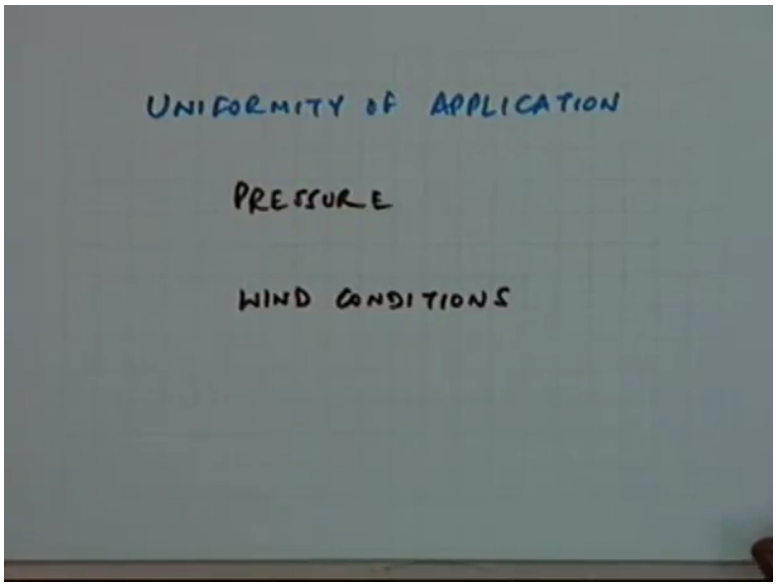
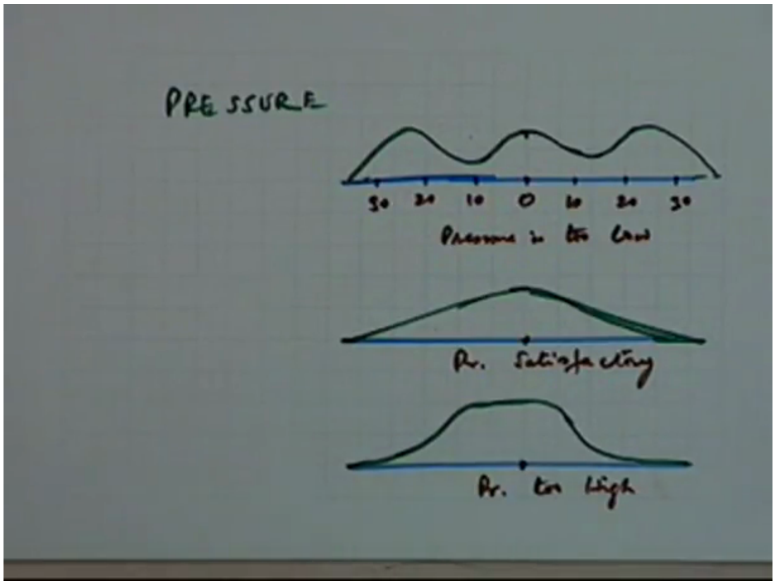
Water Management
Prof. Dr. A. K. Gosain
Department of Civil Engineering
Indian Institute of Technology Delhi
Lecture 30
Sprinkler Irrigation System

(Refer Slide Time: 1:11)



The last class we had started looking at the uniformity of application and we had mentioned that the uniformity of application is dependent two aspects, is highly influenced by the pressures which are the prevailing pressures in the network of the sprinkler irrigation system and the wind conditions which are the natural conditions. So these two are the factors which influence the uniformity to a large extent.

(Refer Slide Time: 1:50)

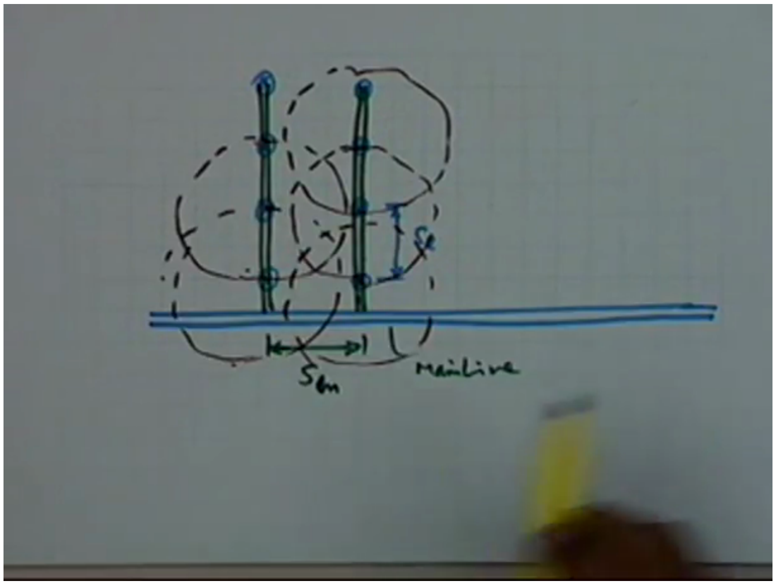


And we had started looking at the influences of pressure, how the pressure changes the uniformity or how it influences the uniformity. And we had discussed that the pressure in the sprinkler systems, these were the distribution patterns of individual sprinkler heads which were taken for under different pressure conditions. So we had discussed that if the pressure is too low, you will get this type of distribution pattern which is similar to a donut. This is a pressure distribution which is having a plateau at the top and this is obtained when you have the pressures which are too high.

