Drilling and Blasting Technology
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Lecture - 34
Blasting Results - 2

Let me welcome you to the 34th lecture of Drilling and Blasting Technology course. In this lecture we will continue our previous lecture of the previous class where we all discussing the Blasting Result and we have already discussed the blasting result up to fragmentation.

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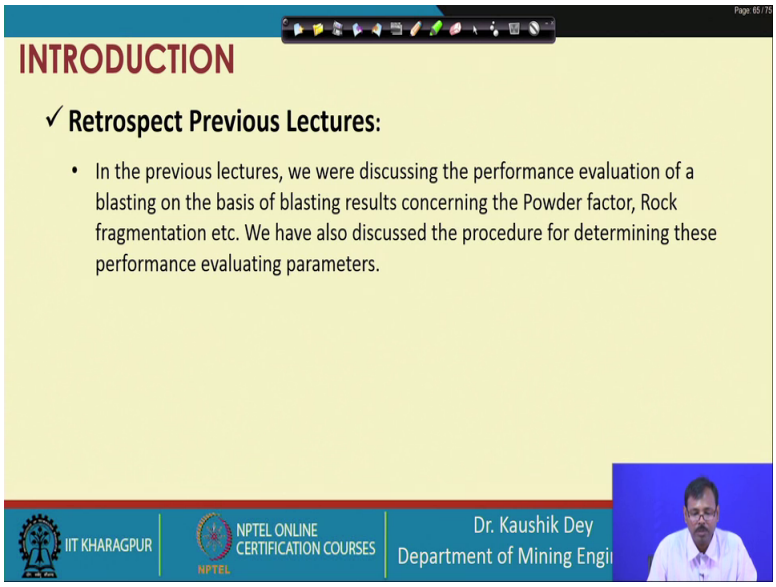

So, let us see the retrospect of our previous lecture. In the previous lectures, we are discussing the performance evolution process for blasting and this performance evaluation we have already covered powder factor and rock fragmentation.

So basically, we are discussing the procedure to determine this performance evaluating parameters and so far we have already discussed two main part; one is the Economic parameter that is powder factor second one is the main objective of the blasting which is nothing but the fragmentation. So, this two part we have already covered, so we will continue this with our next other parameters which are required.

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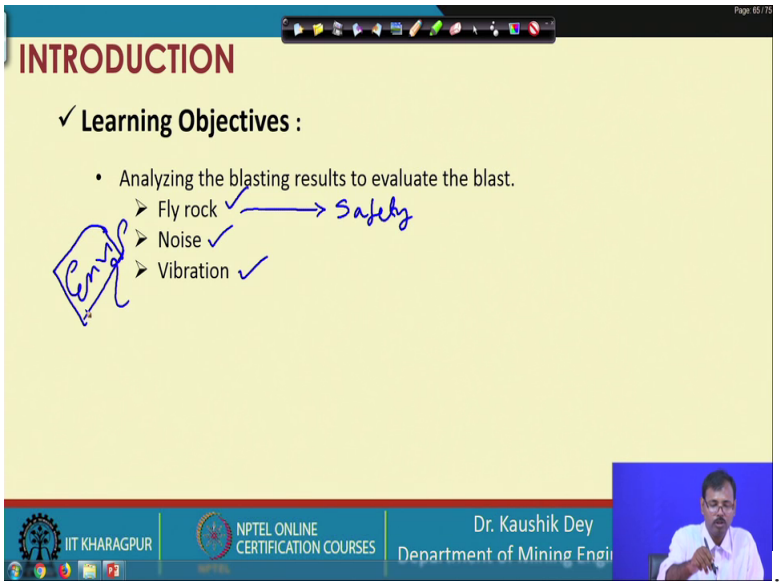

So, our learning objective is to analyze the blasting result to evaluate the blast and in this we will discuss in this class three parameter; one is Fly rock another is Noise another is Vibration.

So, last class we have already discussed fly rock is basically essentially required for the safety of the blasting process and these two are the environmental constraint environmental constraint essentially required essentially required to be addressed in the blasting process. So, this is our objective of this lecture and like every class let us observe a blast video so that in this video basically we will see how the fly rock may be generated.

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So, if you observe this video you will see the blasting is being; in this video you can see the blasting is being carried out and the rock are basically throwing at a higher speed to all the direction. You can see the rock is coming towards the camera coming towards the camera and now it is almost hitting the camera. So, these rocks are hitting the camera. So, basically this rocks which are generated from the blast is became air born coming to the trying towards the different directions and it may hit in this case it is hitting the camera it may hit any other any other thing also.

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Particularly I would like to show you this video this videos are available in YouTube. We will see here the blasting is carried out at a very far distance at a very longer distance despite that one or two boulders are coming towards the camera. You can see the blasting is carried out at a very large distance. Now see still now the rock is in the air bone you see this rock is now coming towards the camera, I would like to request you that you must see this video again so, that you can understand there may be one or two the overall blast may be good, the most of the rock may be inside the mine area or inside the blast vicinity of the blast.

But one or two fugitive rock pieces may be there, you can see the one or two fugitive rock pieces are became fly away from the palace and now hitting towards the area which in which may be cattles are there, may be human beings are there or may be some structures are there which may be struck by the fugitive rock piece.

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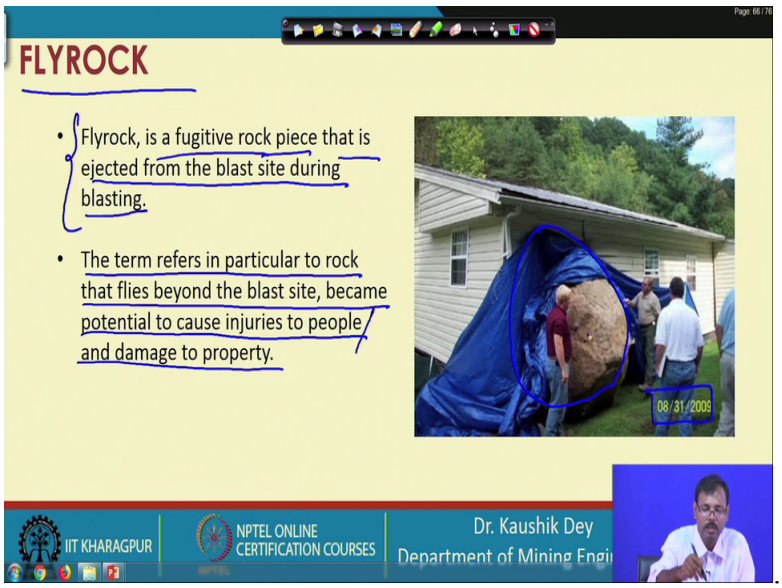

So, that is why this flying rock is basically creates danger. So, what is a fly rock? This is termed as a fly rock. The fly rock is basically a fugitive rock piece that is ejected from the blast side during the blasting. So, this is basically unwanted throwing of the rock and because of the uncontrolled execution of the blasting energy exclusive energy this happened and the rock may go a longer distance.

