DETAILED SOLUTIONS

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MPSC 2019 : Main Exam

ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 10

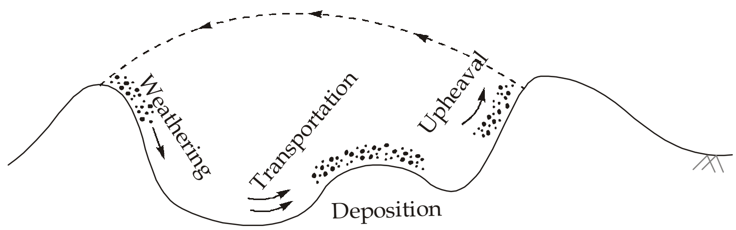
Full Syllabus Test-4 | Paper-II

ANSWER KEY

1.	(d)	18.	(a)	35.	(b)	52.	(c)	69.	(a)	86.	(d)
2.	(b)	19.	(c)	36.	(d)	53.	(b)	70.	(b)	87.	(c)
3.	(a)	20.	(c)	37.	(a)	54.	(c)	71.	(c)	88.	(d)
4.	(d)	21.	(a)	38.	(d)	55.	(a)	72.	(b)	89.	(a)
5.	(b)	22.	(b)	39.	(c)	56.	(a)	73.	(a)	90.	(a)
6.	(a)	23.	(c)	40.	(c)	57.	(a)	74.	(c)	91.	(c)
7.	(c)	24.	(d)	41.	(c)	58.	(c)	75.	(a)	92.	(d)
8.	(a)	25.	(c)	42.	(a)	59.	(b)	76.	(c)	93.	(b)
9.	(d)	26.	(d)	43.	(c)	60.	(c)	77.	(d)	94.	(b)
10.	(b)	27.	(c)	44.	(b)	61.	(a)	78.	(d)	95.	(c)
11.	(d)	28.	(b)	45.	(d)	62.	(c)	79.	(c)	96.	(d)
12.	(b)	29.	(b)	46.	(a)	63.	(c)	80.	(a)	97.	(c)
13.	(d)	30.	(b)	47.	(d)	64.	(c)	81.	(a)	98.	(b)
14.	(b)	31.	(b)	48.	(d)	65.	(d)	82.	(d)	99.	(b)
15.	(a)	32.	(d)	49.	(b)	66.	(c)	83.	(c)	100.	(c)
16.	(c)	33.	(d)	50.	(a)	67.	(b)	84.	(a)		
17.	(c)	34.	(b)	51.	(c)	68.	(b)	85.	(d)		

DETAILED EXPLANATIONS

1. (d)



2. (b)

Given, Porosity, $n = 0.562$

$\therefore$ Void ratio, $e = \frac{n}{1-n} = \frac{0.562}{1-0.562} = 1.283$

3. (a)

Relationship between γ_d, G, w and n_a:

$$V = V_s + V_w + V_a$$

$$1 = \frac{V_s}{V} + \frac{V_w}{V} + \frac{V_a}{V} = \frac{V_s}{V} + \frac{V_w}{V} + n_a$$

$$(1 - n_a) = \frac{V_s}{V} + \frac{V_w}{V} = \frac{W_s/G\gamma_w}{V} + \frac{w\,W_s/\gamma_w}{V}$$

$$= \frac{\gamma_d}{G_s\gamma_w} + \frac{w\,W_s/\gamma_w}{V} = \frac{\gamma_d}{G\gamma_w} + \frac{w\gamma_d}{\gamma_w} = \frac{\gamma_d}{\gamma_w}\left(\frac{1}{G} + w\right)$$

$$\gamma_d = \frac{(1-n_a)\,G\gamma_w}{1+wG}$$

4. (d)

$$(V_s)_{\text{fill}} = (V_s)_{\text{Borrow pit}}$$

$$\left(\frac{V}{1+e}\right)_{\text{fill}} = \left(\frac{V}{1+e}\right)_{\text{Borrow pit}}$$

$$\left(\frac{20,0000}{1+1}\right)\times(1+1.5) = (V)_{\text{Borrow pit}}$$

$\therefore$ $V_{\text{Borrow pit}} = 250000\ \text{m}^3 = 0.25\ \text{m}^3$

5. (b)