This plateau is formed because of the fact that when the breakup of the stream or the jet is too excessive, then the size of the particles will be very small and they will have a tendency to settle very near to the sprinkler head position which is somewhere here. So because of that you will have most of the water getting settled in the near vicinity and you will get this type of pressure (distrib) the application distribution. This is the water distribution.

Whereas under some in between pressure you will get a distribution which is more triangular type of distribution. And this distribution is more suitable because of the fact that ultimately you want to overlap these individual distribution patterns and get a uniformity which is quite high.

(Refer Slide Time: 4:06)

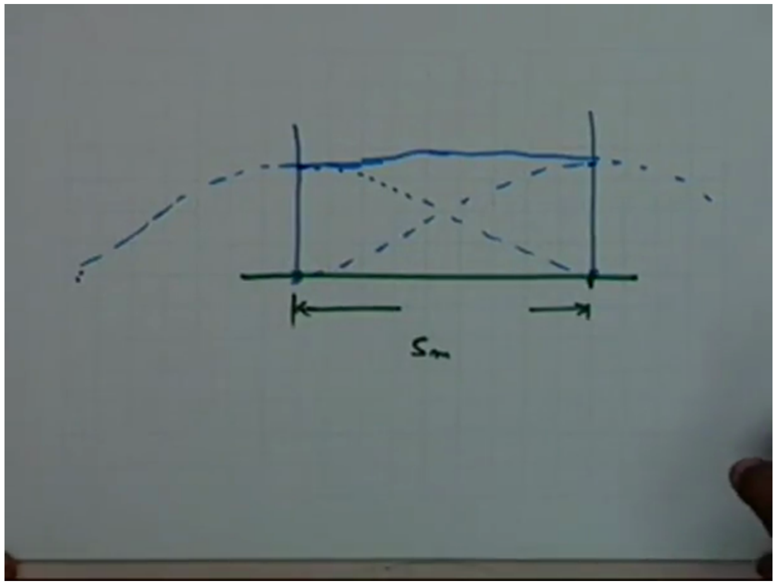


So let us have a look that if you try to overlap, let me say that this is a situation where you have one main line. On that you have the laterals. So if you look at the individual distribution pattern of the individual sprinkler heads on the lateral because lateral is done which is having the sprinkler heads. So when you talk of the spacings, the spacings are of, this is the main line, now the overlap will be because of the spacing, the two spacings which we have considered.

And these spacings are the spacing between the laterals and this we were calling the main line spacing. And on the lateral you have these individual sprinkler heads installed. So the other spacing will be the spacing between the sprinkler heads on the lateral. These two spacings will decide, by the combination of these two spacings you will get the overlaps. These overlaps will be in two directions. Suppose the individual influence area of this sprinkler head, if there is something like this, then this will have its own influence area.

And similarly the next one. So each one is having its own influence area. Similarly there will be more sprinkler heads here and the influences, influence area of these individual sprinkler heads will also be having the overlap in the other direction. So this total overlap will decide how much is the net effect of the water application at that particular level.

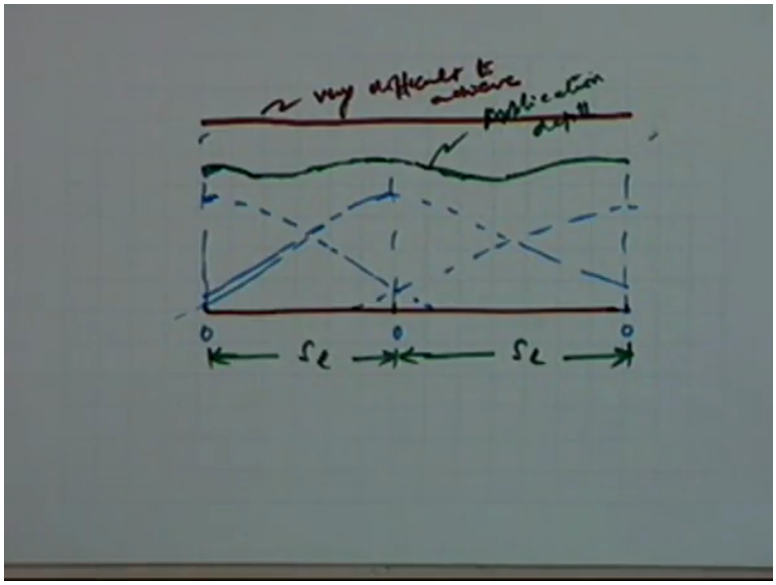
(Refer Slide Time: 6:53)



If we draw the same thing in terms of, in one section let us say that if is the spacing between the laterals which is the main line spacing, on this case you have one lateral here, the other lateral here and you will have some sprinkler nozzle at this level because all these sprinkler nozzles will be in the same line. So the pattern of the individual sprinkler nozzle is somewhere like this and similarly the pattern of the other sprinkler nozzle is somewhere, somewhat like this.

Then the overall application will be the combination of these two which if you combine these two you might get some total depth which is the net effect of these two individual. This is the half the portion. The other half will be on this side. Similarly this will have the other area of influence. This total distribution pattern is for a specific individual sprinkler head.

