

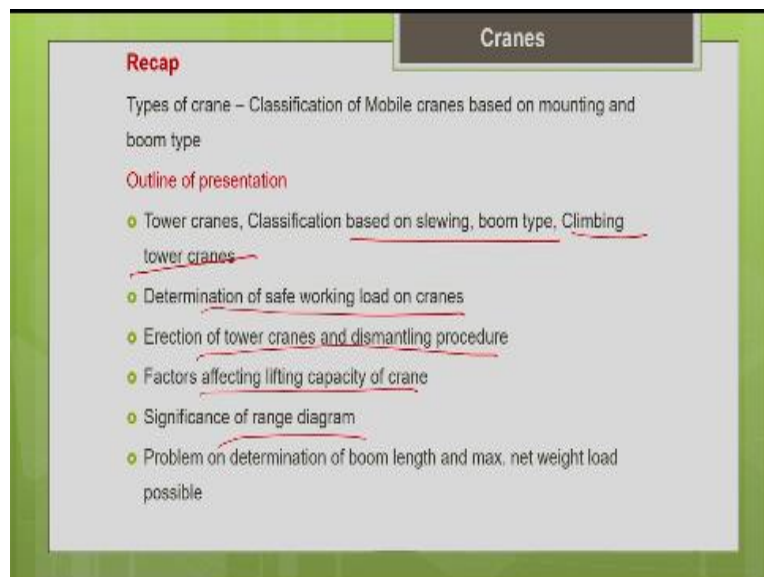
Construction Methods and Equipment Management
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Lecture - 19
Lifting Equipment – Cranes (Part 2)

Hello, everyone. I welcome you all to the lecture 19 of this course construction methods in equipment management and today's lecture, we will be discussing about tower cranes. So, in the last lecture, we have discussed about the different types of mobile cranes like lattice boom crawler mounted crane, lattice boom truck mounted crane and truck mounted telescopic boom crane.

So, we have classified the mobile cranes based on the mounting, based upon the boom type and we have discussed the merits and demerits of different types of cranes. Now, in today's lecture, we will be discussing specifically about the tower cranes.

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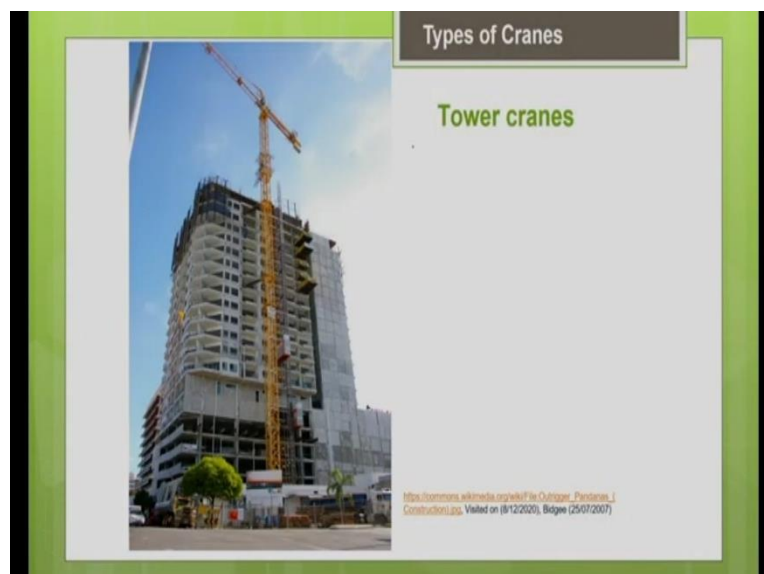


So, what are the different types of tower cranes? So, classification based on the method of slewing of tower crane the method of the boom type and about special tower cranes like climbing tower cranes, its application and all those things will be discussed today. And we will also see how to determine the safe working load on the crane for the tower cranes and we will see what is the erection procedure and dismantling procedure for the tower cranes.

And what are all the factors which affect the lifting capacity of the crane will also be discussed. I will highlight you the significance of the crane range diagram and we will work out a problem on determination of boom length of the crane for the particular project. For a particular working range, how to determine the boom length needed? And also want to see what is the maximum net weight with a weight load possible for a particular crane.

So, these things will be discussed in the today's lecture. So, I hope everyone might have seen tower cranes already.

