Soil and Water Conservation Engineering
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Lecture - 48
Wind Erosion and Control Basics

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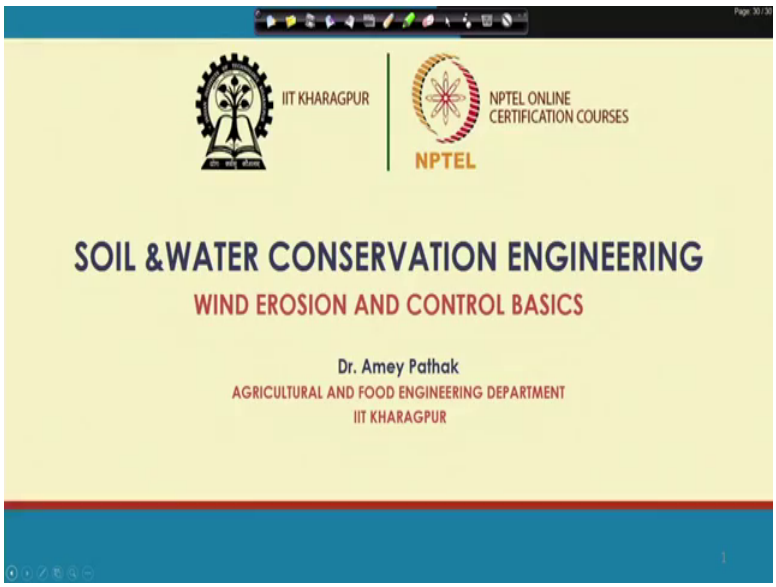

Hello friends, I welcome you all in this week-11 of this NPTEL online course on subject Soil and Water Conservation Engineering. So, my name is Amey Pathak. And in this module we will be understanding the we will be understanding and studying the wind erosion, and what are the different measures to control wind erosion ok. So, let us start this class ok.

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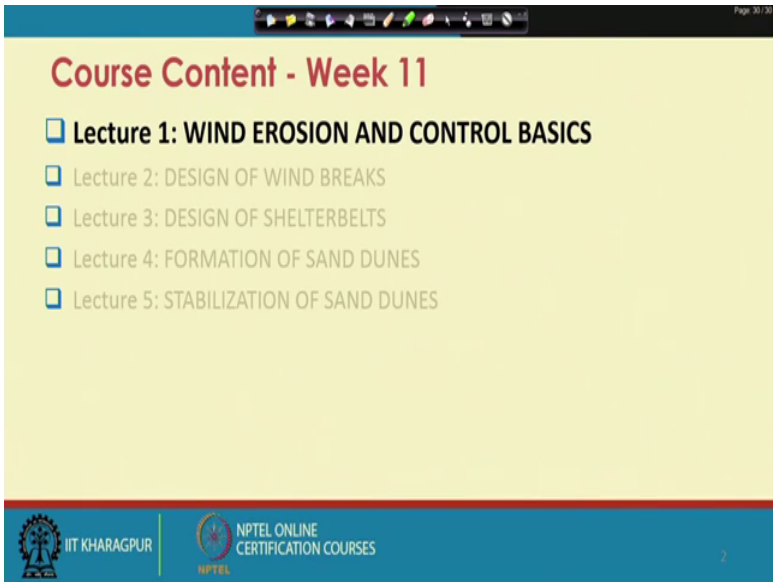

So, in this module of week 11, so as I said we will be studying wind erosion and different measures to control the wind erosion. So, this module is divided into 5 lectures. So, we will be covering 5 lectures. So, first lecture that is today's lecture it will be on wind erosion and its control basics.

Similarly, on the second lecture it will be on designing of windbreak, then desired designing of shelter belts; lecture 4 will be on formation of sand dunes; and lecture 5 will be on stabilization of sand dunes ok.

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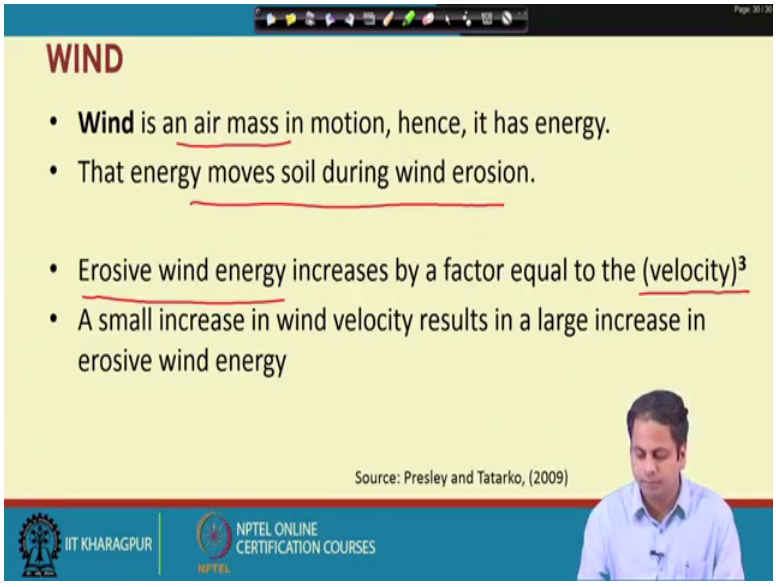

So, let us see ok. So, before going further before understanding wind erosion, we need to understand what is wind ok. So, wind is nothing but it is an air mass ok. So, wind is wind is nothing but it is a air which has some mass and which has some velocity ok. So, because since, this air has some mass and velocity, it acquires some kind of energy ok. And this energy moves the soil during the process of wind erosion ok.

So, we can see this erosiveness of wind or we can say erosive wind energy, it increases by a factor equal to velocity cube ok. So, it means a small increase in wind velocity can results into larger increase in wind erosive energy ok. So, it is of this erosiveness of wind is increases by a factor equal to velocity cube.

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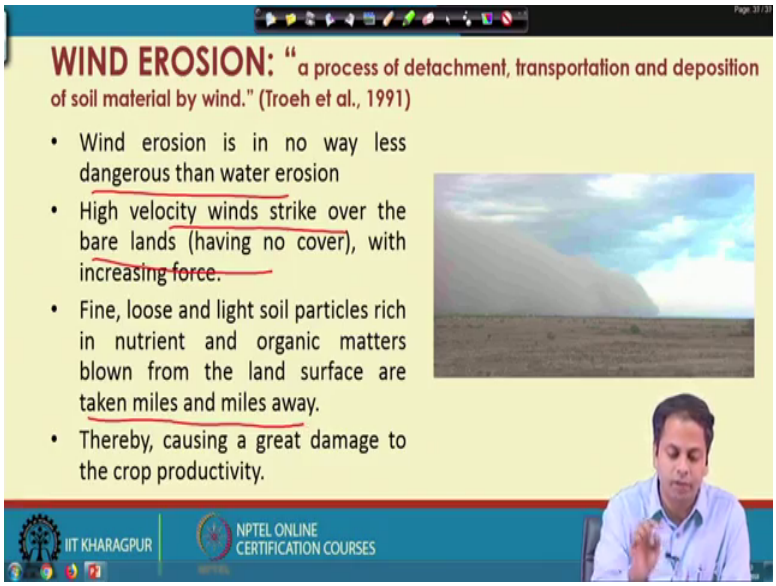

So, now let us see what is wind erosion ok. So, wind erosion it is a process.

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So the definition of wind erosion. So, it is a process of detachment transportation and deposition of soil material by the wind. So, it is a combination of three steps, first the detachment of lose or fined grains soil particle from the surface, then the transportation of the soil particles from one place to another place and the deposition to a place which is far away from the place where the process of detachment has started ok.

So, in that sense wind erosion is actually is very dangerous and you can say comparative to water erosion also it is similar. So, wind erosion is no way less dangerous than the water erosion. So, what happens when the high velocity wind when it strikes over the bare lands with increasing force.

