Hydrostatics and Stability

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Module No. # 01
Lecture No. # 32
Bilging - IV

We are moving into the lecture 32 and we continue with the bilging. We will most probably finish up the bilging section today. As we have explained, there are couple of different ways in which you can have the bilging that occurs in different parts of the ship in all our simulation. So far we have considered bilging to be occurring in the midship compartment of the ship that is definitely one possibility.

You have the bilging occurring in one compartment which is a distance that is smaller than the length. If the total length of the ship as length between perpendiculars you have a small length between two fixed stations. You have a compartment which has the flooding in it and bilging occurs only in that compartment.

Then, another possibility is that you can have the bilging at different other sections of the ship for instance, you can have bilging in the front part of the ship that is, the bore region of the ship, you can have bilging occurring at the aft region of the ship. As this happens when you have the flooding occurring in different other regions of the ship. In case, the flooding occurs at the front part of the ship that is in bow the ship if some compartment there gets flooded then, the ship will trim forward. Of course, what we mean by trim forward is, the draft in the forward section of the ship will become more than the draft in the aft section of the ship. So, if you consider this to be the ship, if this is the front and this is aft of the ship, the ship will trim like this (Refer Slide Time: 02:23).

So, this is what happens if this compartment is flooded you can look at it - in any ways you can look at it - one possibility is, in increase of weight as we have already explained the analysis for flooding is usually done using two methods, one is using the method of added weights and one is using the method of loss buoyancy. Both the methods are exactly identical in the sense that not identical in the method of calculations they are different, but they are identical in the result. For example, if you are considering the righting arm finally, you will get the same result whether you use the method of added weight or the method of loss buoyancy.

If you consider this problem of flooding using the method of added weight, you can see what happens; the ship is initially on even keel, I have already described that when you say something on even keel it means that the water line is horizontal. Initially, if the ship is on even keel or any other trimmed condition, suppose that one compartment in the bow region of the ship gets flooded. There is an increase in weight in that section of the ship and the ship is trimmed by forward. So, the front part of the ship is actually going down as you can see it will be like this now (Refer Slide Time: 03:40).

That is another kind of problem and that is one of the problem that we will consider today. As we have already described there is another possibility is that the ship can be flooded not exactly midships, means not exactly along the center line. If you consider it symmetrically flooded means, the port side and the star board side are evenly flooded or we say that the amount of water that is entered on the port side is equivalent to the amount of water that is entered on the star board side. If it is like that then, it is one class of problem but, a second class of problem occurs when the ship gets flooded on one side completely. That is, if you have the center line suppose, the flooding occurs only on one side of the ship, may be the star board side of the ship.

Now, if you have a situation like this, first of all, as the ship gets flooded the draft will increase, so that means the ship will sink first of all. Another thing that happens is - you can now see that this is not exactly the centroid of this water plane it is not on this, because if you consider the method of loss buoyancy some volume is lost here but, you have this volume.

Therefore, the centroid shifts to here; shift to somewhere away from the center line at some distance etched from this end which is not equal to this B by 2. If you consider the total breadth as B, this is B by 2. Now, this distance is f, distance h from this edge which is greater than B by 2. When this happens you will have heeling the weight of the ship is unsymmetrical about the center line that is there is more weight on the right side of the ship compared to the left side or if other way around depending on which side is flooded, when this happens therefore, that side of the ship will heel.

If there is more water coming here if that is side gets flooded the ship will heel like this. Let us consider this problem first, then we will go to the problem of trimming. They are just different ways of looking at the problem - different possibilities that can exist.

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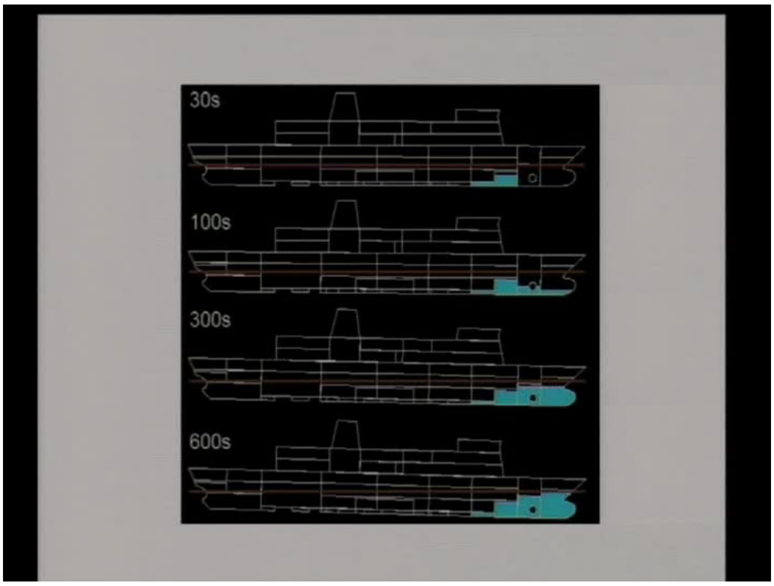

Now, if you consider flooding this is what I talked about in case of if you consider this is the whole ship and as you can see one compartment has got flooded here, this blue color is indicating water, so this gets flooded.

As you can see it keeps getting flooded and of course, if there is damage this depends upon the ships damage condition, because of this whole region is getting flooded, so one by one different compartment are getting flooded. As this keeps continuously happening, what will happen is that the ship will start trimming about the forward. So, ship will trim about the forward and that is the secondary condition that we will simulate today.

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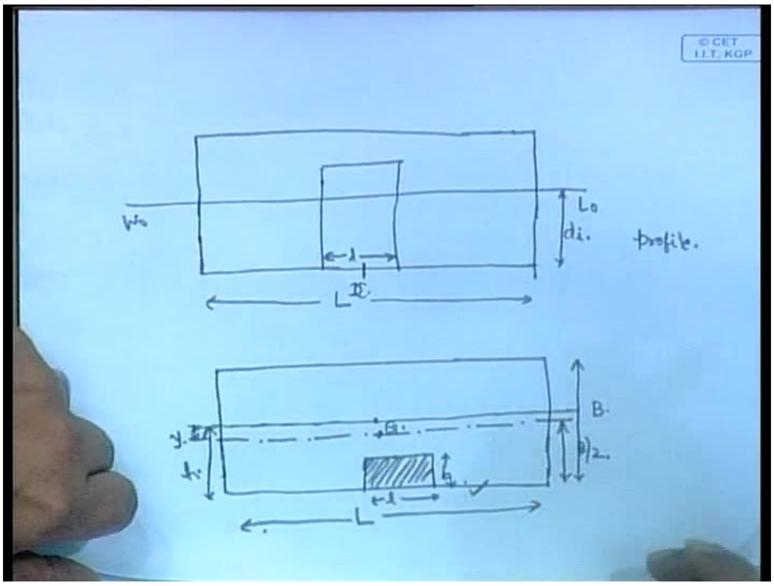

Let us consider a box shaped vessel of existing at a water line W 0 L 0. It is at a draft initially of d I; d initial it represent the initial draft. Now, this is the elevation view or what we call as the profile view. This length becomes the length of the ship which is capital L and this is the draft. Now, let us consider that a small region gets flooded in the center. If you consider this to be the center midship, I have already told you midship is represented like this. If you consider the midship and consider the flooding to occur symmetrically about the midship some region has got flooded to some height greater than the draft, so it is flooded initially. Then, let us look at it is planned view, so this is again the length of the ship and this represents B, this distance is B by 2.

Now, this problem is designed in such a fashion that it allows for that particular case that we talked about, so it is flooded with midship alright but, it is flooded at one side means this region is flooded. If you have a ship, if you consider this to be the center line, so you have the ship like this; this is the center line, it is flooded with the midship alright but, it is flooded at one side if this is the ship, this one corner here is flooded. So, extending over the full depth of the ship but, it is flooded in one side, so like this it is flooded.

Now, let us consider it is dimensions to be b; this is the breadth to which it is flooded. Let us consider it is length to be l - this length l. Now, let us say that as I have already explained initially the ship is at the upright condition and in that case, this is the center line and this will be G the position of the center of gravity.

