Advanced Hydraulics
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Module - 2
Uniform Flows
Lecture - 8
Design of Erodible Channels

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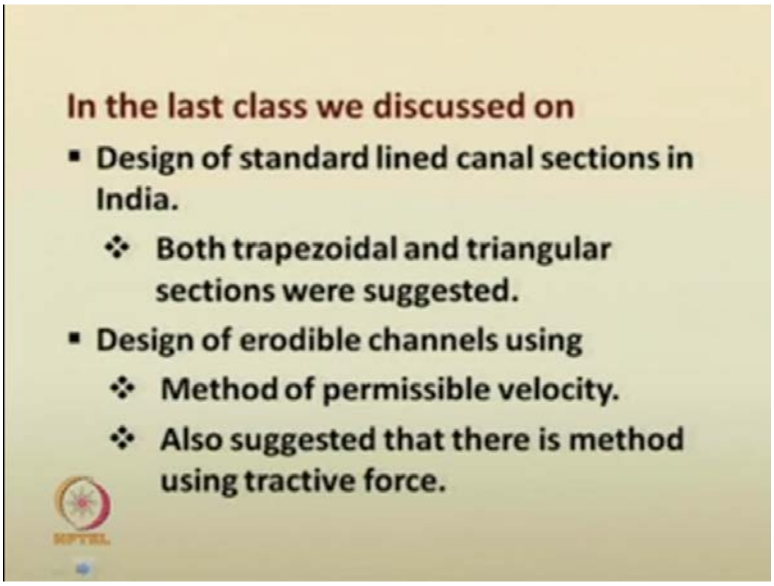

Welcome back to our lecture series on Advanced Hydraulics. So, we are in last few classes dealing with the module 2 on uniform flows. In the last class, we discussed on the design of standard lined canal sections in India, both the trapezoidal and triangular sections, how it has to be designed were suggested? We also briefly started the design procedure of erodible channels. We introduced you the concept of method of permissible velocity. We also suggested that there is a method called method of tractive force to design the erodible channels.

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So, in this lecture, we will continue on the same topic that is design of channels for uniform flows. So, we will continue the design of erodible channels.

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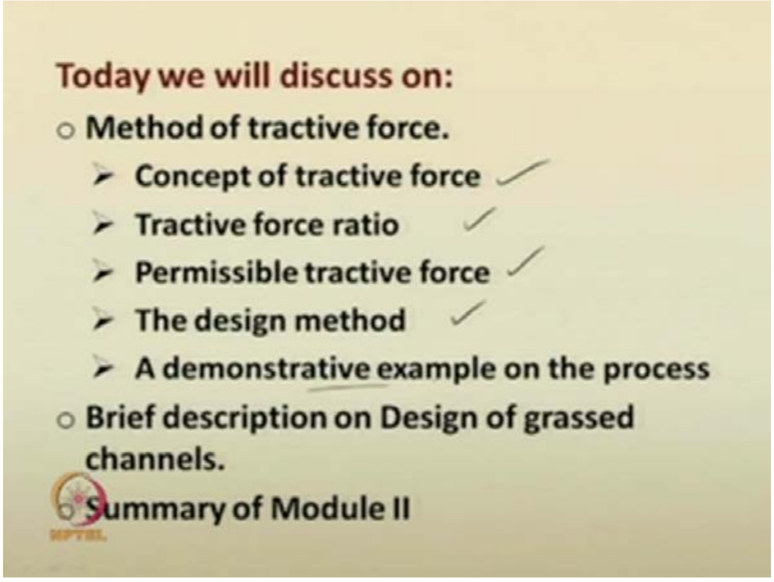

So, in the design of erodible channels we are going to discuss on the method of tractive force. We will introduce you the concept of tractive force, what is meant by tractive force ratio? We will also discuss on permissible tractive force, the design method using the method of tractive force for designing channels in uniform flow. We will also give a demonstrative example on the process. We will also briefly describe how to design a grassed channel? We may not give an elaborate design description and all, but just briefly a conceptual view. Then finally, we will summarise our module 2 as we are going to conclude the module 2 today.

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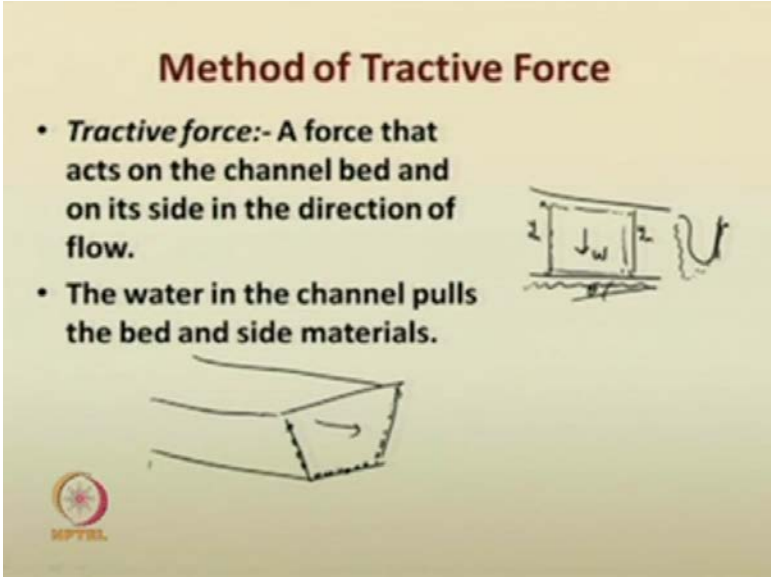

So, let us start with the method of tractive force, what is meant by tractive force? If you see that if you just take the channel, if you take the channel section. So, this in this section or in this stretch of the channel, you will see that the wetted perimeter that is the channel bed having the wetted perimeter at any section that the wetted perimeters, they will be encountering some sort of force on its particles, on the particles that is occupying the channel bed and channel side slopes and all. They will be encountering some sort of force due to the water in the channel. So, the water will be exerting some sort of force on these materials in the direction of flow. Suppose, if the flow of water is in this direction. So, the particles along this side slopes as well as on the beds, they are felt by a force from the water in the channel from the water in the channel some sort of force is being felt by them in the direction of flow.

So, if this force if it is too much you can just imagine these particles start coming out from the bed as well as from the sides so that is called this force is called tractive force. So, a force that acts on the channel bed and on its side in the direction of flow. The water in the channel pulls the bed and the side materials in the direction of flow that is the property of the tractive force. So, we are dealing with uniform flows. So, if you just take the stretch of this thing, you are having the normal depth between 2 stretches uniform flow means all the properties will be uniform. So, it will be having a bed slope theta, you can imagine a theta; you can just consider any arbitrary cross section need not be trapezoidal or a prismatic cross, need not be a regular cross section like trapezoid rectangular triangular and all. Even any para shape if it is prismatic throughout the stretch that can have a uniform flow. And you can just consider the depth between 2 reaches.

So, you can easily recall that from this entire portion as we had studied earlier from this entire portion. You can consider as a control volume and the weight of water enclosed by that volume, it will be acting vertically downwards, you can call it w if you wish. So, that based on that weight now these component of the weight that we will try to remove the particles on the bottom of the bed as well as on the sides of the channel. That is the quantity that you have to determine, how much is the tractive force and all?

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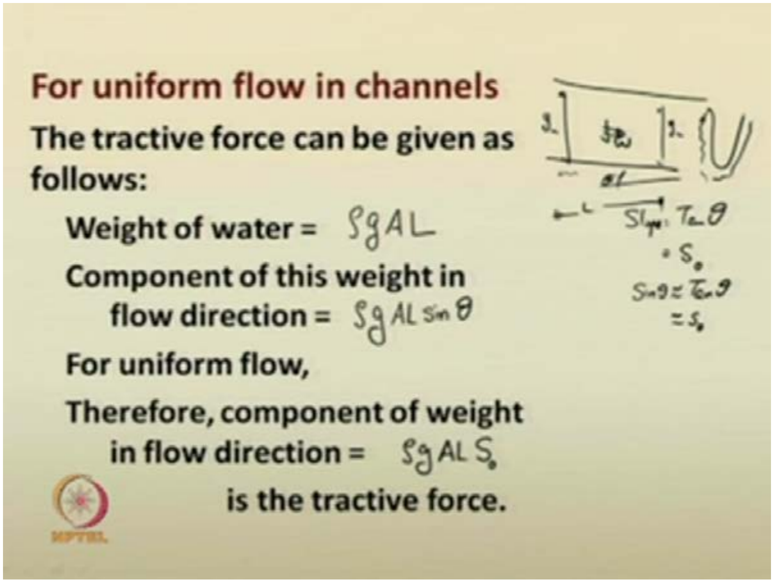

So, as we mentioned so the weight of water again for your convenience I am just drawing it. So, if the channels is having a slope, slope this is equal to tan theta. So, that slope of the channel it can be a given as the bed slope S 0 then the weight w is acting here and the weight of the water. Now, if this length if this length is L, then you know that this is nothing but density into acceleration due to gravity into area of cross section whichever area of cross section you are dealing with into L. So, this is the weight of water w.

Now, the component of this weight in the flow direction; what is the component of this weight in the flow direction? So, this till the flow direction is like this. So, there will be a component of this weight in this flow direction. So, you have to determine that so what is that quantity now? It is nothing but rho g A L sin theta. For uniform flow as we are dealing with uniform flow and all we have long time onwards suggested that the theta or the slope whichever is being considering this theta this angle theta it is too small means it is a small quantity So, you can approximate sin theta with tan theta there by you can suggest this as your bed slope S 0.

So, your component of weight in the flow direction therefore, I can write it as now rho g A L S 0. Now, this is the quantity that is that will be the tractive force for the bed materials in the channel.

