Rock Engineering
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Lecture – 01
Introduction

Hello everyone. We are going to discuss about this course Rock Engineering and I am Priti Maheshwari from Department of Civil Engineering IIT Roorkee. So, first of all let us see that why do we need to study this subject rock engineering. As you know that these days lot of infrastructure development is taking place and especially in the Himalayan region where a lot of hydropower projects are coming up and you must have heard about the railway line that is being laid between Rishikesh and Karnaprayag.

Likewise, you can think about the Konkan railways and many other such projects you must have heard about most of these cases the founding material is rocks not the soil. So, it is very important as a geotechnical engineer for us to know about this material and to know the branch of engineering which deals with this material called rock engineering. So, we will be discussing various aspects related to this material in this course Rock Engineering.

And it is very important as a geotechnical engineer for us to know the engineering associated with this natural occurring material which is rock which is very much different than that of the soil and of concrete. So, in today's lecture what we are going to discuss is that what all are going to be the topics that we are going to take up. I will be discussing and sharing with you the course material the references and then we will start with the introduction part. So, let us see that what all are the topics which we are going to cover.

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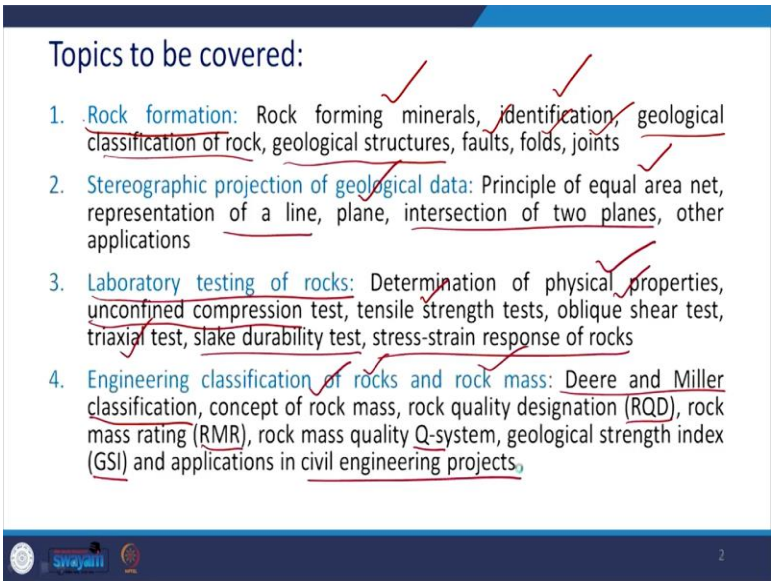

So, the first one includes the rock formation in this one we will discuss about various rock forming minerals. How we can identify those minerals? What are the geological classification of various types of rocks? then various geological structures that include faults, folds and joints. So that will constitute the first lecture. Coming to the next one that after this rock formation we will discuss about the stereographic projection of the geological data.

Now why it is required? How it is done? all these things will be discussed in this chapter. So, some of the components that we will be discussing will be principle of equal area net, then how we represent our line which is there in 3 dimensional situations how we represented in 2D form. So that we will discuss. Then how do we represent a plane and then intersection of the 2 planes and other applications, like where we are going to need this stereographic projection of the geological data. So, all those things will be discussed in this chapter. Then after that the third chapter will include lab testing of the rocks. So, in this one first we will learn about the determination of the physical properties then we will see that how this unconfined compressive strength of the rock is obtained using unconfined compression tests.

As against soil this material rock, possess some tensile strength. So how to determine those tensile strength properties that we will discuss. Then followed by some of the shear tests that would include oblique shear test, triaxial tests and then how do we determine the degree of weathering that can be determined using slake durability tests. So that also would be discussed

and then when we conduct these tests what we are going to get is the stress strain response for any particular type of rock. So, we will learn that how to analyze those stress strain response of rocks in this chapter.

Once we are done with this and then we will move to engineering classification of rocks and rock masses. I will introduce you know that what is the difference between rock and rock masses before that and then we will have the classification system for the intact rock that is Deere and Miller classification. Then we will learn something about the rock mass.

And then some of the classification systems related to rock mass that is rock quality designation RQD, rock mass rating RMR, rock mass quality that is Q system then geological strength index system that is GSI and then we will see what are the applications of these classification systems in various civil engineering projects. Then we will learn about the strength criteria for rocks and rock masses.

