Advanced Hydrology
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Lecture – 27

Good morning and welcome back friends to this video course on advanced hydrology. We have been looking at chapter 6 on unit hydrograph. In the last class, we looked at few methods of derivations of unit hydrograph given the rainfall and flow data. We looked at the method for single storm or the isolated storm which was very simple, and then we looked at the next method which is called the method of successive approximation. In which, we were able to use all the data. The first method which is the method of substitution does not or is not able to use all the data that is why we said that it is not or does not give the unique solution.

Then we looked at a couple of methods based on the matrix algebra or you know use of the matrix equations. First one of them was the method of least squares or linear regression. Then we used the optimization technique and we use the linear programming method to formulate the problem for determining the unit hydrograph from a complex storm. What is a complex storm? Well, it is a storm or a rainfall event in which we have more than one rain fall impulses.

In fact the method of least square can also be used for the complex storm. Now, what I will do is, I will just look at the optimization problem which we had formulated in the last class. And then we see what are the major or what is the major advantage of this method and what could possibly be the limitations.

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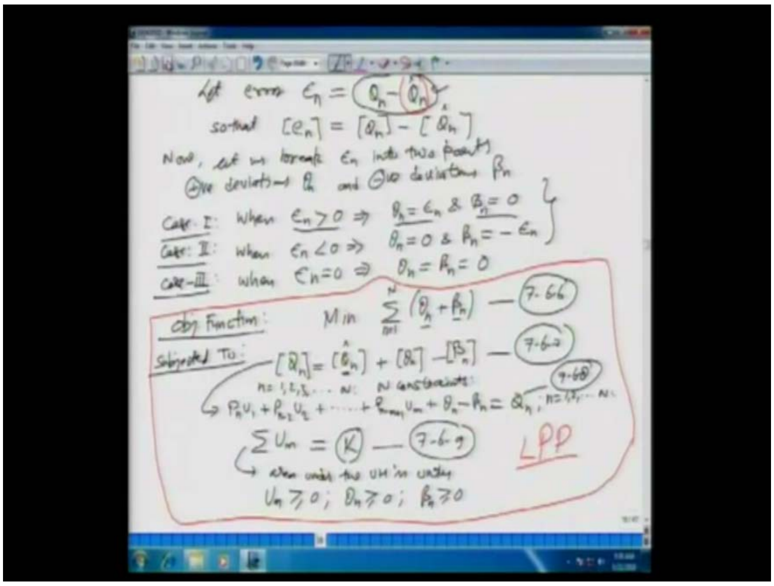

So, if we come here, we formulated the objective function which is given here. For example, this equation 7.6.6, it gives you the minimize its minimization problem in which you are trying to minimize the deviations from the actual value. What are the thetas and betas? These are the positive and the negative deviations. Then, we applied the convolution equation or the discrete convolution equation which we impose that as a constraint and which in the expended form is given by this equation which is 7.6.8.

Another constraint which we impose is a summation of your unit hydrograph ordinates should be equal to unity or the area under the unit hydrograph should be 1. So, k is some factor which converts the units and it ensures that the area under the unit hydrograph is 1.

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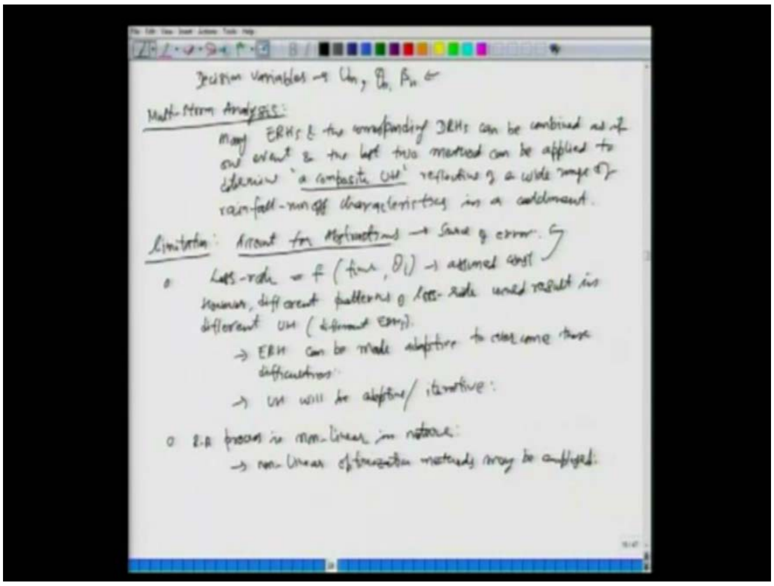

So, in this equation what are the decision variables? Basically, the decision variables in this problem are all the U's that is we are trying to find out and we know that our solution will not be perfect. So, there are going to be some errors. So, we want to find out the magnitude of those errors. So, you will have theta n and beta n. So, these are your decision variables or the output from your linear programming problem solution.