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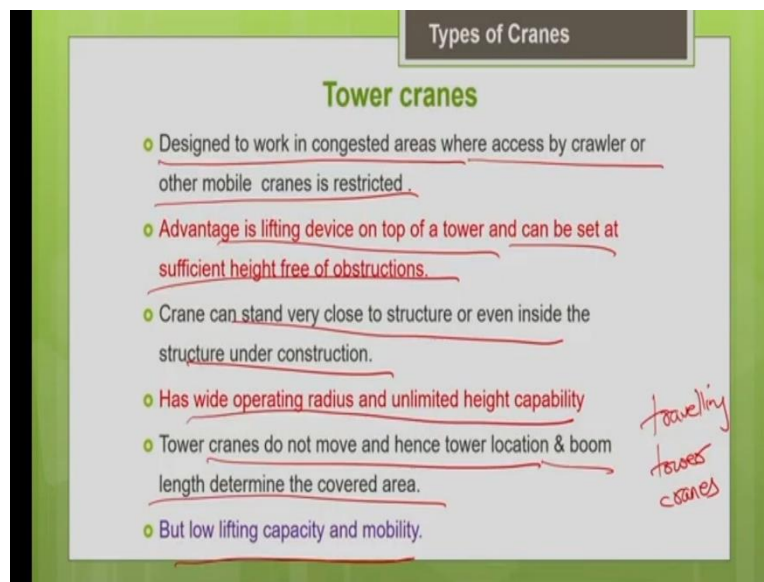
So, this is a picture showing the tower crane. So, it is a very special type of crane more commonly used nowadays for all the high-raised buildings, skyscrapers and big infrastructure projects. You can commonly see this tower crane usage. So, you can see how closely the tower crane is placed near the structure and it is braced at appropriate intervals to the structure. So, that it can take the overturning moment.

So, the overturning moment will be transferred to the structure for the stability of the crane. So, particularly when the free-standing height of the tower crane is very high, we need to take the support from the nearby structure. So, we need to brace it to the structure to transfer the load to the structure for the safety of the crane. So, when do we generally go for this tower cranes?

Basically, in congested areas where the mobility of the mobile cranes is not feasible, we go for the tower crane. So, another important requirement may be; sometimes, we need to reach a very high vertical reach. So, the height needed, the height requirement will be very high which is not possible to be achieved with the conventional mobile cranes. In that case, we can go for the tower crane because tower crane gives you the advantage of unlimited height capability. So, that is another advantage of tower crane.

And you can have a very wide working range with the tower crane because you can place it very close to the structure and you can even place it inside the structure. So, that facilitates you to have a better working range with the tower crane. It all depends upon the position of the tower. So, let us see where this tower crane is commonly used.

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So, this is mainly designed to work in congested areas. Where the access by the other mobile planes like crawler mounted cranes is restricted, you can go for the tower crane. So, main advantage is, your lifting device is on the top of the tower and it can be set at a sufficient height free of all obstructions. So, you can have a very high vertical reach, unlimited height capability as I mentioned you, is possible with the tower crane.

And you can place the crane very close to the structure or even inside the structure at the construction that will help you to have a better working range. As wide operating radius, unlimited

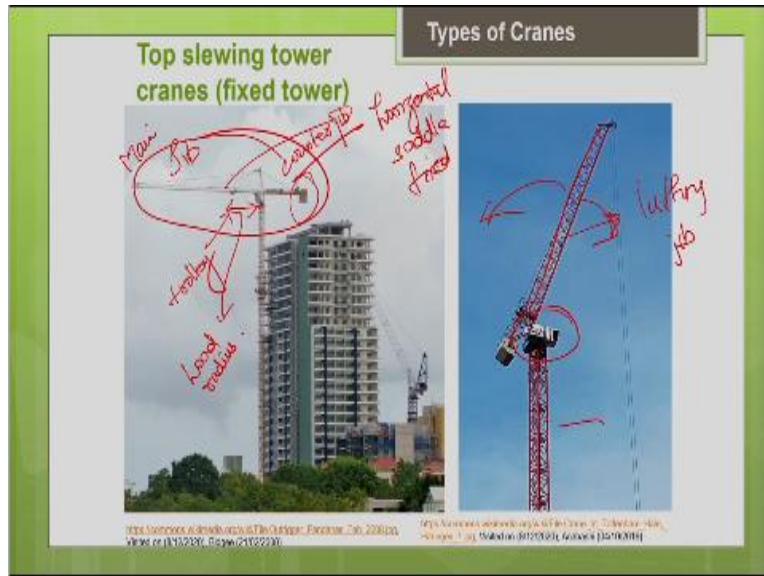
height capability, these are all the merits of the tower crane. So, basically the tower cranes mobility will be limited. Most of the tower cranes which you commonly see are only static tower cranes. They do not move.

