Strength and Vibration of Marine Structures
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Lecture - 31
Analysis of Bulkhead II

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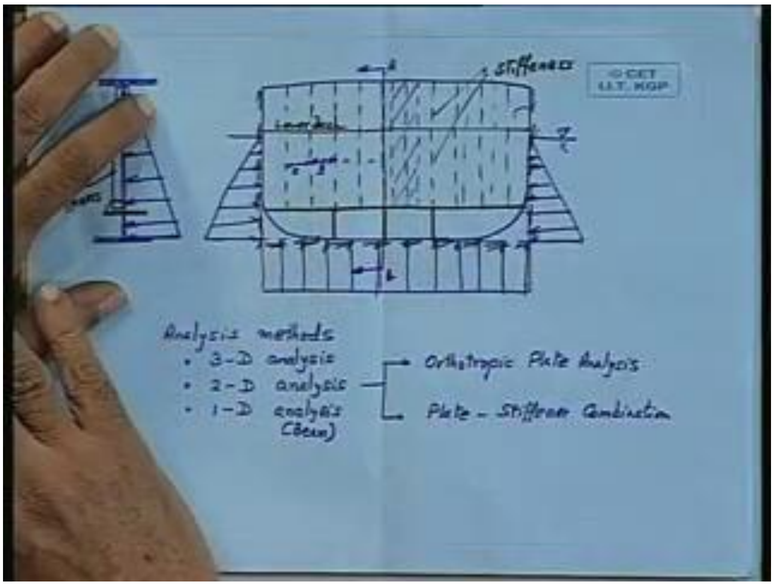

I think bring back. That is enough. See what we did here. We considered a strip out from this bulkhead. I suppose this is visible. Yes sir. I have taken a strip from here instead of this because everything I say that uniformly spaced, same plate thickness and same stiffener cross-section. So, I could have taken a strip from here and also I could have taken the last strip also.

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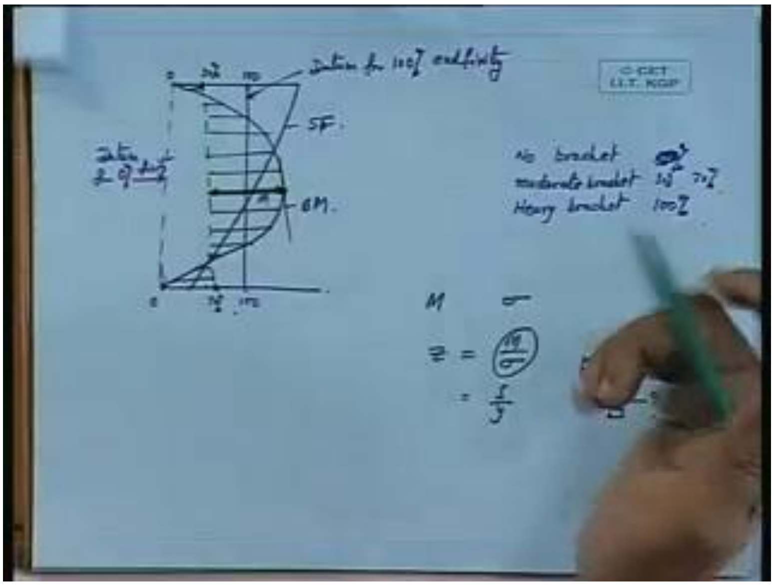

So, whichever strip I take, the problem will give me the same result here. I am coming back to Mr. Mukherjee's question that this is welded here connected. This is also water tight connection. Of course, there is no stiffener here. I have not considered any stiffener and therefore, at this boundary, the deflection at least is 0 and therefore, this is likely to be bended in this shape. This is likely to bend it in this shape, which I am getting it because I am considering this part, but along this also it is going to bend.

So, if I am considering a strip out from here, anywhere the displacement, which I get the bend shape which I get is identical for any of the strip, but in practice what happens? If you see here the one which is towards the center will experience the largest displacement and one which is next to the shell hull will experience the minimum displacement. How do I take care of it? I cannot take care of it. So, what I have done? I have virtually given a strip a slit here and taken the strip out. So, if you are going to put a slit here, that means you are disconnecting it from the adjoining area and then each one of them will behave in exactly the same manner because now it is only connected the top and the bottom subjected to that loading and therefore, it is free to deflect.

See this strip. This strip I am considering for analysis. So, what virtually I have done is I have only taken this part of it and applied. So, this boundary is no where constraint because of the adjacent thing in my analysis part. So, if I use the same thing here, again this is free. From that point of view, it is the free of those two adjacent sides, but because the adjacent sides is a virtual slit, not an actual slit and therefore, it is an integral part and that tries to put it in this deflected form.

So, there by the 2D effect is coming into it. I try to close my eyes because I am trying to use this for the design purpose and in design case, I would like to overestimate, so that in the real practice, the stress developed will be slightly on the lower side and this does give me an over estimation. But I do not know that how much is the overestimation to 10 percent, 5 percent may be, but if the estimation goes beyond say 100 percent over estimation, then I will say that this is a bad design. So, the basic thing is that if you try to consider this problem as a true two-dimensional problem, then this will be taken care of and two-dimensional problem means one of this. So, when you are trying to take one of these, now what do we do there?