So, what happens then? So with the wind with very high velocity when its strike over the bare land, so let us say when there is no vegetation cover or the soil surface is compiled completely smooth and baron then in that case the finer particles or fine, loose, on you can see light soil particles that are actually rich in nutrients or which make the soil more fertile they are actually being lifted by this wind and they are being transported to miles and miles away.

So, in that sense so wind erosion actually is responsible for causing great damage to crop productivity, because the most fertile layer is getting transported or is being eroded by the wind ok. So, in that sense the wind erosion is very dangerous.

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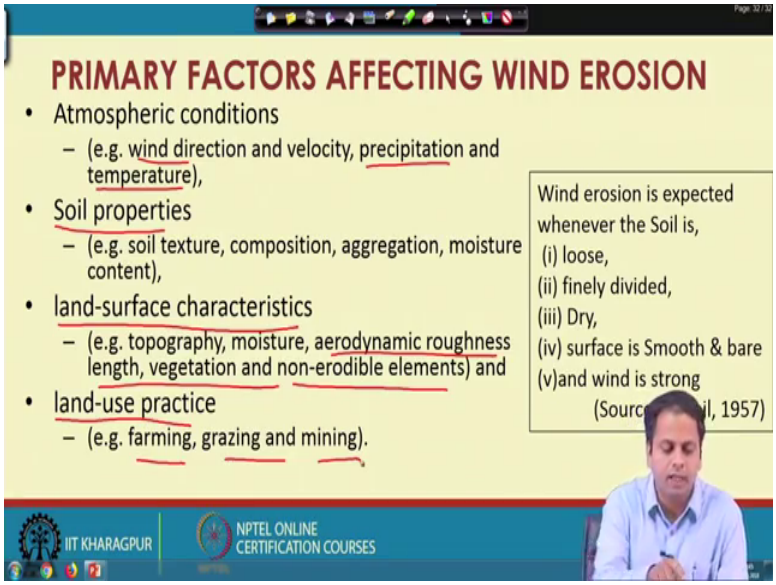

So, if you see the there are different factors that affect the wind erosions. We can group this factors into a different categories ok. So, loosely if we can say there are two things first the factors that influence the climate over that regions and factors that affect that affects the soil surface or that define the soil or the surface parameters ok.

So, we can say the climatic variables so most of the time we know whatever overall what are the climate variable. So, like wind over a region then wind over a region, then precipitation and temperature. So, all these together all this climate variable they actually define the atmospheric conditions that make file more prone to or more vulnerable to the erosion.

Then coming to the soil properties. So, soil properties such as the texture of the soil, composition of the soil, aggregation and the moisture contents. So, how much dry the soil is there, and what is the texture, whether it is well graded soil or poorly graded soil that that are all soil properties that defined the that that makes soil more vulnerable to the erosion.

Then comes to the land-surface characteristics for example, topography of a region whether it is smooth or undulating hilly regions then moisture present there, aerodynamic roughness length, vegetation cover or any of the or presence of any non-erodible element that can reduce the effect of wind erosion ok.

And then finally, how we use the land that is a land-use practice, example farming, grazing and mining. So, these are the different primary factors that that controls or that affect the wind erosion. So, in a broader term we can say the wind erosion is expected when the soil is very loose, when it is finely divided when it is relatively dry and the surface conditions are smooth and bare. And wind is on the top of that wind is strong enough to start the wind erosion. So, all these factors are actually contributes to the wind erosion ok.

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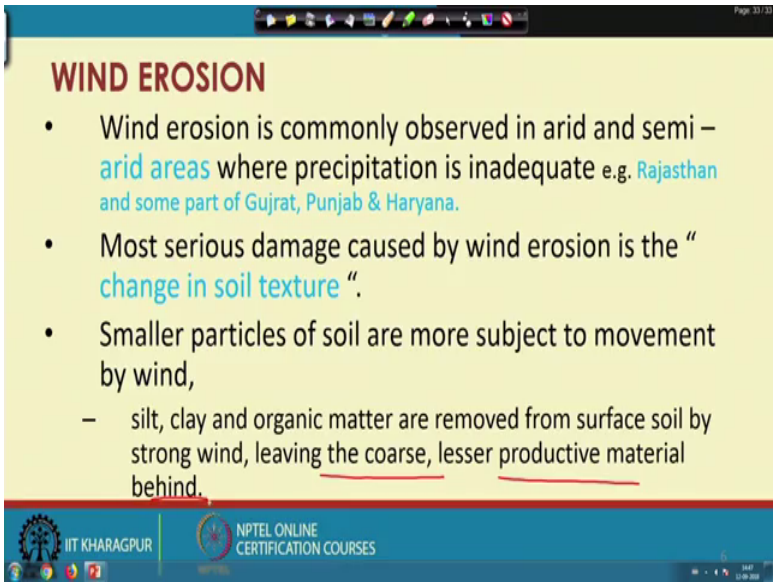

So, wind erosion it is commonly observed in mostly in a climate like arid regions and semi-arid regions where the precipitation is very inadequate which make soils very dry. For example, in case of Indian subcontinent we can see the Thar Desert in India Rajasthan, and some part of Gujarat and Haryana. And globally if you can see there are some regions like Middle East regions and over some part of some Northern Africa, Sahara Desert, so all these regions all these regions, the winds erosion wind erosion is more prominent.

So, one of the most serious damage that is caused by this wind erosion is the change in soil texture ok. So, what happens this for smaller particles of soil are more subjected to moment by wind. So, what happens this silt, clay and organic matters are being transported or are being removed from the surface, and they are transported to some another places ok. So, what is left there is actually very coarse and lesser productive material behind ok.

So, in that sense the wind erosion is actually up is makes soil more sandier. So, most of the fertile layer is being removed by this wind erosion. So, so that is why this wind erosion is dangerous is and we need to control it ok.

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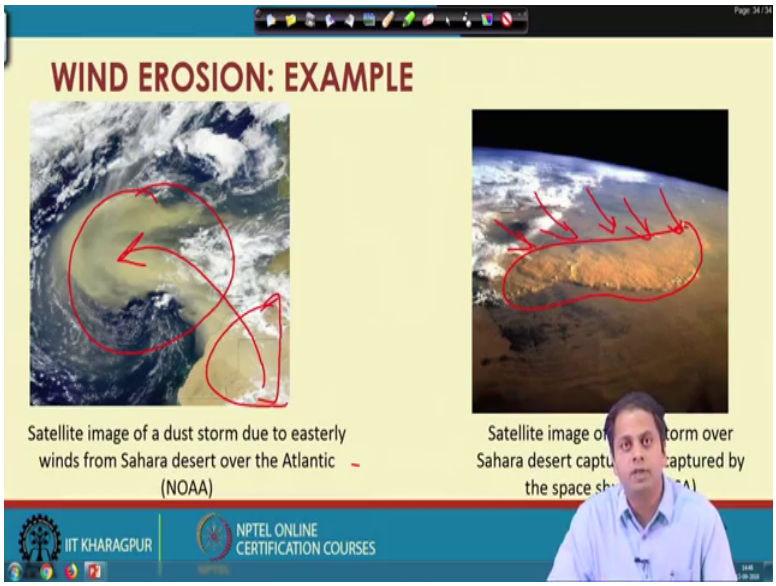

So, this is a very good example of wind erosion we can see here. So, in the first image, it is of both of these are like satellite image. And the first image we can see the extent of this phenomena ok. So, you can see this is actually somewhere over the North Atlantic North Atlantic region and this is like a Northern Africa.

So, that this is a image of dust storm. So, you can see here. So, dust is being transported from the Sahara desert to this over the North Atlantic oceans. So, you can see the distance it covers actually. So, once this soil gets soil layer get lost, it is very difficult to make favorable condition over that regions ok. So, see the distance the extent of this phenomena ok.

