Water Management
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Lecture 28
Furrow Irrigation System

Okay. Having looked at the various relationships which can be used for the design of furrow irrigation system we will look at another aspect of the system design. Let us put a question to ourselves that what is the guarantee that the parameters which we have obtained from those relationships are those the valid parameters when you will be applying those parameters in the field?

So quite often it is required that we should check those parameters and try to define some procedure by which you can check those parameters. We had seen that in the case of border irrigation design also that we had gone for the field trials or the field evaluation. Similarly in this case also we can adopt a similar procedure to check those parameters which we have obtained, whether those parameters are close to the parameters which you actually obtained through the field trials.

If they are, well and good. If they are not, then you will have to revise some of those parameters depending on what are the actual conditions because many times what is the reason behind? If you look at the reason behind, you are trying to use the relationships which represent the conditions in the field. So that representation if it is faulty or if it is not, is always dependent on some observations which we have made at some discrete points in the field.

If those are not proper, then you might get some parameters which are not representative parameters because many times you might be basing all your criteria on the infiltration observations which you have made. Those observations they belong to certain point locations in the field. So when you do the trial run, you will be able to verify those parameters.

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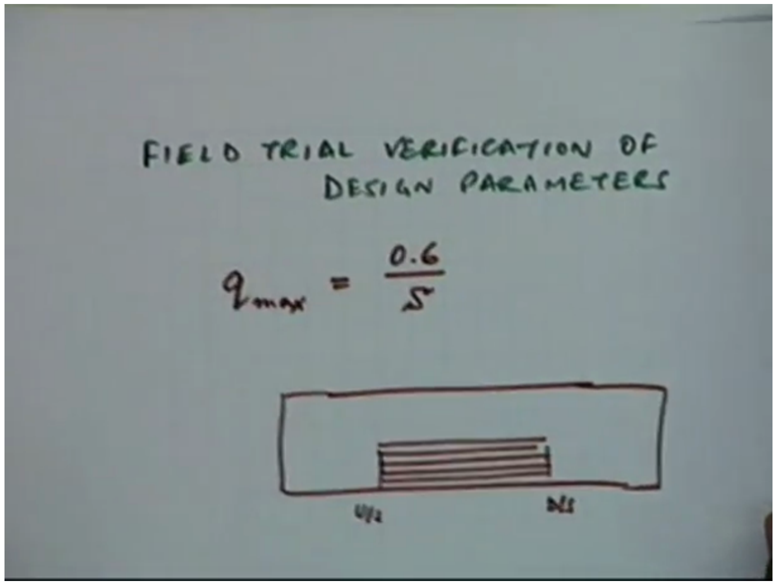

Let us have a look at the field trial verification procedures of some of the design parameters. In the case of furrow irrigation the first which you want to find out is that what is the maximum stream size which should be taken and you have used this relationship to find out that q maximum. Having obtained this q maximum now you set up a length in the field which is representative length of the furrow field and select around four to five furrows. For example if you have, this is your total field having different furrows.

You can select some segment maybe somewhere here where you can, you have this is upstream end and this is the downstream end where you are making the measurements. And then you select some of the furrows. So you have selected a representative segment of the total field. And this segment is the portion of the field where you will be making the observations so as to check the various design parameters.

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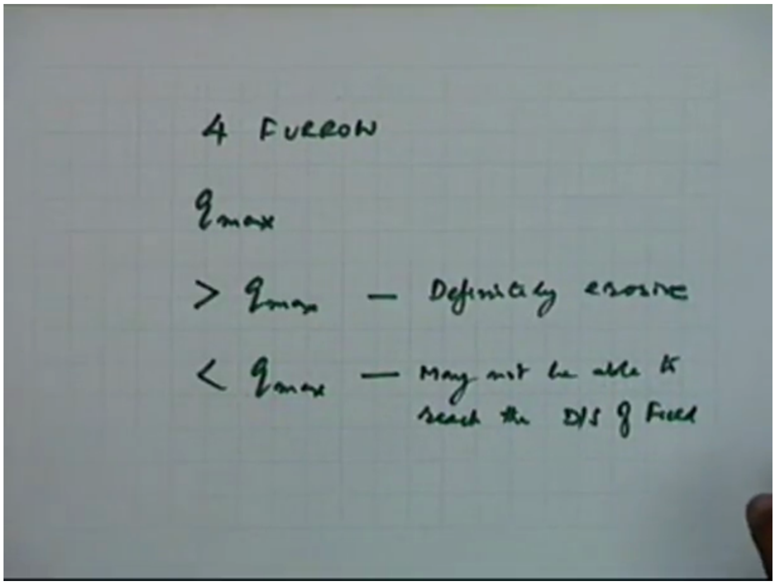

Now the q maximum which you have obtained, so let us assume that you have selected four furrows and you have q maximum which you know, which is a desirable stream size which you have obtained from the relationship. Now select four different stream sizes in such a way that some of them are more than q maximum and some of them are less than q maximum value. The one which is less, you try to select one out of these which hardly, which may not be able to even reach the downstream end of the field.

So solo you are trying to select those stream sizes which are extreme stream sizes. The one which is very low and on this side you might select one which is definitely erosive, so as to have a range of these stream sizes because you want to make the observation that how the movement of water will behave with respect to these different ranges of the stream size.

