Dynamics of Ocean Structures

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Module - 1
Lecture - 6
Environmental Forces

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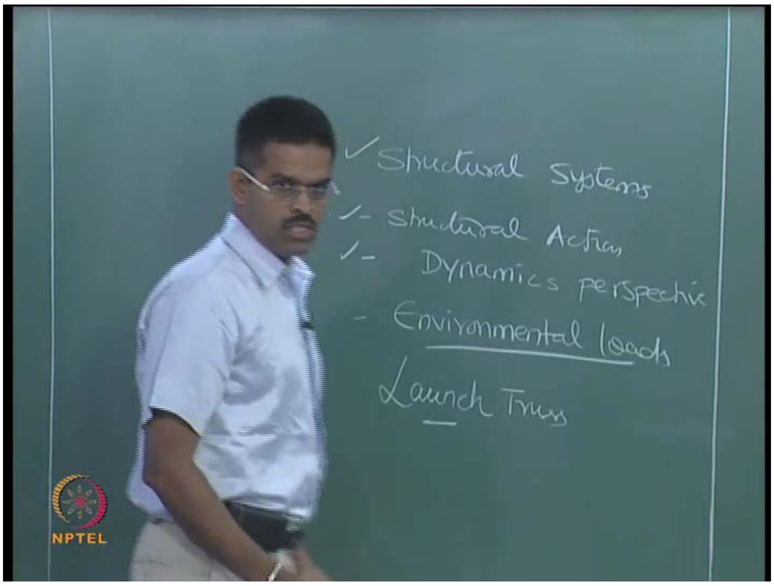

So, we will have the sixth lecture now on Dynamics of Ocean Structures. In the previous lectures, we discussed about various structural systems; we discussed about various structural systems, their structural actions and some characteristics which are important in dynamics perspective. What we will see in this lecture today and the next lecture will be different kinds of environmental loads; we will see what are the different kinds of environmental loads which are important in dynamics perspective in this lecture and the next lecture.

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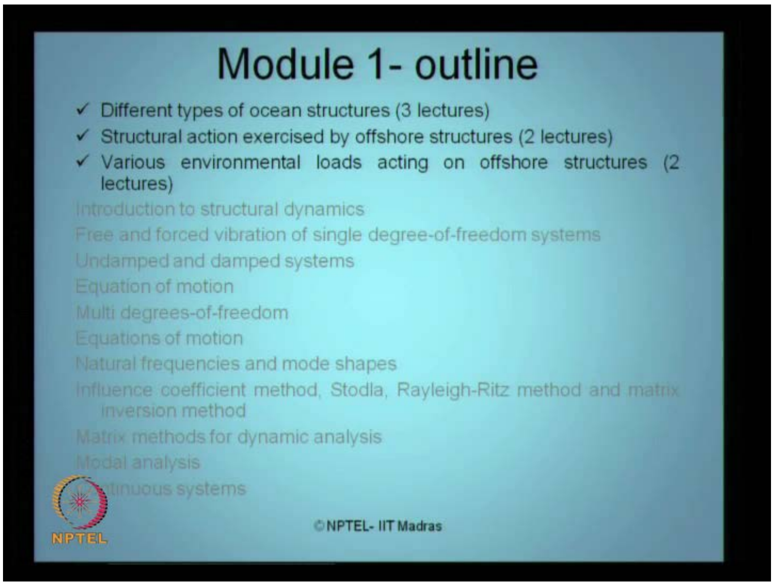

So that is what we are trying to explain here that module one outline may be committed to have different types ocean structures. Structural action exercised by various offshore structures and coastal structures. We discussed them in five lectures. Now we will talk about various environmental loads acting on offshore structures in another two lectures - today and the next lecture. Then we will move on further to introduction to dynamics, free and forced vibration, undamped and damped systems, equation of motion, multi degree equations of motion, natural frequencies and mode shapes, and influence coefficient methods, Stodla, Rayleigh method, and matrix inversion method, and matrix methods for dynamic analysis.

And we will talk about model analysis and continuous systems that is what we are going to commit in the first model which will I have about total 15 lectures. So, we are now running the sixth lecture. Any questions in the previous topics what we discussed. So, we have understood the structural action of various type of structures, the necessity and the requirement of shifting structures from shallow water to deep waters. And how the structure was been formulated accordingly to cater to the dynamic action requirements from shallow water to ultra deep waters which we talk about new generation offshore platforms.

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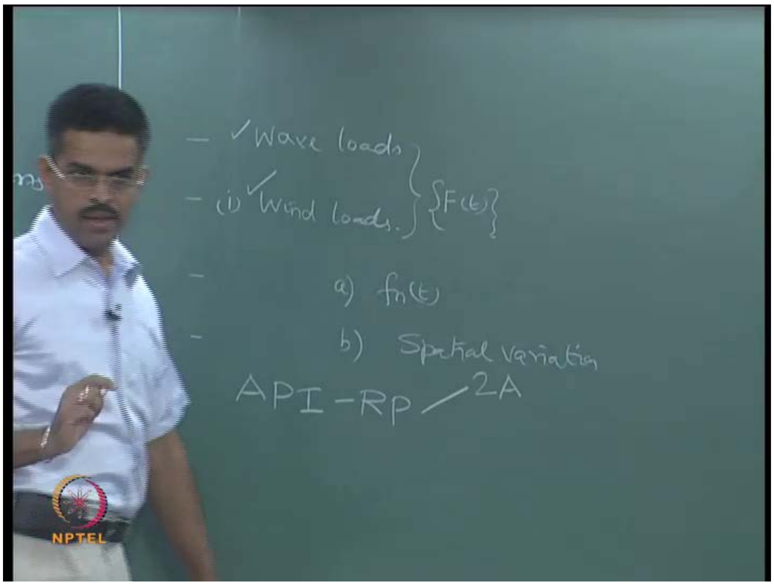

When we talk about different kinds of environmental loads which are encountering an offshore structure the foremost loads which will come to mind for any engineer who speaks about design of offshore structure is of course, the wave loads, and wave loads will have influences from current tides tidal variation etcetera. We will also speak about wind forces, there are further more loads acts on loads, buoyancy forces, ice loads, shock and impact load which will talk about in the next lecture. In the present lecture, we will quickly focus on wind loads; then we will speak about wave loads. Remember both these loads have a very important characteristic, they vary or the magnitude vary with respect to time, so it is a function of time.

There are two important characteristics of the wave and wind load, which will act on offshore structures. The first characteristic is it is a function of time; the second characteristic is it varies with space also this is spatial variation also. So, we must look into both these aspects quickly, because this force will not focus in detail estimates of these forces on any member. But will quickly touch upon for the benefit of all the leaders that how to quickly estimate these forces, but one should have a perquisite of understanding how to estimate wind loads and wave loads on given offshore members. Because our focus is on analysis when these loads are known to me, but anyway nevertheless we will introduce very quickly in this lecture, how to estimate wind forces and wave forces when we talk about wind force interestingly.

