

CIVIL ENGINEERING

PAPER—I

Time Allowed : Three Hours

Maximum Marks : 200

QUESTION PAPER SPECIFIC INSTRUCTIONS

**Please read each of the following instructions carefully
before attempting questions**

There are EIGHT questions in all, out of which FIVE are to be attempted.

Question Nos. 1 and 5 are compulsory. Out of the remaining SIX questions, THREE are to be attempted selecting at least ONE question from each of the two Sections A and B.

The number of marks carried by a question/part is indicated against it.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary, and indicate the same clearly.

Neat sketches may be drawn, wherever required.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

Answers must be written in ENGLISH only.

SECTION—A

1. (a) A block (weight = W) is suspended by means of a spring, whose spring constant = k_2 , from the end of a rigid weightless beam, which is of length l and hinged to a wall by a frictionless connection at its left. It is held in a horizontal position by a spring, whose spring constant = k_1 , attached to it at a distance b from the hinge end to the ceiling as shown in Fig. 1(a) below. Determine the deflection of point A :

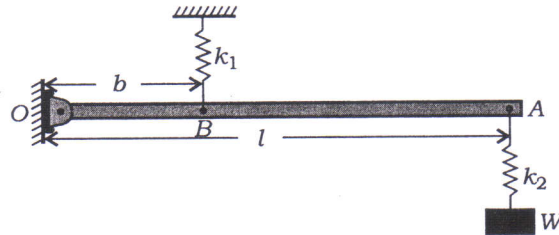


Fig. 1(a)

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- (b) An RCC retaining wall has been constructed as shown in Fig. 1(b) below. Draw the deflected shape of the retaining wall and sketch the position of main reinforcement only in stem, heel slab and toe slab :

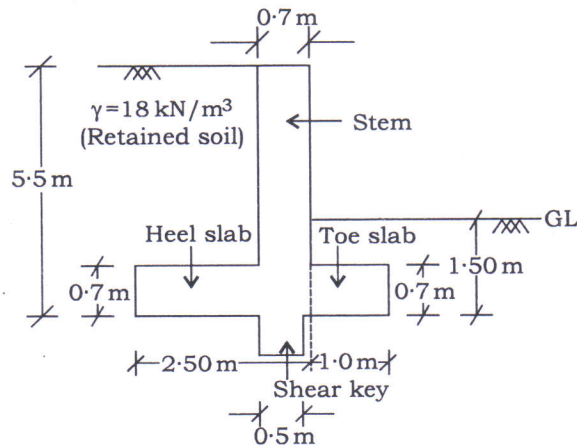


Fig. 1(b)

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- (c) Two identical bars MP and MN , each of mass m , are hinged together at M and supported by two pegs at B and C such that each of the bars makes an angle α with the horizontal in equilibrium position as shown in Fig. 1(c) below. The pegs are in the same level horizontally and x distance apart. If the bars are of length l each, express α as a function of x and l . Consider ends P and N as free end :

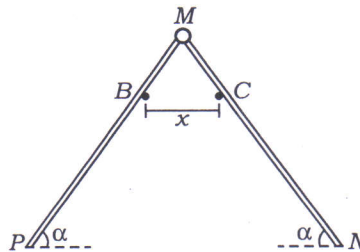


Fig. 1(c)

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- (d) Calculate vertical, horizontal and resultant deflections of joint *D* of the truss shown in Fig. 1(d) below by using unit load method. The cross-sectional area of all the members is 1500 mm^2 . Take $E = 205 \text{ kN/mm}^2$ ($AE = \text{constant}$) :

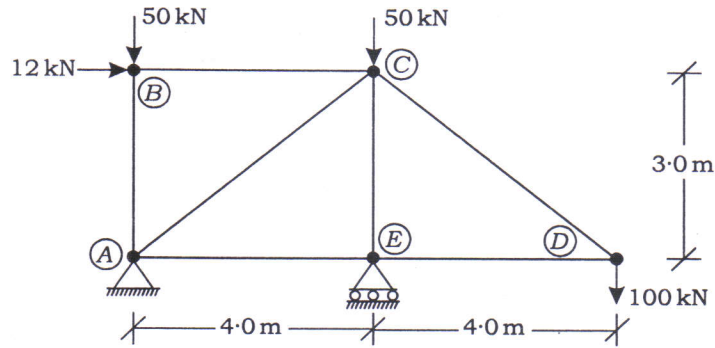


Fig. 1(d)

