Advanced Hydraulics
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Module - 2
Uniform Flows
Lecture - 6
Design of Channels for Uniform Flow

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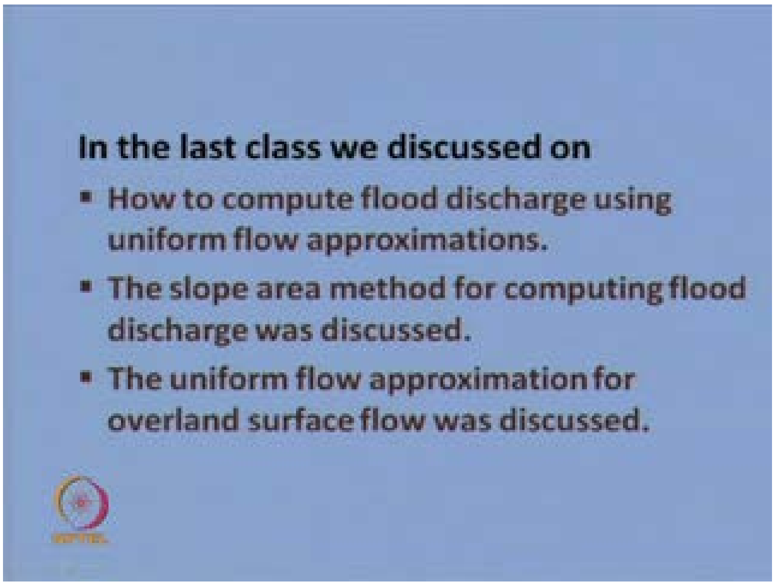

Good afternoon to everyone. So, we are back into our lecture series on advanced hydraulics. And we are in the module 2, discussing on uniform flows. In the last class we discussed on, how to compute flood discharge using uniform flow approximations. We also discussed on the slope area method for computing flood discharge. We also discussed on how to give uniform flow approximations for overland surface flow, where overland shit flows, and all are witnessed.

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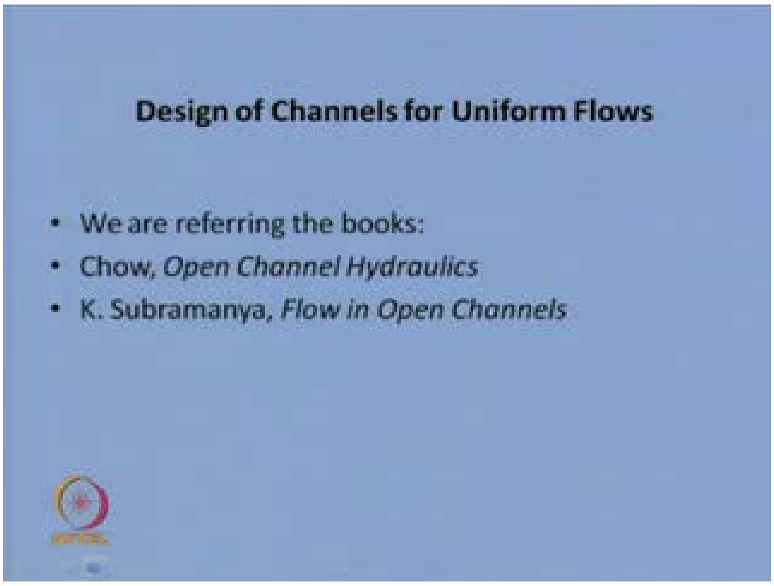

So, today we will discuss on design of channels for uniform flows. The books we are going refer in this chapter, especially it is Ven te Chow's Open Channel Hydraulics and K. Subramanya's Flow in Open Channels. What are the channels that are to be designed for uniform flows? As we mentioned in this chapter, we are going to discuss on design of channels for uniform flow. What are the general channel, type of channels you witnessed or where you encounter the, what are, where you required to design channels for uniform flow.

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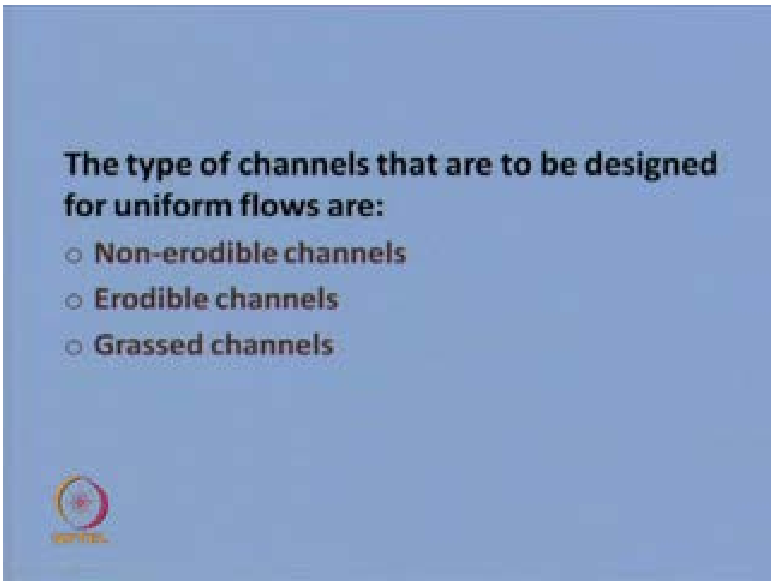

Some of the things are: non-erodible channels, how to design non-erodible channels for uniform flow, then next is how to design erodible channels for uniform flow, and subsequently, how to design grassed channels for uniform flow. So, we will see all this things partially, not in quite a large extend, but we will see as per our limit, and as per the course like duration and all; we will see as some of the things, aspects for the designed criteria of this channels.

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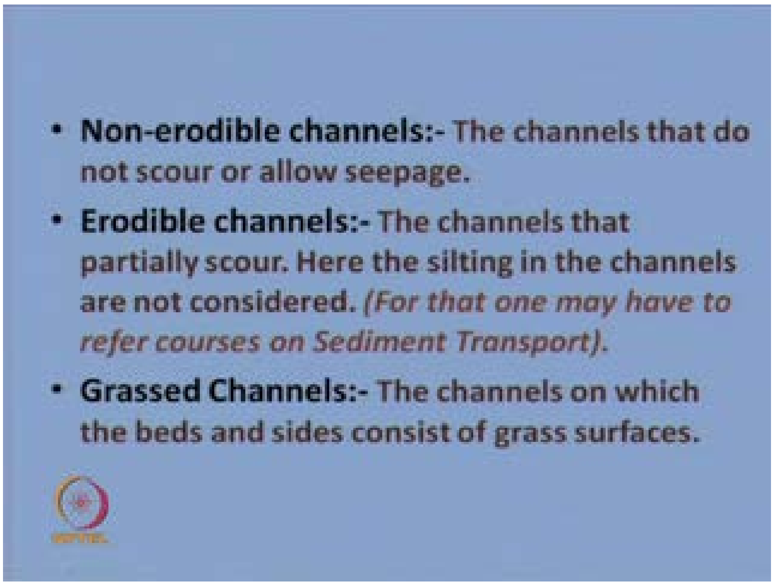

So, what is meant by non-erodible channels? So, the channels that do not allow scour or it do not allow seepage through its bed and through the sides; such channels are called non-erodible channels. Generally, you use to line the channels in the channel beds as well as on the slides you line it with certain materials, so as to avoid these properties.

Erodible channels, the erodible channels, the channels that partially scour. Here, you will see that the silting in the channels are not considered. We are not going to consider the silting properties of the channel; that is further a higher level course, especially on sediment transport and all. We are only going to see partial scour in the channels that will be followed; how this scour partial scouring and all occurs; so and how you can design channels for such erodible conditions and all, that we will see.

Grassed channels, the channels on which the beds and sides consist of grass surfaces, they are called grassed channels. You will see, they have different properties compared to other non erodible channels and all. You will see, and there is quite difference there, especially in the roughness aspect and all; grass offers much, much resistance to the flow, and you will see the roughness co efficient considerably different in this case.

