7 CHAPTER

# Floods

Q.1 A culvert is designed for a peak flow $Q_p$ on the basis of the rational formula. If a storm of the same intensity as used in the design but of duration twice larger occurs, the resulting peak discharge will be
(a) $Q_p$ (b) $2Q_p$
(c) $Q_p/2$ (d) $Q_p^2$

Q.2 A watershed of area 90 ha has a runoff coefficient of 0.4. A storm of duration largor than the time of concentration of the watershed and of intensity 4.5 cm/h creates a peak discharge of
(a) 11.3 $m^3/s$ (b) 0.45 $m^3/s$
(c) 450 $m^3/s$ (d) 4.5 $m^3/s$

Q.3 A rectangular parking lot, with direction of overland flow parallel to the larger side, has a time of concentration of 25 minutes. For the purpose of designs of drainage, four rainfall patterns as given below are to be considered.
$A$ = 35 mm/h for 15 minutes
$B$ = 45 mm/h for 10 minutes
$C$ = 10 mm/hr for 60 minutes
$D$ = 15 mm/h for 25 minutes
The greatest peak rate of runoff is expected in the storm
(a) $A$ (b) $B$
(c) $C$ (d) $D$

Q.4 For an annual flood series arranged in decreasing order of magnitude, the return period for a magnitude listed at position m in a total of $N$ entries, by Weibull formula is
(a) $m/N$ (b) $m/(N+1)$
(c) $(N+1)/m$ (d) $N/(m+1)$

Q.5 The probability that a hundred year flood may not occur at all during the 50 year life of a project is
(a) 0.395 (b) 0.001
(c) 0.605 (d) 1.33

Q.6 The probability of a flood equal to or greater than 1000 year flood, occurring next year is
(a) 0.0001 (b) 0.001
(c) 0.386 (d) 0.632

Q.7 The probability of a flood equal to or greater than 50 year flood, occurring atleast once in next 50 years is
(a) 0.02 (b) 0.636
(c) 0.364 (d) 1.0

Q.8 The term 'mean annual flood' denotes
(a) mean floods in partial duration series
(b) mean of annual flood flow series
(c) a flood with a recurrence interval of 2.33 years
(d) a flood with a recurrence interval of N/2 years
where N = Number of years of record

Q.9 The use of unit hydrographs for estimating floods is generally limited to catchments of size less than
(a) 5000 $km^2$ (b) 500 $km^2$
(c) $10^6$ $km^2$ (d) 5000 ha

Q.10 The Probable Maximum Flood is
(a) the standard project flood an extremely large river
(b) a flood adopted in the design of all kinds of spillways
(c) an extremely large but physically possible flood in the region
(d) the maximum possible flood that can occur anywhere in the country

Q.11 The Standard Project Flood is
(a) smaller than probable maximum flood in the region
(b) the same as the design flood used for all small hydraulic structures
(c) larger than the probable maximum flood by a factor implying factor of safety
(d) the same as the probable maximum flood

Q.12 A hydraulic structure has been designed for a 50 years flood. The probability that exactly one flood of the design capacity will occur in the 75 years life of the structure is
(a) 0.02 (b) 0.220
(c) 0.336 (d) 0.780

Q.13 The return period that a designer must use in the estimation of a flood for a hydraulic structure, if he is willing to accept 20% risk that a flood of that or higher magnitude will occur in the next 10 years is
(a) 95 years (b) 75 years
(c) 45 years (d) 25 years

Q.14 A hydraulic structure with a life of 30 years is designed for a 30 year flow. The risk of failure of the structure during its life is
(a) 0.033 (b) 0.638
(c) 0.362 (d) 1.00

Q.15 The probability that a 100 year flood is equalled or exceeded, at least once in 100 years is
(a) 99% (b) 64%
(c) 36% (d) 1%

Q.16 A catchment area of 90 hectares has a run-off coefficient of 0.4. A storm of duration larger than the time of concentration of the catchment and of intensity 4.5 cm/hr creates a peak discharge rate of
(a) 11.3 $m^3/s$ (b) 0.45 $m^3/s$
(c) 450 $m^3/s$ (d) 4.5 $m^3/s$

Q.17 If one wants to be 90% sure that the design flood in a dam project will not occur during the design life period of 100 years, the recurrence interval for such a flood would be
(a) about 90 years
(b) equal to 100 years
(c) about 110 years
(d) roughly 1000 years

