Offshore structures under special loads including Fire resistance
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture – 20
General Design Requirements

Friends, welcome to this 20th lecture in the NPTEL course title offshore structures under special loads including fire resistance. In this lecture we will try to convert some important design requirements in general and see how we can derive them intuitively depending upon our understanding of offshore structure behavior under conventional environmental loads and special loads whatever we so far discussed.

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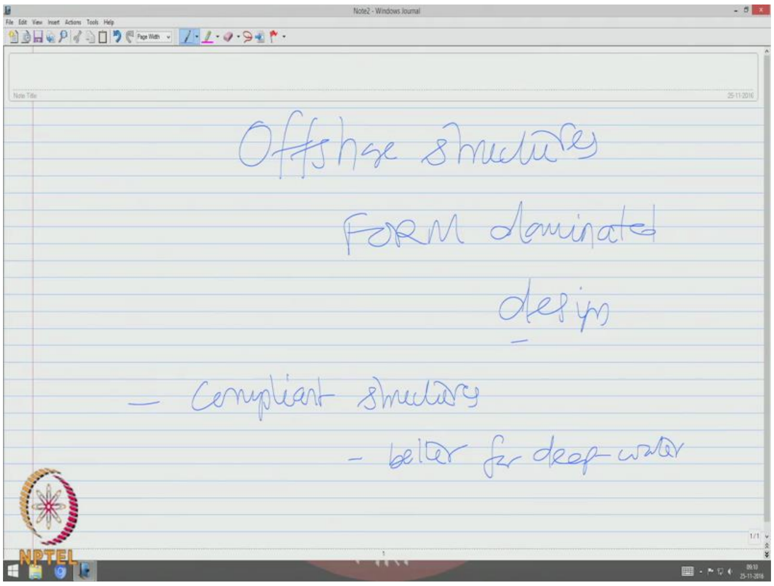

We already said that offshore structures an actually form dominate design, out of which compliant structures are better for deep waters due to the reduction and displacement because of relative motion with respect to the fluid particles.

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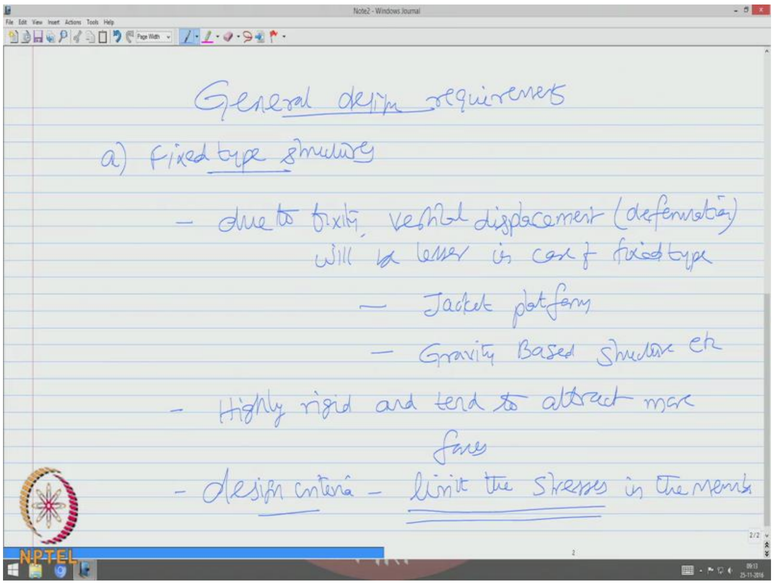

Let us see some general design requirements, which will be useful to understand the design of these structural (Refer Time: 01:41) under special loads. When you talk about general design requirements, one should really understand that these design requirements will be different for different classification offshore structures, let us talk about for fixed type structures. We understand that due to fixity, vertical displacement lets a deformation is design to be lesser. In case of fixed type structures we agree that depending upon the behavior, we are realize that the vertical displacement will be for lesser compare to other kind of structures example could be a jacket platform; second could be gravity based platform etcetera. The second issue what we have here which we must remember when we converts to some design requirements is that, they are highly rigid and therefore tend to attract more forces therefore, the design criteria should be should be two actually limit this stresses in the members.

So, the main issue here is to control the stress level in the members and not the member displacement or displacement of the system as a rigid body.

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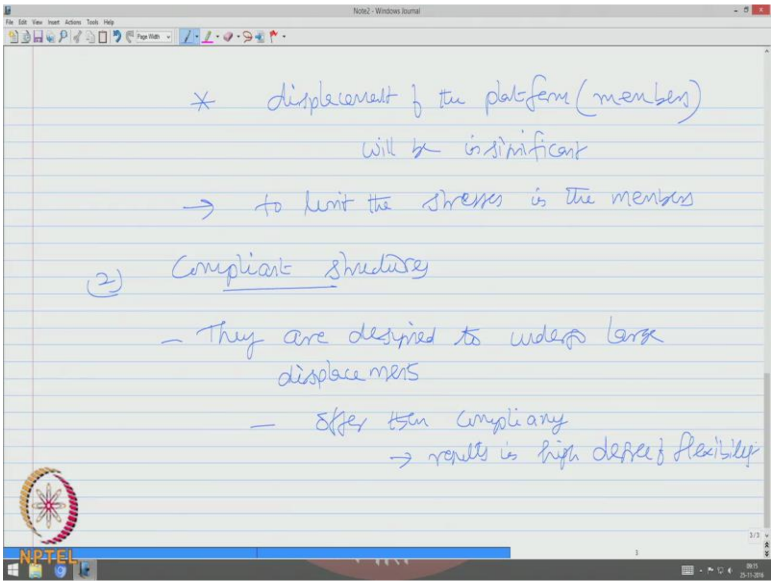

So, we also have one important statement displacement of the platform or even to that extent of the members will be insignificant. So, the design criteria are to limit this stresses in the members. Then we talk about complaint structures, we understand that this structures undergo large displacements, they are actually designed to undergo large displacements because large displacements offer them compliancy and which into in fact, results in high degree of flexibility. Now one can realize that when we improves flexibility the low carrying capacity may be reduce because of one fundamental reason.

