Welding Metallurgy
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Lecture No. 42
Types of Welding Distortions

Welcome to the lecture on types of welding distortions. So, we talked about the introduction about welding distortion and towards the end we had also mentioned about the different types of welding distortions. So, we will have more detailed discussion about these types of welding distortions.

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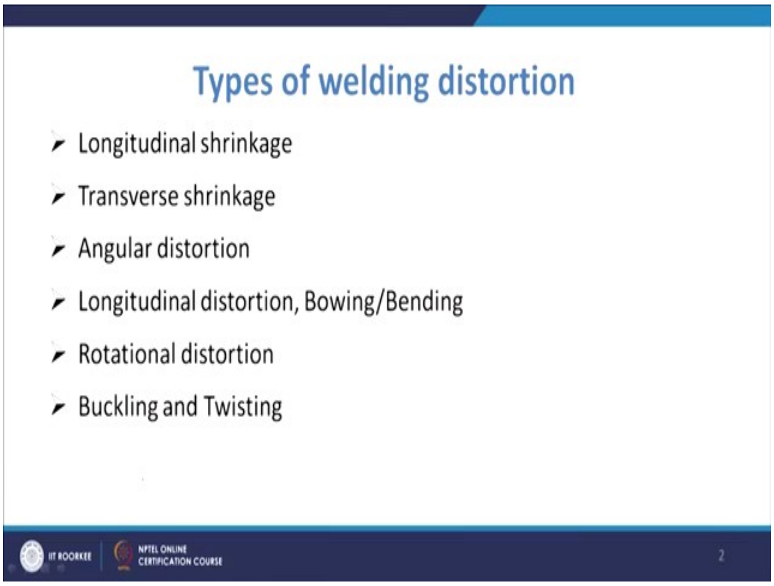

As we know, you have the distortions which are primarily of different types; like, you have the longitudinal shrinkage which is there along the longitudinal direction, that shrinkage which takes place along the longitudinal direction, that is longitudinal shrinkage. Similarly, you have the shrinkage in the transverse direction, that will be your transverse shrinkage. Then, you have the angular distortion, longitudinal distortion, bowing or bending, you have the rotational distortion, and then finally you have buckling or twisting.

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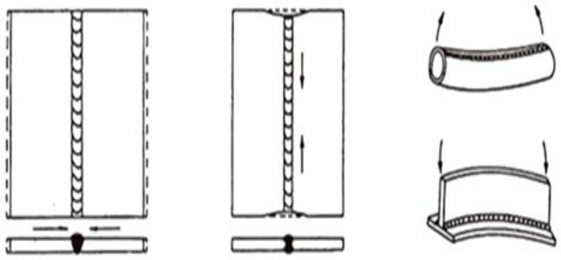

Transverse shrinkage

Longitudinal shrinkage

Longitudinal distortion

So, if you try to see or feel how these distortions look like, so we can have the figures of these distortions. So, as we see that, in this case, as there will be shrinkage in this proportion, so ultimately you will have shrinkage along the longitudinal direction. So, that will be your longitudinal shrinkage. Similarly, the shrinkage which is there in the transverse direction, so that will be basically your transfer shrinkage. Then, this is the example of the longitudinal distortion which is normally taking place. So, we will talk about it.

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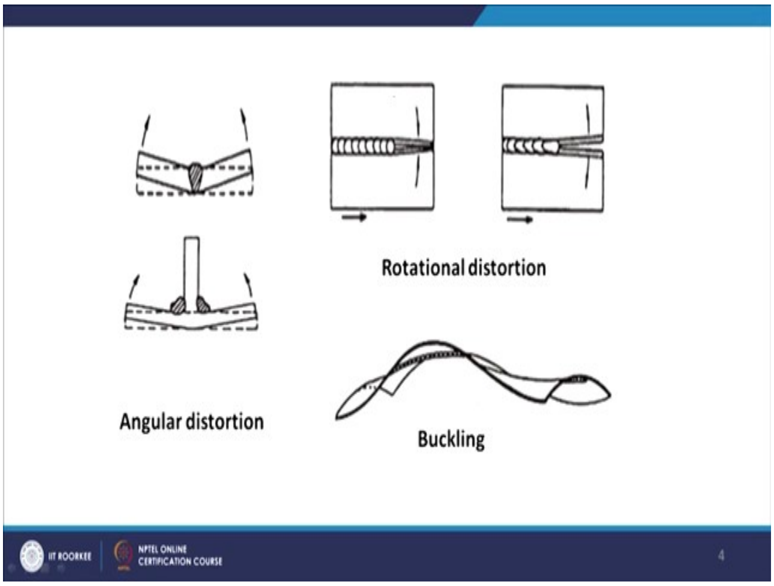

