Surface Mining Technology
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Lecture – 47
Haul Road - II

Let me welcome you to the 47th lecture of NPTEL online certification course Surface Mining Technology. This is the second lecture on haul road. And in this lecture, we will cover the construction of the haul road.

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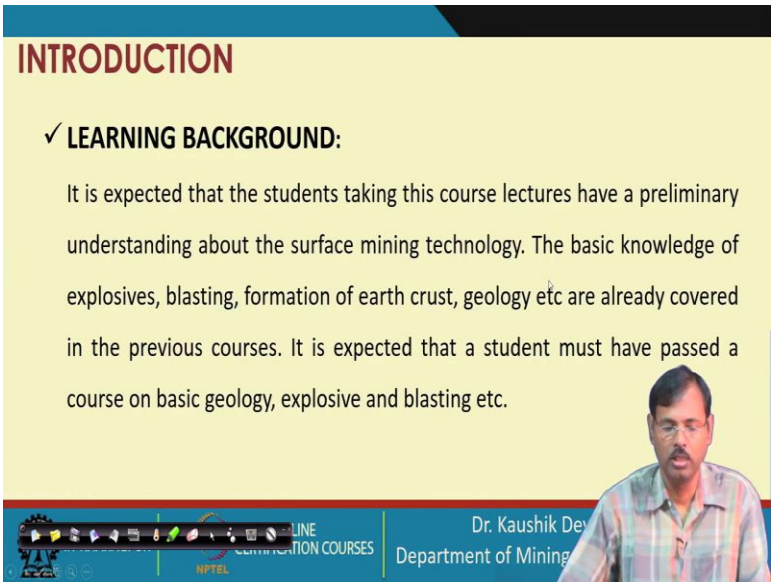

But as we do for every lecture, let us have one look into the learning background required for Surface Mining technology course.

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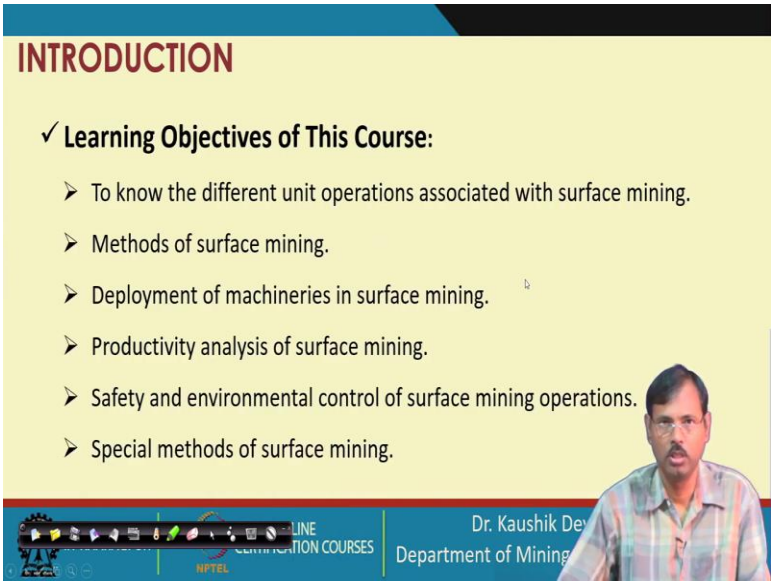

These are the learning objectives for Surface Mining technology course.

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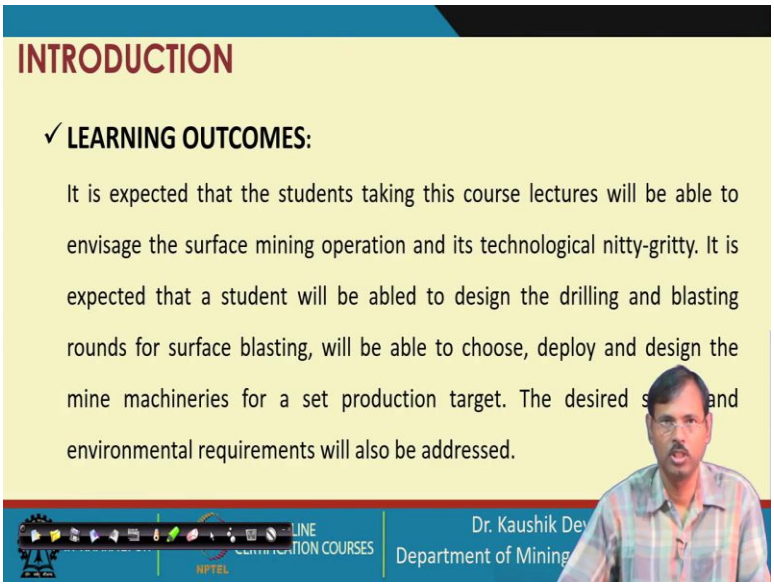

And these are the expected learning outcomes from the participants of the Surface Mining Technology course.

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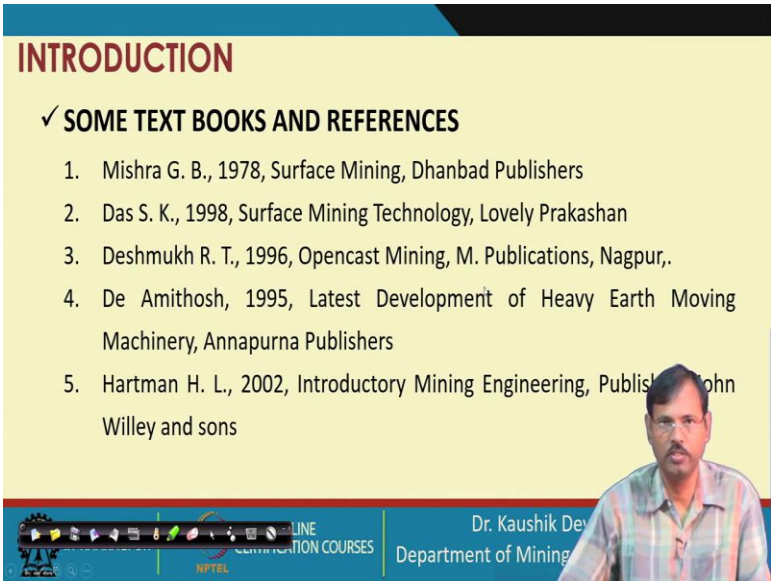

And these are some of the textbooks and references.

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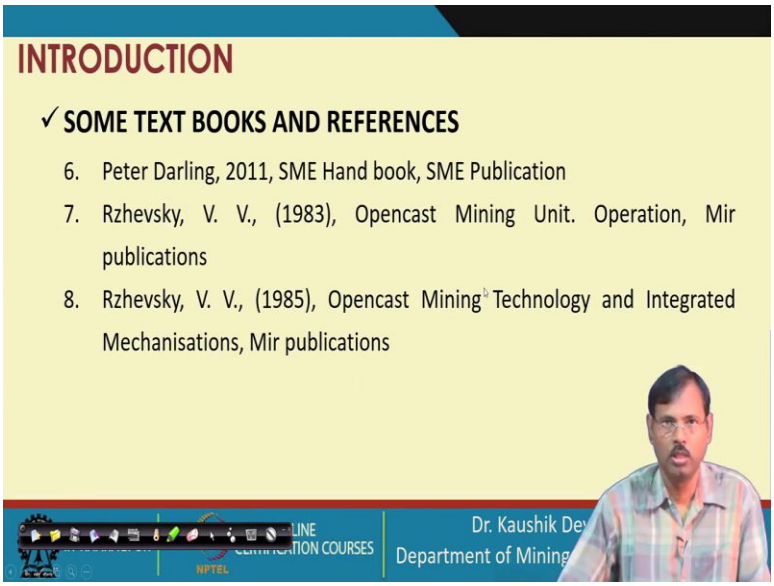

These are some of the textbooks and references particularly for this haul road and construction of haul road, maintenance of haul road. I would like that participant may see the book of the tenant. Actually, that is the research report of the tenant which is available in the internet as well as a good coverage is also given in the open pit mine planning and design written by Hustalidd and Kuchta, in that book also a significant portion of the haul road construction and maintenance is also provided.

Apart from that, there are several civil engineering books available on the road construction. So, the basic difference is that civil engineering roads are very permanent type, having a substantial life of 20 years, 30 years. But mining roads are not that much permanent life and it is basically having maybe one, two years or something like that apart after that the position of the roads are changed.

So, that is why in general the construction costs are kept very low for the mine haul roads. Basically, it is found that the surface civil engineering roads are constructed with a cost of around four crore rupees, five crore rupees per kilometer. The mining road cost are not that much high in that respect.

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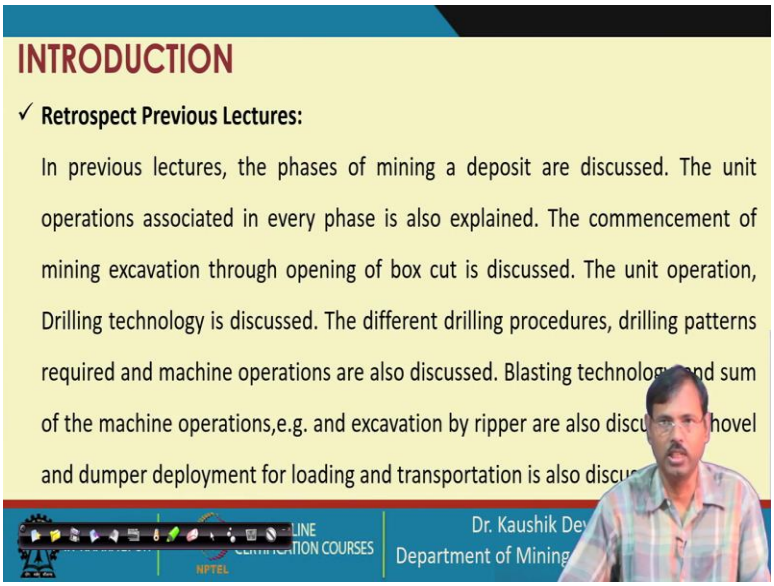

So, as we do in every class, let us retrospect whatever we have covered in the previous lectures. Previously we have covered the phases of mining a deposit. We have covered the commencement of surface mining through the opening of box cut. We have covered the unit operations like drilling blasting. Then excavation using the ripper after that, excavation of blasted muck is in the shovel or excavator.

