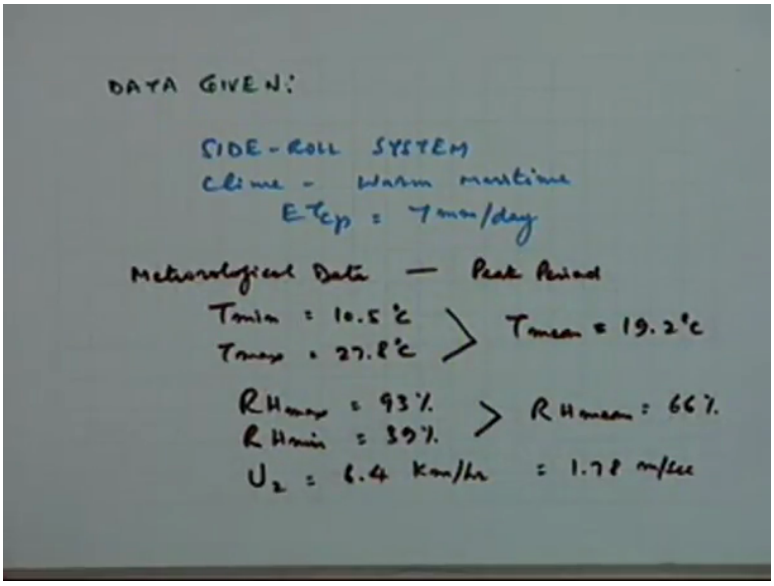
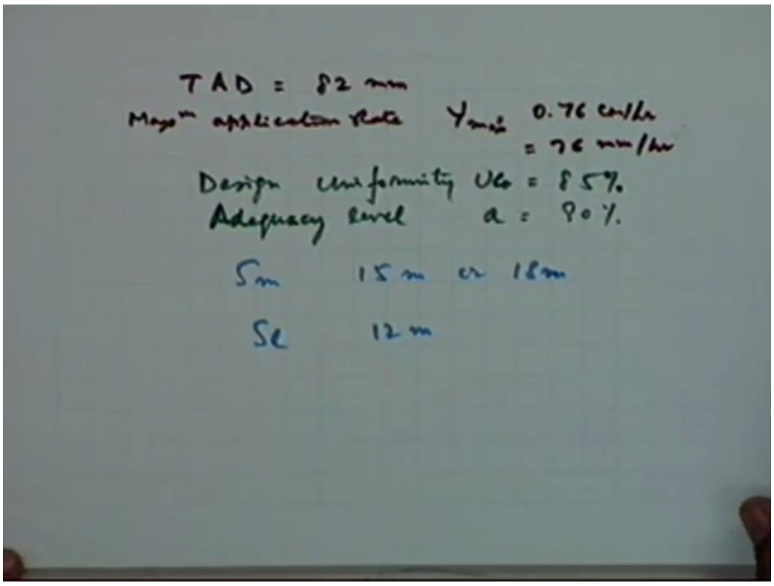
Water Management
Professor Dr. A. K. Gosain
Department of Civil Engineering
Indian Institute of Technology Delhi
Lecture 34
Sprinkler Irrigation System (Continued)

(Refer Slide Time: 1:24)



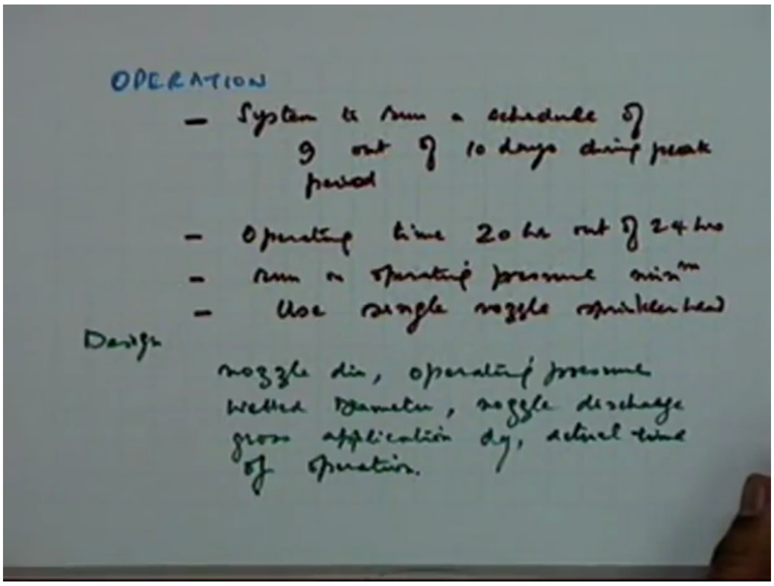
In last lecture we had decided to go through a one exercise, look at some of the design concepts which we have been studying and we had and seen that the data given for this particular exercise is we have a side-roll system, climate is long maritime with the evaporate transpiration activity, the peak evapor transpiration rate of 7 millimeters per day and the meteorological data we had noted down what is the meteorological data which is available for that area during that period.

(Refer Slide Time: 1:48)



The total allowable deficit which we can have is 82 millimeters, maximum application rate is also given, then there was some constraints that the uniformity coefficient which is desirable 85 percent and adequacy level of 90 percent is desirable, the constraints on the spacings the main line spacing either you can choose 15 meters or 18 meters and the lateral spacing of 12 meters.

