Marine Construction and Welding

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Module No. # 01
Lecture No. # 17

Structural Alignment and Continuity

We will take up today, Structural Alignment and Continuity.

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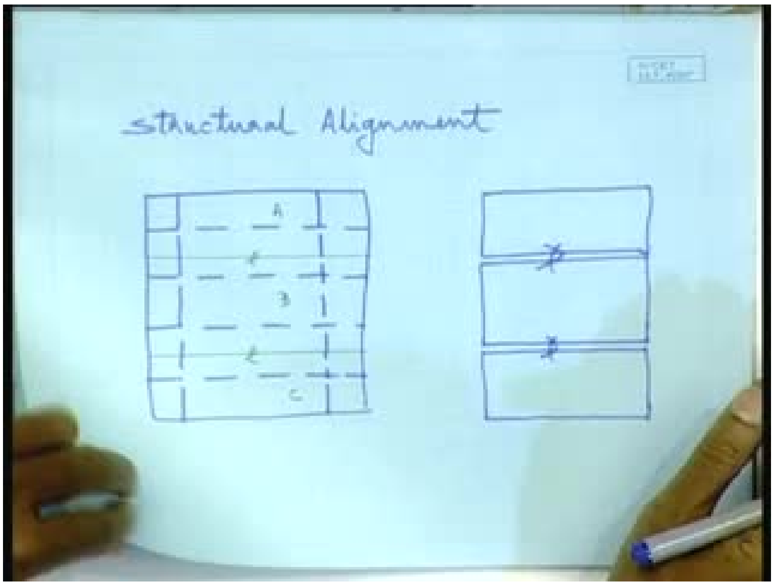

So, slowly we are now shifting towards actual production work, because till now, we had been looking into the so called paper work, the design work, the different kinds of layout, different arrangements - all those things.

We are slowly coming to the so called production. So, here, those structural alignment and continuity, all these things, it is somewhere in between production and design because alignment is a production work; whereas, continuity has to be implemented in design; then only you get the structural continuity in actual product. So, this is somewhere in between. So, before taking up the so called hard core production work, we will discuss about this.

What is this structural alignment? As the name suggests, you can see, alignment means essentially aligning it to some predetermined things. What they could be like? If we look into our basic structural component or a basic assembly that is this, that means a stiffened plate - a panel having longitudinal stiffness, obviously there will be transverse members also at a much wider spacing. So, to do this, how is it fabricated?

The fabrication is first the plates are connected; that means this green line we are drawing is one of the welding lines. There are these Let us assume that we have in this panel 3 plates: plate A, plate B, plate C. These are the 3 plates put together butt welded along those seam lines or butt lines. Once that is done, then the stiffeners are put; the longitudinals are put; transverses are put. So, if we actually see the sequence of production, it would be: You will have to first take the plate A; then the plate B is aligned to it and welded; then the plate C is aligned to this combination of A and B put together and welded; so, this is what is alignment.

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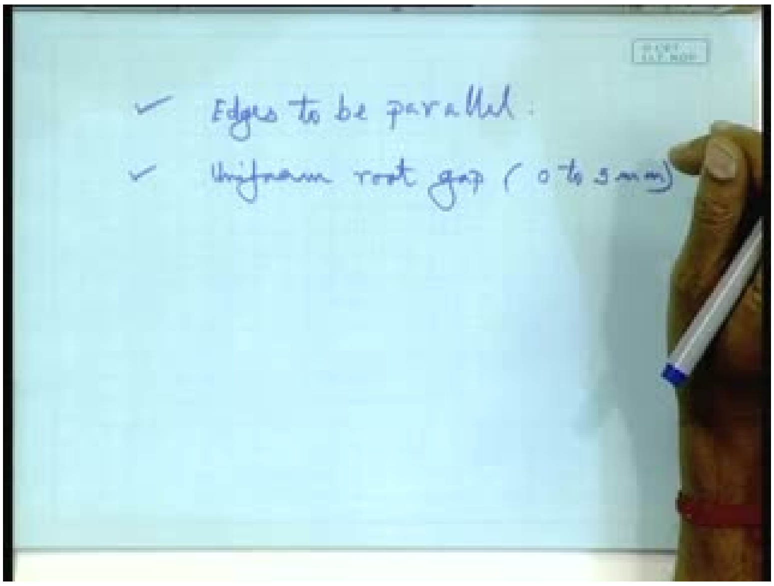

So, what is the alignment requirement for plates? If we talk about alignment requirement for plates, it will be: first one is that the 2 edges; both the edges are to be to be parallel. These 2 edges have to be parallel and then we will say something called there ought to be uniform root gap.

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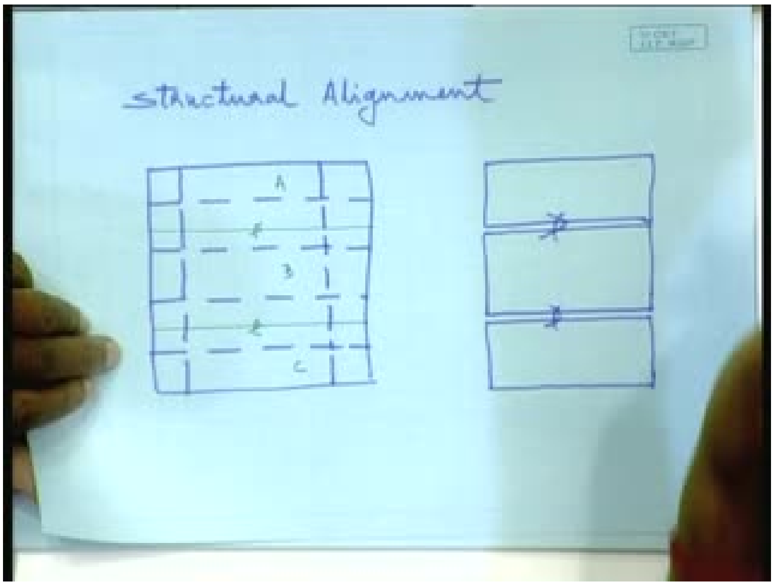

As you can see, we have drawn; these two lines are parallel and there is a uniform gap between them; so, that is also needed. So, that gap may be 0, or may be something else; generally this gap varies between 0 to around 5 millimeter depending on what kind of plate you are welding, depending the what thickness of the plate; it can be depending on what method of welding you are implementing; it could be either 0, 1, 2, 3, 4, 5 generally in that range; there is no hard and fast rule. It depends on what process. But whatever we put, it has to be uniform because if it is not uniform, at one place it is 0 and at another place it is say 3. Then what happens?

The deposition, weld deposition changes; the weld quality will change. So, that has to be plated; that has to be so aligned that the edges remain parallel and by maintaining them parallel, we get uniform root gap. Also if it is 3 millimeter, it remains 3 all through that has to be same.

