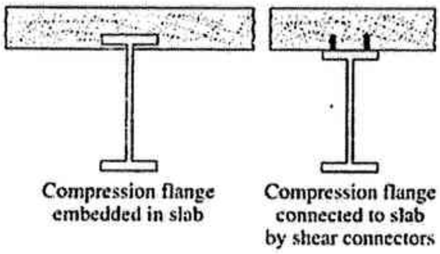
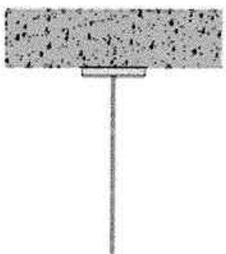
## SCHEME OF VALUATION
### (Scoring Indicators)

**Revision: 2021**

**Course Name: Design of Steel and RCC Structures**

**Course Code: 5012** **QID:210923002**

| Qst. No | Scoring Indicator | Split up Score | Sub Total | Total |
|---|---|---|---|---|
| | **I. PART A** | | | **9** |
| I.1 | Single angle section, double angle section ,channel sections, I sections, hollow circular sections ,hollow square sections. etc. *(Any two sections )* | | 1 | |
| I.2 | The area of the cross-section of the member that is effective in carrying the load under tension.. Gross area minus holes due to rivets or bolts | | 1 | |
| I.3 | Mp = Yield Stress (fy) x Plastic Section Modulus (Zp) | | 1 | |
| I.4 | Servicability | | 1 | |
| I.5 | Under Reinforced | | 1 | |
| I.6 | $L_d = \varphi\sigma_s/4\tau_{bd}$ | | 1 | |
| I.7 | Short Column | | 1 | |
| I.8 | 0.80% | | 1 | |
| I.9 | Slenderness Ratio | | 1 | |
| | **II. PART B** | | | **24** |
| II.1 | For ISA100x100x6mm, Area, Ae = 1167 $mm^2$ | 1 | 3 | |
| | Least radius of gyration, r = 19.5 mm | 1 | | |
| | Slenderness ratio = KL/r = 2550/19.5 = 130.77 | 1 | | |
| II.2 | Zp = A/2 $(y_1+y_2)$ b= 100 mm d= 100 mm<br>= (10000/2)*(25+25) $y_1$= $y_2$= 100/4 = 25 mm<br>= **250000 $mm^3$** A= 10000 $mm^2$ | 2 | 3 | |
| | Mp = fy * Zp fy= 250 $N/mm^2$<br>= 250*250000<br>= 62500000 N-mm ($62.5\times10^6$ N-mm)<br>= **62.50 kNm** | 1 | | |
| | **or**<br>Zp = $bd^2/4$ = 250000 (If done in single step also can<br>Mp = fy * Zp = **62.5 kNm** give full 3 marks) | | | |
| II.3 | a) Compact Section<br>Cross sections which can develop plastic moment of resistance, but have inadequate plastic hinge rotation capacity for formation of plastic mechanism due to local buckling. | 1.5 | 3 | |