So, where you decide the location of the tower, we should be very careful in deciding its location because that is only going to decide your working range possibility. So, the boom length determines your covered area. So, other than the static tower cranes, you also have the travelling tower cranes like crawler mounted or rail mounted.

In certain project sites where you need to mobilize, where you need to have the mobility of your tower crane to various locations within your site, say, they prefer to have the rail track laid and we can have the tower crane moving over the rail track. So, sometimes, the cost of erection and dismantling of the tower crane is going to be very high when compared to the cost of the rail track. So, that is why in that case they go for the rail mounted tower crane. So, that they can reduce the cost of erection, dismantling.

The demerit is low lifting capacity when compared to mobile crane because it is lifting a great height. So, generally the lifting capacity will be lower for the tower cranes when compared to the mobile cranes which are operating from the ground and the mobility is also mostly as I told you, they are mostly static; their mobility is limited.

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So, based on the method of slewing, so, you can classify the tower crane into top slewing tower crane and bottom slewing tower crane. In top slewing tower crane as you can see the picture, you have the turn table or the slewing ring at the top. The tower will be fixed. The tower is fixed that is not going to slew only the top portion your turn table, your jib, this is your main jib and this is your counter jib.

This is your main jib which carries the weight. Here, you can see the trolley. So, this trolley, you can travel along the jib. It can move or travel along the jib that is how you can vary your load line and the load radius. So, by this trolleying, you can vary the load radius. So, basically, the top portion will move. The top slewing tower, you can see that the turntable is at the top, the operator cab and the main jib, the counter jib, everything will slew but the tower will be, the vertical tower is fixed.

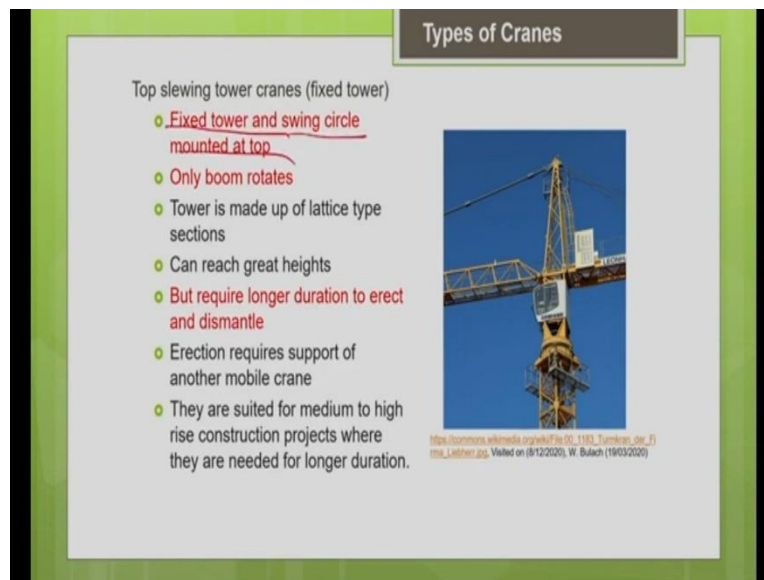
So, and you can see that it is properly braced to the structure at regular intervals as I told you. From the safety perspective, we have to brace it to the structure to transfer the load to the structure and you can see that in the counter jib, you have the counterweights to balance. Also, you have the counterweights at the base also. For balancing the moments, you need to put the counterweights in the counter jib as well as at the base.

So, basic thing is your top slewing means the top portion the entire top portion will rotate. It can give you 360-degree slewing. So, here the jib is fixed. This is kind of horizontal jib. We call it as

horizontal jib or saddle jib or fixed jib. That means you cannot change the angle of inclination of this jib but here, this one is called as a luffing jib. That means you can change the angle of inclination of the boom.

You can change the angle of inclination of the boom that is how you change the load radius in this case. So, but both the cranes are top slewing here. The turntable is at the top and only the top portion will slew. The tower will be fixed.

