Rock Mechanics and Tunneling
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Lecture 51
Problems Associated with Tunnels &Tunneling
In Various Subsoil Conditions and Rocks

Hello everyone, I welcome all of you to the fifth lecture of module 10. So, in module 10 we are discussing about the basic features of Tunneling. Today is the last lecture of this module. So, today we briefly discuss about different problems associated with Tunnels and Tunneling in various subsoil conditions and rocks. So, these are the things what I will discuss today briefly.

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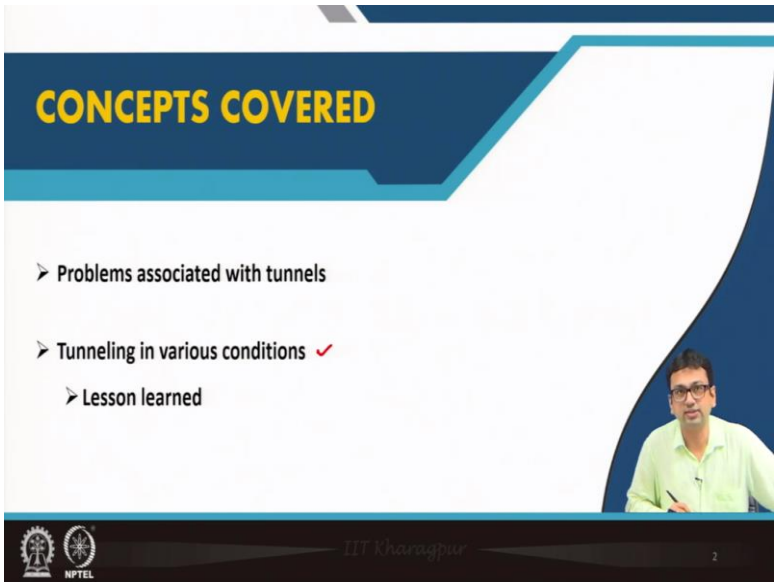

We will discuss of the problems associated with tunnels and then tunneling in various conditions. In this part, we will discuss about three case studies briefly and we will try to understand what lesson can be learned from that. So, the lesson actually was learned from the three real tunnel construction case studies. So, from there what was learned so, that we will also discuss briefly.

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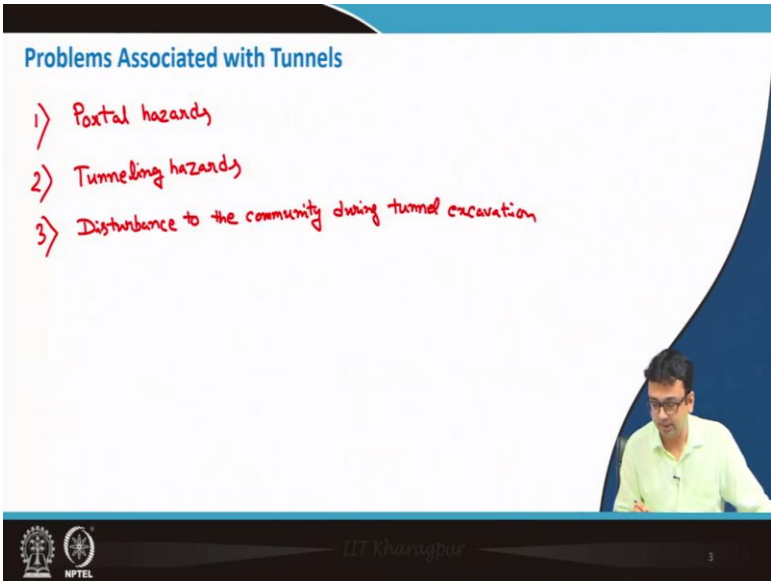

So, first we will discuss about problems associated with tunnels. So, there may be like the Portal hazards, tunneling hazards. In addition, there may be like Disturbance to the community during tunnel construction or tunnel excavation. So, that can be another problem associated with tunnels. So, there may be a few more obviously here are listed or I have divided into main 3 categories so, third one is disturbance to the community during tunnel excavation. So, let us discuss about these three things in a little bit more detail.