And the transportation of that blasted muck loaded by shovel to the dumper transport system. Then we have covered excavation by surface miner. We have covered excavation by dragline, we have covered excavation by bucket wheel excavators. And apart from that, we have also

covered the highwall mining system which is the recent trend of the excavating highwalls in the surface mines. So, this is mostly covered before the haul road.

In previous class on the haul road, we have discussed or we have introduced to the haul road, we have seen the haul roads are of permanent nature, temporary nature or semi-permanent nature. So, and based on that we have seen the generalized layering of the haul roads.

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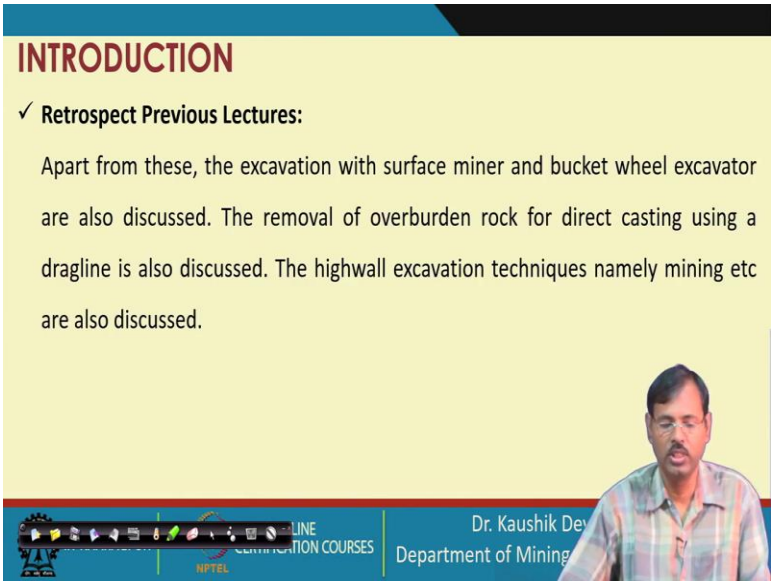

And we have seen an overall idea about the haul roads.

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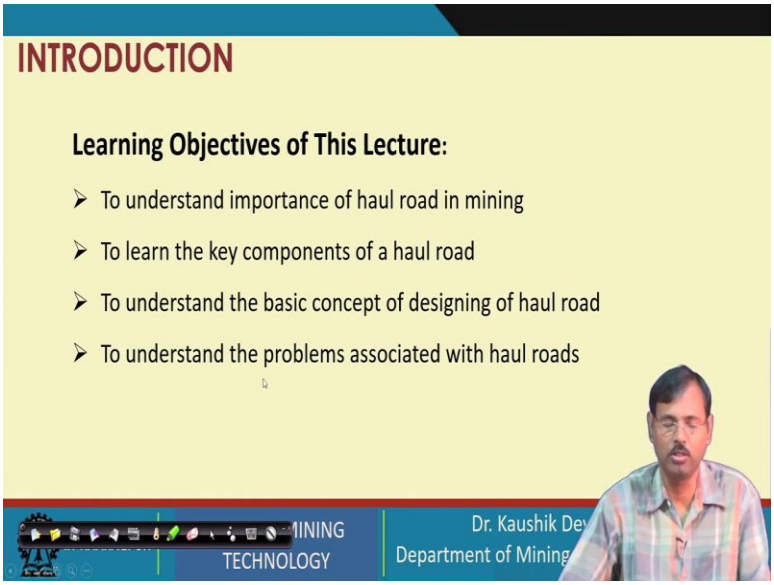

So, these are the learning objectives of the three lectures of haul road. So, understand the importance of haul road is already covered. The key components of the haul road is also covered. In this class, we will understand the basic concept of designing a haul road. And we will understand the problem associated with haul road or safety features of the haul road in the next class.

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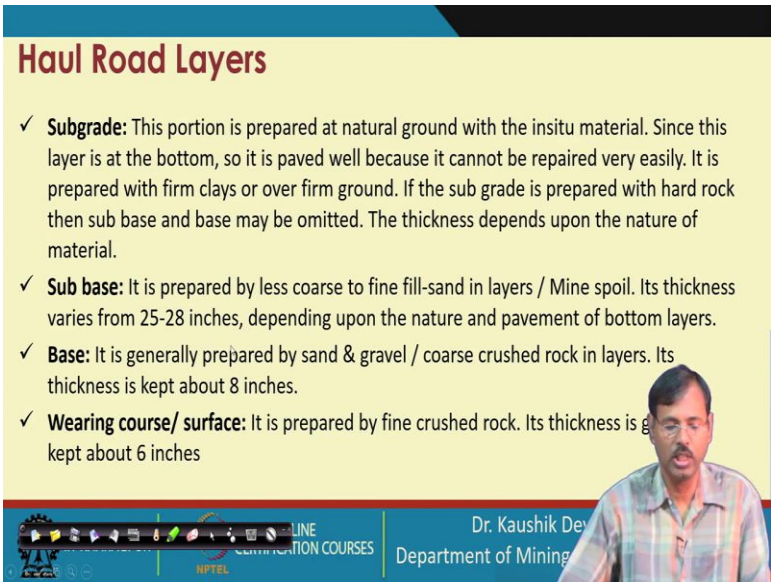

So, as we have seen, the haul roads are having four layers.

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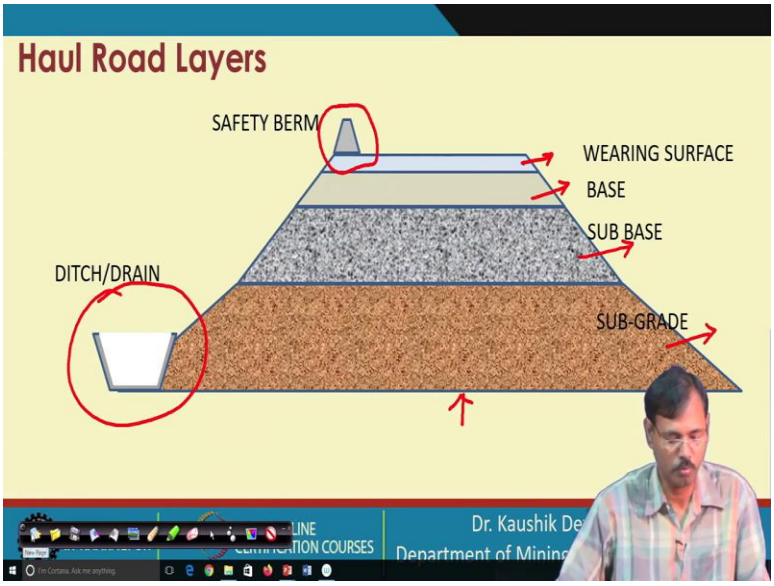

So, in other way, you can see there are four layers. First layer is the wearing surface, second is base, third is sub base and fourth this sub grade. So, this is from the top and but, when the construction is carried out, we have to construct from the bottom. So, that means first we have to laid the subgrade material, then we have to lay the sub base material then we will provide the base and wearing surfaces. There are also two features shown which are in general associated with the haul roads. One is the safety berm and another is the ditch or drain, which is in general provided in a haul road.

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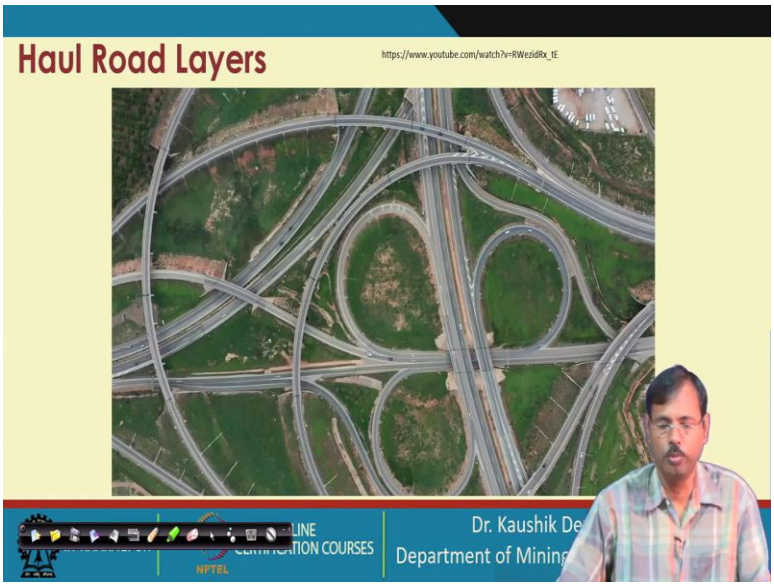

So, let us just look how these layers are laid for a road. But in this case, we will look not further mining road, let us look into the modern road feature basically constructed in a civil project.

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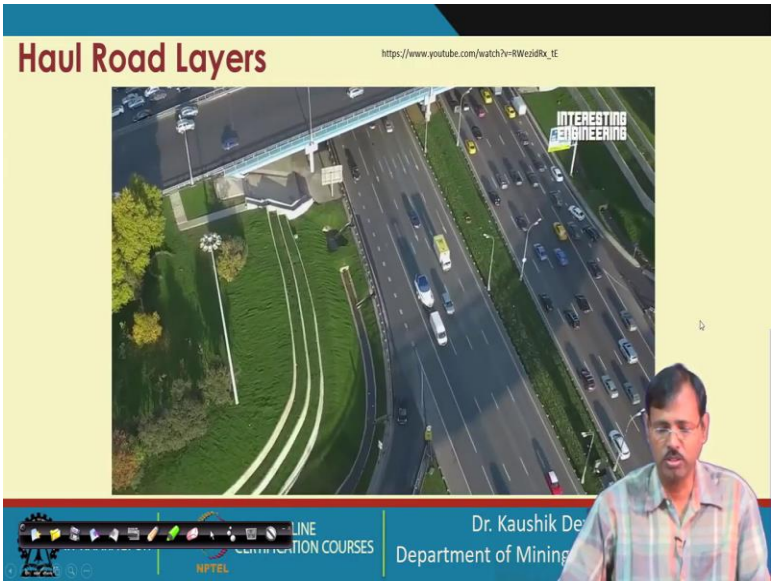

