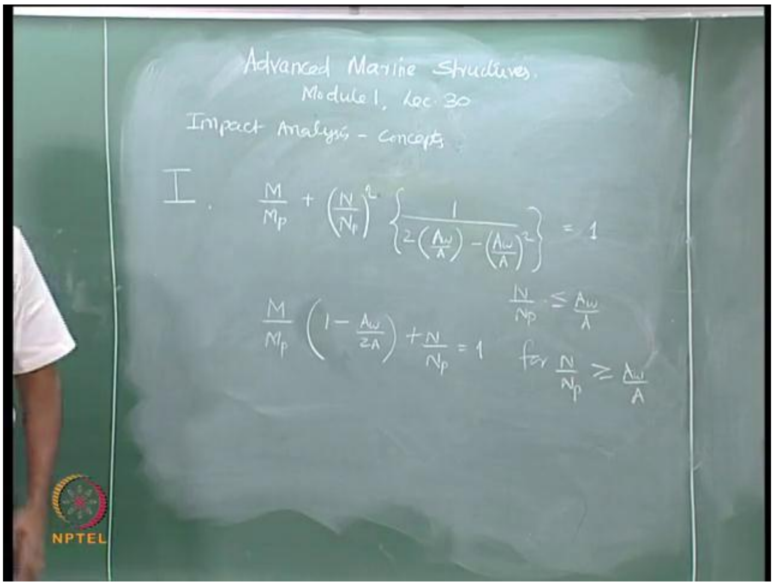
Advanced Marine Structures
Prof. Dr. Srinivasan Chandrasekaran

Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture - 30
Impact analysis – fundamentals - I

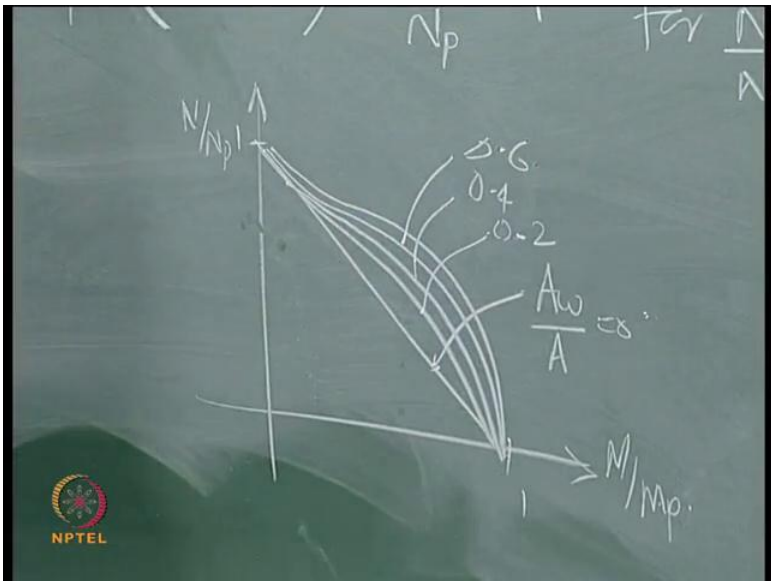
So, in the last lecture, we discussed about the plastic movement carrying capacity of sections into combined loading.

(Refer Slide Time: 00:22)



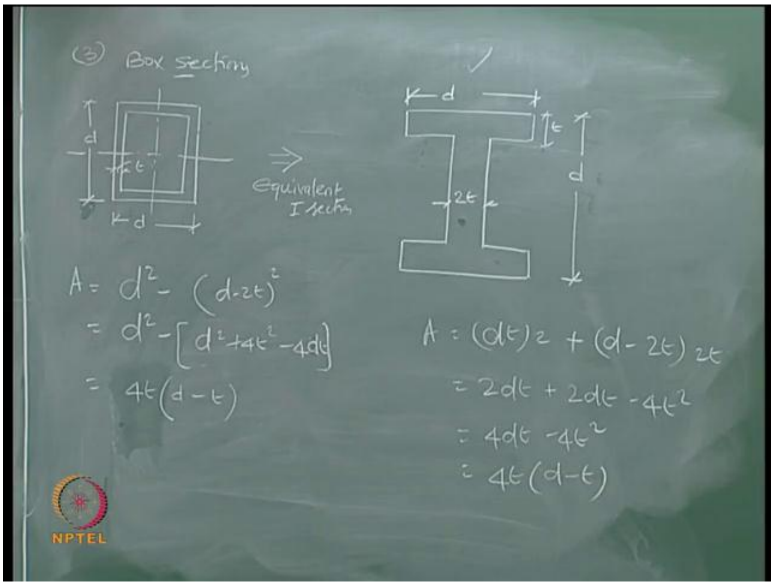
So, we discussed for the I section, the combined axial loading under bending moment and axial force. Let us say p N interaction, we said that M by M p plus N by N p square. This is one kind of interaction diagram where, the value of N by N p is lower than the capacity of the web. Alternatively its true interaction for N by N p greater than or equal to A w by A.

