Lighter-Than-Air Systems
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Lecture - 69
Types of Mooring Masts and Design Requirements

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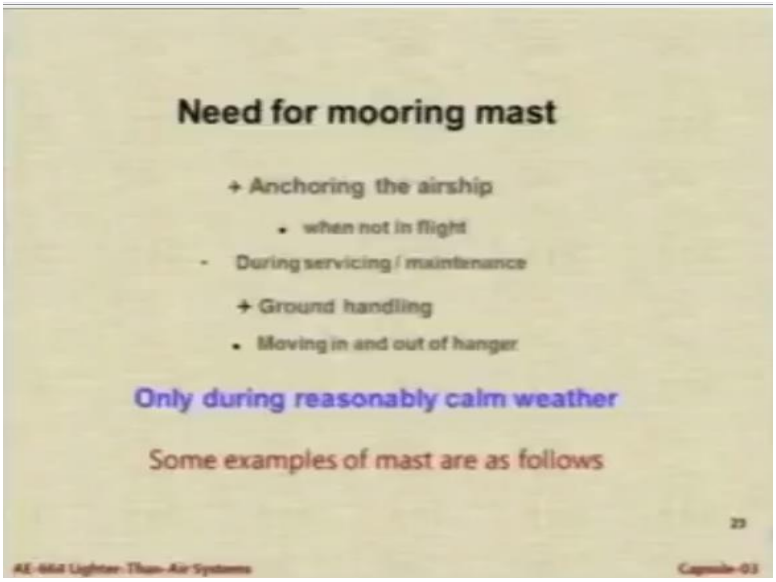

This already we have seen what are the need for mooring mast.

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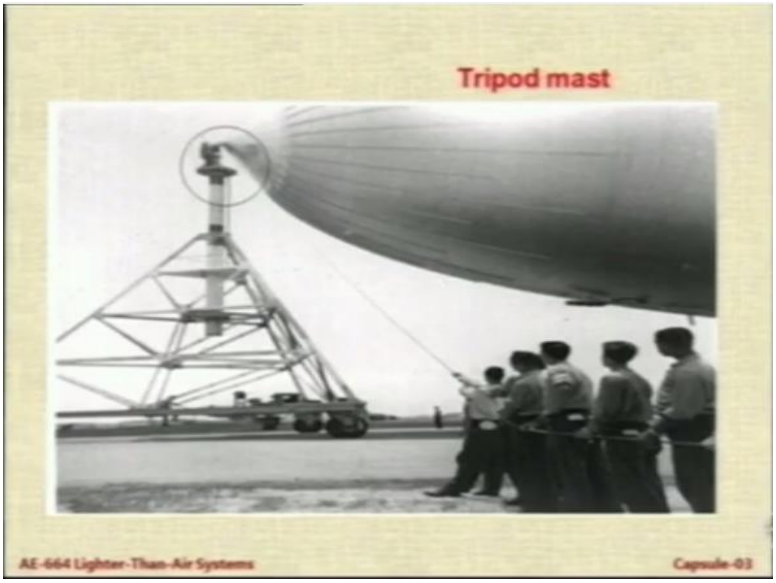

I want you to look at various types of mooring masts. For example, this is the tripod mast. A large tripod mast which is nothing but like a camera tripod. In this case we have wheels so that

we can move it around. This tripod mechanism gives it strength and stability. So, it can withstand the jerks and the loads.

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You also have something called as a guyed mast which is a central member which has got then these ropes that can be attached to the ground just like you have a tent pole. You have a main pole and then you have the ropes which will be attached to the ground. So, a guyed mast is normally used for medium. This is a medium airship. This is an airship called A 60 which can carry I think 5 passengers.

So, a version of this airship called as A 60 plus had come to India to take part in the aerial flight during the finals of the first IPL tournament. Unfortunately, it did not get a place to fly. So, it did not actually happen. But it did come to Mumbai. It came to Juhu Airport and we were there to receive it and to see it and to talk to the people who are working in that airship. So, they have this guyed mast.

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And then we have this exped mast which is a truss type structure. A truss type structure which also is then attached to the ground. This is also one more type of mast structure which is used for attaching the airships. And also what you see in the front of the airship is some kind of a disc where which the mast is attached and then you see these members. So what do you call them?

These members, these are called as nose battens. There was a question in the mid semester paper about nose battens, their purpose. We will study about them a little bit more today.

