

GATE 2008 CIVIL ENGINEERING¹

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Q.1 – Q.20 CARRY ONE MARK EACH.

- 1) The product of matrices $(PQ)^{-1}P$ is (**GATE CE 2008**)
- a) P^{-1}
 - b) Q^{-1}
 - c) $P^{-1}Q^{-1}P$
 - d) PQ^{-1}
- 2) The general solution of $\frac{d^2y}{dx^2} + y = 0$ is (**GATE CE 2008**)
- a) $y = P \cos x + Q \sin x$
 - b) $y = P \cos x$
 - c) $y = P \sin x$
 - d) $y = P \sin^2 x$
- 3) A mild steel specimen is under uni-axial tensile stress. Young's modulus and yield stress for mild steel are 2×10^5 MPa and 250 MPa respectively. The maximum amount of strain energy per unit volume that can be stored in this specimen without permanent set is (**GATE CE 2008**)
- a) 156 Nmm/mm³
 - b) 15.6 Nmm/mm³
 - c) 1.56 Nmm/mm³
 - d) 0.156 Nmm/mm³
- 4) A reinforced concrete structure has to be constructed along a sea coast. The minimum grade of concrete to be used as per IS:456 - 2000 is (**GATE CE 2008**)
- a) M 15
 - b) M 20
 - c) M 25
 - d) M 30
- 5) In the design of a reinforced concrete beam, the requirement for bond is not getting satisfied. The economical option to satisfy the requirement for bond is by (**GATE CE 2008**)
- a) bundling of bars
 - b) providing smaller diameter bars more in number
 - c) providing larger diameter bars less in number
 - d) providing same diameter bars more in number
- 6) The shape of the cross-section, which has the largest shape factor, is (**GATE CE 2008**)
- a) rectangular
 - b) I-section
 - c) diamond
 - d) solid circular

- 7) Group symbols assigned to silty sand and clayey sand are respectively (**GATE CE 2008**)
- a) SS and CS b) SM and SC c) SM and CS d) MS and CS
- 8) When a retaining wall moves away from the backfill, the pressure exerted on the wall is termed as (**GATE CE 2008**)
- a) passive earth pressure
b) swelling pressure
c) pore pressure
d) active earth pressure
- 9) Compaction by vibratory roller is the best method of compaction in case of (**GATE CE 2008**)
- a) moist silty sand c) clay of medium compressibility
b) well graded dry sand d) silt of high compressibility
- 10) A person standing on the bank of a canal drops a stone on the water surface. He notices that the disturbance on the water surface is not traveling upstream. This is because the flow in the canal is (**GATE CE 2008**)
- a) sub-critical c) steady
b) super-critical d) uniform
- 11) A flood wave with a known inflow hydrograph is routed through a large reservoir. The outflow hydrograph will have (**GATE CE 2008**)
- a) attenuated peak with reduced time-base
b) attenuated peak with increased time-base
c) increased peak with increased time-base
d) increased peak with reduced time-base
- 12) A stable channel is to be designed for a discharge of Q m³/s with silt factor f as per Lacey's method. The mean flow velocity (m/s) in the channel is obtained by (**GATE CE 2008**)
- a) $(Qf^2/140)^{1/6}$ c) $(Q^2f^2/140)^{1/6}$
b) $(Qf/140)^{1/3}$ d) $0.48(Q/f)^{1/3}$
- 13) The base width of an elementary profile of a gravity dam of height H is b . The specific gravity of the material of the dam is G and uplift pressure coefficient is K . The correct relationship for no tension at the heel is given by: (**GATE CE 2008**)
- a) $\frac{b}{H} = \frac{1}{\sqrt{G-K}}$ c) $\frac{b}{H} = \frac{1}{G-K}$
b) $\frac{b}{H} = \sqrt{G-K}$ d) $\frac{b}{H} = \frac{1}{K\sqrt{G-K}}$

14) Two primary air pollutants are: **(GATE CE 2008)**

- a) sulphur oxide and ozone
- b) nitrogen oxide and peroxyacetyl nitrate
- c) sulphur oxide and hydrocarbon
- d) ozone and peroxyacetyl nitrate

15) Two biodegradable components of municipal solid waste are: **(GATE CE 2008)**