Q.18 Probability of a 10-year flood to occur at least once in the next 4 years is
(a) 25% (b) 35%
(c) 50% (d) 65%

Q.19 If $Q_p$ = flood discharge; $A$ = catchment area; $i$ = intensity of rainfall; $C_1$, $C_2$ and C are constants, then which of the following pairs are properly matched?
1. Dicken's formula: $Q = CA^{2/3}$
2. Ryves formula: $Q = CA^{3/4}$
3. Rational formula: $Q = CAi$
4. Inglis formula: $Q = \frac{C_1 A}{\sqrt{A + C_2}}$

Codes:
(a) 1, 2 and 4 are correct
(b) 1, 2, 3 and 4 are correct
(c) Only 3 is correct
(d) 3 and 4 are correct

Q.20 Flood flows can be determined by
1. means of empirical formulae
2. envelope curves
3. statistical probability methods
4. unit hydrograph method

The correct answer is
(a) both 1 and 3 (b) only 2
(c) 1, 2 and 3 (d) 1, 2, 3 and 4

Q.21 Study the following statements with regards to the determination of peak flood discharge:
1. Dicken's formula is generally used for the catchments of North India.
2. Ryve's formula is generally applicable to South Indian catchments.
3. Inglis formula is applicable to fan shaped catchment areas.

The correct statements (s) is(are):
(a) only 1 (b) only 3
(c) both 2 and 3 (d) 1, 2 and 3

Q.22 For the estimation of a flood with a return period of T years by Gumbel's method, which of the following sets of data regarding the annual flood series would be required?
(a) Mean and standard deviation (SD) of the flood flow series
(b) Mean flood flow, SD of the flood flow series and length of record
(c) SD of the flood flow series and length of record
(d) Mean, SD and coefficient of skew of the flood flow series

Q.23 The general equation of hydrological frequency analysis states that $x_T$ which is the value of a variate with a return period of $T$ years is given by $x_T$ =
(a) $\bar{x} - K\sigma$ (b) $\bar{x} + K\sigma$
(c) $K\sigma$ (d) $\bar{x}/K\sigma$

Q.24 The design flood commonly adopted in India for spillways of major projects is the
(a) standard project flood
(b) flood with a return period of 100 years
(c) probable maximum flood
(d) flood with a return period of 10, 000 years

Q.25 The design flood for a culvert should be, preferably be,
(a) the probable maximum flood
(b) obtained from statistical considerations, say a flood of 50 years return period
(c) the highest observed flood
(d) obtained from flood formula

Q.26 The live storage requirement for a reservoir is to be determined by
(a) topographical survey
(b) annual demand
(c) double mass curve analysis
(d) mass curve analysis

Q.27 While making flood estimation by Gumbel's method for a return period of 200 years, the value of Gumbel's reduced variate is
(a) 0.5170 (b) 1.2835
(c) 4.6000 (d) 5.2960

**Q.28 Inglis formula is used for estimating flood discharge for**
(a) The catchment basins of former Bombay Presidency
(b) The catchment basin of old Hyderabad state
(c) The Madras Catchment basins
(d) England Catchments

Q.29 For an annual flood series arranged in decreasing order of magnitude, the return period for a magnitude listed at position $m$ in a total of $N$ entries is
(a) $m/N$ (b) $m/(N+1)$
(c) $(N+1)/m$ (d) $N/(m+1)$

Q.30 Of the various empirical formulae relating the flood peak to the catchment area,
(a) Ryves formula is used all over the country
(b) Dickens formula is used all over the country
(c) Inglis formula is in use in a large part of North India
(d) Dickens formula is in use in a large part of North India

Q.31 To estimate the flood magnitude with a return period of $T$ years by using log-normal distribution, the following statistics of data are absolutely necessary:
(a) mean and standard deviation of discharges
(b) mean and standard deviation of the logarithm of the discharges
(c) mean and standard deviation of the discharges and also the length of record
(d) mean, standard deviation and coefficient of skew of the logarithm of discharges

Q.32 The confidence interval for the estimation of a value $x_T$ by Gumbel's method depends on
(a) the confidence probability only
(b) the return period only
(c) the confidence probability and return period
(d) the confidence probability and number of years of record

**Q.33** A bridge has an expected life of 50 years and is designed for a flood magnitude of return period 100 years. What is the risk associated with this hydrologic design?

