# 10

CHAPTER

# Design of Sewage System and Sewer Appurtenances

**Q.1** Consider the following statements:

Assertion (A): All the sewer pipes are generally laid starting from their tail end towards their starting end.

Reason (R): It helps to save cost of construction.

(a) both A and R are true and R is the correct explanation of A

(b) both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

**Q.2** The sewer pipe sections are tested between manhole to manhole, for leakage, under a test pressure of about

(a) 1.5 m of water head

(b) 5 m of water head

(c) 10 m of water head

(d) 12 m of water head

**Q.3** When the drainage is taken alongwith the sewage, it is called as

(a) Mixed sewer system

(b) Sanitary sewer system

(c) Storm sewer system

(d) Combined sewer system

**Q.4** Large sewers that are used to convey waste water from main sewers to treatment or other disposal facilities or to large intercepting sewers are known as

(a) Building sewers

(b) Trunk sewers

(c) Lateral sewer

(d) Branch sewers

**Q.5** The design of sewers are based on

(a) Average daily discharge

(b) Peak flow discharge

(c) Maximum daily discharge

(d) Average flow discharge

**Q.6** In Hazen-William's formula, $V = 0.849 \, CR^a S^b$, the values of 'a' and 'b' respectively are

(a) 0.67 and 0.5     (b) 0.5 and 0.67

(c) 0.63 and 0.54     (d) 0.54 and 0.63

**Q.7** Match List-I (Type of pipe material) with List-II (Value of $C_H$ for Hazen-William's formula) and select the correct answer using the codes given below the lists:

| List-I | | List-II |
|--------|--|---------|
| A. RCC pipes | 1. | 170 |
| B. Cast iron pipes | 2. | 120 |
| C. Galvanized iron pipes | 3. | 130 |
| D. Steel pipes with rivets | 4. | 140 |

Codes:

|  | A | B | C | D |
|--|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 |
| (b) | 4 | 2 | 3 | 1 |
| (c) | 1 | 3 | 2 | 4 |
| (d) | 4 | 3 | 2 | 1 |

**Q.8** Kutter's formula is given as

(a) $C = \dfrac{\left(\dfrac{23 + 0.00155}{S}\right) + \dfrac{1}{n}}{1 + \left(23 + \dfrac{0.00155}{S}\right) \times \dfrac{n}{\sqrt{R}}}$

(b) $C = \dfrac{\left(23 + \dfrac{0.00155}{S}\right)}{1 + \left(23 + \dfrac{0.00155}{S}\right) \times \dfrac{n}{\sqrt{R}}}$

(c) $C = \dfrac{\left(23 + \dfrac{0.00155}{S}\right) + \dfrac{1}{n}}{1 + \left(23 + \dfrac{0.00155}{S}\right) \times \dfrac{n}{R}}$

(d) $C = \dfrac{\left(23 + \dfrac{0.00155}{S}\right) + \dfrac{1}{n}}{1 + \left(23 + \dfrac{0.00155}{S}\right) \times \dfrac{n}{\sqrt{R}}}$

Q.9 The slope of 1 m diameter concrete sewer laid at a slope of 1 in 1000 develops a velocity of 2 ms⁻¹, when flowing full. When it is half-full, the velocity of flow through the sewer will be
(a) 0.5 ms⁻¹     (b) 1 ms⁻¹
(c) 2 ms⁻¹     (d) 4 ms⁻¹

Q.10 What is the self cleansing velocity of a sewer according to Shield's formula with particles of size 1 mm and specific gravity 2.65? Diameter of sewer is 1 m, Manning's n = 0.012 and the value of $k_s$ is 0.8.
(a) 2.1 ms⁻¹     (b) 2.4 ms⁻¹
(c) 2.7 ms⁻¹     (d) 3 ms⁻¹

Q.11 In the design of storm sewer, "time of concentration" is relevant to determine the
(a) Rainfall intensity
(b) Velocity in the sewer
(c) Time of travel
(d) Area served by the sewer

Q.12 Match List-I (type of method) with List-II (Applicable in case of) and select the correct answer using the codes given below the lists:
List-I
A. Manning's equation
B. Darcy-Weisbach
C. Hardy Cross method
D. Rational method
List-II
1. Estimation of frictional head loss in pipe flow
2. Sanitary sewer design
3. Storm sewer design
4. Water distribution system design