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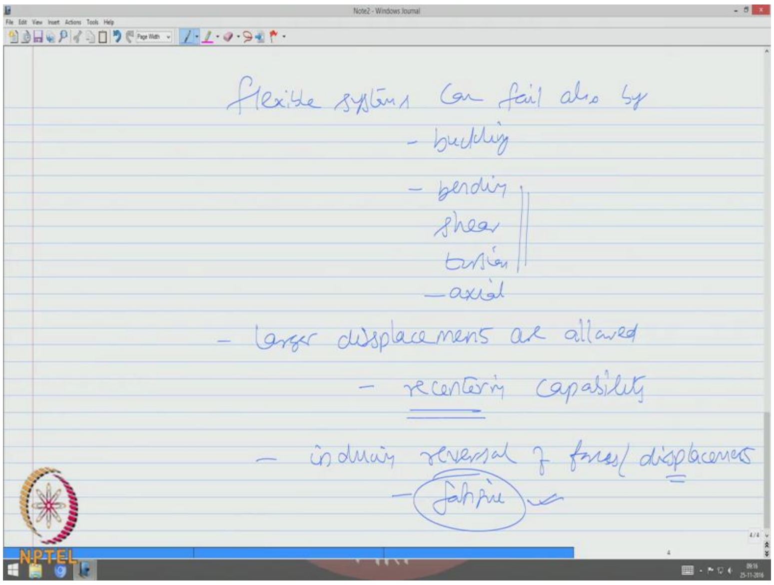

Flexible systems can fail also by buckling other than that they can in way fail in bending, shear and torsion and of course, axial forces, but in addition to that they can also fail by buckling, once is say larger displacements are allowed, I must also ensure that the system should have good recentering capability; it means the system should try to reach the equilibrium position at all instant of time under the given action of forces. The moment we agree that the system should have a go recentering capability, we are inducing either reversal of forces or displacements in both ways this may result infinities. So, compliance structures are forced to undergo cyclic stresses or reversal of displacements, which will be result in fatigue.

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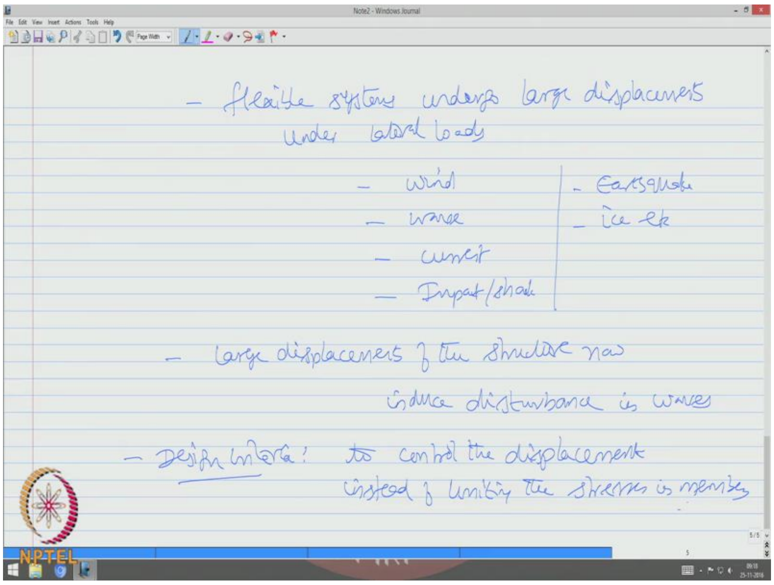

Keeping this in mind flexible systems undergo large displacements under lateral loads, this may include conventional wind load, wave load, loads arise from currents, loads arise from impact and shock, load also arise from earthquake, load arise from ice etcetera. Large displacements of the structure, now also induces disturbances in waves.

So, some second order effects in wave action is also initiated which was absent in the case of fixed structures therefore, if we talk about the design criteria, the design criteria should be to control the displacement instead of limiting the stresses in members.

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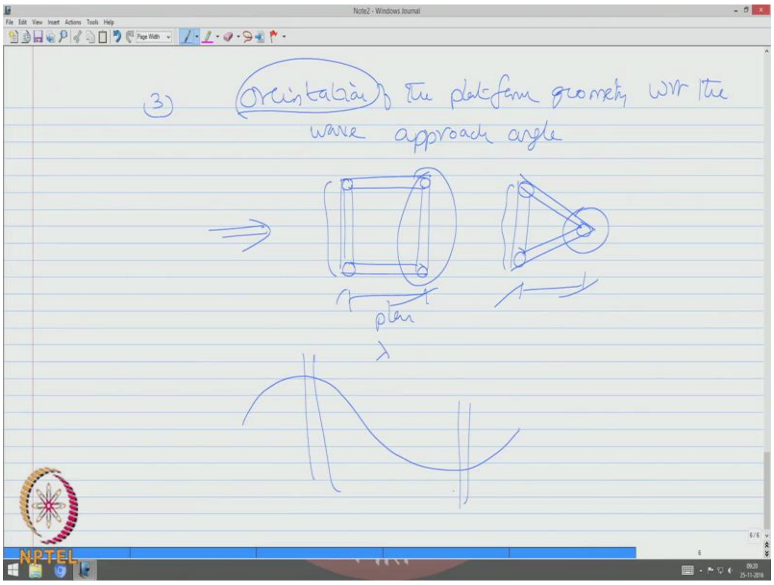

The third issue which we must pictures in this cases orientation of the platform geometry with respect to the wave approach angle; because you seen that in the last lecture a triangle of platform in plan which may be a TLP, compare to which we investigated a triangular TLP we should show better performances on certain degrees of freedom depending upon the wave approach angle, how many members do encounter the forces in the 4 direction and how many in the after direction, and what is the spacing of the legs there is very important role.

So, orientation of the platform with respect to the wave approach angle is another important aspect in design including what should be the spacing of the legs, so that when the wave passes through one leg attracts cursed and other give become (Refer Time: 10:22) therefore, the members cancel each other in terms of forces attracted by the lateral loads.

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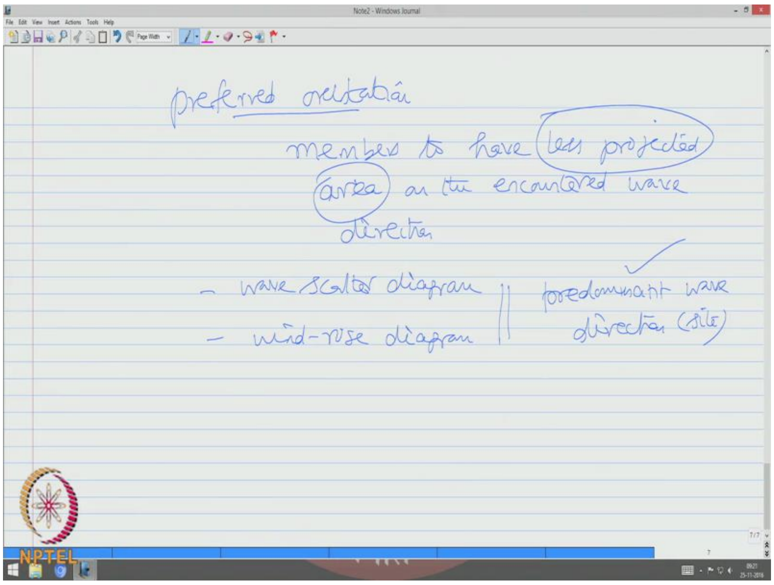

So, then one may ask me a question, what is the preferred orientation? The preferred orientation is members should have less projected area on the encountered wave direction. So, one may ask me a question wave is approaching the platform in all directions, how can be design the platform to have less projected area only on specific give direction? If look at the wave scatter diagram and look at the wind rose diagram, we will be able to find what we call predominate wave direction for a specific site.