The angular distortion is this one because we see that this is moving at some angle. So, that type of distortion which is coming in this case this is your angular distortion. This is your rotational distortion where either it comes in this fashion or it is going away from, you know, this way. That kind of distortion is known as the rotational distortion. And this is a typical example of the distortion that is known as buckling or twisting. So, that is this one, the distortion is.

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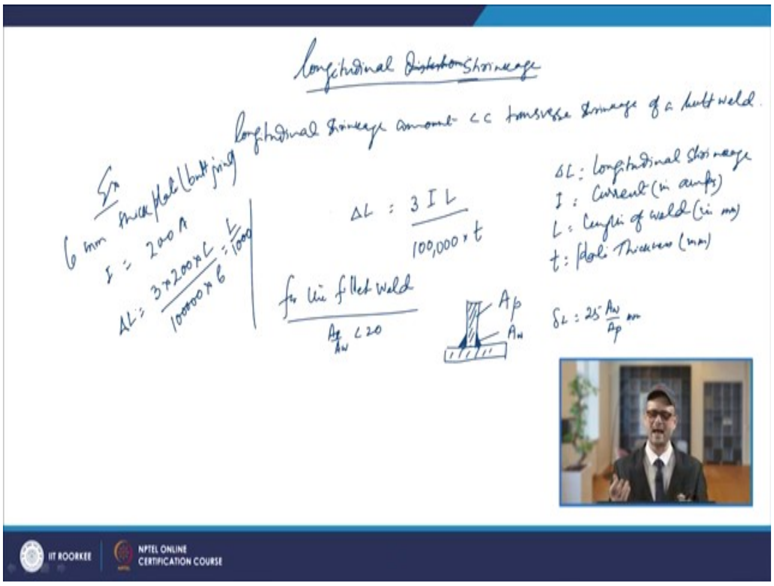

So, if you talk about the distortions one by one, so first of all we will talk about the longitudinal distortion. Now, if you see the longitudinal distortion, so basically, not longitudinal distortion, it is longitudinal shrinkage. So, if you talk about a normal butt weld, so you have the shrinkage which is taking place; one is in longitudinal direction and another in transverse shrinkage.

Now, the shrinkage which is taking place in the longitudinal direction in the case of butt weld is quite small as compared to that which takes place in the transverse section. So, the longitudinal shrinkage that amount is much less as compared to the transverse shrinkage of a butt weld. So, normally, it is about 1,000th parts. So, if it is 1, so it will be $1/1000$, you know, the longitudinal shrinkage, if 1 is the transverse shrinkage.

So, it can be quantitatively represented by the formula and that is $\Delta L = \frac{3IL}{100000 \times t}$. So, your ΔL is the longitudinal shrinkage, then you have I is the current in amperes, and similarly, L will be the length of weld, so that will be in mm, and t will be the plate thickness.

So, this is also again in mm. So, this way, if you are given any butt weld or so and you are to calculate longitudinal shrinkage, you can use this formula for finding the longitudinal shrinkage. For example, if suppose you have a 6-mm thick plate and you have to do the butt joint welding. So, you are doing the welding using butt joint and you are the using the shielded metal arc welding. So, ampere is 200Å. So, for that what will be its longitudinal shrinkage? So, you can calculate this value, so you can have for the length itself.

