مراجعه Steel
رابعه انشاءات
م/ رمزي ٦

Final Term Revision

Part (2-B)

Exams

2013-2014

Exams Table

1-May 2003 (2nd term)

2-May 2004 (2nd term)

3-May 2005 (2nd term)

4-May 2006 (2nd term)

Ain Shams University.
Faculty of Engineering.
Structural Engineering Dept.

4th year Civil Engineering.
May 2003
Time allowed: 3 hours.

CES 452 CF: Design of steel bridges-(Second Term)

- Material of construction is steel 52
- Any missing data may be reasonably assumed

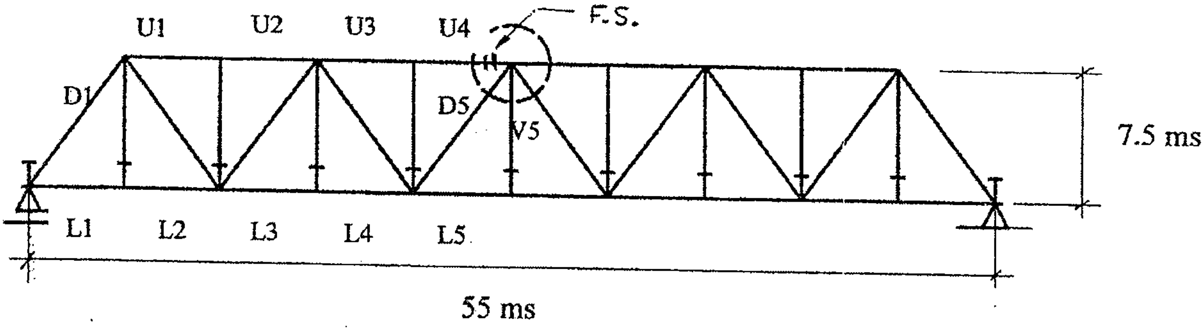
Question 1:

The main girders of a triple-track open timber floor railway through bridge are composed of warren trusses having a span of 55 ms divided into 10 equal panels 5.5 ms each. The depth of main girders is 7.5 ms. Depth of upper chord or lower chord members as well as the spacing between gusset plates; is 50cm. Cross girders are overhanging beams of depth 1.5 ms. The central span of the cross girders (spacing between main girders) is 12.6 ms. which is divided into 7 equal sub-panels 1.8 ms each; i.e. the spacing between any two stringers is 1.8 ms. The cross girders have double cantilevers of length 2.5 ms supporting 16 cm R.C. slab side walk.

Stresses for St. 52
- $F_y = 3.6$ t/cm^2
- for $\lambda < 100$ $f_c = 2.1 - 0.000135\,\lambda^2$ t/cm^2
- for H.S.B. quality 10.9 M27 : $P_s = 9.08$ t
- for $\lambda > 100$ $f_c = 7500/\lambda^2$ t/cm^2

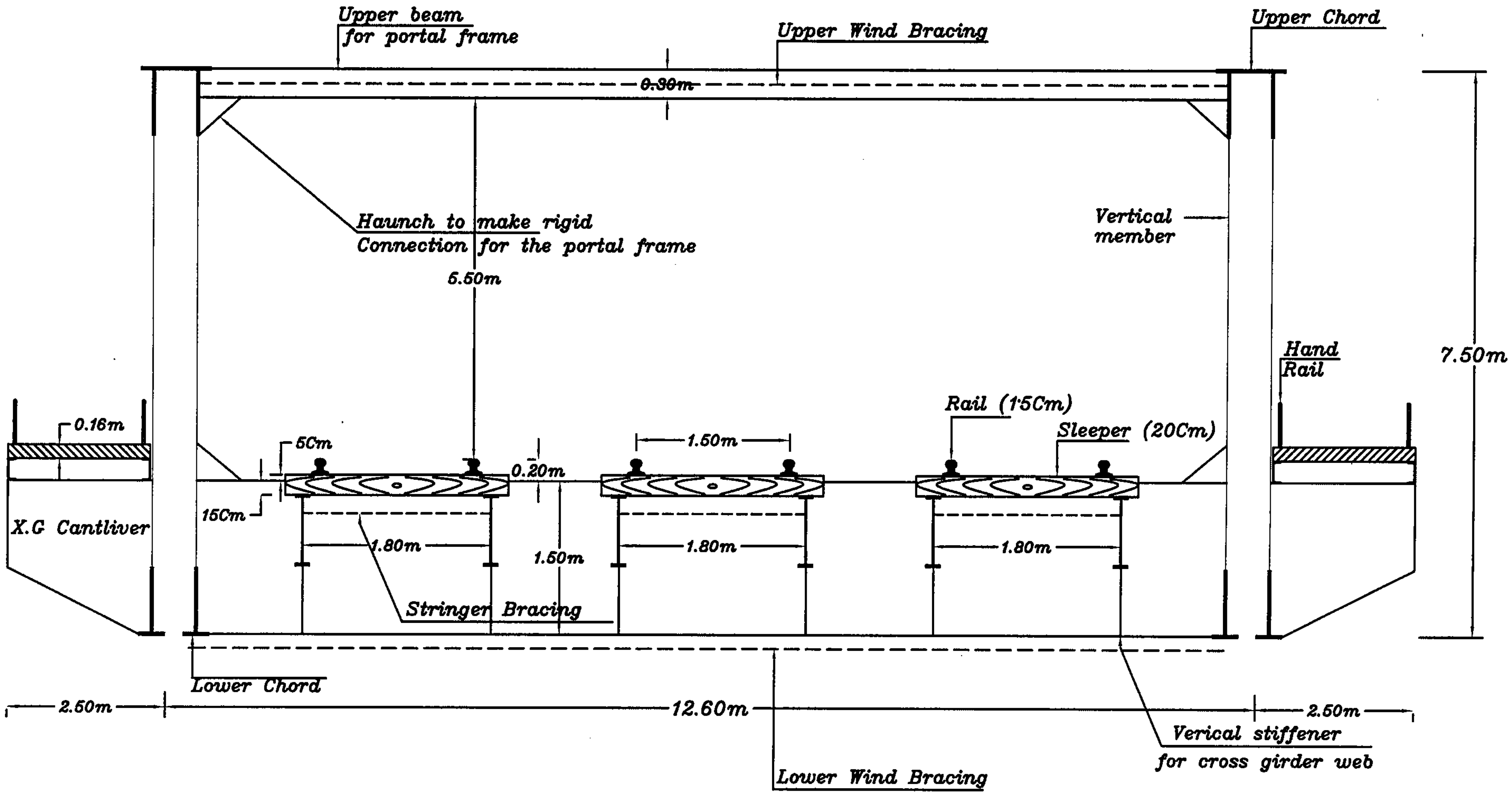
It is required:

1. Using a scale (1:50), draw a layout for the bridge cross section; [show all elements comprising the typical cross section].
2. Design a welded section for an intermediate cross girder and the necessary web-to-flange fillet welds (consider only in-plane bending [Note: F_{sr} at mid span of the cross girder and at its supports are 1.45 t/cm^2 and 1.12 t/cm^2; respectively].
3. Propose (using neat sketches) a system to transfer reaction from upper wind bracing to lower wind bracing; and explain briefly how this system is analyzed.
4. If the maximum forces in the truss members L5, U4, D5 are as noted, design a welded section for member U4 and choose without check suitable section for members V5, L5, and D5. [Note: F_{U4}=-1350t; F_{L5}=+1400 t and +330 t; respectively, also F_{D5}= -250 t and +160 t; respectively. Also consider F_{sr} = 1.62 t/cm^2 and assume that all upper nodes of the truss are laterally braced].
5. Design a field splice for member U4 using HSB quality 10.9 M27.
6. Using H.S.B. quality 10.9 M27; design and draw to scale 1:10 the marked joint along with the field splice of member U4; [in elevation and side view].



May. 2003 (Str.)

Question (1-1)

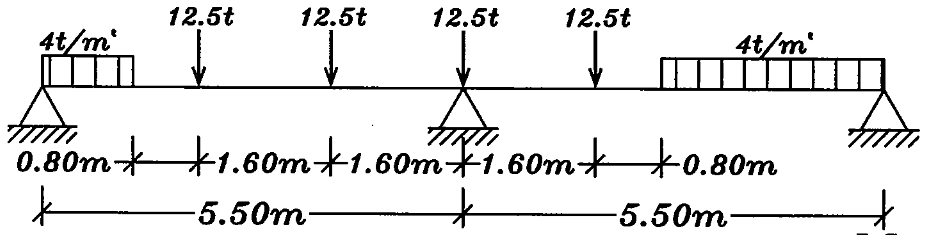


May. 2003 (Str.)

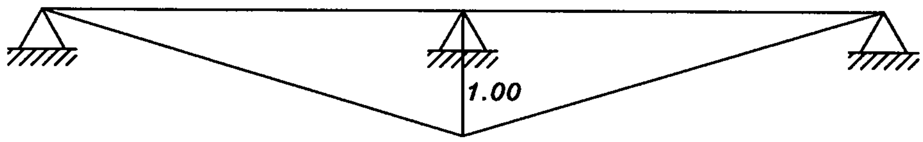
Question (1-2)

1)Live Loads

For Rail Way Part



I.L Reaction



$R_{LL} = 3*12.5*0.709+12.5*0.709+4*1.5*0.136+4*3.1*0.281$

$R_{LL} = \boxed{39.75t}$

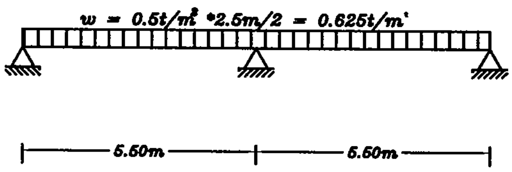
$$\boxed{(1+I) = 0.73 + \frac{2.16}{\sqrt{L_1}-0.2}}$$

$L_1 = 2*12.6 = 25.20m$

$$(1+I) = 0.73 + \frac{2.16}{\sqrt{25.2}-0.2} = 1.17 \boxed{> 1.1 \ , \ < 2.00}$$

$R_{LL+I} = 39.75*1.17 = 46.5075t$

For Side Walk



$\therefore R_{LL} = 0.625*5.50m = \boxed{3.43t}$

2)Dead Loads

For Rail Way Part

$W_{Dead} = 600/2 + 40/2 + O.W = ...Kg/m'$

$W_{Dead} = 0.6/2 + 0.04/2 + 0.15 = 0.47t/m'$

$R_d = W_d * S = 0.47 * 5.50 =$ **2.60t**

$O.W =$ **0.3t/m'**

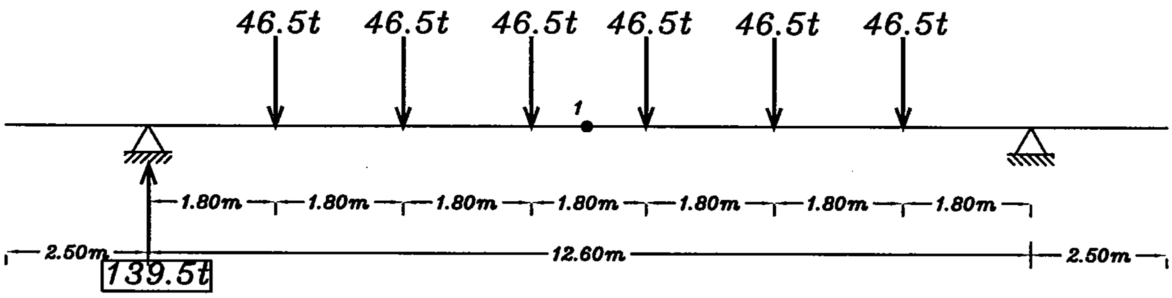
For Side Walk

+0.15t/m'

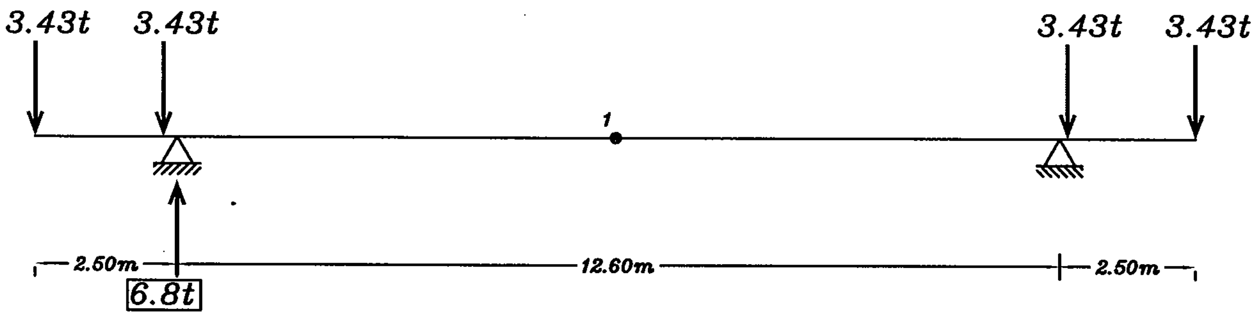
$W_{Dead} = (t_s * \gamma_c + F.C.)*a/2 + o.w = (0.16*2.5+0.15)*2.5/2 =$ **0.84t/m'**

$R_d = W_d * S = 0.84 * 5.50 =$ **4.60t**

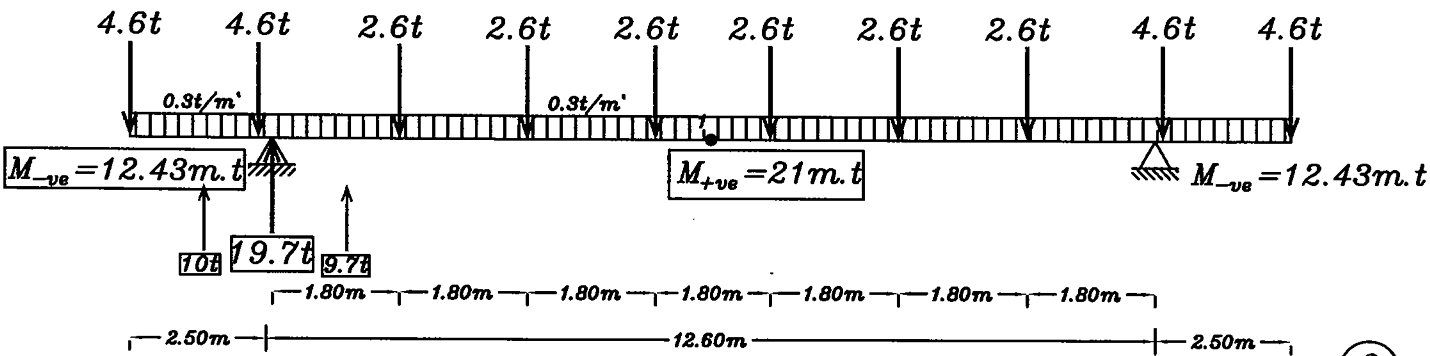
Max. +ve moment @ Sec. 1 due to LiveLoad+Impact



Max. −ve moment @ Sec. 1 due to LiveLoad+Impact



Total dead Loads



$Q_{LL+I} = 139.5t$ rail

$Q_{LL+I} = 6.8t$ road

$Q_d = 9.7t$ (right)

$Q_d = 10t$ (Left)

$M_{LL+I} = 509$ m.t (@ mid. Span)

$M_d = 21$ m.t (@ mid. Span)

$M_{ll+I} = 8.5$m.t(@ Support)

$M_d = 12$m.t(@ Support)

$M_{max.} = M_{d+ll+I} = 530$ m.t (@ mid. Span) | Mid. Span Values

$M_{max.} = 20.5$ m.t(@ Support) | Support Values

$M_{Fatigue} = 509 + 8.5*0.3 = 511.55$m.t

$Q_{d+LL+I} = 139.5t$ (rail) + $9.7t$ (dead) = $149.2t$

Design Of Built-Up Section

Calculate Web depth = 150Cm

Calculate Web thikness

1. $\rightarrow \dfrac{d_w}{t_{w1}} \leq \dfrac{830}{F_y}$ $\quad \dfrac{150}{t_{w1}} \leq \dfrac{830}{F_y}$ $\quad \therefore t_{w1} = 0.65Cm$

2. From Shear $\rightarrow \dfrac{Q_{d+u+I}}{d_w * t_{w2}} = 0.35F_y$ $\quad \dfrac{116.5t}{150 * t_{w2}} = 0.35*3.6$ $\quad \therefore t_{w2} = 0.61Cm$

3. $\therefore d_w = 150$ Cm, Vl. Stiff. Only $\rightarrow \therefore \dfrac{d_w}{t_{w3}} = \dfrac{190}{\sqrt{F_y}}$ $\quad \dfrac{150}{t_{w3}} = \dfrac{190}{\sqrt{F_y}}$ $\quad \therefore t_{w3} = 1.49Cm$

From 1,2,3 $\therefore t_{w3} = 1.60Cm$

Get Flange Dimension

$\therefore$ allwable Stress=2.10t/Cm^2

$$0.58F_y = \frac{T \text{ or } C}{A} \quad \therefore \text{get } A = \ldots\ldots Cm^2$$

Calculate $T=C= \dfrac{M_{d+u+I}}{0.98d} = \dfrac{530*100}{0.98*150} = 360.54t$

$\therefore \dfrac{360.54}{A} = 2.10 \quad \therefore A = 172Cm^2$

$A = b_f * t_f + 1/6 d_w * t_w$

$172 = b_f * t_f + 1/6*150*1.6 \quad \therefore b_f * t_f = 132 \; Cm^2$

$b_f \triangleq 20t_f \quad \therefore 20t_f^2 = 132 \; Cm^2$

$\boxed{t_f = 2.8Cm}$ use $\boxed{b_f = 52 \; Cm}$

$$I_X = \frac{t_W * d_W^3}{12} + 2b_f * t_f * (d_W/2 + t_f/2)^2 = ...Cm^4$$

$$I_X = \frac{1.6*150^3}{12} + 2*52*2.8(150/2+2.8/2)^2 = 2149722.7Cm^4$$

$$\boxed{\therefore I_X = 2149722.7 \; Cm^4}$$

<u>Checks</u>

<u>Check max. Stresses</u>

$$\frac{M_{d+u+I}}{I_X} *(d/2+t_f) = \frac{530*100}{2149722.7}(150/2+2.8) = 1.91t/Cm^2 \ngtr 2.1t/Cm^2$$ safe

<u>Check Stress Range</u> $\boxed{(+ve \; Section)}$

$$\frac{M_{Fatgiue}}{I_X} *(d/2+t_f) = \frac{511*100}{2149722.7} *(150/2+2.8) = 1.84t/Cm^2 \ngtr F_{Sr} = 1.45t/Cm^2$$ Unsafe

<u>Check Shear Stress</u>

$$\frac{Q_{d+u+I}}{d_W * t_W} = \frac{116.8t}{150*1.6} = 0.48 \; t/cm^2 \ngtr 0.35*3.6$$

<u>get Size of Weld</u>

$$\frac{Q_{d+u+I} *[b_f * t_f *(d_W/2 + t_f/2)]}{I_X} = 2*S*0.2F_U$$

$$\frac{149.2[(52*2.8)(2.8/2+150/2)]}{2149722.7} = 2*S*0.2*5.2$$

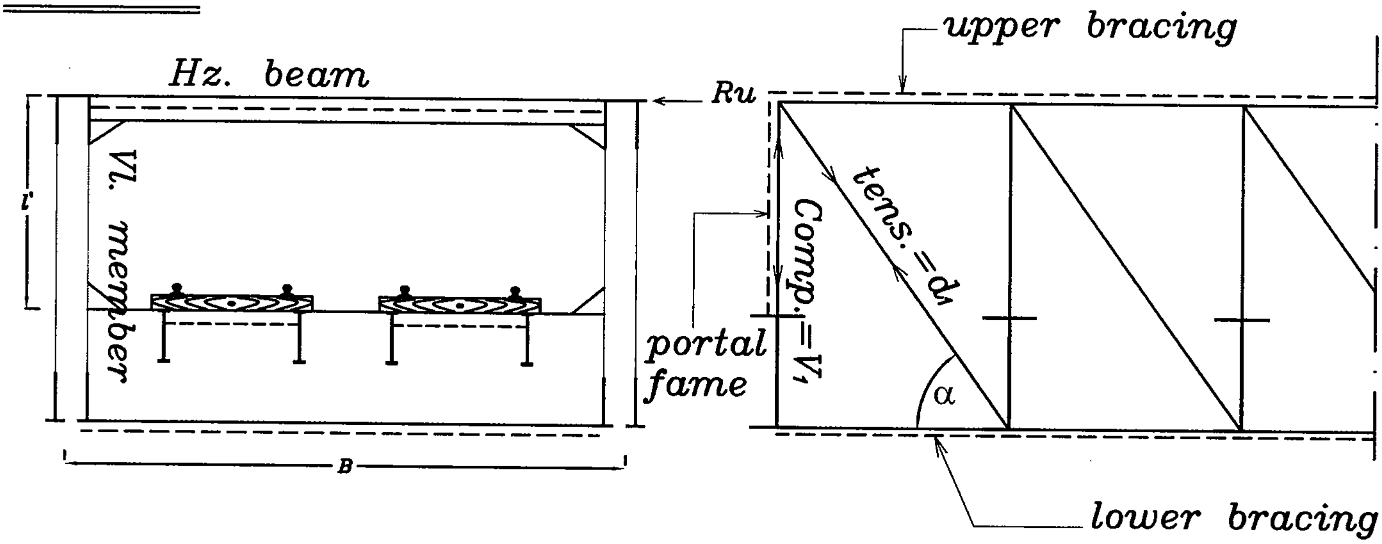
$S = 0.26Cm$ Use $S = 0.6Cm$

Example one

Question (1-1)

