UNIT CONVERSIONS

LENGTH

1 in	= 2.54 cm	1 cm	= 0.3937 in
1 ft	= 30.48 cm	1 cm	= 0.0328 ft
1 yard	= 0.9144 m	1 m	= 1.0936 yd
1 mile	= 1609.30 m	1 m	= 0.000621 miles
1 nautical mile	= 1853.27 m	1 m	= 0.000539 nautical miles

1 mil = 10^{-3} inches = 2.54×10^{-3} cm.

1 micron = 10^{-3} mm = 0.0000394 inch

AREA

1 Sq. in	= 6.4516 Sq. cm	1 Sq. cm	= 0.155 Sq. in
1 Sq. ft	= 0.0929 Sq. m	1 Sq. m	= 10.7639 Sq. ft
1 Sq. yard	= 0.8361 Sq. m	1 Sq. m	= 1.1960 Sq. yard
1 Acre	= 4046.86 Sq. m	1 Sq. m	= 0.000247 Acres
1 Sq. mile	= 2.590 Sq. km	1 Sq. km	= 0.3861 Sq. mile
1 Sq. m	= 1×10^{-4} Hectares	1 Hectare	= 10000 Sq. m

VOLUME & CAPACITY

1 Cu. in	= 16.3871 Cu. cm	1 Cu. cm	= 0.061 Cu. in
1 Cu. ft	= 0.0283 Cu. m	1 Cu. m	= 35.315 Cu. ft
1 Cu. yard	= 0.7645 Cu. m	1 Cu. m	= 1.308 Cu. yard
1 Cu. m	= 1000 Litres	1 Litre	= 0.001 Cu. m
1 Gallon (Imp)	= 4.546 Litres	1 Litre	= 0.22 Gallons (Imp)
1 Cu. ft	= 28.3161 Litres	1 Litre	= 0.03532 Cu. ft
1 Cu. ft	= 6.2288 Gallons (Imp)	1 Gallon (Imp)	= 0.1605 Cu. ft

WEIGHT

1 Grain (Avoir)	= 0.0648 Grams	1 Gram	= 15.4324 Grain (Avoir)
1 Ounce (Avoir)	= 28.3495 Grams	1 Gram	= 0.0353 Ounce (Avoir)
1 Pound (Avoir)	= 0.4536 Kiligrams	1 Kilogram	= 2.2045 Pound (Avoir)
1 Kilogram	= 0.001 MT	1 MT	= 1000 kilogram
1 Hundred weight (Cwt. Br.)	= 0.0508 MT	1 MT	= 19.684 Hundred weight (Cwt. Br.)
1 Ton	= 1.0161 MT	1 MT	= 0.9842 Tons

TRIGONOMETRICAL FORMULAE

$$\sin^2\theta + \cos^2\theta = 1$$

$$\sec^2\theta - \tan^2\theta = 1$$

$$\operatorname{cosec}^2\theta - \cot^2\theta = 1$$

$$\sin(\theta+\phi) = \sin\theta \cos\phi + \cos\theta \sin\phi$$

$$\sin(\theta-\phi) = \sin\theta \cos\phi - \cos\theta \sin\phi$$

$$\cos(\theta+\phi) = \cos\theta \cos\phi - \sin\theta \sin\phi$$

$$\cos(\theta-\phi) = \cos\theta \cos\phi + \sin\theta \sin\phi$$

$$\tan(\theta+\phi) = \frac{\tan\theta + \tan\phi}{1 - \tan\theta \cdot \tan\phi}$$

$$\tan(\theta-\phi) = \frac{\tan\theta - \tan\phi}{1 + \tan\theta \tan\phi}$$

$$\sin\theta + \sin\phi = 2\sin(1/2)(\theta+\phi)\cos(1/2)(\theta-\phi)$$

$$\sin\theta - \sin\phi = 2\cos(1/2)(\theta+\phi)\sin(1/2)(\theta-\phi)$$

$$\cos\theta + \cos\phi = 2\cos(1/2)(\theta+\phi)\cos(1/2)(\theta-\phi)$$

$$\cos\theta - \cos\phi = -2\sin(1/2)(\theta+\phi)\sin(1/2)(\theta-\phi)$$

$$\sin\theta \sin\phi = 1/2\,[\cos(\theta-\phi)-\cos(\theta+\phi)]$$

$$\sin\theta \cos\phi = 1/2\,[\sin(\theta+\phi)+\sin(\theta-\phi)]$$

$$\cos\theta \cos\phi = 1/2\,[\cos(\theta+\phi)+\cos(\theta-\phi)]$$

SOLUTION OF TRIANGLES

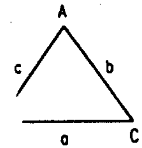
Applicable to any triangle ABC in which AB = c, BC = a, AC = b :

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\text{area} = \frac{bc \sin A}{2} = \frac{ac \sin B}{2} = \frac{ab \sin C}{2}$$

$$= \sqrt{[s(s-a)(s-b)(s-c)]} \quad \text{where} \quad s = (a + b + c)/2$$

$$\sin\frac{A}{2} = \sqrt{\left[\frac{(s-b)(s-c)}{bc}\right]}$$



$$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$$

ROOTS OF QUADRATICS

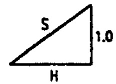
$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a} = -\frac{b}{2a}\left[1 \mp \sqrt{\left(1 - \frac{4ac}{b^2}\right)}\right]$$

MATHEMATICAL AND TRIGONOMETRICAL FUNCTIONS

APPLICATIONS

1. Roof slopes, $s = \sqrt{(1 + H^2)}$:



   (a) Limiting slope for inclined roof loading = 20° :

   $H = \cot 20° = 2.7475$

   Therefore limiting slope = 1:2.75.

   (b) Limiting slope for inclined roofs = 10° :

   $H = \cot 10° = 5.6713$

   Therefore limiting slope = 1:5.67.

2. Earth pressures :

$$k_a = \frac{1 - \sin\theta}{1 + \sin\theta} = \tan^2\left(45° - \frac{\theta}{2}\right)$$

$$k_p = \frac{1}{k_a} = \frac{1 + \sin\theta}{1 - \sin\theta} = \tan^2\left(45° + \frac{\theta}{2}\right)$$

3. Hopper bottom slopes :

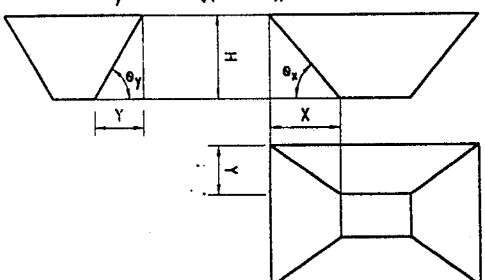
   Specified minimum slope in valley = ϕ

$$Y / X = R$$

$$X = H \cot\phi / \sqrt{(1 + R^2)}$$

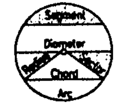
$$\tan\theta_x = \tan\phi\sqrt{(1 + R^2)}$$

$$\tan\theta_y = \tan\phi\sqrt{(1 + R^2)}/R$$



GEOMETRICAL PROPERTIES OF PLANE FIGURES

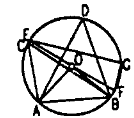
DEFINITIONS



∠ACB = ∠ADB

∠AOB = 2 ∠ACB = 2 ∠ADB

∠EGF = 90°

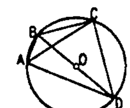


For any cyclic quadrilateral

∠ABC + ∠ADC = 180°

∠BAD + ∠BCD = 180°

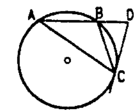
AC x BD = (AB x CD) + (AD x BC)



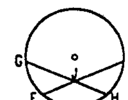
If CD is tangential at C

∠BCD = ∠BAC.

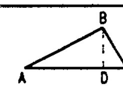
$DC^2 = DA \times DB$



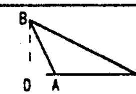
GJ x JH = EJ x JF



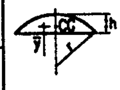
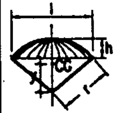
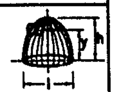
$AB^2 = BC^2 + AC^2 - 2(AC \times CD)$



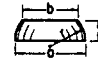
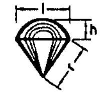
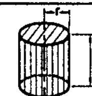
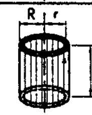
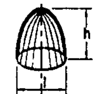
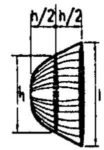
$BC^2 = AB^2 + AC^2 + 2(CA \times AD)$



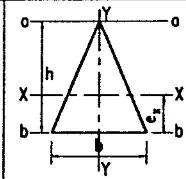
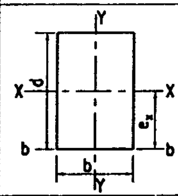
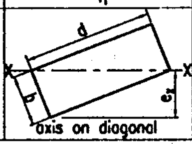
CENTRES OF GRAVITY OF CURVED SURFACES AND SOLIDS

	POSITION OF CENTRE OF GRAVITY		DIAGRAM
	SURFACE	SOLID	
SPHERICAL SEGMENT	$\bar{y} = (1/2)h$ (convex surface only)	$\bar{y} = \frac{h(4r-h)}{4(3r-h)}$	
HEMISPHERE	$\bar{y} = (1/2)r$	$\bar{y} = \frac{3}{8}r$	
SPHERICAL SECTOR	$\bar{y} = \frac{h^2+(r-h)(2h+l/3)}{2h+l/2}$ (convex and conical surfaces combined)	$\bar{y} = \frac{3}{8}(2r-h)$	
HOLLOW HEMISPHERE		$\bar{y} = \frac{3(R^4-r^4)}{8(R^3-r^3)}$	
PARABOLOID		$\bar{y} = \frac{1}{3}h$	
OCTANT OF ELLIPSOID		$\bar{x} = \frac{3}{8}a$ $\bar{y} = \frac{3}{8}b$ $\bar{z} = \frac{3}{8}c$	
PYRAMID OR, CONE	$\bar{y} = \frac{1}{3}h$ (slant surface only)	$\bar{y} = \frac{1}{4}h$	

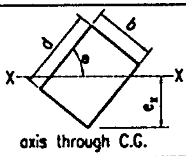
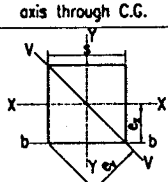
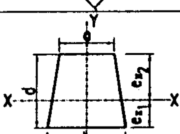
CURVED SURFACE AREAS AND VOLUMES OF SOLIDS

SOLID	CURVED SURFACE AREA	VOLUME	DIAGRAM
SPHERE	$4\pi r^2$	$\frac{4}{3}\pi r^3$	
SPHERICAL ZONE	$2\pi rh$	$\frac{\pi h}{24}(3a^2+3b^2+4h^2)$	
SPHERICAL SECTOR	$\frac{\pi r}{2}(4h+l)$	$\frac{2\pi r^2 h}{3}$	
SPHERICAL SEGMENT	$2\pi rh$	$\pi h^2(r - h/3)$	
RIGHT CIRCULAR CYLINDER	$2\pi rh$	$\pi r^2 h$	
HOLLOW CYLINDER	$2\pi h(R+r)$	[illegible] $^2)h$	
PARABOLOID	$\frac{2\pi l}{3h^2}\left[\left(\frac{l^2}{16}+h^2\right)^{3/2}-\left(\frac{l}{4}\right)^3\right]$	[illegible] $\frac{}{8}$ [illegible] l^2h	
HYPERBOLOID		$\frac{\pi h}{24}$ [illegible] $l_1^2)$	

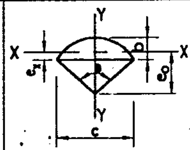
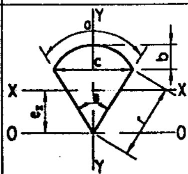
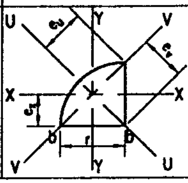
GEOMETRICAL PROPERTIES OF PLANE SECTIONS

	SECTION	AREA	POSITION OF CENTROID	MOMENT OF INERTIA	SECTION MODULI
TRIANGLE		$A = bh/2$	$e_x = h/3$	$I_{xx} = bh^3/36$ $I_{yy} = hb^3/48$ $I_{aa} = bh^3/4$ $I_{bb} = bh^3/12$	Z_{xx} base $= bh^2/12$ apex $= bh^2/24$ $Z_{yy} = hb^2/24$
RECTANGLE		$A = bd$	$e_x = d/2$	$I_{xx} = bd^3/12$ $I_{yy} = db^3/12$ $I_{bb} = bd^3/3$	$Z_{xx} = bd^2/6$ $Z_{yy} = db^2/6$
RECTANGLE		$A = bd$	$e_x = \frac{bd}{\sqrt{b^2 + d^2}}$	$I_{xx} = \frac{b^3 d^3}{6(b^2 + d^2)}$	$Z_{xx} = \frac{b^2 d^2}{6\left(\sqrt{b^2 + d^2}\right)}$

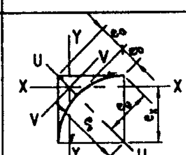
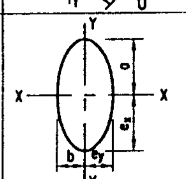
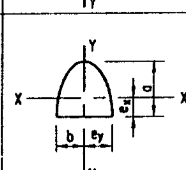
GEOMETRICAL PROPERTIES OF PLANE SECTIONS

	SECTION	AREA	POSITION OF CENTROID	MOMENT OF INERTIA	SECTON MODULI
RECTANGLE		$A = bd$	$e_x = \frac{b.\sin\theta + d.\cos\theta}{2}$	$I_{xx} = \frac{bd(b^2\sin^2\theta + d^2\cos^2\theta)}{12}$	$Z_{xx} = \frac{bd(b^2\sin^2\theta + d^2\cos^2\theta)}{6(b.\sin\theta + d.\cos\theta)}$
SQUARE		$A = S^2$	$e_x = s/2$ $e_v = \frac{s}{\sqrt{2}}$	$I_{xx} = I_{yy} = s^4/12$ $I_{bb} = s^4/3$ $I_{vv} = s^4/12$	$Z_{xx} = Z_{yy} = s^3/6$ $Z_{vv} = \frac{s^3}{6\sqrt{2}}$
TRAPEZIUM		$A = d(a+b)/2$	$e_{x_1} = \frac{d(2a+b)}{3(a+b)}$	$I_{xx} = \frac{d^3(a^2 + 4ab + b^2)}{36(a+b)}$ $I_{yy} = \frac{d(a^3 + a^2 b + ab^2 + b^3)}{48}$	$Z_{xx} = \frac{I_{xx}}{d - e_x}$ (two values) $Z_{yy} = \frac{2\ I_{yy}}{b}$

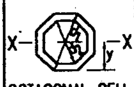
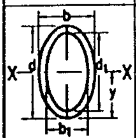
GEOMETRICAL PROPERTIES OF PLANE SECTIONS

	SECTION	AREA	POSITION OF CENTROID	MOMENT OF INERTIA	SECTION MODULI
SEGMENT		$A = \frac{r^2}{2}\left(\frac{\pi\theta}{180} - \sin\theta\right)$	$e_0 = c^3/12A$ $e_x = e_0 - r.\cos(\theta/2)$	$Ixx = r^4/16(\pi\theta/90^\circ - \sin 2\theta) - \frac{20r^4(1-\cos\theta)^3}{\pi\theta - 180\sin\theta}$ $Iyy = r^4/48(\pi\theta/30 - 8\sin\theta + \sin 2\theta)$	$Zxx =$ base $= Ixx/e_x$ crown $= Ixx/b - e_x$ $Zyy = 2\ Iyy/c$
SECTOR		$A = (\theta/360^\circ)\pi r^2$	$e_o = \frac{2}{3} rc/a$ $e_x = r^2c/3A$	$Ixx = Io - 360^\circ/\theta\pi\ \sin^2(\theta/2)(4r^4/9)$ $Iyy = \frac{r^4}{8}(\pi\theta/180 - \sin\theta)$ $Io = \frac{r^4}{8}(\pi\theta/180^\circ + \sin\theta)$	$Zxx =$ centre $= Ixx/e_x$ crown $= Ixx/r - e_x$ $Zyy = 2\ Iyy/c$
QUADRANT		$A = \pi r^2/4$	$e_x = 0.424r$ $e_v = 0.6r$ $e_u = 0.707r$	$Ixx = Iyy = 0.0549r^4$ $Ibb = 0.1963r^4$ $Iuu = 0.0714r^4$ $Ivv = 0.0384r^4$	Minimum values $Zxx = Zyy = 0.0953r^3$ $Zuu = 0.1009r^3$ $Zvv = 0.064r^3$

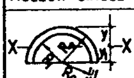
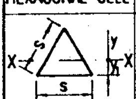
GEOMETRICAL PROPERTIES OF PLANE SECTIONS

	SECTION	AREA	POSITION OF CENTROID	MOMENT OF INERTIA	SECTION MODULI
COMPLEMENT		$A = 0.2146r^2$	$e_x = 0.777r$ $e_v = 1.098r$ $e_u = 0.707r$ $e_a = 0.316r$ $e_b = 0.391r$	$Ixx = Iyy = 0.0076r^4$ $Iuu = 0.012r^4$ $Ivv = 0.0031r^4$	Minimum Values $Zxx = Zyy = 0.0097r^3$ $Zuu = 0.017r^3$ $Zvv = 0.0079r^3$
ELLIPSE		$A = \pi ab$	$e_x = a$ $e_y = b$	$Ixx = 0.7854ba^3$ $Iyy = 0.7854ab^3$	$Zxx = 0.7854ba^2$ $Zyy = 0.7854ab^2$
SEMI ELLIPSE		$A = \pi ab/2$	$e_x = 0.424a$ $e_y = b$	$Ixx = 0.1098ba^3$ $Iyy = 0.3927ab^3$ $I_{base} = 0.3927ba^3$	Zxx - base $= 0.2587ba^2$ Zxx-crown $= 0.1907ba^2$ $Zyy = 0.3927ab^2$

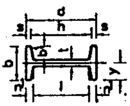
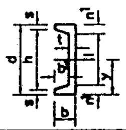
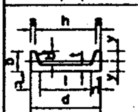
GEOMETRICAL PROPERTIES OF PLANE SECTIONS

SECTION	AREA	POSITION OF CENTROID	MOMENT OF INERTIA ABOUT XX	SECTON MODULI	RADIUS OF GYRATION
 OCTAGONAL CELL	$0.7071\ (d_1^2-d_2^2)$	$0.4620d_1$	$0.0399(d_1^4-d_2^4)$	$0.0863\left(\frac{d_1^4-d_2^4}{d_1}\right)$	$0.2376\sqrt{(d_1^2+d_2^2)}$
 HOLLOW ELLIPSE	$\frac{\pi}{4}(bd-b_1d_1)$	$\frac{d}{2}$	$\frac{\pi}{64}(bd^3-b_1d_1^3)$ $= 0.0491\ (bd^3-b_1d_1^3)$	$\frac{\pi}{32d}(bd^3-b_1d_1^3)$ $=0.0982\left(\frac{bd^3-b_1d_1^3}{d}\right)$	$\frac{1}{4}\sqrt{\left(\frac{bd^3-b_1d_1^3}{bd-b_1d_1}\right)}$
 HOLLOW SQ. OR RECTANGLE	$bd - b_1d_1$	$\frac{d}{2}$	$\frac{bd^3-b_1d_1^3}{12}$	$\frac{bd^3-b_1d_1^3}{6d}$	$\sqrt{\left[\frac{bd^3-b_1d_1^3}{12(bd - b_1d_1)}\right]}$
 HOLLOW SQ. ON EDGE	$b^2 - b_1^2$	$\frac{b}{\sqrt{2}} = 0.7071b$	$\frac{b^4 - b_1^4}{12}$	$\frac{\sqrt{2}}{12}\left(\frac{b^4 - b_1^4}{b}\right)$ $= 0.1178\left(\frac{b^4 - b_1^4}{b}\right)$	$\sqrt{\left(\frac{b^2 + b_1^2}{12}\right)}$

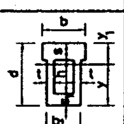
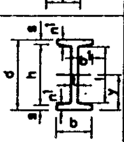
GEOMETRICAL PROPERTIES OF PLANE SECTIONS

SECTION	AREA	POSITION OF CENTROID	MOMENT OF INERTIA ABOUT XX	SECTON MODULI	RADIUS OF GYRATION
 HOLLOW CIRCLE	$\pi(R_e^2 - R_i^2)$	R_e	$\frac{\pi}{4}(R_e^4 - R_i^4)$	$\frac{\pi}{4}\left(\frac{R_e^4 - R_i^4}{R_e}\right)$	$\frac{\sqrt{(R_e^2 + R_i^2)}}{2}$
 HOLLOW SEMI CIRCLE	$\frac{\pi}{2}(R_e^2 - R_i^2)$	$y = R_e - y_1$ $y_1 = \frac{4}{3\pi}\left(\frac{R_e^3 - R_i^3}{R_e^2 - R_i^2}\right)$	$0.1098(R_e^4-R_i^4)-$ $\left(\frac{0.2829R_e^2R_i^2(R_e-R_i)}{R_e + R_i}\right)$ $\frown 0.3\ (R_e-R_i)R_o^3$	$\frac{I}{y}$ $I = M.I$	$\sqrt{\left(\frac{I}{A}\right)}$ $I = M.I$
 HEXAGONAL CELL	$0.6495\ (d_1^2-d_2^2)$	$\frac{\sqrt{3}}{4}d_1 = 0.4330d_1$	J.0338$(d_1^4-d_2^4)$	$0.0780\left(\frac{d_1^4-d_2^4}{d_1}\right)$	$0.2281\sqrt{(d_1^2+d_2^2)}$
 EQUILATERAL TRIANGLE	$\frac{\sqrt{3}}{4}S^2 = 0.433S^2$	$y=0.5774S$ $y_1=0.2887S$	$0.0180S^4$	$0.0313S^3$	$0.2041S$

GEOMETRICAL PROPERTIES OF SECTIONS

Section	Area A	Distances to Extreme Fibres y and y_1	Moment of Inertia I	Section Modulus $S=\frac{I}{Y}$	Radius of Gyration (r)
	$td+2b'(s+n')$	$y=\frac{b}{2}$ g=slope of flange=$(n'-s)\div b'=(h-l)\div(b-t)=1/6$ for standard sections	$\frac{1}{12}[b'^3(d-h)+lt^3+\frac{g}{4}(b'^4-t^4)]$	$\frac{I}{Y}$	$\sqrt{\frac{I}{A}}$
	$td+b'(s+n')$	$y=\frac{d}{2}$ g=slope of flange=$(n'-s)\div b'=\frac{(h-l)}{2}\div(b-t)=1/6$ for standard sections	$\frac{1}{12}[bd^3-\frac{1}{8g}(h^4-l^4)]$	$\frac{I}{Y}$	$\sqrt{\frac{I}{A}}$
	$td+b'(s+n')$	$y_1=[b^2s+\frac{ht^2}{2}+\frac{g}{3}(b-t)^2(b+2t)]\div A$ $y=b-y_1$ g=slope of flange=$(n'-s)\div b'=\frac{(h-l)}{2}\div(b-t)=1/6$ for standard sections	$\frac{1}{3}[2sb^3+lt^3+\frac{g}{2}(b^4-t^4)]-Ay_1^2$	$\frac{I}{Y}$	$\sqrt{\frac{I}{A}}$