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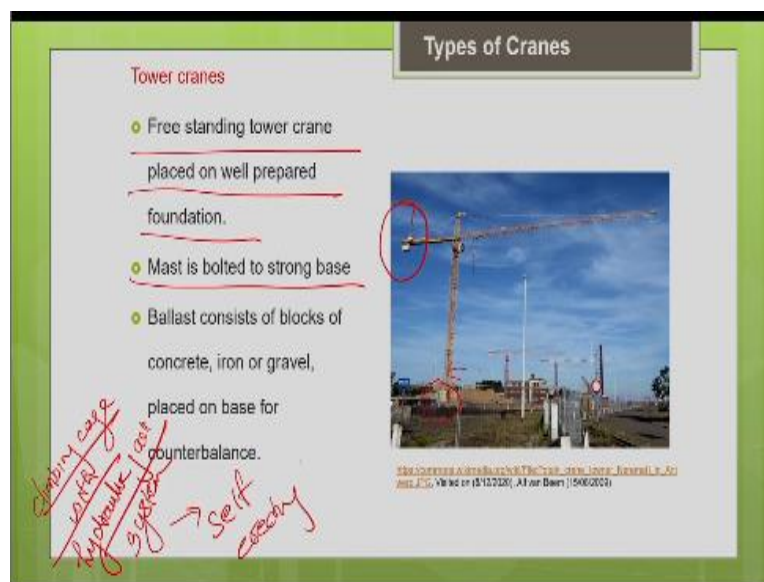
So, top slewing tower cranes has fixed tower and a swing circle mounted at the top. You have the turntable at the top. Only the boom will rotate. Your turntable, your operator cap, boom that means your main jib and the counter jib will rotate and the tower is made up of lattice type sections. I hope, you already know about lattice type sections. You can see the steel pipes connected. So, these are lattice boom sections.

They can reach great heights. Generally, these top slewing cranes are used for greater heights. The mobilization of the crane to the project site, erection and dismantling takes more time for this lattice boom cranes. That is why if you need this crane for a longer duration of the project site, it is going to be economical. It requires longer duration to erect and dismantle and for the erection of this crane, we need the support of another mobile crane.

Another mobile crane is needed for erecting and dismantling this crane. So, they are generally suited for medium to high-raised construction projects where they are needed for longer duration. Longer duration, this can be justified. The erection cost, dismantling cost, mobilization cost can be justified if you need the crane for a longer duration at the project site. So, another important thing to be noted is all these tower cranes should have a proper foundation.

You should have a proper foundation. You should design its foundation very carefully, heavy reinforcement.

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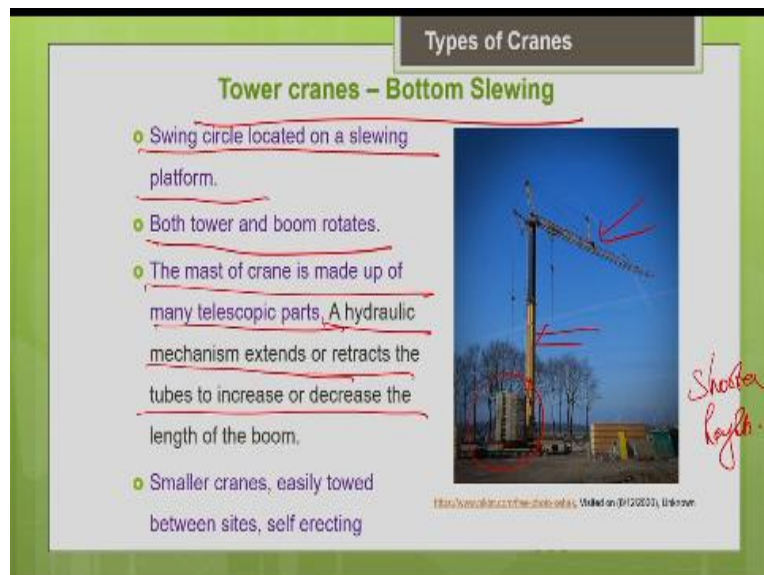
So, that the load can be transferred through the travel to the foundation. You should go for heavy foundation and the tower sections will be bolted on with collars and external bolts to the foundation. You can see that. That is what is summarized in this slide. The free-standing tower crane is placed on well-prepared foundation. The mast is bolted to the strong base and you should put the appropriate counterweights for the stability of the crane.

