Drilling and Blasting Technology
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Lecture – 09
Drillability of Rock

Let me welcome you into the 9th lecture of Drilling and Blasting Technology. In this lecture we will discussed Drillability of Rock.

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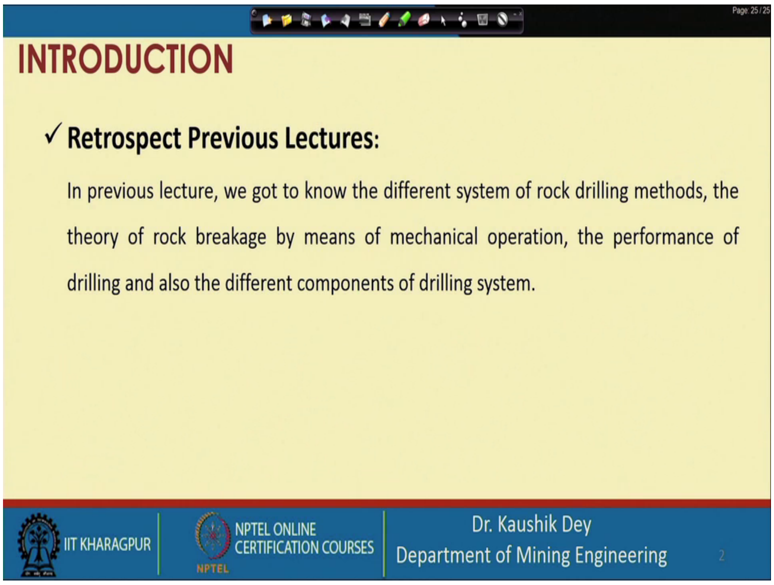

But like every class let us retrospect our previous lecture. In last class we have we have covered the different system of rock drilling methods, the theory of rock breakage by means of mechanical operation. We have seen there are different theories of rock breaking.

But in mining or you can say the drilling and blasting cases, we carry out drilling only by means of mechanical operation. We are not using other thermal seismic etcetera; we use only mechanical operation. And in that mechanical operation, we use only rotary percussive or rotary percussive hybrid operation. And the performance of drilling and also the different components of drilling systems we have discussed. That means, how the energy is transferred from it is source; that is the drill machine to the drill bit through the drill steel. And how drill bits are having different crossing action, then the chipping action is carried out for increasing the depth of the penetration in its action of drilling.

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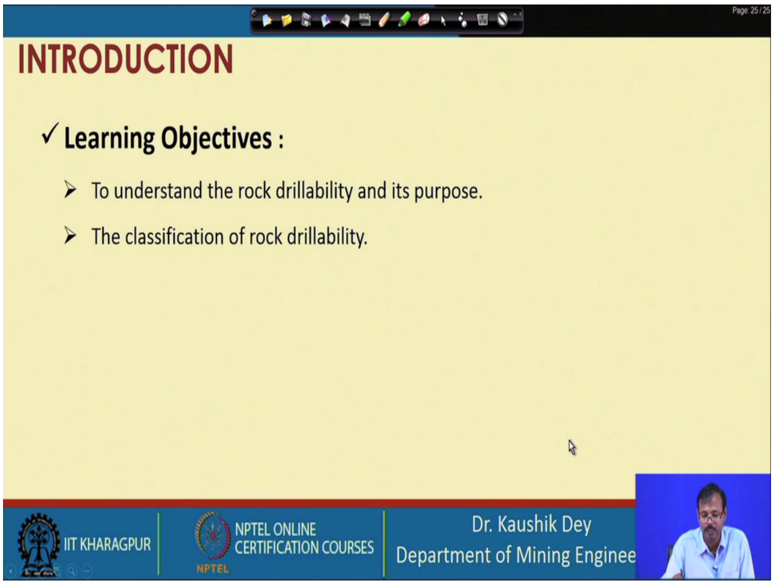

Now, our learning objective for this class is to understand the rock drillability. And why it is required we will also discussed that, we have also find out the classification of the rock drillability that is the different methods of the rock drill drillability we use in our practical field. Basically, we have introduce ourselves with the rock drillability in that last class. But we will discuss this matter in details in this class. So now, let us discuss what is drillability.

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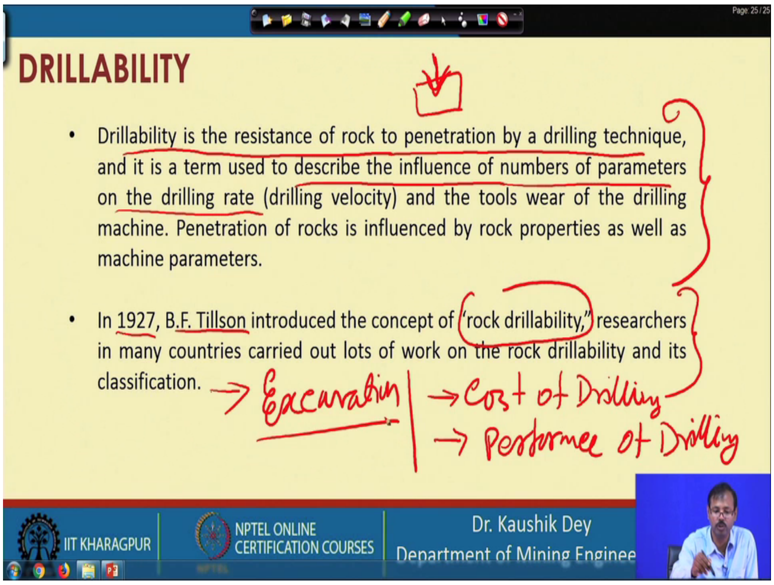

Basically, drillability is the resistance of a rock. It is the resistance of a rock to be penetrated by a drill machine. So, that means, a rock is there which has to be penetrated by a drill machine. And this term is used to describe the influence of number of parameters on the drilling rates. So, basically while some drilling has to be carried out on the rock, how the rock is resisting to be penetrated that can be considered as the drillability. The first tilson has used in 1927 first this term rock drillability. And after that a long research is carried out on the drillability, because drillability is a prime factor on two thing.