(Refer Slide Time: 8:31)



Similarly on the, on a lateral line you might have, these are the three sprinkler positions. That means this is a 0 level for these three individual sprinkler heads. And each one has its own pattern. So if the pattern of this is somewhat like this, pattern of this one is the portion which is influencing up to this area. Similarly on this side if this is the portion which is influencing to this area.

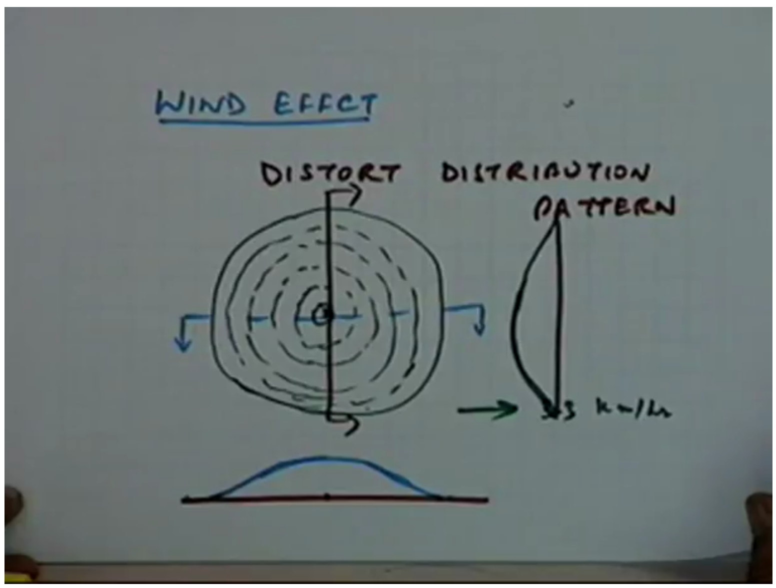
Now the end effect of this will be this, this level which is from this sprinkler head plus the amount which is coming from here. This combination will give some pattern which might look something of this nature, so is a function totally. This is your application depth, so that ultimate application depth is totally dependent on how these individual sprinkler heads distribution patterns are overlapped which is in turn a function of the spacing.

In this case this is the spacing between the sprinkler heads on the lateral. So these two level of overlaps will decide what is the ultimate uniformity coefficient or what is the distribution pattern, the overall distribution pattern. And you will also understand at this stage, that is very difficult to get a distribution pattern which is very uniform, which is almost a straight line. This is very difficult to achieve.

Because of the fact that the individual distribution patterns will not be of such a shape, that if you combine the two you will get exact straight line. But still in comparison to the other irrigation systems which we have seen so far, the surface irrigation systems where you are using the gravity flow, you will be able to achieve much better distribution. Because of the this particular situation that you are providing the water from each individual sprinkler head which has its own area of influence, but there will be some level of percolation, there will be some level of losses, mainly in this case the percolation losses and that we will discuss.

And the design aspects in this system they pertain to having a combination of these parameters, the two parameters we have just now discussed, the spacing between the laterals and the spacing between the sprinklers on a lateral. These two parameters are very important because they are the ones which will decide what will be the distribution pattern, overall distribution pattern. And that in turn will decide how much will be the extent of losses. Okay.

(Refer Slide Time: 13:08)



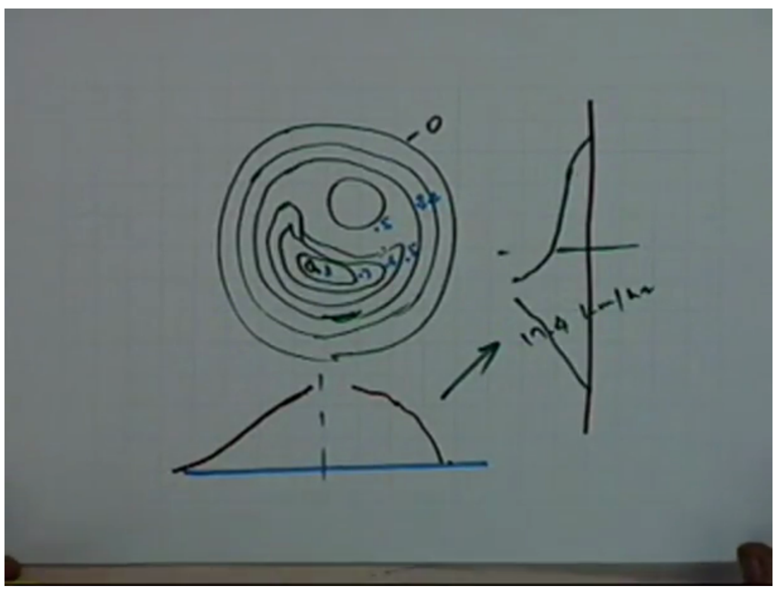
So having discussed the influence of pressures on the uniformity of application, let us look at the wind effects. But how the wind affects the uniformity of application? Now the main effect of the wind will be to distort the distribution pattern. So the main, major effect of or the only effect of the wind is to distort distribution pattern.

Once the distribution pattern gets distorted, then overlap, to get the overlap becomes more difficult and that is the situation where you will find that you will be able to, you will not be able to get a depth which is uniform. It will be more and more difficult to get a uniformity of the application depth.

