Marine Construction & Welding

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Module No. # 01
Lecture No. # 39
Distortion Mechanism & Types of Distortion

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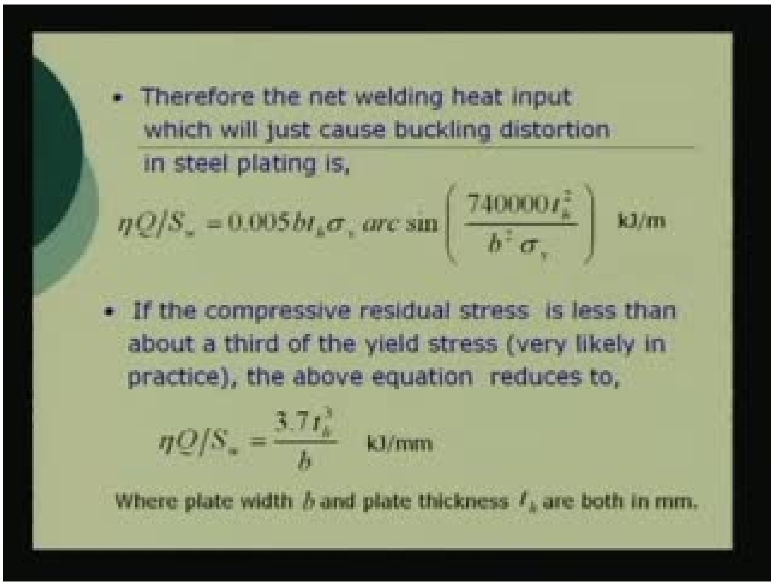

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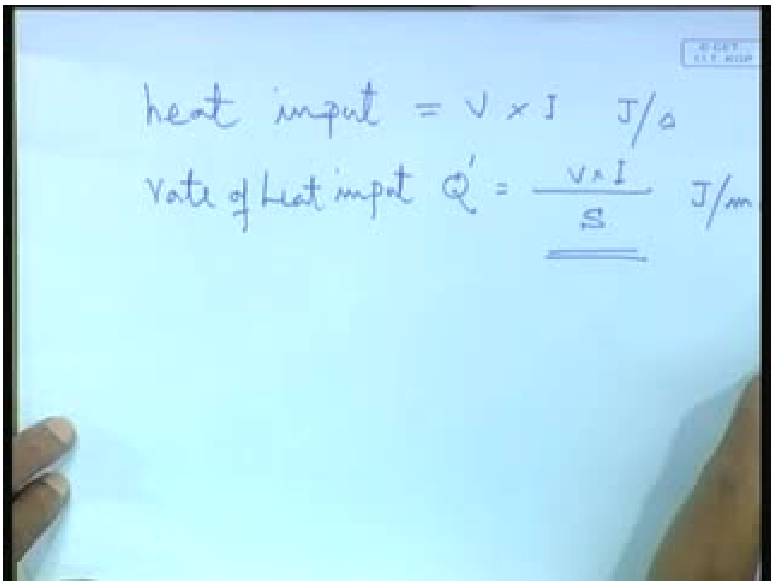

Continuing with distortion mechanism and types of distortion, we have been talking about buckling distortion. So, what you saw that when the heat input, the rate of heat input this heat input is an important parameter in welding.

This heat input is nothing but the amount of energy being used, that is voltage into the current, volt is the arc voltage, and I is the current in the welding circuit. So, many joules per second say and then what happens is it is not only enough to say how much energy is being consumed, but one is to see how much energy is going into the structure, at what rate it is going into. So, more significant is rate of heat input, which is generally referred to as by Q dashed that is V I by welding speed; if the speed is in say millimeter per second, then it becomes joule per millimeter.

So, this is what is important that means how much Q dashed, what is the amount of heat going in per unit length? Instead of per unit time, here we are bothering about per unit length that means total quantum of heat going in the structure.

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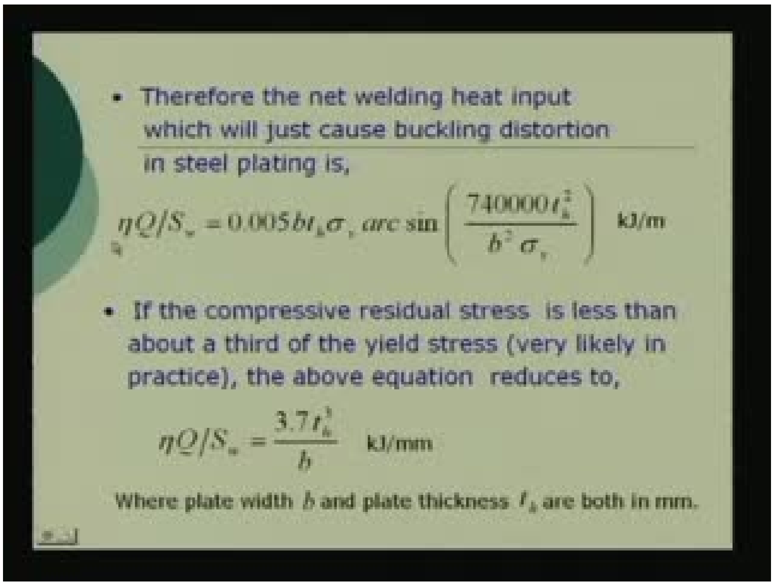

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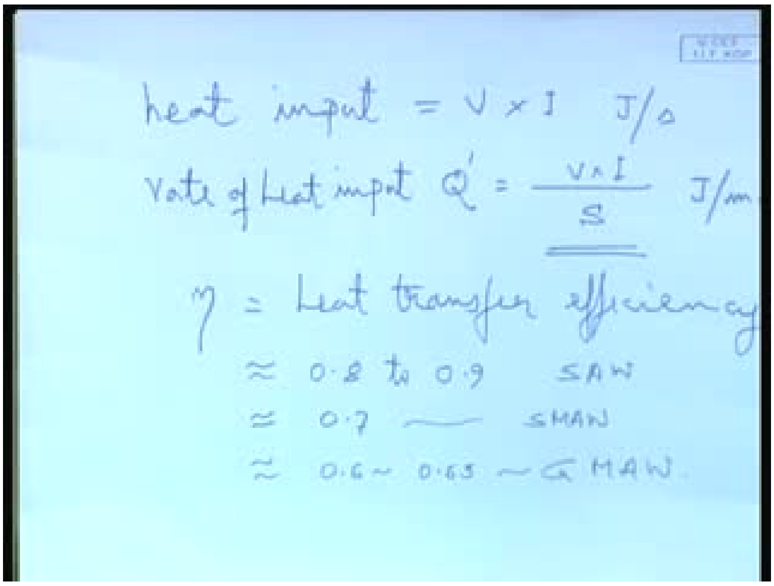

So that is what is important. That is what you can see here, it is given on the left hand side Q by s w, s w is the welding speed, and eta is a heat transfer efficiency factor. It is a heat transfer efficiency means, for different welding conditions you have different eta that means V into I is the total energy, VI divided by s is the total energy per unit length, but is that the total energy going? No, it is again factored by eta, because some of the energy is getting dissipated.

So, it is something like this it is around say, this I mean just for your information, you can note down this is 0.8 to 0.9, these figures are also important for submerged arc welding. That means what? About 80 to 90 percent of the energy is used, it goes in the structure; when it is going in the structure or in the plates means, I would say it is being used to heat up the plate, to melt the plate, etcetera.

It is around 0.7 in case of shielded metal arc welding manual welding around 0.7, it is around 0.6 to 0.65 in case of gas metal arc welding. You see it was maximum in submerged arc welding and minimum in gas metal arc welding that is very well expected. Because submerged arc welding if you recall, it is covered with a layer of flux, and the entire arc column is covered by a flux.

So, heat lost due to radiation and natural convection is minimal, whereas in gas metal arc welding a strong jet of gas is there to provide the shielding; so that is taking a lot of heat. So, it is so less 0.6 to 0.65and shielded metal arc welding it is somewhere in between because that flux is burning and forming the slag, it covers that molten pool; so heat loss is less.

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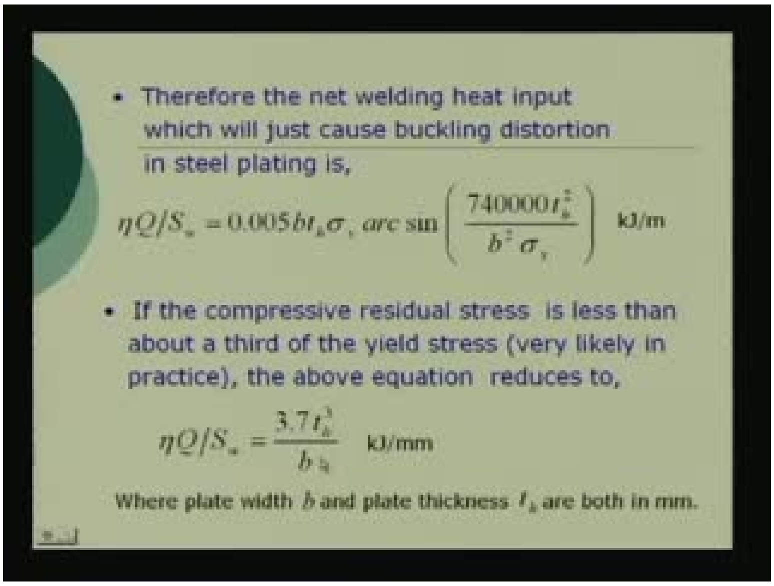

So, this is the heat transfer efficiency. So that is how we see the left hand side it is giving the amount of rate of heat input, which when equals to this particular figure, which is given on the hand side, which we get that if it becomes equal to this then it says that buckling may start, it may cause buckling with these parameters. So, I calculate this and then accordingly set this.

So, I may be able to avoid buckling. Like here, it has been further simplified why? Because the compressive residual stress here, we have mentioning that if the compressive stress, residual stress is less than about one third of the yield stress, which generally happens. Because what we are trying to do is find out very simple numerical tools which can be easily implemented and checked, for a quick check before finalizing the welding procedure. Welding procedure means, the welding method we will be following, the welding parameters we will be using.

So, here I can take that value equal to one third of the yield stress, then these equations simplifies to this. It is only 3.7 this thickness cube by b, b is the breadth of the plate, width of the plate, and t h is the thickness.

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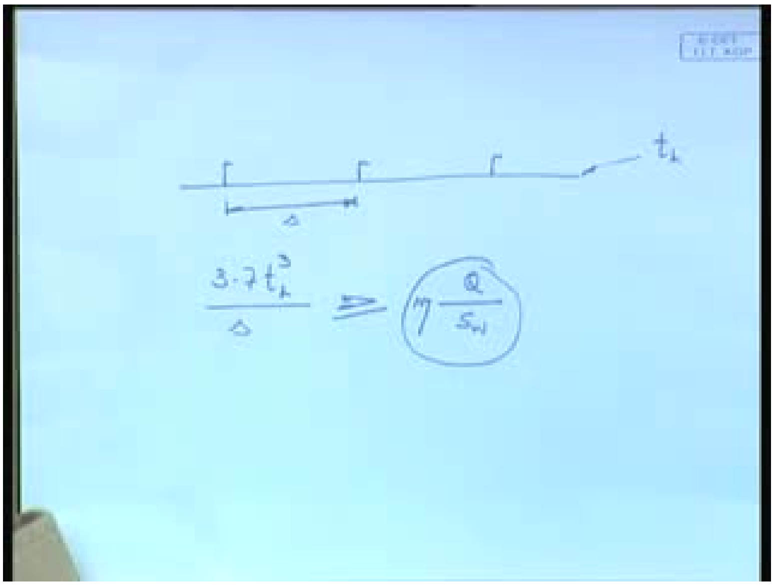

So, for a given plate structure suppose, you have to fabricate a stiffened panel like this, you have this is my frame spacing s. So, what I calculate this plate thickness, thickness is t h, so what I calculate is 3.7 t h cube divided by s whatever value it is giving that should be my i should be finalizing the weld parameters, such a way that it remains less than this figure.

