Engineering Hydrology
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Module - 5
Lecture-65
Numerical Examples on SUH

Hello all, welcome back. In the previous two lectures, we were discussing about synthetic unit hydrographs. For the ungauged catchments for carrying out hydrologic studies, we can make use of the data or unit hydrograph which is derived for the neighboring gauged catchment. The condition is that the gauged catchment should be hydrologically and climatically similar to that of the ungauged catchment. Two different types of synthetic hydrographs which we have covered are Snyder's synthetic unit hydrograph and SCS dimensionless synthetic unit hydrograph. Today, let us solve some numerical examples related to these synthetic unit hydrographs.

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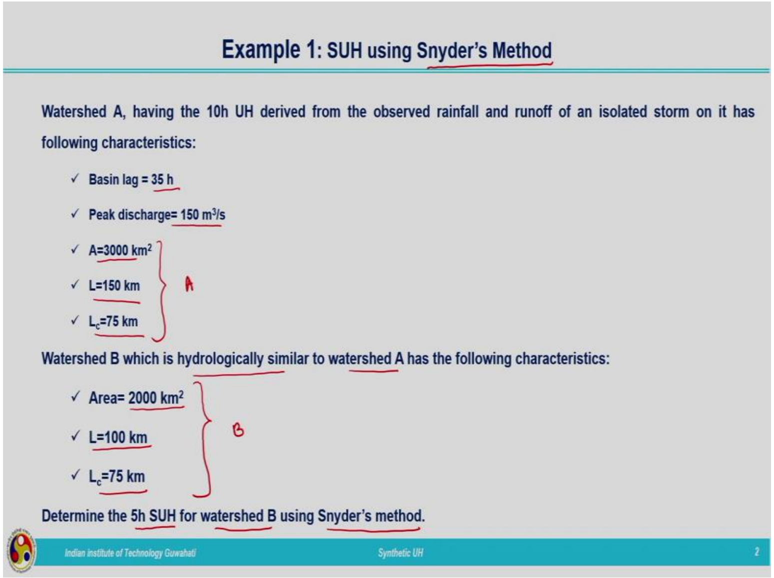

First one is related to Snyder's method. The first example is, watershed A having the 10-hour unit hydrograph derived from the observed rainfall and runoff of an isolated storm on it has the following characteristics: basin lag 35 hours, peak discharge 150-meter cube per second, area of the watershed 3000 kilometers square, length of the mainstream 150 kilometers and length of the stream from a point near to the centroid to the outlet point is 75 kilometers. Watershed B which is hydrologically similar to watershed A has the following characteristics: area 2000 kilometers square, L 100 kilometers and L_c 75 kilometers. Determine the 5 hours synthetic unit hydrograph for watershed B using Snyder's method?

We know in the case of Snyder's synthetic unit hydrograph the relationships between the geomorphology characteristics and hydrograph characteristics were found out. So, here in this case the geomorphology characteristics given are: the area of the catchment 3000, L 150 and L_c 75 kilometres in the case of watershed A, and in the case of watershed B which is ungauged catchment is having area 2000 kilometres square, L 100 kilometres and the L_c 75 kilometres. So, we need to derive the synthetic unit hydrograph for the ungauged catchment, catchment B by making use of the data from the gauged catchment. For the gauged catchment, there will be rainfall runoff data available, that is the effective rainfall and the corresponding streamflow data will be available and from that unit hydrograph can be derived, that step we do not have to carry out here because we have been given the hydrograph characteristics of the gauged catchment here, that is the basin lag and peak discharge.

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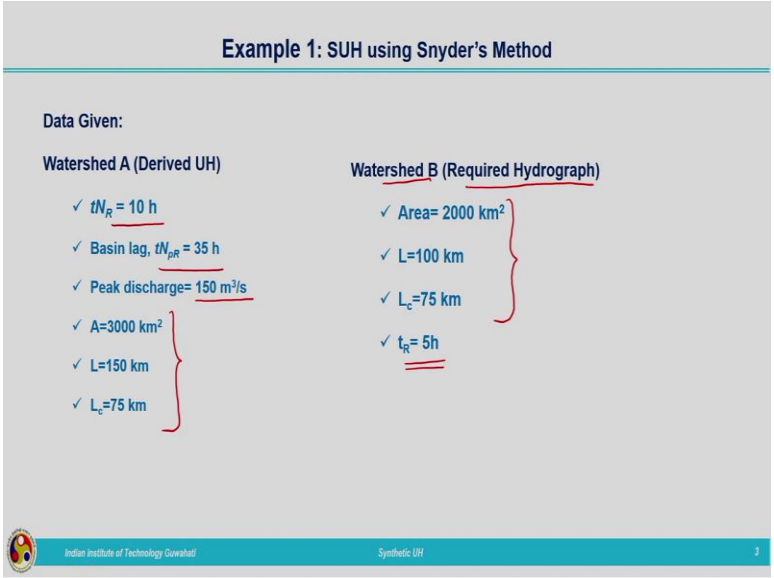

Now, let us start solving the problem, data given we have already seen. For the watershed A, which is the gauged catchment. So, for that the hydrograph which is given to us that is the details which are given to us is from the derived unit hydrograph. For the gauged catchment the unit hydrograph if we have to derive or it is already available, that is termed as the derived unit hydrograph. The characteristics of the derived unit hydrograph is given that is the effective rainfall duration tN_R is 10 hours, basin lag tN_{pR} is 35 hours, peak discharge is 150-meter cube per second and the geomorphological characteristics are given to us.

Now, we need to make use of this data for deriving the Synthetic unit hydrograph for ungauged catchment. So, the synthetic unit hydrograph which we are going to derive for the ungauged catchment is the required unit hydrograph. So, watershed B, we need to derive the required hydrograph. Area, L, L_c of the ungauged catchment is given to us, we need to derive the unit hydrograph having duration of effective rainfall 5 hours, i.e., we need to derive the 5-hour unit hydrograph for the ungauged catchment.