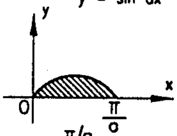
GEOMETRICAL PROPERTIES OF SECTIONS

Section	Area A	Distances to Extreme Fibres y and y_1	Moment of Inertia I	Section Modulus $S=\frac{I}{Y}$	Radius of Gyration (r)
	$bs+2ht+b_1s_1$	$y=\frac{2td^2+[b_1-2t]s_1^2+[b-2t][2d-s]s}{2A}$ $y_1=d-y$	$\frac{by^3+b_1y_1^3-[b_1-2t][y-s_1]^3-[b-2t][y_1-s]^3}{3}$	$\frac{I}{Y}$	$\sqrt{\frac{I}{A}}$
	$td+2b'(s+n')$	$y=\frac{d}{2}$ g=slope of flange=$(n'-s)\div b'=(h-l)\div(b-t)=1/6$ for standard sections	$\frac{1}{12}[bd^3-\frac{1}{4g}(h^4-l^4)]$	$\frac{I}{Y}$	$\sqrt{\frac{I}{A}}$

DIAGRAMS FOR PROBLEMS ON AREAS:

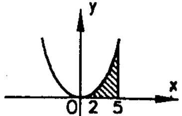
(Shaded portion is enclosed area)

1. Curve: One arch of $y = \sin ax$



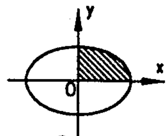
$$\text{Area} = \int_0^{\pi/a} \sin a x \, d x$$

2. Curve: $y = x^2$



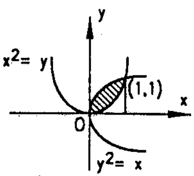
$$\text{Area} = \int_2^5 x^2 \, d x$$

3. Curve: $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$



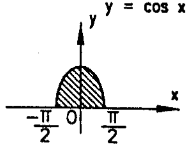
$$\text{Area} = \int_0^a b/a\sqrt{a^2 - x^2}dx$$

4. Curve: $y^2 = x$, $x^2 = y$



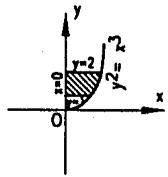
$$\text{Area} = \int_0^1 (\sqrt{x} - x^2)dx$$

5. Curve: One arch of $y = \cos x$



$$\text{Area} = 2\int_0^{\pi/2} \cos x \cdot dx$$

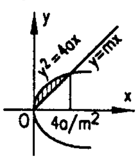
6. Curve: $y^2 = x^3$



$$\text{Area} = \int_1^2 y^{2/3} \, dy$$

7. Curve: $y^2 = 4ax$

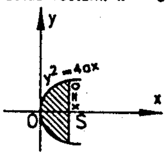
Line: $y = mx$



$$\text{Area} = \int_0^{4a/m^2} (\sqrt{4a}\sqrt{x} - mx)dx$$

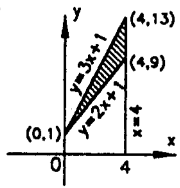
8. curves: $y^2 = 4ax$

Lotus rectum: $x = a$



$$\text{Area} = 2\int_0^a \sqrt{4a}\sqrt{x} \, dx$$

9.

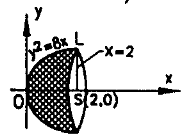


$$\text{Area} = \int_0^4 [(3x+1) - (2x+1)]dx$$

DIAGRAMS FOR PROBLEMS ON VOLUMES:

(Shaded portion is enclosed volume)

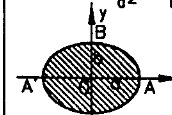
10. Curve: $y^2 = 8x$



Volume of solid got on revolving OLS around X axis

$$\text{Volume} = \pi\int_0^2 8x \, dx$$

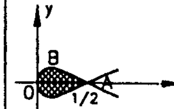
11. curve: $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$



Volume of solid got on revolving A'OAB around X axis

$$\text{Vol.} = 2\pi\int_0^a \frac{b^2}{a^2}(a^2 - x^2)dx$$

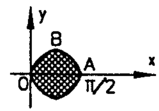
12. Curve: $y^2 = x(2x-1)^2$



Volume of solid got on revolving OAB around X axis

$$\text{Volume} = \pi\int_0^{1/2} x(2x-1)^2dx$$

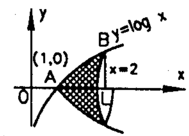
13. Curve one arc of $y = \sin 2x$



Volume of solid got on revolving OAB around X axis

$$\text{Vol.} = \pi\int_0^{\pi/2} \sin^2 2x \cdot dx$$

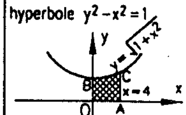
14. Curve: $y = \log x$



Volume of solid got on revolving ALB around X axis

$$\text{Vol.} = \pi\int_1^2 (\log x)^2dx$$

15. Curve: $y = \sqrt{1+x^2}$ or one branch of the hyperbole $y^2 - x^2 = 1$

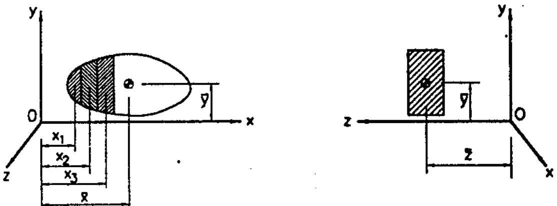


Volume of solid got on revolving OACB around X axis

$$\text{Vol.} = \pi\int_0^4 (1+x^2)dx$$

CENTER OF GRAVITY (C.G)

Center of Gravity (Method of Moments)



FRONT ELEVATION   SIDE ELEVATION

Consider a body of mass M whose c.g. is required to be found out. Divide the body into small masses, whose centres of gravity are known, as shown in fig.

Let m_1, m_2, m_3...... etc. be the masses of the particles and (x_1, y_1, z_1), (x_2, y_2, z_2), (x_3, y_3, z_3)...... be their coordinates of the centres of gravity respectively from a fixed point O as shown in fig.

Let $\bar{x}$, $\bar{y}$ and $\bar{z}$ be the co-ordinates of the c.g. of the body. From the principle of moments

$$M\bar{x} = m_1 x_1 + m_2 x_2 + m_3 x_3 .....$$

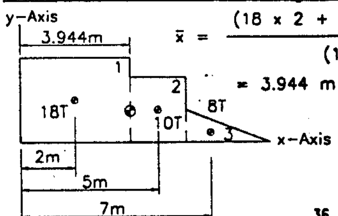
(or)

$$\bar{x} = \frac{\Sigma mx}{M}$$

similarly $\bar{y} = \frac{\Sigma my}{M}$ and $\bar{z} = \frac{\Sigma mz}{M}$

where, $M = m_1 + m_2 + m_3 + ...$

Example for calculation of c.g. for composite object:

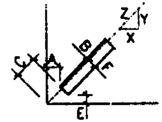


$$\bar{x} = \frac{(18 \times 2 + 10 \times 5 + 8 \times 7)\text{Tm}}{(18+10+8)\text{T}}$$

= 3.944 m from left edge of the load.

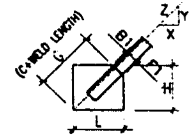
The calculation can also be used to find position of c.g along y-Axis and z-Axis for three dimensional objects.

FORMULA FOR GUSSET CUTTING DIMENSION CALCULATION



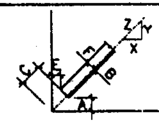
WHEN ANGLE TOUCHES 'A' $C = \frac{AZ+BY}{X}$

'E' $C = \frac{EZ+FX}{Y}$



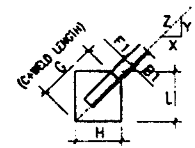
$L = \frac{GX + F1Y}{Z}$

$H = \frac{GY + B1X}{Z}$



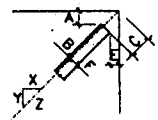
WHEN ANGLE TOUCHES 'A' $C = \frac{AZ+BX}{Y}$

'E' $C = \frac{EZ+FY}{X}$



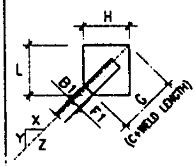
$L = \frac{GY + F1X}{Z}$

$H = \frac{GX + B1Y}{Z}$



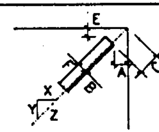
WHEN ANGLE TOUCHES 'A' $C = \frac{AZ+BX}{Y}$

'E' $C = \frac{EZ+FY}{X}$



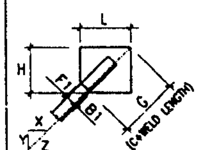
$L = \frac{GY + F1X}{Z}$

$H = \frac{GX + B1Y}{Z}$



WHEN ANGLE TOUCHES 'A' $C = \frac{AZ+BY}{X}$

'E' $C = \frac{EZ+FX}{Y}$

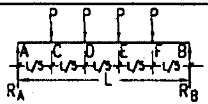


$L = \frac{GX + F1Y}{Z}$

$H = \frac{GY + B1X}{Z}$

SIMPLY SUPPORTED BEAMS

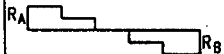
LOADING



MOMENT

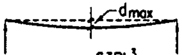
$M_C = M_F = 2PL/5 \quad M_D = M_E = 3PL/5$

SHEAR



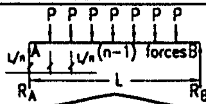
$R_A = R_B = 2P$

DEFLECTION



$$d_{max.} = \frac{63PL^3}{1000EI}$$

LOADING

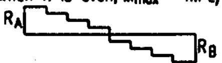


MOMENT

when n is odd, $M_{max} = (n^2-1)PL/8n$

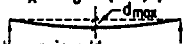
when n is even, $M_{max} = n.PL/8$

SHEAR



$R_A = R_B = (n-1)P/2$

DEFLECTION

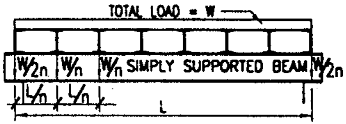


when n is odd,

$$d_{max.} = \frac{PL^3}{192EI}\left[n - \frac{1}{n}\right]\left[3 - \frac{1}{2}\left(1 - \frac{1}{n^2}\right)\right]$$

when n is even,

$$d_{max.} = \frac{PL^3}{192EI} \cdot n.\left[3 - \frac{1}{2}\left(1 + \frac{4}{n^2}\right)\right]$$



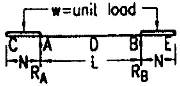
When n>10, consider the load uniformly distributed. The reaction at the supports = W/2, but the max. S.F. at the ends of the beam = W(n−1)/2n = A.W. The value of the maximum bending moment = C.WL

The value of the deflection at the centre of the span = k. $\frac{WL^3}{EI}$

value of n	A	C	k
2	0.2500	0.1250	0.0105
3	0.3333	0.1111	0.0118
4	0.3750	0.1250	0.0124
5	0.4000	0.1200	0.0126
6	0.4167	0.1250	0.0127
7	0.4286	0.1224	0.0128
8	0.4375	0.1250	0.0128
9	0.4444	0.1236	0.0129
10	0.4500	0.1250	0.0129

SIMPLY SUPPORTED BEAMS

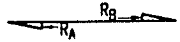
LOADING



MOMENT

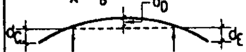
$M_A = M_B = -wN^2/2$

SHEAR



$R_A = R_B = wN$

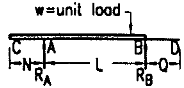
DEFLECTION



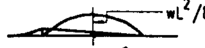
$$d_C = d_E = \frac{wLN^3}{8EI}(2 + N/L)$$

$$d_D = -\frac{wL^2N^2}{16EI}$$

LOADING



MOMENT



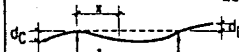
$M_A = -wN^2/2$

SHEAR

$R_A = w(N+L)^2/2L \qquad R_B = \frac{w(L+N)(L-N)}{2L}$

$m = x/L \qquad n = N/L$

DEFLECTION

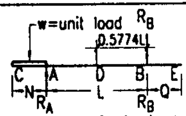


$$d_C = \frac{wL^3N}{24EI}(3n^3 + 4n^2 - 1)$$

$$d_x = \frac{wL^4}{24EI}[m^4 - 2m^3(1-n^2) + m(1-2n^2)]$$

$$d_D = \frac{-wL^3Q}{24EI}(2n^2 - 1)$$

LOADING

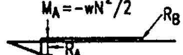


Max. upward deflection is at D.

MOMENT

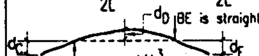
$M_A = -wN^2/2$

SHEAR



$R_A = \frac{wN(2L+N)}{2L} \qquad R_B = \frac{wN^2}{2L}$

DEFLECTION

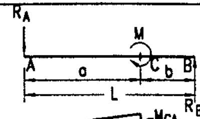


$$d_C = \frac{wLN^3}{24EI}(4 + 3N/L)$$

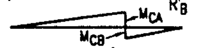
$$d_D = \frac{-0.032wL^2N^2}{EI}$$

$$d_E = \frac{wLN^2Q}{12EI}$$

LOADING

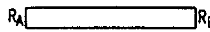


MOMENT



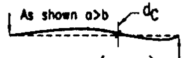
$M_{CA} = M.a/L \qquad M_{CB} = M.b/L$

SHEAR



$R_A = R_B = M/L$

DEFLECTION

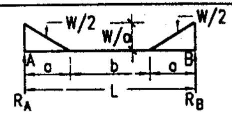


$$d_C = \frac{M.ab}{3EI}\left(\frac{a}{L} - \frac{b}{L}\right)$$

For anticlockwise moments the deflections are reversed

SIMPLY SUPPORTED BEAMS

LOADING



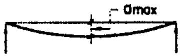
MOMENT

$M_{max} = Wa/6$

SHEAR

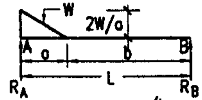
$R_A = R_B = W/2$

DEFLECTION



$d_{max} = \frac{Wa}{240EI}(18a^2 + 20ab + 5b^2)$

LOADING



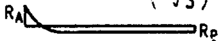
MOMENT

$m = a/L$

$M_{max} = \frac{Wa}{3}\left(1 - m + \frac{2m}{3}\sqrt{\frac{m}{3}}\right)$

when $x = a\left(1 - \sqrt{\frac{m}{3}}\right)$

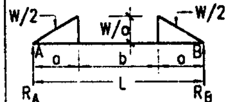
SHEAR



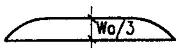
$R_A = W\left(1 - \frac{m}{3}\right)$

$R_B = Wm/3$

LOADING

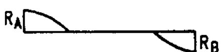


MOMENT



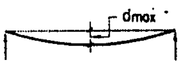
$M_{max} = Wa/3$

SHEAR



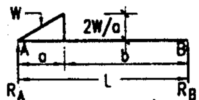
$R_A = R_B = W/2$

DEFLECTION



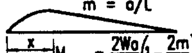
$d_{max} = \frac{Wa}{120EI}(16a^2 + 20ab + 5b^2)$

LOADING



MOMENT

$m = a/L$



$M_{max} = \frac{2Wa}{3}\left(1 - \frac{2m}{3}\right)^{3/2}$

when $x = a\sqrt{1 - \frac{2m}{3}}$

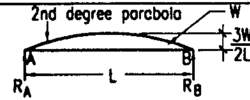
SHEAR

$R_A = W\left(1 - \frac{2m}{3}\right)$

$R_B = 2Wm/3$

SIMPLY SUPPORTED BEAMS

LOADING



MOMENT

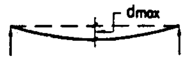
$M_x = WL(m^4 - 2m^3 + m)/2$

$M_{max} = 5WL/32$

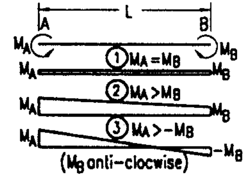
SHEAR

$R_A = R_B = W/2$

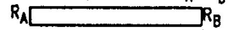
DEFLECTION



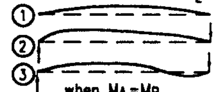
$d_{max} = \frac{6.1WL^3}{384EI}$



Shear diagram when $M_A \neq M_B$



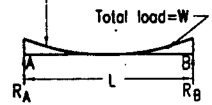
$R_A = -R_B = \frac{M_A - M_B}{L}$



when $M_A = M_B$

$d_{max} = \frac{-ML^2}{8EI}$

LOADING



MOMENT

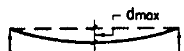
$M_x = WL(m - 3m^2 + 4m^3 - 2m^4)/2$

$M_{max} = WL/16$

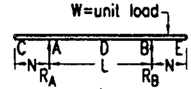
SHEAR

$R_A = R_B = W/2$

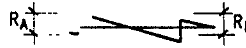
DEFLECTION



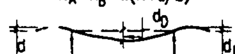
$d_{max} = \frac{2.8WL^3}{384EI}$



$M_A = -wN^2/2$ $M_D = M_A + wL^2/8$



$R_A = R_B = w(N + L/2)$



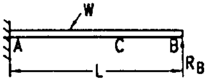
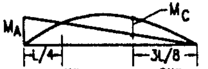
$d_C = d_E = \frac{wL^3N}{24EI}(3n^3 + 6n^2 - 1)$

$d_D = \frac{wL^4}{384EI}(5 - 24n^2)$

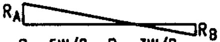
Where $n = N/L$

PROPPED CANTILEVERS

LOADING / MOMENT / SHEAR / DEFLECTION

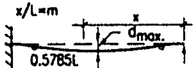



$M_A = -\frac{WL}{8}$ $M_C = \frac{9WL}{128}$



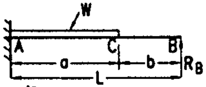
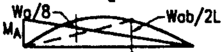
$R_A = 5W/8$ $R_B = 3W/8$

x/L=m



$d = \frac{WL^3}{48EI}(m-3m^3+2m^4)$

$d_{max.} = \frac{WL^3}{185EI}$

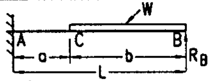
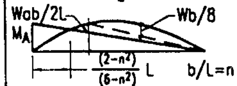
$M_A = -\frac{Wa}{8}(2-n)^2$ where a/L=n

$+M_{max.} = \frac{Wa}{8}\left(-\frac{[8-n^2(4-n)]^2}{16}+4-n(4-n)\right)$

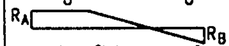
$R_A = W[8-n^2(4-n)]/8$ $R_B = Wn^2(4-n)/8$

$d_C = \frac{Wa^3}{48EI}(6-12n+7n^2-n^3)$

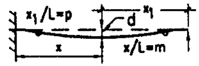
LOADING / MOMENT / SHEAR / DEFLECTION

$M_A = -\frac{Wb}{8}(2-n)^2$ $M_C = \frac{Wb}{8}(6n-n^3-4)$

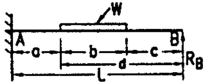
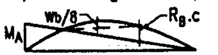


$R_A = Wn(6-n^2)/8$, $R_B = W(n^3-6n+8)/8$



when x≤a, $d = \frac{WbL^2}{48EI}[(n^2-6)m^3-(3n^2-6)m]$

when x≥a, $d = \frac{WL^4}{48bEI}[2p^4-p^3n(n^2-6n+8)+pn^2(3n^2-8n+6)]$

$M_A = -\frac{W}{8L^2b}(d^2-c^2)(2L^2-c^2-d^2)$

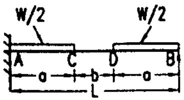
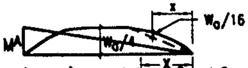
$R_A = r_A + M_A/L$ $R_B = r_B - M_A/L$

Where r_A and r_B are the simple support reactions for the beam (M_A being considered positive)

BM, SF & Δ — FORMULAE FOR BEAMS

PROPPED CANTILEVERS

LOADING / MOMENT / SHEAR / DEFLECTION

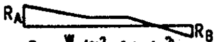



If m=a/L, then between B and D.