(Refer Slide Time: 02:17)



And we already saw that interactions diagrams for M by M p versus N by N p at 1 and 1 for A w by A ratio becoming 0. This becomes a linear line then this keeps on varying for different ratios of this curve is for A w by A is 0, and of course this is for 0.2, 0.4 and 0.6 and so and so on.

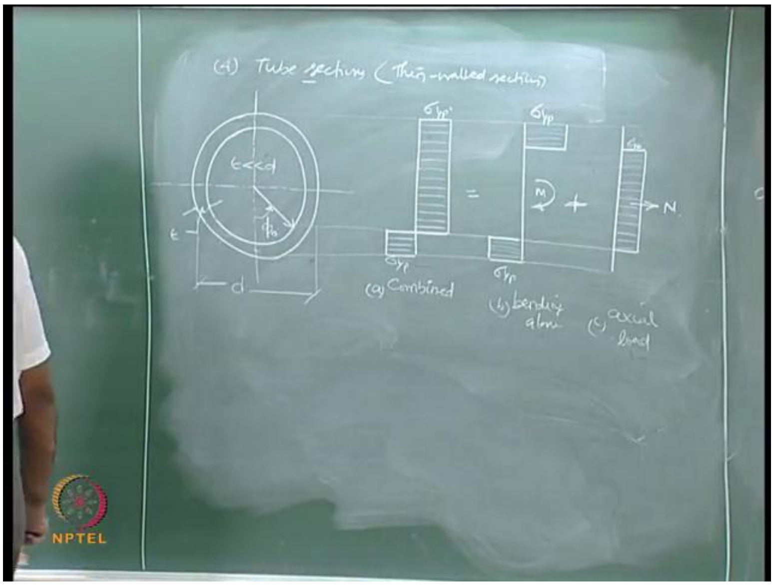
(Refer Slide Time: 03:09)



So, the third kind of section which is commonly used in marine structures, which we will complete today will be the box sections. Box sections look like this, when we want to really find out the interaction diagram for box sections as similar to that of I sections, this is considered as an equivalent I section, as drawn here. You wonder that how these two sections are equivalent? Let us try to work out the area of the section. So, the area of the section can be simply d square minus in the inner one, which is d minus 2 t the whole square, a simplified d square minus.

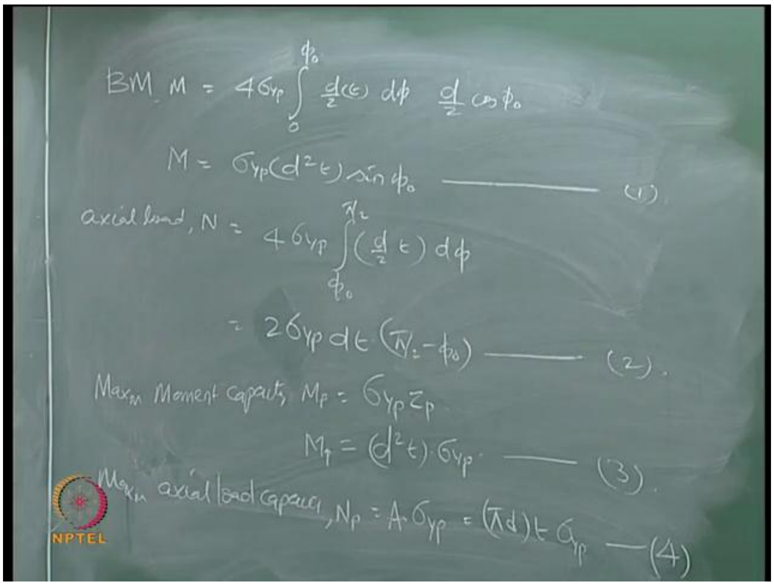
So, I will get 4 t of 1 minus t is it d minus t square it is d t. This is d t here, d minus t let us try to work out this area. So, the area in this case is going to be d t of 2 plus d minus 2 t of 2 t. So, 2 d t plus 2 d t minus 4 d square is 4 d t minus 4 t square, I can say 4 d minus t areas are same. Therefore, this section considered to be equivalent of that of the other box section. Once we have derived in equivalent I section, they can be used in this interaction diagrams, which has been given for the I section by the literature for finding out the plastic movement carrying capacity under the combination of bending and axial forces. Let us talk about the tube section.

