Water Management
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Lecture 39
Drip Irrigation System (Continued)

So far we have discussed the various types of emitters which we can use and what is the different characteristics under which type of layout they will be more suitable.

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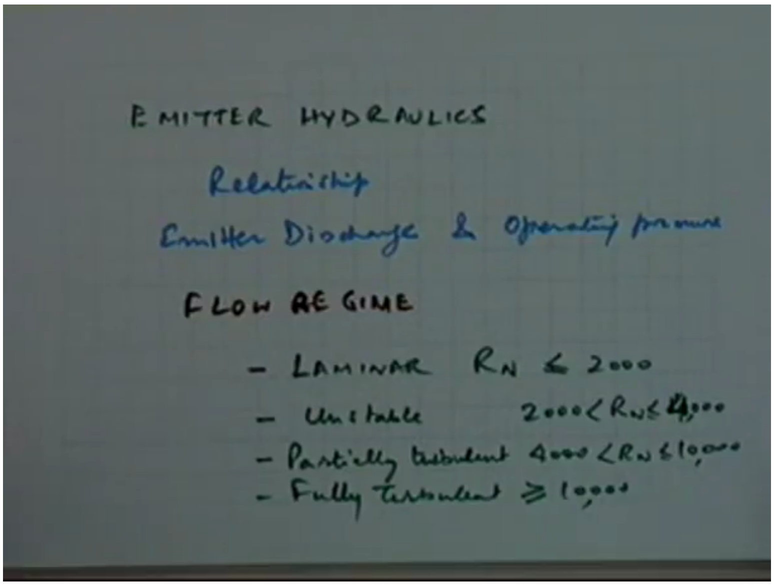

Now let us go on to the next aspect of the drip irrigation system design and for that we will like to see that how the emitter hydraulics work, what basically we are interested in is that what is the relationship between the emitter discharge you can say emitter discharge and the operating pressure because basically we are we are ultimately our main interest is how uniform the application can be applied the irrigation application how uniform it can be applied in that sense we know that is a function of the operating pressure, we also know that there are some losses which encore as we have seen in the case of sprinkler irrigation system.

So the drip and sprinkler irrigation system the design aspects are almost similar you have the similar situations in the case of sprinkler irrigation system, you had the along the lateral you had the discharge which was reducing discharge as you go downstream the lateral specific lateral the same was true for the main line also. In this case also is the similar situation the only difference is that the pressures when you come to the lateral level pressures are much lower the pressures are much much lower in comparison to what the pressures were in the case of sprinkler irrigation system.

So though the philosophy will remains same but the relationship might change that is what we are trying to look into when we go into the details of the design aspects which which relationships are relevant now when we talk in terms of the drip or the the trickle irrigation system. So in other words we can as we know most of us have gone through the basic hydraulics courses and we have seen that the flow regime is a very important aspect and you had you had introduced the Reynold numbers to designate the flow regime.

So in this in this case also we use we take the help of Reynold number and we evaluate the flow regime because the flow regime will decide what is the order of magnitude of the the prevailing pressures and the flow regime can accordingly change which in turn will change the characteristics of the flow or in what we are interested that how what will be the behaviour of flow in terms of the pressure variations which will be cause because of the retardants which will be introduced in the flow due to the friction losses.

So the flow regimes are laminar this we have already gone through that depending on the Reynold number we will define the Reynold number once again if this Reynold number is less than 2000 the flow regime is known to be laminar. It will be a unstable flow regime if the Reynold number is between 2000 and value of 10000. Is partially turbulent in this range sorry this is instead of 10000 this is 4000 extremely sorry and the when it is 10000 that limit will be the beginning of fully turbulent flow. So anything beyond 10000 is the fully turbulent flow.

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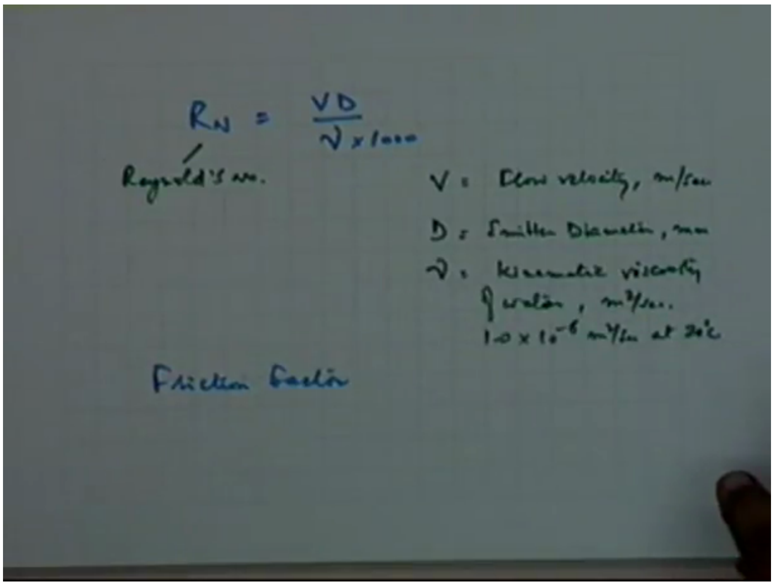

As we know the Reynold number is expressed as VD by Nu and because of the the various dimensions which you are of the units which you are using for different items we will put this constant of 1000 also. This is the Reynold number which is a number and V is the flow velocity in meters per second, D is the emitter diameter in millimetres and Nu is the kinematic viscosity of water and this is expressed in meters cube per second and normally the value of kinematic viscosity is taken as 1 into 10 to the power minus 6 meters cube per second at 20 degrees centigrade.

