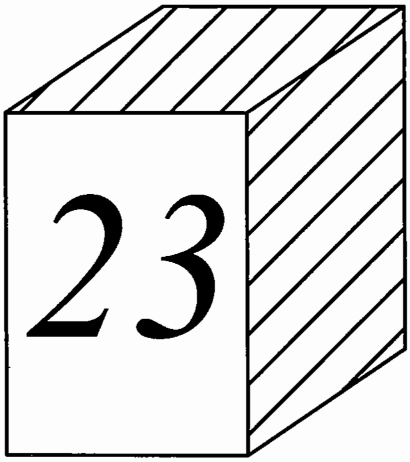
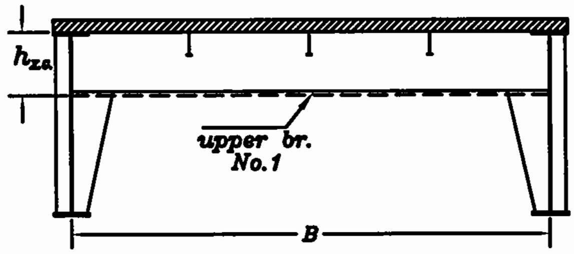
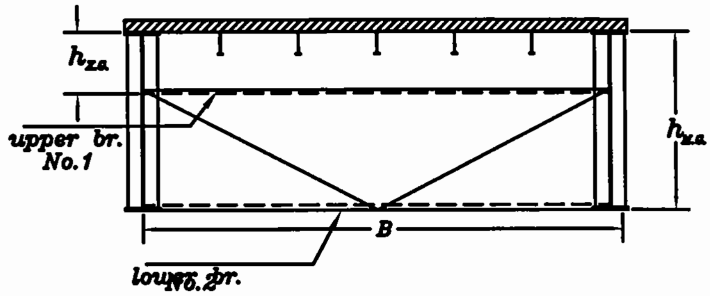
Steel رابعه
R ١٢



Wind Bracing
Plate Girder

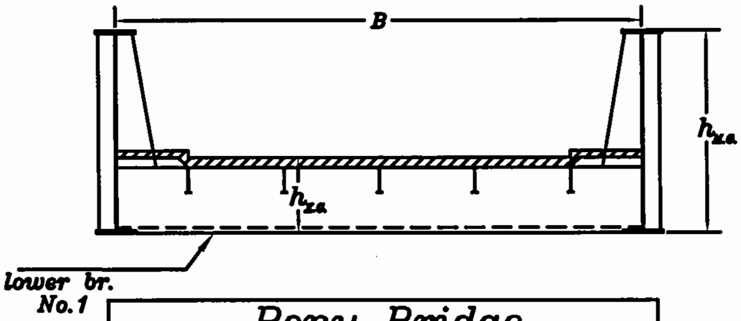
Wind Bracing



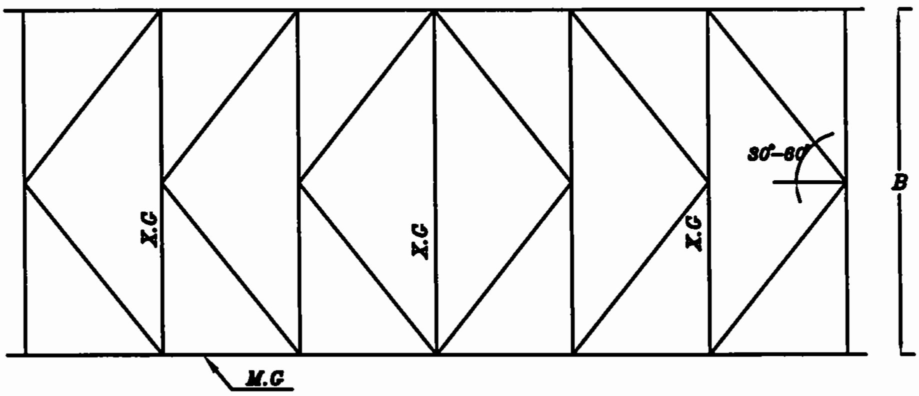


Deck Bridge
(with one bracing only)

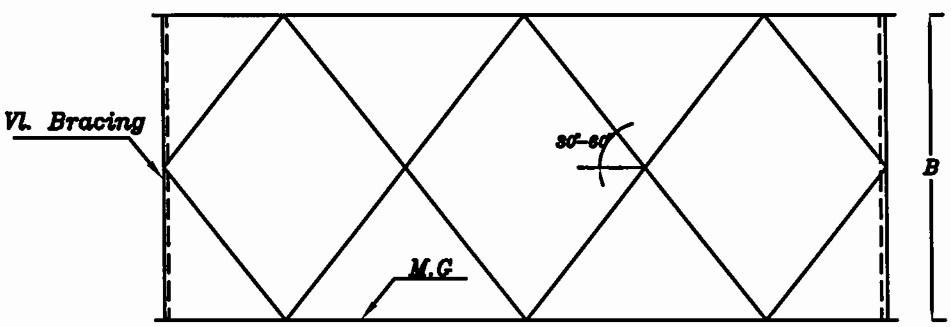
Deck Bridge
(with two bracings)



Pony Bridge
(with one bracing only)



Plan of bracing No.1 (lower for pony & upper for deck)



Plan of bracing No.2 (lower for deck)

Loads:

Case(1)during construction(unloaded):

wind intenisity=0.7*200Kg/m² =140Kg/m² = **0.14t/m²**

$\angle$reduction for case of during construction only

the wind effects on the two main girders.

فى حالة عدم وجود بلاطة خرسانية يتم تحميل الـ2M.G. باحمال الرياح

Case(2)after construction(unloaded):

wind intenisity= **200Kg/m²**

فى حالة وجود بلاطة خرسانة Roadway يتم تحميل M.G. واحد فقط

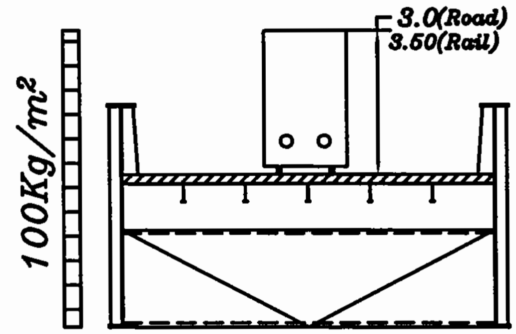
فى حالة عدم وجود بلاطة خرسانة Railway يتم تحميل 2M.G. معا

Case(3)after construction(loaded):

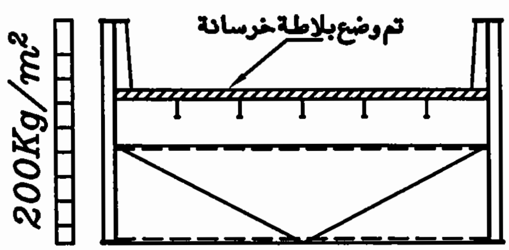
wind intenisity= **100Kg/m²**

فى حالة Roadway يتم نحميل M.G. واحد فقط بالاضافة الى عربيات ارتفاعها ٣,٠٠ م .

