Underground Space Technology
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Module No # 03
Lecture No # 14
Application of Stereographic Projection Method: Sidewall failures -1

Hello everyone, in the previous class, we discussed the application of stereographic projection method with reference to roof failure of a underground excavation. So, today we will continue with that discussion, and we will see that, how we can handle the side wall failure with the help of this stereographic projection method.

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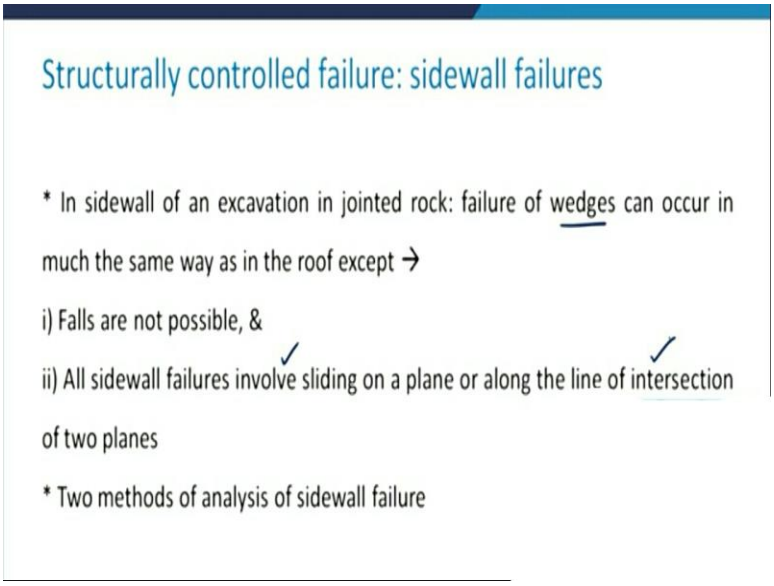

So, in the side wall of an excavation in jointed rock, the failure of the wedges can occur in exactly the same manner as it was in case of roof, except that 2 facts are there that falls are not possible from the side walls. Then, all side wall failures, they involve sliding on a plane, or along the line of intersection of 2 planes. Now, there are 2 methods of the analysis of side wall failure, we are going to discuss the first method today, and then we will continue in subsequent classes with the other method.

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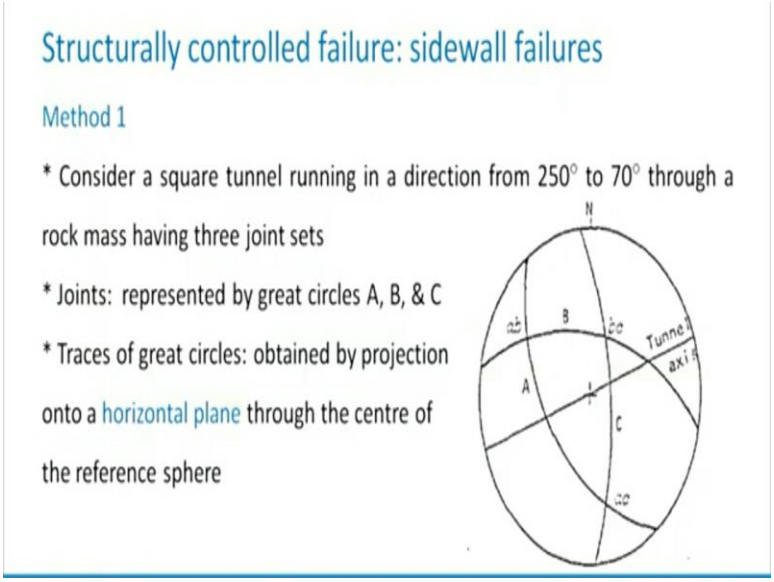

So, in the first method, I take an example of, let us say the square tunnel which is running in the direction from 250^0 to 70^0 through the rock mass which has 3 joint sets. So, these joints are represented by great circles a, b, and, c which has been drawn here in the corresponding stereographic projection, that is point, or the great circle a, great circle b, and, great circle c and as the tunnel is running from 250^0 to 70^0.

