Water Management
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Lecture 35
Sprinkler Irrigation System (Continued)

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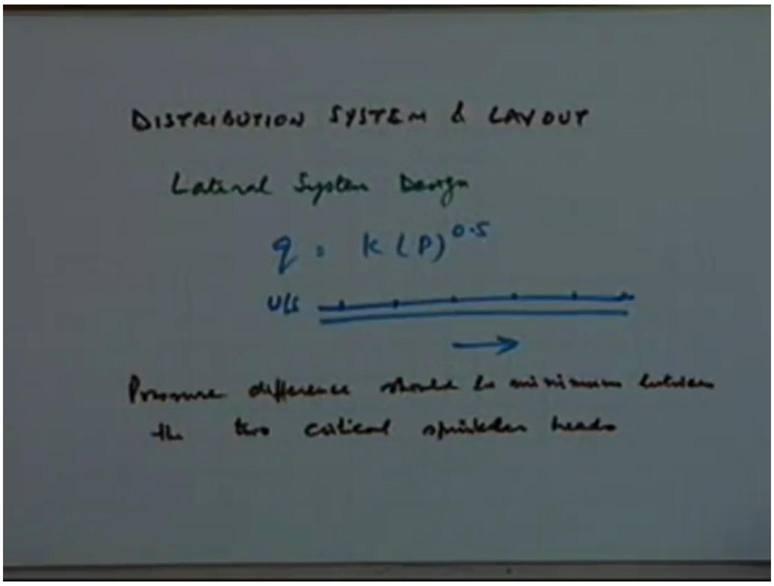

We were discussing the distribution system and the layout, we had started with the distributed system in terms of considering the lateral system design first to start with and we had mentioned that so far we have been assuming that there is no difference in the discharge, we were only considering a single sprinkler head when we take the total lateral is not possible to have the uniform discharge from the one lateral to another lateral and so on because of the fact that the discharges reducing as you go down a lateral and the pressure is also reducing because of the fact that there are some losses occurring on the way as you travel down the lateral.

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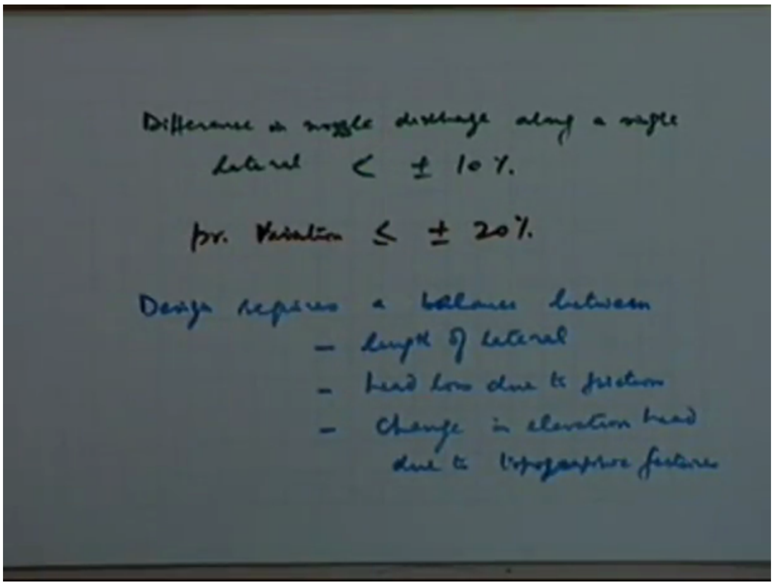

Now from the point of view of the design since started that you cannot keep a uniform pressure in the lateral there will be some variation in the pressure as well as in the discharge also because both are related. The acceptable limits which are used for the design are the difference in nozzle discharge along a single lateral should be less than plus minus 10 percent or in terms of the pressure variation, pressure variation should be less than plus minus 20 percent.

So that is the limiting ranges which are given so you have to design your system distribution system in such a manner that you are within these ranges and that is the reason that you will have to go in for a trade-off between some of the parameters which are within your permissible range in terms of the situation, in terms of the environmenting terms of the parameters which are flexible parameters.

In general you have the balance between the length of the lateral, either you if the length of the lateral is flexible in terms of you can have the option to reduce or increase the length of the laterals that is one parameter which you can manipulate which you can work on, the design will also require the balance between the head loss due to friction you will have to consider the head loss due to friction and you will have to incorporate the change in the elevation due to the topographic features.