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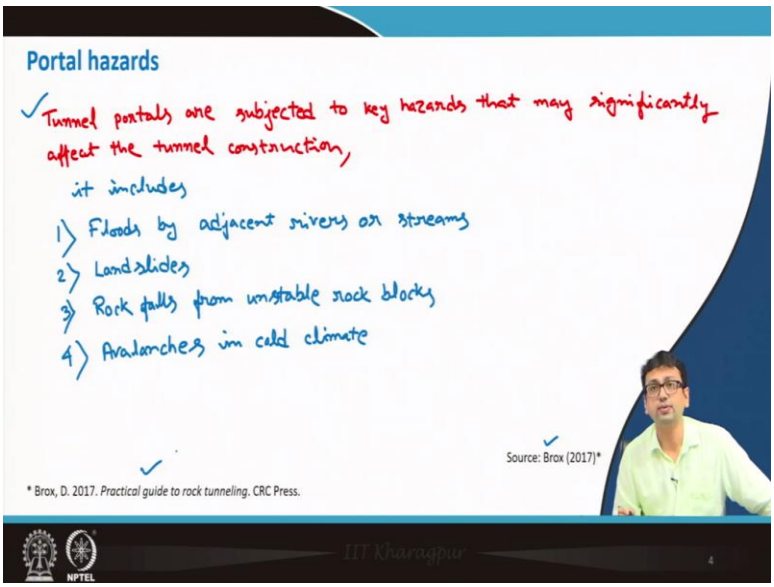

So, first one is Portal hazards as I mentioned. The tunnel portals are subjected to key hazards that may significantly affect the actually the tunnel construction.

There are different sources of this Portal hazard. First is floods by the adjacent streams or rivers that may create these portal hazards. Because of landslide, the tunnel portal may be some damage obviously.

Then third is maybe the rock fall which is also a kind of landslide only, but just specifically since, we are mainly discussing all the tunneling in rock here so, rock falls from unstable rock maybe blocks and also there may be avalanches in cold climate. There because of these things this tunnel portals on the tunnel, this portal hazards may occur. These are the some of the things that are listed over here. So, for more detail you can refer this book "Practical Guide to Rock Tunneling" by Brox (2017).

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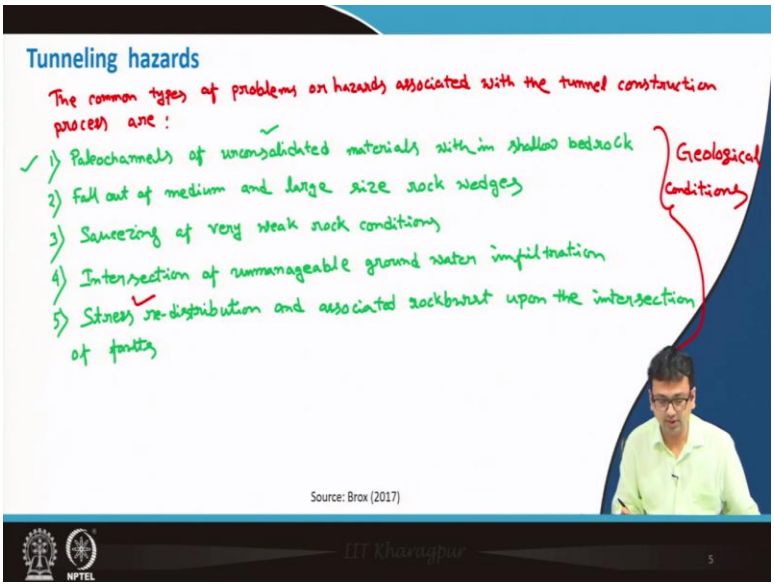

This book is a nice book that you can read for further details. Regarding tunneling hazards, there are the common types of these problems or hazards associated with tunnels construction. These tunnel construction processes are mostly related to the actual geological conditions. So, the main thing is geological condition other than that a few more sources are there. So, we will discuss about that one by one.

