Advanced Marine Structures

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Lecture - 31
Impact analysis- fundamentals - II

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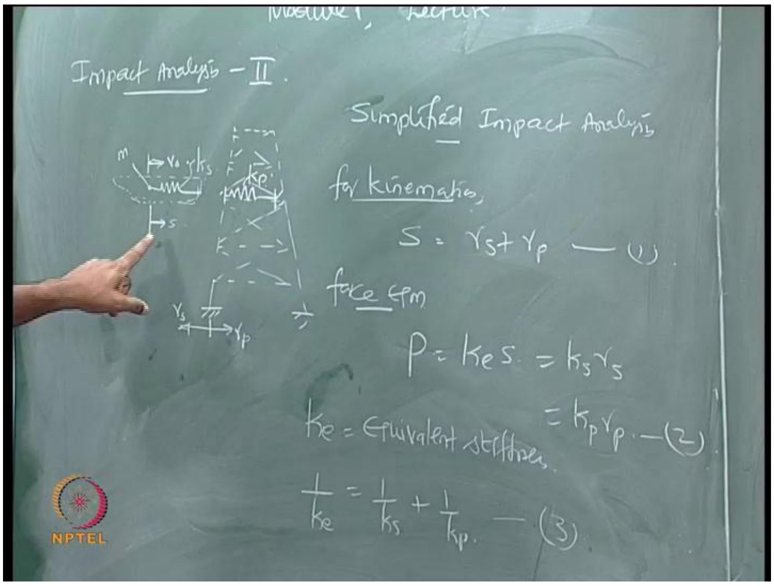

So, we continue to discuss the impact analysis. So this was the example what we discussed in the last lecture, you are talking about simplified impact analysis. So, if you look at for kinematics in this case s should be equal to r s and r p. For force equilibrium P the impact load should be k e into s, will also be equal to k shift into r s, will also be equal to k platform into r p. Suppose if I know that the k s and k p are the idealist stiffness of the ship in the platform respectively, I can find k e, which is equivalent stiffness to module this problem as 1 by k e is 1 by k s plus 1 by k p looking at this figure, equation number 3.

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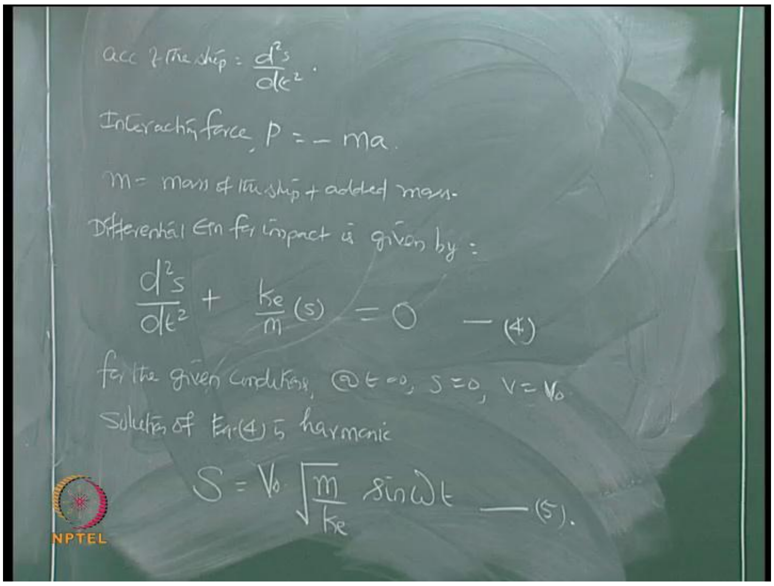

So, since this is the motion or displacement of the ship, acceleration of the ship can be d square s by d t square. The interacting force P is minus m a, I can now write the equation of dynamic equilibrium of that where m is nothing but the mass of the ship plus added. So differential equation for impact is given by, said to 0. For the given initial conditions, the solution of the equation 4 is harmonic which is given by s is equal to v naught m by k e. Call this equation number 5.

