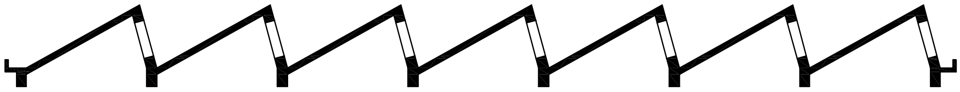
(*Systems*) *Saw Tooth.*

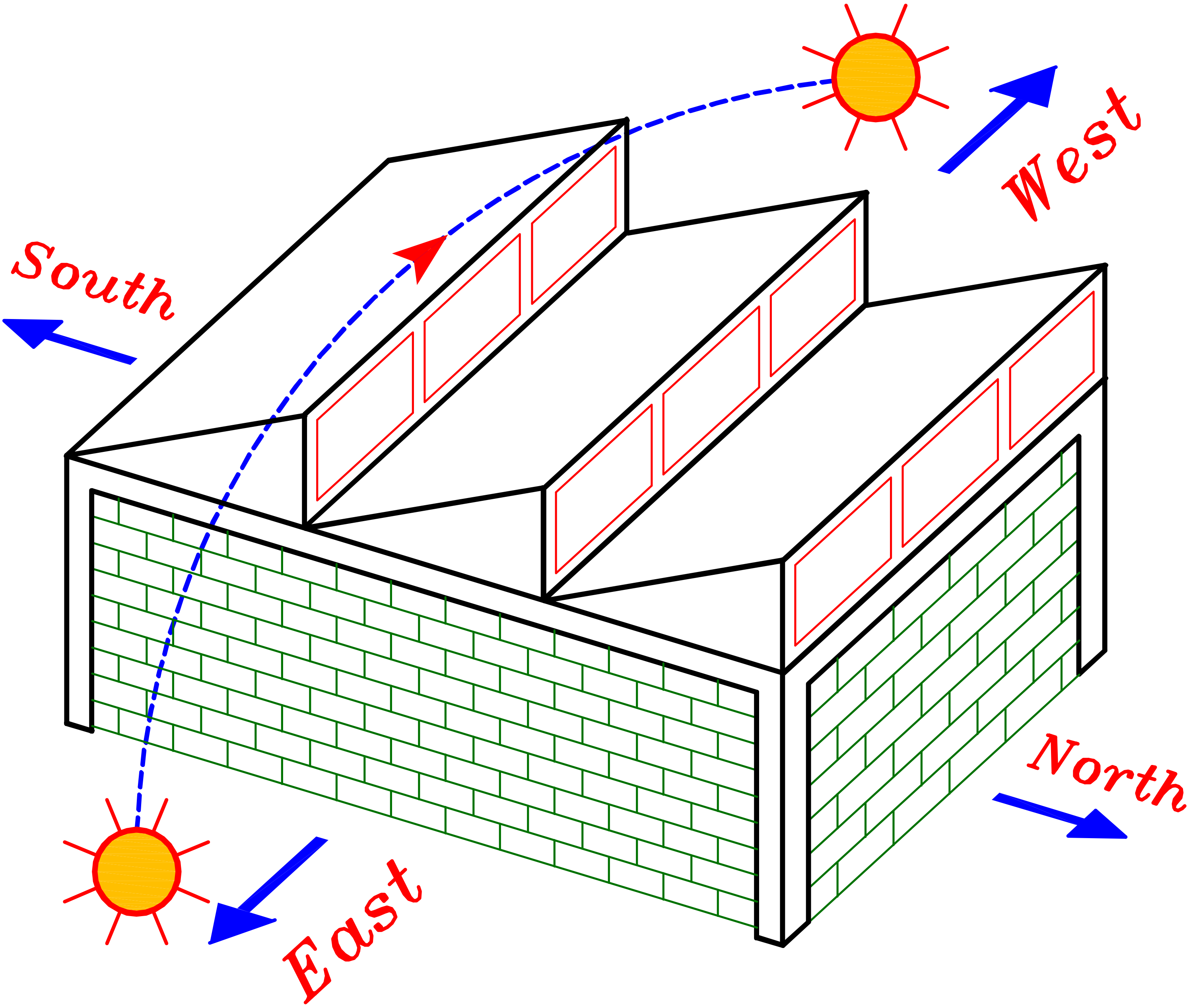
Saw Tooth. Table of Contents.

Saw Tooth Structures



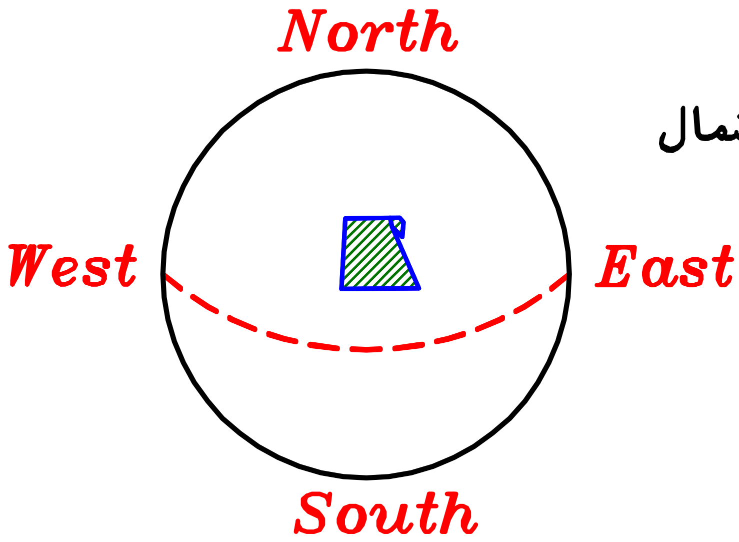
Introduction.

Saw Tooth عباره عن بلاطات مائله (تشبه أسنان المنشار) محموله على System إنشائى يعتمد نوع هذا ال System على المسافه بين الأعمده .



حفظ | دائماً سهم الشمال خارج من الشباك

و يستخدم هذا النوع من البلاطات عند طلب إضاءه غير مباشره داخل المبنى .
لذلك نضع النوافذ فى إتجاه الشمال فقط وذلك ل :



١- لعمل إضاءه غير مباشره
لوجود مصر عند مدار السرطان أى شمال
شمال خط الاستواء فتشرق الشمس
على مصر من اتجاه الجنوب الشرقى
و تغرب من اتجاه الجنوب الغربى

أى أنه لعمل اضاءه غير مباشره فى مصر لا نضع أى نوافذ فى اتجاه الجنوب .

٢- لكى تكون النوافذ فى إتجاه البحرى (للتهويه الجيده).

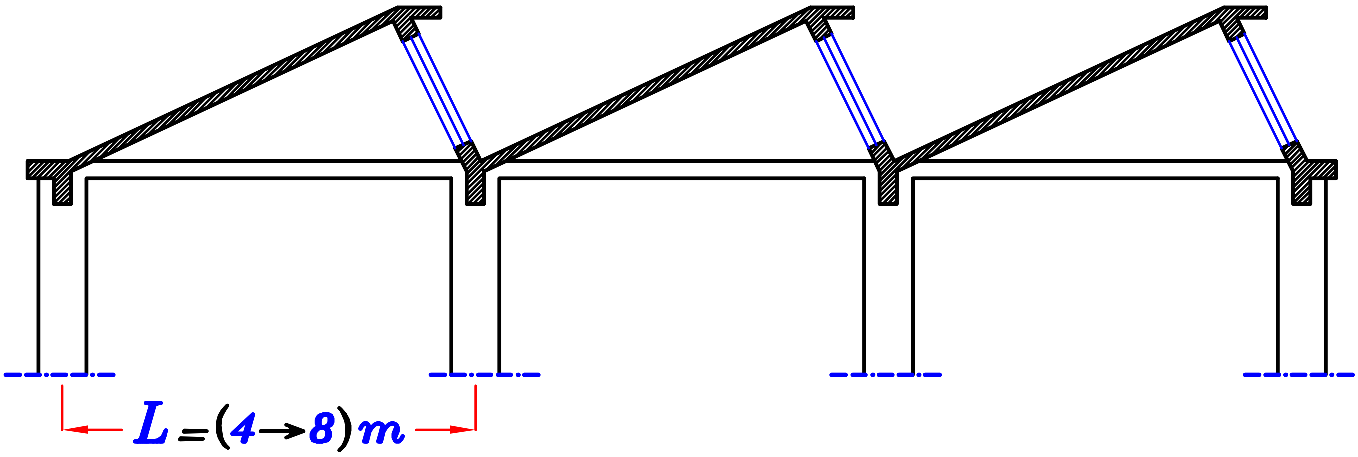
و لذلك فإنه ممنوع وضع أى نوافذ فى هذا الـ *System* إلا فى إتجاه الشمال فقط .

حفظ

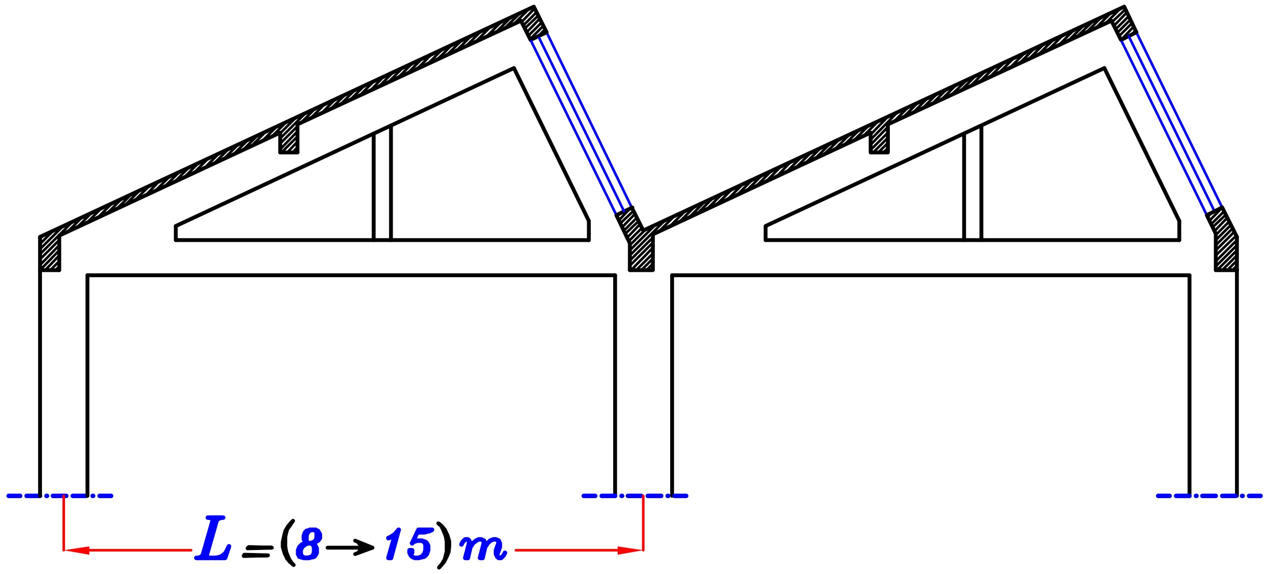
دائماً سهم الشمال خارج من الشباك

Types of Saw Tooth Structures.

① Slab Type. $L = (4 \rightarrow 8)\,m$



② Girder Type. $L = (8 \rightarrow 15)\,m$

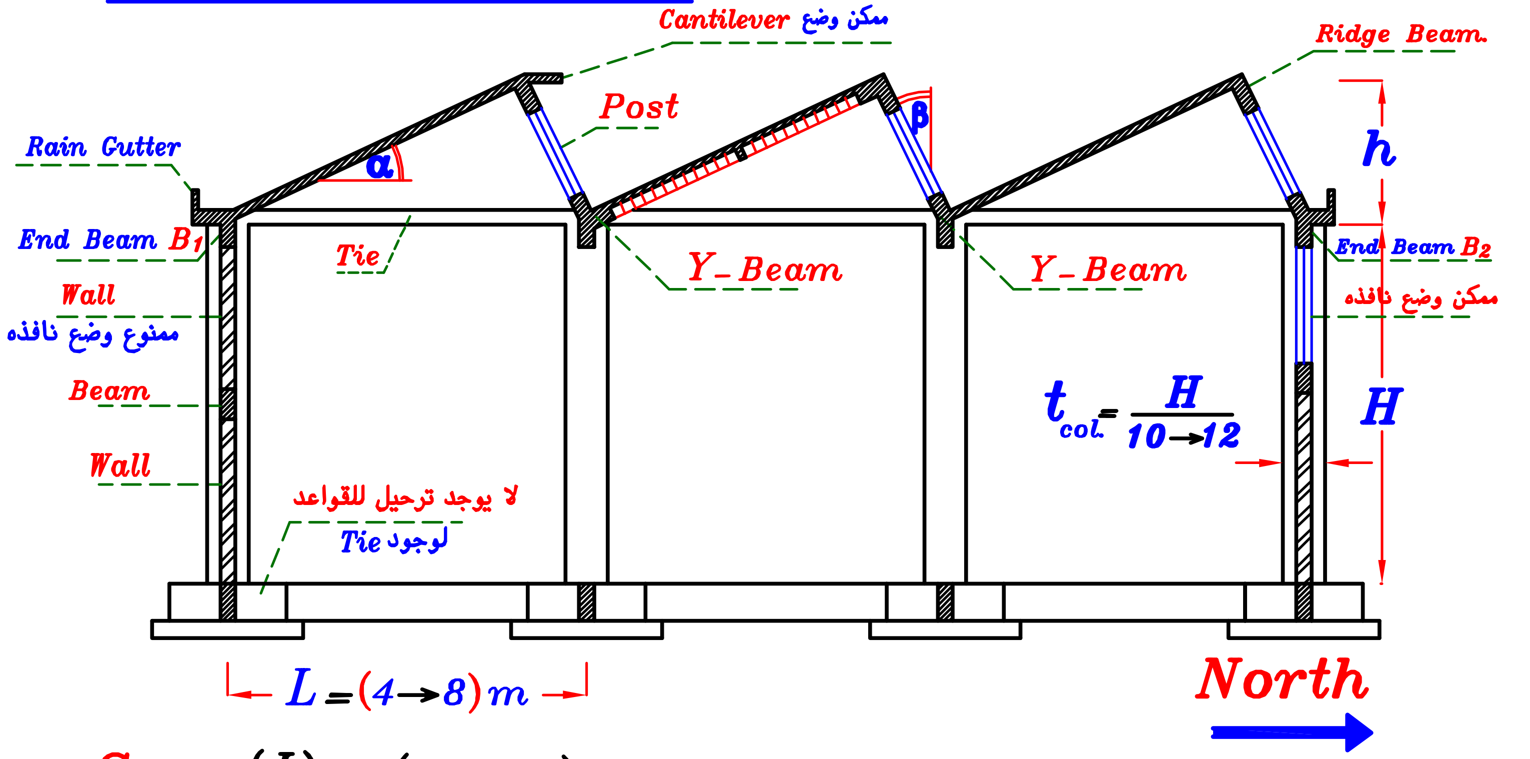


③ Saw Tooth Supported on:

- ⓐ Frames. (2 Hinged or Fixed) ---------- $L = (12 \rightarrow 24)\,m$
- ⓑ Triangular Polygon Frame. -------- $L = (12 \rightarrow 16)\,m$
- ⓒ Trapezoidal Polygon Frame. ------- $L = (12 \rightarrow 25)\,m$
- ⓓ Arch Girder ------------------------ $L = (20 \rightarrow 40)\,m$
- ⓔ Truss. --------------------------- $L = (15 \rightarrow 40)\,m$
- ⓕ Vierendeel. ------------------------ $L = (15 \rightarrow 40)\,m$

Saw Tooth Slab Type.

① With Inclined Posts.



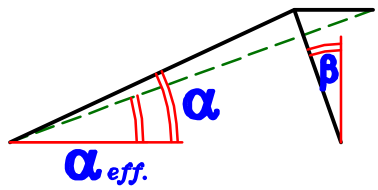
* **Span** (L) = (4 → 8) m

ممكن وضع Cantilever صغير فى النهايه
للتحكم فى زاويه ميل الضوء و لحمايه الزجاج
و لتقليل الـB.M.D. (+)Ve على البلاطه

* **Slabs.**

  One Way S.S. → $L \leqslant 6.0$ m

  One Way H.B. → $L = (6.0 \to 8.0)$ m



* **Inclination of slab.** $(\alpha_{eff.}) = (20 \to 30^\circ)$ مع الأفقى
* **Inclination of Post.** $(\beta) = (0 \to 15^\circ)$ مع الرأسى
* **Tie** (300×300) يجب وضع الـ Ties لـ ١- حمل القوى الأفقيه
  ٢- تربيط الأعمده
* **Posts** (250×250)

  Distance between Posts (a) = (2 → 3) m
* **Side Beams** (250×500)

  فوائدها :

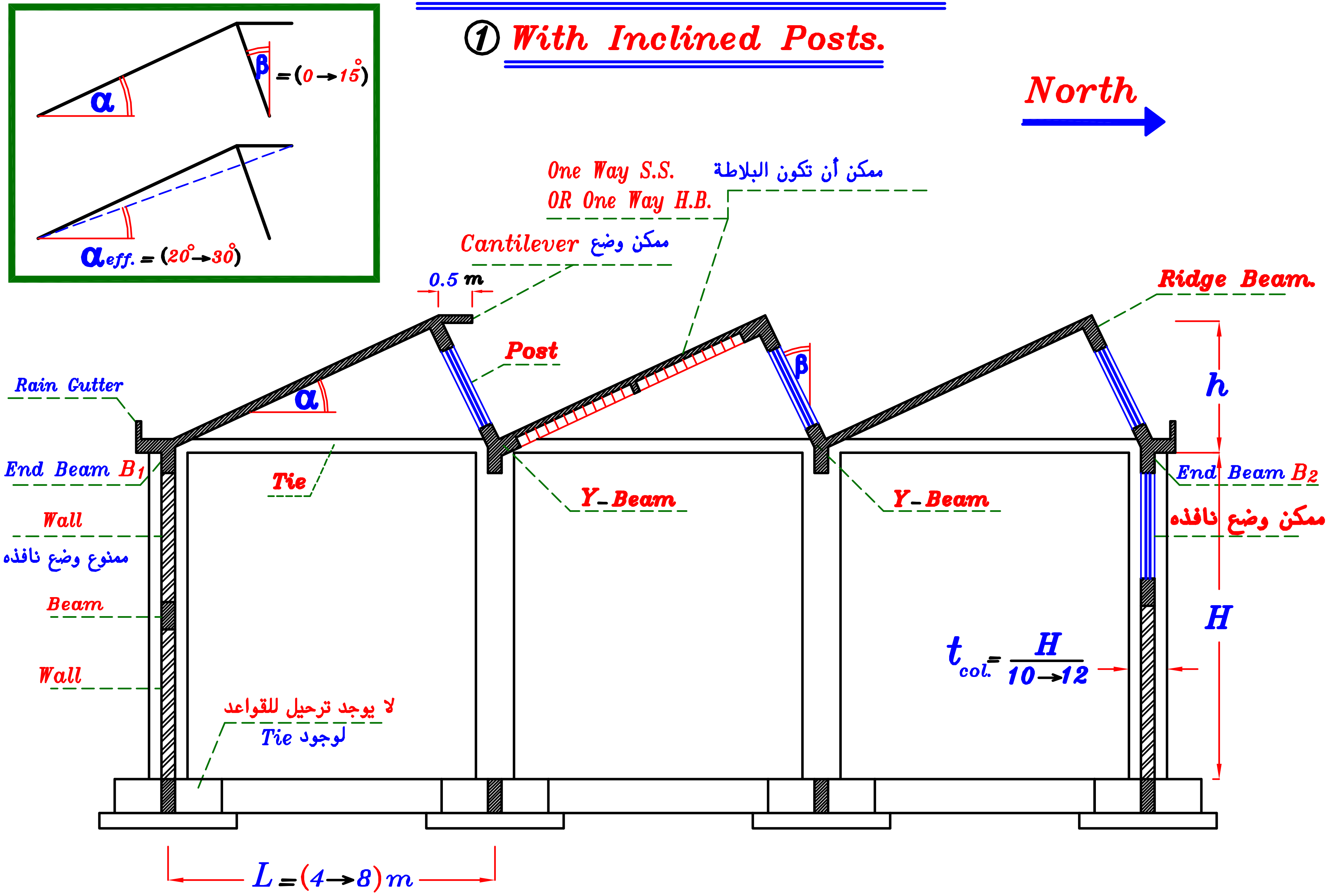
  ١- تقلل من مساحه الحائط بحيث لا تزيد مساحته عن ٣٠ م٢ .

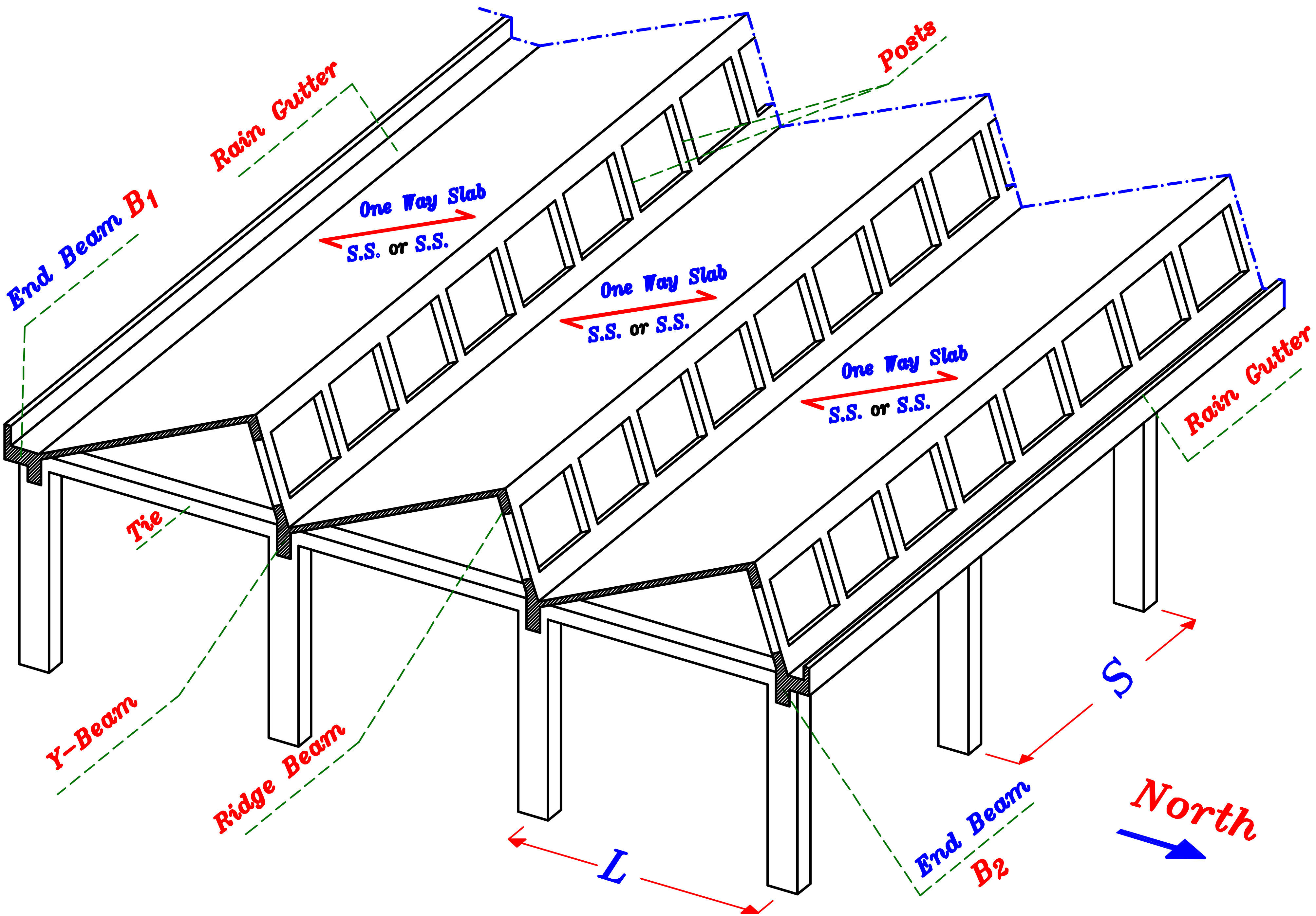
  ٢- تعمل على تربيط الأعمده فى اتجاه Out of plane .
* **Smell** طول السمله لا يزيد عن ١٫٠٠ م

  نضع مخدات من الخرسانه العاديه إذا زاد طول السمله عن ٠٫٧٠ م
* $t_{col.} = \frac{H}{10 \to 12}$

Saw Tooth Slab Type.

① With Inclined Posts.

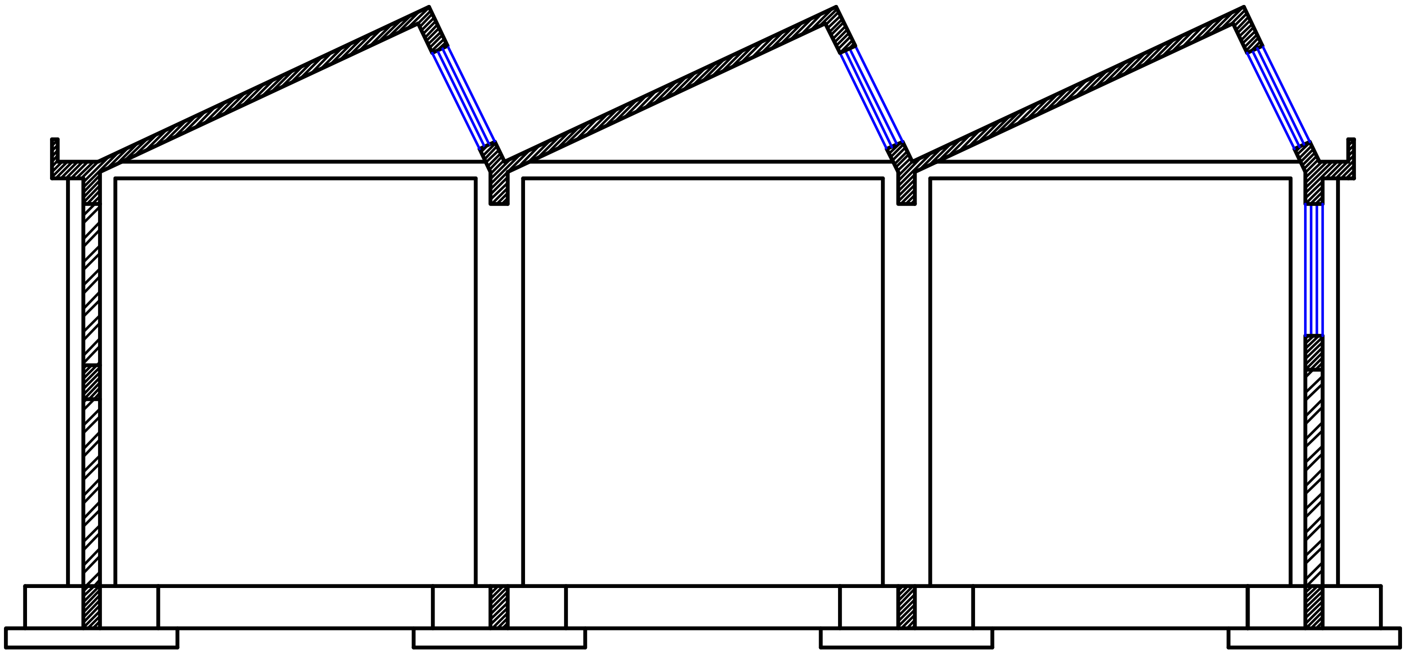




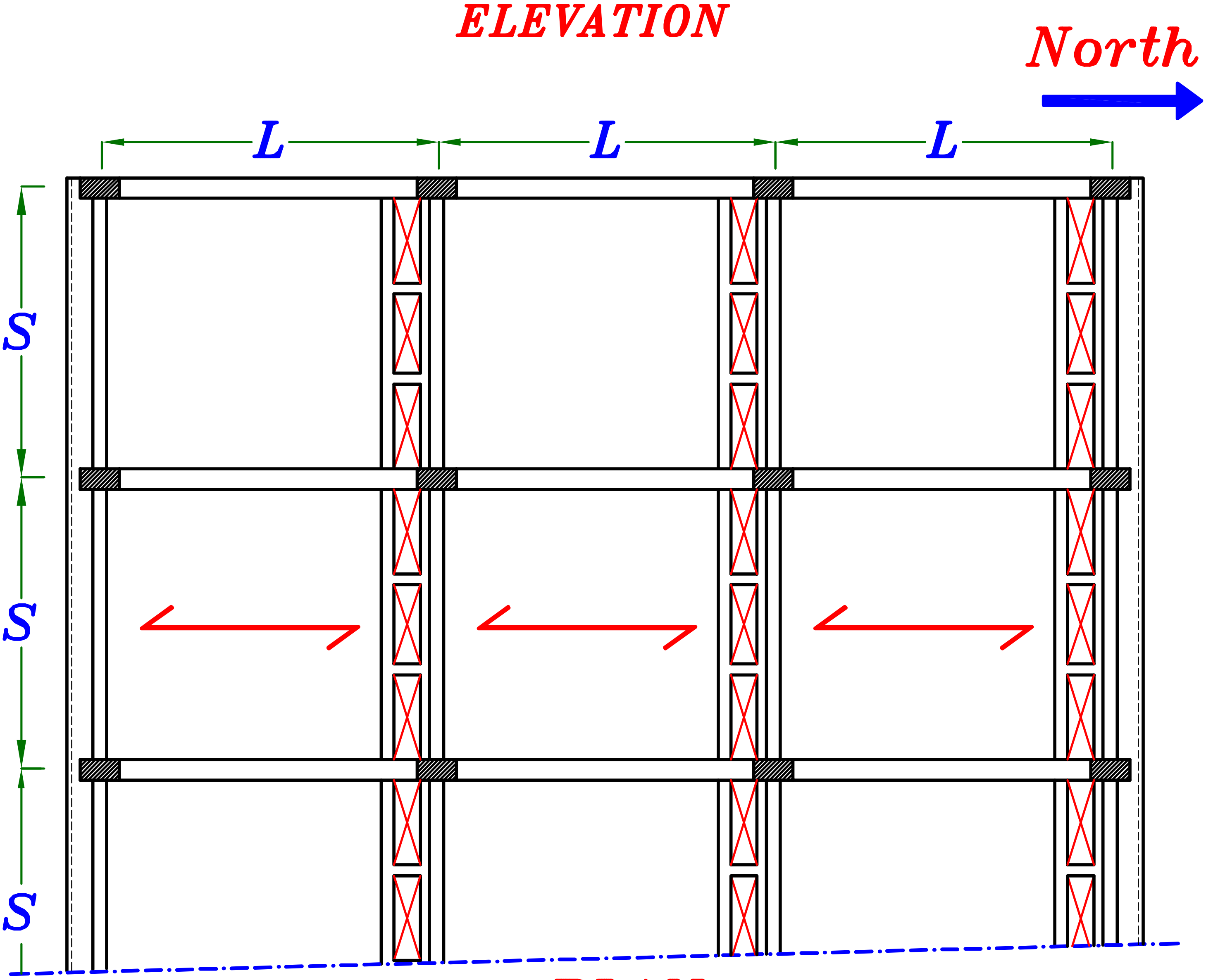
Rain Gutter
End Beam B1
One Way Slab
S.S. or S.S.
Posts
One Way Slab
S.S. or S.S.
One Way Slab
S.S. or S.S.
Rain Gutter
Tie
Y-Beam
Ridge Beam
L
S
End Beam B2
North

Saw Tooth Slab Type

Solid Slab $L \leqslant 6.0m$

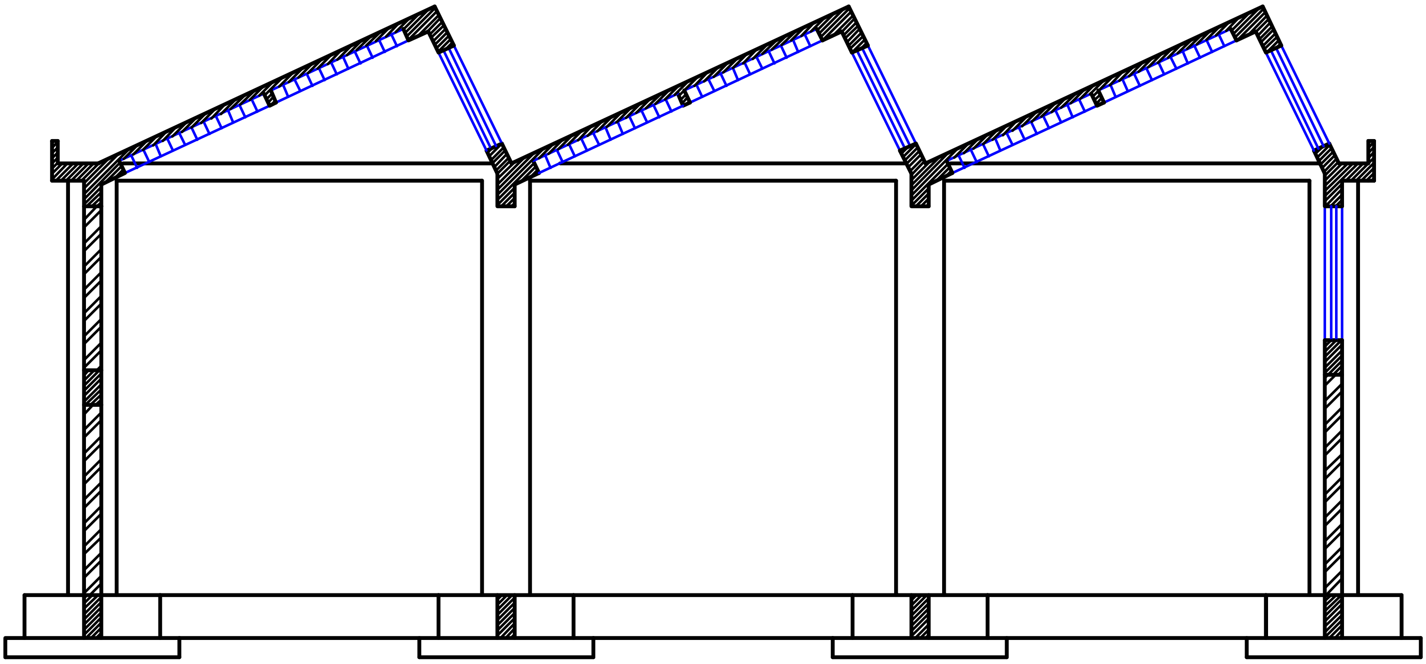


ELEVATION

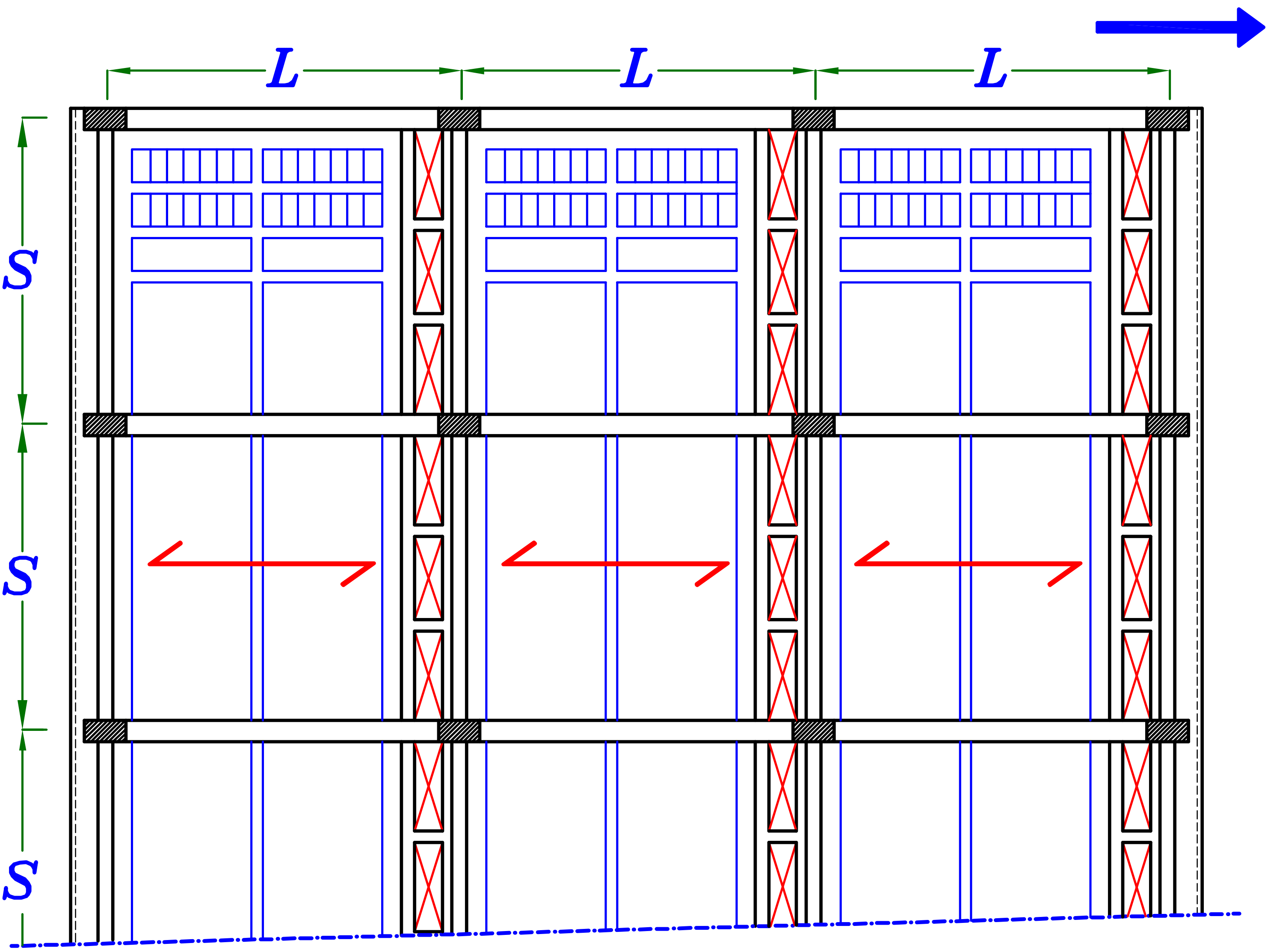


PLAN

Saw Tooth Slab Type H.B. Slab L > 6.0 m



ELEVATION



PLAN

Design of Slab.