First, we will discuss about the geological conditions mainly so number one can be the paleochannels of unconsolidated materials within shallow bedrock.

There may be a potential cause of tunneling hazards because that the tunnel may fail due to unconsolidated material through that we are constructing our tunnel. Then, second, maybe the like the Fallout of medium and like large size rock wedges.

We already have learnt about the wedge failure remember in slope stability. So, the location through which you are actually excavating a tunnel if there are some like this kind of fallout of medium or large sized rock wedges actually happens then also that may create tunneling hazards. So, that is also another reason can be written over here.

Then also may be some of the like the squeezing, squeezing of very weak rock conditions that may be also another squeezing of very weak rock condition that also obviously can create tunneling hazards. If you are constructing a tunnel through that kind of geological formation then also there may be intersection of unmanageable groundwater infiltration.

If ground water infiltration becomes unmanageable, then again constructing tunnel can be quite difficult and there may be a chance of rock fall because as we know if groundwater is present there then effective stress will reduce and obviously, that may become a potential cause of tunnel failure.

Also, another point we can write like the stress redistribution and associated rock burst upon the intersection of faults. So, as we know in case of rock, presence of fault is a very common thing. That is why, it is mentioned over here that stress is redistribution and associated rock part because of that associated rock part upon the intersection of faults. So, that can also be a reason for this tunneling hazard.

So, these are the some points which are related to the geological condition. These are with the geological conditions. Now, apart from that there may be other reasons also.

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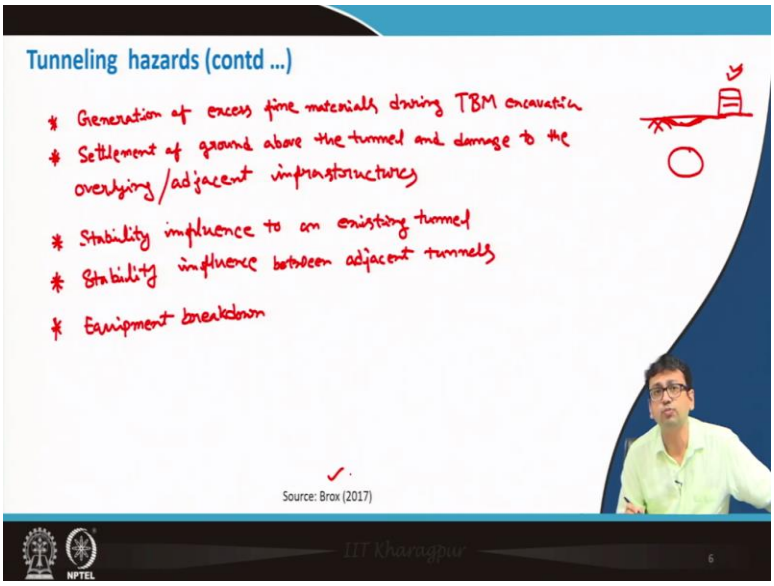

So, there may be some other few reasons also such as you see. So, generation of excess fine materials during this TBM excavation that may create one obviously hazard then obviously the another thing is you see because of constructing tunnel there may be the settlement of ground above the tunnel.

What I mean to say, suppose you were constructing a tunnel over here. So, what may happen this may the settlement can be there and if there are, any structure is present that may also get affected because of the presence of these tunnel. So, that is what I mean to say. The settlement of ground above the tunnel and which may damage the whole line or adjacent actually infrastructure.

Let me write little more over here tunnel and damage to the maybe overlaying or adjacent infrastructures. So, other than that maybe the is it two tunnels are we are constructing simultaneously then one tunnel may affect the stability of another or if we are constructing one new tunnel near a existing tunnel in that case also the construction of new tunnel may affect the stability of the existing tunnel.

So, that also we can write so, stability influence to an existing tunnel and stability influence between adjacent tunnels. So, other than that they are maybe the Equipment Breakdown that may cause also tunneling hazards.

