DETAILS EXPLANATIONS

1. (A) Trial-Cycle Method :

$$X_A = \frac{n_A}{15\times 60}\times T$$

$$X_B = \frac{n_B}{15\times 60}T$$

Where, X_A = Number of vehicle accumulated in one cycle time on Road 'A'.

X_B = Number of vehicle accumulated in one cycle time on Road 'B'.

T = Cycle-time in 'Sec'(Assumed)

n_A = Traffic count on Road A in 15 min.

n_B = Traffic count on road B in 15 min.

∴ Green time on Road A

$G_A = 2.5X_A$

on Road B

$G_B = 2.5X_B$

∴ Total Cycle time

$T' = (G_A + A_A) + (G_B + A_B)$

Approximate Method :

$$R_A = G_{AP} = \left[7+\frac{W_A}{1.2}\right]$$

$$R_B = G_{BP} = \left[7+\frac{W_B}{1.2}\right]$$

where, R_A = Red time of Road 'A'.

R_B = Red time of Road 'B'

G_{AP} = Green time on road A for pedestrians.

G_{BP} = Green time on Road 'B' for pedestrians.

W_A = Width of Road A

W_B = Width of Road B

1.2 m/sec = Speed of pedestrians

$G_A = R_B - A_A$

$G_B = R_A - A_B$

Where, G_A and G_B are green times on Roads A and B. A_A and A_B are amber times on Roads A and B.

Webster's Method:

$$C_o = \frac{1.5L + 5}{1 - \gamma}$$

$$L = 2n + R$$

Where, C_o = Optimum cycle time

L = Total lost time

n = Number of phases

R = All Red time

$$Y = y_1 + y_2$$

$$y_1 = \frac{q_1}{S_1} \text{ and } y_2 = \frac{q_2}{S_2}$$

$$G_A = \frac{y_1}{\gamma}(C_o - L) \text{ and } G_B = \frac{y_2}{\gamma}(C_o - L)$$

Where, q_A = Normal flow on road A

q_B = Normal flow on road B

S_A = Saturation flow on road A

S_B = Saturation flow on road B

(B) Jayakar Committee Suggestions :

- Road development should be considered as a matter of national-interest.
- Tax on petrol should be levied for funding of Road-development. So central road fund was formed in 1928.

- A semi-official technical body should be formed to act as advisory body on various aspects of roads. IRC was formed.
- A research organisation should be instiuted to carryout reasearch and development work.

So, CRRI was formed in 1950.

OR

(A) ***Assumption :*** The ruling design speed for NH passing through a Rolling terrain is 80 kmph.

As per IRC

The coefficient of lateral friction

$$f = 0.15$$

The maximum permissible superelevation

$$e = 0.07$$

Case-(a)

Step-1 : Find 'e' for 75% of design speed, neglecting f i.e.,

$$e_1 = \frac{(0.75V)^2}{127R} = \frac{(0.75\times 80)^2}{127\times 450} = 0.0629$$

$$V = 80 \text{ kmph}$$

Step-2 : $e_1 \leq 0.07$ hence the design is sufficient.

Answer : Design super elevation

$$e = 0.06$$

Case-(b)

Step-1 : Find e for 75% of design speed, neglecting f'

i.e., $$e_1 = \frac{(0.75\times 80)^2}{127\times 150} = \frac{(0.75\times 80)^2}{127\times 150}$$

$$= 0.1889$$

Step-2 : Maximum 'e' to be provided = 0.07

Step-3 : Find 'f_1' for design speed and maximum e, i.e., $(e + f_1)$

$$= \frac{V^2}{127R} = \frac{80^2}{127\times 150}$$

$$f_1 = 0.3359 - 0.07 = 0.2659$$

Step-4 : Find allowable speed V_a for the maximum e = 0.07 and f = 0.15

$$V_a = \sqrt{0.22gR} = \sqrt{0.22 \times 9.81 \times 150}$$

$$V_a = 17.99 \text{ m/sec}$$

$$V_a = 64 \text{ kmph}$$

2. **(A) (i)** Lacey regime scour - depth

$$= 1.35\left(\frac{q^2}{f}\right)^{1/3}$$

(ii) $$\Delta = \frac{8.64B}{D}$$

Where Δ = Delta in (m)

B = Base period in Days

D = Duty in hectare/Cumec

(B) Unit hydrograph

It is the hydrograph of direct runoff resulting from one unit depth (1 cm) of rainfall excess occuring uniformly over the basin and at a uniform rate for a specified duration (D hours).