The toughness index (I_t) of a soil is defined as the ratio of the plasticity index (I_p) to the flow index (I_f).

$$I_t = \frac{I_P}{I_f}$$

6. (a)

(Type of equipment)	(Suitability for soil types)
1. Rammers or tampers.	All soils
2. Smooth wheeled rollers.	Crushed rocks, gravels, sands
3. Pneumatic tyred rollers.	Sands, gravels, silts, clayey soils not suitable for uniformly graded soil
4. Sheeps foot rollers	Clayey soil
5. Vibratory rollers	Sands

7. (c)

Given, $w_L = 44\%, w_p = 21\%$

∴ $I_P = 44\% - 21\% = 23\%$

$(I_P)_{\text{A-line}} = 0.73(w_L - 20) = 0.73(44 - 20) = 17.52\%$

∴ $(I_p)_{\text{A-line}} < (I_p)_{\text{soil}}$

⇒ Soil is clay.

Also, $35\% < w_L = 44\% < 50\%$

Classification of soil 'CI'.

8. (a)

$$\text{Relative compaction} = \frac{(\gamma_d)_{\text{field}}}{\text{Maximum } \gamma_d \text{ from the proctor test}} \times 100$$

$$\text{Relative density } (I_D\%) = \frac{e_{\max} - e}{e_{\max} - e_{\min}} \times 100$$

- Relative density is the most important property of coarse grained soil.
- Relative density can be zero, but relative compaction can never be zero.

9. (d)

For same degree of consolidation

$$t \propto d^2$$

$$\frac{t_1}{t_2} = \left(\frac{d_1}{d_2}\right)^2 \qquad 1 \rightarrow \text{single drainage, } 2 \rightarrow \text{double drainage}$$

$$\frac{4}{t_2} = \left(\frac{H}{H/2}\right)^2$$

$$t_2 = 1 \text{ year}$$

10. (b)

The compression index of a clay is related to its index properties, especially the liquid limit.

For undisturbed soils,

$$c_c = 0.009(w_L - 10)$$

For remoulded soils,

$$c_c = 0.007(w_L - 7)$$

11. (d)

$$m_v = \frac{a_v}{1+e_o} = \frac{\Delta e}{(\Delta\bar{\sigma})(1+e_o)} = \frac{(0.6-0.4)}{(1+0.6)\times(250-200)}$$

$$= 2.5 \times 10^{-3}\ \text{m}^2/\text{kN}$$

12. (b)

$$\sin\phi = \frac{\bar{\sigma}_1-\bar{\sigma}_3}{\bar{\sigma}_1+\bar{\sigma}_3} = \frac{\left(\frac{\bar{\sigma}_1}{\bar{\sigma}_3}\right)-1}{\left(\frac{\bar{\sigma}_1}{\bar{\sigma}_3}\right)+1} = \frac{4-1}{4+1} = \frac{3}{5}$$

$$\sin\phi = 0.6$$

$$\phi = 37°$$

13. (d)

(Disadvantages of direct shear test):

- Drainage condition cannot be controlled and pore water pressure cannot be measured.
- Failure plane is always horizontal and pre-determined, which may not be the weakest plane.
- Non-uniform stress distribution on shear plane failure starts at edge and progress towards centre.
- Area of specimen under normal and shear does not remain constant during the test.
- Direction of principal plane are not known at every stage of the test. It is only when Mohr's failure envelope is known that direction of principal stress will be known.

15. (a)

$$B = \frac{\Delta u}{\Delta\sigma_3} = \frac{0.15-0.07}{0.26-0.10} = \frac{0.08}{0.16} = 0.5$$

16. (c)

$$\sigma_c = \gamma_t \times 2 + \gamma_{sat} \times 0.3 = 19 \times 2 + 20 \times 0.3$$

$$= 44\ \text{kN/m}^2$$

$$u_c = -(0.7)\gamma_w = -0.7 \times 10 = -7\ \text{kN/m}^2$$

Now,

Effective stress at point *C*,

$$\bar{\sigma}_c = \sigma_c - u_c$$

$$= 44 - (-7) = 51\ \text{kN/m}^2$$

17. (c)

The seepage passes along streamlines. The streamlines are perpendicular to the equipotential lines.

