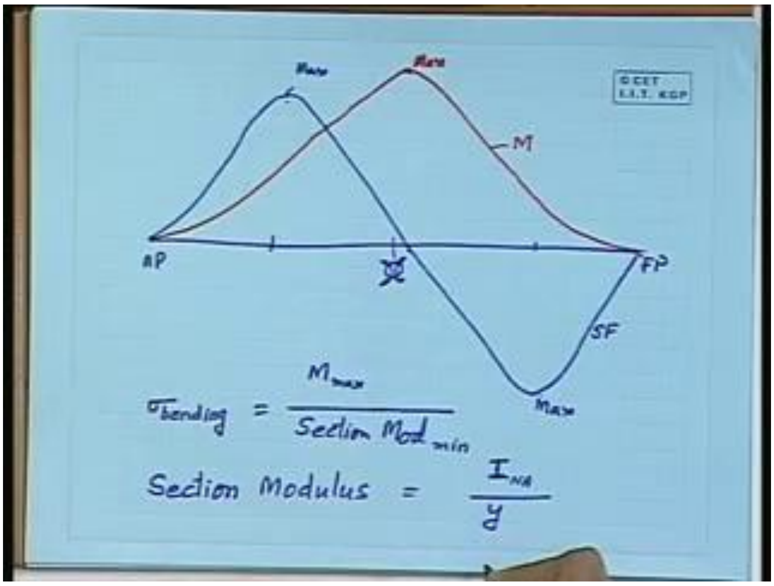
Strength and Vibration of Marine Structures
Prof. A. H. Sheikh and Prof. S. K. Satsongi
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Lecture - 15
Longitudinal Bending of Hull Grider – III

So, what we have seen in the previous class was that the variation of shear force and variation of bending moment along the length of the vessel. Now the two curves, which we tried to draw I have just given a small example here.

(Refer Slide Time: 01:20)



S F depicts the shear force diagram and M curve depicts the bending moment diagram. Now what we can see from these two diagrams that the shear force is 0 at the after perpendicular; that means at the after end, also at the forward end and somewhere near the midship region. And the bending moment is 0 at the two ends and is maximum somewhere near the midship where basically the 0 shear force in the beam is occurring. From the mathematical point of view also, this satisfies this condition, and the maximum shear force which we can see either positive or negative is somewhere near l by 4 from the ends.

Now these conditions fulfill our basic boundary conditions because when the ship is floating in water, the two ends are free, and therefore, we say that a ship girder is floating in water in free free condition and surfing; how it flexes is a different thing. So, when it flexes basically there will be some nodes one can perceive which will be away from the two ends and somewhere there the 0 displacements will be there; that we will try to say it in a more detail when we try to do something about the ship vibration, okay.

So, here we have a maximum value of SF, here we have another maximum value; out of the two, one will be absolute maximum, and somewhere here we have the maximum value for the bending moment. Now what are we going to do with these maximum values? Just knowing a particular figure and it position does not satisfy our condition or out requirement; we do not know what to do with them. So, basically the maximum shear force we should relate it to the maximum shear stress in the material, and the maximum bending moment should be related to the maximum bending stress in the material.

Now this stress values we understand that they are something as the ultimate strength of that material. So, if it crosses a particular limit, then we will say that the material may not behave in a matter which we would like it to behave. Say for example, if we consider the elastic behavior of the hull girder or the equipment and if it crosses the elastic limit and goes to the plastic limit, then that behavior is not acceptable to us. That means when the load is removed from the structure, it will have a permanent deformation which we do not want.

So, we specify that maximum limit depending on the material which we are using for the hull girder. Now there is another thing that there are many forces which we cannot foresee or we are not in a position to either understand the mechanism or evaluate them in a proper manner. If that is the case, then we have to give some margin to this value and that margin which is because of the uncertainty in the behavior, uncertainty in the forces, uncertainty in our calculation procedure; whatever you call it can be a cumulative effect or they may try to cancel each other; it can be either way.

Now we do not know, and therefore, we have to be slightly on the safer side and to take into account this safety, we say that we apply a factor of safety to the materials stress limit. In fact, this is nothing to do with the load in loading factor; many a times people say that you have taken a factor of safety of two; that means whatever load you have considered for the design, you can load it twice that amount without failure, it is not so.

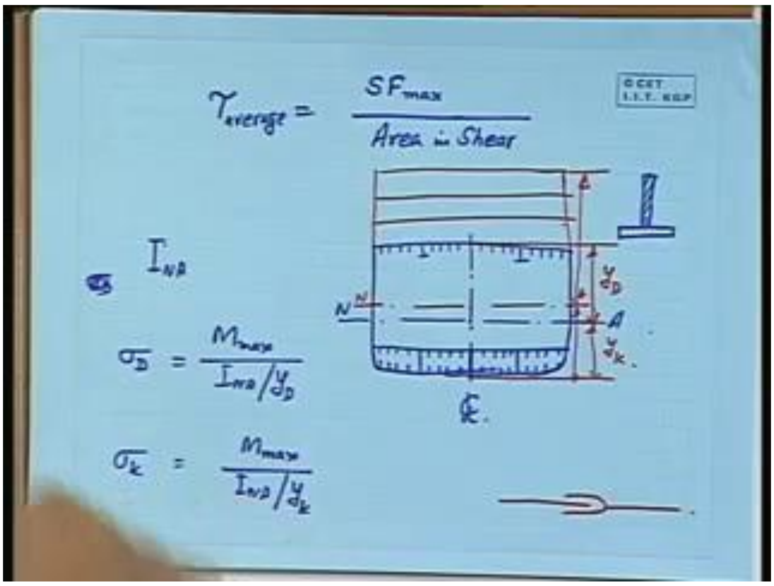
We have taken a two because the other 50 percent I am not sure whether that load is going to be there or not. So, I am keeping a margin for some unforeseen circumstances, okay. So, factor of safety is put and we say that we have a permissible stress level. Now this permissible stress level can be calculated on the basis of the elastic limit on the basis of the plastic limit whatever the case maybe. Nowadays people are going for ultimate failure analysis and on that basis they try to specify what is the factor of safety, okay.