(Refer Slide Time: 07:21)



The thickness of the tube is t, the diameter of the tube is d. And as I understood we are talking about thin walled section, what does it mean is t is much lower than d. So, is a very slim tube, so let us consider a section at an angle of phi naught from here and try to draw the stress distribution at that level. So, under the combined action the stress distribution looks like this, this is positive and negative sigma y p and sigma y p, this is a combined action. This can be spilt as two bending and axial force alone. Independently now, we can say this is subjected to bending that is of course, sigma y p and sigma y p, yes. This is bending alone, this is axial load alone, I called this as b c and this is of course, a, the combined effect.

(Refer Slide Time: 10:18)

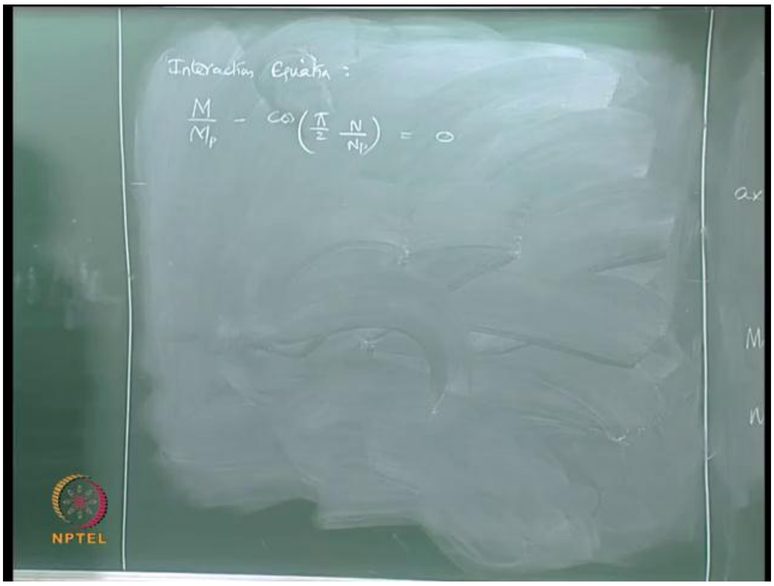


Now, we can say the bending moment M is given by 4 sigma y p. I will come to the point, why it is 4 sigma y p? I am looking for 1 quadrant 0 to 90, so the variation is from 0 to phi naught, that is what I am looking at d by 2 into t r into t d by 2 into t is my area of course, d phi is that elemental strip. Thickness and the moment of that strip with respect to c g will be d by 2 cos phi naught, is it not? Though d by 2 cos phi naught will be from the center it should have been d by 2 minus t by 2, but I am neglecting t by 2 because t is very small compare to d. So, it is d by 2 cos phi naught, so if you integrate, tell me what is M?

So, sigma y p d square t sin phi naught, let me call this equation number 1. Now, the axial force or axial load N can vary 4 sigma y p phi naught to phi by 2 only one quadrant. And the area is again d by 2 into t into d phi. If you integrate, you get 2 sigma y p d t phi by 2 minus phi naught call this equation number 2. The value we know, maximum moment carrying capacity of the section M p is simply given by what is the equation into Z p. And what is the Z p value for a tubular section? Considering the t is very very less compare to d.