The position of the center of gravity does not change, because from now all the calculations will be based on the method of loss buoyancy. Remember, the method of loss buoyancy implies that volume is lost from the ship. Automatically it assumes that area is also lost from the ship therefore, the centroid of this water plane area is not going to be at the center line there at G but, it is going here, at a distance may be, let us call it y at this point. This height is let us call it as h, it is the distance between the one side of the ship and the position where the ship has its centroid, so this is the final condition.

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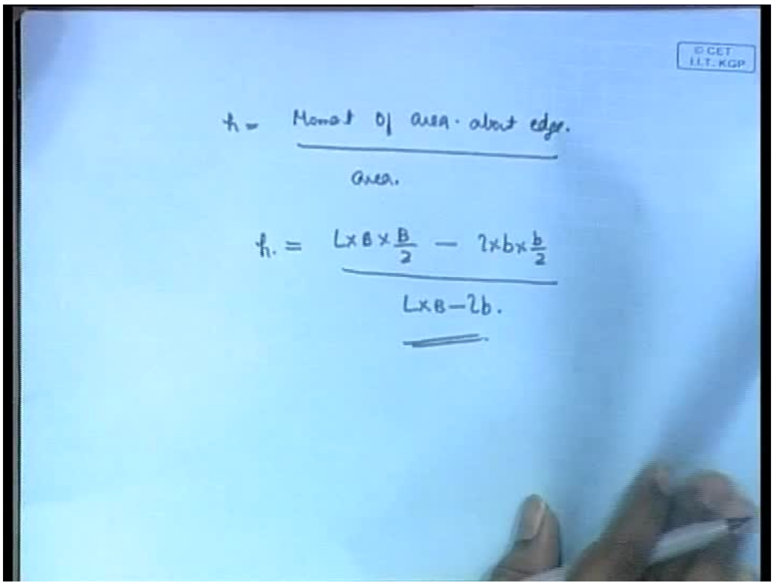

Now, how will you get h? It is very easy to get h; h can be defined as the moment of area. We can do many things, we can calculate the moment of area about some center line, it can be about that B by 2 and it can be about the line where that G acts initially, so along that line is a possibility but easier because of some reasons. First of all we are calculating edge from one side, let us calculate all the moments use about one edge of the - this is the rectangle - so one edge; let us take the moments about the edge.

Therefore, h is defined as the moment of area about the edge divided by the total area. Now, the moment of area, what we have here first of all, we had complete rectangle. So, this l into b we had a complete rectangle, because of flooding some volume is lost. Some volume is lost directly imply that some area is lost in that water area plane. So, if you take that water plane area initially you have l into b and finally, you have l into b minus some area here. This area is again small l into small b, so that much area is lost that we need to figure out. Based on that we get the moment of area about the edge divided by area will get h.

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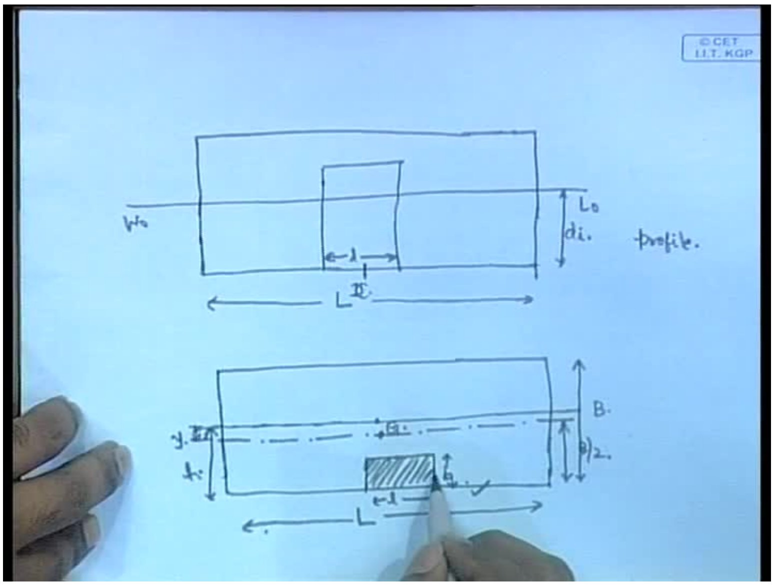

You will get h to be L into B into B by 2 and moment is means here, you have a L into B this is the whole area and into the position of it is center of gravity which is B by 2. So, L into B into B by 2 minus – a small area is gone here, this is of small l, it is of breadth small b and it is centroid is at a distance small b by 2.

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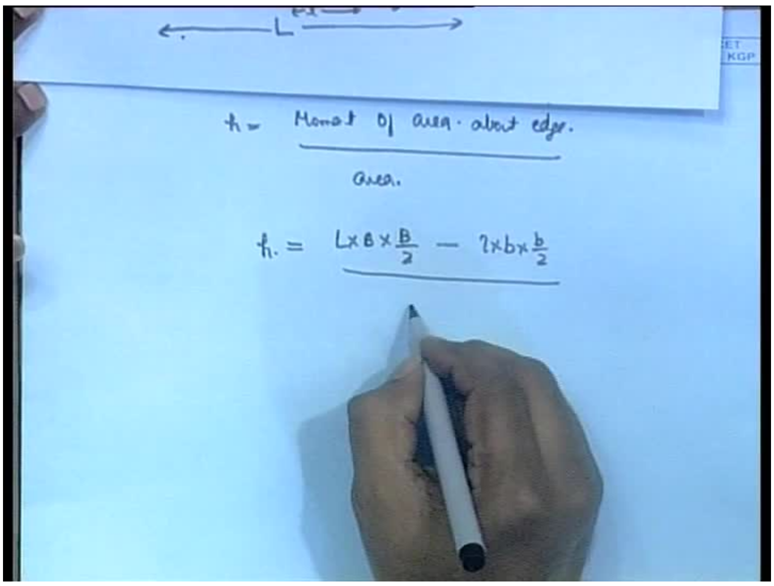

Therefore, its moment is l into b into b by 2 divided by the total area which is L into B minus small l into b, so this will give you your h. This gives you this distance h which is the position of the new centroid, this is where the new centroid occurs. The initial centroid is here and that is when the ship was in the alter right condition without the flooding when the flooding occur, note again that the G which is the center of gravity has not shifted, but it is only the centroid of the area has shifted to a new point. Now, why do we need the centroid of area? We will see in the next figure, we will draw it. So, these become h then, let us draw the other one.

We have always drawn sectional figures, cross sections means, if you have the ship like this, you make a section like this. We have already done these sections which the lines plan, we actually call it as the body plan. The body plan section will give you the different stations and all that.

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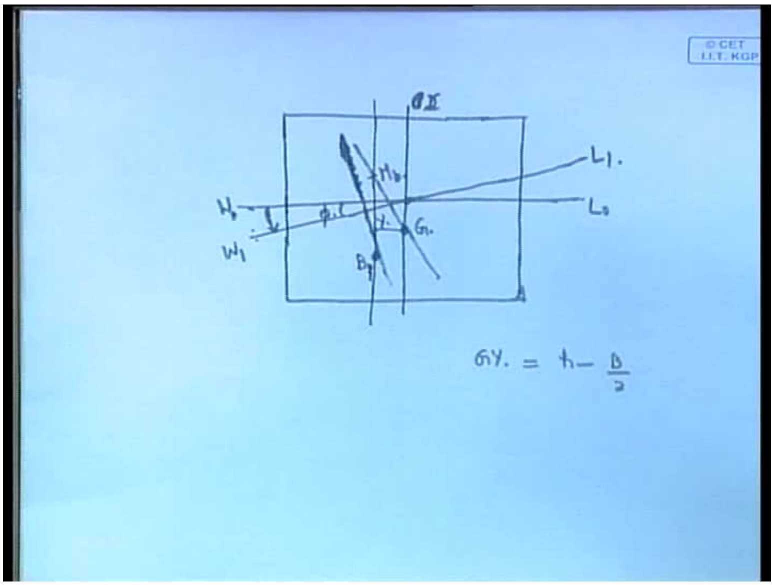

Now, just like that if you draw, this is the box shaped vessel, now for this we are drawing the. So, this is the section, let us consider this to be the initial water line and the final water line. Initially, the ship is at G, it is at midship section. So, this is G; somewhere you have G, where the weight of the ship is acting.