- a) plastics and wood
- b) cardboard and glass
- c) leather and tin cans
- d) food wastes and garden trimmings

16) The specific gravity of paving bitumen as per IS:73 – 1992 lies between: **(GATE CE 2008)**

- a) 1.10 and 1.06
- b) 1.06 and 1.02
- c) 1.02 and 0.97
- d) 0.97 and 0.92

17) A combined value of flakiness and elongation index is to be determined for a sample of aggregates. The sequence in which the two tests are conducted is: **(GATE CE 2008)**

- a) elongation index test followed by flakiness index test on the whole sample
- b) flakiness index test followed by elongation index test on the whole sample
- c) flakiness index test followed by elongation index test on non-flaky aggregates
- d) elongation index test followed by flakiness index test on non-elongated aggregates

18) The capacities of One-way 1.5 m wide sidewalk per-sons per hour and One-way 2-lane urban road (*PCU per hour, with no frontage access, no standing vehicles and very little cross tra-*) are respectively: **(GATE CE 2008)**

- a) 1.10 and 1.06
- b) 1.06 and 1.02
- c) 1.02 and 0.97
- d) 0.97 and 0.92

19) The shape of the STOP sign according to IRC:67-2001 is: **(GATE CE 2008)**

- a) circular
- b) triangular
- c) octagonal
- d) rectangular

20) The type of surveying in which the curvature of the earth is taken into account is called: **(GATE CE 2008)**

- a) Geodetic surveying
- b) Plane surveying
- c) Preliminary surveying
- d) Topographical surveying

Q.21 – Q.75 CARRY TWO MARKS EACH.

21) The equation

$$k_x \frac{\partial^2 h}{\partial x^2} + k_z \frac{\partial^2 h}{\partial z^2} = 0$$

can be transformed to

$$\frac{\partial^2 h}{\partial x_t^2} + \frac{\partial^2 h}{\partial z^2} = 0$$

by substituting: **(GATE CE 2008)**

a) $x_t = x \frac{k_z}{k_x}$

c) $x_t = x \sqrt{\frac{k_x}{k_z}}$

b) $x_t = x \frac{k_x}{k_z}$

d) $x_t = x \sqrt{\frac{k_z}{k_x}}$

22) The value of

$$\int_0^3 \int_0^{3-x} (6 - x - y) dx dy \quad \text{is}$$

(GATE CE 2008)

a) 13.5

c) 40.5

b) 27.0

d) 54.0

23) Three values of x and y are to be fitted in a straight line in the form $y = a + bx$ by the method of least squares. Given: $\sum x = 6$, $\sum y = 21$, $\sum x^2 = 14$ and $\sum xy = 46$, the values of a and b are respectively: **(GATE CE 2008)**

a) 2 and 3

c) 2 and 1

b) 1 and 2

d) 3 and 2

24) Solution of $\frac{dy}{dx} = \frac{-x}{y}$ at $x = 1$ and $y = \sqrt{3}$ is: **(GATE CE 2008)**

a) $x^2 - y^2 = -2$

c) $x^2 - y^2 = -2$

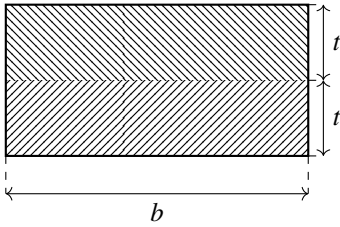
b) $x^2 + y^2 = 4$

d) $x^2 + y^2 = 4$

25) If the probability density function of a random variable X is

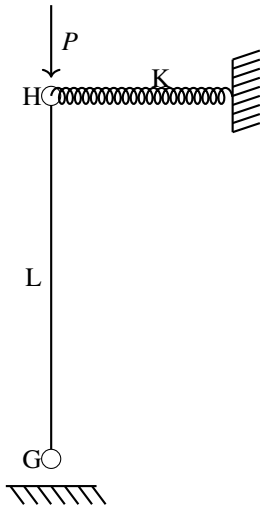
$$f(x) = \begin{cases} x^2, & \text{for } -1 \leq x \leq 1 \\ 0, & \text{for any other value of } x \end{cases}$$

then, the percentage probability $P\left(-\frac{1}{3} \leq x \leq \frac{1}{3}\right)$ is: **(GATE CE 2008)**