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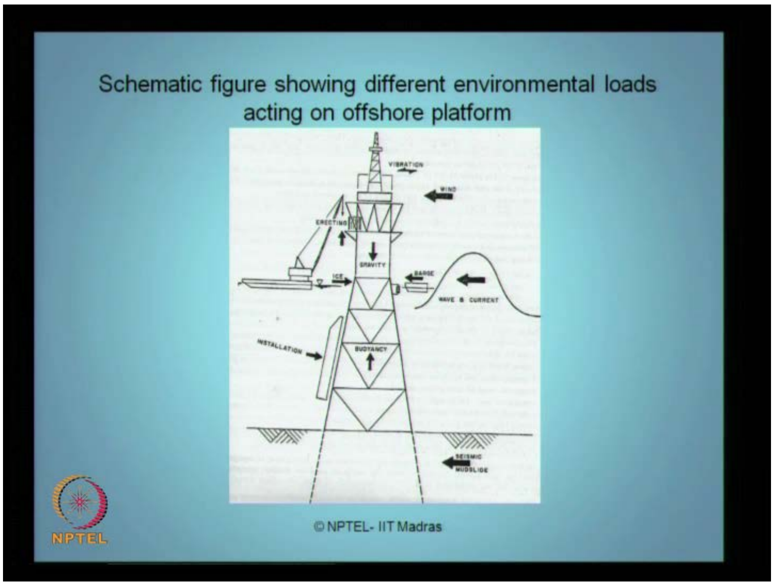

Let us look at the schematic diagram of on offshore plat form. A glossary of different kinds of loads acting on a offshore platform. So, this is typical. can you tell me what kind of structure is this?

Student: (( ))

Professor: What kind of land diagram structure is this?

Student: Jacket structure

Professor: So, it is a jacket structure or a template structure sub cede in this portion any way is embedded. These are the pipes these are the bracing these are the members these are top side the deck is a drilling rig etcetera. So, different kinds of forces which will act on this kind a platform are listed here in this figure there can be vibration induced because of the mechanical components on the top side like drilling like movement of the cranes helipad take off and landing helicopters take off and landing etcetera. The super structure can be also subjected to wind action as you see from here; it can be also subjected to erection loading. Of course, the weight of the platform will act what we call gravitational load or self-weight or dead weight, there can be movement of i's which can also cause loading on the plat form there can be a movement of barge.

In case of any off loading vessel, which can come and hit the platform, it can cause an impact on the platform. Of course, there will be loads predominantly acting from wave and current and we all know when a member is partially or fully submerged there will be buoyancy forces acting because of the displaced volume of this members in water. So, we call this as the buoyancy force which is acting here and of course, there’s a component which is attached to this jacket structure. What is the name of this component?, What is that buoyancy cans node? , it is not a floating structure, it is a template structure sorry, this is a launch truss used for launching the platform launch truss it is similar to a handle of a brief case tends to similar to an handle of a brief case.

So, you can understand what are the forces generally acting on a handle of a brief case similar way. So, this is actually a handle which is being used to launch the truss of a jacket template right. So, this will have installation forces what we will mention here is erection loads or commissioning loads are installation forces. In addition to this very interestingly which makes offshore structure analysis more complicated is that the seismic loads which are otherwise taken as extraordinary loads in buildings here. It is a fundamental environmental load now name any kind of environmental load coming in nature all of them all of them will be included in the list of loading communing structure system here.

So, offshore structure in general is a structural system which is encompassed by almost all kinds of loads which exist on a system by the environmental. So, in that way it is a platform or is a site or type of a structural system which has or which addresses almost all varieties of loads, the structure can otherwise receive from the environmental, starting from wave wind current of course, tidal action vibrations secondary loads, because of the dynamic action of the machineries.

Then impact loads because of the just and from the i’s etcetera. Erection loads on the top side because you know the top side units are fabricated after the structure is installed in the side. And of course, erection loads because of the launch truss or the installation load of course, buoyancy loads and of course, a seismic action which is coming from the sea bed movement. So, almost all loads which are listed in nature. Almost all of them, you will see the long list here, acting now. The difficulty is how can we quantify all of these forces coming on the member?

So, therefore, international codes are available which will help us to estimate these forces on the members; one classic international code which is very popular and common which is used to estimate or assist as in estimating these forces is API RP given by American petroleum institute. For example RP stands for recommended practice, I can give one example code which is 2 A, this is one of the codes. There are many codes, we will talk about them slightly later. There are many codes available, it's one example is AP RP 2 A, which is a very common code being use to estimate forces on template structures like this. So, these codes should quantify the forces acting on the member, but how do they quantify? Because you do not know the geometry of the structure, because, as I said offshore structures are formed driven configuration this is not function driven configuration.

So, you keep on altering the geometry configuration. Therefore it is very difficult for any code to predict the load or to estimate the load for a fancy form which you arrive at. So obviously, these forces given by the structures or the codes will give you forces acting on any specific point, because the forces not only vary function of time, they also vary the special variations. So, x, y, z-coordinates, where you want to estimate the force matters and will govern the magnitude of the force acting on the system. So, codes will advice you in general how to estimate these forces. But for you to estimate the force on the members, it is important the first quantify the dimensions of the member. The spatial allocation of the member the arrangement of the member system in a given configuration then arrived at the force on these members may be at a point may be different points on a given system etcetera will talk about the slightly later at the end of the presentation.

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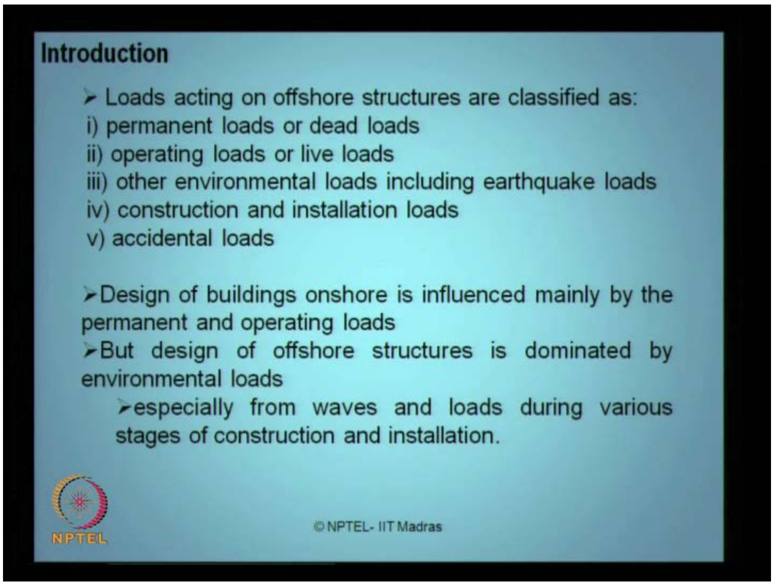

So, in this list, we will talk about, from the top we will talk about the wind loads. So, interestingly loads which can act on offshore structures, I have got variety permanent loads or dead loads operational loads or otherwise, named as live loads. Other environmental loads including a fake loads construction installation forces and accidental forces or loads, the design of buildings onshore is influence mainly by the permanent and operating loads. Whereas, design of offshore is influenced mainly by environmental loads. That is the difference between the design or analysis of an offshore structural system with that of a onshore structural system. So, in particular, loads from the waves are very important during the stage of construction installation and of course, during the service timings.