In the second image you can see this is also for Sahara desert and it can see the dust storm over the Sahara desert and you can see the magnitude ok. So, all this magnitude actually how much quantity is being transported and being disturbed from the from its original location. So, this is the actually very extreme case of wind erosion which is observed in the satellite image ok.

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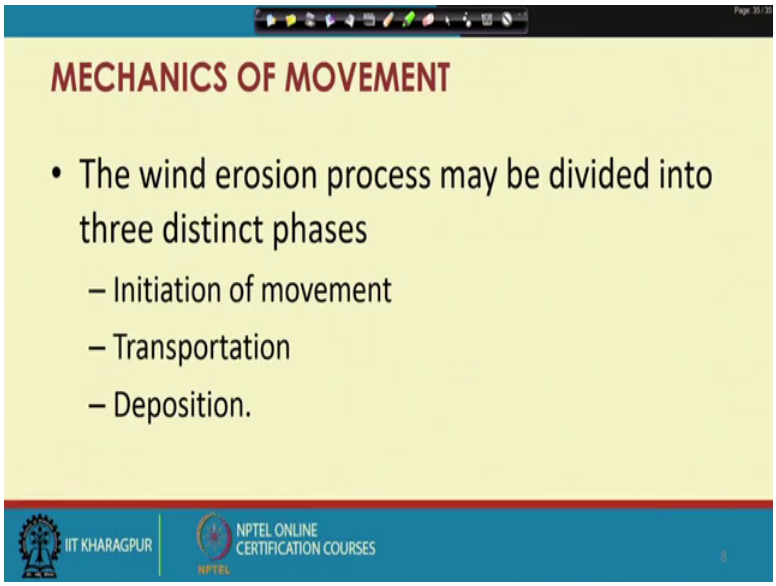

So, now let us see the mechanics of the movement of wind erosion ok. So, wind erosion as a process, it can be divided into three distinct phases. We can call it as initiation of movement or detachment of soil particle from where the wind erosion actually starts, then the transportation, and finally deposition over a distance a far away from the original location of the soil particle.

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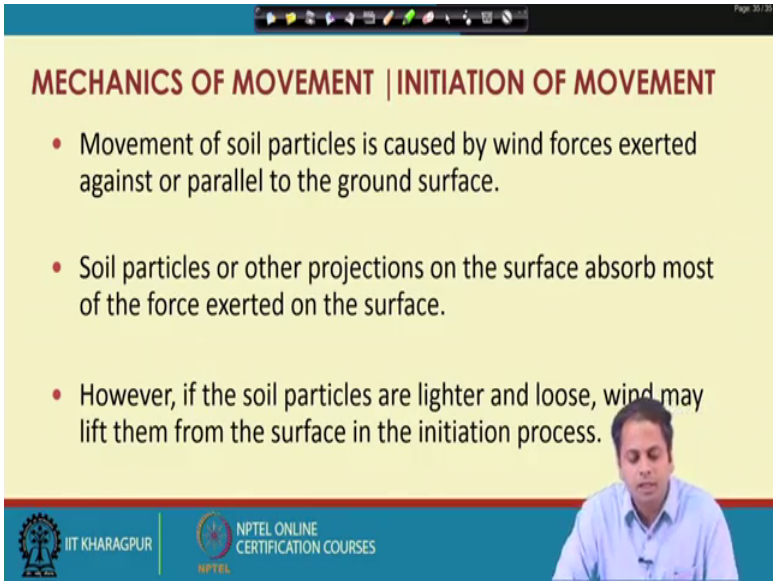

So, now let us see this movement one by one ok. So, in the mechanics of movement let us see how the initiation of movement takes place ok. So, what happens this movement

of soil particle is actually is caused by wind forces exerted against or parallel to the ground for ground surface.

What happens, when the wind with very high velocity, when it strikes over the surface soil surface. So, most of this velocity force is observed by the upper layer of soil particles. So, in the in the absence of any protective layer, so most of the force is bared by the soil particle ok.

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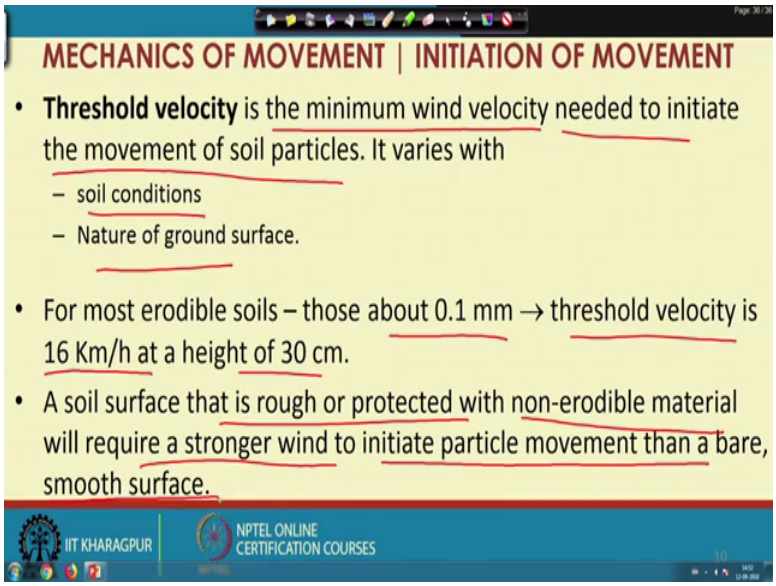

So, if the soil is in that case so in that case, if the soil particles if they are happened to be very loose and lighter or finer, then wind may lift them from the surface in the initiation process. So, the process of initiate detachment starts here. So, first it targets the finer particles fine or medium size particle ok.

So, this motion actually the initiation of this movement starts, when the wind acquires some kind of velocity ok. So, if the velocity crosses that threshold limit, then wind has that potential to cause erosion ok so that velocity is called as the threshold velocity.

So, threshold velocity is the minimum velocity. So, threshold velocity is the minimum velocity, which is needed to initiate the movement of soil particles or which is required to detach the finer or medium size soil particle from the surface ok. So, but it depends on the characteristics of the ground and the soil conditions. So, this threshold velocity is not a constant, but it changes with the surface condition ok.

So, for example for most erodible soil, which is of size about 0.1 mm the threshold velocity is in the range of likes 15 to 16 kilometer per hour at the height of 30 centimeter ok. So, when a soil surface that is rough or protected with non-erodible material in that case, it will require a very stronger wind to initiate the particle movement than compared to the smoother surface ok.

So, soil surface that is very rough and protected with some kind of non-erodible material for them, the threshold velocity it will be very high. So, to initiate that movement very high threshold velocity is required ok.

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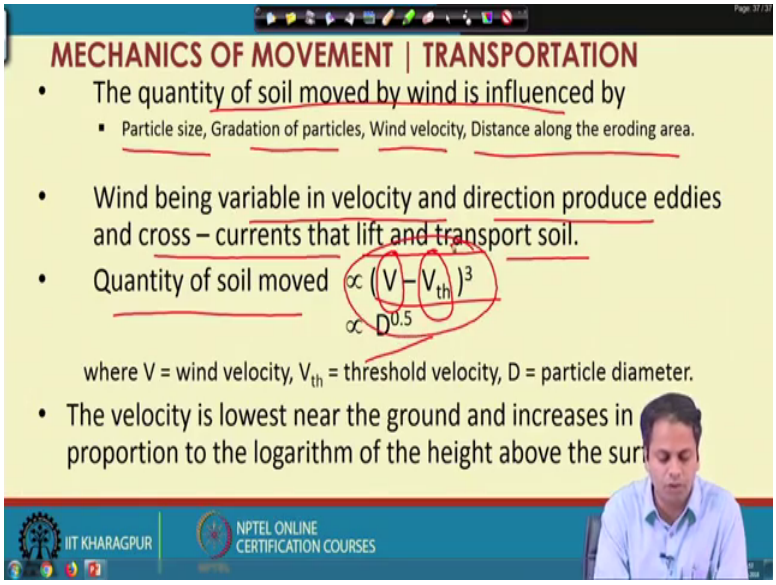

Now, next is the transportation. So, once the detachment or initiation starts of the process of wind erosion, so the soil particle will being will be transported from one place to another place. So, the quantity of soil moved by the wind is actually influenced by the particle size, the characteristics of the soil particle that is particle size, gradation of the particles, wind velocity whether winds are very strong, and the distance along the eroding area.