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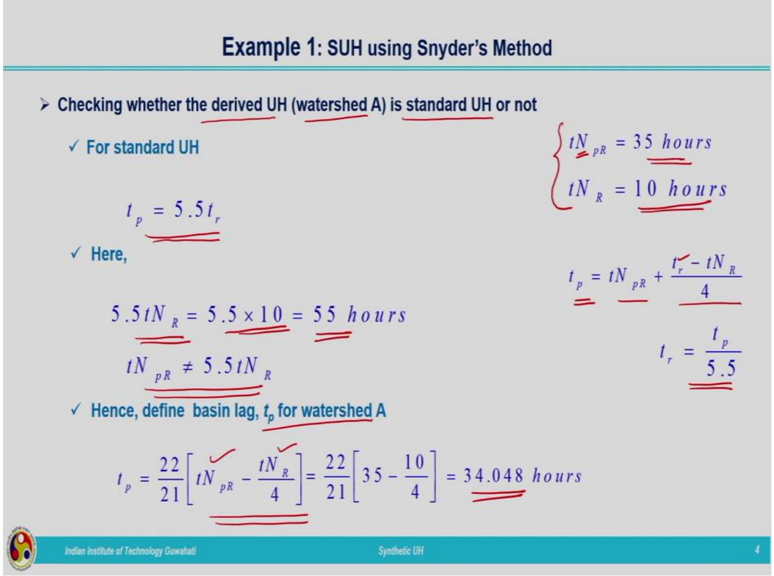

In this type of problems, the first step is to check whether the derived unit hydrograph or the unit hydrograph of the gauged catchment is a standard unit hydrograph or not. So, first let us check whether the derived unit hydrograph of watershed A is a standard UH or not? How can we check that? We know the condition for that, for a standard unit hydrograph the basin lag is given by 5.5 times the duration of the effective rainfall. So, the equation is

$$t_p = 5.5t_r$$

t_r is the duration of the effective rainfall and t_p is the basin lag. For the derive unit hydrograph tN_{pR} is 35 hours and tN_R is 10 hours, I am putting a notation N for the derive unit hydrograph which is known data or the given data. Now, we can check whether this UH is a standard UH or not. So, we can calculate

$$5.5tN_R = 5.5 \times 10 = 55\ hours$$

So, that is coming out to be 55 hours. We are having $5.5tN_R = 55\ hours$ and $tN_{pR} = 35\ hours$, so much of difference is there. So, from that we can understand that the derived unit hydrograph or the known unit hydrograph for the gauged catchment A is not a standard unit hydrograph. So,

$$tN_{pR} \neq 5.5tN_R$$

So, this is not a standard unit hydrograph. Then we have to go for redefining the basin lag. So, basin lag t_p for watershed A can be calculated by the formula given by Snyder, i.e.,

$$t_p = tN_{pR} + \frac{t_r - tN_R}{4}$$

This is the formula for the basin lag for the unit hydrographs which are not standard UH. Since we are assuming that this is a standard unit hydrograph this t_r should be equal to

$$t_r = \frac{t_p}{5.5}$$

So, we can substitute that $t_r = \frac{t_p}{5.5}$ and the above equation for t_p can be modified as

$$t_p = \frac{22}{21}\left[tN_{pR} - \frac{tN_R}{4}\right]$$

tN_{pR} and tN_R we know as it is already given to us related to derived unit hydrograph. So,

$$t_p = \frac{22}{21}\left[tN_{pR} - \frac{tN_R}{4}\right] = \frac{22}{21}\left[35 - \frac{10}{4}\right] = 34.048\ hours$$

We have found that the unit hydrograph of the gauged catchment is not a standard UH. So, the basin lag is redefined by the formula given by Snyder and the value is calculated to be 34.048 hours. Now, we will be making use of this basin lag for the consequent steps.

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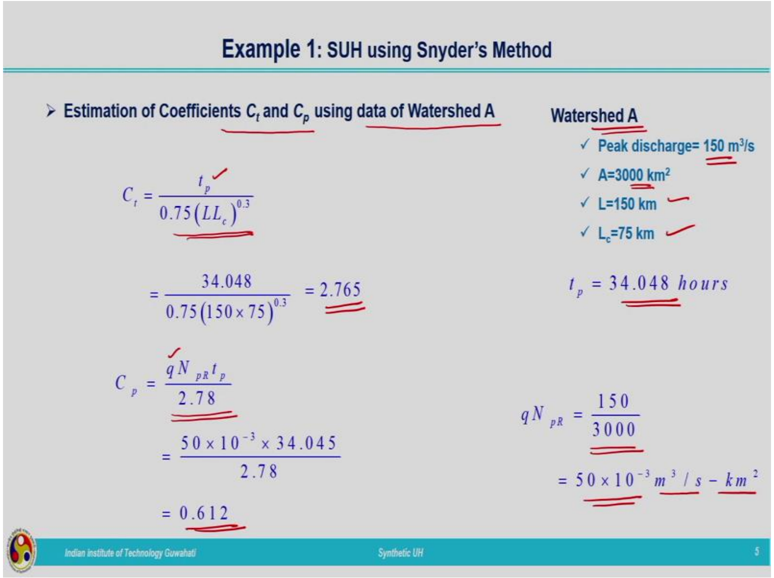

Next step is to estimate the coefficients C_t and C_p using the data of watershed A. We have to make use of the data corresponding to watershed A and the formula for C_t

$$C_t = \frac{t_p}{0.75(LL_c)^{0.3}}$$

t_p should be the value which we have calculated based on the modified formula, that is 34.048 hours, that we can substitute here and also L and L_c for Watershed A. So, once we substitute these values we can calculate C_t as

$$C_t = \frac{t_p}{0.75(LL_c)^{0.3}} = \frac{34.048}{0.75(150\times 75)^{0.3}} = 2.765$$