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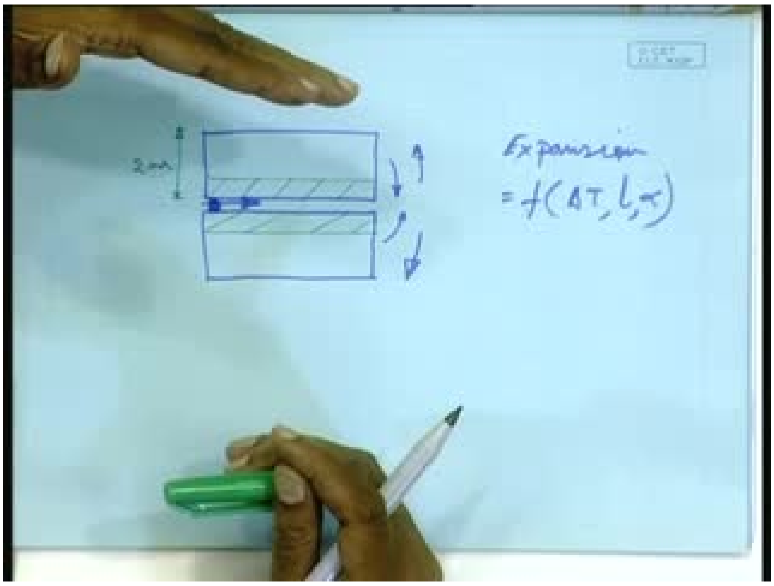

So, how that is to be achieved because there is one aspect of what happens is when 2 pieces of plates are welded, suppose I draw like this, welding starts from here and it is progressing. Depending on the welding method, the plates will either move in this direction or it will try to move out; that means either the plates will try to close; means there is a gap. It will try to close and even overlap or a different welding method may lead to its opening up. Why that happens because when you do welding, it results in a so called information of a stress field because of expansion and contraction.

Why contraction because welding is a process which keeps moving with time. It leads to a transient phenomenon; means it is never a steady state phenomenon. You know steady state and transient. Transient means which keeps changing with time; that means it never attends a steady state. In a steady state case, it is independent of time. Welding is a phenomenon which is dependent on time because every time instant, the welding torch is at a different location. Since it has a different location, so temperature profile which is forming over this plate, the amount of heat being conducted, it is changing with time continuously. So, thereby, the part which was getting heated up possibly in the next instant it has started cooling down because the welding heat source is moving away. So, when it was here, the plate around it was getting heated up; next instant it has moved away; so, this started cooling. That is why we say that the plate undergoes a thermal cycle of heating followed by cooling.

So, in the heating phase the plate wants to expand because of the phenomena of thermal expansion and in the cooling phase, it contracts. Since in the heating phase it will try to expand, means what? Expansion is given by what? It is a function of essentially your temperature difference and if it is a linear expansion; then some length component, and of course, the material property of coefficient of thermal expansion in that.

Now, this delta T is the main component - the difference of temperature. Now, consider this particular situation where the welding is progressing. It is moving. So, you will find that part of the plate is only getting heated up. Only a certain part of the plate is getting heated up because this plate dimension could be substantially high. It can be say around 2 meter. If it is 2 meter, if you weld it here, not the entire 2 meter plate will get heated up; only closer to the welding line, some part will be heated up so that delta T component will only work closer to the welding line.

So, in that zone which we have approximated by this green shaded area, in that zone, the plate will try to expand; the rest part of the plate is something which can be termed as a cold plate. It is the cold part of the plate which is not expanding. So, that will oppose expansion. This part is not free to expand. That cold part of the plate will oppose expansion. So, what will happen? Stresses will develop.

So, that is how basically the thermal stresses develop. That means you assume a small cube of steel, say 1 inch by 1 inch by 1 inch; a steel cube, if I put it in a furnace, will it undergo any stress or strain? It will not because it is getting uniformly heated up. But I take a long steel plate at one end, I take a gas torch - oxy acetylene gas torch and keep heating it, the plate will undergo certain level of thermal stress, followed by thermal strain; part of the strain could be plastic strain. At the end of heating that, you will find that when the plate has cooled down, the plate has deformed.

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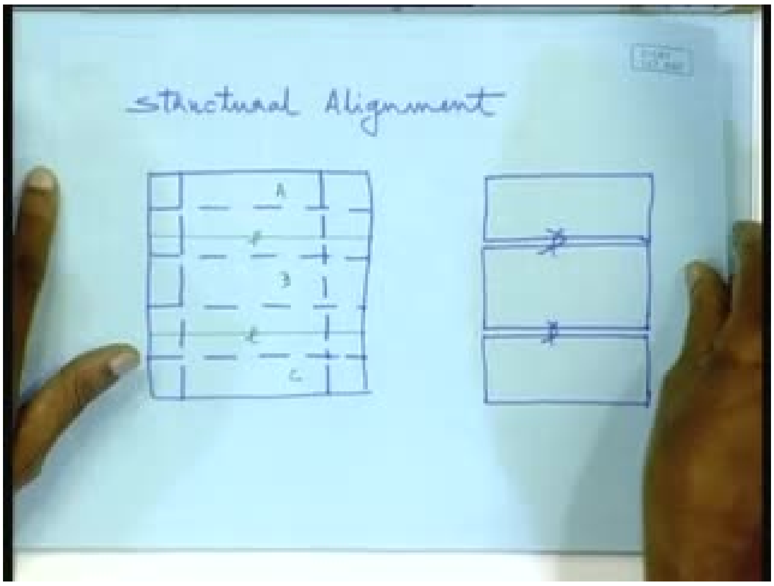

You have not applied any hammering force or anything; nothing. all that you did is you just heated it up and removed. For example, you have a piece of plate like this and heat it at the center; some heating you do and leave it. When it cools down, you will find, the plate has become like (Refer Slide Time: 12:10) this; the plate has bent like this. You have done nothing. You have just only heated it up and left, but that heating was localized heating along a line. So, a local narrow zone was heated up and left. The plate has bend like this. That is what thermal stresses are working. That phenomenon, of course, it has a name; it is called line heating. Because that phenomenon I can use to bend plates, suppose I want to bend a plate in the forward section, in the bow section, the plate has to be bent. So, I can do it by mechanical means or by thermal means also.

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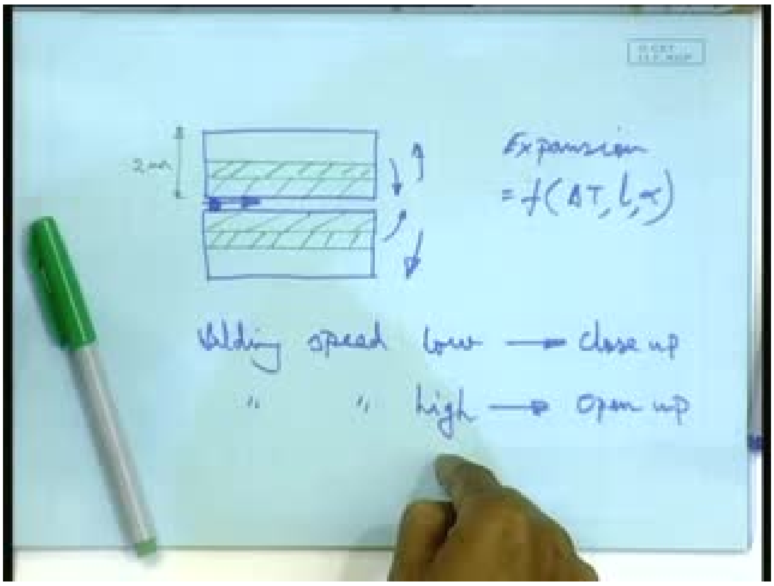

So, in any case, that is how the thermal stresses develop. So, though those thermal stresses may work and lead to this kind of phenomena, that means that thermal stresses will lead to some strains that will lead to some displacements. So, what happens? When the welding speed is low, then it will tend to close up; the plates will tend to close up.

