Elements of Ocean Engineering
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Lecture - 37
Structural Analysis of Jacket Platforms

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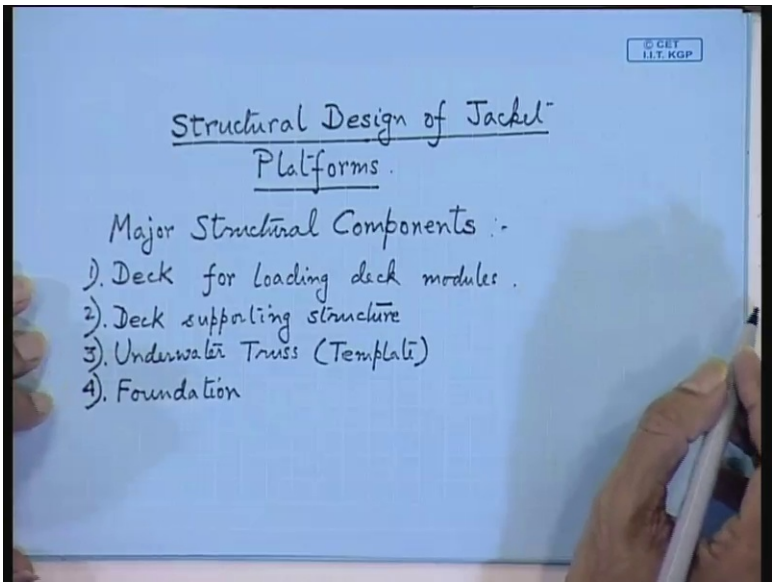

Today, you let us see out the Structure Design of Jackets. So, major structural components I have already told you, so these are number 1, you find is these deck. So, decks are the major, the structural component where you load your deck modules, so let me tell what are the different structure in deck modules? So this is one object where we have to concentrate. So, number 2 is the deck supporting structure, so this has to be designed, so in your previous class I was discussing that most of its platforms are the working platform is the deck.

So, deck supporting structure is has to design, now how you design that, so that depends on the functional aspect to the platform. And I believe this you have you the one is called the underwater trust, now some times this is called a template, so deck whenever a truss last is what, last is your foundation. So, these are the major structure items which we have to look at for jacket platforms, these are the 4 basic components. Now, deck I told you now you be careful we whenever you do this structure design, so we have to be thorough on what are the functional aspects of the structure.

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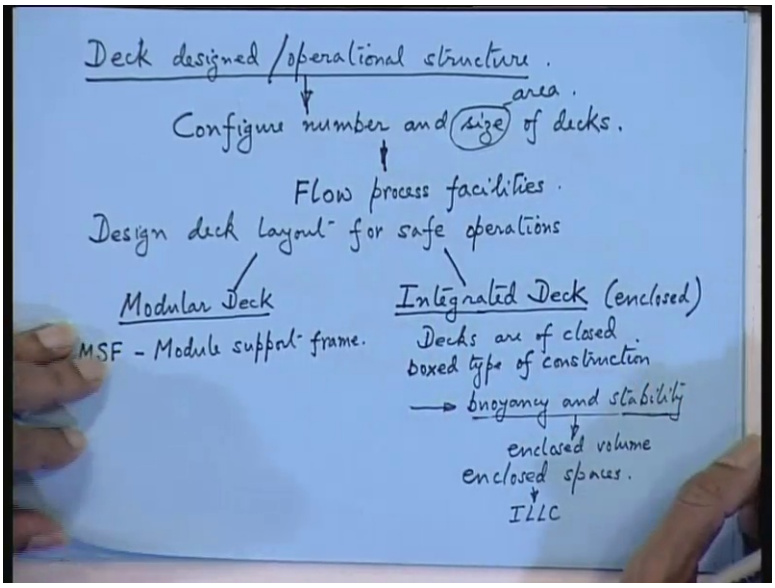

So, decks these are the what is called deck design platforms for deck designed and opportunely structures, you main operation is going to take place on the deck of the platform. So, next I give you some of the loads that are acting which we have to consider, so this you have to configure the decks, so this you the first thing that use design, the configure number and size of decks.

So, this has to be really thought about, so I told you nowadays we do all this drawing in the auto camp. So, here you first fix up glue number and size of decks, now this is again based on the equipment configuration that is your processing facility etcetera and all these things. So, you have to have all some idea of the gas and the grid processing there is slow process diagrams, this is actually the way of view chemical engineering, so if you go into any offshore company you will find besides never updates are offer engineer, we have flow process engineers, so this depends on this.

