Rock Mechanics and Tunneling

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Lecture 09

Rock coring (Continued) and Geophysical Methods

Hello everyone. I welcome all of you to the third lecture of the module 2. So, already in our previous two lectures we have discussed about rock coring. Little portion is left. So, we will continue with that discussion and then we will proceed towards the geophysical methods. So, that part we will learn in detail today.

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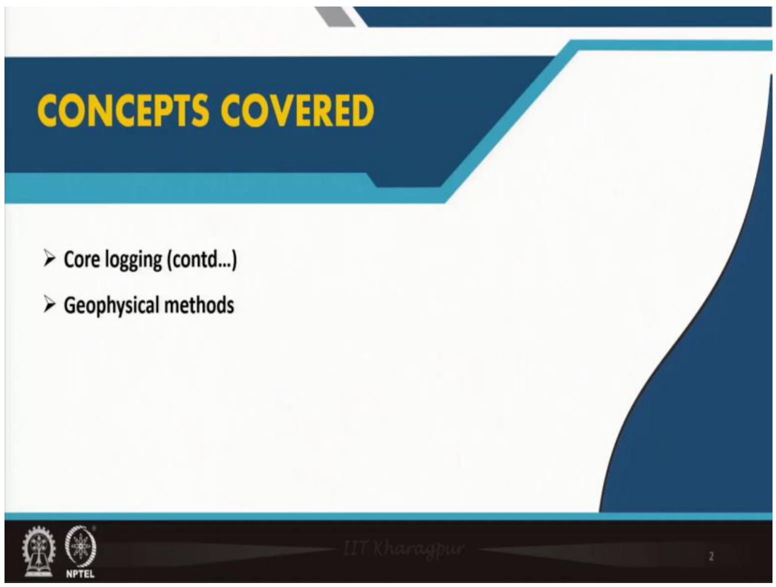

So, these are the things which we will do today.

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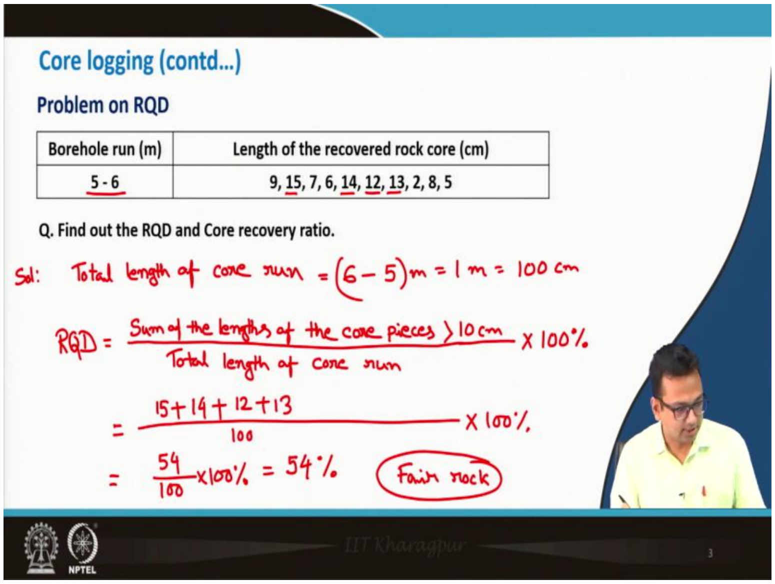

Regarding RQD and core recovery, we did a problem in our previous class. Another small problem, the data may be provided in this form (())(01:20). So, the problem is we need to find out the RQD and core recovery ratio. Here, the bore run is provided between 5 meters to 6 meters. And these are the lengths of the recovered bore core in centimeters. They are provided over here.

So, first thing is that we have to find out the total length of the core run. It is written that it is between 5 to 6 meters. So, total length of core run must be 1 meter, that means 100 centimeters.

Next, we have to find out RQD. RQD is nothing but the sum of the lengths of the core pieces greater than 10 centimeters dividedby total length of core run. And generally it is represented in percentage form.