<table>
<tr><td></td><td>b) Plastic Section<br>Cross sections which can develop plastic hinges and has sufficient rotation capacity required for failure of structure by forming plastic mechanism.</td><td>1.5</td><td></td></tr>
<tr><td>II.4</td><td>a) When factored shear force doesnot exceed 0.6 times design shear strengt<br>$M_d = \beta_b Z_p f_y / \gamma_{m0} \quad \leq 1.2 Z_e \frac{f_y}{\gamma_{mo}}$ (for simply supported beam)<br>$\leq 1.5 Z_e \frac{f_y}{\gamma_{mo}}$ (for cantilever beam)</td><td>1.5</td><td rowspan="3">3</td></tr>
<tr><td></td><td>$\beta_b$ = 1.0 for plastic and compact sections;<br>$\beta_b$ = $Z_e/Z_p$ for semi-compact sections;<br>$Z_p$, $Z_e$ = plastic and elastic section modulii of the cross-section, respectively;<br>$f_y$ = yield stress of the material; and<br>$\gamma_{m0}$ = partial safety factor (see 5.4.1).</td><td>1</td></tr>
<tr><td></td><td>a) When factored shear force exceeds 0.6 times design shear,<br>$M_d = M_{dv}$<br>$M_{dv}$ = design bending strength under high shear as defined in 9.2.</td><td>0.5</td></tr>
<tr><td>II.5</td><td>a) Laterally Supported Beams<br>Beam that is supported or restrained laterally (sideways) along its length. It can resist lateral movement or buckling due to the presence of supports or lateral restraints.<br><br></td><td>1.5</td><td rowspan="2">3</td></tr>
<tr><td></td><td>a) Laterally Unsupported Beams<br>Beam that lacks sufficient lateral support along its length. It cannot resist lateral movement or buckling on its own. These beams undergo lateral torsional buckling.<br></td><td>1.5</td></tr>
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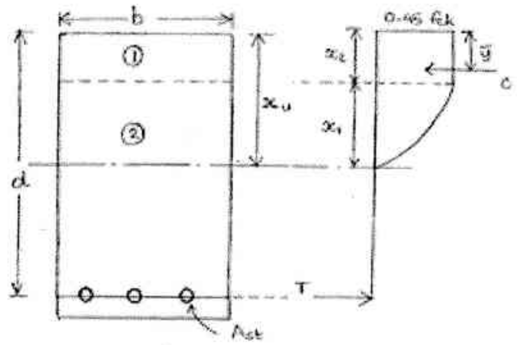
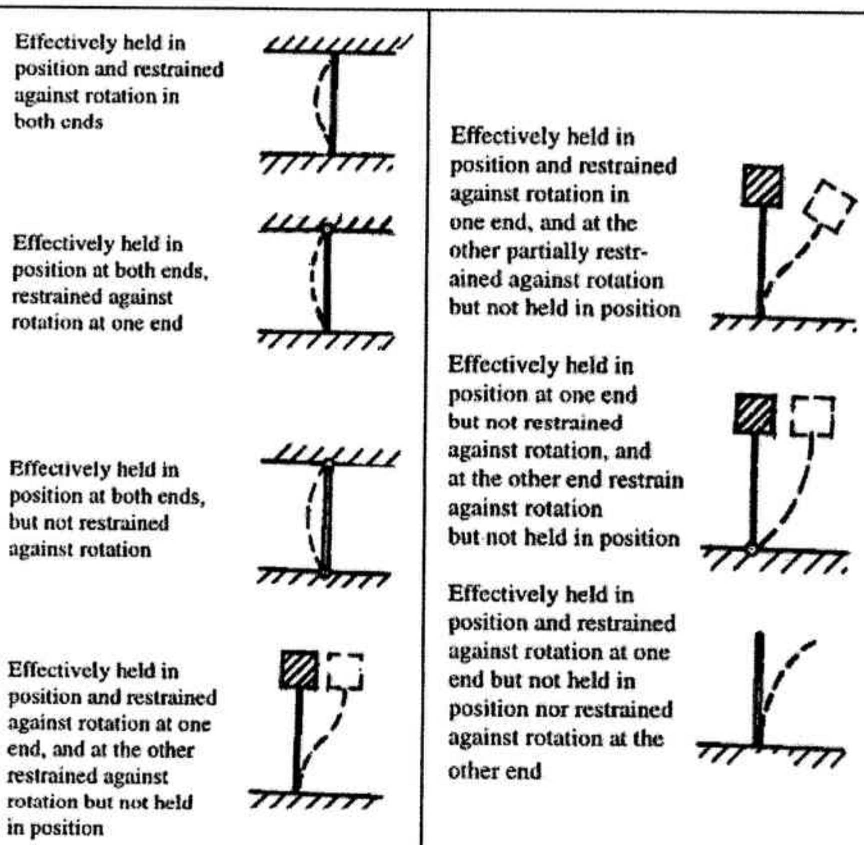
<tr><td>II.6</td><td>
</td><td>3</td><td>3</td><td></td></tr>
<tr><td>II.7</td><td>

