Water management
Dr. A. K. Gosain
Department of Civil Engineering
Indian Institute of Technology Delhi
Lecture No 25
Furrow Irrigation System

We will new topic on Furrow Irrigation System. We will look into the details of the furrow irrigation system. The design aspects, the various design parameters which are required for the detail design.

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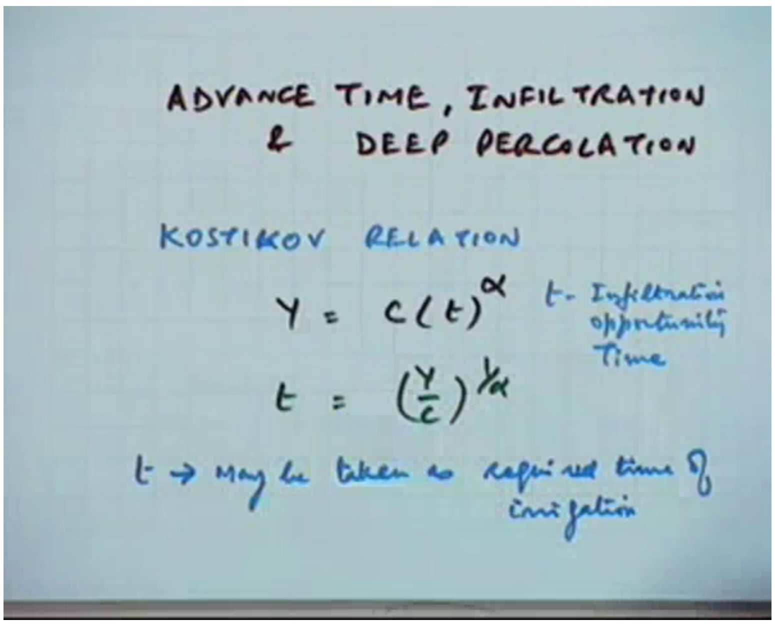

But before we do that, I will like to establish a relationship between the various elements which are Advance Time Infiltration and Deep Percolation. This relation will be a generation purpose relationship which will be used for all these surface irrigation method. Even the border irrigation method which we have considered earlier this will be applicable to that, this will give you a general understanding that how these items, the advance time infiltration and the deep percolation are related to each other and these relationships you can exploit for the design purposes.

So this will be a very important way of looking at the overall process. Let's take the Kostikov Relationship which we had defined earlier and this gives the infiltration depth the accumulated infiltration depth with respect to the opportunity time and these two parameters which we had defined. C and Alpha are the empirical constant of these parameters. We had also seen that how we can derive these parameters from the observed infiltration data which is taken from on the field. So these are basically defining the type of soil for each type of soil these parameters are known. And T is nothing but is the infiltration opportunity time.

In other words if I write T I can write this T in terms of Y and these two parameters. I can approximate this T which is the infiltration opportunity time to this T here as we have used. This T is nothing but infiltration opportunity time which means that the surface of the the ground for how the water was available and for how long the infiltration opportunity was prevailing. So accordingly the depth of infiltration can be determined depending on what is the time of a infiltration or what is the time for which at least that assumption is valid that the amount of water is more than the infiltration opportunity or the infiltration capacity.

Those things we have seen and since in irrigation when we are applying the irrigation water we are ensuring that the depth of irrigation is always more than the infiltration opportunity or the infiltration capacity prevailing at that particular time. But we can make an approximation that this time can be approximate to the time of irrigation. So when we find out this time the T, T now may be taken as the required time of irrigation. What assumption we are making is that the time of infiltration opportunity is equal to the time of irrigation. So indirectly we can find out that time if we know the the characteristics of the soil, this relationship is known which we have already worked at.

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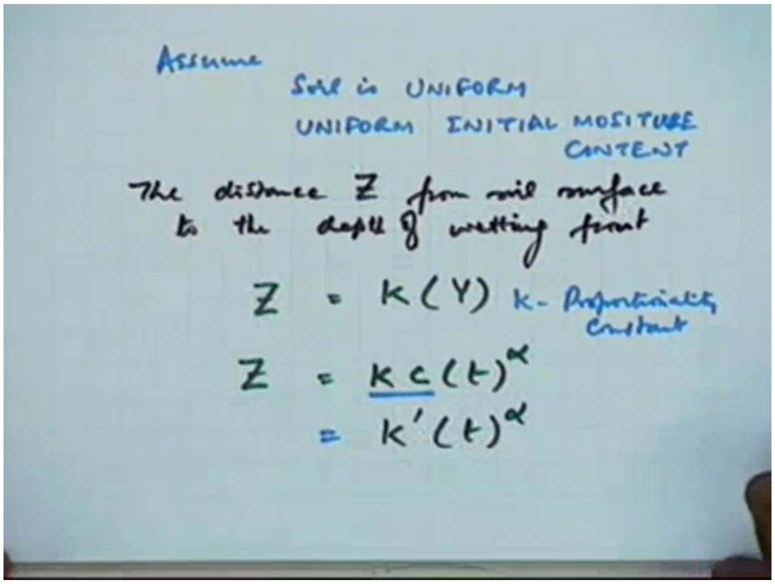

Now let's assume that the soil is (())(6:38) two more assumptions, first the soil is is a uniform that means the soil characteristics are not changing for that particular field which is in question. And we also make another assumption that the initial moisture content is also uniform. Making these two assumptions let's take that the distance Z we take Z as a vertical distance the distance Z from the soil surface to the depth of wetting if we when we when you will irrigate that soil, when the infiltration will take place the wetting front will move. So if you want to express that wetting front in the form of distance Z then this distance Z can also be expressed, it can be expressed as a function of Y okay. That will be proportional to with some proportionality constant if K I define as a proportionality constant. If K is then I can express Z with respect to Y and if I substitute Y from the Kostikov equation this can be expressed as CT to the power of a into K. Now this these are two constants I can express this as new constant which is K dash K to the power alpha okay.

