Water Management
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Lecture 21
Border Irrigation System

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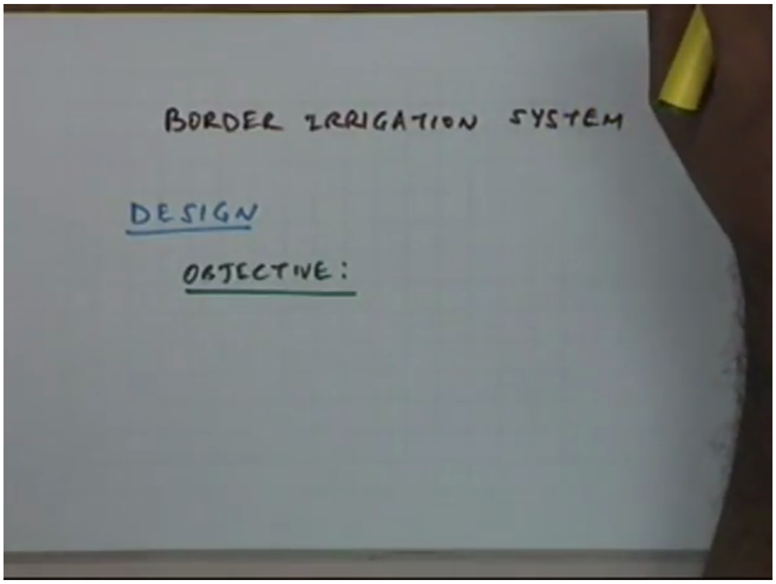

Okay. We will start with the new topic today, the topic of Border Irrigation System. Having looked at all the various possible methods which are being used in the present day context and some of those methods are age-old methods, we will start looking into each individual method and going to the depth even those old methods, for example, the border irrigation method is old method. But we will try to look at how we can make use of the present knowledge to refine those methods, to make those methods more efficient and based on better principles the design parameters have to be evaluated. So that is what we will go into.

Now I do not want to again repeat those things that what the border irrigation method is. We will directly start with the design aspect. How we look at the design aspect? Which are the various design aspects which we will have to concentrate on? And that will be quite inline. So if you think of the design aspects, you have to first look at what is the objective of your design. Objective of design in this method or for particular purpose in all the methods which we will look into, the objective will remain same. So it is more important to first clarify what is the objective, with what objective we are trying to go into the design aspects.

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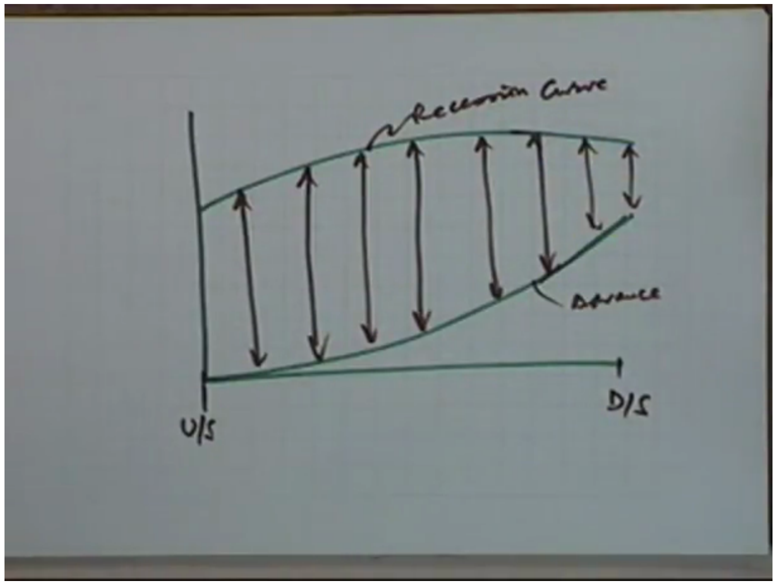

And this I think if you remember we had discussed this in detail and we had said that if you take the help of the two curves, the recession curve and the advanced curve, this is the recession curve and the advanced curve, these curves are characteristic of other parameters. For example, this will be depending on what type of soil you have, what type of slope is the prevailing slope and along with that what is the stream size. All those things put together, they will decide what is the advanced curve.

In this, if you look at this total picture, we had also mentioned that at each individual point, this is the upstream end and this is the downstream end of the field. This is the field. Along the field at each individual location, we can know what is the opportunity for the water to infiltrate into the soil and thereby get absorbed into the soil is the function of what is the difference between these two curves.

So the first objective and the only objective which will satisfy all your other requirements will become that if we can find all those techniques or all those possible settings if we can make so that we can get a balance between these two curves in such a way that these two curves produce opportunity time along the total length of the field which is comparable from one to the other opportunity time.

