Transportation Engineering - II
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Lecture - 29
Aircraft Controls, Airport Site and Size selection

Dear students, today we are starting with another lecture in the lecture series on course materials of Transportation Engineering – II. In today's lecture we will be discussing about the various types of aircraft controls which are used when the aircraft is in motion that is in air and at the same time we will also be discussing about the various factors which contribute towards the selection of site of an airport as well as the size of an airport. In the previous lectures we have already discussed about the development of the airport engineering or the development of the aircrafts and then we have also looked at that thing in the perspective of world as well as in India, the various organizations which are playing a role in the control of navigation facilities, the classification of various airports and likewise. We have also seen about the various characteristics of aircrafts and how they create an effect in the design parameters of any airport.

Starting in this lecture, this lecture has been outlined in the, this particular form.

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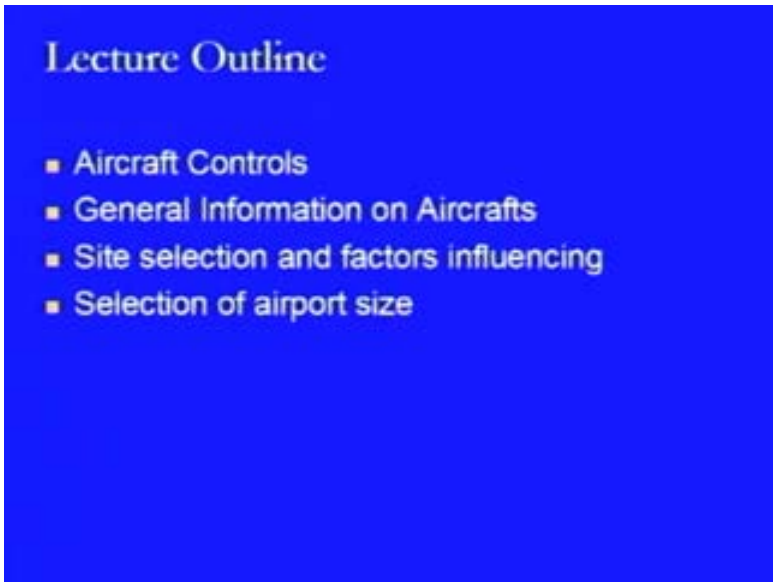

That is first of all we will be discussing about aircraft controls, then we will be discussing the general information on aircrafts. Then, site selection and the factors influencing the site selection and selection of airport size.

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We start with the various forces which are acting on the aircrafts and in this category what we found is that the various forces which can act on any of the aircraft can be shown in the form as been depicted in this diagram. Here what we can see is that there is an aircraft which is being shown along with all its accessories which helps in controlling its path as well as its flight in the air. Here, this is what we have discussed previously is a fuselage with a nose on this side and a tail on this side and two wings on either side. The engines are placed on the wings, as we have discussed previously that that is a symmetrical orientation of the engines and then there is a tail. At the tail we have again the small wings with the wind in the vertical direction.

So, in this case we can have three axis which can be there like this is a longitudinal axis of this aircraft can be termed as an x-axis. Then, there is another axis which goes along these wings. That is if we take up an intersection of these wings or along these wings and that is the y-axis and there is a third axis which goes perpendicular to these two axis that is x and y-axis in this direction and this is termed as z-axis.

Now, in this particular diagram some forces have been shown. The weight which is always acting in the downward direction, through the CG of any aircraft, so if we assume that the CG is somewhere here, then the weight will be acting vertically downwards like this. Then there is another force which is acting in this direction, which is basically a propulsive force being generated due to the thrust generated at the back if it is a jet engine or otherwise, if it is a propeller engine then it is taking, sucking the air on this side and it is pushing the aircraft in the forward direction. So, that way there is a thrust with which this aircraft keeps on moving in the forward direction. So, this is acting in the x-axis direction, longitudinally in the forward direction.

Similarly, at times there is another force which will be acting along this longitudinal axis, but in the opposite direction of the movement of the aircraft and that force is known as drag and this drag force is useful in controlling the velocities of the aircraft especially at the time when the aircraft is landing on any airport. Similarly, with respect to the weight there is a counter measure which acts again from the CG, but in the vertically upward direction that is opposite to the weight in this case and that force is known as lift.

This lift is basically a mechanical force which is generated because of the movement of this solid body into a medium and is totally related with the hydrodynamic conditions of the solid itself as well as of the medium and this lift is essential, so as to bring the aircraft into the air at the time when it is taking a speed during takeoff. So, at that point of a time lift becomes very important and with the help of this lift, the aircraft keeps on moving in the upward direction and then, as soon as the lift as well as the weight becomes equal, then it takes a horizontal path and starts moving in the horizontal alignment condition. So, these are some of the forces which act principally on any of the aircraft and on the basis of these forces, we have to look at that what are the things which needs to be provided, so that there is a smooth movement of the aircraft in the air medium.

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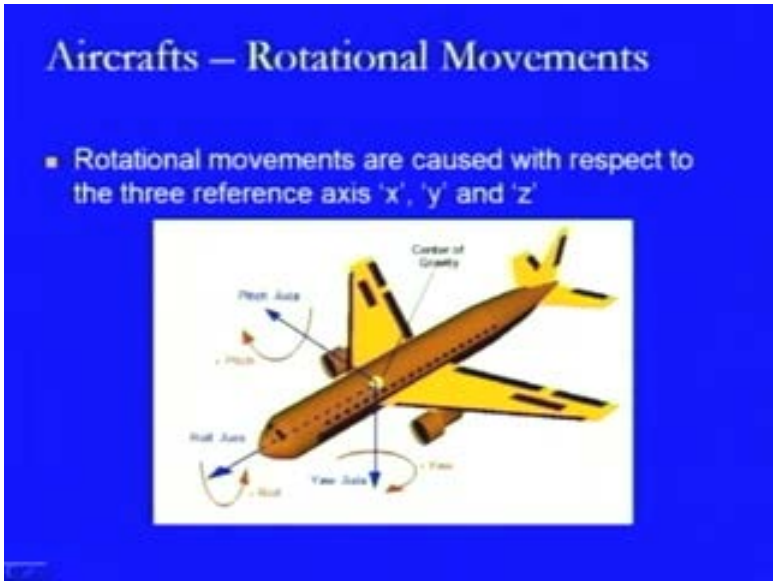

Now, in this case, what we can see is that there can be different type of movements which can take place, because as we have discussed there are three reference axis – x-axis, y-axis and z-axis. With respect to all these three axes there can be the movements. Now, what type of movements can be there that we can also see in this diagram. This is a diagram which is trying to depict all the axes as being noted. That is this is the x-axis, then this is a y-axis and then this is z-axis and then, there is a center of gravity of this aircraft somewhere here. So, all the axes are coming out of this particular point.

Now, with respect to these axes, there can be different type of movements of this aircraft. If you look at the longitudinal axis, then with respect to this longitudinal axis which is moving like this, the aircraft can take a movement like this or it can take a movement like this. So, it may be a clockwise or it may be an anticlockwise condition movement which can take place here. Now, when this type of movement is being taken by an aircraft then this type, this movement is known as the rolling movement means the aircraft is rolling with respect to this line. So, it can take circular motion like this which you must have seen at the time when, whenever there is an air show and we found that there are some aircrafts which comes down like rolling and we feel that there is something wrong happened to them, but that is a controlling mechanism which the pilot is using and by that, he is or she is rolling the aircraft along the x-axis. So, this is what is one case of the rotational movement and on the basis of this

rotational movement, sometimes this axis is also known as roll axis and this motion is known as roll motion or the rolling motion. It may be a positive rolling motion, it may be negative in the other direction.

Similarly, when we look at the y-axis that is coming in this direction, then there is a possibility that the aircraft can take a movement like this means this nose will go up and the tail will come down or the tail will go up and the nose will come down. So, that is the way the movement which can be taking place in this case of a y-axis and this type of movement of going up or coming, coming up or going down that is known as pitching, as we have also discussed in the railway engineering part and this pitching provides or it helps in the movement of the aircraft in the upward direction or bringing the aircraft for landing towards the airport. So, at that point of a time the pitching becomes important and because of this action, this y-axis is also known as pitch axis and at the same time the movement which can be taken in this form or in this form that is the arrow going this way, then that motion will be known as the pitching motion.

