Water Management
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Lecture 33
Sprinkler Irrigation System (Continued)

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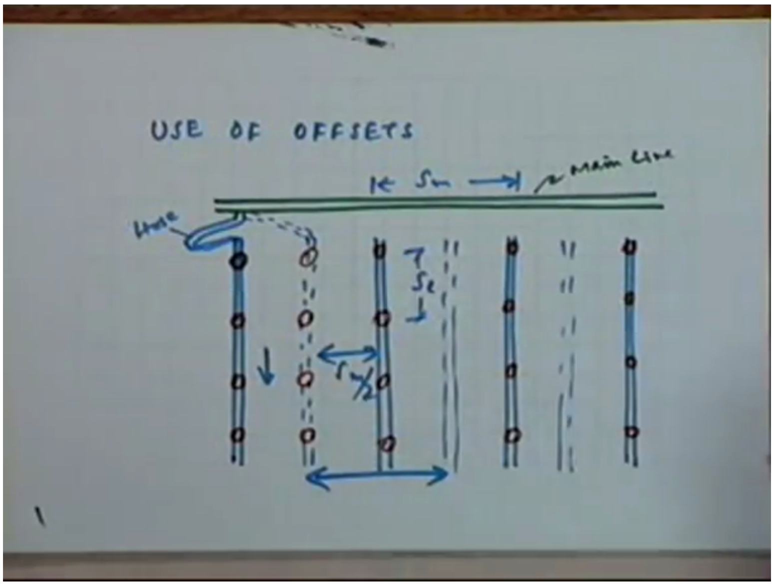

In last lecture we were discussing the use of offsets and we had seen that how we can effectively use the offset to take care of many situations in which you can have much better efficiencies by using this method which is only the method of application and changing your layout. One thing which I like to point out here that by the use of this offset it can also make lot of difference in terms of your parameter selections or in terms of the design of the system you can get much more flexibility of the design.

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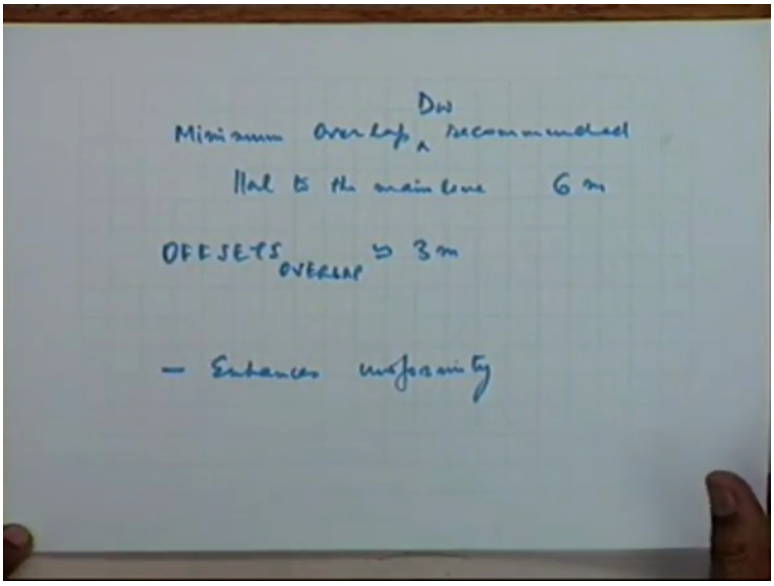

For example the minimum overlap which is recommended parallel to the main line is 6 meters. So in sprinkler irrigation design you must have at least 6 meters of overlap in terms of the overlap on the wetted diameter, knowing the wetted diameter you must have for the design to be acceptable along the main line, you must have at least overlap of 6 meters. But by utilizing the offset when you use the offsets this limit can reduce to 3 meters, this overlap overlap in the case of offsets can reduce to 3 meters.

Now this gives you lot of flexibility in terms of if you have a situation where your D w requirement is coming to be very large. Now by using the offset you can take a D w which is you can make the selection of the nozzles in such a manner that D w which is lower than that level can also be made use of, so from that angle you can get lot of flexibilities by using the offset procedure.

And it also the use of offset also enhances uniformity that we have seen in the last lecture we had taken up the situation where we had seen that how the uniformities can be enhanced by the way we make the applications by creating that offset and locating the position of the lateral.