(Refer Slide Time: 2:33)

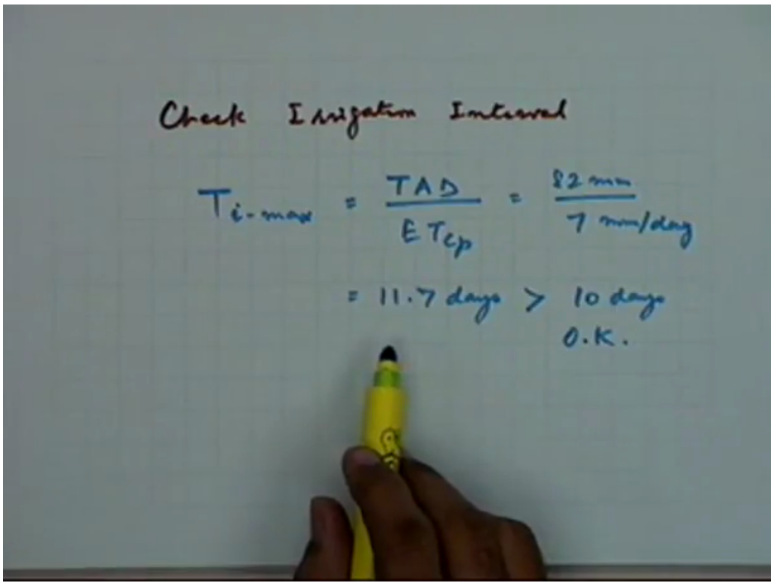


And then we had mentioned about some constraints on the operation. The operation has to be performed in such a way that the system to run schedule of 9 out of 10 days during peak period which makes the time interval to be something of the order of magnitude of 10 days, this becomes a time interval which is available you can also have a bigger time interval but it should be multiple of this limit, okay.

If you want to have a if you feel that the time interval is of this 10 days is not sufficient you might go in for 20 days time interval but it has to be multiple of this 10 days period which is the basic period of schedule then in terms of number of hours available in a day which you can do the perform the operation of the sprinkler system is 20 hours out of the 24 hours for these many hours you can have the sprinkler system on and these 4 hours is kept for the moves or if you have a system where you might be removing the pipes and going to the next sets that time is required.

Then it was also desirable that the operating pressure should be as low as possible but then you have to see that they are within the permissible limits and use of single nozzle is put as another constraint.

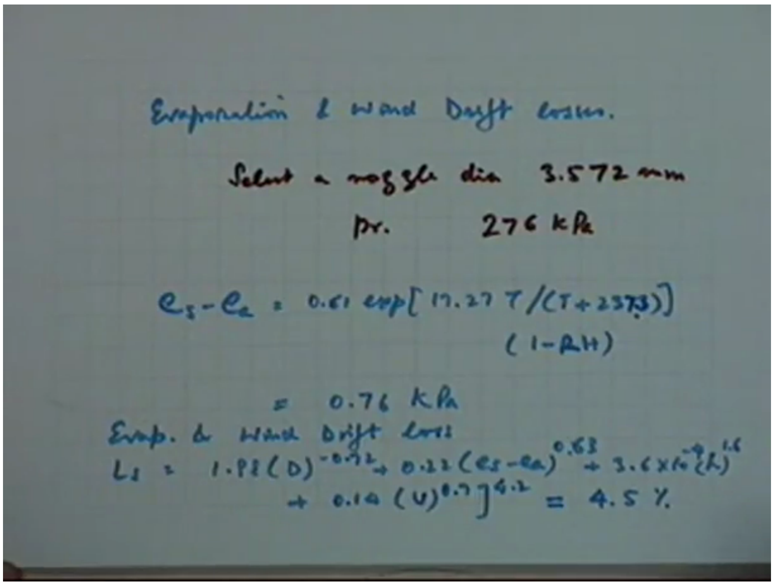
(Refer Slide Time: 4:31)



Now lets us go through the procedure how we should go about the design if we have this basic data available. So the first thing which you will check is whether the irrigation interval is adequate or not. Say if I say that the maximum irrigation interval which will be required has to be dependent on what is the total allowable deficit by peak evapor transpiration rate of the crop which in this particular case this is 82 millimeters and this is 7 millimeters per day which you get as 11.7 days.

So the maximum period which can be made available for performing your irrigation operation can be 11.7 days and this is more than 10 days operation schedule which you are which is the desirable limit which has been put. So from that angle this is this interval is okay because it is less than 11.7 days, okay. As long as your actual period of irrigation is within this period is okay you can manage that but if it was more than this 11.7 days then you have problem, in that case by the time you come back to the same area you might find that the deficit in the soil has gone to a level which is detrimental for the crop production.