(Students can write any 3 of these)</td><td>1*3 = 3</td><td>3</td><td></td></tr>
<tr><td>II.8</td><td>The pitch of lateral ties shall not be more than the least of following<br>i) Least lateral dimension of the column<br>ii) Sixteen times the smallest diameter of the longitudinal bar<br>iii) 300 mm</td><td>3</td><td>3</td><td></td></tr>
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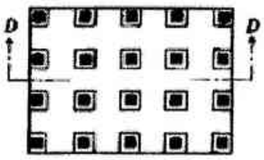
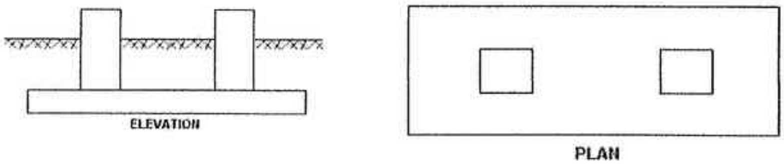
| | | | | |
|---|---|---|---|---|
| II.9 | <u>Raft Footing</u><br>1 Raft footing, also known as mat footing or slab footing, is a type of foundation that is used to distribute the load of a building or structure over a large area.<br>2 Raft footings are typically a single, thick concrete slab that extends over the entire area of the building<br>3 Raft footings are commonly used for large or heavy structures such as high-rise buildings in regions with weak or compressible soil.<br><br> | 1.5 | 3 | |
| | <u>Combined Footing</u><br>1 Combined footings are used when two or more columns are so close together that individual footings would overlap or merge<br>2 Combined footings are rectangular or trapezoidal in shape and are designed to support two or more columns.<br>3 Combined footings are used when it is not feasible to provide separate footings for adjacent columns.<br><br> | 1.5 | | |
| II.10 | <u>a) Oneway Shear</u><br>One-way shear, also known as beam shear or flexural shear, occurs when the applied shear force acts predominantly in one direction within a structural element. In footings, this typically happens when the load from a column or wall is distributed over the width or length of the footing. | 1.5 | 3 | |
| | <u>a) Twoway Shear</u><br>Two-way shear, also known as punching shear or diagonal shear, occurs when the applied shear force is distributed in two directions (two way action) within a structural element. It indicates the tendency of column to punch through the slab. | 1.5 | | |
| | **PART C** | | | **42** |
| III | Given<br>fy = 250 MPa fu = 410 MPa<br>Weld length, Lc = 140 mm Outstanding leg , w = 80mm<br>From steel tables, Area of ISA80x80x6 mm, Ag = 929 $mm^2$<br><u>a) Design Strength in Gross Section Yielding</u><br>**Tdg = (Ag * fy) /γm0** *(IS800:2007 Clause 6.2)* | | | |

| | | | |
|---|---|---|---|
| | $\gamma m0$ = 1.1 Ag = 929 $mm^2$<br>**Tdg** = (929*250)/1.1<br>= 211136.3636 N<br>= **211.14 kN** | 2.5 | |
| | <u>b) Design Strength in Net Section Rupture</u><br>**Tdn = (0.9 * Anc * fu / $\gamma$m1) + ( $\beta$ * Ago * fy / $\gamma$m0)** *(Clause 6.3.3)*<br>Net area of connected leg, Anc = [80-(6/2)]*6 = 462 $mm^2$<br>Gross area of outstanding leg, Ago = [80-(6/2)]*6 = 462 $mm^2$ *(1 Mark)*<br><br>$\gamma$m0 = 1.1 $\gamma$m1 = 1.25<br><br>$\beta$ = 1.4 - 0.076 * (w/t) * (fy/fu) * (bs/Lc) ≤ ( (fu*$\gamma$m0) / (fy*$\gamma$m1) ) and ≥ 0<br>= 1.4-[0.076*(80/6)*(250/410)*(80/140)] ≤ (410*1.1)/(250*1.25)<br>= 1.04692 ≤ 1.4432 ≥ 0.7<br>So, $\beta$ = 1.05 *(2 Marks)*<br><br>Tdn = (0.9*462*410)/1.25 + (1.05*462*250)/1.1<br>= 136382.4 + 110250<br>= 246632.4 N<br>= **246.63 kN** *(1.5 Mark)* | 4.5 | 7 |
| IV | <u>Design of Single Angle Strut Members as per IS800:2007</u><br>1 Assume the design stress in compression, fc. For rolled steel beam s design stress can be assumed as 135 N/$mm^2$ and for angles as 90 N/$mm^2$ or a value of 0.5 to 0.6 times fy can be assumed.<br>2 From the given factored load Pu and assumed design stress value fc calculate the area of section (A = Pu/fc). Based on the area obtained, a section can be selected from steel tables.<br>3 Calculate the least radius of gyration and then the slenderness ratio of the section (KL/rmin)<br>4 Find actual design stress fcd based on the buckling class and slenderness ratio of the section from Table 9 of IS 800<br>5 Calculate the design compressive strength Pd = fcdxA<br>6 If Pd<Pu, section is not adequate. Hence select a new section and repeat steps till step 5<br>7 If Pd>Pu, selected section is adequate. | 7 | 7 |
| V | From steel tables ,<br>For ISA100x100x8mm, Area, A =1539 $mm^2$<br>rzz =30.7 mm cyy=czz = 27.6 mm Iyy = 145.1x$10^4$ $mm^4$<br>Given thickness of gusset, tg = 10 mm | 1 | |
| | Now for double angle connection of ISA100x100x8mm,<br>Area, Ae = 2*1539 = 3078 $mm^2$ | | |