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And then we have these modern vehicle mounted telescopic masts. So on your left you see the blue colored truck. It is a hydraulic mast and it can actually fold and go on the truck. The truck can move with the mast in the unfolded condition. So, the idea is that if you launch it from a

place let us say from A to a place B, by the time the airship reaches the place B the ground system can reach much faster quiet possible.

Sometimes not possible in which case you have to put something at B before the airship goes. But for short distance locations when they have these demo flights, etc. for example let us say there is a flight from Mumbai to Nasik. Now, the airship will reach very quickly because it is a very short distance, but suppose the airship is going to fly in Mumbai for half an hour, one hour, and then go to some other place, hover and then go to Nasik in between the mast truck can proceed to Nasik and wait till the airship arrives.

Remember also that subject to weather and subject to the weather conditions you might not be able to land at the place that you want to. You may have to move a little bit here and there. So, it has to be something which can be taken to a ground and it can be used there.

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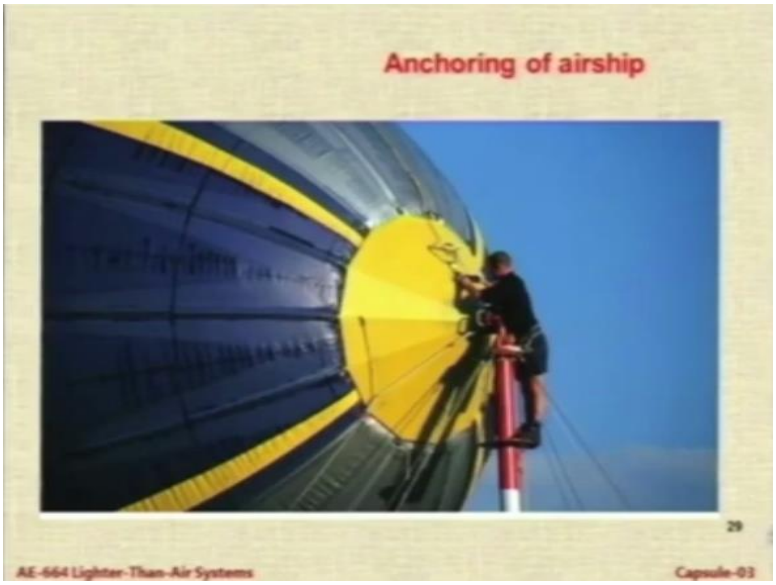

This is how on guyed mast the airship is anchored. Even today there is the mast man one particular position who basically receives the airship and attaches it to the to the mast. Now, we have done some work in our laboratory on mooring masts with the help of students like you mostly undergraduate students. So, mast have been made, designed and fabricated both for indoor air ships as well as outdoor air ships. So, now I want to showcase some of the work that we have done.

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These are the design requirements that were given to a group of students for the design of the mast for outdoor remotely controlled airships. So, from the point of view of portability, we said that the total weight should be below 50 kilograms. And then it should not take too much time for people to assemble it on the field. So half a minutes, so one man hour. So two people for half an hour for work on it and be able to erect it on the site.

And normally we expect an airship to be not higher than 6 feet at the center of the nose and not below 4 feet if it is outdoor airship. So we give these kinds of the requirements. We wanted the mast to allow a pitch freedom of plus minus 20 degrees. So the airship should be able to have 20 degrees plus and minus nose rotation, but complete yaw rotation so that airship can go around any direction the wind is blowing.

A roll freedom was kept optional to the team because normally you do not expect airships to be rolled except when let us say you discover there is a problem or let us say a small hole in the bottom side. So rather than going below and touching it up, you might say okay roll it 5 degrees, bring the patch this side so we can patch it. Thess kind of rare cases are there, otherwise we do not need roll freedom.

Moreover, the airships are extremely stable in roll because of what is called as pendulum stability. The bottom of the airship has got this gondola which is very heavy that is the heaviest part of the whole structure. So, if it moves this way, it comes automatically by gravity, it may exceed and then oscillate and then stop. So there is no problem in roll stability. Then there was a need to use this also as a drag mooring device.

So we thought if there were airship which is moored to a mast and it is completely free. If there is a way of calculating or observing the force acting on it, it will be great to validate our drag estimation because we can measure the wind velocity and you can read the force acting and then you can say the drag is so much, what did you estimate? So it is a very good way of getting experimental data.