- a) 2
b) 4
c) 6
d) 8

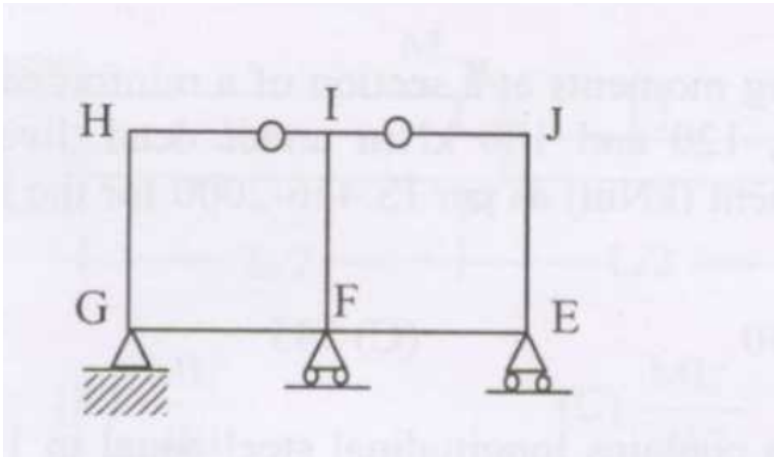
31) A rigid bar GH of length L is supported by a hinge and a spring of stiffness K as shown in the figure below. The buckling load, P_{Cr} , for the bar will be (GATE CE 2008)



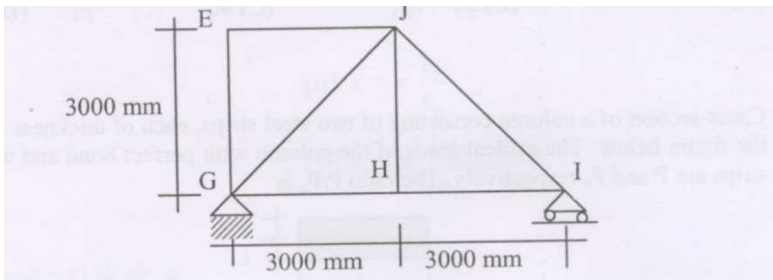
- a) $0.5KL$
b) $0.8KL$
c) $1.0KL$
d) $1.2KL$

32) The degree of static indeterminacy of the rigid frame having two internal hinges as shown in the figure below, is (GATE CE 2008)

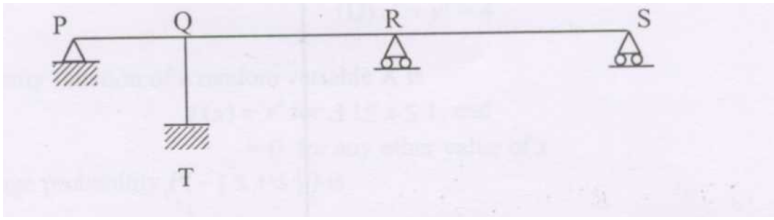
- a) 8
b) 7
c) 6
d) 5



- 33) The members EJ and IJ of a steel truss shown in the figure below are subjected to a temperature rise of 30°C . The coefficient of thermal expansion of steel is 0.000012 per $^{\circ}\text{C}$ per unit length. The displacement (mm) of joint E relative to joint H along the direction HE of the truss, is (**GATE CE 2008**)



- a) 0.255
b) 0.589
c) 0.764
d) 1.026
- 34) The maximum shear stress in a solid shaft of circular cross-section having diameter d subjected to a torque T is τ . If the torque is increased by four times and the diameter of the shaft is increased by two times, the maximum shear stress in the shaft will be (**GATE CE 2008**)
- a) 2τ
b) τ
c) $\tau/2$
d) $\tau/4$
- 35) The span(s) to be loaded uniformly for maximum positive (*upward*) reaction at support P, as shown in the figure below, is(are) (**GATE CE 2008**)



