**Design of Offshore Structures**
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**Module - 5**
**Lecture - 2**
**Jack-Up Rigs - Analysis and Design II**

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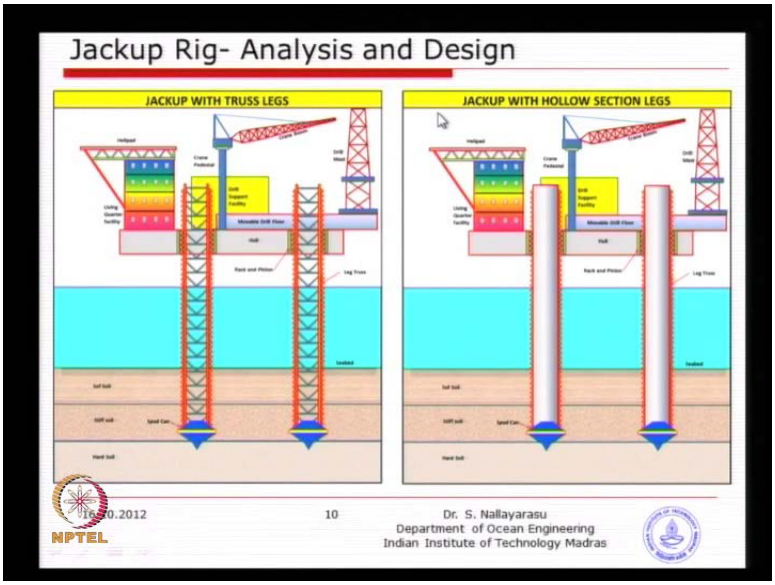


So, we will continue with the discussion that we had on the the jack-up rigs various types. So, you can see from this picture truss versus tubular is only a choice and basically the design will be very similar except here wave load to be more whereas, here is a transparent structure which you might see it is slightly reduced wave loads advantages disadvantages both sides we we have you know basically strength wise tubular numbers will be far better than the truss member here. So, many connections are there. So, you may have to maintain it periodically because of hectic whereas, here there is no such connections.

So, you could just keep adding necessary advantages and disadvantages, but commonly used one is the the truss you know because of the size that you can go whereas, the tubulars you may not be able to go very large like two metre three metre only small vocalised noise jack-ups with spud leg diameter two metre three metre can be used whereas, this legs made of truss is can go as much as six metre eight metre size. So, you

can see almost like this room one of the leg could become something like this quite huge especially the bigger jack-ups.

So, the advantage of the truss legs flexibility in in going size length because if you if you look at this tubular one it all depends on your k l by r ratio I think which you have studied earlier when we are designing the members single-member l by d ratio d by t ratio and kl by r ratio. So, if you look at it there is certain limitation beyond forty fifty metres your diameter will become. So, large that without the internal stiffening you may not be able to really work out. So, that is where the restriction on circular sections though it is easy because fabrication of this is going to be definitely very easy and maintenance very very simple compared to the truss legs with with regards to the design.

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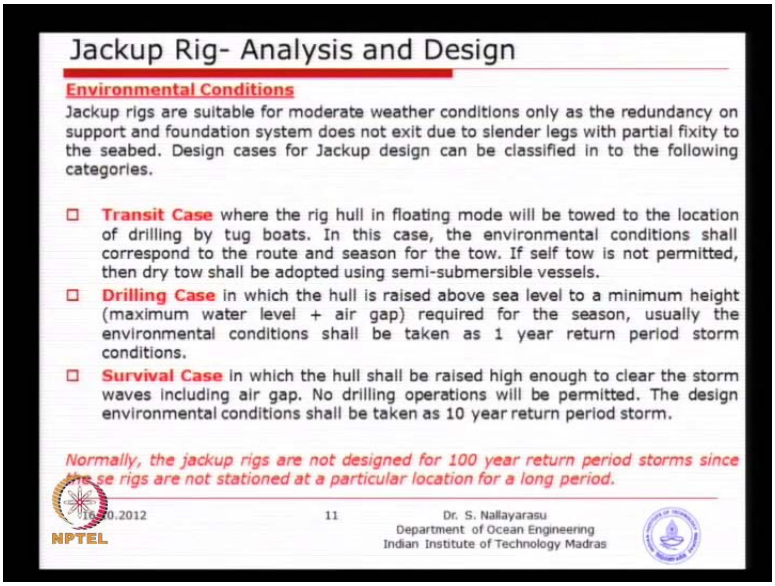


Environmental conditions we just need to understand one important thing this is being a temporary structure it has got three faces the phase during which it is always going from one place to other transits k's where it is going to go through several you know conditions sea state conditions could be different from what it is used to be operating, but of course, we have a choice the some of the jack-up rigs can be towable; that means, you can use a tugboat to tow in floating mode suppose if you want to take the jack-up rig from say north sea you want to bring to here instead of self towing actually you can do one thing you can put it onto a semisubmersible ship and then transport it then offloaded it.

So, by doing this you do not need to design for a severe environmental conditions that you will encounter from north sea all the way down to number one and also the towing operations could be very slow because these jack ups are simple rectangular pontoons or triangular pontoons cannot be towed very fast it may take three months to come that need three months of towing time three months of your loss of revenue instead if you put it onto a semisubmersible ship you can just bring it in fifteen days. So, you could save substantial amount of time and basically do not have to design for all the transit condition; that means, along the route you have several sea conditions which you do not need to design because anyway it is sitting safely on a ship. So, that is where the transit case depends on each time when you're transporting of course, if it is a short tow from say two hundred kilometres then you to re-verify.

So, every time when you are actually using this jack-up for a new location the transit case needs to be verified; that means, you will have to look at the environmental conditions along the route at that time whichever the period and then analyse. So, you'll do a motion response study to see whether the the hull is stable number one and then you will look at the stresses induced during towing operation based on the weight based on the buoyancy and calculate the stresses including the superstructure under hull. So, this transit case is not going to a strong case because you're not going to tow this during a storm for sure you will not take this operation. So, you will select a window period by which you will be having control over the period which you want to tow unless you have a job in a particular country you need to go there in a particular time then you have no choice where you'll go through, but you will design and verify the jack-up within the limits of what was originally designed unless you know it is designed for such a small sea state then it may not be suitable in many cases when you have designed for the survival case.

You know automatically it will qualify for a larger sea state for transit which I think is inherent in the design. So, the second one is a drilling case wherein basically you're going to operate at a particular location and the sea conditions corresponding to that location is to be selected, but how much is the written period you have to select depends on how long the rig is going to be stationed there as I mentioned earlier on most of the time the rig will not be stationed forever it will be three months one year two years. So, depending on that if it is going to be substantial period you may actually select one year

written period; that means, the maximum sea state that is going to occur during one year written period you'll select and then design suppose if you want to station it more you may actually select ten year suppose you your rig is going to be there for two years normally not required because most of the well platforms you may have ten wells fifteen wells each of the well could be drilled in fifteen days you know you're not going to stay there for very long period.