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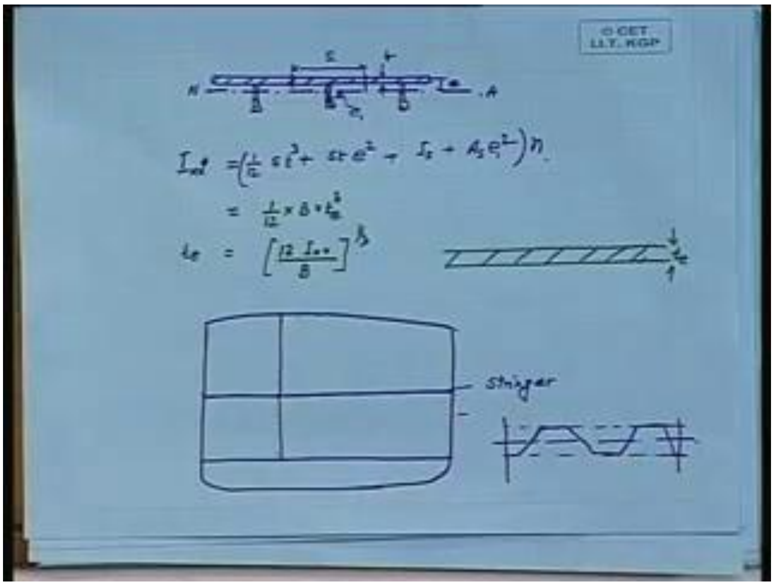

Now, if you take a plate which is this thick, and you attach several stiffness to it. At some regular interval, this tries to increase the rigidity of this particular plate towards flexible bending. So, how much does it increase? We have done some plate theory. No? Yes or no? I do not have much idea now. Let me assume once again. This is the strip I am considering and if this is your S, this is your t, then the moment of inertia of this plate will be 1 by 12 S into t cube, and then by putting the stiffener here, the neutral axis get shifted to this place. So, if I say that this becomes an eccentricity, this much, then the eccentricity is taken into account. Then area is this much and this becomes moment of inertia, second moment of inertia about this neutral axis.

To that I add I of the stiffener. Whatever you get for this roll section from this table about its own neutral axis plus area, and then again this one will be known to me, because I know the centroid location with respect to this end. Therefore, I can find out how much this distance is. So, this will become. Now, if the width of the plate, if the bulkhead b is divided into n number of these spaces, so this total multiplied by n gives me the total I of the plate about xx. Now, if I try to say that this quantity is 1 by 12 into the width, width is how much say beam of the shell t equivalent q, then I can calculate t equivalent is equal to this or not.

Sir, this 1 by 12 B t divided q means you taking a generalized for this. I have just assumed that the whole bulkhead is extending from this end to that end, and if I say that this expression can be expressed by some such formula, then what I get is something like this, where I xx is given by this expression where n is the number of spaces you have to make B. That means, n into s is equal to B. Basically n into s is equal to B. Then, t equivalent is this. So, in that case I can replace this particular structure by a plate, a Bayer plate whose thickness is te and this has got the same rigidity as this bulkhead plate. Then, I perform a 2D analysis of this particular bulkhead plate on the basis of its end condition, and the loading and whatever moment I get I say that this is the moment at this particular position.

So, I will get a true deflection the way I want, because now the boundary conditions are at the four edges, and the shape which I am expecting I will get the same deflection as it should be, but the moments which I will get will be the good true moment, but from those true moments, I will not be in a position to find out how much is the stress coming here and how much is the stress coming here. I get the moment, but I would not get the stresses in the plate and stresses in the stiffness to my satisfaction. I may try some sort of a calculation to estimate the thing, but I will not be very much sure that how much is the stress.

So, this will be a drawback here and the similar lines people have tried to use this plate stiffener combination, and that is also not very much successful. But plate stiffener combination on the basis of what is known as the numerical method of finite element analysis gives you how a true picture of the deflection and the stresses within the structure at all desirable points. So, if one wants to do the analysis of this particular bulkhead based on actual loading, the actual condition of this thing, now here it is possible for us to consider the bracketed connection which is only along the stiffener location here, not all along the plate. The brackets are put only at these points, not all along and therefore, if we try to analyze it on the basis of plate stiffener combination and use a finite element method of analysis, then we can simulate the true picture of this. We will be in a position to simulate the true picture of it and try to analyze with that particular method to get the deflection shear force, and the bending moment at any desired location is that through.

So, therefore, though we say that finite element method is a numerical method of analysis, but to get to such situations, it can cater it in a very decent manner and therefore, many times people normally use and they say that I have used finite element method and therefore, it has to give me the best result. The question will be asked by me say if the finite element method itself is an approximate method, then how do we get the best result, best amongst the available methods. Whatever method is available to solve a particular type of problem based on that the finite element will give you the best result, but still it is a method of approximation and finite element method again there are so many elements. One element is superior to the other one depending on which element you choose, you get a type of answer from that.

So, apart from this if you have any questions here, I will be very happy to answer that. What is there? We do have additional. Now, suppose if we do not have the second deck, now let us see that condition also. Suppose we have a bulkhead like this. We have the double bottom here, and we do not have any second deck and we find that this particular span is too high. Before that let me also say that why we do not have the horizontal one? Now, we have seen that more or less the depth here is half the beam of the vessel individually. So, this span works out to be less and if you see the bending moment expression, you will find that it works out to be proportional to the maximum bending moment will be proportional to the span square.

So, now if this is your d and this is of the order 2d, so if you are putting a particular stiffener here, your span is becoming twice and square of. That means four times. So, the bending stress in the same location for a horizontal stiffener will be four times or the bending moment will be four times more than the vertical one. Therefore, to counteract the stresses means if the permissible stress limit is same, you recover four times the section modulus compared to the vertical one, but the next question will be let you will have less number of horizontal stiffener and therefore, the weight may not increase. Weight will definitely increase because the span is increasing here.