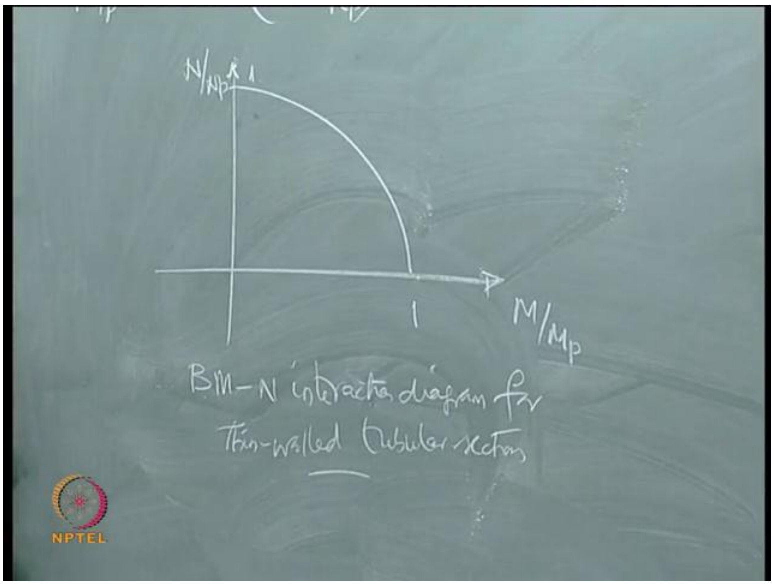
We already worked out the shape factor, we can easily find out Z p, I can say this is d square t of sigma y p, call the equation number 3 and maximum axial load capacity N p is actually A into sigma y p, which is phi d t sigma y p, call this equation number 4. I want to now, draw the interaction diagram, so using the above equations, 1 to 4, I can rewrite this equations like this.

(Refer Slide Time: 14:48)



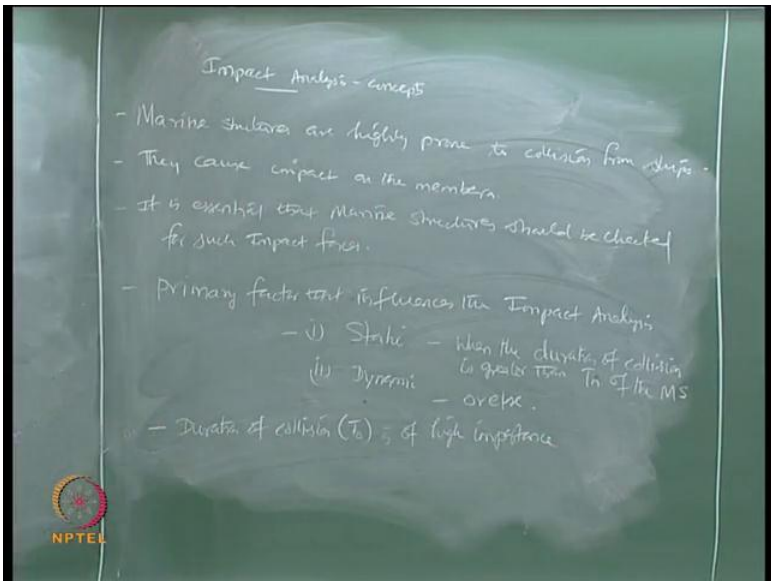
The interaction diagram now, will become or I should say interaction equation not the diagram, I should say M by M p… Now, unfortunately you will see that N as variable of argument phi naught, so we cannot directly write like this. So, M by M p minus the argument of the angle, phi by 2 N by N p, where there is variation, what we are talking about is it not, if it is a maximum variation of one quadrant. And that should be equal to 0.

(Refer Slide Time: 16:01)



This the B M N interaction diagram, for thin walled tubular sections. Now, we will talk about some of the concepts of impact analysis.

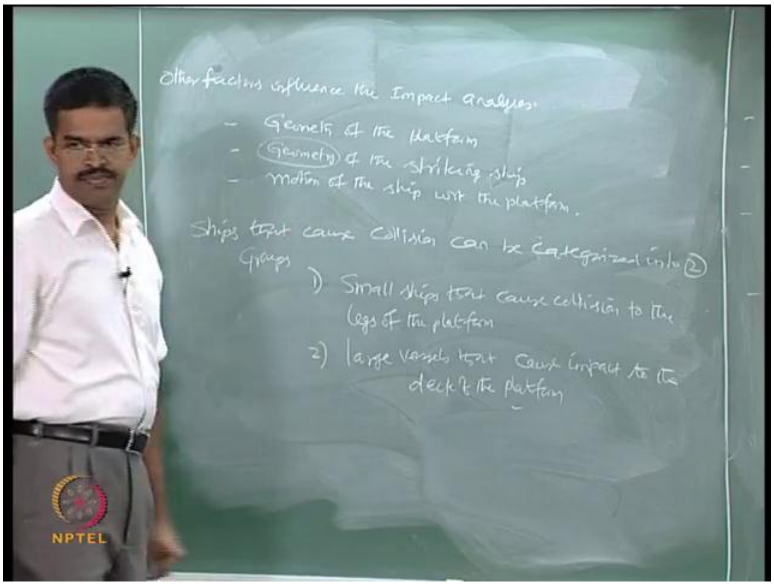
(Refer Slide Time: 17:08)



