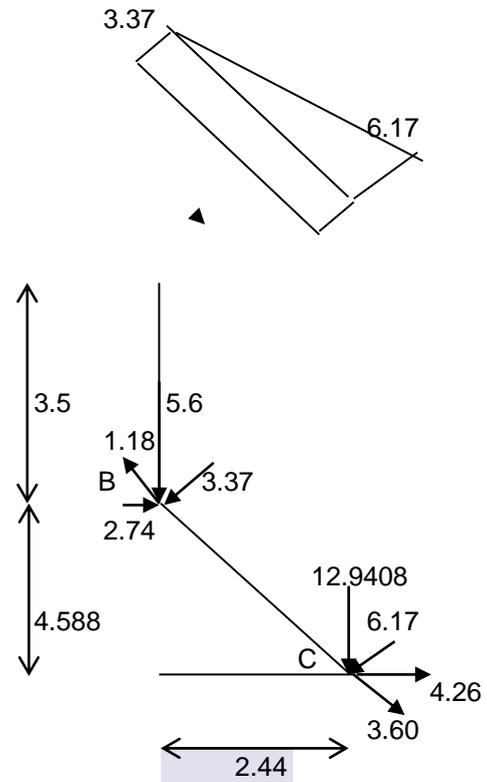


DESIGN OF STEEL SILO

Height of top portion of silo = **3.5** m
 Height of tapered portion of silo = **4.588** m
 Internal diameter of silo = **6** m
 Bulk Density of material stored = **1.6** T/m³

Maximum pressure = $w R / K_f \mu$
 Internal diameter of silo = 6 m
 $R = A/P = D/4 = 1.50$
 Angle of internal friction $\phi = \mathbf{25}$ deg
 Pressure ratio for granular material $s \geq 0.2$ mm
 For filling, $K_f = \mathbf{0.5}$
 For emptying, $K_f = \mathbf{0.7}$
 The angle of wall friction for filling $\phi_f' = 1.0 \phi = 25$
 Emptying $\phi_e' = 1.0 \phi = 25$
 For filling, $\mu_f' = \tan \phi_f' = 0.466$
 For emptying $\mu_e' = \tan \phi_e' = 0.466$
 $wR = 2.400$
 $Z\mu_f = \frac{R}{\mu_f K_f} = 6.434$
 $Z\mu_e = \frac{R}{\mu_e K_e} = 4.595$



Length BC = 5.196 m
 $\cos \alpha = 0.469$
 $\sin \alpha = 0.883$
 The horizontal and vertical pressures are found at different depths

Ht from top	z	h/z	$1 - e^{-h/ze}$	phT/m^2	pv
1	6.434	0.155	0.144	0.741	1.48
2	6.434	0.311	0.267	1.375	2.75
3	6.434	0.466	0.373	1.918	3.84
3.5	6.434	0.544	0.420	2.160	4.32

Pressures while emptying are tabulated here

Ht from top	z	h/z	$1 - e^{-h/ze}$	phT/m^2	pv
1	4.595	0.218	0.196	1.007	1.44
2	4.595	0.435	0.353	1.816	2.59
3	4.595	0.653	0.479	2.468	3.53
3.5	4.595	0.762	0.533	2.744	3.92

Hoop tension = $p_h D/2 = 8.231$ T/m

Design of wall plate

Let the wall thickness be **8** mm

Hoop stress = 10.09 N/mm²

Total vertical load = $A_x H_x \gamma = 158.34$ T
 $P_v = A \times 3.920 = 110.83$ T
 Vertical load on side wall = 158.34 - 110.83 = 47.51 T

total cap
242.86

Weight of silo including stiffeners = **0.100** T/m²
 Self weight = $0.1 \times \pi D \times H = 6.60$ T

Weight of lining for thickness used is assumed as = **0.12** T/m²
 Self weight of lining = 0.12 x PI() x D x H = 7.92 T

Weight of top cover is assumed as = **0.40** T/m²
 Self weight of top cover = 11.3 T

Vertical load per mm of periphery = 38.154 N/mm
 Compressive stress = 4.769 N/mm²

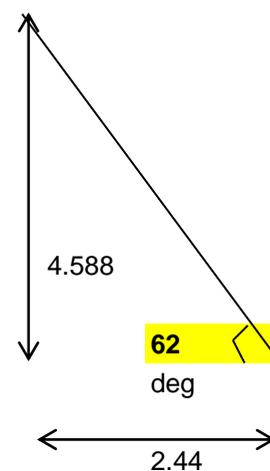
Assuming a Poissons Ratio = **0.3**
 Total compressive stress = 4.769 + 10.09
 = 14.9 N/mm²

Tensile stress = 11.5 N/mm²

Provide 30 x 6 (nominal) horizontal stiffeners at every 1m to avoid buckling of plate

Design of hopper

Thickness of plate in hopper portion = **8 mm**
 Vertical load = 122.12 T
 Opening size = 1.12 m Dia
 Volume of hopper portion = 52.83 m³
 Weight of material in the hopper portion = 84.53 T
 Assuming self weight = **6.3** T
Total load T = **213.00** T



Length of sloping side = 5.20 m

Longitudinal tension = 213 x 5.2 / pi x 6 x 4.588 = 12.81 T/m = 125.60 N/mm

Thickness of plate 8.0 mm
Longitudinal stress 15.70 N/mm²
Hoop stress 10.09 N/mm²

Tangential pressure = (P_v - P_h) sin α cos α

Emptying condition:

Location	Z _{emptying}	h	1 - e ^{-h/ze}	Vert press due to wall (T/m ²)	Hor pressure (T/m ²)	Normal pressure (T/m ²)	Tangential Pressure (T/m ²)
Top of hopper B	4.595	3.5	0.533	5.6	2.74	3.37	1.18
Bottom of hopper C	4.595	8.088	0.828	12.9	4.26	6.17	3.60