So, basically after obtaining this curve we are interested to find out what is the maximum stress generated in the structure somewhere and see whether that is within the permissible limit or not. Now as we can say the shear force is maximum at these two points, and therefore, somewhere here in this section, the shear force will be maximum. On the other hand, the bending moment is somewhere here maximum and the position is where the maximum bending stress occurs, there the shear stress is 0.

So, they are two different locations and at these two different locations one has to see that those sections are safer from shear stress and from the bending stress point of view. Now let me write down what is the expression for the bending stress; sigma bending sigma is the notation we use is nothing but the bending moment maximum I take M max and section modulus minimum.

Now this is the geometrical property of the structure; we will talk about this section modulus in more details when will take it up. But what is section modulus is basically I of the material that is second moment of area about its neutral axis. So, we call it I N A divided by the skin distance where I am trying to evaluate the stress, so I by y.

(Refer Slide Time: 08:08)



Now when we try to find out what is the shear stress, shear stress is the shear force we are taking maximum divided by all that area which participate in taking up the shear force. So, we say area in shear. It has been found that all vertical cross sectional all vertical material participates in the shear stress. The horizontal members in that particular section for this particular case will not be effective for the shear taking load. So, that means when we take a particular cross section, then wherever we have the webs; suppose, you are having a longitudinal there in the form of a T-section, let me draw it.

Then it is these vertical members of the web which will participate in taking the shear load not the flange of this, okay. And therefore, we also try to say or we will try to find it out now that shear stress is a position dependent within the section; like in bending moment we can say that as y increases, I by y will decrease. Because the cross sectional second moment of area is constant, the material is constant, and therefore, I that geometrical property is constant, but the y near the neutral axis is 0, and there we have 0 stress value bending stress.

That is why it is neutral, because there is no stress. And when you go away from that place y increases, yeah, z also increases or the section modulus decreases. So, M maximum divided by you have a minimum section modulus which gives you the maximum stress, and the variation is linear, because y is a linear function of the depth, okay. Now here we will find that at the two skins that is the deck part and the keel part, the shear stress value will be zero, but it will become maximum near the neutral axis.

But if we are trying to find out shear force maximum divided by the area in shear, what we get is shear stress average, okay. I will come back to the bending moment or the bending stress once again; let us take a typical cross section of a ship. This is the centre line; this is the bottom I have drawn. We can have an inner bottom here; you have a centre girder here, somewhere here is the side girder, and we can have some the deck girders here. And then we are having longitudinals in the deck, longitudinals in the inner bottom, longitudinals in the outer bottom.

In this particular location, there may be a web frame or may be every third frame there is a web frame or some such thing that the rule governs that the distance between the two web frames should not be more than 3.2 meters or some such thing. Now when we are trying to find out I, this I is of this material sections which are continuously extending from one end to the other end or for the major part. Normally, we consider that from the after peak bulk head to the fore peak bulk head in that region or if we want to take the super structure which by definition is extending from side to side and the extent is not less than 40 percent of the length.

So, that will contribute towards the longitudinal strength; all these members we try to find out what is the second moment of area. So, this neutral axis will be somewhere here and I of this section have to be calculated. And then we say that the y value for the deck it is here and for the keel this is this value. Now when the ship undergoes say hogging or sagging bending moment if we take the hogging condition, then the deck is under tension, and the keel is under compression. It is a hogged condition, and therefore, that deck stress which is in tension and the keel stress, which is in compression will have two different values.

And what we can write is sigma for the deck; sorry, sigma for the deck is M max by I N A divided by y deck. And sigma for the keel will be M max divided by I N A the same I by y of the keel value. Now here we can see that I by y for the keel will be numerically greater than I by y for the deck, because this neutral axis by virtue of the materials the way it has been dispositioned, this neutral axis will be slightly more than half the depth of the vessel from deck side.