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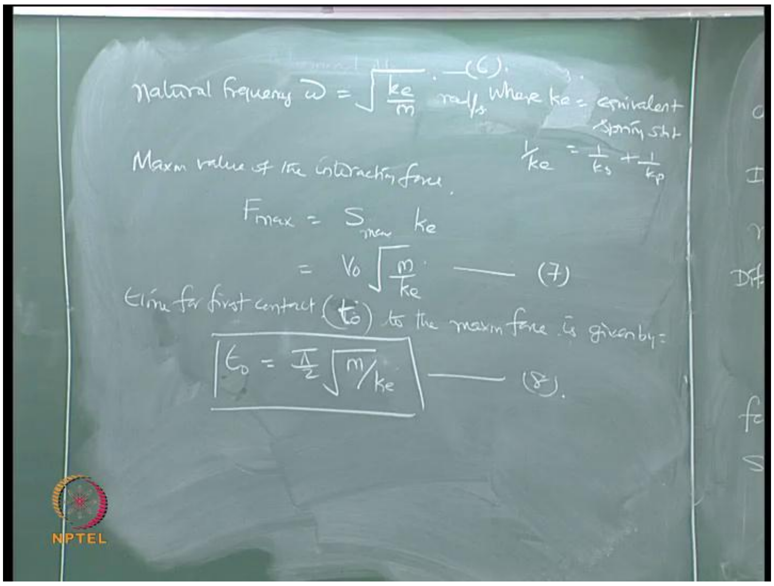

The natural frequency omega is square root of k e, where k is equivalent stiffness. Where k is the equivalent spring stiffness which is 1 by k e is that of the stiff in the platform like this. So many radians per second, so let us find out the maximum value of the interacting force which I call as F max which is S into, S max into k e. S already we have here, so I can simply say V naught root of m by k e.

When we call this equation number 7, this is 6, make him from maximum. Now the time for the first contact which we are interested in which I call as T naught to the maximum force or to cause the maximum force, this is small t is given by t naught pi by 2 of root of m by this make duration of impact or collision. F max also be computed by the other way by an alternate method.

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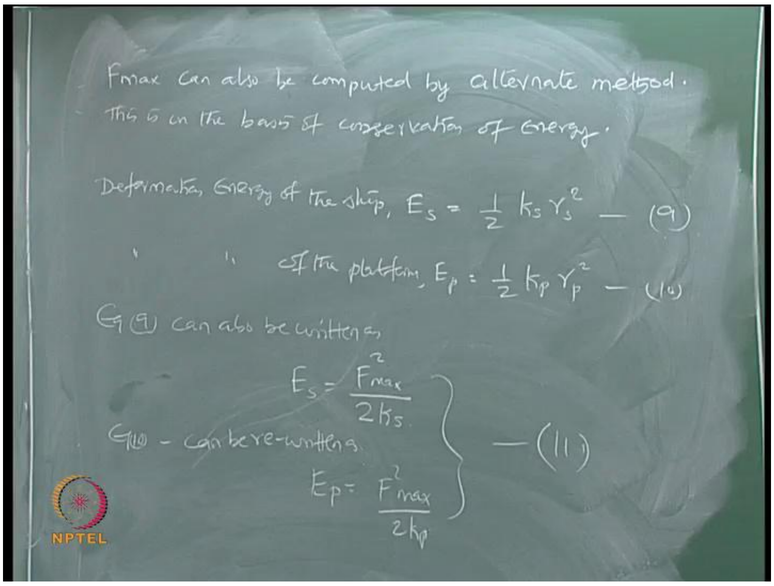

In compute f max, this is on the base of law of conservation of energy. We already know the deformation energy of the ship which is given by E s, which is half k s r s square, equation 9 and that of the platform E p is half k p r p square. Equation 9 can also be written as E s is F max square by k s. Similarly, equation 10 can be rewritten as E p is F max square by 2 k p.