Member	Forces due to external loads (kN)	Forces due to unit vertical load at D (kN)	Forces due to unit horizontal load at D (kN)
AB	- 50.0	0	0
AC	+ 181.70	+ 1.67	0
AE	- 133.30	- 1.33	+ 1.0
BC	- 12.0	0	0
CD	+ 166.70	+ 1.67	0
CE	- 259.0	- 2.0	0
DE	- 133.3	- 1.33	+ 1.0

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- (e) An unequal angle ISA $125 \text{ mm} \times 75 \text{ mm}$ is required to carry a tensile load of 160 kN . The angle section is connected to the gusset plate through the longer leg by 18 mm dia bolts as shown in Fig. 1(e) below. Select a suitable thickness for the angle :

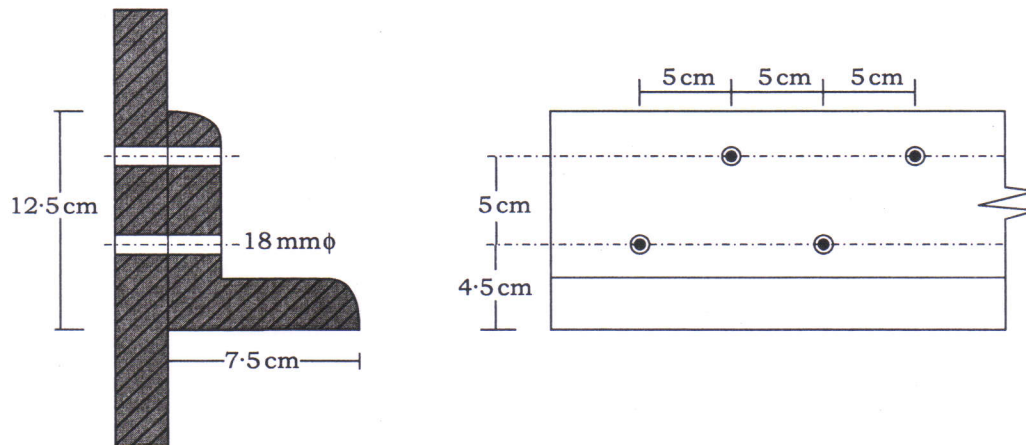


Fig. 1(e)

Assume $f_y = 250 \text{ N/mm}^2$ and $f_u = 410 \text{ N/mm}^2$.

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2. (a) The blocks A and B are kept in equilibrium by the arrangements shown in Fig. 2(a) below. Assuming the pulleys smooth, compute the least and the highest magnitude of W to keep the system in equilibrium. In each case, also compute the tension induced in the string :

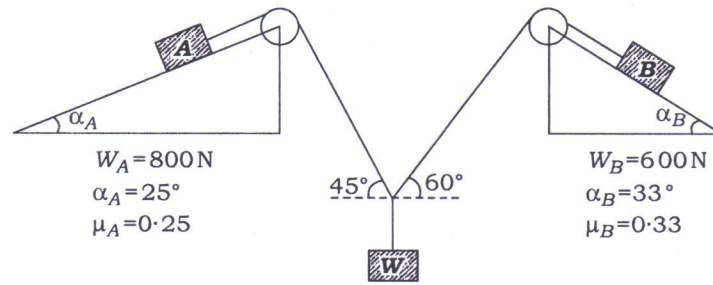


Fig. 2(a)

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- (b) Determine the induced moment in each end of each member due to application of external moment of 50 kN-m at joint D shown in Fig. 2(b) below. Use moment distribution method. Take EI constant for all the members. Sketch the deflected shape of the frame also :

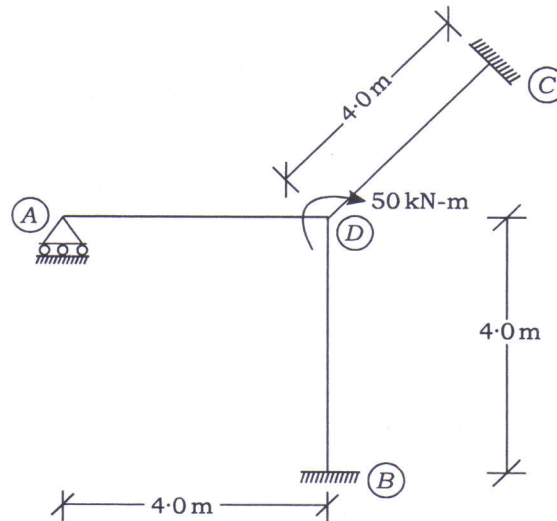


Fig. 2(b)

