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Important Questions for GATE 2022

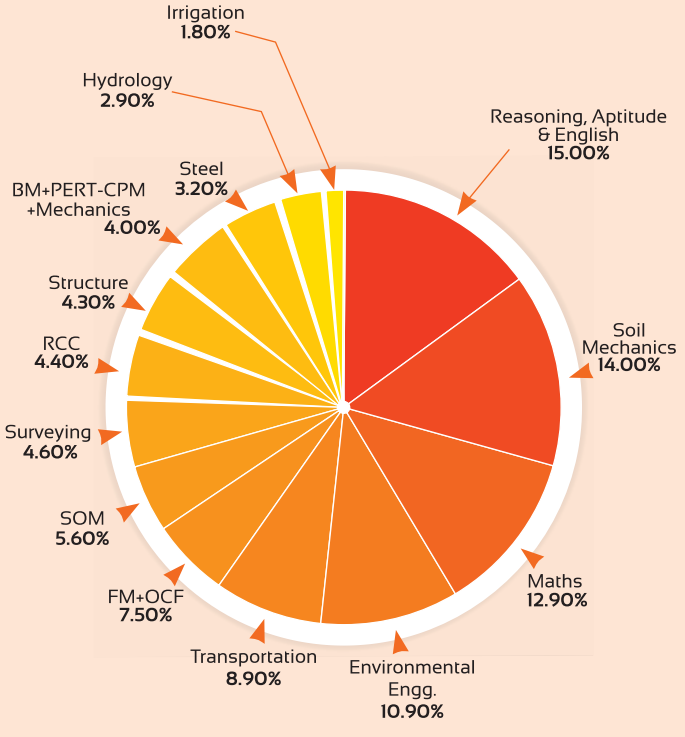
CIVIL ENGINEERING

Day 5 of 8

Q.101 - Q.125 (Out of 200 Questions)

Environmental Engineering + Construction Management + Building Materials

SUBJECT-WISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude and English	15.00%
Soil Mechanics	14.00%
Engineering Mathematics	12.90%
Environmental Engineering	10.90%
Transportation Engineering	8.90%
Fluid Mechanics + OCF	7.50%
Strength of Materials	5.60%
Surveying Engineering	4.60%
Reinforced Cement Concrete	4.40%
Structural Analysis	4.30%
Building Materials+PERT-CPM+Mechanics	4.00%
Steel Structures	3.20%
Engineering Hydrology	2.90%
Irrigation Engineering	1.80%
Total	**100%**

Environmental Engg. + Construction Management + Building Materials

Q.101 The sludge from the aeration tank of the activated sludge process (ASP) has solids (content by weight) of 3.5%. This sludge is put in sludge thickener, where sludge volume is reduced to half. Assume that the amount of solids in the supernatant from the thickener is negligible, the specific gravity of sludge solids is 2.4 and density of water is 1000 kg/m^3. The density of the sludge (in kg/m^3) removed from the aeration tank and solid content (in percentage by weight) of the thickened sludge are respectively

(a) 1020.84 and 8%
(b) 1042.36 and 8%
(c) 1020.84 and 7%
(d) 1042.36 and 7%

Q.102 Match **List-I** (Pollutants) with **List-II** (Sources) and select the correct answer using the codes given below the lists:

List-I	**List-II**
A. Acid water	**1.** Volcanoes
B. SO_2	**2.** Automobiles
C. CO	**3.** Thermal power station
D. Fly ash	**4.** Mining

Codes:

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

Q.103 22 MLD of water is flowing through a 3 km long pipe of diameter 50 cm. The chlorine at the rate of 40 kg/d is applied at the entry of this pipe so that disinfected water is obtained at the exit. There is a proposal to increase the flow through this pipe to 28 MLD. Assume the dilution coefficient, n = 1. The minimum amount of chlorine to be applied to achieve the same degree of disinfection for the enhanced flow is