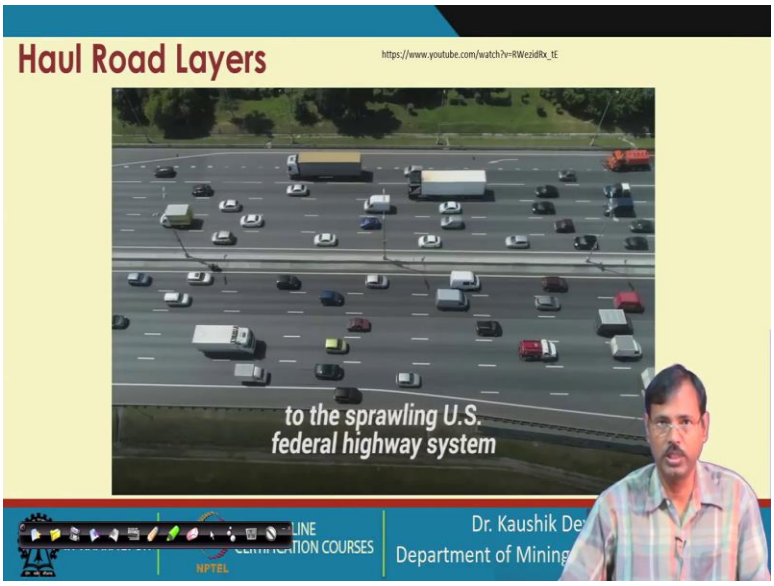

So, these are modern constructed civil projects, where multi layer roads are there. And most of this multi layer roads except the ground one all are in general made on a concrete surface, you can see these are the piled. And then the concrete structures are made.

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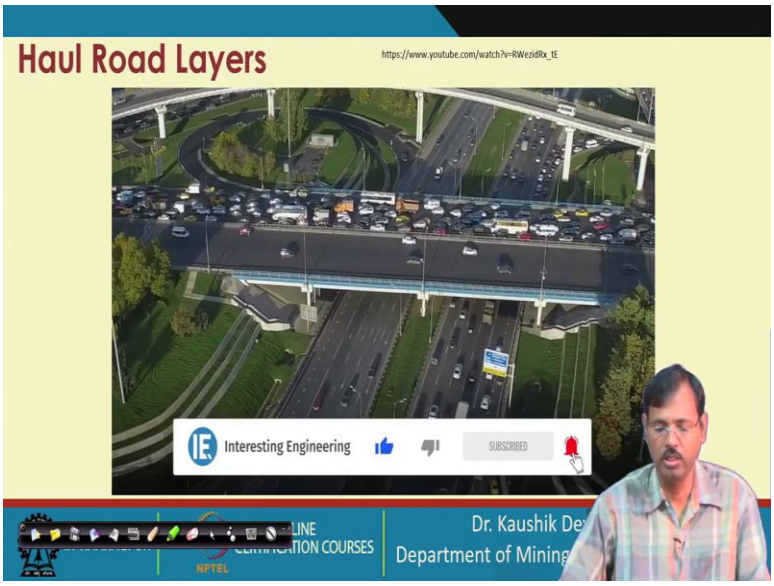

And these modern roads are highly popular, because the elevated roads are having better utilization as it is not affected by the traffic. And most of the cases, these roads are made with the proper foundation, then above that, the precast concretes are used. But in general, when a road is made on a particular ground, how that is made? This video is basically showing a good education related to that.

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Now, the construction basically starts with the leveling of the ground, which is the first job needs to be done. In fact, prior to that, the positioning of the roads is very important. So, that part is very important. And in a terrain, first from the starting point to the destination point, these positions are marked from where the road has to be constructed. So, that positioning of the road has to be made.

This is same for a mine and this is same for a civil also. In civil you have to avoid different inheritances etc., but that is not there mine, but in mine you have to position the haul roads in such a way, so that the overall distance can be limited. So, first job is that you have to provide a very strong subgrade.

And in general, we have to provide the subgrade material which is basically also called embankment. And that has to be laid properly. So, these soils are basically taken out. And then that is dumped. And after that, then that has to be properly spreaded, then properly rolled. Vibratory rollers are used for compacting them.

And this is the laying of the material. After that, they are providing the drainage pipes. Now, after providing the embankment, then the sub base is provided. Sub base is basically a granular rock dust, that is provided and sub base size should not be exceeding 75 mm size. So, those are basically placed and every time a layer is placed that has to be properly laid. Then it is compacted.

So, this is in general and this is the concrete road, this is the bitumen road. These are showing in different cases and how the smoothness is achieved. Generally, nowadays pavers are used. Generally, pavers are used for constructing the roads. And road pavers are basically automatically laying the road. And if, very good and excellent smooth surface is obtained from this. So, this is the concrete road, how the paver is laid the concrete, that can be seen in this video.

So, this laying is very old maintained and these are guided by this site which is basically surveyed and this guide rope is provided for the proper positioning and proper revision controlling of the road.

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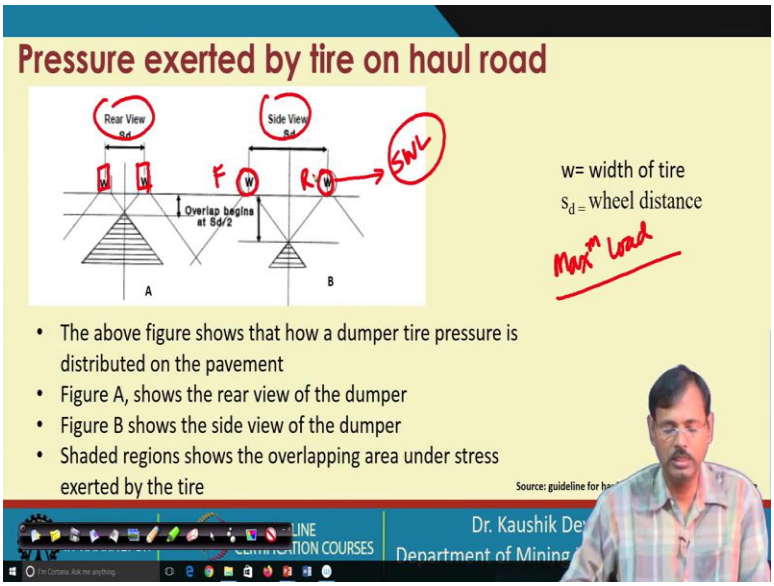

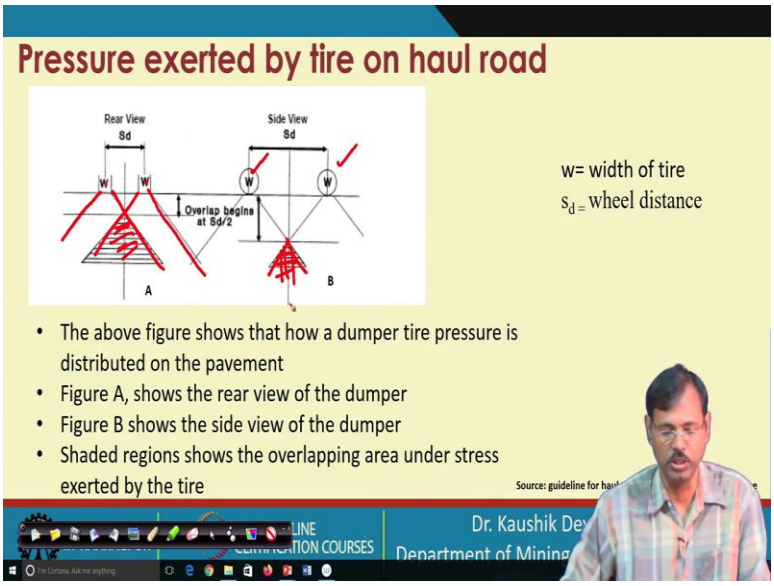

Now, let us understand how the designing is carried out. Basically, the concept of design is to see the road should take the load of the vehicle. So, what is the maximum load a vehicle is taking, we have to consider the load coming to a single wheel, this is called single wheel load. So, this single wheel load how much is acting on the road surface is very important. And this is a rear view suppose, and this is a side view.

Suppose a truck or dumper is working, this is one rear wheel, this is another rear wheel and this is the front wheel and this is the rear wheel. So, these are the positioning of this one. And this is basically showing how the load is being distributed for these two cases as the two rear wheels are at this position, then the load of these wheels are basically distributed like this way. And this is the zone where the load of both the wheels are coming.

And if we are looking from the side view, this is the front wheel, this is the rear wheel and this is the zone where the load of the both the wheel is acting at this position. So, this has to be considered for, this has to be considered while the designing of the road is carried out.

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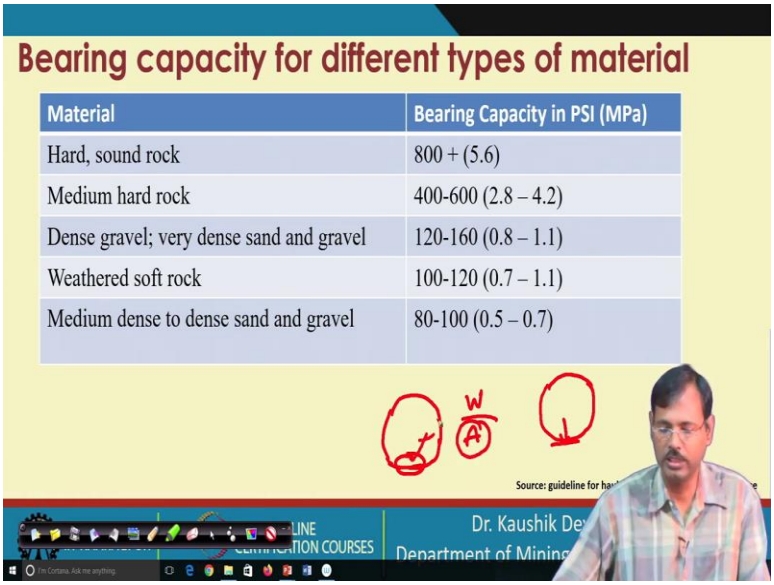

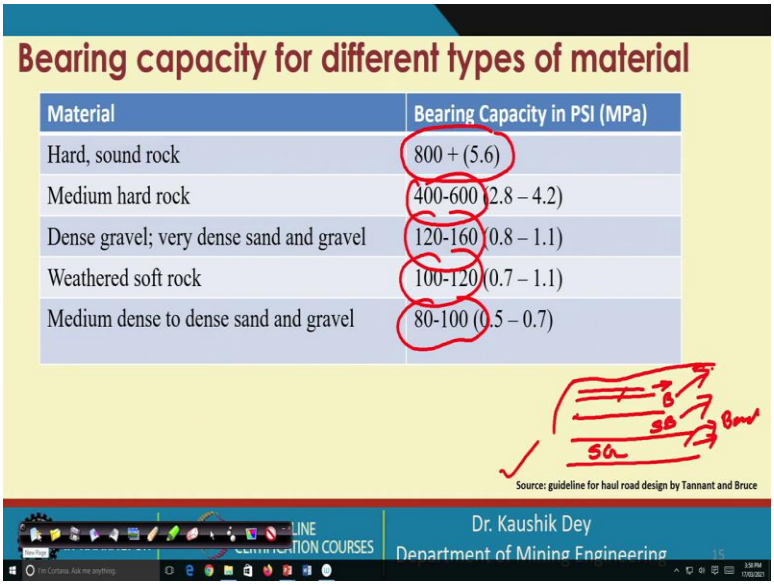

Generally, this load ideally, we may think that a tire, which is a circular or wheel is a circular in nature, then the load when acting on the wheel is basically acting on a line or on point but it is not actually the case. It is observed that the wheel when it is taking the load at the bottom part, the wheel become flattened at the bottom and basically creating a equivalent circle at this position.