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- (c) A prestress concrete beam of rectangular cross-section 300 mm wide by 600 mm deep is 12 m long and supports a live load of 12 kN/m in addition to its self-weight. The beam is prestressed by a cable having high tensile wires of 2000 mm^2 area stressed to 800 N/mm^2 . The cable is straight and located at a distance of 175 mm from the soffit of the beam. Determine the shift in the pressure line at one quarter span and centre of the span, when the beam supports the service load. Plot the location of thrust line in the beam and compute the stress distribution at quarter and midspan using resultant thrust. 15

3. (a) A train of moving load of 20 kN/m and 35.0 m length will pass through the truss as shown in Fig. 3(a) below. Work out the maximum forces in the member U_2L_3 due to this moving load by drawing influence line diagram :

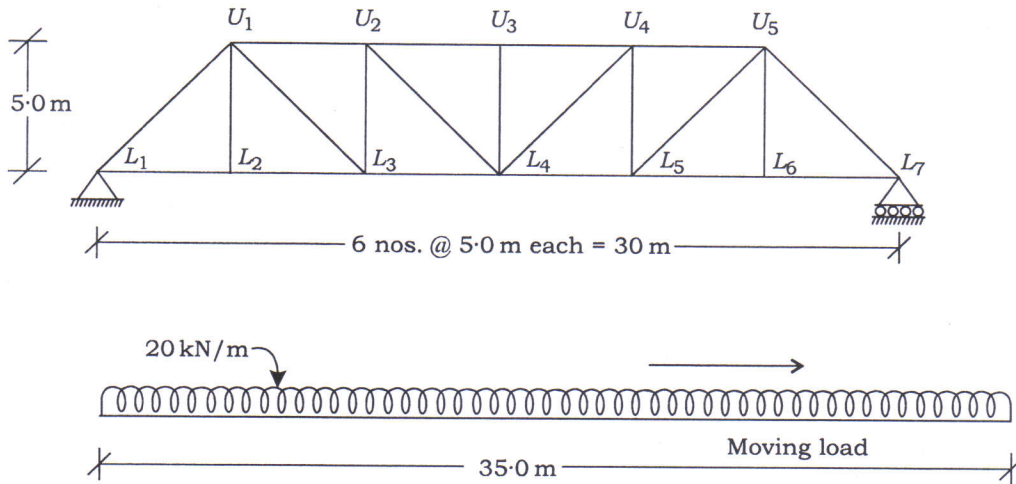


Fig. 3(a)

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- (b) At a point in a material state of plane stress as shown in Fig. 3(b) below, using Mohr's circle, determine—

- (i) the angle between plane P and Q ;
- (ii) the principal stresses and their orientation relative to the plane P ;
- (iii) the maximum shear stress.

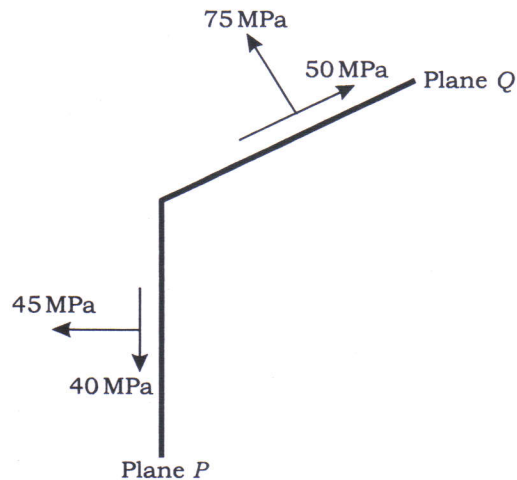


Fig. 3(b)

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(c) Bending moment and shear force diagrams for a plane frame (at a particular beam level) have been shown in Fig. 3(c). An additional torsion of 100 kN-m is also acting on this continuous beam. Design the beam portion 'BC' only by working stress method for total maximum bending moment at support and at midspan, and for corresponding total maximum shear force. Sketch the reinforcement section at support and at midspan only. The following parameters may be used :

