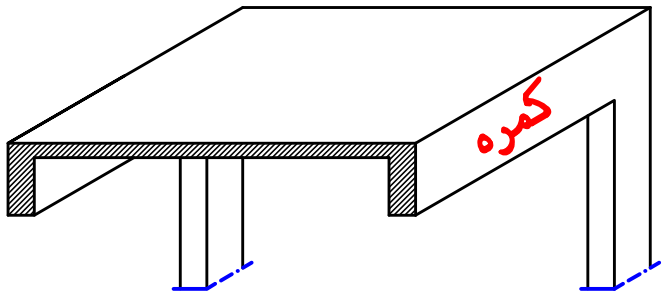
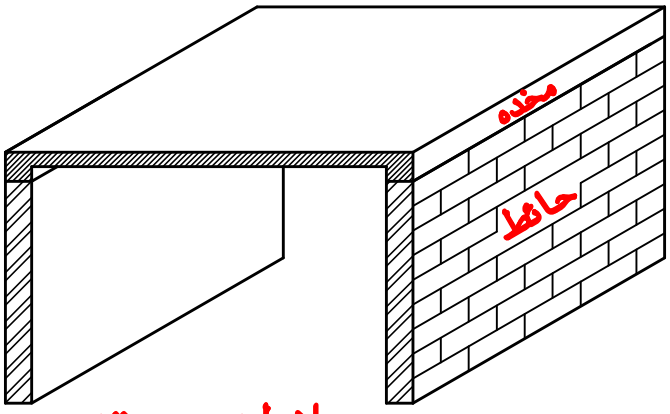
Introduction.

البلاطات المصمته (*solid slabs*) هى عباره عن بلاطات خرسانه مسلحه محموله على كمرات أو محموله على حوائط.

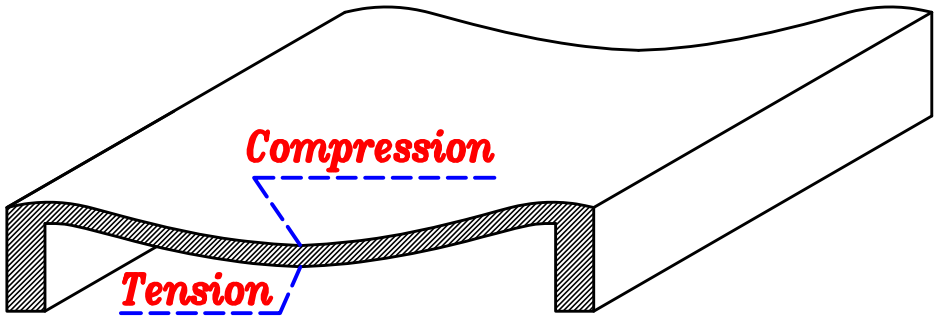


بلاطه مصمته
محموله على كمرات

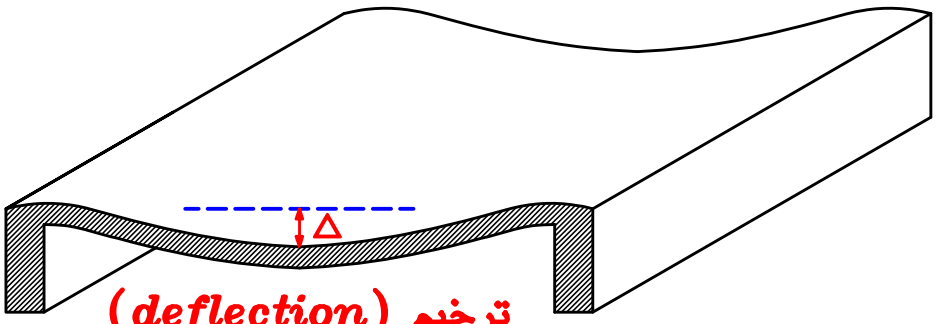


بلاطه مصمته
محموله على حوائط

نتيجه للاحمال الواقعه على البلاطه يحدث لها عزم انحناء (***bending moment***) و يحدث لها ترخيم (***deflection***).



(*bending moment*) عزم انحناء



(*deflection*) ترخيم

لذا يجب عند تصميم البلاطات المصمته مراعاه كلا من عزوم الانحناء و الترخيم

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Types of Solid slabs. أنواع البلاطات المصمته .

① One way solid slab. ① البلاطات المصمته ذات الاتجاه الواحد .

② Cantilever solid slab. ② البلاطات المصمته الكابوليه .

③ Two way solid slab. ③ البلاطات المصمته ذات الاتجاهين .

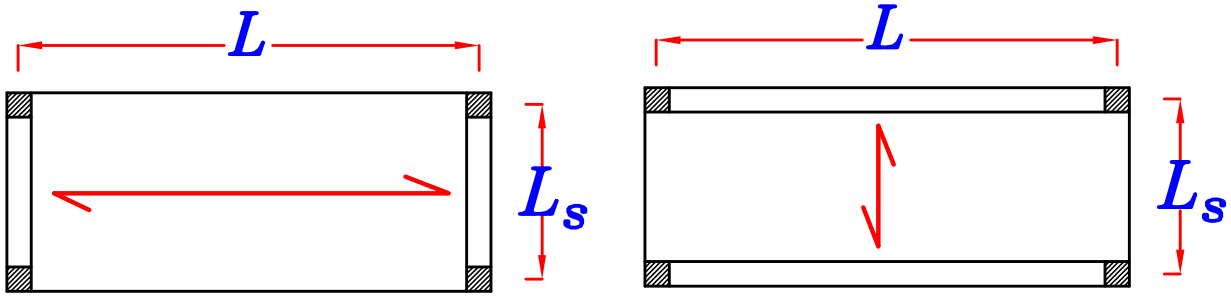
① One way solid slab.

و هى البلاطات المصمته التى يسير فيها الحمل فى إتجاه واحد فقط .

و تسمى البلاطات One way عنـــدمـا :

1 – The Slab Rested on Two Beams only.

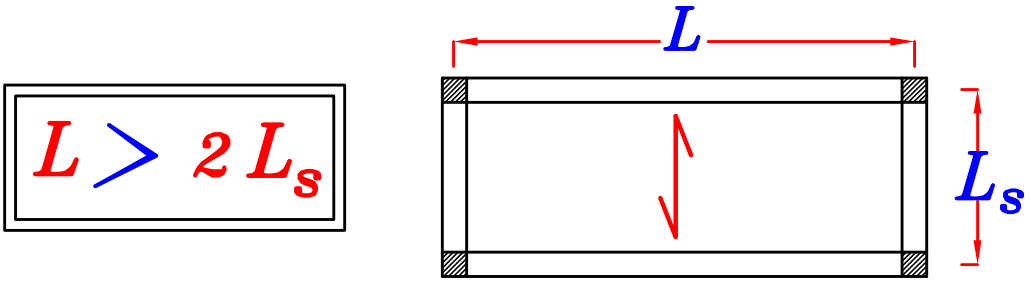
تكون البلاطه محموله على كمرتين متقابلتين فقط.



و فى هذه الحاله يسير الحمل فى أتجاه الكمرتين أياً كان الطول القصير أو الطويل .

2 – The Slab Rested on Four Beams.

تكون البلاطه محموله على أربع كمرات .



و فى هذه الحاله يسير الحمل فى الإتجاه القصير فقط.

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Steps of design One way Solid Slab.

خطواط تصميم البلاطات المصمته ذات اتجاه واحد .

1- Choose the thickness of the slab. (t_s) (m)
to satisfy the bending moment & deflection considerations.
اختيار تخانه البلاطه (t_s) بالمتر لتحقيق متطلبات عزوم الانحناء و حدود الترخيم .

2- Calculate the Loads on the Slab (w_s) ($kN\backslash m^2$).
حساب وزن المتر المربع من البلاطه (w_s) .

3- Take a strip (1.0 m width) at the Load direction
and take uniform load on the strip = (w_s) ($kN\backslash m$)
and then calculaet the bending moment ($kN.m\backslash m$) on the slab.
يتم أخذ شريحه فى البلاطه عرضها ١,٠ م فى اتجاه الحمل و وضع حمل منتظم على الشريحه يساوى (w_s) ثم حساب قيمه عزوم الانحناء .

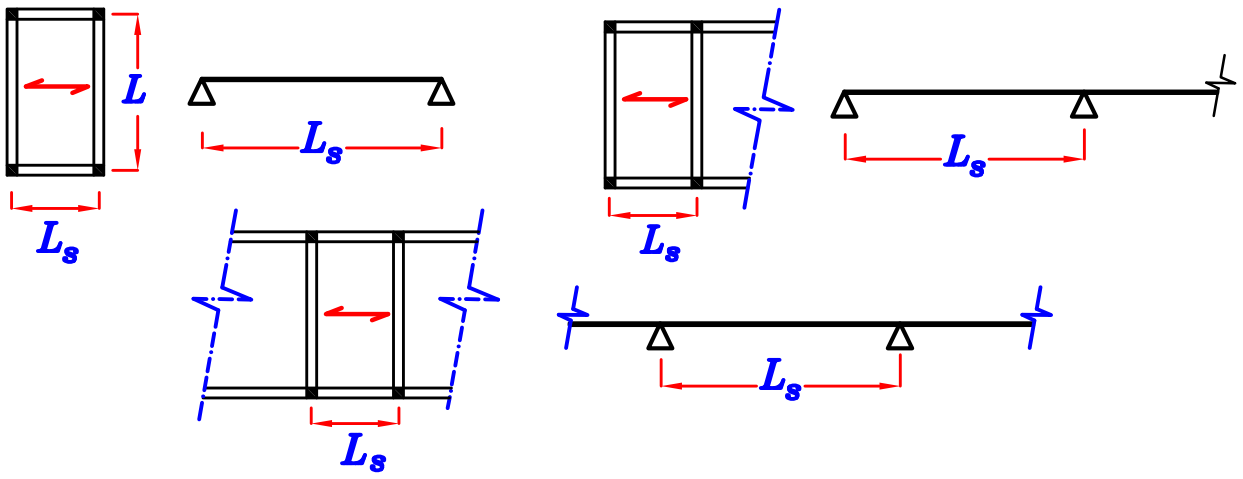
4- Design the slab as a beam subjected to B.M. only.
but with width 1.0 m and depth t_s .
Then get the Reinforcement. (RFT.) ($mm^2\backslash m$)
يتم تصميم البلاطه على عزوم الانحناء مثل الكمرات و لكن بعرض ١,٠ م و تخانه (t_s) و تحديد كميه الحديد فى المتر الواحد .

1- Thickness of the Slab. (t_s). تخانه البلاطات

نحدد تخانه البلاطه (t_s) بالمتر لتحقيق متطلبات عزوم الانحناء و حدود الترخيم .
اذا حددنا قيمه (t_s) لتحقق متطلبات عزوم الانحناء فقط غالبا ستكون التخانه صغيره و لن تحقق متطلبات الترخيم .
لذا لن نستطيع تحديد تخانه البلاطه من القانون الاتى

$$d = c_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}}$$

و لكى نضمن أن تكون البلاطه (Safe deflection) يتم اختيار قيم لـ (t_s) موجوده فى الكود المصرى تضمن تحقيق متطلبات العزوم و أن تكون البلاطه (Safe deflection) فى نفس الوقت و هذة القيم تعتمد على الطول الذى يسير فيه الحمل (L_s) و تعتمد على اتصال البلاطه بالبلاطات المجاوره .



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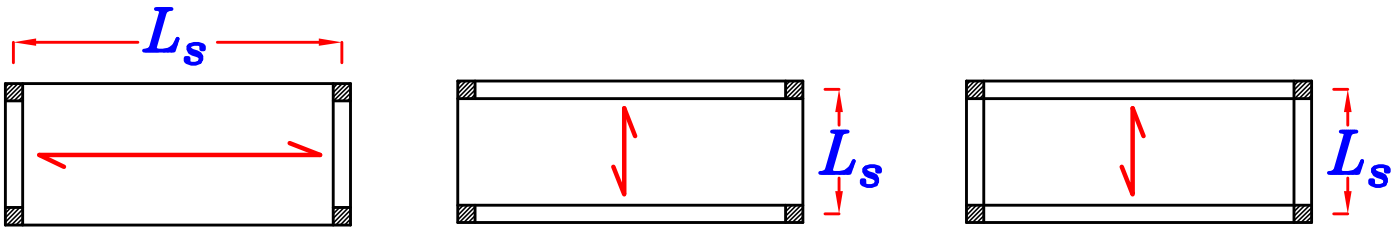
اذا أخذنا قيم (t_s) لا تقل عن القيم الاتيه لن نحتاج لعمل *Check deflection*			
	L_s	L_s	L_s
st. 360\520	$\frac{L_s}{25}$	$\frac{L_s}{30}$	$\frac{L_s}{36}$
st. 240\350	$\frac{L_s}{25 * 1.25}$	$\frac{L_s}{30 * 1.25}$	$\frac{L_s}{36 * 1.25}$

حيث L_s المقصود به هو الطول الذى يسير فيه الحمل .



ملحوظه اذا لم يتم الالتزام بقيم (t_s) الموجوده فى الجدول السابق لن نضمن أن البلاطه (***safe deflection***) و يجب فى هذه الحاله عمل (***check deflection***) على البلاطه .

مع مراعاة

$t_{s\,min} = 80\ mm$ (***Static Load***) (المبانى-البيوت العاديه)

$t_{s\,min} = 120\ mm$ (***Dynamic Load***) (مصانع-جراجات -كبارى)

و عند إختيار تخانه البلاطه (t_s) يتم التقريب لأقرب ٢٠ مم بالزياده أو أى رقم يقبل القسمه على ٥٠ مم .

$t_s = 80\ mm$ ⟵ أقل تخانه فى ال *Code* للمبانى العاديه

$= 100\ mm$ ⟵ أقل تخانه عمليه

$= 120\ mm , 140\ mm , 150\ mm \& 160\ mm$ ⟵ الأكثر استخداماً

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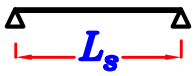
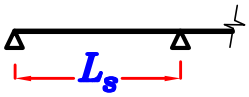
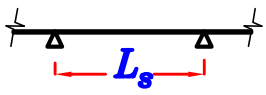
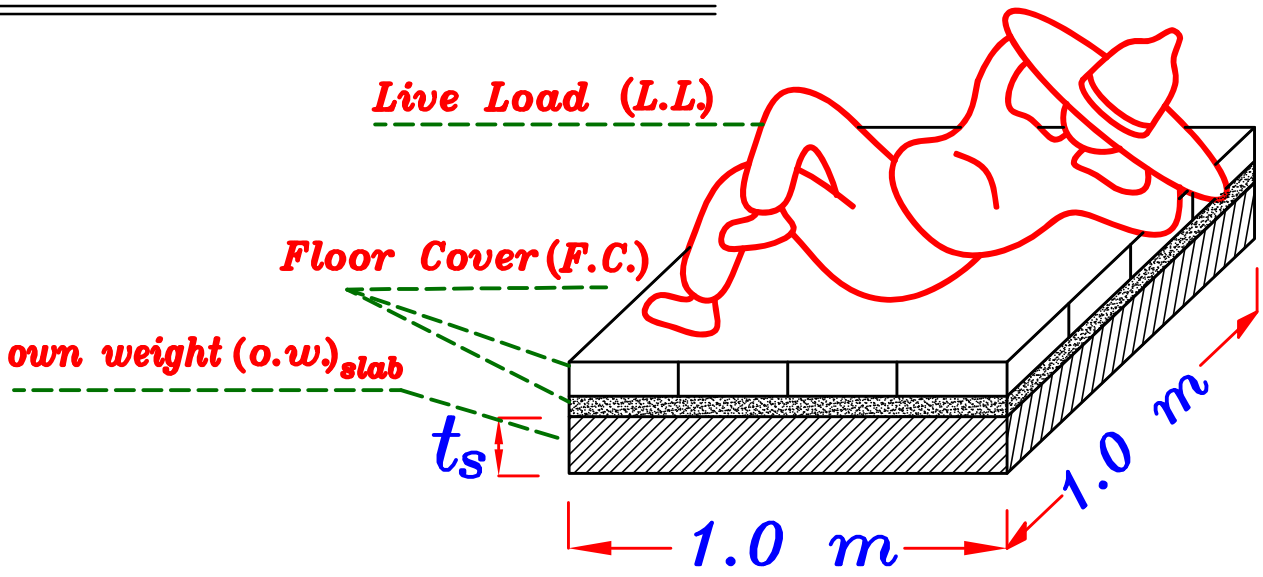
ملحوظه لا تستخدم تخانات لا تقبل القسمه على ٢٠ مم و لا يستحب زيادة t_s عن *160 mm*

لذا إذا زادت تخانة البلاطه عن *160 mm* نأخذها ***160 mm*** و نعمل ***Check deflection***

Check deflection و عموما يجب أن لا تقل قيمه (t_s) عن القيم الاتيه حتى اذا عملنا			
			
st. 360\520 & ***st. 240\350***	$\frac{L_s}{30}$	$\frac{L_s}{35}$	$\frac{L_s}{40}$

2_ Loads on the Slab. (w_s)



$w_s = g_s + p_s$ = D.L.+ L.L. = ✓ $kN\backslash m^2$ وزن المتر المربع من البلاطه

$g_s = t_s\,\gamma_c + F.C.$ (*Floor Cover*) = ✓ $kN\backslash m^2$

$p_s =$ L.L. (*Live Load*) = ✓ $kN\backslash m^2$

$(w_s)_{U.L.} = 1.4\,g_s + 1.6\,p_s$

$$(w_s)_{U.L.} = 1.4\,(t_s\,\gamma_c + F.C.) + 1.6\,(L.L.)\ kN\backslash m^2$$

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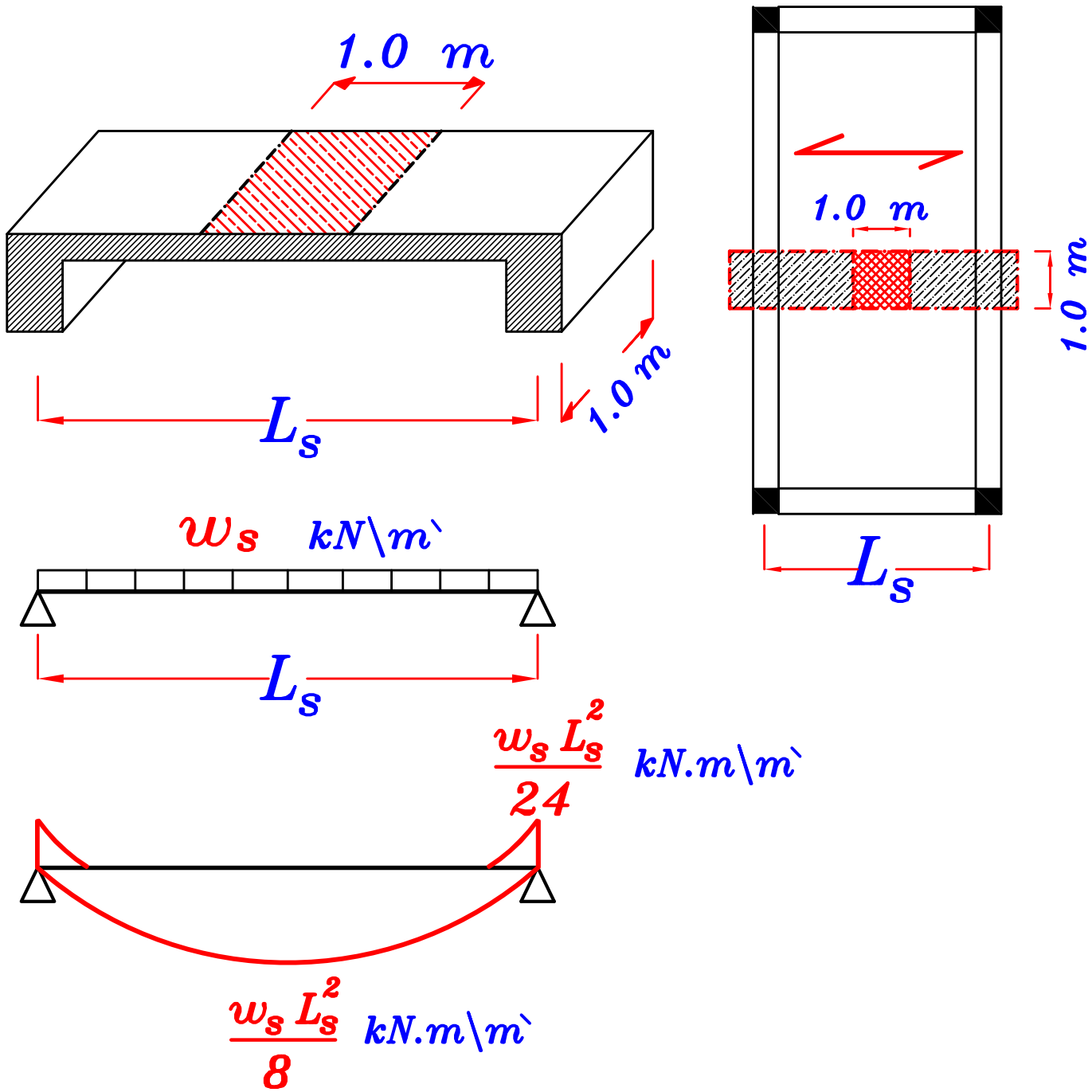
3 – Take a strip (1.0 m width) at the Load direction And Get the B.M. on the Slab.

يتم أخذ شريحه فى البلاطه عرضها ١,٠ م فى اتجاه الحمل و وضع حمل على الشريحه يساوى (w_s) ثم تحديد قيمه عزوم الانحناء .



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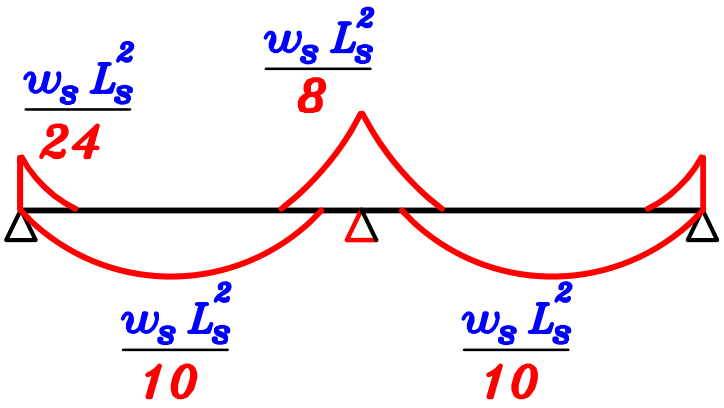
2 equal spans.



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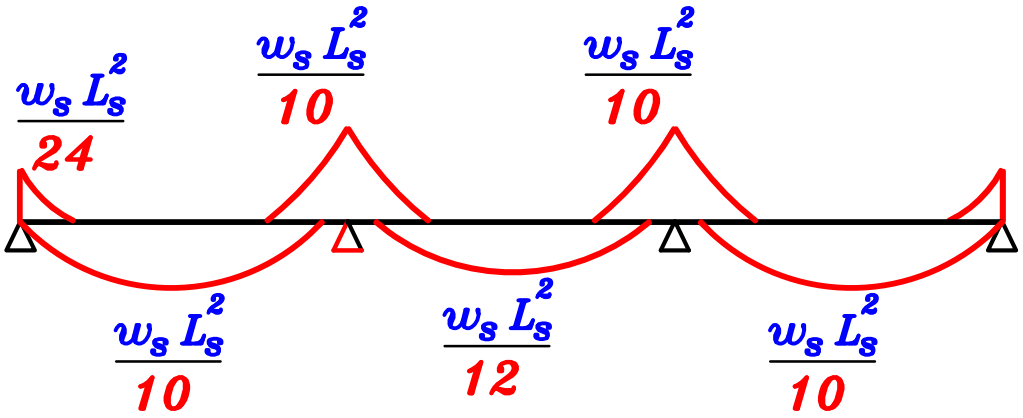
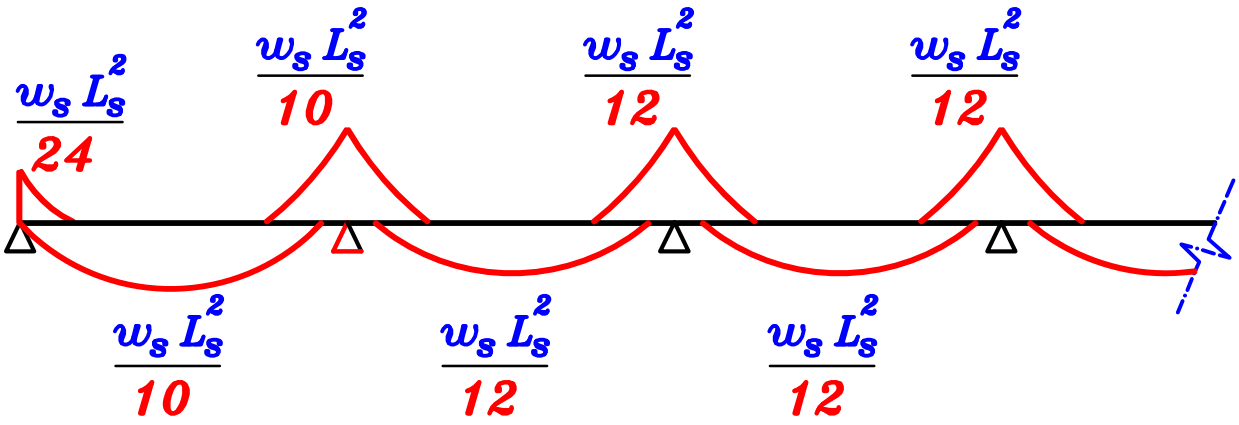
3 equal spans.



More than 3 equal spans.



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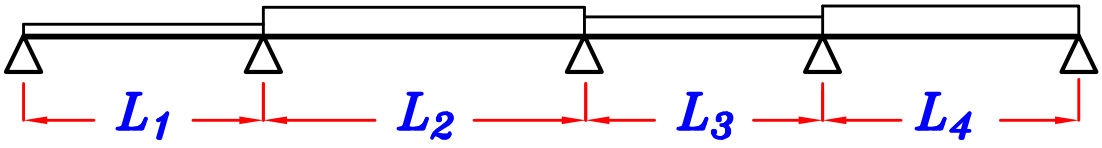
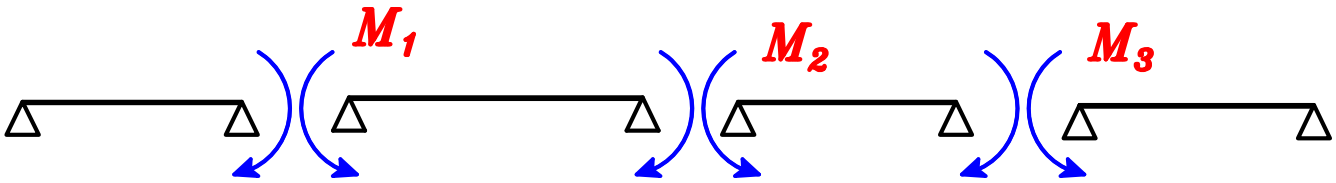
فى حاله البحور أو الاحمال غير متساويه و الفرق بينهم أكبر من ٢٠ ٪
نضطر لحل الشريحه بأستخدام 3 moment equations





$$M_1 (L_2) + 2 M_2 (L_2 + L_3) + M_3 (L_3) = -6 (r_1 + r_2)$$

ملحوظه : العزم فوق الـ datum تكون إشارته (-ve)
و أسفل الـ datum تكون إشارته (+ve)

$$Elastic\ Reactions = \frac{w L^3}{24}$$

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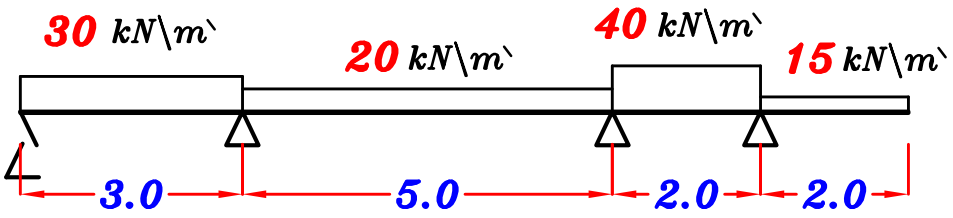
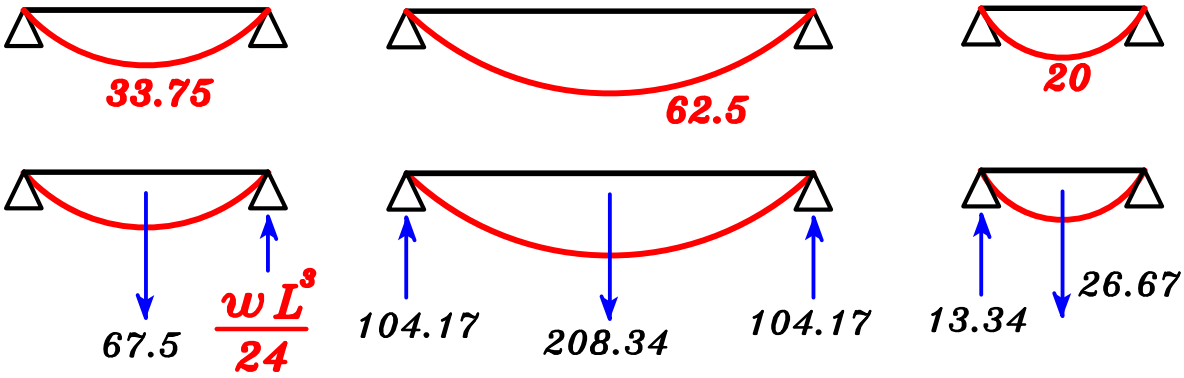
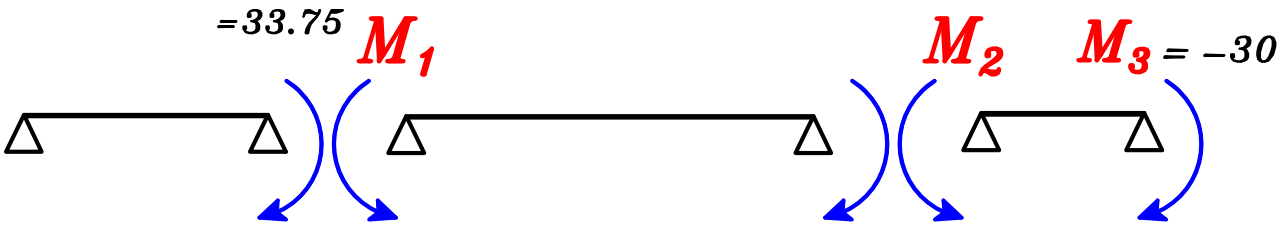
Example.







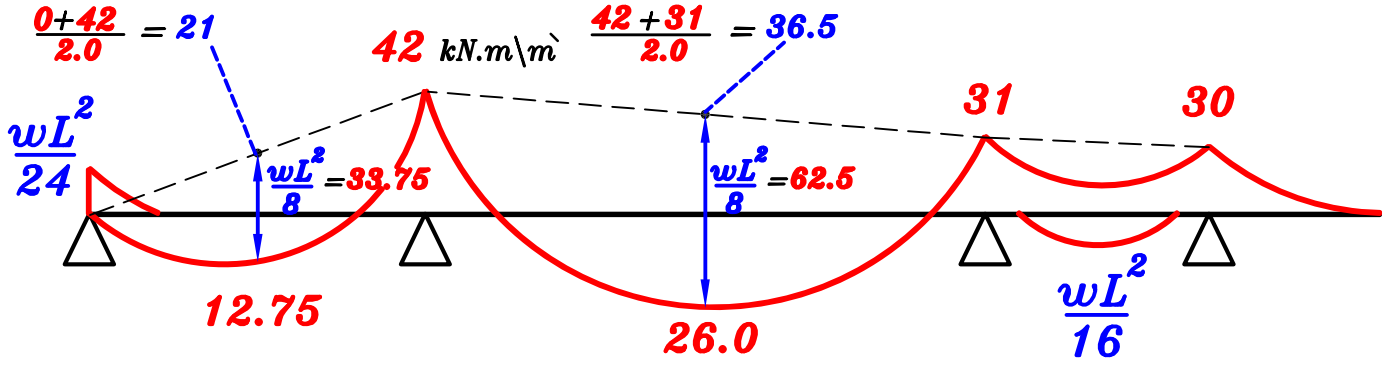
$$0.0 + 2M_1(3+5) + M_2(5) = -6(33.75 + 104.17)$$

$$16M_1 + 5M_2 = -827.52 \quad \text{------} (1)$$

$$M_1(5) + 2M_2(5+2) + (-30)(2.0) = -6(104.17 + 13.34)$$

$$5M_1 + 14M_2 = -645.03 \quad \text{------} (2)$$

$$\boxed{M_1 = -42.0 \text{ kN.m}} \qquad \boxed{M_2 = -31.0 \text{ kN.m}}$$



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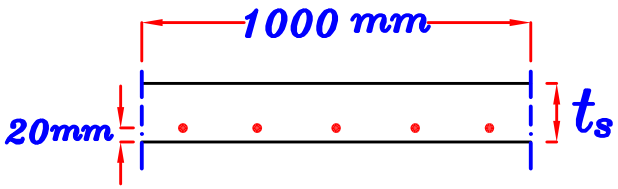
4 – Design ths slab and get Reinforcement (RFT.) التسليح

لتحديد قيمه التسليح الرئيسى فى البلاطه

نصمم قطاع الشريحه كأنه كمره بالابعاد التاليه :



عمق القطاع $(t = t_s)$

عرض القطاع $(B = 1000\ mm)$

الغطاء الخرسانى $(cover = 20 \longrightarrow 30\ mm)$

$\because M_{U.L.} = \checkmark\ kN.m\backslash m`$

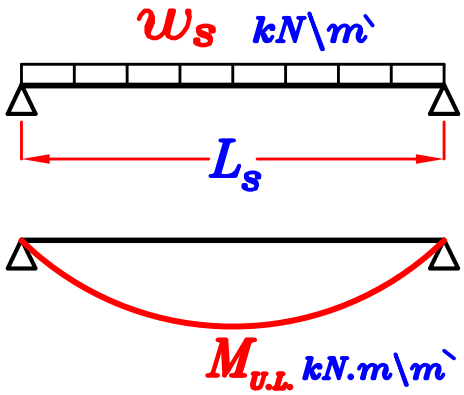
$, \quad t_s = \checkmark\ mm$

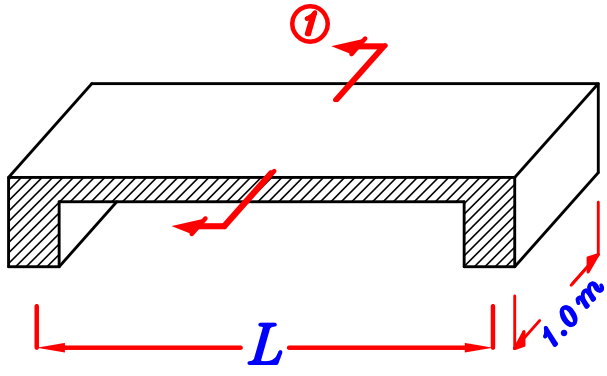
$\therefore d = t_s - 20\ mm(Cover) = \checkmark\ mm$

$\because d = C_1 \sqrt{\dfrac{M_{U.L.}}{F_{cu}\ B}} \quad , B = 1000\ mm$

$Get \quad C_1 = \checkmark \longrightarrow J = \checkmark$

$$A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \checkmark\ mm^2.\backslash m`$$

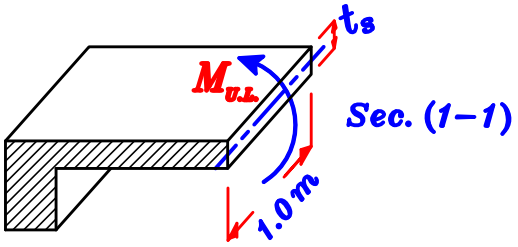


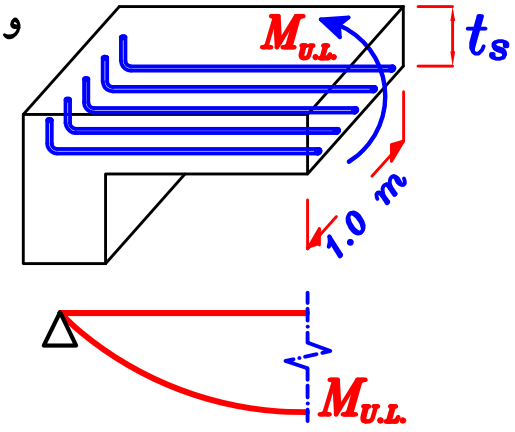


ملحوظه :

قيمة الحديد المحسوبه من المعادله السابقه توضع فى عرض ١,٠ متر من البلاطه هو عرض الشريحه و يكون تسليح باقى الشرائح له نفس التسليح

و يوضع التسليح الرئيسى موازى للـ moment كما هو موضح بالشكل .





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إختيار حديد التسليح Choosing Steel Bars.

١- أقل عدد أسياخ فى المتر = ٥ أسياخ/م

أكبر عدد أسياخ فى المتر = ١٠ أسياخ/م

٢- عدد الأسياخ فى الشريحه ثابت (أى أن تسليح كل الشرائح تسليح واحد) .

٣- أقل قطر لأسياخ الحديد = ϕ 8 (عملياً) ϕ 6 (Code) .

٤- أقل قطر موجود فى مصر من حديد (st. 240/350) هو ϕ 8

و أقل قطر موجود فى مصر من حديد (st. 360/520) هو ϕ 10

٥- أكبر قطر مستخدم للحديد يكون حسب تخانة البلاطه (t_s)

t_s (mm)	$\phi_{max.}$ (mm)
80	8
100	10
120,140	12
150,160	16

أى أن البلاطه التى سُمكها t_s=120mm ممكن إستخدام أسياخ بأقطار 8,10,12

٦- مسموح إستخدام قطرين مختلفين بشرط : ١- متتالين فى الجدول .

٢- تساوى عدد كل منهما فى المتر الواحد.

3ϕ8 + 3ϕ10\m`  OR  2.5$\phi$10 + 2.5$\phi$12\m`

٧- يستخدم حديد ثانوى (secondary steel) (مكونا شبكه مع الحديد الرئيسى و يكون عموديا عليه)

و تكون قيمه الحديد الثانوى تساوى ٢٠ ٪ من قيمه الحديد الرئيسى

و لا تقل عن 4ϕ8\m`  و غالباً تؤخذ 5$\phi$8\m`

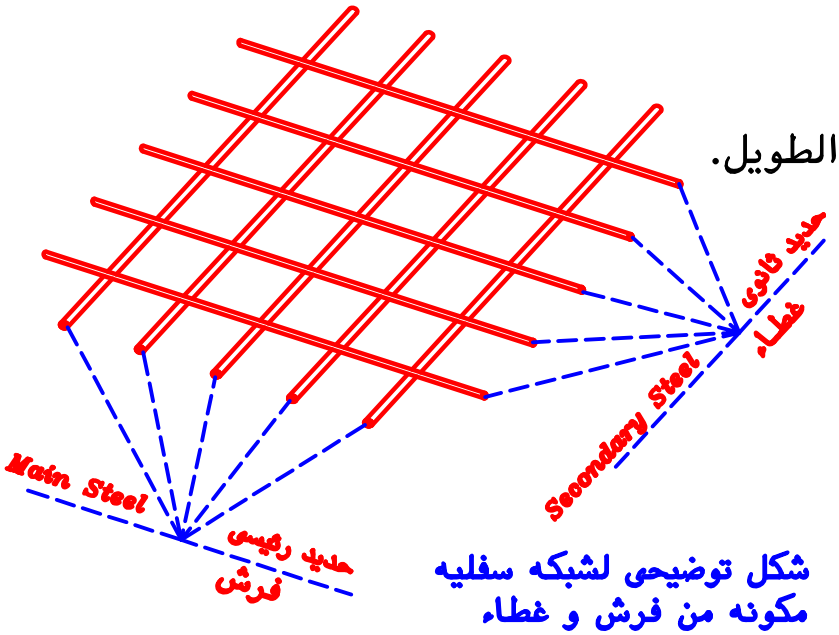
فائده الحديد الثانوى

١- مقاومه الأحمال فى الإتجاه الطويل.

٢- توزيع الأحمال.

٣- تقليل الـ Deflection .

٤- تقليل الـ Shrinkage .



شكل توضيحى لشبكه سفليه
مكونه من فرش و غطاء

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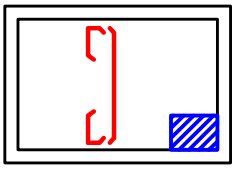
Drawing reinforcement in plan. رسم التسليح فى المسقط الافقى

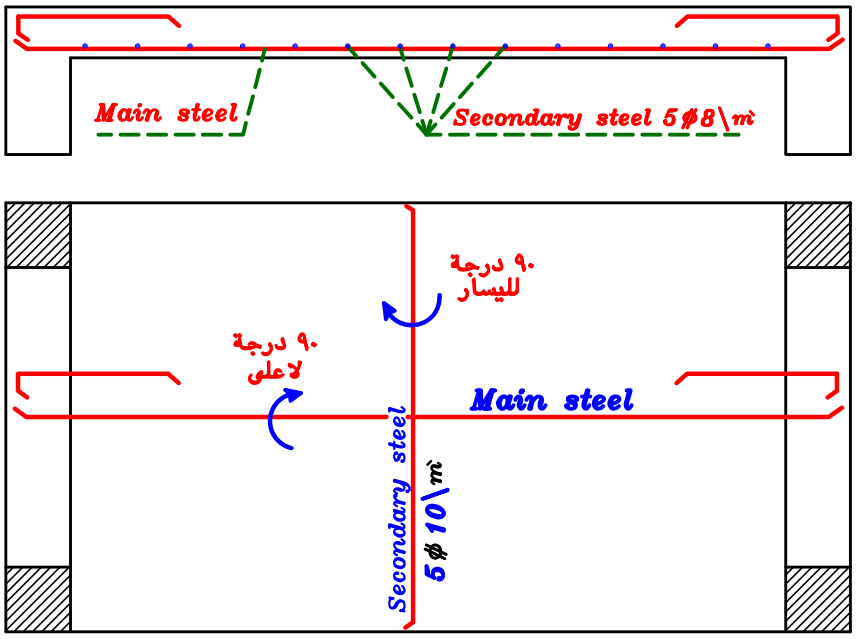
التسليح الافقى فى المسقط يلف للأمام بزاويه قدرها ٩٠ درجه .

التسليح الرأسى فى المسقط الافقى يلف لليسار بزاويه قدرها ٩٠ درجه .

- التسليح الأفقى يرسم فى المسقط الافقى (Plan) كما يرسم تماماً فى الـ Cross-sec.
- لرسم التسليح الرأسى نقف على يمين اللوحه ثم نرسم التسليح تماما كما يرسم فى الـ Cross-sec.

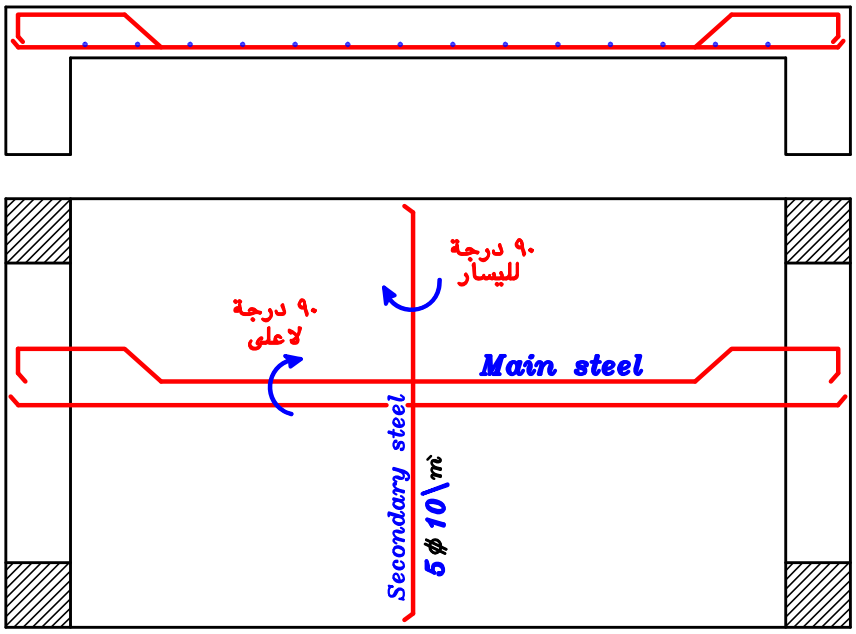


نقف على يمين اللوحه و نرسم مثل الـ Cross-sec.



Straight Bars

أسياخ مستقيمه



Bent Bars

أسياخ مكسحه

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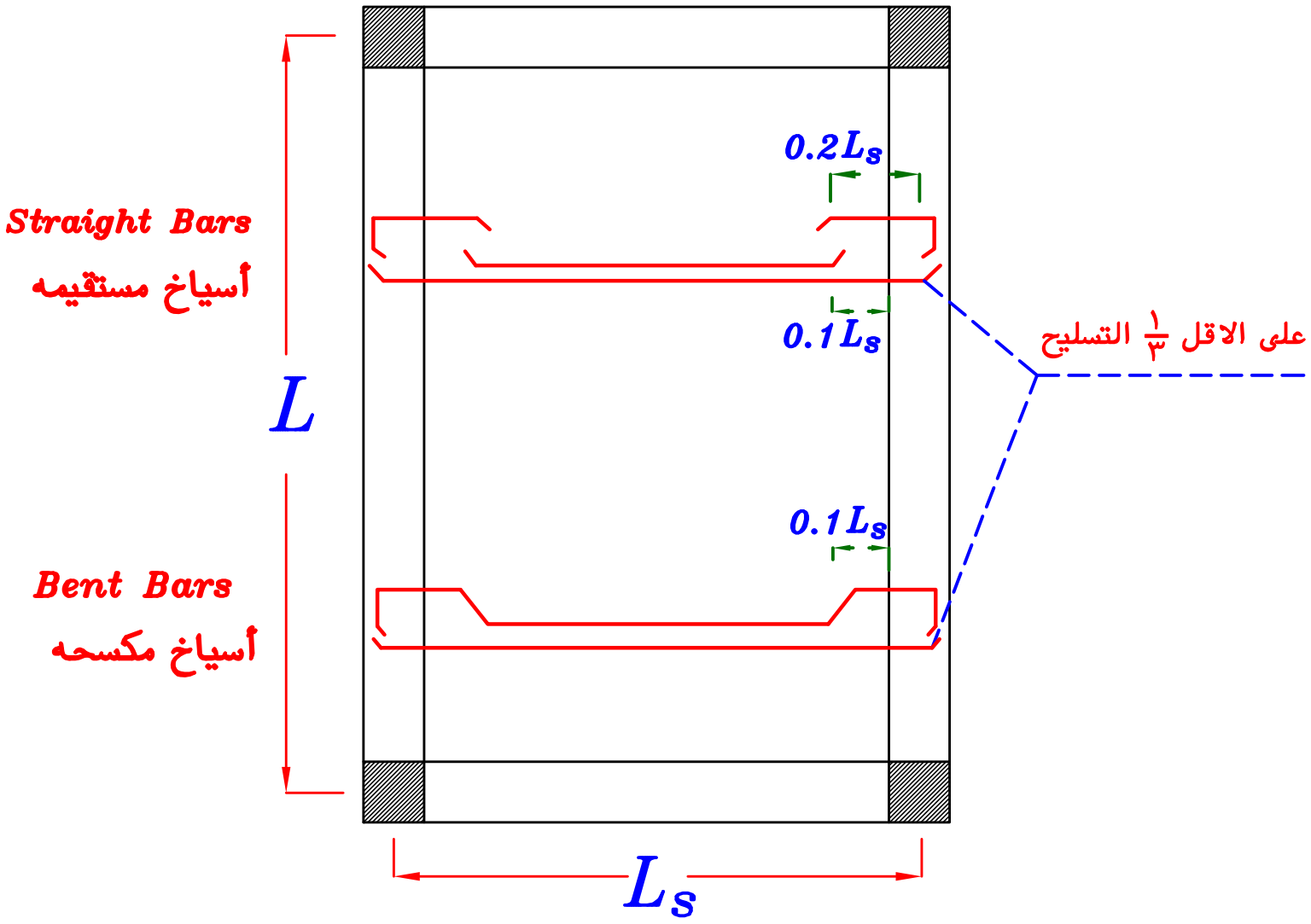
Simple Span. Main Steel only.



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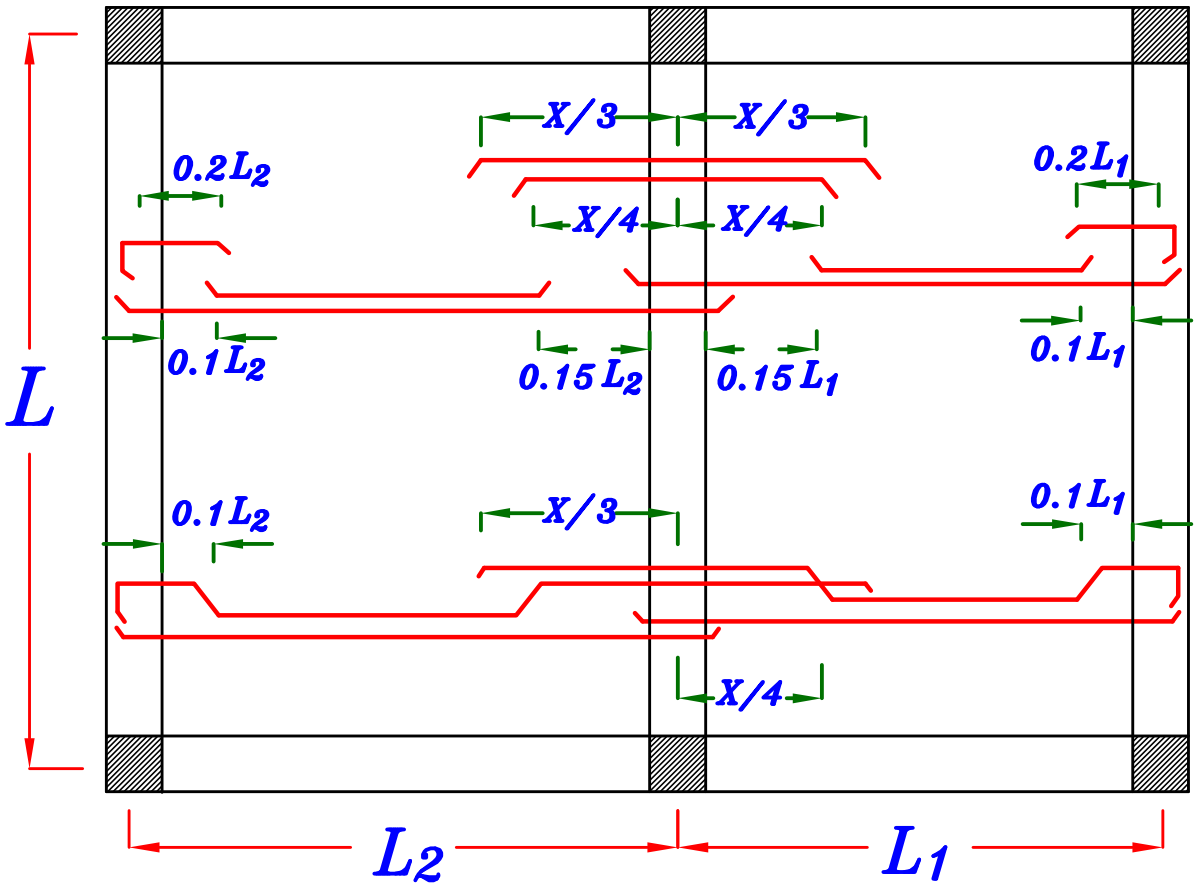
2 Spans. Main Steel only.



X = bigger of (L_1 or L_2)

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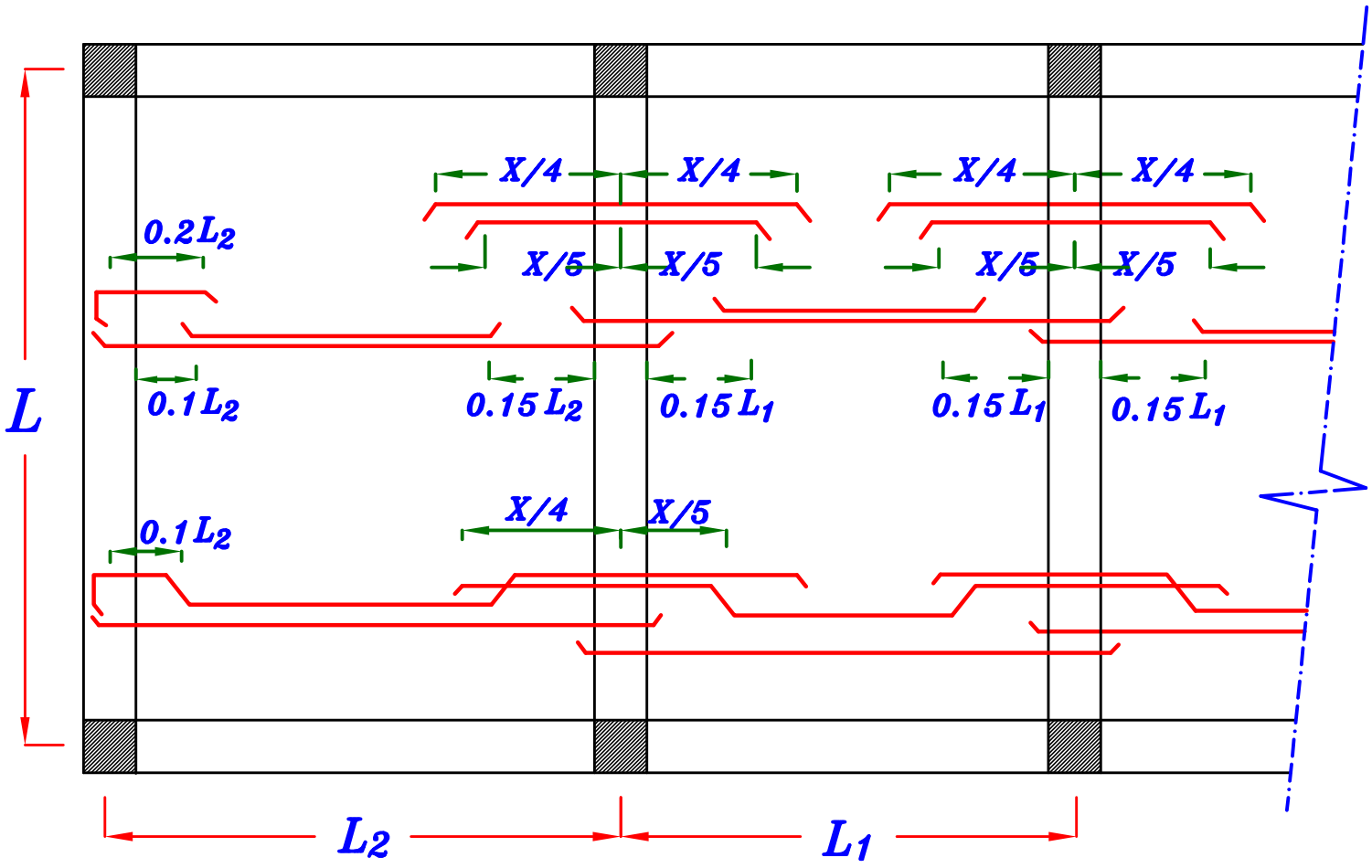
More than 2 Spans. Main Steel only.



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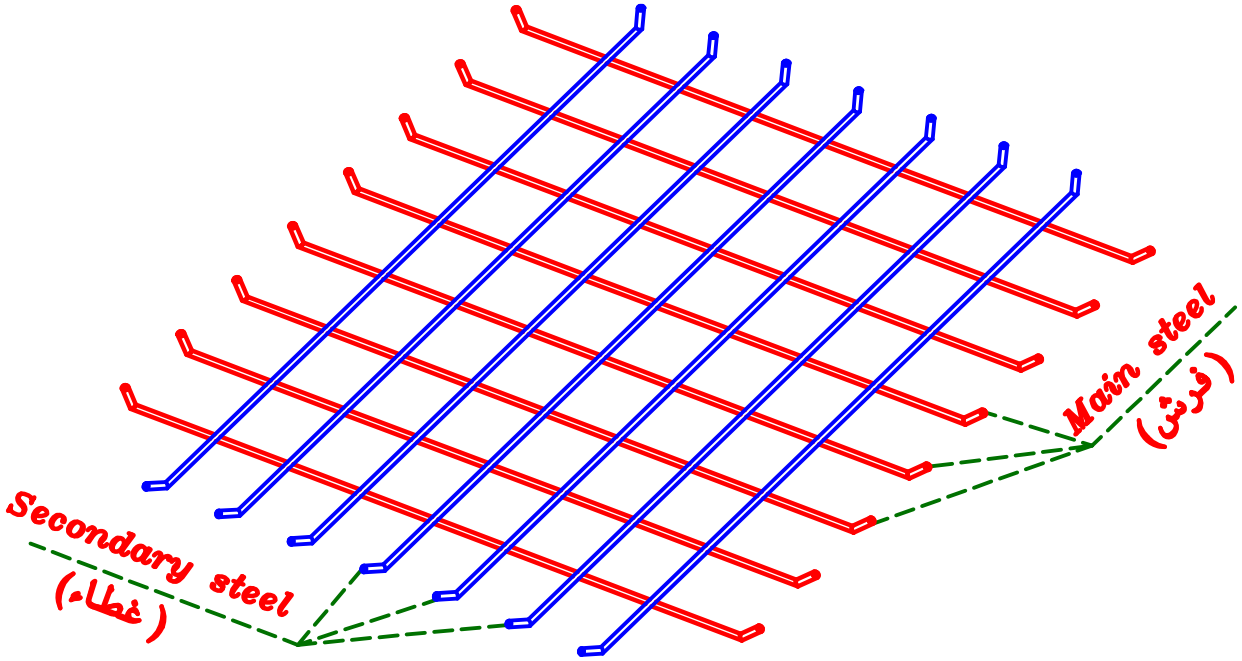
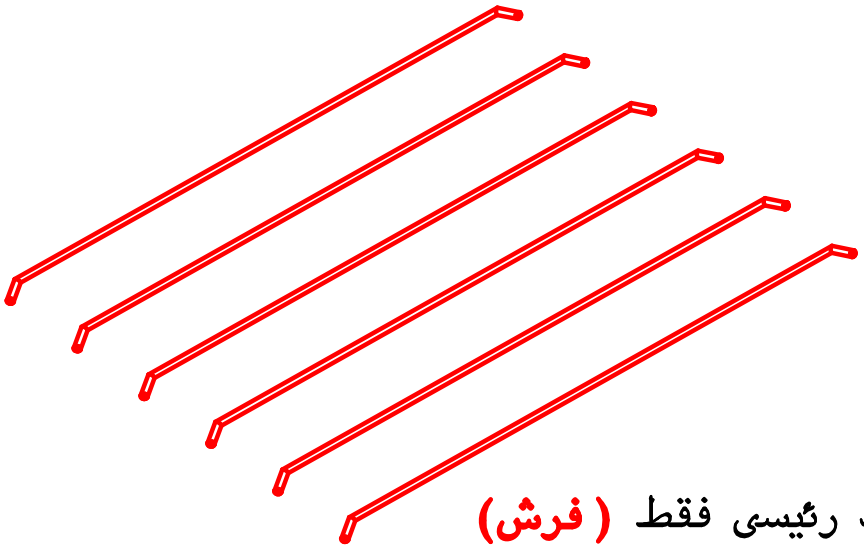
اذا كان العزم سفلى (+ve) moment .

يكون تسليحها على شكل شبكه سفليه فقط .
و هى مكونه من تسليح رئيسى (فرش) فى اتجاه الـ Load
و تسليح ثانوى (غطاء) فى الاتجاه العمودى على الـ Load .



اذا كان العزم علوى (-ve) moment .



التسليح العلوى مكون من حديد رئيسى فقط (فرش)
و لا يوجد حديد ثانوى .

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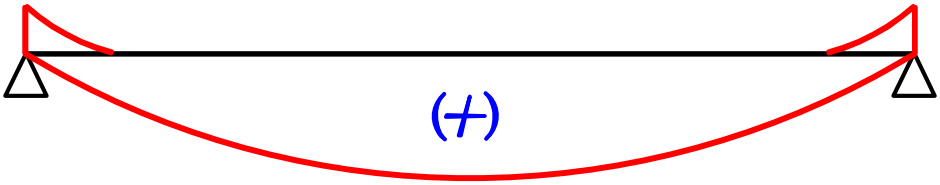
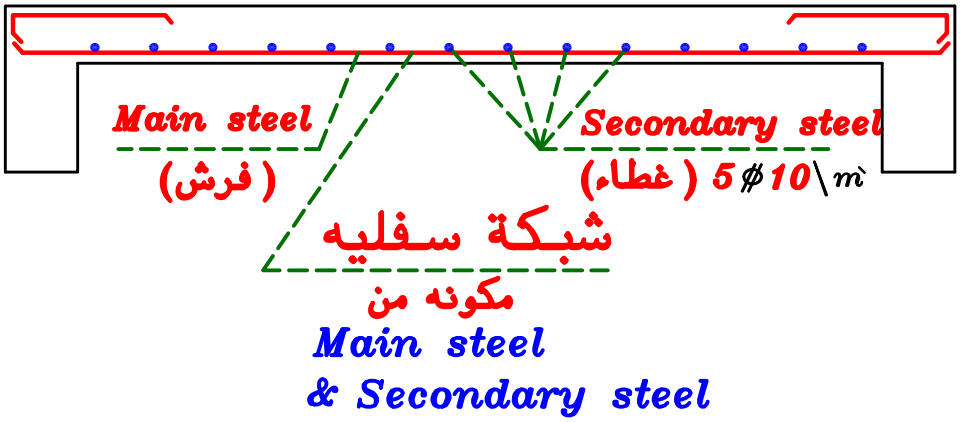
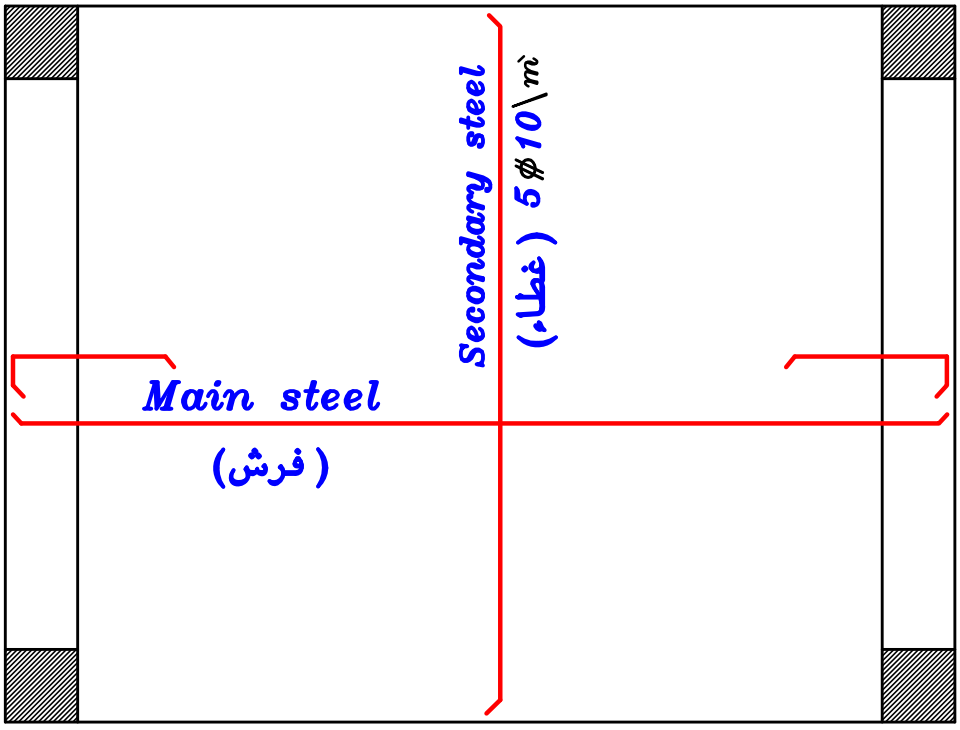
أشكال تسليح البلاطات

ملحوظه هذه الأشكال تكون مع البلاطات ال One Way و ال Two Way أيضاً.