Now, what has happened is in this case, as you see from this side some area or volume has gone, so what will happen? The ship will tilt in this side and as the result the water line will tilt up. The ship will tilt in this fashion up that means the water will come down like this. Initially, the water line is here, W 0 L 0 and the ship is tilted in this direction, so water line is tilted into W 1 L 1, so this is tilted by an angle phi.

Now, first of all the position of B will shift here in some new point that means some volume is lost from here, which implies that it is equivalent to saying that some volume is added on this side or what it means is if some volume is lost here, we know that the center of buoyancy has to shift here, so B shifts to this point B 1. If you draw a vertical at G you get the metacenter which is M b. So, this will give you the position of the metacenter.

The distance is let us draw a perpendicular from G to this point Y, let us call this distance as X or at least the distance GY - as you can see - is the distance between G and the new position of the centroid. This is what we did in the last time just previously, we saw that we need to find the position of the centroid. The position of the centroid is required for this purpose that is to find the distance between G and the new position of the centroid. So, that distance is measured as GY, we get here GY is actually equal to h minus B by 2.

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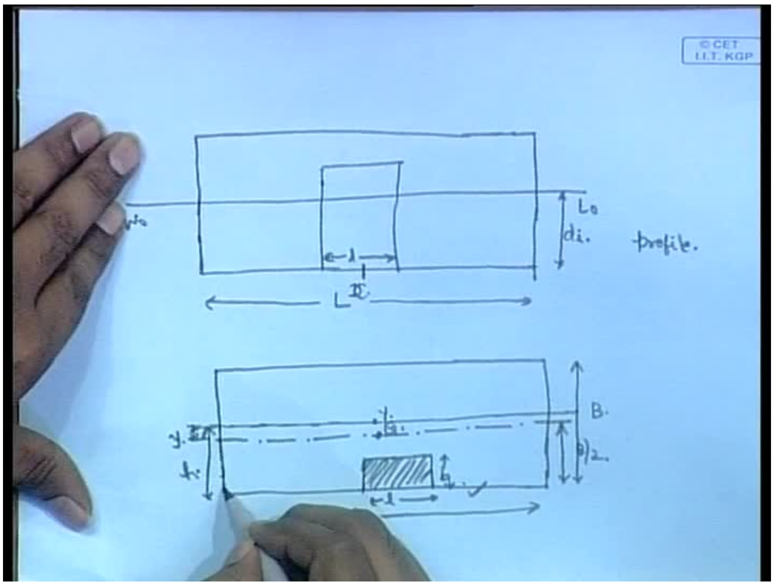

You can see here, how do I get this, just look at this, this is Y coming here. This distance that I am talking about GY is h minus B by 2, this is h and this is B by 2. So, h minus B by 2 is the distance between G and Y it is one thing we need.

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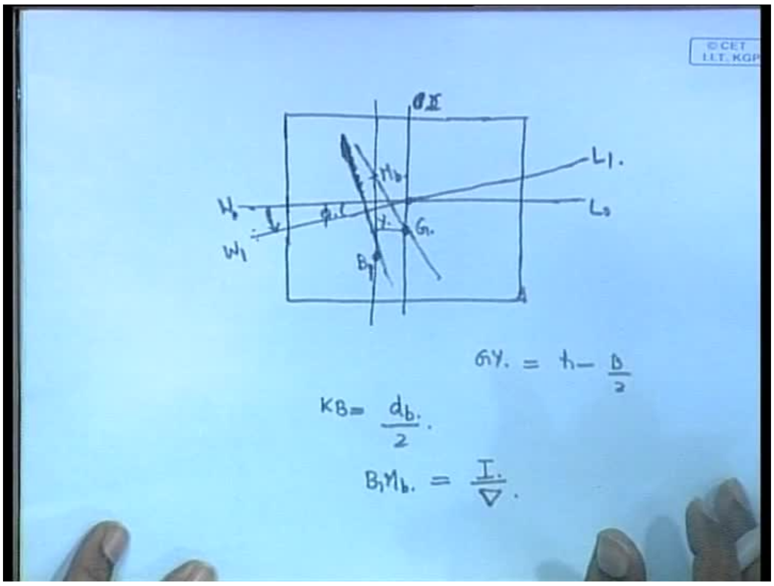

Then other things we need are one KB, we have to find the final KB of the ship. We always say that KB is the vertical distance of the center of the buoyancy from the keel, now that distance is always measured as half the draft, whatever is the draft. So, it is d b divided by 2 this will give you the KB. Another thing we need to calculate is BM, in this case BM which is equal to defined as I by v or I by del - I by del that is the metacentric radius is defined as v 1 M b is equal to I by del.

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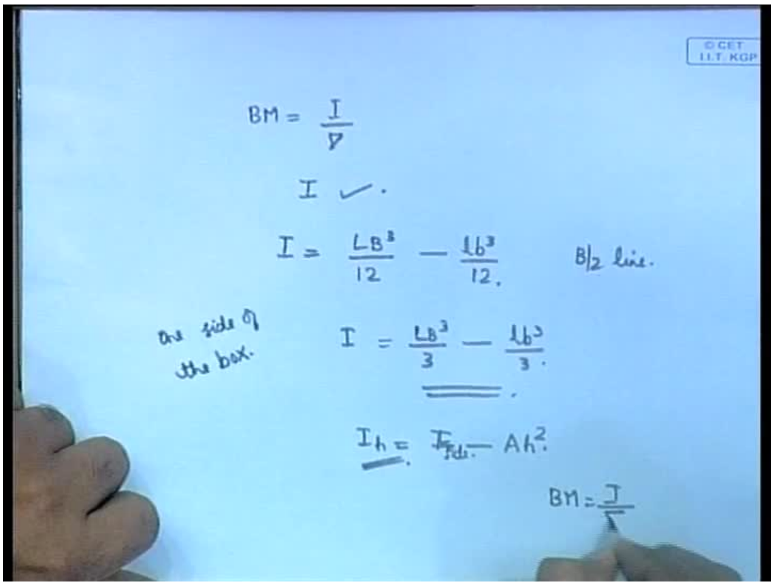

Now, only thing you have to know here or slight catch here is in the calculation of I note that I finally - so what did we had? What did we have initially? We had a whole box. Now, what happen is, it got flooded on one side as a result of which one small volume got lost here. What are we finding? We are finding the I which is the moment of inertia of the water plane area. When you are finding the moment of inertia of the water plane area then, in this case this much area here is lost. So, you actually have to find the moment of inertia of the rest of the area which is equal to the moment of inertia of the whole area minus the moment of inertia of this small region. That is very easy but it is still important it can be calculated very simply as LB cube by 12 minus lb cube by 12. So, this is about the B by 2 lines.

Now, in this case it is just easier to do all the moment of inertias about one side of the box therefore, we say that I - if you remember the formula the moment of inertia of a rectangle about a edge of the rectangle is represented as LB cube by 3. It is equal to LB cube by 12, if it is about the center line it is equal to LB cube by 3 if it is about an edge.

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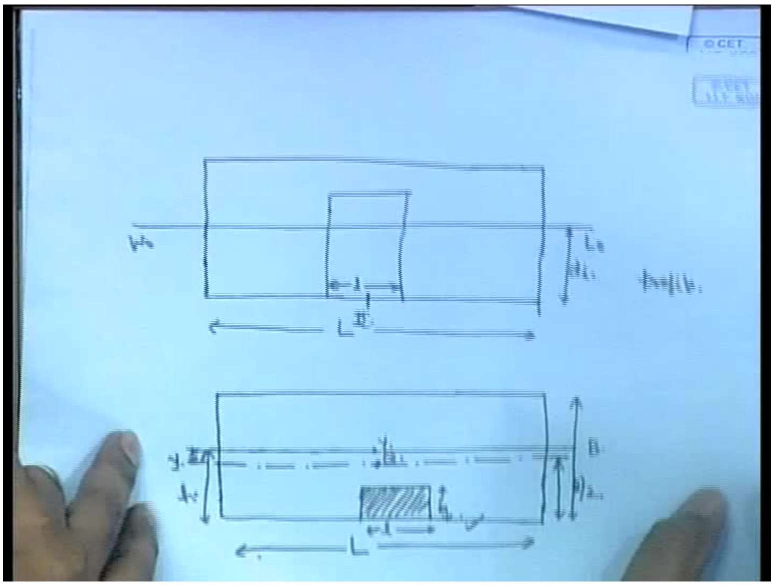

So, LB cube by 3 minus lb cube by 3, this is the moment of inertia of the whole rectangle now about an edge, means which edge? This edge, so it is a moment of inertia about this edge. Now, note that we always need the moment of inertia. Now, in the derivation of BM equal to I by del that BM metacentric radius was derived using the assumptions, we have done all this derivations that derivation of BM del assume that I is always the I about the centroid of the water plane area.