Or in other words, if these two curves are parallel to each other, the more they are parallel to each other, you will have the chances of opportunity time being seen, those chances will increase. So as you go further down, if you will try to go further down, you will find that the opportunity time is reducing. And this opportunity time on what basis it reduces? This is all a function of the other set of conditions which are prevailing in the area, in the location which is your target location.

So that is what are when you are looking at the design, you have to first consider all those conditions which are important conditions from this point of view and then evaluate what will be the possible recession in the advanced curve and then come out with the design parameters which are many. For example, to give you an idea when you say design parameters, they are some parameters which are in your control. So if you change those, the whole concept or all this, all these details will also change.

For example, if you change the stream size, your advanced and the recession curve is going to be different. If you change the, that is immediately in your control. You can afford to, your maximum might be dependent what the irrigation department or what is the maximum capacity available at that particular location. But below that is under your control. You can always reduce your stream size lower than what is available at that location. So there is one option. Then you can also think in terms of shaping your area to get a different grade.

So if you change the slope of your field, then again you will get different set of curves. That is something which you can take a decision at the time of when you farm your land before the sowing is done, when you are preparing the field for the sowing. So at that time you can decide do you want that grade or you want different grade. Again that is in your control. Now when it comes to the soil type, it might not be in your control.

But to certain extent, by doing some cultivation practices you can slightly modify the behavior of the soil by doing the (())(09:06) process. All those things, all those different procedures can help the farmer to certain extent but not to a very large extent. If the basic type of the soil is, some if it is silt soil, it will remain silt soil. Or by adding them the manure you might be slightly modifying the characteristics of the soil, infiltration characteristics of soil or the moisture holding capacity of the soil.

Those are only slight modifications. So they are some out of the total set of parameters. For example, in this case now the size of the field, what is the length of the border which you will select in this particular specific case when you are looking at the border irrigation system? The length of the field will be again in your hand. As a farmer you can decide what is the maximum length of the field which you should be selecting.

So out of the total set of parameters, there are some parameters which are easily manipulated, there are some parameters which are not as easily manipulated. So once you decide on what is the, what is your preferences, how you want to, which parameters you want to restrict and which parameters you have the flexibility, accordingly your design will be, you can use the design procedures and find out the set of dimensions with respect to the other selected conditions. Okay, that is the whole gambit of the total this design procedure which we are going to look into.

Now with that objective let us try to look at the various other quantities which will be requiring when we go in for the design and which are very important, which we have to consider. We cannot help, we cannot proceed without those quantities, those items. The first of thus, though we have discussed all these things in some form or the other, we will try to just look over, consider those things once again.

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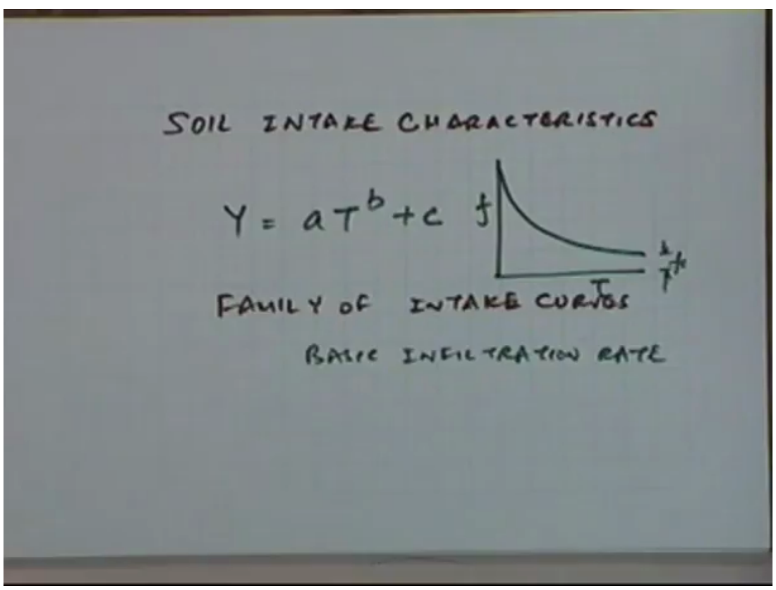

The soil intake characteristics, this we had discussed in detail when we are, when we were discussing the infiltration process. So that time we had mentioned that soil intake characteristics and the area of irrigation water management, we are basically interested, more interested in the accumulative infiltration depths. We had also mentioned that this we can express in the form of this equation. This we have discussed already.