So, if you calculate the δL, that will be $\frac{3 \times 200 \times L}{100000 \times 6}$. So, you see that this 6 and 6 is cutting, so you will have $L/1000$. So, that way you can calculate the longitudinal shrinkage of the butt joint. You can have even the fillet weld also.

You can calculate the longitudinal shrinkage for the fillet weld. So, if you have the fillet weld, so in the case of fillet weld as we know, so the fillet weld normally you have, so this way you have the plate and on this this is how it is joined. So, this is your fillet which is looking like this. Now, in this case, the fillet weld, this area, cross section of the welded plates in the transverse section which is also called the straining cross sections, so that is also important.

So, you have two types of cross sections; one is for the plates and another is for the welded parts. So, this we call it as A_p and this we call is as A_w. Based on that, normally we calculate the longitudinal shrinkage for the fillet weld. Now, when its ratio is less than 20, when the ratio A_p/A_w is less than 20, in that case if you try to calculate the longitudinal shrinkage that is given by the formula, $\delta L = 25 \times \frac{A_w}{A_p}$, so that is mm.

So, this way you calculate the language shrinkage in the case of the fillet weld. So, you can have any fillet weld joint.

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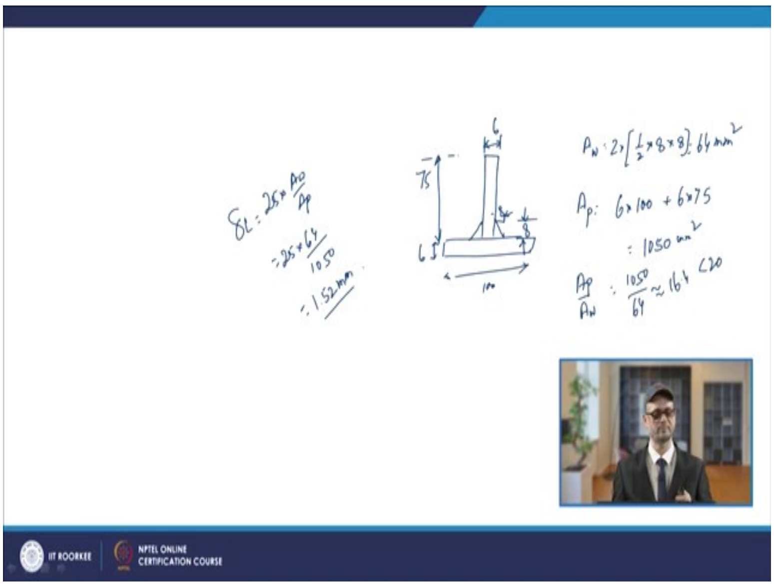

Suppose you have a fillet weld given like this and this dimensions are given, like say, this is given as 8 and this is given as 6, then this length is also given as 8 and this thickness again is 6 and this length is given as 75. So, based on that, you have to calculate the A_w and A_p and then you have to find the δL. So, if you calculate the A w for this material. So, you have two fillet welds, so it will be two times the area here.

This is a triangular area. So, $2 \times \left[\frac{1}{2} \times 8 \times 8\right] = 64\,mm^2$. All the dimensions in this case are in mm. So, it will 64 mm^2. Similarly, if you want to calculate the A_p. Now, A_p will be, this is 6 and this is 75, so accordingly you will calculate these values.

So, this area will be 6 * 75 here and this length is 100. So, you will have 6 * 100 + 6 * 75. So, it is 600 + 450. So, it will be 1050 mm^2. So, $\frac{A_p}{A_w}$ if you calculate, it will be 1050/64, so it is something between 16 and 17, so it is somewhere close to 16.4. It is less than 20, so we can use the formula for the fillet weld that is δL, that will be $25 \times \frac{A_w}{A_p}$.

So, you have $25 \times (\frac{64}{1050})$. So, that way it will be 42 and then you have a 21 and this is your 32. So, that way it will be somewhere close to 1.52 mm. So, this way we calculate the longitudinal shrinkage in the case of either the joint or you have the fillet joint. So, we calculate these longitudinal shrinkage in such manner.