18. (a)

Soil is stratified and anisotropic, hence westergaard's formula is applicable,

$$\sigma_z = k_w \frac{Q}{z^2}$$

$$k_w = \frac{1}{\pi\left(1+2\left(\frac{r}{Z}\right)^2\right)^{3/2}}$$

For $\frac{r}{z} = 0$

$$k_w = \frac{1}{\pi} = 0.318$$

$\therefore$ $\sigma_z = 0.318 \times \frac{800}{(2)^2} = 63.6 \text{ kN/m}^2$

19. (c)

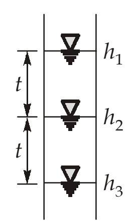
In falling head permeability test

Coefficient of permeability

$$k = \frac{La}{At} \ln\left(\frac{h_1}{h_2}\right)$$

t = time interval during which head h_1 falls to h_2

When



then $\frac{La}{At} \ln\left(\frac{h_1}{h_2}\right) = \frac{La}{At} \ln\left(\frac{h_2}{h_3}\right)$

$\Rightarrow$ $\frac{h_1}{h_2} = \frac{h_2}{h_3}$

$$h_2^2 = h_1 \times h_3$$

$$h_2 = \sqrt{h_1 \cdot h_3}$$

Now, for sample A,

$$h_2 = 32 = \sqrt{40 \times 25.6} = 32$$

For sample B, $h_2 = 30 = \sqrt{40 \times 22.5} = 30$

For sample C, $h_2 = 20 = \sqrt{40 \times 12} = 21.9$ (Inconsistent)

For sample D, $h_2 = 36 = \sqrt{40 \times 32.4} = 36$

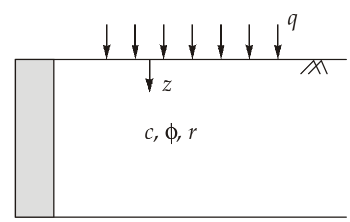
21. (a)

$$D_f = \frac{D+H}{H}$$

Here, D = 10 m, H = 30 – 10 = 20 m,

$$\therefore \quad D_f = \frac{30}{20} = 1.5$$

22. (b)



$$k_a\gamma z = 2c\sqrt{k_a} - k_a q$$

$$z = \frac{2c}{\gamma\sqrt{k_a}} - \frac{q}{\gamma}$$

$$\therefore \quad z = \frac{2c}{\gamma}\tan\alpha - \frac{q}{\gamma}$$

$$\bar{\sigma}_z = \text{Effective stress at any depth } z$$

$$= (\gamma \cdot z + q)$$

Also,

$$k_a = \frac{1}{\tan^2\left(45^\circ + \frac{\phi}{2}\right)} = \frac{1}{\tan^2\alpha}$$

$$\tan\alpha = \frac{1}{\sqrt{k_a}}$$

We know that

$$p_a = k_a\bar{\sigma}_z - 2c\sqrt{k_a}$$

$$p_a = k_a(q + \gamma z) - 2c\sqrt{k_a}$$

$$p_a = 0$$

$$k_a q + k_a\gamma z - 2c\sqrt{k_a} = 0$$

23. (c)

Square bearing plate, B_p = 300 mm = 0.3 m

Size of square footing, B_f = 1 m

Settlement in bearing plate, s_p = 15 mm

For clayey soil,

$$\frac{S_f}{S_p} = \frac{B_f}{B_p}$$

$$S_f = \frac{B_f}{B_p} \times S_p = \frac{1}{0.3} \times 15 = 50 \text{ mm}$$

24. (d)

Passive zone rise with $45° - \frac{\phi}{2}$ angle from horizontal

$$= 45° - \frac{22°}{2} = 34°$$

25. (c)

$$Q_{nf} = k\bar{\sigma}\tan\delta(\pi d)\times L$$

$$= 0.6\times\left(\frac{18\times 8}{2}\right)\times\tan(30°)(\pi\times 0.15)\times 8 = 94 \text{ kN}$$

26. (d)

Under-reamed pile is a special type of bored pile which is provided with a bulb/pedestal at the end. The usual size of such piles are 150 mm to 200 mm shaft dia., 3 m to 4 m long. The diameter of bulb is taken as 2 to 3 times shaft diameter.