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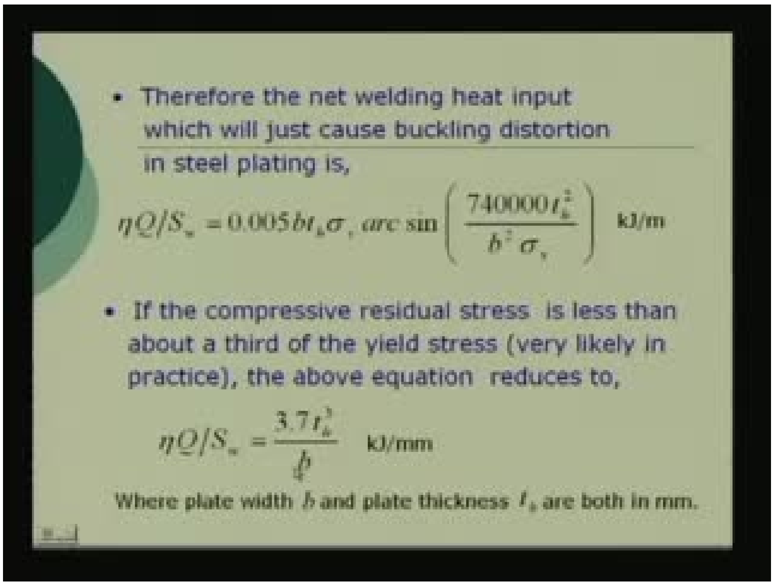

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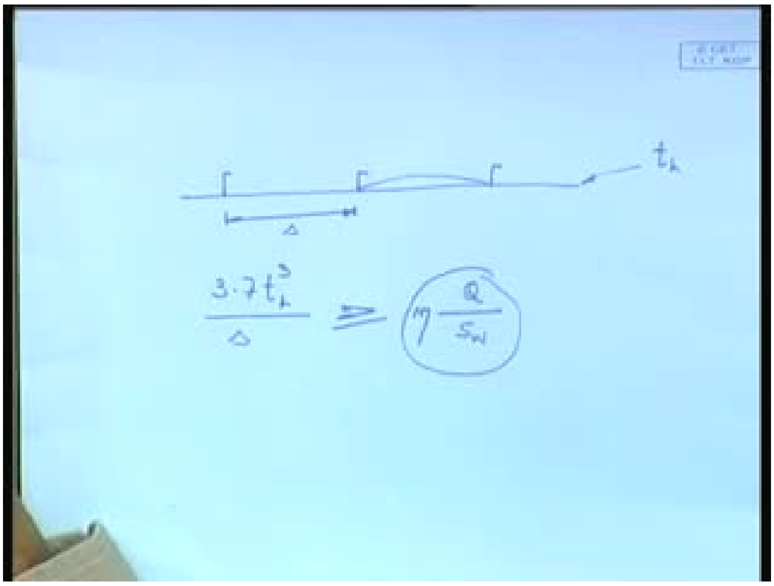

This b, here in this equation this b the plate width it is actually in case of a stiffened panel, the width spacing between two stiffeners, because it will tend to buckle between these two. So that is my plate breadth and the buckling stress does not depend on the length, it will be along that length in which the compressive in plane stresses are working; so these are actually the s, so 3.7 t h cube divided by s.

So, this gives me very easy factor through which I can calculate and then check with the welding whatever Q s w I have worked out, such that, that figure remains less than this figure then I can say well, possibility of buckling deformation is less. Because you see if buckling deformation takes place it is very difficult to remove that, so one tries all means to remove to control prevent buckling deformation.

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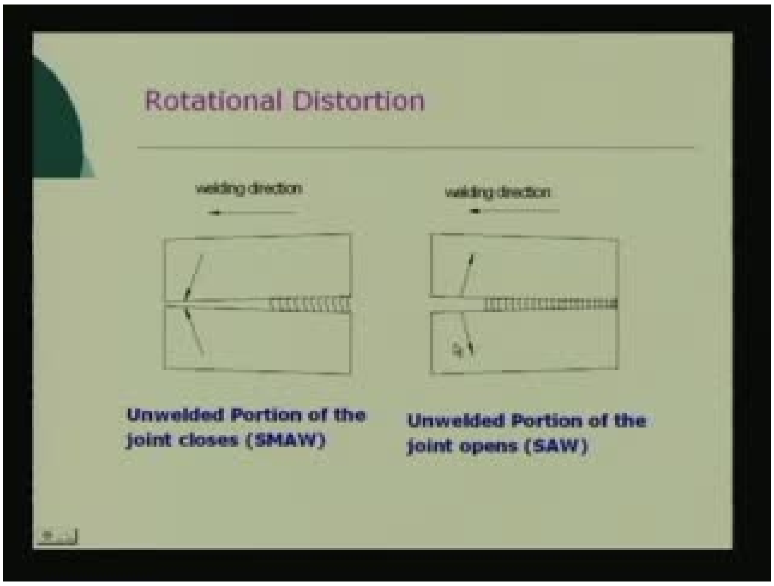

Rotational distortion, this is another very typical type of distortion. As you can see in the figure, there the two plates are being welded; in one case, this un-welded portion is closing as the welding is progress suppose, from here it has started the root gap design root gap is this much what you can see at the beginning, from this my welding direction so it is started from here, so much was the root gap say, root gap was 3 millimeter or say 5 millimeter design root gap. It means what the plate edges were aligned to have a uniform 5 millimeter gap and you started from one end progressing to the other half way through, you will find that the other end it is closing and truly if you continue plate will overlap, they will simply overlap. So, as if the plates are rotating, so that is how it is called rotational distortion. In another case, as you progress then you will have to stop physically because the root gap it opens up, it opens up so much you cannot weld. In both the cases you will have to stop because in one case they are overlapping you cannot proceed; in another case they are opening up so much, you cannot proceed.

So that closing takes place when the welding speed is when you are doing a welding with a method whose welding speed is slow. That means if say 10 meter long, 2 plates are there you are welding with a manual method with shielded metal arc welding, you will find as you are crossing almost the half of the plate you will gradually find that the gap is becoming less and less and beyond half the length that means 5 meters is over you will find, you would not be able to proceed any further because they are touching. If you forcibly try to forcibly means ignoring that you try to put more heat and weld, it will just one will ride the other that happens in case of shielded metal arc welding. So, why it happens?

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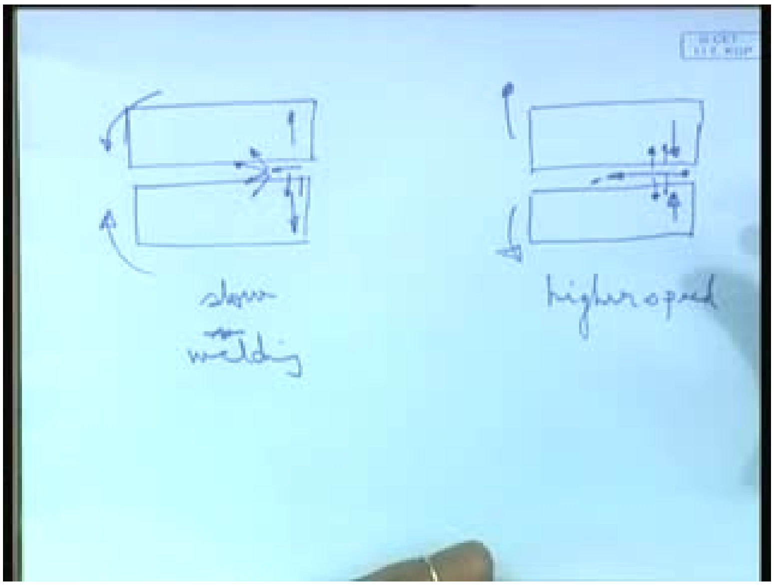

Whereas in the other case it is just the opposite, it opens up that means, what basically is happening? In one case forces are acting as if to the edges are rotating in this direction that means, here they are tending to go in the opposite direction that is how the other half is tending to close.

In the other case it is just the opposite, it is in the slow case, slow welding, and in the higher speed welding it is happening just the opposite case that means the plates are going outwards; if this is going outwards means these are tending to come inwards at this end, this is in higher speed welding.

So, basically what is happening? In the higher speed welding means it is going very fast means, the heat flow in the forward direction is absolutely nominal before any heat can flow, it is going faster; whereas in this case it is going very slow, heat flow is substantially in the forward as well as in the side. So, the shrinkage forces are more and the heat flow in the forward direction will be more, whereas in this case there will not be any heat flow, whereas heat whatever heat dissipation it is only in the transverse direction, there is no heat dissipation in the forward direction because speed is fast enough.

So, before a significant heat flows in the forward direction, because heat flow it takes, it happens in time domain that means it takes it is not instantaneous phenomena. It takes time for the heat to travel to flow, but if the speed is significantly high then what happens? Whatever heat is flowing, heat dissipation that will be transverse. Transverse means more shrinkage force is at the back; so it will tend to close. In a higher speed welding, more shrinkage forces at the back of the weld, at the trilling edge of the weld means welding is progressing by, shrinkage forces are generating at the back.

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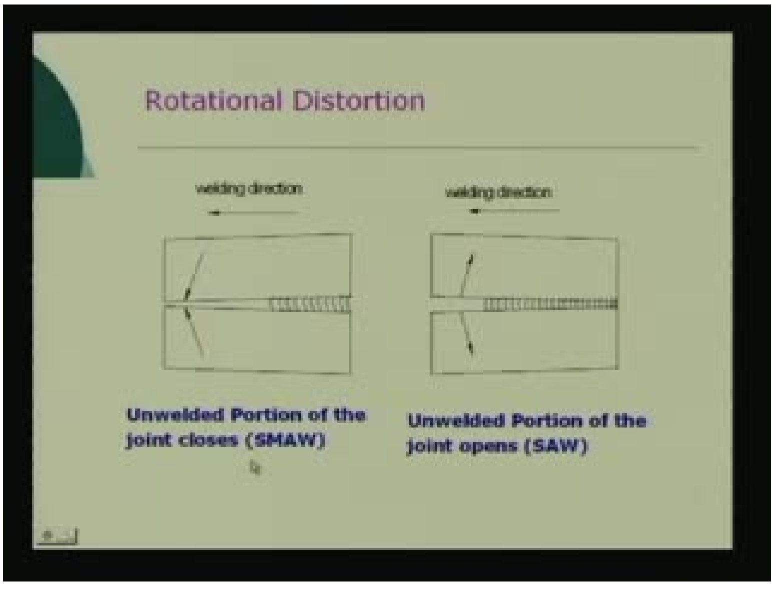

So, if it is generating, it will be balanced by an opening force kind of, opposite will act. Because any forces anywhere it should be balanced somewhere. So, balancing that will cause a moment to rotate it outwards, whereas in the slow welding process the weld speed is slow. Generally S M A W means manual welding. Here, I have mentioned S M A W, shielded metal arc welding it is a manual welding and here I mentioned submerged arc welding that is an automated welding. So, I can go for higher speed. In slower speed what will happen? The heat flow in the leading edge of the welding will be substantial; so contractional forces will work in the front also and we will try to close it.

