Rock Engineering
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Lecture-11
Laboratory Testing of Rocks-Preparation and UCS

Hello everyone. In the previous class, we started our discussion on a new chapter titled laboratory testing of rocks. So, before the lab testing is done on the rock specimen, we need to first do sampling in the field. So, I mentioned to you that what should be those points, those need to be kept in mind while doing sampling in the field.

If you have a long stretch, you need to sample all along the stretch in such a manner that wherever there is any change in the lithology or any such change, because of the geological structure, those should be captured in those sampling. After the sampling is done, then I mentioned to you that it is very different than that for the soil. So, I mentioned to you that what should be the diameter of the cores, which are to be obtained from the field and as per International Society of Rock Mechanics, we saw that the NX size core of diameter 54 mm should be used.

Then we saw that how these cores should be arranged in core boxes, according to the depth from which they have been obtained. And then those core boxes are to be transported carefully to the lab, why we need to be careful about the transportation of these samples is because that during the process of transportation, there should not be the occurrence of any kind of new cracks because that will weaken the rock.

And therefore, whatever tests that we will conduct in the lab will not give us the actual picture, but it will give us the lesser value of a strength characteristic, whether it is compressive, whether it is tensile or whether it is shear strength characteristic, as it is there in the field. Now, the samples have been transported to the lab. So, corresponding to the requirement of each test, we have to now prepare the specimen.

So, today we are going to learn about the sample preparation, what are the guidelines that need to be keep in mind while doing this process of sample preparation? How it is done? And then we will start our discussion on first test, that is, unconfined compression test on rocks. Let us start our discussion with the process of sample preparation.

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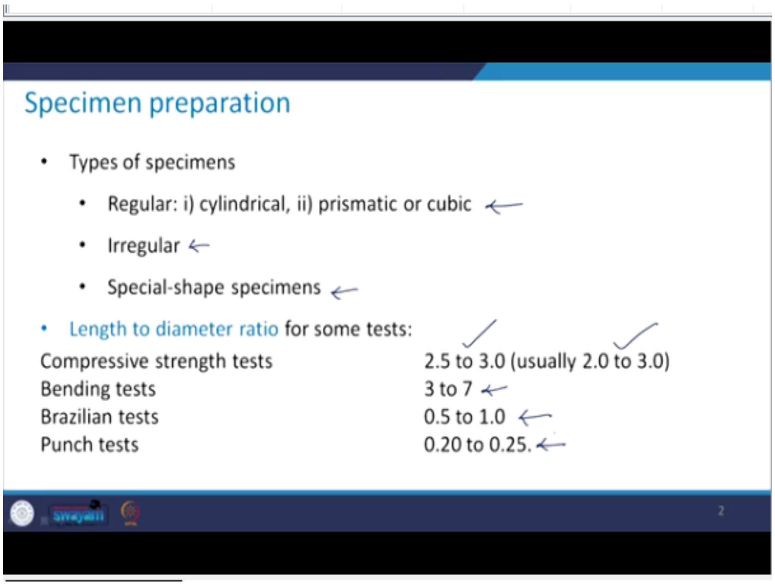

You can have different types of specimen they can be off regular shape, which may include the cylindrical or it can be prismatic or cubic depending upon what is the type of test that we want to conduct. For example, you can see here that this is a regular specimen and of cylindrical in shape. So, that is what we call as cylindrical specimen, you see. Then the next one is the irregular specimen.

You see, a typical irregular specimen will look like this. That means it will have no specific shape. Some of the tests they are carried out on such type of specimen if it is not possible to get the regular specimen. Then you can have some special shaped specimen depending upon the type of the tests or the kind of the tests that you want to perform. So, we will discuss about these one by one.

Now, in case if the specimen is regular and it is cylindrical, then depending upon what is the type of the test that you want to conduct, you have to fix the length to diameter ratio for that. For example, let us say this is the cylindrical specimen. So, when I say length to diameter ratio means, this dimension is the length dimension and this is because it is the circular in cross section, so, whatever is its diameter. So, the ratio of this dimension to this dimension that we have mentioned here in this slide.

So, in case if you have compressive strength tests, then the length to diameter ratio which is recommended should be taken as 2.5 to 3, sometimes it is very difficult to retrieve this big specimen, especially in case of the weak rocks then in that case, if it is 2 to 3 that also serves the purpose. For the bending test, this *L/d* ratio is to be 3 to 7.

Because, you know that the bending has to take place for such type of tests. Therefore, this dimension length dimension is kept larger as compared to the width direction. For the Brazilian tests, which is done to obtain the tensile strength this *L/d* ratio is kept as 0.5 to 1.
So, you see here this is a typical test specimen for the Brazilian test. So, you can see that *L/d* ratio here is between 0.5 to 1.

Likewise, for punch test it can be 0.25 to 0.2. So, this is what ISRM guidelines are for the length to diameter ratio for some of these salient tests. One needs to keep this in mind while preparing the specimen. Now, you see, sometimes in the field it may not be possible to go for the coring. So, what we do is, let us say, because of some activity the blasting has taken place or it has been planned at the site.

So, what will happen the loose mass of the rock it will be in the form of large blocks. So, instead of doing the coring these large blocks they are transported to the lab. Now, the tests cannot be conducted on such large blocks. We have to have a regular specimen. So, therefore, what is done is, first these large blocks which have been brought from the field to the lab, they are cut into the small ones either on the machine or manually.

How we do it manually is with the blows of the hammer. Again, we have to be extremely careful about it because in this process we should not introduce new cracks or any kind of additional disturbance to the rock sample that has been obtained from the field. Then what is done when you get the small piece then the cores are drilled out from these blocks using either the modified workshop drills or small quarry drills. Then you can use a lathe machine which utilizes a coring bit.

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See here, these are the 2 pictures of the machinery that we have in our lab here at IIT Roorkee. So, if you just have a look here, see this is what is the small block that has been cut from a large block of the rock and then this is placed here at this platform. And then here you see that this is the drill bit. So, with the help of the motor which is mounted here, the whole assembly is brought down.

And because this bit is of very hard material like diamond drill bit. So, that goes inside the rock. So, you can see here that one hole, you can see here. So, one sample has been taken out from this particular block. So, this drill bit goes inside this block and drills it and then a core can be retrieved by this procedure. Now, since we have seen that there is a specific requirement for *L/d* ratio corresponding to each of these tests.

So, let us say that you have got a particular length of the specimen for let us say, NX size of a specimen. So, diameter is 54 mm and the length of the specimen say it is 150 and I want to do it at let us say *L/d* = 2. So, what will be L? That will be 2*54 mm, that would be 108 mm. So, roughly I want to have it in this particular range, the length. Now, whatever that I have retrieved, let us say it is say 150 mm.