Now, coming to C_p, the formula is

$$C_p = \frac{qN_{pR}t_p}{2.78}$$

qN_{pR} we do not have, actually this q is the discharge divided by area of the catchment. We have been given the peak discharge, we do not have the value of the small q that we need to calculate that is

$$q = \frac{Q}{A}$$

Area is 3000 kilometers square and peak discharge is 150-meter cube per second. So, we can calculate qN_{pR} as

$$qN_{pR} = \frac{150}{3000} = 50 \times 10^{-3} m^3 / s - km^2$$

So, we got the value corresponding to qN_{pR}. Now, we can substitute here in order to calculate C_p. So, C_p can be calculated as

$$C_p = \frac{qN_{pR} t_p}{2.78} = \frac{50 \times 10^{-3} \times 34.045}{2.78} = 0.612$$

Now, we are with the coefficient C_t and C_p, these two coefficients which are derived from the properties of the gauged catchment can be utilized for deriving the hydrograph characteristics of the ungauged catchment.

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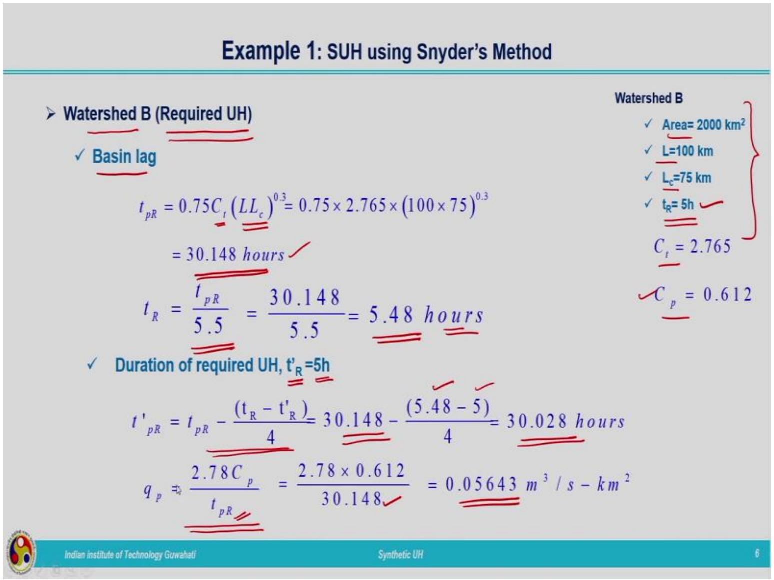

Now, we are moving on to next step related to watershed B that is the derivation of required unit hydrograph. The synthetic unit hydrograph which needs to be derived is for the ungauged catchment that is termed as the required unit hydrograph and watershed B is having these characteristics, area, length of the mainstream, L_c we know already and we need to derive a unit hydrograph for main effective rainfall having a duration of 5 hours. So, here we are going to derive 5 hours synthetic unit hydrograph. The values for C_t and C_p we have already found out and those values can be utilized here. So, first we will calculate the basin lag. How can we calculate base in lag? The formula is

$$t_{pR} = 0.75C_t \left(LL_c\right)^{0.3}$$

The same formula which is used for calculating C_t in the case of gauged catchment is utilized here. Now, we know the value of C_t that can be substituted over here to calculate the basin lag of the synthetic unit hydrograph of the ungauged catchment. Here we are going to substitute L and L_c values of the watershed B for which we need to derive the synthetic unit hydrograph, i.e.,

$$t_{pR} = 0.75C_t \left(LL_c\right)^{0.3} = 0.75 \times 2.765 \times \left(100 \times 75\right)^{0.3} = 30.148 \; hours$$

The basin lag t_{pR} calculated for the ungauged catchment is 30.148 hours.

Now, next step is to check whether this unit hydrograph which is having a basin lag of this much value is corresponding to a standard unit hydrograph? If it is a standard unit hydrograph, it should follow the relationship:

$$t_p = 5.5t_r$$

Our synthetic unit hydrograph that is the required unit hydrograph is of duration 5 hours. So, we are having already the value corresponding to duration of the effective rainfall that is 5 hours. Now, we have calculated the basin lag also. Now, we need to find out whether this hydrograph is corresponding to a standard unit hydrograph. We can check that

$$t_R = \frac{t_{pR}}{5.5}$$

So,

$$t_R = \frac{t_{pR}}{5.5} = \frac{30.148}{5.5} = 5.48 \; hours$$

But the required duration is 5 hours. So, the effective rainfall duration for which the synthetic unit hydrograph has to be derived as 5 hours, and the duration of the standard unit hydrograph for the ungauged catchment is 5.48 hours. So, definitely we need to redefine the basin lag by using the formula suggested by Snyder as we have done in the case of unit hydrograph of the gauged catchment.

So, we can modify that. So, here I am putting a notation $t_R^{'} = 5\ hours$. In order to avoid confusion, I have put a prime notation here $t_R^{'} = 5\ hours$, do not get confused it is the duration of the effective rainfall. We can redefine the basin lag by using the formula as

$$t'_{pR} = t_{pR} - \frac{(\mathrm{t_R} - \mathrm{t'_R})}{4}$$

So, here we can substitute the corresponding values t_{pR} is 30.148 and t_R is 5.48 and t'_{pR} is the duration of the required unit hydrograph. So, this value is calculated as

$$t'_{pR} = t_{pR} - \frac{(\mathrm{t_R} - \mathrm{t'_R})}{4} = 30.148 - \frac{(5.48 - 5)}{4} = 30.028\ hours$$

Now, for making the synthetic unit hydrograph to be a standard unit hydrograph, we have recalculated the basin lag, that is found out to be 30.028 hours. So, now, the 5 hours effective rainfall duration and the corresponding basin lag is standing for the standard unit hydrograph.