Now, total length of core run is 100 centimeters. So, what we can notice here first piece is 9 centimeters. We will not consider that, we will consider 15; then 7, 6 we will not consider; we will again consider 14, then we will consider 12 then 13; then again 2, 8, 5 these core pieces also that whatever recovered pieces are provided here that we will not consider in this calculation. So, we only write 15 plus 14 plus 12 plus 13, right? So, if we add these things it is giving us how much? It is54; 54 by 100 into 100 for the percentage, it is becoming simply 54 percent.

Now, in our previous class, we have seen that depending on the RQD, you can tell that whether the rock is very good quality, very poor quality or fair. if you remember, there it was 50 to 75, the range was fair. So, this is a fair rock. The first part is done. Now, second part is core recovery ratio. So, for that, let us move to the next page.

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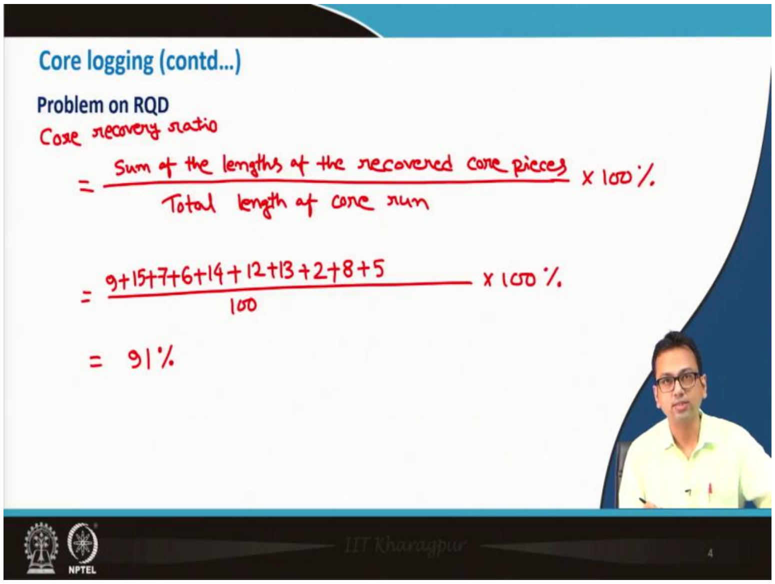

Core recovery ratio is nothing but the sum of the length of the recovered core pieces by the total length of core run. So, you know this is 100 centimeter.

So, here, what will happen? What we need to write in the numerator, it is all the quantities. So, these are the recovered rock pieces; 9 plus 15 1 plus 7 plus 6 plus 14 plus 12, 13 plus 2 plus 8 plus 5. So, if we add them we will get as 91 percent total. So, quite good core recovery you can see here. I hope your concept about this RQD, core recovery and all these things are now clear.

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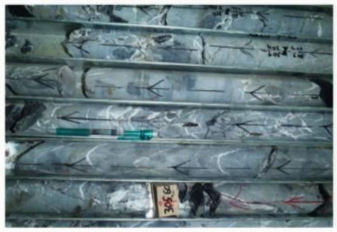
Core orientation

- If the design data on discontinuity orientation are not sufficiently available from surface mapping, then it may require to obtain orientation from drill core. (Wyllie and Mah, 2004*)