The third axis which is the z-axis which is perpendicular to both of these axes that is roll axis and the pitch axis is working like this. Now, when we talk about this axis, then the motion which can be there with respect to this aircraft is taking a turn either in this direction or taking a turn in this, this direction. So, with respect to a vertical axis like this it can be moving in this way or it will be moving in this way. So, it means this is the axis about which the aircraft takes a turn, may be in the right hand direction or may be in the left hand direction. So, that is another type of movement and on the basis of this movement which is known as yawing movement, this axis is termed as yawing axis or yaw axis.

So, what we have seen is that there can be three types of rotational movements in any of the aircraft and these three type of rotational movements are rolling, pitching and yawing and these all three types of rotational movements are with respect to the three different axis that is axis x, axis y and axis z respectively. So, in these cases, if we are interested in looking at the rolling condition or we are looking at the turning of an aircraft in the left or the right hand direction or we are interested in taking the aircraft up or bringing the aircraft down, then these cannot be a possibility unless and until

some of the specific type of accessories have been provided on this aircraft and the accessories which needs to be provided on these aircraft have been shown in this diagram in the form of these black patches, has been shown on the wings, that is here and as well shown on the tail side on the wings that is this, this and this one. So, we will be discussing about all these patches and what are the names of these patches or what are the, what the significance of these parts are in the coming discussion.

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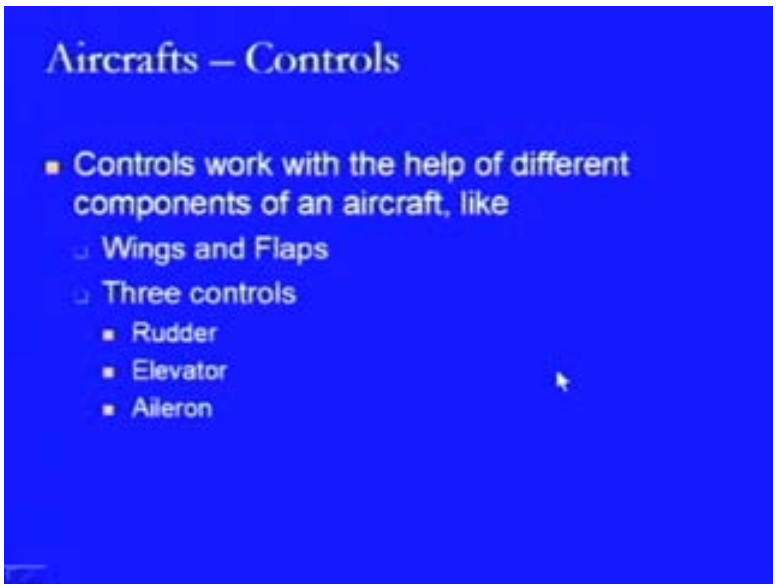

Now, on the basis of this, what we can look at is that there needs to be some type of controls and these controls will help in the movement of the aircraft in a more efficient and safer way. So, there are some components on the aircraft itself as I have shown in the previous diagram, which can provide us these controls and these are the wings and flaps and the three controls that is rudder, elevator and aileron.

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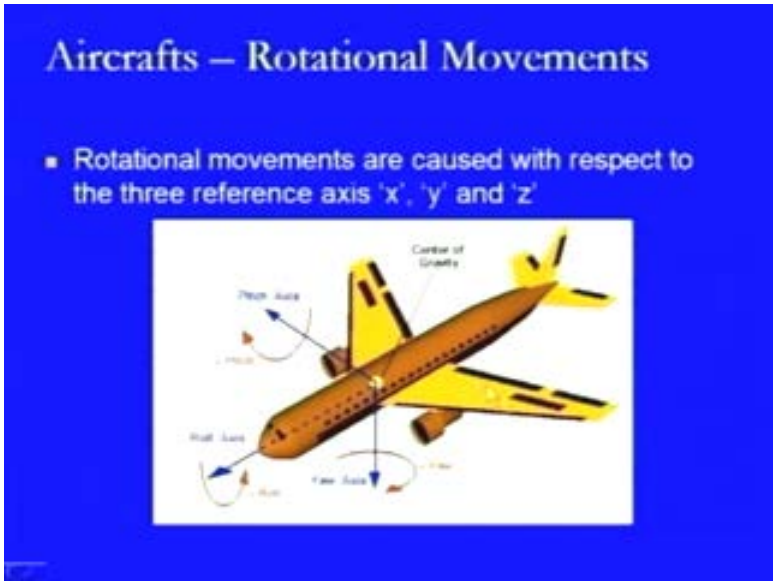

So, if we go back to the diagram which we have seen in the previous one, then what we found is that these are the flaps being provided. This is another one, the flap on this side and the flap on this side. This is aileron being provided at the end side, this is aileron. Then we have the rudder on this side. This is known as rudder and then we have the elevators that is this one and this one. So, these are, these are the elevators. So, they all have their specific use when the aircraft is in motion, as soon as it starts taking off from any of the airport. So, we will be looking at all these components as well as all these three types of controls and how we can achieve these types of controls.

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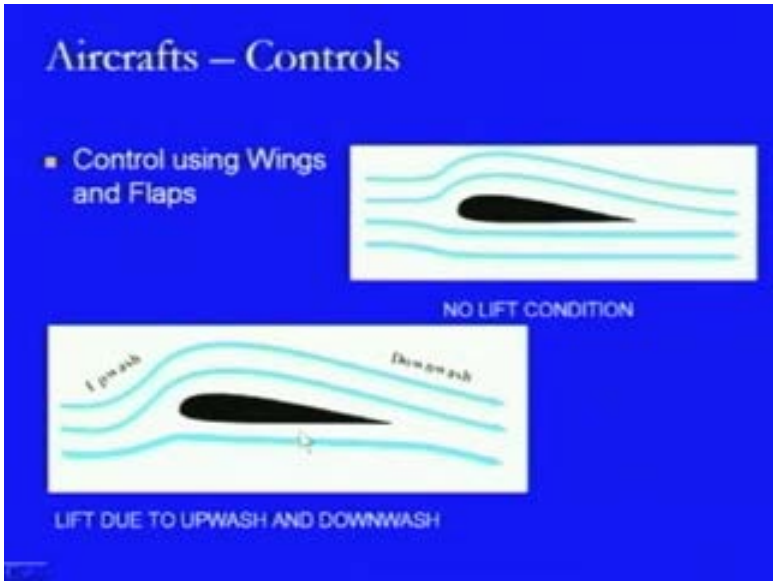

So, when we look at these controls, what we can find is that if we are using the wings and the flaps for providing the control, then there can be two conditions which may happen. One is that there is no lift condition. It means there is no requirement of taking an aircraft in the upward direction and second thing is that there is the lift which is being caused because of the movement of the air on the peripheries as well as on the upside as well as on the downside of the wings or the aircraft, especially it is the wings which creates the lift and this is what we will be looking at in the diagrams.

Now, in this diagram where we are looking at the no lift condition what we can see is that there is an aircraft and this is the diagram of the wings of the aircraft, basically. If we look at the wing from the side of the aircraft, then it will be looking like this only. So, this is a profile, this is aerodynamic profile of any wing of aircraft and when it is moving in the air medium, then this is the air medium. This air medium will be segregated because of the movement of this wing and if the motion is very less, then what will happen is that this will be segregating it at the two levels and at both the two levels the wind will keep sticking to the side of the wing like this or to the side of the wing at the bottom side like this. So, it means there is no gap between the wing as well as this air which is coming from this way or this way. When it is coming from the upward side, then it is known as upwash and when it is coming from the downward side, then it is known as downwash. So, in this case there is nothing like upwash and downwash which is getting separated from the wing area. So, it is totally,

this wing is moving within the medium itself and that is why the pressure at the top and the pressure at the bottom they are seen. They are the air pressure at the top as well as the atmospheric air pressure at the bottom and that is the reason why there is no lift and it remains in the horizontal direction or horizontal position.

Now, we look at this diagram, where there is certain higher amount of movement with a velocity and in this case, because of this movement there is some upheaval at the front side of this wing and due to which there is an upwash something like this by which the air is getting in the upward direction at a tremendous value. So, when it is going in the upward direction in the tremendous value like this and it is getting lifted up, what happens is that with the angle of strike at this location, the air is striking at this location at this one. So, if this aircraft is going in this direction, so there is an angle of strike with respect to air and due to that angle of strike, as the air strikes on this wing in this direction, it gets lifted, it gets separated from the wing surface that is this one and it goes in the upward direction like this. So, slowly and slowly we will find that this will keep on increasing this way and this is the way how it will be happening and finally there will be a location, there will be a condition by which this air will get separated from wing surface.