Now, the same thing applies if suppose this span is also more. If you have a second deck, second deck is trying to cut this span. If suppose you do not have a second deck and consider here, say this clear depth is about say 10 meter, then once again you are going to have a very deep stiffeners and to cut the stiffeners, what is done is normally you put a stringer here. Stringer is nothing, but a deep horizontal stiffener. So, you put a stringer here and then this particular stiffener is getting a midpoint support here or you can cut this stiffener into two spans by putting a stringer here.

In fact, in majority of the tankers, they try to do this. Only thing that if you are going to put this stringer, the stringer will be a deep stringer and it will try to occupy the useful volume in case of ordinary vessels, but in case of a tanker, the liquid has to be filled in. So, there is no problem. So, you can have a ring sort of a thing. In fact, in the tankers structure, you have in the shell also a stringer. So, what you said that you can provide this here to cut this span. Now, if that is not possible, many times you go for a corrugated bulkhead.

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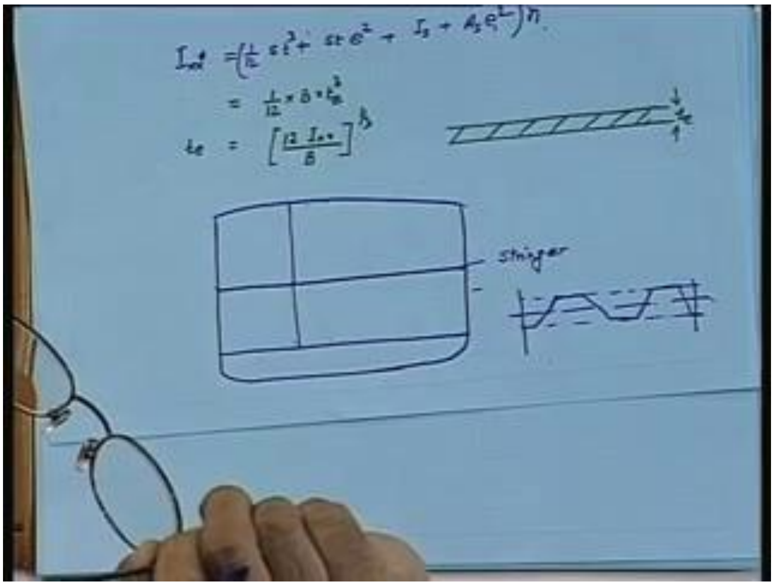

So, you have the space here, this is the side shell and then you go for a corrugated bulkhead like that. So, now this corrugation also tries to increase the transverse strength. Now, because the mass is separated and you have to find out this is the neutral axis and the moment of inertia of this along this across, this neutral axis is much higher and therefore, the rules are there which will guide it. So, this type of corrugated bulkhead will be useful for bulk carriers and also for tankers. Anymore questions here?

Now, you will be wondering that what type of questions can be asked here. Now, let us say that you have a ship whose dimensions are given to you. Mainly the depth, the double bottom, height, what else and there is a bulkhead. The bulkhead plate thickness is known to you, the stiffness spacing is known to you and you have been asked to find out what should be the section modulus of the stiffener when you are trying to design this particular bulkhead. The basic thing is that first of all considering it to be flooded, this thing we have to there is no intermediate lower deck. Therefore, it is a single span with a triangular loading.

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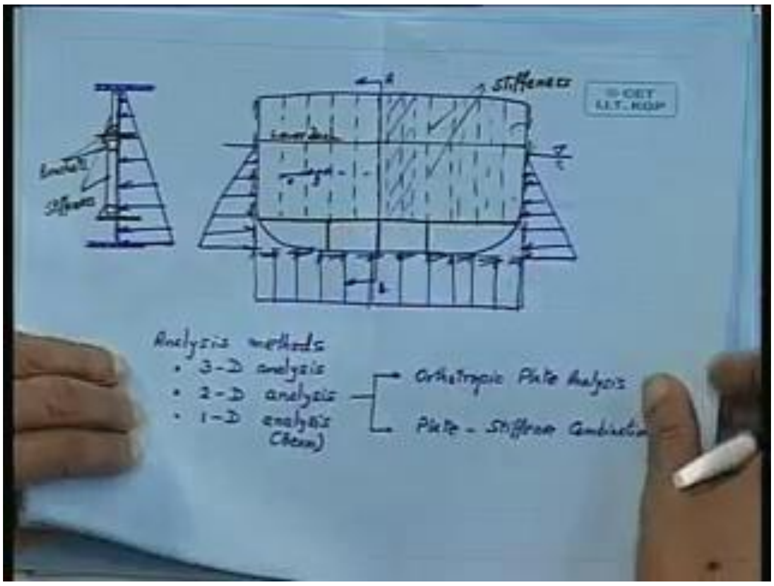

Find out what is the maximum bending movement, where it is occurring, at which location, what is the amount of that bending moment. Obviously, the other input will be what the end condition is. So, based on that you construct what is the bending moment diagram. Find out what is the maximum bending moment and then based on the maximum bending moment, what we have calculated.