① فى البلاطات التى يكون عليها (+ve) moment فقط.
يكون تسليحها على شكل شبكه سفليه فقط .
و هى مكونه من تسليح رئيسى (فرش) و تسليح ثانوى (غطاء) .







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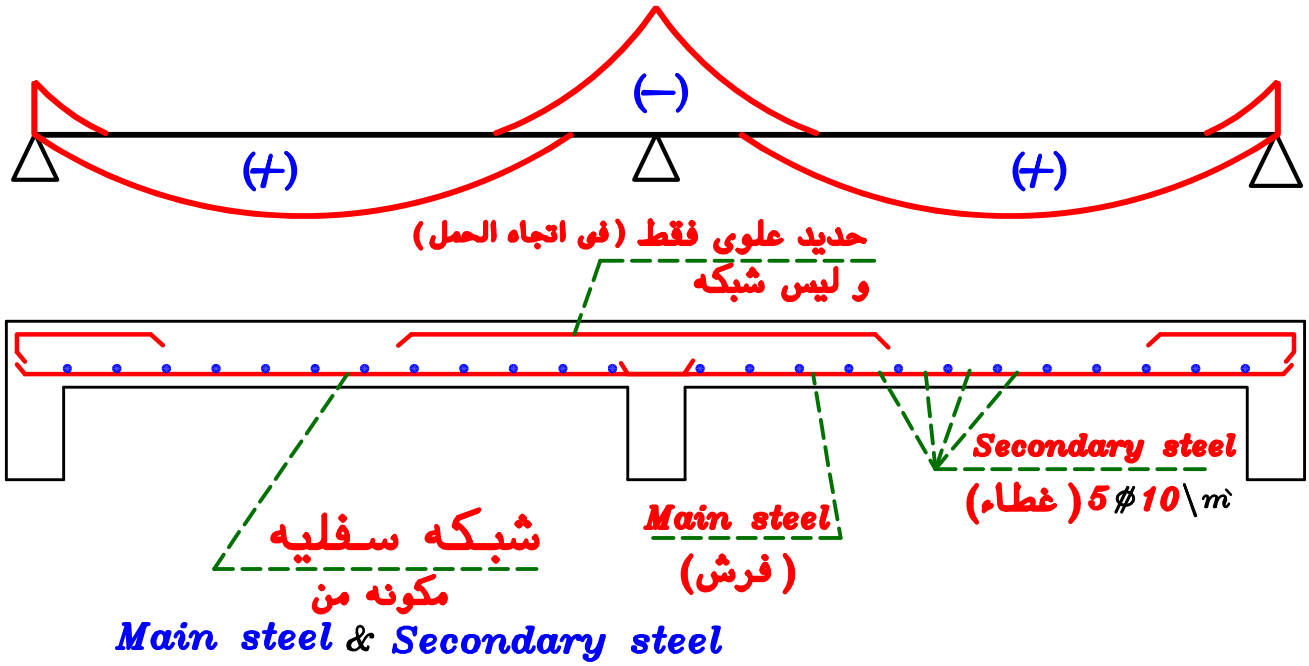
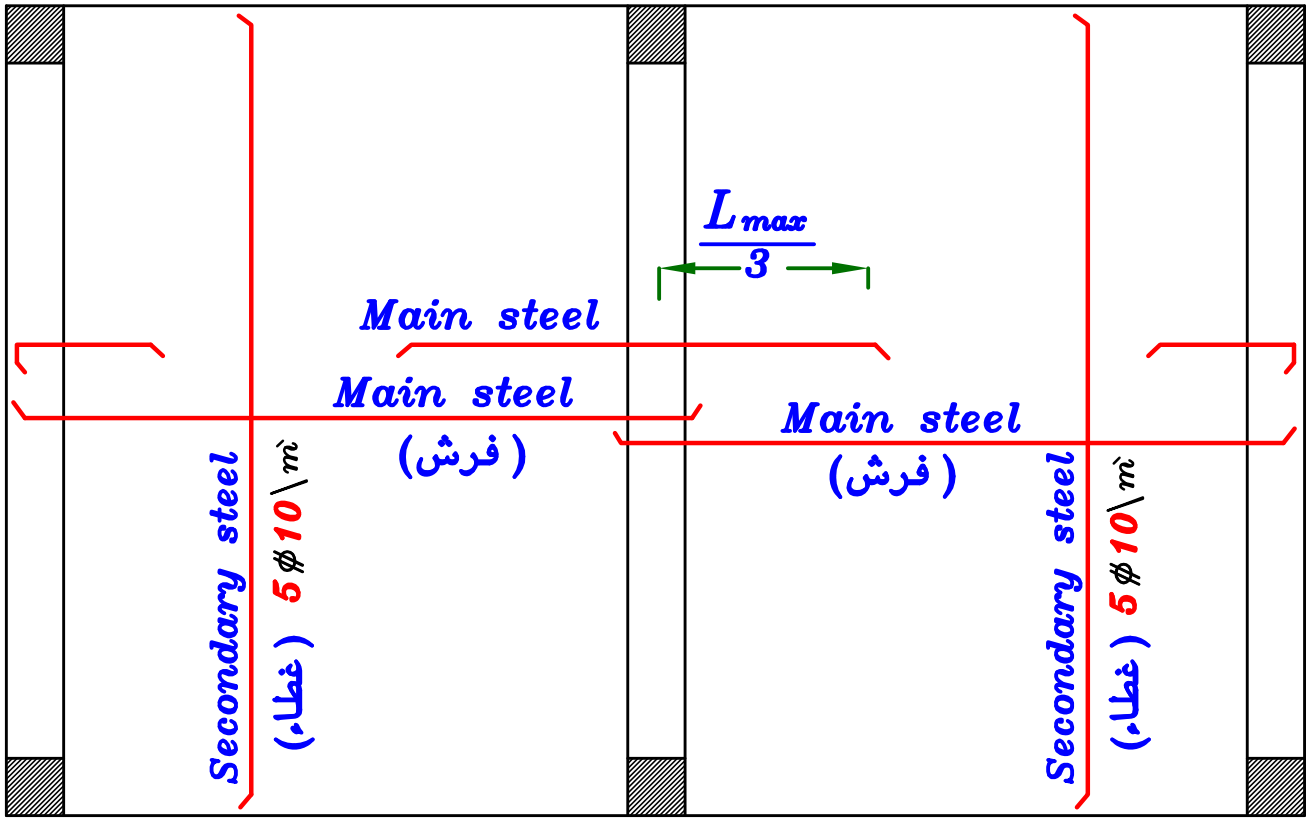
② فى البلاطات التى يكون عليها (+ve) moment و (−ve) moment معاً يكون تسليحها سفلى و علوى :

- التسليح السفلى مكون من شبكه سفليه عباره عن تسليح رئيسى (فرش) و تسليح ثانوى (غطاء) .
- التسليح العلوى مكون من حديد رئيسى فقط (فرش) و لا يوجد حديد ثانوى .





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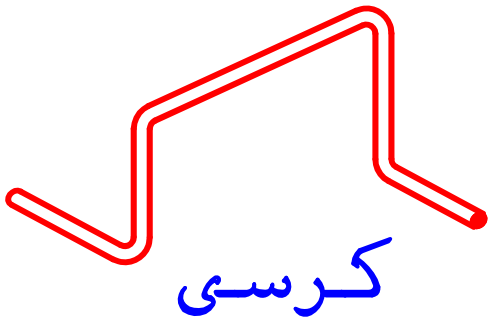
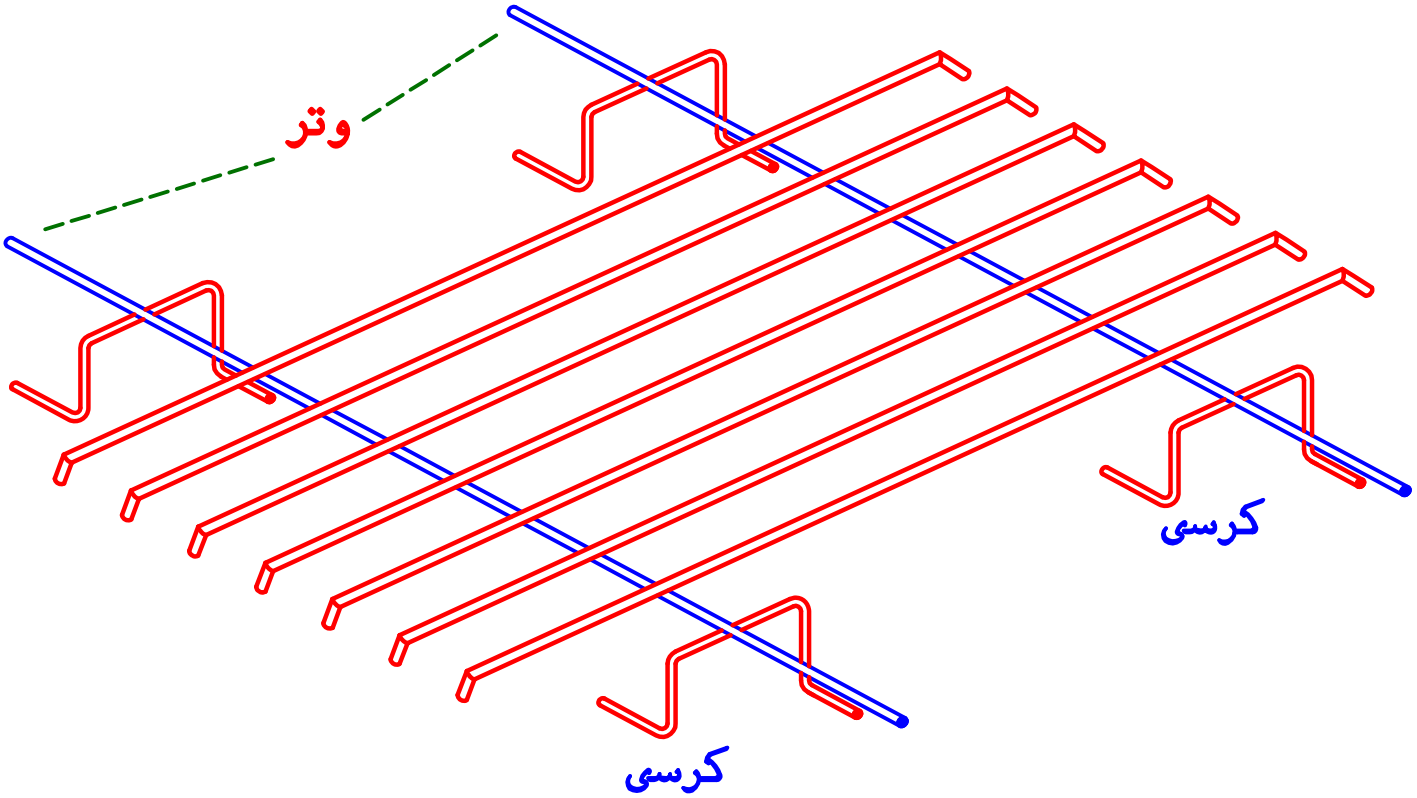
و يعلق الحديد العلوى على كراسى و أوتار لرفع مستواه قبل الصب .





و هذه الكراسى و الاوتار لا ترسم مع تسليح البلاطه .

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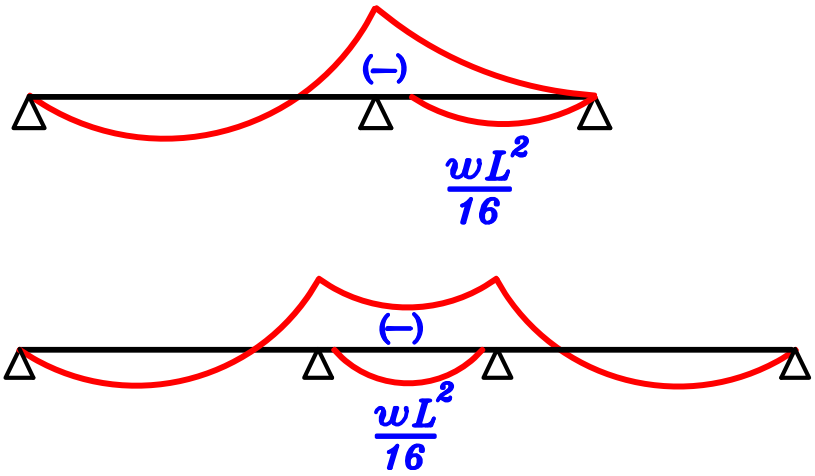
③ فى البلاطات التى يكون عليها ***moment (–ve)*** على كل الباكيه

مثل البواكى الصغيره *Small Spans*

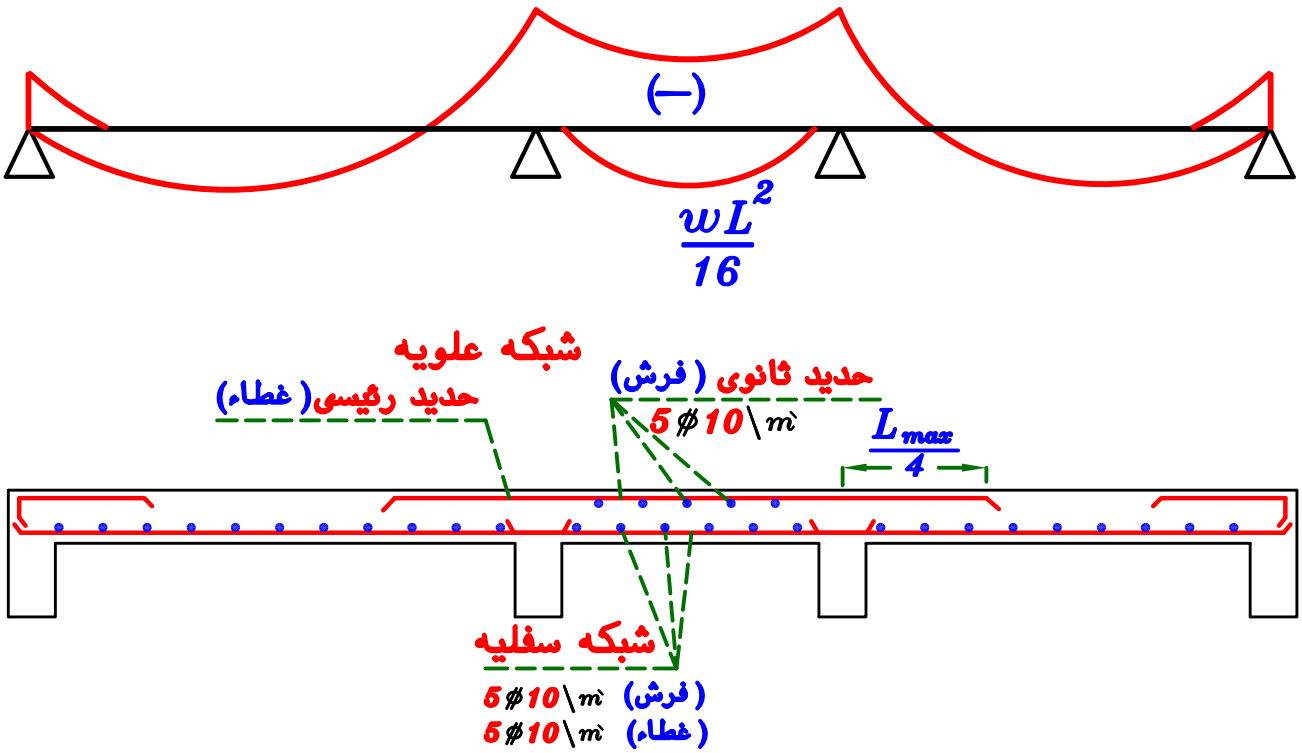


يكون التسليح عباره عن شبكه علويه مكونه من حديد رئيسى (**غطاء**)

و حديد ثانوى (**فرش**) $5\phi10\backslash m`$ و نعمل إحتياطياً شبكه سفليه

على أساس قيمة $moment = \frac{wL^2}{16}$

مكونه من (**فرش**) $5\phi10\backslash m`$ و ( **غطاء** ) $5\phi10\backslash m`$



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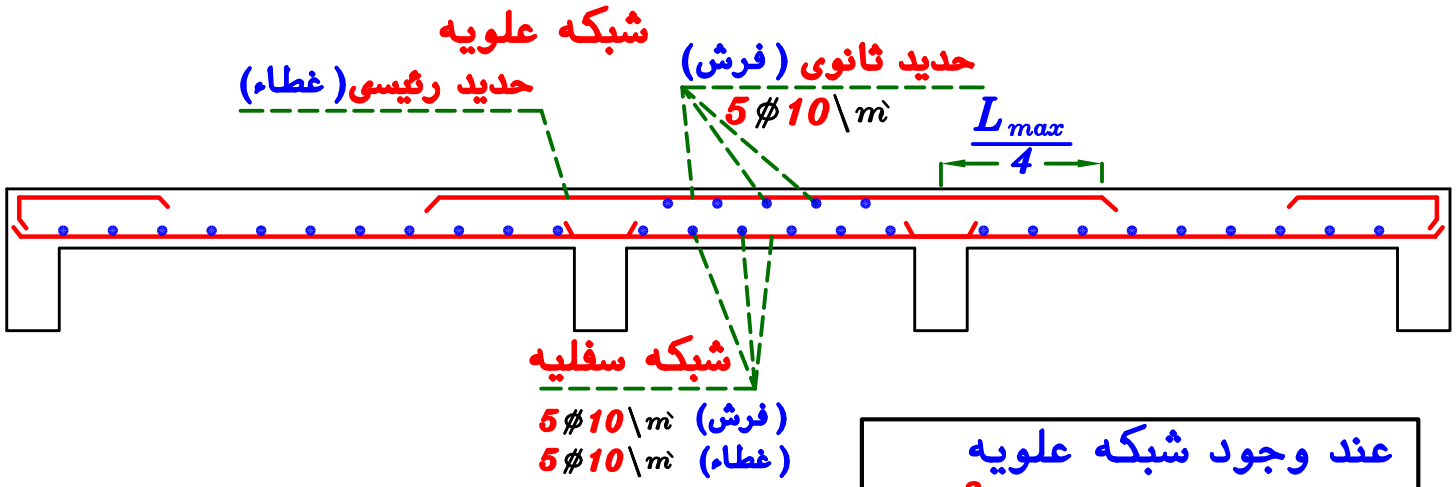
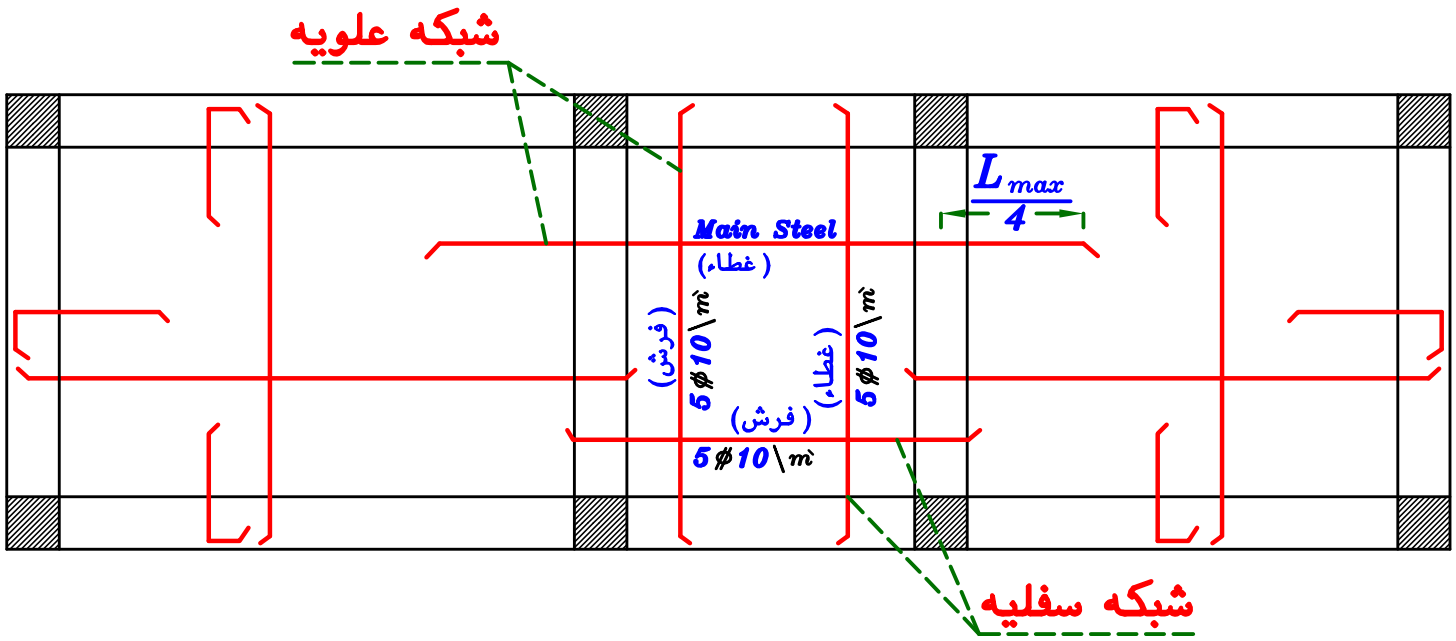


عند وجود شبكه علويه

لا نحتاج لوضع تسليح $\frac{wL^2}{24}$



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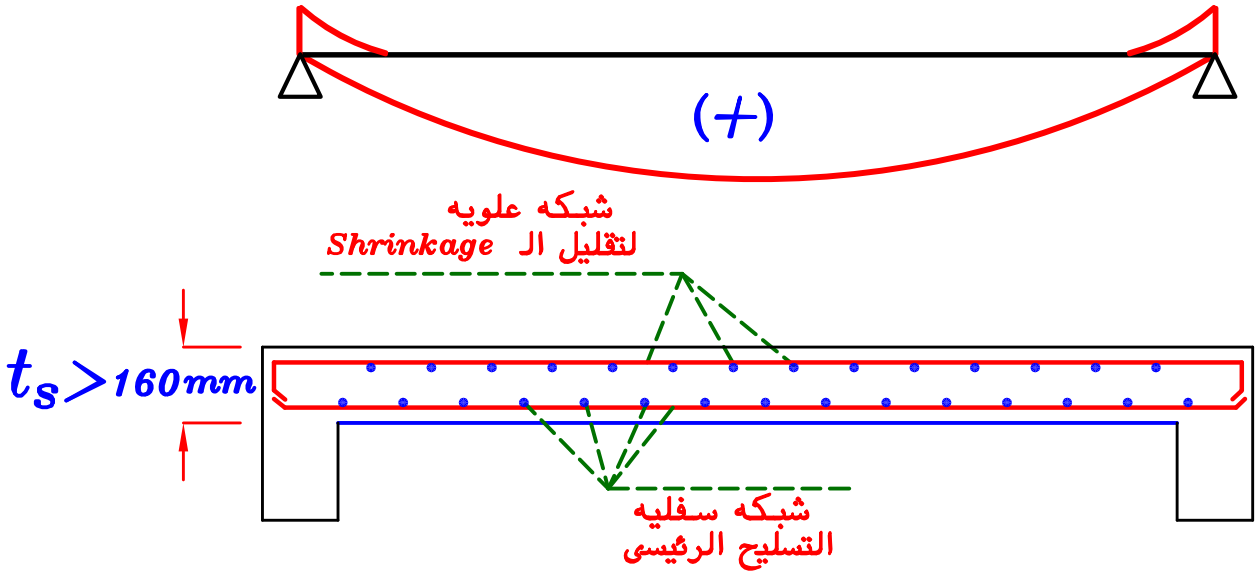
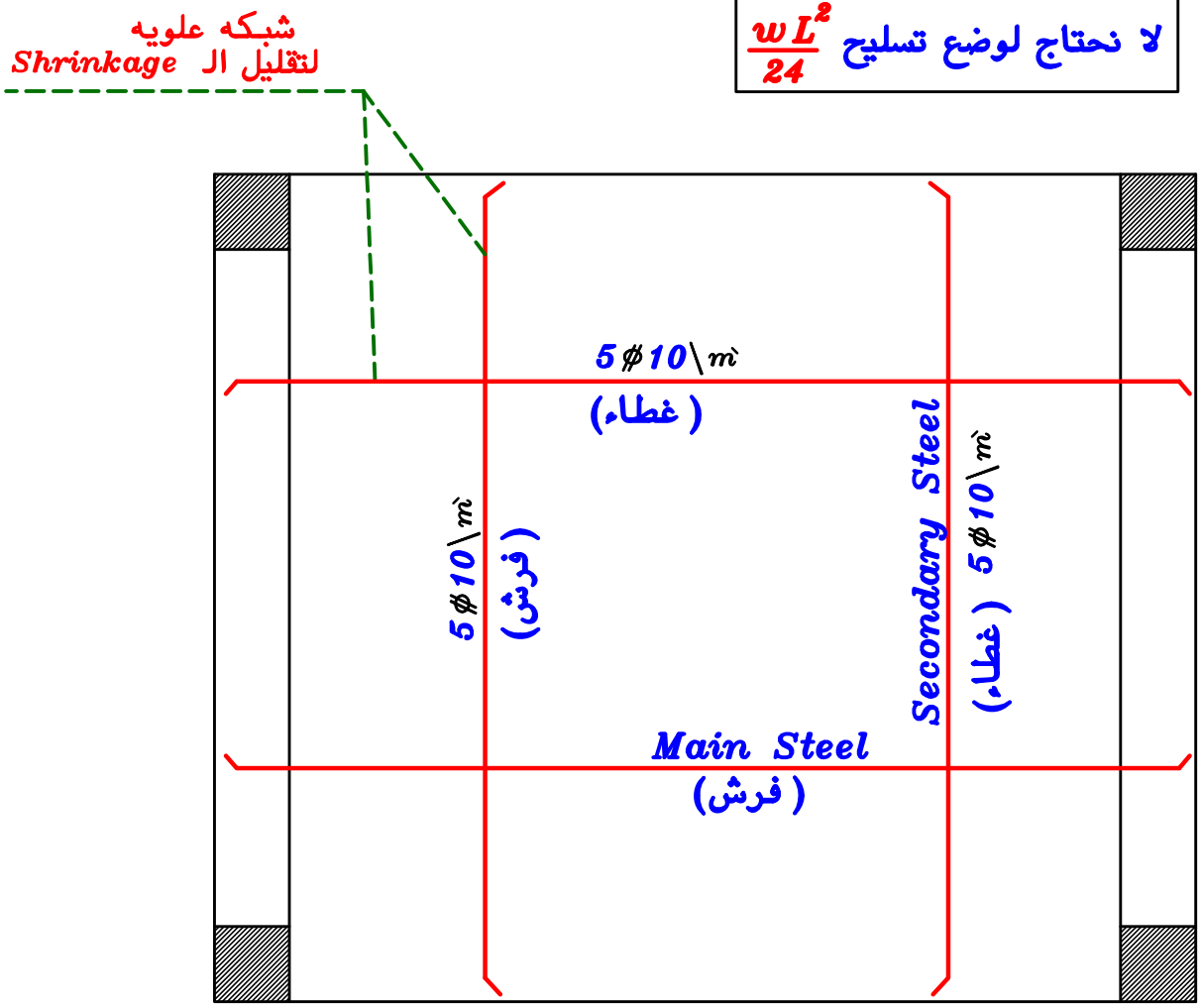
④ إذا زاد سُمك البلاطه عن ١٦٠ مم $t_s > 160\ mm$

يجب عمل شبكه علويه $5\phi 10\ \backslash m`$ وذلك لتقليل الإنكماش .



عند وجود شبكه علويه
لا نحتاج لوضع تسليح $\frac{wL^2}{24}$



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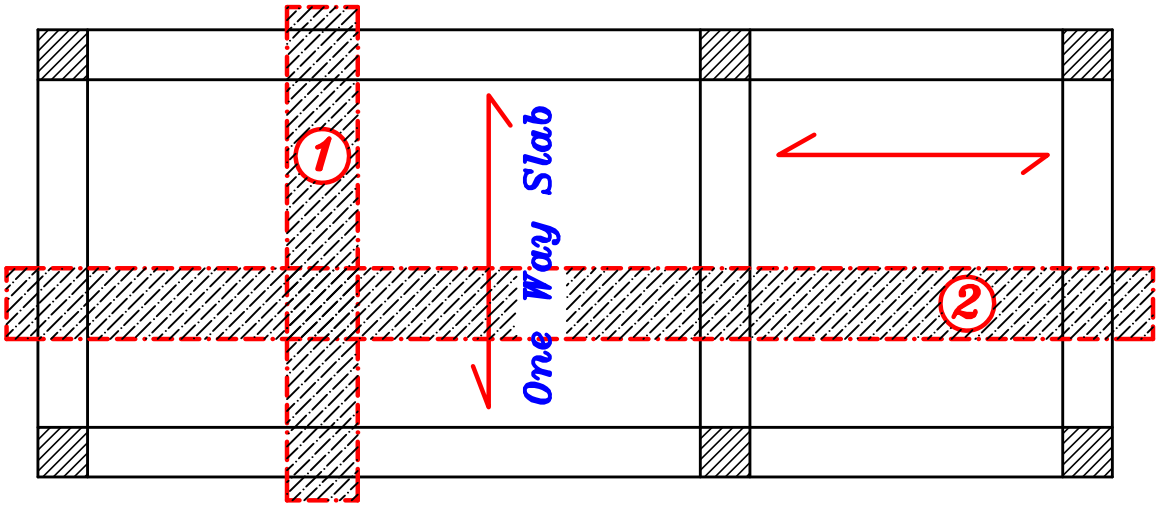
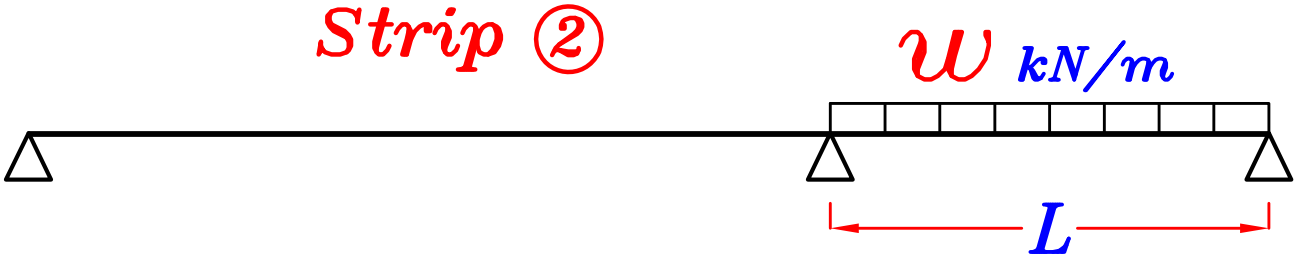
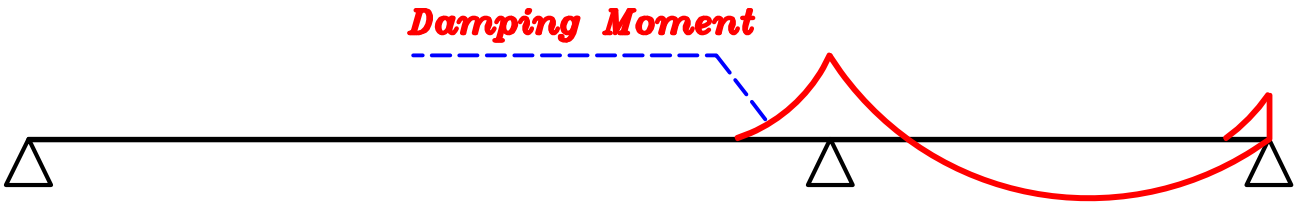
⑤ عندما يكون هناك حمل على شريحه البلاطه
ثم يختفى هذا الحمل مع تكمله الشريحه
يحدث هبوط مفاجئ للـ *moment* و يسمى *Damping Moment*

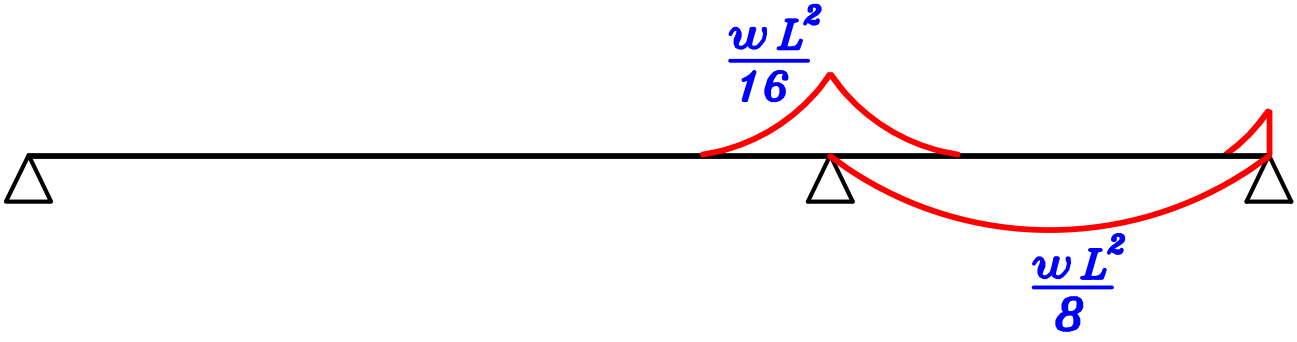




تحل بأستخدام ***3 Moment equations.***



أو تحل بال ***Imperical values***



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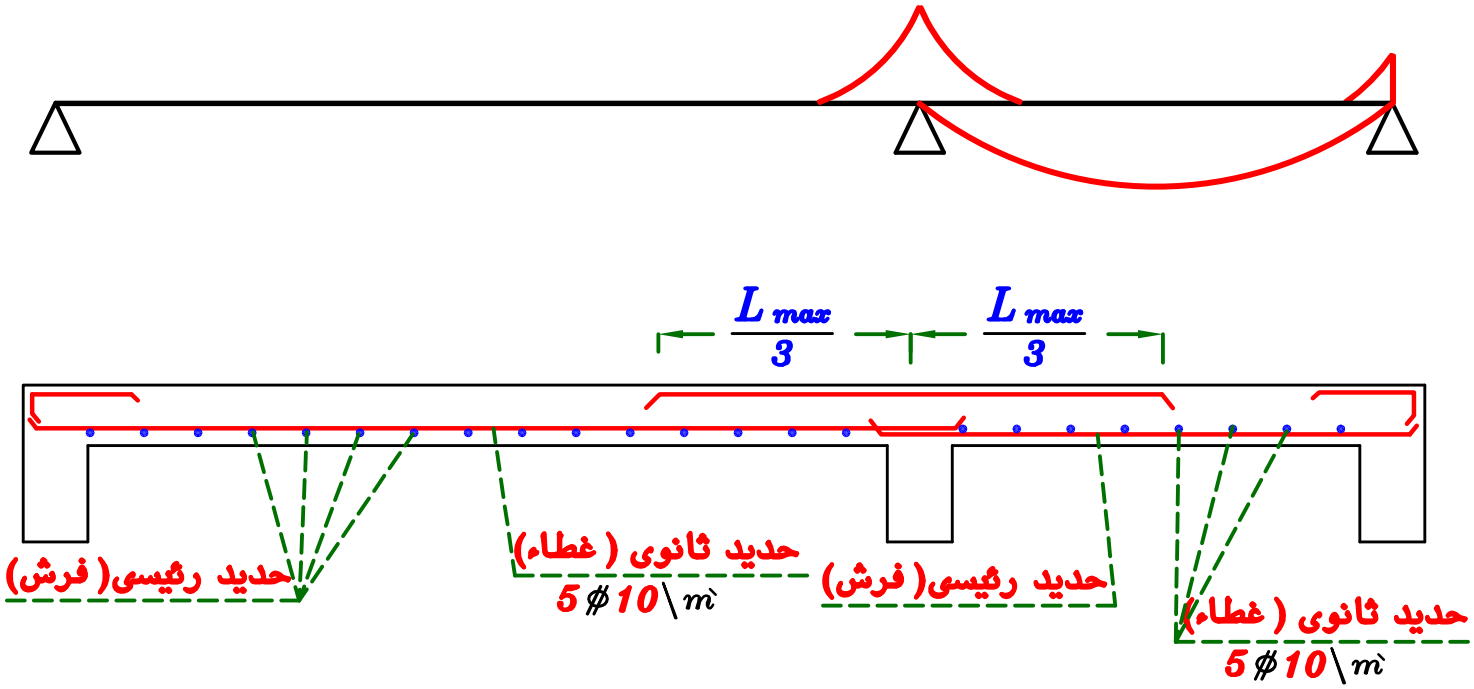

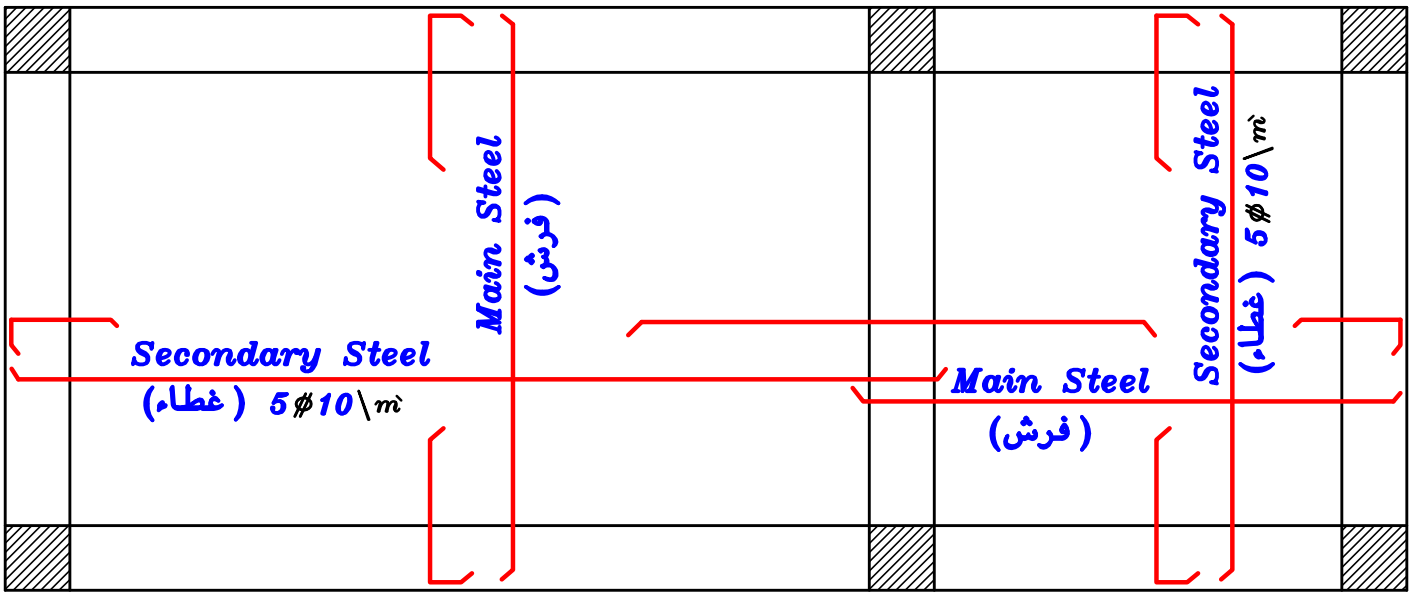

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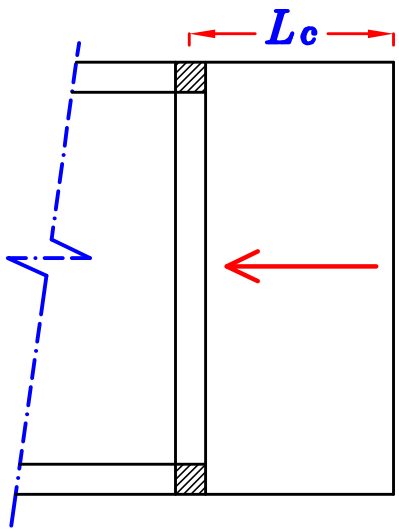
② Cantilever solid slab.



البلاطات المصمته الكابوليه .

هى بلاطه محموله على كمره واحده فقط

و بالطبع يسير الحمل فى اتجاه الكمره .

L_c هو الطول الذى يسير فى اتجاهه الحمل .

Steps of design Cantilever Slab.

1_ Thickness of the Slab. (t_s). تخانه البلاطات

To choose t_s

It is better to use this equation to get a reasonable value.

$$t_s = \frac{L_c}{10}$$

IF $L_c = 1.0\ m \therefore t_s = \frac{1000}{10} = 100\ mm$

IF $L_c = 1.2\ m \therefore t_s = \frac{1200}{10} = 120\ mm$

IF $L_c = 2.0\ m \therefore t_s = \frac{2000}{10} = 200\ mm \xrightarrow{Take\ it} = 160\ mm$

and check deflection

2_ Loads on the Slab. (w_s)

$w_s = g_s + p_s$ = D.L.+ L.L. = ✓ $kN\backslash m^2$ وزن المتر المربع من البلاطه

$g_s = t_s\ \gamma_c$ + F.C. (Floor Cover) = ✓ $kN\backslash m^2$

p_s = L.L. (Live Load) = ✓ $kN\backslash m^2$

$(w_s)_{U.L.} = 1.4\ g_s + 1.6\ p_s$

$$(w_s)_{U.L.} = 1.4\ (t_s\ \gamma_c + F.C.) + 1.6\ (L.L.)\quad kN\backslash m^2$$

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3 – Take a strip (1.0 m width) at the Load direction And Get the B.M. on the Slab.

Take the distributed Load on the strip = ✓ kN\m`

$\because M_{U.L.}$ = ✓ kN.m\m`

, t_s = ✓ mm

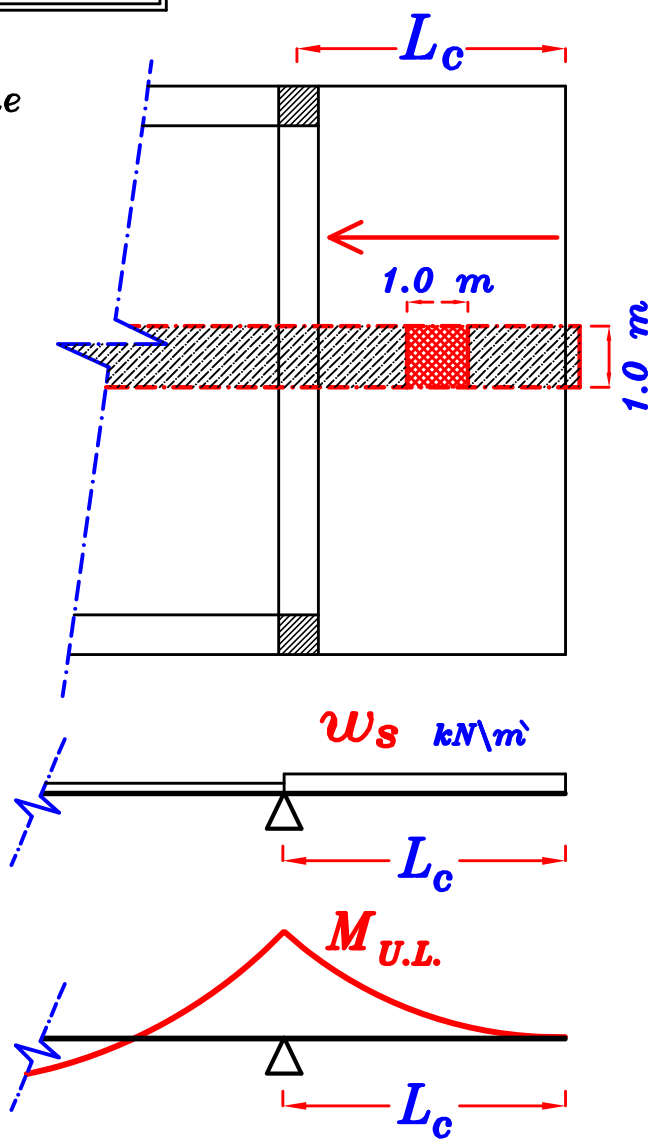
Take Cover = (20 ⟶ 30) mm

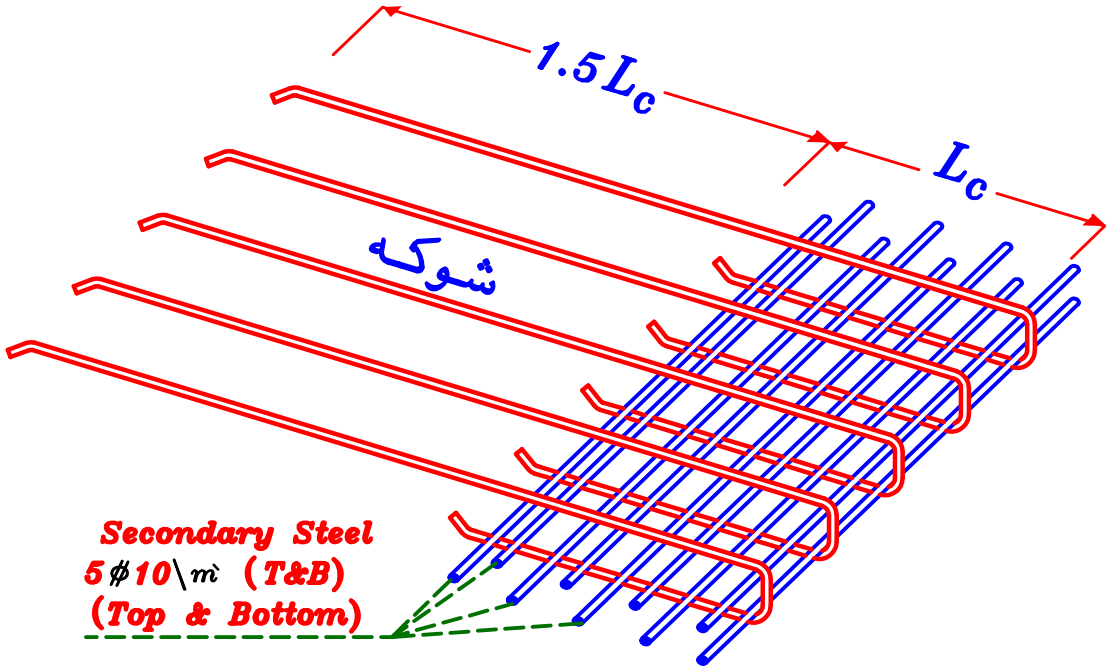
$\therefore d = t_s - 20$ mm (Cover) = ✓ mm

$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, B}}$, $B = 1000$ mm

Get C_1 = ✓ ⟶ J = ✓

$A_s = \frac{M_{U.L.}}{J\, F_y\, d}$ = ✓ mm^2\m`





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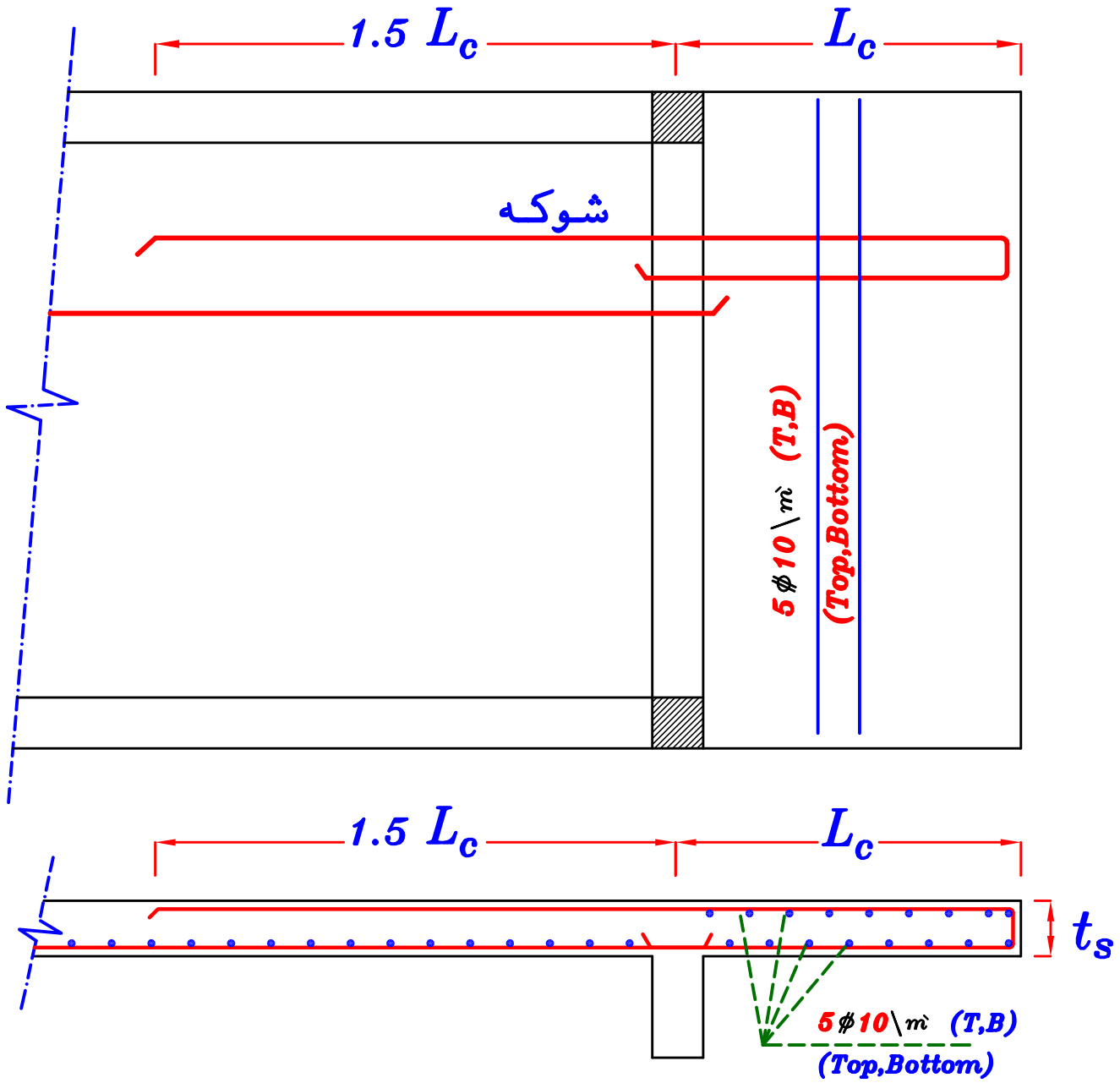
RFT. of the Cantilever Slab. تسليح الكـابولـى

نستخدم الشوك دائما فى تسليح الكوابيل .

و يكون الحديد الثانوى $5\phi10\backslash m`$ علوى و سفلى .



فائده الشوك فى الكوابيل هو زياده كميه الحديد فى الخرسانه .

و بالتالى زياده معاير المرونة (E) للخرسانه المسلحه و زياده الـ (I_e) $Inertia$

و بالتالى تقليل قيمه الهبوط $(Deflection)$ $\Delta_{act} = \frac{\checkmark}{E_c\ I_e}$

و يوضع الحديد الثانوى سفلى و علوى و ذلك لزياده كميه الحديد فى الخرسانه لتقليل الهبوط أيضاً .

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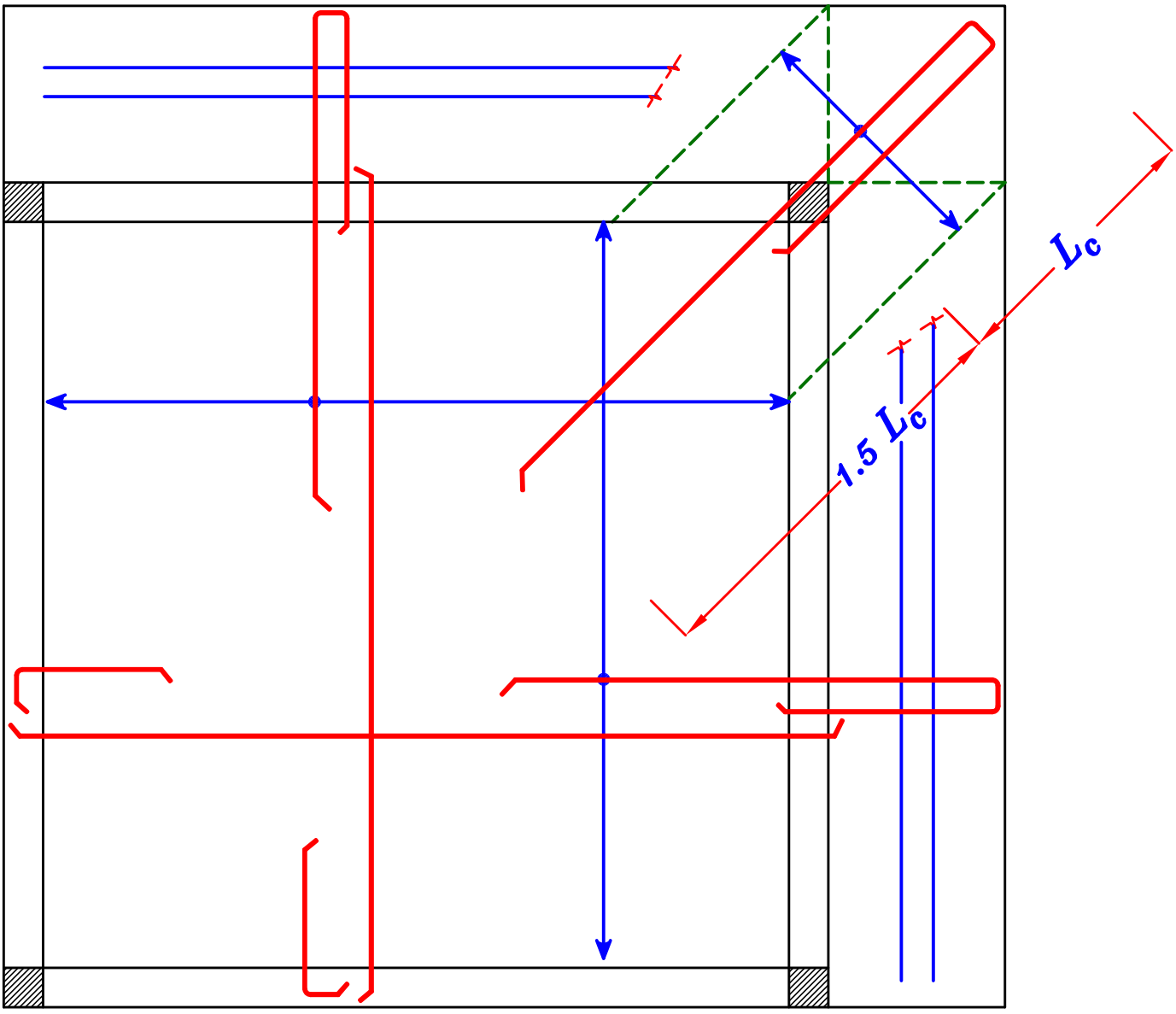
Corner Cantilevers.

الكوابيل الركنيه .

عند تقاطع **2 Cantilevers** كما بالشكل يكون هناك عده أشكال للتسليح :

Solution ① ✓✓



هذا النوع من التسليح سيئ فى التنفيذ و صعب فى الصب .

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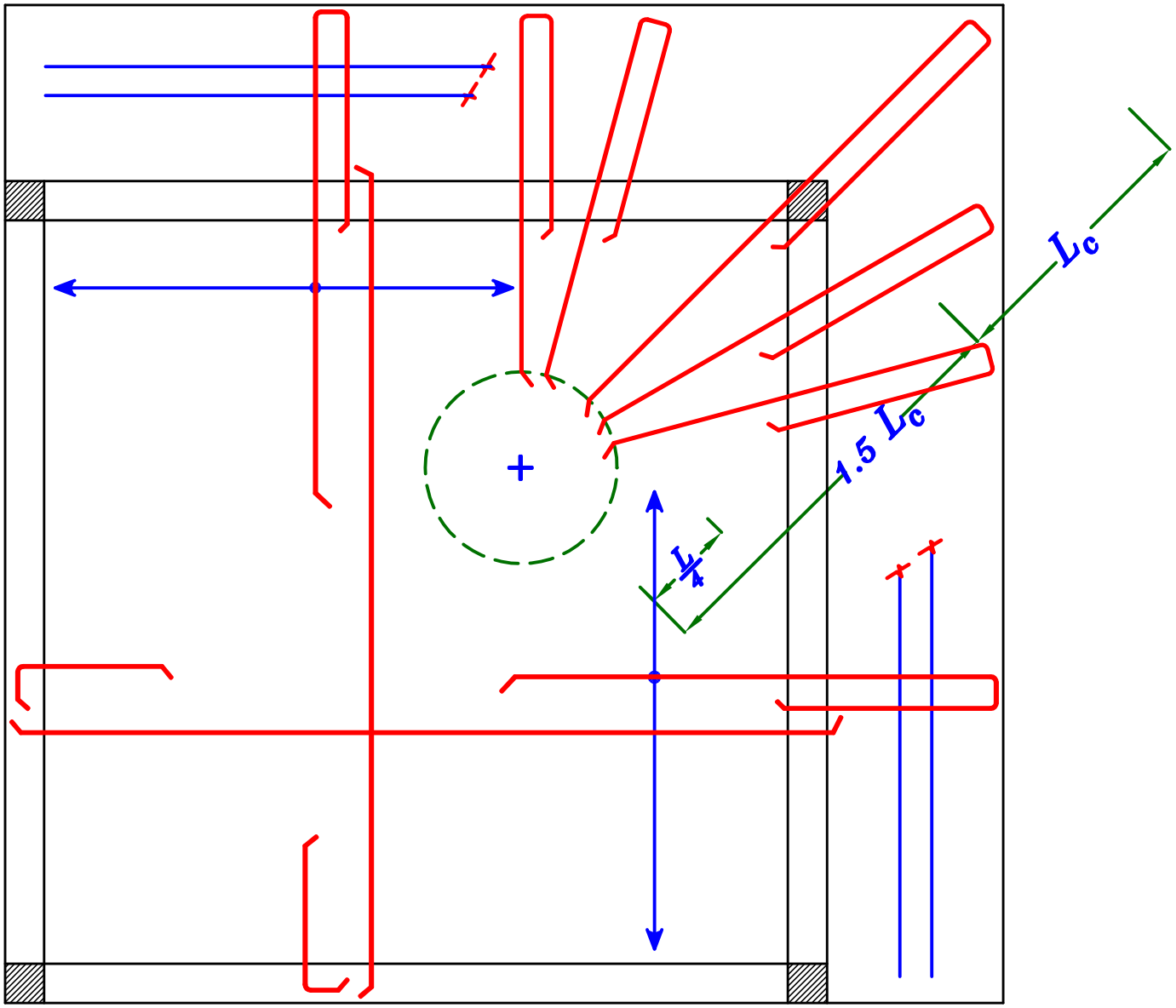
Solution ②



هذا النوع من التسليح أفضل فى التنفيذ
و لكن رسمة صعب و تشكيله صعب.

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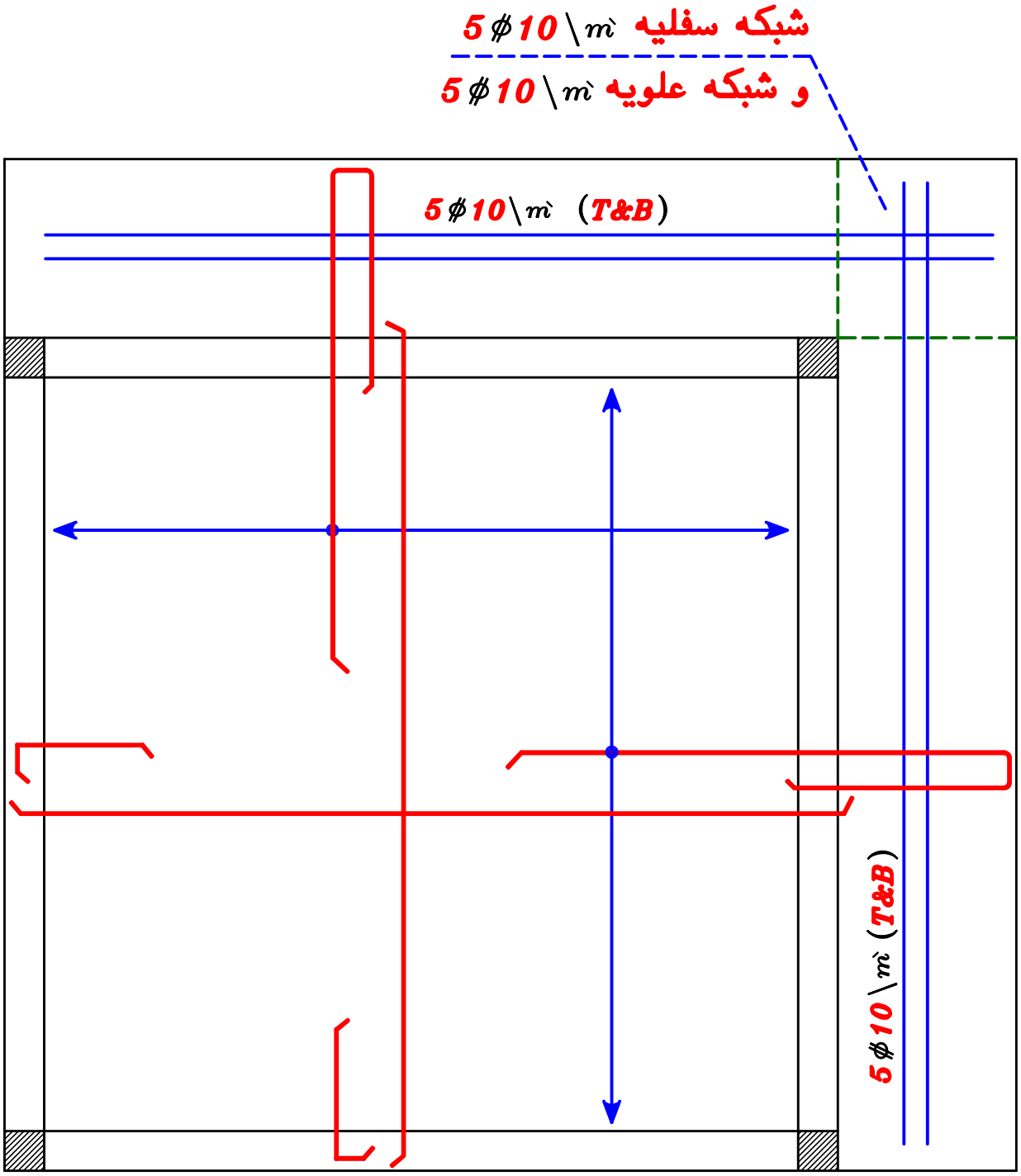
Solution ③



أسهل فى التنفيذ و لكن يصلح فى الكوابيل القصيره فقط

$$IF \quad \boxed{L_c \leqslant 1.0\ m}$$

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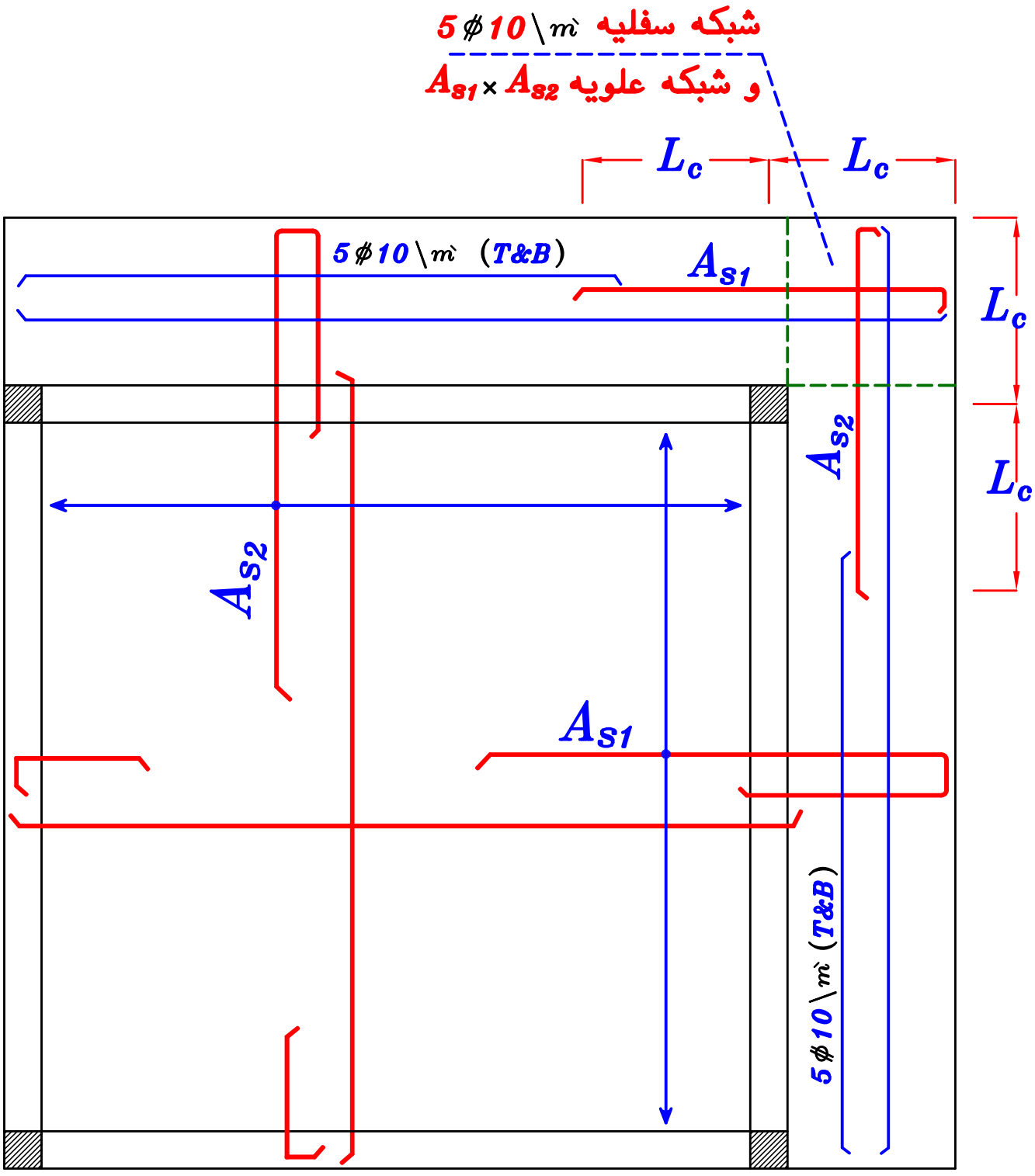
Solution ④



أسهل فى التنفيذ و يصلح للكوابيل الكبيره أيضا .