$M_x = W[-2x^2+xa(4-3m+2m^2)]/8a$

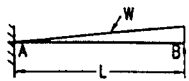
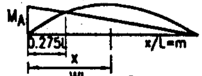
$+M_{max.}$ when $x=(a/4)(4-3m+2m^2)$

$M_A = -Wa(3L-2a)/8L$



$R_A = \frac{W}{4L^2}(2L^2+3aL-4a^2)$

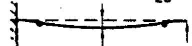
$R_B = \frac{W}{4L}(2L^2-3aL+4a^2)$

$M_x = -\frac{WL}{60}(20m^2-27m+7)$

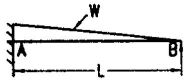
$M_A = -\frac{7WL}{60}$ $+M_{max.} = 0.0846WL$ [when x=0.67L]

$V_x = \frac{W}{20}(9-20m^2)$ $R_A = \frac{9W}{20}$ $R_B = \frac{11W}{20}$



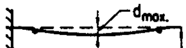
$d_{max.} = \frac{0.0061WL^3}{EI}$ when x=0.598L

LOADING / MOMENT / SHEAR / DEFLECTION

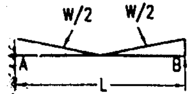



$M_A = -\frac{2WL}{15}$ $+M_{max.} = 0.0596WL$ [when x=0.447L]

$R_A = \frac{4W}{5}$ $R_B = \frac{W}{5}$

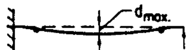


$d_{max.} = \frac{0.0047WL^3}{EI}$ when x=0.447L




$M_A = -\frac{3WL}{32}$ $+M_{max.} = 0.0454WL$ [when x=0.283L]

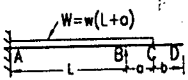
$R_A = \frac{19W}{32}$ $R_B = \frac{13W}{32}$



$d_{max.} = \frac{0.0037WL^3}{EI}$ when x=0.404L

PROPPED CANTILEVERS

LOADING



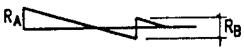
MOMENT

$M_B = -wa^2/2 \quad M_A = -w(L^2 - 2a^2)/8$

$+M_{max.} = wL^2(36p^4 - 28p^2 + 9)/128$

when $x/L = 5/8 - 3p^2/4$

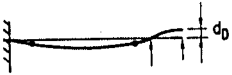
SHEAR



$R_A = wL(5/8 - 3p^2/4)$

$R_B = wL\left(\frac{3p^2}{4} + p + 3/8\right)$

DEFLECTION



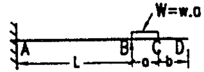
$d_D = \frac{wL^4}{48EI}[(8p^3 + 6p^2 - 1)(p+q) - 2p^4]$

$d_x = \frac{wL^4}{48EI}[2n^4 + (6p^2 - 5)n^3 - (6p^2 - 3)n^2]$

$d_{max.}$ when

$x/L = \frac{1}{16}[15 - 18p^2 - \sqrt{324p^4 - 156p^2 + 33}]$

LOADING



MOMENT

$M_B = -2M_A = -wa^2/2$

$p = a/L$

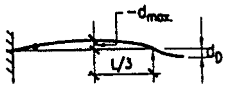
$q = b/L$

SHEAR

$R_A = -3wap/4$

$R_A = wa(1 + 3p/4)$

DEFLECTION

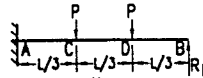


$d_D = \frac{wL^4}{48EI}[p^2(8p+6)q + 6p^3(p+1)]$

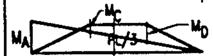
$-d_{max.} = \frac{-wL^4 p^2}{54EI}$

PROPPED CANTILEVERS

LOADING



MOMENT



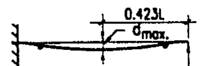
$M_C = PL/9 \quad M_D = 2PL/9$

$M_A = -PL/3$

SHEAR

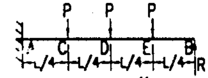
$R_A = 4P/3 \quad R_B = 2P/3$

DEFLECTION

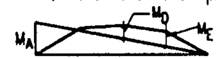


$d_{max.} = 0.0152\frac{PL^3}{EI}$

LOADING



MOMENT



$M_A = -15PL/32 \quad M_D = 17PL/64$

$M_E = 33PL/128$

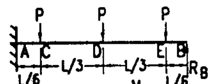
SHEAR

[illegible] 63P/32 $\quad R_B = 33P/32$

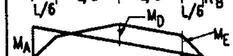
DEFLECTION

[illegible]ax. $= 0.0209\frac{PL^3}{EI}$

LOADING



MOMENT



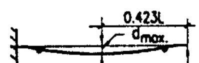
$M_A = -19PL/48 \quad M_D = 21PL/96$

$M_E = 53PL/288$

SHEAR

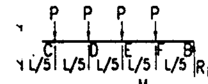
$R_A = 91P/48 \quad R_B = 53P/48$

DEFLECTION

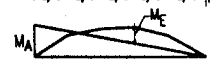


$d_{max.} = 0.0169\frac{PL^3}{EI}$

LOADING



MOMENT



$M = -3PL/5 \quad M_E = 9PL/25$

SHEAR

$R_A = 13P/5 \quad R_B = 7P/5$

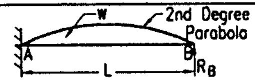
DEFLECTION

$d_{max.} = 0.0265\frac{PL^3}{EI}$

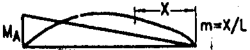
PROPPED CANTILEVERS

Case 1: total load W as a 2nd degree parabola

Loading (W, 2nd Degree Parabola; A, B, L, R_B)



Moment (M_A, X, $m = X/L$)

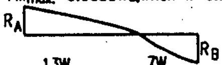


$M_A = -\frac{3WL}{20}$

$M_X = \frac{WL}{20}(10m^4 - 20m^3 + 7m)$

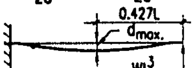
$+M_{max.} = 0.0888WL$, when $x = 0.3985L$

Shear (R_A, R_B)



$R_A = \frac{13W}{20}$ $R_B = \frac{7W}{20}$

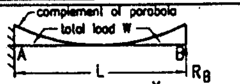
Deflection (0.427L, $d_{max.}$)



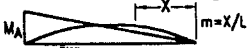
$d_{max.} = 0.00674\frac{WL^3}{EI}$

Case 2: total load W as the complement of a parabola

Loading (complement of parabola, total load W; A, B, L, R_B)



Moment (M_A, X, $m = X/L$)

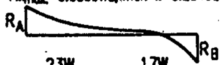


$M_A = -\frac{3WL}{40}$

$M_X = \frac{WL}{40}(-40m^4 + 80m^3 - 60m^2 + 17m)$

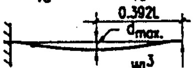
$+M_{max.} = 0.0399WL$, when $x = 0.2343L$

Shear (R_A, R_B)



$R_A = \frac{23W}{40}$ $R_B = \frac{17W}{40}$

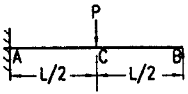
Deflection (0.392L, $d_{max.}$)



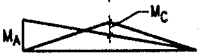
$d_{max.} = 0.00278\frac{WL^3}{EI}$

Case 3: point load P at midspan

Loading (P; A, C, B; L/2, L/2)



Moment (M_A, M_C)

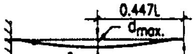


$M_A = -\frac{3PL}{16}$ $M_C = \frac{5PL}{32}$

Shear (R_A, R_B)

$R_A = \frac{11P}{16}$ $R_B = \frac{5P}{16}$

Deflection (0.447L, $d_{max.}$)

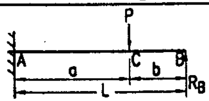


$d_C = \frac{7PL^3}{768EI}$

$d_{max.} = 0.00932\frac{PL^3}{EI}$

Case 4: point load P at distance a from A

Loading (P; A, C, B; a, b, L, R_B)

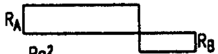


Moment (M_A, M_C)

$M_A = -\frac{Pb(L^2 - b^2)}{2L^2}$ max. $M_A = -0.193PL$ when $b = 0.577L$

$M_C = \frac{Pb}{2}\left(2 - \frac{3b}{L} + \frac{b^3}{L^3}\right)$ max. $M_C = 0.174PL$ when $b = 0.366L$

Shear (R_A, R_B)



$R_B = \frac{Pa^2}{2L^3}(b + 2L)$ $R_A = P - R_B$

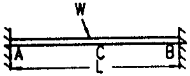
Deflection (d_C)

$d_C = \frac{Pa^3b^2}{12EIL^3}(4L - a)$

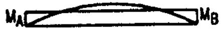
BUILT-IN BEAMS

Case 1: uniformly distributed load W

Loading (W; A, C, B; L)



Moment (M_A, M_B)



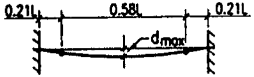
$M_A = M_B = -WL/12$

$M_C = WL/24$

Shear (R_A, R_B)

$R_A = R_B = W/2$

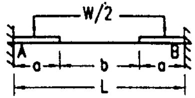
Deflection (0.21L, 0.58L, 0.21L; d_{max})



$d_{max.} = \frac{WL^3}{384EI}$

Case 2: two loads, each W/2, at the ends

Loading (W/2, W/2; A, B; a, b, a, L)



Moment (M_A, Wa/4, M_B)

$M_A = M_B = -Wa(3L - 2a)/12L$

Shear (R_A, R_B)

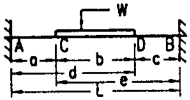
$R_A = R_B = W/2$

Deflection (d_{max})

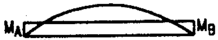
$d_{max.} = \frac{Wa^2}{48EI}(L - a)$

Case 3: load W spread from C to D

Loading (W; A, C, D, B; a, b, c, d, e, L)



Moment (M_A, M_B)



$M_A = \frac{-W}{12L^2b}\left[e^3(4L - 3e) - c^3(4L - 3c)\right]$

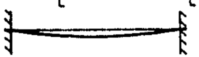
$M_B = \frac{-W}{12L^2b}\left[d^3(4L - 3d) - a^3(4L - 3a)\right]$

Shear (R_A, R_B)

When r is the simple support reaction

$R_A = r_A + \frac{M_A - M_B}{L}$ $R_B = r_B + \frac{M_B - M_A}{L}$

Deflection

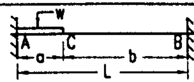


when $a = c$,

$d_{max.} = \frac{W}{384EI}(L^3 + 2L^2a + 4La^2 - 8a^3)$

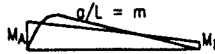
Case 4: load W spread from A to C

Loading (W; A, C, B; a, b, L)



$a/L = m$

Moment (M_A, M_B)



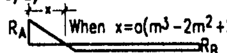
$M_A = \frac{-WL}{12}.m(3m^2 - 8m + 6)$

$M_B = \frac{-WL}{12}.m^2(4 - 3m)$

$+M_{max} = \frac{WL}{12}.m^2 *$

$[(-3/2)m^5 + 6m^4 - 6m^3 - 6m^2 + 15m - 8)]$

Shear (x, R_A, R_B)



*When $x = a(m^3 - 2m^2 + 2)/2$

$R_A = W(m^3 - 2m^2 + 2)/2$ $R_B = W.m^3\frac{(2 - m)}{2m}$

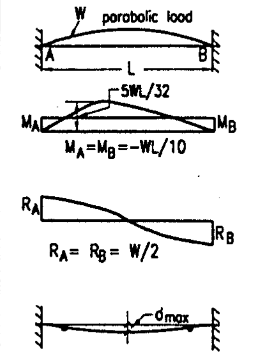
Deflection (d_{max}, x_1)

When $a = L/2$ and $x_1 = 0.445L$,

$d_{max} = \frac{[illegible]}{[illegible]53EI}$ $d_C = \frac{WL^3}{384EI}$

BUILT-IN BEAMS

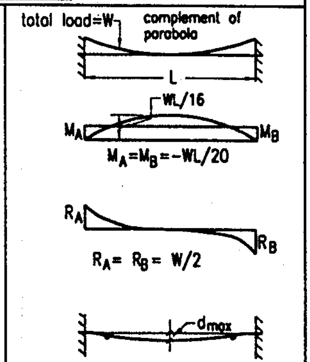
LOADING / MOMENT / SHEAR / DEFLECTION



$M_A = M_B = -WL/10$

$R_A = R_B = W/2$

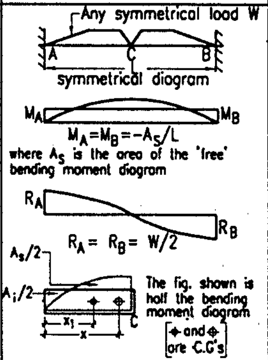
$d_{max.} = \frac{1.3WL^3}{384EI}$



$M_A = M_B = -WL/20$

$R_A = R_B = W/2$

$d_{max.} = \frac{0.4WL^3}{384EI}$



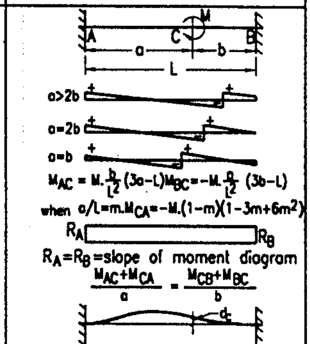
$M_A = M_B = -A_S/L$

where A_S is the area of the 'free' bending moment diagram

$R_A = R_B = W/2$

d_{max} at $C = \frac{A_s x - A_i x_1}{2EI}$

where A_i is the area of the fixing moment diagram



$M_{AC} = M.\frac{b}{L^2}(3a-L)$ $M_{BC} = -M.\frac{a}{L^2}(3b-L)$

when $a/L = m$. $M_{CA} = -M.(1-m)(1-3m+6m^2)$

$R_A = R_B$ = slope of moment diagram

$\frac{M_{AC}+M_{CA}}{a} = \frac{M_{CB}+M_{BC}}{b}$

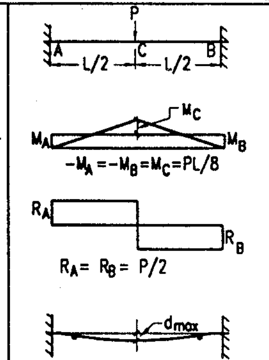
when $a/L = m$

$d_c = \frac{M.L^2 m^2 (1-m)^2 (1-2m)}{2EI}$

For anticlockwise moments reverse the deflections

BUILT-IN BEAMS

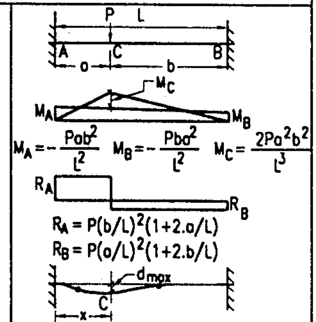
LOADING / MOMENT / SHEAR / DEFLECTION



$-M_A = -M_B = M_C = PL/8$

$R_A = R_B = P/2$

$d_{max.} = \frac{PL^3}{192EI}$



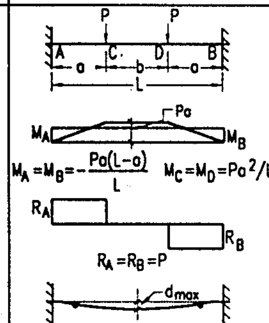
$M_A = -\frac{Pab^2}{L^2}$ $M_B = -\frac{Pba^2}{L^2}$ $M_C = \frac{2Pa^2b^2}{L^3}$

$R_A = P(b/L)^2(1+2.a/L)$

$R_B = P(a/L)^2(1+2.b/L)$

$d_C = \frac{Pa^3b^3}{3EIL^3}$ $d_{max} = \frac{2Pa^2b^3}{3EI(3L-2a)^2}$

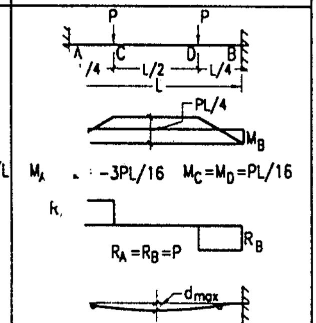
when $x = L^2/(3L-2a)$



$M_A = M_B = -\frac{Pa(L-a)}{L}$ $M_C = M_D = Pa^2/L$

$R_A = R_B = P$

$d_{max} = \frac{PL^3}{6EI}\left[\frac{3a^2}{4L^2} - \left(\frac{a}{L}\right)^3\right]$



M_A . -3PL/16 $M_C = M_D = PL/16$

$R_A = R_B = P$

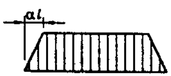
$nax = \frac{PL^3}{192EI}$

CONTINUOUS BEAMS: SHEARS FROM EQUAL LOADS ON EQUAL SPANS

LOAD	ALL SPANS LOADED (E.G.DEAD LOAD)		IMPOSED LOAD(SEQUENCE OF LOADED SPANS TO GIVE MAX. SHEAR FORCE	
Concentrated at midspan	0.313 0.688	0.688 0.313	0.406 0.688	0.688 0.406
Concentrated at midspan	0.350 0.500 0.650	0.650 0.500 0.350	0.425 0.625 0.675	0.675 0.625 0.425
Concentrated at midspan	0.339 0.554 0.446 0.661	0.661 0.446 0.554 0.339	0.420 0.654 0.607 0.681	0.681 0.607 0.654 0.420
Concentrated at midspan	0.342 0.540 0.500 0.460 0.658	0.658 0.460 0.500 0.540 0.342	0.421 0.647 0.636 0.615 0.679	0.679 0.615 0.636 0.647 0.421
Concentrated at third points	0.333 0.667	0.667 0.333	0.417 0.667	0.667 0.417
Concentrated at third points	0.367 0.500 0.633	0.633 0.500 0.367	0.433 0.611 0.656	0.656 0.611 0.433
Concentrated at third points	0.357 0.548 0.452 0.643	0.643 0.452 0.548 0.357	0.429 0.637 0.595 0.661	0.661 0.595 0.637 0.429
Concentrated at third points	0.360 0.535 0.500 0.465 0.640	0.640 0.465 0.500 0.535 0.360	0.430 0.631 0.621 0.602 0.659	0.659 0.602 0.621 0.631 0.480

CONTINUOUS BEAMS: SHEARS FROM EQUAL LOADS ON EQUAL SPANS

LOAD	ALL SPANS LOADED (E.G.DEAD LOAD)		IMPOSED LOAD(SEQUENCE OF LOADED SPANS TO GIVE MAX. SHEAR FORCE	
Uniformly distributed	0.375 0.625	0.625 0.375	0.438 0.625	0.625 0.438
Uniformly distributed	0.400 0.500 0.600	0.600 0.500 0.400	0.450 0.583 0.617	0.617 0.583 0.450
Uniformly distributed	0.393 0.536 0.464 0.607	0.607 0.464 0.536 0.393	0.446 0.603 0.571 0.621	0.621 0.571 0.603 0.446
Uniformly distributed	0.395 0.526 0.500 0.474 0.605	0.605 0.474 0.500 0.526 0.395	0.447 0.598 0.591 0.576 0.620	0.620 0.576 0.591 0.598 0.447
Triangularly distributed	0.344 0.656	0.656 0.344	0.422 0.656	0.656 0.422
Triangularly distributed	0.375 0.500 0.625	0.625 0.500 0.375	0.437 0.605 0.646	0.646 0.605 0.437
Triangularly distributed	0.366 0.545 0.455 0.634	0.634 0.455 0.545 0.366	0.433 0.628 0.589 0.651	0.651 0.589 0.628 0.433
Triangularly distributed	0.369 0.532 0.500 0.468 0.631	0.631 0.468 0.500 0.532 0.369	0.434 0.622 0.614 0.595 0.649	0.649 0.595 0.614 0.622 0.434

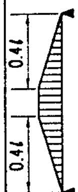
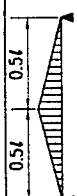


For any trapezoidal load

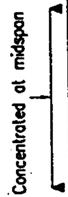
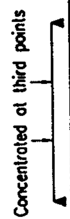
SF COEFFICIENT = $(k - 1/2)(1 + \alpha - \alpha^2) + 1/2$
WHERE k IS SF COEFFICIENT FOR UNIFORM LOAD, READ FROM ABOVE TABLE.

E.g. IF α = 0.5. COEFFICIENT AT CENTRAL SUPPORT OF TWO-SPAN BEAM IS (0.625−0.5)(1+0.5−0.25)+0.5=0.656.

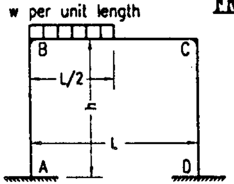
CONTINUOUS BEAMS: MOMENTS FROM EQUAL LOADS ON EQUAL SPANS

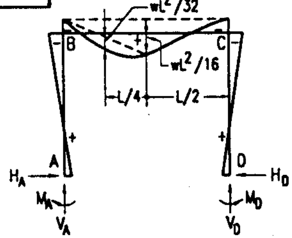
LOAD	ALL SPANS LOADED (E.G.DEAD LOAD)	IMPOSED LOAD(SEQUENCE OF LOADED SPANS TO GIVE MAX. BENDING MOMENT)
	0.155 ▲0.094▲0.094▲ 0.124 0.124 ▲0.107▲0.040▲0.107▲ 0.133 0.089 0.133 ▲0.103▲0.054▲0.054▲0.103▲ 0.131 0.098 0.098 0.131 ▲0.104▲0.050▲0.066▲0.050▲0.104▲	0.155 ▲0.127▲0.127▲ 0.145 0.145 ▲0.134▲0.102▲0.134▲ [0.133] [0.089] [0.133] (0.144) (0.133) (0.144) 0.149 0.133 0.149 ▲0.132▲0.109▲0.109▲0.132▲ [0.131] [0.098] [0.098] [0.131] (0.144) (0.132) (0.132) (0.144) 0.149 0.138 0.138 0.149 ▲0.133▲0.107▲0.115▲0.107▲0.133▲
	0.156 ▲0.095▲0.095▲ 0.125 0.125 ▲0.108▲0.042▲0.108▲ 0.134 0.089 0.134 ▲0.104▲0.056▲0.056▲0.104▲ 0.132 0.099 0.099 0.132 ▲0.105▲0.051▲0.068▲0.051▲0.105▲	0.156 ▲0.129▲0.129▲ 0.146 0.146 ▲0.136▲0.104▲0.136▲ [0.134] [0.089] [0.134] (0.145) (0.134) (0.145) 0.151 0.134 0.151 ▲0.134▲0.111▲0.111▲0.134▲ [0.132] [0.099] [0.099] [0.132] (0.145) (0.133) (0.133) (0.145) 0.150 0.139 0.139 0.150 ▲0.135▲0.109▲0.117▲0.109▲0.135▲

CONTINUOUS BEAMS: MOMENTS FROM EQUAL LOADS ON EQUAL SPANS

LOAD	ALL SPANS LOADED (E.G.DEAD LOAD)	IMPOSED LOAD(SEQUENCE OF LOADED SPANS TO GIVE MAX. BENDING MOMENT)
	0.188 ▲0.156▲0.156▲ 0.150 0.150 ▲0.175▲0.100▲0.175▲ 0.161 0.107 0.161 ▲0.170▲0.116▲0.116▲0.170▲ 0.158 0.118 0.118 0.158 ▲0.171▲0.112▲0.132▲0.112▲0.171▲	0.188 ▲0.203▲0.203▲ 0.175 0.175 ▲0.213▲0.175▲0.213▲ [0.161] [0.107] [0.161] (0.174) (0.161) (0.174) 0.181 0.161 0.181 ▲0.210▲0.183▲0.183▲0.210▲ [0.158] [0.118] [0.118] [0.158] (0.174) (0.160) (0.160) (0.174) 0.179 0.167 0.167 0.179 ▲0.211▲0.181▲0.191▲0.181▲0.211▲
	0.167 ▲0.111▲0.111▲ 0.133 0.133 ▲0.122▲0.033▲0.122▲ 0.143 0.095 0.143 ▲0.119▲0.056▲0.056▲0.119▲ 0.140 0.105 0.105 0.140 ▲0.120▲0.050▲0.061▲0.050▲0.120▲	0.167 ▲0.139▲0.139▲ 0.156 0.156 ▲0.144▲0.100▲0.144▲ [0.143] [0.095] [0.143] (0.155) (0.143) (0.155) 0.160 0.144 0.160 ▲0.143▲0.111▲0.111▲0.143▲ [0.140] [0.105] [0.105] [0.140] (0.155) (0.142) (0.142) (0.155) 0.159 0.148 0.148 0.159 ▲0.144▲0.108▲0.115▲0.108▲0.144▲

FRAME - I





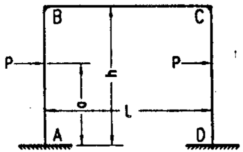
$$M_A = \frac{wL^2}{8}\left[\frac{1}{3N_1} - \frac{1}{8N_2}\right] \qquad M_B = -\frac{wL^2}{8}\left[\frac{2}{3N_1} + \frac{1}{8N_2}\right]$$