(Refer Slide Time: 6:58)

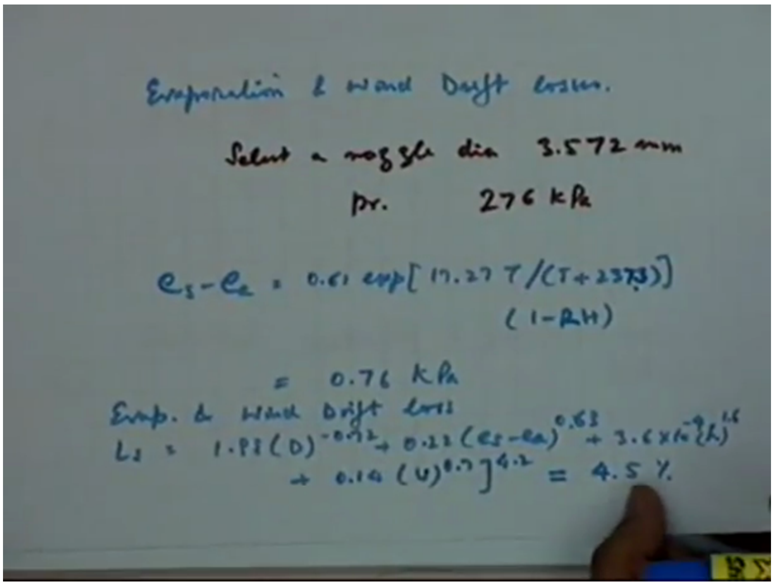


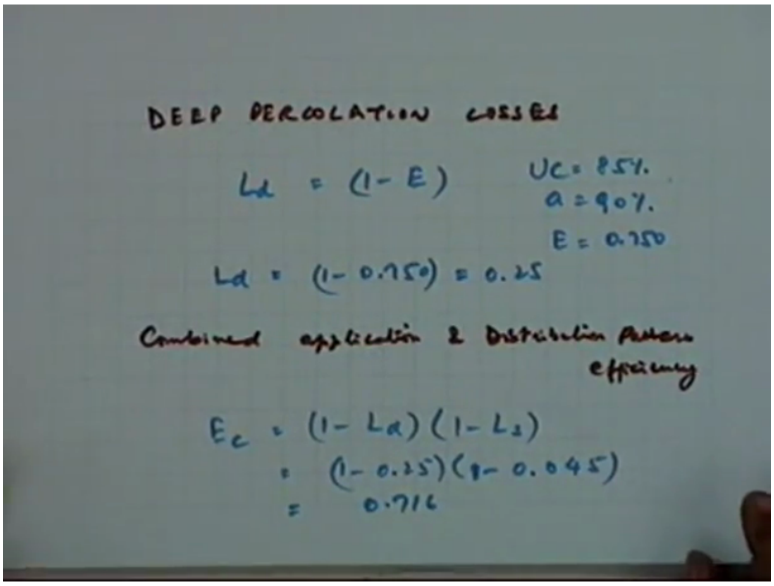
Now next we look at what is the evaporation and wind drift losses. With this stage we can go in for the selection of a nozzle we can select a nozzle and we can also select that under what pressure this nozzle will operate. So if you make a selection of the nozzle select a nozzle diameter of 3.572 millimetre, we had seen the tables of these respective this just randomly selected and the pressure the operating pressure of this nozzle the minimum operating pressure as recommended by the manufacturer was 276 Kilo Pascal.

So if we take this as the initial pressure with respect to the nozzle which we have selected then we can check the other quantities with respect to this selected set. Now let us find out the evaporation and the wind drift losses to do that the expression for the evaporation and wind drift losses you need in that expression the vapour pressure deficit which we had expressed as into T divided by T plus 237.3.

So this is the vapour pressure deficit which we have the expression and if we put these values we now we have the values of temperature which is the mean temperature and the mean rate of humidity which we have the data available on and putting those values you will get that the vapour pressure deficit comes to 0.76 Kilo Pascal and knowing this vapour pressure deficit now you can find out the evaporation and wind drift loss, the expression is given earlier to you and this gives the value of L s as 4.5 percent. This is only a substitution of value which you have the expressions for.

(Refer Slide Time: 12:07)

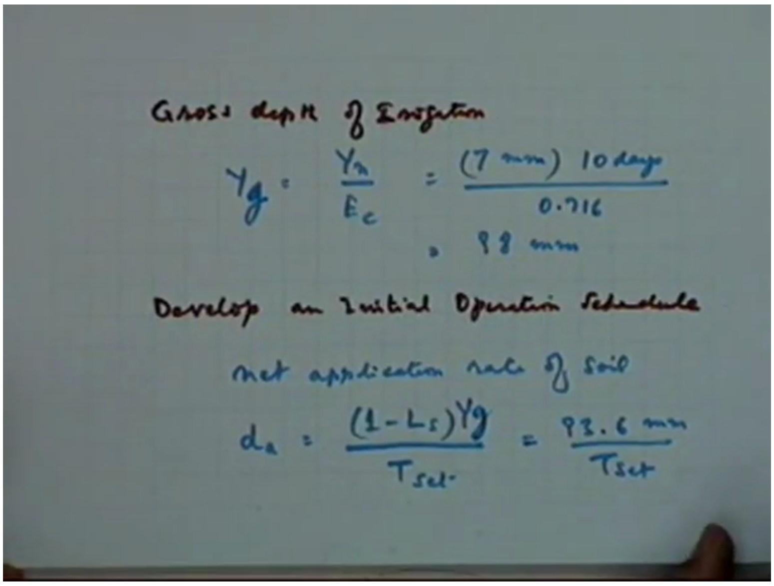




Now the evaporation and wind drift loss is one loss, the other loss which is turbulent in the system is the deep percolation loss, deep percolation losses we had used this expression, where E is the function of uniformity coefficient and the adequacy level we had that we had look at that table where we had said that the E can be evaluated with respect to what is the Euc and what is the value of adequacy and you can read the value of E from that table for UC is equal to 85 percent and a is equal to 90 percent, the value of E is 0.750, thereby the deep percolation losses 0.25.