That means in this case, you need to calculate this I about the centroid as well. Now, you know by the parallel axis theorem that once, you have the moment of inertia about one edge, if you can just do I about that point minus A y square will give you that moment of inertia of that rectangle about that new position, so that we can calculate using the parallel axis theorem which proceeds as this. So, I about the h point or the centroid will be equal to this I which I have just written here, I minus A into h square. This I is actually I about the side, so this will give you I about the h or I about that line through h, the position which is at a distance h from the side.

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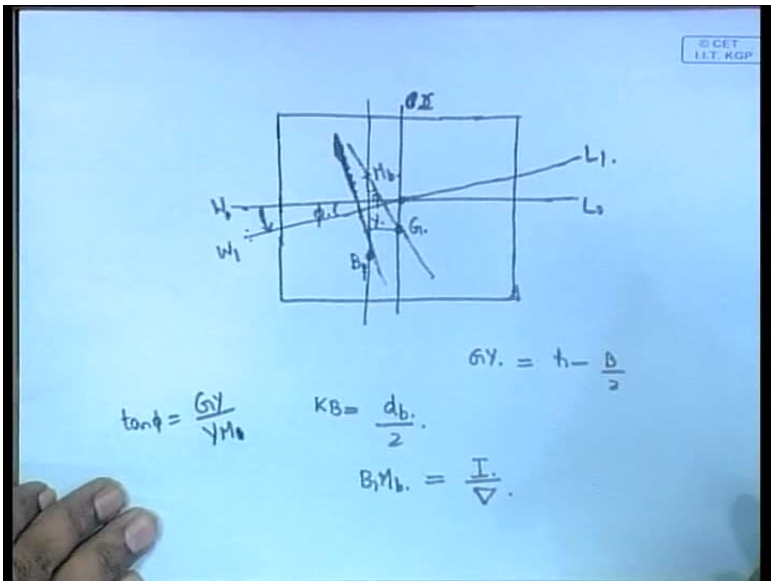

From that you will get BM equal to I by del then once, you have that let us look at this figure, you see that if it is tilted through an angle phi, from this you can directly read that tan phi is equal to GY divided by YM. In this case, GY we have already calculated it is equal to h minus B by 2, which is the distance between the G and that vertical position of M or the position of the projection of M, so that gives you GY divided by YM.

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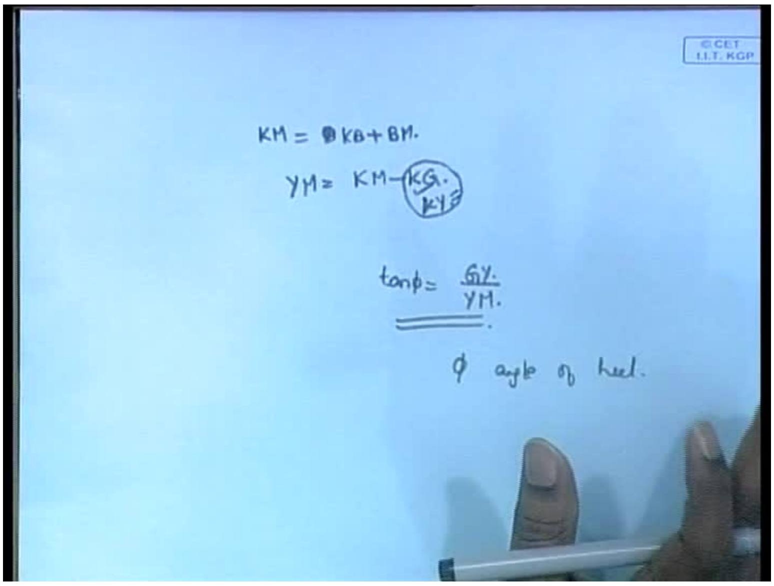

Once, you have that you get KM is equal to KB plus BM, YM is equal to KM minus KG. Just look at this figure YM - why is it so, because remember this will be the keel. So, if you are looking at the vertical distances KM; this vertical distance is the same as this vertical distance. So, this is KG, this is also equal to KG, KG YG or KY is equal to KG. This KG is actually equal to Y KY which is equal to KG because of this you can get this expression.

We know all these things, we have to know KG that is now it calculated. KG is the center of gravity of the ship or the box shape vessel the vertical position that needs to be known and this is a box shaped vessel anyway. So, you can use the formula that KM is equal to d by 2 plus b square by 12d that is a known formula for box shaped vessels, where d is the draft of the vessel. When you have that you can get it as b square by 12d that will give you the KM or in case of if you are dealing with a large scale ship the value of KM will be given from the hydrostatic data.

From the hydrostatic data or from the hydrostatic particulars, you get hydrostatic curves, you get the KM value, KG value has to be known, it has to be given by in the problem itself. Once you have that you find YM as we have seen YM comes as KG itself then, KY is equal to KG. As a result you get YM the distance between Y and the metacenter as KM minus KY. Once you get that then you can just use the formula that tan phi is equal to GY divided by YM, now that will give you phi which is the angle of heel.

Therefore, in this particular case where we had a ship which is flooded in the midship section but close to one side, it is not flooded symmetrical to the center line, but it is flooded on one side.

When this happens the ship initially sinks as a result of which its water line goes up and the draft increases and then the ship heels depending on which side gets flooded, depending upon that side will go down. Either way, if you look at it in case of weight you see that weight has increased there, so it has to heel there. It is comes as one of the many problems that we have done in the shifting of weights in fact the inclining experiment itself was device using this. That is, along the deck you shift a weight from one side to another you see that the ship heels in that direction and then you calculate the heel and the horizontal distance of the center of gravity moved and the GM, that is the inclining experiment.

Now, just like that in this case ship gets flooded, so additional weight comes on the right side, because of that the ship heels to that side or if you look at it the other way round, ship loses its volume there, it is still the same thing ship heels again to the right side either way. So, this explains one type of problem dealing with the ships flooding.

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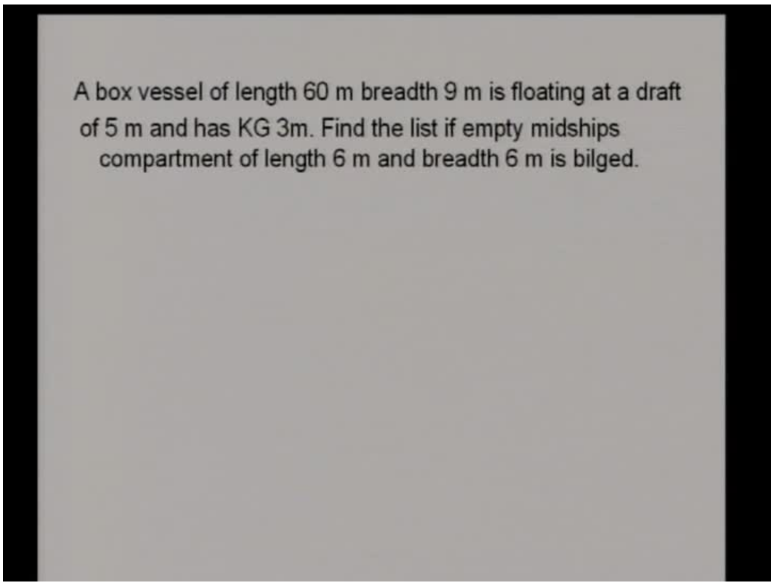

Now, we will look at one problem; suppose, you are told that there is a box shaped vessel of length 60 meters, breadth 9 meters and it is floating at a draft of 5 meters and it has a K G of 3 meters. You are asked to find the list if a midships compartment of length 6 meters and breadth 6 meters is bilged. It is a midship compartment therefore, it is occurs in the midship but the figure is given along with a problem we say the problem is something like this.