So, we have to keep some margin for the smoothing of the end surfaces and then we have to put that longer specimen in this cutting machine, here you can see our sleeve is there. So, you place the specimen here and you can see here that this is what is your cutting blade. So, when this blade rotates, what happens it just cuts that specimen. So, we have to fix it in such a manner that we have approximately the length of this whatever that we require.

And remaining portion can be cut by this cutting plane. So, this is how we get the desired *L/d* ratio of any regular cylindrical specimen. Now, when we are cutting, when we are drilling the ends of the specimen, they may not be smooth or there may be some ridges or hollows at the specimen ends.

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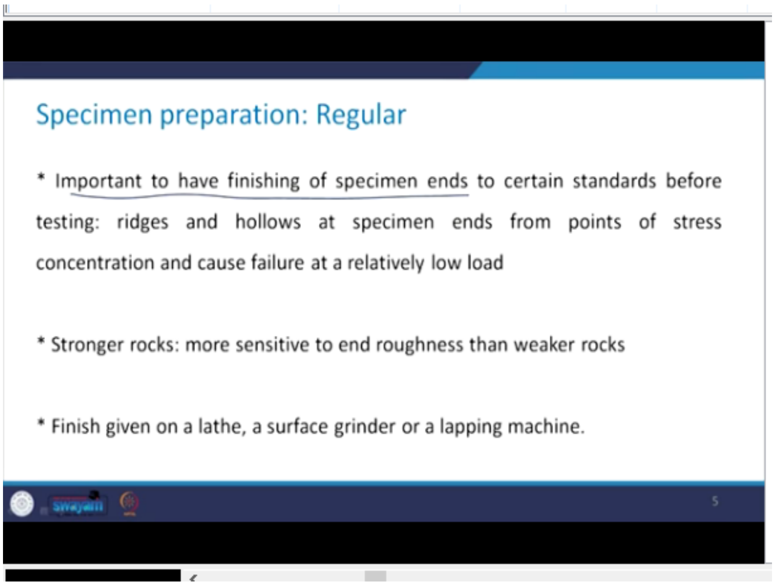

So, we need to be careful about that. So, it is very important for us to have the finishing of the specimen ends. Let us say this is the specimen. So, what I mean to say by a specimen ends are this end and this end. So, there should not be ridges or hollows here at the specimen ends. Because what will happen here is if you have these ridges and hollows when you apply the load, there is going to be the stress concentration at those points.

And that will cause failure at a relatively low load. So, that is not desirable. Now, as far as the stronger rocks are concerned, they are more sensitive towards the end roughness as compared to those of the weaker rocks. So, we need to give the finish to the specimen ends, for that we have to use a lathe machine or a surface grinder or a lapping machine. So, once we cut the specimen then the specimen has to be lapped or it has to be finished, its end should be finished.

Now, this ISRM committee has given some tolerance on the dimension of the cylindrical specimen for compressive strength tests. So, these are given here, that the first one is ends of a specimen shall be flat to 0.02 millimeter.

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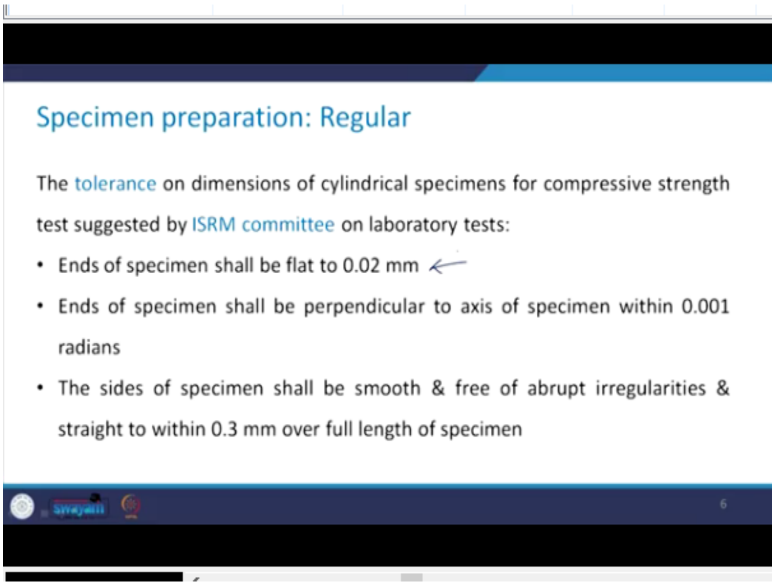

What does that mean is? If this is your specimen these ends should be flat only permissible dimension which can be here and there that is allowed as low as 0.02 mm. Then these ends of the specimen shall be perpendicular to the axis of the specimen. So, you see, this is from the center, this is the axis of the specimen. And these are the ends. So, you see these ends are perpendicular to this axis.

And you see that, the variation from this orientation can be within 0.001 radians. So, we have to be extremely careful. Then the size of the specimen should be smooth and it should be free of the abrupt irregularity and it should be straight to within 0.3 mm over the full length of the specimen. So, you see, this is the full length of the specimen, these sides should be straight all along its length. And only difference can be which is allowed is 0.3 millimeter over the full length of the specimen.

So, specimen preparation in case of the compressive strength tests or wherever you need the regular specimen is very, very important. If the specimen is not prepared properly, whatever is the strength that you will get it will not be the actual strength of the rock, whether it is compressive strength, tensile strength or the shear strength. So, one needs to be very careful while preparing these specimens.

Again, it comes through practice. Once you make 4 or 5 specimens then you will get the idea that how these things can be ensured. Then of course, we have some tools to make sure that all the 3 conditions, these are satisfied. So, we take the help of those tools. In case if we have the irregular specimen like this. So, you can see here that this specimen has very sharp edges here or sharp corners.

So, that is what is not required. So, what we need to do is we blunt these sharp edges by slight taps of a small hammer. So, because wherever these are very sharp and let us say you apply the load at that point. So, stress concentrations are going to be extremely high and we will not get the correct picture about its strength characteristic. So, it is important to blunt those sharp edges and the corners.