So, all this parameters that defines the quantity of soil, which is being moved by the wind. So, the quantity of soil since the wind is variable in velocity and direction, often it produce eddies and that makes that make soil get that that is responsible in detachment of soil from the surface and transportation ok.

So, the quantity of soil moved is actually again, we can it is a dependent on two conditions or two variables. One is related to the climate that is a wind. And another is a particle that is a soil surface ok. So, the quantity of soil moved is directly proportional to the difference between actual velocity is represented by V minus theoretical velocity q, actually cube of that.

So, quantity of soil moved is actually directly proportional to the quantity of soil moved is directly proportional to the cube of difference between these two velocity, actual velocity minus theoretical velocity. And it is also directly proportional to the square root of particle diameter ok.

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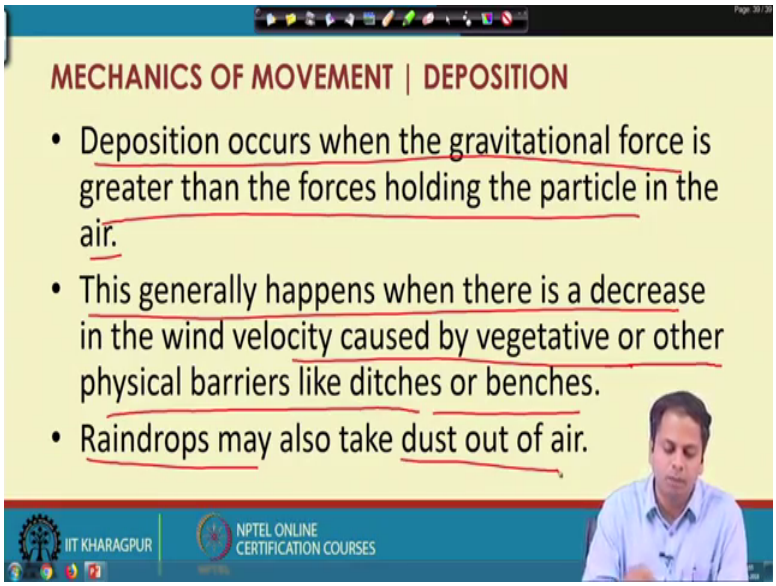

So, once the initiation starts and for soil particles are being transported, then deposit over a distance, which is some distance away from the from the originating place. So, depositions occur deposition occurs, when the gravitational force is greater than the force holding the particle in the air ok. So, what happens when the file particle, which is in air stream, when the gravitational force acting on that is actually greater than the force holding the particle in the air stream, then the process of deposition starts.

So, this generally happens when there is a decrease in wind either by itself or by which is or caused by any barrier may be it is kind of solid barrier, vegetative barrier or any barriers like ditches and benches ok. In addition to that this rain drop, they may also take the dust out of air ok. So, this is the deposition step ok.

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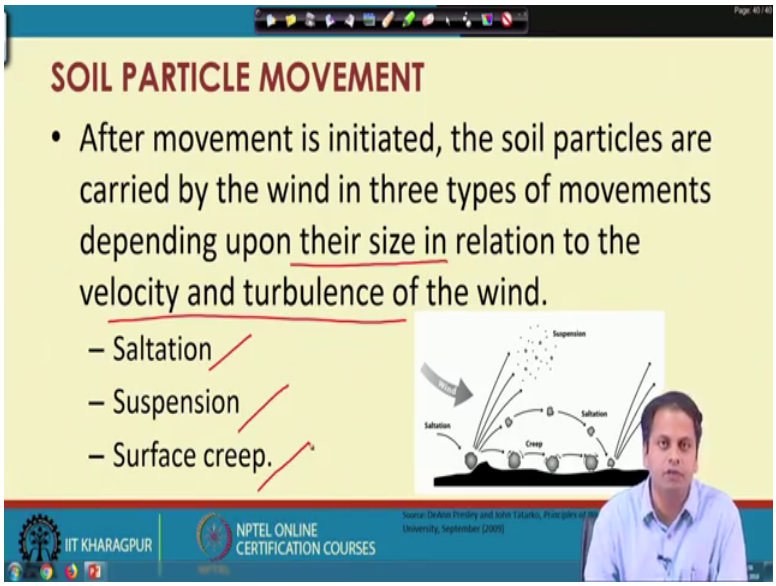

Now, you are seen the movement of the soil. So, let us see how the now we send the move mechanics of movement. Now, let us see the soil particle movement here, so it depends on the particle size.

So, after the movement of wind after the movement is initiated or soil particle is detached, the soil particles are carried by the winds in three types of movement depending on their size; depending on their size in the relation to the velocity and turbulence of the wind ok. So, these three movements are like saltation, suspension, and surface cream. So, the wind erosion is a combination of these three kinds of movement ok.

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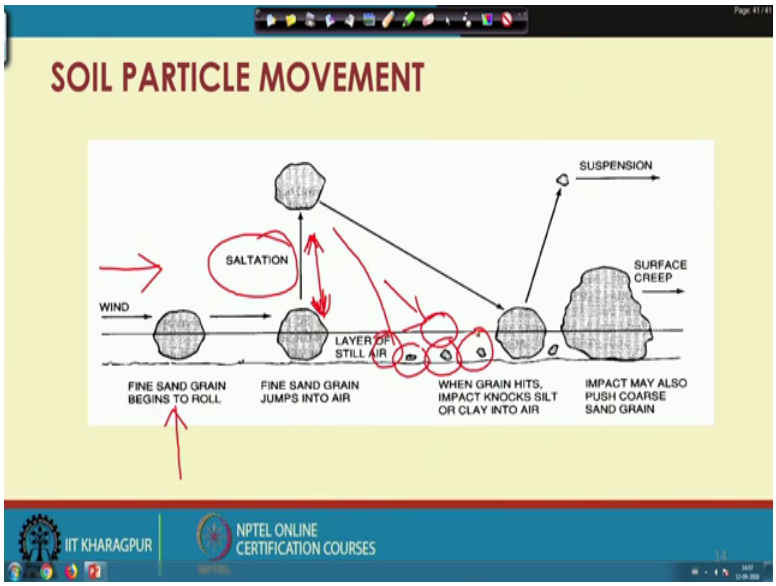

So, this is a very good figure, which talks about the particle movement soil particle movement. So, you can see here at initially, when there is a fine or medium grained soil particle and wind is blowing in this direction. And when the wind velocity it is it crosses the threshold velocity, so the process of saltation starts.

So, what happens during this process, this soil particles makes some kind of abrupt gems or some kind of bouncers over the surface ok. And this process and so that it got it gets lifted or sometimes it gets trolled over the surface. So, this process is called as a saltation.

So, saltation is a process during which the soil particle is being is being is being jumped or like it bounces from its position ok. So, what happen because of this motion; because of this motion this particle, when it collides with the surface or with some other others other grains it disintegrate into smaller particles ok.

