Marine Construction & Welding

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Module No. # 01
Lecture No. # 03
Structural Requirement

So, today we will take up the so-called aspects of structural requirement. For this main structures means the type of ships offshore structure, we have talked about yesterday in the last lectures will discuss about the structural requirement. Why this structural requirement? Why we are talking about this? Because if we look into the basic objective is that you want to produce, you want to manufacture a kind of product, which will serve some purpose obviously.

One is manufacturing something, because he expects some functions forming and he expects the functions to be carried out as efficient as possible by their set product. Now here our products are sort of, I mean one can say floating vessels, which are meant for transportation of cargo, some products which will assist in this transportation of cargo; that means, assist in operation of those vessels which we refer to as the support vessels.

Then, there are some products we talked about the offshore platforms for offshore exploration, offshore sort of oil exploration such that these products, they delivered the required level of satisfaction to the clients.

What we need; we need that it should function perfectly in all the aspects. What are the aspects, like as far as ships are concerned, aspects would be as I said the client wants a certain capacity. He wants a certain speed. So, these things are determined by the capacities determined by the very geometry of the thing that how big the hold you are providing, whether you are providing the right size of the hold to carry the right amount of cargo.

Then speed, it has the high dynamic aspects that whether we have taken the correct high dynamic features, you have incorporated the right kind of high dynamic features in the all form such that it gives you the desired speed at the minimum power.

Because if it is badly designed then still you made there the speed, but the power may be very high, if the power is high naturally, the owner is not happy because you will have to burn more fuel. So, more expenses.

So, these are understood. What is the next, next is the client also wants that his cargo is delivered safely in a safe and sound manner; that means, the structure which is carrying this, all this serving this functions, a ship carrying the cargo offshore platform housing all the machineries and equipment for offshore trailing operations or exploration operation should have sufficient strength to withstand all the service loads. We should be able to design a structure and subsequently fabricate, construct it such that it withstands the service loads. Why you call service loads because the loads which the structure is going to encounter why rendering the desired service because when you bell the ship for example it is in the so called in the shipyard, if the dry dock not yet floated out. It may behave perfectly behave means structurally. It is not being used it is a static standing there, but when you put it in water, then it may behave in a different fashion because the load distribution has changed.

When it was sitting in the dry dock, the entire load was supported at certain points because the over the keel blocks and when the ship is floated out. Then it is supported by buoyancy. So, the load distribution is changing. Now when you are loading it fully loaded then again the load distribution is changing. When it is coming back or suppose it is touching intermediate port discharging some cargo it is going half loaded, again the loading pattern is changing. So, the structure should be able to withstand all kinds of service conditions and also suppose it is sailing in the nice winter days, I mean Indian winter days. So, the seas are calm and quite there is no storm nothing. So, that is one situation of service condition.

It may be the other; heavy stormy weather. So, it will encounter huge waves. So, that is another loading condition. That is also a service condition. So, service load; that means, a structure is always designed considering the worst possible service condition, worst possible loading condition it may encounter in its life span. That is how a structure is always designed. So, that is how one will look at it look at the loads and then one identifies what are the loads which are going to come.

Like to be very brief, loads will be essentially the static load of the structure. It is own load like you design a beam suppose a cantilever beam and you hold a cantilever beam you hold at one end, the beam may sag out of its own weight; that means, it is a deflection it is failing sort of it is supposed to remain straight, but it is bending; that means, that particular structure is failed under its own weight and then the other situations come when there is other loads are acting.

So, that is how the static load then the cargo load, the buoyancy load, the wing load, the wave loads all kinds of loads. So, all these loads taken together, it will call for strengthening the structure against certain precise requirement. So, those requirements can be written as longitudinal strength.

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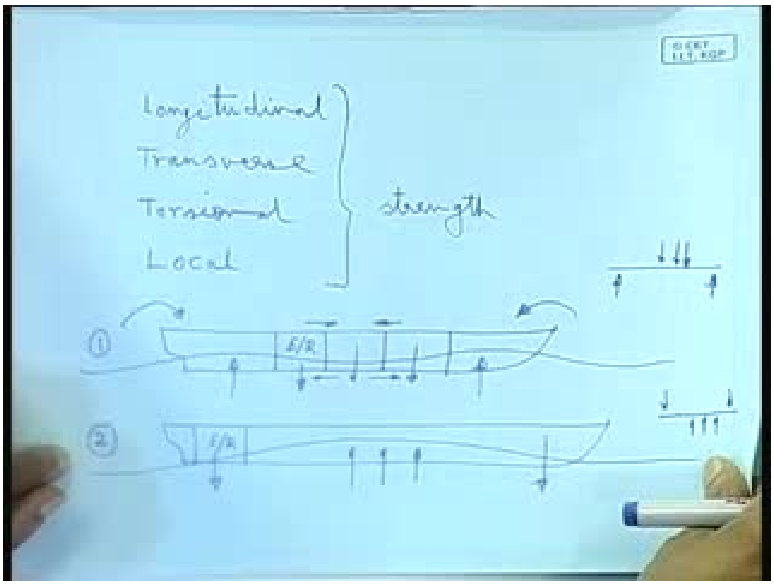

Because otherwise as you can see, the ship structural as well as if we consider a ship structure on offshore platforms, it will be encounter by loads from all directions and that will have all kinds of effects.

One of the effects could be longitudinal bending; the ship is undergoing a longitudinal bending movement and along the length it is undergoing a bending movement. There can be a situation is undergoing a twisting movement and so there can be situation that its undergoing a severe local loading.

The severe local loading could be for example, the place where you have installed the main engine of a ship you know the ships the engine power can range anything from I mean to say 2000 horse power to 100000 horse power.

Imagine the very big ones or even the small ones immaterial because if it is a 2000 horse power engine, it is located at in a small region. So, very concentrate loads are acting. If it is a 50000 horse power engine also same thing the engine size is little bigger. Again the load distributor over that, but a concentrated weight is acting there.

The ship is sailing in the sea and it is encountering little rough weather and in starts executing a slamming motion; slamming motion means it goes and it keeps heating the water. So, there is a local load at the forward that is a slamming load. So, all these loads will give rise to different kinds of stresses in the structure.

So, that makes things very complicated. So, to simplify things will divide them in certain precise requirement like longitudinal strength requirement, then transverse strength requirement, then torsional strength and local strength.

So that means, we will try to design a structure or we will try to make a structural arrangement which should be able to provide necessary strength against longitudinal loads, transfers loads, torsional loads and local loads. That is the idea and some of the examples how the longitudinal like I was telling longitudinal bending. What happens a ship structure or a ship hall is generally considered as an equivalent to a beam, the typical feature of a beam is it has a very high l by b ratio length to breadth ratio. So, ship is also somewhat similar to that of a beam anyway.

So, how it can suffer longitudinal loads like when it is sailing, there can be cases of waves. It is encountering like this if the wave is like this then as you can see the buoyancy at this points are higher because the wave crests are at the ford and the aft and somewhere suppose the situation become worse if you have engine room somewhere located here, that means, in a semi aft region, semi aft because it is preferable to have the engine as aft as possible, but there can be some cases where you cannot put it fully haft.

Haft means on the back side of the ship. So, you put it semi aft. So, what happens this gives me a concentrated loading. So, this is one of the situations where we have a heavy bending movement acting on the vessel and the bending movement of this pattern.

This is what is called sagging bending movement. This whole profile will lead to a sagging bending movement; that means, sags in between the just opposite to this would be a situation suppose your profile like this and as I said, it is preferable to have the engine room as aft as possible and let us assume in this particular ship, you have the engine room absolutely aft. So, you have a concentrated loading here and in this case not only engine room in the previous case also see the cargo holds are full, the middle cargo holds there are cargo holds there. So, all these are putting load.