Next step is to calculate the peak discharge per area that is small q_p. Small q_p is given by the formula

$$q_p = \frac{2.78 C_p}{t_{pR}}$$

C_p value is already here 0.612 and q_p can be calculated as

$$q_p = \frac{2.78 C_p}{t_{pR}} = \frac{2.78 \times 0.612}{30.148} = 0.05643\ m^3 / s - km^2$$

You look at this equation in the denominator, we are having the value corresponding to t_{pR}, this t_{pR} I have substituted 30.148 that is from the calculation which we have done before making it as a standard unit hydrograph. If you want to substitute it as the basin lag of the standard unit hydrograph that is also possible, but according to Snyder, there is another formula given to calculate q_p. So, when it comes there, there we will be substituting the duration of standard unit hydrograph. Even if you are substituting here you will get the correct answer because there we are multiplying with the time factor, there this value gets cancelled. So, you will be getting the same answer whether you are substituting here as the t'_{pR} value or the according to the formula given by Snyder. So, according to Snyder's formula I have followed the steps. So, q_p is calculated to be 0.05643.

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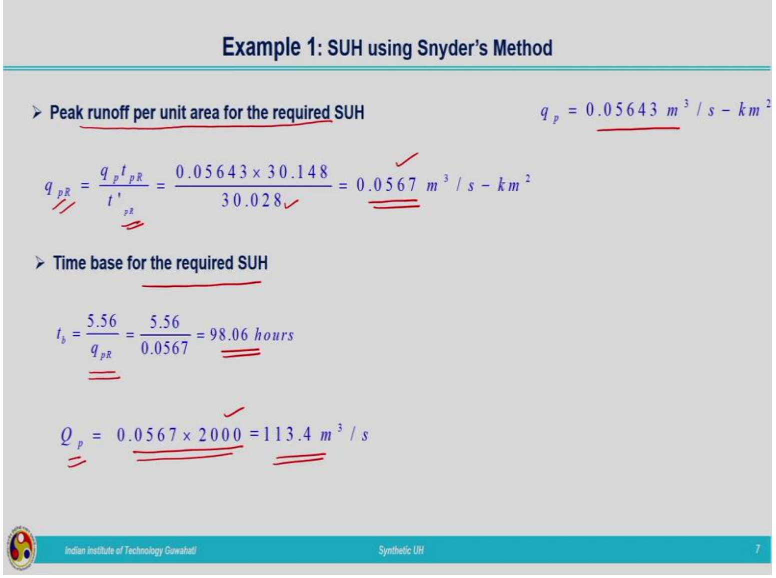

Now, we are going to make use of the formula provided by Snyder for finding out peak runoff per unit area for the required synthetic unit hydrograph. So, that is

$$q_{pR} = \frac{q_p t_{pR}}{t'_{pR}}$$

This is the factor which I was talking about that is $\frac{t_{pR}}{t'_{pR}}$. So, here that t_{pR} which we have divided over there in the previous step is getting cancelled and in effect what we are doing qp divided by that particular t'_{pR} which we have calculated. Here we can substitute the corresponding values q_p is equal to 0.05643 and t_{pR} is 30.148 and t'_{pR} is 30.028, this is the basin lag corresponding to standard unit hydrograph. The value is calculated as

$$q_{pR} = \frac{q_p t_{pR}}{t'_{pR}} = \frac{0.05643 \times 30.148}{30.028} = 0.0567\ m^3/s - km^2$$

Next is time base for the required synthetic unit hydrograph. For that also we are having the formula i.e.,

$$t_b = \frac{5.56}{q_{pR}}$$

So, here for q_{pR} we can substitute as 0.0567 and the time base is coming out to be

$$t_b = \frac{5.56}{q_{pR}} = \frac{5.56}{0.0567} = 98.06 \; hours$$

So, here we are with the q_{pR} value and also time base value. Here we have calculated the peak discharge per unit area, we need to get the value corresponding to peak discharge that is capital Q_p. Capital Q_p can be obtained by multiplying q_{pR} with the catchment area, catchment B is having an area of 2000 kilometer square. So, this can be calculated

$$Q_p = 0.0567 \times 2000 = 113.4 \; m^3/s$$

Now, two more parameters we need to find out. According to Snyder two other factors which are required for deriving the synthetic unit hydrograph were the widths corresponding to 50 percentage of the peak discharge and 75 percentage of the peak discharge.

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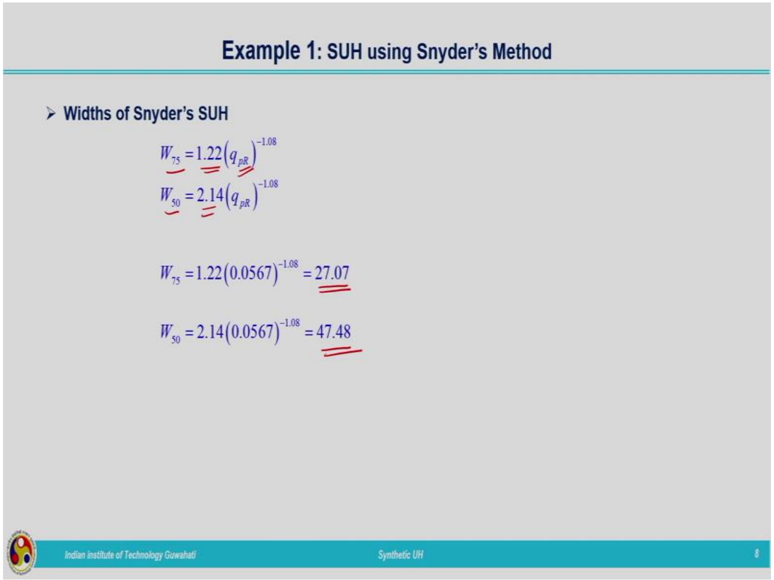

