Construction Methods and Equipment Management
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Lecture - 18
Lifting Equipment – Cranes (Part 1)

Hello, everyone. I welcome you all to the lecture 18 of this course, construction methods and equipment management. So, in this lecture, we are going to discuss about the lifting equipment specifically about the cranes. So, in the last lecture, we discussed about the pile hammers, the different types of pile hammers and how to select the pile hammer according to the soil type and according to the pile type. We have discussed about that in the last lecture. So, let us look into the outline of today's presentation.

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So, today's presentation will be discussing about what is the basic lifting mechanism of the crane. What are all the different types of crane motions possible and how to classify the crane particularly the mobile crane with respect to its mounting and with respect to the boom type? So, we are going to discuss about the different crane configurations so, in this lecture and also, we will see how to determine the safe working load for a mobile crane.

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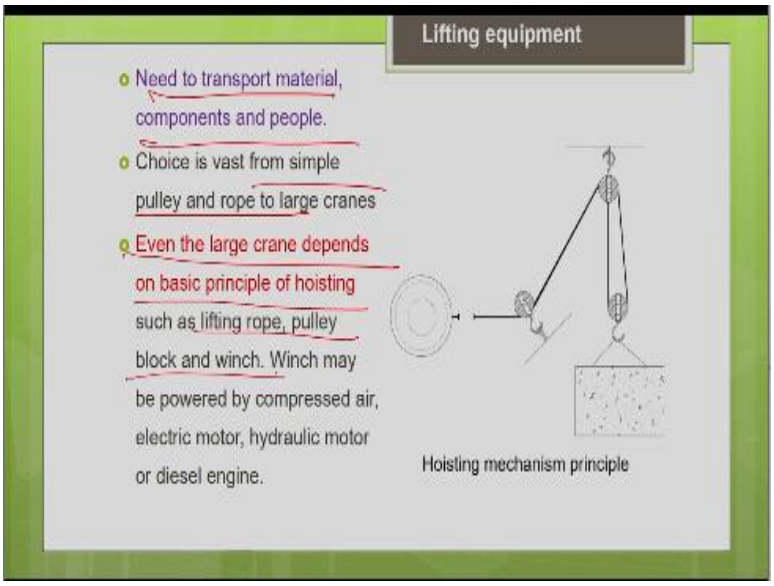

So, basically, the need for the lifting equipment as everyone knows, we need lifting equipment at the construction project site to transport material components and people. So, you may have to transport the concrete to a particular floor level or you may have to transport the precast the components to the particular floor level or you may have to transport the people or you may have to even transfer some smaller machines to a particular height.

So, for all these things, we need lifting equipment. So, there are different options available ranging from a simple pulley and rope mechanism to the complex cranes, larger cranes, we have lot of options available but one thing we have note that here is even in a larger crane, the basic lifting mechanism is going to be same only. So, even in the crane, you have the same, the pulley rope and the winch mechanism only for lifting.

I hope everyone remembers what this means which is nothing but a you have a rotating drum rotated by a motor. So, on the drum, you can see the rope winding over the drum. So, with this rotating drum, I can either pull in or pull out the rope. So, this is a common winching mechanism. We use most of the lifting machines. So, the same mechanism is used in crane also. So, even the large crane, depends upon the basic principle of hoisting such as lifting rope, pulley block and winch.

So, the winch may be powered by either compressed air or electric motor or hydraulic motor or diesel engine whatever.

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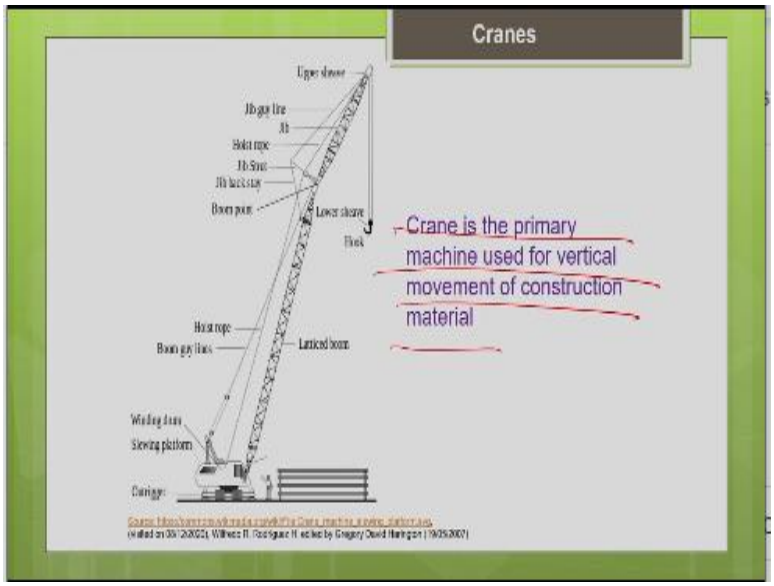

So, as everyone knows nowadays, crane is a primary machine used for vertical movement of the construction material. So, for all the high-raised buildings, multi-storage buildings and big infrastructure projects, it is impossible to implement the project without a crane. So, we have become more dependent on cranes nowadays. So, crane is a very commonly used machine. So, we need to learn about the cranes.