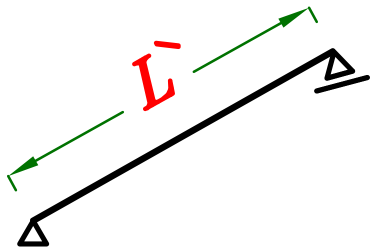
One Way S.S. → $L \leqslant 6.0\ m$

One Way H.B. → $L = (6.0 \rightarrow 8.0)\ m$

– Calculate t_s

For Solid or Hollow Blocks Slabs

we can take $t_s = \dfrac{L`}{30 \rightarrow 35}$



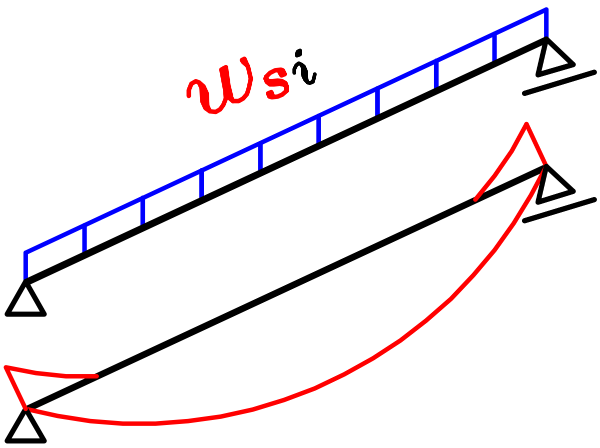
لان البلاطه مائله لاعلى فبالتالى ال L.L. يكون صغير فيكون ال deflection قليل .

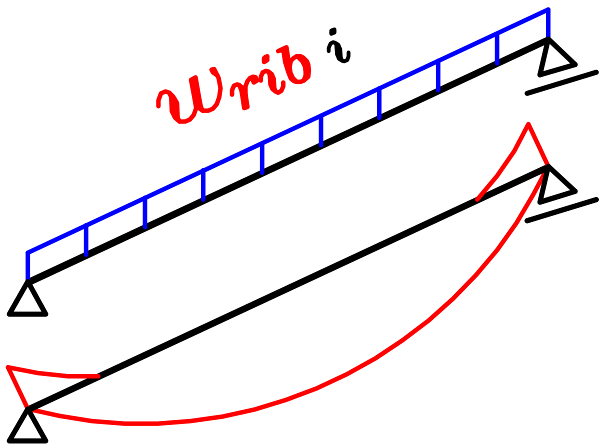
– Calculate w_s For S.S.

w_{rib} For H.B.

– Take a strip at Load direction

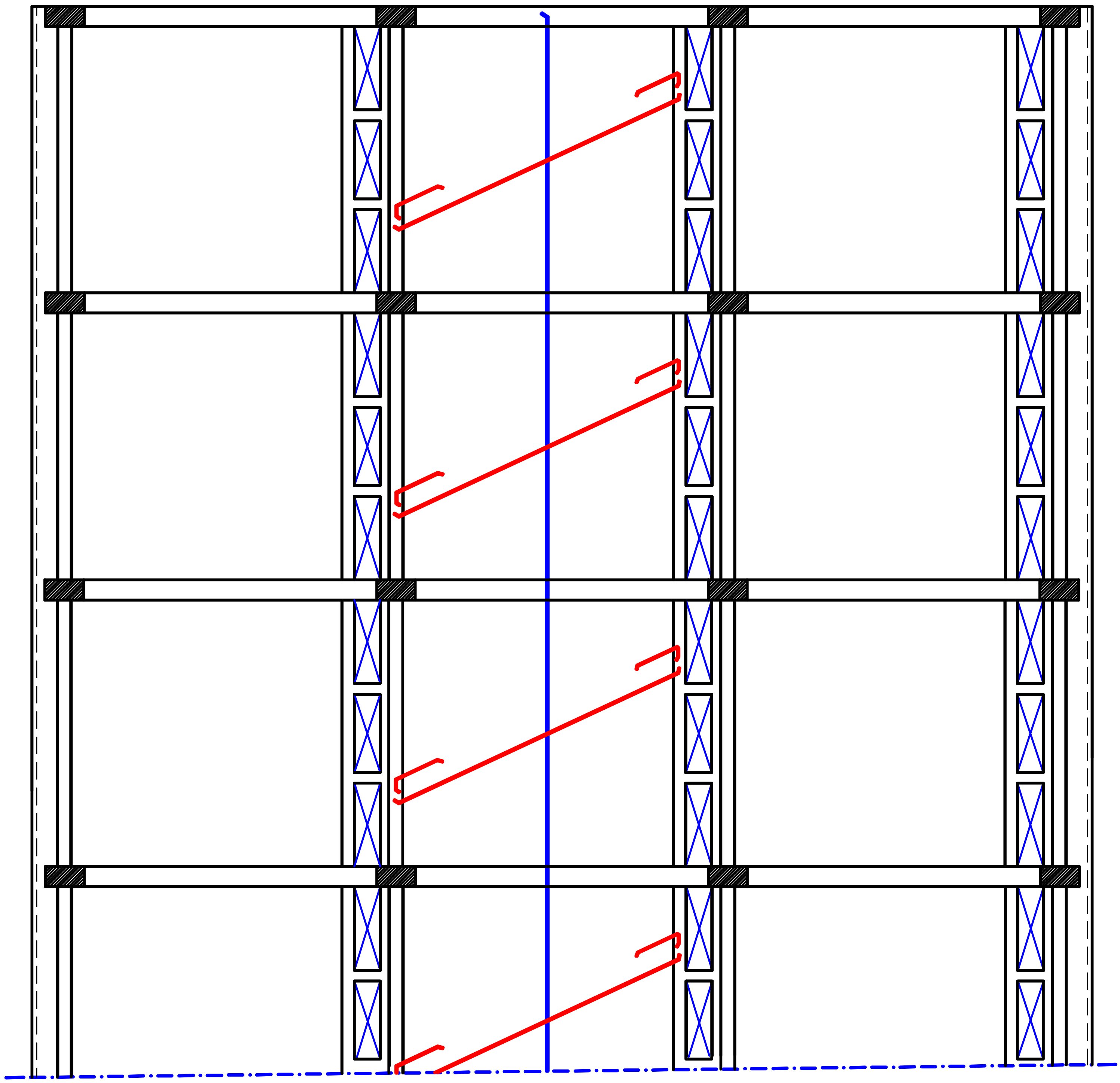
For S.S. | For H.B.



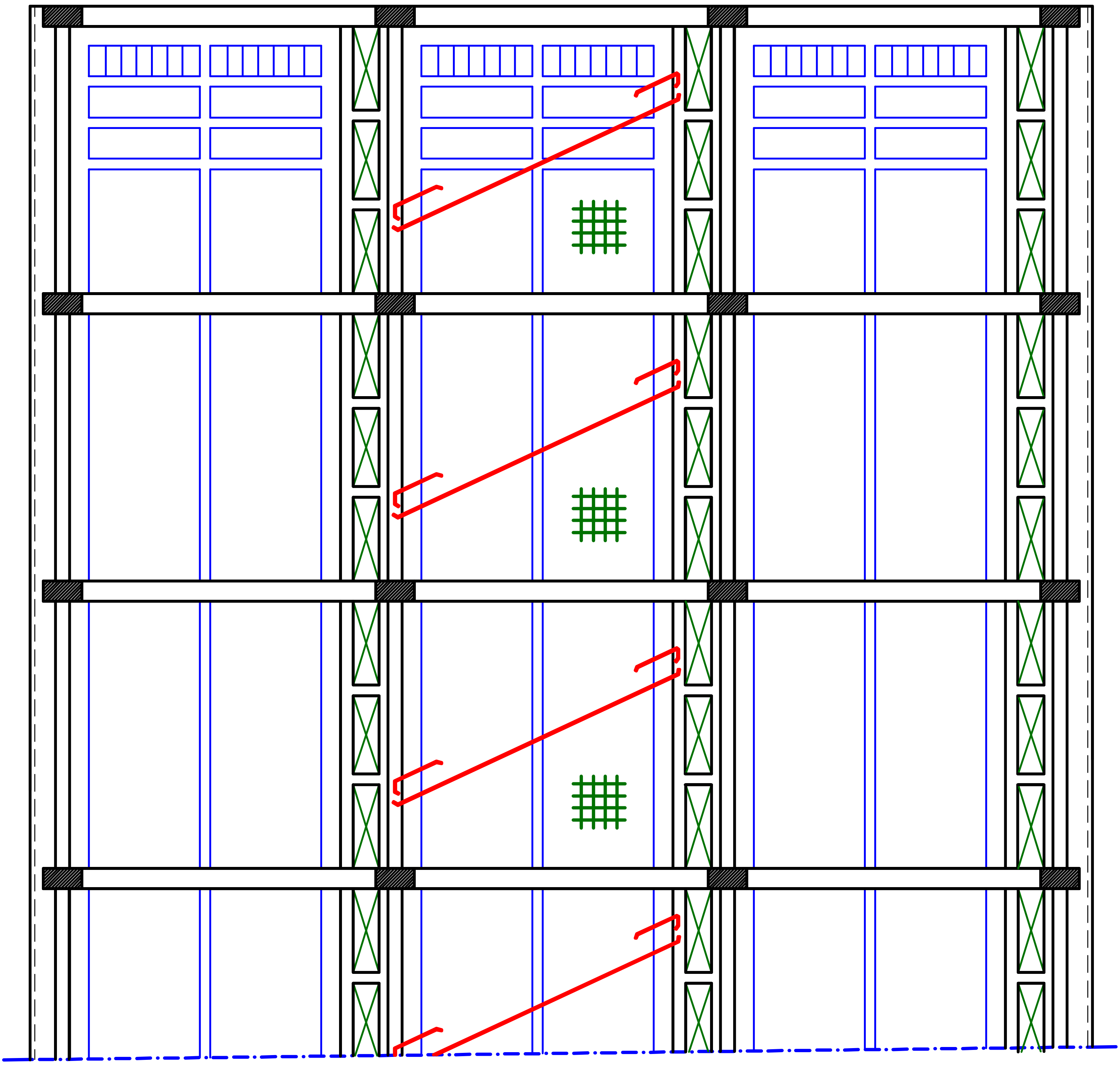


– Design the strip and get the RFT.

RFT. of the slab *Solid Slab.*

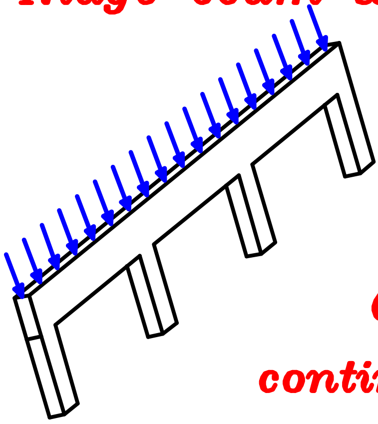


RFT. of the slab *H.B. Slab.*



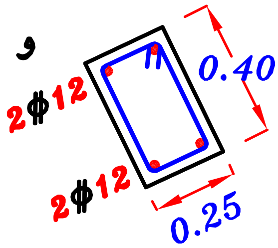
Analysis of Loads.

- ينتقل الحمل من البلاطه الى كمرتين Ridge beam & Y–beam



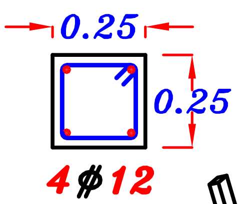
- اذا كان ال post مائل نأخذ ال Ridge beam مائله بنفس ميل ال post حتى تحول الاحمال فى نفس اتجاهه . axial load

- يتكرر ال post كل مسافه $a = (2.0 \rightarrow 3.0\,m)$
لذا تكون الكمره ال Ridge beam كمره continuous
و لكنها عاده تؤخذ min

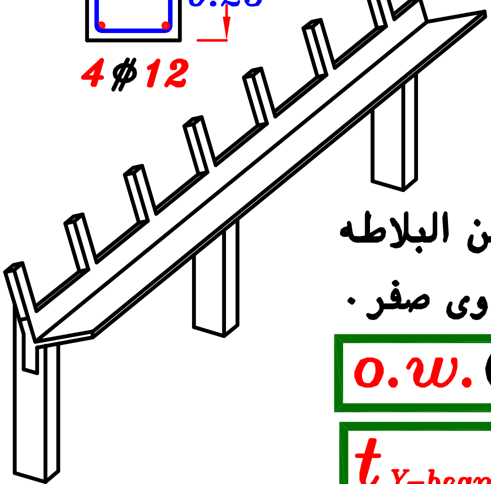


$$O.W.(Ridge\ Beam) = 4.2\ kN/m\ U.L.$$

- ينتقل الحمل من ال Ridge beam الى الpost و عاده يؤخذ min



$$O.W.(Post) = 3.5\ kN\ U.L.$$

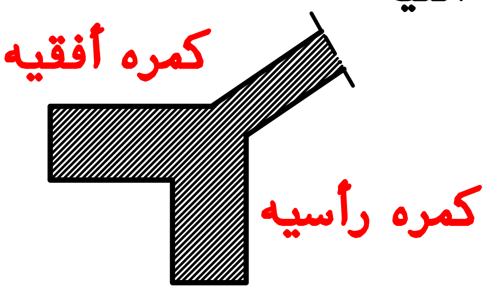


- ينتقل الحمل من ال post الى ال Y–beam
و تكون ال Y–beam كمره continuous
تحمل احمال مركزه من ال post و أحمال منتظمه من البلاطه
و تكون محصله القوى الافقيه على ال Y–beam تساوى صفر .

$$O.W.(Y\text{-}Beam) = b\ t\ \gamma_c * 1.4\ kN/m\ U.L.$$

$$t_{Y\text{-}beam} \simeq \frac{Spacing}{12} + 150\ mm$$

- الكمره الطرفيه End beam يوجد عليها مركبه أفقيه
اذا كان ال post مائل لذا تتكون من كمرتين
كمره رأسيه لتحمل الاحمال الرأسيه
كمره أفقيه لتحمل الاحمال الافقيه .



$$t_{H.L.} \simeq t_{V.L.} \simeq \frac{Spacing}{12}$$

$$O.W.(End\ Beam\ VL + HL) = 7.0\ kN/m\ U.L.$$

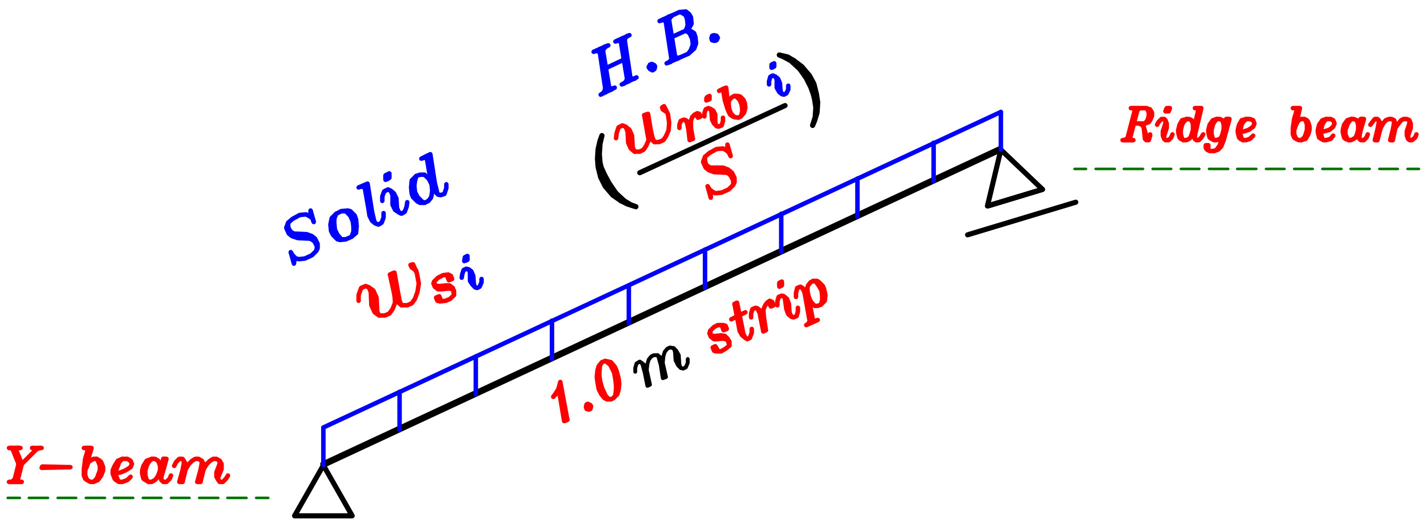
Steps of Design.

① Loads From Slab.

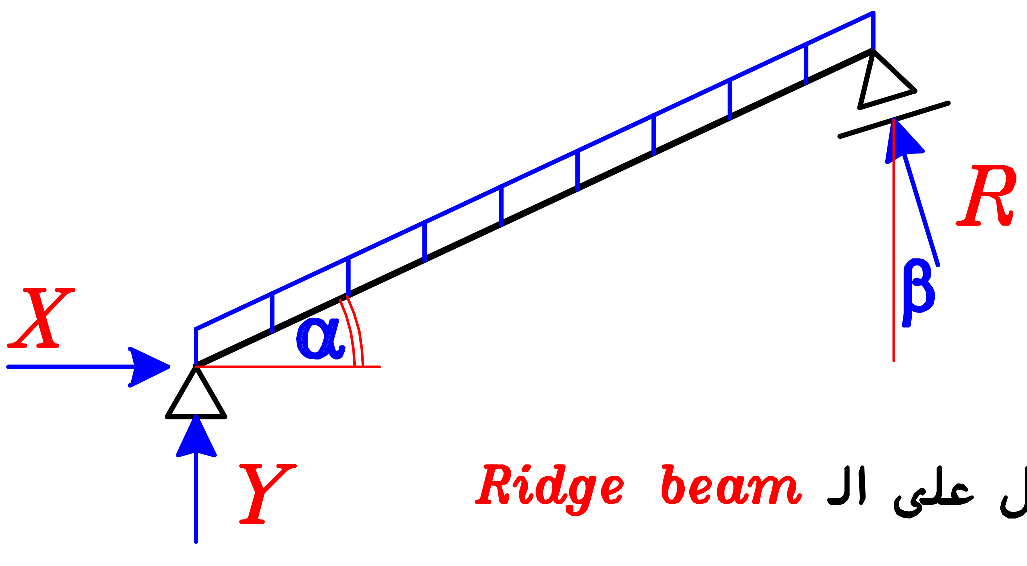
نأخذ شريحه فى البلاطه عرضها ١,٠ م

مع اعتبار ال *Y-beam* كأنها *hinged support*

و اعتبار ال *Ridge beam* كأنها *Roller support* مائل بنفس ميل ال *post*



نحدد *Reactions* شريحه البلاطه .

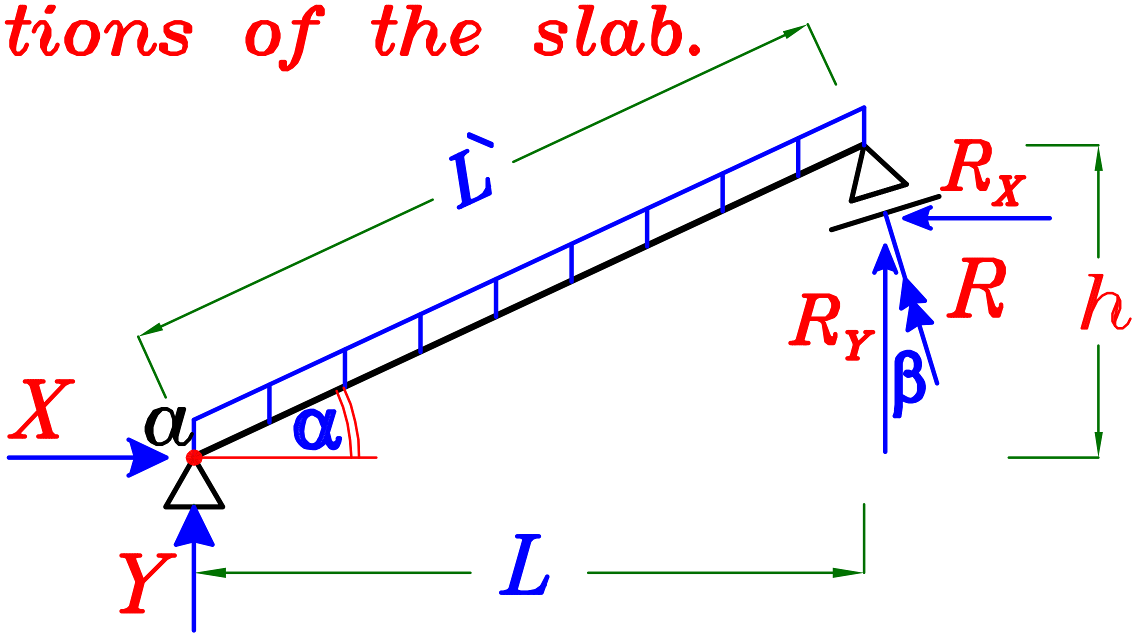


حيث *R* ينتقل على ال *Ridge beam*

حيث *X*, *Y* ينتقلا على *Y-beam*

ملحوظه *R* , *X*, *Y* يعتبروا أحمال منتظمه على الكمرات
لانها *Reactions* لشريحه بلاطه عرضها ١,٠ م

Reactions of the slab.



Using Equations.

$$R_Y = R \cos\beta$$

$$R_X = R \sin\beta$$

$$\because \sum M_a = Zero$$

$$w_s\, L`\left(\frac{L}{2}\right) - R_Y\,(L) - R_X\,(h) = 0.0$$

$$\therefore\ w_s\, L`\left(\frac{L}{2}\right) - R \cos\beta\,(L) - R \sin\beta\,(h) = 0.0$$

Get $R = \checkmark$

$$\therefore\ R_Y = R \cos\beta = \checkmark$$

$$\therefore\ R_X = R \sin\beta = \checkmark$$

$$\therefore\ X = R_X = \checkmark$$

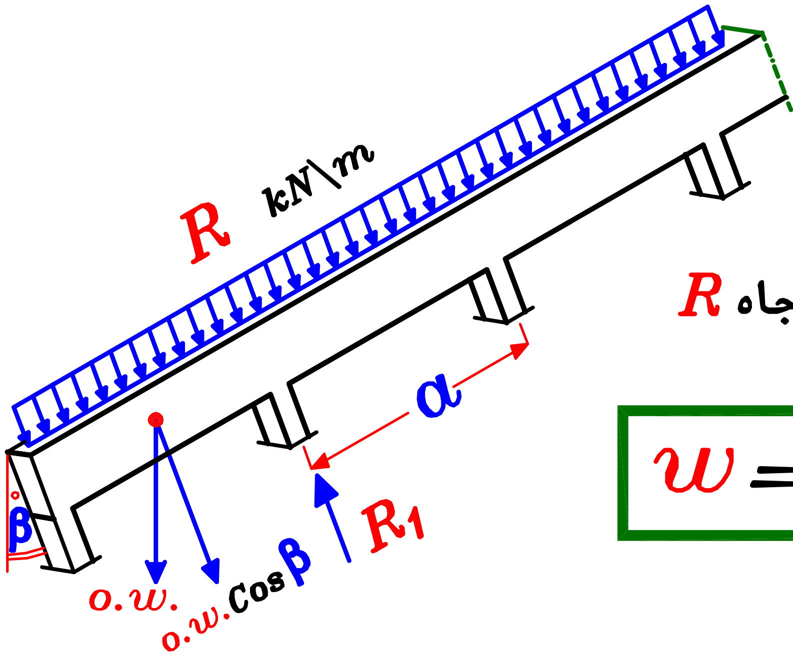
Get Y From $\sum y = Zero \longrightarrow$ Get $y = \checkmark$

Ridge Beam.

- الكمره ال *Ridge beam* كمره *continuous*
محموله على *post* يتكرر كل مسافه $a = (2.0 \rightarrow 3.0\,m)$

- اذا كان ال *post* مائل نأخذ ال *Ridge beam* مائله بنفس ميل ال *post*
حتى تحول الاحمال فى نفس اتجاهه (*axial load on the post*)

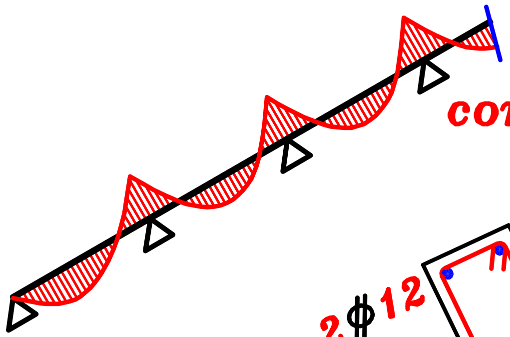
- تحمل ال *Ridge beam* حمل منتظم من البلاطه قيمته R



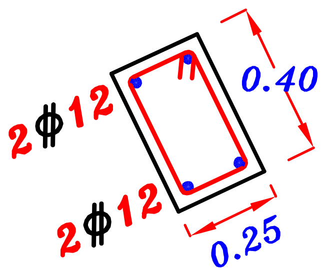
اذا كان ال *post* مائل
نحلل وزن الكمره الى المركبه
المائله حتى تكون فى نفس اتجاه R

$$w = o.w \; Cos\,\beta + R$$

و عاده نأخذ *o.w.* الكمره $= 3.0 * 1.4 = 4.2\ kN/m$



- لان الكمره ال *Ridge beam* كمره *continuous*
بحرها صغير جدا $(2.0 \rightarrow 3.0\,m)$
اذا بدون تصميم سوف نأخذ الكمره *min*



- *Reaction* الكمره يحمل على ال *post*

$$R_1 = w * a$$

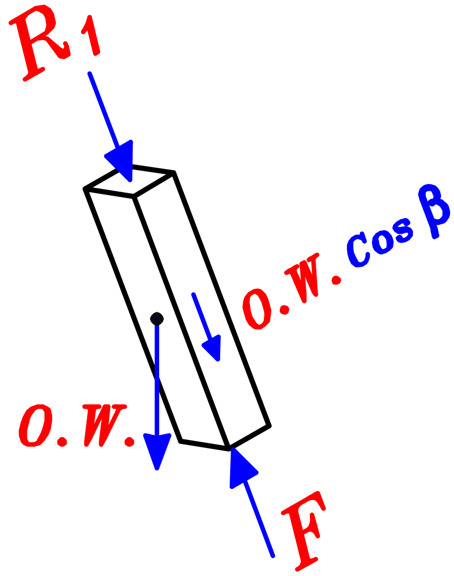
Post.

- ينتقل الحمل من ال Ridge beam الى ال post

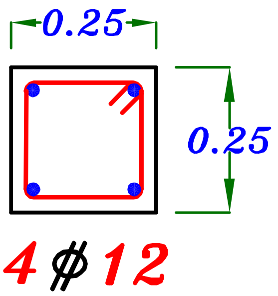
نحلل وزن ال post حتى يكون فى نفس اتجاه R_1

$$F = O.W._{(Post)} * \cos\beta + R_1$$

$$O.W._{(Post)} \simeq 3.50\ kN\ (U.L.)$$



عاده يؤخذ ال post



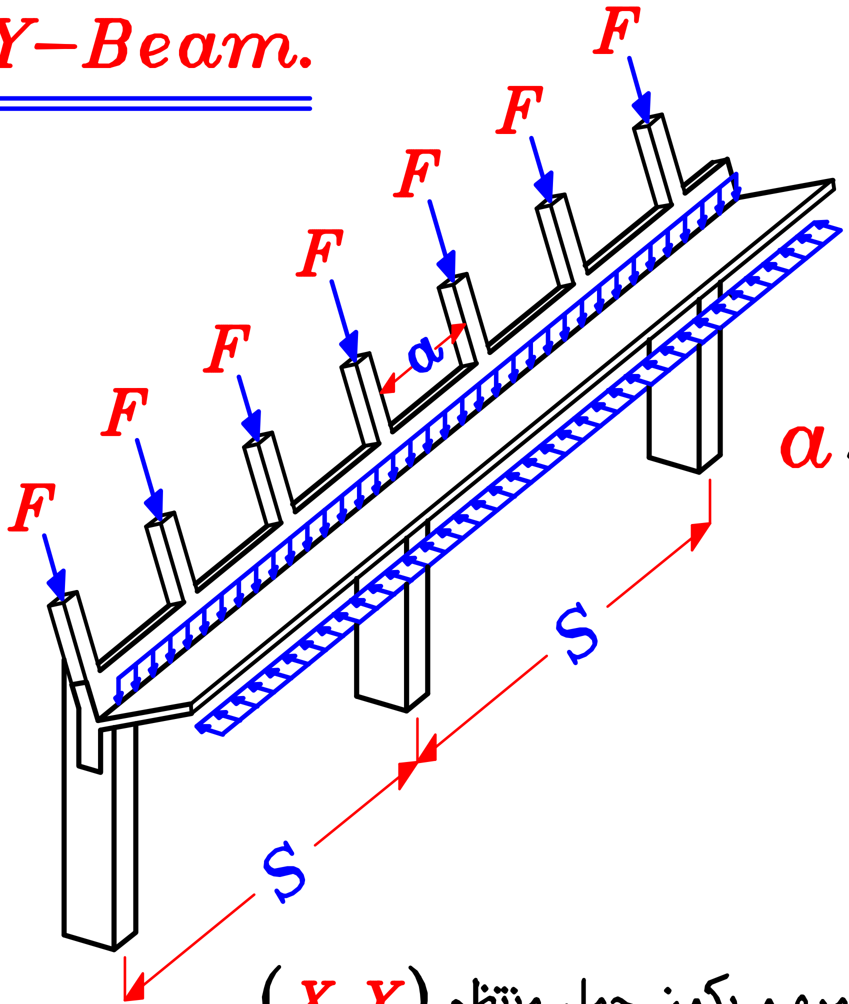
Y-Beam.

- الكمره ال Y-beam كمره continuous

- ينتقل الحمل F من ال post الى ال Y-beam و تكون أحمال مركزه تتكرر كل مسافه a

- يتم تحليل الحمل F الى مركبتين F_X & F_Y

$$F_Y = F \cos\beta$$
$$F_X = F \sin\beta$$



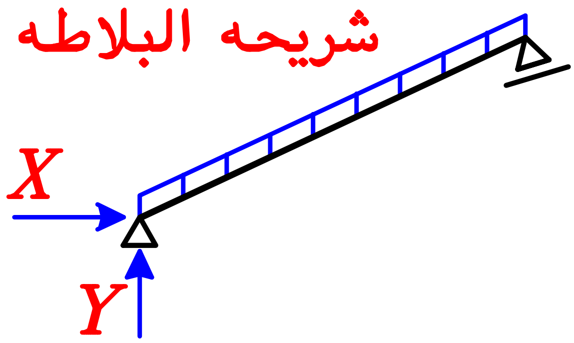
- ينتقل الحمل من البلاطه الى الكمره و يكون حمل منتظم (X, Y) و تكون محصله القوى الافقيه على ال Y-beam تساوى صفر .