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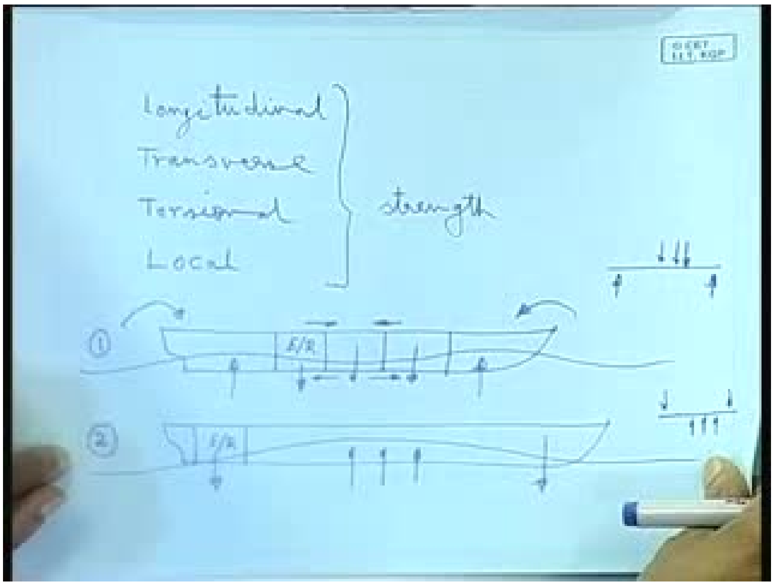

So, this is equivalent case of as if it is supported at the ends and all the major loads are acting at the middle. So, it gives a very high bending movement. In this case, just the opposite. The buoyancy is more and assume the vessel is coming half empty can be a situation half the cargo it has delivered it is going half empty. So, in this case it is just the opposite. Just the opposite means, it is as I supported at the middle and being acted upon by like this. So, it gives a hogging bending movement. This is referred to as hogging bending movement. In any case these are the extreme cases. Not necessarily always the ship will encounter one of these, but it can be a combination of this whatever. So, this gives rise to a severe longitudinal bending movement. So, we will have to design the structure such that the longitudinal bending movement does not give rise to stresses which may lead to failure. What kind of failure it can cause in these two types of bending say this is my case 1 sign condition, case 2 is a hogging condition. What may happen if a vessel suffers extreme sagging condition. Will it really break? If it breaks, where from the failure will start? Because every time you will know any structural failure it has an initiation point; from there the failure propagates. Failure can be of 2 types: one is a failure due to formation of a crack and the crack propagates. So, it breaks in two pieces or not necessarily too fully separated in two pieces, but a severe crack develops and renders the object nonfunctional or there can be a buckling failure. Because if a structure buckles that is also taken as failure because once it has buckled means, it has lost its load bearing capacity. It cannot sustain load. So, that is also a failure. Now on that basis you tell me, in case 1, what kind of failures are expected and where it will initiate buckling, where why semi aft region? Why not more in the middle region? Buckling is due to what? Why buckling takes place?

Because of compressive stresses, because of compressive load if you remember those oilier buckling a coulomb being compressed. So, it can buckled there can be different modes of buckling from the oilier coulomb formulae if you remember you have studied probably that if it exceeds the stress, the critical buckling stress, then it will buckle. Once it has buckled means what does that mean; that means, any delta increment in the load it will go on deflecting or deforming; that means, it does not have any more strength to sustain any further load. It will continue to deform sort of things any way. So, here buckling would be expected at the mid region approximately the mid region because the bending is in this mode as I have drawn. So, the deck plating will be in under compression isn't it? So, the deck plate if it buckles; obviously, there will be a tension in the keel plate isn't it. The keel plate will be under tension now naturally the stresses at the deck level will be little higher compared to the stresses at the keel plate.

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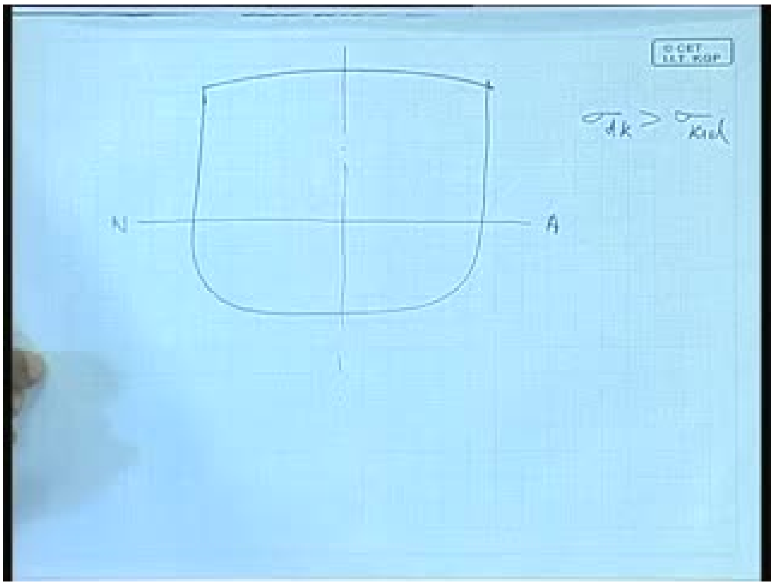

Why because if we see, the cross section at the mid ship region, the mid ship region is somewhat like this. Because of the structure arrangement inside which we will look later, it will gives rise to a k situation of position of neutral axis somewhere here. That means closer to the bottom, why because the bottom is more heavily strengthen, more heavily structured. So, that leads to neutral axis closer to the lower side. If that is so, then what happens the sigma deck will be rather always higher compared to the sigma keel for a given bending movement, for a given bending movement, the stresses developing at the deck will be greater than stresses developing at the keel. What are the stresses, how we get this stresses suppose we know this.

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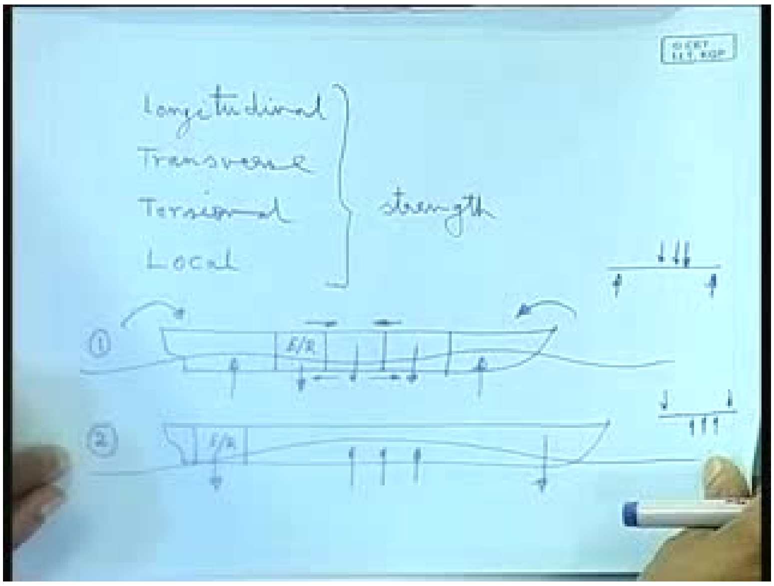

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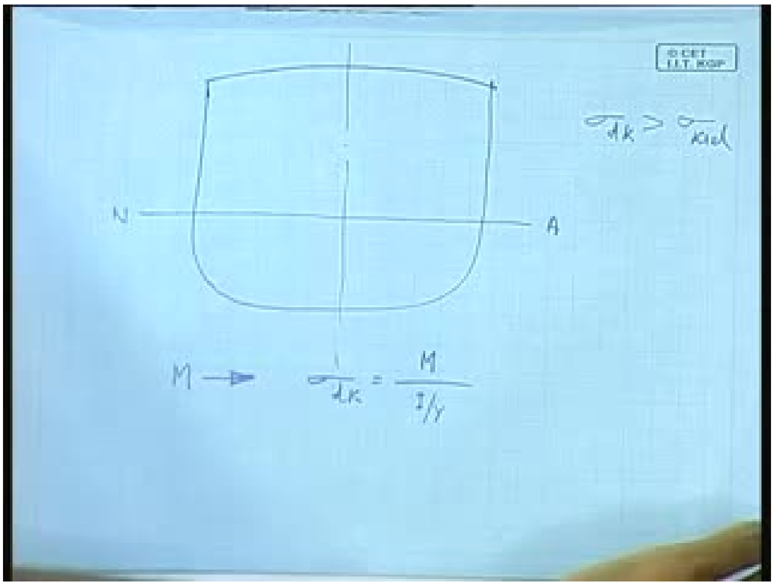

Because of this bending, this sagging condition or the hogging condition, I have the bending movement. Let us assume that I could calculate or I could assist the bending movement. Then from this, how do I get the stress which will be acting because of bending movement there will be some stress generated at the deck plate or the keel plate or the overall structure? Why I am only bothered about primarily with the deck and the keel that is the position where the maximum values of stress will occur. So, that may lead to failure see that does not fail then; obviously, any other structure in between will not fail. So, we are only that is why bothered about the extreme members which will undergo most severe stressed conditions. So, what the stress would be at the deck for a given bending movement M; that means, sigma deck will be how we calculate a simple… You are right. It is simply M by I by Y let I by Y is a section modulus of this that is why later you will see, when you design a structure we check the section modulus primarily at the mid ship region because mid ship region is the region where you have the maximum bending movement.

