Rock Mechanics and Tunneling
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Lecture 41
Underground Excavations

Hello, everyone, I welcome all of you to the 5th and final lecture of this module 8. So, in module 8 we are discussing about basically slopes and underground excavation. So, till now in last 4 lectures we have discussed a lot about the slope stability analysis. We have discussed about different type modes of slope failure like plane failure, wedge failure, toppling failures, circular failure and also in our last lecture we have learned a nice thing to determine the likelihood of slope failure from the stereographic projection in detail by solving one problem.

So, today, we will discuss about the underground excavations. Here, we will briefly discuss about the different types of underground excavations and to construct different structures as well as what are different methods of constructing those things briefly we will just discuss today.

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So, yes, as I mentioned, we will discuss about underground excavations, types of underground excavations first, we will discuss then different methods of underground excavations and also rock failure mechanisms due to excavation. These are the main topics we will discuss in our today's lecture.

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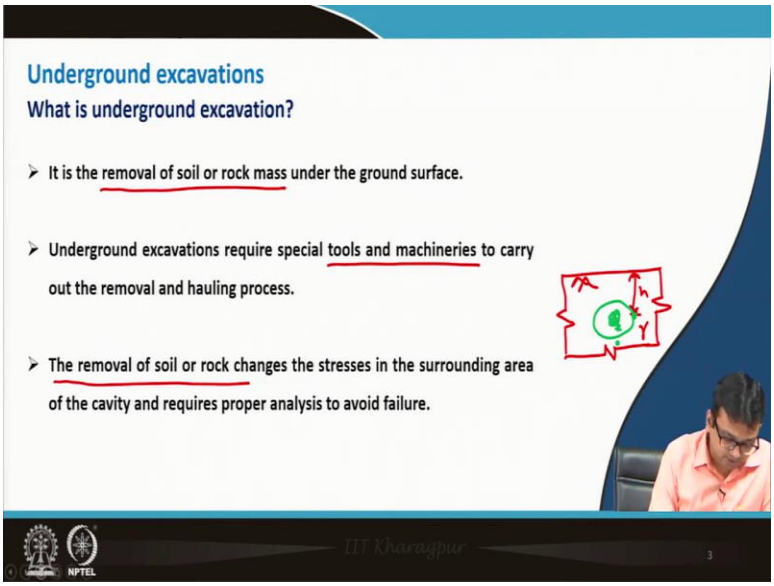

So, what is underground excavation? All of us are having some idea definitely from our common sense we can understand you have seen several underground excavations. So, it is the removal of soil or rock mass under the ground surface. Now, underground excavations require special tools

and machineries to carry out the removal and hauling process. Suppose, for tunnelling, we need a lot of equipments, we will discuss about that obviously, in future, but all of us can understand that there are several special tools and machineries that are required for underground excavations.

The removal of soil or rock changes the stresses in the surrounding area of the cavity and requires proper analyses to avoid failures.

So, just for example, suppose this is some domain. So, initially at this location suppose the vertical stress was suppose γh. Now, if we construct suppose one tunnel near to this point, vertical will be fine but you see initially there are some horizontal stresses, that is going to change at this location or more importantly if you consider maybe the suppose this location if this is the even the let me make it like these maybe a tunnel is suppose tunnel is also going through this point so, this is suppose at the periphery of the tunnel, the lateral stresses what is acting over here will change because there is now cavity. So, this is the cavity created over here. Now, at this point if we consider a constructed tunnel. So, the soil or rock is removed from this location. So, if we do that, what will happen obviously, the vertical stress at this location is removed and the effect is going to come.

So, that is what actually stated over here that the removal of soil or rock changes the stresses in the surrounding area of the cavity and requires proper analysis to avoid this failure. So, that is what we learn. Basically when you learn the tunnelling part then we discuss different mathematical formulations and how to analyse those scenarios or say those situations we will understand.