IF $\boxed{L_c > 1.0\ m}$

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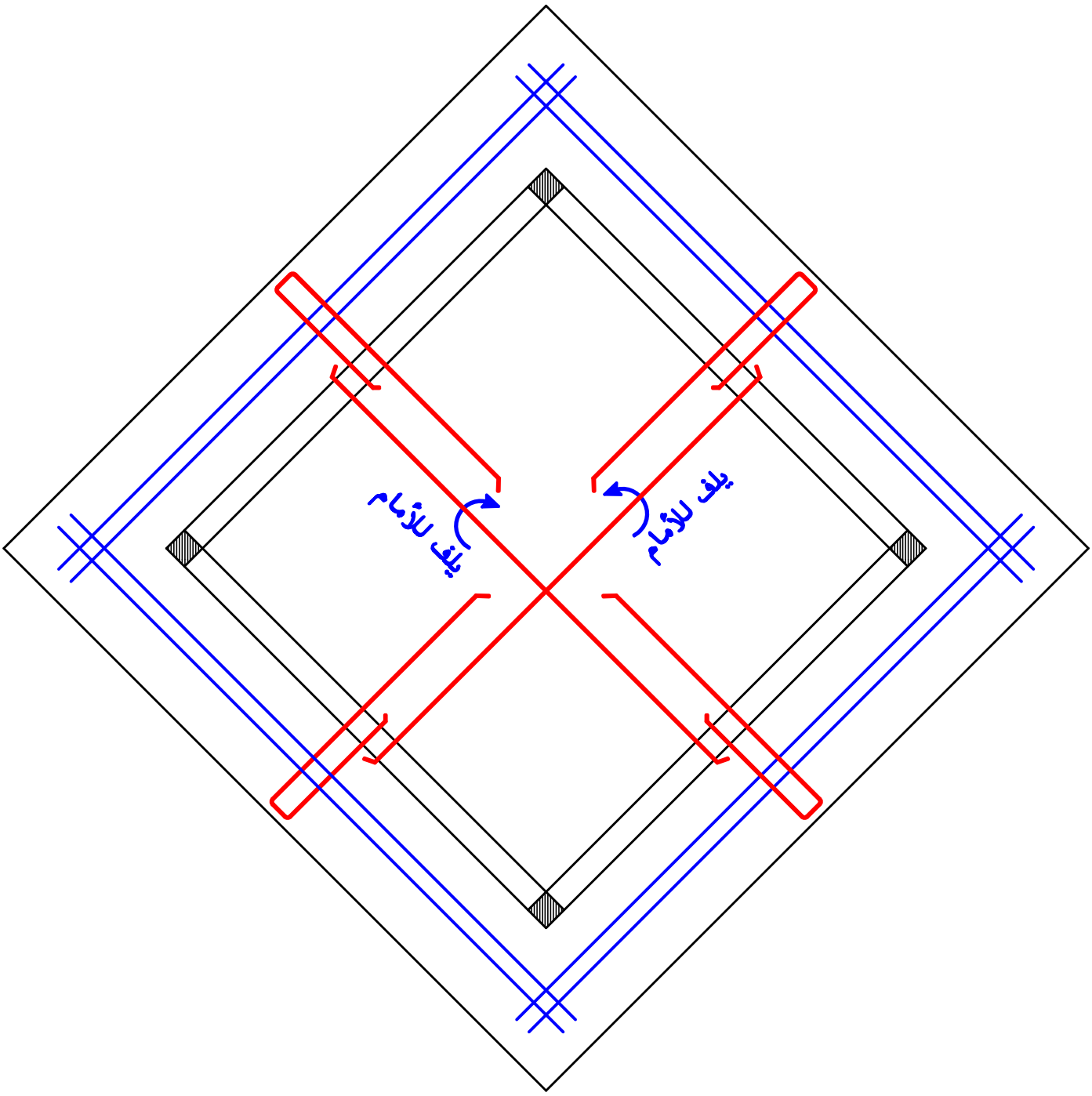
Example.

كيفية رسم التسليح المائل بزاوية ٤٥°

يرسم التسليح المائل بزاوية ٤٥° مثل التسليح الأفقى تماماً أى يلف للأمام بزاوية قدرها ٩٠ درجه .



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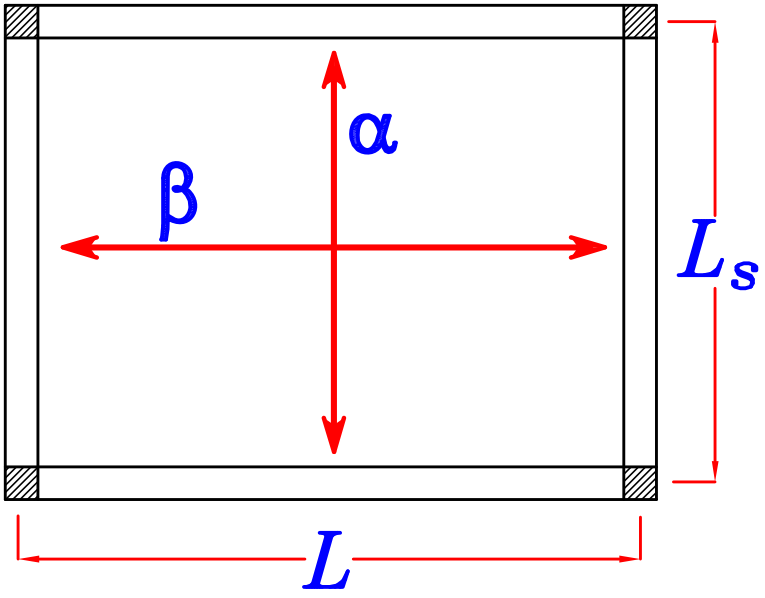
③ Two way solid slab.

البلاطات المصمته ذات الاتجاهين .

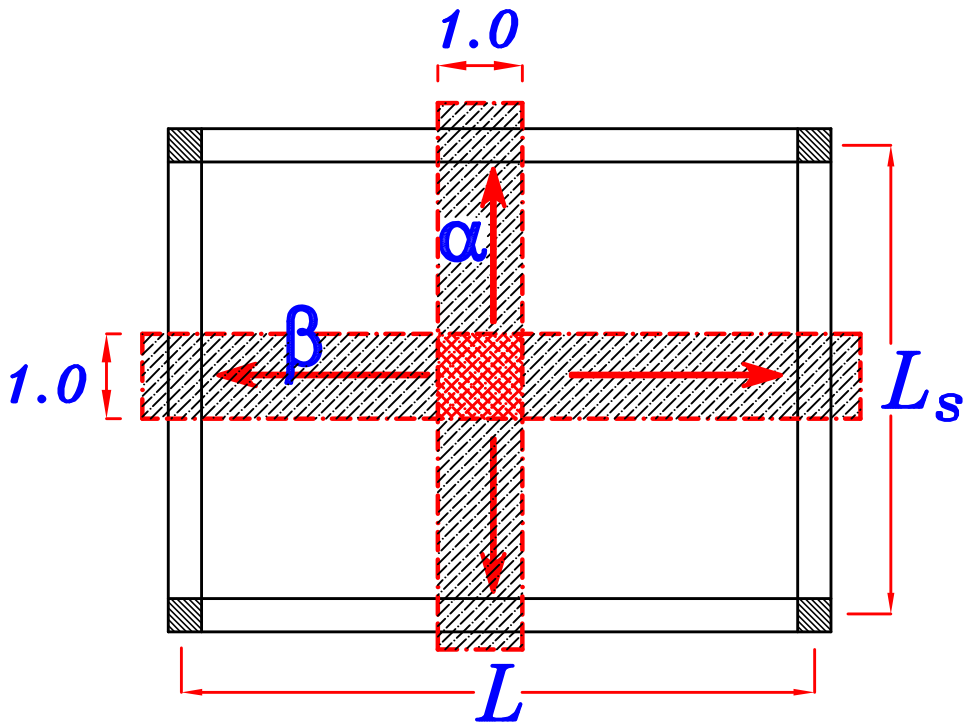
تكون البلاطه (*Two way*) عندما تكون محموله على ٤ كمرات و يكون $L \leqslant 2L_s$

فى البلاطه (*Two way*) يسير الحمل فى اتجاهين و ليس اتجاه واحد .



أى عند وضع أى حمل على البلاطه الـ (*Two way*) يتوزع جزء من الحمل فى الاتجاه القصير و جزء أخر فى الاتجاه الطويل .

و يعتمد الجزء المنقول من الحمل فى أى اتجاه على طول هذا الاتجاه و على وجود بلاطات مجاوره لهذا الاتجاه .



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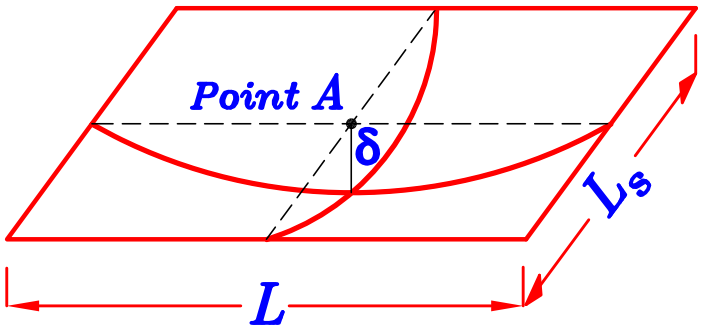
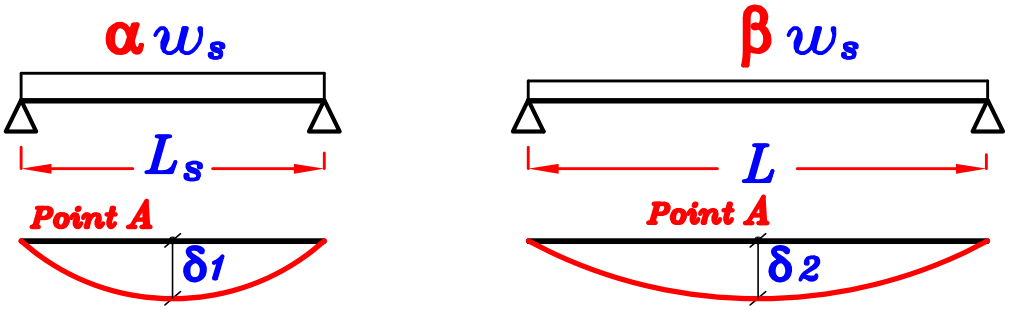
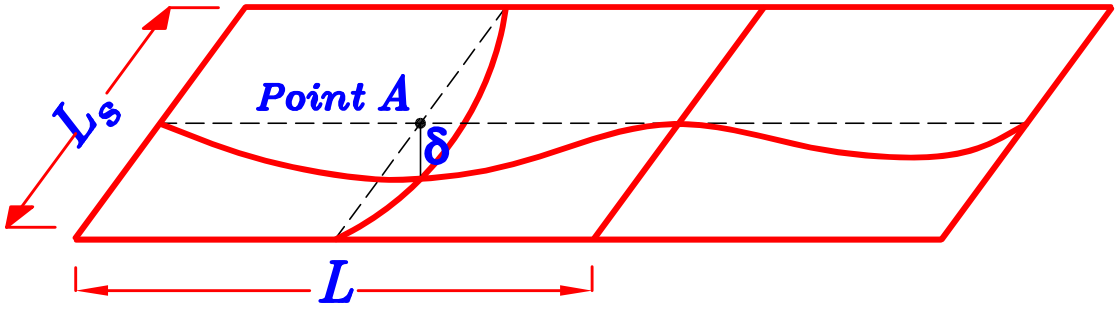


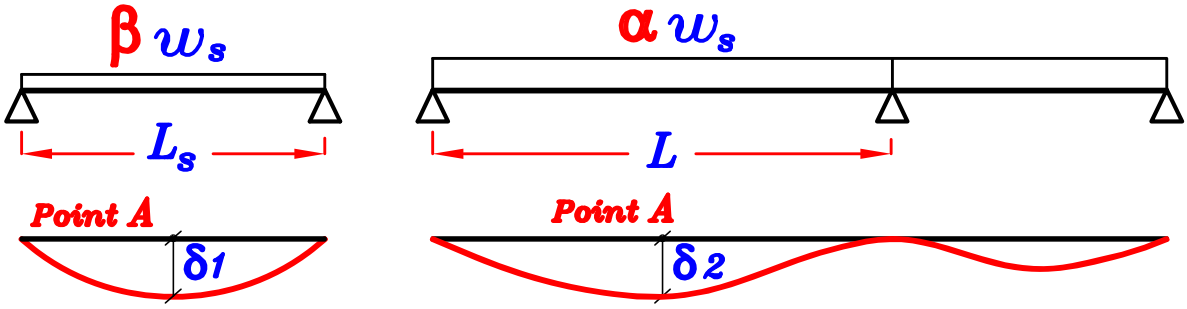
نظراً لتساوى الـ (δ) ***Deflection*** فى البلاطه عند أى نقطه فى اتجاهى البلاطه .
فذلك يعنى أن الطول الاقصر يحتاج لنسبه من الحمل أعلى من الطول الاكبر
لكى يتساوى معه فى الـ (δ) *Deflection* . $\boxed{\alpha > \beta}$



$\because \quad \delta 1 = \delta 2 \quad at \ Point\ A \qquad \because \quad L_s < L \qquad \therefore \quad \boxed{\alpha > \beta}$

حاله خاصه اذا كان الطول الاكبر توجد بلاطه بجواره و لا توجد بلاطه
بجوار الطول الاقصر فمن الممكن أن يحتاج الطول الطويل الى نسبه من الحمل
أعلى من الطول الاقصر لكى يتساوى معه فى الـ (δ) ***Deflection*** .





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Steps of design Two way soild slab.

خطواط تصميم البلاطات المصمته ذات الاتجاهين .

1- Choose the thickness of the slab. (t_s) (m)
to satisfy the bending moment & deflection considerations.
يتم اختيار تخانه البلاطه (t_s) بالمتر لتحقيق متطلبات عزوم الانحناء و حدود الترخيم .

2- Calculate the Loads on the Slab (w_s) ($kN\backslash m^2$).
يتم حساب وزن المتر المربع من البلاطه (w_s) .

3- Calculate rectangularity (γ) & the distribution Factors (α, β)
حساب معامل استطاله البلاطه (γ) و معاملات توزيع الاحمال (α, β).

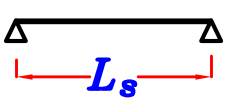
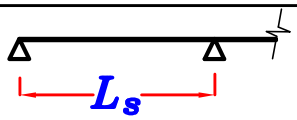
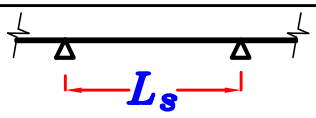
4- Take a strip (1.0 m width) at the two directions (α, β)
and take uniform load on the strip = (αw_s) or (βw_s) ($kN\backslash m$)
and then Get the bending moment ($kN.m\backslash m$) on the slab.
يتم أخذ شرائح فى البلاطه عرضها ١,٠ م فى اتجاهى الحمل (α, β) و وضع حمل منتظم
على الشرائح يساوى (αw_s) أو (βw_s) ثم تحديد قيمه عزوم الانحناء .

5- Design the sections of the strips as a beam subjected
to B.M. only, but with width 1.0 m and depth (t_s).
Then get the Reinforcement. (RFT.) ($mm^2\backslash m$)
يتم تصميم القطاعات فى شرائح البلاطه على عزوم الانحناء مثل الكمرات
و لكن بعرض ١,٠ م و تحديد كميه الحديد فى المتر الواحد .

Steps of Design.

① Choose t_s

يتم أخذ قيم (t_s) من الجدول التالى حتى نتفادى عمل (check deflection)

			
t_s	$L_s/35$	$L_s/40$	$L_s/45$

حيث L_s المقصود به هو الطول الأقصر للبلاطه .

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② Get $(w_s)_{U.L.} = 1.4\,(t_s\,\delta_c + F.C.) + 1.6\,L.L.$

OR $(w_s)_{U.L.} = 1.5\,(t_s\,\delta_c + F.C. + L.L.)$

③ Calculate the degree of rectangularity (γ) and the distribution Factors (α, β)

Degree of rectangularity. (γ) معامل استطاله البلاطه

يعتمد معامل الاستطاله على بعدى البلاطه (L, L_s) و على وجود بلاطات أخرى بجوار هذين الطولين لتحديد أى طول سيحمل الحمل الاعلى .

$$\gamma = \frac{m\,L}{m`\,L_s}$$

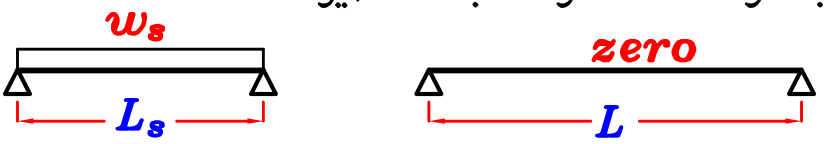
$m, m`$ are Factors depends on the Continuity of the slab strip.

the strip			
m OR $m`$	1.0	0.87	0.76

Notes:

* IF $\gamma > 2.0$ ∴ the Slab is One Way Slab.

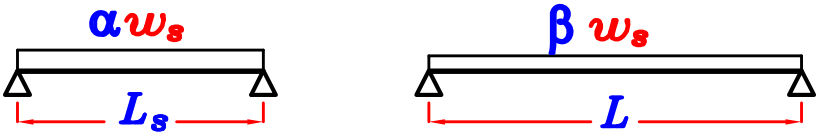
الحمل كله يسير فى الاتجاه واحد فقط هو الاتجاه القصير .



* Always $\gamma \geq 1.0$

$\gamma = \frac{m\,L}{m`\,L_s}$ Takes β — β الطول الموجود فى البسط يأخذ دائما

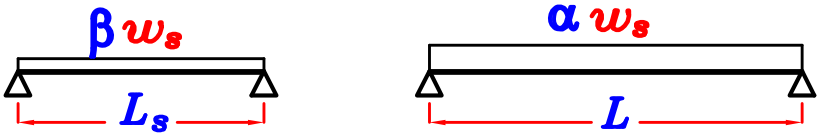
Takes α — α الطول الموجود فى المقام يأخذ دائما



* IF we Fined $\gamma < 1.0$ Reverse γ

$\gamma = \frac{m`L_s}{m\,L}$ Takes β — β الطول الموجود فى البسط يأخذ دائما

Takes α — α الطول الموجود فى المقام يأخذ دائما



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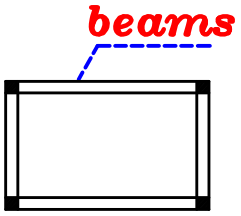
Then Calculate α, β

① IF L.L. $\leqslant$ 5.0 kN\m²

@ The Slab rested on Beams.

Use C.P. (Code of Practice) الحاله العامه



Use Code Page 6–9 Table 6–1

$$\alpha = 0.5\,\gamma - 0.15$$

$$\beta = \frac{0.35}{\gamma^2}$$

Note: $\alpha + \beta \simeq 0.7$

ملحوظه

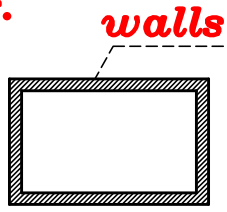
وهذا معناه أن حوالى ٠,٧ من حمل البلاطه يذهب إلى الكمرات عن طريق الـ moment أما باقى حمل البلاطه (حوالى ٠,٣ من الحمل) فيذهب إلى الكمرات عن طريق :

1 – Torsion of Beams.
2 – Memberain behavior of the Slab.
3 – Corner Effect of the Slab.

ⓑ IF the Slab rested on walls not on beams.

L.L. $\leqslant$ 5.0 kN\m²

Use Marcus



Use Code Page 6–10 Table 6–2

old Tables Page 90

ليس لة معادلات

Note: $\alpha + \beta \simeq 0.8$

2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	γ
0.849	0.830	0.806	0.778	0.746	0.706	0.660	0.606	0.543	0.473	0.396	α
0.053	0.063	0.077	0.093	0.113	0.140	0.172	0.212	0.262	0.333	0.396	β

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② IF L.L. > 5.0 kN\m² (Beams or walls) Use Grashoff

Use Code Page 6-10 Table 6-2

old Tables Page 90 **Grashoff**

$$\alpha = \frac{r^4}{1+r^4} \qquad \beta = \frac{1}{1+r^4}$$

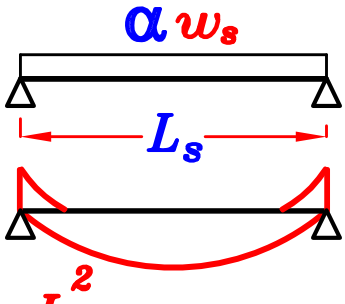
Note: $\alpha + \beta = 1.0$ **ملحوظه**

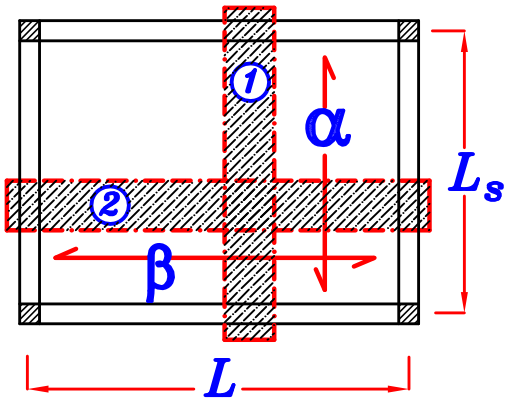
و هذا معناه أننا إفترضنا أن كل الحمل أنتقل للكمرات عن طريق الـ moment فقط و أننا أهملنا جميع العوامل الاخرى لنقل الحمل .

④ Take a strip (1.0 m width) at the two Load directions. and get the B.M. on the Slab.

يتم أخذ شرائح فى البلاطه عرضها ١,٠ م فى اتجاهى الحمل (α , β) و رسم عزوم الانحناء.

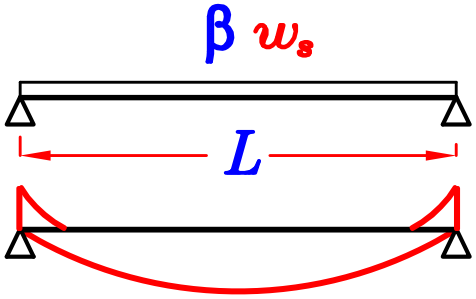
Strip ①





$$M_{U.L.}\ (\alpha\ Dir.) = \alpha \frac{w_s L_s^2}{8}$$

Strip ②



$$M_{U.L.}\ (\beta\ Dir.) = \beta \frac{w_s L^2}{8}$$

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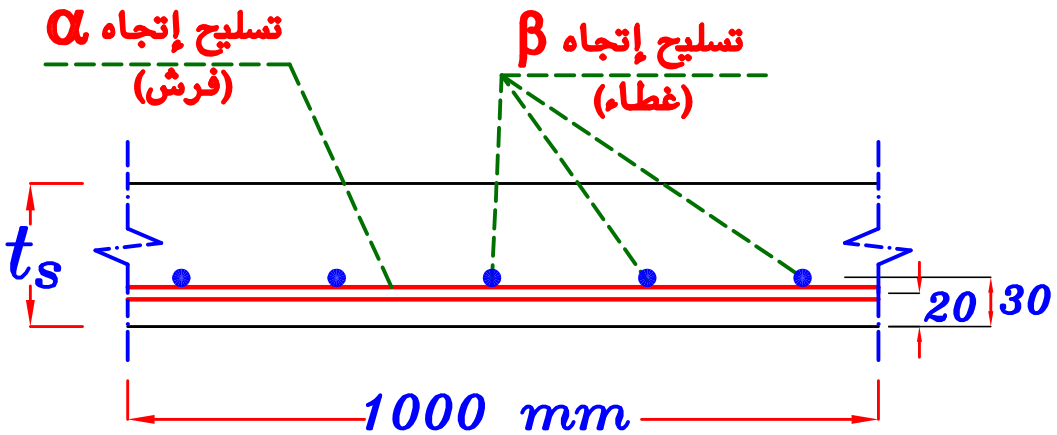
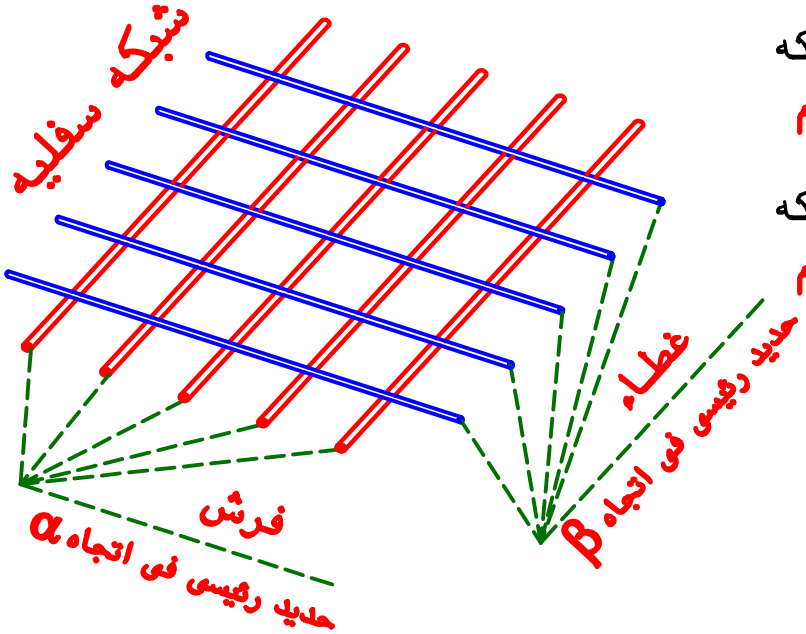
⑤ Design the sections of the strips.

تصميم القطاعات فى شرائح البلاطه





يؤخذ الغطاء الخرسانى لحديد الشبكه السفليه فى اتجاه α يساوى ٢٠ مم

يؤخذ الغطاء الخرسانى لحديد الشبكه السفليه فى اتجاه β يساوى ٣٠ مم

يؤخذ الغطاء الخرسانى للحديد العلوى يساوى ٢٠ مم

Cover For (+ve) RFT.

1- Take cover For (α) Direction = (20 → 30) mm

$$d_{\alpha\ Dir.} = t_s - 20\ mm$$

2- Take cover For (β) Direction = (30 → 40) mm

$$d_{\beta\ Dir.} = t_s - 30\ mm$$

Cover For (−ve) RFT.

Take cover For −ve RFT. = (20 → 30) mm

$$d = t_s - 20\ mm$$

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1- Design of Sections For (+ve) Moment.

@ For α direction.

$$d_{\alpha\ Dir.} = t_s - 20\ mm = C_1\sqrt{\frac{M_{U.L.\ \alpha\ Dir.}}{F_{cu} * 1000}} \longrightarrow C_1 = \checkmark \longrightarrow J = \checkmark$$

$$A_{S\ \alpha\ Dir.} = \frac{M_{U.L.\ \alpha Dir.}}{J\ F_y\ d_{\alpha Dir.}} = \checkmark\ mm^2/m`$$

ⓑ For β direction.

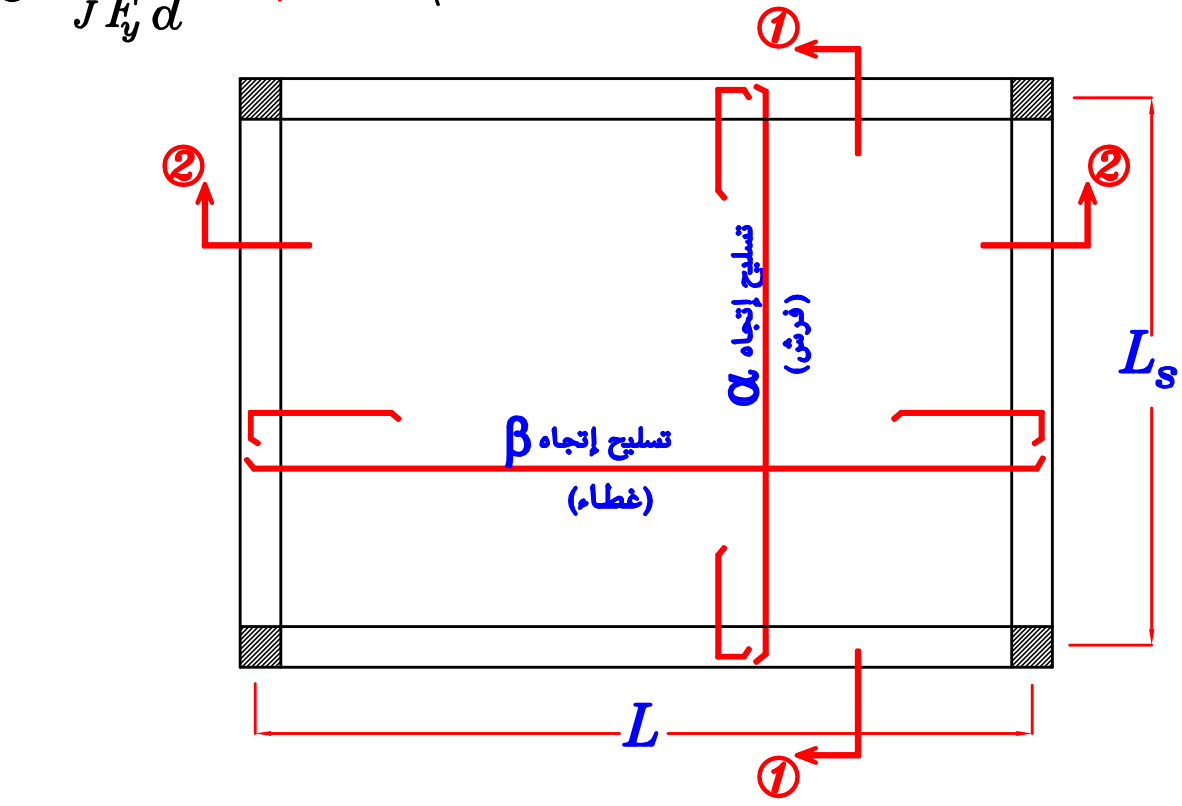
$$d_{\beta\ Dir.} = t_s - 30\ mm = C_1\sqrt{\frac{M_{U.L.\ \beta\ Dir.}}{F_{cu} * 1000}} \longrightarrow C_1 = \checkmark \longrightarrow J = \checkmark$$

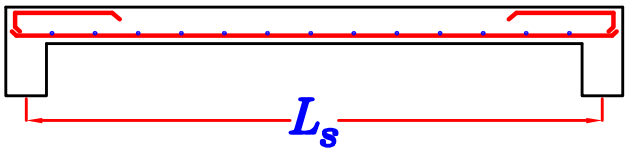
$$A_{S\ \beta\ Dir.} = \frac{M_{U.L.\ \beta Dir.}}{J\ F_y\ d_{\beta\ Dir.}} = \checkmark\ mm^2/m`$$

2- Design of Sections For (-ve) Moment.

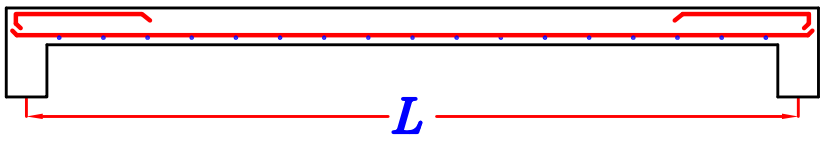
$$d = t_s - 20\ mm = C_1\sqrt{\frac{M_{U.L.}}{F_{cu} * 1000}} \longrightarrow C_1 = \checkmark \longrightarrow J = \checkmark$$

$$A_S = \frac{M_{U.L.}}{J\ F_y\ d} = \checkmark\ mm^2/m`$$





Sec. (1-1)



Sec. (2-2)

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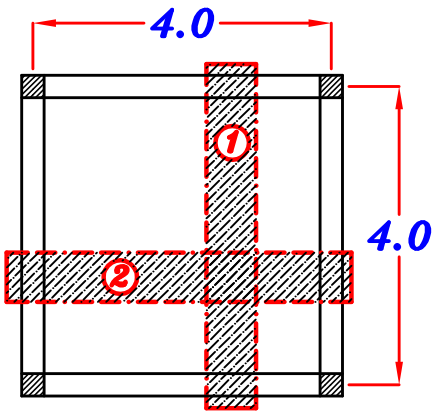
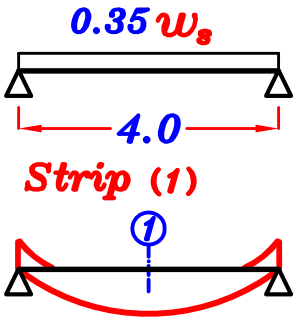
Notes:

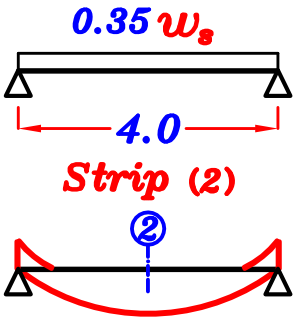
اذا كانت البلاطه مربعه و متماثله من جميع الجهات .

$$\because \quad r = \frac{1.0\,(4)}{1.0\,(4)} = 1.0$$

$$\therefore \quad \alpha = \beta = 0.35$$

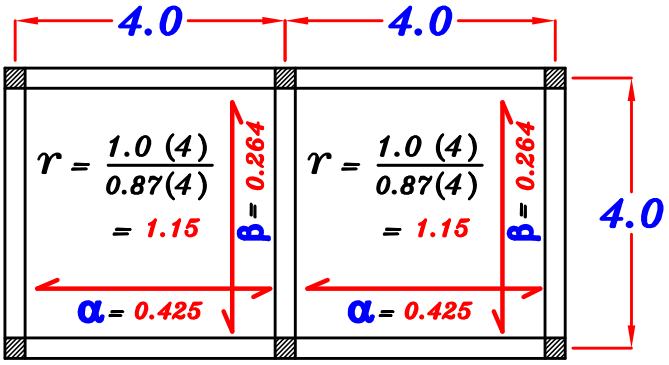




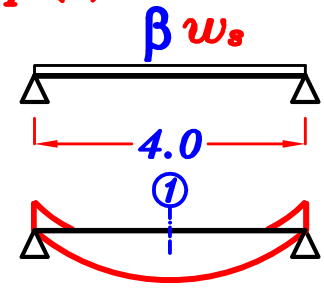


لتوفير الوقت نأخذ قطاع واحد فقط $d = t_s - 30$ و يكون التسليح متماثل فى الإتجاهين

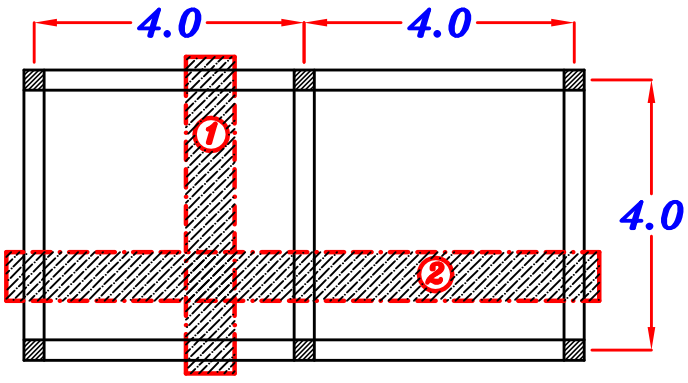
Example.



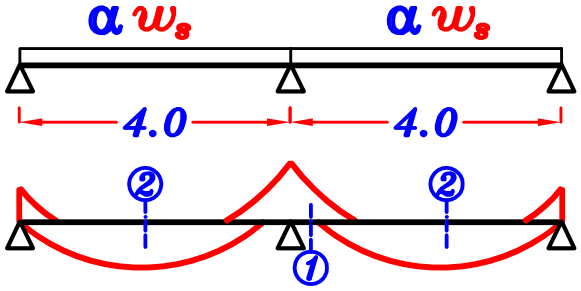
Strip (1)



For sec. ① $d = t_s - 30$



Strip (2)



For sec. ① $d = t_s - 20$

For sec. ② $d = t_s - 20$

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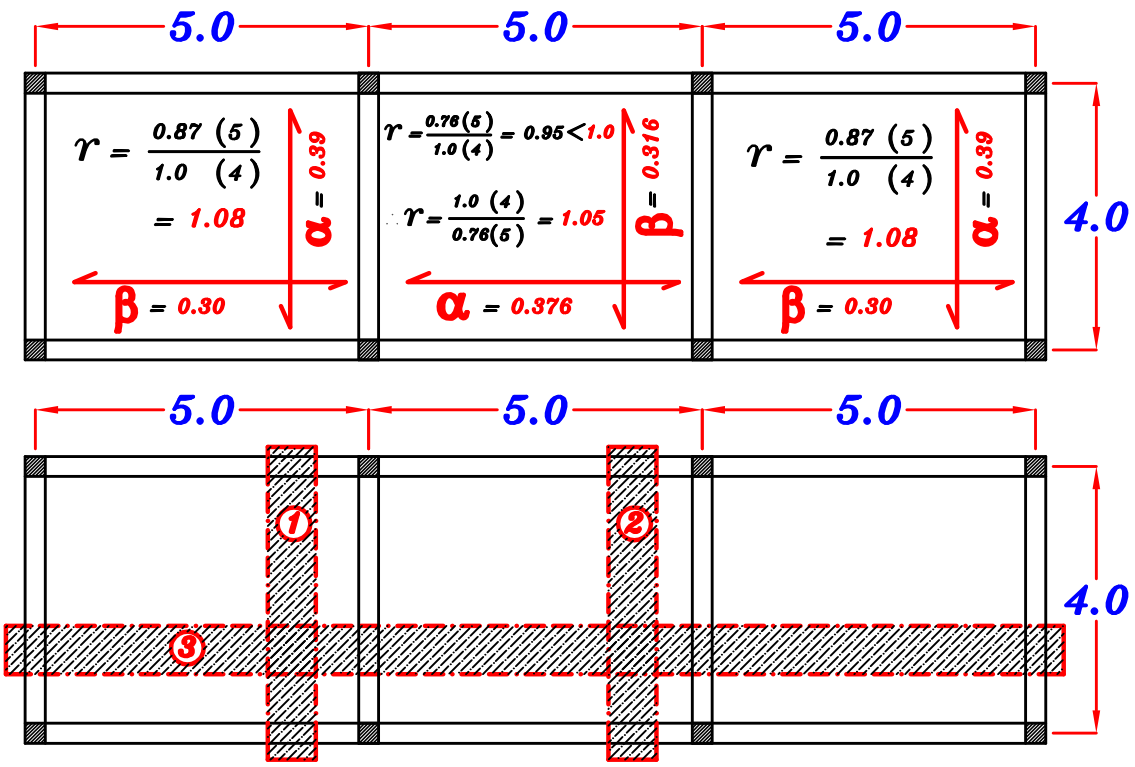
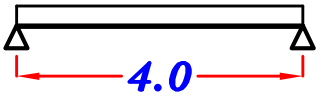
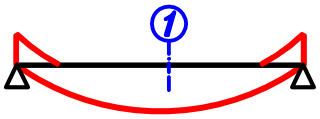
Example.



Strip (1)

$\alpha\, w_s = 0.39 * w_s$

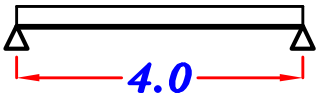


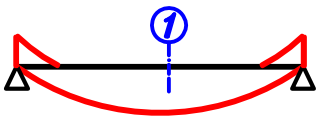


For sec. ① $d = t_s - 20$

Strip (2)

$\beta\, w_s = 0.316 * w_s$

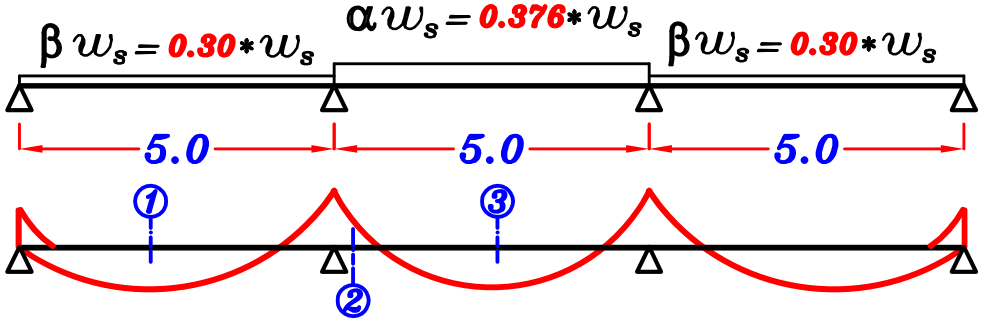




For sec. ① $d = t_s - 30$

Strip (3)

$\beta\, w_s = 0.30 * w_s$ $\quad \alpha\, w_s = 0.376 * w_s$ $\quad \beta\, w_s = 0.30 * w_s$



For sec. ① $d = t_s - 30$

For sec. ② $d = t_s - 20$

For sec. ③ $d = t - 20$

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Steps of Design and Reinforcement For Slabs.

خطوات تصميم و تسليح البلاطات .

رسم الـ Plan و وضع الاسهم عليه.

خطوات التصميم .

① يتم اختيار تخانه البلاطه (t_s) بالمتر لتحقيق متطلبات عزوم الانحناء و حدود الترخيم .

② يتم حساب وزن المتر المربع من البلاطه (w_s) .

③ حساب معامل استطاله البلاطه (r) و معاملات توزيع الاحمال (α , β) .
للبلاطات الـ Two Way فقط .

④ يتم أخذ شرائح فى البلاطه عرضها ١,٠ م فى اتجاهى الحمل (α , β) و وضع حمل منتظم على الشرائح يساوى (αw_s) أو (βw_s) ثم تحديد قيمه عزوم الانحناء .

⑤ يتم تصميم القطاعات فى شرائح البلاطه على عزوم الانحناء مثل الكمرات و لكن بعرض ١,٠ م و تحديد كميه الحديد فى المتر الواحد .

خطوات التسليح .

① نرسم تسليح الشرائح الافقيه (مثل الـ Cross section) .

② نرسم تسليح الشرائح الرأسيه (ننظر من على يمين اللوحه ثم نرسم التسليح مثل الـ Cross section) .

③ نرسم الـ(Secondary Steel ∅ 10 \ m` 5) للشبكه السفليه فى البلاطات الـ One Way .

④ نرسم الـ (Top & Bottom ∅ 10 \ m` 5) لـ Cantilevers إن وجدت .

⑤ نرسم بقيه الشبكه العلويه فى الباكيه اذا كان الـ moment على كل الباكيه .

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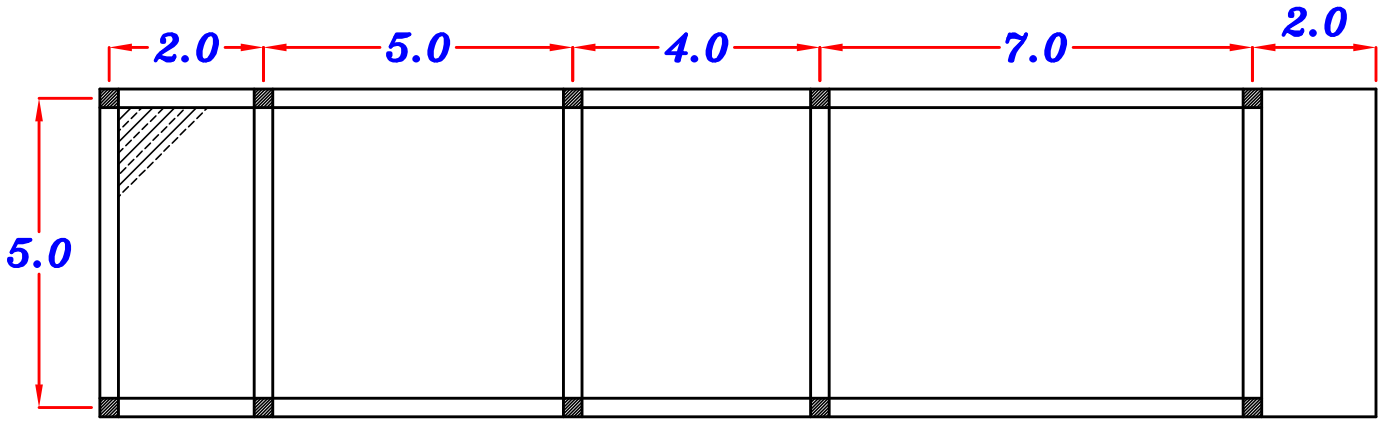
Example.



Data.

$F_{cu} = 25 \quad N\backslash mm^2$ $\qquad$ $F_y = 360 \quad N\backslash mm^2$

$F.C. = 1.50 \quad kN\backslash m^2$ $\qquad$ $L.L. = 2.0 \quad kN\backslash m^2$

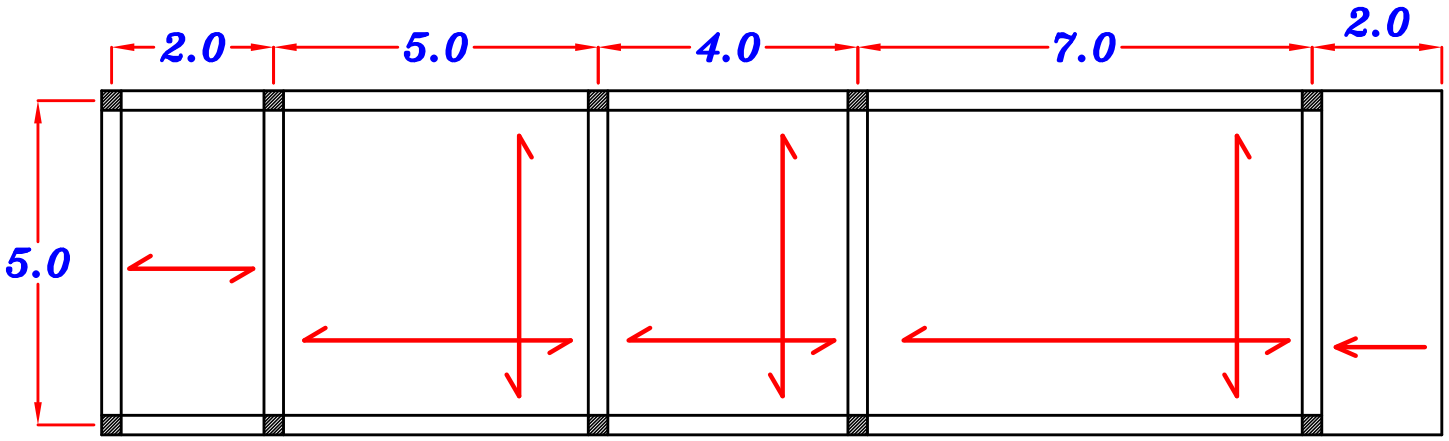
Req.

① Design the Slab as Solid Slab.

② Draw Details of RFT. in plan.

Solution.

رسم الـ Plan و وضع الاسهم عليه.



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$$t_s = \frac{2000}{25} = 80 \ mm$$
$$= \frac{2000}{10} = 200 \ mm$$
$$= \frac{5000}{35} = 142.8 \ mm$$
$$= \frac{4000}{45} = 88.8 \ mm$$

$$t_s = 160 \ mm$$

Check Deflection

لأن بلاطه الحمام فى مستوى مختلف عن باقى البلاطات
لذا فمن الممكن إعتبار بلاطه الحمام منفصله عن باقى البلاطات .
و تُعامل بلاطه الحمام على أنها *Simple* من جميع الجهات .
و المفروض تكون تخانه بلاطه الحمام مختلفه عن باقى بلاطات المبنى
و لكن توفيراً للوقت نأخذها نفس تخانه بلاطات المبنى .

$$w_s = 1.4 \left(t_s \gamma_c + F.C. \right) + 1.6 \left(L.L. \right)$$

$$w_s = 1.4 \left(0.16 * 25 + 1.50 \right) + 1.6 \left(2.0 \right) = 10.9 \ kN\backslash m^2$$

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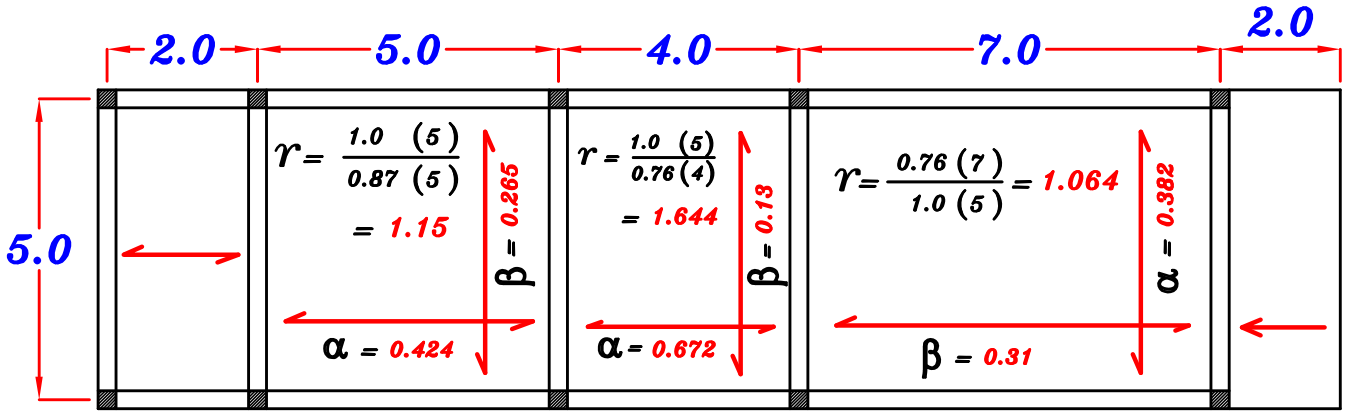
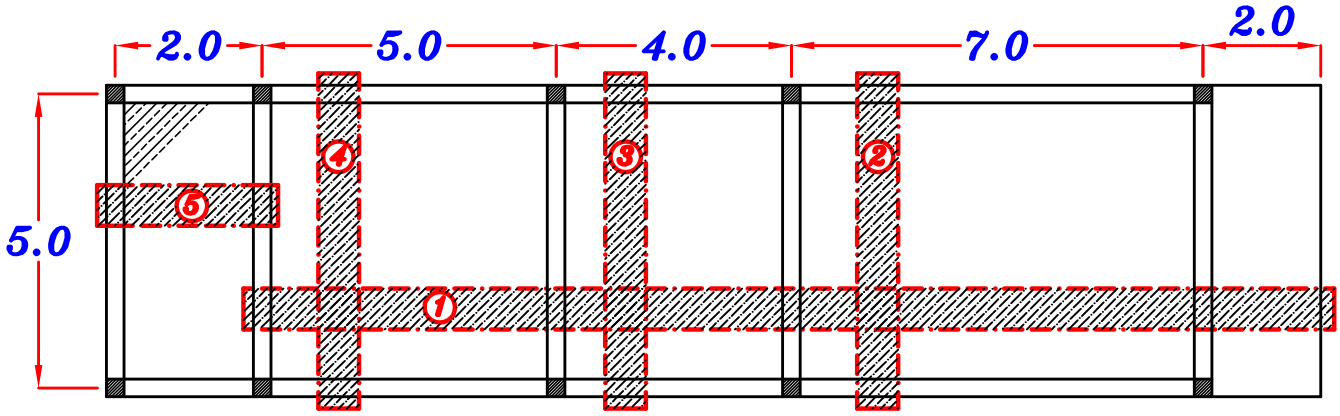
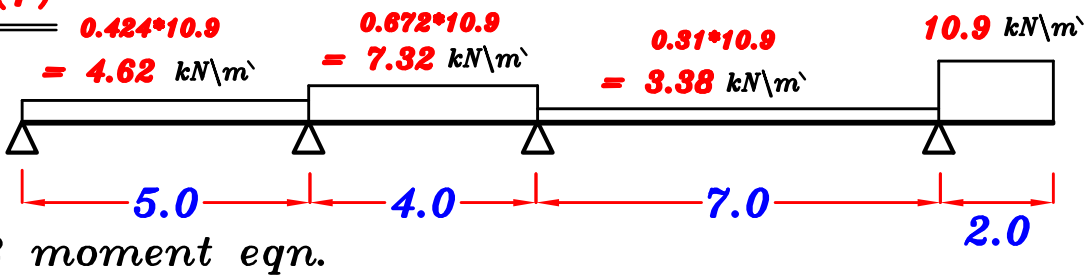
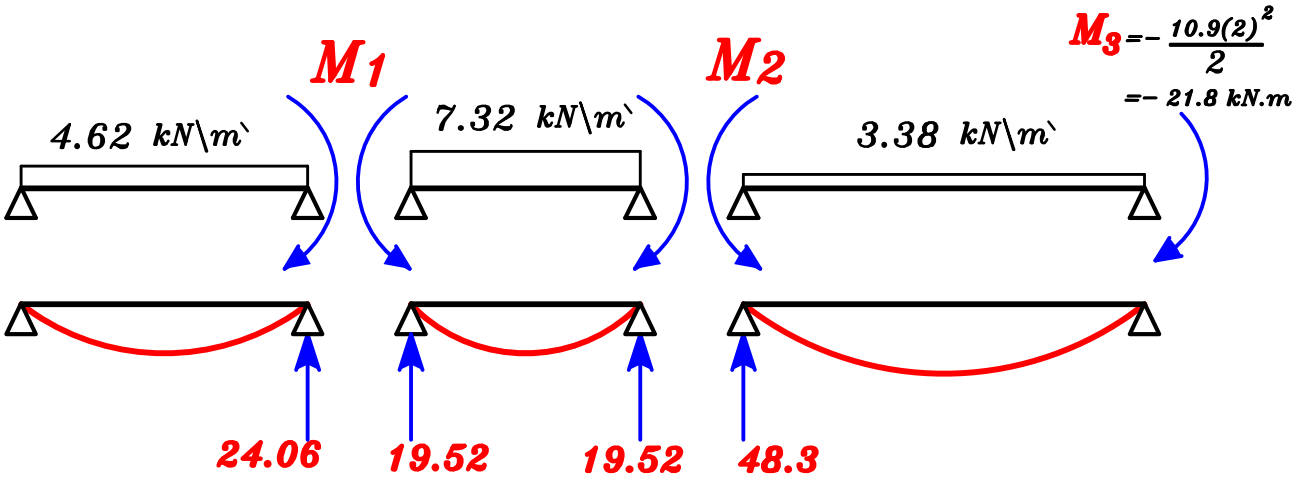




Strip (1)



using 3 moment eqn.