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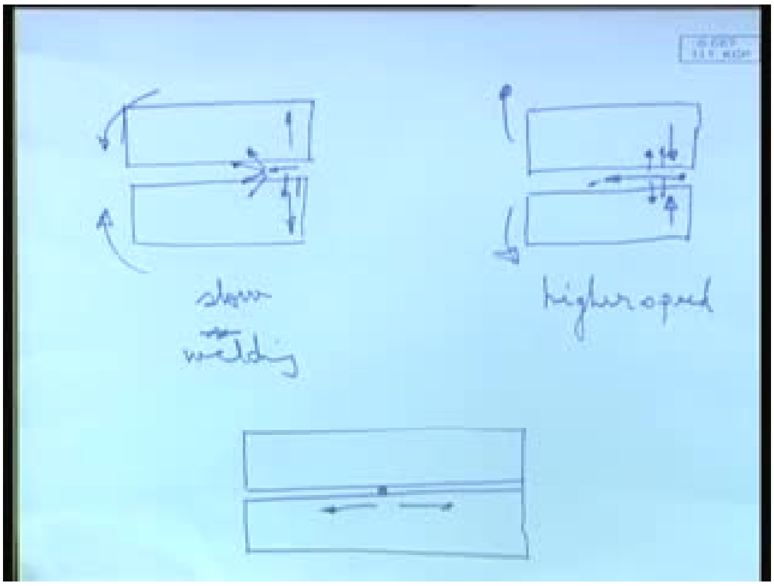

So that is how, these are the problems that means for a long welding run, you cannot weld from one end. So, what is the solution? You have to start at the middle and go both wards I mean outward, start at the middle that means for a long welding, whether it is a manual welding or an automatic welding, immaterial. Because in both the cases you are having difficulty either it is opening up or it is closing, the difficulty is same that means you cannot weld.

So, the best is to start from the center and go simultaneously outwards then this will negate the effect of this, go simultaneously outward. So, one from the center to the positive side and center to the negative side, each one will cancel the effect of the other; so there is no problem. So that is the only solution, when a long run long welding is done, it is necessarily to be done from center going outward, you cannot do it from the middle, I mean from one end.

So, these are the various methods or various types of welding distortions as well as mechanism of those distortions. So, what you need to do is, now there would be we can see these welding distortions are unavoidable as such as it appears (( )) that are unavoidable. Because my objective is to join and the process of joining is by mean applying some thermal effect that means, I melt the material and thereby put them together.

So, naturally the process involves heat the process involves heat flow and the moment there is a heat flow, there will be a differential in expansion and contraction. The structure is such that they are at some places, they are un-restrained some places, they are restrained and the structure is huge. So, uniform expansion is not feasible, neither uniform heating nor cooling is also not feasible. So, everything leads to one thing that is unavoidable distortion.

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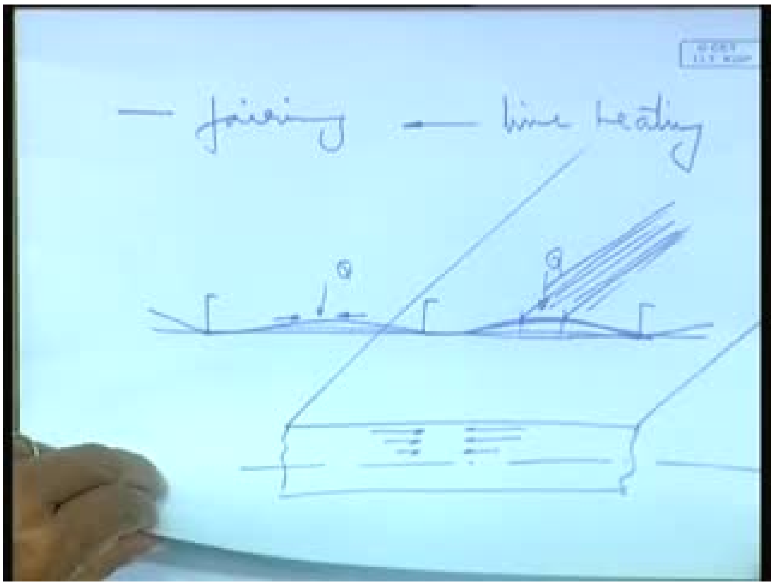

But these are undesirable things happening. So, we will have to look into the aspects, how we can get rid of it. So, getting rid of it could be by two ways - one is let it happen and then do fairing, by fairing I mean deformation has taken place. Now, you have to try to straighten it, obviously that is not a very good way of doing things. Because you do additional work, once welding is done and then you implement fairing techniques, such that you negate those deformations.

One of the fairing techniques is by use of line heating, because as you have already seen in line heating, when I am applying it in a controlled fashion, I am getting a curved plate out of a flat plate; same thing works, I apply it to a curve plate, I get a flat plate that is also true like here.

When this buckling deformation has taken place suppose, here angular thing has taken place; here your buckling has taken place. So, how to reduce this buckle part? If I apply heat here, what will happen? A contractional forces, shrinkage forces will work. The plate will shrink, once the plate shrinks it will tend to flatten out. So, because it has buckled in these directions means what, the plate has elongated at this edge on this, surface plate has elongated. Now, I shrink that how can I shrink? Same way I apply heat, apply heat in this fashion. You see in the thickness, this is the part of the section along with thickness, so when I am heating again, this is the along this plate.

So, I am heating only some lines like this, along this, along this it has buckled, along that if this is my y axis, along the y axis it has buckled. So, along that y axis, along this lines if I heat, heat means what? I am applying the heat here, so heat is penetrating.

And it is creating shrinkage forces again in the same way not uniform, but maximum at the top and gradually less.

So, it shrinks the upper plate and gives a bending movement. It shrinks the upper part more, the bending it cannot do, but shrinks. So, I will apply in such a fashion that it remains above the neutral axis more, a controlled heating. So, it tries to shrink, so it comes down means, it flattens up that is what is line heating.

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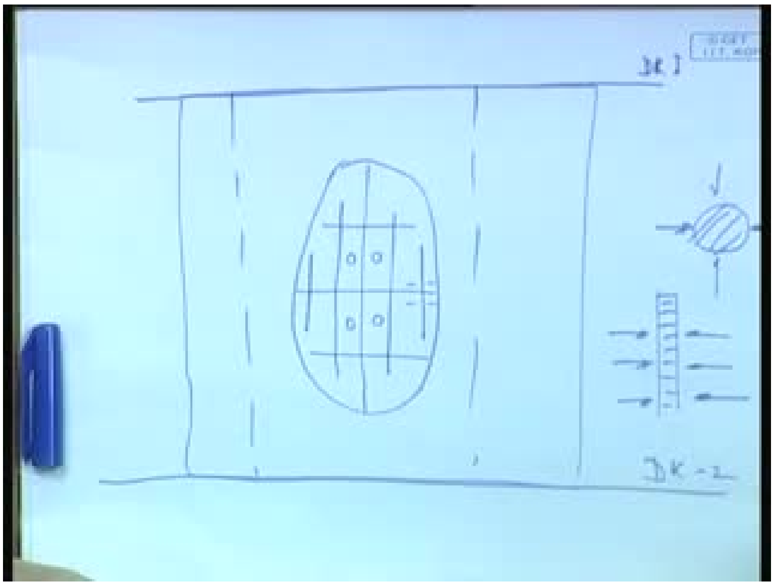

Now, thus we will not go in detail of this. Various ways it is done, I mean through by sport a combination means suppose, say this is your panel, this is one stiffener, this is another stiffener, this part has buckled what will happen is, you will see a flat panel this is welded to a deck. Suppose, deck number one this is welded to another deck, deck number two. This weld that is say deck number two, this is deck number one, the one of the side accommodation bulk head you have the stiffeners. So, in between, it will buckle between the stiffener that buckling will not because here it is welded; so that will be a straight line, the buckling will not be there again here it is restrained, but in between it is free.

So, this will buckle, it will bulge out like this both direction. So, what you will do? You will have to do the shrinkage, so how do you do? You give a hitting line like this, then another line like this, gradually you are reducing. So, this tries to bulge, reduce the bulge, it shrinks; along every line there is a shrinkage taking place in this direction, a shrinking.

Similarly, now it has a bulge in this direction also, you may need to give certain hitting lines like this. In addition to that spot, because in spots what is happening? It is shrinking from all direction. A circular zone if you are heating, so it will shrink from all direction.

When there is a longitudinal heating, this is a heating line means it will not be a line, it will be a wide zone depending on the heating torch, say a zone of ten millimeter. this

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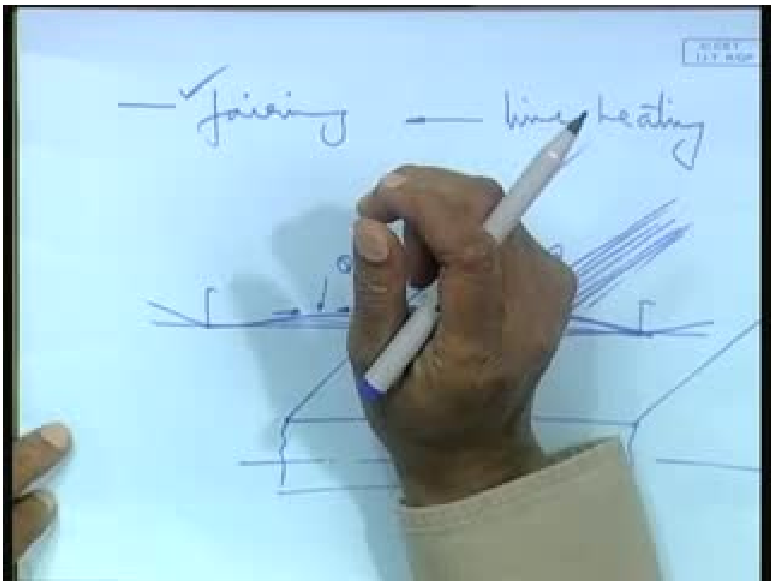

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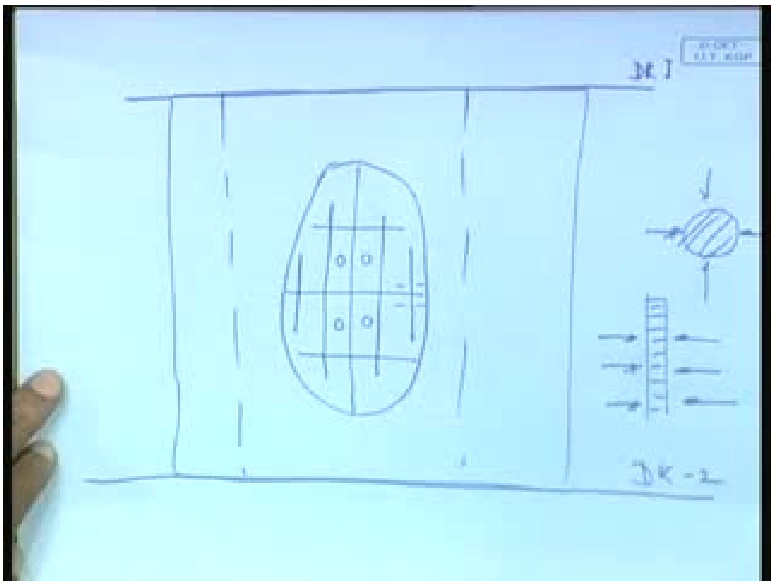

So, here the predominance shrinkage is this, along this. So, this is a combination of heating lines both vertical, horizontal spot; so that is what is called fairing. This would be one way of combating or mitigating, I would say weld deformations, but obviously that is not a good practice because this is a quite a lot of work purely a manual work and also skill based one will know how much to heat and where to heat etcetera.