Codes:

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 2 | 1 | 4 | 3 |
| (b) | 1 | 4 | 3 | 2 |
| (c) | 2 | 1 | 3 | 4 |
| (d) | 1 | 4 | 2 | 3 |

Q.13 The ventilation in sewers is needed to avoid the
(a) development of explosive mixture of sewer gases
(b) build up of odorous gases
(c) danger of asphyxiation of sewer maintenance employees
(d) anaerobic decomposition of organics

Q.14 Which of the following statement is not correct?
(a) In combined sewerage system, one set of sewer is laid for both sanitary sewage and storm water.
(b) In separate system, the design of sewage system is economical.
(c) In separate system, self cleansing velocities are not available and occasional flushing is required.
(d) As the sewage is diluted by storm water in combined system, cost of treatment is low.

Q.15 A sewer that receives the discharge of a number of house sewers is called
(a) house sewer
(b) lateral sewer
(c) intercepting sewer
(d) submain sewer

Q.16 An egg shaped section of sewer
(a) is economical than circular section
(b) provides self cleansing velocity at low discharges
(c) is more stable than circular section
(d) is easy to construct

Q.17 Laying of sewers is usually done with the help of
(a) a theodolite
(b) a compass
(c) sight rails and boning rods
(d) a plane table

Q.18 Corrosion in concrete sewers is caused by
(a) septic conditions
(b) dissolved oxygen
(c) chlorine
(d) nitrogen

Q.19 If $D$ is the diameter of upper circular portion, the area of cross-section of a standard egg shaped sewer, is
(a) $\dfrac{(18 + 5\pi)}{32} D^2$    (b) $\dfrac{(12 + 5\pi)}{32} D^2$
(c) $\dfrac{(18 + 5\pi)}{16} D^2$    (d) $\dfrac{(85 + 5\pi)}{32} D^2$

Q.20 $D$ is the diameter of a circular sewer and $b$ is the side of a square section sewer. If both are hydraulically equivalent, the relationship which holds good, is
(a) $\pi D^{8/3} = 4 b^{8/3}$    (b) $\pi D^{3/8} = 4 b^{3/8}$
(c) $\pi D^{2/3} = 4 b^{2/3}$    (d) $\pi D^{3/2} = 4 b^{3/2}$

Q.21 For drains up to 15 cumecs, the depth $d$ and width $B$ are related by the expression
(a) $d = 0.2\sqrt{B}$    (b) $d = 0.5\sqrt{B}$
(c) $B = 0.2\sqrt{d}$    (d) $B = 0.5\sqrt{d}$

Q.22 A manhole is generally provided at each
(a) bend
(b) junction
(c) change of gradient
(d) all the above

Q.23 Pick up the incorrect statement:
For allowing workers to enter sewers
(a) the particular manhole and one manhole on up stream and one manhole on down stream should remain open for 30 minutes
(b) proper tests for the presence of poisonous gases must be carried out
(c) the man entering the manhole should be advised to smoke in the sewer
(d) warning signals should be erected

Q.24 To prevent settling down of sewage both at the bottom and on the sides of a large sewer, self-

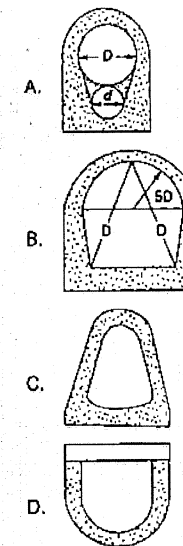cleansing velocity recommended for Indian conditions, is
(a) 0.50 m/sec    (b) 0.60 m/sec
(c) 0.70 m/sec    (d) 0.75 m/sec

Q.25 The minimum diameter of an opening of a manhole should be
(a) 25 cm    (b) 50 cm
(c) 75 cm    (d) 100 cm

Q.26 Match List-I with List-II and select the correct answer using codes given below the lists:
List-I



List-II
1. Horse shoe shaped sewer
2. Parabolic shaped sewer
3. Standard egg-shaped sewer
4. U-shaped sewer