Now, we look at a concept, what is called a multi storm analysis. Both of these methods that is, your method of least squares and the linear programming method for finding out the unit hydrograph from a complex term. We can apply, what is called a multi storm analysis to both of these methods. What do we mean by that? We can combine more than 1 storm; in 1 storm you may have more than 1 impulse of rainfall. Let us say we can have 3 impulses of rainfall and then, you have some gap in the rainfall and then, you have another storm. So, you can combine more than 1 storm events may be 2, 3, 4, 5 and then, determine the unit hydrograph which is representative of all of those storms that is called multi storm analysis. So, if we want to say that, many ERHs, that is your effective rainfall hyetograph and the corresponding direct runoff hydrographs. Each ERH which is complex will result in certain ERH.

So, we can combine all of those; can be combined as if 1 event. And the last 2 methods that is your linear regression and the optimization can be applied to determine what is called a 'Composite UH'. Composite unit hydrograph is reflective of a wide range of rainfall runoff characteristics of a catchment, rainfall runoff characteristic in your basin or in your catchment.

So, what we are seeing here is that, we have catchment in which we have lots of data. If you pick up only 1 data set corresponding to either a single storm or a complex storm and we determine the unit hydrograph. So, the performance of our developed model will be good during the calibration dataset. However, when we apply it to some other storms or the when we carry out the validation or application its performance may not be very good because each and every storm event is different. There may be slightly a different conditions and the catchment may respond slight differently. So, this method or these 2 methods allow us to carry out what is called a multi storm analysis in which we can take the rainfall and flow data from more than 1 storm and combine them as if it was a single storm. And then, we can find out a single unit hydrograph which is called composite unit hydrograph. . Exactly the same methods we can follow, which will be reflective of a wide widely ranging rainfall runoff characteristic of the catchment.

So, this is about the multi storm analysis. However, whatever is the method we are using for calculating the unit hydrograph, there is 1 major problem with all of these methods, which is calculating the abstractions. So, the limitation is of all the method in fact, is what? Being able to account for the abstractions, which actually then becomes a source of error. As you know that the rainfall runoff modeling using unit hydrograph is for the effective rainfall, effective rainfall runoff modeling. So, we need to calculate the abstractions or the losses before we actually we can go for the unit hydrograph of method. And as we have seen there are many methods of calculating infiltration interception and all other losses.

So, depending upon the different methods you know there may be different types of errors are involved as per as the data is concerned, as per as the method is concerned. So, this accounting for the abstraction or the losses adds to the uncertainty or the errors in your overall model. Normally, the losses are changing continuously as a function of time. But, when we are using the abstraction methods we just calculate the effective rainfall. Normally, we use a fine index or some very simple method. Once we have done that, we are assuming the abstraction to be constant but, actually they are not. So, somehow we need to be able to account for the continuously changing a loss characteristics.

So, if you want to say that, the loss rate infiltration and others is actually function of your time during a storm event and also the initial conditions, which are assumed constant mostly, which results in this sources of error. However, different patterns of loss rate would result in different unit hydrograph, why because different ERX. How can we solve this problem? What is the remedy? Well, we can develop or use a method which is adaptive in nature, which does accounts for the loss rate as a function of time. For example, the green amp method we have seen. How is the green amp method? Well, it does account for the variation of your infiltration as a function of time and also it is able to account for different initial conditions in the catchment.

So, ERH can be made adaptive to overcome these difficulties. However, the thing which comes for free, there is a price one has to pay. So, the UH will be adaptive in nature or has to be solved iteratively or it will be iterative. Well, another problem is that the rainfall runoff process is non-linear in nature. However, the unit hydrograph theory which we use is linear; as we have seen it is based on the linear assumption theory. So, what we can do is, this optimization problem which we have used it is linear. However, if we know that the process, the physical process which we are modeling is non-linear in nature then, we can adopt certain method which is accounting for the non-linearity or the complexities of the physical system.

So, in order to obtain better results or improved results, we can use what is called the non-linear optimization methods may be employed. I would not like to go too much into the details of this non-linear method because it will become out of these scope of the particular course. So, what we will do is, we will move on and look at a brand new topic within this unit hydrograph chapter, which is on the Synthetic Unit Hydrograph.