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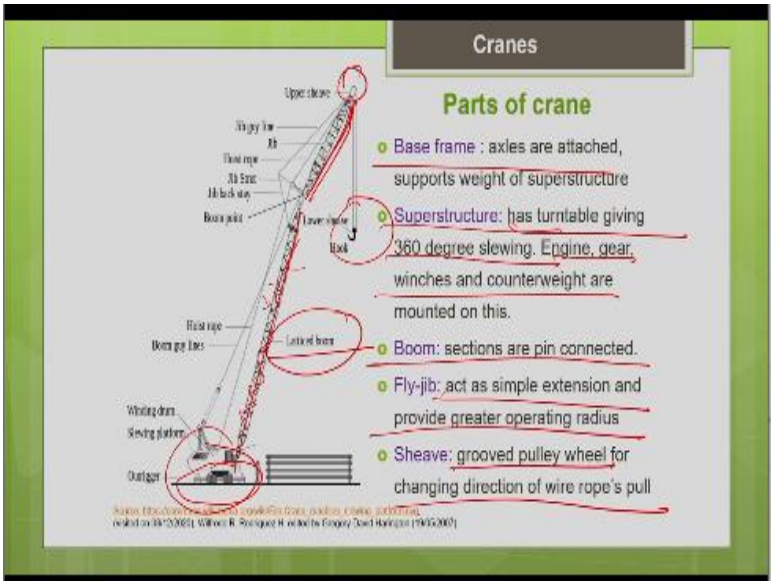

So, what are all the basic operating parts of the crane? You can see starting with the base frame and base frame is nothing to that only the axles of the crane are attached. So, the axles are attached to the base frame and this base frame has to support the superstructure. So, what will be the components of the superstructure? Your superstructure will have your slewing platform or the turntable which can rotate to 360 degree and it has the operator cap, then the counterweights, then the winch, your gears, engine, all these things, boom, everything forms a part of the superstructure.

So, the superstructure is a turntable giving 360-degree slewing, engine, gear, winches, counterweight, all are mounted on the superstructure. Then you have the boom. There are different types of boom. Here, what we are seeing is lattice boom. Lattice boom is nothing but you can see, steel pipes are connected. You can see, the hollow steel pipes are connected to each other.

So, we can see lot of voids or spaces between the steel pipes. So, it is not a solid boom because of these voids and between the pipes so, this boom is likely to be more lighter in weight. Lattice booms are lighter in weight. So, what is the advantage of going for lighter weight booms? So, basically, your crane has to lift not only the load but also the boom. The crane is going to lift its boom also.

So, if the boom is going to be heavier, in that case, lifting capacity will be reduced. So, if the boom is going to be lighter, in that case, it provides you for additional lifting capacity. You understand. So, basically, the crane has to lift the load as well as its boom. So, it is preferable to go for lighter boom. So, that you have the provision to lift a heavier load. So, if you are going to use a heavier boom, then your lifting capacity is reduced.

So, you can see all these sections are pin connected. You can see, it is pin connected. So, this is your boom. This is your fly jib. So, this fly jib serves as an extension for the boom. To have an external working range, I can go for a fly jib. So, fly jib acts like a simple extension and provide greater operating radius, greater working range. So, next is your sheave. Sheave is nothing but a grooved pulley wheel for changing the direction of the wire rope pull. So, these are all the basic parts of the crane.