So, yes there may be other reasons also, I have listed some of the important points. So, again these things you can see in detail in Brox 2017 also.

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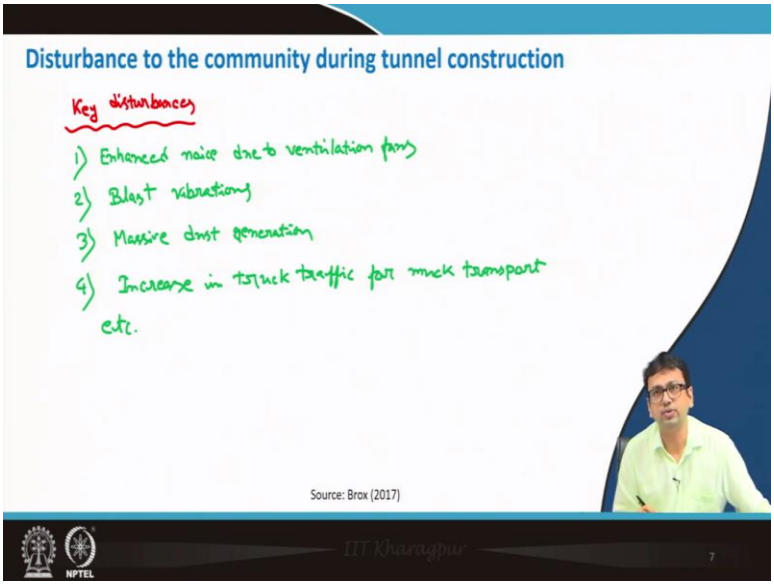

Now, another interesting thing is this disturbance to the community during tunnel construction. So, again from our common sense we can understand obviously, if the tunnel construction is going in an urban areas suppose and obviously, that may cause a lot of problem. There will be huge vibration that will develop due to the tunnel boring process or blasting and drilling.

So, huge blasting may cause damage to the adjacent structures and continuous sound will develop. So, which may be annoying for the people living there and a lot of like dust may develop. The fine particles will come out and because of that, dust may develop and continuous. You see that after tunnel boring, lot of mucks will develop. So, that needs to be transported to some other location.

So, that is why a lot of truck movements will increase. So, these are the key things we can obviously write over here.

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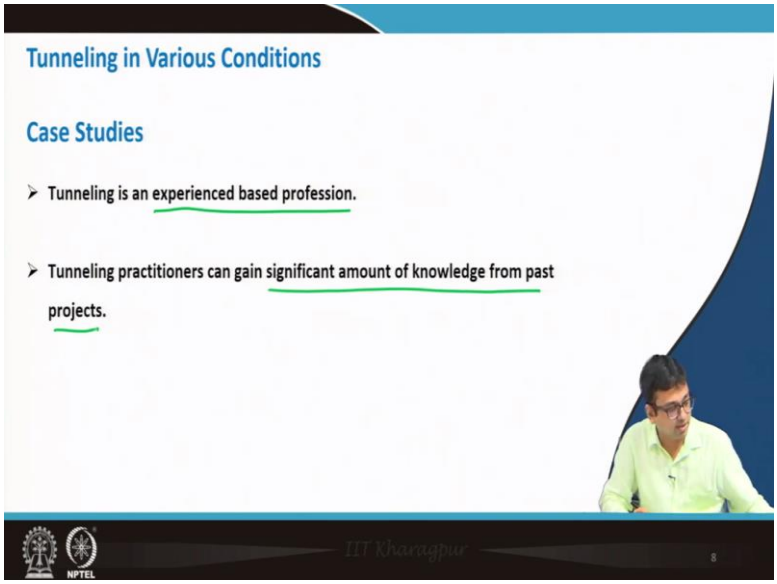

Now we will discuss about tunneling in various conditions mean sub soil condition and rock. So, in that book of Brox also going to find several case studies and basically what can be stated is like tunneling is an actually experience based profession actually. So, what I mean to say is tunneling practitioners can gain significant amount of knowledge from past projects. So, that is why I will just briefly discuss about three projects maybe. A significant amount of knowledge from past projects can be gained.