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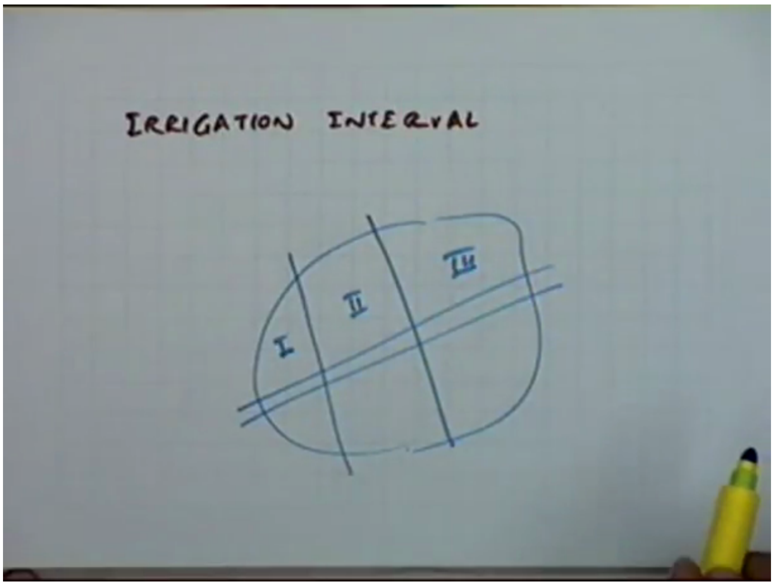

With that we will go to the next element which is irrigation interval. Now irrigation interval is a very important element in the design what do you mean by the irrigation interval first of all? The irrigation interval pertains to the time which is available for applying the irrigation if you have a area you let me take any one area. Now if you have a area now you are irrigating the total area through some system we have different options available as a designer you have different options available you might run a main line and then try to irrigate the area through two different settings half the area in one setting, half the area in another setting.

You also might try to divide this into three components, now whether I divide it into one component or the two components or three components this decision makes a lot of difference in terms of the total equipment requirement. If I want to irrigate the total area in one go I will need more equipment is not just the equipment also, I might need different discharges, I might need different set of all those parameters which can take care of this combination.

But that question is something different right now we are trying to look at the irrigation interval, from the irrigation interval point of view if I have the total area divided into three compartments or three separate sub areas I first I irrigate this area then at number 2 setting I irrigate this area, number 3 setting I irrigate this area and then again I come back to the previous area.

Now how much time I have taken in irrigating in each of the area and how much time has lapsed in total between the first irrigation and last irrigation, we have to look at that laps time is it a time which cannot be this area cannot wait that long by the time I come back to this area if that is the situation then your irrigation interval is much larger than what is the desirable interval, your irrigation interval cannot be of such a length where the soil moisture reaches below specified or desirable level.

So if your irrigation interval is going beyond that that means you have to do something to ensure that you are irrigating the whole area in such a manner that you are able to come back to the first area where you started with within a period which is the desirable period which you can delay the irrigation or you can use the second irrigation after that much period and that will be a function of the climate, what is the rate at which the water is getting lost from that soil zone.

So all those things we have to look into at and decide accordingly how the parameters have to set. So when we say irrigation interval we are what we means is that what is the duration of the time which we can use for actual application of the water, okay.

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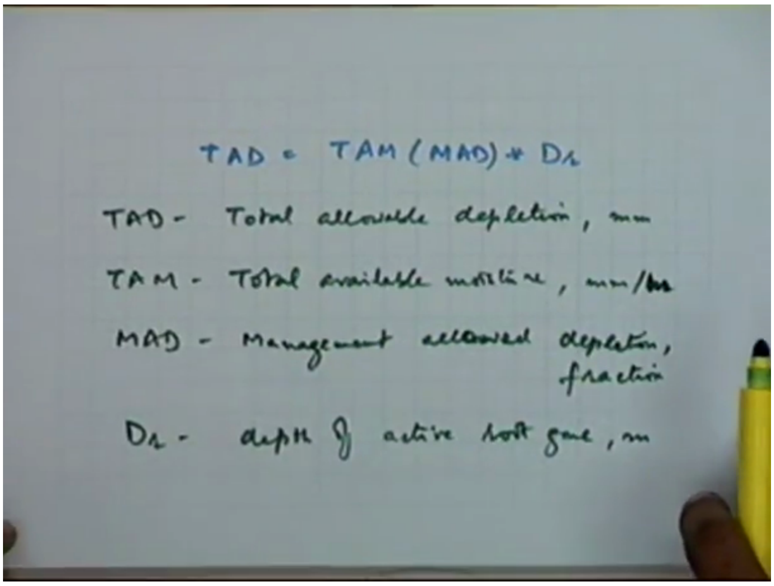