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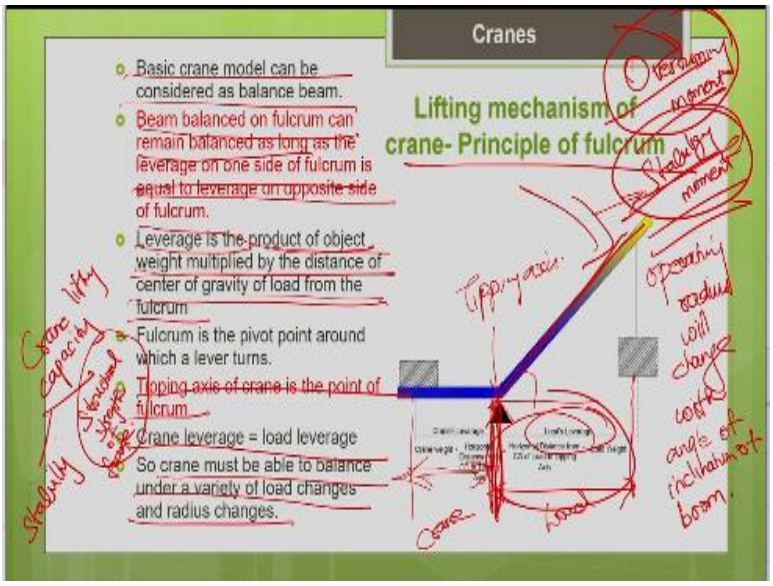

So, let us look into the lifting mechanism of the crane. What is the basic principle of lifting mechanism adopted in the crane? It is based on the principle of fulcrum. So, your basic crane model can be considered as a balanced beam. The similar to the balance beam model, you can consider your crane model also. So, I hope you remember about the balance beam and the principle of fulcrum which you might have studied during your schooling.

So, what is this principle of fulcrum states? For the beam to be in the balance condition, deliveries on both the sides of the fulcrum should be equal. So, what is this leverage? Leverage is nothing but the product of the object weight multiplied by the distance of center of gravity of the load from the fulcrum. So, the same similar to the beam, I can model the crane also. So, here also, I am going to apply the principle of fulcrum and balance this model.

So, I have to balance the two leverages here. One is the load leverage and other one is a crane leverage. So, what is the point of fulcrum here? Your fulcrum point is your tipping axis. Your tipping axis of your crane is your point of fulcrum. Now, what is contributing to the load leverage? So, whichever results in the overturning of your crane, say the load which your crane is actually lifting.

So, that contributes to the load leverage and similarly the weight of the boom also contributes to the load leverage, wind load, everything should be considered in the lower leverage and not only

that the accessories which are used for lifting, the sling weight, the pulley block, the sheave, everything should be considered as a part of the load leverage. Now, coming to the crane leverage, what is the way to consider?

You consider the self weight of the crane excluding the weight of the boom but including the counterweights. So, that will be the weight which you consider under the crane leverage. Now, what is basically leverage? It is a product of object weight multiplied by the distance of center of gravity of the load from the fulcrum. So, your object weight multiplied by the distance from the center of gravity of the load and the fulcrum.

Fulcrum is nothing but your tipping axis. Similarly, your crane leverage is nothing but your crane weight, your crane weight multiplied by the horizontal distance from the center of gravity of the crane to the tipping axis. So, these 2 leverages, this is your load leverage; this is your crane leverage, these two leverages must be balanced for the stability of the crane. So, this is the basic principle of the fulcrum which you apply in the, even in the larger complex cranes also.

So, this is what is discussed in this slide. Let me summarize. Being balanced from the fulcrum can remain balanced as long as the leverage on one cell of fulcrum is equal to the leverage on the opposite side of the fulcrum. So, you know how to calculate the leverage. So, in this case, your fulcrum point is nothing but your tipping axis. Tipping axis of the crane is the point of fulcrum. So, you have to balance the crane leverage and the load leverage.

And one thing you have to note that as you change the angle of inclination of your boom, this is a boom, as you change the angle of inclination of the boom of your crane, your load leverage will change accordingly. Your distance will change accordingly. Distance is nothing your operating radius. Your operating radius will change with the angle of inclination of the boom that you have to note it.

As you change the angle of boom, so, either I can increase the angle of boom, angle of boom measure with respect to horizontal. If I increase the angle of boom, what will happen? My operating radius will get reduced. My load line will come towards the center of the crane. So, in

that case, you can see that your lifting capacity will be more. So, as I decrease my angle of boom, what happens? Your operating radius will increase.

So, your load line will move away from the center of crane. So, in that case, you can see that that the lifting capacity will get reduced because the stability of the crane is reduced as the load length moves away from the center of the crane. So, one thing you have to note that your crane must be able to balance for a variety of load changes as well as the radius changes. As you change the radius, your leverage is going to also change.

So, that is why when you do the rating of the crane that is a rating of the lifting capacity of the crane, we have to consider the different leverages possible and you have to think about balancing of the leverages accordingly and do the rating accordingly. So, one basic thing you have to always keep in mind is your crane lifting capacity is governed by 2 main factors. One is your stability of your crane.