Let us have a look at a pattern. Suppose let us take one individual the plan, in plan let us take the distribution pattern of individual sprinkler. How the, if this is the location where the sprinkler nozzle is, sprinkler head is, you will find that if you try to join the points of equal depth, you will get a pattern which is quite well-distributed around the, might be some influence if the level of wind is not very high. This is a pattern which might be because of the wind of very low intensity. Let us say 3.3 kilometers per hour.

In this case if you take the distribution pattern around the two cross-sections, one cross-section is in this direction, you will find that the distribution pattern will be quite uniform. Similarly on this side also if you take the cross-section in the other direction, again the distribution pattern is not very much different than the pattern which you have obtained in the other direction.

(Refer Slide Time: 16:53)



Whereas the situation will be very different if you have wind conditions which are very excessive wind conditions. Let us assume that for a similar situation where you had a single sprinkler head, and the wind velocity is now quite excessive, 17.4 kilometers per hour, these pattern which I am showing you they are the actually observed patterns for these two different wind conditions.

On this case because of this wind which is prevailing at that particular site during the period when the sprinkler was on, you will find that now the if this 0 level, 0 depth, the other patterns there might not be much difference in the pattern when where the depths are low which are the side segments. But the difference will be quite excessive when you come to the central portion. Here you will find that this is a type of pattern which gets developed where you have the maximum depth here, 0.8, 0.5, 0.5, 0.3, 0.2, 0.1 somewhere in between and 0.

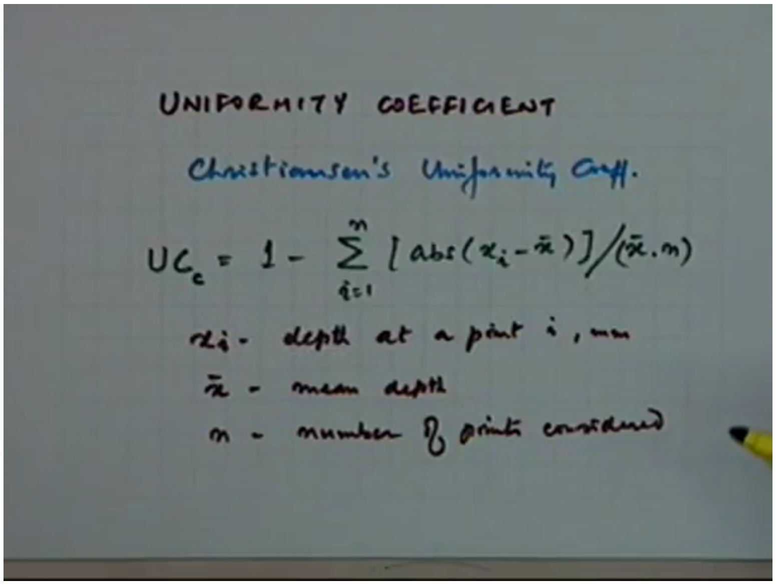
If we take the sections now, when I take a section in this direction, you will find that the distribution pattern will be somewhat of this nature which will have this and then similarly on this side if I take the section here, the distribution will be somewhat of this nature. You will find that most of the water has deposited in this area because of the fact that the wind was going in this direction.

And this distortion in the distribution pattern will create lot of undulations in the application depth which you intend to apply. Because of this reason in most of the systems, sprinkler irrigation system, people shift their time of, timings of application. Because in general most of the areas it has been found that the wind velocities during the night time they are much lower in comparison to the wind velocities in the, during the day time.

So they intend to run these systems during the night time just to avoid the wind effects. The other way of taking into consideration the wind effect is by changing the spacings. So that is another way but by doing so you might still incur some losses. You might be able to take care of the requirements of the irrigation, the net irrigation requirements. But in doing so, you might indulge in more losses which is again something which you want to avoid.

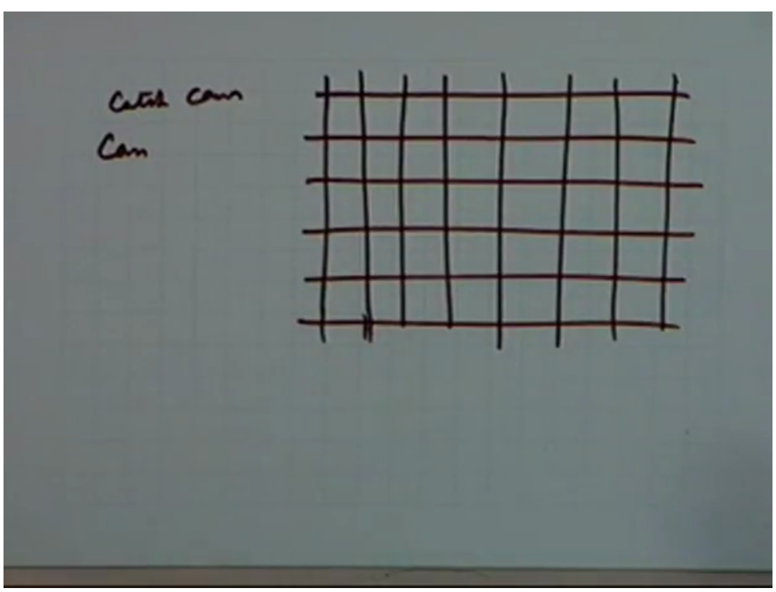
Now with this initial background let us discuss another aspect which is very important which we have been referring to very often during our talk which is that how we account for the uniformity of the depth or the uniformity of the application, what is the way by which we can measure how much is the uniformity of application. That is where we use the uniformity coefficient. We had discussed that at the time when we were discussing the efficiencies that how we, what is uniformity coefficient. But that is more relevant to this system than anywhere else because this is very sensitive to the uniformity coefficient.