You can see here this size of very big boulder probably this is more than 5 meter 5 cube boulder that boulder has fly away from the mine side to the to this place, which may be a

residence or may be a may be an office and this is occurred in 31st august of 2009, this photograph is also available in the net from where it is taken.

So, you can see this type of cases are also possible. So, the term refers in particular to rock that flys behind the blast site become potential to cause injuries to people or the cattles or damage the property. So, in this case no injuries are there, but damage to the property is there. So, basically fly rock is very dangerous in nature and that is why a person or the blasting engineer must be very careful related to the fly rock issues.

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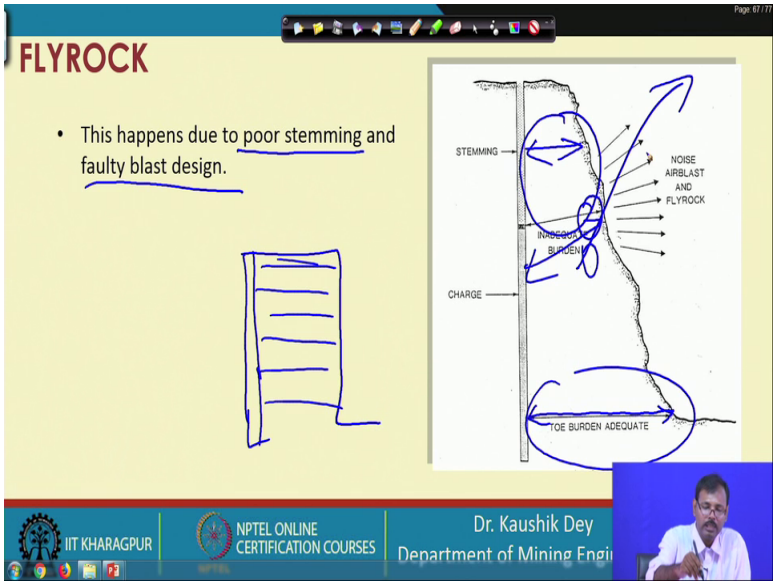

What is the main cause of fly rock? The fly rock is mainly happen because of the poor this stemming or may be the faulty blast design. You can see in this particular case the toe burden is adequate, but the burden in the top portion of the bench is not adequate, basically ideally we want a blasting bench must be very close to the perpendicular.

So, that there will be a consistency of the burden throughout the whole length that is essentially requirement for the designing the blast, but in this type of case the burden become in adequate in the top part and it is adequate in the bottom part. So, the design made in these cases the burden became in adequate. So, the fragmented rock may be thrown at a longer distance in this condition.

So, that is why proper burden proper blast design is very important to arrest the fly rock. In general there are different techniques popularly used in the blasting site to control the fly rock one is called muffling technique in muffling technique.

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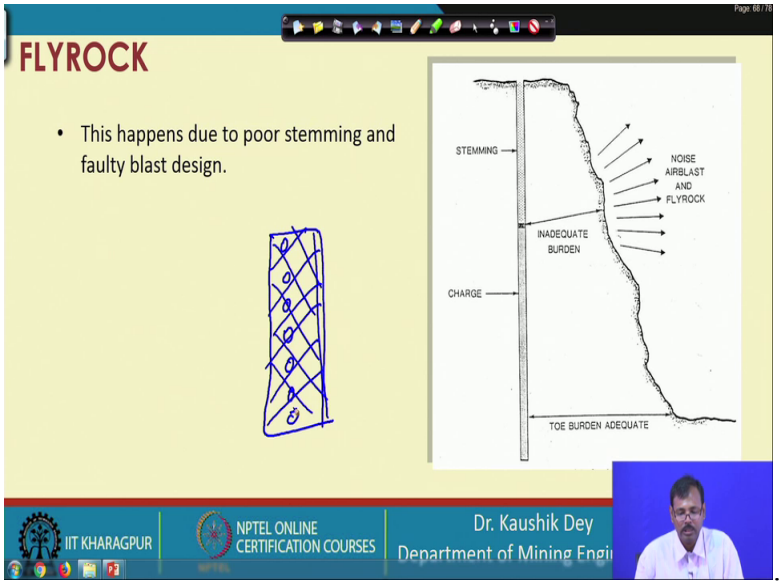

If these are the holes the holes are charged with a small amount of explosive and the top part is basically covered with some kind of clothing system or muffling system it may be a chain, it may be the belt conveyers or it may be some Teflon cloths something like that clothing system has been placed.

So, that the fly rock will not be generated in this case Be in fact, we control the charge quantity also significantly in this case. Another is very important.

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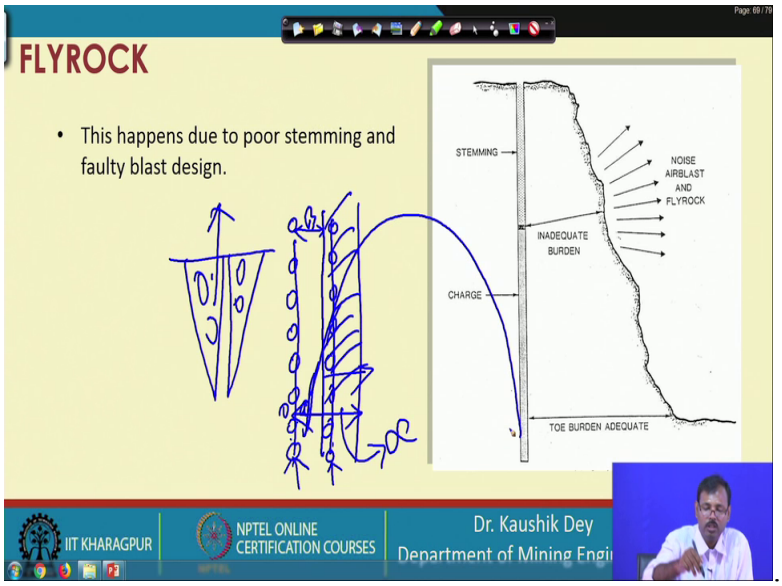

Often fly rock occurs often fly rock occurs because of the improper movement of the burden, in case of multi row blasting. So, what will happen as this row the first row is blasted a head of the second row? So, the second row is blasted a little bit later part and it is respected before the blasting of the second row, this portion of rock material must be blasted and moved in the front direction moved in the front direction So that it is considered that there is free face for the next row is at this position. So, this will act as the burden for the next row.