- (i) Beam size : 300 mm × 1150 mm
- (ii) Grade of concrete : M 35
- (iii) Grade of reinforcement steel : Fe 415
- (iv) Nominal cover : 40 mm
- (v) Diameter of flexural reinforcing bar : 20 mm
- (vi) Diameter of shear reinforcing bar : 10 mm
- (vii) $\sigma_{cbc} = 11.50 \text{ N/mm}^2$
- (viii) $\sigma_{st} = 230 \text{ N/mm}^2$
- (ix) $m = 280 / (3 \times \sigma_{cbc})$
- (x) $\tau_c = 0.30 \text{ N/mm}^2$
- (xi) $\tau_{c\max} = 2.3 \text{ N/mm}^2$
- (xii) Minimum shear reinforcement $\frac{A_{sv}}{(b)(S_v)} \geq \frac{0.40}{0.87f_y}$
- (xiii) Face reinforcement : 3 nos. 10 mm # on each face
- (xiv) Torsional moment = $T_u \frac{\left(1 + \frac{D}{b}\right)}{1.7}$
- (xv) Additional shear = $\frac{(1.6)(T_u)}{b}$

(xvi) Size of column : 400 mm × 400 mm

(All notations are as per IS 456 : 2000)

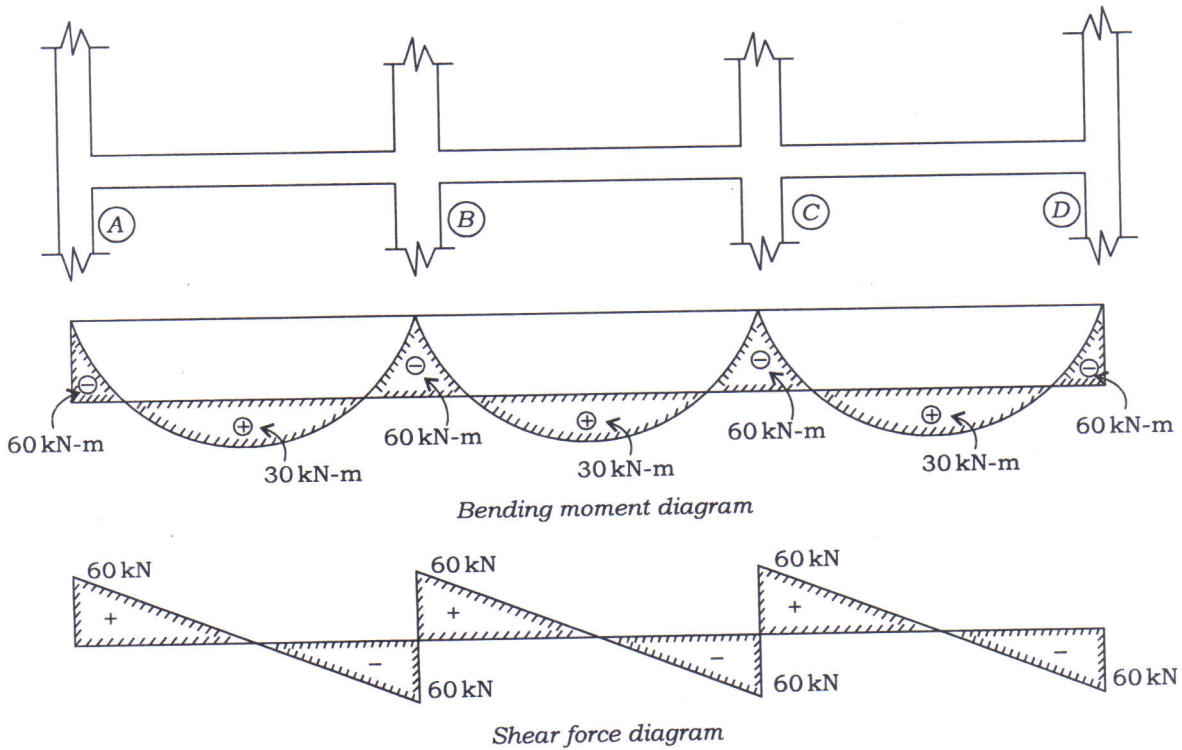


Fig. 3(c)