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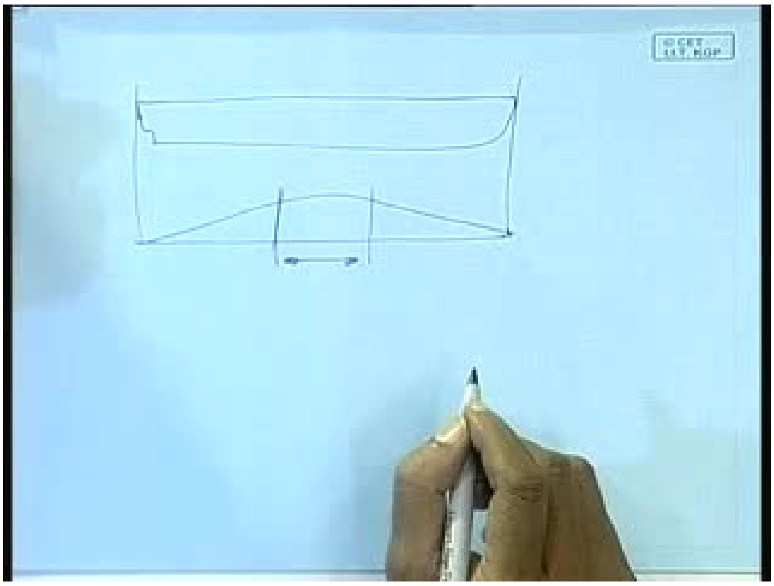

For all kinds of loading conditions as far as longitudinal strength is concerned, generally the bending movement pattern would be somewhat like this. You will have in the mid ship region, the maximum bending movement it keepers off and; obviously, 0 at the ends.

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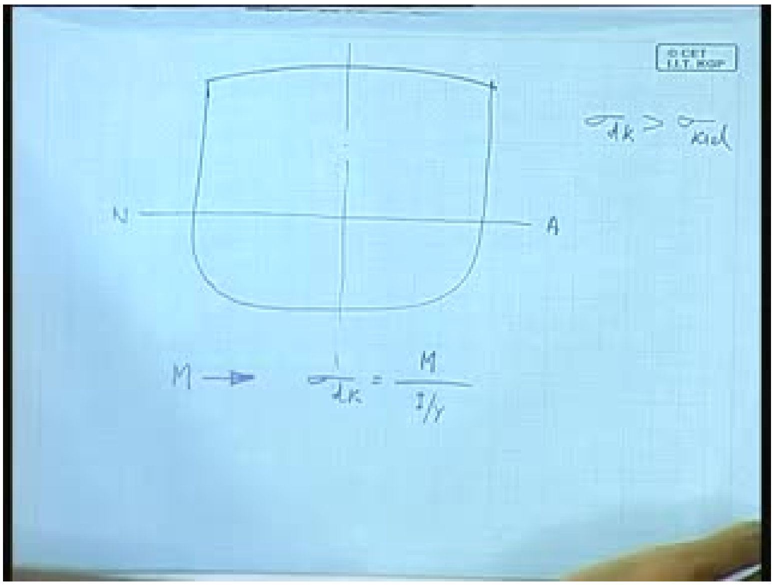

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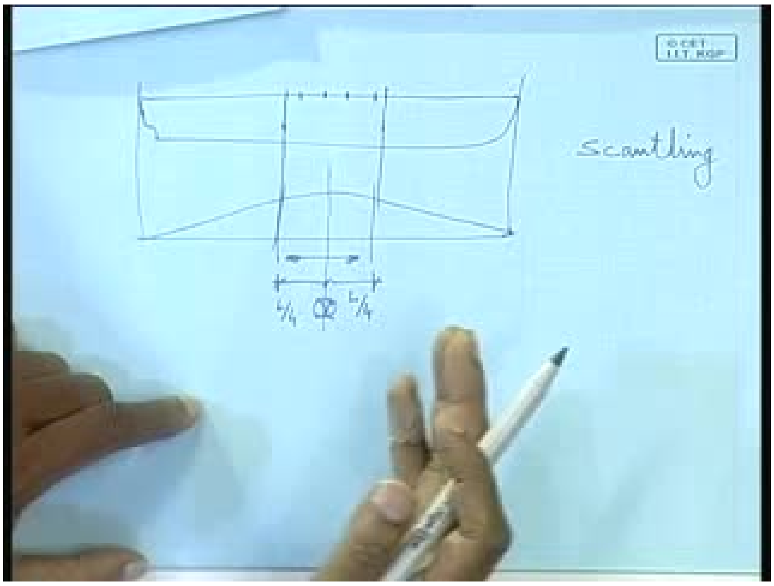

So, any guess that is how we will check the bending movement we will check the stress levels at the mid ship region; I am taking about mid ship region means this length is, this is my mid ship position, this is L by 4 and this L by 4; this region is referred to as mid ship region.

L is the length over all. One fourth length after mid ship, one fourth length forward of mid ship. So, that region that half-length of the ship is referred to as the mid ship region because not necessarily exactly at the midpoint of the vessel, you will have the maximum stress. You will have within that zone that is why all the structural arrangements what is done will be same identical in this zone. What does that imply that implies? That whatever is the deck plating thickness at this region will also be in the same this region also in this region; that means, over this L by 4 forward and aft, the structural dimensions in our terminal is referred to as scantlings. These are certain terms some nomenclature scantling. This term is used scantlings scantling is nothing, but like if I say what the scantlings are. So, that will imply what is the deck plating thickness, what is the stiffener dimension, what is the I mean all those structural dimensions. So, this scantling will remain constant over this region. Even constant means well the shape may change the hall form may change depending on the type of the hall etcetera the hall form from this point to this point may change.

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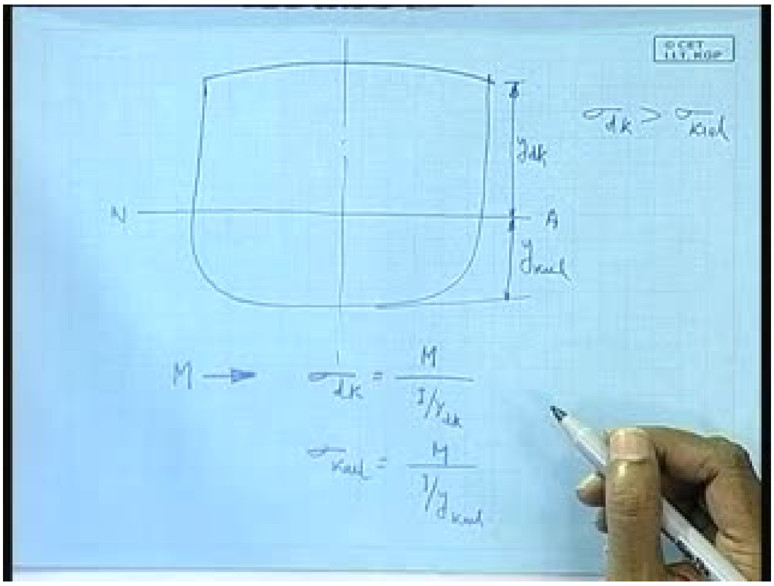

But the structural arrangement, the structural scantlings will remain same. Anyway so again coming back to this, we see that here we have the stresses at keel deck is this I by Y, this Y is Y deck isn't it because this is the distance and this is my Y keel.

So obviously, this value the stress at the deck will be higher than the stress at the keel.

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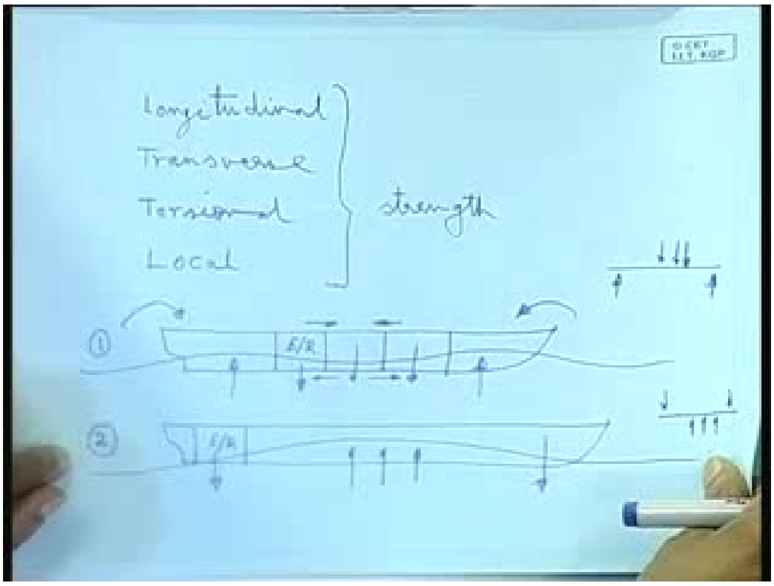

Because your Y keel is less than Y deck generally. So, that is how we would expect a buckling taking place in the sagging condition a buckling taking place at the deck. So, there can be a tearing action in the bottom shell. In the other case, it is more severe, the hogging is more severe why because there the deck will be in under tension. Deck is under tension and here if I see in terms of the deck plan, How the deck of a say any of these cargo ships excepting passenger ship over oil tanker would look somewhat like this.