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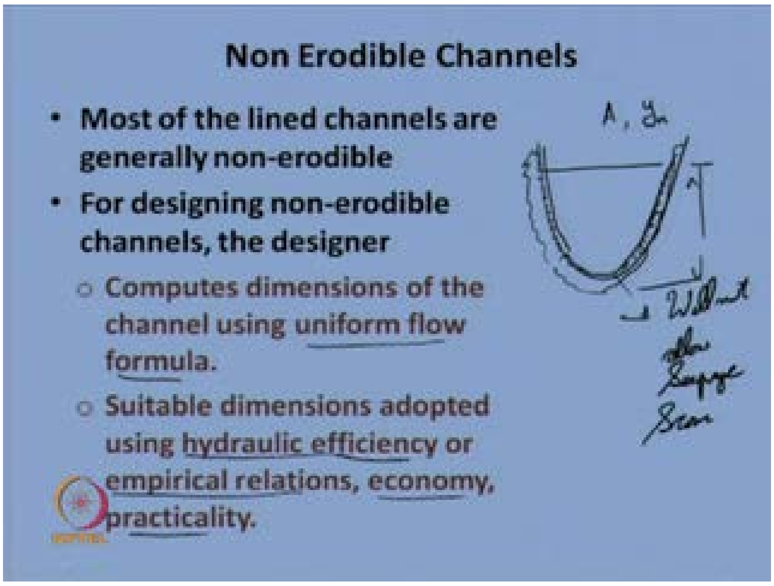

Then non erodible channels. So, most of the lined channels, most of the channels which are lined, for example, if you have any arbitrary cross section of the channel, if this is channel bed, and if you line the channel bed with some material, such channels are called lined channels. So, they allow, means they would not allow, will not allow seepage, or will not allow scouring along the bed; along the bed it will not allow. So, such lined channels are generally called non erodible channels.

For designing non erodible channels, what do the designer do? A designer, he has to first compute the dimensions of the channel using uniform flow formula. So, once, say, if he has computed the dimensions, he has suggested, he got the area of the flow, he is then subsequently understood means, subsequently he suggested the depth of flow and all. Based on that one can design the dimensions of the channel; what type of channel is to be incorporated; or, for the amount flow, what is a amount, for the given amount flow, what is the depth and all required and all; he can compute it using the uniform flow approximations. This you have already seen, how to compute uniform flow and all.

Then, the suitable dimensions, they are adopted after suggesting, say, certain dimensions. Then this suitable dimensions among them, we will adopt it as per the hydraulic efficiency of the channel, say, hydraulic efficiency; or, you can also use some other efficiency criteria or empirical relationship; or, you can also see economy, whether it is economical or viable to use certain dimensions of the channel; whether it is practical or not. You may see, some of the most economic hydraulic efficient channels may not be able to be incorporated with the ground level; you cannot construct such type of channels, it may be quite possible, then there is no point on designing such side type of channels. So, you have to see various practical conditions and all, whether it is economically feasible or not.

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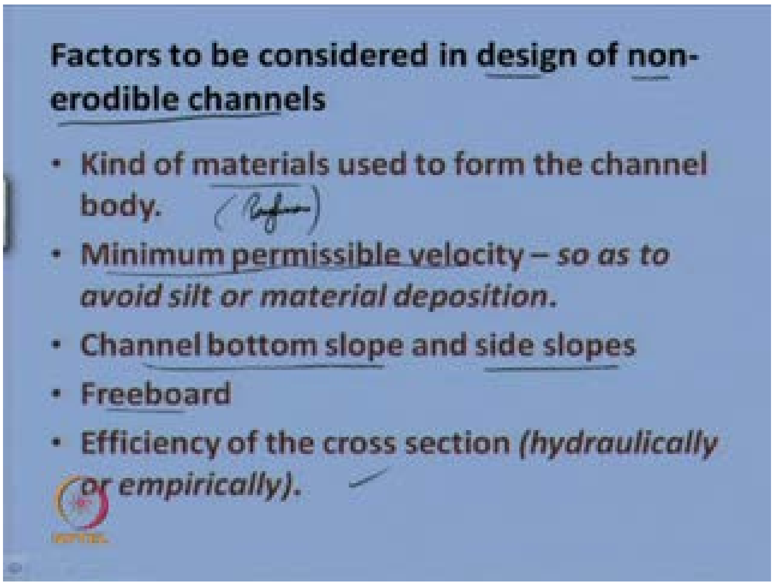

What are the factors to be considered while designing of non erodible channels? Of course, when you design the channels, especially the non erodible channels, you have to consider some of the factors. The first one as it is been suggested here, the kind of materials, is what is the material you are going to use to construct the channel; that is quite essential, because it is the material that determines the roughness of the channel, right. You are quite aware now, because different materials have different types of roughness coefficient, and once the roughness coefficient changes the flow or the discharge charges quite immensely. So, it is one of the most important aspects, while designing the non erodible channels

You also need to consider the minimum permissible velocity. Why the minimum permissible velocity, and why not the maximum permissible velocity? As mentioned, this title is design of non erodible channels. So, the non erodible channels, we are suggesting that the bed of the channels, it is not getting eroded or even the side, bans a side of the channels, they are not getting eroded. So, usually, the amount of suspended materials in the water, they are negligible; you can consider as negligible, or there is no erosion of the bed. So, definitely, the maximum permissible velocity is not coming into picture; it is the maximum permissible velocity, or the maximum velocity that determines how much amount of covering will take place and all, in a given bed.

So, people who are interested to do sediment transport analyses and all, interested to undergo courses on sediment transport; or, who are, whoever are doing them, they will be quite aware of this fact that, the velocity of the water is quite important in determining the scouring, how much amount of scours takes place and all. In our case here, we are suggesting the minimum permissible velocity for non erodible channels. This is to avoid, if at all any suspended materials are there, we have to avoid that thing, and also to avoid growth of aquatic plants and all.

Then, the another factor, it quite, that is quite important in designing of the channels are, non erodible channels are the channel bottom slope and the channel side slope. Next important criteria is the freeboard. What do you mean by freeboard? The amount of, ok, we will discuss it, in a extended way. The amount of height, means free height whichever we are going to give, beyond the normal depth of the flow for the given design, that is called freeboard, we will discuss that definitely. Also, you need to consider the efficiency of the cross section; whichever design you have done, you have to see whether it is hydraulically efficient, or whether it is empirically efficient, whether it is economically efficient, all those things you need to take into criteria.So, like this factors, we will just slowly discuss each of this factors and see how the design of channels can be done.

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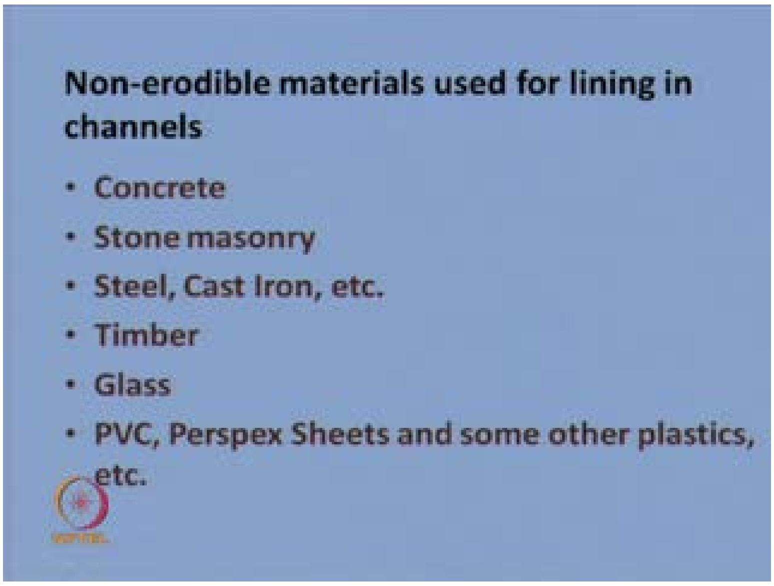

The non erodible materials used for lining in channels. As we mentioned here, for the various factors to be considered in design of non erodible channels, the first criteria we suggested or the first factor we suggested is the kind of material that are to be used in forming or in designing the, and using the, developing the channel body and all.

So, what are the different materials that are used for lining the channels? Concrete, as you know concrete, it is quite strong; and it does not erode that much. So, concrete is generally used in many of the channels, cross sections and all, to, as a lining material. Next one is stone. There are various rocky stones and all, or stone masonry, where the stones are much much stronger, and also it avoid erosion of the bed and sides. So, stone masonry is also quite done for the lining of the channels. You can also use steel, or you can also use caste iron, various materials like that that do not erode in water. Can also use timber, a good sisu timber is quite resistant to erosion; and it also will be carrying enough amount of water. So, timber is also quite used in lining of the channels.

Glass materials are also used for the lining of the channels. People have also used PVC, or they have also used perspex sheets, or they are also used some other type of plastics etcetera, as lining materials in channel. So, there are not only this much, there are many other materials which you may be quite aware also, which I have not discussed here. So, you can, or you refer many other books related to lining of channels and all. So, there you will be getting a better picture.