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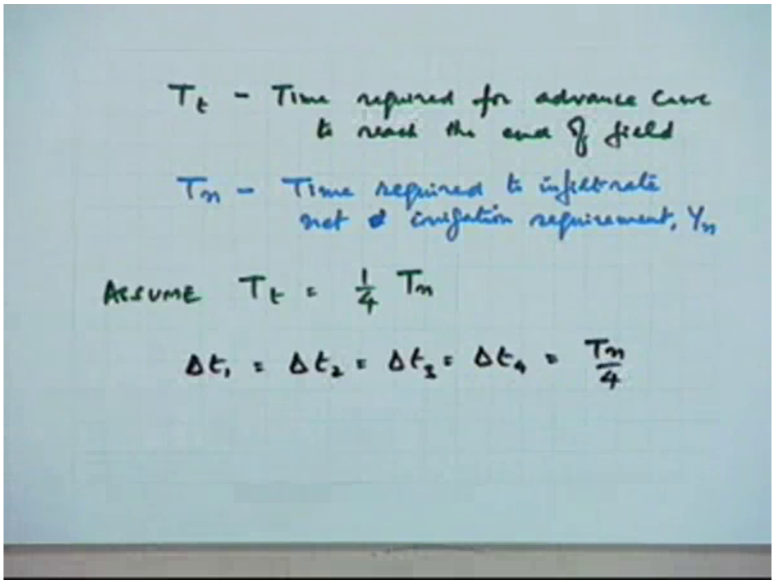

Let's take two more quantities. T t is time required for advance curve, end of the field. Time required for advance curve to reach the end of the field and T n is the time required to infiltrate the net irrigation requirement which is Y n. So T to achieve the net irrigation requirement if you need the time T n that is the time which is required to get this depth of irrigation and T tis the time of advance of the water front to reach the downstream end. No here comes the the various options available to you. It depends on your type of soil as well as the length of the field that what will be the the value of T in terms T n or what is the proportion of T t of T n which is required for the water front to move in the downstream direction and to reach the downstream end of the field.

For example right now we will assume that we will take assumption we will take one case were we will assume that this T t is one-fourth the time of that infiltration. That if that infiltration is one unit it will take one-fourth the time of the advance curve to reach the downstream end. So we make that assumption there can be various cases it might it depends on the the characteristics of the soil it depends on the length of the field that what will be the T t because the movement is a function of how much of the water is infiltrating with the soil as the water is moving in the forward direction and it's also a function of what is the length of the field.

So these are there is only one possibility there can be many possibilities depending on how you have fixed the other parameters. So let's make an assumption that assume we're making assumption that T t for the present case which we are going to consider is one-fourth the T n. Time take for the net irrigation depth to be achieved is is four times the time take for the advance curve to downstream end. So with this assumption we divide the total time taken which is the T n into 4 different parts in such a way that Delta t1 each one of these are the various intervals which you are going to consider and each one is equal to T n by 4 okay.

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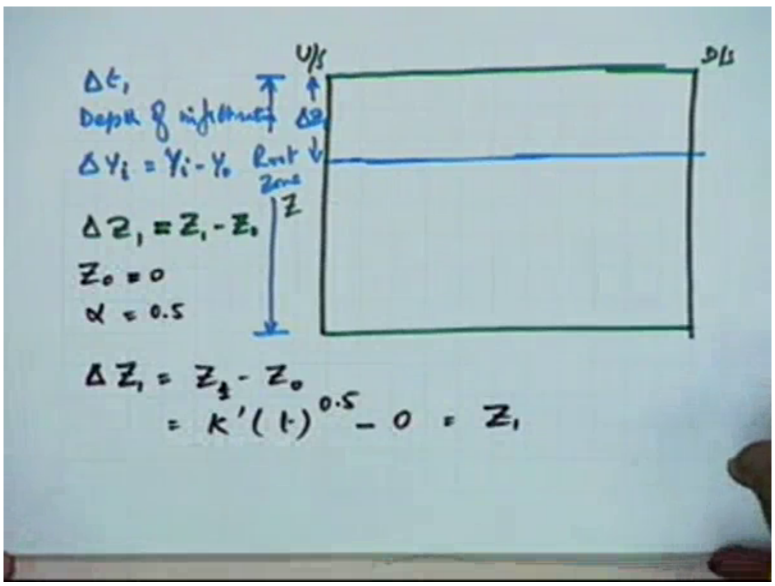

Let's try to look what we have done so far try to sketch this that this is your, this is your total field this is upstream end the downstream end okay. I say that this is the root zone depth which we are interested in irrigating fine. And this root zone depth the total time taken you are divided you are trying to consider what will happen each time interval which you have considered each one is equal to one-fourth the total time requirement. So if that is the case let's look at the that what will be the the depth of water infiltrated in the first time interval. The first time interval is delta t 1. Depth of infiltration is if I say that in general the depth of infiltration if you want to take in any one interval it will be function of what is the initial depth in this oil and what is the depth infelted during this time interval.

So if Y I is the the infiltration during that or at the end of the interval and Y0 is the infiltration which was already available in the beginning. Then during that interval you have the the increment depth, the depth of infiltration is Delta Y I. So similarly the depth of soil which will become wet which we will call as Delta Z 1 you can write because we are we are saying that this is our total Z this root zone is the Z which we have considered. This is the total depth, so in the first interval this will be the the depth of soil which will be wetted the very first interval. If we assume that Z 0 to start with, let's make an assumption that Z0 0 to start with. If it is known you can take that value but if it is not known then if it was totally dry you can always take it to be zero not a very inappropriate assumption.

So once you assume this you also need the value of alpha to be used in that equation the Kostikov equation let's assume that the value of alpha is also known. Just for the present problem let's take this to be 0.5. Then if these 3 things are know then the very first interval Delta T 1 you can write this Delta Z 1 is equal to Z 2 minus sorry Z 1 minus Z 0 and Z 1 is nothing but we have said that 0.5 minus 0 in this particular case. So this is nothing but Z1 okay. So in this particular case if this is Delta Z 1. I can similarly write the expressions for other intervals.