So, this is your first job, now first think that you have to find out from the deck design is left area of configure number and size, size of course, this is here the area of decks. So, this is first job, now after your design this design deck or rather you write design deck layout for safe operation, safety is the prime consideration in offshore platforms because it is giving with all. So, all these thing you have covered in your deck designs, so no need to go into indicates of this is layout configuration how you do the horizontal and vertical layering in connection between the spaces etcetera all these thing come into this.

Now, here actually you have to design the decks whether you have going for a this two types of decks you find, the one is called the modular deck we have modular deck and the other one is called a integrated deck. So, your structural design will actually vary on this two types of decks that and normally you find in the jacket platforms, the modular construction or the integrated type. So, this I have already discuss now in the modular deck actually first thing that is build is a module support frame or this is in short list called MSF.

MSF is nothing but a Module Support Frame, so this has to be design now this actually supports a different modules and where you are going to support the different modules is the that is the location. So, this is one type which have bit the module support frames is called a modular deck, and the integrated type is a the deck is in one piece, so deck is normally decks or of closed box type construction. Now, actually from the point of safety the integrated deck is much most suitable.

Because, the personal loan both the jacket beyond safer from the way when all win forces, they people generate the do not like to work in a exposed environment. So, this is a sort away enclosed deck, so the if you make a structure enclose, so that is enclose the enhance the safety of the structure, and also from the naval architecture point of view this will give you in case of capsize this will give you buoyancy and stability, so now, a day's actually they design this type of integrated deck buoyancy and stability.

Now, this is actually of prime importance not in the jacket platforms, but you will find this type this very, very important in case floating structures. In close remember, the buoyancy and stability only contributed by this is given by what by enclosed volume this you should remember. If the volume has any large openings, thorough which the water can common flooding or incase of ships also this is also thru in place of ships also, then it is not to be considered in the calculation of buoyancy and stability.

So, there are definite rules in the amole forceless which this must have should have come across the definition of what is called enclosed spaces. And for more details study related to ships such type of floating such an you refer to International Load Line Convention ILLC, I think all those things you should have come across. So, I will see has stimulated guidelines for assignment of load line or the maximum draft on the ship, which is based on again enclosed bases.

So, this one of the major advantage of a having integrated deck, so which is more relevant to floating structure rather than fix structure, because fixed structure of course, we are not going to sink jacket platforms the only danger to jacket platforms we will come in case of there are column breakage, and column breakage if that happens then the break is going to toggle.

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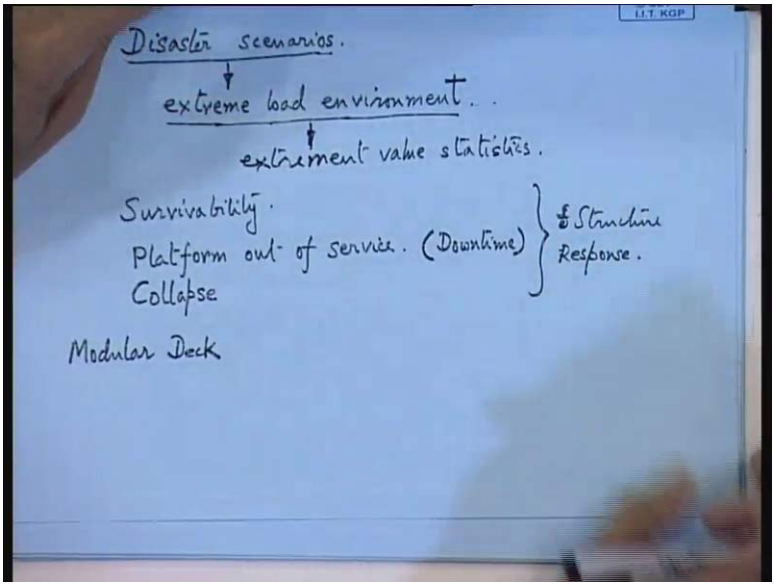

So, then of course, you should actually in offshore we have certain what is called disaster scenarios you have to create certain disaster scenarios. Now, a days in case of major structure engineering problem they do this analysis, they in case of extreme now in your disaster scenario is always related what is called the extreme load environment. Now, this is actually very tricky subject; that means, in which condition the structure that is boost up because of fixed platforms because fixed platforms you cannot through it away from sight.