So, typically drilling case is one year written period wave at hope all of you understand what is that written period which we are talking about earlier on hundred years storm condition versus one year storm conditions similarly the survival case in case during drilling unforcing things happen an extreme storm hits the location because hundred year storm also can hit the probability of hitting is one in hundred whereas, the one year storm is definitely going to occur within that one year if you hundred percent stay there. So, basically the survival case we need to look for unforeseen you know the environmental conditions which can occur any time during that one year it can be hundred year storm or it can be ten year storm or it can be one year storm.

So, mandatory that we need to design for ten year written conditions that no drilling operations; that means, you will design the jack-up rig with completed drilling loads plus your one year written period storm conditions wind wave and current or you'll design for ten year written period environmental conditions, but no drilling operations what exactly is the different drilling operations does not take place means there will not be any fluid in the circulation system; that means, mud's can be discharged no live loads no crane operations. So, you have slightly reduced gravity loads, but maximum environmental loads that is the idea behind and this three cases needs to be evaluated for each time when an new site is selected for drilling and transit.

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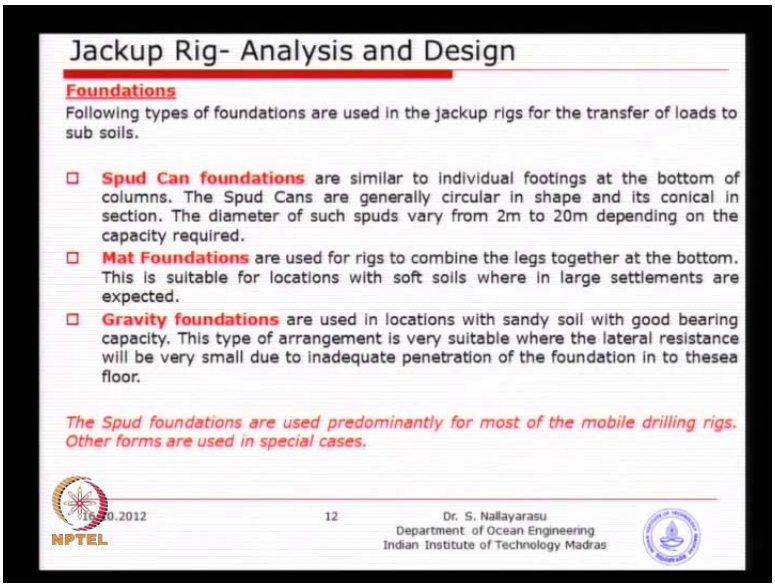


We will just look at the the types of foundations normally used for stabilising the jack-up at a particular location spud can is definitely a predominant size almost ninety nine percent of its jack-ups. Do have spud can type of foundation which is nothing, but a circular shape sometimes rectangular I have seen and basically vocalised noise like a spread footing some of you might have studied foundation design you know civil engineering simple spread footing on a column you know. So, basically just sitting on the seabed and trying to penetrate as long as the bearing capacity is not enough it will penetrate as soon as you get the equilibrium of applied loads and the resistive capacity of the soil it will stabilise and will stop settlement. So, that the idea behind these footing. So, the larger the size you may get bigger capacity.

So, that is where we want to find out what is the size of the spud can is a technical name used in the industry for a simple spread footing foundation for gravity type structures no pile foundations here mat type of foundation is again instead of individuals spud footings if you have three legs or if you have four legs combine all of them and make a larger spread like if you have this room you have four columns individual columns will have individual foundation instead if you make all of them combine together like a floor and that becomes a a mat foundation which is very commonly used for multi-storey buildings in clay type of soils you know.

You were in Chennai you will see many occasions people use spread mat foundations for three storeys four storeys types of structures. So, you just combine all of them all the columns together and make a complete slab of sufficient thickness which can take the foundation pressure from the bottom and just sink it. So, this mat type of foundations is very useful whenever you have very soft clay because you know you allow the soil to squeeze away then the bearing capacity will reduce instead you just make completely make not allow the soil to squeeze away then you will get a better capacity gravity foundations normally not very good in if you have clay type of soil because gravity type of foundation rely highly on the weight of the structure you know you make it heavier and the stability is achieved basically the horizontal stability against sliding rotational stability against overturning.

So, you make it heavier and heavier what happens the structure cannot be moved even if you apply larger horizontal loads due to wave current and wind. So, this gravity foundations do have some amount of embedment into the ground, but not substantially you know like maybe one metre one and a half metre whereas, if you look at the spud can or mat type of foundation they have to go through sufficient depth. So, that it gets enough bearing capacity as well as enough horizontal resistance against sliding and overturning. So, we will see some of the pictures you'll be able to understand easily gravity foundations are very common whenever the soil is very good you know basically the the structure is made. So, heavy that the stability against horizontal and overturning stabilities are achieved by its own weight and the vertical stability is very simple because the soil is good you got enough bearing capacity.

So, that is a type of foundations even it is used for off load platforms you know gravity type concretes structures I think I might have shown some pictures earlier on or I can show you few of them like three or four column structures with large concrete circular structures with a big base which can be ballasted to create the additional weight. So, it'll be sitting straightaway on the seabed with some amount of penetration depending on vocalised noise what is the capacity, but then the stability and overturning is achieved by purely by its own weight and vocalised noise this type of structures are suitable only when soil conditions are reasonably good. So, you will among among these you'll see that the spud can foundation is very common, which we have seen earlier on.

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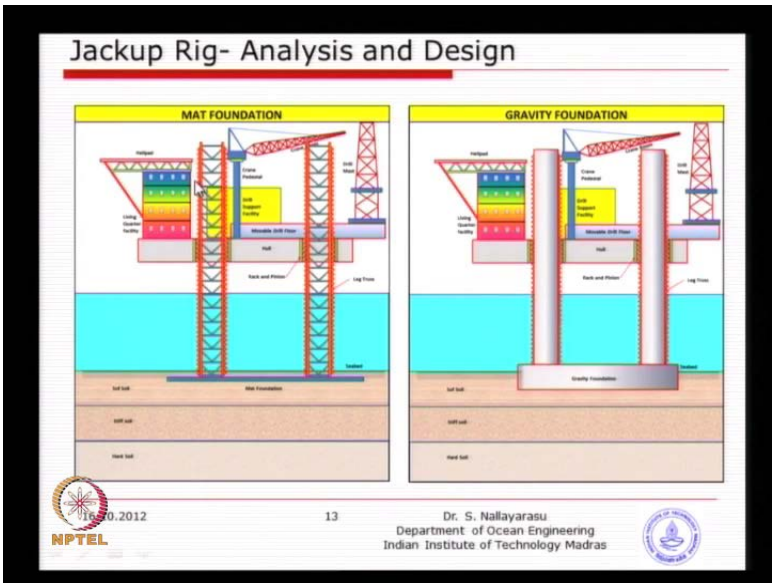


So, this mat foundation and the gravity foundations is typically you could see there is a combined footing cist like a large size footing with only the type of behaviour in in terms of mat foundation its going just bent upwards it is a elastic material characteristics should be used whereas, the gravity foundation it will be assumed as a very rigid because it is very thick number one made of concrete and you know basically it is going to be a rigid body motion rather than the bending type of alias, so you will see that this is the type of structures very rarely used because transportation becomes very difficult unless it is one time structure located for one one particular location for example, fixed offshore platform by concrete structures it is not going to be moved every few months.