But if something happened that this row is not this portion of rock is not moved then, while the blasting is carried out at this position the burden consideration for this row is become this one which is very large and it may be considered in that case the burden is in finite. So, in those case the rock which are fragmented here may as the burden is infinite the rock fragmented here will try to charge will try to fragment the rock and throw the rock in the upward direction.

So, this holes will try to throw the rock in the upward direction and that is why it may come like this way in the upward direction and go a very longer distance it can travel a very long distance. So, these are the different possibilities where the fly rock may be generated and in those cases the precise delay use of precise delay where scattering is not there we have already discussed the scattering is not there may be very advantages gives

us the better results. So, that is why this is very important for the controlling of the fly rock in blasting.

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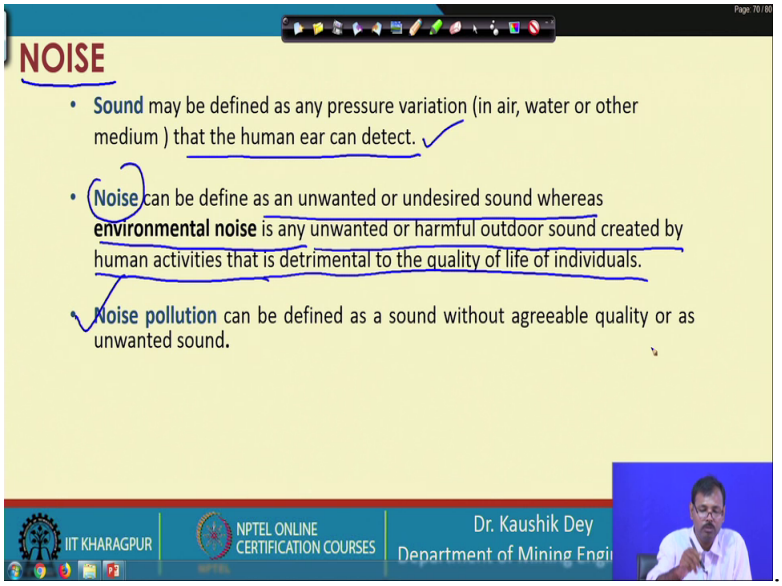

So, our next parameter which is essentially required to be a monitored to be measured is noise. So, before going into the details of this let us understand, what is noise. Sound may be defined as any pressure variation that the human ear can detect. So, that we call sound which basically happened in air, water or any other medium. So, it basically nothing it is nothing, but a mechanical wave which create a vibration or the create a pressure in the air and that is detected by our human ear.

Noise is basically defined as an unwanted sound whereas, environmental noise is any wanted or harmful outdoor sound created by the human activities that is detrimental to the quality of the life of individual. So, what is happened this is that noise it may be not always that it is basically effecting our ears or our hearing ability it may affect us mentally also that those annoying noise may create the announce in the human brain and may mentally disturb a person. So, that is why noise is very disturbing and that is why one must be very carefully about the noise which are generated by the human activities.

So, basically noise pollution can be defined as a sound without agreeable quality or as unwanted sound that is called noise pollution. So, let us understand some basic about the noise measurement techniques also.

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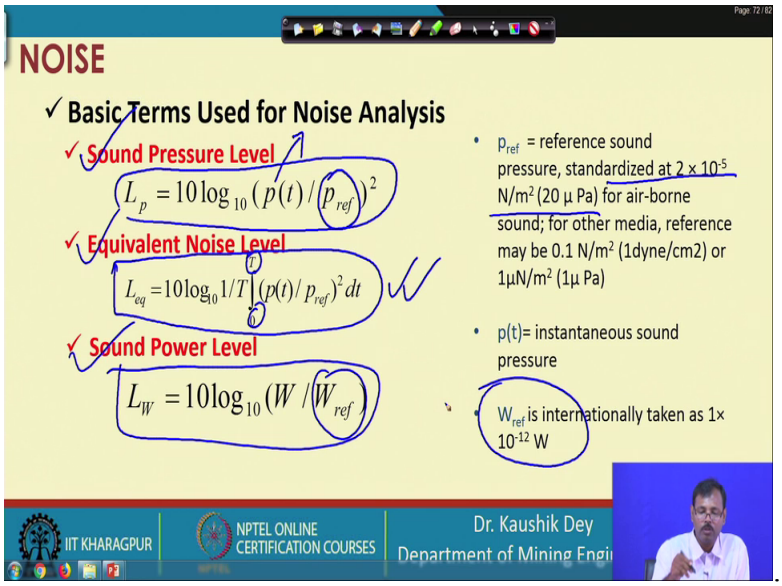

Noise is basically measured in three terms; Sound Pressure Level, Equivalent Noise Level and also Sound Pressure Level for if it is converted in the power sound power level. So, the sound pressure level may be defined as this formula, where the pressure is a compared with a reference pressure and the reference pressure is standardize as this one or you can consider it as 20 mu Pascal as for the air borne sound.

So, it is in a logarithmic scale the sound pressure level which is measured at present condition referring to that to the reference condition, how much pressure level is absorbed that is called sound pressure level. The equivalent noise level is nothing, but the monitoring of the sound pressure level for a prior of 0 to T then integrating that with the same scale we can get the equivalent noise pressure noise level.

So, this basically we convert our sound pressure level which is instantaneous in nature, we convert that into a time span and get the equivalent noise level for a particular time period. The sound power level is considered as this one where the power reference power again in the reference power scale is considered as 10 to the power minus 12 watts. So, these are the basic of the sound while we discuss about the noise for the blasting we should understand this.