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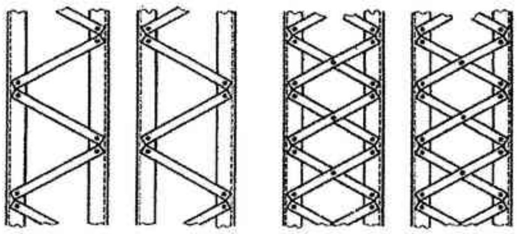
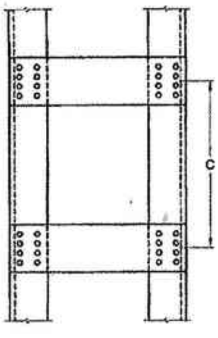
|---|---|---|---|---|---|
| | rzz =30.7 mm (remain same)<br>$I_y = 2[I_{yy}+A(c_{yy}+t_g/2)^2] = 2*[145.1*10^4+(1539*(27.6+5)^2)]$<br>$= 6173175.28$<br>$r_y = \sqrt{(I/A_e)} = \sqrt{(6173175.28/3078)} = 44.78$ mm<br>So minimum radius of gyration is rzz = 30.7 mm | 2 | 7 | | |
| | Design Compressive strength, **Pd = Ae x fcd** (IS800,Clause 7.1.2)<br>To find fcd,<br>Slenderness ratio = KL/r = 2550/30.7 = 83.06<br>Angle sections comes under buckling class c<br>From Table 9c of IS800,<br>For Slenderness ratio 80, fcd = 136 $N/mm^2$<br>For Slenderness ratio 90, fcd = 121 $N/mm^2$<br>For Kl/r of 83.06, fcd = 121+[(136-121)*(90-83.06)]/10<br>= 131.41 | 2 | | | |
| | Design Compressive strength, **Pd = Ae x fcd**<br>= 3078*131.41<br>= 404480 N<br>= **404.48 kN** | 2 | | | |
| VI | i.Laced Column<br><br><br>These are built up memebers composed of individual steel angles or channels seperated by a distance and connected in a lattice or crisscross pattern by lacings. Lacings are provided to keep the induvidual members in positionn | 3.5 | 7 | | |
| | ii. Battened Column<br>These are built up sections of identical longitudinal elements slightly separated and connected to each other at only a few places along their length by means of battens.<br><br><br>*(For i and ii, 2.5 marks for sketch and 1 mark for definition can be given)* | 3.5 | | | |

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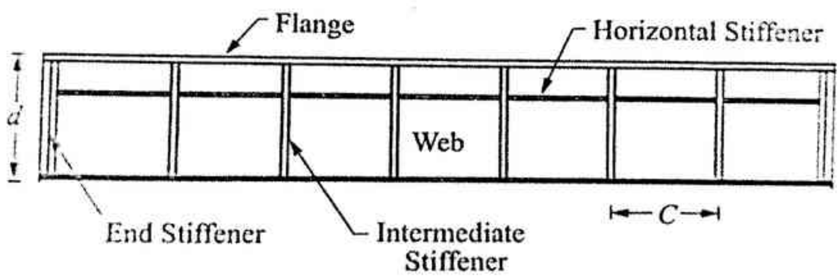
| VII | a) | A plate girder is a built up steel beam formed by welding or bolting together steel plates to support heavy loads over long spans in construction and engineering applications.<br>Elements of a plate girder are web plate, flange plates, vertical stiffners and horizontal stiffners | 2 | 7 | |
| | b) | <br>*(Give 3 Marks for Sketch and 2 Marks for accurate labelling of components)* | 5 | | |
| VIII. | | For ISMB 400<br>$Zp = 1176.163 \text{x} 10^3\ mm^3$   h=400 mm   $t_w = 8.9$ mm<br>Given, $fy = 250\ N/mm^2$   and   $\gamma m0 = 1.10$<br><br><u>Check for shear</u><br>Design Shear Strength, $V_d = (f_y{*}A_v)/(\gamma_{mo}{*}\sqrt{3})$<br>$Av = 400{*}8.9 = 3560\ mm^2$<br>So, $Vd = (250{*}3560)/(1.1{*}\sqrt{(3)})$<br>$= 467129$ N<br>$=$ **467.128 kN** $>$ 120 kN<br>Hence safe in Shear | 3.5 | 7 | |
| | | <u>Check for Bending Strength</u><br>$0.6\ Vd = 0.6{*}467.128 = 280\ kN > 120\ kN$<br>So,<br>$M_d = \beta_b Z_p f_y/\gamma_{mo} \leq 1.2{*}Z_e f_y/\gamma_{m0}$<br>For plastic section, $\beta b = 1$   $Z_e = 1022.7 \text{x} 10^3\ N/mm^2$<br>So, $M_d = (1{*}1176.163{*}10^3{*}250)/1.1 \leq (1.2{*}1022.7 \text{x} 10^3{*}250/1.1)$<br>$= 267309772.7\ Nm \leq 28728572.73\ Nm$<br><br>$M_d =$ **267.31 KNm** $>$ 180 kNm<br>Safe in Bending | 3.5 | | |