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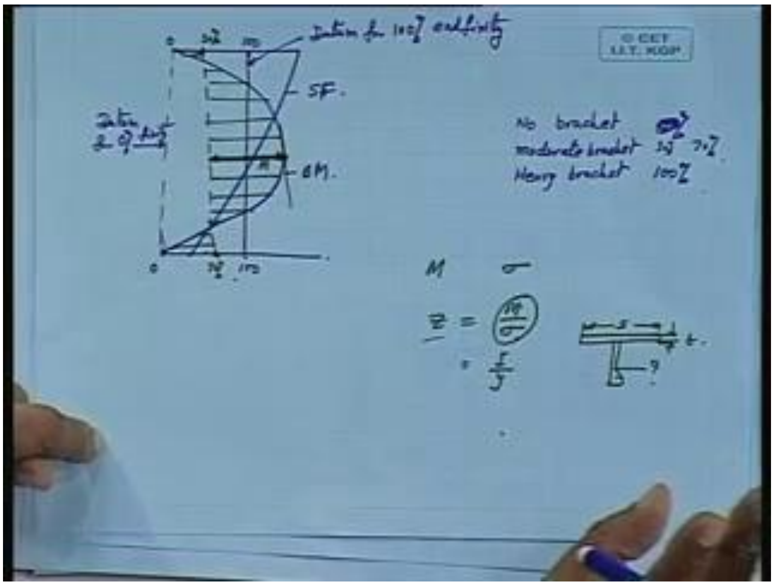

This bending moment is known as the sigma is given to you. So, we know what the section modulus of the plate stiffener combination is. So, now if the plate thickness is given to you, even then it will be difficult to this thing. You require the stiffener particulars to know about its section properties, and then only you can add this say as this plate thickness here to come to what should be the section modulus. You take a rolled section, add to that this particular thing, find out the section modulus and check against this required section modulus. So, whatever section modulus you will get should be more than this value obtained here.

So, the problem will only state that what the minimum section modulus required is. So, you have to calculate up to this and finish it off. Now, we get some questions from this sir. Some questions? You may get exercise. I can give it. I have got some I will give it to you. Now, the same problem can be twisted a little bit also in the sense that say that the plate and the stiffener is such that the contributions of the stiffener is the section of the cross-sectional area of the stiffener of the tune of say 20 percent of the plate area. What is the stress generated? So, you know the bending moment, you know the plate, the plate cross-sectional area is known to you and you know what the stiffener cross-sectional area is. Find out for this combination what the section modulus you are going to get is.

This whole thing we do, we have to find out. So, once you have found out that, then getting the stress value is not a big problem because section modulus is known to you, bending moment we are calculating M by Z will give you the stress value. Then, many times if suppose you are having a three point supports, you have this, you have this, you have this or as I told you that stringer is there. Here is my back paper. You have used a stringer here. So, now, you have one support, you have second support, you have third support. You have done this type of a beam problem with Prof. Sheikh. I suppose yes or no. You have done it multi-span problem or multiple support problems, indeterminate beam problem you have done it.

So, you can even start that way because in all those methods which we have used, you can start applying it to any type of problem. You can say the bulkhead bending, you can even say that the top deck bending, you have the hatch and beams, you have one bulkhead here, another bulkhead here.

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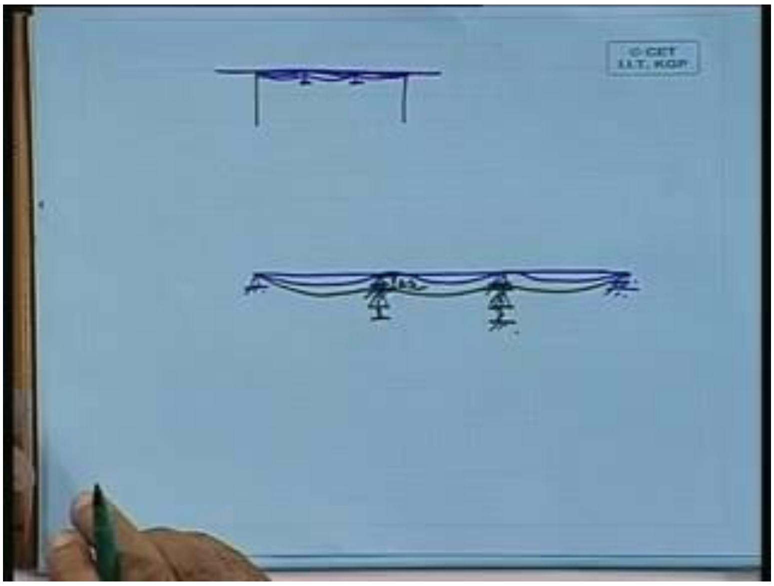

So, if I try to say this is the bulkhead. Yeah sorry this is the deck. You have the bulkhead here and you are having one hatch and beam here, and another hatch and beam here and you want to find out how this particular hatch side girder is behaving. So, we can take the hatch side girder to be supported on the bulkhead here, bulkhead here and at the two hatch side girders here. So, it becomes a three span problem supported at intermediate supports here.

Now, depending on whether this particular thing is heavy enough to give a rigid support or they are flexible support. So, you can consider them to be elastic support or sinking support. What do we say? So, we can say that this goes like this, or we say that this goes like this. One way say you can have a roller support here. In that case, under the transverse loading or if you say that this is a support, which is on spring. This is a support on spring. In that case, as soon as the load is given, the support sinks. In that case, we can say that it goes like this and the whole thing comes down. So, you can have a sinking support or you can have a rigid support. Basically speaking the girder should be treated as a sinking support, and find out that how much will be the deflection here first. So, this will give you a true picture, right.

