Design of Offshore Structures
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Module - 5
Lecture - 1
Jack-up RIGS - Analysis and Design I

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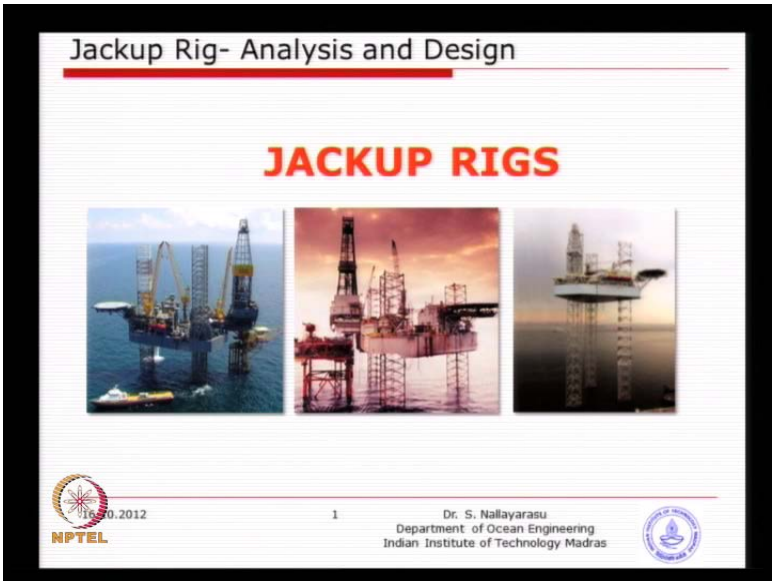

So, today we will start with the new topic on the jack-up rigs I think I might have shown some pictures on during the introduction stage, where these these rigs are used for drilling purposes only in the olden days you know basically the drilling was done by a you know when there when the oilfields were found on land you'll see many of the drilling rigs were on shore or rig based drilling facilities which can be relocated place to place by means of dissembling.

The whole equipments and then putting onto a truck taking to a new place, but later you'll find several drilling rigs are actually assembled on a truck and can go from place to place similar idea you know if you look at these pictures three pictures what you see there is assembled drilling rig which can be transported without the help of another transport vessel you know basically it is housed inside such that it can be towed from location to another location where you can position it. So, if you see this picture on the left side you see here there is a pontoon which is basically a floating hull supporting all

the equipments which are used for drilling including you know when you're having a drilling rig we need power. So, you need a power generating equipments also to operate those you'll have people to live. So, you have a living facility.

So, it becomes actually a complete offshore facility only difference is it is not going to be stationed at one location for a very long duration probably for few months few years, but not more than one or two years. So, basically it is a temporary facility of course, one advantage of this kind of facility is you can bring back to shore you can do repair you can do.

All the retrofitting required changes and then bring it backwards. So, that advantage makes the design slightly different from a fixed offshore platform whereas, when you're designing a fixed offshore platform we must make sure that it is serving the purpose for complete design life whether it is twenty five years or fifty years you need to design into make sure that you do not need periodical repair you know very often which will become more troublesome whereas, in jack-up rigs you your do not have that problem because you can bring back. So, the idea of this rig is is twofold one is drilling and bring back and then do all the services and take it back to another location so; that means, every time when you take it to a new location these rigs needs to be designed for the new environmental conditions new water depth new soil conditions. So, you can see that every time it becomes a new design. So, that is one challenge I would say and we need to see how we have the flexibility in it you know when you design a offshore platform for one location.

You make sure that it is safe for that location, but then when you take to another location you may see that that environmental conditions could be different or in a soil conditions can be substantially different you know the bearing capacity will be different. So, what we need to see is the design should have such flexibility that you can manipulate modify the parameters to suit you do not want to do a complete change of the rig just from one location to another location that does not serve the purchase. So, you need to have a design in such a way that it can be used in many locations with minimum modifications

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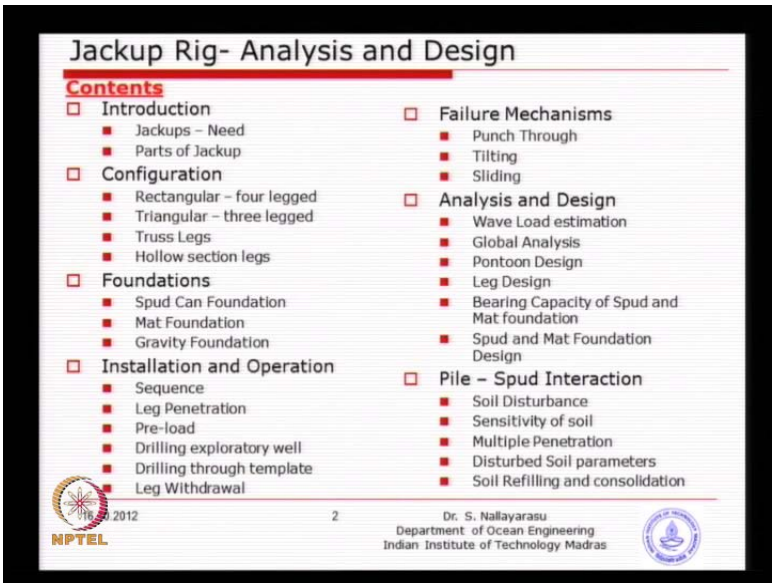

So, that is the idea of the jack-up rigs we will be spending few hours probably two or three hours in the the initial stage probably one more hour for design procedure. So, probably I thing we are looking at about four hours for jack-up rigs which is sufficient enough to cover the topics.