Now knowing these two losses you can find out the overall efficiency of the combined combined application and distribution pattern efficiency which is if we say the efficiency combined efficiency 1 minus L d expressed in fraction, this L d which you have found out earlier now this L d is 0.25 only but L s we have found out as 4.5 percent when we use as the combined efficiency expression we are still keeping it as L s what is expressed in fraction now. This will be 1 minus 0.25 into 1 minus 0.045 that is 4.5 percent and this is 0.716 that is the combined efficiency which you will get of the present system.

(Refer Slide Time: 14:51)

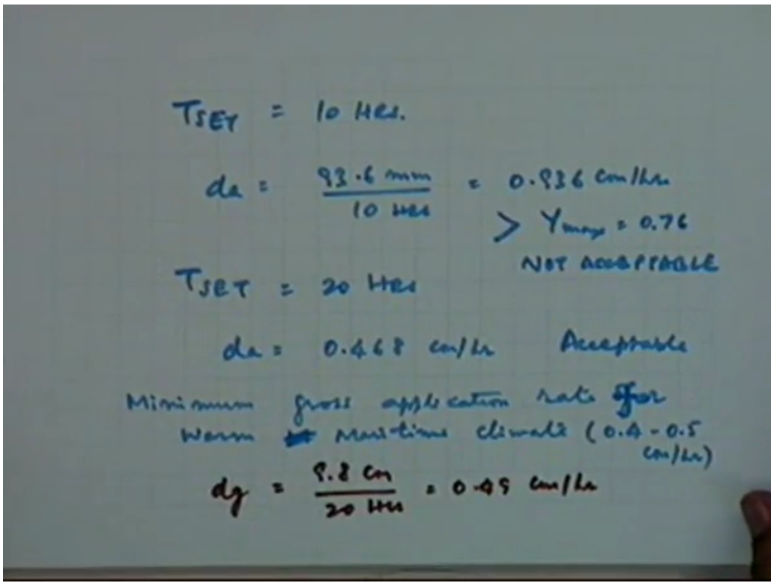


Now this combined efficiency can be used to compute the gross depth of irrigation if we call it Y g is net depth divided by the combined efficiency, net depth is we have 7 millimeters for 10 days so this is your the gross depth of application which is required, okay net we have assumed that is equal into what is the requirement, which is the peak (())(15:53). Now having reached here having found out the gross depth of irrigation we now want to look at the operation how we are going to operate the system.

So if we look at a initial let us develop an initial operation schedule as a first step first find out the first approximation of net application rate, to find out the net application rate let me say that this is Y g this is the gross application taking care of for the losses which are wind and evaporation and wind drift losses so that we need not when we are looking at how much will be coming on to the soil will be less by those losses, okay the gross application less by the evaporation and wind losses divided by for how long was the time.

This the this particular component this is 98 into 1 minus L s which is 93.6 millimeters, now this time which is the the set time how long you want to irrigate, how long you want to operate the system is dependent on that whether you want to operate for complete 20 hours which you have kept or you want to use a lesser time or can you operate within those 20 hours, can you have two settings of the sprinkler is all that is going to decide how much will be the quantities of water needed and what will be the rate all those things you will have to check.

(Refer Slide Time: 19:03)



Let us assume that each set the time for which one setting is to be operated is 10 hours you are keeping at as a multiple of that time available 20 hours is available with you for operation in a day out of 24 hours. So if we say that let us complete one setting in 10 hours if we do that then the da will be 93.6 millimeters by 10, which is 0.936 centimeters per hour because this is 10 hours.

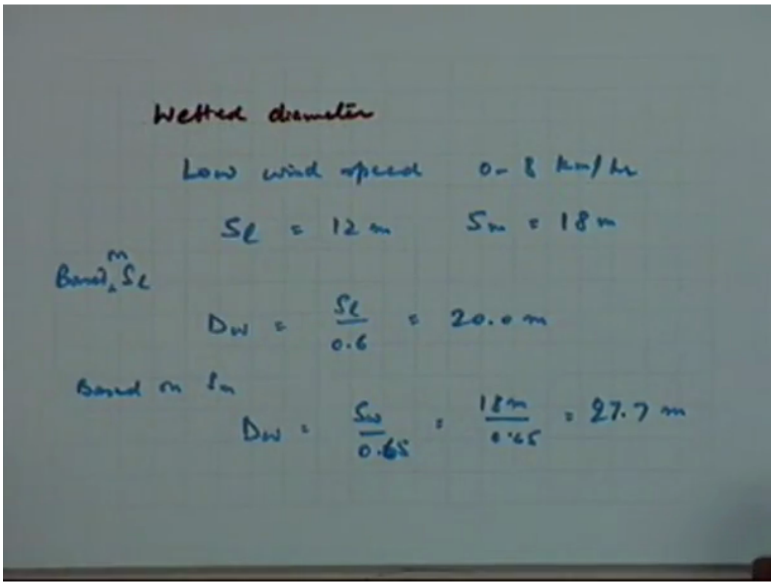
Now this rate this is the rate of application of water onto the soil, we can check with what is the permissible rate of application, the permissible rate Y maximum we have mentioned at the beginning as part of the (())(20:13) that Y maximum is 0.76, the maximum rate which is applicable which you should confine your rate to is 0.76 centimeters per hour that means if you have the setting time as 10 hours you want to dump the water in 10 hours then the rate of application will be much higher than what is desirable, okay.