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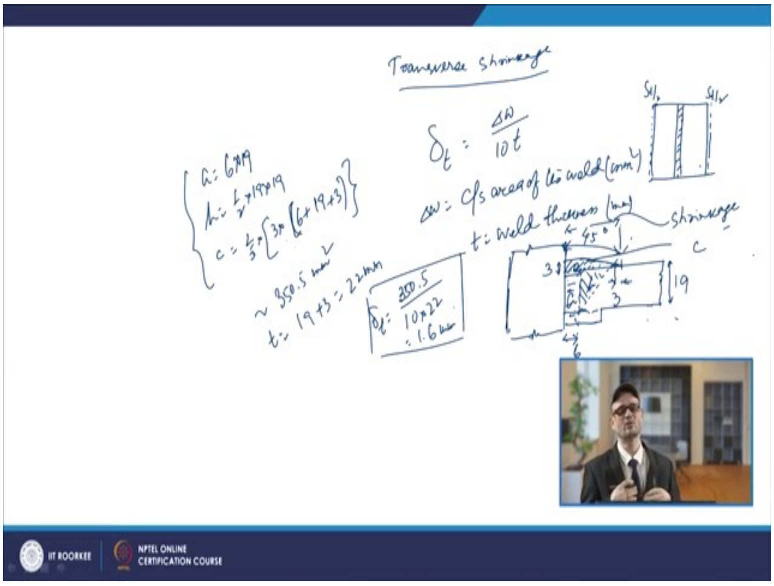

Then, next comes your transverse shrinkage. So, transverse shrinkage, basically the major factor which will be causing this transverse shrinkage in butt weld is basically the rotational distortion and the constraint. So, these are the two reasons because of which this transverse shrinkage takes place in welding. So, if you talk about the transverse shrinkage, we have already seen that when you have the weld bead in this fashion, so the shrinkage which is going to take come on both these sides.

So, this is your transverse shrinkage and half of the transverse shrinkage is taking place here and half of the transverse shrinkage is taking place here. As we discussed, basically there are two major factors; one is the rotational distortion which is because of, you know, as we are seeing that if you talk about the spot of welding, so ahead of the arc, the arc is moving, so ahead of the arc, that basically unwelded portion of the joint, that causes that rotational distortion and accordingly you have the transverse shrinkage which takes place.

So, one reason is that and another is the constraint. So, if you are providing more constraint, in that case, the transverse shrinkage is likely to be less. So, many a times the constraint is also not uniform, so that way also it will be affecting the amount of transverse shrinkage as it should be. So, normally, when we talk about the transverse shrinkage that can be predicted by a relationship that has been suggested and that relationship is δ_t, that is your transverse, for that δ_t is taken, and that is normally $\frac{\Delta W}{10t}$.

Delta w is basically the cross sectional area of the weld and then you have t is the weld thickness. So, this has the unit of mm square and this is in the unit of mm. So, if you have any kind of weld, you can predict the amount of transverse shrinkage in that well. So, you have to basically find the cross sectional area of the weld. So, basically, suppose you have a weld which is suppose shown like, you know, you have such kind of weld.

So, this is the weld which is given and this dimension is about 19 and this is the dimension here, and from here you have this shape which is coming. So, that way, if suppose this is the geometry and this side you have the dimension which is given. Now, in this case, if you look at this angle, this angle is supposed to be about 45°. So, if you talk about from here to this, this basically is the shrinkage. This shrinkage is the transverse shrinkage which is taking place.

Now, this much here it is showing to be 6. So, this length is 6 and this length is shown to be 3, and here also this is shown to be 3. So, all the dimensions are in mm. So, this is a and this is your b area. So, we are talking about the different areas which is that is found. So, you have three areas basically if you talk about the weld area. You have three areas a, b, and c. So, this is your c. This is a and this is b. So, basically, if you talk about, you know, for such problem, what we need to know is we have to find first of all the area of that weld.