These are areas we will just spend some time today about the introduction configurations and then the types of foundations used by this time I think you're all familiar with you know basically the different types of foundations that is used for fixed offshore platforms already you've been familiar with main pile spud pile and all that kind of stuff. So, we will see what kind of foundations because this is being relocatable what kind of foundations can be used because you do not want to have a very deep pile foundation for jack-ups which you cannot remove you know.

So, basically the foundation forms a primary concept changing from fixed platform to movable drilling rigs you will see that in the recent times this type of concept also coming for permanent facility especially when mandatory requirements are there nowadays to remove the platform once they are actually completing that designed life or service life you cannot just leave the platform and just abandon which is not permitted as per the new environmental regulations. So, in such a case when you design a fixed platform itself you should look at how to remove it. So, that is basically the relocatable platform or sometime.

Now, we come up with the new concept called platform designed for a shorter duration fixed platforms, but then after five years you do not want to abandon it you want to reuse it. So, basically reusable relocatable these are the concepts coming where the foundation plays a major role because you have a firm foundation fixed to the ground is very hard to cut and remove if you find a methodology by which simple method can give you an idea to remove and relocate that will be the the best choice. So, in here you'll see a very interesting idea jack-up rigs the foundations are made in such a way that you could easily get out of the soil and then just relocate. So, you will just see few types of foundations spud foundation.

Mat foundation gravity foundation and then we will just spend some time on looking at how the installation can be happened you know you bring in a floating structure I think you might now be very clear on the difference between the floating structure and the fixed structure fixed structures the response is too small basically because it is firmly fixed to the ground by means of pile foundation whereas, the floating structures response could be larger or smaller depending on the hull design now the hull becomes like a rectangular pontoon you'll see that the response is going to be larger as you might study in some other courses. So, you could see that floating structure you want to make it fixed to the ground by means of a temporary foundation system.

So, we will see how we can do it what are the troubles and problems that we are going to get during the process and how do we mitigate. So, this installation operation is a very tricky operation unlike you're jacket installation which are established procedure whereas, in this we have to you know establish a procedure for every time when you install it in a new new place and then during the installation what types of failures that we can expect and then corresponding design procedure to avoid.

So, those things or incorporate some of them if possible for example, a punch through of a foundation happens which will drastically pull the rig you know substantially into the water which we need to estimate whether such things can happen tilting sliding these are some stability problems which usually you do it for a rigid objects on seabed. So, very similar idea and then we will just look at the global analysis procedure for these type of structures how they are different from a typical wave you know just a jacket type of structure and then some simple design procedure and then finally, we have to look at one important thing is if you see this picture on the left side you see here that jack-up rig

hope you can see is. So, large compared to a tiny jack-up jacket structure is on the right side. So, this jacket is looking.

So, small compared to the jack-up rig and it is installed in the vicinity basically very close to the jacket because you cannot install jack-up very far you would not be able to do the drilling on top of the the jacket which is installed. So, you need to go closer and closer. So, when you go closer and closer when you install this new big structure what happens to the soil below number one and the soil in the vicinity of that structure the existing jacket structure is going to behave slightly different or substantially different depending on what type of disturbance you are making because you're going to install a big structure nearby like you might see in many times in the onshore on ground projects when somebody is digging big underground tunnel near your structure.

What happens there will be a disturbance to your foundation and similar problems are going to come in this kind of problem. In fact, you might have heard in recent times when they are doing the tunnelling operations some places in chennai there was disturbances to the foundations to the neighbouring structures which could cause potential problem cracks failure.

So, you need to see what happens in this case the foundation just wanted to show you the size of the structure is several times bigger than the jacket structure when such things you're installing nearby you know the soil gets remoulded or disturbed or completely you know becoming a very loose and may actually provide no support to the existing structure originally you have designed with certain pile parameters and some of you are civil engineers you could understand soil parameters could be long-term parameters which you've used, but later when this rig comes and disturb the soil the soil parameters becomes loose or less stronger than becoming the structure becomes unstable or may become you know close to failure.

So, we need to see this interaction that is why whenever we are installing a jack-up near the jacket we need to see how they are going to interact and then estimate the soil disturbance and estimate the sensitivity of the soil to strength deformation characteristics and then sometime what happen you bring this rig you do this operation for the say first year you might have ten wells twenty wells drill three or four wells and go away because you do not want to station the rig permanently.

Here you go away and then bring it back what happens is when you have installed this rigs at the first time what happens there might be a big crater formed because you are extracting this foundation upwards next time when you bring the rig you may not be able to position it at same place if you try to position it that hole will make the legs unstable. So, what you need to do is you need to fill up that area with a better material. So, that after a several years you can bring back the rig. So, this multiple penetration becomes a problem if you cannot do refill for example, you bring it you reposition it in such a way that the legs are not going to be penetrated in the same location which was earlier done; that means, you will see a substantial area of the soil gets disturbed. So, you could see that this is a little bit of a a different types of problem we're going to deal with because we made it mobile imagine instead of making it mobile if I transfer all these equipments drilling equipments.