Now this a Reynold number you might have seen the moody diagram which gives a relationship between the Reynold number and the friction factor is basically we are interested in the friction factor that how this friction factor changes with respect to the the regime of the flow and that is our basic interest that is why we want to know that what is the regime when you are having a particular system when it is operating at the time of design also you will know that what will be the operation policy, how it will operate, what will be the pressures, which will be the prevailing pressures or operating pressures and that will decide what will be the regime of the flow and accordingly you will use the appropriate relationships.

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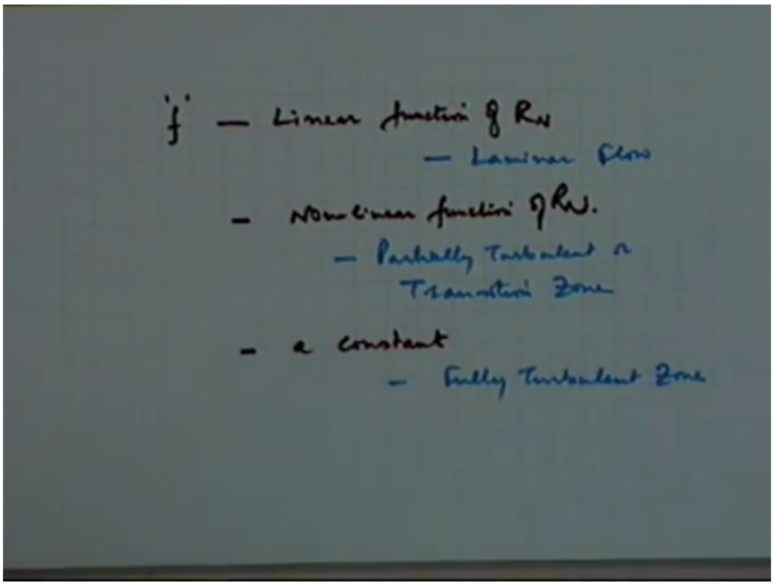

Now it is from the moody diagram you must have seen that the friction factor f that is the friction factor is a linear variation is a linear function of Reynold number in the case of laminar flow. It will be a nonlinear function of Reynold number when the flow is partially turbulent or is also called the transition zone and the friction factor f will be a constant when you have the fully turbulent or in general you will find that the flow is very unstable in this in this zone when it is partially turbulent in most of the field conditions you will not be able to have such a flow available for a longer period, it will be either laminar or it will be turbulent flow.

So as far as the relationships are concerned you will be either using the relationships depending on which what is the prevalent flow at that time, if it is laminar you will be using those relationships which are relevant to the laminar flow otherwise you will use the turbulent flow relationships.

Now let us see some of the possible relationships which might be which might be put to use when you go in for the designs and some of the possibilities are because if you look back and see that we have gone through many of the individual emitters so it will be a function of emitter, what type of flow will be prevalent along with the with the pressures and other things.

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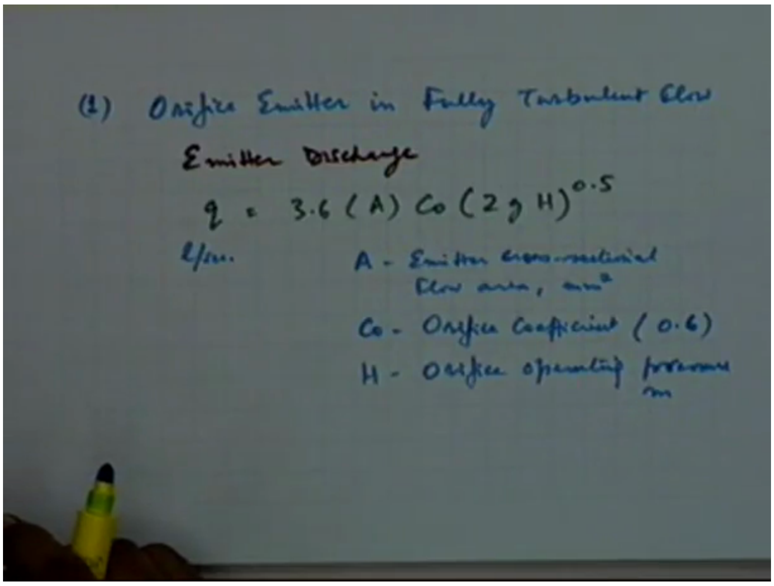

