Introduction to Aircraft Design

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Lecture-55
Estimation of Maximum Lift Coefficient

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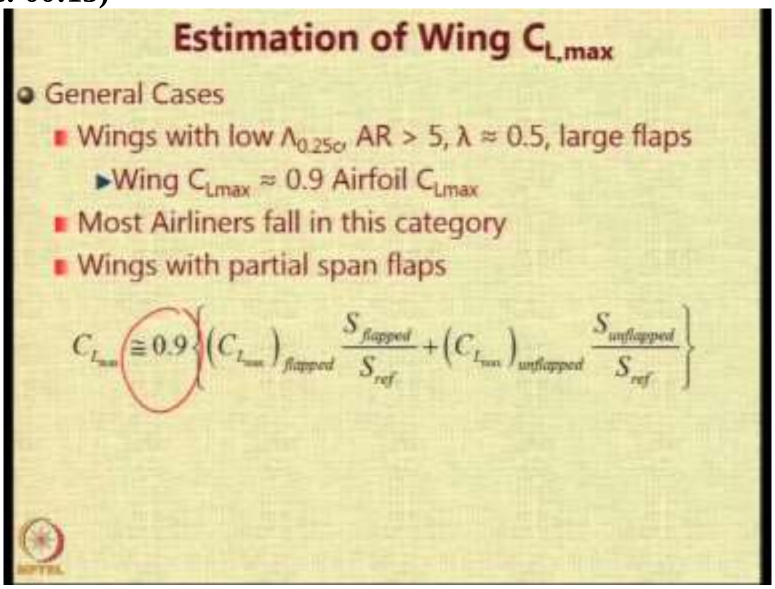

Remember we have to proceed from 2D to3D. So the information that we have seen so far is mainly for 2D. If you look at 3 dimensional effects generally what happens is that if you have low quarter chord sweep if you have reasonably high aspect ratio and if you have a taper of nearly 0.5 and large flaps then the loss because of the 3D effects is only around 10%. So therefore the wing $C_{L_{max}}$ would be approximately 0.9 of the $C_{L_{max}}$ of the aircraft.

And most airline airliners will fall in this category. So the most airliners will you can assume for most airliners that the 3D effects are only above 0.9. Now when you use partial span flaps then it is possible to use this formula assuming that 0.9 is what you will get but it this particular additional term helps you to identify the effect of flapped.

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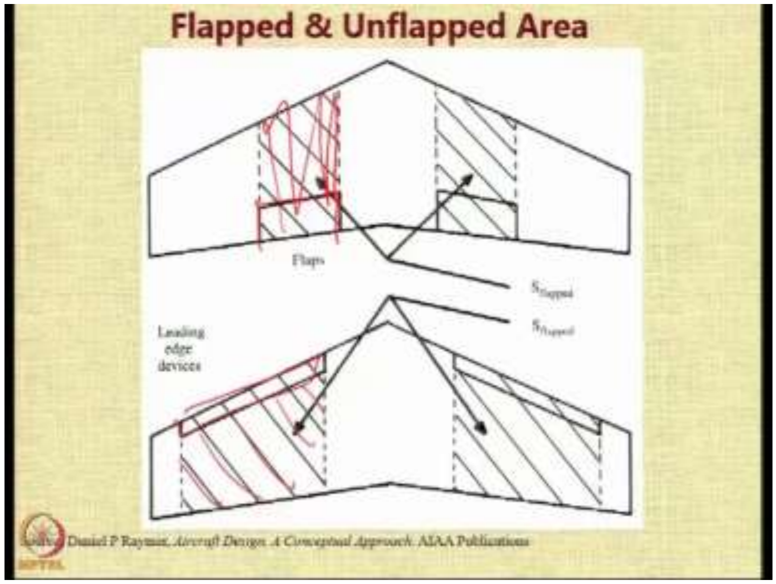

And unflapped area and just to show you that the flapped and the unflapped area are the areas which are under the influence of the flap. So if you have a trailing edge flap then the area ahead of it also becomes a part of the flapped area and if you have leading edge flaps then the area behind it also is a part of the flapped area. So you have to use these ratios and notice if you have almost full span flaps. For example suppose you have a wing where you have full span flaps then you know the ratio between the 2 is going to be almost equal to 1.