One is the cost of drilling, second one is the performance of drilling; that means, how fast we can achieve the completion of a drill hole. Not only this, not only drillability is defining the drilling only, but also drillability gives us some idea about the mechanized excavation: mechanized excavation; that means, how easy to cut a rock, that is also possible to be assess if we know the drillability of a rock.

So, that is why drillability is a very very important parameter required in the rock blasting or rock drilling part.

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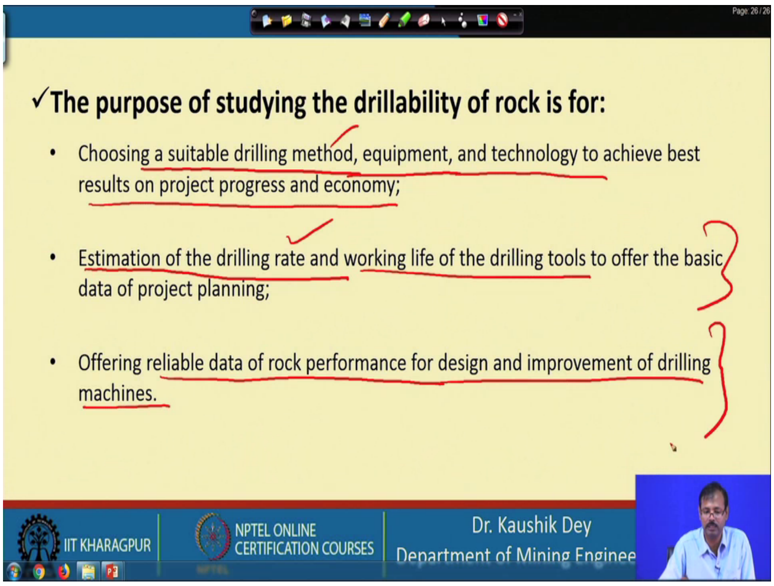

So, basically what is the purpose of this? The purpose is we have to choose a suitable drill machine for drilling that particular rock. We have to choose a suitable method of drilling. We have to find out the suitable technology to achieve the best result while we are carrying out the drilling. That means, our options are that whether we will use a percussive drilling, or whether we will use a rotary drilling, or we will use a rotary percussive drilling, should we use the circulation fluid, which type of circulation fluid can be used. All these decisions are dependent on the drillability of that particular rock.

This drillability also discussed the drilling rate. Working lives of the drill tools; that means the drill bit drill steels etcetera. And these are very very important as these are directly dictating the economics of the drilling. Apart from that drillability also gives us the performance and improvement of the drilling machines. That means, what should be the drill feeding rate to be provided by the drilling machine to achieve the optimum drilling.

How much should be the thrust? How much should be the rotary force to be given by the drilling machine to achieve the best performance, this all decisions depends on the drillability of the rock.

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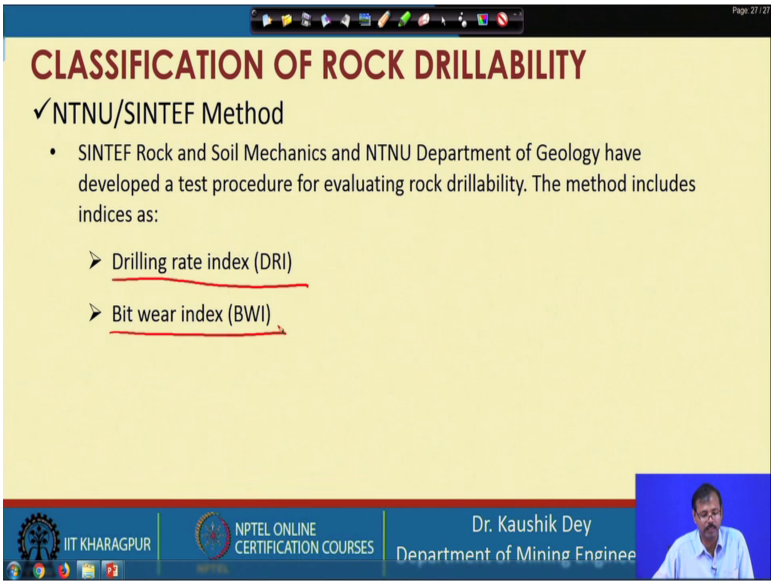

So, basically drillability is a term which dictating or which is basically guided by the rock properties and also the machine properties. So, mostly we are using NTNU or SINTEF method, where drillability is basically governed by 2 thing: one is the drilling rate index, another is the bit wear index.

Now, to have a detailed look on this, let us see what is drilling rate index.