So, you see that this is what is the tunnel axis? So, this corresponds to 250^0 and this is 70^0. So, this represents the tunnel axis, now the traces of these great circles, they can be obtained by projection onto a horizontal plane through the centre of the reference sphere. So, you see that it is ab, bc, and, ac, this is how these traces can be obtained.

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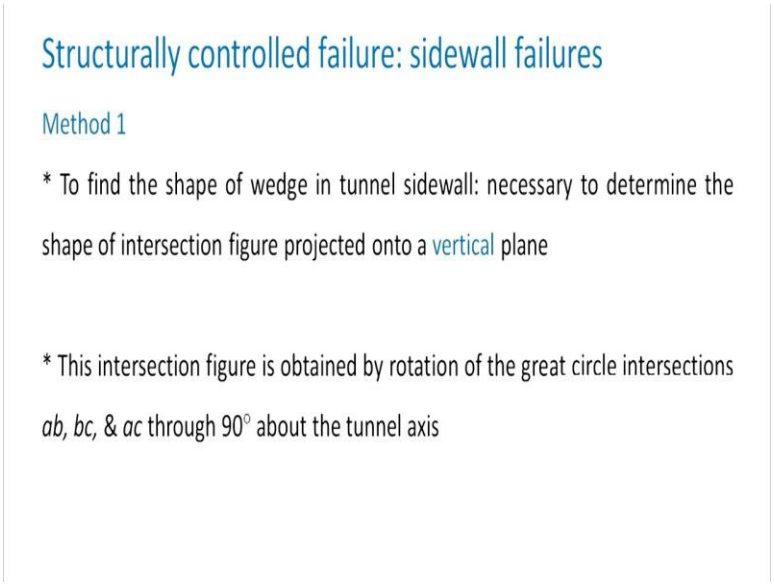

Now to find out the shape of the wedge in the tunnel sidewall, it is necessary to determine the shape of the intersection figure, which is projected onto a vertical plane because, now we want the true shape in the tunnel sidewall, which is the vertical plane. So, this intersection figure can be obtained by the rotation of the great circle intersections, which are ab, bc, and ac, through 90^0 above the tunnel axis.

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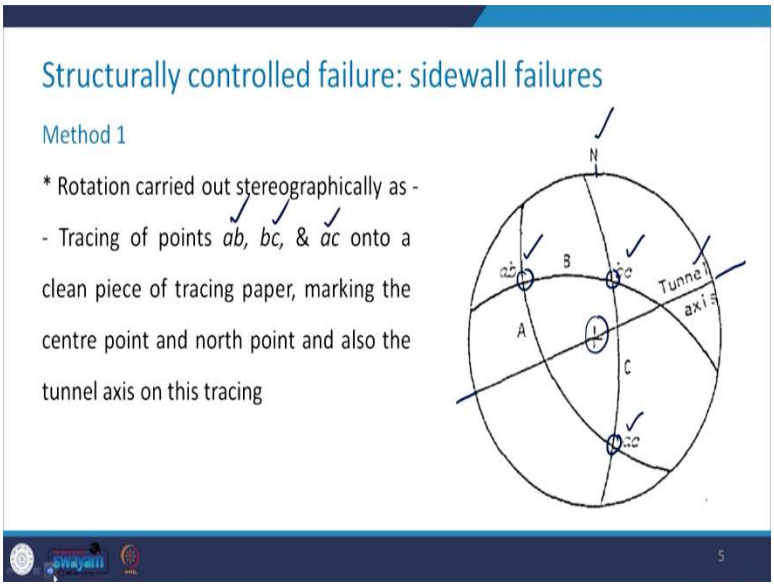

So, how this is done, this is what is the tunnel axis which is running 250^0-70^0. So, we have to rotate these points ab, bc, and ac, by 90^0. So, what we should do is, first we should have tracing of these points ab, bc, and ac, onto a clean tracing paper, you mark the centre of the this

stereographic net. Then, mark the north direction, as well and then plot the three grade circles which will give you these points ab, bc, and ac, and you should also plot the tunnel axis onto this tracing.