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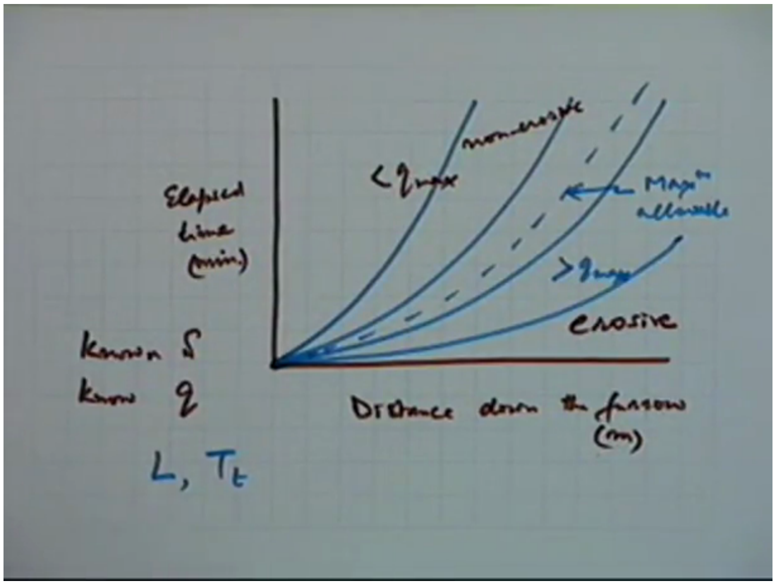

So once you have selected stream sizes, you make the observations. The observations are only made in terms of the elapsed time. But how the waterfront moves from the upstream end of the furrow to the downstream end? So you plot these with respect to the distance down the furrow. This is in meters. This is in minutes. Depending on what sizes you have selected you might find that you are, once you plot those you will get a family of these advance curves belong to different stream sizes.

For example, this is, if you take this as the, you might now be able to observe one. If you have many of them you might, out of these you might know that which is the one which is the maximum allowable stream size as you want to select one which is non-erosive. Okay. That you can call as the maximum allowable stream size. Here you will have all these stream sizes will be, this will be more than q maximum if we call this as the q maximum.

Now you can also match that whether the q maximum which we have obtained from the relationship, from the empirical relationship, does it match with the allowable maximum as per the field conditions or not. That is the first check. So if you find that maximum allowable is different, choose that as the maximum allowable. And the others now, these are the sizes which are greater than q maximum and they will be creating erosion in the field.

And on this side of the, this is maximum allowable, these are the stream sizes which are less than q maximum and they are non-erosive. At the same time they are of course non-erosive but we have seen that to have less of deep percolation you should try to have the maximum stream size. The FAR which we have seen, we can, we have seen the justification. Now having obtained this family of the curves, now this family of curve is with respect to non-slope and non q values. You can always use iterative procedure to find out what is the length to be adopted and what is the corresponding time of advance.

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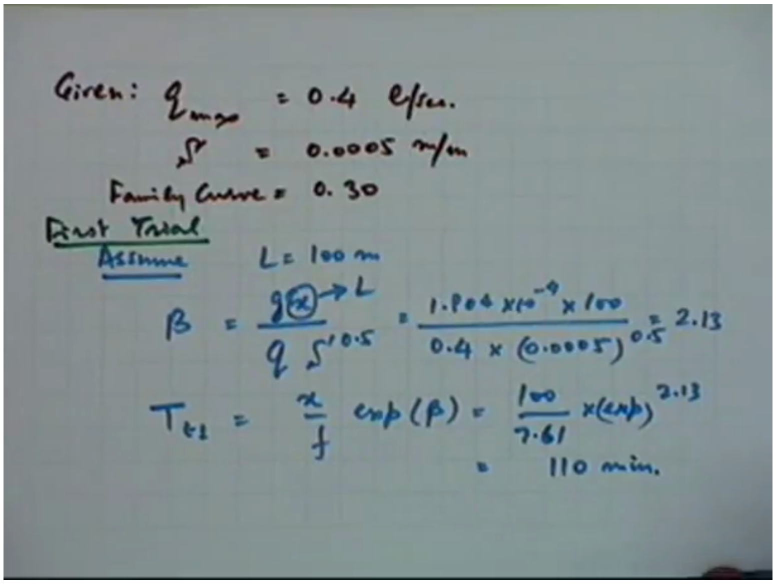

To show you the how you do the, use the iteration to find out which are the proper parameters, let us take one case where you have been given data as that q maximum is 0.4 liters per second, the slope of the field is also given and the family curve or the properties of the soil in terms of the family curve is known. So once the family curve is known you know all the coefficients, a, b and c. So now as the first trial you have to make trial runs. Assume a length of the field, let us say we assume 100 meter length. Let us call this as the first trial.

You can evaluate beta since we know the values of all these parameters. g is known since the family curve is known and the x is 100 meters that is what we have taken as the segment of the length. So x is basically the length of the field considered. This is the value of g with respect to the family curve, into 100 meters and q is known to be 4 liters per second, 0.0005 to the power 0.5. And this is 2.13. Now with this beta you can find out what is the advance time. I will call it T1 because this is the first trial. This is given as, all these relationships we have seen earlier. So this will evaluate to be into exponent of beta is 2.13. This is 110 minutes.

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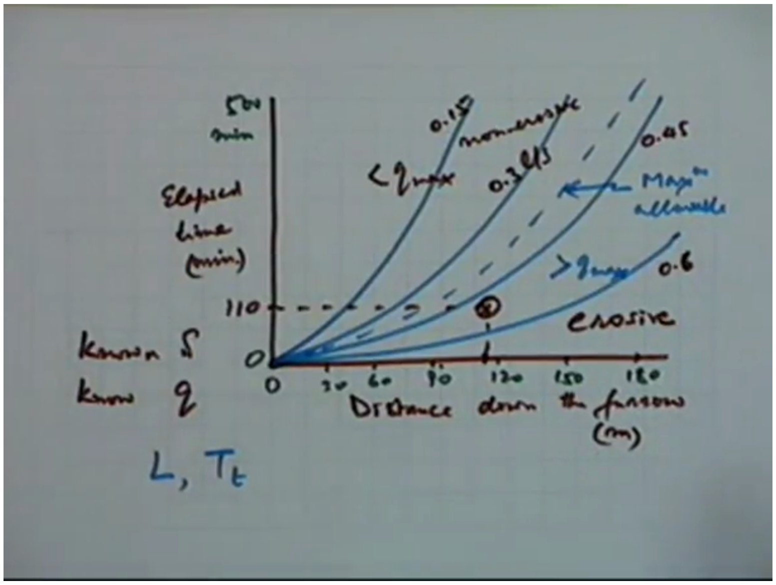

Having found this advance time let me assume that when once I have found out the stream size, if the stream size is 0.4, I have taken this stream size to be, I have chosen these stream sizes for which the family curves have been plotted. These belong to these values: 0.15 liters per second, 0.3, 0.45, 0.6. Okay. So let us assume that these belong to the given case we have just taken. And let us give some values to distance and so on. I am just trying to sketch it in a rough manner.