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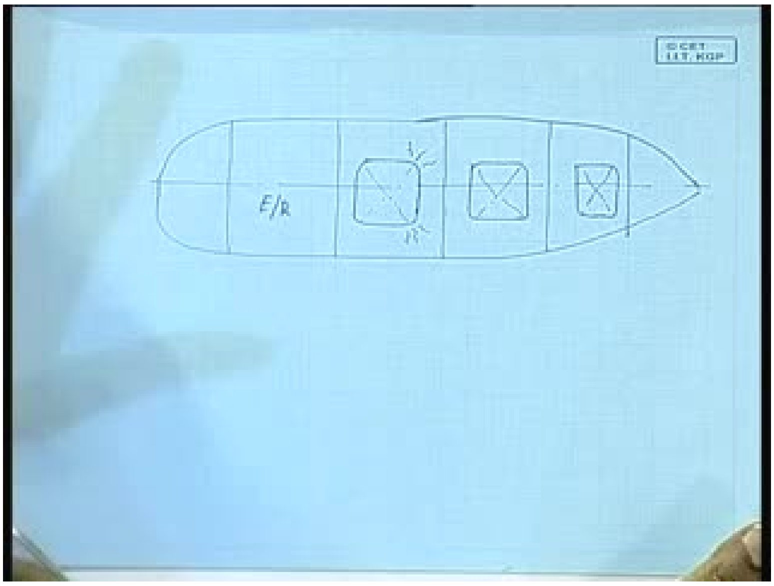

Let us assume different holes, this is my engine room, this is hold 1, hold 2, hold 3. So, all this will have some hatch opening, some opening on the deck.

Because we need have to some opening through which you are going to put the cargo in. That is why I said this you will not having in case of a passenger ship. Also you would not have in case of a Ro-Ro ship, you are not going to put the car through a hold. It will have other mechanism. This also will not have in case of oil tanker because you would not pour crude oil through the hole through a big opening rather you will have pipe connections through which it will go.

But rest all other ships will have such hatch openings. So, what is happening now in case of a hogging condition when it is under tension, the deck plating is under tension and you have the deck huge openings. So, high level of stresses will develop in this region at the hatched corners why; because of some stress concentration.

You know something called stress concentration. If there is a certain change in the cross section of a structure certain change, so stress level if the normal stress level is s at that point where that the certain change is taking place that can be several times of s; it can be three four times that is what is referred to as stress concentration.

So, that is what is expected at the hatched corners. So, in that case, there is a very high probability that a crack might develop at this corners and crack is a particular that is again a typical phenomena that if a crack develops, then it progresses and meets to structure failures.

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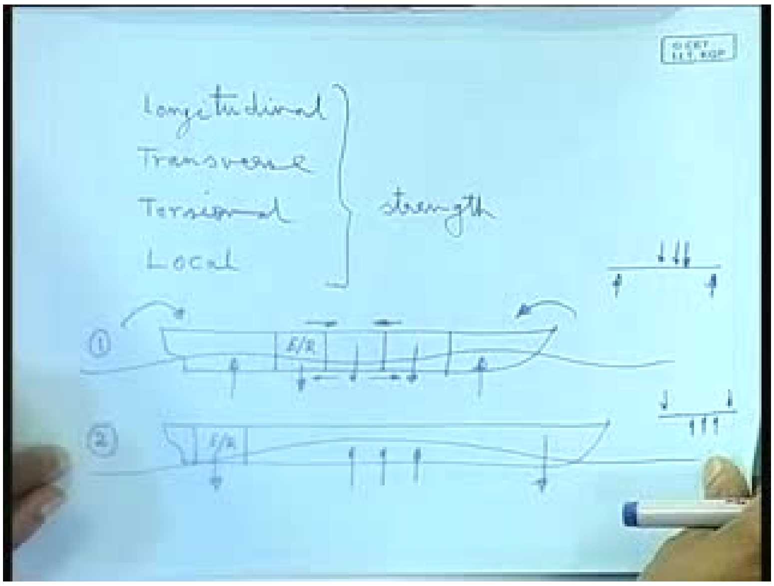

So, in any case that is how you see that these are very important aspects that we will have to have strengthening arrangement suitable such that it can sustain such longitudinal loads. So, we satisfy the longitudinal strength requirement. Then there are transverse loads coming on the ships how the transverse loads may come it is something like this.

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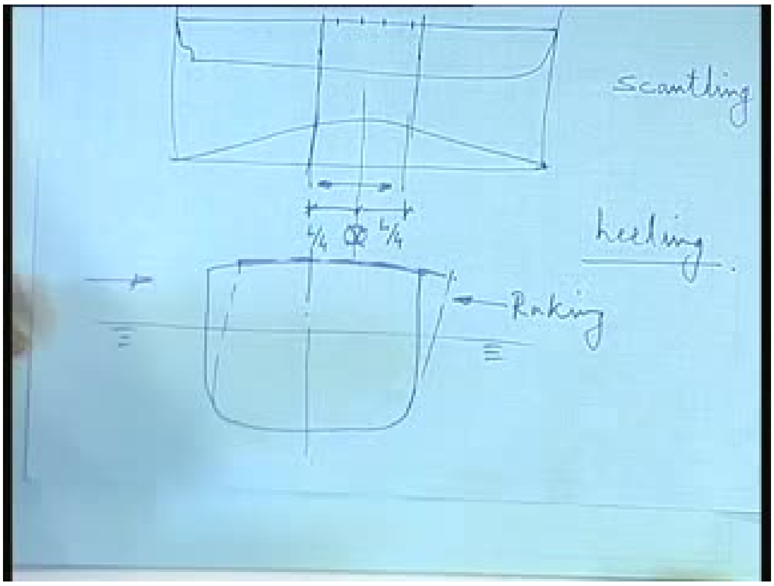

Transverse means perpendicular to the longitudinal direction. The ship is floating in such condition and when it sails it encounters all kinds of waves there can be oblique waves coming and hitting the vessel; that means, hitting from this side, if it is not suitably adequately transversely strengthened, the structure may deform like this.

What I have drawn by this dotted line is not the structure has healed. A term heeling that is equivalent to tilting, but we do not say that the ship has tilted; we say the ship has heeled a heeling angle; that means, when it is floating. So, the ship is floating give a force it will heel by port side and it will keep oscillating for some time till it again comes to the operate condition.

Here is not a question of heeling, it is deforming. The basis remain horizontal. Heeling would be the whole as a rigid body the whole thing is moving, but here the two side shells are deformed. So, this kind of deformation is referred to as raking. So, this may happen because of inadequate transverse strength. So, you would have to provide for that.

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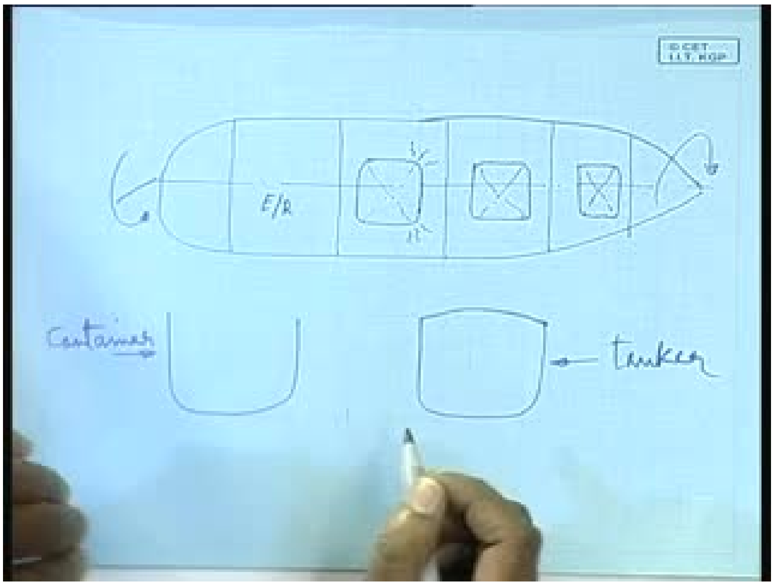

Torsional strength torsional strength is an aspect the whole shape just imagine a situation if it is lack of torsional strength and we subjected to this kind of torsional movement, then it may deform longitudinally. It may deform. Now if it deforms what will happen, what is the problem? In case of longitudinal we have seen if longitudinal strength is not adequate, then we have seen what are the problems one can face.