So looking at the type of emitter along with the type of flow that is what is required, so you might not be going through all the possible combinations we will give you some of the possible type of emitters which are which are discussed here. Let us say the orifice emitter in fully turbulent flow so if you have this emitter and the flow is fully turbulent then the emitter discharge that is what we are interested in if I designate the emitter discharge as small q this is equal to 3.6 to A into C not into the emitter discharge in is in litres per second and A is the emitter cross-sectional flow area is in millimetres square, C not is the orifice coefficient and a typical value of this coefficient is taken as 0.6 normally, g is the escalation due to gravity and H is the orifice operating pressure and is expressed in meters.

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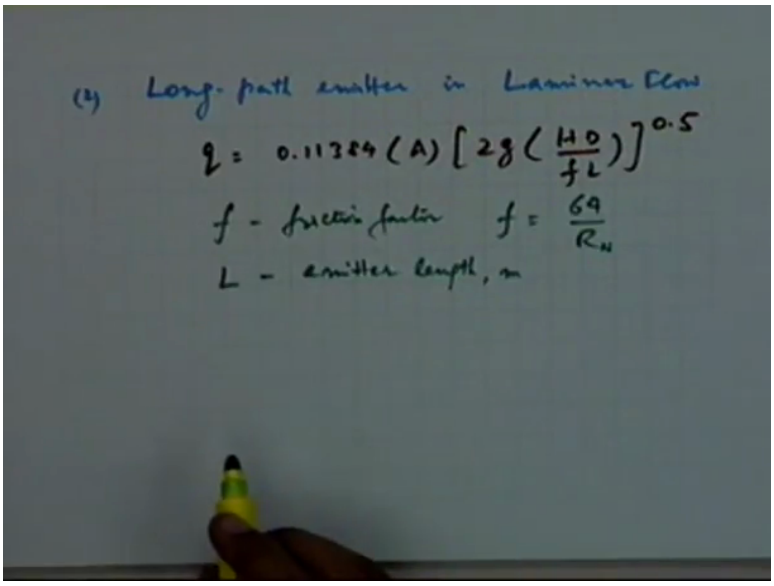

Let us take a case of if you have a long-path emitter and the flow regime is laminar then the emitter discharge q is expressed as this given expression. Now in this case this term we have already all the other terms are same only f is introduced which is the friction factor is the dimensionless quantity. Now f as you see that is the laminar flow range the flow regime is laminar in this case if you remember the moody diagram the in the laminar range the friction factor is expressed as 64 by Reynold number.

So that is what you have to see that if your if your flow regime is known then you have to use the up value the friction factor value accordingly and in this case the other term which we have not expressed so far is the L which is the emitter length in meters. The emitter length is the long-path emitter the emitter length is not the physical length of the emitter is the length of the path the spiral groves which you have provided inside the long length of the long-path emitter, what is the length of that because that is the effective length through which the water is passing and that is what has to be used in the case of a long-path emitter. So that will be given when you have given that this is the path emitter, the length of the grove will also be given along with that.

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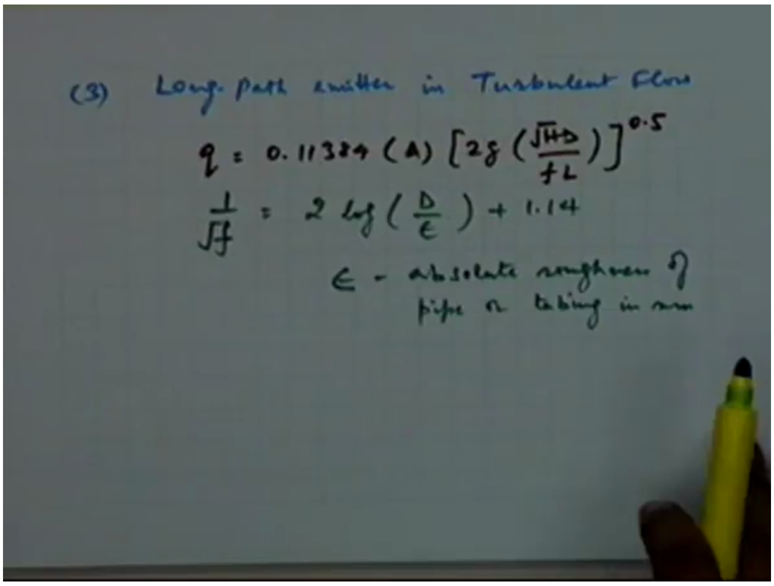

Let us take another case where you have used the same long-path emitter but now is in the turbulent flow the regime has changed, the type of emitter is same but the regime has changed to turbulent flow regime. In this case the equation which will be used is also slightly different, this H under root only not including the so this is the expression which has to be used for the turbulent flow case to find out the emitter discharge.