Now, when the air gets separated from the wing surface, then there will be vacuum created in this area. So, that is the area where the vacuum will be created. Now, because the air is striking at some angle like this, then some part of this air will be moving in this form. So, this is the way how some part of the air will be coming and it will be moving. So, in this sense this air will keep sticking to the bottom most part of this wing. So, what is happening now is that there is an atmospheric pressure being created at this bottom most portion of the wing, but where there is a vacuum at the top most portion, so there is unbalancing of the forces and due to this unbalancing of the forces, the force will act in the vertically upward direction and when the force is acting in the vertically upward direction, this wing will start lifting in the upward direction. It means the aircraft will also start lifting in the upward direction and that is how the aircraft goes into the air.

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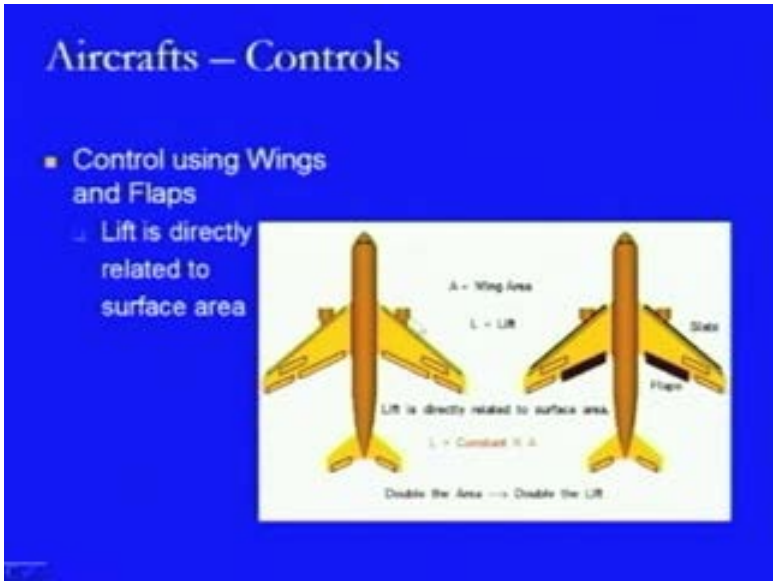

Then another thing is that how this lift is going to be related with the surface area of wing. Basically what happens is this is the overall surface area of the wing and similarly this is another overall surface area of the wing and these wings are more or less are flatter surfaces, whereas this fuselage is a round surface. So, the separation of the air with respect to this round surface is more and this will keep on moving like a bullet within the air medium, whereas the pressure will get exerted on these surfaces. So, if there is a, A is the wing area, if we assume that it has a wing area like this, then this wing area is going and L is the lift, then this lift is directly proportional, directly related to the surface area.

Now, if the surface area is reduced, then the lift is reduced. If the surface area increases, then the lift will be increasing. It means if we increase the surface area to the double value, then the lift will also be doubled. So, at this point of time, then the use of the flaps which are provided on the wings, now these flaps are provided on both the sides of the wings, now you will find that there is a bigger flap which is provided at the backside of the wing and there is a smaller flap which is provided in the front of the wing and it is a continuous sort of a flap which is provided like this. So, there is a flap on this side and there is another flap on this side.

So, this is known as slabs and this is known as flaps and this is wider and this is a little less wide. So, using the surface area being provided by these flaps, by tilting

these flaps in the upward or in the downward direction we try to generate, we try to increase the area, if at a time it is required, at the time of taking off, whereas we try to reduce the area at a time when we are just landing on an aircraft. So, that is the one aspect which is related to the wings and as well as to the flaps being provided, the slabs being provided on the wings. They help in generating the lift by which the aircraft can go up or if it is coming down at the landing, then it reduces the surface area, so that there is no effect of the lift at the time of landing and there is no jerk which will be felt by the passengers when the aircraft lands smoothly on the pavement.

Now, these flaps also play another role. Now, when these flaps are brought towards the downward direction, in the case of the wing, the wing if we assume that this wing is in a horizontal position and then this is a flap being provided at the backside of the wing and it is brought towards down means it is tilted downwards, now as soon as it is tilted downwards, then there is a wind which is coming from this, the air which is putting a pressure from this forward direction on this wing span will keep a pressure on these flaps and this pressure is nothing but a drag and this drag pressure will help in reducing the speed of the aircraft at the time of landing.

So, what we do is that at the time of landing the pilot is not using the breaks, so as to reduce the speed of the aircraft from something like 300 kilometers per hour to 90 kilometers per hour at the time when it is going to take a turn from the runway and coming to the taxiways, so the speed which is being reduced in this portion from 300 to something like 100 kilometers per hour is being done with the help of these flaps only and the drag force which is generated by using the flaps. Then only, after that the pilot starts putting some breaks as and when they are required.

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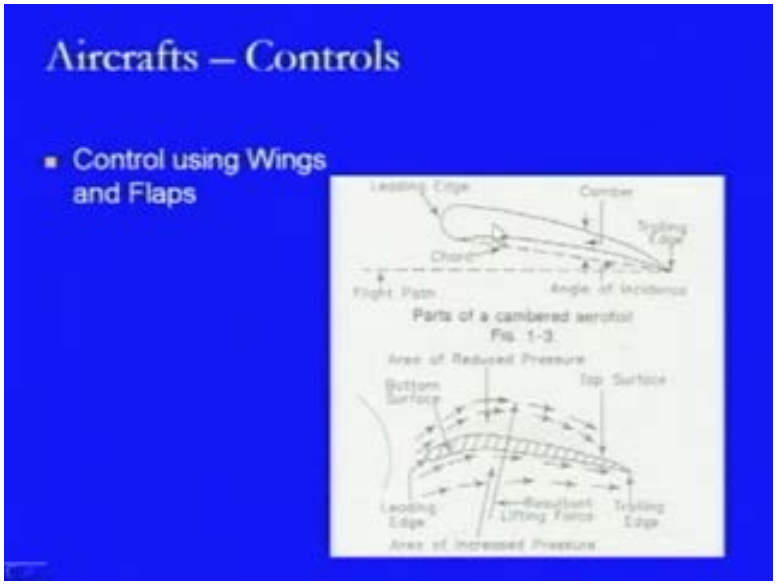

This is another diagram which is trying to show the same sort of lift condition here. Here, this is an aerodynamic profile of the wing. That is we can see this is an overall chord. So, if we join from this point to this point that is a chord and this is the type of the camber being provided. This is the front side, this is the back side. So, this is trailing edge and this is the leading edge and when it moves in the air, the air will be coming from this direction. So, as we see in this diagram, what we can see is that the air is coming from this direction, but because of this shape of the wing, there will be separation of the air and this air will go in this direction as well as in this direction like this.

So, if it is going in this direction, it will go away from the wing and the vacuum will be created in this area, whereas here the air is coming along the surface of the wing and therefore, there is a big pressure zone at this level. So, due to this higher pressure zone in this one and the lower pressure zone in this one, this force will start acting in this direction, upward direction and that is what is the lift.

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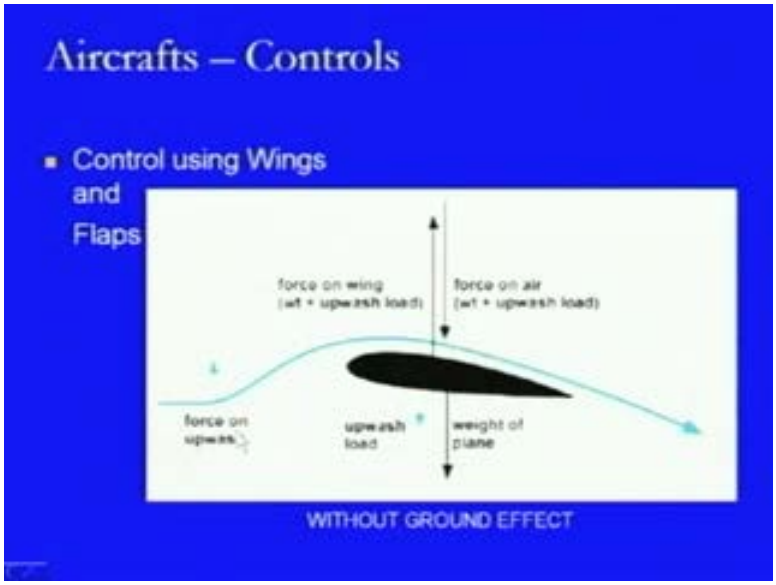

Now, this is another diagram which is trying to just discuss the same sort of the condition which we have already discussed. There is an upwash which is coming in this direction and a downwash remains after that one and this upwash is acting in the upward direction and whereas the weight of the plane is acting in the downward direction and the force which is acting on the wing will be the weight plus the upwash load and with respect to this weight plus upwash load that is if we take their signs also into consideration we have a force which will act here like this and that will bring the lift, whereas there is a, in this direction when it is going in the downward direction, then this upwash load and weight may be going in the downward direction and that will create the tilting of this other one in the downward direction and for just putting this side of the leading edge in the upward direction, so that is how it will go into the air like this. So, here we can talk it with respect to the ground effect or with respect to the without ground effect. So, this case, we are talking about without ground effect means we are in the air.