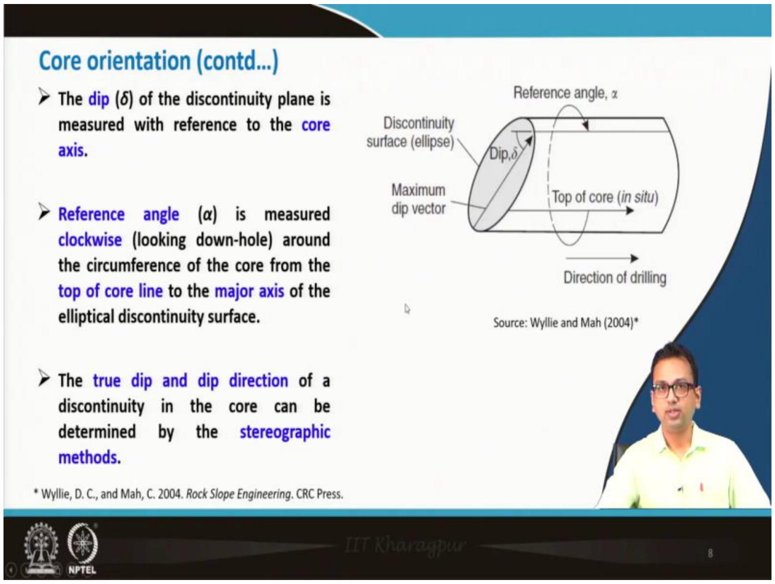


Source: https://www.majordrilling.com/major-definitions-core-orientation/

* Wyllie, D. C., and Mah, C. 2004. *Rock Slope Engineering*. CRC Press.

Core orientation (contd...)

- Core orientation involves determining the plunge and trend of the drill hole using down-hole survey tool.
- The tool consists of an aluminum drill rod containing a dip meter and a compass, both of which can be photographed.
- The core orientation can be obtained from the photographs of the dip meter and compass at the recorded depths.



Next, we will discuss about another small topic, core orientation. What is core orientation? If the design data on discontinuity orientation are not sufficiently available from the surface mapping then it may required to obtain the orientation from the drill core. So, using the drill core you can get some useful informations regarding the core orientation. So, that is the idea which we will just discuss in brief.

So, you see, on this recovered core some markings are there. These markings are done for a particular reason actually, to obtain the core orientation. So, basically the core orientation involves determining theplunge and trend of the drill hole using downhole survey tool. This term, plunge and trend we have discussed in our previous module when we have discussed about the stereonet. what is downhole survey tool? This tool consists of aluminum drill rod, basically non-magnetic material. . So, generally aluminum drill rod containing a dip meter and a compass, are present. The arrangement should be such that it can be photographed. The core orientation can be obtained from the photographs of the dip meter and the compass at the recorded depth. So, we can obtain this core orientation from this instrumentation only by taking photographs of the dip meter and the compass at the recorded depths.

How is this marking done? With the help of the picture in slide number 5 we will try to understand. The method of orienting core involves marking a line down the core.

There are some few things written over there. This is the recoveredcore piece. And you see that this is the discontinuity plane, and direction of drilling is this. And this one, the top of core or top of hole, what is this? The method of orienting the core involves marking a line down the core or down the hole representing the top of the hole. So, this line we have to first draw. Then, the orientation of all discontinuities are measured with respect to the top of the hole line. So, this line is now used, top of the hole or top of the core line with keeping that as the, your benchmark or your fixed line this, with respect to this, all the other orientations are measured actually.

So, what I am stating here, the orientation of all the discontinuities are measured with respect to the top of the hole line. Then this discontinuity surface, how it looks like? As you can see from this diagram that it is like elliptical shape. As expected that from your basic knowledge of engineering drawing also you know this, if you cut this one at a particular angle, so inclined plane if you consider, that will be elliptic in shape. The plane intersected by the core has an elliptical shape. That is only written over here.

Then what we can do? We need to identify the major axis of this ellipse. So, marking the major axis of the elliptical discontinuity surface is the next step. Then, the dip of the discontinuity plane is measured with reference to the core axis.

So, as per the image in Slide 8, your core axis is like this. Its parallel line is, suppose you can say this line also, so your dip of the discontinuity plane is measured with reference to the core axis. You can see the dip as expected, nothing new. This dip is a vertical angle. Then, reference angle, this alpha is measured clockwise looking down-hole. Looking down-hole, your clockwise you have to measure this angle around the circumference of the core from the top of core line or top of hole, this line you have to measure to the major axis of the elliptical discontinuity surface.