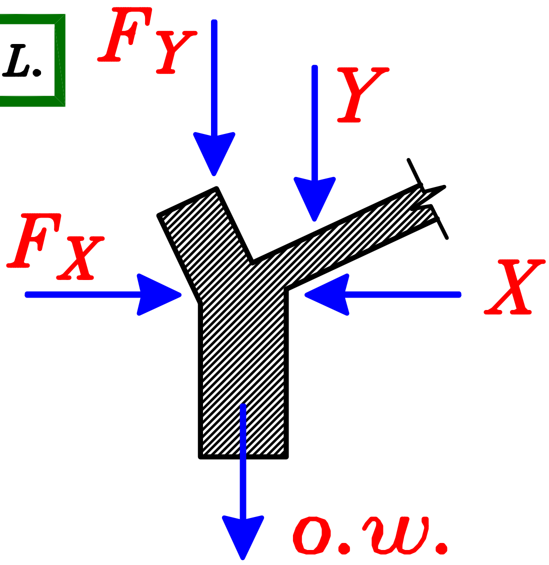
Distributed Loads.

$$t_{Y\text{-}beam} \simeq \frac{Spacing}{12} + 150\ mm$$

$$o.w.(Y\text{-}Beam) = b\,t\,\gamma_c * 1.4\ kN/m\ U.L.$$

X , Y From slab.



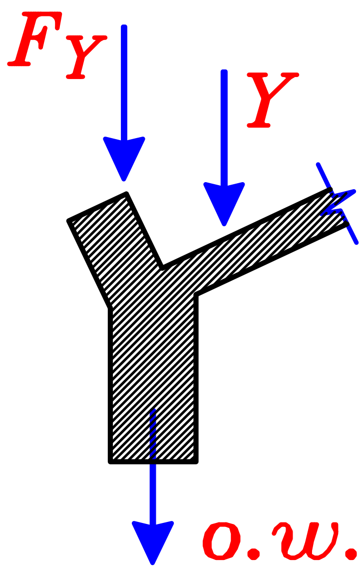


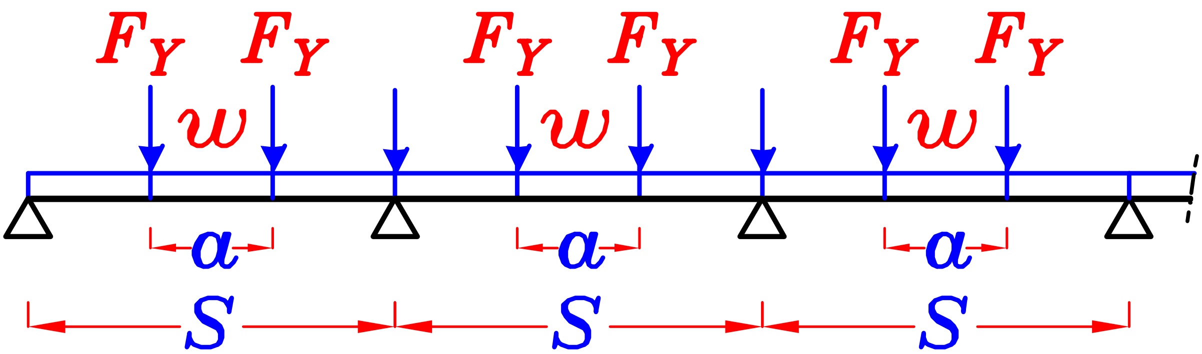
Concentrated Loads.

F_X , F_Y From post

F_X تساوى محصله X محصله

$$\Sigma X = zero$$

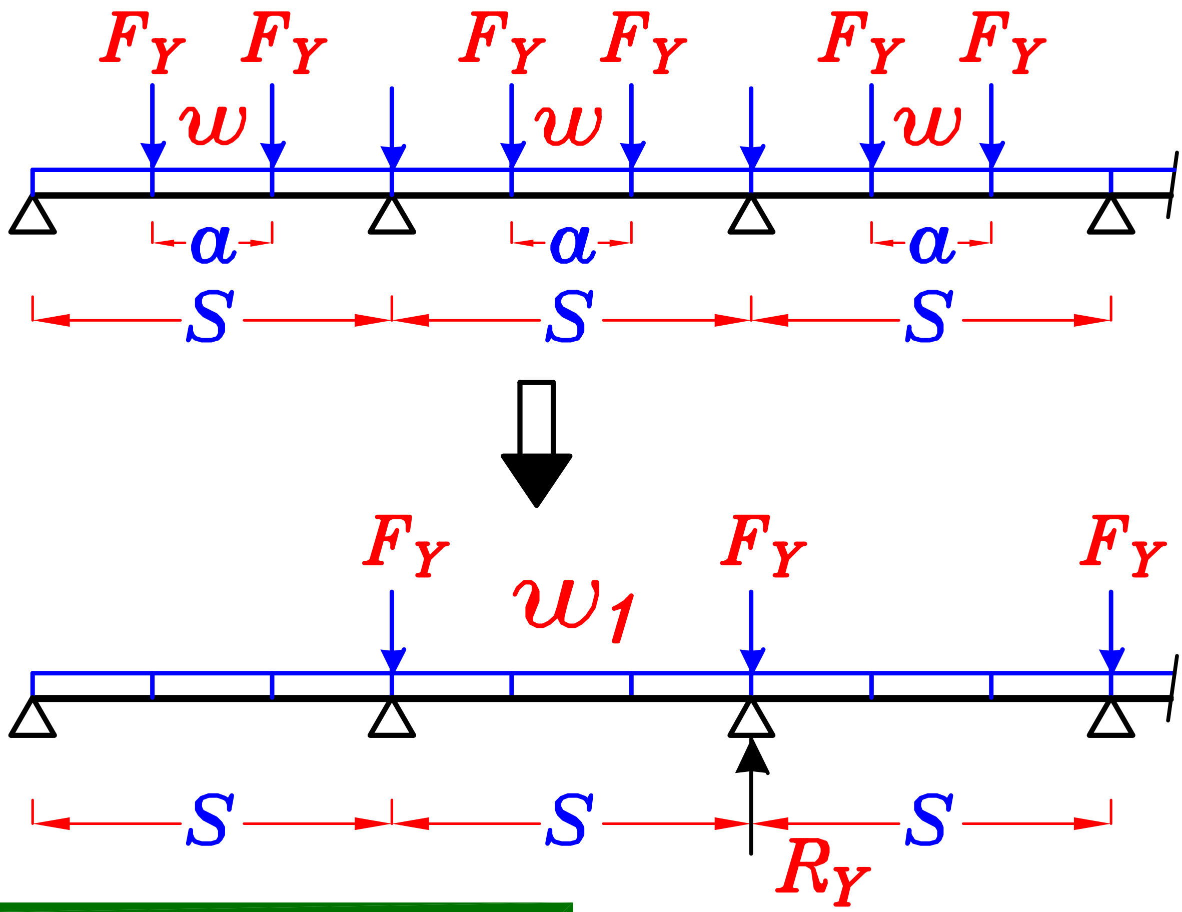




$$w = o.w. + Y$$

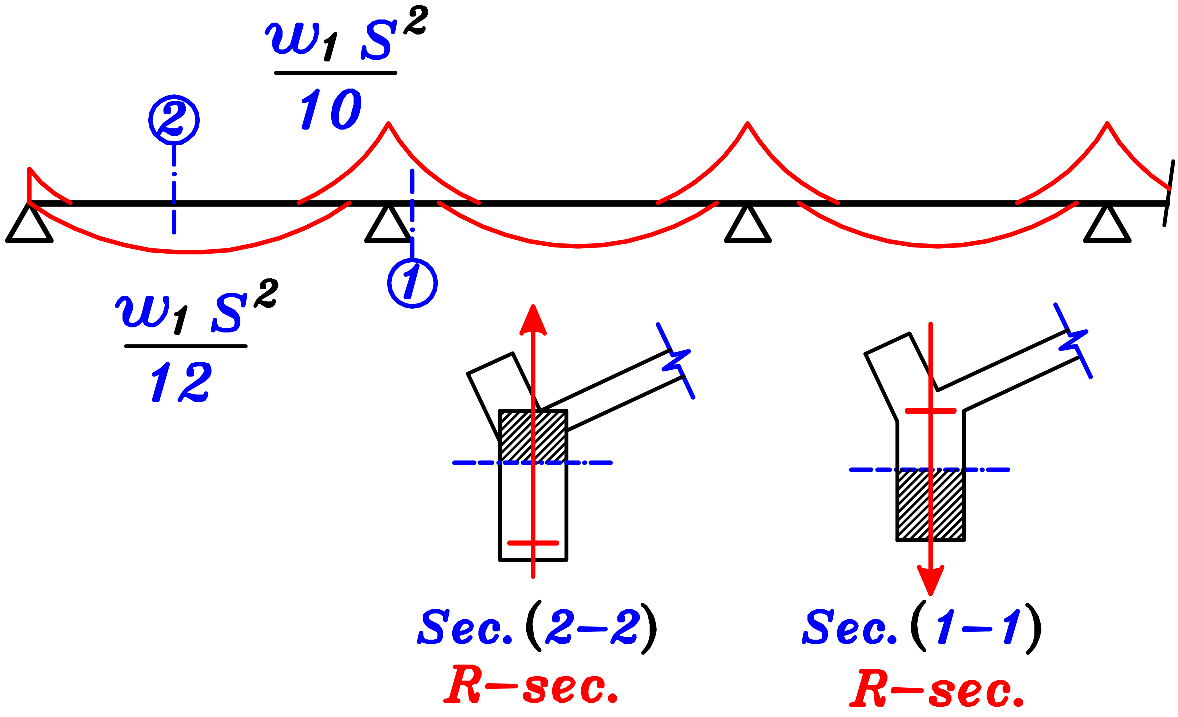
لتسهيل حل الكمره الـ Y-beam نعمل حل تقريبى

و ذلك بتحويل الاحمال المركزه الى أحمال منتظمه .

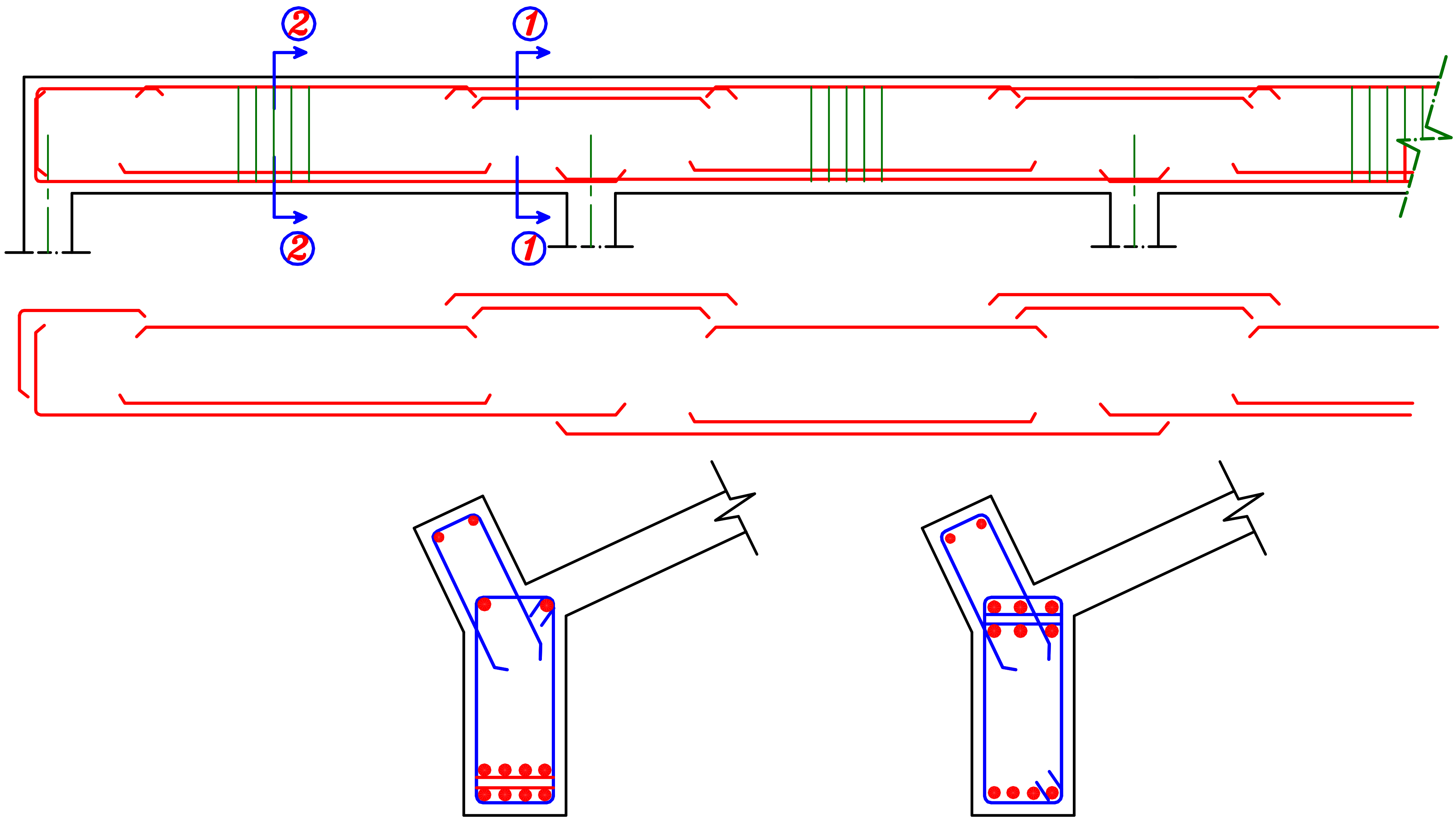


$$w_1 = w + \frac{\sum F_Y}{S}$$

$$R_Y = w_1 * S + F_Y$$



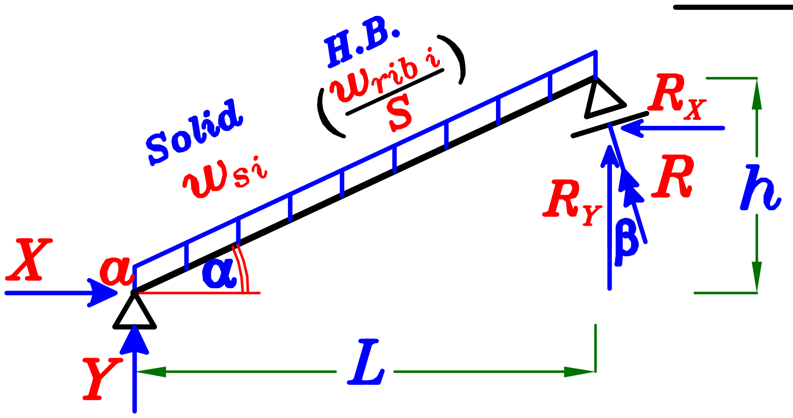
RFT. of Y-Beam.



Sec. (2–2)

Sec. (1–1)

خطوات تصميم Y-Beam الشباك مائل



نأخذ شريحه فى البلاطه عرضها ١,٠ م

و نحدد ال R , X , Y Reactions

$$w = R + o.w \cos\beta$$

$$R_1 = w * a$$

→ Ridge Beam

$$F = R_1 + o.w \cos\beta$$

$$F_Y = F \cos\beta$$

→ Post

$$w_1 = o.w + Y + \frac{\Sigma F_Y}{S}$$

$$R_Y = w_1 * S + F_Y$$

→ Y-Beam

---

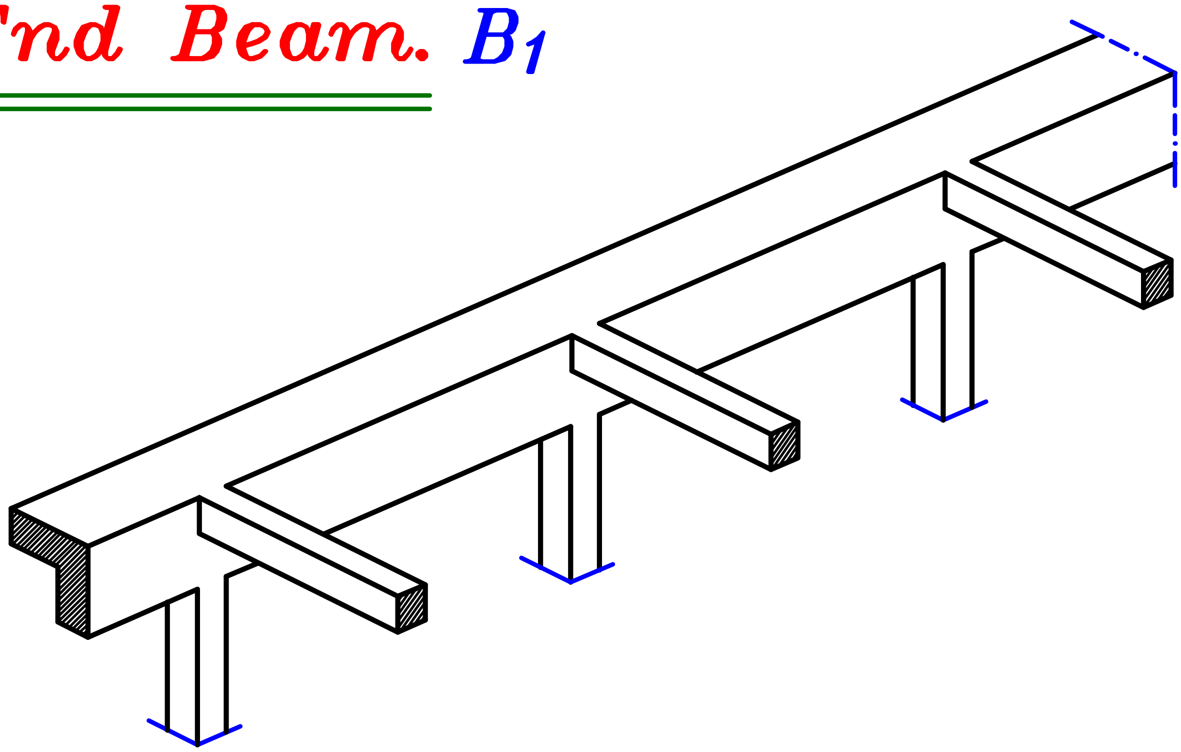
o.w. (Ridge Beam) = 4.2 kN/m U.L.

o.w. (Post) = 3.5 kN U.L.

o.w. (Y-Beam) = $b\, t\, \gamma_c * 1.4$ kN/m U.L.

$$t_{Y-beam} \simeq \frac{Spacing}{12} + 150 \text{ mm}$$

End Beam. B_1

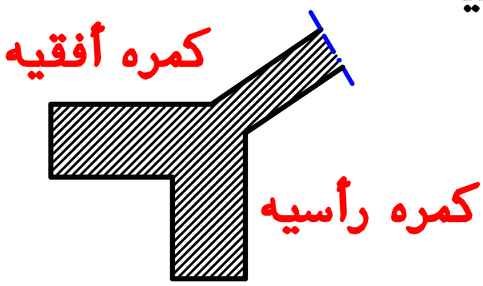


- الكمره الطرفيه *End beam* يوجد عليها قوه أفقيه

اذا كان ال *post* مائل لذا تتكون من كمرتين

كمره رأسيه لتحمل الاحمال الرأسيه

و كمره أفقيه لتحمل الاحمال الافقيه .



- أى قوى رأسيه تذهب الى الكمره الرأسيه

أى قوى أفقيه تذهب الى الكمره الافقيه .

- وزن الكمرتين هو حمل رأسى لذا يذهب الى الكمره الرأسيه فقط.

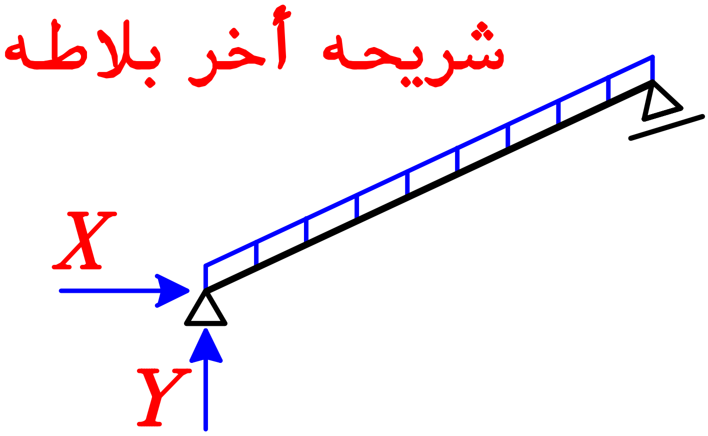
$$O.W._{(beam)} \; (VL.+HL.) \simeq 7.0 \; kN/m$$

- X, Y من أخر بلاطه تذهب

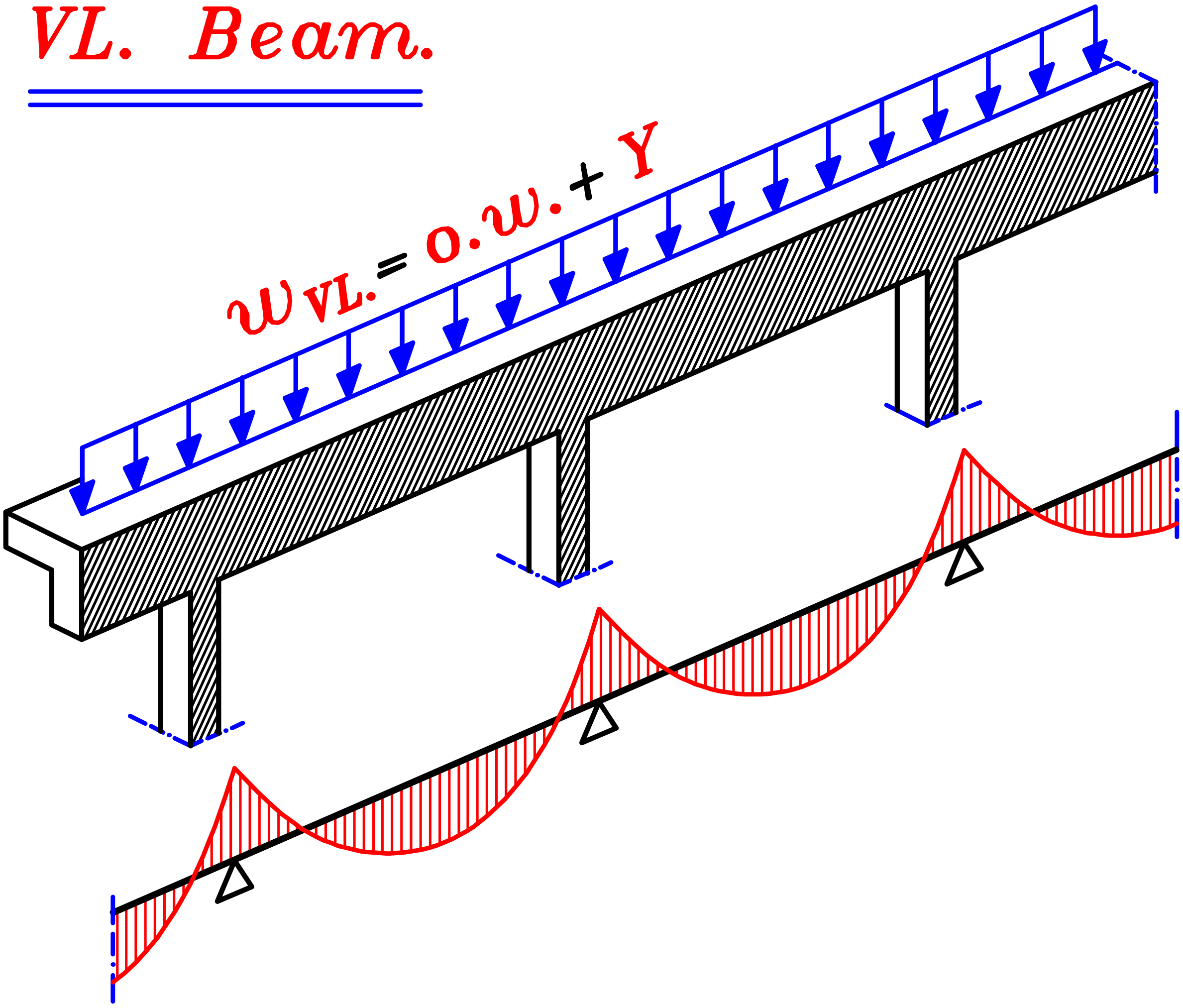
على ال *End beam*

Y تذهب الى الكمره الرأسيه .

X تذهب الى الكمره الافقيه .

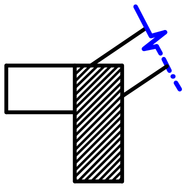


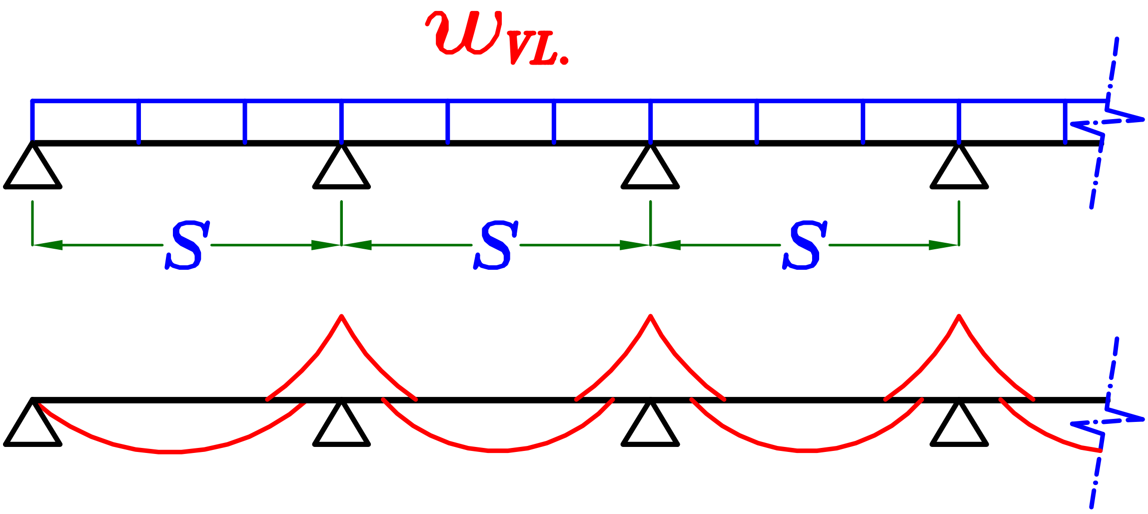
VL. Beam.

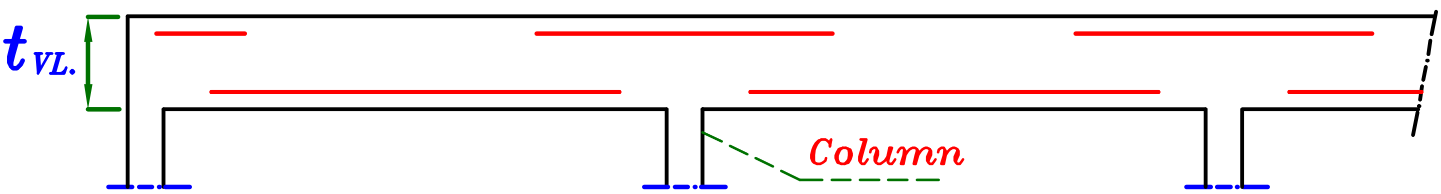


$$w_{VL.} = O.W._{(beam)} + Y \quad kN\backslash m`$$

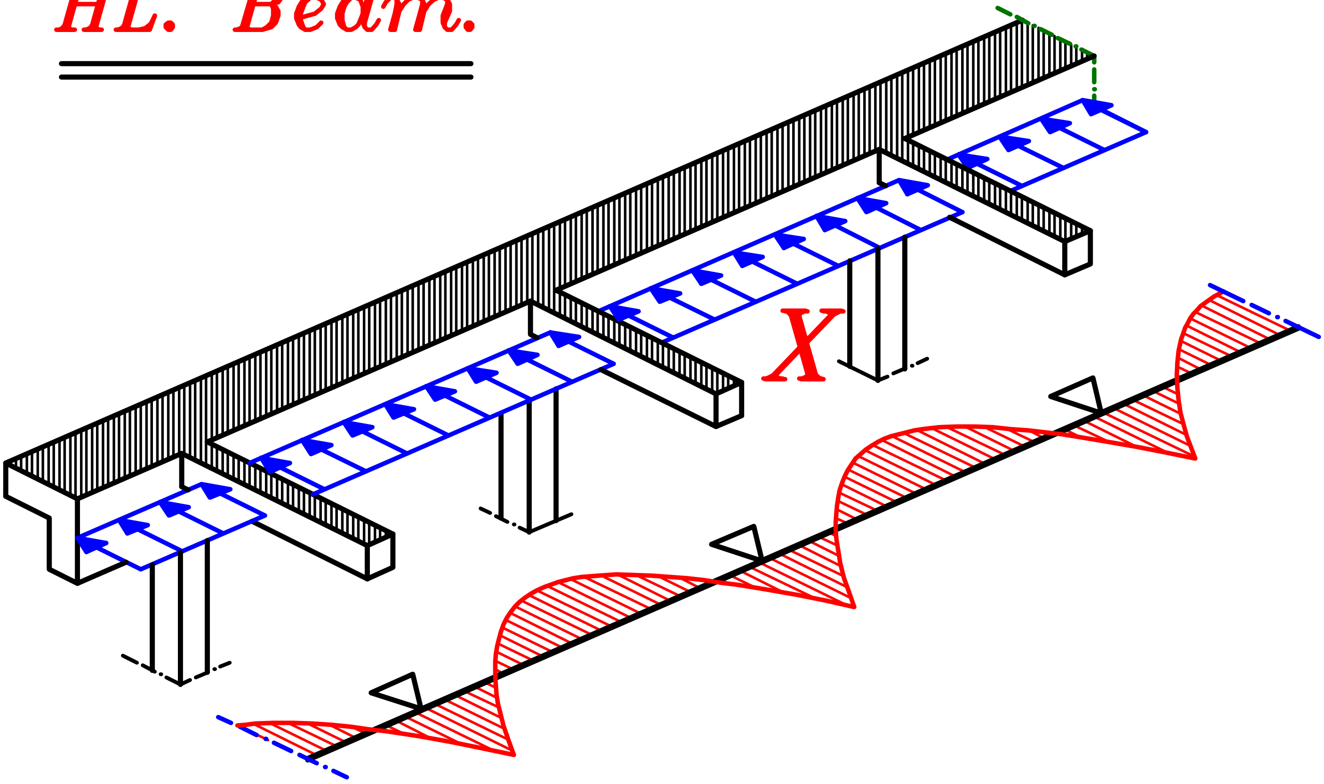
Designed as R-Sec.

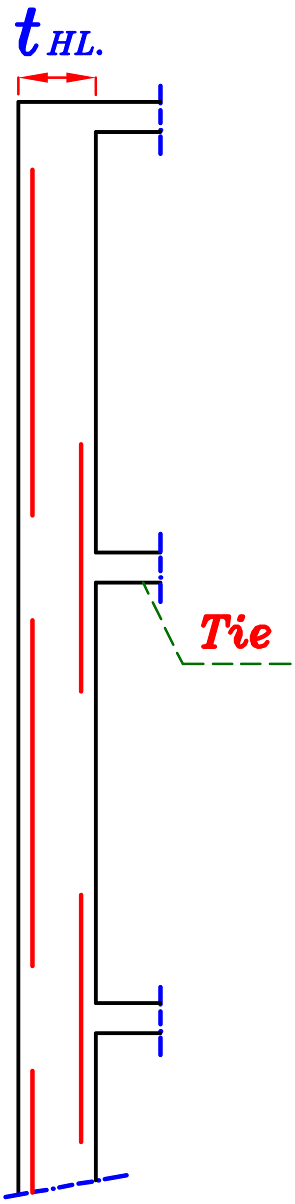




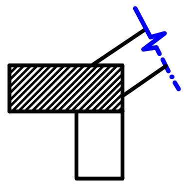


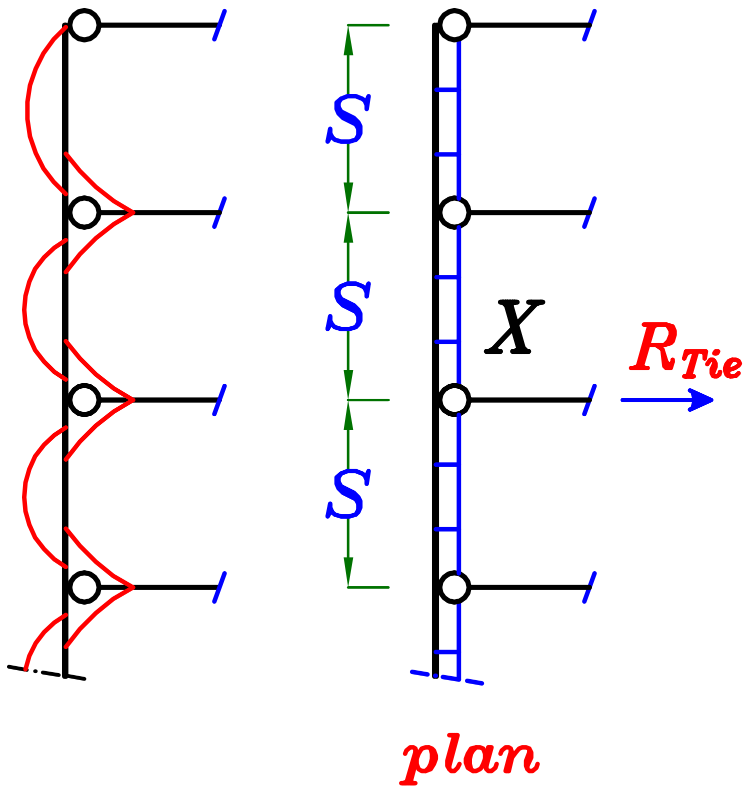
HL. Beam.