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4. (a) A composite bar of rectangular cross-section 20 mm × 24 mm is loaded in tension by a force $P = 1$ kN as shown in Fig 4(a) below. The shaded part of the bar is made of a material where Young's modulus is $E_2 = 210$ GPa. The remaining part is made of a material with $E_1 = 105$ GPa. If the bar is to deflect in the x -direction, determine the stresses in each material and the location of the loading axis relative to the centre of the bar :

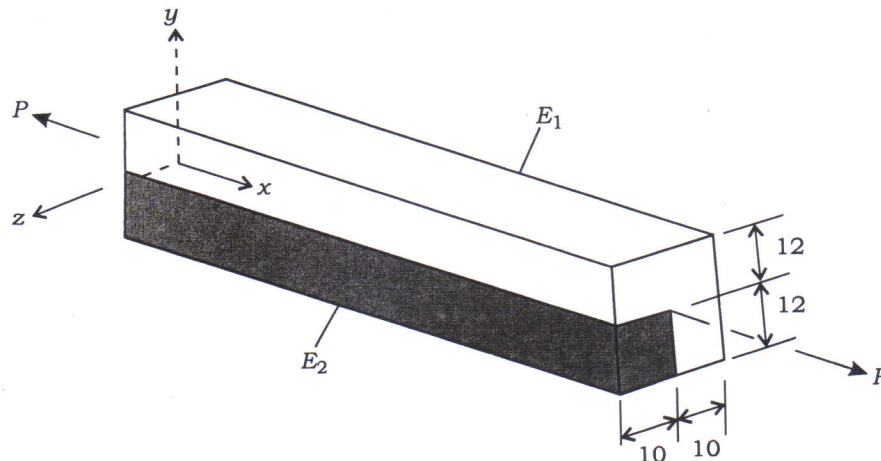


Fig. 4(a)

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(b) Design an interior slab panel 'S-1' as shown in Fig. 4(b) by limit state method. This slab panel is supported and monolithic constructed with RCC frame structure. The following parameters may be used :

- (i) Limit state of collapse : Flexure design only
- (ii) Live load (imposed load not fixed) : 3.0 kN/m^2
- (iii) Grade of concrete : M 20
- (iv) Grade of reinforcing steel : Fe 415
- (v) Span to overall depth ratio : 32
- (vi) Value of partial safety factor for dead load : 1.5
- (vii) Value of partial safety factor for live load : 1.5
- (viii) Unit weight of RCC : 25 kN/m^3
- (ix) Unit weight of PCC : 24 kN/m^3
- (x) Unit weight of ceiling plaster : 20 kN/m^3
- (xi) Load combination : Only (dead load + live load)
- (xii) Floor finish thickness : 50 mm thick PCC
- (xiii) Maximum nominal cover : 20 mm
- (xiv) Ceiling plaster : 12 mm thick cement mortar
- (xv) Maximum diameter of reinforcement : 8 mm #
- (xvi) $(x_{u \text{ max}} / d) = 0.4791$
- (xvii) Bending moment coefficients :

	Short span	Long span
-ve moment at continuous edge	0.053	0.032
+ve moment at midspan	0.041	0.024

(xviii) Percentage reinforcement p_t for M 20 grade concrete and Fe 415 grade steel may be taken as :

$\frac{M_u}{bd^2}$	up to 0.692	0.758	0.823	0.888	0.952
p_t	0.20%	0.22%	0.24%	0.26%	0.28%

- (xix) Total depth calculated shall be round off to next 10 multiplier
 (xx) Largest calculated depth shall be finally provided

