**UAV Design - Part II**
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**Lecture - 10**
**Flight Demonstration of Flat Plate**

Yeah, hello friends, we are in the aeromodelling laboratory of IIT Kanpur. So we have done enough exercises in the classroom. So let us now have some fun flying some of these models here. Yeah, so you can have a quick overview of this lab. Meanwhile, so the motive of this outing from the lecture hall is to demonstrate whether we can fly a flat plate or not, okay.

So for that, we need a planform, which is a flat plate, right. So what do we need for a flat plate? How to make a flat plate fly? So first of all, let us pick some flat surface out of styrofoam, which is easy to like, is easy for me to handle. So these are we have some of them here, right? So let me pick the biggest one. So I am keeping these two styrofoams aside. Yeah. Yes. So I can see.

You can see this is a flat plate, right. So maybe thickness is close to say around 10 mm. So let me just measure the dimensions of this. So first of all, what are you thinking about this right? So do you think that I am going to cut this and make a wing out of it? Instead of that, I would prefer I want to fly this entire planform. How many of you can imagine this entire platform planform as a wing.

Which configuration do you prefer, right? Either should I fly something like this? Should I throw it like this similar to the one that I have demonstrated in the class where I checked out a aerofoil, a wing made out of an aerofoil. But here we have a flat plate. And I think mostly it is a square, right? So let me just measure the dimensions. So I can see it is 0.9 meters cross 0.9 meters.

Yeah, I can see this. It is 0.9 cross 0.9. You can have a look at it, close to 0.9, 0.99 I am sorry, 0.99 meters not 0.9. Yeah it is 0.99 cross 0.99. So this is again 0.99 cross 0.99. Yes, we have a square here. Thank you. So I need your help. Prabijit I want you

to be here. So today is Sunday, so I do not have much of my research staff available other than Prabijit. I will trouble him a bit.

So how should I make this fly? As soon as I look at this, I immediately imagine it like a kite, right a diamond shape, a diamond wing. So can I imagine this as my wing? How many of you thought that I will turn it to this particular orientation. So I consider the diagonal, one of these diagonal as the root chord, right. And I have no tip chord here right. So it is the taper ratio is zero.

So do you remember we have solved example problem during this lectures? So in that, yeah, the root chord is about if I remember properly, yeah, the diagonal is about 0.1 meter, right. But in this case, it will be bit different. Because the sides are 0.1 meter, close to 1 meter each side. So and then the diagonal must be close to root over 2, which is 1.414 meters.

So the diagonal or the root chord is 1.414 meters. And I do not have a tip chord here. So the taper ratio is zero and it is tapered about yes, it is tapered about mid chord, is it not? At each and every location, if you take a section, right span wise section, if you measure the chord, then and if you figure out what is the mid chord of that particular span wise location.

So then you will be and if you draw a locus of it, they all lie on the opposite diagonal here right. Say this is one diagonal, which is the right which is the root chord of our configuration here. And then on the opposite diagonal, you will find all the taper axis, you will find the temper axis of this which is in fact the midpoint of the root chord, midpoint of the chords at each and every span wise location.

Now how to make this fly? You can see this is very weak. Let me add two structural members to this. So that just like what we used to make no, during your childhood, we used to make a kite, right? So I am just yeah, this is a carbon tube. I am just trying to strengthen this with this carbon tube, strengthen this planform. And I am using a masking tape for it. So one carbon tube, I will use it near the root chord.

The other one on the perpendicular diagonal. So I have used one carbon tube along the root chord. Say this is my root chord, right. So I will try to add the other carbon tube, which is here. So I am trying to add this on the other diagonal, right? So we have one diagonal, I am sorry. So we have added carbon tube along the root chord, which we considered as one diagonal.

So on the upper surface, perpendicular to it, I am adding this other carbon tube, right. So while adding this Prabijit, you try to press this surface up, right. Otherwise, because or you can do this way. Yeah. So first let me complete with this portion and then we can, okay. Yeah, so I think this is good enough. Or do you want me to add some more here? So let me add a small tube.

Yeah, so we just finished adding these two tubes. So one on the bottom side of this planform. The other one on the top side, right on the top surface. So now, so it is not so weak know compared to what we had earlier. It is not so weak. Yes, right. So assume that this is my root chord. So this is how I want this if I attach a motor to this, right, one brushless motor along with a battery, I expect this to fly.

But in the first place, will it fly? So what is the weight of this particular? Yeah, so let me just figure out what is the weight of this planform along with this tubes, which is about 345 grams, right. This is close to 345 grams. So this one. And now as you know so this is almost a constant thickness flat plate and we have a homogeneous carbon tubes right two carbon tubes added almost symmetrically distributed about this plane of symmetry, right.

Let us assume, let us assume this tube is my plane of symmetry. So the other tube is also almost symmetrically distributed, right. The mass of the tube as well as the geometry. So I can safely assume that the C.G must be acting at the centroid of this. Am I correct or not, which is say 0.7 meters along the diagonal or say 0.5, 0.5; 0.5, 0.5 meters right.

If we consider this as the origin of this coordinate frame. So I say 0.5, 0.5 will be this particular point, which is a intersection of this point of intersection of diagonals. So this current C.G is at this particular location. And we know the mean aerodynamic

chord is will be somewhere along the span wise location. And it is also tapered about its mid chord, is it not?