If the transverse strength is not adequate well it may rake, it may deform like this, but what is the problem if it is twisted what is the problem. I mean it is not that severe that it will sheer off. This raking also will not be that severe because we are designing it, but because of some inadequacy somewhere this things may happen. Most severe most conditions are the longitudinal conditions. Once the longitudinal strengths are fully satisfied, it automatically takes care some of these transverse and torsional. But in some particular cases, you will have to additionally look into the transverse and torsional things. So, they are not that severe, but in longitudinal if it fails means it breaks in two pieces or it renders totally unusable the vessel, I mean totally it becomes unsafe for use. But if it raking has taken place or is some little bit of torsional deformation has taken place, it is not that unsafe, but it has rendered here it is a functional efficiency functional quality has gone down. Why?

What happens if it has deformed like this or if along the length imagine a situation it has twisted. So, what will happen, when you are sailing you will never be able to sail straight. You will always have a tendency to deviate from your course. So, if we deviate from course then what happens? Instead of reaching your Sydney you may reach Shanghai somewhere else you may land.

So, that is not affordable. So, you will have to always deviate steering force to keep back bring back the vessel to the path what in the process you are doing. We are consuming unnecessarily energy. The spot of the energy is dissipated to bring it back to the course. How that is done? It is basically giving a radar angle; that means, the you will have to probably give a radar angle continuously to head straight I needed the radar to be straighten line, but now I will have to give a radar angle so that I keep my course giving a radar angle means what I am forcing the vessel to bring back to the course where from that force is coming from my engine. So, at the cost of my speed. So, there will be a drop in speed, if there is a drop in speed I may lose one round-trip in the long run or if need to bring the thing to the desired speed, I have to burn more fuel, if possible this is not that not like car engine that you have sufficient extra power no not always. If you have then you will think to burn I mean speed of the engine burn more fuel to deliver the required speed.

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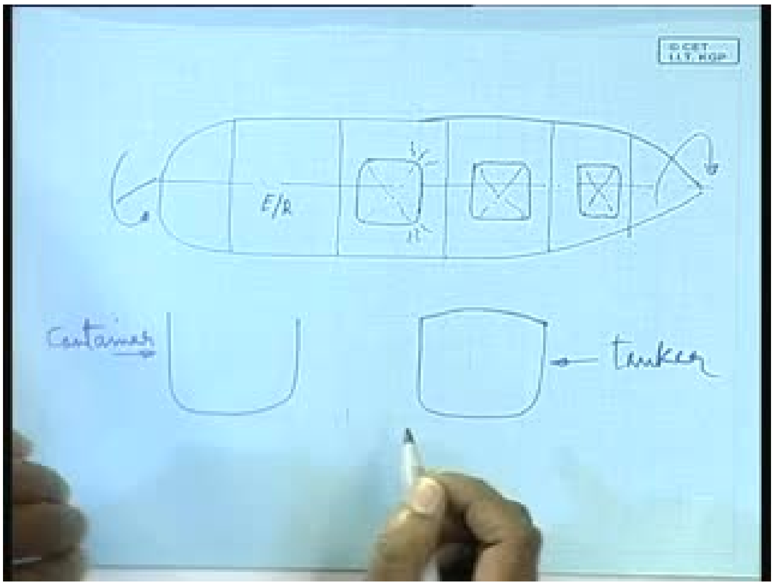

So, it is in the economics. So, these are the problems. So, where one can have this torsional strength problem primarily where you know a structure open structure is torsionally weak, a closed structure is torsionally very strong. This is a case of a tanker oil tanker where torsional problem is not a problem as such. Because this is a closed box kind of structure and that is very strong. It is an open structure does not have torsional strength. This is a case of container vessel. So, in case of containerships, this torsional strength requirement is important. There you have to specifically look into this specific assumption is to be provide in the structure arrangement for designing container vessels.

So, that is what is the torsional and the other vessels are in between general cargo ship, bulk carrier and all that are in between because there neither fully closed nor fully opened.

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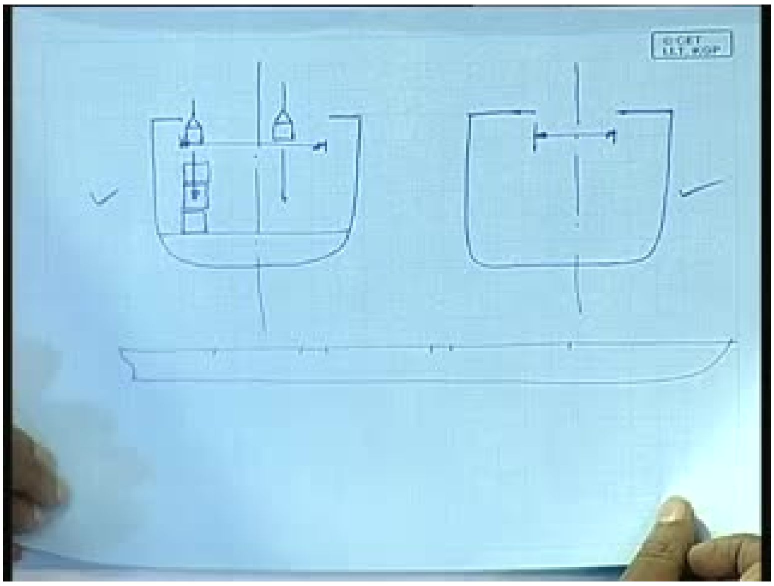

There the basically what happens I mean; obviously, container ship also does not mean that the hall will look like this fully opened. What it means is something like this. If is schematic compression if we do of a bulk carrier or a general cargo carrier and a container vessel, the compression of the deck opening size, it would be something like this. Otherwise we have identical size of the both the vessels then the deck openings would be somewhat like this. That means, this is the one with general cargo bulk carrier like that, this is the one the container. So, you can see the opening is much bigger, it is almost fully opened whereas, and this is compatibly much smaller. Can you tell me why this is making it much bigger opening make all kind of structural problems and when you make a big and big and big containerships.

So, what is happening? It is becoming long and slender and you have huge hatch openings in between. So, that that itself makes things even more challenging and difficult, but why that is so? Why so big hatch opening and why it is small in case of a bulk carrier a bulk carrier can also be this big say 100000 ton of bulk carrier will be a huge one, but you have small hatch opening because in bulk carrier the loading is well is a cargo in bulks. So, you have an opening, you load through a sort of a hopper. It falls or use a grab to unload it whereas, in container what happens is you have to lower the containers hanging in a crane. This is how the containers will be lowered in its locations and once it is lowered here or suppose you have a small opening then what happens you lower it say some are in the middle region then you have to shift it left or who will shift that how do you shift it. So, then the whole purpose of containerization is lost. We started taking about containerization because to reduce loading unloading time.

There is one of the main important thing a containership is I mean loading unloading is done in just two to three days finish; it hardly stays in a port whereas, the general cargo ship will stay for a month. Now if you have to lower the container, then maneuver it to the left or right then again the whole purpose is lost. That is why you have a huge opening. See your right you lower the container wherever it is to be stored and it is stuck like this one on top of the other. So, you need to huge opening because the whole space has to be utilized. So, in any case that is what I was saying the functional requirement, depending on the functional requirement your structural arrangement will depend. So, this is one of the simple example of the functional requirement that we will have to have a very wide hatch opening. So, it is almost referred to as an open deck ship because the deck plating is so small compared to the inter breadth of the ship. So, it does not have much strength. So, you will have to provide for adequate strengthening against torsional deformation. So, that is what the thus torsional strength requirement is.