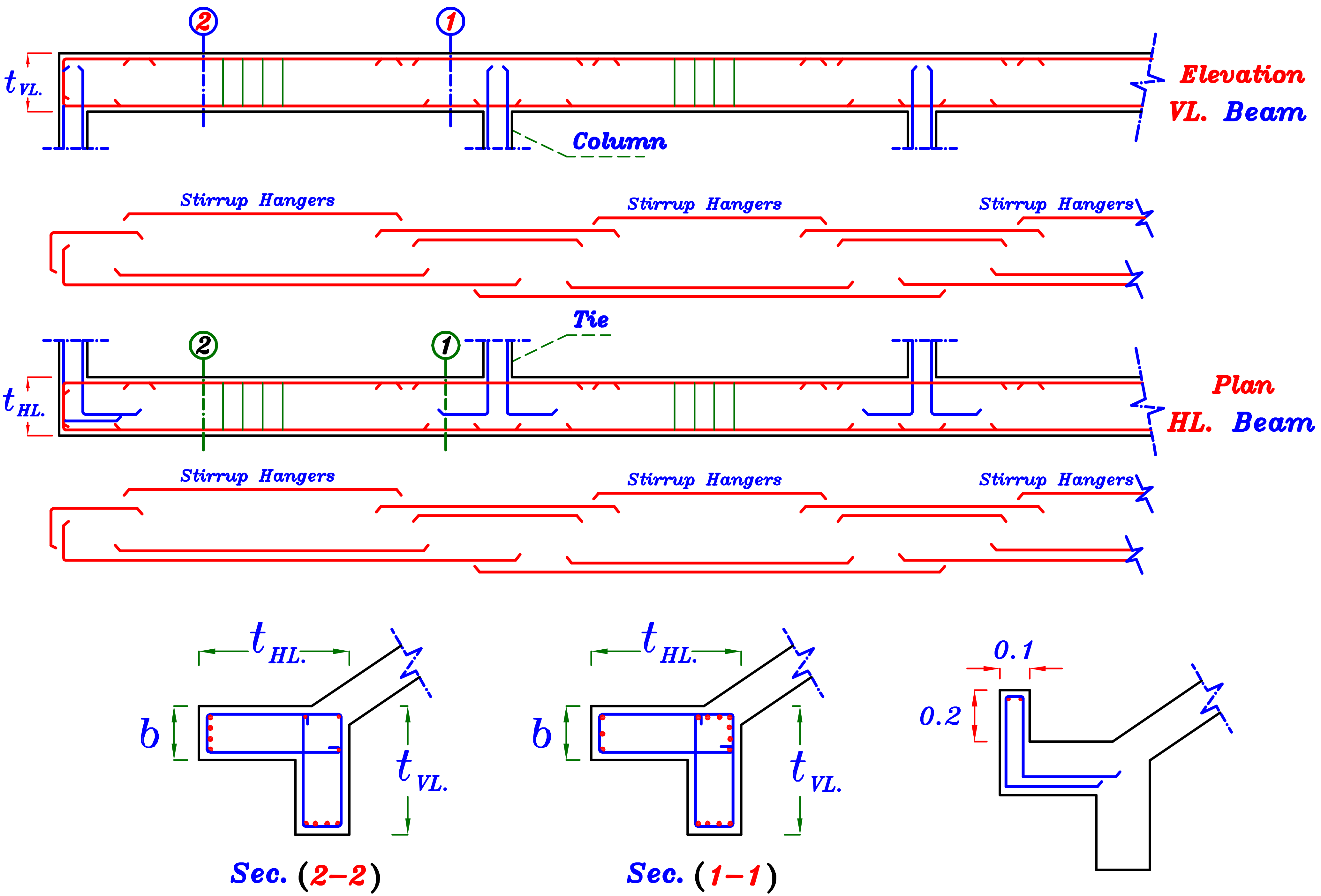
Designed as R–Sec.



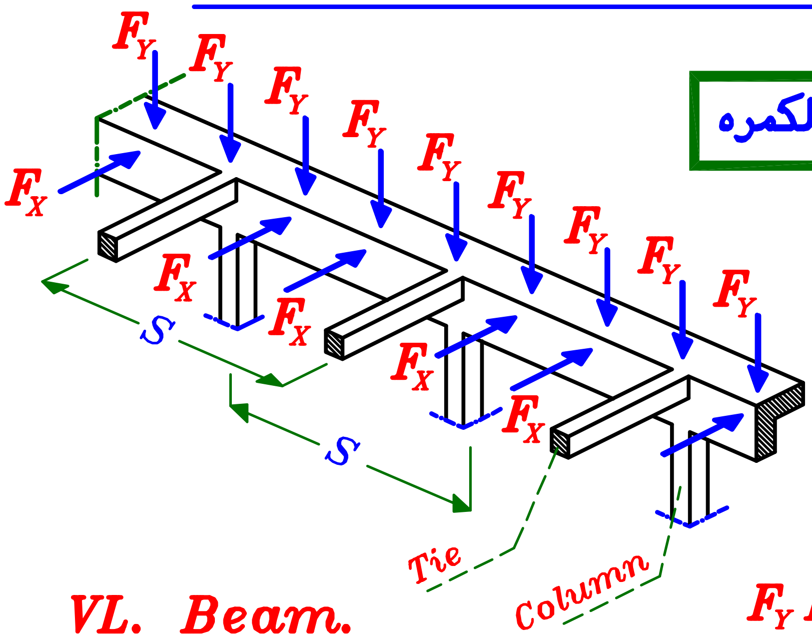


$$R_{Tie} = X * S$$

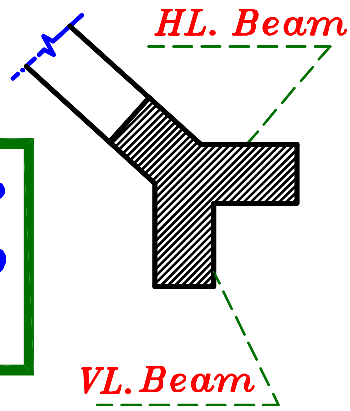
RFT. of End Beam.



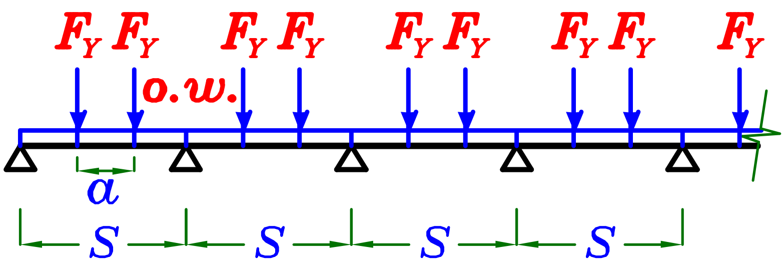
* Design of End Beam. B_2



ممكن اهمال هذه الكمره
و أخذ تسليحها
مثل B_1



VL. Beam.

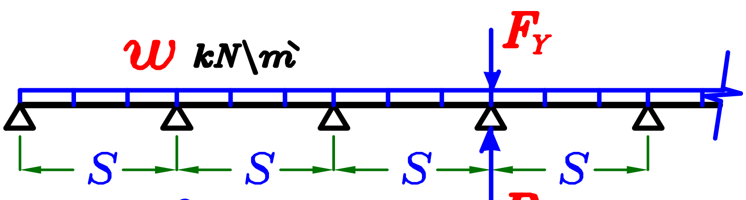


O.W. (beam) (VL.+HL.) $\simeq$ 7.0 kN (U.L.)

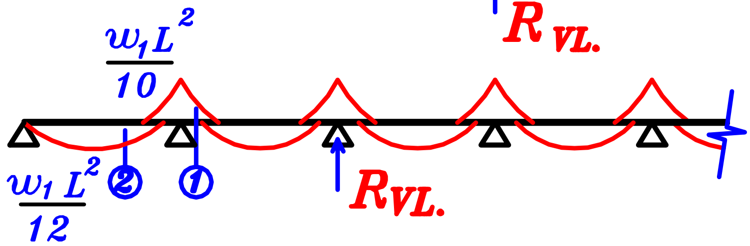
Solved by using Moment Dist. or use Approximate Solution.

$$F_Y = F \cos \beta$$

$$w = o.w. + \frac{\sum F_Y \text{ (at one span)}}{Span}$$



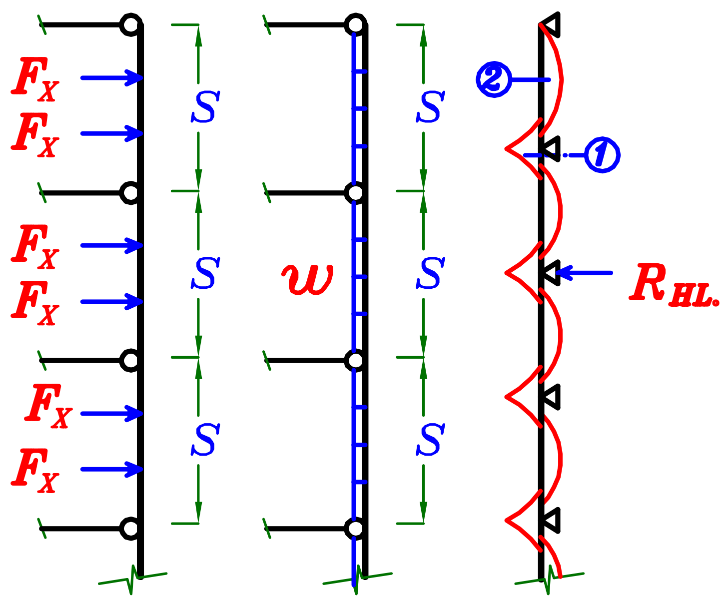
Designed as R-Sec.



HL. Beam.

$$F_X = F \sin \beta$$

$$w = \frac{\sum F_X \text{ (at one span)}}{Span}$$



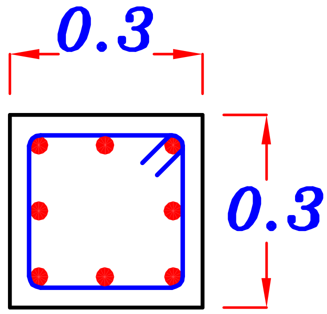
Tie.

ـ الشد الموجود فى ال *Tie* ناتج من *Reaction of HL. Beam*

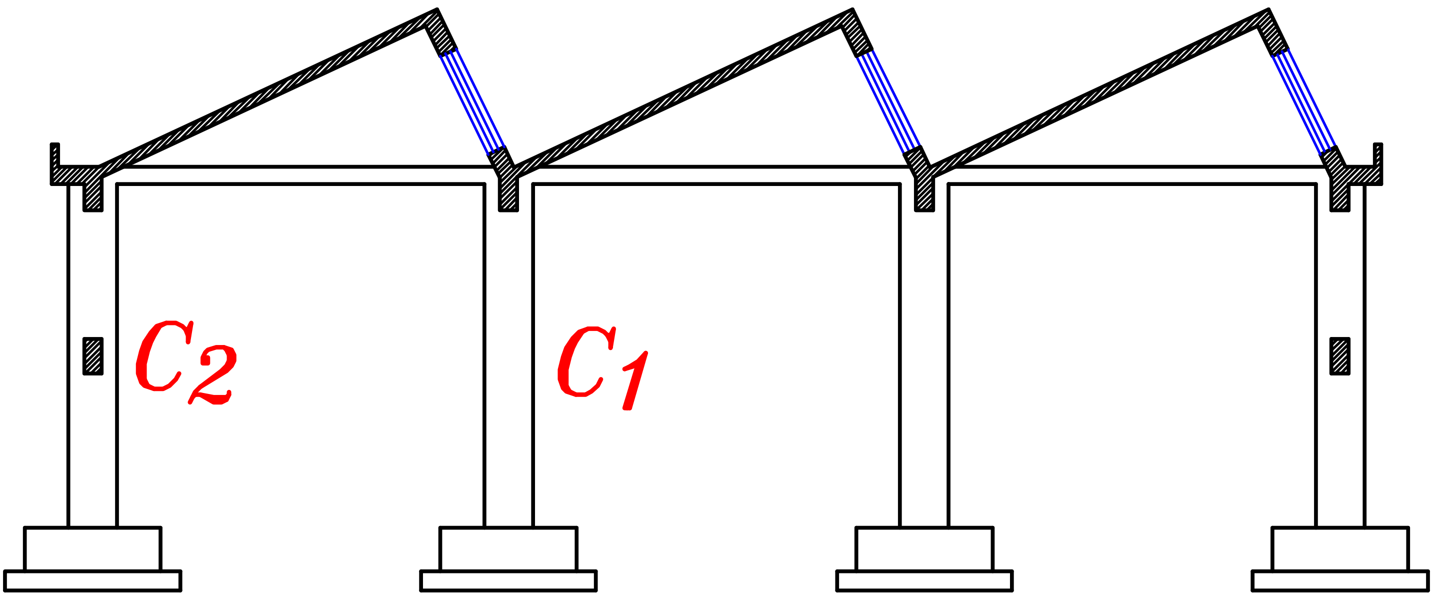
$$T_{Tie} = X * S$$

$$A_s = \frac{T_{(Tie)}}{F_y \backslash \gamma_s} = (\text{Total area of steel})$$

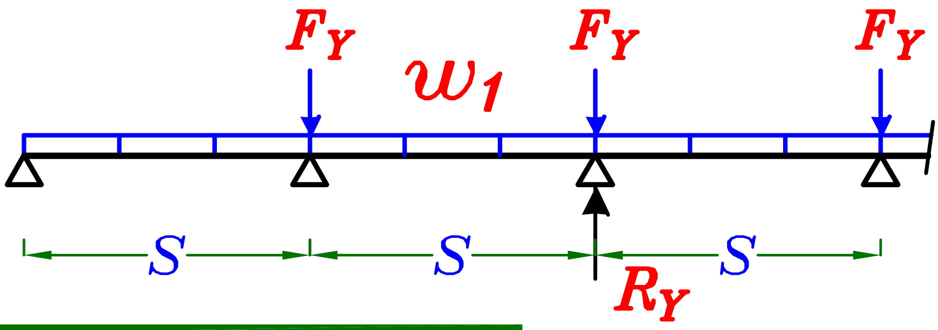
$$A_c = \text{Take } (300 \times 300)$$



Columns. C_1 & C_2



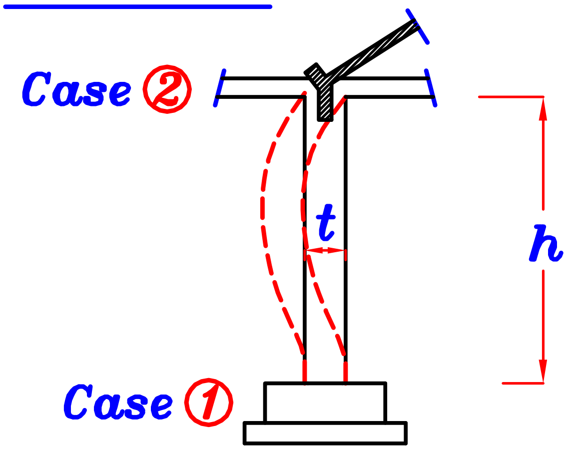
C_1 — P = Reaction of Y-beam. R_Y



$$R_Y = w_1 * S + F_Y$$

Check Buckling.

① In plane.

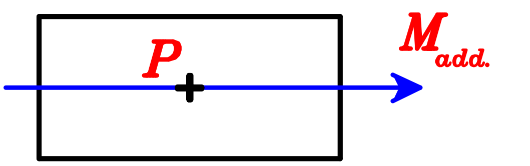


$$H_\circ = h$$

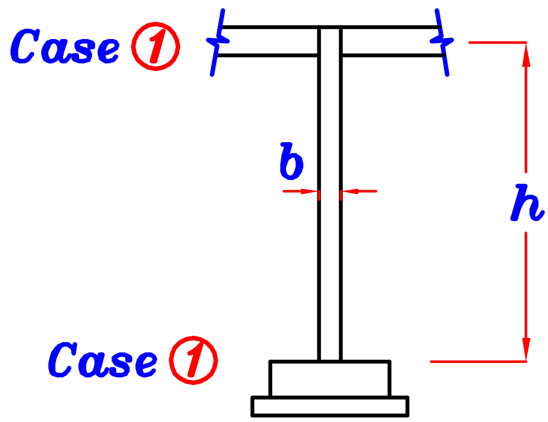
$$\lambda_b = \frac{1.3 * H_\circ}{t}$$

IF $\lambda_b \leqslant 10 \xrightarrow{\text{Designed}} P \text{ only}$

$\lambda_b > 10 \xrightarrow{\text{Designed}} P,\ M_{add.}$



② Out of plane.

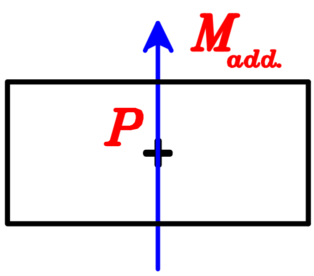


$$H_\circ = h$$

$$\lambda_b = \frac{1.2 * H_\circ}{b}$$

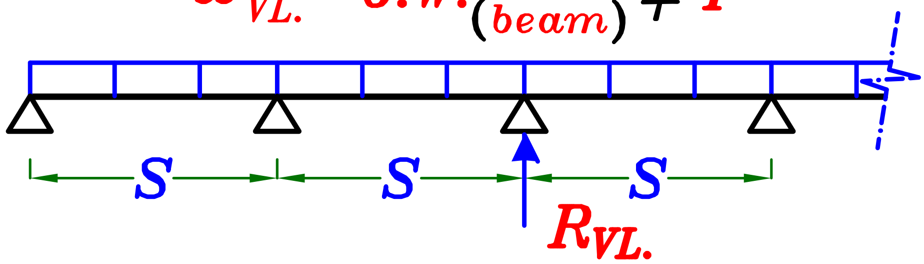
IF $\lambda_b \leqslant 10 \xrightarrow{\text{Designed}} P \text{ only}$

$\lambda_b > 10 \xrightarrow{\text{Designed}} P,\ M_{add.}$



C_2 P = Reaction of VL. beam $R_{VL.}$

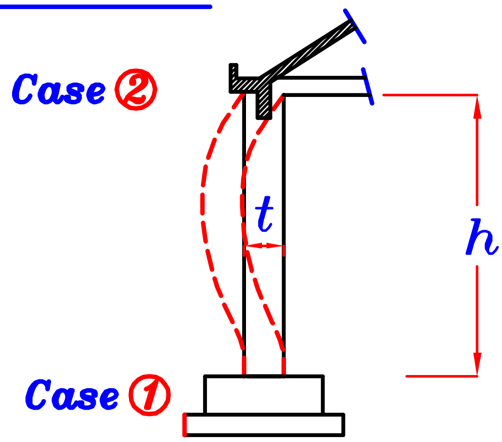
$$w_{VL.} = O.W._{(beam)} + Y$$



$$R_{VL.} = w_{VL.} * S$$

Check Buckling.

① In plane.

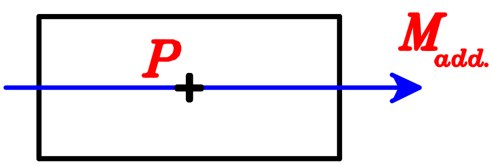


$H_{\circ} = h$

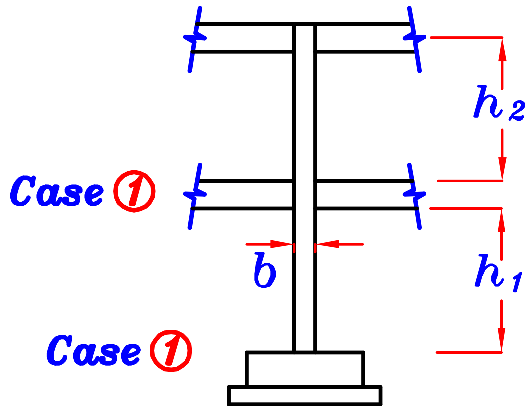
$$\lambda_b = \frac{1.3 * H_{\circ}}{t}$$

IF $\lambda_b \leqslant 10$ $\xrightarrow{\text{Designed}}$ P only

$\lambda_b > 10$ $\xrightarrow{\text{Designed}}$ P, $M_{add.}$



② Out of plane.

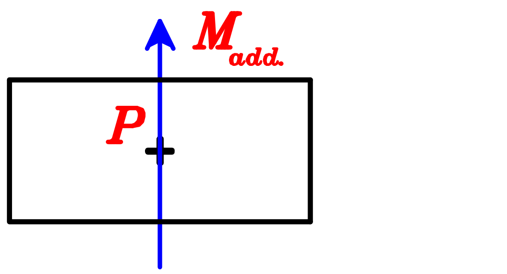


$H_{\circ}$ = bigger of h_1 & h_2

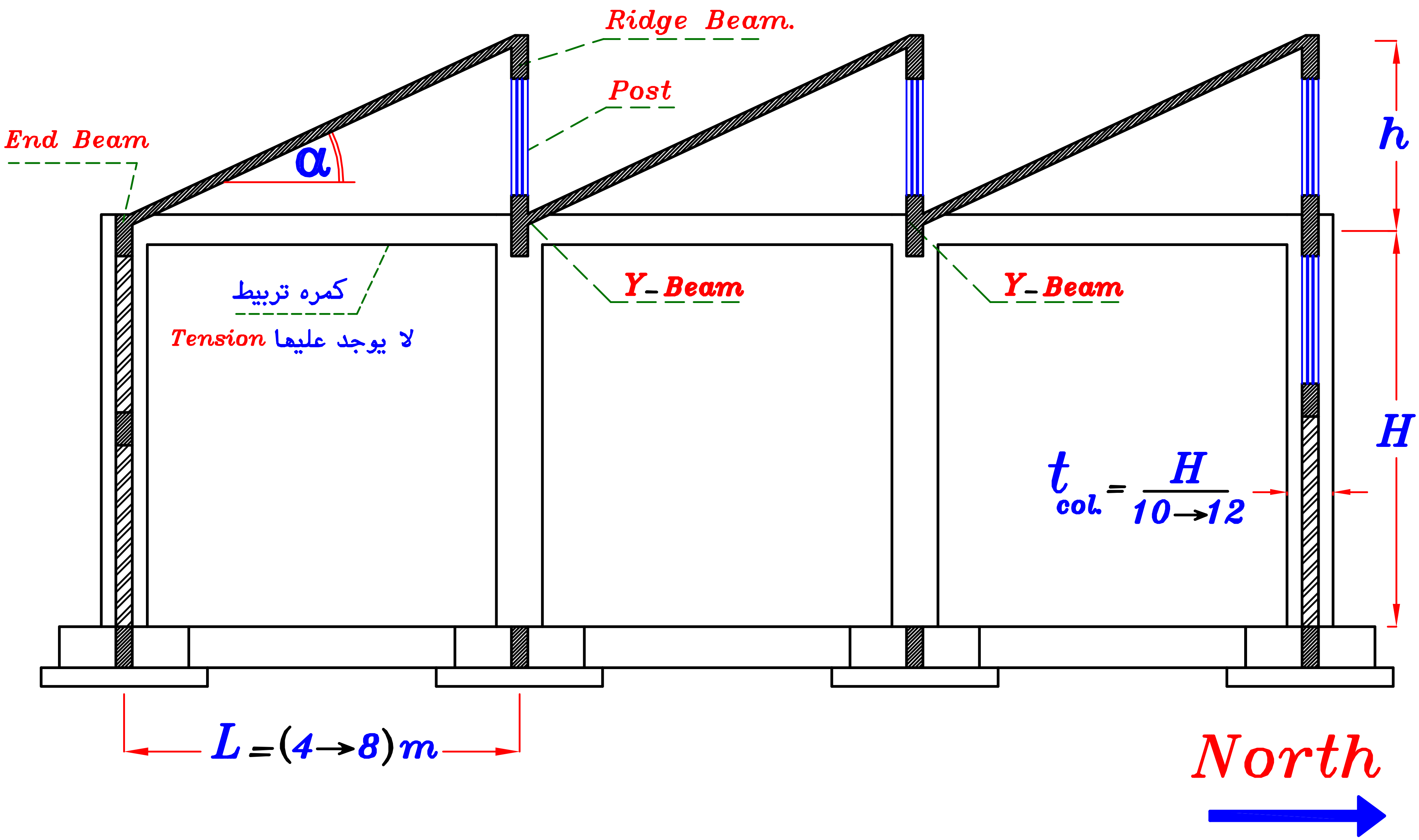
$$\lambda_b = \frac{1.2 * H_{\circ}}{b}$$

IF $\lambda_b \leqslant 10$ $\xrightarrow{\text{Designed}}$ P only

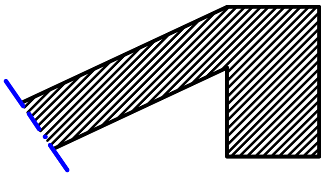
$\lambda_b > 10$ $\xrightarrow{\text{Designed}}$ P, $M_{add.}$



Saw Tooth Slab Type with Vertical Posts. $\beta = 0.0$

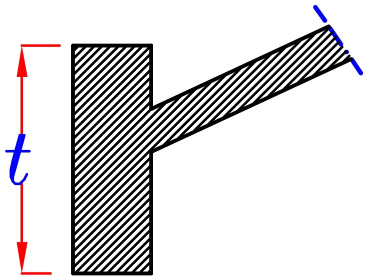


Saw Tooth Slab Type with Vertical Posts.



- عندما يكون ال **post** رأسى ستكون ال **Ridge beam** رأسيه حتى تكون الاحمال فى نفس اتجاه ال **post**
axial loads on post

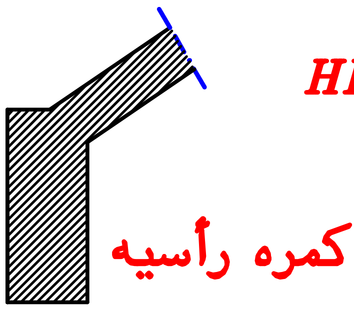
Ridge beam



- لان ال **post** رأسى فتكون ال **Y-Beam** رأسيه .

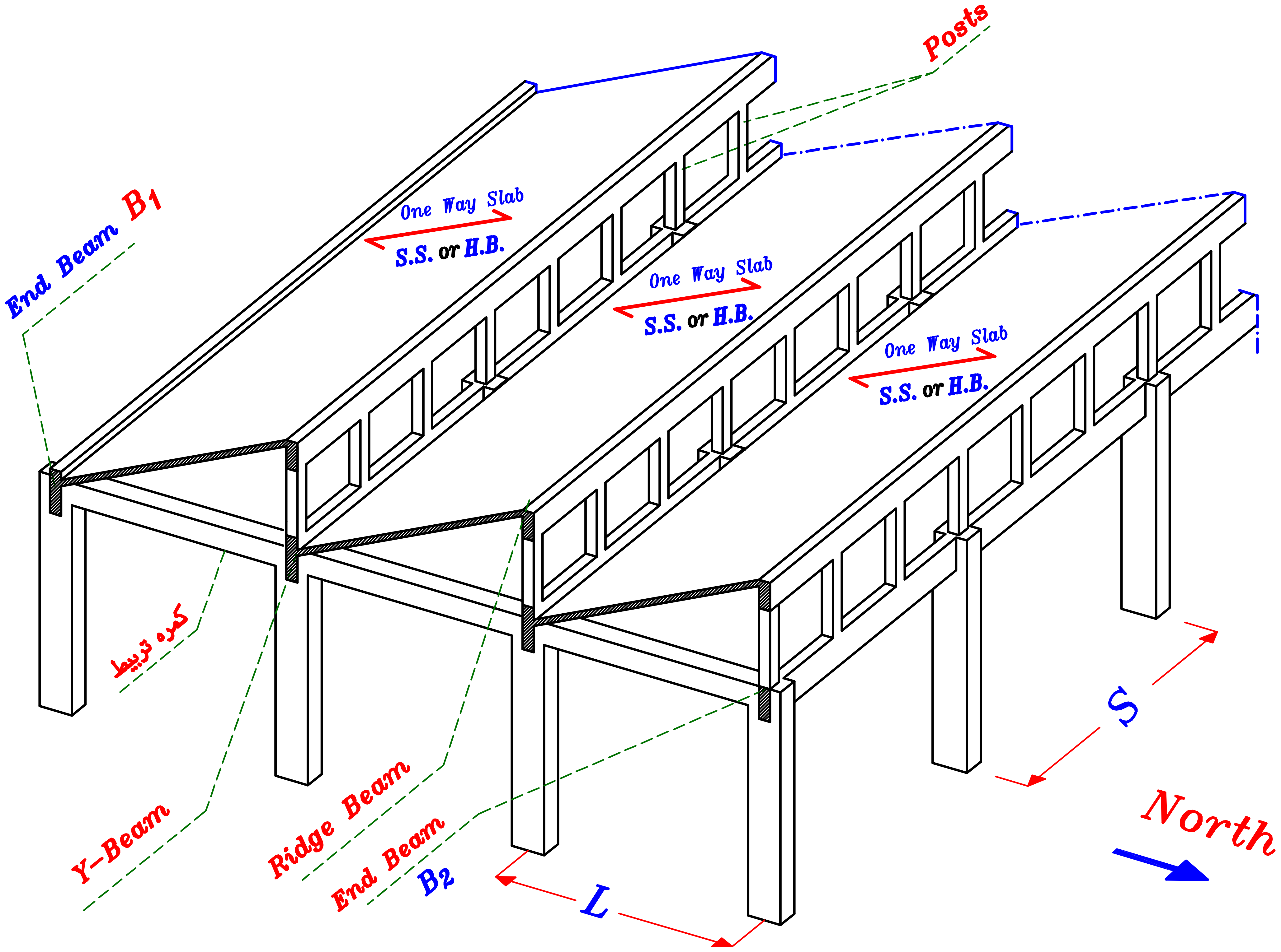
Y-Beam

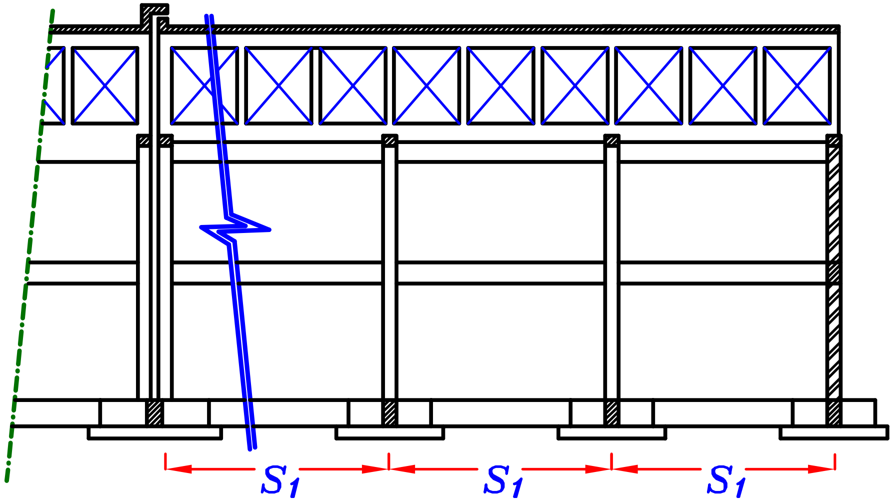
- لان ال **Ridge beam** رأسيه فلن توجد مركبه أفقيه .



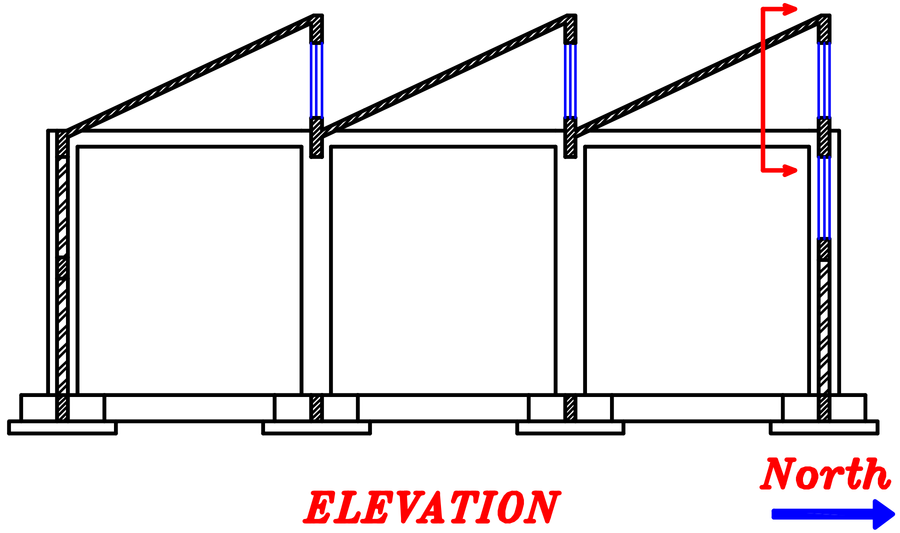
- لانه لا توجد مركبه أفقيه فلن نحتاج ل **HL. Beam** فتتكون ال **End Beam** من كمره رأسيه فقط.