Suppose a large wave come say freak wave or tsunami has come, then the jacket has platform has to this thing this thing twisting the extreme node. So, in our ocean engineering calculation most of the structural design or loads you have to take for extreme load calculations, for extreme their extreme combination of loads you may get load comma wave along with current, current is also very high. So, in the Gujarat coast there is saying current convenient 7 knots. So, 7 not current is very high Andhra coast is having 3 not current.

So, extreme load your environment has to be calculated and this is here to this a statistical calculation or extreme that is statistics you have to do, this is actually if you can to going to details, but you have to use of your who are going into this environment. So, extreme environment statistics or in some times you call statistics of extremes and this is another branches study anyway. So, this has to be calculated then from this you find out what should be your structure distance.

So, here you create concurrent here you create certain disaster scenarios with extreme with loads, and then you find out what is the survivability criteria. Whether you can survived in the whole thing disaster or not, so now there are certain cases where there are two thing which you should keep in mind that is the platform is out of service. Now, which conditions will give you the out of service platform, so this is called down downtime.

And the other is what is collapse structure collapse, so this actually the extreme load collision, in which this is a disability criteria where this structure is disabled after certain period of time, and then with comes to collapse of course, we cannot the structure. So, we have to create certain disasters scenarios with all these extreme loads, and you have evaluate basically this is your structure response. So, this is the we number of two criteria's which we have to it.

Now, coming to the layout to this structure that is the decks, so modular deck now modular deck has this three configurations. Now, last class previous class I told you whether you go for a modular deck type construction or a integrated deck type, so this will depends large wave on the there are two factors on the these two one is the cost, and the other is here shipyard capacity. So, the shipyard may not be capable of earning a 2500 term integrated deck, you belong may not have the prime capacity neither you deep water facility will be there.

So, most of the structure with your jacket perform is say more than say 100, 200, 300 meters long got to have deep water facility for taking the deck harm to the structure. So, there are now two installation criteria, one is called the hook up method and the other is called the floato gone method for the deck, which you come in position itself on the top of the platform. So, now, a day's actually you can do in two ways, one either you can with deck up or take the deck down on the truss, so that is called floato gone method.

Now, in the hook up method actually it depends on the capacity or the crimes, so all these things will play a part on which type of deck view come on to the platform. So, either modular deck or integrated deck, and the remember this modular deck wherever you are going for the integrated deck type this will recover more steam. Steam wake is going to increase in case of the integrated sorry in the other case I think in the modular deck type. Because of this, so modules support frame now you are actually you can see the type of decks you have a module support frame is also quite vast.

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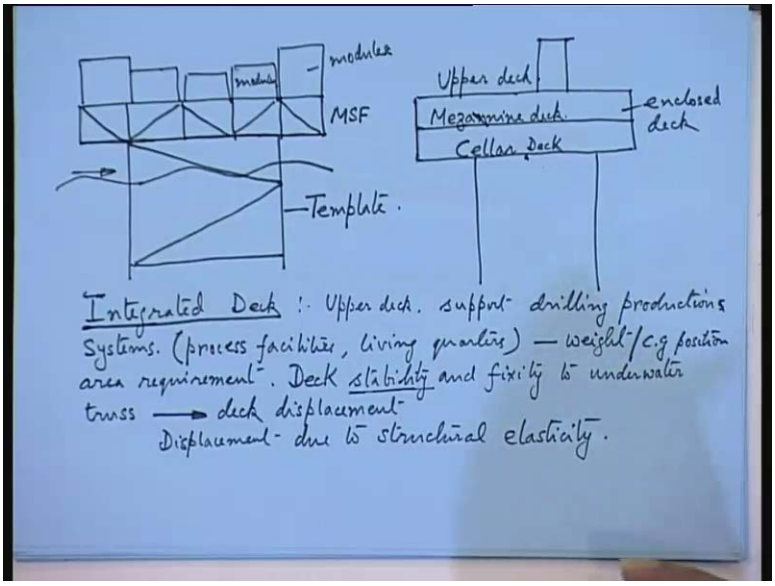

So, is not a simple structure, so here actually this is your jacket truss you have to build a another truss on top of you are the underwater is truss, say like this, this quite as substantial because this will know more or less like a bridge truss. So, this type of truss is build, so this is your module support frame or in short I am writing this as MSF, now on this you locate your deck modules these are come something like this. So, this is your module support frame, these are your modules.