Codes:

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 |
| (b) | 3 | 1 | 2 | 4 |
| (c) | 3 | 1 | 4 | 2 |
| (d) | 2 | 4 | 1 | 3 |

Q.27 Match List-I with List-II and select the correct answer using codes given below the lists:

List-I
A. Curb inlet
B. Horizontal inlet
C. Catch pits
D. Flushing tanks

List-II
1. Concrete box having gratings in horizontal direction
2. Street inlets provided with a settling basin for the settled grit, sand debris etc.
3. The devices used to flush the sewers
4. Concrete box having gratings in vertical direction

Codes:

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 1 | 3 | 4 | 2 |
| (b) | 1 | 4 | 3 | 2 |
| (c) | 1 | 2 | 3 | 4 |
| (d) | 4 | 1 | 2 | 3 |

Q.28 Match List-I (Size of sewer) with List-II (Method of cleaning) and select the correct answer using codes given below the lists:

List-I
A. Small sized sewers
B. Medium sized sewers
C. Badly clogged medium sized sewers
D. Large sized sewers

List-II
1. Cane rodding
2. Pills of suitable size are used
3. By manual labour
4. A flexible fire hose with 2.5 cm nozzle

Codes:

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 1 | 3 | 2 | 4 |
| (b) | 4 | 3 | 2 | 1 |
| (c) | 1 | 2 | 3 | 4 |
| (d) | 4 | 1 | 2 | 3 |

Q.29 Consider the following statements:
1. Maximum daily flow of sewage is twice the average daily sewage flow.
2. Maximum hourly sewage flow is one and half times the maximum daily flow of sewage.
3. Maximum hourly average flow is three times the average daily sewage flow.

Which of these statement/s is/are correct?
(a) Only 1    (b) Only 3
(c) Both 2 and 3    (d) 1, 2 and 3

Q.30 Consider the following statements :
1. Sewers upto 400 mm diameter should be designed to run at half depth at maximum discharge.
2. Sewers between 400 to 900 mm diameter should be designed to run at $2/3^{rd}$ depth at maximum discharge.
3. Larger diameter sewers should be designed to run at $3/4^{th}$ depth at maximum discharge.

Which of these statement/s is/are correct?
(a) Only 2    (b) Both 1 and 3
(c) Both 2 and 3    (d) 1, 2 and 3

Q.31 Consider the following statements :
1. Shallow manhole is about 0.7 to 0.9 m in depth.
2. Normal or medium manhole is about 1.5 m in depth.
3. Deep manhole is having depth more than 1.5 m.

Which of these statement/s is/are correct?
(a) Only 2    (b) Both 1 and 2
(c) Both 2 and 3    (d) 1, 2 and 3

Q.32 The drainage discharge of a town of 16 hectares area, consisting of 40% hard paved ($k = 0.8$), 30% unpaved ($k = 0.20$), and remaining as wooded ($k = 0.1$), with a maximum rainfall intensity of 5 cm/hr, would be computed by Rational formula, as equal to
(a) 0.91 cumecs    (b) 0.091 cumecs
(c) 9.1 cumecs    (d) None of these

Q.33 The drop manholes are provided in a sewerage system when there is
(a) change in alignment of sewer line
(b) change in size of sewers
(c) change in the elevation of ground level
(d) change from gravity system to pressure system

Q.34 When a sewer line is dropped below the hydraulic gradient line to pass it through an obstruction, the arrangement is known as
(a) inverted syphon
(b) sag pipe
(c) depressed sewer
(d) All of these

Q.35 The intake opening is generally covered by a screen to prevent entry of debris etc. and its level is kept
(a) at the level of water of the source
(b) at the bottom of water of the source
(c) at about 2.5 m above the bottom
(d) none of these

Q.36 Match List-I (Pipe material) with List-II (Property of material) and select the correct answer using codes given below the lists:

List-I
A. Concrete sewer
B. Stone ware sewer
C. Cast iron sewer
D. Steel sewer

List-II
1. Cannot withstand large external loads
2. Corrosion resistant in most natural soils
3. Resistant to corrosion from most acids
4. Unsuitable where soil contains excessive sulphates