So you have to choose this is not acceptable, you will have to choose the T set as 20 hours which will provide the depth of application or the rate of application on soil of 0.468

centimetres per hour which is much lesser than 0.76 centimetres per hour which is the maximum limit so this is acceptable. Now with respect to this selection of T set you can also find out the minimum gross application rate for those the warm maritime condition, we had we had seen a table where we had given the what is the minimum gross application rates under different climatic conditions and for the warm maritime conditions if you look back you will find that the minimum gross application rate can vary between 0.4 to 0.5 centimetres per hour, okay.

Now you can make a check that in the present case the dg dd is 9.8 centimetre and we have to complete this in 20 hours is works out to be 0.49 centimetres per hour, which is just within the acceptable range. So from that angle also the gross the minimum gross application rate under the prevailing conditions is also satisfied.

(Refer Slide Time: 23:50)



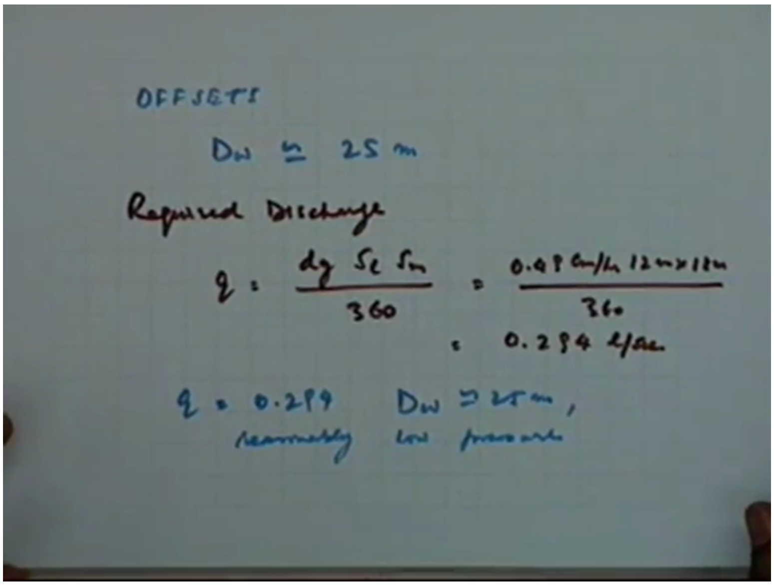
Now the next item which you want to look at is to find out what is the wetted diameter? Again if you remember we had we had shown a small table where you had looked at the various recommended spacings, the relationship between the (())(24:12) spacing that is the main line spacing or the lateral spacing and the wetted diameter based on the wind speed range.

In this case the wind speed range is taken as low wind speed range which is between 0 to 8 kilo meters per hour and let us take S l to be 12 meters which is given and the main line spacing you have the option either to go in for a 15 meter spacing or 18 meter spacing we will check first with 18 meter spacing if we can afford to have 18 meter spacing then we will rather have a 18 meter spacing because it will be more economical so we will take this as the first choice.

Now using that table based on S l we can find out what is the value of wetted diameter because S l and wetted diameter ratio is given in the table so you can find out from there the wetted diameter which is S l by 0.6 because S l by D w was 0.6 which is the value corresponding to the low wind speed conditions, this gives the wetted diameter of 20 meters checking on the basis of the main line spacing the D w works out to be this is 0.65 so this is 18 meter by 0.65 27.7 meters.

Now you have to you have to check your parameters which you have selected the nozzle size and the pressure which was selected, can you afford to get a wetted diameter of 27.7 meters that is what the check has to be made because you have made a selection about the nozzle size and the operating pressure you can check whether this is no problem this is wetted diameter is smaller than this so this will be the governing wetted diameter which has to be checked.

(Refer Slide Time: 27:34)



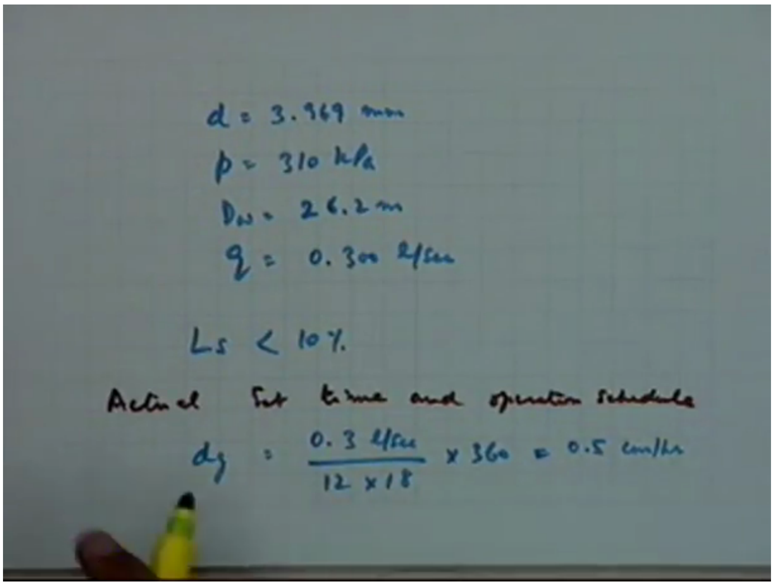
You can also at this stage you can also take advantage or the fact that you can use the offsets which we have studied, if you decide to use the offsets then you can you can accommodate the overlap by around 3 meters is what we have mentioned and your wetted diameter can be reduced appropriately. So by using the offsets at least 3 meters of adjustment can be made in the wetted diameter.

