Irrigation and Drainage
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Lecture - 57
Endrain Model

This is a lecture number 57 on Irrigation and Drainage lecture series. So, in this lecture we are going to focus mostly on drainage model it is called EnDrain.

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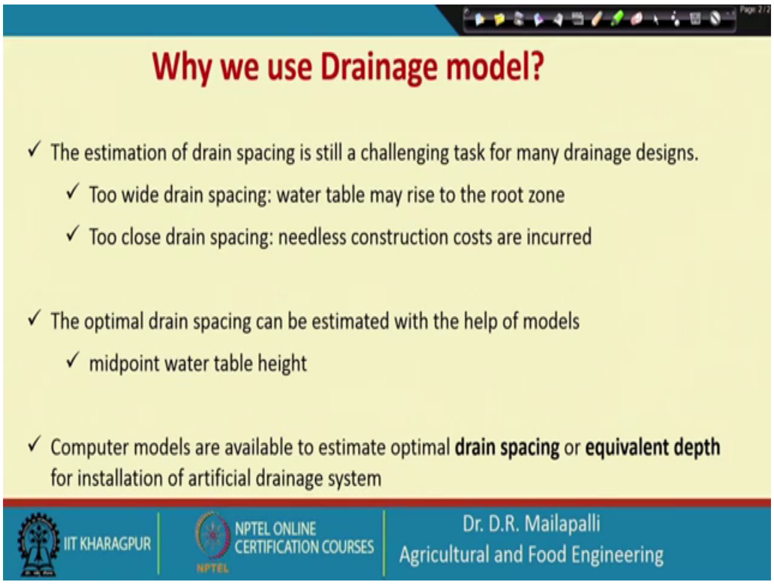

So, what do why do we need drainage model in this case because, you have Hooghoudt equation right for both steady state and, also we have seen on steady state equations for finding out the drain space as well as to track the hydraulic head along the I mean pressure line. So, here we exactly need the drainage model just estimate the drain spacing and because this is a challenging task for many drainage designs so, challenging task in the sense suppose if you live if you planned wider drain spacing. So, the system is not able to you know take out water enough water.

So, then the water table will be staying close to the ground whereas, if you have you know drain space closer so, it involves lot of cost ok. So, so we need to really optimize these you know drain spacing and at the same time you need to understand how the soil properties are influencing the hydraulic head ok. So, these things can be visualized using mathematical models. So, EnDrain is a developed basically to understand the hydraulic heads as well as I mean the behavior of hydraulic heads with different and magnitude of inputs.

And, then so the good thing is it contains both Darcy kind of equation as well as energy balance equation, which is developed by Oosterbaan is the Professor Oosterbaan in Netherlands. So, here the optimal drain spacing can be estimated with the help of models. So, the basically the models will simulate or calculate up to mid midpoint water table height. The computer models are available already to estimate the optimal spacing and equivalent depth for installation of artificial drainage systems.

So, this is very important the model is very important to understand the behavior of the soil, when the drainage system is installed whether we will be able to extract or the excess water from the surface as well as subsurface. And also we can visualize the cost whether I mean based on the drained spacing and all the dynamics, we can visualize the cost whether it is beneficial for going for such you use investment ok.

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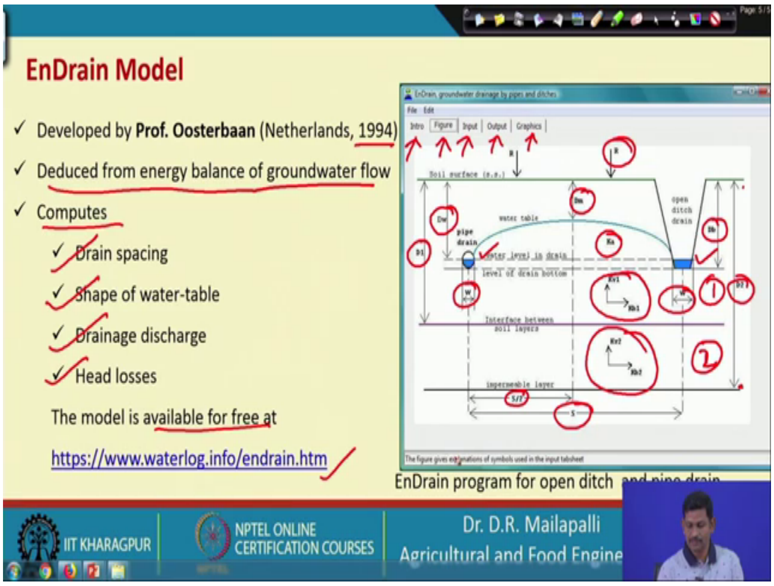

So, here so, EnDrain this is the model which is developed Professor Oosterbaan so, it is in Netherlands in 1994. So, this is deduced from energy balance groundwater flow. So, using the energy balance equations so, they have developed this model. So, and also this model contains the Darcy's you know that is a Hooghoudt equation what you say. So, it computes the drain spacing, shape of water table and drainage discharge and head losses.

So, all these things can be you know obtained in a single model that is a drain and this is freely available, you can download this model at this address ok.

So, the first window it looks like this. So, it contains 5 you know input sheets or tab sheets you can say. So, one is intro, figure, input, output and graphics. So, these 4 5 tab sheets and you can clearly see a picture here. So, it contains you know the both tile drain as well as the open ditch, open ditch and tile drain and there are several parameters you know mentioned. So, R for recharge, you know Dw for this is a drain base width and our base depth or D 1. So, it has 2 layers a soil system this is a layer 1, this is the layer 1 and layer 2 ok.

So, for these 2 layers you have D 1 is the distance from the surface to this layer 1 soil layer 1 and D 2 is the distance from the surface to layer number 2 ok. And so, these are the hydraulic conductivity of for layer number 2. This is vertical hydraulic conductivity Kv 2 and Kb 2 is a horizontal hydraulic conductivity. So, similarly for layer 1 and Ka is the hydraulic conductivity just above the base width of the drains. And, Dm is the water table depth below the soil exactly at the midpoint between the 2 drains ok. And then of course, Db is the depth to the bottom of the drain ok. So and W is the water width which is present in the drainage. So, similarly here width of the channel you can see here.

So, like that so, s is the spacing between the 2 drains, s by 2 is the halfway I mean half spacing between the 2 drains ok. So, in this picture itself you can visualize 2 kinds of drainage system: one is open ditch system and pipe drainage system just for schematic purpose it is not exactly you need to design both tile and open ditch system together ok. So, I mean based on your choice, if you want to determine the drain spacing or if you want to determine the shape of water table or if you want to determine the drainage discharge or a head losses ok. So, all these things I mean you have a options. So, based on a particular option the input levels will vary ok.