Filling Condition:

Location	Z _{filling}	h	1 - e ^{-h/ze}	Vert press due to wall (T/m ²)	Hor pressure (T/m ²)	Normal pressure (T/m ²)	Tangential Pressure (T/m ²)
Top of hopper B	6.434	3.5	0.420	5.6	2.16	2.92	1.43
Bottom of hopper C	6.434	8.088	0.716	12.9	3.68	5.72	3.84

Normal load on trough wall without self weight

Reaction = $\frac{3.373 + 6.17}{2} \times 5.196 = 24.81$ T

Assuming a self weight of trough plate W_s = **0.4** T

Normal component of self weight = $W_s \sin\alpha = 0.353 \text{ T}$
 Total normal load = 25.16 T
 Tangential component = $W_s \cos\alpha = 0.19 \text{ T}$

Design of plate in trough portion

Provide stiffeners at **600** mm spacing.
 Thickness of plate used = 8 mm
 Maximum BM = 0.093 Tm/m
 Bending Stress = $144.71 \text{ N/mm}^2 < 165 \text{ N/mm}^2$

Design of stiffeners in trough portion

BM at midpoint per m = 16.11 Tm
 For a spacing of stiffeners = 0.6 m , the BM = 9.67 Tm
 Direct Tension at the mid point of stiffeners = 8.040 T

Considering a Tee section ISST 250

ISST 250

Sectional properties

Area = 47.75 cm^2
 $I_{xx} = 2774.4 \text{ cm}^4$
 $C_{xx} = 6.4 \text{ cm}$ D- $C_{xx} = 18.6 \text{ cm}$
 Plate thickness = 0.8 cm
 Width of Plate at bottom = 32 cm

Properties for the builtup section:

Area of builtup section = 73.35 cm^2
 Cg of built up section is at 12.77 cm s 13.0
 $I_{xx} = 4874.11 + 3917.83$
 $= 8791.94 \text{ cm}^4$
 $Z_{xx} = 674.68 \text{ cm}^3$
 Bending stress = $1432.9 \text{ kg/cm}^2 < 1650$
 Axial tensile stress = 109.6 kg/cm^2

In addition to the trough stiffeners, the trough is also stiffened by plate stiffeners at **600** mm spacing

The bm is made half for 2 way bending of the plate.

Bending Moment = $6.18 \times 0.6^2 / 12 / 2 \times 0.6 = 0.0556 \text{ Tm}$ 6.18 0.6
 Assuming thickness of plate stiffener = 6 mm
 Section modulus required = 337.09 mm^3
 Required depth = 18.36 mm 30.00
 Provide 6mm x 30mm plate

Design of ring beam:

Weight of material stored = $158.34 + 84.53$
 $= 242.9 \text{ T}$

Self weight

Silo = 6.60 T
 Lining = 7.92 T
 Cover = 11.31 T
 Platform = 5.00 T (Assumed)

Total load = 273.7 T

Assuming no of column supports = 8

Reaction = 34.2 T

Shear = 17.1 T

Bending moment at support =

$$K1 = 0.00827$$

$$K3 = 0.00063$$

$$\text{Maximum BM at supports} = K_1 W_r r = 6.8 \text{ tm}$$

$$\text{Maximum Torsional Moment} = K_3 W_r r = 0.52 \text{ tm}$$

$$\text{Compression} = 257.37 \text{ T}$$

Assuming a section Double ISMB 500

500

Properties of MB 500

$$D = 500 \text{ mm}$$

$$\text{Thickness of flange } T = 17.20 \text{ mm}$$

$$\text{Thickness of web} = 10.20 \text{ mm}$$

$$\text{Flange width} = 180 \text{ mm}$$

$$\text{Area} = 110.74 \text{ cm}^2$$

$$I_{yy} = 1369.8 \text{ cm}^4$$

$$Z_{xx} = 1809 \text{ cm}^3$$

Properties of Double ISMB 500

$$\text{Area} = 221.48 \text{ cm}^2$$

$$I_{yy} = 20679.48 \text{ cm}^4$$

$$r_{yy} = 9.66 \text{ cm}$$

$$Z_{xx} = 3617 \text{ cm}^3$$

$$\text{Length between columns} : \pi D / 8 = 2.356 \text{ m}$$

$$l / r_{yy} = 24.4$$

$$D / T = 29.07$$

$$\text{Allowable bending comp stress} = 159.00 \text{ N/mm}^2$$

$$\text{Moment carrying capacity of the section} = 58.67 \text{ Tm}$$

$$\text{Allowable compressive stress} = 146.50 \text{ N/mm}^2$$

$$\text{Actual compressive stress} = 114.0 \text{ N/mm}^2 \quad \begin{matrix} 0.778 \\ 0.118 \end{matrix}$$

$$\text{Actual bending compressive stress} = 18.77 \text{ N/mm}^2$$

$$\frac{\sigma_{ac,cal}}{\sigma_{ac,al}} + \frac{\sigma_{bc,cal}}{\sigma_{bc,all}} = 0.90 < 1$$

Check for Torsion:

Considering the box formed by the double ISMB section,

The shear stress due to torsional moment = $T / 2 t_1 A$ (Ref P C Varghese Pg 392)

$$\text{where } t_1 \text{ is the web thickness} = 10.2 \text{ mm}$$

$$A = 482.8 \times 169.8 = 819.79 \text{ cm}^2$$

$$\text{Shear stress} = 30.9 \text{ Kg/cm}^2 < 1000 \text{ Kg/cm}^2 \text{ Hence OK}$$