In this case the friction factor the friction factor f is having a different relationship and in this relationship the friction factor is given as this expression where this term ties absolute roughness of pipe or the tubing in millimetres. Now is a function of the the ratio of the diameter to the absolute roughness because the friction factor will be dependent on what is the what is the extent of the roughness of that material which is being used in the case of the turbulent flow.

The only in this while using this equation you have to be careful that the units used for D and eta are the same units they are not different units because earlier we have expressed D in meters and right now we are giving eta is in millimetres. So when we are using this both the units should be same that is very important for this for this relationship be used.

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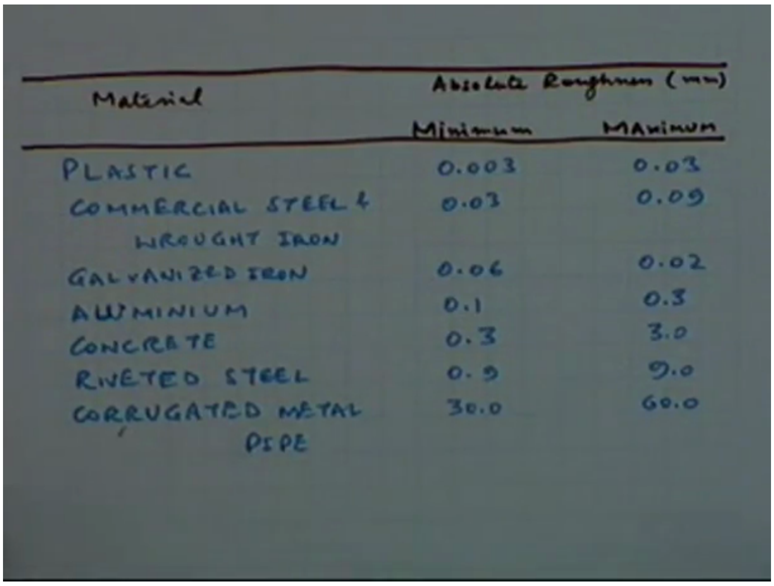

Material	Absolute Roughness (mm)	
	Minimum	Maximum
PLASTIC	0.003	0.03
COMMERCIAL STEEL & WROUGHT IRON	0.03	0.09
GALVANIZED IRON	0.06	0.02
ALUMINIUM	0.1	0.3
CONCRETE	0.3	3.0
RIVETED STEEL	0.9	9.0
CORRUGATED METAL PIPE	30.0	60.0

In literature you will find that the value of the absolute roughness for different types of materials is available, these are the materials or some other materials which are normally used for the drip irrigation system network for the plastic the minimum and the maximum absolute roughness is given. So you will get a idea that what is the range, what is the range to be used or the value has to fall within this range while doing the design the exact might change because in this case also there is lot of variation between the the minimum and the maximum value.

In the commercial steel and wrought iron this is the range, galvanized iron is slightly higher, so this is in the standing order, aluminium is more than galvanized iron, then concrete, riveted steel, corrugated metal pipe so all these these are the suggestive values which can be used while doing the design.

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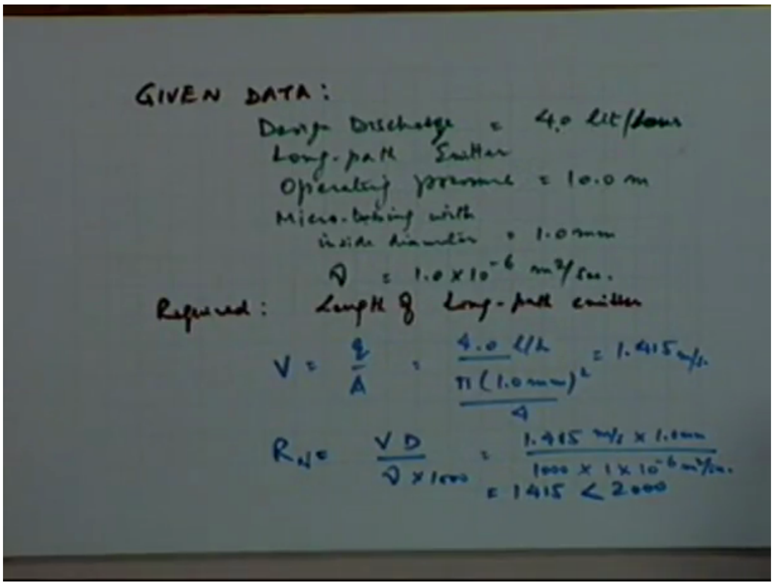

I will like to go through a small problem to give you a an idea that how much the these parameters can change when you go from one regime to another regime using the same type of emitter. In this case in this problem there is some data given the given data is the design discharge is 4.0 litres per second which is the requirement, the type of emitter to be used is long-path emitter and the operating pressure is 10 meters, you are using a micro-tubing which has the inside dia of 1 millimetre. When we are discussing the long-path emitter I had not shown you but I had just mentioned that you can at a outlet you can have a micro-tubing instead you can have 1 or 2 micro-tubings for the water to lead the emitter.