(a) 64.79 kg/day
(b) 54.76 kg/day
(c) 42.57 kg/day
(d) 36.35 kg/day

Q.104 An ideal horizontal flow settling basin is 2.8 m deep having surface area of 1500 m^2. Water flows at the rate of 16000 m^3/day at water temperature of 20°C, dynamic viscosity, $\mu = 1 \times 10^{-3}$ kg/m-sec and density of water, ρ = 1000 kg/m^3. Assuming Stoke's law to be valid, the approximate percentage of spherical sand particles (0.01 mm in diameter with specific gravity 2.6) that will be removed is

Q.105 A rapid sand filter is to be provided in a water treatment plant to process the water for a town with a population of 4,50,000. The peak water demand is 225 litre/capita/day. The rate of filtration is 20 m^3/m^2/hr. Allow 5% of filtered water for storage to meet the backwash requirements. Each back washing period is 30 minutes. The number of filters required including one as a standby unit is _____.

[Assume the available surface area configuration of one filter unit is 70 m^2]

Q.106 Calculate the weight of cement required to make 0.25 m^3 of concrete have the mix design of 1 : 2.1 : 3.5 with water cement ratio of 0.50 and air content of 3%. Consider specific gravity of cement, fine aggregate, coarse aggregate are 3.15, 2.65, 2.7 respectively.

(a) 83.44 kg (b) 292.56 kg
(c) 175.22 kg (d) 91.67 kg

Q.107 An activated sludge system is operating under equilibrium conditions with following information:

Waste water related data:
Flow rate = 800 m^3/hour
Influent BOD = 125 mg/l
Effluent BOD = 10 mg/l

Aeration tank related data:
Hydraulic retention time = 7.5 hours
Mean-cell residence time = 300 hour
Volume = 500 m^3
Mixed liquor suspended solids = 3000 mg/l
Effluent suspended solids = 2000 mg/l

Food-to-biomass (F/M) ratio for the aeration tank is

(a) 0.2 day^{-1} (b) 0.6 day^{-1}
(c) 1.6 day^{-1} (d) 3.2 day^{-1}

Q.108 A 30 ml of water sample was tested for acidity and it consumed 10 ml of 0.01 N NaOH solution. The total acidity of water sample expressed in terms of $CaCO_3$ was _____ mg/l.

Q.109 If a bacterial cell count increases from 10^3 to 10^9 in 10 hours, then (doubling) time will be _____ hr.

Q.110 A township is required to treat 400000 litres of sewage per day which has a 5 day BOD of 140 ppm. The oxidation pond is used for the purpose. The effluent can have a BOD of 15 ppm. The loading is to be 25 kg of 5 day BOD per hectare per day. The required area of the pond is _____ ha.

Q.111 Elevation and temperature data for places A, B and C are tabulated below:

Place	Elevation (m)	Temperature (°C)
A	45	21
B	350	18.5
C	500	14

Based on above data, for dry air lapse rate of place A to B and place B to C respectively are

(a) Subadiabatic and Subadiabatic (b) Superadiabatic and Subadiabatic
(c) Subadiabatic and Superadiabatic (d) Superadiabatic and Superadiabatic

Q.112 The area required for a new landfill site with a projected life of 20 years for a population of 150000 generating 25 kg per household per week will be _____ ha.
Assume the density of waste is 500 kg/m^3. A planning restriction limits the heights of landfill to 10 m. Also assume 3.5 person per household.

Q.113 250 cumecs of sewage of Varanasi city containing no dissolved oxygen (DO) is discharged into the Ganga river which is fully saturated with oxygen and flowing at a rate of 2000 cumecs with a minimum velocity of 0.15 m/sec. The 5 day BOD of sewage is 350 mg/litre. The value of critical DO deficit is _____ mg/*l*.
[Assume coefficient of purification of river is 3.0, coefficient of deoxygenation is 0.12, the ultimate BOD is 1.5 times of the 5 day BOD and saturated DO of river is 12 mg/*l*]
(a) 11.49 (b) 13.24
(c) 15.12 (d) None of these

Q.114 Match **List-I** (Cement) with **List-II** (Characteristic) and select the correct answer using the codes given below the lists:

List-I	**List-II**
A. High alumina cement	**1.** High early strength
B. Blast furnace slag cement	**2.** Gypsum free cement
C. Quick setting cement	**3.** Selenetic cement
D. Rapid hardening cement	**4.** Used in mass concrete work
	5. Used in chemical factories and mines

Codes:

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

Q.115 Four main oxides present in ordinary portland cement are: CaO, Al_2O_3, SiO_2 and Fe_2O_3. Identify the correct ascending order of their proportions in a typical composition of OPC.
(a) Al_2O_3, Fe_2O_3, CaO, SiO_2 (b) Al_2O_3, CaO, Fe_2O_3, SiO_2
(c) Fe_2O_3, Al_2O_3, SiO_2, CaO (d) Fe_2O_3, SiO_2, Al_2O_3, CaO

Q.116 For different concrete specimens, each hydrated to the same degree, the permeability is
(a) Higher with lower water cement ratio and higher cement content.
(b) Lower with lower water cement ratio and higher cement content.
(c) Lower with higher water cement ratio and lower cement content.
(d) Lower with higher water cement ratio and higher cement content.

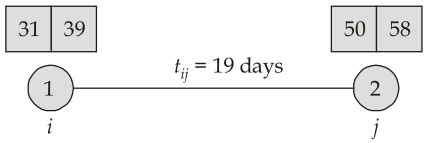
Q.117 Consider the following statements related to PERT and CPM network:
1. Only one time estimate is required for each activity.
2. Three time estimates for each activity.
3. Time and cost are both controlling factors.
4. It is built-up of event-oriented diagram.

Which of the above statements are correctly applicable to CPM network?

(a) 1 and 3 (b) 1 and 2

(c) 2 and 4 (d) 3 and 4

Q.118 Consider the following activity of a certain network:

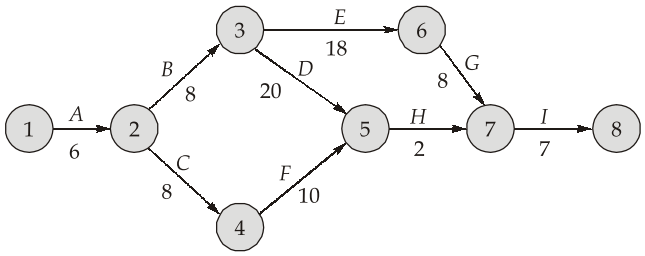


The value of $\left\{\text{Total float} - \left(\frac{\text{Free float}}{\text{Independent float}}\right)\right\}$ is

(a) 8 (b) 10

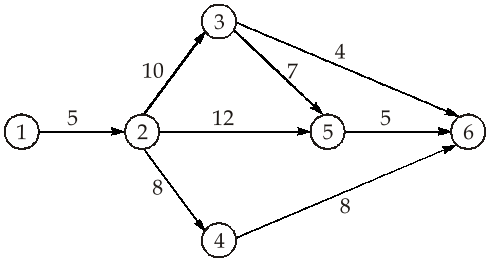
(c) 12 (d) 14

Q.119 Network diagram for a project with activities and duration in days is as shown below.



If variance of the project is 9 then the normal deviate for project to be completed in 50 days is _____.

Q.120 In the network shown below, the number on the arrow gives the duration (in days) of the each activity. The earliest expected time for event 6 to be attained is



(a) 22 days (b) 27 days

(c) 23 days (d) 24 days

Multiple Select Questions (MSQ)

Q.121 Consider the following pairs:

(a) Hand compaction of heavily reinforced sections : Low workability (0-25 mm slump)
(b) Concreting of shallow sections with vibrations : High workability (125-150 mm slump)
(c) Concreting of lightly reinforced sections like pavements : Low workability (5-50 mm slump)
(d) Concreting of lightly reinforced section by hand or heavily reinforced sections with vibration : Medium workability (25-75 mm slump)

Q.122 Consider the following statements:
Sand in cement mortar is used for

(a) increasing the strength
(b) reducing the shrinkage
(c) decreasing the surface area of the binding material
(d) decreasing the quantity of cement

Q.123 Consider the following statements regarding waste stabilization ponds. Pick the incorrect statement.