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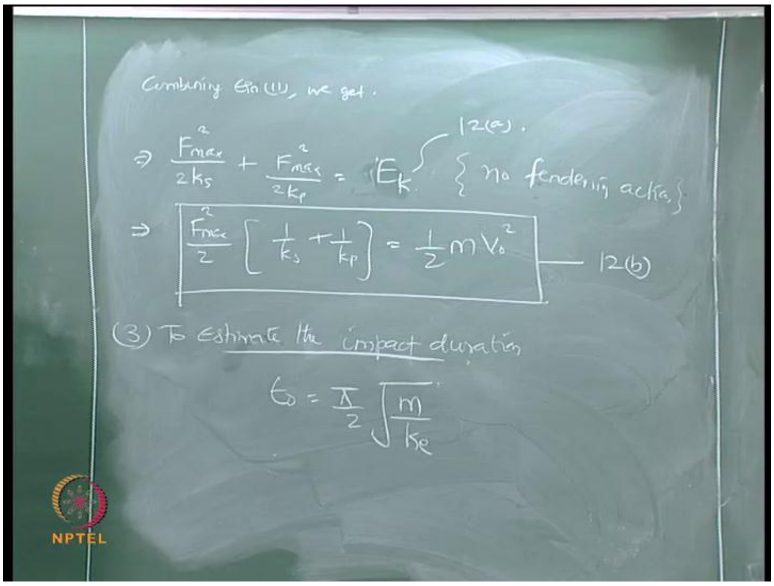

Combining equation 11 we get, let say F max square by k s plus F max square by k p should be equal to make total kinetic energy of the vessel before impact which is E k, is it not? Considering there are no fenders. No fendering action, this is f, no fendering action. So that implies F max square by 2 1 by k s plus 1 by k p is half m v naught square, that is my kinetic energy. You can also find out F max from this equation alternatively using the conservation of energy, I call this equation number 12 b, this is 12 a. Now ultimately I am interested in estimating the impact duration. The impact duration t naught is given by p i by 2 root of m by k e. Let us take up an example and see whether this example demands dynamic analysis of a passes static analysis for the impact. We will take an example and see.

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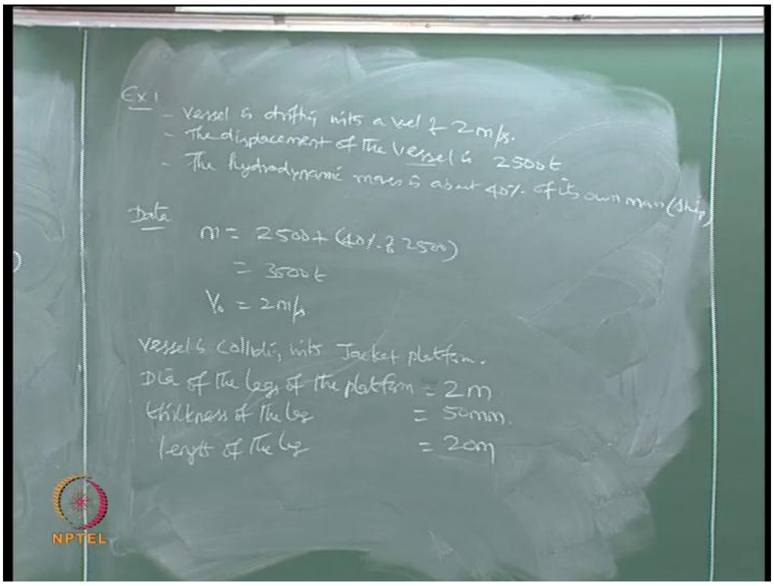

Let us say I have a vessel is drifting with the velocity of 2 meter per second. The displacement of the vessel is 2500 tones; the hydrodynamic mass that is the added is about 40 percent of its own mass. This is for the ship not for the platform, this is also for the ship is a vessel. Now we have data as follows, m is 2500 plus 40 percent of 2500 which makes 3500 tones and v naught is 2 meter per second. Velocity v naught is given. The vessel is impacting, and colliding with jacket platform. The diameter of the legs of the platform is 2 meters, sorry 2 meters, thickness of the legs is 50 millimeter, length of the leg 20 meters.

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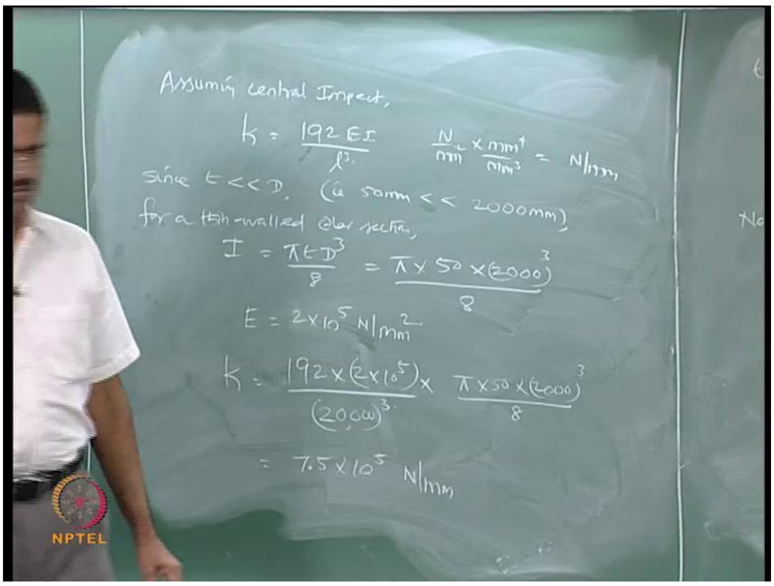

