Soil and Water Conservation Engineering
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Lecture – 11
Bunds- Introduction

Hello friends. Welcome to NPTEL online certification course on Soil and Water Conservation Engineering. I am Rajendra Singh, Professor Agriculture and Food Engineering Department, IIT Kharagpur. And we are starting week 3 today, that is lecture 11, and the topic today is Introduction of Bunds. Just to give you an idea about the course content that we will be covering in this week. This particular week lecture 11 we will introduce bunds.

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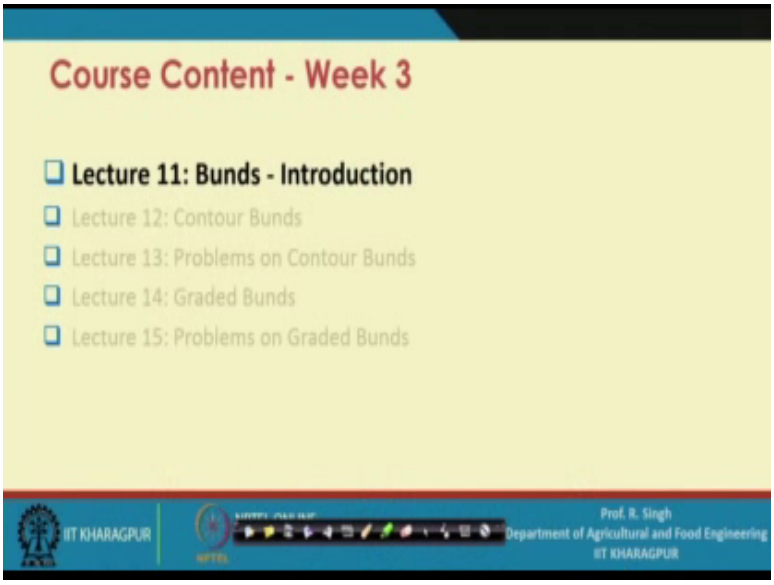

In lecture 12 we will go for contour bunds, that is we will see the theory behind contour bunds what is their applicability, where they are able, what is their adaptability and what are the design features. And then in lecture 13 we will use those concepts to solve certain problems dealing with design of contour bunds. That is what how to design various the cross section or various other parameters related to contour bunds. Lecture 14 will be on graded bunds, where we will be seeing the adaptability the theory behind design of graded bunds. And then in lecture 15 we will handle the problems on design upgraded bunds using the concepts, which we will lead read learn in to lecture number 14.

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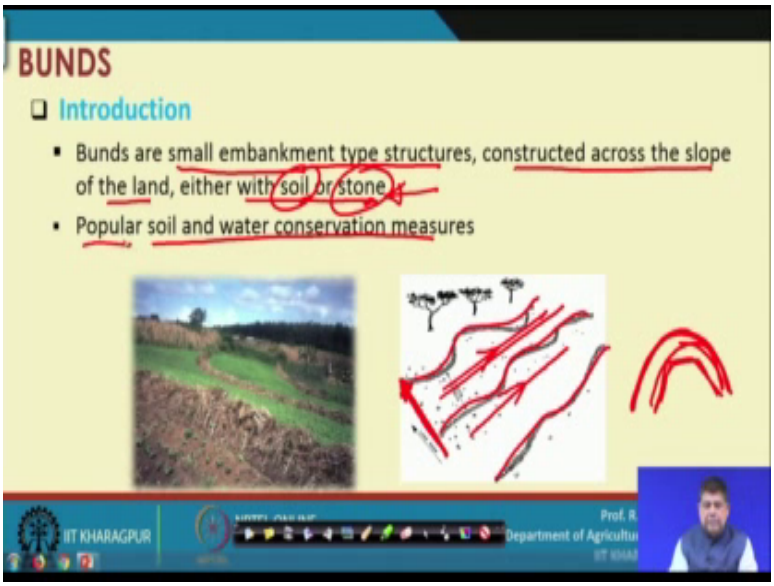

To start with the bunds; bunds are basically a small embankments, embankment type structures constructed across the slope of the land either with soil or stone. So, their important components are: they are small embankment type of structures; that means, simply kind of embankment or dam what you see, that is some kind of a cross section some like this or whatever be the section this is how they will look like.

And they are constructed across the slope of the land; that is very important you remember that all previous classes, we discussed that most of the soil conservation measures we take or adopt across the slope not along the slope, that is the regions also we know. So, if the land slope is in this direction is shown this picture then; obviously, our bunds will be constructed across the slope in this direction. So, that is how you see this is a bund, this is a bund line, and this is another bund line. So, it is always taken across the across the slope that is this is the slope along the length of the field and this is across the slope.

And the material of construction is soil or stone. So, that is the material which is readily available in the nearby positions. That is, it could be soil, which is preferred because the cost economy with a major constraint. Or if soil is not of good quality soil is not available, then we bring stones also to build this cross section as I mentioned that cross section could be trapezoidal or just a semi-circular kind of thing.

And these bunds are popular soil and water conservation major because of their ease of which the advantages we will see little later. But just at this point of time I must tell you that because of the ease of construction, ease of maintenance, because of the economics that is there because they are inexpensive, because they can be built using the local locally available soil or stone. So, that is why these are one of the very popular soil and water conservation measures adopted in field conditions.