Other one is your structural strength of your frame of the machine. So, here we are mostly we discussed so far, only about the stability or from tipping point of view. So, you are over. There are 2 moments acting basically you know that. One is your overturning moment. So, there are 2 moments acting on the crane. One is the overturning movement. Other one is your resisting movement or the stabilizing movement. These are the two moments acting.

What are the things which are contributing to the overturning movement? The load the crane is going to lift, the wind load and even, the weight of the boom, all these things contributes to the overturning movement. So, which is going to be stabilized by a stabilizing moment? What is going to be this stabilizing movement? It is nothing but your self-weight of the crane excluding the weight of the boom and including the counterweights that is going to be the stabilizing movement of the crane.

So, concern about the stability of the crane in that sense, we always try to make sure that the overturning moment should never exceed your stabilizing moment. So, that is what is the main concern so, that is from tipping point of view or stability point of view. So, there is another type

of failure which is possible that is called a structural failure because sometimes, you can see that the boom may break if you are going to load the machine beyond its structural capacity, beyond the structural strength of the boom, the boom itself will give away a break. So, that is called a structural failure.

So, we should also consider the structure the strength of the frame when we do the rating. So, not only the tipping perspective but also from the structural strength perspective, we have to do the rating because structural failure still more serious because a tipping failure when the crane is going to tip at least you will get some warning. The operator can sense that tipping is going to happen when the overturning moment is greater. But the structural failure occurs all of a sudden.

So, that is why we have to make sure that the lifting capacity, I mean the load which are going to appear on the crane, it should be well within the structural capacity of your crane. So, both of the types of failures, we should consider when you do the safe rating of the crane.

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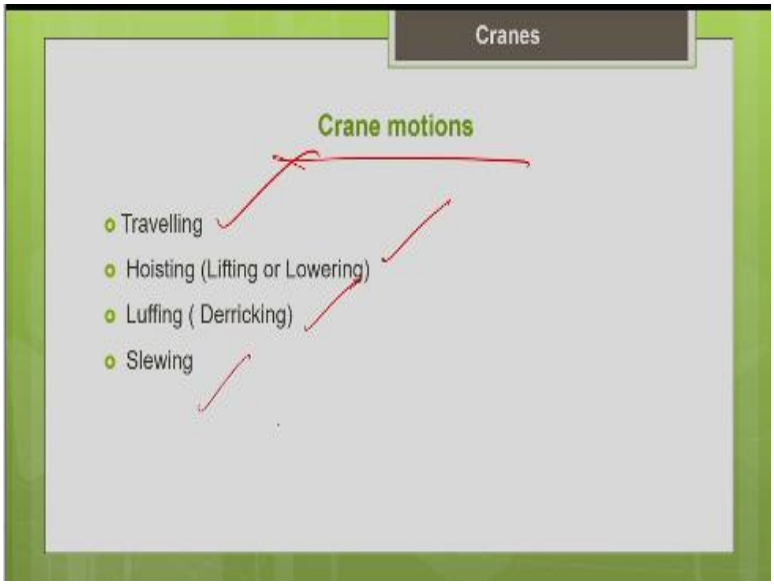

So, what are the different types of motions possible with the crane? One is your traveling, hoisting, luffing and slewing. So, basically, traveling you know for the mobile cranes, everyone knows about the mobility of the crane. Then what is this hoisting? You can either lift the load or lower the load with the pulley and drop mechanism. You can lift it or lower it that is called as hoisting. So, the other motions are luffing and slewing. We will see that.

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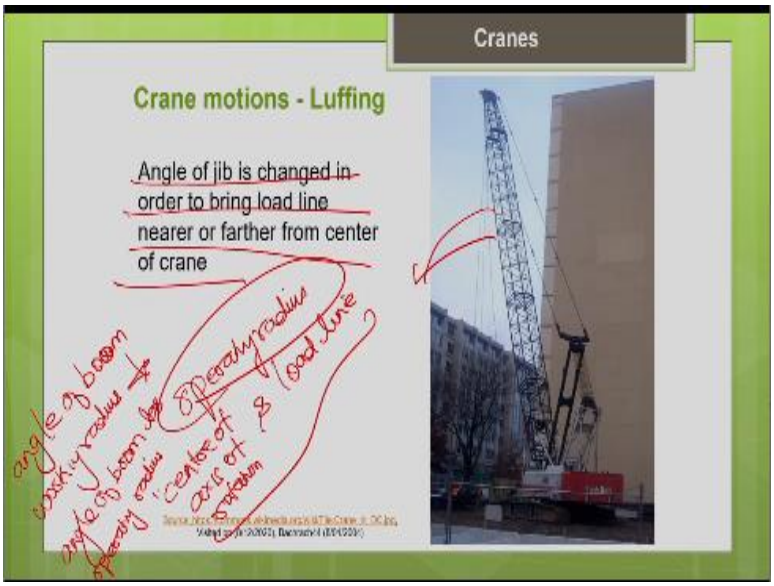