(a) $1 - (0.99)^{50}$ (b) $(0.5)^{50}$
(c) $(0.99)^{50}$ (d) $(0.99)^{100}$

**Q.34** Kirpich's equation is used to determine which one of the following?

(a) Run-off from a given rainfall.
(b) Base time of a unit hydrograph
(c) Time of concentration in run-off hydrograph
(d) None of the above

**Q.35** If the risk of a flood occurring in the next 10 years is accepted to 10%, then the return period for design should be

(a) $1 + (0.9)^{0.10}$ (b) $1 - (0.9)^{0.10}$
(c) $1/(1 - 0.9^{0.10})$ (d) $1/(1 + 0.09^{0.10})$

**Q.36** According to Dicken's formula for estimating floods, the peak discharge is proportional to

(a) $A$ (b) $A^{1/2}$
(c) $A^{2/3}$ (d) $A^{3/4}$

where $A$ is catchment area in square kilometres.

**Q.37** Consider the following statements:

1. A 100 year flood discharge is greater than a 50 year flood discharge.
2. 90% dependable flow is greater than 50% dependable flow.
3. Evaporation from salt-water surface is less than that from fresh-water surface.

Which of these statements are correct?

(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

**Q.38** By using Gumbel's method, the flood discharge with a return period of 500 years at a particular township neighbourhood was estimated as 18000 m³/s with a probable error of 2000 m³/s. What are the 95% confidence probability limits of the 500 year flood at the location? (For 95% confidence probability use $f_c = 1.96$)

(a) 16100 m³/s to 19900 m³/s
(b) 17050 m³/s to 18950 m³/s
(c) 14080 m³/s to 21920 m³/s
(d) 13600 m³/s to 22400 m³/s

**Q.39** The design flood commonly adopted in India for barrages and minor dams is

(a) probable maximum flood
(b) a flood of 50-100 years return period
(c) peak flood
(d) standard project flood or a 100-year flood, whichever is higher

**Q.40** The I-D-F relation for watershed is given by

$$I = \frac{80T^{0.2}}{(t+12)^{0.5}},$$ $I$ in cm/hr, $T$-year, $t$-min. The watershed consists of 1.5 km² of cultivated area ($C$ = 0.2), 2.5 km² under forest ($C$ = 0.1) and 1 km² under grass cover ($C$ = 0.35). There is a fall of 20 m in length of watercourse 2 km. The peak rate of runoff for 25 year frequency is:

(a) 36.5 cumecs (b) 56.5 cumecs
(c) 46.5 cumecs (d) 66.5 cumecs

**Q.41** The number of times a storm of intensity 6 cm/hr was equalled or exceeded in three rainguage stations in a region were 4, 2 and 5 for respective periods of records of 36, 25 and 48 years. Using station-year method, the recurrence interval of 6 cm/hr storm in that area is:

(a) 15 years (b) 10 years
(c) 12 years (d) 18 years

**Q.42** The return period for flood is $n$ years and life of structure is $n$ years. The risk for the structure for large value of $n$ is

(a) 63.22% (b) 36.22%
(c) 56.14% (d) 46.24%

**Q.43** For proposed bridge on the river Narmada, it is decided to have an acceptable risk of 10% in its expected life of 50 years. The return period to estimate the flood magnitude is:

(a) 354 years (b) 395 years
(c) 475 years (d) 495 years

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## Answers Floods

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|---|---|---|---|---|---|---|---|---|---|
| 1. (a) | 2. (d) | 3. (a) | 4. (c) | 5. (c) | 6. (b) | 7. (b) | 8. (c) | 9. (a) | 10. (c) |
| 11. (a) | 12. (c) | 13. (c) | 14. (b) | 15. (b) | 16. (d) | 17. (d) | 18. (b) | 19. (d) | 20. (d) |
| 21. (d) | 22. (b) | 23. (b) | 24. (c) | 25. (b) | 26. (d) | 27. (d) | 28. (a) | 29. (c) | 30. (d) |
| 31. (b) | 32. (c) | 33. (a) | 34. (c) | 35. (c) | 36. (d) | 37. (c) | 38. (c) | 39. (d) | 40. (c) |
| 41. (b) | 42. (a) | 43. (c) | | | | | | | |

## Explanations Floods

**2. (d)**

$$Q = CiA$$
$$= 0.4 \times \frac{4.5 \times 10^{-2}}{3600} \times 90 \times 10^4 \text{ m}^2$$
$$= 4.5 \text{ m}^3/\text{s}$$