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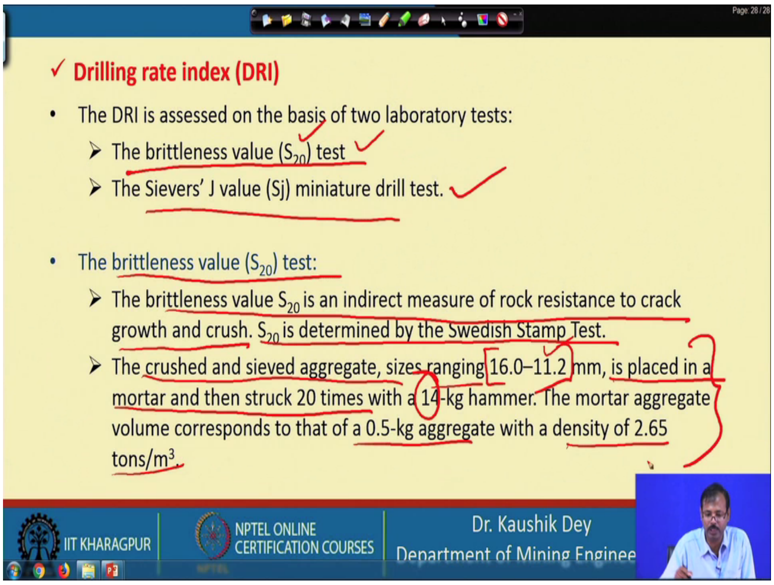

Drill rate index is basically assessed by a nomograph. In that nomograph we have to plot 2 thing. One is the brittleness value S 20 value, and second one is the Sievers' j value, which is come which comes out from the from the miniature drill test. So, we have to carry out brittleness test, we have to carry out miniature drill test to come with the value of drill rate index.

Now, let us see what is the brittleness value test or say S 20 test. The brittleness value S 20 is an indirect measure of rock resistance to the crack growth and crush. And S 20 is determined the Swedish stamp test. What is carried out here? The crushed and sieved aggregates sizes ranging from this to this size. So, this size range of material is placed in a mortar, and that struck 20 times with a 14 kg hammer, ok.

So, this 14 kg hammer is strucking 20 times of a fixed quantity of this size aggregate. So, this is half kg of aggregate, and this is compared with the standard material of this much kg of density of this one, specific gravity of 2.65. Now as this is compared with this, we find out the S 20, we find out the S 20 value as the equal percentage of undersize material that passes through 11.2 mm mesh size that passes through 11.2 mm mesh size after this drop test.

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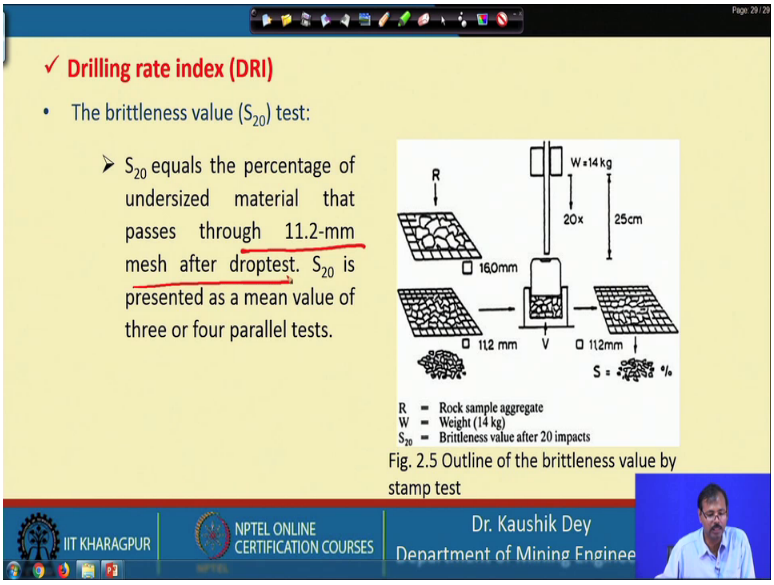

So, the percentage of material which is coming below this is considered as the brittleness value of the test.

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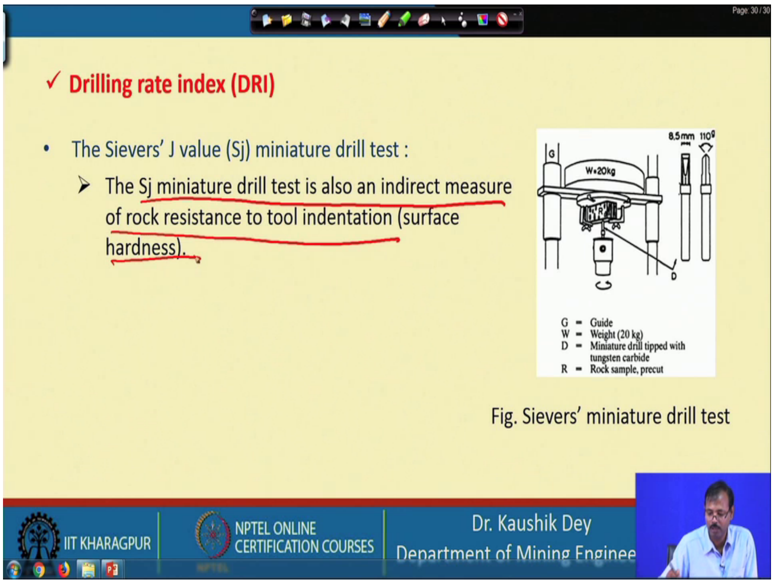

Now, in Sievers' j value, miniature drilling is carried out in the in the rock sample.