The under-reamed piles are suitable for expansive soils.

27. (c)

In this contract, a method of payment to a contractor in which an additional amount of money, expressed as percentage, is paid by the client to contractor in form of cost of construction plus certain profit with it.

28. (b)

Valuation is a technique of finding the present value of an existing building or an asset. It is needed for investment analysis, rent fixation etc.

29. (b)

Tender : It is an offer in writing to execute some specified work at certain rates within a fixed time under certain condition of contract and agreement between the contractor and the owner.

Analysis of rates: The method of determination of rate per unit of a particular item of work considering the cost of quantities of materials, the cost of labourers, hire of tool and plants, overhead charges, water charges, contractor profit etc is known as analysis of rates.

Abstract estimate: It is an estimate prepared in initial stages to know the approximate cost of the project.

30. (b)

The most important feature of item rate contracts is the schedule of items, rates and quantities (also known as bill of quantities) which forms an integral part of the contract.

31. (b)

The unit of measurements of DPC work is square meter.

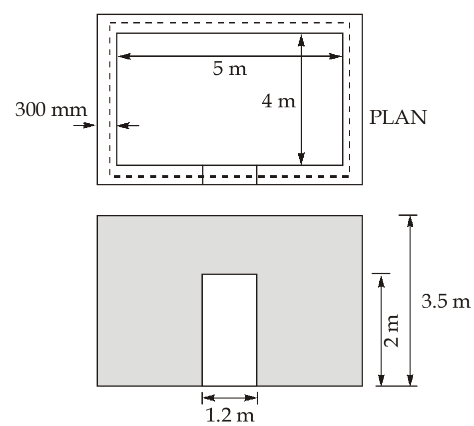
32. (d)

$$\text{Cost} = \text{Plinth area} \times \text{Plinth area rate}$$
$$= 150 \times 5500 = 825000$$
$$\text{Cost of electrification} = 0.07 \times 825000 = 57750$$
$$\text{Cost of sanitary fittings} = 0.16 \times 825000 = 132000$$
$$\text{Cost of roads and lawns} = 0.065 \times 825000 = 53625$$
$$\text{Cost of contingencies} = 0.045 \times 825000 = 37125$$
$$\text{Total cost} = 825000 + 57750 + 132000 + 53625 + 37125$$
$$= 1105500$$

33. (d)

Lump sump items is the item of work which is very difficult to measure or assess during its execution. Since plastering of wall can be estimated accurate hence it is not a lump sum item.

35. (b)



$$\text{Total centre line length} = 2[(5 + 0.3) + (4 + 0.3)] = 19.2 \text{ m}$$
$$\therefore \quad \text{Quantity of brickwork} = 19.2 \times 0.3 \times 1.5 + (19.2 - 1.2) \times 0.3 \times 2 = 19.44 \text{ m}^3$$

36. (d)

There are two principles of surveying:

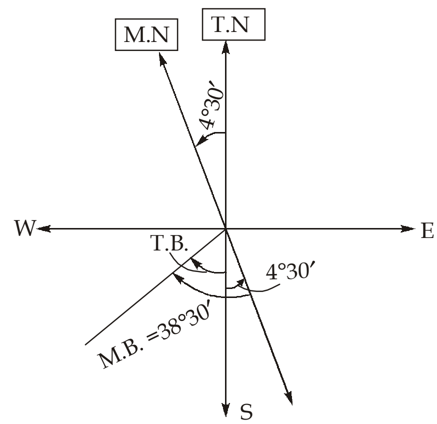
1. Work from whole to part.
2. Locate a point by atleast two measurements

37. (a)

Higher the representative fraction (R.F) value, larger the scale.

So, scale $\frac{1}{1000}$ is larger than scale $\frac{1}{5000}$.