$* \quad 0 + 2M_1(5+4) + M_2(4) = -6(24.06 + 19.52)$

$18M_1 + 4M_2 = -261.48$ ------ (1)

$* \quad M_1(4) + 2M_2(4+7) - 21.8(7) = -6(19.52 + 48.3)$

$4M_1 + 22M_2 = -254.32$ ------ (2)

From (1), (2)

$M_1 = -12.46$

$M_2 = -9.29$

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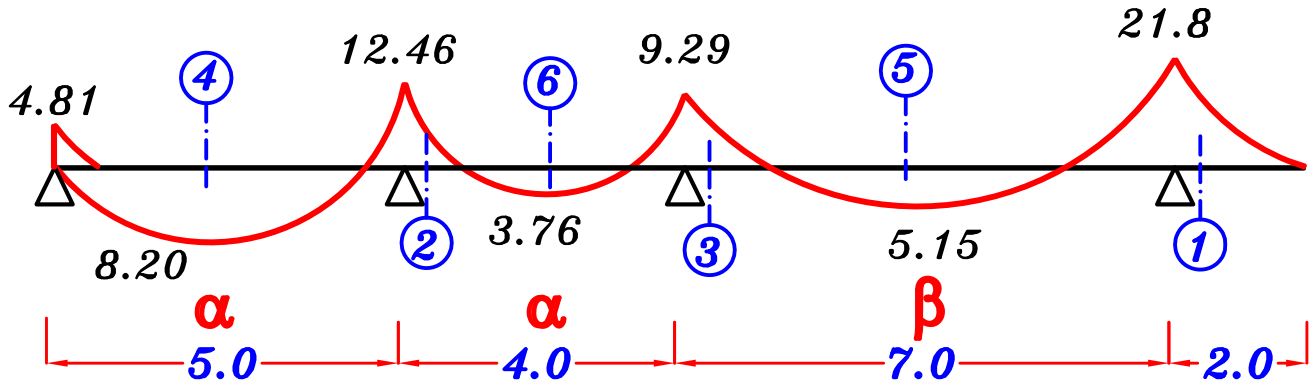

Sec. ①

$M_{U.L.} = 21.8 \ kN.m\backslash m$, $t_s = 160\ mm$, $d = 160 - 20 = 140\ mm$

$140 = C_1\sqrt{\frac{21.8 * 10^6}{25 * 1000}} \longrightarrow C_1 = 4.74 \longrightarrow J = 0.824$

$A_S = \frac{21.8 * 10^6}{0.824 * 360 * 140} = 525 \ mm^2/m$ → **7 ϕ 10 \ m**

Sec. ②

$M_{U.L.} = 12.46 \ kN.m\backslash m$, $t_s = 160\ mm$, $d = 160 - 20 = 140\ mm$

$140 = C_1\sqrt{\frac{12.46 * 10^6}{25 * 1000}} \longrightarrow C_1 = 6.27 \longrightarrow J = 0.826$

$A_S = \frac{12.46 * 10^6}{0.826 * 360 * 140} = 299 \ mm^2/m$ → **5 ϕ 10 \ m**

Sec. ③

$M_{U.L.} = 9.29 \ kN.m\backslash m$, $t_s = 160\ mm$, $d = 160 - 20 = 140\ mm$

$140 = C_1\sqrt{\frac{9.29 * 10^6}{25 * 1000}} \longrightarrow C_1 = 7.26 \longrightarrow J = 0.826$

$A_S = \frac{9.29 * 10^6}{0.826 * 360 * 140} = 223 \ mm^2/m$ → **5 ϕ 10 \ m**

Sec. ④ & Sec. ⑥ α direction

$t_s = 160\ mm$, $d = 160 - 20 = 140\ mm$

$\because M_{U.L.} < 9.29 \ kN.m\backslash m$ $\therefore A_S =$ **5 ϕ 10 \ m**

Sec. ⑤ β direction

$M_{U.L.} = 5.15 \ kN.m\backslash m$, $t_s = 160\ mm$, $d = 160 - 30 = 130\ mm$

$130 = C_1\sqrt{\frac{5.15 * 10^6}{25 * 1000}} \longrightarrow C_1 = 9.057 \longrightarrow J = 0.826$

$A_S = \frac{5.15 * 10^6}{0.826 * 360 * 130} = 133.2 \ mm^2/m$ → **5 ϕ 10 \ m**

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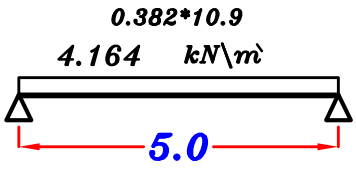
Strip (2)

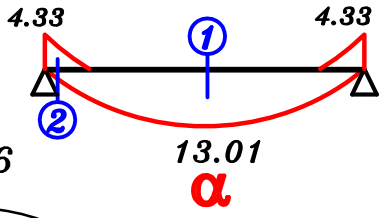


Sec. ① α direction

$M_{U.L.} = 13.01\ kN.m\backslash m$

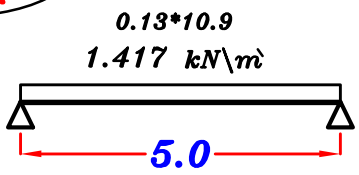
$, t_s = 160\ mm\ ,\ d = 160 - 20 = 140\ mm$

$140 = C_1\sqrt{\frac{13.01*10^6}{25*1000}} \longrightarrow C_1 = 6.137 \longrightarrow J = 0.826$



$A_S = \frac{13.01*10^6}{0.826*360*140} = 312.5\ mm^2/m`$ → 5 ϕ 10 \m`

Strip (3)

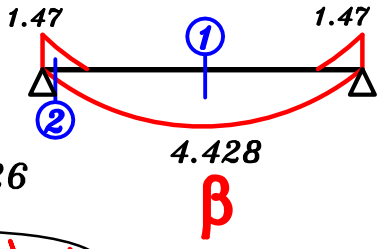


Sec. ① β direction

$M_{U.L.} = 4.428\ kN.m\backslash m$

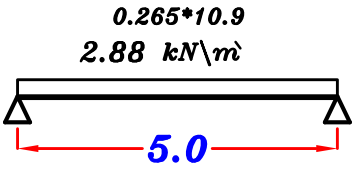
$, t_s = 160\ mm\ ,\ d = 160 - 30 = 130\ mm$

$130 = C_1\sqrt{\frac{4.428*10^6}{25*1000}} \longrightarrow C_1 = 9.76 \longrightarrow J = 0.826$



$A_S = \frac{4.428*10^6}{0.826*360*130} = 114.5\ mm^2/m`$ → 5 ϕ 10 \m`

Strip (4)

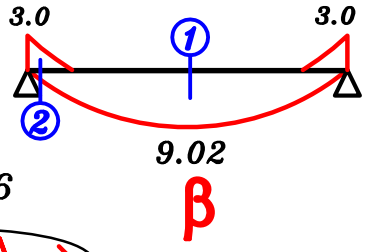


Sec. ① β direction

$M_{U.L.} = 9.02\ kN.m\backslash m$

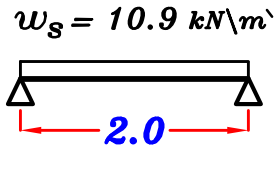
$, t_s = 160\ mm\ ,\ d = 160 - 30 = 130\ mm$

$130 = C_1\sqrt{\frac{9.02*10^6}{25*1000}} \longrightarrow C_1 = 6.844 \longrightarrow J = 0.826$



$A_S = \frac{9.02*10^6}{0.826*360*130} = 233\ mm^2/m`$ → 5 ϕ 10 \m`

Strip (5)

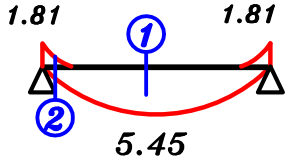


Sec. ① One Way

$M_{U.L.} = 5.45\ kN.m\backslash m$

$, t_s = 160\ mm\ ,\ d = 160 - 40 = 140\ mm$

$14.0 = C_1\sqrt{\frac{5.45*10^6}{25*1000}} \longrightarrow C_1 = 9.48 \longrightarrow J = 0.826$



$A_S = \frac{5.45*10^6}{0.826*360*140} = 130.9\ mm^2/m`$ → 5 ϕ 10 \m`

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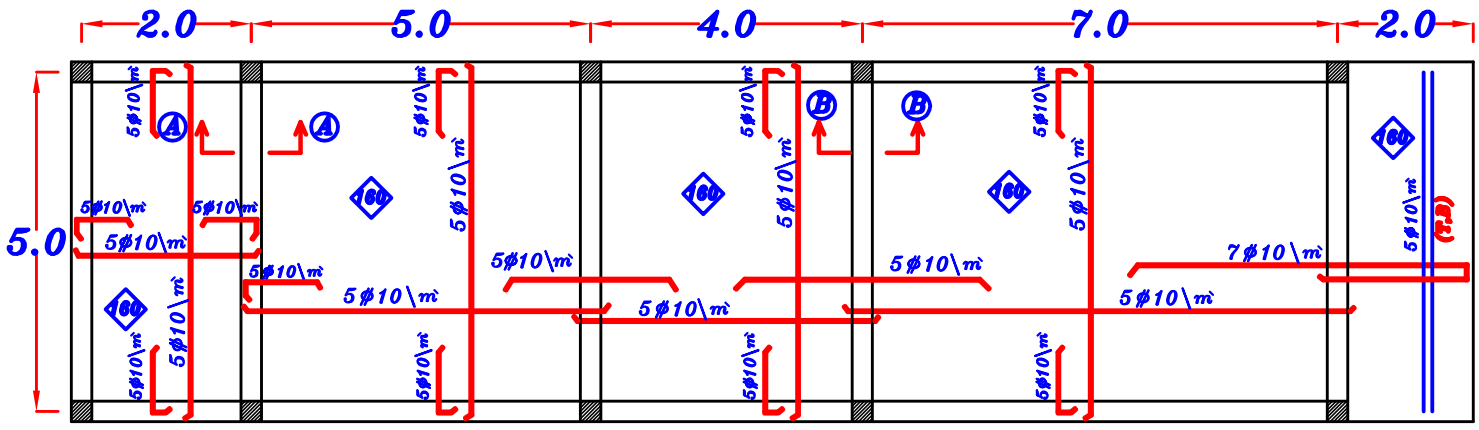
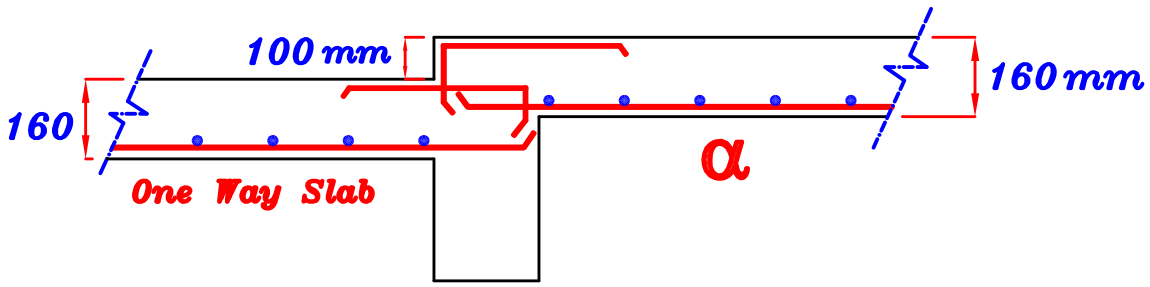
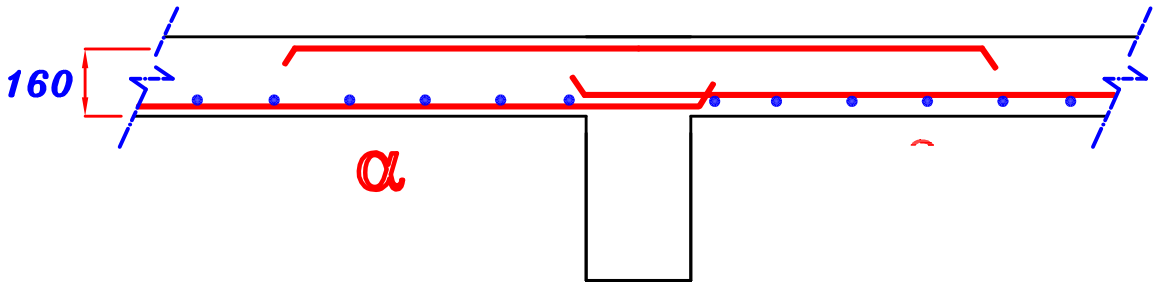




Sec. (A– A)



Sec. (B– B)

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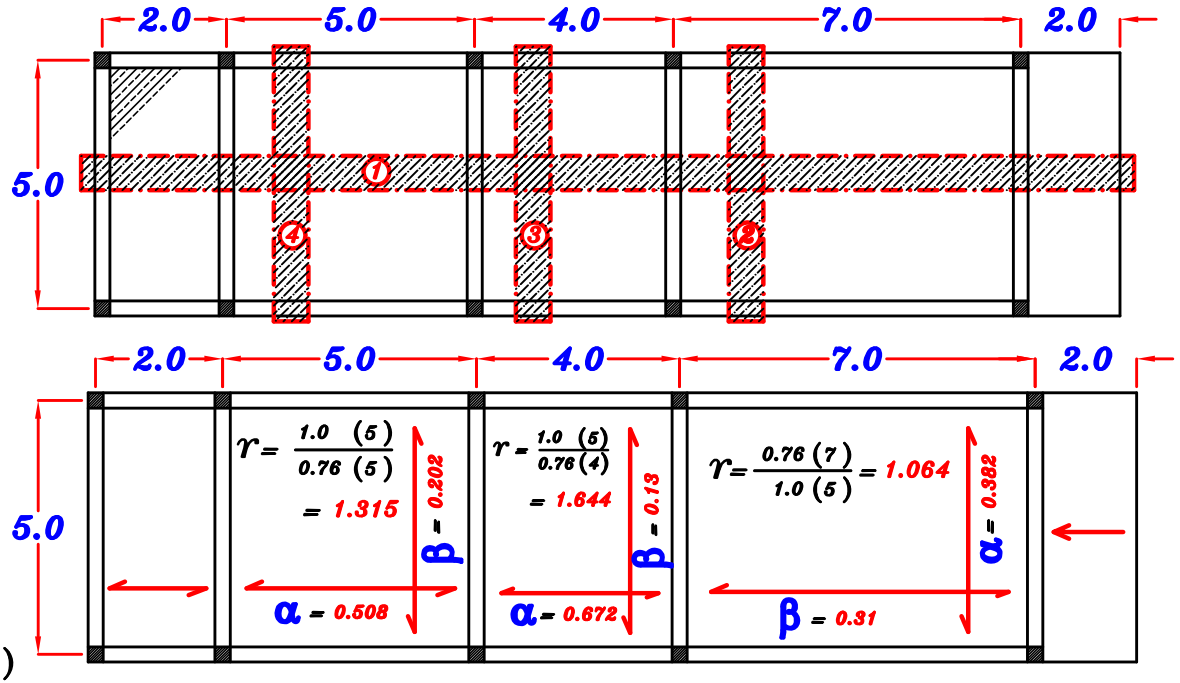
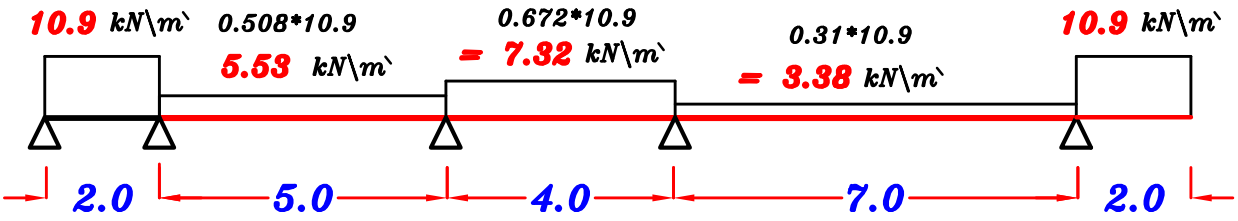
حل أخر

ممكن أخذ بلاطه الحمام *Continuos* مع باقى بلاطات المبنى

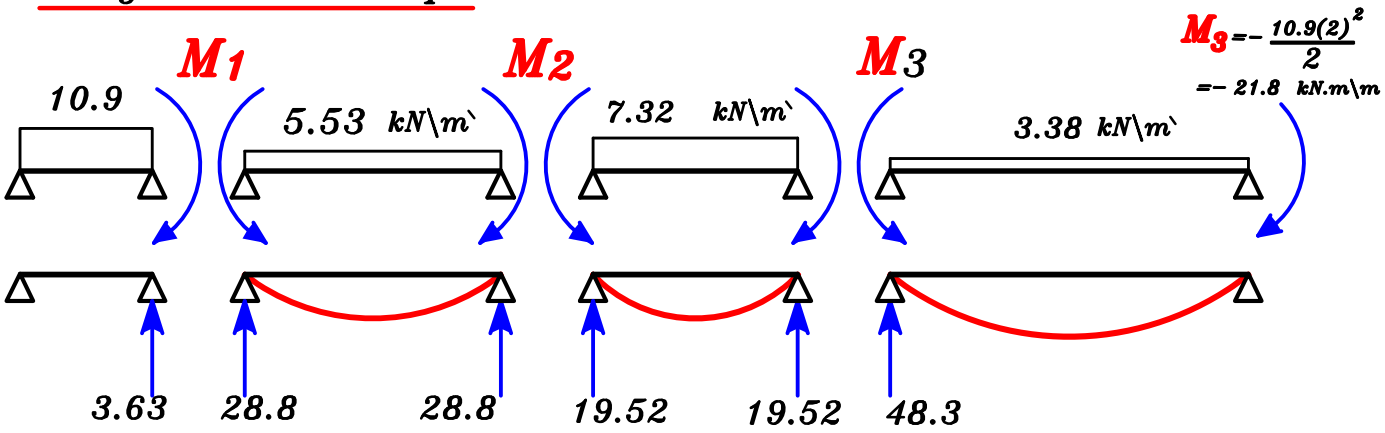
و الشرط لكى تكون البلاطات *Continuos* أن نكمل الـ *RFT.* (*−ve*) بين البلاطتين



Strip (1)



using 3 moment eqn.



$* \quad 0 + 2M_1(5+2) + M_2(5) = -6(3.63 + 28.8)$

$14M_1 + 5M_2 + 0.0\,M_3 = -194.58$ ——— ①

$* \quad M_1(5) + 2M_2(5+4) + M_3(4) = -6(28.8 + 19.52)$

$5M_1 + 18M_2 + 4M_3 = -289.92$ ——— ②

$* \quad M_2(4) + 2M_3(4+7) + (-21.8)(7) = -6(19.52 + 48.3)$

$4M_2 + 22M_3 - 152.6 = -406.92$ ——— ③

From ①, ②, ③

$M_1 = -9.88$

$M_2 = -11.24$

$M_3 = -9.51$

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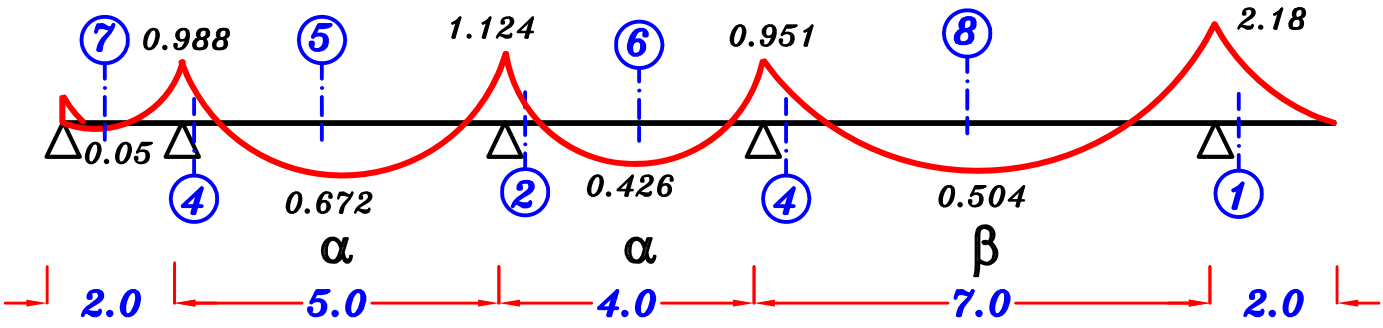
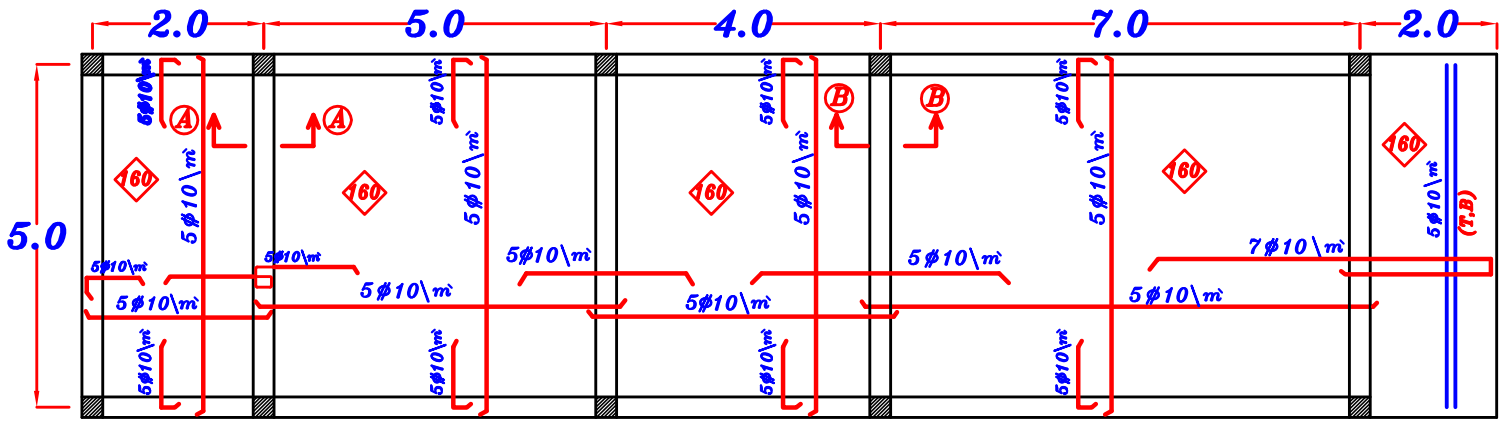
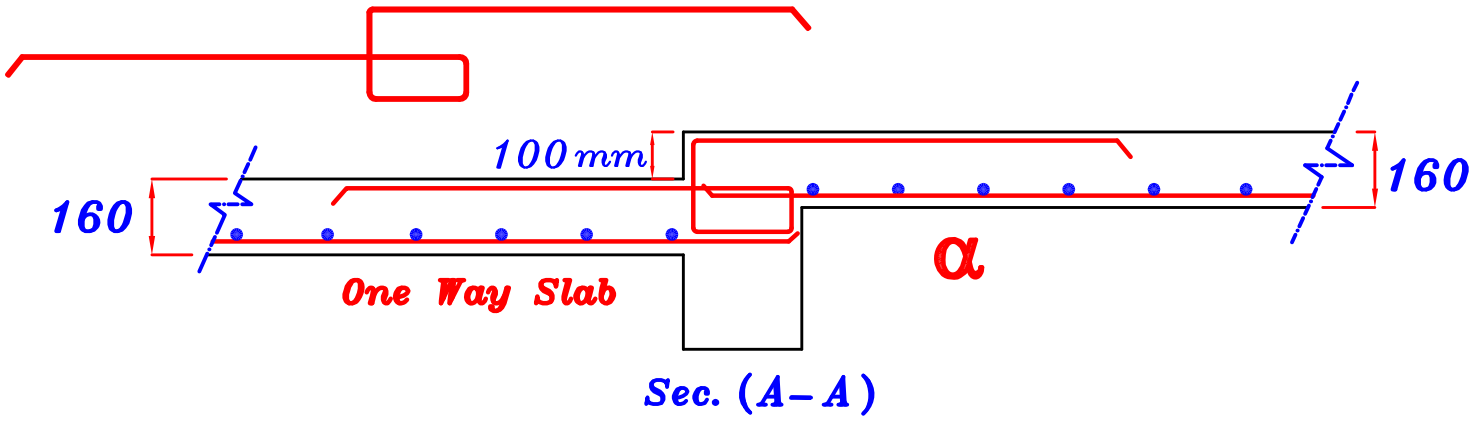
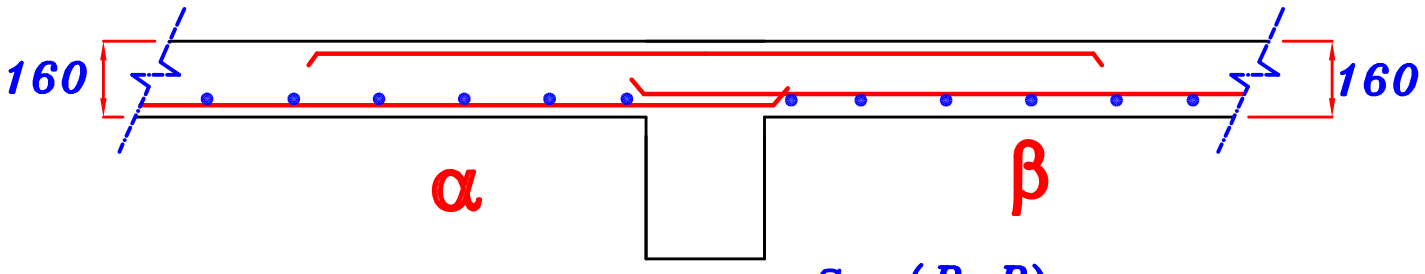






Sec. (A – A)



Sec. (B – B)

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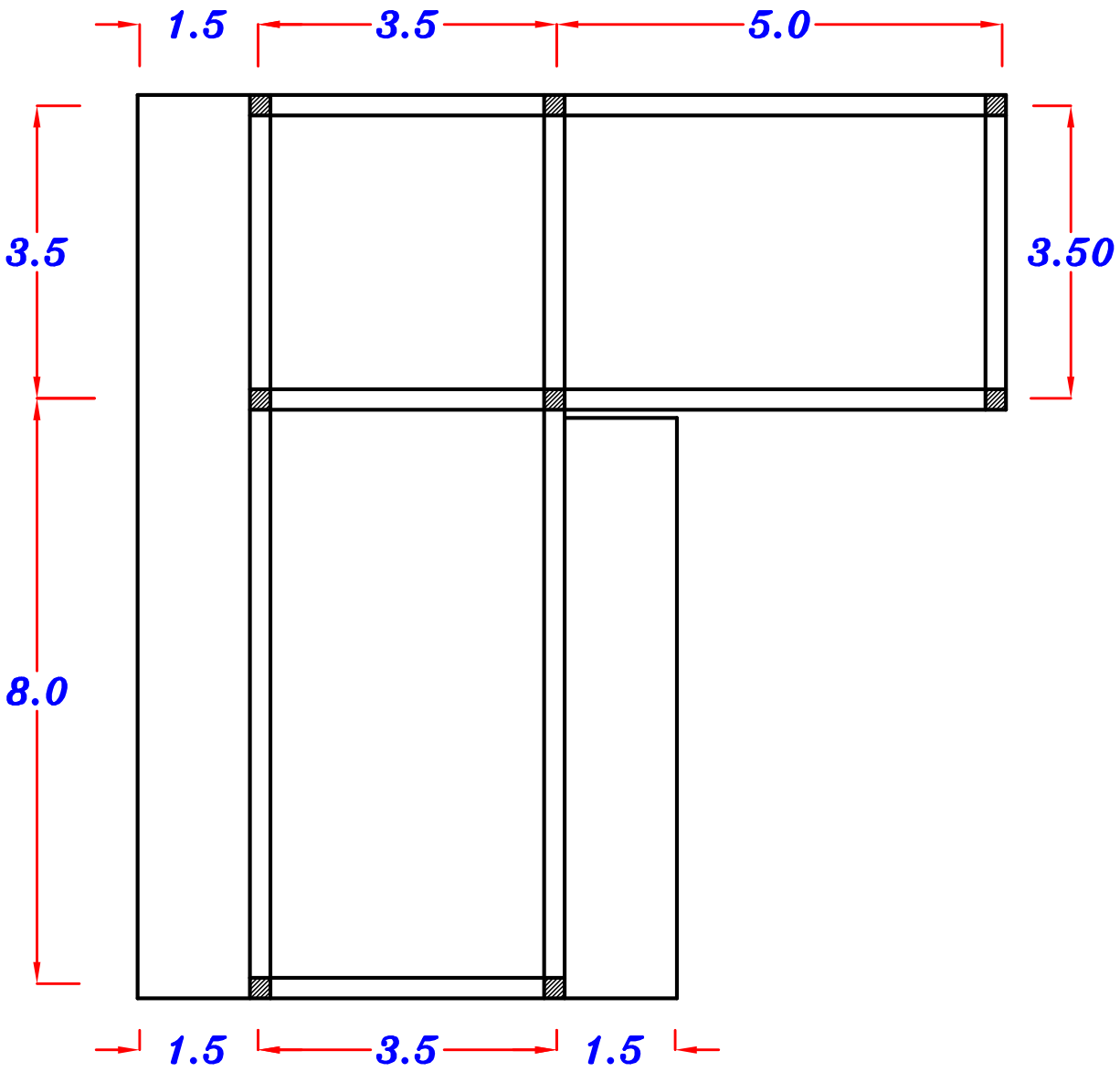
Example.



Data.

$F_{cu} = 25 \ N\backslash mm^2$ $F_y = 360 \ N\backslash mm^2$

$F.C. = 1.50 \ kN\backslash m^2$ $L.L. = 2.0 \ kN\backslash m^2$

Req.

① Design the Slab as Solid Slab.

② Draw Details of RFT. in plan.

③ IF the beam a b not exist
Design the Slab & Draw Details of RFT.

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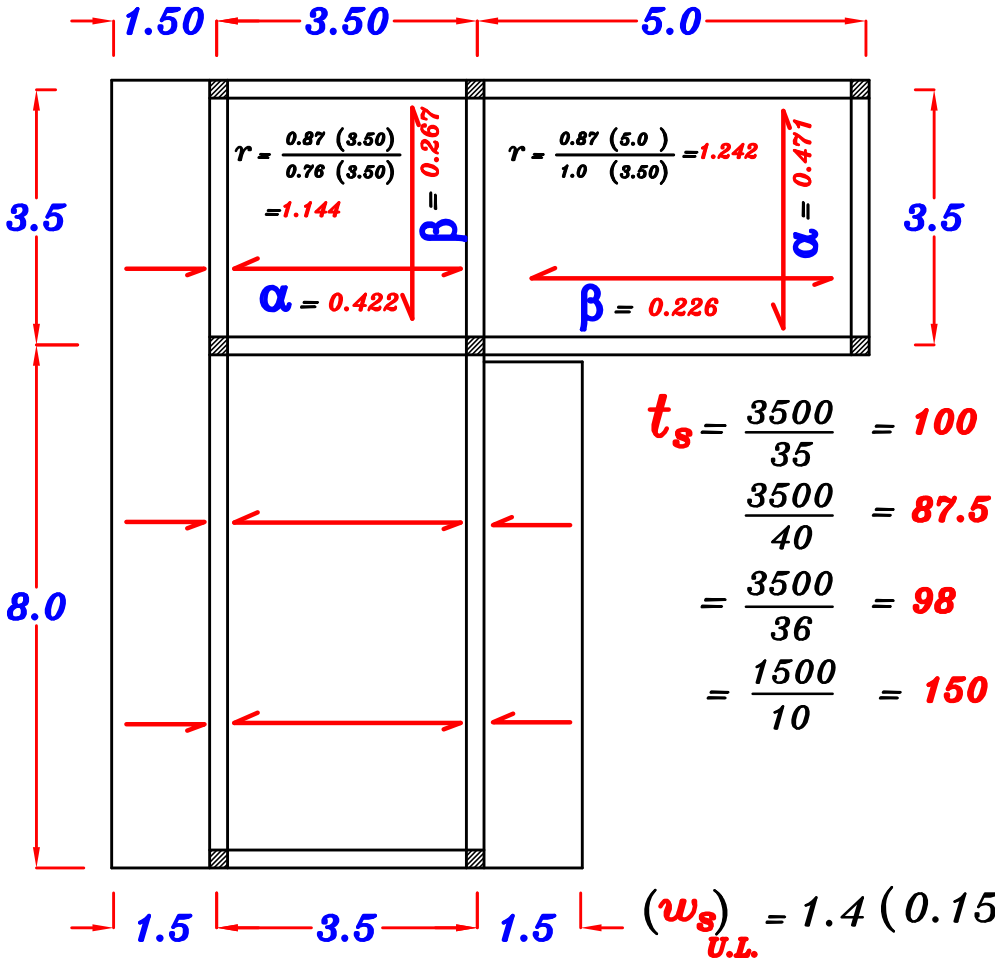


$$t_s = \frac{3500}{35} = 100 \text{ mm}$$

$$\frac{3500}{40} = 87.5 \text{ mm}$$

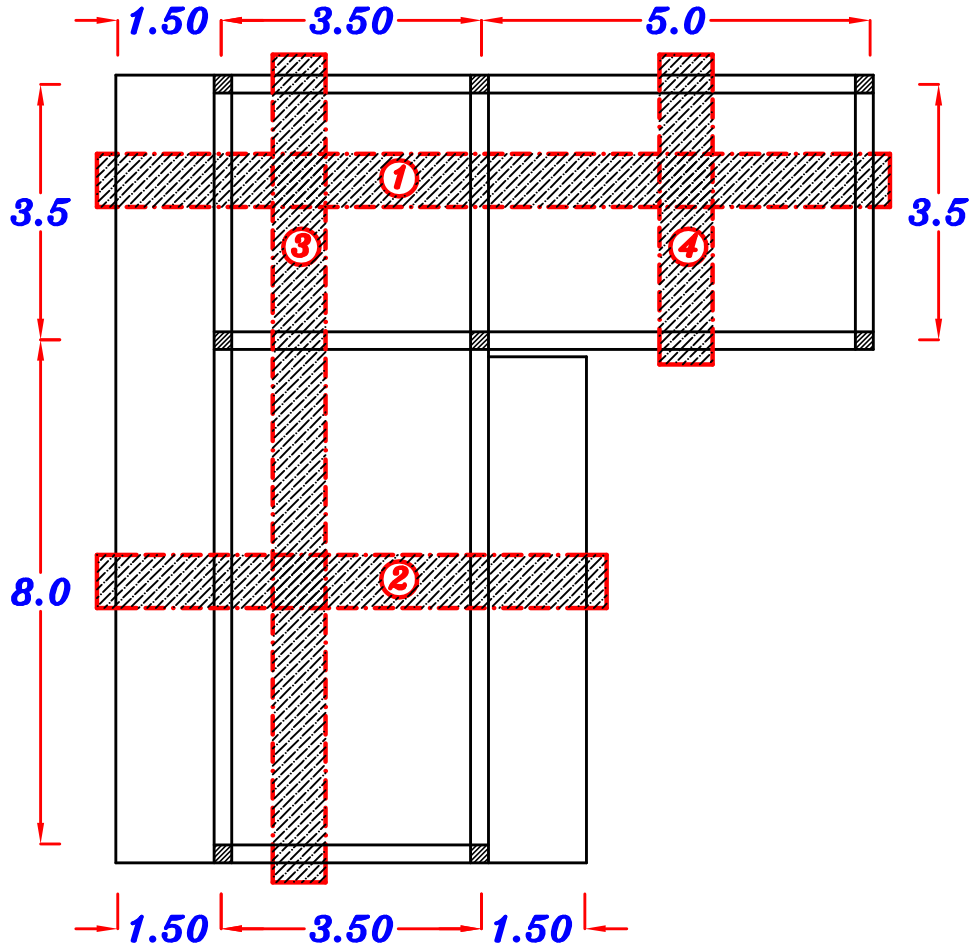
$$= \frac{3500}{36} = 98 \text{ mm}$$

$$= \frac{1500}{10} = 150 \text{ mm}$$

$$= 150 \text{ mm}$$

$$\boxed{t_s = 150 \text{ mm}}$$

$$(w_s)_{U.L.} = 1.4\,(0.15 * 25 + 1.50) + 1.6\,(2.0) = 10.55 \text{ kN/m}^2$$



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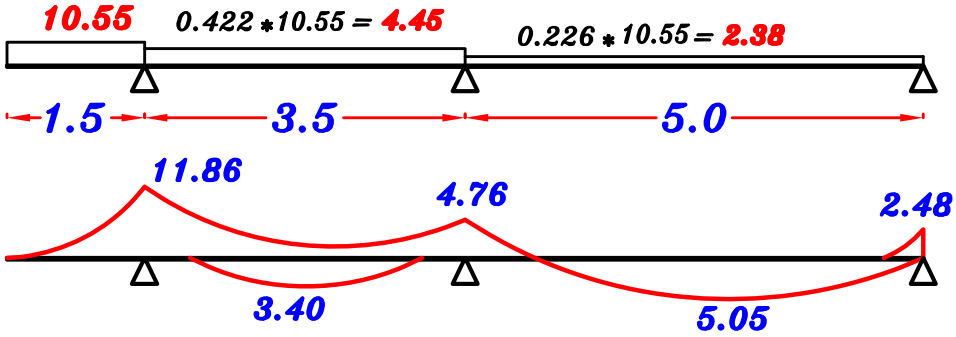
$$(w_s)_{U.L.} = 10.55 \ kN\backslash m^2$$

Strip (1)



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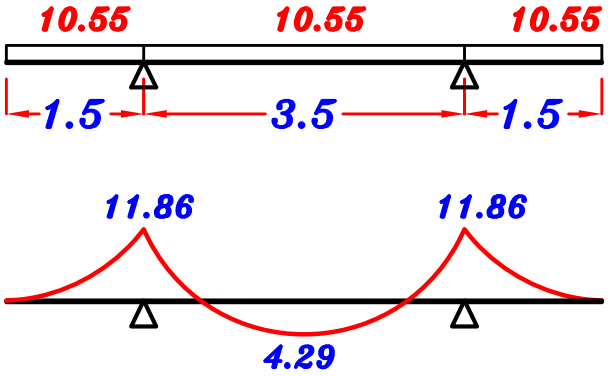

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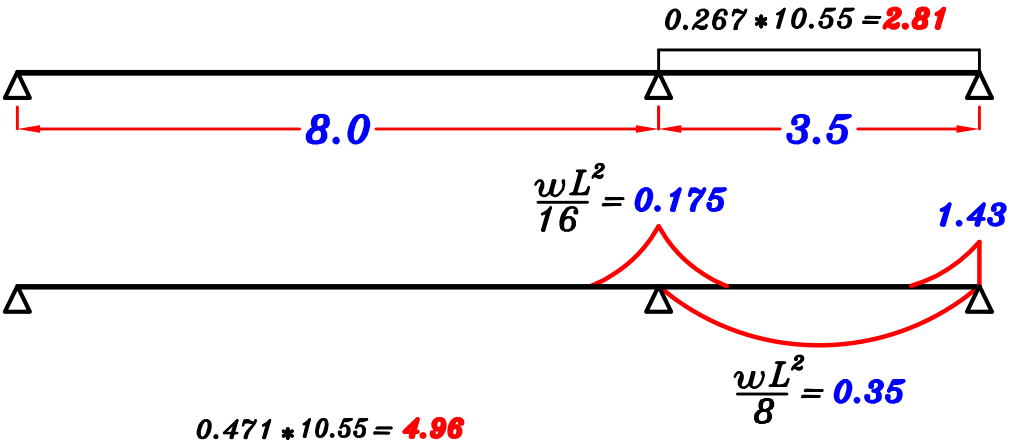
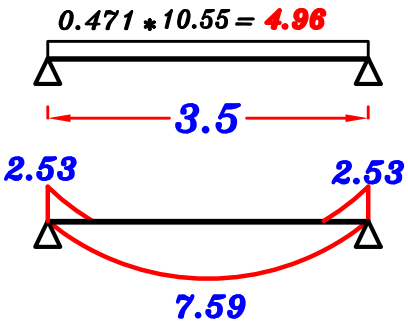


Strip (4)



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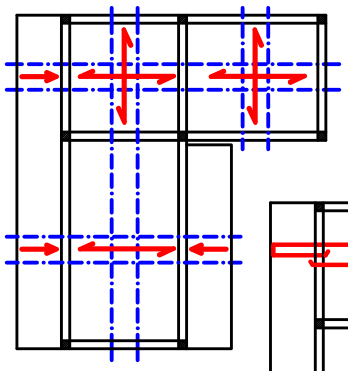
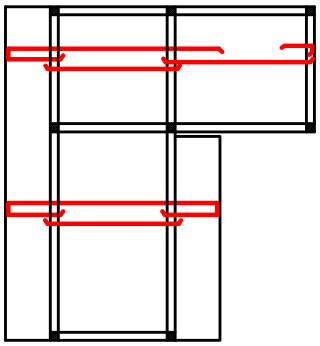
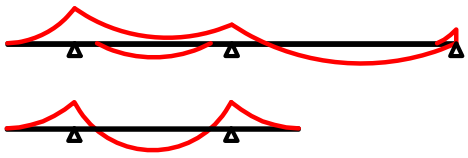
خطواط رسم تسليح البلاطات :



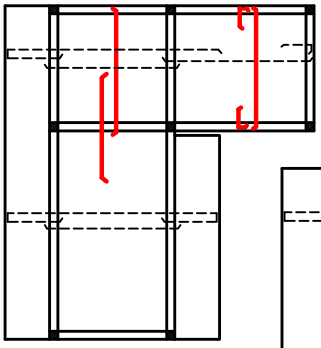
رسم أسهم للبلاطات *one way, two way or cantilever slabs*
و عمل الشرائح الافقيه و الرأسيه .

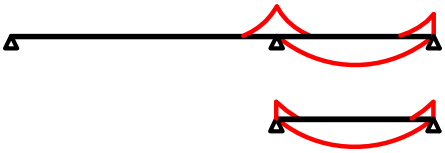
① نرسم تسليح الشرائح الافقيه .
حسب شكل العزوم فى الشرائح الافقيه .

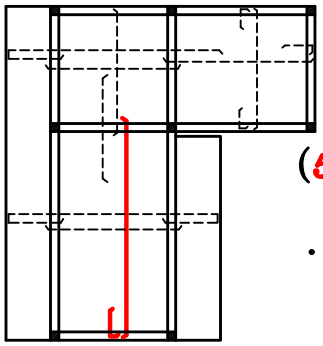




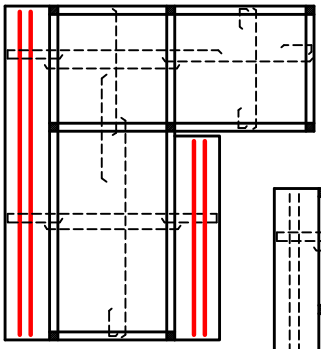
② نرسم تسليح الشرائح الرأسيه .
حسب شكل العزوم فى الشرائح الرأسيه .



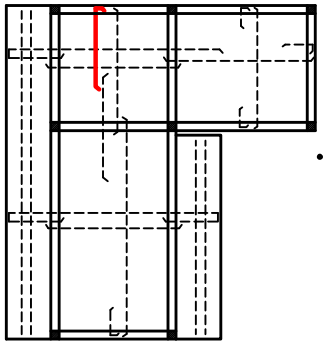




③ نرسم الـ (*Secondary Steel* 5Ø10\m`)
للشبكه السفليه فى البلاطات الـ *One Way* .



④ نرسم الـ (*Top & Bottom* 5Ø10\m`) لـ *Cantilevers*
إن وجدت .



⑤ نرسم بقيه الشبكه العلويه فى الباكيه
اذا كان الـ *moment* على كل الباكيه .

نرسم بقيه الشبكه العلويه اذا كانت تخانه البلاطه أكبر من ١٦٠ مم .

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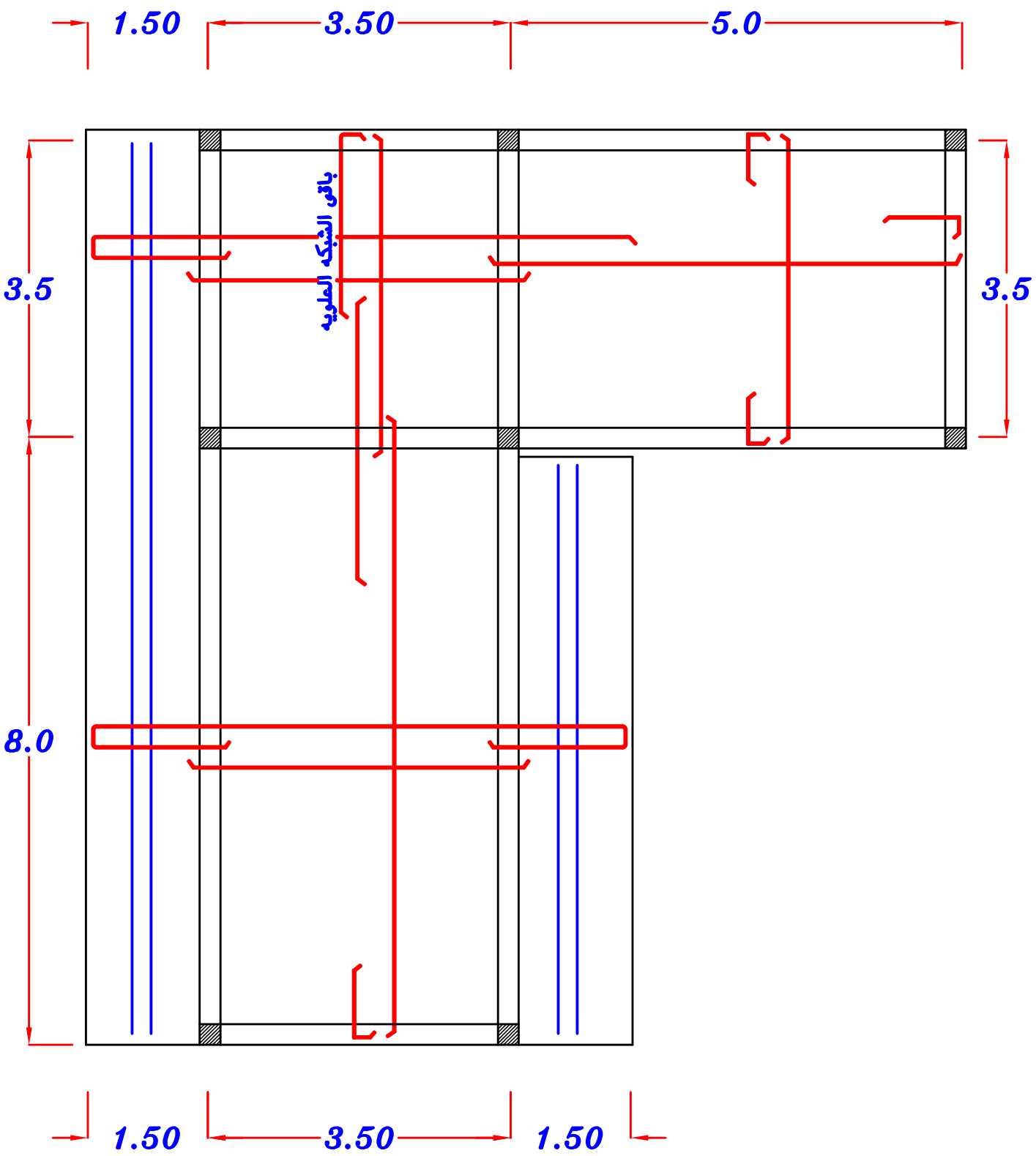
RFT. of the Slab.



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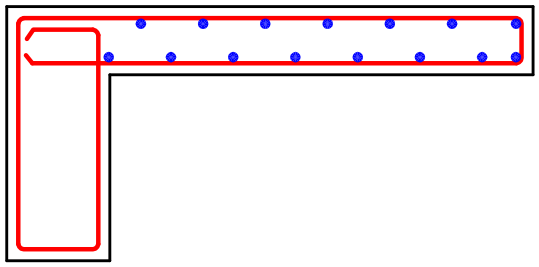
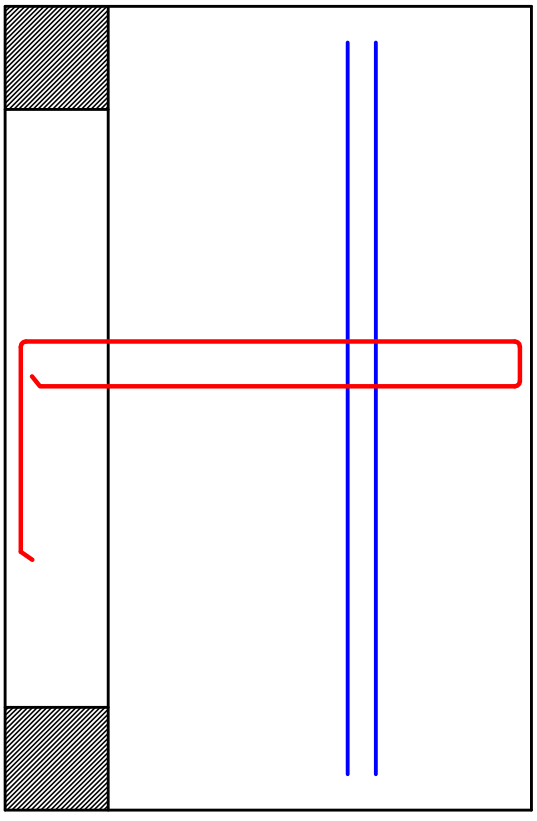
Special Case.

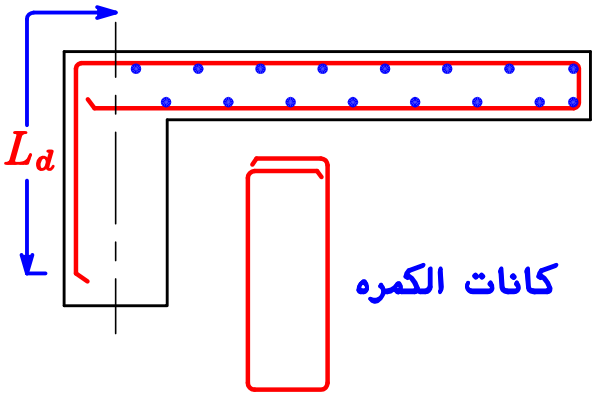
اذا كانت شريحه البلاطه محموله على كمره واحده فقط
تعمل Torsion على الكمره ، فيكون التسليح كالاتى ·

الحل الاول ✓✓





الحل الثانى



ملحوظه
كانات الكمره لا تظهر فى ال plan

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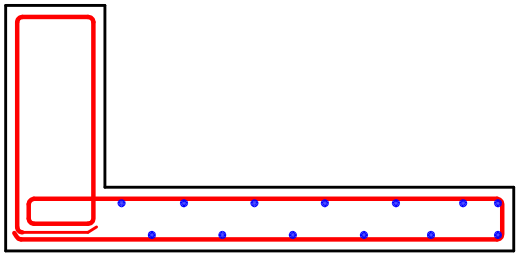
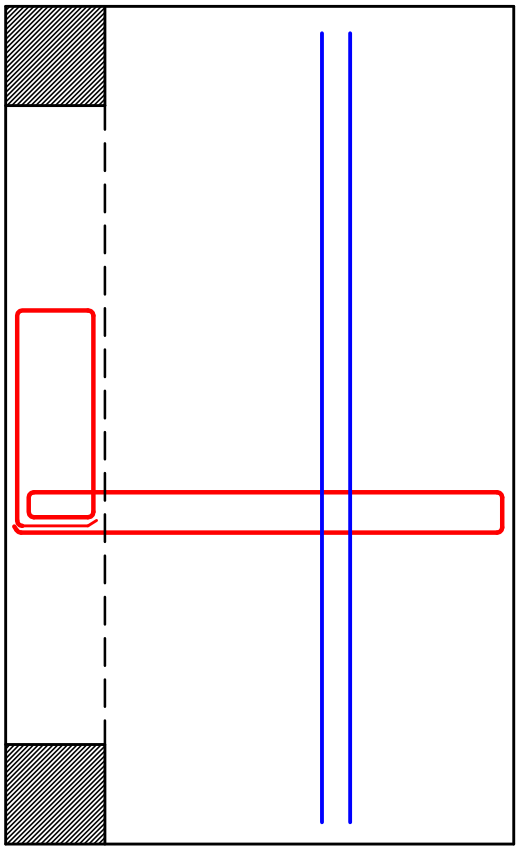
Special Case.

اذا كانت الكمره مقلوبه و البلاطه محموله على كمره واحده
يجب عمل فيونكه فى التسليح حتى لا يكسر الـ cover

الحل الاول ✓✓

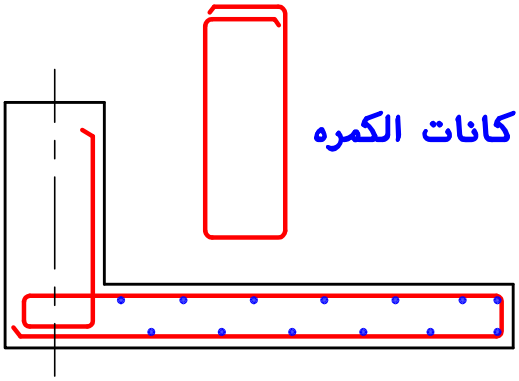
يكون تسليح البلاطه هو نفس
كانات الكمره

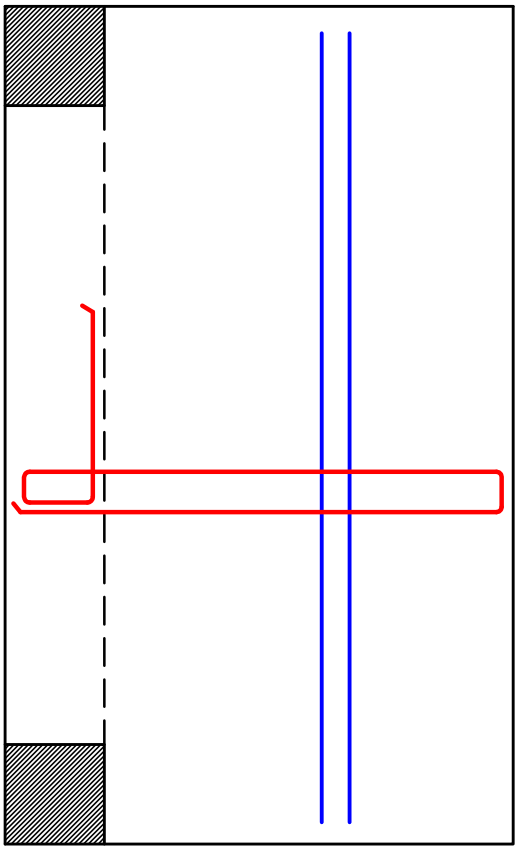




الحل الثانى

يكون تسليح البلاطه
غير كانات الكمره





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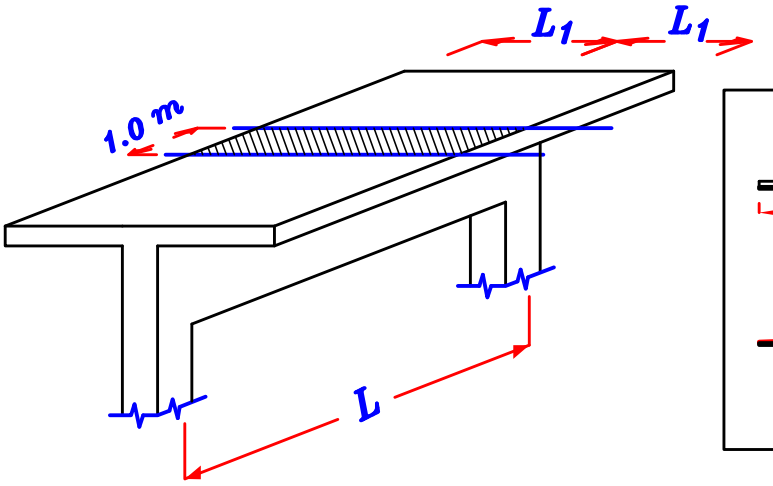
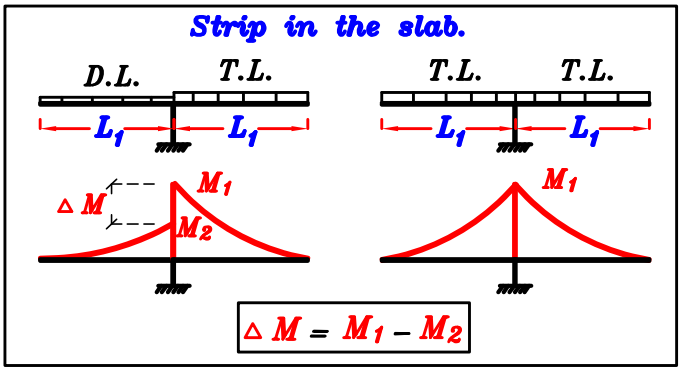
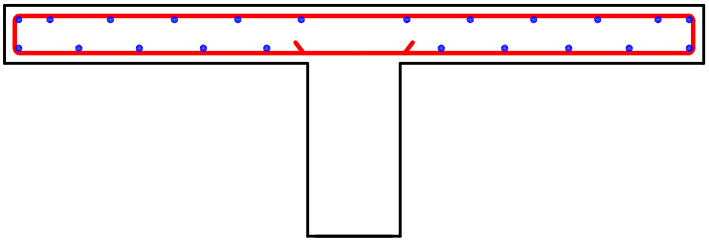
Special Case.

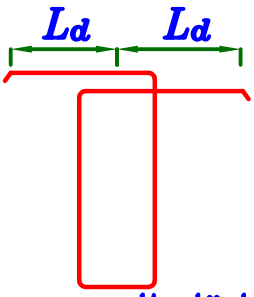
عند وجود *Double Cantilever* متساويه فى الطول
نعمل حالات تحميل فنضع *T.L.* على أى منهما



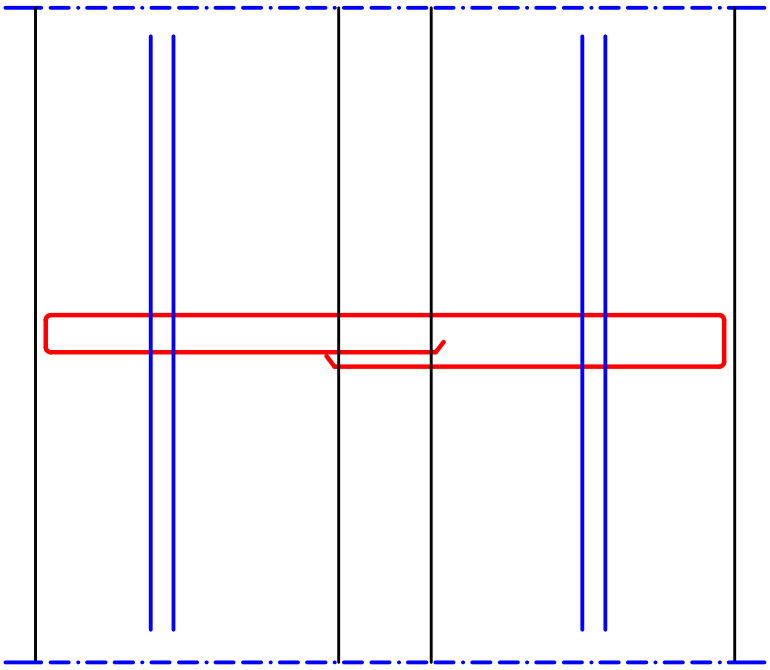


يكون تسليح البلاطتين نفس السيخ
و نضع كانات كما بالشكل للربط بين البلاطه و الكمره





كانه لنقل العزم
من البلاطه الى الكمره



ملحوظه
كانات الكمره لا تظهر
فى الـ *plan*

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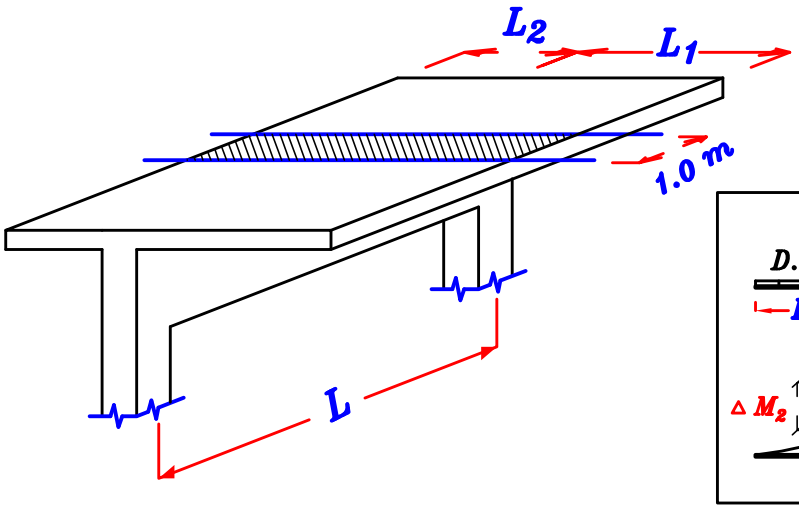
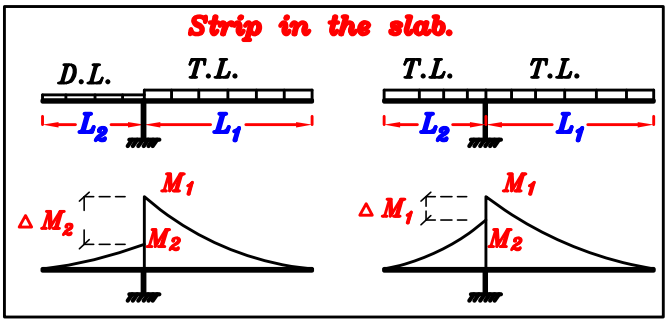
Special Case.

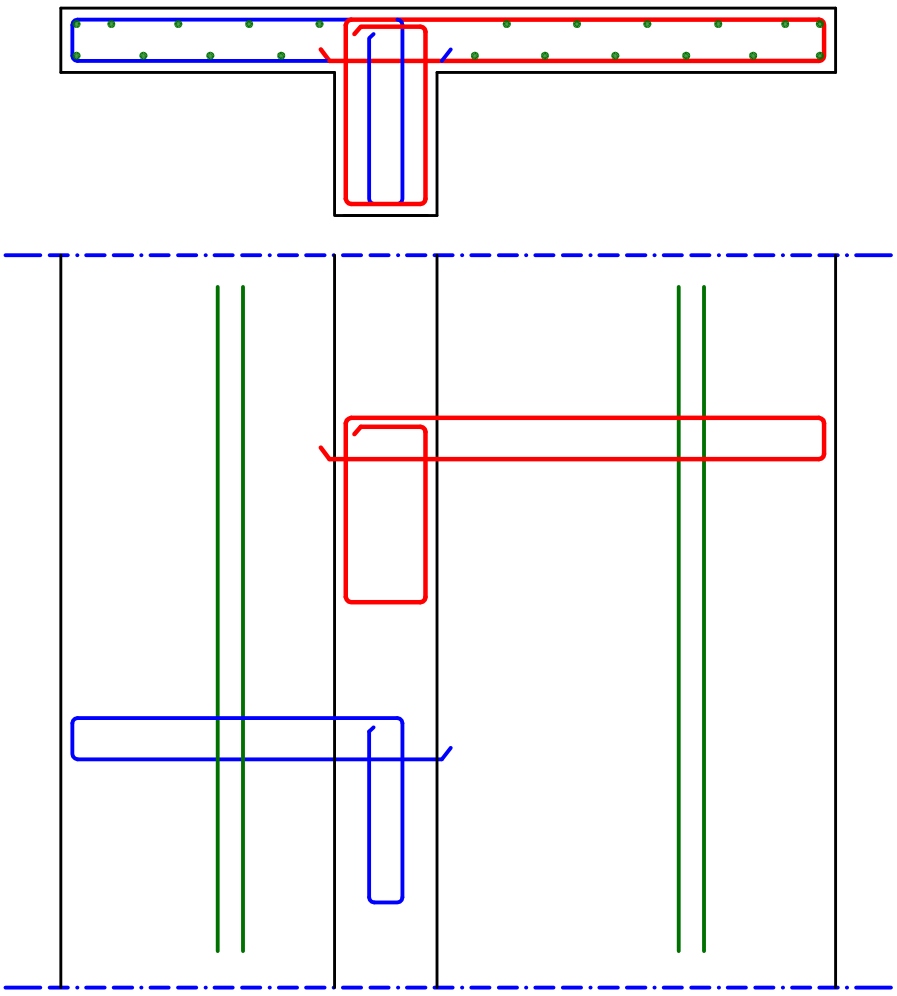
عند وجود *Double Cantilever* غير متساويه فى الطول

نعمل حالات تحميل فنضع *T.L.* على الـ *Cantilever* الاطول





يكون تسليح البلاطه هو نفس كانات الكمره كالاتى



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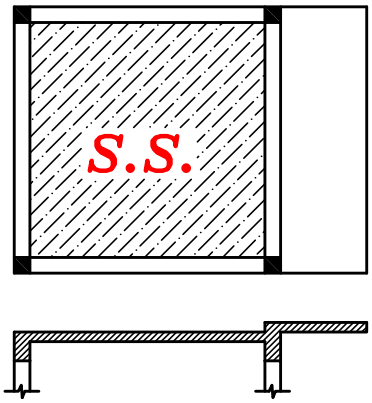
Special Case.

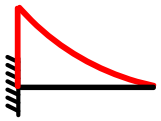


إذا وجد كابولى بجوار بلاطه الحمام
يكون منسوبه أعلى من منسوب بلاطه الحمام بـ ١٠ سم

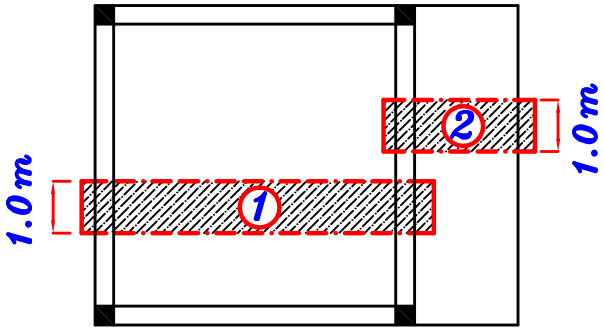
يوجد طريقتين للتسليح :

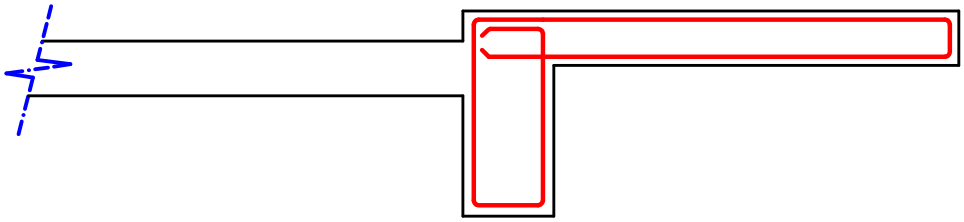
① نأخذ كل شريحه بمفردها
فيكون هناك Torsion على الكمره

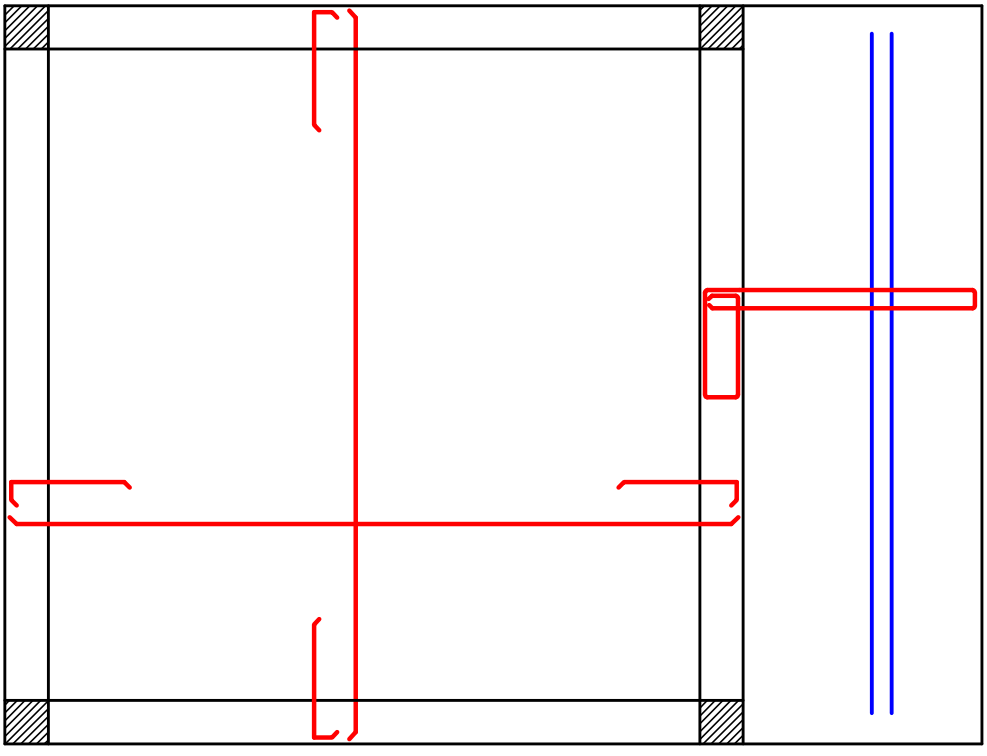
Strip ①



Strip ②







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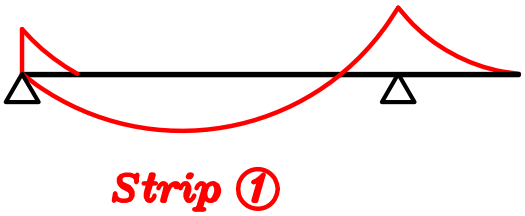
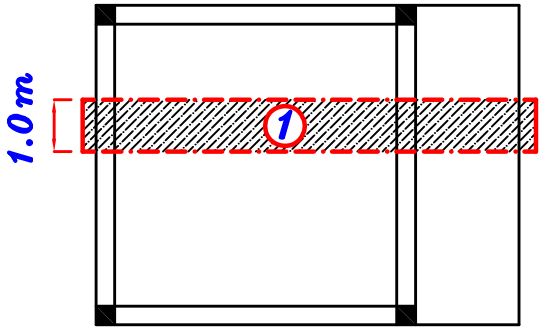
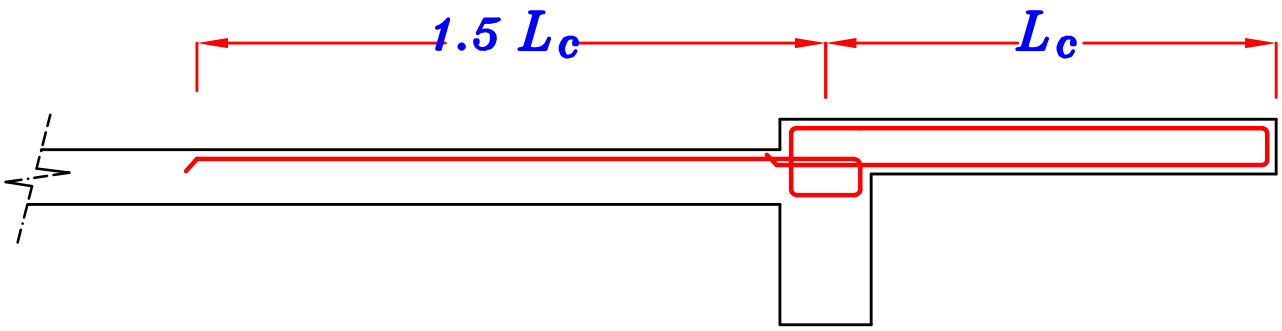
② نأخذ شريحه على البلاطه و الكابولى معا

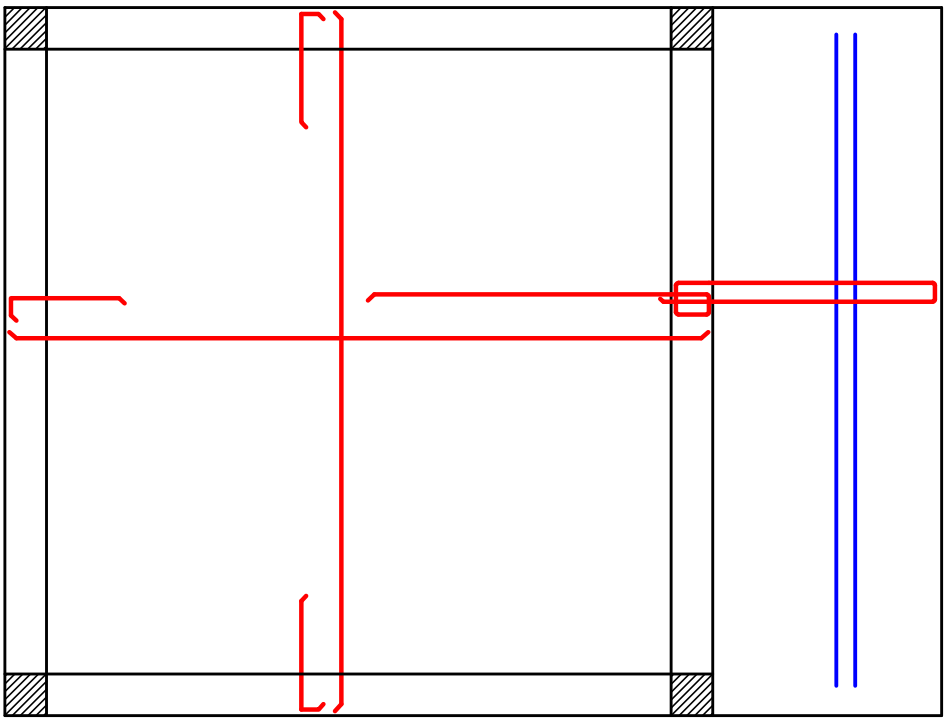
فتكون محموله على أكثر من *one support* فلا يتكون *Torsion* على الكمره



Strip ①







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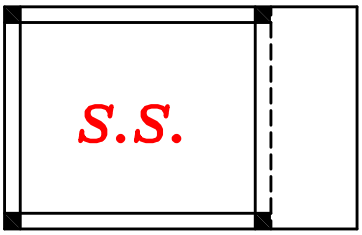
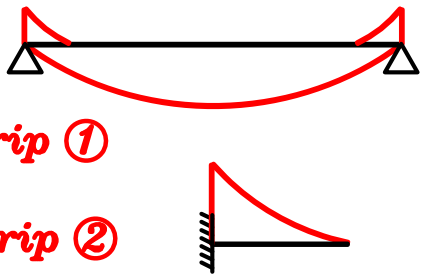
Special Case.

