Design of offshore structures

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Module No. # 02

Lecture No. # 05

Concepts of Fixed Offshore Platform Deck and Jacket 5

So, what we are going to discuss today is the continuity of the loading and the combination of loading that we discussed yesterday.

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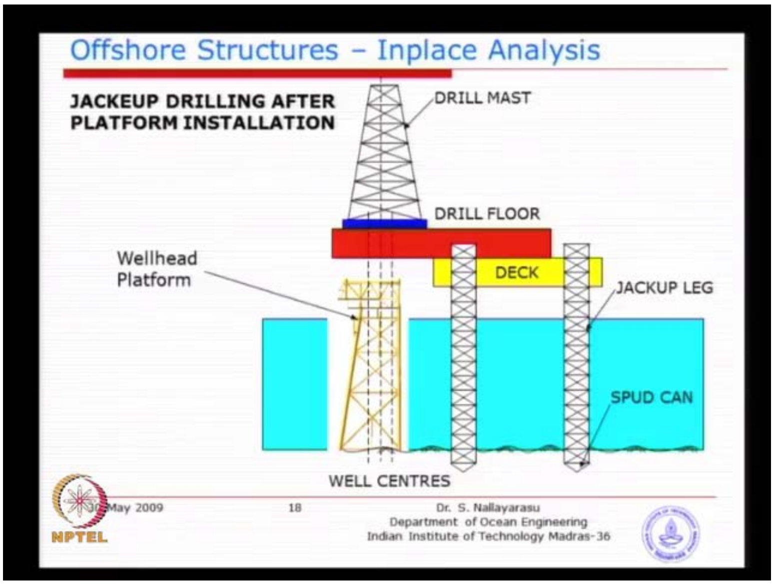

As you can see from this picture the drilling loads is only going to be in our loader onto the structure if it is the stand alone rig. In this case what we are seeing is the rig supported on the jack up and basically there is no load transferred from jack up to the structure, so is a standalone rig.

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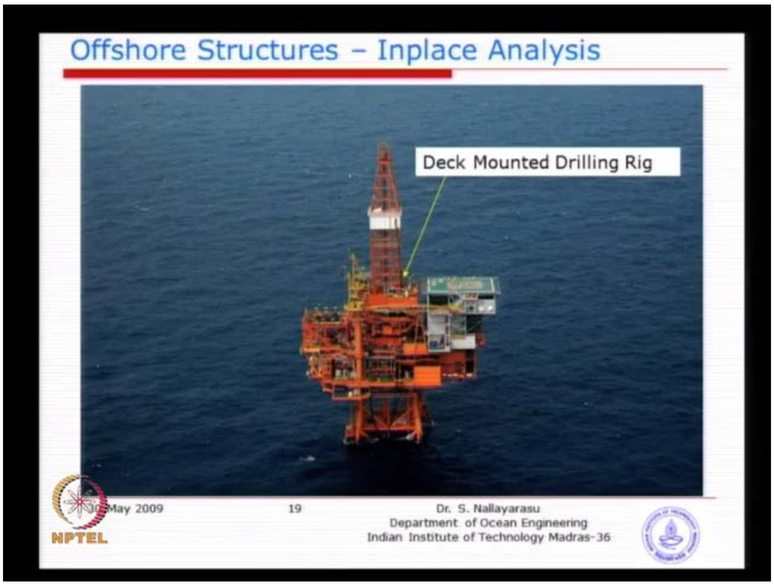

Whereas, if you see the that this type of platforms where complete drilling rig is on the platform itself so this work over rig or drilling work over is basically complete loading transferred to the top sides and to the jacket. So, in this case what we need to see is every time when you drill one particular well slot we need to see the variable loading the loading position changes because it is not going to be 1. Well in each platform we may have several wells, so every time when the well is being changed from drilling you will see that the location of loading could be different basically see. Here, there are 3 wells planned in this particular platform when the drilling is going on, here the load is on the left side when the drilling is going on the right.

The second well or the third well position of loading will be different, but fortunately for this jack up rig does not matter because whichever the well is being drilled all the loads are taken by the jack up itself. Whereas, when you come to this type of stand alone rigs on the top sides you will see that there is a potential change of location of loading and the magnitude of loading is very large, this drilling rigs could be a as heavy as a top side itself you have seen from this picture.

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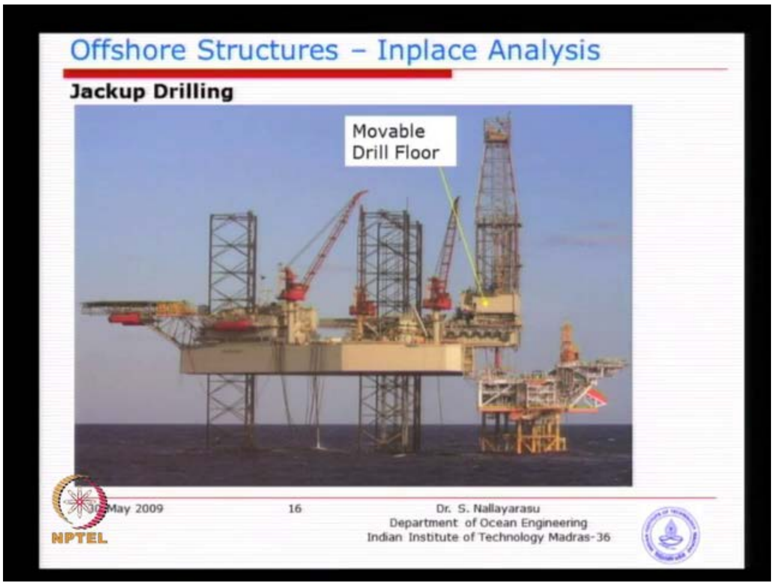

You can see the complete rig is very massive and that type of loading when the location changes is basically it is a variable loading and that is why we want to discuss about this because the variable loading could cause one of the pile. For example, when the load is on this left side this pile could actually cut higher actual loading when the load is shifted to the right side well and the same thing can higher on right side. At the same time when there is a environmental loading for example when the rig is on the right side and the load is coming from for example the wind.

