

TUTORIAL-6

DESIGN FLOOD ESTIMATION USING UNIT HYDROGRAPH APPROACH

Problem

The ordinates of a mass curve of rainfall from a severe storm in a catchment is given. Ordinates of a 12 hour unit hydrograph applicable to the catchment are also given. Using the given mass curve, develop a design storm to estimate the design flood for the catchment. Taking ϕ index as 0.15 cm/hour, estimate the resulting design flood hydrograph. Assume the base flow to be 50 m³/s.

Time (hour)	Cumulative rainfall (cm)	12 hour unit hydrograph ordinate (m ³ /s)
0	0	0
12	10.2	32
24	30.5	96
36	34.0	130
48	36.0	126
60		98
72		75
84		50
96		30
108		15
120		7
132		0

Solution

The computational steps are :

- (i) Enter the time intervals in column (1) of Table T 6.1
- (ii) Enter the cumulative rainfall (cm) in column (2) of Table T 6.1.
- (iii) Compute the 12 hour increment rainfall and enter in column (3) of Table T 6.1.
- (iv) Enter the given ordinates of 12 hour unit hydrograph in column (4) of Table T 6.1.
- (v) Arrange the maximum rainfall increment against the maximum unit hydrograph ordinate, the second highest rainfall increment against the second largest unit hydrograph and so on as shown in column (5) of Table T 6.1.
- (vi) Reverse the sequence of rainfall increments obtained from step (v) in such a way that the last item becomes first and the first item becomes last. The sequence of rainfall is called as design sequence of rainfall increment. Enter those values in column (6) of Table T 6.1.

- (vii) Enter the infiltration loss ($=0.15 \times 12$ cm) equal to 1.8 cm in column (7) of Table T 6.1.
- (viii) Compute the rainfall excess of design storm after subtracting the infiltration loss from the design sequence of rainfall increments. Enter those values in column (8) of Table T 6.1.
- (ix) Enter the time from start of effective rainfall in hours in column (1) of Table T 6.2
- (x) Enter the 12 hour unit hydrograph ordinates in column (2) of Table T 6.2.
- (xi) Enter the excess rainfall for design storm, obtained at step (viii), in column (3) of Table T 6.2.
- (xii) Compute the direct surface runoff in cumecs due to different excess rainfall and enter them in column (4), (5), (6) and (7) of Table T 6.2 respectively.
- (xiii) Compute the total direct surface runoff ordinates at each time interval after adding the corresponding values of column (4), (5), (6) and (7). Enter these values in column (8) Table T 6.2.
- (xiv) Enter the constant base flow values in column (9) of Table T 6.2
- (xv) Add the values of column (8) with the values of column (9) and enter them in column (10) of Table T 6.2. These values are the design flood hydrograph ordinates.

Table T 6.1 Calculation of Design Storm

Time (hour)	Cumulative rainfall (cm)	12 hour incremental rainfall (cm)	Ordinate of 12 hour unit hydrograph (m^3/s)	First arrangement of rainfall increment (cm)	Design sequence of rainfall increment (cm)	Infiltration loss	Rainfall excess of design storm (cm)
1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	0
12	12.2	10.2	32	0	3.5	1.8	1.7
24	30.5	20.3	96	2.0	10.2	1.8	8.4
36	34.0	3.5	130	20.3	20.3	1.8	18.5
48	36.0	2.0	126	10.2	2.0	1.8	0.20
60			98	3.5	0.0	0	0
72			75				
84			50				
96			30				
108			15				
120			7				
132			0				

Table T 6.2 Computation of Design Flood Hydrograph

Time from start of effective rainfall (hours)	12 hour unit hydro-graph ordinates (m ³ /s)	Rainfall excess of design storm cm	Direct runoff due to effective rainfall increments				Total direct surface runoff (m ³ /s)	Base flow (m ³ /s)	Design flood hydrograph ordinate (m ³ /s)
			1.7 cm (m ³ /s)	8.4 cm (cm ³ /s)	18.5 cm (m ³ /s)	0.20 cm (m ³ /s)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(9)	(9)	(10)
12	32	1.7	54.4	—	—	—	54.4	50	104.40
24	96	8.4	163.2	268.8	—	—	432.0	50	482.00
36	130	18.5	221.0	806.4	592.0	—	1619.4	50	1669.40
48	126	0.20	214.2	1092.0	1776.0	6.4	3088.6	50	3138.60
60	98		166.6	1058.4	2405.0	19.2	3649.2	50	3699.20
72	75		127.5	823.2	2331.0	26.0	3307.7	50	3357.70
84	50		85.0	630.0	1813.0	25.2	2553.2	50	2603.20
96	30		51.0	420.0	1387.5	19.6	1878.1	50	1928.10
108	15		25.5	252.0	925.0	15.0	1217.5	50	1267.50
120	7		11.9	126.0	555.0	10.0	702.9	50	752.90
132	0		0	58.8	277.5	6.0	342.3	50	392.30
144				0	129.5	3.0	132.5	50	182.50
156					0	1.4	1.4	50	51.40
168						0	0	50	50.00