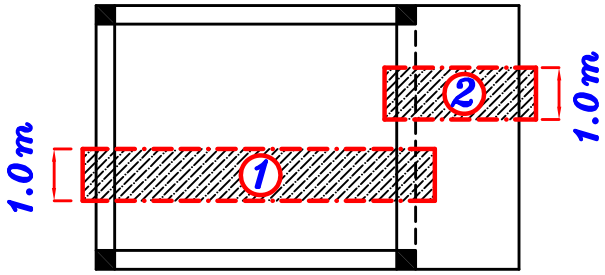


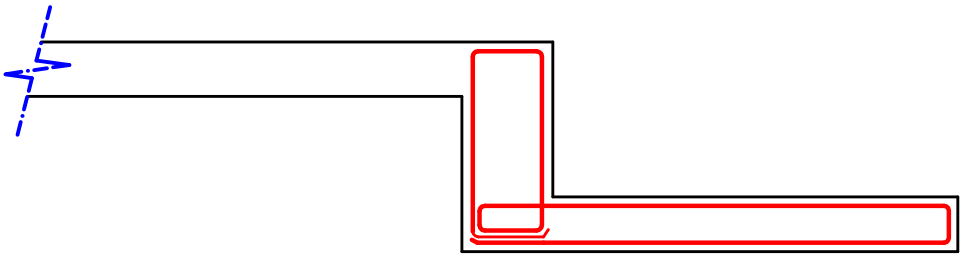
إذا وجد كابولى سفلى كما بالشكل

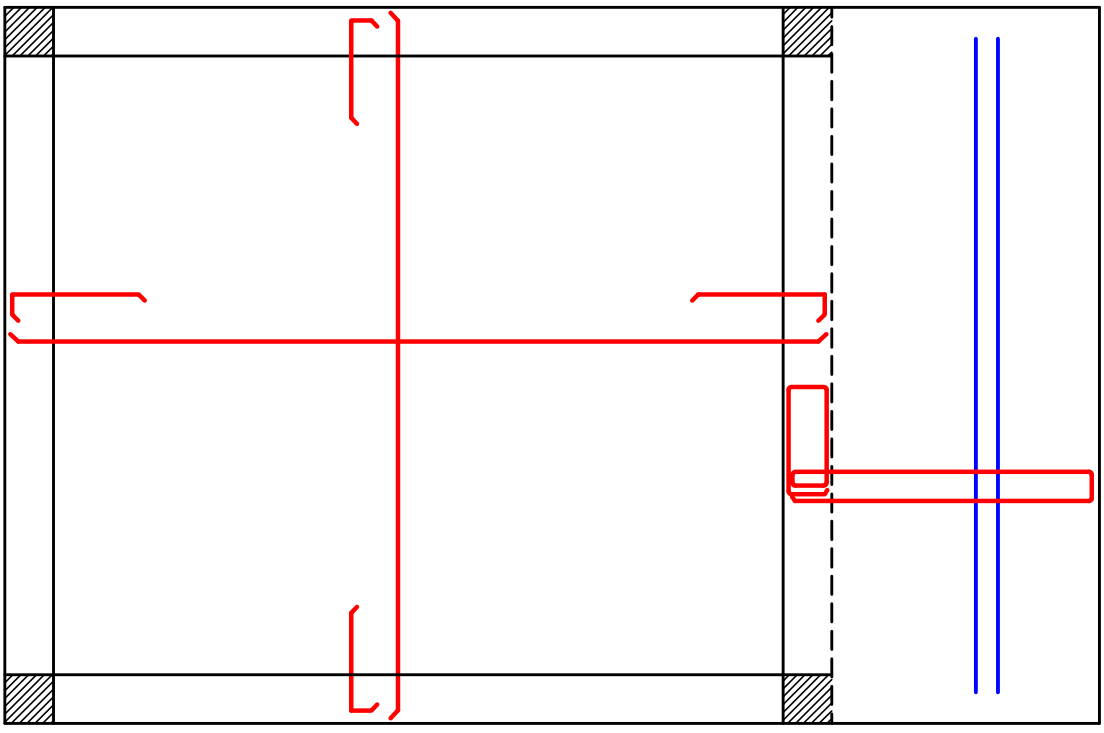
يوجد طريقتين للتسليح :

① نأخذ كل شريحه بمفردها
فيكون هناك Torsion على الكمره









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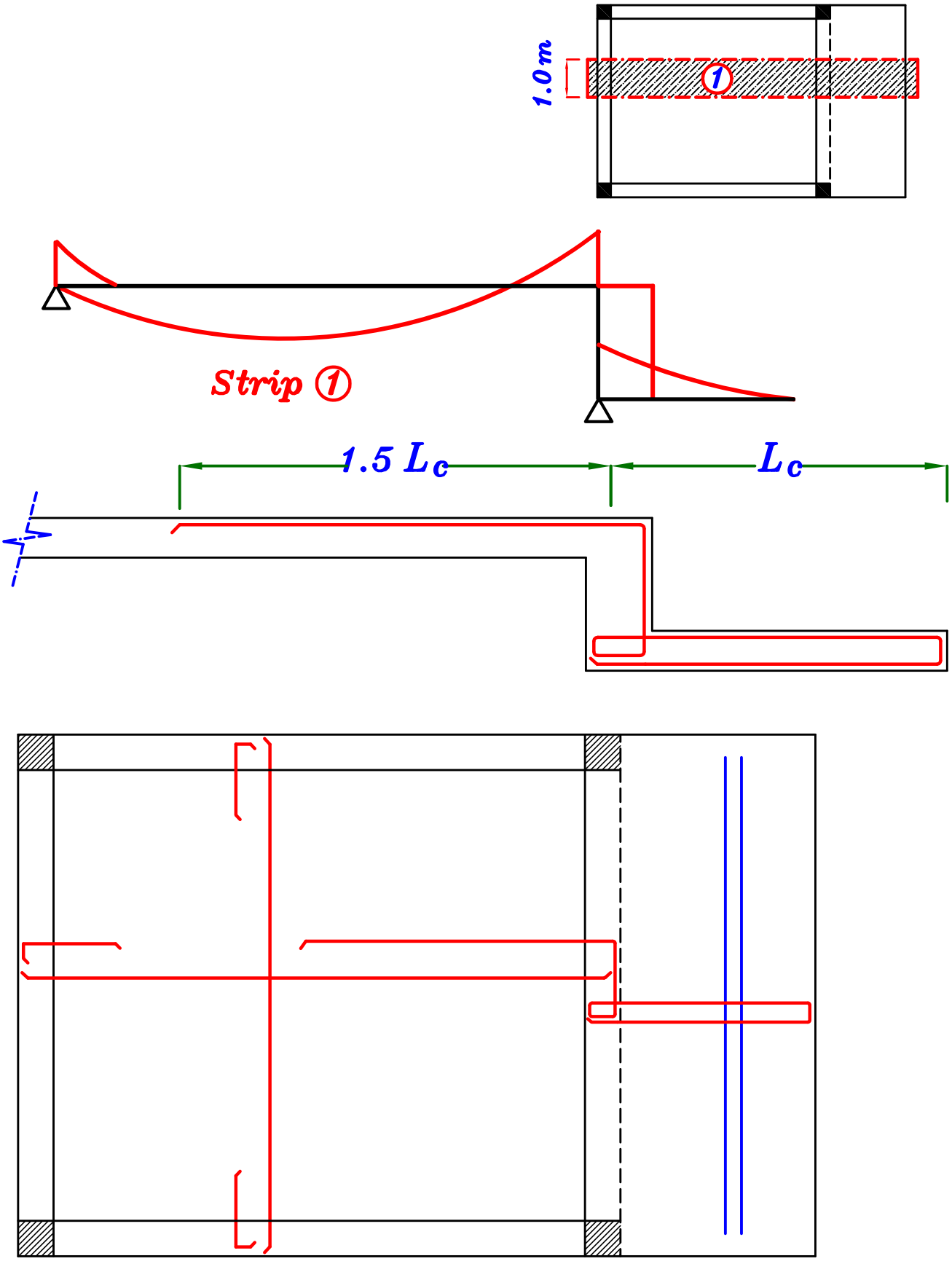
② نأخذ شريحه على البلاطة و الكابولى معا

فتكون محمولة على أكثر من *one support* فلا يتكون *Torsion* على الكمره



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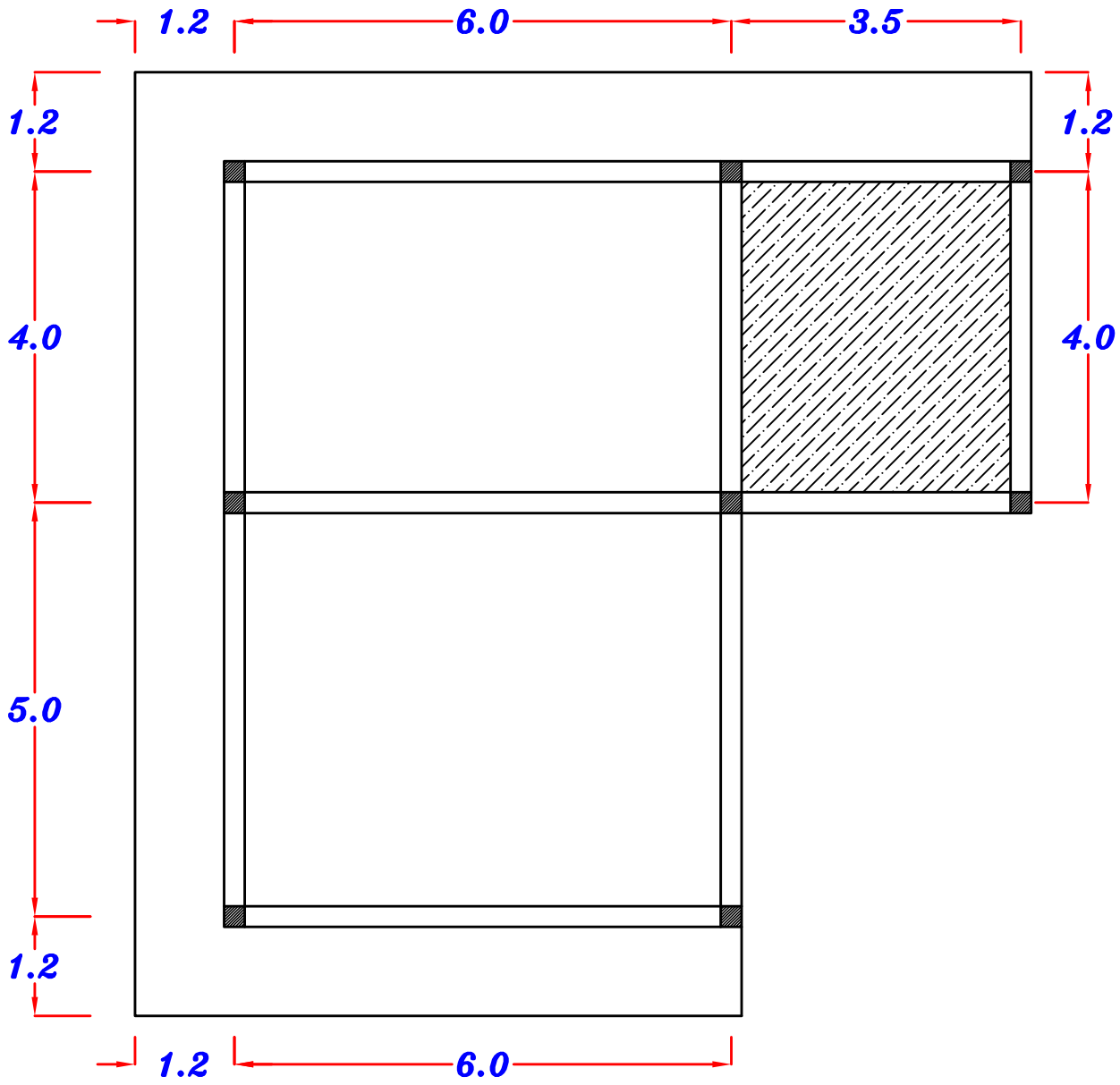
Example.



Data.

F_{cu} = 25 $N\backslash mm^2$ F_y = 360 $N\backslash mm^2$

F.C. = 1.50 $kN\backslash m^2$ L.L. = 2.0 $kN\backslash m^2$

Req.

① Design the Slab as Solid Slab.

② Draw Details of RFT. in plan.

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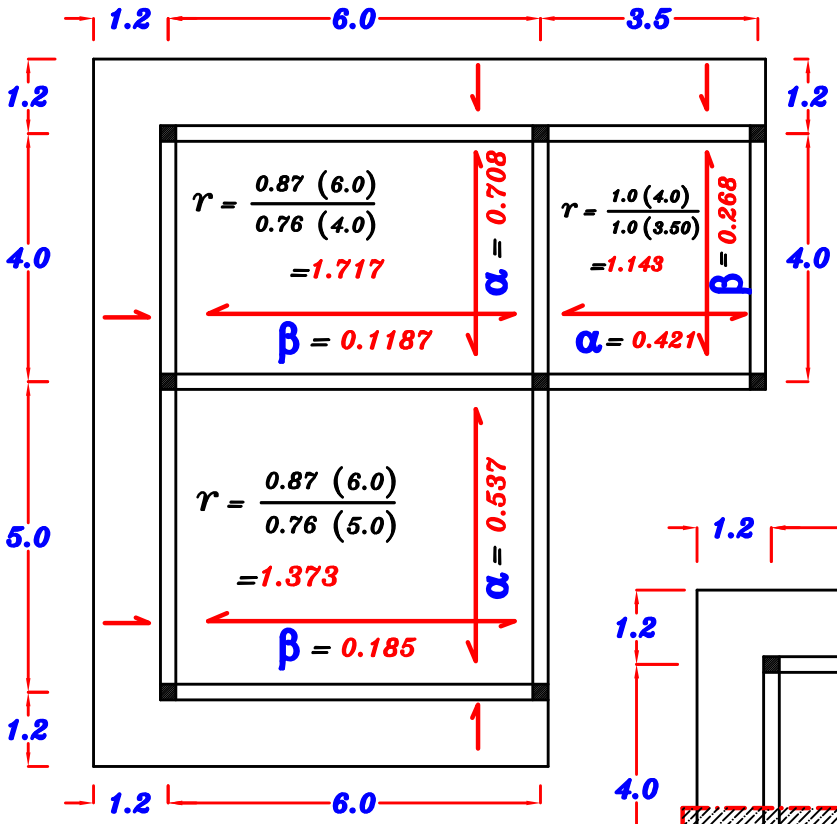
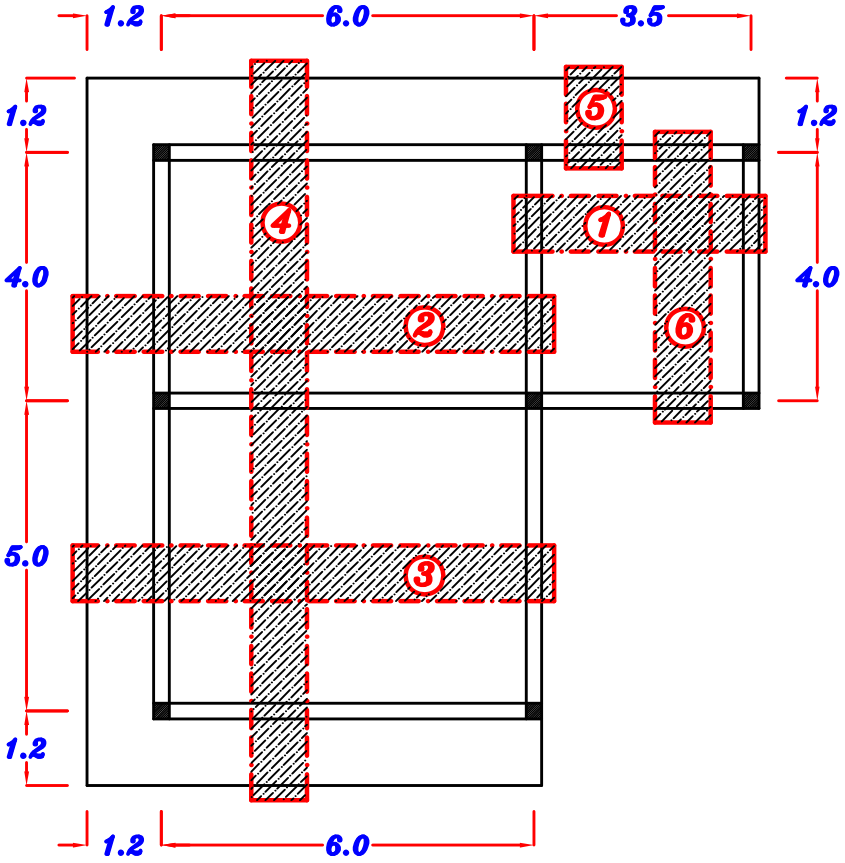
لان بلاطة الحمام فى مستوى مختلف عن باقى البلاطات
لذا فمن الممكن اعتبار بلاطة الحمام منفصلة عن باقى البلاطات
و تعامل بلاطة الحمام على أنها *Simple* من جميع الجهات .

$$t_s = \frac{3500}{35} = 100\ mm$$
$$= \frac{4000}{45} = 88.8\ mm$$
$$= \frac{5000}{45} = 111.1\ mm$$
$$= \frac{1200}{10} = 120\ mm \quad \Big\} = 120\ mm$$

$$\boxed{t_s = 120\ mm}$$

$$(w_s)_{U.L.} = 1.4\,(0.12 * 25 + 1.50) + 1.6\,(2.0) = 9.50\ kN\backslash m^2$$





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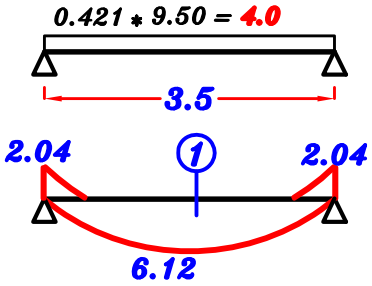
Strip (1)

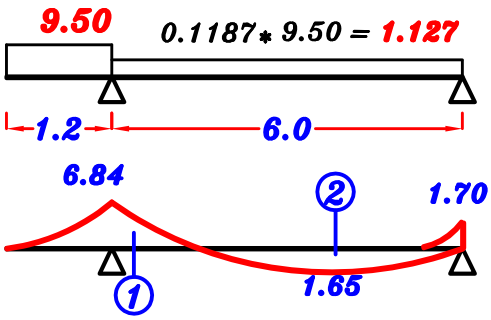
For sec. ① $d = t_s - 20$



Strip (2)

For sec. ① $d = t_s - 20$

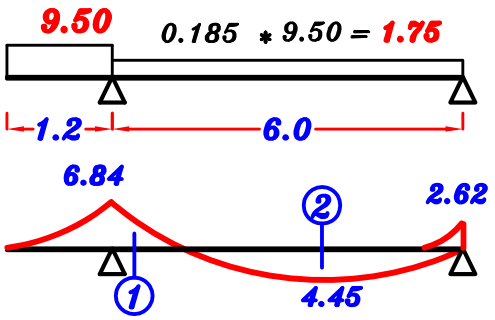
For sec. ② $d = t_s - 30$



Strip (3)

For sec. ① $d = t_s - 20$

For sec. ② $d = t_s - 30$



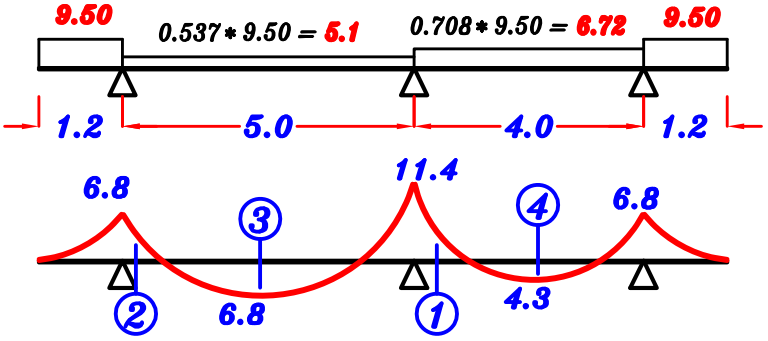
Strip (4)

For sec. ① $d = t_s - 20$

For sec. ② $d = t_s - 20$

For sec. ③ $d = t_s - 20$

For sec. ④ $d = t_s - 20$

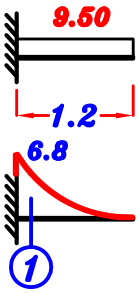


Strip (5)

For sec. ① $d = t_s - 20$

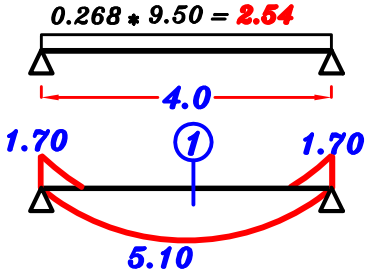
∵ شريحه البلاطه لها ركيزه واحده فقط *One Support*

∴ يكون على الكمره عزم إلتواء M_t .



Strip (6)

For sec. ① $d = t_s - 30$



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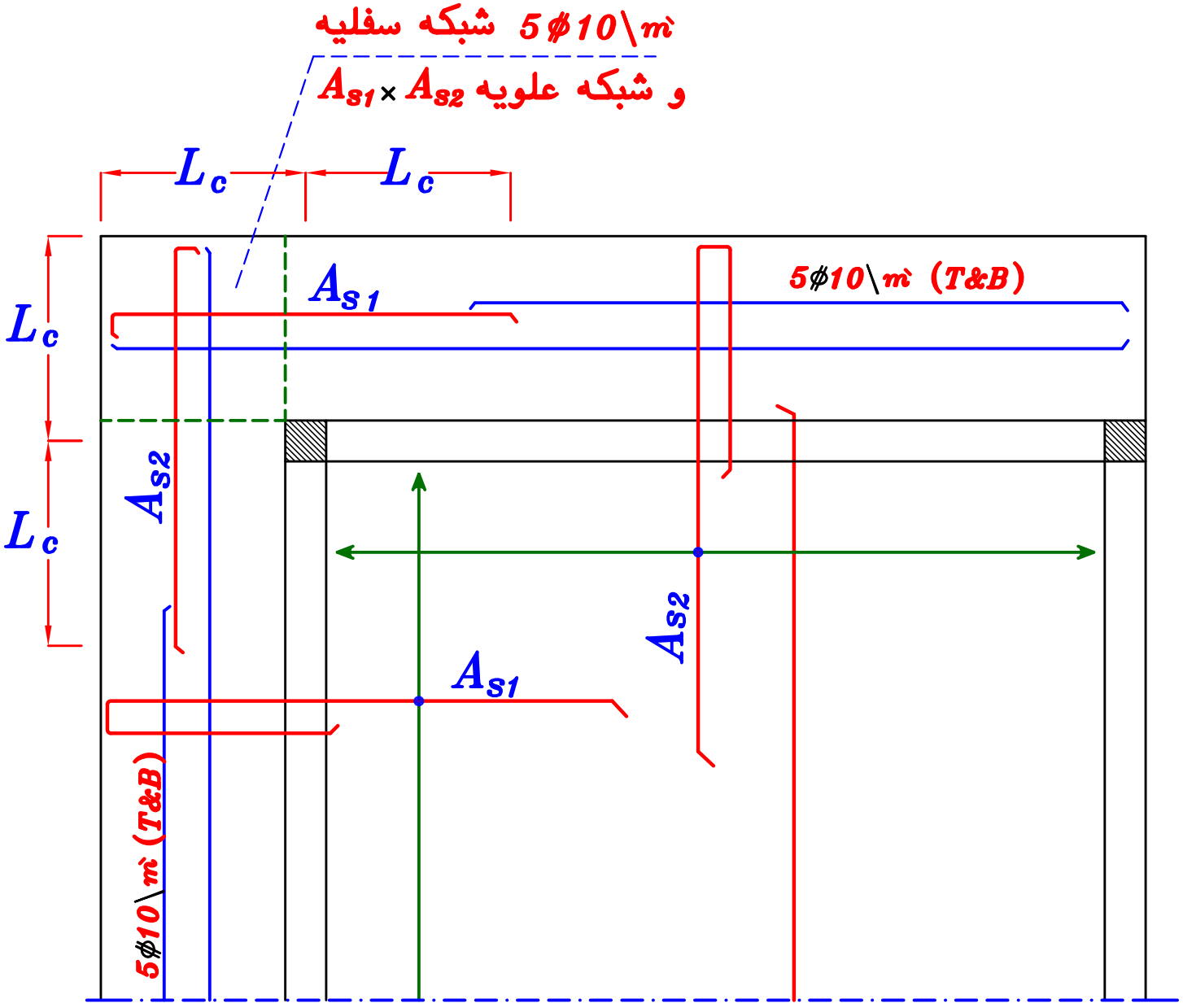
ملحوظه هامه .

فى الكوابيل الركنيه عندما يزيد طول الكابولى عن ١,٠- م
يفضل التسليح فى الشغل كالاتى



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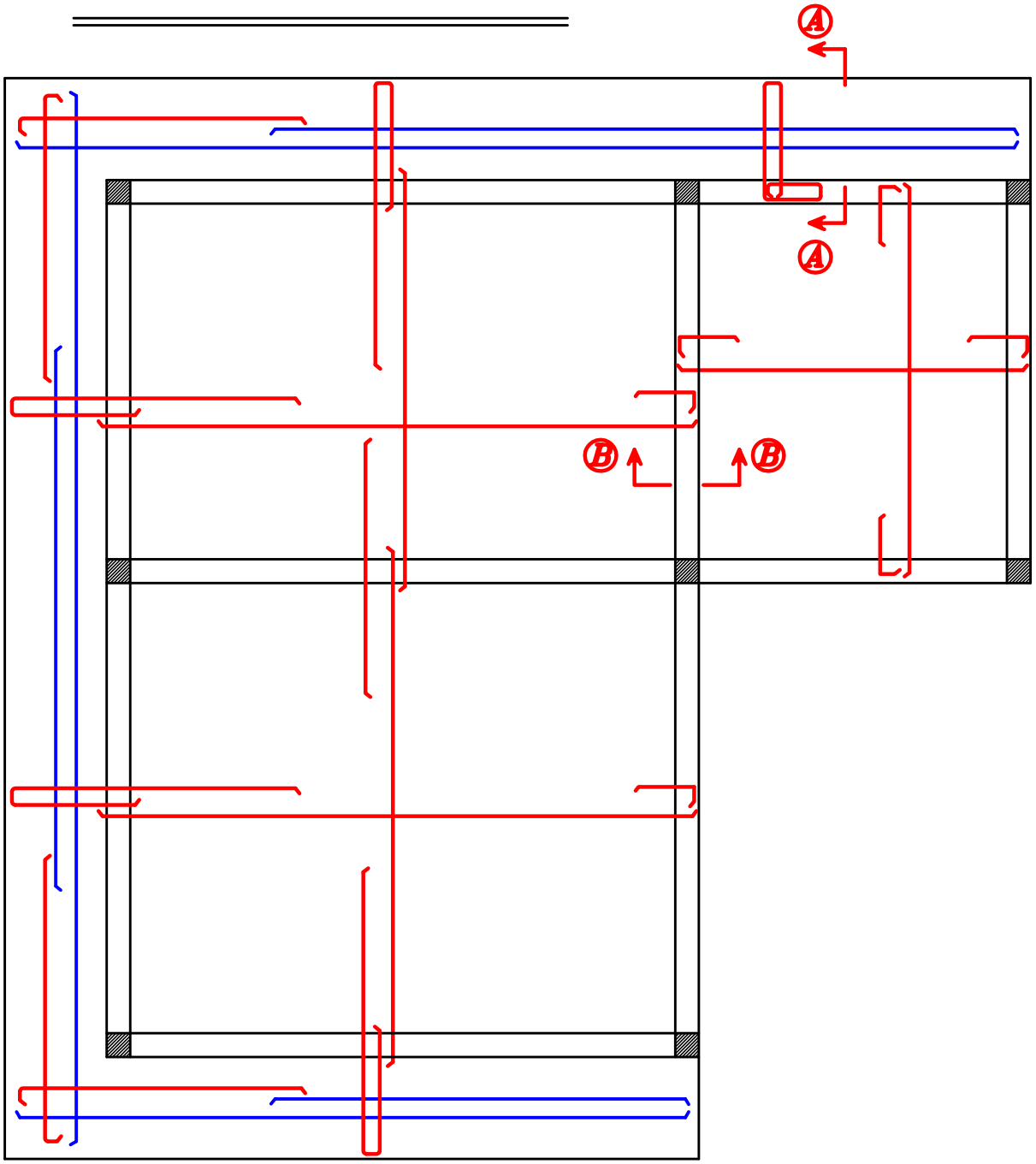
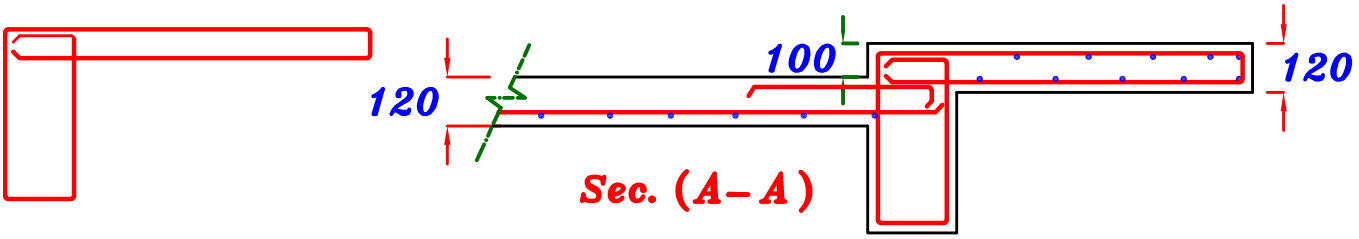
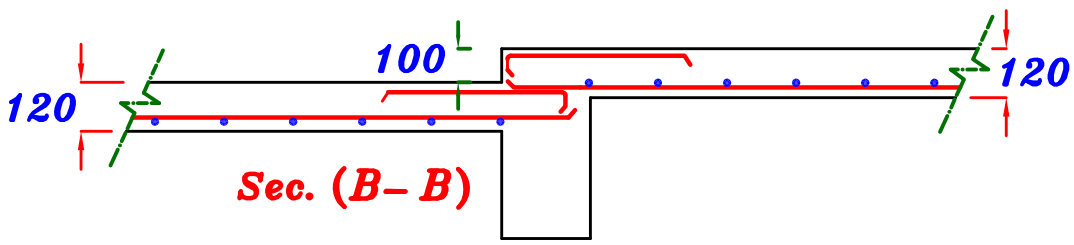
RFT. of the Slab.







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حل أخر

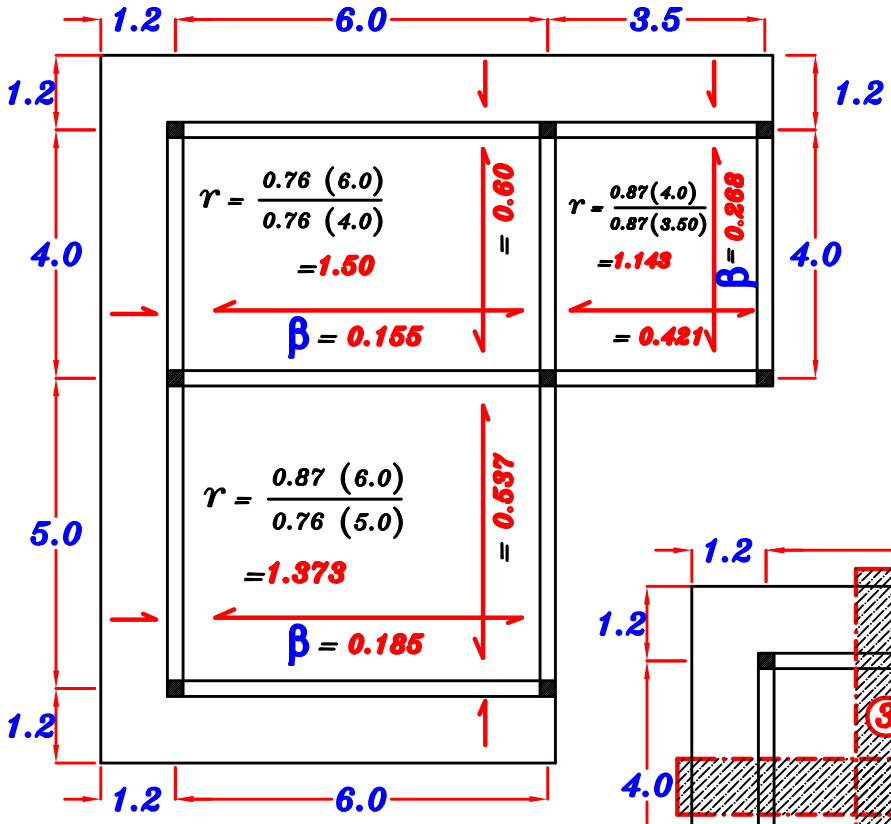
ممكن أخذ بلاطه الحمام Continuos مع باقى بلاطات المبنى

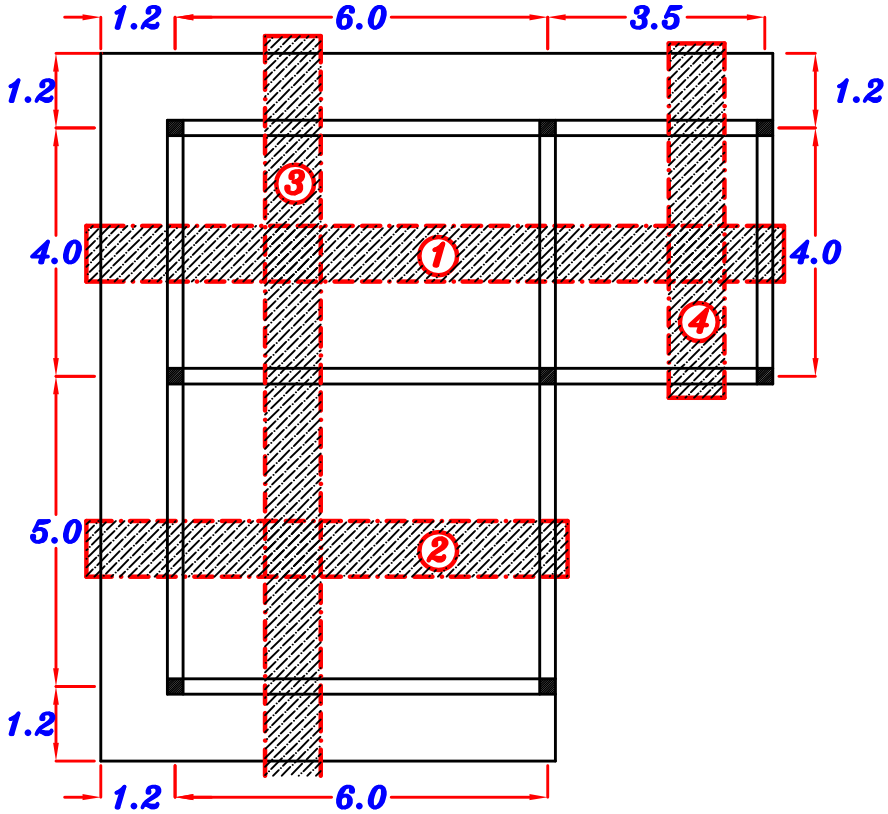
و الشرط لكى تكون البلاطات Continuos أن نكمل الـ RFT. (−ve) بين البلاطتين .

$$t_s = \frac{3500}{35} = 100\ mm$$
$$= \frac{4000}{45} = 88.8\ mm$$
$$= \frac{5000}{45} = 111.1\ mm$$
$$= \frac{1200}{10} = 120\ mm \quad \Big\} = 120\ mm$$

$$\boxed{t_s = 120\ mm}$$

$$(w_s)_{U.L.} = 1.4\,(0.12 * 25 + 1.50) + 1.6\,(2.0) = 9.50\ kN\backslash m^2$$





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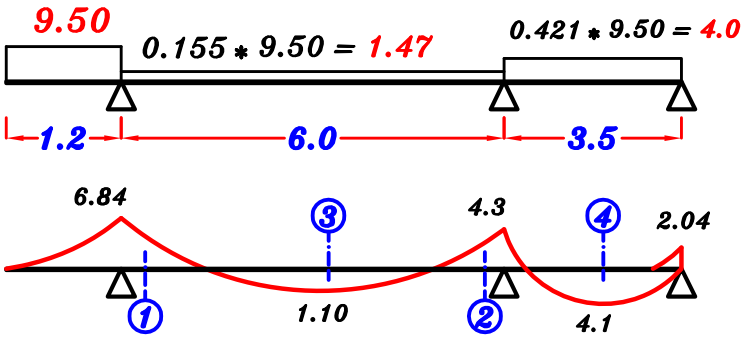
Strip (1)

For sec. ① $d = t_s - 20$

For sec. ② $d = t_s - 20$

For sec. ③ $d = t_s - 30$

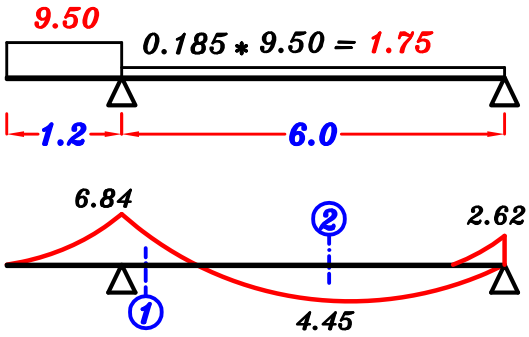
For sec. ④ $d = t_s - 20$



Strip (2)

For sec. ① $d = t_s - 20$

For sec. ② $d = t_s - 30$



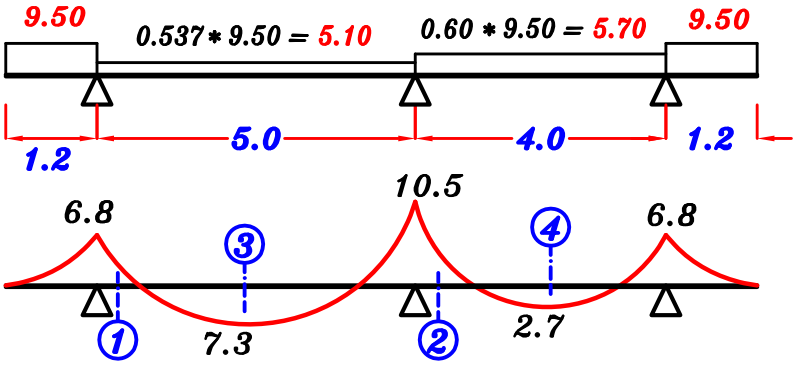
Strip (3)

For sec. ① $d = t_s - 20$

For sec. ② $d = t_s - 20$

For sec. ③ $d = t_s - 20$

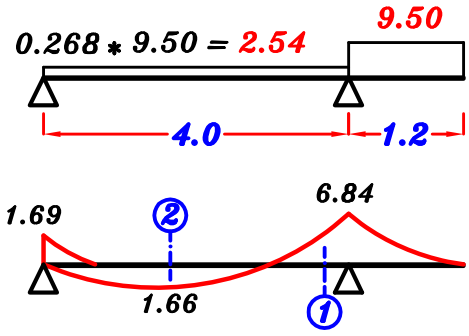
For sec. ④ $d = t_s - 20$



Strip (4)

For sec. ① $d = t_s - 20$

For sec. ② $d = t_s - 30$



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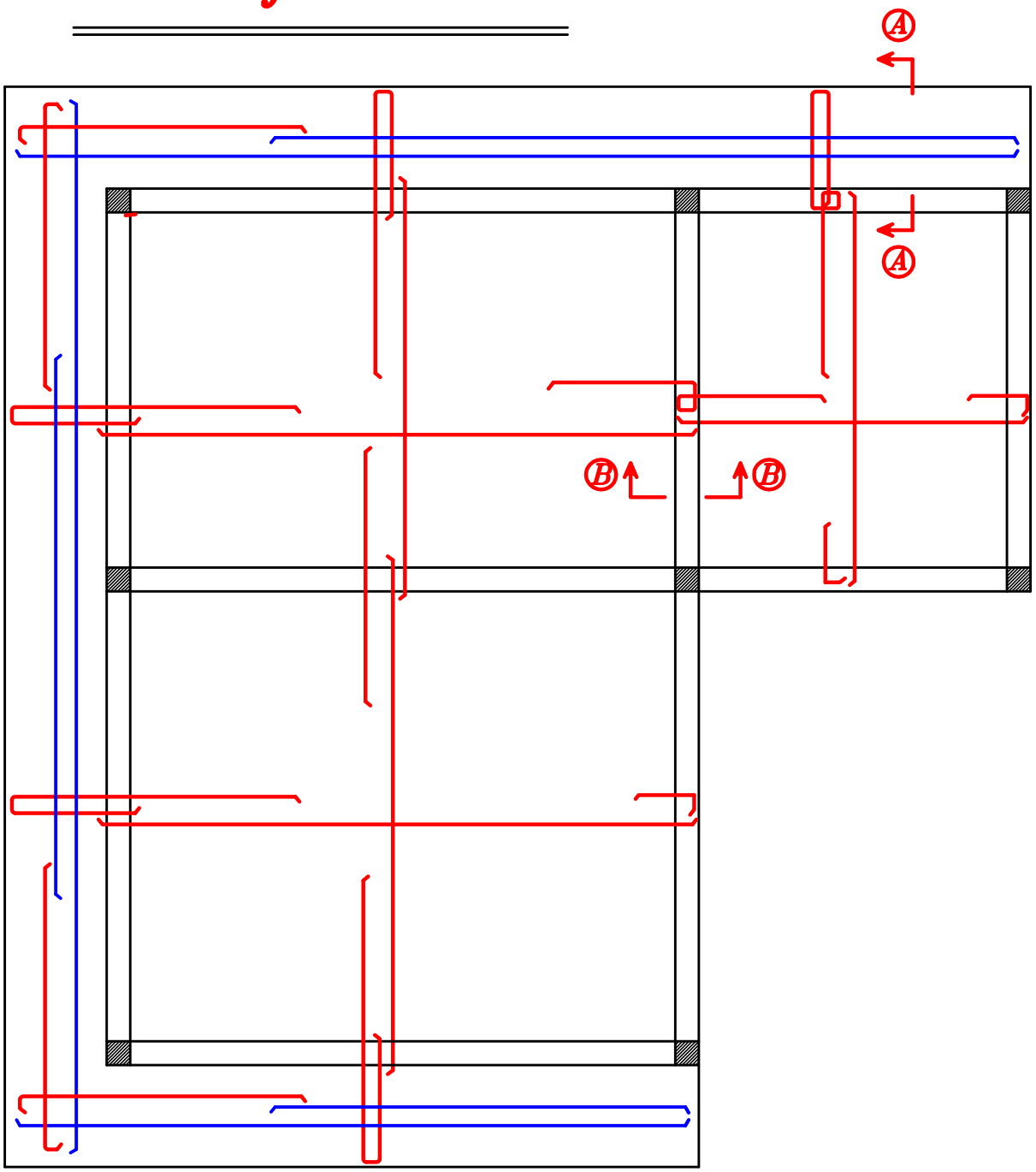
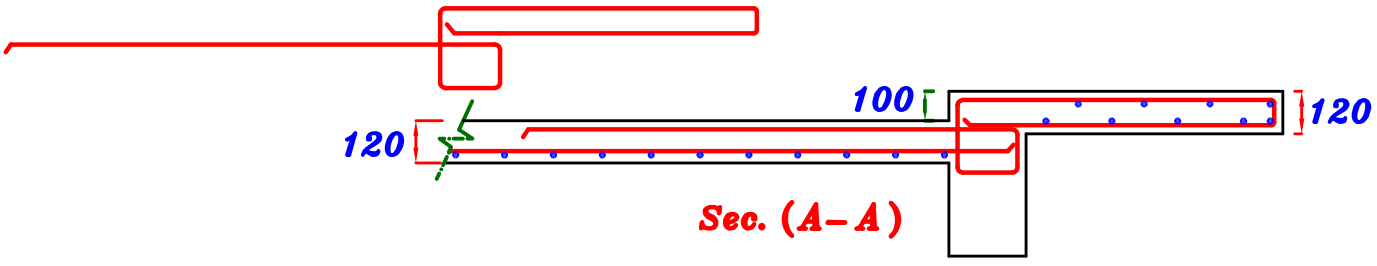
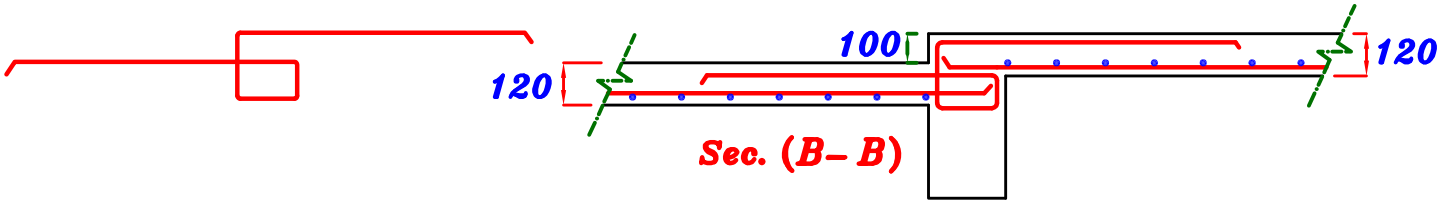
RFT. of the Slab.







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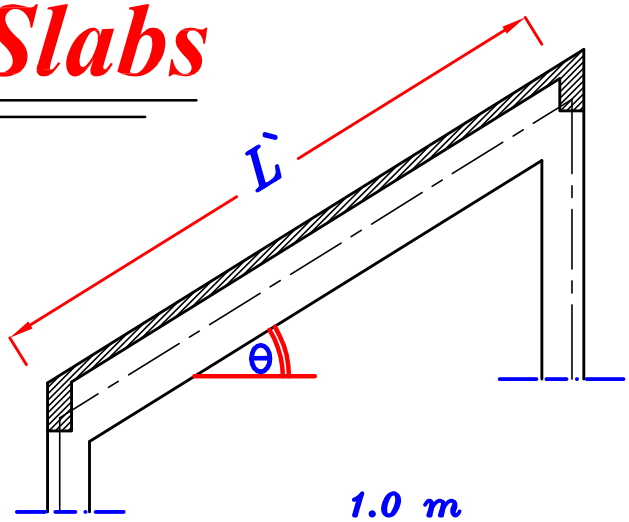
Inclined Slabs



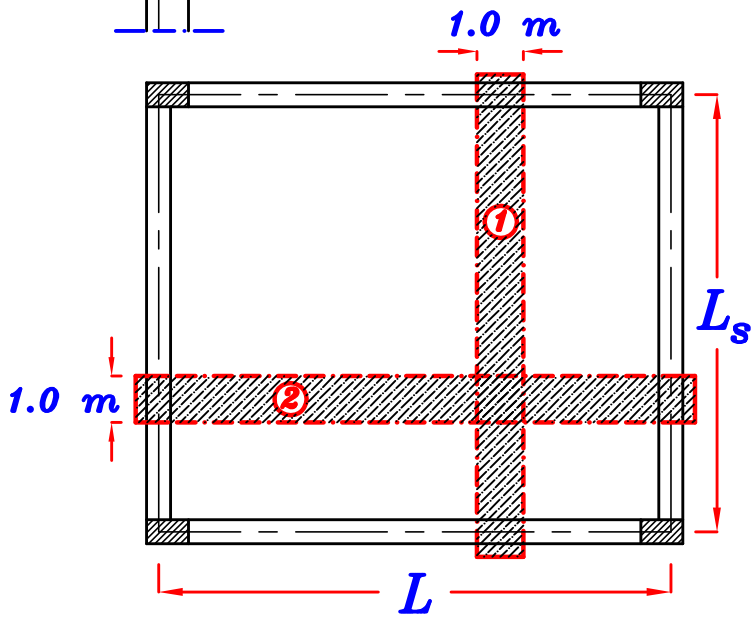
فى البلاطات المائله
يجب مراعاه الأتى :

١- التعامل مع الأطوال الحقيقيه

$L`, L_s$

٢- الـ L.L. يؤثر على المسقط الأفقى.

و الـ D.L. يؤثر على الطول المائل .



Steps of Design.

① Take

$$t_s = \frac{L_s}{25 \text{ or } 30 \text{ or } 36} \quad (\text{One Way})$$

$$t_s = \frac{L_s}{35 \text{ or } 40 \text{ or } 45} \quad (\text{Two Way})$$

$$t_s = \frac{L_c}{10} \quad (\text{Cantilever})$$

② Get $(w_s)_{U.L.} = 1.4\,(t_s\,\delta_c + F.C.) + 1.6\,L.L.\,\cos\theta$

OR $(w_s) = 1.5\,(t_s\,\delta_c + F.C. + L.L.\cos\theta)$ لجعل تأثيرها على الطول المائل

③ Get α , β IF Two Way Slab.

$$\gamma = \frac{m\,L`}{m`\,L_s}$$ الطول الحقيقى

$\alpha = 0.5\,\gamma - 0.15$, $\beta = \frac{0.35}{\gamma^2}$	C.P.
$\alpha = \frac{\gamma^4}{1+\gamma^4}$ $\beta = \frac{1}{1+\gamma^4}$	Grashoff

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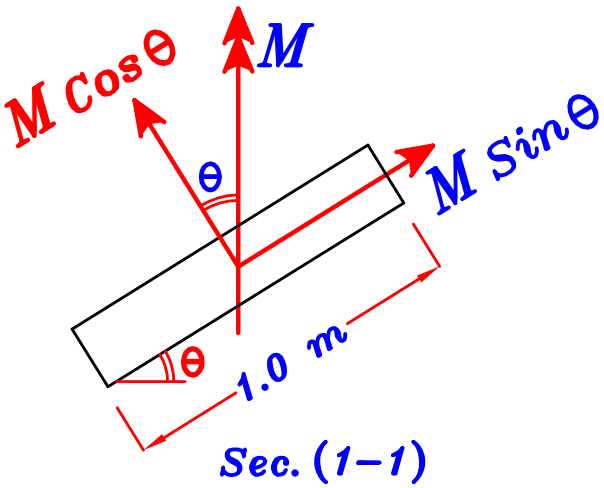
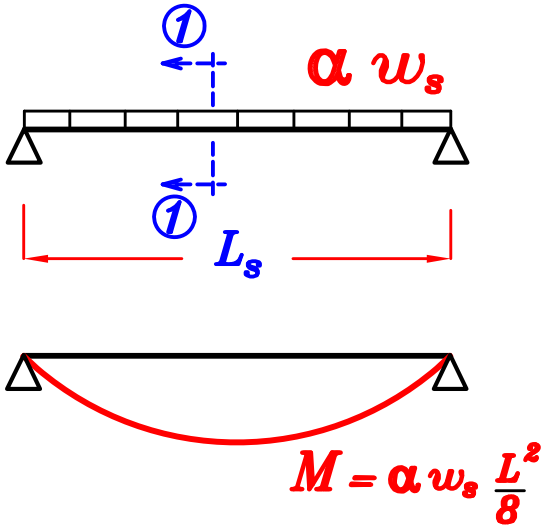
④ *Take a strip (1.0 m width) at the Load direction And Get the B.M. on the Slab.*

Strip (1) (HL. Strip)





يؤثر على القطاع كلاً من $M\,Sin\,\theta$, $M\,Cos\,\theta$

و لكننا نهمل تأثير $M\,Sin\,\theta$ للأتى : ـ

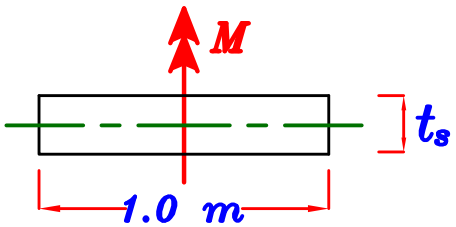
١- قيمه العزم $M\,Sin\,\theta$ صغيره جداً .

٢- عمق القطاع (*depth*) المقاوم للعزم $M\,Sin\,\theta$ كبير جداً $= \frac{1.0\,m}{Cos\,\theta}$.

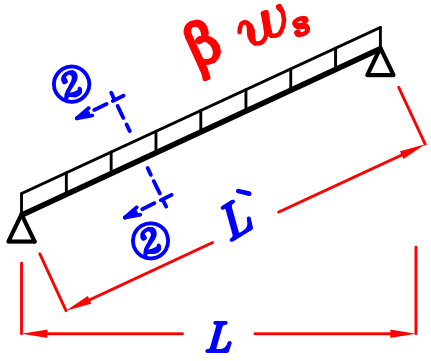
∴ نصمم الشريحة على $M\,Cos\,\theta$ فقط .

الشريحه الأفقيه فى البلاطه الماثله تصمم دائماً على ($M_* Cos\,\theta$)

Strip (2) (Inclined Strip)

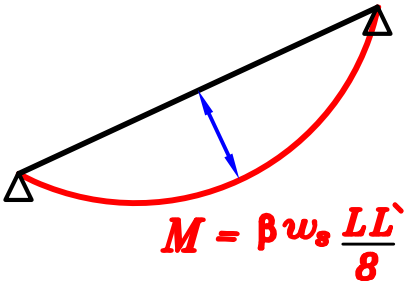


Sec. (2–2)



فى الشريحه الماثله نصمم على الـ *moment* العادى بدون الضرب فى $Cos\,\theta$

$$M = \beta w_s \frac{LL`}{8}$$



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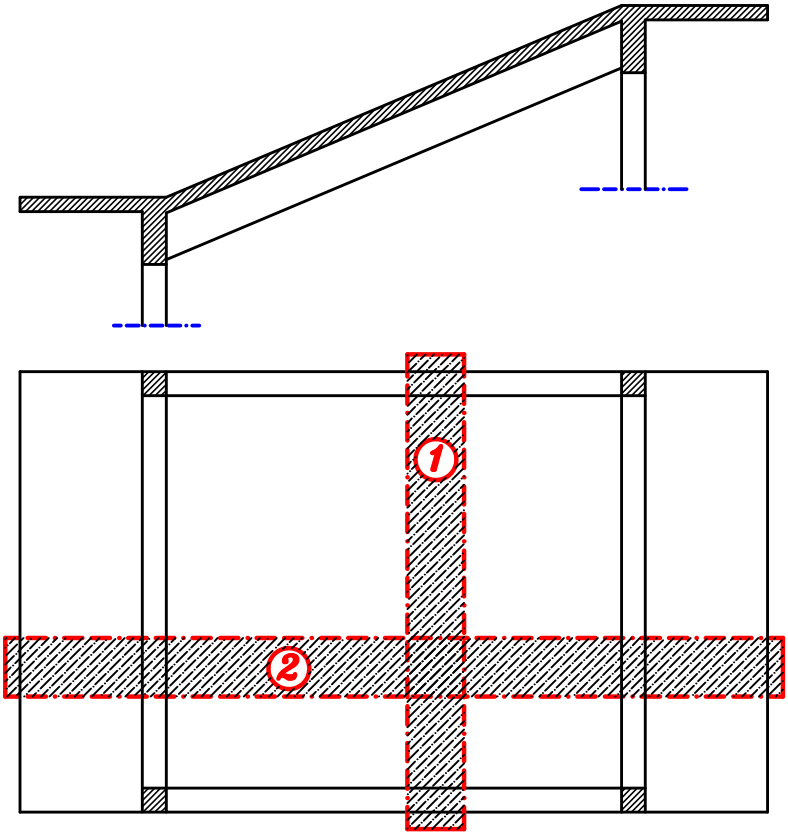
RFT. of Inclined Slabs.

ملاحظات :-

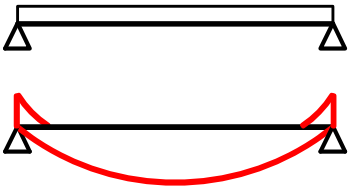
١- إذا كانت الشريحه مائله سوف يرسم التسليح مائل (مثل الـ $X-Sec.$).
و إذا كانت الشريحه أفقيه سوف يرسم التسليح أفقى (مثل الـ $X-Sec.$).

٢- أى بلاطه مائله يوجد بها تسليحان فى الإتجاهين
دائماً يكون تسليح من الإتجاهين مائل و يكون التسليح فى الإتجاه الأخر أفقى .

Example.