The wave and the current is coming from the left side it could cause substantial pile and the leg load on this light because the environmental loading is coming from this side and the drilling is going on the right side. So, you could see the combination of effect so we need to see whether that type of thing will happen and the make sure that that combination is taken care. So, basically all what we are going to look at how do we do a combination and basically realistic situation over a period of the design life and every time what load changes especially when the loads are changing. For example the dead load is not going to change is always going to be constant or slightly varying as you see there.

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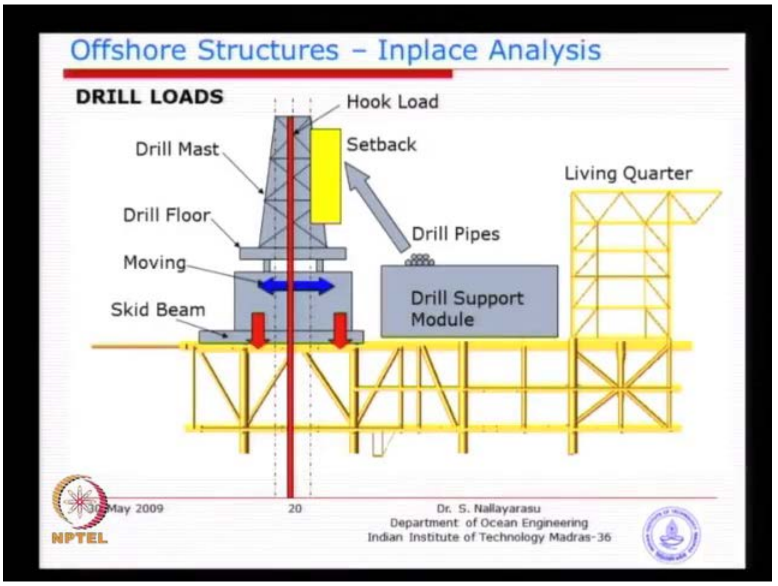

So, typically a standalone rig or we call it work over rig standing on a top side you can see here the red line is the load that goes down below the ground making it possible to drill and that is hanging on to the tower. This tower is basically the drill tower or drill mast where you will have a hook by which you will have the tub drive which will rotate the drilling rig strings and on the sides you will see a lot of utilities.

Wherein, you will see that heavy load is there because you need drilling mud you know during the drilling process to cool down the drill pit you need a coolant fluid which normally we have a sementeus fluids supplied from the top. It gets circulated it goes down and comes up and after cooling the drill bit otherwise what will happen after several meters of drilling the drill bit will gets spoiled. That is why you need to continuously supply conditionally drilled fluid and that is why you need such a large structure there because each of the tank could be bigger than this room is about 10 meter diameter circular tanks.

Wherein, you mix the fresh water with cement and supply this through the drill, so that the drill bit gets cooled and when the hot fluid comes up again it re circulate. So, that is the whole idea of this drilling requires large space huge amount of weight and a manipulation of all this equipments required. That is why when you put the complete drilling rig on the top of the structure you actually have lot of weight management in addition you also need power supply to this drilling rig who will supply.

So, that is why that you need a power generating system on the platform which will be huge requirement it is not going to be a small power requirement because you are going to drill 6 kilometer down the earth and that is why the facilities required for drilling could be substantially larger. So, in this you basically see here what is our concern is the loads from the drilling rig is shifting from one location to other depending on which value it is being drilled. So, first if you look at the design of the top sides the grader itself have to be designed for variable position of this loadings and then the corresponding position for jacket depending on which side the environmental loads are active.

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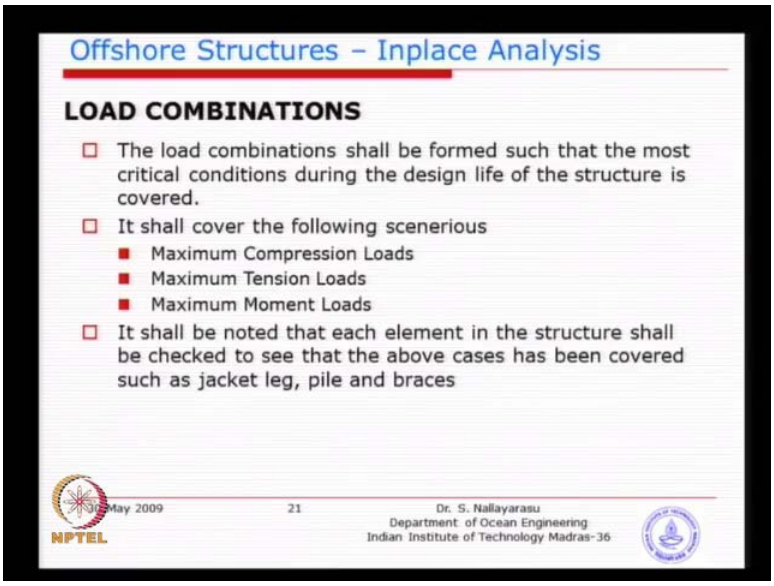

So, when we talk about combination what is the meaning of combination the combination is to verify the structure of different class of loading coexistence at any one given time. For example, almost all the time the dead load is going to be there unless you are going to remove it I do not think any dead load will be removed unless you want to demolish the structure. So, in this case dead loads will be throughout the design life may be the facilities loads could vary in a sometime you may drill sometime may produce, so you could see that the drilling loads will be maximum or the time of drilling.

But, during the time of drilling you may not have the production going on you may have already shut down or there may be some platforms only very few concurrent drilling and production. You call it this type of platforms wherein drilling you can also have a production because previously few wells have been drilled. So, what you need to do is just write down all the sequential loading and then form the set of combination and which needs to be designed in such a way that the structure gets the corresponding loading in the analysis and simulation.

So, the idea is we need to understand how the planning has been done in fact this will come from the owners we want to produce as well as drill or we will drill during non storm conditions we may not drill during high sea conditions. So, you just need to write down the sequence that has been accepted by the owner and then you just correspondingly design the structure. So, ultimately what we need to make sure that we have to see whether we have covered all worst case scenarios in this case we have got maximum compression loads maximum uplift loads and then maximum moment loads. So, these 3 scenarios are covered for the design of the structure why we need to maximize is in case if it happens the structure should be safe.