We are going to go in detail talk about some of the important aspects, which are all the factors, which will affect impact analysis and how to compute them approximately? We are not going in detail, by generally marine structures are highly prone to collision from ships, they cause impact on the members. It is essential therefore, that marine structures should be checked or such impact force. What is the primary factor, what is the primary factor that influences the impact analysis? If this question is asked the primary factor that influences the impact analysis, is whether the analysis should be static or dynamic?

Now, successively the question comes when the analysis will be considered static, when it will be considered or should be considered dynamic, when the duration of collision is greater than the natural period fundamental period of the structure. I should say M s. M s means marine structure, then take it as a static analysis or else take it as a dynamic analysis. So, essentially one is interested to know, how to compute the duration of collision? What I call as t naught, the duration of collision I can call t naught is of high importance because this decides whether the analysis is going to be static or quasi static or dynamic.

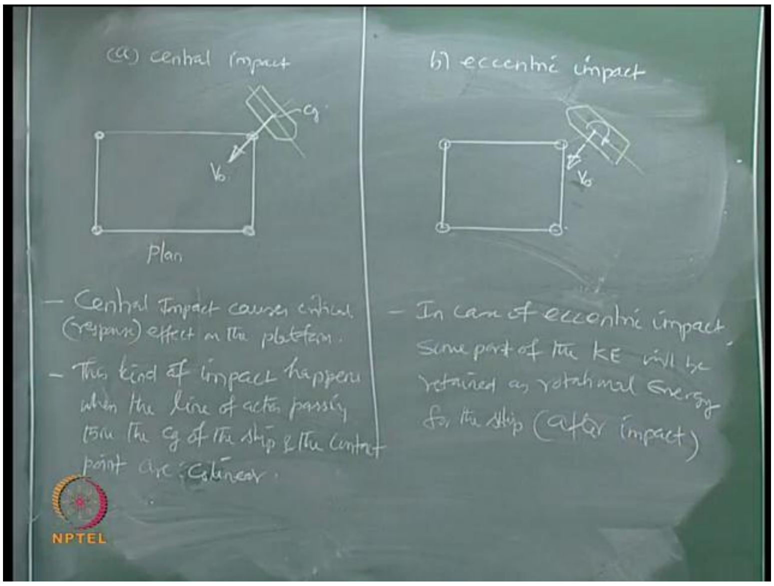
(Refer Slide Time: 20:56)



Now let us see now, what are the other factors that influence the impact analysis? Geometry of the platform, geometry of the striking ship, the motion of the ship with respect to the platform, here I should say other factors. The primary factor is the duration of collision here, some other factors which also influence the impact analysis. Then we talk about effect of collision on marine structures. Now, there is two types of ships, ships that cause collision can be categorized into two groups. Group one small ships that cause collision to the legs of the platform that is one part of it.

The second could be large vessels that cause impact to the deck of the platform, that is why we said the other factors that influence the analysis is geometry of the ship. So, small ships essentially will cause collision to the legs and larger vessels essentially will cause impact to the deck that is the key word here. When we talk about impact of ship on of shore structure or on marine structures, there are two ways by which this impact can be caused.