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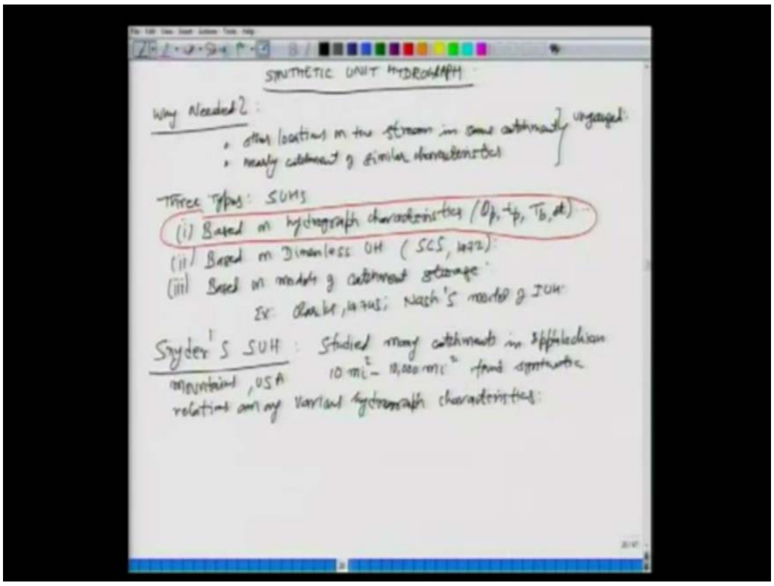

So, you have Synthetic Unit Hydrograph. As the name suggests we will try to develop a unit hydrograph which is synthetic or artificial. Why do we need this? Why do we need a Synthetic Unit Hydrograph? Basically, we need the Synthetic Unit Hydrograph in a catchment or at a location in a catchment where, we do not have the data or we have the catchment which is unguaged.

So, number one: We may need it at some other locations on the stream, let us say some upstream location in a same catchment. Or, we may want to develop a unit hydrograph in a nearby catchment or in a catchment of similar characteristic to the one for which we have the data. And both of these are basically you say are unguaged. What do you mean when we say ungauged? Ungauged, means that there is no gauging done at the river. So, you may not have the rainfall data, you may not have a flow data to apply these 3, 4 methods which we have looked at. Obviously, all those methods which we have looked at, need rainfall and flow data and if you do not have them we cannot give so. So, that is why we need what is called SUH or the Synthetic Unit Hydrograph. Ok.

Now, in this course we will look at only 1 type of Synthetic Unit Hydrograph. However, there can be 3 different types of Synthetic Unit Hydrograph. What are those? All the Synthetic Unit Hydrographs can be characterized or classified as into 3 different categories Synthetic Unit Hydrograph. What are those? First one, are the ones which are based on the hydrograph characteristics. the ones that are based on the hydrograph characteristics What are those? For example, the peaks discharge of the unit hydrograph, the time to peak, the time base etcetera. Can anybody give me an example of this type of a unit hydrograph, synthetic unit hydrograph that is? I am sure you may have seen something similar which is based on the characteristics of the UH, it is called the Snyder's Synthetic Unit Hydrograph and we will look at it in more details in this course.

So, the first one is based on the hydrograph characteristics. The second one is based on the dimensionless UH. For example, SCS method which was developed in 1972; in the dimensionless UH what is done is, you develop the sections or the factors of your time versus your discharge or the direct runoff as a fraction of the peak discharge and the time to peak or you know some dimension. So, it is in dimensionless units or there is no units, you will be given some form from 0 to 1, as per as the time scale is concerned and the cube scale is concerned. Then, for different catchments you have to estimate the value of that particular parameter that is, your peak discharge or the time to peak etcetera and then, you can calculate and you can write down the values of your ordinates in the proper units. We will not go into the details of this method too much as I said will look at the first one only.

The third category of Synthetic Unit Hydrograph methods or models is based on the models of water shade storage or catchment storage. For example, you have clerk’s method or the clerk’s unit hydrographs, 1943. And then, we have what is called the Nash, Nash’s the model of IUH. So, the third categories of methods of calculating the Synthetic Unit Hydrograph are based on the catchment storage characteristics, and one of them is the clerk’s method. Again we will not going to the details of it. But, some of you may have seen Nash model in which the catchment is simulated using a series of reservoirs, linear reservoirs and then, we say that there are n number of reservoirs and n can be an integer or a real.