Secondly, when the drag exceeds a particular limit that means the forces acting are very large and now there is a chance that either the mast will be dragged because or it will topple or there can be a situation of break away. So my idea was I wanted to have an alarm and that is inside this particular mast. So if the drag force exceeds a particular safe number, I wanted some kind of oral alarm so that you can quickly go and bring the airship to a safe place.

You are deploying the airship in the Gymkhana ground and you are doing some work. You do not know how much load is acting. The alarm will alert you and you can run and then bring it into a safe area in case it exceeds. Secondly, we worked in many institutions to do our flight demonstrations and invariably when you carry an airship component with you, you have remote controller, you have servo motors, you have batteries.

These cannot be sent by air because there are restrictions. So, our team from the point of view of economics of transportation as well as the restriction has to travel by train or by bus. So, our constraint was that this box which carries this mast should fit below a typical second AC, third AC train compartment. So, understand these requirements have come by a dedicated dialogue with the user.

I always teach students that when you do design, the first thing you do is requirements capture. The first thing you do is understand what the customer wants. So, we did an exercise during this design of requirements capture and we came up with these requirements. So that there is a clear indication with the design team on exactly what the customer needs. So based on these requirements, the mast was designed.

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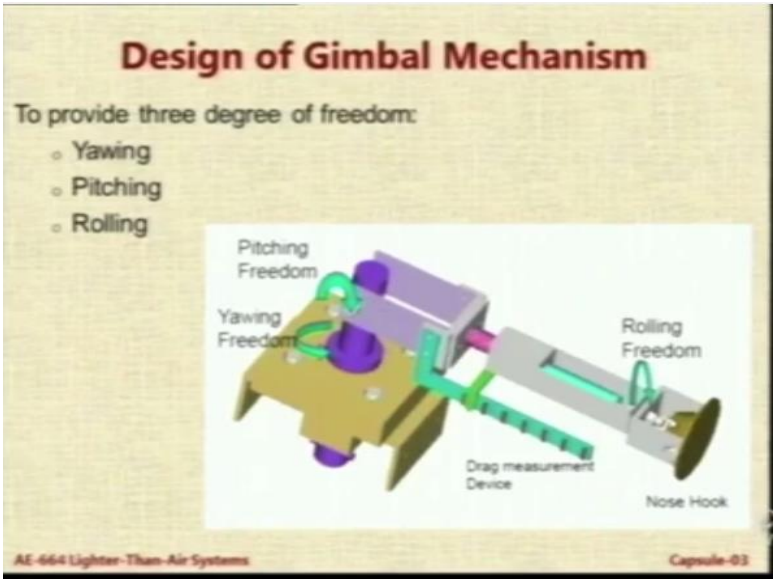

So here is a pictorial indication of the kinds of freedoms that we are expecting on the airship. And this is a closer view of the Gimbal mechanism. They were designed by one student. His name is Sagar Kale. He did this work in the year 2005 if I am not wrong where he said that we can have a system on the top of the mast which will have a facility for rolling freedom. As you can see by this particular system, this cap.

This nose hook attaches on the airship nose and then there is a spring mounted system which would be pulled as the drag force acts onto the airship. The airship is behind the nose hook towards the right side. And by mounting it carefully, you are able to provide the yawing freedom and the pitching freedom. So this was the design that was suggested.

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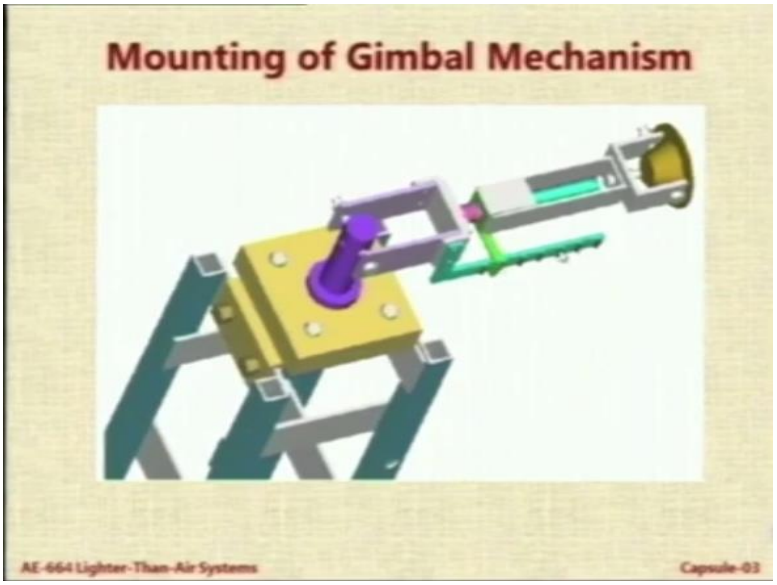

This is another view of that. So his design was to go for a structure consisting of an assembly of 4 rectangular channels which are commercially available in the market joining them by either welding or by bolting and creating this system. And then there was an indicator here which gave indication of the force acting which could be calibrated. And the idea was that when this is going to touch some number, there will be a contact and the alarm will go off.