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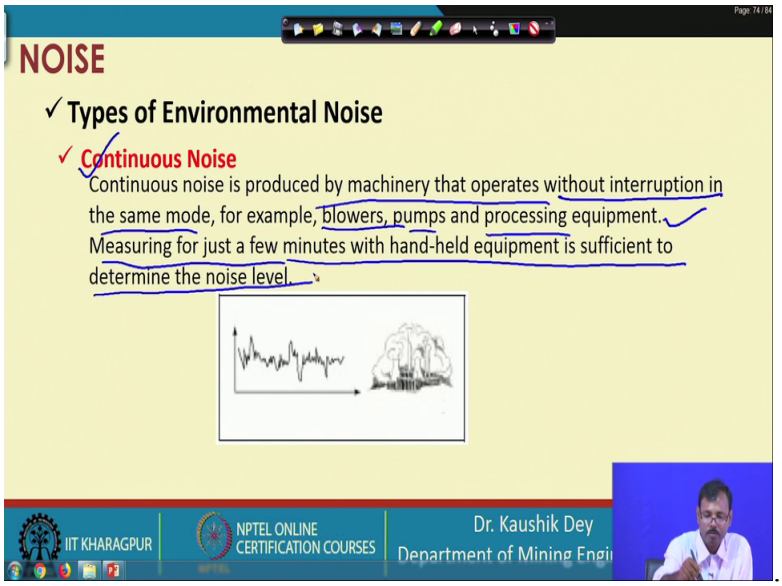

Basically noise can be categorized in three categories one is the Continuous Noise continuous noise means; this is the noise which is produced continuously from machinery or any other any other thing, which is moving without interaction in the same mode say like blower, pump or may be the compressor, may be the motor that is moving there is the rotering system, that is moving and creating the vibration creating the noise and basically it is creating a continuous noise. Continuous noise may be measured for a few minutes with handled equipment and that is sufficiently gives us the idea about the noise levels.

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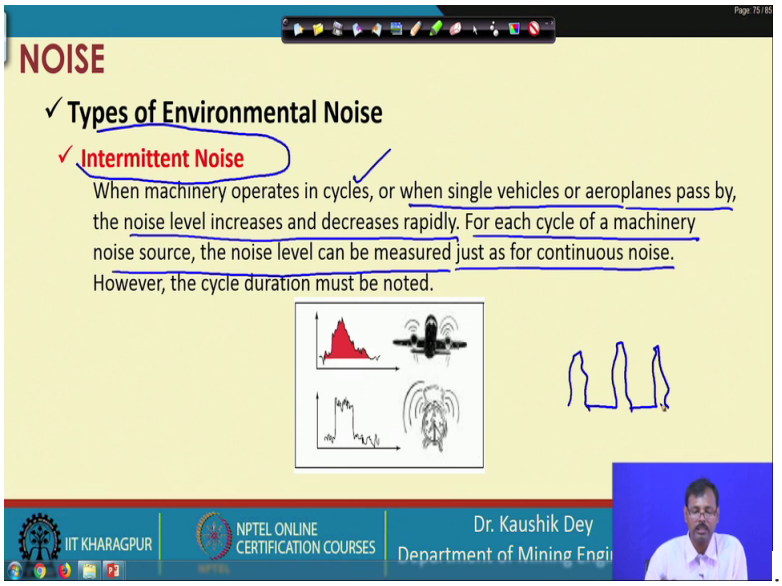

Noise can also be categorized as the intermittent noise, intermittent means it is basically repetitive in nature. So, when machinery operates in cycle say like eccentric motors those are operates in cycles and when single vehicles or aeroplanes passing by the noise level increases and decreases rapidly, for each cycle of a machinery noise source the noise source can be measured just as for continuous noise. So, basically these are the cycle operation.

So, once the cycle is there then there may be some stop then another cycle is there similar cycle then another cycle may be there. So, like that way noises are generated in cyclic order that is called Intermitted Noise; however, our blasting does not come into any this type these two type of noise.

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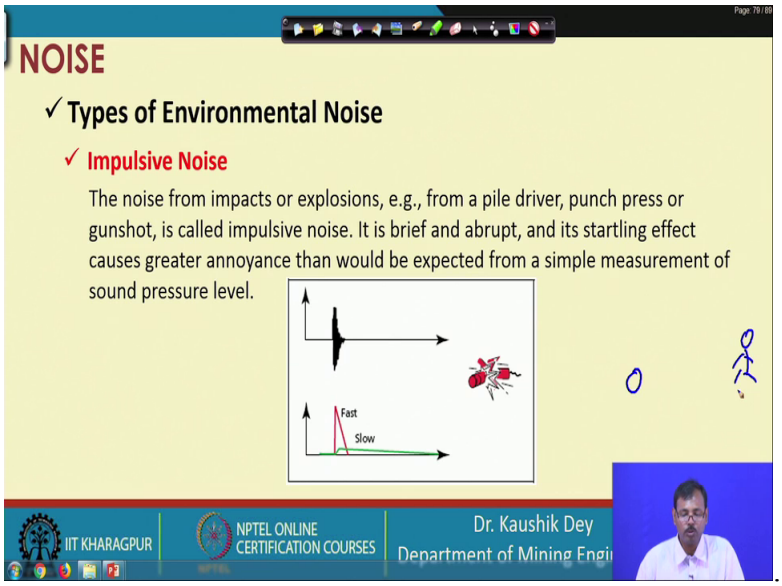

The third type of noise is called Impulsive Noise, where a sudden sound is generated and then that basically damp.

So, this is called impulsive noise when a noise is generated a sound is generated suddenly then it is also stopped. So, hammering may be one such type of noise impact noise explosive may be one type such type of noise which is generated suddenly and also damp immediately following the generation of the sound. So, that is why blasting comes under this impulsive noise and generally we measure it in the similar technique measure the other sounds.

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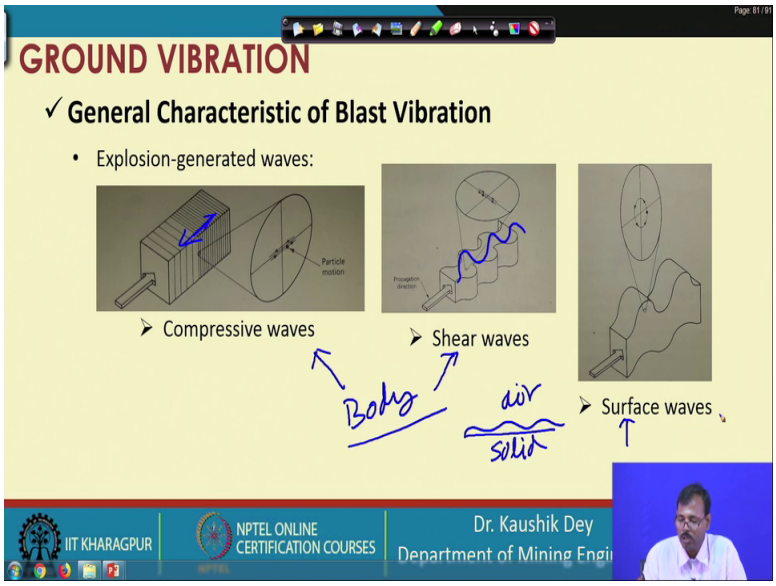

So, basically noise is not that much significant in blasting unless and until there is a nearby residence. So, if nearby residence in blasting generally the noise levels as it is impulsive suddenly it is generated the physical effect is not that much problematic, but the problem in noise is that; the if nearby residence is there then the people who are living who are living close to that area they feel that the noise as noise is generated very high; that means, very high amount of explosives are being exploded or huge amount of explosives are being exploded that may damage their belongings or damage their buildings.