Now this accumulative intake equation is used because at any time we want to know what is the value of infiltration which has taken place at a particular location with respect to the opportunity time. So this time is the opportunity time, this is the time for which the water availability was there on the top of the soil surface. And the other a, b, c are the coefficients which can be evaluated for a particular soil, which means that when you talk of the accumulative infiltration depth, because basically the accumulative infiltration depth is nothing but indirectly is your demand.

That is what you want to store into the soil which has to be used by the crop ultimately. So when you look at this equation, this equation is dependent on what type of soil you are talking about. And with that thing in mind, it is quite difficult to evaluate these parameters every time. Every time you go in for design, you might not, might find it difficult to have these a, b, c evaluated for that specific soil.

What the soil conversation service of US department of agriculture, they came out with the set of family of intake curves. And this I had shown you at that time when we were discussing the infiltration process. The set of intake curves, what they are giving? They give us the characteristics of the soil intake with respect to the specific type of soil. So if you know your soil type, you can find out what will be the various parameters of this equation.

This is available in the form of coefficients, is also available in the form of actual curves, in the form of a plot or the set of curves which are plotted on. And they can be used directly. These family of intake curves, what do they mean? What has been done is that we had discussed that every infiltration curve if we take the infiltration capacity curve, this is the rate of infiltration versus time.

Depending on the soil characteristics, the infiltration capacity or the infiltration rate which is the capacity rate, that gets a specific value depending on the type of soil you are considering. This steady state infiltration capacity rate, we had called it basic infiltration. Basic infiltration rate is something which is unique for the soil. For a specific soil, you will get a steady state infiltration rate which will remain same, which will remain similar irrespective of the condition of the soil because that is something which is achieved after a long period under the conditions when the soil becomes quite saturated.

And that is what has been used to designate these families. The family numbers have been given with respect to the basic infiltration rate. So once you know the family with respect to the basic infiltration rate which is unique characteristic, then you can find out what is the relevant. For that number, this has been drawn, the (infiltra), the accumulative infiltration curves have been drawn for that basic infiltration rate number. The family of numbers, the intake curves have been given numbers which are dependent on basic infiltration rate.

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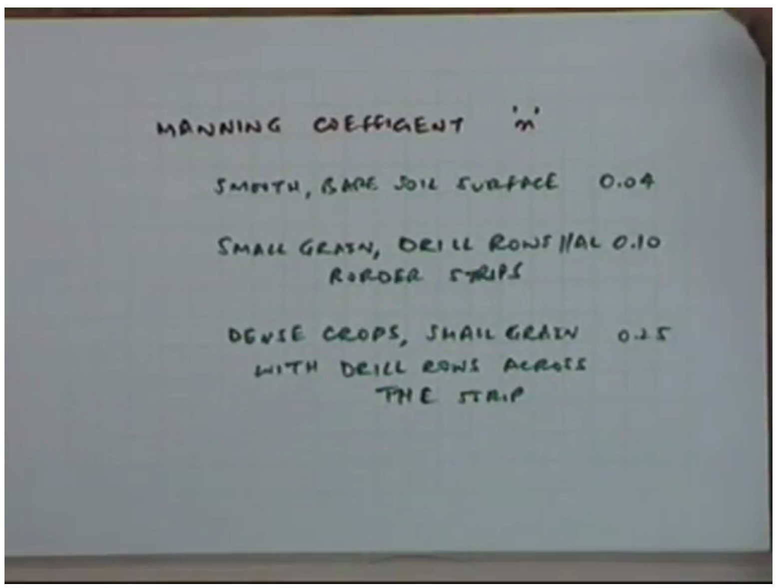

Okay. Then another parameter which is quite important and you will be using quite often is the Manning coefficient of roughness is normally designated as ‘n’. Now whenever you are talking in terms of the flow characteristics, it will be highly dependent on what is the roughness coefficient. And the roughness coefficient varies a lot in the case of agricultural fields because the fact that agricultural fields, they go from change of surface which is experienced on the fields is so much different and it varies from the time of preparation of the fields to the time when the ultimately the crop is cultivated.

So you will find that this one parameter and it needs a very good evaluation. You need to know this parameter quite closely. You have to have reasonable values evaluated for this parameter because if this will go wrong, all your computation which you are making during the process of your design, they will also have a tendency to go wrong and will give you some inferences which are not a true reflection of the actual conditions.

To give an idea, you can see that the variation, how much it varies. Let us take the case of a smooth bare soil, value of and can be 0.04. If you take small grain crops and you have drilled the rows parallel to the strips, value might be 0.1. If you change the way you have done the sowing, because in the case of it depends how you have sown the area, so if the sowing is done in the perpendicular direction, you have drilled the holes in the perpendicular direction of the border, then you will have a value, let me say dense, either you have dense crops or you have small grain crops with drilled rows across the strip. The value can be as high as 0.25.