So, you construct it and leave it there whereas, if you make it very heavy the ballasting time next time to transport from one location to another location becomes substantial offshore exercise which we really do not want, but they do have I think few of the jack-ups with a ballast is available for I think in Nasik about hundred metres range, where the soil conditions are not allowing any of these rag jack-ups to be used for examples spud can if it is a very hot soil the spud can will not penetrate if the spud can does not penetrate what will happen the jack-up will not be stable for overturning and sliding because it does not have enough fixity into the ground of course, it will have nice bearing capacity vertically, but it will not be very good against sliding and overturning that is why you have to come up with the alternative design of this wherein you'll be able to use, but very few of them the next thing that.

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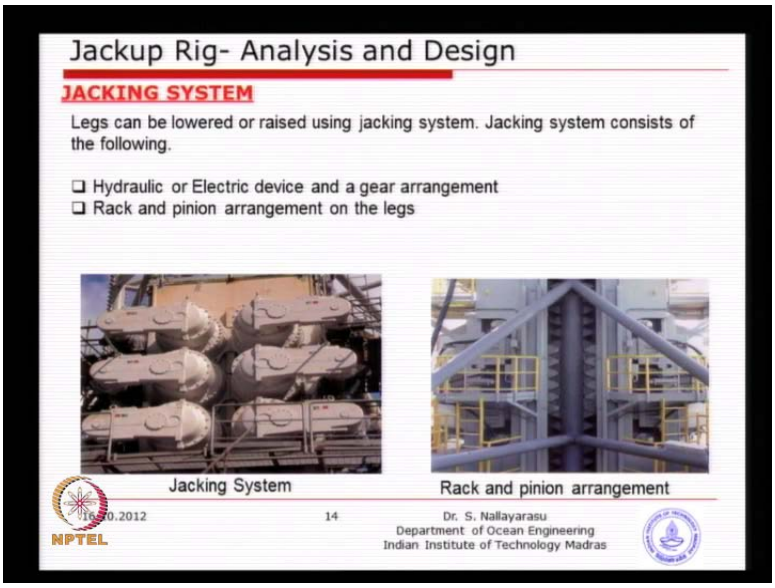


We need to learn about is the jacking system how these things work you know how the jack-up legs are going to be moved up and down vice versa how the hull is going to be moved up and down with respect to a given reference plane. So, you see here the jacking system consist of vocalised noise first the mechanical gear arrangement with electrical devices mostly sometime you do have a hydraulic devices and then the rack and pinion arrangement attached to the one in on the structure side the other one on the mission side. So, you can see these legs attached with the the rack the cut plate into similar to a gear arrangement and also you will see this kind of electric devices which can be rotated only the arrangement needs to be made perfectly correct because you're going to have three legs or four legs each leg will have two sets of this rack and pinion arrangement imagine if one of them go slightly faster or higher than the other legs there will be a racking and there will be definitely a failure of the leg itself.

So, all the motors have to be synchronised. So, that they move together and not only one leg you have to make sure all the other three legs or four legs which are the legs they have to move together you know you make one of the leg go higher than the other leg you automatically create a failure by large bending at the connection between a hull and the leg. So, this is where these missionary become very important because this you're going to do it very often it is not that one time and then every time when you want to setup at one location and move away from that location you're going to use this machinery. So, they have to be hundred percent designed properly dimensional

tolerances is very important it is we were we were talking about I think dimensional tolerance of few millimetres in offshore structures here it has to be even less because you're dealing with machineries moving and and basically have to be thorough control.

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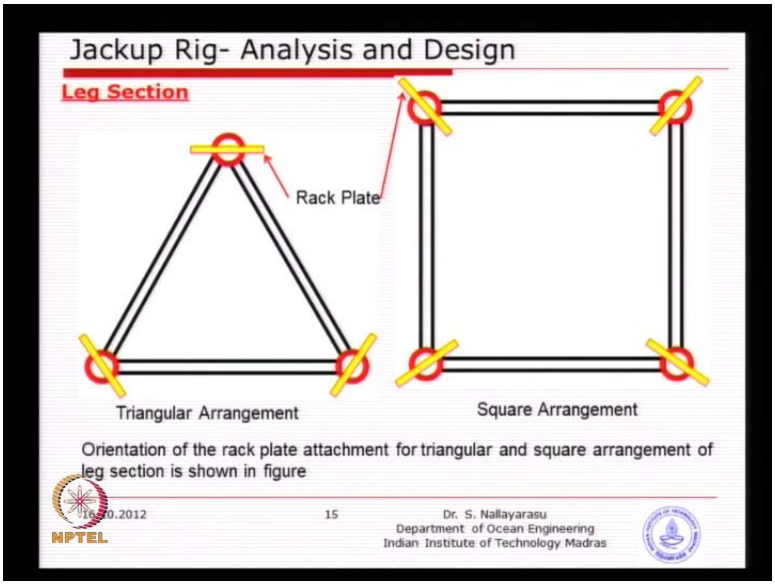


There. So, how it is done for triangular legs normally you you fabricate using tubular members like this and these rack plates are just slotted into the circular sections. So, that you get enough strength as well as low transfer is easier. So, you have three of them slaughter inside. So, if you look from vocalised noise perpendicular to the view you will see something like this.

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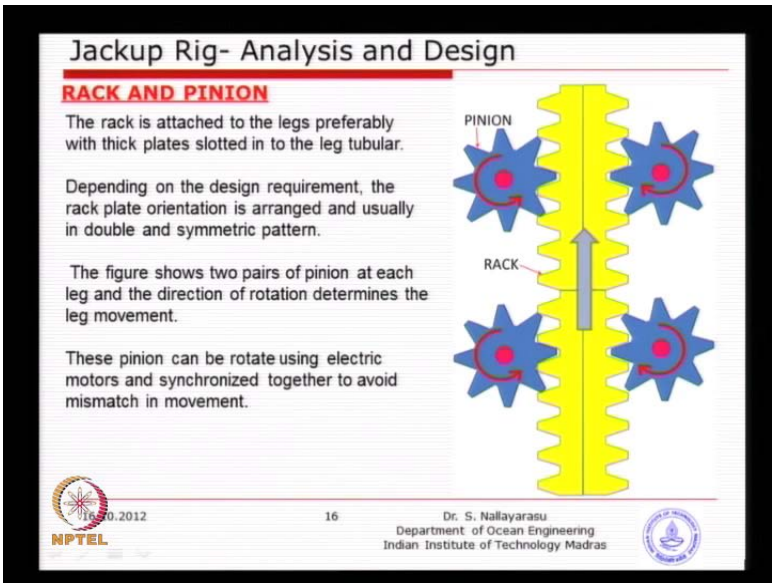


You know the rack plate is I just purposely did not draw the the pipe, but you can see the the yellow colour is the plate and made it into a gear shape arrangement where each location you will have at least four gearboxes with electrical motors attached. So, when you want to move up or down you just synchronise the motors and automatically move or move down vice versa you can actually when the hull is floating legs will be freely moving up and down when the legs are touching the seabed and having sufficient reaction then you can actually move the hull upwards or downwards.