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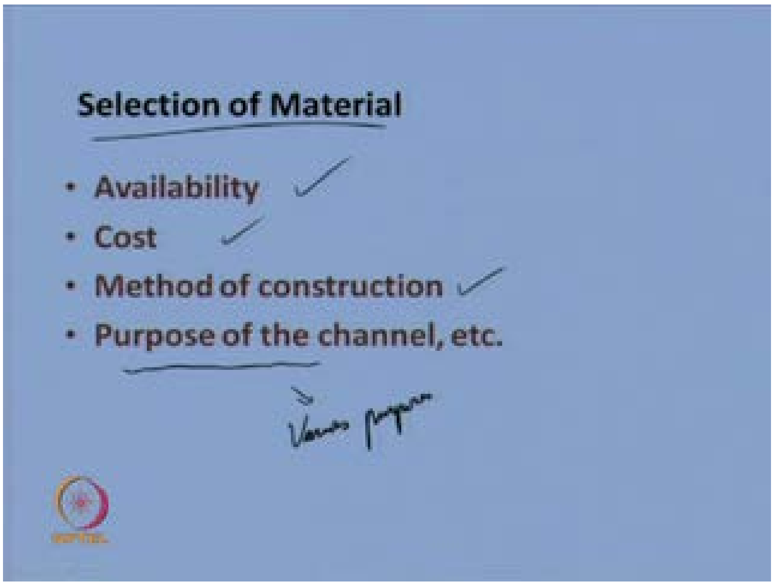

As you have seen, there are various materials that can be used for lining of the channels. So, what are, how do you select a certain material; or, what are the criteria for selecting a certain material. Definitely, the availability of the material plays a very strong role in adopting that material as the lining material for the given channel. If, for example, if it is a slightly hilly area where a certain type of rock is very much available, that rock can be readily used as a lining material in the channel passing through that region.

It is cost efficient also. The cost involved in incorporating that particular lining material in the channel; whether the cost is getting escalated considerably, if you line the, if you line the channel with certain type of material; whether the cost is getting escalated or not, depends on that. if it is economically viable, ahead of that material.

The method of construction of that channel for various type of constructions, say, if you require means what, for what is the method of construction; certain contractors may be having different type of materials available with them to construct a certain sections or certain works and all, certain other contractors may be having another type of materials, so depends on all those things. So, you cannot, you cannot say that only this, so and so material has to be used always for the channel construction and all. So, various things of, the method of construction, what are the different methodology for construction, one can use pre stress concrete, one can use already available fabricated concrete that are already fabricated somewhere else, you can just incorporate that lining material in the location, or, one can fabricate in the location. So, all this things plays means a different picture; it will give a different picture.

So, what are the purpose of the channel? Say, what is this channel for? Whether it is for carrying pure portable water, or whether it is for carrying irrigated water, whether it is for a hydraulic project, whether it is for carrying waste water, or whether it is for other type of waste, or whatever thing that are coming into your picture, depends on various purposes. So, you have to adopt the materials as per. If it is waste carrying channel, definitely, if you use timber or if you use steel and all, you may see that steel may react with the various chemicals in the waste and your channel may get eroded, or something else means erosion, this is chemical erosion and all that may occur there. So, you have to avoid such things.

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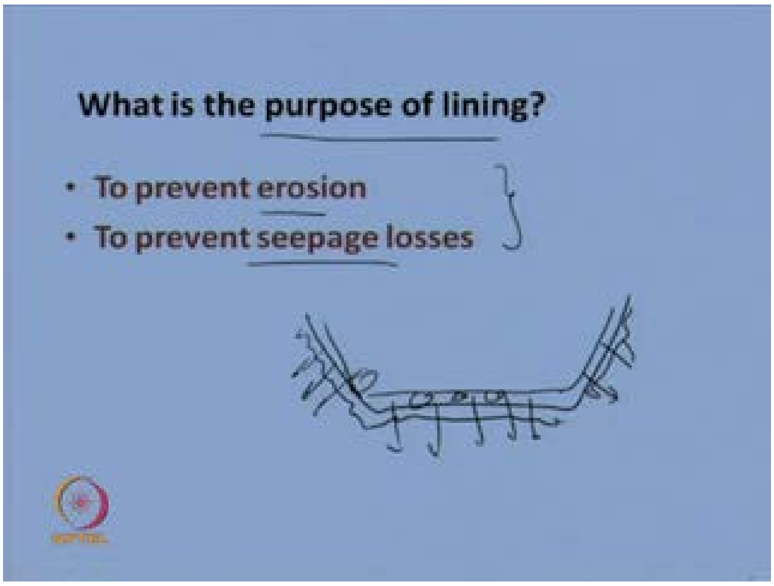

So, as I asked you earlier, what is the purpose of lining? Now, in between this lecture, why I need to pose you this question? Because, again to reiterate in front of you; that is the purpose of lining of the channel is, as this is the non erode, design of the non erodible channels, you have to line the channels. And this lining is done to prevent erosion of the bed as well as the side, and to prevent seepage of water into the channels. So, if you have such a channel this thing, you may see that the beds here, it may get eroded due to the flow of water.

So, if it starts getting loosen, then the lining is not proper. So, if a proper lining material is incorporated, the loosing of the soil can be avoided. Also, if any water is infiltrating or seeking into the soil, and if you see that the loss of water due to that such type of seepage if it is quite high, then you can avoid seepage by proper lining of the channel.

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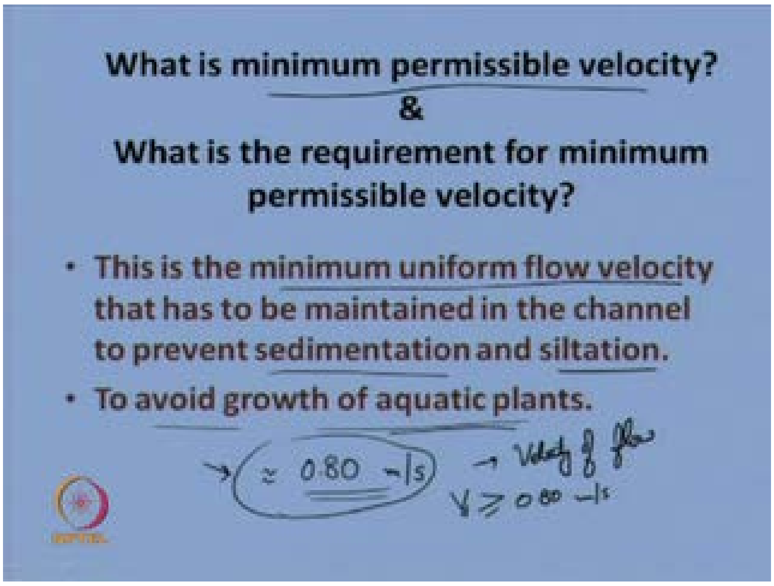

So, the next factor, which we suggested while designing of the non erodible channels where, minimum permissible velocity, if you recall that; minimum permissible velocity. Now, I would like to ask you, what is meant by minimum permissible velocity? And what is the requirement for minimum permissible velocity? We had already hinted earlier. The minimum uniform flow velocity that has to be maintained in the channel to prevent sedimentation and siltation, this is called the minimum permissible velocity for the designed channel, non erodible channel.

For the design non erodible channel, a minimum uniform flow velocity has to be maintained; otherwise, whatever suspended materials are there, already there in the channel, that may start getting sedimented, means deposited. So, you have to avoid that deposition. So, you have to avoid that deposition.

Also, if you see that, if the velocity of flow of water in the channel, if it is too slow, there are chances of plants, aquatic plants growing in the channel. So, you need to avoid, means you have to keep a certain, from the velocity, so that the aquatic plants are not grown. You will also see that, as this is the non erodible channel, most of the cases, the sediments or the suspended materials present in the channel are negligible; then you need to design, or you need to design, give the minimum permissible velocity based on the growth of aquatic plants; for many cases, it is been observed that approximately around 0.80 meter per second, velocity of flow.

If you keep the velocity of flow approximately around this thing, means not less than 0.8 meter per second. Most of the aquatic plants that are present that may means, that are not allowed to grow, means it will avoid the growth of most of the aquatic plants around atleast, atleast around this velocity. So, you have to keep the velocity v, designed atleast to be greater than or equal to 0.8 meter per second.