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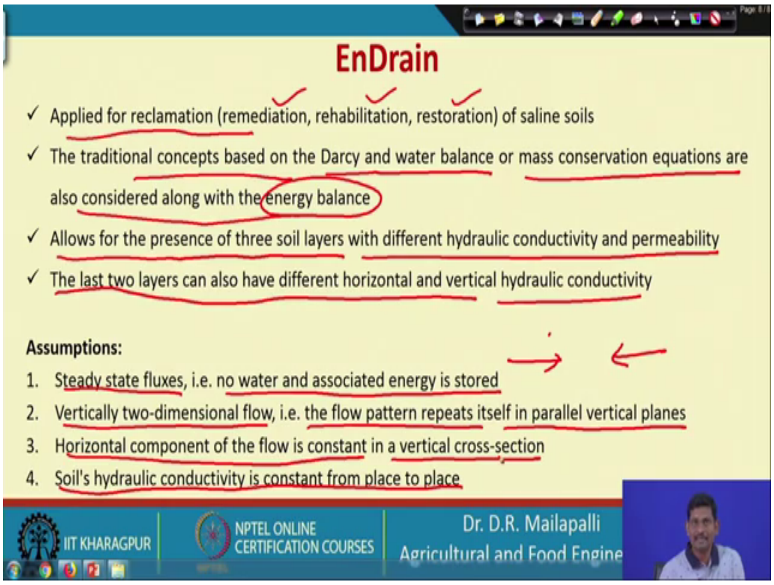

We are going to see those I mean one by one. So, EnDrain so, the basically it is applied for reclamation; that means, remediation, rehabilitation, a restoration of saline soils. And, traditional concepts based on Darcy and water balance or mass conservation equations are also considered along with energy balance equation, basically the energy balance equation based on energy balance equation. So, this model was developed, but in addition to energy balance there is a Darcy and water balance, I mean Darcy water balance or mass conservation equations are also included.

So, energy balance is not covered in this, but you can go through the literature I am going to show you in the end of the lecture. So, you can understand that easily and allows for the presence of three soil layers ok, with different hydraulic conductivity and permeability that we have seen the hydraulic conductivity and permeability of different layers in the previous slide. So, you can give different numbers and that will calculate the drain spacing and other options you choose. So, the last two layers can also have different horizontal and vertical hydraulic conductivities, I have shown that.

Assumptions: in energy balance this is a steady state fluxes and no water and associated energy stored ok. Vertically two dimensional flow, this one the flow pattern repeats itself in a parallel vertical planes ok. Horizontal components of the flow is constant in a vertical cross section. So, every time so, the horizontal I mean flow is assumed to be constant. So, the flow is constant. So, and soils hydraulic conductivity is constant for a place to place.

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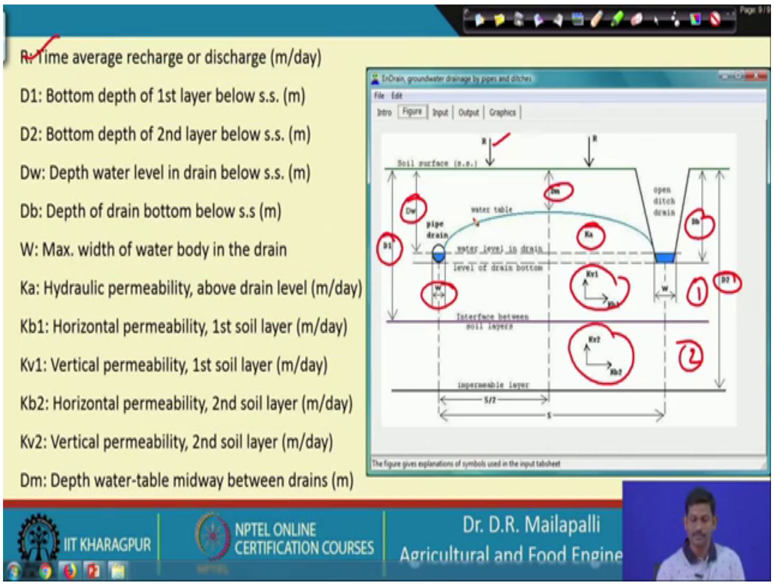

So, for a particular layer so, the soil hydraulic conductivity seems to be constant and then these are the input values I mean the terminologies I already explained. For example, R is a time average recharge or discharge meter per day and D 1 is the bottom depth of first layer. So, this is the layer number 1 and layer number 2 and D 2 is the bottom depth of second layer and D w that is this is the D w ok. So, which is the depth of water table it will drain below the soil, a D b depth of drained bottom.

So, this is the bottom of the drain and W is a maximum width of flow water body and K a hydraulic permeability of the above drain level and K b 1 v 1 K b 2 K v 2 all the hydraulic conductivities of first and second layers. And D m is the depth of water table midway between the drain. So, these are the inputs maximum inputs you have to provide in EnDrain and it will calculate the drain spacing or hydraulic heads or discharge and other parameters.

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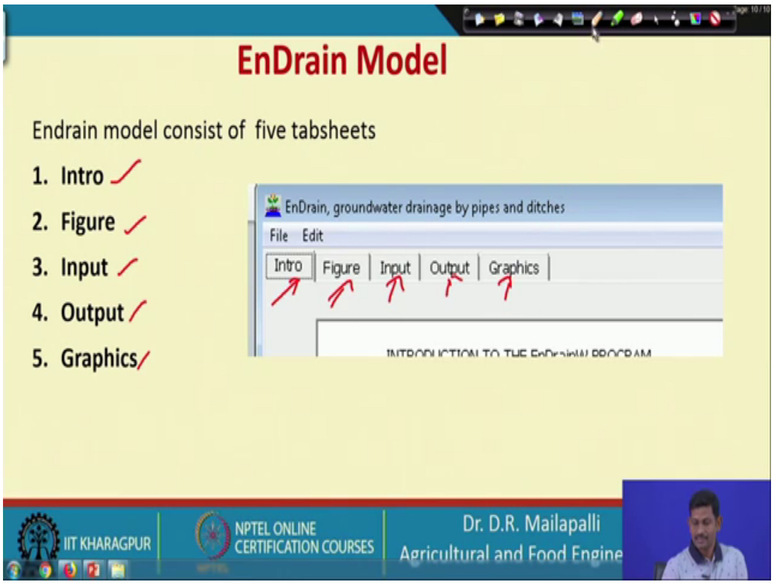

So, the tab sheet I already told there are 5 tab sheets that intro, figure, input and output and graphics. So, this is already coming here right. So let us see one by one what it tells.

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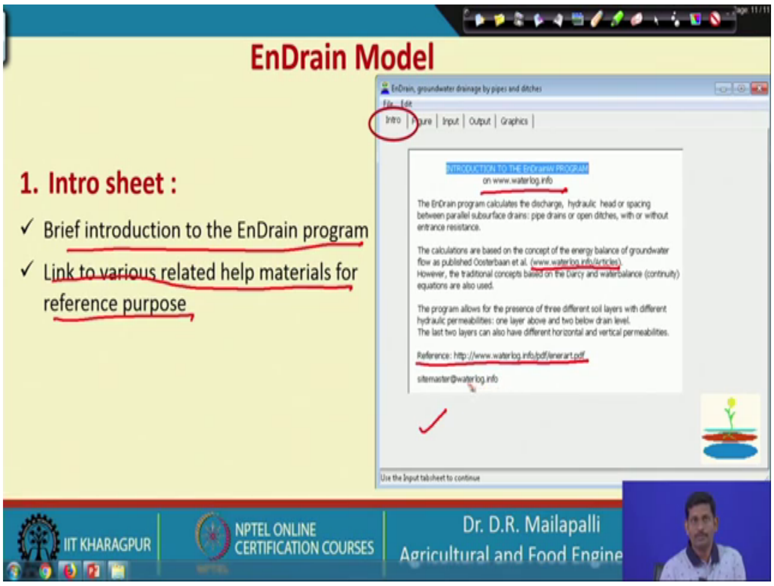

So, for example, intro sheet. So, if you click on intro sheet so, it will show you this window ok, this is the window. So, it is a brief introduction to the EnDrain program about the reference, where you can get the articles related to EnDrain. And, the reference for you know finding out the article based on which it is developed ok. And, this is the web address where you can go to download the EnDrain program.