So, this is normally they do it like this and the problem that is you have will come is the module support frame how you are going to integrated this with the underwater template or truss. So, this is your template these are the your modules MSF, and the other one is you find the integrated deck type this is rather it closed form of deck, now integrated deck type actually you will find there are two or three decks inside the platform.

So, this is the integrated deck type and inside you will find there is one deck, the top one is called the upper deck in the lower one I think they have special name they call it the cellar deck let we see. So, this is your cellar deck and the middle one you can leave it as a mezzanine deck this is a mezzanine deck, so this the total thing is this is enclosed, so this your enclosed deck, just like a ships.

Now, only upper deck you press all you are the deck during the etcetera will come some idea, now in this case there is no module support frame. So; that means, in on the upper deck actually these two deck mezzanine and the cellar deck is taking maximum amount of load, so; that means, your well head assembly. So, that is your conductor five such the normally they are lead somewhere here, on cellar deck if you have mezzanine deck then also you can go up here this you have to decide.

They can the one deck out here or two decks out here, according to the number of equipments and size of the equipments you will get. So, this has to be clearly thought about and the integrated deck type, so here actually most of the time you spend is in the deck layout. So, integrated deck type is having an upper deck, now this actually supports drilling production systems.

Now, what has an naval architecture or ocean engineer, what you have to do is you find out the rate sorry production systems, all this things you do make a process facilities, then you have living quarters etcetera. Now, this you have to do the g a drawing g i alignment dine integrated deck, now only the drawing is not going to help you, but what you have to find out is weight center of gravity c g the position that is your both b c g, l c g everything.

So, weight c g position area requirement, now this has to be careful configured in case of the jacket platform. Now, remember your jacket platform the size of the truss will also depend on your what this what is the template doing template is essentially a support to the deck, basic always it is resisting a wave loads that is which will smallest study when we study your file formation. So, always it is resisting your horizontal wave load that is coming on to the platform.

But, this is also acting as a support to the deck, now the underwater truss has to initially support the deck such that the deck is not in the danger of the toper lower or set away that deck fixity is highly importance. So, here actually one thing that we have to decide

is deck stability or they call it fixity, deck stability and fixity two underwater truss, now remember this is a steam construction. So, that is harvest strong you make the underwater truss it will have some displacement.

So; that means, normally you can take a need not record this is say 80 feet depth of underwater truss can give as highest 3 feet of deck displacement remember this is a fix structure not a floating tab of platform. So, decks steams stability that is why I mentioned deck stability, stability of course, not in terms of a buoyancy, but there is also structure engineering they call it the stability criteria, structure the stable or not. So, structure is stability will come from the main criteria is beguiling, beguiling and bending. So, that is called structure stability.

So, deck stability and fixity to underwater truss is very important, so this actually from this you get deck displacement. So, you have find element modeling of the underwater truss, you have to calculate what is the total stiffness of the underwater truss, we will make it very strong deck displacement will be reduced, for other same time this will also increase the wave load. Because, stiffness wave intend increasing member size, where column and basic member size will increase if you want increase a stiffness.

So, that will happened anyway, so you have to strike a balance between these two, now deck stability is important in case of jacket platforms of course, here wherever you get a very minimum displace. But, in case floating platforms the deck displacement will be order of say 79, 80 feet there will called deck percussion, deck you have percussion that a large and see motion are all around to move on. So, that will be have of with the lifting of the oil from the well head.

But, in case of the main reason why you go for a jacket platform is there are substantially reduced motions or practically no motions, always need jacket platform you will not get always is each. So, as an sea motions will not be there, but only the structural that is the displacement due to what that is displacement due to structural elasticity. So, you remember that you have believe a elastic structure, so structural elasticity will give you some rise to your displacement of the deck.

Now, how you reduce the deck of course, that will depend on the stiffness when it will depend on the stiffness here the materials we are not changing, but here is no ((Refer Time: 27:32)) where the that is increased going to increase the cost of the platform. So,

anyway, so that is the prime consideration in case of deck, so the integrated deck type this is the main this is first you perform the upper deck, then you come to your cellar deck that is the lower deck.