This is how an engineer has to see the problem. It is not that is one tries to see in a very complex manner. You see what the situation is and see how it actually behaves and how it can be modeled. If you find that this modeling is very difficult, then we can consider it to be on this basis, but if one understands this that actually it is getting deflected or the support goes down, then it is always better that you consider that in that case, you will come to the truer picture. Otherwise, whatever you calculate, there will be an error and that error you do not know in which side it is going and how much error is there. If there is a measure to find out the error, fine. If there is no measure, then with what degree of confidence you can see that say that your calculation is good. So, the same thing happens here also.

Now, when I said that finite element method, in that finite element method there are different elements which will take into account not only the bending part of it, but also the inclined loading which we are giving and if we incorporate those, obviously this will also increase some sort of fiber stress in it. If I consider this to be the bulkhead and I say that it is bending like this, so this fiber will be stretched. At the same time if I try to compress it here because of the side forces, inclined forces, then whatever stretching is coming here on to that, there will be some sort of compression or some stress. A readjustment will take place and that should give me the true picture of the stress level there.

So, why should I overestimate or underestimate. Suppose one stretching is there, on top of that there is a compression. So, tension and compression added together will try to reduce the tensile force though predominantly and that particular fiber, the tension will be the dominating picture. But the total tension will try to get reduced because there is a compression along with it on the other phase, then there is a compressive stress and top of that there is further compression and therefore, two compression will get added. Therefore, the true stress picture will be slightly more than what it will be from the bending point of view. So, why should I under estimate. Here I should be in a position. So, there are elements in standard packages which will take care of these two loadings and on top of that, may be that you can also add shear force there.

So, all such possibilities are now available and one should be in a position to select the tool to suite his requirement. So, once you know that how a particular structural member is trying to behave and to get that true behavior of it, one can take the numerical tool accordingly to solve that type of a problem that what I would like to emphasize here. Still we have some time. If you have any further questions you can ask me once. Earlier I told you that I will be taking the planet element part, but now I thought that I will take it after the examination if you are still interested. Yeah.

Sir, which side longitudinal where for the side shells? They are basically stringer.

No, if are you trying to give it on the side shell and the longitudinal bulkhead, they also take active part in the longitudinal bending of the ship. So, if they take active part in the longitudinal strength calculation, then the overall structural weight can be reduced, but not all type of ships you will have. No, you will have it only some special type of ships because in another types of cargo ships, you know they may come in the way of the cargo storage. Yes, wherever you have the liquid part even the grain carriers or other thing, you have crystal carriers like urea, fertilizer, sulphur, you would not find it because they will get stuck and cleaning becomes a problem, but wherever you have to carry the liquid, there you can have any stiffener. That is why you may have the stringers in tankers because there is no cleaning problem. Oil is there and oil will be anti-corrosive.

So, it is better to have vertical things, so that everything goes down and in the down place, you can carry. That is the main reason. The other technical reason you can give that the vertical type, the span is less compared to the horizontal one and bending moment increases according to square of the span. So, that is another reason and moreover if you try to give it in the horizontal side, the lower you go, the hydrostatic pressure will be more there. So, at the lower end, you may require heavier cross-section say for example, suppose you want to stiffen the bulkhead.

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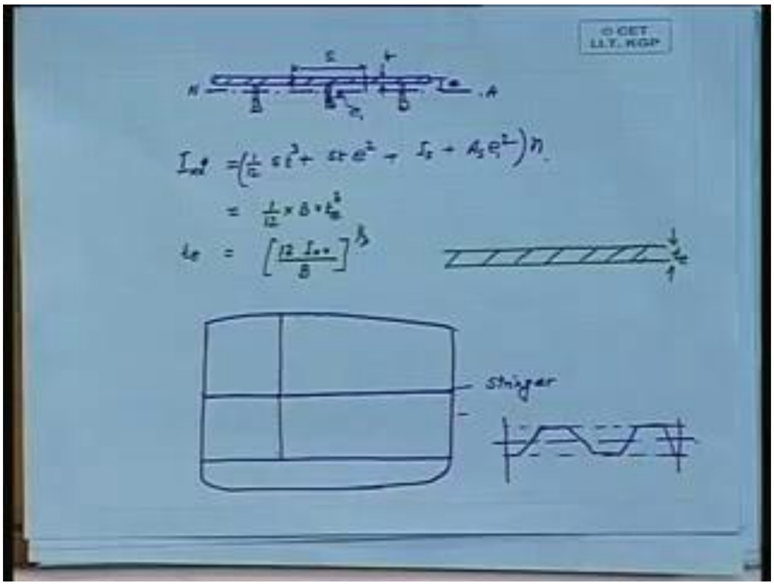

They say this plate you want to stiffen it with the horizontal stiffener, now the flooding when it takes place, it will be triangular loading. So, if it is triangular, then what is the pressure coming at the bottom stiffener? It is the maximum. So, it has to withstand that load. If you are taking all horizontal, all will be subjected to the triangular loading only, but here all the stiffeners will be subjected to uniformly distributed load, but the intensity of the loading will be a function of its position. The lower most will have the maximum, the upper most will have the lowest pressure. Accordingly, you would not like to use the same section at the bottom and the top because it is going to make the structure very heavy and that increases the inventory.

So, what should we do now if corrugated bulkhead is shown? No, actually what happens here at regular interval, you try to close that. So, you try to make it stiff from this side also. So, it is not only this, but this is used for your grain carriers and tankers. So, you do not lose space basically and you give good scallops here, so that it can be you know for solid materials, you can put some sort of air jet and vacuum suction is there for unloading and if you want to clean it, you have some air jet there and you can try to clean it off. So, that part can be taken care of here. These days in fact you go for a cellular structure. Also you have a double skin. One two plates are put very together and then I will try to discuss that once this has been raised, you see another type of bulkheads cross section. This is based on something like this.