Support equipments everything permanently onto this structure the structure which is already there all this problem can be eliminated isn't it, but the at what cost because you have to make this platform. So, much bigger because this is only a ten metre by ten metre well platform now now if you want to make the hole drilling facilities to be permanently stationed there one is the cost of the drilling equipments because you cannot reuse it or elsewhere and also the structure becomes substantially bigger unnecessarily redundant because the drilling is going to happen only may be the first two years after that you will never do drilling only work over cleaning up operations for the well. So, the remaining design life the redundant structure is going to be there unnecessarily and the rig is not possible to remove.

So, why to do this that is why as early as nineteen seventies these mobile rigs were you know designed and used for substantial number of locations. In fact, out of all the shallow water applications less than two hundred metres less than hundred and fifty metres almost ninety nine percent of the wells drilled offshore is using this type of jack-up rigs only in the recent times when the water depth goes beyond hundred metres two hundred and fifty metres these rigs may not be possible to position themselves because of the water depth and the design conditions. So, you try to go for a mobile drilling rigs, but only floating structures not to. So, this you could see that the idea behind understanding of this jack-up rigs is not only with the design of the jack-up, but also to interact with existing jack-up structures which is substantially important.

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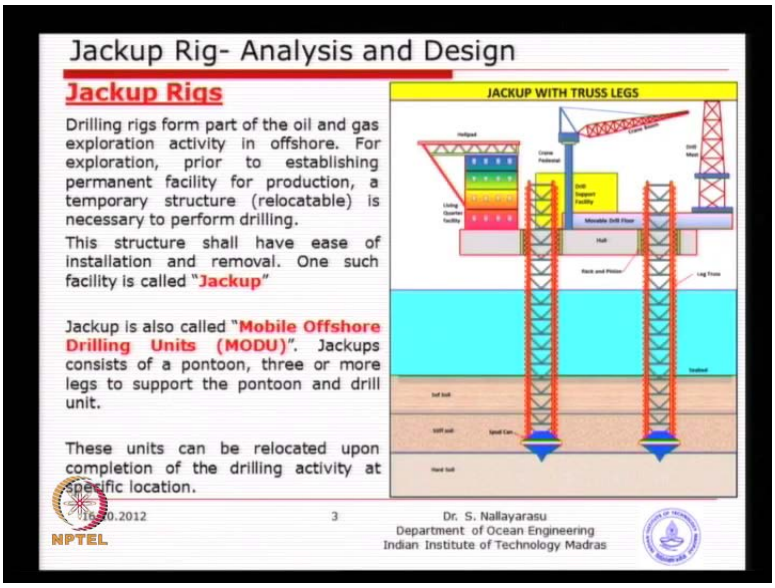

So, population just introduce various parts of vocalised noise these type of rigs. So, you can see here a hull which is typically can be of any shape according to our design it can be a rectangular pontoon just like a bars I think most of you are familiar ship or it can be a triangular shape. So, we could come up with the best shape that could be suitable for towing because it is to go from one place to another place number one and also when you're trying to setup it should easily fix up onto the ground without multiple issues. So, we need to see the hull having sufficient strength to carry all the top pile loads at the same time it should float and also when it is out of water it should be able to support it. So, two conditions one is when it is floating sufficient amount of buoyancy is there. So, the hull need not require. So, much of strength whereas, when it is above water no buoyancy, but supported at three points or four points depending on the number of locations.

So, you can see here different types of requirements. So, basically this is nothing, but a a simple pontoon as deep as we want it could be three metre deep five metre deep depending on what is the girder strength required and supports several pieces of equipments the primary part is basically the drilling rig or the drilling support system basically a mast with all the drill facilities together with a facility for which you have built this rig because you do not want to drill only one location you can actually move the rig in horizontal positions either longitudinal or laterally.

So, that you can do several locations, so that is why you can see here it is called movable drill floor. So, the drill floor can go back and forth and the vocalised noise the drill mast can go laterally perpendicular to the screen. So, you can drill many locations vocalised noise according to the position which you want to drill on a platform and you also have a drill support facility drill support facility means several equipments you will have mud circulation system I think the first few classes I have introduced you know when you're doing drilling you need to cool off the drill pit otherwise what will happen the drill pit will get heated off and break.

So, what we need to use supply continuously a cooler fluid through the drill system and circulate back isn't it. So, when this you need a large volume of supply of the drill fluid which we just need to condition it particular viscosity particular temperature because when it goes down goes in a conditioned manner when it comes up it might be hotter than because it is going few kilometres down and also get mixed with the mud which is coming from nature and the drill you know the the material coming from the bottom. So, that system requires a substantial volume because you're not drilling hundred metres two hundred metres you are going to drill six to five to six kilometres.