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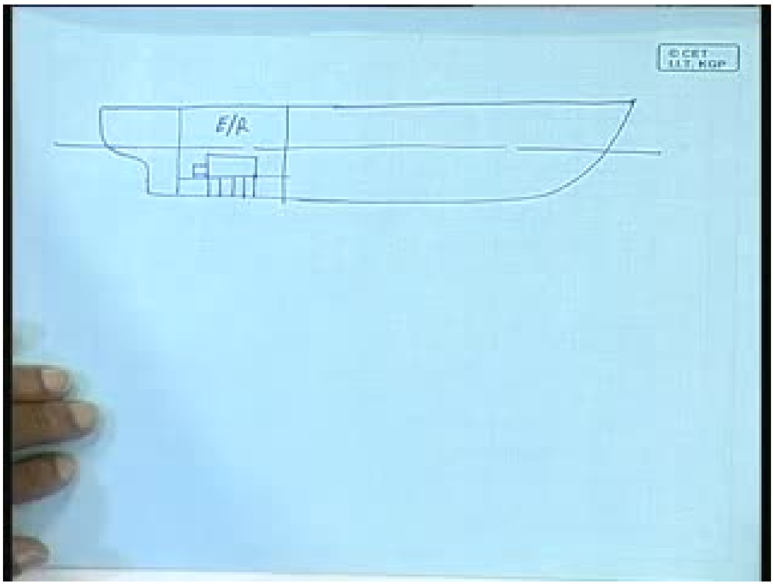

And then last we are taking about the local strength; local as we have said one is well once again if we look in terms of a ship will give references primarily best on ships, reference of offshore platform will be very minimal because in offshore platform. It is primarily this deck all decks and other typical things are well the hugeness of its construction that is all otherwise there is no structural difference as such. Well in ships as well as local strength is concerned say this is my engine room, engine room means you have a huge main engine. So, a quite a huge load is acting locally.

So, you will have to have proper strengthening arrangement. If I do not have a proper strengthening arrangement, local stresses will develop. So, that is the local load; that means, local strengthening is needed. This has nothing to do with torsional load or the longitudinal bending movement or transverse loads etcetera

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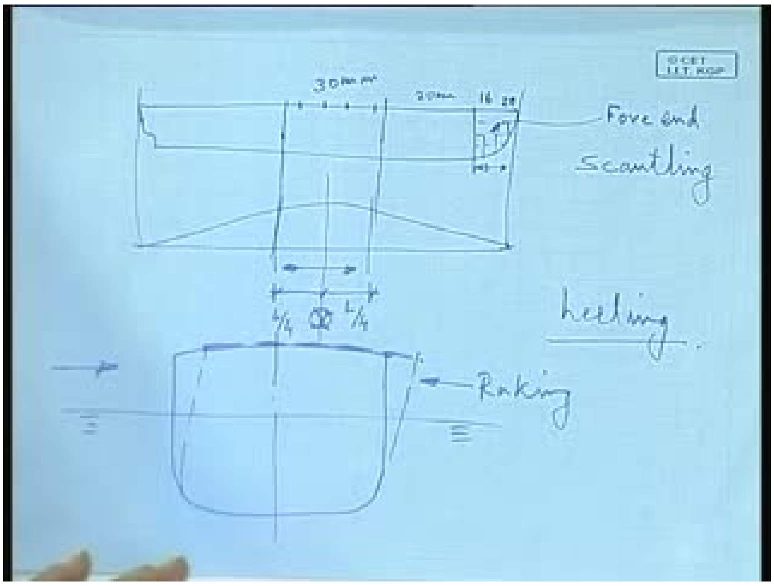

Similarly, you will see we have talked about the bending movement and we saw that the bending movement is highest somewhere around the mid ship region. So, that automatically implies the immediate effect what one can see is the shell plating thickness, the deck plating thickness will be highest in the mid ship region and we will gradually taper off. Obviously, I will not continue the same plating thickness as we have in the middle region away from that in the forward or in the aft region. But the simple reason if that way I design then the structure will be over strengthen it will be overweight it will be costlier. So, I will try to use here if the plate thickness is 30 millimeter say, the deck plating thickness there I can refer to have a plate thickness I am just saying indicative 20 millimeter as I go further forward I can even come down to 16 millimeter and so on.

Same thing is true because here the bending movement is 0, there is no load as such from longitudinal point. Same thing is true in the side shell, same thing is true in the bottom shell, but we will find the bottom shell part of this region or this forward end this region is also referred to as fore end forward end or fore end; this region will find that the shell thickness have increased. Also we will see I am in the bottom shell thickness we have increased the deck plating thickness just prior to this it was 16 and here probably again we have gone back to 20.

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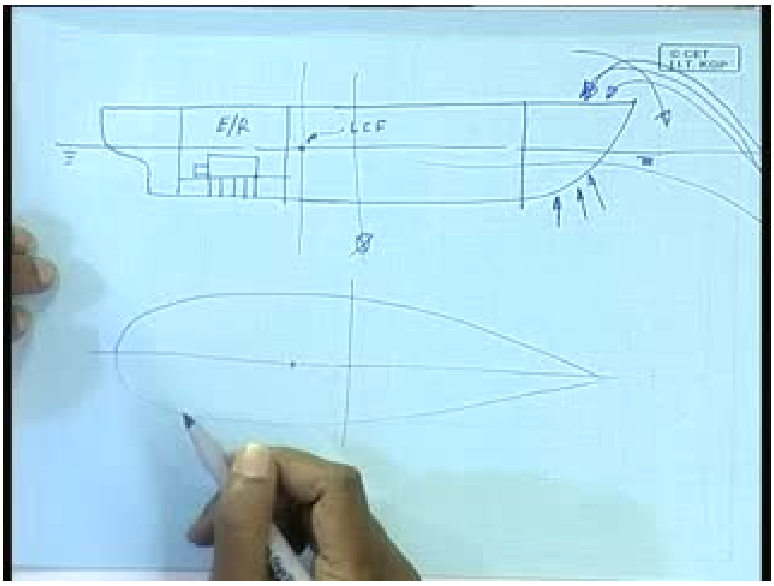

And also we will see that in this zone, it is more heavily stiffened, heavily structured. Why, because of local loading to withstand local loads where from the local loads will come there because when it is sailing it is encountering waves. Not only that, in stormy seas it may start doing the slamming. Slamming is a motion of the vessel about its center of flotation.

This point is referred to as this may say load water line at this level the vessel is floating and sailing. So, on the water plane, you will have a geometrical point LCF it is called longitudinal center of flotation. So, if the ship makes any movement, this slamming motion, it will be as if the ship is hinged about this LCF and making this movement. LCF generally will be aft of mid ship why because the water plane is fuller in the haft and finer in the forward. It is finer in the forward full in the aft. So, this LCF will be obviously aft. So, if that happens; that means, it will have a huge movement. So, with a huge force it will be heating the water surface; that means, you will have a forces acting here which are called slamming loads. These are called slamming load. So, in other words, this forward end part this may experience huge loading because of the slamming and also what about the deck why you will strengthen the deck also. Deck is not heating the water.

Because of slamming what happens is, in again in rough seas there can be huge waves coming and hitting and falling over the deck if you look into I mean you happen to some pictures you will see in a very stormy sea condition, a vessel will look like well in an ocean. It is a small item how are big it is to us here and the waves can be as high as several times higher than the ships depth. So, there can be situation the huge wave will come and hit the deck like this.

So, that bulk of water falling on the deck, it will punch at the deck and go. If it is not properly strengthen there are accidents like that. So, you will have to strengthen it in the forward part. So, that is how we will see that is what the local strength is.

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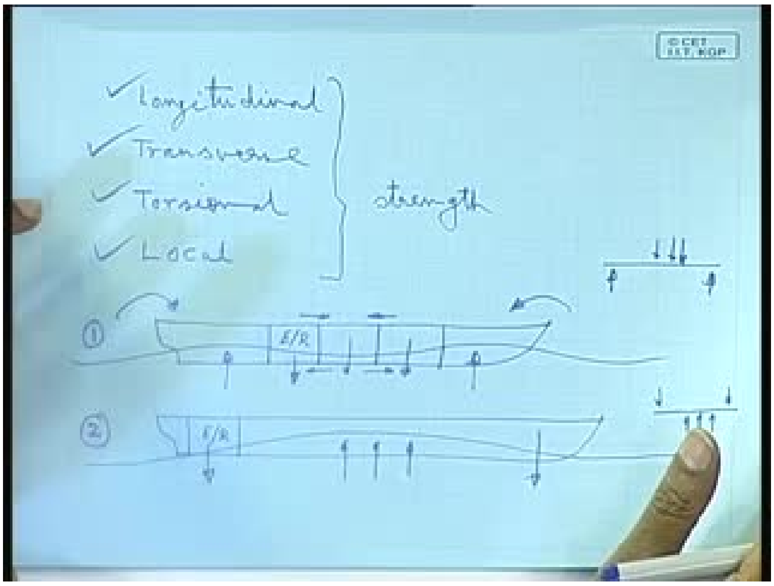

So, that is how if we take care of this longitudinal, transverse, torsional and local; these strength requirements, then we can say that the structure is the product is structurally sound; that means, it will safely transport your product between the destinations where is the places you want to sell or you will serve the required purpose.

So, we have talked about that these are needed. Now how do I do that, how do I provide for the necessary strength, what is done in these cases in case of shelf's of shell platforms etcetera.

