# Final

# Revision

## في

## المنشآت المعدنية

## STEEL

مراجعة
Cold Formed Sec
فقط

## إختياري ثالثة مدني

3rd - year Civil Eng.

Sammar

With my best wishes...

# Cold Formed Sections

be العرض الفعال

## حساب العرض الفعال for stiffned elements

1. $b$ : الطول الصافي للعنصر

2. $\frac{b}{t}$ = Flat width ratio ⟹ نسبة العرض إلى السمك (بدون وحدة)

3. $\psi$
   - → $\psi = 1.0$ (لو كان شكل الإجهادات مستطيل أو كان ▯)
   - → $\psi = -1.0$ (إذا كان شكل الإجهادات مثلثين مختلفين في الإشارات)

4. $K_\sigma$ = plate buckling factor ⟹ يتم إيجادها من الكود ص 23
   - → if $\psi = 1.0$ ⟶ $K_\sigma = 4.0$
   - → if $\psi = -1.0$ ⟶ $K_\sigma = 23.9$

5. $\lambda_p$ = Plate slenderness ⟶ يتم إيجادها من معادلة في الكود ص 21

$$\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K_\sigma}}$$

6. $\rho$ = Reduction factor ⟶ يتم إيجادها من معادلة في الكود ص 21

$$\rho = \frac{\lambda_p - 0.15 - 0.05(\psi)}{\lambda_p^2}$$

← وخلي بالك يتم التعويض عن ($\psi$) بإشارتها ولازم تكون ($\rho \leq 1.0$) ولو كانت ($\rho > 1.0$) يتم أخذ $\rho = 1$ وفي هذه الحالة يكون القطاع fully effective

7. be : العرض الفعال ⟶ يتم إيجاده من معادلة في الكود ص 21

$$b_e = \rho * b_c$$

$b_c$: الطول المعرض في الضغط

## حساب العرض الفعال for Un stiffned elements

1. $b$ : الطول الصافي للعنصر

2. $\frac{b}{t}$ = Flat width ratio ⟹ نسبة العرض إلى السمك (بدون وحدة)

3. $\psi$
   - → $\psi = 1.0$ (لو كان شكل توزيع الإجهادات ▯ أو كان شكله ▯)
   - → $\psi = -1.0$ (لو كان شكل الإجهادات مثلثين مختلفين في الإشارات)

4. $K_\sigma$ = plate buckling factor ⟹ يتم إيجادها من الكود ص 24
   - → if $\psi = 1.0$ ⟶ $K_\sigma = 0.43$
   - → if $\psi = -1.0$ ⟶ $K_\sigma = 23.8$

5. $\lambda_p$ = Plate slenderness ⟶ يتم إيجادها من معادلة في الكود ص 21

$$\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K_\sigma}}$$

6. $\rho$ = Reduction factor ⟶ يتم إيجادها من معادلة في الكود ص 21

$$\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2}$$

← ونفس الكلام نعوض عن ($\psi$) بإشارتها ولازم تكون ($\rho \leq 1.0$) ولو كانت ($\rho > 1.0$) يتم أخذ $\rho = 1$ وفي هذه الحالة يكون القطاع Fully effective

7. be : العرض الفعال ⟶ يتم إيجاده من الكود من معادلة ص 21

$$b_e = \rho * b_c$$

$b_c$ : الطول في منطقة الضغط

# حساب العرض الفعال For Partially stiffned elements

be
العرض الفعال

1. b : الطول الصافي للعنصر
2. $b/t$ = flat width ratio
3. $\psi \Rightarrow$ $\psi = 1.0 \Rightarrow$ (+ OR −) ; $\psi = -1.0 \Rightarrow$
4. $K\sigma$ ←

← يتم إيجاد قيمة المعامل (S) من معادلة في الكود ص 188

$$S = 1.28\sqrt{\frac{E}{F_y}}$$

$E = 2100\ t/cm^2$ → في الكود ص 2

$F_y$ → حسب نوع الحديد من الكود ص 2

← بعد ذلك يتم مقارنة قيمة ($b/t$) بالقيمتين $S$ و $S/3$

و بالتالي ينتج (3) إحتمالات (الكود ص 186 و ص 187)

## ① $b/t \leq S/3$

$$be = b$$

Fully effective

أسهل حالة

ومنكملش ولا نعمل أي حاجة

## ② $S/3 < b/t < S$

* $I_a = 399\left[\frac{b/t}{S} - 0.33\right]^3 * t^4 = \checkmark\ cm^4$
* $I_s = \frac{t\,d^3}{12} \Rightarrow$ for lip (lip → d = D)
* $C_2 = \frac{I_s}{I_a} \leq 1.0$ & $C_1 = 2 - C_2$ (بإهمال قيمة R)
* ← يتم إيجاد قيمة النسبة ($D/b$) ومقارنتها ب 0.25

$0.25 < D/b \leq 0.8$:

$$K\sigma = \left[4.82 - 5\left(\frac{D}{b}\right)\right]\left(\frac{I_s}{I_a}\right)^{1/2} + 0.43 \leq 5.25 - 5\left(\frac{D}{b}\right)$$

$0.25 \geq D/b$:

$$K\sigma = 3.57\left(\frac{I_s}{I_a}\right)^{1/2} + 0.43 \leq 4$$

## ③ $b/t \geq S$

* $I_a = \left\{\left[\frac{115\,(b/t)}{S}\right] + 5\right\} t^4 = \checkmark\ cm^4$
* $I_s = \frac{t\,d^3}{12} = \checkmark\ cm^4$
* $C_2 = \frac{I_s}{I_a} \leq 1.0$ & $C_1 = 2 - C_2$
* يتم إيجاد قيمة النسبة ($D/b$) ومقارنتها ب 0.25

$0.25 < D/b \leq 0.8$:

$$K\sigma = \left[4.82 - 5\left(\frac{D}{b}\right)\right]\left(\frac{I_s}{I_a}\right)^{1/3} + 0.43 \leq 5.25 - 5\left(\frac{D}{b}\right)$$

$0.25 \geq$ ... : $K\sigma = 3.57($ ...

5. $\lambda_p$ : $\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K\sigma}}$ → Page 21
6. $\rho$ : $\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2}$ → page 21
7. $be$ : $be = \rho\, b_c$ → page 21

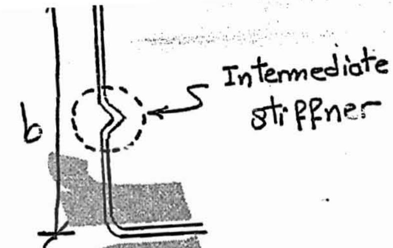
← ويتم حساب $d_s$ (للـ lip)

$d_s = C_2\, d_s$ ($\rho * be$ for unstiffned)

3

# be العرض الفعال

## Effective width of Uniformly Compressed elements with one intermediate stiffener




1. $b$ : الطول الصافي للعنصر
2. $\frac{b}{t}$ = Flat width ratio نسبة العرض للسمك
3. $\psi \rightarrow \left[ \begin{array}{l} \psi = 1 \\ \psi = -1 \end{array} \right.$
4. $K_\sigma \longrightarrow$ يتم إيجاد قيمة (S) من معادلة فى الكود ص 188

$$S = 1.28\sqrt{\frac{E}{F_y}}$$

$E = 2100\ t/cm^2$

$F_y \rightarrow$ page 2 حسب نوع الحديد

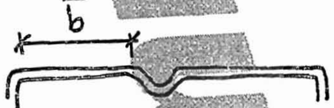
بعد ذلك يتم مقارنة قيمة $\left(\frac{b}{t}\right)$ بالقيمتين $S$ , $3S$