- a) PQ only
 b) PQ and QR
 c) QR and RS
 d) PQ and RS

- 36) A vertical rod PQ of length L is fixed at its top end P and has a flange fixed to the bottom end Q . A weight W is dropped vertically from a height $h > L$ on to the flange. The axial stress in the rod can be reduced by (**GATE CE 2008**)
- a) increasing the length of the rod
 b) decreasing the length of the rod
 c) decreasing the area of cross-section of the rod
 d) increasing the modulus of elasticity of the material
- 37) Un-factored maximum bending moments at a section of a reinforced concrete beam resulting from a frame analysis are 50, 80, 120 and 180 kNm under dead, live, wind and earthquake loads respectively. The design moment (kNm) as per IS:456-2000 for the limit state of collapse (flexure) is (**GATE CE 2008**)
- a) 195
 b) 250
 c) 345
 d) 372
- 38) A reinforced concrete column contains longitudinal steel equal to 1 percent of net cross-sectional area of the column. Assume modular ratio as 10. The loads carried (using the elastic theory) by the longitudinal steel and the net area of concrete, are P_s , and P_c , respectively. The ratio P_s/P_c expressed as percent is (**GATE CE 2008**)
- a) 0.1
 b) 1
 c) 1.1
 d) 10
- 39) A pre-tensioned concrete member of section 200 mm x 250 mm contains tendons of area 500 mm^2 at centre of gravity of the section. The prestress in the tendons is 1000 N/mm^2 . Assuming modular ratio as 10, the stress N/mm^2 in concrete is (**GATE CE 2008**)
- a) 11
 b) 9
 c) 7
 d) 5
- 40) Rivets and bolts subjected to both shear stress $\tau_{vf, \text{ cal}}$ and axial tensile stress ($\sigma_{tf, \text{ cal}}$)

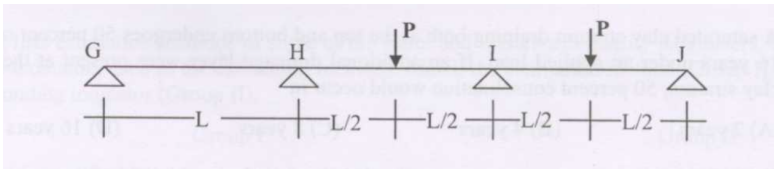
shall be so proportioned that the stresses do not exceed the respective allowable stresses τ_{vf} and σ_{tf} and the value of

$$\left(\frac{\tau_{vf, \text{ cal}}}{\tau_{vf}} + \frac{\sigma_{tf, \text{ cal}}}{\sigma_{tf}} \right)$$

does not exceed (**GATE CE 2008**)

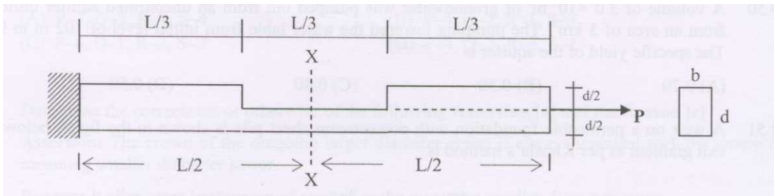
- a) 1.0
- b) 1.2
- c) 1.4
- d) 1.8

- 41) A continuous beam is loaded as shown in the figure below. Assuming a plastic moment capacity equal to M_p , the minimum load at which the beam would collapse is (**GATE CE 2008**)



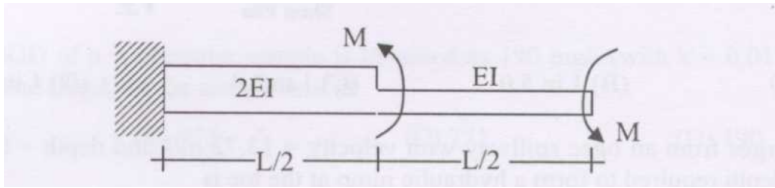
- a) $\frac{4M_p}{L}$
- b) $\frac{6M_p}{L}$
- c) $\frac{8M_p}{L}$
- d) $\frac{10M_p}{L}$

- 42) The maximum tensile stress at the section X-X shown in the figure below is (**GATE CE 2008**)



- a) $\frac{8P}{bd}$
- b) $\frac{6P}{bd}$
- c) $\frac{4P}{bd}$
- d) $\frac{2P}{bd}$