So, that is why we need to just see that whether we have actually simulated such scenarios and then because you cannot assume it will never happen because you do not know what will be the probability of that coexistence of such loads. For example, typically maximum compression loads maximum dead load plus maximum this facilities loads and corresponding environmental load which may maximize load on one of the leg which may we do not know it may or may not happen. But, the probability of occurrence we do not know unless you evaluate it, so in the working stage design we always assume that it may happen and have that combination included unless you are sure that it will not happen, you cannot remove that load combination from the design process.

So, basically that is the idea behind setting a combination of loads you could do one thing we can simply forget about this thinking we simply can add everything that the loads are subjected to on the structure and you can add them without thinking. But, that may not be the right way of doing it because you may be over designing it typical example will be for example you have a drill loads only going to happen during non storm conditions. That means during storm nobody is going to do drilling because of the safety issues and in that case you do not need to combine the drilling loads with the storm loads.

But, if you do not want to think you can simply add everything together and that is what normally is done in on source structures we do not differentiate to sequential occurrence of loading for example when you design a building. You do not design for 2 types of winds the normal wind and the extreme wind we design for the extreme wind and that is the end because we do not differentiate between these two.

Whereas, in off shore we could differentiate and we should differentiate to economize the structure in basically the extreme occurrence of ((Refer Slide Time: 09:20)) storm is going to be probability of very small number. That is why that will not be combined with normal operation because that will be rare occurrence, so that is the idea behind this load combinations.

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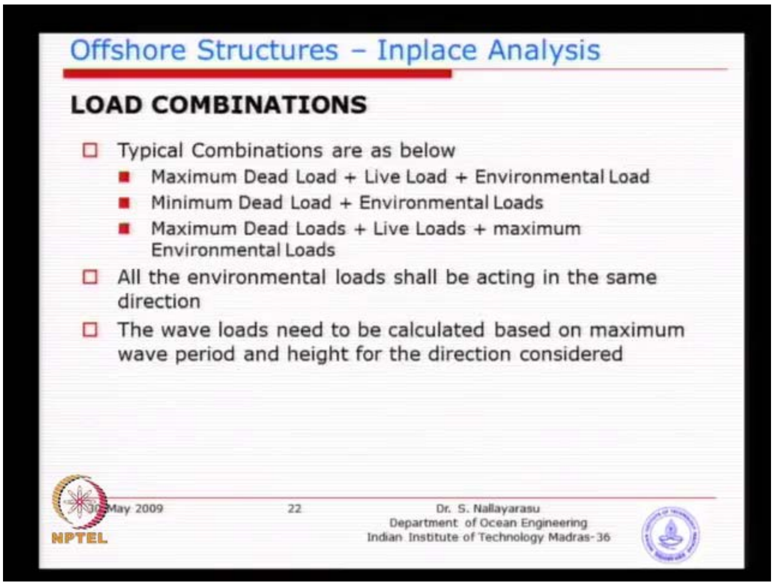

You could easily see that the purpose behind is maximizing compression for design a pile capacity and their corresponding columns tensions. Basically, the tension load could cause potential problem with pile capacity it could actually come out isn't it and the moment for bending. So, here for typical example we maximum dead load plus the live load plus the environmental load on one of the leg this could produce compression the other side it could produce yesterday we were looking at simple calculation know for horizontal load. Now, you see here the second one the minimum dead load and removed the live load this produces definitely a minimum or the the compression effect is minimum on one side that means the tension effect will be higher on the opposite side. So, if you have 4 legs, so the idea behind here is minimizing the gravity loads could potentially cause more tension load because the horizontal load is not minimized is exactly the same as the previous case. So, this could produce maximum compression this could produce maximum tension because the live load why did we remove it. It is not simply because of magic of number what we have decided is the live load may exist at some time or may not exist some other time for example during storm conditions you may not be able to load or areas with live load.

So, during storm you may actually evacuate or remove some loads, so that is why the live load is no permanent number 1 and may or may not exist throughout the life sometime it may be there sometime it may not be there. But, that condition we already have covered sometime it may be there it is already we have covered for the compression capacity. Whereas, for tension capacity we need to make sure that that is basically removed because this may not exist. So, like this is only a typical example we just need to see what else can happen during the life and make sure all the combinations are listed down and simulated.

Wave loads can be need to be calculated based on maximum wave period and height for the direction to be considered this is something that we will discuss again during our the wave load calculation. Basically, we need to see throughout the design life what is the maximum sea state that can occur and their occurrence interval it could be a regular interval of a year or 10 year or 100 year. Then see that we need for each one of the activity in this case we divide into 1 year operating condition and then 100 year storm condition that is means if the return period is 1 year that is going to occur more frequently.

In the design period or life of the structure which will be designed in coexistence with all activities as normal why we call it normal operation is the storm conditions are. So, called the operating storm will always exist we should not be shutting down the platform or any operation restricted. Basically, regular normal operation should be continuing together with this wind wave and current because if you keep shutting down every time a small increase in wave height you may not be able to perform very efficiently. So, you should design in such a way that such a wave height could be tolerable by the structure.

Whereas, when an extreme condition extreme storm of hundred year return period comes you may actually restrict the operations not necessary that you will shut down some of the platform actually continue to operate. But, you may restrict few operation for example lifting by a crane you saw one platform picture you see that is a crane here this purpose of this crane is to transfer cargo from boat to ship boat to platform to boat either way.

Now, during storm nobody will use this crane because it is quite obvious that it will be a risky operation during a storm condition, so you could restrict some of the operations. But, then we could continue to produce because none of these operation is risky because except probably a large load on the jacket could be designed as a structural engineer. Whereas, when you have equipment producing whether it is a 100 year storm condition or 1 year storm condition does not matter because the vessel is the equipments are fully supported on the structure which is designed for the condition.

That is experienced by the structure itself so the production can continue without any disruption. But, only some cases some of the production platforms may involve slightly different conditions wherein you may have to shut down, so it all depends on the operator of the platform he can decide.