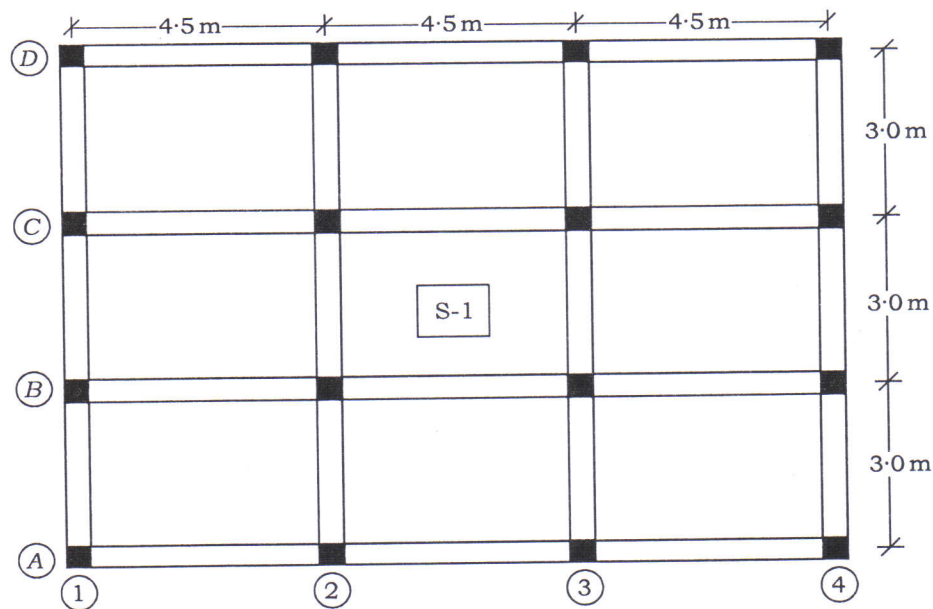


Fig. 4(b)

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- (c) Calculate the compressive resistance of pin-ended ISMB 350 column having length of 3 m if it is encased in concrete of compressive strength 20 N/mm^2 as shown in Fig. 4(c) below :

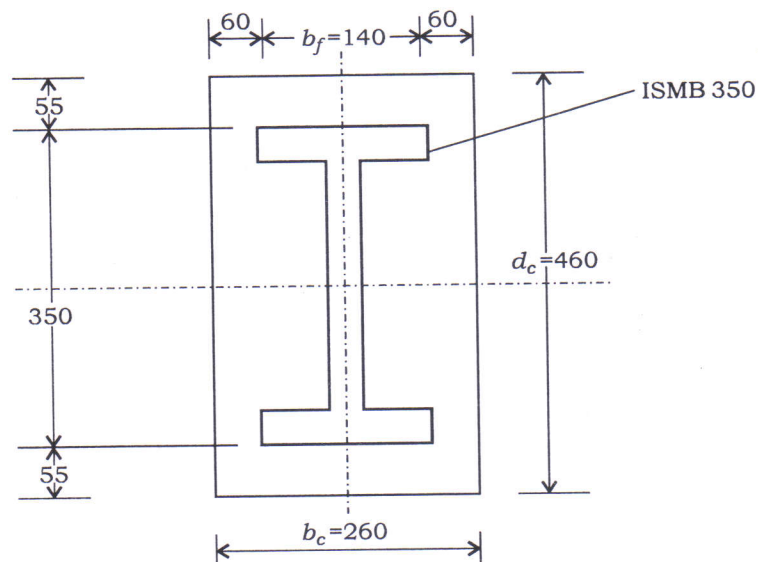


Fig. 4(c)

The properties of ISMB 350 are as follows :

- Flange width, $b_f = 140 \text{ mm}$
 Depth of section, $h = 350 \text{ mm}$

Cross-section area, $A_g = 6670 \text{ mm}^2$

Radius of gyration, $r_z = 143 \text{ mm}$, $r_y = 28.4 \text{ mm}$

Area of concrete $= b_c \times d_c = (260 \times 460) \text{ mm}^2 = 119600 \text{ mm}^2$

Assume $f_y = 250 \text{ MPa}$

Use the following table to compute f_{cd} :

Design compressive stress f_{cd} (MPa) for column buckling class 'a'

$\frac{KL}{r_z}$	Yield stress ($f_y = 250 \text{ MPa}$)
10	227
20	226
30	220

Design compressive stress f_{cd} (MPa) for column buckling class 'b'

$\frac{KL}{r_y}$	Yield stress ($f_y = 250 \text{ MPa}$)
40	206
50	194
60	181

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SECTION—B

5. (a) Fig. 5(a) below shows two line loads on the ground surface. Determine the increase of stress at point A :

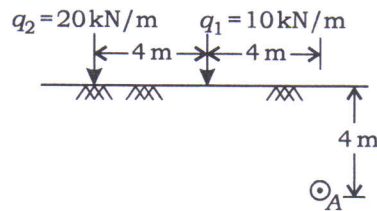


Fig. 5(a)

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- (b) A consolidated-drained triaxial test was conducted on a normally consolidated clay. The results are as follows :

$$\sigma_3 = 80 \text{ kN/m}^2; (\Delta\sigma_d)_f = 120 \text{ kN/m}^2$$

Determine the (i) angle of friction ϕ' and (ii) angle θ that the failure plane makes with the major principal plane.