If we look into this structures of the vessels shelf's as well as our offshore platforms or even submarines or any such product, what we are finding is that it needs to have adequate strength, what does that adequate strength means; that means, under the service load the stress level should be within the working limit. What about the permissible stress level limit within that.

That is the number 1 requirement. And number 2 requirement is that it should be done in such a fashion that it is strength to weight ratio is maximized; that means, I do not unnecessarily make the structure very heavy.

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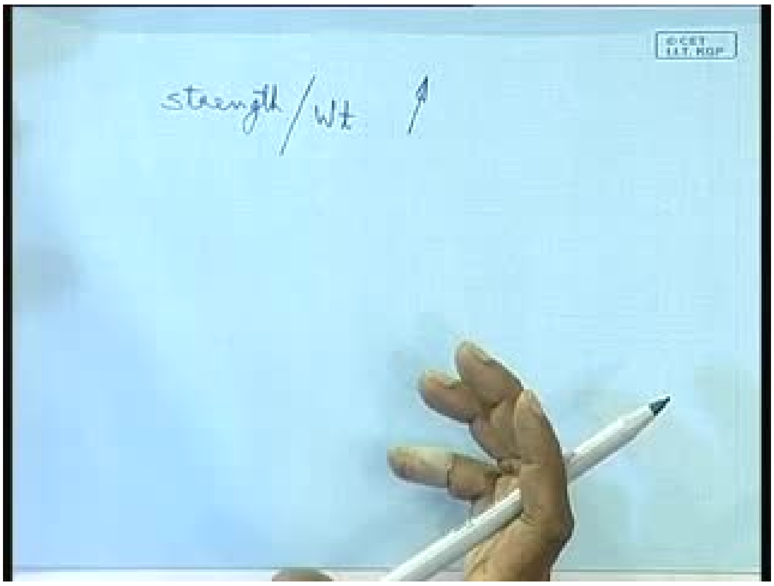

I have to do it in such a fashion that its strength is high at the same time weight is not that much or in other words, this is the particular criteria that this ratio has to be maximized.

A good design, a good structural design is where I have this maximum because how do I satisfy longitudinal strength requirement, transverse strength requirement; all these you know these are not a case of a problem where you have unique solution no. You can have several solutions depending on the designer how you are looking at the thing you can keep your own solutions which will satisfy all these four requirements.

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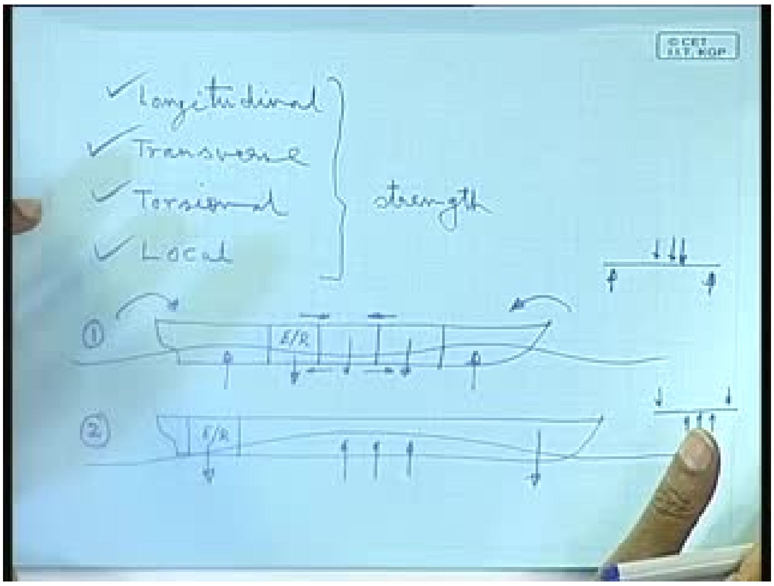

But the one which will also satisfy this requirement; that means, strength to weight ratio have maximized or the reverse weight to strength ratio have minimized, that will be the best design sort of from structural point of view. Keeping in mind all the other requirements, obviously that means, other requirements are your high dynamic requirement, your production requirement, your functional requirement because a design can be a very nice high dynamically, but it may not be absolutely suitable. It may be a very difficult design as far as production is concerned, manufacturing is concerned. At the same time you have to keep in mind the maintenance aspect of it.

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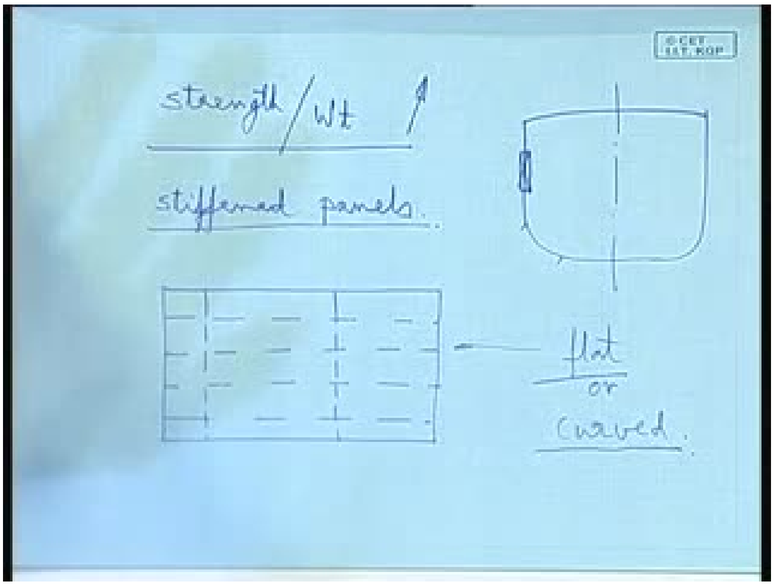

Anyway. So, you will have to maximize the strength to weight ratio. So, what is done here in these cases is the basic structural blocks are the stiffened panels. That means, the entire structure if I really start cutting it down and take out small pieces from various arbitrary locations from the shape suppose I cut down a little piece of say 2 meter by 3 meter deck plate if I cut it off, if I cut similar patch from the shell here or shell there or a patch from the bottom shell; anywhere any piece, you cut out you will find it is nothing but a stiffened panel. What a stiffened panel means stiffened panel means it is nothing but a piece of plate and you will see there some stiffeners are welded in certain fashion. You will very lightly to encounter such type of panels. So, from this we can say that the entire structure is primarily built out of such stiffened panels; only difference should be for example, let us take a look at the one of the section, suppose I cut a piece from here, it will be a some stiffened panel I may except of this nature; that means, a plate with certain stiffeners welded. If I cut a piece from here only difference will be it will be curved. So, the stiffen panels can be either flat or curved. So, we can see that the entire structure I can construct if I had such panels fabricated through the required size shape and all that and go on putting them together, you get the entire ship. Like analogous could be building civil I mean this houses the buildings. What it is made up of? Basic building blocks, bricks one after other brick you put you get the wall. Why do not you think in terms of basic building blocks are walls.

Bricks are fabricated in some brick factory, you bring them put the bricks one after another make the building similar fashion I think of a factory which is making the walls readymade walls whatever is the material they are using let them use readymade walls. So, instead of buying bricks, you buy the walls and put them; your thing is done.

Similarly here, basic things are of course, the stiffeners and the steel plates. The next stage we are talking that then in house if we fabricating this there also basic thing may be clay and sand whatever cement.

But I can have a situation where in instead of brick I can buy the walls and put the walls and make the building. Is it feasible? Do not say that you are intelligent being why do not you think it is not feasible. That is the way you can build houses very fast and that is how it is built. Probably not here yet, but where you need to build houses very fast, there only thing what you need is a very high level of standardization; like bricks are also standard you know I mean you buy a piece of brick in Kashmir or in Kanyakumari the size is same there are I think. So, two different sizes I have encountered of bricks. They are fixed 8 inch, 5 inch, 3 inch; some such thing is there standard sizes.

Anyway, but this, I mean if you can there are standard sizes of wells available readymade. So, lift the wall and put it in place. So, in couple of hours time your whole wall is erected.

So, four walls you put, may be in one shift you erect the four walls then comes the roof slab. Only technology is joints. How you ensure the water tight strong joints that is how buildings are made I have seen building in this fashion.

So, anyways to see because I never thought of that you need a crane to build a building because there are high rises. So, with a crane they are just lifting these blocks and putting it in place.

And it was as I can recall I mean I do not remember may be some twenty-one storey building, it is completed in some nine months time or so. Huge. That is only feasible provided you have such technologies involved.