Codes:

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 |
| (b) | 4 | 3 | 2 | 1 |
| (c) | 4 | 1 | 2 | 3 |
| (d) | 2 | 1 | 3 | 4 |

Q.37 Match List-I with List-II and select the correct answer using codes given below the lists:

List-I
A. Waste pipe
B. Soil pipe
C. Vent pipe
D. Anti-siphonage pipe

List-II
1. Carries waste water
2. Carries liquid wastes that do not include human excreta
3. Preserves the water seal of traps through access to atmospheric air
4. Carries liquid wastes including human excreta
5. Provides flow of air to or from a drainage system in order to prevent vacuum pressures and excessive pressure and provides escape for foul gases

Codes:

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 2 | 4 | 5 | 3 |
| (b) | 3 | 5 | 1 | 2 |
| (c) | 4 | 5 | 1 | 2 |
| (d) | 1 | 4 | 5 | 3 |

Q.38 Factors which are to be considered while selecting a particular material for constructing sewer pipes are
1. resistance to corrosion and abrasion
2. strength and durability
3. light weight and imperviousness
4. economy aspects and hydraulically efficiency

Which of these statements are correct?
(a) 1, 2 and 3    (b) 1, 3 and 4
(c) 2, 3 and 4    (d) 1, 2, 3 and 4

Q.39 Consider the following statements with reference to RCC sewer pipes :
1. They are easily available upto 1.8 m diameter.
2. They can be easily joined with a mortar caulked bell and spigot joint.
3. RCC pipes, P1, P2 and P3 are used for carrying sewage under gravity.

Which of these statement/s is/are correct?
(a) Only 2
(b) Both 1 and 2
(c) Both 2 and 3
(d) 1, 2 and 3

**Q.40** Two pipe system of providing building drainage consists of
(a) one soil pipe + one waste pipe + one vent pipe + one sullage pipe
(b) one soil pipe + one waste pipe + two vent pipes
(c) two soil pipes + two waste pipes
(d) two soil pipes only

**Q.41** The value of the coefficient of runoff for perfectly impervious areas, tend to:
(a) zero
(b) 0.5
(c) 1.0
(d) infinity

**Q.42** Pick up the incorrect statement:
(a) Sewer pipes carry sewage flow by gravity
(b) Sewer pipe material has to withstand wear and tear due to abrasion
(c) Sewer pipes should be designed for self-cleansing velocity of at least 0.45 m/sec at minimum discharge, or 0.8 m/sec at full design discharge
(d) None of these

**Q.43** The diameter of a circular sewer has following ratio to the side of a hydraulically equivalent square section of sewer
(a) 0.95
(b) 1.0
(c) 1.095
(d) 1.25

**Q.44** The maximum velocity in a sewer of diameter $d$ will be obtained when depth of flow is equal to
(a) $d$
(b) $0.5 d$
(c) $0.808 d$
(d) $0.95 d$

**Q.45** What is the maximum distance between successive manholes in sewers of diameter more than 1.5 m?
(a) 75 m
(b) 300 m
(c) 500 m
(d) 150 m

**Q.46** Consider the following statements:
1. The velocity of flow in the rising main should not be less than 0.8 ms$^{-1}$ at any time.
2. Maximum velocity of flow is generally limited to 1.8 ms$^{-1}$ and never allowed to exceed 3 ms$^{-1}$.

In the design of large sewage pumping stations, which of the above conditions must be satisfied?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

**Q.47** In a design of storm sewers, if the time taken by rain-water to flow from the farthest point of the watershed to the sewer inlet is '$t_i$' and the time of flow of water from sewer inlet to the point of sewer that is under consideration is '$t_f$' then the time of concentration will be
(a) $t_i$
(b) $t_f$
(c) $t_i + t_f$
(d) Greater of $t_i$ and $t_f$

**Q.48** Which of the following are storm water regulators?
1. Slide weir
2. Leaping weir
3. Syphonic spillway
4. Float actuated gates or valves
5. Inverted syphon
Select the correct answer using the codes given below:
(a) 1, 2, 3 and 4
(b) 1, 3 and 5
(c) 2, 3, 4 and 5
(d) 1, 2, 4 and 5