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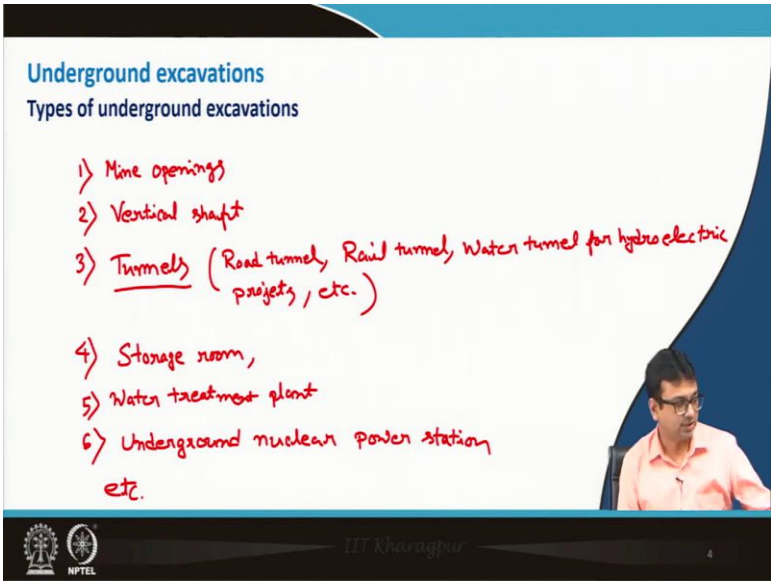

So, now the type of underground excavations. So, we know that there are different types of underground excavation some of them let me write down over here maybe number 1 we can write it as like mine openings, this is very common in the mining industry. Then vertical shafts I will show you some diagram also for vertical shafts. Vertical shafts are also quite frequently required to construct. Other than that the tunnels are the most important one of the underground structures.

So, now tunnels may be of different types like road tunnel then rail tunnel then maybe for constructing the hydroelectric power project there also we may have to construct the tunnel. So maybe water tunnel for hydroelectric projects then also the things like mining opening. Other than that maybe underground storage room that also we need to construct. Storage room maybe you may have to construct the water treatment plant then maybe for the nuclear power plant that also nuclear power station they are constructed after doing underground excavation.

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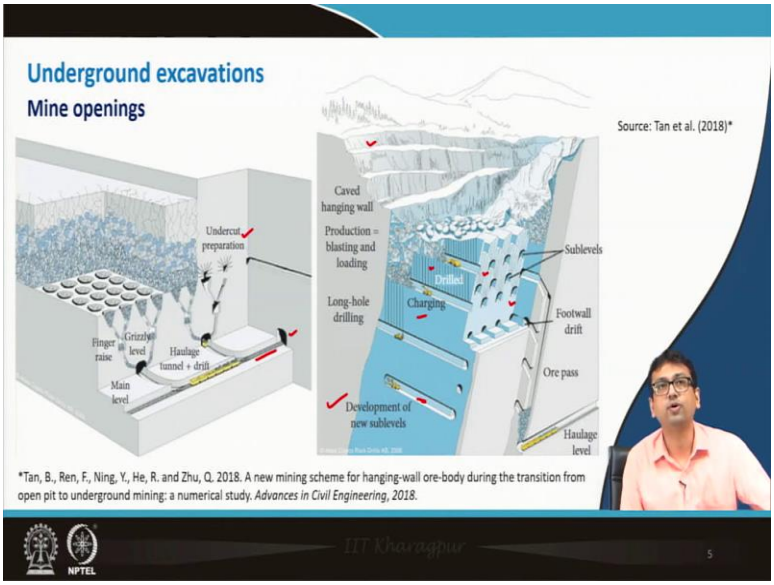

Now, suppose first one we can see some diagrams or pictures for that mine openings. So, you see, first this kind of excavations are going on over here then you see the tunnels sub levels. You see the tunnels are constructed over here. Likewise, here also you can see the this undercut preparation is going on over here. Now, here also you can see tunnel. So, the rail is there also you can see over here, so, maybe to bring the minerals from this location the rail line is also there. So, likewise you see, you can get some idea from this diagram also. So, this is of these kinds of underground excavations are required for different mining operations.

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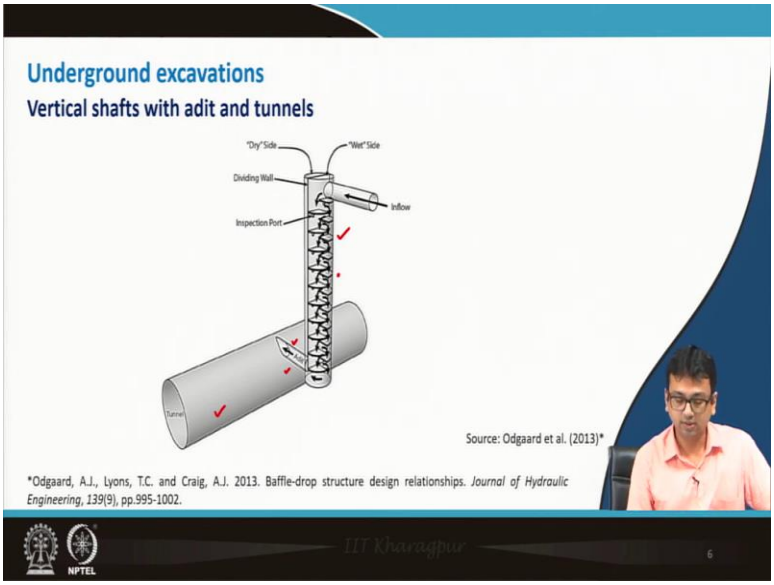