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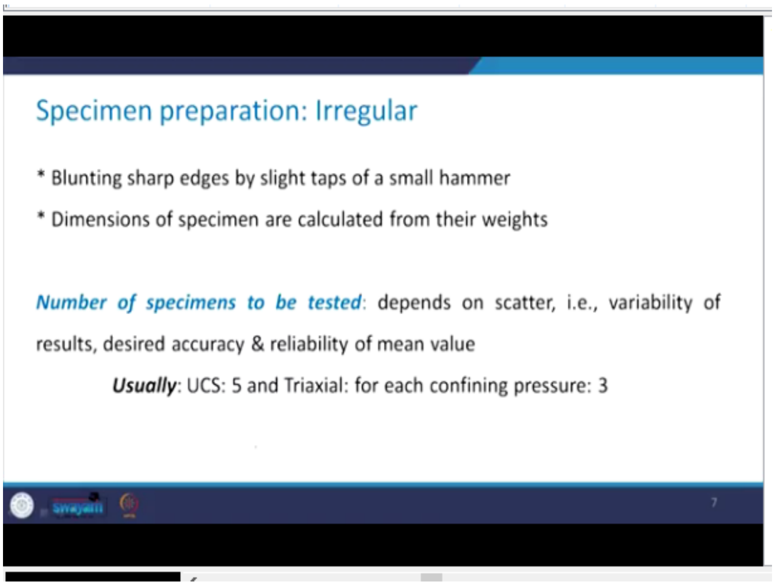

Now dimensions of the specimen, how to calculate them? So, in case of the irregular specimen they are calculated from their weight. We take the equivalent volume and then from there we try to find out the dimension of the specimen. Next question is sample is prepared, how many samples should we test? If you recall for the soil for a UCS test, you at least go for 3 tests. In case of the direct shear tests, you go for 3 tests at 3 different normal loads.

In case of the tri axial tests, you go for 3 tests at 3 different confining pressure in order to get the strength characteristic. So, similarly in case of the rocks the scatter is much more as compared to the soils. So, depending upon the scatter that is the variability in the result, desired accuracy and what should be the reliability of the mean value we decide upon the number of specimens to be tested. Let us say, at a site that geological structures are like that that you do not have much variability.

So, in that case, minimum specimen let us say, for UCS is prescribed as 5. So, if you do it, let us say the minimum number of a specimen that will serve the purpose. But in case if the site has non homogeneity to a large extent then in that case, one needs to go for as many numbers as possible for these tests. But keep that in mind that usually for UCS, we go for 5 specimen and for triaxial tests for each confining pressure, we go for the 3 tests.

Now, you see this is a little bit different than that of the soil, because in case of the soil, the variability is not that much as compared to rocks. So, therefore, here for each confining pressure we are going for the 3 specimens. However, for soils we take only 1 specimen for each confining pressure. So, for rocks we have to be careful. Now, specimen is prepared we are ready to conduct the uniaxial compression test.

So, in short, we will be calling it as UCS test. I mentioned to you, see, this is a specimen for UCS where you have *L/d* ratio as equal to 2. So, and then this specimen has been prepared as per the guidelines which were given by ISRM as discussed earlier.

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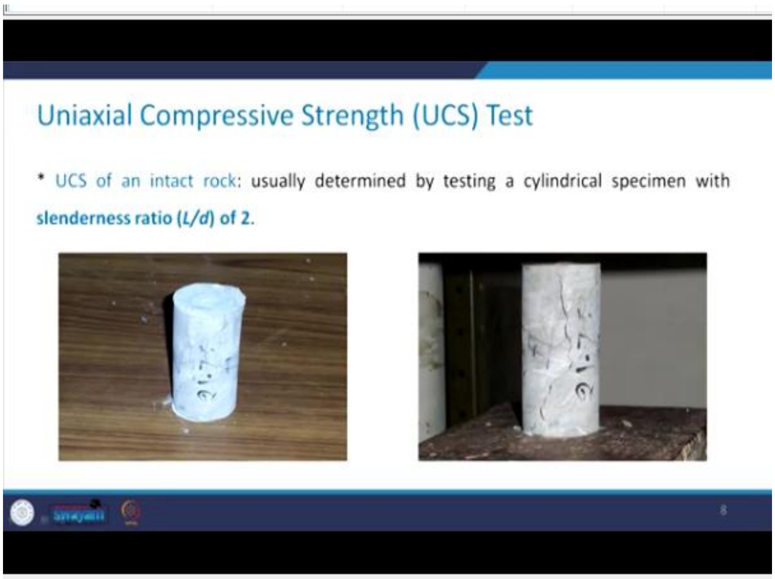

Now, these are the 2 pictures which we have taken after the conduct of the UCS. So, this was just to show you that how the specimen looks like, before I have already shown you and after the tests. This is the MTS machine; this has been taken from a textbook.

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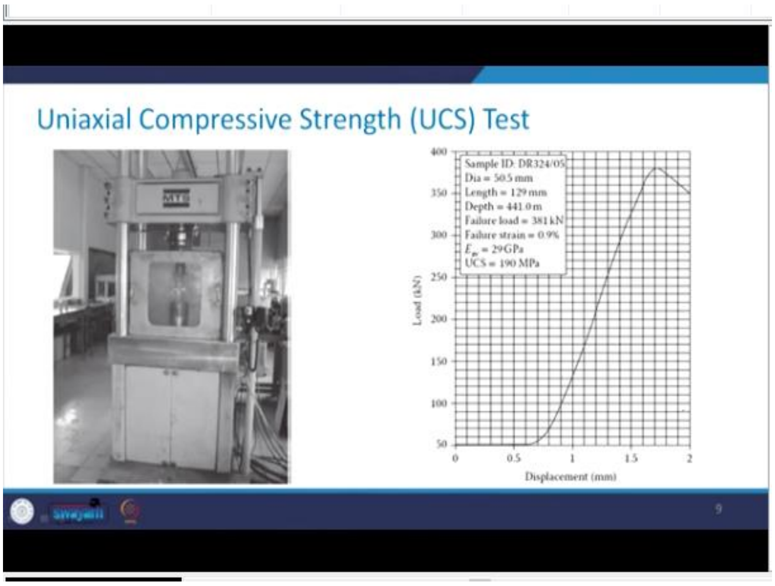

And then the result which you get from this UCS test will be in the form of load versus displacement plot in this manner. How to analyze these tests data? Let us see. So, before we go for the analysis, first we will see how the test is conducted.

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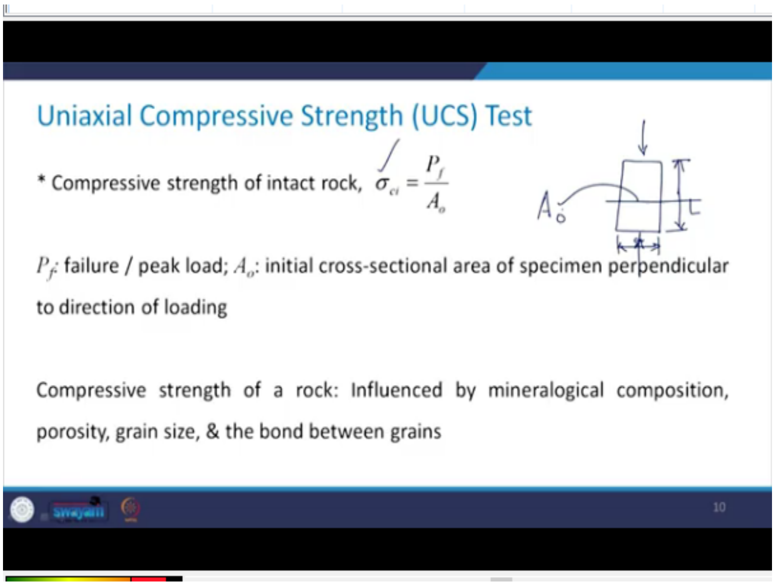

So, the compressive strength of the intact rock which we will be representing by σ_{ci}, that is equal to the failure or peak load, which is divided by the initial cross-sectional area of the specimen perpendicular to the direction of loading. So, you see, if this is your specimen with this dimension as L and this dimension as d, then the loading is applied in this particular manner.