So, what we mean they say here is, members should be design in such a manner, should be oriented in such a manner that they should have less projected area with respect to the predominate wave and wind direction.

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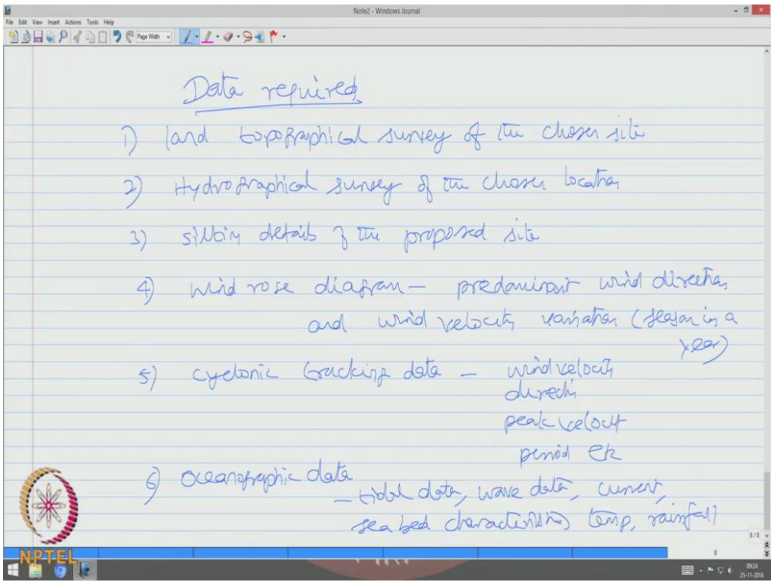

So, few data are required to design the platform depending upon the type of load acting on the platform, land topographical survey of the chosen site, hydro graphical survey of the chosen location, silting details of the proposed site, wind rose diagram indicating the predominate wind direction and wind velocity variations for the season in a year, cyclonic tracking data which indicates the wind velocity, direction peak velocity, period etcetera, we also need oceanographic data which includes the tidal data, wave data, current data, sea bed characteristics, temperature, rainfall etcetera.

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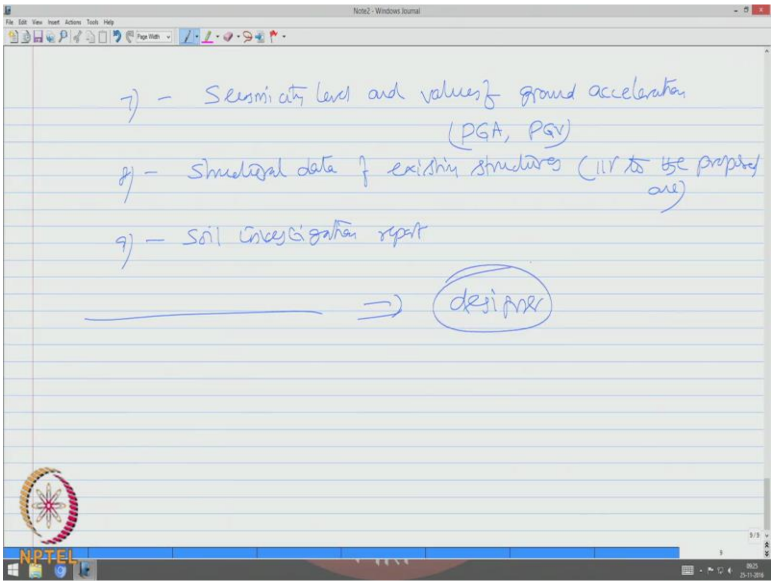

We should also have the seismicity level and values of ground acceleration in the last study we saw how will be using the peak ground acceleration and the peak ground velocity for finding out the response of complain system in combination of distinctly high sea waves.

We also need structural data of existing structures similar to the proposed. We also require soil investigation report etcetera. So, all these data or require to supply input information for the designer, before we design we need to find out the governing forces and the displacements and sustain values in given system.

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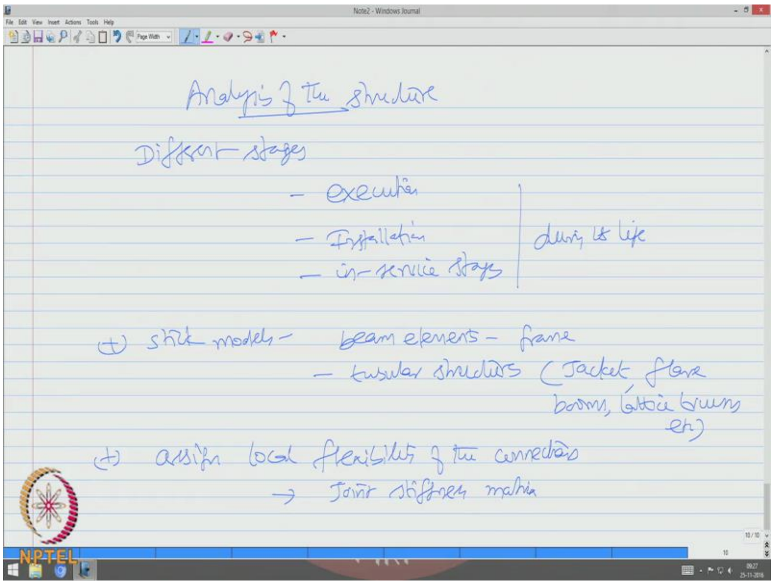

We need anyway performed analysis of the structure, just for information say let us completed this discussion as well in this slide; you do analysis at different stages like execution, installation, in service stages, during its life time.

People generally use strict models that is beam elements associated in the frame, this are use for tubular structures example jacket platforms, flag booms, lattice tresses to support the deck etcetera. Most importantly one should assign local flexibility of the connections, which is generally done by developing what we call as a joint stiffness matrix.

