**Irrigation and Drainage**
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**Lecture - 52**
**Surface Drainage System Design - 2**

Friends welcome to lecture number 52. So, in this we are going to learn these Surface Drainage System Design 2. So that means, in the previous lecture we were talking about hydrologic design. So, in this the hydraulic design of you know the surface ditches will be taught ok.

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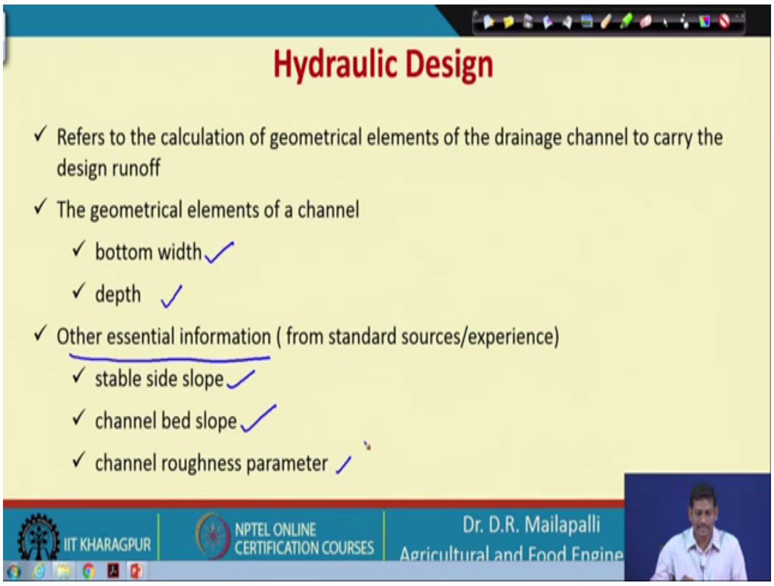


So, basically in this so what the hydraulic design means; so it basically refers to calculation of geometric elements of the drainage the mostly you know the width and depth you know and side slopes. So, all these design parameters we are going to estimate by knowing the maximum carrying capacity of the channel.

So, basically this geometric elements of the channel because open channel. So, this could be you know like a rectangular channels or it could be like a not trapezoidal channels or maybe parabolic channels was us you know semi-circular channels ok.

So, all these a different a shapes are available, but mostly will be focusing on these trapezoidal channels here. So, the design geometric parameters are bottom width and depth. And in addition to that we are going to you know estimate the other information such as a stable side slopes.

So, in order to you know avoid he collapsing of the wings, and the channel bed slope or in order to you know maintain the non-erosive a flow rate. And the channel roughness parameters like Manning's roughness coefficient. So, this is very important in order to avoid channels covering and you know having the enough scarring capacity of the channel ok.

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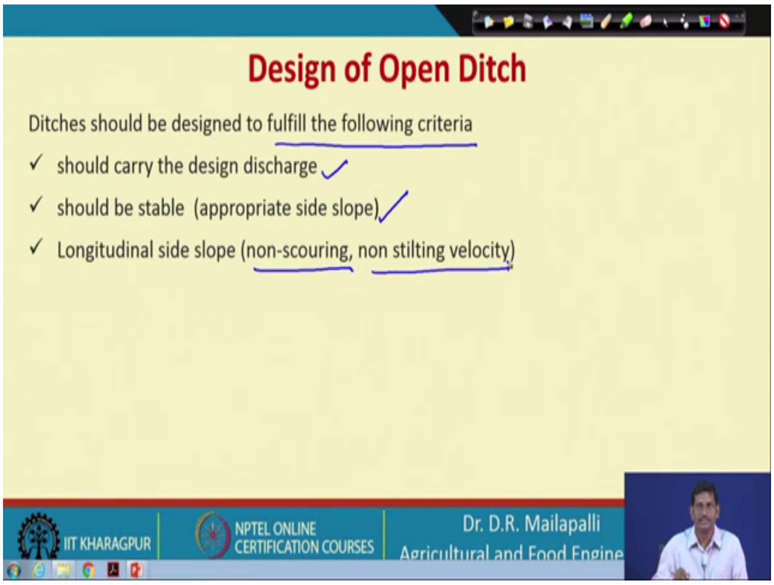


So the open ditch should designed to full fulfil the following criteria. The first one is should carry the design discharge so that is the I mean important parameter that is bare minimum. So, then should have stable side slopes and also longitudinal side slope for non-scouring the non-stilting velocity.