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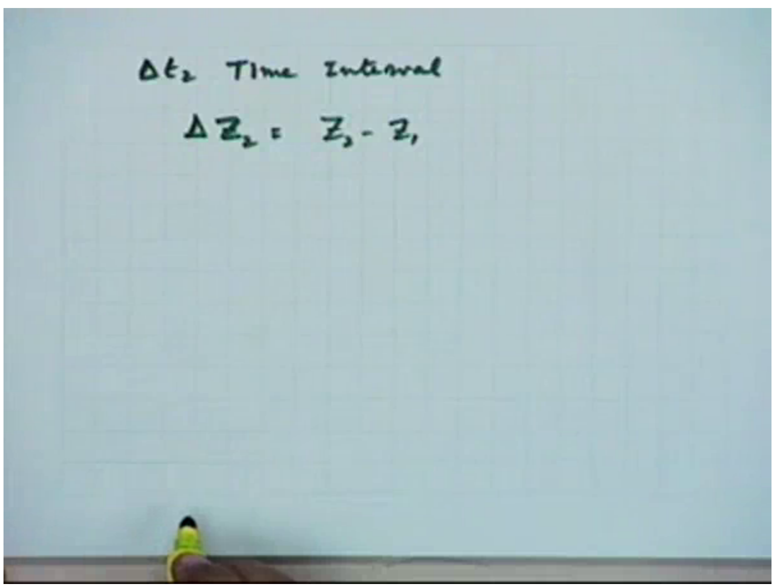

For Delta t 2 time interval I can find out what will be Delta Z 2 is Z 2 minus Z 1 okay.

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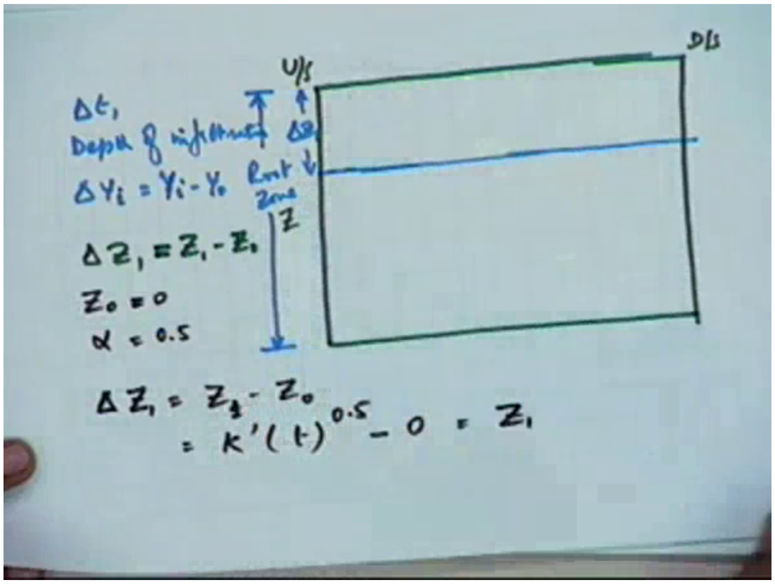

Now Z 1 is nothing but this much depth isn't it, this is Z 1 is equal to Delta Z 1. So to find out the next depth I am trying to reduce this.

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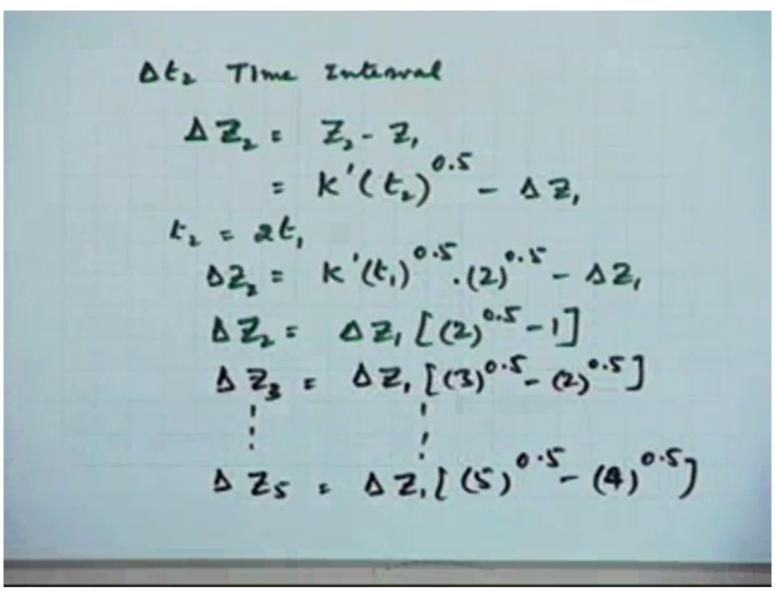

Z 2 minus the previous depth which has been considered earlier and the previous interval. So Z 2 minus Z 1 which will be equal to K Dash into t 2 to the power 0.5 minus Delta Z 1 because Z 1 is equal to Delta Z 1. Now t 2 two times t 1 okay, so if you substitute that your Z 2 will be K Dash into T 1 to the power 0.5 into 2 to the power 0.5 minus Delta Z 1 which is nothing but Delta Z 1 this part is Delta Z 1 into 2 to the power 0.5 minus 1 okay. Similarly you can write the the other forms also Delta Z 3 will be Delta Z 1 into 3 to the power 0.5 minus 2 to the power 0.5 and so on. At Z 5 will be 5 to the power 0.5 minus 4 to the power 0.5. So this general relationship can be established and if you plot this.