And then, we determine the parameters of that model using the data of the nearby catchments somehow. So, based on these catchment characteristics or the storage characteristics we may have, first we can develop what is called the instantaneous unit hydrograph as I said the Nash’s model of IUH. And once we have the instantaneous unit hydrograph, we know how to determine your s curve in the unit impulse response function which is your unit hydrograph. So, there is a relationship between IUH and s curve and the unit hydrograph.

So, we will stop at that and then, we will take up as I said the first one which is this one and in this one also we will take, what is called the Snyder's Synthetic Unit Hydrograph. What Snyder did is, he studied he carried out some experiment many catchments in the US in the Appalachian mountains and actually other catchment across the US whose, drainage area varied from 10 square miles to 10,000 square miles. So, from small catchments to a bigger catchment and what they did is they found after studying this synthetic relations among various hydrograph characteristics. So, what is done in developing a Synthetic Unit Hydrograph actually is that, there is no rainfall or flow data available; we are applying this method because we do not have the data. But, what we have is, we have the topographic map of the area. So, we develop the basin, you know some geomorphological parameters. We can calculate the length of the stream and you know the drainage density and so on. We have looked at some geomorphological parameters or characteristics in the earlier chapter.

So, we make use of that information about the map using the topographic map of the catchment. Using those we can develop or those geomorphological characteristics actually will be related with the size and shape of your unit hydrograph and that is the relationship the Snyder exploited. So, they took or they studied all these maps and then, they had the data also in these catchments. So, they tried to establish the relationship between the, between the hydrograph of characteristics and the geomorphological parameters. And they developed a series of equations or they gave series of equation for the Synthetic Unit Hydrograph characteristics. So, we are going to look at that next. But, before that let us understand what those are? So, they basically define 5 different hydrograph characteristic.

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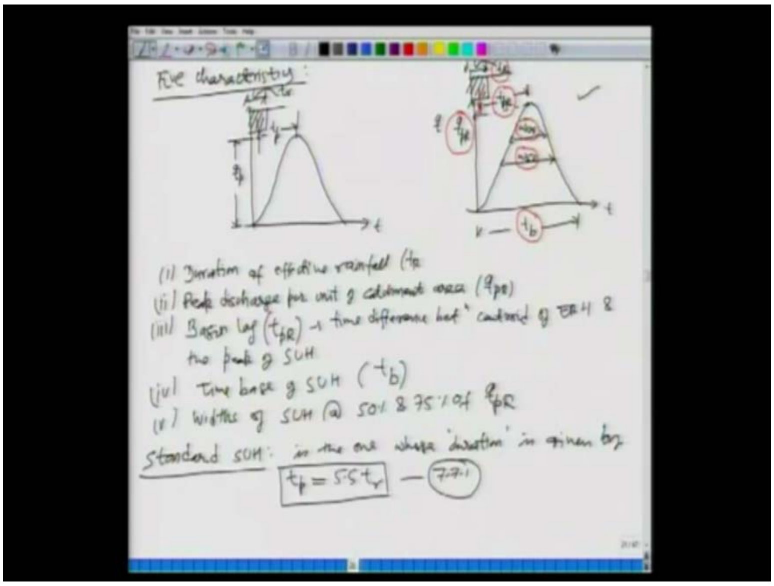

So, let us start looking at them. They looked at what is called or they defined rather I should say 5 characteristics. I will draw a diagram first and then, will write those. This may be your time domain and this is your small q and then, this is your t R, t capital R; this is t b, this is your q p capital R and the distance between the centroid of your ERH to the time to peak is t p R. I am going to define all these in a second. Then, you have, this is your w 50 and then, you have another one at 75 percent which is w 75. So, let us look at these 5 characteristics and the first one of them is what is called the duration of your effective rainfall. Whenever we are defining a unit hydrograph as you all know it is define for certain duration. And, what is that duration? That is‘d’ our unit hydrograph, you always say you always associate this d with the unit hydrograph. So, in this case, he defined that duration of that effective rainfall as one of the characteristics of the Synthetic Unit Hydrograph which is called t R here. If you look at in this diagram, you see that the t R is nothing but the duration of the effective rainfall. This is t R. And if I want to show you that is what I mean here; this one. This is the duration of effective rainfall.

The second one is the peak discharge per unit of catchment area and we are defining this as q p capital R. What is this? This is the peak discharge per unit of catchment area. So, in this curve you see that, the y axis is q p R, it is not capital q which is the total flow. This is the flow or the discharge per unit of your catchment area small q.