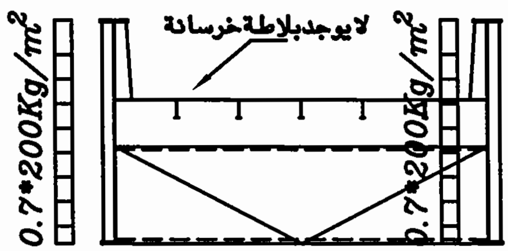
فى حالة Railway يتم نحميل 2M.G. معا بالاضافة الى قطار ارتفاعه ٣,٥٠ م .



case(3)



case(2)



case(1)

Notes:

-فى حالة وجود *one bracing* فانه يتم تحميل كل الارتفاع

-فى حالة وجود *two bracing* فاننا ننصف المسافة بينهما و يتحمل كل *bracing* الارتفاع الذى جواره

-فى حالة وجود بلاطة خرسانة فانها تتحمل الاحمال بدلا من *bracing* ولذلك لا نصمم ال*bracing* فى حالة وجود بلاطة خرسانة بجواره

-فى حالة التصميم على *(case1: during construction)* فاننا نزيد الاجهادات المسموح بها بمقدار 25% $(F_c = \frac{7500}{\lambda^2} * 1.25 = ...t/cm^2)$

For pony bridge:

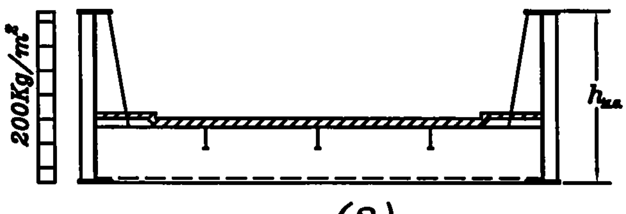
case(1): $W_w = (0.7*200/1000)*2*h_{M.G} = ... \ t/m'$.

case(2): $W_w = (200/1000)*1*h_{M.G} = ... \ t/m'$.

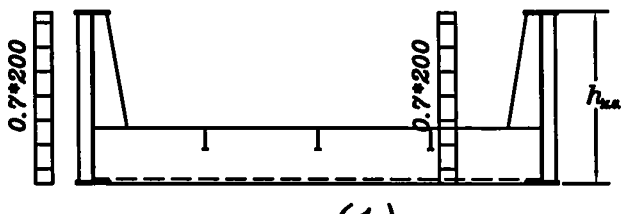
case(3): $W_w = (100/1000)*[3.0m + h_{X.G} + 0.25m)]*1 = ... \ t/m'$.

-فى حالة *roadway* يتم تصميم على *case(1)* فقط اما الحالتين الاخرتين فانه توجد بلاطة خرسانة تعمل على تحمل احمال الرياح

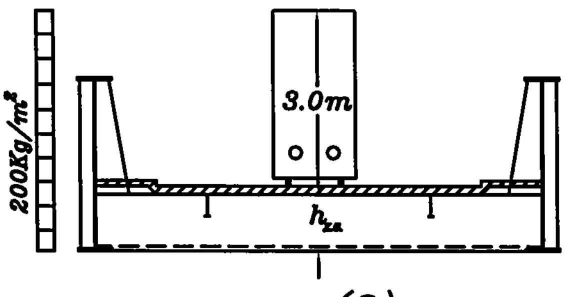
-فى حالة *railway* يتم اخذ الرقم الاكبر من *case(1),(2),(3)* حيث انه لا توجد بلاطة خرسانة فى اى حالة *(open timber floor)*



case(2)



case(1)



case(3)

For deck bridge with two bracings:

Upper bracing:

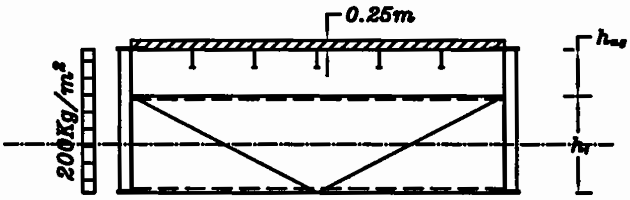
case(1): $W_w = (0.7*200/1000)*2*(h_1/2+h_{x.g})$

case(2): $W_w = (200/1000)*1*(h_1/2+h_{x.g}+0.25m)$

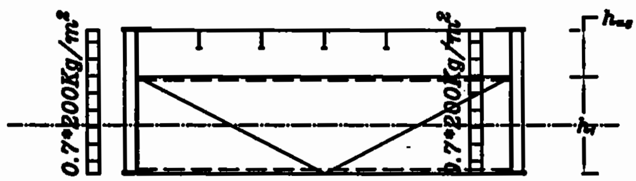
case(3): $W_w = (100/1000)*1*(h_1/2+h_{x.g}+0.25m+3.00m)$

-فى حالة roadway يتم تصميم على case(1) فقط اما الحالتين الاخرتين فانه توجد بلاطة خرسانة.

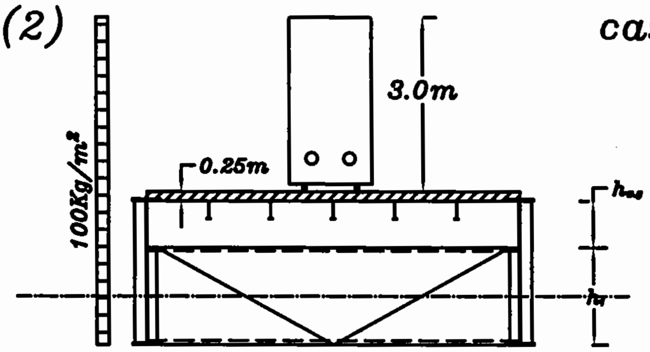
-فى حالة railway يتم اخذ الرقم الاكبر من case(1),(2),(3) حيث انه لا توجد بلاطة خرسانة



case(2)



case(1)



case(3)

Lower bracing:

case(1): $W_w = (0.7*200/1000)*2*h_1/2$

case(2): $W_w = (200/1000)*\boxed{1}*h_1/2$ } -فى حالة railway يتم الضرب *2

case(3): $W_w = (100/1000)*\boxed{1}*h_1/2$ } -فى حالة roadway يتم الضرب *1

-يتم التصميم على الرقم الكبير من case(1),(2),(3) سواء railway,roadway حيث انه لا فرق بين وجود بلاطة خرسانة من عدمه.

For deck bridge with iverted U-Frame

Upper bracing:

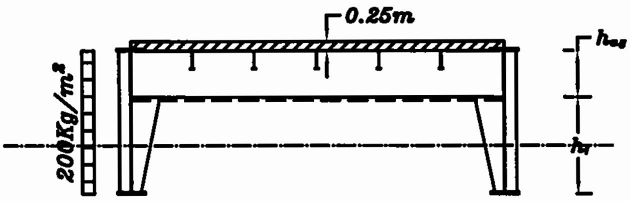
case(1): $W_w = (0.7*200/1000)*2*h_{M.G} = \dots\ t/m'$.

case(2): $W_w = (200/1000)*1*[h_{M.G}+0.25m] = \dots\ t/m'$.