Vertical shafts with adit and tunnels. So, you see this is a vertical shaft, suppose this your ultimate important structure is suppose this tunnel, but maybe in order to suppose the air circulation is there for that this type of maybe shaft you may have to construct and this is the adit, to access this tunnel from this one this vertical shaft this is constructed. This is also nothing but the underground structure by underground excavation only this is constructed and from this vertical shape you can access this tunnel through this only. So, these are all the examples of underground excavations and underground structures.

And you see because of this construction of these things, obviously when suppose there was no excavation or cavity created then at this point what was the stresses or state of stress at this point means horizontal vertical stresses or lateral stresses. So, that will obviously change if you construct either if you construct the vertical excavation, vertical shaft or if you construct tunnel. So, obviously in the surrounding region up to a certain extent, the state of stress at some locations will change. So, because of that it should not fail that we have to keep in our minds accordingly up to design it, but obviously we will see later when we will discuss about the tunnelling that beyond a certain distance there will not be any effect actually the stresses will not at all get affected because of the construction of these underground structures. But anyway it is having that influence zone is very important. So what is the influence zone that we should identify and accordingly we have to design these type of structures.

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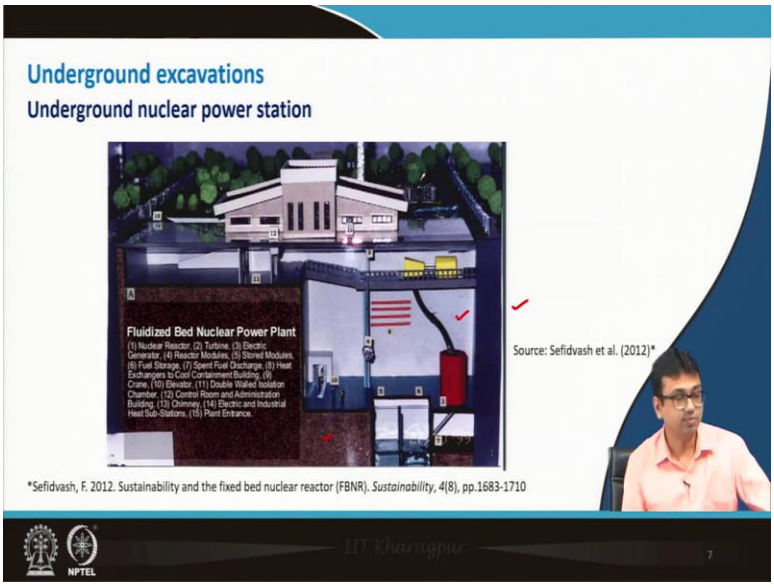

So, now, similarly, underground nuclear power station you see here you can clearly see that here written that the underground, this is the underground portion and here the nuclear power station is constructed. So, that is again nothing but a underground structure and that it was possible to construct by doing the underground excavations. The stress changes because of the construction of these and the surrounding region definitely, it is required to consider so otherwise there may be a failure.

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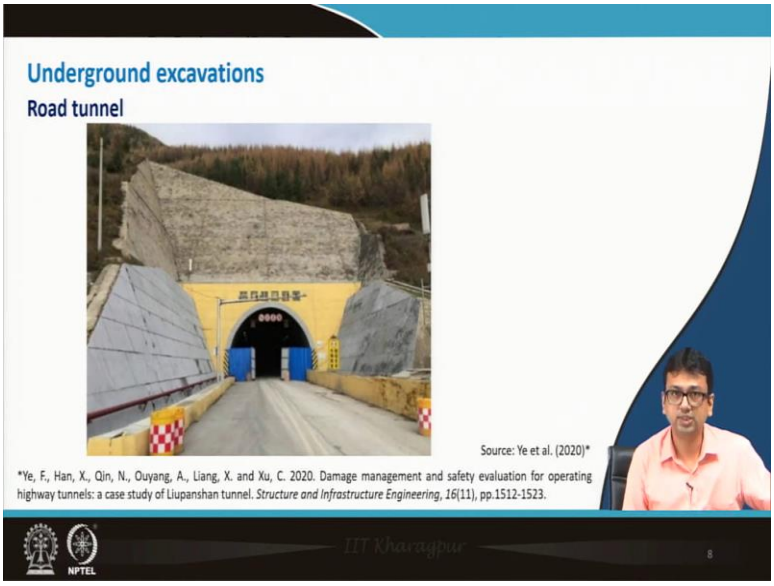