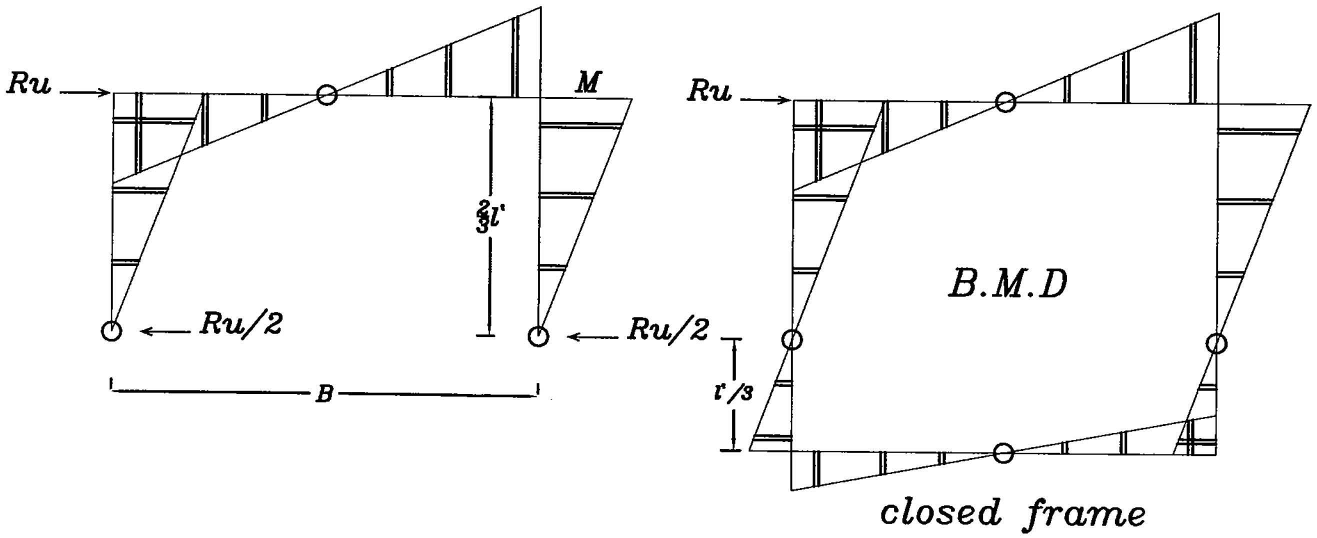
Systems to transfer reaction from upper to lower bracing

Case one



the function of the portal frame is to trasnsmitte the loads from the upper bracing to the bearing.

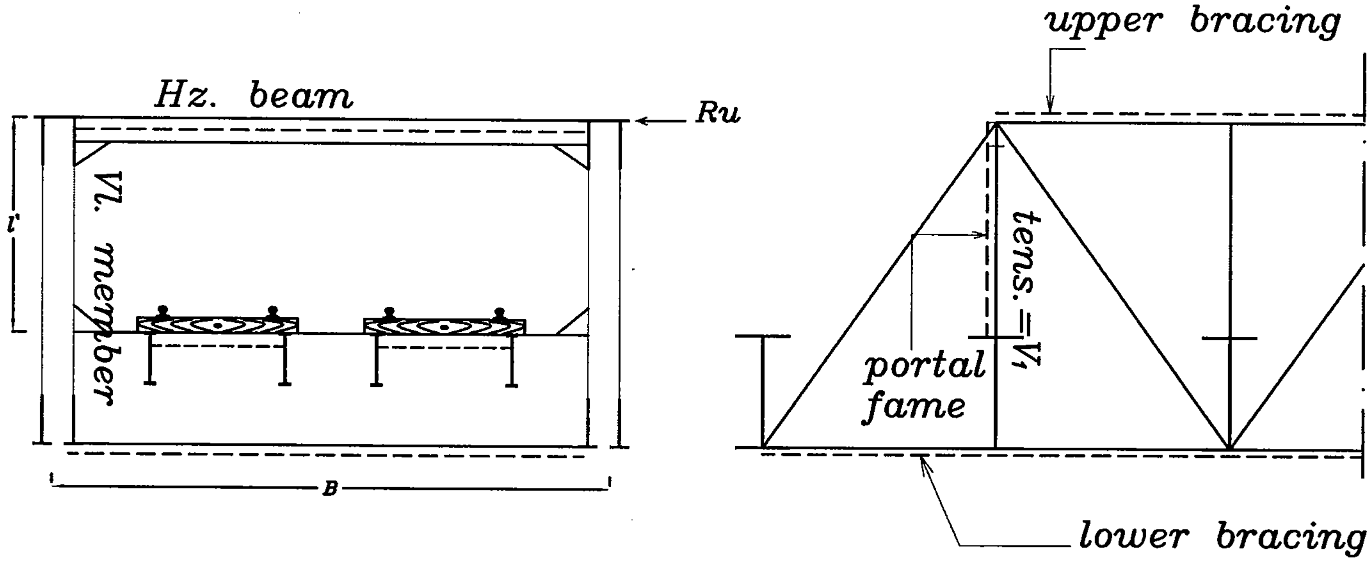
so all the intermediate vertical members are designed on Comp. Only , While the first vertical member is designed on (M+N)

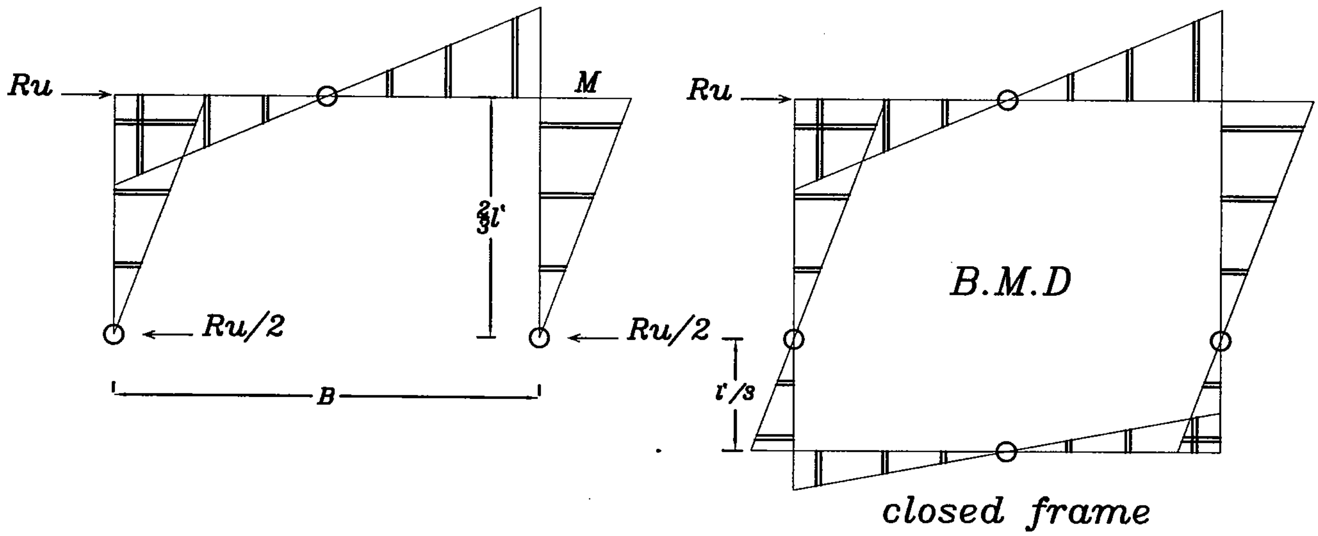


Case two

W–truss without first vertical member

Case two–1



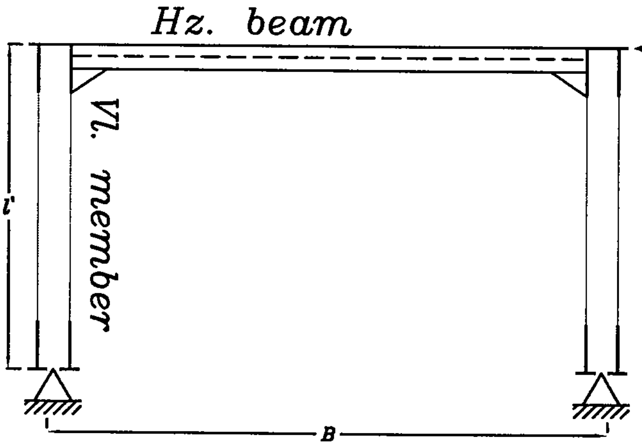


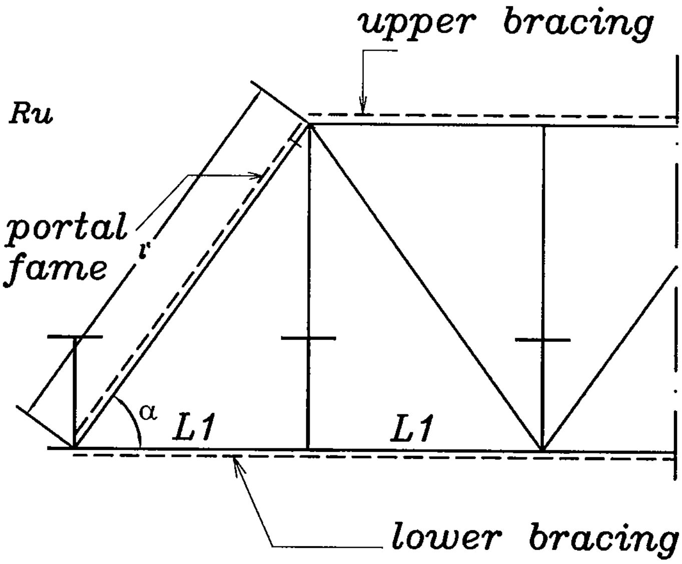
Loads in vertical member

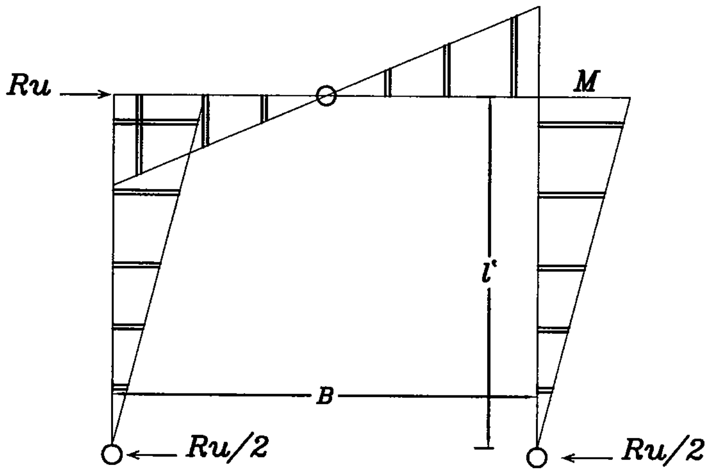
$M = \frac{Ru}{2} * 2/3 l'$ $\qquad$ N = Reaction of X.G (tens.)

W–truss without first vertical member

Case two–2

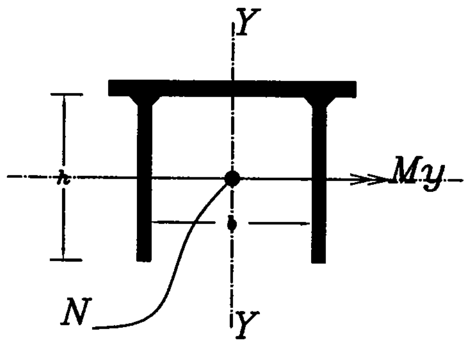






Loads in Diagonal member

$M = \frac{Ru}{2} * l'$ $\qquad$ $N = L_1 / \cos\alpha$



Example one

Question (1−2)

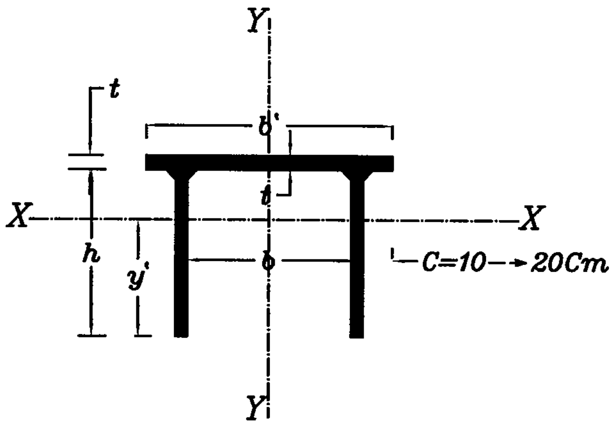
Design of Upper chord U4

1)assume compression stress to be :

$F_c = 1.8 t/Cm^2$ For St.52

use h = 50Cm (given)
use b = 50Cm (given)

$b' = b + 2*(10 \longrightarrow 20Cm)$



$b' = 50 + 2*(10 \longrightarrow 20Cm) = 70Cm$ to $90Cm$ use $b' = 85Cm$

2) $F_c = \dfrac{max.\ force}{area}$ $\quad 1.8 = \dfrac{1350t}{area}$

area = $750Cm^2$

$A = 2ht + b'*t = ...Cm^2$

$750 = 2*50*t + 85*t$, $t = 4.00Cm$

take $t = 4.00Cm$

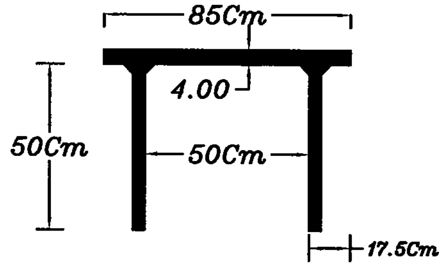
Checks

1−Check Compactness

$\dfrac{b}{t} = \dfrac{50-2*1}{4.00} = 12.00 < \dfrac{64}{\sqrt{3.6}} = 33.7$

$\dfrac{C}{t} = \dfrac{17.5-4-1}{4.00} = 3.1 < \dfrac{21}{\sqrt{3.6}} = 11.1$

$\dfrac{h}{t} = \dfrac{50-1}{4.00} = 12 < \dfrac{30}{\sqrt{3.6}} = 15.8$



2-Check global buckling

$$y' = \frac{(2ht*0.5h)+b'*t(h+0.5t)}{2ht+b't} = ...Cm$$

$$y' = \frac{(50*4.00*25*2)+(85*4.00*52)}{(50*4.00*2)+(85*4.00)} = 37.4Cm$$

$$I_X = 2*\frac{t*h^3}{12} + 2*t*h*(y'-0.5h)^2 + b'*t*(y'-h-0.5t)^2 = ...Cm^4$$

$$I_X = 2*(\frac{4.0*50^3}{12} + 2*4.0*50*(37.40-25)^2 + 4.0*85*(37.40-52)^2$$

$$\boxed{I_X = 217312 \quad Cm^4}$$

$$I_Y = [\frac{4.0*85^3}{12}] + 2*4.0*50*(25+2.0)^2 = \boxed{496308 \ Cm^4}$$

$$A = (4.0*2*50) + (85*4.0) = 740 \ Cm^2$$

Calculate $r_X = \sqrt{\frac{I_X}{A}} = \sqrt{\frac{217312}{740}} = \boxed{17.10Cm}$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{493308}{740}} = \boxed{25.9Cm}$

$$\lambda_{in} = \frac{L_{in}}{r_X} = \frac{0.85*550}{17.10} = 27 < 90$$

$$\lambda_{out} = \frac{L_{out}}{r_Y} = \frac{0.85*550}{25.9} = 18 < 90$$

3-Check Compressive Stresses

actual stresses $= f_{ca} = \frac{1350t}{740} = 1.82 \ t/Cm^2$

allwable stresses $= F_c = 2.1 - 13.5*10^{-6} * \lambda^2_{max.}$ For St.52

allwable stresses $= F_c = 2.1 - 13.5*10^{-6} * 27^2 = 2.00 \ t/Cm^2$

Safe section

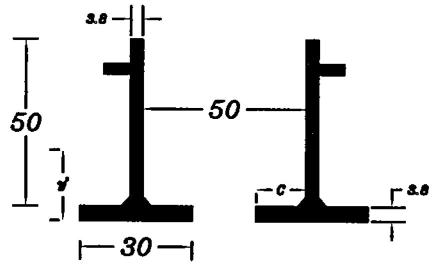
Design L5

$h = 50Cm$ $\quad\quad b = 50Cm$

$b' = (1/2 \longrightarrow 2/3)*b \quad = 25Cm \text{ to } 33Cm \quad \text{use } b' = 30Cm$

1)assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1 - \frac{T_{min.}}{T_{max.}}} = \frac{1.62}{1 - \frac{330}{1400}} = 2.11 \ t/Cm^2$$



$F_{max.} > 2.1 \ t/Cm^2$

use $F_{max.} = 2.1 \ t/Cm^2$

2)$F_t = \dfrac{\text{max. force } T_{D+LL+I}}{\text{area}}$ $\quad\quad 2.1 = \dfrac{1400}{\text{area}}$

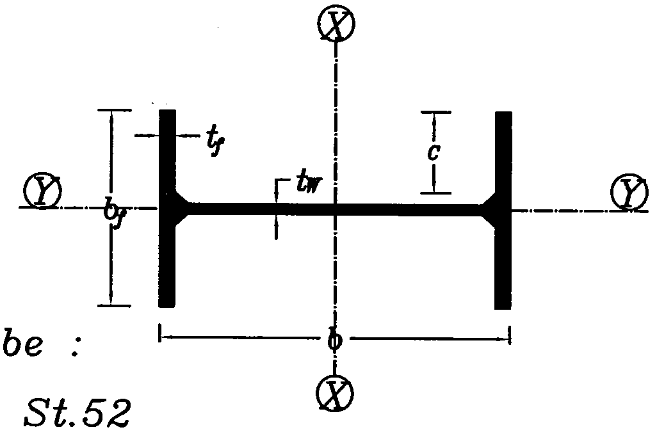
get $A = 667 \ Cm^2 = (2*30+2*50)*t \quad t = 4.17Cm$

use out stand stiffener 10Cm

get $A = 667 \ Cm^2 = (2*30+2*50+2*10)*t \quad t = 3.71Cm$

use $t = 3.80 \ Cm$

Design of D5



1)assume compression stress to be :

$F_c = 1.5t/Cm^2$ to $1.9t/Cm^2$ For St.52

2)$F_c = \dfrac{\text{max. force}}{\text{area}}$ $\quad\quad 1.7 = \dfrac{250}{\text{area}}$ $\quad\quad A = \boxed{147Cm^2}$

3)assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1-\frac{T_{min.}}{T_{max.}}} = \frac{1.62}{1-\frac{160}{-250}} = 0.99\ t/Cm^2$$

$F_{max.} < 2.1\ t/Cm^2$

use $F_{max.} = 0.99\ t/Cm^2$

4) $F_t = \frac{max.\ force\ T_{D+LL+I}}{area}$ $\qquad 0.99 = \frac{160}{area}$

get $A = \boxed{162\ Cm^2}$ (govern)