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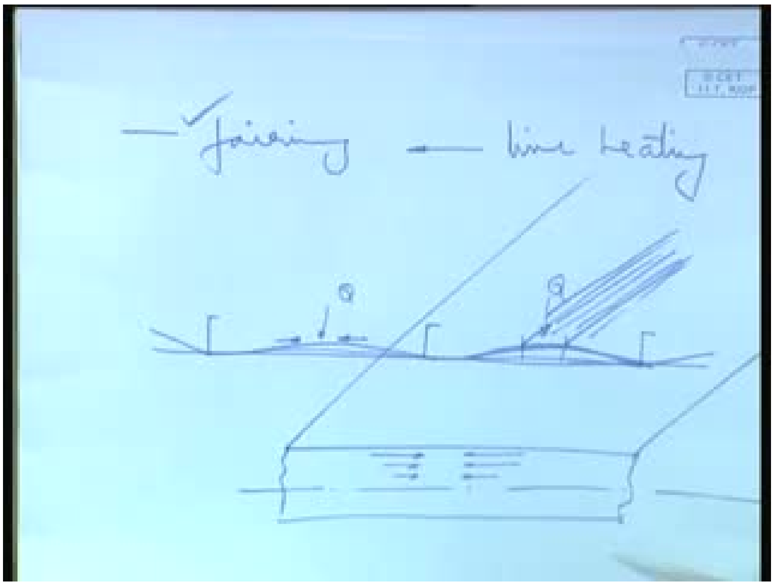

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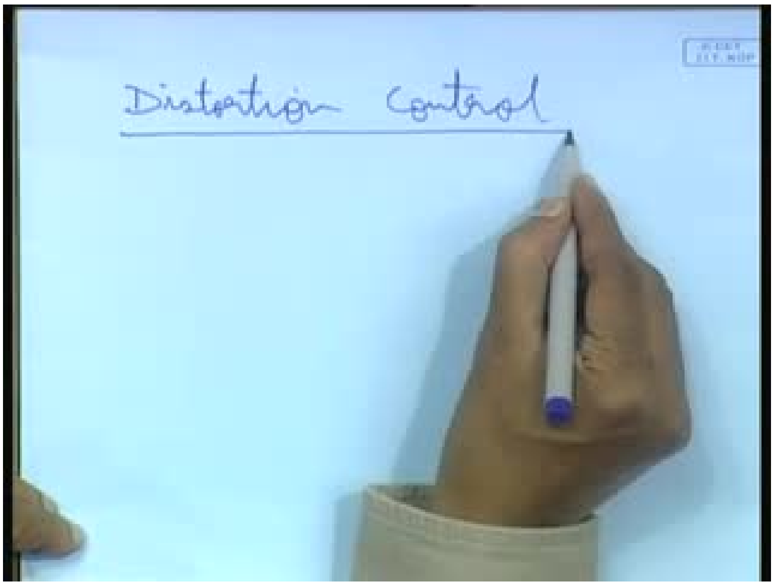

Simple thumb rule is heat on the convex side obviously, because I want to shrink on the convex side, it has elongated. So, I want to shrink; so heating on the convection side that is fairing best would be distortion control that means that I do the welding in such a fashion that I do not let it happened. I control it across and that to control in real time, real time means whenever the welding is being done, such that the distortions are minimized by control means obviously the objective should be to eliminate, but well if not possible to eliminate at least to minimize.

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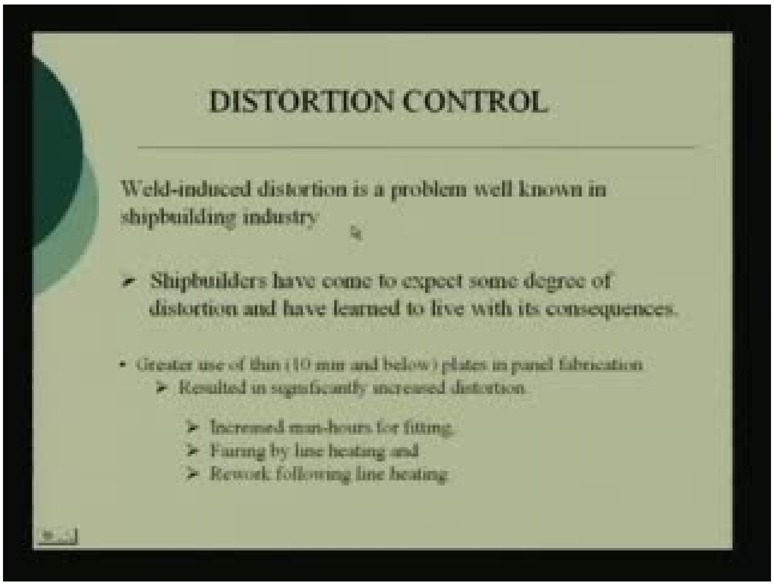

So, what we see is now is that this is a problem which is weld into ship building industry that means this welding is distortion, it is a ship building industry is very much aware of this problem and this is one of the interesting observation. You can see I have mentioned here that ship builders had come to expect some degree of distortion and have learned to live with its consequences what does this mean? This means that you expect distortion and you are satisfied with it complaisant it happens. You cannot help it that is the kind of attitude because truly as you have seen, if you have to welding distortion will happen.

So, they are forgetting the aspect of control if I do not implement any control mechanisms, then I know it will happen and cannot help it. You will have to bear with it live that is why I say, learn to live with its consequence. What are the consequences? well consequences One of the consequences is rework, fairing if at all I mean if at all means, if you have real difficulty after that major difficulty is alignment. Because one panel has distorted means the other panel matching will be difficulty. So, lot of rework is needed such that you do that alignment.

Next, since the panel is not flat enough, so further erection of any item or equipment anything becomes difficult, because they will not fit because the surface is wavy. All deformations primarily will be angular or buckling because all are panel structures; you have stiffeners, so in between it will either buckle or will have angular deformation.

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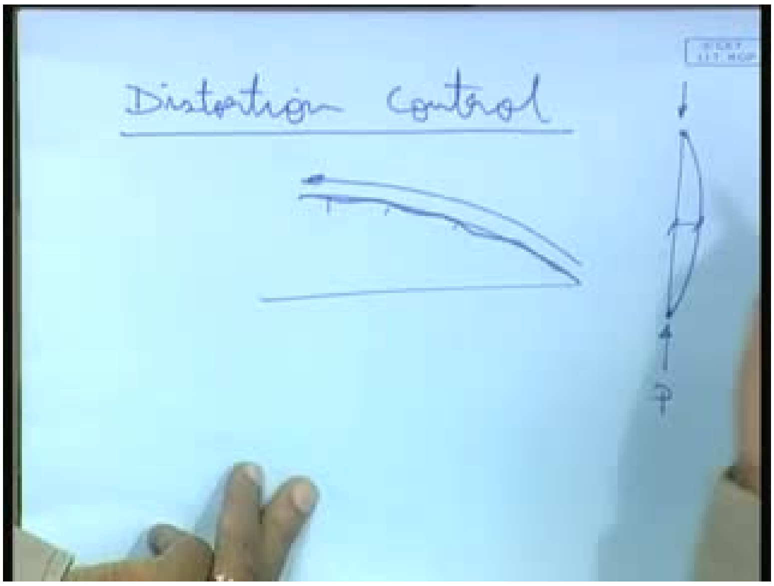

Third well, because of the shrinkage, the end alignment - panel to panel alignment as I was saying that will not match. Fourth is one as you deform structure, it is structural buckling strength has drastically reduced. Buckling is what, if the in-plane compressive load I mean ability to sustain in-plane compressive load. Now, if the plate is already deformed then it is no more, whenever there is in-plane compressive load, it is just a compressive load. It is a bending load because in in this case it is a compressive load in-plane when it exceeds the critical buckling load it buckles, but if it is already like this then just a little load you have so much of leaver, a bending load. So, structural integrity has reduced, load bearing capacity has reduced and lastly esthetics has drastically reduced. Because if you look at the hull structures I mean the ships, the four part of the ship primarily one finds or even at the middle part that you can see the frame lines inside.

Suppose the side central part of the hull is transversely stiffened like in that of a bulk carrier, the hold, the side shell is transverse stiffening that means vertical stiffeners are there. So, we can see the stiffeners from outside see means, those lines and in between the plates have bulged in that is what as if they ribs of a hungry horse. It is called hungry horse look. A hungry horse, starving horse, he is thin down his ribs are deep surfaceableare visible. So that is a not a pleasant view and other aspects are like the deck suppose, the deck is undulated means buckling has taken place, deck is longitudinally stiffened say in between the longitudinal it has buckled.

So, what will happen? When it rain, water will remain accumulated. So, corrosion may increase. Functionally it may become not very comfortable, because it will give raise to those fungal growth algae and all that. So, it may become slippery for the crew to work on both boat. Apart from your corrosion, the hull is wavy; so it may add to your so called hull resistance. Because the flow pattern may change from laminar at the fronted may become turbulent because the hull is expected to be smooth. Instead of smooth, it may become like this, wherever the stiffener is there, in between it has bulged in.

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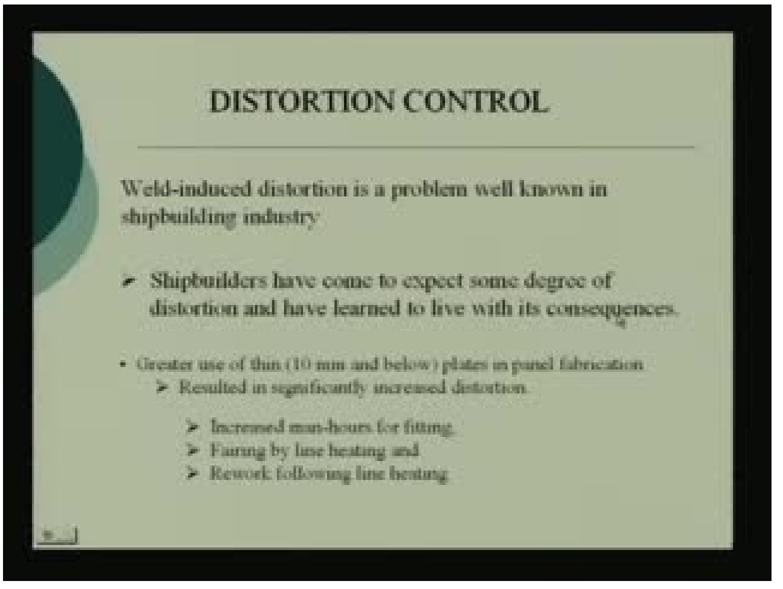

So, the flow may get disturbed, resistance may increase, so all aspects. So, one will have to either that is what I am saying that people have learnt to leave with its consequences. It will happen wherever it is unavoidable, you try to implement fairing measures distortion fairing measures that means line heating and there is no other method because by hammering you cannot straighten it impossible.

So, only method is some thermal treatment. You cannot take back the structure to the roller and straighten it. So that is at the basis of it and then what do we see that greater use of thin plates in panel fabrication. This distortion control is becoming more and more important or has assumed more importance because of much greater use than ever before thinner plates in panel fabrication, thinner by the time end 10 millimeter and below how we are going to use thinner plates? More and more people are inclined to use higher tensile steel, but for specific applications generally this is not a case. In case of so called merchant vessel construction, but naval ships there is a higher degree, higher use of higher tensile steel why? Just to reduce the weight, for reduction of weight because there you may require much higher speed of operation and you cannot have a higher performance craft. You will have a so called buoyancy supported displacement vessels because the size and weight is such that you cannot have a plaining craft or the hovercraft as a say frigate or any metal shape, but at the same time you want to attain high speed means high power engine; so keep the weight low, high tensile steel.

So, for all the accommodation structures the entire deck house they are generally of plates of 4 5 millimeter thick, so thin even 3 millimeter, but high tensile steel 3 millimeter plate. So, it is very prone to buckling primarily buckling when thinner they get, buckling is the problem.

So, any way that has result in significantly increase distortion because of these thin plates. So, what that leads to? It leads to increased man hours for fitting, firstly that alignment all that problem then fairing by line heating. You will have to faire because the distortion so much it becomes difficult to align other things put the equipment or whatever, hen again rework following line heating.

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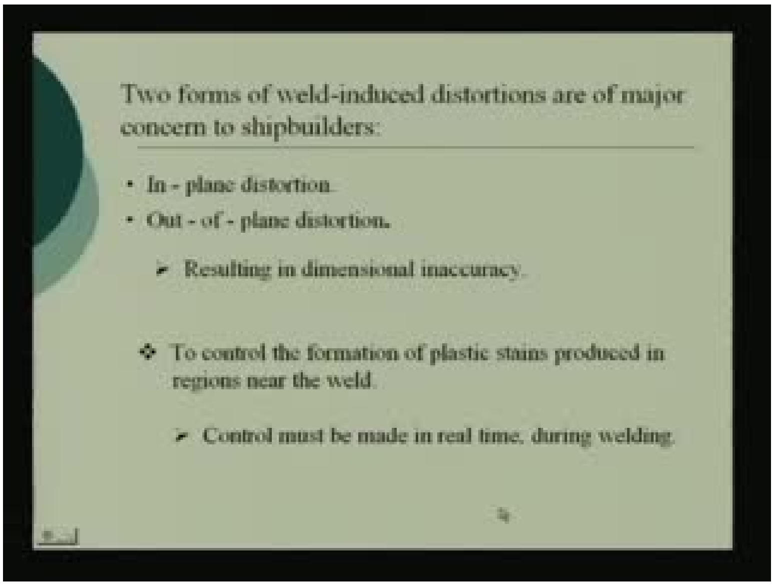

So, what do we see that we have already seen that types of distortion there. We are saying that here, we have grouped into in-plane and out of plane deformation. In-plane deformations are essentially the shrinkages as we said, out-of plane are the buckling and angular deformation.