So, that much of fluid of storage reconditioning remixing so; that means, the it is a huge tanks are required if you visit one of the drill rig you will see that the tanks are as much as ten to fifteen metre diameter. So, you can see the the the structures required to support such facility is enormous. So, that is why you'll see that huge drill support facility which is primarily the tanks for storage of cement and water and mixing and then reconditioning all those things and then also large size pumps because they have to be pumped under pressure otherwise it would not be able to go down then you need power to operate those pumps these drilling rigs. So, you'll see a huge power plant it is not just little power will be enough because you are going to drill. So, deep.

So, you need a power plant support facility and to operate this facility you require reasonable manpower typically about hundred people. So, you need a support facility for all of them so you can see it is it is not such a simple drilling rig. So, you will require reasonable facility and basically as I mentioned earlier these rigs are a primary component from seventies to now because almost everywhere you do this drilling sometimes this is also called modu mobile offshore drilling rigs the new class of structures now we start to use this is mobile offshore production units you know instead

of only for drilling we actually use this for even protection. So, you can actually use this for a temporary location and go away. So, that concept last ten to fifteen years has been catching up because there are. So, many small oilfields which has got limited amount of oil and gas. So, instead of drilling a building a jacket why do not we make this kind of structures go there get it fixed and explore and then relocate and by simply doing this you you your scale of economy comes down because you're just going to reuse it at various locations number one and with required minimum modification. So, mobile offshore production units also mopu is getting familiar.

So, that is why this this topic of jack-up rigs mobile drilling units mobile units are just introduced only this this term last term it was not there. So, the idea here the topside contains a hull movable drill floor drill mast support facility and living facility and probably with few cranes. So, that you can handle several a typical size of this you should understand what is whether it is five metre ten metre twenty metre typically about thirty to forty metre in dimension you know. So, you will look at as big as like fifty metre sometimes, but very rarely, but most of the jack-up rigs are about thirty to forty metre in plan size the hull depth not very large probably lesser than the ships typically about five metres four to five metres you know hull depth.

So, you could see it is not very large, but still it is comparatively larger than a well platform when you place it in vicinity well platforms are ten metre fifteen metre and a tiny size vertically whereas, this one occupy larger plan size. So, you will also see one important thing is the legs carrying these loads and you'll see a zigzag arrangement basically a rack and pinion arrangement with gearboxes motor as well as hydraulic devices. So, that either way whether you want to raise the hull or lower the hull can be done and basically that is the idea behind them. So, you will you will see the operation later on you'll see in this picture zigzag arrangement of plate connections on the leg these legs can be rectangular.

Here I am just showing you in a two d, but actually if you look at it in three d you will see whether it is a triangular shape or rectangular shape our circular shape whichever the design according your many of these some rigs built in the recent times mostly a triangular truss lattice truss whereas, some of the rigs earlier they had used circular pipes because it is quite easy to fabricate whereas, this multiple member lattice truss is a little difficult also issues are more like fatigue could be a potential problem and sometimes

you will see rectangular truss like this or square truss, but many occasions we see a triangular truss. So, basically there will be three columns or four columns depending on whether it is a triangular or rectangular and this braced with several small sized tubular members it is not going to be very big one like three inches four inches five inches each of these.

What you see in this insight and the vertical column could be ten inches just like this. So, it is just a tiny members, but assembled to get the loading sufficient. So, how do we design will do it at the end. So, basically these leg at the bottom you see a a large size basically a plated structure which is fitted to the leg. So, when it goes on touchdown the seabed what happens it is not allowing the structure to go down because you got a little foundation fixed to the bottom of the leg. So, as long as you get sufficient capacity of the soil the settlement will be less, but unfortunately we have of bigger issue than this because the horizontal loads due to wave and current and wind could be larger. So, if you do not have sufficient penetration into the ground what will happen the rig will topple and that is where the biggest problem. So, we need to find a way we should get sufficient bearing capacity, but at the same time we should get sufficient penetration below ground.

So, the larger the footing size you make what will happen it would not be able to it would not be able to go down because you already have a sufficient bearing capacity. So, how the rig will go the legs will not be able to penetrate. So, we need to get a design that we should be able to go down at the same time you get a bearing capacity and also at the same time is easy to remove you make very deep you make very big later on when you want to pull it off what will happen it would not be able to come out. So, we got a difficult problem a difficult task in hand which is to get the size shape and is to be arrived accordingly. So, basically this whole assembly the jacket the jack-up leg and this bottom needs to be reviewed carefully depending on the location and this bottom foundation is called spud can is basically a spud foundation circular in shape.

Most of the time ninety nine percent of the time which you can see a conical shape with a a cone attached at the bottom to make feasibility to penetrate easily at the same time have sufficient diameter to get the bearing capacity and you see the upper side also have been made slightly conical. So, that next time when it comes to come up above ground above sea bed also can facilitate little bit of soil sliding instead of make it flat what will happen you'll see that very difficult to remove because the soil weight will make the

foundation preventing it from coming up so, but if you have a little bit of conical it will break break break and then soil will spill off on the sides and can come out. So, idea is little simple conical base with a sharp at the bottom and a conical shape at the top and the structure is skeletal frame not a solid structure. So, that the soil can escape otherwise what will happen if you make this whole thing is a pipe big pipe soil will be contained inside and would not be able to escape it. So, all that ideas have already been done.