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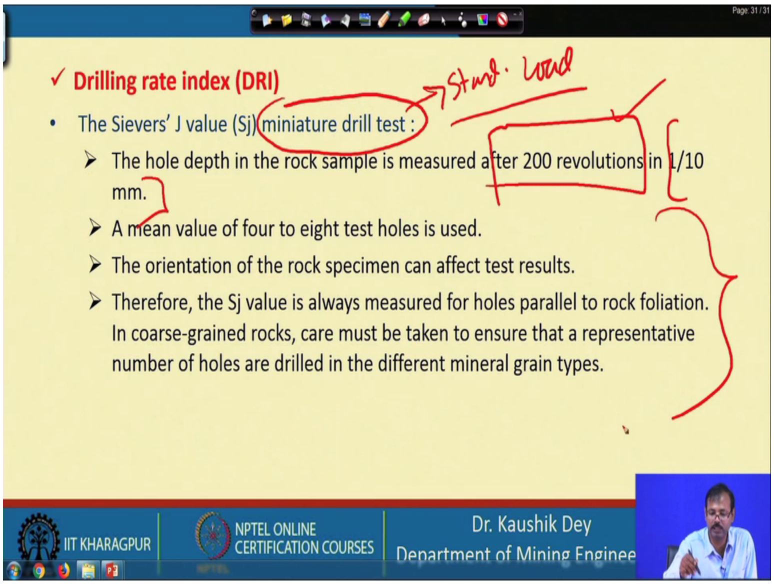

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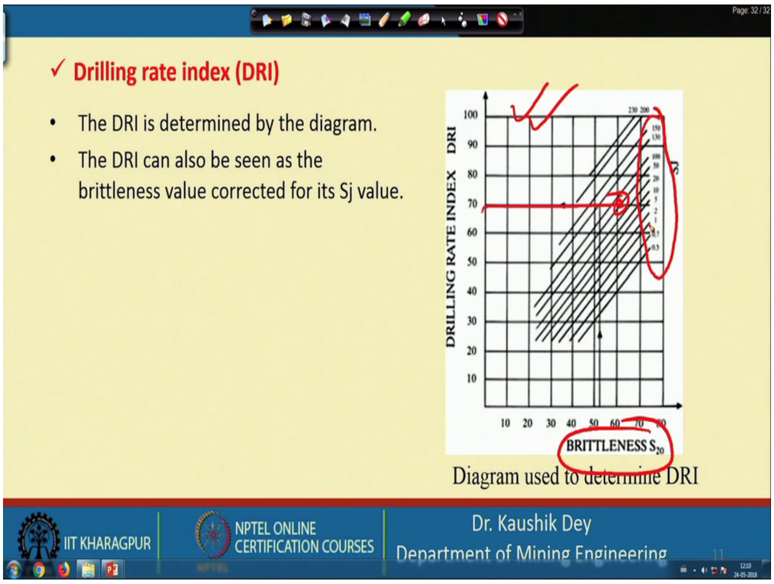

And in this test, the standardized drill bit is allowed to penetrate the rock sample and the penetration depth is measured after 200 revolution.

So, this rotary drill this is miniature rotary drill, which is carried out under a standard load and after 200 revolution the penetration depth is measured in a one 10th mm scale. And that value is considered as the drill rate index value. So, 4 to 8 tests are carried out on that, and that value is considered as the Sievers' j value. And then this Sievers' j value is plotted against thus this brittleness value. This Sievers' j value are plotted against this brittleness value to arrived at the particular drill rate index.

So, in this nomograph the brittleness value and Sievers' j value are plotted to have a drilled rate index.

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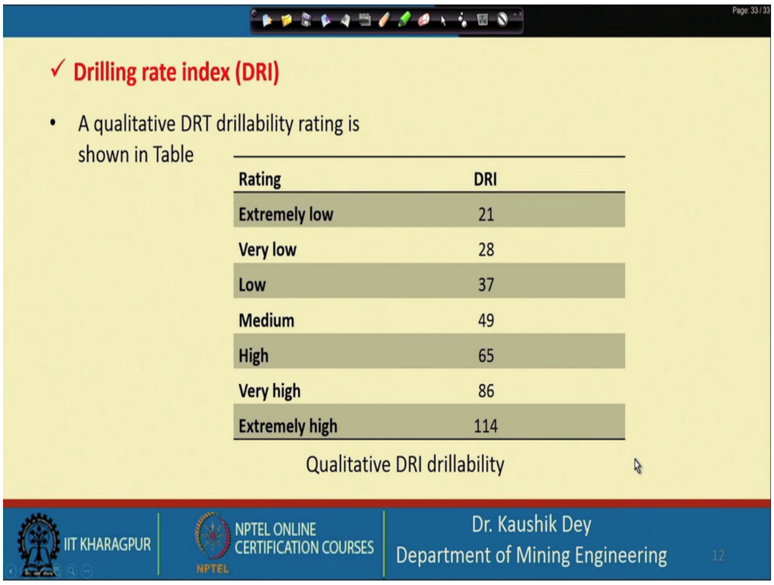

Now, these are some of the a drill rate index the qualitative assessments are given, the DRI 21 is considered as the extremely low, 28 is considered very low, 37 is low, 49 is high, medium 65 is high 114 is extremely high. That is drilled rate index may be considered as per the table value.

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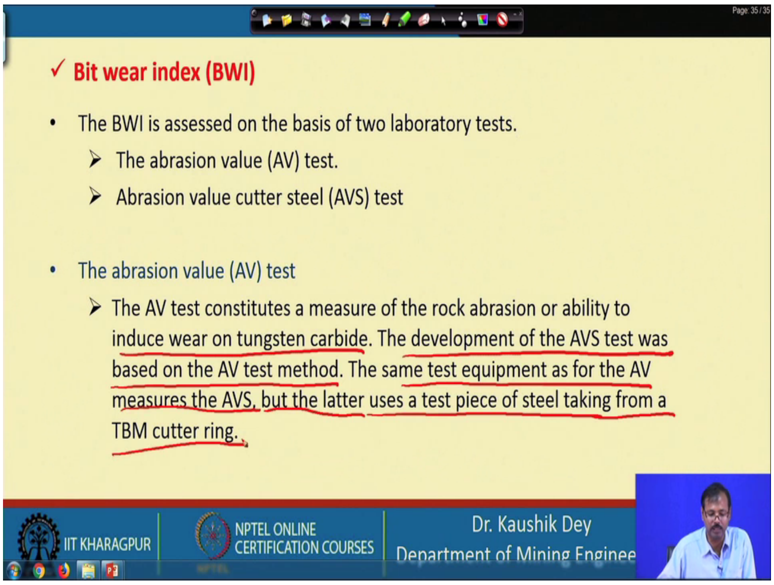

Bit wear index is basically giving us the loss of the bit and this can be this can be assessed again by 2 tests. One is the abrasion value test, second is the abrasion value cutter steel test. So, if you see the abrasion value test. Abrasion value test continues a measure of rock abrasion, or ability to ability to induce wear on the tungsten carbide. The development of abrasivity steel test was based on the abrasivity AV test abrasivity value test method. And the same test equipment are used for as for the AV is measured the AVS.