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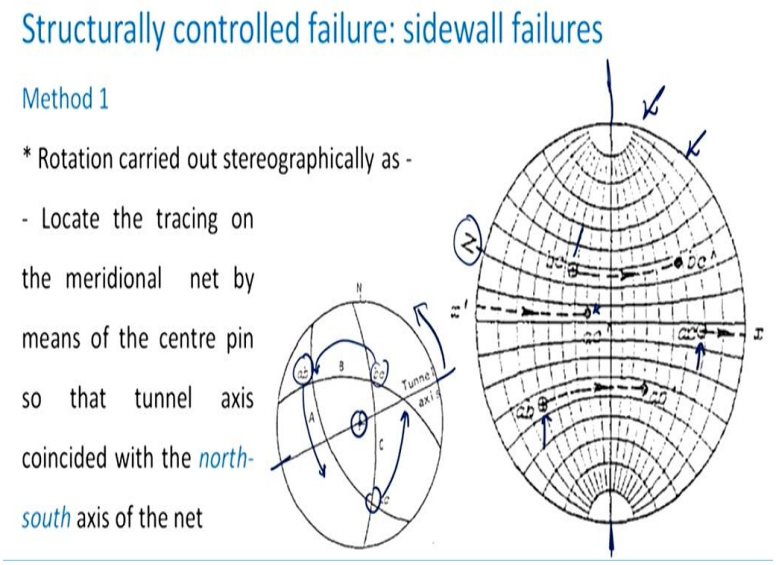

Now, should we carry out the rotation? So, what we do is, we locate that tracing sheet on to the meridional net, or the sterographic net, here in such a manner that, we pin it at the centre here, and make or rotate the tracing sheet onto this, in such a manner that, this tunnel axis this one coincides with the north-south direction, so what will happen? If I just try to rotate it what will happen? This point bc will be rotated, ab will also be rotated and of course this ac will be rotated by same amount.

So, you see that when I rotate this and merge this tunnel axis north-south direct axis of the net, you see that the north come here now and accordingly all these points they have their new place. So, bc will come now, here and ac is here, and ab comes out to be here, sorry ac is going to be here.

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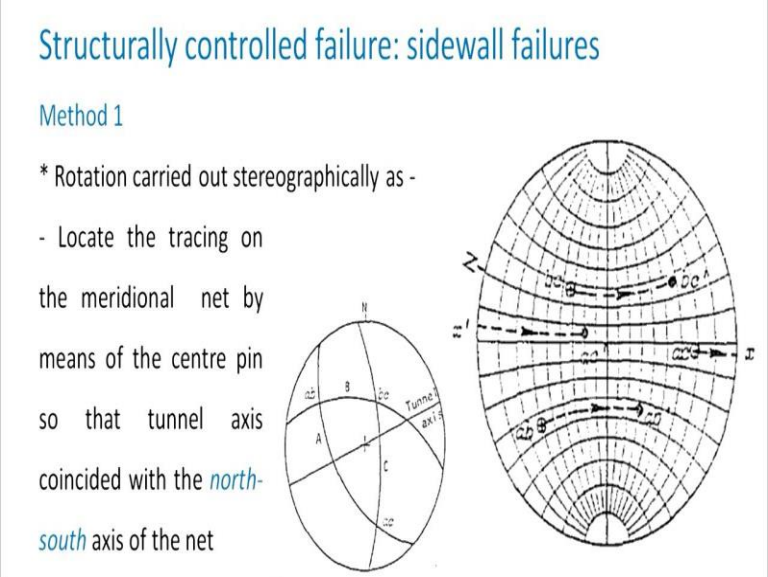

Now, I have to rotate it by 90^0, how I do it? There are 2 things, which one needs to keep in mind that we need to rotate all these points in the same direction. So, this helps us to keep all the points in the same hemisphere, and makes it easier to understand. When I have to rotate this point bc so what I do is, I count 90, so see, 10, 20, 30, 40, 50, 60, 70, 80 and 90 will be here but then little bit of angular dimension was here.

So, I left it, so that is how we get another point, which is bc′, this is bc′, after rotating this bc by 90^0. Now, come to this point ac, and if you just try to rotate it, in the same direction by 90^0, see what is happening. You have available as only 20^0, or may be little more than 20^0. So, what happens that is goes out of this net, and then it enters in the diagonal manner over here, in this particular manner.