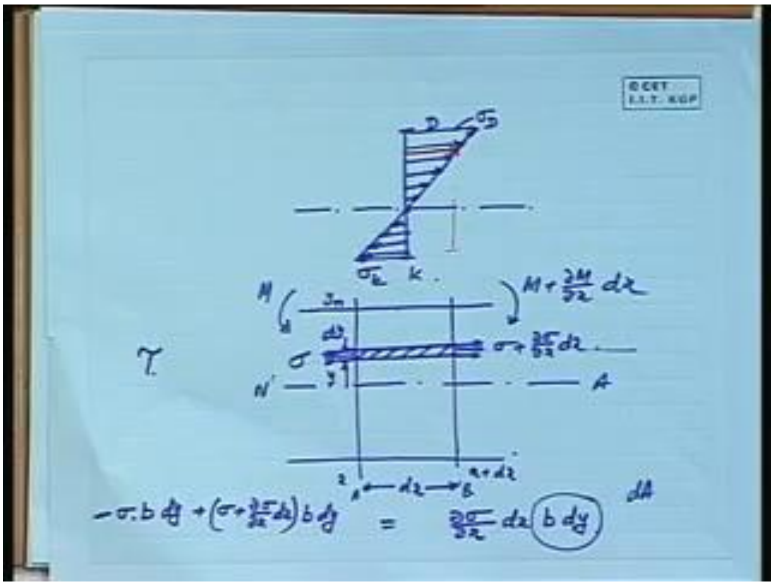
That means y D is greater than D by 2 and y k is less than D by 2, and by virtue of that the numerical value of I by y for the deck will be lower than I by y for the keel value. And therefore, the stress at the keel will be somewhat lower than the numerical value at stress at the deck level, okay. This is the reason why people say that when you have a superstructure by definition a super structure, which is 40 percent length or more extending from side to side should be avoided in a ship, because that number of tears will add onto this y D.

If you have some super structure here extending let me draw it with a different color. Suppose, I had three tears here, this will virtually raise this neutral axis position also, but what happens this value will be far far greater than this value here. And this will drastically reduce the permissible stress there, or it will increase this stress at this level which will become dangerous for the health of the structure. And therefore, they say that do not have more than 40 percent, try to reduce it or split into two three parts, provide some sort of an expansion joint flexible joint. So, that each segment is less than 40 percent; after all there is no problem of sea getting shift in side, it is far above the deck.

So, one tries to put some sort of a expansion joint if it is a passenger vessel; if not then you put it in set, you have prominent sort of a thing or you have passage, etcetera, and you take the continuous valve, say, one and half to 2 meters inside the two sides. That is the reason even if the deck extends like this you can see in some of these passengers vessels; maybe one or two decks they have given in line with this side shell. But remaining of them it is only the curtain plate the deck is extending, but it is being supported somewhere inside here. And you are giving some setting space or moving spaces for the passengers in open space.

So, you are getting rid of this definition, and you are structurally changing the arrangement. And as far as the length is concerned, you try to get some sort of an expansion joint which sometimes looks like this. You can have some sort of soft material which can be a packing material here. So, expansion joint above the deck level if you do not want to increase the height, okay. So, this is how we try to change the stress. Now if this is the case, then how the stress will vary?

(Refer Slide Time: 18:29)



If we take the section here and say that this is the neutral axis. This is the keel point K; this is the deck point D; this stress varies something like this. It is linear. So, this is the variation. If you consider the top is tension, then the bottom is compression in the opposite direction. So, bending stress is always we consider to be linear and at the neutral axis it is going to be zero.

Now many a times what happens? That it is not possible to have very thick plates and this stress the limiting stress which we consider maybe up to here, and then we say that beyond this let us use height tensile steel. You can still use in the core as mild steel, but where higher strength is required you can go for high tensile steel. So, from here one can say that because the high tensile steel will have a higher limit. So, this analysis is required. So, that you can make an assessment that which portions of the structure can be of high tensile steel; after all that is much more expensive than the ordinary mild steel.

It is no point unnecessarily using mild steel for the entire region where the stress level is not going to exceed the permissible stress limit of mild steel itself. So, only where you expect normally in tankers very large tankers where the depth is very high; one can go for the deck and the keel construction the high tensile strength, but the remaining part of the hull and internal arrangement can still continue to be mild steel, okay.

Now coming to shear stress, now for the shear stress let us try to draw the block and try to see that how this will behave. Let us take a section here and another section here A and B. A is at x, B is at x plus d x; that means the distance between these two is d x, and from the neutral axis, this is the neutral axis position I have drawn here; some distance away which is say y, you take a small layer of thickness d y, and let us see what is the state of stress.

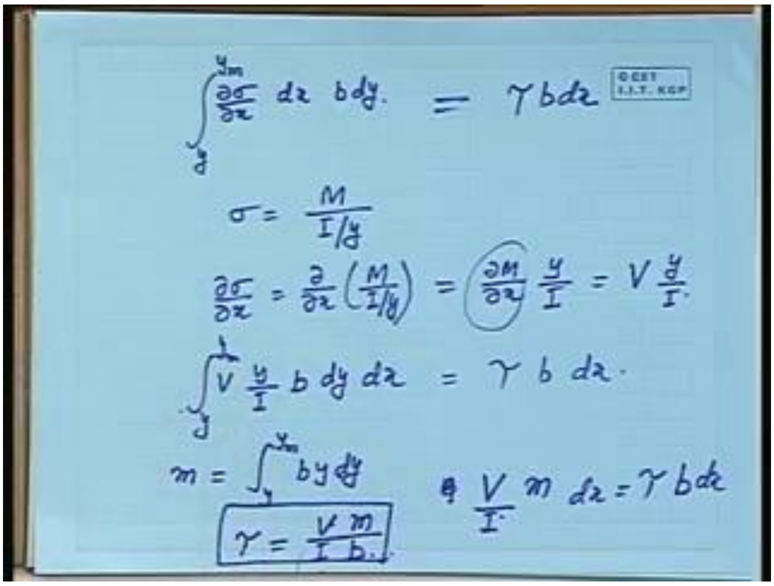
Now here we can assume that the stress is sigma, here the stress is sigma plus d sigma by d x into d x. Now this sigma and this sigma are created because of the bending moment which is being applied here, and this side is M; this side is M plus d M by d x, okay. Now this has to be in equilibrium; indeed, it is in equilibrium. Now what is the net force which is acting onto this slice here? So, you have on one side sigma into the depth here which I can say is the width of the cross section which is b.