Remember in ships when you design how many decks do you call the upper deck, so in between the upper deck and ten tar if you have another deck that is called a twine deck, and lower most deck or the sometimes. So, here also that similar term as come, so cellar deck is actually the bottom deck, now here the cellar deck now remember that you have to make what is called whenever you are doing a g I design remember this, these are the crime objects which should be there in your you make a list see 1, 2, 3, 4 you write down is in each structural items.

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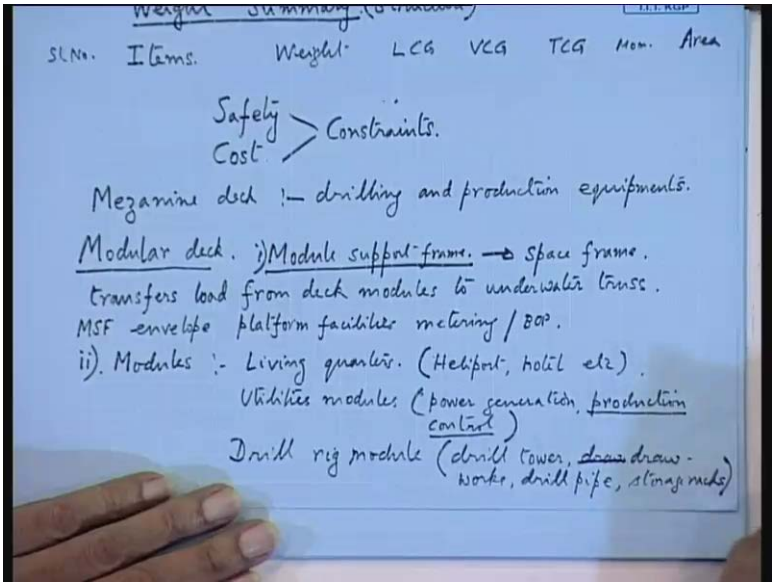

Now, in case of ships and offshore structure you make a weight normally they call it the weight summary if you go your this training you have to make this kind of table. And this is actually a weight tedious job, now in ships how do you make it you first stay on left hand side write down the serial number, then you write down the each and every item. Now, these items will be all these structural components see plating's, stiffness weight summary if you say you can call this structural first you make a structural weight history.

Now, in case of offshore platform this is quite simple because the shape is not changing in ships you will find that you have to make as a weight summary of the shell, shell

having some curvature you see. So, how you break down the share into number of stations, and from each station you calculate the girth and from that you find out the weight. So, each station will have this kind of summary, so items you make here you write down the weight.

Now, this has to lead for ships also now next you write down the LCG, VCG now TCG position Transfer Center of Gravity there you find out all the movements perform this, and at the end you find out the whole structure LCG, VCG, TCG. So, that is the main object of weight summary, so this is a detail calculation which is normally done the drawing ux.

Now, in ships actually you find that this distribution along with your hydrostatics, with hydrostatics you find out the LCB and displacement. Here also after you add all the bit that should match your displacement your particular water line in case floating structure, but not of course, in case of jacket platforms. So, here, so now, this I told you because you have to do it for floating structure or ships anyway, but similar thing also you to make for in case of jacket platforms.

Because, the jacket the main problem that your coming from the jacket is here the structural design is mainly based on your external environmental loads, and this is fix to the ground. So, always the buoyancy allow it is there because of the summer pushing on the truss, so that will contribute to your the boiled force, but that is not substantial. So, you name that is the resisting force is coming from where, in ships actually ships the weight is being supported by buoyancy.

But, in this case the weight is being supported by what, here in the buoyancy is in single layer because you columns heights similarly very reduced thickness, but why is there any I think your weight contribute is it critical or not. So, it is critical in one sense because all your weight that is the load of the deck the load that is coming from the truss will ultimately find in ships way to the wear to the soil. So, your foundation is going to during the resistance force not the buoyancy from the water.

So, here your foundation is not water, but it is the soil, so the resisting force on the movement is going to come from the soil. So, that is why here to the weight and the external load is very, very important in that case, so if you increase the weight on the

deck. So, unnecessary you will be increasing the load on the pie foundation listen it, and then of course, we cause to go up.

So, that is one aspect you should remember, the other aspect is if you are not care full about, so; that means, unnecessary you subject the truss to have a larger amount of load, and if you increase the area of the deck. So, the truss size is going to increase, here always if you will make the truss a narrower your deck is going to become a curved like this because it is not going to have the edge support.