Now the advantage or disadvantage which is there because of which the topographic features that has to be exploited. In some case the prevailing slopes can be exploited to gain some some of the head which can compensate the loss due to friction that has to be we will look into those aspects when we will go for the layout that how the network, how the distribution system should be laid out that is where we will exploit the topographic features and we will set some thumb rules or some guidelines which can be used for the layout for a proper layout which will exploit those natural features which are prevailing in that particular location.

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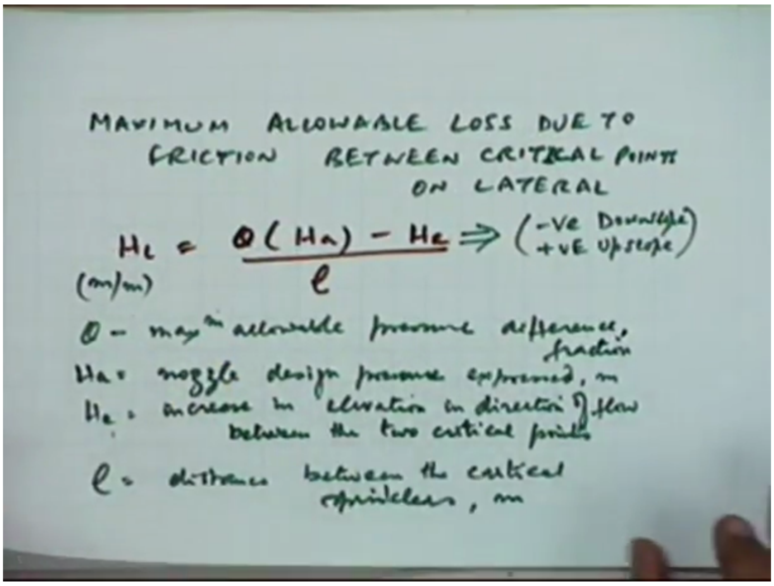

Let us look at the maximum allowable loss due to friction between critical points or between critical sprinklers on lateral. First of all before we going for the expression is important to know which are the critical points now if you take a lateral on the lateral in normal circumstances the first point and the last point or the first sprinkler and the last sprinkler will give you the two critical points provided you have the lateral laid on a uniform slope that case the difference between the first sprinkler and the last sprinkler will be the maximum, the pressure difference between these two sprinklers will be the maximum.

But there can be situations where you have some other two sprinklers giving you the two critical points. A situation can be where you are having lateral lay down on non-uniform slope where there can be a rise or fall of the laterals slope or the natural slope. So the lateral is not on a uniform slope in that case some other sprinkler position can be critical because in that case you will find that the other differences which are made because of the elevation difference or that will make the major change in the overall pressure available at that particular location and that can be much different or it can be much higher than the sprinkler which is even further away.

So from that angle from the design purpose that particular in between sprinkler can also be a critical sprinkler because you are designing for the extremes whichever is the extreme case you will have to first select which is the extreme sprinkler head which is having the maximum which is creating the maximum difference that has to be picked up.

So when you look at the maximum allowable loss due to friction between the critical points on the lateral is you are trying to (())(8:58) to that critical difference on a particular lateral and that is given by this expression where H L is the maximum allowable loss due to friction between the critical points and this is expressed in meters per meter, theta is the maximum allowable pressure difference this is given in fraction.

Now here we have earlier we have said that the pressure difference should be less than equal to 20 percent what is the exact value that is what is theta what is the proportion, what is the maximum allowable pressure difference which is which can be used or which is acceptable that is what is theta, H a is the nozzle design pressure expressed in meters and H e is the increase in elevation in direction of the flow and this increase in elevation has to be taken between the two critical points, this H e basically it can be negative or positive if you have downslope if you have downslope is negative if you have upslope is positive and l is the distance between the critical sprinklers in meters.

Now this give you the maximum allowable friction loss which you can which is permissible for this particular lateral the actual can be much different and the actual loss is this is only the permissible you will like to be much within or very to be on the conservative side you can be having this as the maximum value but to have better design to have the reduced cost to have the design which is more effective you will like to be much much below this.