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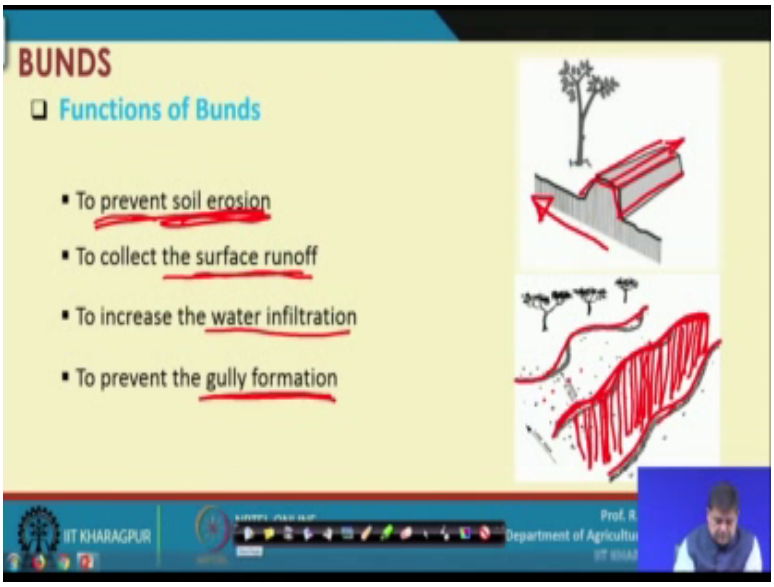

Now, coming to functions of bunds; the functions are, that is they are built to prevent soil erosion, to collect surface runoff, to increase water infiltration and to prevent gully formation. As we have already seen we have seen that this is this is the typical cross section which we have seen which is a trapezoidal kind of cross section, which is shown in this picture.

So, these are this is the slope direction, and this construction is done across the slope in this direction. And the same thing is shown in the here in this picture. So, as you can see that these are this is one line of a bund, and this is another line of bund. So, because of this kind of shape which is constructed here, then what happens that whatever rainfall occurs over this area, whatever rainfall occurs over this area; that is gets collected within these 2 bunds, which is this within this area itself.

So, as you if you remember, we when we discussed the soil erosion, we saw the types of erosion that is the first water erosion processes raindrop splash erosion that whenever

rainfall occurs because of the impact of the kinetic energy impact the splash takes place; that means, detachment takes place. And then next is a detachment if you remember the process is this is detachment, then transportation and deposition these are the 3 processes.

The second process is transportation. And for transportation we saw that is the overland flow which causes the transportation. And here what we are doing is that, we are storing the water whatever water is falling within this area that is rainfall occurring over this area, we are storing that we are not allowing that to flow beyond this bund structure. Same is true whatever is whatever rainfall will occur here that will be stored between this and this bund.

So, that is how what we are doing is that, we are basically preventing the flow of water. And that is how this function comes that is to collect the surface runoff. So, surface runoff gets collected between the 2 bunds whatever rainfall occurs that gets collected that surface runoff that gets collected. And because we are checking the flow of water, that simply means when we because we are checking the overland flow process itself; that means, there is no chance of occurring occurrence of sheet erosion and one sheet erosion does not take place; obviously, there will be no soil transportation; that means, there will be no soil erosion, and that is how the bunds prevent soil erosion.

Now, the another function increase the water infiltration. Now when you have seen that whatever rainfall occurs that will get stored in between these 2 bund sections. And if that happens; that means, water is standing there for longer period of time. So, enough time is available with the water to infiltrate into the soil so; that means, there will be increase in the total infiltration that would have taken otherwise when the flow was allowed to take place.

And also you remember the next function is the prevention of gully formation. You remember we say we said that there will be sheet erosion, which results in rail erosion, which if continues results in gully formation or gully erosion. That is the others these are the various types of erosion. So, once we are checking the sheet erosion itself, there is no question of rail erosion and no question of gully erosion or gully formation.

So, this is how by simply storing whatever rainfall occurs within between these stones within this particular area, which is in which is enclosed by 2 bunds, neighbouring

bunds, we are we are ensuring that various functions of bunds are taken care of that is prevent soil erosion collection of surface runoff increase in the water infiltration and prevention of the gully formation. So, all these functions take place; coming to suitable conditions for bunding.

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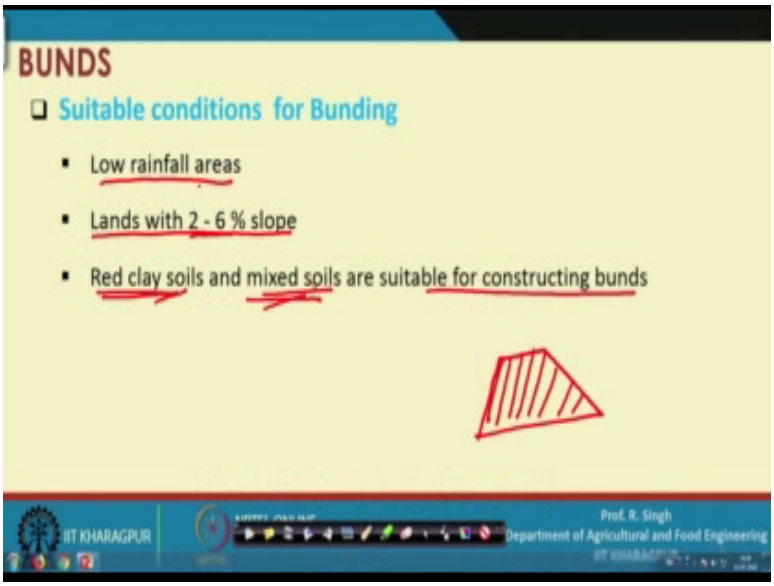

If you consider the suitable conditions of bunding, then these are preferred in low rainfall areas; because as you can see that whatever rainfall occurs we try to store that in between 2 bund areas. So, if it is a very high rainfall area; that means, either the cross section has to be too big; that means, the cost will be a factor or and also too much of land will be required for constructing these bunds.

So, that is why they are always referring low rainfall areas. And also the land slope has to be within 2 to 6 percent slope. So, these are the 2 limiting cases that is they are preferred bunding is preferred in low rainfall areas, and for land slopes which are limited to 2 to 6 percent and then red clay soils and mixed soils are suitable for constructing bund. As we saw that we simply build a trapezoidal section, most that is the most preferred section so; obviously, that is because we simply use the soil to create this.

So, obviously, from the stability point of view we have to see the soil should have I mean a soil should be stable. And that is why red clay soils or mixed soils are preferred. Generally, typically just pure sand will not be preferred because stability will not be there. So, from stability point of view red clay soils and mixed soils are the preferred one

for constructing bunds, these are the from the suitability point of view; Then coming to advantages of bunds.