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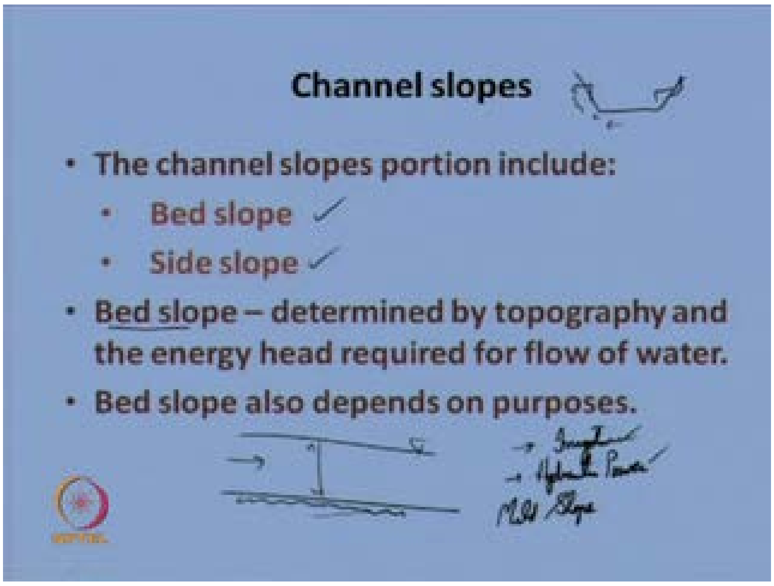

The next factor we suggested, while in the design of the channels are the channel slope. So, what are the channel slopes that are present? For any channel, you know, there are bed slope and side slope. You know, what is meant by bed slope? Say, if the channel is like this, if it is carrying water uniform flow, uniform flow depth, this is the longitudinal view flow is occurring, then the slope of the bed, this is called bed slope, the slope of the sides of the channel, as given here, that is called side slope.

So, the bed slope, it is determined by the topography of the region. Mostly the topography is the region, as well as the energy head require for flow of water, you know; that means, based on means, you require the water flow especially in open channel flow, water always flows from higher energy to the lower energy. So, when you compute the energy head, you need to see that the energy head at the upstream is always greater, then only it can flow to the downstream. So, you have to design it appropriately. So, bed slope need such criteria, and also the topography plays a quite important role, various.

The bed slope also depends on various purposes. Say, for example, if there are multiple projects, irrigation projects, or hydraulic power projects, if such projects are there, you will see that the channels, the water at the entry of the channels here, in the channels for irrigation purpose as well as the hydraulic power projects and all, at the entry of the channel, it should be at quite higher elevation. If it has to be at higher elevation, what do you mean by that? Then the feeding, or whichever channel is feeding to this channels, they need to be at a higher elevation. So, in those channels the bed elevation also need to be kept at a higher level, so that, you will be able to feed the water properly for the irrigation projects, hydraulic power projects, and all. Most of the cases you use mile slopes, in such situation mile slope channels are used, or negligible slope channels are used.

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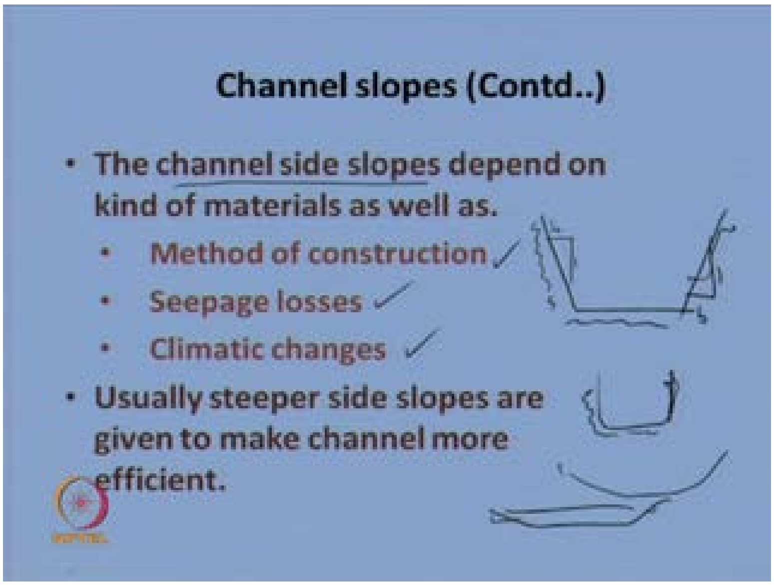

So, in the channels slopes, we suggested that the channel side slopes are also quite important. The channel side slopes, it depends on the various kinds of materials, you have seen that. You can use different types of materials for construction of channels. So, based on the materials, one may have to adopt the sides slopes; say here, in the side slope, what should be this ratio, 1 is to b, this ratio 1 is to b is are the side slope.

If it is a rock, you will see that you can almost keep the channel cross section, or the channel side slope as vertical. If it is a very loose soil, sand, loose sand soil, you may not be able to keep it in a vertical, then you may have to give some side slopes. So, there are different, based on different materials and different this things, also based on the method of construction, you have to design the channel side slopes. You also need to see whether the seepage loses, you have to minimize or whether you are allowing certain seepage losses, so that, the general area and region is getting recharged. Also, you need to see the climatic changes.

All this factors, all this things depends on determining the channel slide slope. So, usually steeper sides are given to make channel more efficient. You will see, later also today, we will discuss them later; if the side slopes are steeper, that channel is able to carry the more water compared to shallow or what you say, non steeper side slope channels. So, those things also come into picture. What is a criteria, of the general social criteria, that is also required.

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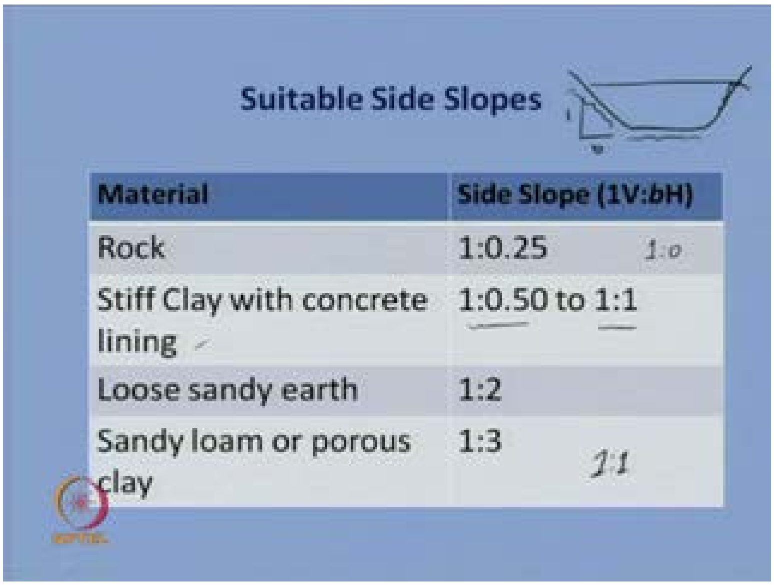

Material	Side Slope (1V:bH)
Rock	1:0.25
Stiff Clay with concrete lining	1:0.50 to 1:1
Loose sandy earth	1:2
Sandy loam or porous clay	1:3

A table, table we had just given for suitable side slopes that are generally adopted. So, in rocks, it is 1 is to 0.25, or almost you can say 1 is to 0, also it can be given, means there is no need of side this thing. For stiff clay with concrete lining, you see that this is 1 is to 0.5 up to 1 is to 1. So, let me draw the here, thing here. So, your 1 is, 1 is to b, this is the thing, quite a suggesting the thing. So, for stiff clay, this 1 is to b is almost 1 is to 1. For loose sandy earth, this is 1 is to 2. For sandy loam or porous clay, this is 1 is to 3.

So, based on materials, as we mentioned earlier, you have adopt the side slope. Or the, if you try to incorporate 1 is to 1 for sandy loam this thing, you will see that the side slopes will get collapsed and your channel gets broke, means, it will, it gets failed. You cannot construct such type of channels. So, you have to see the material that is being adopted for channel design.