$b = 50Cm$

$\frac{b}{t_w} = \frac{64}{\sqrt{F_y}}$ $\qquad \frac{50}{t_w} = \frac{64}{\sqrt{3.6}}$ $\qquad t_w = 1.48\ Cm$ $\quad$ use $t_w = 1.60\ Cm$

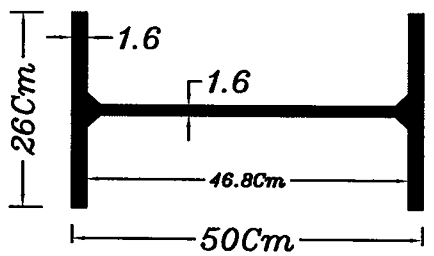
$A = 2*b_f*t_f + b*t_w = ...Cm^2$

$162 = 50*1.6 + 2*b_f*t_f$

$b_f*t_f = 41\ Cm^2$

$b_f = 20*t_f$, $\boxed{t_f = 1.6Cm}$ $\quad \boxed{b_f = 26Cm}$

$b_{f\ min} = 6\phi + t_w + 2S \triangleq 20Cm$



Design V5

$R_{LL+I} = 106.8+4.2 = 111 \ t$

$R_D = 19.7 \ t$

$F_{max.} = \boxed{130.7 \ t}$ (tension)

$F_{min.} = \boxed{19.7 \ t}$ (tension)

1) assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1-\frac{T_{min.}}{T_{max.}}} = \frac{1.62}{1-\frac{19.7}{130.7}} = 1.91 \ t/Cm^2$$

$F_{max.} < 2.1 \ t/Cm^2$

use $F_{max.} = 1.91 \ t/Cm^2$

2) $F_t = \frac{\text{max. force } T_{D+LL+I}}{\text{area}}$ $\qquad 1.91 = \frac{130.7}{\text{area}}$

get $A = \boxed{68.4 \ Cm^2}$

$b = 50Cm$

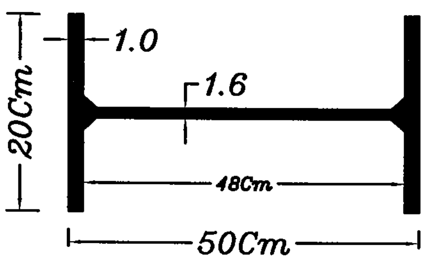
$\frac{b}{t_w} = \frac{64}{\sqrt{F_y}}$ $\qquad \frac{50}{t_w} = \frac{64}{\sqrt{3.6}}$ $\qquad t_w = 1.48 \ Cm$ $\qquad$ use $\boxed{t_w = 1.60 \ Cm}$

$A = 2*b_f*t_f + b*t_w = \ldots. Cm^2$

$68.4 = 50*1.6 + 2*b_f*t_f$

$b_f*t_f = -ve$ value

$\boxed{b_{f\,min.} = 6\phi + t_w + 2S \triangleq 20Cm}$ $\qquad \boxed{t_f = 1.00Cm}$

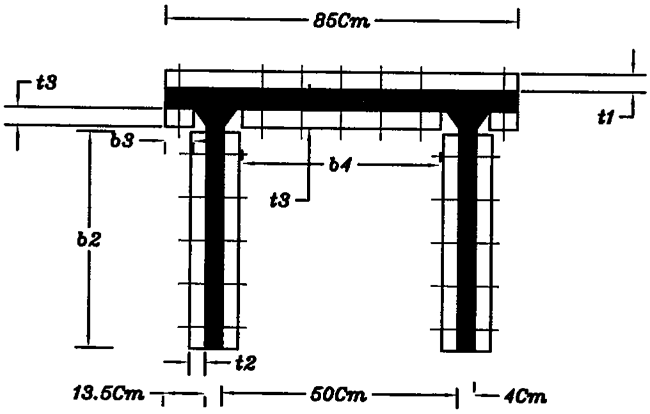


Example one

Question (1-3)

Bolted Field slpice

i)Upper chord



number of bolts in one flange (n1) $= \dfrac{F_c *(b_f * t_f)}{P_s \quad *2}$

number of bolts in one flange (n1) $= \dfrac{2.00*85*3.80}{2 * 9.08} = 37.4$ Bolt

No. of bolts/row = 37.4/7row = 5.3 use 6 Bolts

Check for flange plates

b1*t1 = 0.5*bf*tf   b1 = bf   **b1 = 85 Cm**

t1 = $0.5*t_f$ = **2Cm**

b4*t3 = 0.50*bf*tf   b4 = 50-4Cm= **46Cm** , then get t3

t3 = 0.5*85*4/46 = 3.69Cm   **t3 = 3.80Cm**

use b3 = 11Cm

Check for Web plates

number of bolts in one Web (n2) $= \dfrac{F_c *(b_w * t_w)}{P_s \quad *2} = \dfrac{2*50*3.8}{2 * 9.08}$

n = 22 bolts

No. of bolts/row = 22/5row = 4.4 use 5 Bolts

b2 = 50 - 3.80 - 2Cm = **44.2Cm**   t2 = **2.4Cm**

Example one

Question (1−4)

Diagonal bolts

$A_{Diagonal} = 2*26*1.6+48*1.6 = 155\ Cm^2$

$F_{Diagonal} = 155*F_t = 155*2.1 = 325.5t$

number of bolts per one flange = $\dfrac{Stress*area}{P_s * 2}$

$n = \dfrac{325.5}{9.08 * 2} = 17.9$ bolt per one flange

use $n = 18$ bolt (2column*9rows)

$b_{f\,min}$ for diagonal $= 2*3*\phi + t_w = 2*3*2.7+1.6 = 17.8Cm \leq 26Cm$

Vertical bolts

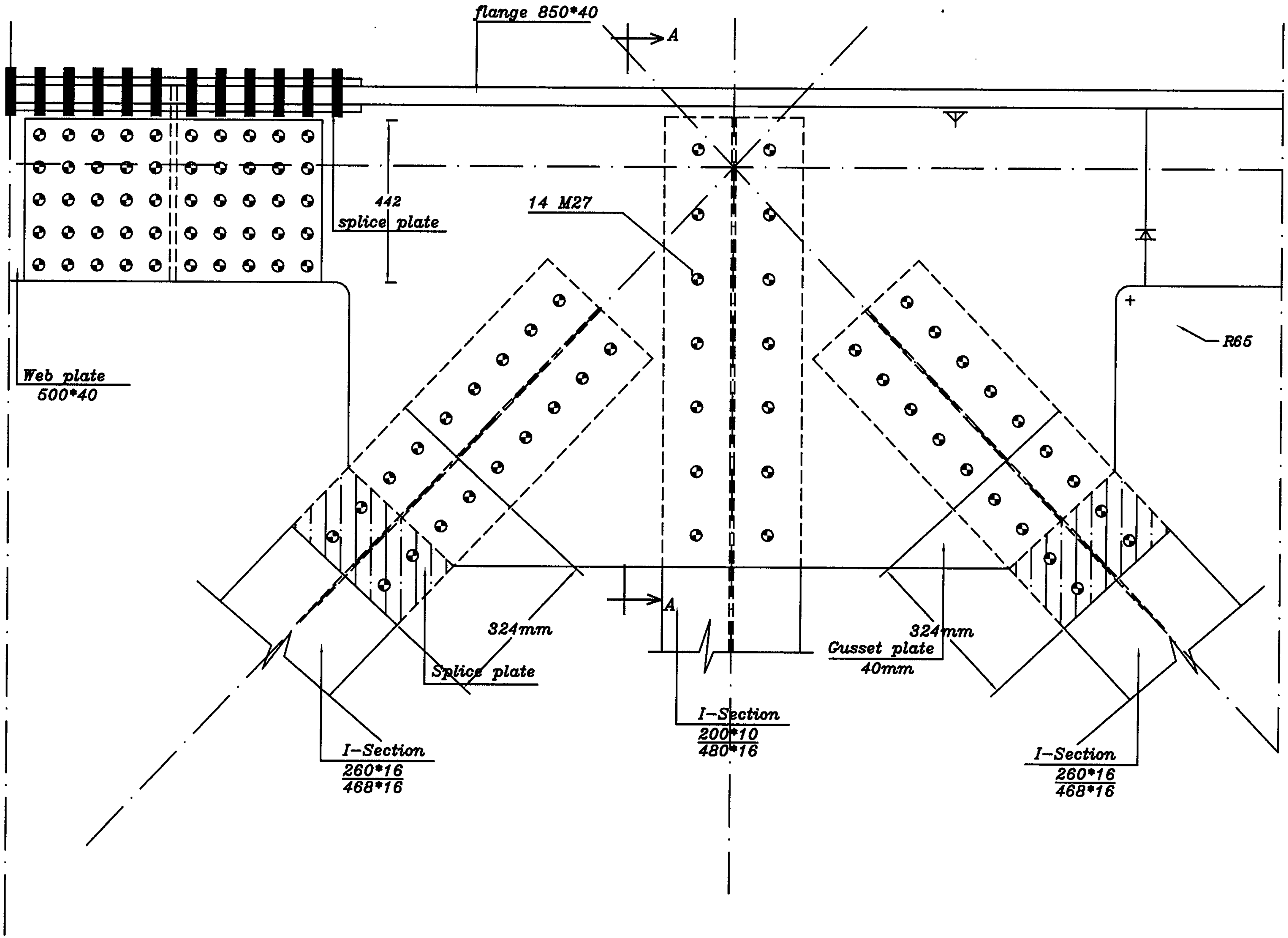
$A_{vertical} = (1.6*48)+(2*20*1.0) = 116.8\ Cm^2$

$F_{Vertical} = 120*F_t = 116.8*2.1 = 245\ t$

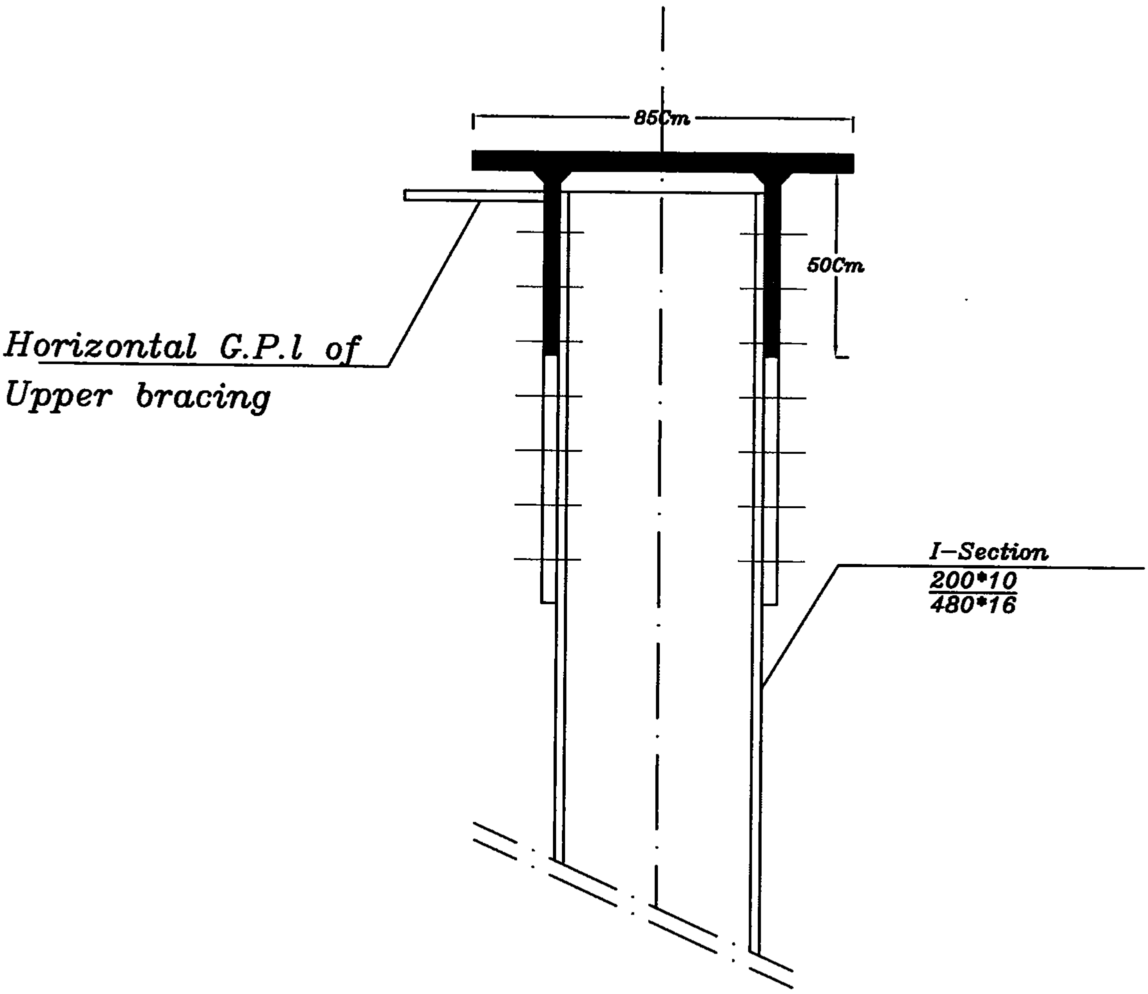
$n = \dfrac{245}{9.08 * 2} = 14$ bolt per one flange

use $n = 14$ bolt (2column*7rows)

$b_{f\,min}$ for vertical $= 2*3*\phi + t_w = 2*3*2.7+1.6=17.8Cm < 20Cm$


flange 850*40
A
442
splice plate
14 M27
Web plate
500*40
R65
324mm
324mm
Gusset plate
40mm
Splice plate
A
I-Section
200*10
480*16
I-Section
260*16
468*16
I-Section
260*16
468*16

17

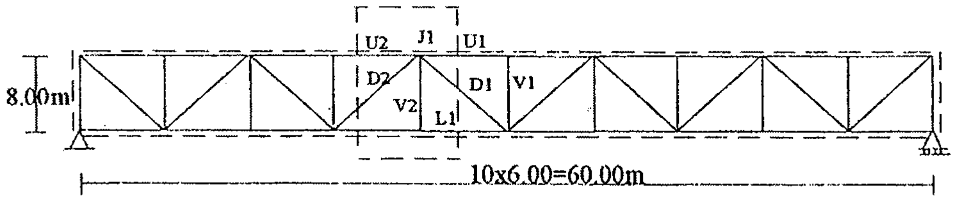

85Cm
50Cm
Horizontal G.P.l of
Upper bracing
I–Section
200*10
480*16

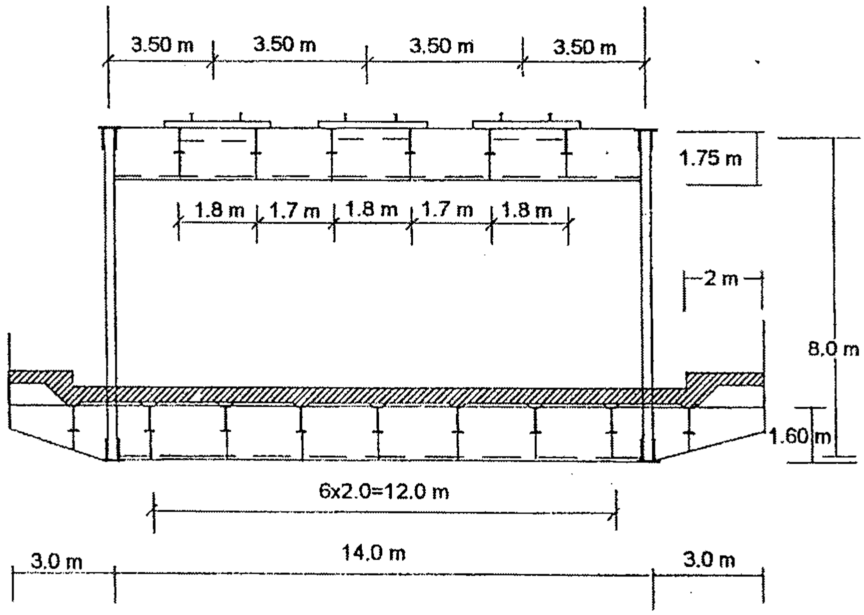
SEC. A–A

تصميم الكباري معدنية   غ / انشاءات

Material of construction is **Steel 52** and Live load is according to the Egyptian Code of Practice.
Data not given may be reasonably assumed.

QUESTION (I) (80%):





Bridge Cross Section

A rail-roadway through welded truss bridge of the shown cross section has a span of 60.0 ms and is divided into 10 equal panels 6.0 ms each. The main trusses are spaced 14.0 ms apart. Depth of the main truss is 8.0 ms. The inner spacing between the gusset plates is 50.0 cm, and depth of the upper and lower truss chords is taken as 55.0 cm. The bridge is provided with upper as well as lower wind bracings.

Required:

1- Design a suitable section for an intermediate continuous upper stringer (only for railway).

2- Design the first diagonal and vertical members of the stringer bracing.

3- Design and draw (to scale 1:10 in elevation & plan) a bolted field connection between the stringer and the cross girder, showing the connections of the stringer bracing members. Use M24 H.S. Bolts, quality 10.9. Assume a welded built up section for the cross girder of web plate 1750x10 mm and flange plates 500x30 mm.

4- Find the maximum axial forces in the vertical members V1 and V2 due to live loads and impact only.

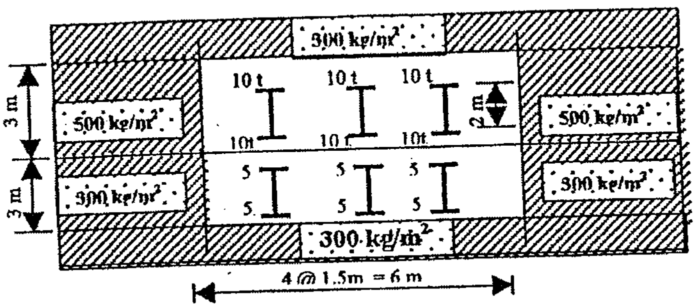
5- Design a suitable section for the upper chord member U1, lower chord member L1, diagonal member D1, and vertical member V1, given that the maximum forces are as shown in the following table. Find, without check, a suitable section for the upper chord member U2, diagonal member D2, and vertical member V2.

MEMBER	MINIMUM FORCES	MAXIMUM FORCES
U1	- 560 t	- 1680 t
U2	- 470 t	- 1420
L1	+ 540 t	+ 1620 t
D1	- 80 t	+ 195 t
D2	- 30 t	- 330 t
V1	- 14 t	- 104 t
V2	+ 46 t	+ 86 t

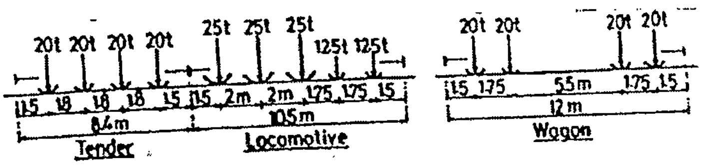
6- Design the joint J1, using M27 H.S. Bolts, quality 10.9. Draw the part A to scale 1:10.

7- Design a roller or rocker bearing for the main truss, using 4 cast steel rollers, given that the maximum reaction is 900 t. Consider the eccentricity of the half section of the vertical member at support (box section) for design of sole plate e = 25.0 cm. Assume a uniform distribution for the reaction on the rollers or rockers. Draw the bearing in elevation to scale 1:5.

8- Draw to scale 1:200 the different bracing systems for the shown bridge (wind, stringer, and breaking force bracing). Design the first diagonal member of the upper wind bracing. Find the additional straining actions on the first vertical truss member due to transferring of the upper wind bracing reactions to the truss bearings. Calculate the forces on the breaking force bracing members (without design of members).