So, what is luffing? Luffing is basically, you are changing the angle of inclination of the boom. You can change the angle of inclination of the boom that is called as luffing of the boom. So, angle of jib or the boom is changed. So, that you can bring the load line towards the center of the crane or you can push the load line away from the center of the crane. So, by changing the angle of inclination of the boom, you can bring the load near to the center of the crane or away from the center of the crane.

So, this is going to change your operating radius that is what we discussed just now. So, operating radius is nothing but your distance between the center of axis of rotation of crane. You know that your crane has a turntable or a slewing ring about which it can rotate the center of axis of rotation, the distance between center of axis of rotation and the load line. So, that gives you the operating radius.

So, by changing the angle of boom, angle of inclination of the boom, I can vary the operating radius. For greater angle of boom, you can see that when the angle of boom is high, measure with respect to the horizontal, when the angle of boom is high, it means that your working radius will be or operating radius will be less. So, when the angular boom is less, your operating radius will be more. That means what?

Your load is away from the center of axis of rotation. So, that is just by changing the angle of boom that is by luffing of boom, this we call it as luffing. I can vary the operating radius. I can bring the load towards the center of the crane or I can make it further away from the center of the crane. As it comes towards the center of the crane, the crane is more, stable you can have a better lifting capacity.

As you move away from the center of the crane, your center of gravity of the system gets shifted. So, the stability of the crane gets affected. So, your lifting capacity also gets reduced. So, this basic thing, you should always keep in mind.

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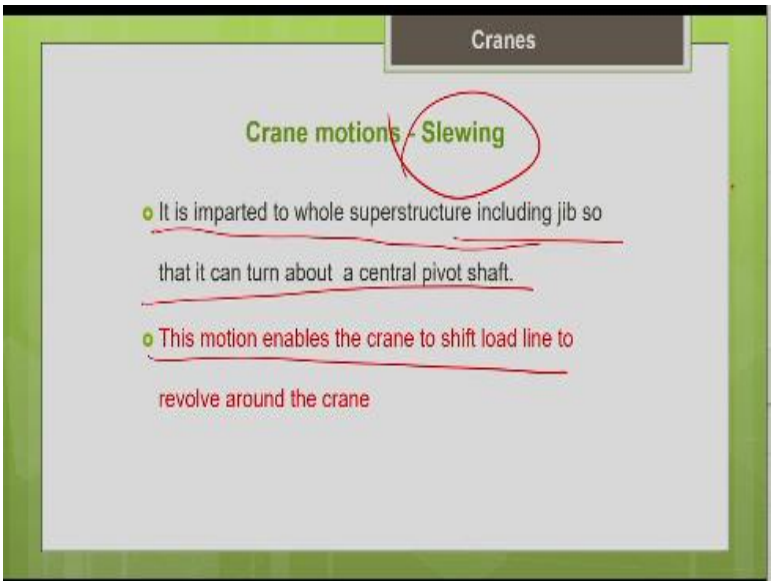

Then about the slewing motion of the crane. So, as you know, you have the slewing ring or the turntable which will give you 360-degree rotation. So, with that I can revolve my load length around the crane. It is imparted to the whole superstructure including the jib. So, that it can turn about a central pivot shaft. So, this slowing motion enables the crane to shift the load line to revolve around the crane.

You can have a complete 360-degree rotation. You can shift the load line to revolve around the crane. So, these are the different types of motions of the crane. So, one is traveling; other one is your lifting or lowering that we called as hoisting, then is luffing or derricking, then slewing.