وبالتالى ينتج (3) إحتمالات (الكود ص 189 وص 190)

### ① $b/t \le S$

$I_a = 0$ (no Int stiffner required)

$be = \bar{b}$ انظر الرسم ص 190



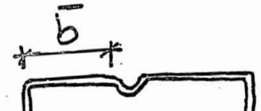

أسهل حالات

مش هنعمل حسابات

### ② $S < b/t < 3S$

* $I_a = \left[\frac{50(b/t)}{S} - 50\right] * t^4 = \checkmark\ cm^4$
* $I_s = \frac{t(b)^3}{12} = \checkmark\ cm^4$
* $K_\sigma = 3\left(\frac{I_s}{I_a}\right)^{1/2} + 1 \le 4$

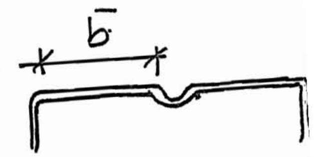
5. $\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K_\sigma}}$
6. $\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2}$
7. $be = \rho\,\bar{b}$




### ③ $b/t \ge 3S$

* $I_a = \left[\frac{128(b/t)}{S} - 285\right] * t^4 = \checkmark\ cm^4$
* $I_s = \frac{t(b)^3}{12} = \checkmark\ cm^4$
* $K_\sigma = 3\left(\frac{I_s}{I_a}\right)^{1/3} + 1 \le 4$

5. $\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K_\sigma}}$
6. $\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2}$
7. $be = \rho\,\bar{b}$



**Example (2)** June 2007

ملاحظات: مسموح باستخدام الكود المصري لتصميم المنشآت المعدنية - تراعى الإجابة على الأسئلة بترتيب ذكرها - للحصول على أعلى الدرجات
لم يتم دعم إجابتك بالرسومات اليدوية المنظمة كلما أمكن.

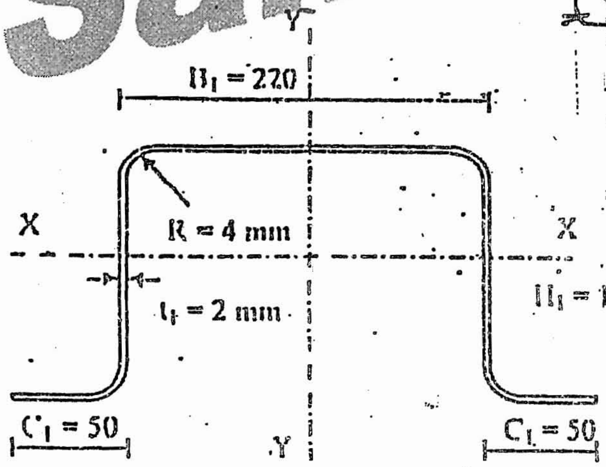



Figure (1)

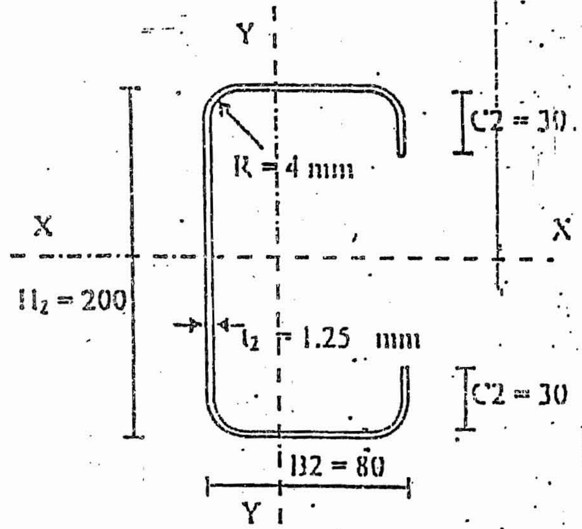



Figure (2)

8t.(37)

## Question No. (3)

Figures (1) and (2) show a cold-formed hat and C-sections made of mild steel (37).

**A) For both sections subjected to axial compression :**

1- Calculate the effective width of the stiffened compression elements of each section.

2- Calculate the effective width of the partially stiffened compression elements of each section.

3- Calculate the minimum thickness $t_1$ and $t_2$ for the un-stiffened compression elements of each section to be fully effective.

**B) For both sections subjected to bending moment +ve or -ve $M_x$ :**

1- Give neat sketches for the effective section in each case. No calculations are required.

2- Regardless of the thickness, which section is more efficient for +ve $M_x$ ? Give reasons for your answer.

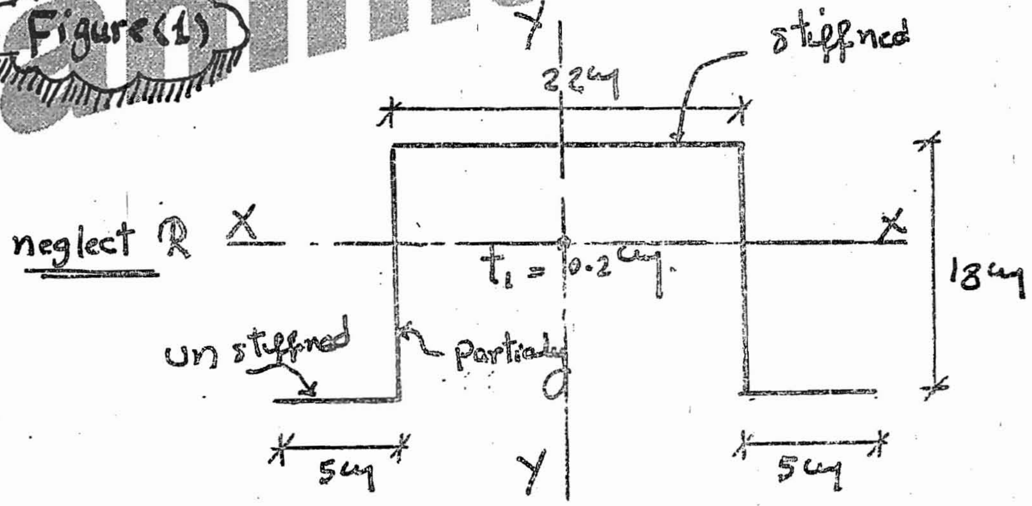
3- Regardless of the thickness, which section is more efficient for shear resistance ? Give reasons for your answer.

4- For each case, calculate the maximum allowable beam reaction at end support for safe web crippling. Assume 12 cm bearing width.

# Solution

## A] For both sections Subjected to axial Compression:-

Figure (1)




### 1 effective width of the stiffned comp. element:-

① $b = 22$ cm

② $b/t = 22/0.2 = 110$

③ $\psi = 1$

④ $k_\sigma \rightarrow$ from code page (23) $\rightarrow k_\sigma = 4.0$

⑤ $\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{k_\sigma}} = \frac{110}{44}\sqrt{\frac{2.4}{4}} = 1.94$

⑥ $\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2} = \frac{1.94 - 0.15 - 0.05}{(1.94)^2} = 0.46$

⑦ $b_e = \rho b = 0.46 * 22 = 10.12$ cm.