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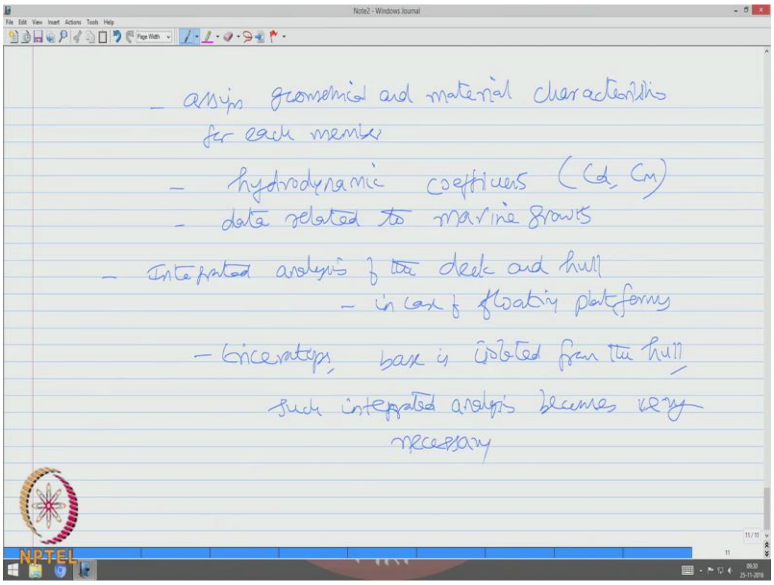

We also need to assign geometrical and material characteristics for each member, we need to also assign hydro dynamic coefficients like dark coefficient, inertia coefficient etcetera for analysis, we assign to data related to marine growth because marine growth we also affect the roughness of the cylinder and there by affecting the draying co efficient. We need also carry out integrated analysis of the deck and hull, this is very important in case of floating platforms. Especially in case of structures like triceratops, since the base is isolated from the hull such integrated analysis becomes very important.

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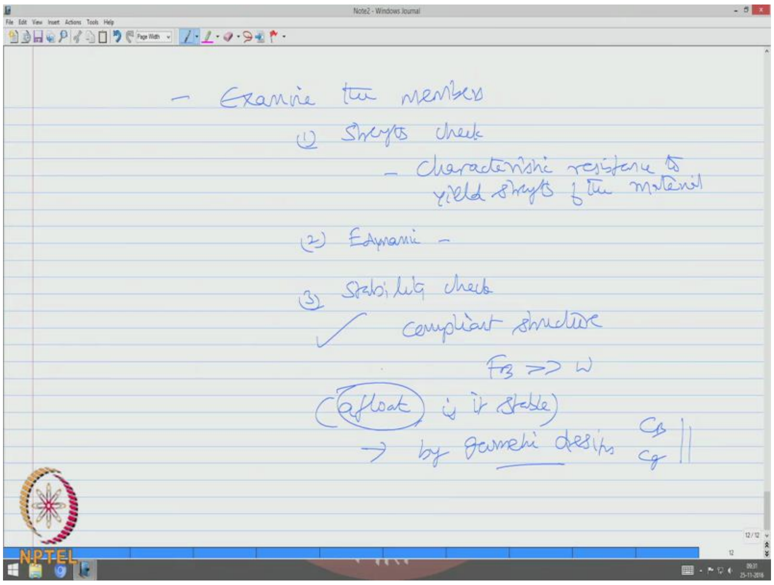

One need to also examine the members for strength check, where you relate the characteristic strength or characteristic resistance to yield strength of the material, when the material of the member is undergoing strictly stresses, we should be able to use dynamic modulus of elasticity. One should also perform stabilities check because complaint structures have a basic design requirement that the buoyancy exceeds the weight they large amount therefore, when system domains are float is it stable. So, stability should be ascertain by geometric design; checking the center of buoyancy, center of gravity etcetera where can ascertain with geometry design whether system is stable even wind domains are float.

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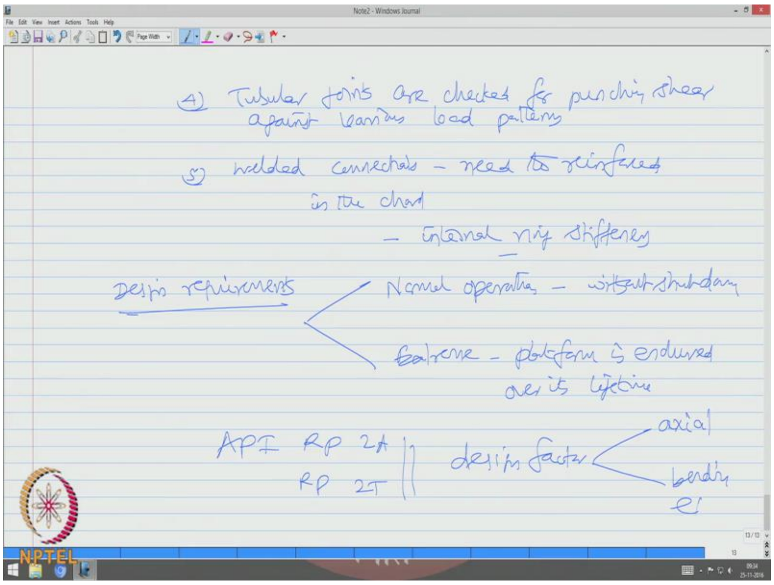

In addition tubular joints are also checked for punching sheer against various load patterns. Sometimes the welded connection need to be rain forced in the chard, one common feature is one can use internal ring stiffness.

So, generally design requirements or check for two cases; under normal operation, under extreme operation. Normal operation is the panties continue to operate without shutdown; where as extreme condition is that the platform is endured over its lifetime. There are various design factors available international course for example, API R p 2A, R p 2T, which are giving various recommended design values, design factor for various kinds of loads like axial, bending etcetera.

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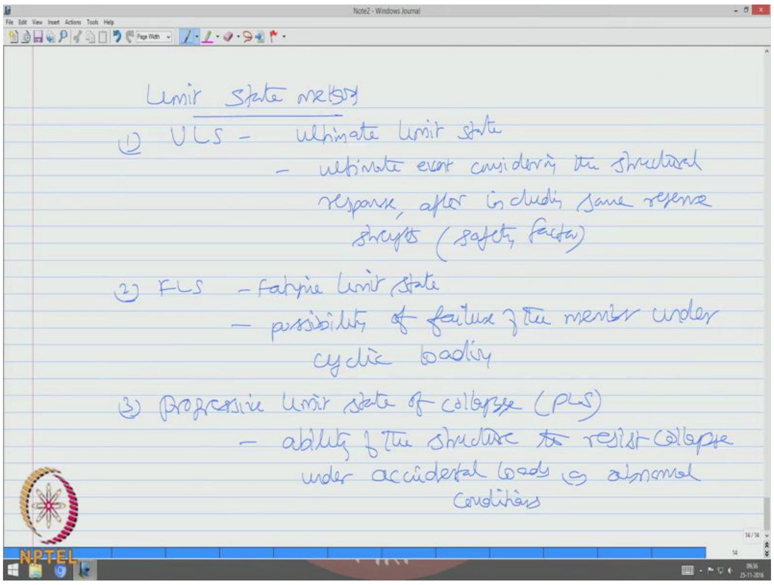

One common design method which will not touching in detail, but very briefly limit state method there are various limit state to be governed by the design ultimate limit state. This corresponds to an ultimate event considering the structural response after including some reserve strength; the reserve strength comes from use of safety factor. Second could be fatigue limit state, which relates to possibility of failure of the member under cyclic loading. The third could be progressive limit state of collapse, which we can call as PLS, this reflects ability of the structure to resist collapse under accidental loads or collapse under abnormal conditions arising from c states.