So, you have sigma into b on this side acting on a slice of d y. So, b into d y is the area in which the normal stress sigma is acting. So, this is the force in the left hand direction, and the force on the right hand direction is sigma plus d sigma by d x into d x and the same cross sectional area. Pardon, on this side the force is in this direction. So, what is this force? Stress into the area. Now what is this area? If I consider that the thickness here is d y and this is extending in this direction to b.

So, b into d y is the elemental area on which this sigma is acting. On the other side on the same area we have a stress which is sigma plus delta sigma by del x into d x. Under the action of this, there will be some net force acting. Now this is I am putting negative because it is in the left hand direction; this is acting on the right hand in the positive direction, so positive. So, these if you try to find out, this value will be d sigma by d x into d x b into d y. This b into d y I can say d A also for the time being.

Now that means there is a net force acting in this direction, and if you try to sum up all the such forces and different slices away from this particular level, then there will be a lot of force which will be acting in this surface here. Now what is that force?

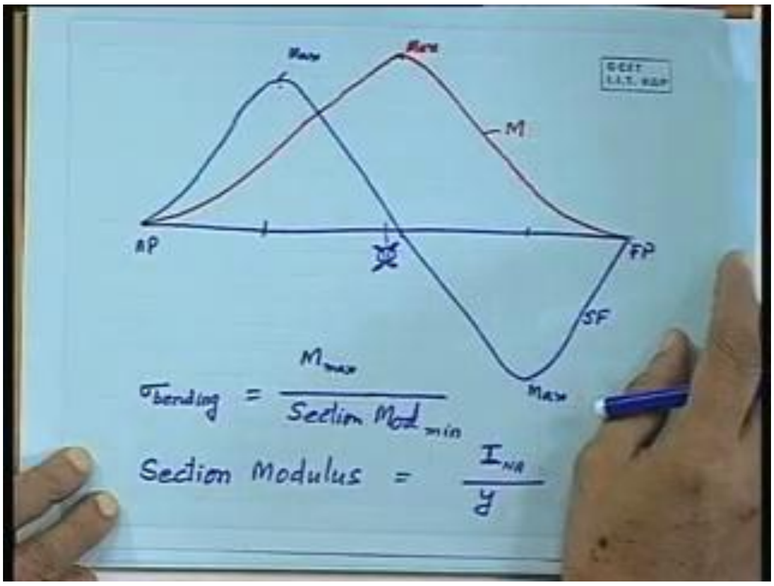
(Refer Slide Time: 24:51)



That force will be you have to integrate this d sigma by d x, and this has to be integrated; if I say that this is y and this is y max here or y m let me say. So, from y to ym, this amount of force will try to pull away from this cross section at this level; that means at this interface, some stabilizing force must be getting generated and that action is this action which is nothing but the shearing action. And this shear force must be generated here; that means there must be some shear stress which will be generating at this interface.

Now that interface area is d x into b, and what is the stress? Let me say that stress is tau at that level, this must balance this here. Now let us see what is this here. Now sigma is M by I by y, and therefore, d sigma by d x is nothing but d by d x of M by I by y. Now I is constant of that particular material and y we have assumed at a particular layer, okay. So, y location is also fixed. So, it is only M which is varying with respect to x, and therefore, this will be d M by d x; we can say y by I. What is this quantity d M by d x?

(Refer Slide Time: 26:46)

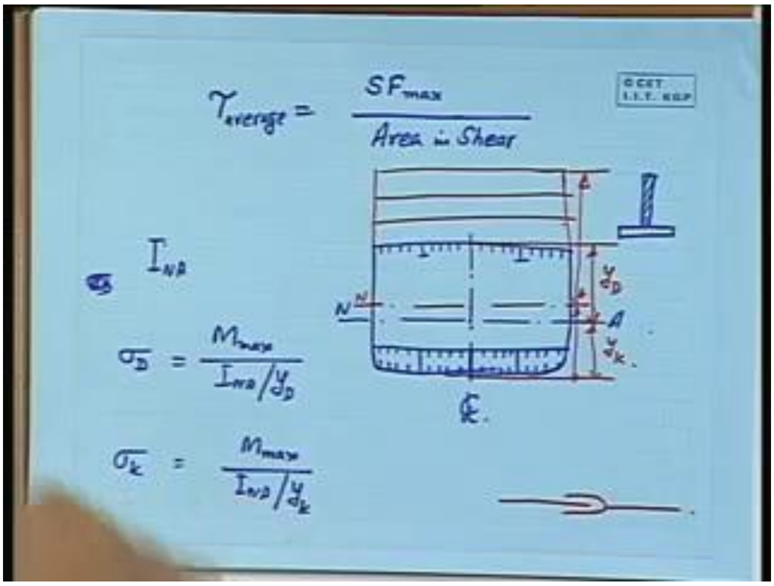


If you remember this diagram, then on integration of this we have got this. So, integration of the shear force is the bending moment, and therefore, differentiation of bending moment is nothing but shear force, right. So, at that cross section this d M by d x in nothing but the shear force V of f whatever notation you use, and this is y by I, okay. So, if we substitute this value here, then what do we get? We get V y by I b d y d x here integration from y to y max and this is tau b into d x.