See the variation that with just the way you have planted the crop, that is also going to make lot of difference, is going to create lot of resistance to the flow of water and that has to be taken into consideration. So the n value, the Manning coefficient is a very important parameter and all your computations are dependent on this one parameter. It can make lot of variations, you have to be careful about this.

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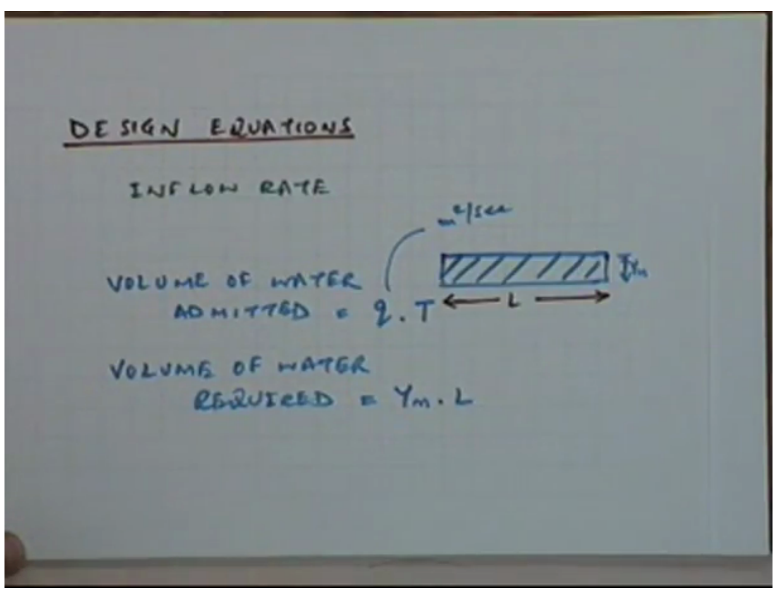

Now let us come to the design equations: how you proceed with the designs. The first of most important parameters which you might like to look into is the inflow rate. What should be the inflow rate or what streams size you should select? One option is that you have fixed stream size where you do not have any option available. You might have to use that and that is the streams of, as such the stream size is quite low. You do not have any option available because you cannot go to a very low value of stream size.

What we will do is that we will first look at, we will have to look at the various design parameters from different angles. First we can look at the various equations which can be used. Then we will try to formulate some check conditions which can be used to check whether your design is appropriate or not. Okay?

So considering the inflow rate, let us try to consider a strip and try to find out what is the volume. If I assume a flow rate of q and I know that what is the opportunity time which is required, because when I start irrigation I am aware of how much is the net irrigation requirement. We have already discussed that the net irrigation requirement is because of the deficit which has been created in the rows and that. So how much deficit has been created at the time when you are deciding to irrigate and that is a function of how much deficit can be tolerated by the crop.

So once you have found that this is the deficit which can be tolerated by the crop, you decide, you have to go in for irrigation. At that time how much is the amount of deficit that you either replenish the total deficit or you might decide to replenish deficit partly. So in that case your depth of irrigation requirement will be less than the total deficit which is available at that time. Okay. But at the most it can be.

So in any case whatever is your decision, I had given you the concept of the deficit which is a function of the management decision. So that is what we are discussing. Let us not go into that. Let us try to assume that whatsoever is the deficit to be replenished, you know. So indirectly you know what is the opportunity time required to take care of that deficit. So if this T is known and you know, you assume that q is the, sorry, if you assume that q is the stream size or the inflow rate, in the case of border irrigation, the q is taken in terms of rate per unit width.

So this q is available in terms of meter square per second. Okay. That is what is the volume which is needed to be admitted into the field and this will give you the total volume. The discharge rate into the time, the opportunity time for which the water has to be limited, this is only one approximation. We are not looking at the other things. We will introduce the remaining concepts also, the remaining requirements which are taking care of the other efficiencies that we have not yet considered.

We are trying to look at what is the volume, the minimum volume you can say which needs to be admitted if this depth, whatsoever is the depth it has to be taken care of. So this volume should be equal to this volume. Similarly on the requirement side, if I want to know what is the volume of water required, it can also be given in terms of this depth. If I say that this depth is Yn, this much depth over the total length of the field, the length of the field is L, this is the volume of the water required per unit width of the border. Okay?