**Q.49** Which is the best sewer material to resist hydrogen sulphide corrosion?
(a) Glazed stoneware
(b) Glazed earthware
(c) RCC
(d) Brick masonry

**Q.50** Consider the following statements:
1. The minimum diameter of siphon pipe is taken as 10 cm.
2. If the length of siphon is more, hatch boxes at interval of about 100 m should be provided for facility of rodding.
Which of these statement/s is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

**Q.51** In a circular sewer of diameter $D$, if the depth of flow is $D/4$, the wetted perimeter well be equal to
(a) $\dfrac{\pi D}{4}$
(b) $\dfrac{\pi D}{2}$
(c) $\dfrac{\pi D}{3}$
(d) $\dfrac{\pi D}{6}$

**Q.52** A primary classifier has an overflow rate of 600 gal/day $ft^2$ and depth of 6 ft. The hydraulic retention time is
(a) 1.80 hour
(b) 2.10 hour
(c) 2.40 hour
(d) 2.60 hour

**Common Data Question 53-54:**
A water treatment plant is designed for 30 million gallons per day (mgd). The flocculator dimensions are length = 100 ft, width = 50 ft, depth = 16 ft. Revolving paddles attached to four horizontal shafts rotate at 1.7 rpm. Each shaft supports four paddles that 6 inch wide and 48 inch long. Paddles are centered 6 ft from shaft. Assume

$C_D = 1.9$ and mean velocity of water is 35% of paddle velocity. Assuming velocity differential between paddles and water is 65% of rotational velocity. The density of water is 1.94 lbs - s$^2$/$ft^3$ and viscosity is 2.73 × lbs/$ft^2$.

**Q.53** The value of $G$ is given as
(a) 15.50 s$^{-1}$
(b) 12.5 s$^{-1}$
(c) 10.5 s$^{-1}$
(d) 13.5 s$^{-1}$

**Q.54** The time of flocculation is
(a) 25.2 min
(b) 26.4 min
(c) 23.4 min
(d) 28.7 min

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**Answers** Design of Sewage System and Sewer Appurtenances

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. (c) | 2. (a) | 3. (d) | 4. (b) | 5. (b) | 6. (c) | 7. (d) | 8. (d) | 9. (c) | 10. (b) |
| 11. (a) | 12. (a) | 13. (a) | 14. (b) | 15. (b) | 16. (b) | 17. (c) | 18. (a) | 19. (a) | 20. (a) |
| 21. (b) | 22. (d) | 23. (c) | 24. (d) | 25. (b) | 26. (b) | 27. (d) | 28. (d) | 29. (d) | 30. (d) |
| 31. (d) | 32. (a) | 33. (c) | 34. (d) | 35. (d) | 36. (b) | 37. (a) | 38. (d) | 39. (b) | 40. (b) |
| 41. (c) | 42. (d) | 43. (c) | 44. (c) | 45. (b) | 46. (c) | 47. (c) | 48. (a) | 49. (a) | 50. (b) |
| 51. (c) | 52. (a) | 53. (c) | 54. (d) | | | | | | |

**Explanations** Design of Sewage System and Sewer Appurtenances

**1.** (c)
The advantages gained in starting from tail end is the utilization of tail end even during the initial period of construction.

**9.** (c)
Velocity of flow is given as,

$$V = \frac{1}{n}R^{2/3}S^{1/2}$$

When flowing full,

$$R = \frac{Area}{Perimeter} = \frac{\pi D^2}{4 \times \pi d} = \frac{D}{4}$$

When flowing half full,

$$R = \frac{Area}{Perimeter} = \frac{\pi D^2 \times 2}{8 \times \pi D} = \frac{D}{4}$$

So, when flowing half full,
$$V = 2 \text{ ms}^{-1}$$
(i.e., same as when flowing full)

**10.** (b)
Self cleansing velocity,

$$V = \frac{1}{n}R^{1/6}\{k_s (G_s - 1) d_p\}^{1/2}$$

Here,  $n = 0.012$

$$R = \frac{D}{4} = 0.25 \text{ m}$$

$k_a = 0.8$
$G_s = 2.65$
$d_p = 1 \text{ mm} = 10^{-3} \text{ m}$

So,  $V = \frac{1}{0.012}(0.25)^{1/6}\left[0.8(2.65-1)10^{-3}\right]^{1/2}$

$= 2.4 \text{ ms}^{-1}$

**15. (b)**
House sewer carries sewage from building to the point of immediate disposal while lateral sewer receives the discharge from number of independent houses.