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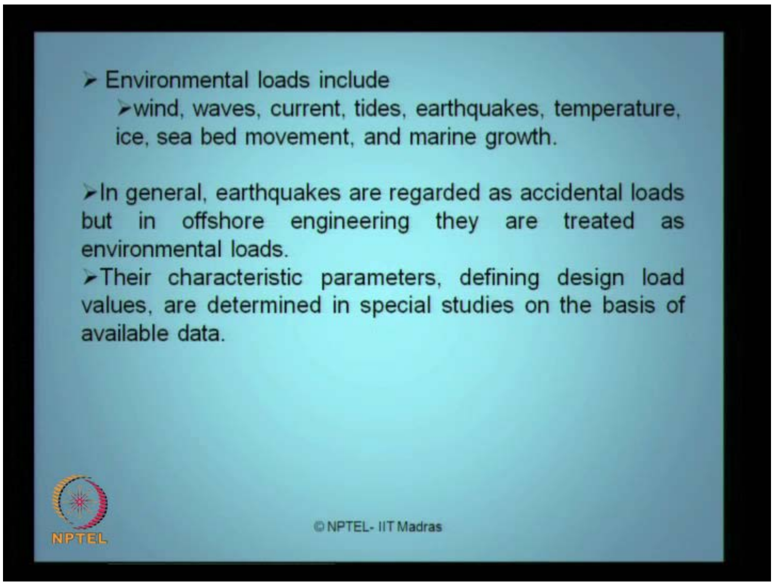

So, environmental loads include wind load wave loads currents tides earth quakes load from temperature variation, that is also very important; ice movement or ice burgs hitting sea bed movement and most importantly there is an indirect load cost on the member by marine growth. We will talk about that slightly later in the next, possibly in the next lecture. So, in this lecture we will talk about wind forces and quickly about wave forces. So, most importantly as I just now said, earth wake forces are considered to be additional or accidental loads in onshore structures where as an offshore they are consider to be fundamentally important.

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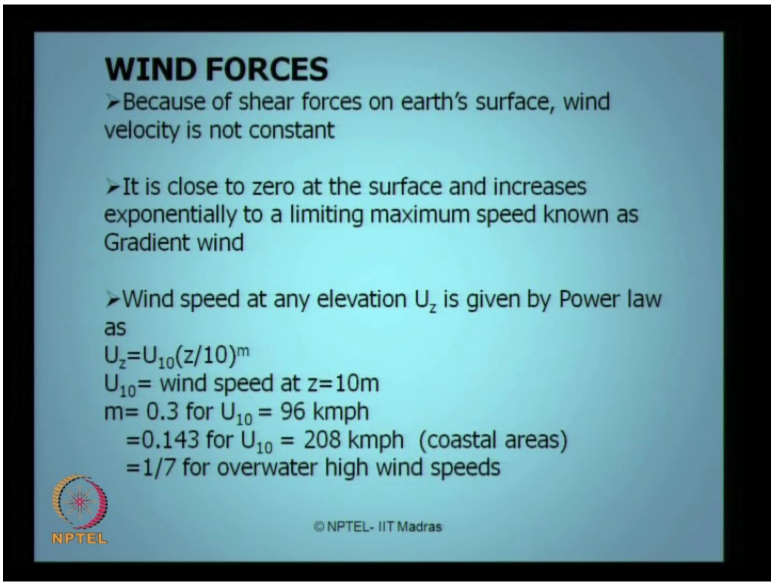

Look at the wind forces in general wind forces actually are caused because of the sheer force acting on the earth surface. Therefore, wind velocity does not remain constant it keeps on changing. So, let us quickly looked at the steps how do we worked out the wind force in brief because all of us have studied how to estimate wind forces in buildings or members on onshore. Now let us see how we can do it in the same principle or offshore structural movements?

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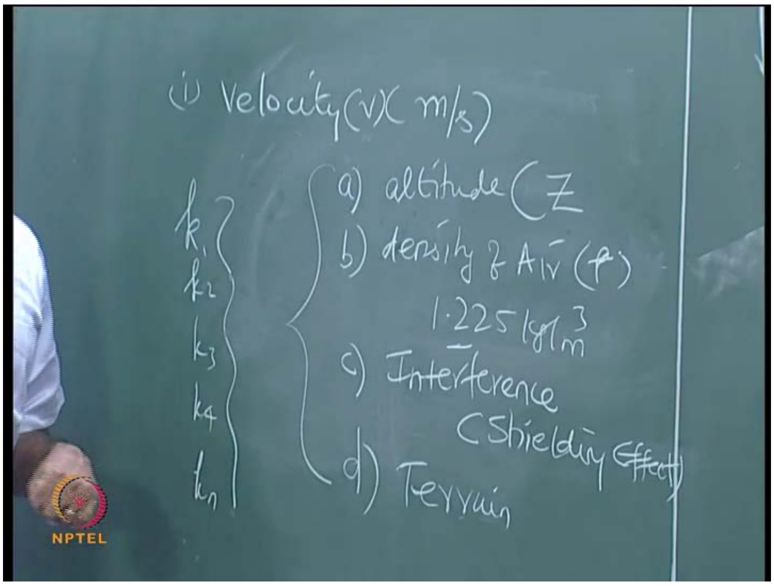

So, let us quickly look at the steps. How do I estimate the wind forces? What I want first is the velocity, let us say in meter per second. So, I want the wind velocity; wind velocity of course, depends on many factors. Number one - it depends on the altitude at what height we are looking at the velocity because obviously, you must have experience as you go higher and higher when velocity will be keep on increasing. So, at what altitude, so I would say z variation, if I say z axis, a vertical axis for my analysis, variation along z will be important for me to express in a velocity at any point of interest. Top, of course, density of air where for rho how much the density of air 1.225 kg per meter cube. So, it depends on density of air as well. See it also depends on interference from the adjacent building or structures what we call as shielding effect. What we understand by shielding effect? You please do not look at the presentation there it is not there. What is shielding effect? I can give you very interesting example.