But the in abrasivity steel test, a test piece of steel is taking from the TBM cutter ring to assess the cutter abrasion values of those steels.

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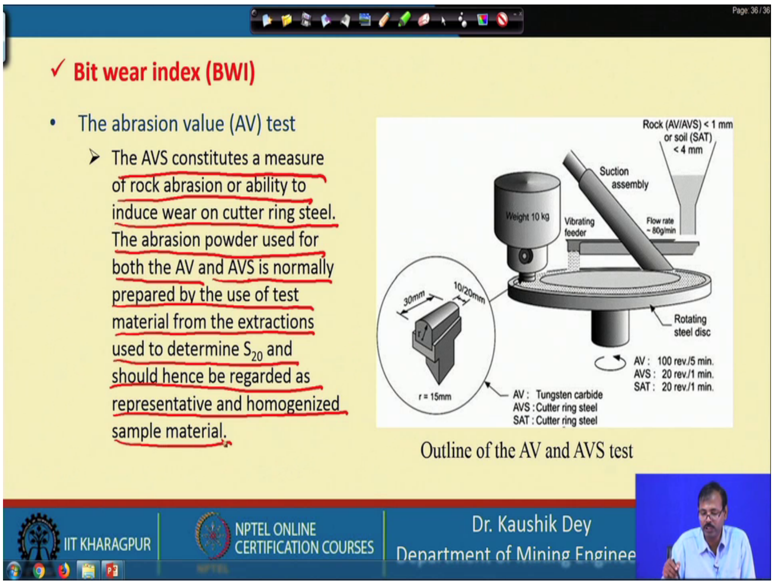

So, this is the abrasion value test, here abrasion value steel continues a measure of rock abrasion or the ability to induced wear on the cutter ring steel. The abrasion powder used for both the abrasion value and a abrasive abrasion value steel is normally prepared by the use of test material from the extraction used to determine S 20, and should hence be regarded as a representative of homogenized sample material.

So, basically in both the cases we use the same abrasive powder for carrying out this test.

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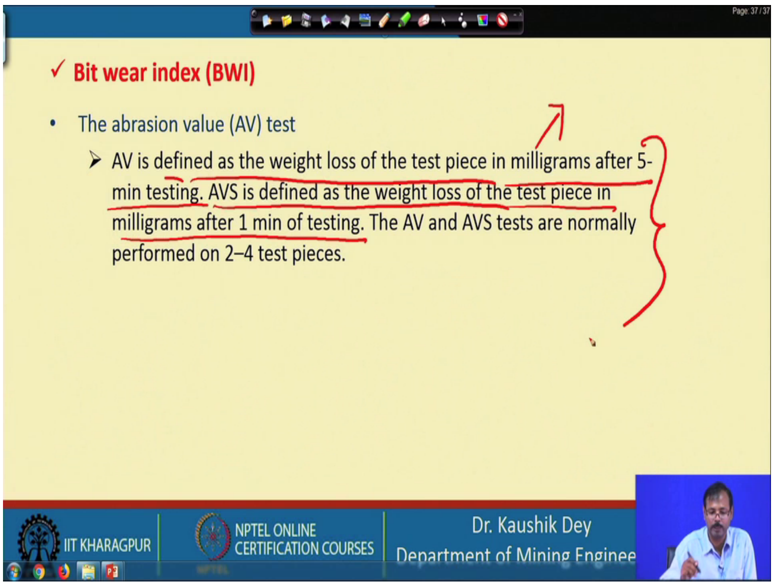

And the abrasivity value is defined is defined as the weight lost of the test piece in milligram after 5-minute testing. So, 5-minute abrasion is allowed on the test piece, and how much weight is lost that is measured here. In the abrasivity steel also the weight lost of the test piece in milligram after 1 minute of testing is used. So, basically these are the test loss of the material of the test samples are basically considered in this case.

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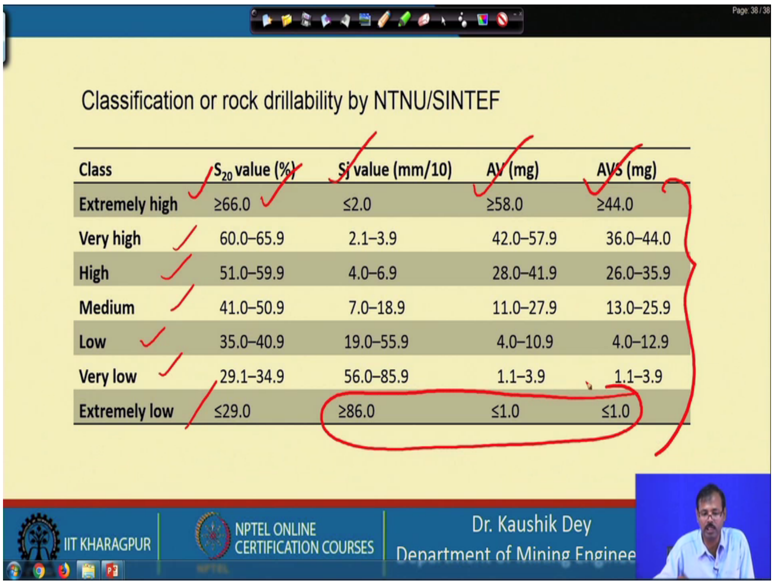

And if it is compared you can see the extremely high considered reversing the table this is the Sievers' j value, sorry this is the Sievers' j value, this is the abrasive value this is the abrasivity steel value, if it is consider. So, this is for a 5 minutes this is for 1-minute test. And these are the different values you can observe for high, very high medium low very, low and extremely low conditions.