So, the area of cross section, that means, which is perpendicular to the loading direction. So, in this direction. So, this area is going to be A_o, that is indeed perpendicular to the direction of load. Now, the compressive strength of a rock is greatly influenced by the mineralogical composition of the rock, its porosity, grain size and the bond between grains. Various factors which influence the compressive strength because of the testing procedure. So, the first one is the specimen features, what is its shape? What is the *L/d* ratio?

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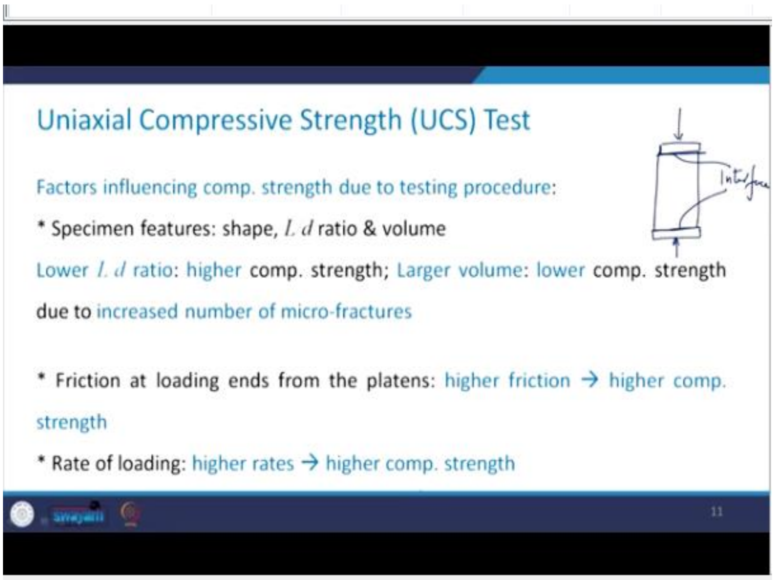

And what is its volume? So, lower value of *L/d* ratio gives the higher compressive strength and larger volume gives the lower compressive strength. Now, what is the reason behind that? When you have the larger volume of the specimen, what happens is, the number of micro fractures which are present in that specimen, they are also larger and the end effect is that as a whole they reduce the compressive strength because of the larger volume.

So, larger the volume more will be the number of micro cracks and therefore, lesser will be the compressive strength. Now, the next very important factor influencing the compressive strength is the friction at the loading ends from the platen. See, what happens is let us say this is your specimen and there are the loading platens. So, which are there in the machine it is there and then through this you try to apply the load.

So, what happens here at the interface here, here and here you have the interface. So, at this interface there is going to be the friction. So, if this friction is high, you get the higher compressive strength. So, apparently, we are getting the higher strength, but the material does not have that much of these strengths. So, we need to reduce this friction to let us say, almost equal to 0.

Because then only we will be getting the actual value of the compressive strength. How to do that? We will see. Rate of the loading, if we apply the load at higher rate, you will get the higher compressive strength.

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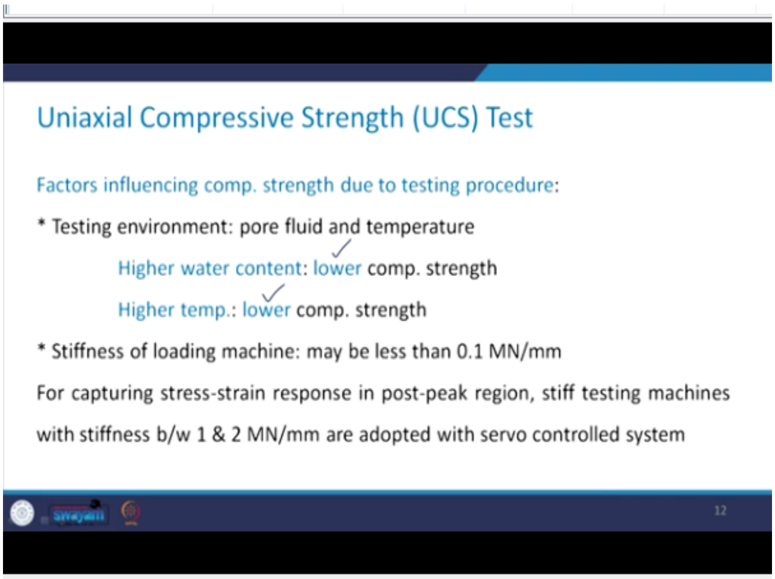

Then the testing environment which includes pore fluid and temperature. So, in case if the sample or the specimen has higher water content, it has lower compressive strength and if you test it at higher temperature, you will get lower compressive strength. Stiffness of the loading machine is another factor which influences the compressive strength. So, it may be less than 0.1MN/mm.

Now, when you conduct the test, you do not apply the load in one go, you apply it in increments like you do in case of the soil. So, first what happens, that it keeps on increasing you apply the load and deformation will keep on increasing and there would be a peak load where the failure will take place and after that the load versus deformation curve will fall down depending upon what is the type of the rock that we are testing.

Now, if the machine is not sufficiently stiff, then that machine will not be able to capture that post peak behavior. So, in order to capture the stress strain response in the post peak region, we need to go for the test using stiff testing machines and the stiffness for these machines can vary between 1 to 2 MN/mm and these have servo-controlled systems. How one can make these stiff machines, is by making the component of the machines stiffer.

So, that is there with the manufacturer and the data related to the stiffness of the machine, that you will directly get from the manufacturer. But then the basic behind this should be known to you and that is why we are discussing this. Now, in what manner the load should be applied? Load can be stress controlled or it can be strain controlled. So, you see that the load is applied to the specimen through a spherical seating platen at a constant stress rate of 0.5 to 1 MPa/sec.