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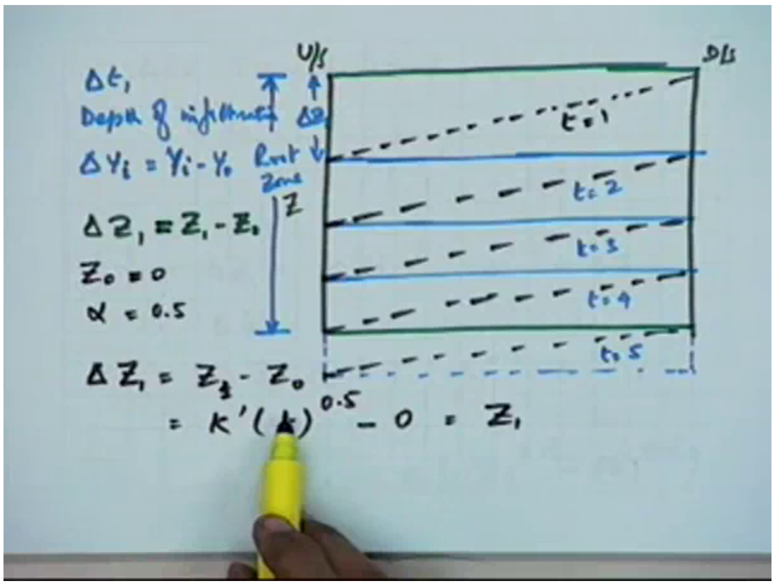

On to this you will find that at the end of t is equal to one this will be the, this will be the general trend if take that this is a linear variation you can find that over the length of the field this will be the variation which will be encountered because of the fact that the water is moving from the upstream end to downstream end. And the water is taking one-fourth the time since the time is equal to the time to reach the downstream when the water will be just the downstream end the infiltration will be minimum there. Similarly the other segment you will find that the size of the segment the depth of infiltration will keep on reducing. That is what you will see in the relationship and each case till will be the the trend of the the infiltration for each of the the smaller segment for example this is for t is equal to 2, t is equal to 3, t is equal to 4 and if you go beyond this, if you go beyond this take another segment you will find, this is for t is equal to 5. So you have gone beyond the root zone depth.

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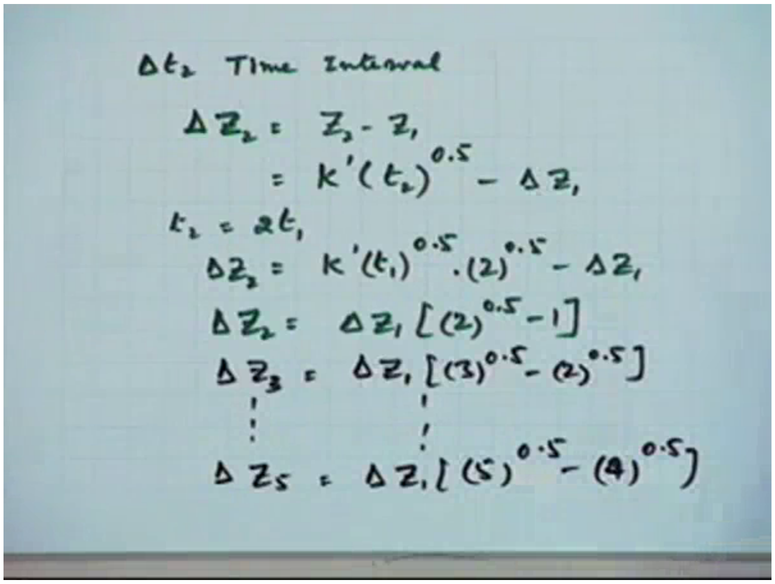

Now these equations you will if you just analyze these equations you will find that this trend will be shown each successive Z, Delta Z which is lowered down will be having smaller and smaller depth.

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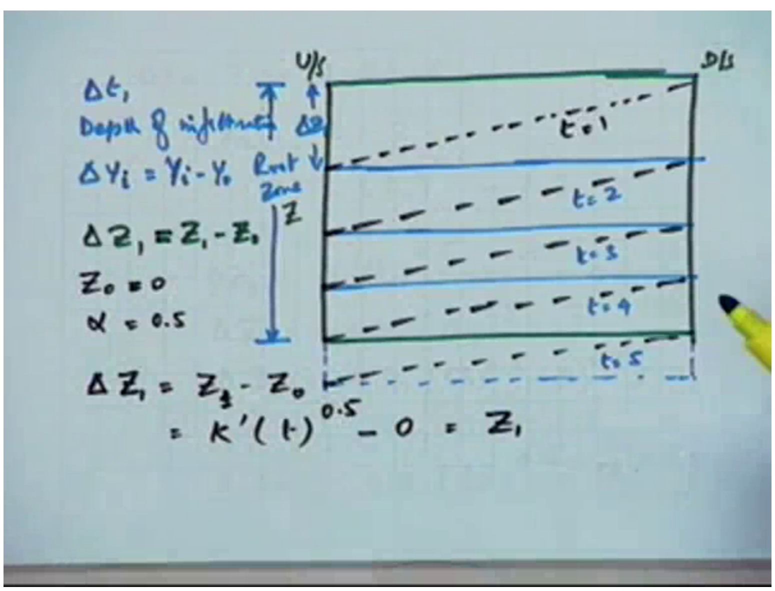

And that is quiet understandable because we have been studying this so far that what happens when you go in, when you have the infiltration for a longer period so that is what is reflected here. The initial infiltration will be at a higher rate the later infiltration will be a lower rate. Now if you want to satisfy the downstream end of the field also you will have to provide the water beyond this root zone depth. That means for additional time period. Only then this component the lower part of the field can also be satisfied. Or in other words what you can say is that if you want to satisfy the deeds of the downstream end also you have to ensure that at least the water should be available there for the end time. What is the net time for which the infiltration should take place so that to get the achieve the the net irrigation requirement okay.

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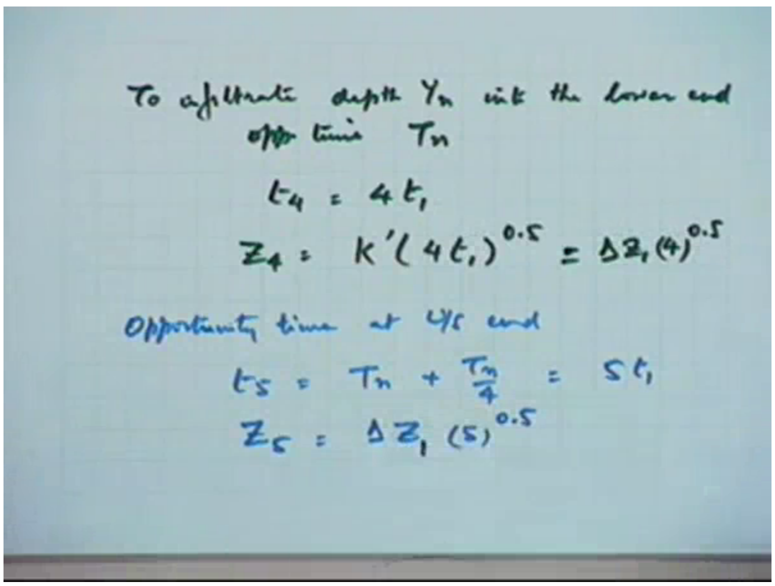