Now what is b into d y from here to here? B into y into d y b into, sorry, b into y into d y; b into d y is the elemental area and at it is located at a distance y. So, what you are trying to do is you are trying to find out the moment of this elemental area about the neutral axis, and such moments you are trying to sum up from y to y M, okay. So, we can designate by some quantity m which is y to y m b y d y. If you replace this in this expression here, then this will reduce to, sorry, V by I m d x is equal to tau into b into d x.

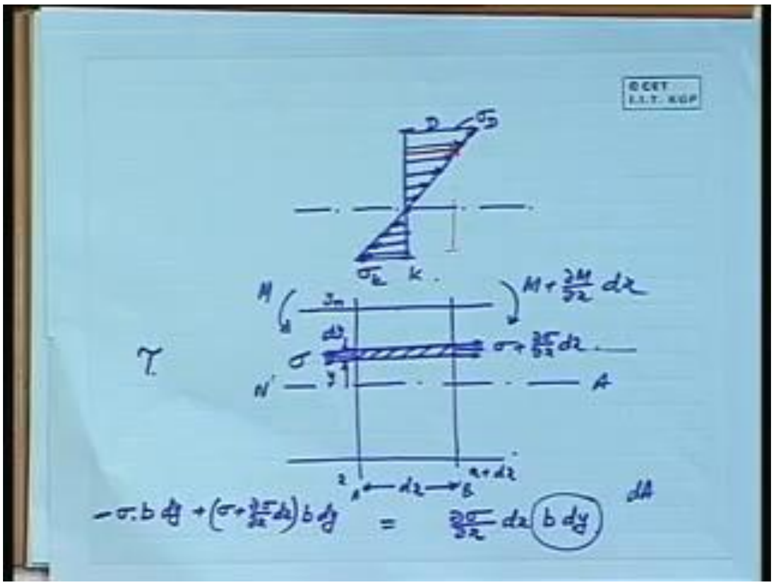
Dx dx we eliminate from both the sides, and what we get an expression for tau which will be given by tau is equal to V by I m by b. This expression gives you the variation of shear stress across the depth of the structure. Now let us try to see here in conjunction with this. Now at this section I say that shear force is given by let me concentrate to this; suppose, I am considering this maximum shear force position. So, this is the sheer force which I have with me.

(Refer Slide Time: 29:46)



Now across that section, if I consider that the section looks like something like this here at that position, then how the shear stress will vary?

(Refer Slide Time: 29:54)



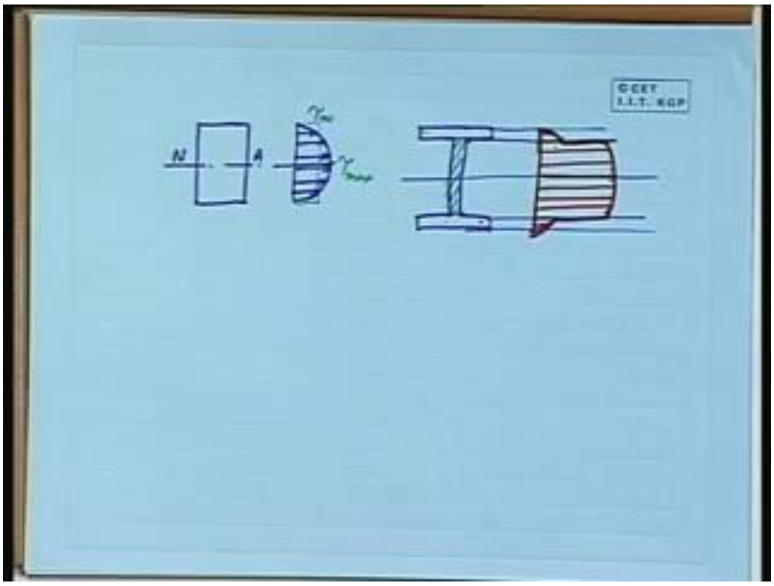
Now look into this expression, what does it say? This is the value of V, okay; this I i am getting from this section here, right. This moment neutral axis is here; all that material which is taking that I am trying to find out all this cross sectional areas moment from here to here if my postion is at this position here y to y max, okay. So, if I am considering the stress here, then from here to here I have to integrate, find out the first moment of this area, right. So, this will be maximum at this level, sorry, at the neutral axis.

If you integrate from here to here, then only it will be maximum; if you integrate from here to here, it is 0. If you take the value at the deck itself, then it is 0, okay, then divided by b; b is the width of the cross section. Now what happens? If you take the deck, this is the cross section; if you take the sides, then this is the cross section plus this is the thickness, b is only the contribution from this.