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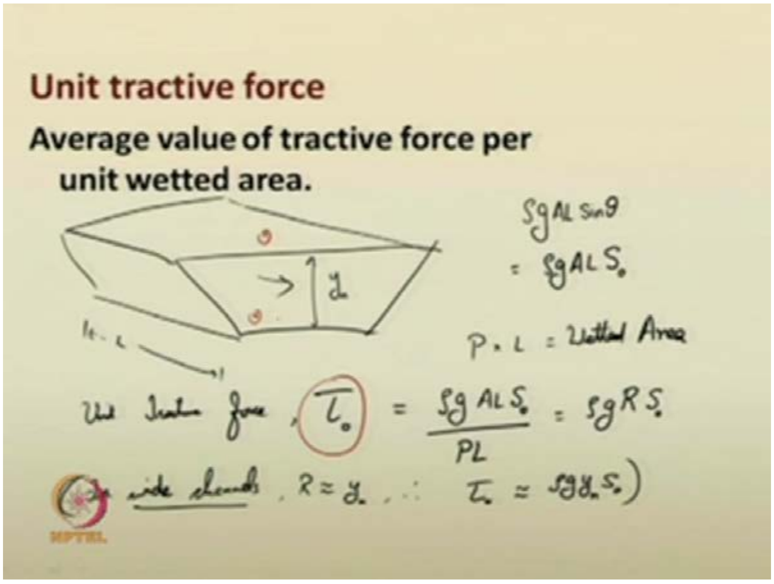

So, we consider define certain terms now. Quantity called unit tractive force can be defined first. So, what is meant by unit tractive force? It is the average value of the tractive force per unit wetted area you have say the cross section of the channel if it is of this shape. You can suggest now and if it is the reach of the channel is like this, the reach of the channel if it is like this. The section cross section area is A however, but for any bed material the tractive force in this thing as we suggested earlier. The tractive force is rho g A L sin theta is equal to rho g for uniform flow A L S naught this was described earlier. The same tractive force that is acting on the wetted area of the entire reach, this reach is of length L it is having a normal depth y n. So, what is the wetted area for this entire reach? That you can easily understand that your wetted perimeter for this cross section is P, and you just multiply by the length L this will give you your wetted area for the reach. So, the average value of tractive force per per unit wetted area that is called unit tractive force.

So I can define unit tractive force now in a symbolic way tau 0 this is equal to, very simple this thing simple arithmetic’s you know what is meant by A by P? So, you can write this as rho g R S naught for a simple situation, please note that just here only I am mentioning for wide channels. This is not a general situation for wide channels you know R is approximately same as y n. Therefore, your tau 0 will become approximately equal to rho g y n S naught only for wide channels.

We can all now introduce to now another concept called tractive force ratio, what is meant by tractive force ratio? So, before going into that thing, again you can see deal with the same channel. Let me change the colour of the ink so that it will be visualised. You just take any so there are as we mentioned the unit tractive force is given by the simple tau’s 0. Similarly, you just consider any particle either on the slide slope or on the bed of the channel, you just consider any particle. So, there will be unit tractive force on the slide slopes as well as unit tractive force on the bed. You can independently define that quantity also just consider a particle on the slide slope.

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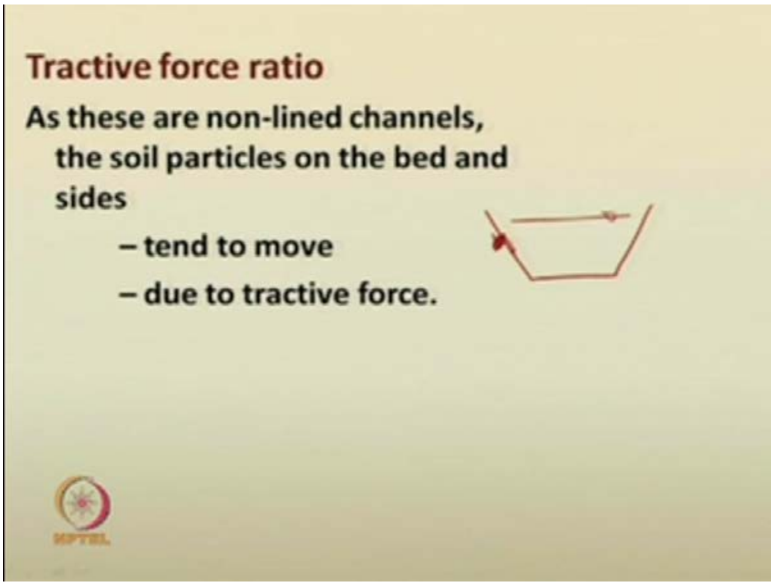

If I just draw the cross section like this. So, any particle on the side slope so this particle here it has means it, it can move or it can get eroded from its location due to 2 reasons. That is the tractive force from the water that is flowing on the channel as well as its own gravity, its own gravity say this particle if it is of a so and so diameter it has a component along the slide slope of the channel. So, if that component is worthwhile means, if it is sufficient there is a tendency for this particle to roll down through the side slope.

And of course, if there is the tractive force from the water held in the means, water in the channel that will also cause movement of this particle from the. So, the bed materials can move due to tractive force as well as the force component of the force that causes component of the gravity force of the particle that can cause the sliding of the particle along the side slopes. So, I will just explain it again.

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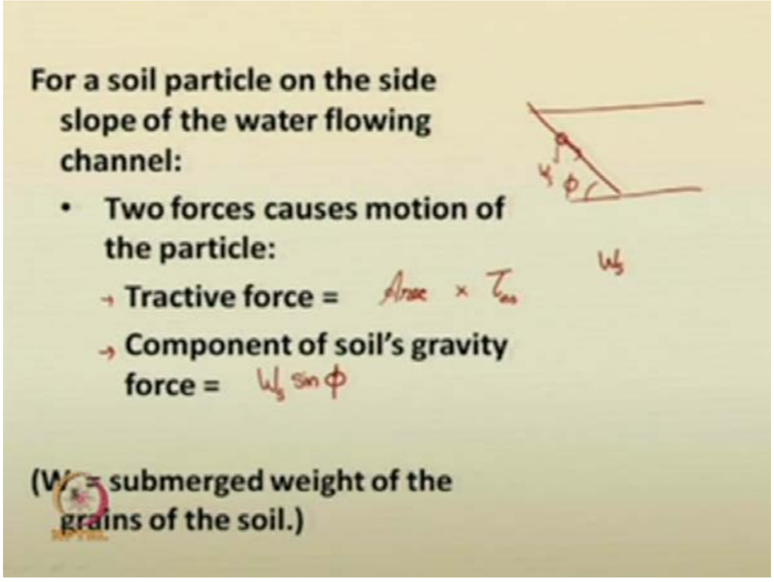

So, for a soil particle on the side slope of the water flowing channel two forces causes motion of the particle that is the tractive force. So, tractive force, how can I write it? It is nothing but the area where the tractive force is there into the quantity tractive force.

So, earlier we gave it as tau 0. Now I am adding another subscript s here to suggest that this tractive force is for the side slope material in a side slope the component of the soils. Next one is the component of the soils gravity force, say if the if you are material here if it is having a certain diameter, certain quantity. There will be certain weight of this thing submerged weight usually it is the submerged, because it is submerged under water in water. So, this particle will be having a submerged way W s, you know the side slope if it is given by an angle phi that is this ratio 1 is to b, if it is equal to tan phi. So, that phi this angle, if it is phi then you can definitely find the component in this direction of this weight. So, this weight is W s vertically down. So, we can easily suggest that. So, the component of the soils gravity force in this direction that I can is write now as W s submerged weight W s into the component is in this direction so sin phi.

So, if this component where W s is given as the submerged weight of the grains of the soil, if you can determine it based on the grain particle, grain density, grain, grain diameter and all. 1 can easily determine that submerged reach. You can now evaluate the component that can cause the sliding of that particle along the slope.

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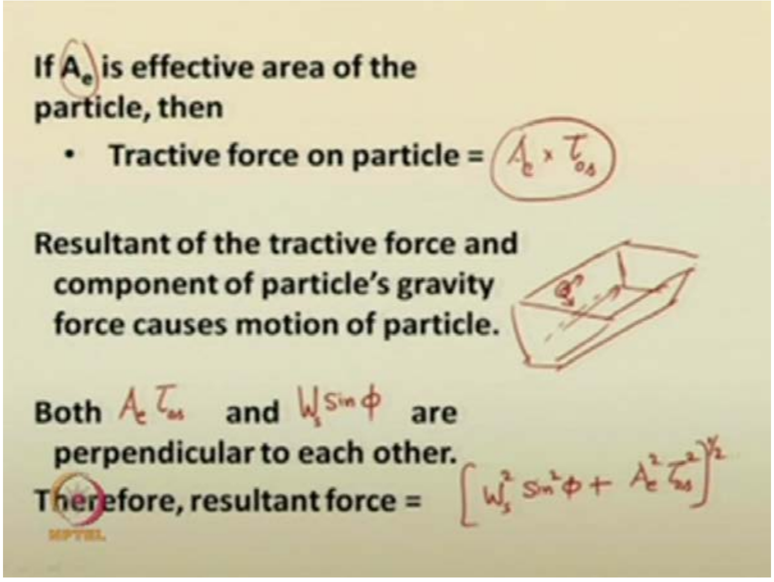

So, if A is the effective area of the particle. Let us suggest that the effective area of the particle is A e. Then the tractive force on the particle we can give it as the tractive force will be nothing but the effective area of the particle into the unit tractive force on the slide slopes. So, these two as we mentioned that the component of soils gravity force W s sin phi that will also be acting on the particle as well as the tractive force will also be acting on particle A e tau 0 s. So, 1 can easily visualise that suppose if I just draw the... So, in this thing, in this channel this is the allocation for side slope here if water is flowing in this direction then there is the tractive force A e into tau 0 s acting in this direction along the that is along the direction of the flow. And there is a component of the gravity force of that material along the bed slope.