### 2 effective width of the partially stiffned element:-

① $b = 18$ cm

② $b/t = 18/0.2 = 90$

③ $\psi = 1.0$

④ $S = 1.28\sqrt{\frac{E}{F_y}} = 1.28\sqrt{\frac{2100}{2.4}} = 37.86$

⑤ $b/t = 90 > S = 37.86$

∴ الاحتمال الثالث

⑥ $$I_a = \left[\frac{115\,(b/t)}{S} + 5\right] t^4$$

$$= \left[\frac{115 * 90}{37.86} + 5\right](0.2)^4 = 0.445\,cm^4$$

⑦ $$I_s = \frac{t d^3}{12} = \frac{0.2(5)^3}{12} = 2.083\,cm^4$$

lip لل

$I_s > I_a$ Not ok $\quad I_s/I_a > 1.0$

take $C_2 = 1.0$

$C_1 = 2 - C_2 = 2 - 1 = 1.0$

* $D/b = 5/18 = 0.28 > 0.25 \quad (0.25 \rightarrow 0.8)$

$$\therefore K_\sigma = \left[4.82 - 5\,(D/b)\right]\left(\frac{I_s}{I_a}\right)^{1/3} + 0.43 \leq 5.25 - 5\,(D/b)$$

* $$K_\sigma = \left[4.82 - 5(0.28)\right]\left(\frac{2.083}{0.445}\right)^{1/3} + 0.43 = 6.15$$

$$\therefore K_\sigma = 5.25 - 5(0.28) = \underline{3.85}$$

* $$\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K_\sigma}} = \frac{90}{44}\sqrt{\frac{2.4}{3.85}} = 1.61$$

* $$\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2} = \frac{1.61 - 0.15 - 0.05}{(1.61)^2} = 0.54$$

* $b_e = \rho b = 0.54 * 18 = 9.8\,cm$

* $d_s = C_2 * d = 1 * 5 = 5\,cm.$

for lip

3 Calculate the Min. thick. $t_1$ for the un-stiffned comp. element to be fully effective:-

$\rho = 1.0$ لازم تكون ← fully effective ← علشان العنصر يكون

$\psi = 1.0 \longrightarrow K_\sigma = 0.43$

$$\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2} = \frac{\lambda_p - 0.2}{\lambda_p^2} = 1.0$$

$$\lambda_p^2 - \lambda_p + 0.2 = 0.0$$

$$\lambda_{p_1} = 0.7236 \quad \& \quad \lambda_{p_2} = 0.2764$$

but $\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K_\sigma}} \Rightarrow \lambda_p = \frac{5/t}{44}\sqrt{\frac{2.4}{0.43}}$

$$\boxed{\lambda_p = \frac{0.268}{t}} \Rightarrow$$ معادلة بين $\lambda_p$ و $t$

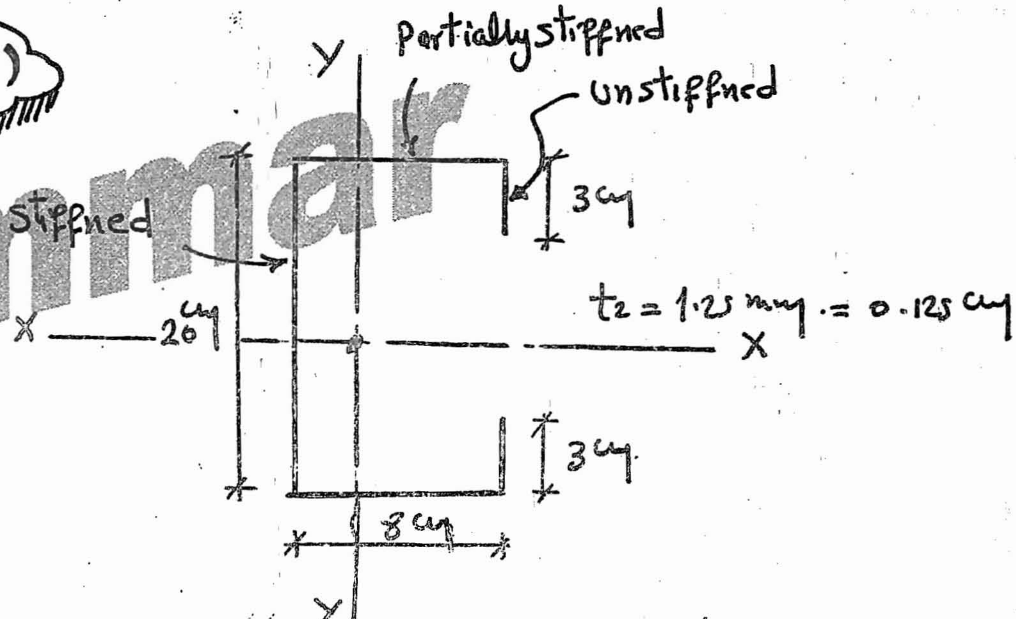
← يتم التعويض عن $(\lambda_p)$ في المعادلة السابقة بالقيمتين $\lambda_{p_1}$ و $\lambda_{p_2}$ وإيجاد قيمة $t$ المناظرة وأخذ الأقل من القيمتين.

| | |
|---|---|
| for $\lambda_{p_1} = 0.7236$ | for $\lambda_{p_1} = 0.2764$ |
| $t_1 = 0.37$ cm | $t_1 = 0.97$ cm |

$$\therefore t_{1\,min} = 0.37 \text{ cm}$$

← من العلاقة السابقة بين $\lambda_p$ و $t$ نجد أن العلاقة عكسية بمعنى أنه كلما زادت قيمة $\lambda_p$ تقل قيمة $t$ والعكس صحيح.

Figure (2)




neglect R



**1** effective width of the stiffned comp. element :-

① $b = 20\,cm$

② $b/t = \frac{20}{0.125} = 160$

③ $\psi = 1$

④ $K_\sigma$ → from code page (23) ⇒ $K_\sigma = 4.0$

⑤ $\lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{K_\sigma}} = \frac{160}{44}\sqrt{\frac{2.4}{4}} = 2.82$

⑥ $\rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2} = \frac{2.82 - 0.15 - 0.05}{(2.82)^2} = 0.33$

⑦ $b_e = \rho b = 0.33 * 20 = 6.6\,cm$

**2** effective width of the partially stiffned elements :-

① $b = 8\,cm$.

② $b/t = \frac{8}{0.125} = 64$

③ $\psi = 1.0$

④ $S = 1.28\sqrt{\frac{E}{F_y}} = 1.28\sqrt{\frac{2100}{2.4}} = 37.86$

25

⑤ $b/t = 64 > S = 37.86$

الاحتمال الثالث :

⑥ $$I_a = \left[\frac{115\,(b/t)}{S} + 5\right] t^4$$

$$= \left[\frac{115\,(64)}{37.86} + 5\right] * (0.125)^4 = 0.05\ cm^4$$

⑦ $$I_s = \frac{t d^3}{12} = \frac{0.125\,(3)^3}{12} = 0.28\ cm^4$$

$$I_s > I_a$$

take $C_2 = 1.0$

$C_1 = 1.0$

$$* \ D/b = 3/8 = 0.375 > 0.25 \quad (0.25 \rightarrow 0.8)$$

$$\therefore k_\sigma = [4.82 - 5(D/b)]\left(\frac{I_s}{I_a}\right)^{1/3} + 0.43 \leq 5.25 - 5(D/b)$$

$$* \ k_\sigma = [4.82 - 5(0.28)]\left(\frac{0.28}{0.05}\right)^{1/3} + 0.43 = 6.5 > \rightarrow$$

$$\therefore k_\sigma = 5.25 - 5(0.28) = 3.85$$

$$* \ \lambda_p = \frac{b/t}{44}\sqrt{\frac{F_y}{k_\sigma}} = \frac{64}{44}\sqrt{\frac{2.4}{3.85}} = 1.148 \simeq 1.15$$

$$* \ \rho = \frac{\lambda_p - 0.15 - 0.05\psi}{\lambda_p^2} = \frac{1.15 - 0.15 - 0.05}{(1.15)^2} = 0.72$$

$$* \ b_e = \rho b = 0.72 * 8 = 5.76\ cm$$

$$* \ d_s = C_2 * d = 1 * 3 = 3\ cm.$$

($d_s$ → for lip)