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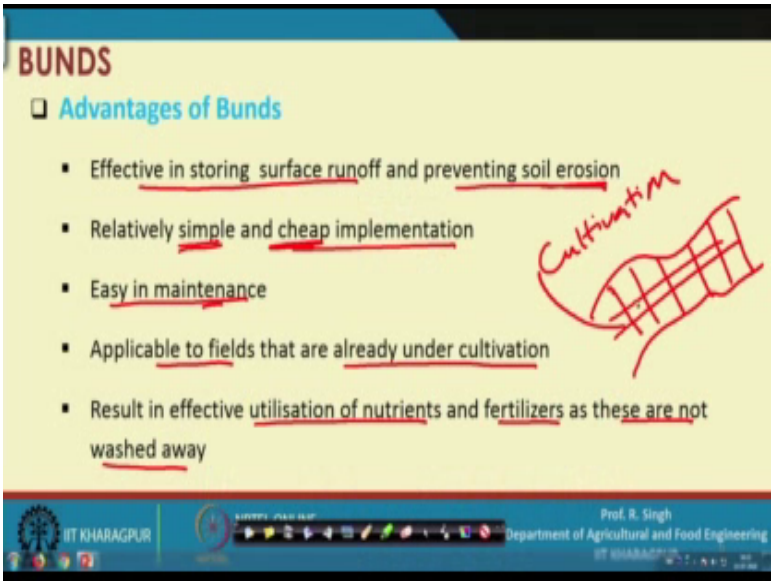

Some of the functions we have already seen. So, advantages are related to that, they are effective in storing surface runoff and preventing soil erosion. We have already seen in great detail that in between 2 bund sections, the surface runoff whatever rainfall is occurring that gets stored. And obviously, because the flow of water is not taking place; so, the soil transportation is not taking place; that means soil erosion is prevented.

Are relatively simple and cheap implementations; as we have seen that the material of construction is soil or stone, which is readily available in the field condition and because they are very simple say trapezoidal shape which provided. So, they are very simple to construct basically and; obviously, because the material of construction is readily available I mean we prefer readily available material of construction. So, generally it is quite economical in construction.

Simply also because of the simple construction they are easy to maintain also because this is just a trapezoidal cross section. So, if any little bit of erosion takes place we can always fill the soils which is again readily available in the near bar area to maintain the shape of the bund. So, the maintenance is very easy. And they are applicable to fields that are all already under cultivation. So, basically they are used also for the land which is under which is for cultivable lands of course, and they can be adopted in areas which

are under cultivation. And it results in effective utilization of nutrients and fertilizers is these are not washed away.

So, we have already seen that when bunds are constructed, and whatever rainfall occurs that is get that gets stored in this area. And this will be used for cultivation also. This area is also used for cultivation. So, obviously, whatever nutrients or fertilizers we apply here, because the flow of water is not there so; obviously, whatever application we make that will be readily available to the crops. And obviously, they are not washed away because flow is not allowed to take place from this area. So, this is these are the some of the advantages of the bunds. Bund but as we know, that along with advantages there also some associated disadvantages also.

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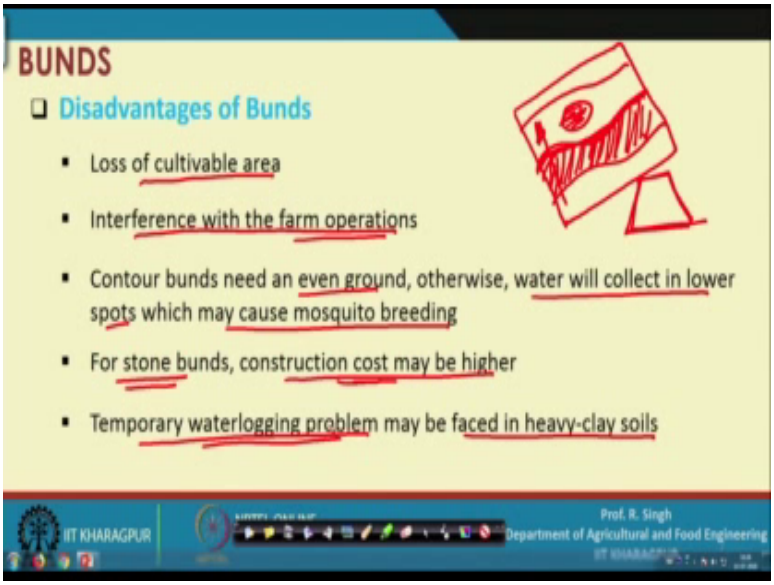

And one major disadvantage of the bunds is loss of cultivable land so; obviously, if you have a certain area available for agriculture, which has a slope in this direction. And if you want to build a bund here which has a typical cross section already we have seen that the cross section typically preferred is trapezoidal. So, obviously, the base area that is equivalent to the base area along this length is really that is not available for cultivation. So, that means, it results in loss of cultivable area, and as they are there are series of bunds in a given area so; obviously, they that results in a considerable amount of loss of cultivable area. So, that is a major disadvantage.

And then they also interfere with the farm operation. So, because if the cross if the flow is large which we if you want to handle large flow then; obviously, the cross section of this bund will be much larger in section, and in that case it they might interfere with the farm operations. Of course, while designing we try to see that the farm operations are not affected, but sometimes it becomes inevitable.

Then contour bunds need an even ground, otherwise water will collect in lower spots which may cause mosquito breeding. So obviously, as we see that initially when we design these we always say that water should get stored in this area. And of course, with time this water will be infiltrated or will be carried away depending upon the function of the bund. But if there are some low lying area here in between these 2 bunds so; obviously, water will be standing there or more water will get collected here and will be standing there for longer period of time. So, that might result in water bond diseases especially it might result in mosquito breeding. So, that is why we must see that there are no potholes in between the bunds or the area there are there no storage possibility of water over longer period of time that we have to ensure.

Then for stone bunds construction cost may be higher, which is quite obvious the alternate material we have seen that is soil, which is readily available in the field and then we allow, that soil or rather they use that soil which is available for constructing the bunds. But in case while is not suitable then; obviously, we have to go for a stone as a material of construction, and in that case a stone has to be brought maybe it has to be purchased. So, that is why the construction cost will definitely be get will be higher in this case compared to what would have been if the soil good quality soil is available in the area.