Rotational deformation is an in-plane deformation, whereas buckling angular they are the and warping one we have not mentioned. I mean, the whole structure it buckles angular all together it rotates, but primarily those are the 4 deformation types, it can be combination two, three things happening together it may result in some other type of shape.

So, all these results in dimensional inaccuracy what I was only talking about. So, to control the formation of plastic stains produced in regions near the weld that is what distortion control means. We will have to implement methods and measures, such that we can control the formation of plastic stains because that plastic stains are forming that is leading to deformation, which are forming near the weld zone in fact. Because away to from the weld zone nothing is happening, away from the weld zone is essentially well the effect of the distortion is becoming visible why? Because the plastics stains are forming near the weld zone and they will form, where there is a higher temperature differential; temperature rise to place only near the weld zone weld zone and the adjacent material to it.

So, control must be made in real time during welding. Unless the control is in real time, then the purpose is not so that means you do welding and come back for repairing that is no more control, it is rework.

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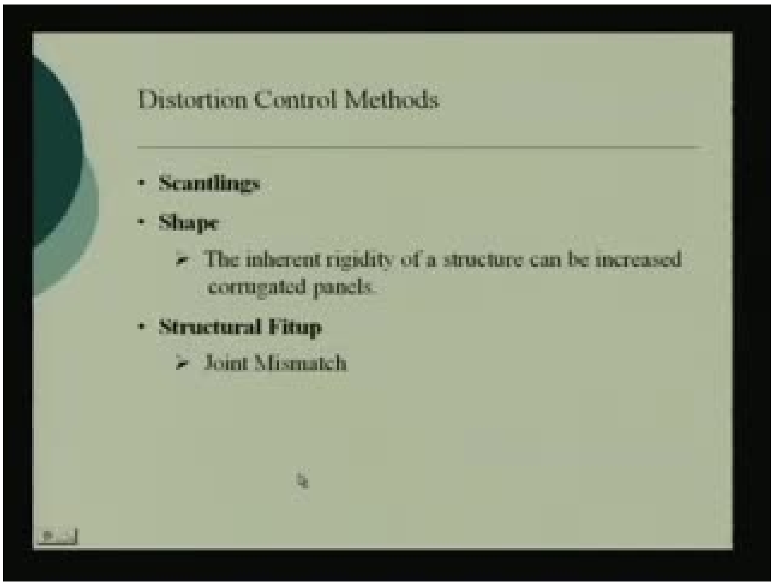

So, it has to be control means try to see how it can be reduced. So, what are the various distortion control methods? We will see in brief the first and foremost is scantlings, to work on the scantlings. Obviously, thinner the plate more deformation.

So, very simple advice would be, do not go for thin plates, but that is the thing that means, one will have to see where there is no requirement. of what do you call. I mean you can sacrifice the weight go for a thicker scantling, bigger sections why? Because you sacrifice the weight and what do you gain? You gain in terms of production quality, you gain in terms of less rework, if deformation takes place you have to fair that all these cost, money, time you gain in that.

So, if it is possible to have a thicker plate, instead of say a 4 millimeter plate, if I can use say 6 millimeter plate go for that. That means using a higher tensile 4 millimeter plate and normal strength steel 6 millimeter plate, it is preferable to use 6 millimeter. Your deformation might be less, provided you can afford to increase the weight of the structure a bit. Cost wise this will be cheaper because you have more steel weight, but less costly steel; less steel weight, costlier steel, high tensile steel.

So that means when you decide for steel I mean construction material of construction the point here is that one should keep in mind this aspect also. When I decide, whether i will use a high strengthen steel or normal strength steel decision will not be best surely on strength requirement definitely not, also not on strength to weight requirement as I said before that. Never any material decision to be taken purely on the basis of strength it should be strength to weight ratio, because strength I can achieve whatever load is coming I can design the structure in such a fashion that it can sustain the load. I increase the thickness of the plate of the scantlings whatever.

So, strength to weight ratio, what is the strength to weight ratio is coming to that again this is coming another aspect. That means if I go for a little lesser strength to weight ratio that means I increase the weight of the structure, I gain in terms of buckling strength. Such that because of welding, distortions will be less that is aspect that means in the production side one we will have to see.

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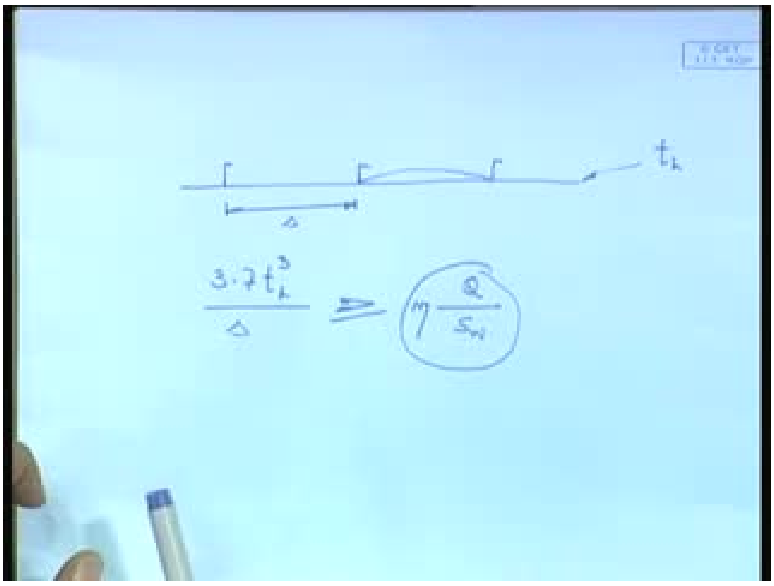

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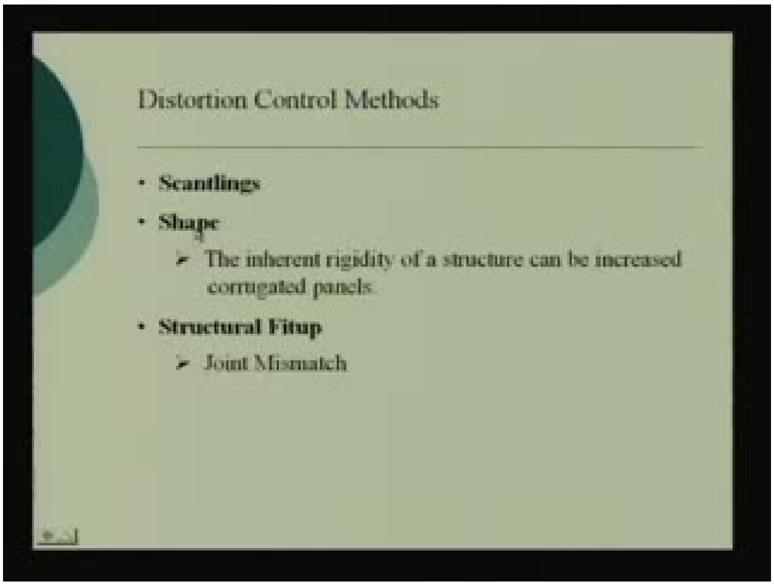

So, while deciding on the scantlings one should take a look at the scantling, such that a higher scantling means always chances of buckling less. Frame spacing 800 millimeter there, we had been talking about this s, if I use higher frame spacing it becomes more prone to buckling for the same thickness lesser frame spacing it is less prone to buckling, but lesser frame spacing on other hand, it may increase the weight. So, all these aspects are to be same that means scantlings one will have to also take a look. Then shape of the structure like the inherent rigidity of a structure can be increased by corrugated panels.

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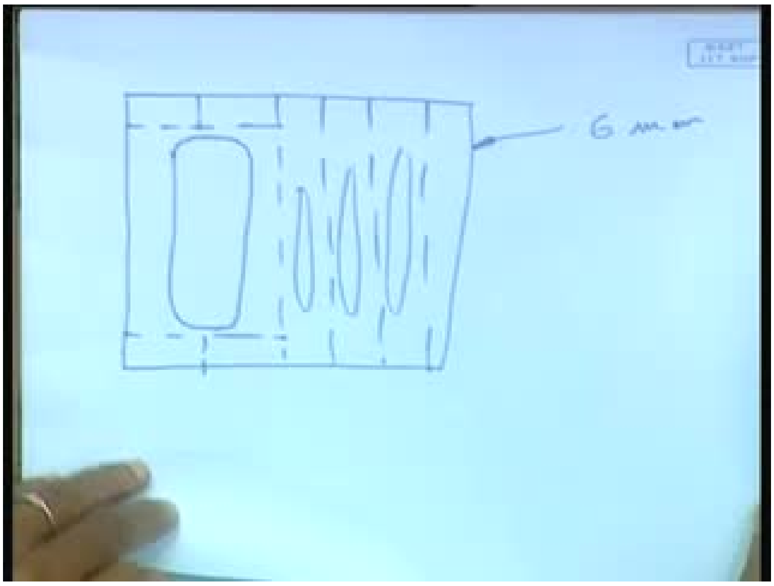

One of the simple examples is when you are talking about say the accommodation bulkhead, accommodation bulkhead means what? Suppose, I am just drawing a vertical accommodation bulkhead here you say, you have the door opening and rest what do you have? You have the vertical stiffeners, such stiffeners are there I mean assume, one of the one of the wall of a accommodation region one of the accommodation bulkhead you have a door opening and vertical (( )) this accommodation bulkheads are generally thinner plates 6 millimeter plate, 5 millimeter plate. In the super structure you do not need much of load is not there in any case they need to be stiffened. So, stiffeners so if you weld the stiffener, it will tend to buckle along this region because they are thin plate.