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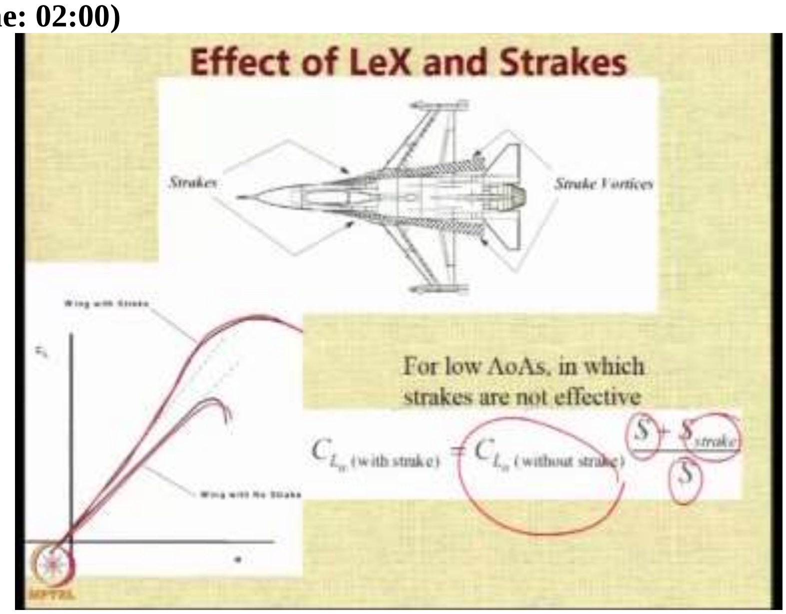

$$C_{L_\alpha \text{(with strake)}} = C_{L_\alpha \text{(without strake)}} \frac{S + S_{strake}}{S}$$

In military aircraft we sometimes see strakes mounted at the root of the fuselage of the wing near the fuselage and these strakes create a vortex so we call them as either as leading extensions or strakes and the effect of the strakes is to create an increase a nonlinear increase in the lift curve slope. So with no strikes even you have a linear curve with strakes it becomes a little bit nonlinear and it is beneficial. So the C_{L_α} with strakes can be simply estimated as the C_{L_α} without strakes that you already know multiply by the summation of the strake area and the wing reference area upon the wing reference area this formula can give you an information regarding the strakes

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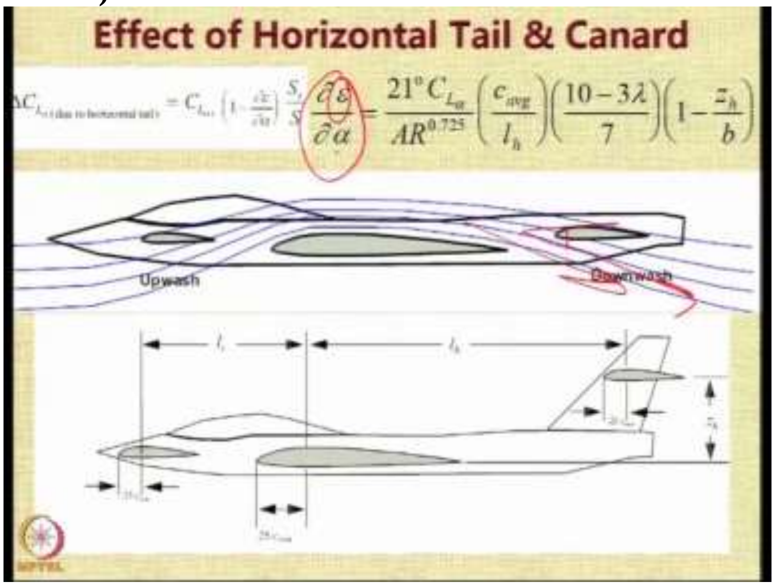