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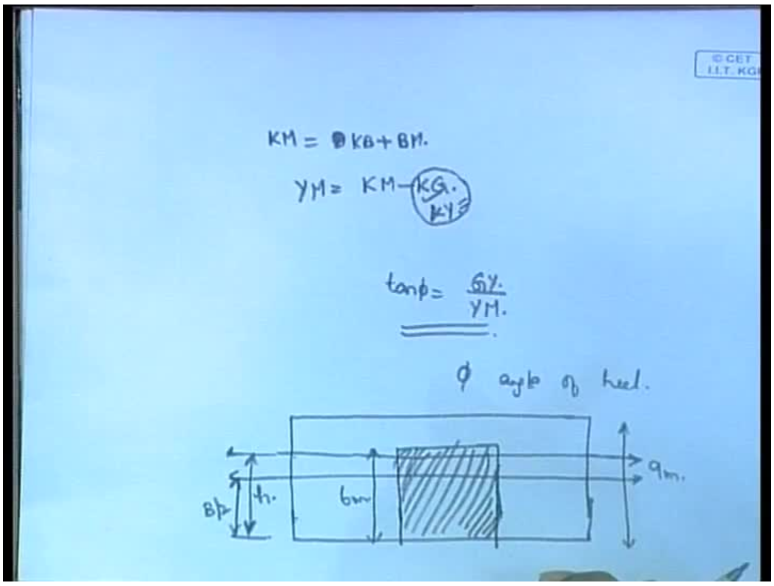

Just like I explain the previous problem it is come something like this. So, you have the center line and in this case a midships compartment somewhere here a region is flooded. The breadth of the ship initially is 9 meter - this is 9 meter - and his breadth of 6 meters. One compartment like this of 6 meters, so this is of breadth 6 meters, so out of the 9 meters 6 meters length, this region is flooded.

Now, this is the same problem that we have done first of all, we need to find the position of centroid here somewhere else, as you can see more volume is lost here and directly more area is lost here. If area is lost here, area is still available here, we see that the centroid should shift here - will shift like this. From this points it shifts here and this distance we have called as h. As in the previous derivation this is h and this is B by 2, so this is B by 2 and that is h. Now, the question is to find the list? Because of the ship flooding like this, it is seen that the ship first sinks and then heels just like as I said.

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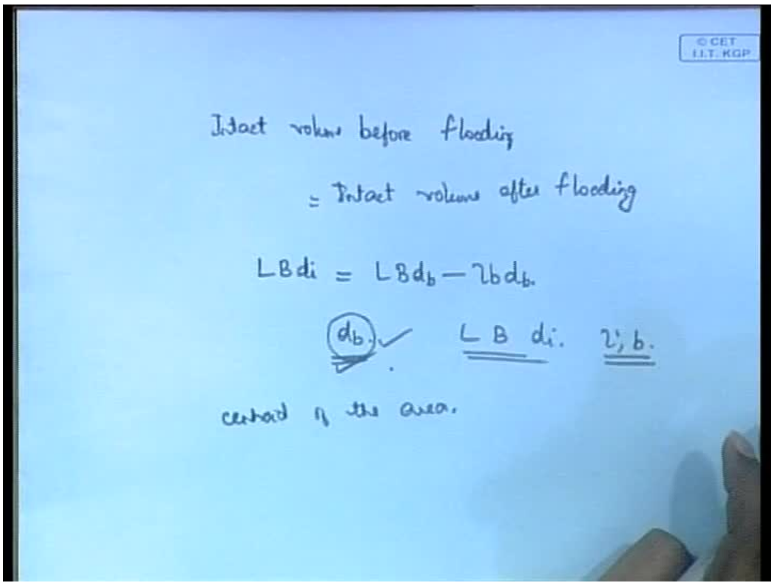

Let us see how this problem has to be done? First of all we use the formula intact volume before flooding equals intact volume after flooding. This is the most general formula intact volume before flooding is equal to the intact volume after flooding. Intact volume before flooding is LBd i length, breadth into the draft initially equals LBd b minus lbd b. This tells you the intact volume after flooding which is capital LB into d b, which is the bilged draft; the draft after the ship has bilged minus lbd b small l small b is the compartment volume, small l represents the length of the compartment b represents the breadth of the compartment - I mean - that small region of the compartment which is flooded. So, l into b will give you the area into draft bilged. So, that will give you the volume of the compartment that is flooded.

As I said before, this equation says - I mean - what it says? That the intact volume before flooding is equal to intact volume after flooding is same as saying, the total weight after flooding is equal to the initial weight of the ship. This equation is actually the same as if the total weight of the ship after flooding is equal to the initial weight of the ship plus the weight of water added. So, it is just saying a mass conservation, it or shifted it becomes the volume conservation. So, that is this equation LBd i is equal to LBd b minus small lbd b.

From this you get d b in this problem since, you have L B, you are given the initial draft, you are told l b which is the dimensions of the compartment that is being flooded. Once, you have all this you can get d b which is the bilged draft, first step. Now, we need to find the position of the h which is the centroid of the area. So, you need to find the centroid of the area.

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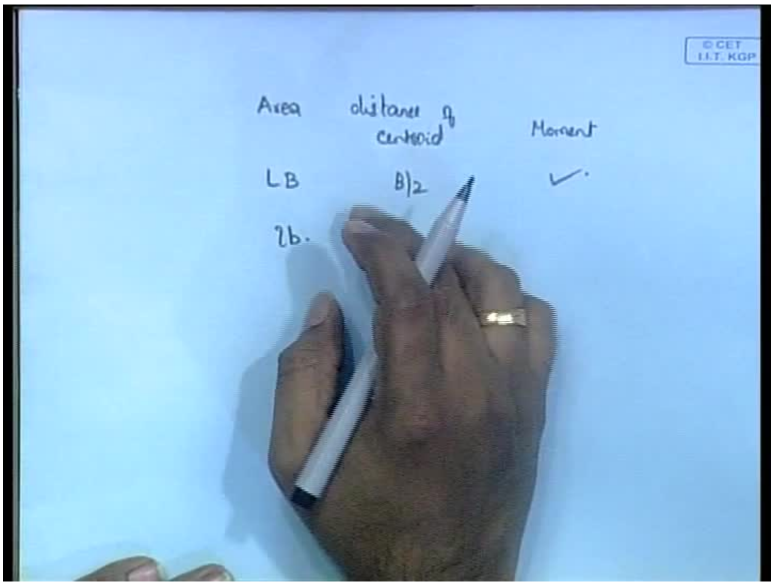

That is based on what we have done so far, it is very simple. What you have here? You have area and have its distance of centroid - you make a table like this - that area is there distance of the centroid and moment. Initial area is L into B is area of the total box that water plane. Distance of the centroid is B by 2 you find it is moment then you have an area of l into b in this case, its breadth is given as 6 meters and length is given as some 6 meters.