So, human annoyance or human resistance towards the mining operation blasting operation excavation operation may arises if the noises are going to the nearby residence. So, that is why it is always unwanted it is always unwanted that noises should be generated and people may hesitate against the activities. So, basically that is the main cause and that is why has the main source of noise is deteriorating fuse the it is advised that noel must be used as the surface connection and remove the deteriorating fuse as the surface connection so that the generation of the noise from the blasting may be reduce at the significant level.

So, that is why this is very important. The next important parameter is the Ground Vibration. In fact, this parameter is very important and we always consider this ground vibration is not only an environmental issue, but also this is a stethoscope to the blasting

engineer and one must go for measuring blast vibration for each and every blast. what is ground vibration, which is coming from the blasting basically this is the explosion generated waves mechanical wave that is travelling through the ground, if the blasting is carried out at this position then the shock waves are generated from the blasting and the shock wave is travelling through the rock medium in all the direction.

So, as the shock wave is travelling through the ground in all the direction, the material at this position oscillates along with the propagation of the shock wave and you can consider this is resembled similar to the case where you drop a stone on the pond and the waves are created in the water of the pond, as the waves are moving if there is a small leaf on the top of the water the leaf is also oscillates at the wave is propagating through the water.

So, this is the same case whatever there in the rock medium whatever there in the above the ground that oscillates with the propagation of the shock wave. So, that is why the ground vibration, impact of ground vibration, annoyance of the ground vibration is very high and that is why in blasting one must be very carefully about this ground vibration.

This wave propagation through the ground basically classifies in three way, it is basically classifies in two way; first one is the Body wave body wave means, which travel through the solid media, this is basically characterized in two way one is the Compressive wave another is the Shear wave. So, compressive wave moves on compression and dilation, shear wave compression and dilution shear wave moves like this in shearing motion will see the animation of this propagation.

So, that is why there propagations are different and they moved through the medium rock through the rock medium through the solid medium, but when this waves reaches on the surface this converts into the surface wave. So, this surface wave is basically moves along the along the contact area contact portion of the two medium, where it is a solid medium that is rock medium this is an air medium.

So, those waves are called Surface Wave. So, basically it is Body wave and Surface wave and body wave categorized in two cases; pressure wave and shear wave and there are n number of surface waves.

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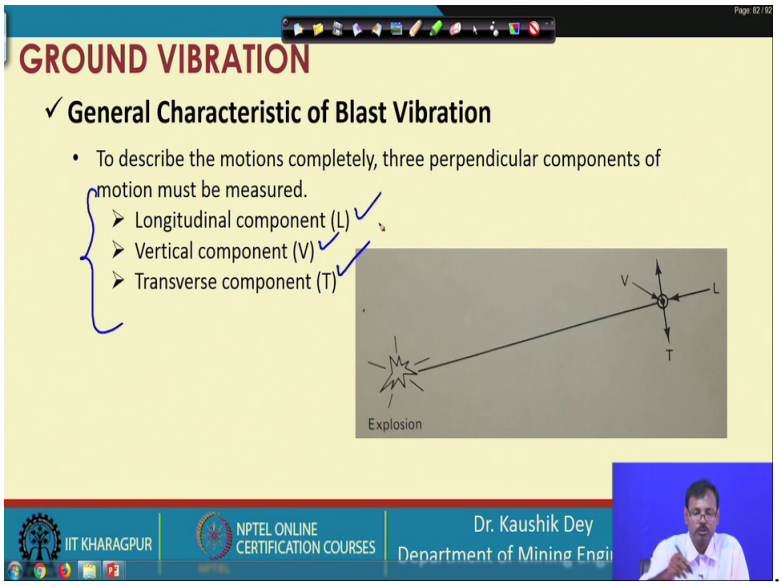

Basically, we consider or we measure the ground vibration in three dimension, one is longitudinal, another is vertical, another is transverse and by getting their vector sum we find out what is the actual magnitude of the vibration.

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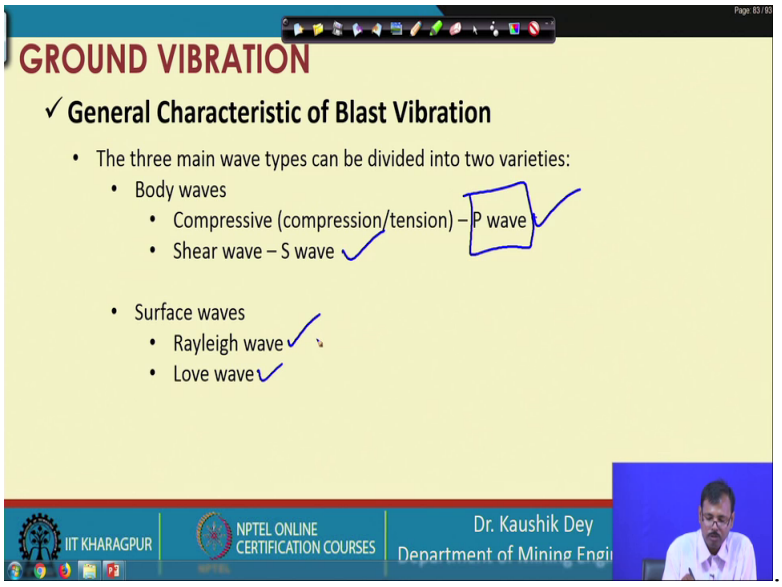

So, let us come back to the body wave again. So, body wave is basically compressive wave, which is called as P wave, shear wave is called as S wave there are n number of surfaces, but the measure one is the Rayleigh wave sometimes we observe the Love wave among this if we carry out vibration monitoring in the blasting, basically we

observe only the P wave the because the vibrations are measured close to the proximity and almost simultaneous occurrence of P and S wave occurs there.