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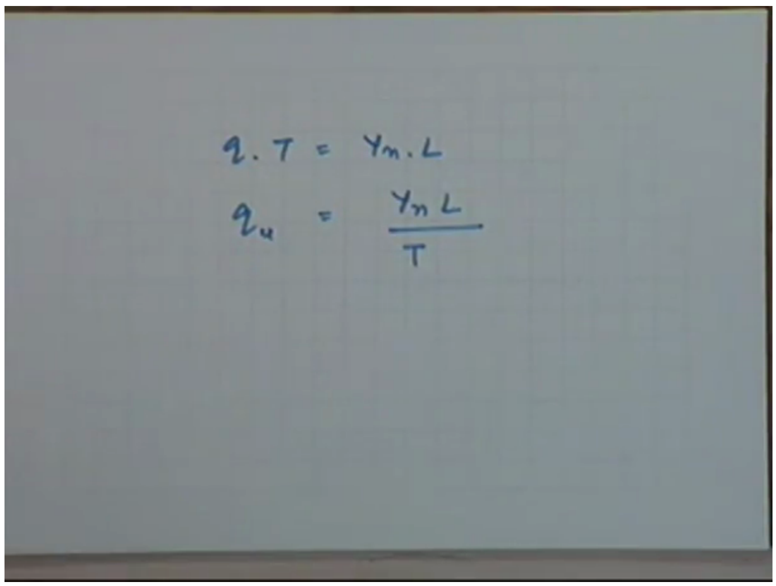

I can use this water balance or these two should match. Basically these two quantities should match. So you can say that q into T should be equal to your Yn into L. This is the first design criteria. This is the first design criteria which you can take, which you can consider. And you can find out now, you have found a relationship between the two, you can find out any quantity knowing the other set of quantities. Now here comes a decision what you know and what you want to find out.

So let us assume that your interest at this stage, the inflow rate, you want to know how much should be the inflow rate. And the inflow rate, let me call it qu to make it per unit width, this will be equal to Yn into L by T. Now this T is the time, is the application time or this is the opportunity time.

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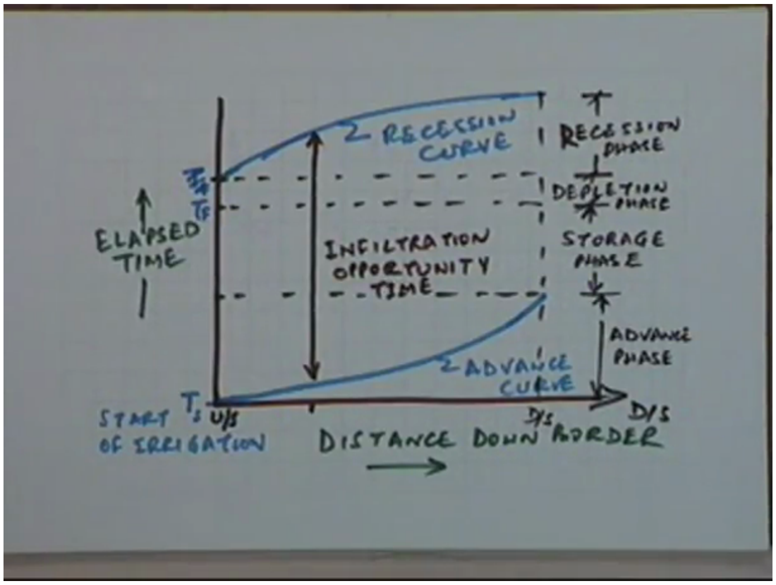

Let us come back to this figure which you had used earlier, you had constructed where we are discussing the total process of irrigation. When we really apply the irrigation, what are the various phases of irrigation? And we had said that when we start the application, there is the time to start and then we keep on supplying the water at the upstream end. At some time, we stop the application, that is the time when you finish the application.

So Tf was corresponding to the time when you have finished application. If I see from that point of view at the upstream end of the border, for how long I have supplied the water only from this end, from Ts to Tf? But for how long the water has been available at the upstream end? Water has been available for some more time because the fact that the water when it was supplied, a depth of water got accumulated over the surface. There was some retention of water.

There was some depth which got accumulated over the surface and that is a function of what are the characteristics, what is the slope of the field. And that, depending on those characteristics, there will be some depth of water which will be established at the top of the surface and it will take some time to deplete from that particular location. And that is what we had said was a depletion phase. So if we, if you are interested in the total opportunity time, the total opportunity time is different than the time for which you require to supply the water. That is the point which we are trying to make.