When the welding speed is high, they will pretend to open up. Why that happens? Because in slow and high, what it means? That when it is slow welding speed means we are giving more time for the heat to flow in the plate to get conducted; so, more amount of plate is getting heated up.

When the welding speed is slow or a slow speed welding, more amount of the plate is getting heated up and in the process what is happening? Stresses will form ahead of the welding arc, which lead to a bending movement, which will bend the plate, bring the plate to close up; means there was a root gap of 5 millimeter. You will see, as your welding is progressing, you will find the root gap is reducing. There are cases even it will try to overlap. So, if that happens, it is totally out of any alignment, what so ever, you cannot weld.

If speed is high, then the reverse thing happens. Then, the movements are generated in the opposite direction. They try to open up. So, the gap becomes instead of 5 millimeter gap, which is designed root gap, it becomes 10 millimeter. You cannot weld. In both the cases welding becomes impossible. Low speed welding is manual welding. You will have a case of closing up. Machine welding, say submerged arc welding, automated welding or machine welding where you can have higher speed of welding tend to open up.

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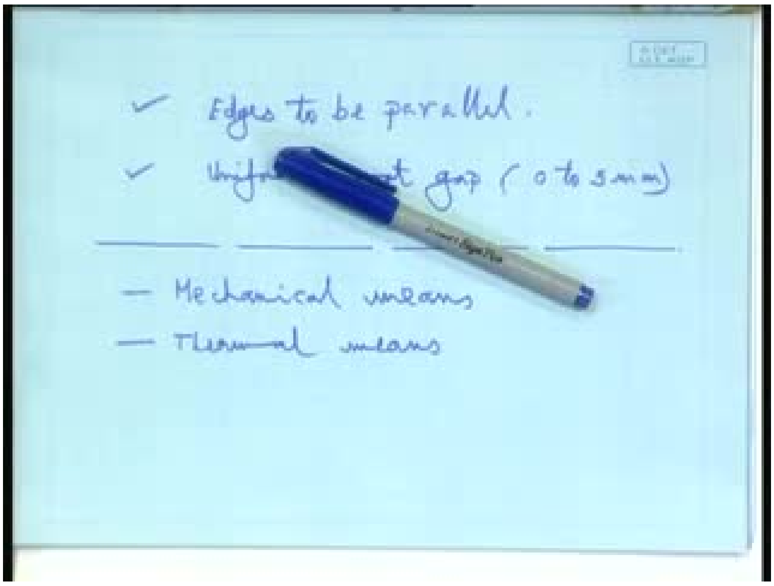

That means it is defined. This basic alignment requirement edges are not remaining parallel. So, root gap is changing. So, what is to be done? That means to maintain alignment, you will have to implement certain methods. How? What is to be done? Yes there can be 2 ways: One way would be by mechanical means; that means you maintain the root gap, maintain the alignment by mechanical means forcibly or by adjusting the thermal stresses; that let us name it as thermal means. Again, the same thing; like I said, you can bend the plate. I mean by subjecting a plate to a kind of heating pattern, you are able to bend the plate.

So, I am saying, the same technique can be used to bend to our requirement to shape a plate. Shaping plate normally is done by mechanical means. We are putting it in hydraulic press and bending it. We can also do by without applying any external force. We apply thermal force. Apply heating in predetermined lines, predetermined location in a predetermined pattern, we heat; the result - the desired shape. So, that is the thermal means.

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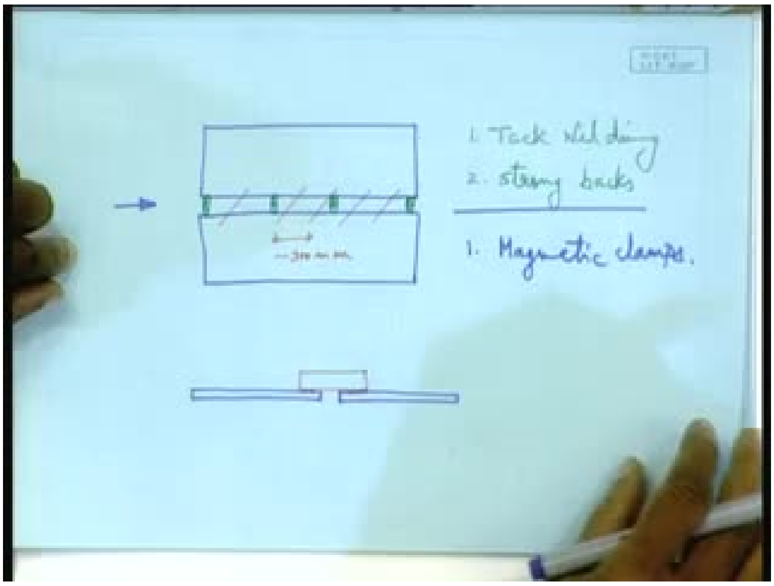

Similarly, here, to maintain the so called alignment, we can use either mechanical means or thermal means (Refer Slide Time: 17:39).

What is the mechanical means? Mechanical means is what is basically done is you have 2 plates; I am drawing with a bigger root gap. One of the ways is that something called tack welding. That means you weld smaller parts all along that; at intervals, you weld. So, this is tack welding. Before actually welding, at intervals, I deposit little bit of metal as if I am tacking the plates. So, holding them together, when I will start welding, they will not move; they are restrained.

Assume the plate length is something like 10 meters; it can be 2 meters; it can be 10 meters. That means my point is, quite a long plate and you have tack welded like this. You start welding and in all probability let us assume we are doing welding with a machine welding because I want higher productivity. So, I implement submerged arc welding with a higher welding speed. So, that leads to trying to open up. So, if only tack welding is used, you will find after sometime, this tacks have started cracking. The force will be so much that it will break off. So, that does not solve the problem. That is number 1.

Number 2: If this is the case, then when you weld, if proper care is not taken, these tack material may not fuse adequately. So, there could be a scope of welding defects in the region of this tack weld; that is another problem.

So, what is the solution? Solution is - along with tack welding, use something called strong backs. What is a strong back? Strong back is nothing but, you weld some such small pieces of plates all through. What are these? These are a cross section. A sectional view, from here if you see, (Refer Slide Time: 20:51) this is your plate, 2 plates and this strong back is nothing but, a small piece of plate. A flat bar, welded; a flat bar - these red lines; there is a flat bar welded to the plates. So, what I am doing?

First, I am putting some small tacks aligning the plate and then I have such small small flat bars of the size of 20 to 25 centimeter, some thickness, and some height. You just put them and weld them. So, if I put several such plates, they are referred to as strong back. If I weld them and then I do the welding, nothing will happen; means, plate will remain in position. That means whatever stresses are developing because of this reinforcement, they will hold it. Alignment problem is solved. I have brought in other problem; means in such a case you cannot do automatic welding.