So, truss is actually giving you the support to the deck, the efficient support to the deck is coming from the truss if you increase size of deck your size of the truss is going to increase. So, now if you increase the spacing between the columns, so you have to increase the basing size and of course, the number of basics likely to increase also because of the higher impact of the waves that will come.

So, that cancellation this will come and they will come to the cellar deck actually cellar deck supports first thing that it is going to support is, now in jacket structure is where the blow of preventer is present, where you are going to locate the BOP. So, this was the first all time which I told you in your previous class, so BOP is normally located on the cellar deck BOP or this is called Christmas tree.

Now, remember this BOP or Christmas tree is not very freeze structure, so in BOP Christmas tree you will wave of the order of safe you under terms. So, as a certain point of the deck you have to make a foundation for this BOP Christmas tree, then you have well head manifolds, manifolds is a junction of your pipe lines. So, they have lot of pipelines which will be on the deck, manifolds you have piping etcetera, so where is the cellar deck, the cellar deck is the just about the truss, so this is your truss.

So, give a some of the you will have other pumps etcetera around this things you will come, now suppose you equipment you find that the cellar deck area that you have allocated cannot accommodate all the equipments. Now, there is a unit to increasing deck size I told you because unnecessarily if you increase the area of the cellar deck, you are going to increase the spacing on the columns of the truss is of course, is not desirable because the plant as to pay out more moaning for a larger truss.

They here actually the main structure is your or the underwater truss is the main cost consideration because it is huge complexity. So, normally you try to unite the size of the deck, and if possible instead of going horizontally you try to go vertically, vertically if you go vertically; obviously, they will not be any requirement for increasing in the column spacing. As soon as you increase the column spacing the size of the truss will increase, and that will increase the wave load.

As soon as you increase the wave load you find that you to increase the column diameter column, diameter increase means the defection problem is going to come. So, lot of trade of are there, so it is better to go vertically up, now if you go vertically up instead of one mezzanine deck you can have number of mezzanine deck, but also you are increasing what, if you increase the size of the integrated deck now all these sides are enclosed there as to implicit's.

So, your wind area is when to increase, so main what are you movement is coming for what, the above water portion is coming from wind and this is your wave, wind is going to increase in case of a toll kind of integrated structure. So, wind problem has to be carefully configure, so all you see whenever you start designing as soon as you designed you will find that you are coming with lot of restrictions, we cannot go on increasing arbitrarily.

So, you have to as design engineer you to very, very confident what you are doing that is heavy case they will trade of optimization and all that will come. Because, the main reason is there are two claim consideration when we go for offshore structure design, and I told you one your safety you cannot play around with this and the other is cost. There are two claim constants you will come, safety constants, cost constants, so this things you will come.

And, so this is the equipments there are going to paste on the cellar deck, and if you find that you are not having sufficient space you go for a mezzanine deck. Now, mezzanine deck also may house may drilling and production equipments, so this a if you go for a integrated deck type, you go for this type of layout. And remember from here you make this your weight summary, and calculate all the weight and the area items make another formulate is area requirement. Now, the other item in your modular deck, now modular

deck the main component is here base you have to design this MSF, so this is called a Module Support Frame.

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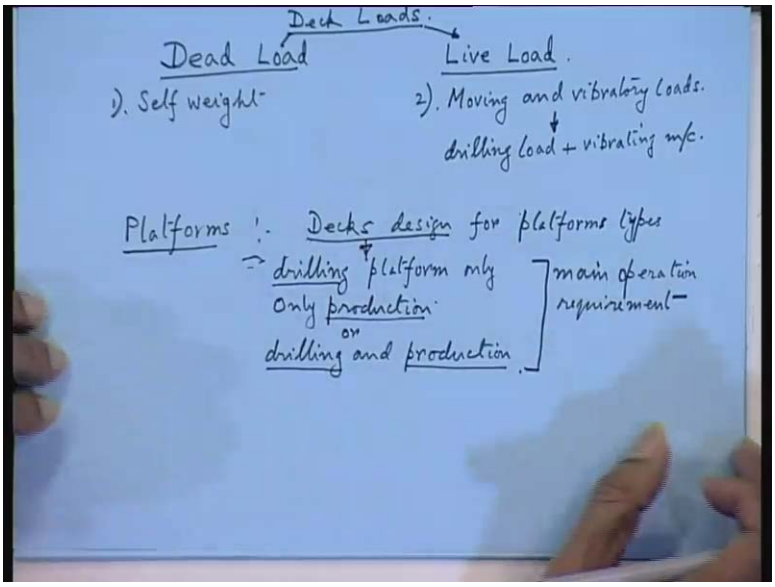