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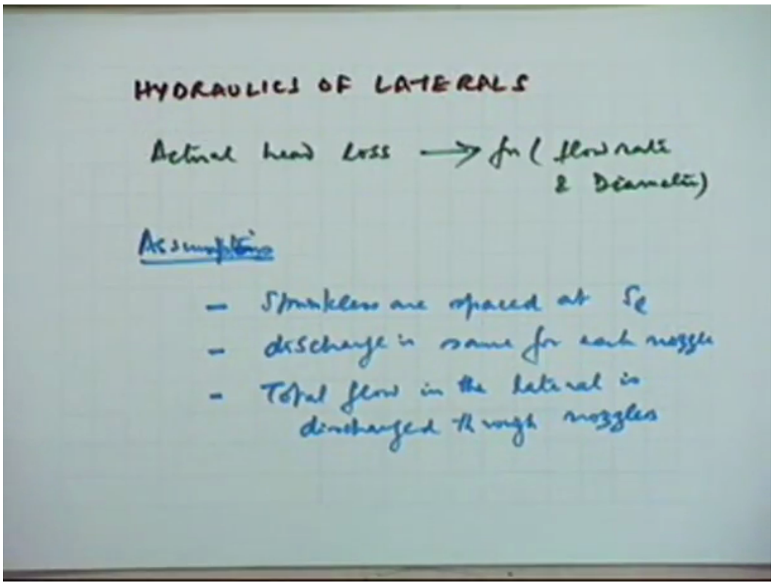

So you have to know compute for the actuals this is only permissible value this is the upper limit which we have computed. To find out the actuals you have to take the help of the hydraulics of the laterals and as we know that the actual head loss we have been dealing with the pipes the flow in pipes the head loss as a function of the flow rate and the diameter of the pipe besides that the other characteristics what is the roughness and all those things these are the two major parameters which will decide what is actual head loss?

Now the trouble is that if we have the uniform pipes, if we have the pipes conventional pipes where the flow is taking place without any loss of flow, without any loss of discharge then we have the formulas which are very well defined formula there are many of them which can be used to find out how much will be the head loss the problem comes when you have this system system which we are indulging in in terms of the sprinkler, where there is loss of water the volumetric flow rate is decreasing as you go along the lateral.

So when you have that situation than those formulae are no more applicable as they are because in that the assumption is that there is no loss of flow. So some approximations have been incorporate, some assumptions have been made to use the same formulae which are available in literature in hydraulics where you can use the pipe flows and use some additional information or use some other empirical relationships to convert those formulae or to make those formulae valid for the present case where we have the loss of discharge along the lateral and that is what we take advantage of and the expression which we are going to consider they are basically of that nature where we have use some non-formulae and then we have provided a correction factor to make them valid for the present case which we have.

So in the present analysis still the assumptions which assumptions which are made are the sprinklers are spaced at a equal spacing of S l which is true because that is what we are resorting to we do not change the spacing, discharges same for each nozzle this is not true this we know that is not true that is why we are ensuring from the uniformity coefficient point of view or from the uniformity of the distribution of water we are assuming we are trying to restrict ourselves within a range which is which we have said less than 10 percent. But for these subsequent formulae we are assuming that the discharge is same for each nozzle and also the total flow in the lateral is is discharged through nozzles only there is no other loss.

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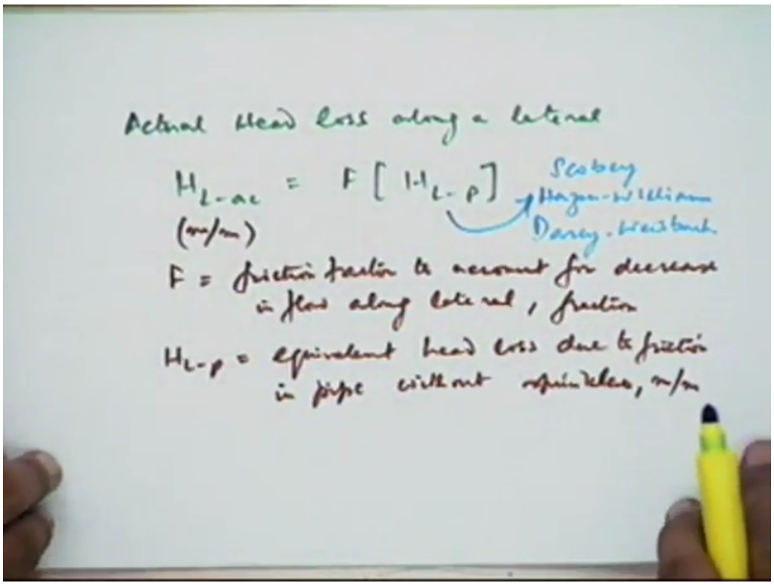

So the actual head loss along a lateral is expressed as the actual head loss is some factor F into head loss an equivalent pipe. Let us see that this is the actual head loss due to friction in meters per meter and F is the friction factor to account for decrease in flow along lateral and this is expressed as a fraction that is what we have said that there will be a factor which will be applied on to the head loss this H L-P is the equivalent head loss due to friction in pipe without sprinklers.