How do you do that? Because they will be spaced, the gap between these strong backs are very small; very small means, of the order of around 300 millimeter because you give too much of gap. I mean these are actually the thing is because of these problems I mean Why I am talking so much on this is that, these problems are real life practical problems. Unless they are tackled properly, this goes by the so called the shipyard practice. In different shipyard, they have their own practice. They go by that and that practice may be wrong.

Like we have seen that in many places, this gap is even less that; means so many strong backs will be there. So, you imagine the job. You bring the plates, align them, tack weld them, bring the strong backs one after another and you go on welding them. These welding will be small welding, but you have to do that. Once that is done, then you start actual welding work. All these preparation were for the actual welding of the seam or the butt between the 2 plates. Once that is done, then you start actual welding. Now, you have problem that around every 250 to 300 millimeter, you have obstructions. So, you cannot take any electrode continuously. That means machine welding is ruled out.

Again, the same problem; because you will have to have fusion on both sides, you will have to have proper reinforcement on both sides. That is one solution, but not with this kind of setup. Because with this kind of setup on opposite side means, again you have to do on the opposite side overhead welding electrode and stick the strong backs. So, that is also not very convenient.

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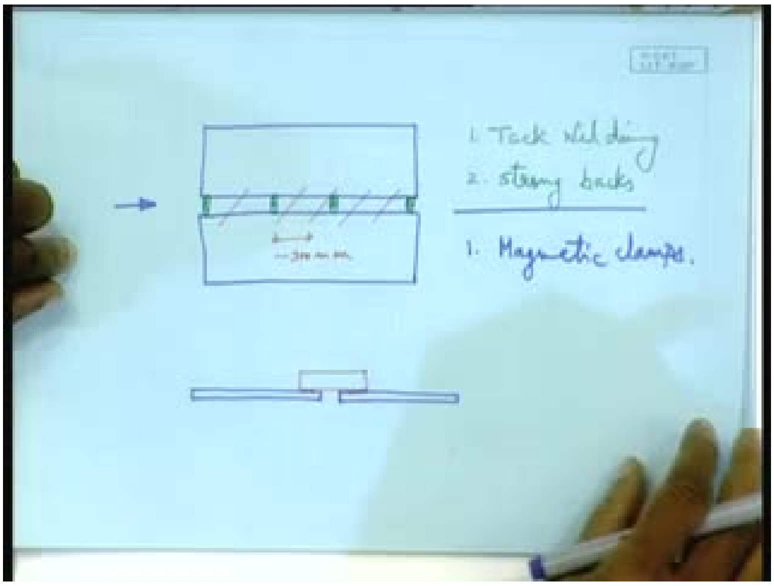

So, the process what is happening? This is a bad practice. Basically, this is not the way to do. In the process what happens? You see, if you follow this technique which is very much followed in many of the shipyards, your actual job of welding is hardly any; that means you will weld just a 10 meter long stretch or 5 meter long stretch. Before that, tripilitary work are not only alignment of the plates, also tack welding of them, putting the strong backs, welding them, and then do a manual welding of the whole thing. Even in manual welding, wherever the strong backs are there, you cannot weld below that. So, there will be gaps in between. So, after welding is done, you will have to cut out all these strong backs. They have to be removed. Then, fill up those gaps.

So, imagine the job. Still the job has not ended because when you remove this, how do you remove? Ideal would have been gas cut it, but in reality, what will happen? The worker will not have time; neither will he have patience to gas cut it. He will just take a hammer and hammer it. So, If one hammers and this thing breaks off; in the process, what happens? It retains some bit of weld material on the plate. So, that has to be ground finished; I mean if it is not grinded to a smooth finish, then again that will be a source of crack formation in future. Worst is in some cases, it will chip off, part of the parentmetal; if that has happened, that has to be re-welded. So, lot of work.

A simple butt welding will bring so much of work because of alignment. If alignment is not kept, then the welding cannot be done. Weld quality will not be to the desired quality. So, this is one of the alignment problems of butt welding of flat plates. So, what would be the good solution for it?

We have seen first solution was only tack welding; it did not work. Tack welding will work for small plates. Then, tack along with strong back - it works, but adds to the production cost heavily, adds to the production time heavily.

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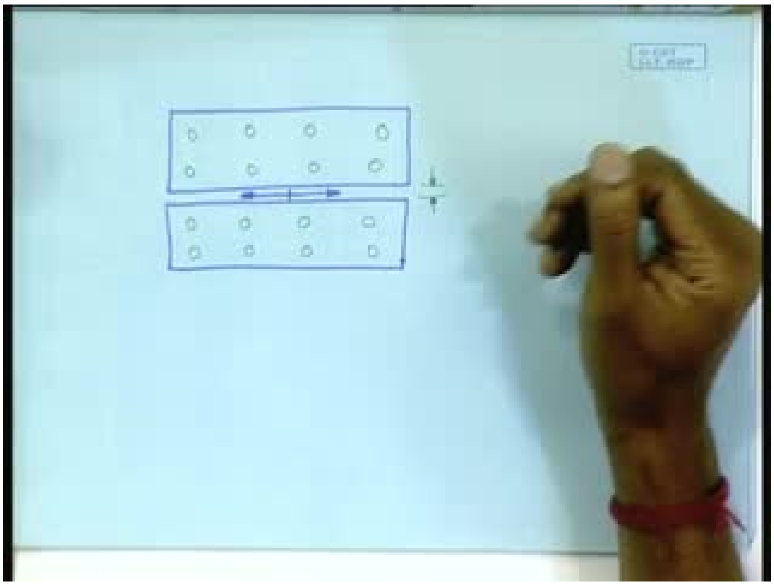

So, next solution would be having magnetic clamps. We are saying that hold it from bottom. Instead of welding this, having magnetic clamps; magnetic clamps means the plate is there and you have mechanism of their array of that; means in the welding bed, this is a flat sort of a welding station or a welding bed, over which these plates are kept and welded. So, on the bed, you will have an array of magnets.

So, once you align the plate means you fix up the edges parallel, fix up the root gap to the desired level, and then energize the magnets. So, it holds back. They can be those electromagnets. It will hold back. Then, use an automatic machine for welding. In that case, not only use automatic machine, again the same thing, redistribution of that thermal; means, apply the thermal mean. That means, from the center, one welding goes this side and another machines goes the other side (Refer Slide Time: 29:06). So, they are welding simultaneously. So, what happens? Whatever stresses this machine A is forming, machine B is nullifying them because both are having opposite things. So, that is one way of doing it so that the stresses are not developed and perfect welding is done keeping the alignment.