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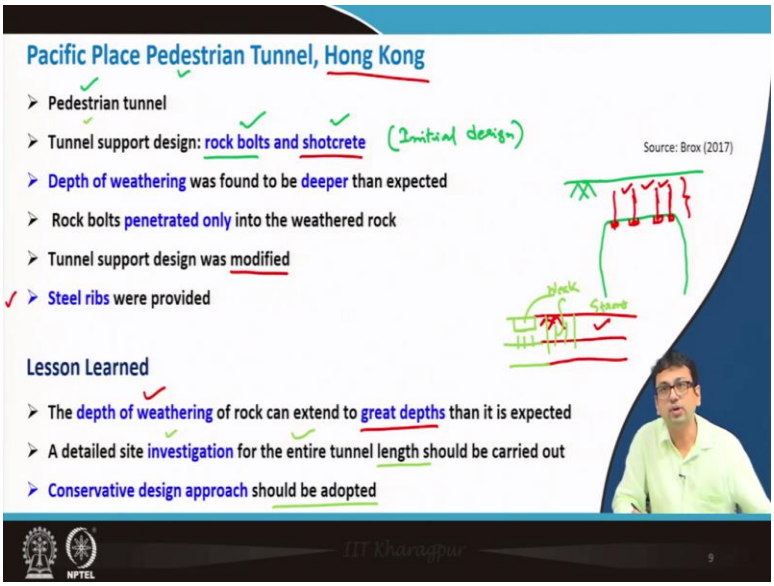

So, the first one is the specific place pedestrian tunnel in Hong Kong. So, as name suggests, it is a pedestrian tunnel. Now, initially it was decided that the tunnel the obviously before starting the construction process, so, we go for the tunnel support design. So, rock bolt and shotcrete was initially planned actually.

Now, what happened actually, during this construction process, it was found that the depth of weathering was actually deeper than the expected. So, it was designed considering a certain up to a certain depth of weather drop, but at the time of construction, the depth of weathering is deeper than the expected. Now if that happens, then what will happen you see since it is based on rock bolts, so rock bolts penetrated only into the weathered rock.

Then obviously, it will not get enough anchorage. Though regarding rock bolt how to design it that we will learn in our last module 12th module. You are constructing suppose tunnel over here what may require you may use maybe like rock bolts. So, actually these bolts will get anchorage from this region.

Now, if this rock is weathered rock, so it is a very weak rock. So, it will not be able to provide enough anchorage. So, rock bolt and shotcreting was not good enough. So then, what was done the tunneling support design was modified. So, this is what I was telling that it is you will begin with one plan maybe but during construction you find that, that is not good enough what design you have prepared, then you may have to change your design.

So, that is what, we can understand and what was done is the steel ribs were provided additionally. These rock bolts and shotcreting was not good enough. So, that is why steel ribs are also provided for increasing the stability of this tunnel. This is something important. So now what lesson learned from this, at least what we can say that in tropical and subtropical environment, the weathering can be actually more than what is expected.

So now, if that happens, what we have to do, number 1, we should go for an actually detailed site investigation that is very important before going for the tunneling operation.

So, a detailed site for the entire tunnel length should be carried out because this is your tunnel path now, what may happen like maybe this region is good rock but what may happen you will find another region is made of the weak rock.

So, obviously, the like if you go for the rock bolting in this case maybe up to this will get the anchorage so, this is a strong rock bolt here it is entirely weak rock. So, that may not be good enough to, to generate enough anchorage so, that is why it is stated that the detailed investigation for the entire length of the tunnel should be conducted that is very important. And you see this was you as you can see it is a pedestrian tunnel that means you can understand it is in urban area right in city area maybe.