So, this is one, that is rectangular area which is to be calculated. So, that area is 6 and this length is 19. So, for finding that weld area, cross section of the weld, you have a as the rectangular area, that is your 6 * 19. Similarly, this is the triangular area. So, again, here also you have, this is half into this length into this length, so that is given as 19. So, b will be $\frac{1}{2}[19 \times 19]$. And this curvature is given as 45°.

So, this area will be $\frac{2}{3}[3 \times (6+19+3)]$. So, this 3 also, 6 + 19 + 3. So, that way, you get this as $\frac{2}{3}[3 \times (6+19+3)]$. So, that way you calculate different areas which we are talking about, that weld of cross section. And once you get that cross section, if you find these values and add them, so that gives you the value of about 350.5 mm^2.

And if you talk about the t, so t will be 19 + 3, this is your 19 and this 3 comes here, so it will be 22 mm. Now, you can use the formula of the transverse shrinkage. Transverse shrinkage will be δ_t and that will be basically ΔW, so ΔW is about 350.5 and you have 10*t, so 10*22, so it is coming out to be about 1.6 mm. So, this way you can have the calculation of the transverse shrinkage in such cases.

So, when we talk about the transverse shrinkages in the butt welds basically, when we talk about the different various welding procedures, so, how they affect on the transverse shrinkage.

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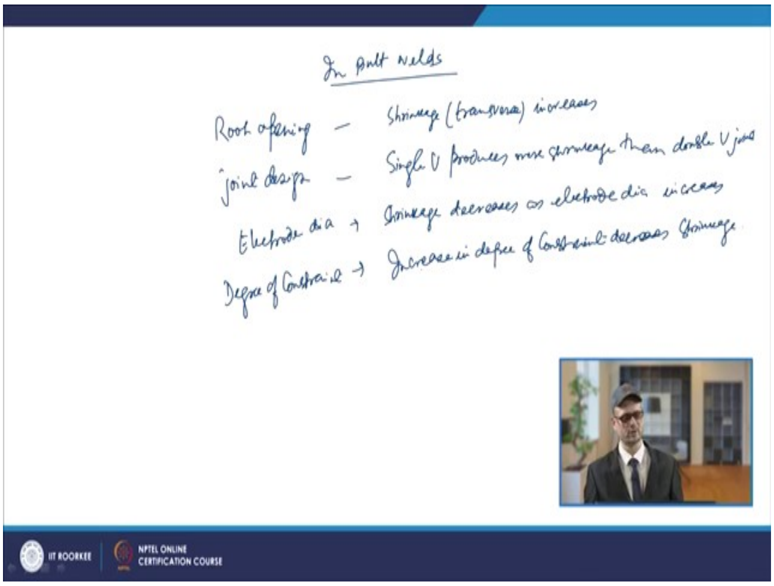

So, if you talk about the root opening, if the root opening is increased, in that case, the transverse shrinkage will increase. So, the shrinkage increases in butt welds. And we also talked about effect on the transverse shrinkage. So, shrinkage that is transverse that increases if increase is there in the case of root opening. Similarly, if you talk about the joint design, you know, single V will produce more transverse shrinkage than the double V joint.

Then, there are other parameters like you have electrode diameter. If the electrode diameter will increase, in that case, the shrinkage will decrease. So, shrinkage decreases as electrode diameter increases. Then, we already talked about the constraint. So, the degree of constraint, if you are increasing the constraint, basically that will be having effect on reducing that transverse shrinkage. So, increase in degree of constraint decreases shrinkage, that is transverse shrinkage.

Then comes the gauging and repair. So, basically, if you do the gauging and repair, so that will be increasing the shrinkage. Similarly, about the pinning, if you do the pinning, then also shrinkage decreases, but the effect of that is very very less, very minor. So, pinning effect is also somewhat better in the sense that it will try to decrease the shrinkage.