And the irrigation interval to arrive at the desirable irrigation interval you will like to find out what is the total allowable depletion will be a function of total allowable depletion which in turn will be a function of these quantities what these quantities are? TAD we have we have dealt with earlier is the total allowable depletion and let us say this is expressed in millimetres, TAM is the total available moisture and total available moisture is the depth per unit depth of the soil so millimetres per meter depth of the soil and the MAD is the management allowed depletion this is something which is provocative of either the management or the former and this is expressed in fraction whether you will deplete 50 percent of the available moisture or upto 60 percent or upto 40 percent that is what and D r is the depth of active root zone or effective root zone in meters.

Now knowing the total available moisture which is the function of the soil type, knowing the management allowed depletion which is a function of again it depends on the crop type how much how sensitive the crop is we have seen all these things and depth of root zone we also know. So knowing these individual quantities you can find out what is the total allowable depletion, how much deficit can be created in a particular soil with respect to the crop which we have.

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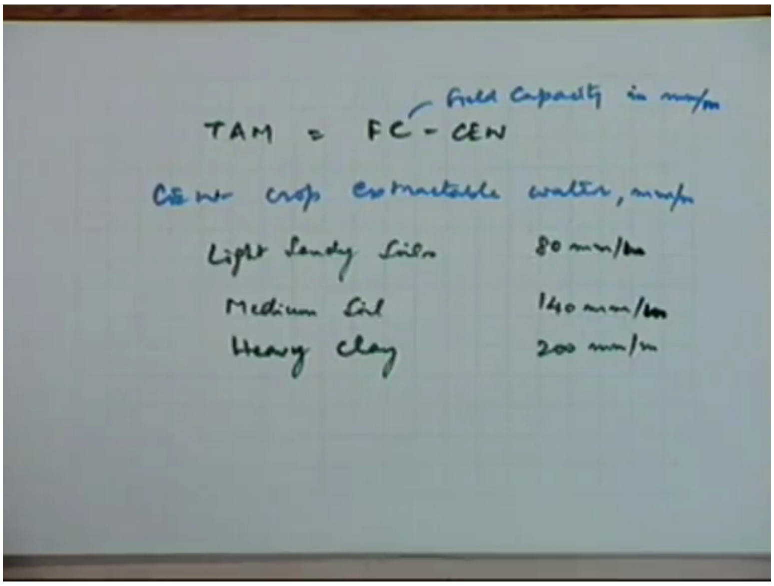

The TAM normally the total available moisture is the difference between the field capacity and the CEW which is the limit of crop extractable water, so CEW this is the crop extractable water millimetres per meter, this is also this is the field capacity in millimetres per meter depth. Now the TAM as we have just said that is the function of the soil type for light sandy soils the TAM is around 80 millimetres per meters sorry and for medium soils all this is available in literature these values are standard values might change when you have more elaborate soil classification.

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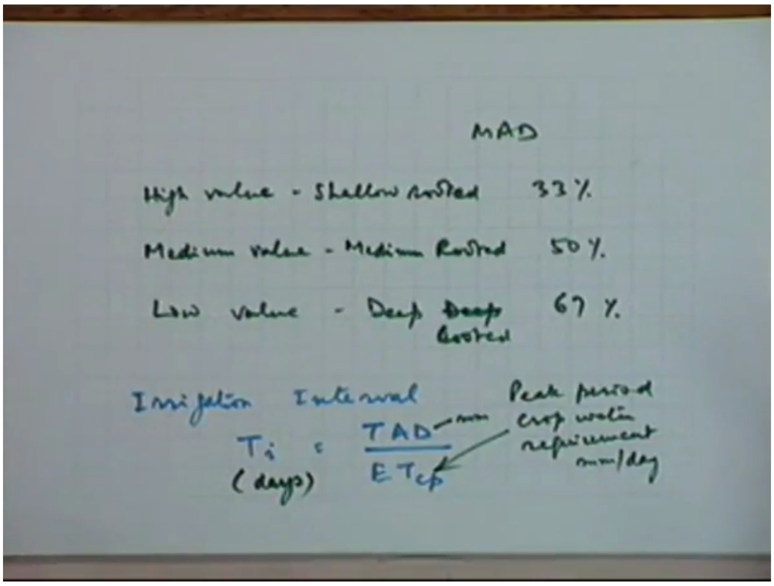

Similarly the MAD values again as we have just mentioned that depends is a function of what type of crop is question if you have high value crop and is the shallow rooted MAD is around 33 percent. So the level of extraction is much lower when you have more sensitive crops, when you have medium value crops medium rooted you can go upto 50 percent and for low value crops normally deep rooted the management allowable depletion can be as high as 67 percent. These are some of the values which are order of magnitudes not literal values, they can change can change from situation to situation.