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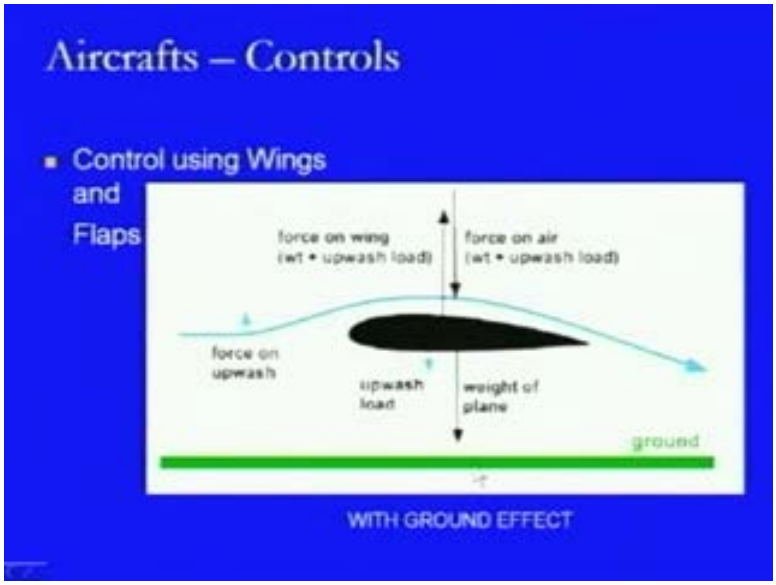

Whereas, this another diagram, we will try to depict the same condition when we are looking at the ground effect and the plane is moving on this ground and therefore, in this condition the wings remains horizontal and that is how the forces remains in this case and the profiles remains in this case.

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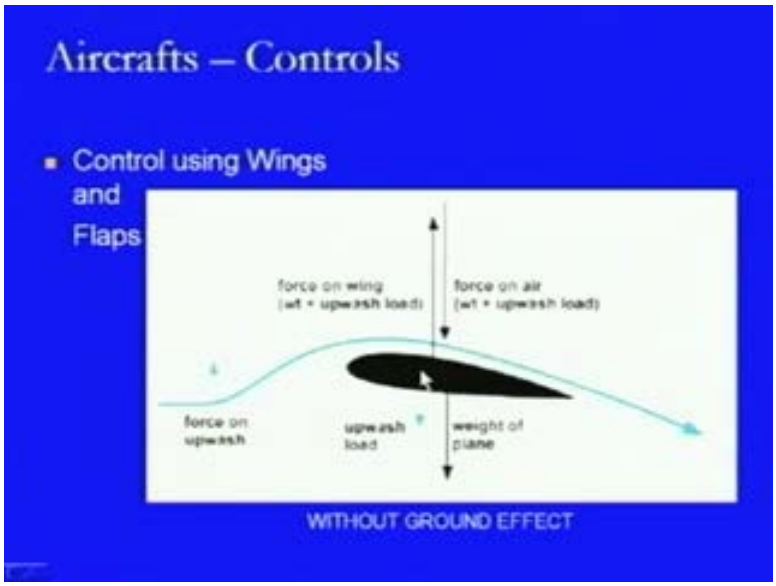

Here, the profile is horizontal, where if you have noted in the previous one it is in the tilted position, because the force here is coming in the downward direction and the force here is going in the upward direction.

Now, we come to the controls. How the control works? The first control we are discussing here is the control using rudder.

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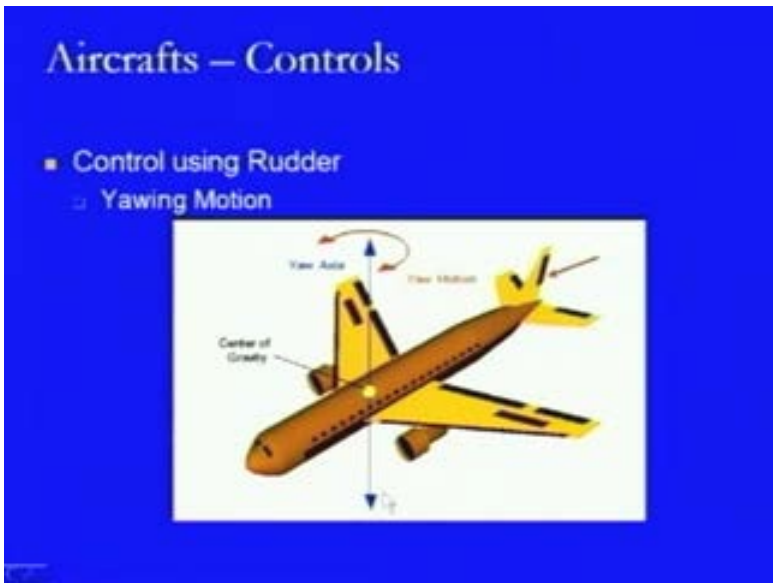

This rudder helps in controlling the yawing motion as we have discussed that there is a yawing motion and this yawing motion is with respect to the z-axis. So, this is the z-axis which is passing through the CG and the rudder is provided here. This arrow is showing the location of rudder. Now, as we have discussed that this aircraft has to move in this direction that is towards left or it may take a turn towards right and that will be done with respect to the rotating about this yaw axis or y-axis that is z-axis. So, we will be operating the rudder.

This rudder will be operated. This is another type of flap being attached to this vertical wing. How this rudder is operated and if we operate this rudder, then what will be the type of the motion which we can see? That is this rudder can move in this direction or it can move in this direction. It is attached at this location at this front side and this is detached at this location and at this location and this is the end. So, therefore this can be rotated about this particular edge in this way or this way. So, if it goes to this side, then there will be a heavy pressure on this direction and there will be a less pressure on this one. So, the aircraft will move in this left side direction, right side direction if we are looking from the tail towards the nose, whereas if this rudder goes in the other side of direction, then this aircraft will take a turn towards the left

hand side. So, that is how this rudder will make a control on the movement of any aircraft in the air and this is what we can see from another diagram.

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This is the diagram where we can see, this is the animated condition of an aircraft where this rudder is working. When the rudder as you see comes this side, then the aircraft goes this way or when it goes the other side, the aircraft is coming in this direction. So, that is how the aircraft is taking a turn either in this left hand side or the right hand side in this way.

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Now, we come to another control. This control is using the elevators. Again, these elevators are provided at the tail of an aircraft. That is on the last small wings which are provided at the tail of an aircraft and these elevators helps in controlling the pitching motion and we have also discussed this pitching motion, where this is related to y-axis or a pitch axis and the motion is nothing but it is either taking the aircraft upwards or bringing the aircraft downwards. So, that means the nose may go down or the nose may go up with respect to this axis. So, that is what is a pitching motion and this is going to be controlled by these elevators being provided at this location.

Again, these elevators work in the similar form as rudder and they are connected at this location, but at this location or at this location or at the ending location they are free. Therefore, these elevators can move up or these elevators can go down with respect to the flat surface of this wing and using this motion we can take the aircraft up or we can bring the aircraft down. So, we will try to look at this aspect further, when we just … This is the arrow which is trying to show the elevators. What we will be looking at is that, this is working like this.

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This is another animated condition being shown, where these elevators when they come up, then they allow the movement in the downward direction and when they goes down, then it allows the movement in the upward direction and in all these cases,

it is going to be controlled by the difference in the pressure being generated at this location at the top of the surface as well as at the bottom of the surface.