- 43) The stepped cantilever is subjected to moments, M as shown in the figure below. The vertical deflection at the free end (*neglecting the self weight*) is (**GATE CE 2008**)



- a) $\frac{ML^2}{8EI}$ c) $\frac{ML^2}{2EI}$
 b) $\frac{ML^2}{4EI}$ d) Zero

44) The liquid limit (LL), plastic limit (PL) and shrinkage limit (SL) of a cohesive soil satisfy the relation (**GATE CE 2008**)

- a) $LL > PL < SL$ c) $LL < PL < SL$
 b) $LL > PL > SL$ d) $LL < PL > SL$

45) A footing $2m \times 1m$ exerts a uniform pressure of 150 kN/m^2 on the soil. Assuming a load dispersion of 2 vertical to 1 horizontal, the average vertical stress (kN/m^2) at 1.0 m below the footing is (**GATE CE 2008**)

- a) 55 c) 80
 b) 75 d) 100

46) A direct shear test was conducted on a cohesionless soil ($c = 0$) specimen under a normal stress of 200 kN/m^2 . The specimen failed at a shear stress of 100 kN/m^2 . The angle of internal friction of the soil (degrees) is (**GATE CE 2008**)

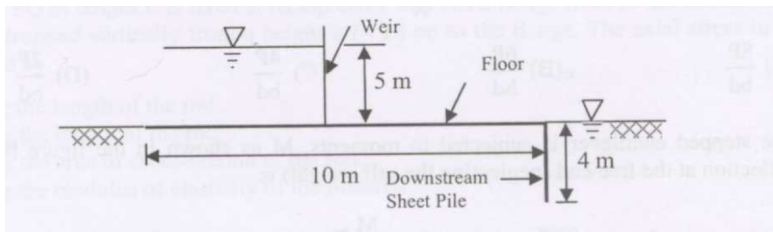
- a) 26.6 c) 30.0
 b) 29.5 d) 32.6

47) A pile of $0.50m$ diameter and of length $10m$ is embedded in a deposit of clay. The undrained strength parameters of the clay are cohesion $= 60 \text{ kN/m}$ and the angle of internal friction $= 0$. The skin friction capacity (kN) of the pile for an adhesion factor of 0.6, is (**GATE CE 2008**)

- a) 671 c) 283
 b) 565 d) 106

48) A saturated clay stratum draining both at the top and bottom undergoes 50 percent consolidation in 16 years under an applied load. If an additional drainage layer were present at the middle of the clay stratum, 50 percent consolidation would occur in (**GATE CE 2008**)

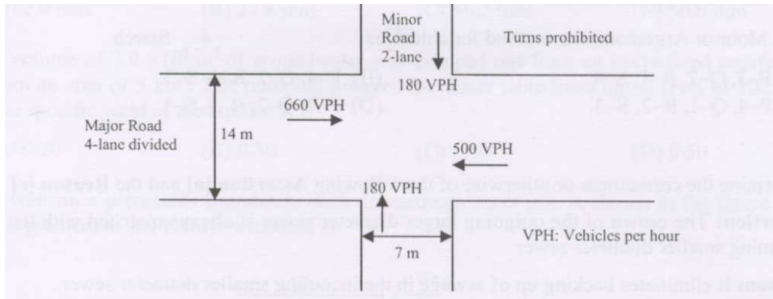
- a) 2 years
b) 4 years
c) 8 years
d) 16 years
- 49) A test plate $30\text{cm} \times 30\text{cm}$ resting on a sand deposit settles by 10mm under a certain loading intensity. A footing $150\text{cm} \times 200\text{cm}$ resting on the same sand deposit and loaded to the same load intensity settles by (GATE CE 2008)
- a) 2.0 mm
b) 27.8 mm
c) 30.2 mm
d) 50.0 mm
- 50) A volume of $3.0 \times 10^6\text{ m}^3$ of groundwater was pumped out from an unconfined aquifer uniformly from an area of 5 km^2 . The pumping lowered the water table from initial level of 102 m to 99 m . The specific yield of the aquifer is (GATE CE 2008)
- a) 0.20
b) 0.30
c) 0.40
d) 0.50
- 51) A weir on a permeable foundation with downstream sheet pile is shown in the figure below. The exit gradient as per Khosla's method is (GATE CE 2008)