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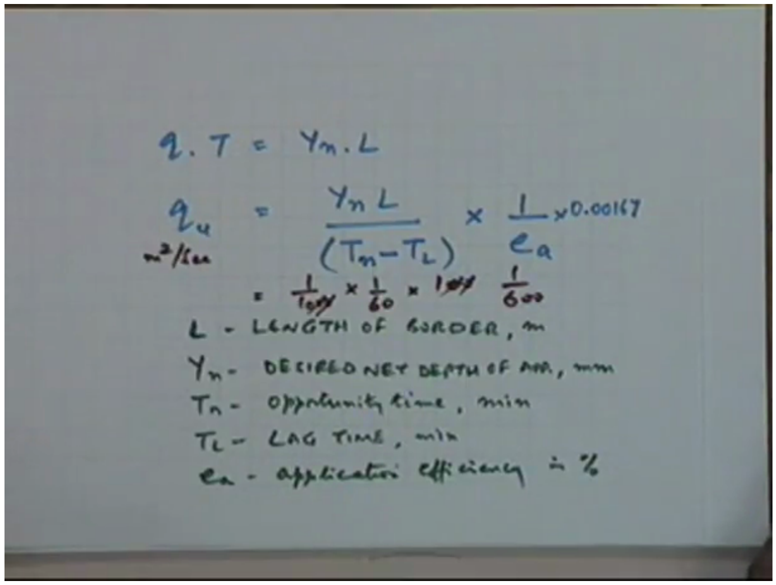

So there is some time which is, if I say that I want to introduce that, but for how long I have to? Because this qu should be a function of the actual time for which we are supplying the water, not the time of, the time, the opportunity time for which the water is standing there because we have seen that water keeps standing there for some time over and above, the time for which we have applied the water.

So if I want to account for that, then I should introduce that, this if Tn is the total time, total opportunity time, I am reducing the lag time which is because of the depletion phase. This TL is we will introduce those quantities: L is the length, okay let me use this, L is the length of the border strip. If we stress that in meters, Yn is the net depth of application and normally this depth we express in millimeters. And Tn is the opportunity time, this is expressed in minutes. And TL is the lag time, again in minutes.

So the lag time is the time for which the water will be available on the, at the head end even after the water supply has been stopped. Okay. Now that is the, we have incorporated that here. Plus, we can also incorporate the efficiency, the application efficiency. We had considered that while applying the water. To achieve this you might need to apply some more water. So it is a function of how much application efficiency we are achieving.

Depending on the application efficiency you can use that application efficiency to find out how much is the intake rate which is desirable. So now this becomes a modified equation where you have ea is the application efficiency in percentage. Now because of the units which we have used you will find that you will have to use some coefficient which has to be evaluated. And that coefficient you can find out.

Okay, let us do that here. Your qu you want and if I say that qu should be in meter square per second, okay, Yn is in millimeters. So if I make this as meters, L is in meters, no problem. Then Tn is time in minute, so you want in seconds. So you divide by 60 because the seconds are, this is to be converted into second. So basically minutes to seconds and what else? You have that ea in percentage instead of a fraction. So you will have to multiply or divide this by 100. You multiple it by 100. Okay.

That is a fraction which will be getting, this fraction is 1 by 600. So you will get a fraction here, into, if you use these units, this will be taken as 0.00167. Is that all right? Is it okay? This equation now, the qu equation is transformed into this equation which where you have taken care of the dimensions, you have taken care of the efficiency, you have taken care of the lag time. And that can be used.

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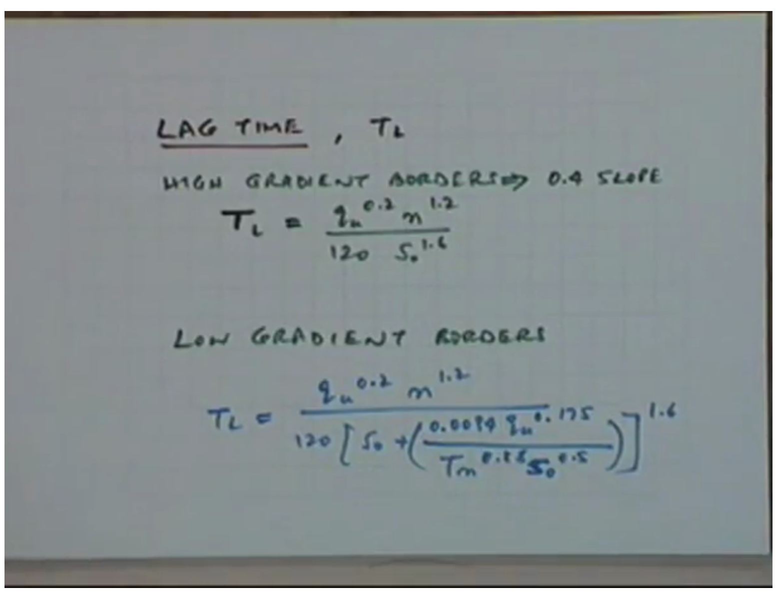

Let us look at the lag time. One way is that you absorb the lag time but for every condition unless you go in for the evaluation procedures, again that also we will try to deal with. For every irrigation method there are two ways. One is that you go into the field, perform the irrigation and absorb the data. So that is experimental method but that you cannot afford to do every time under every situation. What is being done is that you are collecting the data through those evaluation procedures and then you are trying to establish the relationships. And then you are, on those relationships you are extending those relationships to find out how those relationships can be diversified to cover all the possible conditions.