**5. (c)**

$$T = 100 \qquad \therefore p = \frac{1}{T} = \frac{1}{100}$$
$$n = 50$$
$$\therefore \quad q = \left(1 - \frac{1}{100}\right)^{50} = 0.605$$

**6. (b)**

$$T = 100$$
$$\Rightarrow \frac{1}{1000} = 0.001$$

**7. (b)**

$$p = 1 - q^n$$
$$= 1 - \left(1 - \frac{1}{50}\right)^{50}$$
$$= 0.6358 \simeq 0.636$$

**12. (c)**

$$T = 50$$
$$n = 75$$
$$p = {}^{75}C_1 \left(\frac{1}{50}\right)^1 \left(\frac{49}{50}\right)^{74}$$
$$= 0.336$$

**13. (c)**

$$\text{Risk} = 20\%$$
$$\Rightarrow 0.2 = 1 - q^{10}$$
$$\Rightarrow q = 0.978$$
$$\Rightarrow \left(1 - \frac{1}{T}\right) = 0.978$$
$$\Rightarrow T = 45.3 \text{ years}$$

**14. (b)**

$$T = 30 \text{ years}$$
$$n = 30 \text{ years}$$
$$\therefore \text{Risk} = 1 - q^n$$
$$= 1 - \left(1 - \frac{1}{30}\right)^{30}$$
$$= 0.638$$

**15. (b)**

The probability of the event occurring at least once in 100 years.

$$p' = 1 - q^n$$
$$= 1 - (1 - p)^n$$

Where, $p = \frac{1}{100} = 0.01$

$$\therefore p' = 1 - (1 - 0.01)^{100}$$
$$\equiv 0.64 \equiv 64\%$$

**16. (d)**

$$Q = \frac{1}{3.6} CiA$$

Where i is in mm/hr, A is in km²

$$\therefore Q = \frac{1}{3.6} \times 0.4 \times 45 \times \frac{90}{10^2} \frac{\text{m}^3}{\text{sec}}$$
$$= 4.5 \text{ m}^3/\text{sec}$$

17. (d)

If one is 90% sure, this means that the reliability of the dam project is 90%.

Now reliability,

$$R_e = 1 - \text{Risk}$$

$$R_e = \left(1-\frac{1}{T}\right)^n$$

$$\therefore \quad 0.9 = \left(1-\frac{1}{T}\right)^{100}$$

$$\Rightarrow \quad 1-\frac{1}{T} = 0.9989$$

$$\Rightarrow \quad T = 949.62 \text{ years} \cong 1000 \text{ years}$$

18. (b)

Probability of occurrence atleast once

$$= 1 - q^n$$

$$P = 1-(1-p)^n$$

where $p = \frac{1}{10} = 0.1$

$n = 4$ years

$$\therefore \quad p = 1-(1-0.1)^4 = 0.3439 \cong 35\%$$

19. (d)

Dicken's formula $Q = CA^{3/4}$ for catchments of north India.

Ryve's formula $Q = CA^{2/3}$ for south Indian catchments

Inglis formula $Q = \frac{C_1 A}{\sqrt{A+C_2}}$ for fan shaped catchments in old Bombay state

($C_1 = 123$, $C_2 = 10.4$)

22. (b)

According to Gumbel's method,

$$x_T = \bar{x} + k\sigma_x$$

Where $\bar{x}$ = mean and $\sigma_x$ = standard deviation of the flood flow series and, $k$ depends on the return period and the length of record.

27. (d)

According to Gumbel's method

Reduced variate,

$$y_T = -\ln\ln\left(\frac{T}{T-1}\right)$$

Here, $T$ = return period = 200 years

$$\therefore \quad y_T = -\ln\ln\left(\frac{200}{200-1}\right)$$

$$y_T = 5.2960$$

Hence option (d) is correct.

28. (a)

Inglis formula,

$$Q_p = \frac{124A}{\sqrt{10.4+A}} \simeq 123\sqrt{A}$$

This is suitable for Western Ghat and Maharashtra Region. Maharashtra was earlier known as Bombay presidency.

Hence option (a) is correct.

29. (c)

Recurrence interval or return period,

$$T = \frac{N+1}{m}$$

Probability of occurrence,

$$p = \frac{m}{N+1}$$

where, $N$ = size of entries

$M$ = Order no. or rank

30. (d)

Dicken's formula is used in the Central and Northern parts of the country. Ryve's formula is used in Tamil Nadu and parts of Karnataka and Andhra Pradesh. Inglish formula is used in Western Ghats in Maharashtra.