So that is what you will you can write in the form that to infiltrate Depth Y n into the lower end of the field. There should be opportunity time at the lower end also equal to T n okay. But we also know that t 4 is how much 4 times t 1. And correspondingly Z 4 is K dash 4 t 1 or Delta Z 1 into 4 to the power 0.5 the same thing. So to achieve this the infiltration opportunity at the in order to achieve this requirement the opportunity time at the upstream end has to be has to be t 5 which is equal to T n plus T n by 4 or it's also equal to 5 times t 1 and the corresponding Z 5 is Delta Z 1 into 5 to the power 0.5 as we have done here the same thing okay.

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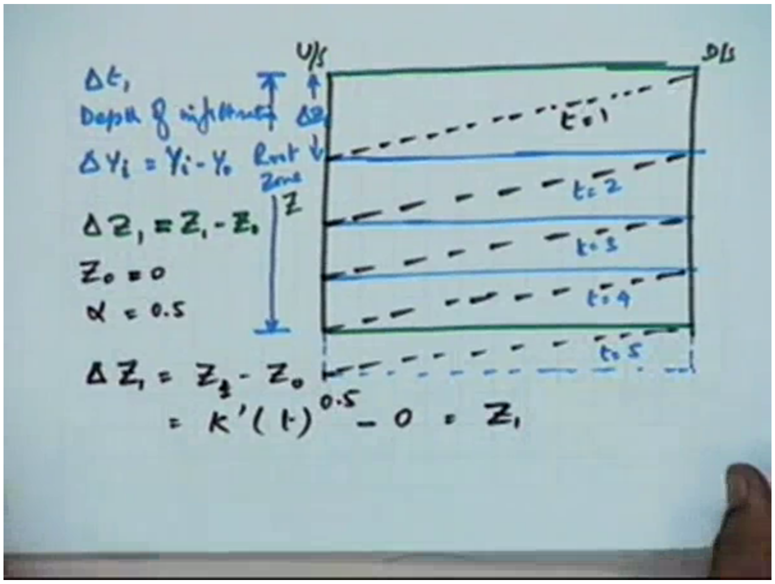

Now if, that is what we have plotted here also. This is basically the same thing which we have plotted that if you want what will happen at t is equal to 5 so that is what we have plotted already here.

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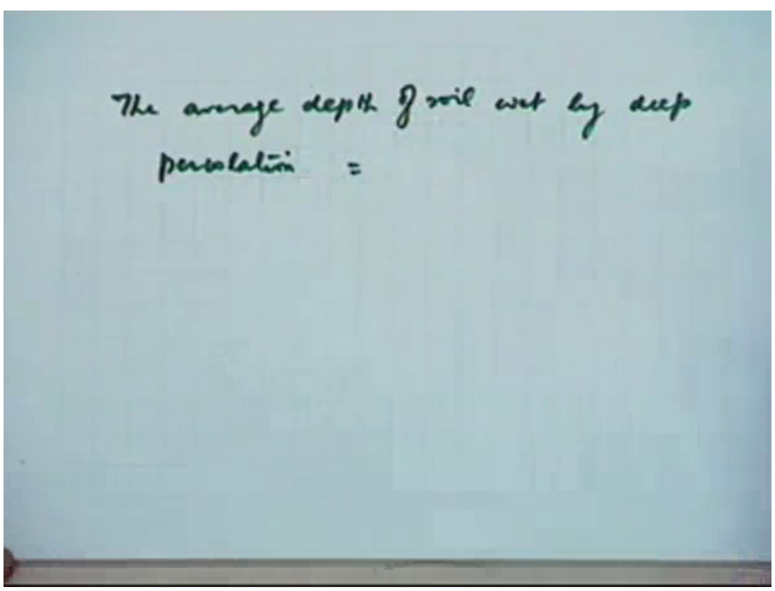

Now we will define two quantities which are very important quantities for our subsequent analyses and design purpose we can utilize these. The first is that if you want to know the average depth of soil which has been wet by deep percolation will be that the average depth of soil.

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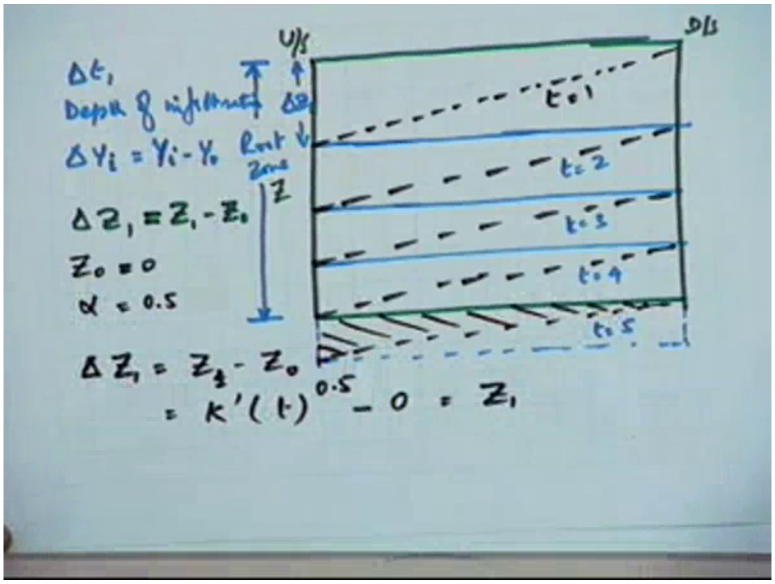

Is basically this part this portion which I can mark here this is the deep percolation which could have been avoided. But since we wanted to take care of the downstream area we have indulged in this deep percolation.