So, this link to various related help material for reference purposes. So, if you open it I mean these references you will be you know knowing more about the energy balance and also EnDrain and related articles ok.

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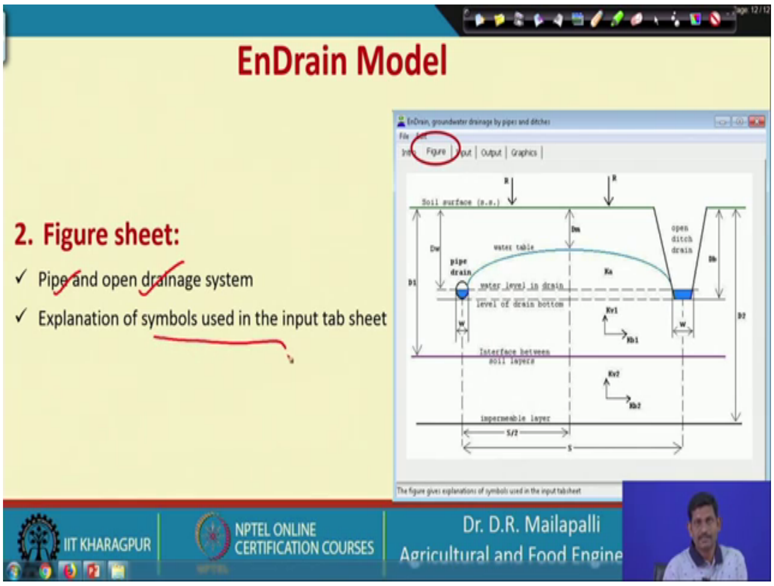

And then the next step is the figure sheet. So, figure sheet is familiar already. So, it tells the different parameters we need to give as input right. So, it contains both pipe and open drain system and it explains the symbols.

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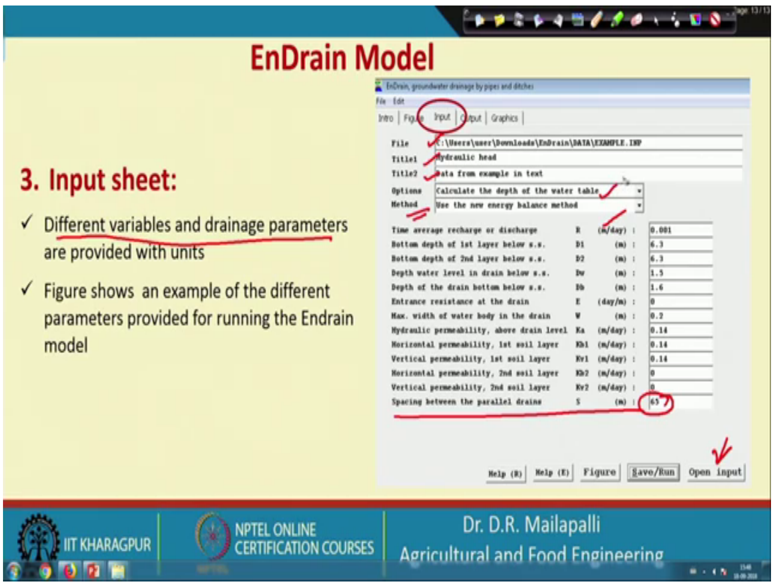

And the third is the input. So, the input or sheet it has a different variables and drain parameters with units. So, look at this here file 1 title 1 title 2 options method ok. So, here you can save this file or you can open input file. So, there is a open input file, if you have already a file already there existing in the folder. So, then you can click on this and select a particular input file. Then it will give the file title you know title 2 or title 1 is hydraulic head, title 2 data from example in text.

And, options you can choose what to be calculated like calculate the depth of water table or calculate the spacing or calculate the hydraulic heads all these things and method. So, are you going to use the energy balance method or Darcy's equation, Hooghoudt method all these things. And, then inputs with so, R D 1 D 2 whatever it is shown in the figure. So, you can give the inputs here ok.

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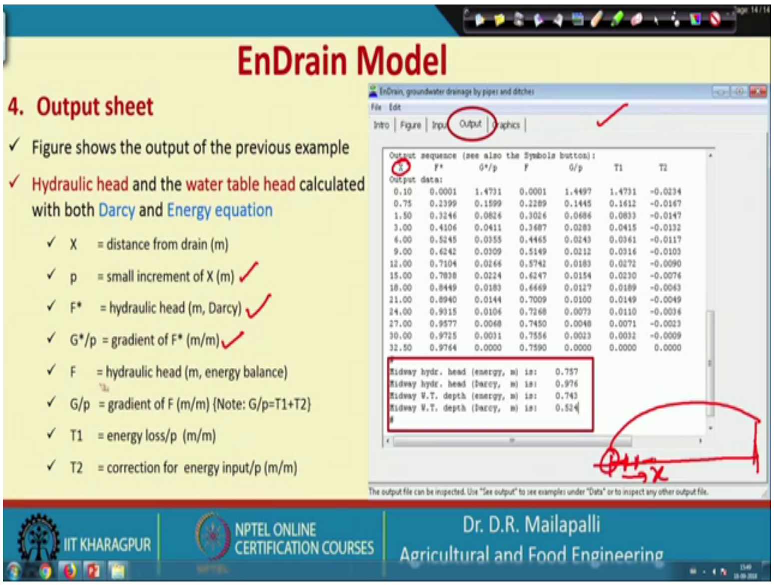

So, here the drain spacing is need to be give given as input because, you are calculating the depth of water tables here ok. So, then the fourth tab sheet is output so, output contains here look at this a figure shows. So, this is the output window so, it contains the X. So, they were what is the that is the distance from the drain to midway ok. So, if this is the drain point I mean tolerant point towards the midway ok. So, this is the distance x and then the sequence F star F star is the hydraulic head in case of Darcy's right Darcy's hydraulic head and then p is the small increment.

So, because this is the model in numerical technique or numerical model you have to give each an increment ok. So, the increment will be here 0.75 0.75 and this is 1.5 and again 1.5. So, it is it is getting you know accumulating here and G star by p gradient of F. So, where G star G star see F star is hydraulic head. So, F is hydraulic head energy balance ok.