Now, deck whenever you doing this approach, now there are two aspects with you should keep in mind one is called the dead load you come across this, in civil engineering you will come across a dead load and live load. Now, deck you find error these two types are loads, the dead load is normally yourself unite, so you will segregated all the weight items into a dead load and live load. And live load is coming from moving and vibrating loads.

Now, this will be mainly coming from what, this mainly comes from drilling, now remember drilling actually the vibrating load is quite large. So, this is your drilling load plus vibrating machinery this is come from forms compressors etcetera, so this have to analyze, dead load and live load there is coming from the dead, the deck loads. So, remember that you will make it through history of the loads that are coming to your truss from the deck sides.

Now, coming to the, which one the module support frame is you this is a space frame, now this module support frame the actually transfers your load to your truss. So, this space frame actually transfers load from deck modules to underwater truss, so that is do a main function MSF. Now, you position this MSF clear of the highest wave crust, so this is called a air gap, the here this is air gap.

Now, in the environmental basic obtained they make tests suppose your wave comes and crashes on the deck, in any eventuality did what is going to be in fact, on this structure. So, here with the MSF you can have certain wave transference because you water will pass out of this, but here actually we exposed see this is a enclosed deck that is you are getting a large amount of surface area to the coming water surface. So, here actually these deck horizontal slid will be more.

So, normally you can carry this experimental of work out in a normally we basis done in a wave basin or a wave tank with we do all these studies. And after that, now why you all these studies are done in order to find out the dimension and the depth of the pile, so that is any way, so that will come to later will we study your pile foundation. So, space frame transfer the main function is transfer of load from deck modules to under water truss, now here we how efficiently you can do it that is based on your MSF design.

Now, here MSF sometimes you can envelope platform facilities, now portion of this module support frame, you can what is this you can enclosed. Say suppose you enclose this portion, where the operational requirement is more especially I told you that is the crew and all that will not like to operate your well head your BOP and all that this better to enclose well, because the personal will be required to operate the BOP and Christmas tree.

So, you will not like to this enclosed part of the cellar deck, so part of the sorry module support frame. So, MSF envelopes a platform facilities now normally you will find the let us called the metering BOP is etcetera is enclosed, so that is and the other is the, so there are two components one is the module support frame in case of modular deck, and the other is the modules themselves. Now, modules are actually positioned on the module support frame here the module, so on module support frame.

So, modules will have living quarters, so this will have a heliport then you have hotel accommodation etcetera, all this in come under the quarters and we have utilities. Now, remember these will have different weights, all these modules will have different weight and not only that is the sometimes say this is your well head module. So, well head module will on top of the well head module will find your deck drilling module, so drilling wind come here.

So, module support frame has to support both you are the BOP etcetera, so it comes here, and on top of that the rig module. So, remember this, so the module support frame you should not make it of uniform structural thickness because this larger independent on the weight of the modules. So, module support frame here there be extra strengthening normally in ships also you do that, in case of your FPSO or, so it drill ship wherever you have the moon pool and you drilling it, so that you will make extra strengthening.

So, similar thing you have to do it here, so that will depend on the weight of these modules. So, that is what I told you the weight summary is very, very important in case of a deck design ships offshore structures, so utilities will have power generation, so these are called utilities modules. So, here power generators will come here, so there is just some of the items, then production control room.

Say if you happened to the one of the platforms, these control station is quite elaborate just either a power station or a this normal chemical processing facility these production control will have we will look at lot of space. So, it will may not have that much of weight that you have to have all the controls, where your computers, your meters, your analyzer etcetera all this as to be clearly visible to the operator. So, there is as ships regional more elaborate, so that is called the production utilities module.

And last one is your drill rig, so this is a major weight item, so here you will find drill tower or sometimes they call this as a rig. Then you have what draw works I think have discussed about drilling sorry this is draw works, then you have drill pipe storage, now there is a another problem in case of jacket platform. So, in why you are drilling where you are going to store your drill things, they made as suppose there again deck design I have to tell you that platform there are number of types, always this is a fix platforms this will depend on the what requirement of the platform.