**20. (a)**
When both sewers are hydraulically equivalent then their discharges are same.
For circular sewer (by using Manning's formula)

$$Q = \frac{1}{N} A R^{2/3} \sqrt{S}$$

Assume sewer is running full

$$A = \frac{\pi}{4} D^2$$

$$R = \frac{D}{4}$$

$$Q = \frac{1}{N}\left(\frac{\pi}{4}D^2\right)\left(\frac{D}{4}\right)^{2/3}\sqrt{S} \qquad ...(i)$$

For square section
$$A = b^2$$

$$R = \frac{b}{4}$$

$$Q = \frac{1}{N}\left(b^2\right)\left(\frac{b}{4}\right)^{2/3}\sqrt{S} \qquad ...(ii)$$

On equating equations (i) and (ii)

$$\frac{1}{N}\left(\frac{\pi}{4}D^2\right)\left(\frac{D}{4}\right)^{2/3}\sqrt{S} = \frac{1}{N}\left(b^2\right)\left(\frac{b}{4}\right)^{2/3}\sqrt{S}$$

$$\Rightarrow \quad \frac{\pi}{4}D^2 \frac{D^{2/3}}{4^{2/3}} = \frac{b^2 \, b^{2/3}}{(4)^{2/3}}$$

$$\Rightarrow \quad \frac{\pi}{4} D^{8/3} = b^{8/3}$$

$$\Rightarrow \quad \pi D^{8/3} = 4 b^{8/3}$$

**21. (b)**
For drains discharge up to 15 cumecs $d = 0.5\sqrt{B}$
For drains discharge greater than 15 cumecs

| Q (cumecs) | Depth (d)(m) |
|---|---|
| 15 | 1.7 |
| 30 | 1.8 |
| 75 | 2.3 |
| 150 | 2.6 |
| 300 | 3.0 |

**22. (d)**
The manholes are generally provided at every bend, junction change of gradient or change of sewer diameter unless there are practical difficulties, the sewer line between two manholes is laid straight with even gradient.

**25. (b)**
Diameter of manhole opening should be about 50-60 cm.

**30. (d)**
Generally, the sewer pipes of sizes less than 0.4 m diameter are designed as running half full at maximum discharge and the sewer pipes greater than 0.4 m in diameter are designed as running 2/3rd or 3/4th full at maximum discharge.

**32. (a)**

$$K_{avg} = \frac{(0.4 \times 0.8 + 0.3 \times 0.2 + 0.3 \times 0.1)}{(0.4 + 0.3 + 0.3)} = 0.41$$

$$Q = \frac{1}{36} k I A = \frac{1}{36} \times 0.41 \times 5 \times 16 = 0.91 \text{ cumecs}$$

**33. (c)**
When a branch sewer enters a manhole by more than 0.5 to 0.6 m above the main sewer, the sewage is generally not allowed to fall directly into the manhole, but is brought into it through a down pipe taken from the branch sewer to the bottom of the manhole. The manhole, in which a vertical pipe is used, is called drop manhole, whereas, the one using an inclined pipe is called a ramp.

**34. (d)**
An inverted siphon is a sewer section constructed lower than the adjacent sewer sections, and it runs full under gravity with pressure greater than the atmosphere. An inverted siphon is usually made of siphon tubes or pipes made of cast iron or concrete.

**36. (b)**
The biggest drawback of concrete sewers is that they easily get corroded and pitted by action of sulphuric acid produced from hydrogen sulphide gas.

The stone ware pipes offer the maximum advantage of being highly resistant to sulphide corrosion.

**38. (d)**
The sewer pipes should be strong enough to withstand all forces that are likely to come on them. The pipe material must be durable as not to give way quickly due to normal wear and tear. The material used should be light, so that sewer can be easily handled and transported. The material should be such as to provide a smooth interior surface so as to provide an hydraulically efficient surface.