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| IX. | a) Given,<br>b=230 mm    fck = 20 N/mm$^2$<br>d=400mm    fy = 415 N/mm$^2$<br>Ast = $4*(\pi/4)*16^2$ = 804.25 mm$^2$ | 1 | 7 | |
| | <u>Depth of Neutral Axis</u><br>$x_u = 0.87*f_y*A_{st}/(0.36*f_{ck}*b)$<br>$= (0.87*415*804.25)/(0.36*20*230)$<br>$=$ 175.35 mm<br>For fy = 415 N/mm$^2$,<br>$x_{umax} =$ 0.48d = 0.48*400 = 192 mm<br>$x_u < x_{umax}$ So beam is under reinforced. | 3 | | |
| | <u>Calculation of Moment of Resistance</u><br>$Mu = 0.87*f_y*A_{st}*(d-0.42x_u)$<br>$= 0.87*415*804.25*(400-(0.42*175.35))$<br>= 94764576.96 Nm<br>= **94.76 kNm** | 3 | | |
| X | <u>Design of Two way slab as per IS456:2000</u><br>1. Assume a slab thickness with proper cover to steel based on span to effective depth ratio of shorter span (IS456, Clause 24.1)<br>2. Calculate the design load from the value of dead and live loads on the sl<br>w = 1.5 (DL+LL)<br>3. Calculate design moment using the moment coefficients obtained from table 26 of IS456<br>$M_x = \alpha_x w l^2_x$<br>$M_y = \alpha_y w l^2_x$<br>4. Calculate steel required in both directions. Choose diameter and spacing<br>Maximum Spacing allowed : 3d or 450mm<br>5. Calculate maximum shear and check for shear in the slab<br>6. Check for deflection based on span to depth ratio.<br>7. Check for cracking minimum steel in both directions. | 7 | 7 | |
| XI | Nominal shear stress, $\tau_v$ = Vu/bd = $(230*10^3)/(300*500)$<br>= 1.53 N/mm$^2$<br>Area of main steel = $4*\pi/4*25^2$ = 1963.5 mm$^2$<br>% steel .p = (1963.5*100)/(300*500) = 1.31 % | 1 | | |
| | For p=1.31, and M25 concrete find design shear strength<br>From table 19 of IS456:200,<br>p=1.25, $\tau_c$ = 0.70 N/mm$^2$<br>p=1.50, $\tau_c$ = 0.74 N/mm$^2$ | | | |

For for a p of 1.31, $\tau_c$ = 0.70+[(0.74-0.70)*(1.31-1.25)]/0.25

$\tau_c$ = 0.71 $N/mm^2$

$\tau_v$ > $\tau_c$ Hence Design for shear — 3

Assume 2-legged 10 mm stirrups.

Area of stirrups, $A_{sv}$ = $2*\pi/4*10^2$ = 157.08 $mm^2$

Spacing of stirrups $S_v$ = [0.87*fy*Asv]/[(τv-τc)*b] page 73 IS456

= **230.54 mm** — 2

Maximum spacing permitted,

i) 300 mm

ii) 0.75d = 0.75*400 = 300 mm

**So provide 2 legged 10 mm dia stirrups at 240 mm c/c.** — 1 — 7

XII a)

| Aspect | One-Way Slab | Two-Way Slab |
|---|---|---|
| Load Distribution | Primarily in one direction | In both directions |
| Span Direction | Suitable for longer spans | Typically for shorter spans |
| Reinforcement Direction | Main bars in one direction | Main bars in two perpendicular directions |
| Support Configuration | Supported on two opposite sides | Supported on all four sides or columns |
| Complexity of Design | Simpler design calculations | More complex design calculations |
| Deflection Control | May require additional measures | Better at controlling deflections |