Now let us come to this part. As soon as you are here, the shear stress will be very high value, but when you come to this part, the shear stress will drop down, because the width suddenly increases from say twice the thickness to the complete width of the vessel here. So, that means the horizontal member is not taking the shear force. This expression says that this becomes too much, okay. As soon as this increases, this stress comes down drastically. The horizontal member do not contribute in taking the shear stress, its contribution is negligible, whereas the vertical members take the maximum shear stress of the loading; that is what I told you earlier, and this expression also tells you the same thing.

So, what happens that when you are considering the top position here, the bottom position here, the shear stress is 0 there. As you are coming down, you will find that at the neutral axis it attains the maximum value by virtue of this m becoming the largest at the neutral axis. As you go away from the neutral axis, once again the value reduces.

(Refer Slide Time: 32:41)



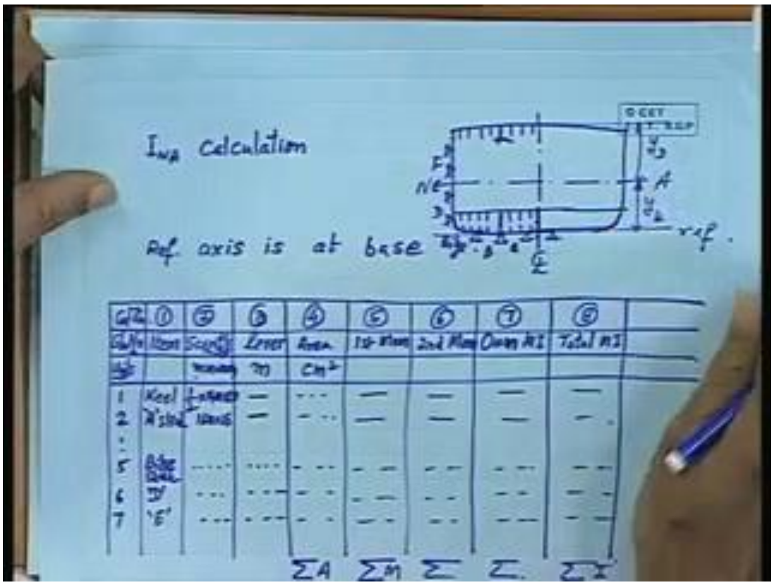
If you just take a rectangular cross section and try to find out how does the shear stress varies; it will be a parabolic distribution having a maximum value at the neutral axis. If you consider a T-section just for illustration, in fact, what you can do is you can take a small example and try to solve it; let me use a different color to show. So, this is a part of parabola here, because this is also a rectangular section. It is a just a part of parabola, but the width is very high, then suddenly the width decreases here. So, it shoots up and then this is constant.

So, the area moment or moment of this area does not increase much. It becomes maximum here and then it drops down to this side, and then suddenly the thickness changes. Hence, there is a sharp drop here and then once again it follows a parabolic path, okay. So, upto this if you have any questions, I think you can ask me. This is very important; that is why I said that in the right in the beginning, if you take the total shear force divided by the shear area, what you get is the average, and when we say the average, then this is what is tau average, and this is what is your tau max, okay.

So, one gets misled while finding out the average value; it is quite a lot here. In such sections you will find that the maximum is 50 percent more than the average value. So, if your calculations are based on the average value may be that the structure will fail in shear because we might not give this much of factor of safety there, okay. Of course for this, it is not very critical, and that is why it is very easy to say that only the vertical members you know carry the shear.

So, here we can fully say that the contribution towards the shear is from this part; this much of force is hardly anything compared to this entire area, any questions here? No. So, should we take up how to calculate the moment of inertia of this cross section. I once again keep this figure in mind or I think I will try to draw it separately here; that will be better.

(Refer Slide Time: 36:58)



This time I am drawing only half the section for the structure. These notations you know these are the same marks, and this is the Keel streak from here to here, and then the other streaks are coming this is the beal streak and so on, so forth, and the last one is the sheer streak here. So, we do the calculation for I N A. So, I N A calculation for a given section in a tabular form and the table we will try to put the headings and see that how we try to put it.

We put the columns here column number, some operations here and then we say the units also. We usually give the serial number for materials in this direction. So, let us say that we are taking column number one. Now what will come in column number one? In column number one, we would like to put the item, the name of the item. Say, serial number one, I start with the keel here, and I put keel.

Student: The second one is station number.

Serial number. Serial number going downwards, units is horizontal, and column number is also horizontal here. In the second column, I try to give the scantlings here. Now usually the scantlings are given either in millimeter by millimeter or centimeter by centimeter or centimeter millimeter combination. So, let me put here, say, millimeter by millimeter. Third one because we have to calculate the moment, and therefore, I put lever here, and usually it is in meters; fourth, now we try to find out what is the area? Area means area of that material cross section and usual units is centimeter square.

Next column we prepare for finding out the first moment of the area about some reference axis; I will come to the reference axis what is the reference axis. The basic idea is I have to find out the second moment of area about its neutral axis, and therefore, the neutral axis has to be evaluated first; I do not know where it is. So, I must have some reference axis about which I do all the calculation and then arrive at the neutral axis.

So, this is the first moment of area I will write, and then in the next one I say it is the second moment of area. And then another column I add and I say own moment of inertia, and then it is the total moment of inertia of that about the reference axis, okay. Now where is the reference axis? We have seen the diagram and we see this structure here; we say that the reference the neutral axis will be below the mid depth.