So if there are no sprinklers put on the pipe how much will be the head loss in meters per meter? For this head loss there are for this the competition of H L-P you must have in your course on hydraulics you must have come across many formulae which are available these are the formula which is given by Scobey, there is Hazen Williams formula, there is another one Darcy-Weisbach formula these are different formulae anyone can be used for finding out how much is the head loss due to friction in the pipe if you do not have any sprinklers.

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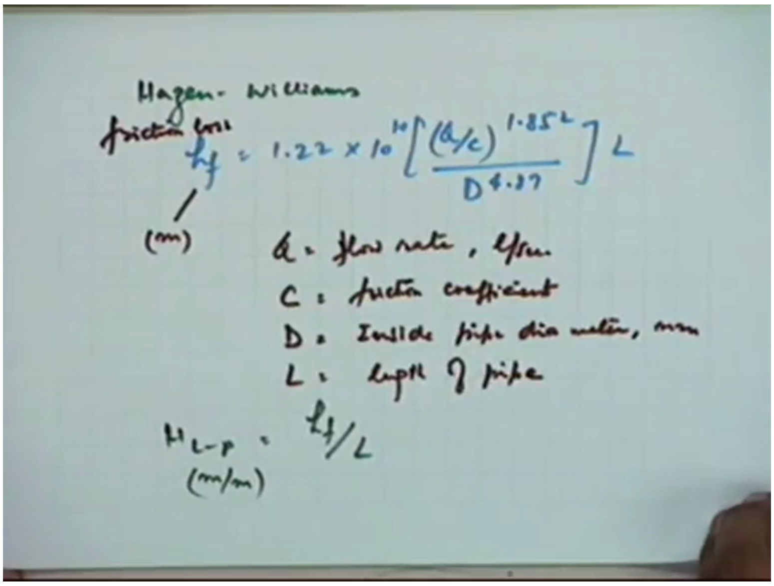

In the present case the Hazen-Williams formula is used which gives h f or the head loss is expressed into L. Now this is the expression used for the friction loss and which this is the friction loss is h f for the total length of the pipe in meters and Q is the flow rate or the discharge in litres per second, C is the Hazen-William friction coefficient and D is the inside pipe diameter in millimetres and L is the length of the pipe.

Now here the H L-P which we have used in the previous expression that will be basically h f divided by L which will give this in meters per meter length of the pipe.

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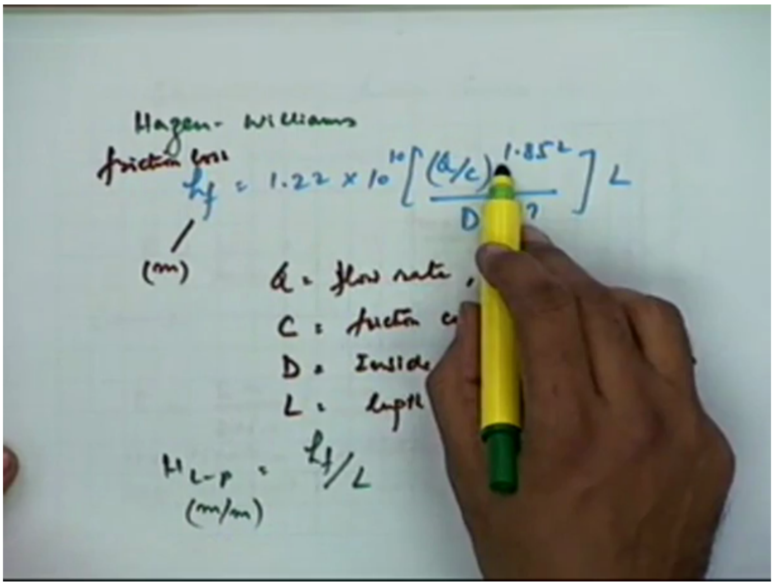