(a) The pond has a symbiotic process of waste stabilization through algae on one hand and bacteria on the other.
(b) The oxygen in the pond is provided by algae through photosynthesis.
(c) The detention period is of the order of two to three days.
(d) The bacteria which develop in the pond are aerobic bacteria.

Q.124 Consider the following statements in respect of ground water aquifers and pick the correct statements.

(a) Specific storages is specific capacity per unit depth of the aquifer.
(b) Specific capacity is storage coefficient per unit aquifer depth.
(c) Specific capacity is a constant for a given well.
(d) For one-dimensional flow in a confined aquifer between two water bodies, the piezometric head line in the aquifer is a straight line.

Q.125 Which of the following remedial measures are taken to avoid negative head and air binding in a rapid sand filter? Pick the correct statement.

(a) Avoiding the occurrence of excessive negative head
(b) Pumping in air
(c) Avoiding increase in water temperature
(d) Control of algae growth

■■■■

Detailed Explanations

101. (c)

$$\text{Solid content} = 3.5\%$$

$$\therefore \quad \text{Water content} = 100 - 3.5 = 96.5\%$$

$$\frac{100}{S_{sludge}} = \frac{96.5}{1} + \frac{3.5}{2.4}$$

$$\Rightarrow \quad S_{sludge} = 1.02084$$

$$\therefore \quad \rho_{sludge} = 1.02084 \times 1000$$

$$= 1020.84 \text{ kg/m}^3$$

After sludge gets thickened,

$$V_2 = \frac{V_1}{2}$$

$$\therefore \quad V_2 = \frac{(100 - P_1)}{(100 - P_2)} \times V_1$$

$$\Rightarrow \quad \frac{V_1}{2} = \frac{(100 - 96.5)}{(100 - P_2)} \times V_1$$

$$\Rightarrow \quad 100 - P_2 = 200 - 193.0$$

$$\Rightarrow \quad 100 - P_2 = 7$$

$$\Rightarrow \quad P_2 = 93\%$$

$$\therefore \quad \text{Solid content} = 100 - 93 = 7\%$$

102. (a)

103. (a)

In this disinfection process, we have the relationship,

$$tC^n = k$$

where,

t = time required to kill all pathogenic organisms

C = concentration of disinfectant

n = dilution coefficient

k = constant

$$\therefore \quad t_1C_1^n = t_2C_2^n \qquad \ldots(i)$$

In our case, $n = 1$

$$t = \frac{L}{V}$$

L = length of pipe, V = velocity of flow

$$\therefore \quad t = \frac{L}{Q/A} = \frac{L \times A}{Q}$$

$$C = \frac{W}{Q}$$

where,

W = weight of disinfectant per day

Q = discharge per day

Substituting C and t in equation (i),

$$\frac{L\times A}{Q_1}\times\frac{W_1}{Q_1} = \frac{L\times A}{Q_2}\times\frac{W_2}{Q_2}$$

$$\Rightarrow \quad W_2 = \frac{Q_2^2}{Q_1^2}\times W_1 = \left(\frac{28}{22}\right)^2\times 40\ \text{kg/d} = 64.79\ \text{kg/day}$$

104. 70.63 (69 to 72)

$$V_s' = \frac{g}{18}(G_s-1)\times\frac{d^2}{\nu}$$

$$= \frac{9.81}{18}(2.6-1)\times\frac{\left(0.01\times10^{-3}\right)^2}{\left(\frac{1\times10^{-3}}{1000}\right)}$$

$$= 8.72\times10^{-5}\ \text{m/sec}$$

$$= 8.72\times10^{-2}\ \text{mm/sec}$$

$$\text{Detention period} = \frac{\text{Volume of tank}}{\text{Water flow rate}}\times\text{days} = \frac{1500\times2.8}{16000}\times24 = 6.3\ \text{hrs}$$

$$\text{Surface overflow rate, } V_s = \frac{\text{Depth of tank}}{\text{Detention period}} = \frac{2.8}{(6.3\times3600)} = 12.346\times10^{-5}\ \text{m/sec}$$

$$\text{Removal efficiency, } \eta = \frac{V_s'}{V_s}\times100 = \frac{8.72\times10^{-5}}{12.346\times10^{-5}}\times100 = 70.63\%$$