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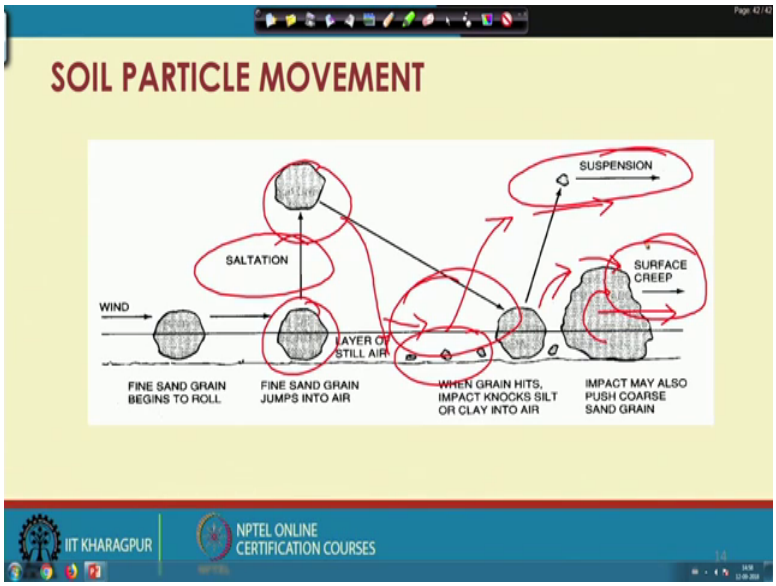

And this smaller particles in the presence of wind; is this smaller particles in the presence of wind, they care they get carried away or they get lifted from the surface, and this process is called as a suspension ok.

And of and meanwhile during the process of saltation itself, the larger soil particle this when this when the finer particle, when it hits the ground or it when it collide through the bigger size particle ok. So, this bigger size particle it cannot be lifted, because of its mass.

But, the energy is actually being transported or energy been energy is being used to make a movement along the direction of the wind. So, over the surface, it start rolling. So, this is so and this movement is called as the surface creep ok.

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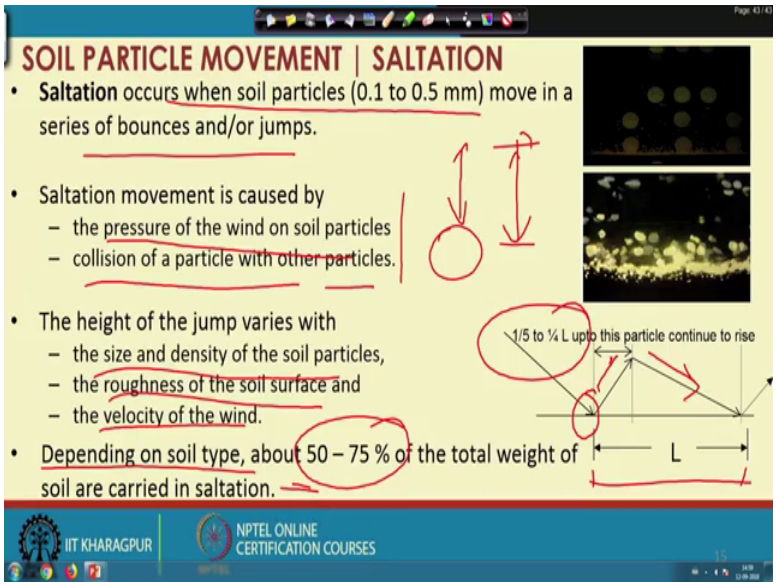

So, now let us have a look at these three types of movement one by one. So, in the process saltation, the saltation occurs, when the soil particles of size of 0.1 to 0.5 mm move in a series of bounces and jumps and jumps. So, soil particle it make some initial bounces and jumps, so that process is called as saltation process that movement is called saltation.

And it is dependent on pressure of the wind on the soil particles, and the collision of particle with other particles. So, these two process defines the saltation movement ok. And the height of this jump; height of this jump varies with the size and density of soil particle, roughness of the soil surface and the velocity of the wind.

So, it and it is important to know that that depending on the soil type around 50 to 75 percent of the total weight of soil are carried in the in the process of saltation ok. So, here this in this figure it is shown that suppose the L is the length of the transport, so the soil particle is getting detached here and it is being lifted. So, to up to the length one-fifth to one-fourth, it is in rising motion, and then there is process of deposition starts ok.

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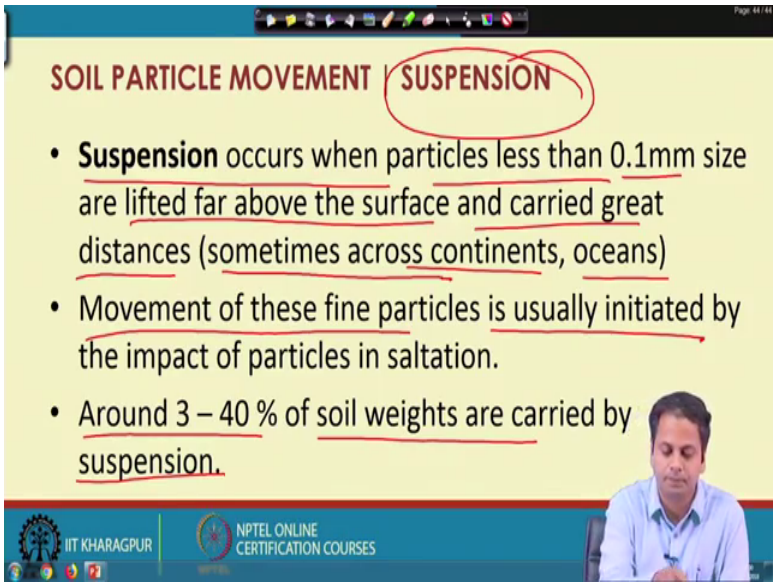

Now, now the suspension we have seen the saltation movements, now let us see the suspension. So, suspension occurs, when the particles lesser than size of 0.1 mm size are lifted far above the surface and carried to a greater distance under the influence of wind velocity. So, sometimes the distance of their distance by which they get transported, it is sometimes across the continents or oceans ok.

So, movement of this fine particles is usually initiated in the process of saltation, when the particles bounce back over the surface and it get disintegrate into finals particle or it lift the finer particle the wind will lift the finer particle and may and the process of suspension or suspension movement starts. So, around 3 to 40 percent of the soil weights are carried by this suspension.

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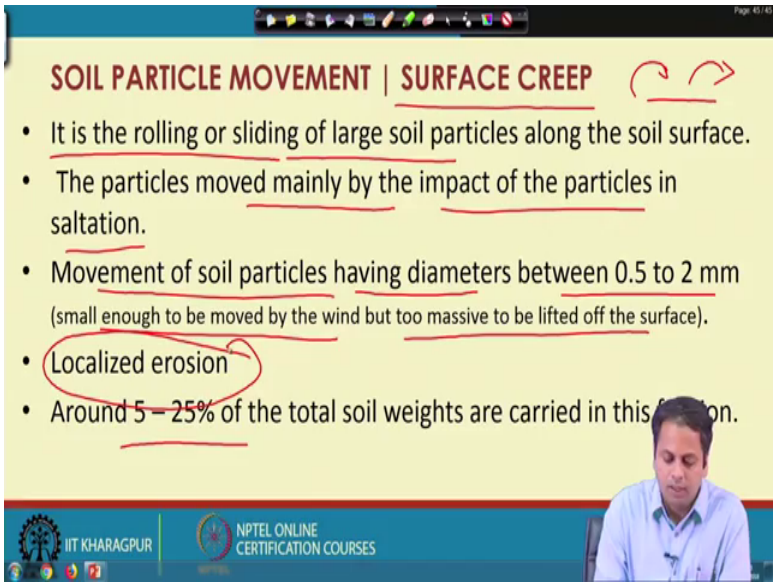

Now, there is another movement, which is applicable to the larger size particle of size 0.5 to 2 mm. So, since this particles cannot be moved by the wind, they cannot be lifted by the wind, but they can be rolled along the surface. So, it is the rolling or this surface creep is a rolling or sliding of large soil particle along the soil surface. And the particles moved mainly by the impact of particles in the saltation.

So, the particles, which are already in the movement of in the in the form of saltation, they start this movement of on a bigger and bigger or like the on a particle, which are generally of more mass ok. So, this movement is called as a surface creep. So, it is a rolling motion along the surface ok. So, around 5 to 25 percent of the total soil weights are carried away in this fashion. And, so localized erosion, because of the mass of the particles ok.