And that is why the load is basically considered by this equivalent surface area which is created by this circle. So, that is considered as the load. And different materials are used for laying the different layer. Say, suppose in the surface we are having wearing surface, then we are having

base layer. So, this is surface wearing surface, then base, then sub base, then subgrade. And we are having different materials, we use in this case.

So, here it is soil or embankment in mining case, it is the direct benchtopused at this position. And this is the granular material, which is used there and this is the base material which is basically the fine grain cover part, rock part which are used. So, as the base material and these are basically working as the haul road. In case of civil load, you provide the some wearing surface on these.

So, this is basically the construction and it has been found that the for very hard material, the bearing capacity comes in this much PSI. For medium hard rock, this is the bearing capacity, sand and gravel, weathered soft rock and say medium dense material, these are the possible bearing capacity, and this is the source of this one.

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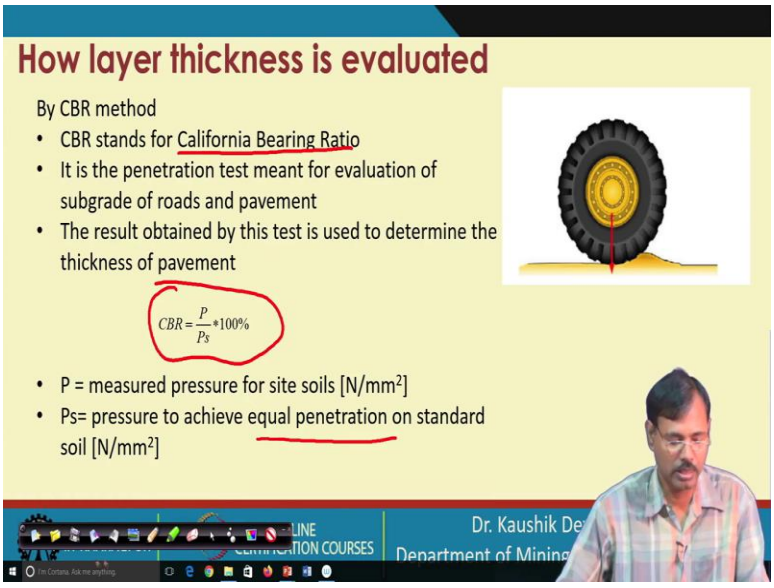

Now, this designing criteria for a haul road is basically based on the California bearing ratio. And this is a very popular and easy to adopt designing criteria used for the haul road designing. So, for this let us first understand what is CBR? CBR is basically a test, which is determining the penetration.

How much the penetration is achieved by a given load on to that particular material is the California bearing ratio, basically is a standard one and the actual which is observed. Based on

that, that ratio is considered as the California bearing ratio. So, as this is the main criteria, let us understand this test, how this test is carried out?

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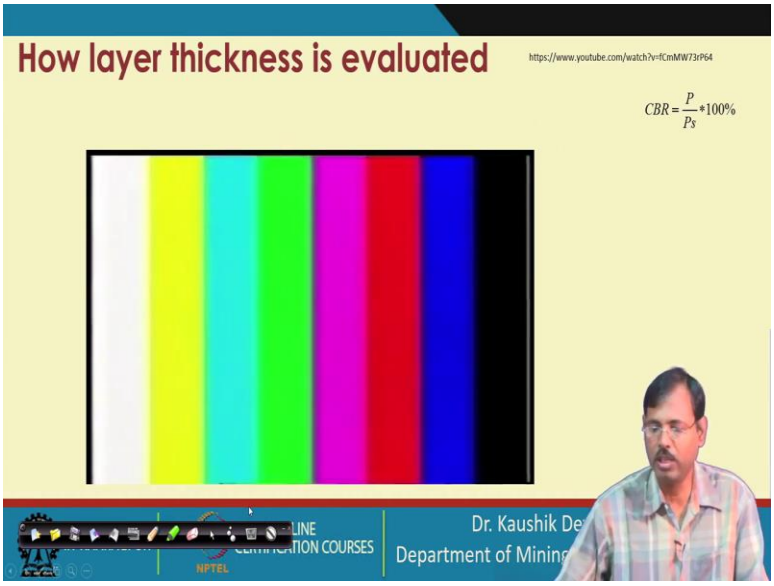

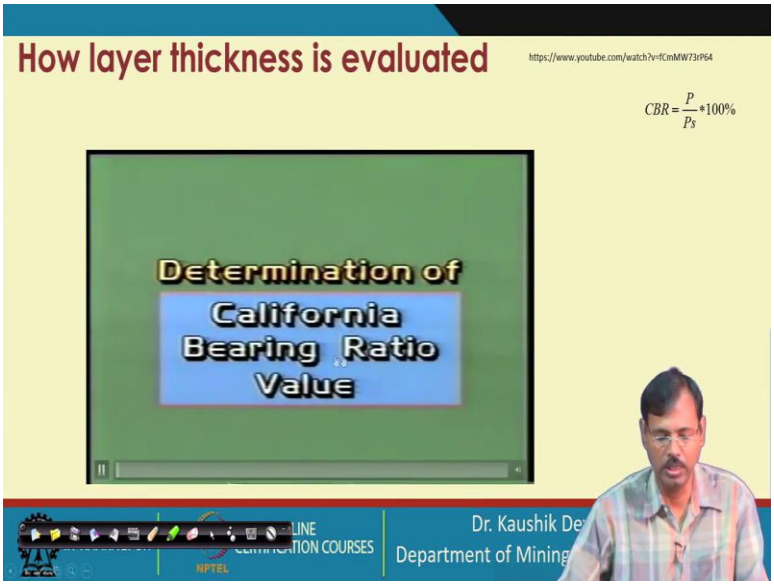

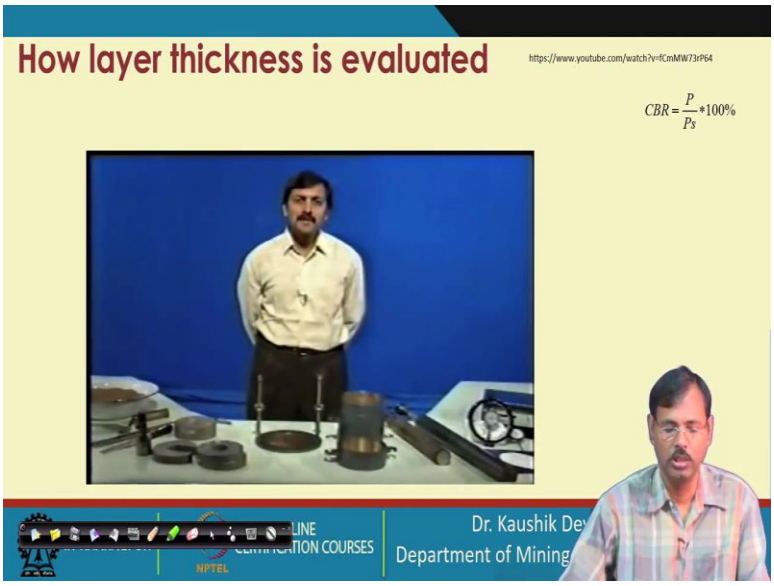

So, this test is available, this is the source, this is the source of this one. This is available in the YouTube. And this is basically the test of the material, which are used for making the embankment, for making the sub base or in mining case also, this is we have used the similar material as the base surface also. So, for those cases for these layers, we are basically considering what is the CBR.