Mid chord of the mean aerodynamic chord. Midpoint of the mean aerodynamic chord. Now when you project that you will be able to figure out what is the corresponding aerodynamic center. Am I correct or not? So two third of root chord, so two third of root chord is how much? So we have 1 meter side and 1 meter side. This must be 1.4 meters. Two third of this 1.4 meters will be approximately 0.9 yeah 0.94.

Yeah, so this is approximately 0.94. C bar will be 0.94. Am I correct or not? So somewhere here, whose length is 0.94 will be the corresponding C bar. So if I project that, so from with respect to root chord yeah so with respect to root chord I know C by 2 C R by 2 minus C bar by 2, right. That will be the distance between leading edge, leading edge of the root chord, and the leading edge of the mean aerodynamic chord plus C bar by 4, right.

So that turns out to be approximately 0.47 meters, right. So which is this particular line. This is my location of aerodynamic center, right? So for a wing alone configuration, if it has to be stable, my C.G should be ahead of the aerodynamic center, is it not here? Aerodynamic center of the wing. I know what is the location of my aerodynamic center, which is about 0.47 meters.

Now I have to shift this C.G the current C.G which is at 0.7 to ahead of aerodynamic center, let us say. Now further what should I do? I need to add some weight here, right? So let me just add some weight. Can you help me Prabijit? So what I did right now just added a 200 grams weight right near to the leading edge of this root chord.

So by doing that, what I am what I achieve is a new C.G location, which is ahead of the aerodynamic center here. So can you notice this? I am able to balance this model about this particular location, right. So I just know I just calculated what should be the weight of the what you call what should be the weight that I need to add so that I can shift the C.G location, say 3 centimeters 4 centimeters ahead of the neutral point.

And I know I fixed the location of the weight that I want to add, right. So I fixed it, the total weight should be at or the weight of this object is acting at about 25 mm from the leading edge here, right. So from there, I was able to figure out and now the current C.G is at this particular location. And this is my aerodynamic center. If you want I can locate this. Do you have a marker here?

So say this is my aerodynamic center, right? So the current C.G is close to this point, okay? So good enough. This is ahead of the aerodynamic center. We will talk about this how much know what should be a typical offset between this aerodynamic center and the center of gravity. That we will talk in the coming lectures. But for the time being let us see, whatever we have derived will it work for any configuration or not?

Or say will it work for a flat plate or not? That is what we are going to do right now. So the current C.G location is at this particular point. Now let us go out and try to check this out and see whether this will fly or not. Right? And then once we have a flight, then we will also remove the weight and we will also check this out and we will see what is its behavior.

Okay, so we are on the tarmac, and I am on a chair on the tarmac of flight laboratory. So you can see we have our classroom is located inside the flight laboratory. So it is a hangar of our flight laboratory. We have multiple powered aircraft as well as powered gliders. So yeah, that is where our runway is located and this is the way for that runway.

Right now you may not be able to see. Yeah, so let us go ahead with our demonstration. So this is a flat plate again. So we have our A.C somewhere close to this and we have now shifted the C.G location by adding a weight to the desired point. Or say ahead of the aerodynamic center here for this wing alone configuration. Now let us see whether it will be able to glide or not, right?

So if at all it glides, that means yeah, so whatever we did is correct, right. So whatever we have derived in our lecture hall is correct. So let me throw it. So Kazi please try to catch this. Okay, so our second TA, Salauddin Kazi. So he is here to help us. So I will

try to throw this and see whether it is it will be able to glide or not, right. Wow, is it not? Is it not good? Yeah.

So I will try to throw it at the minimum possible angle. Wow! So let me do it one more time. So Kazi, now do not try to catch this. Let us see how far it can glide, right? Okay? Am I throwing it properly? Or you want me to decrease the angle? Wow! Right? So one more time. So do you accept it, it is able to glide because of the C.G location? Do you accept it or not? Okay.

So let me do it again. Yeah. Okay? Fine. Now let us see what happens when we remove this weight, right? So let us see what happens when we remove this weight, additional weight. So right now I have removed that additional. So I am not I am sure that it is not going to, like travel till the grass. I do not want to damage this. So I will try to stand here, okay.

So Kazi then you can, yeah, here itself. Yeah, there. So now the C.G again shifted back to the centroid of this, right? Let us see. I have not done anything, right? So I have not, I did not like try anything new. So see, I am trying to cautiously throw it with the same angle what I tried earlier, with an added weight. So you better move out, right. Okay?

So see this. So, now it is not happening. So we have to maintain C.G ahead of the aerodynamic center. Okay? So let me do it one more time. You may not believe this, right. So let me also put the angle a bit more down, right. I am trying to throw it down. See, whatever I do, it is just flipping, right? It is in an unstable mode right now.

So since yeah, now you can, you will be in a better state to appreciate the location of the center of gravity with respect to aerodynamics center for wing alone configuration, right. So let us now can you see this ATC, air traffic control tower here? Can you see the tower? So I would like to climb it up and then throw it from there. Let us see what happens.

So I am now adding the weight and then bringing again the C.G to the same location what we did earlier, bringing C.G ahead of the aerodynamic center. I am throwing this

again. As you know this is a low aspect ratio wing, b square by s is almost close to 2. So we cannot expect much glide ratio with this configuration.