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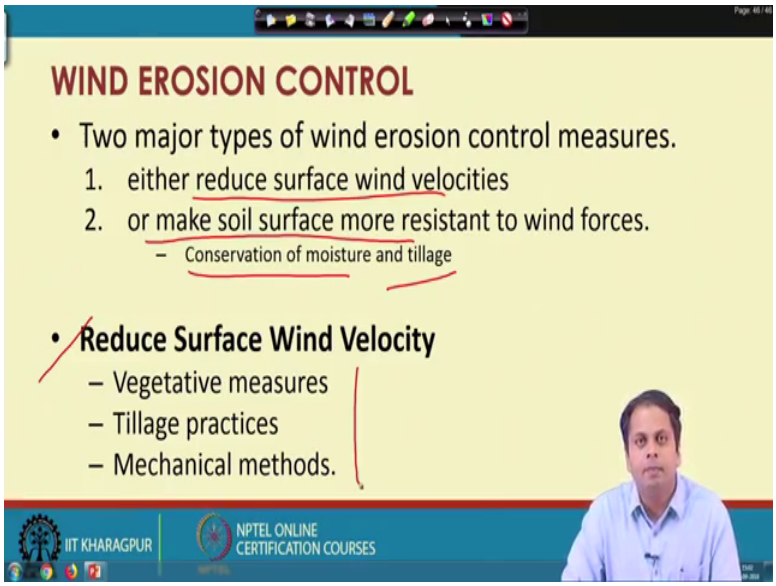

Now, let us see the different ways to control the erosion. So, we can control the erosion by two step the parameter, which are responsible for wind erosions. If we adopt some kind of preventive measures, we can reduce the effect of erosion by adjusting by adopting this wind erosion control measures ok.

So, we can either reduce the surface wind velocity or means that means, we can reduce the erosiveness of wind or we can make soil surface more resistant to the force wind forces ok, so that can be achieved by conservation of moisture and proper tillage operation.

So, let us see first step to reduce the surface wind velocity. So, if you have to reduce the surface wind velocity, so there are different ways or different measures that can be used such as vegetative measures, tillage practices and mechanical methods.

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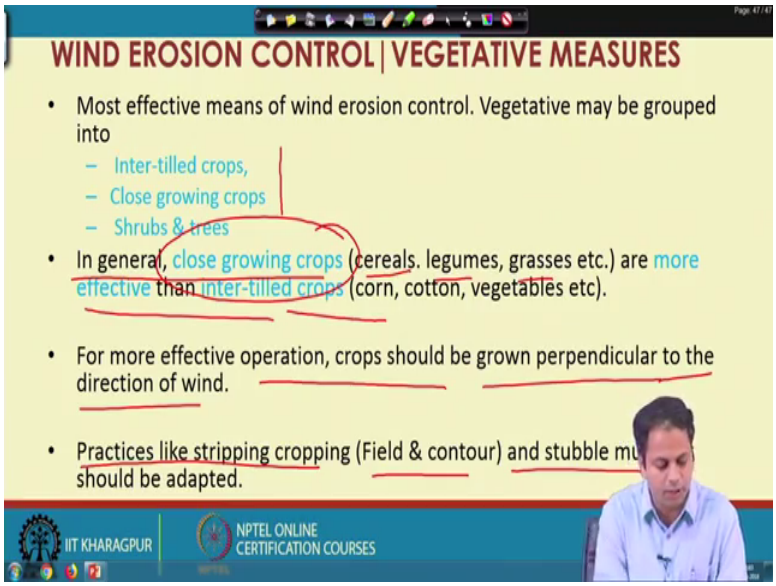

So, let us see this measures one by one ok. So, first is the vegetative measure, so it is the most effective means of wind erosion control measures. So, if you are using inter tilled crops, close growing crops, shrubs and trees, so they can they can reduce the erosive par they can reduce the effect of wind, they can reduce the wind velocity. So, the effect of wind erosion make it reduce.

So, in general the close growing crops, such as cereals cereals, legumes, grasses et cetera are more effective than the inter-tilled crops, because this close growing crops. Actually, they will held the soil particles together and also they will protect the upper layer of soil.

Another measure is to plant crop in a such a way that the prevailing wind direction is perpendicular to that. So, for more effective operations, crop should be grown perpendicular to the direction of wind. And other practices like strip cropping, field on filed and control and stubble mulching should be adopted to control the wind erosion ok.

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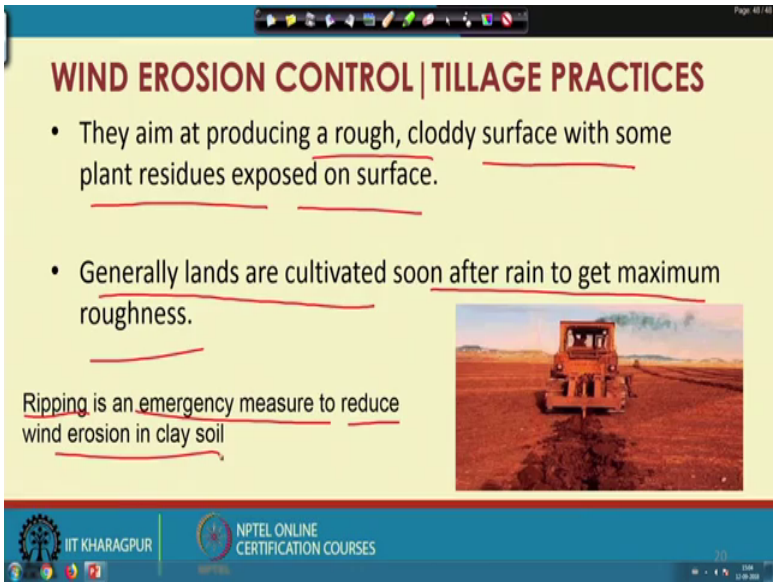

Next is by a proper tillage operation. So, the our aim of tillage operation should be such that it should make a rough, cloddy surface with some plant residues expose on surface. So, the effect of high velocity wind can be can be minimized ok.

So, generally lands are cultivated soon after rains to get maximum roughness ok. So, sometimes if I have to if there is a chances of erosion wind erosion, so sometimes as a emergency measures, we use ripping as a ripping as a emergency measures to reduce the wind erosion in clay soils ok. This is, this was the tillage operation.

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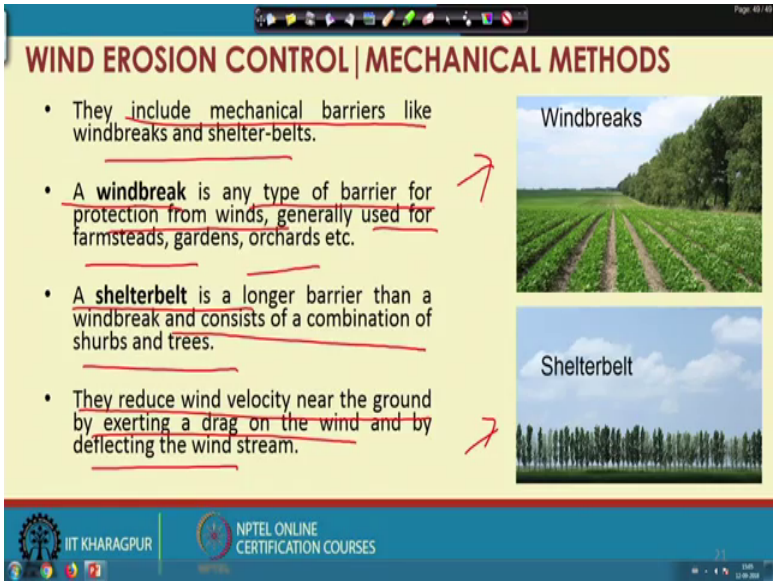

Now, now there are some measures like mechanical measures ok, so that can be used. So, mechanical measures means it can we can plant some series of trees on shrubs on the on the border of the field, so that the effect of high winds can be reduced.