So, this is the major axis. And here you have a line corresponding to this where this is major axis cutting this vertical, your length of core. There if you draw a line, now if you want to get the orientation of this line, with respect to this top of core line, that will give us the reference angle. So, reference angle is measured clockwise around the circumference of the core from the top of the core line to the major axis of the elliptical discontinuity surface.

We have discussed stereographic method in detail, so basically the true dip and dip direction of a discontinuity line in the core can be determined by the stereographic method. Now we have some idea of stereographic method.

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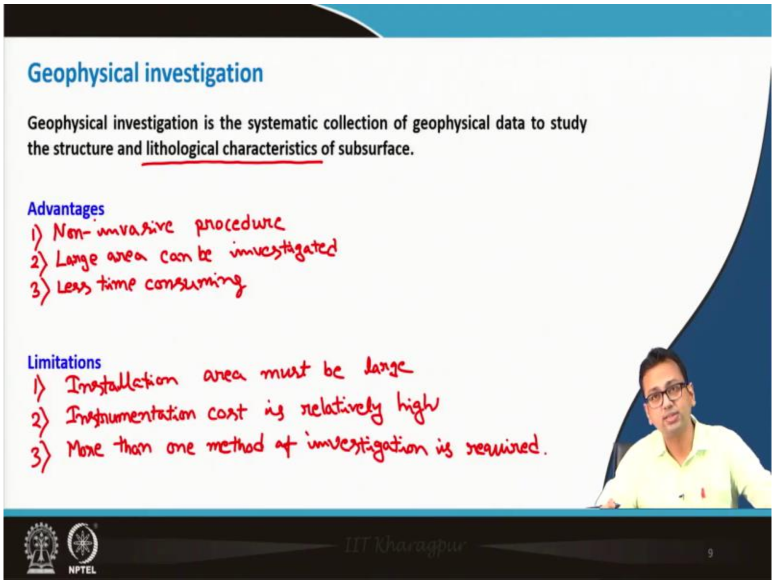

Next is our main topic of our discussion- geophysical investigation. We will try to cover as much as possible within this given time. Mainly you will focus on the major geophysical investigation techniques, primarily the seismic methods.

Geophysical investigation is the systematic collection of geophysical data to study the structure and lithological characteristics of subsurface. Now, what are these methods? We will obviously learn in detail.

Now, before going to in this detailed discussion about different geophysical methods, let us try to first understand what are the advantages of this method. First advantage is it is non-invasive procedure. So, generally in geophysical investigation we do not go for any rigorous drilling.

Sometimes we need to go for some small bore holes but most of the time you will see that it is mainly non-invasive. Second advantage is, by doing these tests, a large area can be investigated quite easily. And another important advantage is it is less time consuming as compared to other tests.

As it is having some advantages, there are some disadvantages also or the limitations of this method. What are they? Like installation, means it is quite large. You need to have few, means some manpower you require, and as well as over a bigger area you have to do this job. On the other hand that is also one of the advantage also that large area can be investigated. So, both advantage, disadvantage both are there. So, installation area must be large. Means where can the problem occur? Like if you do not have much bigger space. Or to conduct this test as it requires a large area. But it may happen that some surrounding structures are already present. So, you may not get proper space to install your instruments. So, that can be a limitation.

And these instruments are quite costly. Instrumentation cost is relatively high as compared to other field test in general. And another thing is, to cross check the results. Generally, we need to take help of another geophysical test or some other field test to cross check its authenticity. So,more than one method of investigation is required. These are some of the limitations. But obviously as you can see, advantages are more predominant.