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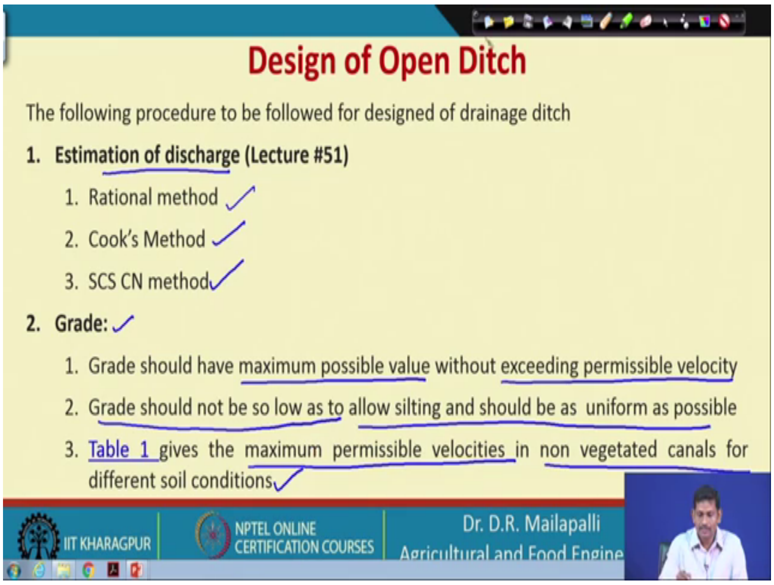


So, we are going to see the procedure how to estimate the design parameters in case of you know channel design.

So, the first step is to estimate the discharge. So, this design discharge is estimated in lecture number 51 using rational method, and cooks method, and SCS CN method. A count number method; so we can use any of these 3 methods to estimate the design or peak discharge from the particular you know watershed area and then the second step is to finalize the grade of the a channel. So, the grade should have a maximum possible value without exceeding the permissible velocity.

So, that is the things if you increase the grave what happens the velocity of flow increases and that will really scour the channels. And then the grade should not be you know so slow that means, so low.

So, what happens so siltation may occur because the flow is not having enough carrying capacity to take out the you know silt a from the channels. So, that will deposit in the channels, so if does not have any I mean at least the permissible velocity. And the table 1 gives the maximum permissible velocities in non-vegetated canal I mean; channels basically not canals, but the channels for different soil conditions if you look into the table 1. So, this will give the maximum permissible velocities for non vegetated channels ok. So, so let us see the table 1 so this is the table 1.

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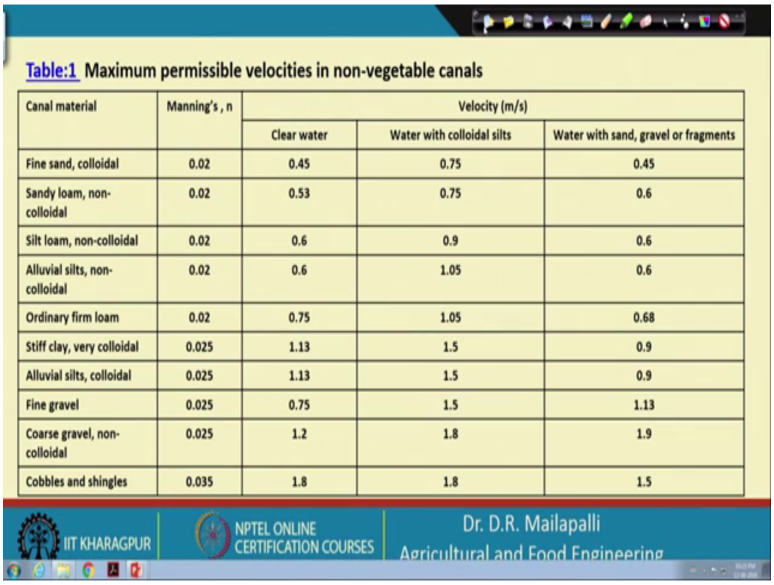


Table:1 Maximum permissible velocities in non-vegetable canals

| Canal material | Manning's, n | Velocity (m/s) | | |
|---|---|---|---|---|
| | | Clear water | Water with colloidal silts | Water with sand, gravel or fragments |
| Fine sand, colloidal | 0.02 | 0.45 | 0.75 | 0.45 |
| Sandy loam, non-colloidal | 0.02 | 0.53 | 0.75 | 0.6 |
| Silt loam, non-colloidal | 0.02 | 0.6 | 0.9 | 0.6 |
| Alluvial silts, non-colloidal | 0.02 | 0.6 | 1.05 | 0.6 |
| Ordinary firm loam | 0.02 | 0.75 | 1.05 | 0.68 |
| Stiff clay, very colloidal | 0.025 | 1.13 | 1.5 | 0.9 |
| Alluvial silts, colloidal | 0.025 | 1.13 | 1.5 | 0.9 |
| Fine gravel | 0.025 | 0.75 | 1.5 | 1.13 |
| Coarse gravel, non-colloidal | 0.025 | 1.2 | 1.8 | 1.9 |
| Cobbles and shingles | 0.035 | 1.8 | 1.8 | 1.5 |

So, it gives you know the first column gives the canal material let us say they fine sand or sandy loam, silt loam, alluvial silts. So, based on the different soil type and the Manning's n in second column and the velocities this is a permissible or maximum permissible velocities for clear water. So, without having the chlorides or the silt, and water with colloidal silts and with the sand gravel fragments.

So, this is a kind of heavier a particles if water contains then the maximum permissible velocities a goes like this ok, for a particular soil type right. So, with this table will be identifying the maximum permissible velocities by knowing the channel material.