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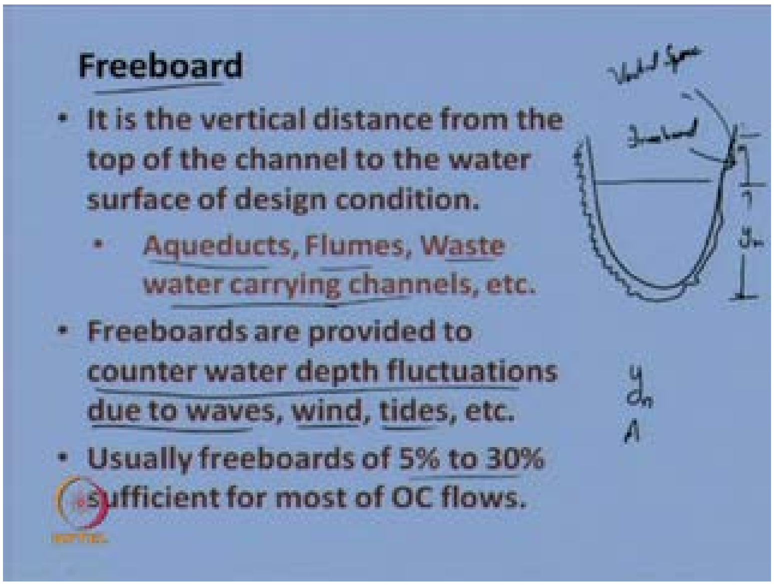

The next design factor while designing the non erodible channels mentioned was freeboard. What is meant by freeboard? Just consider a channel section; in the channel cross section, you have designed, means, using the various design criteria parameters you have designed that, say, the depth loop, y n should be so and so. Then you suggested that the area of flow should be so and so.

Once you have designed all those parameters, the depth of flow, y n is incorporated. Then while constructing the channel, you need to give further space, further vertical space; you have to incorporate further vertical space, that is you have to extend this sides slope further to particular, particular height; and this height is called freeboard; means, if your designed height, designed height for the discharge, uniform discharge is y n, then y n plus certain freeboard height also need to be given, that has to be incorporated while you design or well you, while you construct the channel.

Why this freeboard is given? Why it is required? Because, there are chances that the water may spill from the channel due to certain fluctuations and all. So, you do not want to allow spilling of water. So, therefore, you need to provide freeboards. Freeboards are very essential when you construct aqueducts, say aqueducts that carry water from one level to another level and all. If there is a spilling of water, it can cause huge loss and all. In laboratory flumes, or even in waste water carrying channels, or waste material carrying channels and all, you will see that if any spilling of the quantity occurs that may hamper the environment, or that may cause the loss of material and all. So, you need to provide sufficient freeboard, or sufficient height while designing the channel; or, you have to construct the channel in such a way that certain free distance, vertical distance is given.

So, freeboards are provided to counter water depth fluctuations due to waves, wind, tides, etcetera. Here, of course, for enforcing circumstances, as you have witnessed in Japan recently due to that tsunami and all, for such situations you cannot design the channels. So, there the nature, it depends on the nature.

Usually, the freeboards are applied up to 5 to 30 percent in most of the uniform flow. Most of the channels, you can design form 5 percent to 30 percent. So, this height is around 5 to 30 percent of the normal depth of the design channel. So, that is sufficient in most of the cases.

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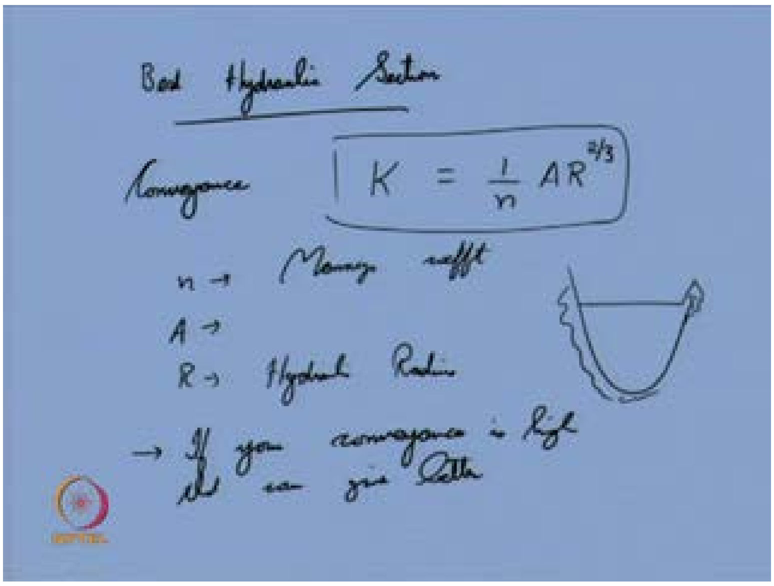

So, the next portion which we are going to discuss is the best hydraulics section. So, what is meant by best hydraulic section? If you recall the term conveyance; I hope you recall them, conveyance K, for uniform flow it was given as, according to Manning, from the Manning's equation 1 by n A R to the power of 2 by 3, where your n is Manning's coefficient, roughness coefficient; A is area of cross section; R is your hydraulic radius.

So, for such a section, for any section, so the conveyance you had already been thought of, and you know, what is the specialty of conveyance? So, if conveyance for a given discharge, if it is more, then do not you think that that section is able to convey more water? Or, it is able to efficiently carry more water compared to some other type of, other section? So, that means, if your conveyance is high, that can give, if your conveyance is high for a given discharge, then that can give a better efficient cross section of the channel. So, how can you suggest those things?

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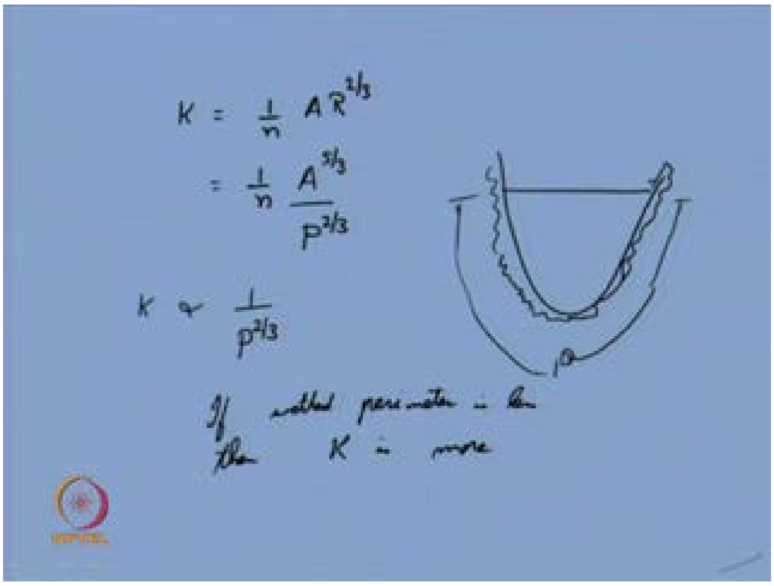

So, for your conveyance factor, K is equal to 1 by n A R to the power of 2 by 3, this is 1 by n A to the power of 5 by 3, P to the power of 2 by 3, fine. So, whatever wetted perimeter you have, whatever wetted perimeter you have for the cross section, you are seeing that the conveyance is inversely proportional to P to the power of 2 by 3. So, if your wetted perimeter, if it is less, if wetted perimeter is less, then K is more, your conveyance is more.

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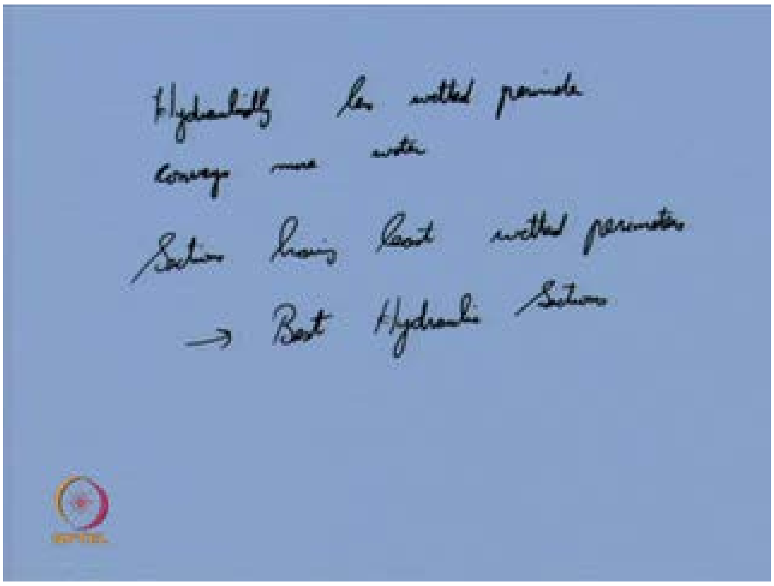

So, hydraulically, so in terms of hydraulics, or hydraulically less wetted perimeter conveys more water fine. So, you can say that the sections having least wetted perimeter, such sections are called, sections having least wetted perimeters, they are called best hydraulics sections.