So, these are very very good situation for carrying out the drilling operation.

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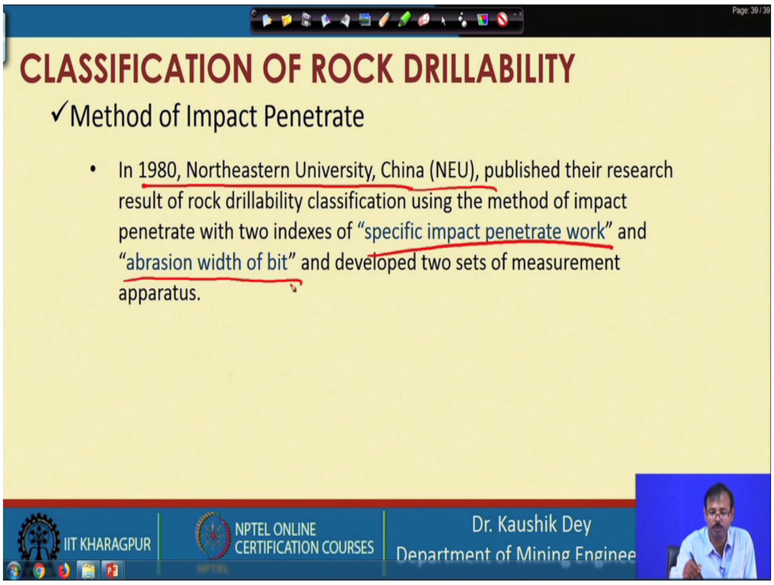

There are, another method of achieving the rock drillability is also possible.

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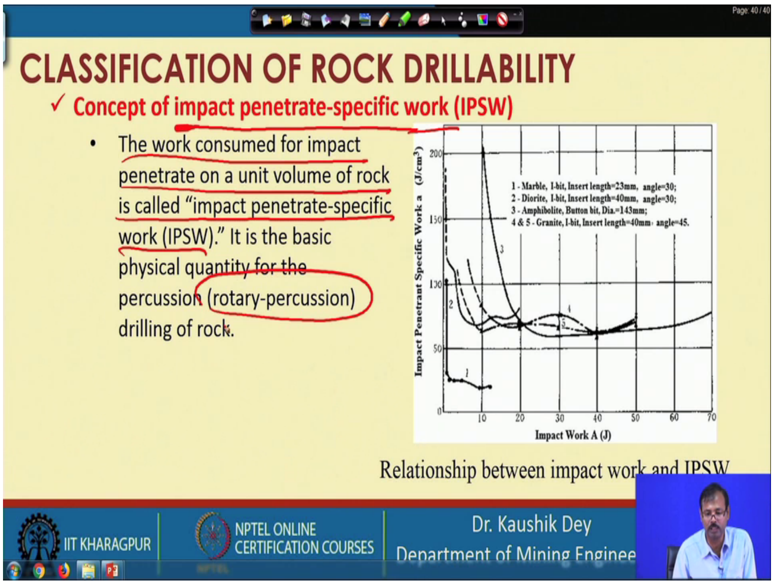

So, here in this case in 19 80 china has developed this one, for specific impact penetration work and abrasive width of the bit is considered and to, these 2 measurements are carried out, these are developed in the china, and that is why this is not that much popularly is. So, first one is the impact penetration specific work.

Here the work consumed for impact penetration on a unit volume of rock is called this. And this is the basic physical quantity where rotary percussion action of the drill drilling is utilized.

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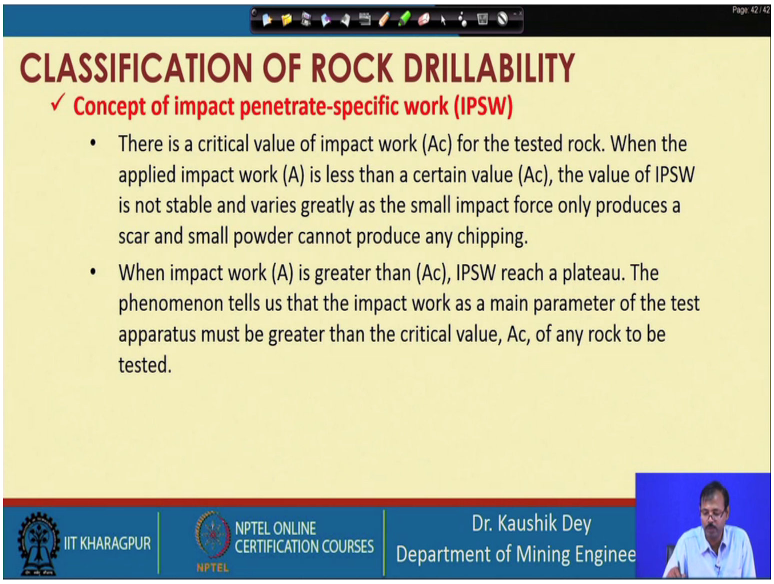

And here there is a critical value of impact work for the tested rock when the applied impact work is less than the certain value; that is the critical value, the value of impact penetration specific work is not stable, and varies greatly as the small impact force only produces a scar on the small powder cannot produce any chipping.