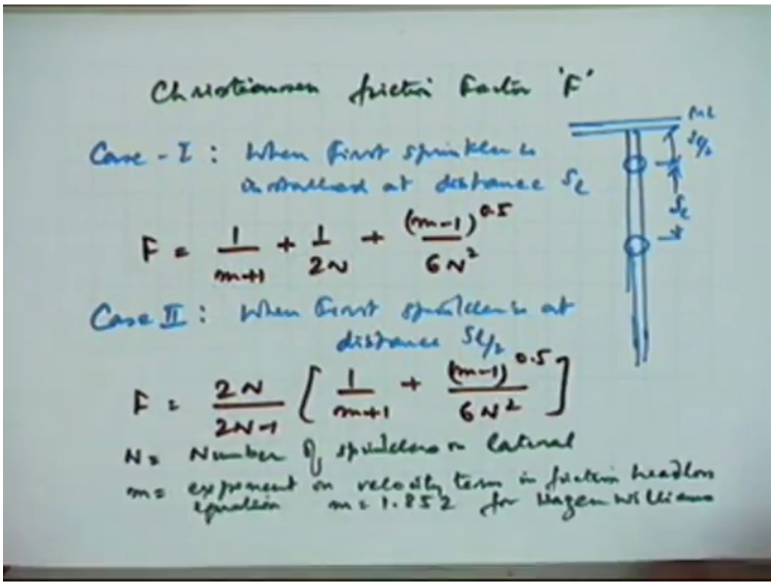

As far as the factor F is concerned which we use for the sprinkler systems (())(24:13) has given a expression for friction factor which we are calling F he has used two cases, case one as this friction factor F changes with respect to the condition whether how you have installed the sprinklers on the lateral there are two options available sometime you might install the sprinkler head first sprinkler head at half the interval or half the S l example if this is the this is the main line and this is the lateral.

Now the first this is your spacing on the lateral and if you install this first sprinkler at half the spacing the lateral spacing then you have one case, the other case is when you install that at one lateral spacing the case 1 is when first sprinkler is installed at distance S l from the main line this is the main line here so this is the case 2 which we have shown here, in case 1 F is given as this expression when the first sprinkler is installed at distance half one time the spacing or at a distance S l.

And case 2 is case 2 is this case when first sprinkler is at distance S l by 2 from the main line in that case F is given as 2N by 2N minus 1 1 over m plus 1 plus m minus 1 to 0.5 6N square and this these two expressions N is number of sprinklers on lateral what is the total number of sprinklers which have been installed on lateral that is N and small m is the exponent on velocity term in friction head loss equation.

In the present case we have used the this will change the value of m will change for from one formula to the other formula and in the present case we have used the Hazen-Williams formula for that if you look at this this the m value will be 1.852 this is the value of the exponent which has been used for (())(29:28). So for Hazen-Williams formula m will be

1.852. So once you find out the value of F you can then use this F value along with the friction loss for those known formulae and you can find out how much is the actual head loss.

One more thing which we must understand here that now the actual head loss suppose you have found out the actual head loss and then you compare with the permissible head loss which you have already seen and that is what is the major item of the design in the lateral in the case of the lateral design but then if you have found out how much is the actual head loss is much more than the permissible head loss then what are the various options available to you that there is no restriction there are different options available you can either adjust the lengths that is one way of looking at it or can change the diameters of the pipes.

There are many situations where you will find that the layout is almost fixed you will not like to because there is they are not many options when you look at the layout, when we will come to that you will find out with respect to the area where you want to install the system the layout possibilities are may be two different layouts you can have which are quite close to optimum or quite close to the layout which should be there so once that layout is fixed you might not be able to have options of changing the lengths the lengths will be restricted by the layouts, you will only be left with the options of changing the sizes of pipes that is how you can look at the option of reducing the head loss which is prevalent and that you will find that might become the restriction on you.