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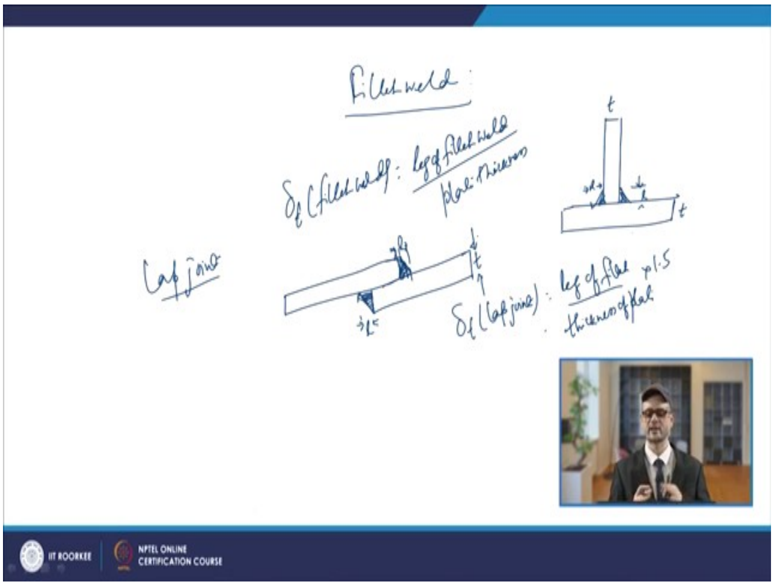

If you talk about the shrinkage in the fillet weld, in case of fillet weld, if we try to calculate the transverse shrinkage, you can have the example of a fillet weld here and you have a plate in this fashion and this is your fillet weld. So, in the case of fillet weld what we see is that we keep this length as l and we also keep this distance also as l, this is fillet length, length of fillet weld and this t will be your thickness of the plate.

So, in the case of fillet weld, the transverse shrinkage, δ_t, for the fillet weld is calculated by the ratio, this is leg of fillet weld, so this is the (length of this fillet l)/(plate thickness). So, that is how you calculate in the case of fillet weld. So, this is normally for two continuous fillet welds, for T joints. Then the formula becomes different when you have the fillet weld in the lap joint. When you deal with the lap joints, so in the case of lap joints as you know you have a lap joint with two fillet welds.

If we draw, so this is one plate and another plate will be lap jointed with this and you have the fillet weld here. So, in this case this will be your l here and similarly you have the l here also and this is your thickness of the plate. So, in this case also when we talk about the lap joint, so in those cases the transverse shrinkage in the case of lap joint, so here what you do is we do the $((leg\ of\ fillet)/(the\ thickness\ of\ plate))*1.5$. So, normally, in the case of these lap welds, l is normally equal to t.

So, that way you calculate, in the case of lap joint, these transverse shrinkage. Now, when we talk about the transverse shrinkage, in these cases, transverse shrinkage in the weld is very much important when the shrinkage of an individual weld is cumulative. So, in those cases it becomes more important. For example, if you talk about the beam to column connections across the length or width of a large building, so that is an example of that. So, in those cases, this transverse shrinkage they are cumulative effect. So, that is important.

So, in those cases, unless if you are taking the allowances for that transverse weld shrinkage, what we normally do in those cases is that usually we do that by spreading that joint so that it will contract after welding. So, that allowance you have to give because there will be some transverse shrinkage. So, cumulative shrinkage will be there of the several beam to column connections.

So, many a times it can be large enough to noticeably shorten that building dimension. So, in those cases, cumulatively its effect will be quite appreciable. So, when you do that at that time you must have that in mind, that what will be the cumulative value of that shrinkage after you do so many of beam to column connections in that building. So, accordingly you calculate it.

Apart from that, as we discussed that we have other kinds of distortions also. Angular distortions are there. We have bowing and bending is there. Longitudinal bending is there. We have also to discuss about the twisting or buckling. So, that we will study and we will try to see how they can be quantified and how you can understand more about those different kinds of the shrinkages which takes place in the welded joints. Thank you very much.