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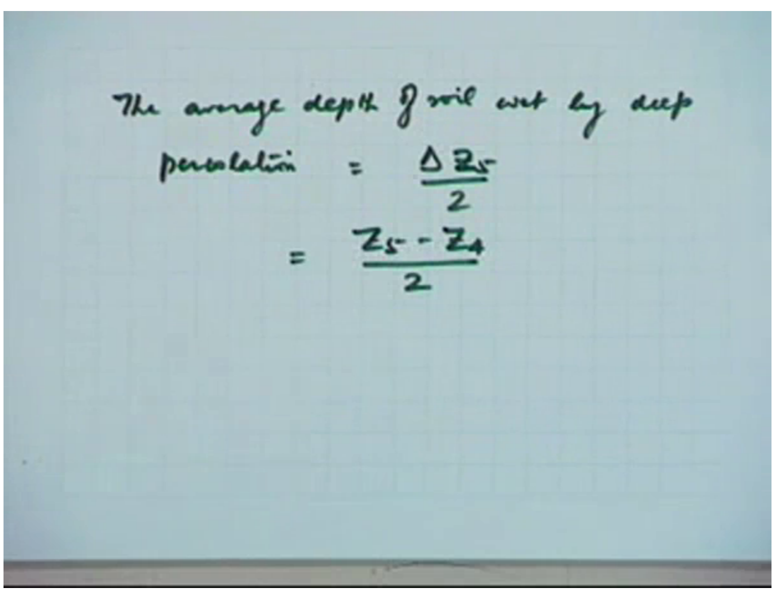

So if you want to know how much deep percolation you have indulged into you can express that as Delta Z 5 by, that's the average deep percolation. Delta 5 is the maximum deep percolation. If we assume that this relationship is linear that is varying from Delta 5 on the upstream end to the 0 level at the downstream end then you can see the average deep percolation is delta 5 by 2 which can also be written as Z 5 minus Z 4 by 2, because Delta Delta 5 is nothing but Z 5 is the absolute value or the total depth up to that level. And Z4 is the depth up to the root zone level of the upstream end.

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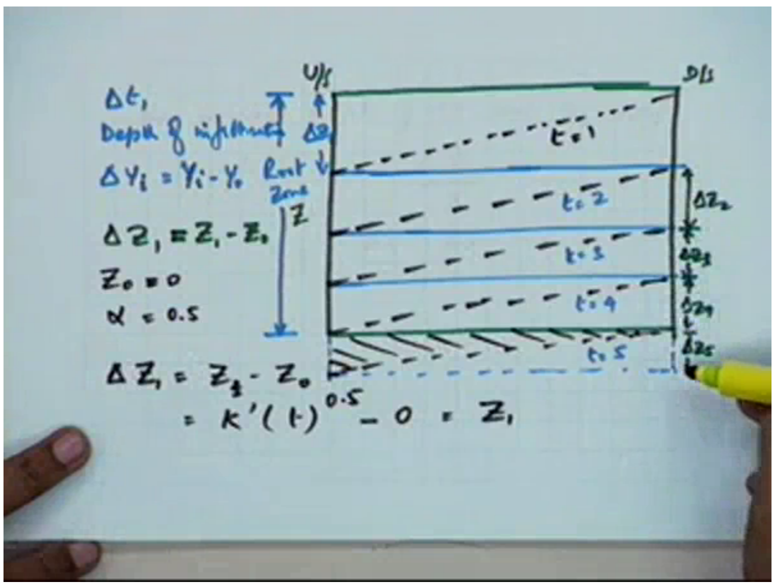

Let me say that this is Delta Z 2 the next one is Delta Z 3 this is Delta Z 4 and Delta Z 5 okay these are the immediate values. But for each one this is the Z 1 up to this up to the next one this is Z 2, Z 3, Z 4 and Z 5.

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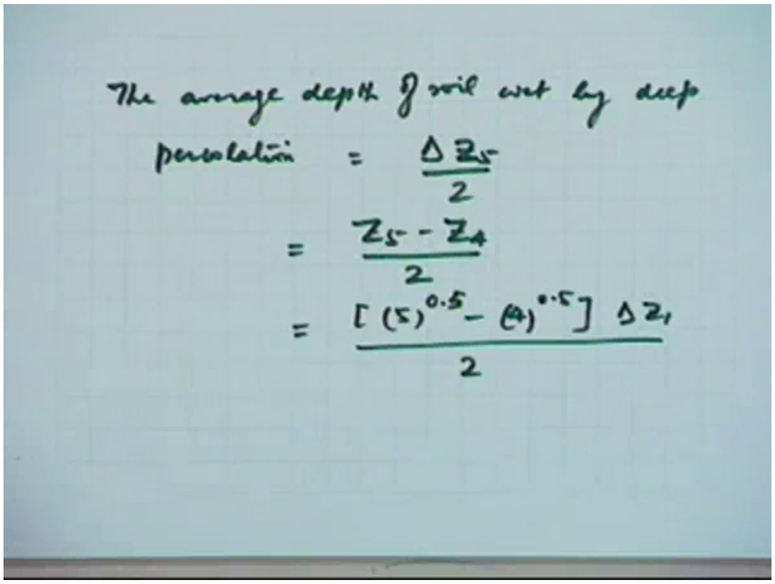

So you can you can use it either way this is Z 5 minus Z 4 is what is Z 5 by 2 that is also you can write. So this in fact is nothing but you can write this in the general form minus 4 to the power 0.5 into Delta Z 1 by 2 okay this is one which gives you that what is the average deep percolation.