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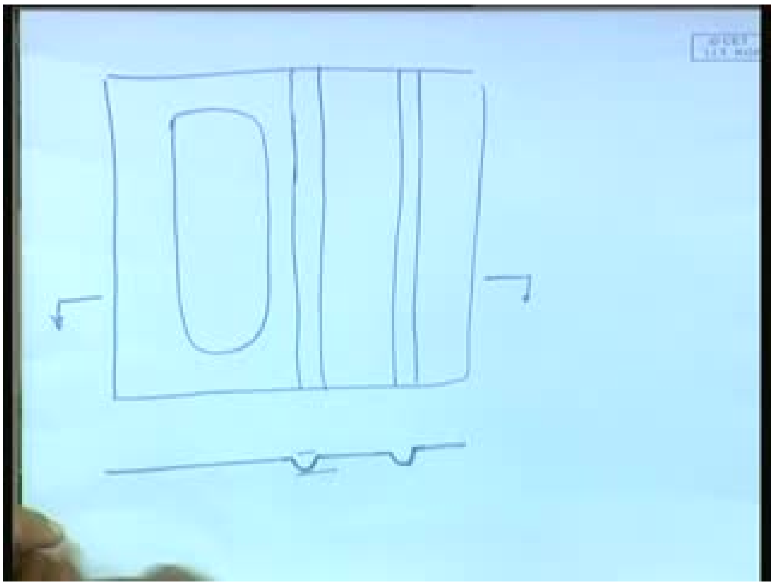

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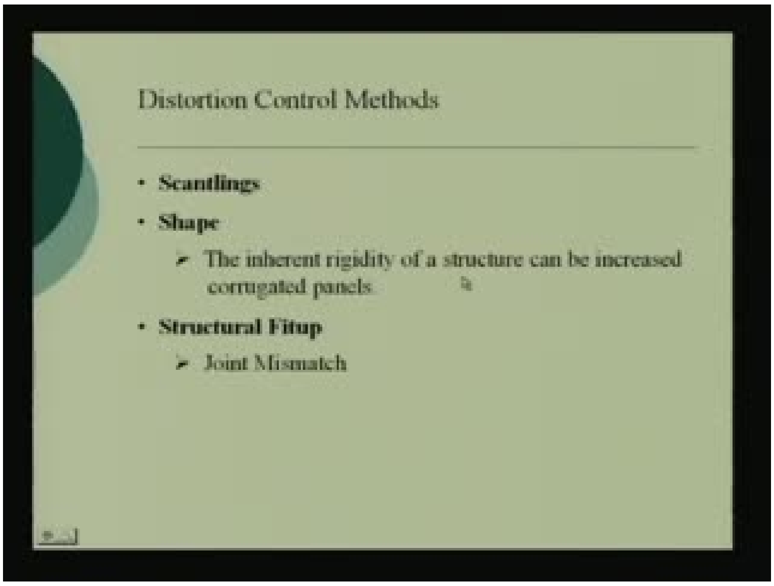

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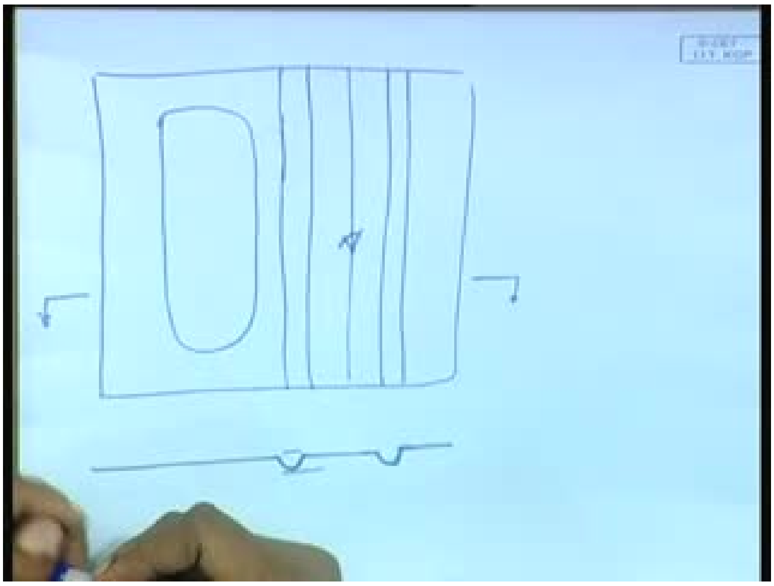

So, instead of stiffened this bulkhead if I make it of corrugated bulkhead means that same thing you have the door opening and here you have corrugations. This double line I am drawing indicating corrugations. How the corrugations are? Take a cross section just a small corrugation small or big that will depend on the design that means, the flat plate was there now i put a corrugation here, so it becomes much more rigid. Like that simple example, I show always you hold the paper like this, it bends, it does not have any rigidity, but you just give a little corrugation it becomes so much rigid. This is corrugation, so that corrugation is given. That means a corrugated bulkhead, if I make that is in the shape the inherent rigidity is increasing and I am doing it with welding I am not welding the stiffeners instead of stiffener I am giving this corrugation, how though a punch through hydraulic press.

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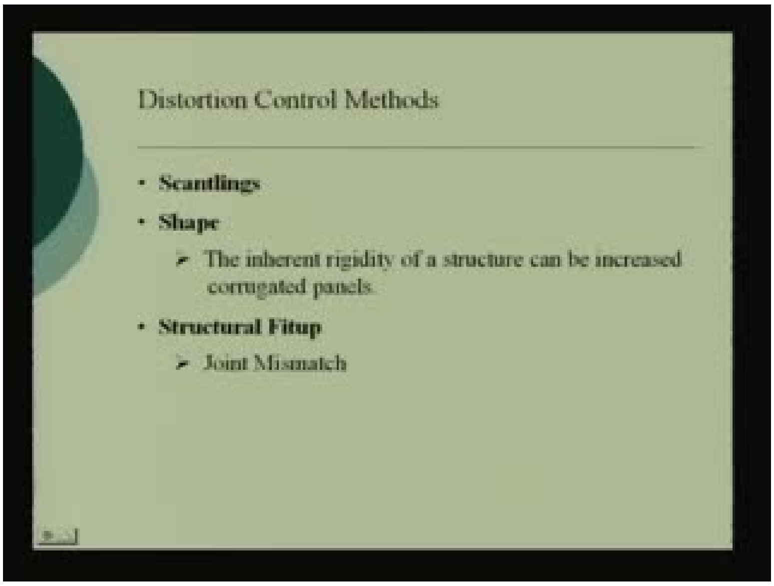

So, here what welding will come probably some butt welding's only some pieces of plates are to be welded and the strength is being provided through corrugations. So, the shape of the that is one way here the distortion control means you are avoiding welding minimizing welding.

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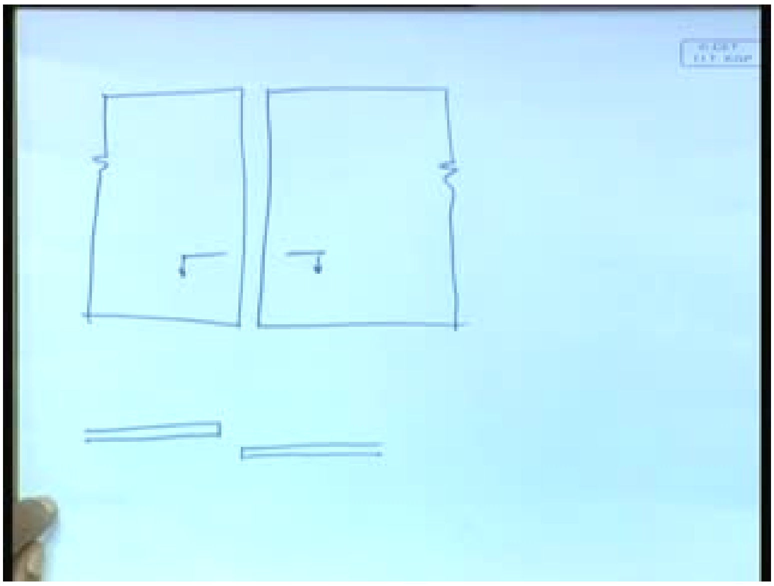

Structural fit-up that is to be said that means, joint mismatch to be avoided. Joint mismatch means what happens? These are the two plates being welded. two flat plates being welded. Now, if I look through this joint, if the joint edges are not matching there can be cases. Suppose, here I see the plate is like this, the edge is not perfect somewhere it is coming below it, somewhere it is going up. So, what you will do? You will have to So, by force you will have to align them, and the moment by force you do, so additional stresses are built up there. Additional stresses are built up, so that may lead to that may add to the thermal stresses lead to more distortion.

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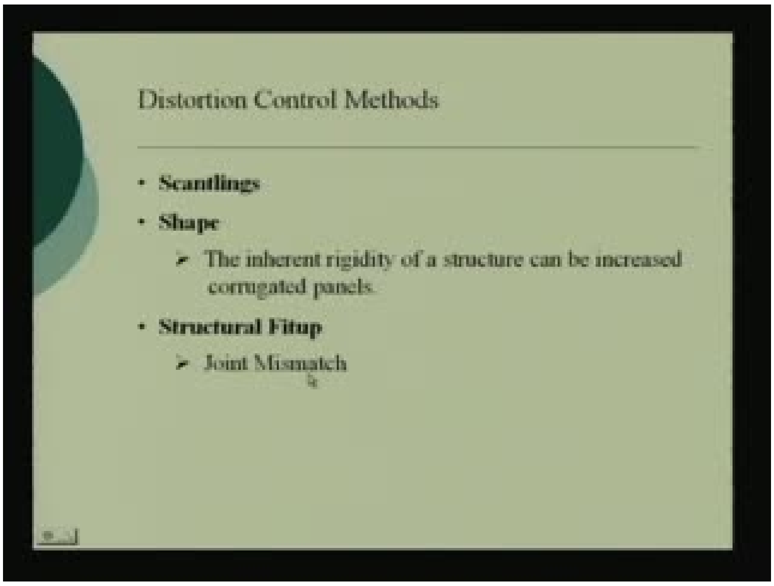

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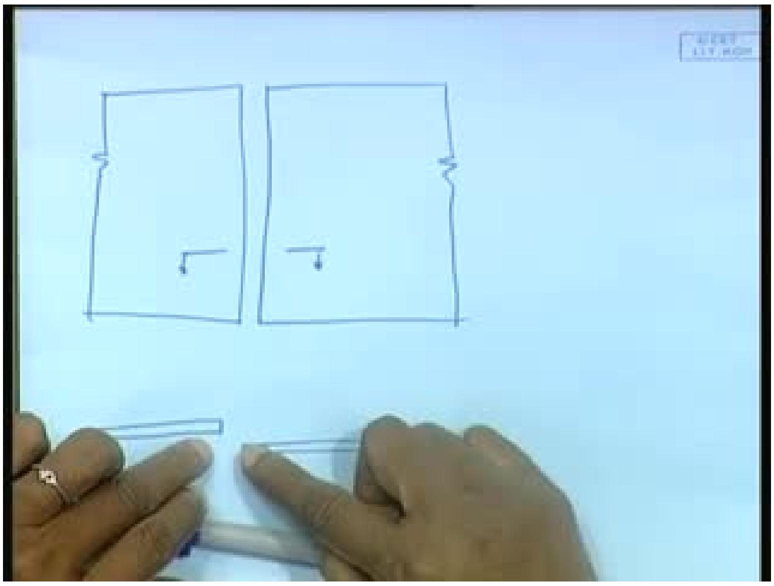

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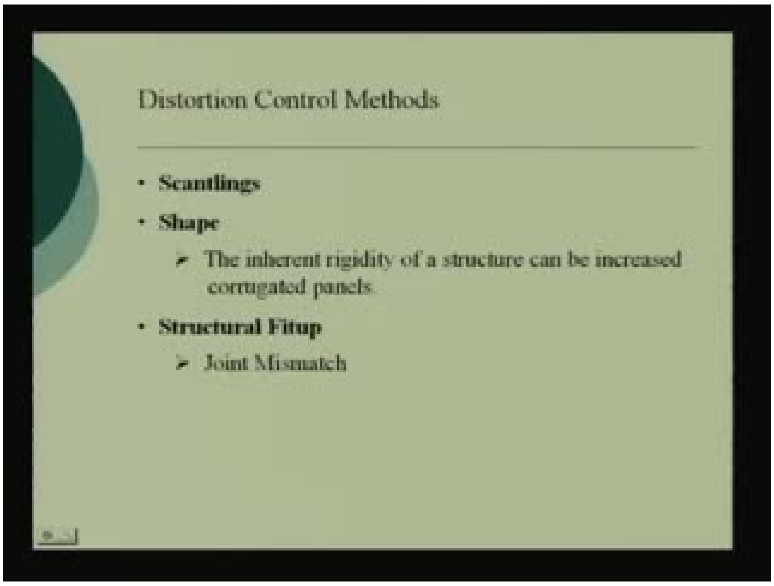