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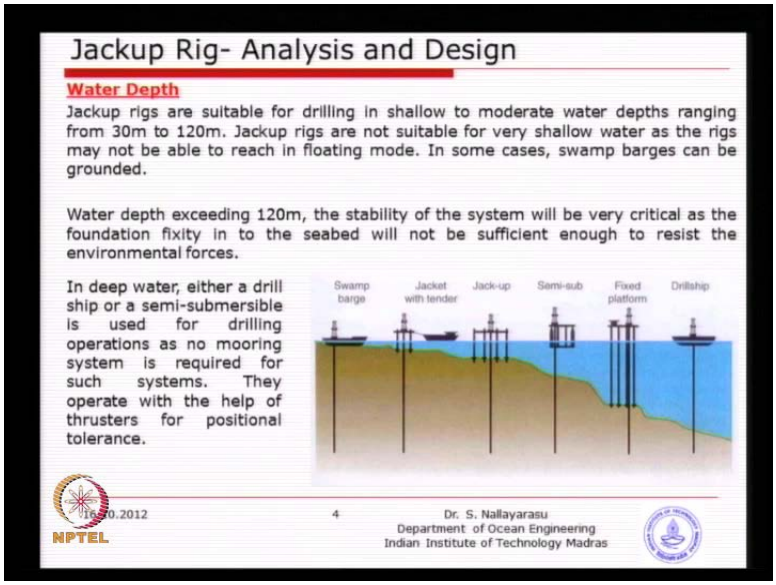

So, what we need to do is just see how they are going to work for us water depth is one of the biggest challenge in these type of rigs hope you have understood what is the idea behind the jack-up rigs the deeper that you go you got amore problem because these legs are slander and they are not too many of them maybe three or maybe four the more that you have the more the problem as you know very well when you're trying to setup onto the ground the number of legs becoming more than three will always be a issue you can see when you have a table more than three four legs you may get a a differential elevation in the ground.

It is not going to be hundred percent perfect. So, one of the leg may not be able to get in contact. So, the centre of gravity will not be able to estimate correctly then you'll see the tilt of the rig. So, three is best automatically you will get three supports without any problem four means one redundancy is expected or maybe not expected. So, always you

will see that three is the best to get the stability easily and basically the distribution of reactions become determinate not indeterminate.

So, that is why most of the jack-up rigs you'll see that only three legs are permitted not four now once you have three legs and. So, slander and. So, high few hundred metres fifty metres hundred metres one twenty metres in case of large horizontal loading they may become very much unstable and they are vertical legs remember jackets we have batter an inclined legs inclined pile foundations. So, that is why beyond certain water depth is very difficult to operate under harsh environmental conditions of course, if it is very very quiet weather conditions you can go for bigger depths, but the problem is most of the offshore conditions except in very a few months of the year everywhere you will see a seasonal variation of wave heights and the corresponding wind. So, basically you would not be able to operate in the other periods.

But once you mobilise the drilling rig you do not want to operate for say twenty days and come back it will be expensive because mobilisation costs bringing the rig back. So, that is why you need to design for a slightly increased sea state and that is why you see that designing the jack-up rig beyond hundred metres. In fact, it was only seventy eighty metre was was the number early days like nineteen seventies no drilling rig could drill beyond seventy metre and that was just basically the first-generation jack-up rigs and then gradually.

You know the designers and researchers have found ways of designing the jack-up rig for more than hundred metres the fourth-generation jack-up rigs can go up to hundred and fifty metre now a days the main problem is the connection between the legs and the hull actually everything can be designed the hull can be designed because you have a hull nowadays floating structures of any size the main problem is the the connection the mechanical connection between the leg and the the hull which is very very difficult to design for large forces because they have to move actually if you have a welder connection no problem you can actually design for any forces, but these are not welder connections there are just hold by the the [vocalised-noise] the rack and pinion arrangement with motor devices.

So, if that fails the jack-up rig will definitely fall down. So, that is one of the challenge. So, that is why the design of jack-up rigs beyond one twenty metre is a is a big

challenge, but some of the new built rigs the last five years can go up to hundred and fifty metre. So, you can see here over a period of time evolution of how the drilling exercise was you know basically the developments if it is very much onto a shallow depth less than five metre ten metre fifteen metre that kind of thing even jack-up rigs cannot go because jack-up rigs do require certain water depth draft. So, that they can go and float and then start sinking. So, in that kind of scenario you simply bring a slam barge and just ground it just like grounded ships.

So, just ground it make a foundation there and just start drilling even now people are doing slam barges are very common especially in coast of Gujarat we have I think some oil mills where the water depth is almost nil during low tide and high tide water will be up. So, those kind of areas we are used slam barges or sometimes you actually make a embankment permanent embankment and drill from that kind of locations and then jacket with tender this is not very common, but sometimes very useful. In fact, some of the projects are using this type of concept put minimum facility on the jacket which is fixed structure, but then this the reminder of the equipments for example, you have power supply you have drill fluids you have other equipments everything sitting on a barrage or a floating structure which not necessarily to be supported on the ground it is just a floating structure only connection to the jacket by means of a bridge a small bridge. So, everything will go from the barge only the drilling rig will sit there.