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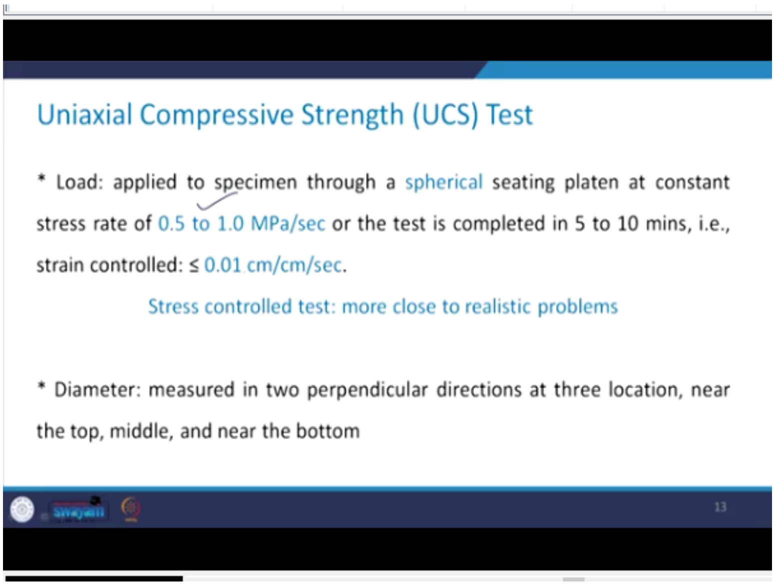

Or the test can be completed in 5 to 10 minutes, that is, it is strain controlled which means that the strain rate is less than or equal to 0.01 cm/cm/sec. See, we are talking about the strain rate, that means it is the strain per unit time, please do not make mistake. Many people they make mistake and say that okay, this is the strain controlled and then they say 0.1 cm/sec, that is deformation controlled, not the strain controlled.

What we are talking here is the strain controlled, that is why the dimension is like this. Take a note of it. Stress control tests they are closer to the realistic problems. Now, how to measure the diameter? So, once again let us take this specimen. So, basically the diameter is measured in 2 perpendicular directions. So, if I show you this cross section when I say 2 perpendicular direction means, one is this direction and another is this direction.

So, you take here only at this plane, you take 2 readings, one in this direction and another is in this direction and the same thing you repeat at 3 locations. One is near the top; another one is at the middle and the third one is near the bottom. So, in all, for a specimen we will have 6 values of the diameter. And the average can be taken for all these 6 values and that can be assigned to the value of the diameter to that specimen. Let us say we are increasing the load slowly. So, let us say stress at any axial strain which is I am not going up to the failure it is somewhere in between the tests.

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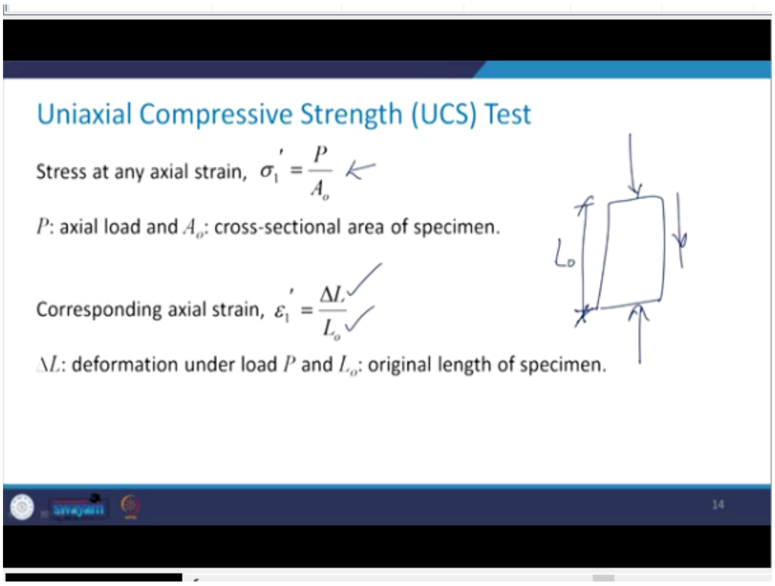

So, we have this $\sigma'_1 = \frac{P}{A_0}$, *P* is the axial load corresponding to this stress level and A_0 is the cross-sectional area of the specimen you know that. So, the corresponding axial strain is going to be see, you need to keep in mind that this is what is the specimen and the load is applied in the axial direction. So, the corresponding axial strain is going to be whatever is the deformation in the direction of the loading that is ΔL. And L_0 be the original length of the specimen, that is L_0. So, that is how you can find out the corresponding value of axial strain.

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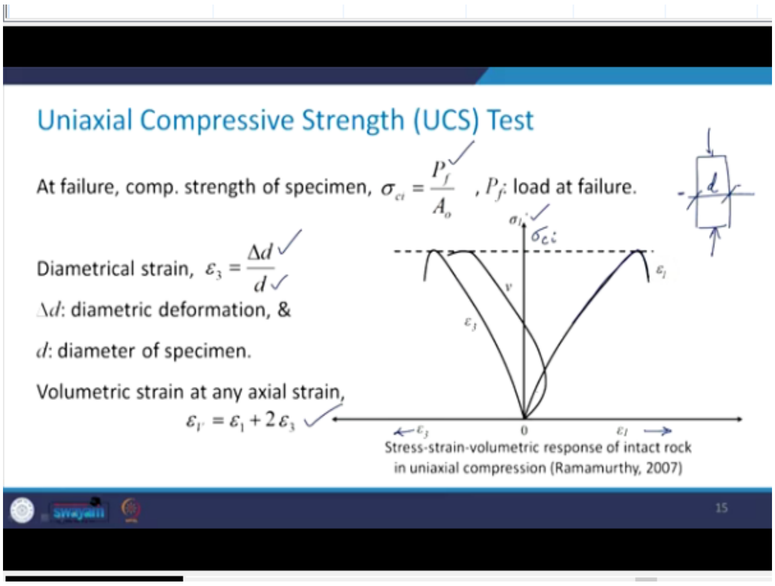

Now, what happens at failure, we have the failure load P_f divided by the cross-sectional area and what we get is the compressive strength of the specimen. Now, you see that, here we have a figure which is having a stress strain volumetric response of the intact rock in uniaxial compression. So, on x axis in one direction, we have the ε_1 means, axial strain and on another direction, we have ε_3, which is the diametrical strain.

And we are plotting it against this σ_1, which is the axial stress. Now, because we are applying the load in this direction. So, what will happen, there is no confinement here on either side all around the specimen. So, what happens, along the application of this vertical load, this specimen is free to deform in the lateral direction as well. So, let us say, that Δd is the diameter deformation.