So, will assume a central impact k, the stiffness will be given by 192 E I by l. Now since t is very very less compared to the diameter that is 50 mm is come very very less compared to 2000 mm. For a thin walled circular section I, you need amount of inertia here, is straight away given by pi d t cube by 8. Let us compute this for this problem, pi 50 2000 cube by 8. Can you give this value? And of course, E is steel taken as 2 10 power 5. I can straight away find the stiffness 192 2 10 power of five 5, pi into 50 into 2000 cube by 8 divided by l cube that is 20000, l is 20 meters.

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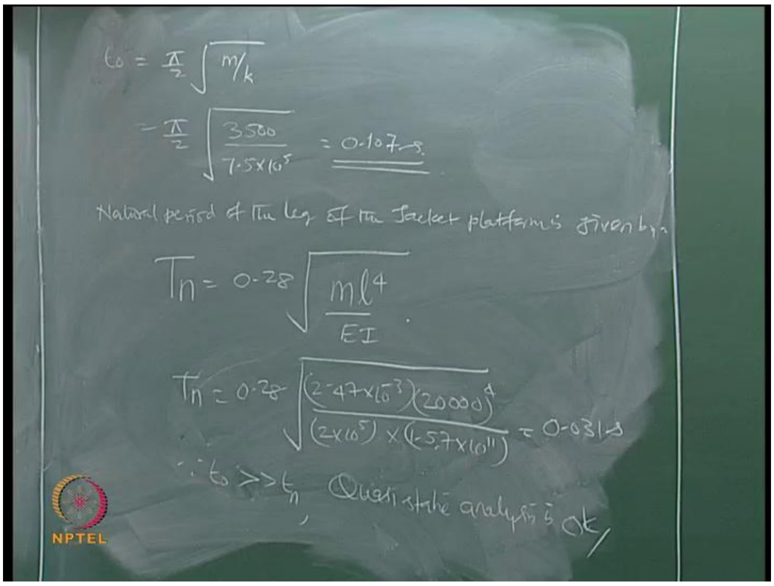

So, look at the units of k, let's say Newton per mm square mm 4 and mm cube. I will ultimately get Newton per mm. So, can you give me what is that value of Newton per mm of k in this example? I get 7.5 10 power 5, that's the k value I get. Therefore, let us find out the duration of collapse, which is pi by 2, m by k which becomes pi by 2 3500 tones, which will be retained as mass unit directly and 7.5 10 comma 5 so many seconds. So this comes to 0.107 seconds that is the duration of my coalition. I want to compare this is natural period of the jacket lay. So natural period of the jacket lay is given by, and approximate equation, which says T n is 0.28 of m l 4 E I. We substitute back and see what is my, so let us compute m, because m of the platform selected by here.

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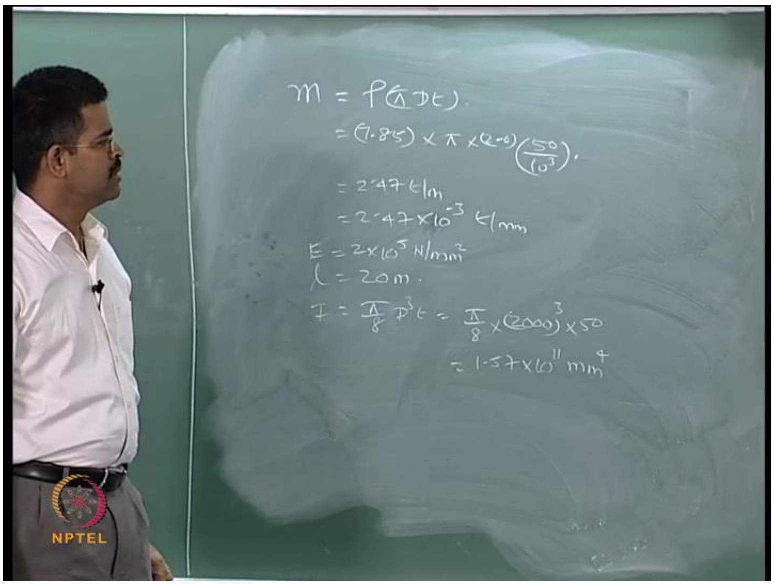