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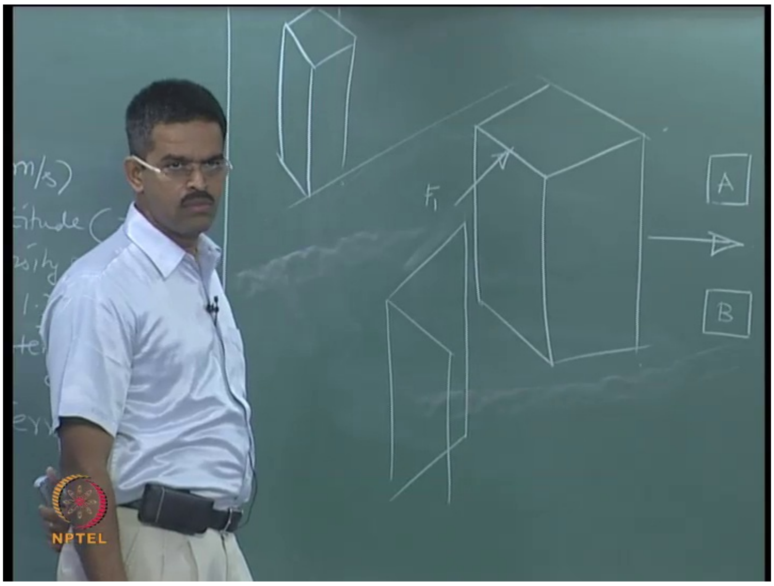

Let's say, I have structur located onshore. Let's say, this is my structure, a three dimensional structures. So, this is my land. I have possibly another structural system here which is either shorter than this, and there is another structural system here which is taller than these. And in plan, this is my system which I am interested in. I have got two structures located here and here, and the wind is flowing this way. I am interested to work out the wind velocity at this point in plan and at this point in the elevation. Imagine the influence of the presence of the buildings A and B on C this, what we called a shielding effect. If A and B would have not been there, the velocity on the building C at any point of your interest will be different from the presence of A and B. Because the presence of A and B will direct the flow of wind which will increase the velocity this is what we call as venturi effect. When you make the wind to flow in open, the velocity will be say, B1. Will you win the velocity of the wind to flow through a specific defined path which is narrow? Then the velocity will shoot up. So, the influence or interference of buildings adjacent to this will influence the velocity of this. So, that is a fact which will affect my velocity.

Calculation of course, the terrain is it a coastal area, is it a vegetation area, it is an open forest, open sea terrain. So, all these factors are associated with certain constants may be k1, k2, k3, k4, kn and all these constants are estimated empirically from a wind tunnel test and these constants are given in the codes clear. So, these constants, sometimes it may be more than one, sometimes may be less than one; these constants are evaluated estimated based on experimental studies conducted on similar bluff bodies on a wind tunnel and they can be calibrated.

So, these values associated with different factors are available in all standard international codes including IS 875 Indian cart. So, we do not have to bother how do I get these factors, that is not our concept here at all. So, these factors will influence the velocity B, once I know the velocity in meter per second, I must know on what area rejecting. If I know the projected area, where it is acting multiply this with the density, I should be able to get my pressure and then the force acting on the member. That is what you are going to see here.

So, this wind velocity is given as uz; the z stands for the variable z in the vertical axis which is given by a power law. The power m depends upon where you are looking at the velocity, is it an open terrain or a coastal terrain, where the wind velocity is around 96 kmph, 200 kmph etcetera. Now why this number ten has come? it has been seen experimentally that up to height of 10 meter from any reference level, the wind velocity does not change much; so that is called datum value of wind velocity ten meter.

So, on the other hand, you are designing a structural system which is around three store building. Let us say, each store may be approximately three meters looking for a nine meters high building from the land wind will not influence much on the building. In sense the variation on the velocity will not be severe, will be more or less constant. But you can imagine the super structure or the hal configuration of any offshore platform. You can see that the derricks, you can see the drilling derricks etcetera. They are as high as about 110 meters 75 meters etcetera, they very tall. So, naturally wind velocity variation will be a dominant factor to estimate forces on these members. You may wonder sir why I am in trust your code the forces on these members because they are not a part of the offshore structure at all

I should look at the structural system, their mass are placed on the structural system and the interference of the behavior of these will influence the behavior of the platform itself; that is what we said in the previous slide, vibration of these ansalle systems placed on the platform. So, I must know how to estimate these forces on that. So, I have equation of a power law, the value of m is also taken from the code. So, it is all available to me, I can compute v or as per the slide uz, at any z value I am interested in. One of the spacial variation is considered in the calculation here. Now wind loaders are two components; one is a static component which we called as a mean wind speed; other is called as the dynamic component, we call a gust wind speed, gust component on the mean component.

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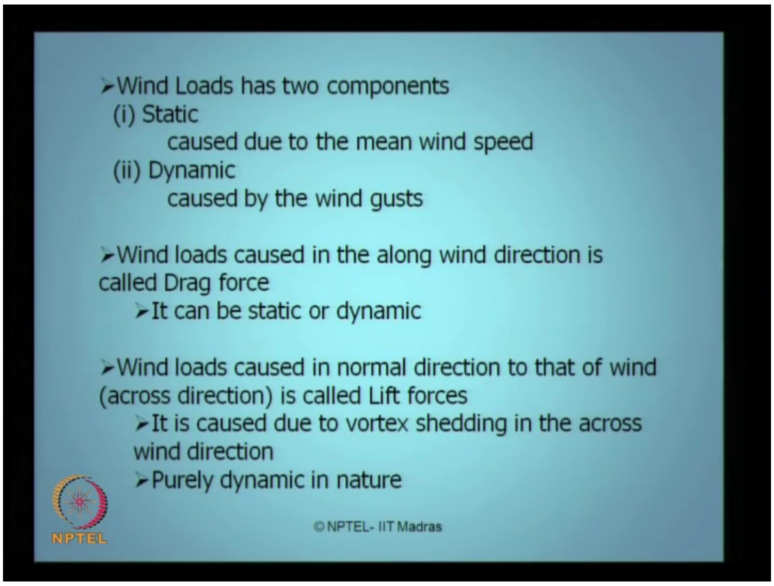

The wind loads along the wind direction is what we called as a drag drag force. They try to drag structure. The drag force can be either static or dynamic whereas wind loads caused in the direction normal to direction of wind, what we call across direction, is a lift force. So, this is essentially caused due to vertex shedding effect in the across wind direction vertex loads or across winds loads are purely dynamic in nature.