So, the impact work must be higher than the critical impact work. And when the impact work is greater than this, then the test can be carried out in the actual condition.

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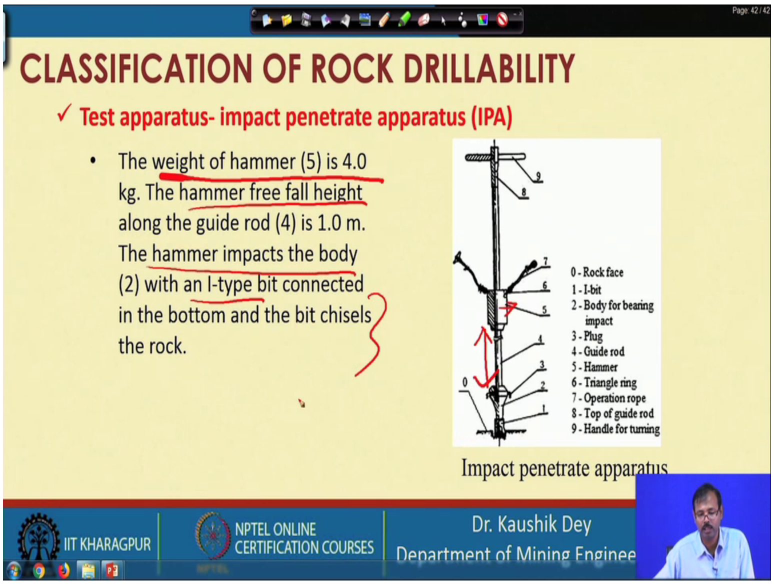

So, here what is carried out? A weight of hammer of 4 kg; so this is the hammer of 4 kg is allowed to free fall from a height. So, this height is fixed, this height is fixed, the hammer impacts the body with a I-type bit. So, I section bit is used, which is connected in the bottom and this is acting on the rock.

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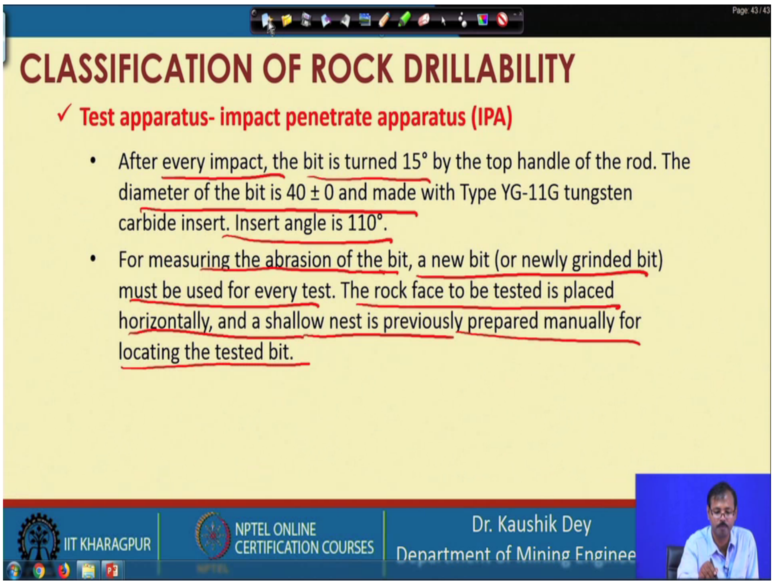

Now, next after every impact after every impact bit is turned 15 degree by the top handle of the rod, the diameter of the bit is this, and insert angle is this one. So, for measuring the abrasion after this every impact the bit is tilted. After the completion of that the measuring for a abrasion of the measuring a new bit is every time used fresh bit. And the rock face is to be tested which is placed horizontal, and shallow next to the previously prepared manually locating tested bit.

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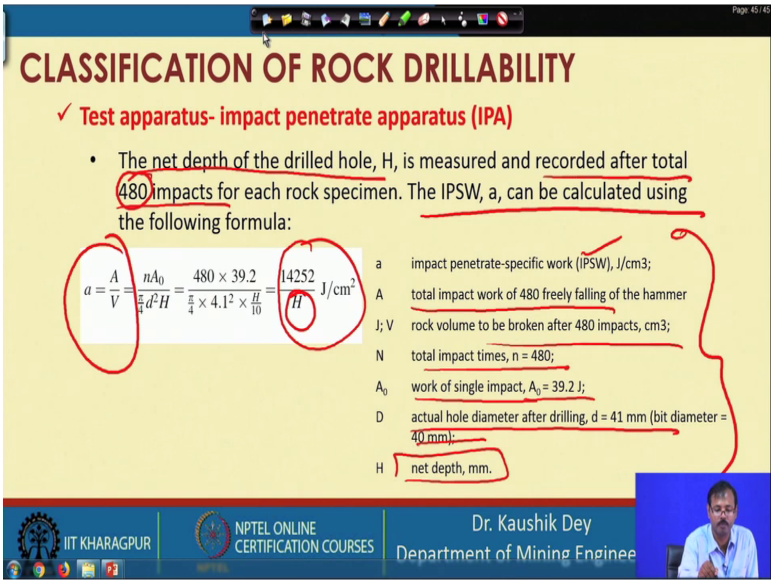

So, the finally, we measure the net depth of the hole which is h is measured. And the number of impacts generally that is kept 480 impacts is carried out, and then this can be calculated using this formula, where this is the value IPSW value have a joule per centimeter cube. This is the 480 total impacts of free falling. V is basically the volume of rock broken. N is the total impact times. A 0 is the work done by a single impact. D is the actual hole diameter and H is the net depth.