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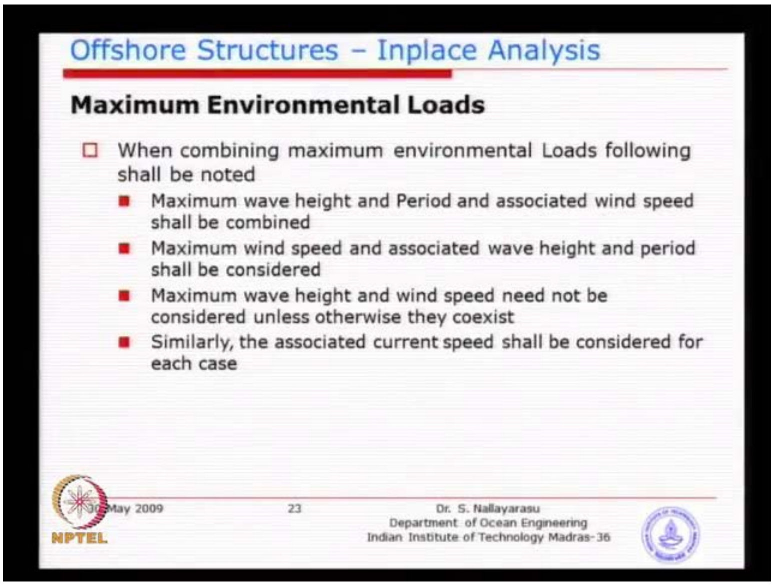

So, in short the load combination needs to be arrived at based on the functional performance requirement of the platform and the structure which is not going to be like given in a textbook this is the right one or this is not the right one. But, only will be a guideline will be given specific to each platform we need to make sure that all scenarios are covered I think maximum environmental loads.

There are several things could be discussed, one of them is basically maximum wave height and corresponding wind that means the joint occurrence probably I think you will come across in your thermodynamic course. The joint probability distribution of various parameters wave height wave period and the direction you know not all 3 of them going to coexist at one instant of time, you may have a maximum wave height. But, the associated wave period and the associated wind and the direction everything to be maximum the probability will be very small this is what we call it the joint probability distribution I do not know whether you have been introduced.

So, most of the cases the probability of coexistence of maximum wave height with the maximum wave period and associated maximum wind and maximum current will be very small and the codes does not require you to design for such a situation. So, what we normally do is maximum wave height associated wind that means you may have ten meter wave height, but a wind speed is slightly smaller than the maximum that may occur at the site. So, likewise you should find out the parameters in association with each of the maximum and a design for it instead you could decide actually take the maximum wave height maximum wind speed maximum current if you design for that I do not think you need to look at our review of all this because you have considered all events to be maximum.

But, that may be a too much of a conservative design which may not be in existence in the real field which is no good because if you design for it it is easy for you but, actually not good for the owner he is going to spend more money. So, that is why each of these you may have to review and find out the associated parameters which is sometimes not available. So, then we have to do a probability calculation ourself what is the probability of again the all of them will be based on mathematical model because unless you have measure data like what we discussed few days back. You may not have any measured data, so you may actually do a simulation based on prediction models and then use that parameters.

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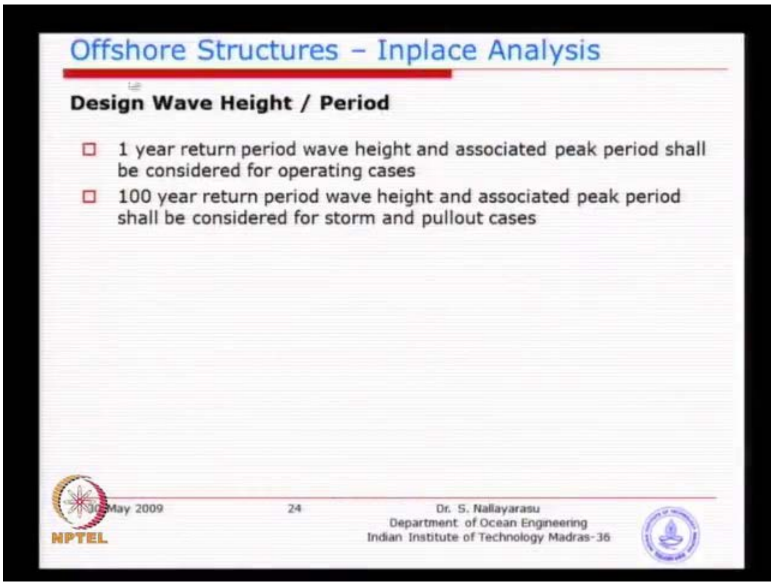

So, what is the difference I think by this time we have got the clear idea what is the difference between 1 year return period and 100 year return period at least once it will occur during the design life which is 100 years if it is spanning across. Then 100 year return period storm is basically nothing but once at least it will occur within that particular period of time. So, one year means is more often it is going to happen that means could be a slightly reduced sea state.

So, that is 1 year and 100 year is the designation nothing but the their occurrence interval and why we have selected this basically A P I recommends for design of any of the platforms if you would like to choose the design life as 25 years. For a typical example select 100 years storm period that means a factor of 4 you do not select the storm of 25 years return period for a 25 years design life you select the design life is 25 years, the wave height associated with 100 years return period is taken as the design storm. Similarly, when you design a structure for earthquake A P I recommends you take 200 years return period earthquake.

Rather than just simply if the design of the building is for 100 years we do not take 100 years return period earthquake, take 200 years that is a suggestion with a because there are uncertainties in evaluation of this parameters. So, they apply almost a factor of 4 and that is the practice for so many years which has been adapted successfully. But, even after this you see that 2, 3 years back I think gulf of Mexico they had wave heights used in the design exceeded by almost 30 to 40 percent which was actually based on experience.

They have been using 100 years storm condition of something like 21 meters, but during the earlier storm it exceeded all of them it became in fact 30 percent higher. Now, they have revised the course they revised the database because the 100 years storm what was in their mind for so many years of design has exceeded at that particular storm condition.

So, this needs to be reviewed every few years to, so that you keep in update with the changes that is happening in the earth. So, basically it will be reviewed every 10 years, 20 years depending on the information available because 100 years storm condition you may not be able to predict that accurately.