105. (5)

Daily water demand of filtered water

$$= 105\%\ \text{of water required daily}$$

$$= \frac{105\times450000\times225}{100} = 106.3125\ \text{MLD}$$

Effective time available for working of filter units

$$= 24 - \text{back working time}$$

$$= 24 - 0.5$$

$$= 23.5\ \text{hr}$$

$\therefore$ Water filtration required in one hour

$$= \frac{106.3125}{23.5} = 4.524\ \text{ML/hr}$$

Now, Filtration rate $= 20\ \text{m}^3/\text{m}^2/\text{hr}$

$$\text{Area of filter required} = \frac{4.524\times10^6\ l/\text{hr}}{20\times10^3\ l/\text{m}^2/\text{hr}} = 226.2\ \text{m}^2$$

$$\text{Area of one filter unit} = 70\ \text{m}^2$$

$\therefore$ Number of filter units required $= \frac{226.2}{70} = 3.23$ say 4 units

Using one filter unit as standby unit,
So total number of filters required = 4 + 1 = 5

106. (a)

$$V = V_a + V_w + V_c + V_{FA} + V_{CA}$$

$$V = V_a + \frac{M_w}{\rho_w} + \frac{M_c}{G_c\rho_w} + \frac{M_{FA}}{G_{FA}\rho_w} + \frac{M_{CA}}{G_{CA}\rho_w}$$

$$V = 0.03V + \frac{0.5M_C}{\rho_w} + \frac{M_c}{3.15\rho_w} + \frac{2.1M_C}{2.65\rho_w} + \frac{3.5M_C}{2.7\rho_w}$$

$$0.25 = (0.03\times 0.25) + \frac{0.5M_C}{\rho_w} + \frac{M_c}{3.15\rho_w} + \frac{2.1M_C}{2.65\rho_w} + \frac{3.5M_C}{2.7\rho_w}$$

$$M_C = 83.44 \text{ kg}$$

107. (c)

Flow rate, $Q_0 = 800 \text{ m}^3/\text{hr}$
Influent BOD, $S_0 = 125 \text{ mg}/l$
Effluent BOD, $S = 10 \text{ mg}/l$
Hydraulic retention time = 7.5 hr = 0.3125 days

Mean-cell residence time, $\theta_c = 300 \text{ hr} = \frac{300}{24} \text{ days} = 12.5 \text{ days}$

MLSS (X) = 3000 mg/l
Volume = 500 m^3
Food (F) = QS_0

$$= \left(800\frac{\text{m}^3}{\text{hr}}\right)\left(125\frac{\text{mg}}{l}\right) = 2400 \text{ kg/day}$$

Biomass (M) = VX

$$= \left(500 \text{ m}^3\right)\left(3000\frac{\text{mg}}{l}\right) = 1500 \text{ kg}$$

$$\therefore \quad \frac{F}{M} = \frac{Q_0S_0}{VX} = \frac{2400}{1500}$$

= 1.6 kg BOD day/kg MLSS

108. 166.67 (165 to 168)

Volume of water sample in terms of $CaCO_3$ = 30 ml
Given, volume of titrant, V = 10 ml
Normality, N = 0.01

$$\text{Total acidity} = \frac{V\times N\times \text{ equivalent weight of } CaCO_3}{\text{Volume of water sample}}\times 1000$$

$$= \frac{10 \times 0.01 \times 50}{30} \times 1000$$

$$= 166.67 \text{ mg/}l$$

Alternatively,

$$N_1V_1 = N_2V_2$$

$$\Rightarrow N_1(30) = 0.01\ (10)$$

$$\Rightarrow N_1 = 0.00333 \text{ eq/}l$$

$$= 0.00333 \text{ eq/}l \times 50 \text{ g/eq}$$

$$= 0.1665 \text{ g/}l$$

$$= 166.5 \text{ mg/}l$$

109. (0.5) 0.49 to 0.51

$$N_t = N_0\, 10^{-kt} \quad (\text{I}^{\text{st}} \text{ order reaction})$$

$$\therefore 10^9 = 10^3\ (10)^{-k \times 10}$$

$$\Rightarrow 10^6 = (10)^{-10k}$$

$$\Rightarrow k = 0.6d^{-1}$$

Now, $N_t = N_0\, 10^{-kt}$ (Given : $N_t = 2N_0$)