Let us remove this, m which is m of the leg is this row pi D t. So I can say and terms 7.85, because density of steel is 7850 kg pi 2.0, that is my diameter and thickness is 50 by 1000. I get so many tones, so this is going to be 2.47 tones per meter, is that ok, then all right? So, which comes to be 2.47 tones per mile meter, is it because I am using the value here like this and off course E we know, and off course l we know.

And I for a tubeless section, pi by 8 d cube t, so pi by t 8 2000 cube into 50. How much is this? 1.57 Into 10 power 11 mm 4. So substitute that and find out T n as 0.28 of 2.47 10 power minus 3, ya 20000 l power for that is mille meters. 2 10 power pi and I 1.57 10 power 11, which gives me as 0.031 seconds because jacket structures are very stiff structures, periods will be very very close, very low. Now comparing the duration of coalition T naught with the terms of T n, since T naught is very large compared to T n, quasi static analysis is sufficient for this impact analysis.

So one can decide like this. So these 2 lectures will very briefly talk about the impact analysis fundamentals which speaks about in necessity of this analysis, the simplified impact modeling, what is central and what is an eccentric impact, cost by vessel on a platform, how will it compute the most important parameter, which is called the duration of coalition, how did desire by the impact analysis will remain co-static of or dynamic analysis with an example. This example will complete the lecture of impact analysis on this. We will move on to the last topic and module 1 which is on tubular joints, it is a last topic on module 1, possibly will complete this either in this lecture or in the next lecture.

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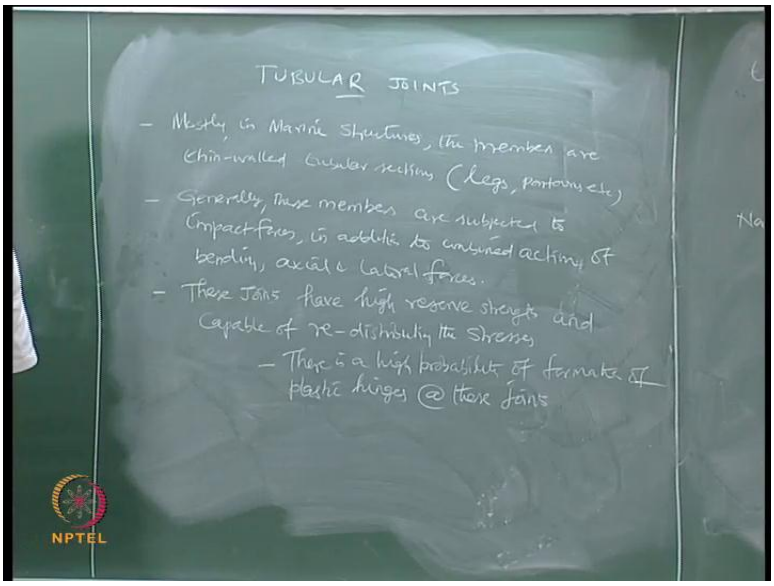

So, will talk about now tubular joints, now there are very important points, which you must understand about the tubular connections are the joints in marine structures. Mostly in marine structures, the members are thin-walled tubular sections. The moment I say members and talking about only the geometric members of the legs, protons etcetera not the deck, deck cannot be tubular member, deck has got to be a plate.

Generally these members are subjected to impact forces, in addition to combined loading of bending axial and layout forces. I should say combined action. Now most interesting part is the following, these joints have high reserve strength and capable of redistributing the stresses. Therefore, there is high probability of formation of plastic hinges at these joints.