Now in this particular case is the long-path emitter and the exit is through the micro-tube which has 1 millimetres of the and then the kinematic viscosity Nu is taken as 1 into 10 to power minus 6 meters cube per second. Now you are required to what is required you are required to compute the length of long-path emitter, how much length is required if these are the design parameters required design parameters to be fulfilled that is design discharge of 4 litres per second with operating pressure of this and the other quantities are given.

In this case you can find out the velocity because q is given, area is known, so q is 4 litres per I am sorry this is not 4 litres per second this will become too much this is 4 litres per hour the design discharge is 4 litres per hour is 4 litres per second is a very huge discharge which is not required specifically in the case of drip irrigation, 4 litres per hour is the design discharge and you have the area and this is 1.415 meters per second.

Now knowing the velocity you can find out the Reynold number because now you have the velocity, you have the diameter, you have the Nu value into 1000 that is what is the expression which we have used. So 1.415 meters per second into 1 millimetres by 1000 into 1 into 10 to the power minus 6 meters cube per second. This works out to be 1415 which is less than 2000. Therefore the flow regime is laminar.

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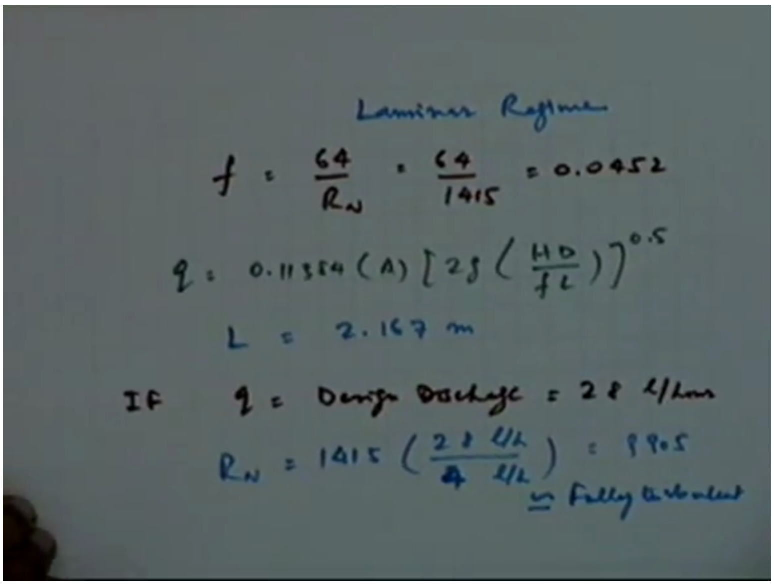

So you have a laminar regime if your flow regime is laminar you can find out the friction factor which is 0.0452. Now once you have the friction factor then the meter discharge can be (())(29:32) using the appropriate equation which we have just written earlier this was the equation which was to be used for the laminar flow of the long-path emitter and this in this everything else is known but for the L and L works out to be 2.167 meter although the quantities are known you already have their values and L is 2.167 meters.

Now if we we change one parameter if we say that the required design discharge is not 4 litres per hour but is 28 litres per hour with this this height is design discharge, you want to find out now what is the change in length you can you can find out the Reynold number and since the Reynold number is a linear function of the velocity which is again a function of the discharge so you can directly find out the Reynold number for this particular velocity which will be prevalent at that time for the discharge of 28 litres per hour by using this proportionality this will be 9905 which is almost close to value of 10000.

So since is towards towards the fully turbulent side because this might it will not be in the unstable zone for a longer period so you can you can assume this to be fully turbulent case that means to get a design discharge of 28 litres per second your flow regime will become a turbulent flow regime.

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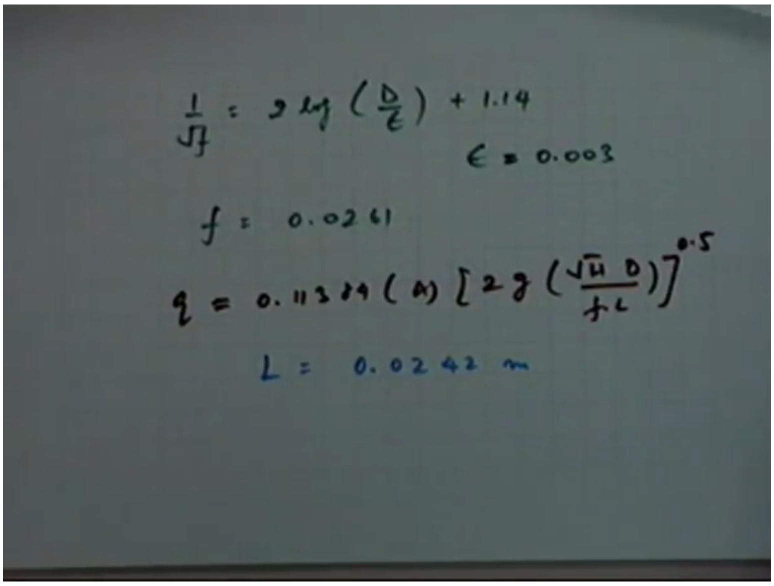

And now the the friction factor will be computed by this expression and in this particular case the material which is taken for that the value of the absolute those the value of the eta which we have found out in this particular case I think from the table the absolute roughness is given as 0.003 which is minimum absolute roughness for the case of class check. So taking eta as 0.003 your all the other quantities are known the f value works out to be 0.0261.

