Water management
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Lecture No 26
Furrow Irrigation System (Contd.)

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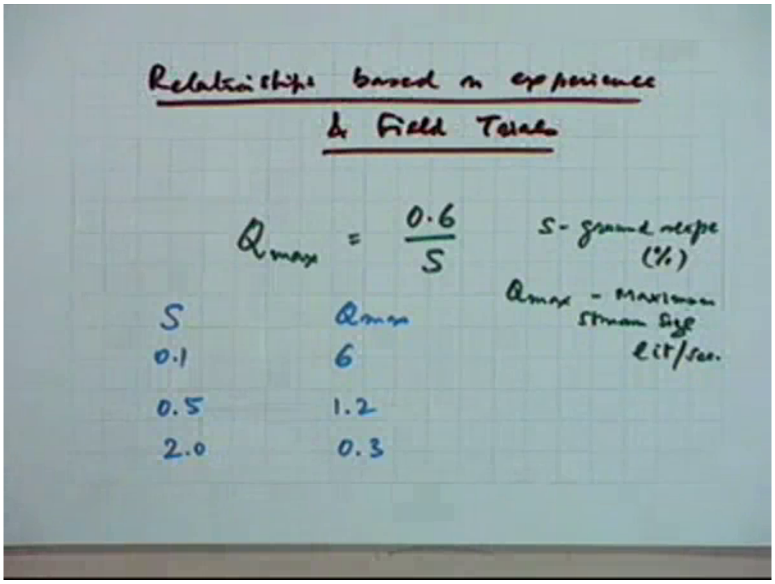

In the last class we were we looked at the general expression for the relationship between the advance curve the type of soil which is applicable to all the methods. And then we had started with the the Furrow Irrigation Systems. And we said that we will start looking at those relationships which are been build up with the experience of the farmers and through the field trials the experimental data. These are general purpose relationship which have introduced with the idea of giving some levels of these parameters may be the upper count then what will be the recommended length of the fields under different conditions of the system. So some of these relationships we will try to have look.

For example a relationship between the value of maximum stream size which should be picked up for a particular condition and it has been seen that it's basically dependent on what is the slope what is the prevailing slope so that parameter has been taken in account. This S the ground slope it is given in percentage. And Q maximum is the maximum stream size and it is per second. There is a very crude relationship in fact if you look at from the point of view that is not having a need any parameter which is soil dependent. So from that angle and since you know that their maximum stream size should be basically based on is some parameters which is related with which is depend on what type of soil is the prevailing soil.

But since it is a very approximate relationship which is only giving a indicative value that is what is the range you shouldn't be very much off the range. So looking into the the ground slope you can pick a value of stream size which is reasonable. For example using this relationship you might get that for a slope of 0.1 you're getting a maximum stream size of 6 liters per second. 0.5 will be 1.5 liters per second. Similarly slope of 2 percent will give you a stream size of 0.3 liters per second. Now comes the the other conditions for example in the case of the Furrow you don't go up to the slope of 2 percent. The 2 percent slope can be very erosive slope under some conditions.

So along with, these relationships are not to be used in isolation. These are only giving you order of magnitudes which have to be used very judiciously and you can make use of these relationships if you're aware of the constraints.

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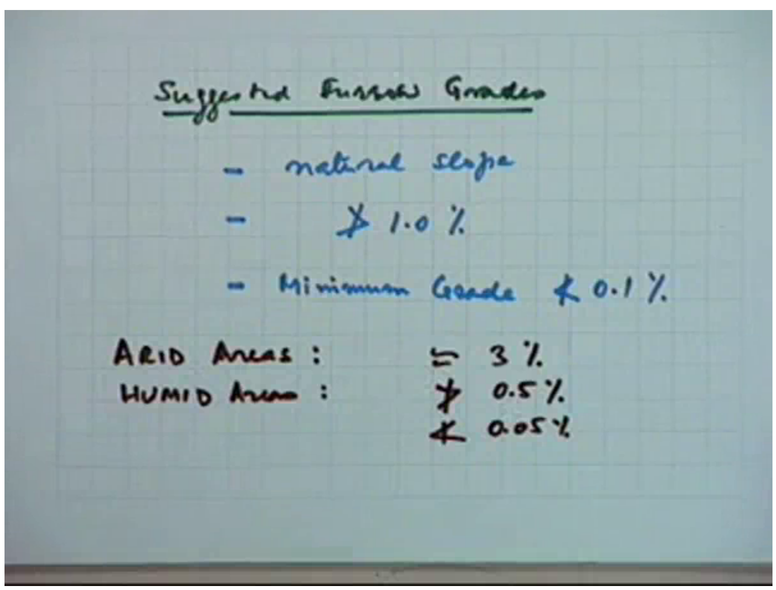

Maximum slope, let's look at some of the the Furrow grades which are normally the recommended grades. These slopes again they have come out, they have been suggested with respect to the trials field trials as well as the experience of the farmers. There are many factors which will influence these suggested for a grades. If you start from the beginning when we are trying to bring some area under irrigation when we are trying to lay the field basically a function of what is the prevailing slope. The natural slope which is prevailing in the area that will be the the major constraint or major condition which will decide what is the grade to be adopted.