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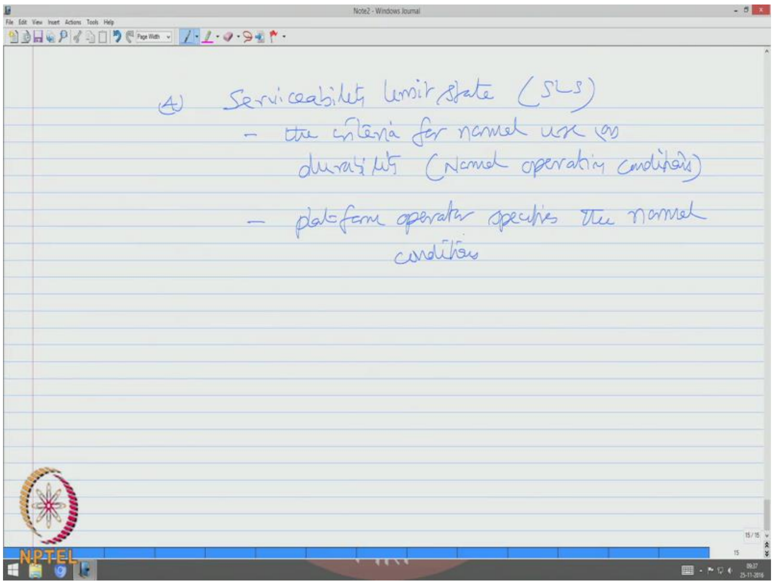

The fourth one could be serviceability limit state, which corresponds to the criteria for normal use or durability under normal operating conditions, which will be specified by the platform operator.

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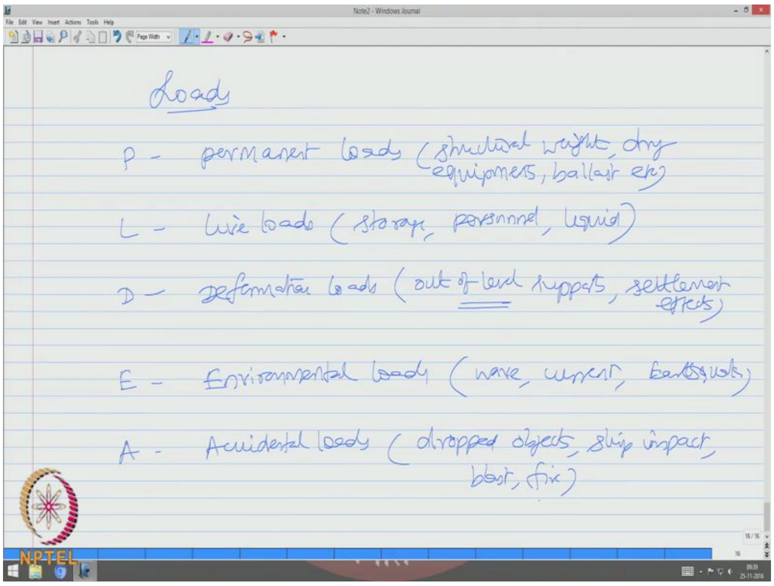

There are different verities of loads, under which these design criteria’s are governed by; we can say P permanent loads example could be structural weight, dry equipments, ballast etcetera. The other could be an L class load, which we call as live loads, which arise from storage personal on board, liquid for ballasting etcetera. The next could be D class load, which represents deformation loads, which arise because of out of level supports, will talk about these kinds of loads especially in the next module where we discuss unsymmetrical bending, settlement effects etcetera. The next could be E class loads, essentially come from environmental loads, which include wave, current, earthquakes etcetera.

The last one is than A class load, which comes from accidental loads, which can cause an result from dropped objects, ship impact, blasting, fire, explosion etcetera.

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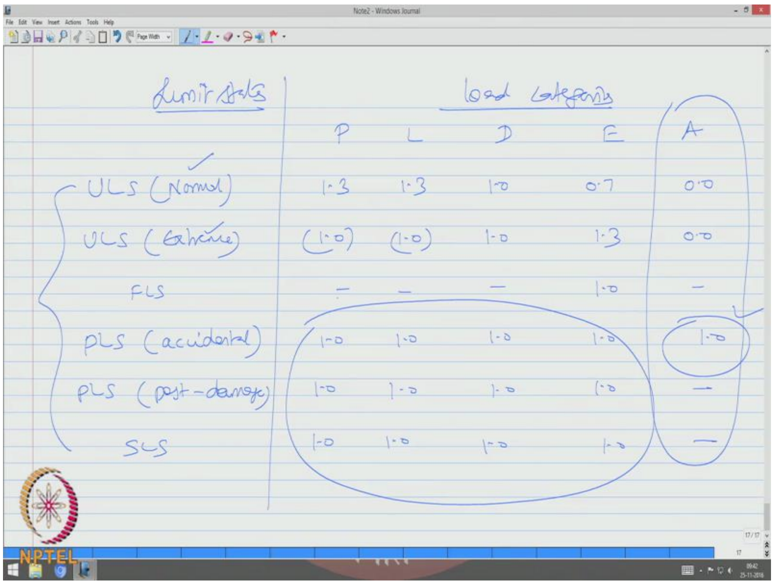

To considering quickly the various limits states and various load categories, let us say P class, L class, D E and accidental classes, all will have different levels of probability of occurrence and significance of these loads causing consequences on the structure or different therefore, different factors will represent these verities of loads in a given system. If we talk about ultimate limit state under normal conditions, then we say that this factors could be 1.3 for P and L class load, 1 for deformation class, 0.7 for environmental loads and do not considered accident loads, because in under normal operating conditions. When we talk about ultimate limit sate under extreme conditions, then we do not multiple the P and L class load by factor simple say one only, but we enhances the environmental loads because extreme condition arise because of this.