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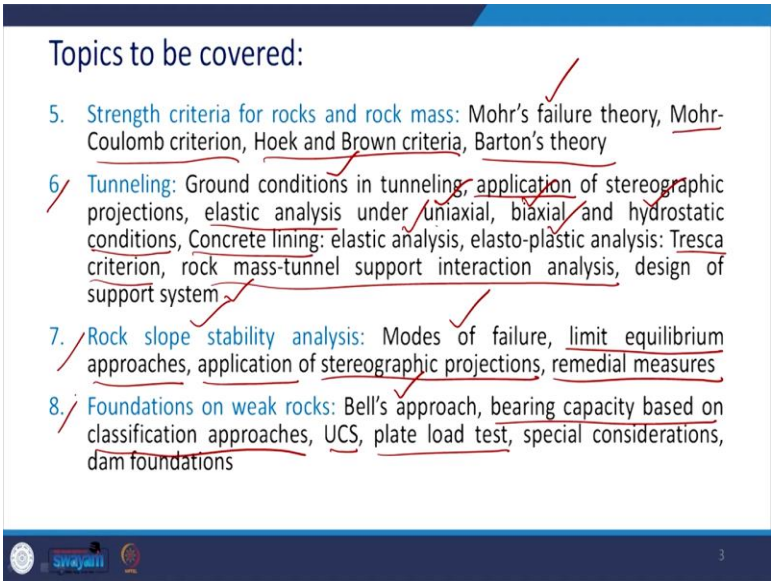

And in that one we will learn about the Mohr's failure theory then followed by Mohr-Coulomb criterion then Hoek and Brown criteria and finally the Barton's theory which is there for the jointed rocks. After this then we will go to various aspects related to tunneling. Now depending upon which area that you have the project related to this tunneling you can have different ground conditions.

So, we will learn about different ground conditions for tunneling then the stereographic projections which we learned in the second chapter the application of that we will see here with respect to tunneling. Then elastic analysis of the tunnels under uniaxial, biaxial and hydrostatic conditions. And when we excavate tunnels are to be provided with lining. So here in the scope of this course we will discuss about the concrete lining.

And we will study elastic analysis as well as the elasto-plastic analysis and for elasto-plastic analysis we will take up Tresca criterion. And then we will discuss about the rock mass tunnel support interaction followed by design of the various support systems like it can be shotcrete it can be concrete lining it can be rock pores it can be anything. So, all those things we will discuss in this chapter.

Now the next chapter will deal with the problems or analyzes related with the slopes which are there in case of the rocks or rock masses. So, we will first learn about what are the various modes of failure then we will see various limit equilibrium approaches towards the analysis of rock slope stability. Obviously then as it says, stereographic projections and it is application in the area of slope stability that we will see.

And then if the slope is failing what can be the remedial measure which can be adopted. So that also we will discuss in brief and finally we will discuss about the foundations on the weak rocks. You all know that in case of soil you have Terzaghi's bearing capacity theory but that does not work here in case of the rocks. So, we will learn about the Bell's approach. Then this bearing capacity which is based on various classification approaches which we have seen RMR, Q etc., all those systems based on UCS based on the plate load test results and some special consideration and some aspects related to dam foundations that will be discussing. So, you must have gotten the idea that in this course we are going to cover almost all the aspects related to analysis and design of rocks and rock masses with respect to various structures whether it is tunnel whether it is slopes or whether it is the foundation. So, the first portion will be dealing with the learning about this material and then we will see some of the application aspects in sixth, seventh and eighth chapter.

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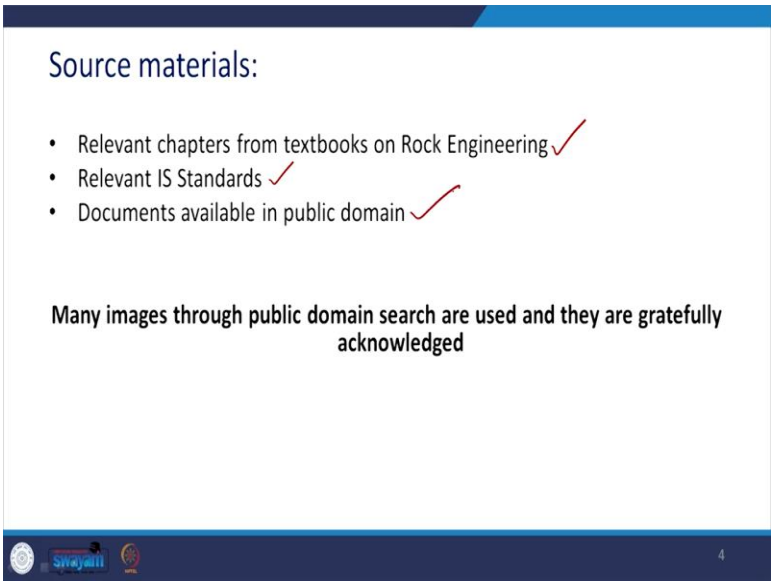