So the wetted diameter using the offsets is approximately 25 meter which is required, okay after reducing from 27.73 meters if you use a wetted diameter of around 25 meters and use the offsets along with that you will be quite safe. Based on this wetted diameter and the other selected spacing which we have just now decided that you will use S m of 18 meters, you can now find out the what will be the required discharge q this is the expression which we have used for finding out the required discharge in litres per second.

Now you know dg is 0.49 centimetres per hour, this is 12 meters into 18 meters by 360 and this gives a discharge of 0.294 litres per second. And now you can the required nozzle operating characteristic which you need to verify on the basis of what you have just computed that you require a nozzle which has a discharge of 0.294, it has a wetted diameter of approximately 25 meters and it runs on a pressure which is reasonably low pressure.

There is a previous selected pressure in the nozzle size combination which we had selected that will fail because of the D w because the wetted diameter is not the desired one which we want to have.

(Refer Slide Time: 31:18)



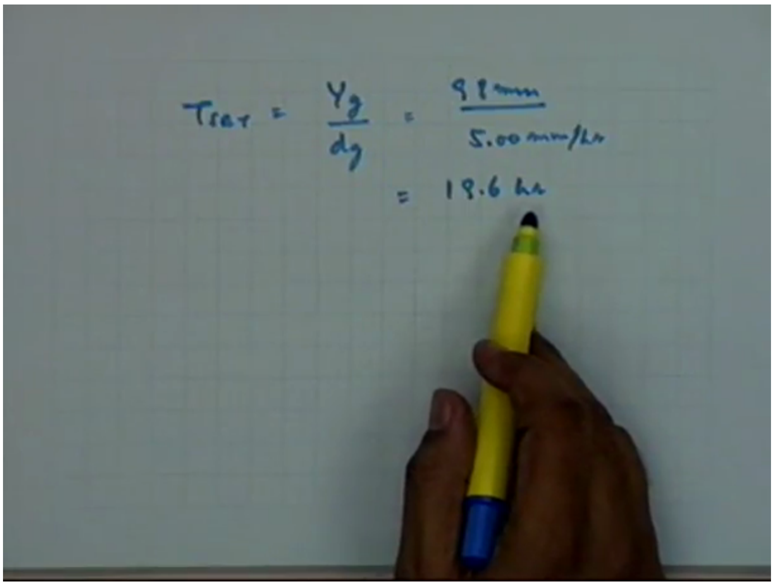
So you will have to make a fresh look on the nozzle sizes and operating pressures with respect to these requirements and you one such selection is that if you have a nozzle diameter of 3.96 millimetres, the pressure selected is 310 Kilo Pascal which is the minimum pressure under which it should be running this diameter nozzle is recommended to be running, the corresponding wetted diameter for this is 26.2 meters and the discharge is 0.3 litres per second.

So you have made a selection which is not having the exact values which because it is not possible you will have to make the selection from the nozzles which are manufactured nozzles which are in the available range and depending on those selection you are trying to be very close to the constraints which you have found out using those calculations, instead of 0.294 you are having q of 0.3 slightly higher is okay within permissible limits, D w also is slightly higher than 25 and this pressure is the one which is quite low with respect to the diameter under which it should be the pressure under which it should be running and that is the lowest possible from the recommendations given by the manufacturer.

So this if this is the one which is selected now you will have to one way is that you re compute all the other things which you have computed earlier but that re competition is not needed if your losses that re competition can be avoided if L s is difference in the L s is less than 10 percent between this setting and the or this selection and the previous selection if the difference in L s the losses the evaporation and wind losses with respect to the present selection and the previous selection if it is less than 10 percent then you can avoid re computing because it will be very close within the acceptable limits you need not check all the competitions again.

But in any case you will like to know the actual when you use this sprinkler nozzles now what will be the actual setting, what will be the actual time for which the operation should be performed. So the actual set time and operation schedule you will like to know. Now let us have a look at the gross application rate with respect to the selected nozzle this will be 0.3 litres per second is the q the same expression you can use which is the expression between the spacings and the gross application rate and the small q, small q is given the spacing is 12 meter into 18 meters into 360. So you get this as 0.5 centimeters per hour, which is still within the permissible limits.