The counterweight is at the counter jib at the top as well as at the base. So, what are the common counterweights we use? Generally, the blocks of concrete, iron or gravel. So, they are placed for the counterbalance for the resisting moment. So that, your overturning movement can be balanced with this resisting moment. So, nowadays, we have even for this top slewing crane and we have this climbing cage.

Climbing cage or climbing collar with hydraulic jack system. So, with that facility in modern cranes even if it is top slewing tower crane, the erection is made now fairly easy because with the climbing cage crane without much assistance from another crane, they are self-erecting in nature, self-erecting. So, we will discuss about the erection of this tower crane with the climbing cage later.

So, but what you need to know is nowadays, in the modern tower cranes even if it is top slewing, it comes with the climbing cage or the climbing collar which helps you to do the self-correcting process which is relatively easier and faster.

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Now, let us discuss about the bottom slewing tower crane. So, in the bottom slewing tower crane, you can see that the slewing ring, the turntable is at the bottom. So, the slewing circle is located on this slewing platform. Here, the entire structure will rotate that means tower will rotate and the boom will also rotate but you can see that there is no counter jib and counterweight is on the top. All the weights are placed at the base only.

So, these are generally smaller cranes because as the tower itself rotates, you cannot brace it to the structure. So, if you want to go for greater height, you have to brace it to the structure. You have to get the support from the nearby structure. For the stability of the crane, for a free-standing height

of greater than say, 120 meters, we have to definitely go for brazing to the nearby structure but since the tower is also rotating, it is not possible to have the brazing with the nearby structure.

Hence, there is always a height limitation for this particular type of bottom slewing tower crane. So, these generally are designed for shorter heights only. They are designed for shorter heights but the main advantage is, it can be easily mobilized to the site because there are many the hybrid varieties available like you can easily fold it and take it on the public highways or foldable type or telescopic type where you can just extend or retract the length of the boom.

All these provisions are now possible which facilitates see, easy mobilization and easy erection and dismantling. So, that way this is going to be very easier if you need the crane for a shorter duration at the project site, this will be the right choice. So, in this case, both the tower and the boom rotate, the mast of the crane is made up of many telescopic paths. A telescopic model is also available.

With hydraulic jack mechanism, you can either extend or retract the tubes to increase or decrease the length of the boom. So, you can increase it or decrease it with the telescopic mechanism as we discussed earlier for the telescopic boom crane, the same way. So, these are generally smaller cranes, easily towed between the sites and they are self-erecting in nature. So, their mobilization and erection are very easy when compared to the top slewing tower crane but the demerit is, there is a height restriction.

You cannot go for height beyond 100 meter or 120 meters because beyond 120 meters, we need support from the nearby structure that cannot be done for the rotating tower.

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Tower cranes – Bottom Slewing

- Cannot be braced to permanent structure because of revolving base. So service height is limited.
- Bottom slewing models are suitable for shorter service duration and low rise buildings.



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So, that is what is discussed here. It cannot be braced to the permanent structure because of the revolving base. So, the service height is limited. So, bottom slewing models are suitable for shorter service duration and low-rise buildings. For low rise buildings, you can generally go for this particular model.

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Types of Cranes

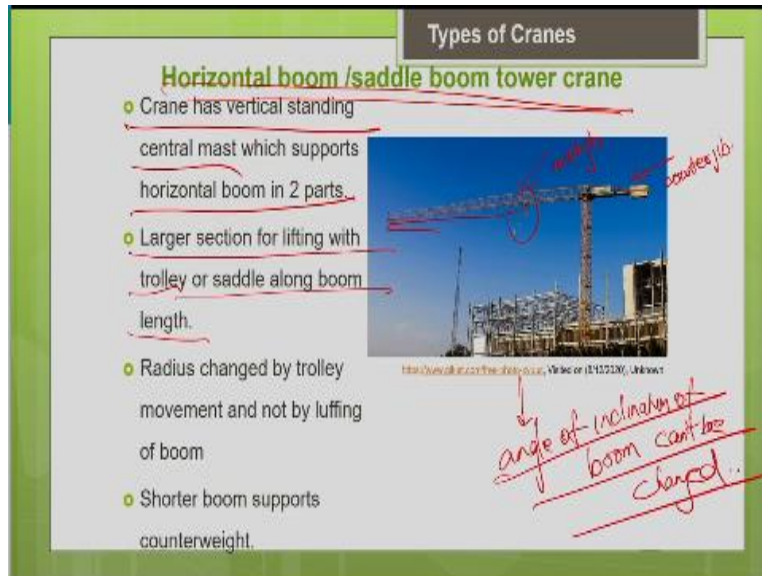
Bottom slewing tower crane



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This is again a picture of the bottom slewing tower crane.