So, your decks normally if you design decks design for two types for platform types, now what are these platform types. Basic thing that you have to design is drilling platform only or rather only drilling, only production or drilling and production, now remember where your designing the decks you please find out whether what the operational requirement, so the platforms. So, these are your main operation requirements, so I am telling you again and again that all those has to be studied in totality.

So, this is your main operation requirement or client requirement, so sometimes your platform will be doing only drilling, only production or it can do both. Now, this where the influence your deck design why because you are the nature of the equipments will be different not widely different, but some among two difference will be there, and also you have the entrap or interface between the different systems, while this will also largely influence your deck layout.

Now, sometimes in now a days or they segregate the drilling and production, there is better if you want to start production at an early stage. So, it is better you go for this type that is you separate to be in production, so if you separate drilling and production normally you go with a offshore I will feel you fine to a two platforms advisor, one is doing drilling and other one doing production, but the problem is that is more costly, but at the same time you can recover oil faster.

So, that is the main object and sometimes the accommodation instead of housing on the same platform you make number of platforms. So, one, so support your accommodation one is the processing facilities, and other are will be in the actually you can spread it out into three different platforms. So, there are number of options when you go to offshore, we have to study these options which is going to the most cost effective, and which will give you larger output.

Whether you can assemble all the operations in one platform or you can split out into say two or three platforms. So, those things have to be configured, now that of course, the you have to talk with the client what operation requirements client requirements or all these things will be there, so here anyway, so what else we have discussing about the module support frame. So, this is in order to control the drilling is the most weight sensitive area, and the other last one you write is the production module. So, if it is a drilling come production, so then we have the last one you write is the your production module.

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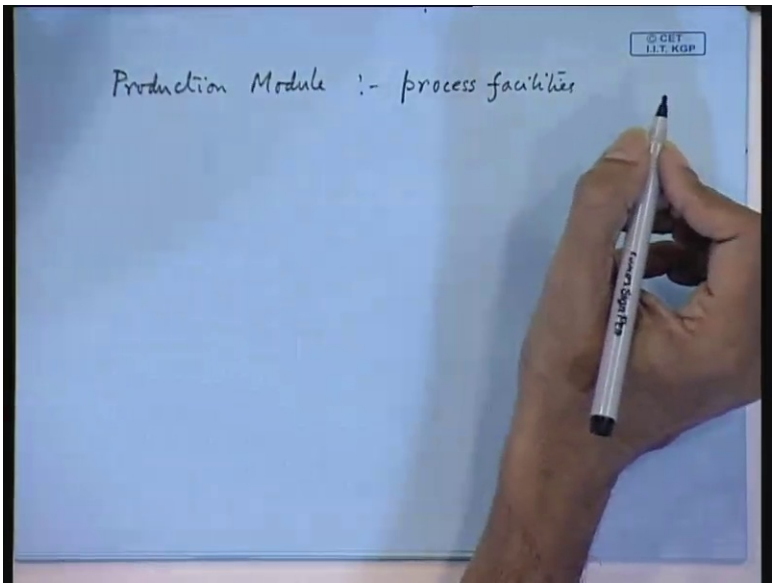

Now, after this you go for their detailed structural design, so this is mainly your process facilities. Remember another thing when you go for this type of platform what else talking about is the storage requirement, there will be large number of drill pipes or connected by, so; that means, when you are going for drilling you are that is your drilling links of drill pipe there are called drill steams inside the sea bed.

So, where you are going to take them, so you have large number of drill pipes, you have to stake them on the deck. So, sufficient area and has to be allocated first storage of drill pipes, and storage and your drill pipe is one item, but even if you are doing also, you should have storage for mud liquid mud. Because, that is your main lubricant, there are most of these platforms you will find, they have they a tanker comes and works among the platform and takes of the oil.

And sometimes this jacket platform they have means of temporary storage of oil, now if you have temporary store oil you should have separate volume for tanks to temporally store oil before it is transfer to a floating storage in it or a oil tanker. So, all these cancellations will come when your designing a say either this type of deck integrated deck or a modular deck. So, deck design is a very, very crucial item in case of jacket platforms, so I think you can have some refreshment and continue with this structural design after the...