In many situation you will find that the if the natural slopes are excessive if you go in farther the formation of those areas or the grading of those area you might turn the upside the soil upside down. The soil which is fertile soil might be taken away and replaced with the soil which is exposed soil, which has come from the lower lower layers that soils is not very fertile. So you will try to avoid that situation where the exposure of the soil might be possibility the grade are very excessive.

Similarly the grades which are generally adopted in furrows they shouldn't be more than 1.0 percent. This is the maximum limit though it can be exceeded depending on the soil type. What type of soil is in question if the erosion is not a problem if the furrows are cultivated furrows the erosion will be again lesser. So you can but this is the general limit which is applicable to most of the soils and shouldn't cross these limits. Similar on the point of the so on the conditions which can be prevailing conditions you might find that the minimum grade. This is the the maximum grade the minimum grade should not be less than 0.1 percent.

Because if it's less than 0.1 percent then it will be a flat area, you might find problem in moving the water in the furrow. So from that consideration the minimum grid is the limitation that if the grade is there should be some grade so that the water can move in the forward direction. Similarly in the case of changing conditions as we were discussing them during the last class that if you have conditions varying from arid areas to semi-arid areas or to humid areas you will find that this slopes will be the grades will be also affected from those considerations.

So in arid areas let's look at some of these, if you have arid areas the rain is naturally will be very small in these areas. You might be able to go up to slopes of around 3 percent. Again the soil will be a constraint what type of soil you're using. But you might be able to achieve such a slope also. Provided your stream sizes are very small. Those are the other conditions if you're stream sizes will be small then it will have it's own repercussions. Repercussions can be that you're length of the furrow might be reduced drastically because of the fact that there will be lot of infiltration taking place in the upstream end of the furrow.

So all those conditions will be the the other conditions which will go on, what slope can be achieved what streams (())(11:10) it has to be looked at along with the other parameters of stream size of the soil type. The humid areas on the our extreme you might find that the slopes may be as low as 0.5 percent. So there shouldn't be this will be the limiting slope that you should try to avoid the slopes more than 0.5 percent. At the same time you will like to give some minimum grade so that you can have the water that gets accumulated in these humid areas which should be these slopes should be able to drain off that water quite comfortable. So the minimum slopes might not be less than 0.05 percent. Now this becomes the range which is only a recommendations the actual slopes will if you want to find out you will have to go in for the actual designs where you will have to look at other parameters in combination with these parameters and suggest or select those parameters accordingly. That is what the design is all about. That you have ensure that the efficiencies are proper the efficiency will be proper if the wastage is less. And then the erosion is avoided, sedimentation is avoided all those things have to be take care of.

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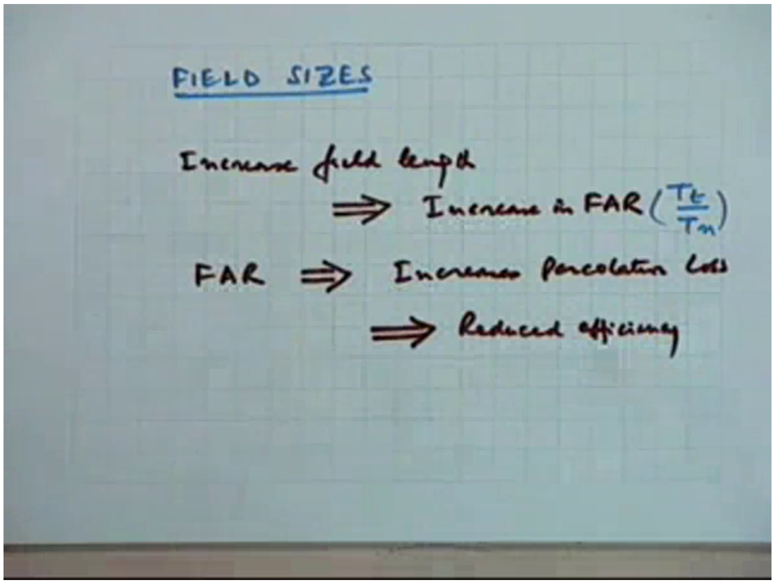

Similarly the along with these slopes of the grades the Field Sizes is another important parameter which must be considered. And there are suggested field sizes which are available in the literature on the basis of field trials as well as on the basis of the experience of the local areas and in general you will find that if you increase the field length in case of furrow irrigation it will be the furrow length because field is composed of many parallel furrows. By increasing the field length what it results in is increase in the FAR. And FAR we had defined as the ratio of Advance time to the Net time.