**3** Calculate the Min. thick. $t_2$ for the un-stiffned comp. element to be fully effective:-

$\rho = 1.0$ ⟵ fully effective كي يكون القطاع

$\psi = 1.0 \longrightarrow k_\sigma = 0.43$

$$\rho = \frac{\lambda_p - 0.2}{\lambda_p^2} = 1.0$$

$$\lambda_p^2 - \lambda_p + 0.2 = 0.0$$

$$\lambda_{p1} = 0.7236 \quad \& \quad \lambda_{p2} = 0.2764$$

$$\lambda_p = \frac{3/t}{44}\sqrt{\frac{2.4}{0.43}} \Rightarrow \lambda_p = \frac{0.161}{t}$$

for $\lambda_{p1} = 0.7236$ & for $\lambda_{p2} = 0.2764$

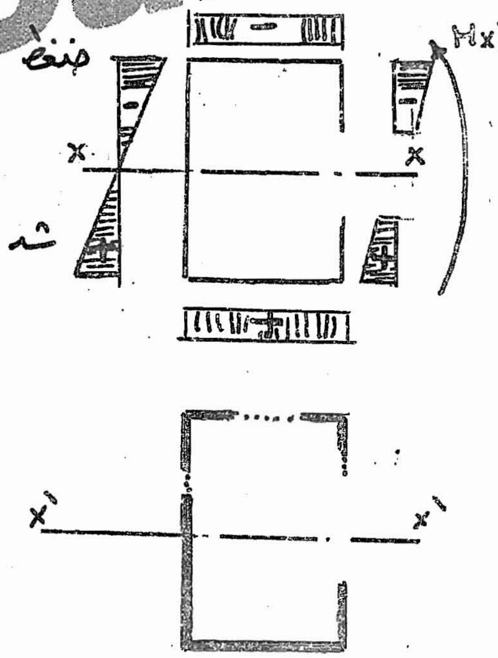
$t_2 = 0.22$ cm $\qquad t_2 = 0.58$ cm

$\therefore t_{2min} = 0.22$ cm

# B] Sections Subjected to +ve or -ve $M_x$ :-

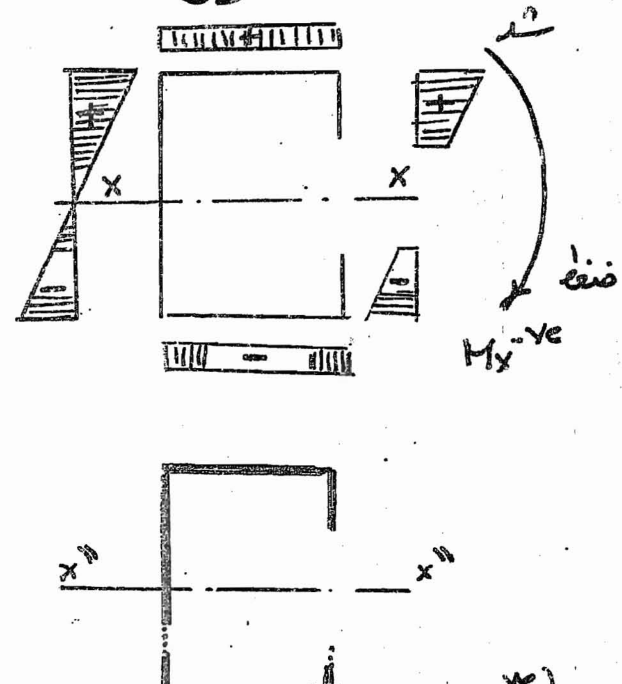
**[I]** Give neat sketches for the effective section in each case. No calculations are required.

Fig(1) $M_x^{+ve}$



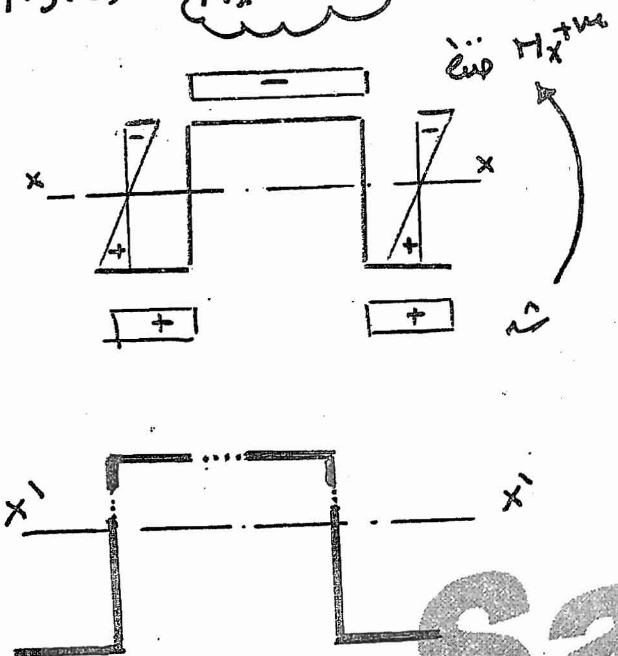

effective section ($M_x^{+ve}$)

Fig(1) $M_x^{-ve}$



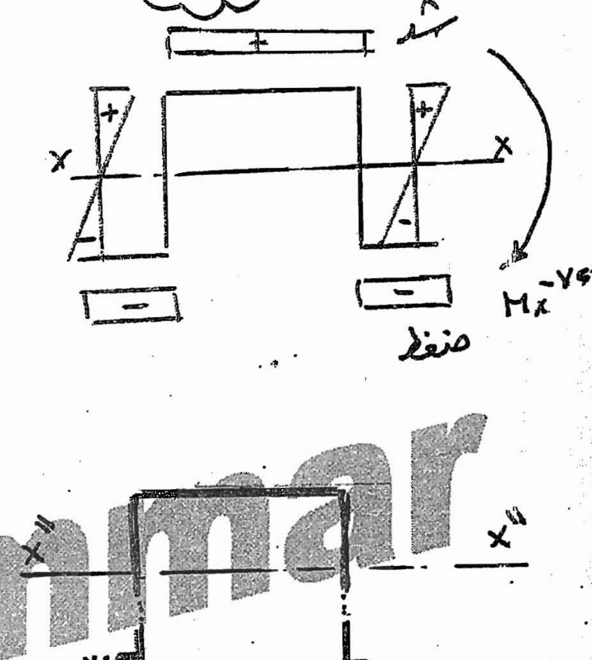

effective section ($M_x^{-ve}$)

Fig(2) $M_x^{+ve}$




effective section ($M_x^{+ve}$)

Fig(2) $M_x^{-ve}$




effective section ($M_x^{-ve}$)