So, widths of Snyder's synthetic unit hydrograph, W_{75} and W_{50} we need to calculate. Only the difference is in the coefficients 1.22 and 2.14, otherwise, the formula is same i.e.,

$$W_{75} = 1.22\left(q_{pR}\right)^{-1.08}$$

$$W_{50} = 2.14\left(q_{pR}\right)^{-1.08}$$

So, once we substitute here in these equations the value corresponding to q_{pR}, we can calculate W_{75} as

$$W_{75} = 1.22\left(0.0567\right)^{-1.08} = 27.07$$

and W_{50} as

$$W_{50} = 2.14\left(0.0567\right)^{-1.08} = 47.48$$

So, now, we have completed the calculations related to the required parameters for deriving synthetic unit hydrograph.

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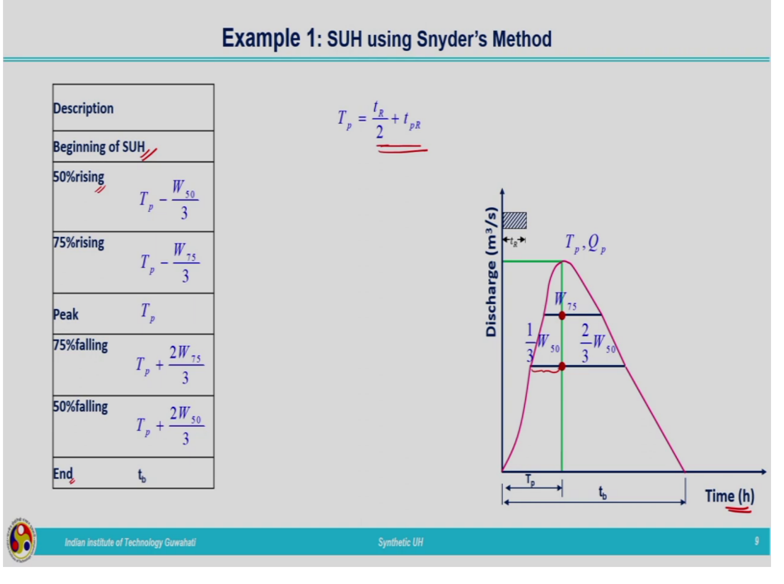

Next step is to plot the synthetic unit hydrograph. Now, we can start plotting the graph we are having discharge along the *y* axis and time along the *x* axis. The synthetic unit hydrograph which we are going to draw is corresponding to an effective rainfall having a duration 5 hours. So, this is the effective rainfall pulse having duration t_R is equal to 5 hours for that we have derived the different parameters. Now, let me describe different terms which are required for drawing the synthetic unit hydrograph. Beginning of synthetic unit hydrograph, 50 percentage rising, 50 percentage rising is the rising limb up to 50 percentage of peak discharge and 75 percentage is the rising limb starting from 0 to the 75 percentage of the peak discharge. Peak you already know, in the similar way 75 percentage of falling and 50 percentage of falling and at the end we will have the ending of the synthetic unit hydrograph that is corresponding to tb base time of the unit hydrograph. So, that base time can be marked first. How much is that base time corresponding to the unit hydrograph? This we have calculated, that can be marked over the figure. Next is T_p, time to peak, we were discussing about basin lag small t_p but here plotting the synthetic unit hydrograph we need to have the value corresponding to time to peak. How can we calculate that time to peak? When we were discussing about basin lag it is the difference between the times corresponding to the centroid of the effective rainfall and the peak of the hydrograph. The time to peak can be marked like this, but we do not have the value corresponding to time to peak we are having the value corresponding to basin lag only. So, if basin lag is there with us, how can we calculate the time to peak? Time to peak can be calculated by taking the sum of $\frac{t_R}{2}$ and t_{pR}, i.e., basin lag plus 1 half of the effective duration of the rainfall,

$$T_p = \frac{t_R}{2} + t_{pR}$$

t_R in our case is 5 hours and t_{pR} we have already calculated. Based on that we will get the value corresponding to T_p. We can draw a line through T_p like this and corresponding to that the discharge value is Q_p. So, this point is corresponding to T_p, Q_p. So, we have determined the point corresponding to the peak discharge in the synthetic unit hydrograph. After that what we will do? We will mark the point corresponding to 50 percentage of peak discharge and 75 percentage of peak discharge.

Now, corresponding to 50 percentage peak discharge and 75 percentage peak discharge, we know the discharge values, but we need to get the time value corresponding to that. For that what we will do? We have already found out the W_{50} and W_{75}. According to Snyder one third of these widths should happen before the peak, that way we need to locate the time corresponding to 50 percentage rising and 75 percentage rising. So, corresponding to 75 percentage rising, it will be

$$T_p - \frac{W_{75}}{3}$$

i.e., one third of that width will be happening prior to the peak discharge, that we can mark over here in the figure. So, one third of W_{75} will be marked here. In the similar way for 50 percentage rising also one third of W_{50} coming before the peak. So, the time corresponding to that 50-percentage rising is

$$T_p - \frac{W_{50}}{3}$$

So, this is corresponding to $T_p - \frac{W_{50}}{3}$. So, this value will be equal to one third of W_{50}. Now, in the similar way on the other side corresponding to 75 percentage falling it will be two thirds of the width, one third has happened before the prior two peak and to third will be happening after the peak has occurred. So, it will be

$$T_p + \frac{2W_{75}}{3}$$

and

$$T_p + \frac{2W_{50}}{3}$$

So, that we can mark over here like this, this is corresponding to two third of W_{75} and below corresponding to 50 percentage peak discharge, it will be two thirds of W_{50}. So, that way the total will be W_{75}, one third of W_{75} plus two third of W_{75}, it will be total W_{75}.