38. (d)



$$\text{T.B.} = \text{MB} - 4°\,30' = \text{S}38°30'\text{W} - 4°\,30' = \text{S}34°\,0'\text{W}$$

40. (c)

$$\text{Shrinkage factor, S.F.} = \frac{4.6}{5} = 0.92$$

$$\text{Now, } (\text{R.F.})_{\text{Shrunk scale}} = (\text{S.F.}) \times (\text{R.F.})_{\text{Original scale}}$$

$$(\text{R.F.})\text{Shrunk scale} = 0.92 \times \frac{1}{8000} = \frac{1}{(8000/0.92)} = \frac{1}{8695.65}$$

$$\Rightarrow \quad 1\text{ cm} = 8695.65\text{ cm}$$

$$\simeq 1\text{ cm} = 86.95\text{ m}$$

41. (c)

$$\text{Relative error of closure} = \frac{\text{Error of closure}}{\text{Perimeter of traverse}} = \frac{e}{p}$$

42. (a)

Resection can be defined as the process of locating the instrument station occupied by the plane table by drawing rays from the stations whose positions are already plotted on the drawing sheet.

43. (c)

In electro optical EDM, inter visibility between the stations is required.

44. (b)

$$f = 160\text{ mm}$$

$$B = 2200\text{ m};\ h = 900\text{ m};\ p = 75\text{ mm}$$

$$\text{Parallax, } p = \frac{Bf}{H-h}$$

$$75 = \frac{2200 \times 160}{H - 900}$$

$$H = \frac{2200 \times 160}{75} + 900 = 5593.33\text{ m}$$

45. (d)

The sensitivity of the bubble tube/level tube can be increase by

(a) increasing the radius of the tube(R)

(b) increasing the length of tube

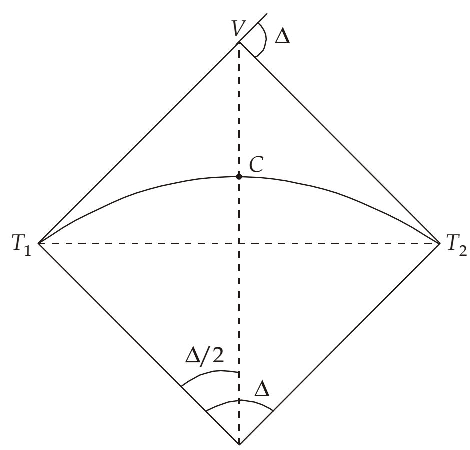
(c) smoothening the inner surface of tube

(d) decreasing the viscosity and surface tension of fluid inside tube

46. (a)

$$\Delta = 60°; D = 8°$$

$$\therefore \quad R = \frac{1720}{D} = \frac{1720}{8} = 215 \text{ m}$$



$$\text{Apex distance } (V_c) = R\left(\sec\left(\frac{\Delta}{2}\right) - 1\right)$$

$$= 215\left(\sec\left(\frac{60°}{2}\right) - 1\right) = 33.26 \text{ m}$$

48. (d)

$$D = \frac{kS}{m} + c$$

s = stadia intercept

m = sum of reading on micrometer

$$60 = \frac{k \times 1.5}{22.5} + c \quad \text{....(i)}$$

$$120 = \frac{k \times 1.5}{11.28} + c \quad \text{...(ii)}$$

Solving equation (i) and (ii), we get

$$k = 904.8$$

$$c = 0.32$$

49. (b)

- Contour lines very close together indicates steep slope.
- If they are well far apart indicates gentle slope.
- If they are equally spaced represents uniform slope.
- A series of straight, parallel and equally spaced contours represents a plane surface.
- Two contours lines do not intersect each other except in the case of an overhanging cliff.

50. (a)

Transiting (also known as plunging or reversing), is the operation of revolving the telescope by 180° in a vertical plane about its horizontal axis.