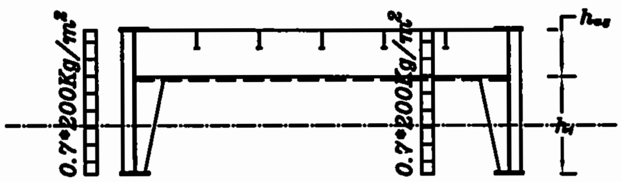
case(3): $W_w = (100/1000)*[3.0m+h_{M.g}+0.25m)]*1 = \dots\ t/m'$.

-فى حالة *roadway* يتم تصميم على case(1) فقط اما الحالتين الاخرتين فانه توجد بلاطة خرسانة.

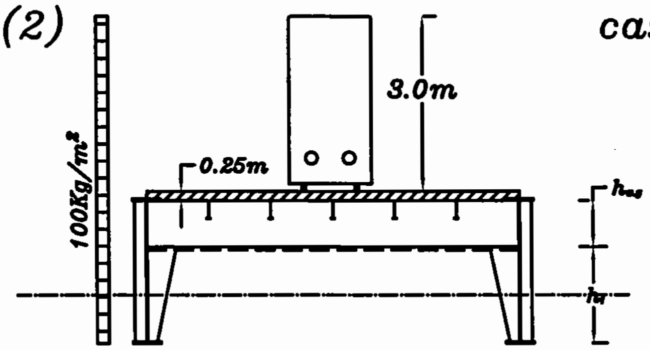
-فى حالة *railway* يتم اخذ الرقم الاكبر من case(1),(2),(3) حيث انه لا توجد بلاطة خرسانة فى اى حالة (open timber floor)



case(2)



case(1)

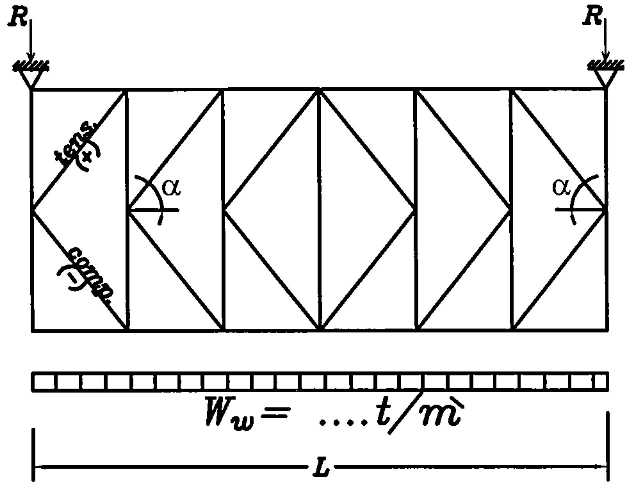


case(3)

Design Procedure of compression member using two angels back to back(⅃L)

Force $= \pm \frac{R}{2\sin\alpha}$

يتم تصميم اول diagonal فقط فى bracing



Assume $\lambda = 140$ (bracing)

$140 = \frac{l_{in}}{r_x = 0.3a_1}$ get $a_1 =$ ....

$140 = \frac{l_{out}}{r_y = 0.45a_2}$ get $a_2 =$ ....

take bigger from (a_1 or a_2)

1-Check Stresses

$f_{ca} = \frac{Force}{2A} =$ .... $t/m^` \ngtr F_c$

$F_c = \frac{7500}{\lambda^2_{max}} *$ 0.85*1.25*0.6*0.8

- 0.8: if using x-bracing for indeterminate structure
- 0.6: if using single angle for eccentricity of load
- 1.25: if design on case(1) for during construction
- 0.85: usually used because we calculate the load as plane structure, while it is space struc.

Where $\lambda_{max} = \frac{l_{in}}{r_{x\perp}}$ or $\frac{l_{out}}{r_{y\perp}}$

2-Check Deflection

$\frac{l}{d} = \quad \ngtr 40$

d → depth of bracing member

(2a+1cm, ⅃L d), for Hz. bracing

while for vertical bracing (d=a, ⅃L d)

-if any check is unsafe, then increase dimension of cross sec.

-if the largest angle (⅃ 200*16) is unsafe, then we can:

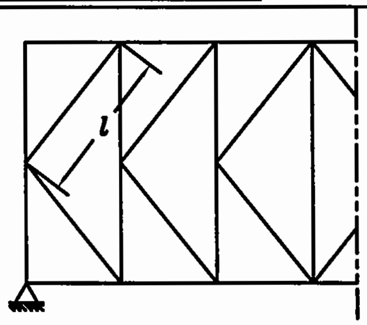
1-rearrange the bracing to reduce the buckling length.

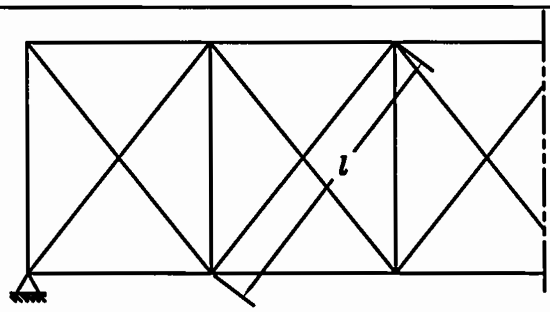
or2-use [channel section instead of the angle L

3-Check Buckling

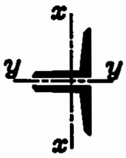
Code page(56,57),(buildings and bridge bracing)

for upper bracing (deck)&lower bracing (pony)or(through):





K-truss(double track)



$l_{in} = l_x = 1.00l$

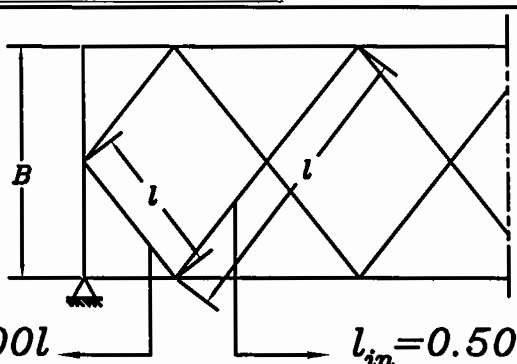
$l_{out} = l_y = 1.20l$

X-truss(single track)

$l_{in} = l_x = 0.50l$

$l_{out} = l_y = 0.75l$

for lower bracing (deck)&upper bracing (through):



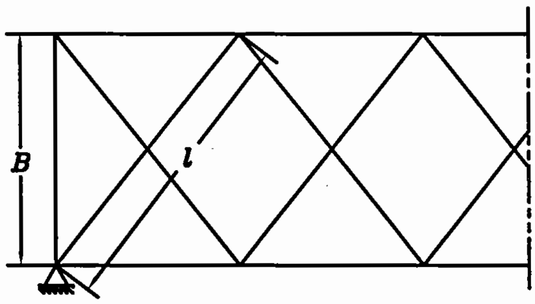
$l_{in} = 1.00l$

$l_{out} = 1.20l$

Type(1)

$l_{in} = 0.50l$

$l_{out} = 0.75l$

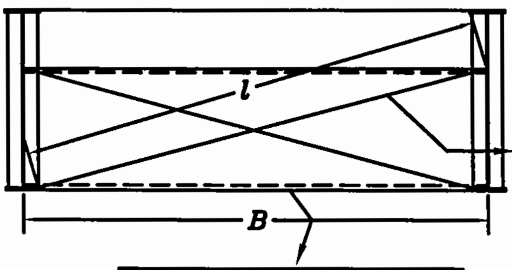


$l_{in} = 0.5l$

$l_{out} = 0.75l$

Type(2)

for vertical cross bracing:



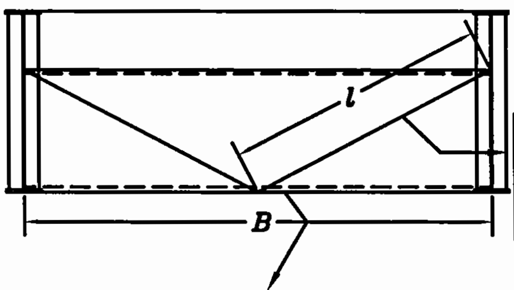
$l_{in} = 0.50l$

$l_{out} = 0.75l$

$l_{in} = B$

$l_{out} = 0.5B$ (Type1)

B (Type2)



$l_{in} = 1.0l$

$l_{out} = 1.2l$

$l_{in} = 0.50B$

$l_{out} = 0.5B$ (Type1)

$= B$ (Type2)

Note:

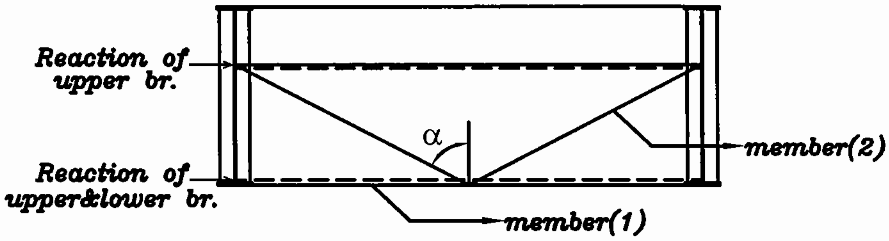
1-Design the cross vertical bracing:

for member(1)

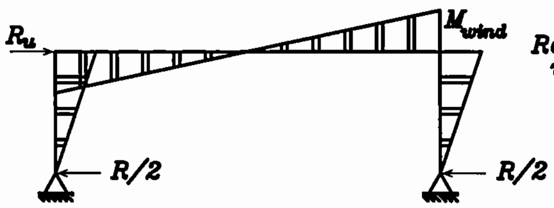
$Force = \pm R_{upper\ \&\ lower}$

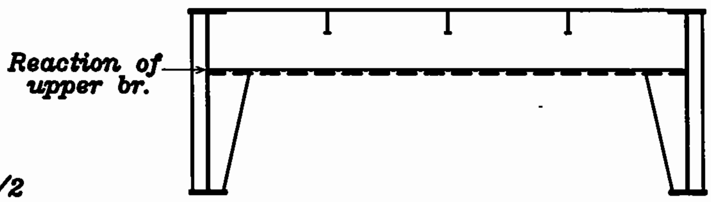
for member(2)

$Force = \pm \frac{R_{upper}}{2 \sin \alpha}$



2-Design the inverted U-Frame:





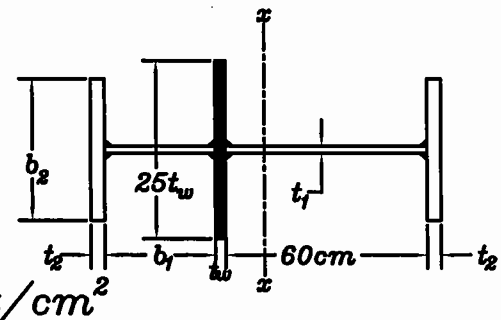
design the bracket on M_{wind}

the bracket like bearing stiffener

but increase b_1 to be 60cm at

side of X.G.

Calculate $\bar{y}, I_x$



Check $\frac{M_{wind}}{I_x} * \bar{y} = \ldots . \not> 1.6 t/cm^2$ (or) $2.1 t/cm^2$

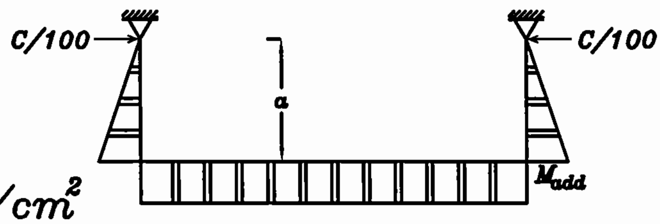
3-Design the U-Frame pony bridge

like the inverted U-frame

but $M = M_{wind} + M_{add}$ from U-frame

check $\frac{M}{I_x} * \bar{y} = \ldots . \not> 1.6 t/cm^2$ (or) $2.1 t/cm^2$

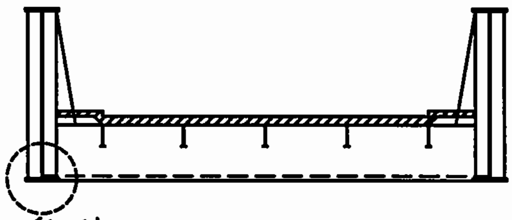
Calculate $\bar{y}, I_x$ for previous section



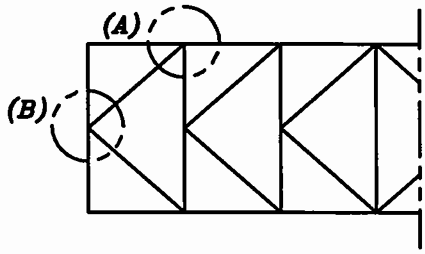
$M_{wind} = w_{loaded} * spacing * \frac{a^2}{2}$

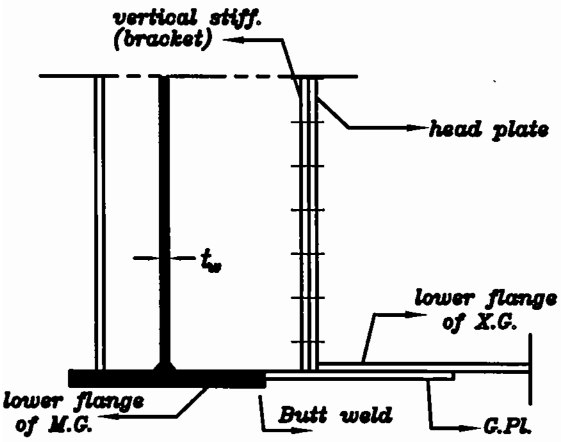
$M_{u-frame} = C/100 * a$

Details:

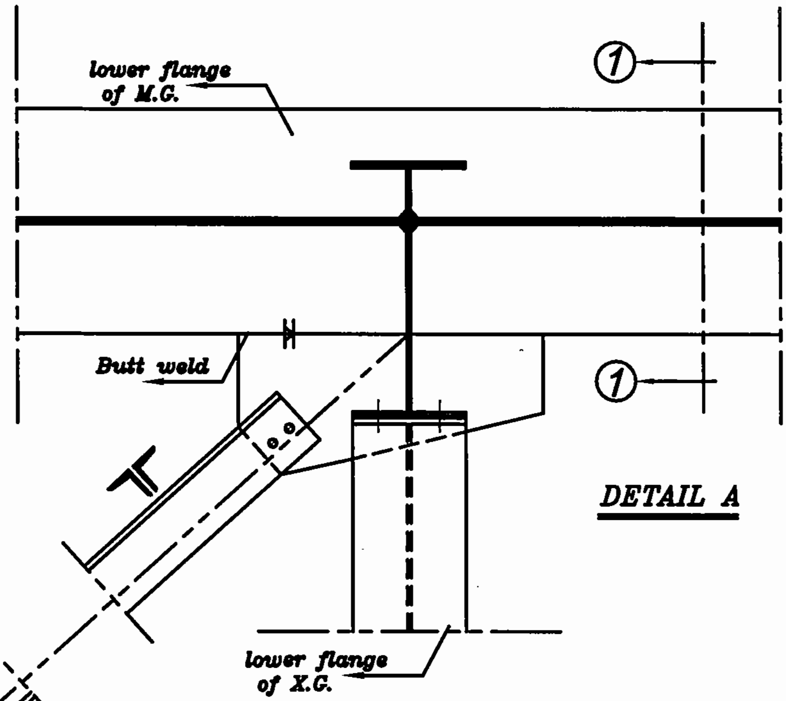


Sec (1-1)

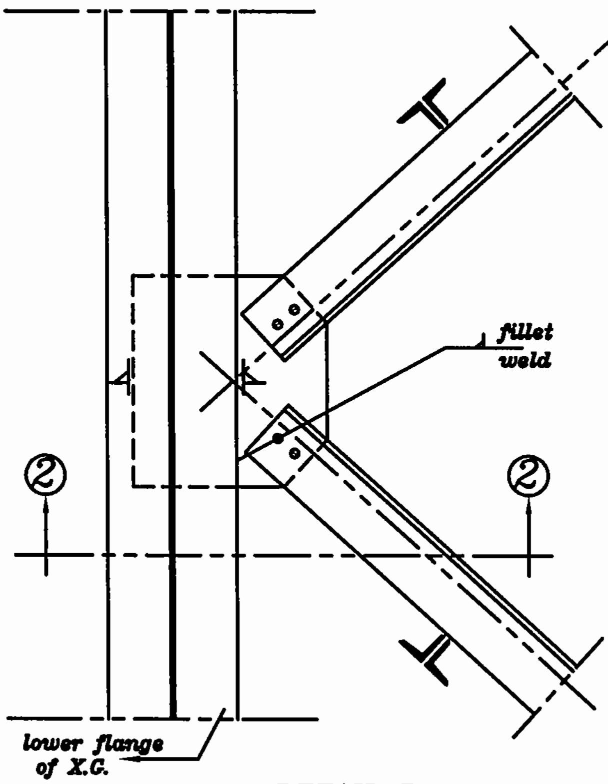




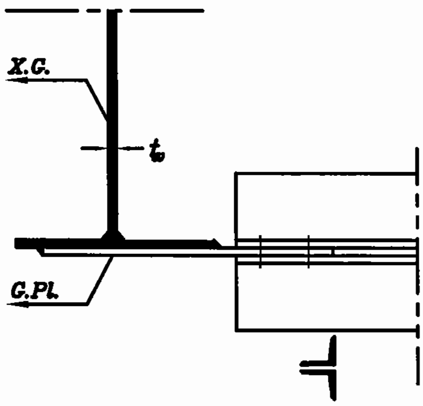
Sec. (1-1)



DETAIL A



DETAIL B



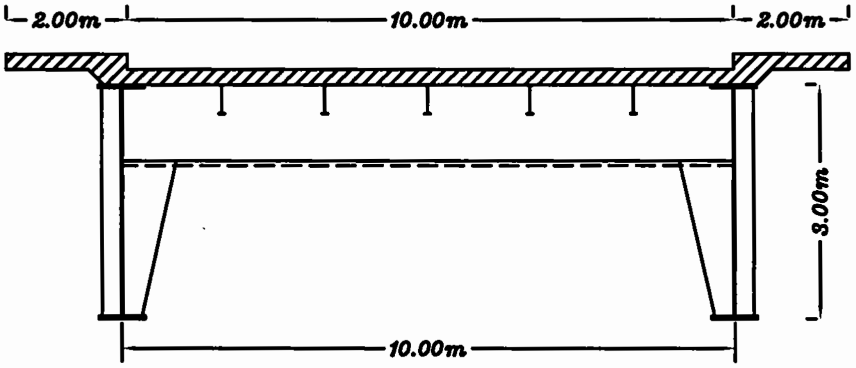
Sec. (2-2)

Example(1)

for the shown deck bridge having B=10m , S=2m , L=30m and the bridge is provided by invetred u-frame bracket

1-design the first member of the upper hz. bracing

2-assume and design a suitable section for u-frame bracket



Solution

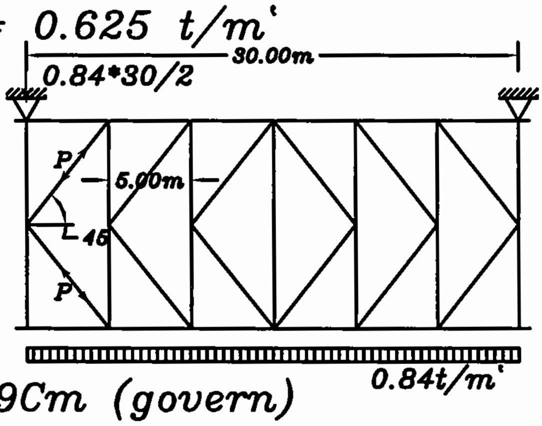
Design of upper wind Bracing

يتم التصميم على الحالة الاولى فقط نظرا لان عند وجود بلاطه خرسانه فانها تحل محل ال Bracing

case(1): $W_w = 0.14*3*2 = \boxed{0.84\ t/m'}$ govern

case(2): $W_w = 0.20*1*(3.00m+0.25) = 0.65\ t/m'$

case(3): $W_w = 0.10*1*(3.00+3.00+0.25) = 0.625\ t/m'$



$$Force = \frac{\pm 0.84*30/2}{2*Sin45^\circ} = \boxed{\pm 8.91t}$$

$$L = \sqrt{5.00^2+5.00^2} = \boxed{7.10m} = L_{in}$$

$L_{out} = 1.2*7.10 = \boxed{8.50m}$

assume $\lambda = \frac{710}{0.3a} = 140$ a=16.9Cm (govern)

assume $\lambda = \frac{850}{0.45a} = 140$ a=13.5Cm

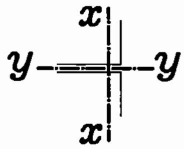
*Check On ⊥L 180*16*

Check buckling $\lambda_{in} = \frac{710}{r_x=5.4} = \boxed{131}$ $\lambda_{out} = \frac{850}{r_y=8.1} = 105$

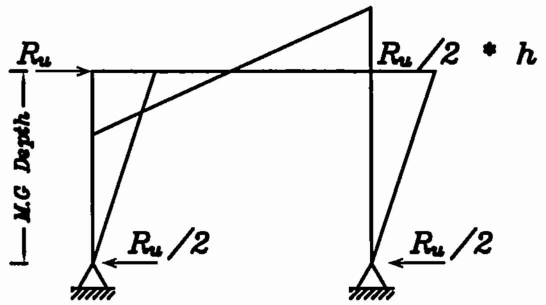
Check Stresses ; $F_C = \frac{7500}{131^2}*0.85*1.25 = 0.46t/Cm^2$