So, both these forces are actually 90 degrees to each other. You can easily identify a resultant force of these two that can cause the movement of the particle from its present location. So, that we can easily suggest now so both A e into tau 0 s and W s sin phi they both are perpendicular, you can find the resultant force. So, the resultant force will be nothing but W s, W s square sin square phi plus A e square tau 0 square the whole quantity’s square root. So, this will be the resultant force. So, you can employ this thing as the resultant force that can cause the movement of the particle.

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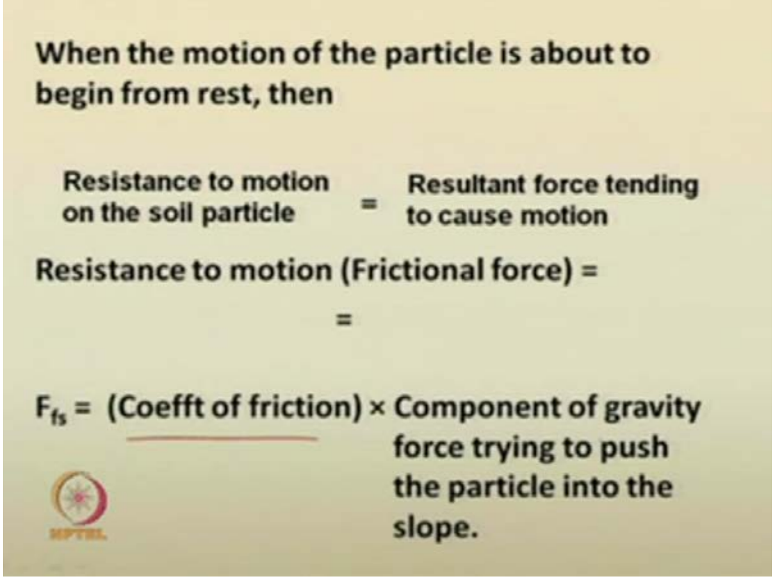

So, when the motion of the particle is about to begin from the rest. It is the simple mechanics principle when the motion of the particle is about to begin from rest. Then the resistance to motion on the soil particle is same as the resultant force tending to cause the motion.

So, the resistance to motion or the frictional force, how it is given? You can easily suggest that we, we already know that frictional force is nothing but the coefficient of friction into the component of the gravity force trying to push the particle into the slope. So, how can you identify this frictional force?

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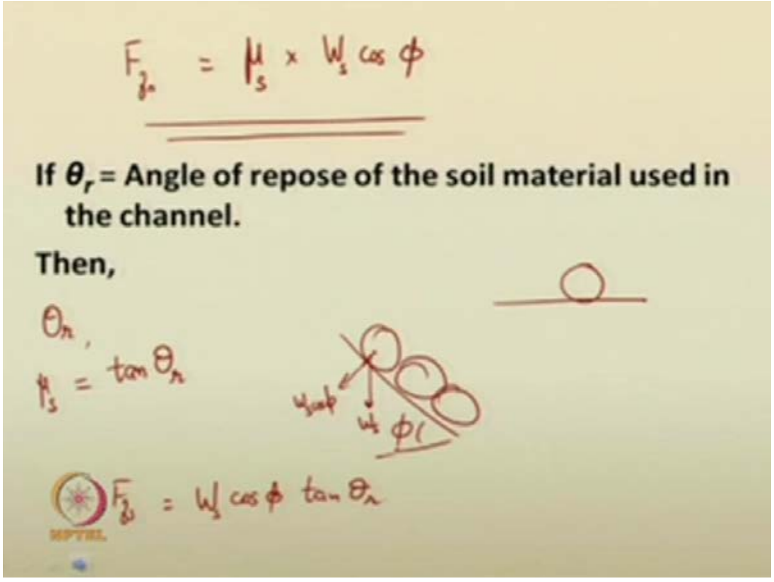

If theta r is the angle of repose of the soil material so please note that I am talking about the material, you take any soil material along the bed or see even say inclined. So, if there are various material soil materials and all. So, the angle of repose is a soil property. For different soil, you will be finding different type of different soil and different type of packing depends on different type of packing you will be having angle different angle of repose. So, from the principles of mechanics and all it has been identified that if you are writing the frictional force as some coefficient of friction into component of gravity force. So, now you know the gravity force of the particle the component, this is phi may I beg pardon.

So, this is angle phi so this component is, is in this direction. This is the actual submerged weight of the particle W s. So, this component can be given as W s cos phi. So, this can be given in the following form F friction force is equal to coefficient of friction into W s cos phi. The angle of repose can be given as the coefficient of friction in many of the cases, in many of the cases it has been identified as the coefficient of friction is same as the angle of repose of their material. So, based on the type of material used and all you can suggest that. So, if theta r is the angle of repose as suggested your mu s is approximately equal to tan of theta r then I can suggest your frictional force is equal to now. So, frictional force is equal to W s cos phi into tan theta r. So, if you can find that now.

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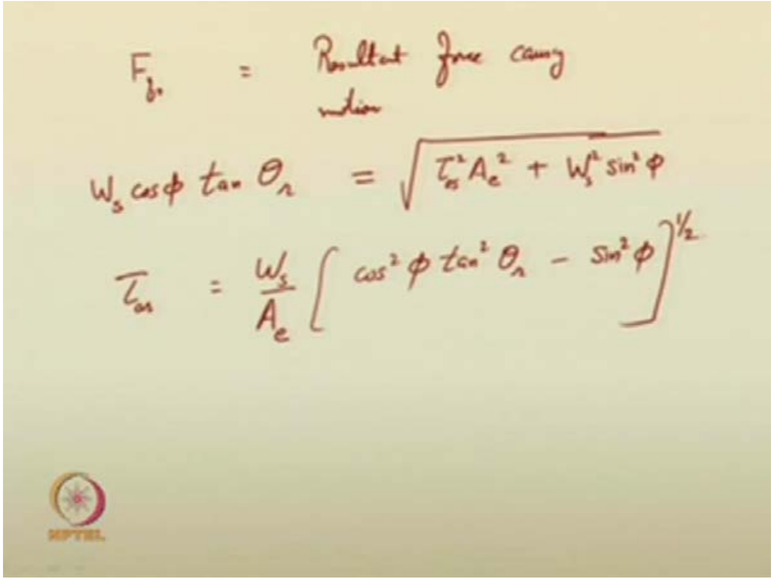

This frictional force is equal to resultant force causing motion. So, you have now W s cos phi tan theta r, this is nothing but equal to your resultant force causing motion, what is that? tau 0 s a square plus W s square sin square phi, rearrange the terms here if you rearrange the terms all the terms you will get tau 0 s that is the unit tractive force on the slide slope. This will be equal to W s by A e into cos square phi tan square theta r minus sin square phi this quantity has to be square rooted. So, this will be the expression for the unit tractive force on the side slopes.

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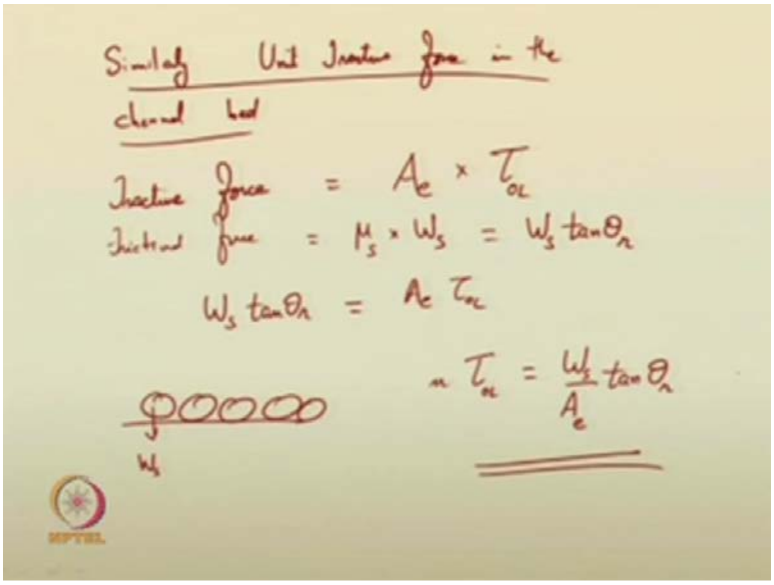

Now, in a similar way, you can also think of unit tractive force in the channel bed not on the side slopes in the channel bed. You can similarly, think on that sort of now. So, what could be the tractive force? Again the tractive force will be so the unit tractive. So, the tractive force on the particle in the bed, say if this is the channel bed now there will be soil material particles of initiate. So, the tractive force acting will be the effective area of the particle into the unit tractive force in the longitudinal direction or on the channel bed. So, that I can give it in the following form, what is this quantity now? You know the on the channel bed the submerged weight W s will be directly acting downwards and all of them can cause now, that is all of them there is no means, there is no component of the weight that may tend to move the particle is it not? There is no component of those things that can cause the movement of particle.

So, you can now write this quantity tractive force is A e into tau 0 L, frictional force as we mentioned here So, all the components of the weight will be acting for its friction So, frictional force is equal to again mu s into W s, this is same as W s. So, we have already found that for any given material mu s can be described through the angle of repose, so W s tan theta r. So, therefore, tractive force can be equated with the frictional force you will get W s tan theta r is equal to A e tau 0 L or your tractive force tau 0 L is equal to W s by A e tan theta r. So, in the previous this thing you had already got an expression for tau 0 s that is the tractive force on the side slope. And here you are already getting an expression for unit tractive force in the channel bed.