(Refer Slide Time: 22:12)



There are different expressions which have been used to express the uniformity coefficient. And we will not indulge in that. We will just pick up one which is most commonly used and which is given by Christiansen. This uniformity coefficient is expressed, let me say UCc which or more often we will use UC only. This is to designate that is the one given by Christiansen, 1 minus summation of, divided by x bar into n, where xi is the depth, what is the depth received at a point i in millimeters. And x bar is the mean depth of application, n is the number of points considered.

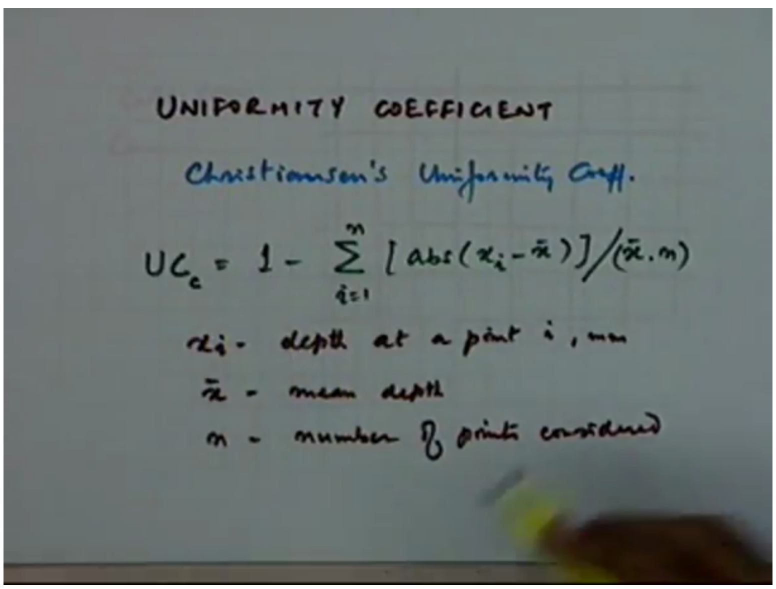
(Refer Slide Time: 25:19)



Now these uniformity coefficients are observed in field through experimentation and the, is very experiment where you create a grid and that grid you install. This grid has to be, now and after creating this grid, you install the measuring devices which are nothing but you use the small cans which are known as catch cans. These catch cans are nothing but they are small vessels which are installed at the known points. Then you run the sprinkler for a specific duration and then actually measure how much depth has been received or it has been collected in those cans.

So that is the simple way of finding out how much is the, what is the distribution pattern and that distribution pattern can be observed under different conditions but the procedure remains same. You install the grid and the spacing of the grid is again, there are some guidelines that what should be the spacing so as to avoid the inaccuracies. And those things we will see but the way you install your grid is also dependent on what type of system you are using, what is the operation methodology or the procedure of operation, are you using more than two laterals at a time or you are using a single lateral. Accordingly that methodology will vary.

(Refer Slide Time: 27:31)

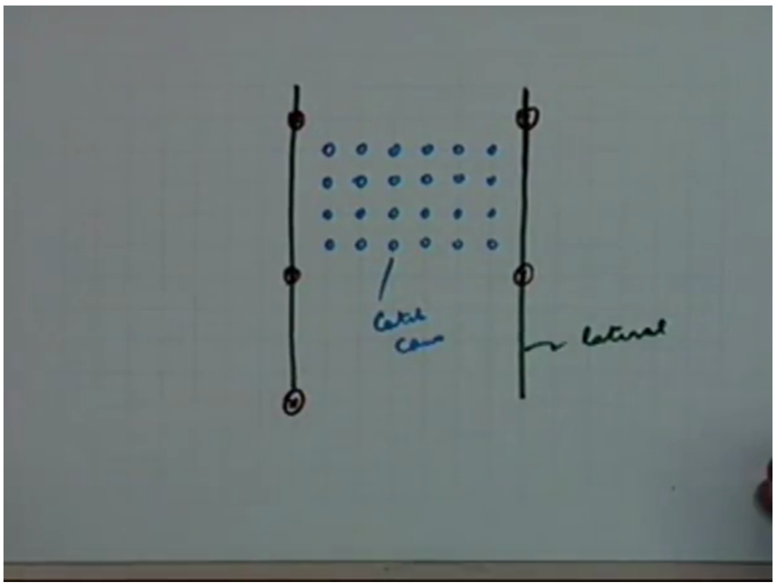


But in general this particular relationship where you are, what you are doing is that you are finding out what is the difference, what is the deviation of each individual observation of depth from the mean and then you are trying to find out the uniformity on the basis of that deviation. More the, higher the deviation, the lower will be the uniformity which is quite understandable.

But the if your, if all the values or all the cans they catch the same amount, that means each individual observation will be equal to the mean value.

So in that situation your uniformity will be 100 percent. Okay. And on the other side if your, if deviations are very high, they are, there are much different than what is the mean value, in that case you will find that the uniformity coefficient will decrease.