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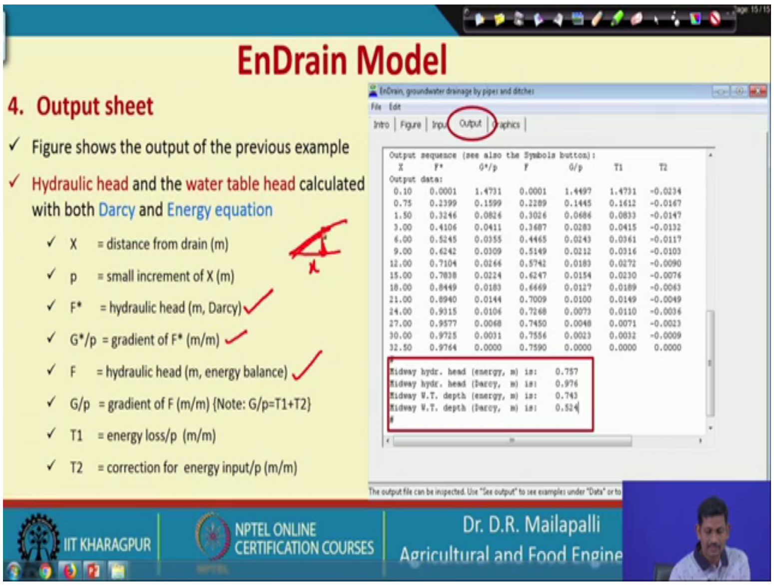

So, here F star is hydraulic head in Darcy’s and F is hydraulic head in energy balance ok, and G star p is a gradient in case of Darcy’s. So, gradient in the sense so, knowing the hydraulic you know the knowing the distance x and the distance this one hydraulic head and you can calculate the gradient ok. This is the hydraulic head and you can calculate the gradient ok. So, similarly G by p energy gradient of F in case of energy equation, if you are using energy balance equation, T 1 is energy loss and correction for energy input. So, these all related to energy balance model.

So, like that you can get both energy balance model as well as Darcy based solutions in this ok. So, in addition to these simulations so, there is a overall you know results like midway hyd hydraulic head, that is you know 0.757 meters. And, midway hydraulic head Darcy’s case 0.976 and midway water table depth so, that is 0.743 in case of energy and midway water table depth in case of Darcy that is a 0.524 ok. So, there is so, you get the results in both energy balance as well as hydraulic sorry Darcy equations ok.

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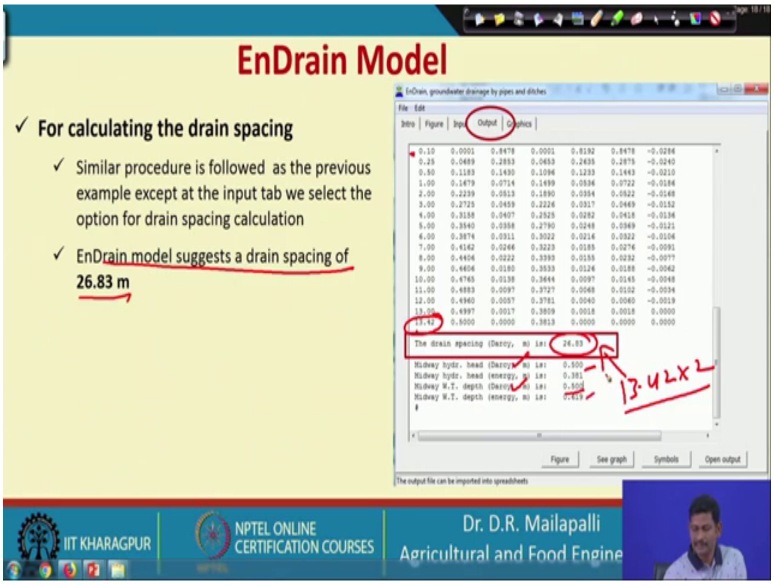

So, for calculating the drain spacing here. So, similar procedure you have to use and you have to choose an option related to drain spacing. So, in this case when you run the model so, the EnDrain suggest the drain spacing of 26.83. So, here you will give like 26.83 because, the simulation starts from here and ends up here that is 13.42.

And, since it is a midway and if you can multiply with 2 this will give the, I mean drain spacing ok, the whole drain between the 2 drains. So, this is a Darcy's hydraulic head and Darcy's water table midway that is 0.5. So, like that energy an energy base ok. So, in this way you can calculate the midway hydraulic head depth and hydraulic head.

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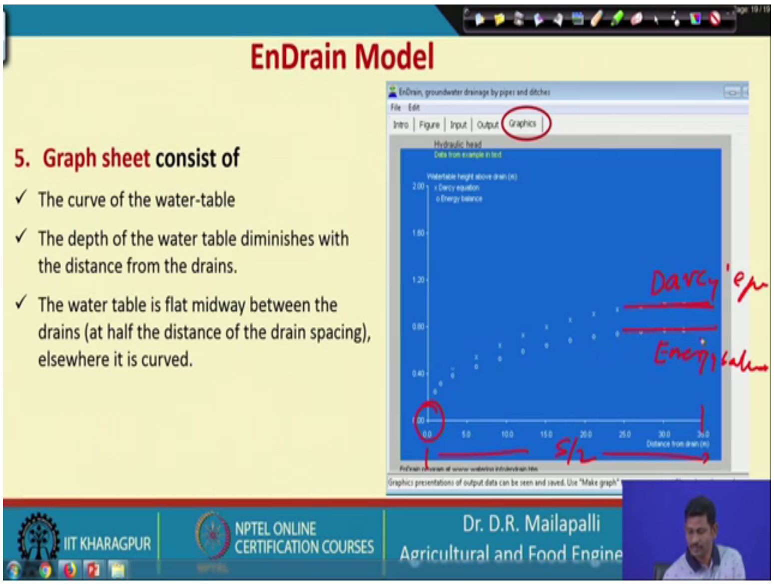

And also you can visualize this whole output in a graphical form, here the curve of the water table so, far it will give. So, on x axis you will give the distance from the drain. So, here there is a drain and this is the midway like s by 2 and then the circles represent the energy balance model whereas, the cross represents the Darcy's equation ok. So, they are close initially, but if you see at the midway so, in both cases they are going you know all parallel ok; they are all going parallel.

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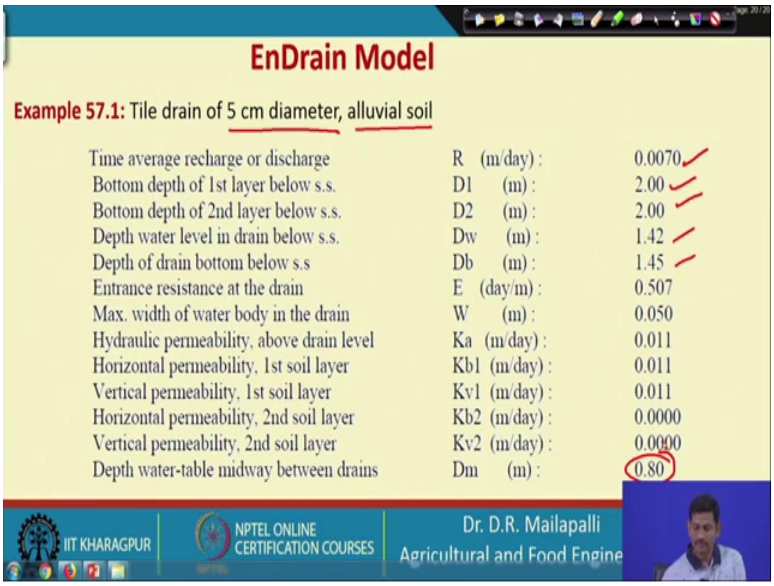

So, and for example, here there is a input data which is available. There is a tile drain of 5 centimeter diameter alluvial soil. So, so the eased EnDrain model to get the water table you know depths as well as to track the hydraulic heads ok. So, here R D1 D2 Dw Db and all values are given here and the water table depth midway between drains.