51. (c)

The width of carriageway for various classes of roads standarised by Indian road congress are given below:

(Class of road)	(Width of carriageway)
1. Single lane.	3.75 m
2. Two lanes, without raised kerb.	7.0 m
3. Two lanes, with raised kerb.	7.5 m
4. Intermediate carriageway.	5.5 m
5. Multi-lane pavement.	3.5 m per lane

52. (c)

Given,

$$V_{min} = 110 \text{ km/h}$$

$$(R_{abs,\ min}) = \frac{V_{min}^2}{127(e+f)}$$

$$e = 7\%;\ f = 0.15$$

$$= \frac{(110)^2}{127(0.07+0.15)} = 433.07 \text{ m} \simeq 440 \text{ m}$$

53. (b)

$$\text{SSD} = 0.278Vt_r + \frac{V^2}{254(f-n\%)}$$

$$= 0.278 \times 80 \times 2 + \frac{(80)^2}{254(0.35-0.03)} = 123.26 \text{ m}$$

55. (a)

Speed limit sign is a regulatory or mandatory sign and should be of circular shape with white background and red border.

57. (a)

$$k_1a_1 = k_2a_2$$

$$k_2 = \left(\frac{k_1a_1}{a_2}\right) = \frac{16\times(30/2)}{(75/2)}$$

$$= 6.4 \text{ kg/cm}^3$$

58. (c)

$$\text{G.I.} = 0.2a + 0.005ac + 0.01bd$$

$$a = p - 35 = 50 - 35 = 15 \ngtr 40\%$$

$$b = p - 15 = 50 - 15 = 35 \ngtr 40\%$$

$$c = w_L - 40 = 40 - 40 = 0 \ngtr 20\%$$

$$d = I_p - 10 = 20 - 10 = 10 \ngtr 20\%$$

$\therefore$ $$\text{G.I.} = 0.2 \times 15 + 0 + 0.01 \times 35 \times 10 = 6.5$$

60. (c)

Gap at expansion join (δ) 25 mm = 25×10^{-3} m

$$\alpha = 10 \times 10^{-6}/°C$$

$$\text{Spacing of expansion joint} = \frac{\delta'}{\alpha\Delta t} = \frac{\delta}{2\alpha\Delta t}$$

$$= \frac{25\times10^{-3}}{2\times10\times10^{-6}\times25} = 50 \text{ m}$$

70. (b)

According to sichardt radius of influence varies between 150 m to 300 m and it can be found using the relation,

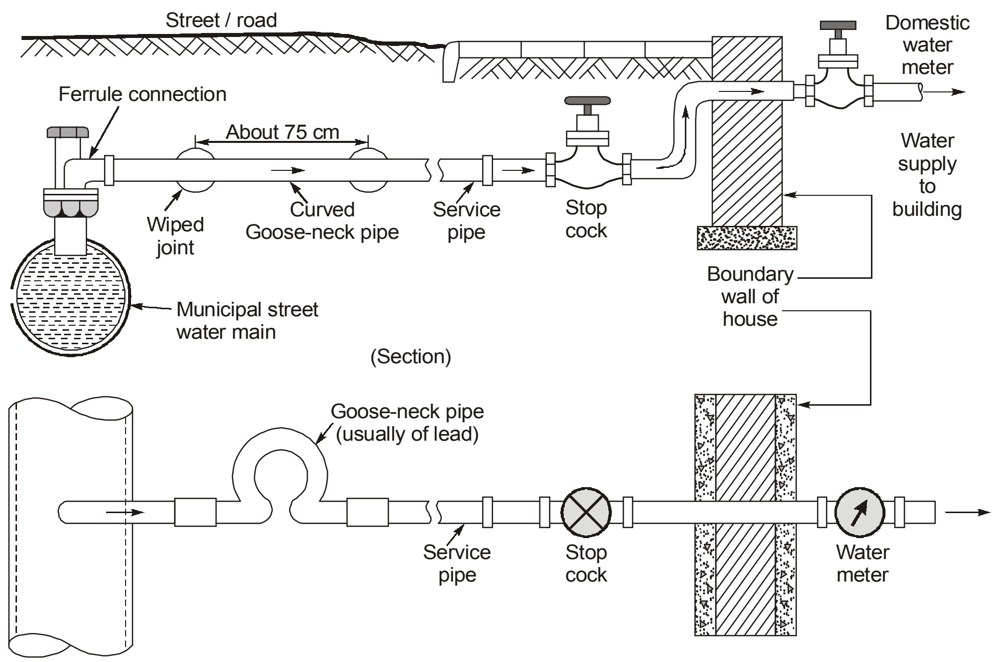
$$R = 3000s\sqrt{k}$$

S = drawdown in the well(in m)

R = Radius of influence (in m)

k = Coefficient of permeability (in m/sec)

71. (c)



72. (b)

$$V_o(\text{surface overflow rate}) = \frac{Q}{(BL)}$$

$$(BL)\text{surface area} = \frac{Q}{V_o} = \frac{1.5\times60\times60\times24}{40} = 3240 \text{ m}^2$$

73. (a)

The purpose of recarbonation after lime-soda process or water softening is the conversion of precipitate to soluble form.