And now using the relevant equation for the emitter discharge you can find out the since the emitter discharge is known which is 28 litres per hour so you can substitute all the other values the only unknown is the length which will work out to be 0.024 meters. Look at the drastic variation in terms of the length requirement the moment your your flow regime has changed and that is what we were saying that in this particular case when you talk in terms of the selection of proper emitters this is very important to know what will be the possible range which it can (())(35:13) to.

And you will also have to see that what is the maximum design discharge which is required, what is the minimum design discharge which is required, whether you will have a situation where you can (())(35:32) the total requirement throughout the season of the crop. In some cases if they are they are the orchards then it is year after year you do not the requirement will still change the requirement will still change because of two things one the climactic changes where you will have the seasonal variation, the other will be the change in terms of the size of the plant the plant when small then you will have less amount of requirement as it matures the requirement will also reduce.

But that will only be different the first few years once it has stabilized then will be only the climactic changes which will bring out bring about the change in the requirement and that will decide how your design should be the options can be again either you can change the number of individual points the number of emitters that can be one option or you can change the operation policy so that is where you have to decide which one is the better option whether you will like to change the number of emitters or you will like to change the pressure which will in turn change the discharge.

Now here the only importance of this particular going through this specific exercise was to tell you that there can be a drastic change in the requirements of the emitter, okay.

Let us now next go into another aspect which we have seen earlier for the sprinkler irrigation system which is the uniformity the case of uniformity everything which we are doing we are doing with the assumption that we will be in a position to have uniformity of application, uniformity of distribution of water and we had seen earlier in the previous case that uniformity cannot be 100 percent it has to be we have to lose something you have to lose some uniformity the higher the coverage you want to have.

So if you are extent of the network is very large then there are chances that the uniformity will be you will be doing that at the expense of the uniformity that is very important to understand because that will decide on your layout it will also decide that the pattern of your operation because if you have a very big area the layout is not the only factor which will decide what will be the uniformity, you might be having a layout but if you are operating an segments then you are reducing the extent of the network which is influencing all these variations.

So that is very important aspect when you go in for the design you will have to take all those things into texture.

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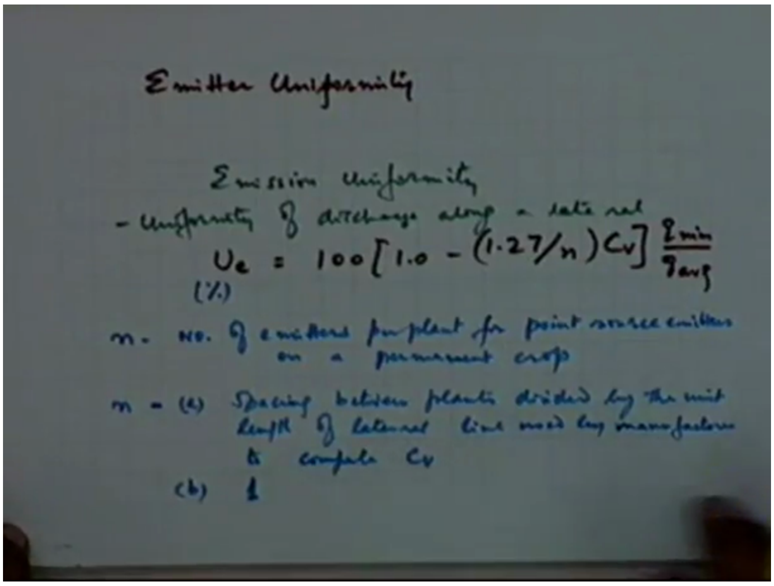

Let us look at the emitter uniformity as we have mentioned in the beginning of this topic that the emitter system or the trickle system is basically is intended to have a very close relationship between the crop water requirement and what is being supplied in terms of the emitter discharge.

Now the emitter uniformity becomes more important because of this fact because if the discharge which you are supplying is not taking care of the requirement and since the requirement has to immediately match with the discharge you do not have very very large interval which is available because of the fact that you are not at no time you are trying to replenish the total deficit which you have been doing in the case of earlier irrigation systems there we were trying to make use of the storage available in the soil that soil storage we are trying to dump the water in that storage and then keep on using that water for a longer duration.