So, basically it depends on which situation, but to both situations these pinion arrangements will be attached to electric drives which can rotate and move upwards. So, the main important aspect in here is the synchronisation of all the electric devices and the all the operations to be at one time together you do not want to have a situation where the racking is going to take place, but actually theoretically speaking we can assume all this, but what if it happens. So, that is why during design process we have to take into account each leg one of the the vocalised noise pipe for example, one of these corner is going slightly higher what will be the stresses induced like codes advice you need to assume at least two inches up down movement. So, one of the location the winch or the electric drives are going two inch higher than the other two what could be the stresses developed on this joint as well as on the members.

So, you need to just though it is hypothetical, but the assumption is if it happens still the legs are safe. So, basically that is the idea behind if it is a square then you will have this kind of arrangement only the drives will be on one side inside there will not be any drives. So, that you will have only one sided motion all depends on the design, but the advantages of the triangular as I mentioned you know basically easy to manipulate and the redundancy is less.

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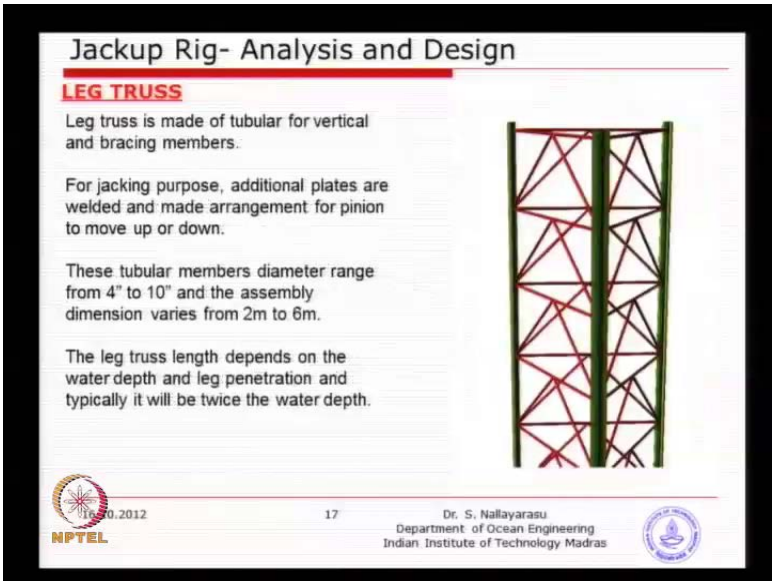


So, this is a typical leg truss which you'll seen in three dimensional arrangement basically which horizontal members with truss members the design becomes very simple like our jacket structure only thing is this is not such complicated it is three legs with several members. So, as long as you can get the design loads on the members of each one of them the design procedure what you have adapted for last two classes which is same procedure only establishing the design actual loads bending moments needs to be by three dimensional analysis and typical sizes of this varies depending on the sizes of the jack-up two metre three metre as much as one of the largest jack-up six metre.

So, almost like half the size of this room you know. So, the leg size tubular members is not going to be very large because you're using a lattice tower. So, you'll see that two inches three inches up to maximum ten inches like three hundred mm diameter.

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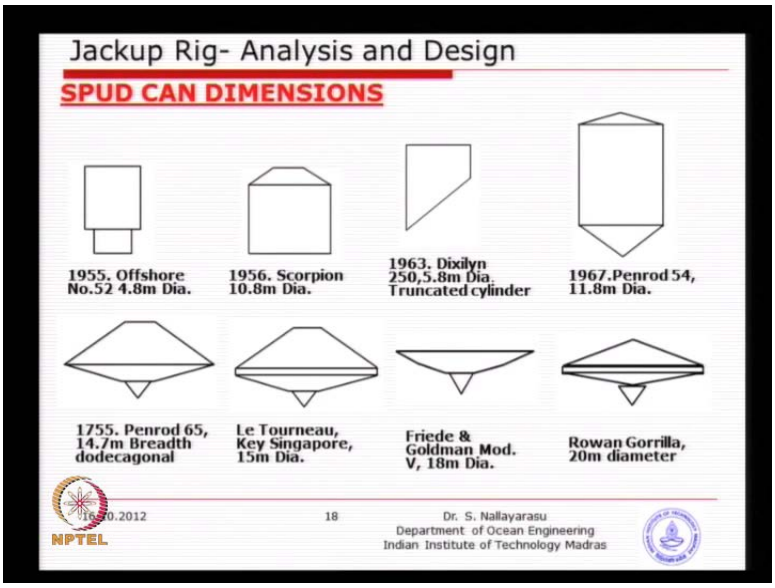


The typical spud ideas what people are been using over the last twenty thirty years can see they started with a simple tubular can just going through the soil to a safe where we were trying to explain the necessity of easy penetration and then easy remover. So, you have a upper cone and a lower cone with a a shape designed in such a way that you enough bearing capacity also can be achieved. So, over a period of time the diameters have been increasing from four and a half to five metre four and a half metres basically quarter size of this room to the size of this room you know if you go to twenty metre at least two or three rooms of this size need to be joined together. So, you can see the size of the spud twenty metre diameter is going to be substantially bigger; that means, it is for the larger jack-ups. So, each one of them has a different applications different types of locations the advantage of this spud can you can change them from location to location for example, when you go to one particular site when the soil is good and the soil conditions are better you do not need to actually use the same spud you may have a fabricated spud can separately for different locations. So, you can bring the jack up to a dried arc reassemble it and take it to.

So, that is the advantages of the spud can foundations where you can replace according to the necessity of course, every time when a jack-up comes to a dried arc you'll do repair work you will do all replacements of mechanical devices at that time you can actually replace the spud also. So, that is one of the thing that normally is done.