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So, next is a horizontal boom or saddle boom tower crane. So far, we have discussed about the classification of the crane based on the method of slewing, top slewing and bottom slewing. Now, we are going to discuss the classification based on the type of the boom. As I mentioned earlier, we have horizontal boom or saddle boom where the boom is fixed, you cannot change the angle of inclination of the boom. Angle of inclination of boom cannot be changed in this case.

So, this is called as a main jib where you carry the load and this you call the counter jib where you put the counterweights and the counterweights are also at the base as I mentioned earlier. So, you can see that the crane has a vertical standing central mast; which support a horizontal boom in 2 parts. One is a main jib; other one is a counter jib. The largest section for lifting with the trolley, you can see the trolley here so, or the saddle along the boom length that is called as a main jib. You can change the load radius by the trolleying action.

You can move this trolley and thereby, you can change the load radius but you cannot do the luffing operation or change the angle of inclination of boom cannot be changed. The shorter boom that is a shorter jib supports the counterweight. As I mentioned earlier, you have to design the proper foundation for the tower crane.

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Types of Cranes

Horizontal boom /saddle boom tower crane

- Resistance to overturning from load or wind pressures is transferred through tower to foundation.
- Maximum wind speed, crane is designed to withstand under operating conditions is 72 kmph (IS 14467: 1997, ISO 4302: 1981)



Lifting capacity of crane → wind speed.

It is very important because your resistance to overturning from load or the wind pressure everything is transferred through the tower to the foundation. So, particularly for the free standing tower cranes, you should be very careful with the foundation because the entire load is going to be transferred through the tower to the foundation and also, know that the lifting capacity of the crane depends upon the wind speed.

So, generally, when the manufacturer gives the rating, the load rating for the particular crane, he assumes certain conditions that say, for example, mobile crane, he assumes that the surface is level. If it is going to be tire mounted, he will assume that you are going to use outriggers in completely extended form and the surface is going to be level and the air is going to be calm.

So, assuming these conditions only, he would have given the actual rating of the crane but if in your project say, the conditions are going to be different from these ideal conditions then you have to reduce the lifting capacity accordingly. Say, for example, if the surface is not level, then we have to reduce lifting capacity. Say, if it is going to be tire mounted crane; if you are not going to use the outriggers, then you have to reduce lifting capacity.

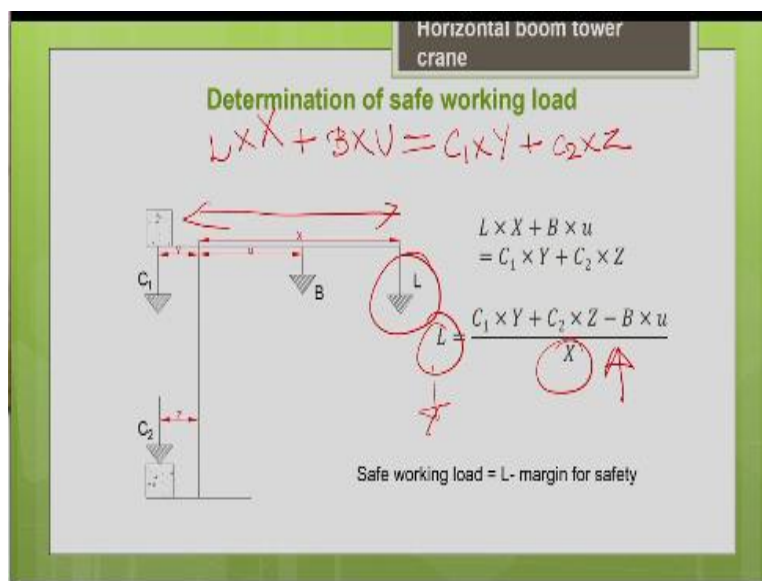
Say, if the wind speed is going to be high, according to the wind speed, the amount of lifting capacity should be reduced in a proportional manner. So, how much reduction that is guidelines would have been given by the manufacturer? So, the wind speed also should be taken into account

when you design the lifting capacity of the crane that is very important because it adds to the overturning movement.