Now, road tunnel likewise we have rail tunnel or as I have stated that for the water tunnel for hydroelectric power projects or several other tunnels are very common in mining operation also we see the tunnels just I have shown you.

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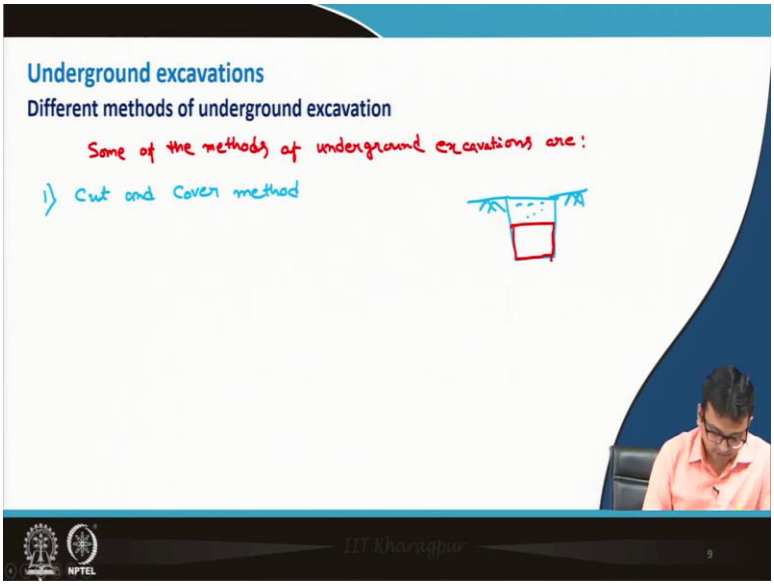
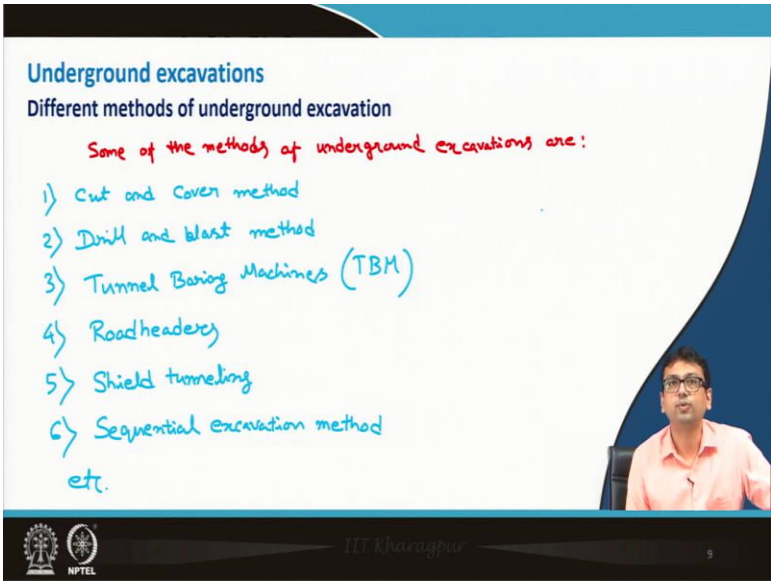
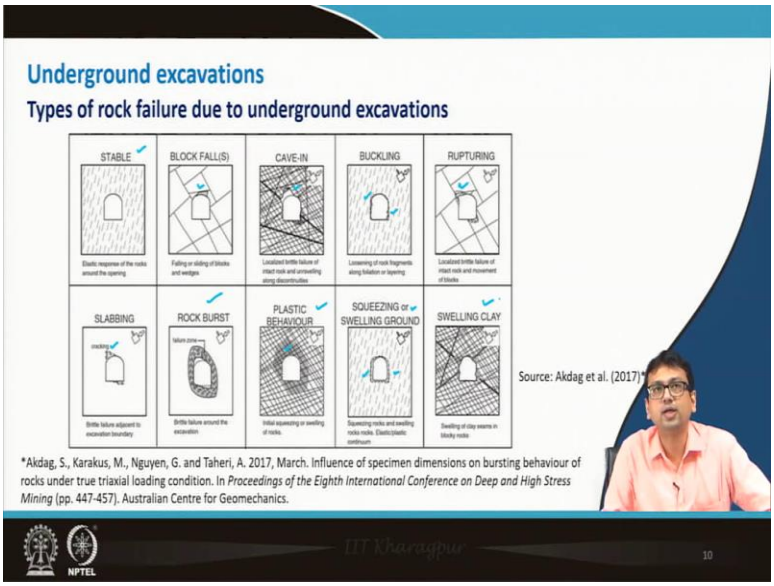