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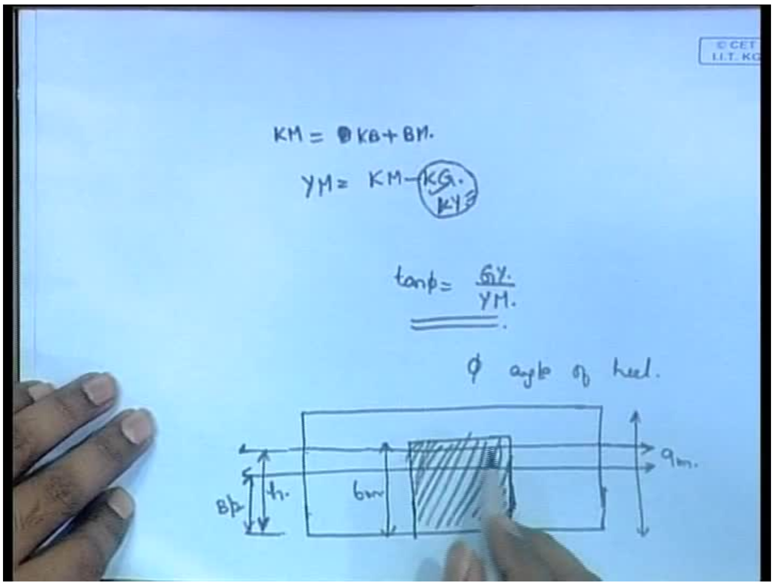

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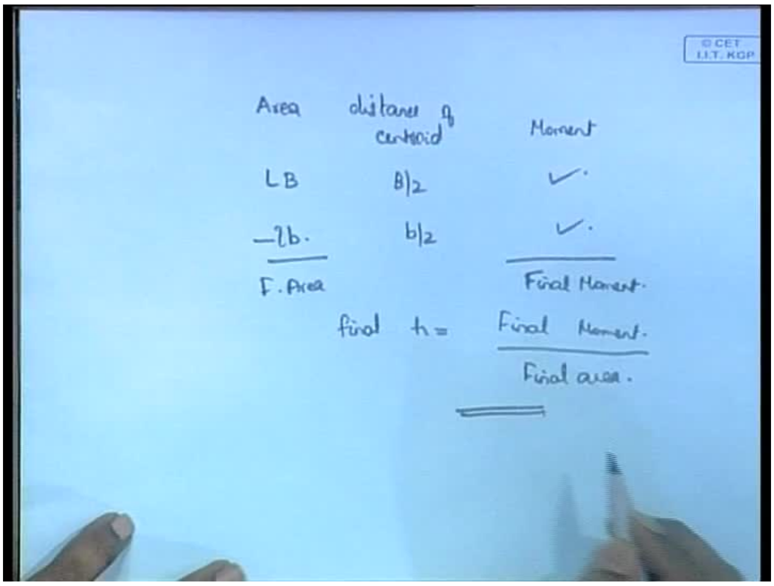

Based on that 6 by 6 area like as we have discussed here in this figure, this 6 by 6 region is flooded, so this area is lost and therefore, it is minus lb into distance of this is B by 2 and you calculate moment. As you know moment is just this first column into the second column, multiplied by the second column, so it gives you this. Finally, you need to find the final h which is equal to the final moment divided by the final area. Therefore, this will give you the final moment and this will give you the final area.

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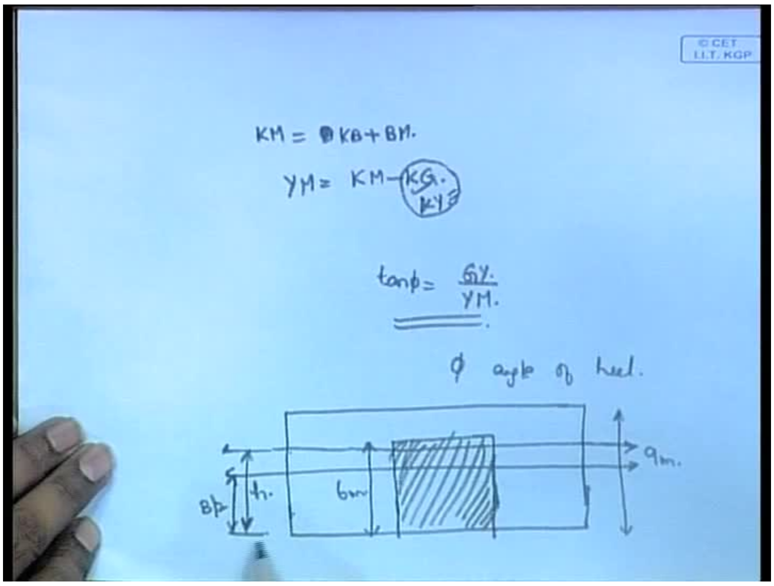

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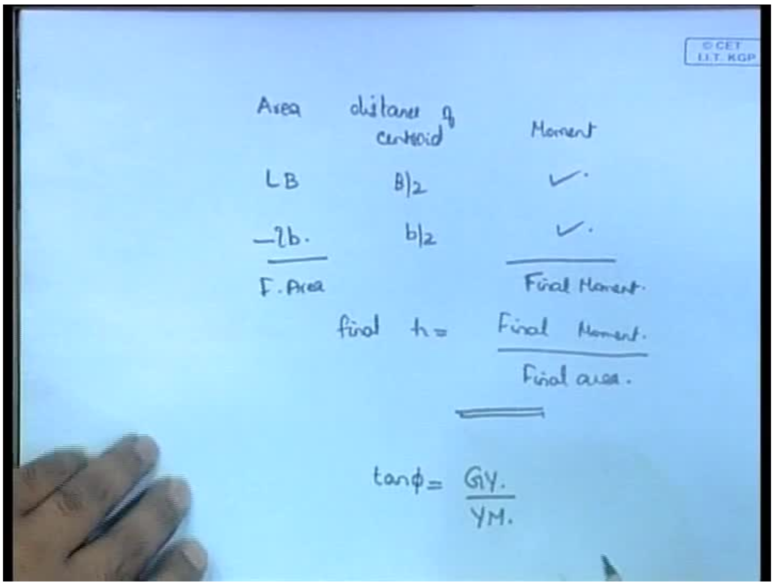

Just doing this you will give you the h, this is the distance of the position of centroid from this edge. This is the side, so distance from this side is here, so this distance will give you the position of h which is the final centroid of the area.

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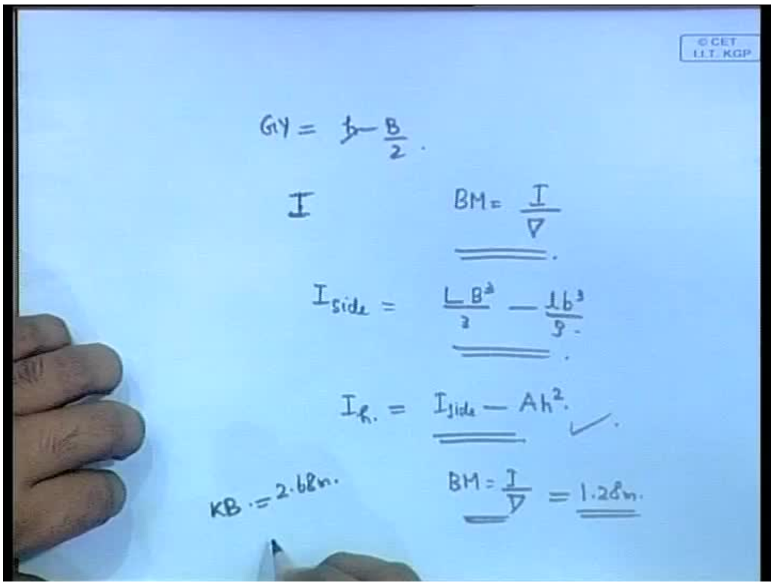

Remember, the main purpose of our work is to find tan phi which is equal to given by GY by YM, this explain to be the equation for tan phi. First thing we need to calculate is GY which is equal to h minus B by 2, I have already described it I need to describe it again h minus B by 2.

For this problem just we have already calculated h, which is the distance from the edge, from the side we have seen the distance of h we have seen the distance of h from one edge we have seen the distance of the position of the centroid from one edge that is what we have measured as h. So, h minus B by 2 then we need to find I this is one important thing. Remember as I have already mentioned BM, this is to calculate BM using this formula, our purpose is to calculate BM using this formula I by del, del is the underwater volume.

You need to calculate I, in this I is the moment of inertia of the final water plane which is actually the whole water plane minus the small area that is lost due to the flooding - that whole area minus the small area. So, that much remaining area moment of inertia of that about the centroid; so it is the moment of inertia about the centroid and not about an edge or not about the symmetrical center line, it is about that centroid.

Now, to get that as we have already seen, it is best to calculate I about one side use the parallel axis theorem and calculate I about that edge or the centroid. First, we calculate I about this side which is given as LB cube by 3 minus l b cube by 3, this will give you I about the side. Then, the h point is given by I about the side minus square. This will give you the formula, then you do BM equals I by del and this will give you an answer of 1.28 meters.