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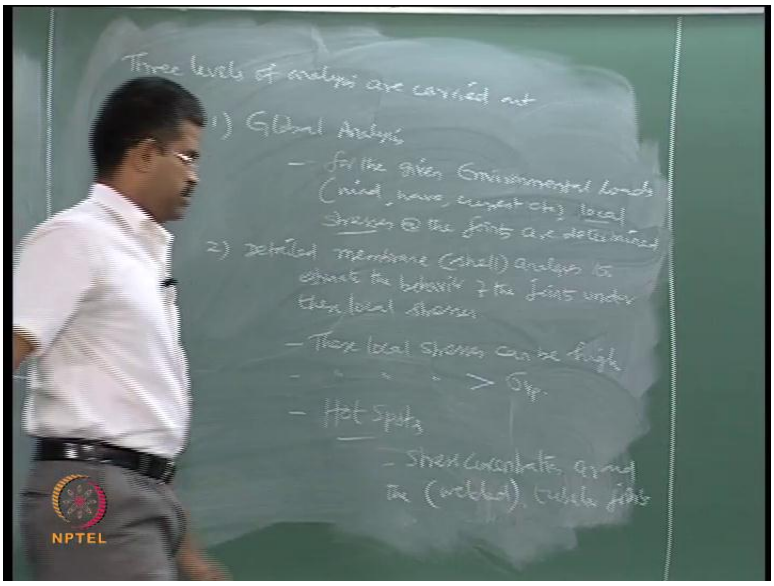

There are 3 types of analysis which are done for tubular joints. Three levels of analysis are carried out for tubular joints, 1 is what we call as global analysis, where for the given environmental loads that arise from wind, wave, current etcetera. Local stresses at this, at the joints or determine that is the first level analysis. The second analysis is detailed membrane analysis or you can say shell analysis, to estimate their behavior of the joints under these local stresses.

These are the local stresses which are computed, now interestingly at this level if you see, these local stresses can be high. These stresses can even exceed the plastic, the sorry yield point stress also in the given material. Therefore, we call them as hot spots. Hot spots are nothing but stress concentration around the most probably welded tubular joints, most probably. Let us quickly see what are the different layouts of joints in this lecture, and move on slowly to how we analyze them. You seeing different caudal provisions using what we call SCF that is called Stress Concentration Factors.

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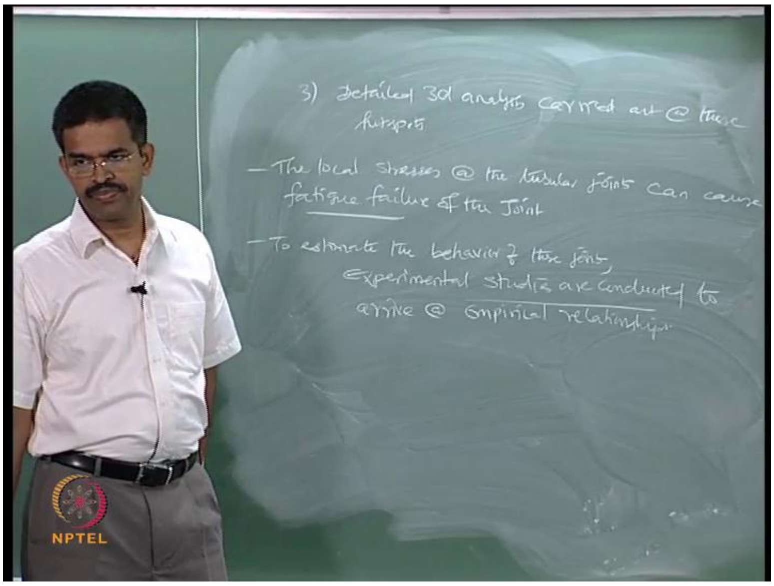

The third level analysis is a detailed 3D analysis carried out at these hot spots. Now interestingly the local stresses at the tubular joints can result in or can cause fatigue failure of the joint. Now to estimate the behavior of the joints, experimental studies are conducted to arrive at empirical relationships, because their behavior is very complex in nature. So people have recommended or conducted and then arrived at certain empirical formulae to handle of to diagnose or to study these joints under hot spots. So what are these joints, the geometric configuration of these joints, how are they named, we will see that in this lecture. Then in the next successive lecture will talk about how they are analyzed.