Now for example, if we say that the depth of the vessel is say 9.5 meters, and mid depth is 4.75 meter. We can consider that the assumed neutral axis is some round figure of that below 4.75, may be 4.5 meters or 4 meters, but still we have to do a calculation. So, if we assume, say, 4.5 meters from the keel, it is the assumed neutral axis. Then above that whatever area is there, I consider it to be positive having a positive lever and anything below it must have a negative lever values.

Now this positive and negative one has to keep in his mind and accordingly you have to find out all this. Now the second moment of area there is no problem because you are multiplying by the same quantity twice. So, positive positive is positive, positive negative is positive, but the first moment depending on positive and negative will change. And there are a number of such items if you just consider here, I think it will go into a big list of about hundred items.

And for each because we are seeing that all these may be of the same profile, but the cross section as it is that things will change, because we may have camber; you may have this raise of flow and so on, so forth. So, they are not at the same level. The stiffener may be identical, but their lever will keep on changing, okay. So, the best will be to get out of this confusion that we can assume that at the keel level, we use the reference axis. So, we can say reference axis is at base or keel or whatever it is. So, no ambiguity regarding plus or minus here; everything is positive, okay.

Now let us see what is the keel. Now keel plate is one single plate; we are considering only half section, the other half is mirror image of it. So, we do half the calculation, multiply it by 2, we get for the entire section. Now keel, center girder, etcetera, may create some trouble, and therefore, one has to be very careful and put that half right in the beginning and say that the dimension is may be that the keel plate width is 1400 millimeter, thickness is 20 millimeter.

So, I write 1400 by 20; I have already said millimeter by millimeter. So, I gave 1400 millimeter by 20 millimeter. What is the lever? If it is 20 millimeter, then it should be 10 millimeter below the keel, okay. Now when I am talking about the ships depth of 9.5 meters with respect to that 10 millimeter is absolutely negligible; it is not going to affect my calculation, and therefore, it is not zero. So, I do not write 0; I just put a dash here, okay.

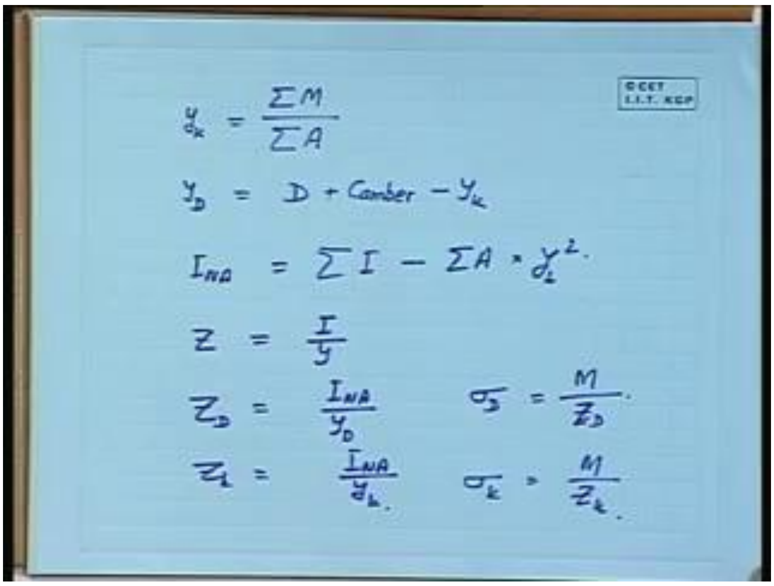
Second item I take, say, this is strake A, strake B; this may be the bilge and so on, so forth. I put a strake; I write, say, 1600 by 18 millimeter, and this lever is also 0, because I am considering it to be a flat bottom ship. So, like that everything will be flat here till you come to, say, item number 5 bilge strake. You have these values, and this value also will be something here. Putting dot dot dot means some value is there, okay, then you come to, say, item number six, bilge is put, say, D E F, etcetera.

So, you put all these strakes D strake, seven, E strake, like that one completes all the outer hull part. Then you can come to the inner bottom, finish all those strakes there. Then you come to these plate items, center girder, side girder, etcetera, okay, center girder, side girder, deck girder, etcetera. Then you come to all these longitudinals and like that one tries to analyst everything and complete this part of the table. Get it checked by one of your colleague, so that you have not missed out anything, because if something goes wrong, it will be only carried over; you cannot rectify later on. So, at stage by stage one has to do the checking.

All this has been done, then you can calculate these values; there is no problem. This here will be 0 0, or I am simply ignoring, but all these values will be there. Now all the areas have to be summed up, and I call it sigma A. All the first moment have to be summed up, I call it sigma M; all the second moment has to be summed up, it is only for checking this sigma and this sigma is required, but I only try to find out what is sigma I here.

These two added up together should give me sigma I. So, this is only for the checking part, but what I require is sigma A, sigma M and sigma I, okay. Now here I have taken this reference and I N A will be somewhere here, and this will become my y k, y of the keel and this becomes y for the deck.