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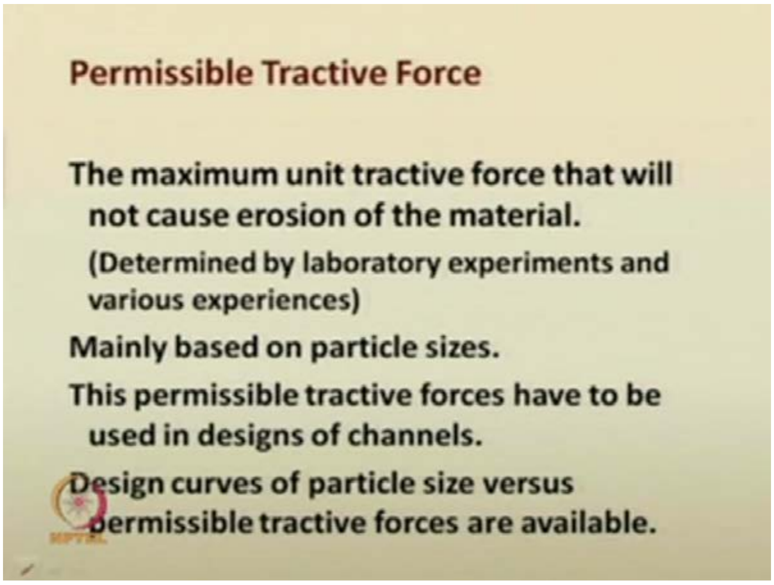

Therefore, the tractive concept.

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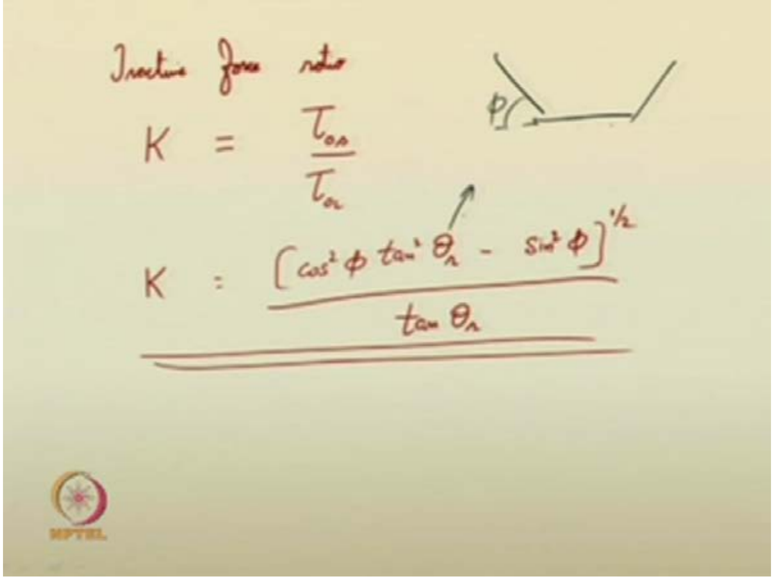

The concept called tractive force ratio, concept called tractive force ratio which is given as K is nothing but the ratio of unit tractive force on the side slope to the unit tractive force on the channel bed. So, what will you get then? Tractive force ratio this is equal to cos square phi tan square theta r minus sin square phi the whole quantity is raised to 1 by 2 by tan theta r. So, this is the expression for your tractive force ratio. What do you find from this particular expression for tractive force ratio? So, your tractive force ratio you can see that your tractive force ratio is a property of your particle, because angle of repose theta r is the particle of the. It is a property of the particle on the channel, it is also a property of the side slope whichever is given side slope is described through phi. If you recall the figure the side slope of the channel.

So, this angle is phi. So, this is described through the side slope. So, and tractive force ratio do, do not contain any other quantities related to force or any other quantities related to weight or friction and all. It is directly related with the angle of repose as well as the side slope angle. Now, once if you are able to identify theta r that is for that particle theta r is well defined for any particle theta r is well defined. And if you suggest that the side slope of the channel is so and so, you can easily find the tractive force ratio.

Now, you can directly employ this tractive force ratio in the design of a channels. Once if you have a certain permissible values and all you can use the corresponding tractive force ratio relation tractive tractive force ratio. Evaluate, what could be the tractive forces on the sides and all? You can design the channel, we will see that later.

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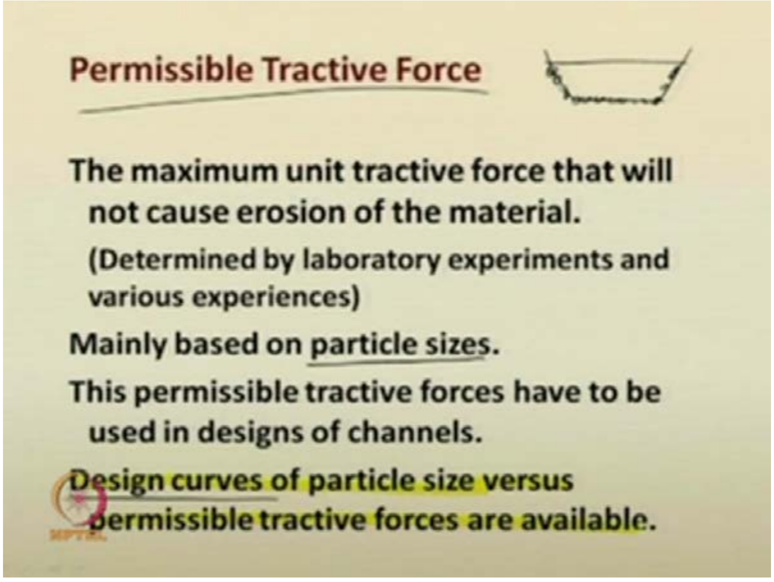

Next, we are going to go through is permissible tractive force. So, what is meant by permissible tractive force? The, it is the maximum unit of tractive force that will not cause erosion of the material. It is defined as the maximum unit force that will not cause erosion of the material. So, as we are dealing with unlined channels and all. Erodible channels means, unlined channels the particles on the bed as well as the sides of the channel. They have tendency to get eroded, because the water is flowing along means, flow water is flowing there, it has its own gravity force various aspects can cause the erosion of the materials.

So, the maximum unit tractive force that will not cause much erosion of the particles from the bed or from the sides that is called the permissible tractive force. We are trying to design channels for uniform flow in erodible conditions that is to design erodible channels for uniform flows. So, the permissible tractive force usually these quantities are determined using laboratory experiments or through various experiences senior scientists senior practitioners of hydraulics and all. They have done various experiments, they have came come up with certain quantities for permissible tractive forces, various designs centres related to hydraulics and all internationally. They are quantifying the permissible tractive forces according to the materials and all.

So, the permissible tractive force it is mainly dependent on the particle sizes. So, what is the particle size and also the material? It is also depend on a material. So, it is mainly based on the particle sizes. So, these permissible tractive forces you can easily apply in the design of channels. There are various design curves, various design curves are available you can use them, particle size versus permissible tractive forces they are available, you can refer many books or any hydraulics bulletins and all. You can get them; you will be able to get permissible tractive force for so and so material. For example, for clay material if the majority of the particles are having 25 millimetre as the diameter what could be the permissible tractive force? If they are having 50 millimetre diameter for sand, what could be the permissible tractive force? Like that various things are available you can just check in the literatures.

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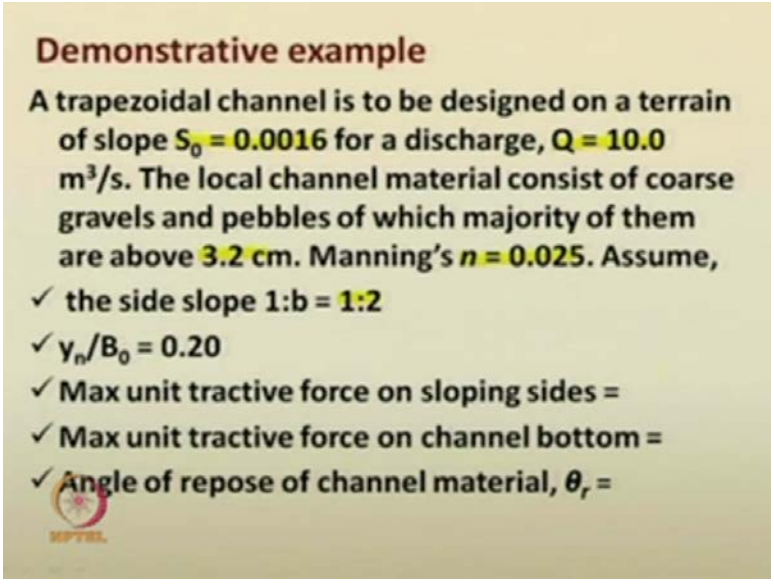

So, the design procedure now based on these concepts and all are first you need to select an appropriate channel section. You can select the channel sections just going by a random selection and all. It is better go through your intuition as well as prior information from the location and all. And select that almost suitable channel section also collect the samples of the materials. You have to collect the samples, because you have to identify various material properties for example, angle of repose and all you have to identify them.

Then, from the design charts or tables and all you indentify what could be the permissible tractive force for such type of materials? Because different materials will be having different unit permissible tractive force, permissible tractive force it will be having a different this thing. So, you can easily identify them. The angle of repose also you can subsequently find the tractive force ratio, because you have seen that tractive force ratio from the previous case. This is a property of the material phi and theta r theta r is this thing. So, you can calculate those quantities also now. So, tractive force ratio is applied. Now, apply the tractive force analysis to find stable stability of the channel and all. You will after determining tractive force ratio all those things and all. Identify what are the tractive forces on each location? Find the corresponding discharge from the channel. You see whether that corresponding discharge is suitable for or it is having the capacity, capacity discharge or it is obeying the capacity discharge of the location or for the requirement of the channel or not you can suggest that.