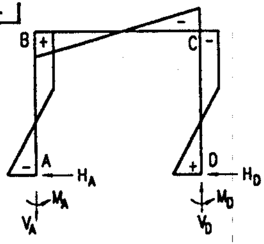
$$M_D = \frac{wL^2}{8}\left[\frac{1}{3N_1} + \frac{1}{8N_2}\right] \qquad M_C = -\frac{wL^2}{8}\left[\frac{2}{3N_1} - \frac{1}{8N_2}\right]$$

$$V_D = \frac{wL}{8}\left[1 - \frac{1}{4N_2}\right] \qquad H_A = H_D = \frac{wL^2}{8hN_1}$$

$$V_A = \frac{wL}{2} - V_D$$

FRAME - I





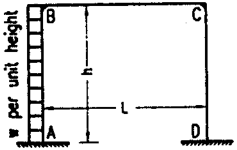
Constants: $a_1 = a/h$, $\quad X_1 = \dfrac{3Paa_1k}{N_2}$

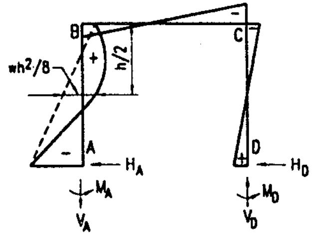
$$M_A = -Pa + X_1 \qquad M_B = X_1$$

$$M_D = +Pa - X_1 \qquad M_C = -X_1$$

$$V_A = -V_D = -\frac{2X_1}{L} \qquad H_A = -H_D = -P$$

FRAME - I



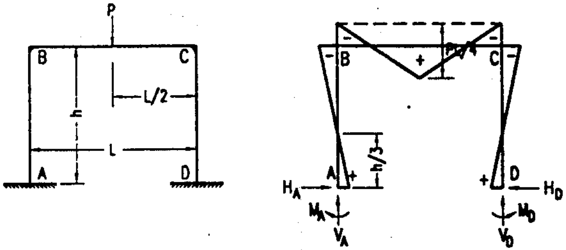


$$M_A = \frac{wh^2}{4}\left[-\frac{k+3}{6N_1} - \frac{4k+1}{N_2}\right] \qquad M_B = \frac{wh^2}{4}\left[-\frac{k}{6N_1} + \frac{2k}{N_2}\right]$$

$$M_D = \frac{wh^2}{4}\left[-\frac{k+3}{6N_1} + \frac{4k+1}{N_2}\right] \qquad M_C = \frac{wh^2}{4}\left[-\frac{k}{6N_1} - \frac{2k}{N_2}\right]$$

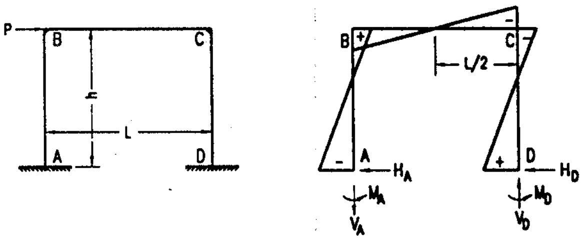
$$H_D = \frac{wh(2k+3)}{8N_1} \qquad H_A = -(wh - H_D) \qquad V_A = -V_D = -\frac{wh^2k}{LN_2}$$

FRAME - I



$$M_A = M_D = +PL/8N_1 \qquad M_B = M_C = -2M_A$$

$$V_A = V_D = P/2 \qquad H_A = H_D = 3M_A/h$$

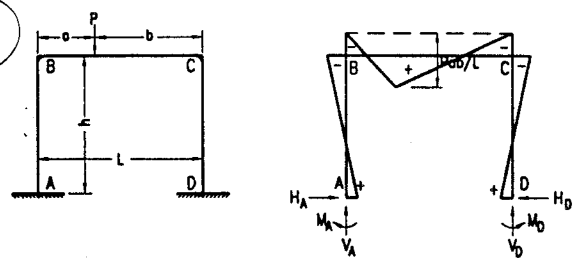


$$M_A = -\frac{Ph}{2}\cdot\frac{3k+1}{N_2} \qquad M_B = +\frac{Ph}{2}\cdot\frac{3k}{N_2}$$

$$M_D = +\frac{Ph}{2}\cdot\frac{3k+1}{N_2} \qquad M_C = -\frac{Ph}{2}\cdot\frac{3k}{N_2}$$

$$H_A = -H_D = -\frac{P}{2} \qquad V_A = -V_D = -\frac{2M_B}{L}$$

FRAME - I



Constants : $a_1 = a/L$, $b_1 = b/L$

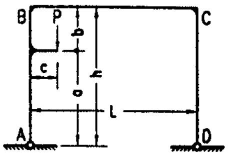
$$M_A = +\frac{Pab}{L}\left[\frac{1}{2N_1} - \frac{b_1-a_1}{2N_2}\right] \qquad M_B = -\frac{Pab}{L}\left[\frac{1}{N_1} + \frac{b_1-a_1}{2N_2}\right]$$

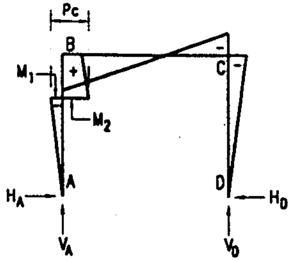
$$M_D = +\frac{Pab}{L}\left[\frac{1}{2N_1} + \frac{b_1-a_1}{2N_2}\right] \qquad M_C = -\frac{Pab}{L}\left[\frac{1}{N_1} - \frac{b_1-a_1}{2N_2}\right]$$

$$V_A = Pb_1\left[1 + \frac{a_1(b_1-a_1)}{N_2}\right] \qquad V_D = P - V_A$$

$$H_A = H_D = \frac{3Pab}{2LhN_1}$$

FRAME - II





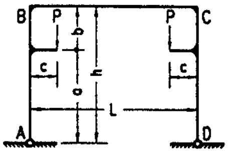
Constant : $a_1 = a/h$

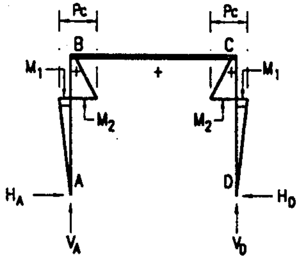
$M_B = \frac{Pc}{2}\left[\frac{(3a_1^2-1)k}{N}+1\right]$ $\quad H_A = H_D = -\frac{M_C}{h}$

$M_C = \frac{Pc}{2}\left[\frac{(3a_1^2-1)k}{N}-1\right]$ $\quad V_D = \frac{Pc}{L}$ $\quad V_A = P - V_D$

$M_1 = -H_A a$ $\quad M_2 = Pc - H_A a$

FRAME - II





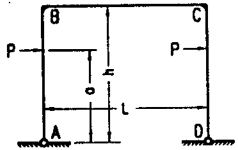
Constant : $a_1 = a/h$

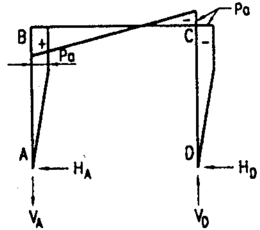
$M_B = M_C = \frac{Pc(3a_1^2-1)k}{N}$ $\quad V_A = V_D = P$

$H_A = H_D = \frac{Pc - M_B}{h}$

$M_1 = -H_A a$ $\quad M_2 = Pc - H_A a$

FRAME - II

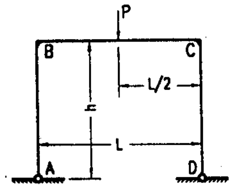


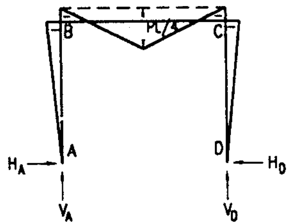


$M_B = -M_C = Pa$ $\quad H_A = H_D = P$

$V_A = -V_D = -\frac{2Pa}{L}$

Moment at loads $= \pm Pa$



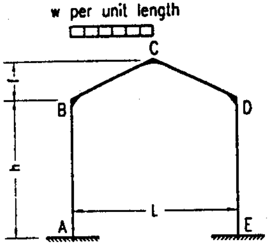


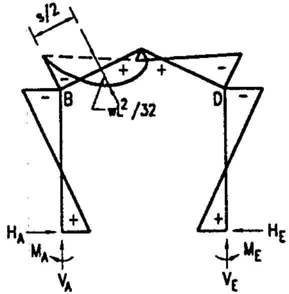
$M_B = M_C = -\frac{3PL}{8N}$

$V_A = V_D = \frac{P}{2}$

$H_A = H_D = -\frac{M_B}{h}$

FRAME - III





Constants : $X_1 = \frac{wL^2}{32}\cdot\frac{k(8+15\phi)+\phi(6-\phi)}{N_1}$

$X_2 = \frac{wL^2}{32}\cdot\frac{k(16+15\phi)+\phi^2}{N_1}$ $\quad X_3 = \frac{wL^2}{32N_2}$

$M_A = +X_1-X_3$ $\quad M_B = -X_2-X_3$ $\quad M_E = +X_1+X_3$ $\quad M_D = -X_2+X_3$

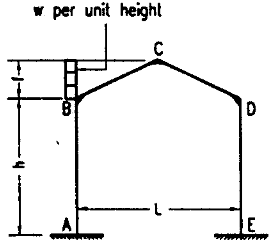
$M_C = \frac{wL^2}{16} - \phi X_1 - mX_2$

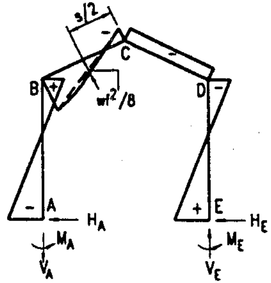
$V_E = \frac{wL}{8} - \frac{2X_3}{L}$

$V_A = \frac{wL}{2} - V_E$

$H_A = H_E = \frac{X_1+X_2}{h}$

FRAME - III





Constants : $X_1 = \frac{wf^2}{8}\cdot\frac{k(9\phi+4)+\phi(6+\phi)}{N_1}$

$X_2 = \frac{wf^2}{8}\cdot\frac{k(8+9\phi)-\phi^2}{N_1}$ $\quad \frac{wfh}{8}\cdot\frac{4B+\phi}{N_2}$

$M_A = -X_1-X_3$ $\quad M_B = +X_2+\left(\frac{wfh}{2} - X\right.$

$M_E = -X_1+X_3$ $\quad M_D = +X_2-\left(\frac{wfh}{2} - X\right.$

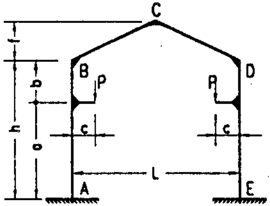
$M_C = -\frac{wf^2}{4} + \phi X_1 + mX_2$

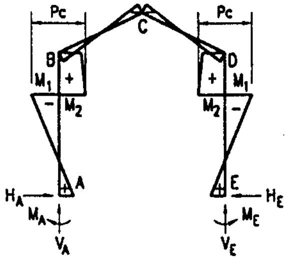
$V_A = -V_E = -\frac{wfh(2+\phi)}{2L} + \frac{2X_3}{L}$

$H_E = \frac{wf}{2} - \frac{X_1+X_2}{h}$

$H_A = -(wf-H_E)$

FRAME - III





Constants : $a_1 = a/h$, $b_1 = b/h$

$Y_1 = Pc[2\phi^2 - (1-3b_1^2)k]$ $Y_2 = Pc[\phi C + (3a_1^2 - 1)k]$

$M_A = M_E = \frac{Y_2 R - Y_1 K_1}{N_1}$ $M_B = M_D = \frac{Y_2 K_2 - Y_1 R}{N_1}$

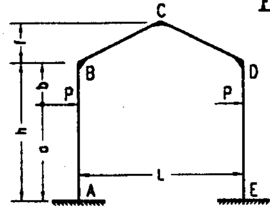
$M_C = -\phi(Pc + M_A) + mM_B$

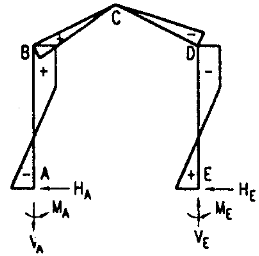
$V_A = V_D = P$

$H_A = H_E = \frac{Pc + M_A - M_B}{h}$

$M_1 = M_A - H_A a$ $M_2 = M_B + H_E b$

FRAME - III



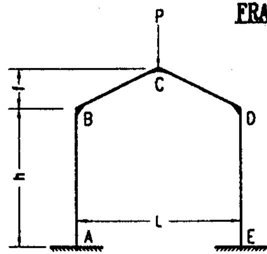


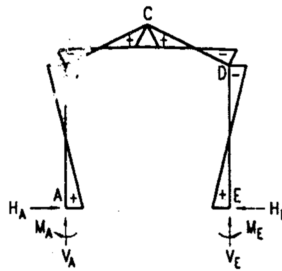
Constant : $X_1 = \frac{Pa(B+3b_1k)}{N_2}$

$M_A = -M_E = -X_1$ $M_B = -M_D = Pa - X_1$; $M_C = 0$

$V_A = -V_E = -2\left[\frac{Pa - X_1}{L}\right]$ $H_A = -H_E = -P$

FRAME - III

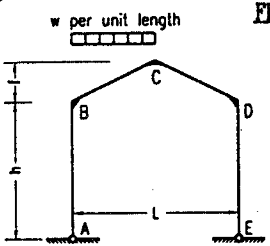


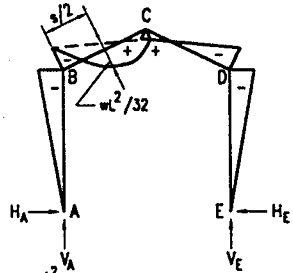


$M_A = M_E = \frac{3PL(k+2k\phi+\phi)}{4N_1}$ $M_B = M_D = -\frac{3PLkm}{2N_1}$

$M_C = \frac{PL}{4} - \phi M_A + mM_B$ $V_A = V_E = P/2$ $H_A = H_E = \frac{M_A - M_B}{h}$

FRAME - IV

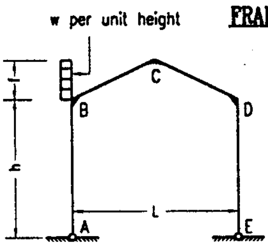


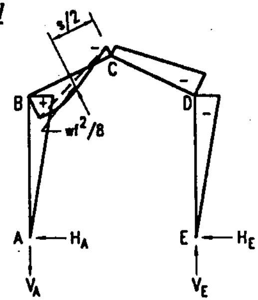


$$M_B = M_D = -\frac{wL^2(3+5m)}{32N} \qquad M_C = \frac{wL^2}{16} + mM_B$$

$$H_A = H_E = -\frac{M_B}{h} \qquad V_A = \frac{3wL}{8} \qquad V_E = \frac{wL}{8}$$

FRAME - IV



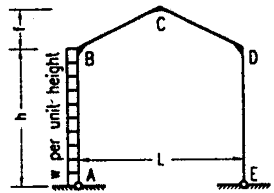


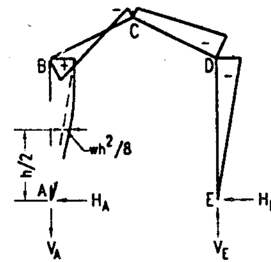
Constant : $X = \frac{wf^2(C+m)}{8N}$ $\qquad M_B = +X + \frac{wfh}{2}$ $\qquad M_C = -\frac{wf^2}{4} + mX$

$$M_D = +X - \frac{wfh}{2} \qquad V_A = -V_E = -\frac{wfh(1+m)}{2L}$$

$$H_A = -\frac{X}{h} - \frac{wf}{2} \qquad H_E = -\frac{X}{h} + \frac{wf}{2}$$

FRAME - IV





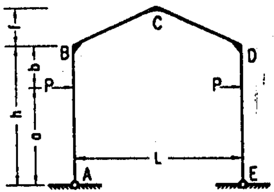
$$M_D = -\frac{wh^2}{8} \cdot \frac{2(B+C)+k}{N} \qquad M_B = \frac{wh^2}{2} + M_D$$

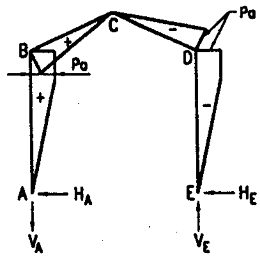
$$M_C = \frac{wh^2}{4} + mM_D$$

$$V_A = -V_E = -\frac{wh^2}{2L} \qquad H_E = -\frac{M_D}{h}$$

$$H_A = -(wh - H_E)$$

FRAME – IV





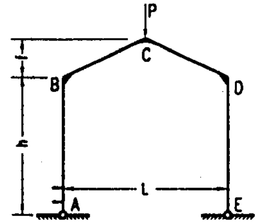
$M_B = -M_D = Pa$ $\qquad M_C = 0$

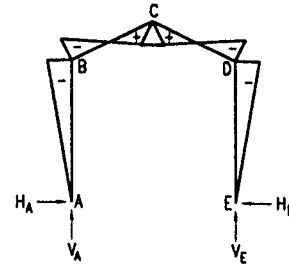
$H_A = -H_E = -P$

$V_A = -V_E = -\dfrac{2Pa}{L}$

Moment at loads $= \pm\ Pa$

FRAME – IV

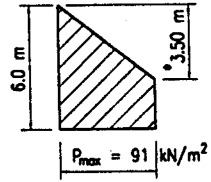
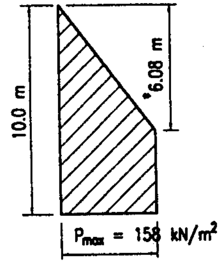
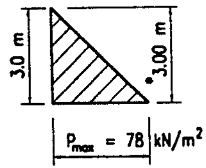




$M_B = M_D = -\dfrac{PL}{4} \cdot \dfrac{C}{N}$ $\qquad M_C = +\dfrac{PL}{4} \cdot \dfrac{B}{N}$

$V_A = V_E = \dfrac{P}{2}$ $\qquad H_A = H_E = -\dfrac{M_B}{h}$

CONCRETE PRESSURE DATA

EXAMPLES	DESIGN PRESSURE DISTRIBUTION
WALL 0.5 x 10.0 x 6.0 m. HIGH OPC concrete with retarder Concrete temperature at placing : 10° C Rate of rise = 3 m/h P_{max} = 91 kN/m² *3.50 m = 91/26	
COLUMN 0.5 x 1.75 x 10.0 m. HIGH OPC concrete without retarder Concrete temperature at placing : 10° C Rate of rise = 10 m/h P_{max} = 158 kN/m² *6.08 m = 158/26	
WALL 0.2 x 2.5 x 3.0m HIGH OPC concrete with retarder Concrete temperature at placing : 5° C Rate of rise = 6 m/h P_{max} = 78 kN/m² *3.00 m = 78/26	

FALSEWORK LOADINGS DUE TO PUMPING OF CONCRETE ON SLABS

Concrete pumping force on falsework	0.25 x pumping pressure (N/mm²) x pipeline cross sectional area (mm²)
Probable maximum pump pressures	Mechanical pumps – 5.00 N/mm² Pneumatic placers – 0.70 N/mm²

CONCRETE PRESSURE DATA

$P_{max} = D\,[C_1\sqrt{R} + C_2 K\sqrt{H - C_1\sqrt{R}}]$ or Dh kN /M²

whichever is smaller

where,

C_1 = coefficient dependent on the size and shape of formwork (see Table 1 for values), $\sqrt{mh}$

C_2 = coefficient dependent on the constituent materials of the concrete (see Table 1, for values), $\sqrt{m}$

D = wet density of concrete kN/m³

H = vertical form height, m

h = vertical pour height, m

K = temperature coefficient taken as $(36/(T+16))^2$

R = the rate at which the concrete rises vertically up the form, m/h

T = concrete temperature at placing, °C

where, $C_1\sqrt{R} > H$, the fluid pressure (Dh) should be taken as the design pressure.

The term $C_1\sqrt{R}$ incorporates the effects of vibrations and workability, because these factors are largely dependent on size, shape & rate of rise. All the effects of the height of discharge, cement type, admixtures and concrete temperatur[illegible] placing are incorporated in the term.