(Refer Slide Time: 49:01)



Now after finding out the summations I can write y k is equal to sigma M by sigma A, okay, and I can find out y D from deck head side this height plus camber minus y k. The depth of the vessel is measured at deck head side from the keel level to the deck head side, and the stresses will be maximum at the extreme skin on the deck which happens to be at the crown of the deck; that is at the center line. There you have the maximum camber.

So, D plus C, C may be 0 if you are having a flat deck, but usually you have some camber. So, let me put it, camber can be 0. So, I put this equation here. So, I get what is y k; I also get what is y D. Now I N A neutral axis will be sigma I minus total area into y k square; this is the parallel axis theorem. So, the moment of inertia about its own neutral axis will have a minimum value about the reference axis whatever is there minus the total area multiplied by the distance square, it is ok.

So, I get what is I N A, and now after getting this I N A, I try to find out what is the section modulus minimum for the deck. The notation for section modulus is Z and Z is nothing but I by Y. So, if I say that Z for the deck will be I N A by y deck, and Z for the keel will be I N A by y keel. Now after getting these Z values, I can find out sigma at deck is equal to M by Z deck, and sigma at keel is equal to M by Z keel, it is ok.

So, these two gives me the numerical value at any section, but usually what we find that the maximum bending moment occur somewhere near the midship section, and at the midship section I have the section, because I draw that detailed drawing for my class approval. And usually a ship has got a parallel middle length and if you see the maximum position of the bending moment, it will be in the parallel middle length. So, calling it to be, say, I midship is not erroneous because the same section goes on for a particular distance around the midship region which I have for my class approval and my maximum bending moment will be somewhere near the midship region.

And therefore, if I call this to be say maximum here, then these are the maximum stresses and if the deck is if it is a hogging condition, deck will be intension, sigma D will be tensile, sigma k will be compressive. If it is a sagging condition, sigma D sigma deck will be a compressive stress; sigma k will be a tensile stress. Fortunately, for steel the permissible limits and tension and compression is identical, but there are materials which do exhibit different properties under tension and compression, for examples, concrete.

Concrete is very strong in compression but very poor in tension. So, in such cases one has to find out what is what, okay. So, other than metal structure if we try to use any other material, then may be that this will be of importance, it is okay; any questions?

Student: Sir, this tabular what we are constructing is for all the members we are calculating?

Yes, we are considering all the members. That basically in a tabular form if you try put it, it becomes easier to check in a metrics form whether you have listed all the item or not. And once we have listed all the items whether these scantlings are given, their positions are given or not.

Student: Then it is a huge calculation, sir.

Yeah, it is a huge calculation; one has to do this calculation. This is for the ship when it is constructed. But for class approval there is another set of calculations, and they are available in the classification society rules. One has to satisfy this value that value, but you have to do this calculation; otherwise, you will not know whether it is going to satisfy that or not, it has to check. That is only a sort of a cross checking. There are certain approximate methods also; I think I will take it up next time. No point hurrying up, then everything will get jumbled up and mixed up. No, this point is fairly simpler part.

Student: One hour class, sir?

Today, one hour class. I said that one hour class today.

Student: we will brush up also, we have studied these things

Yeah.

Student: But may be 15 years backs or for him may be around 25 years.

No, but he is a teacher already. So, his colleague must be talking about such things.

Student: Which book to refer for this, sir?

Unfortunately, there is no latest book on this. So, what we try do is that different portions we have taken from different text books sort of a thing and then we have try to give a latest flavor to this. We used to have a book by Michael long long back, but Michael died and after that nobody has revised his edition. And we were fortunate that Michael also came to this campus and he has delivered lectures here also.

Student: Michael?

Yeah.

Student: Which year was that?

Student: Which year was that?

Most probably 1975.

Because his direct student was our head of the department; so he requested him once that why do not you visit India. So, he said, okay, I will come to India. So, I went to the station to receive him; he was an old man at that time, and he came he gave a lecture. Unfortunately, that book is not revised and after that lot has changed. In fact, after 78 when the fuel crisis was there, the Suez Canal was closed. The ship size is increased and a dramatic change took in the ship building in shipping field totally.

The size blew up like anything, and once the size grows, then the economics will be different and the design feature changed. Before that only three types of conventional vessel either a over carrier or a crane or over crane; that was the type of bulk carrier in those days and general cargo carrier and tanker. There was no third variety. Container was available much later; before that came the variety of tankers, and tankers in those days was only crude carrier, either crude or vegetable oil or water tanker, nothing more than that.

And then after that started coming these product tankers, chemical tankers and perishable goods tanker and so on, refrigerator tankers. And to take into account all those things, definitely the rules cannot cover all the things. Something is being taken in, say, high pressurized low temperature condition. Something else is taken in heater condition; something else is taken in a cryogenic condition. Outside ambient temperature is 30 degrees, and inside temperature is, say, minus 40 degree centigrade, and this is the thickness you are having.

Can you have it or not? You have a corrosive material highly corrosive inside, say, acid you are taking; outside is also corrosive but not that severe. Now how are you going to carry it, hazardous materials. So, totally the things changed. When it was a coal fired steam engines, then machinery was at midship; when the diesel engine then again conservative, you put it at the midship; otherwise, there will be a heavy drip. But then they started shifting it slowly and slowly. Today you do not see any ship which has got a whole behind the engine room; engine room is the last.

Student: Room across the ship is there, sir?

No, that must be old or a very new concept where you have put it in the forward region.