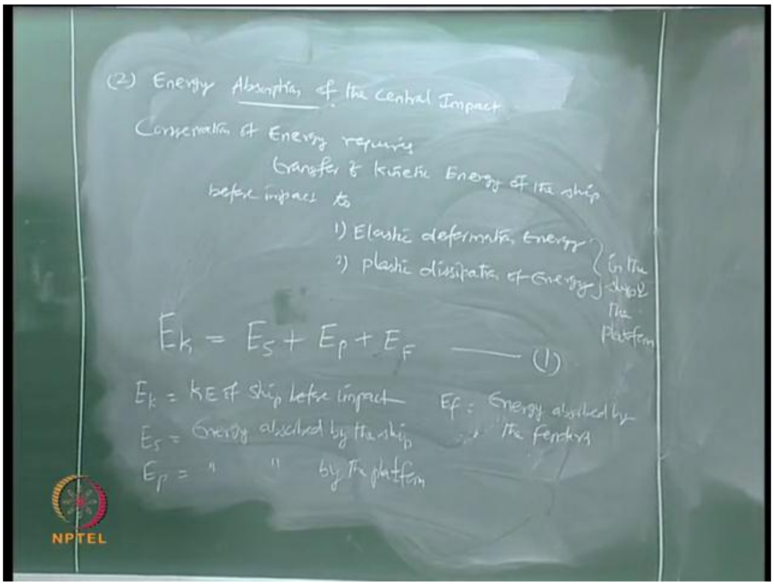
(Refer Slide Time: 24:18)



One is what we call as central impact other is what we call as eccentric impact. Let say a platform like this these are all legs is plan. This is my vessel, this may C g of the vessel, this becomes be elastic is called central impact I will explain this is plan for eccentric impact. You have a platform, these are the legs of the platform, you have a vessel a velocity in a different direction is called as eccentric impact. Now, central impact causes critical response or critical effect on the platform. This kind of impact happens, when the line of action passing through the C g of the ship and the contact point, this kind of impact happens in the line of the action passing through the C g of the ship.

And the contact point or the same line in the case of eccentric impact, some part of the kinetic energy will be retained as rotational energy for the ship because once the ship collides, it keeps on rotating. So, that energy, or this kinetic energy of this ship is retained for rotating this vessel. So, in eccentric impact, full impact load or the full impact energy of the vessel is not transferred to the platform, where as in case of central or critical impact full energy is transferred to the platform. Now, the question comes, what are those energy content present in such impact analysis, will talk about that. And this is required after impact that absorbed by the ship after impact.

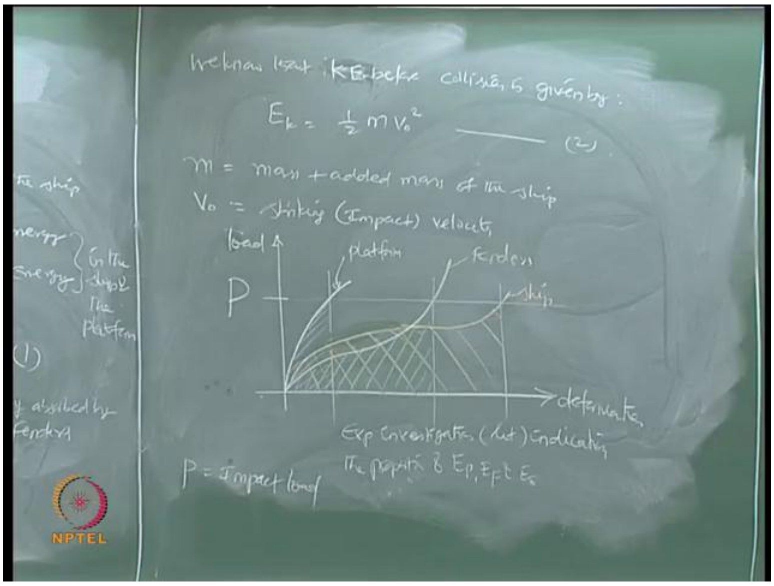
(Refer Slide Time: 30:19)



Now, let us say energy absorption of the central impact the consideration of energy requires transfer of kinetic energy of the ship before impact to elastic deformation energy. And plastic dissipation of energy, the kinetic energy of the vessel should be now transferred into these two components. In the ship and the platform, so I can write a simple equation saying E kinetic energy should be now be the sum of E s plus E p plus E f equation number 1, where E is the kinetic energy of the ship before impact E s is the energy absorbed in the ship, E p is the energy absorbed by the platform.

And E f is the energy absorbed by the fenders platforms to the fenders all around, so that to prevents or to protect the structure. We understand what are fenders? Fenders are nothing but shock absorber, which are kept on the side of the surface of the platform in the periphery. Generally they are placed at equal intervals along the jetties, even off shore platforms will also fenders along the peripheries. So, that the structure or the platform is not damaged by the impact caused by vessels or ships, so fenders will also absorb energy is nothing but they are actually energy absorbing elements to remove this.