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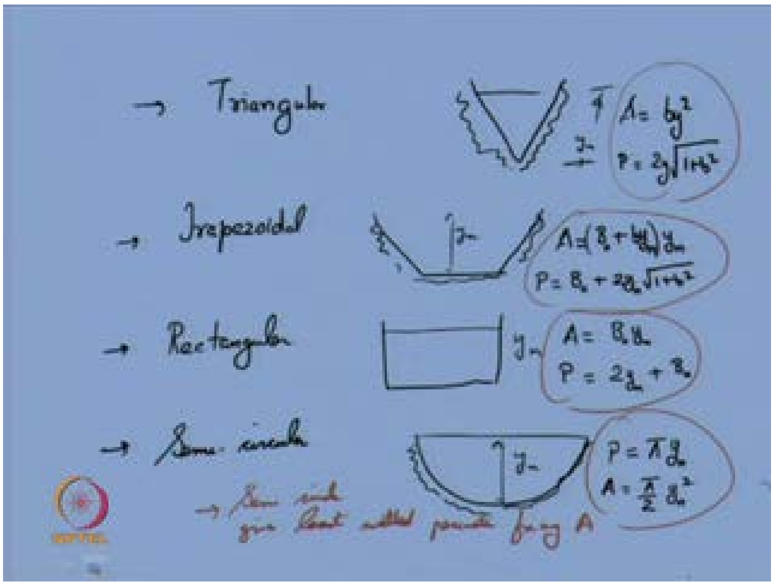

So, you have seen various type channels, say, triangular; you have seen trapezoidal; you have seen rectangular; also you have, you have, although we have not discussed much on this thing, semicircular channels. So, you have seen such channels. Now, there is no need to for me to further, you know that for such triangular channels your area, area is. So, we have seen for, earlier also in our various parts of the courses, this is, in the triangular section, you know what is the area, area is equal to, say, for such given thing, if side slope is 1 is to b, then you can give your area as A is equal to b y square; your wetted perimeter P is equal to 2 y root of 1 plus b square, right.

In the trapezoidal section, you have seen area A is nothing but it is equal to, say, if the bottom width of the trapezoidal channel if it is equal to B 0. So, we are following the same convention. So, B 0 plus, and the side slope if it is 1 is to small b, b y n; your wetted perimeter P, this is equal to B 0 plus twice y n, root of 1 plus b square.

The rectangular section, you have already seen that earlier also, your area is equal to B 0 y n; your wetted parameter P is equal to, yes, 2 y n plus B 0. Now, for a semicircular case, we have not discussed like that, but still it is quite obvious for you; your wetted parameter here, this is equal to 5 times y n; and your area is equal to pie by 2 y n square. So, you have the following quantities. So, as to be mentioned, the hydraulically best cross section of the channel is the one that is having least wetted perimeter.

So, among this channels itself, now seeing the various formula, seeing your various formula, you have seen these formulae, say, for any given area, for any given, if you just give, if you, from your design you have already suggested that the area of flow should be so and so value; and if that area is given, then if you want to find the hydraulically efficient cross section, then you know that for the given area semicircle is the one that is having least wetted parameter, for any given area A, you say, if A is equal to same here and here, then the least wetted parameter case will be observed in semicircle; that you can just work it out also; you can use your normal differentiation and just see that.

So, semicircle is having, semicircle gives least wetted perimeter; or, any area A given to you, then you can adopt semicircular channels and all; that, of course, you will see that, to construct semicircular channels and all, it may not be that much cost efficient and all. But, theoretically or hydraulically, through the mathematical computation, it is observed, semicircle gives you the least wetted perimeter for any given area.

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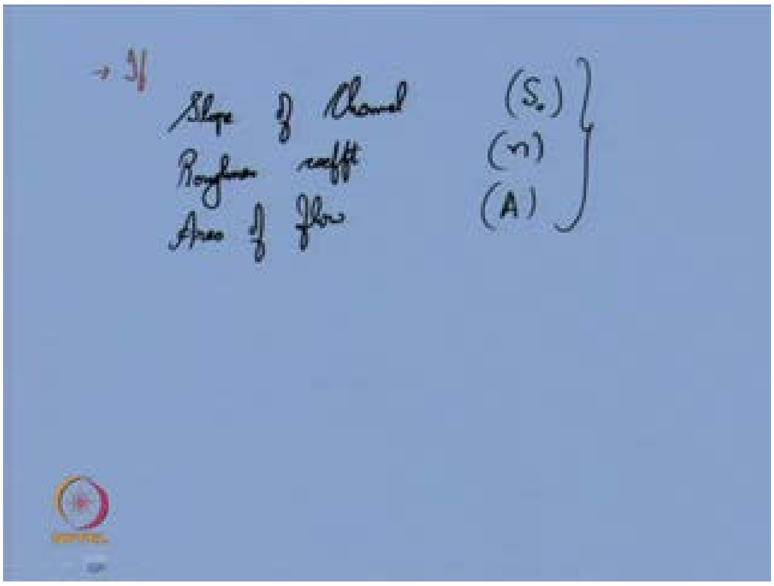

Now, the question, or what we want to suggest is that, if the slope of channel, that is S 0, roughness coefficient, area of flow, if these 3 are already given to you or it has been already determined through other processes, now the next purpose for you is to find the dimensions, that has to follow the efficiency criteria. And we suggested that a minimum wetted parameter section will be having the most efficient, efficiency in conveyance of the discharge. So, the conveyance of flow, or in the uniform flow, the conveyance will be maximum for the least wetted perimeter sections.

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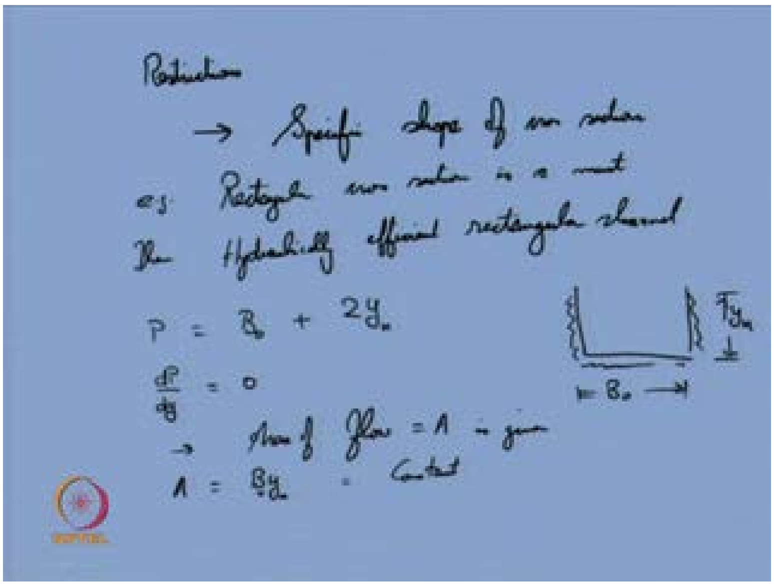

So, you have to see that if there are some restrictions, say, you cannot construct, you have to definitely construct, say, restrictions like, specific shape of the cross section that has to be maintained, for example, one, some criteria from any organization who is developing that project and all or any funding agency, or any requirement from the locality and all. If suggest that, you have to have a rectangular cross sectional channel for carrying the wetter from this location to that location, if such a criteria is there, then how will you suggest the most economical rectangular cross section?

For example, rectangular cross section is a must; if it is a must, then hydraulically efficient rectangular channel has to be determined. How will you determine that? You know, the wetted perimeter P for rectangular channel is B 0, for rectangular channel it is this thing. So, you require a wetted perimeter that is having least property, means the wetted parameter is least. So, according to the differentiation rule, I am just differentiating d P by d y to get a minimum value; it has to be, d P by d y has to be equal to 0. Now, you are already suggesting the area of flow equal to A is given, right; you already know A is equal to B y n, B 0 y n; and now this is a constant.