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- (c) The relative compaction of a sand in the field is 88%. The maximum and minimum dry unit weights of the sand are 18.55 kN/m^3 and 15.41 kN/m^3 respectively. Determine the—

- (i) dry unit weight in the field;
- (ii) relative density of compaction;
- (iii) moist unit weight at a moisture content of 12%.

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- (d) For the simple pipe system shown in Fig. 5(d) below, the pressures measured are $p_1 = 19.58$ kPa, $p_2 = 14.685$ kPa and $p_3 = 9.79$ kPa when the discharge is 11 L/s. Determine the head loss (i) between 1 and 2, and (ii) between 1 and 3. Take $\gamma = 9.79$ N/m², $g = 9.81$ m/s² :

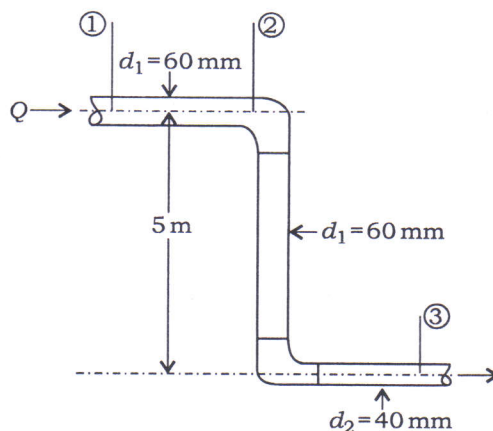


Fig. 5(d)

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- (e) Determine the cross-section of the greatest hydraulic efficiency for a trapezoidal channel if the design discharge is 17.32 m³/s, the channel slope is 0.0004 and Manning's $n = 0.020$. Provide a sketch showing final dimensions.

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6. (a) The plan of a group of 9 piles driven into a soft clay is shown in Fig. 6(a) below. The diameter and the length of piles are 30 cm and 12 m respectively. The unconfined compressive strength of the clay is 80 kN/m². Calculate the allowable load on the pile group on the basis of shear failure criterion for a factor of safety 3.0. Assume $\alpha = 1$, $N_c = 9$:

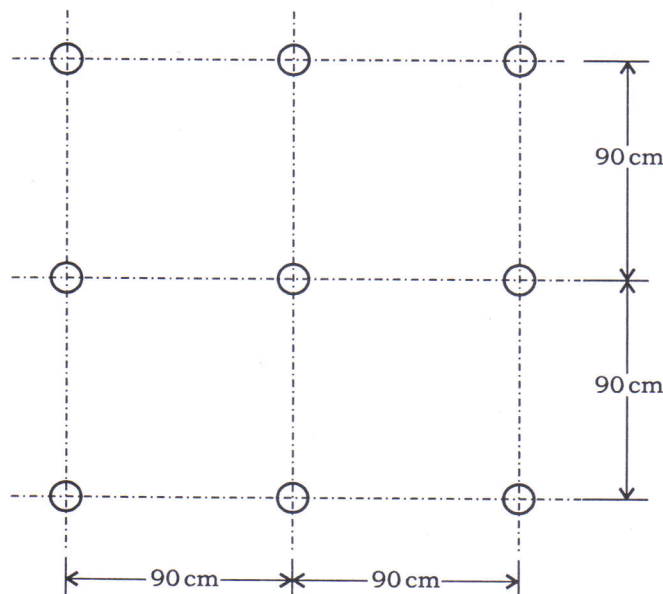


Fig. 6(a)

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(b) A viscous liquid ($\rho = 1.18 \times 10^3 \text{ kg/m}^3$, $\mu = 0.005 \text{ N-s/m}^2$) flows at a rate of $4\pi \text{ mL/s}$ through a horizontal 4 mm diameter tube.

(i) Determine whether the flow is laminar.