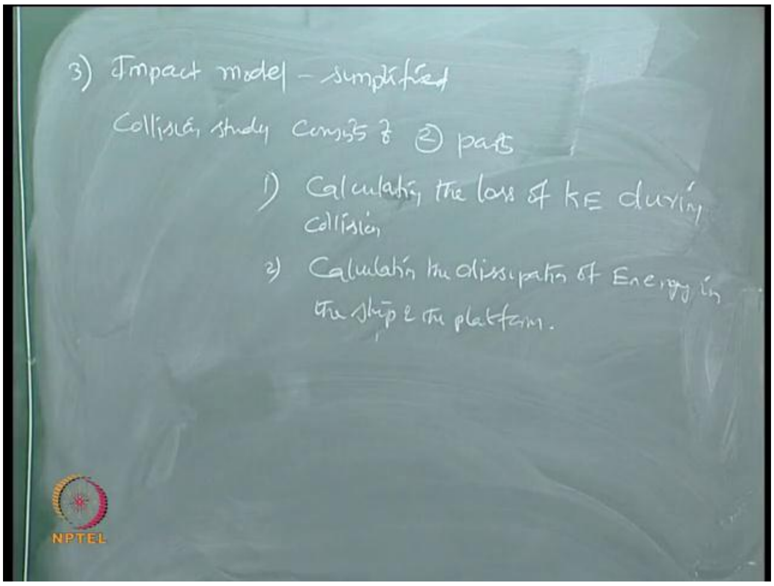
(Refer Slide Time: 34:14)



We know that the kinetic energy before collision is given by half M V naught square where M in this case is mass of the ship and added mass and V is what we call as striking velocity. Some literature called this as impact velocity there have been experimentally studied conducted by people in the research and they have shown that what to be the component of energy absorbed by the ship. Energy absorbed by the platform and fenders by conducting a load deformation diagram. So, I am going to draw the diagram for you this is deformation and this is load, this is what we call as effect of the platform area.

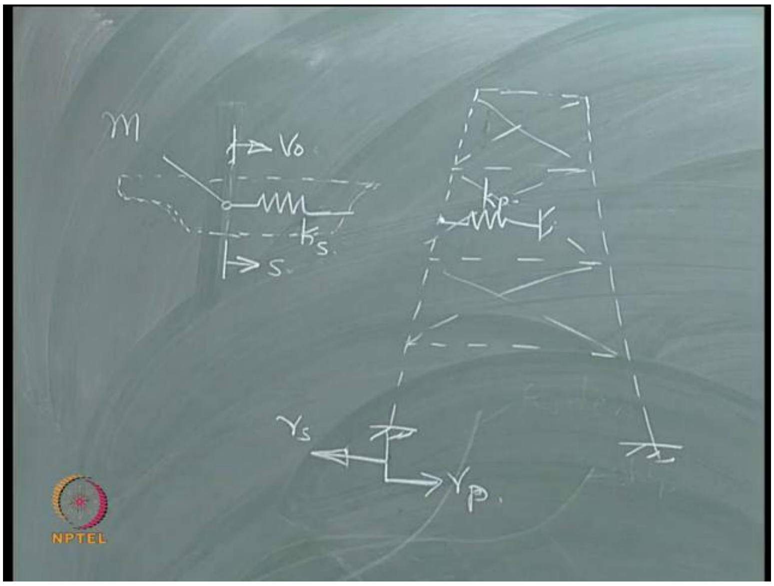
Under this curve with respect to x axis, will give the energy absorbed by the platform that is the proposition schematic proposition. The next is the fender, this is fenders and area under this curve will give you the energy absorbed by the fenders experimentally. And third one is a ship and of course, the energy absorbed by this will given by curve is probable. You can slightly reduce this is very close and goes like these are experimental investigations shown in the literature indicating the proposition of E p, E f and E s this is my given load P. P is the given load.