Then temporary water logging problem may be faced in heavy clay soils; which is quite obvious because we are allowing water to stay here for longer period of time. Assuming that most of this water will get infiltrated; but if it is a heavy clay soil which has a infiltration rate is very, very low then; obviously, water will not get infiltrate and; that means, water will be standing there for longer period of time which might result in water logging problems or may affect the crop production in that particular area. So, that is why we have to be careful when in what kind of soils we are constructing the bunds. So, this is a matter of concern and we have to be careful about that. Then we come to the types of bunds.

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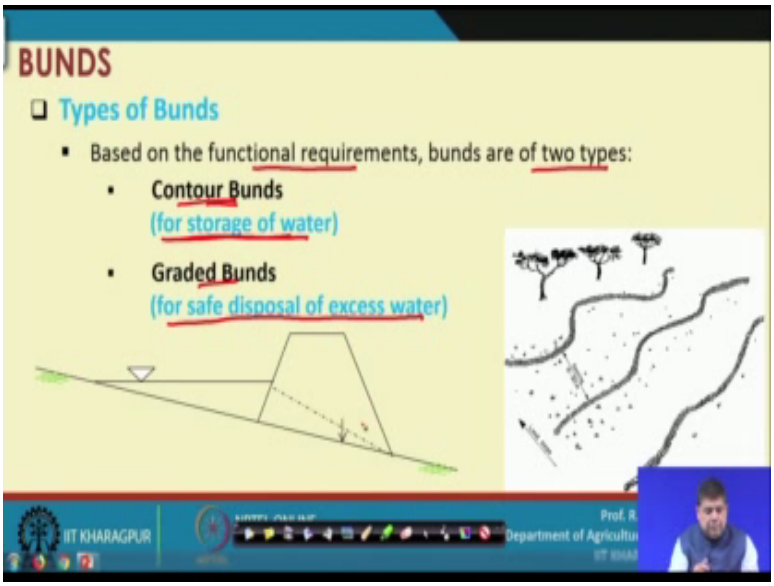

Now coming to types of bunds; bunds are of based on the functional requirements bunds could be of two types that is contour bunds, which are used for storage of water, and graded bunds which are primarily used for safe disposal of excess water. So, two category of bunds are used, similar kind of structure we will go into details of these in the following lectures.

So, when we say contour bund it is basically meant for storing water for long period of time, when we say graded bund they are for safe disposal of excess water. Of course, the cross section remains this similar cross section is used in both cases only little bit of changes take place which we will see in detail when we go further in the next lectures of this week.

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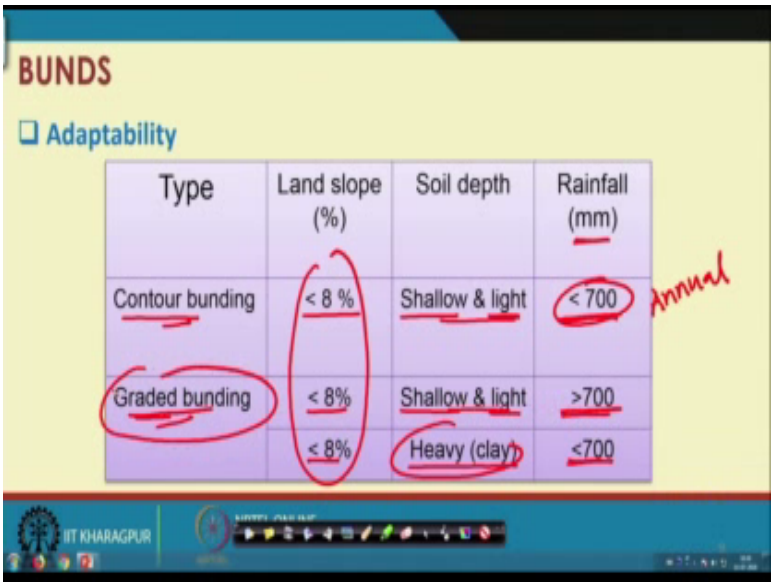

Coming to adaptability of these two particular types of bunds; if you consider contour bund, then typically we adopt them for low rainfall areas we have also seen. And the magnitude here is less than 700 millimetres. So, this is a annual rainfall. So, if annual rainfall is less than 700 millimetres. This is annual rainfall we are talking about. So, annual rainfall is less than 700 millimetres, then we go for contour bunding. Also the land slope has to be less than 8 percent. We saw that typically they are adopted for 2 to 6 percent, but in any case land slopes should be less than 8 percent.

And soil should be shallow and light. Light in the sense that infiltration capacity will be capacity should be little bit higher. So, that infiltration and groundwater recharge takes place, and what logging problem is not faced because water is allowed to store for longer period of time. On the other hand, if we consider the graded bunding, where the function is a safe disposal of water from the area, then we have 2 cases. One is that when the rainfall is greater than 700 millimeters annual rainfall. In that case; land slope conditions remains the same that it should be less than 8 percent.

But also in this case it should be shallow and light. So, if shallow and light less than 8 percent, rainfall is greater than 700 mm then we go for graded bunding because we do not want the water to withstand. We want safe disposal of water, if it is less than 700 then we go for contour bunding under similar conditions; but if the land slope is less than 8 percent. Rainfall is less than 700 mm, and the soil is heavy clay where infiltration is very

low we saw that in case of contour bunding if a very clay soil is there the infiltration if infiltration is not taking place then water logging may happen.

So, in that case we go for graded bunds. So, these are the conditions that slope in any case for bunding should be less than 8 percent. Rainfall should be less than 700 and if shallow and light soil then we go for contour bunding if it is less than 700 percent, but heavy soil we go for graded bunding. If greater than 700 even for shallow and light soil; we go for graded bunding. So, these are the adaptability conditions for 2 types of 2 major types of bunds which are available which we will see in the next few lectures also.