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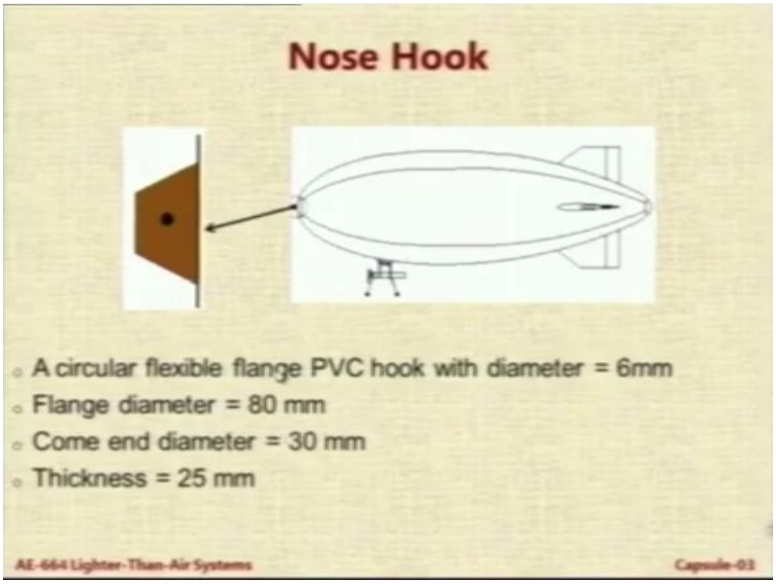

Now, nose hook is very important because you need to have some kind of a contact between the flexible envelope and the rigid mast. So, there are many schemes possible as we will see. In this particular scheme, this airship was just under 5 meters long, it is around 15 feet in length. So, for this particular airship and we were very critical here about the weight because it did not have too much of spare lifting capacity.

So, we could not afford to put a nose bearing structure in this airship. So, what we thought is that we will integrate one small circular flange of a PVC material. So it is a flexible material and this particular thing is solid PVC and on that we drilled a hole vertical hole. So with that vertical hole, you can pass a bolt and then the both will become the link between the airship and the length of the bolt was decided based on the expected load which would come in this particular system.

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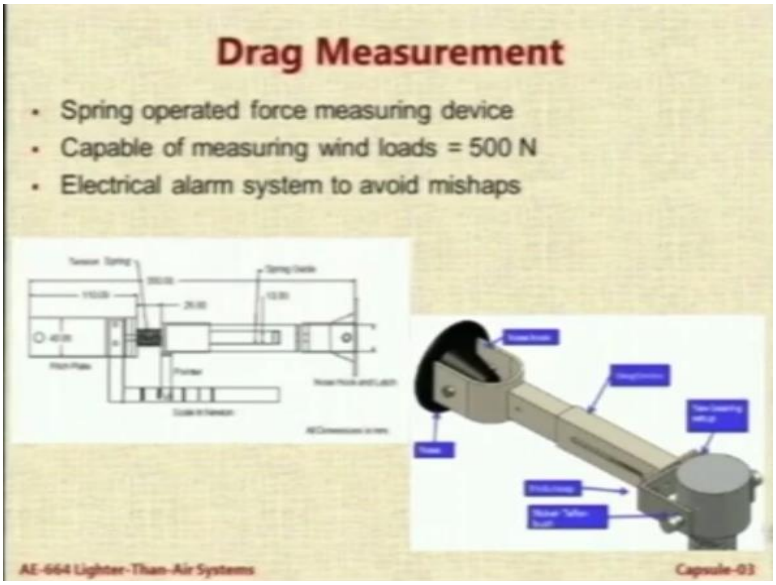

And then the system that was actually fabricated for drag measurement was much simpler than what was given in the previous. This is the improved design. In this improved design, you can see that there is a small enclosed drag measuring device.