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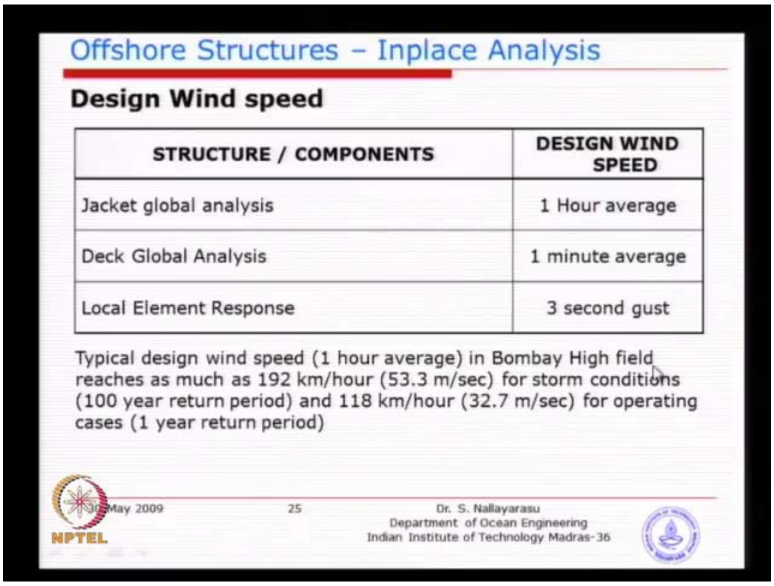

Similarly, the design wind speed for sub structures and super structure we just need to I think we did speak about this may be may be not the variation of wind speed with time I think we did talk about this. So, the A P I does give a guidance very easily for jacket structure design using one hour average for deck structure you design with a 1 minute average that means slightly increased wind speed. Whereas, compared to the jacket one hour average which will be slightly reduced and the local design with the highest are so called the gust wind that will be the highest you will see mostly 3 second gust could potentially be higher.

A typical design wind speed is given in this at the bottom of the table you can see their 53 meter per second which could be substantially high if you cannot even stand when a wind blows in that kind of speed 192 kilometer per hour. In fact if you remember few months back there was a storm in the east coast the wind speeds were as much as 180 per hour. So, probably if you have visited south so much of trees and houses and all the electrical polls were just dismantled just within few hours.

So, you could see this kind of speed if a, if it is on the platform what you see, here for example you go this through this picture is fully congested and basically covered with so much of facilities. If a 180 or 190 kilometer per hour wind speed is acting you could see the amount of loads induced on the structure could be substantial and that is where you will see that the design of sub structure becomes very important. Otherwise, you will see toppling or pull out or the piles especially when the wind is acting from this direction this legs. This leg will get substantially higher pull out loads, so unless the pile is designed for you could see that the pile can come out.

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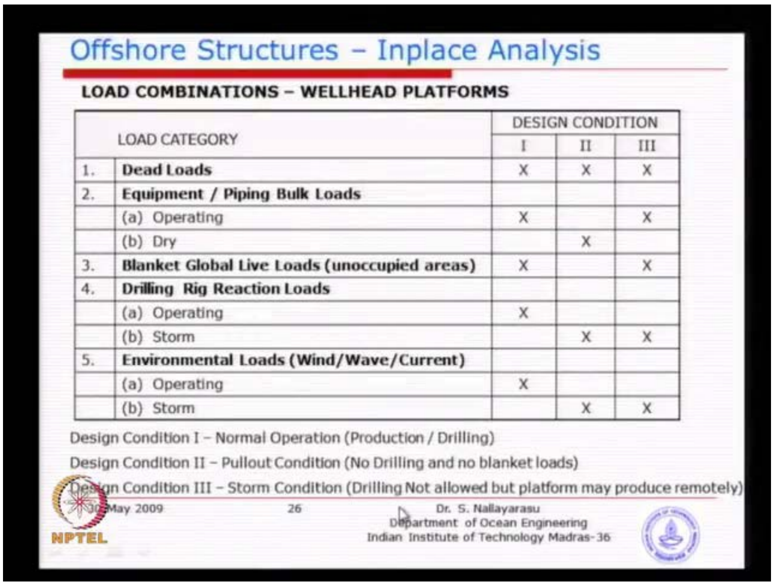

	LOAD CATEGORY	DESIGN CONDITION		
		I	II	III
1.	Dead Loads	X	X	X
2.	Equipment / Piping Bulk Loads			
	(a) Operating	X		X
	(b) Dry		X	
3.	Blanket Global Live Loads (unoccupied areas)	X		X
4.	Drilling Rig Reaction Loads			
	(a) Operating	X		
	(b) Storm		X	X
5.	Environmental Loads (Wind/Wave/Current)			
	(a) Operating	X		
	(b) Storm		X	X

So, that is the idea behind looking at these a simple table we will spend few minutes on this table and this table, so the first table is for the well platforms where the drilling and pumping will be happening. The difference between this table and this table is only the drilling loads you see the table, the drilling loads are added on the well platforms.

Otherwise, dead loads, equipment loads, live loads, environmental loads this going to be there for both cases the only difference is the drilling rig reaction loads during operating condition. Basically, that means the storm is normal storm you have the operation that means the normal operation drilling is going on, but in the case of two pullout condition also. But, basically the drilling loads are there, but reduced sometimes you may actually hang the drilling and hold on we do not want to do the drilling it does not mean that we will remove the drilling rig equipments it will be staying there. But, then we stop the drilling that means all the facilities will be there used for drilling, but we may not actually rotate the drilling rig.

So, basic idea is there and then you have the last condition which is not allowed completely you may decide this depending on the situation, so you have to cover this. So, you see here the environmental loads operating means 1 year storm means 100 years, so you may choose to some of the platforms people use to use 50 years also slightly reduce the instead of 100 years you can use 50 years depending on the design life. If the design life is only 5 years for example instead of 25 years typically everybody uses 25 years design life depending on what is available, but there is a marginal field then you can actually go for reduced.

So, that is why I specifically not put the 1 year and 100 year, here it is depending on the owner and the platform design, so you could see the first condition is basically the normal operation everything is very normal second one it is the normal operation, but the pull out. So, basically you have the loads to be maximized for tension capacity the last one you may or may not allow the drilling to happen.