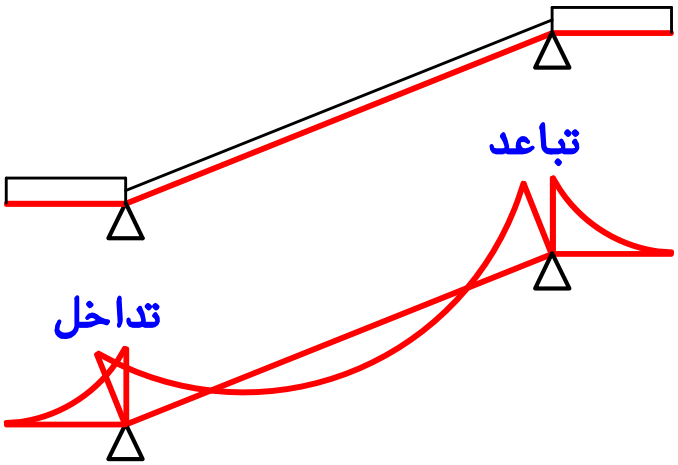


Strip ①



شريحه أفقيه ⟵ تسليح أفقى (ليس مائل)

Strip ②



الشريحه جزء منها أفقى و جزء منها مائل ⟵ التسليح جزء منه أفقى و جزء منه مائل

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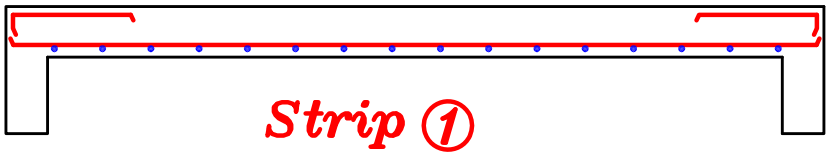

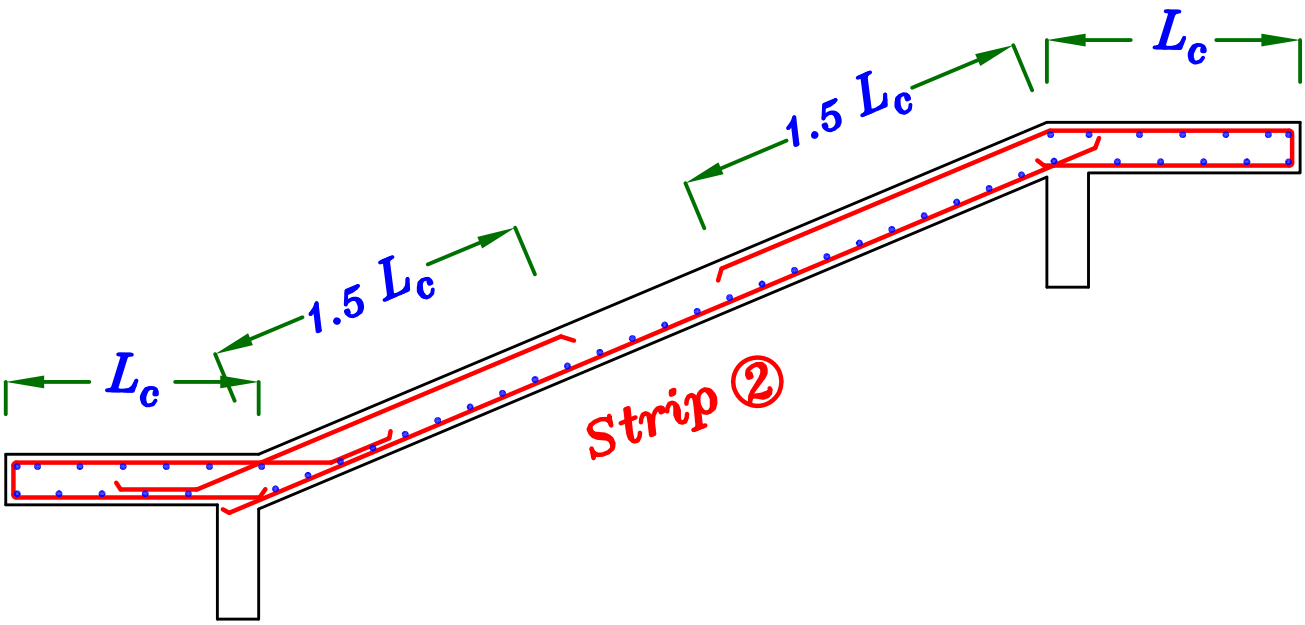

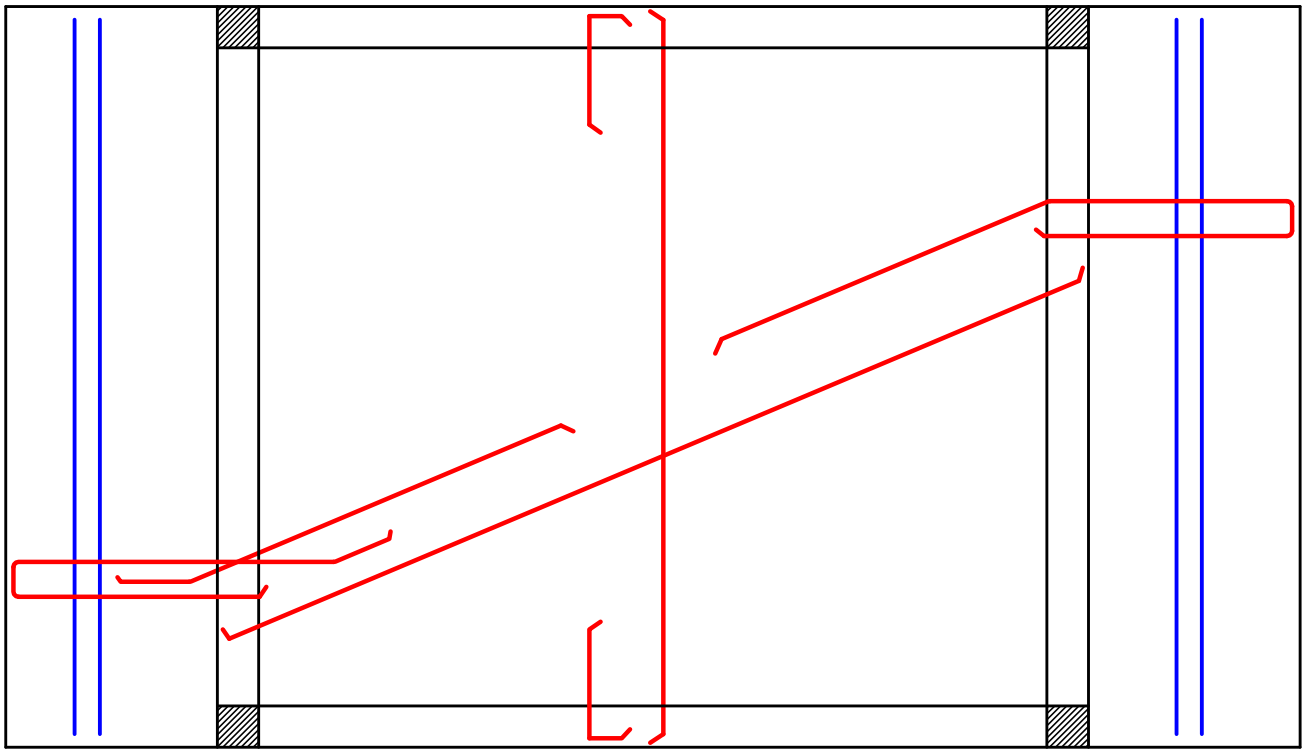

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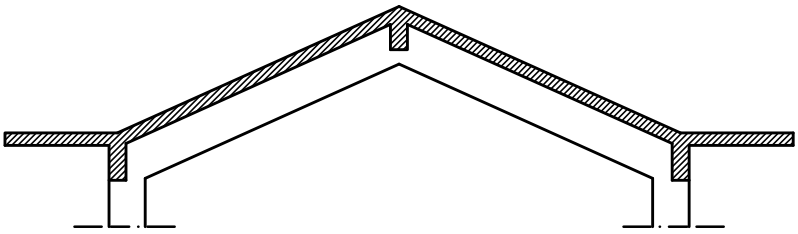
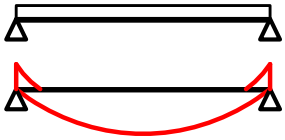
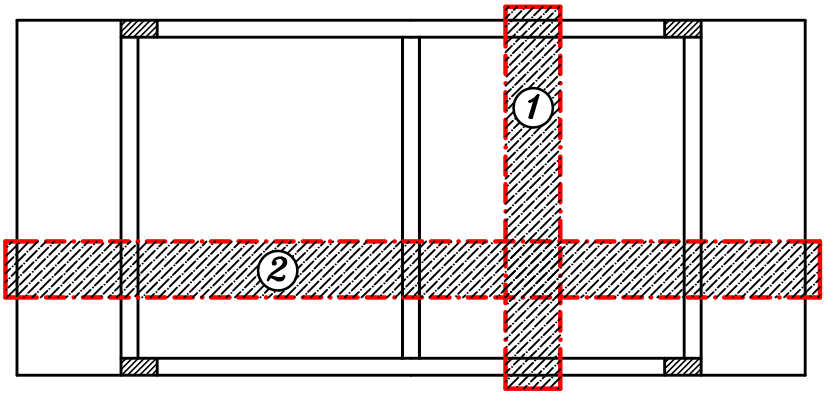
Example.



Strip ①



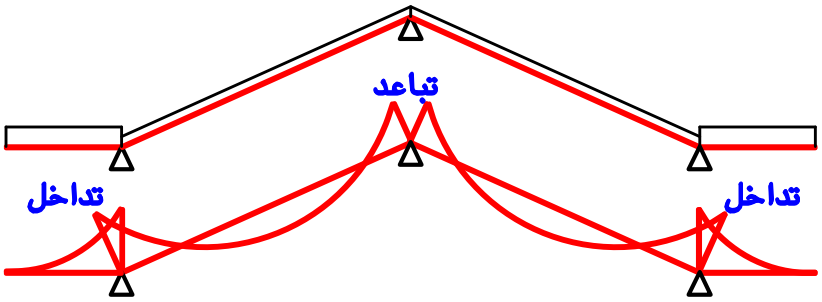
شريحة أفقية ← تسليح أفقى (ليس مائل)

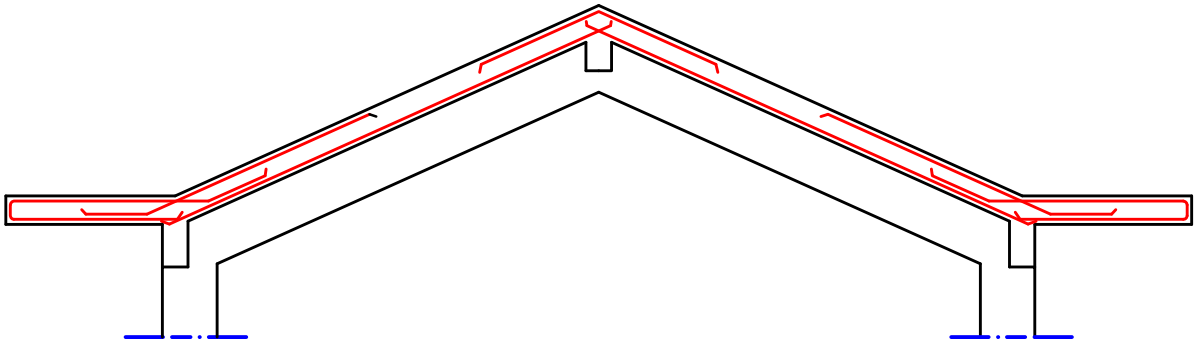


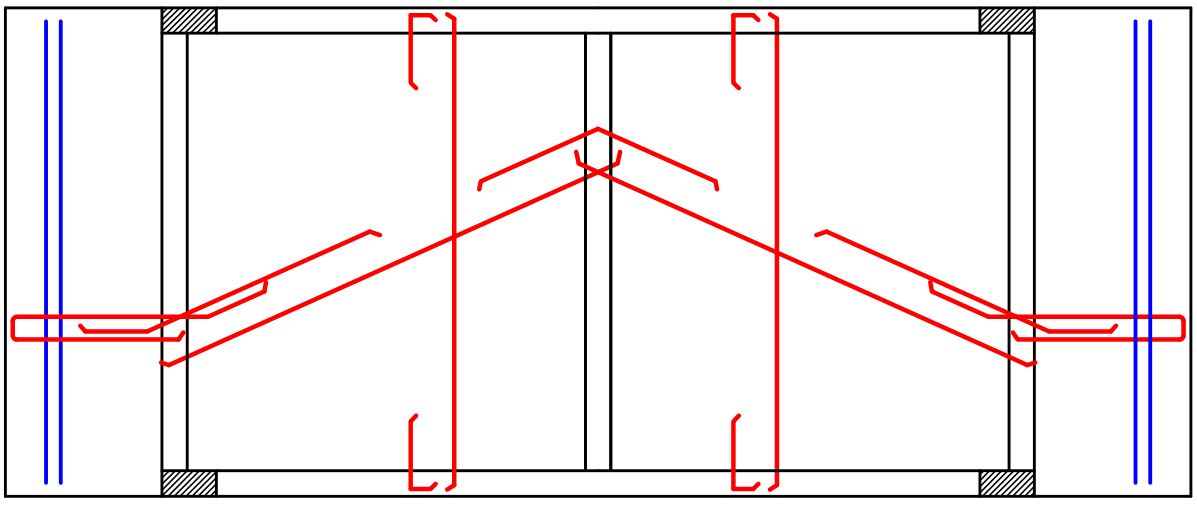
Strip ②

الشريحه جزء منها أفقى و جزء منها مائل

∴ التسليح جزء منه أفقى و جزء منه مائل







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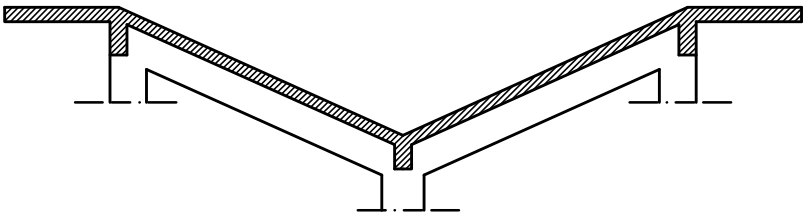
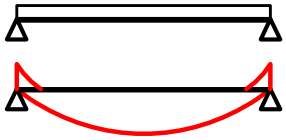
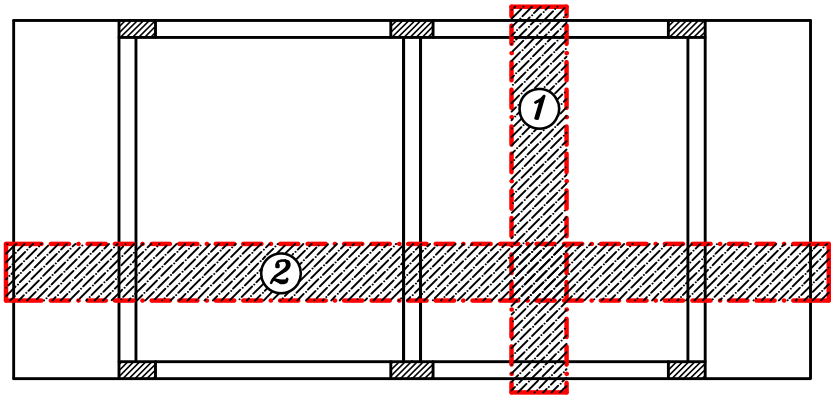
Example.



Strip ①



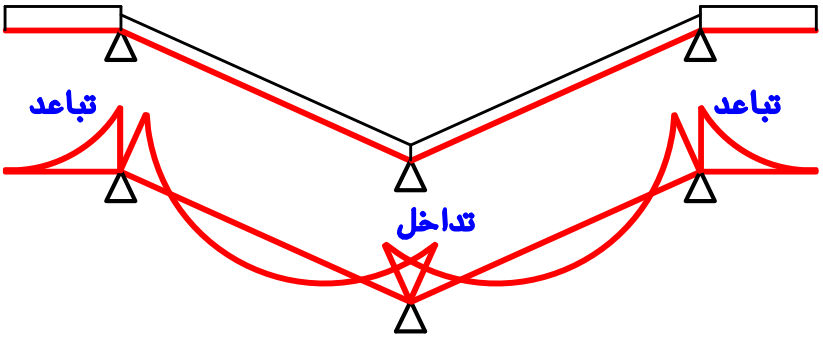
شريحة أفقية ← تسليح أفقى (ليس مائل)

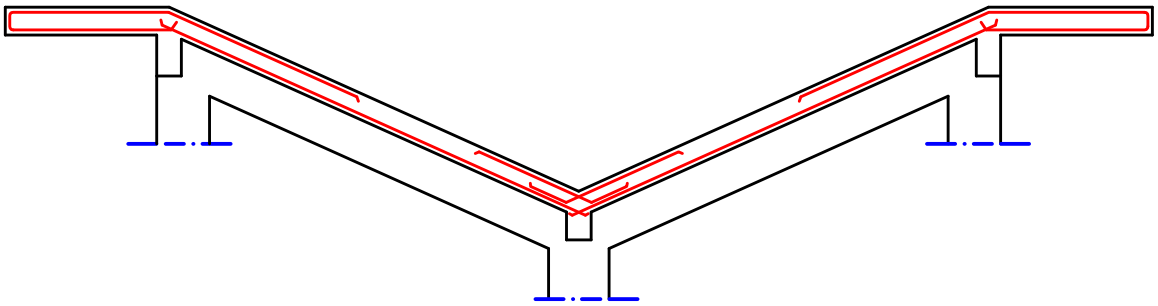


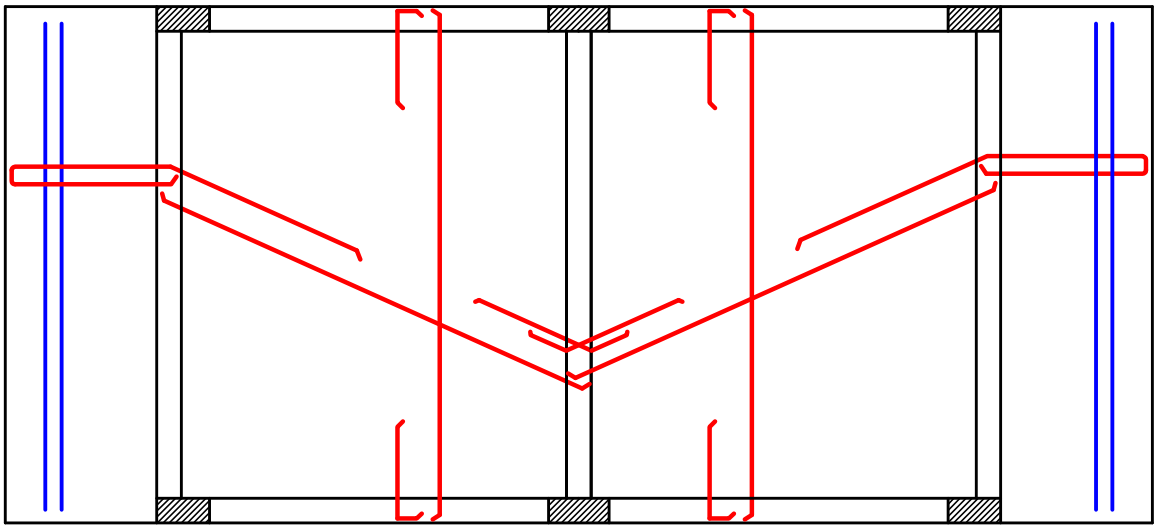
Strip ②

الشريحه جزء منها أفقى و جزء منها مائل

∴ التسليح جزء منه أفقى و جزء منه مائل







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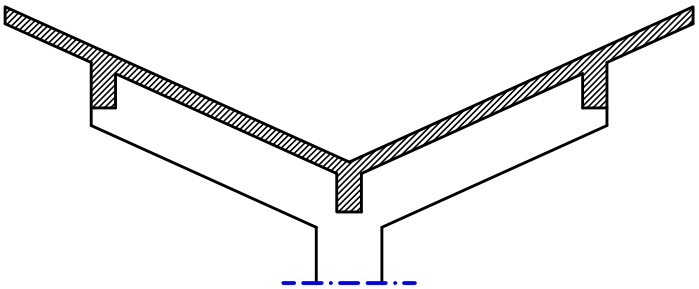
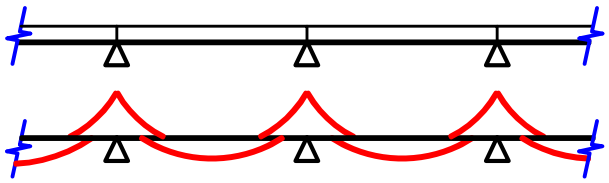
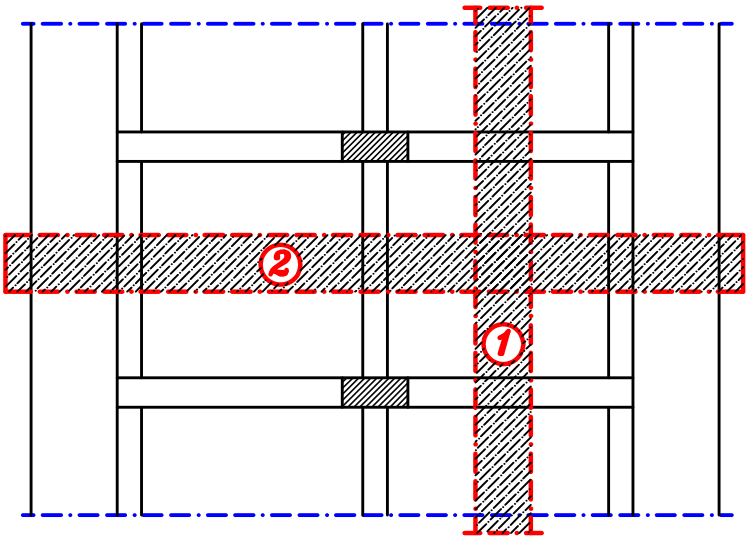
Example.



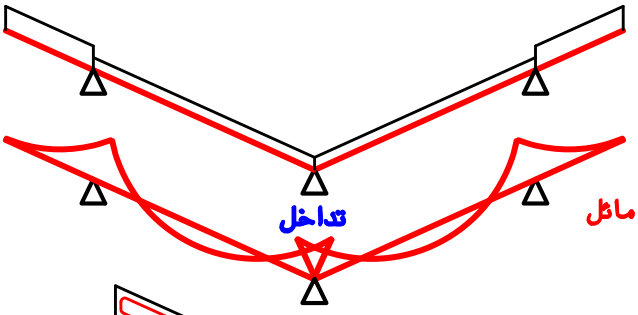
Strip ①



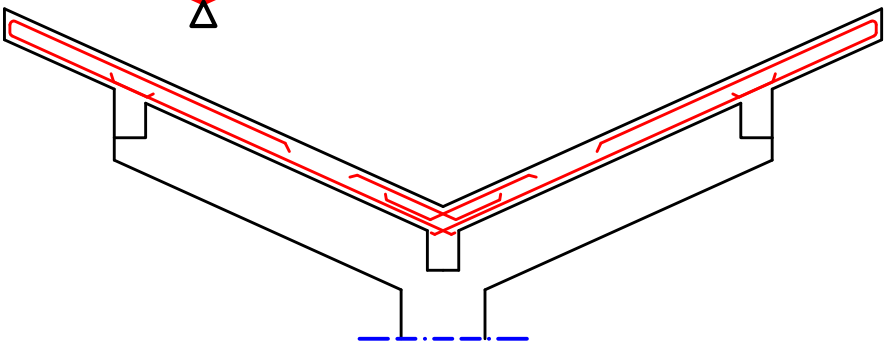
شريحه أفقيه ← تسليح أفقى (ليس مائل)

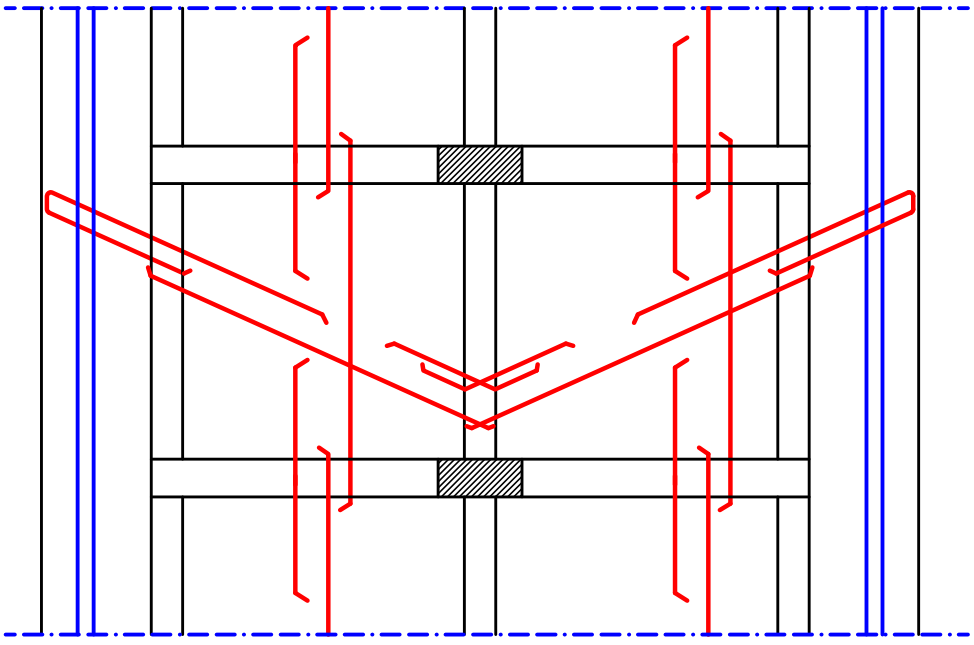


Strip ②



شريحه مائله ← تسليح مائل





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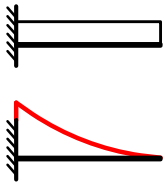
Example.

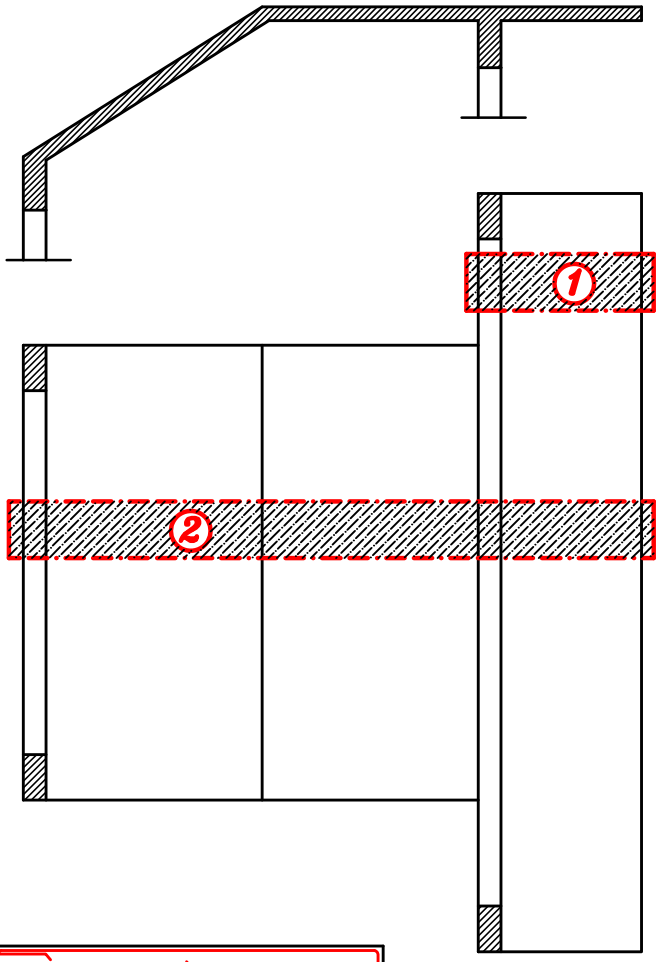
Strip ①



∴ شريحه البلاطه لها ركيزه

واحده فقط One Support

∴ يكون على الكمره عزم إلتواء M_t .



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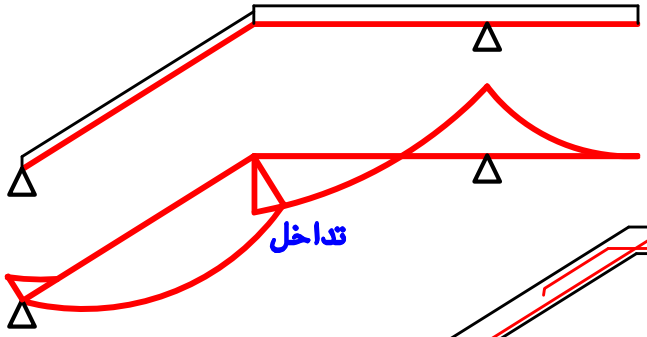

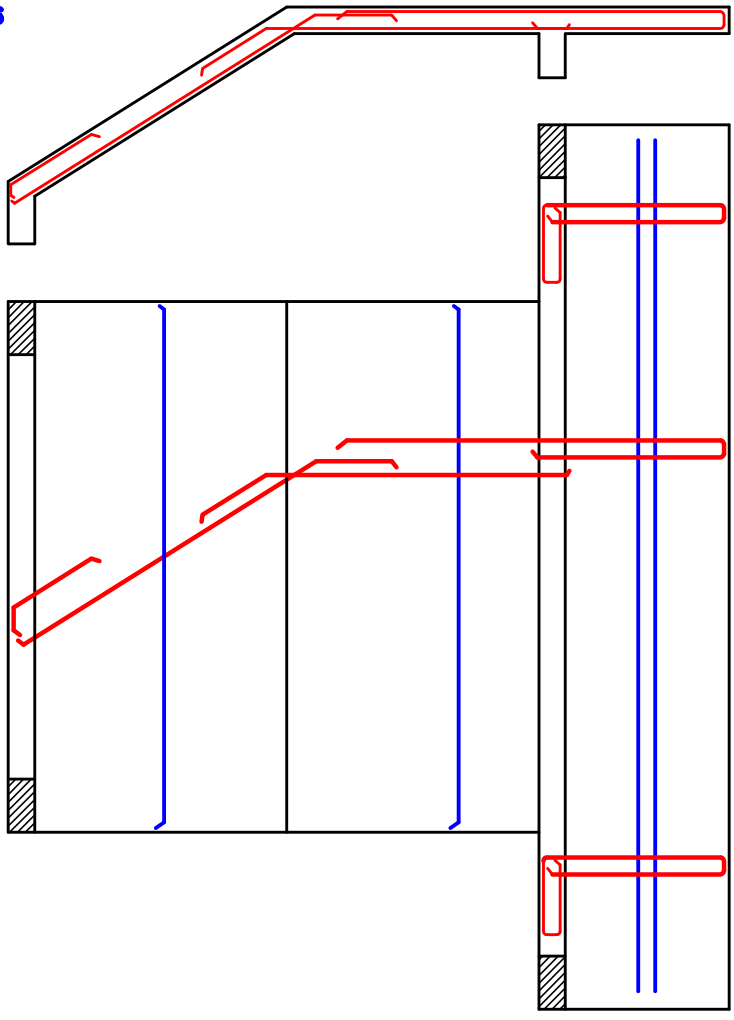

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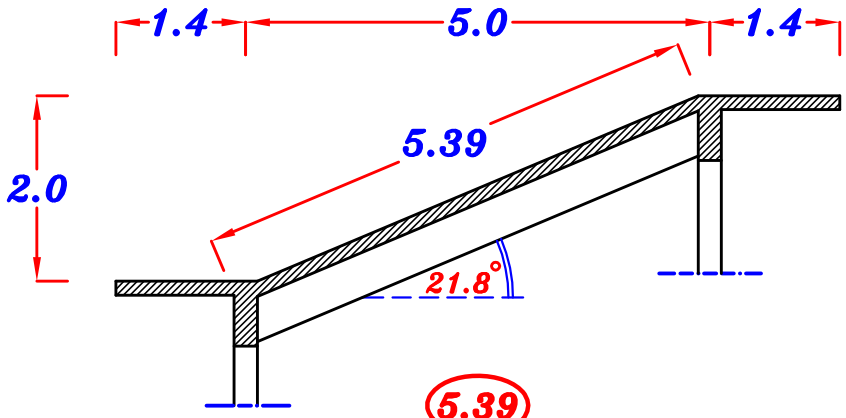
Example.



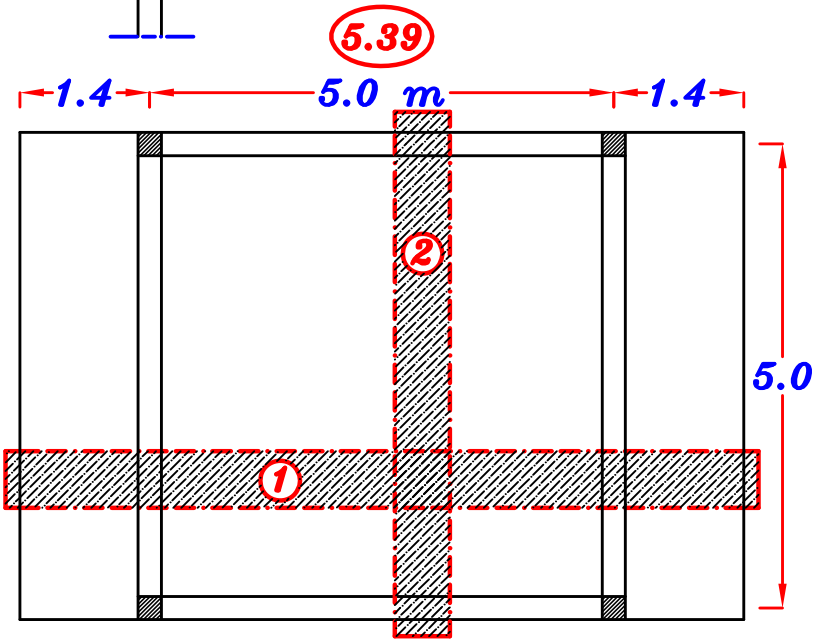
Data.

$F_{cu} = 20\ N\backslash mm^2$

$F_y = 360\ N\backslash mm^2$

$L.L. + F.C. = 4.0\ kN\backslash m^2$ H.P.

(Per Horizontal Projection) = H.P.



Req.

① Design the Slab as Solid Slab.

② Draw Details of RFT. in Plan & Cross-Sec.

Solution.

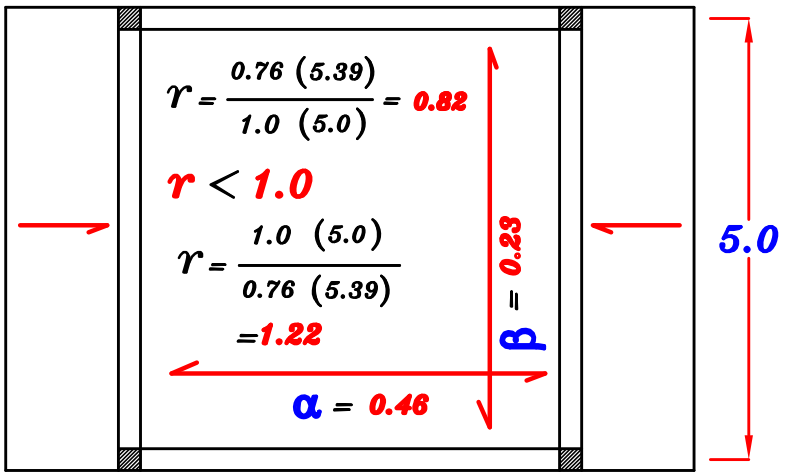
$$t_s = \frac{5000}{35} = 142.8\ mm$$

$$= \frac{1400}{10} = 140\ mm$$

$\Big\}$ $= 160\ mm$ $\qquad$ $t_s = 160\ mm$

$$(w_s)_{H.L.} = 1.5\,(0.16 * 25 + 4.0) = 12.0\ kN\backslash m^2$$

$$(w_s)_{Inclined} = 1.5\,(0.16 * 25 + 4.0\ Cos\ 21.8^\circ) = 11.57\ kN\backslash m^2$$



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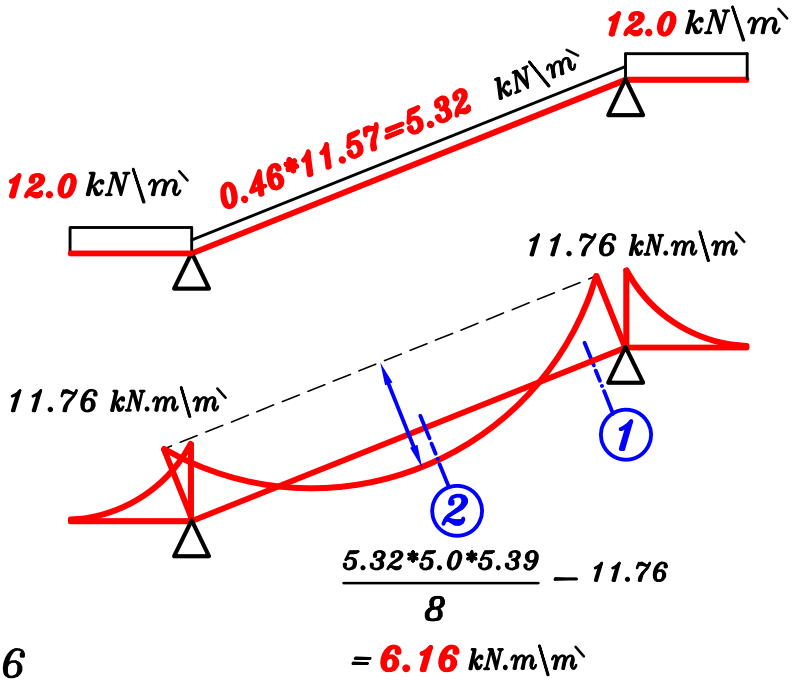
Strip (1)

Sec. ①



$M_{U.L.} = 11.76$ kN.m\m`

, $t_s = 160$ mm

, $d = 160 - 20 = 140$ mm

$$140 = C_1\sqrt{\frac{11.76*10^6}{20*1000}}$$

$\longrightarrow C_1 = 5.77 \longrightarrow J = 0.826$

$$A_S = \frac{11.76*10^6}{0.826*360*140} = 282 \ mm^2/m`$$

5 ϕ 10 \m`

Sec. ②

$M_{U.L.} = 6.16$ kN.m\m`

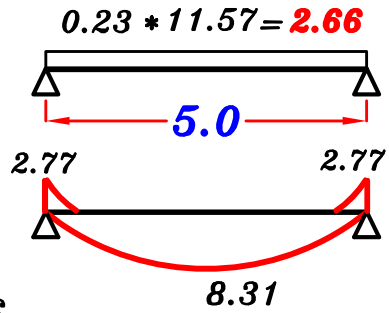
, $t_s = 160$ mm , $d = 160 - 20 = 140$ mm

$$14.0 = C_1\sqrt{\frac{6.16*10^6}{20*1000}} \longrightarrow C_1 = 7.97 \longrightarrow J = 0.826$$

$$A_S = \frac{6.16*10^6}{0.826*360*140} = 148 \ mm^2/m`$$

5 ϕ 10 \m`

Strip (2) شريحة أفقية فى بلاطة ماظة



$M_{des.} = M_{U.L.} \cos\theta = 8.31 \cos 21.8^\circ = 7.71$ kN.m\m

, $t_s = 160$ mm , $d = 160 - 30 = 130$ mm

$$130 = C_1\sqrt{\frac{7.71*10^6}{20*1000}} \longrightarrow C_1 = 6.62 \longrightarrow J = 0.826$$

$$A_S = \frac{7.71*10^6}{0.826*360*130} = 199 \ mm^2/m`$$

5 ϕ 10 \m`

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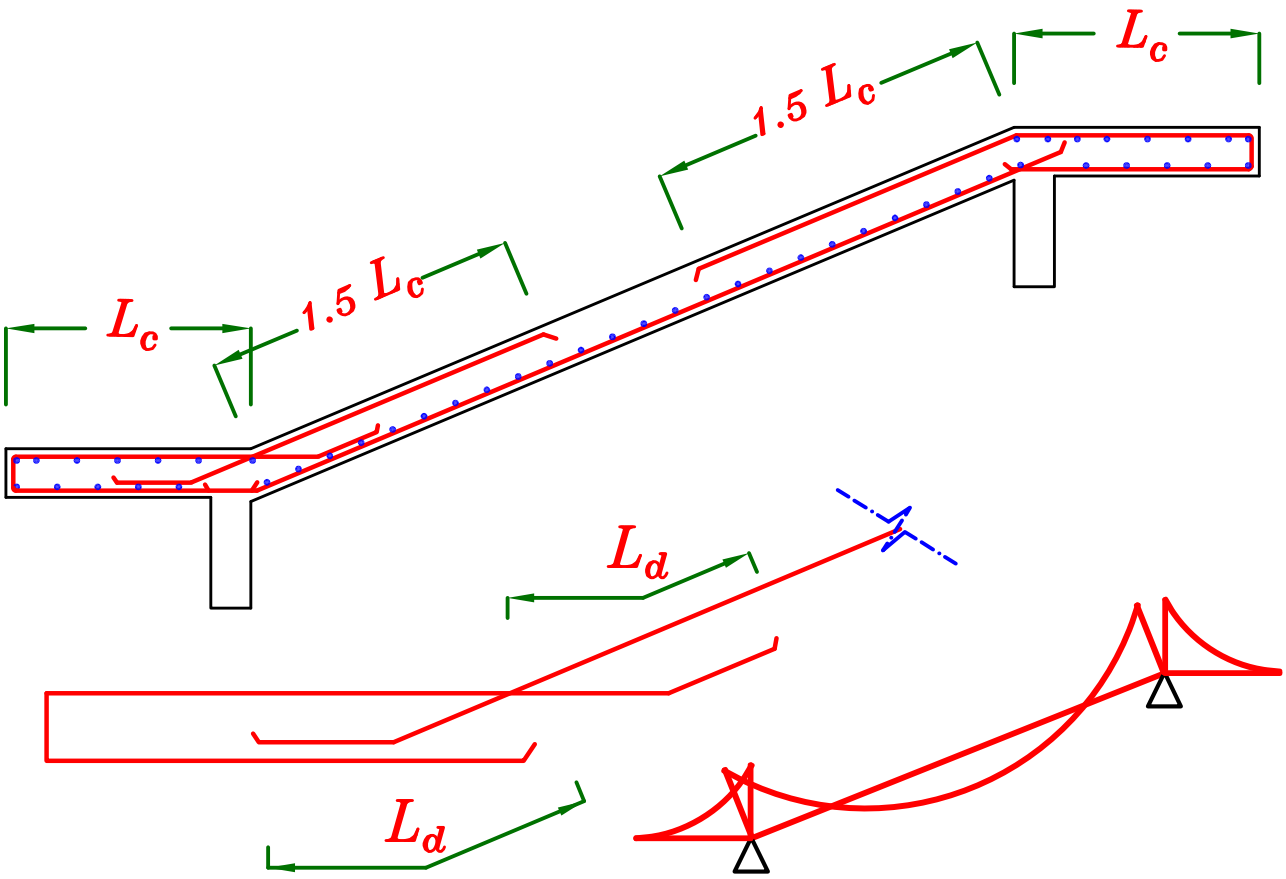

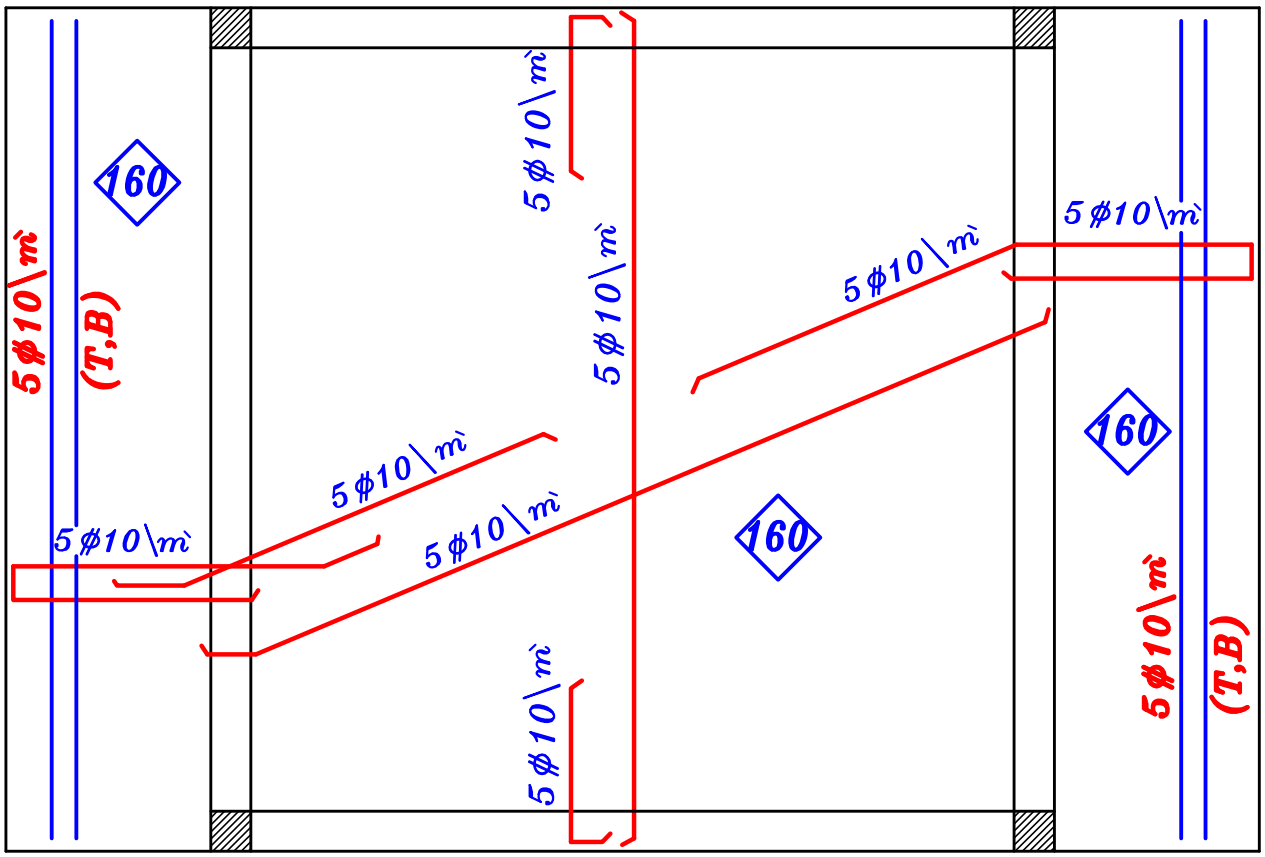

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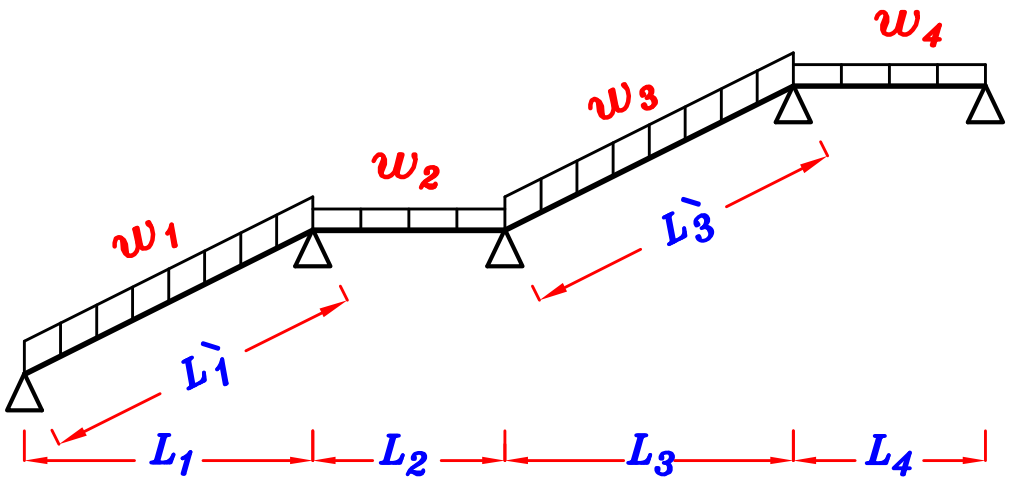
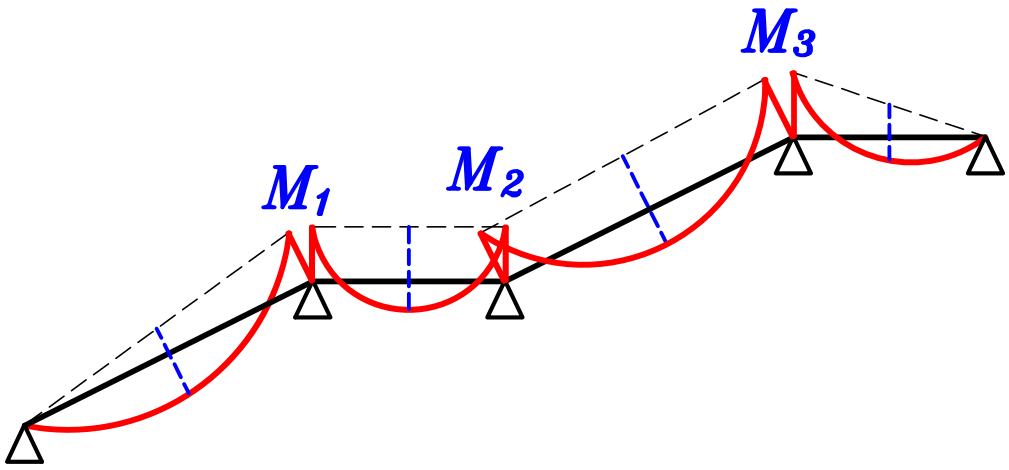
How to solve inclined slabs by using 3 Moments equations.

① When the supports at the corners.

عندما يكون ال support عند الكسرات





$$0.0 + 2M_1(L_1` + L_2) + M_2(L_2) = -6\left(\frac{w_1 L_1 (L_1`)^2}{24} + \frac{w_2 L_2^3}{24}\right)$$

$$M_1(L_2) + 2M_2(L_2 + L_3`) + M_3(L_3`) = -6\left(\frac{w_2 L_2^3}{24} + \frac{w_3 L_3 (L_3`)^2}{24}\right)$$

$$M_2(L_3`) + 2M_3(L_3` + L_4) + 0.0 = -6\left(\frac{w_3 L_3 (L_3`)^2}{24} + \frac{w_4 L_4^3}{24}\right)$$

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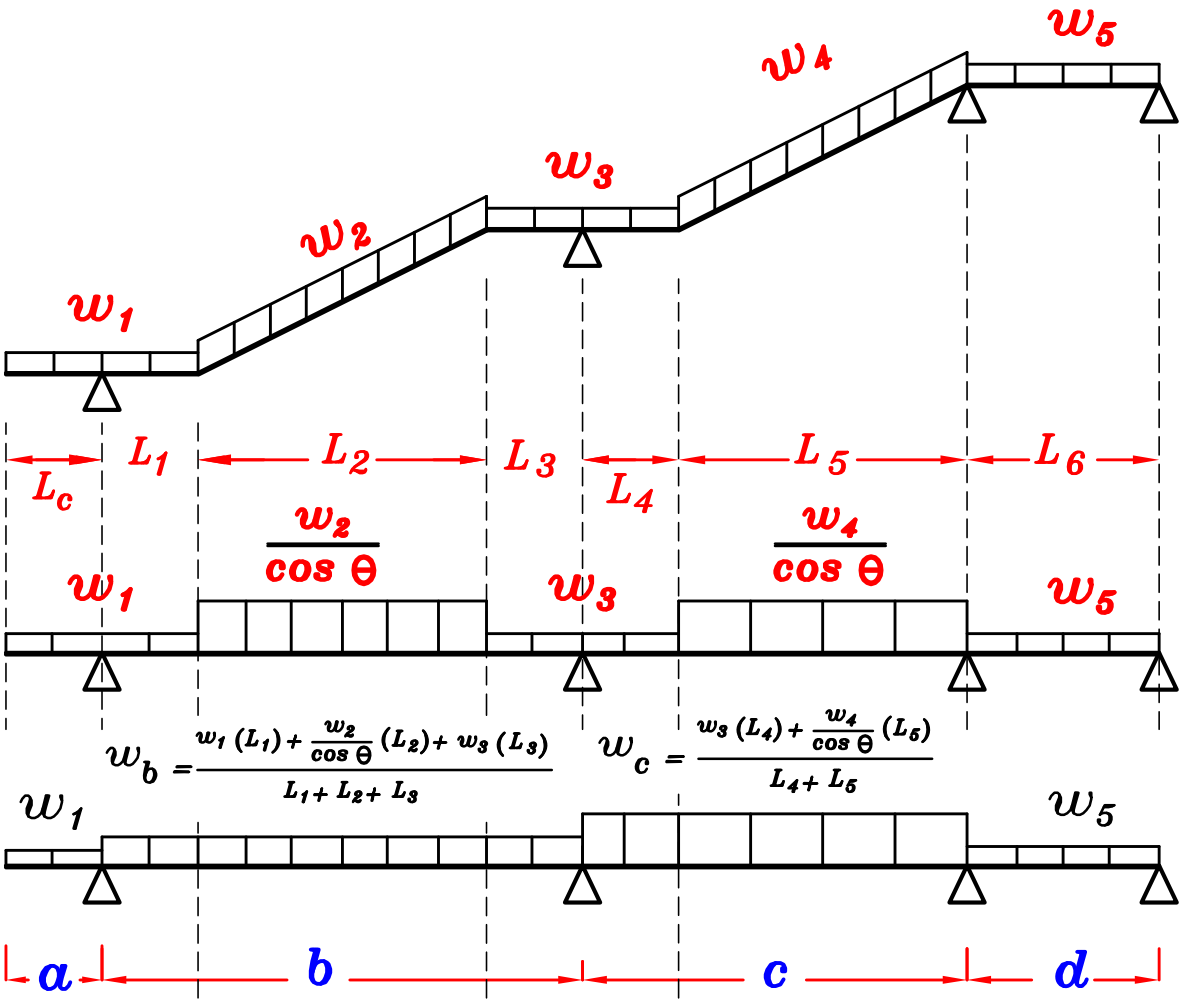
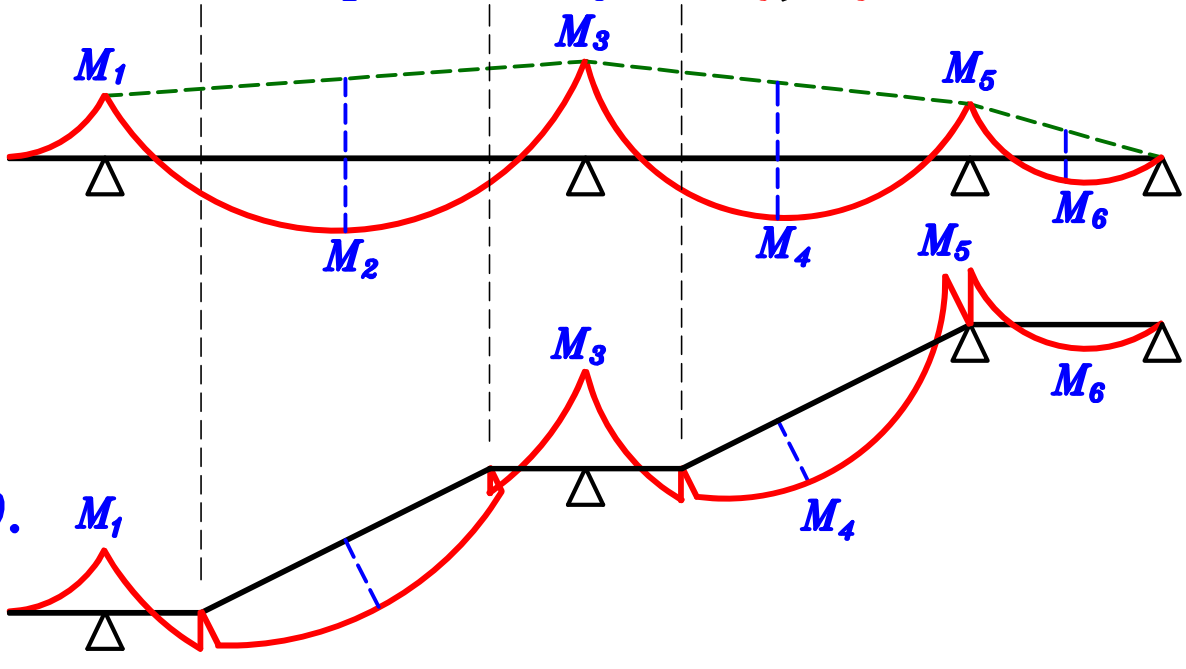
② When the supports not at the corners

عندما يكون الـ support ليس عند الكسرات

نعمل طريقه تقريبيه للحل



Using 3 Moment equations get M_3, M_5



B.M.D.

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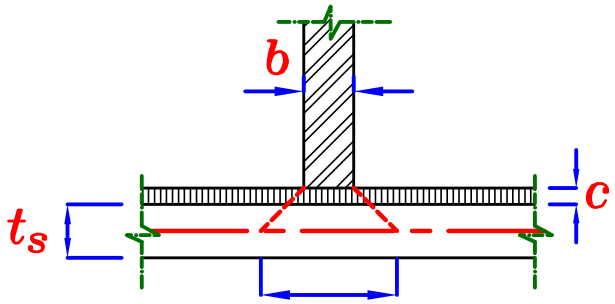
Concentrated Loads on Slabs.

① Wall on One Way Slab.

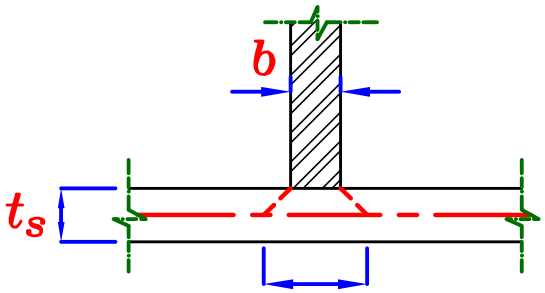
@ Line Load at Load Direction.

with F.C.



$$S_1 = b + t_s + 2c$$

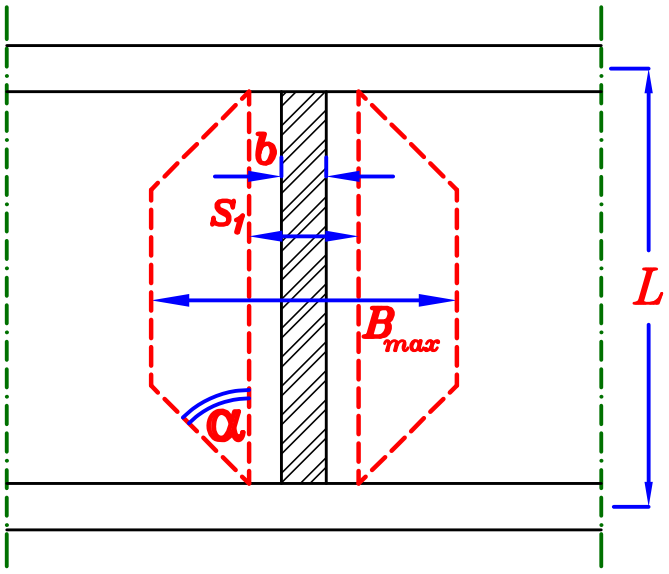
without F.C. ✓✓



$$S_1 = b + t_s$$

$\alpha = 45^\circ$ For Bending

$$B_{max} = S_1 + \left[\frac{A_s\,(sec.)}{A_s\,(main)}\right] * K\,L$$



Where: $B_{max} \not> S_1 + 20$ mm

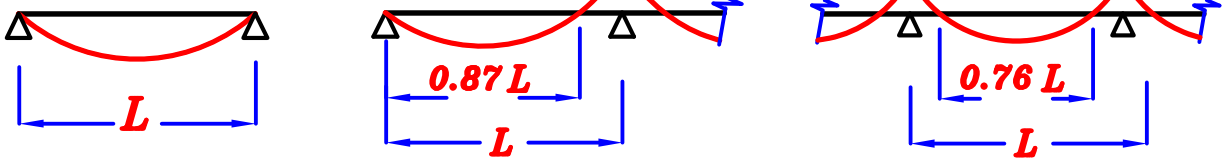
$$\left[\frac{A_s\,(sec.)}{A_s\,(main)}\right] \not> \frac{2}{3}$$

Take:

① $S_1 = b + t_s$

② $\left[\frac{A_s\,(sec.)}{A_s\,(main)}\right] \simeq 0.2$

③ $K =$



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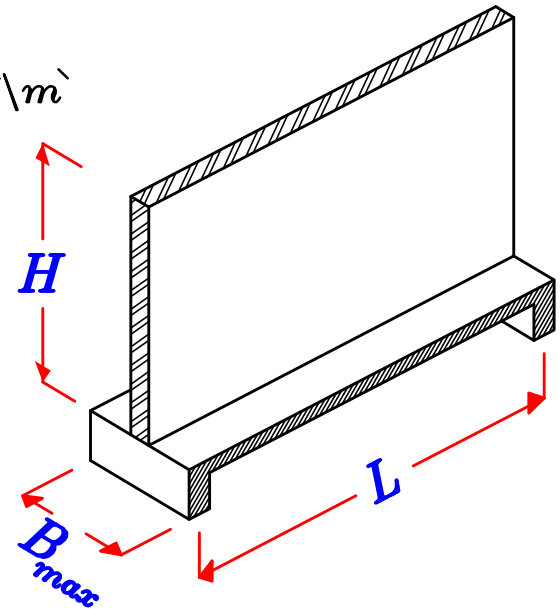
Design a strip under the wall with width B_{max}

$O.W.\,(walls) = \gamma_w\,(kN\backslash m^3) * b * H = \checkmark\ kN\backslash m`$

Take: $\boxed{\gamma_w = 18.0\ kN\backslash m^3}$

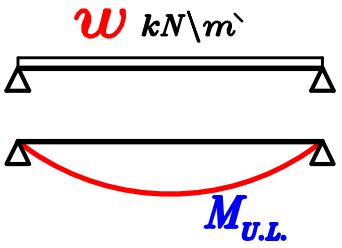


– *Take a strip of width* B_{max}

– $w = w_s * B_{max} + O.W.\,(walls) = \checkmark\ kN\backslash m`$

– *Get* $M_{U.L.} = \checkmark\ kN.m\backslash B_{max}$

– *Get* $A_{s_t} = A_s\ (total)$



From $d = c_1\sqrt{\dfrac{M_{U.L.}}{F_{cu}\,B_{max}}} \longrightarrow c_1 = \checkmark \longrightarrow J = \checkmark$

$$A_{s_t} = \frac{M_{U.L.}}{J\,F_y\,d} = \checkmark\ mm^2\backslash B_{max}$$

– $\boxed{A_{s_{add.}} = A_{s_t} - A_s\,(slab)\,(mm^2\backslash B_{max})} = \checkmark\ mm^2\backslash B_{max}$

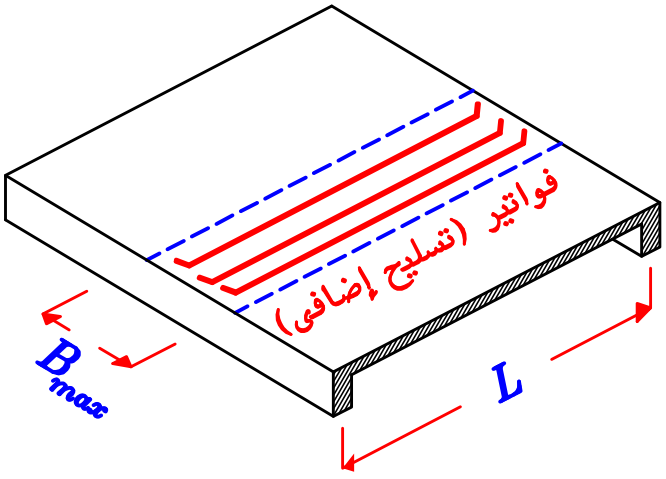
where:

$A_s\,(slab)\,(mm^2\backslash B_{max}) = A_s\,(slab)\,(mm^2\backslash m`) * B_{max} = \checkmark\ mm^2\backslash B_{max}$

$A_{s_{add.}}$ يوضع التسليح الإضافى

B_{max} فى الشريحة التى عرضها

و يسمى (فواتير) .



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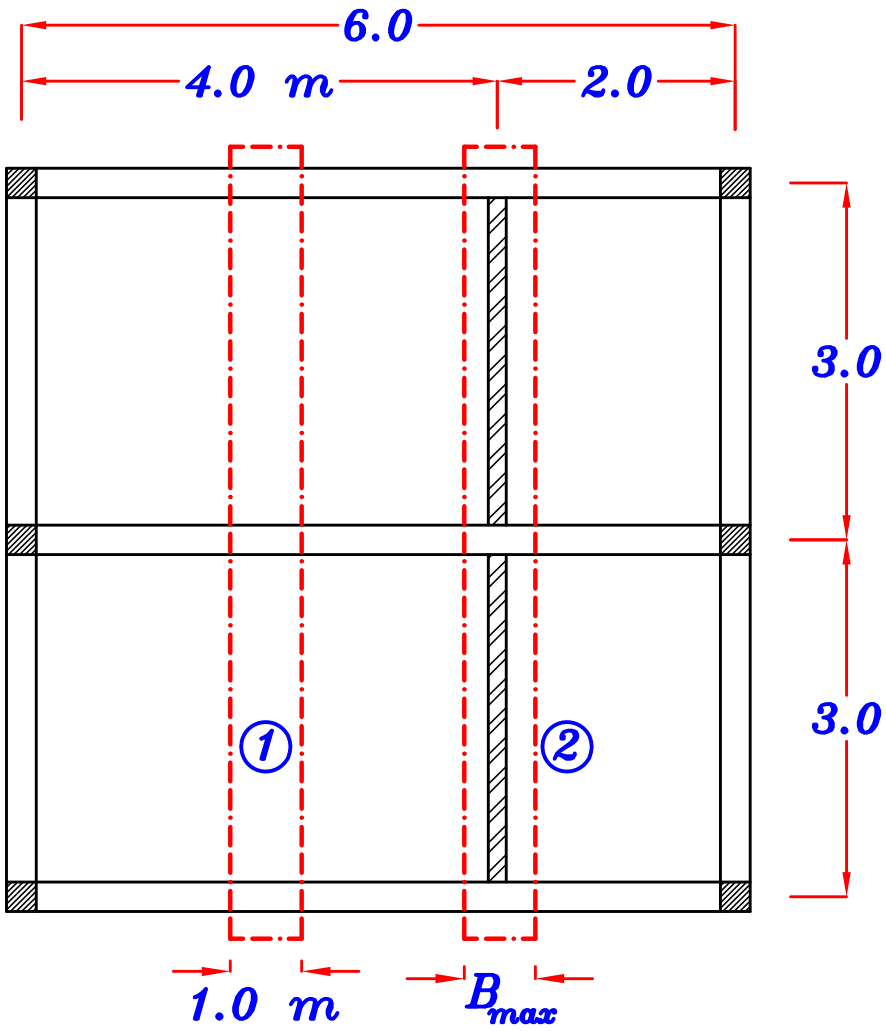
Example.



Data.

$F_{cu} = 30 \ N\backslash mm^2$ $F_y = 360 \ N\backslash mm^2$

$F.C. = 1.50 \ kN\backslash m^2$ $L.L. = 2.0 \ kN\backslash m^2$

For walls. $\delta_w = 18.0 \ kN\backslash m^3$ $b_w = 120 \ mm$ $H_w = 2.50 \ m$

Req.