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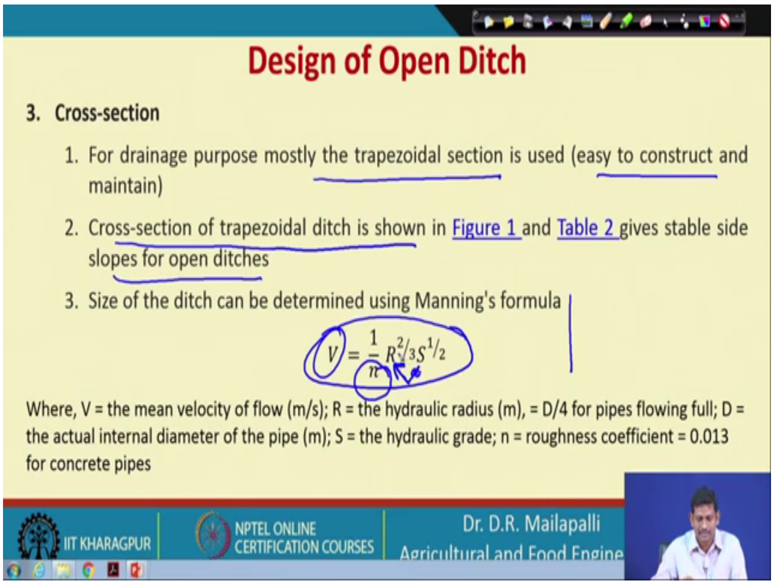


And the next is a; so, step number 3 so finding out the cross section area. So, for drainage purpose mostly the trapezoidal section is used because it is easy to construct and it can be maintained easily. And the cross section of trapezoidal ditch which is shown in figure 1 and figure 2, we are going to use in the next slide. Use the stable side slopes for open ditches ok.

So, and this size of the ditch can be determined using Manning's a formula. So, once we once we know the channel geometry or decided the channel a cross section, so, then will be using the Manning's equation V equal to 1 by n R power 2 by 3 S power half. By knowing the you know Manning's n and knowing the permissible velocity V, see unknown parameters which are plugged in R and R not S is known a name. So, unknown parameters like geometry parameters R will be estimated.

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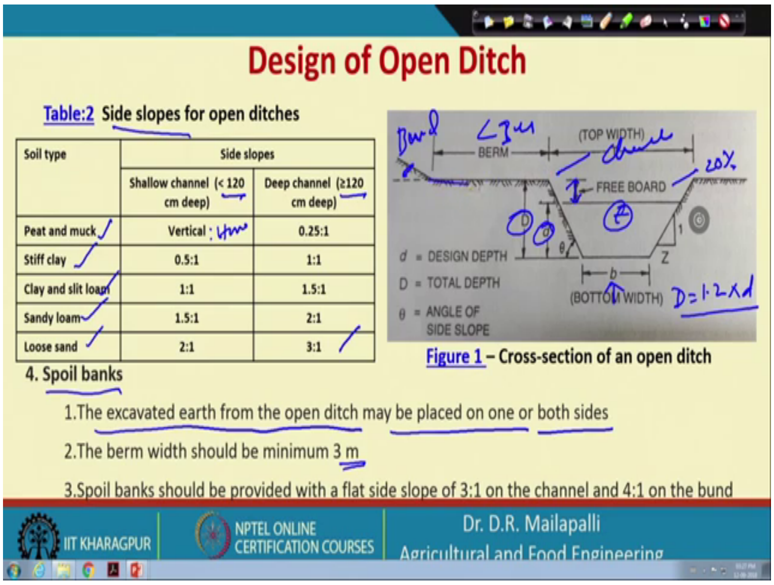


So, you see the table number 2 so in which so the side slopes are given the side slope for a particular channel. So, here the soil type if you deserve p 10 muck and stiff clay and clay and silt loam, sandy loam and loose sand; for all these in a soil type the shallow channel suppose you are planning for shallow channels that is less than 120 a centimetre deep is a deep channel so greater than or equal to 120 centimetre deep.

So, the vertical and horizontal vertical and a horizontal you know slopes are 0.1 is to 1 1 is to 1 1.1 is to 1 2 is to 1 for there is different soil types. Similarly, you can find the side slopes for deep channels.

So here this is the trapezoidal channel, so for trapezoidal channel it has a parameter b the bottom width and depth d ok. So, and then we need to increase a include a free board in order to accommodate if there is a silty siltation or other things ok. So, generally the free board can be up to 20 percent of d; I mean this is extra. So, that will be and once we put capital D, you can find out the top width according to you know the capital D. So, capital D which is equal to let us say if the maximum is 20 percent so that is a 1.2 times d.

So, knowing the capital d you can update you know the top width accordingly and there is a berm is also like a spoil banks. So, spoil banks are very important so this will help in you know help in controlling the you know collapsing the side slopes and other things. So, the excavated earth from the open ditch may be placed on one of on or both sides.

So, whatever the excavation you are taking. So, this will be kept in one side, and the berm which should be minimum 3 meter.