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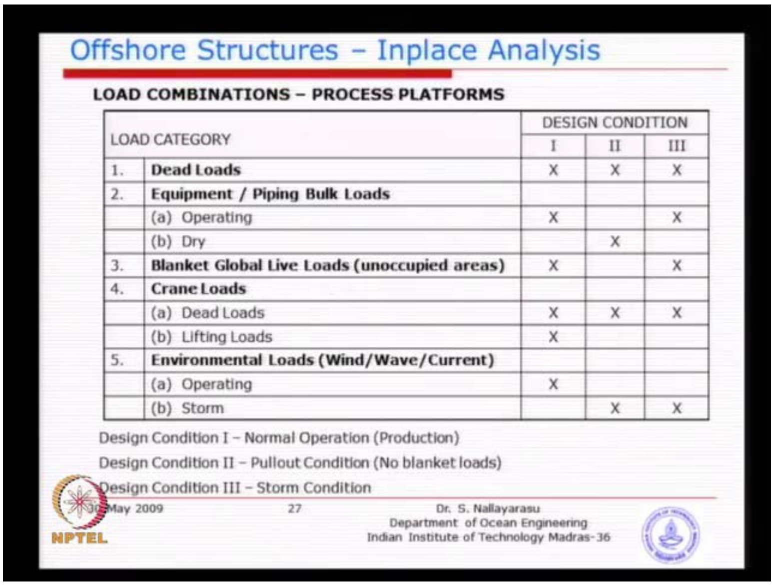

Now, if you go to the last one or the second one the process platform you see, here the drilling is replaced by the crane you may actually operate the crane or may not operate the crane. So, this is basically first you need to understand this table similar table to be created for the platform and then go and add the combinations we try to do this analysis method. So, basically what we have discussed is geometry I think to some extend we have understood basically how the structure would look like and then loading load combinations the purpose of them we just quickly see.

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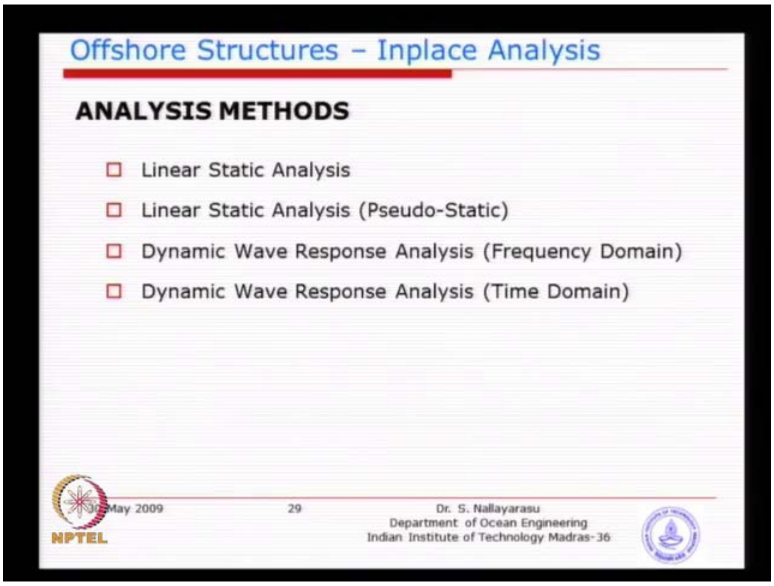

What are the analysis that we normally perform for various class of structures and you see here the first one the linear static analysis is a simplified methodology of analyzing beams columns portal frames and then a three dimensional structure. So, if you look at a beam static analysis is basically the load is not varying with time isn't it loads are constant throughout the design life. So, when such a thing happens there is no interaction going to happen with the structure because the load is static structure is definitely not going to respond dynamically to the load itself.

So, such an analysis is very simple I think the other day we were talking about various methods available to simulate the response characteristics of structure. For example if you have a beam you apply a point load you have a response of deflection bending and rotation shear force. So, you could easily calculate, so for a simple beam no problem portal frame you could spend more time in developing such things.

But, for a 3 dimensional structure you may use the computer software to generate such information because after all what we require is design of those elements or design of the structural system. Now, the second one so the linear static analysis how do we solve this for example if you look at a simple cantilever column subjected to a horizontal load, so you have a load you have a displacement.

So, the load and the displacements could be related as the load is more the displacement is going to be definitely more without any problem so basically the load and the displacement can be related by a parameter called stiffness. So, basically these three parameters could be related in a simple matrix form which is what you have studied in your applied mechanics using different methodologies like slope deflection moment distribution and then simple matrix methods, so basically which could be.

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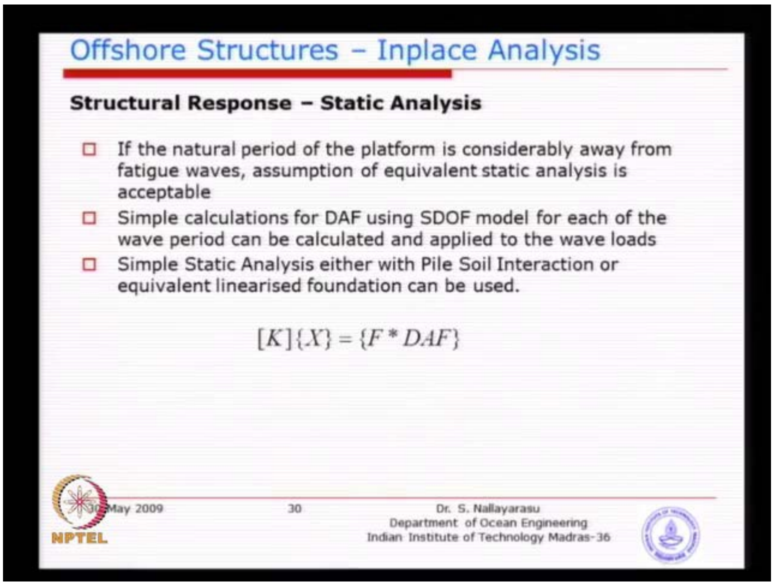

Written in this form the K is the stiffness, X is your displacement and F is your force the load applied. So, if you go back and then sit down write down the equation for your cantilever column F is the applied horizontal force X is your displacement horizontal and K is the stiffness you can easily find out all the methods will produce exactly the same result including the computer simulation. So, what is the meaning of stiffness the stiffness is how much load is required to displace the structure for unit displacement. So, basically it is like a characteristic information about the structure how stiff how soft the structure behaves when you have an external load is applied on the structure that is called stiffness. Now, you have axial stiffness you may have bending stiffness for example the load is applied horizontally in this fashion.