You will also if you just look at the various relationship we have derived so far, if you increase the FAR what it amounts to the FAR is more will be more of deep percolation, that's what we have seen earlier in the previous lecture if the FAR increases I had given you a table also, if the FAR increases what happens. Your basically your advance time is increasing that means the length the higher the length of the field the larger the length your T t will be larger the T n may or there is something which is the requirement. So for a larger T t FAR will be larger, if the FAR is larger the disparity of infiltration will be much higher and you will have more of deep infiltration or the the percolation loss will be more. So this increases percolation loss and which in turn will result in reduced efficiency.

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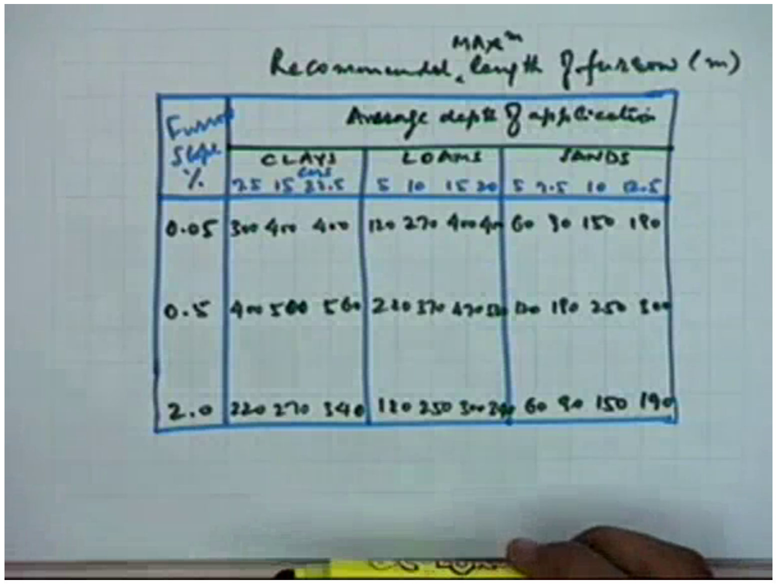

From these types of relationships which have been put forward ultimately you will find that you have been given recommendations in the front forms. One form of recommendation is may be in the form of relationship or a table which is giving you for different slopes and for different average depth of application. The application, the irrigation application requirement is not a fixed requirement. It might be different it might be varying. It is something which is dependent on the amendment in the farmer at what time they want to irrigation and accordingly the amount of water which has to be applied as irrigation water depth can vary. It also is a function of different types of schemes whether it is a rotational irrigational scheme or the on demand irrigation scheme we will look at those things later.

But it's true that the depth of applications can vary. So for different depths you might find that there are different relationships and these depths are also dependent on what type of soils are the prevailing soil. You might have clays you might have Loam soils or Sandy soils. So under each of these soils the actual depth of irrigation I am just taking some representative values or the values which are normally used as depth. These are the depths in centimeters. All these are in centimeters 7.5 centimeters, 15 centimeters and so on. These are the possible these are the normal depths which are used in irrigation. So the suggestion or the suggested parameters of this trial that for specific slope under different conditions of soils for different depths of application will be the recommended length of the furrow.

This is giving a recommended length of furrow in meters. I am just picking up some of the values just to show you that how much variation can be there from one type of soil to another type of soil and from one slope to another slope. Then let's have a look at these two more values for a slope of 0.5 if you want, you can see the variation. When you have for a increased slope you could get the same type of soil and for the similar depths you could get you could use the longer lengths of the furrows. When it became more steep for example for 2 percent slope if we look at the recommended maximum lengths these are basically let me put here, these are the maximum lengths.

So your lengths should be preferably below these lengths there will be many other constraints which might force you to reduce the lengths than these lengths, these are just the recommended maximum lengths which can be used under (())(22:22) conditions. Now you see here that the slope has increased the grade has increased lengths are again reduced. In all the cases is the same I just picked up 3 slopes in the beginning the slope was 0.05 the lengths were more for the clay soils less than that for the loams soils and even lesser for sandy soils. This is quite understandable because of the variable infiltration rate under these in the infiltration rates or maximum under sandy soils. So you cannot afford to have very longer lengths otherwise you will have lot of the deep percolation losses.But when the slope increased to 0.5 percent for the same soils the lengths the possible lengths which you can adopt they are much higher lengths but the trend is same. When you go from clay to loam to sand again the for those slopes you cannot your lengths are reducing in order of magnitude.