So, that is 0.8 meter, this is this for a particular crop you have to maintain this 80 centimeter below the ground, the water table should be below 80 centimeter from the ground surface. So, in this case once you run the model with this input so, this will give. So, as I said this is the distance from the drain and F star is hydraulic head in case of Darcy's right.

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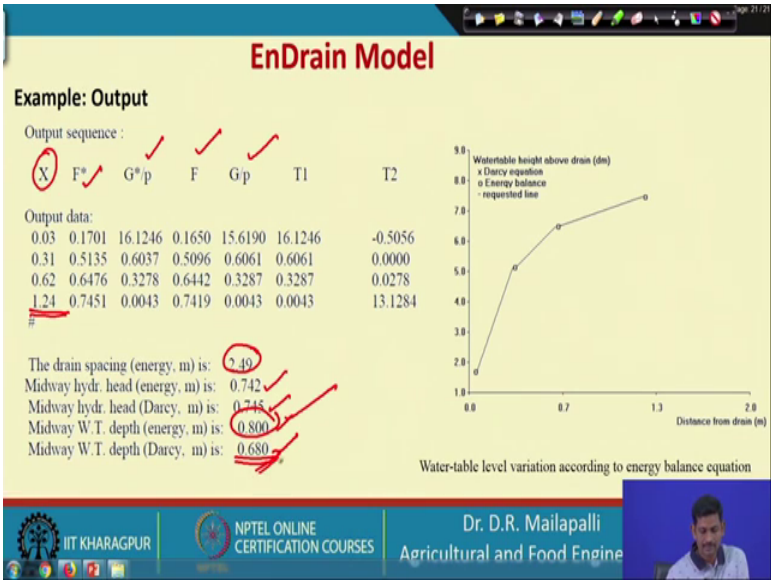

And, this is a gradient hydraulic head in case of energy balance equation and gradient in case of energy balance equation. And, T 1 T 2 also refers to energy balance equation. So, drain spacing here 2.49 because so, it is stopping at 1.24 meter that is halfway if you multiply with 2, you get drain spacing 2.49 meter. And, midway hydraulic head is 0.742 which is close to 0.8 and, midway hydraulic in case of Darcy's they are close in a way.

And, midway water table depth is 0.8 and water table depth in case of Darcy this is 0.68. So, the energy balance I mean midway water table depth this is what we are expecting because, that is 0.8 and the midway water table depth in case of Darcy's is you know it's a less than what we expect ok. So, this is a I mean the star Darcy's equation and whereas, this is the energy balance. So, this is only showing the energy balance equation in case ok.

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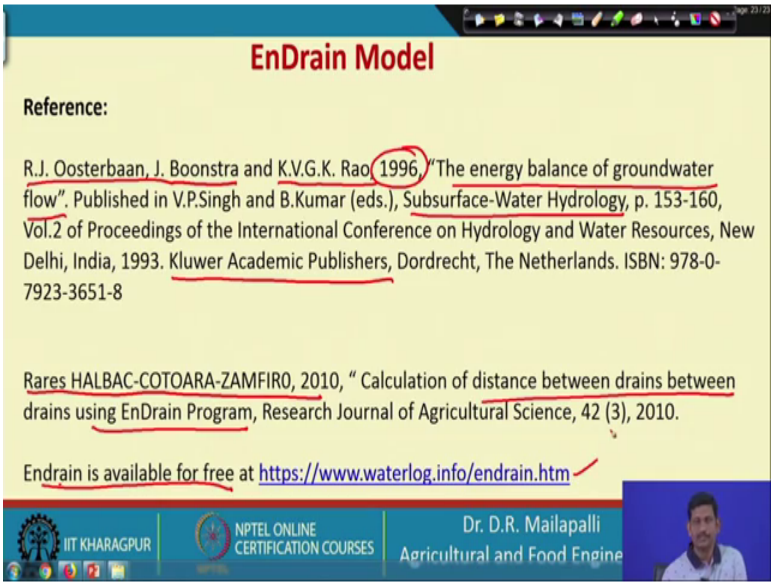

So, this way you can get the drainage you know information design information like drain spacing, drain discharge and hydraulic heads and water table depths and all things. So, you can go through this reference to know more about the energy balance equation. This is Oosterbaan and Boonstra and K.V.G.K Rao 1996 so, the energy balance of groundwater flow. So, this is published in Subsurface-Water Hydrology in the proceedings, its public publishers are Kluwer Academic Publishers. So, you can go through this paper to understand the energy balance equation.

So, the last example was taken from this difference now "Calculation of distance between drains using EnDrain program ok. This also you can find you can Google it, you can get the paper and EnDrain is available for free; you can download it and use it for research purpose ok. So, with this some I mean let us work on running the model. So, I have the models is I will show you the model here. So, this is the EnDrain once you get the model, it will ask us to extract the whole you know the model. Then once you extract it, it will have two files EnDrain this is the executable file and data where you get all the data files input data files ok. So, then click on EnDrain application file and run it. So, then you will get the so, so again I will go through it ok.

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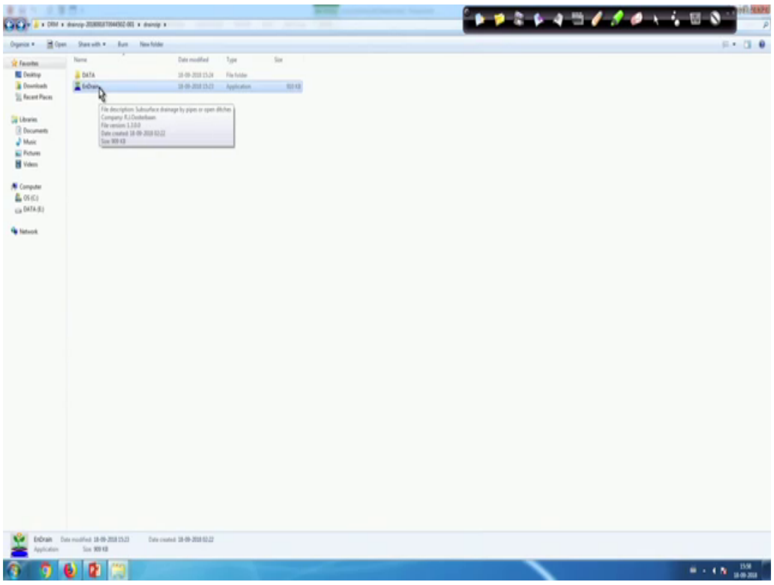

So, here there is a EnDrain ok. So, the two files EnDrain is the application file and data.