Live Loads on Roadway Bridges



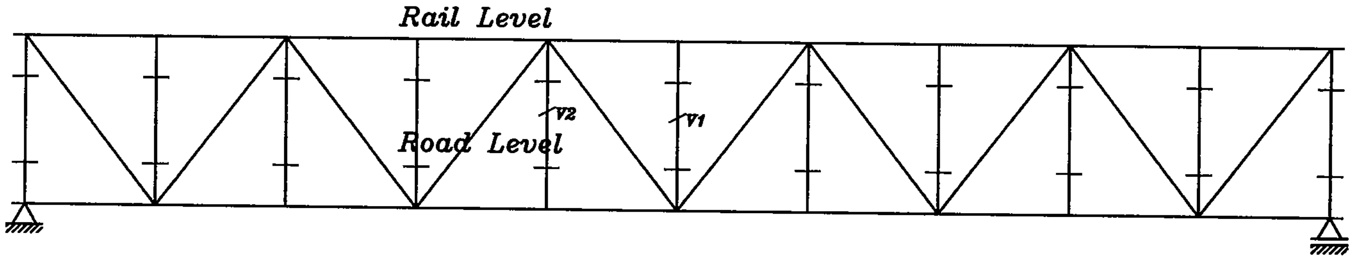
Live Loads on Railway Bridges

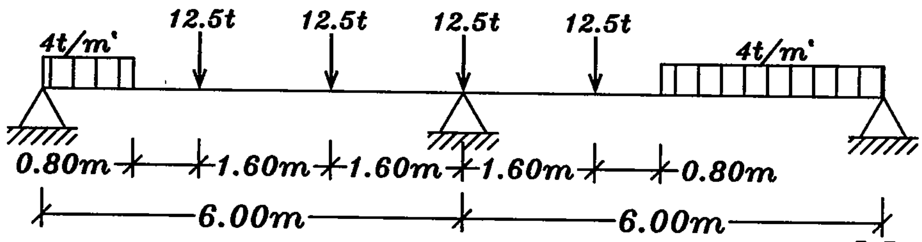
June 2004 (Str.)

Question (1-4)

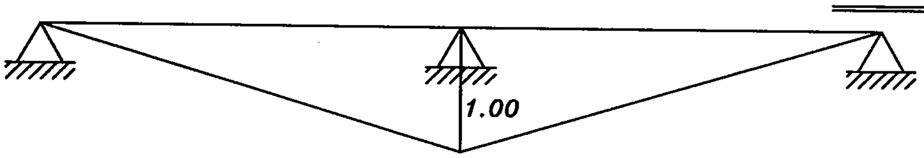
For Member V1

Live Loads





I.L Reaction



$R_{LL} = 3*12.5*0.733 + 12.5*0.733 + 4*2.0*0.167 + 4*3.6*0.30$

$R_{LL} = \boxed{42.30t}$

$$(1+I) = 0.73 + \frac{2.16}{\sqrt{L_1} - 0.2}$$

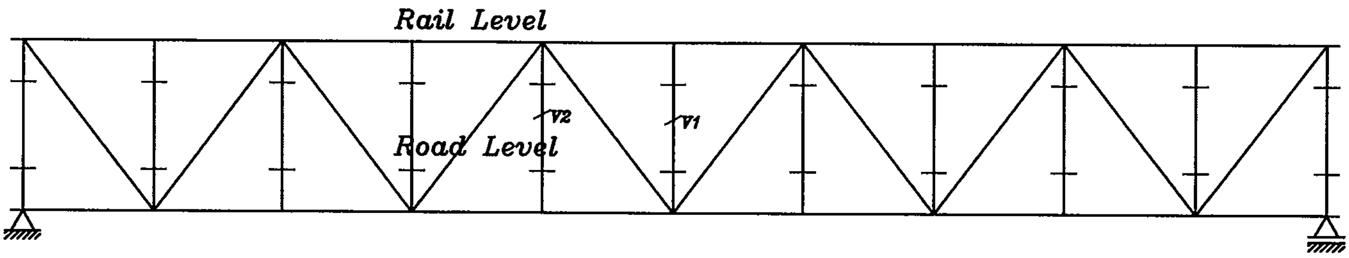
$L_1 = 2*14.0 = 28m$

$$(1+I) = 0.73 + \frac{2.16}{\sqrt{28.0} - 0.2} = 1.15 \boxed{> 1.1 \;,\; < 2.00}$$

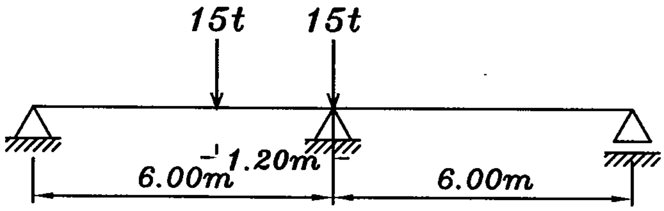
$R_{LL+I} = 42.30*1.15 = 48.645t$

For Member V2

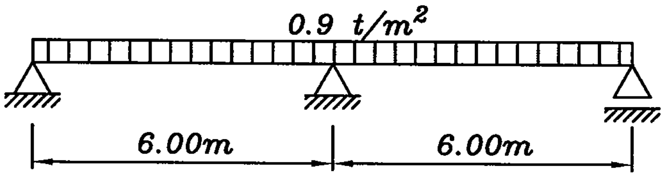
Live Loads



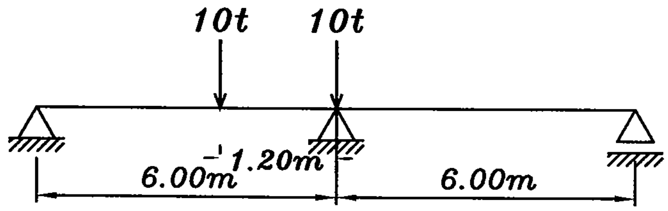
Strip1
Get R_1



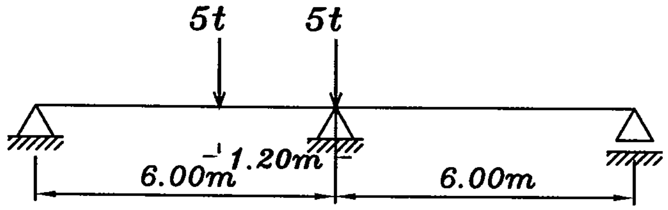
Strip2
Get W_1



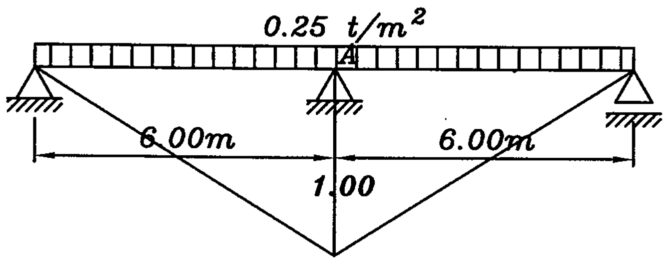
Strip3
Get R_2



Strip5
Get R_3



Strip4
Get W_2



$$R_1 = 15*(1+0.80) = 27t$$

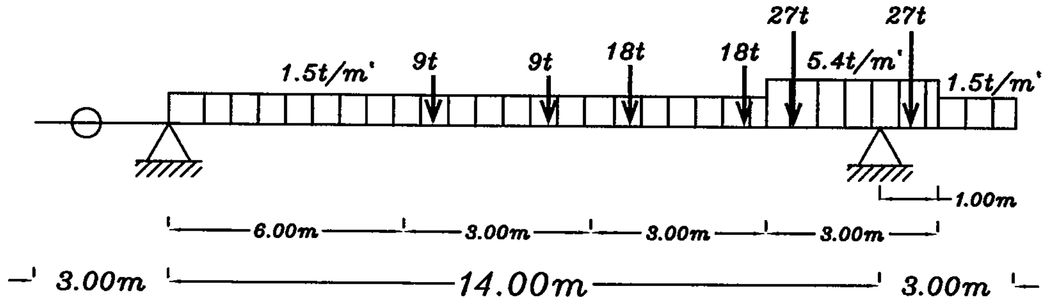
$$R_2 = 10*(1+0.80) = 18t$$

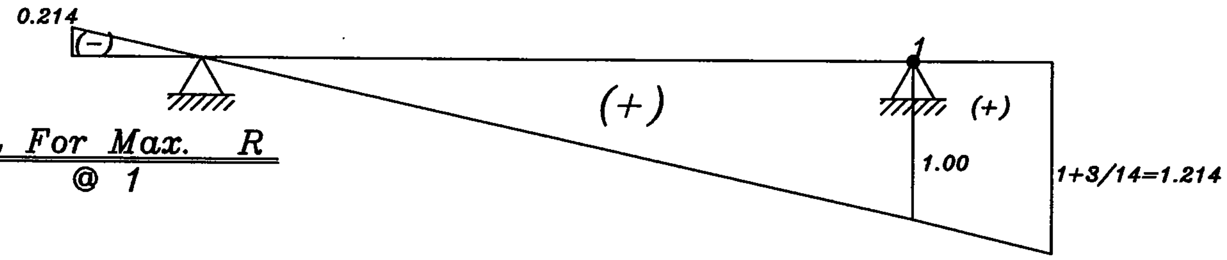
$$R_3 = 5*(1+0.80) = 9t$$

$$W_1 = 0.90*6.00 = 5.40t/m'$$

$$W_2 = 0.25*6.00 = 1.50t/m'$$

Case Of Max. Reaction





I.L For Max. R @ 1

$Q_{LL+I} = 1.5*2.0*1.14+5.40*3.0*0.96+2*27*0.964$
$2*18*0.785+2*9*0.53+1.5*12*0.428 = 116.532\ t$
$= \boxed{116.5t \quad (tension)}$

Example two

Question 3

Design of Upper chord U1

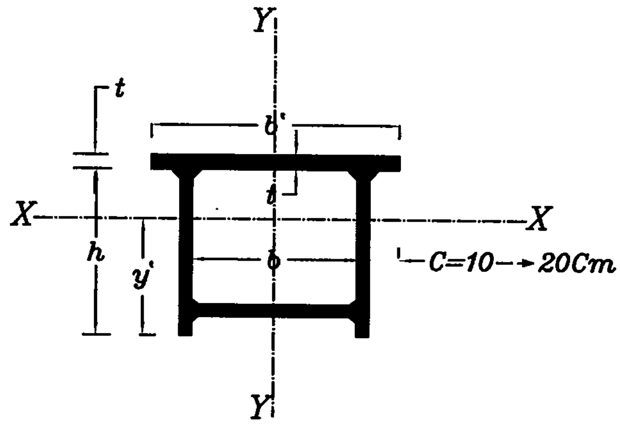
1)assume compression stress to be :

$F_c = 1.8t/Cm^2$ For St.52

use h = 55Cm (given)

use b = 50Cm (given)

$b' = b+2*(10 \longrightarrow 20Cm)$



$b' = 50+2*(10 \longrightarrow 20Cm) = 70Cm$ to $90Cm$ use $b' = 90Cm$

2) $F_c = \frac{max.\ force}{area}$ $\quad 1.8 = \frac{1680t}{area}$

$area = 933Cm^2$

$A = 2ht + b'*t = ...Cm^2$

$933 = 2*55*t + 90*t$, $t = 4.665Cm$

try to use closed box setion

$933 = 2*55*t + 90*t + 50*t$, $\boxed{t = 4.00Cm}$

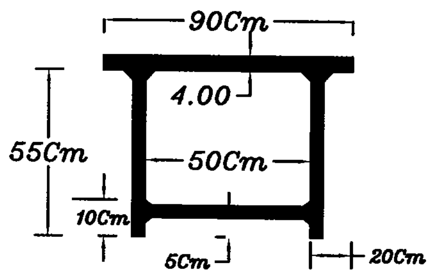
Checks

1-Check Compactness

$\frac{b}{t} = \frac{50-2*1}{4.00} = 12.00 < \frac{64}{\sqrt{3.6}} = 33.7$

$\frac{C}{t} = \frac{20-4-1}{4.00} = 3.7 < \frac{21}{\sqrt{3.6}} = 11.1$

$\frac{h}{t} = \frac{55-1-10}{4.00} = 11 < \frac{64}{\sqrt{3.6}} = 33.7$



2−Check global buckling

$$y' = \frac{(2ht*0.5h)+b'*t(h+0.5t)}{2ht+b't} = ...Cm$$

$$y' = \frac{(55*4.00*27.5*2)+(90*4.00*57)+(50*4*7)}{(55*4.00*2)+(70*4.00)+(50*4)} = 34.02Cm$$

$$I_X = 2*\frac{t*h^3}{12} + 2*t*h*(y'-0.5h)^2 + b'*t*(y'-h-0.5t)^2 = ...Cm^4$$

$$I_X = 2*[\frac{4.0*55^3}{12} + 2*4.0*55*(34-27.5)^2] + 4.0*90*(34-57)^2 + 50*4(34-7)^2$$

$$\boxed{I_X = 484336 \quad Cm^4}$$

$$I_Y = [\frac{4.0*90^3}{12}] + [\frac{4.0*50^3}{12}] + 2*4.0*55*(25+2.0)^2 = 605427 \ Cm^4$$

$$A = (4.0*2*55) + (90*4.0) + (50*4) = 1000 \ Cm^2$$

Calculate $r_X = \sqrt{\frac{I_X}{A}} = \sqrt{\frac{484336}{1000}} = 22.00Cm$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{605427}{1000}} = 24.60Cm$

$$\lambda_{in} = \frac{L_{in}}{r_X} = \frac{0.85*600}{22.00} = 23 < 90$$

$$\lambda_{out} = \frac{L_{out}}{r_Y} = \frac{0.85*600}{24.60} = 21 < 90$$

3−Check Compressive Stresses

actual stresses = $f_{ca} = \frac{1680t}{1000} = 1.68 \ t/Cm^2$

allwable stresses = $F_c = 2.1 - 13.5*10^{-6} * \lambda^2_{max.}$ For St.52

allwable stresses = $F_c = 2.1 - 13.5*10^{-6} * 23^2 = 2.02 \ t/Cm^2$

Safe section we can reduce 't' to be economic section

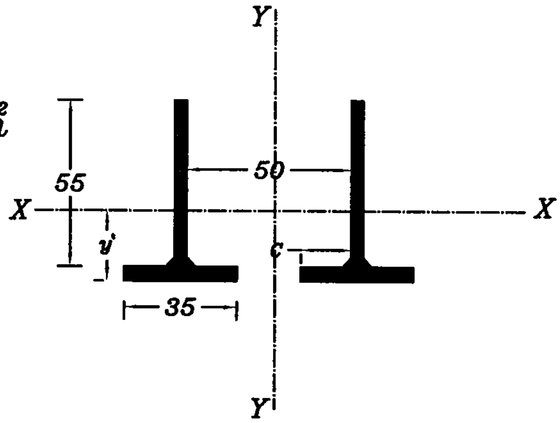
Design L1

$h = 55Cm$ $\qquad$ $b = 50Cm$

$b' = (1/2 \longrightarrow 2/3) * b \quad = 25Cm \text{ to } 34Cm \quad$ use $b' = 35Cm$

1)assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1 - \frac{T_{min.}}{T_{max.}}} = \frac{1.12}{1 - \frac{540}{1620}} = 1.68 \ t/Cm^2$$



$F_{max.} < 2.1 \ t/Cm^2$

use $F_{max.} = 1.68 \ t/Cm^2$

2) $F_t = \dfrac{\text{max. force } T_{D+LL+I}}{\text{area}}$ $\qquad$ $1.68 = \dfrac{1620}{\text{area}}$

get $A = 965 \ Cm^2 = (2*35+2*55)*t \qquad t = 5.36Cm$

use stiffeners to increase section area

get $A = 965 \ Cm^2 = (2*35+2*55+4*15)*t \qquad t = 4.00Cm$

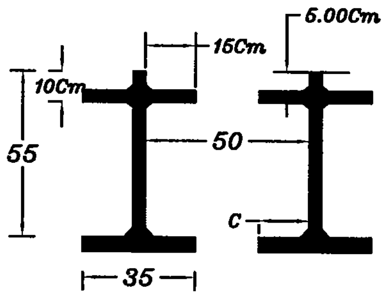
use $t = 4.00 \ Cm$

1-Check Compactness

لايفضل عمل هذا ال check فى حالة الtension

$$\frac{h}{t} = \frac{55-10}{4.00} = 11.0 \quad < \frac{64}{\sqrt{3.6}} = 33.73$$

$$\frac{C}{t} = \frac{15Cm}{4.00} = 3.7 \quad < \frac{21}{\sqrt{3.6}} = 11.06$$



2-Check global buckling

$$y' = \frac{2*h*t*(0.5h+t) + 2*b'*t(0.5t) + 4*c*t(t+h-5-t/2)}{2ht+2b't} = ...Cm$$

$$y' = \frac{(2.0*4.0*35*2)+(2*55*4.0*31.5)+(4*15*4*52)}{(2*20*3.4)+(2*40*3.4)+(4*15*4.00)} = 28Cm$$

$A = 2*35*4.0 + 2*55*4.0 + 4*15*4.00 = 960 \ Cm^2$

$$I_X = 2*[\frac{4.0*55^3}{12} + 2*4.0*55*(28-31.5)^2] + 2*35*4*(2-28)^2 +$$

$$4*15*4*(52-28)^2 = \boxed{I_X = 449216.66\ Cm^4}$$

$$I_Y = 2*\frac{4.0*35^3}{12} + 4.0*35*2*(50/2+4.0/2)^2 + 4.0*55*2*(25+2)^2 +$$

$$2*\frac{4.0*30^3}{12} + 4.0*15*4*(50/2+4.0/2)^2 = 746423\ Cm^4$$

$$\boxed{I_Y = 746423.333\ Cm^4}$$

Calculate $r_X = \sqrt{\frac{I_X}{A}} = \sqrt{\frac{449216}{960}} = 21.60Cm$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{746423}{960}} = 27.8Cm$

$$\lambda_{in} = \frac{0.85L}{r_X} = \frac{0.85*600}{21.6} = 23.6 < 160$$

$$\lambda_{out} = \frac{0.85L}{r_Y} = \frac{0.85*600}{27.8} = 18.3 < 160$$

3-Check Stresses

3-i)Check max. Stresses

actual stresses $= f_t = \frac{1620}{960} = 1.69\ t/Cm^2 \not> 2.1$

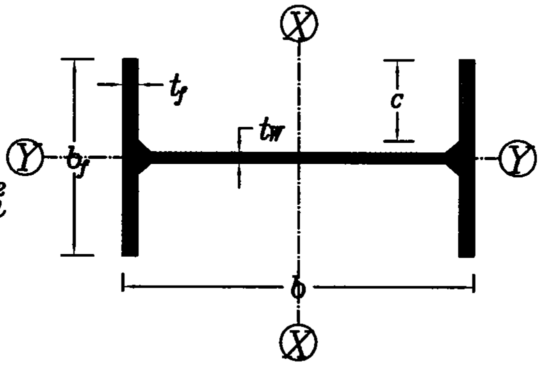
3-ii)Check stress range

$\frac{1620-540}{960} = 1.12 = 1.12\ t/Cm^2$ safe

Design D1

N (roadway) = 2,000,000 Detail B, F_{sr} =1.26t/Cm²

N (railway) = 500,000 Detail B, F_{sr} =2.00t/Cm²



1)assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1-\frac{T_{min.}}{T_{max.}}} = \frac{1.26}{1-\frac{-80}{195}} = 0.89 \ t/Cm^2$$

$F_{max.} < 2.1 \ t/Cm^2$

use $F_{max.} = 0.89 \ t/Cm^2$

2) $F_t = \dfrac{max.\ force\ T_{D+LL+I}}{area}$ $\qquad 0.89 = \dfrac{195}{area}$

get A = 219 Cm²

b = 50Cm

$\dfrac{b}{t_w} = \dfrac{64}{\sqrt{Fy}}$ $\qquad \dfrac{50}{t_w} = \dfrac{64}{\sqrt{3.6}}$ $\qquad t_w = 1.48$ Cm $\qquad$ use $t_w = 1.60$ Cm

$A = 2*b_f*t_f + b*t_w = ... Cm^2$

$219 = 50*1.6 + 2*b_f*t_f$

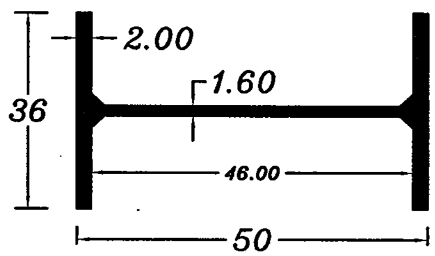
$b_f*t_f = 69.5\ Cm^2$ use $\boxed{b_f = 36Cm}$, $\boxed{t_f = 2.00Cm}$