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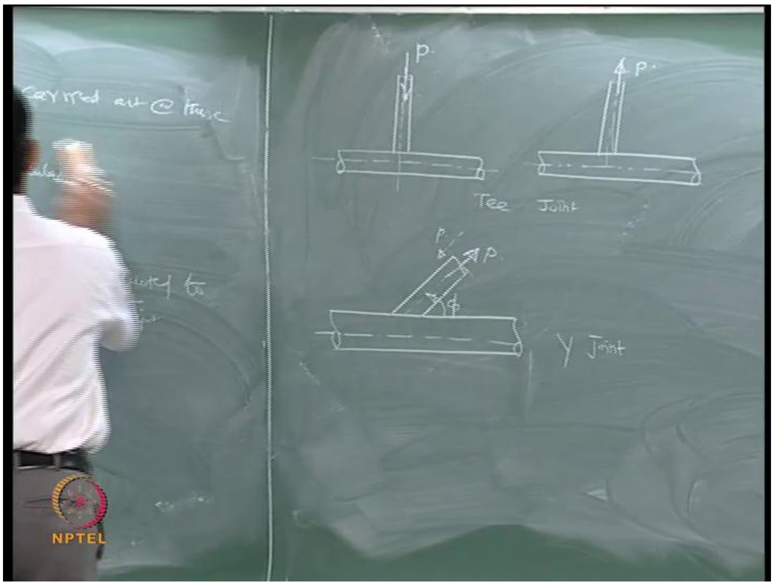

We will talk about the tee joint, N or P acting here, N or P acting outward also, is what we call as tee joint. This is called as a y joint, and again have p acting outward, can also have P acting inward; this call Y joint.

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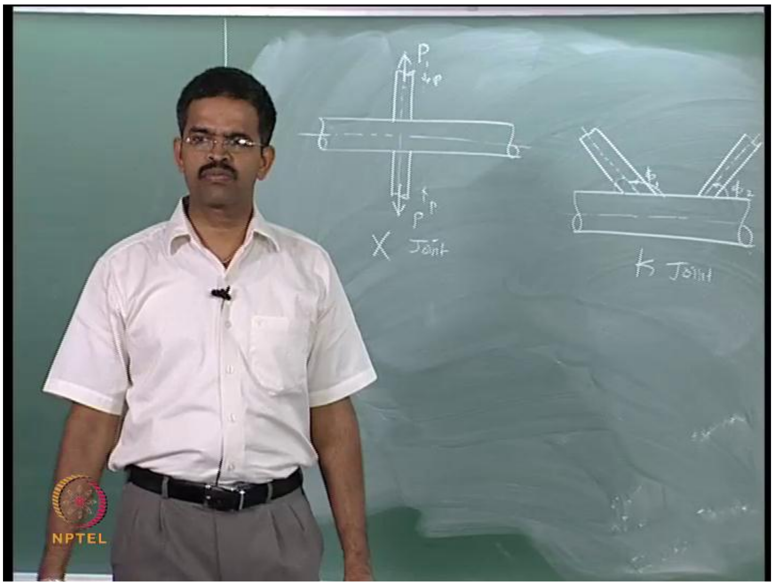

Either you can have P acting outward or you can have p acting inward, also this called X joint. It is called K joint. What are the different implications of these kinds of joints is to estimate the capacity, when they are subjected to either inward and outward forces as you see here, what is influence of the angle of pi on to the perspective flow direction or the stress direction of the main tube etcetera.

You will see in the next class so will discuss then and as I said the analysis of hot spot stresses in these kinds of junction of joint or complex people have used the empirical relationship and derive what we call stress concentration factors. We will see how they are used for assessing the capacity of these kinds of joints and that will be the last lecture what we have in the first module. So we have completed almost all the discussions what we want to discuss in the first module, the first module talks about introduction to different types of marine structures which we discussed, environmental loads, ultimate design principles, load design principles, plastic analysis and design of sections, beams frames etcetera, upper bound lower bound theorems, safety factor estimates. Then plastic capacity of tubular joints and members under axial and combined force of bending extortion, we have discussed that. Then the fundamental of impact analysis and discussion of capacity estimates of tubular joints, so, we will complete this in the next lecture and first module will be completed. Then subsequently we will discuss the second module where we talk about fluid structure interaction and fluid induced vibrations FIVs.

Thank you.