(Refer Slide Time: 35:49)

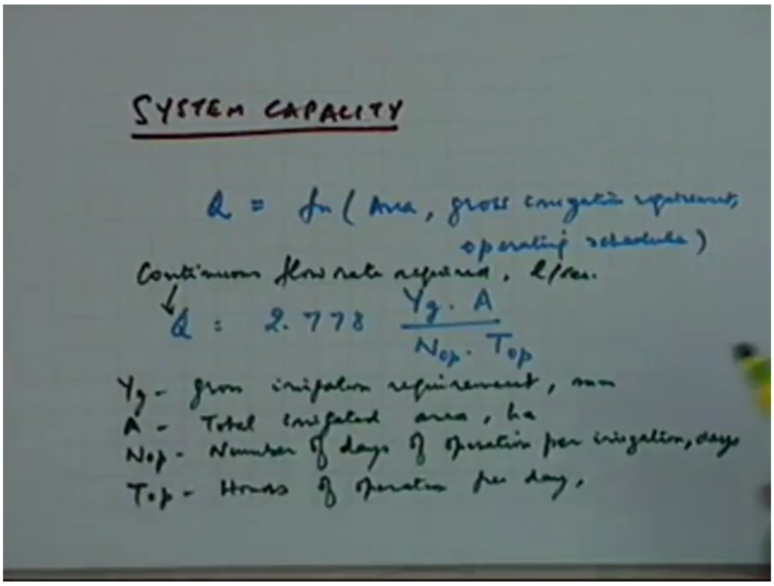


And the set time is 98 millimeters is the Y g or the gross depth and 5 millimeters per hour is the dg which we have just found out is 0.5 centimeters per hour, or 5 millimeters per hour and this gives you a requirement of 19.6 hours as a set time. So now you will have to run the system with respect to the selected nozzle for 19.6 hours for completing that irrigation, okay. So that is what is just a glimpse of what the design is pertaining to in this particular method, what you look for when you go in for the design, there is only one type of one example which has been picked up and shown to you to make the things clear.

But the many other things which are this is only half the story we have not yet taken into consideration the network of the these pipes we are just looking we are still at the individual nozzles level, we are looking at the averages the average rates with respect to the nozzles or specific nozzle assuming that whatsoever values are assigned to this one nozzle which is only of many in the total area they will be applicable to the other nozzles also which is something which is not exactly true is that will come to we will come to that stage in may be by the next lecture.

At this stage let us look at another associated aspect when we try to go beyond that one single nozzle, what happens or what are the other requirements, we will like to know what is the total discharge requirement and that total discharge requirement will be function of how many nozzles are operating simultaneously, what is the extent of one setting, as we have been talking of one setting right now what is that one setting that is one segment of the network which you are operating that setting is lot of flexibility in that setting is entirely in the hand of the operator, how he confines his setting in terms of its dimensions, how many laterals he wants to use at one particular instance simultaneously that will decide how much is the the requirement in terms of the total discharge, small q is only the discharge of a single nozzle. So what is the total discharge that will in turn decide, what type of pump will be required, okay how much will be the pump capacity which has to be selected.

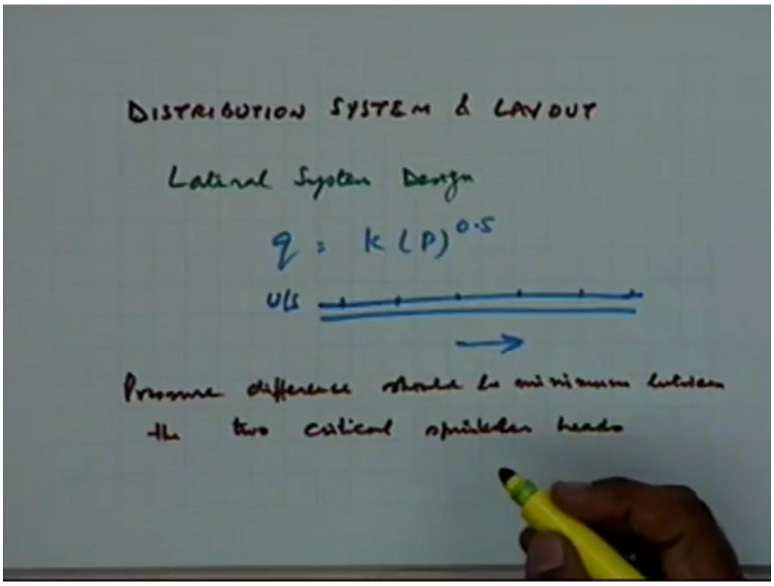
(Refer Slide Time: 39:40)



So let us talk of the system capacity, we will we are interested in knowing what is the flow rate required which I will call capital Q this capital Q as I have just mentioned will be a function of how much area you are considering for one setting, what is the gross irrigation requirement and it will also depend on what is the operating schedule? Q is expressed as here Q we have just mentioned that this Q is the continues flow rate required and expressed in litres per second, Y g we have already seen earlier is the gross irrigation requirement expressed in millimetres, A is the total irrigated area which is in hectors and Nop is the number of days of operation per irrigation per irrigation interval in days.

So for how many days the irrigation has to be done and Top is the number of hours of operation per day. Now knowing this you can find out how much is the total Q requirement and that will be dependent on the setting when we are talking of these quantities is for one single setting where that setting the flexibility that is how you use the flexibility you can divide your total area which might be much more into different settings and then you have to look at what is the total irrigation period available, can you have those many settings done on those in that period that is what is the overall game of designing and there can be some difference because there is (())(44:28) subjectivity which can come here that how you want to operate your system, though there are guidelines which if we use those guidelines strictly you will find that the subjectivity will be reduced given those guidelines if the difference different individuals are using those guidelines and coming out with the design it might not very much, there can be some variation because of the fact that the way you are going to select various items from the available items that is what we have seen just now.