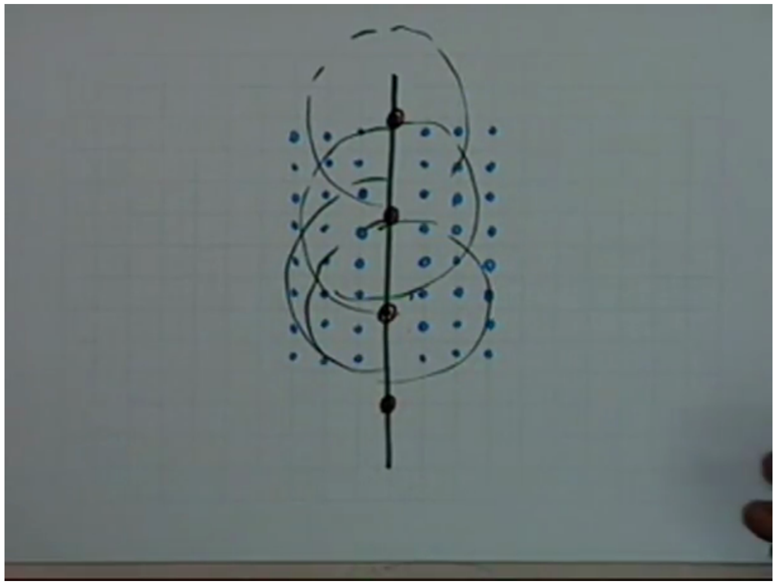
(Refer Slide Time: 28:58)



So in a case if you have a situation where you have many sprinklers which might be operating at a particular time, as you want to look at the uniformity with respect to the operation of the system, so if you have a case where you have these sprinklers, let us assume that the catch cans are provided at these locations. You have another lateral. These are the laterals. You have another sprinkler system here and another sprinkler that is here.

So all this area you will have the catch cans. All these are the catch cans. When you will operate these four sprinklers simultaneously, the catch in these cans will give you the uniformity coefficient because now this area is the one which is getting the water from all these four individual sprinkler heads. So the overlap is taken care of whereas it depends on the situation. If your spacing is such that the overlap is such, that even a sprinkler head which is somewhere here, the next on location, that is also influencing this area, then you will have to take that also into account. So it is entirely dependent on how your system is designed and the uniformity coefficient has to be obtained accordingly.

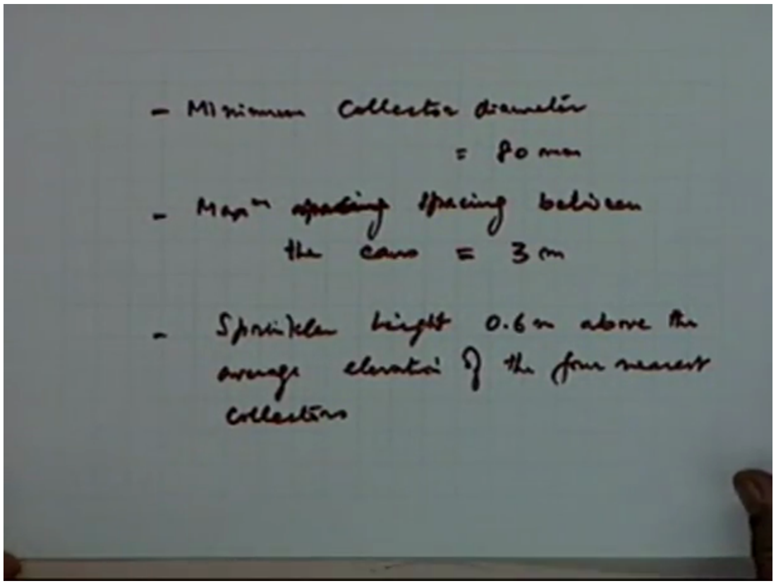
(Refer Slide Time: 31:35)



So in such cases where you have a single, let us discuss another situation where you have one lateral only working at a time, you want to know that what will be the uniformity coefficient due to that if you have different sprinkler nozzles attached on the same one. Now your catch can should be installed in such a way that each of these is coming somewhere in the middle of these catch cans. The location of each sprinkler nozzle, so now you can have the catch cans spread like this, these are the individual catch cans. Similarly on this side.

Once you have these installed, and when you run the system, in this particular case now the overlap has to be, in general the overlap on the same lateral is high than the overlap between the laterals. From this the area of influence depending on what is the, how much is the extent of the area of influence, you might find that if you operate around three of the, sorry, if you operate these three simultaneously, they will give you quite a sufficient coverage. And then picking up one representative area, you can find out how much is the uniformity coefficient. The procedure can vary, that is what we are trying to emphasize here.