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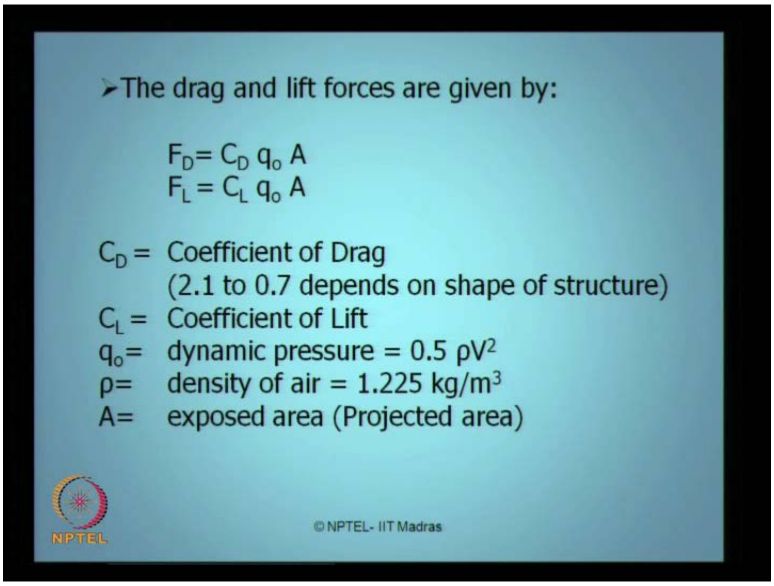

Once I know the wind velocity, based on the wind velocity, I will work out the dynamic pressure which is q_o in this equation. q_o is actually half rho v square where rho is the density of air, which is 1.225 k g per cubic meter; v is what I am getting from this earlier expression of power law. So, I use this half rho v square that is this equation to compute q naught. Once I know q naught, I will substitute here to get the drag force and the lift force. So, I need the coefficients C_D and C_L. As I just now said, velocity it depends on various factors etcetera. All these are empirically studied and C_D and $C_L$values, which are drag and lift coefficient values, are estimated and available in the standard international codes for our ready reference. So, C_D C_L are available to me, for example, it varies from 0.7 to 2.1. for a cylindrical structure it is 1.0; depends on the shape of the structure the drag coefficient.

So, once I know C_D and C_L from the codes, once I know q_o which is a dynamic pressure, which varies, which is equal to half rho v square and v is a variation along z. If I know the projected area what I call as an expose area, I can compute the force at any specific point now. Force has now become a function of force. has now become a function of (x,y) that is, it's geometric coordinates specific any horizon and of course, z and of course, t also. So, in a given structural system, at any specific point, I know f1 . Now how do we compute the projected area?

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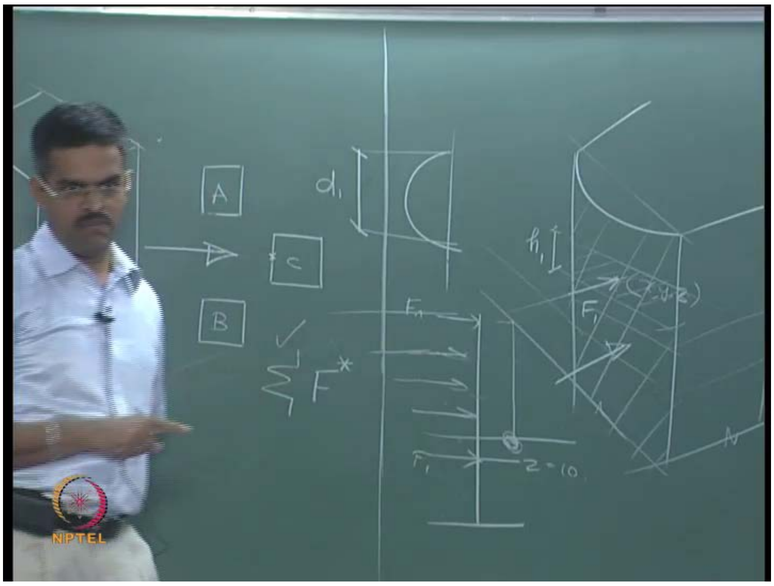

For example, I have a curve linear system, so three-dimensional system. Let’s say, I want to compute the force at this specific point, and this is my data; this is my ground level. My data is here, it is my data where I called z as 0; I can set data anywhere I want. I can set this as 0, I can set this as 0 as well. I take this as 0. I want to know, so first what I want to know at this point is what is my x, y and z value of this point ? Geometrically I can know that. So, what I will look at the projected area of the curvilinear surface on the surface normal to the wind direction? So, if I try to project this in plan, this is my shape. I try to project it in plan, I get this line or this dimension d1 which will be equal to the diametre of the semicircle. I multiplied d1 with my h1; I get this projected area of the point where my F1 will act.

Now there are methods to do this. I can say the whole area say d1 multiplied by whole h and at the center put F1; that is one way of doing it. I can divide this into different segments and do it. Now by your opinion which will be appropriate?

Students: (( ))

Professor: Dividing segments and doing it. Why ? Height; there is a power law keeps on varying. So, intelligently up to ten meter from here, you can take a single value; beyond ten meter, keep on dividing it as close as possible and finding out F1, F2, F3 and Fn.

Now I have another question. Suppose in a given structural system, this is my z which is ten, I have F1 here, I have F2, F3, Fn here. Which will vary? Fn will be more than this and so on, which will vary? Can I sum all of them and say F star and use this value for my analysis? Let me put my question once again. I am able to estimate the wind force at every point. Is there anybody who has confusion in estimating the force at these points? Because at any point in the z variation, I have the velocity. I know how to compute the projected area, therefore, I know the pressure, I know the C D A and C L value; I can estimate the force at a specific point. So, I have estimated F1, F2, F3 and Fn.

Now my question is can I sum all of them and find F star and use this alone instead of F n's for my analysis, yes or no?

Student: That is, that is very dangerous no, because you cannot have both the answers immediately after the pass. That is in fact, which is more dangerous we give a pass. Practically it is no, I will tell you. Why we are not interested in the magnitude of F star? we are interested in the point of application of F1, because these forces not only cause motion in x axis, but also rotation about y axis. I am interested in what you got the moment of these forces. Now you may wonder, sir, F 1 x a, F 2 x 2, F 3 x 3 will all be equal to F n x bar how does it matter? Can you answer this question again?

See each one of them let's say, this is xn with respect to any point, let us say this is my one of the forces acting, what we call as the. What is this point called where I am trying to find out the point of application of all the lateral forces? sorry?

Student: (( ))

Professor: Center of pressure is a wrong statement, which force? What is the point of application of the lateral force on a given structural system? What is the point of application of vertical force in a given structural system? Center of gravity is shear center; it is a point where my lateral force are subject to be concentrated right. So, if I know the ordinates of these forces from the shear center vertically, x and y will also be there I am not showing that. I am showing only the z variation; obviously, the moment caused by these forces will be equal to the net moment caused by F star at this point clear? Then why I still bother about F1, F2 and Fn.

The reason is F star will give you the global response of the whole system, I am interested in the local response caused by these force on a member of a system. So, dynamic analysis is not the global response, it is the local response of a system. Each and every member has got to be analyzed. Then you may have infinite number of members. Do you have to do infinite times of analysis? you identify critical members and analyze them. So, to identify a critical member, I would like to know what is the force effective on that member only, I am not interested in knowing what is the total force acting on the whole platform. Whereas F star or F star multiplied by x star, will give me the force and the moment on the whole platform which I am not interested.