Now, we can move on to plotting the synthetic unit hydrograph. So, this way we can plot the synthetic unit hydrograph by connecting these points corresponding to W_{75}, W_{50} and peak discharge. Now, we have seen how to plot the synthetic unit hydrograph based on the data from the known unit hydrograph from the gauged catchment.

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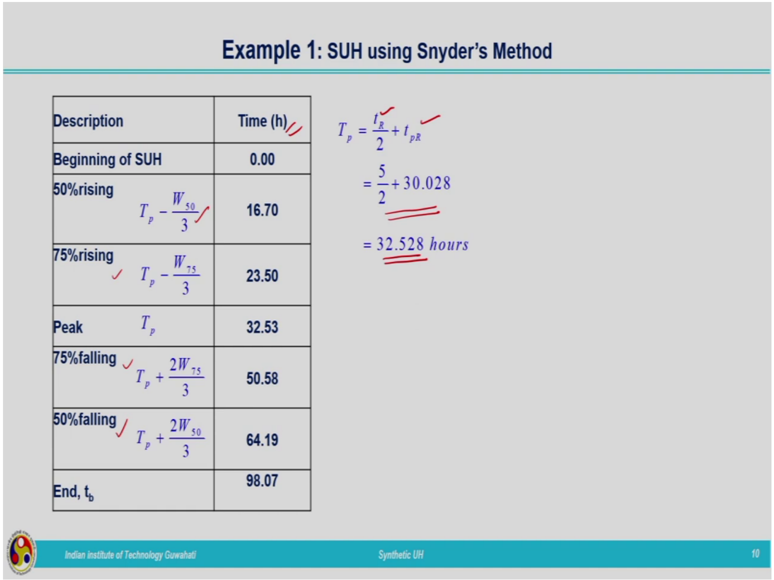

So, we can complete this with the values from the numerical example. So, we need to calculate the value corresponding to time to peak. Time to peak is calculated by using the effective rainfall duration and the basin lag. Effective rainfall duration is 5 hours and t_{pR} is 30.028 based on that the value of T_p is coming out to be

$$T_p = \frac{t_R}{2} + t_{pR} = \frac{5}{2} + 30.028 = 32.528\ hours$$

Now, by making use of this T_p we can calculate the time corresponding to 50 percentage rising and all other time corresponding to 75 percentage rising, 75 percentage falling and 50 percentage falling. So, these are the times corresponding to each discharge. Now, we need to calculate the values corresponding to peak discharge. The values corresponding to peak discharge we have already calculated, we just have to take those values for plotting the synthetic unit hydrograph, that is Q peak and 75 percentage of Q peak and 50 percentage of Q peak.

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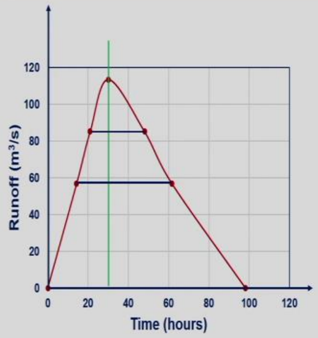
Example 1: SUH using Snyder's Method

Description		Time(h)	Ordinates of SUH (m³/s)
Beginning of SUH		0.00	0.00
50%rising	$t_{pR} - \frac{W_{50}}{3}$	16.70	56.69
75%rising	$t_{pR} - \frac{W_{75}}{3}$	23.50	85.04
Peak	t_{pR}	32.53	113.39
75%falling	$t_{pR} + \frac{2W_{75}}{3}$	50.58	85.04
50%falling	$t_{pR} + \frac{2W_{50}}{3}$	64.19	56.69
End, t_b		98.07	0.00



So, those values are given over here in this column. The ordinates of synthetic unit hydrographs are corresponding to *Q* peak, 75 percentage of *Q* peak, and 50 percentage of *Q* peak. Now, we can start plotting the synthetic unit hydrograph. So, the synthetic unit hydrograph can be plotted as shown in this figure. In this way, we can derive the synthetic unit hydrograph based on Snyder's method.

Now, let us move on to the second method that is based on SCS dimensionless synthetic unit hydrograph. In the case of SCS dimensionless synthetic unit hydrograph, dimensionless unit hydrograph and the corresponding ordinates have been given by SCS after conducting so many studies in different watersheds. So, those dimensionless ordinates we will be utilizing here for deriving the synthetic unit hydrograph for our ungauged catchment.

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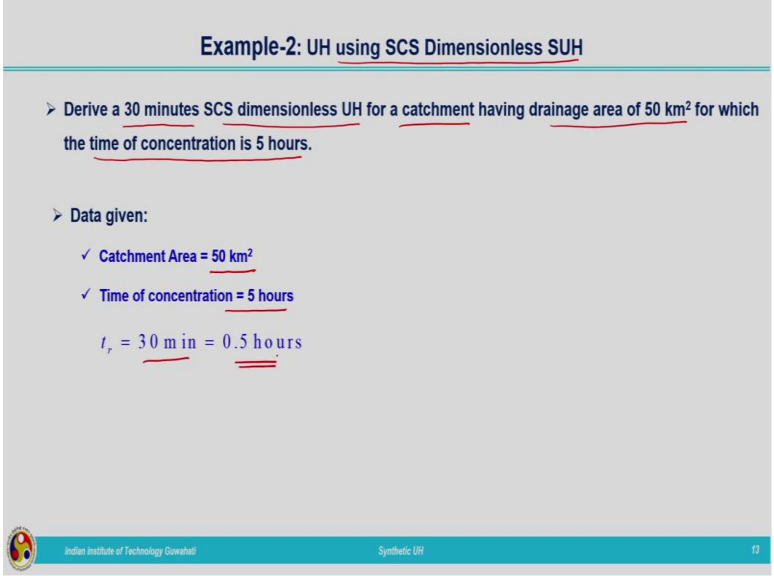

So, the next example is related to unit hydrograph derivation using SCS dimensionless technique. Derive a 30 minutes SCS dimensionless unit hydrograph for a catchment having drainage area of 50-kilometre square for which the time of concentration is 5 hours. Here in this case we need to have the time of concentration, time of concentration is given to us as 5 hours and area of the catchment 50 kilometer square and we need to derive 30 minutes synthetic unit hydrograph. Data given are: catchment area 50-kilometer square, time of concentration 5 hours, the effective duration of the rainfall is 30 minutes that is 0.5 hours.