So, the extreme C states distantly IC waves we all come under this classification still in this case we know can consider short and impact loads. When we talk about fatigue limit state, we only considered environmental loads in these cases as factor and no other forces are considered for this multiple factor. If we talk about progressive limit state which is cost because of accidental, then we include presence for all the loads without any enhancement including the accidental loads; when we talk about progressive limit state of post damage analysis, then we considered all the loads, but we do not considered the accidental load; we talk about SLS service limits state, we considered all the loads present in the system a without accidental loads.

So, friends please note that in most of the limits states in design, we generally do not include the accident case and the multiplying factor in most of the cases remains unity. It means it is understood that all these verities of loads like permanent, live load, deformation an environmental loads, at with same amount of probability which is a very important level of complexity in analysis design of offshore platforms.

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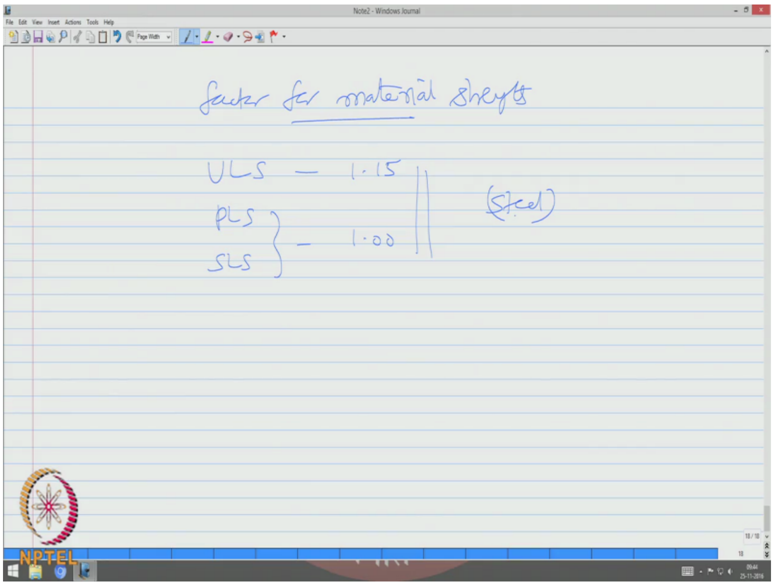

These are about the factors for the loads, we also use factor for material strength because the characteristic definition applies to both material and the loads. Loads we are already saw in different verity in the last slide, material strength generally for ultimate limit state we use 1.15, and for progressive limit state and service limit state we use 1.00 as the material strength factor when we use steel as material for construction.

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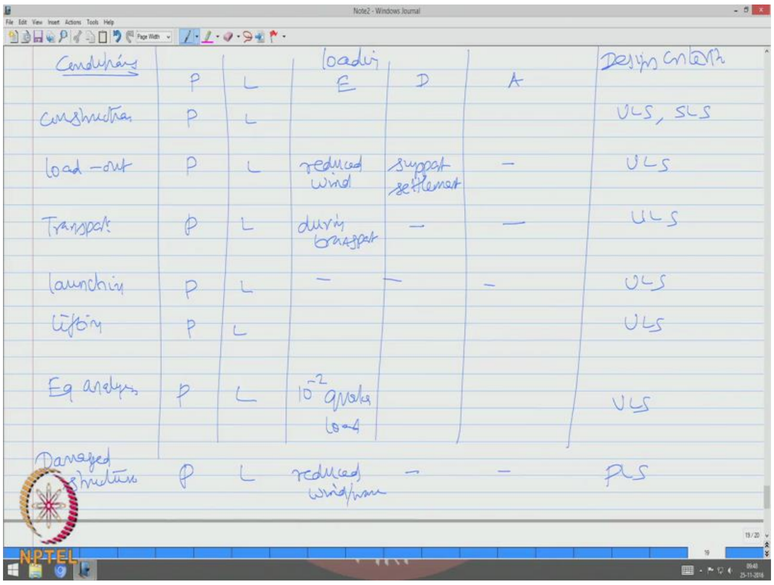

When we talk about various limits state in terms of constructability, we can again divide the loading on the design criteria; let us say P class, L class, E class, D and accident class, we talk about the different conditions where we do analysis, let us say for construction condition, we use P class and we do generally ultimate limit state and service limit state. For load out which is one of the important segment in construction process, we include permanent loads and live load we use reduced wind in this case we use or we considered displacement of support and we do not considered accident, then we do ultimate limit state.

During transporting we considered P class and L class loads, we also considered environmental loads, during transport we do not considered suppose displacement and accidental loads, we do ultimate limit state. During launching we considered P class and L class loads, and we do ultimate limit state. During lifting operation we considered P class and we do ultimate limit state. During earthquake analysis we do P class L class loads, we considered wind and wave action with specific return period as specified the course.

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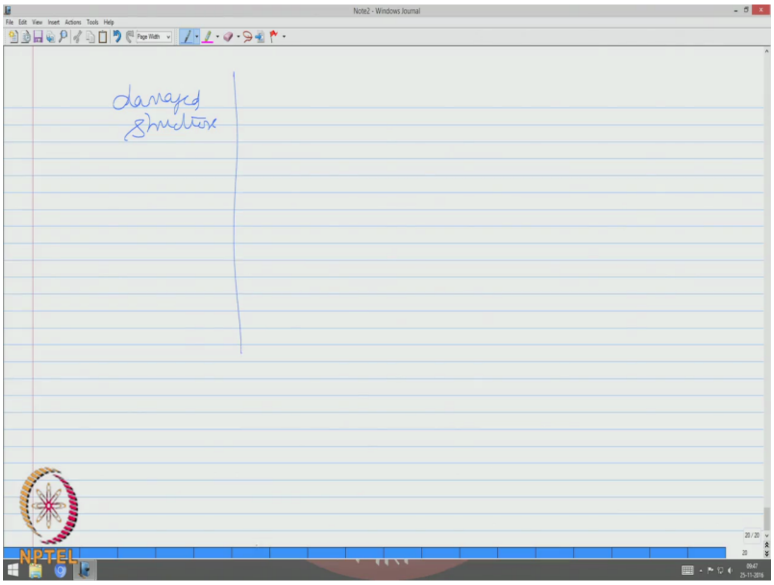

Suppose displacement whatever happens actually will be considered no accidental loads.

We will talk about damage structure; in earthquake analysis we considered permanent load and live load, we considered earthquake load with return period of 10 powers minus 2 and we do ultimate limit state. In case of damage structure we want to do analysis for reliability condition, we do considered permanent load and live load, we considered reduced wind and wave; we do not considered suppose settlement and accidental loads we generally do progressive limit state at this thing.