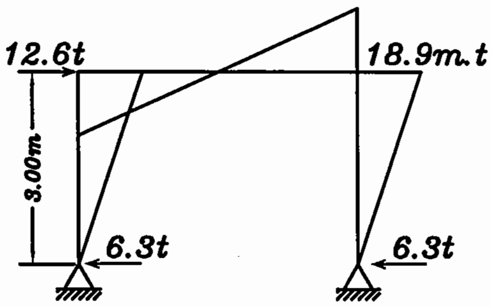
$f_{ca} = \frac{8.91}{2*55.4} = 0.08t/Cm^2 \ngtr 0.46t/Cm^2$ safe

Check Deflection ; $\frac{L}{d} = \frac{710}{18*2+1} = 19 \not> 40$ safe

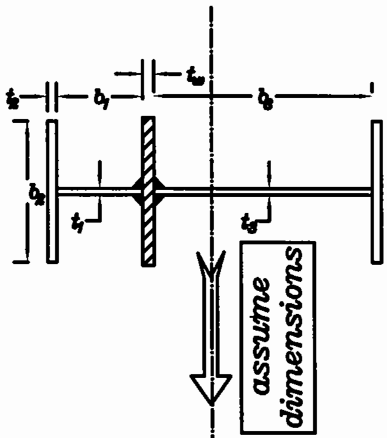


2-Design the inverted u-frame



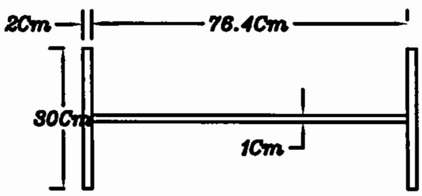


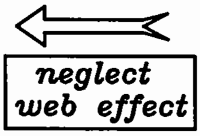
$R_u = 0.84*30/2 = \boxed{12.60t}$

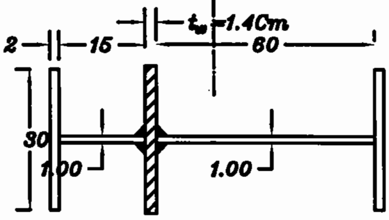


assume Dimension of the stiffener
if not given

neglect effect of the Part of Web On
M.G inertia







$$I_x = \frac{1.0*76.4^3}{12} + 2*30*2(76.4/2+2/2)^2 = 221558.7787 Cm^4$$

$$\boxed{\therefore I_x = 221558.7787 Cm^4}$$

هناك حاله اخرى وهى حالة ال Loaded حيث يكون ال Bracket
معرض ل M+N نتيجة الاحمال المؤثره على الكوبرى

Checks

Check max. Stresses

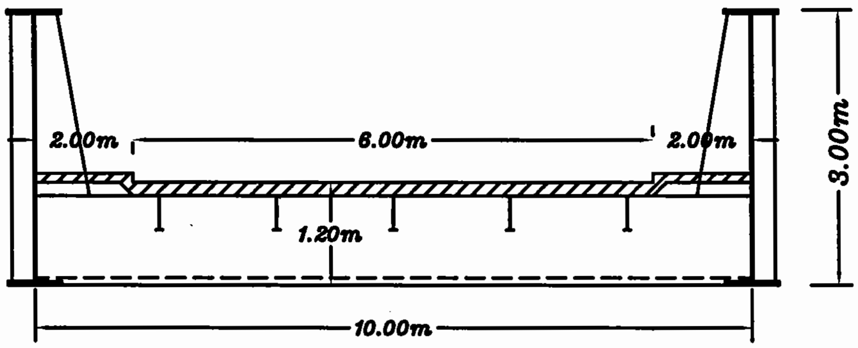
$$\frac{M_{Wind}}{I_x} *(d/2+t_f) = \frac{18.9*100}{221558.7787}(76.4/2+2) = 0.34 t/Cm^2 \not> 1.6*1.25 t/Cm^2$$

Example(2)

for the shown pony bridge having B=10m , S=2m , L=30m and the bridge is provided by u-frame bracket and maximum moment affecting main girder = 1400m.t

1-design the first member of the hz. lower bracing

2-calculate the maximum moment on the u-frame



Solution

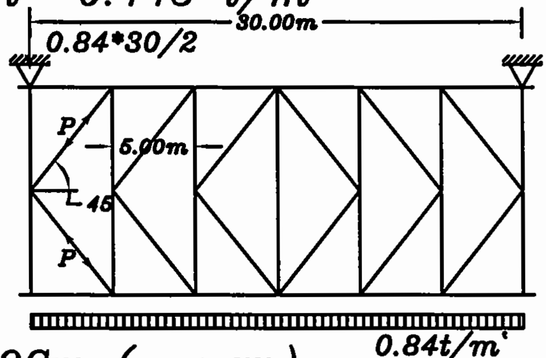
Design of upper wind Bracing

يتم التصميم على الحالة الاولى فقط نظرا لان عند وجود بلاطه خرسانه فانها تحل محل ال Bracing

case(1): $W_w = 0.14*3*2 = \boxed{0.84 \ t/m'}$ (govern)

case(2): $W_w = 0.20*1*3.00m = 0.60 \ t/m'$

case(3): $W_w = 0.10*1*(3.00+1.20+0.25)m = 0.445 \ t/m'$



$$Force = \frac{\pm 0.84*30/2}{2*Sin45^{\circ}} = \boxed{\pm 8.91t}$$

$$L = \sqrt{5.00^2 + 5.00^2} = \boxed{7.10m} = L_{in}$$

$L_{out} = 1.2*7.10 = \boxed{8.50m}$

assume $\lambda = \frac{710}{0.3a} = 140$ $\quad$ a=16.9Cm (govern)

assume $\lambda = \frac{850}{0.45a} = 140$ $\quad$ a=13.5Cm

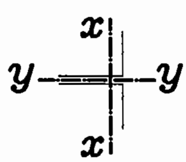
Check On ⊥⊥ 180*16

Check buckling $\lambda_{in} = \frac{710}{r_x = 5.4} = \boxed{131}$ $\quad \lambda_{out} = \frac{850}{r_y = 8.1} = 105$