So, they include mechanical barriers like windbreaks and shelter-belts. So, windbreak by definition is any kind of barrier ok, so any kind of barrier for protection of wind generally from for protection of winds, and it is generally used for farmsteads, gardens, gardens and orchards etcetera.

And similarly, a shelterbelt is a longer barrier than the wind break and it consists of combination various shrubs and trees. So, these wind breaks and shelter-belts they reduce the wind velocity near the ground by exerting a drag on wind and by deflecting the wind stream. So, this is a example you can see the wind break. So, this it is a wind break and this is a shelter-belts. So, we will be looking this thing in a detail in the subsequent lectures.

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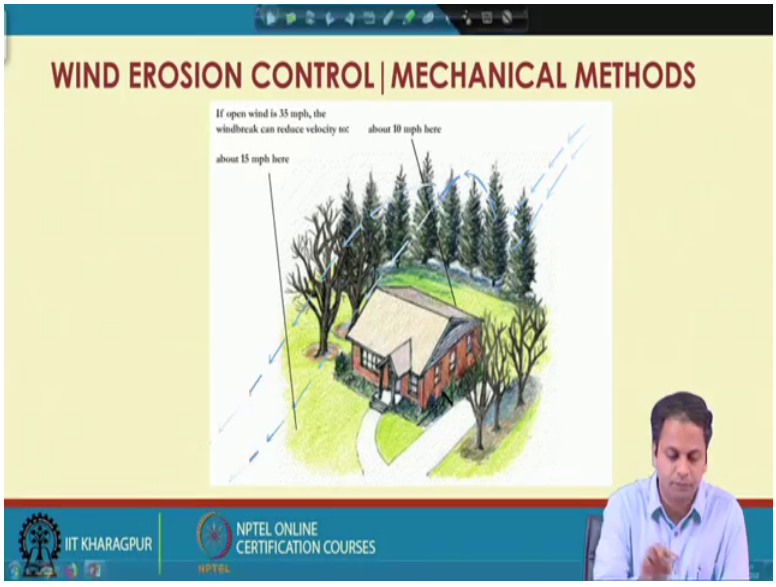

So, now this is just for introduction I am giving some information here ok. So, this is so this is the example of wind erosion here. So, you can see here, you know in a open wind or open air steam suppose the wind velocity is around 35 miles per hour. And by planting this windbreak, we can reduce the wind velocity over this location around time min 10 miles per 10 miles per hour.

So, there is a significant reduction in wind speed on the windward side sorry on the livered side of the windbreak. Similarly, its distance it can protect us to some particular distance ok. So, let us see here also the effect is visible. So, around wind speed is around 15 miles per hour here ok.

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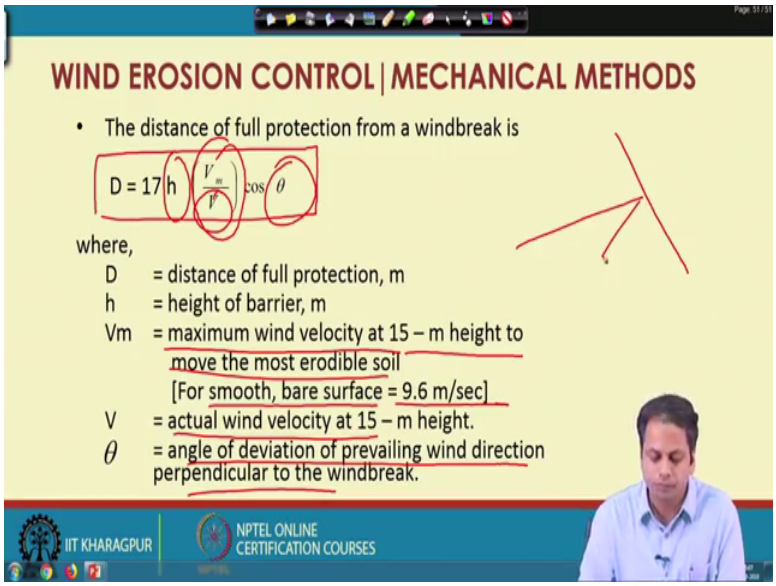

So, the distance of full production is can be calculated by this equation, which is given by D is equal to 17 times height of the barrier multiplied by ratio of two velocities. These velocities are like first is a V m that is a threshold velocity.

The maximum velocity at 15 meter height, which is required to initiate the movement. And for smooth and smooth and bare soil this threshold are maximum velocity is 9.6 meter per second. And this V is actually the actual velocity at 15 meter height. And this theta is angle of deviation of prevailing wind direction perpendicular to the wind break ok.

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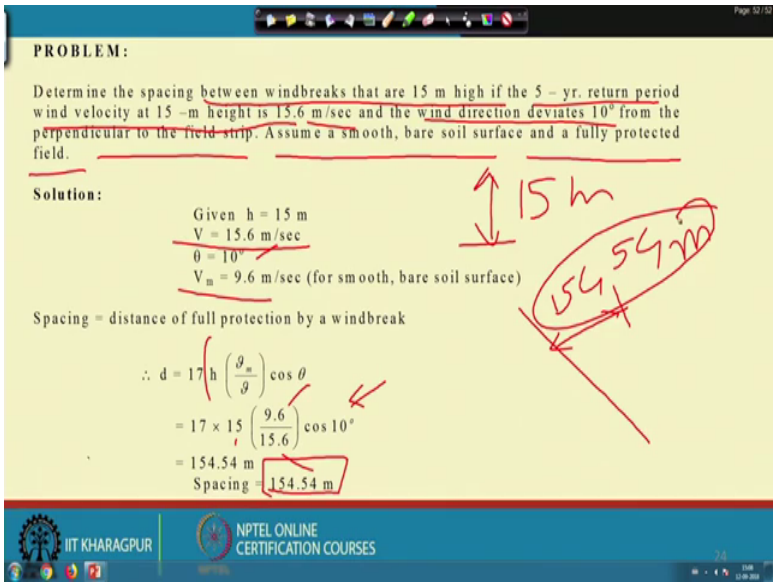

So, now let us see the example. So, we can have a better understanding by the example here ok. So, this is the example. So, in this example we have to determine the spacing between wind breaks that are 15 meter height if the 5-year, return periods of wind velocity at 15-meter height is 15.6 meter and the wind direction deviates 10 degree from the perpendicular to the field stream. So, in the problem we have to assume a smooth, bare soil surface and fully protected soil field.

So, what is given here, so given here is like we have to plan for windbreak of height 15 meter, the actual velocity given here is 15.6 meter, the angle of deviation from the perpendicular from a direction perpendicular to the wind break is 10 degree and the theoretical velocity for a smooth and a bare surface is 9.6 meter, so if we substitute all this value here.

So, height is 15 meter, V m is 9.6, V is 15.6, and theta is 10 degree. So, we get d is equal to 154.54 meter. So, what it means, so if we plant now one row of wind break, so we will get a protection of this 154.54 meter, we can get protection from this windbreak. So, the another windbreak layer of wind break should be planted at the spacing 154.54 mm at a distance away from this first wind break ok.