So, as per the ISO code, we also have the ISO code where the regulations are given. The maximum wind speed, the crane is designed to withstand under the operating conditions is 72 kilometre per hour. So, beyond this, we are supposed to stop the operation of the crane. So, many of the crane accidents happens because of the high wind speed. When the crane operation is continued; when the wind speed is high, many accidents are reported to have occurred.

So, that is why we should note the lifting capacity of the crane according to the wind speed and if the wind speed is very high, you should stop the operation of the crane and when the wind speed is high, you should not apply the brake. You should allow the boom to swing in the direction of the wind. We should release the brake and we should allow it to slewing in the direction of the wind. Otherwise, it will result in the damage of your breaks.

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Now, let us see how to determine the safe working load for the tower crane? This is horizontal boom tower crane. So, you can see, we have to just equate the overturning moment to the stabilizing movement to find the safe working load. So, what is the overturning moment here? The load the boom is carrying, here, you can see L into the distance between the load line and the fulcrum point is X .

L into X plus the weight of the boom is B and the distance from the centre of the boom to the point of fulcrum is u. So, these are the thing which adds to the overturning moment because I have not taken the wind load. Equal to the stabilizing moment, the resisting moment is from the counterweights. So, one counterweight is in the counter jib. Other one is at the base. So, C 1 is the weight of counterweight into the distance to the point of fulcrum Y plus C 2 is the counterweight at the base C 2 into distance Z.

$$L \times X + B \times u = C_1 \times Y + C_2 \times Z$$

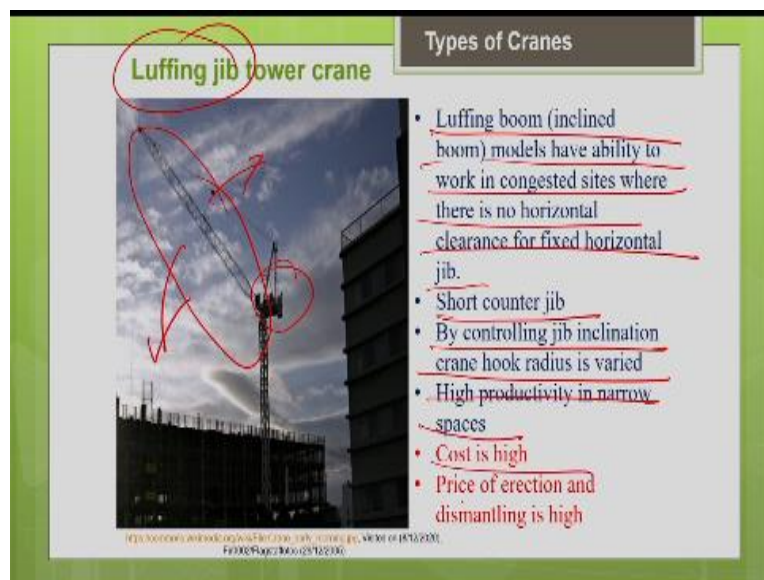
If you simplify, you will get the L. So,

$$L = \frac{C_1 \times Y + C_2 \times Z - B \times u}{X}$$

So, you can note that as X increases, as the radius increases, your lifting capacity reduces. As the radius increases, your lifting capacity releases. So, that is why at minimum operating radius, your lifting capacity will be more. At the maximum operating radius, your lifting capacity will be less because the stability of the crane is disturbed.

Stability of the crane is affected at higher operating radius when the load line is near the centre of axis of rotation. When the load line is near the centre, you can say that the crane will be more stable. So, lifting capacity is more. When the load line is away from the centre that means; when the radius is more, your stability will be less. So, the lifting capacity will be less.