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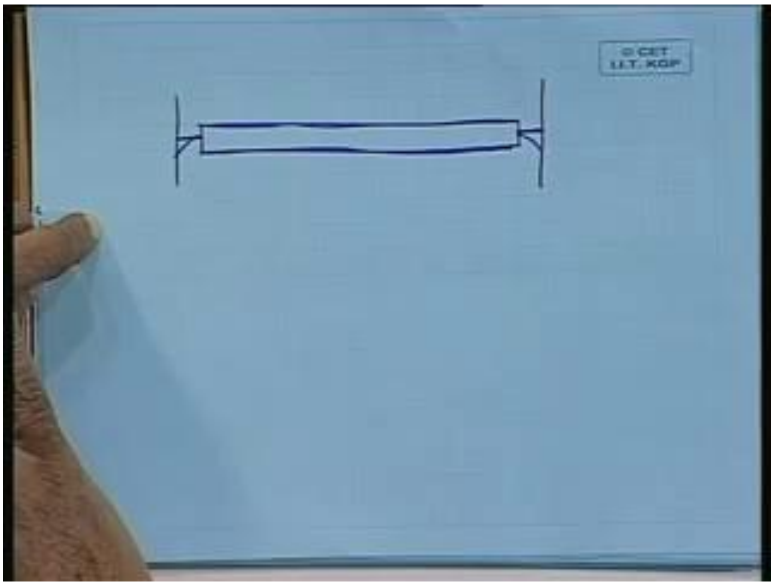

Suppose you take a bulkhead like this. I do not know whether it has been implemented or not, but people are in the thinking stage and I am also thinking for last five years, but not in a position to do any substantial work on it. Say you have the side shell and you take the bulkhead which is a double plated structure and in between how you connected is a different thing altogether. Now, the basic idea is that this bulkhead will be connected by small strips wherever welding is to be required. So, now when due to some loading, if it gets damaged say flooding. Now, flooding will damage it and in that case, we may allow normally in the flooded condition what we do is that we allow the bulkhead to go or stretch beyond the elastic limit keeping the joints intact or water tight. The basic idea is that the water should not enter from this hole to the adjacent hole.

If that is satisfied because within the elastic limit, you have the capacity, but even beyond elastic limit, you still have the strength. So, if it is not a tanker where it is not a regular affair that you keep loading and unloading with the liquid pressure, one side is loaded and unloaded. It is only in case of emergency that when the flooding takes place, it gets loaded to one side. In that case, it may occur only in case of emergency. So, there is all probability that it will never occur. There is no probability that it will go. Now, by chance if the flooding takes place and we do not want to lose the vessel, we can afford to lose the bulkhead in the sense that let the bulkhead become a balloon, keeping the welded connection intact.

Now, allowing the water to go there, but it has become a balloon and there is a permanent deformation. So, if you pump out the water, go to the next port, pump it out and try to repair the hull, you will find out the bulkhead is totally damaged. In that case, you are in a position to replace the bulkhead with a new one because you have saved the vessel. You can take that much of risk because it is onetime risk. Now, in some cases it so happen that you may be in a position to take the risk, but at the same time you should be in a position to replace that very quickly. You are losing the bulkhead, but at the same time the repair should be done very quickly. Now, how quickly it can be done?

So, if you are going to have a cellular structure, then if suppose this side gets flooded, then the whole thing may get distorted in the sense that this will remain intact whereas, the joint will go and undergo a plastic deformation. In that case, I only cut out this part. The remaining part is all intact. I cut out this part, replace this strip and put it back in position again or in service again. It would not take much time and this material is also not much which is to be changed. You see if you have to change the entire bulkhead, what you require that you have to cut it open, bring it into pieces, take it out from that whatever opening is available and then how are you going to take it in, you have to take piece by piece, try to assemble it there and put it in position.

Otherwise, you cut open the deck, takeout this damaged part, prepare the thing in the hull shop, bring it in the position and put the deck once again. Hell of a job, but if this happens, I go the site I know that entire bulkhead is intact. Only this strip is out. I simply gas cut the whole thing, measure the whole thing, I can bring it immediately and start welding from one side, start replacing from one side and repair it on the another side. You gas cut from here and start welding from there, keep on gas cutting it and keep on welding it. So, this is a new concept and there I am aligned that this particular strip can go beyond the elastic limit. I am not saying that this should not go beyond the elastic limit. The joint should go beyond the elastic limit, but only for such cases because this initial cost will be much more, but in such cases where this type of risk is more say for example, defense vessel. If really the war takes place and there is a hole here, this thing is flooded. Still in the flooded condition, they have to go to the enemy and then run away and you cannot lose the vessel. May be that day or two, you bring it back, try to repair it and once again put it in service. You want a quick repair here.

Now, if you as soon as you go for a twin plate, it will be distance away definitely even if you take half the thickness and put it apart. It will be much stronger than a single plate there, but the thickness, which you are splitting into two thicknesses; there also there will be for single thickness, there will be a minimum thickness. So, suppose you are having a 12 millimeter plate and you want to make it 6. That may not be allowed. It will be asked to say 8 millimeter 2 plates and you are putting them say 10 centimeter apart to 20 centimeter apart. So, it is not going to take much of space also there, but at the same time you are going to have a flexible bulkhead with a repair time minimized.