(Refer Slide Time: 33:51)

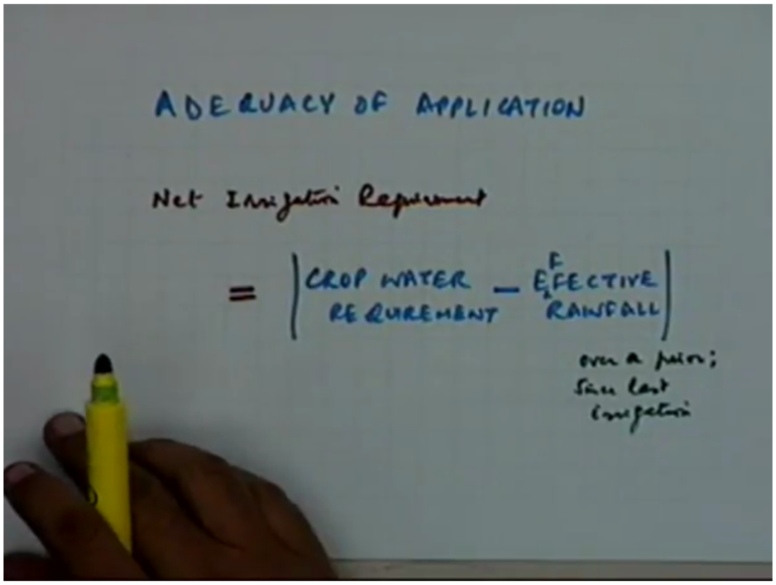


There are some recommended conditions which have to be observed. For example, the minimum collector diameter, the catch can diameter should be at least 8 centimeters. Similarly the maximum spacing between the cans should be of the order of 3 meters. You should not try to have spacing between the cans more than 3 meters. Another condition which is recommended is the sprinkler height of 0.6 meters above the average elevation of the four nearest collectors. So the level of the sprinkler head should be at least 0.6 meters above the four nearest collectors.

You can observe the other data, the related data which can be important when you are performing this test for the uniformity coefficient evaluation. You can also observe the data which can give you how much is the loss from the evaporation and that can vary drastically with respect to the climatic conditions. So you should observe the data along with the this experimentation, the data on temperature, the relative humidity, and the related parameters which can give you the indication about the evaporation activity.

And those losses can also be incorporated. Okay. Because if you are using the same method for different climatic conditions, you might find that in one case the loss where the conditions are very severe and they are very dry and hot, the level of evaporation can be very high. And you might get results. If you want to generalize those results, you might find that there can be problems later on. So for those purposes you will like to have the data on wind conditions, the data on temperatures.

(Refer Slide Time: 37:50)



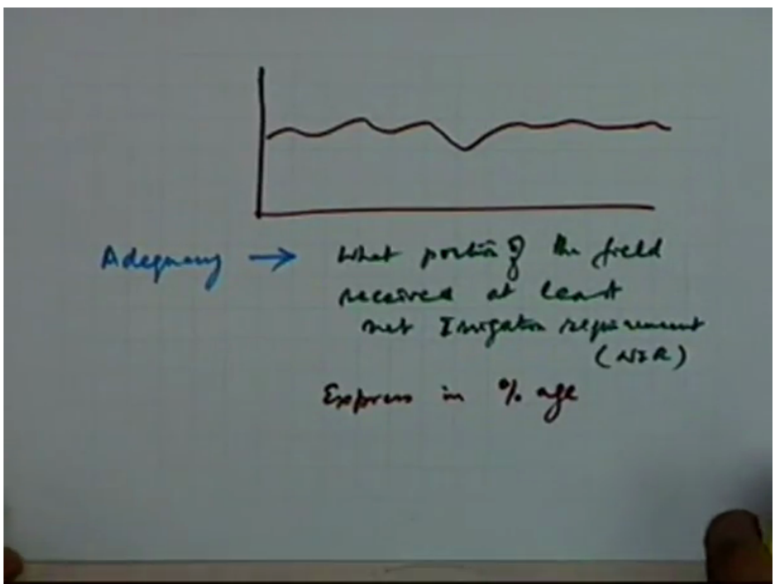
Let us now discuss the aspects of adequacy of application. So far we have looked at what is the behavior of the sprinkler irrigation system. But why we are using the sprinkler irrigation system? Is to use this system for application of water which is basically meant for taking care of the crop water requirements. Unless we look into the question of adequacy, whether that amount of water which you are going to make available how adequate that water is, that is why this term of adequacy of application has been introduced which is very useful in designing the system.

Because you have to evaluate your system with respect to some parameters, some quantities and adequacy of application is one term which has been introduced. So if we look at the final requirement which we want to take care of which is the net irrigation requirement, this net irrigation requirement, how much this net irrigation requirement is there? Net irrigation requirement is basically the difference between crop water requirement. We have seen this in detail that why we are irrigating. To take care of the crop water requirement. The crop water requirement is a function of the climate and the crop put together.

And that crop water requirement is also to be associated with respect to when we have done the last irrigation. So the crop water requirement and there can be another quantity which can be adjusted in the crop water requirement which is the effective rainfall. So if you want to take care of, take account of the effective rainfall or rather effective precipitation you can say this over a period and what is that period? Since last irrigation.

This much difference but how much is the crop water requirement during the period since we have given the application, the last irrigation application and after taking into account the effective rainfall during this period, the period in question, that is our net irrigation requirement. And we have also seen just now that this net irrigation requirement we achieved through the superposition of those individual distribution patterns. So what happens, you might find that looking at those patterns the way we have seen them, there are some places where you are having more water, there are some places where you are having less water.