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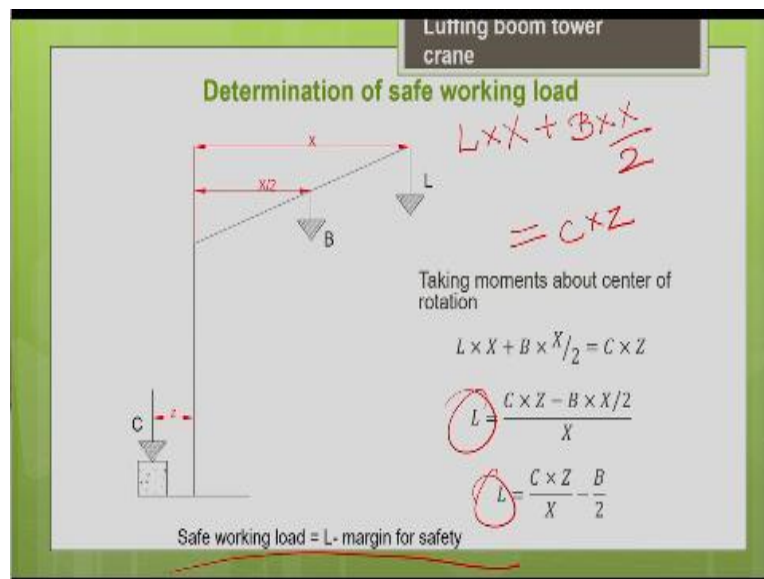


So, we have discussed so far, about the horizontal jib or the saddle boom or the fixed jib crane. Now, we are going to discuss about the luffing jib tower crane. So, luffing jib as the name indicates, you can change the angle of inclination of the boom. You can change the angle of inclination of the boom accordingly you can change the operating radius. So, when do we need this crane?

Basically, when you are working in congested spaces; when you are working near already existing building nearby structure is there; where the fixed boom will not have the sufficient space to move about. When there is a restriction in the space availability, then we have to go for the luffing boom. Luffing boom or the incline boom models are the ability to work in congested sites where there is no horizontal clearance for the fixed horizontal jib and you can note that it will have a shorter counter jib.

The counter jib is shorter. By controlling the jib inclination, the hook radius or the load radius, you can vary. Particularly in narrow spaces, this will give you higher productivity but the cost is high. The erection and dismantling cost are also high for this particular crane.

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Now, let us see how to determine the safe working load for the luffing boom tower crane. The same way to equate the overturning moment to the stabilizing moment.

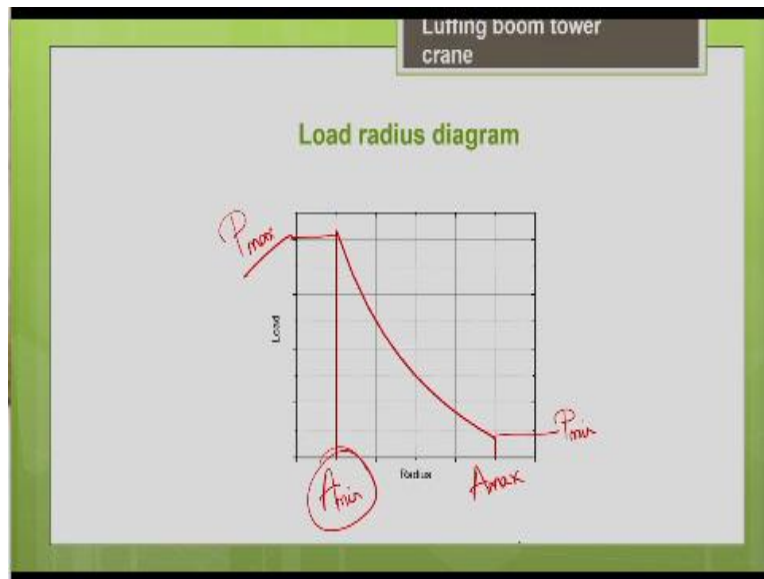
$$L \times X + B \times \frac{X}{2} = C \times Z$$

So, to find a safe working load from this L, you have to detect the margin for safety. According to the guidelines, you have to detect the margin for the safety.

$$L = \frac{C \times Z - B \times \frac{X}{2}}{X}$$

$$L = \frac{C \times Z}{X} - \frac{B}{2}$$

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So, if you plot the load radius diagram, you can see that when the radius is maximum say, when the, here, this is minimum radius, this is maximum radius. When the radius is maximum, the load is, the lifting capacity is minimum. When the radius is minimum, the lifting capacity is maximum. You can note that. So, with increase in operating radius, you can see that the lifting capacity gets reduced.

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