This is a concept I wanted to work on this and see how it behaves. Now, I am not in a position because there are number of aspects involved with this. It is not only when somebody around there is no bracket here. There is no bracket here. I take the bulkhead in a double shell form and I take another strip here. Both side connect the thing and put it here and then weld it all around finished. You see how neat it will look like from both sides. It is neat. You can use it for bulk carry, you can use it for tanker, and you can use it for defense vessel. No problem in cleaning, no bracket, nothing of that sort. The corrosion problem will be solved. You take a hose jet and clean it, wash it whatever you want, but only thing is how to manufacture that.

What are the construction details that will be number one? What will be the cost involved in it? Cost involvement will not be too great according to the way we people waste money in our shipyards. I think the cost involved will not be much, but one has to see that how it can be done. I think I will switch it off.

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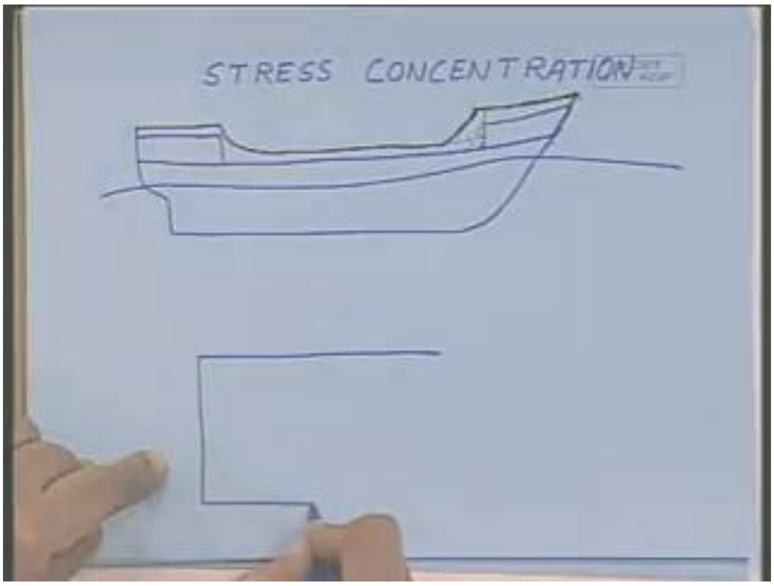

Then, in any structure we come across this phenomenon. When there is an abrupt change in the structural arrangement or what we say when there is a structural discontinuity, say for example in our ships we find let me draw the profile and let us verify. I am drawing the old type of profile say you have the main deck here and then you usually have sometimes you may have some increased portion here also known as the puck and if you see it from outside. What we do that we have a bulwark goes like this. So, this plating which is there, goes like this and actually the deck is something like this. So, there is a discontinuity here. Now, if you wanted if the bulwark, we could have finished it here. Put a ladle sort of a thing here and then start bulwark and then finish it, but we do not do that and we are trying to leave it.

Now, there must be some reason why we are not doing that. Can you tell me what the reasons are? Load comes later on, number one. What we do that this is the part which can be seen outside. It should look pretty and if you have a discontinuous thing does not give you a very appealing look and therefore, if you have some smooth covering like this, it gives a good look. So, look wise it is good smooth and then comes the structural part that all these discontinuities are concealed. Now, the actual thing comes that this vessel when it flexes, there is some sort of an additional stress comes in. So, if we continue in this fashion, then the stresses will come here and for that let me try to just take a simple example.

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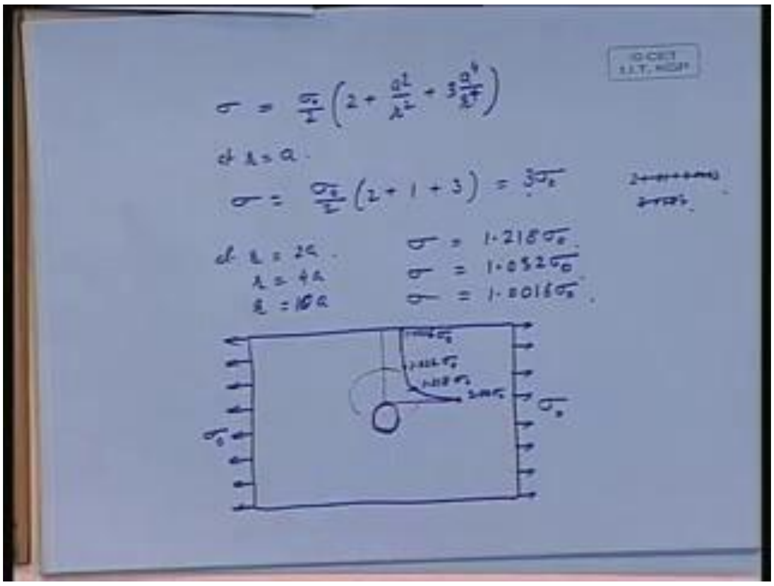

You have a plate 0. How much is it? This we should be in a position to calculate 1.0016. So, you see how it changes. If now I try to plot it, what is the value? I have taken 1, 2, 3, 4, 5, 6, and 7. This is 3. We need 2. 2 is 1.2344. So, let us say 1.0016, this value is 1.032, this value is 1.218. This is 3. So, you see in the vicinity, this is 200 percent more, this is 22 percent more, this is 3 percent more and of course, this is only 0.16 percent more here just because some material is not available. Some increase will be there because they have to share it. This material is missing, but you see who shares the maximum is this vicinity. So, the concentration of the stresses is around this area. So, when we come to the ships part radius, we try to put that. One can see that more will be the radius here, again from elasticity we will find that this stress, which is here will get slightly tapper down.