It can be done by:

1. Aeration
2. Pumping CO_2 into the water
3. Addition of CO_2

74. (c)

At breakpoint chlorination: Chlororganic and chloramines are get destructed and bad smell suddenly disappears. Any further chlorine addition simply appears as free chlorine.

75. (a)

- Chlorine residuals can be tested by orthotolidine test, DPD test, chlorotex test, starchiodide test.
- The dissolved oxygen of sewage is generally determine by Winkler's method.
- Chlorides are estimated by Mohr's method in which raw water is titrated with standard $AgNO_3$ solution using K_2CrO_4 (Potassium chromate) as indicator.

76. (c)

- The leachate from sanitary landfill tend to pollute ground water.
- Incineration and pyrolysis release air pollutants.
- Compositing does not have any harmful effect.

77. (d)

Turbidity which one milligram of finally divided silica produces in one litre of distilled water is taken as one unit.

78. (d)

For sewage,

$$Q_s = 1.5 \text{ m}^3/\text{sec}$$
$$(\text{BOD})_5 = 250 \text{ mg/L}$$

For river,

$$Q_R = 20 \text{ m}^3/\text{sec}$$
$$(\text{BOD})_R = 10 \text{ mg/L}$$

$$C_{\text{mix}} = \frac{C_s Q_s + C_R Q_R}{Q_S + Q_R} = \frac{(BOD)_S \cdot Q_s + (BOD)_R \cdot Q_R}{Q_S + Q_R}$$

$$= \frac{250 \times 1.5 + 10 \times 20}{1.5 + 20} = 26.74 \text{ mg/L}$$

79. (c)

The peak sewage flow can also be determined by connecting it with population,

$$Q = \frac{18+\sqrt{P}}{4+\sqrt{P}} \cdot Q_{\text{av}} = \frac{18+\sqrt{P}}{4+\sqrt{P}} \cdot q$$

80. (a)

Primary air pollutants are those which emitted directly from identifiable source.

Ex:

(a) Finer particles.

(b) SO_2

(c) NO_2, NO

(d) CO

(e) Halogen compounds, organic compounds and radioactive compounds.

82. (d)

In oxidation pond, depth is kept less so that sunlight can penetrate upto full depth to perform aerobic decomposition. If the depth is less than we require more surface area means more land requirement.

85. (d)

For sugarcane:

$$\text{II} = 20\%$$
$$\text{CCA} = 1000 \text{ ha}$$
$$\text{Area to be irrigated} = 1000 \times 0.2 = 200 \text{ ha}$$
$$\text{Duty} = 700 \text{ ha/cumec}$$

$$Q_{\text{sugarcane}} = \frac{200}{700} = 0.285 \text{ cumec}$$

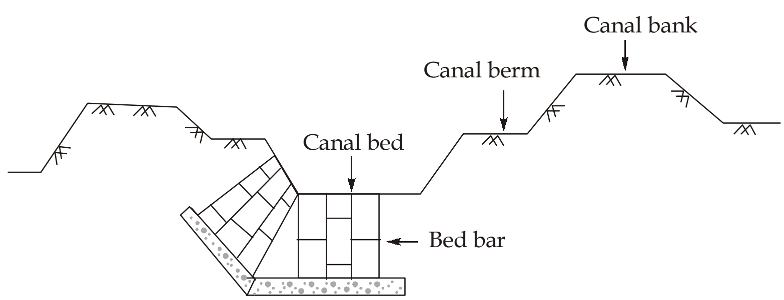
For wheat:

$$\text{II} = 30\%$$
$$\text{CCA} = 1000 \text{ ha}$$
$$\text{Area to be irrigated} = 1000 \times 0.3 = 300 \text{ ha}$$
$$\text{Duty} = 1500 \text{ ha/cumec}$$
$$Q_{\text{wheet}} = \frac{300}{1500} = 0.2 \text{ cumec}$$
$$\text{Time factor} = 0.8$$
$$Q_{\text{design}} = \frac{0.285 + 0.2}{0.8} = 0.60625 \text{ cumec}$$
$$\simeq 0.6 \text{ cumec}$$