That is deformation in this direction and d is of course the original diameter. So, the diametrical strain can be defined as $\varepsilon_3 = \frac{\Delta d}{d}$ which has been plotted here on this scale. So, the total volumetric strain at any axial strain we can find out which is $\varepsilon_1 + \varepsilon_2 + \varepsilon_3$ and we are representing it with the help of ε_V, that is V stands for the volumetric strip.

So, you have seen that how the variation is going to look like. Let us have a look once again here. So, you see that when we have this plot, so, σ_1 versus ε_1 is going to be like this, that is with increase in σ_1 this is how your axial strain is going to vary up to this peak value. So, here it is your this is σ_{ci}, which is the maximum value at the failure. Now, this is how the ε_3 that means, diametrical strain is going to be there. And the variation of the Poisson's ratio will look like this.

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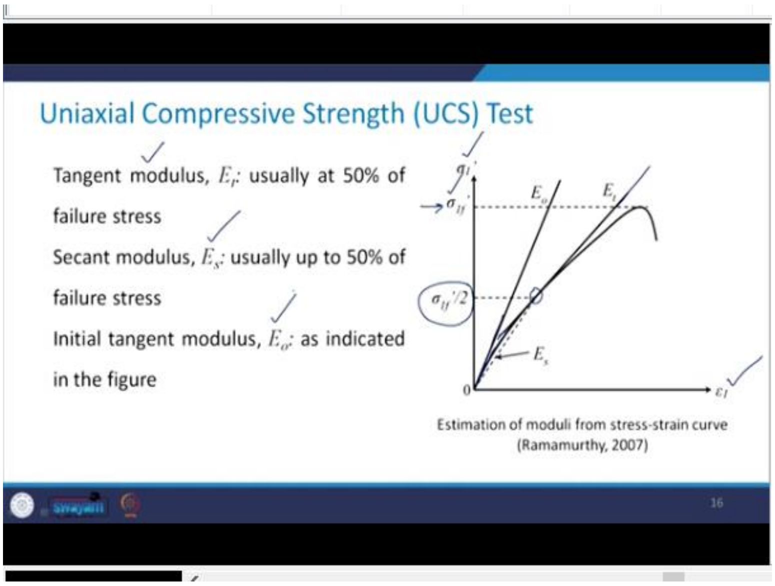

Another important aspect which we get from the UCS test, this information, which is the determination of the modulus. Now, there are different types of modules which have been defined, which are used in the design and the analysis. So, those have been explained here in this figure. So, you see that this figure is the plot between the axial stress and the axial strain. So, as we saw in the previous slide, the typical shape of this stress versus strain response is like this portion.

So, the first modulus which is defined, that is called as a tangent modulus. So, this is what is your peak. So, at the failure whatever is the stress that we are writing here as σ_{1f}', so, half of this σ_{1f}', which is $\sigma_{1f}'/2$, you take this point, draw a horizontal line along this wherever that meets this curve, you draw a tangent at that point. So, this is a tangent at this point.

The slope of this is going to give me the tangent modulus. So, this is defined usually at 50% of the failure stress. Then the second modulus is defined as the secant modulus which is E_s. So, you see what how this is obtained? You join the origin with this point which is 0.5 times of this failure stress level. You join this and whatever is the slope that gives us this secant modulus E_s.

Then the initial tangent modulus is defined as the slope of the tangent which is drawn at the initial portion of this stress strain response. So, you see, this is the initial portion. So, you draw the tangent here and whatever is the slope that is going to give you the initial tangent modulus which is E_o. So, that is how different moduli are obtained from this stress strain curve. We can also obtain the Poisson's ratio. I already showed it to you that how the variation will look like.

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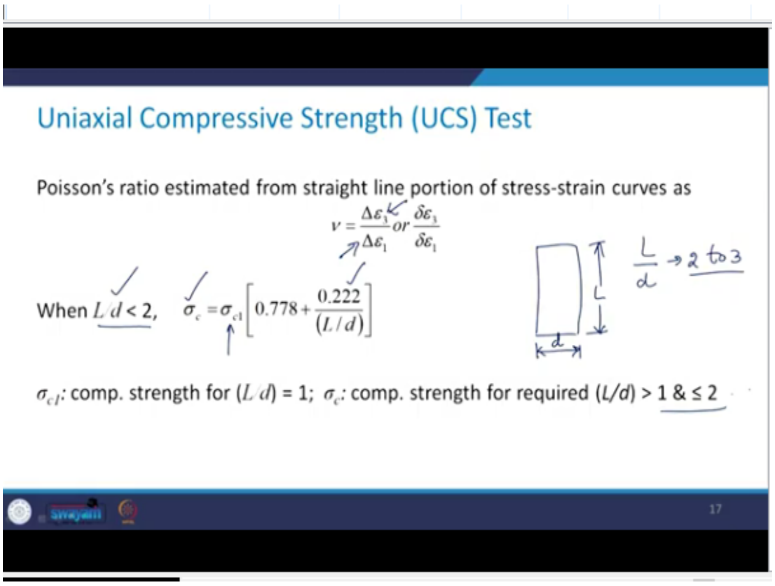

So, as per the definition of the Poisson's ratio, you see the lateral strain and the axial strain, their ratio defines the Poisson's ratio. So, that can be estimated from the straight-line portion of the stress strain curve that I have already explained it to you. Now, sometimes it may not be possible to get the specimen with *L/d* equal to 2 or more than 2. So, you see, this is your L dimension and this dimension is d.

So, what ISRM guideline is that this *L/d* should vary between 2 to 3, but depending upon what is the dimension that we can obtain from the course, which you have got from the field. Depending upon that you will be able to extract the specimen or prepare the specimen. Many times, it may not be possible to get the specimen of *L/d* of 2 to 3. So, in that case it is not that we cannot find out the UCS.

In that case, we have to apply some kind of a size correction. So, for that an expression has been given here.

When L/d <2,

$$\sigma_c = \sigma_{c1}\left[0.778 + \frac{0.222}{(\frac{L}{d})}\right]$$

σ_{cl} =compressive strength for L/d =1; σ_c =compressive strength for required L/d>1 & ≤2.

But then the requirement is that this should lie between 1 and 2, if it is less than 1, we cannot conduct UCS test on such specimen. So, it has to be between 1 and 2. I will just take an example that will clarify how to use this expression. So, we have this expression. So, I have written it again here on this slide.