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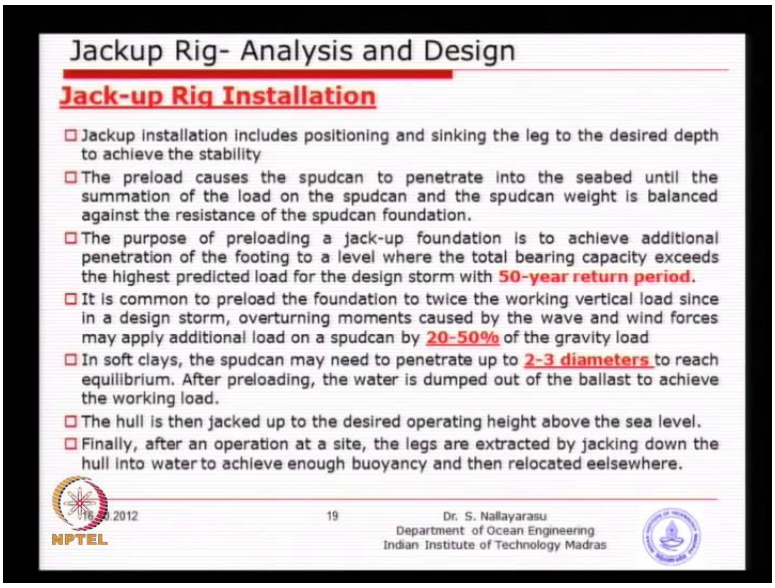


How do we install a jack-up rig I think this is a very simple exercise the first thing is positioning with respect to a particular location you know if you're doing a drilling in you know appraisal well no jackets no structures are existing. So, basically you will mobilise a jack-up rig at that place no other structures in the vicinity then there is no worry because positioning becomes easier, but if you have to position it with respect to existing structure that is where biggest problem because you need to worry about other structure during the placement whether any damage is going to be done to the existing structure and basically the jack-ups are going to be positioned and the penetration of leg depend primarily on its weight because we do not have any other forces like when you're installing a pile what you normally do you in the pile and take a hammer. And you hammer it I think we have explained enough this particular case we have a jack-up we have legs we have a hull and it is going to be penetrating the soil just primarily based on its own weight. So, the larger the weight it is better, but not always better because you cannot keep the jack-up under such a condition for longer period of time. So, what we want to do is we want to achieve longer penetration, but then later the load has to be lower than the the weight used for driving. So, we are going to use this weight of the structure itself as driving mechanism; that means, if you flood enough water inside the hull the legs will penetrate downwards, but later on remove the water during drilling operations. So, which we call it preload.

So, the preload is nothing but we create artificial weight by flooding water inside the hull which is empty and then after achieving sufficient depth remove the water because now we're going to do drilling operations you will get additional drilling loads and environmental loads. So, basically that is the idea behind. So, this the terminology called preloading is nothing, but making it heavier by ballasting and then making the hull to go deeper enough that the hull will become stable, because you want to horizontal stability and making sure that the spud can reaches the good soil one great advantages is as you go down and down definitely the soil is going to be definitely better conditions you will get enough bearing capacity and that is the idea soft clay basically two to three diameters. That means, if you have a diameter of twenty metre you expect thirty forty metre penetration of the spud leg inside the. So, imagine if you have to if you have to have the leg of say six to eight metres size and ten to twenty metre diameter you have to take this whole thing down by forty metre the amount of soil that is going to be replaced or going to be disturbed is very large. So, that is where when you have a small structure in the vicinity I have shown you some photograph earlier on that structure looks.

So, tiny compared to the jack-up itself. So, you'll be actually disturbing the soil in the vicinity of the existing structure to such an extent that the existing structure might become very much unstable. So, that is where you have to be little bit cautious taking any jack-up near the existing structure a thorough study and investigation is required not only on the safety of the jack-up, but also on the safety of the existing jack-up structure.

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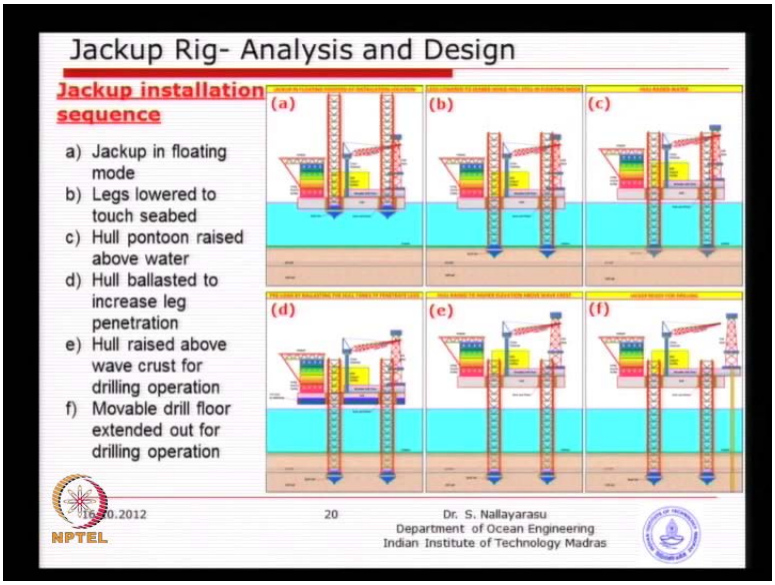

There are various sequences I just put out in a in a sketch form. So, that you can easily understand jack-up in floating mode which is going to come from another location to the location of interest legs lowered to touch seabed which is this one; that means, still in floating mode the legs are just allowed to go down using your drives and rack and pinion arrangements which can bring down hull pontoon raised above water.

So, basically in that condition some amount of reactions or some amount of bearing has been achieved. So, basically the hull can be tried to move as it moves the leg also will penetrate because as the as the hull is going upwards what happens its coming out of water it becomes heavier and if it becomes heavier the legs will. So, these are the. In fact, this is the the situation where it is slightly dangerous because the instability will occur because at the same time.

Legs are penetrating and the hull is trying to come out and then you have flooded water inside the hull this is a artificial flood compound water from sea and put it into hull make it even heavier and the hull will try to go down because of your additional weight and the leg will penetrate below as much penetration has happened with predefined preload we have to define what is our preload depending on type of soil depending on size of spud can we will calculate I need twenty metre pre-penetration in order to get twenty metre penetration how much load I have to create. So, you will pump only that much of water once you complete that exercise achieve sufficient penetration then stop remove water and remove water by deballastic and then raise the hull higher up because you do not want the keep the hull lower because next time when the sea wave comes it will hit the hull and create large horizontal forces green wave effect will be very large on this type of rectangular pontoons which we do not want to have. So, basically this six step operation each step is very critical and basically any time things can go wrong.