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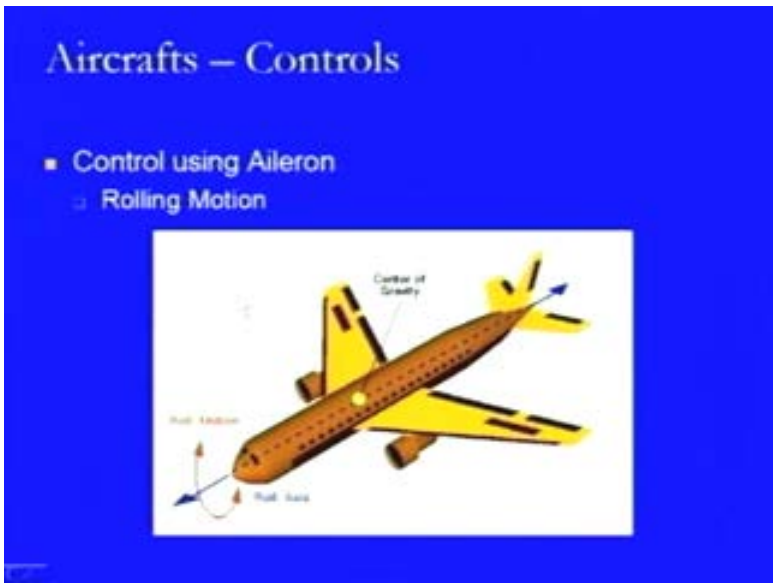

Now, another control is the control using ailerons which are provided on the main wings and this helps in controlling the rolling motion which is with respect to the x-axis or the roll axis, whereas we have discussed, it can take a roll as a counter clockwise direction or a clockwise direction like this and the ailerons have been provided here. Again, these ailerons will be working in the similar fashion as the elevators were working and they can go up or go down. That is how we can control the motion that is we can control the rolling of the one, so if this is taking up, then it remains down. Then, that is how in the reverse form they will be acting and when they act in the reverse form, the rolling action will be there. Again, we will be looking in an animated form that how it is going to be happening, how this rolling can take place.

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So, if we look at the diagram, this is the diagram how it is working. You can see that these two ailerons which have been provided, they work opposite to each other, then only this rolling action will take place. If this is coming up, then this will be going down and if this is coming up, then this will be going down and with respect to that one as soon as it goes down, then there will be a motion in this way and if it goes up, then the motion will be taking place in this form. So, that is another type of motion which can be there and this is how we can control or the pilot controls the motion. So, these are the three main types of motion which needs to be controlled during any flight, maybe during take-off or during the landing or in the air itself, at the time when it is at a much higher altitude. So, the pilot needs to take care of all these systems being provided on the wings.

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Now, let us have a quick look at some general information regarding the aircrafts. We have different type of aircrafts, like in the case of Boeing it started with 707. Then, 747 came and 707 is now-a-days being taken out and there is the next generation aircrafts like 737-700 or now, if you have gone through the news items, then they are coming out with the 787 Green Dreamliner. That is another Boeing of some capacity of around 300 again, but it takes up to 25% less of the fuel and at the same time, the emissions are less deadlier or they are more greener, in the sense than the emissions being given out by other aircrafts and this is going to be launched soon. Whereas, in the case of airbus we have A319, A320, A321 which are still in use and now, they have come up with A380, which is one of the biggest passenger aircraft having a capacity of up to 800 passengers and it visited India some time back. There was news and you must have heard about that.

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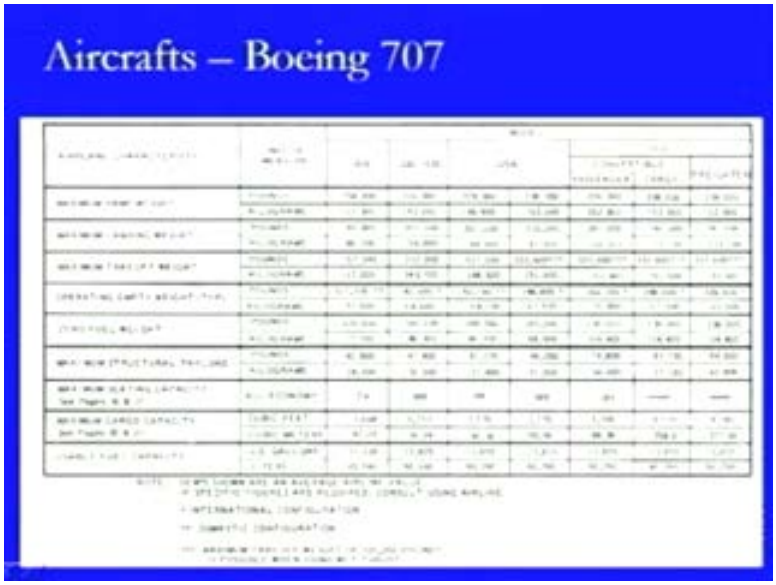

In the case of this Boeing 707, if we look at the details, the details remain basically starting from the ramp weight to landing weight to take-off weight or operating empty weight or zero fuel weight and likewise and then there remains for different types of model. That already we have discussed that what type of the weights can be there.

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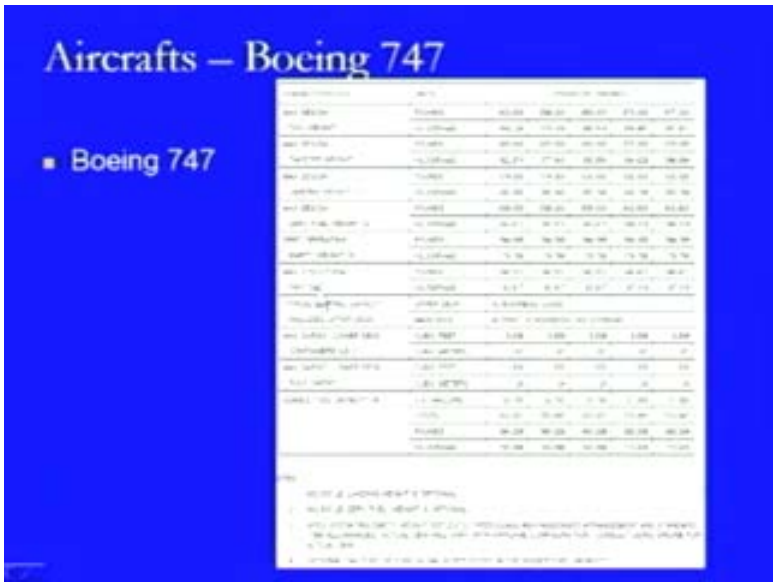

Then, similarly there can be certain other characteristics like taxi weight or this is for 747, the previous one was for 707 that we have just an idea that what type of details can be there.

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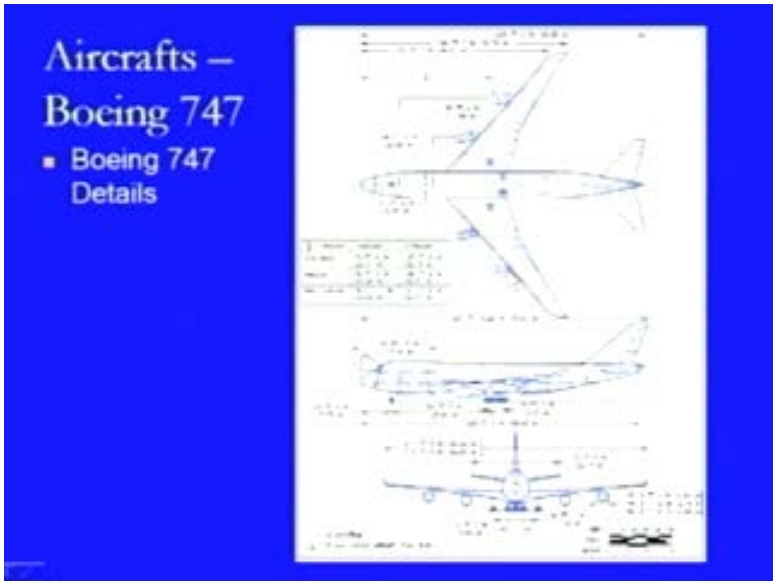

This is a diagram which tries to show the dimensions of the aircraft. Here, it is related to 747. What are the lengths, what are the wing spans, what is the distance from the nose this engines have been provided that is the details being given here. Then, what is the height, what is the height of the tail? These all again we have discussed when we discussed about the size of the aircraft and the significance of the size of the aircraft. So, these are some details related to 747.