(Refer Slide Time: 38:49)



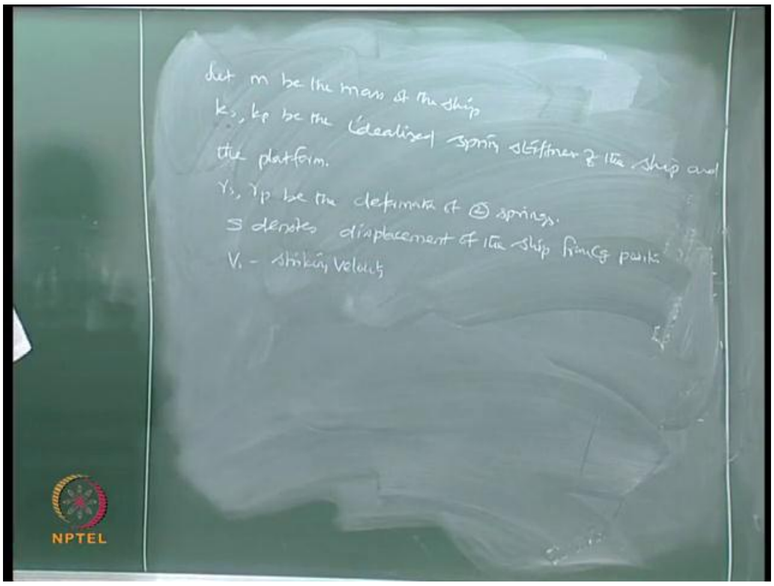
If you look at the impact analysis, we should say study of impact model this can be simplified. In two ways the collision study, what people conduct consist of two parts, one calculating the loss of kinetic energy during collision, calculate the dissipation of energy in the ship and the platform. Let us say, we have a very simplified analysis to find out the impact caused by the vessel on a platform.

(Refer Slide Time: 40:27)



Say this is my platform jacket platform under a vessel. The vessel has a C g and let call this as s. This is my C g, I will idealize this as spring stiffness, which is k s. s stands for ship, k is the stiffness. And similarly, for the platform I have k p, let say the point of impact, I call this as r s and this as r p, p stands for the platform and s stands for the ship. And this is the mass of the ship, I call this is m and this is my striking velocity, which is V naught, which is moving forward and hitting the platform.

(Refer Slide Time: 43:50)



Let m be the mass of the ship. k s, k f be the idealized spring stiffness of the ship and the platform respectively r s and r p be the deformation of two spring. s denotes displacement of the ship from its C g position and of course, V naught is the striking velocity or the impact velocity. This is just before impact not after impact. After impact the velocity will be different, so looking into this algorithm, we will discuss in the next lecture, how I can simply model this impact analysis and find out the collision period or the collision time and compare the time with the natural period of a rigid structure like a jacket structure. And then say whether the impact analysis going to remain static or dynamic, we will discuss them in next lecture. So, any doubt as on now?

So, in this lecture to summarize, we started with the p m interaction behavior of I sections where N by N p is lesser than the web capacity is more than the web capacity. Then we discussed about the plastic capacity of sections, which are box sections, which are considered as equivalent I sections in the literature on with respect to its area of equivalency, which we showed here. How to get the width thickness as 2 t, when the fringes are t, whereas, the breadth and depth of the overall section is reaming same then of course, we also derived expressions of the interaction diagram for the circular tubes. That is tube sections of thin walled sections. We showed you how interaction diagrams can be plotted for a thin walled tube sections, we started discussing the fundamentals of impact analysis, we understood that for marine structures impact or collision caused by vessels are important because they are unavoidable, but it depends some essentially.

What is the time of the collision or duration of collision? If that time is much larger than the fundamental time period of the system, you may not have to bother as dynamic analysis. You can considered this a quasi-static or static analysis and do the analysis, if it is very short, then we must considered the vibrations effect secondary vibrations caused by the impact on the platform, which we do a dynamic analysis for the platform or the structure. Apart from that other factors also there, which influence the impact analysis is the geometry of the ship, geometry of the platform, the striking velocity and we have two kinds of impacts caused on the vessel by the caused on the platform by the vessels central impact or critical impact on the eccentricImpact, depending upon how the vessels is positioned with respect to the striking point in the platform. Then essentially one looks at in collision analysis or collision impact analysis, one looks at what is the competition of kinetic energy, lost by the ship or what is the energy dissipation happening in the ship on the platform.

So, we have shown you experimental results available in the literature, how the total kinetic energy which is available to the ship before impact is distributed by the law of conservation, in terms of three concepts of energy taken by the ship, energy by the absorbed by the platform and energy absorbed by the fenders in its proposition. Now, we are interested in working out an example and show that what would be the collision time t naught for this specific example by using a simplified impact analysis, which will be discussed in the next lecture.

Thanks.