The dumping is at a at a much not let us put it this way that the dumping is at a much quicker rate. So you are using the basic storage which is available in the soil by bringing the soil moisture to the field capacity level, whereas in this particular case you might not be doing that you are keeping the deficit some level of deficit still might be there and in some cases if even if you have started with the low level of deficit by providing the the uniform rate of input you are keeping that deficit at a lower level.

If you wait for a longer period the deficit might increase which might in turn increase the stress in the crop so that will have a detrimental effect. So in this case since we are the rate at which you are supplying the moisture is very low if you are if your crop water requirement is not being satisfied, if there is a deficit which is being created continuously then if you accumulate that deficit over some period it might become so much that it will have some drastic some ill effect on the crop system or the crop that particular plant or even that row of crop. So the uniformity becomes more important from that angle.

The uniformity in this case we we measure in terms of emission uniformity is only a name or the nomenclature given to that uniformity. If we call U e as the emission uniformity this is expressed this is expressed as 100 into since it is expressed in percentage so 100 1 minus 1.27 by n into C v q minimum divided by q average. The various terms which are used here this is emission uniformity in percentage and n is the number of emitters per plant. Let me let me tell you that this is the uniformity of discharge along a lateral the emission uniformity which we are expressing through this is the uniformity of discharge along a lateral.

So n will be number of emitters per plant for the case of point source emitters on a permanent crop or n can also be there is one case either n will be this if you have the point source emitters if you have used the point source emitters on a permanent crop or n will be case a the spacing between plants divided by the unit length of lateral line used by the manufacturer used by the manufacturer to compute C v C v is basically the coefficient of variation and b is case b is 1.

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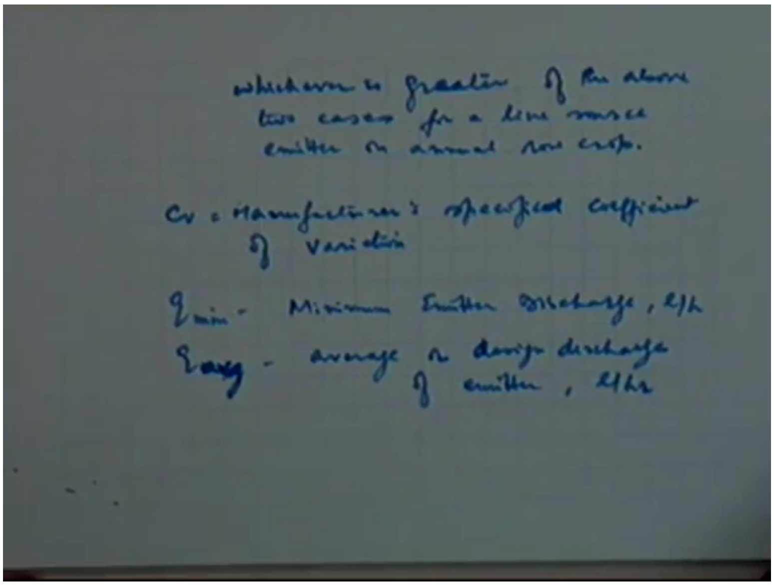

Now the n value in this particular case will be either of the two whichever is greater of the above two cases cases a and b which you have given for a line source on annual row crops that is how you determine the n will be either of the two cases whichever is the greater value when you have the line source if you have the point source than it will be the number of emitters per plant.

Now C v is the is the manufacturer specified coefficient is provided by the manufacturer and is the coefficient of variation the coefficient of variation of discharge and that is normally when the manufacturer provides the emitter he gives the value of the coefficient of variation of discharge and q minimum is the minimum emitter discharge in litres per hour. Similarly the q maximum is the we are calling it q average q average is the average or design discharge again in litres per hour.

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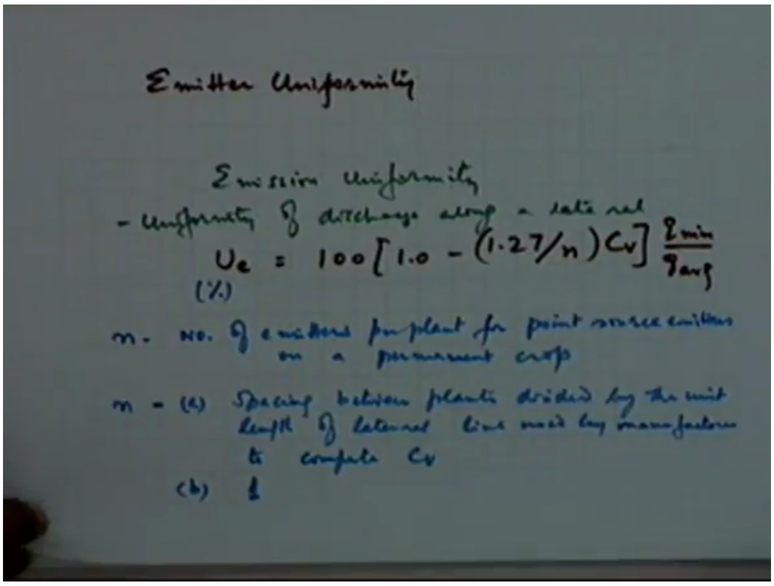

That means if you know the various quantities if you know what is the minimum discharge which is prevalent in particular setting what is the q average you can find out how much is the uniformity emission uniformity provided you also know what is the value of C v and you know what is the type of setting or the type of system which you have adopted that will decide what is the n value the C v is available for various types of emitters which have been manufactured by the various manufacturers.