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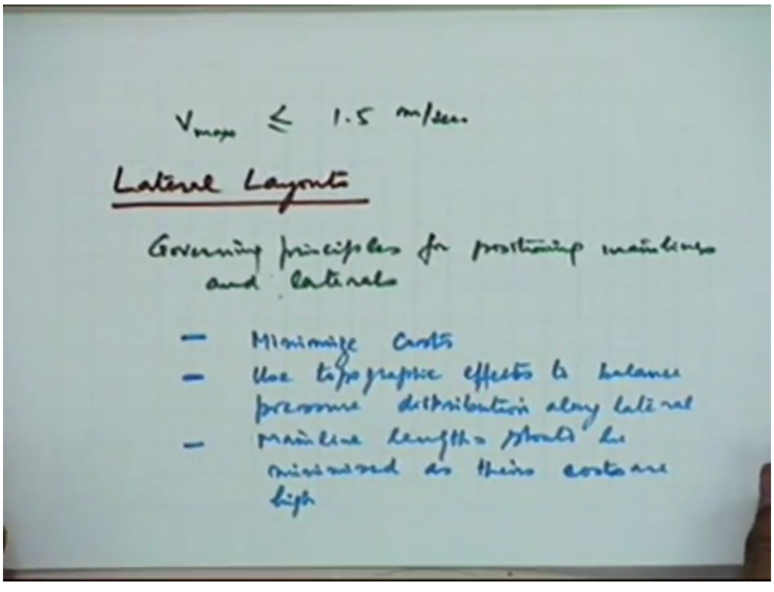

By the same time you will have to also see some other requirements for example the maximum velocities which are possible or which should be restricted in the lateral design V maximum should be less than equal to 1.5 meters per second. So the maximum velocity in the pipe this is the restriction enforced in terms of specially in those cases where the bends are there where you might have problems of a deformations specially in the case of lateral you have two places where the there will be just sudden change of direction of the flow one will be when the water will be coming from the main line and entering the lateral is one place, the other place is when the water will be coming from the lateral and entering the riser pipe and then coming to the sprinkler head.

So from that criteria to avoid the those situations where you have the excessive loss you try to restrict the velocities maximum velocities to be less than this value, there is also additional parameter which has to be looked into. Next let us come out now and look at the lateral layouts I will look at how we looked at look at the various losses which are prevalent one way of reducing the loss or reducing the or to be within the permissible loss state you can have a proper design of layouts.

What are the possible layouts we will look at some of them because you cannot possibly think of all the possible layouts which are which can be adopted by a user or by a designer because it is a function of so many parameters the major thing which will decide this layout will be the topography of the area. So the topographies cannot be generalized still we will try to look at some of the typical examples of these layouts which totally is dependent on the designer or he goes in for the actual layout this will be also function of what type of system he already has available with him, what are the lengths of the various pipe lines which are available, what type of pump is already available.

If you design with a fresh designer yes you can have the choice on almost every component but if you have the some part of the equipment already available with you then will be constraint by those equipment and you will try to check if you use that equipment whether you will be within the limits permissible limits or not. The layouts the governing principles for positioning main lines and laterals if we try to look at first what are the governing principles which should be kept in mind when you go in for the layout of main lines and the laterals some things which are important are that you want to minimize the cost that is the very important factor which must be considered that what is the layout which can give you the minimum cost.

You must use topographic effects to balance pressure distribution along the lateral for example since you know that if you have a situation where you have the natural downslope available and if you lay your lateral on that downslope since there will be some friction loss, some head loss due to friction as you go along the pipes this head loss can be compensated because of that downslope which is additional head which you gain because of the downslope.

So because of this compensation of head you can ensure over the total length of the lateral you can ensure that the pressure variation is minimized. So in other words if you can have a layout if it is possible wherever possible if you can layout your laterals on the downslopes you will gain you will gain in terms of the uniformity of application that is what we mean that use topographic effects to balance pressure distribution along the laterals.

But when it comes to the main line the main line lengths should be minimized as their costs are high the cost of the main lines are much higher so if you can reduce the length of the main line there will be much more advantages.

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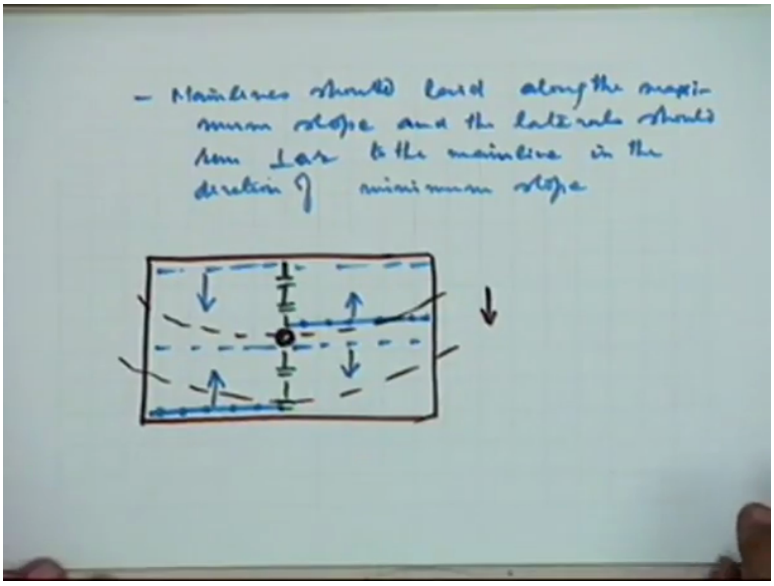