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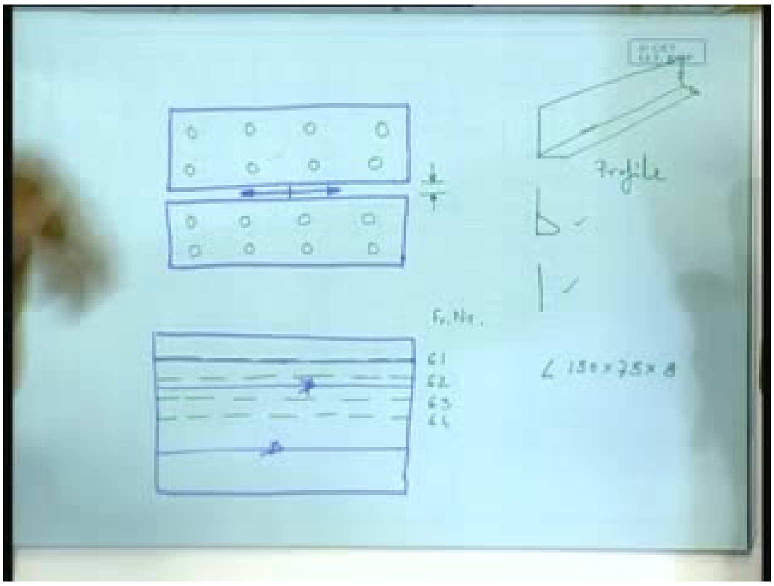

One example of putting strong backs is the example of mechanical means; you hold them mechanically. The thermal means (Refer Slide Time: 29:35) is one of these; I mean here even if I do welding from center, I am going outwards. Even these magnetic clamps are not needed, but of course, it is better to have them because there can be some mismatch in the welding speed, etcetera. There can be some disturbance, some variation of the root gap because the welding parameters or the welding procedure is so selected that it can absorb certain amount of variation; not a wide variation. So, that is one aspect of it.

So, that is how this is one of the aspect of structural alignment and that is regarding structural alignment of flat plates. Now, when we come to the alignment of a stiffener, same thing will come in case of stiffeners. So, once the plate has been welded because the sequence is first, the so called seam lines, that means the flat plate panel is fabricated. The plate panel is first fabricated and then you put the stiffeners here, our stiffeners that are say longitudinals running in this direction. So, what is done is you will have to bring in the longitudinal, locate it, and put it in the position. How is that done?

It is essentially all plates, these plates say: plate A, plate B and plate C - all these plates are marked, numbered. You know which part of the ship this plate will belong to; say some part it belongs to where you have the frames for example, 61, 62, 63 and so on. These are frame numbers, say some part of the deck or somewhere which is equivalent to these frame positions. So, all these markings will be there where you have to actually locate the stiffener.

So, how that marking is done? One of the basic operations of production operation is more of the operation in the early stage is plate cutting. When you cut the plates to the required size, from there you take the plates for shaping, bending if required. Some of them are remaining flat. On that, you start further fabrication operation of putting stiffeners, welding them, etcetera. So, when you are cutting them there itself, this frame marking is done.

So, physically the locations where the stiffener will be placed, a longitudinal will be placed, or a transverse member will be placed, are marked. Their marking is again automatically done in the flame cutting machines because a flame cutting machine has cutting torches which can follow the cutting path as it is programmed. If that is so, there I remove the torch with a marker; some kind of marker. It can be again the same thing. I program it to move along positions, and thereby, it marks the frame position. It is very simple. So, that is how this frame positions are marked.

So, the job is you will have to bring in the stiffener, put it along the frame position, and align it. Once it is aligned, then only the welding is done. So, what are the aligning aspects? Aligning aspects are like this: when you have the frame it should perfectly match with the line. Suppose this blue line is my frame line and the green dotted line is the actual stiffener line; that means it should match along that line. It will match provided the stiffener is straight.

What is a stiffener? These stiffeners are essentially or it can be either an angle section or it says bulb section in some very rare cases. It is just a flat bar either angle section or a bulb or a flat bar. Generally, these three are the group of stiffeners which may be used for working as longitudinals or transverse of different scantling obviously.

So, these angle sections have long sections. The length is, the plate standard length you get is 10 meter by 2 meters. Similarly, these profiles are also referred to as profiles. These profiles also can be of that length 10 meter. So, suppose an angle profile of say 150 by 75 by 8 means what? This web depth is 150 millimeter breadth of the flange or the phase plate is 75 and thickness is only 8, and length is say 10 meter. So, it is very heavy. While handling it - lifting it, brining it with a crane, and putting there, it may get bent. That is number 1.

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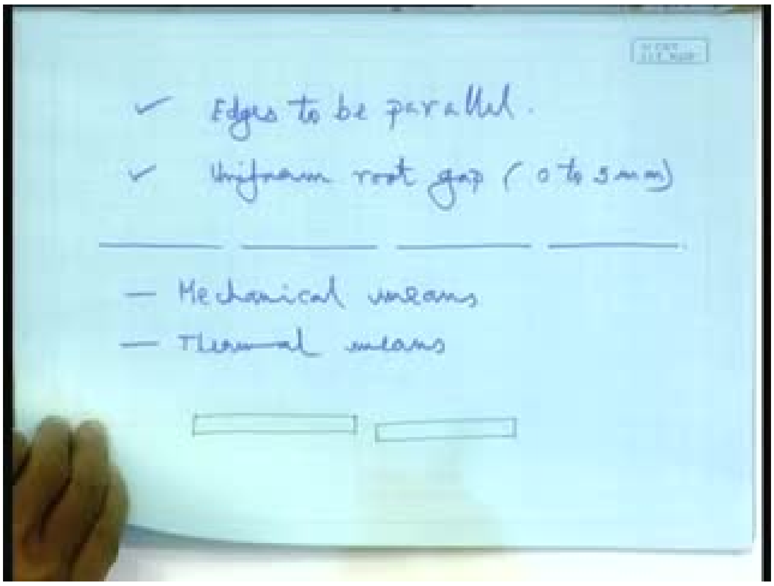

Number 2: The very section profile, which arrived at the shipyard from the manufacturing house, while keeping it, it has already got bent. So, if it is bent, you put it; it would not. You will have to straighten it. So, first operation is in the production thing. One of the first operations is straightening of plates and sections; not only that this plate, we are talking about this alignment edges to be parallel and uniform root gap. Once little bit we are going back to the alignment of plates, say this is my one plate; there can be a situation when the plate is like this; the next plate; possibly I have not drawn it properly; may be let us draw once again(Refer Slide Time: 36:54).

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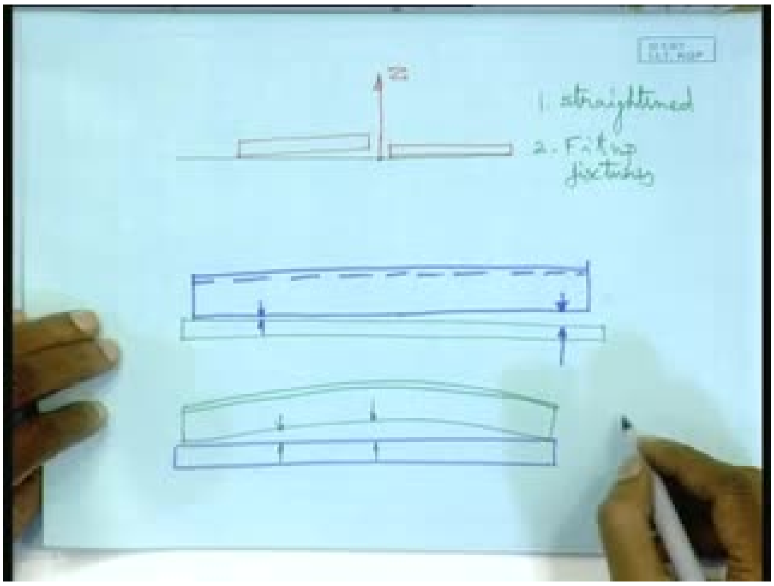

So, this surface, I mean the table where it is being fabricated; so, one plate could be like this; other plate could be like this; you have the edges parallel and the root gap uniform, but in the z direction they are not uniform; that is also a possibility. So, it is not only enough to have edges parallel and uniform root gap; also, you will have to have proper alignment along thickness; that means this should not happen (Refer Slide Time: 38:16). So, also the alignment phase, this has to be taken care of that, that not only they are parallel, but also they are in the z direction. So, it has to be in the same plane of say z 0s; if this is my z 0, so it has to be in the same plane of z 0. So, that is also needed.