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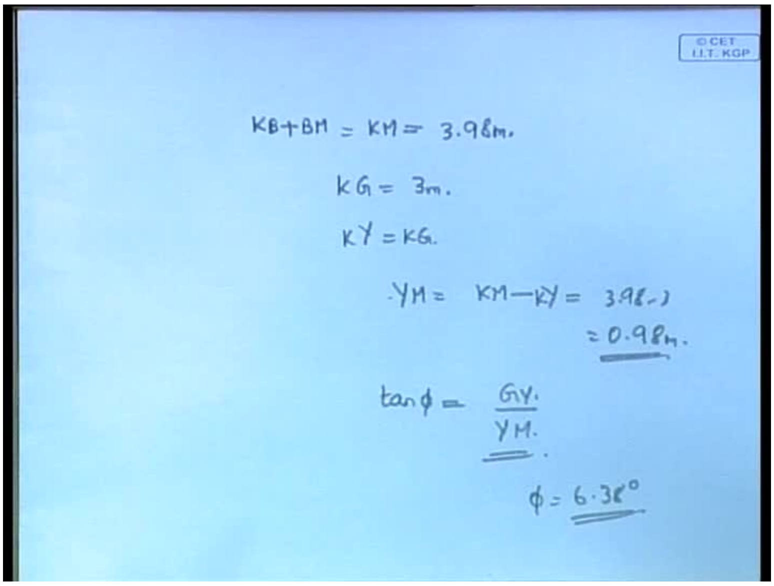

You are given in this problem KB is 2.68 therefore, KB plus BM will give you KM, is equal to 3.98 meters KM. Then, KG is given for the ship it is 3 meters - it is already given in the problem 3 meters. We have already seen that KY is equal to KG from the figure. Therefore, YM is equal to KM minus KY which is equal to 3.98 minus 3, so this is about 0.98 meters. This gives you the value of YM and remember, what we were supposed do is to calculate tan phi given by GY by YM.

Now, it becomes straight forward, we have already calculated GY which is equal to h minus B by 2; h minus B by 2 gives you GY the distance through which the centre liner shifted. YM gives you the distance between that Y and the metacenter. Using this equation, we can get the value of GY by YM which is equal to the tan of the angle of phi. So, you get the angle of phi in these problems to be about 6.38 degrees. This is one sort of problem which we work on.

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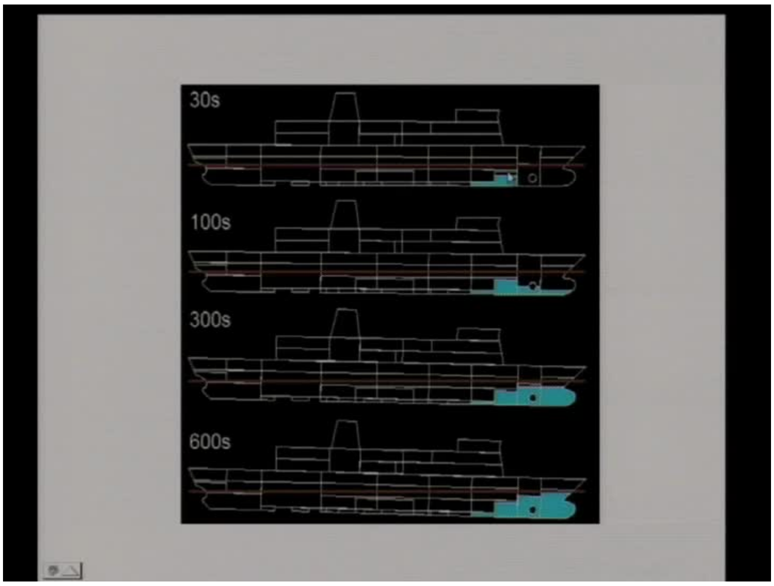

Now, we move into the second type of problem that I mentioned at the beginning of this lecture. That is, we have seen in this figure that instead of having the bilging occurring at the midship compartment like here. The problem that we have concerned so far deals with that, we consider that bilging occurred in the midship compartment here, instead of that happening. We are going to consider bilging to be occurring at 1n compartment most likely in the forward side, here it floods in the forward side. We are not considering progressive flooding, one sides get flooded and that is the problem that we are considering next.

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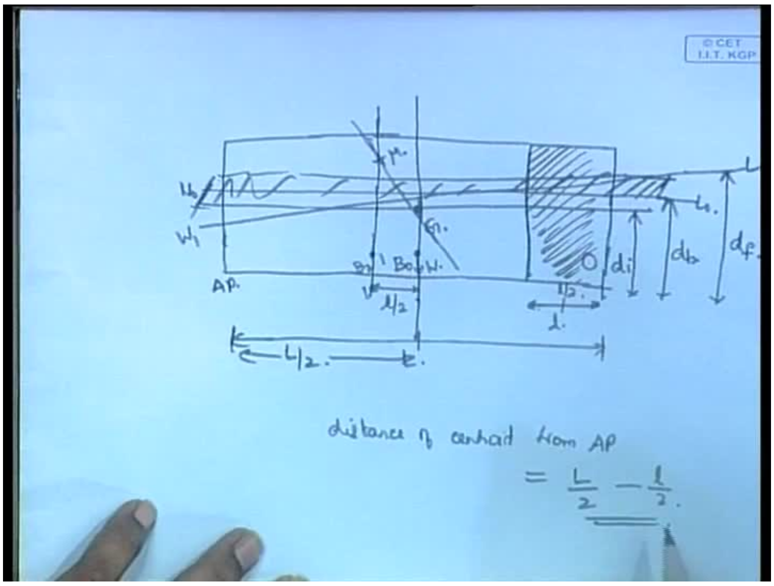

In this case, let us consider the ship in the box, so you have the box shape vessel, so one compartment like this in the front part of the ship gets flooded. Let us say that there is a hole here, this compartment gets flooded here, this is of length small l, the total length of the ship is capital L, so this compartment gets flooded.

Let us assume this is the water line initially therefore, the initial draft is d initial - d i - is an initial draft. Finally, because of this bilging just like I explain the previous problem, in this case also something happens that is the ship is like this initially at some draft. In the forward side of the ship one compartment has got flooded as the result of which this compartment gets flooded and initially the ship sinks because of the added weight the ship sinks.

There is an increase in draft and in this case, since this side has no more weight than this side, because of this unevenness in weight this will trim like this. The ship is going to go down at the forward side, so the front part of the ship will trim now. So, this is the new process that we are trying to mathematically study here.

Initially, the draft increases to d b and then, the ship trims and it goes up the draft increases to d f, so the final draft is d f that water line is - let us call to be W 1 L 1 this is the final water line - where finally the ship has come to this position. We will have here G, this is the position of G - the centroid initially - then, at G let us assume that the ship initially it is B 0.

Because of its trimming the B shifts to - it is a loss of buoyancy, so the B is now here. So, this is B 1 or B 2. The final position of the centre of buoyancy is B 2 and M is the position of the metacenter, this is the same explanation as in the previous figure, weight of the ship acts here W, so B 2 in this is the position of the centre of buoyancy, the same method as we did.

If you take that the distance through which the same concept that is, in this problem the only difference that is, in the last problem we consider that one area is lost on one side as the result of which that centerline shifted to slightly higher - slightly the other side to the star board side.

In this problem instead of the centerline shifted like this, we are talking about G shifting here, it is this shift, it is no longer this shift but it is this shift. Similarly, this area here this part of the ship is flooded, so out of this some area will be lost in the front part of the ship.

So, how much distance does it shift? Same way that is you take the moment of the area divided by the total area. If you take the water plane area remember water plain area will be like this - water plane area will be section like this. Now at that point you will have some area lost here, by doing that we can find it is very easy if you take the moment you will see that if this is shifted by l and if you assume it is centroid to be at l by 2 you will see this will be shifted by l by 2.

Now, let us call this to be the aft perpendicular, so the distance of centroid from aft perpendicular is given to be L by 2 which is this - this is L by 2 - distance as we know this whole distance is L, this is L by 2, this distance from here. Therefore, it is L by 2 minus small l by 2. So, this will give you the distance of the centroid from the aft perpendicular.