$b_{f\ min.} = 6\phi + t_w + 2S \triangleq 20Cm$

1−Check Compactness

$$\frac{b}{t_w} \le \frac{64}{\sqrt{Fy}} = \frac{50-2*2.0-2*1}{1.60} = 27.5 < 33$$

$$\frac{C}{t_f} \le \frac{21}{\sqrt{Fy}} = \frac{18-1.60/2-1}{2.00} = 8.10 < 11$$



2-Check global buckling

$$I_X = \frac{t_W * d_W^3}{12} + 2b_f * t_f * (d_W/2 + t_f/2)^2 = ...Cm^4$$

$$I_X = \frac{1.6*46^3}{12} + 2*2.0*36*(25-1.0)^2 = 95922.13\ Cm^4$$

$$I_Y = 2*\frac{t_f * b_f^3}{12} = ...Cm^4$$

$$I_Y = 2*\frac{2.0*36^3}{12} = 15552\ Cm^4$$

$$A = (1.6*46.0)+(2*36*2.0) = 217.6\ Cm^2$$

Calculate $r_X = \sqrt{\frac{I_X}{A}} = \sqrt{\frac{95922}{217.6}} = 20.99Cm$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{15552}{217.6}} = 8.45Cm$

$$\lambda_{in} = \frac{\text{buckling length inplane} = L_{in}}{\text{raduis of gyration @ Y axis} = r_Y} \ngtr 90 \quad \text{(RailWay)}$$

$$\lambda_{in} = \frac{0.70*1000}{8.45} = 82 < 90 \quad \text{safe}$$

$$\lambda_{out} = \frac{0.85*1000}{20.99} = 41 < 90$$

3-Check maximum Stresses

3-i Tension Stresses

actual stresses $= f_{ta} = \frac{+195}{217} = 0.89\ t/Cm^2 < 0.58F_y = 2.1 t/Cm^2$

fatigue stresses $\frac{195+80}{217} = 1.26 < 1.26\ t/Cm^2$ safe

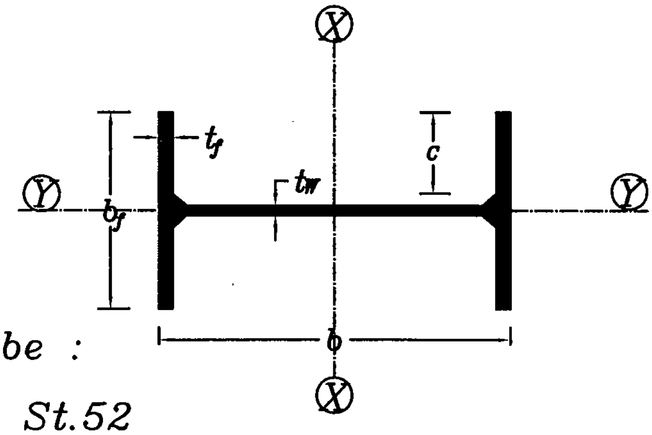
3-ii Compression Stresses

actual stresses $= f_{ca} = \frac{-80}{217} = 0.37\ t/Cm^2$

allwable stresses $= F_c = 2.1 - 13.5 * 10^{-5} * \lambda^2_{max.}$ For St.52

allwable stresses $= F_c = 2.1 - 13.5 * 10^{-5} * 82^2 = 1.19\ t/Cm^2$

<u>Design V1</u>



1)assume compression stress to be :

$F_c = 1.5t/Cm^2$ to $1.8t/Cm^2$ For St.52

2)$F_c = \frac{max.\ force}{area}$ $\quad 1.7 = \frac{104}{area}$ $\quad A = 61Cm^2$

$b = 50Cm$

$\frac{b}{t_w} = \frac{64}{\sqrt{F_y}}$ $\quad \frac{50}{t_w} = \frac{64}{\sqrt{3.6}}$ $\quad t = 1.48\ Cm$ $\quad$ use $t = 1.60\ Cm$

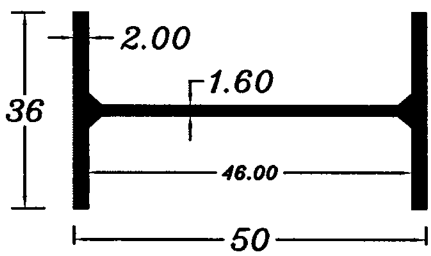
$A = 2*b_f*t_f + b*t_w = ...Cm^2$

$61 = 50*1.6 + 2*b_f*t_f$

$b_f*t_f = -ve\ value$

use $b_f = 36\ Cm$ $\quad t_f = 2Cm$

<u>1-Check Compactness</u>



$$\frac{b}{t_w} \leq \frac{64}{\sqrt{F_y}} = \frac{50-2*2.0-2*1}{1.60} = 27.5 < 33$$

$$\frac{C}{t_f} \leq \frac{21}{\sqrt{F_y}} = \frac{18-1.60/2-1}{2.00} = 8.10 < 11$$

<u>2-Check global buckling</u>

$$I_X = \frac{t_w*d_w^3}{12} + 2b_f*t_f*(d_w/2+t_f/2)^2 = ...Cm^4$$

$$I_X = \frac{1.6*46^3}{12} + 2*2.0*36*(25-1.0)^2 = 95922.13\ Cm^4$$

$$I_Y = 2*\frac{t_f*b_f^3}{12} = ...Cm^4$$

$$I_Y = 2*\frac{2.0*36^3}{12} = 15552\ Cm^4$$

$$A = (1.6*46.0)+(2*36*2.0) = 217.6\ Cm^2$$

Calculate $r_X = \sqrt{\frac{I_X}{A}} = \sqrt{\frac{95922}{217.6}} = 20.99 Cm$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{15552}{217.6}} = 8.45 Cm$

$$\lambda_{in} = \frac{\text{buckling length inplane} = L_{in}}{\text{raduis of gyration @ Y axis} = r_Y} \ngtr 90 \quad \text{(RailWay)}$$

$$\lambda_{in} = \frac{0.7*800}{8.45} = 66 < 90$$

$$\lambda_{out} = \frac{0.85*800}{20.99} = 32 < 90$$

<u>3-Check Compressive Stresses</u>

actual stresses $= f_{ca} = \frac{104}{217} = 0.48\ t/Cm^2$

allwable stresses $= F_c = 2.1 - 13.5*10^{-5} * \lambda^2_{max.}$ For St.52

allwable stresses $= F_c = 2.1 - 13.5*10^{-5} * 66^2 = 1.51\ t/Cm^2$

Suitable Section for U2

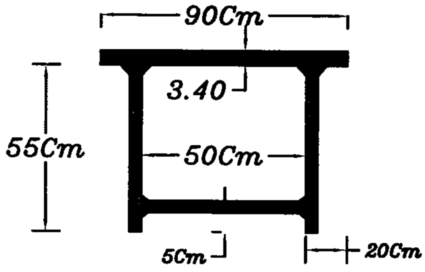
1)assume compression stress to be :

$F_c = 1.8 t/Cm^2$ For St.52

use h = 55Cm (as before)

use b = 50Cm (as before)

use b' = 90Cm



$$2)F_c = \frac{max.\ force}{area} \qquad 1.8 = \frac{1420t}{area}$$

$area = 835 Cm^2$

$835 = 2*55*t + 90*t + 50*t$, $\boxed{t = 3.40 Cm}$

Suitable Section for D2

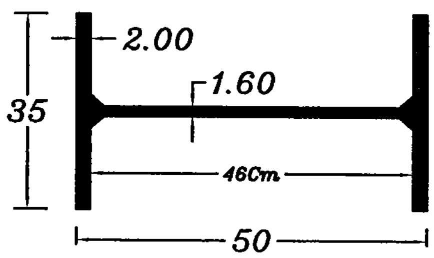
1)assume compression stress to be :

$F_c = 1.5 t/Cm^2$ to $1.8 t/Cm^2$ For St.52

$$2)F_c = \frac{max.\ force}{area} \qquad 1.7 = \frac{330}{area} \qquad A = 194 Cm^2$$

b = 50Cm

$$\frac{b}{t_w} = \frac{64}{\sqrt{F_y}} \qquad \frac{50}{t_w} = \frac{64}{\sqrt{3.6}} \qquad t = 1.48\ Cm \quad use\ t = 1.60\ Cm$$



$A = 2*b_f*t_f + b*t_w = \ldots.Cm^2$

$194 = 50*1.6 + 2*b_f*t_f$

$b_f*t_f = 57\ Cm^2$

$\boxed{use\ b_f = 36\ Cm \qquad t_f = 2Cm}$ to safe global buckling

Suitable Section for V2

1)assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1-\frac{T_{min.}}{T_{max.}}} = \frac{1.26}{1-\frac{46}{86}} = 2.70\ t/Cm^2$$

$F_{max.} > 2.1\ t/Cm^2$

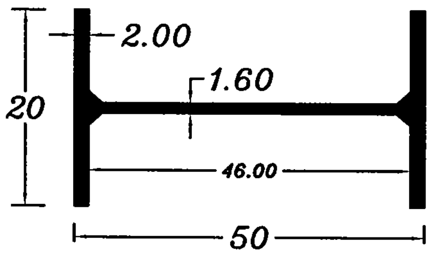
use $F_{max.} = 2.10\ t/Cm^2$

2) $F_t = \frac{max.\ force\ T_{D+LL+I}}{area}$ $\qquad 2.10 = \frac{86}{area}$

get $A = 41\ Cm^2$

$b = 50Cm$

$\frac{b}{t_w} = \frac{64}{\sqrt{F_y}}$ $\qquad \frac{50}{t_w} = \frac{64}{\sqrt{3.6}}$ $\qquad t_w = 1.48\ Cm$ $\quad$ use $t_w = 1.60\ Cm$



$A = 2*b_f*t_f + b*t_w = \ldots.Cm^2$

$41 = 50*1.6 + 2*b_f*t_f$

$b_f*t_f = -ve\ value$

$b_{f\ min.} = 6\phi + t_w + 2S \triangleq 20Cm$ $\quad$ use $t_f = 2Cm$

| use $b_f = 36\ Cm$ $\qquad t_f = 2Cm$ | to safe global buckling

Example two

Question 4

Diagonal bolts D1

$A_{Diagonal} = 217\ Cm^2$ (tension stress govern in this member)

$F_{Diagonal} = 217*F_t = 217*2.1 = 455.7\ t$

number of bolts per one flange $= \dfrac{Stress*area}{P_s * 2}$

$n = \dfrac{455.7}{9.08 * 2} = 25$ bolt per one flange

use $n = 28$ bolt (4column*7rows)

$b_{f\,min}$ for diagonal $= 4*3*\phi + t_w = 4*3*2.7+1.6 = 34Cm \leq 36Cm$

Diagonal bolts D2

$A_{Diagonal} = 217.6\ Cm^2$ (Compression stress govern in this member)

$F_{Diagonal} = 217*F_c = 217*1.1 = 238\ t$

number of bolts per one flange $= \dfrac{Stress*area}{P_s * 2}$

$n = \dfrac{238\ t}{9.08 * 2} = 13$ bolt per one flange

use $n = 16$ bolt (4column*4rows)

$b_{f\,min}$ for diagonal $= 4*3*\phi + t_w = 4*3*2.7+1.6 = 34Cm \leq 36Cm$

Vertical bolts

$A_{Diagonal} = 217\ Cm^2$

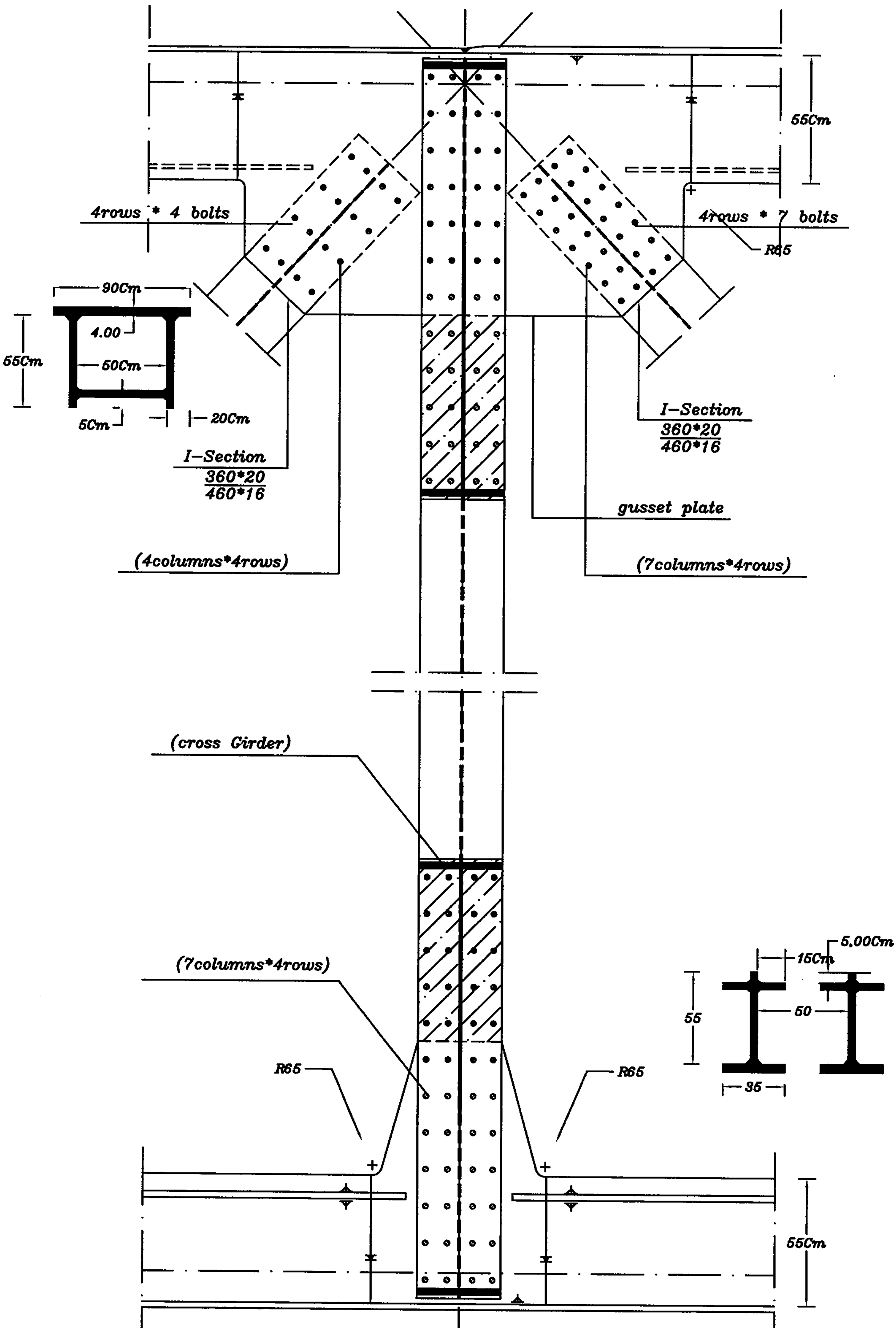
$F_{Diagonal} = 217*F_t = 217*2.1 = 455.7\ t$

number of bolts per one flange $= \dfrac{Stress*area}{P_s * 2}$

$n = \dfrac{455.7}{9.08 * 2} = 25$ bolt per one flange

use $n = 28$ bolt (4column*7rows)

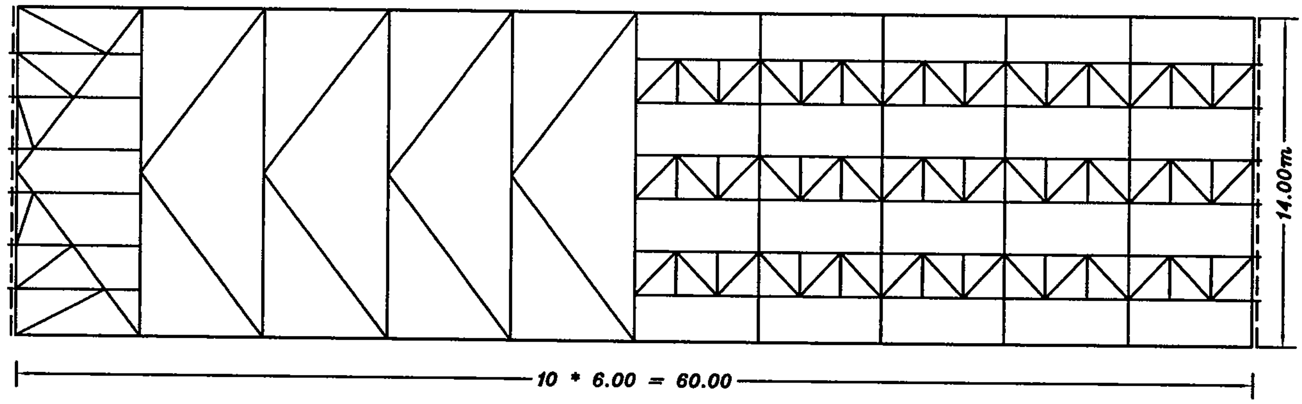
$b_{f\,min}$ for diagonal $= 4*3*\phi + t_w = 4*3*2.7+1.6 = 34Cm \leq 36Cm$


55Cm
4rows * 4 bolts
4rows * 7 bolts
R65
90Cm
4.00
55Cm
50Cm
5Cm
20Cm
I-Section
360*20
460*16
I-Section
360*20
460*16
gusset plate
(4columns*4rows)
(7columns*4rows)
(cross Girder)
(7columns*4rows)
5.00Cm
15Cm
55
50
35
R65
R65
55Cm

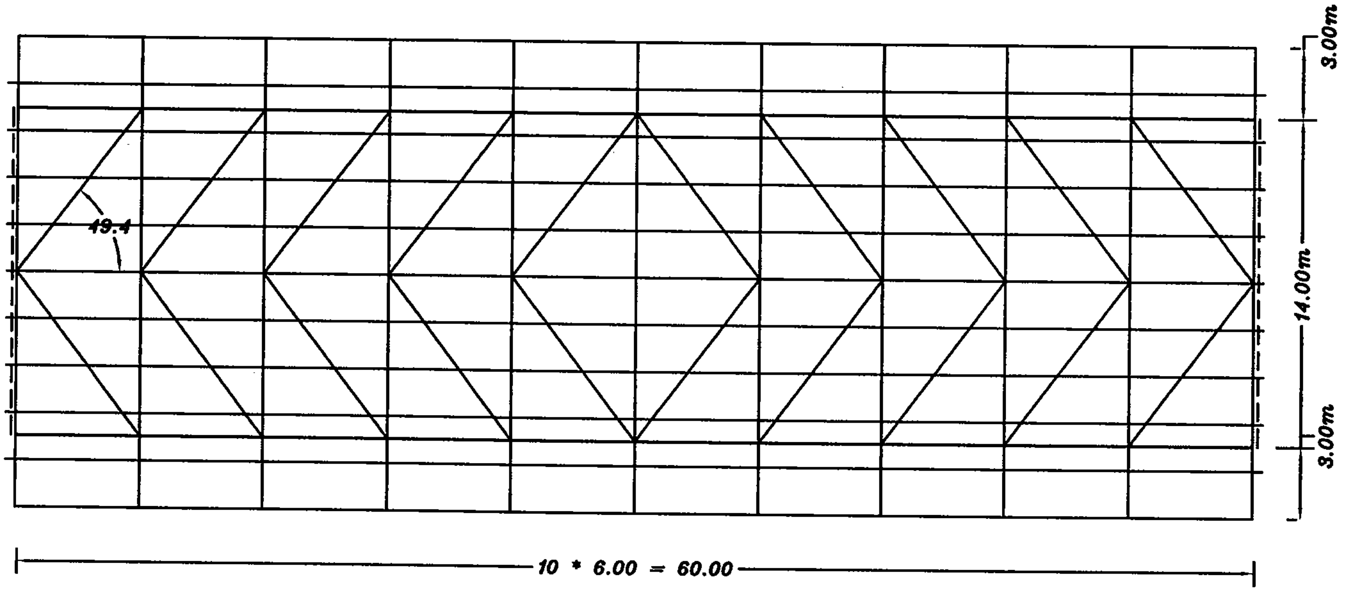
Example two

Question 6

Different Bracing System



Plan of Rail Way Bridge



Plan of Road Way Bridge

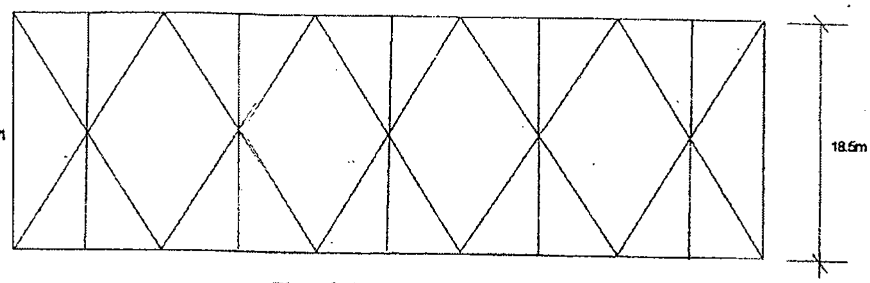
AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
STRUCTURAL ENGINEERING DEPARTMENT

Fourth Year Civil – (Structural Section)
DESIGN OF STEEL BRIDGES
COURSE NO. CES 452
May 2005
Time : 3.00 Hrs

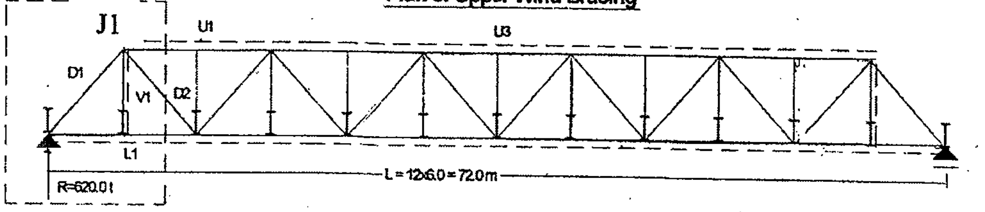
The Exam Consists of **Four** Questions in **Three** Pages.