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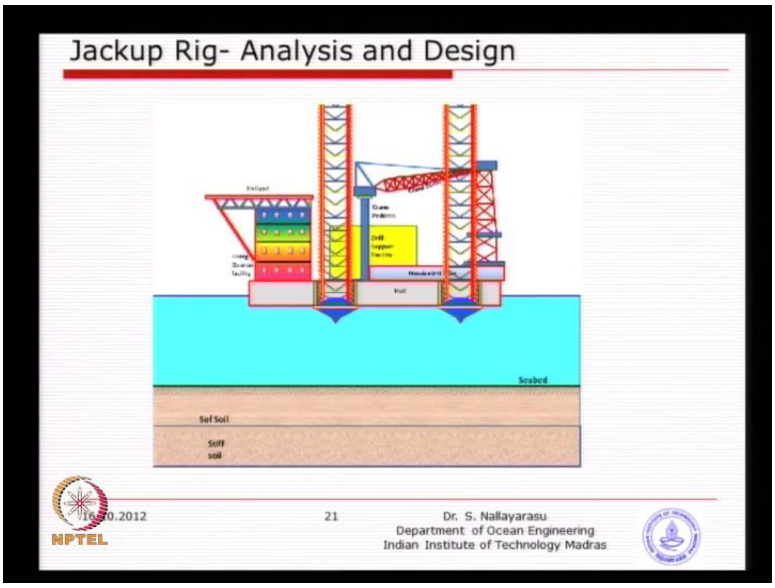


We will see just a quick animation how it happens carefully watch basically this is the stage you have to be very careful before raising because at that stage the hull was still floating and then the ballasting is happening once it is ballasted then it is trying to penetrate by displacing the soil onto the side you know completely you have no control over it and basically then you raise the hull to the higher elevation. So, this is the sequential operation all the time all these mechanical devices are being used to get the then the last one after raising the hull your cantilever rig can be projected.

Outwards and then can be used for drilling. So, this whole operation takes about two days you know basically within those two days if the environmental conditions are not good you may actually retrieve back and then hold it onto floating mode because floating mode is more safer than this partially penetrated legs because it may actually because in floating mode you will always be stabilizing the rig with the tug boats position it. So, that you do not lose the rig after everything is done then probably you can start doing drilling either near the jacket or at the open sea conditions.

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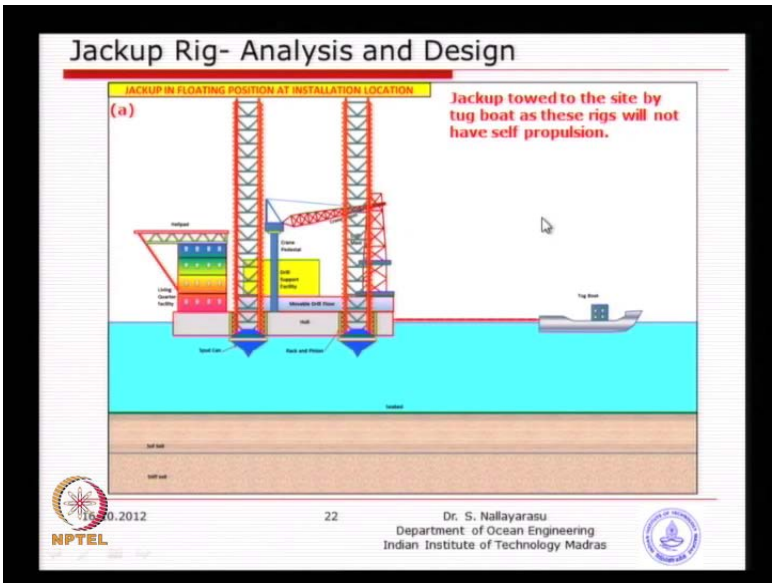


Basically none of the jack-up rigs are popular. So, it cannot come on its own most of ninety nine percent you will have to tow by tug boats and of sufficient full capacity because they are going to come from several thousand kilometres. So, basically at that time you can see here what is happening is you want to make sure that the the legs are not penetrating downwards into water you know some of you might be studying hydrodynamics interaction with moving objects the more friction you create at the bottom especially the legs extended down the resistance will be more full capacity required will be very large.

So, you need to make sure that the leg is pulled upwards, but there is a problem the higher that you go up the stability of the jack-up during tow also becoming a. So, that is where there is a limitation by which you cannot have five hundred metre of leg sticking upwards for using four hundred metres water depth because you cannot really transport them. So, that is where even the fourth generation jack-up's the maximum leg stickup is about hundred and fifty metres hundred and twenty metres that itself is very large for a size of a jack-up of say fifty by fifty you want to have three times of the size sticking upwards during transportation could potentially be a big problem unless you have stabilities which are properly calculated. So, that is why there is definitely a limitation on on which how much water depth.

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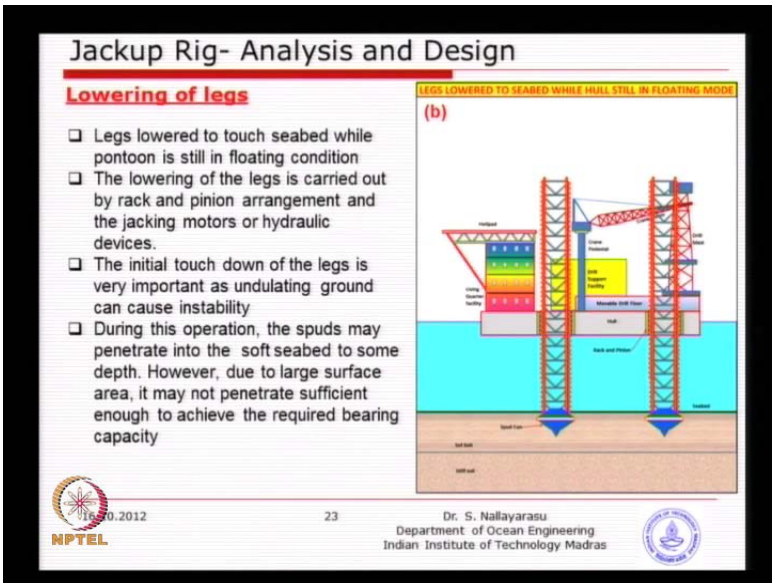


You can use jack-ups for drilling. So, let us as you try to lower it basically you've seen the graphics it is a sequence that is hundred percent depends on the mechanical device of course, to some extent you have to do this operation in a controlled environmental conditions because there could be horizontal loads at the time of lowering legs which can actually spoil the connection between the rack and pinion, because if the legs are moving then when the legs are moving downwards at the same time the if there is sufficient horizontal load due to wave and current it can bend a legs and create large amount of stresses especially on the vocalised noise. In fact, several studies have been done many times failures have happened at one of the connections losing the legs. So, quite a number of studies and research papers are there available for this kind of jack-up rig arrangement as soon as the legs touchdown we need to make sure that all of them touch down at the same time suppose if you have two of them one of them is still not touching then you need to make sure that that touches before you start moving up because that is the time more load will transfer to the legs.