And Rayleigh waves S waves are also coming at around similar way and their magnitude also very less, that is why we basically measure the p wave while we are carry out or measurement in the blasting.

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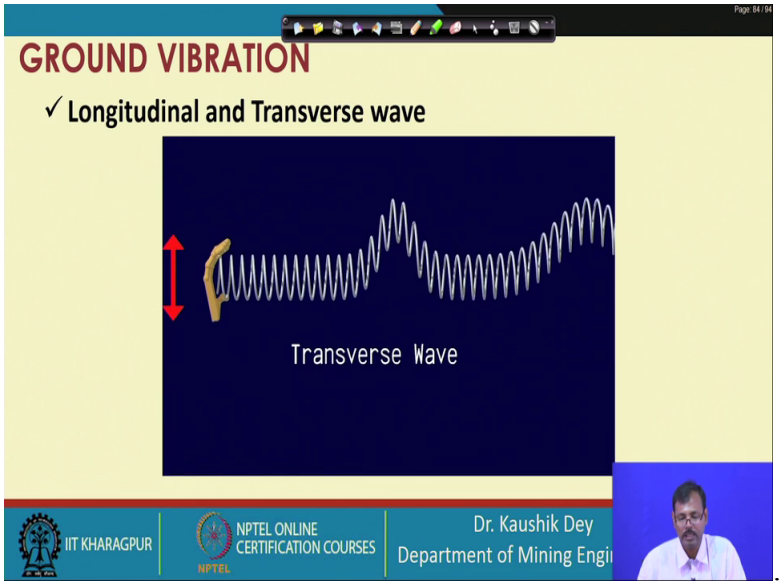

So, now let us see how the longitudinal wave or the pressure wave moves in the moves in the medium you can see this is the compression this side it is the compression and this side it is the dilution. So, now, you see the S wave propagation see this is the S wave which is basically shearing the medium. So, basically in compressive wave the volume of the medium is being changed, but the volume of the medium in compressive wave the volume of the medium is being changed, but the shape of the medium does not change.

Whereas, in the transverse wave or in the shear wave the shape remain same, you can see; the shape remain same sorry volume remains same, but the shape is changed in the transverse wave.

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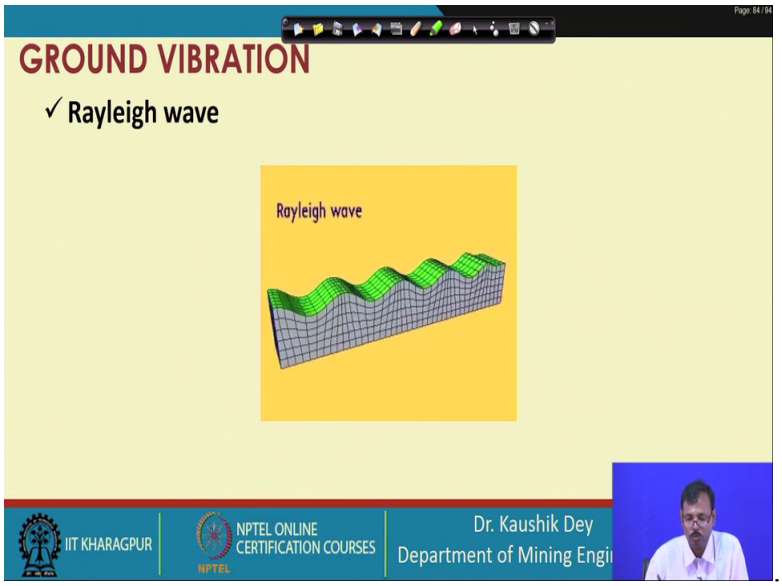

So, let us see how the Rayleigh wave moves, which is the surface wave. So, this is the movement of the Rayleigh wave which is almost in a you can say this is almost in elliptical motion you can again see this is almost in a elliptical motion you can again see this is almost in a elliptical motion, you can see this is the elliptical motion, which is through which it is being moved.

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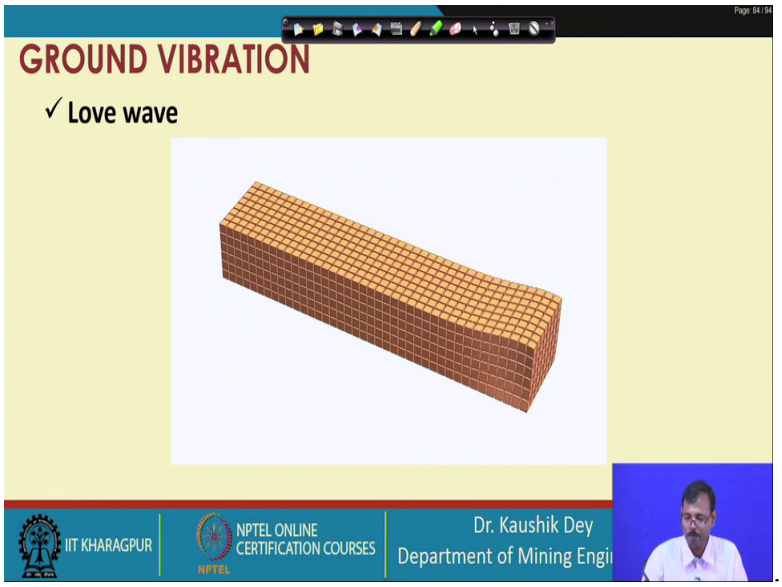

And this is the Love wave for our own understanding let us see which is very similar to the shear wave propagation, but in a horizontal direction not in the vertical direction.