Now, what happens if the plates are deformed? So, in many cases you will not have z 0; you will have some deformities. Not only that, when you are having the flat plate there, it is not perfectly flat. Your profile, when you put it on this, you may have gaps varying like this. That means suppose you have aligned the angle section and you see here it is a 0 gap; just to show you I have kept some intentional gap, but when you make a T section, it matches perfectly with the surface, but if the plate is not straight, then at some places, you will have a sufficient gap.

If the angle section itself is bent, you have the plate and the angle section is sitting like this, this is little exaggerated, but just to show, this is angle section, you see there is a variation of the gap. This is not root gap; it has to be 0. So, in such cases, one will have to take proper care to make these gaps uniform and in T sections essentially to bring it to 0, putting proper fixes. That means first step is to straighten the plates and profiles; that means first step would be straightening operations; straighten the plates and profile. So, this gives us that, from requirement of alignment, we are coming to one of the production requirement; that means first the plates and sections are to be straightened.

After straightening also while aligning because again some in between handling will be required, there can be thinner sections or what to say where section modulus is less; lower scantling material - they may get deformed. So, you will have to have proper fit up mechanisms, proper fit up fixtures which will eliminate these gaps. Those things are to be done before actual welding starts. So, fit up fixtures is nothing but, one of the simple examples, for this particular case, as you can see in this particular case, what is done?

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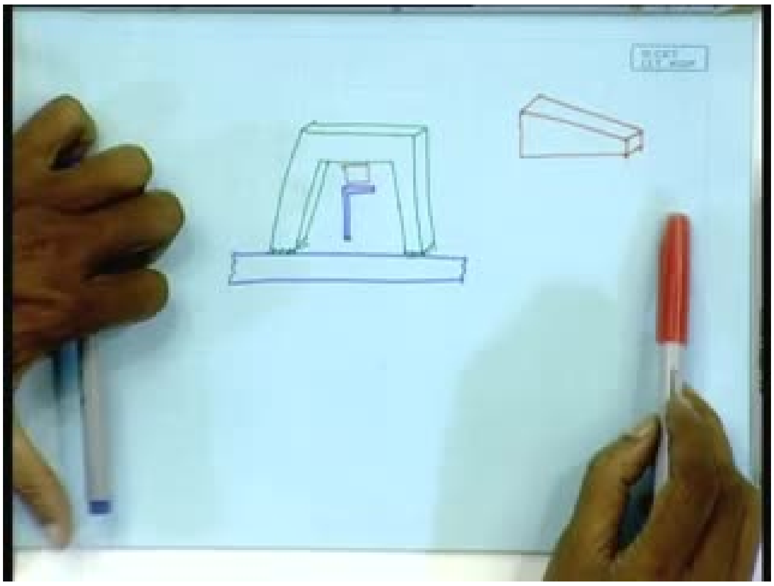

Suppose you have the plate and there is a let us assume an angle section is being aligned. So, in this particular place, I am drawing a section. So, you have this gap. So, this gap has to be made 0. So, what is done is a very simple device like this; a frame like this is welded here.

This green thing what we are drawing is nothing but a frame of a thick plate; like this is welded to this plate and then a wedge. You know these are all practical things. A wedge is inserted here. What is wedge? Wedge is a block like this, a wooden wedge; insert here; hammer it; so, it presses it down.

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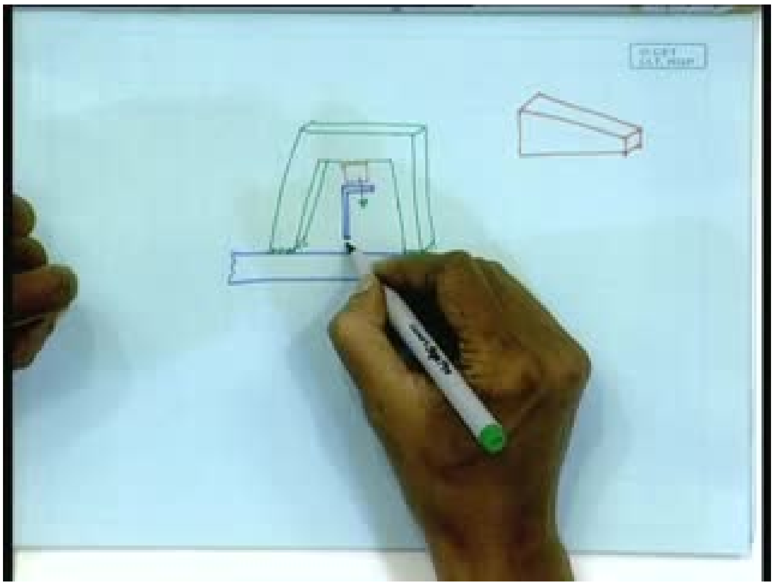

Why I am showing? There are two reasons for it. One: These are the practical difficulties we will face while actually fabricating because in drawing, it is very easy to show that you have the plate and you have the longitudinal, and you weld it. But when you do actually the job, these are the difficulties you will have to look for.

The proper alignment: Now, to have proper alignment, what are the steps to be taken? It has to have proper straightening operation. have to be done Still there is something; then you will have to have some applications; some way of doing it. So, this is one of the simple way. Put a wedge and hammer; then hammer it inside. So, that will press this longitudinal down such that this gap is then killed.

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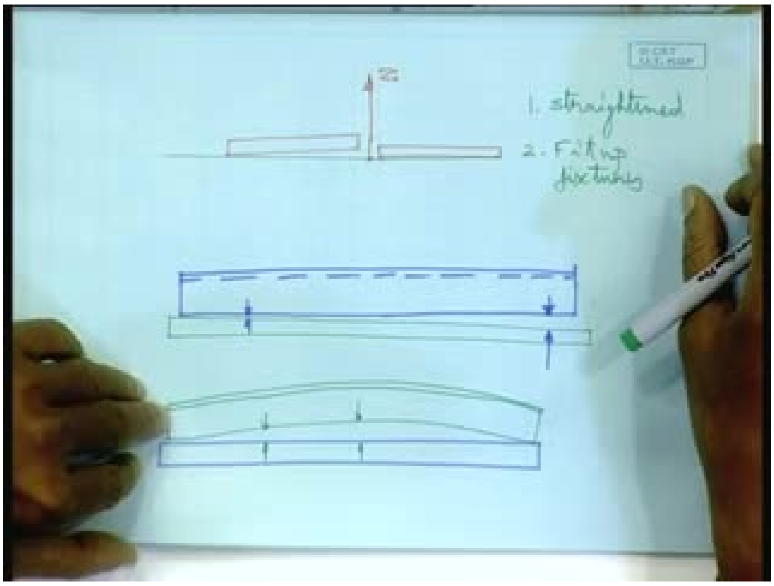

So, in that condition, it has to be now welded. Once the welding is done, then again this is something equivalent to that strong back which we did for alignment of plates. So, this is a kind of a strong back for alignment of sections stiffness. Then, it is removed again; that job of grinding these arrays and all that. So, that shows that it becomes difficult now. When one thinks of mechanizing the whole process of this alignment fit up and welding, you have to keep all these things in mind because not only, we had been talking about that, if such strong back things are put, it is difficult to do automatic welding. It is not only enough if there is a miss alignment like this; you cannot do automatic welding because in automatic welding, one of the most important thing is that dimensional accuracy of fit up.