Time Invariance : The first basic assumption is that the direct-runoff, response to a given effective rainfall in a catchment is time invarient.

This implies that the DRH for a given ER in a catchment is always the same irrespective of when it occurs.

OR

(A) The various types of linings can be grouped into two categories :-

(a) Exposed and Hard Surface Lining

(b) Buried Membrain Lining

(a) Exposed and Hard Surface Lining

Exposed linings include all linings exposed to wear, erosion and deterioration effect of the flowing water, operation and maintenance equipments and other hazards. Such linings are constructed across of cement concretes and mortars, ashphaltic materials, bricks, stones and exposed membranes. This lining includes

(i) Cement Concrete

Cement concrete lining is one of the most conventional type of lining which has successfully been used in India and other parts of the world. It is more preferable than any other lining where channel is to carry high velocity water because of it's greater resistance to erosion. Velocities upto 2.5 m/s are generally considered permissible.

(ii) Shot Crete Spacing

In this type of lining cement mortar is applied by peunmatic pressure. The lining may be considered with or without reinforcement. Although reinforcement (in the form of mesh or expanded metal), when laid over earth subgrade, it increases it's useful life.

(iii) Soil-cement :

Asphaltic concrete has greater ability to withstand changes in the subgrade. This lining can be used for repairing cement concrete lining. It is not weather resistant.

(iv) Bricklining

This type of lining has been extensively used in india and elsewhere. This lining is economical where aggregates for concrete lining are not available.

In addition to these linings, exposed and hard surface lining also include Earth lining, Asphalic-concrete lining etc.

(b) Buried Membrain Lining

Hot asphaltic lining, prefabricated asphalt materials, plastic film and a layer of bentonite and other types of clays protected by earth or gravel cover are cheap linings. These linings can be provided immediately after completion of excavation or even later.

Consideration of Selection

Type of subgrade, position of water table, climatic conditions, availability of materials, size of canal, service requirements and experience are the major factors affecting the economy and selection of suitable lining material.

3. (A) Fire Demand

It is the amount of water required per day to achieve the fire solutions.

The rate of fire demand is sometimes treated as a function of population and is worked out on the basis of empirical formulas:

I. Kuichling's Formula :

$$Q = 3182\sqrt{P}$$

Q → Amount of water (lit/min)

Q → Population in thousands

II. Freeman's Formula :

$$Q = 1136\left[\frac{P}{10}+10\right]$$

III. National Board of Fire Under Writer's Formula

(a) For a congested high valued city

(i) Where population < 2 lac

Q = 54600 lit/min for first fire

Q = 9100 – 36400 lit/min for a second fire.

(b) For a Residential city

(i) Small or low building:

Q = 2200 lit/min

(ii) Larger or higher buildings:

Q = 4500 lt/min

(iii) High value, apartments, tenements

Q = 7650 to 13500 lt./min

(iv) Three storeyed buildings in density build up sections

Q = 27000 lt/min

IV. Buston's Formula

$$Q = 5663\sqrt{P}$$

The probability of occurance of a fire, which inturn, depends upon the type of the city served, has been taken into account in developing a above formula on the basis of actual water consumption in fire fighting for Jabalpur city of India. The formula is given as:-

$$Q = \frac{4360\,R^{0.275}}{(t+12)^{0.757}}$$

Where, R = Recurrance interval of fire i.e. period of occurance of fire in years, which will be different for Residential, Commercial and Industrial-Cities.

$(R)_{minimum} = 1$ year

t = duration of fire in minutes

$t_{min} = 30$ min

OR

(A) Estimation of storm water discharge drain of separate system.