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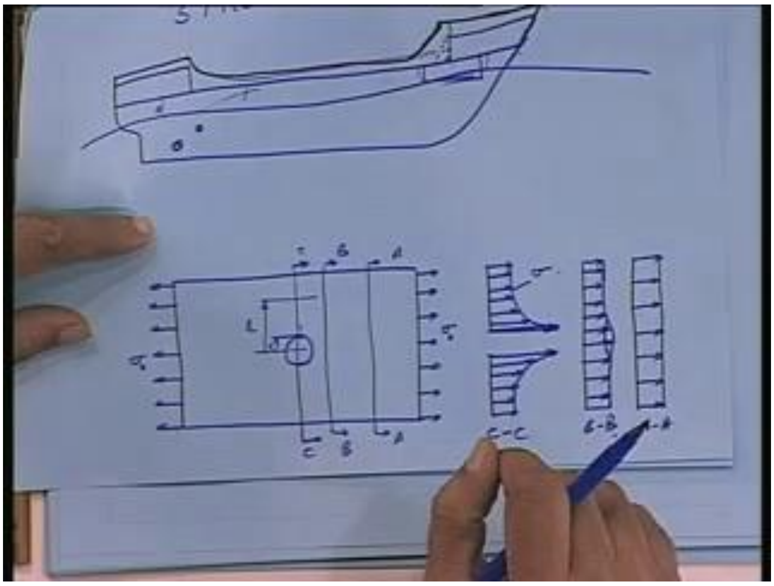

So, if you are having a smaller hole, more concentration will be there. If you have a bigger hole, then the concentration is reduced. Now, this phenomenon I will try to explain. We must have read it that during the early 90s, lot many bulk carriers we lost in this sea. I think according to the records, this thing some about 56 bulk areas or 56 ships in which majority of them, the bulkers between I think 91 and 93, we lost and when some sort of investigation was carried out, they found that the average age of the bulkers was there something between 12 to 15 years.

There are about 20 percent vessels which were beyond 20 years old, but there were about 15 percent vessels which were 6 years and younger, and they were also lost. There was no question of any cyclone. Somewhere there was no question of any grounding. The sea was deep and in a way so-called undisturbed condition of the sea, the vessels were simply lost. Some of the vessels, they could get the rex in some of the cases. They could get some surviving crew member. In majority of the cases, they could not even trace a single sole of the vessel itself because they went so deep that they did not know where it is. So, whatever rex they got and whatever verdict they heard from those surviving crew member, they tried to analyze and came to a conclusion that the bulkers if we just see the cross-section of the bulk carrier.

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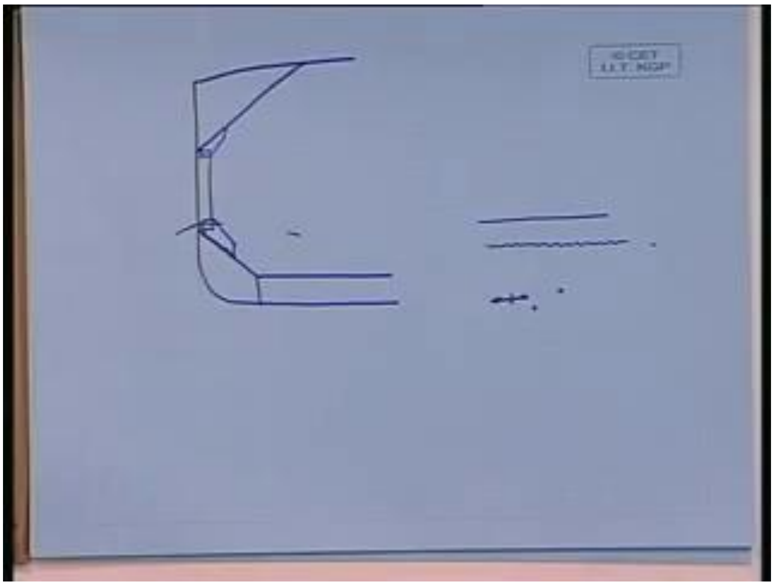

I am drawing the half of it. You have the upper going tank here, and you have the main tank like this here. You are having the frame here, which was being connected to some sort of a bracket down here and some sort of a bracket up here. Now, the majority of the vessels, they found that the crack started from here and this crack and the bracket which started progressively propagated to the stiffness here and then finally to the hull and opening it to the sea. Therefore, from this side the water entered and slowly it flooded this part.

It basically is a combination of many aspects. They found that why this is not if it not fatigue here, fatigue could have been here also, but why it is always on the bottom knee or knee bracket and why not in the top bracket. The thing is that when you are carrying any solid material in a loose condition, this corner cannot be clinked properly whereas, it does not stick here, but it can stick here into some sort of joints or knuckles there. The area is dark and therefore, if the inspector or surveyor whoever goes there, we cannot see it properly and it cannot make out whether the thing is properly cleaned or even for the structural aspect, the welding aspect we cannot find it out.

So, if the cleaning is not done properly here, the same is the case with the painting also and with all those materials which goes and sticks there, either it is husk or it is some chemical or it is some dust particle whatever you call it, they are prone to observe moisture and along with the moisture oxygen. So, they are rich in oxygen moisture and a lot of corrosion takes place. The effect of the corrosion is a smooth surface like this becomes a surface like this.

Now, if you see the surface top, each dent here is nothing, but a pit hole here and when this thing is subjected to some bending, there is a tension here and tension means at this part, the stress is going to be three times the surface stress there. It is a small circular hole on to the surface and on the surface whatever the fiber stress is you can expect that in this side, it is three times of that and if that is the stress value, you are likely to have a failure here a crack or hairline crack.