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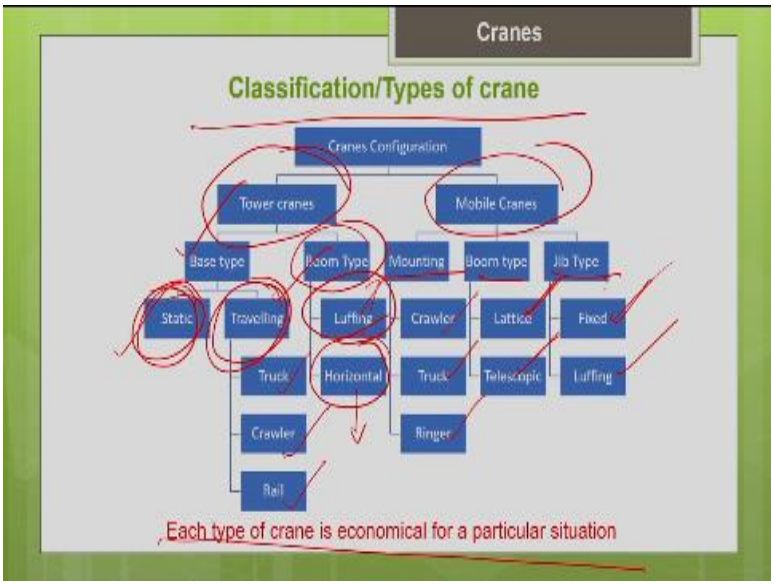

Now, let us look into what are all the different crane configurations possible. Different types of cranes are available. You can classify it from different perspective. So, basically, the crane is classified into 2 important categories based on mobility. One is mobile crane; other one is tower crane. So, when compared to mobile crane, your tower crane has relatively lesser mobility.

The tower cranes can be further classified based upon the base type into static and travelling. That means static means; your tower crane is fixed either fixed to the foundation to the ground or fixed on the top of the tower. So, it is static. Other type of tower crane is traveling, your tower cranes can also be traveling. It can be mounted on a truck or mounted on a crawler or truck or it can be mounted on a rail. Then we call this as travelling tower crane.

In the next lecture, we will be discussing about the tower cranes in detail and similarly, the boom of the crane, you can classify into horizontal boom and luffing boom. Horizontal means the boom is fixed saddle type where I cannot change the angle of inclination of the boom that is called as horizontal. Luffing means, I can change the angle of inclination of the boom. So, similarly, mobile cranes also can be classified based on mounting, boom type and jib type.

So, mounting, you can mount it on a truck or a crawler or a ringer base. Boom type, you can have lattice boom or telescopic boom. Just now, we discussed about the lattice boom. They are lightweight booms. Telescopic or solid booms which are heavier. Then jib type, as you know, jib

is nothing but an extension for the boom. So, this jib can be either fixed or it can be luffing. You can change the angle of jib or it can be fixed.

So, there are different types possible. So, we are going to discuss some of the important types. So, one thing, you have to note that each type of crane is economical for a particular situation. So, I cannot just generalize. For a particular situation only, particular type of crane can be economical. The first type of crane which we are going to discuss is about the lattice boom crawler crane.

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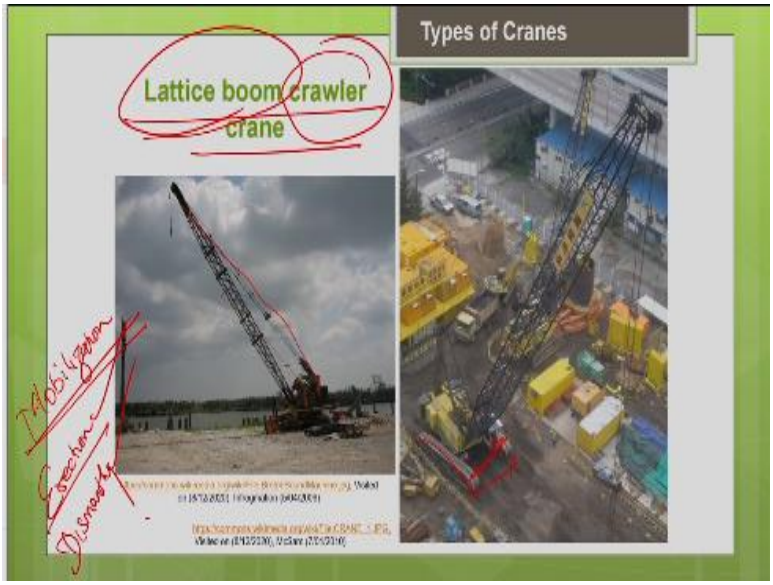

As the name indicates, it is going to be crawler mounted and it has a lattice boom that is what it is called as lattice boom crawler crane. So, what are the advantages of the crawler mounting? You know that already when you go for a crawler or track mounting so, even in very poor underfoot conditions, you can have the mobility with this type of crane and moreover, when it is crawler mounted or track mounted, it has a broader contact area. So, greater tractive effort.

Its lifting capacity is generally higher when compared to tire mounted cranes. So, particularly for heavy lifting capacity, you can go for longer tracks and wider tracks. So, that you can improve the stability and improve the lifting capacity and it can also vary the distance between the tracks. That option is also available in the modern cranes nowadays that is going to have an effect on the stability of your crane.