So, it is it is basically called tender assisted drilling sometimes we call it is is basically ninety percent of the facility is sitting on a mobile platform and only the rig will be sitting there this is reasonably common in moderate water depth like hundred and fifty to two hundred metres where the drilling rigs by jack-ups is not feasible nineteen nineties and eighties which is no jack-up can drill in that kind of water depth and you do not want to put everything on top of the jacket which makes the project very expensive.

So, you bring in a floating pontoon supports all the facilities, but the same time only rig is mooted on it. So, this is a new type of ideas and when then you have a conventional jack-up which nowadays can go up to a one fifty metres also you have other classes of drilling rigs mobile, but no such thing called a jack-up legs required because they are floating structures semi-subs and drill ships are very common for deepwater drilling very rarely.

You see a fixed platform of course, in gulf of mexico they have done up to five hundred metres there are a few platforms existing five hundred metre jacket rig jacket with the rig mounted on it there no other solution at that time because jack-up was not feasible nineteen nineties because jack-up cannot go beyond seventy eighty metres and mobile drilling units like semi-subs and drill ships were not at all feasible at that time no design exist. So, that is why they have to go for a fixed platform and then build up everything on top and do the drilling some three or four platforms were built in that kind of water four hundred metres to six hundred metres because those days nineties and you know those those those period jack-ups not feasible mobile drill units using either semi-sub concept or by drill ship also was not feasible because the trusting as well as the positioning was not that much technology available at that time.

Now, you do not need to go to this fixed platform beyond hundred metres because most of the drill ships are available in lower cost can go and do drilling and come away. So, you can see something is not feasible at that type now it is feasible because the the ideas and technology changing. So, this water depth is playing a major role in the jack-ups because of the you know the design limitations we have with respect to the legs.

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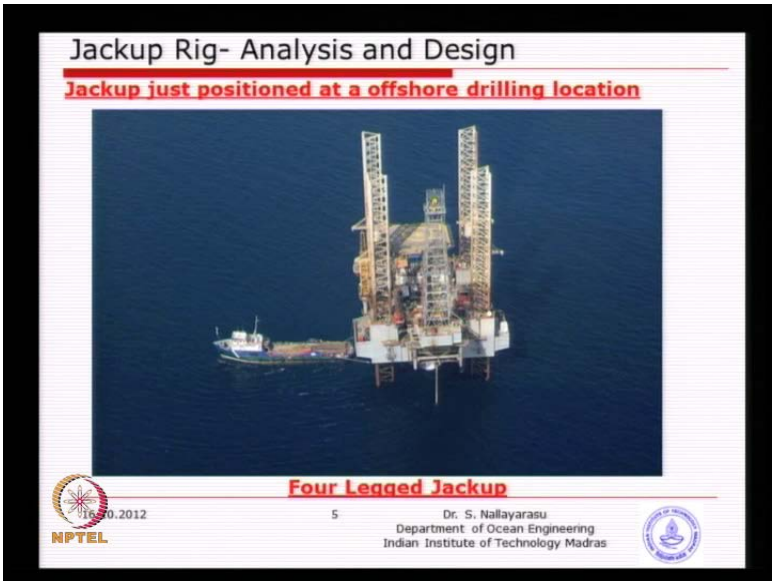

A typical jack-up rig in this particular case you can see there are four number of legs very rare I i would say it is very very rare mostly you will see three and you can see here the legs are made of triangular truss with three columns with several small size members

and this is the drilling rig you could see here and a supply board on tug boat I would say this is a tugboat.

Just moved on to the jack-up rig basically this was the one bringing this towing this jack-up to the position and you can see here this location the drilling is done at a location where there is no jacket is is installed yet it is a open condition. So, you just do a exploratory drilling this is not exploitation yet because you're just doing drilling to find out whether oil is there or not once you find the oil then locate the oil location and then take this rig back bring and put a jacket then you will do the few more wells afterwards.

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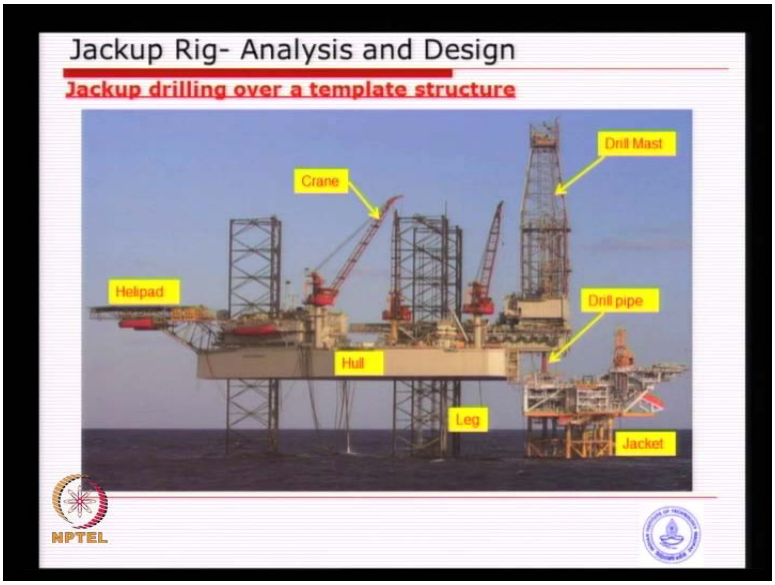

So, this basically and appraisal drilling a three legged one you can see here again the size of these structures compared to the jacket.