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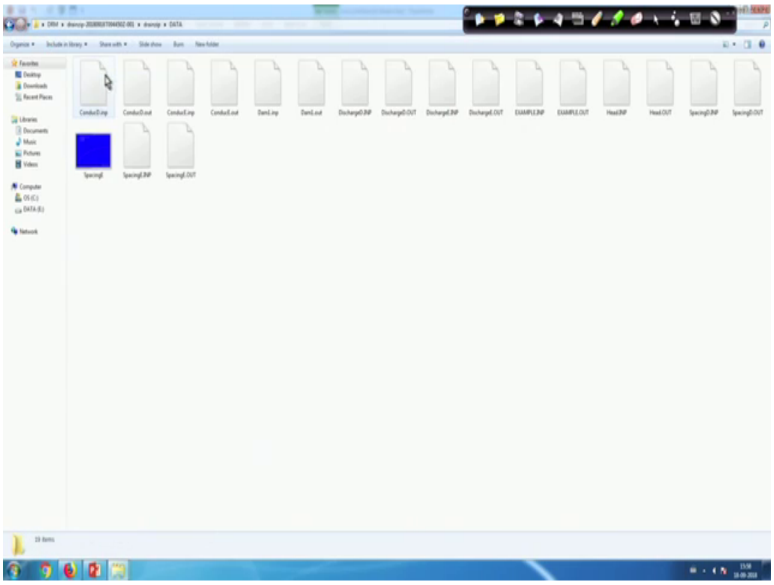

It is a data file where you can see, if there is a lot of you know input data.

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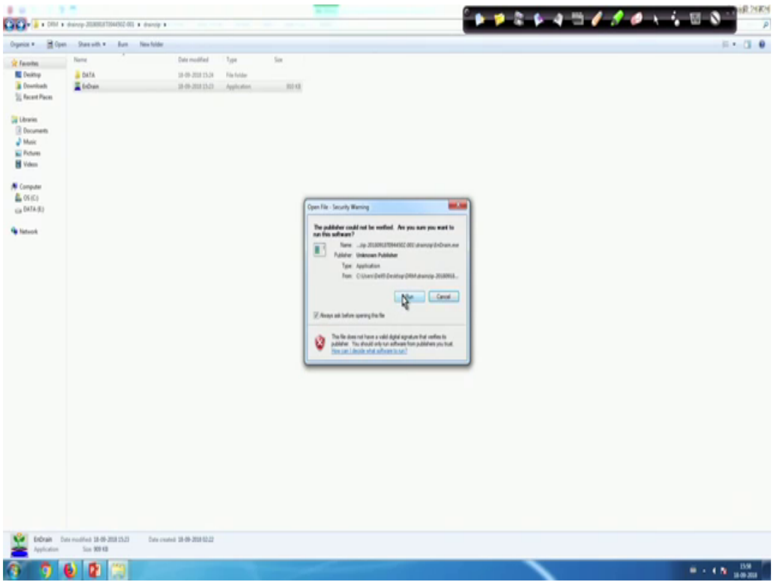

So, click on EnDrain and will ask us to run. So, run it.

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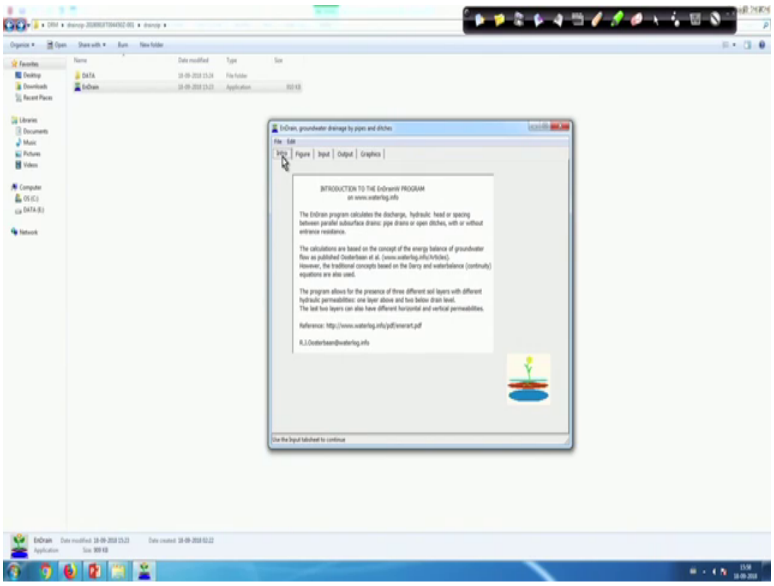

And look at the first window which starts with intro that is introduction. So, this a first tab sheet introduction to the EnDrain W program ok. So, EnDrain program calculates the discharge, hydraulic head or spacing between the parallel surface drains. It could be pipe drains or open ditches with or without entrance resistances ok. So, this is information and you can also go through the other links. So, that you get the articles, program and all relevant information.

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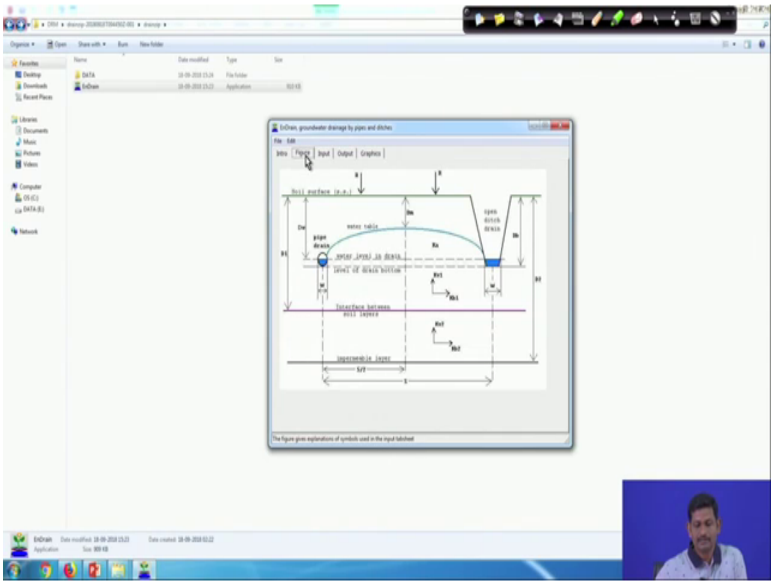

So, then the next is the figure. So, here if you see the figure, figure contains both tile drains and open ditch here and all the information related to inputs like terminologies we use for input purpose. So, D 1 D w all already explained.