Design the Slab as Solid Slab.

Solution.

$$t_s = \frac{3000}{30} = 100 \ mm \qquad \boxed{t_s = 100 \ mm}$$

$$w_s = 1.4\,(0.10 * 25 + 1.50) + 1.6\,(2.0) = 8.80 \ kN\backslash m^2$$

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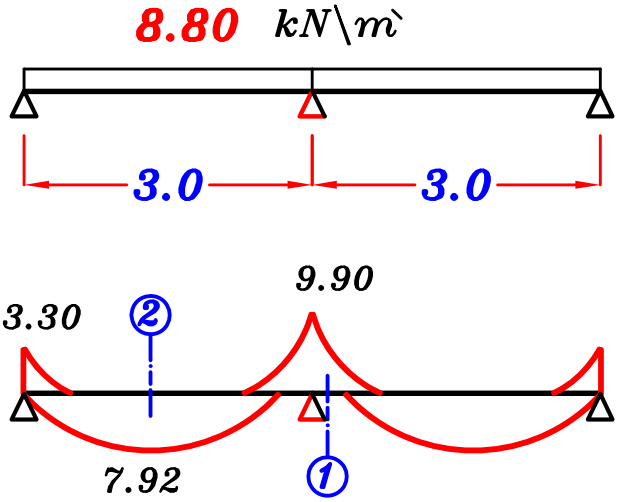
Strip ①



Sec. ①

$M_{U.L.} = 9.90 \quad kN.m\backslash m`$

$, t_s = 100\ mm\ ,\ d = 100 - 20 = 80\ mm$

$$80 = C_1\sqrt{\frac{9.90 * 10^6}{30 * 1000}} \longrightarrow C_1 = 4.40 \longrightarrow J = 0.815$$

$$A_S = \frac{9.90 * 10^6}{0.815 * 360 * 80} = 421.7\ mm^2/m`$$ **6ϕ10\m`**

Sec. ②

$M_{U.L.} = 7.92\ kN.m\backslash m`$

$, t_s = 100\ mm\ ,\ d = 100 - 20 = 80\ mm$

$$80 = C_1\sqrt{\frac{7.92 * 10^6}{30 * 1000}} \longrightarrow C_1 = 4.92 \longrightarrow J = 0.826$$

$$A_S = \frac{7.92 * 10^6}{0.826 * 360 * 80} = 332.9\ mm^2/m`$$ **5ϕ10\m`**

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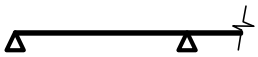
Strip ②

$S_1 = b + \quad s = \qquad\qquad m$

$B_{max} \qquad \left[\frac{A\ (\ )}{A\ (main)}\right] *$

take $\left[\frac{A_{s\,(sec.)}}{A_{s\,(main)}}\right]$ **0.2** **0.87**



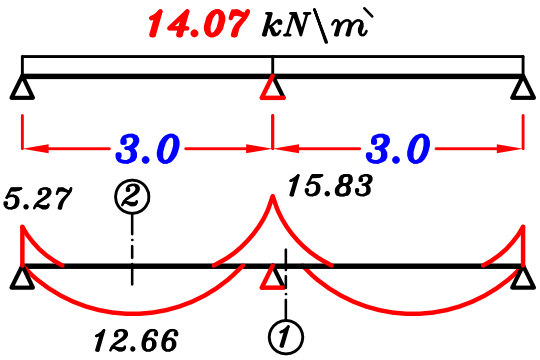
B_{max} 0.? + ( ) ( )

$O.W.\,(walls) = \quad b \quad * \gamma_w * 1.4 \quad (kN\backslash m$

$O.W.\,(walls) = 0.12 * 2.5 * 18.0 * 1.4$

$w = w_s * B_{max} + O.W. \qquad kN\backslash m`$

$w = 8.80 * 0.74 + 7.56$ $kN\backslash m`$



Sec. ①

$M_{U.L.} = 15.83 \ kN.m\backslash m$

$, t_s = 100\,mm \ , \ d = 100 - 20 = 80 \ mm$

$80 = C_1\sqrt{\frac{15.83 * 10^6}{30 * 740}} \longrightarrow C_1 = 2.99 \longrightarrow J = 0.741$

$A_{st} = \frac{15.83 * 10^6}{0.741 * 360 * 100} = 593 \ mm^2/0.74\ m$

$A_{s\ add.} = A_{st} - A_{s\,(slab)} = 593 - 421.7\ (0.74) = 280.9 \ mm^2/0.74\ m$

$3\phi 12 \backslash 0.74\ m$

Sec. ②

$M_{U.L.} = 12.66 \ kN.m\backslash m$

$, t_s = 100\,mm \ , \ d = 100 - 20 = 80 \ mm$

$80 = C_1\sqrt{\frac{12.66 * 10^6}{30 * 740}} \longrightarrow C_1 = 3.35 \longrightarrow J = 0.771$

$A_{st} = \frac{12.66 * 10^6}{0.771 * 360 * 80} = 570.1 \ mm^2/0.74\ m$

$A_{s\ add.} = A_{st} - A_{s\,(slab)} = 570.1 - 332.9\,(0.74) = 323.75 \ mm^2/0.74\ m$

$3\phi 12 \backslash 0.74\ m$

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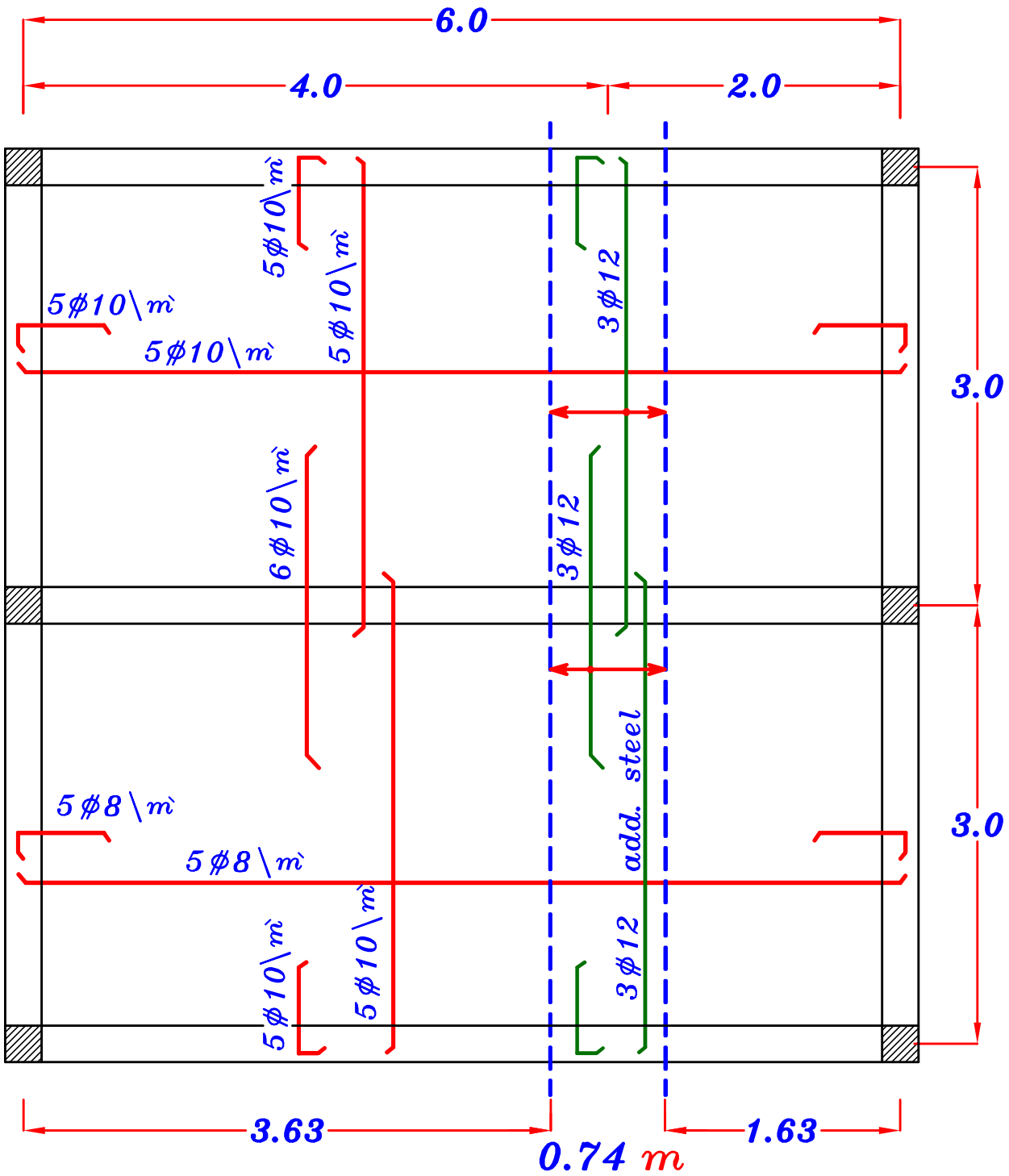

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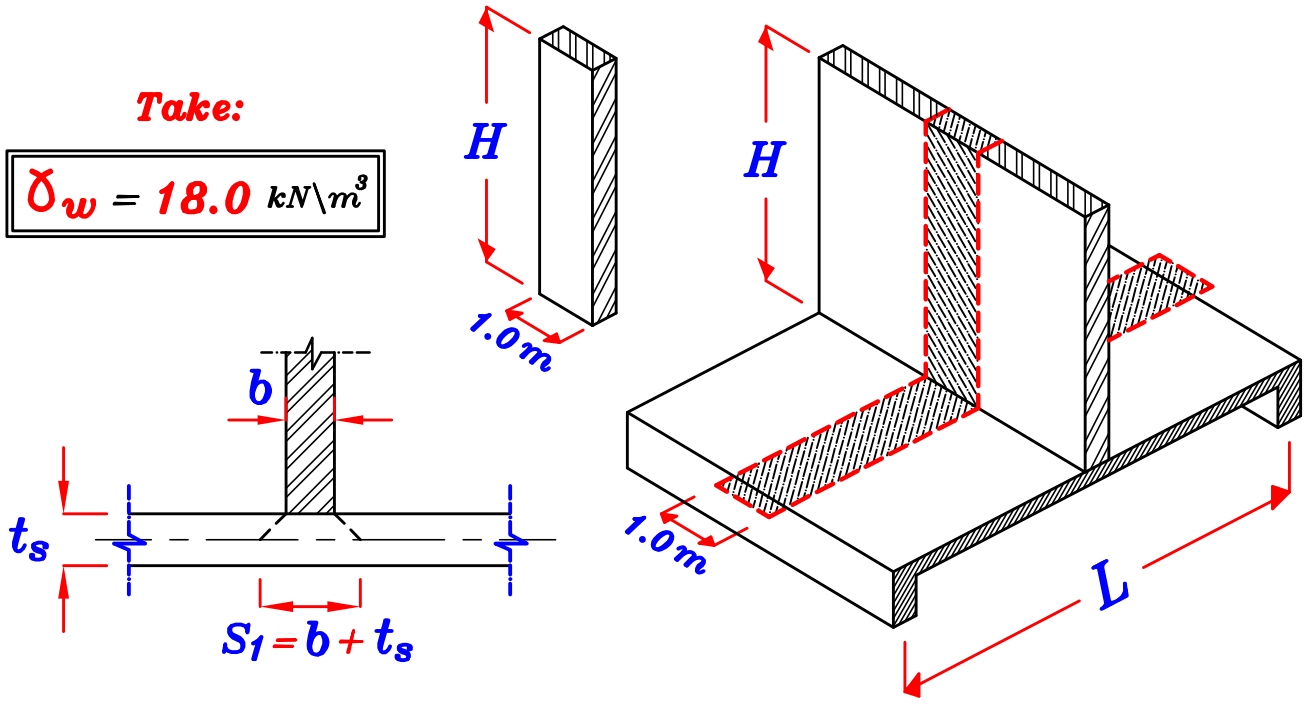
Line Load perpendicular to Load Direction.

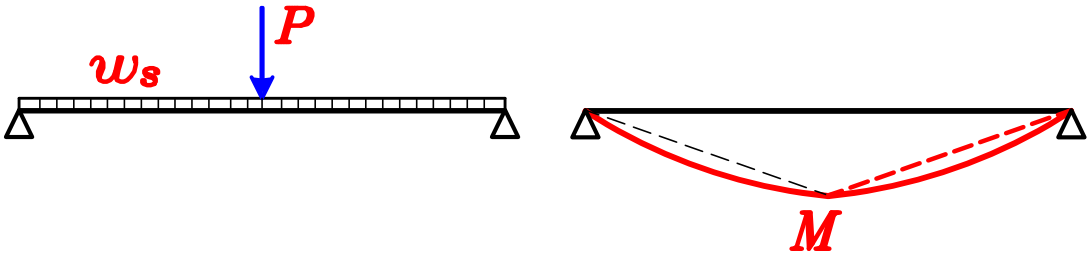
Take:

$\gamma_w = 18.0\ kN\backslash m^3$



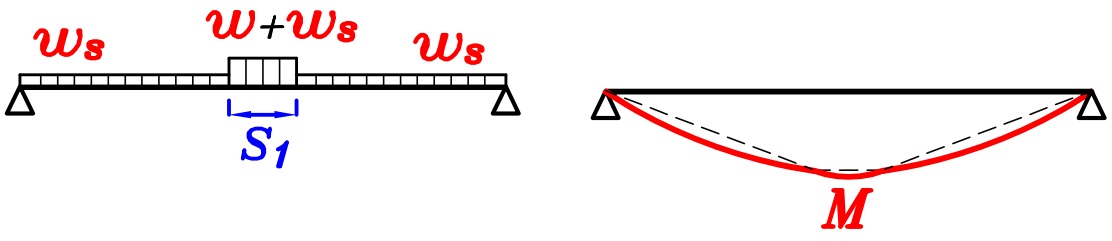
$$O.W.\,(walls) = 1.4\left[b * H * \gamma_w(kN\backslash m^3)\right] = \checkmark\ kN\backslash m`$$

$P = 1.4(b * H * \gamma_w)$ *concentrated Load* وزن الحائط يوضع كـ



الحل الدقيق لهذه الشريحه هو أن يتم توزيع وزن الحائط على

العرض (S_1) فتكون قيمه الحمل المنتظم تساوى $w = 1.4\left(\frac{b * H * \gamma_w}{S_1}\right)$



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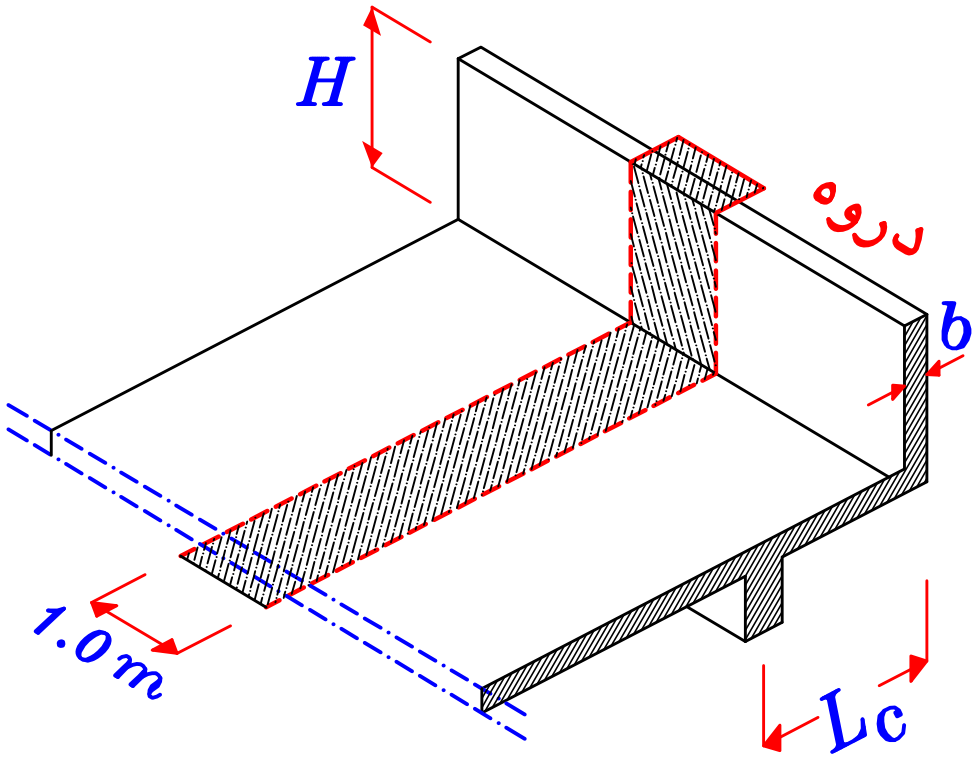
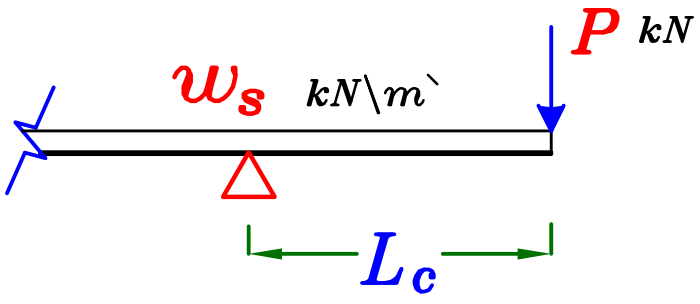
parpet on cantilever Slab.





Take the strip width = 1.0

The parapet will acts as a concentrated Load

$$P = \delta_c * b * H \quad kN$$

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Example.

Data.

$F_{cu} = 25 \ N\backslash mm^2$

$F_y = 360 \ N\backslash mm^2$

$F.C. = 2.0 \ kN\backslash m^2$

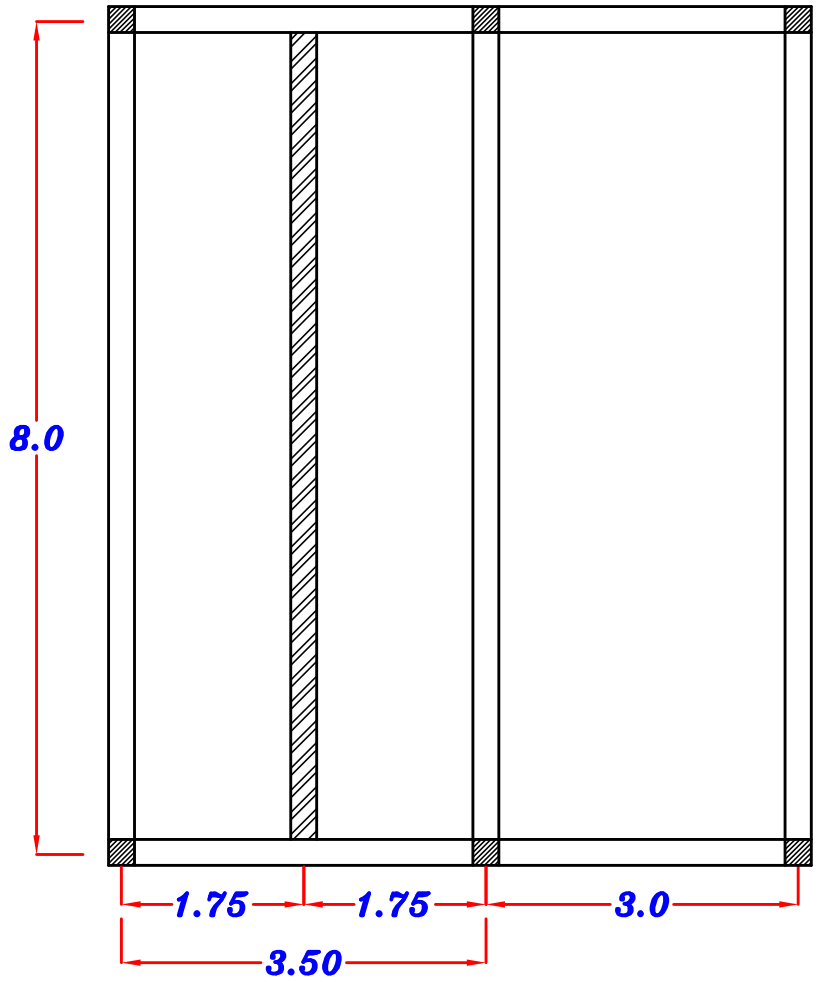
$L.L. = 2.50 \ kN\backslash m^2$

For walls.

$\gamma_w = 18.0 \ kN\backslash m^3$

$b_w = 250 \ mm$

$H_w = 2.50 \ m$

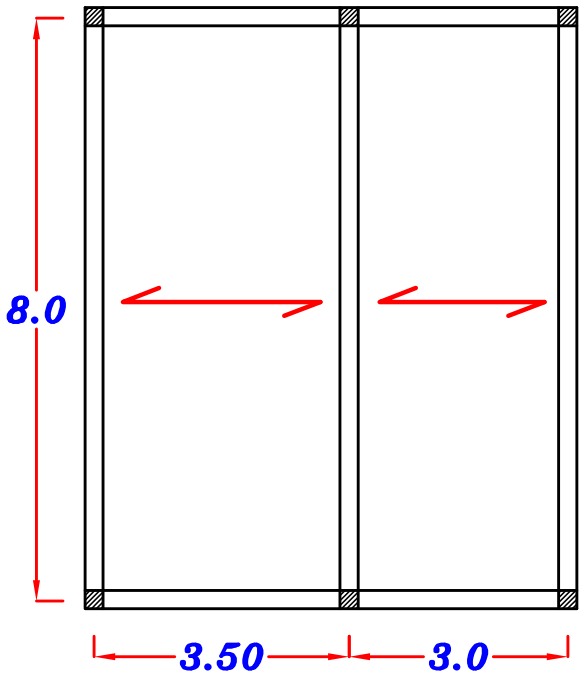


Req.

① Design the Slab as Solid Slab.

② Draw Details of RFT. in plan.

Solution.



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$$1-\ t_s = \frac{3500}{30} = 116.6\ mm \qquad \boxed{t_s = 120\ mm}$$

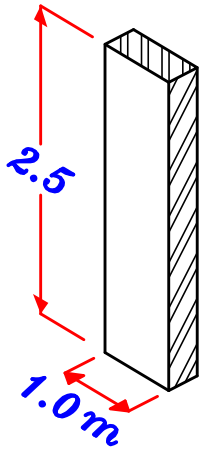
$$2-\ (w_s)_{U.L.} = 1.4\,(t_s\,\gamma_c + F.C.) + 1.6\,(L.L.)$$

$$(w_s)_{U.L.} = 1.4\,(0.12*25 + 2.0) + 1.6\,(2.50) = 11.0\ kN\backslash m^2$$

3- Calculate the weight of 1.0 m of the wall.

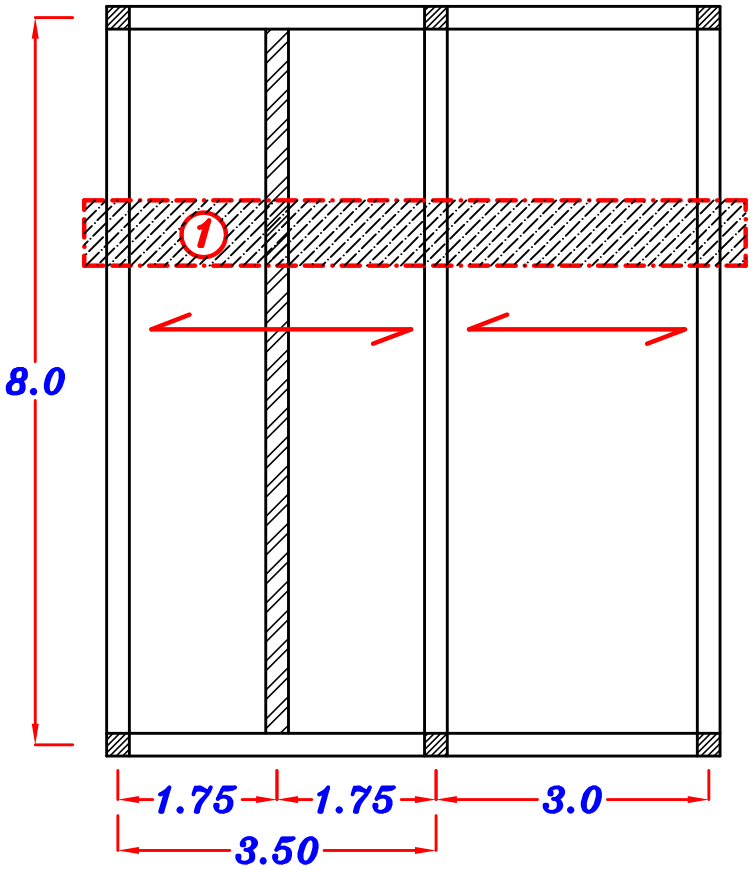
$$O.W.\,(walls) = 1.4\,(b*H*\gamma_w)$$

$$= 1.4\,(0.25*2.50*18.0) = 15.75\ kN\backslash m`$$



3- Take a strip at the Load direction.

نأخذ شريحه فى اتجاه الحمل .



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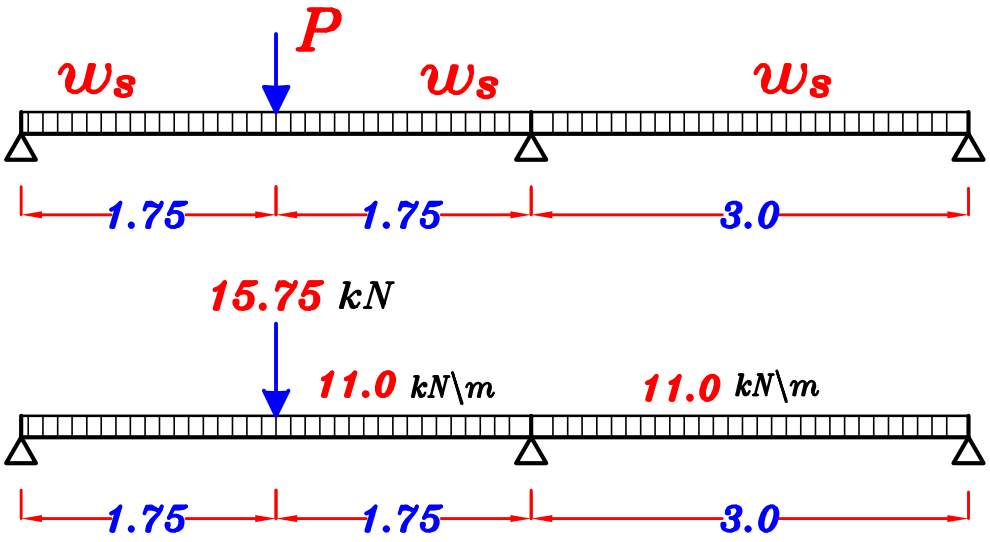
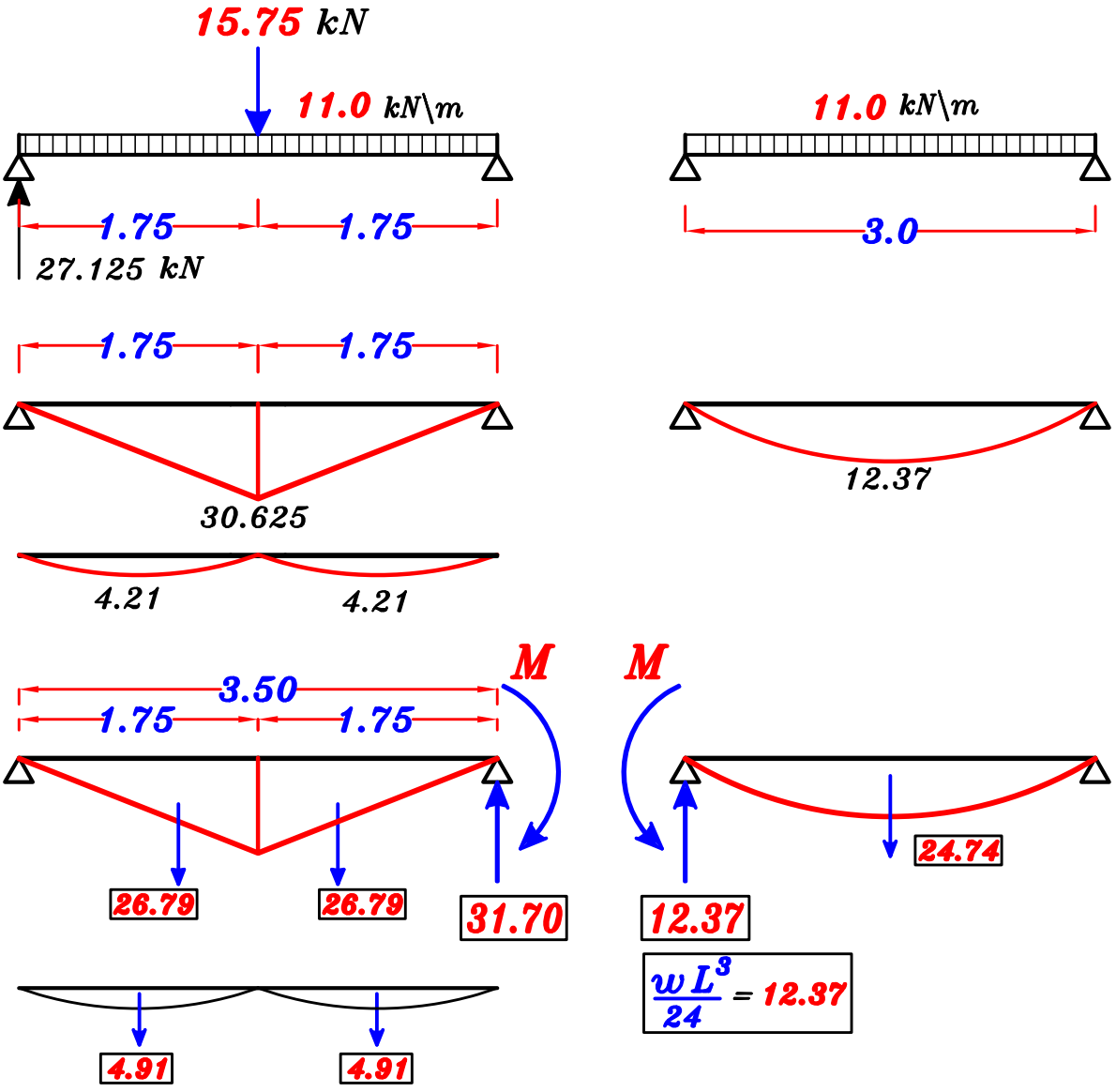


Solve the strip using 3 moment equation.

Elastic reactions.



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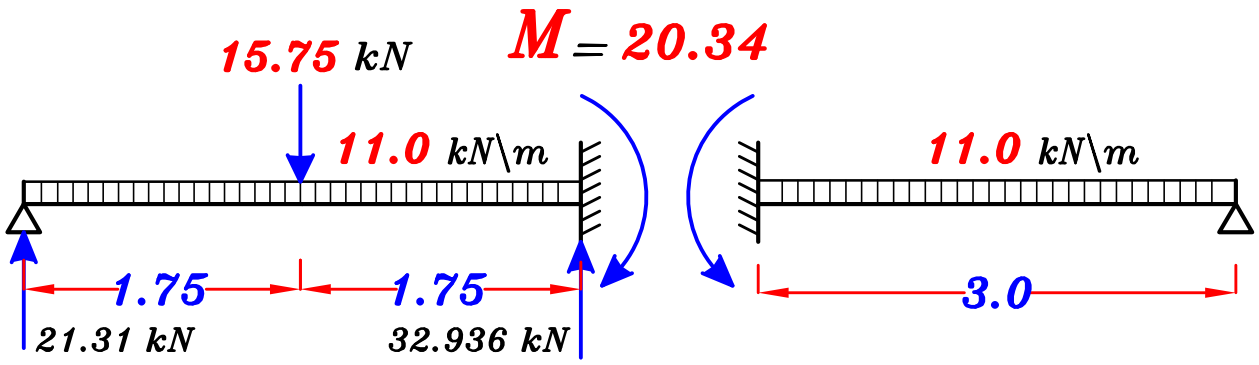
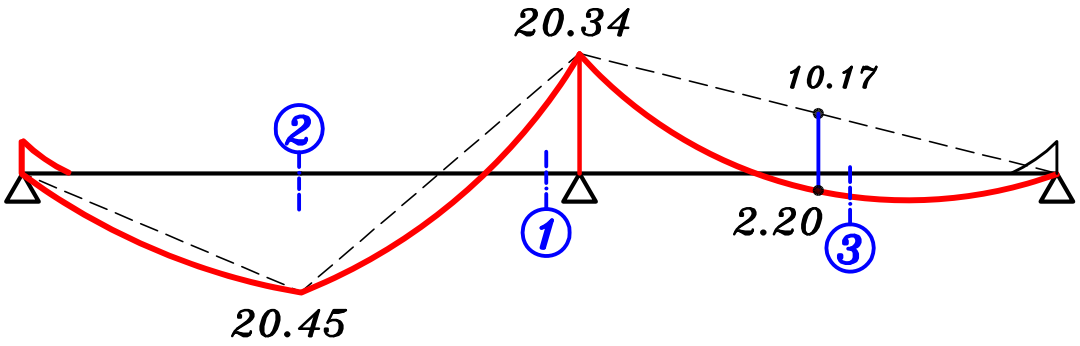
$$0.0 + 2M(3.50 + 3.0) + 0.0 = -6\,(31.70 + 12.37)$$

$$\boxed{M = -20.34 \ \ kN.m}$$





Sec. ① $M_{U.L.} = 20.34 \ \ kN.m\backslash m$

, $t_s = 120\,mm$, $d = 100\,mm$, $B = 1000\,mm$

$$100 = C_1\sqrt{\frac{20.34 * 10^6}{25 * 1000}} \longrightarrow C_1 = 3.50 \longrightarrow J = 0.78$$

$$A_S = \frac{20.34 * 10^6}{0.78 * 360 * 100} = 724.3 \ \ mm^2/m\grave{}$$ **7 ϕ 12 \ m`**

Sec. ② $M_{U.L.} = 20.45 \ \ kN.m\backslash m$

, $t_s = 120\,mm$, $d = 100\,mm$, $B = 1000\,mm$

$$100 = C_1\sqrt{\frac{20.45 * 10^6}{25 * 1000}} \longrightarrow C_1 = 3.50 \longrightarrow J = 0.78$$

$$A_S = \frac{20.45 * 10^6}{0.78 * 360 * 100} = 728.2 \ \ mm^2/m\grave{}$$ **7 ϕ 12 \ m`**

Sec. ③ $M_{U.L.} = 2.20 \ \ kN.m\backslash m$ **5 ϕ 10 \ m`**

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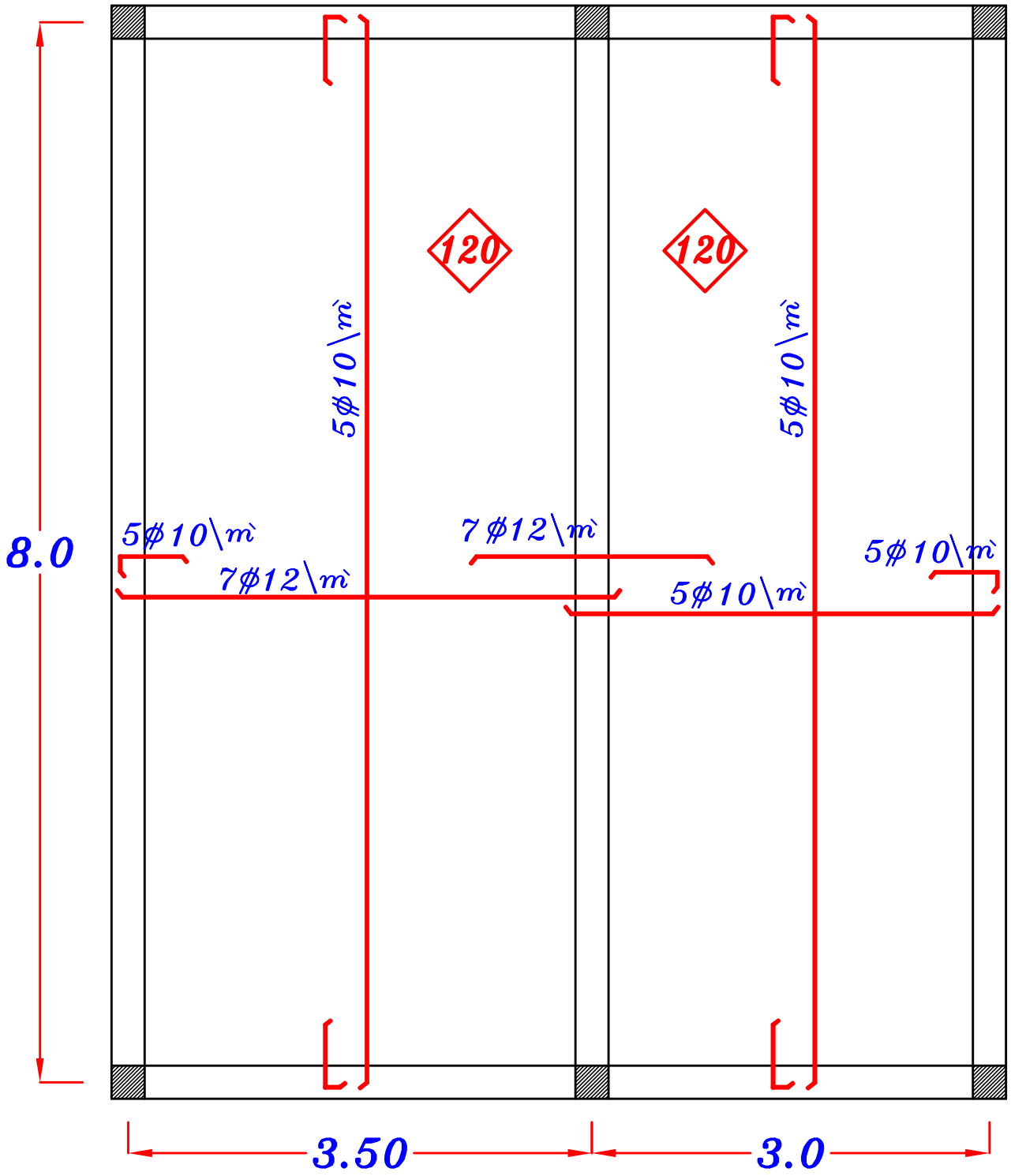
RFT. of the slab.



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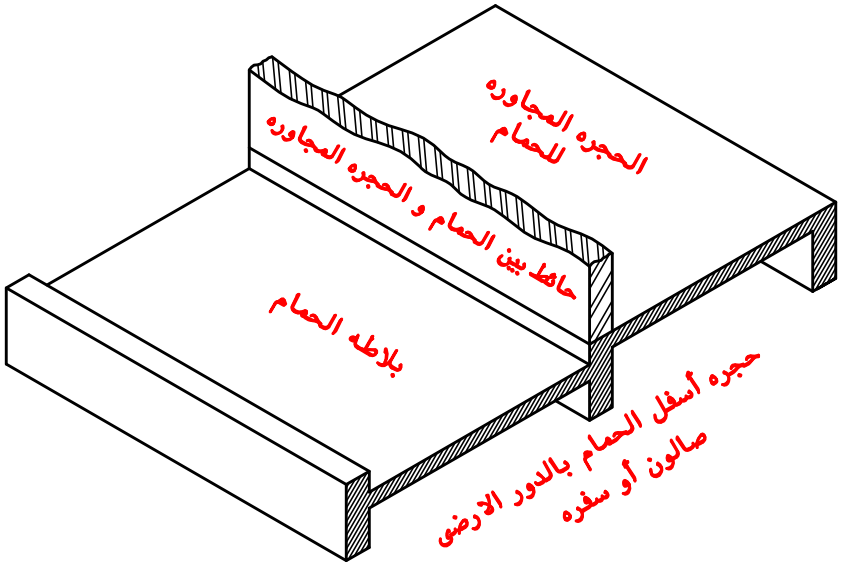
Special case.

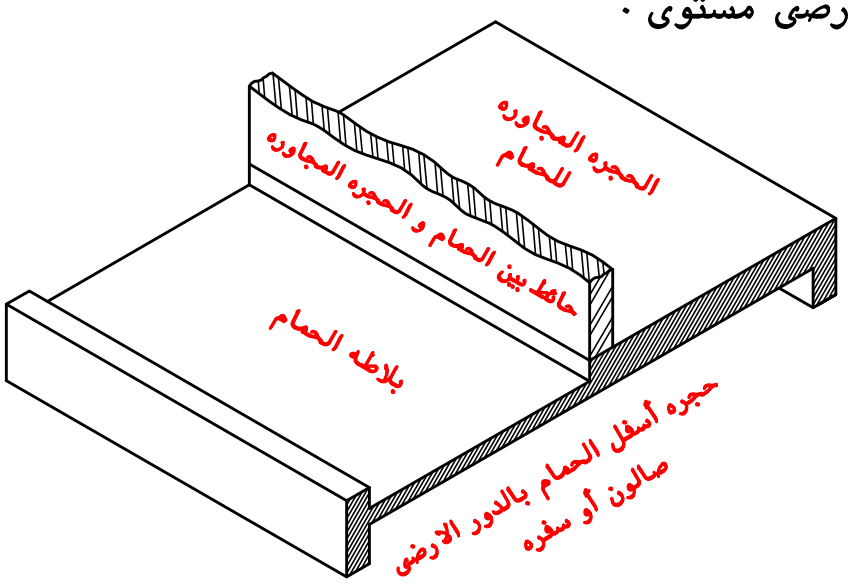
حاله خاصه.

عاده فى الفيلات يكون الدور الارضى للاستقبال
(صالونات و سفره و مطبخ و حمام للضيوف و حجره نوم للخدم)
و يكون فى الدور الاول حجره النوم الرئيسيه (*master bed room*)
(ملحق بها حمام خاص) و حجرات نوم للابناء و حمام كبير .
أى أن التصميم الداخلى للدور الارضى ليس مثل الدور الاول .
لذا فى أحيان كثيره يكون فى الدور الاول حمام و أسفله مباشره حجره أستقبال
أى أنه اذا هبطنا منسوب بلاطه الحمام سنضطر لعمل كمره بين الحمام و الحجره المجاوره



و فى هذه الحاله سنكون قد وضعنا كمره فى منتصف سقف حجره الدور الارضى .

لذا يفضل فى هذه الحاله عمل المنسوب السفلى البلاطه مستوى حتى يظهر سقف حجره الدور الارضى مستوى .



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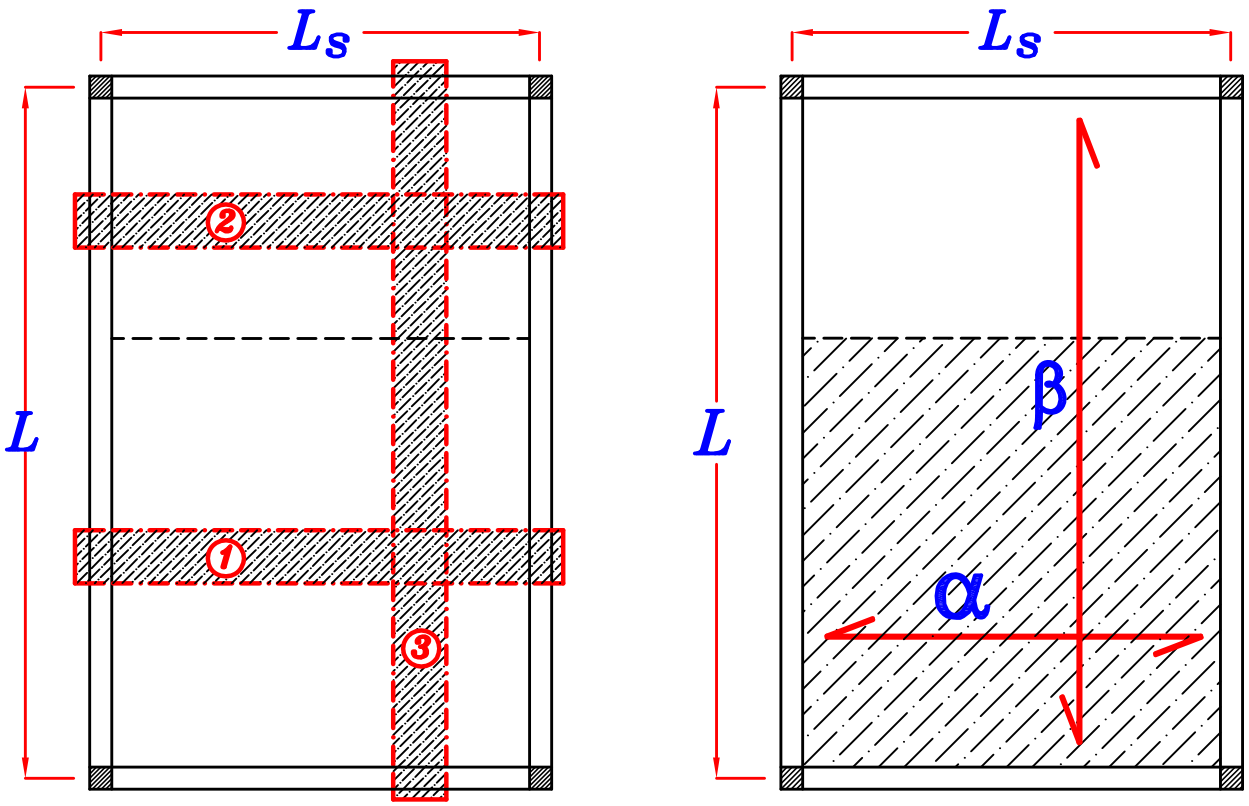
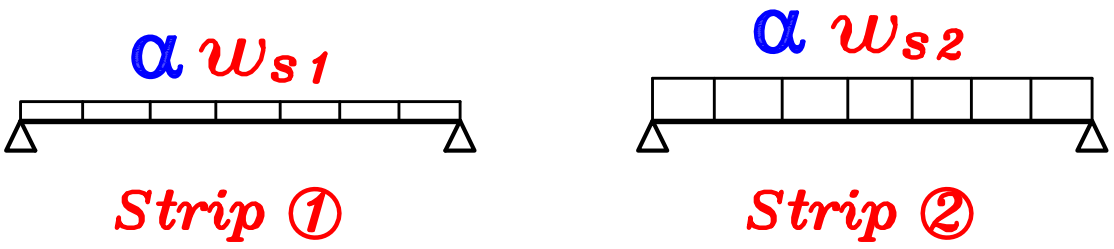
من الممكن اعتبار أن البلاطه محموله على الاربع كمرات الخارجيه .

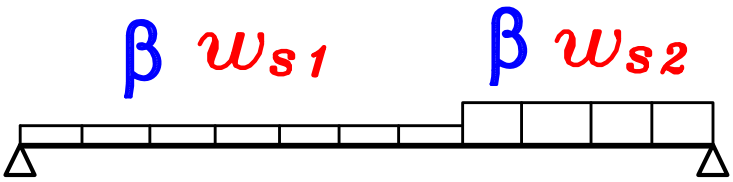
و لكن مع الاخذ فى الاعتبار أن هناك قيمتين لـ (t_s) لذا سوف يكون هناك قيمتين لـ (w_s)





Strip ①

Strip ②



Strip ③

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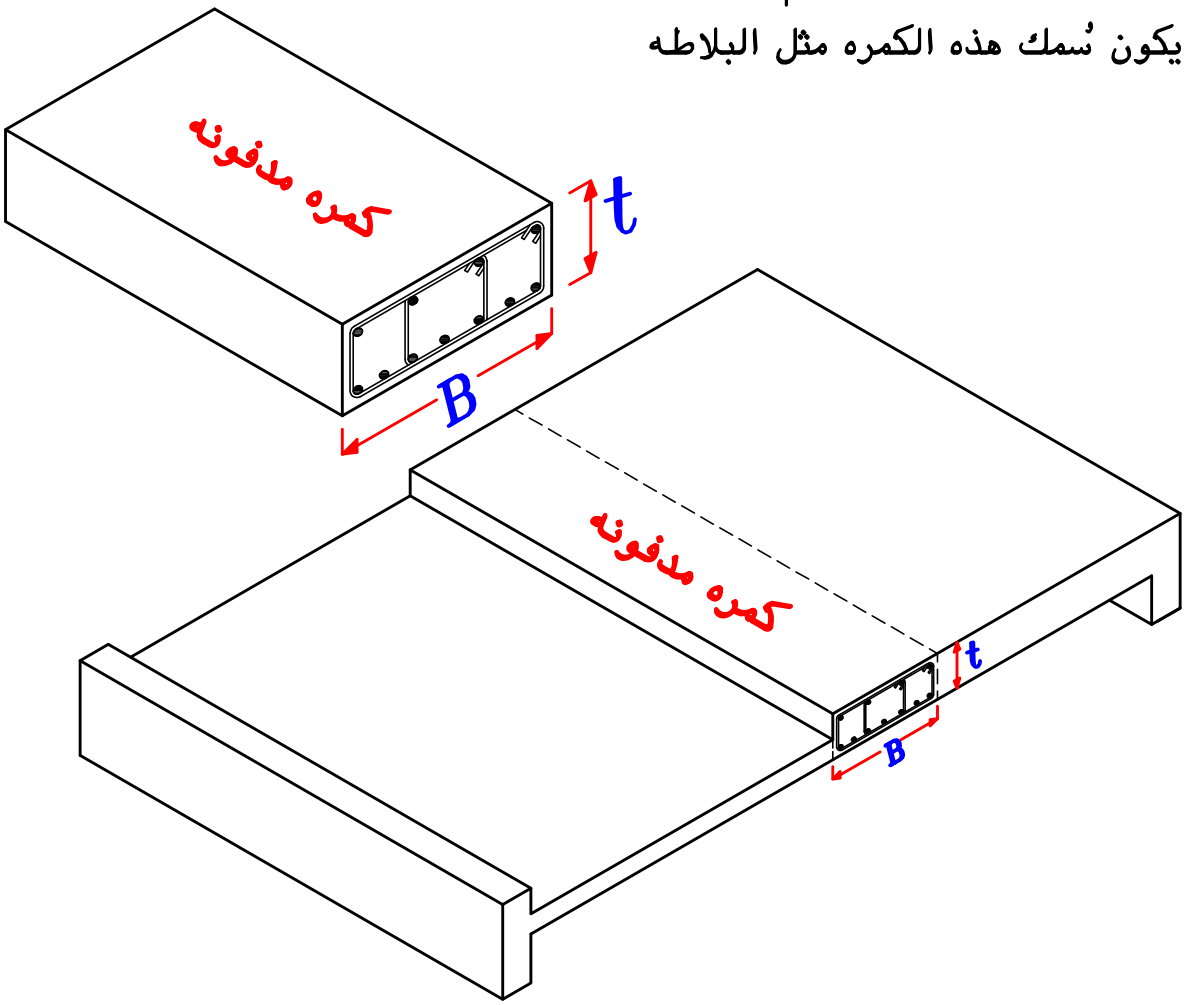
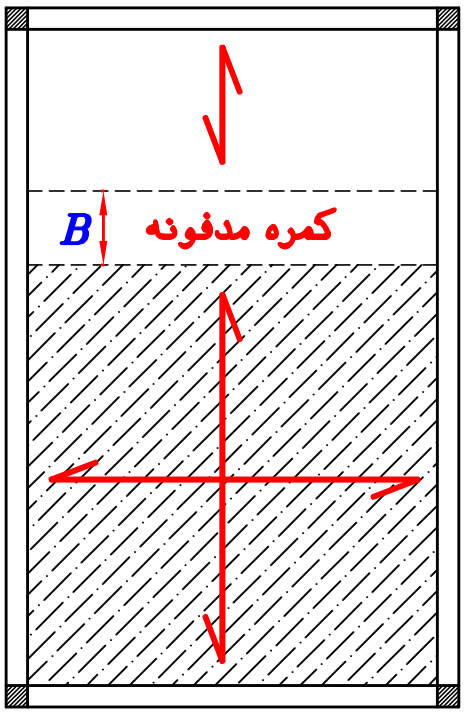
حل أخر

و لعمل مثل هذه البلاطه يتم عمل كمره مدفونه (مخده)

و يكون سُمك هذه الكمره مثل البلاطه





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Example.

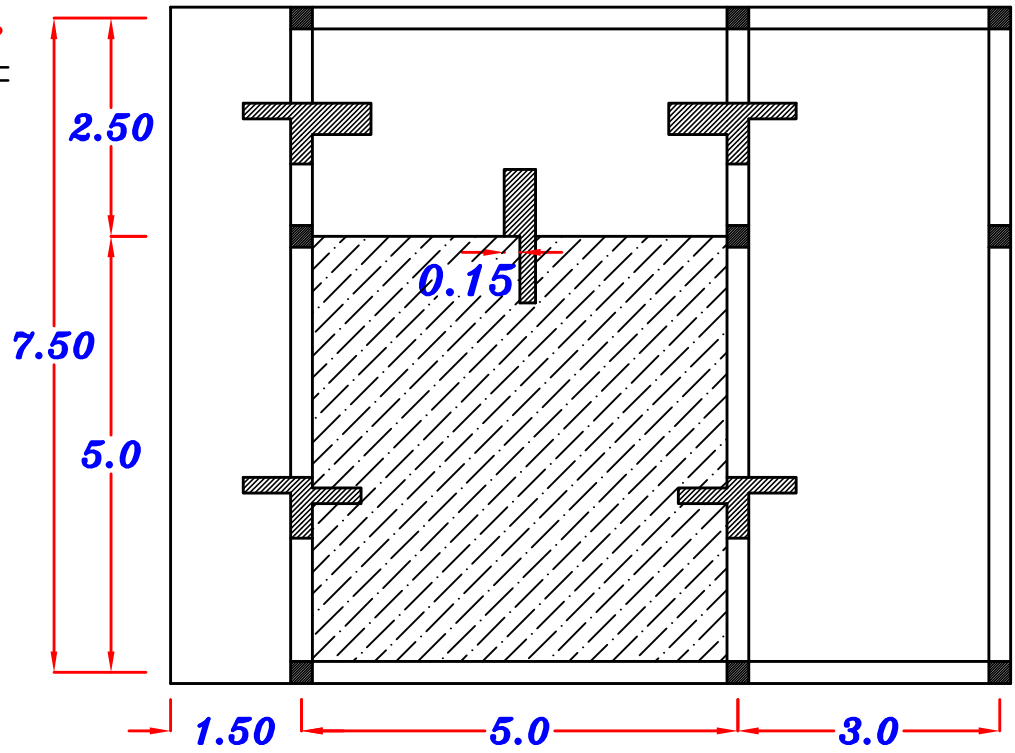
Data.

$F_{cu} = 25 \ N\backslash mm^2$

$F_y = 360 \ N\backslash mm^2$

$F.C. = 1.5 \ kN\backslash m^2$

$L.L. = 2.0 \ kN\backslash m^2$



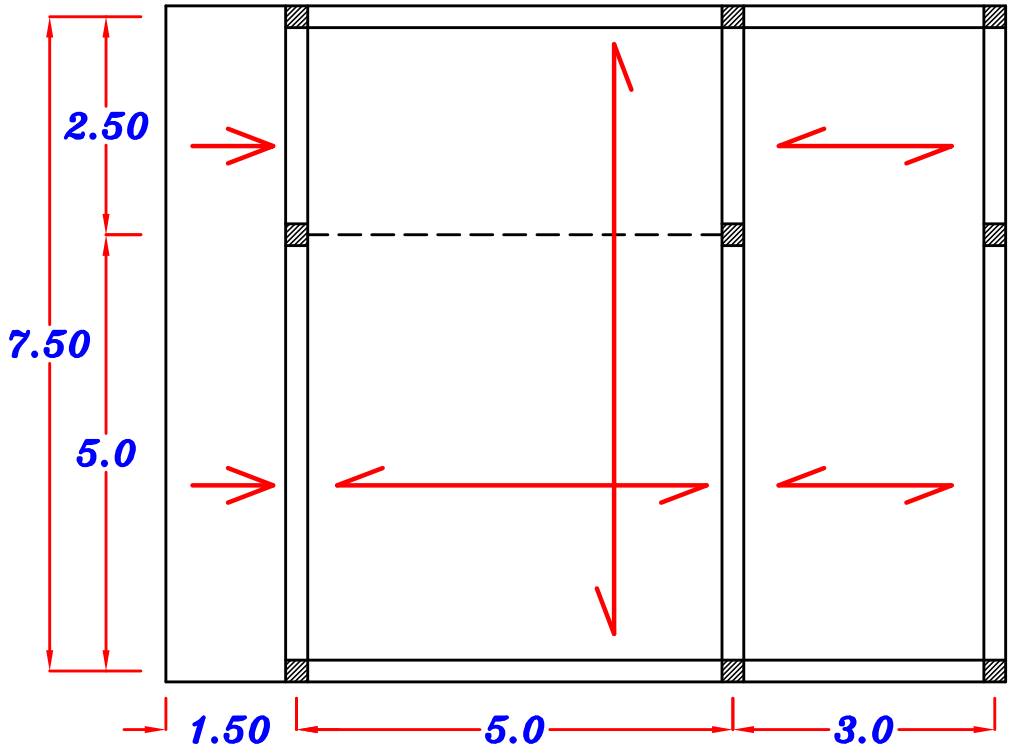
Req.

① Design the Slab as Solid Slab.

② Draw Details of RFT. in plan.

Solution.

نعتبر أن البلاطه كامله (٧,٣٠ × ٥,-) مع وجود تخانتين للبلاطه .