So, the hull is basically a pontoon with all the facilities mounted then you can see here several cranes because the area is. So, large that the handling of equipments handling of other pieces require and you can see that drill mast is quite large typical drill mast height is around fifty metres about forty fifty metres in this particular case probably less, but you will see the drift depth of drilling is going to govern the the drill mast and you can see this is the drill movable drill floor can move forward backward in this direction and this whole assembly can move on the lateral direction.

So, you can do anywhere, but within the envelope of drilling parameters you know you cannot just extend this cantilever you know very large there is a limitation because the more that you come out the stability of this rig becomes a problem. So, normally when you design with respect to the cantilever about ten metres not more than ten metres laterally not more than five metres because that is another limitation and vertically you can see this hull can be moved up on little bit more you cannot move.

Any more further not just because the the leg length is available are not available the main problem is the stability of the system you know the higher you go the wind induced wave induced moments could be larger and can put design problem. So, that is why when you design a jack up we will specify what is a maximum height the drill floor can go. So, immediately you'll put a limitation on what is the maximum height of this structure that is allowed you know you cannot have a jacket and deck structure very high the jack-up cannot come and do drilling there. So, you have to just do a interface most of the time you know this is quite large compared to this one's.

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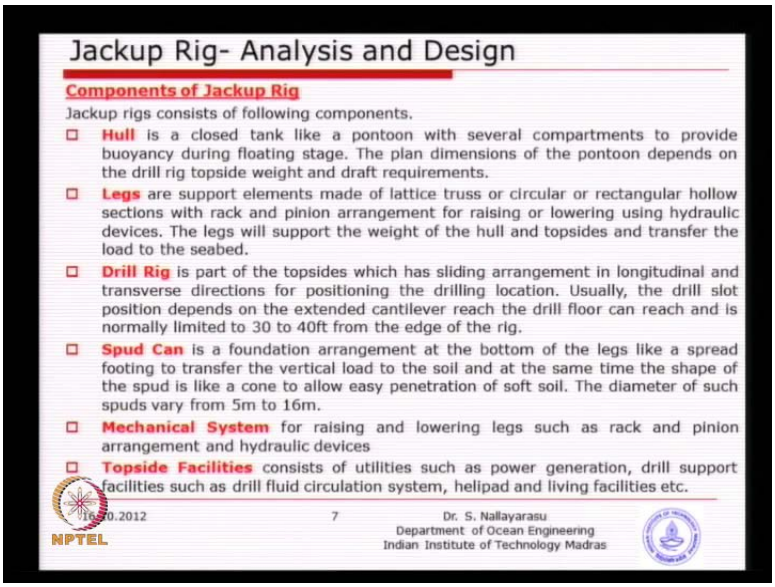

So, basically these are the several components of a typical jack-up rig hull I think I have already explained to you earlier it is just a closed pontoon waterproof should help sufficient buoyancy sufficient strength and sufficient capacity for filling water later on legs just like any jacket leg only thing is this is a open truss drill rig.

How much is is the cantilever design you have to design it according to that is a movable rig which basically with a large deep depth girder spud can is part of the leg of course, is nothing, but a spread footing foundation just like your column foundation you have for buildings and structures mechanical systems basically the the devices to move the hull up down or vice versa or the leg up down when the when the whole pontoon is floating you can actually raise the legs up down when the pontoon is above water then the other way. So, basically this mechanical system is very very important part we will see the details.

Little bit later and then the topside facilities which I explained power generation drill supports and then the drill fluid circulation system helipad living facilities. So, you will see that it is a complete facility required to operate.

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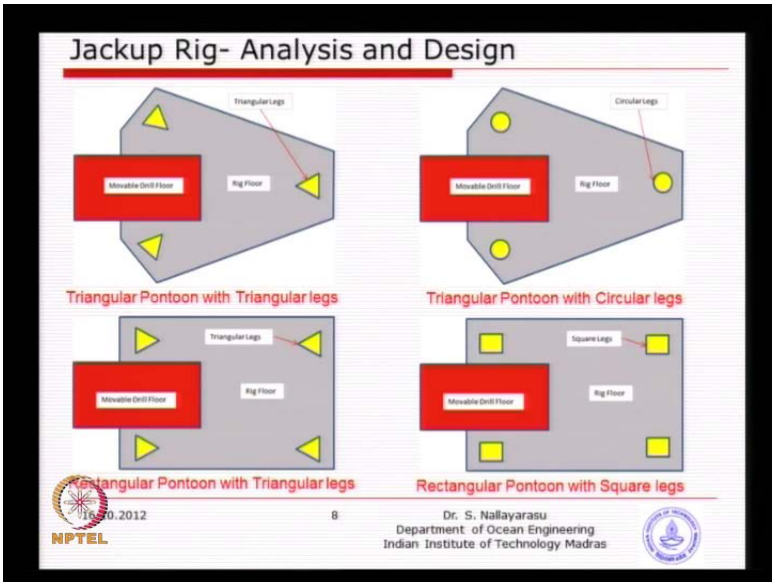

This typical jack-up rigs I think I mentioned about rectangular versus the advantage of triangular as I mentioned ninety nine percent of the rigs we have triangular in shape, but not exactly triangular it is a it is a kind of faceted shape with the triangular arrangement of legs. So, that the you know the the reactions can be easily determined based on geometry and centre of gravity.