But in general you will find that the deficit which you can create which you can afford to have will be much less if your value of the crop is quite high and it can go up if the value of the crop is low because it is attached with the yields how much the yields will be effected because of these higher deficits because if you create higher deficit there will be more stress in the crop, the crop can take that stress or not that is the question.

Now the irrigation interval is basically now if we say that T i is the irrigation interval is nothing but total allowable deficit by what is the rate at which this deficit is being created or if you say that this is the the availability of the moisture because that is what you will like to replenish and then at this rate this is going to be lost this E T crop is the peak period crop water requirement, this is peak period crop water requirement in millimetres per day and this quantity is in millimetres.

So you will have T i the irrigation interval in this. So this basically shows that how long you can wait for the next irrigation and that is dependent on at what rate the crop is utilizing the water and how much water is available, TAD is the we are basically saying the total allowable depletion. So this is the moisture which can be extracted, which can be allowed to be extracted and that moisture is depleting at this rate so you can get a value of the irrigation interval which is permissible.

Now it is not necessary that you have to complete the irrigation in that period, you might decide is that is again a management decision that is a decision which is dependent on you as a irrigator or as a farmer, how much time you want to utilize for the irrigation to be completed but it cannot increase this period the irrigation interval period. You must complete the irrigation within this interval it can be much lesser than this but when you try to reduce it drastically then to apply that water quickly you will have you will encore other problems.

So you might not be able to you at for the design to be better for the design to be economical you will find that you might try to be close to this irrigation interval which is available to you because of the various other reasons which we will just look at as we go further.

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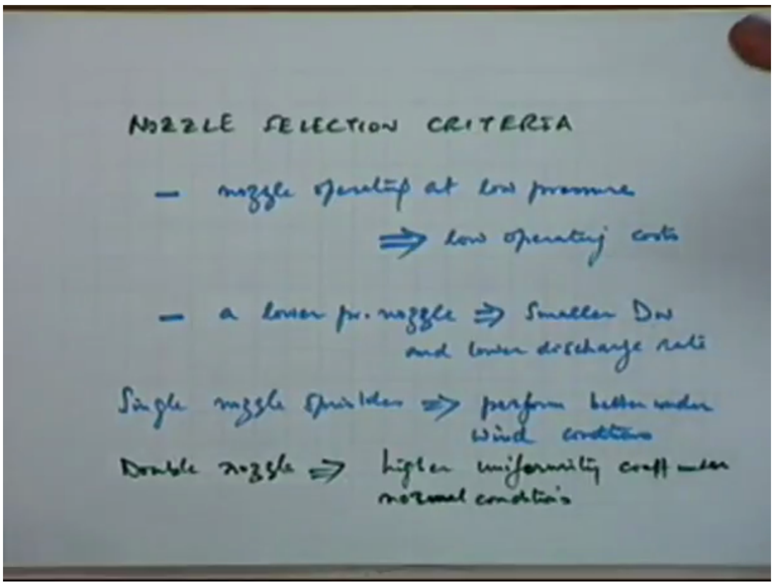

Then comes the aspect of nozzle selection criteria, this is a very important aspect in the sprinkler irrigation design because this is the main thing which is deciding most of the other parameters because selection of this will influence almost all the other parameters whether is the rate of application or is the discharge or is the pressure or is the wetted diameter all those things are inter dependent and even the spacings because all those the spacing also is a function or is dependent on which sizes you are using and what will be that distribution pattern, what will be the wetted diameter all those things are inter related.

So if you look at this the background of this the nozzle selection let me give you some of the statements which are which will give you the inter connections which are there or the dependencies that if we have a nozzle operating at low pressure, this will result in low operating cost the pressures are low the operating cost will also be low is quite understandable. But if you have a lower pressure nozzle what is the impact of this selecting a lower pressure nozzle, the impact is that you will have smaller wetted diameter as well as lower discharge rate. After taking this step you have landed yourself into this result that by selecting a lower pressure you have reduced the wetted diameter, you have reduced the discharge rate also.