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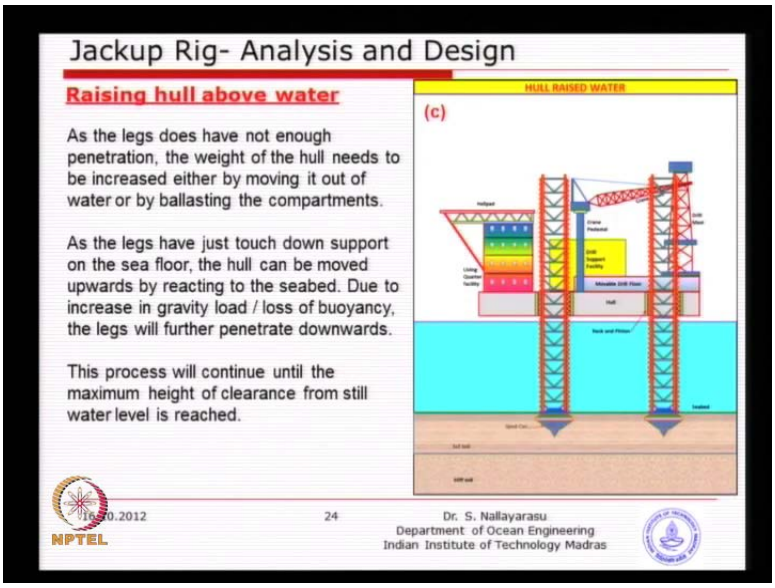


Raising hull above water basically just to create additional weight just is again opposite operation, but this is not going to be a kind of thing that I have drawn here because it is going to be interactive as soon as you increase the weight by moving up. The legs are also going to be penetrating. So, it is actually a slightly complex operation then just step-by-step is not that leg is going to stay in the surface when you're moving upwards and then you're going to do this filling.

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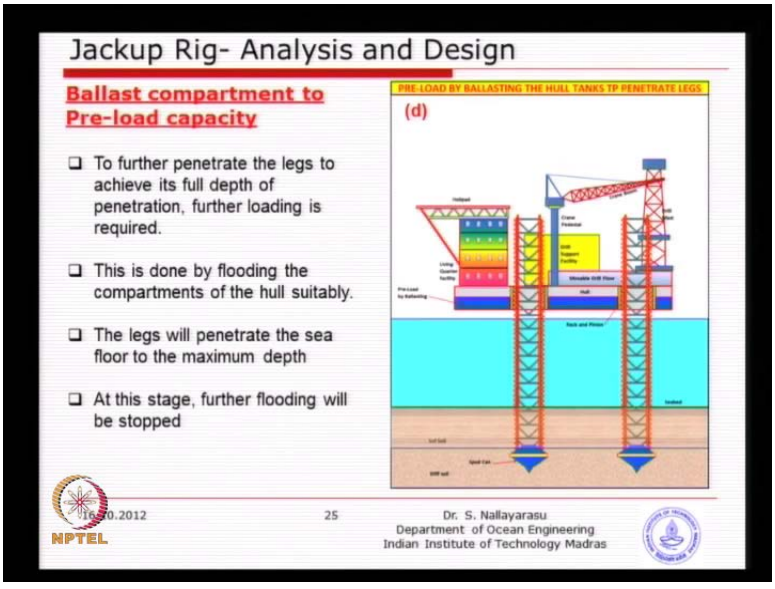

So, it is just a next basically flooding water by pumping water from vocalised noise sea you will have ballast pumps pumping water from sea and back put it there and basically the legs would have sufficiently penetrated. If you have made a calculation that is why every time when you new location you're going you do a bore well get the soil data calculate what is the weight required and what is a bearing capacity of course, we will learn all this bearing capacity calculation in the next semester in the foundation's course I do not think we want to introduce that one now basically a simple bearing capacity calculations to make sure that the weight required into the hull to get a penetration of. So, many metres. So, you will need to recalculate and flood that much of water inside.

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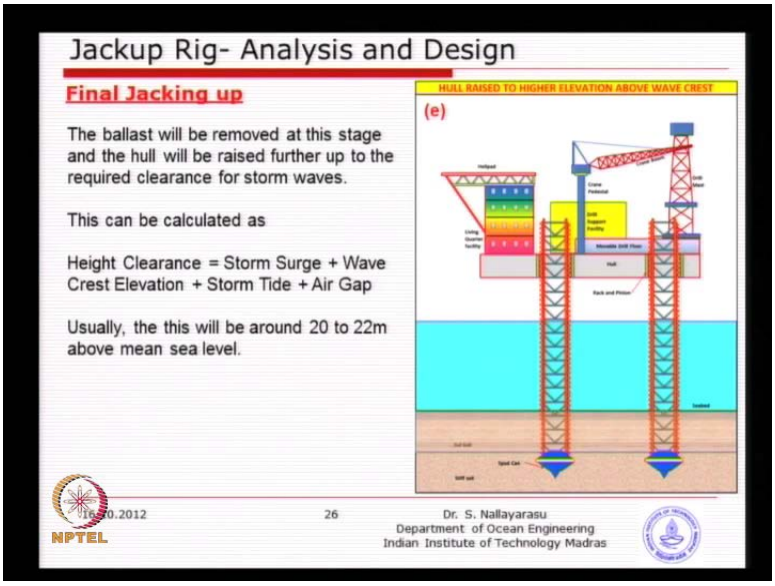


And then ultimately you raise the hull to a level where the sea conditions during drilling does not affect now there is one vocalised noise one thing you have to be careful here you do not raise this hull to a very high elevation not very good because also stability would be problem because you know you try to avoid a hundred year storm wave it is going to come may or may not come the probability is one in hundred and do not want to do that one during normal drilling operations you want to keep it as low as possible during drilling operations depending on what is the one year sea conditions and then whenever a survival condition is arising then you raise the hull to a higher level. So, every time you will calculate storm surge wave crest typically fifty sixty percent of the wave height I think you might be doing your hydrodynamics course if it is a sinusoidal wave fifty percent if it is...

Non-linear wave slightly higher sixty seventy if it is a shallow water wave sometimes goes to eighty percent of the total wave height as the crest height. So, you will add that and then this tide and then the air gap normally air gap of one and a half metre five feet as per api. So, you add all of them moves the bottom of the hull to that elevation typically about eighteen to twenty metres that is the kind of number normally you will get for a sea condition of twenty metres wave height and basic idea is you move this one up making sure that there is no green wave effect on the hull itself because that will be substantially large force which you would not to be able to stabilise these rig jack-up rigs I think that is what has happened in many of the jack-up rigs got have drifted during a cyclonic storm in gulf of mexico I think you might have read the internet news back into two thousand five I think hundreds of jack-up rigs were just washed off.

Because the sea height the wave height at that time exceeded what was specified by the design course and completely the green effect on the hulls almost more than hundred rigs were just on the shore line just got drifted off because of huge green loads on the hull itself. So, they are very vulnerable to such loads and unlike jackets even if green load is going to hit the deck or slightly below still they will be able to survive because there is a good amount of pile foundation and fixed to the ground whereas, here there is no special activities done simply resting on the seabed may be penetrate it little bit on a loose soil because when it is penetrating it is disturbing the soil and the soil is quite loose.

So, if you have larger forces applied at the top it will just topple the rig and get washed away to shore and that is one of the biggest worry jack-ups how to be very careful you first storm is expected you better evacuate because you you may not be able to sure to survive.