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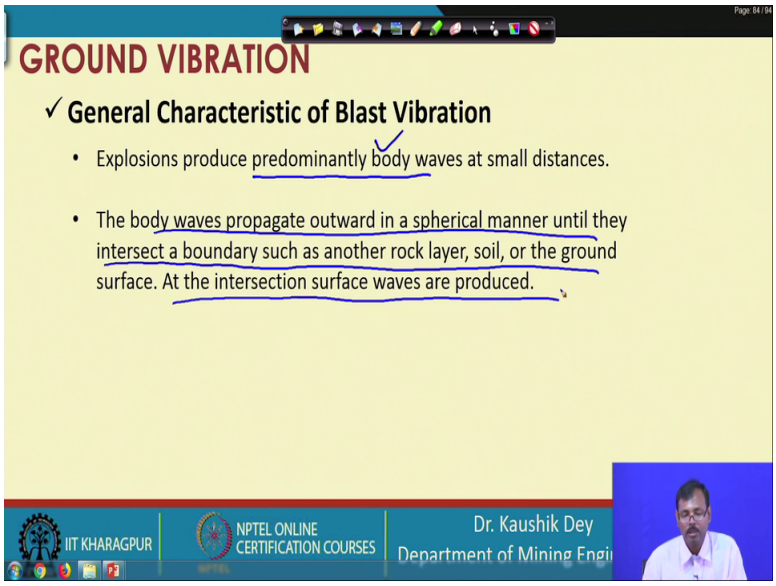

So, basically explosion produces predominantly body wave or in other way it is predominantly the P wave and it travels up to a smaller distance, body wave propagates outward in a spherical manner in all the direction until they intersect a boundary such as another rock layers soil etcetera and in the intersection surface waves are produced. So, that is the main characteristics how the surface waves are produced and the effect of surface waves are very nominal in the blasting.

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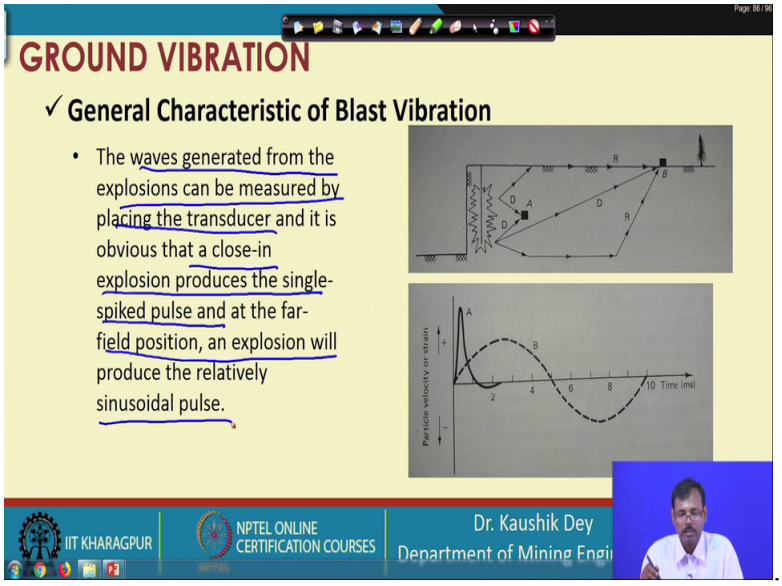

So, you can see the waves generated from the explosion can be measured by placing a transducer, which we have discussed which measure in LVT at this that is the close in explosion producers a single spiked pulse, at far field it is almost sinusoidal pulse.

So, in far field if you are measuring it is the sinusoidal wave formation and if it is measured in the close then it is a triangle or you can say a single spike pulse.

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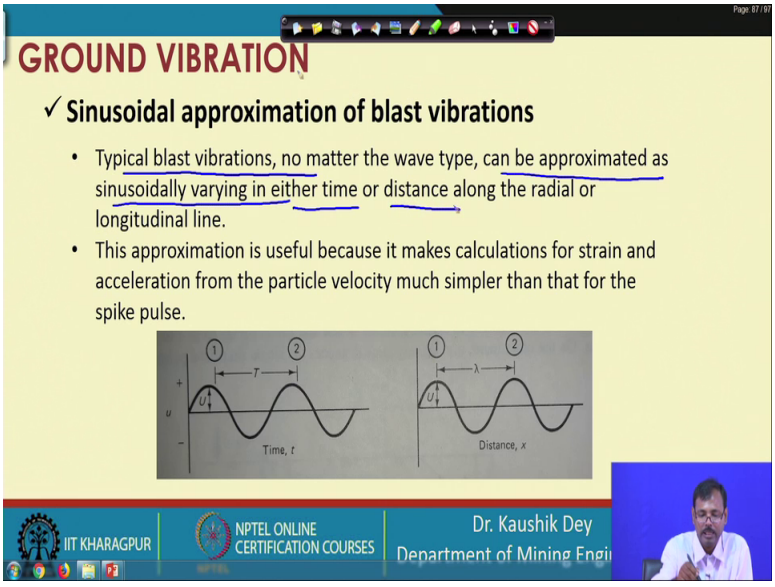

So, Typical blast vibration can be approximated as sinusoidal wave which is varying with time and distance and therefore,.

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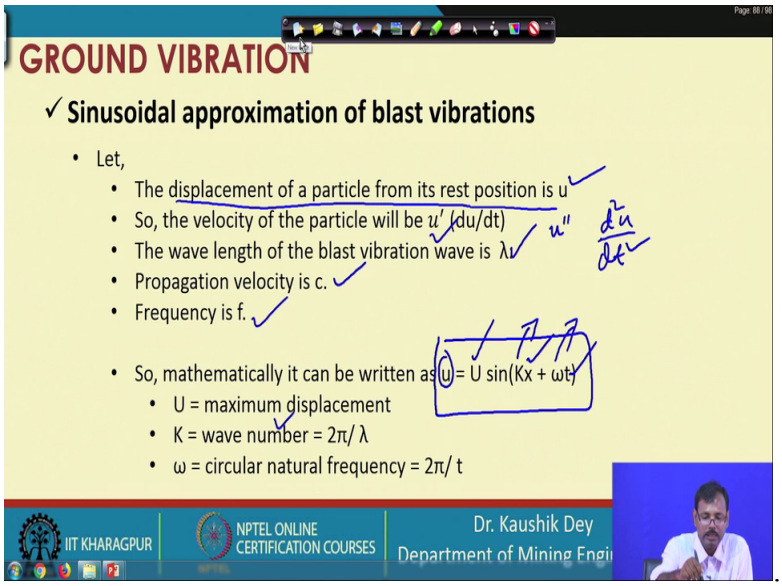

Therefore we go for sinusoidal approximation of the blast vibration and let us consider displacement of a particle from its rest position is u then the velocity is du by dt acceleration is d 2 u by dt square consider the wave length is lambda, propagations velocity is c and frequency is f. Then the sinusoidal approximation o f the blast wave can be considered as u displacement at a particular x and t where U is the maximum displacement then the sign of the Kx, K is a constant called wave number, omega is the circular natural frequency of the medium, t is the time, x is the distance from the source.

So, by this equation any time we can define the state or the displacement of the medium at the because of the propagation of the sinusoidal waves generated from the blasting.