The third one, the third characteristic is what is called the basin lag and this is defined as t p R. What is this? This is the time difference between the centroid of your effective rainfall hyetograph and the peak of the unit hydrograph or I am I would say Synthetic Unit Hydrograph. So, what is t p R? If you go to this figure, I have denoted it here; as you see, this is your t p R. What is this? This is the time difference between the midpoint of the ERH and the time to peak. So, that is your t p R, that is one characteristic.

The next one or the fourth characteristic is the time base of the Synthetic Unit Hydrograph which is denoted as t b in this figure. You see that is what we are talking time base. This is the total duration for which the direct runoff hydrograph will be effective or you will or you will observe or obtain the direct runoff from the catchment. So, let us say the direct runoff starts at 8 a.m. it ends at 5 p.m. in the evening; so, all of that time difference is the time base of the Synthetic Unit Hydrograph t b.

The last one is what is called the width of your Synthetic Unit Hydrograph at 50 percent and 75 percent of your q p R. What do we mean by that? If you come here on this figure, these are the widths we are talking about, this is w50 and this is w75. So, what this is representing is that, this is the width of your unit hydrograph, at what height? 50 percent of the peak distance charge. Similarly, you have another one at 75 percent of the peak discharge. So, these are the widths which is the fifth basically your characteristics. So, if you come here, what we are trying to do basically is that, you have these coordinate axis x and y for example; time versus q p. So, on this you want to just a synthetically or artificially somehow draw the Synthetic Unit Hydrograph and for that what we need to do is, we need to locate certain points on that two dimensional piece of paper. And what are those 2 things or few things? Basically, if you can say that this is a time base, you can determine the time base and then, if you can locate a point which correspondence to the peak, time verses time as well as the peak discharge. .

So, if you have located the time to peak and the peak discharge point on this two dimensional space and also the time base. That actually gives you very good information. You can just draw a triangle. Basically, you are defining the vertex, you know the base and you can draw a triangle. So, a triangle is a simplest form of a unit hydrograph. However, we know that the distribution of your unit hydrograph before the peak and it is shape etcetera it is after the peak is different. So, then we define this width 50 50 percent and 70 percent because, different persons will draw this widths differently. So, there are certain guidelines for that also. I will come to that little later. But, first what we will do is, we will look at a very important concept the Snyder's has given, which is on the standard Synthetic Unit Hydrograph.

They defined what is called a Standard Synthetic Unit Hydrograph. All of these parameters which we are looked at are either for Standard or for the required one. So, let us look at what is a Standard Synthetic Unit Hydrograph or a Standard UH. Well, it is nothing but, is the one or is the unit hydrograph whose duration, what is duration? t r; is given by or satisfies you can say this relation t p is equal to 5.5 t r. That is all. This I am going to number as 7.7.1. So, what is this equation telling us is that, a Synthetic Unit Hydrograph, I am sorry the the Standard Synthetic Unit Hydrograph is the one for which the relationship between the duration of the effective rainfall and the time to peak is such that this satisfies this equations 7.7.1, which is t p is equal to 5.5 times of your t r.

So, if I draw this Standard Synthetic Unit Hydrograph by the side of the same curve. Let us do that. This is time. This is t small r. Just notice that the distinct distinction in the required one that is in this case we are denoting this as t subscript of capital r and here it is t subscript of small r. And then, this is your hydrograph other things are same this is your t subscript p, we do not have r here and then, the peak discharge is this much which is your q p, time to peak we have define and then, we are not defining the widths for this. So, you seen that only difference in the in the standard UH and the required UH is that, it should satisfy the equation time to peak roughly equal to 5.5 times of the duration. And what Snyder's then has given or done is given us some equation for the standard UH and then, some equation for the required UH; for which the duration is not equal to 5.5 times of this. So, let us start looking at the equation or the actual method.

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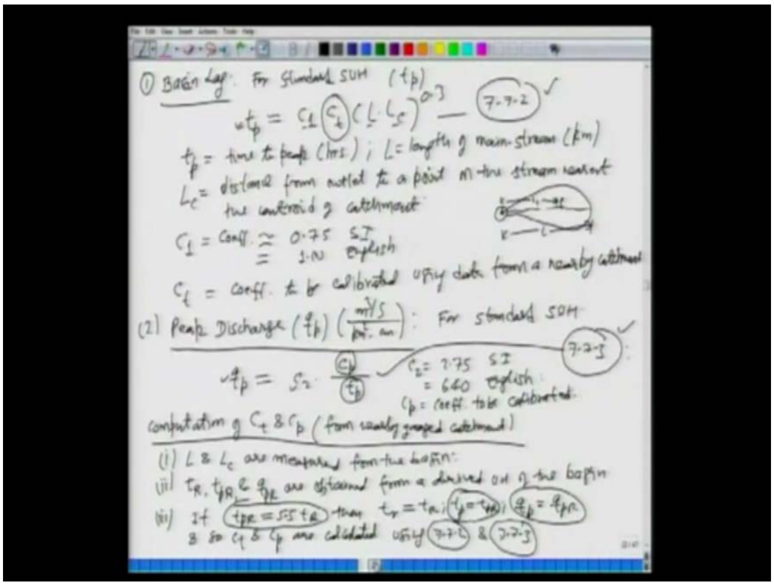