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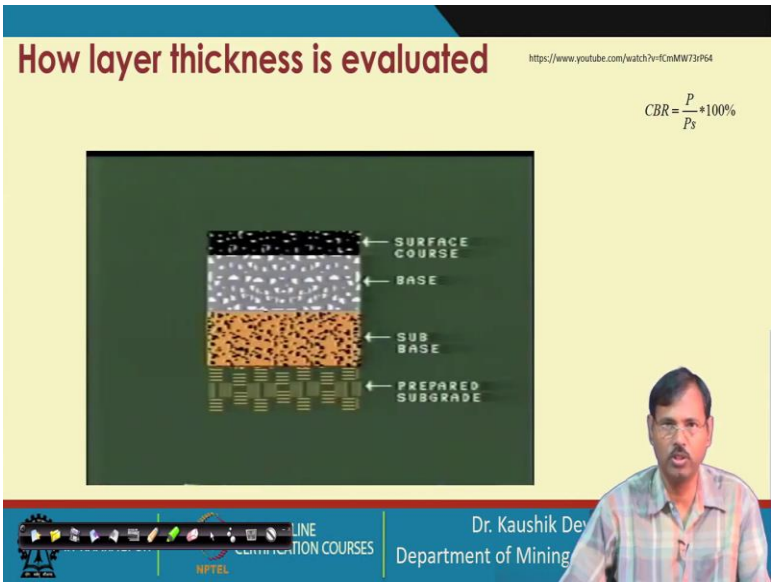

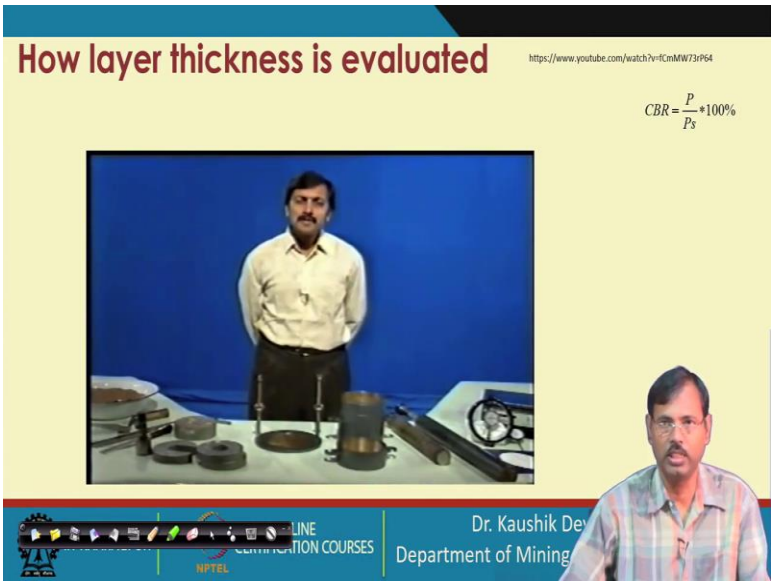

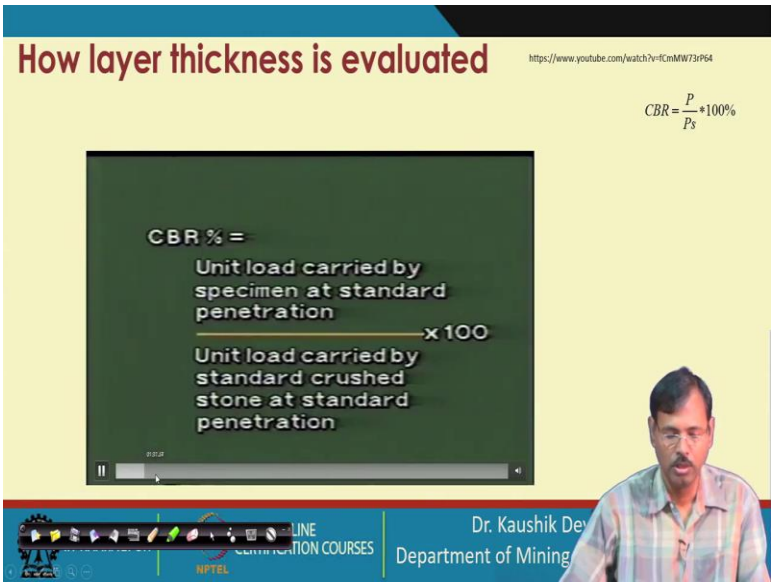

Or if you are doing all, for all the four cases you see, whatever these four layers are there, those materials are utilized in this testing to get the CBR value or CBR California Bearing ratio value. So, there are different standards, this is the formula.

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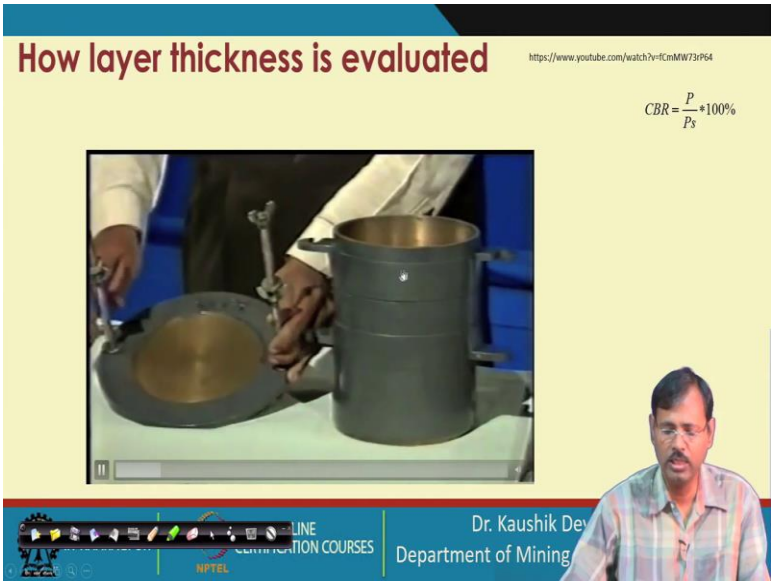

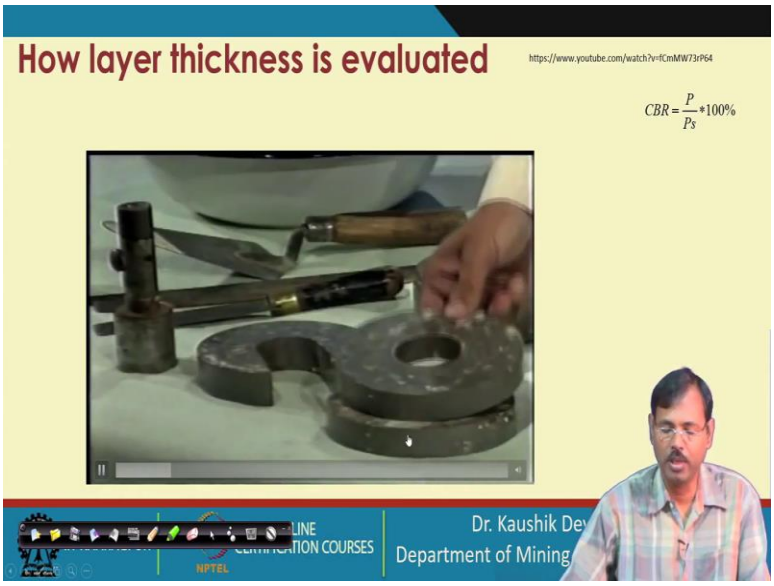

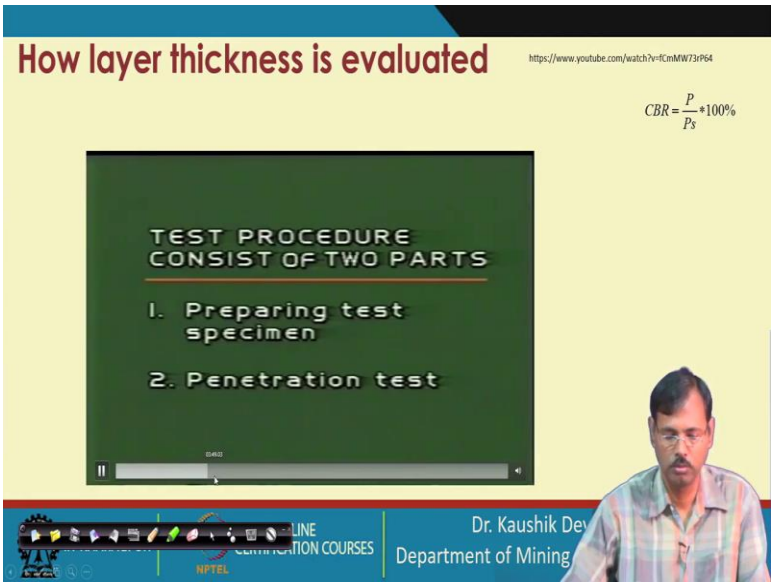

And this is the apparatus in which these specifications are given as per the IS code. These specifications are given, all these are basically shown in this video. And you have to basically place those materials in a wet condition. So, there is a desired level of moisture to be maintained. So, the material has to be mixed with the desired level of moisture. Then the material is placed in this. And after that, it is hammered with a hammering device.

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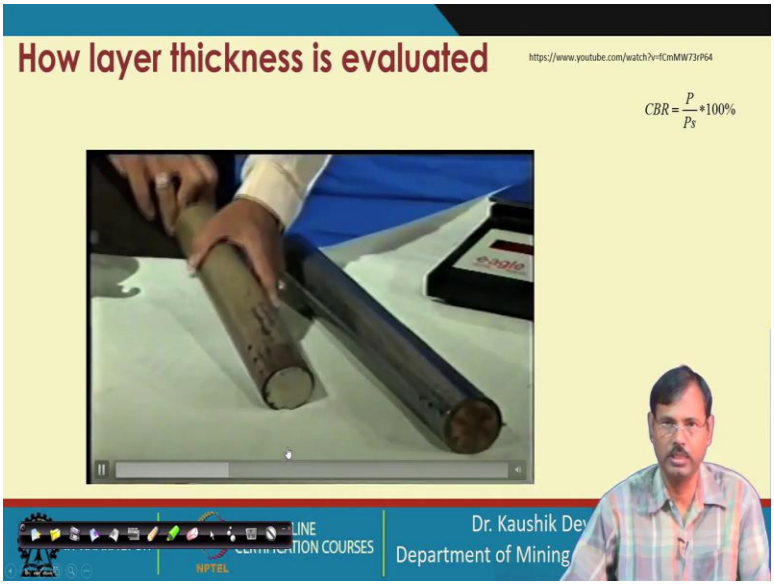

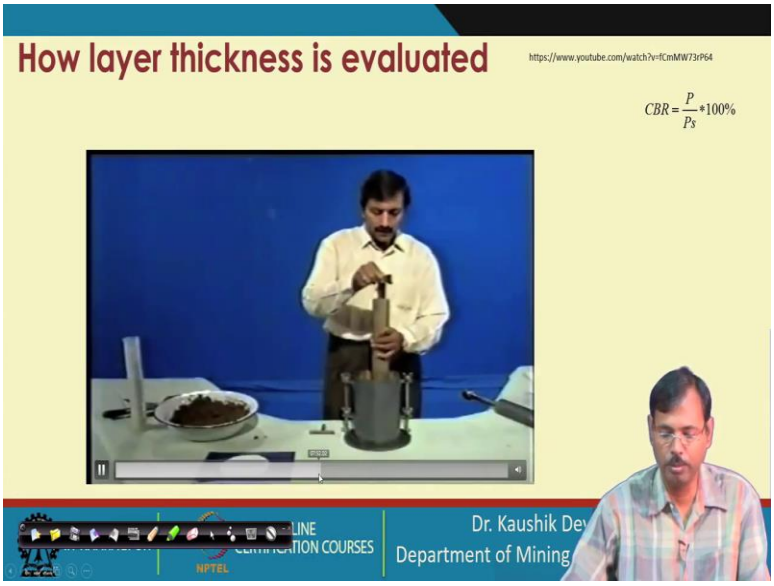

So, this is the hammering device, which is utilized to hammer the material. And this hammering is basically giving the similar compactness into the layers. So, that is basically giving the similar compactness. So, the compaction is given. So, this is the mixing of the material along with the water. Then the material is placed, then the material is hammered. So, there are different level of hammerings are available.