Then there is another governing principle that wherever possible the main lines should be laid along the maximum slope and the laterals should run perpendicular to the main line in the direction of minimum slope. Wherever you have the situation where you have the slope in both the directions main line should be laid on to the maximum slope and then from there you will have the laterals going out along the slope in the other direction which is not as excessive as the main line slope.

Let us have some of the typical situations where you can look at what is the possible let us take one field where you have quite a moderate slopes are there the slope is in this general direction you have the source the source of water this is the source of water in the middle of the field now in the source of the water is in the middle you can in this case now this is your maximum slope and there is some slope in the other direction also if you lay your main line along the slope you can run the laterals, you can have one lateral in this direction this is one lateral and there can be another lateral it is somewhere here you have all these sprinkler heads put on the lateral.

Now this lateral can be moved in this direction, it can cover the area upto this then you might bring the lateral to the other side of the area and move it down from there. Similarly this lateral can move up cover this area and then from there move down it depends on how many laterals you want to utilize in this case only two laterals are being utilized but then this is not the only way to look at it you will also have to look at how much is the discharge which is which you are having in the sprinkler heads, how much time is available, how much time it will take to cover this total area all those things we have already seen that how they can be looked at by designing.

But we are just looking at one option available if you want to use only two laterals and you want to cover the whole area if you find that the two laterals are not sufficient you might going for two more laterals and four laterals will be there you can have this one going here there can be another one which is covering this area and each one can cover one fourth of the area.

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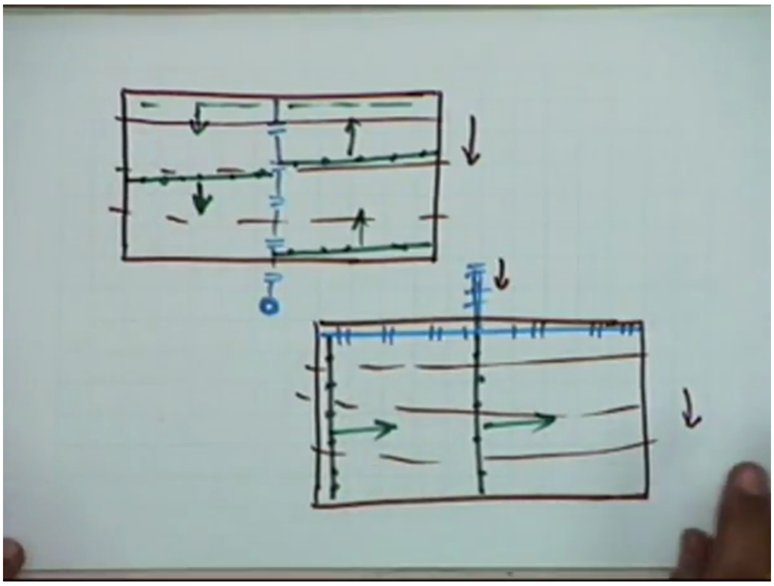

Let us look at another situation where you have again the moderate slopes but now in this particular case the sources not within the area the sources outside the area there is the source and in this case again the slope the general slope is that you have this is the downslope you lay the lay the main line the middle of the field and here now you can you can think of having laterals which are not two which are again can have more than two laterals depends how many laterals you need to cover the whole area the one possibility can be that this lateral is moving in this direction, this lateral is moving in this direction and after covering this area it might be covering some part of this area also and this lateral is moving in this direction.

Actual coverage how settings will be needed that has to be known that how many settings will be required to cover the total area that will be a function of how many what is the total length, what is the spacing between the laterals, what is the and that will decide how many total number of setting will be required because that has been decided on the basis of the overlaps ,what are the overlaps required and then the number has to be found out from the point of view how much time is available to the farmer or to the operator to cover that total area that is basically the total crux of the whole game of designing because operation and design.