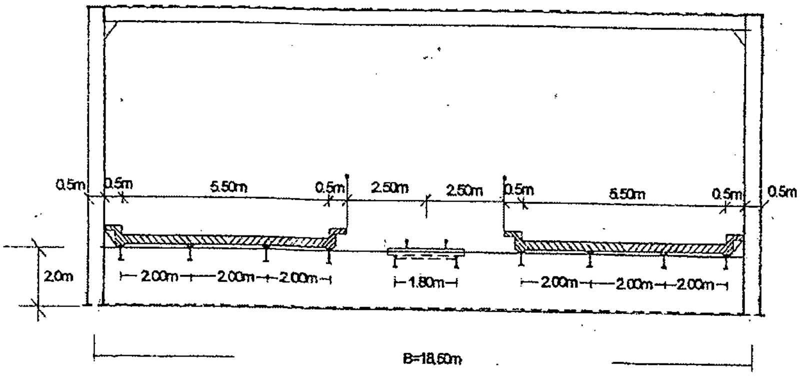
Material of construction is **Steel 52** Data not given may be reasonably assumed.

QUESTION (I) Truss Bridge:



Plan of Upper Wind Bracing





Cross Section at Mid-span

The main girders of a rail-roadway through bridge are welded W-trusses of the shown cross section having a span of 72.0 ms divided into 12 equal panels 6.0 ms each. The main trusses are spaced 18.5 ms apart. Depth of the main truss is 8.5 ms. The flooring for the single-track railway is the usual open timber type while for the roadways on either side consists of a 20 cm R.C. slab covered with a layer of bituminous concrete. The bridge is provided with lower bracing, special braking force bracing, upper bracing as well as end-portal-frames as shown in Fig. The inner spacing between the truss gusset plates is 50.0 cm, and depth of the upper and lower truss chords is taken as 55.0 cm.

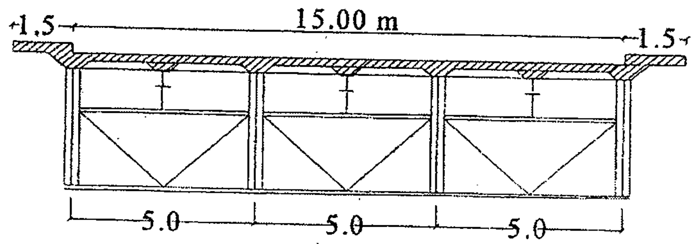
Required:

1- Design a suitable section for the upper chord member U3, and choose without check suitable sections to U1& lower chord member L1, diagonal members D1& D2, and vertical member V1, given that the maximum forces due to dead loads, live loads and impact are as shown in the following table.

MEMBER	MINIMUM FORCES	MAXIMUM FORCES
U1	- 340 t	- 720 t
U3	- 610 t	- 1300
L1	+ 170 t	+ 365 t
D1	- 340 t	- 722 t
D2	+ 240 t	+ 519 t
V1	+ 48 t	+ 102 t

2- Design the first vertical member of the upper bracing (VW1).
3- Design the joint J1, using M27 H.S. Bolts, quality 10.9. Draw the part A to scale 1:10 (Assume a reasonable section for the cross girder and the rocker bearing).
4- Suggest a suitable lower wind bracing and braking force bracing for the bridge. Find the forces on the first diagonal members of the lower wind bracing for **the case of loaded bridge only**.

QUESTION (II) : Composite Grid Bridge

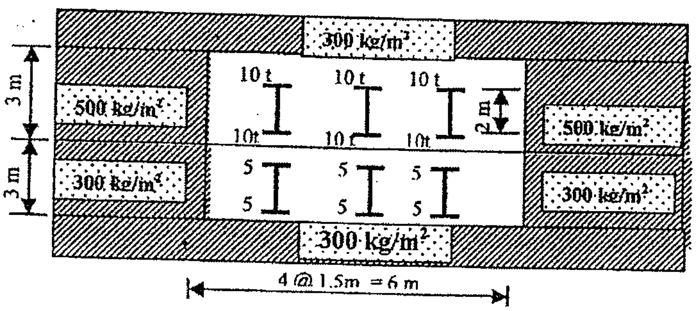


CROSS SECTION

A roadway plate girder composite deck bridge of the shown cross section has a span of 48.0 ms and is divided into 8 equal panels 6.0 ms each. The main girders are spaced 5.0 ms apart and provided with cross frames every 6.0ms. The main girder is composed of a web plate of thickness 14 mm and depth 2.5 ms. The web plate is stiffened with transverse stiffeners every 1.5 ms along with longitudinal stiffeners at one fifth of the depth from compression flange.. Depth of the cross girder is taken as 0.80 ms. Thickness of the R.C. slab is 20.0 cm with a haunch of 8.0 cm depth. Consider C_{cu} of concrete as 400 kg/cm^2 with modular ratio n = 8.

Required:

1- Assuming infinitely rigid cross beams, calculate the maximum bending moment and the maximum shearing force for the outer main girder, due to dead loads, live loads and impact.
2- Using shored method of construction, design a suitable composite section for the outer main girder.
3- Find the pitch for stud shear connector with diameter 24 mm. (Note: R_{sc}=0.17 $A_{sc}[F_{cu}E_c]^{0.5}$)



Live Loads on Roadway Bridges

May. 2005 (Str.)

Question (1-1)

Design of Upper chord U

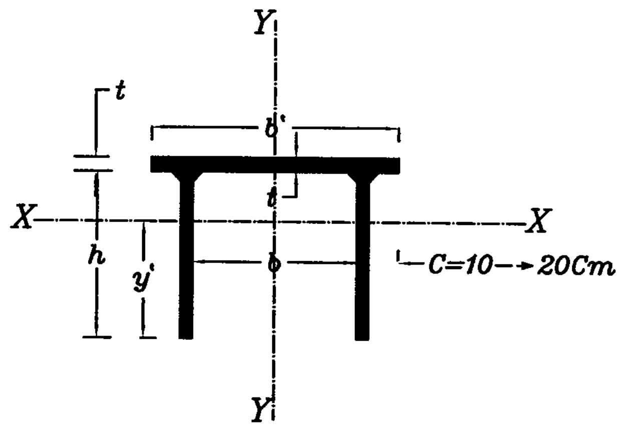
1)assume compression stress to be :

$F_c = 1.8 t/Cm^2$ For St.52

use h = 55Cm (given)

use b = 50Cm (given)

$b' = b + 2*(10 \longrightarrow 20Cm)$



$b' = 50 + 2*(10 \longrightarrow 20Cm) = 70Cm$ to $90Cm$ use $b' = 70Cm$

2) $F_c = \dfrac{max.\ force}{area}$ $\qquad 1.8 = \dfrac{1300t}{area}$

$area = 722 Cm^2$

$A = 2ht + b'*t = ...Cm^2$

$722 = 2*55*t + 70*t$ $\qquad , \ t = 4.00Cm$

take t = 4.00Cm

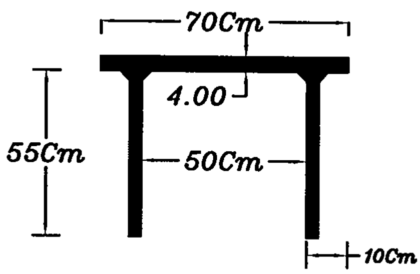
Checks

1-Check Compactness

$\dfrac{b}{t} = \dfrac{50-2*1}{4.00} = 12.00 < \dfrac{64}{\sqrt{3.6}} = 33.7$

$\dfrac{C}{t} = \dfrac{10-4-1}{4.00} = 1.2 < \dfrac{21}{\sqrt{3.6}} = 11.1$

$\dfrac{h}{t} = \dfrac{55-1}{4.00} = 13 < \dfrac{30}{\sqrt{3.6}} = 15.8$



2-Check global buckling

$$y' = \frac{(2ht*0.5h)+b'*t(h+0.5t)}{2ht+b't} = ...Cm$$

$$y' = \frac{(55*4.00*27.5*2)+(70*4.00*57)}{(55*4.00*2)+(70*4.00)} = 38.9Cm$$

$$I_x = 2*\frac{t*h^3}{12} + 2*t*h*(y'-0.5h)^2 + b'*t*(y'-h-0.5t)^2 = ...Cm^4$$

$$I_x = 2*(\frac{4.0*55^3}{12} + 2*4.0*55*(38.9-27.5)^2 + 4.0*70*(38.9-57)^2)$$

$$I_x = 408743 \quad Cm^4$$

$$I_Y = [\frac{4.0*70^3}{12}] + 2*4.0*55*(25+2.0)^2 = 435093 \ Cm^4$$

$$A = (4.0*2*55) + (70*4.0) = 720 \ Cm^2$$

Calculate $r_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{408743}{720}} = 23.82Cm$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{435093}{720}} = 24.5Cm$

$$\lambda_{in} = \frac{L_{in}}{r_x} = \frac{0.85*600}{23.82} = 21 < 90$$

$$\lambda_{out} = \frac{L_{out}}{r_Y} = \frac{0.85*600}{24.5} = 21 < 90$$

3-Check Compressive Stresses

actual stresses $= f_{ca} = \frac{1300t}{720} = 1.80 \ t/Cm^2$

allwable stresses $= F_c = 2.1-13.5*10^{-5} * \lambda^2_{max.}$ For St.52

allwable stresses $= F_c = 2.1-13.5*10^{-5} * 21^2 = 2.04 \ t/Cm^2$

Safe section

suitable section for u1

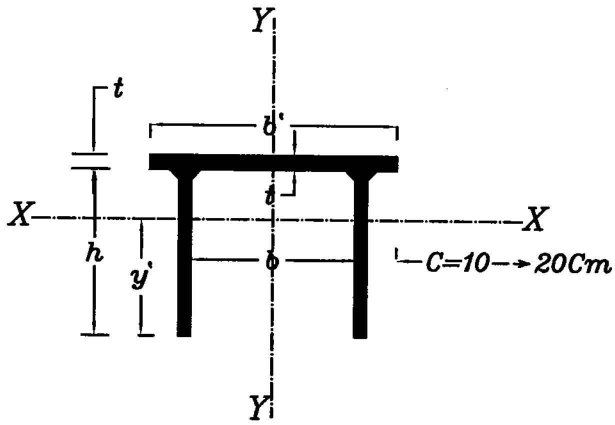
1)assume compression stress to be :

$F_c = 1.8t/Cm^2$ For St.52

use h = 55Cm (given)

use b = 50Cm (given)

$b' = b+2*(10 \longrightarrow 20Cm)$



use web to be 18 mm in thikness

$b' = 50+2*(10 \longrightarrow 20Cm) = 70Cm$ to $90Cm$ use $b' = 70Cm$

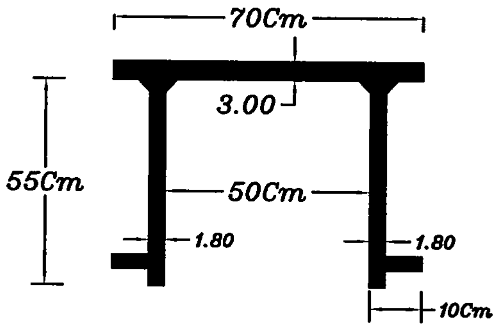
2) $F_c = \frac{max.\ force}{area}$ $1.8 = \frac{720t}{area}$

area = $400Cm^2$

$A = 2ht_1 + b'*t_2 = ...Cm^2$

$400 = 2*55*1.8+70*t_2$, $t = 2.88Cm$

take t = 3.00Cm



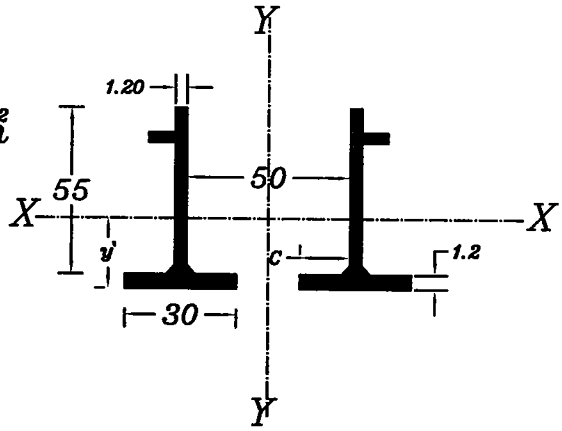
suitable section for L1

$h = 55Cm$ $\qquad$ $b = 50Cm$

$b' = (1/2 \longrightarrow 2/3)*b$ $= 25Cm$ to $33Cm$ use $b' = 30Cm$

1) assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1 - \frac{T_{min.}}{T_{max.}}} = \frac{1.12}{1 - \frac{170}{365}} = 2.11 \ t/Cm^2$$



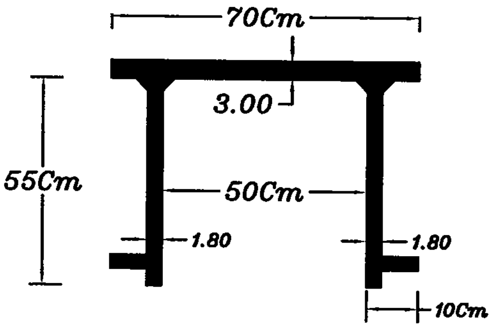
$F_{max.} > 2.1 \ t/Cm^2$

use $F_{max.} = 2.1 \ t/Cm^2$

2) $F_t = \frac{max.\ force\ T_{D+LL+I}}{area}$ $\qquad$ $2.1 = \frac{365}{area}$

get $A = 174 \ Cm^2 = (2*30+2*55)*t$ $\qquad$ $t = 1.20Cm$

suitable section for D1



same as U1

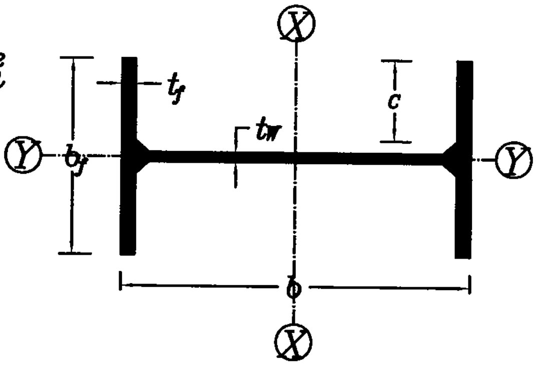
suitable section for D2

N = 500,000 for train single track, N = 2,000,000 roadway

use N = 2,000,000 $F_{sr} = 1.26\ t/Cm^2$

1)assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1-\frac{T_{min.}}{T_{max.}}} = \frac{1.26}{1-\frac{240}{519}} = 2.30\ t/Cm^2$$



$F_{max.} > 2.1\ t/Cm^2$

use $F_{max.} = 2.1\ t/Cm^2$

$$2)F_t = \frac{max.\ force\ T_{D+LL+I}}{area} \qquad 2.1 = \frac{519}{area}$$

get $A = 247\ Cm^2$

$b = 50Cm$

$$\frac{b}{t_w} = \frac{64}{\sqrt{F_y}} \qquad \frac{50}{t_w} = \frac{64}{\sqrt{3.6}} \qquad t_w = 1.48\ Cm \quad use\ t_w = 1.60\ Cm$$

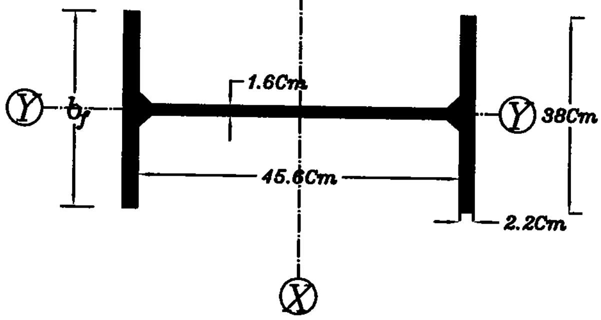
$A = 2*b_f*t_f + b*t_w = ...Cm^2$

$247 = 50*1.6 + 2*b_f*t_f$

$b_f*t_f = 83.3\ Cm^2$

$b_f = 20*t_f$, $t_f = 2.2Cm$ $b_f = 38Cm$

$b_{f\ min.} = 6\phi + t_w + 2S \triangleq 20Cm$ use $t_f = 2Cm$



May. 2005 (Str.)