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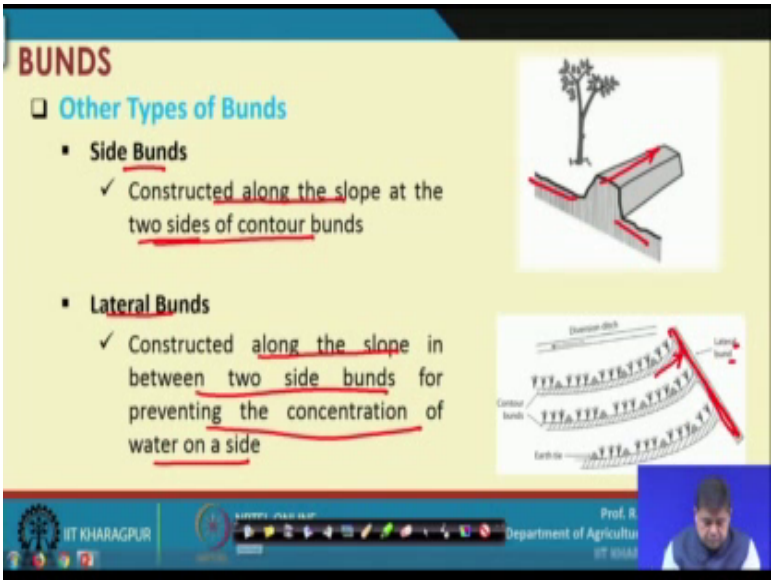

Then there are some other types of bunds associated bunds also. For example, side bunds. The side bunds are constructed along the slope at the two sides of contour bunds. So, this is across the slope and along the slope just on this side of the contour bund. We construct these bunds which are referred to as side bunds; because they are built on the side.

Then another category is lateral bunds, which are constructed along the slope in between two side bunds for preventing the concentration of water on a particular side. So, basically as you can see here if you just join together all the side bunds, all along the length of the field then it is referred to it is lateral bund. And obviously, the idea is that no water should be allowed to flow in this direction. There is no flow of water will be

possible because there is a bund here. So, if you want to check flow of water in this direction we construct the lateral bunds on the side.

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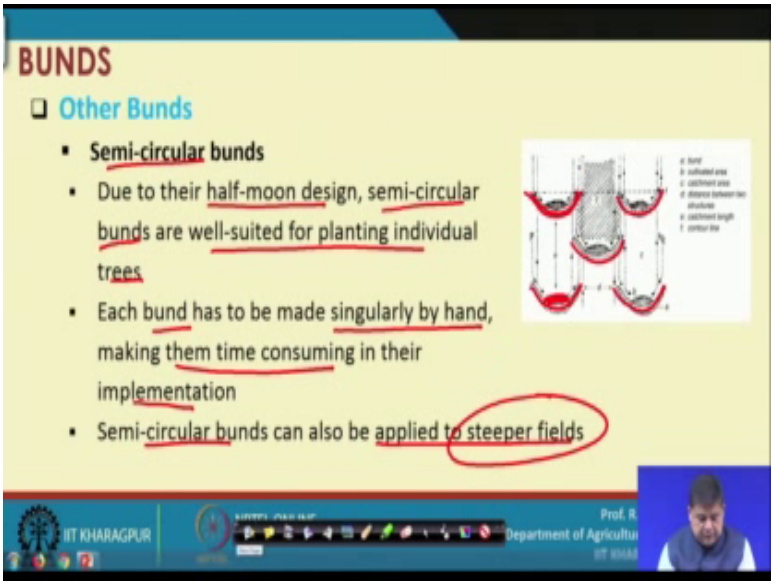

Another type of bund is a semi-circular bund. And as the name itself suggest, they are semi-circular shape or half-moon design. And they are well suited for planting individual trees. So, as you can see here this is how they look like. So, they are semi-circular or half-moon shape or half-moon design. They are built and then moulds are build here and trees are planted here; so, for planting individual trees.

And each bund because of their typical shape, each bund has to be made similarly by hand, making them consuming in implementation which is quite obvious as you can see that if you have if all these has to be build individually by hand so; obviously, the time required and the labour requirement will be much higher in this case.

And semi-circular bunds can also be applied to steeper slope, because they have their own catchment, and the shape typical shape which can store water behind the bund. So, even on a steeper slope they can be preferred as compared to the contour or greater bunds which we have seen earlier.

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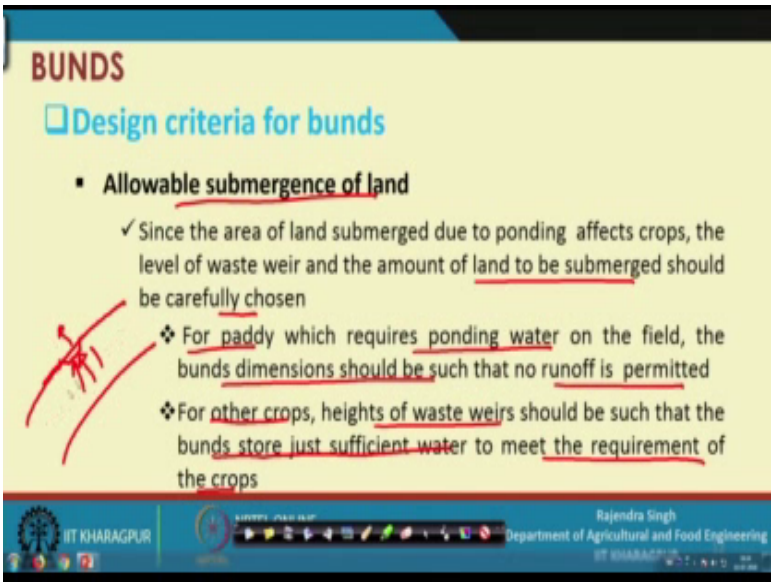

Then coming to the design criteria for bunds there are certain design criteria which we must always remember. Like, one is the allowable submergence of land. Since the area of land submerged due to ponding affects crops, the level of waste weir and the amount of land to be submerged should be carefully chosen. So obviously, we should allow only limited area to get submerged under different conditions. For example, if we have paddy which requires ponding water that is it requires ponding water on the field in general then the bund dimension should be such that no runoff is permitted. So, that means, we would like to store most of the water in between bunds so that water is standing what is there to sustain the paddy crop or to meet the paddy crop requirement.