Within the same soil if you see here from 0.05 to 0.5 to 2 percent it increased first and again it reduced. Now this reduction is on account of the erosion problem. The erosion plus also the velocities which are the movement, the rate at which water is moving it might have problems of erosion plus the accumulation of water the surface run off also can be another problem which can be very detrimental in terms of losses because those surface run off is again a a form of loss the water is just getting passed over the furrow is not getting infiltrated into the soil that is of no use is basically is again a loss. So whether is the loss because of deep percolation or whether because of surface run off that is a loss. So this is these recommendations are on the basis of those evaluations that so that your efficiencies can be maximum under these prevailing conditions.

So if you're starting with a design these recommended values can be taken as the starting values. These can be taken as treated as the first assumptions of the design parameters. That is what these recommended values should be used for. So once you have these starting values or if the data is not available you cannot do anything, you might have to do your designs approximately on the basis of these you select the parameters and look at the combination of various parameters and select a value which is a reasonable value and even you can find out under various conditions what will be the the efficiency which were producing. Either you can go in for the evaluation of those those some segment or the furrows the actual test runs and find out what will be the efficiency. And then on the basis of those efficiency select a set of parameter which give you the best efficiency or you go in for the better relationships provided you have the data and as well as the competitional facilities or even in some cases the other related data which is required for these these competitions which are based on better relationships which are closer to hydraulic relationships.

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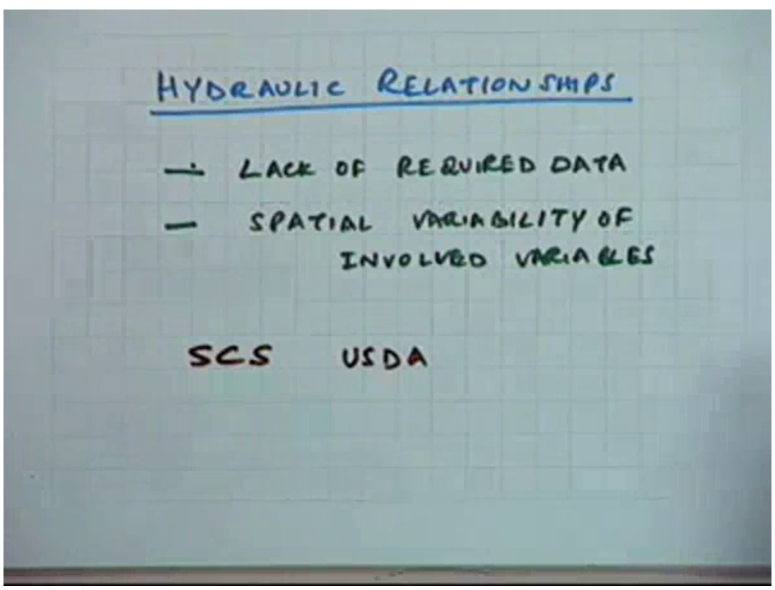

So let's have a look at some of these relationships which are based on Hydraulic Relationships. These hydraulic relationships which are used for design purpose of furrow irrigation design. They are not again exact relationships because there is no need, you don’t justify using the exact relationships of hydraulic rules in these areas because of the the 3 major reasons. One is that the lack of required data you require quiet a good amount of data even that can be take care of if the data requirement is there if you're going to get the best results no problem you can get the data you can afford to spend money on collection of the data. But it's not that only that is one aspect only the aspect is that even if you go in for data collection still there is lot of Spatial variability in all those parameters which are the the parameters which are influencing these these processes.

So the Spatial variability of the involved variables for example even if you take the infiltration properties of a soil in a particular field you're not certain that how much that those properties are changing from that point where we have done the infiltration analysis using the infiltrometer may be. That is only at point in the field if you go from that point to another point your infiltration characteristics are going to be different. Similarly the properties like the the roughness coefficient is changing from point to point the soil might (())(30:13) true uniform. So it's not worthwhile using very exact relationships if your data is known to have spatial variation okay.

So many of the relationships which have been put forward they are their approximate relationships based on the hydraulic relationship to start with but using lot of assumptions on the way and they have ultimately been transformed into more empirical relationship. You cannot say that they are they are based on the hydraulic relationships but the with lot of assumptions there were assumptions were needed. They have been incorporated and they don’t remain to be as exact as you will like to be or when you use them in the experimental setups in the laboratory conditions. That is not that is not justifiable, so most of these relationships which we're going to look at they are they are approximate relationships and most of these have been put forward by the soil conservation services of USDA US Department of Agriculture.