So, you see, 10, 20 then 30, 40, 50, 60, 70, 80 and 90. So, this is the point which will be ac′ here, similarly this point ab which was earlier here. So, you rotate it by 90, so 10, 20, 30, 40, 50, 60 70, 80 and 90. So, this is going to be your point ab′. So, this is how all the 3 points ab, bc, and ac they should be rotated.

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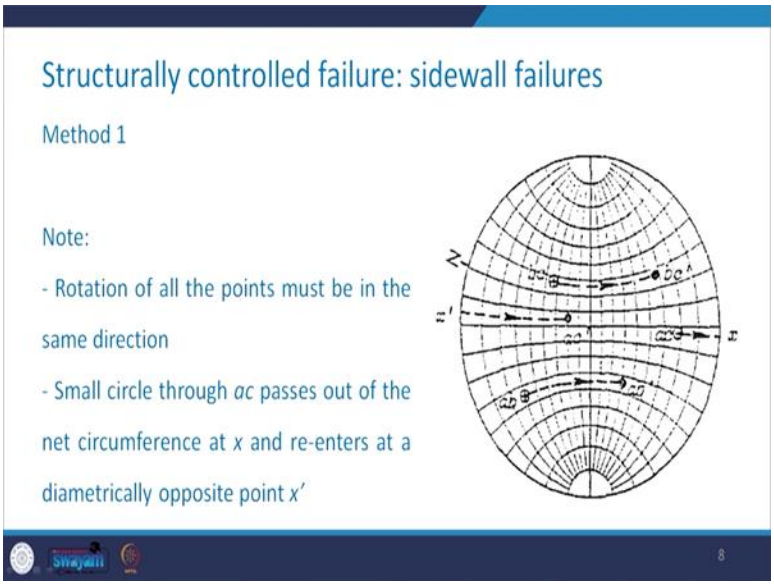

So, as I mentioned that you should keep in mind that, rotation of all the points must be in the same direction, then the small circle through ac, it passes out of this stereo net circumference, after let us say may be little more than 20^0 degrees. But then, it enters diagonally at these particular points, so, this I explained that, how will you measure 90^0 for the rotation of this point ac.

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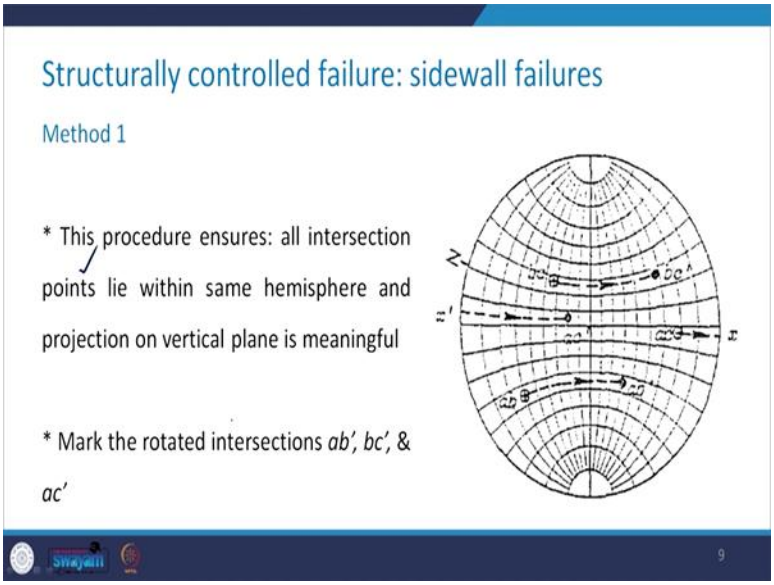

Now, this particular procedure, it ensures that all the intersection points, they lie within the same hemisphere and the projection on their, on the vertical plane is going to be meaningful. Because, if they are in the 2 different hemispheres, then if you project it in the vertical plane, you will not

be able to get the shape of the wedge on to that. So, what we do here now we mark the rotated position of these points which is bc′, ac′, and ab′ like this.