## Example ( ) June 2007 *

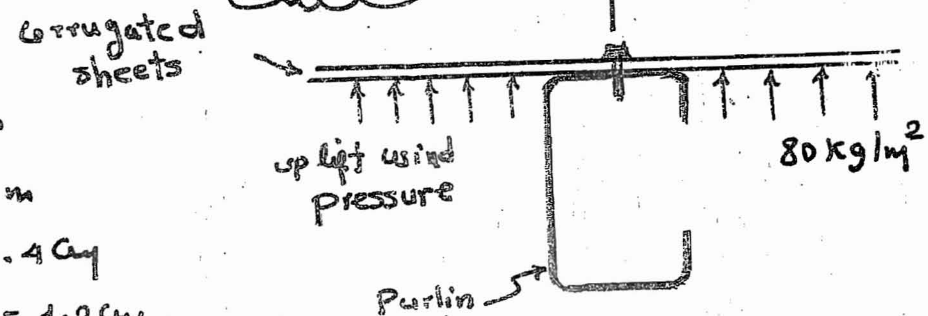


**Question No. (4)**

Calculate the number of screws, per one meter length of roof purlin, required for fastening corrugated thin steel sheets in order to resist uplift wind pressure. Use the following data:

- purlin span = 7.50 m
- purlin spacing = 1.75 m
- total uplift wind pressure = 80 kg / m$^2$
- dead load is neglected
- screw diameter = 4 mm
- washer diameter = 12 mm
- purlin material thickness = 1.25 mm
- covering sheets thickness = 0.7 mm
- screws are top drilled
- all materials = steel (52)

### Solution




* **Given:-**

- Span = 7.50 m
- spacing = 1.75 m
- $d = 4\ mm = 0.4\ cm$
- $d_w = 12\ mm = 1.2\ cm$.
- $t_{purlin} = 1.25\ mm = 0.125\ cm. = t_2$
- $t_{sheets} = 0.7\ mm = 0.07\ cm. = t_1$

$$T = \text{windload} = 80 * 7.50 * 1.75 = 1050\ kg = 1.05\ ton$$

$$P_{not} = 0.28\ t * d * F_{u2}$$

$$= 0.28 * 0.125 * 0.4 * 5.2 = 0.073\ ton$$

$$P_{nov} = 0.5 * t_1 * d_w * F_{u1}$$

$$= 0.5 * 0.07 * 1.2 * 5.2 = 0.2184\ ton$$

Fore = least of $\begin{cases} P_{not} \\ P_{nov} \end{cases}$ Force = 0.073 ton

↑ Screw allawable tension

$$T/_{screw} = \frac{T}{N} = \frac{1.05}{N} = 0.073$$

$$N = \frac{1.05}{0.073} = 14.4 \simeq 15 \text{ Bolts}$$

$$\text{number of bolts per one meter} = \frac{15}{7.5} = 2 \text{ bolts}$$

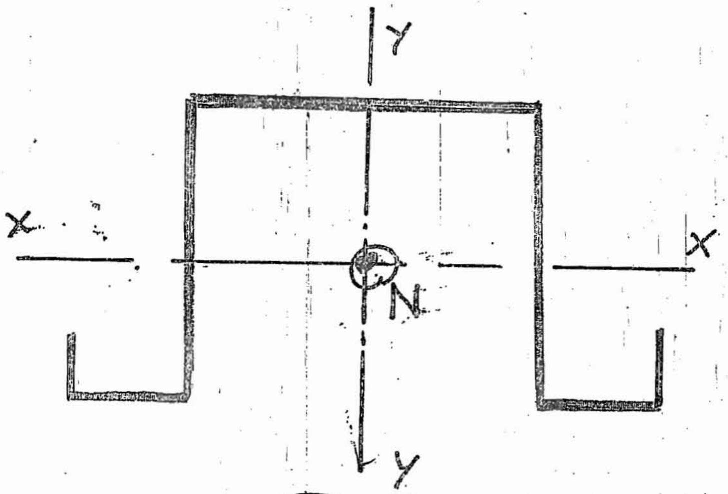
ك ممكن أنه يعطي بعض القطاعات ويطلب رسم شكل ال

Effective Section لها

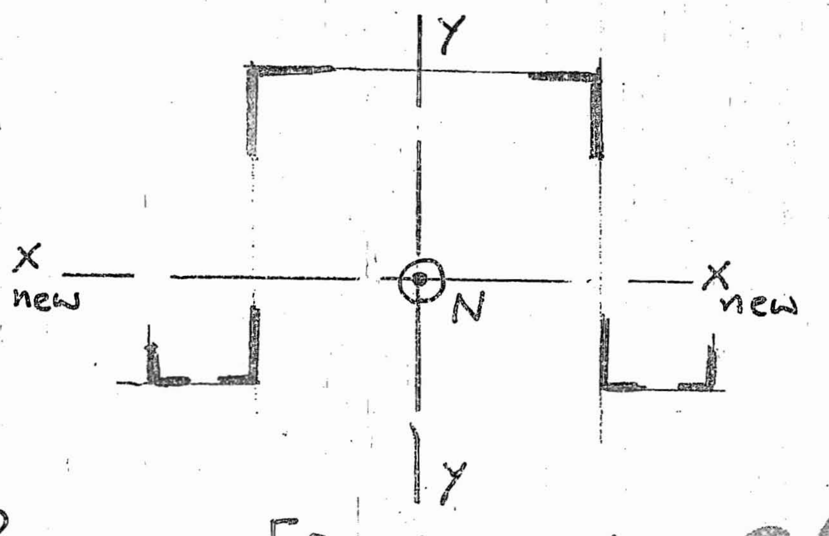
تحت تأثير Mx أو My أو N

***EX:** without Calculations

Draw the effective section for the shown section if it is projected to a Normal force.




Solution




Effective Section

bye..bye..!!

وربنا معاكو ا...!!

## صفحات الكود التى سوف نستخدمها فى الإمتحان

جزء الـ Cold Formed Sec.



⇒ Page. 21, 22, 23, 24

- ρ, λp, be
- جداول الـ stiff. & unstiff.

⇒ Page 186, 187, 188

قوانين الـ Partially stiff.

⇒ Page 208, 209

صفحات الـ Screw Connections



Page 189 & 190

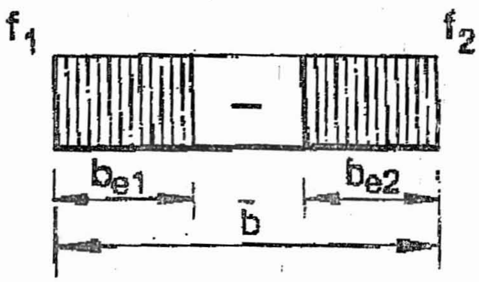
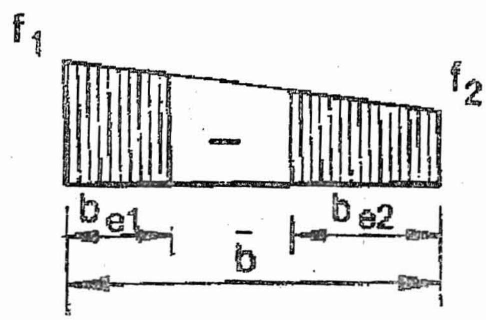
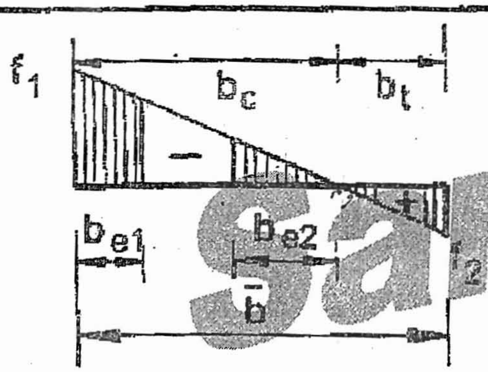
intermediate stiffner

لا تدخل بهذه الورقة الإمتحان ..!!