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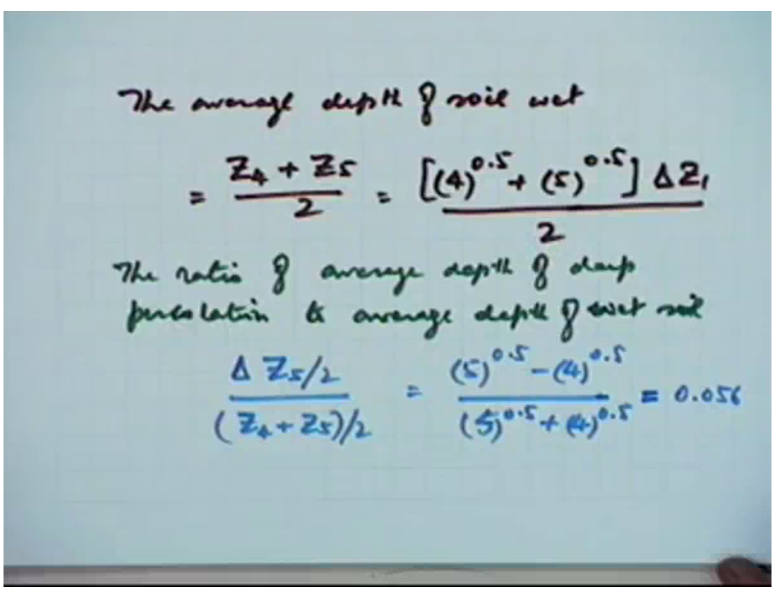

And if you want to find out the average depth of soil which has been wet then you can express that as Z 4 plus Z 5 by 2 so the total depth which has been wet was the average value of that is the the average of the 2 extremes on one side is Z 5 and other side is Z 4. So the average of that will give you the the total depth which has been wet. This you can also express as 4 to the 0.5 plus 5 to the power of. Okay. Now if we take the ratio of these two quantities the ratio of average depth of deep percolation to average depth of wet soil. You can write this as Z delta Z 5 by 2 by Z 4 plus Z 5 by 2. Which is 5 to the power 0.5 minus 4 to the power 0.5 by 5 to the power 0.5 plus 4 to the power 0.5. And Delta Z 1 is cancelled out. So this is the ratio which is in this particular case is 0.056.

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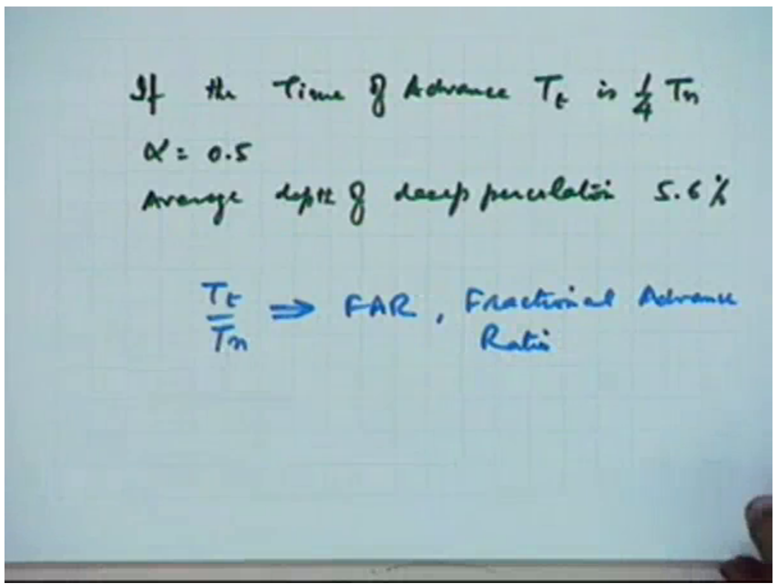

Now in this, this specific case what it amounts to is you can now formulate that if the Time Of Advance T t is one-fourth the T n is one-fourth the net infiltration time T n. And for Alpha of 0.5 the average depth of deep percolation is 5.6 percent okay. This is only one instance which has been analysed similarly there are many other instances which has been analyzed by taking different values of Alpha which means that by taking different characteristic of the soil and by taking different F A R ratios which is the Fractional Advance Ratio. This ratio T t by T n we call it as FAR or Fractional Advance Ratio so if these are know then you can you can formulate the relationships which can be used subsequently for your analysis.

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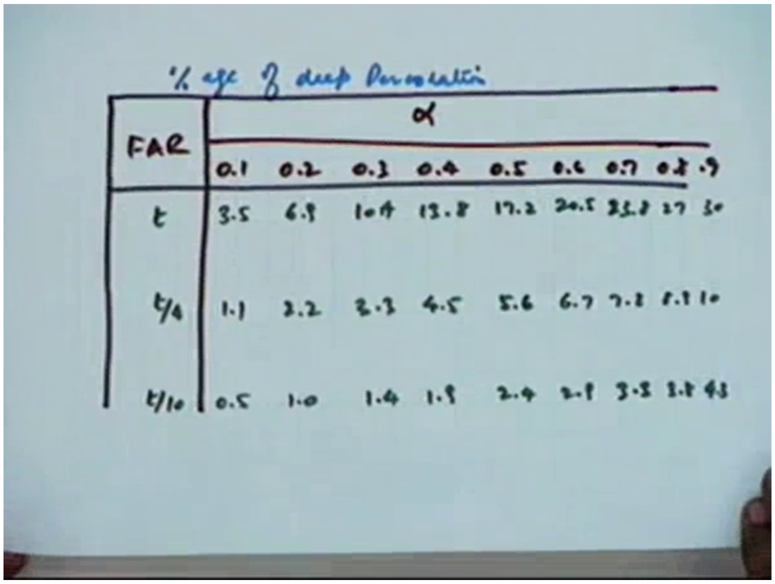

And I will show you some values of the table which have been which has been provided through the similar analysis which we have done just now. This table looks like this I will just pick up some of the values out of this table so that you get a feel of. This table gives the expected percentage of deep percolation. And on this side you have the Fractional Advance Ratio FAR. Here you have the Alpha value of different soils may be ranging from 0.1 to 0.9. For a FAR ratio of one or you can write it as t that means the time of opportunity is same as the time taken by the the advance curve to reach the downstream end. You will have the values.

You can look at (())(41:13) magnitude of these values that how much if you have this parameter fixed in such a way that your advance curve or the time taken to reach for the advance curve to reach the downstream end is equal to the opportunity time requirement for the net infiltration to take place. You will incur lot of losses and those losses will also vary from soil to soil. The soil is a function of Alpha so if your Alpha is increasing the deep percolation losses are also increasing.