So, other one is your lattice boom. You can see the steel pipes connected, they are pin connected. You have a lot of voids in between them. These are not solid boom. It is lighter in weight and this boom is you can see, suspended by the cable. So, it acts like a compression member that is to be noted. So, one advantage of lattice boom crawler crane is even poor underfoot condition, it can work.

Since, it is crawler mounted, it can give you very heavy lifting capacity because of lattice boom also, you get higher lifting capacity because of the reduction of the weight of the boom which permits you have additional lifting capacity but what is the demerit of this claim is mobilization. Mobilization is very tough with this crane. Mobilization, erection and dismantling, all this takes more time with lattice boom crawler crane.

It cannot be taken on the public highways. So, you have to dismantle it and take it in trucks or trailers. You may need even 10 to 15 trucks depending upon the size of your crane to mobilize one crawler crane to the project site. So, mobilization cost will be high. Similarly, it will take more time to erect the crane and dismantle it after the job is done. You need the support of another say, truck mounted crane to help in the erection of this lattice boom crane or that lattice boom crawling mounted crane, you need the support of another crane.

So, all these things are the demerits of this crane. So, your erection process and dismantling process may take even more than a week. So, that is why if you need this crane for a longer duration in the project site in that case, it is going to be economical for you. But, if you need the crane only for few hours or a couple of days, in that case, it is not going to be economical. So, that is why I told you every crane is economical only for a particular situation.

Only for a longer duration in a project site, this is going to be economical because you spent a lot for mobilization, erection and dismantling. So, for according to that you should be able to use it for a longer time in your project site, then it you can justify its cost. So, let me summarize what we discussed here.

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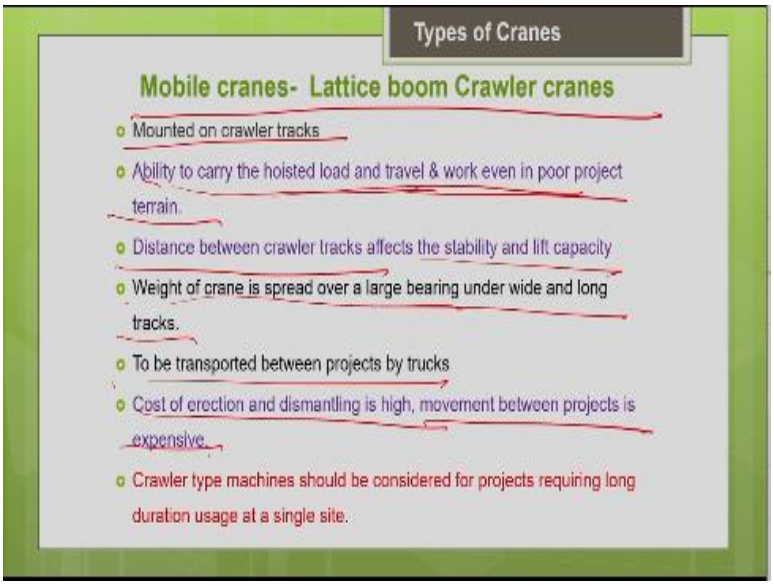

So, your lattice boom crawler crane, it is mounted on the crawler trucks as you know. So, it has the ability to carry the hoisted load, travel and work even in poor project terrain because of the track mounting. You can vary the distance between the crawler tracks which will affect the stability and the lifting capacity. So, the weight of the crane is spread over a larger bearing and the wider and longer tracks.

So, you can go for a wider and longer track. So, that you can have a larger bearing area which will improve the stability and the lifting capacity of your crane. So, the main disadvantage is to be transported between the projects by trucks. So, mobilization cost is high. The cost of erection and dismantling is also high and movement between the projects is expensive. So, this machine should be considered for the projects requiring for longer duration usage at a single site. Only in that case, it is going to be economical.