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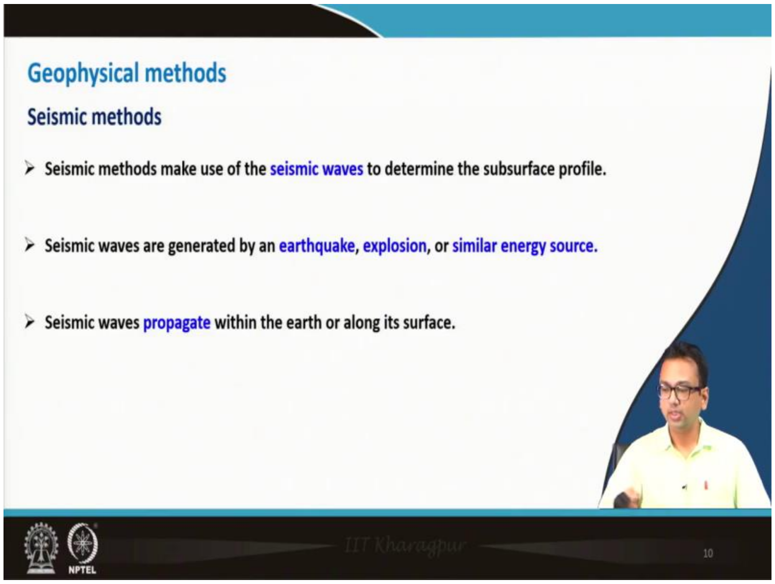

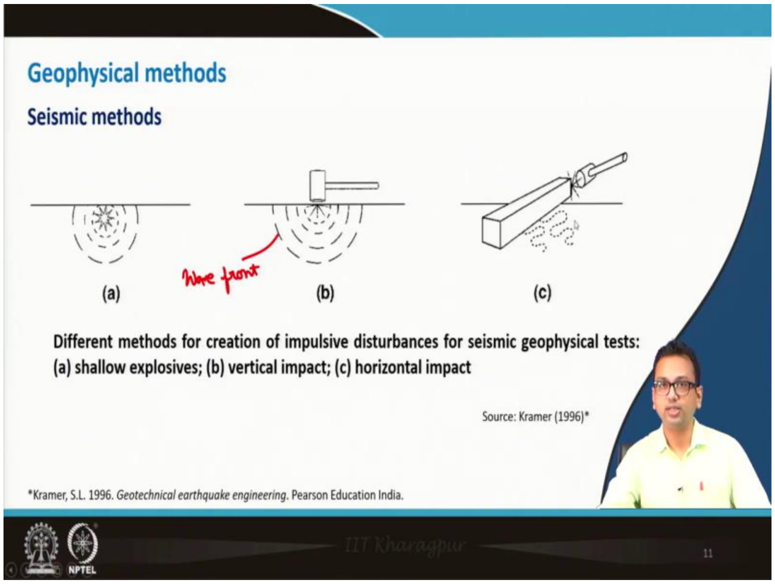

There are several geophysical methods. Out of that, because of time constraint, I have mainly thought about considering the seismic methods which are very popular and very useful first techniques.

As long as this geophysical investigation or methods are concerned, we will try to mainly focus on the seismic method. Several methods are there. As name suggests, seismic methods make use of the seismic waves to determine the subsurface profile.

Now, seismic waves are generated when earthquake occurs.. But for conducting the tests, obviously we cannot generate earthquake. These seismic waves can be generated with the help of small explosion or similar energy source like with the help of the hammer. And seismic waves propagate within the earth or along its surface, along means earth surface. So, that is another point we should remember.

Now, this picture or diagram is showing some of the ways of developing these seismic waves. There are different methods for creation of impulsive disturbances for seismic geophysical tests. First one is shallow explosives. So, with the help of shallow explosives, you can generate seismic waves. Likewise with the help of this hammer. If you give a vertical impact, wavefronts are generated.

Now suppose this is a rigid beam. It means you have to keep this beam fixed at a location with the help of some pressure and if you hit it, this will generate some seismic waves. This is nothing but the horizontal impact.