So, now different methods of underground excavations that is important. So, let me write down some of the methods of underground excavation. First one is we can go for cut and cover method. You will cut a portion suppose this is the ground you will cut like this and after maybe constructing your structure suppose over here then again you will feel this portion covered this portion. So, that cut and cover method that is also done sometimes as per requirement then we can have the drill and blast. So, drill and blast method then third there maybe for tunnelling is special equipment is there that is called tunnel boring machine.

So, that is also used quite frequently we will discuss about this later when we will discuss about the tunnels. Tunnel boring machine is TBM. Then other than that other equipment is used for

underground excavations is road headers that shield tunnelling that is also another common thing also there may be sequential excavation methods. So, that is also used sometimes mean mining operation open pit mining there for that sequential excavation method is adopted et cetera. So, these are the things commonly these are the some of the methods how underground excavation. (Refer Slide Time: 18:48)



Now, types of rock failure due to underground excavation. So, let us see this nice picture. So, from here you can clearly understand you see here in this case it is quite stable. But, you see here you see the block failure is occurring whereas here cave-in then here you see the sides are if you look at here, here buckling then here rupture has occurred then clearly you see that cracking has developed.

So, likewise there are rock burst that you can see. Then plastic behaviour can observe in this region then squeezing or swelling and ground you can see here, here and swelling clay. So these are different types of rock failure due to underground excavations. So, you should have some idea that is very important.

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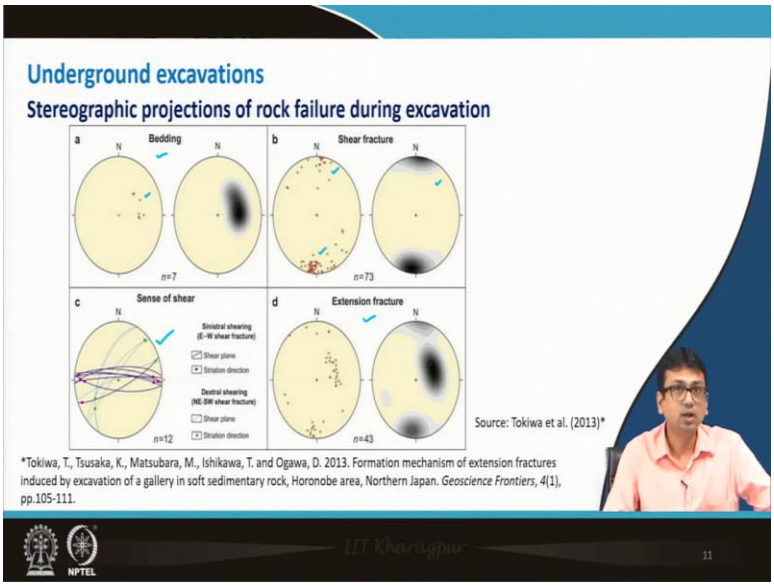

Then you see stereographic projection what we have learned in our first module and also we have applied it for understanding the likelihood of slope failure in our last lecture also. So, now, I think we have good idea was stereographic projection. So, now, stereographic predictions of rock failure during excavation.

So, some of the diagrams are shown over there you see through stereographic projection as I have stated we can identify that you see we can identify the poles and based on that means for the bedding planes like we can identify okay in this region maybe the bedding plane are located in this way.

Likewise, shear fracture you see, these we can plot the polls and from there we can understand the shear fracture zones. Other cases like sense of shear you see these are different planes you can clearly notice from here and they are intersecting with each other and extension fracture all these things with the help of pole you can identify the zone where the extension fractures are present or bedding planes are present all these things.