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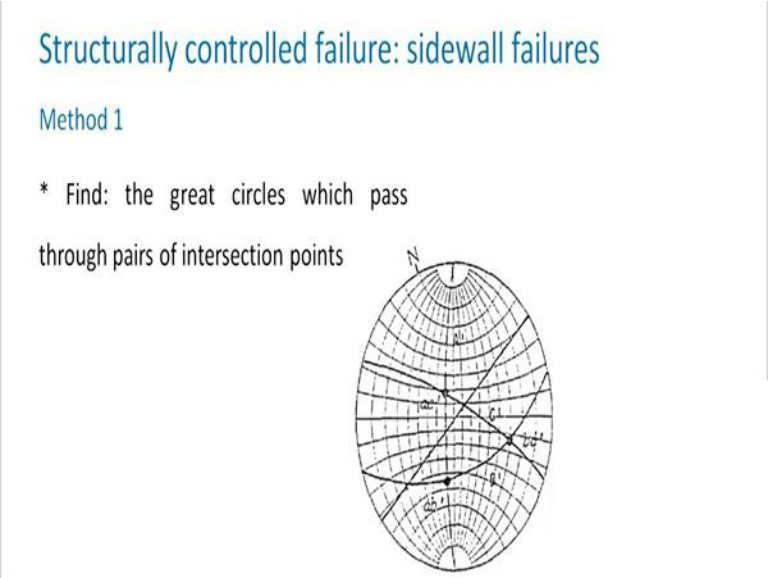

Then, what is our job then? We get the great circles, which pass through the pairs of the intersection points. So, we already have with us ab′, bc′ and ac′ and then, we keep rotating the tracing sheet on to that stereo net, and then we keep trying to find out that, what is the great circle that will pass through the pair of intersection points? So, you see that in this particular process, see this is the great circle which passing through the 2 points, which are ab′ and ac′.

Similarly, you have this great circle and the third one is this, is of course the tunnel axis. Now, once I know these great circles, can I not find out the strike for each one of these? take a look here.

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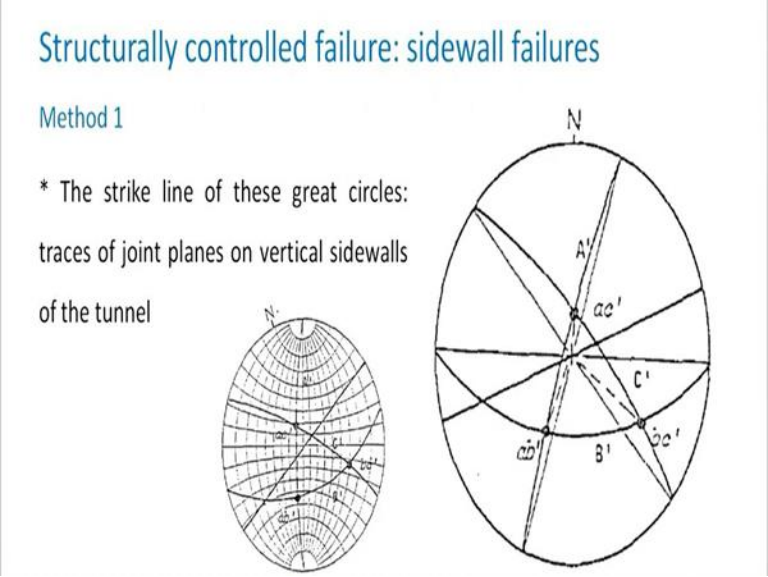

So, I merge this north with the north of the stereo plot, now, so, then for the circle a′ this is what is going to be the strike direction for this circle b′, which is this you will have the strike direction like this. And for the circle c′, which is this you have this as the strike direction and whatever they intersect each other. For example, b′ and c′, they intersect here so this represents the point or the trace bc′.

Similarly, the intersection of, a′ and b′, it represents the trace ab′ and likewise, you can get the trace ac′. So, we follow the same principle, but right now we are discussing it with reference to the side wall failures.