But if paddy is not the crop we are growing for some other crop then; obviously, which may not require ponding water. Then height of west waste weir should be designed in such a way that bunds store just sufficient water to meet the requirement of the crops. So, what is done basically when we construct these bunds in the field. So, here what we will do we will provide some kind of weir here over which even if excess water is there that overflows and goes to delivery one. So, obviously, if the flow is allowed, but in a controlled fashion so thus; to allow just to see that not enough water is standing here to affect the crop production. So, that is how the submergence is important criteria while designing these bunds.

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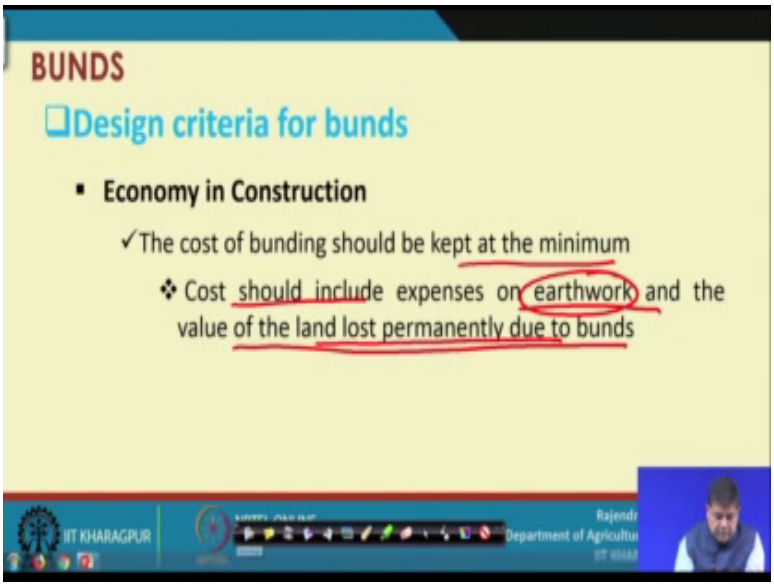

Then economy in construction which is obvious that cost of bounding should be kept at minimum which is; obviously, not only true for bunding, but for any measures that the cost should is always a major criteria. And here important thing is that cost should include expenses on earth work and the value of land lost permanently due to bunds. So, this is important that not only the cost involved in earth work while for building the building the or constructing the bunds that should be taken into account. But also the land lost permanently due to bund that also makes a component cost component which should be taken into account while calculating the total cost of any kind of bunding structures.

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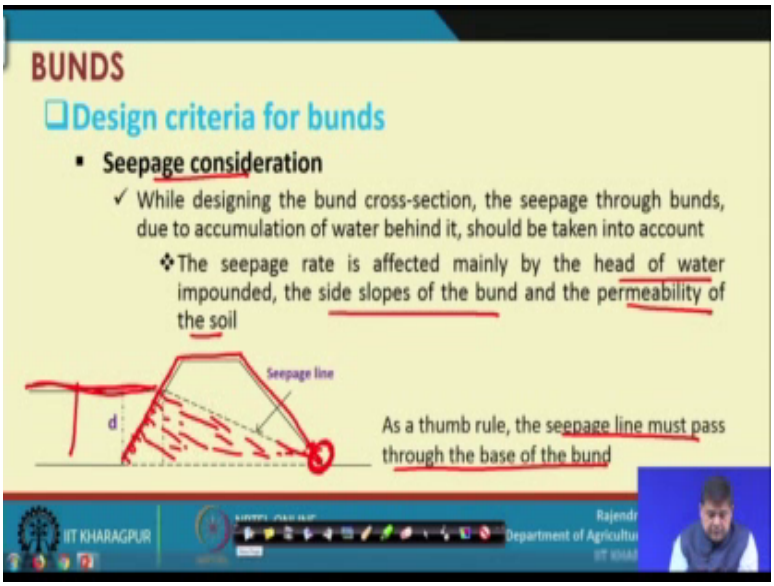

Then another very important design criteria for bunds is the seepage consideration. Typically, what happens is that when we have this kind of a design. So, obviously, we allow water to stand on the on behind the on the upstream side of this dam. So, once the standing water is there, and once the material of construction is soil then; obviously, some seepage will take place over this. So, this is basically referred to a seepage phase, if you have read little bit of soil mechanics probably you already know in case of earthen dams we handle this. That there is seepage phase through which seepage takes place and that obviously, this because it is standing water.

So, seepage will continue and the water will go further and further the seepage water. And it will wet the entire cross section. And this top fretting line is referred to as the seepage line. And in that case, what is done is, what is a important is that is a thumb rule; the seepage line must pass through the base of the bund. So, we design in such a way that this seepage line should never cross the downstream section, because if that happens then these two becomes susceptible to failure.

So, that is why we always see that the seepage line crosses through the base of the bund and basically the seepage that is affected mainly by head of water. The side slope of the bund and the permeability of the soil. So, these head this material of construction and this side slope that determines the seepage through the structure.

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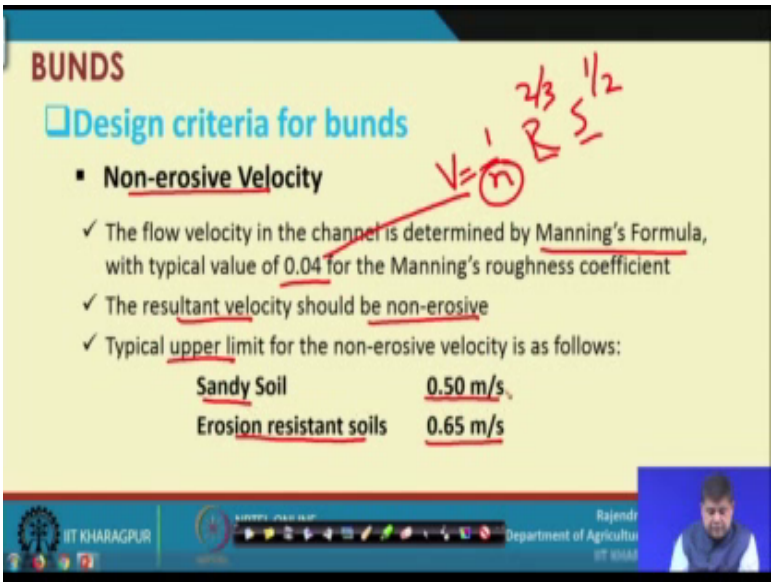

Then another important criteria is the non-erosive velocity. The velocity basically is used calculated using manning's equation which we know already one by n R to the power 2 by 3 S to the power half. And this is hydraulic radius this is the bed slope. And is the manning's roughness coefficient and typical value of 0 point 0 4 of this n is used for calculating the flow velocity.