(Refer Slide Time: 42:21)

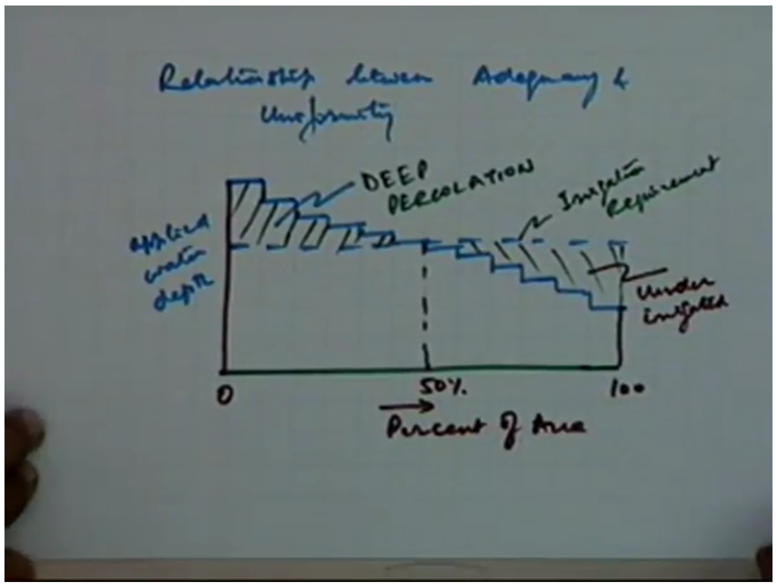


There is some undulated application. You might find that can be something of this nature. So if we want to look at the overall field, you have to see in terms of the total area or the total field how much area you have been able to achieve at least the net irrigation depth which is the required depth. And those areas where you have not been able to achieve this net irrigation depth, those are the areas where you are having deficit conditions.

So the adequacy has been defined, the term adequacy has been defined to address the various concerned items. The first one is that what is, what portion of the field received at least the net irrigation requirement. Let us call it NIR. All those areas which are at least receiving the net irrigation requirement they are adequately irrigated. All the remaining areas are under-irrigated areas. And this adequacy level we normally express in percentage. If we say the adequacy level is 25 percentage, that means only 25 percentage of the area received the irrigation equal to or greater than the net irrigation. All the remaining areas received water which is less than that level, the level of net irrigation.

Now the two things which we have introduced, the uniformity and the adequacy. These two things put in conjunction, these two things when you look at the two items together, you will get the feel how well you have been able to irrigate the area. The uniformity as well as the adequacy.

(Refer Slide Time: 45:30)



So if you try to establish a relationship between adequacy and the uniformity, we will explain this through another graphical presentation. Let us assume that this is your, this is the field where I am expressing this as percent of area. This is 0 percent. Let us say this is 100 percent. And the applied water depth is different. So if we take for every 10 percent interval the increment how much is the average depth, we can, normally you can show it as continuous line but you can show it as a bar if you take only 10 percent of the area in one interval.

So if this is the actual applied water depth which you have either obtained from the by using the catch cans or by using some other way, you might find that if this is the way it changes. So this is a total variation and if this was the irrigation requirement, if this is the level which shows the irrigation requirement, this particular case this was the irrigation requirement and this is the actual application which we have made.

Then the at this level, this is 50 percent level. What is the adequacy of irrigation? Is only 50 percent because only 50 percent of the area is receiving equal to or more than the net irrigation requirement because your requirement was, this is the level of requirement. And this is the area, this area, if I shade this area, this is the area which is the deep percolation. We did not want this water. This water is not being used for the crop production. This is excess water which has been dumped because only this much portion of the water was required.

This is the net irrigation requirement. Whereas on this side this portion and this area on this side means for the remaining 50 percent of the area, the irrigation is not adequate, it is under-irrigated. This area is under-irrigated. If you wanted to have a higher uniformity coefficient, then for the uniformity coefficient to be higher, this disparity, this deep percolation extent of the area should have been minimal.

So you should have got a distribution pattern which is giving you depth, the actual depths which is quite closer to the required depth. That is what you have to achieve for a specific level of adequate irrigation or the adequacy of the irrigation. These two factors put together there will be the one which will be very useful because of the fact that these two things are not independent, they are interdependent. And they are also associated with the other indirect forces, for example, the economy of the system.

I can get a much better uniformity coefficient if I am willing to have very closer spacings. The spacing between, by adjusting the spacing between the sprinklers and the spacing between the laterals I can achieve much higher level of uniformity coefficients thereby reducing the deep percolation. At the same time my expenses go up. So it depends what type of crop you are having, what type of condition you are having and thereby you can decide what type of system is adequate for your conditions.

Therefore it is very important to understand at this juncture. It is not merely a function of how these things vary, there is lot of subjectivity and that subjectivity has to be resolved by many different parameters. Some of the parameters are economic parameters, the other parameters are also dependent on the crop which is in question, the requirements of the crop or how sensitive the crops are, what is the value of the crop, how much you will lose in terms of the yield, whether that is justifiable or not. So there has to be a tradeoff.

That is why these designs they become subjective. You have to put in lot of effort in arriving at those final parameters and those parameters might not be generic parameters. They cannot be, you cannot say that yes, these parameters for this set of conditions if you have applied in one area they will be true for the other area also. It is not true. They are highly subjective because of these different conditions. So we will try to learn more about these items in the next class. We will stop here today. If you have any questions, I can answer your question. Thank you then.