Now the source material for this course is going to be some of the relevant chapters from the textbook on Rock Engineering. I will be telling you about these textbooks then we will have relevant IS quotes. Then documents which are available in public domain and in order to make you understand some of the aspects many images through public domain search have been used and they would be greatly acknowledged in due course of this subject. Now some of the books I have listed here so you can just take a look.

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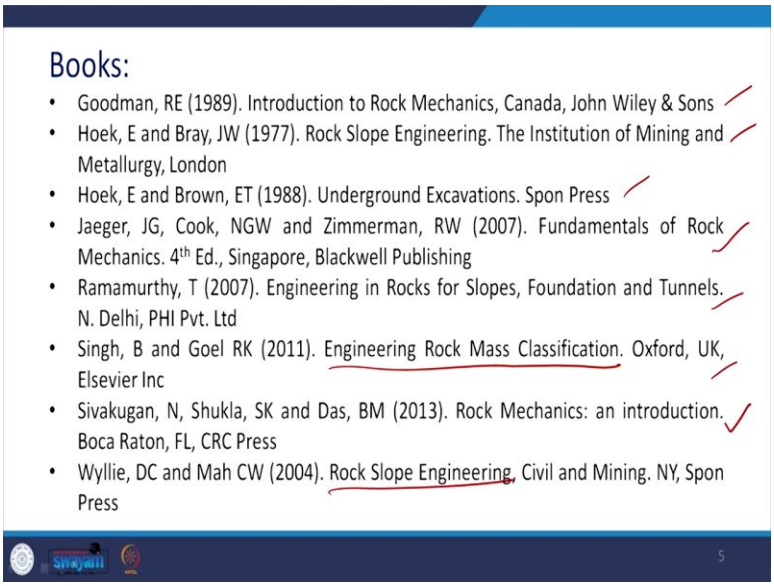

This is by Goodman. So, it is overall it gives you the idea about the introduction to rock mechanics then the book by Hoek, E and Bray basically deals with rock slope engineering then Hoek E and Brown book this deals with mainly the tunneling aspects that is underground

excavations then the fourth one is by Jeager et al that is again overall rock mechanics textbook then the one by Ramamurthy and then Singh and Goel.

So, this one we will discuss with respect to the rock mass classification systems. And then finally we have others that is rock mechanics and introduction and this one will be with respect to rock slope engineering. Now let us start with this introduction. So, first of all let us understand what this material rock is?

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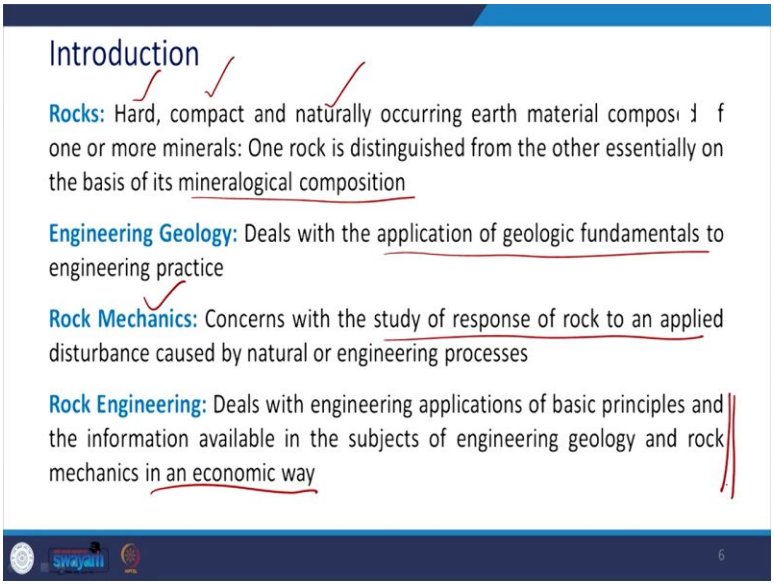

So basically, it is hard compact and natural occurring earth material which is composed of one or more than one mineral. Now how one rock is going to be different from the other that will depend upon its mineralogical composition. So, that is how we overall manner that we define the material rock. Now the next term which is very important for us to understand is engineering geology. So, this deals with the application of geological fundamentals to the engineering practices.