So, identify the minimum section that appears stable. So, we will do a demonstrative example, based on this design procedure. Our question is we are asking you there is a trapezoidal channel means, you have to design a trapezoidal channel on a terrain of slope S 0 is that is bed slope is 0.0016. And the design discharge, the requirement for the channel means that channel should have a capacity of carrying 10 cumecs it should have that capacity. So, if you design a channel and find that the discharge the capacity discharge from that channel is less than 10 then it is not effective means it is not going to solve the criteria. So, your requirement here now is it should have 10 meter cube per second discharge. So, you have to suitably design the channel an erodible channel. So, the local channel material consist of coarse gravels and pebbles of which majority of them are above 3.2 centimetres. So, the diameter majority of the particles are having diameter greater than 3.2 centimetre. Manning’s n from the literature it was observed that it was 0.025.

You can assume the side slopes 1 is to be as 1 is to 2. Initially that is initially you are assuming it has 1, 1 is to 2. You can also suggest the ratio y n by B 0 is equal to 0.20, 0.20. The maximum unit force on sloping sides that can also be available, maximum unit tractive force on channel bottom that can also be available, angle of repose of the channel material theta r that also is available for the material. So, what, what are these things and all?

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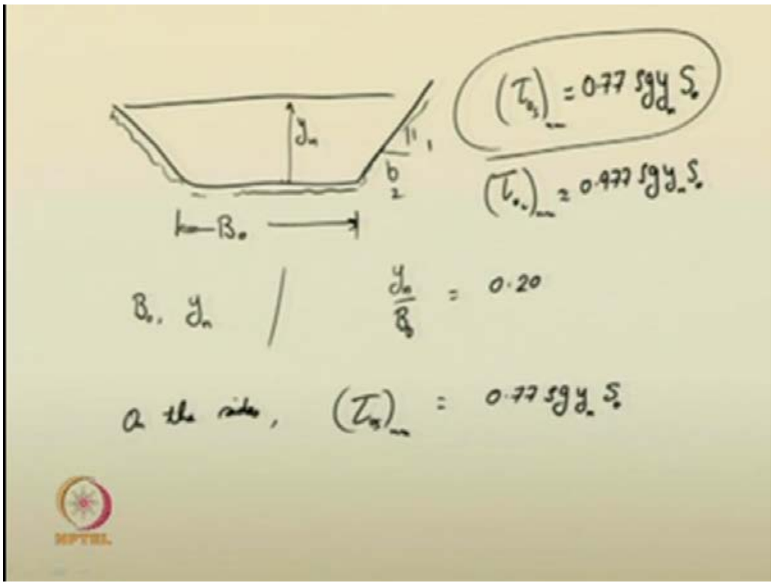

So, let me suggest that you are asked to design a trapezoidal channel, its bottom width is B naught, side slope is 1 is to B. The normal depth y n the channel so now you have to design this you have to identify what is B 0? What is y n? All these quantities you need to identify that is what is meant by design of this trapezoidal channel? If so here in the problem it is suggested that y n by B 0 is equal to 0.21 design criteria means or design specifications is given to you that means, if you find any normal depth for the flow.

Then, the width of the bottom width of the channel should be a phi times than that of this normal depth. So, like that 1 can easily suggest the criteria and all. If you want less than this, go ahead you can just try that. So, let us start with the design procedure. So, maximum unit tractive force on the sloping sides, what it could be? What are the things? So, from the literature it is being observed that.

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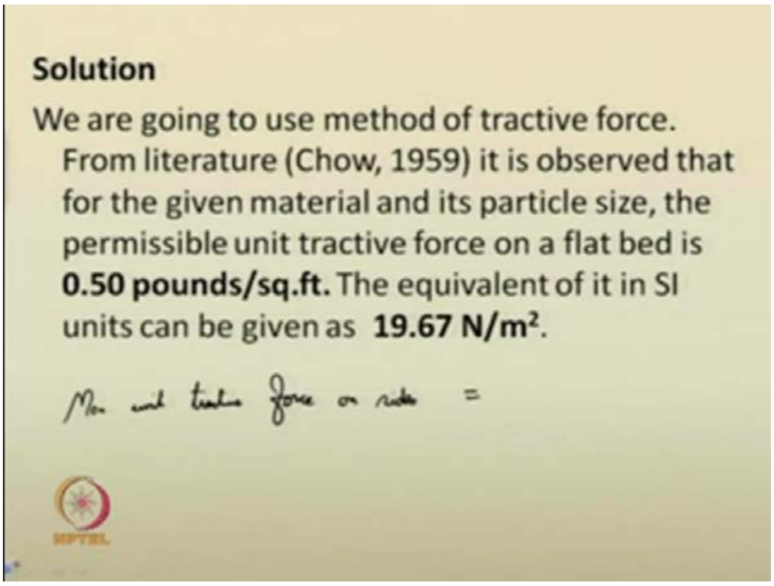

I will write it in next page, see maximum unit tractive force on sides. So, the maximum unit tractive force on sides for such a channel we have suggested that the channel is 1 is to B means that is, this is 1 is to 2 is already given to you. So, for such type of channels for the given material, it is been observed that tau 0 s maximum can be approximately 0.77 times rho g y n into S naught. Similarly, on the bed it is being observed that 0.977 rho g y n S naught. So, through there are various design charts that suggests these relationships. So, our objective is now to hold this thing that is take care of this particular relationship, how?

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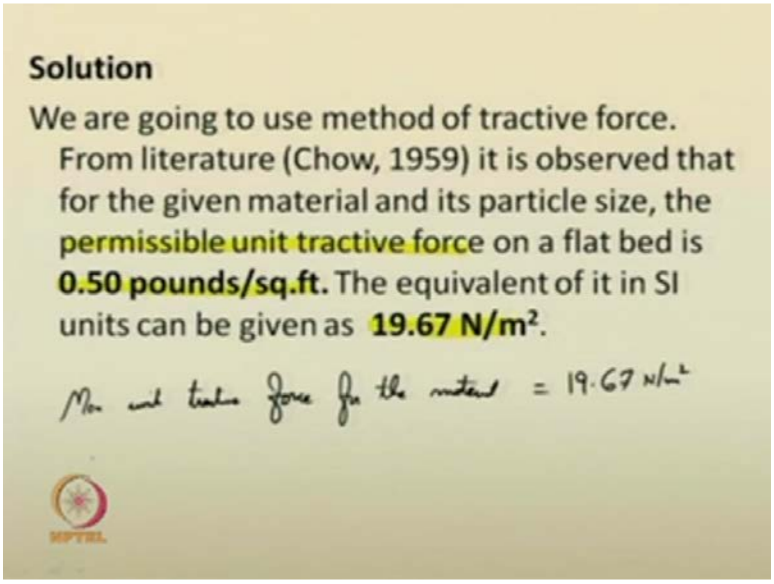

We are going to use the method of tractive force. So, from the literature and all it is observed that for the given material, and the particle size the permissible unit tractive force, the permissible unit tractive force on a flat bed for the given material it is 0.5 pounds per square feet. So, the equivalent of it in the SI units, we can convert it and you can get this as 19.67 Newton per meter square. So, this is the maximum unit tractive force for the material is equal to 19.67 Newton per meter square as we suggested here on the sides 0.77 rho g y n S naught.

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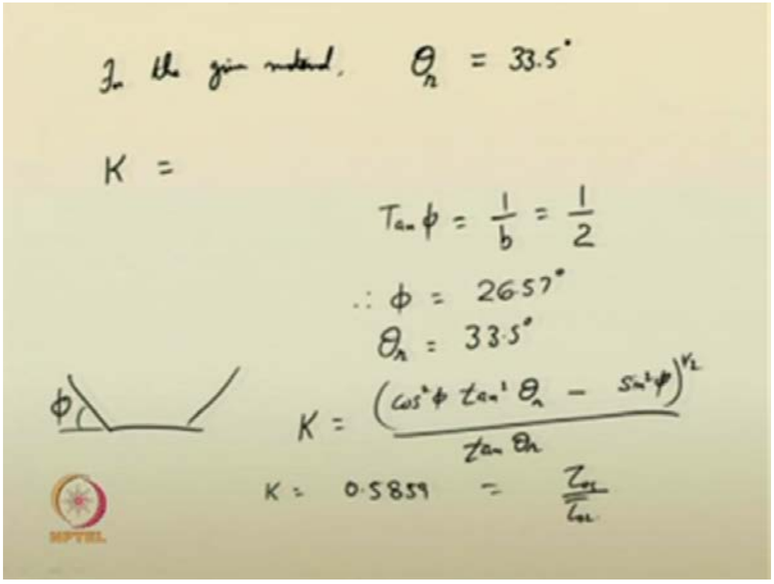

For the given material, it is observed that your angle of repose is equal to 33.5 degrees. If you have this particular data 33.5 degrees, then well you can easily find what is the tractive force ratio now? Because this phi is already known to you, this angle phi is already known to you, because tan phi is equal to 1 by B is equal to 1 by 2. Therefore, phi is equal to 26.57 degrees theta r is also given to you 33.5 degrees.

Therefore, the unit tractive force K is equal to cos square phi into tan square theta r minus sin square phi, the whole quantity raise to half by tan theta r. Now, you can find it what is K? Substitute the quantities I have got the value as 0.5859 you can verify them. So, this is nothing but ratio that is unit tractive force on the sides divided by unit tractive force on the bed. So, we have already suggested now.