**39. (b)**
RCC pressure pipes, classified as P1, P2 and P3 pipes, are generally used for carrying water supplies under pressure and are usually not used as sewers which are designed as gravity conduits.

**40. (b)**
In this system, two sets of vertical pipes are laid, i.e., one for draining night soil, and the other for draining sullage. The pipes of the first set carrying night soil are called soil pipes, and the pipes of the second set carrying sullage from baths etc., are called sullage pipes or waste pipes. The soil pipe as well as the waste pipe, are separately ventilated by providing separate vent pipes or anti-siphonage pipes.

**43. (c)**
Hydraulically equivalent square section is the one which gives the same discharge when running full at the same gradient.

Circular sewer : $Q_c = \frac{1}{n} A_c R_c^{2/3} S^{1/2}$

Square sewer: $Q_s = \frac{1}{n} A_s R_s^{2/3} S^{1/2}$

For hydraulic equivalence

$$\Rightarrow \quad \frac{\pi D^2}{4} \times \left(\frac{\pi D^2}{4 \times \pi D}\right)^{2/3} = B^2 \times \left(\frac{B^2}{4B}\right)^{2/3}$$

$$\Rightarrow \quad \frac{\pi D^2}{4} \times (D)^{2/3} = B^2 (B)^{2/3}$$

$$\Rightarrow \quad \left(\frac{D}{B}\right)^{8/3} = \frac{4}{\pi}$$

$$\Rightarrow \quad \frac{D}{B} = 1.095$$

**44. (c)**
The maximum velocity is obtained not when the sewer is running full but when the depth of flow is 0.81 times the full depth, and is about 12.5% greater that when running full. Similarly, the maximum discharge is obtained not when the sewer is running full, but when the depth is about 0.95 times the full depth, and is about 7% greater than that when running full.
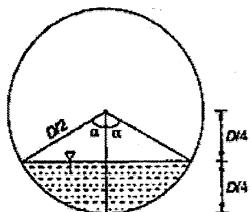
**45. (b)**

| Size of the Sewer | Recommended Spacing of Manholes on straight reaches of Sewer lines as per IS 1742-19609 |
|---|---|
| Dia. up to 0.3 m | 45 m |
| Dia. upto 0.6 m | 75 m |
| Dia. upto 0.9 m | 90 m |
| Dia. upto 1.2 m | 120 m |
| Dia. upto 1.5 m | 250 m |
| Dia. greater than 1.5 m | 300 m |

**50. (b)**
The minimum diameter of the siphon pipe is taken as 15 to 20 cm.

**51. (c)**



$$\cos\alpha = \frac{D}{4}\times\frac{2}{D} = \frac{1}{2}$$

$\therefore \qquad \alpha = 60°$

Proportionate perimeter

$$\frac{P}{P} = \frac{2\alpha}{360} = \frac{120}{360} = \frac{1}{3}$$

$$\therefore \qquad P = \frac{\pi D}{3}$$

**52. (a)**

$$V_0 = \frac{600\,\text{gal}}{\text{day}\,ft^2}\times\frac{1ft^2}{748\,\text{gal}}$$

$$= 80.2\,ft/\text{day}$$

$$\bar{t} = \frac{6ft}{80.2ft/\text{day}}$$

$$= 0.0748\,\text{day} = 1.8\,h$$

**53. (c)**

Rotational velocity,

$$V_t = \frac{2\pi N}{60} = \frac{2\pi\times6\times1.7}{60}$$

$$= 1.07\,ft/\text{sec}$$

$$V = 0.65\,V_t = 0.70\,ft/\text{sec}$$

$$\text{Power, } P = \frac{1.9\times16\times0.5\times48\times1.94\times0.7}{2}$$

$$= 243\,ft/\text{lbs}$$

$$G = \sqrt{\frac{243}{100\times50\times16\times2.73\times10^{-3}}}$$

$$= \frac{10.5\,ft/\text{sec}}{ft}$$

**54. (d)**

$$E = \frac{V}{Q} = \frac{100\times50\times16\times7.48\times24\times60}{(30\times10^3)}$$

$$= 28.7\,\text{min}$$

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