And the time, elapsed time is from 0 to 500 minutes. Now in the first case when I have found that the advance time is 110 minutes. So for that case I find out for this advance time and the distance I know. The distance taken is 100 meters. If this is the 100 meter distance here, I try to project it. And if this belongs to 110 minutes, I find that this point lies much below the maximum allowable stream size. This point with respect to these two parameters, if I take 100 meters as the length of the field and for which the advance time with respect to the given parameters is 110 minutes, then this point lies below this, the maximum allowable which suggest that if you use these parameters you are going to get the erosive conditions.

So that means either the length is not proper or, since length dependent on the advance time or the advance time is dependent on the length, is the either way, they are both interconnected. So I can take another length as the second trial. That means this particular condition is not acceptable.

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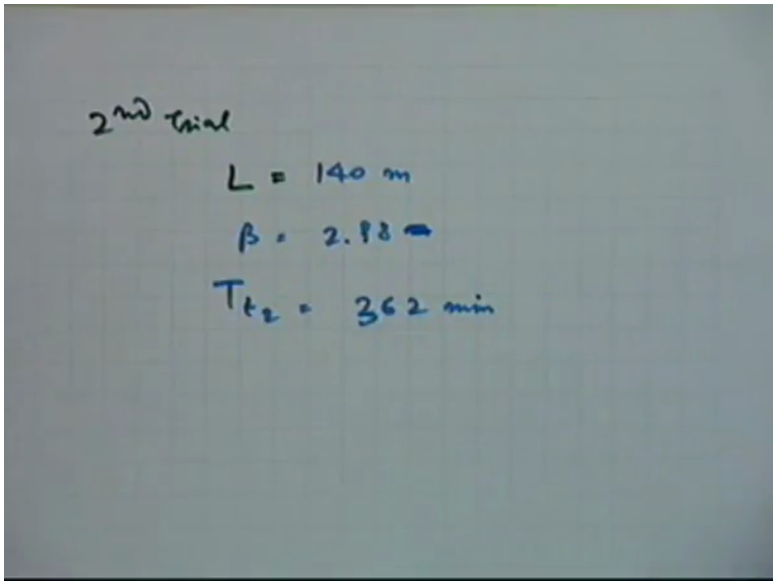

I take the second trial and assume a length which is larger than the previous case. Take a length of 140 meters. Now for 140 meters length, beta gets evaluated to, sorry, 2.98 and the corresponding advance time is 362 minutes.

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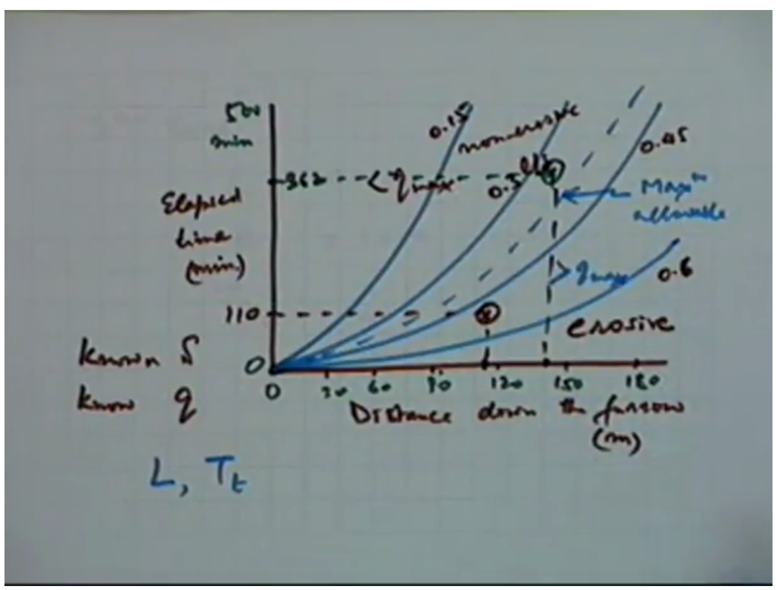

Again if I get back to this for 140 meter, I project a vertical line here. And on this side the elapsed time is 300 something, 362. If this is the point here, for 362 I project it and you are getting a point which is slightly above the maximum discharge curve, the maximum allowable discharge curve.

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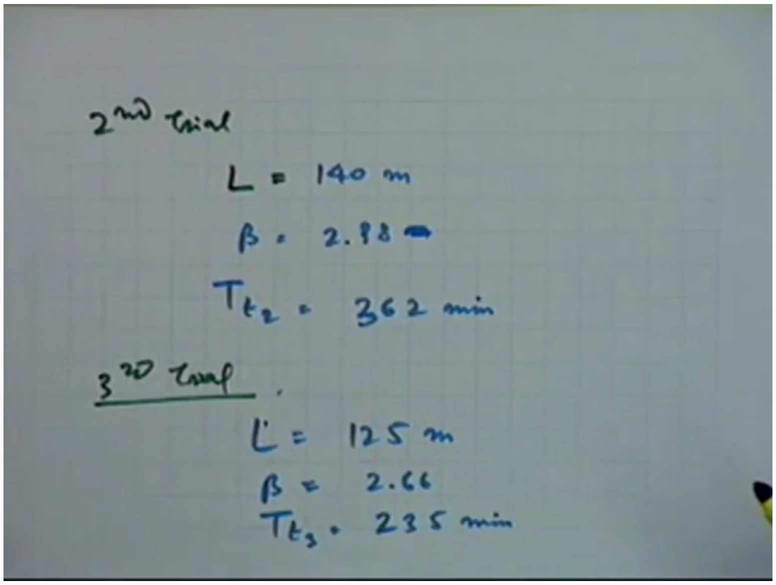

So this shows that we have achieved the condition now with respect to these two length of 140 and the resultant advance time is 362 minutes. So this give you a condition where you can, you will have a situation where the erosion is not a problem. But you might be getting efficiency which is not as much as achievable, is not optimum efficiency. The optimum efficiency you will get when you will be able to closer to the maximum allowable stream size.