These are very important because an automated work station can tolerate a certain level of non-alignment. If it is beyond that, the tolerance level is very low. The process will stop. If it is a manual welding also, process will stop, but the difference is you invested huge sum of money in automating the process and that is stopping. So, you incur more loss. The whole purpose of automation is lost, because every now and then, if you have to stop your welding again and just again do, then the whole purpose of automation is gone.

So, that is why it is said that it is not only enough. One of the bottom line requirements is how to improve productivity? How to increase productivity because then you become more competitive and more profit earning. So, one of the easiest answer is to implement methods and techniques, which can be automated or implement automaton. In one word that is not correct unless this background work is done; that means mechanism set for proper alignment, you cannot implement automation. So, that is actually you will have to have a proper dimensional control.

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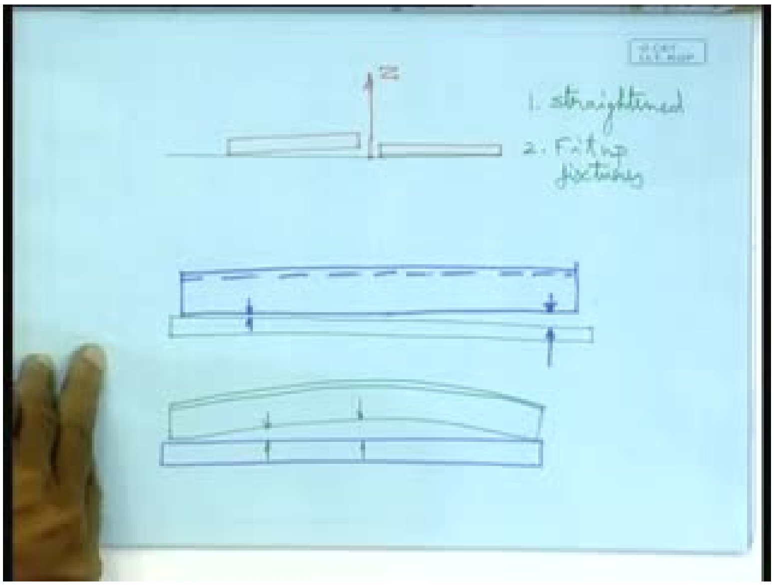

You will have to implement a proper dimensional control, where in simple words, you will be able to keep the edges parallel; you will be able to keeps the roots gaps uniform; you will be able to have alignment along thickness; you will be able to have alignment of these stiffeners. So, that is how so that is in very brief about this structural alignment.

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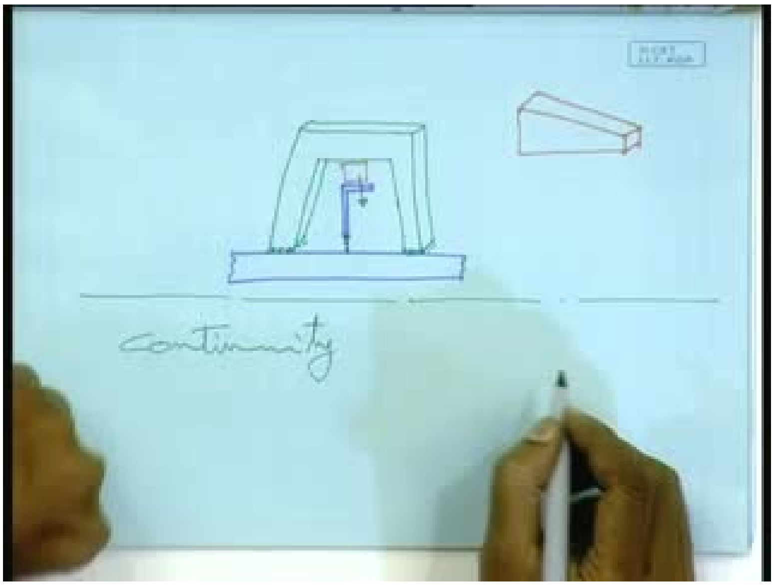

We thought of talking about continuity also. Continuity is nothing but we have already seen that, where ever there is a structural discontinuity. I mean to understand continuity, it is easier to see the discontinuity because that becomes easily visible. What is a discontinuity? An opening in a plate, the hatch opening, a hole in the bulkhead wall for the door, for window - they are discontinuities.

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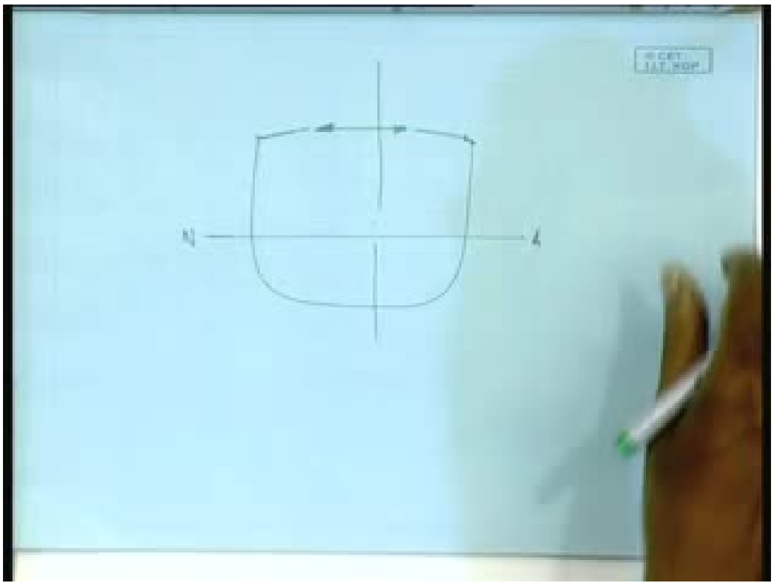

So, wherever you have discontinuity, there what is the problem? We can have strength of that particular structural panel may become weaker, may become less like, for example, you see the any section of a cargo ship, a section here. If I take about the neutral axis, the section modulus is less because this much of material is not there. Had this been a continuous structure like in oil tanker, your section modulus is more. So, that is one aspect of it, you are looking at wherever there is a discontinuity.