Overall runoff coefficient

$$C = \frac{A_1C_1 + A_2C_2 + A_3C_3 + ... + A_nC_n}{A_1 + A_2 + A_3 + ... + A_n}$$

$$C = \frac{\{(0.15\times0.90)+(0.15\times0.80)+(0.25\times0.15)+(0.20\times0.40)+(0.15\times0.1)+(0.10\times0.50)\}}{0.15+0.15+0.25+0.20+0.15+0.10}$$

$C = 0.44$

Therefore quantity of storm water,

$$Q = \frac{C.I.A.}{360°}$$

$$Q = \frac{0.44\times30\times300}{360} = 11 \text{ m}^3/\text{sec}$$

Estimation of sewage discharge for sanitary sewer of separate system

Quantity of Sanitary sewage

$= 300 \times 350 \times 200 \times 0.80$

$= 16800 \text{ m}^3/\text{day} = 0.194 \text{ m}^3/\text{sec}$

Considering peak-factor of 2, the design discharge for sanitary sewers = $0.194 \times 2 = 0.389 \text{ m}^3/\text{sec}$.

Estimation of discharge for partially separate system.

Storm water discharge falling on roofs and paved courtyards will be added to the sanitary sewer. The quantity can be estimated as :

Average coefficient of Runoff

$$= \frac{\{(0.90\times45)+(0.80\times45)\}}{90}$$

$= 0.85$

$$\text{Discharge} = \frac{0.85 \times 30 \times 90}{360} = 6.375 \text{ m}^3/\text{sec}$$

Therefore total discharge in the sanitary sewer of partially separate system

$= 6.375 + 0.389$

$= 6.764 \text{ m}^3/\text{sec}$

and the discharge in storm water drains

$= 11 - 6.375 = 4.625 \text{ m}^3/\text{sec}$

4. **(A)** Length of transition curve :

(i) As per Rate of change of Centrifugal-Acceleration

$$L = \frac{0.0215V^3}{CR}$$

$$C = \frac{80}{75 + V}$$

Where, V = Speed of Vehicle(kmph)

C = Allowable rate of change of Centrifugal-Acceleration (m/sec^3)

R = Radius of Curve

(ii) As per Empirical Formula :

$$L = \frac{2.7V^2}{R} \rightarrow \text{For plain and Rolling terrain}$$

$$L = \frac{V^2}{R} \rightarrow \text{For hilly Area}$$

(iii) According to Rate of change of Super Elevation

$$L = \begin{cases} 150\,x \rightarrow \text{For plain and Rolling Terrain} \\ 100\,x \rightarrow \text{For built up area} \\ 60\,x \rightarrow \text{For hilly area} \end{cases}$$

Where, x = Raise of Outer line of Road.

(B) (i) Water Conveyance Efficiency (η_c) :

It is the ratio of water delivered to the field and the water delivered from the reservoir. So it basically shows the losses in canals.

(ii) Water Storage Efficiency (n_s) :

It is the ratio of actual water stored in the root zone and the water needed to store to bring the water content upto the field capacity.

5. (A) (i) Aridity Index

$$\text{A.I.} = \left(\frac{\text{PET} - \text{AET}}{\text{PET}}\right) \times 100$$

PET = Potential - Evapotranspiration

AET = Actual - Evapotranspiration

(ii) Dalton's Law

The rate of evaporation is proportional to the difference between the saturation vapour pressure at the water temperature, e_s and the actual vapour pressure in the air, e_a. Thus,

$E = K(e_s - e_a)$

E = Rate of evaporation (mm/day)

e_s = Saturation vapour pressure of air (mm)

e_e = Actual vapour pressure of air (mm)

$(e_s - e_a)$ = Saturation Deficiency.

(B) Extrawidening on curve :

$$E_w = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$E_w = \frac{3 \times (2.5)^2}{2 \times 200} + \frac{75}{9.5\sqrt{200}}$$

$E_w = 0.675$ m

Where, n = Number of lanes = 3 (for 10.5 m width)

l = Length of wheel base = 2.5 m

V = Design speed = 20.83 m/s

$\simeq$ 75 kmph

R = Radius of Curve = 200 m