صفحات الكود الخاصة بال C.F.S

## Table (2.3) Effective Width and Buckling Factor for Stiffened Compression Elements

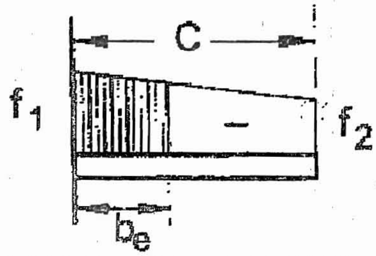
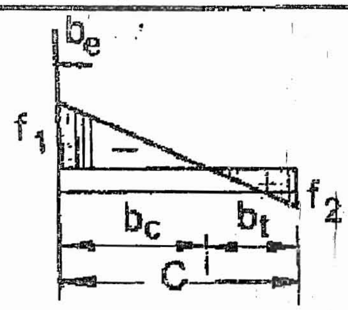
① b
② b/t

<table>
<tr><td colspan="4">Stress Distribution</td><td colspan="3">Effective Width $b_e$ for<br>$\rho = (\bar{\lambda}_p - 0.15 - 0.05\psi) / \bar{\lambda}_p^2 \leq 1$</td></tr>
<tr><td colspan="6">For $1 > \psi \geq -1$:<br>$$k_\sigma = \frac{16}{[(1+\psi)^2 + 0.112(1-\psi)^2]^{0.5} + (1+\psi)}$$</td><td rowspan="2">$-1 > \psi > -2$</td></tr>
<tr><td>③ $\psi = f_2 / f_1$</td><td>1</td><td>$1 > \psi > 0$</td><td>0</td><td>$0 > \psi > -1$</td><td>-1</td></tr>
<tr><td>④ Buckling Factor $k_\sigma$</td><td>4.0</td><td>$\frac{8.2}{1.05+\psi}$</td><td>7.81</td><td>$7.81 - 6.29\psi + 9.78\psi^2$</td><td>23.9</td><td>$5.98(1-\psi)^2$</td></tr>
<tr><td colspan="4"></td><td colspan="3">ψ = 1:<br>$b_e = \rho \bar{b}$<br>$b_{e1} = 0.5\, b_e$<br>$b_{e2} = 0.5\, b_e$</td></tr>
<tr><td colspan="4"></td><td colspan="3">1 > ψ ≥ 0:<br>$b_e = \rho \bar{b}$<br>$b_{e1} = 2\, b_e / (5 - \psi)$<br>$b_{e2} = b_e - b_{e1}$</td></tr>
<tr><td colspan="4"></td><td colspan="3">ψ < 0:<br>$b_e = \rho\, b_c = \rho\, \bar{b} / (1-\psi)$<br>$b_{e1} = 0.4\, b_e$<br>$b_{e2} = 0.6\, b_e$</td></tr>
</table>

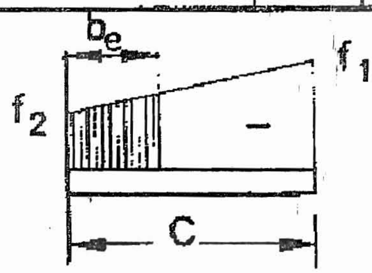
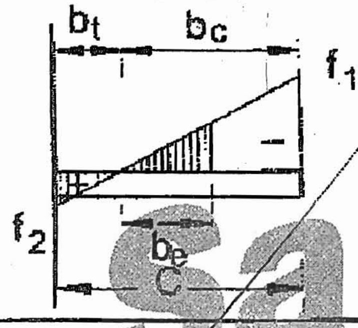
## Table (2.4) Effective Width and Buckling Factor For Unstiffened Compression Elements

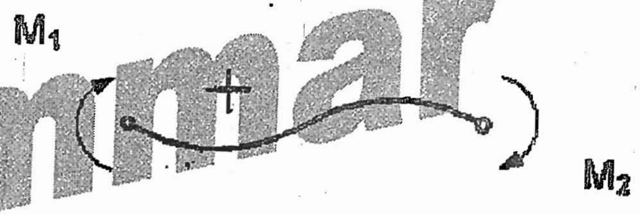
| Stress Distribution | Effective Width $b_e$ for $\rho = (\bar{\lambda}_p - 0.15 - 0.05\psi)/\bar{\lambda}_p^2 \le 1$ |
|---|---|

| $\psi = f_2/f_1$ | 1 | $1 > \psi > 0$ | 0 | $0 > \psi > -1$ | -1 |
|---|---|---|---|---|---|
| Buckling factor $k_\sigma$ | 0.43 | $\frac{0.578}{\psi + 0.34}$ | 1.70 | $1.7 - 5\psi + 17.1\psi^2$ | 23.8 |

| Stress Distribution | Effective Width |
|---|---|
|  | $1 > \psi \geq 0$: $b_e = \rho C$ |
|  | $\psi < 0$: $b_e = \rho b_c = \rho C / (1-\psi)$ |

| $\psi = f_2/f_1$ | 1 | 0 | -1 | $1 > \psi > -1$ |
|---|---|---|---|---|
| Buckling factor $k_\sigma$ | 0.43 | 0.57 | 0.85 | $0.57 - 0.21\psi + 0.07\psi^2$ |

| Stress Distribution | Effective Width |
|---|---|
|  | $1 > \psi \geq 0$: $b_e = \rho C$ |
|  | $\psi < 0$: $b_e = \rho b_c = \rho C / (1-\psi)$ |




Where:

**$(M_1/M_2)$** is the algebraic ratio of the smaller to the larger end moments taken as positive for reverse curvature bending.

When the bending moment at any point within the unbraced length is larger than the values at both ends of this length, the value of $(C_b)$ shall be taken as unity.

**II.** Compression on extreme fibres of channels bent about their major axis and meeting the requirements of Table 2.1.

$$F_{ltb} = \frac{800}{L_u . d / A_f} C_b \le 0.58\ F_y \qquad \text{.................} \qquad 2.29$$

**III.** Slender sections which do not meet the non-compact section requirements of Table 2.1 shall be designed using the same allowable stresses used for non-compact sections except that the section properties used in the design shall be based on the effective widths $b_e$ of compression elements as specified in Table 2.3 for stiffened elements and Table 2.4 for unstiffened elements. The effective width is calculated using a reduction factor ρ as $b_e = \rho\ \bar{b}_e$ where:

$$\rho = (\bar{\lambda}_p - 0.15 - 0.05\psi)/\bar{\lambda}_p^2 \le 1 \qquad \text{....................} \qquad 2.30$$

and

$\bar{\lambda}_p$ = normalized plate slenderness given by:

$$\bar{\lambda}_p = \frac{\bar{b}/t}{44}\sqrt{\frac{F_y}{k_\sigma}} \qquad \text{..............................} \qquad 2.31$$

$k_\sigma$ = Plate buckling factor which depends on the stress ratio ψ as shown in Tables 2.3 and 2.4.