$C_2 K\sqrt{H - C_1\sqrt{R}}$

Design Formwork Pressures (In kN/sq.m) for COLUMNS*

Concrete Groups ---->		1) OPC, RHPC or SRPC without admixtures 2) OPC, RHPC or SRPC with any admixture, except a retarder										1) OPC, RHPC or SRPC with a retarder 2) LHPBFC, PBFC, PPFAC or blends containing less than 70% ggbls or 40% pfa without admixtures. 3) LHPBFC, PBFC, PPFAC or blends containing less than 70% ggbls or 40% pfa with any admixtures, except a retarder.										1) LHPBFC, PBFC, PPFAC or blends containing less than 70% ggbls or 40% pfa with a retarder 2) Blends containing more than 70% ggbls or 40% pfa									
Conc. temp. (deg C)	Form ht. (m)	Rate of rise (m/h)										Rate of rise (m/h)										Rate of rise (m/h)									
		0.5	1	2	3	4	6	8	10	15	20	0.5	1	2	3	4	6	8	10	15	20	0.5	1	2	3	4	6	8	10	15	20
20	3	38	49	62	72	78	78	78	78	78	78	44	53	66	75	78	78	78	78	78	78	49	58	70	77	78	78	78	78	78	78
	4	41	51	66	77	86	100	104	104	104	104	48	57	71	81	90	102	104	104	104	104	54	64	77	86	94	104	104	104	104	104
	6	45	56	71	82	92	107	121	132	154	156	54	64	78	89	98	113	126	136	156	156	62	72	86	96	105	119	131	141	156	156
	10	51	62	77	89	99	115	129	141	167	189	63	73	88	99	109	125	138	150	175	196	74	84	99	110	119	135	148	159	183	203
	15	57	68	83	95	105	122	136	148	175	197	71	82	97	109	119	135	149	161	187	208	86	96	111	122	132	148	161	173	198	219
25	3	36	46	61	71	78	78	78	78	78	78	40	50	64	73	78	78	78	78	78	78	44	54	66	75	78	78	78	78	78	78
	4	38	49	63	75	84	99	104	104	104	104	43	53	68	78	87	101	104	104	104	104	48	58	72	82	90	102	104	104	104	104
	6	41	52	67	79	88	105	118	130	154	156	48	58	73	84	94	109	122	133	155	156	54	65	79	90	99	114	126	137	156	156
	10	46	57	72	84	94	111	125	137	163	185	55	65	80	92	102	118	132	144	170	191	64	74	89	100	110	126	139	151	176	196
	15	50	61	77	89	99	116	130	143	169	192	61	72	88	99	109	126	140	152	178	200	72	83	98	110	120	136	150	162	188	209

*Plan dimensions in both the orthogonal directions within 2m => assumed as column

Design Formwork Pressures (In kN/sq.m) for WALLS*

Concrete Groups ---->		1) OPC, RHPC or SRPC without admixtures 2) OPC, RHPC or SRPC with any admixture, except a retarder										1) OPC, RHPC or SRPC with a retarder 2) LHPBFC, PBFC, PPFAC or blends containing less than 70% ggbls or 40% pfa without admixtures. 3) LHPBFC, PBFC, PPFAC or blends containing less than 70% ggbls or 40% pfa with any admixtures, except a retarder.										1) LHPBFC, PBFC, PPFAC or blends containing less than 70% ggbls or 40% pfa with a retarder 2) Blends containing more than 70% ggbls or 40% pfa									
Conc. temp. (deg C)	Form ht. (m)	Rate of rise (m/h)										Rate of rise (m/h)										Rate of rise (m/h)									
		0.2	0.3	0.4	0.5	1.0	1.5	2.0	3.0	5.0	10	0.2	0.3	0.4	0.5	1.0	1.5	2.0	3.0	5.0	10	0.2	0.3	0.4	0.5	1.0	1.5	2.0	3.0	5.0	10
5	2	40	42	43	44	49	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
	3	48	50	52	53	58	62	66	71	78	78	67	68	69	70	75	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
	4	55	57	59	60	66	70	74	80	89	103	76	78	80	81	86	89	92	97	104	104	98	99	101	102	104	104	104	104	104	104
	6	66	68	70	71	77	82	86	92	103	121	93	95	96	97	103	107	110	116	125	140	120	121	123	124	129	132	135	140	147	156
	10	82	85	87	88	95	100	104	111	122	142	118	120	122	123	129	134	138	144	154	172	153	155	157	158	164	168	171	177	186	202
10	2	30	32	34	35	41	45	48	52	52	52	40	41	43	44	48	52	52	52	52	52	49	50	51	52	52	52	52	52	52	52
	3	36	38	39	41	47	52	56	62	71	78	47	49	51	52	58	[illegible]	65	70	78	78	59	61	62	64	68	72	74	78	78	78
	4	40	42	44	46	52	[illegible]	[illegible]	[illegible]	74	96	[illegible]	56	58	59	65	69	73	79	88	103	68	70	71	73	78	82	85	90	98	104
	6	47	49	51	53	59	63	69	76	87	107	64	67	58	70	76	81	85	91	102	120	82	84	86	87	93	97	101	107	116	133
	10	58	60	62	64	71	76	81	88	100	121	81	83	85	87	93	98	102	110	121	141	104	106	108	110	116	120	124	131	141	160
15	2	25	27	29	30	37	41	45	50	52	52	31	33	35	36	42	46	49	52	52	52	38	40	41	42	47	50	52	52	52	52
	3	28	31	33	34	41	46	50	57	67	78	37	39	41	42	48	53	57	63	72	78	45	47	49	50	56	60	63	69	77	78
	4	31	34	36	37	44	49	54	61	72	92	41	44	45	47	53	58	62	69	79	97	51	53	55	57	62	67	71	77	86	101
	6	36	39	41	43	50	55	59	67	79	100	49	51	53	55	61	66	71	78	89	109	61	63	65	67	73	78	82	88	99	118
	10	44	47	49	50	58	63	68	75	87	110	60	63	65	66	73	79	83	90	102	123	77	79	81	83	89	94	98	106	117	137

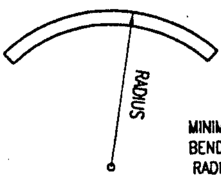
*Plan dimension in any of the orthogonal directions exceeding 2m => assumed as wall

PROPERTIES OF SAWN TIMBER

d (depth), b (breadth)

b x d (INCHES)	AREA (Sq.cm.)	Zxx (cm^3)	Ixx (cm^4)	r min.(cm.)
2 x 2	23.0	18.5	45.5	1.16
2 x 2.5	29.0	29.0	89.0	1.27
2 x 3	34.5	42.0	154.0	1.27
2 x 4	46.5	76.5	378.0	1.27
2 x 4.5	49.0	94.0	533.0	1.31
2 x 5	58.5	121.5	725.0	1.26
2 x 6	71.0	176.5	1319.0	1.26
3 x 3	53.0	64.5	236.5	1.9
3 x 4	71.5	117.5	580.0	1.88
3 x 5	90.0	186.5	1155.0	1.87
3 x 6	109.0	271.0	2022.5	1.862
4 x 4	96.5	158.5	782.0	2.85
4 x 6	147.0	365.0	2726.0	2.47
4 x 8	185.8	629.3	6393.3	2.54

PROPERTIES OF PLYWOOD FOR CONCRETE SHUTTERING WORKS (Ref: IS: 4990-1993)



		DIRECTION ACROSS THE GRAIN OF OUTER PLIES	DIRECTION PARALLEL WITH THE GRAIN OF THE OUTER PLIES
MINIMUM BENDING RADIUS	6mm	0.9m	1.25m
	9mm	1.65m	2.15m
	12mm	2.55m	3.30m
TENSILE STRENGTH		22.5 N/mm^2	32.5 N/mm^2
MODULUS OF ELASTICITY		4000 N/mm^2	8000 N/mm^2

NOTE: The sum of the tensile strengths in both directions shall be not less than 60.0 N/mm^2. Plywood without any plastic coating or suitable overlay may be bent to still smaller radii by soaking in cold or hot water (temperature up to 70° C) before fixing.

IS 456-2000 (CLAUSE:11.3) STRIPPING TIME

Forms shall not be released until the concrete has achieved a strength of at least twice the stress to which the concrete may be subjected at the time of removal of formwork. The strength referred to shall be that of concrete using the same cement and aggregates and admixture, if any, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work.

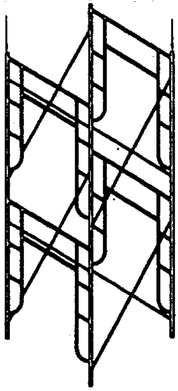
While the above criteria of strength shall be the guiding factor for removal of formwork, in normal circumstances where ambient temperature does not fall below 15°C and where ordinary portland cement is used and adequate curing is done, following striking period may deem to satisfy.

TYPE OF FORMWORK	MIN. PERIOD BEFORE STRIKING FORMWORK
a) Vertical formwork to columns, walls, beams	16-24 h
b) Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
c) Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
d) Props to slabs:	
1) Spanning up to 4.5m	7 days
2) Spanning over 4.5m	14 days
e) Props to beams and arches:	
1) Spanning up to 6.0m	14 days
2) Spanning over 6.0m	21 days

For other cements and lower temperature, the stripping time recommended above may be suitably modified.

The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full deac of the slab, beam or arch as the case may be together with any li ikely to occur during curing or further construction.

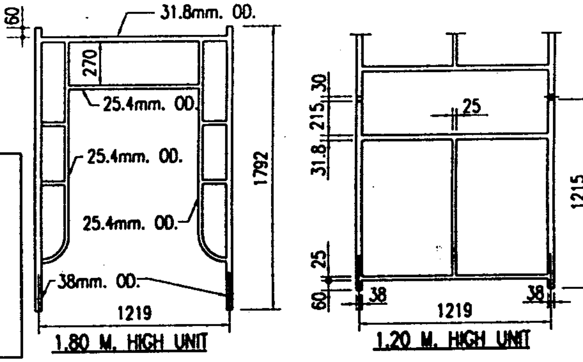
Where the shape of the element is such that the ork has re-entrant angles, the formwork shall be romoved as soon sible after the concrete has set, to avoid shrinkage cracking occurring due the restraint imposed.



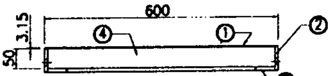
LOADING DATA

	WELDED FRAME MODEL M-45	WELDED FRAME MODEL M-32
1. FOR SINGLE TIER LOAD APPLIED ON VERTICAL LEGS.	4.50 MT PER LEG	3.4 MT PER LEG
2. FOR 2 TIER LOAD APPLIED ON VERTICAL LEGS.	3.75 MT PER LEG	2.7 MT PER LEG
3. FOR 3 TIER LOAD APPLIED ON VERTICAL LEGS.	3.6 MT PER LEG	2.2 MT PER LEG
4. FOR 4 TIER LOAD APPLIED ON VERTICAL LEGS.	3.2 MT PER LEG	1.8 MT PER LEG

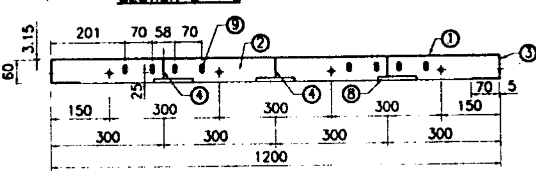
NOTE:
IF USED AS A SCAFFOLDING OF MORE THAN 2 TIERS HEIGHT FASTEN THE SYSTEM TO A STABLE STRUCTURE LIKE A BUILDING AT EVERY 2nd. TIER.



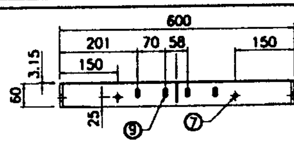
DETAIL OF EWL FRAME (Production stopped since 1995)



SECTION B - B



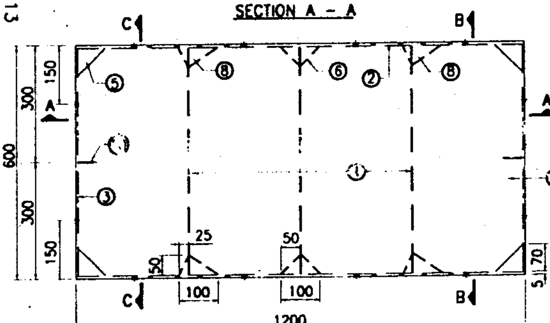
SECTION A - A



SECTION C - C

SL NO.	DESCRIPTION	LENGTH
10	50x3.15 tk., PLATE	50
9	8x20 RECT. HOLE	
8	50x10 tk. PLATE FOR BEARING	100
7	ø12 HOLE FOR ø10 BOLT	
6	50x10 tk. PLATE FOR BEARING	100
5	70x3.15 tk. PLATE	70
4	50x3.15 tk. PLATE	590
3	60x5 tk. PLATE	590
2	60x5 tk. PLATE	1200
1	600x3.15 tk. PLATE	1200

TOTAL WEIGHT = 30.80 Kg.



PLAN

NOTES :
1. ALL DIMENSIONS ARE IN MM.

DETAILS OF L&T FLOOR FORM SIZE 600 x 1200.

TABLE 3 ENVIRONMENTAL EXPOSURE CONDITIONS

MILD:

Concrete surfaces protected against weather or aggrsive conditions, except those situated in coastal area.

MODERATE:

Concrete surfaces sheltered from severe rain or freezing whilst wet
Concrete exposed to condensation and rain
Concrete continuously under water
Concrete in contact or buried under non-aggressive soil/ground water.
Concrete surfaces sheltered from saturated salt air in coastal area.

SEVERE:

Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.
Concrete completely immersed in sea water.
Concrete exposed to coastal environment.

VERY SEVERE:

Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet.
Concrete in contact with or buried under oggessive sub-soil/ground water.

EXTREME:

Surface of members in tidal zone.
Members in direct contact with liquid/solid aggressive chemicals.

TABLE 9 PROPORTIONS FOR NOMINAL MIX CONCRETE

Grade of concrete	Total quantity of dry aggregates by mass per 50 kg of cement, to be taken as the sum of the individual masses of fine and coarse aggregates, kg (max.)	Proportion of fine aggregate to coarse aggregate (by mass)	Quantity of water per 50 kg of cement, max Litres
M 5	800	Generally 1:2 but subject to an upper limit of 1:1.5 and a lower imit of 1:2.5	60
M 7.5	625		45
M 10	480		34
M 15	330		32
M 20	250		30

NOTE: The proportion of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of fine aggregates becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used.

MINIMUM CEMENT CONTENT, MAXIMUM WATER-CEMENT RATIO AND MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH NORMAL WEIGHT AGGREGATES OF 20mm NOMINAL MAXIMUM SIZE.

SL No.	EXPOSURE	PLAIN CONCRETE			REINFORCED CONCRETE		
		Min. cement content kg/cum.	max. free water cement ratio	min. grade of concrete	Min. cement content kg/cum.	max. free water cement ratio	min. grade of concrete
1	MILD	220	0.60	-	300	0.55	M 20
2	MODERATE	240	0.60	M 15	300	0.50	M 25
3	SEVERE	250	0.50	M 20	320	0.45	M 30
4	VERY SEVERE	260	0.45	M 20	340	0.45	M 35
5	EXTREME	280	0.40	M 25	360	0.40	M 40

NOTES:

1. Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in clause 5.2 IS 456 - 2000.
   The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (part 1) and 455 respectively.
2. Minimum grade for plain concrete under mild exposure condition is not specified.

FLEXURE – REINFORCEMENT PERCENTAGE, p_t FOR SINGLY REINFORCED SECTIONS

f_{ck} = 25 N/mm²

Mu/bd^2 N/mm²	fy = 415 N/mm²	Mu/bd^2 N/mm²	fy = 415 N/mm²	Mu/bd^2 N/mm²	fy = 415 N/mm²
0.30	0.084	1.55	0.466	2.80	0.916
0.35	0.099	1.60	0.482	2.85	0.936
0.40	0.113	1.65	0.499	2.90	0.956
0.45	0.127	1.70	0.515	2.95	0.977
0.50	0.142	1.75	0.532	3.00	0.997
0.55	0.156	1.80	0.549	3.05	1.018
0.60	0.171	1.85	0.566	3.10	1.039
0.65	0.186	1.90	0.583	3.15	1.061
0.70	0.201	1.95	0.601	3.20	1.082
0.75	0.216	2.00	0.618	3.25	1.104
0.80	0.231	2.05	0.635	3.30	1.126
0.85	0.246	2.10	0.653	3.32	1.135
0.90	0.261	2.15	0.671	3.34	1.144
0.95	0.276	2.20	0.689	3.36	1.153
1.00	0.291	2.25	0.707	3.38	1.162
1.05	0.307	2.30	0.725	3.40	1.171
1.10	0.322	2.35	0.743	3.42	1.180
1.15	0.338	2.40	0.762	3.44	1.189
1.20	0.353	2.45	0.781		
1.25	0.369	2.50	0.799		
1.30	0.385	2.55	0.818		
1.35	0.401	2.60	0.837		
1.40	0.417	2.65	0.857		
1.45	0.433	2.70	0.876		
1.50	0.449	2.75	0.896		

FLEXURE – REINFORCEMENT PERCENTAGES FOR DOUBLY REINFORCED SECTIONS

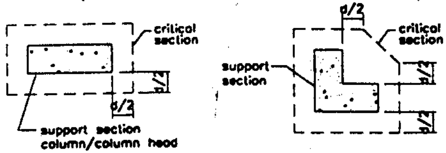
f_{ck} = 20 N/mm²

f_y = 415 N/mm²

Mu/bd^2 N/mm²	d'/d = 0.05		d'/d = 0.10		d'/d = 0.15		d'/d = 0.20	
	Pt	Pc	Pt	Pc	Pt	Pc	Pt	Pc
2.77	0.958	0.002	0.958	0.002	0.959	0.003	0.959	0.003
2.80	0.967	0.011	0.968	0.012	0.968	0.013	0.969	0.015
2.90	0.996	0.042	0.998	0.045	1.001	0.049	1.004	0.054
3.00	1.025	0.072	1.029	0.077	1.034	0.084	1.038	0.093
3.10	1.055	0.103	1.060	0.109	1.066	0.119	1.073	0.132
3.20	1.084	0.133	1.091	0.142	1.099	0.154	1.108	0.171
3.30	1.113	0.164	1.122	0.174	1.131	0.190	1.142	0.210
3.40	1.142	0.194	1.152	0.207	1.164	0.225	1.177	0.249
3.50	1.171	0.224	1.183	0.239	1.197	0.260	1.212	0.288
3.60	1.200	0.255	1.214	0.271	1.229	0.295	1.246	0.327
3.70	1.230	0.285	1.245	0.304	1.262	0.331	1.281	0.366
3.80	1.259	0.316	1.276	0.336	1.294	0.366	1.315	0.405
3.90	1.288	0.346	1.306	0.369	1.327	0.401	1.350	0.444
4.00	1.317	0.376	1.337	0.401	1.360	0.437	1.385	0.483
4.10	1.346	0.407	1.368	0.433	1.392	0.472	1.419	0.522
4.20	1.375	0.437	1.399	0.466	1.425	0.507	1.454	0.561
4.30	1.405	0.468	1.429	0.498	1.457	0.542	1.489	0.600
4.40	1.434	0.498	1.460	0.530	1.490	0.578	1.523	0.640
4.50	1.463	0.528	1.491	0.563	1.523	0.613	1.558	0.679
4.60	1.492	0.559	1.522	0.595	1.555	0.648	1.593	0.718
4.70	1.521	0.589	1.553	0.628	1.588	0.683	1.627	0.757
4.80	1.550	0.620	1.583	0.660	[illegible]	[illegible]	1.662	0.796
4.90	1.580	0.650	1.614	0.692	1.653	[illegible]	1.696	0.835
5.00	1.609	0.680	1.645	0.725	1.686	0.789	1.731	0.874
5.10	1.638	0.711	1.676	[illegible]	1.716	0.825	1.766	0.913

PERMISSIBLE SHEAR STRESS IN FLAT SLAB

(Refer clause: 31.6.3. of IS:456-2000)



When shear reinforcement is not provided, the calculated shear stress at the critical section shall not exceed $k_s \tau_c$,

where

k_s = $(0.5 + \beta_s)$ but not greater than 1, β_c being the ratio of short side to long side of the column / capital; and

τ_c = $0.25\sqrt{f_{ck}}$ in limit state method of design, and $0.16\sqrt{f_{ck}}$ in working stress method of design.

when the shear stress at the critical section exceeds the above values, but less than $1.5\tau_c$ shear reinforcement shall be provided. If the shear stress exceeds $1.5\tau_c$, the flat slab shall be redesigned. Shear stresses shall be investigated at successive sections more distant from the support and shear reinforcement shall be provided up to a section where the shear stress does not exceed $0.5\tau_c$. While designing the shear reinforcement, the shear stress carried by the concrete shall be assumed to be $0.5\tau_c$ and reinforcement shall carry the remaining shear.

COMPRESSION MEMBERS-CONSTRUCTION OF INTERACTION DIAGRAM

(EXTRACTS FROM SP-16)

CASE - I

For the case of purely axial compression, the points plotted on the y-axis of the charts are obtained as follows:

$$\frac{P_u}{f_{ck}\,bD} = 0.446 + \frac{p}{100\,f_{ck}}(f_{sc} - 0.446\,f_{ck})$$

CASE - II

When bending moments are also acting in addition to axial load, the y & x points on the charts are obtained as follows.

(a) When the neutral axis lies outside the section

$$\frac{P_u}{f_{ck}\,bD} = C_1 + \sum_{i=1}^{n}\frac{p_i}{100\,f_{ck}}(f_{si} - f_{ci}) \quad \Big| \quad \frac{M_u}{f_{ck}\,bD^2} = C_1(0.5 - C_2) + \sum_{i=1}^{n}\frac{p_i}{f_{ck}100}(f_{si} - f_{ci})\frac{y_i}{d}$$

(b) When the neutral axis lies within the section

$$\frac{P_u}{f_{ck}\,bD} = 0.36k + \sum_{i=1}^{n}\frac{p_i}{100\,f_{ck}}(f_{si} - f_{ci})$$

$$\frac{M_u}{f_{ck}\,bD^2} = 0.36k\,(0.5 - 0.416k) + \sum_{i=1}^{n}\frac{p_i}{f_{ck}100}(f_{si} - f_{ci})\frac{y_i}{d}$$

Where, f_{ck} = Characteristic compressive strength of concrete

f_{sc} = Compressive stress in steel corresponding to strain o. 0.002.

p = reinforcement percentage

C_1 = coefficient for the area of stress block to be tak... m Table below

p_i = $\frac{A_{si}}{bD}$ where A_{si} is the area of reinforcement in the ... row;

f_{si} = stress in the ith row of reinforcement, compressi... ing positive and tension being negative;

f_{ci} = stress in concrete at the level of the ith row o... ement;

n = number of rows of reinforcement

C_2D = is the distance of the centroid of the concrete ... block, measured from the highly compressed edge;

y_i = is the distance from the centroid of the section ... ith row of reinforcement; positive towards the highly compressed edge and ...ive towards the least compressed edge.

$$k = \frac{\text{Depth of neutral axis}}{D}$$

$k = \frac{x_u}{D}$	Area of stress block ($C_1 f_{ck} D$)	Dis... co... f centroid from highly ...d edge (C_2 D)
1.00	0.361 f_{ck} D	0.416 D
1.05	0.374 f_{ck} D	0.432 D
1.10	0.384 f_{ck} D	0.443 D
1.20	0.399 f_{ck} D	0.458 D

CHECK FOR COMBINED AXIAL LOAD AND BIAXIAL BENDING

$$\left[\frac{M_{ux}}{M_{ux1}}\right]^{\alpha_n} + \left[\frac{M_{uy}}{M_{uy1}}\right]^{\alpha_n} \leq 1.0$$

Where,

M_{ux}, M_{uy} = moments about x and y axes due to design loads,

M_{ux1}, M_{uy1} = maximum uniaxial moment capacity for an axial load of Pu, bending about x and y axes respectively.

$\alpha_n = f\,(Pu/Puz)$

$Puz = 0.45\,fck.\,Ac + 0.75fy.\,As.$

α_n vary linearly from 1 to 2 for Pu/Puz = 0.2 to 0.8 for Pu/Puz values < 0.2 α_n is 1.0, for values > than 0.8 α_n is 2.0.