So, you can understand failure of an urban tunnel can cause huge life loss. So, that is why the conservative design approach should be adopted specifically in these type of urban areas as adopted it is obvious for all areas but specifically when you are constructing like pedestrian tunnel which will be mainly in the urban areas there we should go for conservative design approach.

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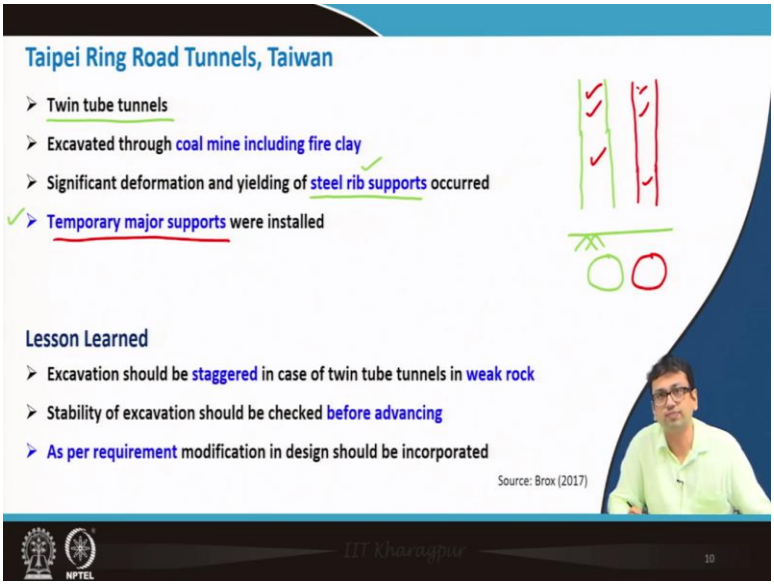

Now another one briefly I will discuss that is Taipei Ring Road Tunnel, Taiwan. So, here actually Twin Tube tunnels were constructed or Twin tunnels you can simply say and excavated through coal mine including fireclay. So, it was through a coal mine including this fireclay and apart from that, what other features are like significant deformation and yielding of steel ribs support occurred.

Means everything was fine here the strong means as we have seen previously in case of previous tunnel, initial design, and the only the rock bolts shotcreting was considered or designed. But here though the steel ribs supports were planned that was planned to provide but still it was found a significant deformation of yielding of steel ribs support so where I will have means were found to be happening.

So now, in case of twin tunnel, the construction sequence is very important. We have discussed earlier right in our earlier lecture that we have to means be very careful when we are constructing like big diameter tunnel. So, sequence of tunneling is very important. So that is true for twin tunnel also obviously.

And so, if the tunneling sequence is not maintained properly or if before like proceeding further if we do not check the stability of the tunnel or the means the what we have constructed presently, then that may create trouble means suddenly some loss may happen. So anyway, though it was planned to provide steel ribs support still there was found to be some failure. So,

what was done? So, temporary major supports were installed there. So that was also an instantaneous decision was taken.

Now or some same the lessons learned like excavation should be staggered in case of twin tunnels in week rock. So, when you are constructing like twin tunnels then the construction should be staggered. So, if I show the top view, so, what we expect suppose this is the green tunnel.

So, maybe the green tunnel is constructed up to these then maybe this red tunnel will be constructed maybe up to this then again maybe as per requirement it may be extended further or then again maybe what if it is found that this is strong enough. Now maybe it may be constructed up to this like in sequence. It needs to be constructed and staggering means, once you go for these and then staggered excavation should be done.

Stability of excavation should be checked before advancing as I was telling before going further. We should check the stability actually that is very important then only we should proceed in case of twin tunnels in weak rock obviously, if it is a hard rock that is obviously a very favorable condition but in the weak rock it is very important. Now as per requirement modification, design should be incorporated as it is done over here like temporary supports were installed. So, these are the lessons that we have learned from this tunnel construction.