So, this is a at least a minimum 3 meter we expect the berm minimum width are showed. And spoil banks should be provided with flat side slopes are 3 is to 1 on channel side and 4 is to 1 on bund side. So, this is the bund right so this is the bund and then channel side.

So, this is a channel so this is a channel and this is a bund. So, the spoil banks so will be provided with flat side slopes of 3 is to 1 at this side, and then a little bit of I mean flat side slopes here. So, that will be 4 is to 1 on the bund side sorry channel side ok.

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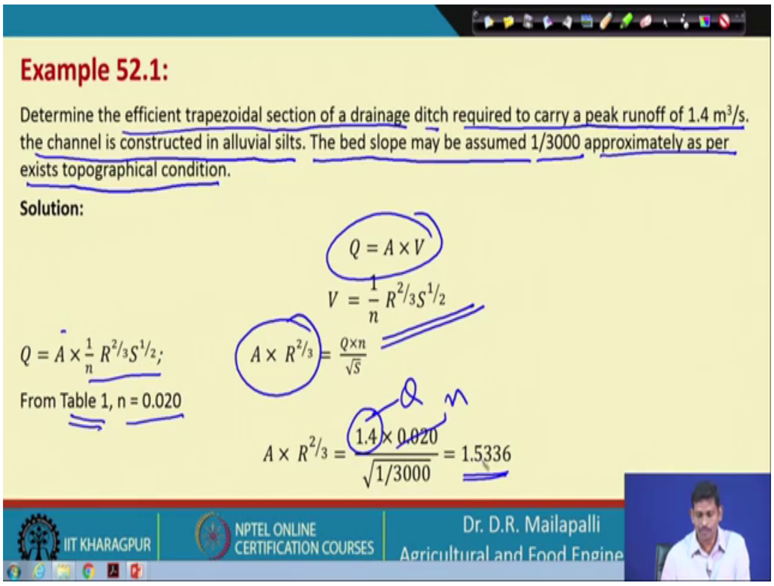


So, here is an example in determining these geometry parameters of trapezoidal channel. So, let us see determine the efficient trapezoidal section of drainage ditch, required to carry a peak runoff of 1.4 meter cube per second.

So, this number we got from a you know using any rational method or SCS Count number method or Cooks method. And then the channel is constructed in alluvial silt so, this from the table we can get a some information on maximum permissible velocity and also Manning’s n. So, the bed slope may be assumed a 1 by 3000, approximately as per exists topographical conditions existing topographical conditions.

So, the solution here is using continuity equation Q is equal A into V, where V is a Manning’s roughness.

Manning's roughness equation that is a one is equal 1 by n V is equal to 1 by n R power 2 by 3 into S for half. So, substituting in Q so A into V. So, then A into A R power 2 by 3 will be taken out and Qn by square root S.

So since so, this from table one from alluvial silt n is equal to 0.2. So, substituting the values like 1 this is Q and this is n and you get A R power 2 by 3 is 1.5336. So, we will carry forward that in the next slide.

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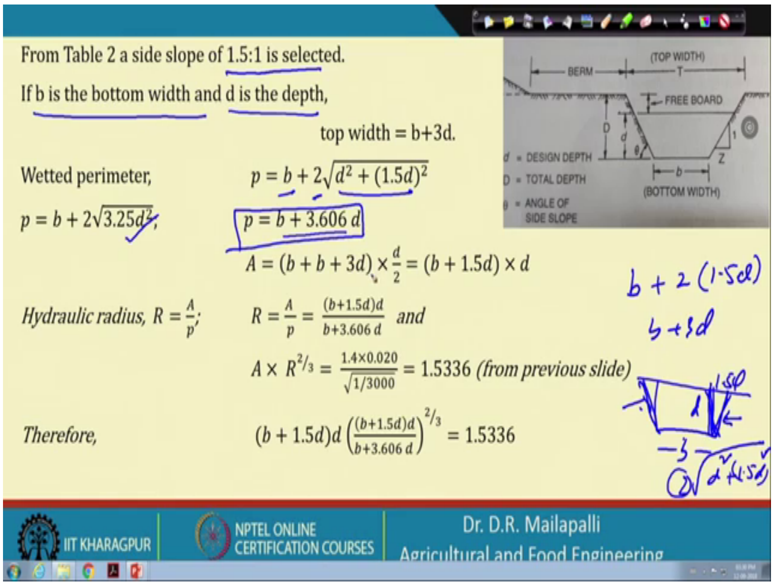


The remaining you know calculations from table 2 now, side slopes for I mean for these kind of salts alluvial soils is 1.5 is to 1. If b is the bottom width and d is the depth. So now, top width is equal to b plus 3 d because this is W1.5.

So, b plus 2 times 1.5 times d. So, that will be b plus 3 d and wetted perimeter p is equal to p plus. So, wetted perimeter so this is b right and then you have to find out the length of this shoulder. So, that will be so, this is 1.5 d and if this is d. So, this will be d square plus 1.5 d square and whole square.