$$2 = 10^{-(-0.6)t}$$

$$\therefore 2 = 10^{0.6t}$$

$$\Rightarrow t = 0.5 \text{ hr}$$

Alternatively,

$$\log N = \log N_0 + \frac{t}{G}\log 2$$

$N = 10^9$, $N_0 = 10^3$, $t = 10$ hour, $G = ?$

$$\frac{t}{G}\log 2 = \log N - \log N_0$$

$$\frac{10}{G} \times \log 2 = \log (10^9) - \log (10^3)$$

$$\frac{10}{G} \times 0.301 = 9 - 3 = 6$$

$$G = 0.5 \text{ hour}$$

110. 2 (1.9 to 2.1)

Sewage produced = 400000 l/day

5-day BOD of sewage = 140 mg/l

($\because$ When water is solvent, 1 ppm = 1 mg/l)

BOD of effluent = 15 ppm =15 mg/l

$\therefore$ BOD removed by pond = (140 – 15) = 125 ppm = 125 mg/l

$\therefore$ Sewage produced per day

$$= 400000 \times 125$$

$$= 50 \times 10^6 \text{ mg} = 50 \text{ kg}$$

Organic loading rate = 25 kg/ha/day

$$\therefore \quad \text{Required area} = \frac{\text{Sewage produced}}{\text{Organic loading rate}}$$

$$= \frac{50}{25} = 2 \text{ ha}$$

111. (c)

From place A to B

$$\text{Ambient lapse rate} = \frac{21-18.5}{350-45} \times 1000 = 8.196 < 9.8°\text{C/km}$$

Since lapse rate is less than the adiabatic lapse rate, so ambient lapse rate is said to be subadiabatic.

From B to C

$$\text{Ambient lapse rate} = \frac{18.5-14}{500-350} \times 1000 = 30°\text{C/km} > 9.8°\text{C/km}$$

Since lapse rate is greater than adiabatic lapse rate. So, ambient lapse rate is said to be superadiabatic.

112. 22.2 (22 to 22.4)

$$\text{Total waste generated} = \frac{150000}{3.5} \times \frac{25}{10^3} = 1071 \text{ tonnes/week}$$

$$= 55700 \text{ tonnes/year}$$

Volume of landfill space required

$$= \frac{55700 \times 10^3}{500} = 111 \times 10^3 \text{ m}^3\text{/year}$$

$$\text{Required land area} = \frac{111 \times 10^3}{10} = 11100 \text{ m}^2$$

$$= 1.11 \text{ ha/year}$$

So, total area required for landfill for 20 years = 1.11 × 20 = 22.2 ha

113. (a)

$$\text{Initial DO of the river} = 12 \text{ mg/}l$$

$$\text{DO of sewage} = 0$$

$$\text{DO}_{\text{mix}} \text{ (at } t = 0) = \frac{2000 \times 12 + 250 \times 0}{2000 + 250} = 10.67 \text{ mg/}l$$

$\therefore$ Initial oxygen deficit in the mix, $D_0 = 12 - 10.67 = 1.33$ mg/l

5 day BOD of mixture of sewage and river water

$$C = \frac{C_S Q_S + C_R Q_R}{Q_S + Q_R} = \frac{250 \times 350 + 0 \times 2000}{2000 + 250}$$

$$= 38.89 \text{ mg/}l$$

$$\text{Ultimate BOD of mixture, } L = 1.5 \times 38.89 = 58.34 \text{ mg/}l$$

Now,

$$\left(\frac{L}{fD_C}\right)^{f-1} = f\left[1 - \frac{D_o}{L}(f-1)\right]$$

$$\Rightarrow \quad \left(\frac{58.34}{3\times D_C}\right)^2 = 3\left[1-\frac{1.33}{58.34}(3-1)\right]$$

$$D_C = 11.49 \text{ mg/}l$$

114. (a)

- High alumina cement has better acid resistance.
- Blast furnace slag cement release low heat of hydration, so can be used for mass concreting.
- Quick setting cement expected to result in initial setting time of 5 minutes. So, gypsum has to be reduced.
- Rapid hardening cement results in early high strength gaining.