Practically it is not possible to cover each individual condition. And if there is a variation, how those conditions will be changing, conditions will be, can be taken care of without going in for the actual practical procedures, that is what we are trying to establish. But basically they are, many times they have been checked, they have been, still there are some experimentation which is being done all over the world in various agricultural universities, in various other agencies where they are trying to improve upon these procedures.

And the set of relationships which are being given, they are also being evaluated, being updated. And we are trying to, is always easy whenever you are talking of a design procedure to have set of procedures which are analytical which you can use comfortably with the help of your system or even manually you can afford to handle those. In the case of lag time, the two possible conditions have been separated out.

One is, because the lag time of the recession, the depletion phase will be a function of what type of slopes you are, what are the prevailing slopes. Or, it will be depend, it will be as, it will be of a value which will be dependent on what is the normal depth, how quickly you achieve the normal depth in that type of flow and which is a function of slope. The slope is the predominant parameter in this particular case. So the two conditions which have been classified, first when you have the high gradient borders and the high gradient borders are the value which has been taken, is that anything steeper than 0.5 or 0.4 percent slope is termed as high gradient border. So if you have the slopes which are steeper than 0.4, then you will use this relationship.

And this qu, we have clearly defined is the intake rate in meters, meter square per second. n is the Manning's coefficient. S0 is the slope of the land surface, so is the slope of the border strip. In this particular care when the gradient is high, you will find that and this is basically this is derived from the Manning's equation. In Manning's equation your S0 is not the land slope, is the gradient length. So what you are approximating is that if the gradient is high, you can take a slope, the land slope can be approximated to the energy-gradient slope.

Whereas this would not be so if you have the gradients which are low gradients. So in that case if you have low gradient borders in which the slope is, slopes are less than 0.4, then your the relationship which is used for the lag time is similar relationship as you had here the other relationship. But it is corrected for, then adjusted the slope of the, the slope is not, cannot be taken as the land slope anymore, that slope has been corrected.

This is the final expression. You see here that this is the additional, this is only additional component which is nothing but it gives you the correction to S0 because in this particular care what is happening is that the normal flow is not reached that early, it takes, it might not be achieving the normal flow. So in that situation you will find that the energy-gradient line and the slope of the field, they will not match.

So the lag time can be, you can use the lag time equation depending on what type of conditions you are having, what type of slope is the prevailing slope and that can be for your design purpose.

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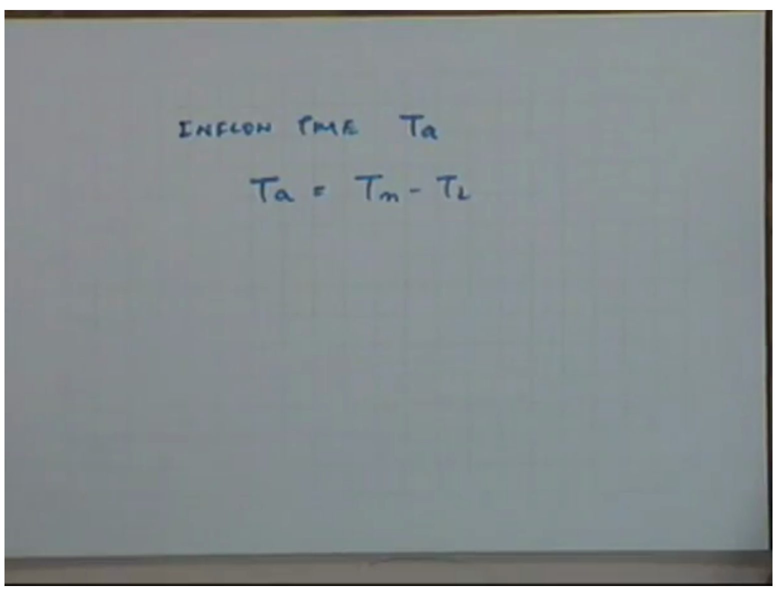

That means that your inflow time, we can call it as Ta. Inflow time for any particular location of the field you can evaluate knowing that how much is the total net time, the net opportunity time and correcting that for the lag time. We will stop here because then we will next time, in the next class we will try to cover the other aspects of the design parameters which can be considered, which are the possible options available. And then we will also deal with the other quantities which are the check quantities.