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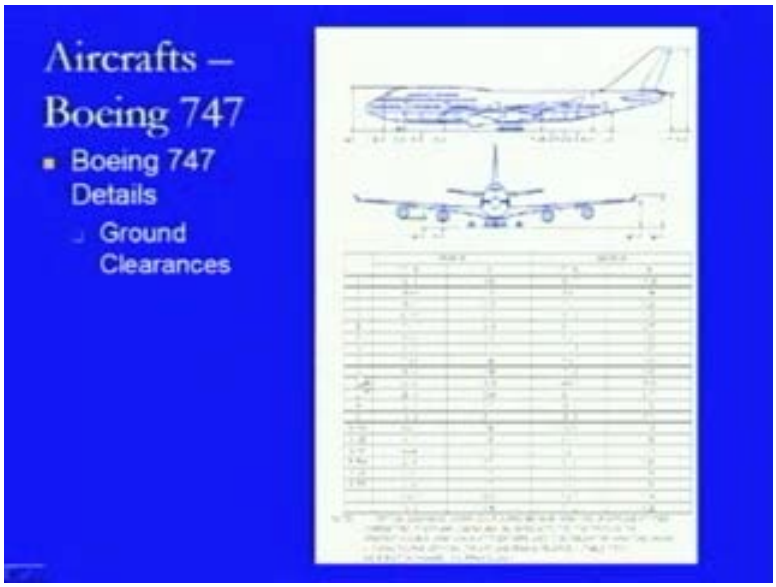

Further there are certain details related to the ground clearances and they are given, they are shown here with respect to different components of any aircraft, because what should be the clearance of this, what should be the clearance of this location or what should be the clearances of the engines being provided on the wings, so those all things needs to be clearly mentioned and that is what this table tries to speak off with respect to A B C D's has been shown at these locations.

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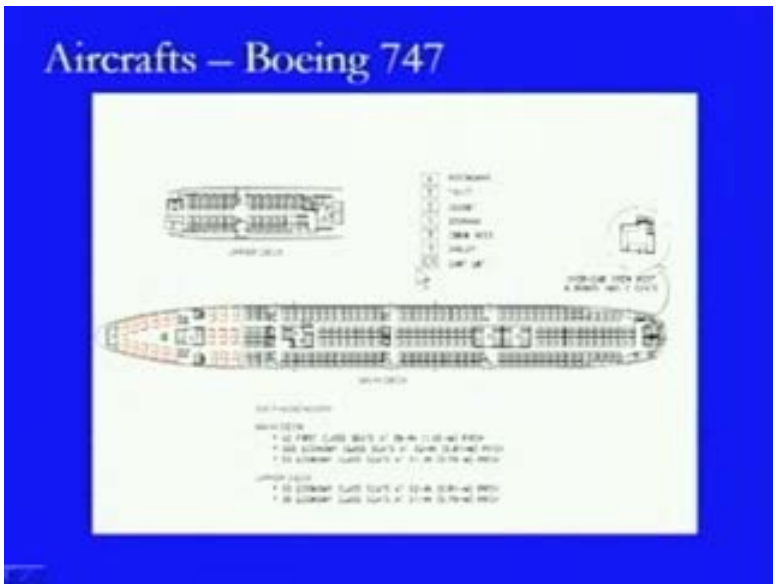

Then, this is the setting … being provided in any like Boeing 747. What is this red) portion is basically for the business class or the upper class persons and then this one is for the economic class condition. So, this is how they are being done and this is for the main deck and at times on the upper deck also we provide some limited area in which this can be provided. So, on the upper deck this looks, may look like something like this. Instead of three lines there can only two lines, because of the converging effect of the top of an aircraft.

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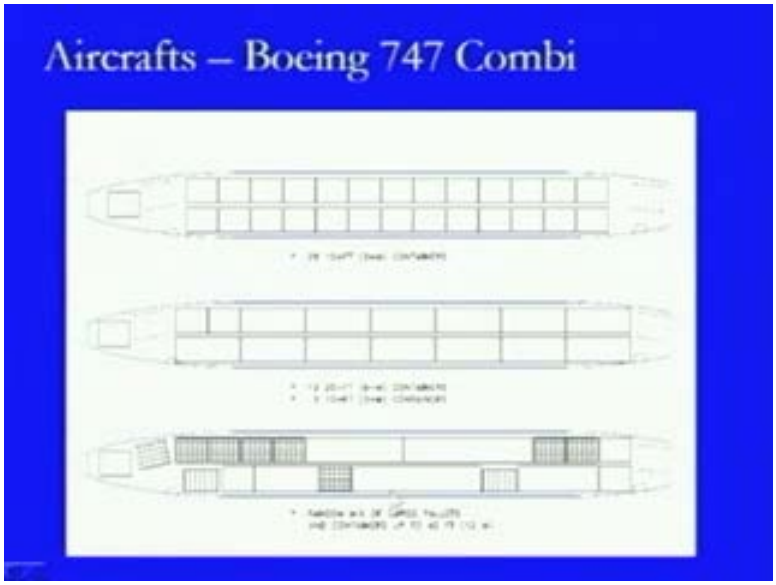

This is regarding 747 Combi, where it can take the passengers as well as the freight or the cargo and there can be different ways in which the cargo can be placed and all these three diagrams are trying to show the cargo condition only, where these are the smaller boxes of 10 feet dimension or 3 meters dimensions or how many can come in this one and then if it is 20 feet and 10 feet combination, then this is how this can be adjusted, whereas at times there can be bigger containers also like shown this way or this way and then these are being merged and this is a mixed condition in this one, where smaller, medium and the bigger containers have been used.

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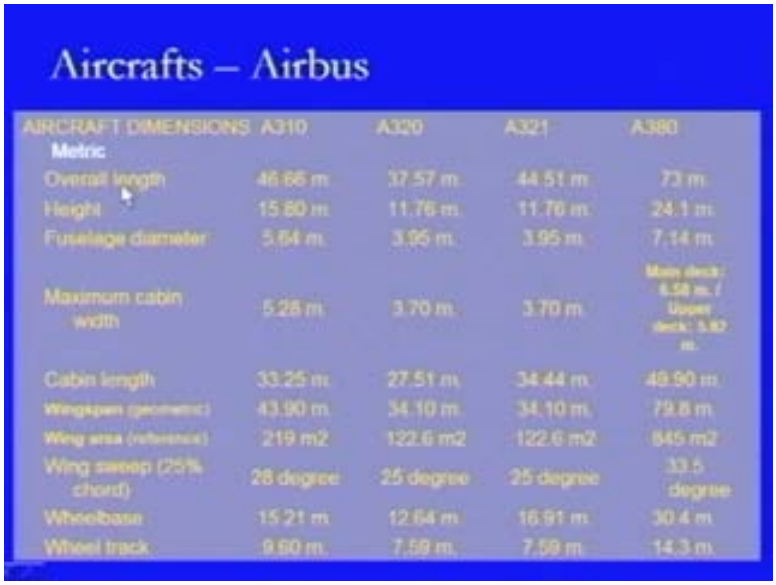

Then, these are the characteristics related to airbus. In this case, they are overall length, height, fuselage diameter, maximum cabin width, cabin length and so on. What we can see is the comparison of this A380, which is of 73 meters long as compared to the other ones which are at the maximum 47 meters long. So, that is a difference in the size of the aircraft which we can see. The height is at the maximum 16 meters in A310, where here it is 24 meters. So, that is the difference in the size and that is where the reason is that we are getting if you look at the wheel base, wheel base with respect to 15 or 17 meters, it is now 30 meters wheel base.

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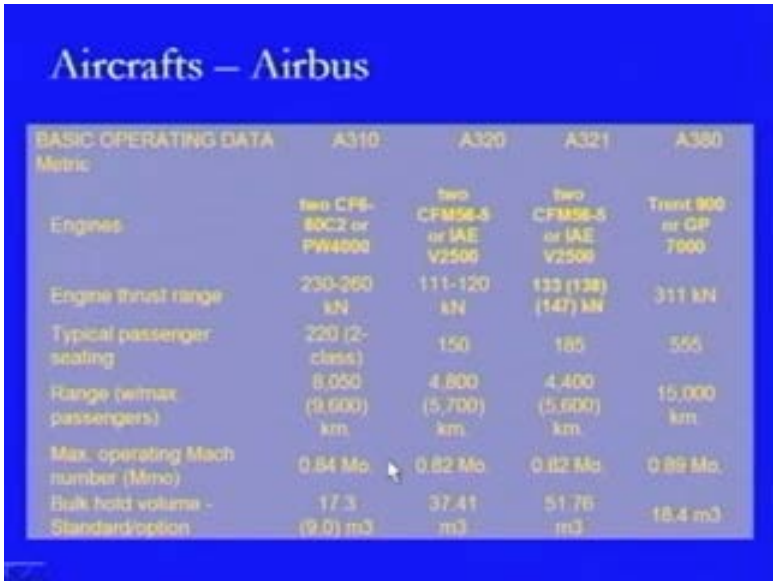

Then, as far as engines are concerned, then the output of the engine is quite more as we can see here and typical passengers seating capacity means in the normal condition it is 555 passengers at one point of a time with respect to 150 or 185 or 220, in the other type of aircrafts of the airbuses. So, this is how different characteristics are generally provided by the manufacturer itself.