And the important thing is that the result build in velocity should be non-erosive. And the upper limits of non-erosive velocity are for sandy soil it should be less than 0.5 meter per second, and for erosion resistance soil even for clay it should be less than 0.65 meter per second. So, wherever we have to calculate the flow velocity we use manning's equation. And then we have to ensure that the velocity is within the non-erosive limits that should be is showed.

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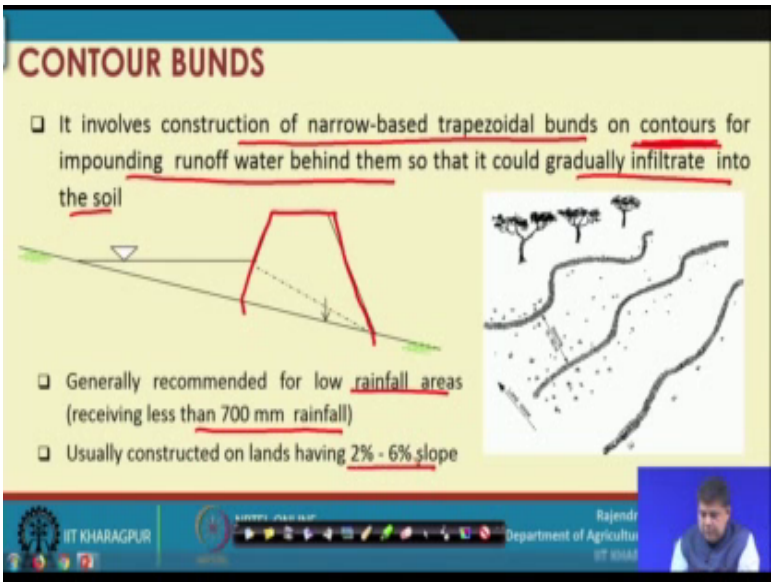

Then just to give you an idea about the two types of bunds we talked about that is contour bund and graded bund; which we will discuss in great detail later on. So, basically contour bund involves construction of narrow based trapezoidal bunds on contours for impounding runoff water behind them. So, that it could gradually infiltrate into the soil.

So, these are the important the underlined points are important. So, these are narrow based trapezoidal bunds. So, basically the cross section is trapezoidal that we are saying and narrow based. So, we should design in such a way that the base width should be as less as possible because, we already saw that when we construct these bunds, it results in a loss of cultivable land. So, obviously, if the base could be limited to certain extent then the loss of soil land fertile land cultivable land can be minimized. So, that we have to take into account.

And these are built on contours. So, that is why the name contour bunds. So, they are always constructed following the contours contour lines in a field. So, that is why I refer to as contour bund. And function is impounding water runoff water behind them. So, obviously, when this is there this is constructed water. So, whatever flow whatever rainfall occurs that gets stored or gets impounded behind the dam and, obviously, when it is allowed to stay there for longer time. So, it gets infiltrated into the soil.

They are generally recommended for low rainfall areas, receiving less than 700 mm rainfall which we have already seen in adaptability. The usually constructed on lands having 2 to 6 percent slopes, that that also we have seen already. In any case slopes should not be more than 8 percent.

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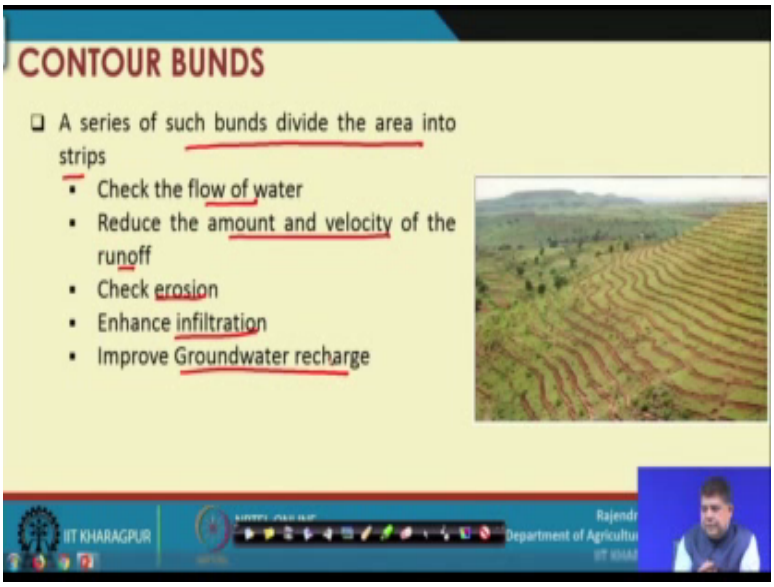

And the functions are the advantages whatever we say we have already seen. Series of such bunds divide the area into strips which we have already seen. Check the flow of water, reduce the amount and velocity of runoff, they check erosion they enhance infiltration and improve groundwater recharge. So, very similar already we have discussed the functions of a bunds. And these functions of contour bunds also are more or less in similar lines.