So, that will gave; so, because again the 2 times including this side so this plus this plus this. So, there will be b plus 2 times of the you know side slope I mean slide length. So, that will be p in the substituting I mean solving simplifying this you get this, where I mean this equation. And then p is equal to b plus 3.606 d. So, this is a perimeter.

Now A is equal to so, this is trapezium trapezoidal equation. So, b plus b plus 3 d into d by 2 ok. So, this basically for trapezoidal channels.

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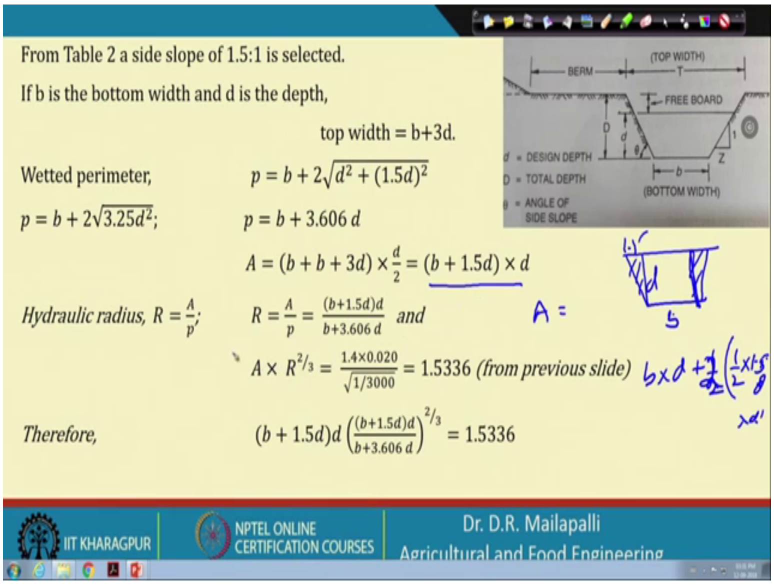


So, area of cross section for trapezoidal channels so will be So, this is one triangle another triangle and then this is b and this is d. So, so 2 triangles here n 1 you know rectangle; so, b into d plus f sorry 2 times f bd ok. So, this will be 1.5 d, 1.5 d into d right.

So, that will be b into d so that will be b plus 1 point 5 into d ok. So now, hydraulic radius R is equal to A by p. So, that will be R is equal to A by p so substitute for A. So, A you get from the previous sorry, from here you get and p so this is from p. So now, substituting A R power 2 by 3 which is equal to 1.4 into 0.02 divided by square root of so this is from the previous a slide. And then 1.5336 from previous slide you get and therefore, you can substitute this A R power 2 by 3.

So, that is substituting this A this is A and R power 2 by 3. So, this is A and R so this 1.5336.

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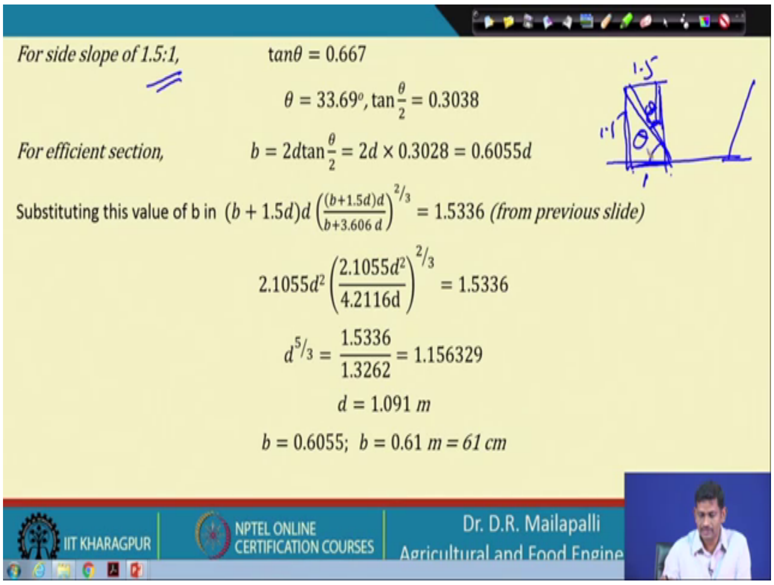


So, after simplification you can still keep it, but here for side slopes we know 1.5 is to 1. So, that is tan theta so tan theta in the sense. So, here this is the theta this is this is theta, and you have so this is this is a theta. So, vertical is 1.5 and horizontal is 1 so that will be tan theta will be 1 by 1 4 ok. So, this is the theta this is theta so 1.5 sorry this is theta so, just a minute.