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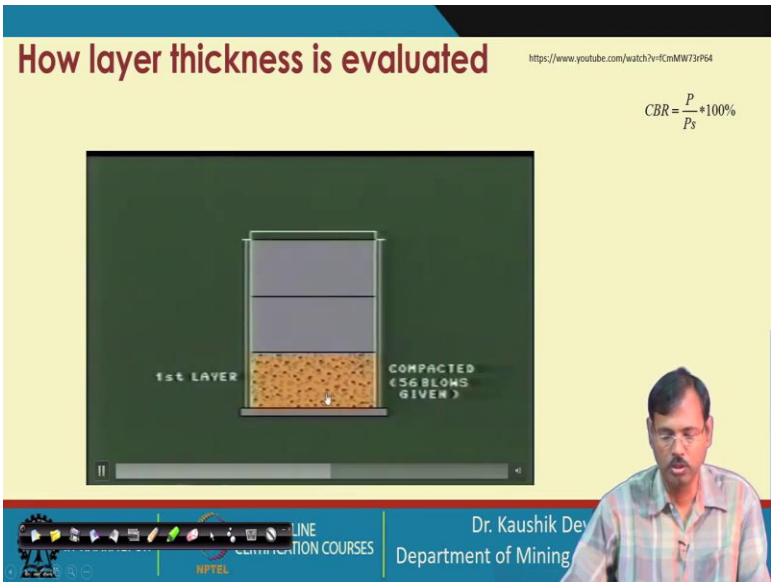

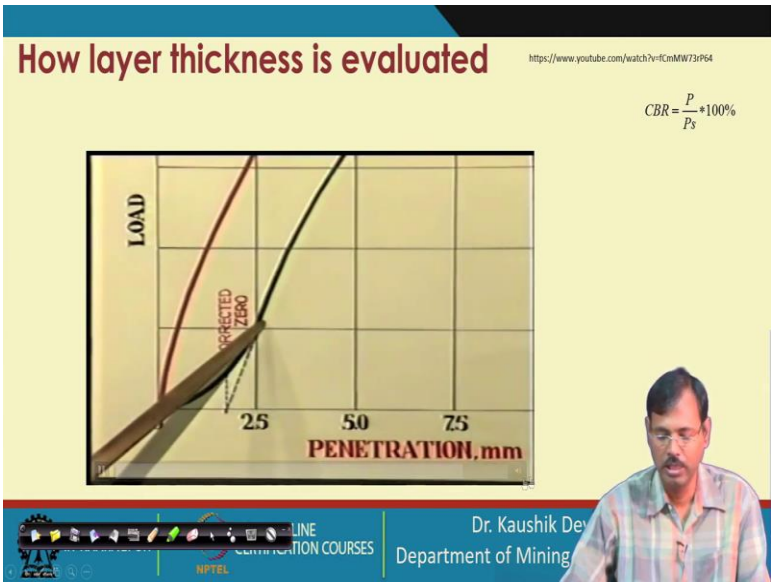

So, by these three layers are made. And after this compaction of the three layers, the material is subjected to a penetration plunger used for the penetration of this one. And the penetration load and penetration distance is measured. And then using this formula, we get this curve and from there we can find out what is the California bearing ratio. So, this is well explained in this video. You can see this video along with the audio in the YouTube.

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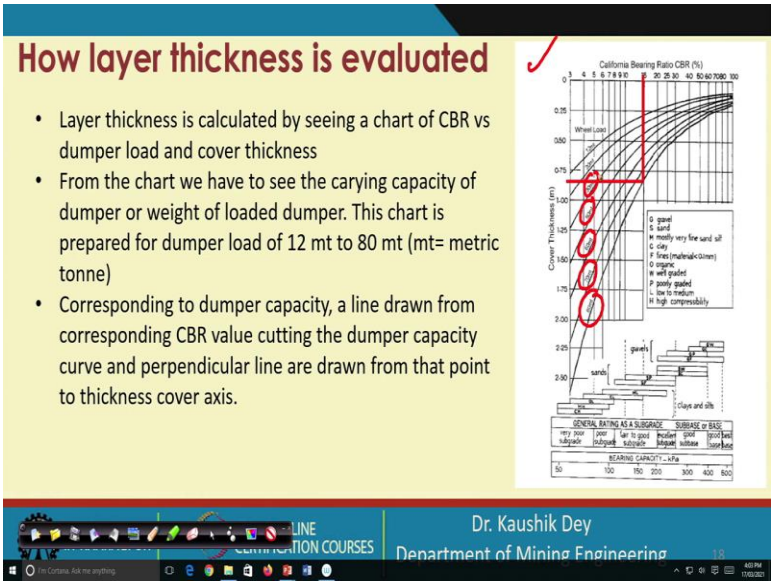

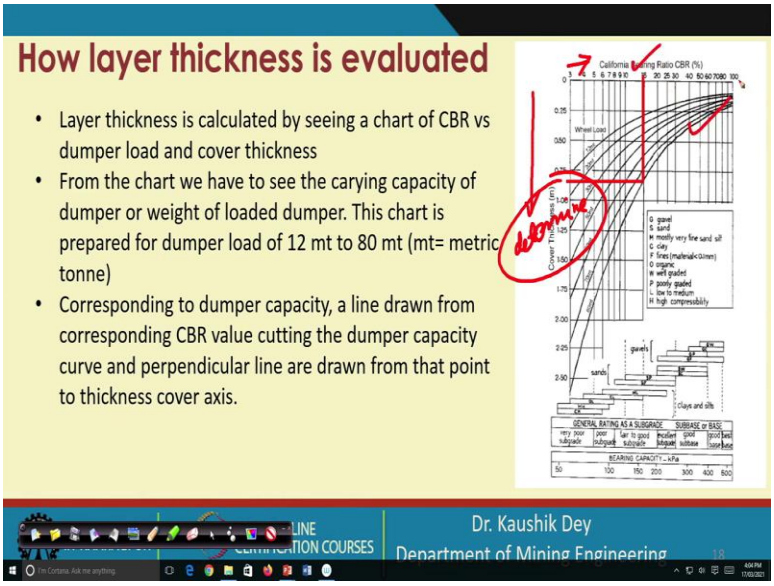

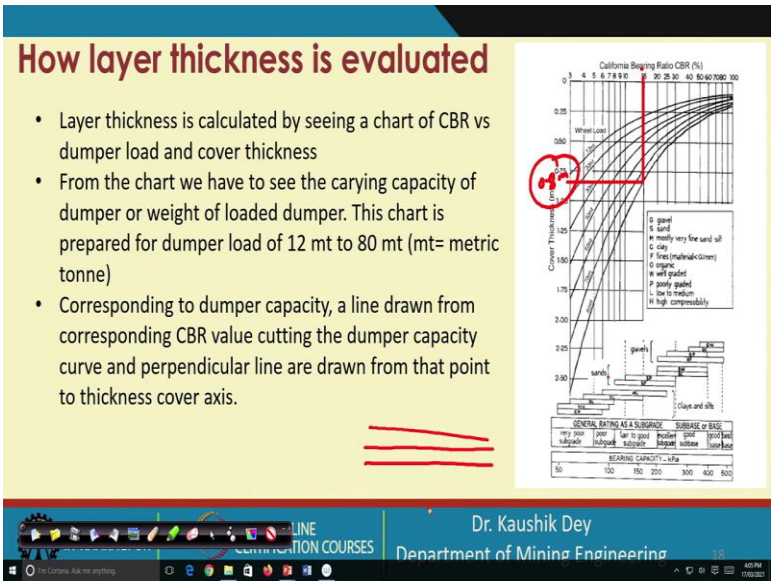

And basically, in CBR based method, a chart is provided here. And it can be seen, this chart is made depending on the load 70 ton, 60 ton, 50 ton, 30 ton. So, like these loads are given. So, these are the load curves. In this side, CBR values are given. And this side cover thickness needs to be determined. So, we have to find out the cover distance, distance from this chart based on the California bearing ratio and this load curve.

So, these are basically a guideline of CBR. The CBR values are in general found for these, these material say sand gravels for this generally, the CBR values are coming around 15. For sand it is around 6, say these are clays and soils. So, these are the different range of the CBR values. And accordingly, the bearing capacities are also expressed in this. But our job is to find out for say 80 tonner load, say for 80 ton load, if the CBR value is 15, then the layer thickness is considered to be as 0.8 meter.

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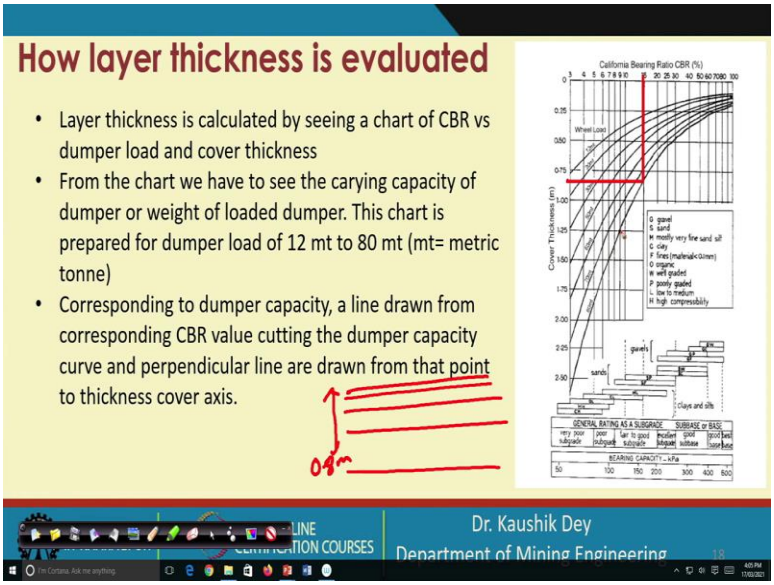

Now, this layer thickness 0.8 means what? This is actually the layer thickness from the surface top to this part. That means, 0.8 means for that particular material, that material must be placed at a depth of 0.8 meter not before that. If we are providing this material before that, then that material cannot withstand the load of 80 ton. So, that cannot be taken by that material. So, this is basically the consideration for this chart.