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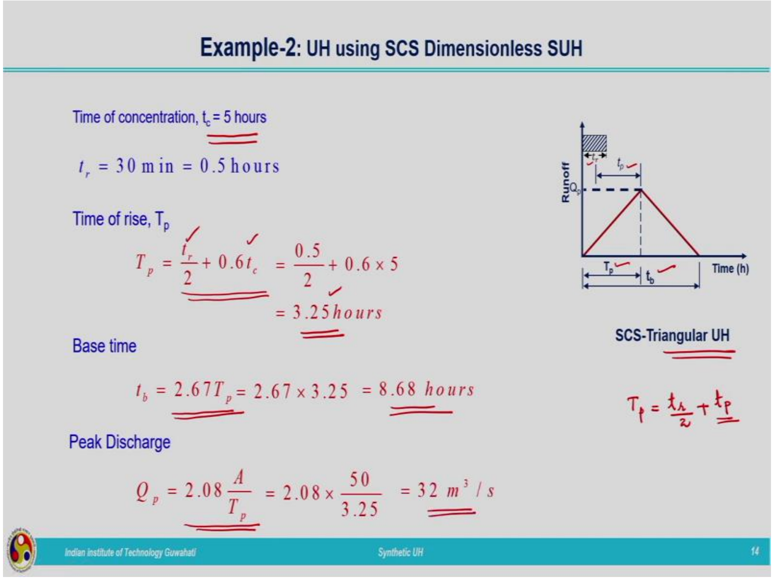

The time of concentration is given to us as t_c is equal to 5 hours. In the case of SCS dimensionless synthetic unit hydrograph, we were approximating the unit hydrograph in the triangular form. This is the SCS triangular unit hydrograph which we have already discussed while discussing the theory related to it. In the same way we will approximate the unit hydrograph for this catchment also, that is we will derive the triangular unit hydrograph first, after that we will go for deriving the synthetic unit hydrograph by making use of the dimensionless synthetic unit hydrograph provided by SCS.

So, here we can calculate the time of rise that is time to peak. How can we calculate? Here we are marked the T_p that is basin lag, t_r is the duration of effective rainfall, capital T_p the time to peak or time of rising that is from the 0th ordinate to the peak discharge where it is happening that much time is T_p. How can we calculate that? Here we are having the basin lag and also duration of the effective rainfall. So, we can calculate T_p that is the time of rise as

$$T_p = \frac{t_r}{2} + 0.6t_c$$

So, this basin lag approximated by $0.6t_c$ .From the experimental studies it is found that basin lag is approximately equal to 0.6 times the time of concentration. So, if t_p is 0.6 times the time of concentration that plus half of the effective duration will be giving us the time to peak or time of rising. Now, by making use of this that is t_r is known to us, t_c is known to us, we can calculate the time to peak or time of rise that is coming out to be

$$T_p = \frac{t_r}{2} + 0.6t_c = \frac{0.5}{2} + 0.6 \times 5 = 3.25 hours$$

So, here in this case, we have found out the point where the peak is coming, point corresponding to *x* value that is time value is calculated corresponding to the peak discharge. Now, for completing the triangular unit hydrograph what else we need? We need to have the value corresponding to t_b, that is the time base of the unit hydrograph. And for t_b also formula is given to us that is based on the principle of mass curve we have seen t_b can be calculated by using the formula

$$t_b = 2.67T_p$$

So,

$$t_b = 2.67T_p = 2.67 \times 3.25 = 8.68 \ hours$$

Now, we are having the time base of the unit hydrograph and also T_p time of rising also there with us.

Next value which is required for completing the triangular unit hydrograph is peak discharge, with these three values time to peak, time base and the peak discharge, we can derive the approximate triangular unit hydrograph. So, the peak discharge Q_p is given by

$$Q_p = 2.08\frac{A}{T_p}$$

Area of the catchment is given to us. So, Q_p can be calculated as

$$Q_p = 2.08\frac{A}{T_p} = 2.08 \times \frac{50}{3.25} = 32\ m^3/s$$

So, all the values corresponding to a triangular unit hydrograph is here with us, we can plot the triangular unit hydrograph. Now, by making use of these data and the data from the SCS dimensionless unit hydrograph we need to derive the synthetic unit hydrograph.