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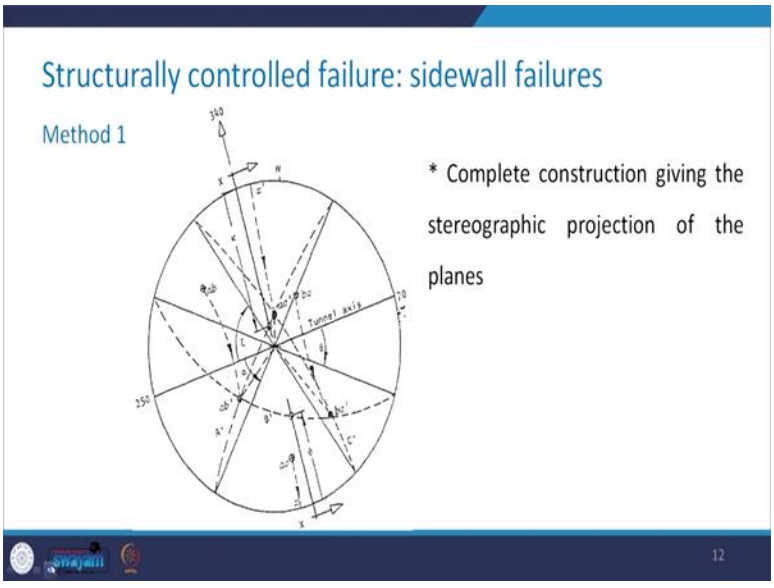

So, from that figure what all things that we can get? Take a look, this is what is your tunnel axis, 250^0, 70^0. So, we have the 3 great circles a′, b′ and this is what is, your c′ corresponding strike direction. Also, we can determine this is for a, this is for b, and this is for c, then corresponding traces ab′, bc′, and ac′, also we can determine. Now, we take a section that is perpendicular to the tunnel axis here this is a 250^0. So, you add 90^0 to that will come out to be 340^0, so, I take this direction.

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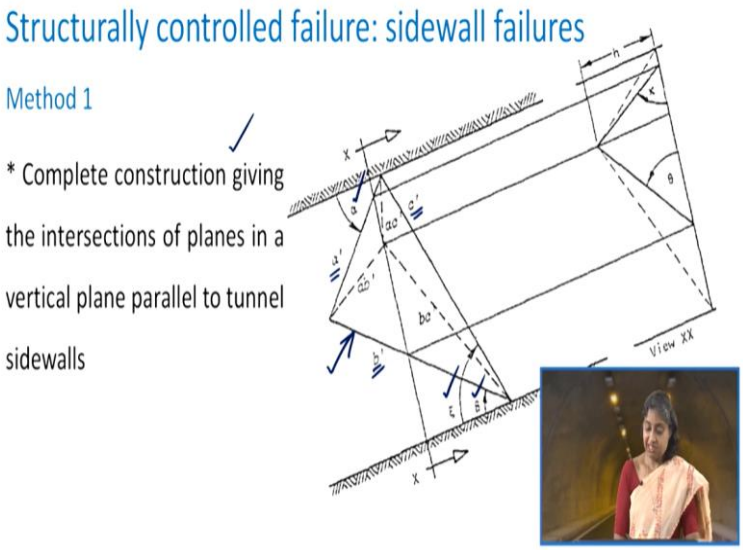

So, the complete construction giving the intersection of planes, in the vertical plane which is parallel to the tunnel side wall, that means onto the vertical plane. So, we have all these values and have already seen in the previous lecture. How we can generate or determine or plot these projections on to any plane once I have it on the stereographic net? So, in the similar way, I can draw the lines parallel to a′, b′, and c′ of the stereographic projection onto this plane.

And, then we can get the dimension of the wedges onto the vertical plane, which is parallel to the tunnel side. And, as far as these angles are concerned angle α, angle β, and, angle ξ, that also we can determine from the stereographic projection, I will show you how.