Whereas the four legged ones are very not very common though they provide larger space, but the operation and installation becomes little difficult as you can see the legs can be triangular or can be square or rectangular or can be circular some of the smaller

rigs nowadays they use these circular pipes simply just with all the arrangements, but not very common

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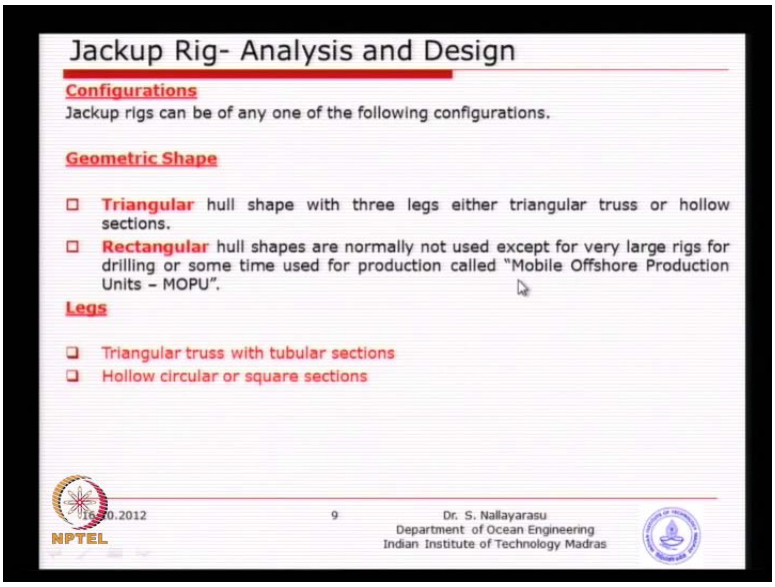

In the recent times the development of mobile offshore production units the use this type of concept this type of concept the reason is they need more space because production means we need to have substantial equipments for larger area and you're not going to relocate every two months every five months because mobile production units may be there for five years maybe ten years. So, in such cases the difficulties that you're going to face during installation because of the centre of gravity and the indeterminacy in the legs can be tolerated because you're going to do maybe two times in ten years whereas, the drilling rigs you're going to do every year two times or three times.

So, the problems are less. So, that is why the rectangular shape reasonably common in in this kind of production units rather than drilling units and you can see here the legs can be made of truss or it can be made of you know simple hollow sections or sometimes square sections are also used is of fabrication.

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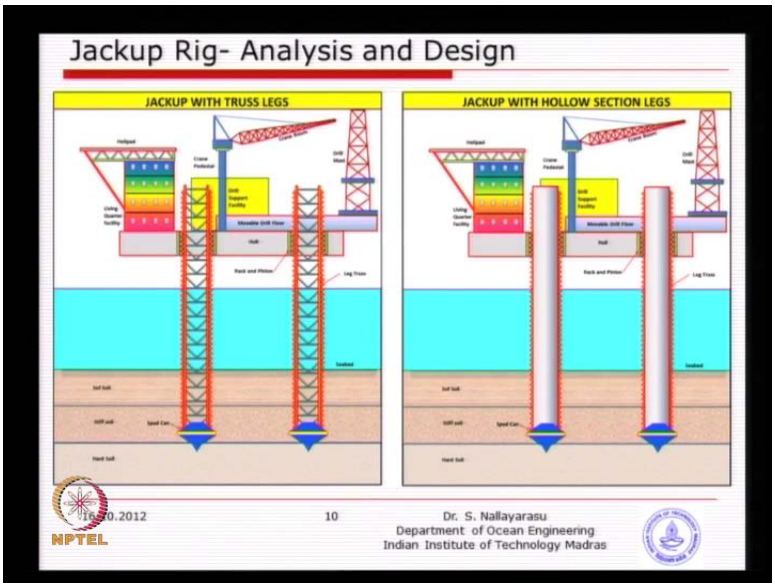

So, you can see this picture this is basically a hollow section will have sufficient holes to drain because you do not want to have large buoyancy it will be very difficult to shut down. So, this will not be a buoyant section. This will be a non-buoyant section whereas, the hull is completely buoyant and you can see here the similar arrangement of welded plates for arranging the hull to go up and down is both either way you can use a truss or you can use a circular section not not going to be a problem only you need to just stiffen it inside because this hollow section becomes little weaker when it carries line load whereas, the triangular truss section is stronger in the corners. So, you can take line load without much problem. So, correspondingly you have to design it.