And moreover there is one more thing that the operations can be different for different periods you if you have the peak period which you are considering the design will have to be done for the peak (())(48:18) to use period but when you talk of the operations in the other periods you might not use the same operation strategy which you are using for the peak period because at that time you might be in a position to wait for longer the irrigation interval can be much bigger then what is prevalent at the time of the peak (())(48:45) to use it, okay.

Let us look at another situation where you have the area in which case the main line is laid along one side of the field and in this case also the areas of similar type that you have the general slope in this direction. Now in this particular case your main line is coming from some other area and then you want to cover this total field the water is water supply is coming from this part of the main line, in this case one possible way of installing the laterals or running the laterals can be that you have these two laterals and this is the this is covering this part of the area, this is covering this part of the area.

Now in this case you might find that the general guidelines which we have given we are not (())(50:52) to those guidelines we are using a pattern which is not lying the main line along the maximum flow is lying the main line along the top of the field and then you are making use of the slope for compensating the pressure in the laterals, in this case now the uniformity can be much much better and the that is the major reason that you are utilizing this particular pattern or the layouts which you have selected is from that concentration.

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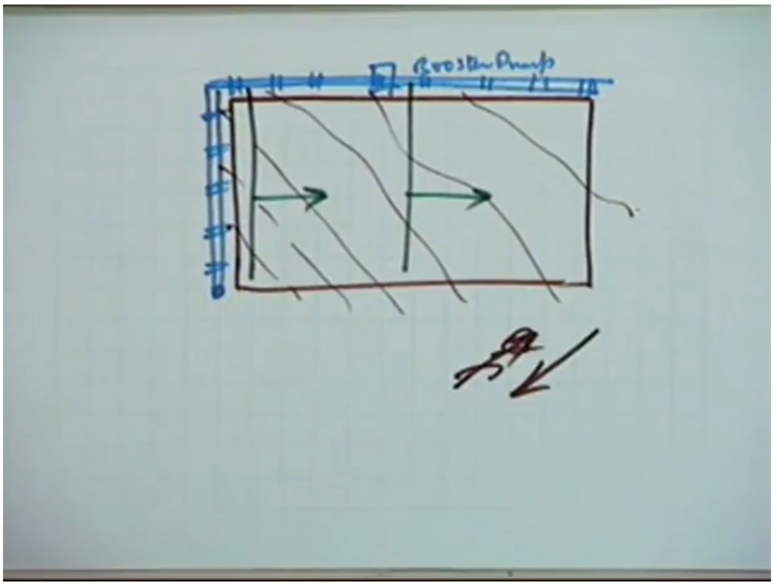

Let us take another situation where you have a area where your slope is somewhere something like this this is the sorry this is the general slope, this is the downslope, this is the points of higher elevation and these are the points of lower elevation and this case the main line is going along this this is the main line and then it is discovering two sides of the field. In this particular situation if you look at if this is the point of supply of the if the pressure which is prevailing here at this location as you go up your pressure requirement or the head requirement increases there are more losses which are taking place and it might happen that by the time you come to this point the pressure requirement is much much excessive, the total pressure requirement will become too much.

Now the problem is that when you when you think of the overall main line, if you require a very very reasonable pressure here at the last point of the main line to get this pressure and if this is the way this is moving is going up slope then the pressure requirement here will be very very high and because of that high pressure requirement (())(53:50) to this pressure the pressure availability has to be very high here that might create a situation where the pressures here might be quite within the range but the pressures here in this zone will become very excessive than what is required.

There is another problem that if you try to (())(54:14) to the pressures of the remote area the pressure just near to the pump will become very highly excessive which are much more than what is desirable. So you will have to you will have to either go in for pressure regulators at each point of these these main line junctions with the lateral that will be very expensive affair or there is another way out that you go in for the boosters you have one pump is supplying the water to this segment of the pipe, you have a booster here you have a booster pump which will take care of the remaining portion of the main line by that you do not have to spend extra money on providing those pressure regulators which can keep the pressures in this segment the lower segment or the that segment which is near to the pump within the permissible or within the range which is not very excessive for the pressures in the laterals.

In this case you can have the movement of the laterals now in this manner that you have one lateral here and one lateral here this will move in this direction, this will move in this direction but the pressure is now there is this booster pump which is providing the pressure requirement in this section of the main line. Any question? I think we will stop here and we will continue this in the next class.