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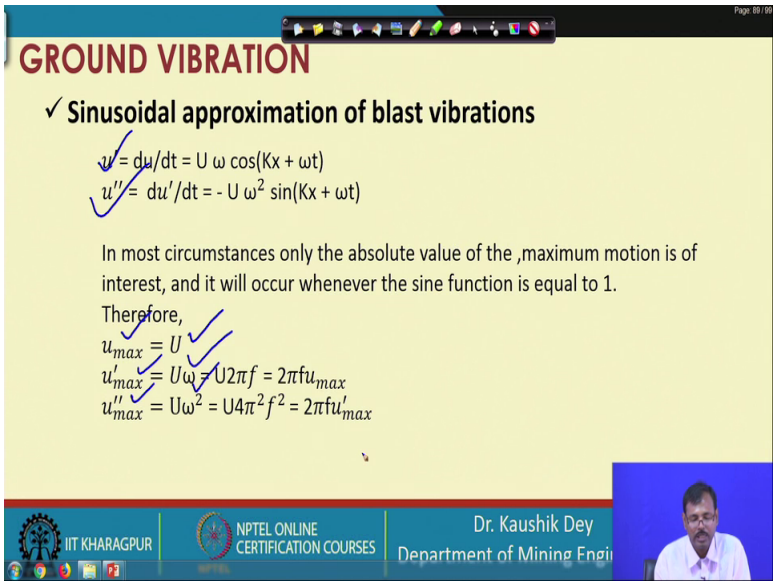

So, we can get by differentiating that we can get the velocity, we can get the acceleration. So, by using replacing that U what you have observed you can say u max maximum u max is U, maximum velocity is U omega, maximum acceleration is U omega square, where omega is the circular natural frequency of the medium.

So, these are basically the different approximation of the Sinusoidal approximation of the blast vibration.

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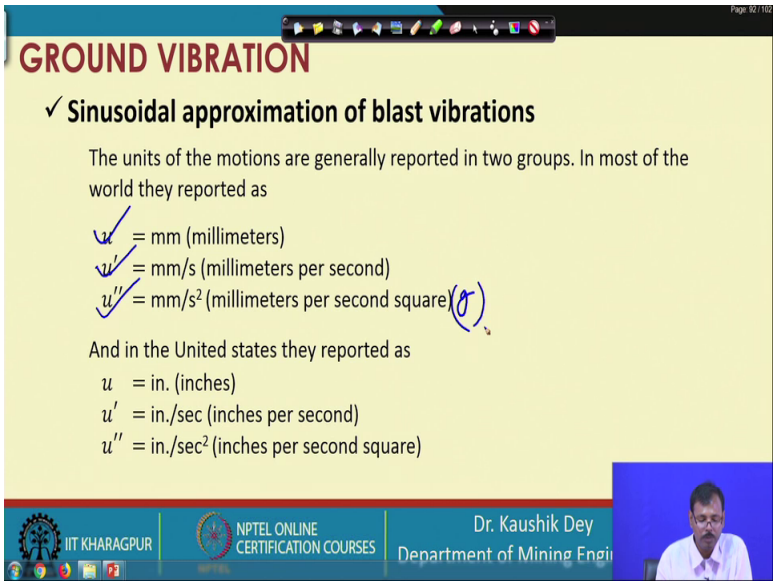

And in general we measure u in millimeter, u dot in millimeter per second and u double dot or acceleration in millimeter per second square which we often express it in terms of g that is the component of the gravitational acceleration.

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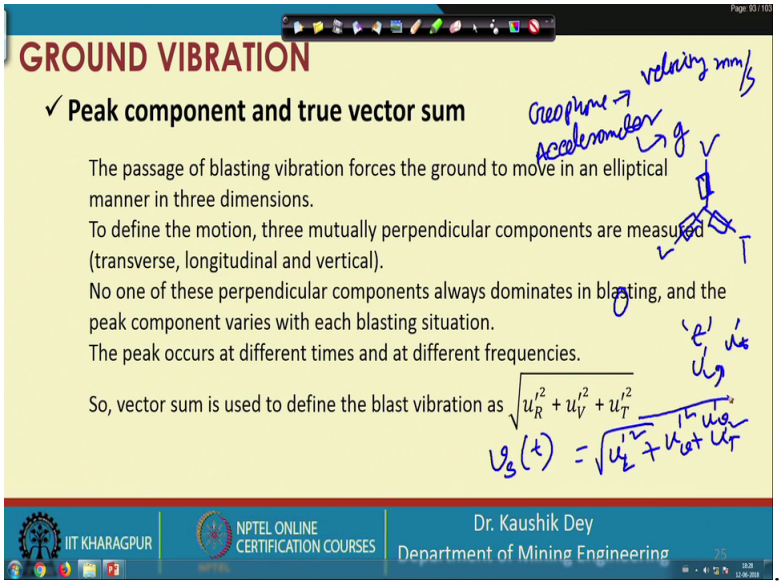

And generally we use two different types of transducers; one is Geophone based Geophone based another is Piezoelectric based. In geophone it is electromagnetic another is piezoelectric based which basically we call accelerometer and we measure in geophone velocity and explicit as millimeter per second and in accelerometer we measure the acceleration in terms of g. And as we have discussed we measure the velocity in three mutually perpendicular component L V T, L is the longitudinal direction which is basically directing towards the source that is the blast point explosive where explosive is placed, transverse is the horizontal perpendicular distance of the longitudinal and vertical is the vertical perpendicular direction of the longitudinal.

So, basically we provide three transducers in this three direction and we get the component of vibration in the each individual transducers. So, for any particular time frame t if we are having value at longitudinal is ul sorry u dot l velocity in transverse u dot t and in vertical u dot v, then we can get the vector sum of that vector sum of that vibration at that particular t that is the vector sum at time t is nothing but the u dot l square plus u dot v square plus u dot t square under root.

So, this is the way we go for the determining the vector sum of the vibration and in general peak component is considered as the vector sum expressed as the vector sum. In fact, there are two methods we follow here, either it is the peak of an individual channel or it is the vector sum of the three channel which is peak maximum, we consider that one as the maximum vibration.

So, basically these are the different criteria we consider the vibration which is being generated from a blast and let us stop our discussion for this class of ground vibration here. We will continue with the blasting result in the next class also and it is expected that you will read more on the noise, ground vibration and fly rock. Especially I want to recommend a book written by Dr. P Paul Roy there is a book written by Jimeno Atol, you can go for more reading from these books.

Thank you.