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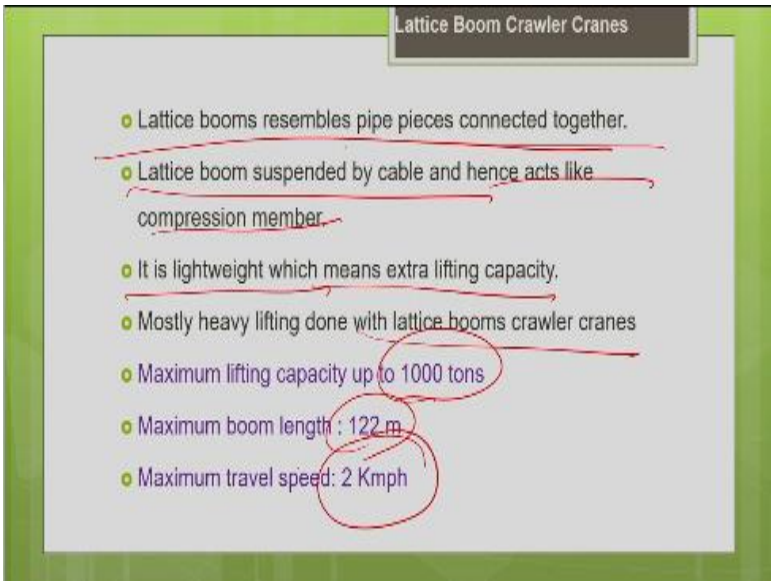

Your lattice boom basically, you know what is lattice boom, it resembles pipe pieces connected together. So, this boom is suspended by cable as you have seen in the picture and it acts like a compression member. The boom is, it is not a solid boom. It is lightweight boom. So, which means you get additional extra lifting capacity. So, whenever you want heavy lifting, we prefer lattice boom crawler cream.

So, you can see that I can go even up to thousand tons lifting with the lattice boom crawler crane that is the main advantage of lattice boom crawler cane. You can have a boom length up to 122 meters but the demerit is a travel speed. It has very limited speed.

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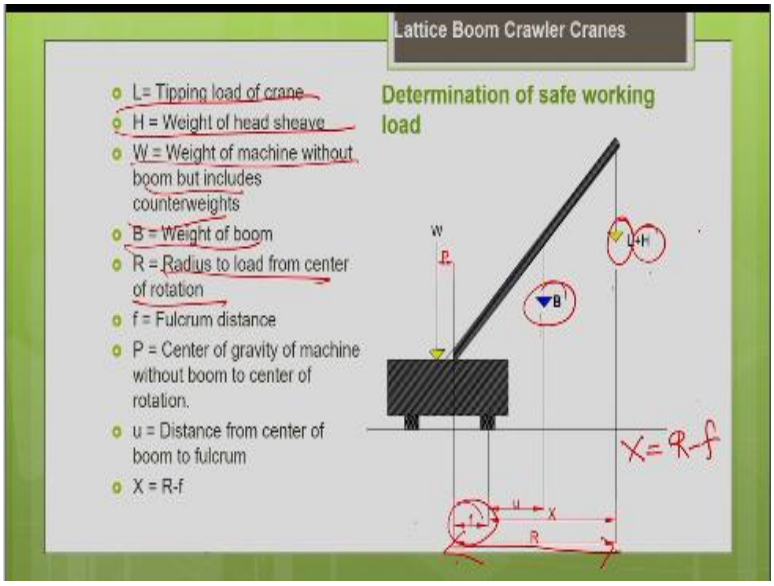

Now, let us see how to determine this safe working load for this mobile crane. So, basically as I told you, there are 2 moments acting on a crane. One is the overturning moment. Other one is your stabilizing moment or the resisting moment. So, we need to balance these 2 moments for the stability of a crane. So, accordingly, only we will choose the counter weights, everything the needle for a particular crane.

So, basically what are the things contributing to the overturning moment? The load, the crane is going to lift. The load, it is going to lift, your wind load, everything, your boom, the weight of the boom, all these things contributes to the overturning moment. So, what is contributing to stabilizing movement? Your self-weight of the crane plus the counterweights excluding the weight of the boom; self-weight of the crane plus its counterweights.

So, we need to balance both for the stability of your crane. So, now, let us see how to find this safe working load allowable on a mobile crane. L is the tipping load of the crane. So, as I told you, when you estimate the lifting capacity, all the weight should be included; your weight of the broom, the weight of the accessories used for hoisting or lifting, the sling weight, the sheave weight, the pulley block, everything should be considered when you estimate the lifting capacity of your crane.

So, L is a tripping load of the crane and H is your weight of the head sheave. You know what is sheave now and W is the weight of the machine. W is the weight of the machine excluding the weight of boom but including the counterweights and B is the weight of your boom. Now, what is this radius, operating radius or working radius? It is nothing but the distance between the center line of axis of rotation of the crane and the load line that is your R.

R is nothing but the distance between the center line of axis of rotation of the crane and the load line that is R radius. And f your fulcrum distance. Fulcrum, you know the point of fulcrum is a tipping axis. f is your fulcrum distance. P is your center of gravity of the machine, center of gravity of your machine without boom to the center line of axis of rotation. This is your P. This is your P distance between the center of gravity of the machine acting point and the center of the axis of rotation of the crane that gives you.