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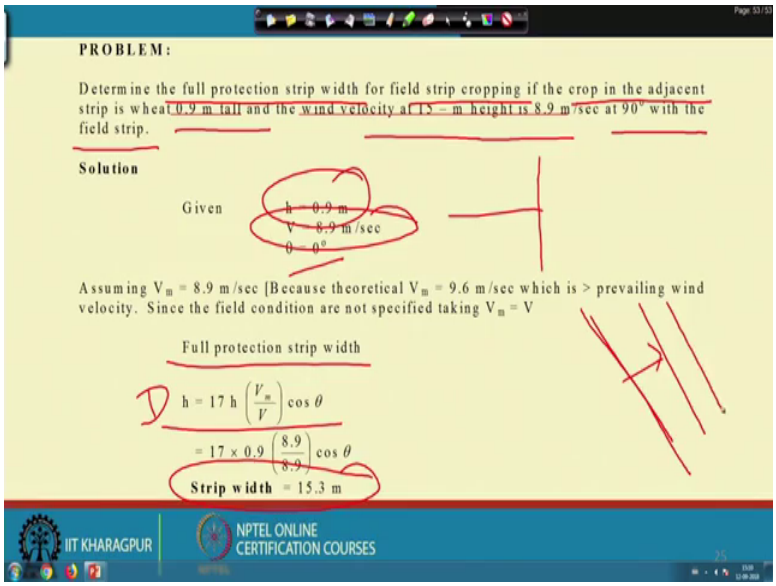

So, now let us look at the another problem here. So, here we have to determine the full protection strip width for a field strip cropping. If the crop in the adjacent field strip is wheat of 0.9 meter tall, and wind velocities wind velocity is 8.9 meter second and winds are prevailing winds are actually perpendicular to the field stream.

So, the height of wheat crop is given as 0.9 meter, the actual wind speed at 15 meter is 8.9 meter per second and since the prevailing wind is perpendicular to the direction to the to the field stream so the angle of deviation is 0 here. So, we need to find out the spacing width ok.

So, so one strip how much by planting one strip, how much distance will get protection that was we have to find it out. So, by putting all the values here in this equation h is equal sorry this is D; D is equal to 17 h V m by V cos theta. So, if you substitute all this value here, we will get strip width of 15.3 meter. So, it means so one row of this field strip is protecting 15.3 meter. So, spacing should be 15.3 meter ok.

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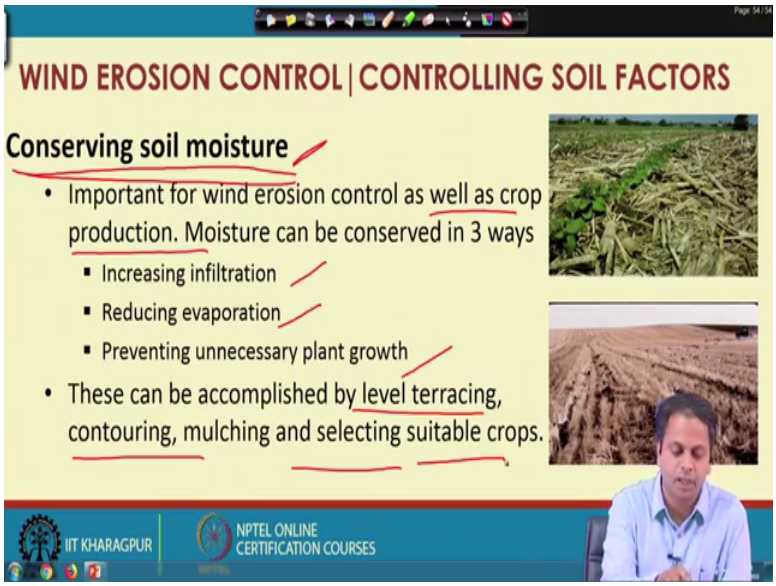

So, now we have seen a how to reduce wind. Now, let us see how to control controlling the soil controlling the wind erosion by controlling the soil factors ok. So, there are two ways. So, there are different ways first is by conserving the soil moisture. So, by conserving soil moisture means, it is helpful to minimize the by conserving soil moisture, we have two benefits. First, so effect of wind erosion can be minimized, and second it can help us it is in so this measure conserving of soil moisture is actually helpful for wind erosion control well as the crop production.

So, the moisture can be conserved in three ways by increasing infiltration, by reducing the evaporation, and preventing unnecessary plant growth. So, this can be achieved by complete; this can be achieved by level terracing, contouring, mulching and selecting suitable crops ok. So, these are the measures to conserve measures to conserve the soil moisture ok.

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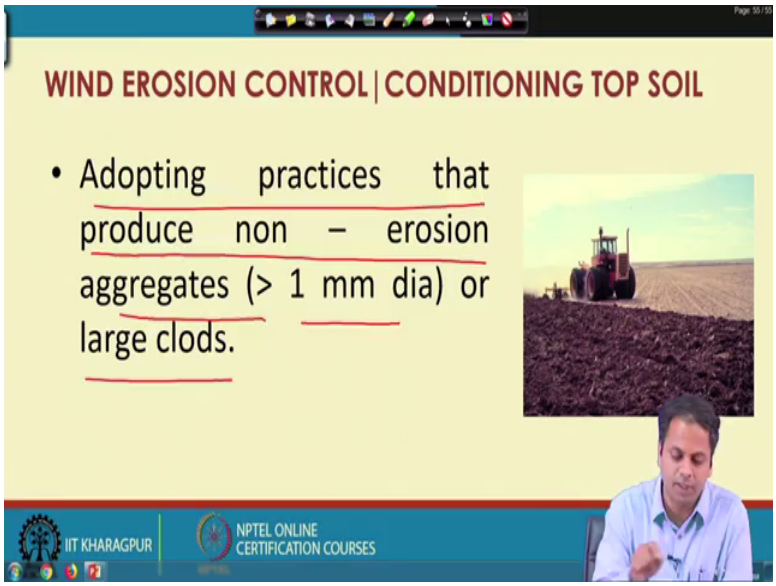

Another measure is to took is the conditioning of topsoil. So, adopting a practices that makes upper layer more non-erosion non-erosive. So, adopting a practices that produce non-erosion aggregates of size greater than 1 mm diameter or which make larger cord that should be our goal, so that is another measure.

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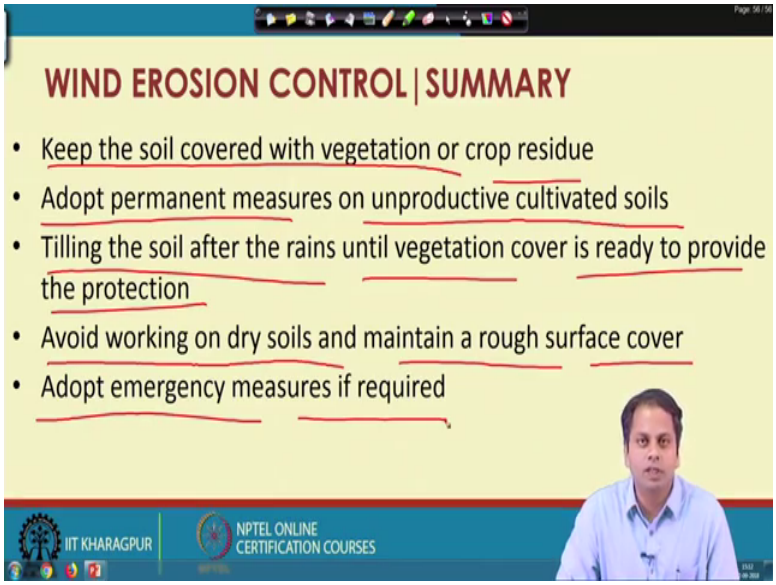

So, finally to summarize this; to summarize this wind erosion control method. So, these are these are the few things you can do actually. So, first by keeping the soil covered with vegetation and crop residue maximum time possible. So, sometimes in case of if the

there is unproductive or unproductive cultivated soil, so you can think of adopting permanent measures to control wind erosion.

Then tilling the soil after the rains until vegetation cover is ready to provide the protection. And directly avoid directly working on the dry soils and maintained by maintaining a rough surface cover. And finally, so in case of any emergency, adopt emergency measures if requires.

So, this is a way so in this lecture we have seen definition of wind erosion, different movements of soil particles under the wind erosion, what are the ways to control the wind erosion by reducing the wind speed or by controlling the surface characteristics, so with that I will stop here. So, we will see the designing part of this wind control measures in the next slide, in the next lecture about windbreaks and shelter-belts ok.

Thank you.