Check Stresses ; $F_C = \frac{7500}{131^2} * 0.85 * 1.25 = 0.46 t/Cm^2$

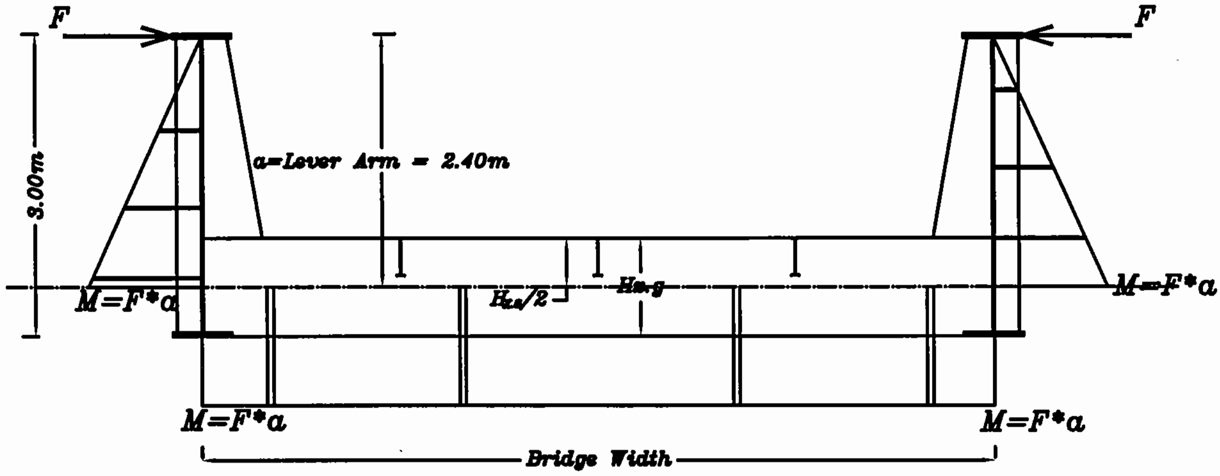
$f_{ca} = \frac{8.91}{2*55.4} = 0.08 t/Cm^2 \not> 0.46 t/Cm^2$

Check Deflection ; $\frac{L}{d} = \frac{710}{18*2+1} = 19 \not> 40$



Design u-frame Bracket

1)Elastic Force



$$F = \frac{1}{100} C_{max.} \qquad C_{max.} = \frac{M_{max.}}{y_{ct}}$$

$M_{max.}$ =max. moment affecting M.G (given)

$M_{max.} = 1400 m.t$

$$C_{max.} = \frac{M_{max.}}{y_{ct}} = \frac{1400}{0.97*3} = 481.1 \ t$$

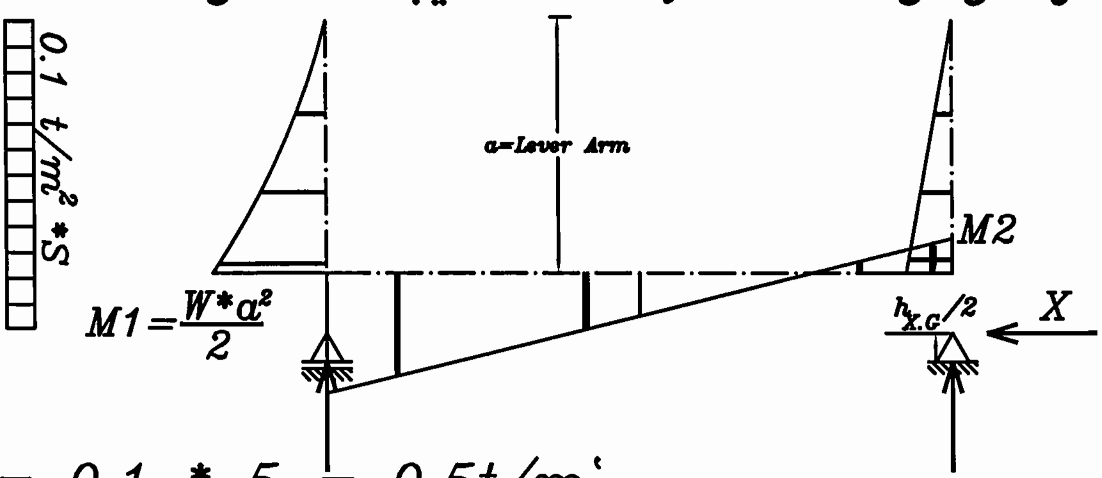
$F = 4.811 t$

$a = 3 - 0.6 = 2.40 m$

$M_{e.f} = F * a = 4.811 * 2.40 = \boxed{11.546 m.t}$

2)Wind Force

تم استعمال حالة ال loadedعند حساب العزوم نتيجة احمال الرياح وذلك نظرا لان ال حالة elastic force نتيجة حالة ال loaded

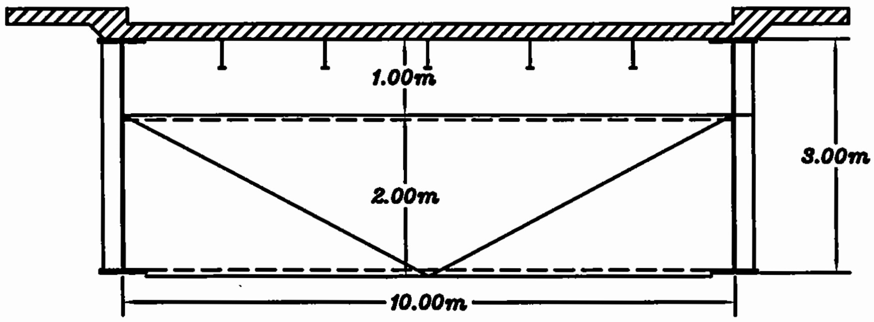


$W = 0.1 * 5 = 0.5 t/m'$

$M_{wind} = \frac{W*a^2}{2} = 0.5*2.4^2/2 = \boxed{1.44 t.m}$, then $M_{total} = 1.44 + 11.5 = \boxed{12.9 m.t}$

Example(3)

Design all the bracing system of the shown deck bridge B=10m S=2m, L=30m If the bridge is provided by vertical bracing



Solution

Design of upper wind Bracing

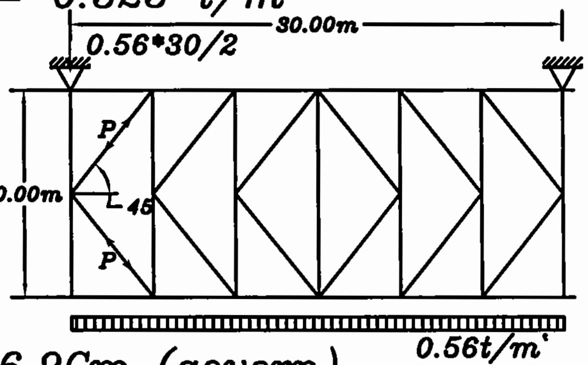
يتم التصميم على الحالة الاولى فقط نظرا لان عند وجود بلاطه خرسانه فانها تحل محل ال Bracing

case(1): $W_w = 0.14*2*2 = \boxed{0.56\ t/m}$ govern

case(2): $W_w = 0.20*1*(2+0.25)m = 0.45\ t/m'$

case(3): $W_w = 0.10*1*(2+3.00+0.25)m = 0.525\ t/m'$

$$Force = \frac{\pm 0.56*30/2}{2*Sin45^{\circ}} = \boxed{\pm 5.90t}$$



$$L = \sqrt{5.00^2 + 5.00^2} = \boxed{7.10m} = L_{in}$$

$L_{out} = 1.2*7.10 = \boxed{8.50m}$

assume $\lambda = \frac{710}{0.3a} = 140$ a=16.9Cm (govern)

assume $\lambda = \frac{850}{0.45a} = 140$ a=13.5Cm

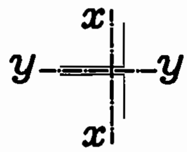
Check On ⊥ 180*16

Check buckling $\lambda_{in} = \frac{710}{r_x = 5.4} = \boxed{131}$ $\lambda_{out} = \frac{850}{r_y = 8.1} = 105$