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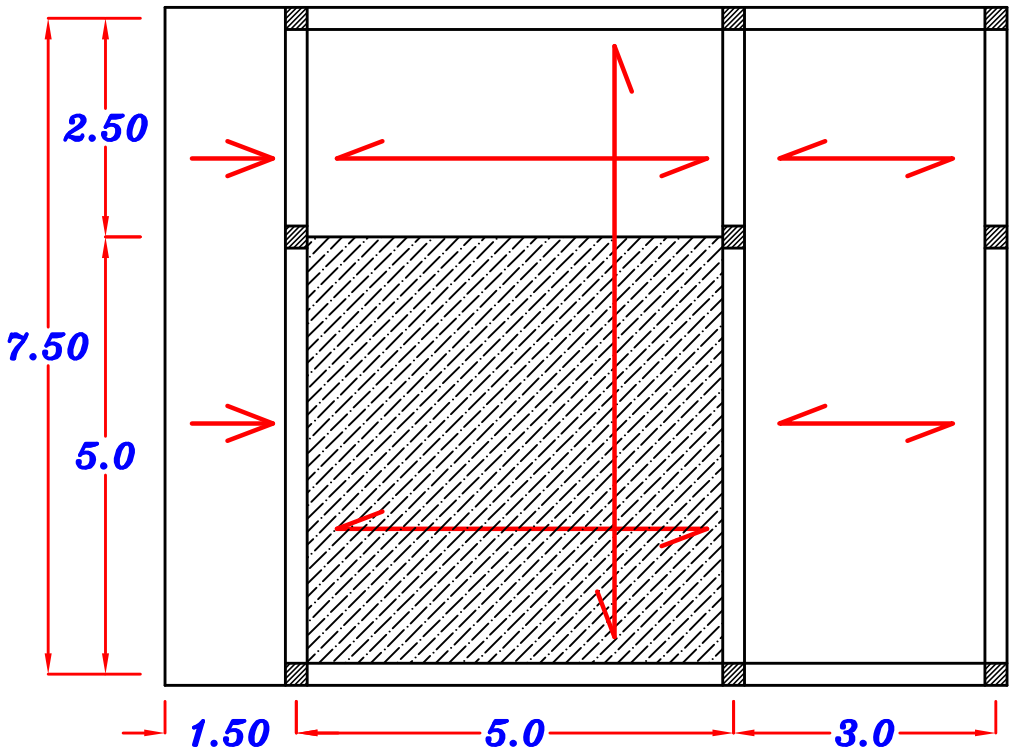
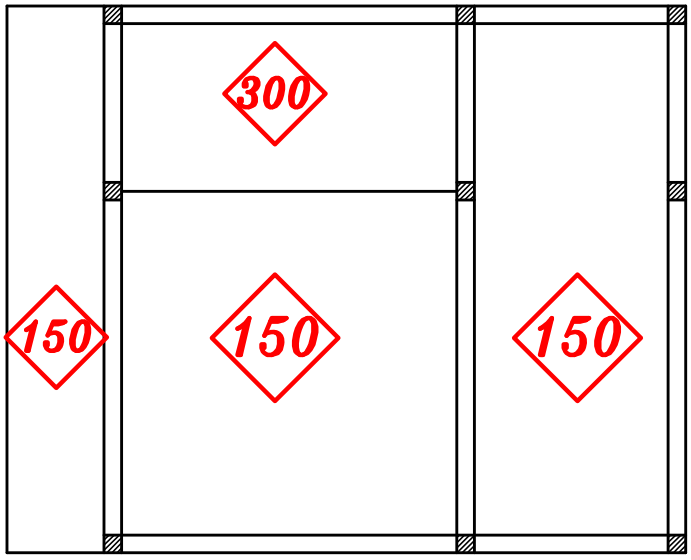


$$t_s = \frac{L_s}{30} = \frac{3000}{30} = 100 \quad mm$$

$$\frac{L_s}{45} = \frac{5000}{35} = 142.8 \quad mm$$

$$= \frac{L_c}{10} = \frac{1500}{10} = 150 \quad mm$$

$$t_s = 150 \ mm$$



$$(w_{s1}) = 1.4\,(0.15 * 25 + 1.5) + 1.6\,(2.0) = 10.55 \quad kN\backslash m^2$$

$$(w_{s2}) = 1.4\,(0.30 * 25 + 1.5) + 1.6\,(2.0) = 15.80 \quad kN\backslash m^2$$

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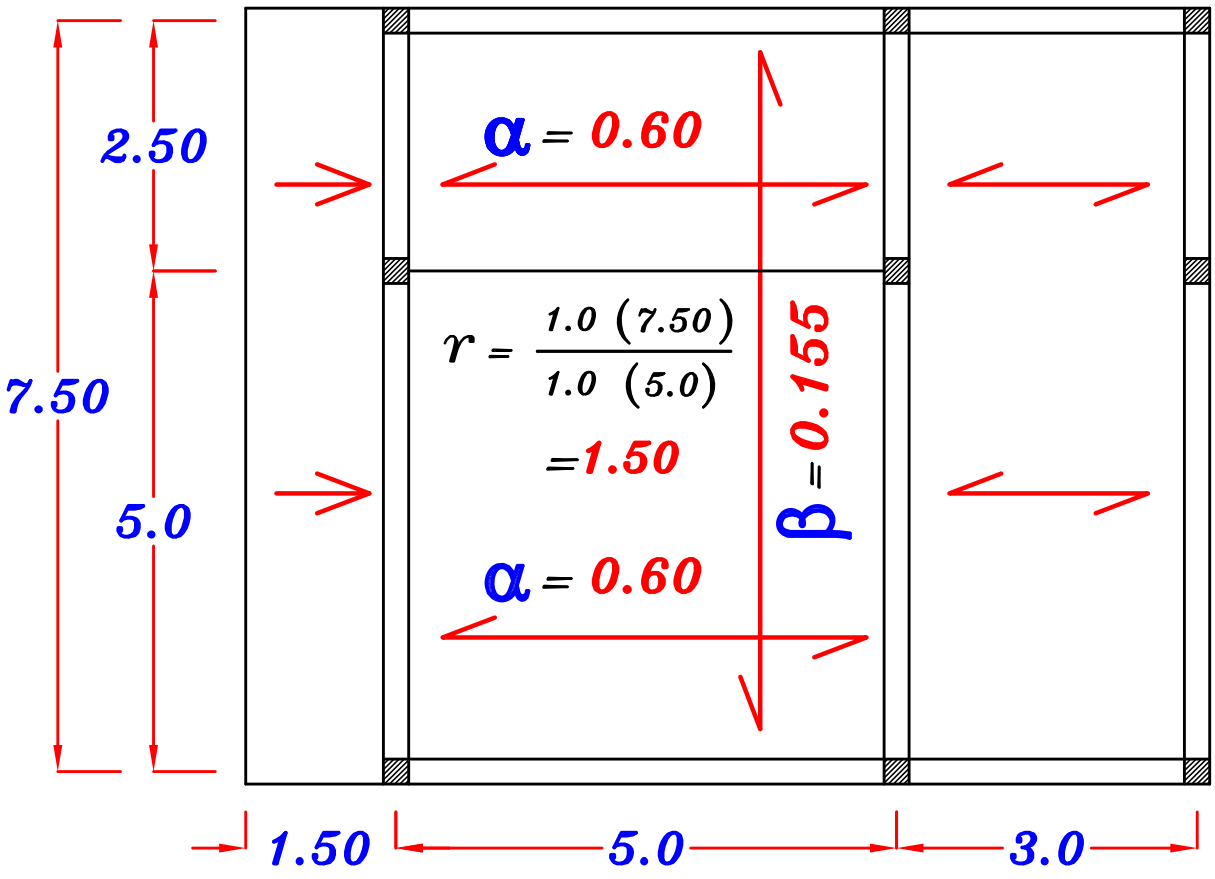

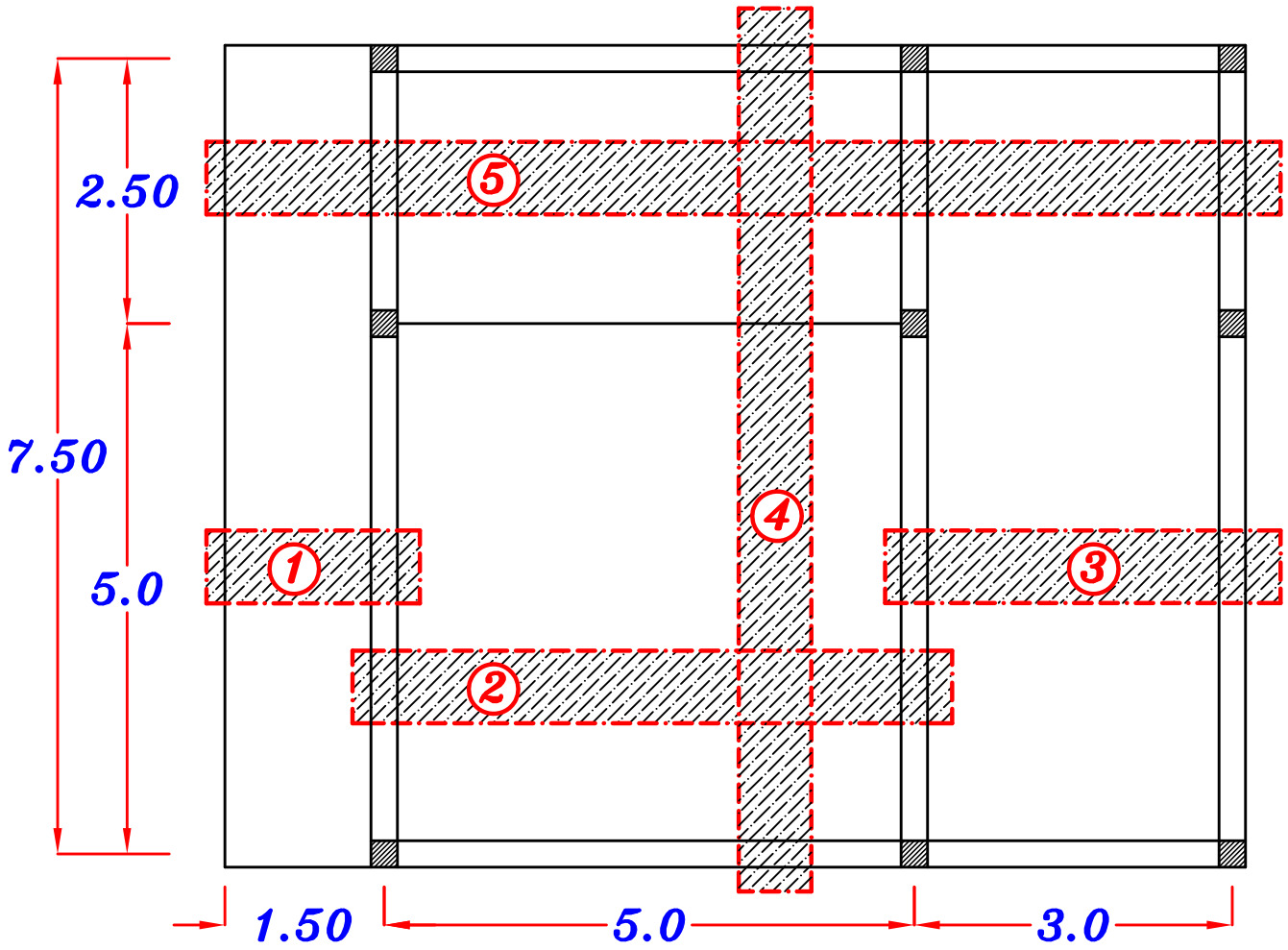

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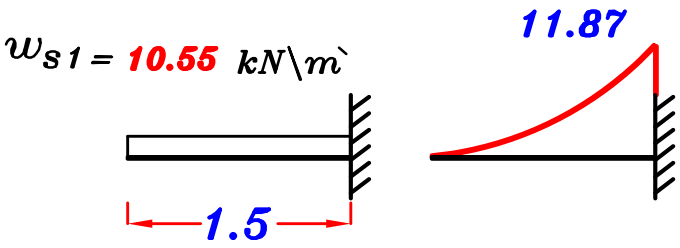

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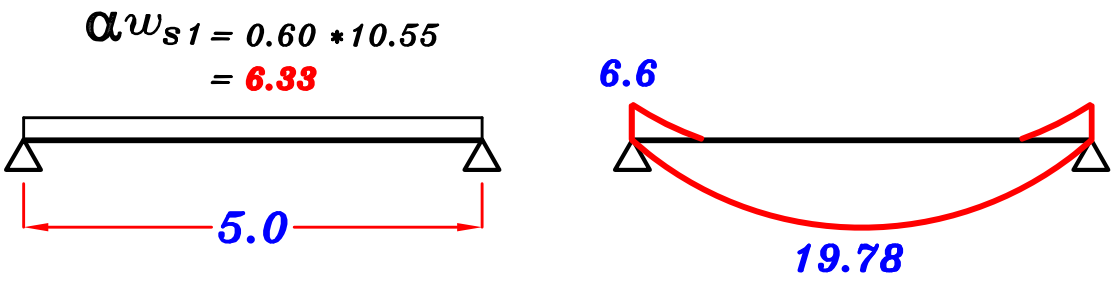

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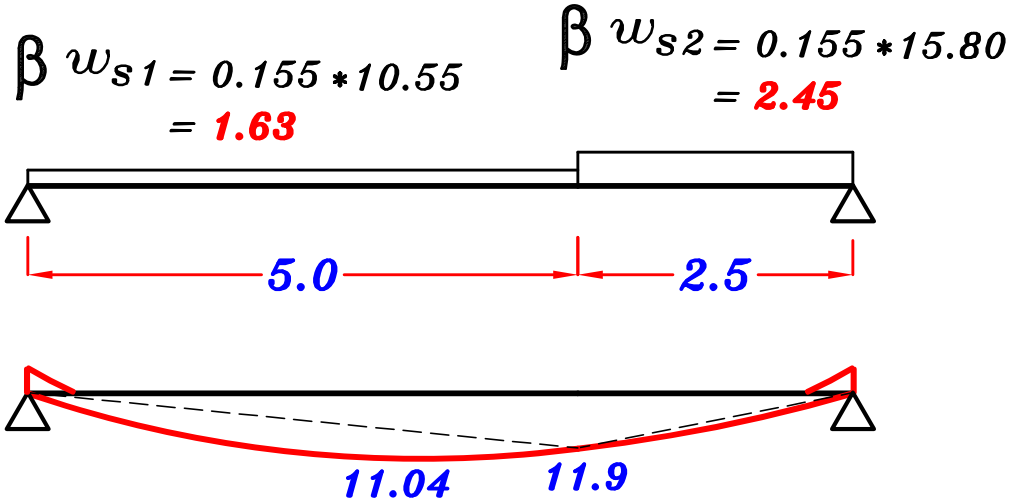
Strip ④



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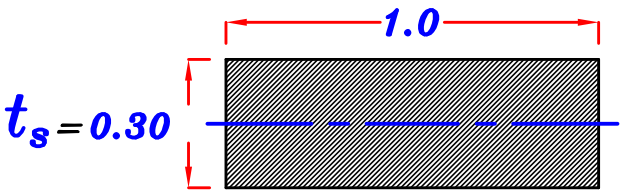
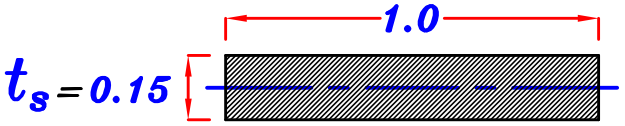




$$I_2 = \frac{1.0 * 0.30^{\,3}}{12} = 2.25 * 10^{-3}$$

$$I_1 = \frac{1.0 * 0.15^{\,3}}{12} = 2.812 * 10^{-4}$$

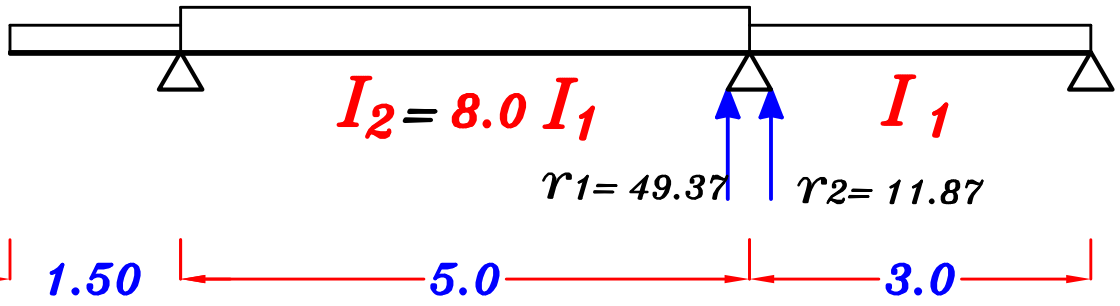
$$\boxed{I_2 = 8.0\ I_1}$$

$\boxed{M_C = -11.87}$

$\boxed{M}$

$\alpha\ w_{s2} = 0.60 * 15.80 = 9.48$

$w_{s1} = 10.55$ $\qquad$ $w_{s1} = 10.55$

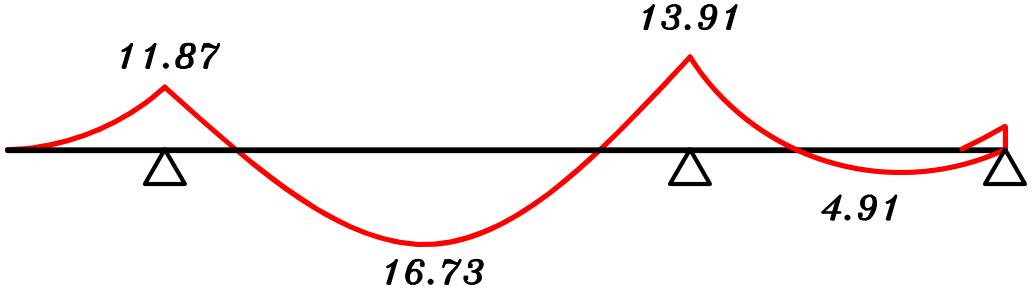


using 3 moment equations.

$$M_C\left(\frac{L_1}{I_1}\right) + 2\,M\left(\frac{L_1}{I_1} + \frac{L_2}{I_2}\right) + 0.0 = -6\left(\frac{r_1}{I_1} + \frac{r_2}{I_2}\right)$$

$$(-11.87)\left(\frac{5.0}{8\,I_1}\right) + 2\,M\left(\frac{5.0}{8\,I_1} + \frac{3.0}{I_1}\right) + 0.0 = -6\left(\frac{49.37}{8\,I_1} + \frac{11.87}{I_1}\right)$$

$$\boxed{M = -13.91\ \text{kN.m}}$$



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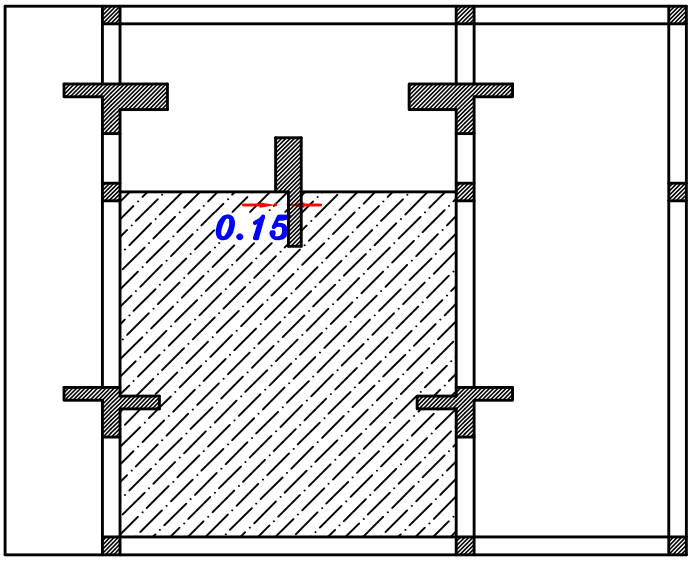
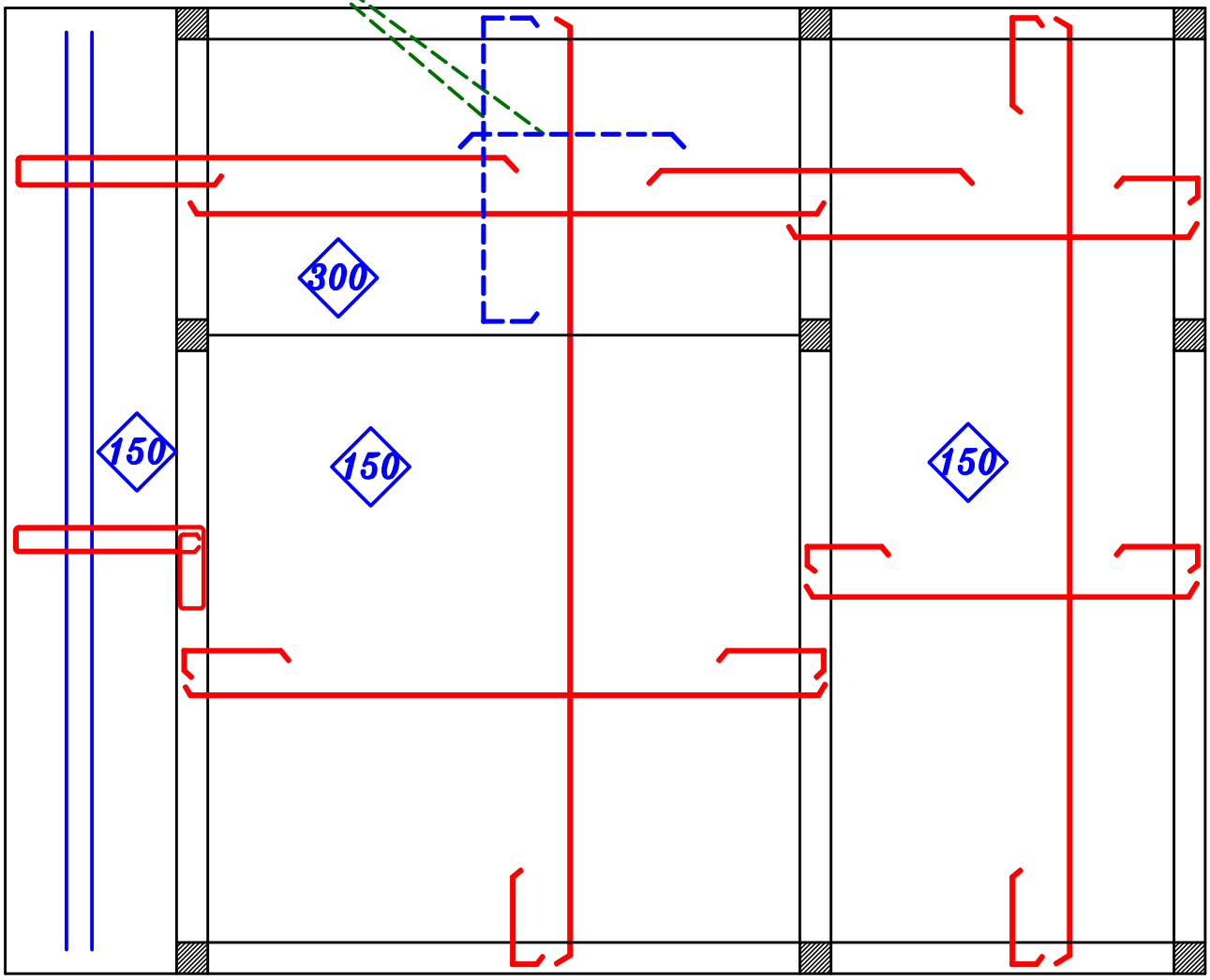
RFT. of the slab.



باقى الشبكه العلويه shrinkage

لان t_s أكبر من ١٦٠ مم



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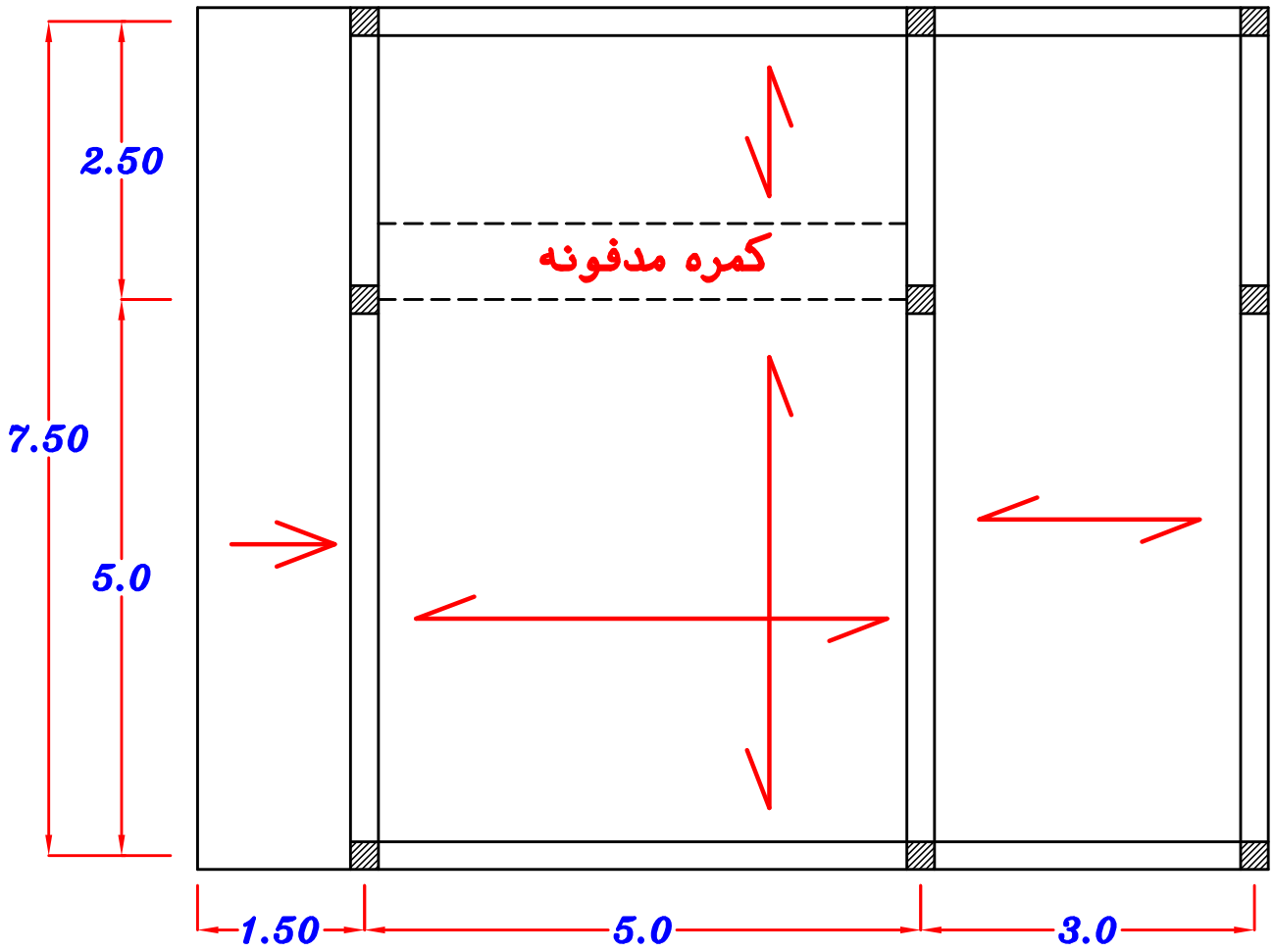
حل أخر



يتم عمل كمره مدفونه و أخذ بلاطه الحمام على أنها (simple)

$$t_s = \frac{L_s}{25} = \frac{3000}{25} = 120 \ mm$$

$$\frac{L_s}{35} = \frac{5000}{35} = 142.8 \ mm$$

$$= \frac{L_c}{10} = \frac{1500}{10} = 150 \ mm$$

$$t_s = 150 \ mm$$

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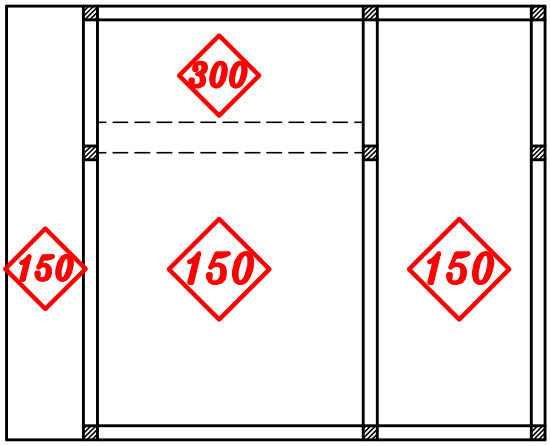
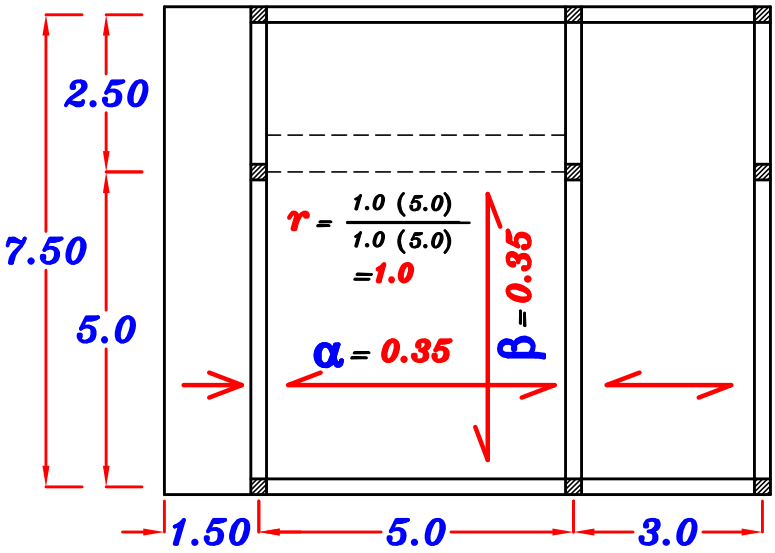
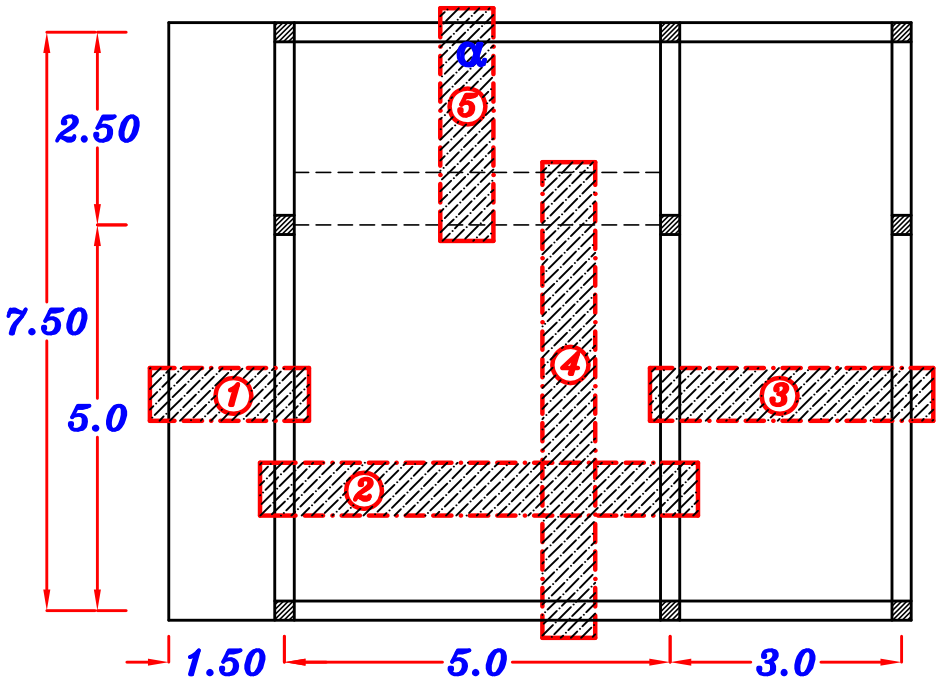


$$(w_{s1}) = 1.4\,(0.15 * 25 + 1.5) + 1.6\,(2.0) = 10.55 \ \ kN\backslash m^2$$

$$(w_{s2}) = 1.4\,(0.30 * 25 + 1.5) + 1.6\,(2.0) = 15.80 \ \ kN\backslash m^2$$





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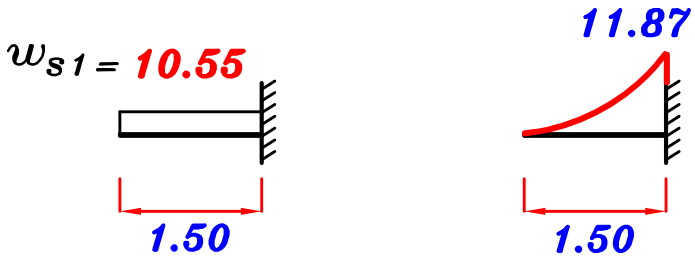
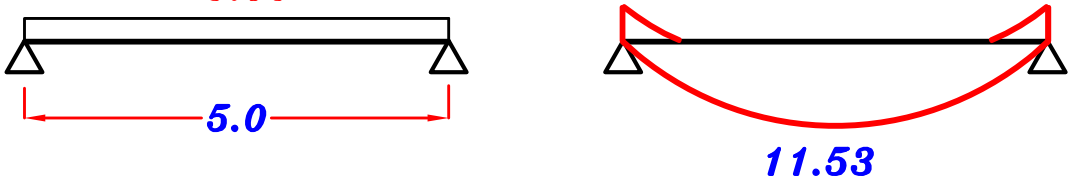
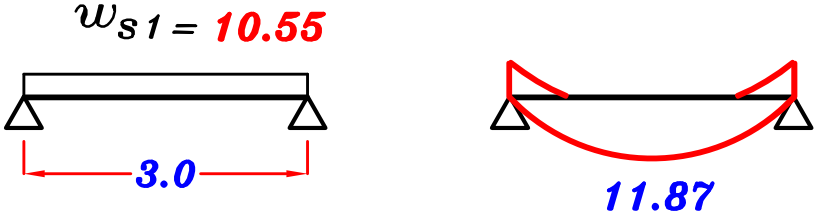


Strip ②

$\alpha w_{s1} = 0.35 * 10.55 = 3.69$

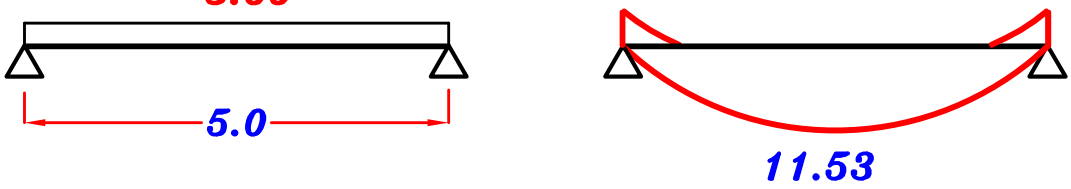


Strip ③



Strip ④

$\beta\ w_{s1} = 0.35 * 10.55 = 3.69$



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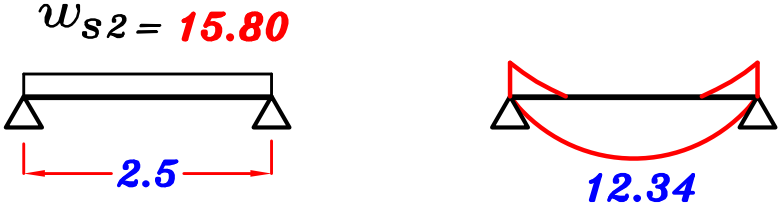

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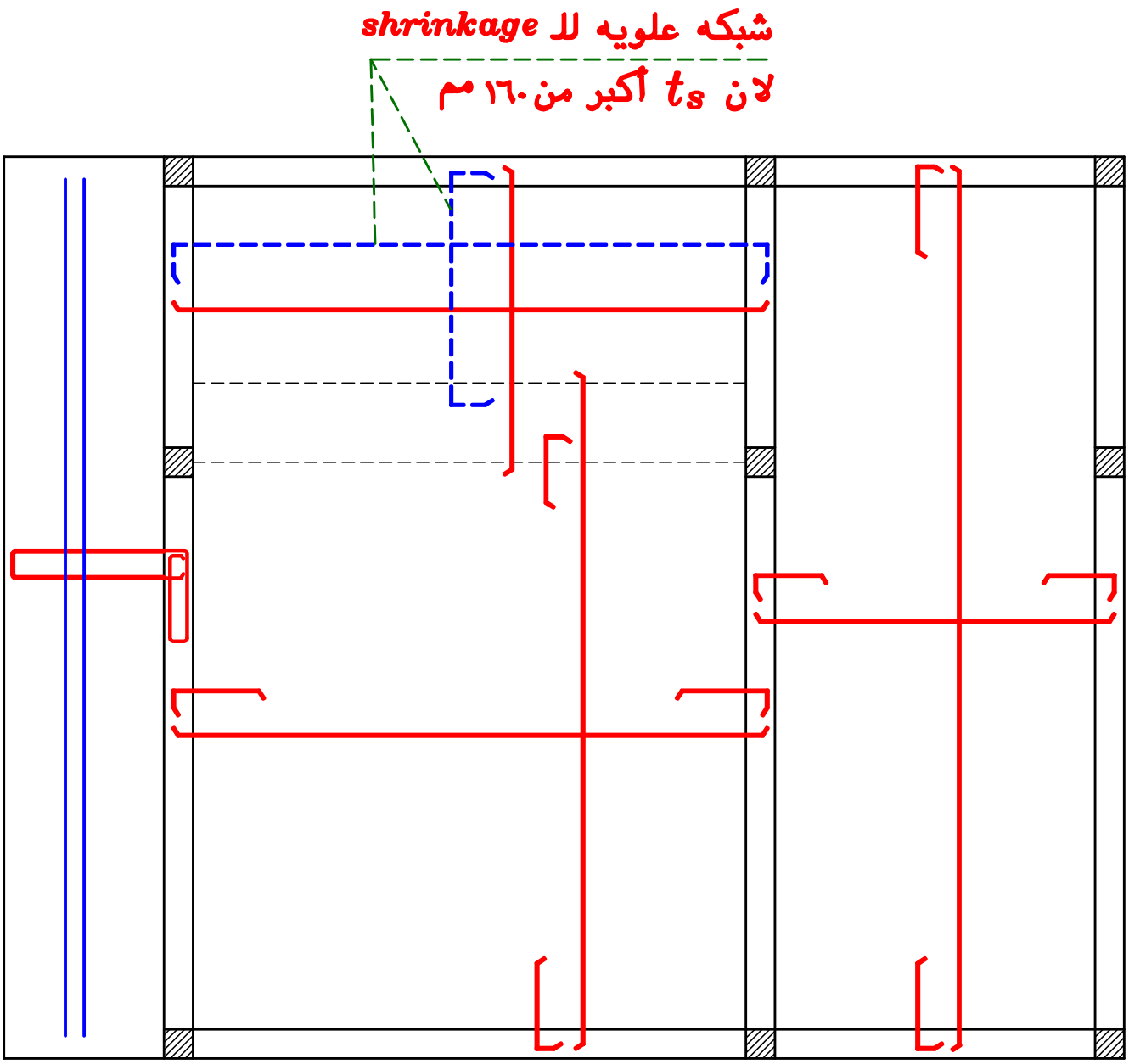

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Check Deflection For Cantilever Slab.

Get.

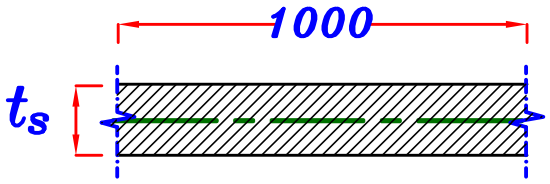
- E_c = Modules of Elasticity For Concrete $E_c = 4400\sqrt{F_{cu}}$
- I_e = effective moment of Inertia For the cracked Sec.

$$I_e = \left(\frac{M_{cr}}{M_{act}}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_{act}}\right)^3\right] I_{nv}$$

Where:

* I_g = gross moment of Inertia.

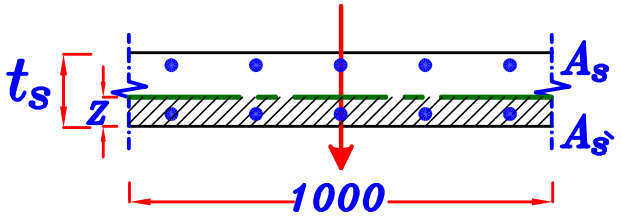
$$I_g = \frac{1000\ t_s^3}{12} \quad mm^4$$



* I_{nv} = moment of Inertia For cracked Sec.

Note: $A_s = A_{s`}$ in Cantilevers

get Z From $S_{nv} = 0.0$



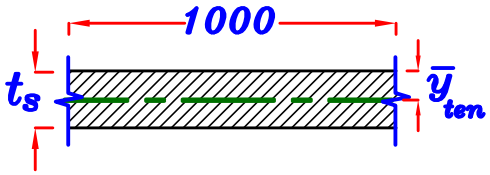
$$\frac{1000\ Z^2}{2} + n\ A_{s`}\ (Z - d`) = n\ A_s\ (d - Z) \text{ ----- get } Z.$$

Where: n = modular ratio = 10

$d = t_s - 20$ mm , $d` = 20$ mm

$$I_{nv} = \frac{1000 Z^3}{3} + n\ A_{s`}\ (Z - d`)^2 + n\ A_s\ (d - Z)^2$$

* M_{cr} = Cracking Moment. = $F_{ctr} * \frac{I_g}{\bar{y}_{ten}}$



where: $F_{ctr} = 0.6\sqrt{F_{cu}}$ $N\backslash mm^2$

$$\bar{y}_{ten} = \frac{t_s}{2}$$

* M_{act} = Actual moment acting on the Sec. (Working Loads)

Note: IF $M_{act} \leqslant M_{cr}$ $\therefore I_e = I_g$

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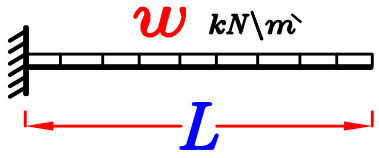
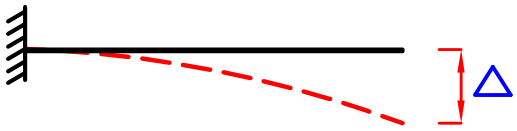
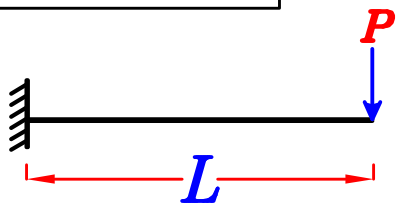
Actual Deflection Values.

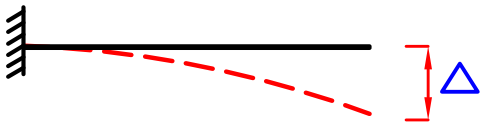
Note: This Loads are Working Loads

① 

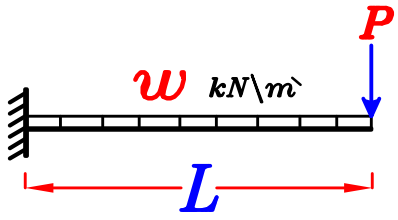


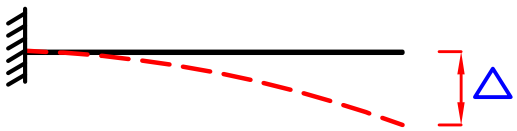
$$\Delta_{act} = \frac{1}{8} * \frac{w L^4}{E_c I_e}$$

② 

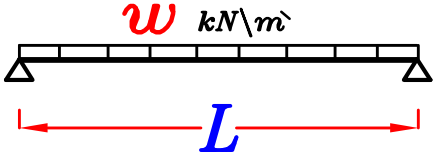


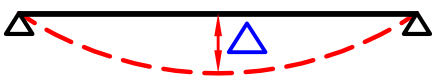
$$\Delta_{act} = \frac{1}{3} * \frac{P L^3}{E_c I_e}$$

③ 



$$\Delta_{act} = \frac{1}{8} * \frac{w L^4}{E_c I_e} + \frac{1}{3} * \frac{P L^3}{E_c I_e}$$

④ 



$$\Delta_{act} = \frac{5}{384} * \frac{w L^4}{E_c I_e}$$

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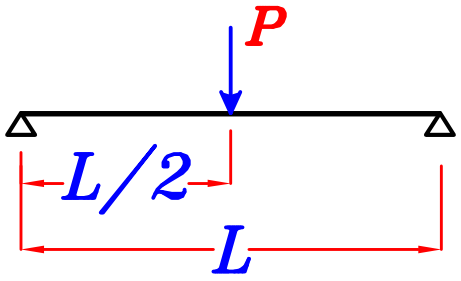
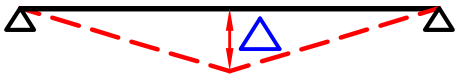
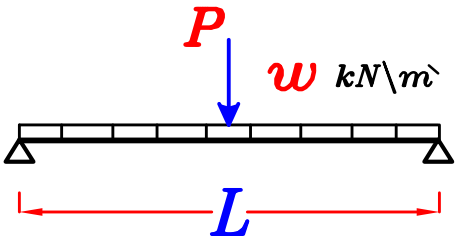
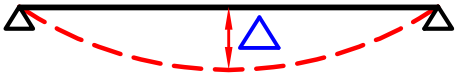




$$\Delta_{act} = \frac{1}{48} * \frac{P L^3}{E_c I_e}$$

⑥





$$\Delta_{act} = \frac{5}{384} * \frac{w L^4}{E_c I_e} + \frac{1}{48} * \frac{P L^3}{E_c I_e}$$

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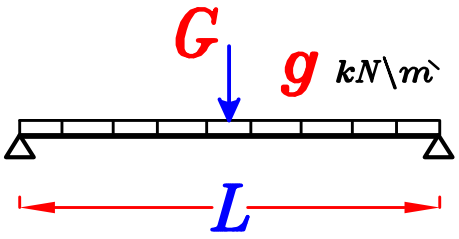
Actual Deflection due to Dead Load

نستخدم نفس القوانين السابقه لكن مع استخدام **D.L.** فقط

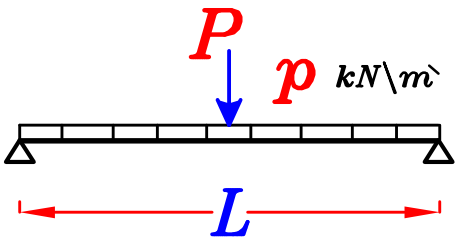
$$\triangle_{D.L.} = \frac{5}{384} * \frac{g\ L^4}{E_c\ I_e} + \frac{1}{48} * \frac{G\ L^3}{E_c\ I_e}$$



Actual Deflection due to Live Load

نستخدم نفس القوانين السابقه لكن مع استخدام **L.L.** فقط

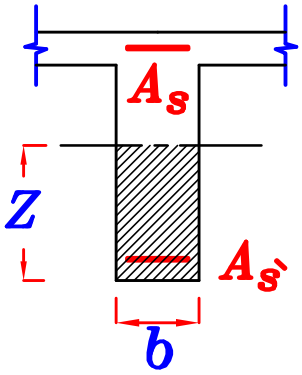
$$\triangle_{L.L.} = \frac{5}{384} * \frac{p\ L^4}{E_c\ I_e} + \frac{1}{48} * \frac{P\ L^3}{E_c\ I_e}$$



Actual Deflection due to Creep. الزحف

$$\triangle_{Creep} = \alpha\ \triangle_{D.L.}$$

$$\alpha = 2.0 - 1.2\left(\frac{A_s`}{A_s}\right) \geq 0.6$$



Short Term Deflection. $= \triangle_{D.L.} + \triangle_{L.L.}$

Long Term Deflection. $= \triangle_{D.L.} + \triangle_{L.L.} + \triangle_{Creep}$

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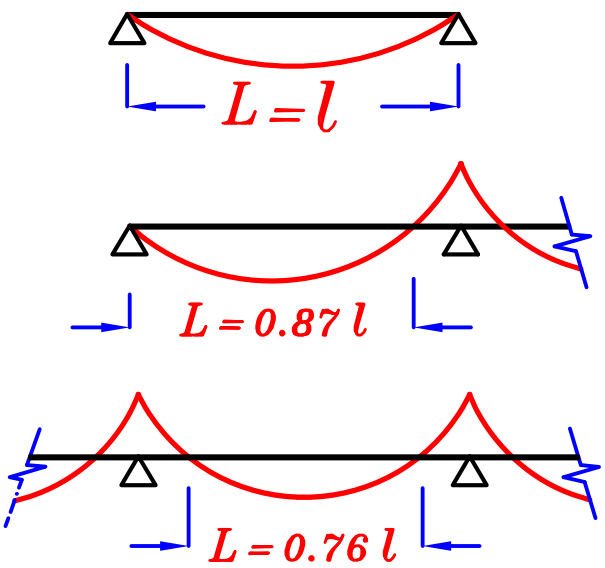
Allowable Deflection Values.

For Beams.

$$\Delta_{all} = \frac{L}{250}$$

Due to

D.L. + L.L. + Creep



$$\Delta_{all} = \frac{L}{360}$$

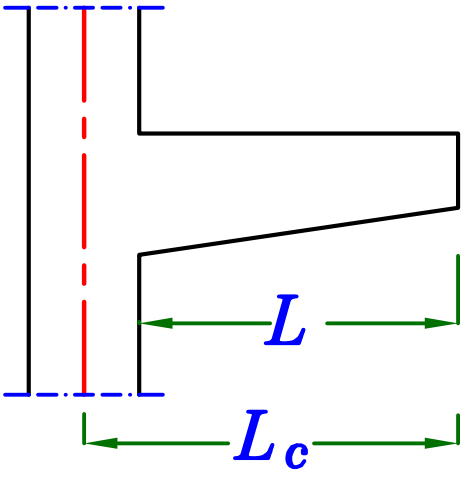
Due to L.L. only

For Cantilevers.

$$\Delta_{all} = \frac{L}{450}$$

Due to

D.L. + L.L. + Creep



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Steps of Check Deflection.

* get $E_c = 4400\sqrt{F_{cu}}$
* get $I_e = \left(\frac{M_{cr}}{M_{act}}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_{act}}\right)^3\right] I_{nv}$
* get $\triangle_{D.L.}$ & $\triangle_{L.L.}$
* get Short Term deflection. $= \triangle_{D.L.} + \triangle_{L.L.}$
* get $\alpha = 2.0 - 1.2\left(\frac{A_s'}{A_s}\right) \geq 0.6$
* get $\triangle_{Creep} = \alpha \triangle_{D.L.}$
* get Long Term deflection.

$$\triangle_{act.} = \triangle_{D.L.} + \triangle_{L.L.} + \triangle_{Creep}$$

$$\triangle_{act.} = \triangle_{L.L.}$$

* get $\triangle_{all} = \frac{L}{250}$ For Total Loads For Beams

$\triangle_{all} = \frac{L}{360}$ For Live Load For Beams

$\triangle_{all} = \frac{L}{450}$ For Total Loads For Cantilever

IF $\triangle_{act.} \leq \triangle_{all}$ Safe Deflection.

IF $\triangle_{act.} > \triangle_{all}$ UnSafe Deflection.

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Example.

Data.

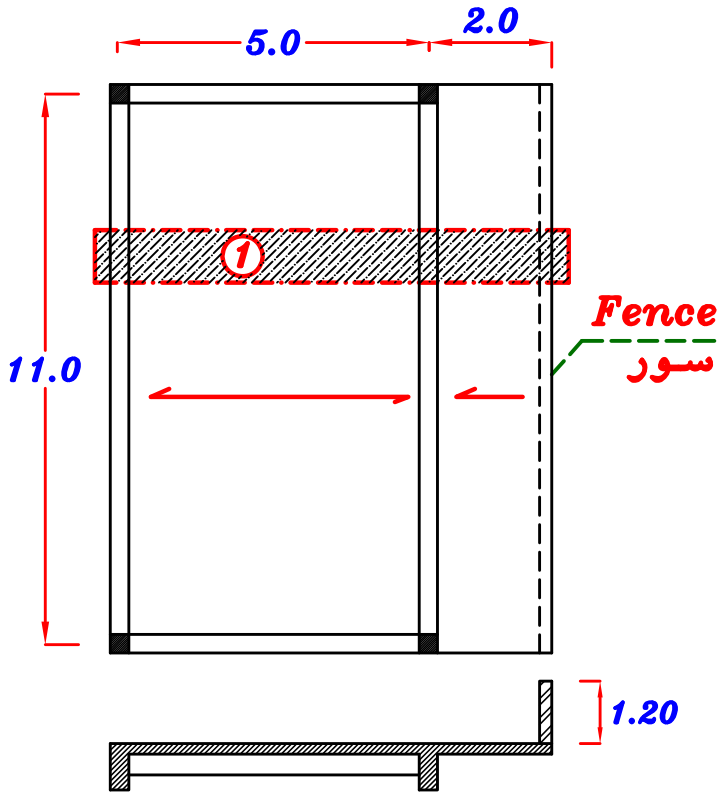
$F_{cu} = 25 \ N\backslash mm^2$

$F_y = 360 \ N\backslash mm^2$

$F.C. = 1.50 \ kN\backslash m^2$

$L.L. = 2.0 \ kN\backslash m^2$

$\gamma_{wall} = 5.0 \ kN\backslash m^2$ (Working)



Req.

① Design the Slab.

② Draw Details of RFT.

③ Check Deflection For the Cantilever. (Short Term & long term)

Solution.

$$t_s = \frac{L_s}{30} = \frac{5000}{30} = 166 \ mm$$

$$= \frac{L_c}{10} = \frac{2000}{10} = 200 \ mm$$

$$\Rightarrow \boxed{t_s = 160 \ mm}$$

$$g_s = t_s \gamma_c + F.C. = 0.16 * 25 + 1.50 = 5.50 \ kN\backslash m^2$$

$$p_s = L.L. = 2.0 \ kN\backslash m^2$$

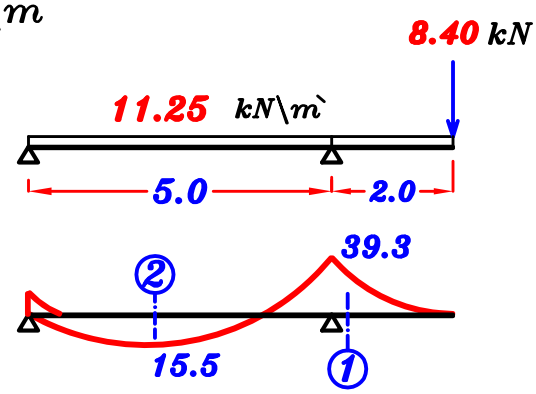
$$w_s = g_s + p_s = 5.50 + 2.0 = 7.50 \ kN\backslash m^2$$

$$(w_s)_{U.L.} = 1.5 * 7.50 = 11.25 \ kN\backslash m^2$$

Weight of the Fence. $= \gamma_w * H_w$

$= 5.0 * 1.2 = 6.0 \ kN\backslash m`$ (working)

$= 6.0 * 1.4 = 8.40 \ kN\backslash m`$ (U.L.)



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Design the Sec. of the Slab.

Sec. ① $M_{U.L.} = 39.3$ kN.m\m` , $t_s = 160$ mm , $d = 140$ mm

$$140 = C_1\sqrt{\frac{39.3*10^6}{25*1000}} \longrightarrow C_1 = 3.53 \longrightarrow J = 0.782$$

$$A_S = \frac{39.3*10^6}{0.782*360*140} = 997 \ mm^2/m`$$

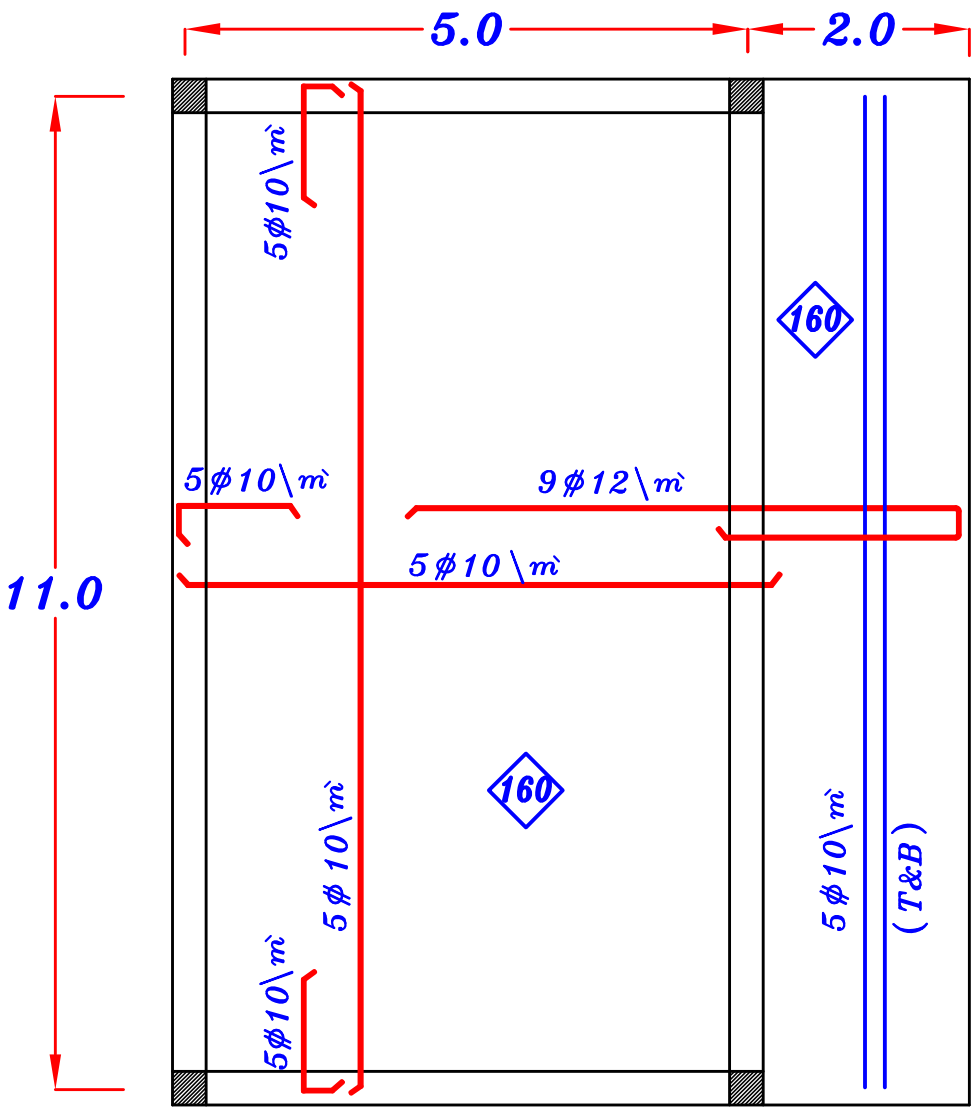
9 ϕ 12 \ m`

Sec. ② $M_{U.L.} = 15.5$ kN.m\m` , $t_s = 160$ mm , $d = 140$ mm

$$140 = C_1\sqrt{\frac{15.5*10^6}{25*1000}} \longrightarrow C_1 = 5.622 \longrightarrow J = 0.826$$

$$A_S = \frac{15.5*10^6}{0.826*360*140} = 372 \ mm^2/m`$$

5 ϕ 10 \ m`



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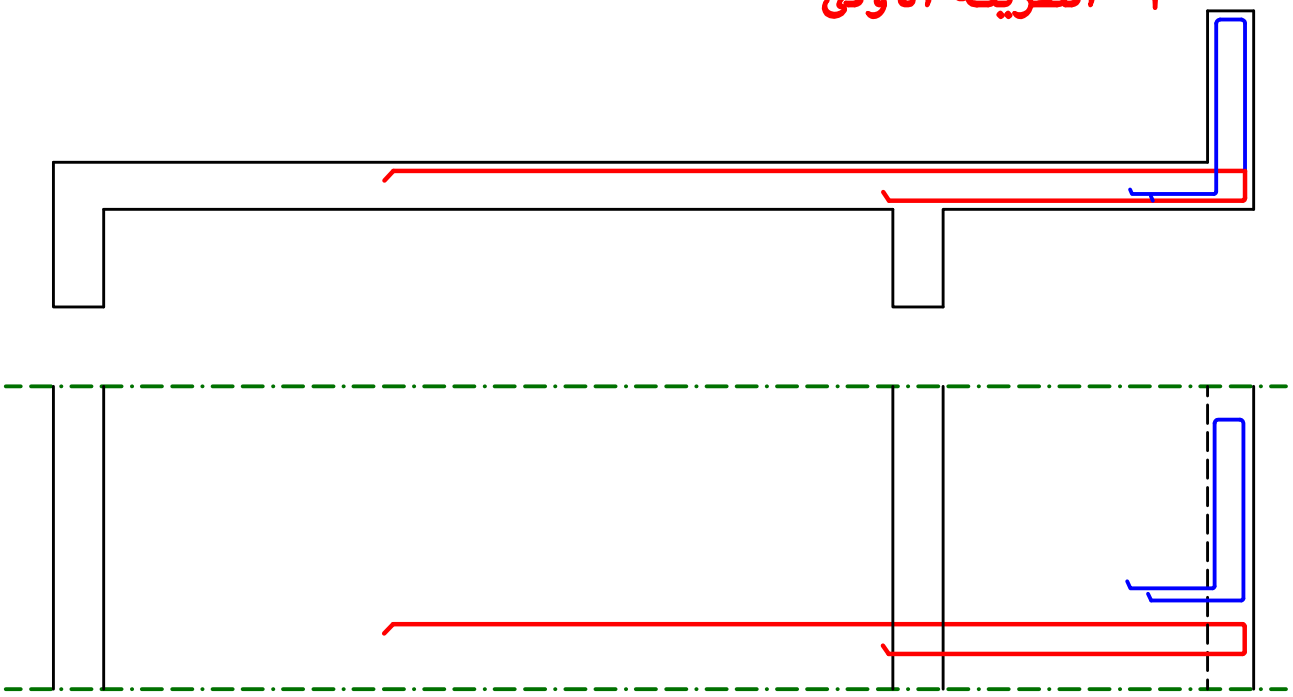
ملحوظه هامه .

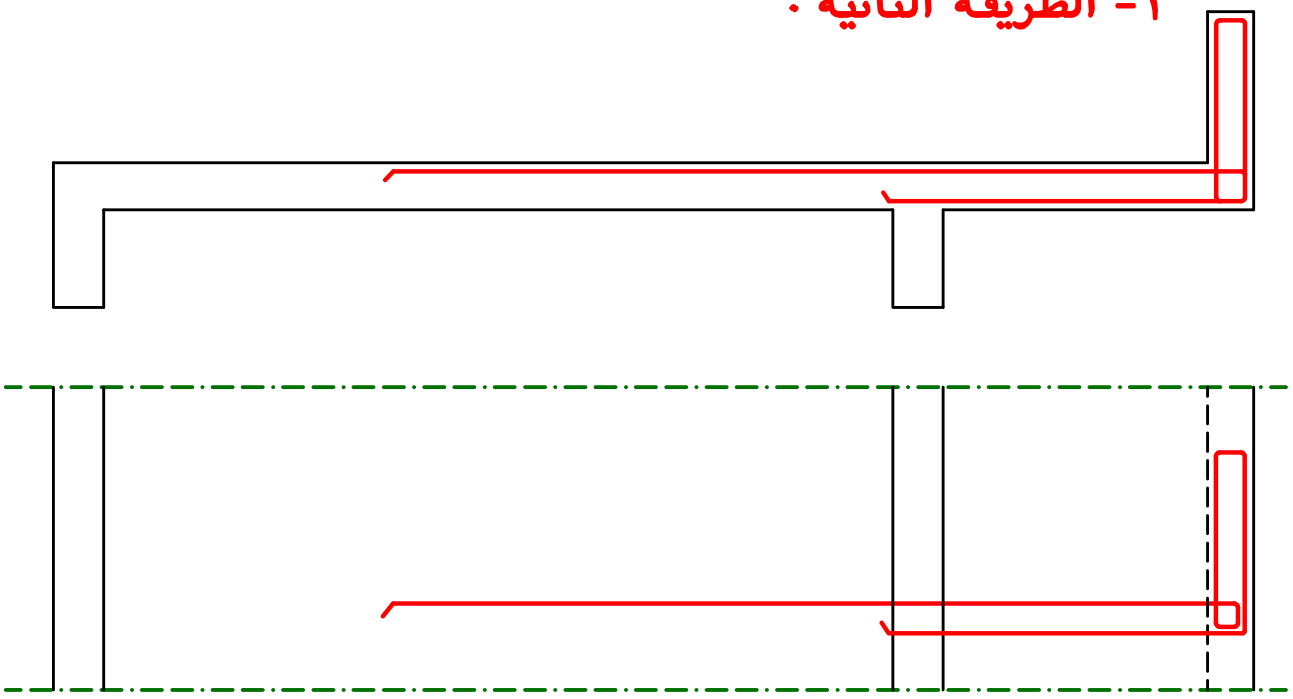
إذا كان السور عباره عن سور خرسانه مسلحه (دروه) *Parapet*

سيكون هناك احدى الطريقتين لتسليح الشوكه .

١- الطريقة الاولى



٢- الطريقه الثانيه .



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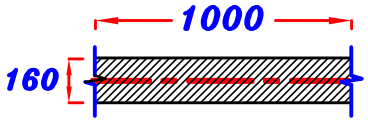
Check deflection in the Cantilever.

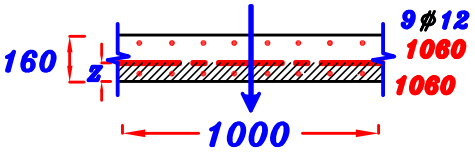
$- E_c = 4400 \sqrt{F_{cu}} = 4400 \sqrt{25} = 22000 \ N\backslash mm^2$

$- I_g = \frac{1000\, t_s^3}{12} = \frac{1000(160)^3}{12} = 341333333 \ mm^4$



$\because S_{nv} = 0.0$ $\boxed{n = 10}$

$\therefore \frac{1000\, Z^2}{2} + n\, A_{s`}\, (Z - d`) = n\, A_s\, (d - Z)$



$\frac{1000\, Z^2}{2} + 10(1060)\,(Z - 20) = 10(1060)\,(140 - Z)$

$\therefore Z = 40.77 \ mm$

$I_{nv} = \frac{1000\, Z^3}{3} + n\, A_{s`}\, (Z - d`)^2 + n\, A_s\, (d - Z)^2$

$= \frac{1000\,(40.77)^3}{3} + 10(1060)(40.77 - 20)^2 + 10(1060)(140 - 40.77)^2$

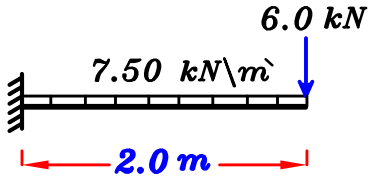
$I_{nv} = 131535851 \ mm^4$

$F_{ctr} = 0.6 \sqrt{F_{cu}} = 0.6 \sqrt{25} = 3.0 \ N\backslash mm^2$

$M_{cr} = F_{ctr} * \frac{I_g}{\bar{y}_{ten}} = \frac{3.0 * 341333333}{80} = 12800000 \ N.mm$

$= 12.80 \ kN.m$

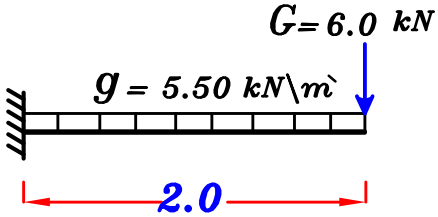
$M_{act.} = 27.0 \ kN.m$



$I_e = \left(\frac{M_{cr}}{M_{act}}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_{act}}\right)^3\right] I_{nv}$

$I_e = \left(\frac{12.81}{27.0}\right)^3 (341333333) + \left[1 - \left(\frac{12.81}{27.0}\right)^3\right] (131535851)$

$I_e = 153941440 \ mm^4$



$\Delta_{D.L.} = \frac{g\, L^4}{8\, E_c\, I_e} + \frac{G\, L^4}{3\, E_c\, I_e}$

$\Delta_{D.L.} = \frac{(5.50 * \frac{1000}{1000})(2.0 * 1000)^4}{8(22000)(153941440)} + \frac{(6.0 * 10^3)\ (2.0 * 1000)^3}{3(22000)(153941440)}$

$\boxed{\Delta_{D.L.} = 7.97 \ mm}$

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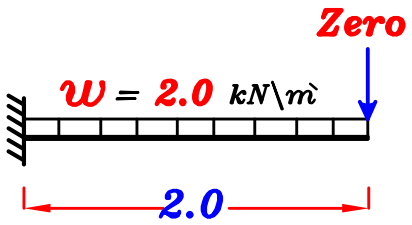
$$\Delta_{L.L.} = \frac{p\ L^4}{8\ E_c\ I_e} + \frac{P\ L^4}{3\ E_c\ I_e}$$



$$\Delta_{L.L.} = \frac{(2.0 * \frac{1000}{1000})\ (2.0 * 1000)^4}{8\ (22000)\ (153941440)} + \text{Zero}$$

$$\boxed{\Delta_{L.L.} = 1.18 \text{ mm}}$$

$$\alpha = 2.0 - 1.2\left(\frac{A_s`}{A_s}\right) = 2.0 - 1.2\left(\frac{1060}{1060}\right) = 0.8$$

$$\Delta_{Creep} = \alpha\ \Delta_{D.L.} = 0.8\ (7.97) = 6.376 \text{ mm}$$

- Short Term Deflection. $= \Delta_{D.L.} + \Delta_{L.L.} = 7.97 + 1.18 = 9.15$ mm

- Long Term Deflection.

$$= \Delta_{D.L.} + \Delta_{L.L.} + \Delta_{Creep} = 7.97 + 1.18 + 6.376 = 15.52 \text{ mm}$$

- Allowable Deflection Values.

$$\Delta_{all} = \frac{L`}{450} = \frac{2000}{450} = 4.40 \text{ mm}$$

D.L. + L.L.+ Creep

- Check Deflection.

$$\Delta_{D.L.} + \Delta_{L.L.} + \Delta_{Creep} = 7.97 + 1.18 + 6.376 = 15.52 \text{ mm} > 4.40 \text{ mm}$$

$\therefore$ UnSafe Deflection.

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