- a) 1 in 6.0
b) 1 in 5.0
c) 1 in 3.4
d) 1 in 2.5
- 52) Water emerges from an ogee spillway with velocity $= 13.72\text{ m/s}$ and depth $= 0.3\text{ m}$ at its toe. The tail water depth required to form a hydraulic jump at the toe is (GATE CE 2008)
- a) 6.48 m
b) 5.24 m
c) 3.24 m
d) 2.24 m
- 53) The flow of water (mass density $= 1000\text{ kg/m}^3$ and kinematic viscosity $= 10^{-6}\text{ m}^2/\text{s}$) in a commercial pipe, having equivalent roughness k_s , as 0.12 mm , yields an average shear stress at the pipe boundary $= 600\text{ N/m}^2$. The value of k_s/δ (δ being the thickness of laminar sub-layer) for this pipe is (GATE CE 2008)

- a) Both $[a]$ and $[r]$ are true and $[r]$ is the correct reason for $[a]$
 b) Both $[a]$ and $[r]$ are true but $[r]$ is not the correct reason for $[a]$
 c) Both $[a]$ and $[r]$ are false
 d) Assertion $[a]$ is true but Reason $[r]$ is false
- 59) The 5-day BOD of a wastewater sample is obtained as 190 mg/l (with $k = 0.01 \text{ h}^{-1}$). The ultimate oxygen demand (mg/l) of the sample will be (**GATE CE 2008**)
 a) 3800
 b) 475
 c) 271
 d) 190
- 60) A water treatment plant is required to process $28800 \text{ m}^3/\text{d}$ of raw water (density = 1000 kg/m^3 , kinematic viscosity = 10 ms). The rapid mixing tank imparts a velocity gradient of 900 s^{-1} to blend 35 mg/l of alum with the flow for a detention time of 2 minutes. The power input (W) required for rapid mixing is (**GATE CE 2008**)
 a) 3800
 b) 475
 c) 271
 d) 190
- 61) Match Group I (*Terminology*) with Group II (*Definition/Brief Description*) for wastewater treatment systems (**GATE CE 2008**)
- | Group I | Group II |
|------------------------|--|
| P. Primary treatment | 1. Contaminant removal by physical forces |
| Q. Secondary treatment | 2. Involving biological and/or chemical reaction |
| R. Unit operation | 3. Conversion of soluble organic matter to biomass |
| S. Unit process | 4. Removal of solid materials from incoming wastewater |
- Options:**
 (A) P-4, Q-3, R-1, S-2
 (B) P-4, Q-3, R-2, S-1
 (C) P-3, Q-4, R-2, S-1
 (D) P-1, Q-2, R-3, S-4
- 62) A roundabout is provided with an average entry width of 8.4 m, width of weaving section as 14 m, and length of the weaving section between channelizing islands as 35 m. The crossing traffic and total traffic on the weaving section are 1000 and 2000 PCU per hour respectively. The nearest rounded capacity of the roundabout (in PCU per hour) is (**GATE CE 2008**)
 a) 3800
 b) 475
 c) 271
 d) 190
- 63) Design parameters for a signalized intersection are shown in the figure below. The

green time calculated for major and minor roads are 34 s and 18 s, respectively.
(GATE CE 2008)



The critical lane volume on the major road changes to 440 vehicles per hour per lane and the critical lane volume on the minor road remains unchanged. The green time will

- increase for the major road and remain same for the minor road
 - increase for the major road and decrease for the minor road
 - decrease for both the roads
 - remain unchanged for both the roads
- 64) It is proposed to widen and strengthen an existing 2-lane NH section as a divided highway. The existing traffic in one direction is 2500 commercial vehicles (CV) per day. The construction will take 1 year. The design CBR of soil subgrade is found to be 5 percent. Given: traffic growth rate for CV = 8 percent, vehicle damage factor = 3.5 (standard axles per CV), design life = 10 years and traffic distribution factor = 0.75. The cumulative standard axles (*msa*) computed are (GATE CE 2008)
- 35
 - 37
 - 65
 - 70
- 65) A linear relationship is observed between speed and density on a certain section of a highway. The free flow speed is observed to be 80 km per hour and the jam density is estimated as 100 vehicles per km length. Based on the above relationship, the maximum flow expected on this section and the speed at the maximum flow will respectively be (GATE CE 2008)
- 8000 vehicles per hour and 80 km per hour
 - 8000 vehicles per hour and 25 km per hour
 - 2000 vehicles per hour and 80 km per hour
 - 2000 vehicles per hour and 40 km per hour
- 66) The plan of a survey plotted to a scale of 10 m to 1 cm is reduced in such a way that a line originally 10 cm long now measures 9 cm. The area of the reduced plan is measured as 81 cm^2 . The actual area m^2 of the survey is (GATE CE 2008)