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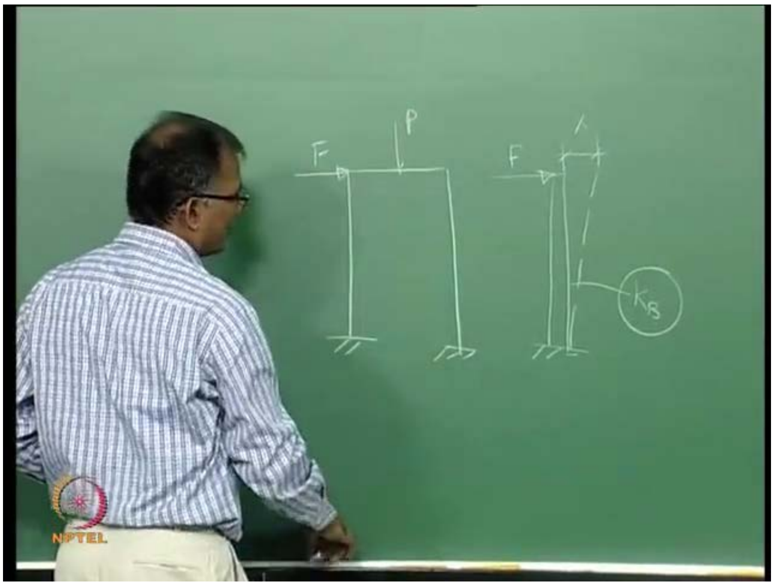

Then it is bending stiffness when I have a column like this and I apply loading and this is your, so bending stiffness K, so this is what we are in fact interested in. But, if the column is subjected to an axial load then you do not have a bending stiffness you have a axial stiffness.

So, corresponding to the degree of freedom being mobilized we need to find out what is the stiffness, so for the same column we could write all 6 directional loading and 6 directions of stiff nesses could be obtained. So, how do we get it this is the basic idea, so what is the axial stiffness and what is the bending stiffness we go back to the basic principle of mechanics and derive them very easily. So, if you have the capacity for example, bending capacity of this column or beam then divide by the unit displacement will give you the their stiffness corresponding.

So, the stiffness the unit of stiffness will be, so many kilo Newton per meter or Newton per millimeter is basically the structure response associated with the unit load or the other way round. So, basic idea is this type of equation could be enlarged for multi elements structure, here I have drawn only one simple cantilever you know. But, if you have a portal frame for example you could write the same equation in a matrix form you may have a various forms of loading something like this. So, the same equation can be derived combined for all three elements and then computer could be used to solve such solutions.

So, basically nowadays because of complexity of structures hand calculations have become really a very rare because of the time required the results are required urgently and many of the time even foe simple columns people use computers. So, you may have to learn any one of the computer software to solve because the basic structures what we have for offshore they are not going to be so simple is going to be quite complicated. So, the simple static analysis is the solution to get the response of the system for a given external loads which are considered to be static most of the time because the loads are not varying.

For example, dead loads they are not going to vary even if they are going to vary is going to be a almost static. If you are talking about changing dead loads after 10 years some amount of facilities are removed and may be you add it that is not a dynamically varying is basically varying very rarely. Whereas, if you look at the wave loads is cyclic number one is going to change up and down we will see this how it varies during the calculation of wave loads on the structure may be next week.

So, they are varying at a particular rate or basically a cyclic in nature and we need to see whether because of the change in load in positive negative or up down variation. Whether it could cause any problem to the structure in its in terms of response whether higher response or lower response or steady. So, basically that is the factor to multiply what we have is dynamic factor or dynamic amplification factor if you have already introduced the single degree of freedom got it. So, you could have derived the equation of motion for a simple single degree of freedom and basically calculated the dynamic amplification the response characteristics of a single degree of freedom system.

You will find that the whole of a jacket could be treated like a simple cantilever and then calculate what could be the increased response due to resonance characteristics of the structure with respect to the loading frequency and that is what we are trying to apply as the factor. Here, in case if you are subjected to such loading and all we know is every jacket is going to be subjected to surely wave loading and that is where the wave loads needs to be multiplied with the multiplication factor which we call it dynamic interaction factor.

Why are we multiplying the loading, here actually there is a increased response due to resonance or near resonance characteristics, but since the loading and the displacements are treated linear. Here, you see here the load is more the displacement is going to be more and is linearly proportional is not it, so that is why we could do this. But, actually if it is a non linear response you may not be possible to multiply on the loading side you have to go and increase the response side. But, because we have got a linear that is why we call it in this previous slide linear static we are not going to have a second order solution here because most class of the structures that we have they behave almost linear with respect to load.

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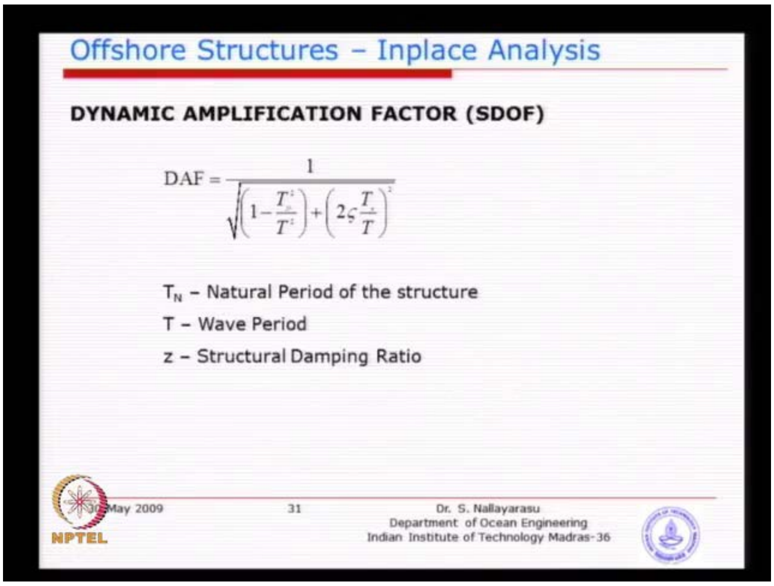