So, the branch which deals with such type of thing we put it under engineering geology. Then the next step is going to be rock mechanics. So, this branch it concerns with the study of response of rock to an applied disturbance and that applied disturbance can be by any natural agency or it can be by human. Because depending upon what are the various engineering processes that are taking place accordingly this branch of rock mechanics will deal with such type of things.

Then finally comes our subject which is the rock engineering. So, you see, whatever is the knowledge that we gain from engineering geology and rock mechanics that we will apply and we will learn how to apply those in the various field condition maybe it is related to tunneling it is related to slope stability problems it is related to foundation on weak rocks in an economic way. So that is what we are going to learn in this course.

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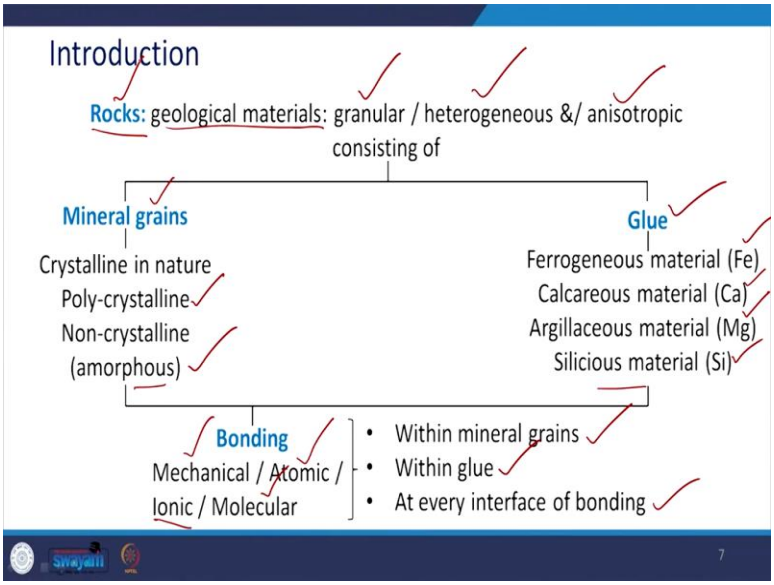

Now coming to this so basically these rocks it is a geological material which is granular it can be heterogeneous and anisotropic and it is consisting of 2 components one is the mineral grain and second is glue. Now these mineral grains can be crystalline in nature and when I say crystalline in nature, they can be poly-crystalline or it can be amorphous. When we talk about this glue material it can be rich in iron, rich in calcium, rich in magnesium or rich in silica.

And when these 2 that is mineral grain and glue, they develop some kind of bonding. Now this bonding can be mechanical, it can be atomic, it can be ionic or it can be molecular and these bonding can exist within mineral grain it can be within glue or at every interface of bonding then the resulting material which is called is rock. So, this is what is an overall basics behind this material rock. Now coming to them one step ahead that is rock mass. So, when this rock has various discontinuities.

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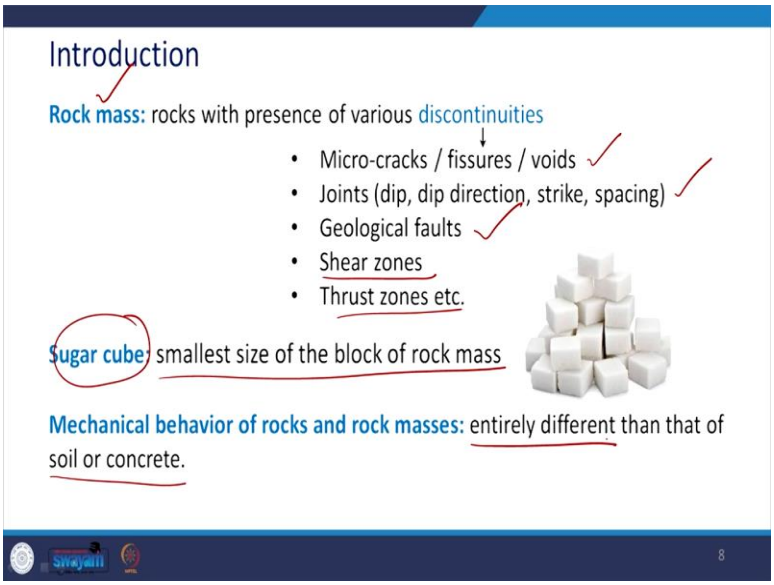