Check Stresses ; $F_C = \frac{7500}{131^2} * 0.85 * 1.25 = 0.46 t/Cm^2$

$$f_{ca} = \frac{5.90}{2*55.4} = 0.05 t/Cm^2 \ngtr 0.46 t/Cm^2$$

Check Deflection ; $\frac{L}{d} = \frac{710}{18*2+1} = 19 \not> 40$



Design of Lower wind Bracing

case(1): $W_w = 0.14*2*1 = \boxed{0.28\ t/m}$ (govern)

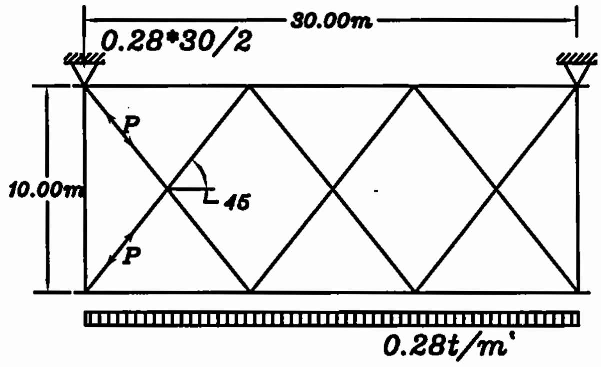
case(2): $W_w = 0.20*1*1.00m = 0.20\ t/m'$

case(3): $W_w = 0.10*1*1.00m = 0.10\ t/m'$

$0.28/0.20 = 1.40 > 1.25$

So 0.28t/m' is critical more than 0.20t/m'

$$Force = \frac{\pm 0.28*30/2}{2*Sin45^{\circ}} = \boxed{\pm 3.20t}$$



$$L = \sqrt{10.0^2 + 10.0^2} = 14.14m$$

$L_{out} = 0.75*14.1 = \boxed{10.60m}$

$L_{in} = 0.50*14.1 = \boxed{7.10m}$

assume $\lambda = \frac{710}{0.3a} = 140$ a=16.9Cm (govern)

assume $\lambda = \frac{1060}{0.45a} = 140$ a=16.8Cm

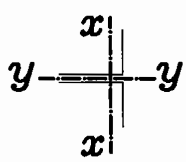
Check On ⊥⊥ 180*16

Check buckling $\lambda_{in} = \frac{710}{r_x = 5.4} = 131$ $\lambda_{out} = \frac{1060}{r_y = 8.1} = 131$

Check Stresses ; $F_C = \frac{7500}{131^2} * 0.85 * 0.80 * 1.25 = 0.37 t/Cm^2$

$f_{Ca} = \frac{3.20}{2*55.4} = 0.02 t/Cm^2 \not> 0.37 t/Cm^2$

Check Deflection ; $\frac{L}{d} = \frac{710}{18*2+1} = 19 \not> 40$



Design of Cross Bracing

case(1): $W_w = 0.14*2*2 = 0.56 \ t/m'$

case(2): $W_w = 0.20*1*(2+0.25)m = 0.45 \ t/m'$

case(3): $W_w = 0.10*1*(2+3.00+0.25)m = 0.525 \ t/m'$

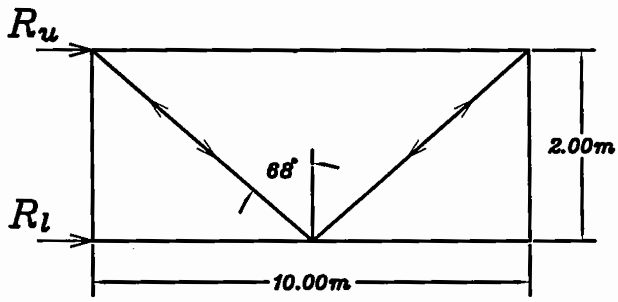
خلى بالك

فى هذه الحاله سوف يتم عمل مقارنه بين الحاله الثالثه والحاله الاولى وذلك نظرا لان فى الحاله الاولى يتم زيادة الاجهادات المسموح بها ب 25% ولكن فى الحاله الثالثه لايتم زيادة الاجهادات ولحساب الحاله التى سوف يتم التصميم عليها

$0.56/0.525 = 1.06 < 1.25$

So $0.525 t/m'$ is critical more than $0.56 t/m'$

$R_u = 0.525*30/2 = \pm 6.8t$



For diagonal member

$$Force = \frac{\pm 6.80}{2*Sin68^\circ} = \pm 3.70t$$

$$L = \sqrt{2.00^2 + 5.00^2} = \boxed{5.40m} = L_{in}$$

$L_{out} = 1.2*5.40 = \boxed{6.50m}$

assume $\lambda = \frac{540}{0.3a} = 140$ $\quad$ a=12.9Cm (govern)

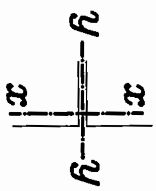
assume $\lambda = \frac{650}{0.45a} = 140$ $\quad$ a=10.3Cm

Check On ⊥ 130*12

Check buckling $\lambda_{in} = \frac{540}{r_x=3.9} = \boxed{138}$ $\quad \lambda_{out} = \frac{650}{r_y=5.8} = 111$

Check Stresses ; $F_c = \frac{7500}{138^2}*0.85 = 0.33 t/Cm^2$

$f_{ca} = \frac{3.70}{2*30} = 0.06 t/Cm^2 \ngtr 0.33 t/Cm^2$



Check Deflection ; $\frac{L}{d} = \frac{540}{13} = 41.5 > 40$

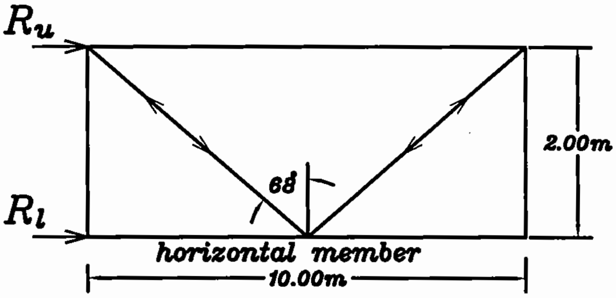
Check On ⊥ 140*13 Check Deflection ; $\frac{L}{d} = \frac{540}{14} = 38 < 40$

Horizontal member (star shape) ┼

case(1): $W_w = 0.56 + 0.28 = 0.84$ t/m'

case(2): $W_w = 0.45 + 0.20 = 0.65$ t/m'

case(3): $W_w = 0.525 + 0.10 = 0.625$ t/m'



0.84/0.65=1.29>1.25

So 0.84t/m' is critical more than 0.65t/m'

$R_l = 0.84*30/2 = \pm 12.6t$

$L_{in} = 5.00m$ $L_{Out} = 10.00m$

assume $\lambda = \frac{1000}{0.38a} = 140$ a=18.5Cm govern

Check On ⊥ 200*16

Check buckling $\lambda_{max.} = \frac{1000}{r_u = 7.7} = 129$

Check Stresses ; $F_c = \frac{7500}{129^2} * 0.85 * 1.25 = 0.47 t/Cm^2$

$f_{ca} = \frac{12.60}{2*61.8} = 0.11 t/Cm^2 \not> 0.47 t/Cm^2$

Check Deflection ; $\frac{L}{d} = \frac{1000}{(2*20+1)} = 25 < 40$