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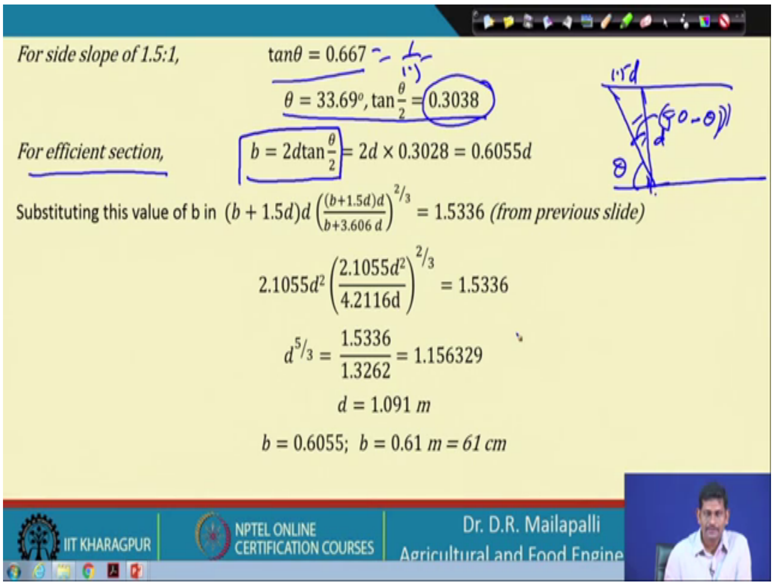


So, tan theta is equal 1 by 1.5 because so 1.5 is to 1. So, if this is the theta right and this 1 is a. So, this is d and this is a 1.5 d this is 1.5 d and this one is 90 minus theta right 90 minus theta. So now, we can estimate you know tan 90 minus cot theta and then estimate the theta when this is the slope ok, this is the slope.

And theta will be now a tan theta by 2 will be 0.3038. So, for efficient section so this b is equal to 2 d tan theta by 2 is the efficient, you know efficient is not most economical channel I mean trapezoidal channel equations. So, we discussed this in the previous lectures, when we were talking about you know the most economical channel depth and width relationship. So, that is 2 d into tan theta by 2.3028.

So, that will be 0.6055 d and substituting this value in b ok. So, b is a value of b in this equation so, this equation we that is A R power 2 by 3. So, from the previous slide so now, if you can substitute a b value then finally, d will lead to d equal to 1.091. And now b is equal to 0.6055 and that will be let us say 61 centimetre.

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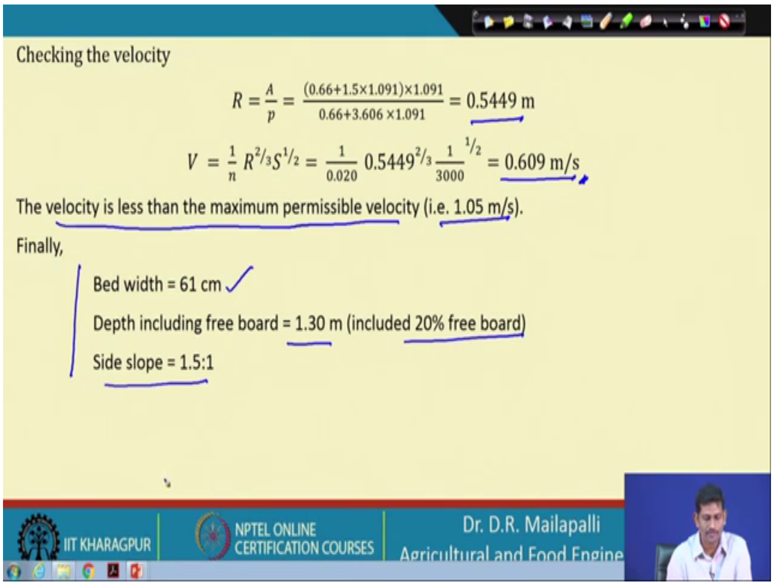


And then now we checking the velocity R is equal to A by p. So, this will be R value and V equal to 1 by n R power 2 by 3. So, substituting they given or estimated values we get 0.609 meter per second. And if you go back to the tables right I mean table number one you see 1.05 meter per second is the maximum permissible velocities. So, this velocity is less than this so within the permissible velocity. And finally, the geometric parameters for the trapezoidal channel or breadth width is 61 centimetre and depth is 1.3 meter.

So, that including 20 percent of free board and side slopes 1.5 east 1 ok. So, this way will be designing the parameters for a cross section trapezoidal cross section.

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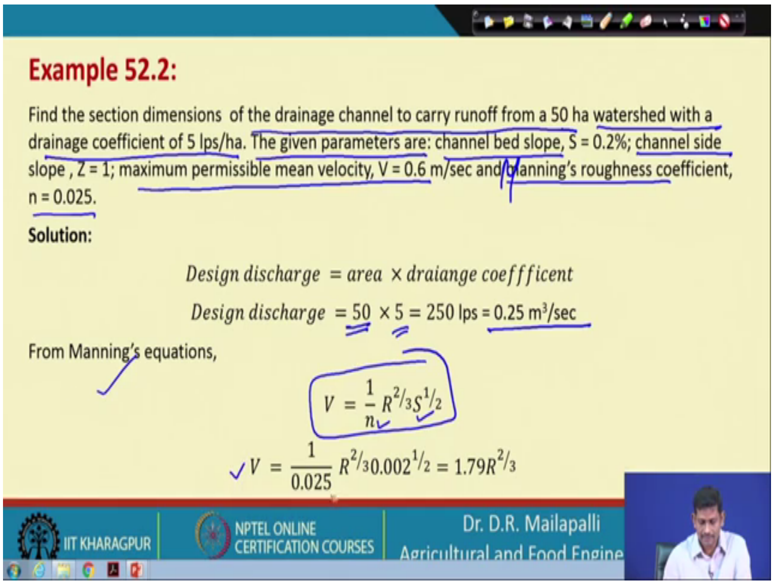