Now these discontinuities can be in the form of micro cracks fissures or voids they can be in terms of joints it can be geological faults, it can be shear zones or thrust zones then we call that as rock mass. Please remember that rock with the presence of various discontinuities is called as rock mass. Now you know this you come across this rock mass every other day in the form of sugar cube. So, you see that here I have just put a picture where these sugar cubes are there.

So, the smallest size of the block of the rock mass is represented by this sugar cube. Now you know how the composition of this material rock is different than that of the soil or concrete and therefore mechanical behavior of rock and rock masses they are entirely different than these of soil or concrete. Now let us see field applications although I have discussed but let us see them one by one. So, let us say you one has to go for the construction of large dam.

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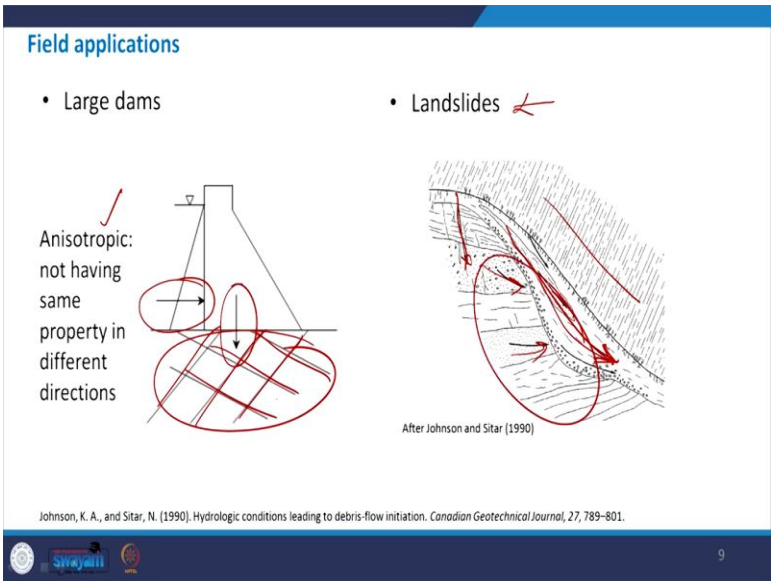

It has to be founded on this type of rock mass which has these set of discontinuities these discontinuities will give rise to anisotropy which will not have the same property in different directions and therefore we need to know what all are these discontinuities what is this rock mass whether they are oriented in the favorable direction or not towards that because you see the weight of the dam will come into picture you see on the upstream side this weight the water pressure will also come into picture. So, this dam foundation should be good enough to support all these forces which will be coming to the dam body and therefore transferred to this rock or the foundation material then the second one is landslides. Everybody knows this, rainfall is occurring and then what will happen. This mass here will start sliding in this direction, you see, so this slope will no more be stable and then what will happen let us say the water that seeps in it will try to go out from here. Further it will make this portion slide. So, until unless we know the shear strength behavior of this material, we will not be able to analyze this. So therefore, it is very important for us to know about this material rock or rock mass.

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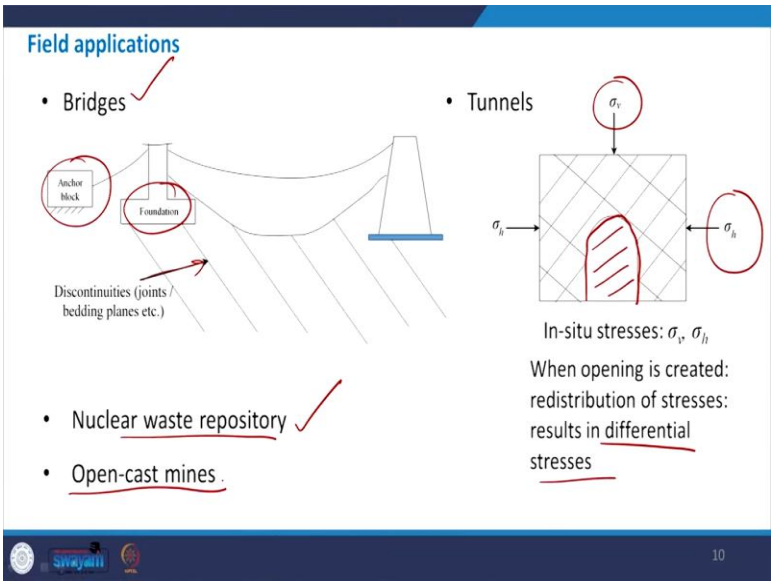