$\bar{b}$ = Appropriate width, (see Table 2.1) as follows:

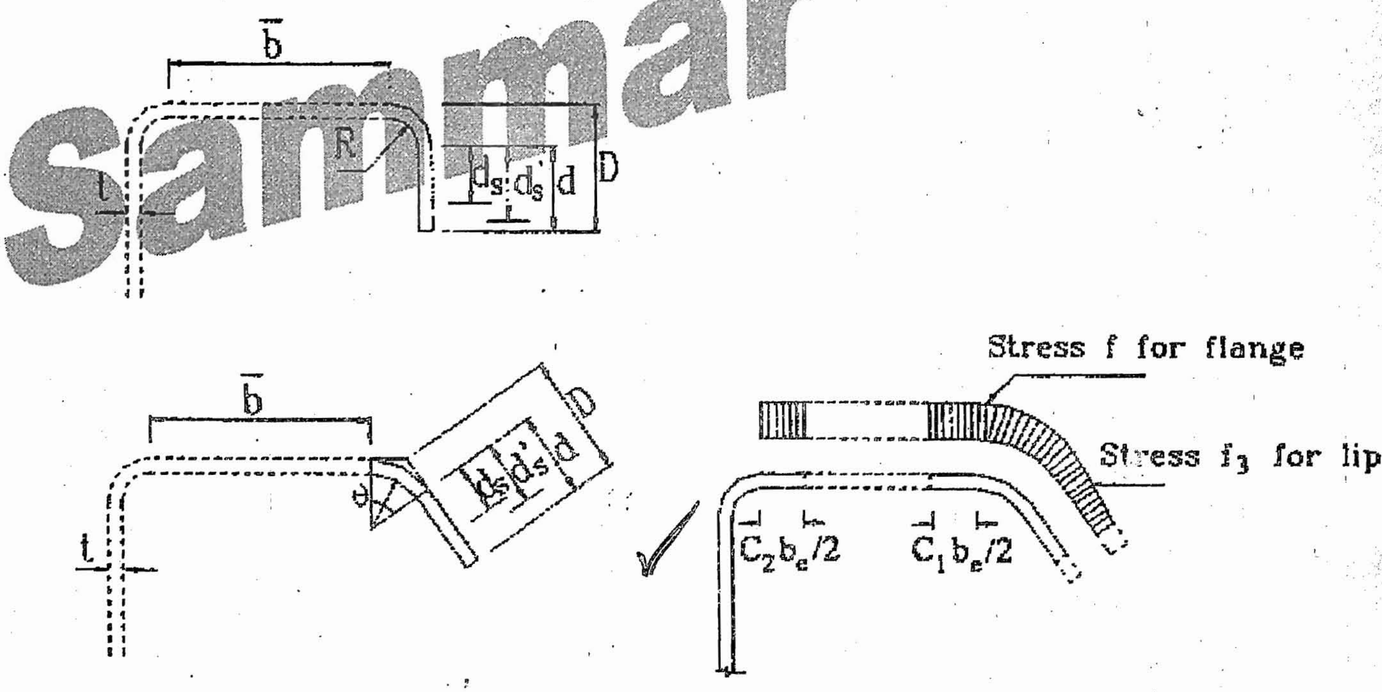



Figure (11.3) Elements with Edge Stiffener

In the previous equations: $E = 2100\ t/cm^2$ (Page(2))

| | | | |
|---|---|---|---|
| S | = | $1.28\sqrt{E/F_y}$ ........................................ | 11.4 |
| $F_y$ | = | Yield stress. | |
| $K_\sigma$ | = | Plate buckling factor. | |
| $B_0$ | = | Dimension defined in Fig. 11.4. | |
| D, d, $\bar{b}$ | = | Dimensions defined in Fig. 11.3. | |
| $d_s$ | = | Reduced effective width of the stiffener, $d_s$ shall be used in computing the overall effective section properties. | |
| $D'_s$ | = | Effective width of the stiffener according to Table 2.4. | |
| $C_1, C_2$ | = | Coefficients defined according to Fig. 11.3 to calculate the effective width instead of Table 2.3. | |
| $A_s$ | = | Reduced area of the stiffener. It shall be used in computing the overall effective section properties. The centroid of the stiffener is to be considered located at the centroid of the full area of the stiffener. | |
| $I_a$ | = | Adequate moment of inertia of the stiffener, so that each | |

## 1.3 STRUCTURAL STEEL



The mechanical properties of structural steel shall comply with the requirement given in Clause 1.4. Under normal conditions of usual temperatures, calculations shall be made for all grades of steel based on the following properties.

| | | |
|---|---|---|
| Mass Density | $\rho = 7.85$ | $t/m^3$ |
| Modulus of Elasticity | $E = 2100$ | $t/cm^2$ |
| Shear Modulus | $G = 810$ | $t/cm^2$ |
| Poisson's Ratio | $\nu = 0.3$ | |
| Coefficient of Thermal Expansion | $\alpha = 1.2 \times 10^{-5}$ | $/ ^\circ C$ |

## 1.4 GRADES OF STEEL

Material conforming to the Egyptian Standard Specification No.260/71 (Ministry of Industry) is approved for use under this code.

| Grade of Steel | Nominal Values of Yield Stress $F_y$ and Ultimate Strength $F_u$ | | | |
|---|---|---|---|---|
| | Thickness t | | | |
| | $t \leq 40$ mm | | $40 \text{ mm} < t \leq 100$ mm | |
| | $F_y$ ($t/cm^2$) | $F_u$ ($t/cm^2$) | $F_y$ ($t/cm^2$) | $F_u$ ($t/cm^2$) |
| St 37 | 2.40 | 3.60 | 2.15 | 3.4 |
| St 44 | 2.80 | 4.40 | 2.55 | 4.1 |
| St 52 | 3.60 | 5.20 | 3.35 | 4.9 |

in Clause 2.6.5.5.

Table (11.3) Maximum Allowable Deflection

| | |
|---|---|
| **Deflection of beams due to live load without dynamic effect** | |
| Beams carrying plaster or other brittle finish. | Span / 300 |
| All other beams. | Span / 200 |
| Cantilevers. | Length / 180 |
| Purlins and side girts (rails). | To suit the characteristics of the particular cladding system. |
| **Deflection of columns other than portal frames due to live and wind loads** | |
| Tops of columns in single-storey buildings. | Height / 300 |
| In each storey of a building with more than one storey. | Height of storey under consideration / 300 |

## 11.8 ALLOWABLE DESIGN STRESSES

The allowable stresses shall follow the slender section design requirements as detailed in Clause 2.6.5.5. Thus, for members under axial compression, axial tension, bending, shear, web crippling, or combined axial compression and bending, the requirements of Chapter 2 shall apply. However the allowable stresses for cylindrical tubular members shall be as given in Clause 11.13.

## 11.9 EFFECTIVE WIDTHS OF COMPRESSION ELEMENTS WITH AN EDGE STIFFENER OR AN INTERMEDIATE STIFFENER

### 11.9.1 Effective Width of Uniformly Compressed Elements with an Edge Stiffener

1- When $\bar{b}/t \leq S/3$

$$
\left.
\begin{aligned}
& I_a = 0 \text{ (no edge stiffener required)} \\
& b_e = \bar{b} \\
& d'_s = d;\ d_s = d'_s \text{ for simple lip stiffener} \\
& A'_s = d'_s\, t \\
& A_s = A'_s \text{ for other stiffener shapes} \\
& I_s = d^3 t/12
\end{aligned}
\right\} \quad 11.1
$$

2- When $S/3 < \bar{b}/t < S$

$I_a = 399 \{ [ (\bar{b}/t) / S ] - 0.33 \}^3 t^4$

$C_2 = I_s/I_a \leq 1$

$C_1 = 2\text{-}C_2$

For simple lip stiffener with $140^\circ \geq \theta \geq 40^\circ$ and $0.25 < D/\bar{b} \leq 0.8$ and $\theta$ is as shown in Fig. 11.3, the effective width for the flange is determined as:

$b_e = \rho\, \bar{b}$ according to Table 2.3 with the following $k_\sigma$

$k_\sigma = [4.82 - 5(D/\bar{b})]\ (I_s/I_a)^{1/2} + 0.43 \leq 5.25 - 5(D/\bar{b})$

For simple lip stiffener with $140^\circ \geq \theta \geq 40^\circ$ and $0.25 \geq D/\bar{b}$ the value of $k_\sigma$ becomes:

$k_\sigma = 3.57\ (I_s/I_a)^{1/2} + 0.43 \leq 4$

The effective width of the stiffener is determined from Table 2.4 as: $d'_s = \rho\, d$ with the value of $k_\sigma = 0.43$

$d_s = C_2\, d'_s = (I_s/I_a)\, d'_s$

$A'_s = d'_s\, t;\ A_s = (I_s/I_a)\, A'_s$ 11.2

3- When $\bar{b}/t \geq S$

$I_a = \{ [115\ (\bar{b}/t) / S] + 5 \}\, t^4$

$C_2 = I_s/I_a \leq 1$

$C_1 = 2\text{-}C_2$

For simple lip stiffener with $140^\circ \geq \theta \geq 40^\circ$ and $0.25 < D/\bar{b} \leq 0.8$ and $\theta$ is as shown in Fig. 11.3, the effective width for the flange is determined as:

$b_e = \rho\, \bar{b}$ according to Table 2.3 with the following $k_\sigma$

$k_\sigma = [4.82 - 5(D/\bar{b})]\ (I_s/I_a)^{1/3} + 0.43 \leq 5.25 - 5(D/\bar{b})$

For simple lip stiffener with $140^\circ \geq \theta \geq 40^\circ$ and $0.25 \geq D/\bar{b}$ the value of $k_\sigma$ becomes:

$k_\sigma = 3.57\ (I_s/I_a)^{1/3} + 0.43 \leq 4$

The effective width of the stiffener is determined from Table 2.4 as: $d'_s = \rho\, d$ with the value of $k_\sigma = 0.43$

$d_s = C_2\, d'_s = (I_s/I_a)\, d'_s$

$A'_s = d'_s\, t;\ A_s = (I_s/I_a)\, A'_s$ 11.3

كود صـ ١٨٩ و صـ ١٩٠

## 11.9.2 Effective Width of Uniformly Compressed Elements with One Intermediate Stiffener

**1- When $b_o/t \le S$** (11.7)

$I_a = 0$ (no intermediate stiffener required)

$b_e = \bar{b}$

$A_s = A'_s$ = area of intermediate stiffener, Fig. 11.4b.

**2- When $S < b_o/t < 3S$** (11.8)

$I_a = \{[50\,(b_o/t)/S] - 50\}\,t^4$

The effective width for the flange is determined as:

$b_e = \rho\,\bar{b}$ according to Table 2.3 with the following $k_\sigma$

$k_\sigma = 3\,(I_s/I_a)^{1/2} + 1 \le 4$

The reduced intermediate stiffener area is calculated from:

$A_s = A'_s\,(I_s/I_a) \le A'_s$

Where $I_s$ is the moment of inertia of the intermediate stiffener about the x-x axis, as shown in Fig. 11.4b.

**3- When $b_o/t \ge 3S$** (11.9)

$I_a = \{[128(b_o/t)/S] - 285\}\,t^4$

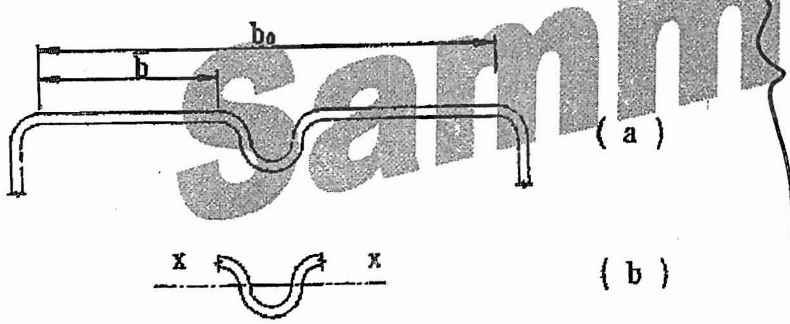
The effective width for the flange is determined as:

$b_e = \rho\,\bar{b}$ according to Table 2.3 with the following $k_\sigma$

$k_\sigma = 3\,(I_s/I_a)^{1/3} + 1 \le 4$

$A_s = A'_s\,(I_s/I_a) \le A'_s$






(a)

(b)

Code page 190

$P_{ns}$ = Allowable shear strength per screw (ton).
$t_1$ = Thickness of member in contact with the screw head (cm).
$t_2$ = Thickness of member not in contact with the screw head (cm).
$F_{u1}$ = Tensile strength of member in contact with the screw head ($t/cm^2$).
$F_{u2}$ = Tensile strength of member not in contact with the screw head ($t/cm^2$).

#### 11.15.3.3.2 Shear in Screws

The allowable shear strength of the screw shall be provided by the screw manufacturer.

#### 11.15.3.4 Tension

For screws which carry tension, the head of the screw or washer, if a washer is provided, shall have a diameter $d_w$ not less than 8 mm. Washers shall be at least 1.2 mm thick.

#### 11.15.3.4.1 Pull-Out

The allowable pull-out strength, $P_{not}$, shall be calculated as follows:

$$P_{not} = 0.28\, t_c\, d\, F_{u2} \qquad \text{11.43}$$

Where $t_c$ is the lesser of the depth of penetration and the thickness, $t_2$

#### 11.15.3.4.2 Pull-Over

The allowable pull-over strength, $P_{nov}$, shall be calculated as follows:

$$P_{nov} = 0.5\, t_1\, d_w\, F_{u1} \qquad \text{11.44}$$

Where $d_w$ is the larger of the screw head diameter or the washer diameter, and shall be taken not larger than 12 mm.

### 11.15.3.1 Minimum Spacing

The distance between the centers of fasteners shall not be less than **3d**.

### 11.15.3.2 Minimum Edge and End Distance

The distance from the center of a fastener to the edge of any part shall not be less than **3d**. If the connection is subjected to shear force in one direction only, the minimum edge distance shall be **1.5d** in the direction perpendicular to the force.

### 11.15.3.3 Shear

### 11.15.3.3.1 Connection Shear

The allowable shear strength per screw, $P_{ns}$, shall be determined as follows:

For $t_2/t_1 \le 1.0$, $P_{ns}$ shall be taken as the smallest of:

$$\left.\begin{aligned} P_{ns} &= 1.4\,(t_2^3 d)^{1/2} F_{u2} \\ P_{ns} &= 0.9\, t_1\, d\, F_{u1} \\ P_{ns} &= 0.9\, t_2\, d\, F_{u2} \end{aligned}\right\} \quad \text{11.41}$$

take Pns هي الأقل

For $t_2/t_1 \ge 2.5$, $P_{ns}$ shall be taken as the smallest of:

$$\left.\begin{aligned} P_{ns} &= 0.9\, t_1\, d\, F_{u1} \\ P_{ns} &= 0.9\, t_2\, d\, F_{u2} \end{aligned}\right\} \quad \text{11.42}$$

take $P_{ns}$ هي الأقل

For $1.0 < t_2/t_1 < 2.5$, $P_{ns}$ shall be determined by linear interpolation between the above two cases.

Where:

$d$ = Screw diameter (cm).