Similarly if you select a particular type of the nozzle, now the nozzles can be they can be sprinkler heads with the single nozzle, they can be sprinkler heads with double nozzle. So let us say that if you select a single nozzle sprinkler, what is the result may be that it might it will have a lower uniformity coefficient the by the same time under the wind conditions it might be quite effective.

So it will be it might perform or it will perform better under wind conditions in comparison to the double nozzle sprinkler, whereas the double nozzle sprinkler will have high uniformity that will under normal conditions. Now this high uniformity is because of the increased discharges. So in this case the discharges will also be higher in the case of double nozzle, they are when you choose one thing there will be some plus points there will be some minus points and that is where is important to understand that the nozzle selection procedure is a very iterative procedure it has pros and cons, so you have to make a selection and see for the various indicators, the various constraints whether they fulfil all the constraints or not and accordingly make the choice, you might have to come back to the various levels, make a selection if it is not satisfying your criteria make another selection and then ultimately select one which satisfies most of your conditions. So is the trial and error is a balancing approach that is important to understand.

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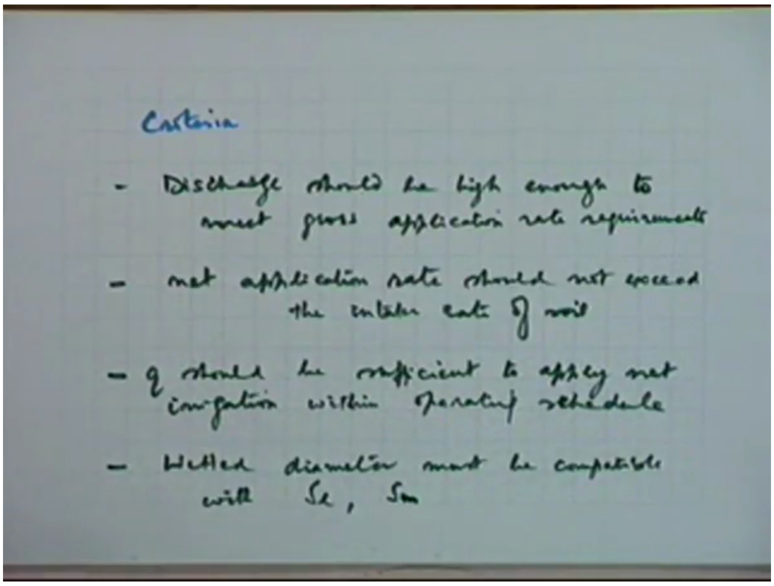

With the general criteria which you must look into when you make the nozzle selections these criteria these are the discharge should be high enough to meet gross application rate requirements. Now you know that what are the gross application rates we have even looked at the table which we had formulated where we had given the gross application rates which are desirable rates under the specific conditions so you should intend to choose those nozzle sizes which have the discharges which are high enough to meet this criteria of having the gross application rate satisfied.

The net application rate because gross application rate takes into account the evaporation under drift losses also that means the amount of water which is coming out of the nozzle should be at least taken care of by that selected nozzle. But when you come to the other side the net application rate you have a criteria which is just diagonally opposite, the net application rate should not exceed the (())(28:43) of the soil.

That means you have constraint on both the sides on one side you are seeing that the gross rate must be sufficient to take care of the application and the gross application rates, on the other side it should not be very high so that the net application rate becomes such that it produces the the (())(29:15). So you have a close range to play within and that is where this nozzle selection becomes a very important aspect.

Similarly the selection of the nozzle in terms of the rate of application or the discharge which is prevailing discharge it should be or we say q should be sufficient to apply net irrigation. Now comes the question of how much time you are taking to make the same application which is related to your irrigation interval, q should be sufficient to apply net irrigation within the operating schedule.

You cannot select a nozzle size which has such a low discharge that when you talk in terms of the time taken it should exceed the total setting or the total irrigation and the total area under your interest, you exceed the irrigation interval so that is another constraint put on the nozzle size because this the discharge will also be a function of a nozzle size along with the other things like pressure and those things of course.