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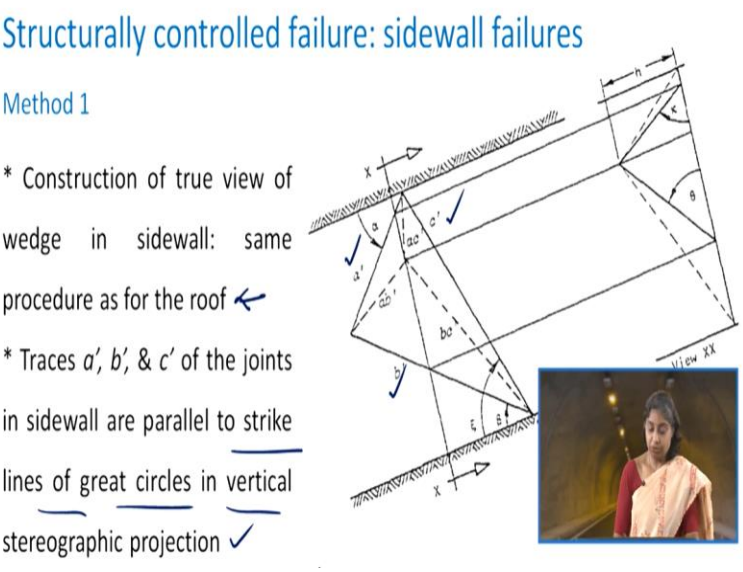

As I mentioned that, the procedure remains the same as we did for the roof. So, we have the traces a′, b′, and c′ which are parallel to the strike lines of the great circle in the vertical stereographic projection.

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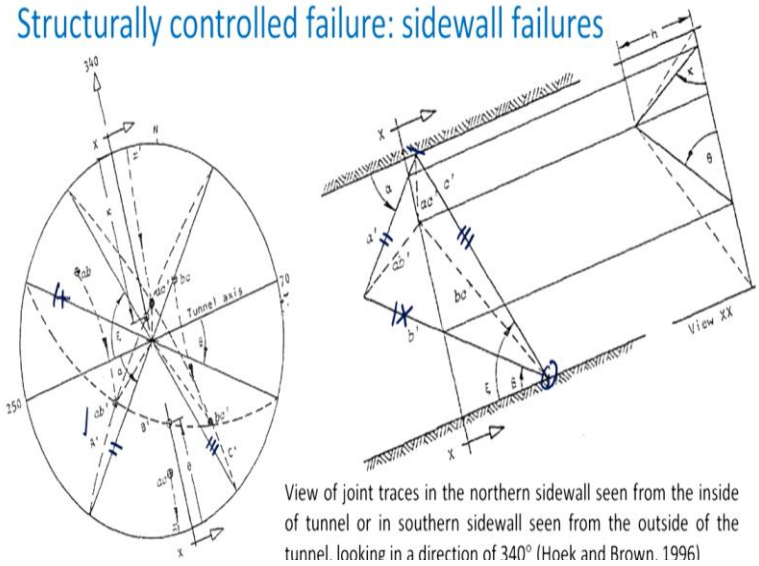

View of joint traces in the northern sidewall seen from the inside of tunnel or in southern sidewall seen from the outside of the tunnel, looking in a direction of 340° (Hoek and Brown, 1996)

So, you see here you have, this is what is your, the strike direction of this great circle a′. So, I draw a line take any point here, draw a line parallel to this, then draw a line parallel to this strike for the great circle c′. Wherever this intersects the 2 points, will be known then we can from this particular point, we can draw the line that is parallel to the strike b′ which is this, so that is how we can complete this triangle.

Now, these angles α which correspond to this angle, take a look here from the tunnel axis to the strike direction angle α, then angle β is from the external axis to the strike direction of this great circle b. So, that is what it is this is β and then this angle is ξ which is, with reference to the great circle c′, so it is from the tunnel axis it is this angle ξ. So, now what you do is you have to get the height, you see the two angles which are needed that is θ and χ here.

So, these can be determined, take a look here, when you have this section x, so wherever it intersects this b, take a look this is what is going to give you the angle θ and wherever this intersects a, so this is what is going to be χ. So, this is intersecting it here from b, I project it like this here and then we get the baseline of dimension. From here, you have the angle θ and χ and wherever it intersects the height or this dimension from the base to this particular point, is going to give you the height of the wedge, that is being formed in the side wall.

So, the view of the joint traces which are there in the northern side wall, if you see it from the inside of the tunnel or in the southern side wall which is seen from the outside of the tunnel looking in a direction of 340^0 which is perpendicular to the tunnel axis. So, this how we can get the height, but then we have few more things related to the side wall failure. Because, I mentioned to you that there are 2 methods which are used to determine the dimension of the wedge, which is formed in the side wall which may slide causing the side wall failure. So, we will continue this discussion in the next class, thank you very much.