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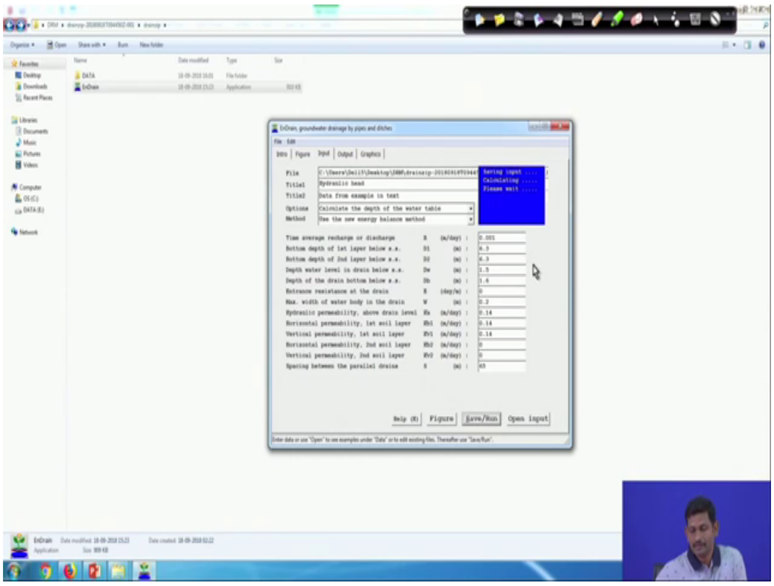

So, then input here. So, we click tab sheet input. So, here if you see help, figure, save and open input ok. So, I am going to get the input file which is already available in the data folder ok. So, you look at the data folder.

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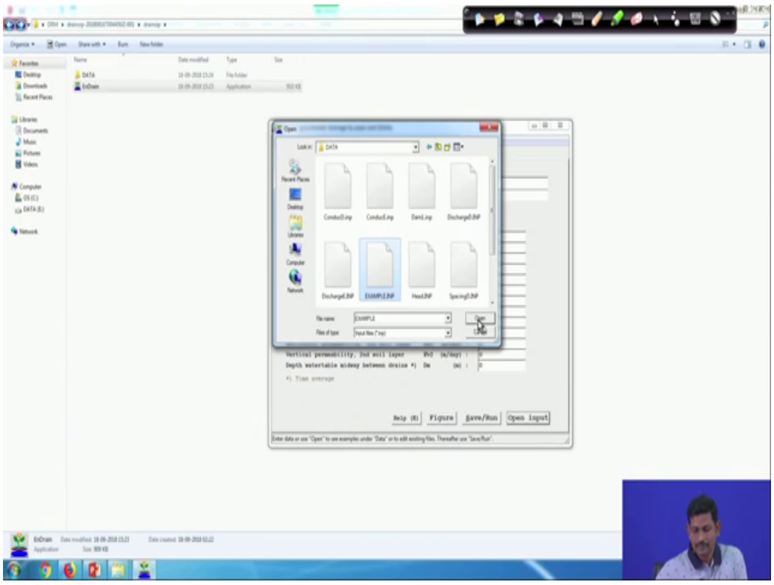

So, if I click open input so, and data folder. So, I will go for example, right I am going for example, which open ok. So, it will show the file where I extracted, a where I linked the data file and the title hydraulic head and data from example in the text. So, it is already available in the text book right and options calculate the depth of the water table. So, this is what we need to calculate and there are other options also available.

Drain spacing to be calculated, drain discharge is to be calculated and calculate the depth of the water table, calculate the hydraulic conductivity. So, there are four options or available you can choose any one of this. But in this example calculate the depth of the water table and here the methods, there are two methods right: one is used the new energy balance method and use the classical Darcy method. So, let us use the new energy balance method and then the input values are given R D 1 D 2 D w all are given here.

And, if you want to change you can change it, update it. And, since it is not for you know estimating the distance between the 2 drains, they have to give the distance between the 2 drain 65, because option is to calculate the depth of the water table. So, now next once you get the water table done I mean input data then save and run. So, save since let us save back to example, let us save and the file already exists over right ok. No problem, yes and then input data were saved, now it is going to you know run, it is running right now.

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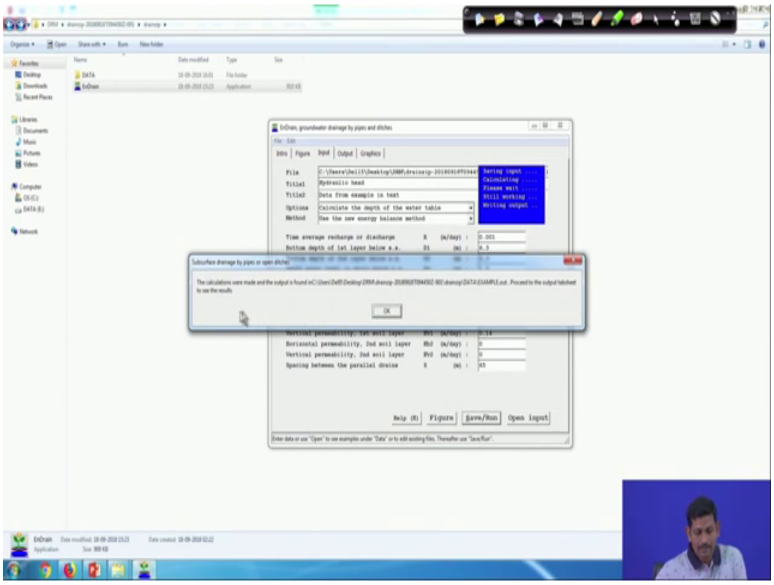

The calculations were made and the output is found.

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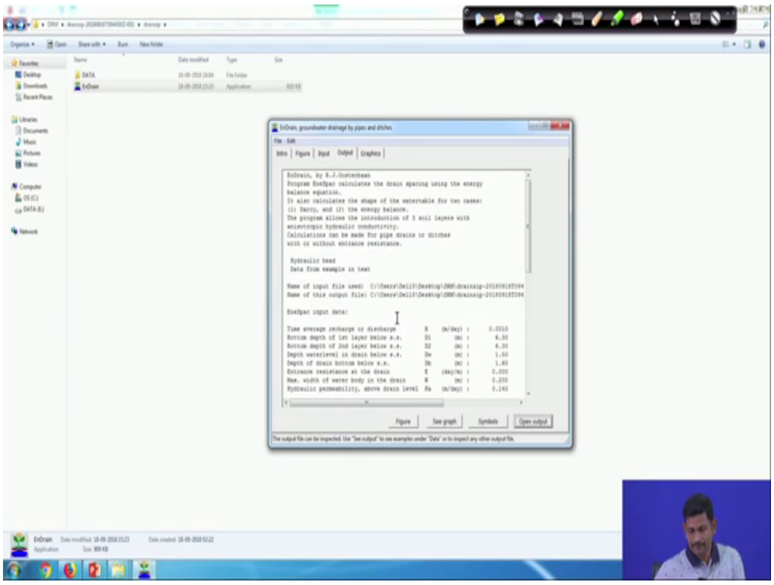

So, output also found. So, now this is output tab.

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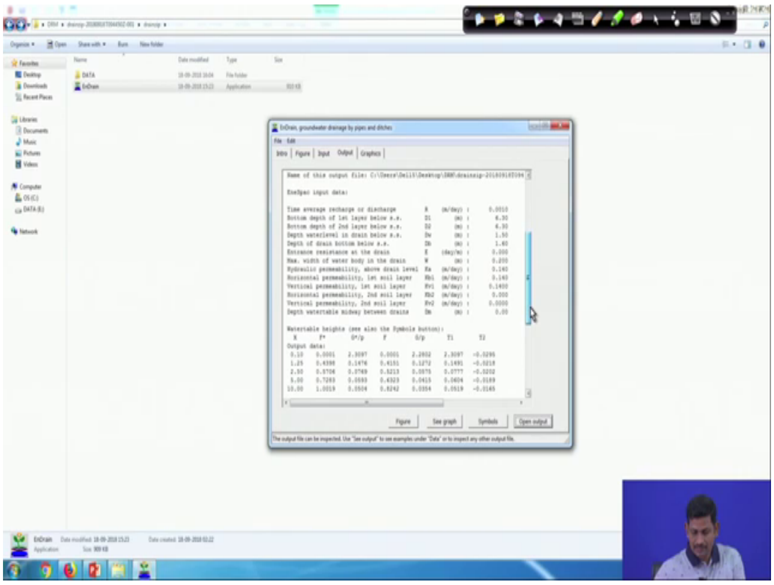

So, output has see this is it will give the input data right, from here to here this is all input data.