Question (1−3)

Diagonal bolts [D2]

$A_{Diagonal} = 2*38*2.2+45.6*1.6 = 240.16\ Cm^2$

$F_{Diagonal} = 240.1*F_t = 240.1*2.1 = 504.33\ t$

$\text{number of bolts per one flange} = \dfrac{Stress*area}{P_s * 2}$

$n = \dfrac{504.33}{9.08 * 2} = 27.7$ bolt per one flange

use $n = 28$ bolt (4column*7rows)

$b_{f\,min}$ for diagonal $= 4*3*\phi + t_w = 4*3*2.7+1.6 = 34Cm \leq 38Cm$

Vertical bolts [V1]

$A_{vertical} = (1.6*46)+(2*20*2) = 153.6\ Cm^2$

$F_{Vertical} = 153.6*F_t = 153.6*2.1 = 322.5t$

$n = \dfrac{322}{9.08 * 2} = 17.73$ bolt per one flange

use $n = 18$ bolt (2column*9rows)

$b_{f\,min}$ for vertical $= 2*3*\phi + t_w = 2*3*2.7+1.6 = 17.8Cm$

Upper Chord & last Diagonal (check on Fillet Weld)

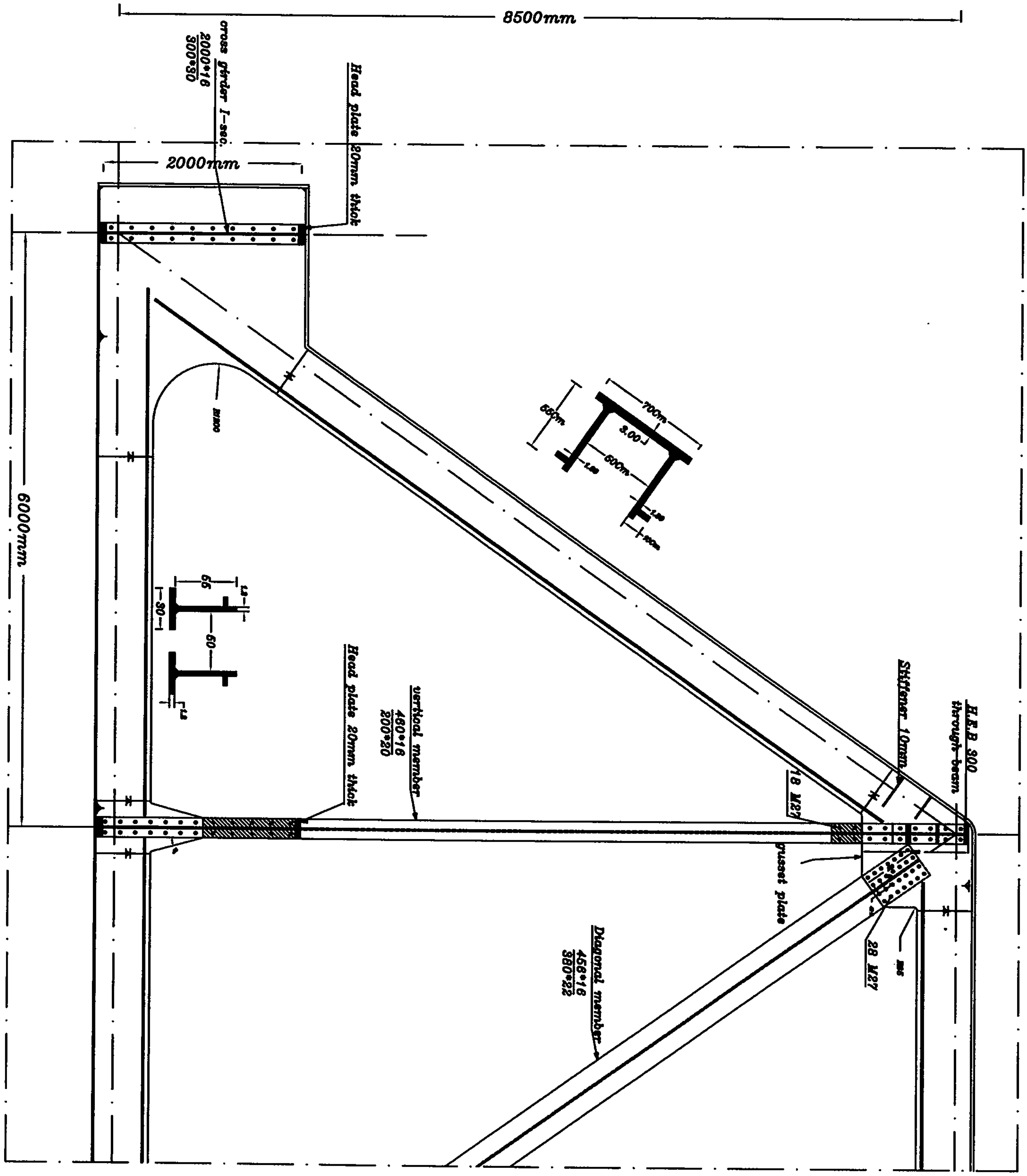
there is no difference between U1 , D1 (U1−D1) = zero

this is Sprate joint (then) use max. strength of flange

$0.2F_u = \dfrac{force\ in\ flange}{area} = \dfrac{F_o * Area\ flange = 1.8 * (70*2.4)}{4 * S * L_{Weld}} = 0.2*5.2$

taking size of weld = 1Cm

$L_{Weld} = 73Cm$


8500mm
2000mm
6000mm
cross girder I-sec.
2000*16
300*30
Head plate 20mm thick
Head plate 20mm thick
vertical member
460*16
200*20
Diagonal member
456*16
380*22
Stiffener 10mm
H.E.B 300
through beam
18 M27
28 M27
gusset plate

Ain Shams University. تصميم كباري معدنية
Faculty of Engineering.
Structural Engineering Dept.

4th year Civil Engineering.
Final-term Exam, May 2006
Time allowed: 3 hours.

CES 452 CF: Design of steel bridges.

- Material of construction is steel 52 - Any missing data may be reasonably assumed

Question 1 (35%):

The main girders of a triple-track open timber floor railway bridge are composed of warren trusses having a span of 72 ms. .The depth of main girders is 8.5 ms. Width of the bridge is 12.6 ms. The spacing between stringers is 1.8 ms. The depth of cross girder (h_w) is =1.5 ms. Height of construction is 2.5 ms.

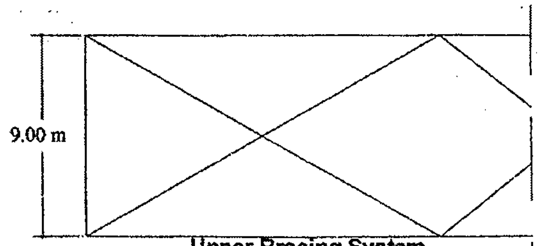
Stresses for St. 52:
- for $\lambda < 100$ $f_c = 2.1 - 0.000135\,\lambda^2$ t/cm²
- for $\lambda > 100$ $f_c = 7500/\lambda^2$ t/cm²
- $f_t = 2.1$ t/cm²
- for H.S.B. quality 10.9 M27 : $P_s = 9.08$ t

1- Draw to scale 1:200 a fully dimensioned layout for the bridge (elevations, plans, and cross section) showing all the necessary bracings. Mention all the horizontal loads and forces acting on the given bridge, and explain how these forces will be transferred to the bearings.
2- Calculate the max. force in braking force bracing system.
3- Design a section for the diagonal member having the max. force. Using neat sketches; draw a longitudinal sectional elevation for the floor beam sub-panel that includes the braking force bracing system., 4- Draw Pannel of Plane to scale 1:10 (wind Bracing)

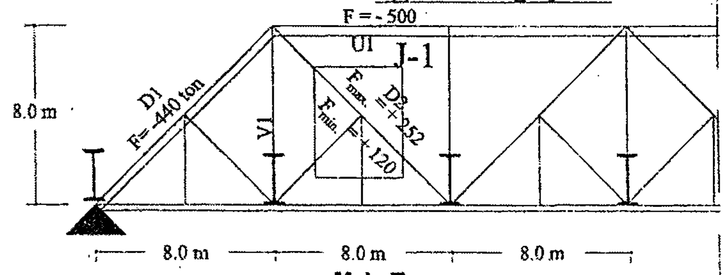
Question 2 (40%):

A double-track, open timber railway, through bridge of span 64.0 ms is shown in figure. The main girders of the bridge are subdivided, warren trusses of depth 8.0 ms. and type shown in figure. The live load affecting the bridge is train type "D". It is required to:

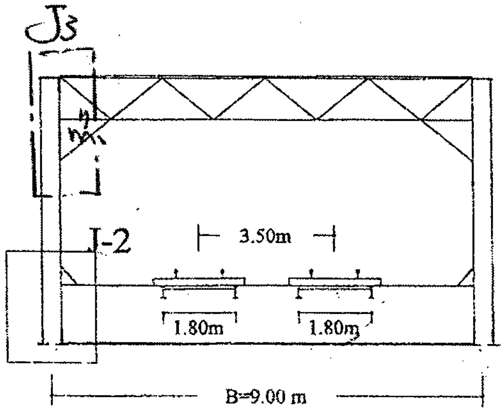
1- Design suitable sections for the members U1 and D2.
2- Draw the influence line of the maximum forces of member V1 and then calculate the maximum force affecting this member.
3- Design the joint J-1 using M 27 pretensioned bolts grade (10.9).
4- Draw joint J-1 to scale 1:10.
5- Without any calculations, draw joint "J-2" to scale 1:10.
6- Design m1
7- draw Joint J-3



Upper Bracing System



Main Truss



Bridge Cross-Section

May. 2006 (Str.)

Question (1–1)

Solution

1–try to use deck bridge

Height Of construction = 850Cm + 35cm =850(given)+52Cm
6Cm
L/800 = 9.00 Cm
2 Cm

1–try to use deck bridge

Height Of construction = 850Cm (given)+ 52cm = 902 Cm.

Height Of construction = 9.02 m

avilable height = 2.50m

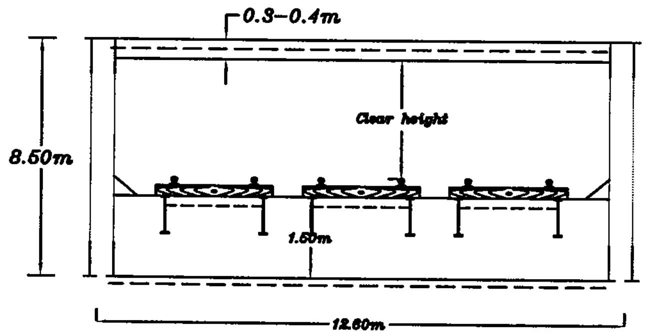
9.02m > 2.50m

Deck Bridge is not allowed

2–try to use through bridge

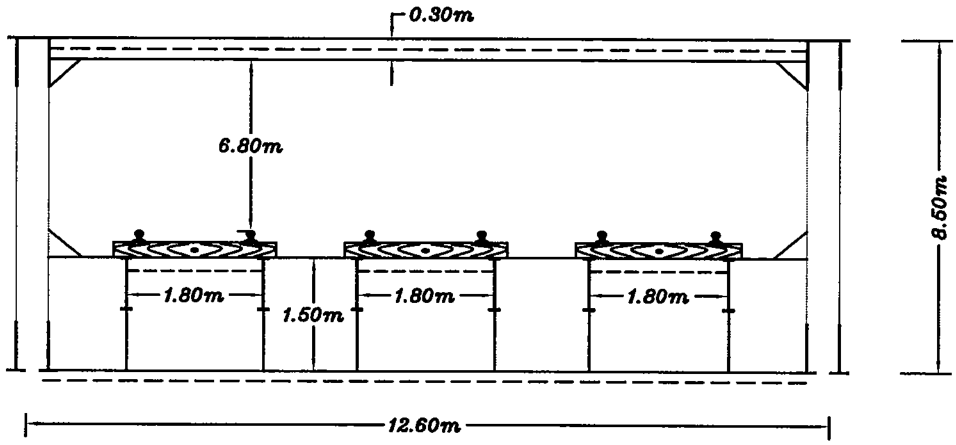
$H_{m.g} - H_{x.g} - H_{beam} - 0.45$ =clear height

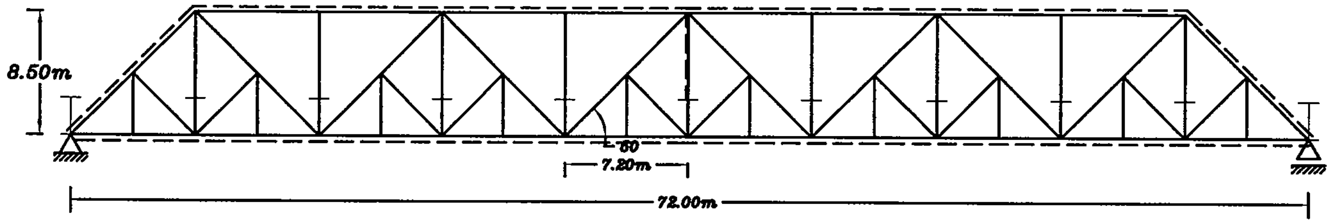
$H_{x.g}$ = (given)1.50m

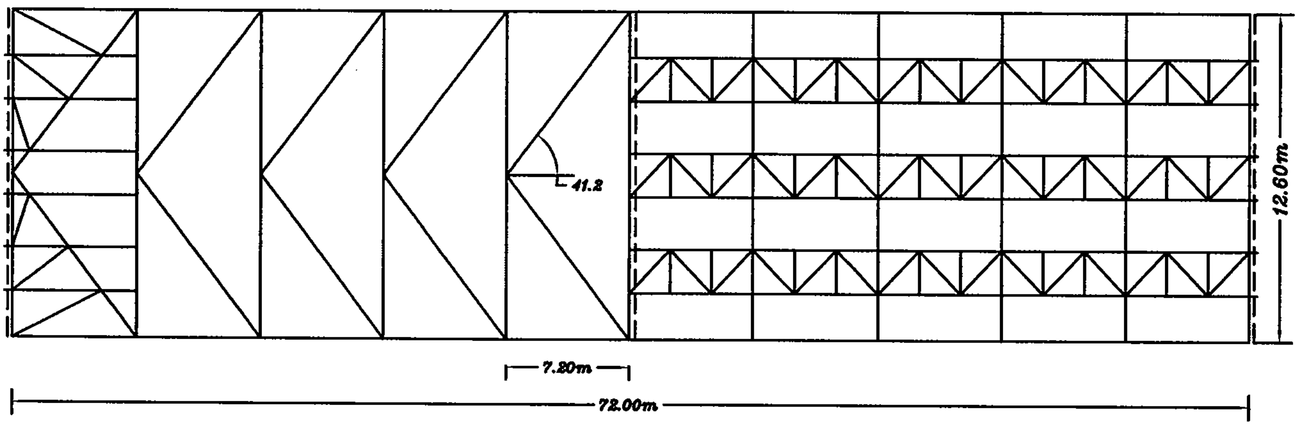


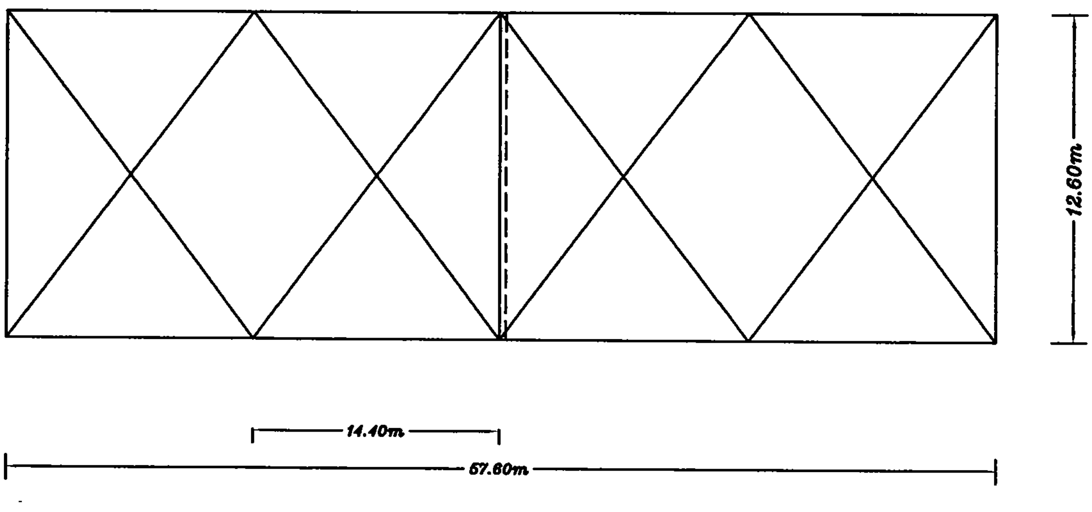
Clear height = 8.50–1.50–0.35–0.3 = 6.35m > 5.50m

∴ use through triple track rail way bridge

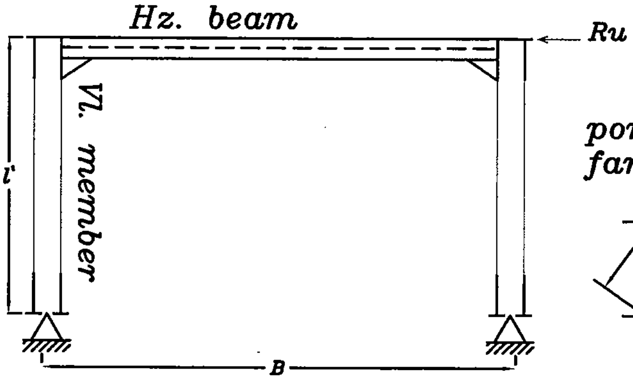

0.30m
6.80m
1.80m
1.80m
1.80m
1.50m
8.50m
12.60m

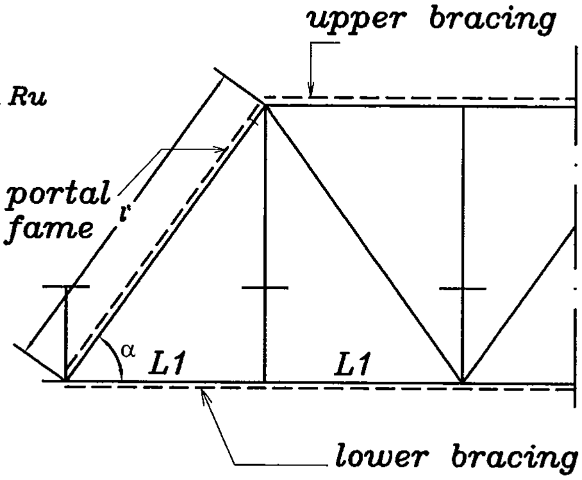

8.50m
60
7.20m
72.00m


41.2
12.60m
7.20m
72.00m

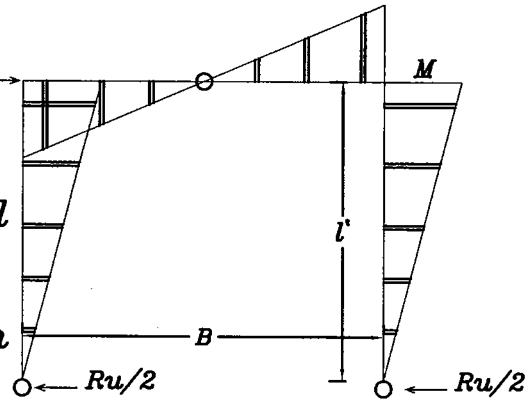

12.60m
14.40m
57.60m

1) Wind Load

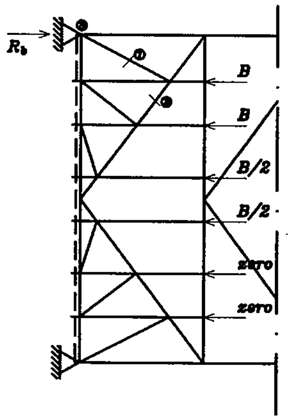




wind transferred to upper & lower bracing, wind acting on lower braicng transferred directly to the bearing level and wind acting on upper bracing transferred to the bearing level through portal frame.