End beam

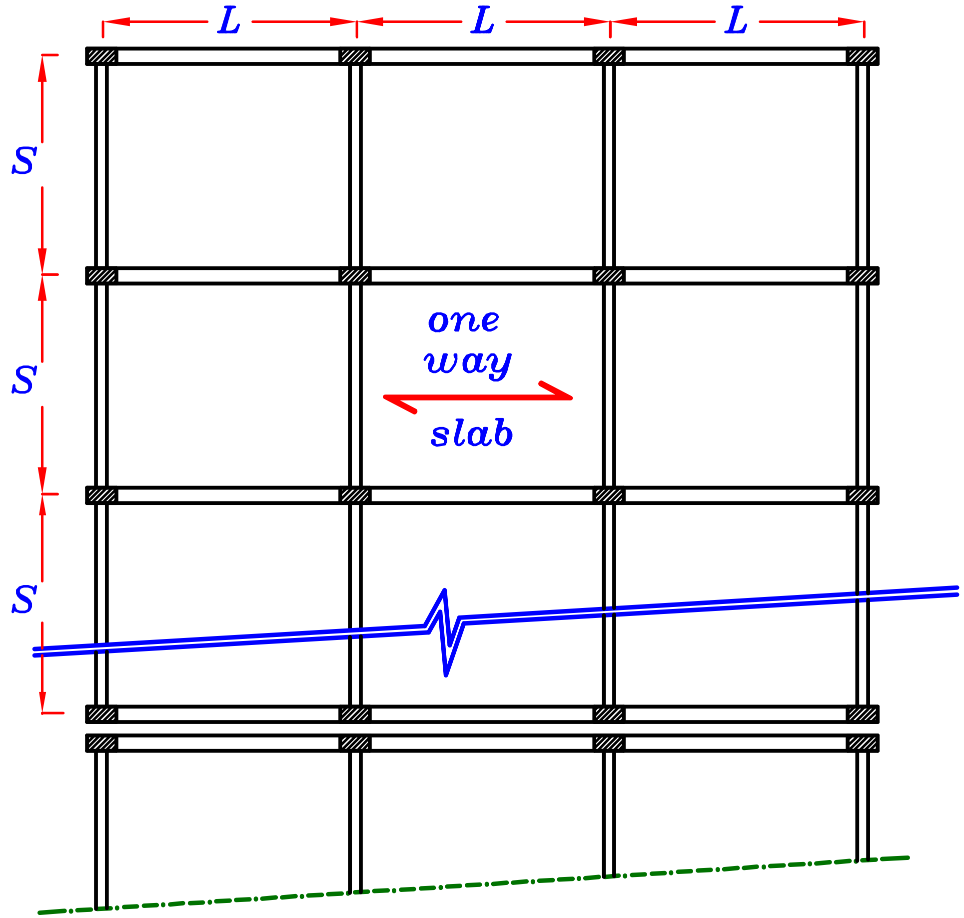

Posts
End Beam B_1
One Way Slab
S.S. or H.B.
One Way Slab
S.S. or H.B.
One Way Slab
S.S. or H.B.
كمره تربيط
Y-Beam
Ridge Beam
End Beam B_2
L
S
North



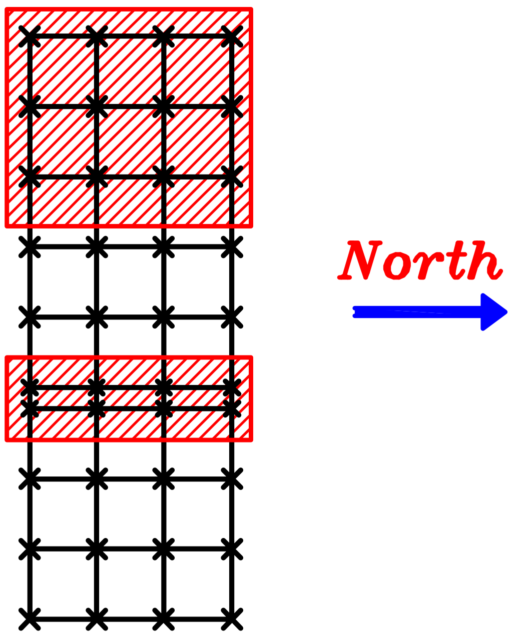
SIDE VIEW



ELEVATION



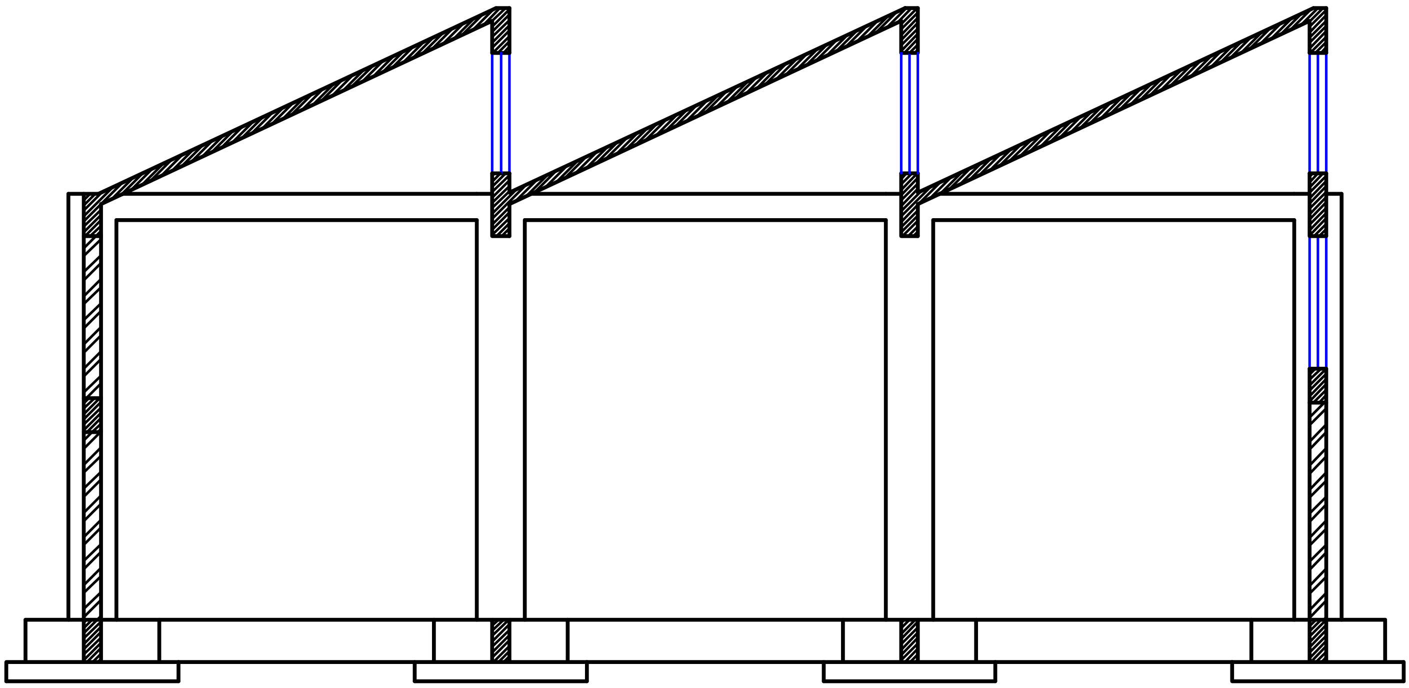
PLAN

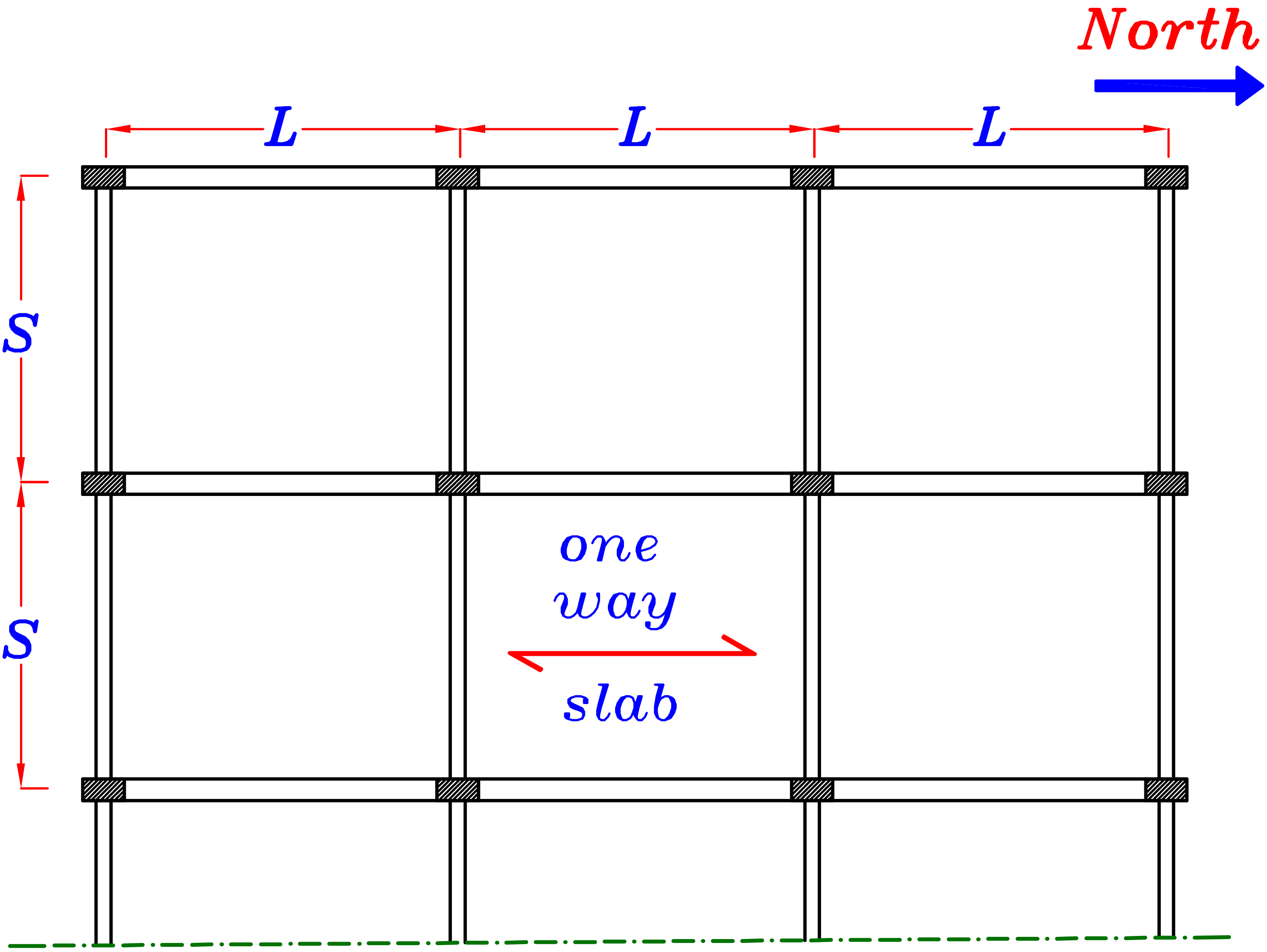


KEY PLAN

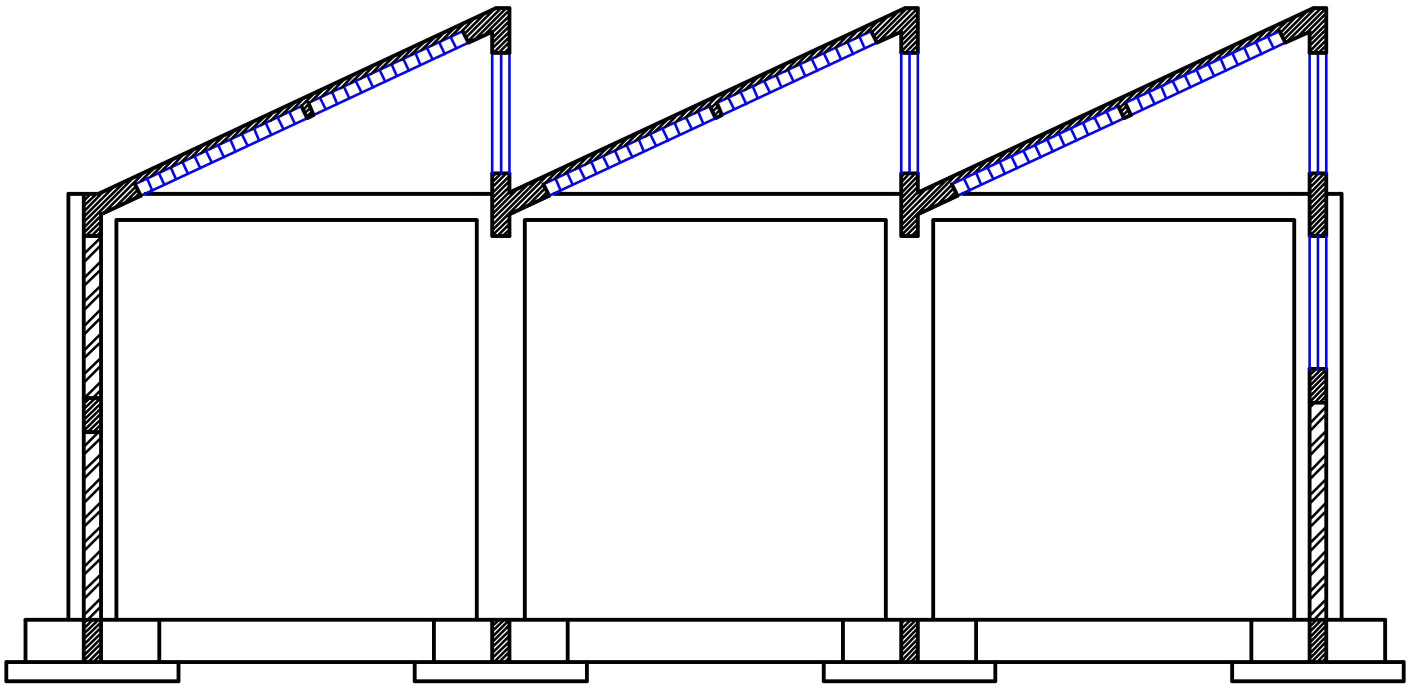
1:200 → 1:400

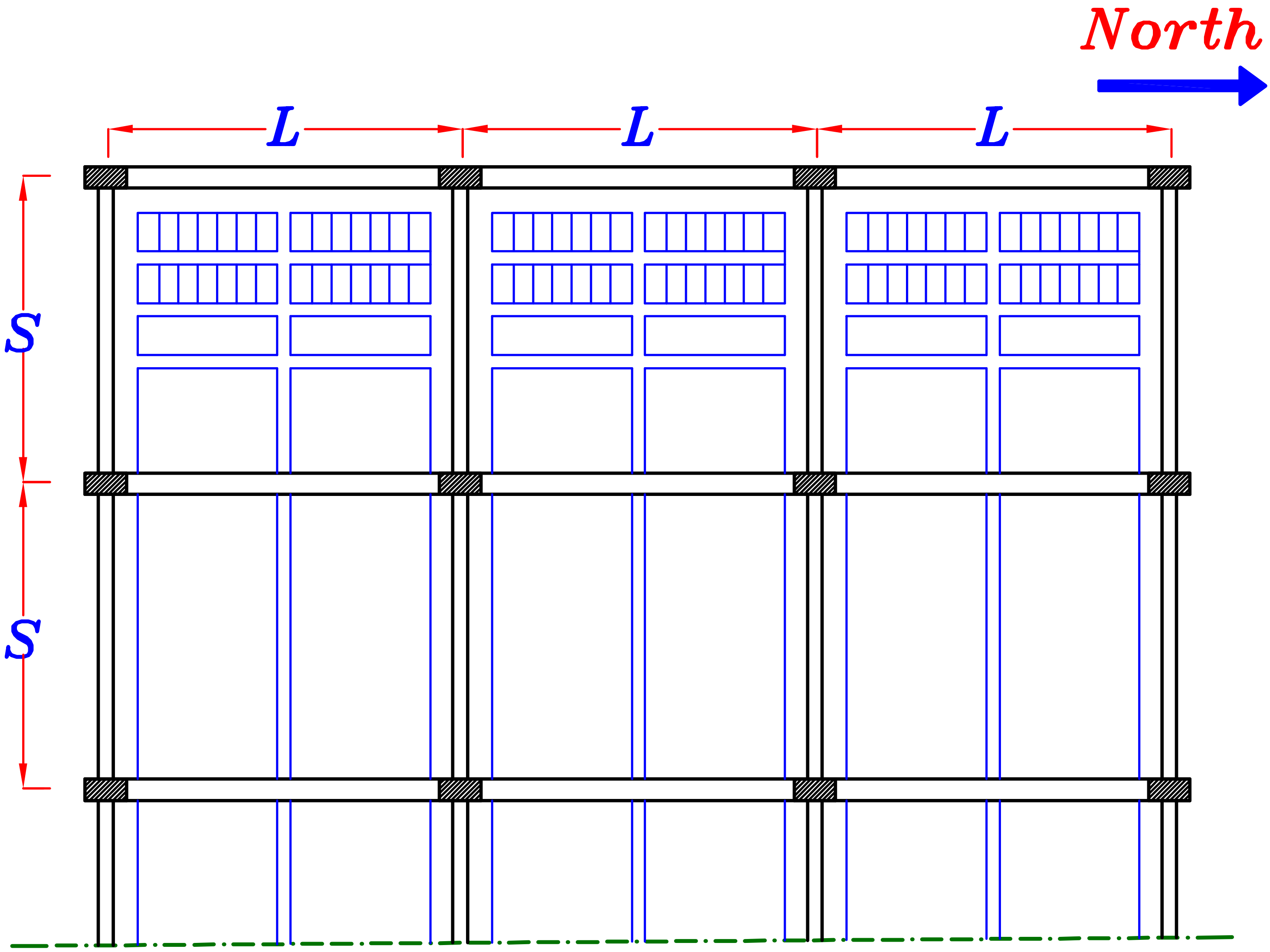
Saw Tooth Slab Type Solid Slab $L \leqslant 6.0\,m$



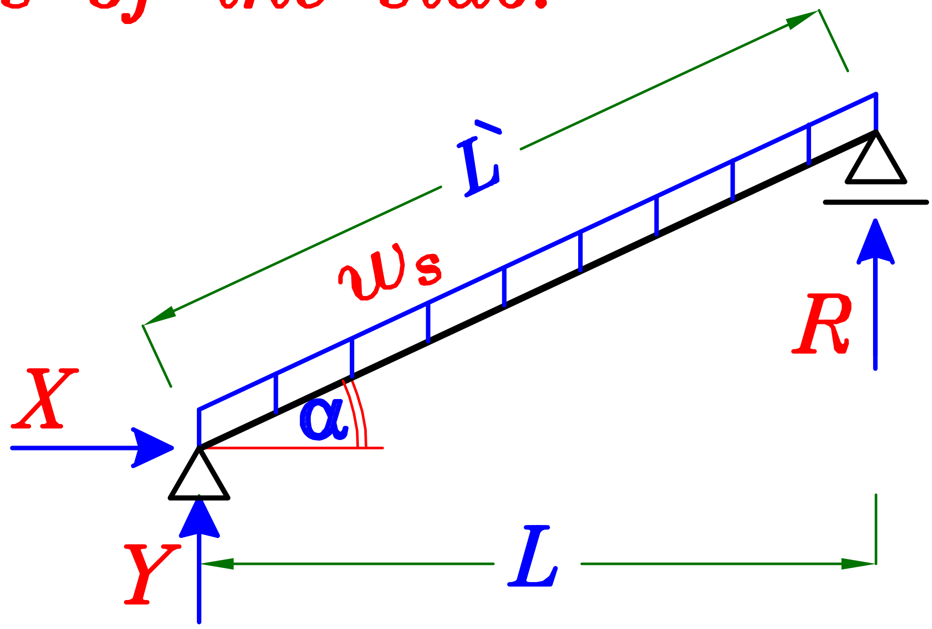


Saw Tooth Slab Type H.B. Slab $L > 6.0\,m$





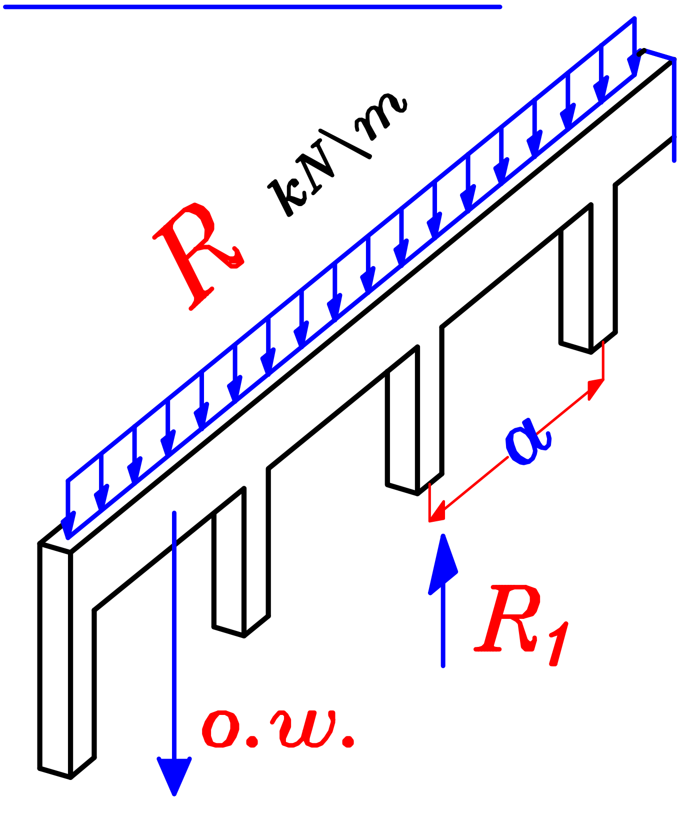
Reactions of the slab.



$$R = Y = \frac{w_s L^`}{2}$$

Ridge Beam.

لا يوجد تحليل للوزن



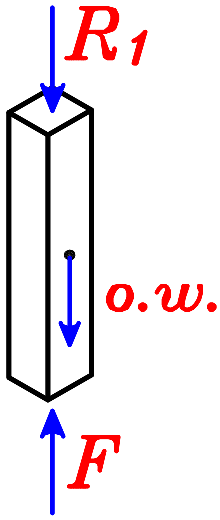
$$w = o.w + R$$

$$R_1 = w * a$$

Post.

- ينتقل الحمل من ال Ridge beam الى ال post

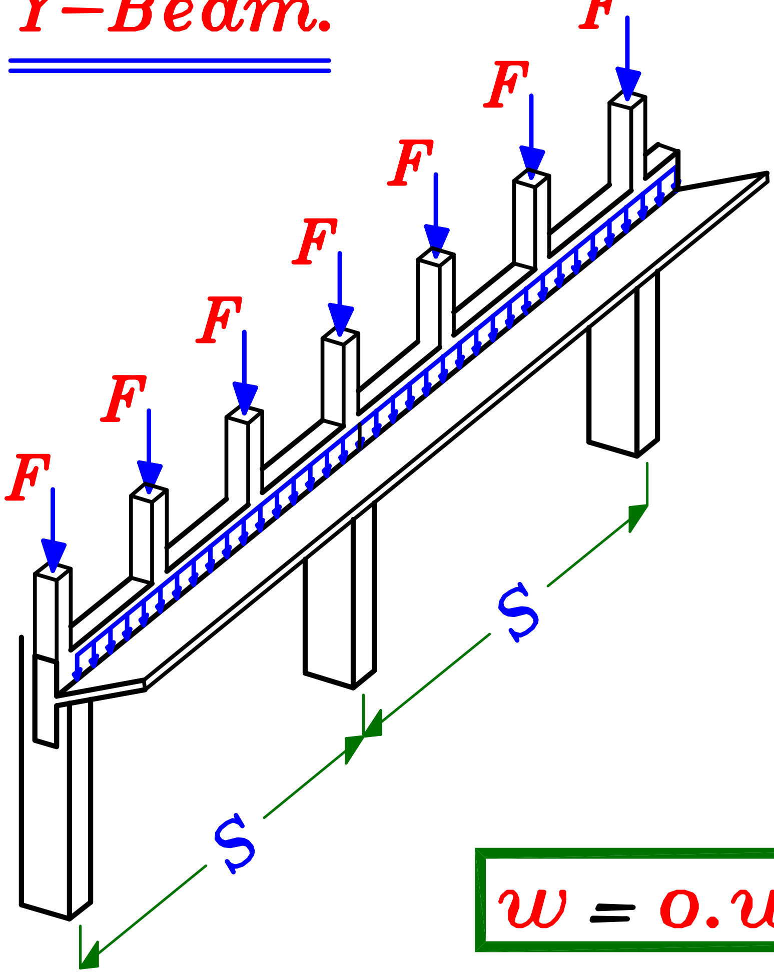
لا يوجد تحليل للوزن

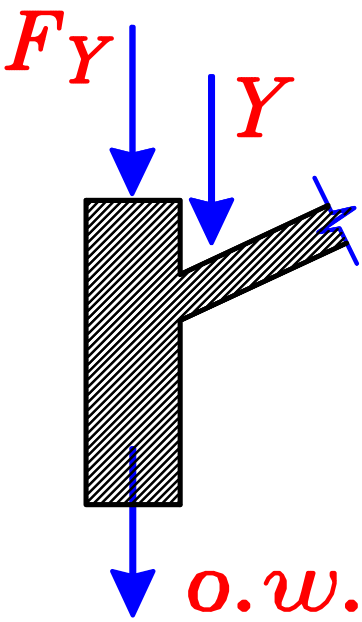


$$F = O.W._{(Post)} + R_1$$

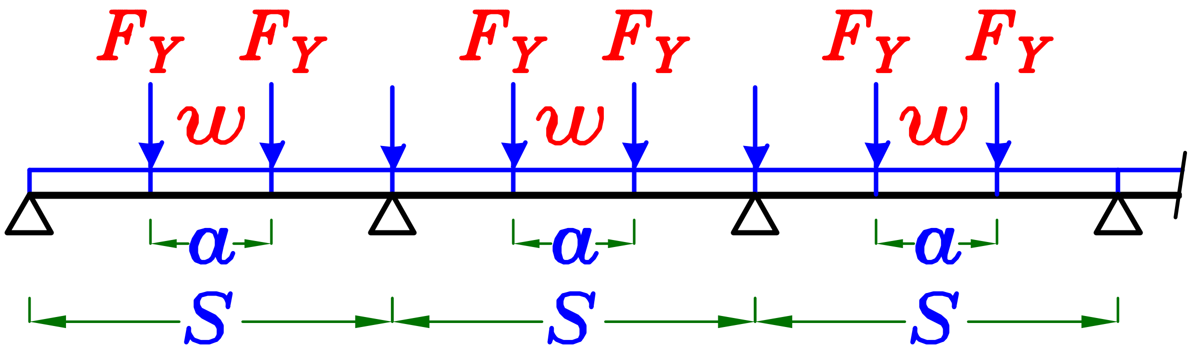
$$O.W._{(Post)} \simeq 3.50\ kN\ (U.L.)$$

Y–Beam.



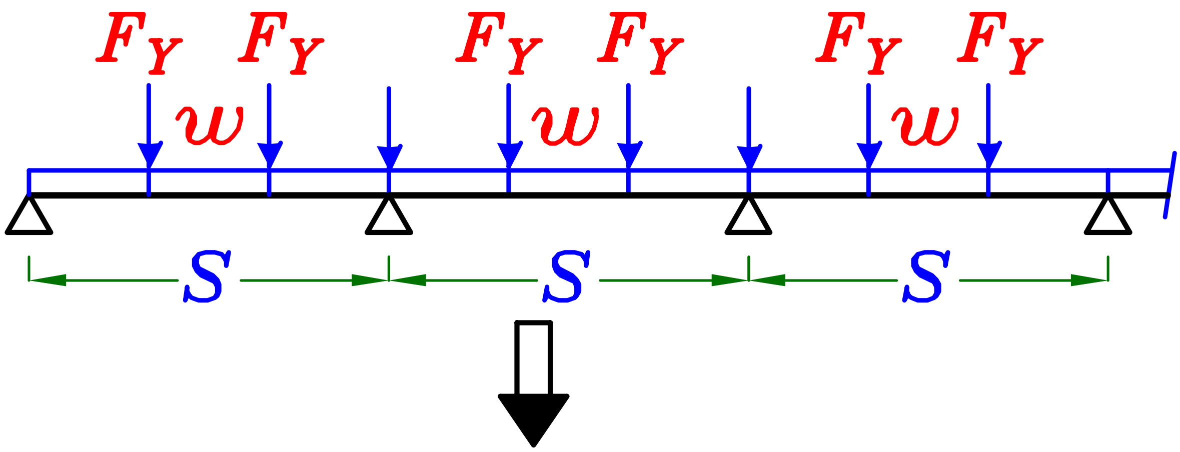


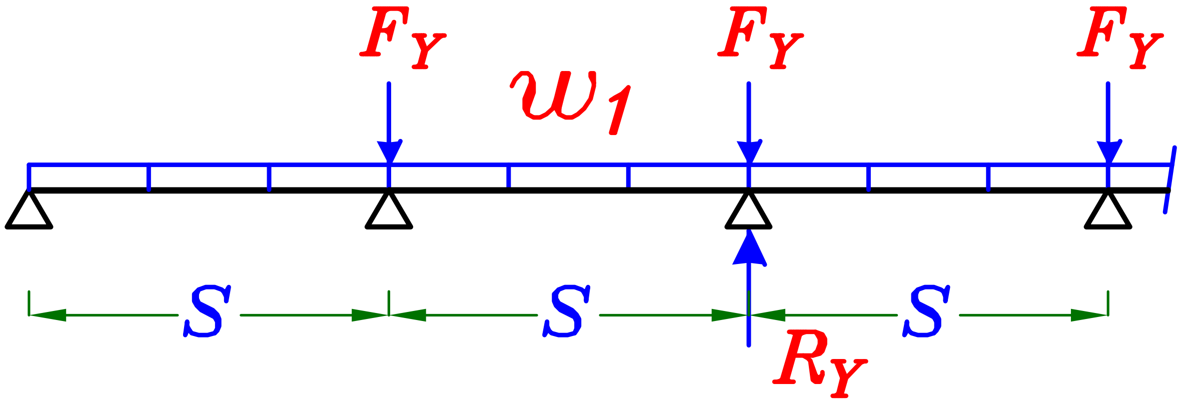
$$w = o.w. + Y$$



لحل الكمره الـ Y-beam

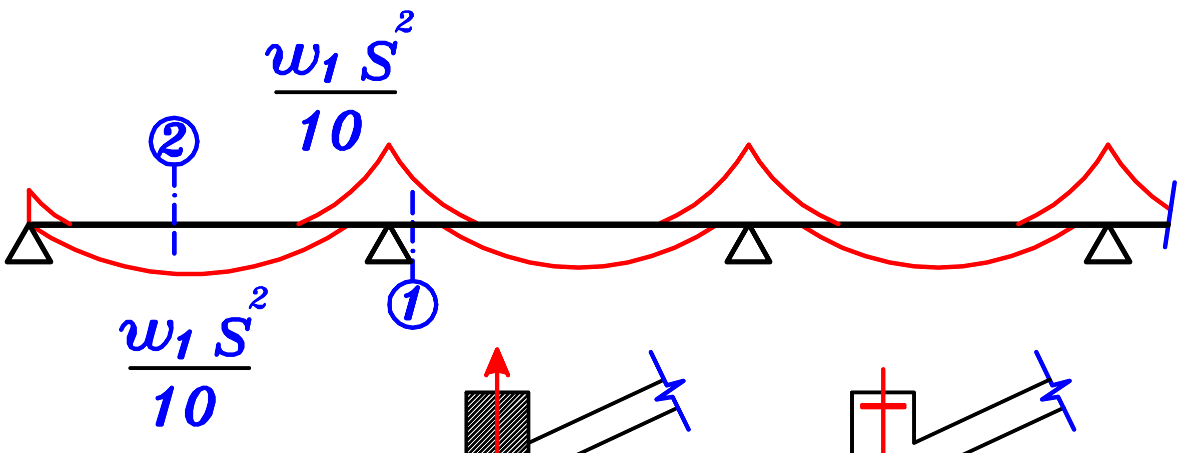
نعمل على تحويل الاحمال المركزه الى أحمال منتظمه .

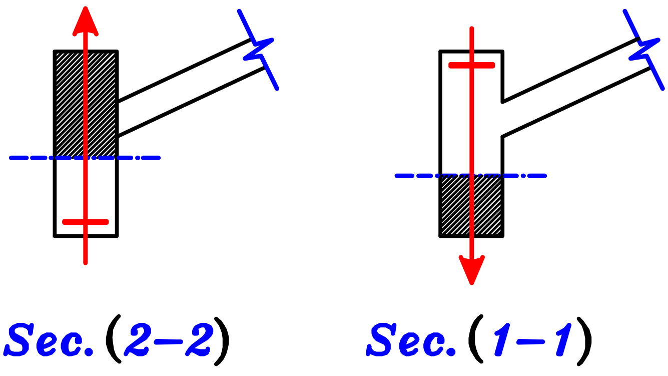




$$w_1 = w + \frac{\Sigma F_Y}{S}$$

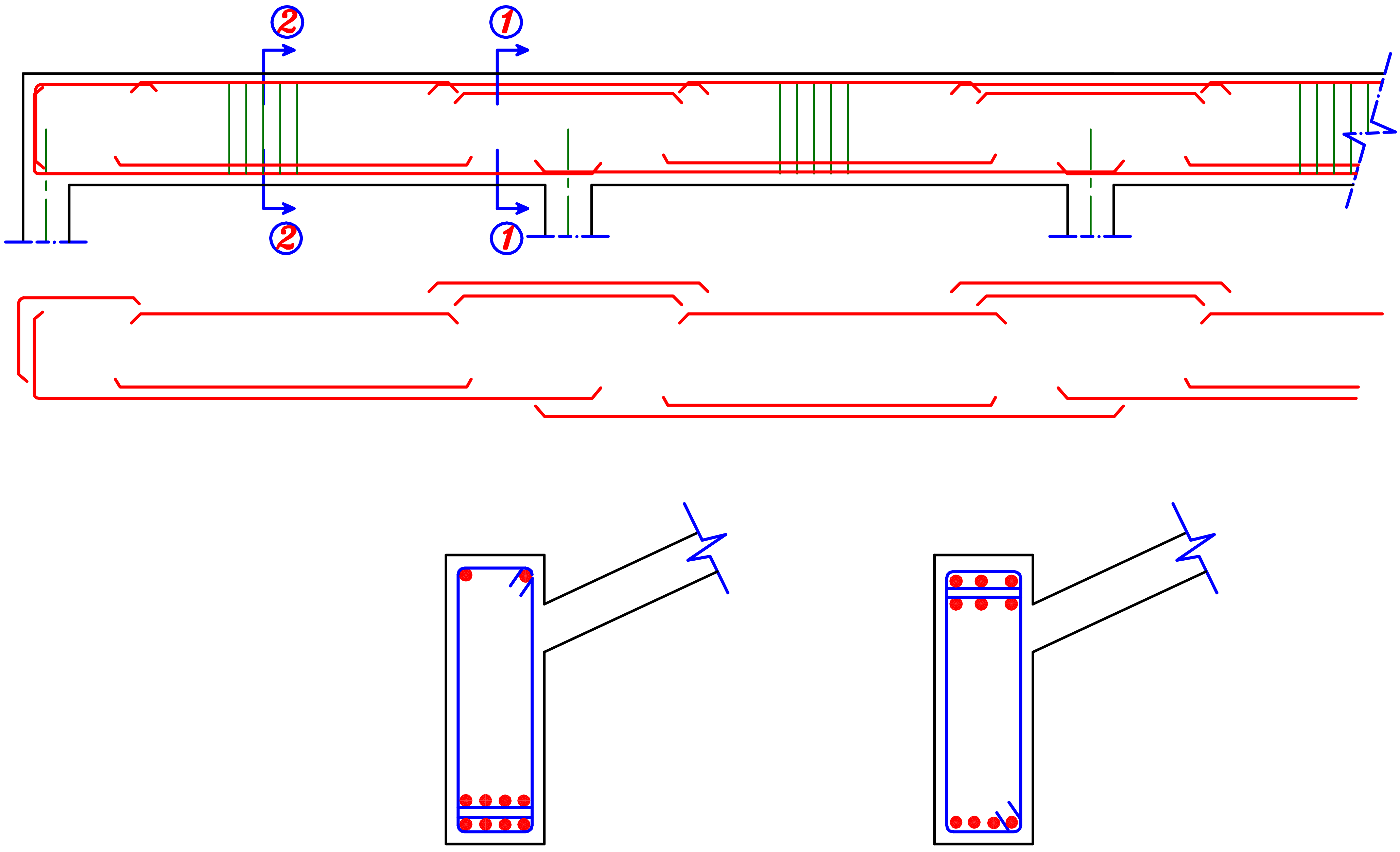
$$R_Y = w_1 * S + F_Y$$





Sec. (2−2) Sec. (1−1)

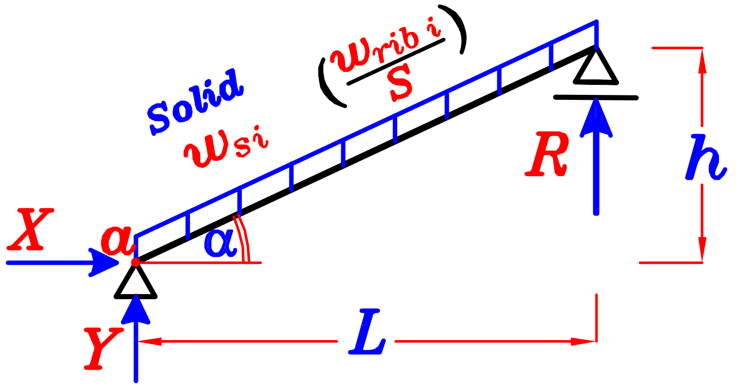
R−sec. R−sec.