So you can, if you feel that you have come quite close to this with respect to these parameters, it is fine. Otherwise you can have another trial where you can still improve upon, take a third trial where you improve upon the length and you feel that you have taken a length which is more than the desirable. You can it to be less than the previous case and have another iteration where this case beta is 2.66 and the advance time works to be 235 minutes. Now this advance time versus the length combination, it falls quite close to the q maximum.

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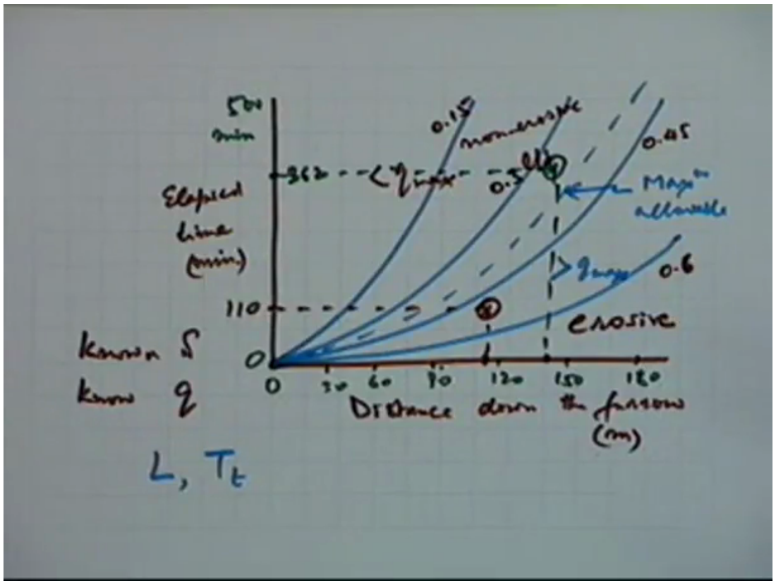

And now you can see that you have achieved a situation which is desirable and at this juncture you now compare the parameters which you obtained here with respect to the parameters which you obtained by the other, the equations which have been provided. And that comparison will give you insight into whether the results which you obtained through the procedural steps using the procedure which you have studied in the last class how close they are to the actual conditions.

So if they are very far, they are far apart, you might have to make some adjustments. So once in a way is always better to keep track of these parameters and wet those parameters, try to check those parameters, do not keep on blindly using those parameters. That is the main reason of having these trial evaluation runs for different systems. We have seen in the case of border and this also. Even in, similarly in the case of level-basin which we are going to consider next. The procedures remain same. Only the expressions, the way you have to conduct the trial runs they will change.

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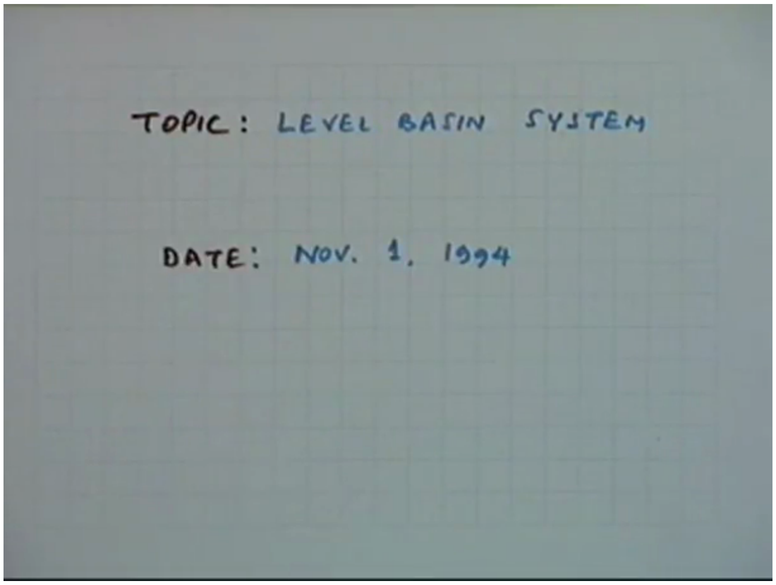

Okay. So with that we conclude this topic on the furrow irrigation system and we will move onto the next topic which topic of level-basin system. If you have any question, I can answer that this juncture. We will not spend much time on the level-basin system because it is quite same procedure as we have done in the case of border irrigation system, only with very small minor differences. And I will quickly go through this particular subject, topic which is a related topic and try to bring out those differences which are considered in the evaluation and the design of this level-basin system.