(Refer Slide Time: 45:16)



Now that is where we will go on to the next aspect of the design which is the distribution system and the layout that is how you are going to layout your network is also going to have lot of impact on the overall design, how you are going to go about, whether you are going to lay the main line in a particular direction, or you are going to lay the lateral in that direction instead of the main line that will decide what will be the sizes, what will be the lengths which will be selected and that can have lot of difference in the design.

Let us first of all have a look at the lateral system design you remember earlier we had use this expression to relate the discharge of a nozzle and the pressure that is the way they are related to each other and we had also by then we had assumed we had made a assumption that the discharge does not vary from one individual sprinkler head to the next individual sprinkler head that assumption is not true that is the assumption which is not true at all, the discharge does vary when you are taking one lateral you might be having many sprinkler heads on that lateral.

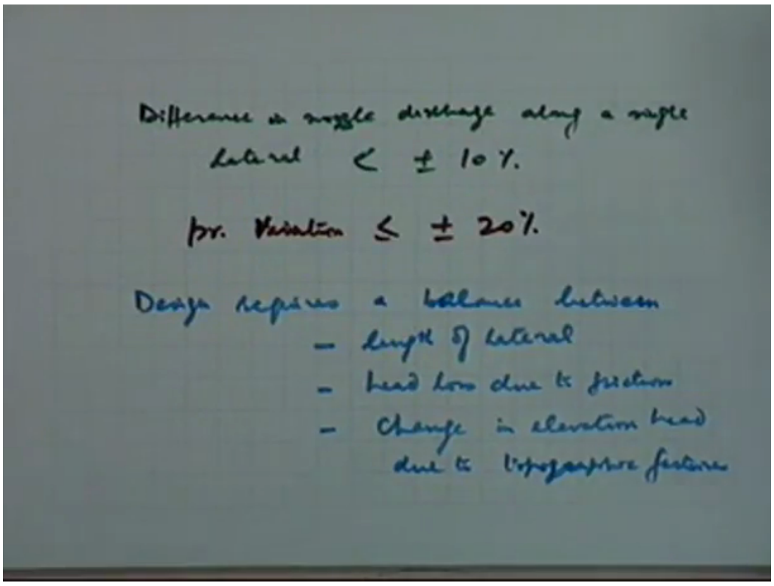
This is one lateral you might have sprinkler head here, head here and you have a series of those sprinkler heads since this particular case if this is the upstream end of the lateral, what is happening in this as you go downstream your discharge is reducing which is the case of specially varied discharge as you go down same in this direction the discharge which is available here is less by the discharge which has already left this sprinkler, as you go to the next one it has to be less by the discharge of two sprinklers.

So that is the reason that the discharge is not it cannot be same on a lateral and when we design a lateral what will be the impact of that if the discharge is not going to be the same is going to have impact on the efficiencies, the distribution pattern because discharge is a function of the pressure and the pressure is also going to reduce because of this variation you will find that if you keep on having a very long length of the lateral, the variation between the discharge of the upstream the upper most sprinkler head or the sprinkler nozzle and the lower most sprinkler nozzle will keep on increasing and that difference can become so much that your total distribution pattern can be entirely different in the two spots on the field.

So when you design a lateral, your aim is to reduce this difference and the thumb rule which is used in the lateral design is that the pressure difference the pressure difference should be minimum between the two critical sprinkler heads why I am saying two critical sprinkler heads instead of saying the first and the last one because in normal conditions will be the first and the last one which will be having the maximum and the minimum pressure.

But in under some conditions is possible that you have a critical nozzle which is not the last one, it depends on how the laterals are laid down if the slopes are uniform then you might have the first and the last one as the most critical nozzles. But if you have a situation where you have the in the middle the slopes are much different than the situation might arise that the critical might become the one which is somewhere in the middle at that location that we will see just now that what are the various conditions. But the design aspects have to be checked for the levels which are recommended levels now if you are using either you can use the pressure variation or you can use the discharge variation.

(Refer Slide Time: 52:01)



If you are using the discharge then the difference in nozzle discharge along a single lateral should be less than plus minus 10 percent, the difference between the two points or if you are using the pressure variation it should be less than equal to 20 percent. So what you are what options you are having when you look at the design the design requires a balance between the various items you have the choice either to adjust the length of the lateral is if you find that the variation is becoming large you can reduce the length of the lateral is one option.

The head loss due to friction is another source of loss that has to be taken care of when you are designing the lateral into account for that you will also be required to account for the change in elevation change in elevation head due to topographic features. Now it is possible that in some situations if you are going up slope you are losing you are increasing the difference between the pressures, on the contrary if you are moving downslope you are reducing the difference in pressure.

So in such designs is much more preferable to compensate some of the pressure variation by through the down slopes if they are prevailing there in that those areas. So that is how you when we will come to the layouts how you decide to use the natural topography for providing a suitable layout those are the things which you will take care of, okay. We will stop here if you have any question I would like to answer those, okay thank you then.