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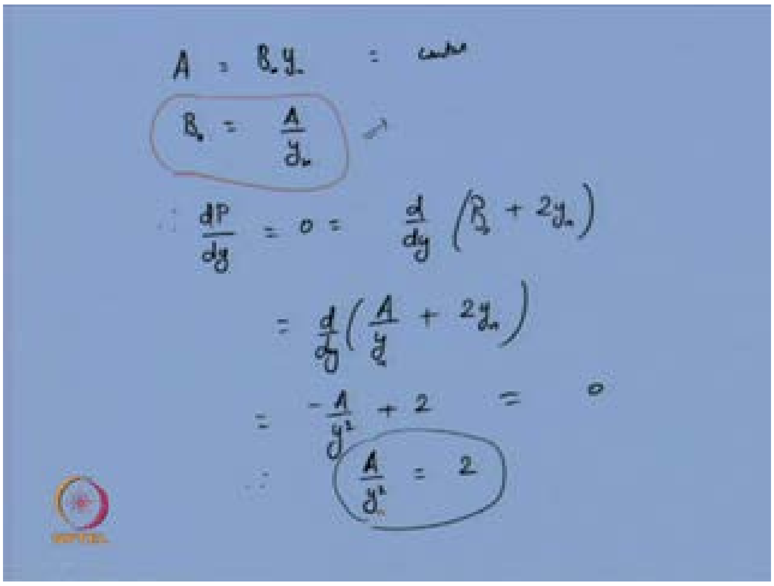

If A is equal to B 0 y n, equal to constant; that means, your B 0 is nothing but A by y n. Therefore, d P by d y equal to 0 means, d by d y of B 0 plus 2 y n; this is d by d y of A by y n plus 2 y n. What is this quantity? A is a constant, we suggested A, all through design already A has been established; A is a constant. So, it is not going to vary.

So, this quantity is minus A by y square, plus 2; and it has to be equated to 0. Therefore, your most efficient cross section, it can be obtained either directly from this, or you can suggest that, you can use the thing here now; A by y square is equal to 2, that criteria can be used now; you will see, you incorporate this the quantity here, in this equation; you incorporate it in this equation, this relationship; of course, this is your normal slope. So, you have seen this relationship; you incorporate this relationship as mentioned, in this particular case.

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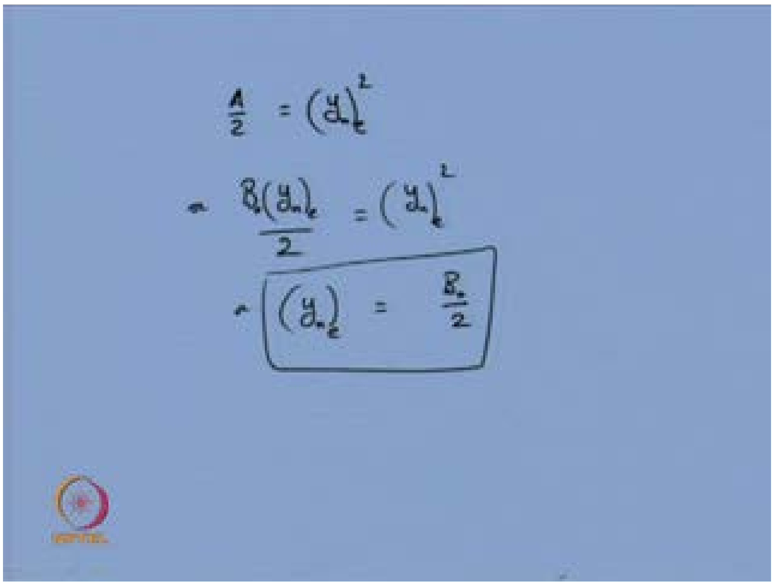

So, you will see that, you will get B 0 y n into e, by 2, is equal to y n the whole square; or, it suggest that; so this is the criteria for the most efficient, hydraulic efficient, or the hydraulically efficient rectangular cross section; that is your depth of flow should be half of the width of the channel. So, that is the criteria. So, here the suffix e is showing the hydraulically efficient channel. So, for rectangular channel, one can prepare it like that.

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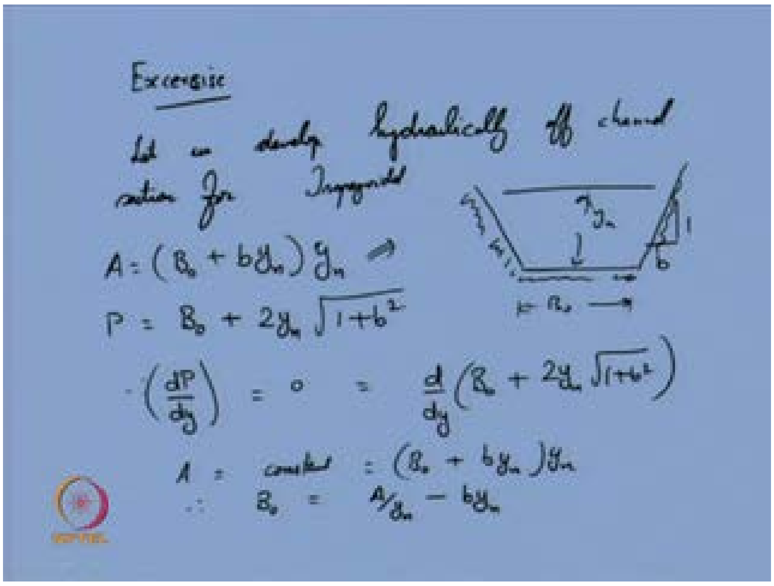

Now, as an exercise, let us develop hydraulically efficient channel section for trapezoidal shape. So, if the local region, if it demands that the channel cross section has to be, it has to be trapezoidal in nature, its shape has to be in, the cross sectional shape has to be trapezoidal, then what is the hydraulically efficient channel cross section?

So, here, again the bottom width is B 0, side slope is 1 is to b, normal depth is y n. Then you use the same criteria, you know A is equal to B 0 plus b into y n into y n; your wetted parameter P is equal to B 0 plus 2 times y n into root of 1 plus b square. To obtain the hydraulically efficient cross section, your d p by d y should be equal to 0; that means, d by d y of B 0 plus 2 y n, root of 1 plus b square.

Now, what is B 0? You already know; from this particular equation, you will see that area of cross section is equal to constant; therefore, B 0 is equal to A by y n minus b y n.

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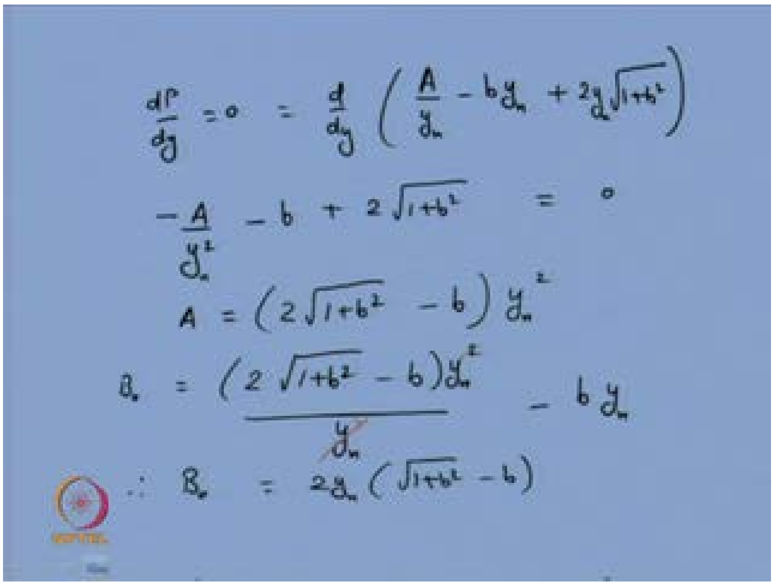

So, you substitute this quantity there. In the relationship d p by d y equal to 0; you substitute for b naught, you substitute for B naught, the criteria given now, develop. So, d by d y of A by y n minus b times y n plus twice y n root of 1 plus b square. So, this is equal to 0, as you know that. Differentiate the quantity, you will get minus A y n square, minus b, plus 2 times root of 1 plus b square, this is equal to 0.

So, you are getting A is equal to 2 times root of 1 plus b square, minus b, a whole quantity into y n square. So, for a hydraulically efficient cross section, your area, if it is given to you that, it can be given in the following relationship; using your normal depth, it can be obtained in the following form. So, now, this quantity as mentioned earlier, is already given to you. So, you substitute this relationship now, for B 0.

So, your B 0 is equal to twice root of 1 plus b square, minus b y n square, by y n minus b y n. Therefore, rearrange the terms, cancel of the terms, whichever you are, is obvious to you. So, this thing and this thing can be cancelled of, like that you will see that you are going to get that B 0 is equal to twice y n into root of 1 plus b square minus b.