86. (d)

Repelling groyne → Pointed upstream
Attractive groyne → Pointed downstream
Deflecting groyne → Deflecting in nature

87. (c)



88. (d)

i. Dicken's formula:

$$Q_p = C_D \cdot A^{3/4}$$

Where,
Q_p = Maximum flood discharge (m^3/s)
A = Catchment area (km^2)
C_D = Dicken's constant

Dicken's formula is used in the central and northern parts of the country.

ii. Ryves formula:

$$Q_R = C_R A^{2/3}$$

Where,
Q_R = Maximum flood discharge (m^3/s)
A = Catchment area (km^2)
C_R = Ryve's constant

It is in use in Tamilnadu, and parts of Karnataka and Andhra Pradesh.

iii. Inglis formula:

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

Q_p = Maximum flood discharge (m^3/s)

A = Catchment area (km^2)

It is based on flood data of catchments in western ghats in Maharashtra.

89. (a)

When outflow from a reservoir is uncontrolled as in freely operating spillway, then the peak of outflow hydrograph will occur at a point of intersection of inflow and outflow hydrograph, whereas if outflow from a reservoir is controlled, then peak will occur after the intersection of the curve.

92. (d)

Panman's equation is based on combination of the energy-balance and mass transfer approaches.

$$\text{PET} = \frac{AH_n + E_a\gamma}{A+\gamma}$$

94. (b)

As per Newton's law of viscosity

$$\tau \propto \left(\frac{du}{dy}\right) \propto \frac{d\theta}{dt}$$

i.e. shear stress (τ) is directly proportional to the rate of deformation $\left(\frac{d\theta}{dt}\right)$ or velocity gradient across the flow.

95. (c)

In case of ships the shifting of cargo may cause the ships to roll. As such along with the consideration of the stability of a ships, its period roll is also required to be determined. This so because increasing the metacentric height gives greater stability to a floating body.

96. (d)

$$\psi = 3xy$$

$$u = -\frac{\partial\psi}{\partial y} = -3x$$

$$v = \frac{\partial\psi}{\partial x} = 3y$$

At $p(2, 3)$

$\therefore$ $$\vec{V} = -6\vec{i} + 9\vec{j}$$

$\therefore$ $$(\vec{V}) = \sqrt{(-6)^2 + (9)^2} = \sqrt{36+81} = \sqrt{117} = 10.817 \text{ units}$$

97. (c)

Positive pressure gradient increases the chances of separation of boundary layer.

98. (b)

In rectangular channel, critical depth of flow

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

For critical flow,
$$F_r = 1$$

$$\frac{V_c}{\sqrt{gy_c}} = 1$$

$$V_c = \sqrt{gy_c} = \sqrt{g \times \left(\frac{q^2}{g}\right)^{1/3}}$$

$$= \sqrt{(qg)^{2/3}} = (qg)^{(2/3)\times(1/2) = (qg)^{1/3}}$$

99. (b)

For maximum power from a Pelton turbine

$$u = \frac{V_1}{2}$$

V_1 = jet velocity

u = bucket speed

100. (c)

$$\frac{\sqrt{H}}{DN} = \text{Const.}$$

Given,
$$N = \text{Const.}$$

$\therefore$
$$\frac{\sqrt{H}}{D} = \text{Const.}$$

$\Rightarrow$
$$\sqrt{\frac{H_1}{H_2}} = \frac{D_1}{D_2}$$

$$\sqrt{\frac{20}{30}} = \frac{500}{D_2}$$

$$D_2 = \sqrt{\frac{30}{20}} = 500 = 612.4 \text{ mm}$$

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