Sec. (2–2)

Sec. (1–1)

خطوات تصميم Y-Beam الشباك رأسى



نأخذ شريحه فى البلاطه عرضها ١م -

و نحدد ال Y ، R Reactions

Ridge Beam

$$w = R + o.w$$

$$R_1 = w * a$$

Post

$$F = R_1 + o.w$$

$$F_Y = F$$

Y-Beam

$$w_1 = o.w + Y + \frac{\Sigma F_Y}{S}$$

$$R_Y = w_1 * S + F_Y$$

$o.w.$ (Ridge Beam) = 4.2 kN/m U.L.

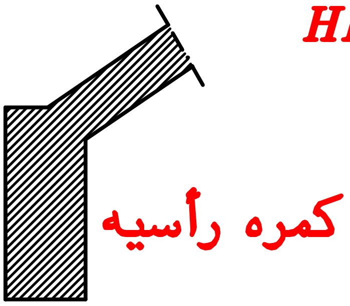
$o.w.$ (Post) = 3.5 kN U.L.

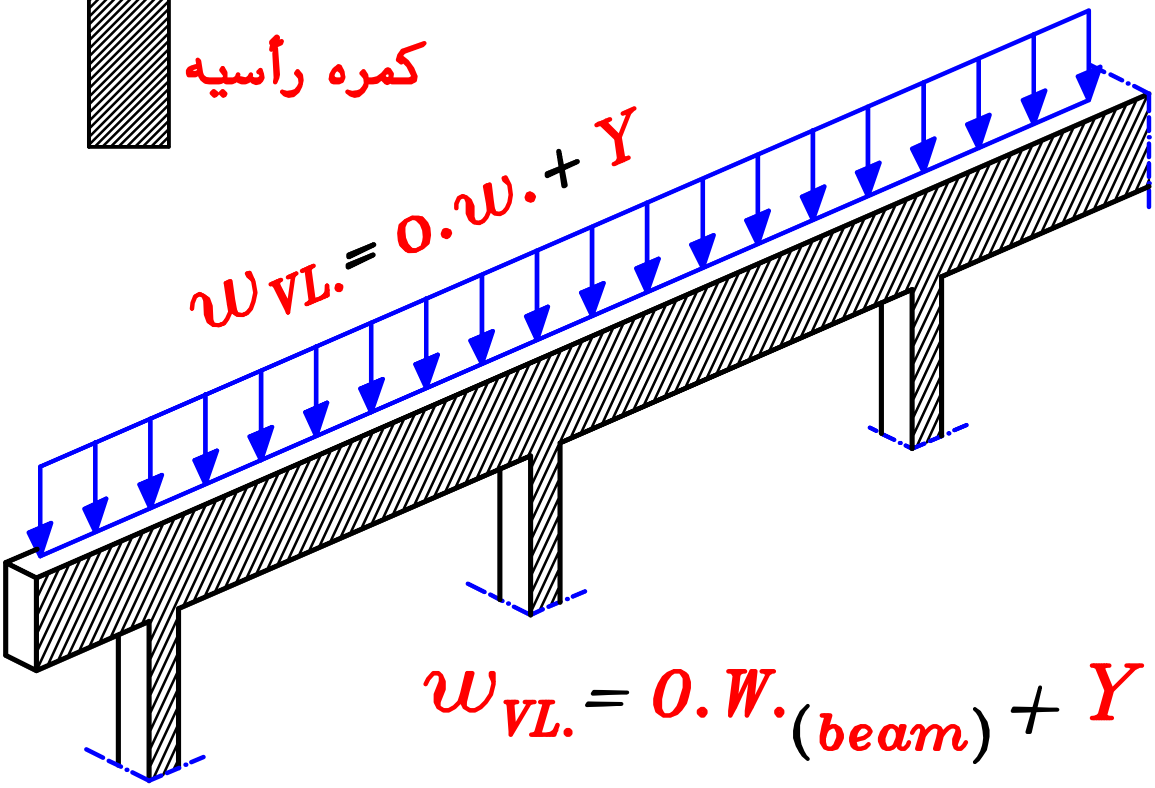
$o.w.$ (Y-Beam) = $b\, t\, \gamma_c * 1.4$ kN/m U.L.

$$t_{Y\text{-}beam} \simeq \frac{Spacing}{12} + 150\ mm$$

End Beam. B_1

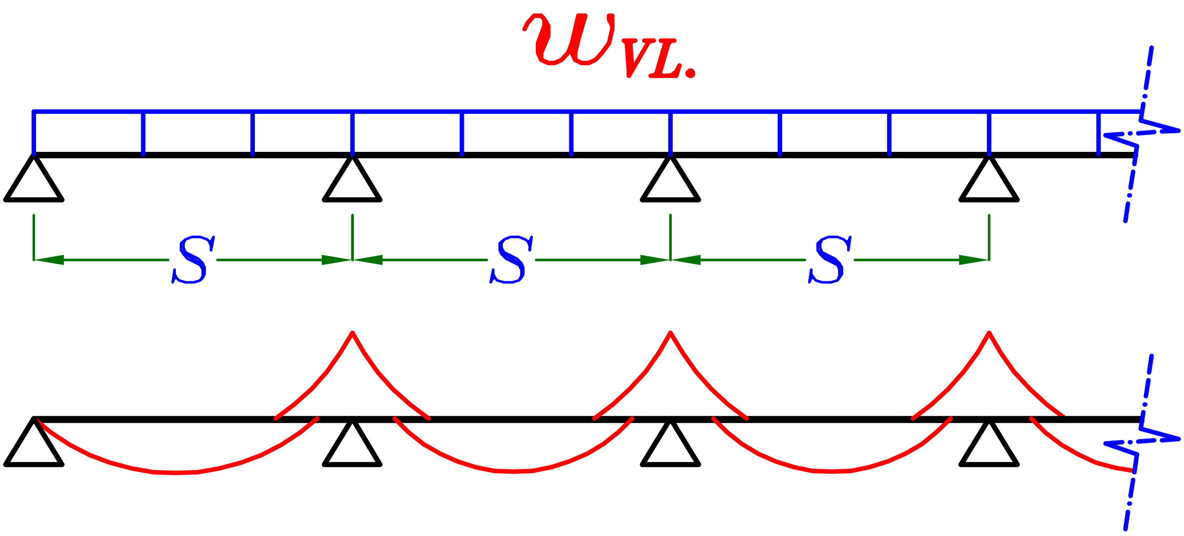
- لانه لا توجد مركبه أفقيه فلن نحتاج لـ **HL. Beam**
فتتكون الـ **End Beam** من كمره رأسيه فقط.

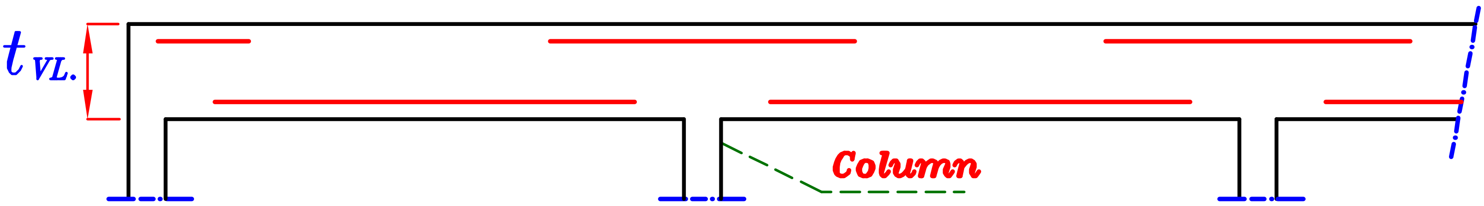


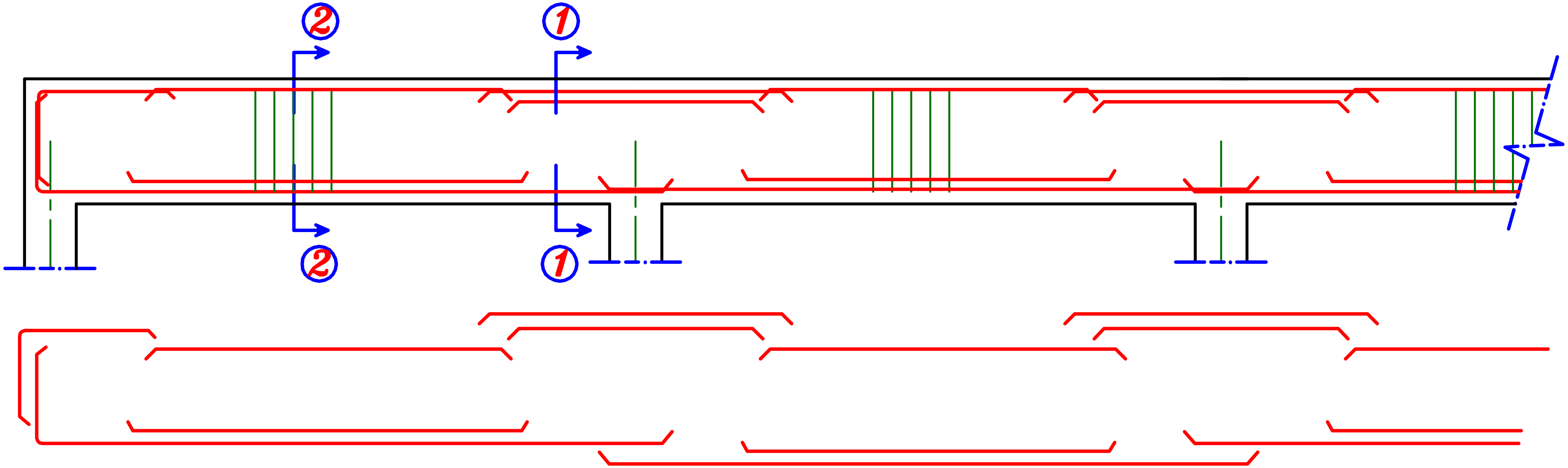


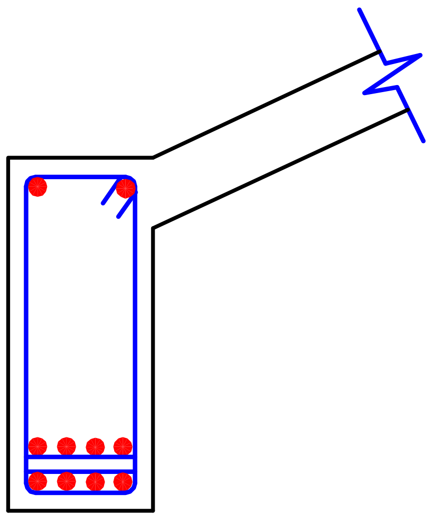
$$w_{VL.} = O.W._{(beam)} + Y \quad kN\backslash m`$$

$$O.W._{(VL.\ beam)} = 3.0 * 1.4 = 4.2 \quad kN/m$$

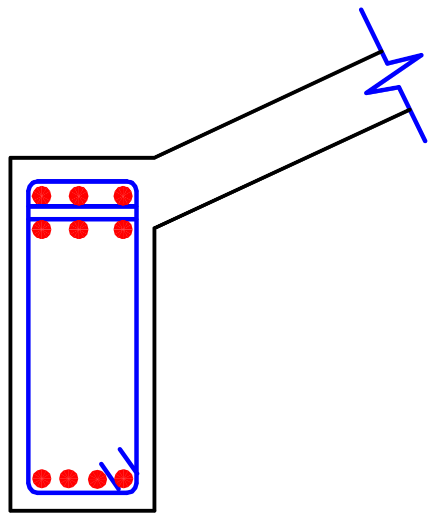




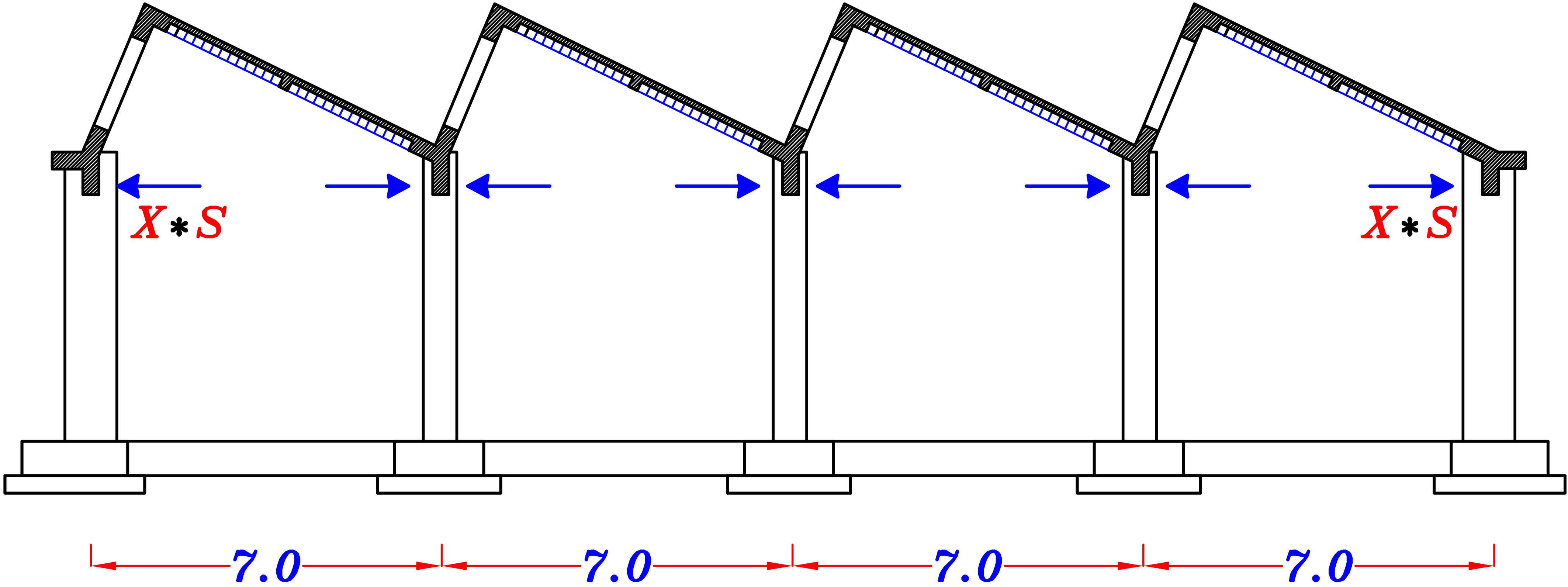




Sec. (2–2)



Sec. (1–1)

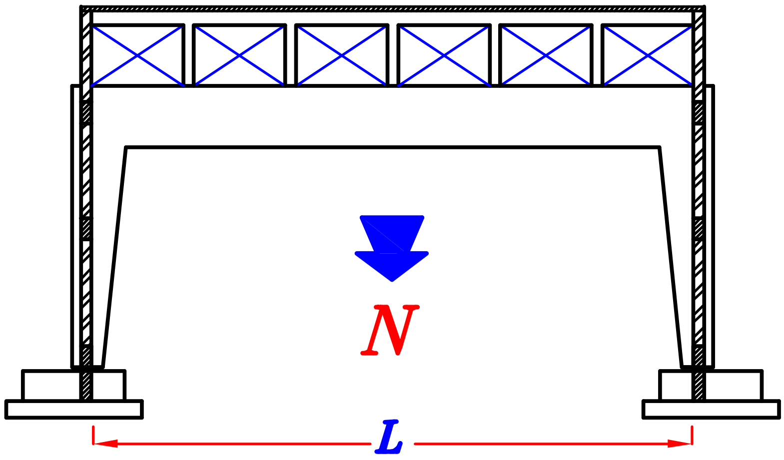


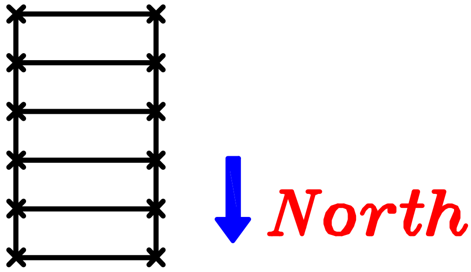
الاعمده فى الاطراف فقط عليها عزوم يتم ترحيل القواعد للخارج و يتم الزياده من تخانه العمود

الاعمده فى المنتصف لا يوجد عليها عزوم فلا يتم ترحيل قواعدها .

Saw Tooth Slab Type Rested on Frame.

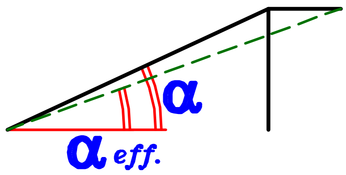
Frame الشباك موازى لل





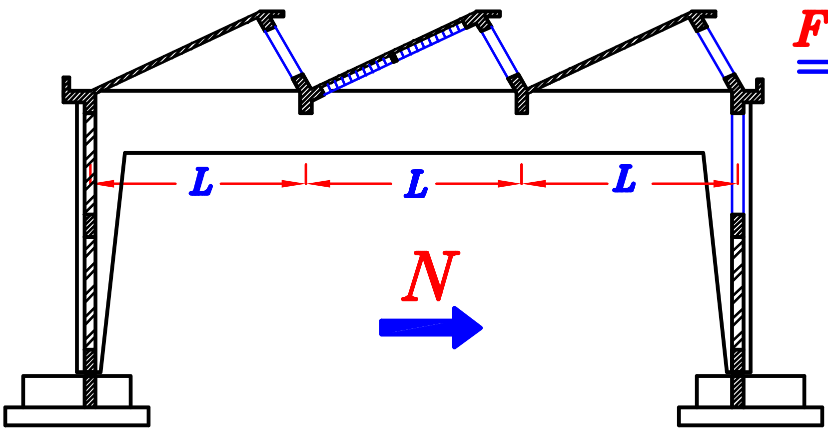
(β=0.0) يجب أن يكون الشباك رأسى

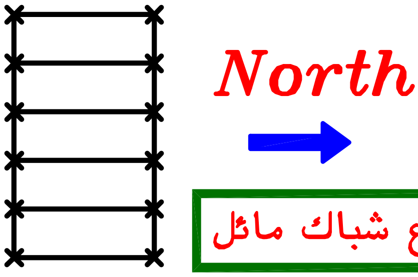
* Slabs. One Way S.S. → $L \leqslant 6.0$ m
  One Way H.B. → $L = (6.0 \rightarrow 8.0)$ m
* Inclination of slab. ($\alpha_{eff.}$) = ($20 \rightarrow 30^\circ$) مع الأفقى



* Posts (250 x 250)
  Distance between Posts (a) = ($2 \rightarrow 3$) m

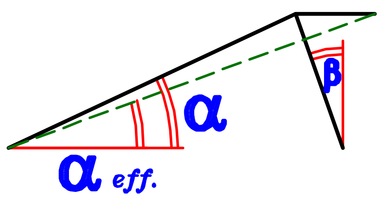
Frame الشباك عمودى على ال





ممكن وضع شباك مائل

* (L) = ($4 \rightarrow 8$) m
* Slabs. One Way S.S. → $L \leqslant 6.0$ m
  One Way H.B. → $L = (6.0 \rightarrow 8.0)$ m
* Inclination of slab. ($\alpha_{eff.}$) = ($20 \rightarrow 30^\circ$) مع الأفقى
* Inclination of Post. (β) = ($0 \rightarrow 15^\circ$) مع الرأسى



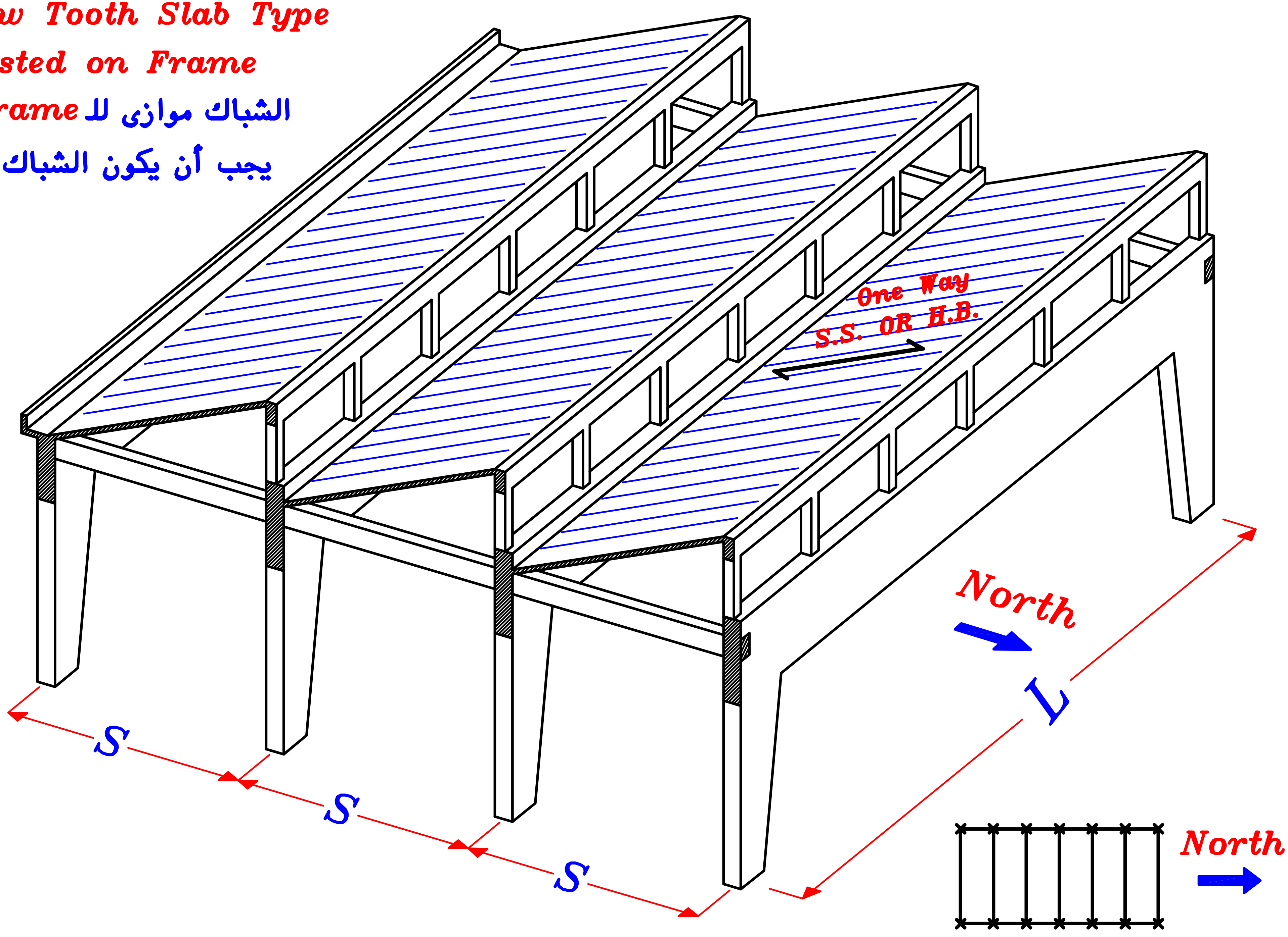
* Posts (250 x 250)
  Distance between Posts (a) = ($2 \rightarrow 3$) m

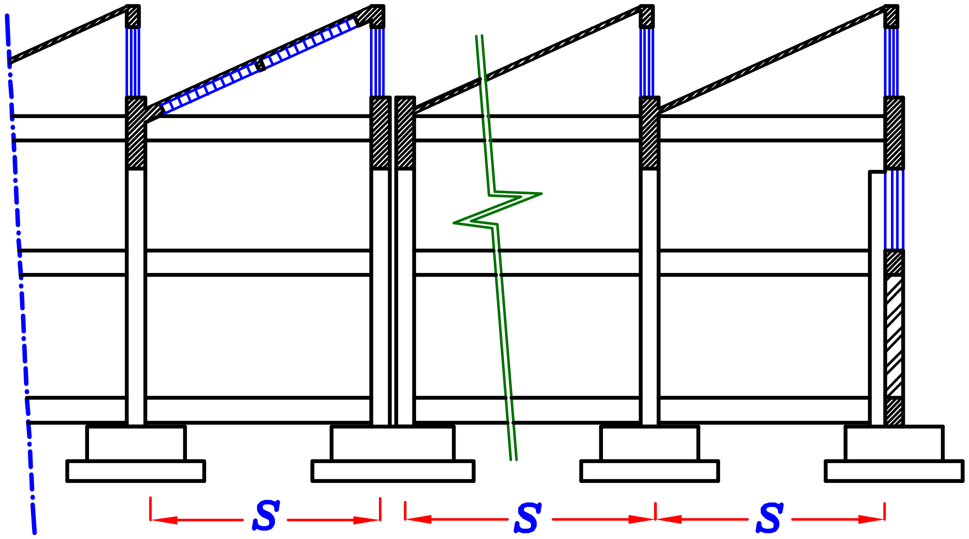
Saw Tooth Slab Type

Rested on Frame

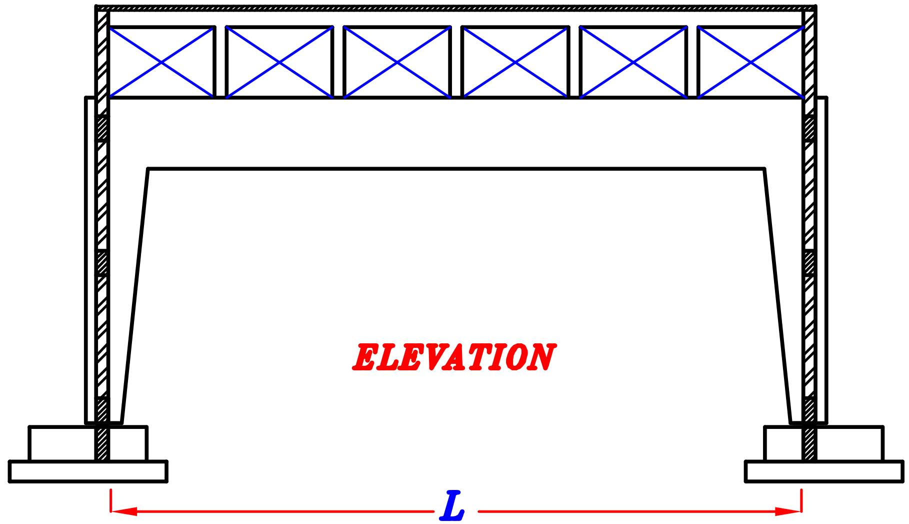
الشباك موازى للـ Frame

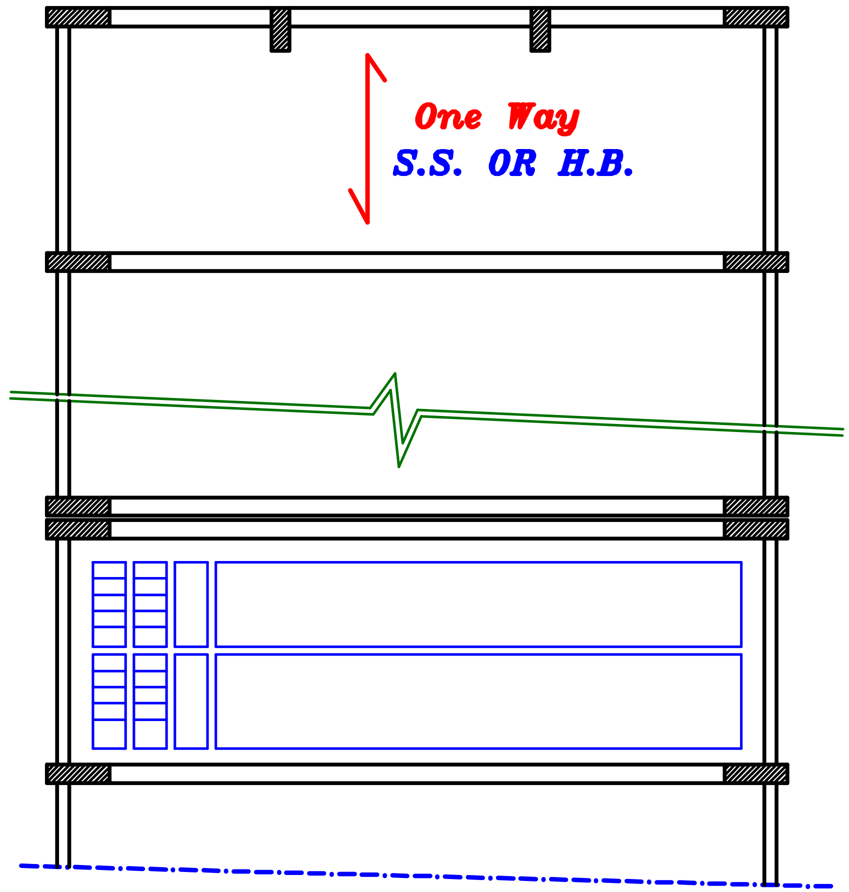
يجب أن يكون الشباك رأسى



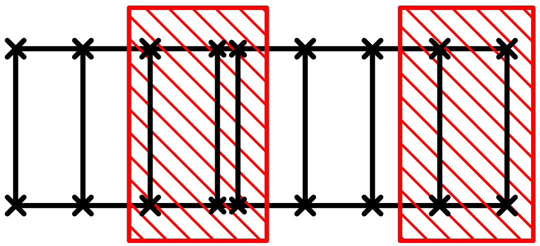


Side View



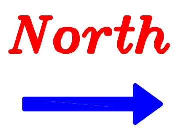


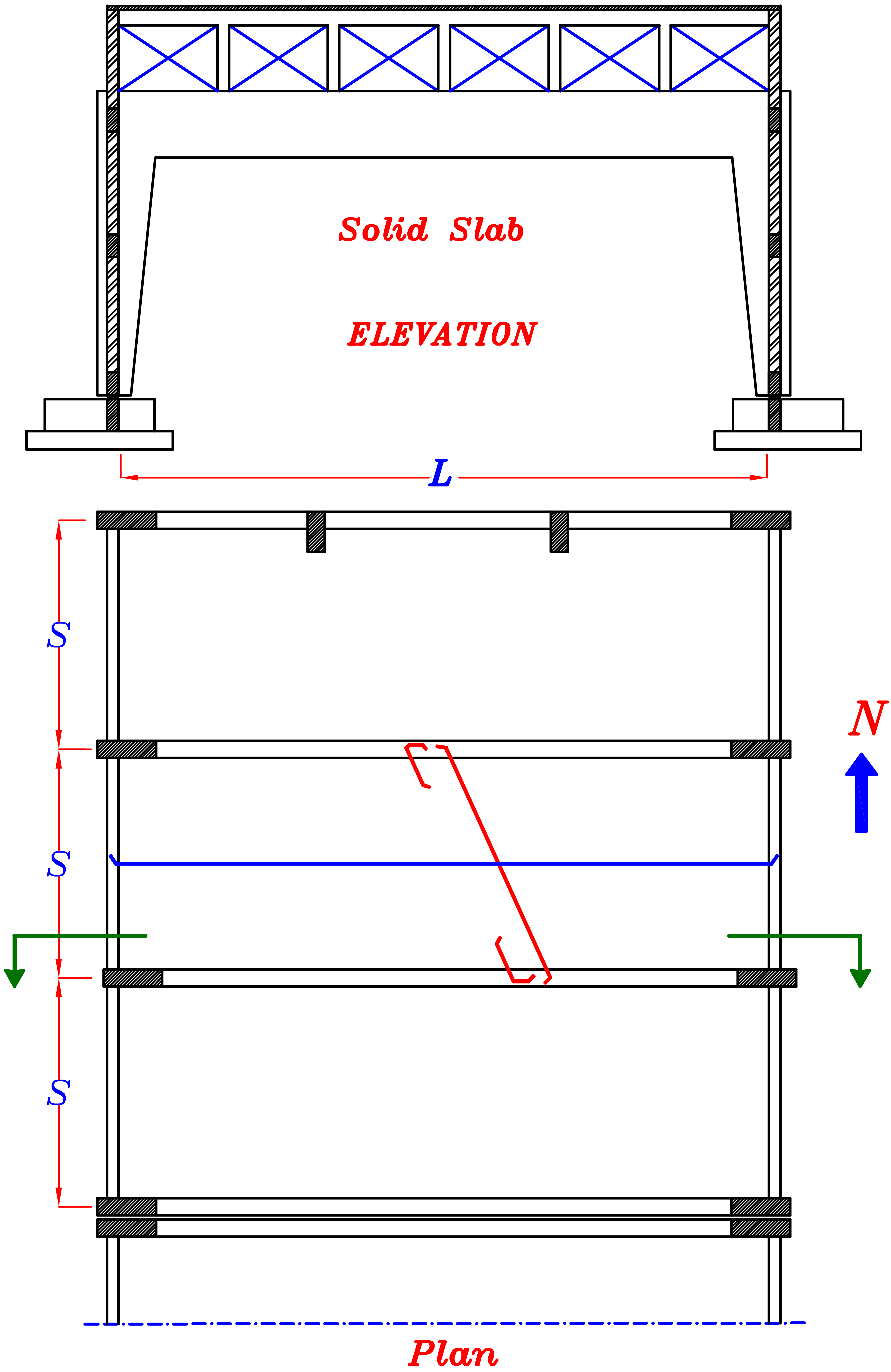
Plan



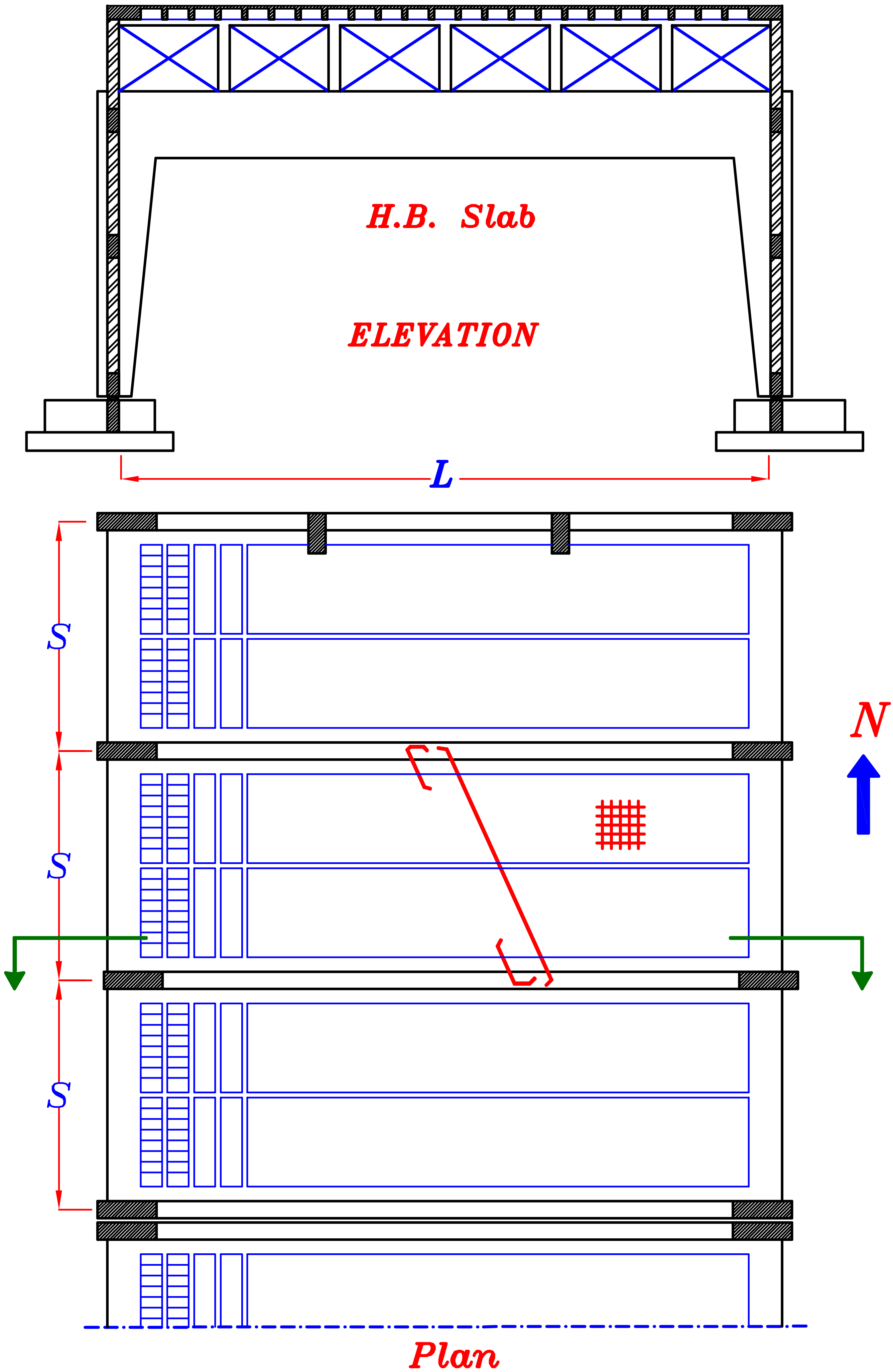
KEY PLAN

1:200 → 1:400





Solid Slab
ELEVATION
L
S
S
S
N
Plan

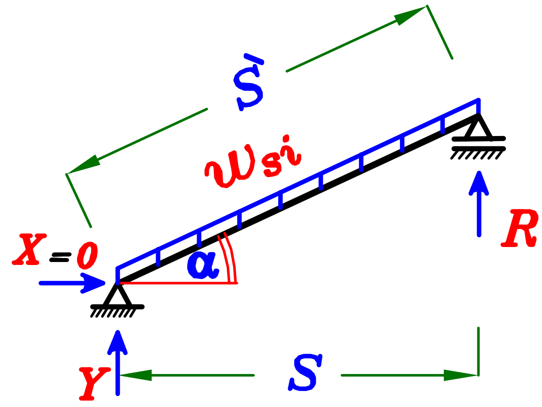

H.B. Slab
ELEVATION
L
S
S
S
N
Plan

Statical System.