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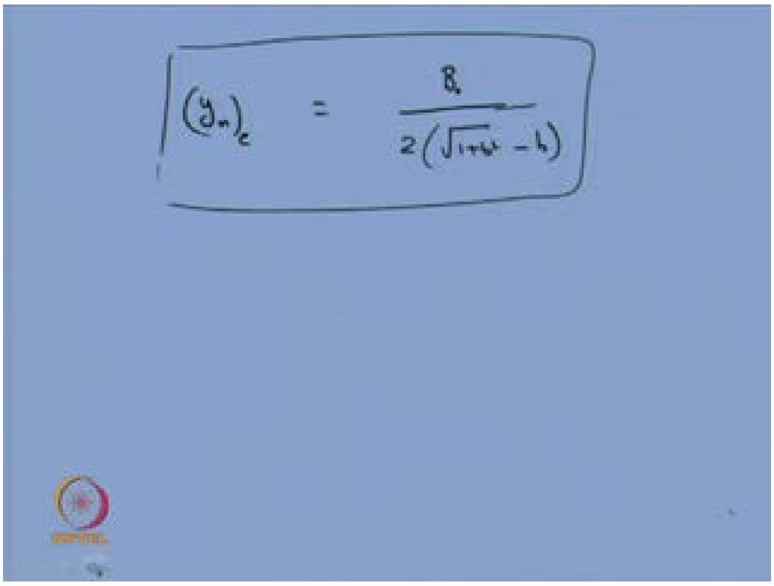

You can also see that, or the hydraulically efficient channel cross section, the normal depth should be equal to B 0 by twice root of 1 plus b square minus b. So, this relationship has to be followed. So, you can use this thing; as seen in the rectangular cross section, the hydraulically efficient cross section, the depth of the normal flow should be equal to the half of the width of the channel. Similarly, here, this is B 0 by 2 into certain quantity, root of 1 plus b square minus b.

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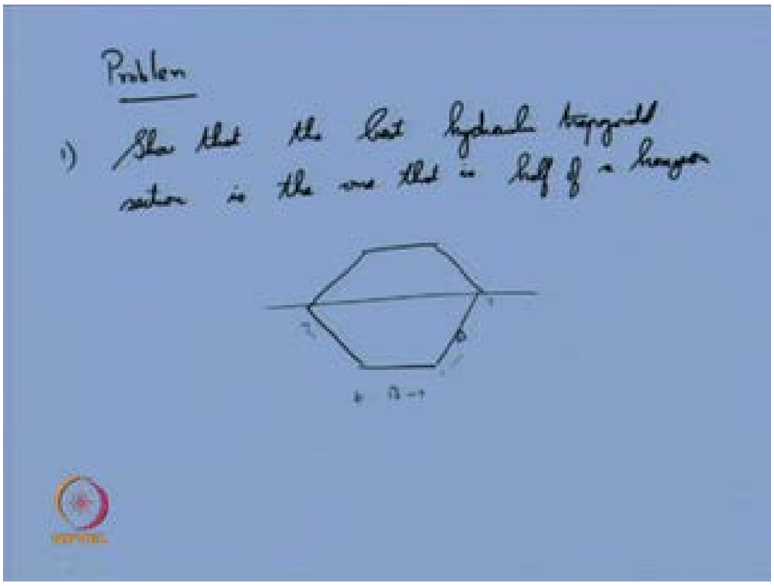

Again, we can see a problem. May be as a quiz, I can ask to you. I can ask as a quiz to you, show that the best hydraulic trapezoidal section is the one that is half of a hexagon. You know hexagon is a regular shape. So, I want you to prove that the best hydraulic trapezoidal section is half of a hexagon. You know what is hexagon. It has all the sides equal; it is a regular shape; it has all the sides equal; say B, something like that you can say.

Now, I asked you that the best hydraulic trapezoidal is one that is half of the hexagon. So, this particular section, this portion, whatever is there, that is the best hydraulic trapezoidal section. How can you prove that? You have already seen, what is the criteria for the best trapezoidal section. You can develop from there itself; how that the best hydraulic trapezoidal section is the half of the hexagon, it can be, just do that.

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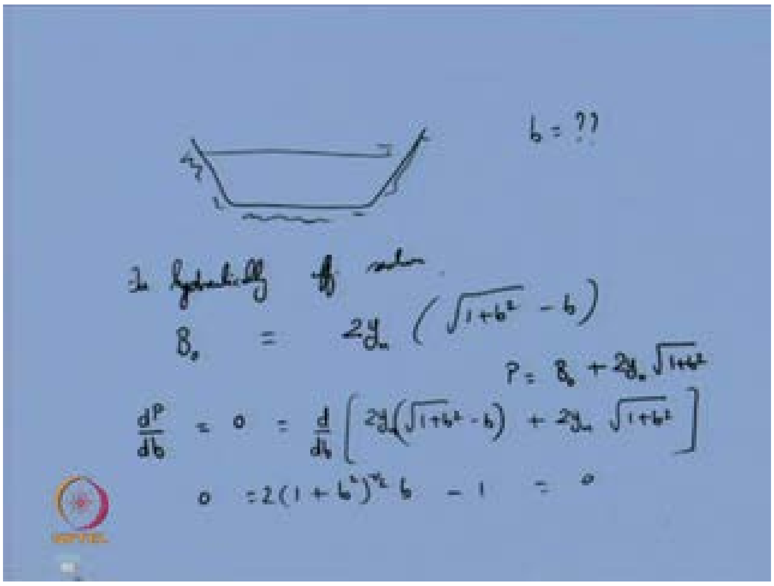

The solution for this particular problem as suggested. So, this is the trapezoidal section; we have asked you, means we have already seen that for hydraulically efficient section your B naught, or the channel bottom width should be equal to twice the normal depth into root of 1 plus b square minus b.

Now, the requirement here is, what should be the channel side slope b, that is the requirement. If you are able to identify, what is the channel sides slope b, based on this given criteria, you can easily find that the channel sides means the channel, or the hydraulically efficient channel section, or a trapezoidal shape is nothing but a half of a hexagon.

Let us see that how that, this thing. Your wetted perimeter here again, it has to be differentiated with the channel slope, channel side slope, and you have to see that that is the minimum one. So, if you equate it, d P by d b equal to 0, what will you get? You know, what is P? P is equal to B 0 plus 2 y n root of 1 plus b square. So, you differentiate that, what will you get? So, the d P by d b equal to 0, that you require that. Now, you have P is equal to B 0 plus 2 y n root of 1 plus b square, and B 0 is equal to 2 y n root of 1 plus b square minus b.

So, in this case, you have to, d by d b of, like this you need to determine the quantity. So, what is this differentiation? I have worked it out, and I got the thing as, I got it around, say, this 0 is equal to, on simplifying, 1 plus, you can do it on your own, 1 plus b square to the power of minus half b, this is twice minus 1 equal to 0, or b by root of 1 plus b square is equal to half.

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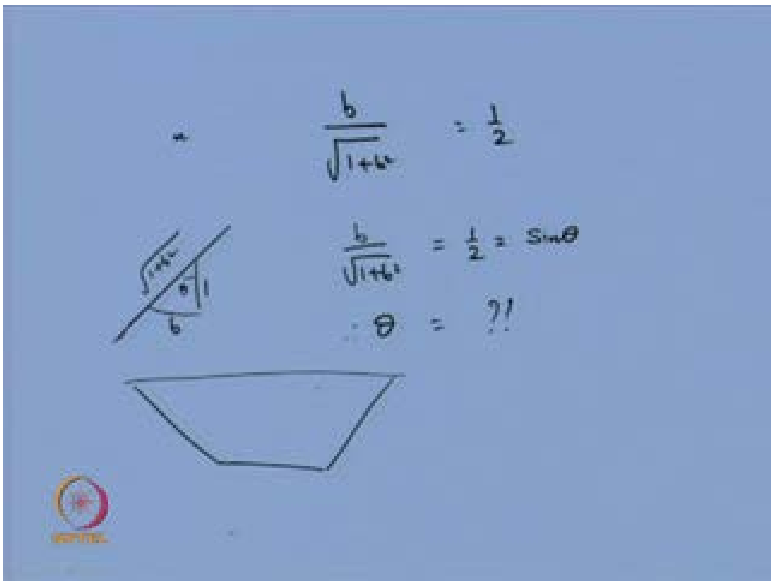

So, you know, for the slide slope, we are talking about the side slope of the channel, 1 is to b. So, root of 1 plus b square, it indicates your hypotenuse of this portion. So, what does this mean? So, this, if you note about this angle as theta, so you can easily suggest that, b by root of 1 plus b square, is equal to half, is equal to your sine theta; therefore, what is theta? That is quite obvious to you. So, I am not going to discuss further. So, if this is so and so value; it is now quite confirm the best trapezoidal section, hydraulic efficient section will be the half of a hexagon.

Thank you.