The first equation is, they have given is for the basin lag. This is for this is for standard SUH. What is that? This is t subscript p. And how they have defined it is as follows, your t p is equal to this equation. So, t p is equal to C 1, C t, L, L c 2 the power point 3. And this let us number as 7.7.2. So, this is again an empirical equation actually where, your t p is in time to peak or basin lag you can say, the way we have define for the standard unit hydrograph.

Let me go back, what is this? This is, this guy here is t p for the standard UH not the required one. So, this is time to peak in hours, comma length is oh sorry, L is the length of your main stream or the major water course in your catchment in kilometers. L c is, I would like to draw your attention is the distance. L c is the distance from outlet to a point out let to a point on the stream or your main stream basically, on the stream nearest the centroid or the catchment. So, what is L c is, L c is a distance from the outlet to a point on the stream which is nearest to the centroid. So, if you look at the catchment let say, if it is looks like this and then, let us say this is your longest stream.

And what is the distance L? Well, L is this distance, total distance L of your main water course. But, what is L c? L c is the distance between the outlets; this is the outlet. And then, let us say you have the centroid somewhere here. If that is the centroid, what you do is, you draw a perpendicular from the centroid on to the main stream. So, you will locate this point on the stream. So, you have this point on the stream. So, this distance from here to here will be your L c. So, the way this L c is defined actually, you see L c is the distance from the outlet to a point on the stream which is nearest to the centroid of the catchment.

Now, this other coefficients in this, I will quickly define those. C 1 is the coefficient or constant which is taken as 0.65 for the SI units and equal to 1.00 for the English units C 1. And then, there is C t is a coefficient which is to be calibrated or found out using data from a nearby catchment. So, these are the definitions of your all the parameters that are involved in this. The second one is what is called the peak discharge. The second characteristic which they have defined which is q p and its units are in meter cube per second per square kilometer per centimeter of effective rainfall. And this is also for standard SUH for which that equation is valid.

Now, this is given by this equation which is very simple again, you have C 2 time's C p over t p. What is t p? t p we have already defined in the previous equation 7.7.2 basin lag. So, in this equation you have C 2 as a constant which is 2.7.5 for SI system and it is equal to 640 for English units for FPS system. And C p again is a coefficient to be calibrated or to be found, how? Using a data in a nearby catchment which is hydrologically and climatically similar. Now, before we actually proceed or before we move ahead, we would look at the method of calculating or how we can find out what are these 2 coefficients which is C t and C p. C t is for the basin lag and C p for the peak discharge.

So, computation of, they have given this method of computation of this coefficients C t and t p. And how do we do that? From nearby gauged catchment. And I think, I forgot to number this equation, this is your 7.7.3. So, we will give you a step by step procedure. First what is done is, L and L c are measured. How? From the basin lag. So, you have a nearby catchment in which you have the flow data also, you have the unit hydrograph available to you, what you do is? You measure these parameters L, L c and so on. Whatever, we are looked at which involve or which are involved in this earlier two equations. So, we calculate these using the basin map.

Then, the second step is, we have the data so, we have t R, which is what? Which is your duration of the effective rainfall; t p R is the time to peak or the basin lag and q p R are obtained. How? From a derived UH of the basin. Now, what we do is we check the condition, if your t p R which you have just found out is nearly equal to 5.5 of your t R. What does that mean? That means the unit hydrograph is your standard one. Then, what you do is, all you do is you just check up these things: t small r, this t capital r, t small p is t p R and q p is equal to q p capital R. And then, your C t and C p are calculated using 7.7.2 and 7.7.3. So, you see what is happening here is, you come up here 7.7.2 is this equation in which we have calculated the L, L c from the basin map. We know C 1 if we are working in a SI system, we have also found out t p. How? Here it is, the t p is equal to t p R for this case, if it is a standard one. So, we have t small p, this quantity, we have C 1 we have L, we have L c. So, from this equation we can find out what C t which is to be calibrated. .