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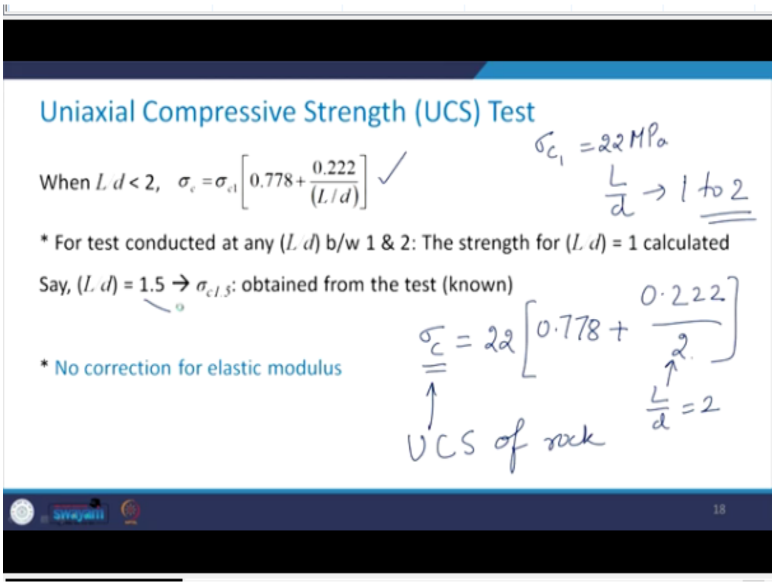

See, I have got L/d = 1.5 and I conducted the test. So, what I am getting from the test. So, test is going to give me σ_c at 1.5. So, this is what that I have. But what I need is σ_c for 2 to 3. So, at least 2 we need. So, what is done? First, I will use this expression and find out σ_{c1}, see how this is done. So, I can write it like this that is σ_{c1}. That is equal to say

$$\sigma_c = \sigma_{c1}\left[0.778 + \frac{0.222}{1.5}\right]$$

Now say this is, let us say for example, this is 35 MPa, that we have got from the lab.

Okay. So, I just substitute here 35, that is equal to this whole thing**.** Now all the things are known in this equation. So, from here I can find out what is σ_{c1}. Now, what should be the next step because we need it for σ_{c2}. So, say I mean you can carry out this calculation and find out the σ_{c1}.

Say that this works out to be say 22 MPa. Say for example. So, now how to obtain it for the total, I mean, the final value of the UCS. So, let us come over again. So, we have this σ_{c1} as 22 MPa, how to obtain it we have just now seen. Now, since this is known to me now. So, I can find,

$$\sigma_c = 22\left[0.778 + \frac{0.222}{2}\right]$$

So, this is L/d = 2.

So, whatever is this value of σ_c that you will get this is going to give me the UCS of the rock. So, this is how you can make the use of this expression in case if you have *L/d* between 1 to 2. This is how it can be used. Now, as far as the elastic moduli value is concerned, no correction is required, because it has been seen that *L/d* ratio does not affect the elastic modulus to that extent as it affects its UCS.

So, whatever is the value of elastic modulus that you obtain for any value, let us say in this case *L/d* = 1.5, that value can be taken as the elastic modulus of that rock.

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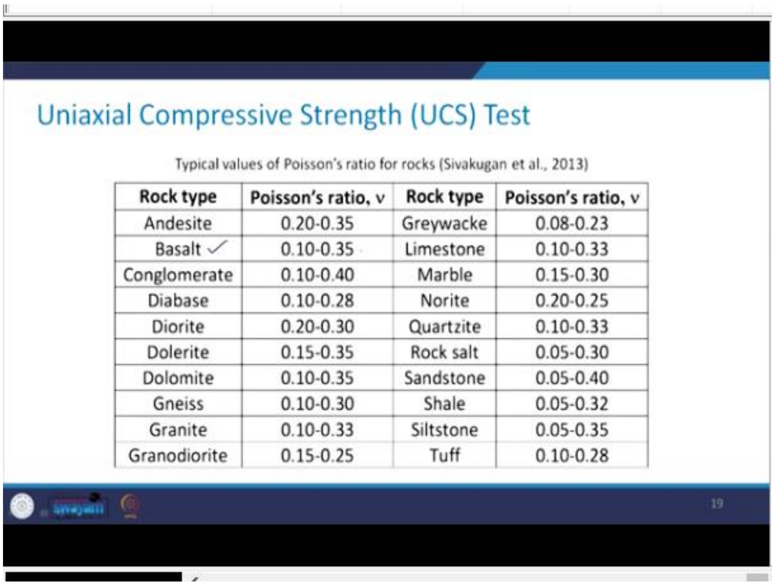

Rock type	Poisson's ratio, ν	Rock type	Poisson's ratio, ν
Andesite	0.20-0.35	Greywacke	0.08-0.23
Basalt	0.10-0.35	Limestone	0.10-0.33
Conglomerate	0.10-0.40	Marble	0.15-0.30
Diabase	0.10-0.28	Norite	0.20-0.25
Diorite	0.20-0.30	Quartzite	0.10-0.33
Dolerite	0.15-0.35	Rock salt	0.05-0.30
Dolomite	0.10-0.35	Sandstone	0.05-0.40
Gneiss	0.10-0.30	Shale	0.05-0.32
Granite	0.10-0.33	Siltstone	0.05-0.35
Granodiorite	0.15-0.25	Tuff	0.10-0.28

Now, these are some of the typical values of the Poisson's ratio for different type of rocks. Now, you should be able to connect our discussion on different type of rocks in the some of the earlier lectures that we had. So, these types of the rocks should not be totally new to you. We have discussed a few things related to some of these rocks. For different types of rocks, typical values of the Poisson's ratio have been given here.

For example, let us say you take basalt, it varies from 0.1 to 0.35. Now, you see such large variation is there, because you can have 10 different types of basalt depending upon their mineralogical composition, main mineralogical composition is going to be more or less same to make that rock as a basalt, but their relative magnitude of different minerals in that particular type of rock, it may make different types of basalt or maybe any other rock.

Like you see, in case of the sandstone, you see it is varying from 0.05 to 0.440. So, from so low to high value. So, likewise, this table gives you the idea about some of these values for the Poisson's ratio for different types of rocks.

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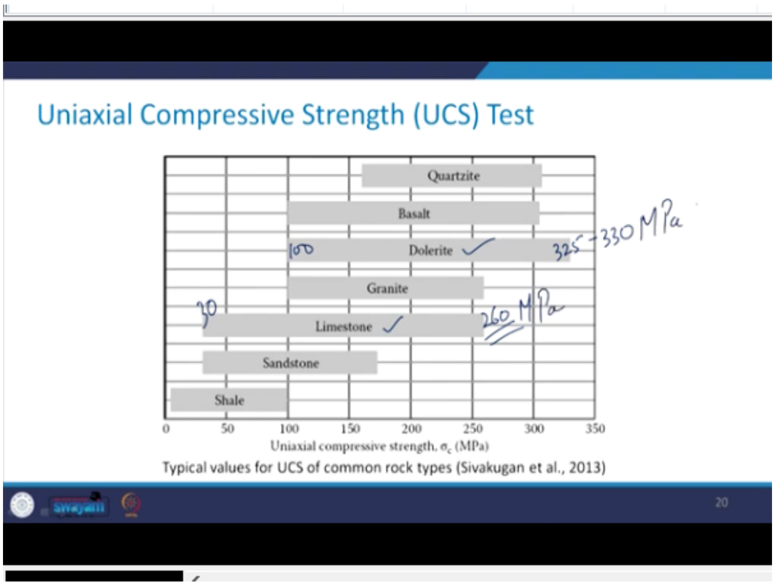

Now, this figure gives us the idea about the uniaxial compressive strength of some of the typical rocks. So, you can see that based upon as the variation in the Poisson's ratio is there because of their mineralogical composition, similar kind of the variation you will have in case of UCS. Again, you see that the same rock type but you can see that the variation is so large. For example, you take dolerite.