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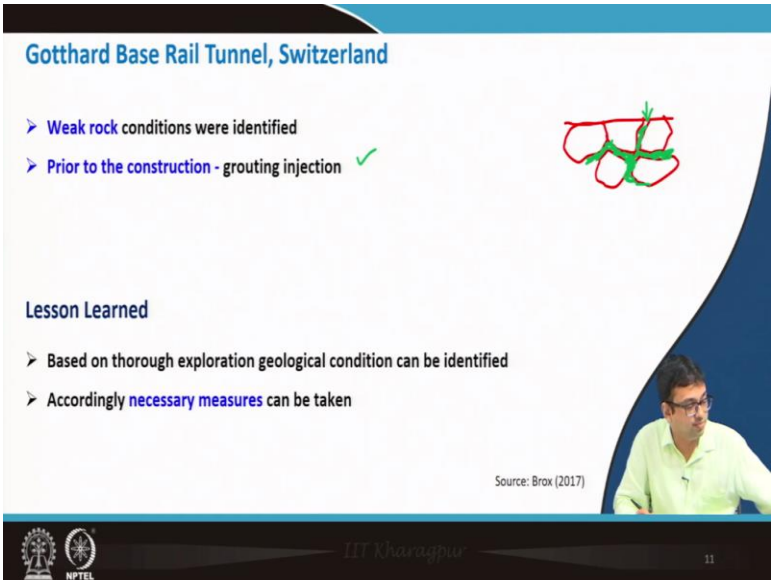

And now the last one I will discuss. The weak rock conditions were identified actually beforehand constructing the Gotthard Base Rail Tunnel, Switzerland. So, it is a rail tunnel. The good thing is before constructing only weak rock conditions were identified and based on the identification what was done prior to construction grouts were injected.

So, again, we are getting grout also learned in our last module, but I hope you have some idea like cement grout. So, cement mix is injected in very liquid form.

So, strength will obviously will increase. Something like that was done prior to the construction. So, actually the ground was improved. The rock mass through which we need to construct the tunnel means they had to construct the tunnel that they actually improve through the injecting grout. So that is very important. Now, what we can learn from this is based on thorough exploration, this geological condition can be identified.

So that is very important and accordingly necessary measures can be taken. So, that is what one other lesson we can learn from this.

But anyway, that is why I have mentioned over here that the tunneling is an experienced based profession and tunneling practitioners can gain significant amount of knowledge from past projects. So that is why just I have presented three projects over here some main points of these three projects I have discussed over here. For more number of case studies, you can read this book.

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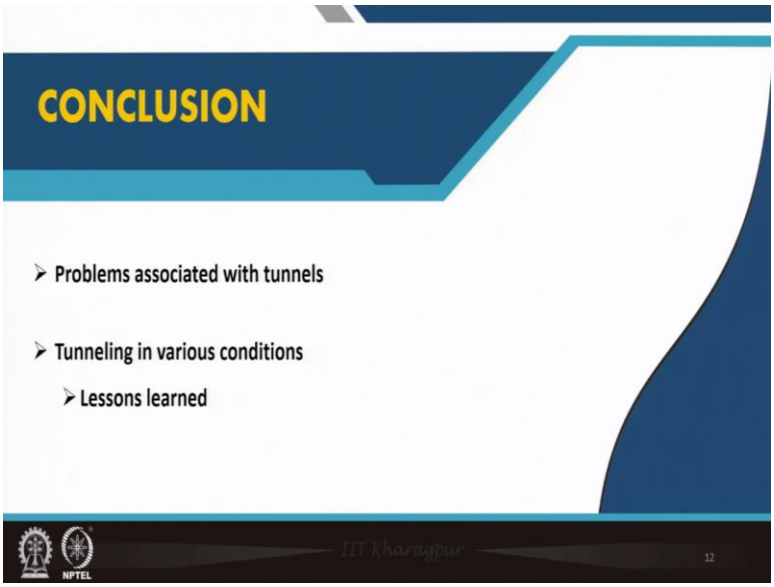

So with this, let me conclude our today's lecture. So, we have discussed today about the problems associated with tunnels and tunneling in various conditions. So and finally, the lessons learned. So, thank you. We are concluding our tenth module.