The second class of I think if you have already studied the dynamics first few classes you might have seen this equation the derivation for which is probably half an hour exercise. You could derive from single degree of freedom to obtain the relationship between 3 parameters the free vibrating period of the structure and the cyclic period of the load and the damping characteristics of the structure itself. So, these 3 parameters will give you the relationship as a dynamic amplification factor which is basically nothing but that increased response of the structure to the dynamic load. So, if the load is static say for example 10 centimeter displacement if the load is dynamic for a similar if there is a close frequency range then you will see that few times increased displacement will happen and that is what is called dynamic amplification factor.

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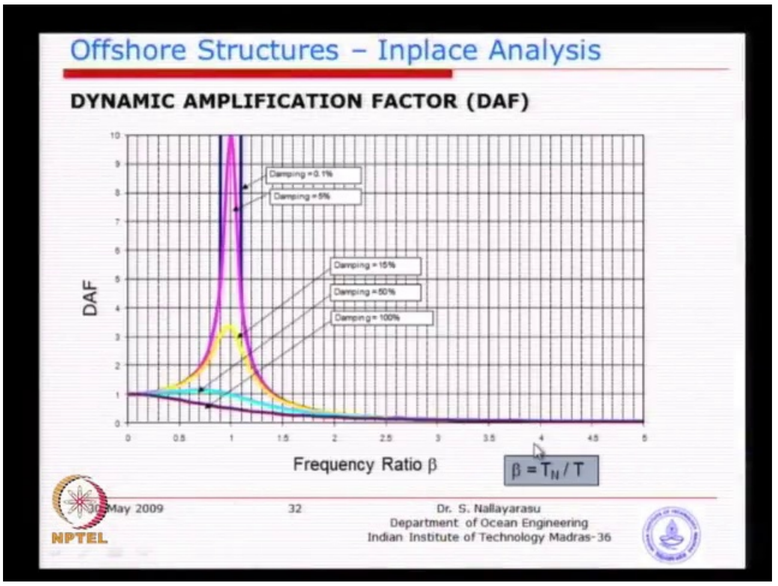

If you plot this whole thing in a in a simple picture this is what will happen the horizontal axis is frequency ratio which is the ratio of the wave period to wave period structure period or wave frequency to structure frequency either way you can write down. In this particular case I have just put it as natural period of the structure which is nothing but the first vibrating mode you could obtain very easily from a free vibration test divided by the period of the load it could be wave it could be other forms of loading.

So, you see here one important information is dynamic amplification of one means the load is static there is no increased response of the system. Whereas, when you look at the right sides there are several colors given as long as the structure is having some damping the response could be lower if the damping is very low then, so how do we actually understand this basically what is the meaning of damping. Damping is the material characteristics nothing to do with a stiffness, stiffness is a characteristics associated with static displacement.

Whereas, the damping is basically consists of several sub components the most important for us is the material damping the second one is the most important for offshore or ocean is the fluid damping. For example, we have a structure built in sea water when the structure is given at the loading is going to oscillate left and right if you have a loading this way right. So, when the structure is trying to oscillate the neighboring fluid is going to offer resistance against the structure movement you get the point now. So, basically fluid will offer some sort of additional damping, but how much is the quantity we just need to see whether it is realistic to take into account or is it possible to theoretically simulate imagine instead of water.

You put viscous oil you construct your structure there what will happen the viscous oil will prevent the structure from moving slow down reduce the response. But, if you construct the same structure in above ground there is only air you will have a almost no damping from the surrounding fluid, so purely the structure should take. So, that is why most of the time the fluid damping is ignored for future structures, but for ships and floating structures fluid damping could be substantially higher because the response is larger.

This is what you need to be clearly keeping in mind the damping should be mobilized nobody is going to come and help you the damping is large as long as the motion is large. For example, you go and compress the fluid and then release it the fluid will make the structure to rotate more, so is actually a interrelated characteristic of this structures which requires a your understanding probably I think if you take few more classes in floating body dynamics you will be able to understand. But, what is structural damping structural damping is the characteristics of material and the atomic structure of the this material bonding the more that it is you will be able to bring the structure back to its original configuration quickly.

For example, you take a rubber you take a metal piece both of them are given similar horizontal push, what will happen. The steel material will actually come back quickly compared to the elastic material which is going to just take longer time and some material may not even come back it continuously. If you have 0 damping it will keep on oscillating for a long period of time, so this material damping is the predominant component.

Most of the structural knowledge is we only take structural damping fluid damping is ignored basically because the damping will be very small compared to structural damping. So, you see here the plot is given for 3 or 4 assumed damping values 0.1 percent, 5 percent, 15 and 100 percent, so if you have a over damped system that means this for example you take a case of a concrete is almost like a over damped system. You know it does not respond too fatty because the elements are very strong and you may actually have a over damped system even does not respond to any of these dynamic loading or the loading is so small compared to the massiveness of the structure or the element.

So, you may have a over damped system or you may have a under damped system where the damping is so small because that is the nature of the material. So, depending on the damping you could see that the dynamic amplification especially for the blue line when the damping is so small you could see it has reaching infinity. If we just go back to this equation when you put the damping is equal to 0 you will see a very large value or infinity and a you could also plot this to get an understanding using a excel spreadsheet. So, you see the blue line the light blue the damping is 50 percent almost is like a steady state there is no dynamic interaction except after the ratio is greater than one in fact the response becomes even less than 1 do we have such a situation you may not.

So, anything factor less than one we should treat it as one cannot take dynamic amplification factor less than 1 which is absolutely not permissible. So, you may have to design for at least the full static load not less than that, so do not go blindly calculate the dynamic amplification using this formula and if comes 0.7 do not multiply. You always have to design as a minimum of one or higher you understand the idea know I think that will be the end of the simulation.