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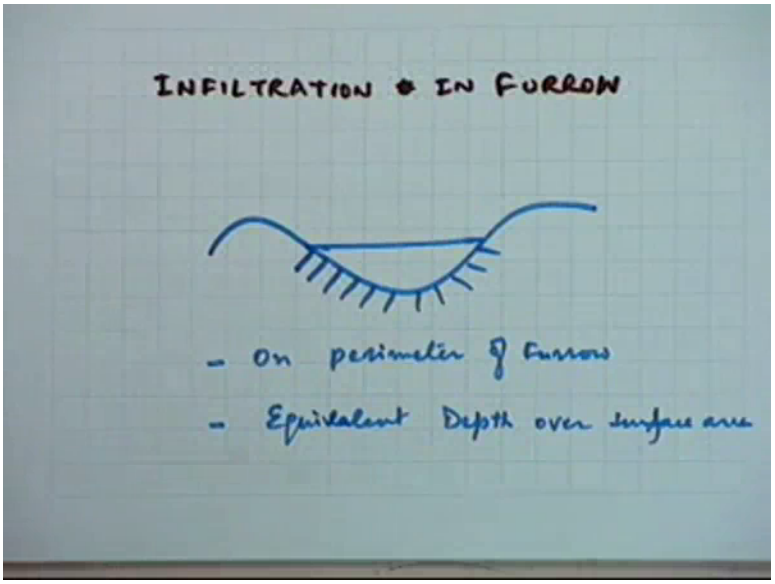

Then there are some other peculiar problem with furrow irrigation we have formulated some equations for infiltration process but they have to be revised. Why because in the case of furrow this is one segment of the cross section of furrow. You have this is your water level at the furrow. In this case the infiltration is taking place along this parameter so the major difference is that the infiltration is taking place on the perimeter of the furrow. And for all practical purposes you want to represent this as the form of depth over the area. So it will be much better if we find can find some equivalent depth over surface area of the field.

So we will have to do some transformation to our equations so that we can we can convert this into equivalent depth. What we can, one possibility is that we just assume that this this curvature can be flattened and then you find out the and that is what is done basically in this particular case. You try to make the corrections to the existing equations so that you can even incorporate this particular fact or having the furrows which are infiltrating water along the perimeter of the.

QUESTION ASKED – Sir this particular equation and the (())(35:05) different or same.

(())(35:09) a good question that the infiltration now in this case we're are, the question is that whether the infiltration which is in this particular case in the case of furrow irrigation is not only vertical it's lateral also. So whether the two will be same or not. Yes they won't be same there will be some difference in infiltration but we're approximating them to be what we're assuming is that if we this perimeter if we try to unfold this furrow how much will be the depth over accumulated over this length of a the perimeter okay. So it will involve some assumption may be that it is given you a value which is slightly less than what is actually happening there will be more infiltration in actual practice because of the lateral dryness of the adjoining parts of the soil.

But that is what is done in the actual practice. If you want to take care of those the additions additional infiltration which is taking place you might have to improve upon those those (()) (36:33) still to an extent but that is taken care of by taking the spacing between the furrows to an extent. So what we're doing is that we're saying, we are having an area which is having furrows and we have laid down the furrows at a known interval. The spacing between the furrows is known. So if the spacing is more there will be less water area which is wetted if the spacing is less the wetted is much more.

When you try to use the perimeter you're in any case you're increasing the length of the area so that is indirectly taken care of their when you're unfolding this. Now the integrates of the furrows there also there is a slight difference in management of these integrates. The case of other irrigation the border irrigation as well as level irrigation what you're doing is you're taking the Infiltration rates through the infiltrometer test. Wherein in this particular case it's not possible to use the infiltrometer test because of the fact that is not, is not vertical infiltration. So what we do is that we do the input inflow outflow analysis and as a segment of the furrow.

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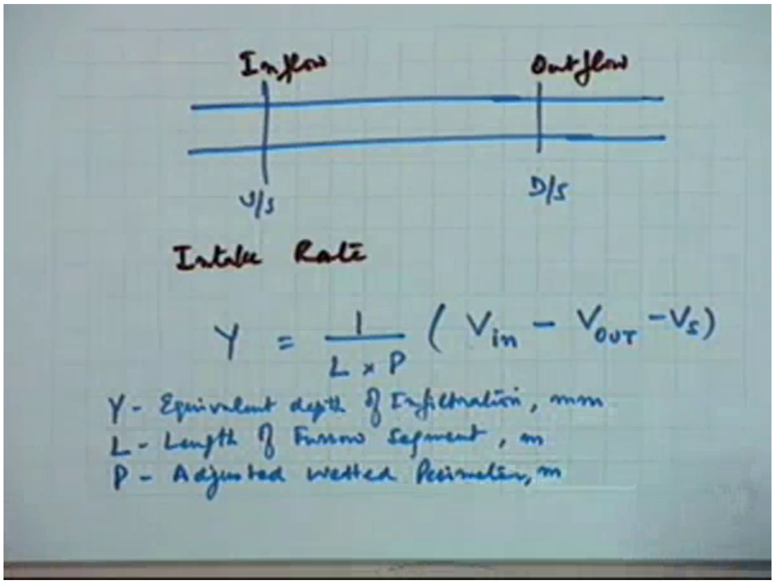

So you take a representative segment of the furrow if we let say that this is a furrow in plan and I take a segment this is my upstream location of the segment and downstream location of the segment. So I install some some device at these two stations which will give me the measurement of the, I can observe how much is the in-flow and how much is the out-flow from this end. So you can even install 2 parshall flumes any device which you feel normally the parshall flumes are used in these furrows. So if I know the inflow and the out flow I can find out how much is the the amount of water which has infiltrated into this segment and that gives me the the intake rate.