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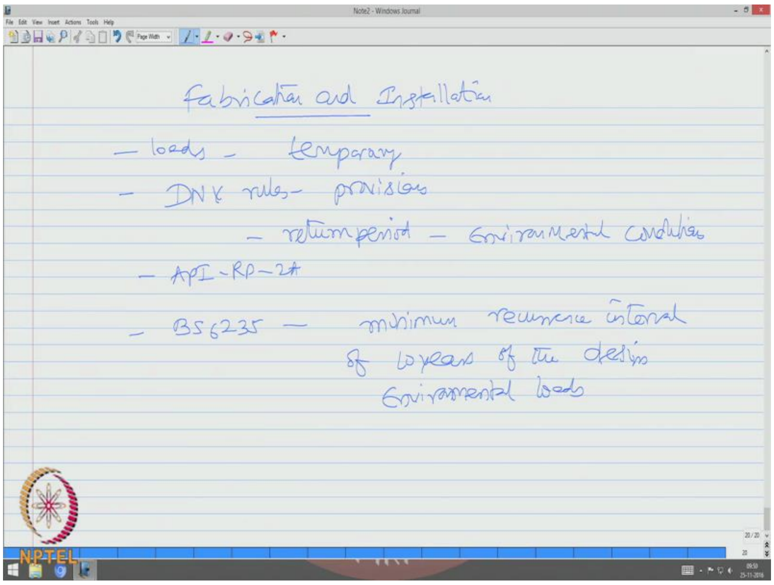

So, friends interestingly different limit states are applied and different stage are construct as well you also in fact attract more loads during fabrication and installation. The loads arise during fabrication and installation are temporary, they are different verities of international course which give you idea about this kind of loads to be considered in analysis, DNV rules or one such provisions, they defined the return period for considering environmental conditions for the design; the other one is API R p 2A.

The third one could be BS 6235, which recommends the minimum recurrence interval of 10 years of the design environmental loads.

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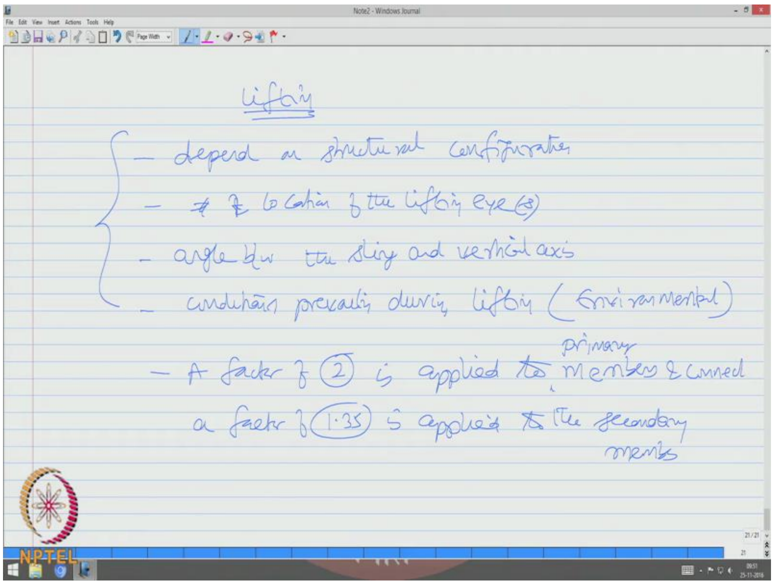

In addition will also have forces arising because of lifting, they depend on the structural configuration, number and location of the lifting eye. I should say eyes because in many locations, angle between the sling and vertical axis, we also talk about the stresses generated in the crane hooks because of lifting forces in the next module conditions prevailing during lifting, I am talking about the environmental conditions. Generally the account for all this second order effects a factor of 2 is applied to members and a factor of 1.35 is applied to the secondary members.

So, I should say here primary members and of course, connections.

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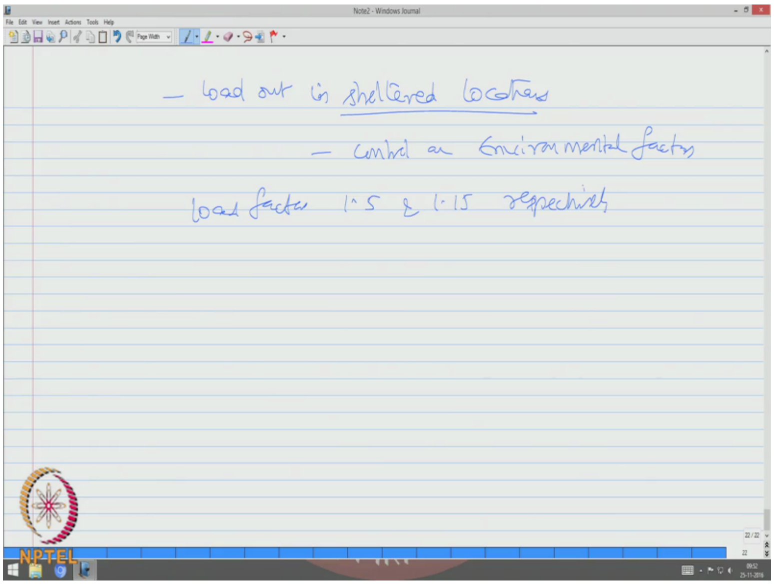

When you do load out in sheltered location that is an advantage sheltered locations will have some control on environmental factors therefore, the load factors used under sheltered condition is 1.5 and 1.15 respectively as in the case of previous considerations.

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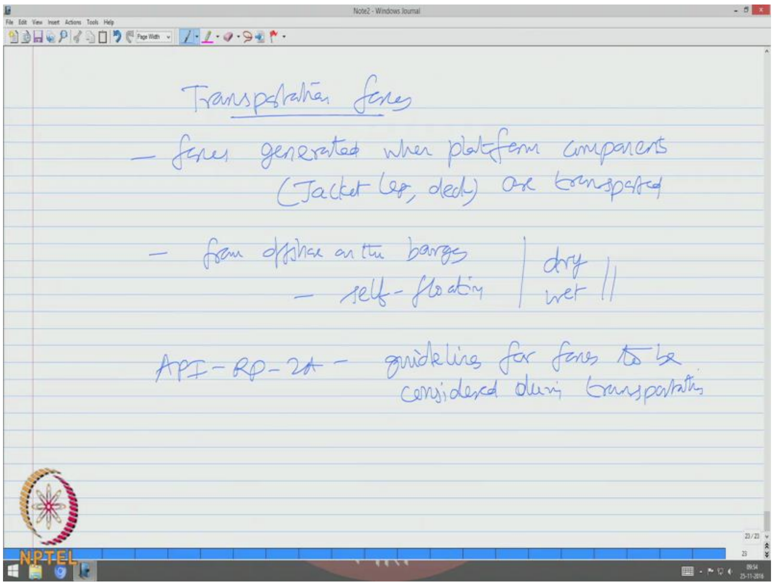

In addition we also have forces which arise from transportation or during transportation these are the forces generated, when the platform components like lets jacket legs, deck of the platform are transported, usually we agree an understanding that transportation happens from offshore on the barges, sometimes they can be even self floating. So, we can have dry or wet rotation. So, API R p 2A an interestingly gives you lot of guidelines for forces to be considered during transportation.