SECTION 6 DESIGN OF MEMBERS SUBJECTED TO BENDING

6.2 BENDING STRESSES

6.2.1 Maximum Bending Stresses - The maximum bending stress in tension ($\sigma_{bt, cal}$) or in compression ($\sigma_{bc, cal}$) in extreme fibre calculated on the effective section of a beam shall not exceed the maximum permissible bending stress in tension (σ_{bt}) or in compression (σ_{bc}) obtained as follows nor the values specified in 6.2.2, 6.2.3, 6.2.5 and 6.2.6, of IS 800-1984 as appropriate:

$$\sigma_{bt} \text{ or } \sigma_{bc} = 0.66\, f_y$$

6.2.2.1 In TABLES 6.1B (page No: 137, 138 & 139)

D = overall depth of beam;

d_1 = i) For the web of a beam without horizontal stiffeners-the clear distance between the flanges, neglecting fillets or the clear distance between the inner toes of the flange angles as appropriate.

ii) For the web of a beam with horizontal stiffeners-the clear distance between the horizontal stiffener and the tension flange, neglecting fillets or the inner toes of the tension flange angles as appropriate

l = effective length of compression flange where each end of the simply supported beam and girder is restrained against torsion shall be taken as follows:

a) With ends of compression flanges unrestrained against lateral bending. l = span

b) With ends of compression flanges partially restrained against lateral bending l = 0.85 x span

c) With ends of compression flanges fully restrained against lateral bending l = 0.7 x span

r_y = radius of gyration of the section about its axis of minimum strength (y-y axis);

τ = mean thickness of the compression flange, is equal to the area of horizontal portion of flange divided by width;

For rolled sections, the mean thickness is that given in appropriate Indian standards.

t = web thickness

MAXIMUM PERMISSIBLE BENDING COMPRESSIVE STRESS IN BEAMS AND PLATE GIRDERS

(CLUASE 6.2.3 of IS: 800 - 1984)

$$\sigma_{bc} = 0.66 \frac{f_{cb} \cdot f_y}{\left[(f_{cb})^n + (f_y)^n\right]^{1/n}}$$

Where,

f_{cb} = elastic critical stress in bending in MPa

f_y = yield stress of the steel in MPa; and

n = a factor assumed as 1.4.

$$f_{cb} = k_1 (X + k_2 Y) \frac{c_2}{c_1}$$

k_1 is $f(\Psi)$ $\Psi = \dfrac{\text{area of both flanges at the point of least BM}}{\text{area of both flanges at the point of max. BM}}$

k_2 is $f(w)$ $w = \dfrac{\text{Iyy of compression flanges at the point of max. BM}}{\text{Iyy of compression+tension flanges at the point of max. BM}}$

$$X = Y\left(\sqrt{\left[1 + \frac{1}{20}\left(\frac{l\,T}{r_y D}\right)^2\right]}\right) \text{MPa}$$

$$Y = \frac{26.5 * 10^5}{(l/r_y)^2} \text{MPa}$$

c_1, c_2 = respectively the lesser and grater distances from the section neutral axis to the extreme fibres. ($c_1 = c_2$ For equal flange beams)

6.2.4.1 Values of f_{cb} shall be increased by 20 percent when T/t is not greater than 2.0 and d_1/t is not greater than $1344/\sqrt{fy}$ where d_1 is as defined in page No: 128 and 't' the thickness of web.

7.1.3 SYMBOLS – The symbols used in 7.1.1 and 7.1.2 shall have the following meaning:

$\sigma_{ac, cal}$	= calculated average axial compressive stress
$\sigma_{at, cal}$	= calculated average axial tensile stress
$\sigma_{bc, cal}$	= calculated bending compressive stress in extreme fibre
$\sigma_{bt, cal}$	= calculated bending tensile stress in extreme fibre
σ_{ac}	= permissible axial compressive stress in the member subjected to axial compressive load only
σ_{at}	= permissible axial tensile stress in the member subjected to axial tensile load only
σ_{bc}	= permissible bending compressive stress in extreme fibre
σ_{bt}	= permissible bending tensile stress in extreme fibre
f_{cc}	= elastic critical stress in compression = $\frac{\pi^2 E}{\lambda^2}$
$\lambda \left(=\frac{l}{r}\right)$	= slenderness ratio in the plane of bending
x,y	= represent x-x and y-y planes
C_m	= a coefficient whose value shall be taken as follows:

(a) For members in frames where side sway is not prevented:

$$C_m = 0.85$$

(b) For members in frames where side sway is prevented and not subjected to transverse loading between their supports in the plane of bending:

$$C_m = 0.6 - 0.4\,\beta \geq 0.4$$

NOTE 1 – β is the ratio of smaller to the larger moments at the ends of that portion of the unbraced member in the plane of bending under consideration.

NOTE 2 – β is positive when the member is bent in reverse curvature and negative when it is bent in single curvature.

(c) For members in frames where side sway is prevented in the plane of loading and subjected to transverse loading between their supports; the value of C_m may be determined by rational analysis. In the absence of such analysis, the following values may be used:

For members whose ends are restrained against rotation

$$C_m = 0.85$$

For members whose ends are unrestrained against rotation

$$C_m = 1.00$$

7.1.4 Bending and Shear – Irrespective of any increase in the permissible stress specified in 3.9, the equivalent stress $\sigma_{e, cal}$, due to co-existent bending (tension or compression) and shear stresses obtained from the formula given in 7.1.4.1. shall not exceed the value: $\sigma_e = 0.9 f_y$

σ_e = maximum permissible equivalent stress.

7.1.4.1 The equivalent stress $\sigma_{e, cal}$ is obtained from the following formula:

$$\sigma_{e, cal} = \sqrt{\sigma_{bt, cal}^2 + 3\,\tau_{vm, cal}^2} \quad \text{or} \quad \sqrt{\sigma_{bc, cal}^2 + 3\,\tau_{vm, cal}^2}$$

7.1.5 Combined Bending, Bearing and Shear Stre[...] – Where a bearing stress is combined with tensile or compressive, bendin[...]d shear stresses under the most unfavourable condition of loading, the eq[...]t stress $\sigma_{e, cal}$ obtained from the following formulae, shall not exceed $\sigma_e = 0.9 f_y$.

$$\sigma_{e, cal} = \sqrt{\sigma_{bt, cal}^2 + \sigma_{p, cal}^2 + \sigma_{bt, cal}\,\sigma_{p, cal} + 3\,\tau_{vm, cal}^2}$$

or

$$\sigma_{e, cal} = \sqrt{\sigma_{bc, cal}^2 + \sigma_{p, cal}^2 + \sigma_{bc, cal}\,\sigma_{p, cal} + 3\,\tau_{vm, cal}^2}$$

7.1.6: In 7.1.4. and 7.1.5 $\sigma_{bt, cal}$; $\sigma_{bc, cal}$; $\tau_{vm, cal}$ and $\sigma_{p, cal}$ are the numerical values of the co-existent bending (compression or tension), shear and bearing stresses. When bending occur about both axes of the member, $\sigma_{bt, cal}$ and $\sigma_{bc, cal}$ shall be taken as the sum of the two calculated fibre stresses. σ_e is the maximum permissible equivalent stress.

TABLE 8.1 MAXIMUM PERMISSIBLE STRESS IN BOLTS

Description of Fasteners	Axial Tension σ_{tf} MPa	Shear, τ_{vf} MPa	Bearing; σ_{pf} MPa
Close tolerance and turned bolts	120	100	300
Bolts in clearance holes	120	80	250

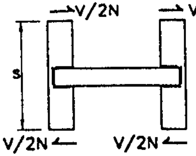
The permissible stress in a bolt (other than a high strength friction grip bolt) of property class higher than 4.6 shall be those given above multiplied by the ratio of its yield stress or 0.2 percent proof stress or 0.7 times its tensile strength, whichever is the lesser, to 235 Mpa.

Under combined shear and tension

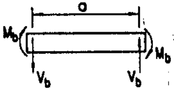
i) $\tau_{vf, cal} < \tau_{vf}$ ii) $\sigma_{tf, cal} < \sigma_{tf}$ and iii) $\left\{\frac{\tau_{vf, cal}}{\tau_{vf}} + \frac{\sigma_{tf, cal}}{\sigma_{tf}}\right\} \nless 1.4$

COLUMNS WITH BATTENS

FORCES IN BATTEN:



The number of battens shall be such that the member is divided into not less than three parts longitudinally.



SPACING OF BATTEN: (Battens be placed opposite to each other)

Slenderness of the component within the batten spacing is

$$\lambda_e = \frac{s}{r_e}$$

where,

λ_e = slenderness of each of the component of the member

s = spacing of the batten

r_e = minimum radius of gyration of each of the component of the member

The design consideration is

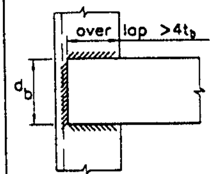
$\lambda_e \leq 0.7\ \lambda_m$ or ≤ 50

λ_m = most unfavourable slenderness ratio of the member as a whole (about its xx)

THICKNESS OF BATTEN (t_b):

Battens can be any of the rolled sections or plates. In case of plates battens, the thickness should be at least one-fiftieth of innermost connecting line of welds.

CONSTRAINTS AT BATTEN CONNECTION:



a) Effective depth (d_b) of intermediate batten plates $\geq$ 0.75 times the distance between the centroid of main members.

b) Effective depth (d_b) of end batten plates $\geq$ 1.0 time the distance between the centroid of main members.

But in no case shall the effective depth (d_b) of the batten plates be less than twice the contact width of one member in the plane of battens.

TABLE 6.1B MAXIMUM PERMISSIBLE BENDING STRESSES, σ_{bc} (MPa), IN EQUAL FLANGE I-BEAMS OR CHANNELS (Clause 6.2.2)

with f_y = 250 Mpa, $\frac{T}{t} \leq 2.0$ and $\frac{d_1}{t} \leq 85$

l/r_y ↓ D/T →	8	10	12	14	16	18	20	25	30	35	40	50	60	80	100
40	161	161	160	160	160	160	160	159	159	159	159	159	159	159	159
45	161	160	159	159	158	158	158	157	157	157	157	157	157	157	157
50	160	[illegible]	158	157	156	156	156	155	155	155	154	154	154	154	154
55	[illegible]	[illegible]	156	155	154	154	153	153	152	152	152	151	151	151	151
60	158	156	154	153	152	152	151	150	149	149	149	148	148	148	148
65	156	154	153	151	150	149	148	147	146	146	145	145	144	144	144
70	155	153	151	149	149	147	146	144	143	142	142	141	141	140	140
75	154	152	149	147	146	144	143	141	140	139	138	137	137	136	136
80	153	150	148	145	143	142	140	138	136	135	134	133	132	132	132
85	152	149	146	143	141	139	138	135	133	131	130	129	128	127	127
90	151	147	144	141	139	137	135	131	129	127	126	125	124	123	123

PERMISSIBLE STRESS IN AXIAL COMPRESSION (N/mm2) FOR STEEL

SECTIONS WITH YIELD STRESS = 250N/mm^2

KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac
1	150.0	17	149.0	33	143.6	49	132.6	65	117.0	81	99.7	97	83.3
2	150.0	18	148.8	34	143.1	50	131.7	66	115.9	82	98.6	98	82.3
3	150.0	19	148.6	35	142.6	51	130.8	67	114.8	83	97.6	99	81.4
4	150.0	20	148.4	36	142.0	52	129.9	68	113.8	84	96.5	100	80.5
5	150.0	21	148.1	37	141.4	53	129.0	69	112.7	85	95.4	101	79.5
6	149.9	22	147.9	38	140.8	54	128.1	70	111.6	86	94.4	102	78.6
7	149.9	23	147.6	39	140.2	55	127.1	71	110.5	87	93.3	103	77.7
8	149.9	24	147.3	40	139.5	56	126.1	72	109.4	88	92.3	104	76.8
9	149.8	25	147.0	41	138.8	57	125.2	73	108.4	89	91.3	105	75.9
10	149.8	26	146.7	42	138.1	58	124.2	74	107.3	90	90.3	106	75.0
11	149.7	27	146.3	43	137.4	59	123.2	75	106.2	91	89.2	107	74.1
12	149.6	28	145.9	44	136.6	60	122.2	76	105.1	92	88.2	108	73.3
13	149.5	29	145.5	45	135.8	61	121.1	77	104.0	93	87.2	109	72.4
14	149.4	30	145.1	46	135.1	62	120.1	78	102.9	94	86.2	110	71.6
15	149.3	31	144.6	47	134.2	63	119.1	79	101.8	95	85.2	111	70.7
16	149.1	32	144.1	48	133.4	64	118.0	80	100.8	96	84.3	112	69.9

PERMISSIBLE STRESS IN AXIAL COMPRESSION (N/mm2) FOR STEEL

SECTIONS WITH YIELD STRESS = 250N/mm^2

KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac	KL/r	Fac
113	69.1	129	57.4	145	47.9	161	40.4	177	34.3	193	29.4	209	25.5
114	68.3	130	56.7	146	47.4	162	39.9	178	34.0	194	29.2	210	25.3
115	67.5	131	56.1	147	46.9	163	39.5	179	33.6	195	28.9	211	25.0
116	66.7	132	55.4	148	46.4	164	39.1	180	33.3	196	28.6	212	24.8
117	65.9	133	54.8	149	45.9	165	38.7	181	33.0	197	28.4	213	24.6
118	65.2	134	54.2	150	45.4	166	38.3	182	32.7	198	28.1	214	24.4
119	64.4	135	53.6	151	44.9	167	37.9	183	32.4	199	27.9	215	24.2
120	63.7	136	53.0	152	44.4	168	37.6	184	32.1	200	27.6	216	24.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31.7	201	27.4	217	23.8
122	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31.4	202	27.1	218	23.6
123	61.5	139	51.2	155	43.0	171	36.4	187	31.1	203	26.9	219	23.4
124	60.8	140	50.7	156	42.6	172	36.1	188	30.9	204	26.6	220	23.2
125	60.1	141	50.1	157	42.1	173	35.7	189	30.6	205	26.4	221	23.0
126	59.4	142	49.5	158	41.7	174	35.4	190	30.3	206	26.2	222	22.8
127	58.7	143	49.0	159	41.2	175	35.0	191	30.0	207	25.9	223	22.6
128	58.0	144	48.5	160	40.8	176	34.7	192	29.7	208	25.7	224	22.4

SIZES AND PROPERTIES OF STEEL TUBES FOR STRUCTURAL PURPOSES

(REF: IS:1161-1998)

{Wt. IN kg/m:NB15 (OD:21.3): (L)0.947/(M)1.21/(H)1.44) Wt. IN kg/m:NB20 (OD:26.9): (L)1.38/(M)1.56/(H)1.87}

NOMINAL BORE mm	OUTSIDE DIA METER mm	CLASS	THICKNESS mm	Wt Kg/m	A cm^2	MOMENT OF INERTIA cm^4	MODULUS OF SECTION cm^3	RADIUS OF GYRATION cm	SQ. OF RADIUS OF GYRATION cm^2
25	33.7	LIGHT	2.60	1.98	2.54	3.09	1.83	1.10	1.21
		MEDIUM	3.20	2.41	3.06	3.61	2.14	1.08	1.17
		HEAVY	4.00	2.93	3.73	4.19	2.48	1.05	1.11
32	42.4	LIGHT	2.60	2.54	3.25	6.47	3.05	1.41	1.98
		MEDIUM	3.20	3.10	3.94	7.62	3.59	1.39	1.93
		HEAVY	4.00	3.79	4.82	8.99	4.24	1.36	1.86
40	48.3	LIGHT	2.90	3.23	4.13	10.70	4.43	1.61	2.59
		MEDIUM	3.20	3.56	4.53	11.59	4.80	1.59	2.54
		HEAVY	4.00	4.37	5.56	13.77	5.70	1.57	2.47
50	60.3	LIGHT	2.90	4.08	5.23	21.59	7.16	2.03	4.13
		MEDIUM	3.60	5.03	6.41	25.88	8.58	2.00	4.02
		HEAVY	4.50	6.19	7.88	30.90	10.20	1.98	3.92
65	76.1	LIGHT	3.20	5.71	7.32	48.79	12.82	2.58	6.66
		MEDIUM	3.60	6.42	8.20	54.02	14.20	2.57	6.60
		HEAVY	4.50	7.93	10.10	65.12	17.10	2.54	6.43
80	88.9	LIGHT	3.20	6.72	8.61	79.23	17.82	3.03	9.19
		MEDIUM	4.00	8.36	10.70	96.36	21.68	3.00	9.00
		HEAVY	4.80	9.90	12.70	112.52	25.31	2.98	8.88

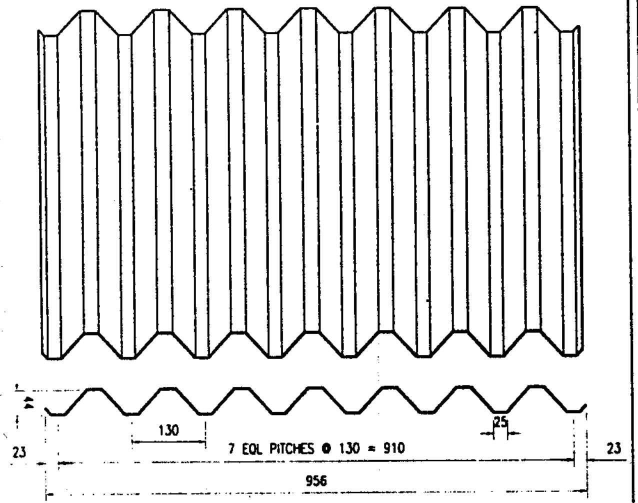
SIZES AND PROPERTIES OF STEEL TUBES FOR STRUCTURAL PURPOSES

NOMINAL BORE mm	OUTSIDE DIA METER mm	CLASS	THICKNESS mm	Wt Kg/m	A cm^2	MOMENT OF INERTIA cm^4	MODULUS OF SECTION cm^3	RADIUS OF GYRATION cm	SQ. OF RADIUS OF GYRATION cm^2
90	101.6	LIGHT	3.60	8.70	11.10	133.27	26.23	3.47	12.03
		MEDIUM	4.00	9.63	12.30	146.32	28.80	3.45	11.91
		HEAVY	4.80	11.50	14.60	171.44	33.75	3.43	11.76
100	114.3	LIGHT	3.60	9.75	12.50	192.03	33.60	3.92	15.36
		MEDIUM	4.50	12.20	15.50	234.30	41.00	3.89	15.10
		HEAVY	5.40	14.50	18.50	274.50	48.00	3.85	14.86
110	127.0	LIGHT	4.50	13.6	17.3	325.3	[illegible]	4.33	18.78
		MEDIUM	4.80	14.5	18.4	344.58	[illegible]	4.32	18.69
		HEAVY	5.40	16.2	20.6	382.0	60.2	4.30	18.52
125	139.7	LIGHT	4.50	15.0	19.1	437.2	62.6	4.78	22.87
		MEDIUM	4.80	15.9	20.3	463.44	66.35	4.77	22.76
		HEAVY	5.40	17.9	22.8	514.5	73.7	4.75	22.58
135	152.4	LIGHT	4.50	16.4	20.9	572.2	75.1	5.23	27.37
		MEDIUM	4.80	17.5	22.2	606.92	79.65	5.22	27.25
		HEAVY	5.40	19.6	25.0	674.5	88.5	5.20	27.05

TRAPEZOIDAL DECKING PROFILE

(FOR COMPOSITE FLOORS & PERMANENT SHUTTERING)

PENNAR INDUSTRIES LIMITED (PIL 44 / 130)



GEOMETRICAL PROPERTIES

SL. No.	THICKNESS mm.	UNIT Wt. kg/sqm.	MOMENT OF INERTIA cm^4	SECTION MODULUS cm^3
1	0.63	6.43	21.03	9.557
2	0.80	8.16	26.70	12.137
3	1.00	10.20	33.38	15.171
4	1.25	12.75	41.72	18.965
5	1.60	16.32	53.41	24.278
6	2.00	20.40	66.77	30.351

TRAPEZOIDAL DECKING PROFILE

(FOR COMPOSITE FLOORS & PERMANE[illegible] SHUTTERING)

PENNAR INDUSTRIES LIMITED (PIL 44 / 130)

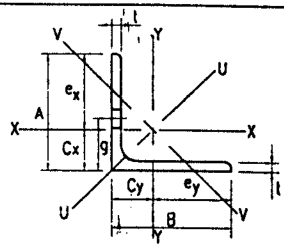
ALLOWABLE LOADS IN kg/sqm.

SL No.	THICKNESS mm.	SPAN IN METRES										
		1.00	1.20	1.40	1.50	1.60	1.70	2.00	2.50	3.00	3.50	4.00
1	0.63	1195	830	610	531	467	413	299	191	133	98	75
2	0.80	1517	1054	774	574	593	525	379	243	169	124	95
3	1.00	1898	1317	966	843	741	656	474	303	211	155	119
4	1.25	2371	1646	1210	1054	926	820	593	379	263	194	148
5	1.60	3035	2107	1548	1348	1185	1050	759	486	337	248	190
6	2.00	3794	2635	1936	1686	1482	1313	948	607	422	310	237

NOTES:

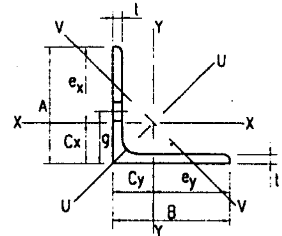
1. The properties given are for one metre width of the profile.
2. Material conforms to IS: 513 (D) quality. / IS 10748–1995 gr.2.
3. Basic design stress of material is 1250 kg/sqcm.
4. Limiting deflection is taken as span / 150.
5. Allowable loads are applicable for sheets spanning over a minimum of four supports and for permanent shuttering only.
6. Above allowable loads may be muliplied by a factor of 0.80 for sheets spanning over 2 or 3 supports.