(ii) Determine the pressure drop along a 1 m length of the tube which is far from the tube entrance so that the only component of velocity is parallel to the tube axis.

(iii) If a 2 mm diameter rod is placed in the 4 mm diameter tube to form a symmetric annulus, what is the pressure drop along a 1 m length if the flow rate remains the same as above? 15

(c) A spillway model is to be built to a scale of 1 : 25 across a flume which is 0.70 m wide. The prototype is 12.0 m high and the maximum head expected is 1.55 m.

(i) What height of the model and what head on the model should be used?

(ii) If the flow over the model at 65 mm head is $0.025 \text{ m}^3/\text{s}$, what flow per m of prototype may be expected?

(iii) If the model shows a measured hydraulic jump of 30 mm, how high is the jump in the prototype? 15

7. (a) A soil mass is contaminated with gasoline. 75% of the void space of the soil is filled with gasoline and water. The volume of gasoline is 25% of the volume of water. The unit weight of soil solids is 26 kN/m^3 and water content of the soil is 25%. The specific gravity of gasoline is 0.9. Find the void ratio, porosity, total density and dry density of the soil. Take $\gamma_w = 9.81 \text{ kN/m}^3$. 15

(b) A retaining wall is shown in Fig. 7(b) below. Determine (i) the active force after the tensile crack occurs and (ii) the passive force per unit length of the wall :

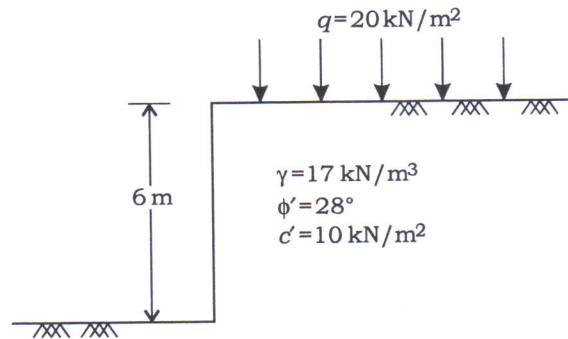


Fig. 7(b)

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(c) A rectangular channel has a width of 2.0 m and carries a discharge of $3.0 \text{ m}^3/\text{s}$. If the depth of flow at a section is 0.35 m, determine—

(i) the specific energy at the given section;

(ii) alternate depth to the existing depth;

(iii) Froude number at the alternate depths. 10

8. (a) A 12 m thick clay layer has impervious layer on the top and drainage can occur from the bottom only. The clay layer settles 10 cm in 3.5 years. The coefficient of consolidation for this layer was found to be $0.544 \times 10^{-2} \text{ cm}^2/\text{s}$. Compute the ultimate consolidation settlement and find out the time for 90% of this settlement. Take average degree of consolidation and time factor values from the table given below :

Average degree of consolidation (U)	0.5	0.6	0.7	0.8	0.9	0.95	1.0
Time factor (T)	0.197	0.287	0.403	0.567	0.848	1.163	∞

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- (b) A reaction turbine having a diameter of 0.6 m, when running at 900 rev/min developed 299 kW when the flow was $1.0 \text{ m}^3/\text{s}$. The pressure head at the entrance to the turbine was 30 m and the elevation of the turbine casing above tailwater level was 2.0 m. The water enters the turbine with a velocity of 3.132 m/s. Calculate—

- (i) the effective head;
- (ii) the efficiency;
- (iii) the speed expected under a head of 81 m;
- (iv) the power under 81 m head;
- (v) the discharge under 81 m head.

Take $g = 9.81 \text{ m/s}^2$ and $\rho = 1000 \text{ kg/m}^3$.

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- (c) Find the magnitude and direction of the resultant force of water on the quadrant gate shown in Fig. 8(c) below. The principal dimensions of the gate are as follows :

Radius of gate = 1 m

Width of gate = 3 m

Water density = 1000 kg/m^3

The position of the centre of gravity is, as shown, $\frac{4R}{3\pi}$ horizontally from the origin. Provide a sketch showing the forces and direction of resultant :

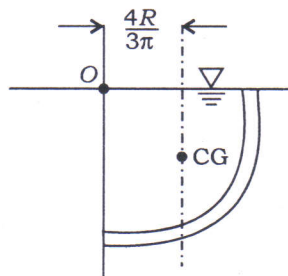


Fig. 8(c)

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