So now the another example so find the section dimensions of the drainage channel to carry run off of 50-hectare watershed with a drainage coefficient of 5 litre per second per hectare. So, each a one hectare land will lead to one 5 litre per second runoff. The given parameters are channel bed slope is given as point 2 percent channel side slope, Z equal 1; maximum permissible velocity 0.6 meter per second and Manning's a roughness coefficient, that is a n equal to 0.025.

So, the design discharge area into drainage coefficient. So, that will be 50 hectares and 5 litre per second per hectare. So, that will give 0.25-meter cube per second. Now from Manning's equation so this is a Manning's equation, and so substituting the given values like n S value, and also there is a V is given. So, substituting except R substituting the values so V equal to 1.7 and R power 2 by 3.

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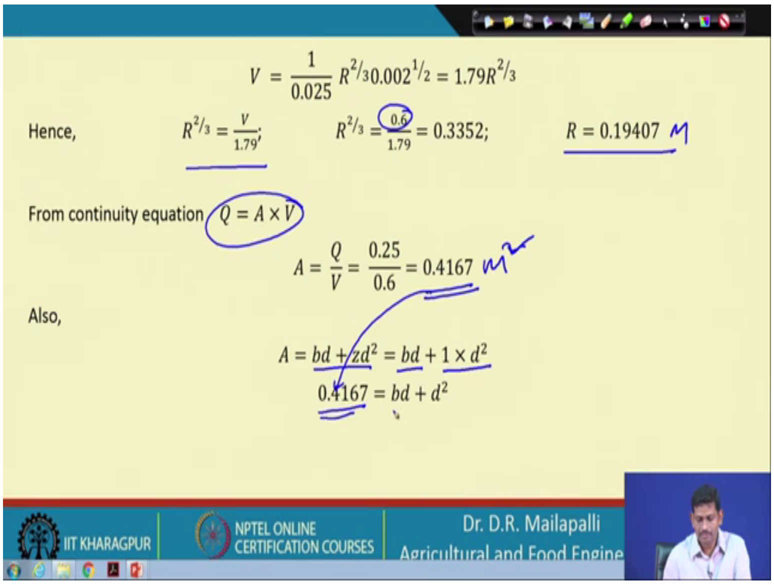


So, that will be so, this is the V and now R power 2 by 3 will be V by 1.79 substituting V value you get R is equal to 0.19407 these in meters from continuity equation Q equal to A into V.

So, where A equal Q by V and you get this is a Q A is in meter square. So, also A so bd into zd square, this is a area of cross section for trapezoidal channel, or b into d into z equal 1 d square and now area from here and b d plus d square.

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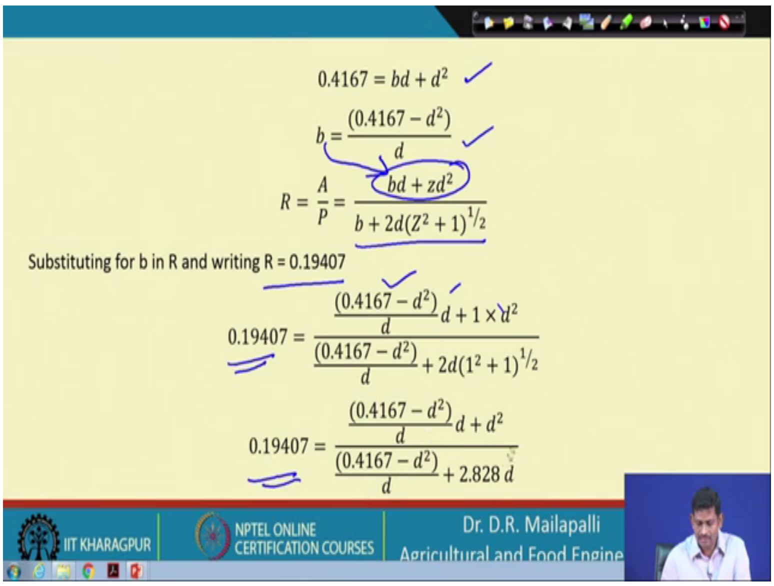

Now so this is a the previous equation b d plus d square equal 0.4167. Now, b is equal to this much and R since R is equal to A by p, so A equation and p equation.

So now, substituting b in R and now R equal to 0.19407 this is we estimated previously and substituting the values which are known for example, like b, b value substitute the b value in this equation ok. So, that you get the b this is b value and d plus 1 by d square plus and like that, now again simplified little bit.