So, using this formula we can calculate. And finally, this can be achieved by this formula where the hammer. So, hammer weight number of penetration, number of impacts and, height of impacts are kept fixed. And from that calculating the energy we can directly if we press the value of H. Then we can directly get the IPSW value.

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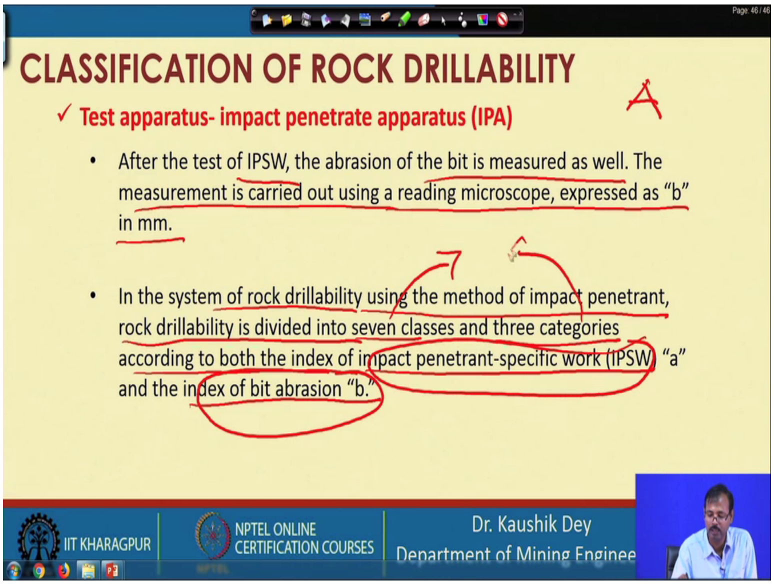

So, after the test of IPSW, the abrasion of the bit is measured as well the measurement is carried out by using a reading microscope and the bluntness of the bit is measured, that is in mm.

So, as we have discussed in the searcher also, the bluntness of the bit is measured and that reading is taken in the microscope. Using this method of impact penetrant, rock drillability is divided into 7 classes and 3 categories, according to both the index of impact penetration specific work and the index of bit abrasion. So, considering these 2 the entire rock drillability is divided into 7 class and 3 categories. You can see this in the next slide.

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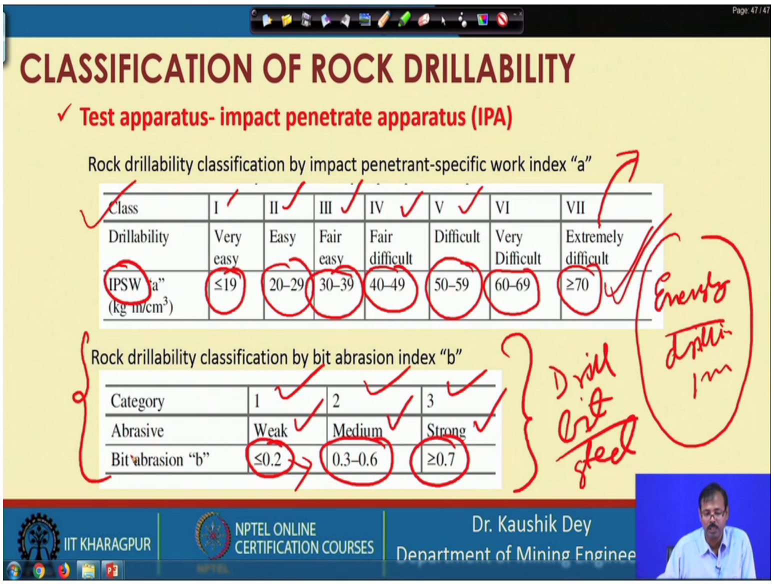

. So, these are the 7 classes. This is the class one is considered to be very easy, if the impact penetration is less than value is less than 90. It is easy if this value is 20 to 29 this is fairly easy. If these values are value varied between 30 to 40. If this is 40 to 50 considered difficult. It is fair difficult, it is difficult if it is 50 to 60, very difficult 60 to 70, and greater than 70 is considered extremely difficult.

So, basically IPSW which is basically considering the energy requirement, this is considering the energy requirement of drilling per meter of per meter of drilling. Considering this energy requirement as the energy requirement is more than 70 kg meter per centimeter cube. Then it is considered as the extremely difficult drilling condition. Now as extremely difficult condition does not means that it is very very abrasive. Abrasivity depends on the abrasivity of the rock. So, that is why this economic part we need to know how much drill bit and drill steel will be consumed. So, this is basically dictating the consumption of the drill bit or consumption of the drill steel.

So, for that it is categorized in 3 part. One is weekly abrasive. Second is medium abrasive. Third one is very strong abrasive. So, the bit abrasion that is a bluntness is coming less than point 2 millimeter. So, if the bluntness on the bit is coming less than point 2 millimeter, then the rock is considered of net weakly abrasive. If it is between point 3 to 0.6, then it is considered as the medium abrasive. And if it is considered as the greater than 7, 0.7 then it is considered as the very very abrasive.

So, basically this abrasivity gives us the loss of the drill bit which is basically an economic term. So, this Chinese method is also very robust system, and that can be popularly used for identifying the drillability of the rock rock. And accordingly the machine can be deployed on that, and we can assess the economics of that drilling also.

This is more or less covering the drillability part. We can stop the drillability part at this point. I request you to have more reading on the drillability from a number of books are available, on the drillability even if all the drilling books rock properties books dealing with this specially, where the TBM are is essentially considered drillability is, must to be drillability test is must to be carried out there.

So, I request you more reading on this drillability. Let us stop at here in this class.

Thank you.