Similarly, 7.7.3 is this equation. In this equation we know q p. How? Using this equation. So, you know q p. We know C 2, depending upon the system of units. We know t p, we just calculated. So, we can find out what, this guy here. So, we can calculate C t and C p both of these, if this is the case using this equation. What if that is not the case?

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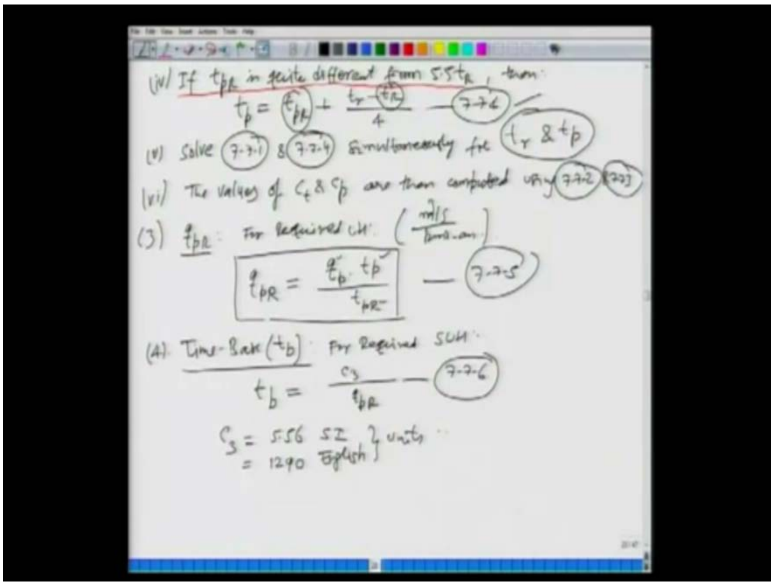

Let us move on. So, in the fourth step you have, if your t p R is quite different from your 5.5 t R. Then, what you do is then also they give a setup set of equation. Then, you say your t p is equal to t p R plus t r minus t r divided by 4.

This is your 7.7, further equations are same. And then you say, solve 7.7.1 and 7.7.4 simultaneously. Simultaneously, for what? For t small r and t small p. Let us look at these 2 equations. So, what they are saying is, if your unit hydrograph is not a standard one that is, this condition. If t p R is not equal to this then, what they are doing is, they are giving us these equations 7.7.4 and then, what we are saying is, we solve 7.7.1 and 7.7.4. Let me go back. What is 7.7.1? You have to go back. This one, this is the equation 7.7.1 which is this equation. So, you solve this one which is a relationship between t small p and t small r for the standard one and 7.7.4. These are the 2 equations in 2 unknowns, this t p R is known and t capital r is also known. Only the thing that is not known is t p and t R in the lower case parameters.

So, we can solve these two simultaneously and determine these two guys here. Once we have done that then, you can say that the values of C t and C p are then computed or can be computed using same 2 equations which are 7.7.2 and 7.7.3. Exactly like they have done earlier, 7.7.2, 7.7.3 are which equations? This one and this one in which everything is known except C t and C p so, which we can calculate. So, this is the method of estimating these parameters. So, this way we have seen that, we have looked at 2 equations which will give you the, one is the basin lag which is the time to peak and the other one is the peak discharge. But, there are 3 more hydrograph characteristics. That also they have given.

So, let us look at the third one, which is q p R. Now, the remaining one they have given is far for the required unit hydrograph. And again, these units are meter cube per second per square kilometers per centimeter of effective rainfall. What is q p R? It is the peak discharge for the required unit hydrograph for which your 7.7.1 is not satisfied. And this is given as, q p times t p divided by t p R. So, as simple as that. We have calculated q p, we have calculated t p and we already know q p R; that is the required duration for which we are trying to find out the unit hydrograph. So, this is I am going to call 7.7.5. The fourth hydrograph characteristic of Snyder's Synthetic Unit Hydrograph is the time base. Now, the time base is defined again only for the required, not for the standard one. And the equation for that is, t b is equal to c3 over q p R. And that is your equation 7.7.6. So, that is the time base.

The last equation or before I actually go to that, let me say that the C 3 is again it constant depending upon the units which is 5.56 for SI and 1290. Yes, that is 1290 for the English units.