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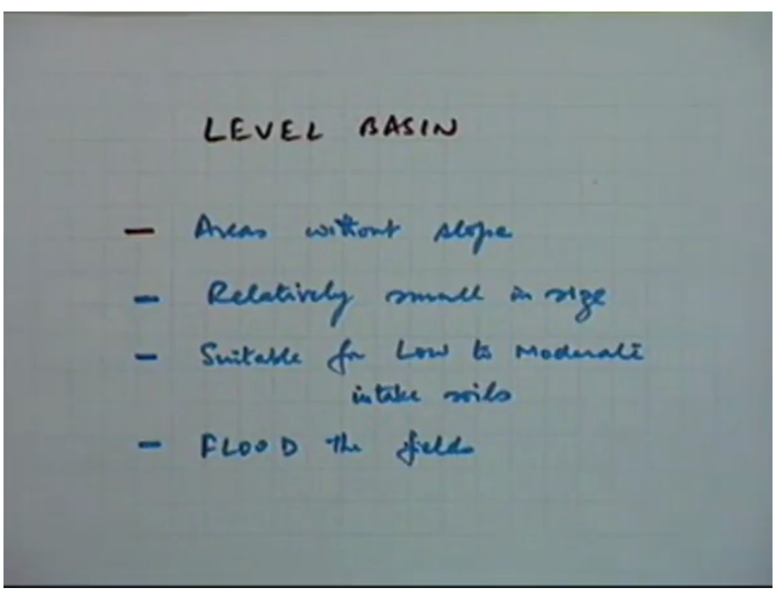

If you remember we have discussed earlier that the level-basin is a special case of the border, only difference is the level-basin, they are not having any slope. They are level areas without slope, they are relatively small in size. And what you are doing, the suitability, in terms of the suitability they are suitable for low to moderate intake soils. So for those soils where the infiltration rates are relatively lower, you can use, you can make use of this system.

The shapes of the fields are normally rectangular but the sizes are not, the lengths are not as big as you have in the case of border irrigation. Because of the fact that you are trying to flood these areas, the reason is that you want to do the flooding in these small basins so that you can let the water stand for a longer period so as to have the available infiltration opportunity time to be there so as to have the desired infiltration take place in the field. Because we have just said that the infiltration rates of these soils are very low. If you let the water pass over the surface of the soil, the amount of time which is available for the infiltration is very small.

And since the infiltration rates are very low, it needs a very long time for infiltration. So that is the reason that the shape of the basin and the size of the basin has been reduced. The slopes are not given so that you can flood the area. You can check the water within the area. That is the idea. If you create slopes, then you will find that the lower portions of the, let me elaborate this point.

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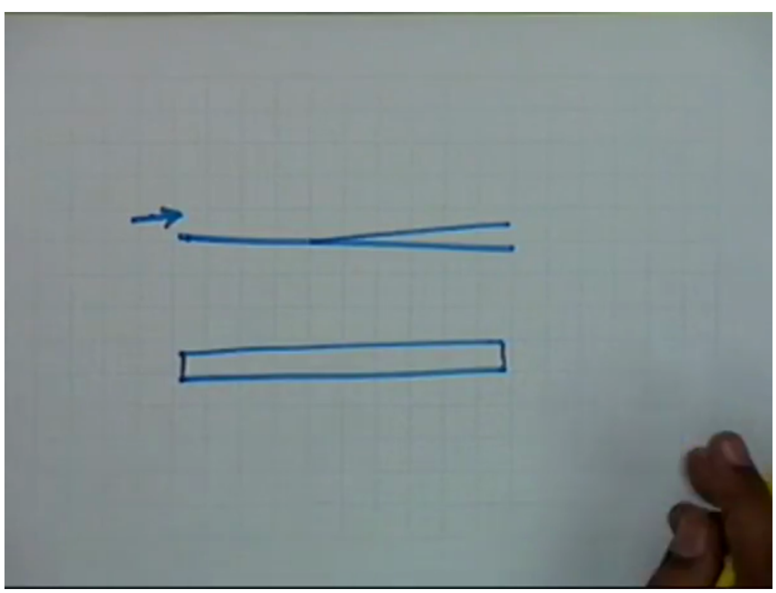

That if I have a field which is having slope, if you want supply a depth of water and you try to trap this water, it will get accumulated only into the lower area. So you have to have a relatively level surface on which you can, now you can establish a depth of water and the depth of water will depend on what is the ridge size, what is the height of the ridge which you have created in creating these basins.

We will come to that. That is also a parameter which has to be considered in the designs. So this particular method from the angle is created for some special purpose or some special circumstances. But with respect to the type of crops which can be grown, we have already considered that in this particular method, the check basin method or the level-basin method, the crops, there is hardly any crop which cannot be grown in this.

Even those crops which are not suitable to be grown with any other method, for example, the rice, or the jute which need the water, inundated water, which need the standing water, they also are used with this method. Other, all the other methods, even the orchids they are also irrigated using this method where you are creating the conditions, where you are taking care of each individual plant by having a ring method which you have considered.

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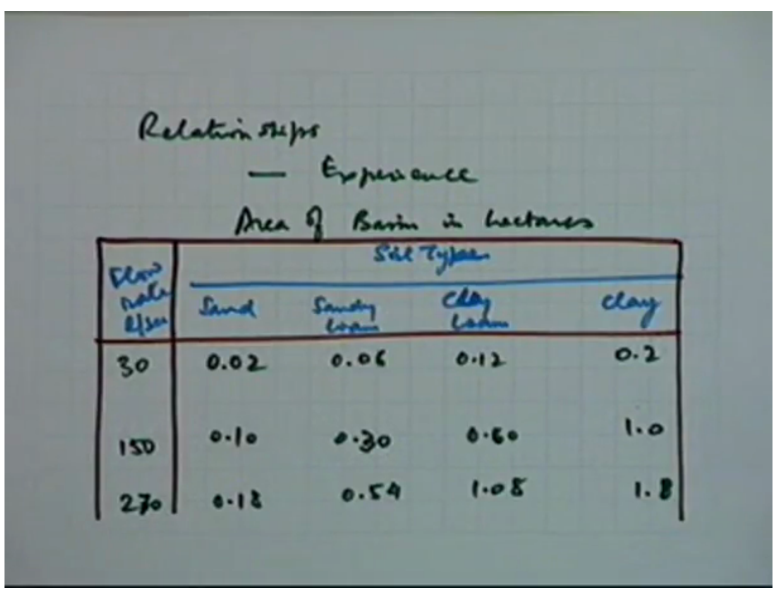
Relationships
— Experience
Area of Basin in hectares

Flow rate l/sec	Soil Types: Sand	Sandy Loam	Clay Loam	Clay
30	0.02	0.06	0.12	0.2
150	0.10	0.30	0.60	1.0
270	0.18	0.54	1.08	1.8

So we have discussed that earlier also and let us at this juncture try to look into the various formulations which have been considered for the design of these systems. In this case also as we have seen in the previous cases, there are some relationships which are based on experience and the even the field trials. And these relationships are ultimately given in the form of a very simple chart which becomes the starting parameters of the design. You can always use them as the thumb rules or as the values which are recommended values. So in this case there is one, they are presented in different forms.

