Welcome to the lecture series in Engineering Geology.
Today we are dealing with model number 21 wherein we'll be discussing tunnels and the influence of geological conditions on tunnels.
For the present lecture we'll be learning about geological investigations to be carried on before tunneling and what is the influence of geological conditions on tunneling.
After completion of this particular module, you will be able to understand what are the geological investigations to be undertaken before tunneling and what is the influence of different geological structures on tunneling.
Now what is the tunnel all of you all are familiar with because we have dealt with it in the previous module. Now we will see and try to answer this question why geological investigation is needed before tunneling we need to do geological investigation in order to select the tunnel route, what should be the excavation method and the tunnel design as well as to assess what will be the cost of tunneling and environmental hazards which will be faced because of the tunneling project to answer all these questions we need to do geological investigation.
Now when we do geological investigation it will be done under three heads we'll try to understand what is the nature of the rocks? what is the geological structure of the area? and what is the groundwater condition in the region before taking up any tunnelling project. So when we study regarding the nature of the rocks, rocks can be very hard and crystalline like our igneous rocks, hard and crystalline rocks are the most suitable because they lack structural disconformities as well as the final cost of lining back filling and grouting is minimal when the rocks which are encountered along the tunnel are hard and crystalline but here the only problem is the initial cost of excavation of the tunnel is very high because the rocks are hard, huge machineries are required in order to break the rocks but the advantage is that after excavation the cost which is involved in backfilling and grouting as well as lining is minimized. The exact opposite case is when we deal with soft rocks.
soft rocks the excavation cost is very less but because of their soft nature the cost of lining grouting and backfilling is very high after the excavation process is complete. Fractured rocks are the rocks which are rich in disconformities like for example rocks which has got fractures, joints, fissured rocks other rocks which are highly jointed sheared in such cases even the hard and the soft rocks they possess a threat for the tunneling project because this are the weaker zones from which there can be seepage of water and a lot of manpower as well as cost is involved in backfilling and lining of the tunnel if the tunneling project is carried out in such regions.
so that is what we need to understand when we study the nature of the rock the second criteria and the most important criteria is to note down the geological structure of the area. when we deal with geological structure of the area what we are studying is what is the nature of the rock, whether the strata is horizontal, inclined-what is the inclination and how it will affect my tunnel.
Now let us take the first example which you all can see in the image wherein there are horizontal stratas which are shown there is case one and case two the color layers are nothing but the bed and the black portion which you can see over here is the tunnel now in case one the situation is favorable because the individual bed is very thick and the tunnel is passing through only one bed and because of which the natural arch action is created which acts like a beam and this is a very safe condition but if you look at the second case wherein the tunnel is encountering two or more beds this becomes an unfavorable Condition because there are many bedding planes which are encountered along the tunnel route tunnel arch as a result of which because of the bedding planes there can be seepage of water inside the tunnel so it is slightly unfavorable condition and precautions needs to be taken before constructing a tunnel in this region the second condition is when you have a moderately inclined strata and the tunnel axis is passing parallel to the deep direction now in this case the load is uniformly distributed and the arch action where the rocks at the roof act as a natural arch transferring the loads onto the side even the

weaker rock can be self-supporting in such a situation however the axis of the tunnel in this particular situation has to pass through number of lithologies which can be undesirable because in such a case there can be hard rocks as well as soft rocks which is encountered along the tunnel root which can lead to problems like instability and over breaking the third situation is again a moderately inclined strata wherein tunnel axis is parallel to the strike direction you can see in this image strike and deep direction is marked when the tunnel is parallel to strike direction there is a symmetrically distributed load which is put on the tunnel along the periphery of the tunnel and the bridge action which is present in part and it is weakened because it is encountering bedding planes along one side of the tunnel so this is also an unsafe situation and since there are bedding planes which are encountered along the tunnel there can be seepage of water inside the tunnel and proper care has to be taken next situation is when the strata is very steeply inclined or it is vertical at that time if the tunnel is passing axis is parallel to the d in this case the formation stench along the sides and the roofs of the tunnel like beams or girders and a appropriate condition is created and provided all the formations are sound the next situation is again when the strata are steeply inclined or vertical and the tunnel axis now is parallel to the strike because the tunnel axis is parallel to strike there are many bedding planes which are intersected at the roof and along the arch so the natural beam action or the arch action is very weakened because there are bedding planes which are encountered all along the roofs of the tunnel and as I said earlier when there are bedding planes encountered bedding planes marks unconformities or deformation planes and there can be water seepage as well as seepage of the beds itself. Now let us look at the next situation where along the tunnel you encounter folded beds. Now can you can see in the image that I have marked beds a b c and d they are folded and when the tunnel is passing along the limbs of the fold parallel to the fold axis the axis of the tunnel is also parallel to the limbs now this is a desirable condition because when you do tunneling in such a region you will encounter similar formation having similar physical properties and all the conditions encountered during the course of the tunnel are the same so tunneling in such a situation is safe let us look at the second case when the tunnel is passing along the crest of the fold parallel to the fold axis along the crest of a fold there are cracks of fractures developed and this makes the rocks along the crest the rock masses are highly fractured and because of this tunnel driven in such a place there may be frequent rock falls from the roof but if it is an antique line the joints which are developed are perpendicular to the bedding planes and a wedge shaped blocks are produced and this wedge shaped blocks acts as a keystone and they prevent the fall of adjacent rock masses third situation is when the tunnel is passing along the trough of the fold now you can see in this image that the trough is the depressed portion of the fold. now this is an unfavorable condition because the joints which are produced will converge upwards so the blocks bounded by joint planes are liable to fall down into the tunnel.

further the inclination of the bedding planes
also may guide or the percolated water towards the trough
and it will create undesirable groundwater problems
when the tunnel is aligned perpendicular to the fold axis this is the fourth situation
and this is also undesirable because under such condition
different rock formations would be encountered from place to place
along the length of the tunnel and also tunnel has to pass through many anticlines and synclines
and because of this heterogeneity in the physical properties of the rock
this conditions become undesirable for any tunnelling project to start. now let us look at the next situation where we are encountering faults
or joints along the tunnel. faults are surfaces along which rock movement had occurred in the past
and this are potential sources for future movements of the rock. fault zones and shear zones are also highly permeable zones
likely to form a passage for ground water to sip
into the tunnel therefore it is necessary that whenever tunnel is interacted by a fault plane or a shear zone
it should be provided with maximum support
and drainage facilities. now let us look at the
third criteria which we need to investigate before tunneling that is what is the groundwater condition
groundwater condition of the region and orientation of the tunnel axis
is one of the major factors influencing the stability of tunnel
let us look at the first condition where

the
water table is quite below the tunnel
and the tunnel axis is not encountering
any
pervious formation so this is highly
desirable condition
wherein you will not encounter any
problem related to groundwater because
the
water table is quite below the tunnel.
the second situation
is when part of the tunnel is coming
under the water table whereas the other
tunnel axis
is not coming under the water table this
is also a desirable condition and most
tunnels
encounter this type of situation only
care or precaution needs to be taken
where the tunnel has encountered the
water table
care in the form of lining and back
filling and grouting so that there is no
water seepage
into the tunnel. here in the third
situation the tunnel axis
is located far below the water table and
this
is a highly undesirable condition
because throughout the length of the
tunnel it is coming
under the water table and there can be
serious issues of
water seepage into the tunnel and has to
be dealt with very carefully
i hope all the geological factors
influencing the tunnel alignment are
clear to you all