregularities should be considered for further evaluation and study, to obtain methods to reduce them.

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