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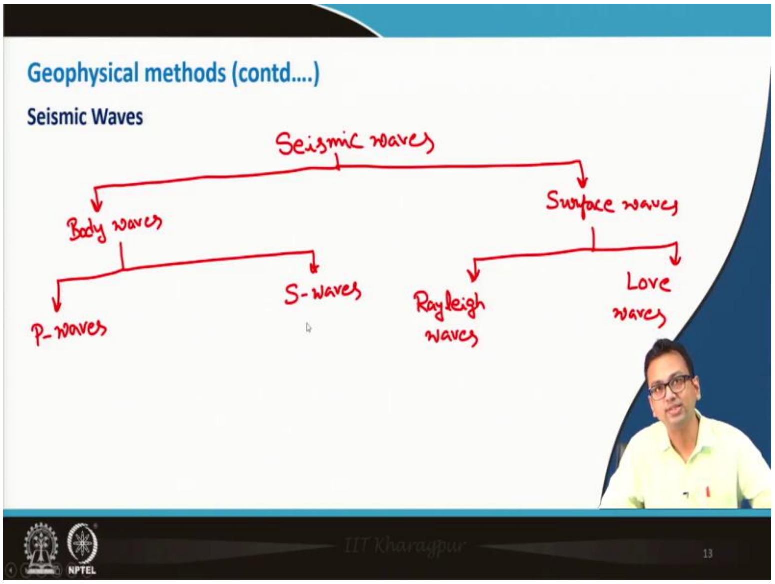

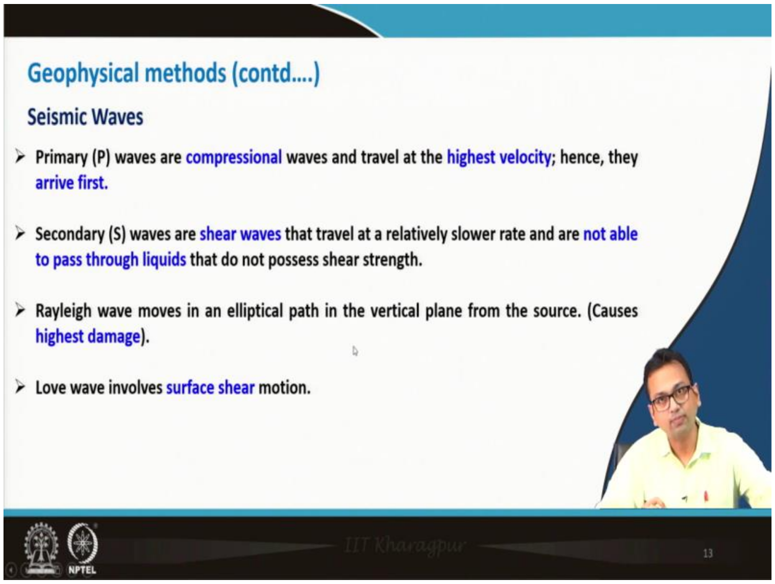

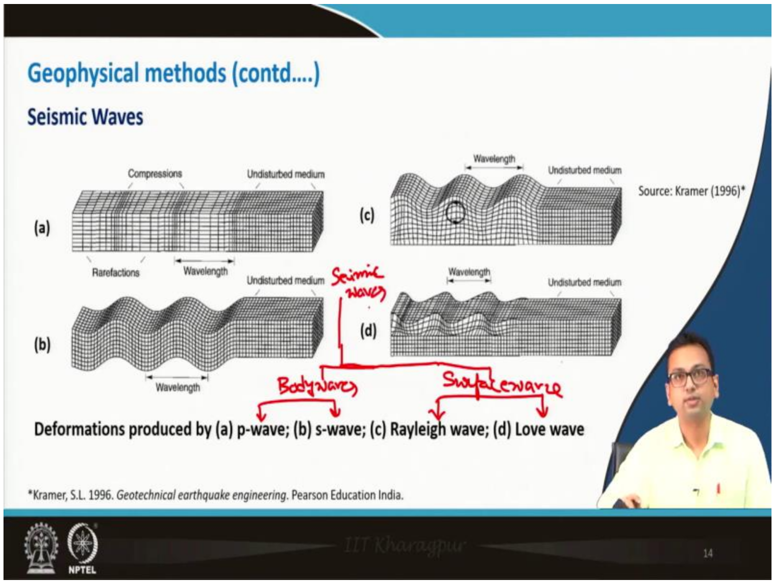

Now, seismic waves can be divided into two categories. First they are nothing but the body waves and surface waves. Now, body waves can be divided into two categories. They are P waves and S waves. Surface waves can be divided into 2 categories broadly. They are Rayleigh waves and Love waves. Again these waves can be divided into other two categories like S h wave, S v wave depending on horizontal and vertical orientation, means movements of particles. So, broadly these are the divisions.