115. (c)

116. (b)

Permeability of concrete is directly related to the porosity of the cement paste, the distribution of capillary pores and the presence of micro-cracks (induced by shrinkage effects, tensile stresses, etc.). The main factors influencing capillary porosity are the water-cement ratio and the degree of hydration. The use of a low water-cement ratio, adequate cement and effective curing contribute significantly to reduced permeability.

117. (a)

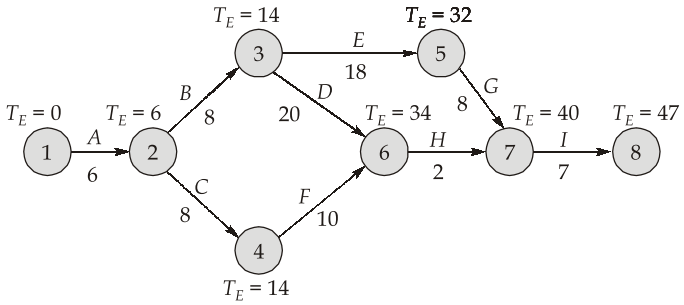
Three time estimates for each activity are required in PERT network. PERT is built up of event oriented diagram.

118. (a)

$$\text{T F} = \text{LFT} - \text{EFT (or LST} - \text{EST)} = 58 - 50 = 8$$
$$\text{FF} = (\text{EFT} - \text{EST}) - t_{ij}$$
$$= (50 - 31) - 19 = 0$$
$$\text{IF} = (\text{EFT} - \text{LST}) - t_{ij}$$
$$= (50 - 39) - 19 = -8$$

$$\therefore \quad \text{TF} - \frac{\text{FF}}{\text{IF}} = 8 - \left(-\frac{0}{8}\right) = 8$$

119. (1)



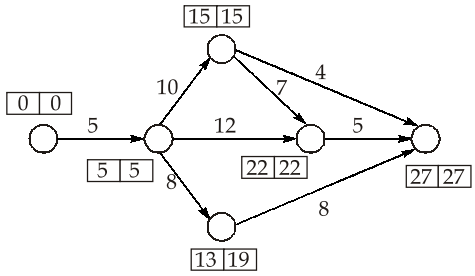
Expected project completion time,

$$T_E = 47 \text{ days}$$

Standard deviation, $\sigma = \sqrt{\text{Variance}} = \sqrt{9} = 3$ days

Normal deviation, $Z = \dfrac{T_S - T_E}{\sigma} = \dfrac{50 - 47}{3} = 1$

120. (b)



The Earliest occurence time and the latest occurence time of each event is calculated above

$(EOT)_j$ = max: $[(EOT)_i + t_{ij}]$

$(LOT)_i$ = min: $[(LOT)_j - t_{ij}]$

121. (c, d)

122. (b, c, d)

123. (c, d)

In stabilisation pond symbiotic relation exist between algae and aerobic micro-organisms. O_2 is provided by algae during photosynthesis and from atmosphere.

Detention period is 2-6 weeks. Bacteria in pond is both aerobic and anaerobic.

The following stages are involved in the biological action involved in the process of sludge digestion.

Hydrolysis → Acid fermentation → Acid regression → Alkaline fermentation → Methane formation.

124. (b, d)

125. (a,b,c,d)

To avoid negative head and air binding, filter is cleaned when the head loss is more than the static head of water over sand bed. Another remedy is to pump in air to reduce the suction effect created due to negative head. Growth of algae can be reduced by avoiding increasing in water temperature. Growth of algae fills the pores of filter media thereby creating negative head.

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