To find out the intake rate I use such a environment. Let say that if Y is the integrate you can express it as length into P into. Where Y is nothing much the equivalent depth of infiltration okay. This is equivalent depth of infiltration over the wetted surface area of the field and this is in millimeters. L is the length of furrow segment considered in meters. P is the adjusted wetted perimeter, this is again in meters.

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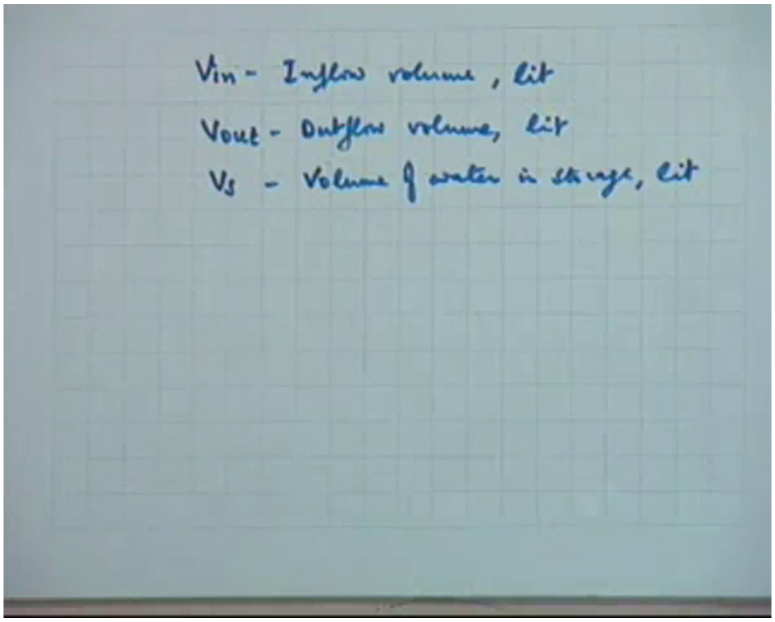

Then we have V in is volume of inflow this is observed in liters. Similarly V out is outflow volume again in liters. And V s is the volume of water in storage. There might be some volume of water which is at that particular time when you're taking that measurement they will be storage between these two fractions. So this is basically In Flow Out Flow analysis and the average value of infiltration if you take if you start the analysis at a particular time and take the final value after very long then what you're getting is average value over this period. So to find out the variation of the infiltration over the segment you will have to take some intermediate observations. So you keep on taking the observations at some interval so that you can find out how this infiltration was varying over time okay. Now this we have used the 2 terms the inflow volume no problem you can bear the out flow volume you bear, length is known.

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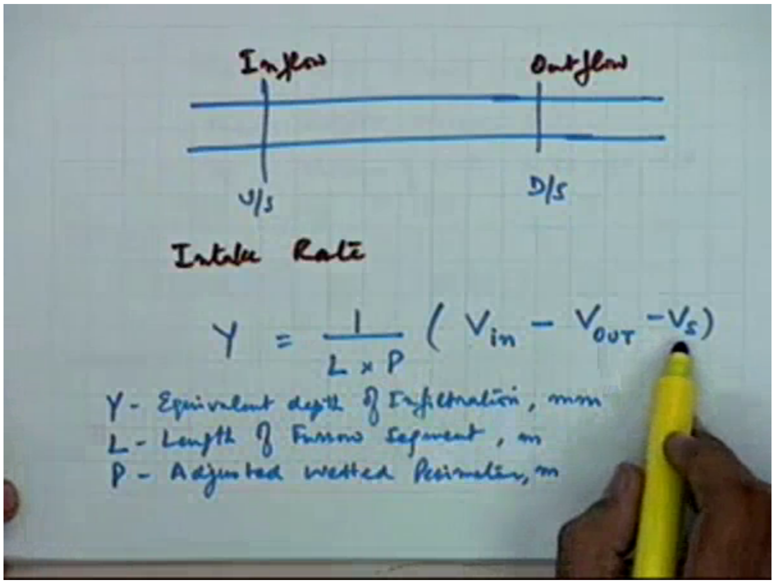

There are only 2 items if you look at this equation again. The adjusted wetted parameter which would be difficult to find and V s which is the volume of storage water in storage between this section.