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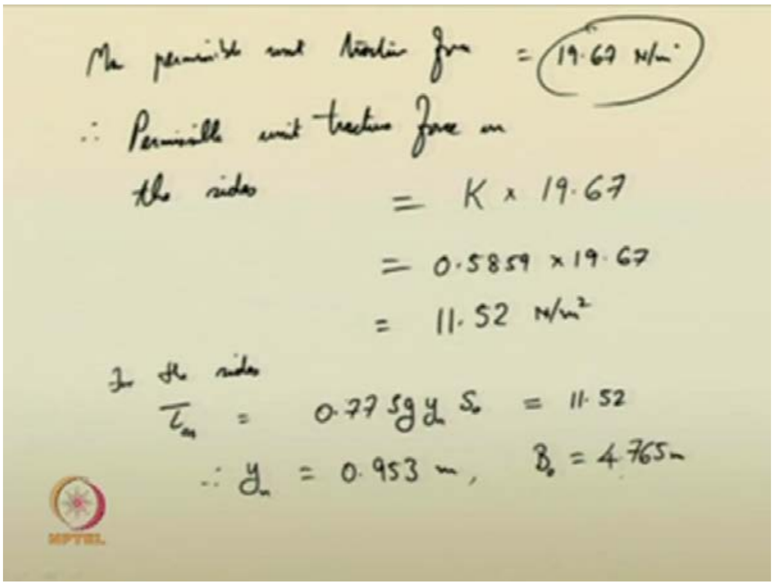

For the given material the maximum permissible unit tractive force is, this is equal to 19.67 Newton per meter square. Therefore, permissible unit tractive force on the sides this is nothing but this particular quantity K into 19.67. So, this is equal to 0.5859 into 19.67. So, this will give you a value of 11.52 Newton per meter square. So, as you know for the sides, for the sides tau 0 s is equal to point rho g y n S naught. This can now be equated with 11.52 as it is obtained here. You know what is the value of rho g S naught.

Therefore, the normal depth can be obtained as 0.953 meter. Subsequently, you can calculate the bottom width of the channel v 0 is equal to y n by 0.2. So, it will become 4.765 meter. So, that is when you designed you got these 2 values that is normal depth as 0.953 bottom width as v 0 is equal to 4.765. Now, you just check whether this can carry the requisite discharge that is Q is equal to 10 cumecs.

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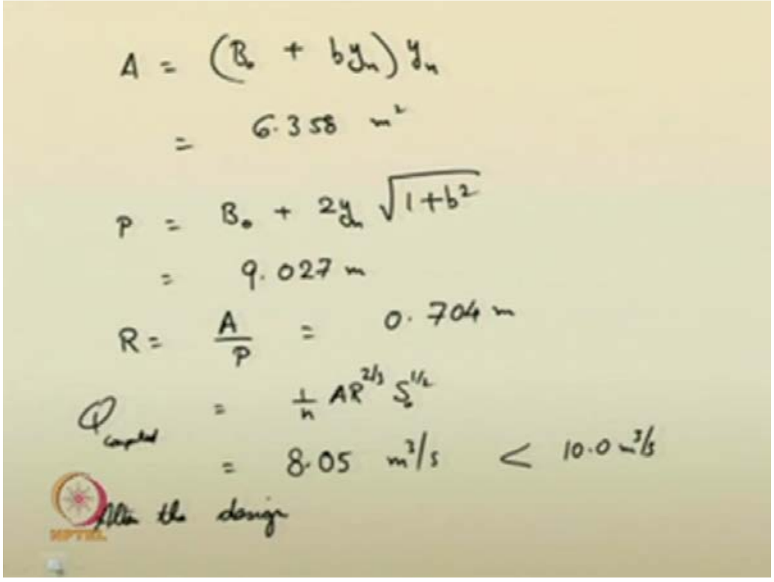

So, you have to find it A is equal to the, what is the A? For trapezoidal channel you know them substitute the quantities you will get 6.358 meter square. You will also get the wetted perimeter B 0 plus 2 times y n root of 1 plus b square, substituting the values you will get 9.027 meter. So, your hydraulic radius A by P, you will get this as 0.704 meter.

So, Q computed just substitute A R to the power of 2 by 3 S naught to the power of half, substitute all the quantities you will see that it is giving you a discharge of 8.05 meter cube per second. So, this is less than the requisite 10 meter cube per second. So, we cannot go with this design, we have to alter the design. So, how will you alter the design? So, let me recommend that. So, let me change the so we have to alter the design.

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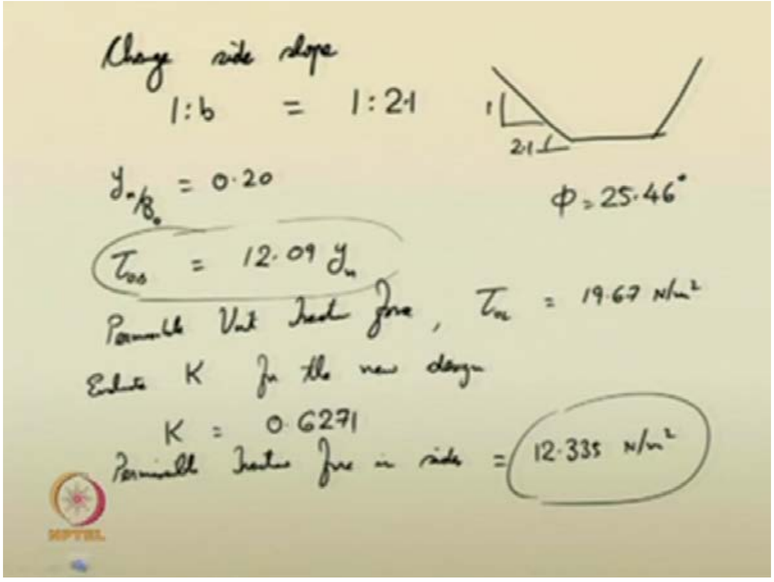

So, change side slope in a small way just change it. Let us see whether it will help us. So, I am now changing this into 1 is to b is now changed into 1 is to 2.1. So, this slope 1 is to 2.1. We are going, we are keeping this ratio y n by v naught is equal to same as 0.20 that we are keeping it same. So, we have the quantity tau 0 s, this is equal to 12.09 y n right as the permissible unit tractive force.

As this is the case, we have to now suggest the suitable quantity evaluate K for the new design K was evaluated. And it was found to be 0.6271, because your phi value is now changing to this angle phi, it is now changing to phi is equal to 25.46 degrees. So, your tractive, tractive force ratio has been changed to 0.627. Therefore, the permissible tractive force, unit tractive force insides, this is now equal to 19.67 into 0.62; 0.6271. So, that will give you a value of 12.335 Newton per meter square. So, again equate this quantity with this relationship.

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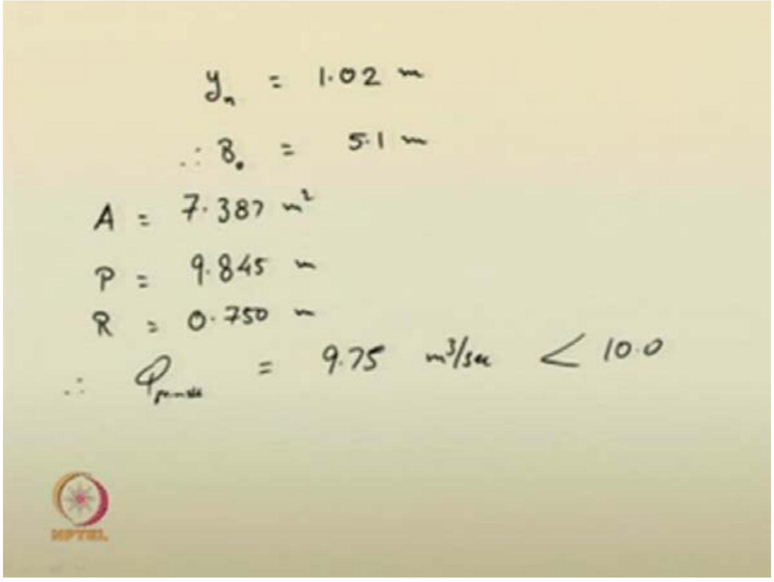

You will get the new depth, normal depth is equal to 1.0, 1.02 meter. Therefore, the corresponding width of the channel will be 5.1 meter, area when computed it was observed to be 7.387 meter square, wetted perimeter P is equal to 9.845 meter, R is equal to 0.750 meter. Therefore, Q permissible; this is equal to it is found to be 9.5 or 9.75cumecs, still this is less than the required one. So, we have to again alter the design so again when I alter the design.

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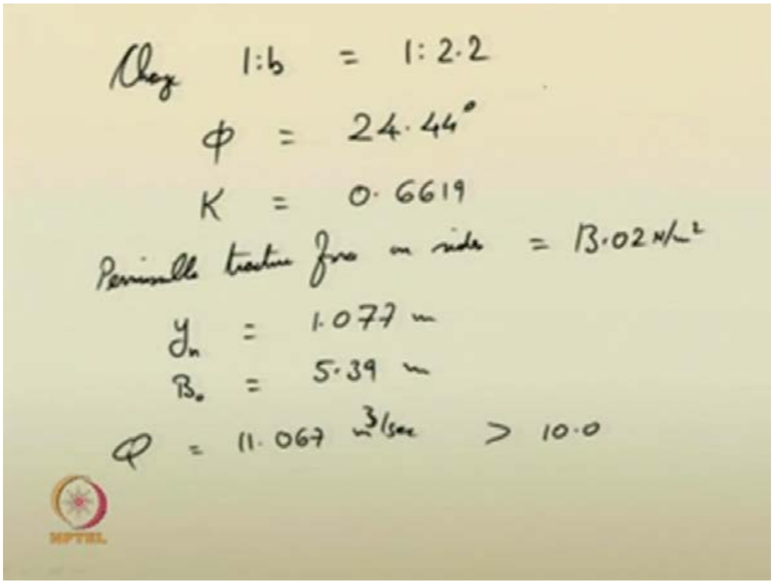

When again the design was altered that is change 1 is to b; 2 1 is to 2.2. Your angle phi becomes 24.44 degrees, unit tractive force was computed as 0.66119. Then the permissible tractive force on sides this was given as 13.02 Newton per meter square. So, you can equate it, you will see that y, y n now will be equal to 1.077 meter corresponding bottom width will be 5.39 meter, Q it was found to be equal to 11.067 meter cube per second. So, this is greater than the required one. So, you can adhere with this design parameters. And you can proceed with the channel, channel dimensions and all. You have to add additional freeboard quantities and all, this thing and subsequently, the channel is designed.