Let's take another sample of when you have t by 4 out of which we have analyzed only one but for the others for example when alpha is 0.1 and have FAR ratio of t by4 in this particular case the deep percolation is assumed to 1.1 percent 2.2, percent 3.3, percent 4.5, 5.6, that is what we have analyzed for alpha is equal to 0.5 and for FAR ratio of t by 4 or 1 by 4 and 6.7, 7.8, point 9 and 10 percent.

Let's take the other (())(43:01) of t by 10 that means your your flooding the total length in very short period is where FAR ratio is T by 10. So in this particular case your deep percolation losses will be still smaller. This table now can be utilized for picking up some of the parameters. You can find out that if you want to accept only the deep percolation losses of a specific range you don't want the deep percolation losses to be more than 10 percent or more than 5 percent. And you know what is the type of soil which is the prevailing type of soil you can pickup take that alpha and you can find out what the most preferable FAR ratio how much is which can be utilized.

And that can give you some indication towards what should be the the time of irrigation should be selected and what will be the time of then accordingly the time of infiltration which will be available is not is not dependent only these things it will also be dependent on then which stream size you will be picking up. What are the other parameters of the field, what is the grid all those things we have not considered so far. This is only the starting the the those parameters which are independent of the other aspects of the field. They are only giving you the relationship between the soil type which is through Alpha and the advance time which is again dependent on the soil type to certain extent. And all these relationships can be utilized to start your design considerations looking at which are the most suitable parameters which you should be start with okay. So this analysis as I mentioned in the beginning that this is not only concerned with the furrow irrigation it is a general purpose analysis which can be made use of in all the surface irrigation method.

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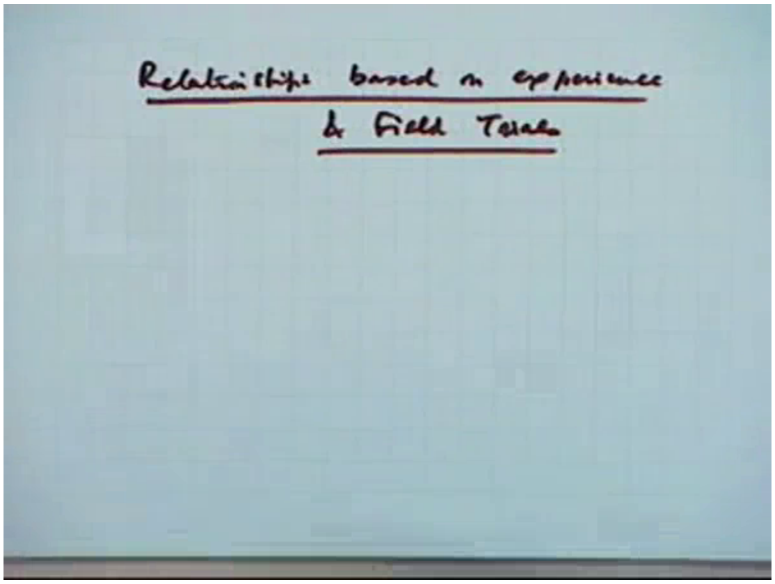

Now next will try to now start looking at the Furrow Irrigation Method in particular. First of all we will try to look at those relationships which are obtained through experience through field trials.

So these relationships which are based on and field trails. These relationships are very important in the absence of detailed data because you can also use the hydraulic relationship which are more exact but many a times you will find that the the required data is not available so you have to you have to start at least looking at the designs with some some indicators which are available. And since it's a very important area all over the world there are world organizations like FAO which have compiled this information and made it available in many reports where it's easily available where people have come out with under different conditions what will be the limiting design parameters from various concentrations and we have already considered the in the case of border irrigation also.

The considerations the major considerations are of the things like the stream size is shouldn’t be erosive, it shouldn’t create problem for your fields. Then there is one consideration, the other is that your efficiencies should be pre-stabilized efficiencies. So that will be basically dictated by what sizes you will choose, will be the combination of discharge, the stream size, the size of the field, with respect to the soil type and with respect to the slope prevailing grades. When you look at the grades then again you will have to look at all those grades excessive which can create problem of erosion. Are those grades very flat which can also create problem of the drainage. So there are there are no specific rules and regulations which are applicable. However the places you will have to look at the climate, you have to look at is it a humid area, is it a aired area. The rules will be different from the if similar soil, but if the area is humid and one extreme. On the other extreme if the area is aired you might have to choose different parameters.

For example let's assume if it's a humid area. Now in the case of humid areas you will have lot of rainfall occurring and that to the intensity of the rainfall will be very high. If you go in for slopes which are steep slopes may be that during irrigation time you can control those those stream sizes. You can control the rate of application of water. But what will happen if rain will occur there won't be any control at that time the slopes which are prevailing in the field they will remain there so when the rain water will be generated the surface run off will be generated that will create havoc. That will create lot of erosion and all your fields might be distorted, it might be divide of all the fertile land which was there. Might damage the crop altogether. So all those things are possible.

So when you look at those (())(50:45) parameters you will have to take into consideration many other conditions which are beyond the irrigation conditions. These things are very important and we will look at all these these relationships which have been formulated on the basis of the experience of the farmer. Because the farmer might not be having the scientific explanation of all these practices we he has been indulging into but through the experience through the common sense he has arrived at some of the combination which are very scientific which are very realistic and those things have also been taken into consideration when various researchers have looked into all these various possible details of these parameters.

And they have taken into confidence or into consideration all those experiences of the local farmers and those have also been brought out in all those publication wherever possible. Along with that the other recommendations are based on experimentation which for example in the case of water irrigation we have seen that how can do the evaluation runs. So through those evaluation runs you keep on taking the observations and then you analyze those those data and come out with the recommended procedures. For example in the case of the erosion you run those stream sizes in the field and see that how much erosion is taking place. You find out which are the stream sizes which are limiting stream sizes beyond which if you will increase the stream size for those specific type of soils and those slopes you will have erosion problem. So that is how you collect the data and you make the recommendations. All those things we will discuss in the next class and along with that we will also look at the hydraulic relationship which have been formatted on the basis on the hydraulic principles and they can be used for the design wherever the data the required data are available okay. Any question at this stage. Thank you then.