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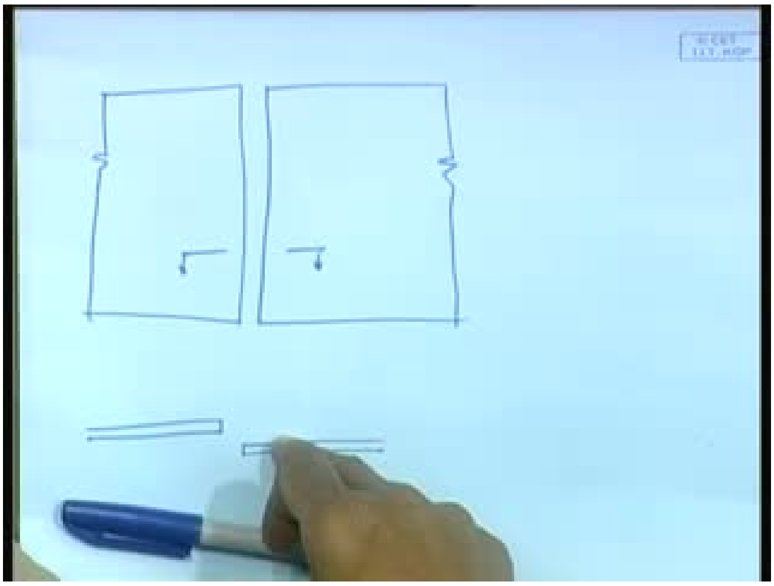

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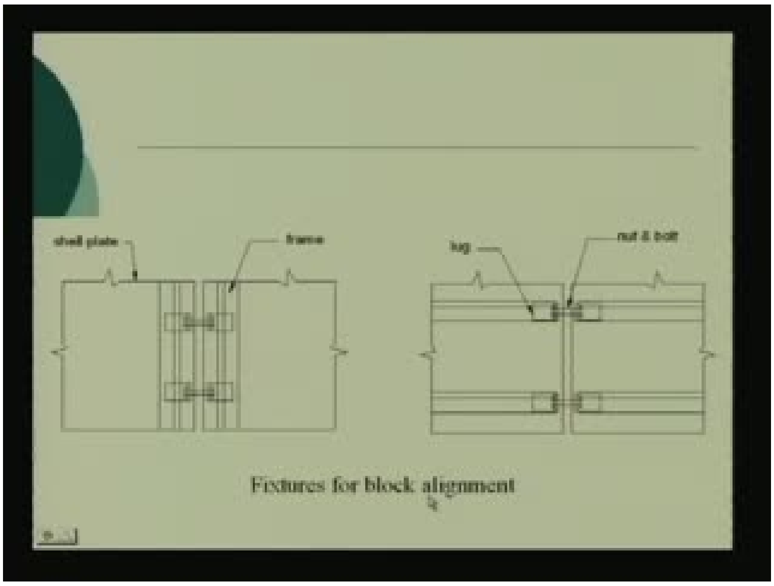

So, joint mismatch has to be avoided or in other words you will have to take care of these. You will have to first fair them and align them this one simple example there can be many other examples. That means essentially whenever the structural fit-up is being done joint mismatch has to be avoided as far as possible. Here I am not avoiding by force I am aligning them and by force means suppose a 12 millimeter thick plate it cannot just like that just lift it and bring it to the position, you have to make all kind of fixture turn buckle and lift it by force. So, this is some of the examples of anyway the joint alignment, etcetera you can leave that.

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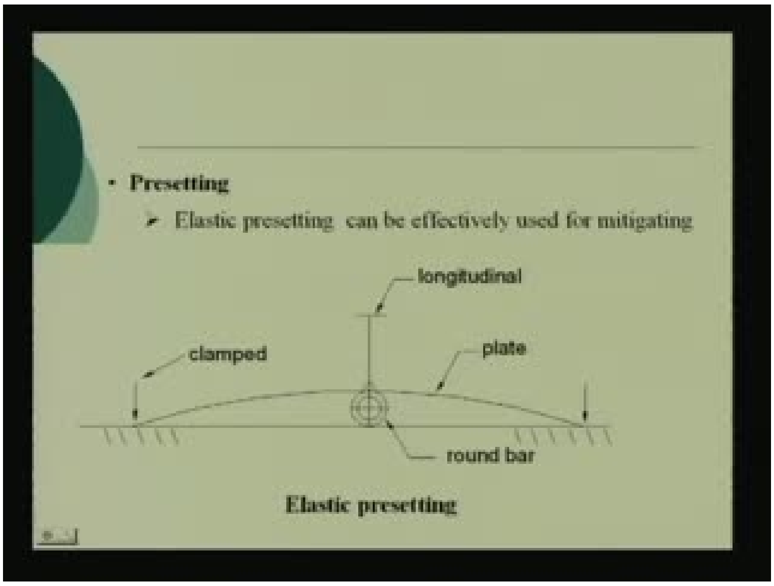

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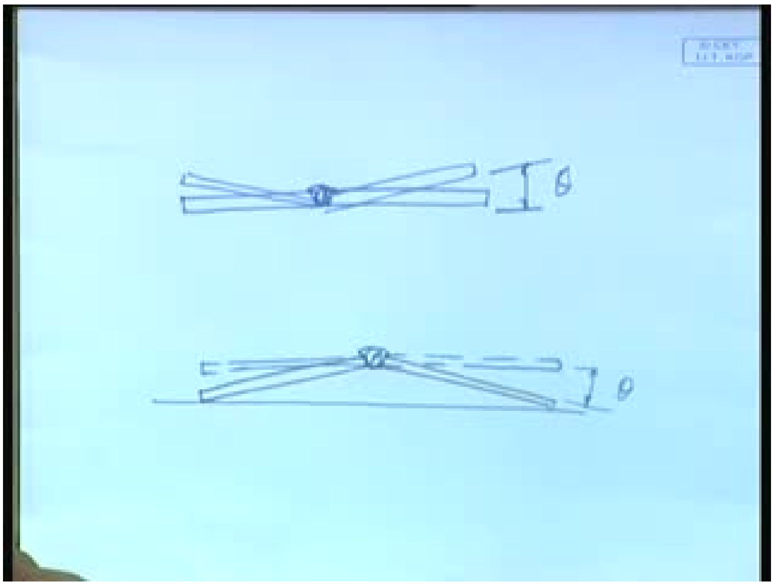

Presetting these are some of the methods we are talking about how to control that distortion in real time this presetting. Presetting is elastic presetting can be effectively used for mitigating the weld deformation. Here the diagram is not very clear what I meant is essentially what happens? That two plates when they are welded, they tend to deform like this is not it they tend to deform like that. So, if I preset, it just the opposite way that means I preset the plates in the opposite way and then weld it, then what will it will lift up and it will become straight that is what is presetting and after the welding is done then it will becomes straight.

So, what I have to know is this, the angle of presetting or in other words this, how much it may deform? If I know how much it will deform, so much pre-deformation I give. I align it in that fashion, such that when the welding is done. Same principle of shrinkage forces and the bending movement will be what? So, it will bended, I have bended it come to straight position that is what is called presetting these are all kind of kind of theoretical concepts in a very limited sense this things can be used.

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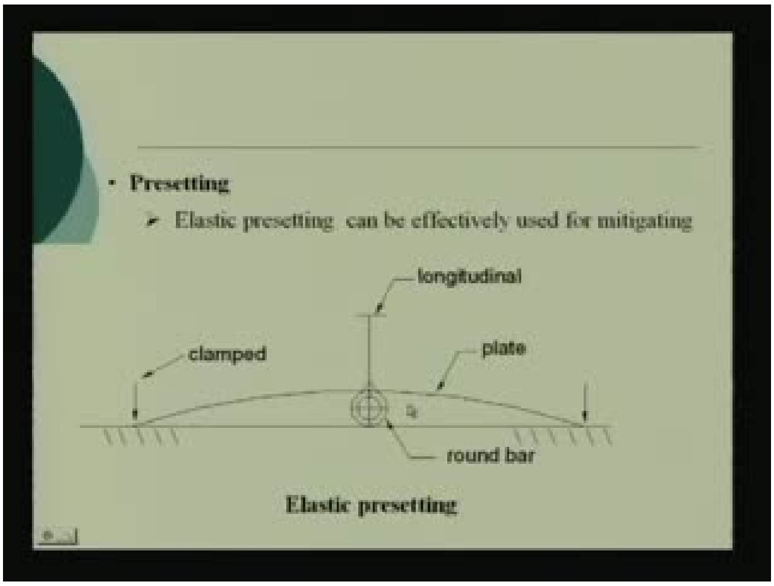

These are possible that means well, wherever it can be possible one can implement it, whatever limited. Because if you can remove a bit of deformation that also helps wherever deformation can be controlled, wherever deformation can be eliminated, it helps. Though it may have a limited application, but still it is worthwhile to look into that.

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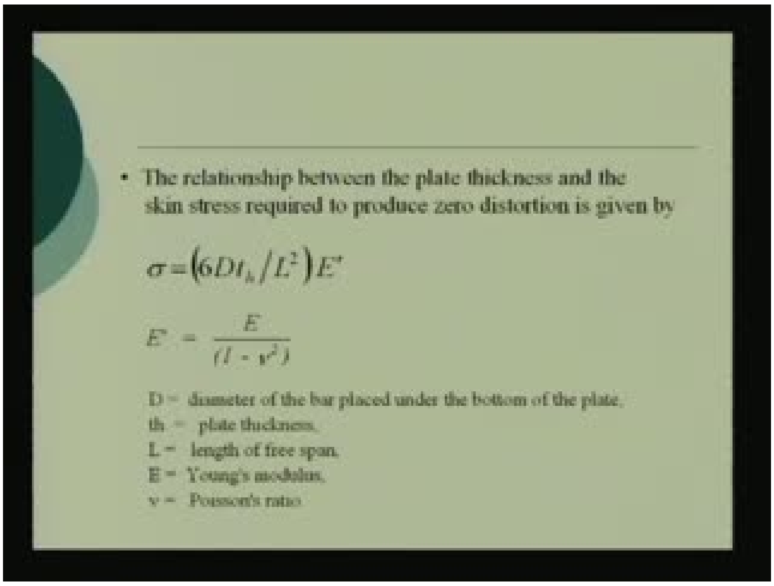

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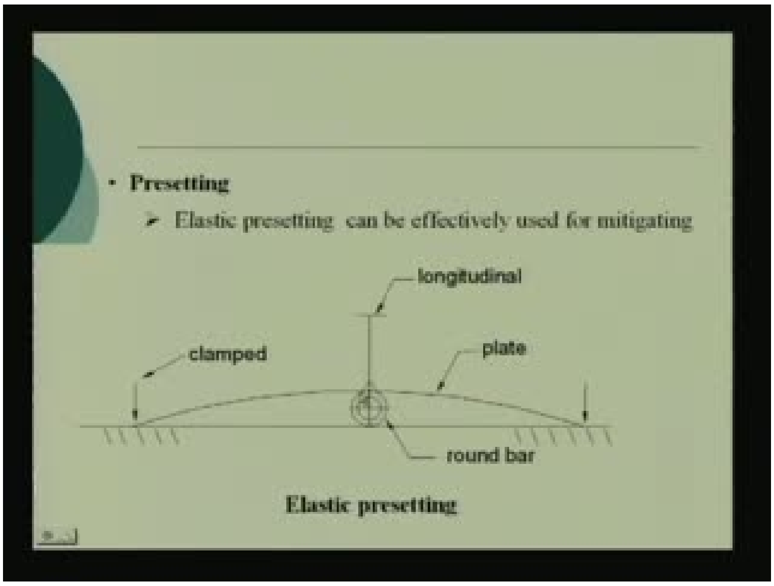

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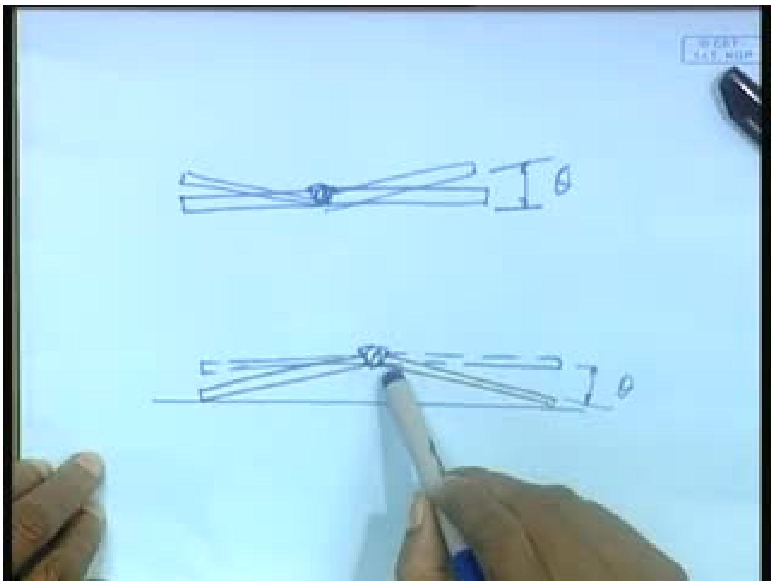