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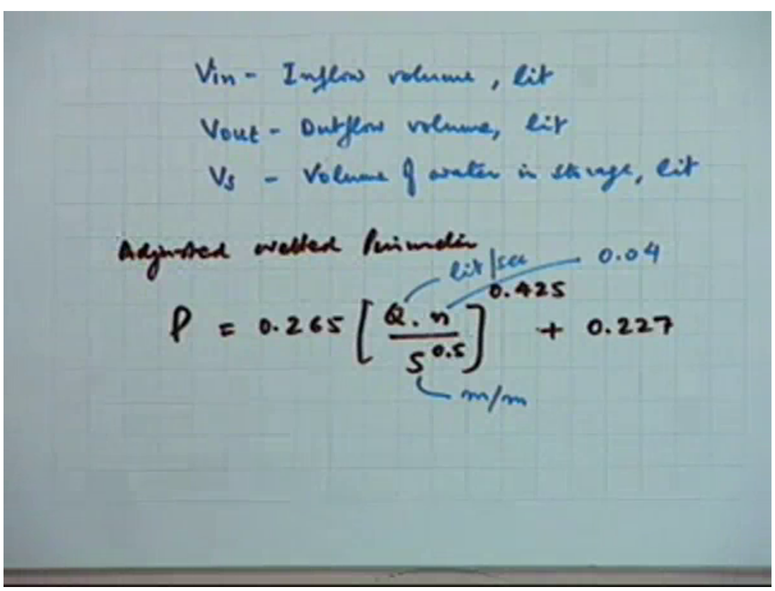

There have been relationships which have been formulated for these two items so that it can be used comfortably. They can be evaluated without any problem within the know quantities which are easily observable. Let's look at the first adjusted wetted parameter P is given as this expression this is basically obtained from the Mannings Formula. You can see the various most of these relationships have been derived from the Mannings formular. This is the expression which has been found to give you the adjusted wetted parameter. And the various terms you already know. Q is the volumetric in flow in liters per second so Q is in liters per second n is the mannings roughness coefficient. And normally the value of n is in general taken as 0.04 and S is the furrow slope basically it's hydraulic gradient is assumed to be equal to furrow slope and this is given as meters per liter.

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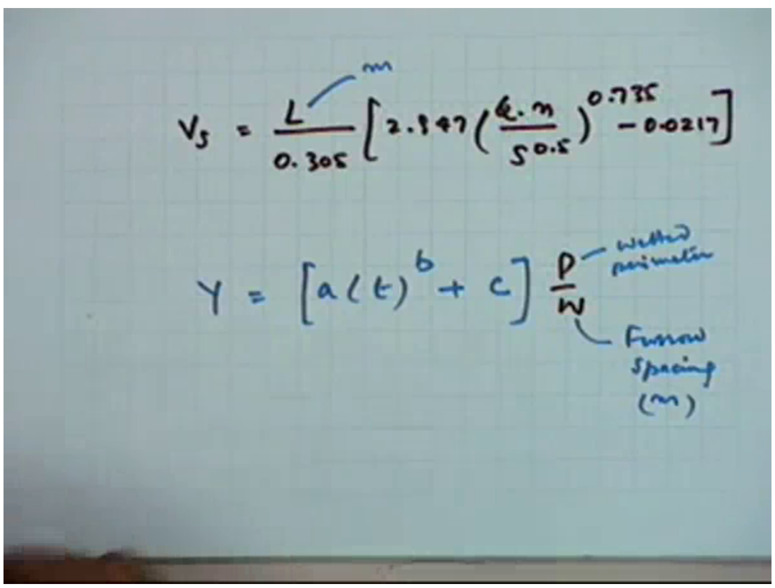

And the the channel storage of the volume of water in storage which we have just mentioned V s the expression used for expressing V s is. So in this expression also the all the quantities which have been expressed they are the same as before. Length is the length of the furrow segment which is considered that is in meters. Now you remember the infiltration equation which we have earlier written in terms of time and these different parameters a b and c. This equation for the case furrow irrigation design is modified to incorporate the wetted parameter. This is the wetted perimeter and W is the furrow spacing in meters. Now you can see that the impact of having a very large furrow spacing will be that your this Y will be reduced considerably. So that is how the the impact of having furrows with at different spacing or even if the space is small still the Y will be much comparatively lesser than if you're using this expression of the same equation on a border irrigation on a border or on a level base okay.