* Loads From Slab.

$$w_s = 1.4\,(t_s\,\gamma_c + F.C.) + 1.6\ L.L.\ \cos\alpha$$

$$Y = R = \frac{w_s * S'}{2}$$

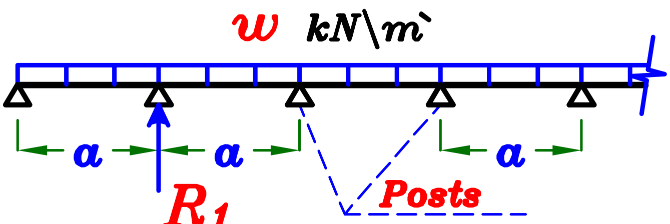


* Loads on Ridge Beam.

$$w = O.W._{(beam)} + R \qquad kN\backslash m'$$

$\alpha = (2 \longrightarrow 3)\ m$ *Distance Between Posts*

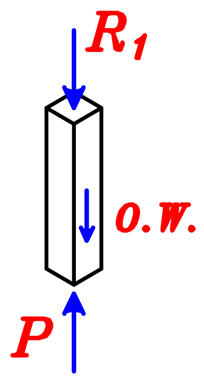
$$R_1 = w * \alpha$$



* Loads on The Post.

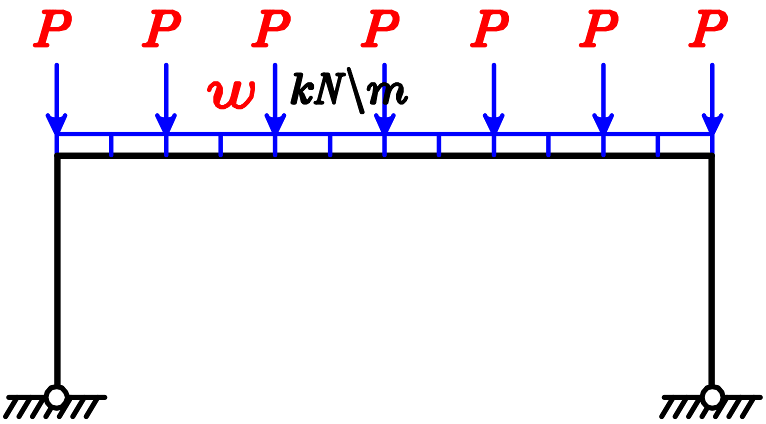
$$P = O.W._{(Post)} + R_1$$

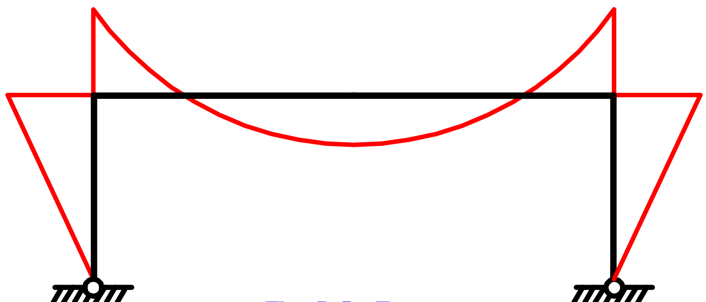
$O.W._{(Post)} \simeq 3.50\ kN$ (*U.L.*)



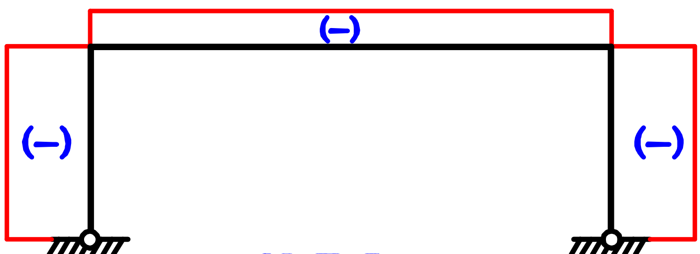
* Loads on The Frame.

$$W = O.W._{(Frame)} + Y \quad (kN\backslash m)$$



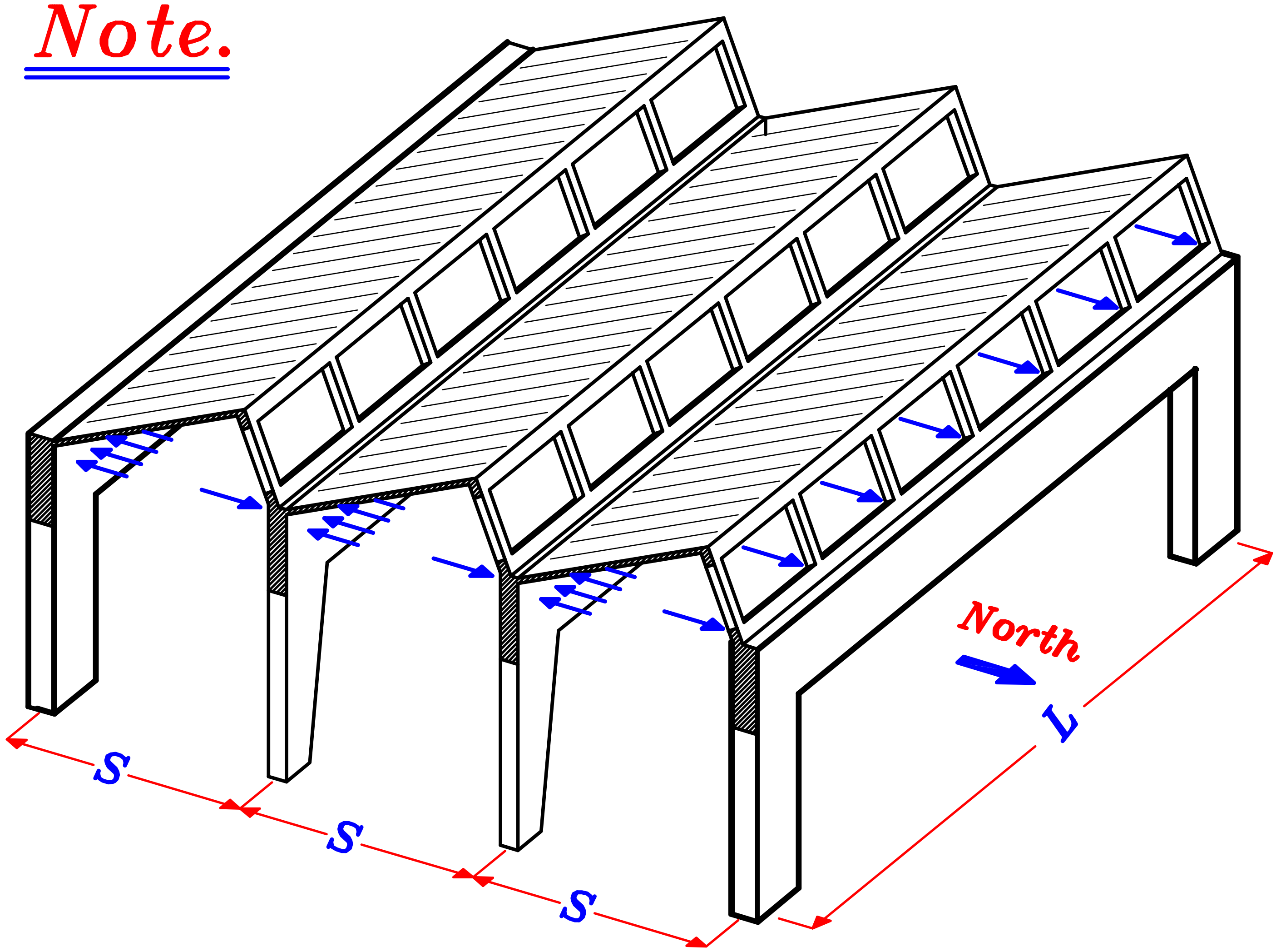


B.M.D.



N.F.D.

Note.



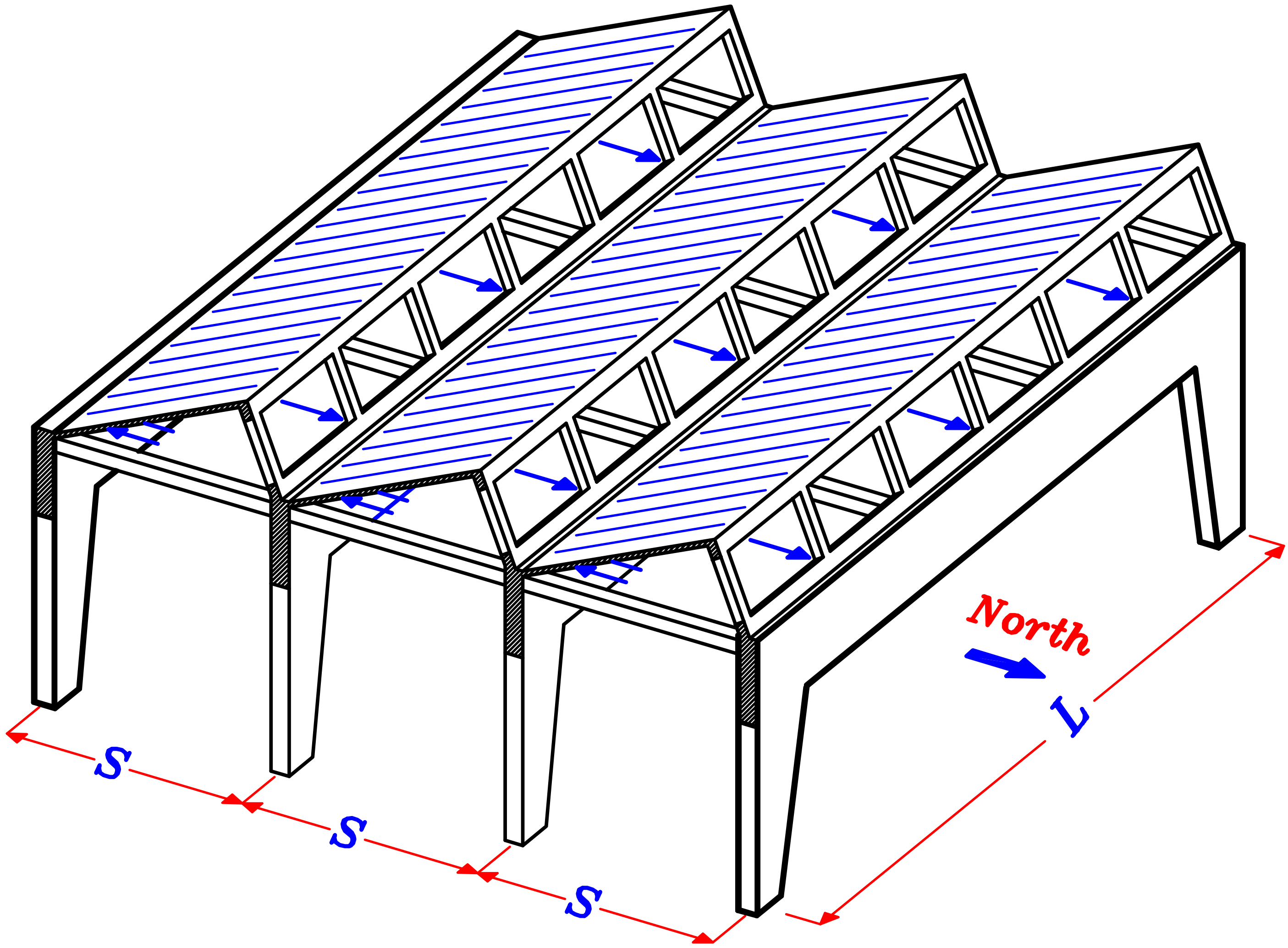
عندما يكون شباك الـ Saw Tooth فى نفس اتجاه الـ Frame لكن مائل تكون هناك قوى أفقيه فى الاتجاه العمودى على الـ Frames

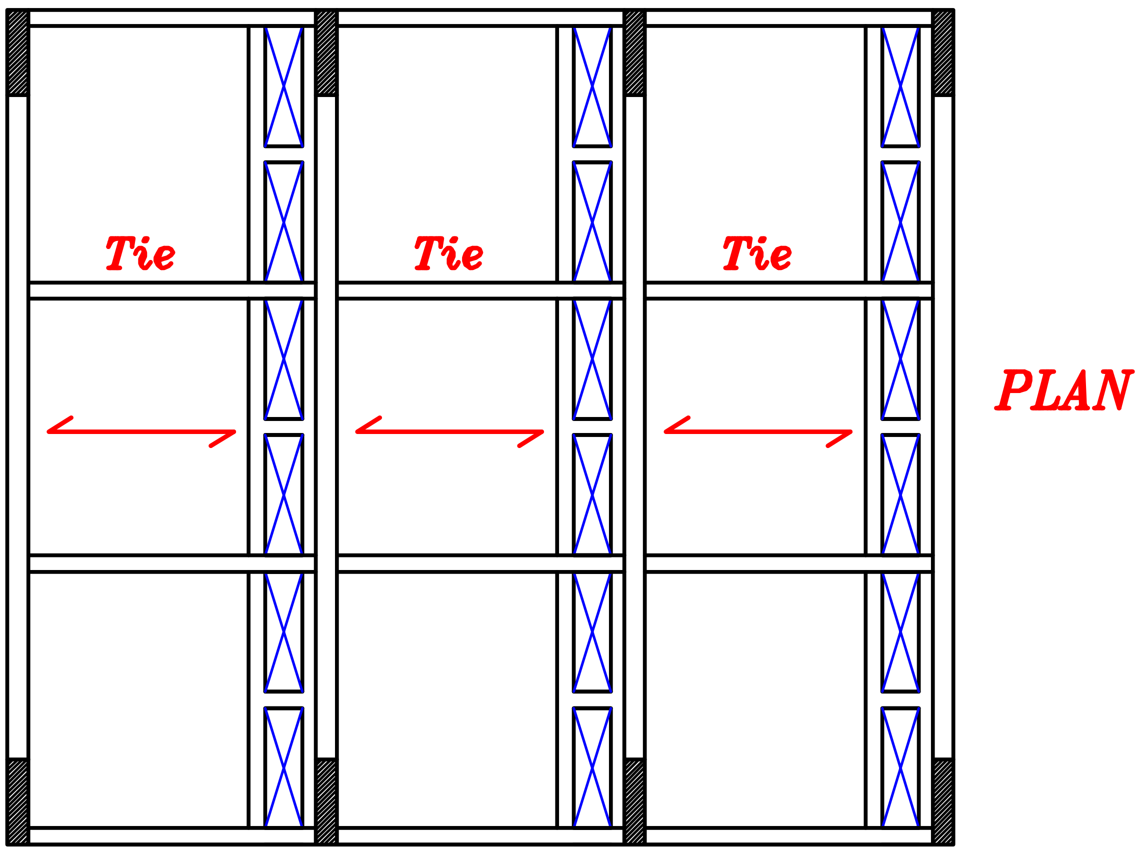
و لكن تأثيرها على الـ Frames المتكرره يكون بسيط لوجود قوى افقيه عكسها مثل الـ (Y-Beam)

لكن أول و أخر Frame سيؤثر عليه قوه أفقيه من جهه واحده .

و لمقاومه القوى الافقيه على أول و أخر Frame يتم عمل حل من الحلين التاليين

١- يتم وضع Tie كل عدد من الشبابيك لتقليل العزم الافقى على أول و أخر Frame

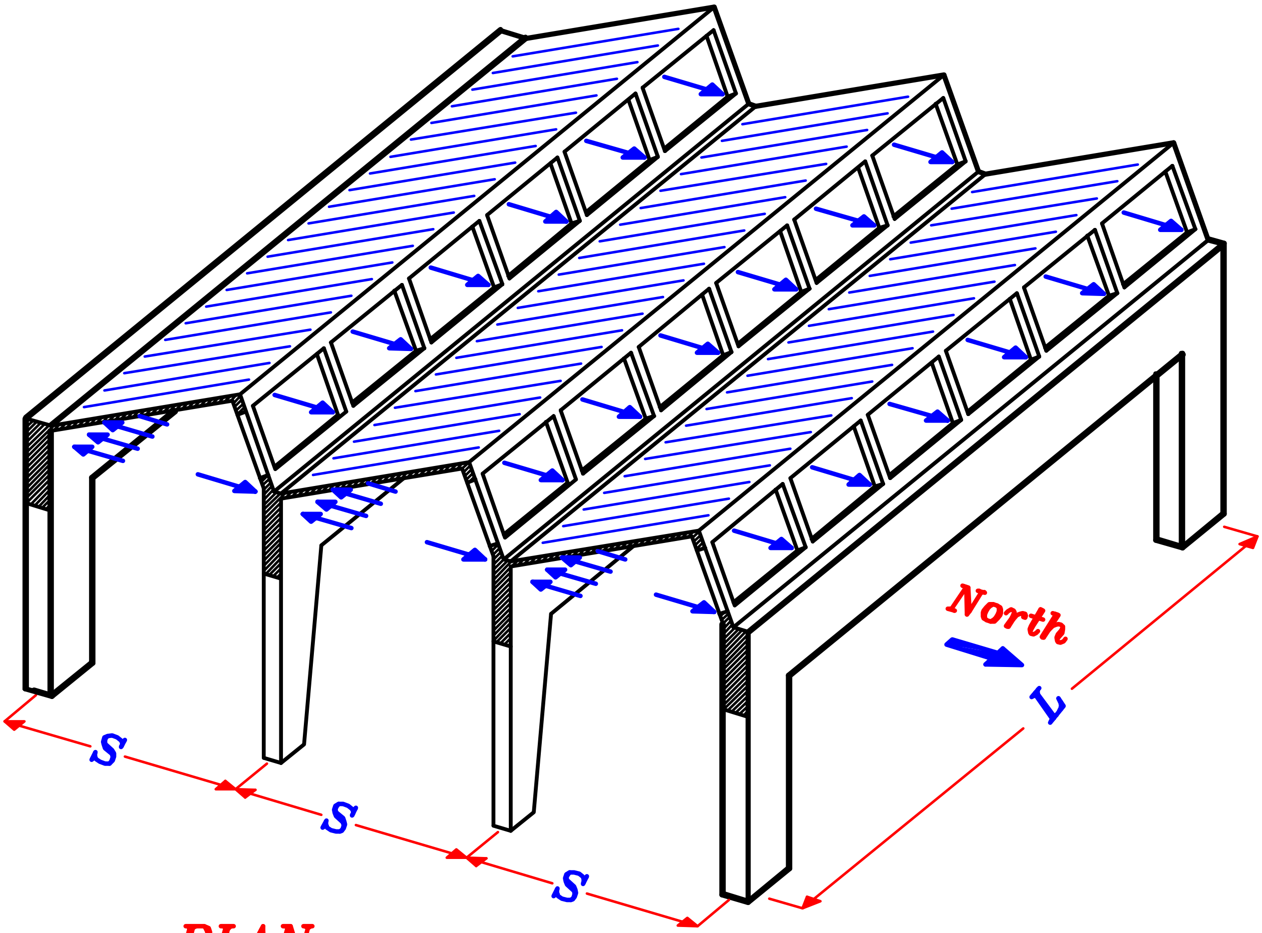


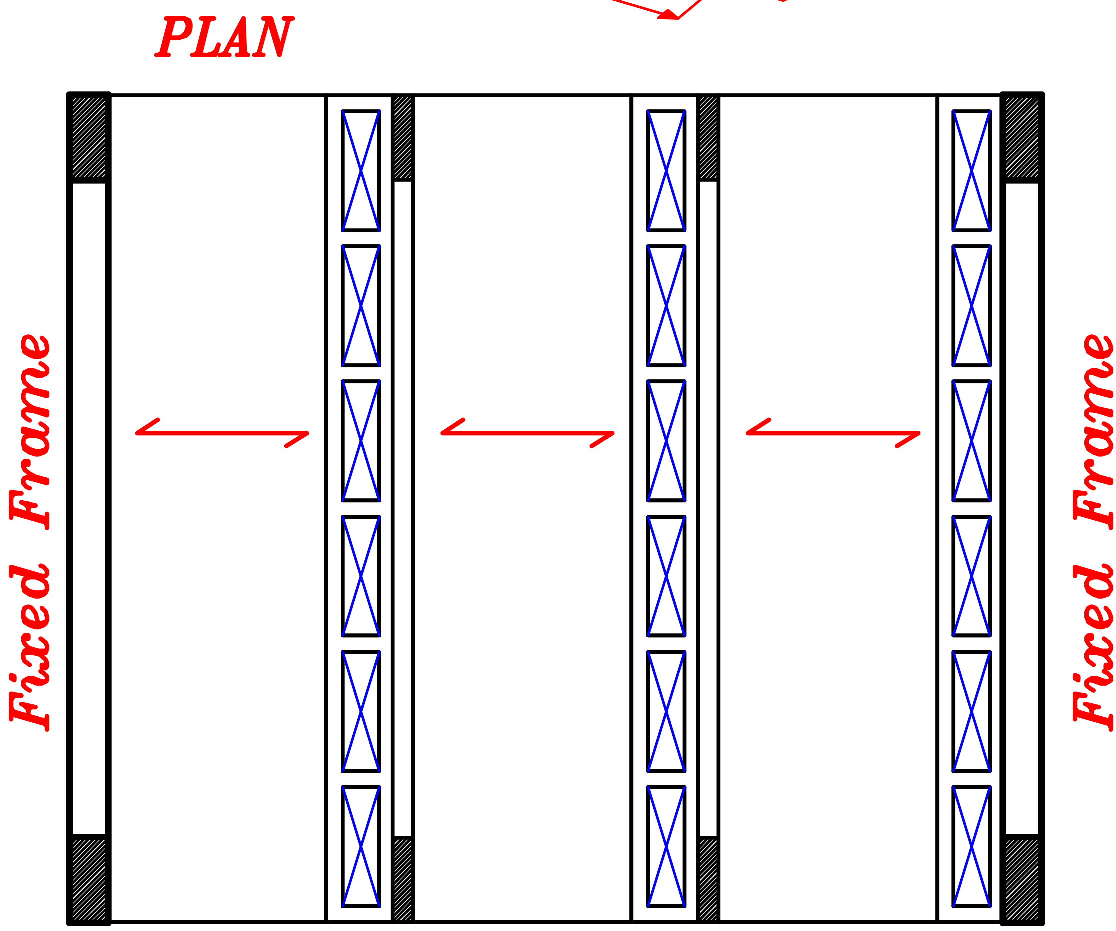


٢ـ يتم تحويل أول و أخر **Frame** الى **Fixed Frame**

و يجب تكبير العرض b $b=500\ mm$

و عند تصميم هذا ال **Frame** يتم تصميمه على عزم رأسى و أفقى معا **Bi-Axial moment**