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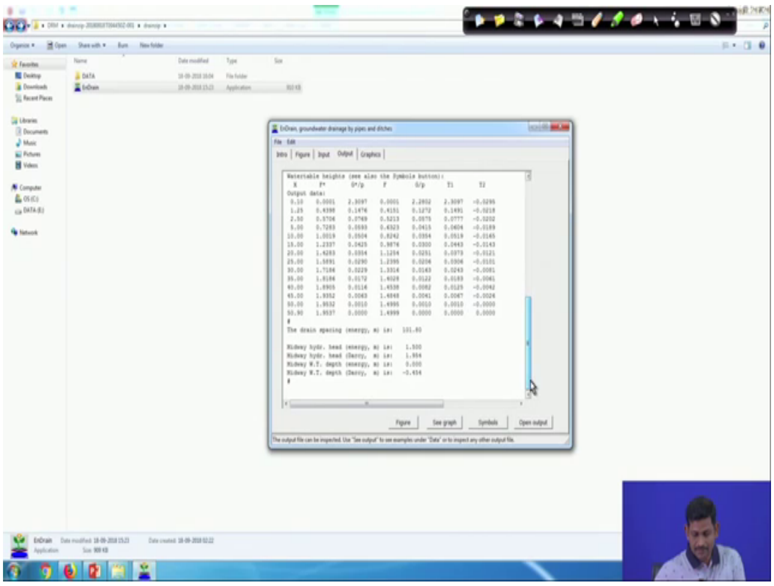

And then this is the output so, in this output you can see 0.10 to 32.50. So, this is midway between the 2 drains. And, this is F star is a Darcy's you know hydraulic head and this hydraulic gradient. And, F is the hydraulic head due to energy balance equation and capital G by p is the hydraulic gradient due to energy balance equation, these are the errors and something like that. And, the midway hydraulic head is 0.758, the midway hydraulic head Darcy's case 0.97 ok.

So, there is a difference right, there is a difference you can also check with the input the spacing between the drain 65 32.5 ok. So, here 32.5 it is good and this is what we what we have what we, I mean calculated this hydraulic heads and water tables ok. And, if you want to see the graph you can see the graph here or figure you can go and check the figure, the input values ok.

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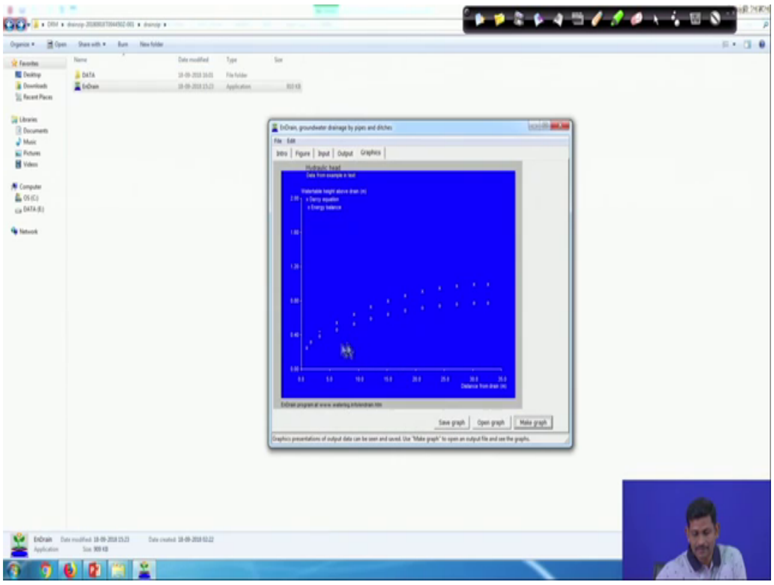

Or you can see the graph; we can also see both energy balance and Darcy's equation from distance from the drain here. And, this is you know hydraulic head on y axis.

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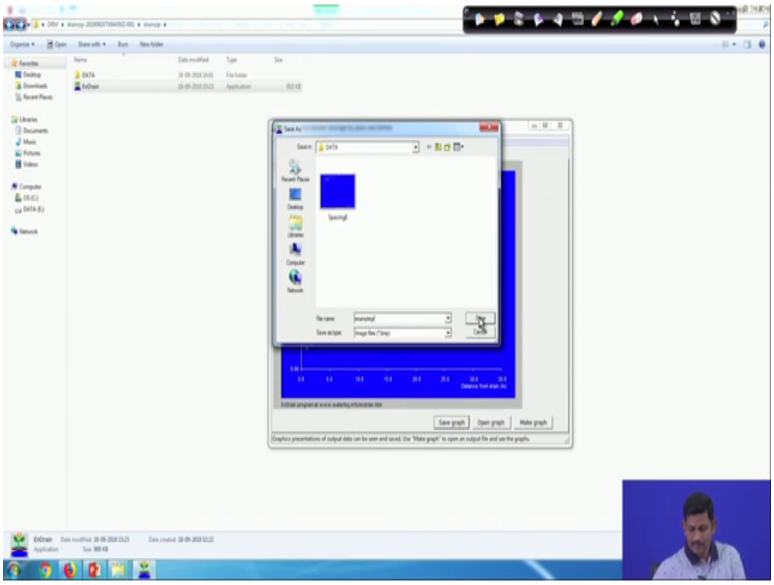

And you can save the graph, you can also save the graph here data and give you know the example right, example outs example graph something like that save. This go into save an example, you know the graph and back to output or you can go to input back and here let us change the options here. So, let us change the, calculate spacing between the drains. So, here depth the spacing between the drains you need not give now because, we have to find out. Now, again save and run let us say example spacing save, yes I would go to calculate ok.

Now, check so, this is the input we gave right and then look at this spacing. So, halfway 50.90 and drain spacing is 101.8, this is the double ok. And, midway hydraulic head is 1.5, midway hydraulic head Darcy's case 1.9 and the midway water table depth is 0 or it is very close to ok, very close to surface ok. So, this is you can see this is all based on your input value ok, based on that you can understand now whether the drainage system is efficient or not. Because, it is not at all taking the water because, the spacing is too long or a large; you know the 101 meter. So, that is the reason water table is not depleting in the midways.

So, this is very useful you know a tool to understand the drainage you know discharges, to calculate the drain spacing between the 2 drains. It could be both tile drain as well as open ditch system and also to understand the hydraulic heads right. So, a please go through the program and install it right. And, you can give the inputs randomly or there is a real life problem then you can design a drainage system ok. So, I think that is all.

Thank you so much.