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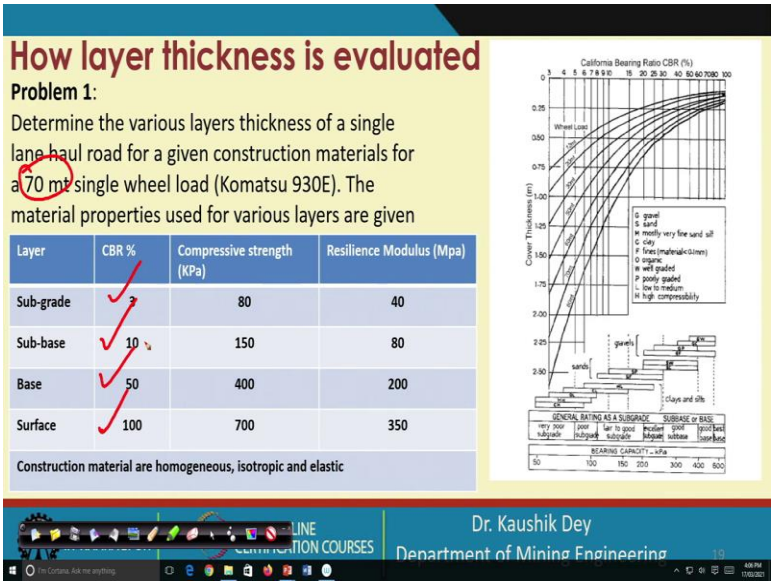

And so, that suppose we are using this one for this particular problem. The problem is that we have to find out for this truck and the material CBRs are given, subgrade 3, sub base 10, base 50,

surface 100. So, as we are considering surface 100, compressive strength, etc are given I think thickness is not determined in this slide. So, let us move to the next slide.

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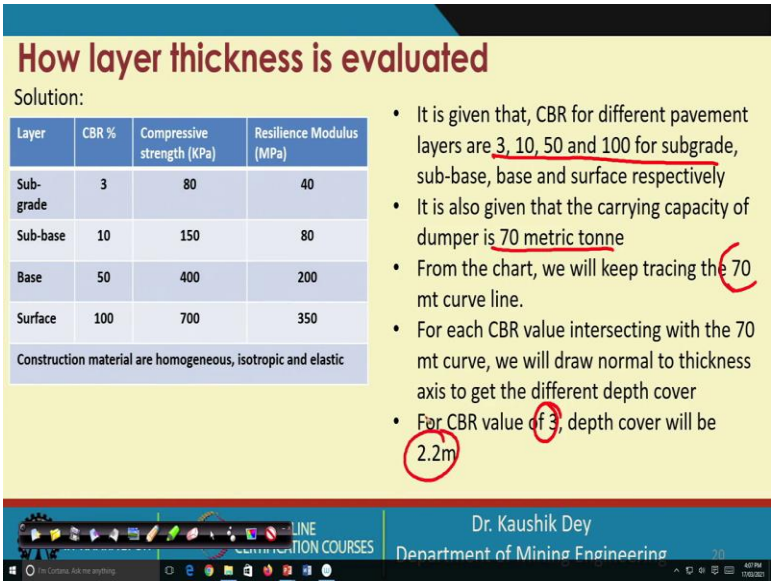

So, now, you can see it is given that the CBR values of the pavements are like this. And these are utilized as subgrade, sub base, base and surface. The load is 70 from the chart, we took this one. And based on that, the depth of cover for the first layer is found 2.2. So, this is basically tabulated in the next slide.

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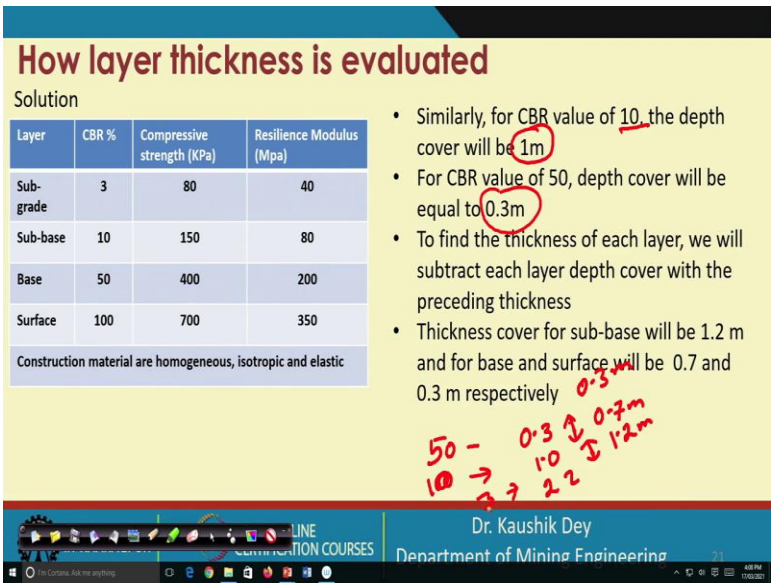

So, it can be seen for 10, the material cover thickness required is 1 meter. For 50, 0.3 meter and these are the cover thickness. So, for the CBR value of 50, we have found the cover thickness required is 0.3 meter. So, this material has to be placed at a depth of 0.3 meter. Then the next layer is 100, which has to be placed at 1.0 meter. So, that means, this this 50 layer should be provided of at least 0.7 meter layer, I must provide.

And above this 50 layer I must provide a 0.3 meter wearing surface layer, which will take the load directly of that one. And the 0.7 meter has to be placed here. And after that, we have to 2.2 meter cover is required for the, this is 10, for the CBR value of 3. So, that means this 10, CBR value of 10 this material which are used as the sub base, that material we have to provide a thickness of 1.2 meters. So, that is, then only this CBR material that having a CBR value of 3 that can withstand the load of the 70 ton truck to this.

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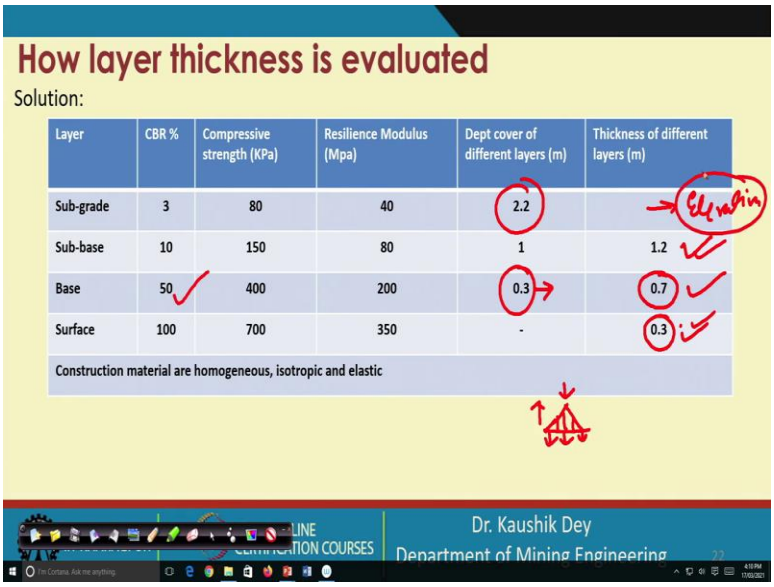

So, this can be seen now, we have to provide a surface cover of 0.3 meter. Then we have to provide a base cover of 0.7 meters. That means, there is, its thickness which can take the load of this one. So, this thickness is basically considered based on these. So, this, as this is the height, the load is if this is w this is distributed like this. So, the distributed load here, that load can be withstand by this material which is having a CBR value of 3, sorry, a CBR value of 50.

So, for this distribution, it needs to cover 0.3 meter which is placed at this. So, this is the concept, which is used in a CBR based design criteria. And based on this, it can be found that the

wearing surface thickness is this one, base thickness has to be provided 0.7 meter and sub base has to be provided 1.2 meter. And subgrade which is required at least 2.2 meter cover, thickness cover above it.

So, that has to be placed after that and the thickness of this subgrade layer depending on the elevation requirement. This is depending on the elevation requirement. And above that, to take the load this much depth of cover is required.

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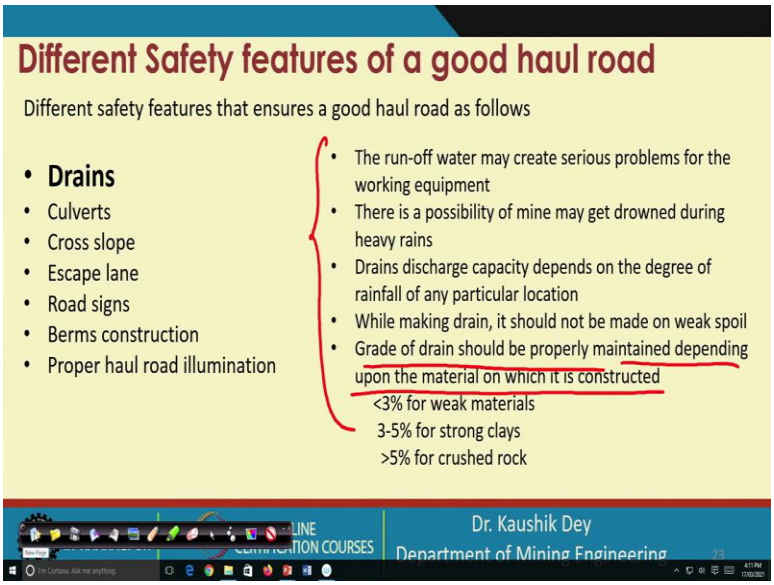