But this is only this is only applicable for low angle of attacks at which the stakes are not very effective because then we assume them to be like additional area of the wing itself. Now the presence of tail whether the horizontal tail or a canard also affects the lift that is produced. So that delta C_L because of horizontal tail is equal to

$$\Delta C_{L_{\alpha(due\ to\ horizontal\ tail)}} = C_{L_{\alpha,t}}\left(1-\frac{\partial\varepsilon}{\partial\alpha}\right)\frac{S_t}{S}$$

where $\frac{\partial\varepsilon}{\partial\alpha}$ is the effectiveness of the flap and or it is the influence.

So this is obtained using a formula which relates to the geometry of the flap this effect is created because there is always a downwash acting behind a wing. And so the angle at which the air comes onto the tail is not the freestream. But there is some kind of a downwash. And this particular downwash angle changes with the angle of attack α also.

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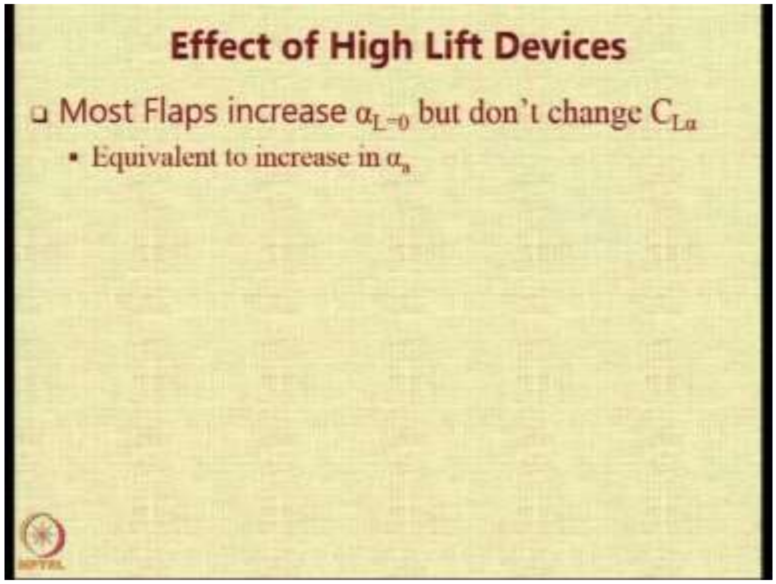

So the effect of high lift devices most flaps they increase the α at $\alpha_{L=0}$ but they do not change $\frac{dC_L}{d\alpha}$. Basically it is like an equivalent increase in the alpha that is why if you noticed the line was parallel.

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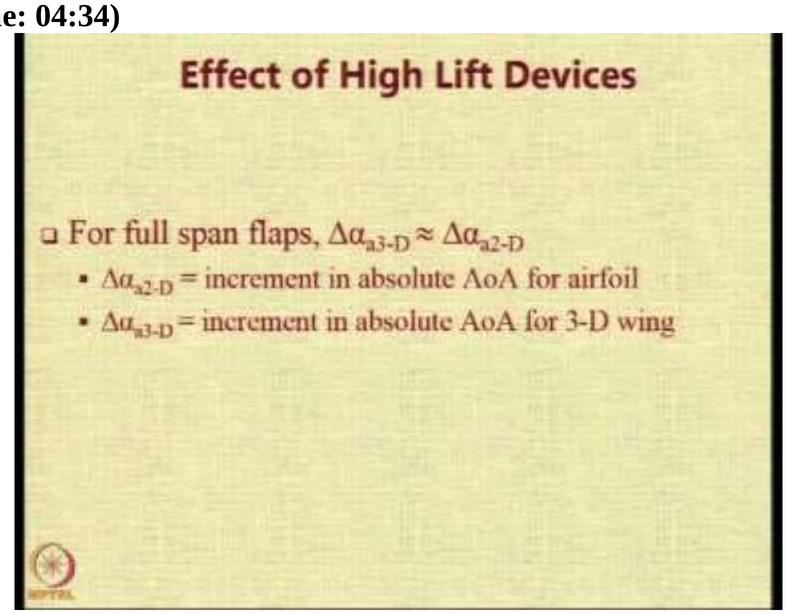