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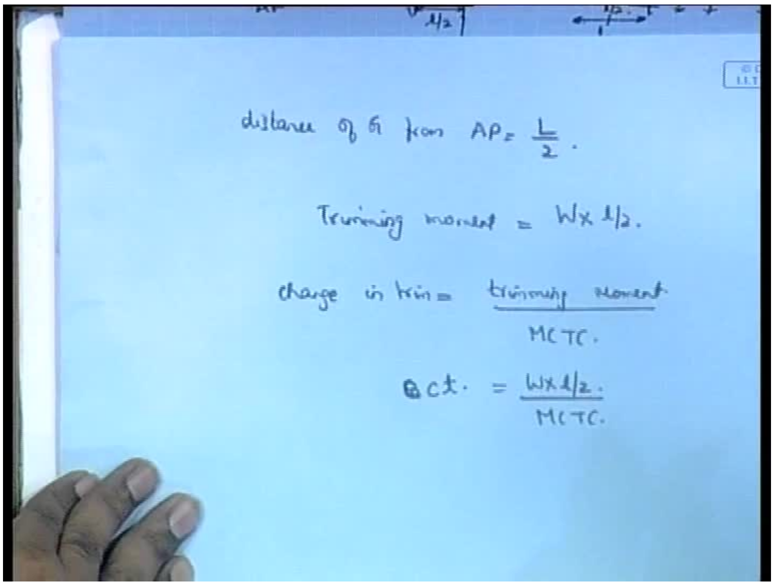

As you can see in this figure the distance of G from the aft perpendicular is again equal to L by 2 always, because this is again the method of loss buoyancy and the centre of gravity remains at G. The only thing we need to do here is, let us consider the weight acting now. So, what we have? About this new position of the centroid that is what we call as centre of flotation - the centre of flotation is now here - centre of flotation is defined as a centroid of the water plane area. In this case, some water plane area is lost in the front because this side is bilged and because of this bilging, some area is lost here, because this area is lost here the centroid of the water plane area shifted here, from here it is shifted here.

This is the centre of flotation and if you take moments about the centre of flotation, we see that at G which is the position of the centre of gravity, there is a weight W acting downwards. The position of the centre of buoyancy is here, so there is no weight acting about it is along that same axis.

So, that net moment acting which is trying to cause the trim is this W, the weight of the ship into small l by 2 which is this distance, so W the weight here, W into small l by 2 this much is the moment causing trim. We write the trimming moment equals weight into l by 2, this is your trimming moment. Now, once you have the trimming moment how do you calculate the change in trim that is very easy, they have already done many times.

The change in trim equals the trimming moment divided by the MCTC moment to change the trim by 1 centimeter. Now, the trimming moment is the W into l by 2 divided by MCTC will give you the change in trim which we usually write as trim t or change in trim. Change in trim will be given by W into l by 2 by MCTC, this will give you the change in trim. Once you are able to find the total change in trim, you need to find the change in trim aft change in trim forward the same way, same equation that is - I mean - in the previous chapter not here. Here, we have used different notations small l in our previous chapters that is the chapter dealing with trim were we were doing.

The small l actually represented the distance between the aft perpendicular and the centre of flotation. If that is so then, the change of trim aft is given by small l which is the distance between the aft perpendicular and the centre of flotation divided by capital L which is the total length of the ship distance between perpendiculars multiplied by the total change of trim. So, that will give you the change of trim aft, so small l by capital L.

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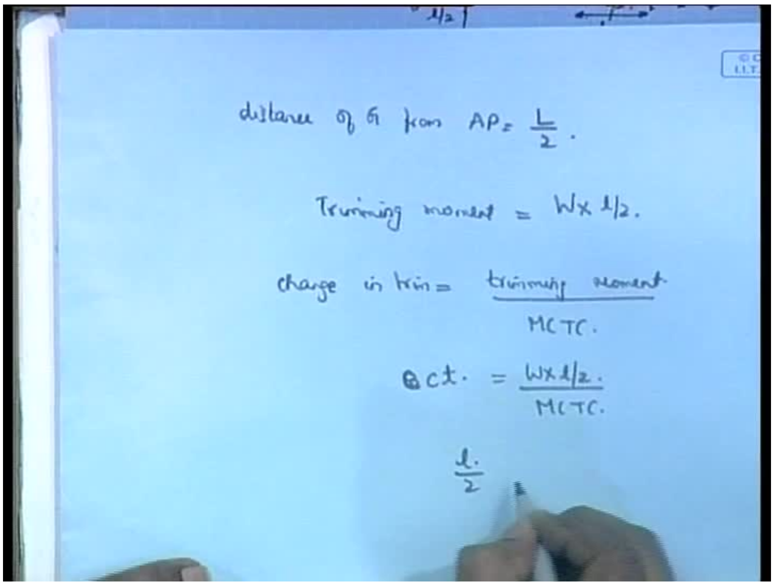

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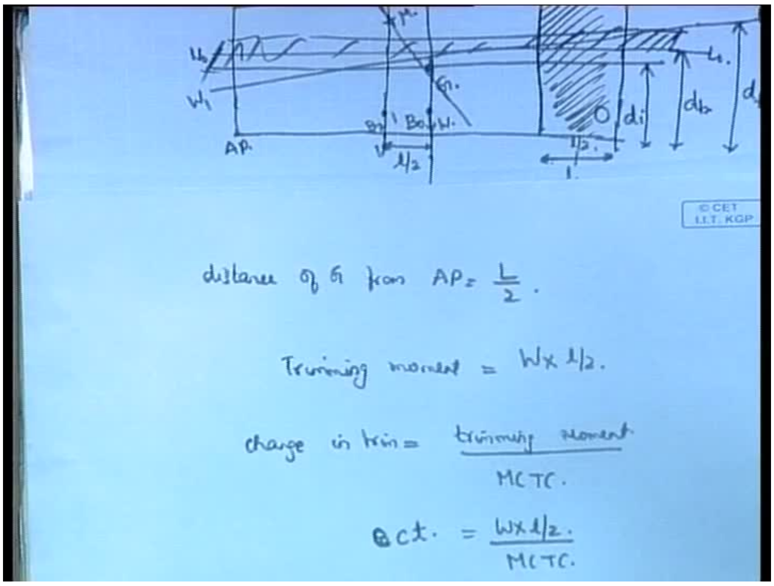

In this case, small l represents not the distance between the aft perpendicular and the centre of flotation, but l by 2 represents this distance, small l represents this distance, so this is l by 2, but the concept remains the same to get the change of aft draft. I need to find the distance between aft perpendicular and the centre of flotation, centre of flotation is this, so it will be small l by 2 or l minus small l by 2 into l into change of trim, so l minus l by 2 l into W into l by 2 divided by MCTC.

This will give you the total change in trim in the aft side and if you want to find the change in the trim in the forward side, instead of l minus l using the previous notations if small l is the distance between the aft perpendicular and center of flotation. What you do is, you do capital L minus small l divided by capital L that will give you the distance from the - instead of taking this distance you take this distance - the front distance that will give you the change in trim in the forward side of the ship.

Once, you find the change in trim forward change in aft, what you generally have to do is whatever is the initial trim you add this change in trim aft to the initial trim aft and you will get the final trim aft. Change in trim forward to the initial trim forward you will get the final trim forward and that will give you the final drafts also that will give you the final draft in the forward and the aft section.

This we have explain two types of dealing with the bilging problems, any kind of bilging problem will be having - now that we have done two extreme types of problems means, we have studied the case when the ship can heel and we have study the case ship an trim due to bilging. These are mainly the two types of process and you can just extrapolate this to say that if you have a time dependent bilging means, as the time goes on the flooding keeps continuous happening. If you are trying to study that problem then it does not become heeling as such it becomes a case of rolling, it becomes dynamic process and not a static study and since this course is on hydrostatics.

We are not dealing with the dynamic process of flooding thought it is definitely a very important point and a very important topic very active area of research. So, that gives to different ways of calculating the trim or the heel as a result of bilging. These are two extreme cases when you have bilging the front part; in the front part of the section this gives that how to the find the trim and in case you have bilging occurring on one side of the ship and not the other side, that gives you the another weight of calculating the heel.

You can combine the two to calculate very complicated cases, where you have some bilging not at the centre not at the end, somewhere in between. The whole process becomes a combination of these two, you can get the trim and the heel due to this process and combine it and get the final value of heel and trim, it might be a combination of two and you get the value of heel and trim, with this I will stop here today, thank you.