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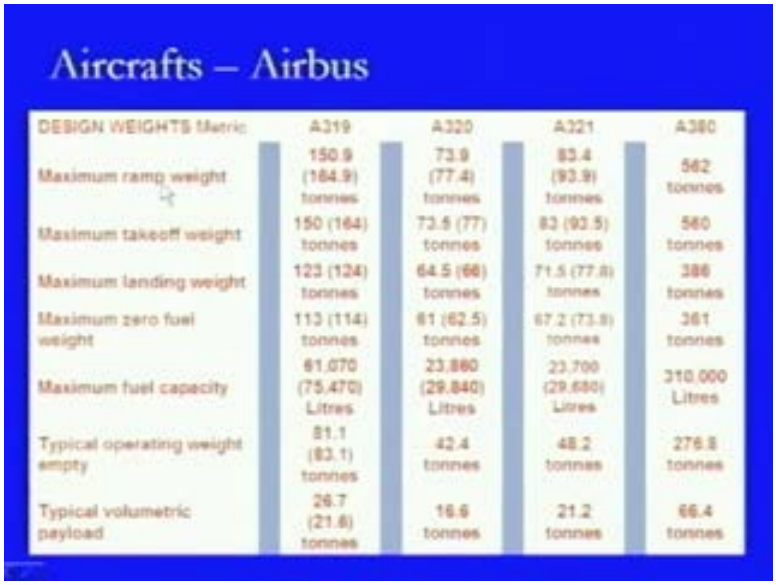

So, more conditions are there. They are related to the design weights as we have discussed previously and the differences that if we look at the maximum takeoff weight, in the case of A 380, it is 560 tonnes with respect to 150 tonnes of A319. So, that is the difference again in this case or if we look at the maximum fuel capacity, the maximum fuel capacity is 3,10,000 litres in A380. That is the amount of fuel it carries with it, so that it can go up to a maximum distance.

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Once we have the idea of the different type of characteristics which can be there of different aircrafts, which are available in the world, then in respect to that one, we will be looking at the selection of an airport site. In this case, the first thing which we can discuss is some of the specific aspects which may create its, which generally creates its effect on the site selection. One is the air traffic potential. We have to look at that whether there is a potential of any traffic, which will be travelling by air in a specific area, where we are interested to put or we are interested in providing an airport. If that is there, then what is the magnitude of that one is going to be discussed and what type of traffic is there. It is more of a passenger traffic or it is more of a freight traffic that is another thing which needs to be taken care of.

Another thing is the adequate access. It, the area should be such that we can reach there very easily, whereas at the similar point of a time the persons who are reaching that location from outside may, should be able to reach the city very easily. So, that access has to be looked at. Then, sufficient airspace should be available for the aircrafts, but now-a-days, we are getting bigger and bigger aircrafts and that is why the circling radius becomes something of kilometers. So, it means we require a very big airspace at the top of the airport, so that there is no hazardous condition getting created. So, that is another requirement for any airport and further whatever facilities needs to be provided on an airport requires a space.

These facilities maybe of different types. It may be related to the management of the air, it may be related to the control system, it may relate to the administrative systems, it may relate to the airline system, it may relate to the security system, it may relate to the passengers handling or the baggage handling systems and so on. So, on the basis of that we have to look at what is the total requirement of the land and that should be there.

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Apart from these, there are different other factors which may create its effect on the selection of a site and these factors are like atmospheric and meteorological conditions, availability of land for expansion in the future conditions, availability of utilities, development of surrounding area, economy of construction, the ground accessibility.

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Then, the presence of other airports in the vicinity, regional plan, soil characteristics, surrounding obstructions and the use of airport. We will be looking at all these factors one by one. We start with the atmospheric and the meteorological conditions.

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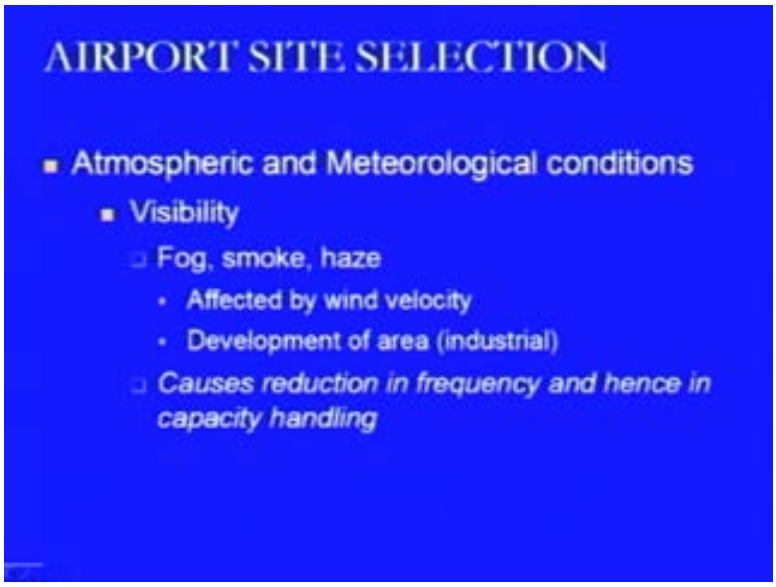

In the atmospheric and meteorological conditions, the very first thing is the visibility, because at the time of taking off or landing, visibility is the one important factor and this visibility gets disturbed by some sort of things like meteorological conditions, which gets created in terms of fog or in terms of haze or there may be a smoke because of again the meteorological condition and the development in the nearby area. That is two factors which causes the smoke on the airport and if that is the condition, then the visibility reduces and airport capacity will be reduced, because it cannot handle many aircrafts at one point of time and these things are also affected by the wind velocity. It depends in what direction the wind is blowing and at what velocity the wind is blowing when we can find that this fog or smoke or haze that gets removed from the airport very fast.

At the same time, another thing which is creating an effect as I have just discussed in the case of a smoke, is the development of an area. If it is an industrial area, then there are more chances of smoke coming out of that and in continuation of that one, if the wind is blowing from the industrial side towards the airport side, then the whole of this smoke will always be coming to the airport side, whereas if the airport is on the

windward side and the industrial area is on the leeward side, then always the wind will be moving away from the airport and there will not be any problem of a smoke. So, the overall condition of these combinations of atmospheric and meteorological condition is that they causes reductions in the frequency that is the number of operations and as well as in the total traffic handing capacity of an airport.

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Further, in the case of meteorological conditions, another point is the wind. This wind is to be discussed in terms of the direction and intensity, as we have just discussed what may be the effect of its direction, similarly is the condition of intensity. If the intensity is very high, then it creates a resistance or an uplift condition to the aircrafts which are standing and then it becomes hazardous condition, again for the movement of the or the operation of the aircrafts.

Similarly, the associated topographical features have to be looked at. That is whether it is a hilly area or whether it is a valley area or in which particular location the airport is being provided or has been proposed. If it is at the top of the hill, then there is no such problem where any such accident can take place, because of the movement or operation of the aircraft and in combination with the high wind intensity. But, if it is in the valley area, then also in most of the time period that may not be creating much effect, but at sometimes it may remain still a safety concern.

Then in what direction this is moving from the airport whether the airport is on the windward direction or in the leeward direction also creates an effect. If it is on the leeward direction, then there are more problems. But, if it is on the windward direction, then the problems are very less. So, locating development with respect to the site of the airport and looking at the effect of the wind direction and intensity is another important aspect, so as to decide about the site of any airport.

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Another factor is that whether we have the land for the expansion in future, because in future the traffic is going to increase and when the traffic is going to increase, then we require space for not only for the parking of the vehicles, but for the terminal facilities, for the aprons where the aircrafts will be parked or the runway lengths on which the aircrafts will be moving. The bigger and bigger aircrafts will be coming, therefore we require a bigger runway lengths needed. As we have seen in the case of A380 which came to Delhi, there was no runway length and which was having a width by which that aircraft could have landed and initially the sides of the runways were cleared, so that this aircraft can land on the airport.