So, we have seen how the design of the channel using method of tractive force is done here by changing various parameters and all. You have seen the quantities 1 is to b these things or even the ratio y n by B 0 those also can be altered and you can design a channel.

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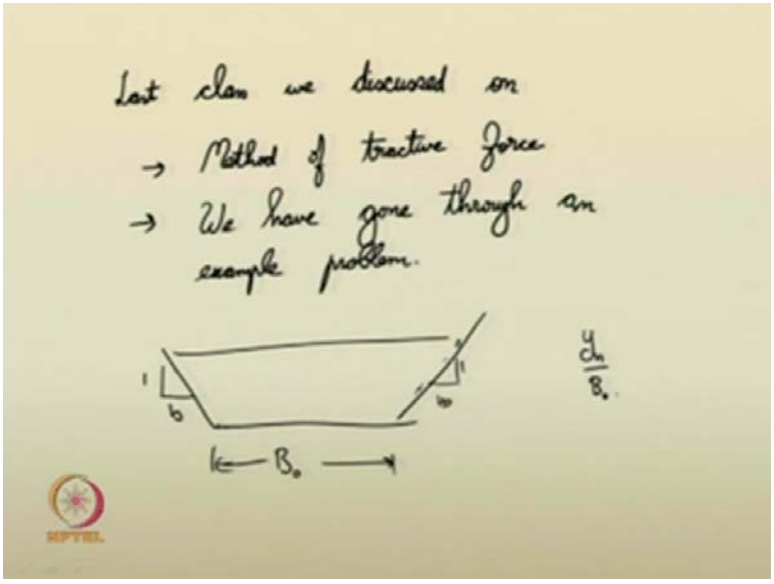

In this lecture, we have seen in the, that portion also various aspects, how the ratios or how? For example, in the channel you can alter the dimensions in the, it was a trapezoidal channel. So, for a given discharge means the discharge is the criteria, discharge will be the thing that will be provided to you means this much the channel should carry this much discharge and all will be a criteria given to you. Based on that, you can suggest the width of the channel; you can suggest the side slope of the channel;

you can a suitable quantity whichever is appropriate based on the material that is being used on the channels and all, you can appropriately design the thing.

So, we have seen clearly through that example problem, how the side slope was varied? You can also, we suggested that you can change the ratio y n by B 0 also, and see how the discharge is getting affected and all?

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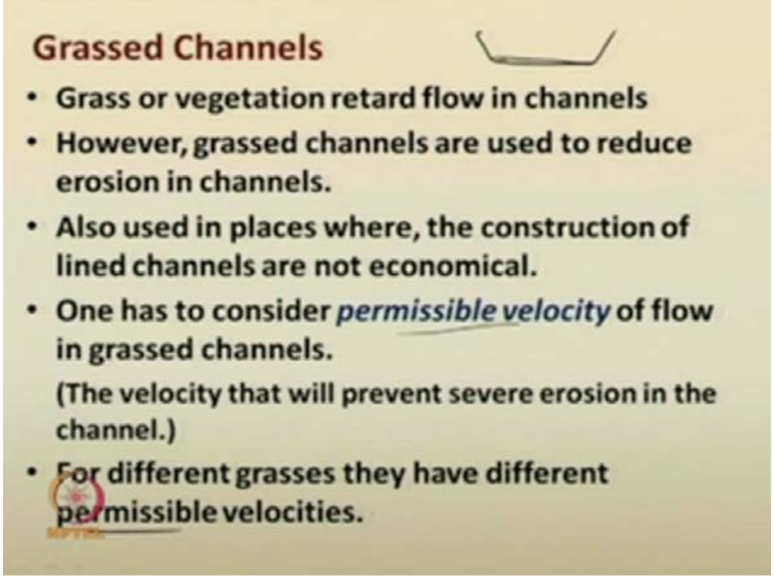

Now, in this class, we will just briefly go through the grassed channels. So, usually grass or vegetation it will retard the flow in the channels, because of the growth of the vegetation or grass and all. It can drastically retard the flow of the water in channels. So, but still grassed channels can be used to reduce erosion in the channels we know any bed any bed you take of the channel, if there are proper grass cover there is a chance that less materials get eroded from that channel. So, you generally it is used as a sort of lining grass channels are also used as sort of line. But this is a natural procedure so also it can be used in places where the constructions for example, concrete lined channels or brick lined channels or motor lined channels or wooden lined channels or whatever be is they are highly costly and all. And if it is not quite possible then you allow the natural growth of a certain type of grass in the bed of a cannel then consider this as a lining.

Here again for the grassed channels also one need to consider the permissible velocity of flow. Grass channels; you cannot have any velocity means any large magnitude of velocity cannot be used in grassed channels. The grassed channels grass can also have bear only certain amount of velocity. So, that permissible velocity you need to take into account so the velocity that will prevent severe erosion in the channel that is called the permissible velocity. And for different grasses you have different permissible velocities. So, then it is again the grass property it is the property of the grass that determine the permissible velocity. So, as we mentioned in the last class there are various hydraulic bulletins or hydraulic charts and all. Where you can get for different grass materials grass and all? What could be the permissible velocities and all?

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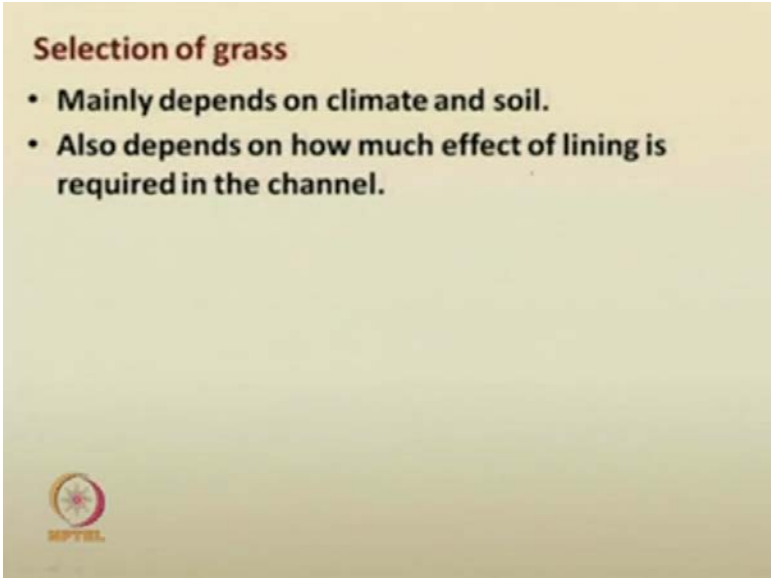

How do you select grass? So, the selection of grass it mainly depends on the climate and soil. For example, if you want to take Bermuda grass, which type of climate it should be? Which type of soil it should be? If you want to take any other type of soil, and if you want to take lemon grass, what type of soil it should be? So, depends on the situation, depends on the location climate and all. You also need means, how much effect of lining should be there? May be if you are constructing a channel in such a way that you are allowing partial erosion. But only the grass cover is made for temporary prevention of erosion and all. Otherwise you are permitting some sort of erosion, but not in a higher magnitude. So, that is based on that aspect also you can use appropriate grass covers and all. So, the how much effect of the lining is required based on that also you can select your grass.

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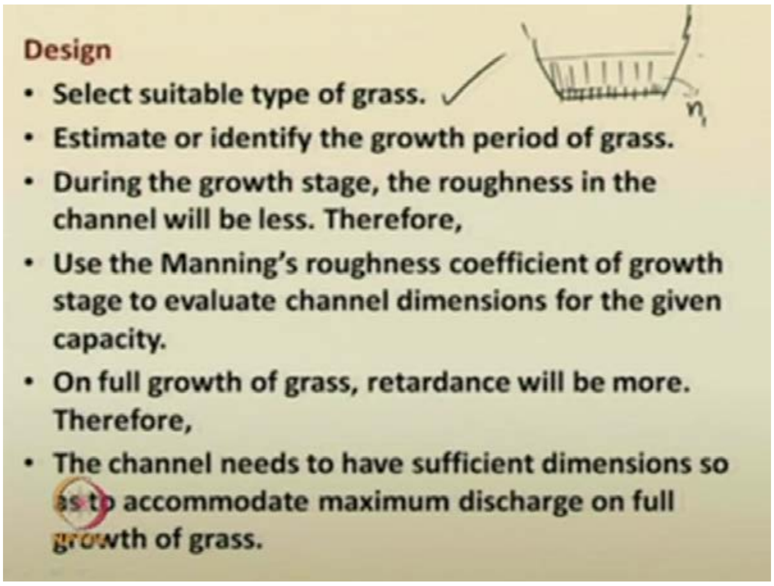

What are the various design procedure in? So, unlike the earlier method of tractive force or method of permissible velocity, we will not be going into deep the design of grassed channel, just to give you an overview of the procedure we will just discuss it here.

So, you have to select a suitable type of grass you estimate or identify the growth period of the grass. So, unlike the other lined channels for example, wood concrete where once you do the lining there will not be any change on the lining that is not the case for your grass. So, grass once you lay the seeds of the grass it will take some time for it to grow and also during growth stage it will be attaining different type of height. So, during the growth stage its roughness will be different at each time, each time interval its roughness on the bed on the sides and all. It will be different we have seen earlier how manning's roughness coefficient varies with the type of grass as well as the growth of grass as well as the height, how much height of grass is there?

So, you have to use the appropriate manning's roughness coefficient. And also you will see that the manning's roughness coefficient is changing with respect to the growth of the grass. So, the manning's roughness coefficient according to the growth stage has to be evaluated for the suitable dimension. Initially suppose, during the growth stage you have suggested some particular manning's roughness coefficient n 1. You design the channel for appropriate dimensions or using this particular quantity of roughness coefficient for the given maximum discharge, you got a particular channel section.

Now, when the grass grows after few month, say up to this level and all. There is a chance the roughness coefficient of the channel is getting changed it is getting much much increased more, not only that the effective area of transmission of water that is also getting change.