I am interested in every member of it, though I will be interested globally, but; obviously, we all know if I know all of them, I can always find this equivalent here, right? By summing them up right? That is why in dynamic analysis, finite element modeling plays a very important role. We are doing component level analysis not a global level analysis. It is through with buildings also, but we are focusing on offshore structures. So, is there any doubt for anybody to estimate the forces or any point which where is with x and y in plan and z in elevation? Of course, given v at a point based on your C_D C_L values given by the code, you should be able to estimate. So, it is a very simple excel spread sheet, is it not?

Now you can divide them into parts, find out the projected area a1, a2, an; find out the velocities v1, v2, vl, keep on finding the forces and keep on finding moment separately it is an excel spread sheet which can easily tell you how to estimate the total wind velocity or wind force on every member and on the whole platform in every degree of freedom. Not only along x, along x, along y, along z, about x, about y, about z, I can compute it is a simple mathematical calculation is it not? I can do that. So, this what I will compute the wind forces on a given offshore structural system. Now do you think wind forces will be predominately acting on substructure of the member in offshore which is underwater? So underwater, the members which are underwater or submerged members will not attract wind forces, but they will attract wave action. Now can I combine both of them?

Can I combine both of them, yes or no? Why, because both of them are acting, no because I do not know, that is not the answer no; you have to justify engineeringly. Why I can combine, why I cannot combine? They are, do you think there is any connectivity between the wind force and a wave force on a member?Student: (( ))

Professor: I agree, waves are wind generated phenomena that is fine, but that has been taken care of in the formulation of the wave forces. Fine, but there is no direct connectivity for example, if I know wind force I do not know the wave force or vice versa this is very difficult there is no equation like that see. These are two different natural phenomenon’s, wave is a different natural phenomena, wind is a different natural phenomena. So, when you want to combine them? You cannot combine them with hundred percent magnitude?

So code reserves the right of combination of loads, which load will combine with what code reserve this right. And of course, as an analyst, as an engineer, we can always try all combinations and pick up the worst one if you have time. But you should not be foolish enough to say, I will add all the loads on a structural member and design the structure, because the frequency of occurrence of all of them together is less probable. You cannot design a system for that combination which is very very least probable, thinking that you are constructing a system over safe. So, I do not wear cotton shirt, woolen, monkey cap and also plug in the ears and also wearing a jacket over that and then I am thinking I may get winter tomorrow morning. So, I am over protecting myself, it will damage your bodies; as well same thing will happen to the system also, because we are worried about the mass.

The moment you add cross section dimension larger enough to combine all these forces where structural dimensions of the member will be larger, the cross dimensions will become larger. There are many serious consequences if the diameter of the member increases. Fundamentally, your inertia load will go high, because of weight; the movement initial load goes high, and the dynamic activation takes place instantaneously because it is an inertia effect.

So, we have to have a genuine compensation or compromise between which forces. I must consider, if at all I want to consider all of them, let’s say I want to be happy with A, B, C options; as well how can judicially I can combine them? So, combination of loads is a very interesting characteristic, looking into the probability of these occurrences in the ester past and codes. I have already recommended these combinations in a tabular form. We are not looking at that part at all. What we have to understand here is, can we combine them? Why do we combine them? How do we combine them? Therefore, can I do it on it? We understand it is possible to do. So, I know how to estimate the wave force in a given member, we will now look at quickly how to estimate the mean wind forces, we now look at the wave loading.

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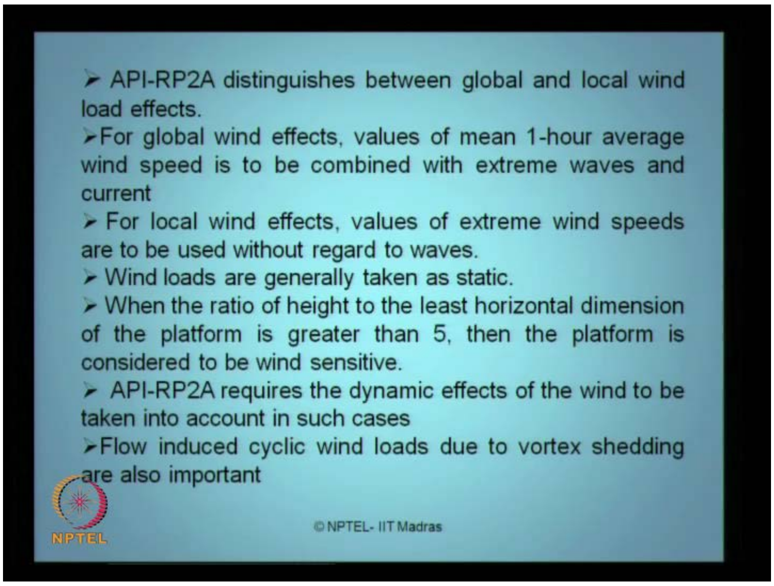

So AP RP2A distinctly differentiates between the global and local wind effects. The global wind effect means, it is a value of mean one-hour average wind speed. So, if you look at one hour wind speed acting on any member, look at the mean of that value, that is what they call global wind effect on structural system. It can be combined with extreme waves and current. The code allows this combination. For local wind effects, the value of extreme wind speed to be considered without presence of waves, so there are two combinations. If we look at mean one-hour average speed combined it with extreme waves, we are looking for the extreme wind speed. Do not combine this with waves; that is an advice given by the code AP RP2A.

Wind loads are generally static; they are not dynamic in nature. You may wonder, sir it is a function of time, because velocity varies when pressure varies; if you look at any specific point A, and keep on measuring the wind forces right from 8 am till 8 pm; do you think it will be static always? It will keep on varying. Especially in coastal sector, it will vary. So, with respect to time t, the velocity or the pressure generated by the wind force on any member has to vary; there is a time effect in this. Then why AP RP or any literature says wind effect is more or less static?

Student: (( ))

So, what his answer is, codes relate this to the dynamic response behavior of the structure, therefore it is considered as static. Do you all agree with that statement? I am asking him why this pen is not writing? He is saying since you are keeping the pen it is not writing probably; if I keep it, possibly it may write. I do not know that is what he is trying to say. He is trying to combine the position of where it is being kept to the reason of why it is not writing. In fact, probably the answer is right. You must look at how the effect of the wind on the structure is there; is it going to create any dynamic effect on the system? So, therefore dynamic analysis is to be done only on those structural systems which influences dynamic action on a system. It is not necessary that the forces should vary with time. If the response on a system receiving that force varies the time, you will consider dynamic analysis.

So, as a thumb rule people said if H by L let's say height of the structural system with the least lateral dimension. What do you understand by least lateral dimension? If it is a rectangular system, L and B look at the lower one of that; it is a square plan. I assume that you are also visualizing this as a square plan, so H by L. If the height of the structural system is larger than 5 times of the least lateral dimension, the structure will have a dynamic response. So, look at our tower massed on a hull of a platform or a top side of a platform. So, the bottom dimension is very large of a derrick and top dimension is very small; have you ever seen a structural system like this?