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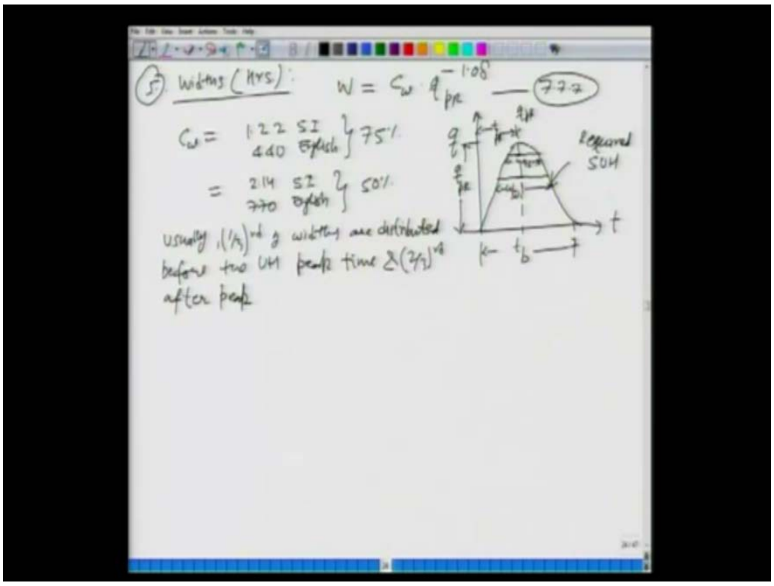

And the last one is the width which is widths at 50 percent and 75 percent and those widths will be given in hours. They have given a very general equation for a 50 percent height and the 75 percent height. And in different units, you have different coefficients. So, what will I do is, I will write a very general expression and give you the values of the coefficient for different units.

So, this w, they have defined is equal to some coefficient which is called C w times q p R to the power minus 1.08, which is we will number 7.7.7. Here, what is C w? Is a constant of course, it is 1.22 for SI and 440 for English or FPS system. This is for 75 percent width and also, this is equal to 2.14 for SI units and 770 for English units and that is for the 50 percent. So, this equation 7.7.7 then gives you the width at 50 percent of the q p and 75 percent of the q p and you can use the different values of these coefficients depending upon the units both for 50 percent and 75 percent. So, we see that on the right hand side these widths actually depend upon the q p R only. The only thing it depends on is the magnitude of your peak discharge per unit per square kilometer of your catchment area.

So, you see that we have determined or we have seen all the equation, all the 5 equations are which will give us the 5 different hydrograph characteristics. What we can do is, if you come here. Let us say you have a blank piece of paper and you want to draw the unit hydrograph. As I said earlier, we can find out what is the time base. So, the time base is let us say this much. Once you have calculated the time base you can put it on that sheet of paper or the graph sheet. Then, you know the magnitude of the peak and the time to peak. magnitude of the peak and time to peak So, that will give you the coordinate of the vertex of this graph for the peak of your unit hydrograph on this coordinate. Let us say it is this, this corresponds to your q p R. So, you have a point in the two dimensional space. Now, you can draw a curve through this point which is non-linear in nature of course, we do not want to draw it a triangle. The simplest one would be a triangle. In order to draw that we have this aides, these widths are called the assistants or the help.

So, you have these widths available to us at 50 percent and 75 percent. So, what would then do is, let us say this is you can draw a vertical from the peak 50 percent is let us say this one, 75 percent is this one. Now, what you do is, you just plot or you just measure out these widths and then, you put them at that particular location. But, where do you put it? Different people may put it in a different location horizontally. So, there is another guideline of distributing these widths with respect to how much you do it before the peak and how much you do it after the peak. The guideline is that, you use this total width one third of that before the peak. If you if you see the shape of a hydrograph it is very steeply raising and then it is slowly goes down.

So, initially because the unit hydrograph is rising very steeply, you have less width before the peak, it reaches very quickly. So, one guideline is that we will say, usually 1 third of widths of these widths are distributed before the UH peak time. And, 2 thirds is done after the peak. That is to say, if you come here on this, you have about 1 third here and 2 third here. And then this is your 1 third here and 2 thirds here. Now, you want to draw a curve, it will be something like this. So, this is your required Synthetic Unit Hydrograph in which this is your q p R. We have seen the equations how to calculate it. This is your t p R, this is your w 50 and this is your w 75. You see that, what we are trying to do is, we have a two dimensional sheet of paper on which we are synthetically just trying to create or trying to draw the Synthetic Unit Hydrograph. But, how we are doing it is, we are using the hydrograph characteristics, we are using the map of the area, we are calculating various lines and different characteristics.

So, this way we have seen the development of what is called a Snyder's Synthetic Unit Hydrograph. So, I think I would like to stop at this point of time today. And in the next class, we will look at the SCS dimensionless unit hydrograph and also, how we can change the duration of the unit hydrograph. Thank you.