So, now you have to use the new value of n as well as the new effective area, all those things concept you have to use; you have raise the bed level then subsequently suggest that. Then you will see that there will be a new dimension for that channel. So, all those aspects you need to take means the design of grass channels usually occurs in 2 stages. Once during the initial growth period of this thing, and second when the grass is fully developed and it got stable then you have to again design it for carrying the full capacity. So, like this 2 stages of design will be there. So, you can just briefly understand them, we are definitely not going to ask you how to design the grassed channel and all? In India very less work is being done on this.

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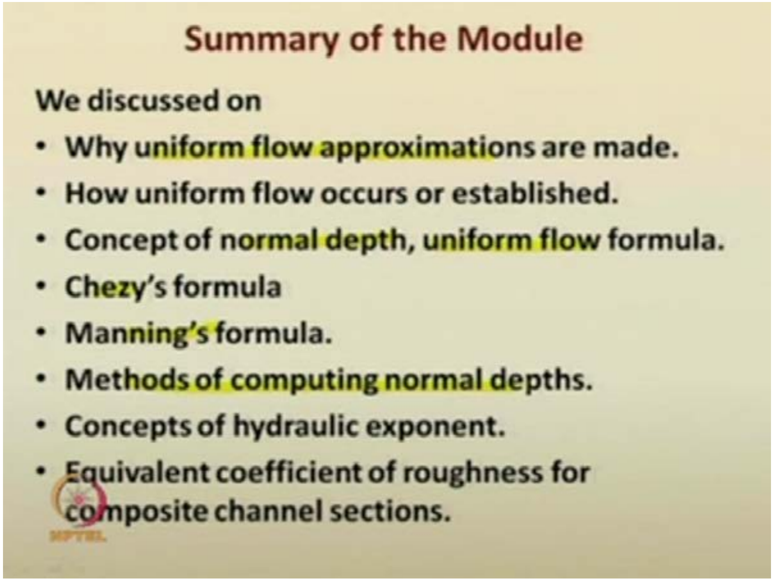

So, with this we would like to summarise our module that is the second module whichever we have discussed, we would like to summarise them. So, if you recall the various things in the lecture series you might have seen that we have discussed, why uniform a flow approximations are made? I hope I need not ask you again why uniform flow approximations are made? As we have suggested, just to simplify the design mechanism, just to simplify or understand the process. You are giving uniform flow approximations for various situation, although it is not the situation in the nature.

How uniform flow occurs or how the uniform flows are established? That also we had discussed. We have discussed on the concepts of normal depth. We have also discussed on the uniform flow formula. We have suggested Chezy's formula, manning's formula. We have suggested various methods to compute normal depth I hope you recall them trial and error method, numerical method, design charts and all. We have introduced you the concepts of hydraulic exponent. We have also suggested you the equivalent coefficient of roughness for composite channel section. How to evaluate the equivalent coefficient of roughness for composite channel sections?

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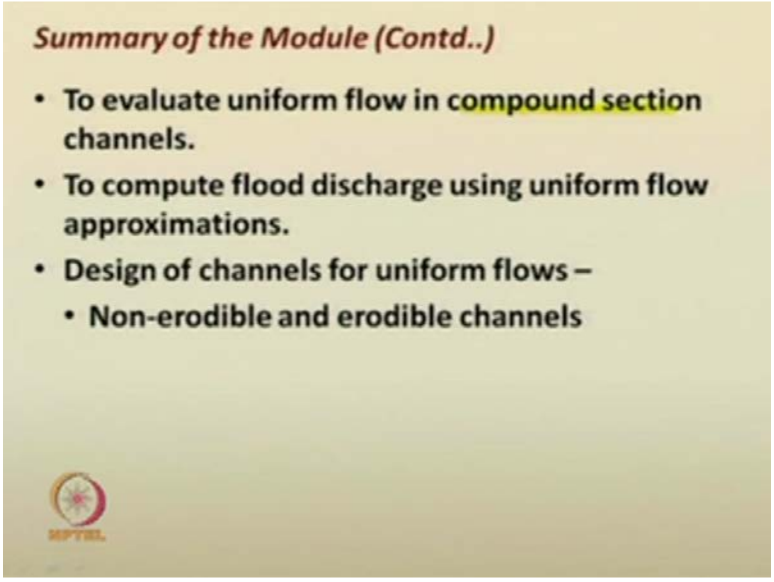

We have also discussed on to evaluate uniform flow in compound sections of the channels. If there are main channel section then flood play along with the flood plains sections and all. How to compute uniform flow in the, that? That was also discussed. you were also given information onto compute flood discharge using uniform flow approximation. You were also; you were also introduced on the designing of channels form flows both the non erodible channels as well as the erodible channels. Some of the examples you have seen, in non erodible channels you have seen about hydraulically efficient sections and all.

So, various things you have studied in this module. So, we would like to conclude this module, and before concluding this module I just like to give you a brief quiz.

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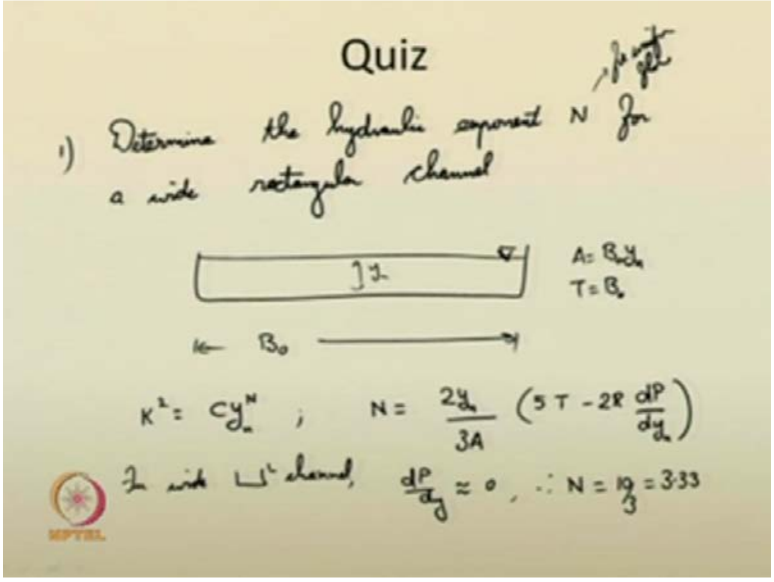

So, the first quiz which I would like to ask the first question is “Determine the hydraulic exponent N for a wide rectangular channel, say if you have a wide rectangular channel”. You determine the hydraulic exponent for uniform flow. Please note that for uniform flow for a wide rectangular channel. So, how will you determine the hydraulic exponent?

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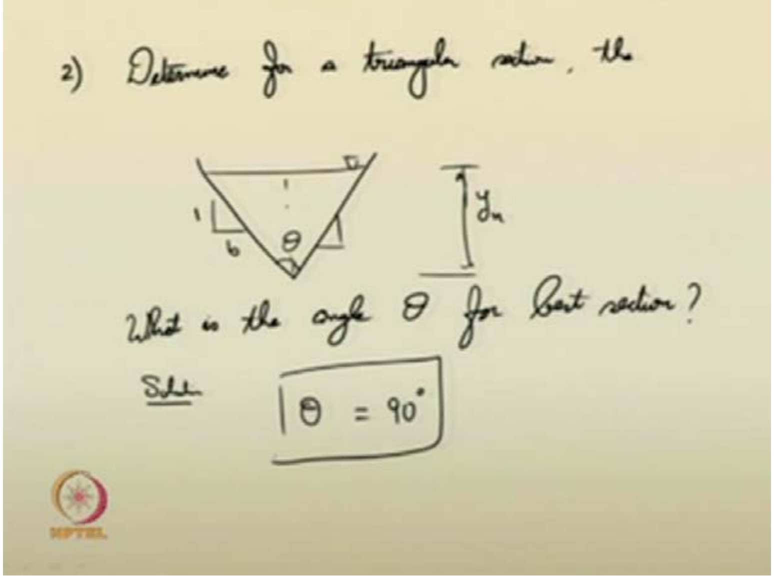

Your second question is “Determine for a triangular section, say you have triangular section the best section or what is the angle theta as given in the figure? So, best section, what is, what is the angle theta for best section?” So, you can just work it out, we will just give you 5 minutes to solve that. So, the solution for the first question so if you recall your hydraulic exponent it was given as K squared C y n N or the hydraulic exponent was given as 2 y s, normal depth by 3 times a, 5 times T minus twice R d P by d y n. So, we had derived this equation in fact in one of the earlier classes.

So, in this end, what are the criteria for the wide rectangular channel? You just substitute that. So, you know for a wide rectangular channel, your hydraulic radius is almost equal to your normal depth, also the change in wetted perimeter with respect to depth in the wide channel rectangular channel, what it will be? For wide rectangular channel d P by d y approximately equal to 0. So, therefore, your N, you just substitute it. You know A is equal to B naught y n, T is equal to B naught, substitute the quantities, delete appropriate terms you will get n is equal to 10 by 3e that is equal to 3.33. So, this is the hydraulic exponent for uniform flow in a wide rectangular channel.

Your next question for a triangular section, you were asked what could be the best possible theta that gives you a efficient triangular section? So, can you do that we have asked you, what is the angle theta for the best section? So the solution for this is so you just do work it out. If this is your depth y n, if this is your 1 is side slope 1 is to b.

Then it is the side slope 1 is to b that determines this particular angle theta. So, that gives you this for. So, based on if you are side slope, if it is steep your theta will be less if side slope if it is very high your theta will be more. So, do you think that for all values of theta the section will be having maximum discharge? So, that is not the case so you use the appropriate minimization principles which we have done earlier. We have worked it out using those things. It is observed that theta is equal to 90 degrees. This will give you the most hydraulically efficient triangular section.

Thank you.