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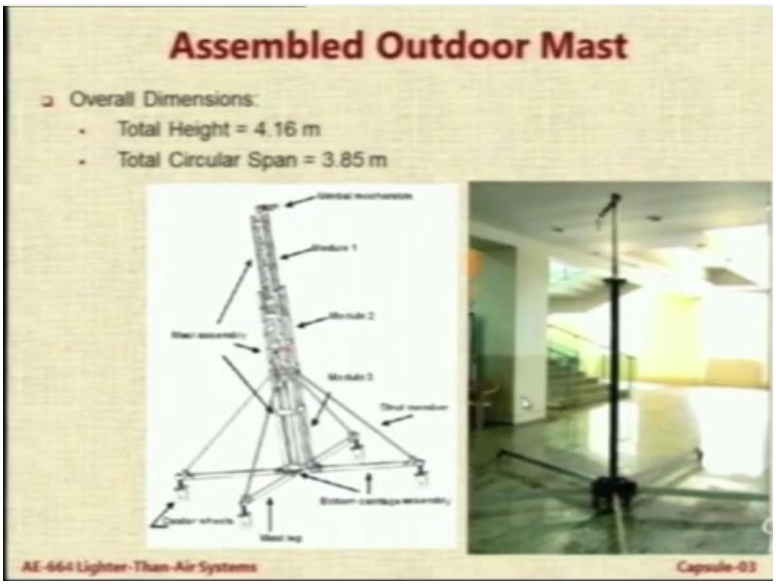

And this is the CAD model of the design which was planned to be fabricated and on the right hand side is the simplified design. So, when we attempted to fabricate this three module design, there is a paper based on this particular design. I will share the paper on Moodle page you will get to know how it was designed. So, it looked okay on computer and it looked okay on paper, but when we actually began fabricating it was found to be too complicated and too heavy.

So, we replaced that by a simple telescopic mast and this telescopic mast had basically a screw type of system. So, there is a small spanner. This is the VMCC Foyer in which this particular

mast was demonstrated. And on the top we have this drag measuring device attached on the top. Now, this particular design has further been improved by another student.

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Now here are the requirements for the indoor remotely controlled airships. These airships are intended to be demonstrated in small auditoria in schools and colleges in an indoor environment. In many cases, we only want them to be showcased, not necessarily flown but just kept for demonstration. So, here the constraint is the weight was to be less than 10 kilograms and assembly should be much faster.

Adjustability was also kept in mind. The expected sizes are the indoor airships. And for this we wanted to have a small suitcase as our transportation box. So, I forgot to mention that this particular work was done over 6 months by a research intern who came funded by IRCC. As you might know, we have a IRCC Research Internship Scheme in which students of final year undergraduate program can spend up to 6 months in IIT, work on a project and that is funded by the institute.

The intern gets rupees 10,000 per month as stipend and there is an additional money available in the project for fabrication and components, etc. So, under that scheme a student from Hyderabad came and designed and fabricated this mast. Subsequently he has gone for higher studies at a university in the Middle East. Now, this is a requirement for the indoor airship.

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And on the left you have the CAD model. On the right you have the actual fabricated structure of the indoor mast. This mast was designed by a student named Utsav Bhardwaj, who was basically a KVPY scholar, KVPY stands for Kishore Vaigyanik Protsahan Yojana, Government of India, DST sponsored scheme in which if someone has a nice innovative idea, they can get support as well as opportunity to work with some faculty members in IITs and IISc.

So this student came to me as KVPY summer intern. He was at that time in his second year of B. Tech mechanical and he designed this mast. Subsequently came again for another 2 months summer internship during which he fabricated this mast. And this mast is now used by us for demonstrating small airship wherever we go, whether you might remember we had one video. I will show you that.

I will show you a small demonstration which was done by us during festival. We had a visit by the then director general of DRDO Dr. V. K. Saraswath. So, to him one small airship was demonstrated. And this airship was attached to the mast which I showed you.

This is an airship that was designed and fabricated by a student of this department called Sayyam Mulay, this was his dual degree project. So, as part of his DDP, he has designed and fabricated this particular airship which is being flown in the VMCC foyer.

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It does not show the mast. So, there you can see the airship fin being installed. So, during that time we are not worried about the airship because there is this mast to which we have this attachment. So, this is the purpose of this particular mast. This student by the way is now pursuing Masters in IIT Madras. He is an M. Tech student now, MS by research in IIT, Madras.