What is P wave? The P waves are compressional waves and travel at the highest velocity. Since it travels with the highest velocity, they arrive first. So, this is one important point you should remember.

Then secondary wave that is S wave are the shear waves. And they travel at a relatively slower rate as compared to P wave, that is relatively slower, and are not able to pass through liquid which do not have any shear strength. Then Rayleigh waves moves in a elliptical path. Rayleigh wave is nothing but a type of surface wave. And P wave and S waves are body waves. So, Rayleigh wave moves in a elliptical path in the vertical plane from the source. This Rayleigh wave actually during earthquake causes highest damage. And another one is Love wave involves surface shear motion.

So, this is some pictorial representation of different type of seismic waves. P wave is nothing but called as the compressional wave. So, what happens here compression and rarefaction are happening over here. You see the rarefaction and these are the compression.

As we have seen here that the secondary wave or shear wave that is only, the shear wave as you can see, its pattern is like this. Now, this is our Rayleigh wave, elliptical as I have stated, over here that elliptical path in vertical plane and it causes highest damage. And this is our Love wave. So, basically these two are falling under body waves and these two are falling under surface waves. And both are nothing but the seismic waves.

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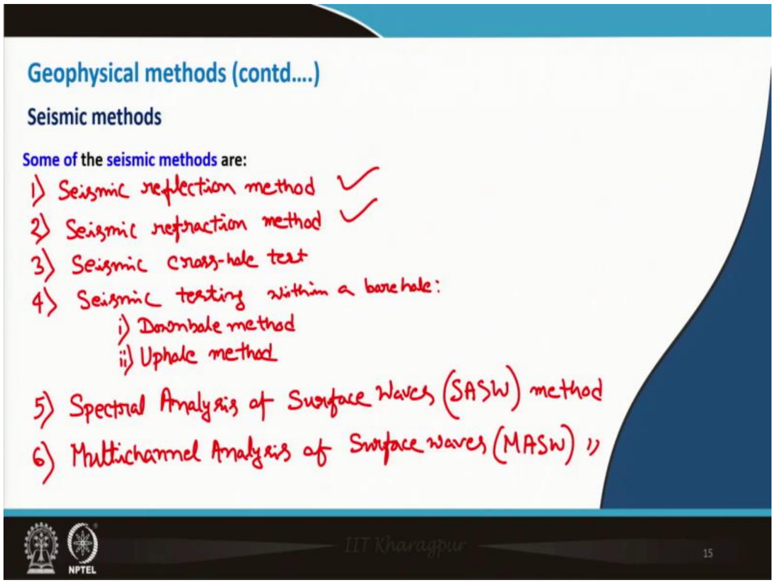

So, now let us write down about some of the common geophysical methods. We will start our discussion with this seismic reflection method. Then we will learn about the seismic refraction method. Apart from that we will briefly discuss about the seismic cross hole test methodthen seismic tests or testing within a bore hole. There are two types of tests. One is downhole method and other one is uphole method. And other than that we will again very briefly discuss about the SASW and MASW technique. The full form is Spectral Analysis of Surface Waves, that is S A S W method; and also briefly discuss about the Multichannel Analysis of Surface Waves, that is M A S W method.

So, out of these, we will spend most of our time on learning seismic reflection method and then seismic refraction method. So, with this let us stop our today's lecture here and we will continue with the seismic reflection method in our next lecture. Thank you.