Then you have another requirement that the wetted diameter must be compatible with the spacing the main line spacing and the lateral spacing the lateral spacing and the main line spacing. Again how much wetted diameter you are going to have is a function of the nozzle selection is dependent on the nozzle and the spacing you have to have a compatibility between the spacing and the wetted diameter because we have said that there should be a minimum overlap of 6 meters now that overlap of 6 meters will come only through the overlap of the wetted diameters and the overlap will be decided also by the spacing which you have utilized. So this spacing is also related with the type of nozzle which has been selected.

Now as a result you can now appreciate that nozzle selection is a very iterative it has to be a very iterative process is very very can be subjective also because there are many sizes of nozzles which are available which one you decide it can be they can be quite close if I give the nozzle selection to three different people they might come out with some nozzles which are keeping track of all their requirements or within their their the setting which they have decided on because all these things can change drastically the way you are going to operate the system.

So you cannot standardize these things they are highly subjective but from that angle only all these constraints have been put they have been made, elaborate elaborated through various different criteria so that you force the designer to be within those constraints. And with that thing in mind there are many tables which have been developed to help the designer in looking at or in picking up these proper design parameters. And the tables I want to give you the tables here I will just tell you that what type of tables are available, what are the various parameters which they are utilizing.

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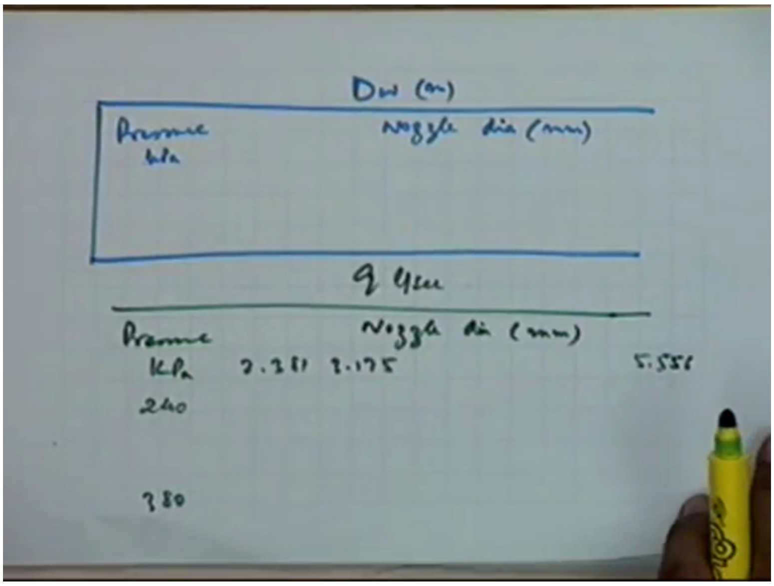

For example there is a table which gives the wetted diameter in meters for different under different pressure the nozzles of different diameter so for different nozzles running under different pressures you have their wetted diameter, how the wetted diameter varies because if you want to select a wetted diameter which is which is a desirable wetted diameter you can use this table.

There can be another table which give you the discharge in litres per second and it is the other parameters are the pressure and then the nozzle diameter as you have in the case above the table above so for different example I can give you the values of some of the nozzle diameters the range can vary and this is from 240 Kilo Pascal to around 380 Kilo Pascal. So you have the discharges which are under these conditions what will be the discharge available.

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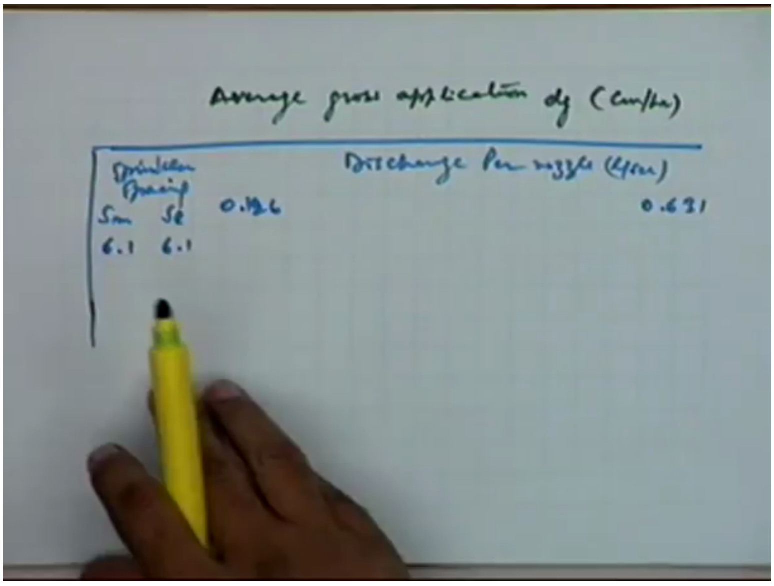

Similarly many other table there is another table which give you the average gross application all these tables will be available in the resource material, the average gross application dg in centimetres per hour and this table discharge per nozzle discharge per nozzle is known for different nozzles in litres per second and these discharges vary from 0.126 litres per second to 0.631 litres per second.