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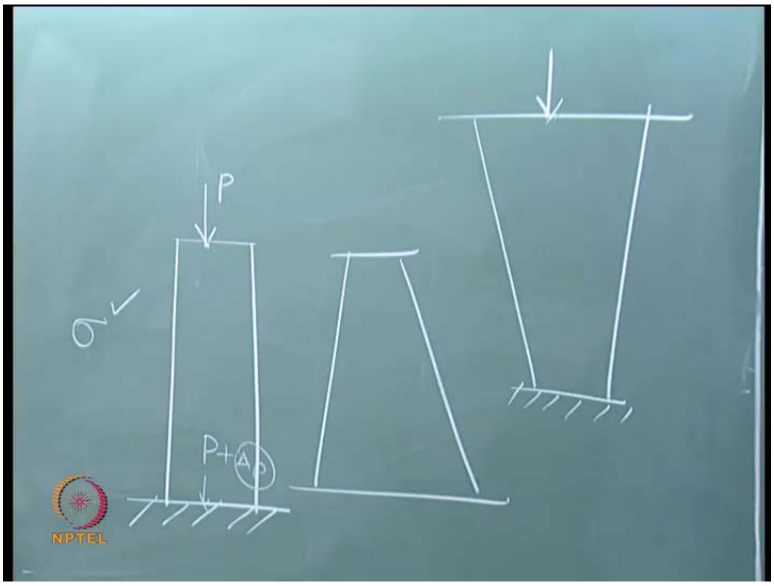

I am just asking a very simple question. We all understand that I have a column, a vertical member, which is founded in soil, subjected to some axial force P. I understand that as I move towards the bottom, if I say this is P plus delta P, this delta P will be an added component to this P and this value will be more than this, because self-weight of the column will get added to it. Therefore, if the stress on the member is constant, the cross sectional area required to resist this force compare to this will be smaller than this. So, expected section could be like this, for example – chimney, expected section could be like this.

Have you ever seen a structural system like this, yes or no? In your opinion, can they sustain? No?

Student: No

Professor: Hundred percent yes, I will show you a video in the next lecture. There is a structural system existing in Germany with the columns invertedly shaped like this. Hundred percent yes, it is existing; it is possible to have a structural system like this. What is the engineering behind this, we will speak about slightly later. But as far our problem is concerned, the derrick has a very large height compared to the least lateral dimension. Obviously, the height of the derrick will be much more than five times of a lateral dimension, therefore derrick will be subjected to dynamic action that will have influence on the platform. So, as he correctly said not necessarily a force has got to vary with time, but we should also see the influence of this force on the member or structural action of the member. As far as wind forces are concerned, that is what international codes also advise to us saying, if the value is above 5, you considered this. Where this magic number 5 has come from or codes vary this number? AP RP says 5, British standard say 10, Indian codes say infinity, do you think there is a variation of this nature can occur?

Where this magic number 5 has come from? So, question left to you for thinking. Search all the codes and tell me, why this 5 has come and what is justification for this 5? Yeah?

Student: (( ))

Professor: No, so all the time you cannot say for example, there is there is a pretty big hall, people said. Do you know why I am wearing a blue shirt? Possibly you are religious. So, it is a Wednesday or Thursday, you should wear a blue shirt, ok. People clap hand and the answer is right. Then the person asks the next question, do you think why I am writing with my left hand? The second person said, sir I think you believe whatever you wrote in left hand was successful. is religious belief, so you keep writing, claps hand.

The third question; people the question asked to this gentleman was, do you know when will I stop my lecture? The people said at eleven o clock isn’t that? By god’s grace only, because I am religious enough; whenever god tells me to stop, I will stop. So, all the time the same answer cannot be repeated right, it will not work out. So, reliability, statistics, probability of failure, studies, internal effects are not answers for the number five. Essentially, it depends on a specific characteristic behavior of a structural system. Look at that behavior and tell me why this 5 is there? So that is what we talk about the wind forces.

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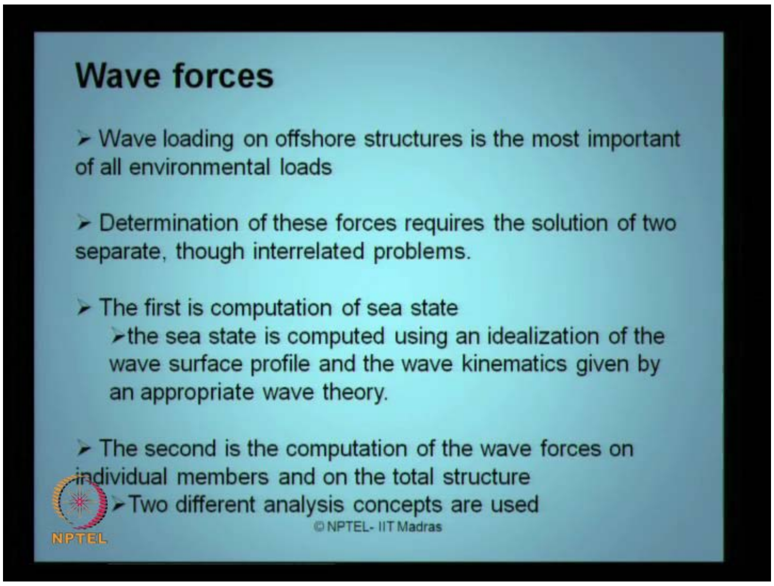

We come to the wave forces quickly, possibly in the next lecture we will cover further. So, I have a submerged member here, I would like to know the wave forces. So, what were the steps we followed to estimate the wind forces? Let us quickly look at that same way I can work out wave forces also that is the beauty. What were the steps I followed to estimate the wind forces? can you give me the steps? First was I wanted to calculate the velocity, then I computed the pressure, then I computed the coefficients, then I compute the forces, then I computed the combine effect of these forces on the systems. Same way, I will talk about the steps involved in calculating the wave forces on the members.