See, its strength can be from 100 to let us say somewhere maybe 325 or 330 as per this block. Likewise, so you see the range is so high, why? Maybe because of the mineralogical composition, little bit here and there, plus the position or the number of the micro cracks which are present in any type of the intact rock, that also influence the strength characteristic and it is really not possible to quantify these micro cracks.

If 100 are the micro cracks number then the strength is going to be this much and if they are 200. So, there are no way that we can find out the exact number of those micro cracks, because those are not the fractures or the joints, those are the inherent property in the rock in any rock even in intact rock they are present. So, depending upon their orientation, their distribution, this randomness is there in the behaviour of all the rocks.

And that is why you will see that in almost all the properties that you obtain from the lab or from the field you will get large variation. For example, here you see for limestone again you see the variation is say about 30 to as high as say to 60 or so, of course, the unit is MPa. So, what I mean to tell you is that there is a range of UCS. So, if it is a limestone you cannot precisely say that okay, limestone has this strength, there is going to be the range and this range is pretty wide in case of the rocks.

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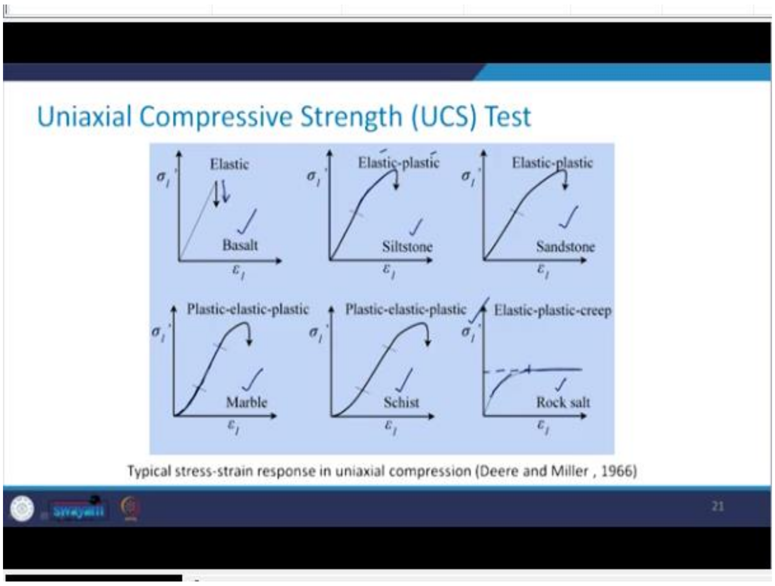

Some of the typically stress strain response in uniaxial compression. So, you see that for different type of rocks I have shown some figure. So, for basalt, it is elastic behavior. So, you see till peak it is going longer linear path and then suddenly it breaks. So, that is how it is. Now, in case of the siltstone the behaviour is elastic plastic, that means in the beginning it is elastic and then here this becomes plastic.

In case of sandstone, again it is elastic plastic. In case of marble, you see it is very interesting in the beginning it is plastic, then it goes linear as elastic and then later part is plastic, same thing you observe in case of schist. In case of the rock salt, you see it is elastic, then it becomes plastic and then it goes as the creep. Creep you know that the deformation under constant stress.

So, you see, if I just extend. So, you see that from this point, it is all the constant stress that is σ_1 and it is just deforming. So, these are some typical stress strain responses under uniaxial compressive condition. Then I mentioned to you about pre peak and post peak failure behaviour.

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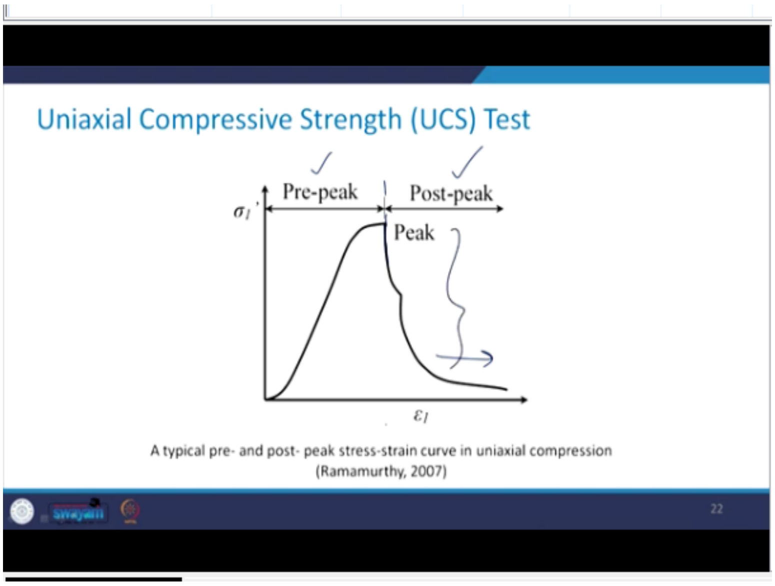

So, this is typically showing the pre peak and the post peak stress strain curve in the uniaxial compression. You can see that in the beginning till it reaches to this peak value with the increase in the stress increment or when you increase the stress in increment, there is the increase in the strain. Once it reaches the peak value, then beyond that, you see the stress levels are reducing.

But you have the increase in the strains under those stress conditions. So, we will discuss more in detail about these aspects that why such type of behaviour is seen as a part of the post peak stress strain curve in some of the following subsequent classes. So, today we learned that how to prepare the specimen for the uniaxial or the unconfined compressive strength test. We saw that *L/d* ratio should be 2 to 3. How to prepare these and then we saw that how to conduct this test and then how to interpret the results of these tests.

How to find out the moduli from the result that is stress strain response. What is the variation of stress versus actually strain, stress versus diametrical strain and stress versus the Poisson's ratio? So, this is what that I wanted to discuss with you with respect to the conduct of uniaxial compressive strength tests. What are the various factors although we have discussed that also today, but then we will have a detailed discussion about the reason behind their direct effect on the UCS values in the next class. Thank you very much.