Then the next one bridges; you can see here there is a foundation and anchor block. And then discontinuities are there which have been shown by this arrow and until unless we know the orientation what is the type of the rock etc., I cannot go ahead with a proper design of these foundation or anchor block or abutment for bridges. So, in case of bridges, it is equally important for us to know about this subject that is rock engineering. Then come to tunnels.

Let us say this is a rock mass this complete rectangular portion is rock mass and in situ stresses they are acting in the vertical direction it is σ_v and in the horizontal direction it is σ_h now I make an excavation here. So, what will happen when I made the excavation this free surface here the stresses are going to be released and when the stresses are going to be released what will happen there is going to be redistribution in the neighboring rock mass.

And that can cause the differential stress. Therefore, we need to know what are the stresses which are occurring? After redistribution what is happening? So, then we will discuss about various aspects related to tunneling all these things will be covered in terms of its elastic analysis elasto-plastic analysis plus the analysis for the lining. Then the next one is nuclear waste repository you know that nuclear waste is really a prime concern for its deposition. So usually what is done is deep below the Earth's crust this is deposited. So, for that again at that level you have the rock. So, we need to appropriately design this structure so that it will be able to serve for a few years like 100, 200 or 300 years. Then the next application which is there is the

opencast mines everybody knows about it when we have to go for any kind of mining operation. So, let us say if it is a rocky strata, I just cannot cut the slope with closed eyes. We need to see whether the slope at which angle that we are cutting it? Whether it is stable are not. So, all those things will be coming here.

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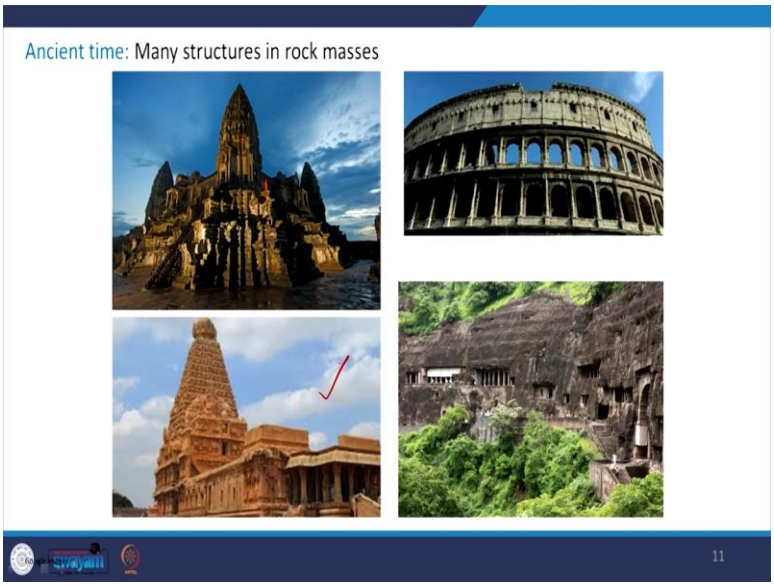

So, it is not that that it is a very new branch. You can see that from the ancient times many structures in rock masses they have been constructed here. This example like this is a big temple in Thanjavur and some others are there. I just downloaded it from the internet for you ready reference that this is not the very recent engineering branch but it is done for a long long time back and then with the development and the various aspects related to this branch of engineering we need to learn we need to update ourselves so as to have better analysis and design of the structures which are founded on rocks and rock masses.

So, in today's lecture we saw that how this subject is going to be helpful to us, why we should learn about it and then what are the various topics that we are going to discuss in this what are the various field applications. So, we will start with the different minerals because rocks I mentioned to you that they are composed of minerals. So, we will learn few aspects related to minerals, how these are identified in the next class followed by different types of rocks. So, thank you so much. Thank you.