PROPERTIES OF ANGLE SECTIONS



DESIGNATION ANGLES A x B x t	Mass Kg/m	a cm^2	Cx=Cy cm	Ix=Iy cm^4	Iu (MAX.) cm^4	Iv (MIN.) cm^4	$r_x = r_y$ cm	r_u (MAX.) cm	r_v (MIN.) cm	Zx=Zy cm^3	g mm	MAX. BOLT mm
80x 80x 6	7.3	9.29	2.18	56.0	89.6	22.5	2.46	3.11	1.56	9.6	45	20
80x 80x 8	9.6	12.2	2.27	72.5	116	29.4	2.44	3.08	1.55	12.6	45	20
80x 80x10	11.8	15.0	2.34	87.7	139	36.0	2.41	3.04	1.55	15.5	45	20
80x 80x12	14.0	17.8	2.42	102	161	42.4	2.39	3.01	1.54	18.3	45	20
90x 90x 6	8.2	10.5	2.42	80.1	128	32.0	2.77	3.50	1.75	12.2	50	20
90x 90x 8	10.8	13.8	2.51	104	166	42.0	2.75	3.47	1.75	16.0	50	20
90x 90x10	13.4	17.0	2.59	127	202	51.6	2.73	3.44	1.74	19.8	50	20
90x 90x12	15.8	20.2	2.66	148	235	60.9	2.71	3.41	1.74	23.3	50	20
100x100x 6	9.2	11.7	2.67	111	178	44.5	3.09	3.91	1.95	15.2	60	20
100x100x 8	12.1	15.4	2.76	145	232	58.4	3.07	3.88	1.95	20.0	60	20
100x100x10	14.9	19.0	2.84	177	282	71.8	3.05	3.85	1.94	24.7	60	20
100x100x12	17.7	22.6	2.92	207	329	84.7	3.03	3.82	1.94	29.2	60	20

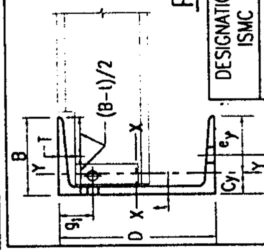
PROPERTIES OF ANGLE SECTIONS



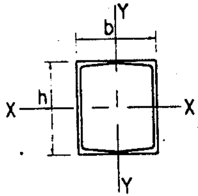
DESIGNATION ANGLES A x B x t	Mass Kg/m	a cm^2	Cx=Cy cm	Ix=Iy cm^4	Iu (MAX.) cm^4	Iv (MIN.) cm^4	$r_x = r_y$ cm	r_u (MAX.) cm	r_v (MIN.) cm	Zx=Zy cm^3	g mm	MAX. BOLT mm
110x110x 8	13.4	17.1	3.00	197	313	81.0	3.40	4.28	2.18	24.6	65	20
110x110x10	16.6	21.1	3.09	240	381	98.9	3.37	4.25	2.16	30.4	65	20
110x110x12	19.7	25.1	3.17	281	446	116	3.35	4.22	2.15	35.9	65	20
110x110x16	25.7	32.8	3.32	357	560	150	3.30	4.15	2.14	46.5	65	20
130x130x 8	15.9	20.3	3.50	331	526	136	4.04	5.10	2.59	34.9	80	20
130x130x10	19.7	25.1	3.59	405	640	166	4.02	5.07	2.57	43.1	80	20
130x130x12	23.5	29.9	3.67	476	757	196	3.99	5.03	2.56	51.0	80	20
130x130x16	30.7	39.2	3.82	609	966	250	3.94	4.97	2.54	66.3	80	20
150x150x10	22.9	29.2	4.08	634	1010	260	4.66	5.87	2.98	58.0	90	22
150x150x12	27.3	34.8	4.16	746	1190	306	4.63	5.84	2.97	68.8	90	22
150x150x16	35.8	45.6	4.31	959	1520	395	4.58	5.77	2.94	89.7	90	22
150x150x20	44.1	56.2	4.46	1160	1830	481	4.53	5.71	2.93	110	90	22
200x200x12	36.9	46.9	5.39	1830	2910	747	6.24	7.87	3.99	125	115	27
200x200x16	48.5	61.8	5.56	2370	3760	968	6.19	7.80	3.96	164	115	27
200x200x20	60.0	76.4	5.71	2880	4570	1180	6.14	7.73	3.93	201	115	27
200x200x25	73.9	94.1	5.90	3470	5500	1440	6.07	7.61	3.91	246	115	27

PROPERTIES OF CHANNEL SECTIONS

DESIGNATION ISMC	Mass Kg/m	a Cm²	t mm	T mm	Cy cm	Ix cm⁴	Iy cm⁴	rx cm	ry cm	Zx cm³	Zy cm³	g mm	g1 Min. mm	MAX. BOLT mm
75 x 40	7.14	9.1	4.8	7.5	1.32	78.5	12.9	2.94	1.19	20.9	4.81	21	-	12
100 x 50	9.56	12.2	5.0	7.7	1.54	192	26.7	3.97	1.48	38.4	7.71	28	50	16
125 x 65	13.1	16.7	5.3	8.2	1.95	425	61.1	5.05	1.91	68.1	13.4	35	55	22
150 x 75	16.8	21.3	5.7	9.0	2.2	788	103	6.08	2.20	105	19.5	40	55	25
175 x 75	19.6	24.9	6.0	10.2	2.19	1240	122	7.04	2.21	141	23.0	40	55	25
200 x 75	22.3	28.5	6.2	11.4	2.2	1830	141	8.02	2.22	183	26.4	40	60	25
225 x 80	26.1	33.3	6.5	12.4	2.31	2710	188	9.02	2.37	241	33.0	45	60	25
250 x 80	30.6	39.0	7.2	14.1	2.3	3880	211	9.97	2.33	310	37.0	45	65	25
300 x 90	36.3	46.3	7.8	13.6	2.35	6420	313	11.8	2.60	428	47.1	50	65	28
350 x 100	42.7	54.4	8.3	13.5	2.44	10000	434	13.6	2.82	571	57.3	60	65	28
400 x 100	50.1	63.8	8.8	15.3	2.42	15200	508	15.4	2.82	760	67.0	60	70	28



PROPERTIES OF BOX CHANNEL SECTIONS



CHANNELS SIZE h x b	DESIGNATION	Mass Kg/m	a cm²	Ixx cm⁴	Iyy cm⁴	Zxx cm³	Zyy cm³	rxx cm	ryy cm
75x 80	ISMC 75	14.28	18.2	157	156.52	41.87	39.13	2.94	2.93
100x100	ISMC 100	19.12	24.4	384	345.51	76.8	69.10	3.97	3.76
125x130	ISMC 125	26.2	33.4	850	813.66	136.0	125.18	5.04	4.94
150x150	ISMC 150	33.6	42.6	1576	1402.63	210.13	187.02	6.08	5.74
175x150	ISMC 175	39.2	49.8	2480	1648.17	283.43	219.76	7.06	5.75
200X150	ISMC 200	44.6	57.0	3660	[illegible]3.13	366	251.08	8.01	5.75
225x160	ISMC 225	52.2	66.6	542[illegible]	[illegible].25	481.78	316.53	9.02	6.17
250x160	ISMC 250	61.2	78.0	77[illegible]	[illegible]22	620.8	369.53	9.97	6.16
300x180	ISMC 300	72.6	92.6	12840	[illegible]	856	524.56	11.78	7.14
350x200	ISMC 350	85.4	108.8	20000	[illegible].31	1142.86	708.63	13.56	8.07
400x200	ISMC 400	100.2	127.6	30400	[illegible].44	1520	834.74	15.43	8.09

LINEPIPE DIMENSIONS

NOMINAL PIPE SIZE 'INCH'	OUTSIDE DIAMETER 'mm'	SCHEDULE 10 'mm'	SCHEDULE 20 'mm'	SCHEDULE 30 'mm'	STANDARD WEIGHT 'mm'	SCHEDULE 40 'mm'	EXTRA STRONG 'mm'	SCHEDULE 60 'mm'	SCHEDULE 80 'mm'	SCHEDULE 100 'mm'	SCHEDULE 120 'mm'	SCHEDULE 140 'mm'	SCHEDULE 160 'mm'	DOUBLE EXTRA STRONG 'mm'
1/4	13.7				2.24	2.24	3.02		3.02					
3/8	17.1				2.31	2.31	3.20		3.20					
1/2	21.3				2.77	2.77	3.73		3.73				4.78	7.47
3/4	26.7				2.87	2.87	3.91		3.91				5.56	7.82
1	33.4				3.38	3.38	4.55		4.55				6.35	9.09
1 1/4	42.2				3.56	3.56	4.85		4.85				6.35	9.70
1 1/2	48.3				3.68	3.68	5.08		5.08				7.14	10.15
2	60.3				3.91	3.91	5.54		5.54				8.74	11.07
2 1/2	73.0				5.16	5.16	7.01		7.01				9.53	14.02
3	88.9				5.49	5.49	7.62		7.62				11.13	15.24
3 1/2	101.6				5.74	5.74	8.08		8.08					
4	114.3				6.02	6.02	8.56		8.56		11.13		13.49	17.12
5	141.3				6.55	6.55	9.53		9.53		12.70		15.88	19.05
6	168.3				7.11	7.11	10.97		10.97		14.27		18.26	21.95
8	219.1		6.35	7.04	8.18	8.18	12.70	10.31	12.70	15.09	18.26	20.62	23.01	22.23
10	273.1		6.35	7.80	9.27	9.27	12.70	12.70	15.09	18.26	21.44	25.40	28.58	25.40
12	323.9		6.35	8.38	9.53	10.31	12.70	14.27	17.48	21.44	25.40	28.58	33.32	25.40
14	355.6	6.35	7.92	9.53	9.53	11.13	12.70	15.09	19.05	23.83	27.79	31.75	35.71	
16	406.4	6.35	7.92	9.53	9.53	12.70	12.70	16.66	21.44	26.19	30.96	36.53	40.49	
18	457	6.35	7.92	11.13	9.53	14.20	12.70	19.05	23.83	29.36	34.93	39.67	45.24	
20	508	6.35	9.53	12.70	9.53	15.09	12.70	20.62						
22	559	6.35	9.53	12.70	9.53		12.70							
24	610	6.35	9.53	14.27	9.53	17.48	12.70	24.61						
26	660	7.92	12.70		9.53		12.70							
28	711	7.92	12.70	15.88	9.53		12.70							
30	762	7.92	12.70	15.88	9.53		12.70							
32	813	7.92	12.70	15.88	9.53	17.48	12.70							
34	864	7.92	12.70	15.88	9.53	17.48	12.70							
36	914	7.92	12.70	15.88	9.53	19.05	12.70							

STRUCTURAL STEEL, RAILS, TUBES AND PIPES

LINEPIPE WEIGHTS

NOMINAL PIPE SIZE 'INCH'	OUTSIDE DIAMETER 'mm'	SCHEDULE 10 Kg/m	SCHEDULE 20 Kg/m	SCHEDULE 30 Kg/m	STANDARD WEIGHT Kg/m	SCHEDULE 40 Kg/m	EXTRA STRONG Kg/m	SCHEDULE 60 Kg/m	SCHEDULE 80 Kg/m	SCHEDULE 100 Kg/m	SCHEDULE 120 Kg/m	SCHEDULE 140 Kg/m	SCHEDULE 160 Kg/m	DOUBLE EXTRA STRONG Kg/m
1/4	13.7				0.63	0.63	0.80		0.80					
3/8	17.1				0.85	0.85	1.10		1.10					
1/2	21.3				1.27	1.27	1.62		1.62				1.95	2.55
3/4	26.7				1.68	1.68	2.19		2.19				2.89	3.63
1	33.4				2.50	2.50	3.23		3.23				4.23	5.45
1 1/4	42.2				3.38	3.38	4.47		4.47				5.60	7.76
1 1/2	48.3				4.05	4.05	5.41		5.41				7.24	9.55
2	60.3				5.44	5.44	7.48		7.48				11.11	13.45
2 1/2	73.0				8.62	8.62	11.41		11.41				14.91	20.39
3	88.9				11.29	11.29	15.27		15.27				21.33	27.67
3 1/2	101.6				13.57	13.57	18.62		18.62					
4	[illegible]				16.07	16.07	22.31		22.31		28.30		33.53	41.02
5	141.3				21.78	21.78	[illegible]		30.95		40.28		49.09	57.42
6	[illegible]				[illegible]	28.26	[illegible]		[illegible]		54.20		67.55	79.18
8	219.1		33.31	36.79	42.53	42.53	64.63	53.09	64.63	75.89	90.43	100.93	111.25	107.87
10	273.1		41.77	51.00	60.29	60.29	81.54	81.54	95.97	114.74	133.00	155.10	172.25	155.10
12	323.9		49.72	65.20	73.82	79.72	97.44	108.96	132.01	159.85	186.92	208.04	238.72	186.92
14	355.6	54.68	67.94	81.28	81.28	94.49	107.38	126.68	158.08	194.90	224.60	253.53	281.68	
16	406.4	62.63	77.86	93.21	93.21	123.29	123.29	160.12	203.48	245.50	286.62	333.11	365.30	
18	457	70.59	87.79	122.36	105.14	156.91	139.19	205.80	254.59	309.76	363.65	408.45	459.51	
20	508	78.54	117.07	155.10	117.07	183.37	155.10	247.85						
22	559	86.50	129.01	171.01	129.01		171.01							
24	610	94.45	140.94	209.54	140.94	255.14	186.92	355.02						
26	660	127.50	202.83		152.87		202.83							
28	711	137.42	218.73	272.18	164.80		218.73							
30	762	147.36	234.64	292.06	176.73		234.64							
32	813	157.28	250.55	311.95	188.66	342.70	250.55							
34	864	167.20	266.46	331.83	200.59	364.58	266.46							
36	914	177.13	282.36	351.72	212.52	420.56	282.36							

APPENDIX A

(CLAUSES 0.3 AND 8.3)

SUPPLEMENTARY LIST OF CRANE RAIL SECTIONS

A - 1. THE DIMENSIONS OF 22, 30, 32, 43, 45, 52A, 52B, 57, 67, 74, 75, 101 AND 125 kg/m CRANE RAIL SECTIONS ARE GIVEN IN TABLE 6 AND FIG. 2 TO 8. THE SECTIONAL PROPERTIES ARE GIVEN IN TABLE 5.

TABLE - 5 (IS:3443-1980)

SECTIONAL PROPERTIES OF NON-METRIC CRANE RAIL SECTIONS

DESIGNATION	AREA	WEIGHT	MOMENT OF INERTIA I_{xx}	SECTION MODULES Z_{xx}	RADIUS OF GYRATION r_{xx}	DISTANCES OF NEUTRAL AXIS e_x	REFERENCE TO FIG./TABLE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
kg/m	cm^2	kg/m	cm^4	cm^3	cm	cm	
22	28.3	22.2	91	27.5	1.79	3.31	TABLE 6
30	38.0	29.8	681	116	4.23	5.87	FIG 2
32	40.7	32.0	182	46.9	2.11	3.88	TABLE 6
43	55.4	43.5	327	73.7	2.42	4.44	TABLE 6
45	56.7	44.5	1584	212	5.30	7.48	FIG 3
52.1	66.0	52.1	1204	199	4.27	6.64	FIG 4
52.2	66.5	52.2	1270	198	4.37	6.43	FIG 5
57	72.1	56.6	545	109	2.74	5.00	TABLE 6
67	85.4	67.0	2705	311	5.63	8.70	FIG 6
74	94.8	74.4	895	170	3.07	5.24	FIG 7
75	95.6	75.2	888	170	3.05	5.21	TABLE 6
101	129	101	1420	249	3.32	5.70	TABLE 6
125	158	122	3745	492	4.87	7.60	FIG 8

ALL DIMENSIONS ARE IN MILLIMETRES

TOLERANCES

(Table 4-IS 3443-1980)

DIMENSION	RAIL SECTION ISCR 50,60 & 80	ISCR 100	ISCR 120 AND 140
HEAD WIDTH	± 2	± 2	+ 2 - 3
THICKNESS OF HEAD	± 1	± 1	± 1
FLANGE WIDTH	± 2	+ 2 - 3	+ 2 - 4
WEB THICKNESS	± 2	± 2	± 2
HEIGHT	± 1	± 1.5	± 2
LENGTH	+ 100 0	+ 100 0	+ 100 0
WEIGHT	+ 3 - 2 PERCENT	+ 3 - 2 PERCENT	+ 3 - 2 PERCENT

10. MARKING

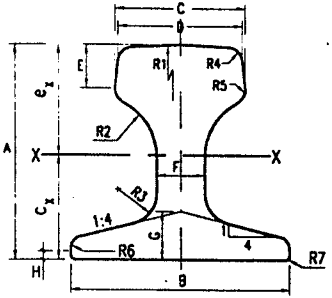
10.1 CRANE RAIL SECTIONS SHALL BE MARKED WITH THE FOLLOWING DETAILS:

a) MANUFACTURER'S IDENTIFICATION MARK, AND

b) DESIGNATION (ISCR (OR) Kg/m AS APPROPRIATE)

10.1.1 THE MATERIAL MAY ALSO BE MARKED WITH THE ISI CERTIFICATION MARK.

TABLE-2 DIMENSIONS OF CRANE RAILS



DIMENSIONS, mm

DESIGNATION (1)	A (2)	B (3)	C (4)	D (5)	E (6)	F (7)	G (8)	H (9)	R_1 (10)	R_2 (11)	R_3 (12)	R_4 (13)	R_5 (14)	R_6 (15)	R_7 (16)
1SCR 50	90	90	55	50	25	20	20	9.70	300	26	18	6	6	5	1.5
1SCR 60	105	105	65.5	60	27.5	24	22	9.82	350	32	20	6	6	5	1.5
1SCR 80	130	130	87	80	35	32	26	9.75	400	44	26	8	8	6	1.5
1SCR 100	150	150	108	100	40	38	30	11.2	450	50	30	8	8	8	2.0
1SCR 120	170	170	129	120	45	44	35	15.3	500	56	34	8	8	8	2.0
1SCR 140	170	170	150	140	50	60	40	20.6	700	60	40	10	10	10	3.0

9. FREEDOM FROM DEFECTS

9.1 THE RAILS SHOULD BE REASONABLY FREE FROM TWIST AND THE CAMBER SHALL NOT EXCEED 0.2 PERCENTAGE OF THE LENGTH.

9.2 THE ASYMMETRY OF THE RAIL CROSS SECTION WITH RESPECT TO THE VERTICAL AXIS SHALL NOT EXCEED 2 mm AND 0.6 mm IN THE RAIL FLANGE AND HEAD RESPECTIVELY.

CRANE RAIL SECTIONS BASED ON IS 3443-1980

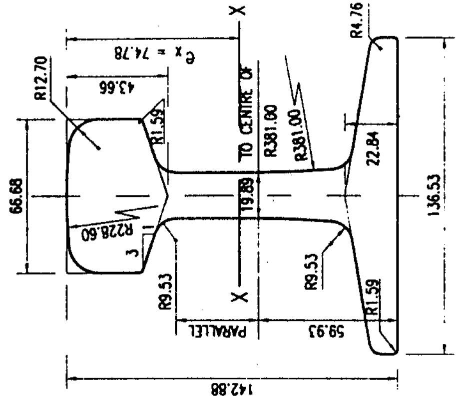


Fig. 3 45 kg/m

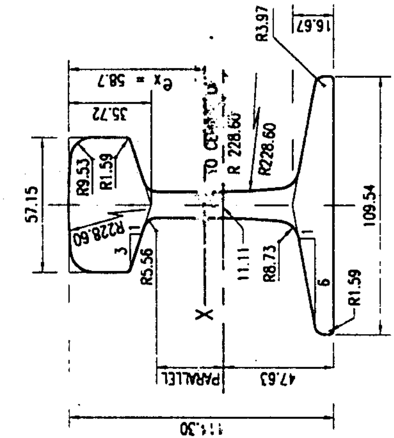


Fig. 2 30 kg/m

ALL DIMENSIONS ARE IN MILLIMETRES

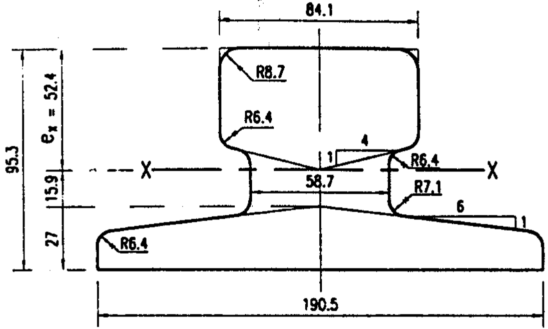


Fig. 7 74 kg/m CRANE RAIL SECTION

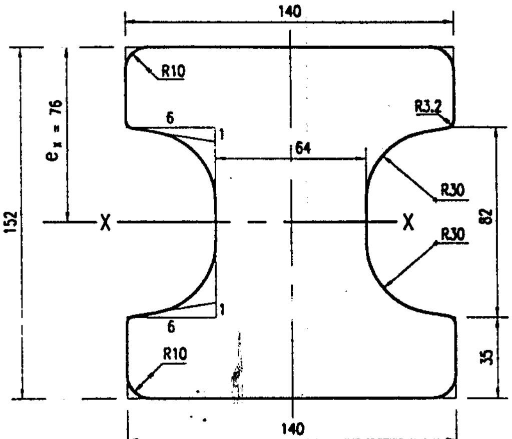
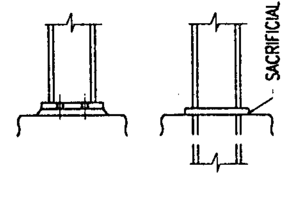
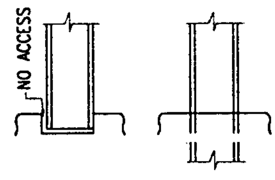
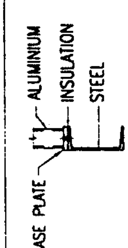
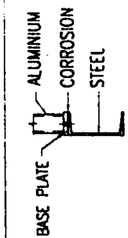


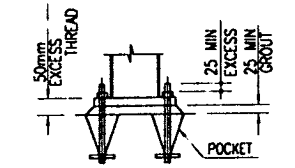
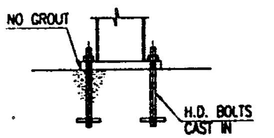
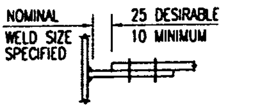
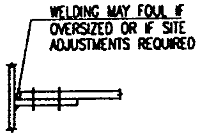
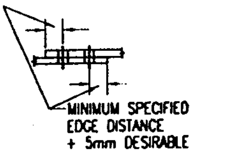
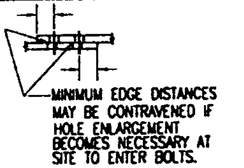
Fig. 8 125 kg/m CRANE RAIL SECTION

ALL DIMENSIONS ARE IN MILLIMETRES

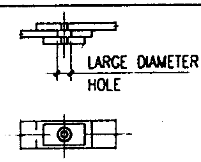
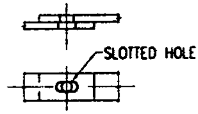
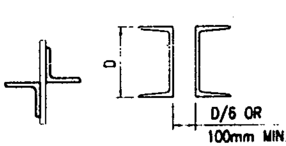
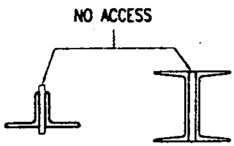
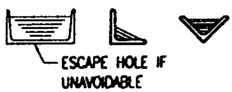
DO'S AND DON'TS IN STRUCTURAL STEEL FABRICATION

DETAIL	DOS	DON'TS	REMARKS
BEAMS TO WALLS			CORROSION AT CONCRETE INTERFACE
BIMETALLIC CORROSION	 BOLTS WITH SLEEVES AND INSULATION WASHERS	 NO INSULATION	BIMETALLIC CORROSION

DO'S AND DON'TS IN STRUCTURAL STEEL FABRICATION

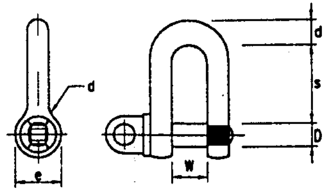
DETAIL	DOS	DONT'S	REMARKS
H.D. BOLTS			SITE PROBLEM
CLEARANCE OF JOINT NEAR WELDS			SITE PROBLEM
MINIMUM EDGE DISTANCE FOR HOLES			SITE PROBLEM

DO'S AND DON'TS IN STRUCTURAL STEEL FABRICATION

DETAIL	DO'S	DONT'S	REMARKS
HOLES REQUIRING TOLERANCE e.g. FOR EXPANSION OR WHERE SITE TOLERANCE TO BE ACCOMMODATED		 DISADVANTAGES: 1. TOLERANCE IN ONLY ONE DIRECTION 2. SLOT HOLES EXPENSIVE 3. CORROSION TRAP	UN ECONOMIC
MEMBERS			MAINTENANCE EASIER
CHANNELS & ANGLES			CORROSION TRAP