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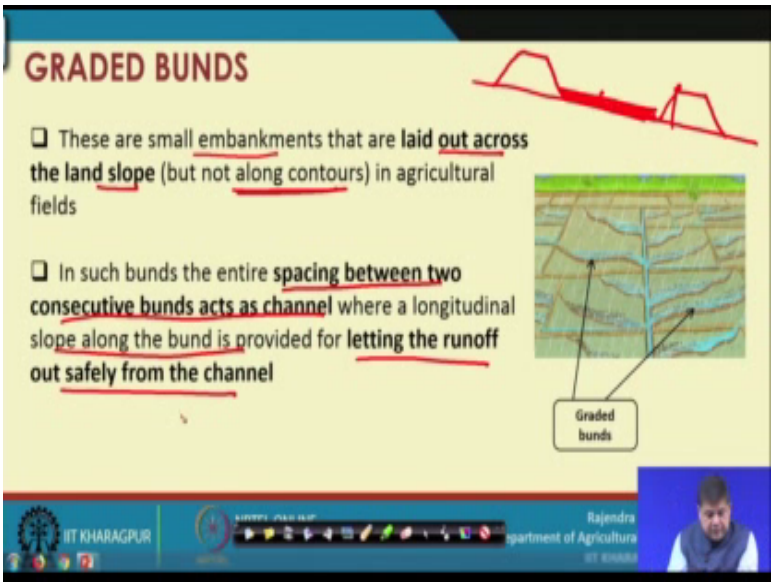

Then graded bunds these are small embankments. That are laid out across the land slope, not along the contours important thing is that they do not follow contours that is the graded bunds do not follow contours in agricultural fields. The entire spacing between two consecutive bunds acts as a channel, where a longitudinal slope along the bund is provided for letting the runoff out safely from the channel.

So, basically what happens suppose if this is the if this is the kind of cross section. And if we build 2 lines so, this portion what we are saying is this portion between these that acts as channel. Because you remember the function of graded bund is safe disposal of water. So, this entire thing one acts as a channel. And a slope is provided perpendicular to the board we provide a slope, longitudinal slope and we are talking about, that is perpendicular board you provide. So, that runoff out runoff water is taken safely out of at a non-erosive velocity.

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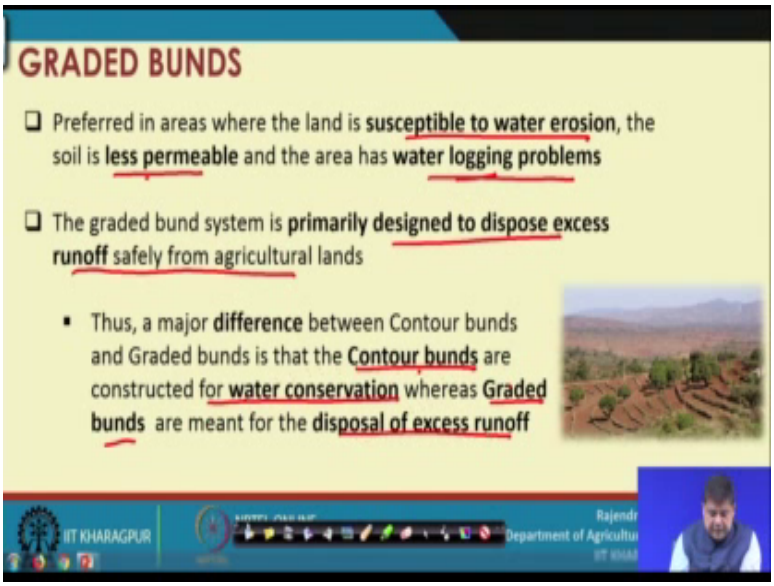

And these are preferred in the areas where land is susceptible to water. Erosion soil is less permeable and water logging problems are there so; obviously, soil is less permeable. So that means, if we stand for longer period time infiltration will not place take place and water logging will take place and that is why we go for graded bunds and primarily designed to dispose excess runoff safely from agricultural land. So, that is the main function.

So, major difference between contour bund and graded bunds is advances that contour bunds are constructed for water conservation, where graded bunds are meant for disposal of excess runoff. So, that you should always remember contour bunds, water conservation, graded bund, disposable or disposal of excess runoff.

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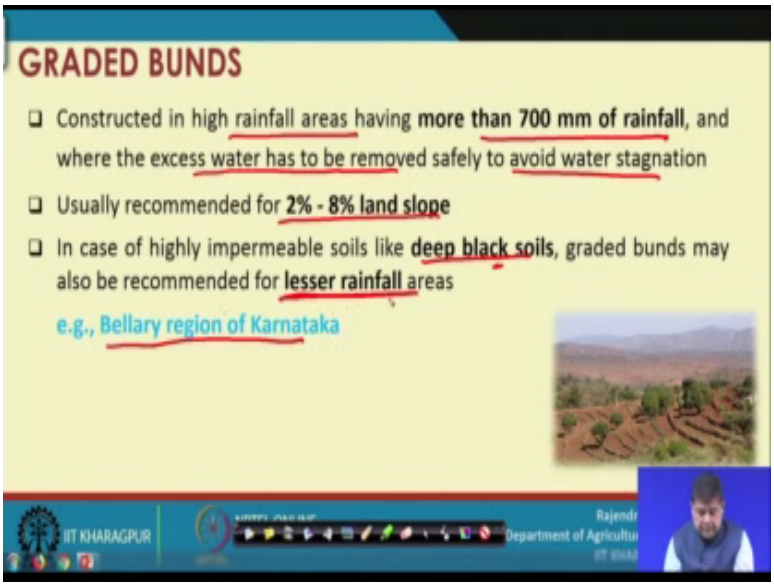

And these are constructed in typically constructed in high rainfall areas, having more than 700 mm of rainfall and where excess water has to be removed safely to avoid water stagnation. Land slope is 2 to 8 percent, maximum 8 percent we have already seen and if the soil is deep black soil or less permeable, then they can also be used for rainfalls lesser rainfalls or rainfall less than 700 percent, which we have already seen in adaptable table. And this typically for example, in Bellary region of Karnataka, where soils are deep black soils, we go for graded bund even though the rainfall is less than 700 millimetres.

So, thus we have seen water bunds, what are the types of bunds, what are the functions what are their advantages. And then we also saw based on functional requirements. There are two major types of bunds, contour bunds and graded bunds. And in future classes on this week, we will go through the details of these contour and graded bunds, and see how to design them by using the principles of design.

Thank you very much.