Statement for Linked Answer Questions 71 and 72:

A rectangular channel 6.0 m wide carries a discharge of $16.0 \text{ m}^3/\text{s}$ under uniform flow condition with normal depth of 1.60 m. Manning n is 0.015.

71) The longitudinal slope of the channel is **(GATE CE 2008)**

- (A) 0.000585
- (B) 0.000485
- (C) 0.000385
- (D) 0.000285

72) A hump is to be provided on the channel bed. The maximum height of the hump without affecting the upstream flow condition is **(GATE CE 2008)**

- (A) 0.50 m
- (B) 0.40 m
- (C) 0.30 m
- (D) 0.20 m

73) The channel width is to be contracted. The minimum width to which the channel can be contracted without affecting the upstream flow condition is **(GATE CE 2008)**

- (A) 3.0 m
- (B) 3.8 m
- (C) 4.1 m
- (D) 4.5 m

Statement for Linked Answer Questions 74 and 75:

A reinforced concrete beam of rectangular cross section of breadth 230 mm and effective depth 400 mm is subjected to a maximum factored shear force of 120 kN . The grades of concrete, main steel and stirrup steel are $M20$, $Fe415$ and $Fe250$ respectively. For the area of main steel provided, the design shear strength τ_c as per IS:456 – 2000 is 0.48 N/mm^2 . The beam is designed for collapse limit state.

74) The spacing (mm) of 2-legged 8 mm stirrups to be provided is **(GATE CE 2008)**

- (A) 40
- (B) 115
- (C) 250
- (D) 400

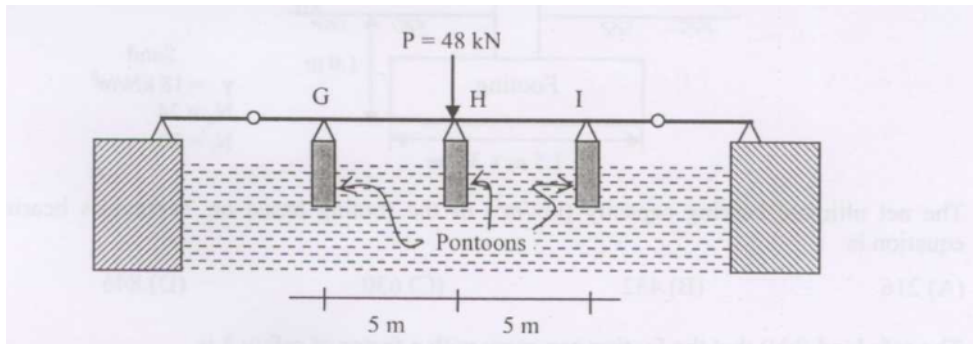
75) In addition, the beam is subjected to a torque whose factored value is 10.90 kNm. The stirrups have to be provided to carry a shear kN equal to (GATE CE 2008)

- (A) 50.42
- (B) 130.56
- (C) 151.67
- (D) 200.23

LINKED ANSWER QUESTIONS: Q.76 TO Q.85 CARRY TWO MARKS EACH

Statement for Linked Answer Questions 76 and 77:

Beam GHI is supported by three pontoons as shown in the figure below. The horizontal cross-sectional area of each pontoon is 8 m^2 , the flexural rigidity of the beam is 10000 kN-m^2 and the unit weight of water is 10 kN/m^3 .