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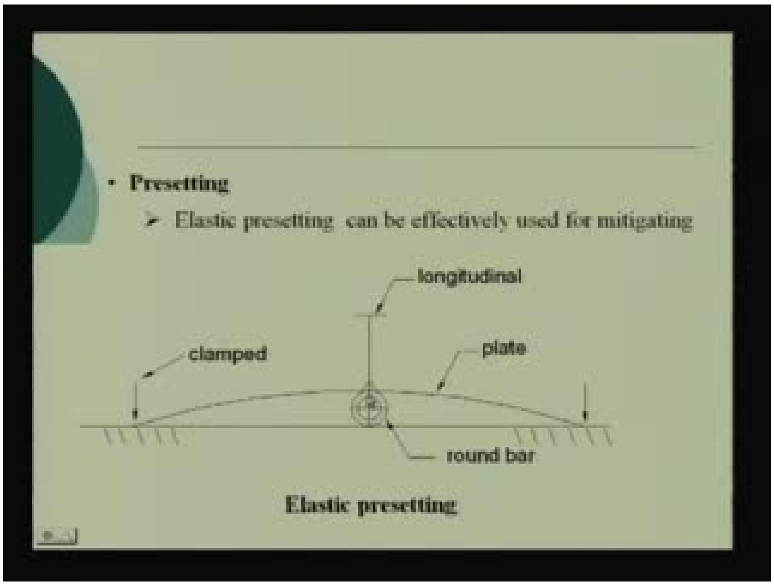

So, this is some of the relations how to get I mean, what has been shown here is that this round bar it is nothing, but the diagram here. I have shown as a case of butt welding in this presentation, I have shown a case of a stiffener being welded. So, when a stiffener is welded, you have angular deformation. So, there it is being pre bend with the extend of deformation what is anticipated by putting a round bar below and then the welding is done.

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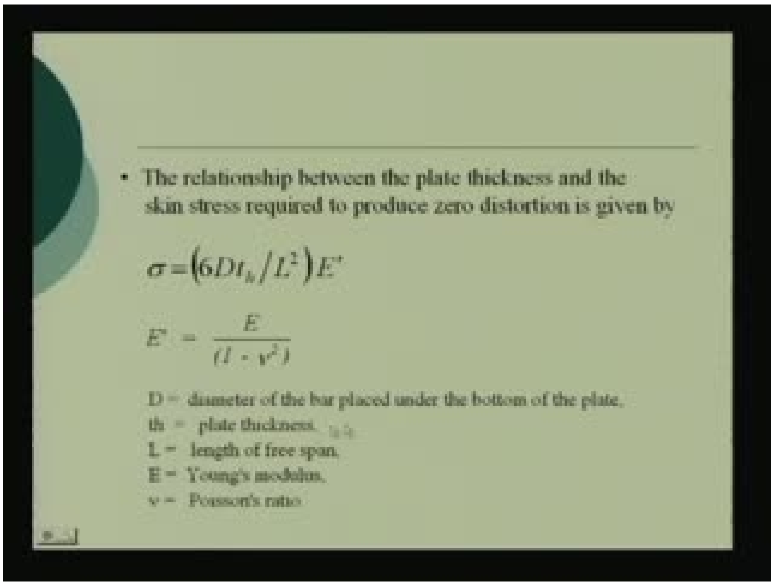

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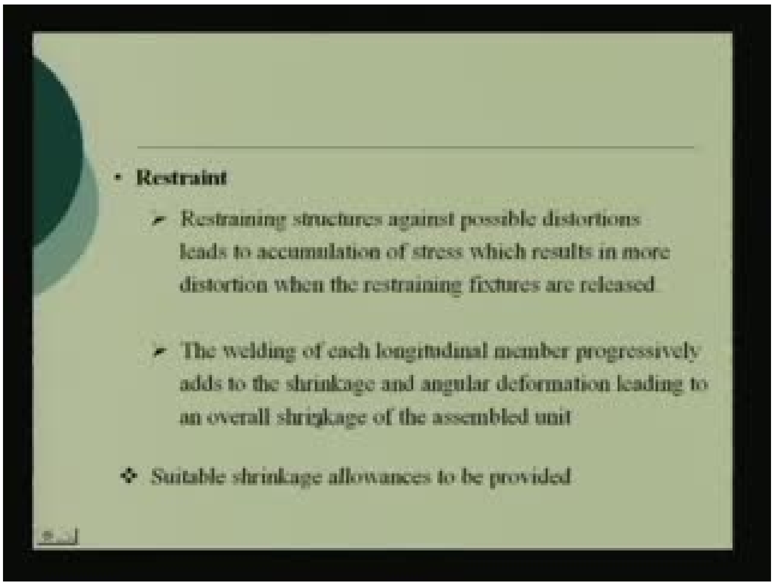

So, one have to calculate the diameter of the bar, which is plus or this is one simple formula given through which one can try to find out through the level of if the skinkeen stress required to produce zero distortion that is given by this, so through that one can calculate. nyway these are that Restrained that is another aspect of putting restrained that means you do not allow the structure to deform you put restrain, but there is a as I have mentioned possibly here their restraining structures against possible distortion leads to accumulation of stress, which results in more distortion when restraining fixtures are released.

Why I have mentioned and why I have made a heading of restraint is that there is a very general belief. Because you see, first and foremost you must realize ship building is such an industry, which is generally very conservative.

Why it is conservative? Because of the varied type of product it produces, it is difficult to put in whatsoever innovation in the production process. Why it is difficult to put? One will have to realize that whenever you put in a innovation there is always a factor of risk involved in it and here the stakes are very high. That means when you designed and manufactures fabricate a space craft, you do not go by innovations; you go by proven things because stakes are just too high. Same thing in ship building stakes are really high, you cannot afford to things go wrong; whatever innovation you do back stage, elsewhere proven then only implement. So, here people are very conservative; you cannot implement anything new that easily.

So, in the process what happens? Many things they go traditionally, one of the traditional thing just I mentioned in the beginning that people realize the distortion will take place why? Because it is a thermal process, so what to do? You have to live with it.

Another restraint you will find, if you go to the shipyard, so when you will find the panels have been fabricated. You will find big huge concrete blocks have kept, the stiffeners are there in between and welding is being done. So, what happens? It is being restrained from deformations. I am saying between two longitudinal buckling takes place, if I put a huge weight there buckling will not take place. Because when I weld the forces are not enough to topple that couple of tonnes of the blocks concrete blocks are sitting there.

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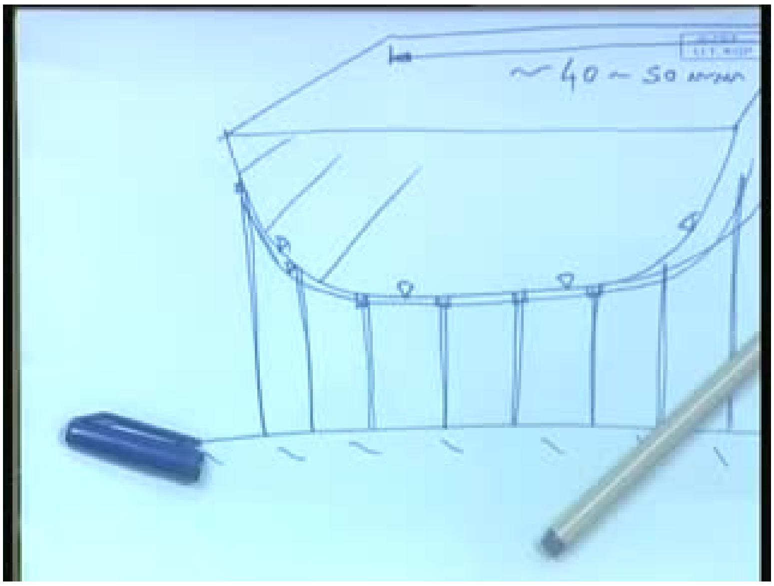

So, apparently no distortion, but when you remove that it is a lot of residual stress because the thermal load, why it has gone? Nowhere it is remain there locked in stresses so it will remain in the form of a stress, then further you work on that panel you weld it somewhere or collect something else to that those, some of the stresses will be revealed and deformation will come that is one way of looking at it. Another is you will find some of you are planning to go to yard, you take a look at all these, you will find there is a suppose, a block is being erected some unit like this part of the double bottom this is your ground level so obviously construction is never done at the ground level you will have a kind of a structure which is called skid also called zig this this vertical lines I am drawing they are essentially frame structure they are essentially frames over which it is sitting this frame structure has two fold purpose it has vertical this thing and also along the some of the frames also basically a kind of a fixture over which you put the curve plates

So, it supports the plate over which you will weld all the say if it is a double bottom say the stiffeners you will weld you put the floats all that will be doing as well as it checks the plate you have curved bent whether it has been bent correctly because those shapes it should match

So, what happens as you put the plates and suppose these two plates are welded here these are my sim lines. So, when you weld these two plates, it will try to bend so such that it does not move and also when you are welding the stiffeners it will try to bend such that it does not bend. What you do at the back? You put a lug and weld it, restrain it to the frame to the skid, to the skid you put small pieces of blogs and you literally weld the plate to the skid. You tack it that means, you restrain it from any kind of movement, so then you weld everything. So, everything is fine, in that condition you take all measurements naturally it will be fine because the forces are not enough to bend the skid; skid is also made of solid sections, so everything is fine.

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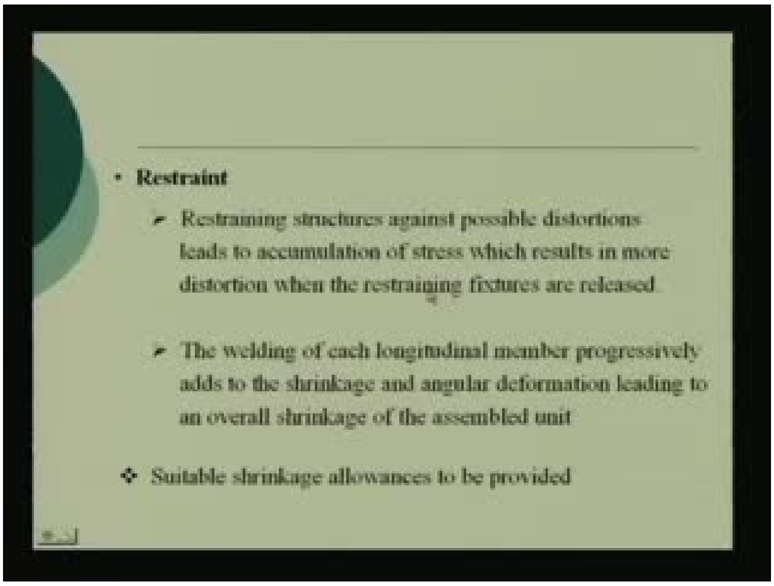

Now, next erection or fabrication on this might be in some other place, some other station. So, what you have to do? You will have to cut all these lugs lift it and shift it there. Once you shift it there and bring in the other components, you might find they are not matching why? You may find that this length has become short, it has shrunk. It may shrink as high as 40 to 50 millimeter; you would not be able to even make out in naked eyes when it was in the skid welded fine. The moment you have removed the tags, it has just shrunk because all those shrinkage forces were being restrained the moment. You will leave it, it shrinks that is what I tried to say here that this restraining does not actually help, much little bit it helps in way of redistribution of stresses, anyway rest will take a look in the next class.