So, stereographic projection is very important when you construct go for the underground excavation if you have the different data related to discontinuities, so, we can plot that on the stereonet. We can get the stereographic projection of those discontinuity present over there and based on that, when we can go for the underground excavation. So, that is quite important. So, that is why this is what I am showing you.

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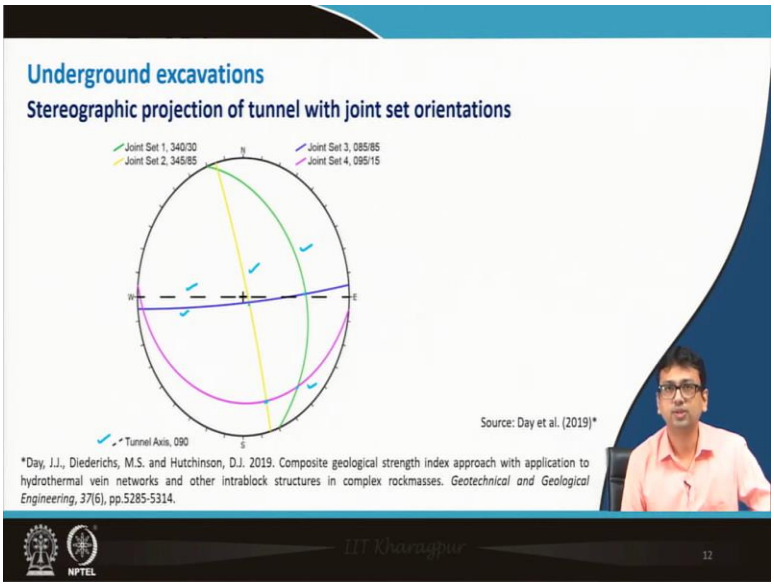

And you see, same way for stereographic projection of tunnel with joints set orientation you see there are 4 joint sets we can clearly notice. So, this is 1, 2, 3 and 4. So, now, they are intersecting like here, one intersection here, here, here these are different intersections and now also that you see tunnel axis is shown within this. So, tunnel exit is shown with this.

Now, before constructing tunnel if you can check that word, the orientation of joint sets if you can check and if you can create this to stereographic projection of disjoint sets and then if you place your where the tunnel you want to construct and whether that will be a good idea to construct or not that make you can find out whether because of the presence of disjoint sets or discontinuity planes whether that can create some problem regarding the stability of the tunnel or not that you can identify quite easily from this stereographic projection and based on that you may change the orientation of your tunnel or maybe if it becomes mandatory then accordingly you may have to design that okay at this location here there is a one intersection of two joint sets.

So, maybe you may have to take a special attention you made to give special attention to that particular design of that particular location otherwise that portion may fail suddenly. So, these are the things we can very easily identify through this stereographic projection and about which already stereographic projection about that I think we have now some good idea.

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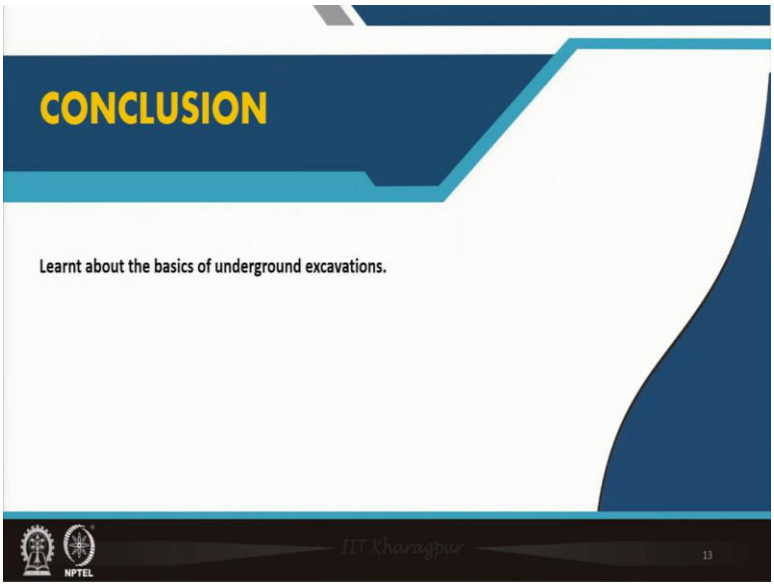

So, with this basically I can conclude that today we have learnt about the basics of underground excavations and as I have mentioned, in our module 10 and 11 we spend some time to discuss completely about the tunnelling. Thank you.