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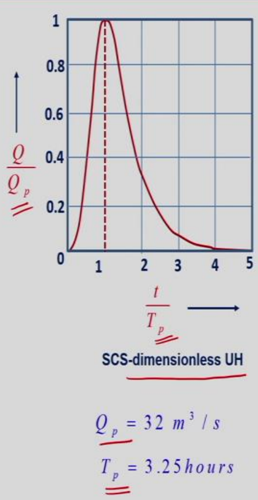
t/Tp	Q/Qp
0	0
0.1	0.03
0.2	0.1
0.3	0.19
0.4	0.31
0.5	0.47
0.6	0.66
0.7	0.82
0.8	0.93
0.9	0.99
1	1
1.1	0.99
1.2	0.93
1.3	0.86
1.4	0.78
1.5	0.68
1.6	0.56
1.7	0.46
1.8	0.39
1.9	0.33
2	0.28
2.2	0.207
2.4	0.147
2.6	0.107
2.8	0.077
3	0.055
3.2	0.04
3.4	0.029
3.6	0.021
3.8	0.015
4	0.011
4.5	0.005
5	0



So, these are the data corresponding to dimensionless synthetic unit hydrograph proposed by SCS and the SCS dimensionless unit hydrograph is plotted over here and along the y axis we are having dimensionless discharge $\frac{Q}{Q_p}$ and along the x axis we are having the dimensionless time $\frac{t}{T_p}$ and corresponding to $\frac{t}{T_p}$ and $\frac{Q}{Q_p}$ we are having the values listed over here in the table. So, we already have the value corresponding to T_p and Q_p. Once we multiply $\frac{t}{T_p}$ with time of rising we will get the corresponding time and corresponding value of discharge Q we will get by multiplying $\frac{Q}{Q_p}$ with Q_p. So, that is what we are going to do here. We are having the value corresponding to Q_p and T_p that is from the triangular unit hydrograph.

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t/Tp	Q/Qp	t (hours)
0	0	0
0.1	0.03	0.325
0.2	0.1	0.65
0.3	0.19	0.975
0.4	0.31	1.3
0.5	0.47	1.625
0.6	0.66	1.95
0.7	0.82	2.275
0.8	0.93	2.6
0.9	0.99	2.925
1	1	3.25
1.1	0.99	3.575
1.2	0.93	3.9
1.3	0.86	4.225
1.4	0.78	4.55
1.5	0.68	4.875
1.6	0.56	5.2
1.7	0.46	5.525
1.8	0.39	5.85
1.9	0.33	6.175
2	0.28	6.5
2.2	0.207	7.15
2.4	0.147	7.8
2.6	0.107	8.45
2.8	0.077	9.1
3	0.055	9.75
3.2	0.04	10.4
3.4	0.029	11.05
3.6	0.021	11.7
3.8	0.015	12.35
4	0.011	13
4.5	0.005	14.625
5	0	16.25

$Q_p = 32\ m^3/s$

$T_p = 3.25 hours$

Once we multiply Q_p and T_p with the values given over here in these columns, we can get the time in hours and the discharge Q in meter cube per second. So, by making use of the dimensionless synthetic unit hydrograph ordinates, we have found out the ordinates corresponding to the synthetic unit hydrograph for the ungauged catchments for which we need to derive with the data given in the question.

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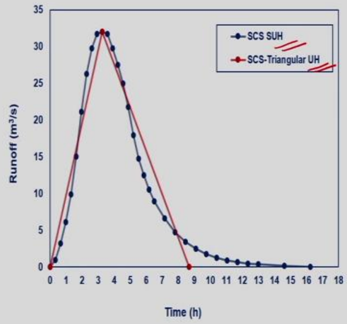
t/Tp	Q/Qp	T (hours)	Q (m^3/s)
0	0	0	0.000
0.1	0.03	0.325	0.960
0.2	0.1	0.65	3.200
0.3	0.19	0.975	6.080
0.4	0.31	1.3	9.920
0.5	0.47	1.625	15.040
0.6	0.66	1.95	21.120
0.7	0.82	2.275	26.240
0.8	0.93	2.6	29.760
0.9	0.99	2.925	31.680
1	1	3.25	32.000
1.1	0.99	3.575	31.680
1.2	0.93	3.9	29.760
1.3	0.86	4.225	27.520
1.4	0.78	4.55	24.960
1.5	0.68	4.875	21.760
1.6	0.56	5.2	17.920
1.7	0.46	5.525	14.720
1.8	0.39	5.85	12.480
1.9	0.33	6.175	10.560
2	0.28	6.5	8.960
2.2	0.207	7.15	6.624
2.4	0.147	7.8	4.704
2.6	0.107	8.45	3.424
2.8	0.077	9.1	2.464
3	0.055	9.75	1.760
3.2	0.04	10.4	1.280
3.4	0.029	11.05	0.928
3.6	0.021	11.7	0.672
3.8	0.015	12.35	0.480
4	0.011	13	0.352
4.5	0.005	14.625	0.160
5	0	16.25	0.000

SCS-Triangular UH Ordinates

T_p	3.25 hours
Q_p	32 m^3/s
T_b	8.68 hours



So, SCS triangular unit hydrograph ordinates we have already computed T_p, Q_p, and t_b. Now, we can plot the synthetic unit hydrograph. So, these are the synthetic unit hydrograph: red one is representing the SCS triangular unit hydrograph and the blue one is representing the SCS synthetic unit hydrograph.

So, this is very simple by making use of the data provided by SCS that is for the SCS dimensionless synthetic unit hydrograph curve and also the corresponding data are given in all the textbooks which are explained this topic and by making use of those data and we are calculating the values corresponding to Q_p, T_p, T_p is not the small t_p that is not the basin lag, it is the time of rising or time to peak and the time base of the unit hydrograph we can get the triangular unit hydrograph and by making use of those values along with the dimensionless ordinates from SCS dimensionless synthetic unit hydrograph we can derive the SCS synthetic unit hydrograph for the ungauged catchment.

So, these are the two types of synthetic unit hydrographs we have covered, that is Snyder's synthetic unit hydrograph which is derived based on the morphological characteristics and the hydrograph characteristics and second one is the synthetic unit hydrograph proposed by SCS that is SCS dimensionless synthetic unit hydrograph is utilized for deriving SCS synthetic unit hydrograph.

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Now, corresponding to this topic, more examples and exercise problems can be seen in these textbooks. Try to solve different numerical questions for making the concepts clear. So, here I am winding up the numerical problem solving related to synthetic unit hydrograph. Thank you.