Now depending on this data plus the sprinkler spacing which is the main line spacing and the lateral spacing for different combination of spacing. For example this table gives this is in meters for different combination of spacing and for different discharge per nozzle what will be the average gross application which you will obtain it gives the information on that. you can make the selection directly whether how much gross application average gross application you are getting under those circumstances when you select a particular nozzle.

So that way there are many such (())(38:37) which have been provided for making the designers effort quite minimal and the designs can be taken up quite quickly. But the fact remains that this is a very very specialized job in the sense that you must understand what you are doing, once you understood the thing properly then there is no problem you can make the designs without any any big problem.

Let us take a one small example to just go through how we make use of whatsoever we have gone through so far, how we actually make use of those those details or those elements which we have studied so far. In a actual case we will take a small very small case where we have some available data and how we can make use of that available data along with the various conditions which we have imposed to come out with a relevant and appropriate design.

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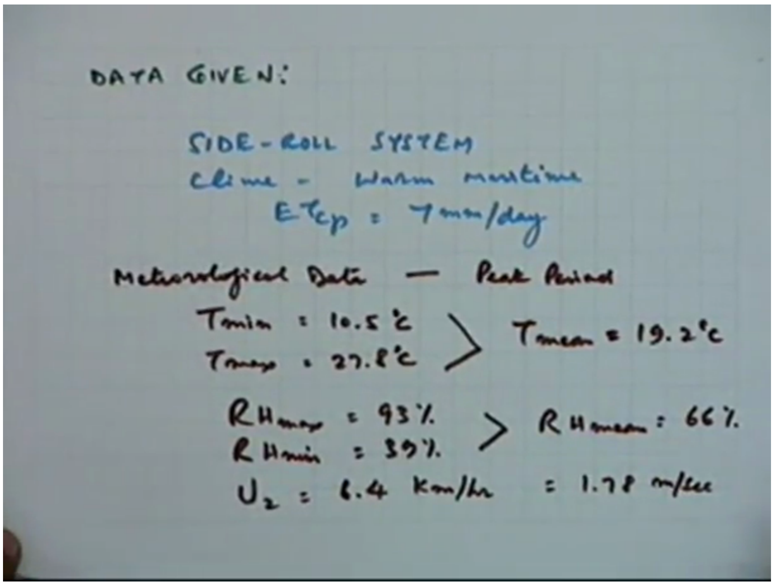

The data given is quite elaborate we are assuming that we are using a side-roll system the climate of the region is warm maritime, the peak crop period requirement E T crop is known to be 7 millimetres per day then you will need some meteorological data and the meteorological data this is this pertains to the peak period and the meteorological data is given in the form of the maximum and minimum temperature minimum temperature is 10.5 degrees centigrade, the maximum temperature observed is 27.8 degrees centigrade now this you can obtain the average temperature over the this 19.2 degrees centigrade.

Similarly the other meteorological variables which are available are the maximum relative humidity is 93 percent and the minimum relative humidity is 39 percent which again gives mean relative humidity of 66 percent. Then you have the wind speed at 2 meters height is given to be 6.4 Kilo meters per hour or if you want to convert that you might need it in meters per second 1.78 meters per second.

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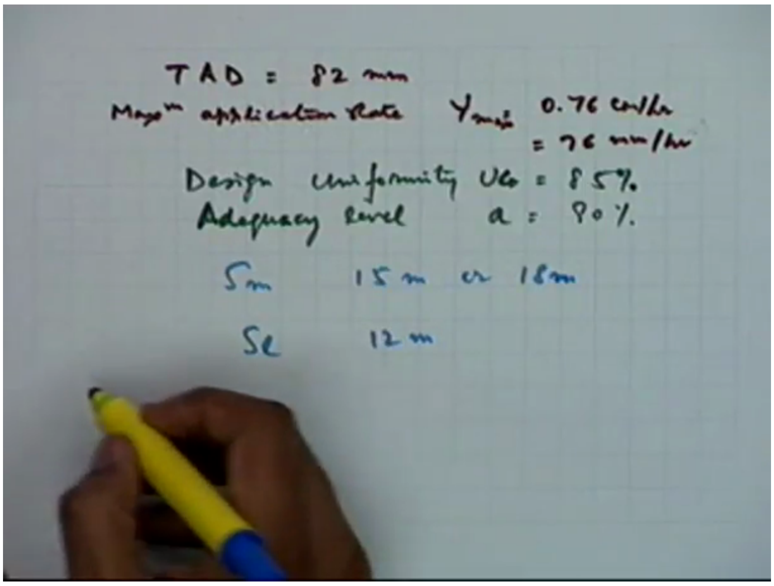