Then, land cost is another important factor, because as soon as the airport is provided, the side areas of the airport will start developing and the cost will keep on increasing. So, therefore we require some land to be acquired in the initial conditions only, so that the effect of the cost of the land is not creating any problem in the further

development, in the future stages. Next is that this availability of the land at the later stage is another factor. Whether that is available at a later stage which is not being acquired in the initial condition looking at the future expansion required, so that if it is not available, then we have to shift the whole of the airport or we have to provide some additional space and on that additional space, the additional facilities have to be created. So, it is more costlier affair.

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Then, availability of utilities in terms of water, power, etc, or in terms of the sewerages which needs to be cleared out. It is also in terms of the communication facilities to be provided to the passengers as well as to the controlling units of the airports by which the navigation will be taking place in air. Further, we also require the generator plants, because if there is a failure of power, then we need to use the generator, so that the things keep on going.

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Then, the development of surrounding area is to be talked in terms of what type of development is taking place, whether it is a residential or sensitive area. In that case the airports cannot be provided, because at the time of taking off or landing they create a lot of noise and that will be hindrance to this sensitive area or residential area. It may cause number of types of noise disorders. Similarly, if we look at the development which is industrial in nature, then we have to look at two aspects. One is the height of development, another one is the zoning of laws which needs to be provided, so as to control this type of development. Otherwise, they will come into the flight path of the aircraft and then, this is another safety problem.

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Further, this development of the area may also cause us, I have just discussed the noise pollution, it may also create a problem in terms of the movement of air pollution, because whatever the pollution is there on the side of the development and with the air, it may move towards the airport and then this type of developments also brings the birds in that area and bird hits is one of the biggest problems in the movement of aircrafts, because as soon as there is a hit of a bird on the engine, the engine will become non-workable and therefore, this is a problem as far as the tractive effort is required, is concerned for any aircraft.

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Then, we come to the economy of construction. In this case, there are alternate sites needs to be examined and we have to look at what is the availability of the local construction material, what is the availability of the man power, what type of terrain is being provided, whether there is a requirement of flattening of the terrain or it is to be gratified and or there are certain problematic areas which needs spatial considerations like water logging areas or reclaimed areas. All of such things becomes costly or they keep on increasing the cost of the project that is the provision of airport and that is why we have to look at that by what way we can reduce the overall cost.

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The next point is the ground accessibilities, a very important point, because we have to look at what is the time it takes to travel from the city to the airport location and if this travel time is more than the travel time being taken in air, then obviously there is no use of providing that type of a facility. So, we have to look at, we have to just correlate and make a trade-off between the travel time on ground and the travel time in air and all these locations where the airports are being provided, they should be easily approachable using different type of modes, so that it should not be very specific to one mode and these should be very near to those areas which are going to create the trips which will be taken up by the air transportation. That is another aspect related to ground accessibility.

Then, facilities need to be provided to the private vehicle users, because they will be coming to see off or receive their guests. So, some facilities have to be provided for such users. Then, efficient transport system has to be provided as a mass transport system, which connects the airport site with the city, as we were discussing in the case of Maglev system, where China is providing a Maglev system from the airport to the city. So, that is the efficient system, which is required depending on the total amount of traffic which will be there.

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Then, if there is any other airport which is available in the area, then, we have to look at some factors like traffic volume that how the volume, how the traffic is going to be divided between those airports which are very near to each …. or whether there is an effect of en-circling radius of the aircraft, because that is another hazardous condition if the two aircrafts are encircling on both the airports, each airport, then they may cross each other and this may be unsafer. Then this is also going to be dependent, this encircling radius is basically going to be dependent, on the type of the aircraft. So, what type of aircrafts are going to use these two different airports being provided side by side, that is another aspect.

We can look at in this case, like domestic airport and the international airport. Then, generally that is not a problem, because domestic airports generally have a smaller aircrafts as compared to the international airports. Then, what is the type of the operating facility? That is another factor which creates an effect on the presence of other airports. It may be the flight rules, which are instrumental flight rules or the visual flight rules. So, depending on these again, the things changes like a ….. specification changes and we have to look at that.

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Another factor which comes with respect to these specifications is the separation distance between the different radii which needs to be provided, so that they remain safe in air and if it is not being taken care of, then it may result in the serious air traffic congestion or it may result in the reduction in the airport capacity.

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Next factor is the soil characteristics. In the case of soil characteristics, we have to look at the strength of the soil sub grade, of the bearing on the cost of construction. Then, we have to look at the drainage aspect, because it should be self-draining, so

that the water goes away and it becomes dry as fast as possible and what is the level of water table and what is the effect of the fluctuations in the water table is to be seen in terms of the sub soil drainage or in terms of the water coming to the top and change of volume of the soil, so which brings deformation.

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Then, the valley sides may have more of the flooding, so therefore it is better to omit those valley sides, otherwise it will always remain un-operational or the soil with reasonable amount of pervious materials like gravel or sand along with suitable natural binder is good, because there is a better drainage in this case as compared to the other type of materials.

Now, another factor is the use of airport.

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What type of use we are going to have, whether it is a civil airport or it is a military airport or whether it is adaptable to use during the emergencies, if at all it is to be done. That is a vice versa conditions civil for military or military airport for civil uses.

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Then, the nature of the obstructions which are available in the surrounding area of the airport site is another factor, because we require air space which should be clear, so that the landings and take offs can take place very easily and therefore, the man-made high-rise structure should not be there in the adjoining areas and that is where the

limits of the height of the buildings comes into picture and the laws are there by which very high buildings cannot be provided in the vicinities. Sometimes, there can be natural obstructions in terms of the big trees, so they need to be cleared off, if they are coming within the flight path of the aircrafts. So, these height restrictions and laws have to be taken care of.

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Next thing which we can discuss now is the size of an airport. How we are going to decide that what should be the size and it is defined by the space which is required for operators that is airlines, the controlling systems, that is for security controls, for the operational navigational controls, for the management staff which is managing the airlines or which is managing the airport and the ground movements which are required for the aircraft for coming to the aprons or the terminal buildings or going to the storage areas or to the hangers. Therefore, it can be controlled by certain things like the peak aircraft traffic during the peak time period. What is going to be the overall traffic of the aircrafts that will govern what should be the size of the airport. Then, what are the characteristics of the aircrafts that we have seen already.

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We will be looking at some of these things one by one. That is what are the various factors which control the airport size, like elevation of airport site above the MSL that is a one factor. As we are going up what happens is that the meteorological conditions deteriorate, the air pressure reduces, the density reduces and it means the bigger size of facilities needs to be provided. So, it is increasing in size as we go up. Then, meteorological conditions in terms of the wind, in terms of the air pressure, in terms of the temperature, needs to be taken care of and again the effect remains the same as I have discussed in the case of the elevation of airport site. That is if pressure is reducing or the wind velocity is more, then we have to look in which orientation it is to be provided, so that it can be used for lift or for drag.

The performance characteristics of the aircraft will also create an effect. Because, in terms of the speed of the aircraft at which it is landing, if this speed is very large and bigger, then it requires a bigger one way strip and therefore, the size of the airport will increase. But, if there are smaller aircrafts which will be requiring lesser lengths of the runway strips or lesser, smaller size of the facilities, then obviously the size of the airport will be lower. Then, volume of air traffic is another factor because it creates its effect in terms of total number of facilities from where the passengers can be handled with respect to one aircraft. So, if there are more of the traffic which is coming, then we require more of such places. It means the size of the terminal building will keep on

increasing and as this keeps on increasing, the size of the facilities will also keep on increasing, thereby increasing the size of the airport.

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These are some of the things which are related with the elevation of airport site selection, like the number of runways required, aircraft performance, which is varying with altitude, density of air and temperature and it has its effect on lifts, drag, length of runway, etc.

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Then, in the meteorological conditions, wind is to be talked in terms of intensity, direction and duration and then, there is effect of temperature.

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They affect the runway orientation and the number of runways required and the length of the runway changes or increases, because of the change in air density and the subsequent lift, etc.

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Further, the traffic volume has its effect in terms of peak hour volume, nature of air traffic, size of aircraft, number of air transporters required, runways, taxiways, aprons, hangers, terminals, etc., that is the facilities and the forecasted traffic.

So, this is where we are stopping now. What we have tried to discuss today is that what are the various types of controls which needs to be provided when the aircraft is in motion, may be in air, may be at the time of taking off or landing and then how we can select any site for an airport and at the same time, what should be the size of airport and what are the factors which may create its effect by selecting these things. This has its significance in the sense that if we have the idea of these things, then there is less of problems in the future time period and we can keep on enhancing the facilities as the traffic grows. But, if we have not given a thinking to this, then this is always a problematic condition. We will be meeting in the next lecture. Till then, good bye and thank you to you.