For full span flaps there is hardly any effect. So the $\Delta\alpha_{3D}$ is same as $\Delta\alpha_{2D}$.

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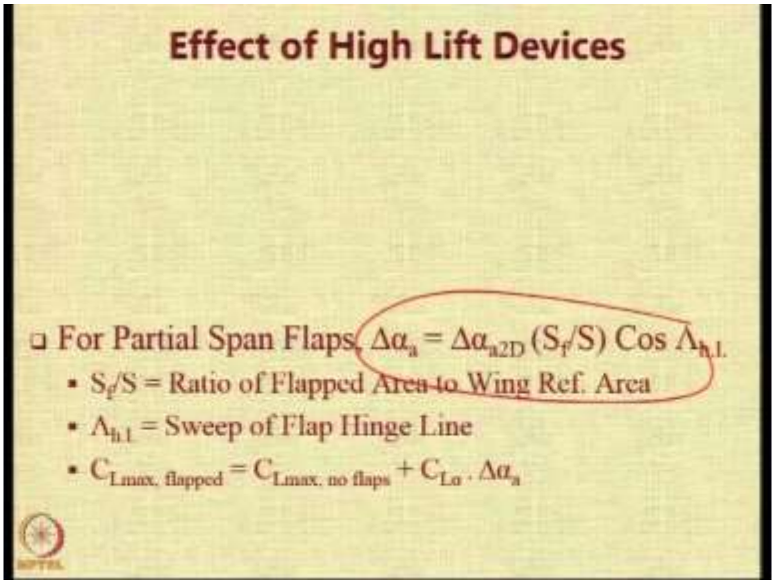

But if you have partials and flaps then you can use this formula to get the value of the delta alpha increase. And notice that.

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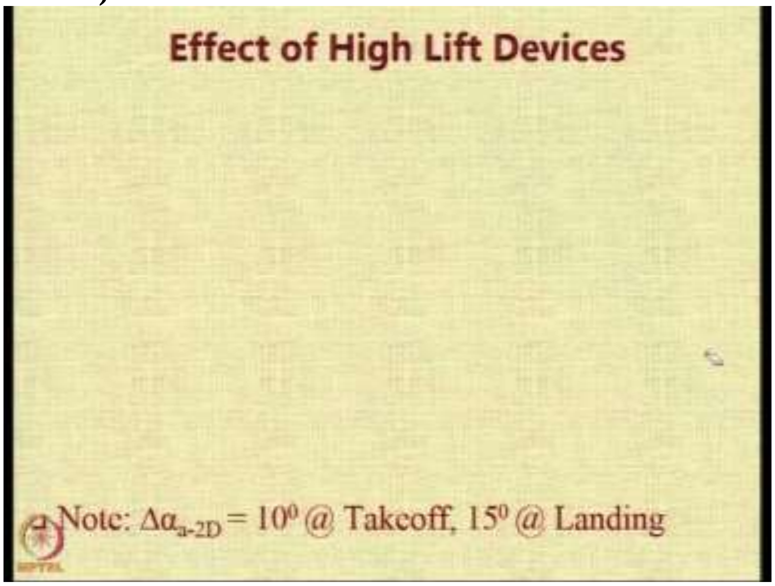

These formulae are going to help you to acquire the in information that you need for your calculations. And notice that the $\Delta\alpha_{2D}$ is 10 degree at takeoff a 15 degree at landing as we saw in the curve in the figure behind. Thanks for your attention. We will now move to the next section.