Besides this basic data there are some other data which are relevant and which is which are required for the design purpose they have been taken accordingly. The total allowable depletion is 82 meters and maximum application rate let me call it Y max is 0.76 centimetres per hour or 76 millimetres per hour. Then along with this you have the design constraints the design uniformity which is desirable is 85 percent and the adequacy level is 90 percent.

Now these are the various data available, there is one more segment of data which is available that the spacings which you will like to have is dependent on what type of equipment you already have available with you. So from that angle the main line spacing should be either 15 meters or 18 meters and the lateral spacing should be 12 meters, these are very realistic constraints which will be normally you will feel that they are there because of the the way things are either the form is already having some equipment so (())(45:41) with each design he will not like to buy new equipment there might be some flexibility in terms of he has two different types of pipelines or what are the pieces are available, how he can join them all those things are equally important.

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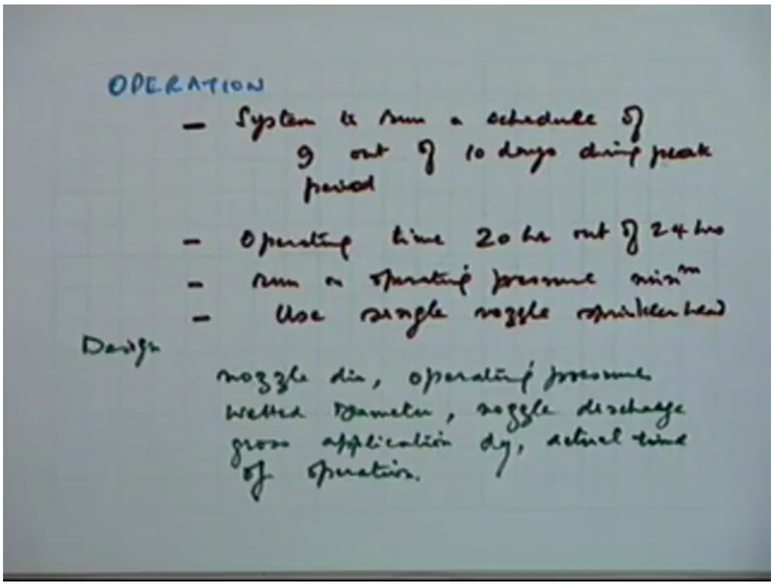

Now besides this basic data there are some constraints on the operations also. So on the operations side the constraints which are there they are the system is to run schedule of 9 out of 10 days during the peak period. Furthermore the operating time is 20 hours out of 24 hours is quite likely that out of the 24 hours the 20 hours are kept for operation remaining 4 hours are moving the pipelines and those activities you need to have sometime which will be the time when the system will not be running. Is also advisable to run the system is desirable that the system should run on operating pressures which are minimum this will reduce the operation cost. So the operator wants to run the system on the minimum possible pressures operating pressures.

Another constraint use single nozzle sprinkler head. Now based on this data and based on all the desirable constraints you have to design the system when you say you have to design the system what you will design it for the design should include the selection of nozzle dia, what size of the nozzle should be used? What should be the operating pressure? What should be the wetted diameter? The nozzle discharge is once you have found out the selected the nozzle diameter and the operating pressure of the nozzle discharge can be known but you are interested in knowing the nozzle discharge also, you are interested in finding out the gross application dg and the actual time of operation.

We have checked that we will try to confine our time within the irrigation interval but the actual time of operation can be much lower or it can be within the irrigation interval, how much will be the actual time of operation that is what we have to find out, that will be a function of what are the other parameters which have been selected. I think we will stop here because we will not be able to finish the thing within the remaining time, I will give the answers to any questions if you have, okay. So we will take up this exercise in the next class.