DIMENSIONS OF DEE SHACKLES AND EYE DIAMETERS

(EXTRACTS FROM IS:6132 (PART-II)-1972)



JAW INSIDE WIDTH W (1)	INSIDE LENGTH s=2.2W (2)	BODY MATERIAL DIAMETER d (3)	PIN DIAMETER D_{min} (4)	EYE OUTSIDE DIAMETER e_{min} (5)	SAFE WORKING LOAD TONNES GRADE 30 (6)	GRADE 40 (7)	GRADE 63 (8)
18	40	10	12	24	-	-	1.0
20	44	12	14	28	-	1.0	1.25
22	49	14	16	32	1.0	1.25	1.6
25	55	16	19	38	1.25	1.6	2.0
28	62	17	20	40	1.6	2.0	2.5
32	70	19	22	44	2.0	2.5	3.2
34	79	22	26	52	2.5	3.2	4.0
40	88	24	28	56	3.2	4.0	5.0
45	99	27	31	62	4.0	5.0	6.3
50	110	30	35	70	5.0	6.3	8.0
56	124	34	39	78	6.3	8.0	10.0
63	139	38	44	88	8.0	10.0	12.5
70	154	43	50	100	10.0	12.5	16.0
80	176	48	55	110	12.5	16.0	20.0
90	198	54	62	124	16.0	20.0	25.0
100	220	60	69	138	20.0	25.0	32.0
107	236	66	76	152	25.0	32.0	40.0
117	258	71	82	164	32.0	40.0	50.0
130	286	79	91	182	40.0	50.0	63.0
140	308	84	97	194	50.0	63.0	80.0
153	337	93	110	220	63.0	80.0	-

GENERAL ENGINEERING ROPES

ROUND STRAND 6 x 19 (12/6/1) FIBRE CORE

DIA METER D mm	TOLE-RANCE %	APPROX. MASS kg/100 Metres	MINIMUM BREAKING LOAD OF THE ROPE CORRESPONDING TO TENSILE DESIGNATION OF THE WIRES OF: 160 kgf/mm^2 OR 1570 N/mm^2		180 kgf/mm^2 OR 1770 N/mm^2		200 kgf/mm^2 OR 1960 N/mm^2	
			10^3 kgf.	KN	10^3 kgf.	KN	10^3 kgf.	KN
1	2	3	4	5	6	7	8	9
3	+7, - 1	3.10	0.44	4.3	0.50	4.9	0.55	5.40
4	+6, - 1	5.50	0.79	7.7	0.90	8.7	0.98	9.60
5	"	8.60	1.23	12.0	1.39	13.6	1.50	15.00
6	+5, - 1	12.40	1.77	17.4	2.00	19.6	2.20	21.50
7	"	17.00	2.40	23.5	2.72	27.0	3.00	29.50
8	+4, - 1	22.00	3.15	31.0	3.56	35.0	3.90	38.50
9	"	28.00	4.00	39.0	4.50	44.0	5.00	48.80
10	"	35.00	4.90	48.0	5.56	54.5	6.10	60.20
11	"	42.00	5.90	58.4	6.72	66.0	7.43	72.80
12	"	50.00	7.10	69.5	8.00	78.5	8.80	86.70
13	"	58.00	8.30	81.5	9.39	92.0	10.40	102.00
14	"	68.00	9.60	94.5	10.90	107.0	12.00	118.00
15	"	78.00	11.10	108.0	12.50	123.0	13.80	136.00
16	"	88.00	12.60	123.0	14.20	139.0	15.70	154.00
17	"	100.00	14.20	139.0	16.10	157.0	17.70	174.00
18	"	112.00	15.90	156.0	18.00	176.0	19.90	195.00
19	"	125.00	17.80	174.0	20.10	197.0	22.20	217.00
20	"	138.00	19.80	19[illegible]	[illegible]2.20	218.0	24.60	241.00
21	"	152.00	21.70	21[illegible]	[illegible].50	240.0	27.10	266.00
22	"	167.00	23.80	233.0	[illegible]7.00	264.0	29.70	291.00

IS 1367 PART III - 1991 EDITION/ISO: 898-1: 1988 (MECHANICAL PROPERTIES OF H.T. STEEL)

MECHANICAL PROPERTY		PROPERTY CLASS 3.6	4.6	4.8	5.6	5.8	6.8	8.8 d≤16	8.8 d>16	9.8	10.9	12.9
TENSILE STRENGTH N/mm^2	Nom	300	400	400	500	500	600	800	800	900	1000	1200
	Min	330	400	420	500	520	600	800	830	900	1040	1220
LOWER YIELD STRESS N/mm^2	Nom	180	240	320	300	400	480	-	-	-	-	-
	Min	190	240	340	300	420	480	-	-	-	-	-
PROOF STRESS N/mm^2	Nom	-	-	-	-	-	-	640	640	720	900	1080
	Min	-	-	-	-	-	-	640	660	720	940	1100
ELONGATION AFTER FRACTURE	Min	25	22	14	20	10	8	12	12	10	9	8
BRINELL HARDNESS	Min	90	114	124	147	152	181	238	242	276	304	366
	Max	238	238	238	238	238	238	304	318	342	361	414

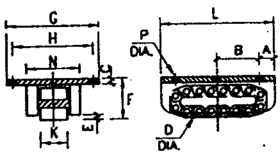
NOTE: Mechanical properties to be developed in the steel are dependent upon the shape and size (i.e, ruling section) at the time of heat treatment.

REF: IS 2062-1999/BS970 PART-1.1972/BS970 PART-2.1970 (CHEMICAL PROPERTIES OF H.T. STEEL)

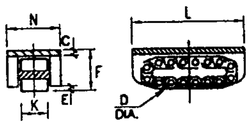
GRADES	MATERIAL (see note)		Min	CARBON	MANGANESE	PHOSPHORUS	SULPHUR	SILICON	CHROMIUM	NICKEL	MOLYBDENUM
4.6 4.8	IS:2062	Gr-A	Max	0.23	1.5	0.050	0.050	0.4			
		Gr-B	Max	0.22	1.5	0.045	0.045	0.4			
		Gr-C	Max	0.20	1.5	0.040	0.040	0.4			
5.6 5.8 6.8/8.8	080M40* (En-8)		Min	0.36	0.60						
			Max	0.44	1.00						
5.6 5.8 6.8/8.8	070M55* (En-9)		Min	0.50	0.50						
			Max	0.60	0.90						
9.8 10.9	709M40* (En-19)		Min	0.36	0.70			0.10	0.90		0.25
			Max	0.44	1.00			0.35	1.20		0.35
12.9	817M40* (En-24)		Min	0.36	0.45			0.10	1.00	1.30	0.20
			Max	0.44	0.70			0.35	1.40	1.70	0.35

* - MARKED STEEL REPLACES CORRESPONDING En STEEL (REF. BS: 970 PART-2 : 1970)

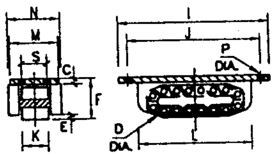
HILMAN ROLLERS



OT/ XOT STYLE

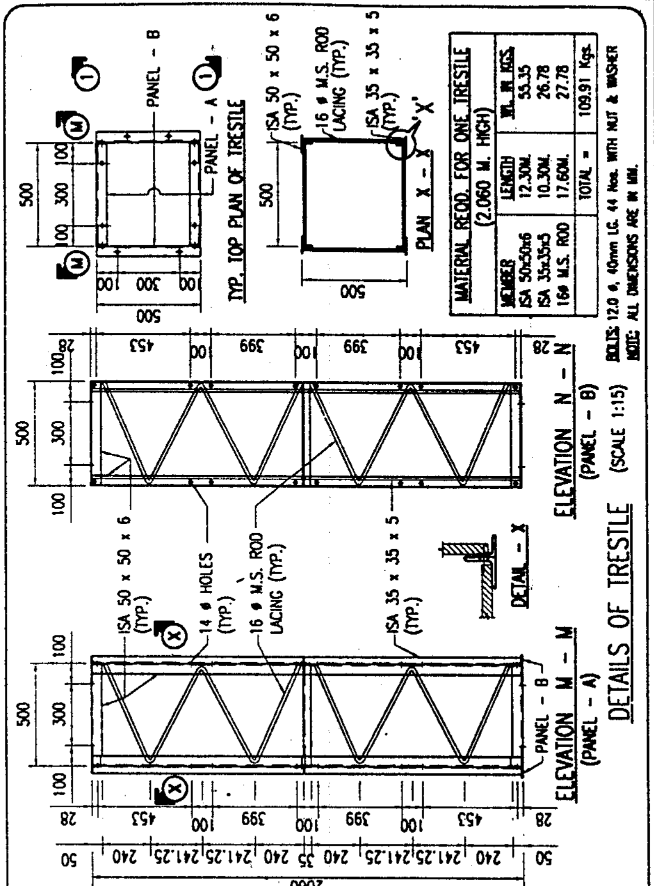


T STYLE



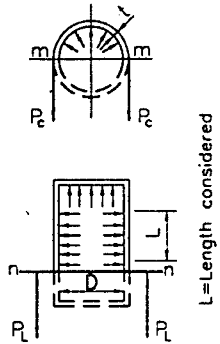
NT STYLE

PRODUCT NUMBERS OT STYLE	NT STYLE	T STYLE	CAPACITY (TONS.)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	S	CONTACT ROLLS	LBS/KGS OT	LBS/KGS NT	LBS/KGS T
0.75-OT	0.75-NT	0.75-T	0.75	3/4 19	2-1/2 64	3/8 10	11/16 17	3/8 10	3-1/8 79	7 178	5-1/2 140	8 203	7-1/4 184	2 51	6-1/2 165	3-1/2 89	3-5/8 92	5/16 8	2 51	6	12 5	12 5	11 5
2.5-OT	2.5-NT	2.5-T	2.5	3/4 19	2-1/2 64	3/8 [illegible]	15/16 24	3/8 10	3-5/8 92	7 178	5-1/2 14	9-1/2 241	8 203	2-7/16 62	6-1/2 165	4 102	4-1/8 105	9/16 14	2 51	4	21 10	19 9	17 8
5-OT	5-NT	5-T	5	3/4 19	3-1/4 [illegible]	3/8 10	[illegible] 24	[illegible]	[illegible]	8 203	[illegible]	[illegible]1-3/4 [illegible]	10-1/8 257	2-7/16 62	8 203	4-1/2 114	4-7/16 113	9/16 14	3 76	5	22 10	21 10	19 9
8-OT	8-NT	8-T	8	3/4 19	3-1/4 83	3/8 10	15/16 24	7/16 11	3-1/8 79	[illegible] 203	6-3/4 171	11-3/4 298	10-1/8 257	3-5/16 84	8 203	5 127	5-5/16 135	9/16 14	3 76	5	25 11	23 10	23 10
15-OT	15-NT	15-T	15	1-5/8 41	3-11/16 94	5/8 16	1-3/16 30	1/2 13	3-7/8 98	10 254	8-1/2 216	14-3/4 375	12-11/16 322	2-3/4 70	10-5/8 270	5 127	5-3/16 132	11/16 17	2-5/16 59	5	25 11	23 10	23 10
20-OT	20-NT	20-T	20	1-5/8 41	3-11/16 94	5/8 16	1-3/16 30	1/2 13	3-7/8 98	10 254	8-1/2 216	14-3/4 375	12-11/16 322	4 102	10-5/8 270	6-1/2 165	6-7/16 164	11/16 17	3-1/2 89	5	49 22	49 22	49 22
37.5-OT	37.5-NT	37.5-T	37.5	2 51	5-1/2 140	3/4 19	1-5/8 41	5/8 16	5-1/2 140	12 305	10-1/2 267	21 533	18-3/4 476	3-1/2 89	15 381	7 178	7 178	13/16 21	4-1/4 108	6	121 55	114 52	105 48
50-OT	50-NT	50-T	50	3-3/4 95	5-1/2 140	3/4 19	1-5/8 41	5/8 16	5-1/2 140	12 305	10-1/2 267	21 533	18-3/4 476	3-1/2 89	18-1/2 470	7 178	7 178	13/16 21	4-1/4 108	8	147 67	142 64	138 63
75-OT	75-NT	75-T	75	1-1/4 32	9-1/4 235	1 25	1-15/16 49	1/2 13	6-3/4 171	14 356	11-1/2 292	27 686	24 610	3-5/8 92	21 533	7-1/2 191	7-3/8 187	1-1/16 27	5 127	7	241 109	227 103	213 97
100-(XOT)			100	32.5	235	25	49	11	171	356	291	-	-	92	535	-	202	25					



THIN PIPES AND CYLINDERS: $(t/r_m) < (1/10)$

INTERNAL PRESSURE.



Hoop stress, sec.m–m,

$$P_c = \frac{wDL}{2};\quad f_c = \frac{wD}{2t} \text{ -------(a)}$$

Longitudinal stress, sec.n–n.

$$P_L = \frac{w\pi D^2}{4};\quad f_L = \frac{wD}{4t} \text{ ------(b)}$$

w=unit internal pressure.

Both Hoop and longitudinal stresses are independant of the form of the ends.

r_m = Mean radius

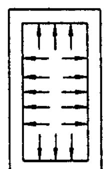
THICK PIPES AND CYLINDERS: $(t/r_m) \geq (1/10)$

INTERNAL PRESSURE.

Longitudinal ten le stress

$$f_{tl} = \frac{wa^2}{(b^2 -}$$

Tensile stress ɔop



$$f_{th} = \frac{a^2 w}{b^2 - (} \left(1 + \frac{b^2}{r^2} \right) \text{ (max. @ r=a)}$$

Radial compr e stress

$$f_r = \frac{a^2 w}{b^2 - a} \left(1 - \frac{b^2}{r^2} \right) \text{ (max. @ r=a)}$$

w = unit internal pressure. r_m = Mean radius

Macalloy post–tensioning bar systems

A. CHARACTERISTIC LOADS

NOMINAL DIAMETER	CHARACTERISTIC FAILING LOAD		MINIMUM 0.1% PROOF LOAD		AREA	MASS/ METRE
	STANDARD	STAINLESS	STANDARD	STAINLESS		
mm	kN	kN	kN	kN	mm²	kg
20*	-	314	-	251	314.2	2.466
25	506	491	410	383	490.9	4.069
26.5	569	-	460	-	551.5	4.560
32	828	804	670	643	804.3	6.661
36	1049	-	850	-	1017.9	8.451
40	1295	1257	1050	1006	1256.6	10.410
50	2022	-	1639	-	1963.5	16.020
75	4311	-	3495	-	4185.4	33.200

WORKING LOAD DURING LIFTING/LOWERING = (25/100) x CHARACTERISTIC FAILING LOAD

B. PHYSICAL PARAMETERS

	ITEM	UNIT	NOMINAL BAR DIAMETER - mm							
			20*	25	26.5	32	36	40	50	75
FLAT NUTS**	LENGTH	mm	25	33	37	41	46	51	71	100
	WIDTH ACROSS FLATS (DIA FOR 75mm BAR)	mm	42	46	50	56	62	65	90	135
FLAT WASHERS**	OUTSIDE DIAMETER	mm	50	60	65	70	75	80	105	-
	THICKNESS	mm	5	5	5	5	5	5	5	-
END PLATES	LENGTH	mm	100	100	110	125	140	150	200	300
	WIDTH	mm	100	100	110	125	140	150	175	250
	THICKNESS - STD.	mm	25	40	40	50	50	60	60	75
	HOLE DIAMETER	mm	26	35	36	41	45	52	61	82

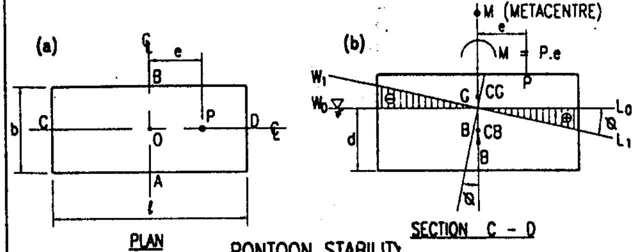
* - Available in stainless grade only

** - spherical nuts and washers are available to accommodate rotation if reqd.

DYWIDAG Bonded Single Bar Tendons

	DIM.	SMOOTH BAR		THREADBAR					
STEEL GRADE (YIELD/ULTIMATE) $f_{p0.1k}/f_{pk}$	N/mm²	835/ 1030	1080/ 1230	835/1030			1080/1230		
DIAMETER TYPE		32G	36C	26E	32E	36E	26D	32D	36D
DIAMETER	mm	32	36	26.5	32	36	26.5	32	36
ULTIMATE LOAD f_{pk} A	kN	828	1252	568	828	1049	678	989	1252
YIELD LOAD $f_{p0.1k}$ A	kN	671	1099	460	671	850	595	868	1099
FATIGUE STRESS RANGE									
STEEL $\sigma_o = 0.9 f_{p0.1k}$	N/mm²	230	230	210			210		
NUT/COUPLER $\sigma_o = 0.6 f_{pk}$	N/mm²	98	98	78			78		
NOM. CROSS SECTIONAL AREA	mm²	804	1018	551	804	1018	551	804	1018
NOMINAL WEIGHT	kg/m	6.31	7.99	4.48	6.53	8.27	4.48	6.53	8.27
SHEATHING (ID STD #)	mm	38	44	32	38	44	32	38	44

FLOATING BODIES
METACENTER CALCULATION



PONTOON STABILITY

Metacentric radius = BM = I/V

I = Moment of inertia of the liquid plane about AB/CD axis.

V = Volume of liquid displaced

METACENTRIC HEIGHT = GM = (BM − BG) > 0, FOR BOTH THE CASES OF MOI ABOUT AB & CD AXES

FOR STABILITY OF PONTOON,

MINIMUM METACENTRIC HEIGHT = 5% OF DRAFT

When moment is about AB axis,
MOI is also about AB i.e. $I = b\ell^3/12$

When moment is about CD axis,
MOI is also about CD i.e. $I = \ell b^3/12$

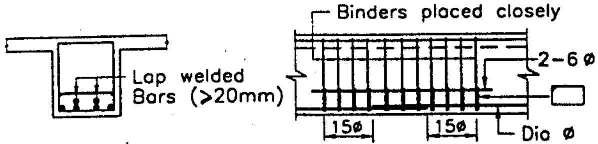
ℓ = Pontoon length
b = Pontoon width
d = Draft
γ = Specific wt. of liquid
θ = angle between the pontoon's original liquid line W_0L_0 and the liquid line W_1L_1 after pontoon tilt.

ANGLE OF TILT DUE TO BM OF M:

$$\theta = \frac{M}{V\gamma(GM)}$$

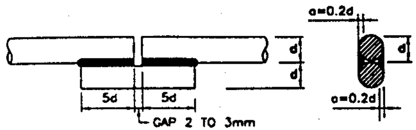
For stability, θ shall be 1:10 (5.7°) or less with smallest freeboard of zero or more.

WELDING DETAILS FOR HYSD BARS

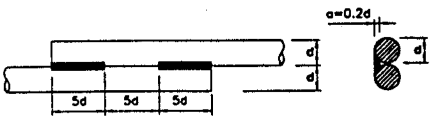


CROSS SECTION   LONGITUDINAL SECTION

LAP WELD OF LARGE DIA BAR-EXTRA BINDER DETAIL



LAP JOINT - TYPE 1



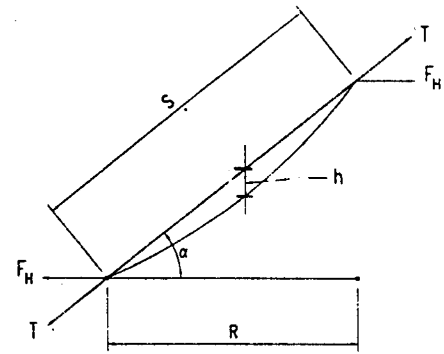
LAP JOINT - TYPE 2

SIZE OF BAR IN mm	SIZE OF ELECTRODE (MIN.) IN mm
UP TO AND INCLUDING 6	1.6
OVER 6 UP TO AND INCLUDING 10	2.0
OVER 10 UP TO AND INCLUDING 14	2.5
OVER 14 UP TO AND INCLUDING 20	3.15
OVER 20	4.0

NOTES:

1. 6013 ELECTRODE SHALL BE USED IF THE CARBON CONTENT OF REBAR IS UPTO 0.25%
2. WHEREVER CARBON CONTENT OF REBAR IS MORE THAN 0.25%, THE REBAR SHOULD BE PREHEATED TO 100°C, BEFORE WELDING AND 7018 ELECTRODE SHALL BE USED SUITABLY.
3. THE CARBON CONTENT OF REBAR TO BE VERIFIED FROM MANUFACTURER'S TEST CERTIFICATE.
4. BUTT-WELD IS NORMALLY ADOPTED TO JOIN BARS OF DIAMETER MORE THAN 20mm.

CALCULATION OF INITIAL TENSION IN GUYS



h = sag = 2% of guy length = 0.02 S.

$\theta = h/R$

W = Self weight of guy

$W' = W \times S/R$

$$F_H = \frac{W' . R^2}{8h}$$

$$\text{TENSION } (T) = F_H\,(1 + 16\theta^2 + \tan^2\alpha + 8\theta\tan\alpha)^{1/2}$$

MAXIMUM SAFE BEARING CAPACITY OF SOILS

TYPE	DESCRIPTION	T/m^2
ROCKS	Hard rock without lamination and defects e.g. granite, trap and diorite.	330
	Laminated rocks in sound condition e.g. sand stone	165
	Residual deposits of shattered and broken bed rock and hard shale, cemented material.	90
	Soft rock	45
NON-COHESIVE SOILS	Gravel, sand and gravel, (compact and offering high resistance to penetration when excavated by tools.)	45
	Coarse sand, compact and dry	45
	Medium sand, compact and dry	25
	Fine sand, silt (dry lumps easily pulverised by the fingers)	15
	Loose gravel or sand gravel mixture; loose coarse to medium sand, dry	25
	Fine sand, loose and dry	10
	Kankar	32
	Sand with clay	20
COHESIVE SOILS	Soft shale, hard or stiff clay in deep bed, dry	45
	Medium clay, readily indented with a thumb nail	25
	Moist clay and sand clay mixture which can be indented with strong thumb pressure	15
	Soft clay indented with moderate thumb pressure	10
	Very soft clay which can be penetrated several inches with the thumb.	5
	Black cotton soil or other shrinkable soil or expansive clay in dry condition (50% saturation)	10
	Red earth	30
	Alluvial soil	3 to 9
	Alluvial loam	9 to 17
	Peat	5 to nil
	Fills or made up ground (consolidated)	5