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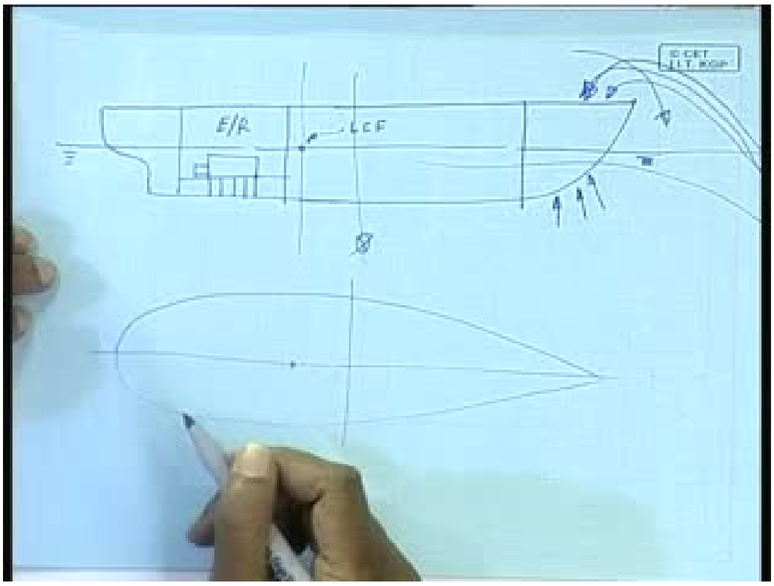

Anyway. So, similar fashion in ships also, we have this stiffened panels of course, here we do not have a stiffened panel production factory. It is not done that way, it is well the shipyard itself will produce these panels of different size shape; shape means some are curved, curved means how the curvature is will; obviously, depend on the hall form.

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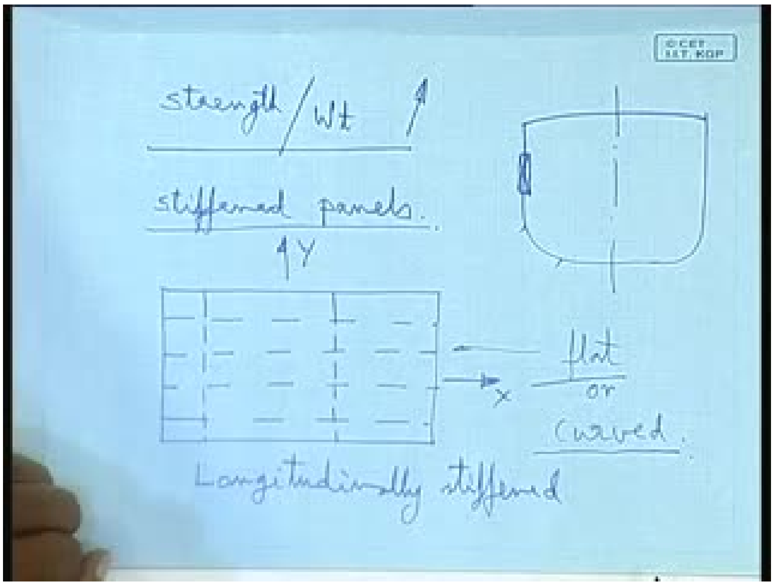

So, that is a different issue, but essentially what we are seeing is that this strength requirement; all these will be actually provided by how you design this stiffened panels.

As you can see what I have drawn here in one simple example of flat stiffened panel is I have certain stiffness in this direction saying the X axis, certain I have drawn in the Y axis. If X axis happens to be the longitudinal axis, this panel goes in such a fashion in the main structure that the X axis is the along the longitudinal direction.

So, then I will refer this panel as longitudinally stiffened; that means, longitudinally stiffened panel because they are the primary members, they are much closely spaced and also I need transverse strength. So, I have two transverse members.

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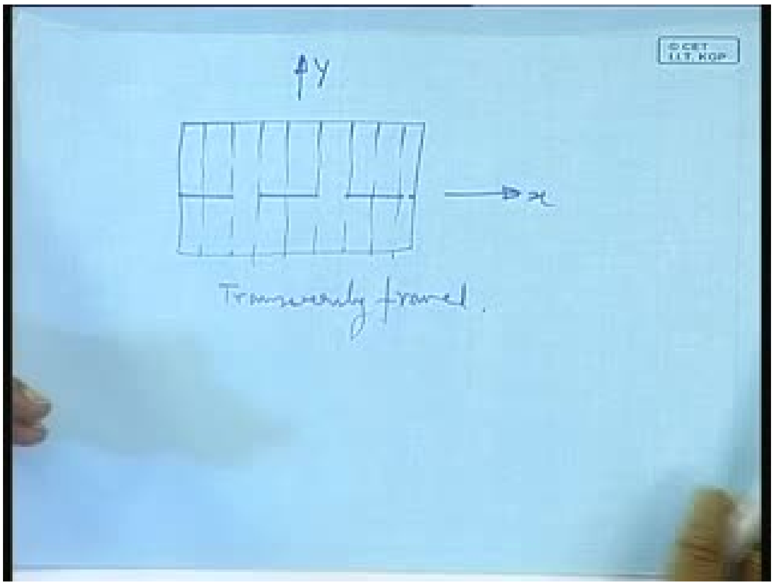

We will come to that later again. Now the similar situation can be in this fashion also. I have members; stiffening members running like this. This is my same X axis and this was my Y axis. So here, I have just reverse the cases. I have put closely spaced stiffeners in the transverse direction.

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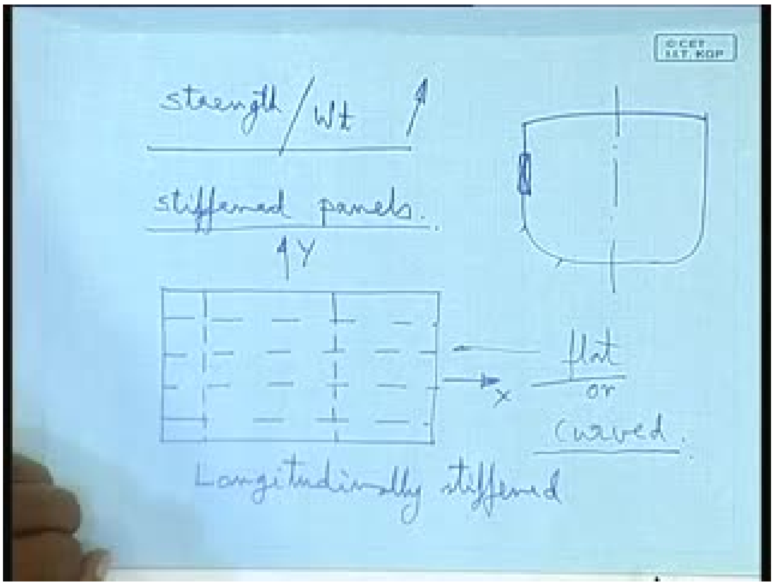

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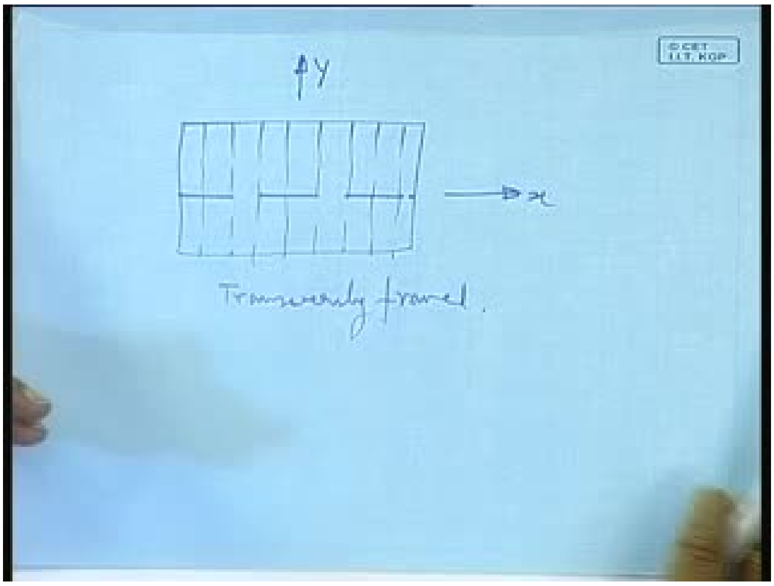

And one I have kept in the longitudinal direction. So, this is a transversely framed or transversely stiffened panel. This is longitudinally framed, this is transversely framed. So, that is just the introduction I gave you about the longitudinally stiffened panel and the transversely stiffened panel transversely framed or stiffened panel. So, this is my longitudinal framing system, this is my transverse framing system. Now we will see more in details in the next class.