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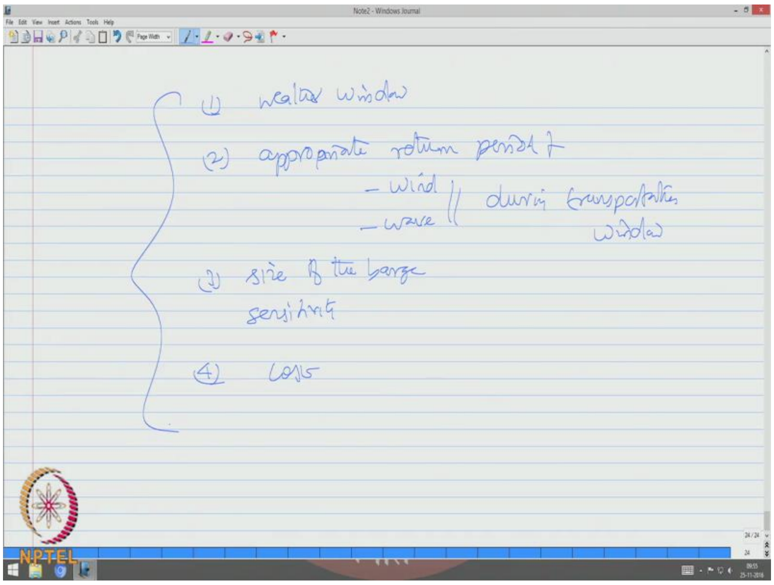

One should considered weather window during transportation, appropriate return period of wind and wave during transportation window, one should also think about the size of the barge, it sensitivity and most impertinently the cost. So, these factors will govern the kind of transportation forces that can be included in the analysis.

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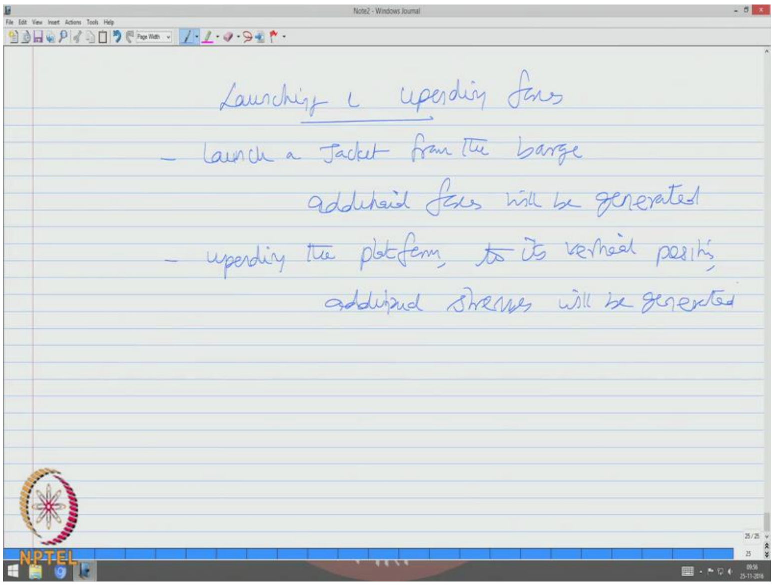

Forces also arise because of launching and upending, when you launch the platform from the barge, additional forces will be generated. While you are upending the platform to its vertical position, it is interesting that additional force in fact I should say additional stresses will be generated.

So, friends interestingly when a member is oriented only we small tilt of few degrees, let us say 1 or 2 degrees, the stress incremental a member can be as high as about 40 percent because that it create additional moment on the members which will result because of unsymmetrical building caused on this members, which will discuss in detail with some examples in the next module.

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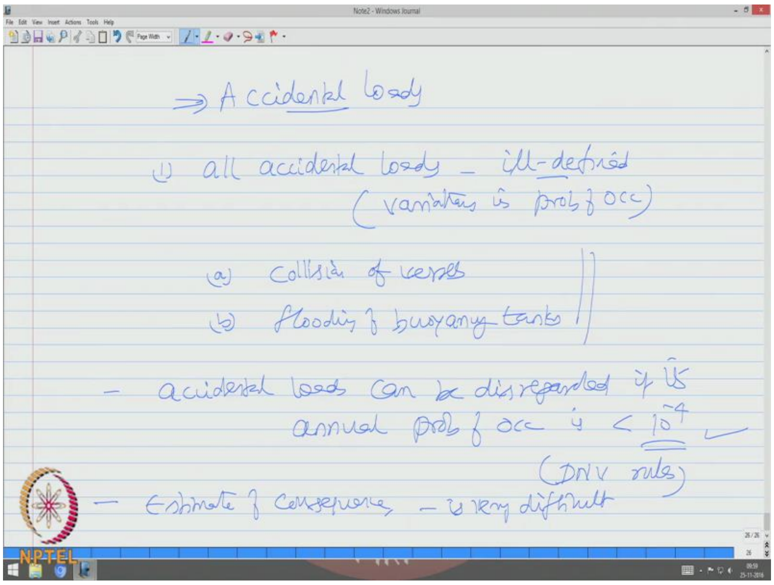

Lastly, there can be accidental loads which arise during installation, commissioning of offshore platforms, most importantly all accidental loads that arise during this operation or very ill defined because they have very serious variations in probability of occurrence.

Accident loads can happened due to collision of the verses, it can also happen because of unintended flooding of buoyancy tanks, they have different probability of occurrence and consequences therefore, one cannot very defined in a proper manner, what could be the intensity of accidental loads on the design. But accidental loads can be disregarded if its annual probability of occurrence is less than 10 power minus 4 this as per DNV rules. The reason is estimate of consequence for this kind of occurrences is very difficult, only when the occurrence exceed this probability then one can have data related to the consequences therefore, some intensity of these loads can be included in the design otherwise they are generally ignored however, accident do occur because of construction (Refer Time: 47:49) stages in offshore platforms.

So, friends in this lecture we convert certain basic design rules, understood verities of additional forces which occur because of construct ability and transporting, lifting etcetera in offshore platforms. We also realize what could be the governing guidelines for design of complaint and fixed type of platforms under classical types of floats may be regular or normal, may be extreme conditions like special loads.

Thank you very much.