76) When the middle pontoon is removed, the deflection at H will be (GATE CE 2008)

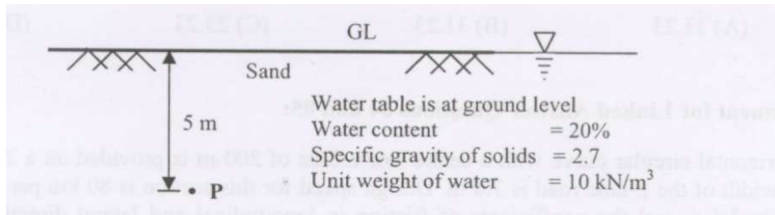
- (A) 0.2 m
- (B) 0.4 m
- (C) 0.6 m
- (D) 0.8 m

77) When the middle pontoon is brought back to its position as shown in the figure above, the reaction at H will be (GATE CE 2008)

- (A) 8.6 kN
- (B) 15.7 kN
- (C) 19.2 kN
- (D) 24.2 kN

Statement for Linked Answer Questions 78 and 79:

The ground conditions at a site are shown in the figure below.



78) The saturated unit weight of the sand (kN/m^3) is (GATE CE 2008)

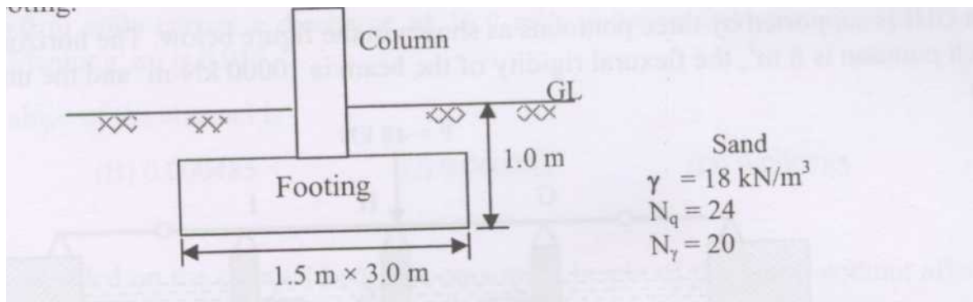
- (A) 15
- (B) 18
- (C) 21
- (D) 24

79) The total stress, pore water pressure and effective stress (kN/m^3) at the point P are, (GATE CE 2008)

- (A) 75, 50 and 25
- (B) 90, 50 and 40
- (C) 105, 50 and 55
- (D) 120, 50 and 70

Statement for Linked Answer Questions 80 and 81:

A column is supported on a footing as shown in the figure below. The water table is at a depth of 10 m below the base of the footing.



80) The net ultimate bearing capacity (kN/m^2) of the footing based on Terzaghi's bearing capacity equation is (GATE CE 2008)

- (A) 216
- (B) 432
- (C) 630
- (D) 846

81) The safe load (kN) that the footing can carry with a factor of safety 3 is (GATE CE 2008)

- (A) 282
- (B) 648

- (C) 945
- (D) 1269

Statement for Linked Answer Questions 82 and 83:

An automobile with projected area 2.6 m^2 is running on a road with a speed of 120 km per hour. The mass density and the kinematic viscosity of air are 1.2 kg/m^3 and $1.5 \times 10^{-5} \text{ m}^2/\text{s}$, respectively. The drag coefficient is 0.30.

82) The drag force on the automobile is (GATE CE 2008)

- (A) 620 N
- (B) 600 N
- (C) 580 N
- (D) 520 N

83) The metric horse power required to overcome the drag force is (GATE CE 2008)

- (A) 33.23
- (B) 31.23
- (C) 23.23
- (D) 20.23

Statement for Linked Answer Questions 84 and 85:

A horizontal circular curve with a centre line radius of 200 m is provided on a 2-lane, 2-way SH section. The width of the 2-lane road is 7.0 m. Design speed for this section is 80 km per hour. The brake reaction time is 2.4 s, and the coefficients of friction in longitudinal and lateral directions are 0.355 and 0.15, respectively.

84) The safe stopping sight distance on the section is (GATE CE 2008)

- (A) 221 m
- (B) 195 m
- (C) 125 m
- (D) 65 m

85) The set-back distance from the center line of the inner lane is (GATE CE 2008)

- (A) 7.93 m
- (B) 8.10 m
- (C) 9.60 m
- (D) 9.77 m