In one form which I am trying to express here is the chart given in terms of the flow rate in liters per second and for different soil type. The soil type vary from sand to sandy loam to clay loam to clay. And you are given the area of the basin in hectares for different flow rates and for different soils. I will only pick some of the values or some intermediate stream sizes and give you the variation that how much variation in size can take place which is the recommended sizes for all these different types of soils.

Let me say that this is 270. You can see the variation. When you have very small stream size within the same, for the stream size when you go from one extreme of the soil type to the other extreme, the area can vary by around 10 times. Same is true in this case also. And for different stream sizes for the same soil, there is still lot of variation in the area which can be used for the level-basin. Beside this, this will give you a very reasonably good starting parameters of the design. But you can always, if you have more data available you can go in for the detailed design which is dependent on the hydraulic relationships which we have been using for other methods.

The relationships basically used in these designs are the soil characteristics which we have seen and the Manning’s equation which have been used very often because with the assumption that the we are considering a channel flow which is a very wide channel for the very small depth. That is the assumption made because basically the Manning's equation is for channel flow.

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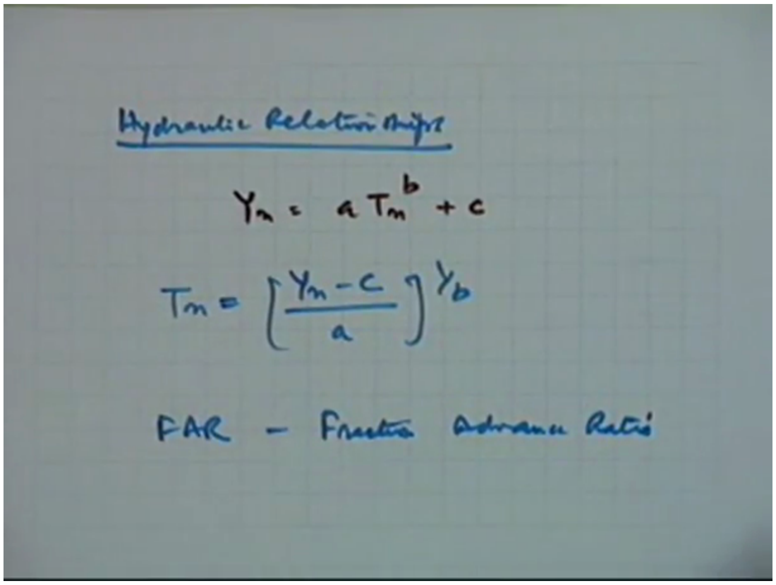

So let us look at the hydraulic relations which we can use for the case of level-basin. This equation is still valid for the net depth of infiltration which is, which we have used very often. So using this equation you can always get the time of infiltration. To have this much net depth of infiltration, what is the desirable time of infiltration? It can be obtained from the same relationship. Once we have this Tn available, now we use the FAR, the fraction advance ratio.

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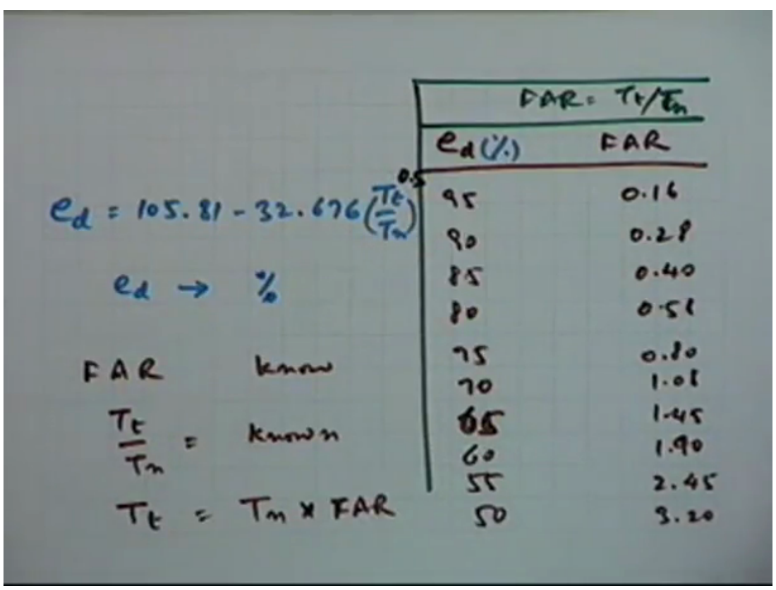

And the fraction advance ratio is given for, this is basically the FAR the way we have defined is the ratio of advance time by the net time. The FAR varies with respect to the distribution pattern efficiency or you can also say that the distribution pattern efficiency is dependent on FAR. And for different distribution pattern efficiencies, FAR values has been computed and given in this table. Similarly for other efficiencies you have, now this is something which is available either in this form or even in the graphical representation, is one of the same thing.