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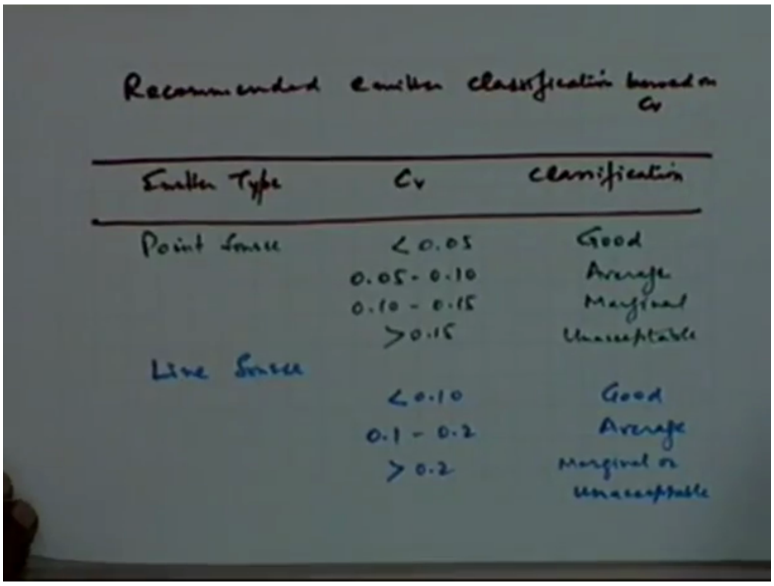

Now I would like to give you some values of C v's for some different types of emitters and how they can be classified on the basis of the the C v value this is this recommendation is given by the American society of agriculture engineers recommended emitter classification based on the value of C v, where this is while selecting a particular emitter you can you can see that whether what type of emitter it is whether it is good looking at the value of C v whether it can be accepted or we should not be accepting it.

So the emitter type the value of C v and the classification which has been it has been put into depending on the value of C v. For point source emitters if the value of C v is less than 0.05 can be termed as a good emitter, if it is between 0.05 and 0.10 is average, is marginal and if it is more than 0.15 is unacceptable. So if your coefficient of variation is quite excessive should not be using those emitters.

Similarly for line source emitters if it is less than 0.1 it is good, so in comparison the coefficient of variation will be higher in the case of line source is unavoidable you can have a better coefficient of variation in the case of point source, if it is between 0.1 and 0.2 it is average class it belongs to average class and greater than 0.2 is marginal or can also term it as unacceptable.

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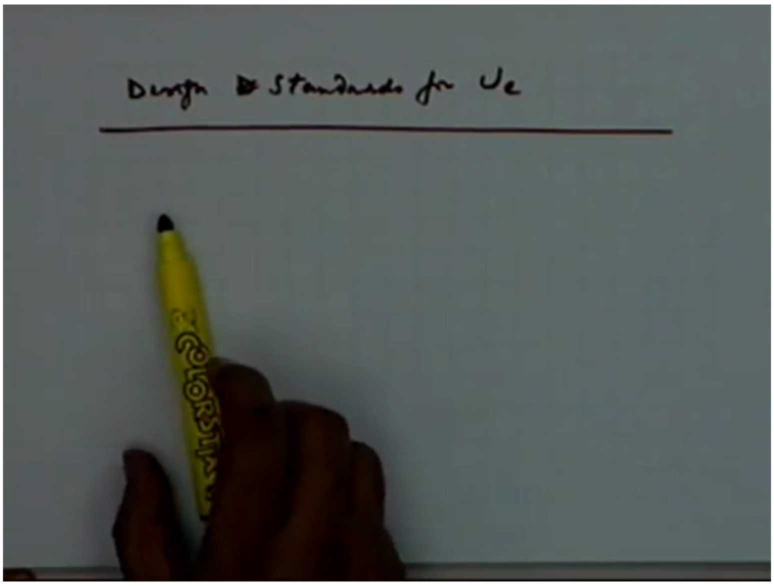

Similarly there is another information of the table which is provided which can also give you a reasonable level of information in terms of what is the emission uniformity which is achievable with respect to the different types of emitters and with respect to the various types of crop spacings. So this is the design standards for the emission uniformity again this recommendation is given by the American society of agriculture engineers and this table I think I will stop here for a while before we discuss this table and then we will go on to the extension of this topic.