1*3 = 3 — 7

*(Any 3 aspects written can be given full credit)*

b) Purpose of Distribution Steel

i) To distribute the effect of point loads

ii) To resist temperature sttresse

iii) To keep the main reinforcement in position — 2

Codal Provisions

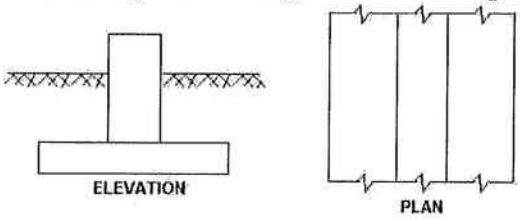
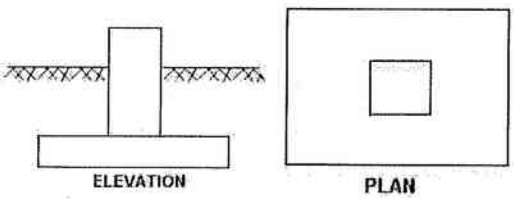
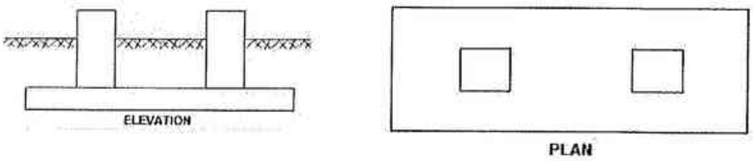
i)Minimum area of distribution steel is,

i) 0.12% of gross area for HYSD bars

ii) 0.15% of gross area for Mild Steel Bars — 2

ii) Maximum spacing of distibution bars is Mininum (5d,450mm)

*(Any two purposes and any two codal provision can be given full credit)*

| | | | |
|---|---|---|---|
| XIII. | Effective length, l = L = 3200 mm<br>l/d = 4000/400 = 10 <12, Hence short column | 1 | 7 |
| | Load carrying capacity, $P_u$ = $0.4f_{ck}A_c+0.67f_yA_s$<br>$1450x10^3$ = $0.4x20x(160000-A_s) + 0.67x415xA_s$<br>$1450x10^3$ = $1280000+270.05A_s$<br>Area of longitudinal steel, $A_s$ = **629.513** $mm^2$ | 3 | |
| | Provide 16 mm diameter bars as longitudinal reinforcement<br>No. of bars required = 629.513/201.062 = 3.13097<br>**Use 4 numbers of 16 mm diameter bars** | 1 | |
| | Lateral ties<br>Diameter of ties = 1/4th of main bar dia = 4<br>Provide 6 mm bars as lateral ties | 1 | |
| | c/c spacing of ties should not be more than the least of ;<br>a) least lateral dimesion of column = 400 mm<br>b) 16x dia of main bar = 16*116 = 256mm<br>c) 300 mm<br>**So, provide 6 mm bars at 250 mm c/c as lateral ties** | 1 | |
| XIV | Strip Footing<br>Provided to throughout the length of load bearing wall.<br><br><br>Spread Footing/Induvidual Footing/Isolated Footing<br>Footing is provided to support an individual column.<br><br><br>Combined Footing<br>A combined footing supports two columns. It is used when the two columns are so close to each other that their individual footings<br><br> | 7 | 7 |

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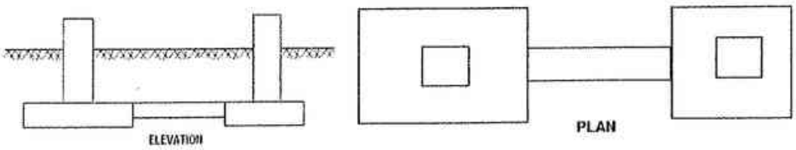
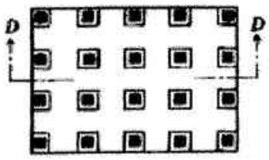
| | Strap or Cantilever Footing<br>A strap (or cantilever) footing consists of two isolated footings connected with a structural strap or a lever.<br><br><br>Mat/Raft Footing<br>A mat or raft footing is a large slab supporting a number of columns and walls under the entire structure or a large part of the structure.<br><br> | | | |