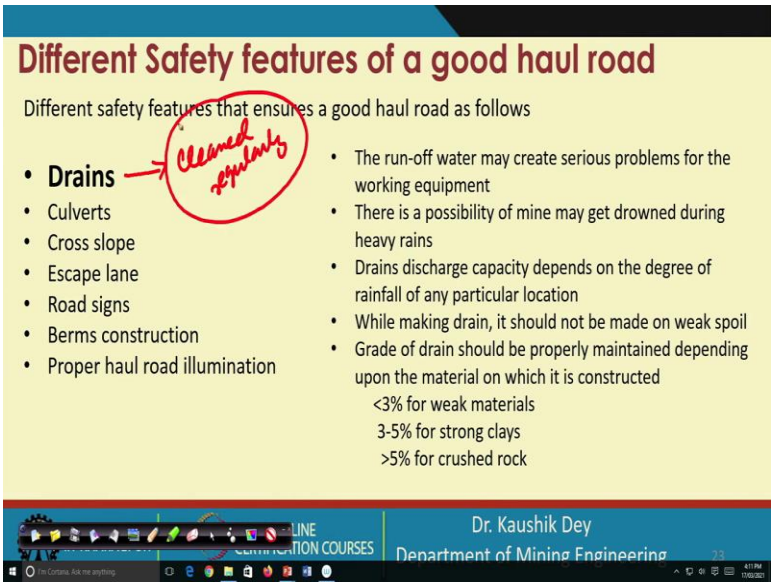

I think this is now clear to you. And these are some of the features which are required essentially for a haul road. The first feature is the drains, drains are essentially required to run off water which may create serious problem in the working as well as it, it will damage the haul road severely. And this is the grade of the drain should be kept depending on the material. And generally, these are the gradient kept, kept for the drains. But the regular requirement is that the drains needs to be cleaned regularly. In fact, only maintaining a good drain reduce the 30 percent of the maintenance cost of the haul road.

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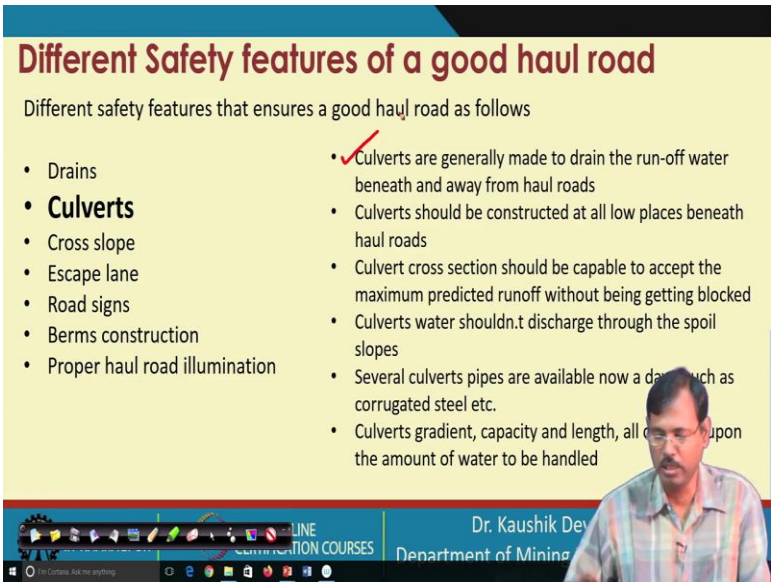

Culverts are generally made for passing the drains or drainage water. Basically, culverts are mostly made of concrete, and based on their, the design criteria have to be made. And generally, these are well maintained throughout the mine.

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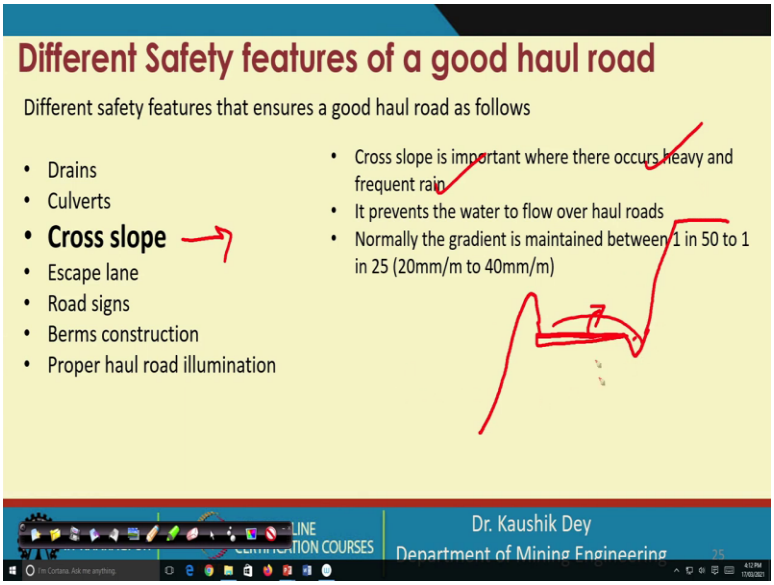

Cross slope is basically provided to give direct the water towards the drain. So, if this is the, then a little bit gradient, this gradient which is provided here. This gradient is basically considered as the cross slope. So, this cross slope is provided to guide the water where the frequent and heavy rain is there. So, it is allowed to throw the water towards the drain. And if any region, if drain is not there, then it has to be provided in the other direction. But that is not a good practice.

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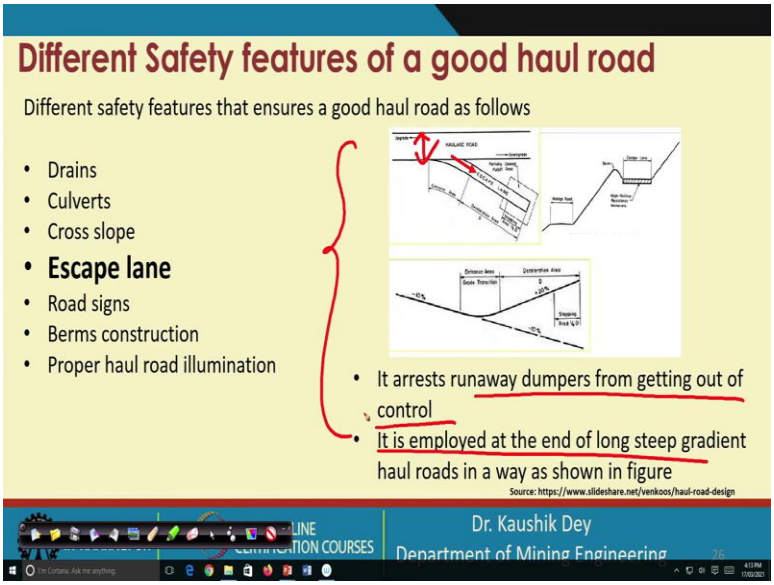

Escape lane is very important. If the proper width of the haul edge is not there, then there must be an escape lane through which the run away dumpers can be sent and controlled. So, this is a

very important one. Often you will find out in the railway stations also, this escape lanes are provided, which is basically allowing the movement of the runaway trains.

So, the similar way the escape lanes are also required where the uncontrolled dumpers are allowed to move and become, stagnant they are at this position. So, often this escape lane ends in some pit or in some places.

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Proper road signs are very important.

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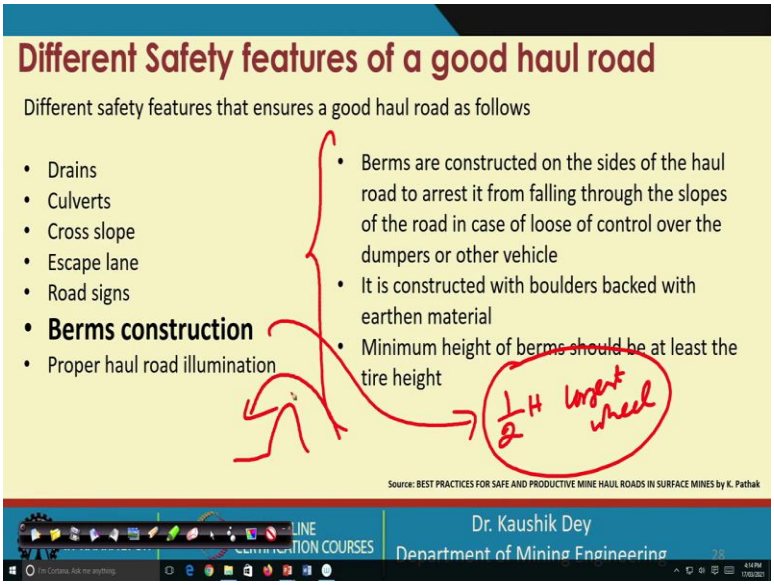

Berm construction is another important part. In fact, all the berms are should have a thickness of at least half height of the largest wheel, or diameter of the largest wheel. So, that must be provided so that dumpers cannot jump out from this berm to fall on a, from a height.

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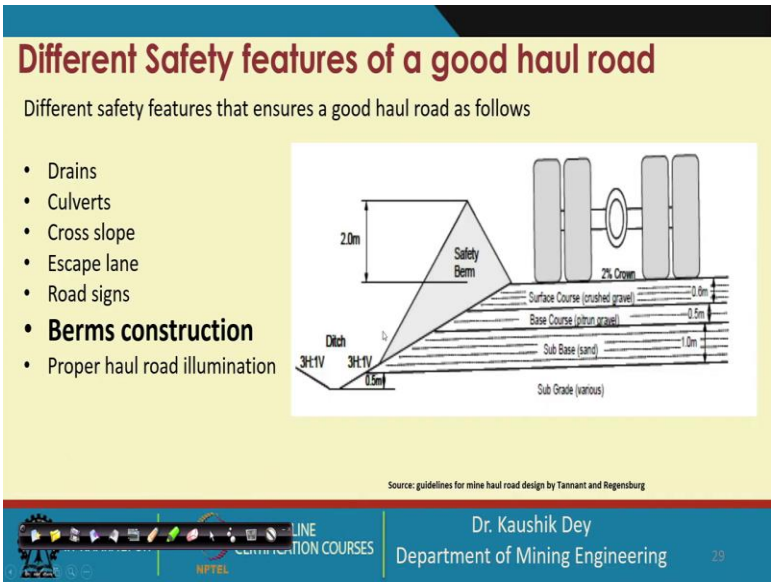

And final requirement is that this is the provided, the berm is provided here.

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And proper haul road illumination is required for the safety of the mine.

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And this illumination, the distance between two consecutive illuminations must be considered as per the result obtained from the illumination study. So, these are the some of the essential requirements in the haul road designing and construction. Thank you.