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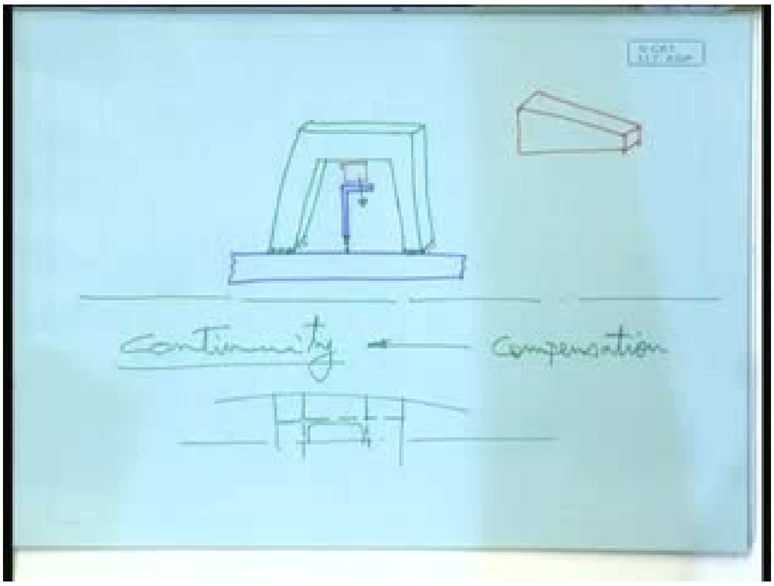

Some of these discontinuities are inevitable. You will have to have it for functional requirement. So, how to compensate for that? It would have been better to have the deck totally closed, but I cannot do that. So, functionally, I need that and that is bringing discontinuity. So, how to bring in pseudo continuousness or bring in continuity in the structure?

So, how this is done? This is done by arranging additional structural members which will compensate for this discontinuity. That means suitable compensation to be provided. What are the compensations? Well, as far as the hatch openings are concerned, you already know what that is. They are hatch side girder and hatch and beam. These are the two basic structural arrangements - hatch side girder and hatch and beam. We have not talked about hatch side girder and hatch and beam; in case of oil tanker, it is not there, not needed.

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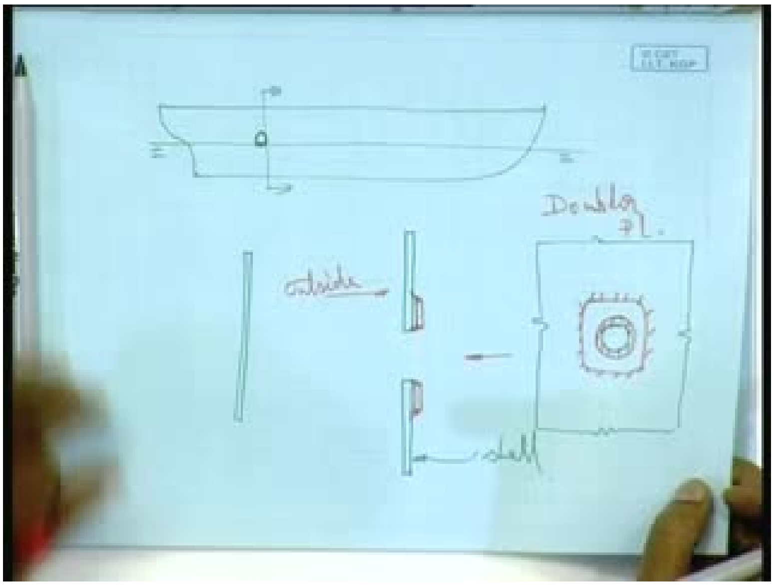

So, this is what is compensating for the loss due to the hatch opening. You can have smaller openings, smaller discontinuities, but discontinuity is a discontinuity. It can be smaller or bigger. So, you will have to have some compensation like this; this is your engine room; you may find there is an opening there; this opening is above the water line. You will see in ships openings. Some discharge, say engine cooling discharge, some discharge will be needed. There could be lot of openings there. So, there is opening in the shell.

So, what happens in this location? Along this, there is a loss of material. So, loss of section modulus will be there, but that is not great because the size is much bigger; opening is more, but it may give raise to stress concentration locally. So, one of the ways is providing doubler plating. What is doubler plate? So, this is the part of the shell structure, or may be through this section, we are drawing. I am drawing a little enlarged. So, this is the shell plate where the opening is there and you provide a doubler plating. This is my outside; this is the outside hull.

So, provide a doubler plate is nothing but additional plate welded to this; this is welded. What is this? If I see from here, you have an opening. You put another plate here and weld it. It is called doubler plate; so, another plate I have provided and welded. So, that provides for additional strength; locally that hole was cut; so, it compensates for that.

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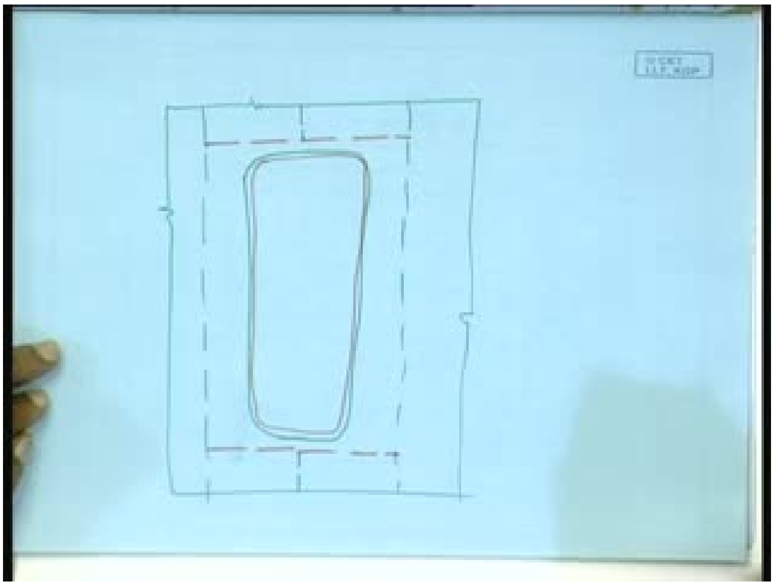

In cases where you have a plate panel and you have a door opening, say this is my deck where you have a door opening. So, opening is coming like this, quite a big opening and the plate had stiffeners in this fashion. This stiffener has got cut. This has also got cut and there you have the stiffeners.

So, this stiffener in the way of falling, in the way the spacing of stiffener say 500 millimeter and your door opening is 600 millimeter. So, you will have to cut one stiffener. So, what is the solution? Provide additional stiffener. There is a local additional stiffener provided. That has got cut; the structure has become weaker. So, you provide additional stiffeners. Not only that, in this cut edge, you provide for additional stiffening of the edge by welding a flat bar all around; a flat bar is welded all around. So, thereby you compensate for the loss of strength due to this opening required for the door. This is how you ensure continuity of the structure.

So, these are some of the examples and this shows the spirit of how to ensure continuity. That means wherever there is an unavoidable discontinuity imparted in the structure because of functional reasons, functional requirement, you need to compensate for it. By compensating for it, as if you are eliminating the discontinuity; means you are bringing in continuity in the structure.

Then, we stop here today. Then, we will go for Steel Material Preparation, etcetera, in the next class.