2)Braking Force



$$B = \frac{\sum \text{Wheel Loads}}{7}$$

1-braking force bracing

2-Wind bracing

3-Bearings

3)Lateral Shock

transmitte to stringer bracing and then to wind bracing and then to bearing level

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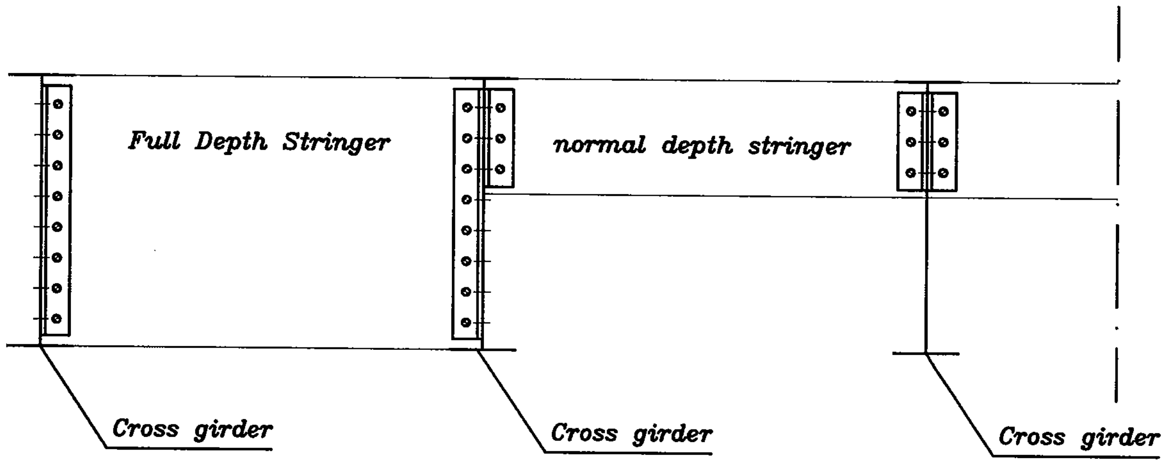
Question (1−3)

Longitudinal sectional elevation

Full Depth Stringer

at the first and last panel and may be at middle pannel (if span > 50.00m) , the stringer is taken with the same hight as cross girder , then the braking force is transmitted to the level of lower flange of the cross girder to the braking force bracing to the wind bracing to the bearing



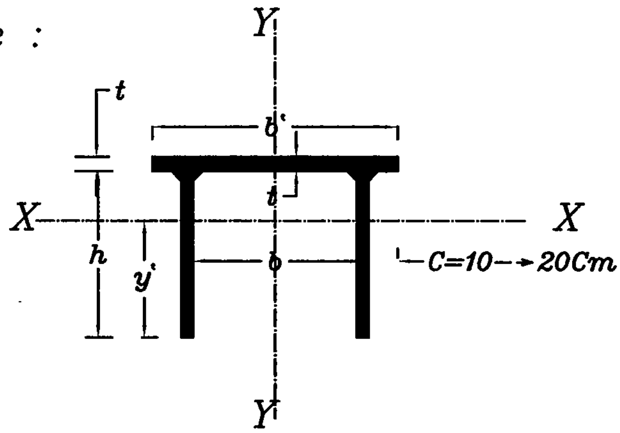
Example three

Question 1

Design (U1)

1)assume compression stress to be :

$F_c = 1.8 t/Cm^2$ For St.52



$$h = \frac{Pannel\ length}{10 \longrightarrow 15} = \frac{800}{10 \longrightarrow 15}$$

h = 80Cm to 53Cm

use h = 60Cm

b=(0.75 ⟶ 1)h For deck or through bridge

b=(0.75 ⟶ 1)*60 = 45Cm to 60Cm

use b = 60Cm

b'= b+2*(10 ⟶ 20Cm)

b'= 60+2*(10 ⟶ 20Cm) = 80Cm to 100Cm use b' = 80Cm

$$2)F_c = \frac{max.\ force}{area} \qquad 1.8 = \frac{500}{area}$$

$area = 277.7 Cm^2$

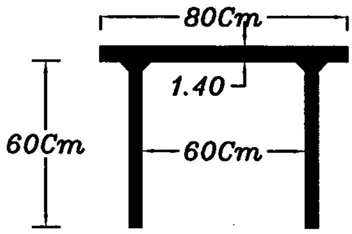
$A = 2ht + b'*t = ...Cm^2$

277.7 = 2*60*t+80*t , t =1.38Cm

take t = 1.40Cm = 14mm

Checks

1-Check Compactness



$$\frac{b}{t} = \frac{60-2*1}{1.4} = 41 \quad > \quad \frac{64}{\sqrt{3.6}} = 33 \quad unsafe$$

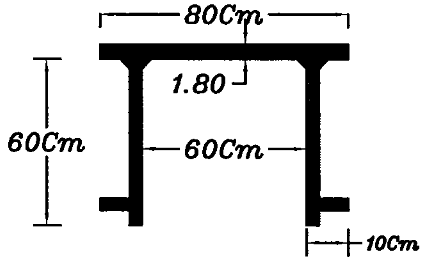
take t = 1.80Cm and recheck

$$\frac{b}{t} = \frac{60-2*1}{1.8} = 33 \quad \not> \quad \frac{64}{\sqrt{3.6}} = 33 \quad safe$$

$$\frac{C}{t} = \frac{10-1.8-1}{1.8} = 4 \quad < \frac{21}{\sqrt{3.6}} = 11.06$$

$$\frac{h}{t} = \frac{60-1}{1.80} = 33 \quad > \frac{30}{\sqrt{3.6}} = 15.8 \quad unsafe$$

use outstand stiffener and recheck



$$\frac{h}{t} = \frac{60-1}{1.8} = 33 \quad \ngtr \frac{64}{\sqrt{3.6}} = 33 \quad safe$$

2-Check global buckling

$$y' = \frac{(2ht*0.5h)+b'*t(h+0.5t)}{2ht+b't} = ...Cm$$

$$y' = \frac{(60*1.8*30*2)+(80*1.8*60.9)}{(60*1.8*2)+(80*1.8)} = 42.36Cm$$

$$I_X = 2*\frac{t*h^3}{12} + 2*t*h*(y'-0.5h)^2 + b'*t*(y'-h-0.5t)^2 = ...Cm^4$$

$$I_X = 2*\frac{1.8*60^3}{12} + 2*1.8*60*(42.36-30)^2 + 1.8*80*(42.36-60.9)^2$$

$$\boxed{I_X = 147295.584 \ Cm^4}$$

$$I_Y = \left[\frac{1.8*80^3}{12}\right] + 2*1.8*60*(30+0.9)^2 = \boxed{283038.96 \ Cm^4}$$

$$A = (1.8*2*60) + (80*1.8) = 360 \ Cm^2$$

Calculate $r_X = \sqrt{\frac{I_X}{A}} = \sqrt{\frac{147295}{360}} = 20.22Cm$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{293038}{360}} = 28.03Cm$

$$\lambda_{in} = \frac{0.85L}{r_X} = \frac{0.85*800}{20.22} = 33.63 < 90$$

$$\lambda_{out} = \frac{2L}{r_Y} = \frac{2*800}{28.03} = 57.08 < 90$$

$L_{out} = 2L$ *from plan of upper bracing*

3-Check Compressive Stresses

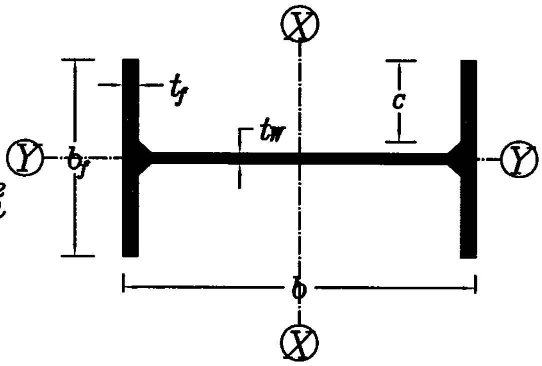
actual stresses $= f_{ca} = \frac{500}{360} = 1.38\ t/Cm^2$

allwable stresses $= F_c = 2.1 - 13.5*10^{-5} * \lambda^2_{max.}$ *For St.52*

allwable stresses $= F_c = 2.1 - 13.5*10^{-5} * 57.08^2 = 1.66\ t/Cm^2$

safe

Design D2



1)assume tension stresses to be :

$$F_{max.} = \frac{F_{sr}}{1-\frac{T_{min.}}{T_{max.}}} = \frac{2.80}{1-\frac{120}{252}} = 5.34\ t/Cm^2$$

$F_{max.} > 2.1\ t/Cm^2$

use $F_{max.} = 2.1\ t/Cm^2$

$$2)F_t = \frac{max.\ force\ T_{D+LL+I}}{area} \qquad 2.1 = \frac{252}{area}$$

get $A = 120\ Cm^2$

$b = 60Cm$

$$\frac{b}{t_w} = \frac{64}{\sqrt{F_y}} \qquad \frac{60}{t_w} = \frac{64}{\sqrt{3.6}} \qquad t_w = 1.77\ Cm \quad use\ t_w = 1.80\ Cm$$

$A = 2*b_f*t_f + b*t_w = ...Cm^2$

$120 = 60*1.8 + 2*b_f*t_f$

$b_f*t_f = 6.00\ Cm^2$

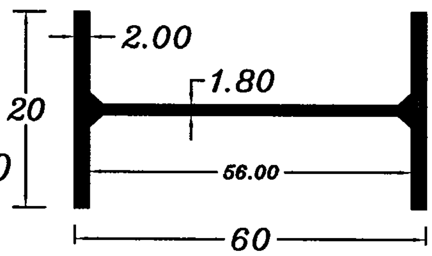
$b_{f\,min} = 6\phi + t_w + 2S \triangleq$ 20Cm use $t_f = 2Cm$

1−Check Compactness

لايفضل عمل هذا ال check فى حالة ال tension

$$\frac{b}{t_w} \le \frac{64}{\sqrt{F_y}} = \frac{60-2*2.0-2*1}{1.80} = 30 < 33$$

$$\frac{C}{t_f} \le \frac{21}{\sqrt{F_y}} = \frac{10-1.80/2-1}{2.00} = 4.05 < 11.0$$



2-Check global buckling

$$I_X = \frac{t_W * d_W^3}{12} + 2b_f * t_f * (d_W/2 + t_f/2)^2 = ...Cm^4$$

$$I_X = \frac{1.8*60^3}{12} + 2*2.0*20*(30-1.0)^2 = \boxed{109280\ Cm^4}$$

$$I_Y = 2* \frac{t_f * b_f^3}{12} = ...Cm^4$$

$$I_Y = 2* \frac{2.0*20^3}{12} = \boxed{2667\ Cm^4}$$

$$A = (1.8*56.0)+(2*20*2.0) = 184.4\ Cm^2$$

Calculate $r_X = \sqrt{\frac{I_X}{A}} = \sqrt{\frac{109280}{184}} = 24.37Cm$

Calculate $r_Y = \sqrt{\frac{I_Y}{A}} = \sqrt{\frac{2667}{184}} = 3.80Cm$

$$\lambda_{in} = \frac{\text{buckling length inplane} = L_{in}}{\text{raduis of gyration @ Y axis} = r_Y} \not> 160 \quad (RailWay)$$

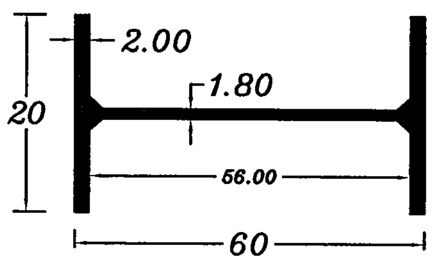
$$\lambda_{in} = \frac{0.85*1131.3\ /2}{3.80} = 126 \not> 160 \quad safe$$

$$\lambda_{out} = \frac{0.7*1131.3}{24.37} = 33.6 < 160 \quad safe$$

3-Check maximum Stresses

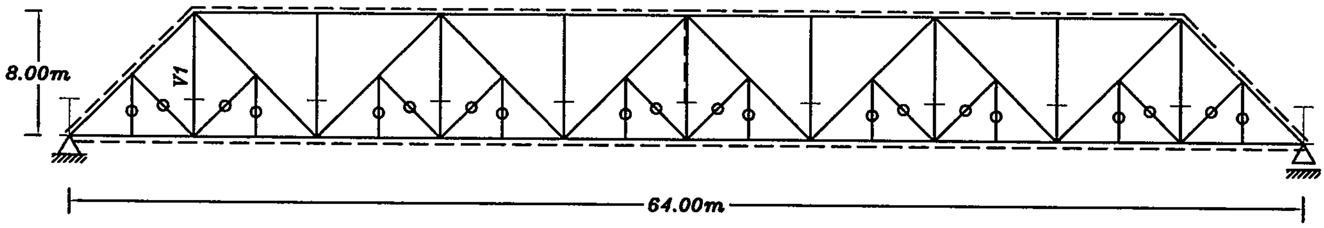
actual stresses $= f_{ta} = \frac{+252}{184} = 1.37\ t/Cm^2 < 0.58F_y = 2.1t/Cm^2$

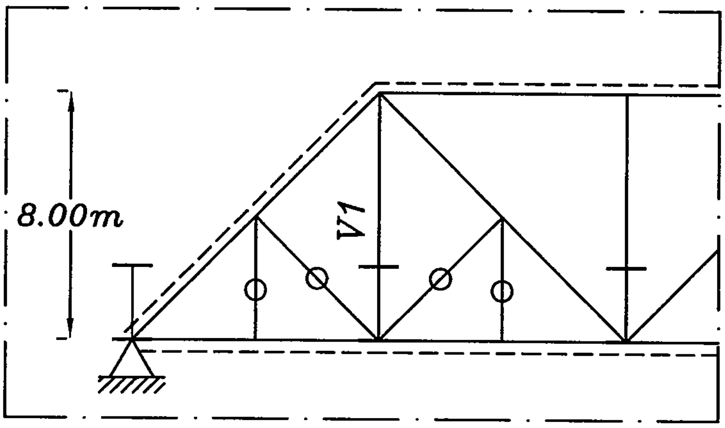
fatigue stresses $\frac{252-120}{184} = 0.86 < 2.80\ t/Cm^2$ safe

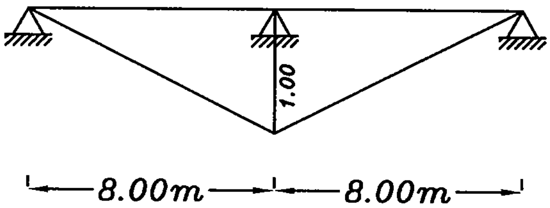


Example three

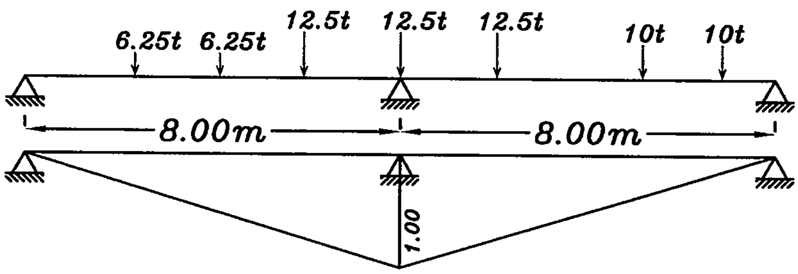
Question 2







I.L vertical



D.L

$W_d = 1.9(0.75+0.05*L=64)/2 + (0.6*2/2) = 4.35 \ t/m'$

$F_d = 4.35*(1*16/2) = 34.8t$

$F_{LL} = 12.5*1+2*12.5*0.75+2*6.25*0.422+2*10*0.26 = 41.7 \ t$

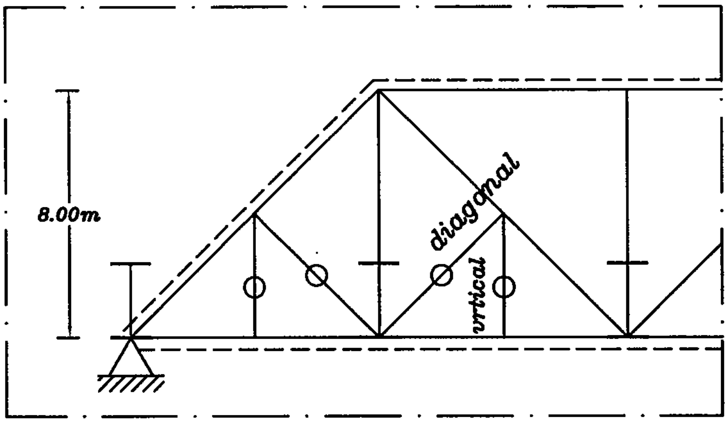
$$F_{\underset{double}{LL+I}} = 41.7 * 0.9 * \left(1 + \frac{24}{24 + 2*16}\right) * 2 = 107.22 \ t$$

$$F_{\underset{double}{d+LL+I}} = F_{max.} = 107.22t + 34.8t = \boxed{142.03t}$$

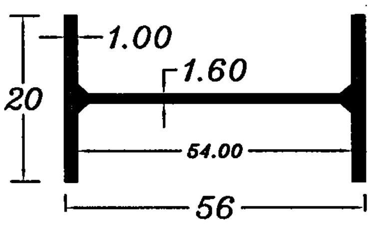
Example three

Question 3

Diagonal & Vertical bolts



diagonal & vertical are subjected to zero force so assume cross section for those members



$A_{\substack{Diagonal \\ vertical}} = 2*20*1.0+54*1.6 = 126.4\ Cm^2$

$F_{\substack{Diagonal \\ vertical}} = 126.4*F_t = 126.4*2.1 = 265.44t$

number of bolts per one flange $= \dfrac{Stress*area}{P_s * 2}$

$n = \dfrac{265.44t}{9.08 * 2} = 14.6$ bolt per one flange

use n = 16 bolt (2column*8rows)

$b_{f\,min}$ for diagonal $= 2*3*\phi + t_w = 2*3*2.7+1.6 = 17.8Cm \leq 20Cm$

take gusset plate length from drawing cause there is no difference in force in the diagonal member.

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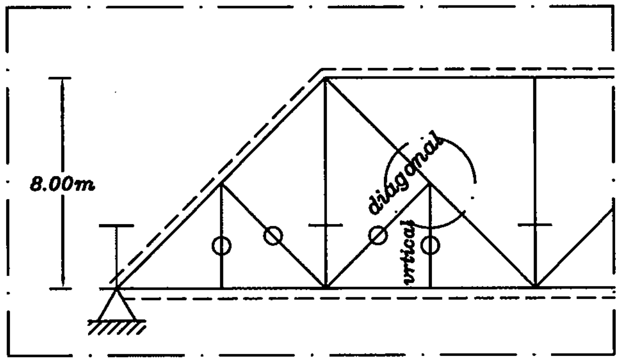
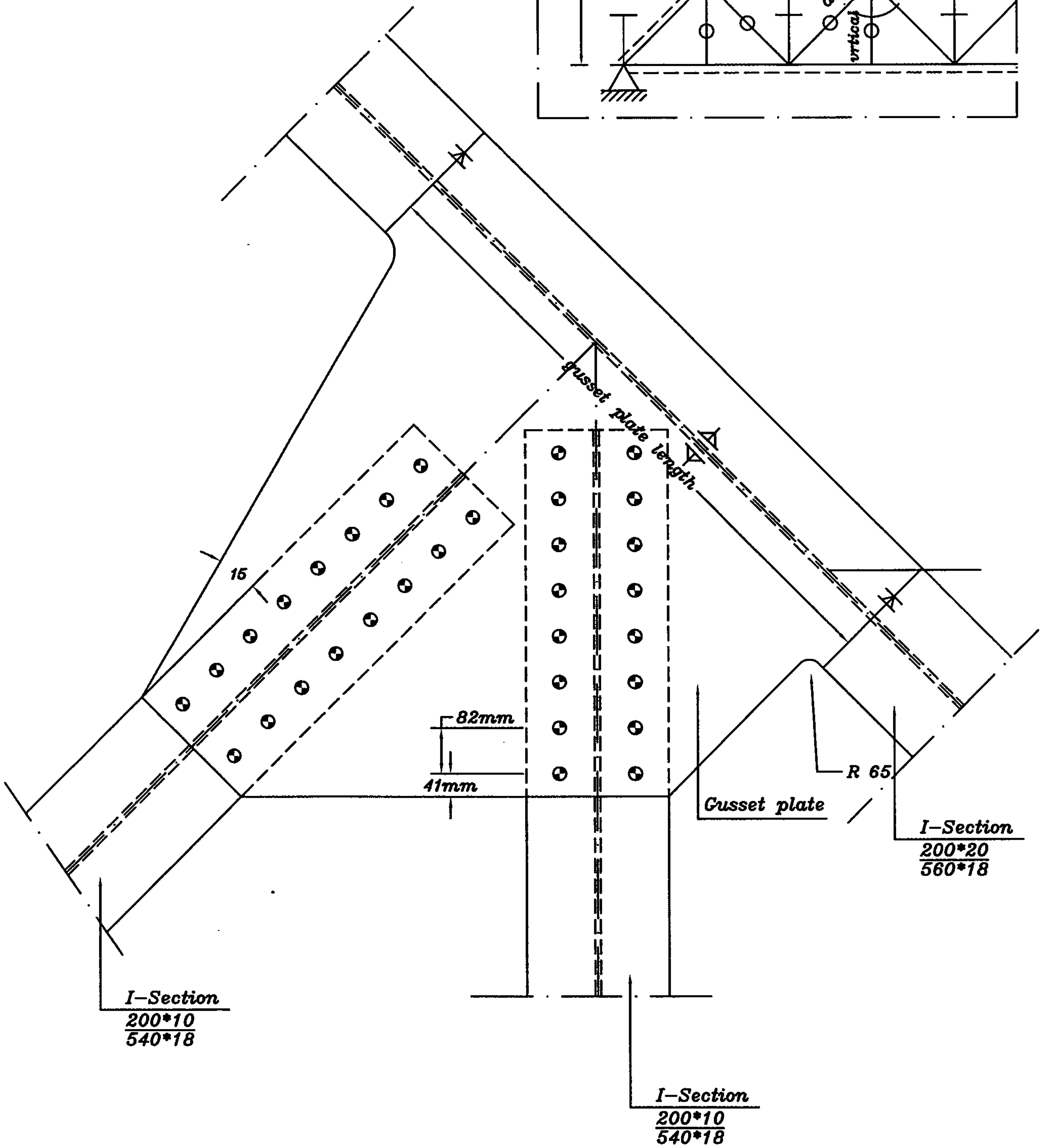
Question (2–4)





لايفضل عمل وصلة مسامير بين ال *diagonal* وال *sub divided member*

وذالك لان ال *diagonal* معرض لشد وهذا يقلل قدرة تحمل *member* فى الكلال F_{sr}

Example three

Question 4