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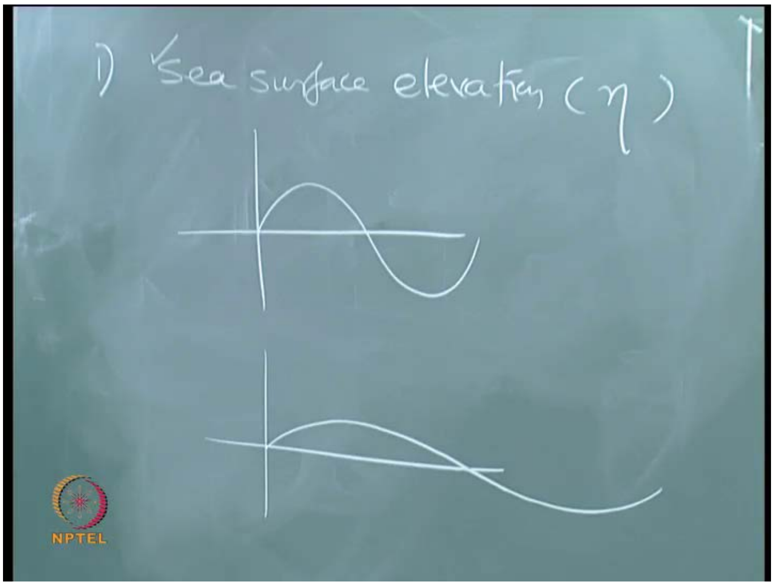

So, for a given wave force, I must first specify my sea surface elevation, which I call as eta, it is a standard notation. So, what do you understand by a sea surface profile? Many literatures say sea surface profile can be a sinusoidal variation; some literatures say. Look at the flat crest now; this tremendous variation given by people. So, the first confusion starts what to new elevation - sea surface elevation.?

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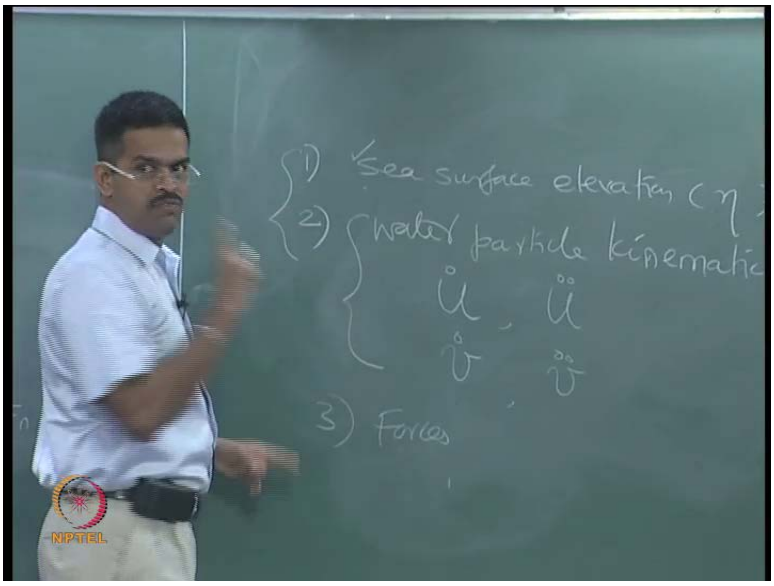

The second thing could be, I will take off this; obviously, the water particle kinematics which I call horizontal water particle velocity, vertical water particle velocity, and horizontal water particle acceleration and vertical water particle acceleration, like we look at the velocity, here, I am looking at the velocity here.

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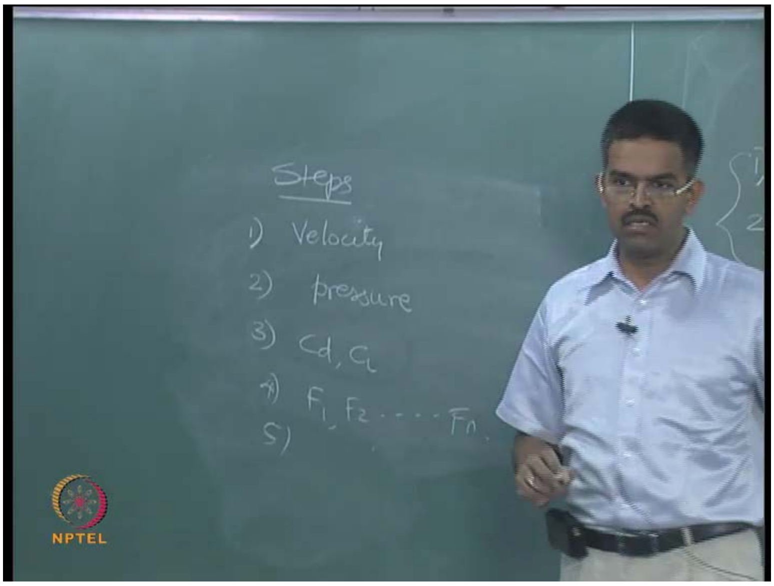

After finding the velocity, I found out the forces; after finding the velocity I will go to the forces. So, same steps I am following for wave action also. Now there are discrepancies in defining the water particle velocity and of course, sea surface elevation by various theories that is a hydrodynamic affect on members. We will not talk about those theories in detailed here in this course, but we will just very briefly show you how these theories vary and what are these values to be computed. All of them ultimately should give me the force on the member.

So, all these theory should tell me what is my sea surface elevation? And with respect to that variation what are my water particle kinematic values like velocity and acceleration in horizontal and vertical directions? It must give me this, every theory what theory would take canonical theory, Airy’s linear, wave theory shallow wave theory, stokes third order fifth order; any wave theory you pick up, it should give me these values.

So, I am interested in picking up these values. I am not interested in defining the hydrodynamics behind how these theories are specified. Remember that I am deviating from here thinking that blindly I believe airy was right in 1856; stokes was right in 1885 I believe them, trust them, pick up those constants and apply in my formula and get my forces. My job is to get my forces; my actions starts only if I get F of t. I am not to bother how to get F of t though there are various theories available, various experiments conducted, I ignore all of them. Focus only here in dynamic analysis. So, dynamic analysis needs a preclusion of understanding all these concepts before you start doing a dynamic analysis. So, it is because of this reason, we are explaining this very briefly, this a part of the dynamic course also, is that clear?

So, I will not be able to take up this wave force description now, because I will run through them; I will take up in the next class, but do you have any questions? I will be happy to answer. So, what we have learnt in this class, not much, very few, but you have learnt how to estimate wave wind forces on a given member. Why wind force can remain static or wind can become dynamic, what are the steps involved in computing a wind force on a given member?

What are the significance of velocity variation or factors influencing this as per the literature? One example literature which gives me this coefficients are available to us AP RP etcetera we saw this. And now we took up an example and see how the venturi effect, how the shielding effect bothers the wind velocity on a specific platform model" We also said what is the dynamic action of a derrick structure on a top side of a platform, how to compute them? Why combining them will not be helpful, why finite element division is essential to compute dynamic analysis? Do you have to do the dynamic analysis even though forces vary with time as per as wind is concerned? We answered all these questions in this lecture.

So, next lecture will talk about the wave forces. Again repeatedly, we are not discussing about how to arrive at these theories, that is not a scope in this discussion at all. We believe that these theories have been arrived, we have these equations, we do not have to mug up them they are all available in the literature, simply copy paste them. My problem is to estimate forces on any given member at any x, y, z variation at any given point of time. If I know this I will do dynamic analysis for them. So, in the next lecture, we will take about, we will speak about wave forces and other kinds of forces very quickly, because we will not be able to drag it beyond one more lecture, after that we will enter into the dynamic, introduction to dynamics and speak about the dynamic analysis.

Thank you.