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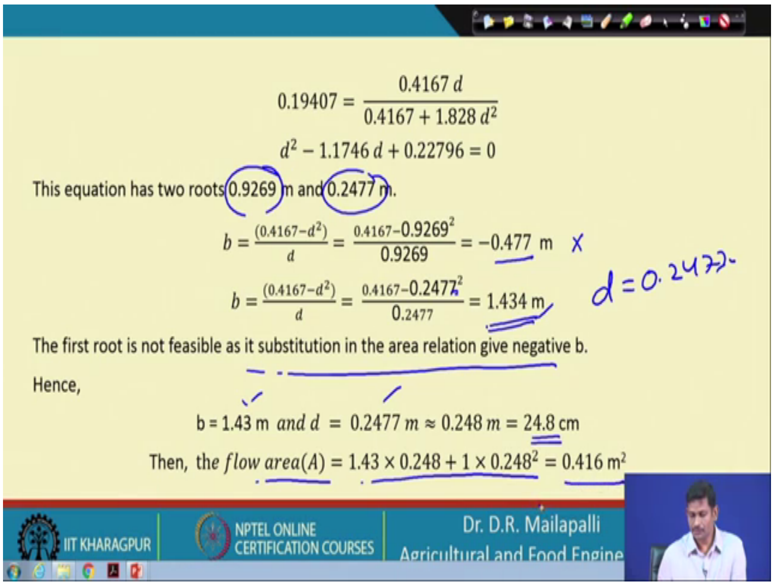


So, after simplification so you get the quadratic equation in d d square minus 1.1746 d plus 0.22796 is equal to 0. So, it has 2 roots so 1 is a minus 4 minus 0.477 and 1.434 this positive and negative. So, so since it has 2 roots, so sorry it has 2 roots there is a 0.9269 and 0.2477. So, substituting the one root into this.

So, that will be and you will get b is equal to so d has 2 roots ok. So, d has sorry, so d has 2 roots here so one is a sorry. So, substituting you know d is equal to equation so substituting d is equal to 0.9269. So, you get minus 0.477 substituting 0.2477 here you get 1.434. So, since it is negative so the root I mean d is equal to 0.92 is not the correct one. So, we have to take d is equal to 0.2477 because giving the positive value.

So, the first root is not feasible so and now b equal to 1.43 and d equal to 0.477 meters that will be 24.8 centimetre. So, and then the flow area so that is 1.43 into so substituting the equation so 0.416 meter square.

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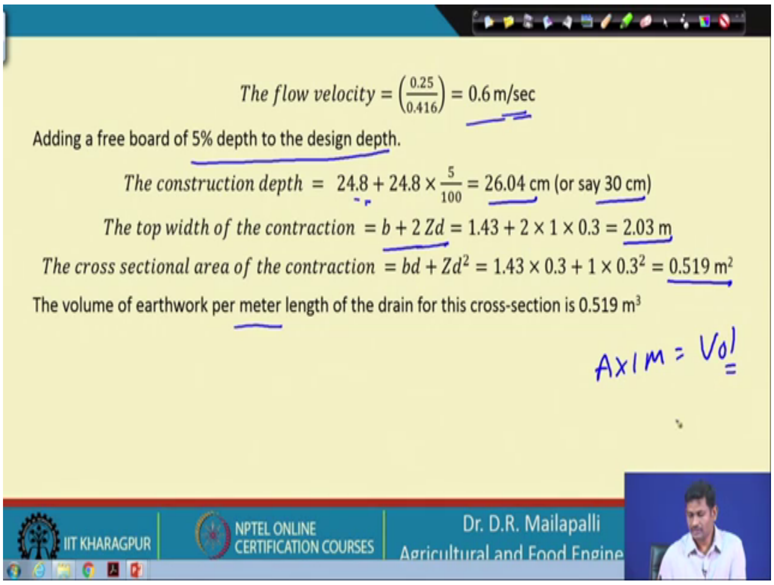


So now we got the flow velocity that is equal to the flow velocity Q by A. So, there is a 0.6 meter per second, adding free board 5 percent depth to the design.

So, since the depth is 24.8 so into multiplied by 5 by 100 you get 26.04 centimetre or say 30 centimetre. Now top width b plus 2 into z d; so that will be 2.03 and the cross sectional area bd zd square. So, this much so now volume of earthwork per meter of length so the drainage will be. So, area multiplied by 1 meter so that this is the volume of earth work I mean that will be 0.519-meter cube.

So, this way you can a estimate the geometric parameters of the trapezoidal cross sections or ditch ok. So, in this the main design so from hydrologic designs will be knowing the Q value. So, in hydraulic design so knowing the Q value, you have to assume so mostly the trapezoidal channels will be used for designing the drainage ditches. So, knowing the Q and permissible velocity and based on the you know based on the soil type. So, and the corresponding roughness coefficients in table number 1.

So, you will be estimating the channel dimensions ok. So, then if the slope is you know not given you have to assume or you have to a takes you know slope for a particular you know soil type from table number 2.

So, using this information you will be able to estimate the channel dimensions like breadth and depth, and also the top width if you can a put maximum you know 20 percent as a free board to avoid any siltation a in the channels. So, with these I think we finished both hydraulic and hydrologic design in case of surface or drainage systems so.

Thank you.