Even there is equation which is available to find out the distribution pattern efficiency knowing the FAR, and this equation is a regression equation. So you can make note of, into Tt by Tn to the power 0.5. There is 0.5 here where ed is in percentage as in this. Now once you either know your Tn to the power 0.5, I am sorry, is I will write with this. Is it visible now? Now there can be different situations. In one case you might select ed that you want to, you do not want to have a distribution pattern efficiency below a particular level.

So in that case you fix your ed and you can find out what will be the FAR possible for that ed. If that is the situation, then you know your FAR. If FAR is known, you can know the FAR or in other words you know this ratio. This you can find out from the table depending on the acceptable distribution pattern efficiency. Once you know this you can now evaluate Tt because Tn is known and the FAR is known. Okay. So knowing the FAR, the advance time can also be evaluated.

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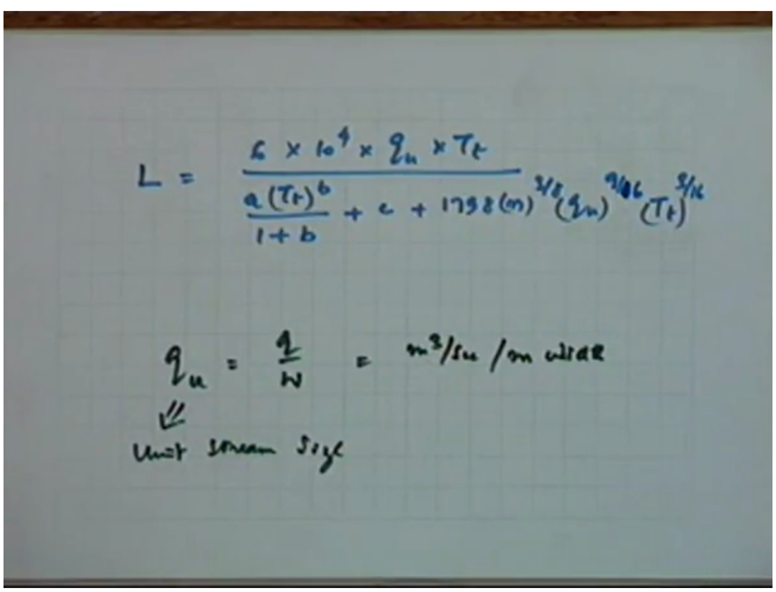

Then there is relationship between the time of advance and the length and the stream size. On this case let me tell you that the stream size which we use is not the stream size for the total strip.

We use per unit strip, so is the unit stream size which you can say is the q divided by the width of the basin. And this will be in meter cube per second per meter width or meter square per second. That is what we call the unit stream size.

And this length is given in terms of the unit stream size and the advance time and the other parameters of the family curve. This is 9 by 16. And advance time by 3 by 16. So that is the expression which is used to find out the length of the basin. And in this the n value is the same as we had used for the border irrigation system.

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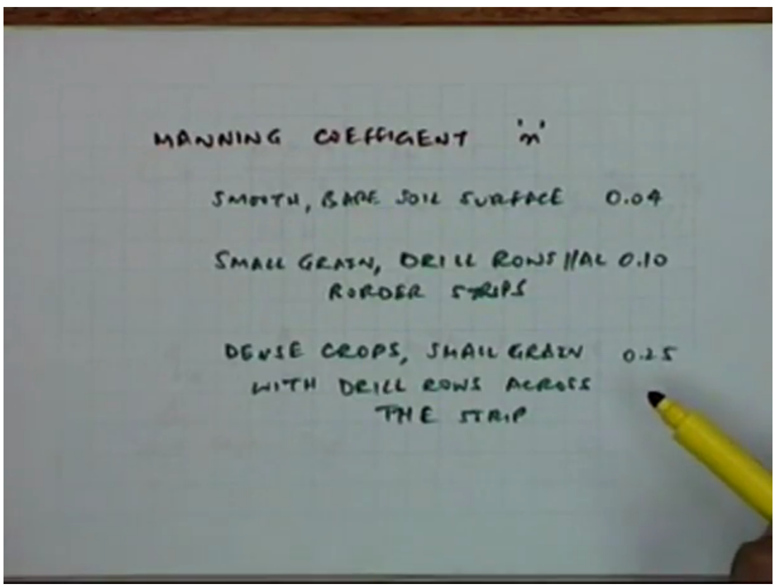

I had given you the three n values which are representative of three conditions. This value was for smooth bare soil surface. 0.1 is taken as the, when the, when you have small grain drill rows parallel to the border strip. And if you have dense crop or when the rows are drilled across the border strip, then you have more resistance, the n value is 0.25. The same n values or similar n values are chosen for, this is the similar situation, the difference is not much. Only difference is that you have the flat areas.

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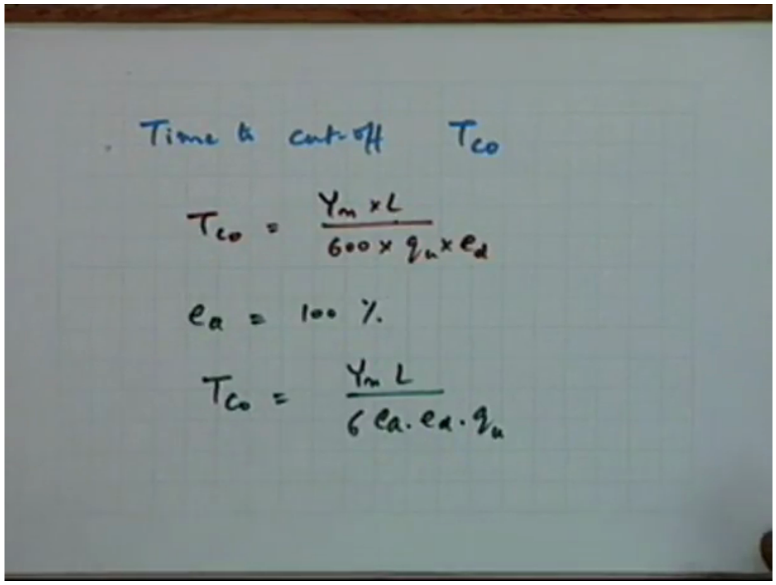

Now beside this you will also be interested in knowing what is the cutoff time. The time to cut off which we are calling as Tc0. The relationship used for the time to cut off, all these quantities you are now quite aware of. This is the unit stream size, this is the distribution pattern efficiency, the length and the net depth of infiltration. And this the ea is assumed to be 100 percent, is the application efficiency. So if the application efficiency is assumed to be 100 percent, then this is the expression.