33. (a)

Risk = Probability of flood being exceeded at least once over a period of n years.

$$= 1-\left(1-\frac{1}{100}\right)^{50} = 1-(0.99)^{50}$$

34. (c)

Kirpich equation is an empirical relation used for the estimation of the time of concentration. It is given as

$$t_c = 0.01947\, L^{0.77} S^{-0.385}$$

where, $t_c$ = time of concentration in minutes

$L$ = maximum length of travel of water (m)

$S$ = slope of the catchment = $\frac{\Delta H}{L}$

$\Delta H$ = difference in elevation between the most remote point on the catchment outlet.

35. (c)

$$0.1 = 1-(1-P)^{10}$$

$$P = 1-0.9^{0.1}$$

$$T = \frac{1}{P} = \frac{1}{1-0.9^{0.1}}$$

37. (c)

For a return period $T$, the magnitude of flood is given by equation of hydrologic frequency analysis as

$$x_t = \bar{x} + k\sigma$$

The value of k increases with higher return period. So flood magnitude for 100 year return period is more than that of 50 year return period.

% dependable flow means number of times the given discharge is equalled or exceeded.

$$\% \text{ Dependability} = \frac{100}{\text{Return period}}$$

90% dependable flow has lesser return period while, 50% dependable flow has higher return period. So, 90% dependable flow is less than 50% dependable flow.

When a solute is dissolved in water, the vapour pressure is less than that of pure water and hence causes a reduction in the rate of evaporation.

38. (c)

For confidence probability $C$, the confidence interval (if variate $x_T$ is bounded by values $x_1$ and $x_2$) is given by:

$$x_1 = x_T - f(c)\, S_e$$

$$x_2 = x_T + f(c)\, S_e$$

Given $x_T = 18000 \text{ m}^3/\text{s}$

$S_e = 2000 \text{ m}^3/\text{s}$

For 95% confidence probability $f(c) = 1.96$

$$\therefore \quad x_1 = 18000 - 1.96 \times 2000 = 14080 \text{ m}^3/\text{s}$$

$$x_2 = 18000 + 1.96 \times 2000 = 21920 \text{ m}^3/\text{s}$$

39. (d)

For permanent barrages and minor dams with capacity less than 60 Mm³ design flood recommended is SPF or flood with a return period of 100 years whichever gives higher value.

40. (c)

Using Kirpich's formula, time of concentration;

$$t_c = 0.02\, L^{0.8} S^{-0.4},$$

$t_c$ in min, and $L$ in metres

$$= 0.02(2000)^{0.8}\left(\frac{20}{2000}\right)^{-0.4}$$

$$= 55 \text{ min} = t$$

$$I = \frac{80\times(25)^{0.2}}{(55+12)^{0.5}} = 18.6 \text{ cm/hr}$$

$$Q = CIA$$

$$= 2.78 \times 18.6\,(1.5\times 0.2 + 2.5\times 0.1 + 1\times 0.35)$$

$$= 46.5 \text{ cumecs.}$$

41. (b)

$N$, Total year of records = 36 + 25 + 48 = 109

$m$, Number of events = 4 + 2 + 5 = 11

The event is equalled or exceeded 11 times in 109 years of record.

$\therefore$ Recurrence interval,

$$T = \frac{N+1}{m} = \frac{(109+1)}{11} = 10 \text{ years}$$

42. (a)

$$\text{Risk} = 1-\left(1-\frac{1}{T}\right)^n = 1-\left(1-\frac{1}{n}\right)^n$$

$$= 1-\left[1-1+\frac{1}{2!}-\frac{1}{2!n}-\frac{1}{3!}+\frac{(3n-2)}{3!n^2}-\dots\right]$$

$$= 1-e^{-1} = 1-(2.7182)^{-1} = 1-0.3678$$

$$\Rightarrow \bar{R} = 1-0.3678 = 0.6322$$

43. (c)

Risk, $\bar{R} = 0.10$

Life period of the structure, $n = 50$ years

Hence, $\bar{R} = 0.10 = 1-\left(1-\frac{1}{T}\right)^{50}$

$$\Rightarrow \left(1-\frac{1}{T}\right) = (1-0.10)^{1/50} = 0.997895$$

$$\Rightarrow \quad T = 475 \text{ years}$$

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