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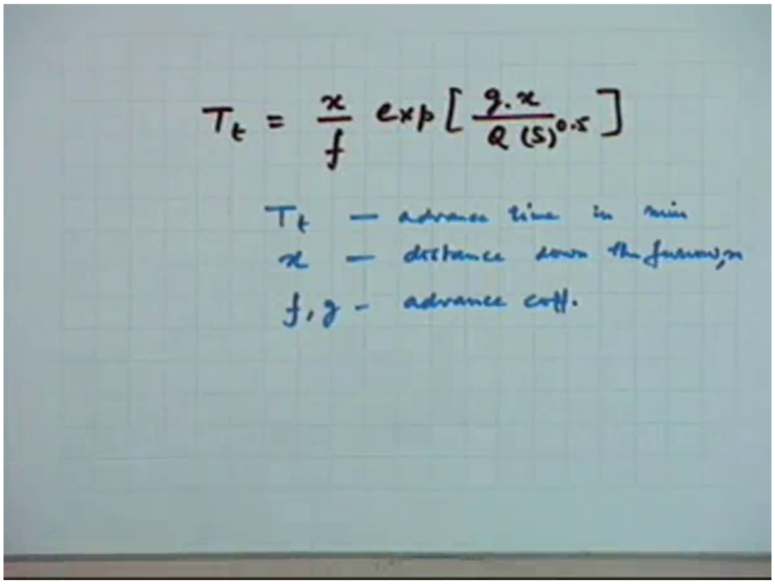

Then let's look at some other expressions which we are going to use one is for the advance time. The advance time can also be computed on the basis of this equation. This is the expression which is derived to express the advance time and the various quantities which are used here. T t we know that this is the advance time in minutes. X is the distance down the furrow that means from the upstream of the furrow what is distance we're considering in the (())(50:45) of the downstream length of the furrow. The long (())(50:49) direction of the furrow and this is in meters. Then f and g are the advance coefficients. And Q and S we have already seen they are the same parameters Q is the volumetric in flow rate in terms of in liters per second. And S the flow the furrow grade or is representative value of the (())(51:34) gradient.

There is a these parameters these coefficients f and g they are available for different family curves along with the parameters a, b and c. So these are these are the coefficients which are available in literature. They are the fixed values for different family curves.

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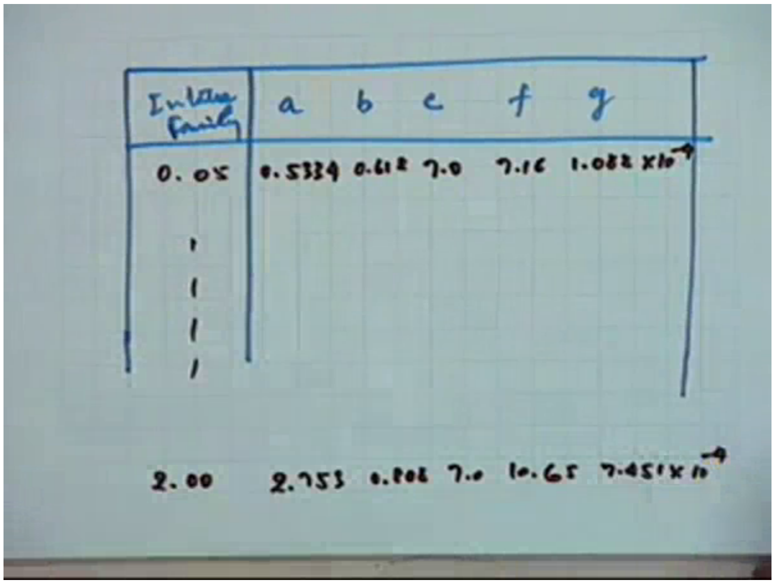

I will provide the table of these coefficients these are basically to give you some order of magnitude for different family curves the intake family. These intake family curves have been designed or they have been defined by the SCS Soil Conservation Service we have discussed that earlier. And they have evaluated these curves for these coefficients along with f and g coefficients. For example they give you 1 or 2 values which will give you some idea about the order or magnitude of these. This is the value of a when the intake family curve is 0.05 and this we had discussed earlier also that the intake family curve of 0.05 it means that this is a relationship this is the equation for which these parameters are applicable for a soil type whose basic infiltration rate stabilizes at 0.05 inches per hour is it inches per hour we will have to check that I am not sure but this gives the stabilized rate and that number they have adopted as the the number associated to the intake family the intake curve and that the set of those curves they are calling the intake family okay.

So this indirectly it designates what type of soil you're you're using and all those characteristics of the soils are given in the form of the intake family curve characteristics. The value of b is 0.618, c is taken to be constant. C is basically introduced to change the shape of the the curve in some cases if the soil characteristics are such that you're getting you're not able to represent the soil through a single parameter then you might be able to change the c and get the and if there are two curvatures of the soil the infiltration capacity curve the the c parameter is helpful but in this particular case all the family curves are having the same c value. F value is 7.16 for this intake family and the g value is 1.088 into 10 to the power minus 4. So this is given for different types of soils and the number goes up to 2 for which the parameters are again given. Now this table will be made available to you and this is quite a useful table. I think that will stop today. If there are any question I will be glad to answer those.