Otherwise if the application efficiency is less than 100 percent which is normally not the case in the case of surface irrigation systems, but if it is, if you are certain that it is not 100 percent, then you can use the expression which is giving ea also. Okay. That will be the revised expression if your ea is not 100 percent.

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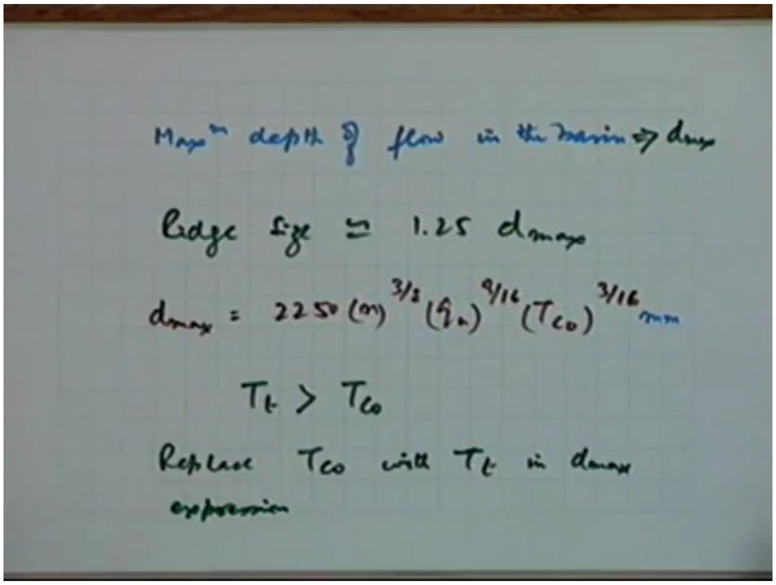

Then lastly we are also interested in knowing that what is the maximum depth of flow in the basin. This maximum depth of flow in the basin is to find out the requirement of the ridge. And normally the ridge size is approximately 1.25 times the d maximum if we call this maximum depth as d maximum. So you can compute the d maximum using this expression. This is the expression used for obtaining the d maximum. And d maximum will be in millimeters. Now here there is one requirement that there might be a situation when the advance time is more than the cutoff time.

If that is the situation which can only happen in the case of level basins, so if that is the situation, then you must, in this equation of d max you must replace Tc0 with Tt. So in this expression which is for d max expression. Okay. That we will have to take care that if your time of advance is happens to be more than that the time of cutoff, then this will be the governing time to compute the d maximum which is quite understandable.

So that is what gives us all the parameters which we are interested in. And similarly in this case also you can go in for the trial runs and check the parameters as we have suggested in the previous two cases. So with that I am, I will conclude the topic of irrigation methods using the surface irrigation or the gravity irrigation flow. And then in the next class we will proceed with the design of other two methods, the sprinkler irrigation and drip irrigation system. Okay.

“Professor-student conversation starts.”

Professor: Any question you want to ask at this juncture?

Student: Sir, any thumb rule for this basin method?

Professor: The question is that is there any thumb rule for the basin method. The thumb rule in terms of, this is the table which we have just looked at. I had given you some values of that table. That was basically a thumb rule.

“Professor-student conversation ends.”

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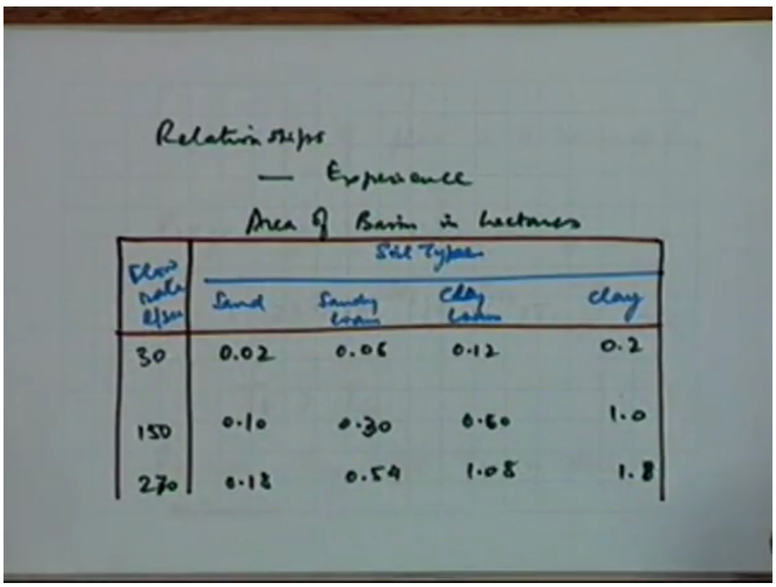

It can be converted into a thumb rule in the sense that this thumb rule, all the thumb rules which you normally formulate they are having lot of experience behind them. So this can be taken as a thumb rule where if you know the stream size because normally what parameters are available to you, the constraints, the constraint parameters are the quantity of stream size or the rate of stream size which is the stream size which is available to a farmer at a particular location.

If that is known and he also know in general what are the type of soil which are prevalent there in that field, then he can use this as the thumb rule. That what is the size of the basin which he should adopt so as to get reasonably good efficiency. So this is nothing but thumb rule. It can be taken as a thumb rule. Okay. Thank you.