What happens in this particular case, you have to ensure and the design parameters can be misleading at times, you might get a value of the intake discharge which is not suitable value from the practical considerations. And there is no provision in the design equations to give you a value, there is no check which can evaluate that whether the value is the permissible value or it is some value which is not spreadable.

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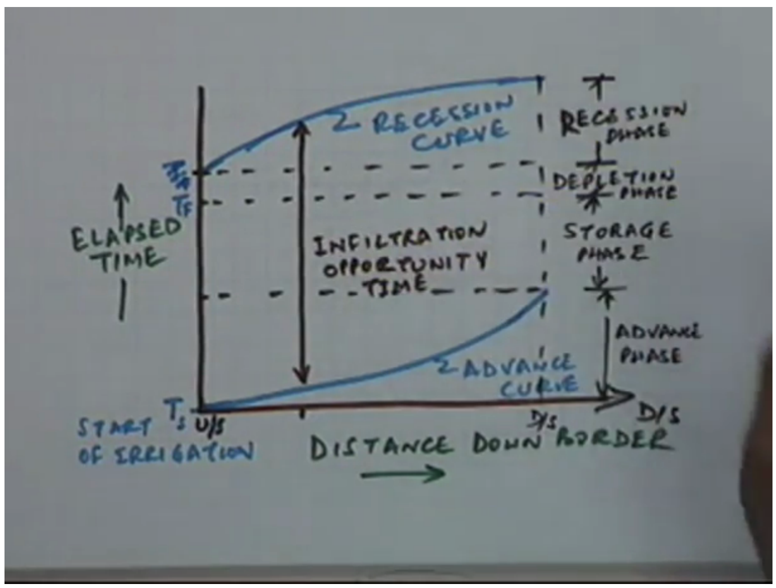

Consider a value which is very low value and you will find that the basic impact of that if you will try to see on this it might give you advanced curve which will become a very sharp, it can be something like this. It can have a very steep slope because of the fact that the water has taken a lot of time to reach the downstream end. If you would have used the stream size which was reasonable size for the same slope, you would have got advanced curve which is something entirely different because the shape of the advanced curve is dependent on the soil characteristics as well as on the stream size, as well as on the slope. So these three things put together will decide what is the advanced curve.

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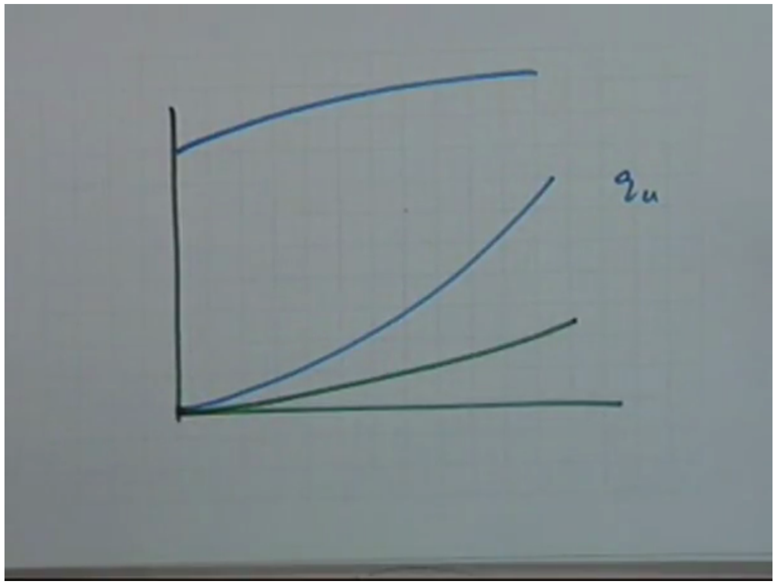

Let me give you an example what I am trying to bring home the point is that if you have one case where the stream size is very low, you might advanced curve which is this. And let us assume that we know the slope for a particular set of conditions, this advanced curve if everything else remains same, only the qu is sent. By changing that qu you can get another advanced curve which is something like this. Now as well as the recession curve is concerned, recession curve is not entirely dependent on the features, what was the flow available or what was the size of the stream, is a function of what has been established on the surface, how much retention store has been established and how it will deplete.

So it might not change very much under the similar conditions when you have these two stream sizes. The recession curve still might be something of this nature. If the recession curve remains similar and this changes drastically, in one case you are getting the opportunity time which is highly different from this end to this end. And the other case, by just changing the stream size you are able to have the opportunity time which is now almost parallel. So that is what you will select. That is what is your intention.

When you go in for the, when you are looking for the design parameters, you are trying to find a combination which can give you this, the set of these two curves so that your opportunity time is not varying very much from one section to the other section of the field. And once you achieve that, then you are indirectly achieving uniform distribution. Okay? Any question? Thank you.