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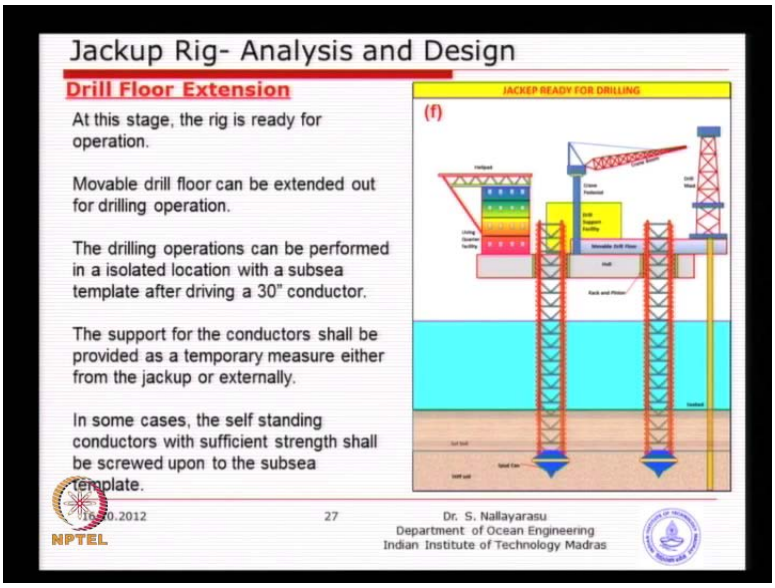


There drill floor I think very important part of the jack up basically this drill floor has got two girders along the if you look at this direction this direction there will be a large depth girder which allow the floor to completely move together with the mast you know this is a drill mast similarly across the longitudinal girders there will be two transfers girders which will allow the the drill mast to move perpendicular. So, you can position anywhere and drill. So, you'll see here in this particular case this drill floor has just moved away from the edge of the jack-up and allowing the drill to happen now you see here when you're trying to do drilling in open sea conditions there is no jacket no structure water depth is fifty metre sixty metre seventy metre. So, you got to be little bit careful because the drill bit goes to directly into water what will happen the drill string get broken because sea conditions are not very good.

So, you need to have a protecting casing that is where we discussed about this. So, called conductors conductors are only a protective casings through which you'll start going your drilling. So, first you will install such conductors, but unfortunately thirty inches only less than a metre and it cannot span for a water depth of fifty metre sixty metre isn't it because normally l by d ratio of fifteen twenty is , but sixty seventy metre you imagine you do this thirty inch conductor definitely is going to be wobbly and will fail. So, you need to make sure that you either get support from the jack-up or somehow you design for a larger diameter only for temporary purpose of drilling later on you can take this structure away, so that's why doing a appraisal drilling or drilling before jacket structure

is constructed you got to be careful with vocalised noise how you're going to the drilling once the jacket is there then you do not need to worry because you have the several support for the conductors at jack-up.

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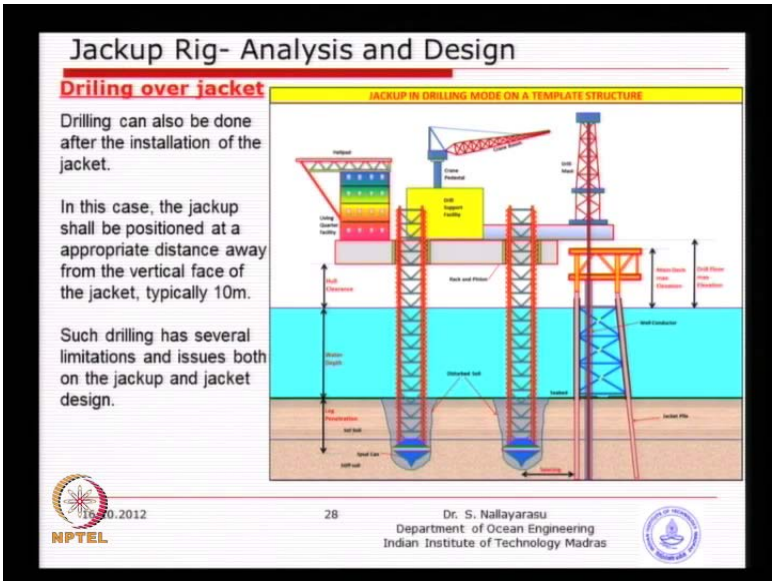


It is jackets typical drilling over a jacket very important to understand the idea. So, once you position the jacket and install it the jacket will have several sublevels of supports for the conductors and positioning the jack-up near the jacket is going to be a challenge. So, as you can see here the spacing between the front leg this leg normally will have two legs. So, basically this is your bow side the front side and stern side. So, these legs will need to be positioned as close as possible, but if you go too close your having a soil condition problem basically there is a pile here and there is a disturbed soil. So, now, you need to see the long the wider that you make this spacing is better for the soil, but the wider that you make is not.

So, good for the drilling because the cantilever cannot go too far as to of course, if you design this cantilever girder strong enough make it very big, but still there is one potential problem is stability this this whole weight of this mast plus this whole thing could be few few hundred tons the the longer that you go away the stability of the system is in question and many times that will become a problem depending on the spacing between this leg to this leg if you keep these two legs very narrow maybe a small rig and

you want to go cantilever twenty metre away what will happen there will be a top leak. So, the larger the rig the larger will be the cantilever section that you can go.

So, basically that is the idea behind how much should be the limit that we want to go away and typical numbers you know I can do a number ten metre fifteen metre the biggest rig can go as much as eighteen metre, but not beyond like you we want to go fifty metre away and then do the drilling impossible. So, that is where invariably if you have a fifteen metre and you'll see that these location it will become six metre because you will occupy half the leg size plus the cantilever and all that things finally, the clear distance available between the pile to the leg could be only five metre six metre seven metre not very large. So, invariably you will see that the soil has been disturbed remoulded strength reduced and basically the pile design becomes problem, but even before when you're actually placing it what happens when the leg is penetrating the soil is getting squeezed away isn't it soil is going to have a horizontal moment putting pressure.

On the jacket piles which may create you may you may think it is just very small actually if you look at the size of the spud going down and the volume of soil replacement or soil pressure you will see that the the stresses on the pile could be substantially larger. So, we need to make sure that that conditions are evaluated and designed accordingly you'll also see in this picture several notations see here in this particular case on the right-hand side the elevation of the deck you know you cannot have a big deck structure fifty metre high and I want to put a jack-up on top which is not feasible because I we cannot jack-up this hull as we think more than fifteen to twenty metre is not feasible.

So, whenever you are having a drilling operation by a jack-up these structures need to be designed sufficiently lower. So, that the jack-ups can come and do the drilling typically about twenty metres twenty five metres and most of the jack-up's cannot go beyond twenty five metres. So, that is where the those kind of limitations either you bring a jack-up which can go slightly higher are you design the structures to have lower deck level. So, that the the drilling operations can I think we will stop.