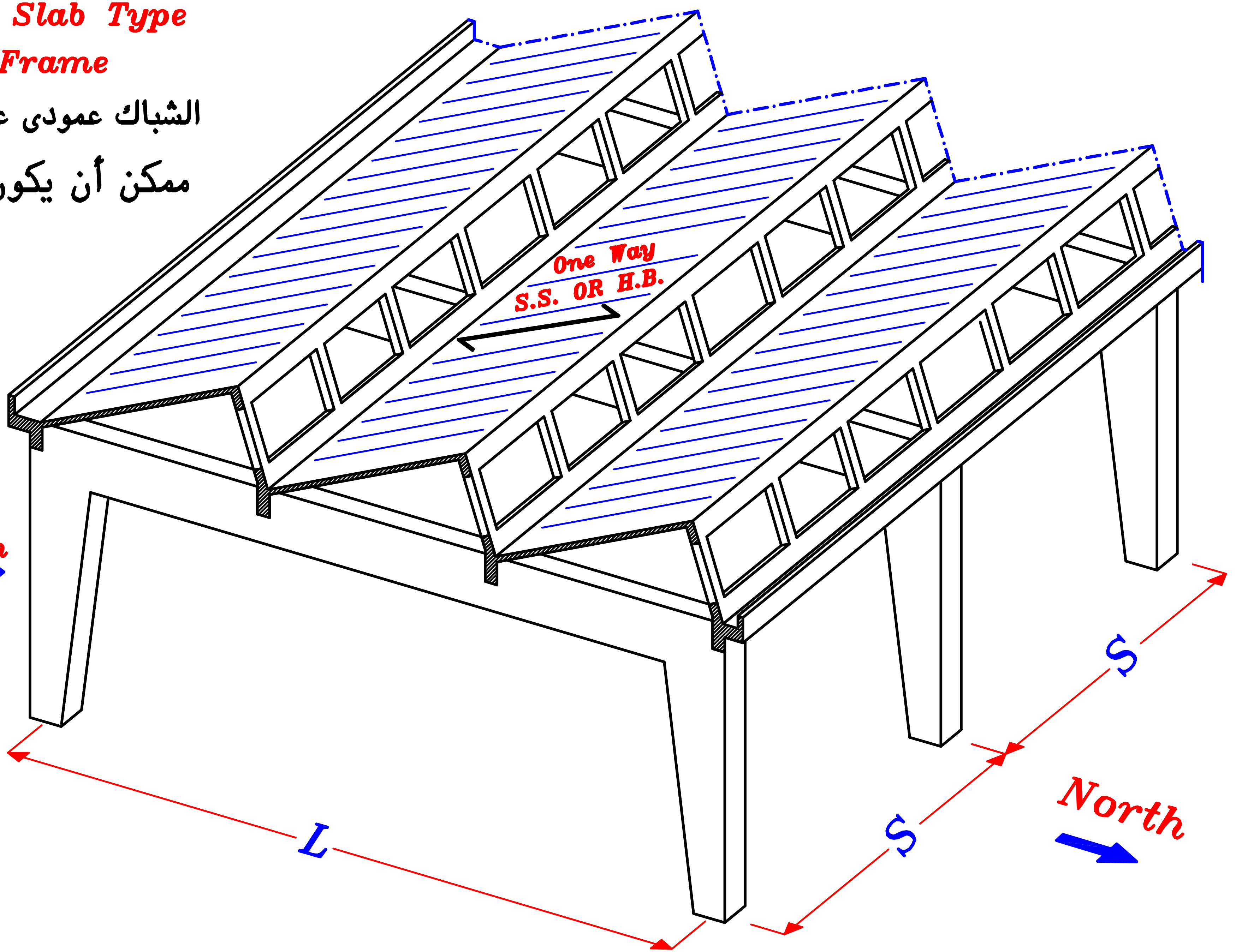


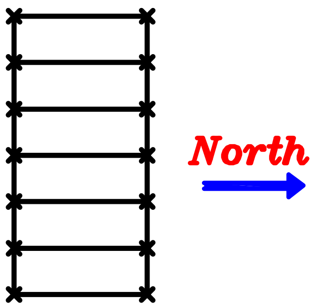
Saw Tooth Slab Type

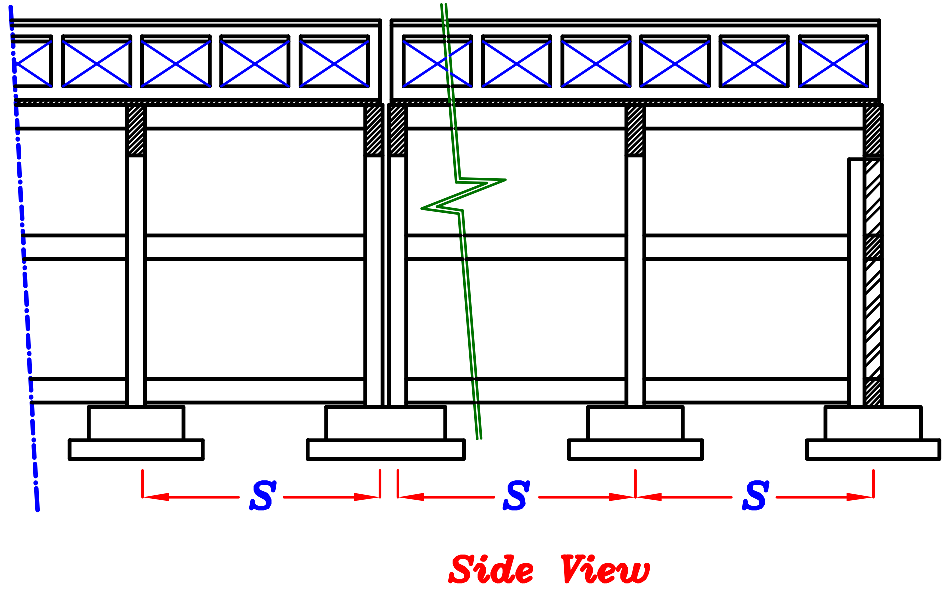
Rested on Frame

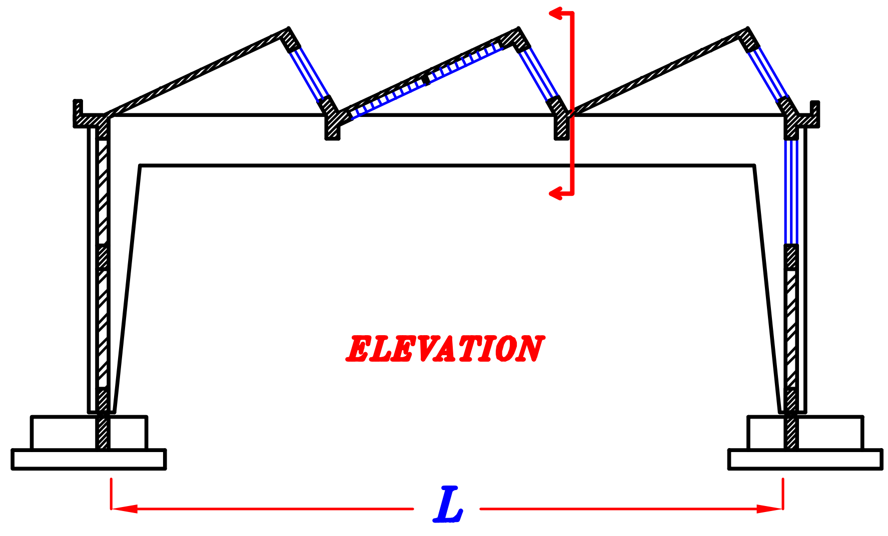
Frame الشباك عمودى على ال

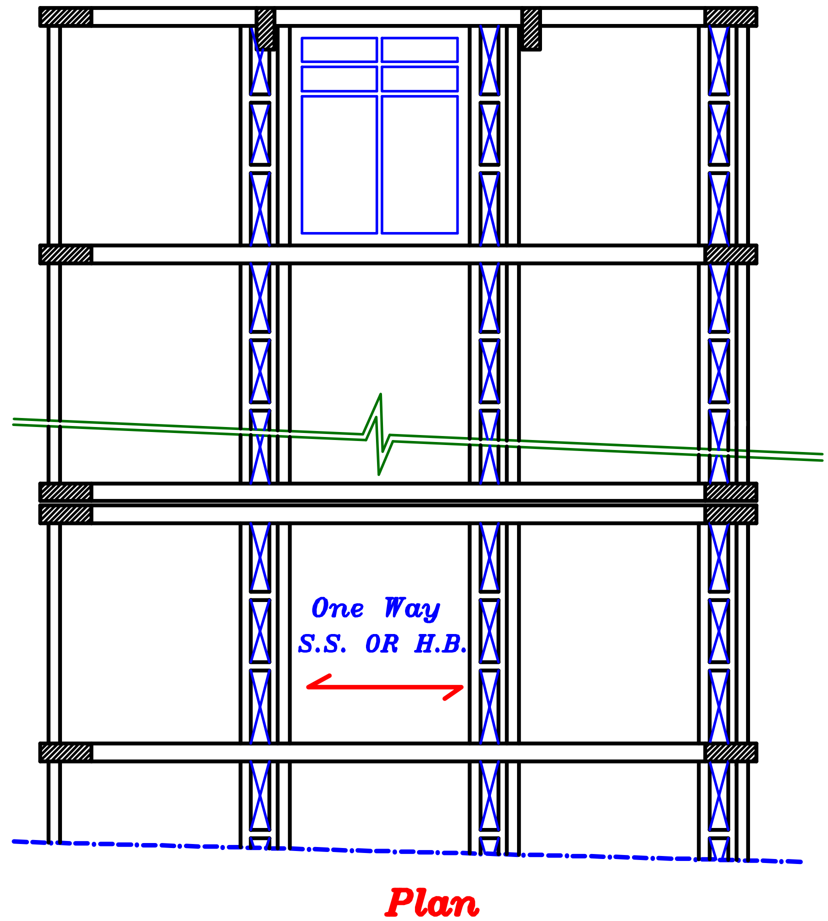
ممكن أن يكون الشباك مائل

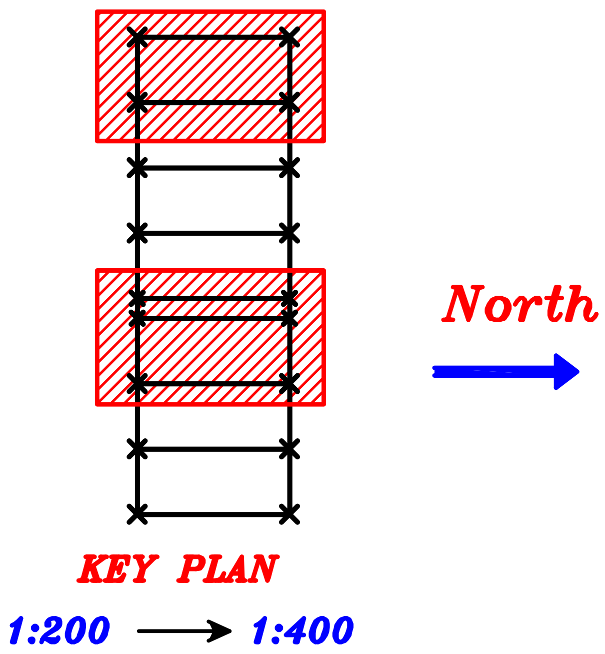


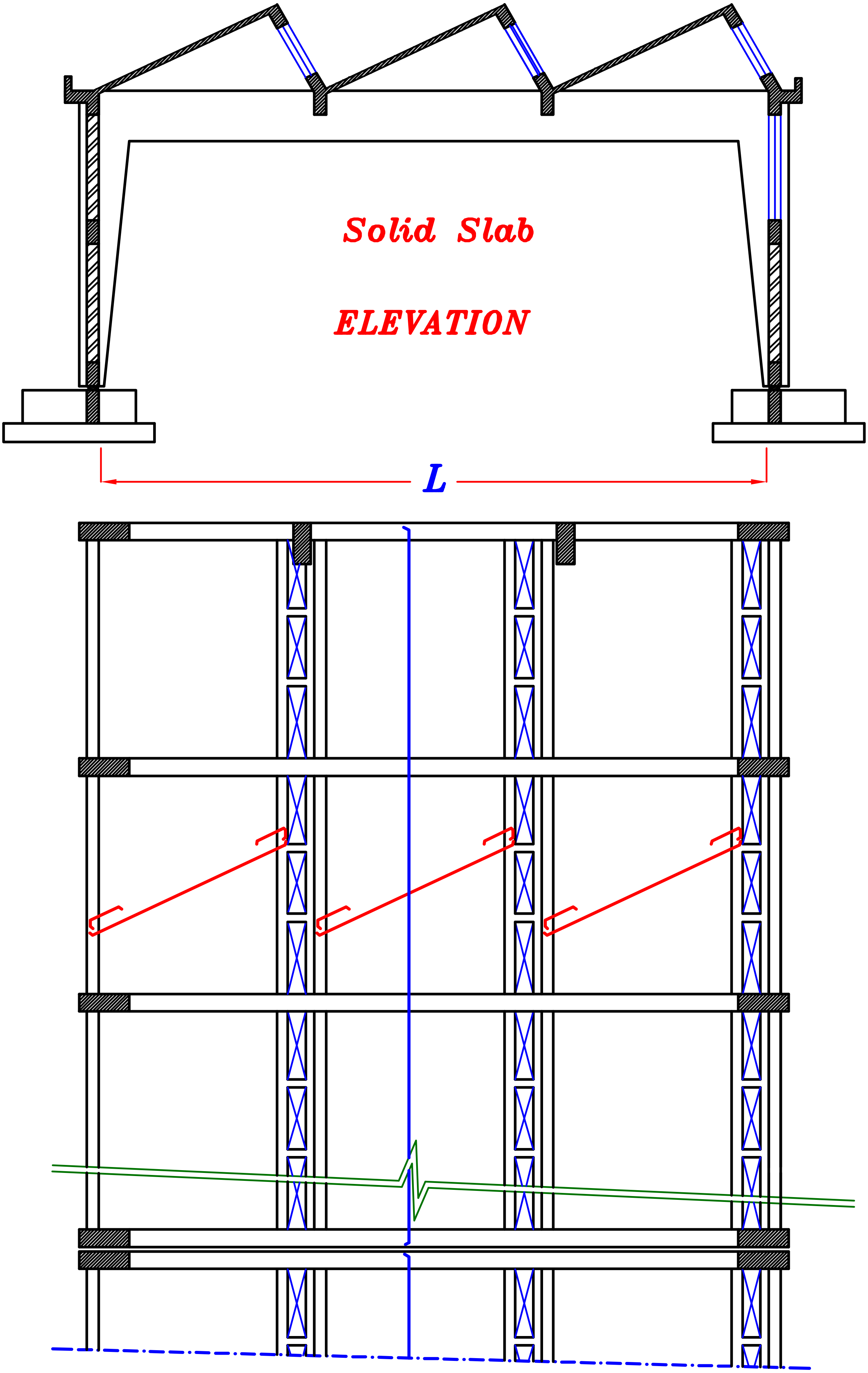



S
S
S
Side View

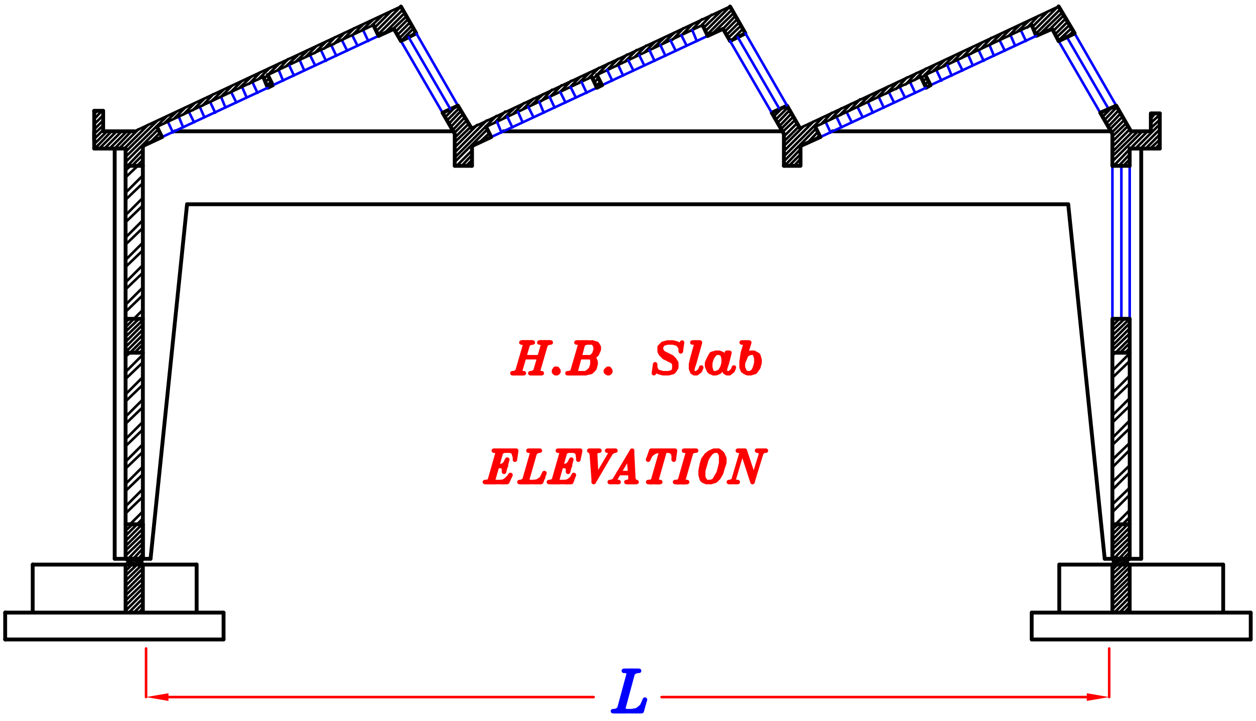

ELEVATION
L

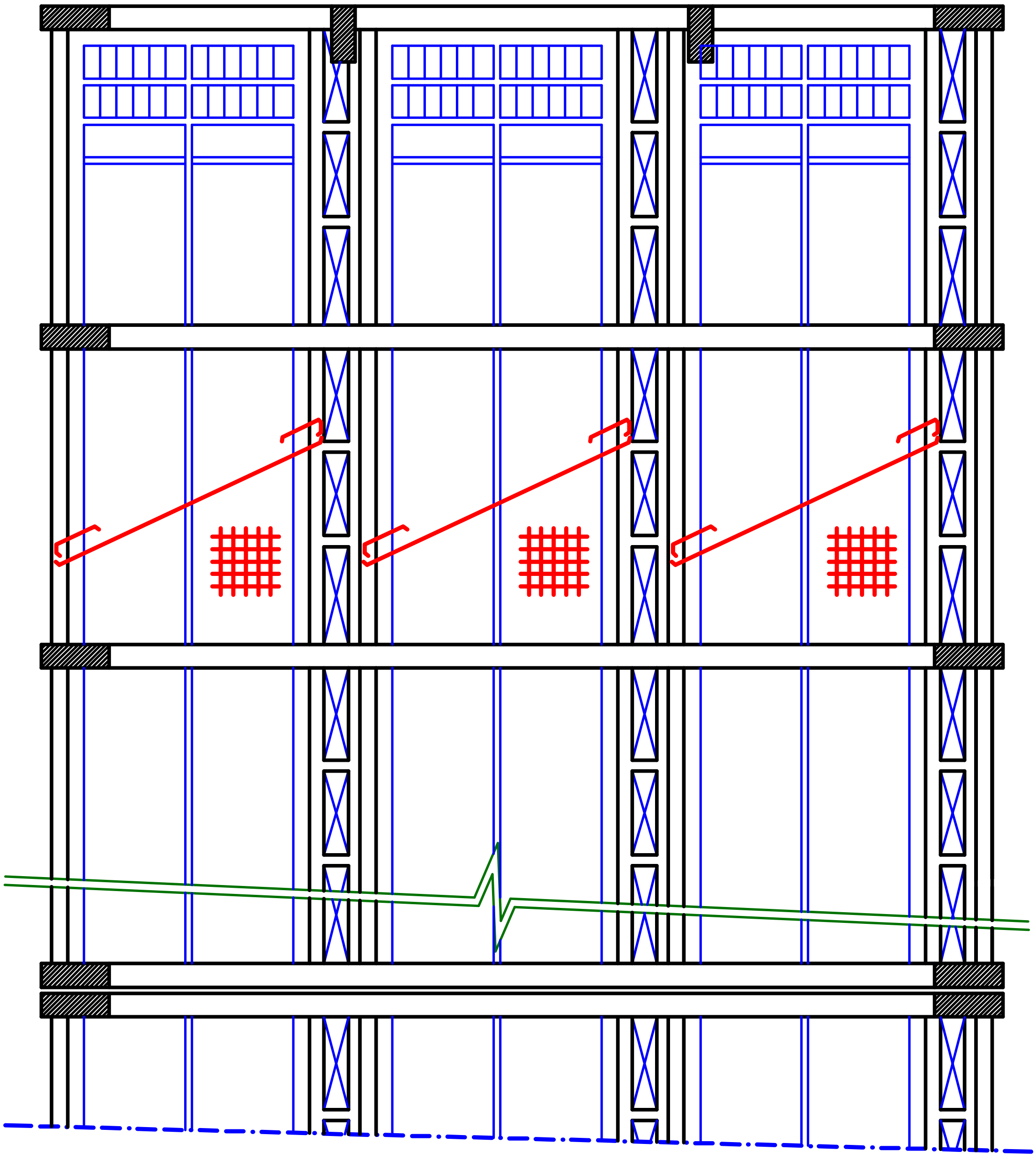

One Way
S.S. OR H.B.
Plan


North
KEY PLAN
1:200 → 1:400



Plan

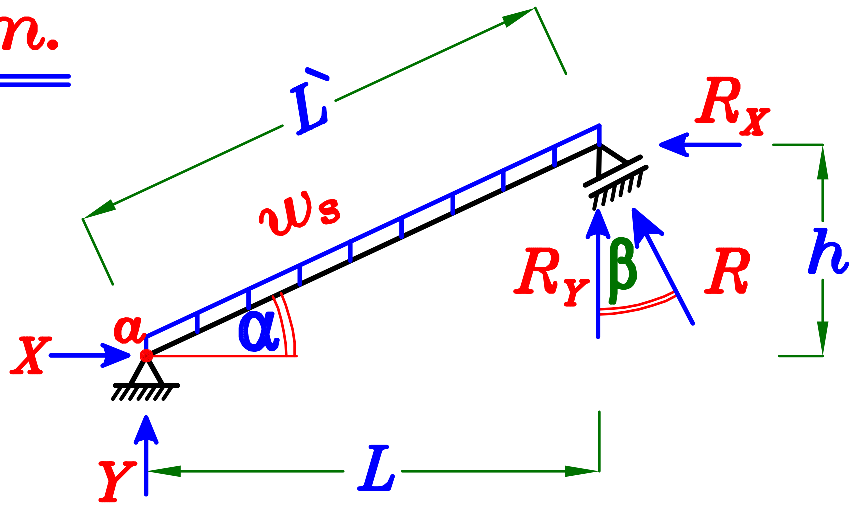




Plan

Statical System.

* Loads From Slab.



$$w_S = 1.4\,(t_s\,\gamma_c + F.C.) + 1.6\ L.L.\ \cos\alpha$$

To Get the Reactions. Using Equations.

$$R_Y = R\cos\beta \quad , \quad R_X = R\sin\beta$$

$$\because \sum M_a = Zero \qquad w_s\,L`\left(\frac{L}{2}\right) - R_Y\,(L) - R_X\,(h) = 0.0$$

$$\therefore\ w_s\,L`\left(\frac{L}{2}\right) - R\cos\beta\,(L) - R\sin\beta\ (h) = 0.0 \longrightarrow \text{Get } R = \checkmark$$

$$\therefore\ R_Y = R\cos\beta = \checkmark \quad , \quad R_X = R\sin\beta = \checkmark$$

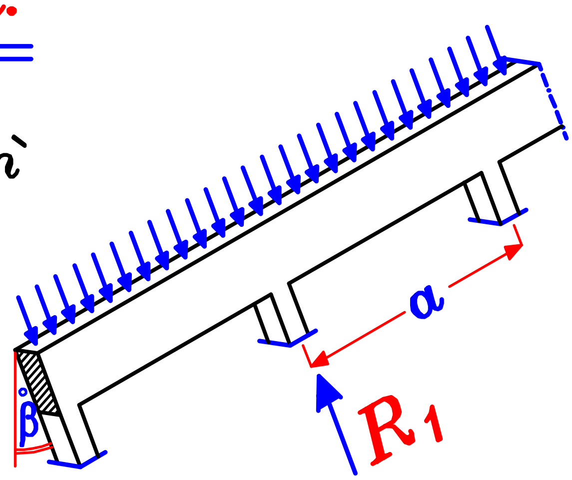
$$\therefore\ X = R_X \quad , \quad \text{Get } Y \text{ From } \sum Y = Zero$$

* Loads on the Ridge Beam.

$$w = O.W._{(beam)} * \cos\beta + R\ \ kN\backslash m`$$

a = Distance Between Posts $= (2 \longrightarrow 3)\ m$

$$R_1 = w * a$$



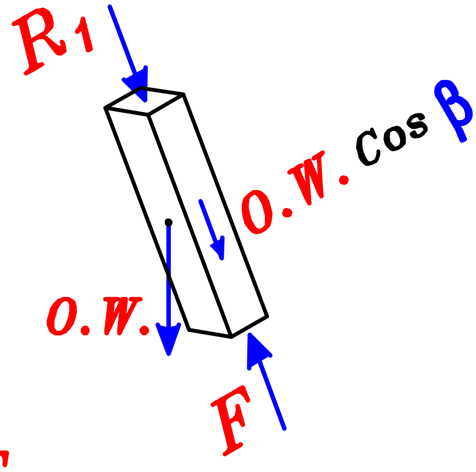
* Loads on the Post.

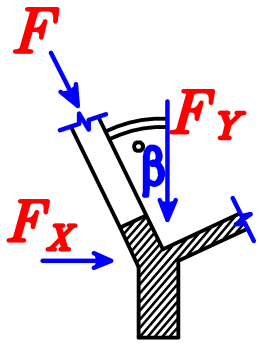
$$F = O.W._{(Post)} * \cos\beta + R_1$$

$$O.W._{(Post)} \simeq 3.50\ kN\ (U.L.)$$

$$F_Y = F \cos\beta$$

$$F_X = F \sin\beta$$



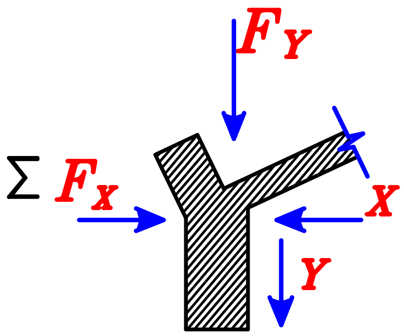


* Loads on Y-Beam.

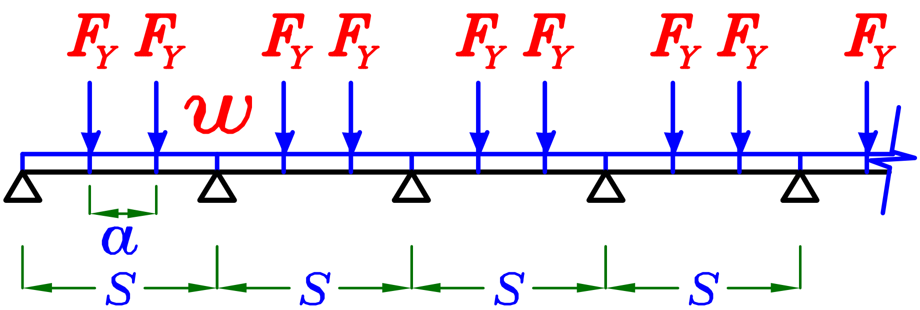
$\because\ X = \sum F_X$ (at one span) $\quad \therefore \sum x = Zero$

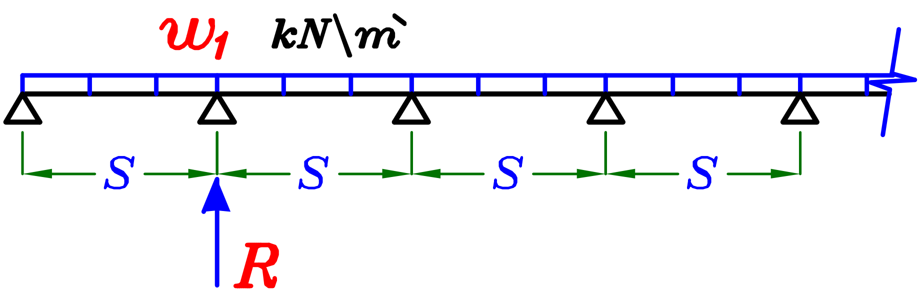
$$w = O.W._{(beam)} + Y = \checkmark\ kN\backslash m`$$

$$w_1 = w + \frac{\sum F_Y \text{ (at one span)}}{Span}$$

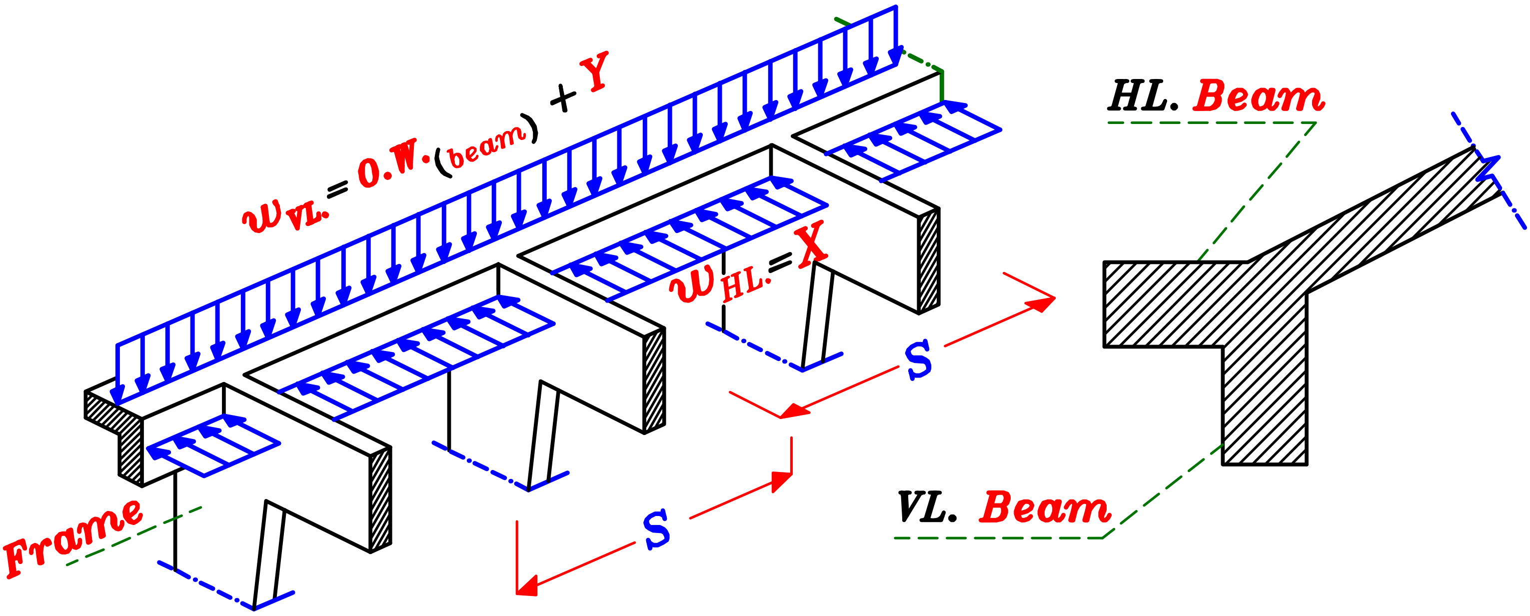


$$R = w_1 * S + F_Y$$

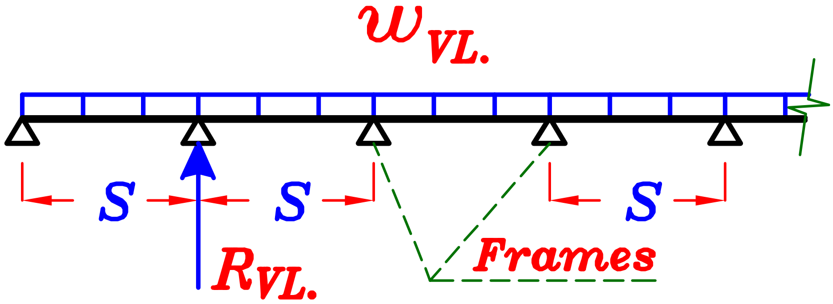




* Loads on End Beam.



VL. Beam.

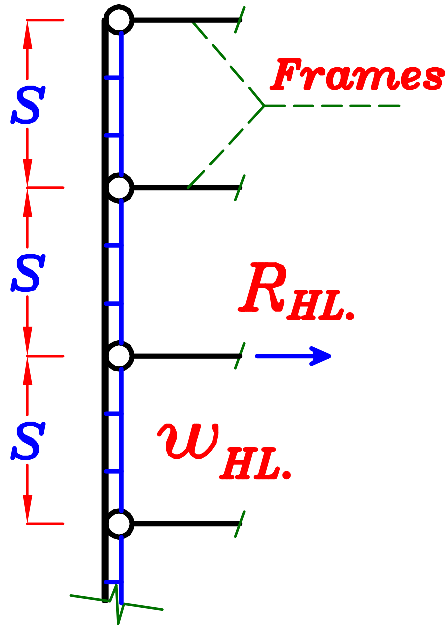


$w_{VL.} = O.W._{(beam)} + Y$ kN\m`

$O.W._{(beam)}$ (VL.+HL.) $\simeq$ 7.0 kN

$R_{VL.} = w_{VL.} * S$

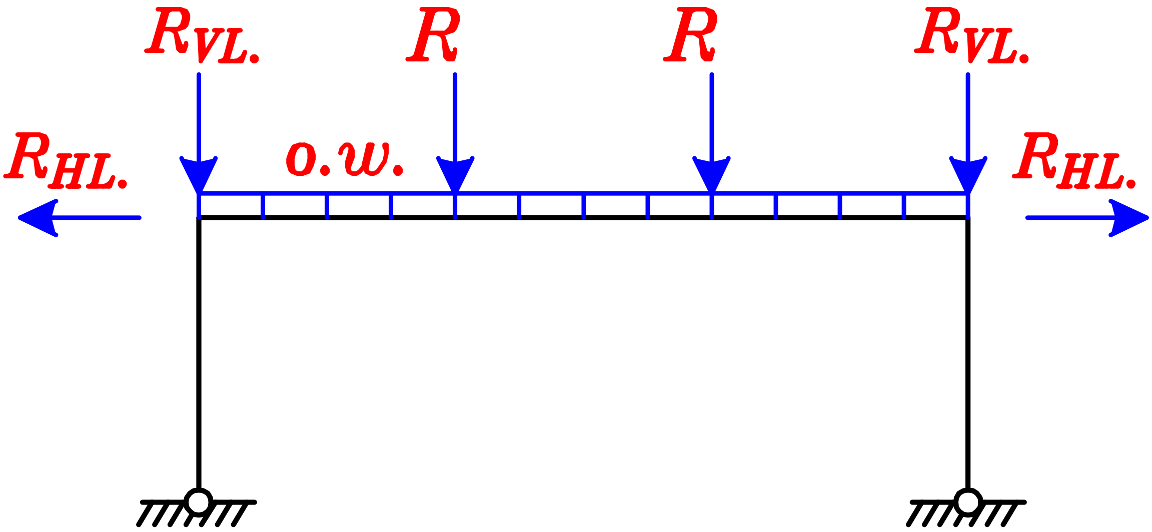
HL. Beam.

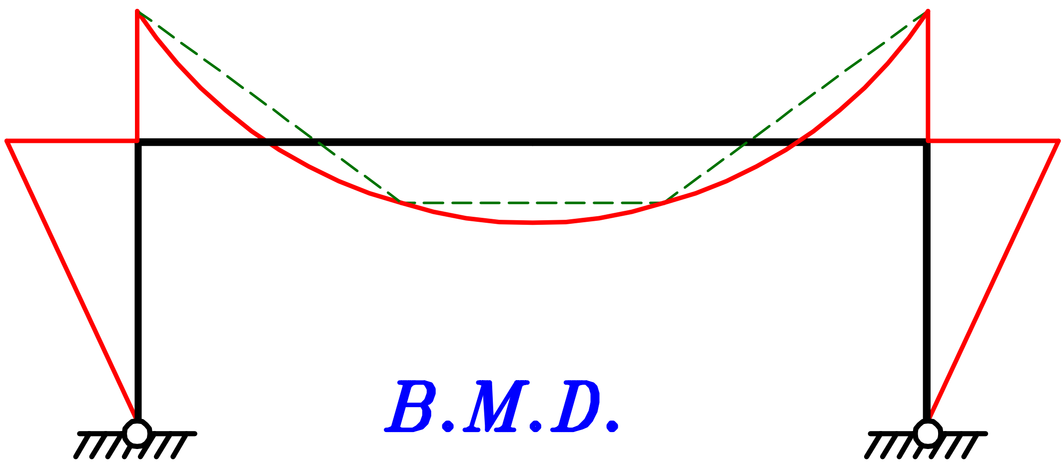


$w_{HL.} = X$ kN\m`

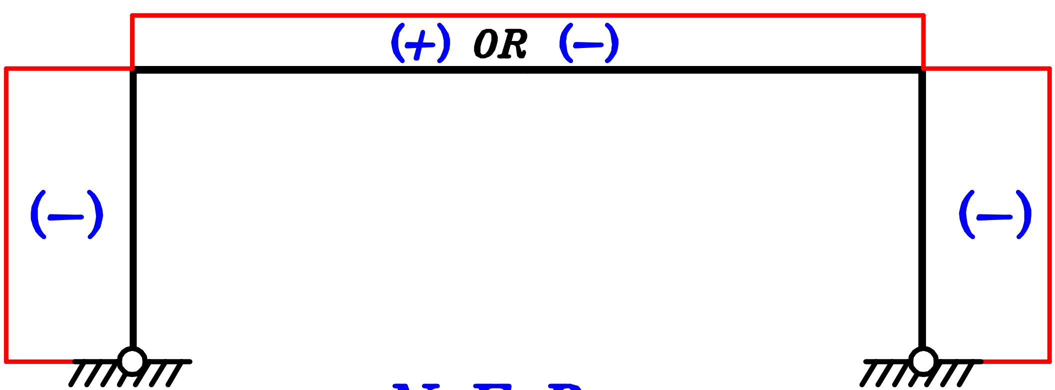
$R_{HL.} = w_{HL.} * S$

* Loads on The Frame.





B.M.D.



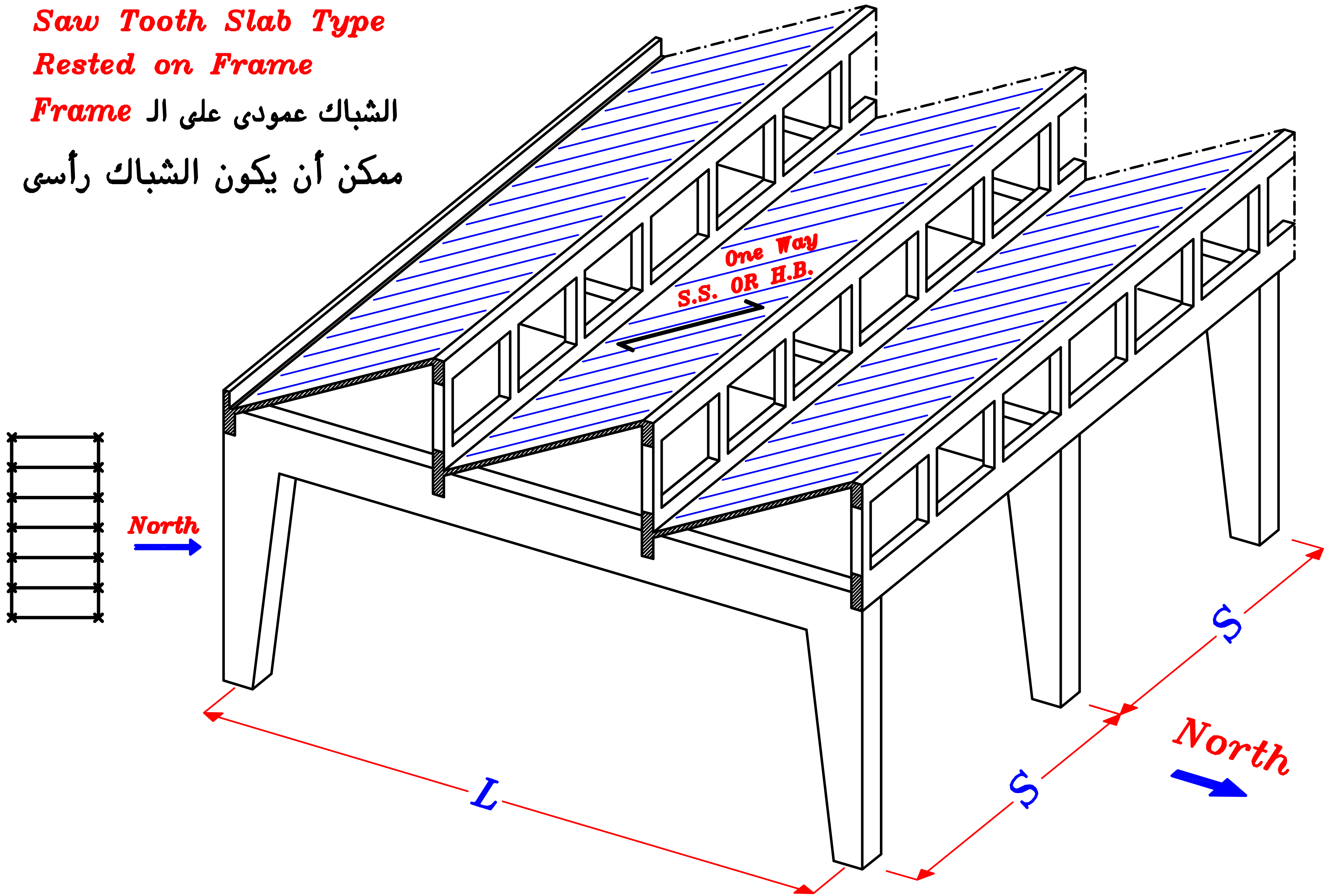
N.F.D.

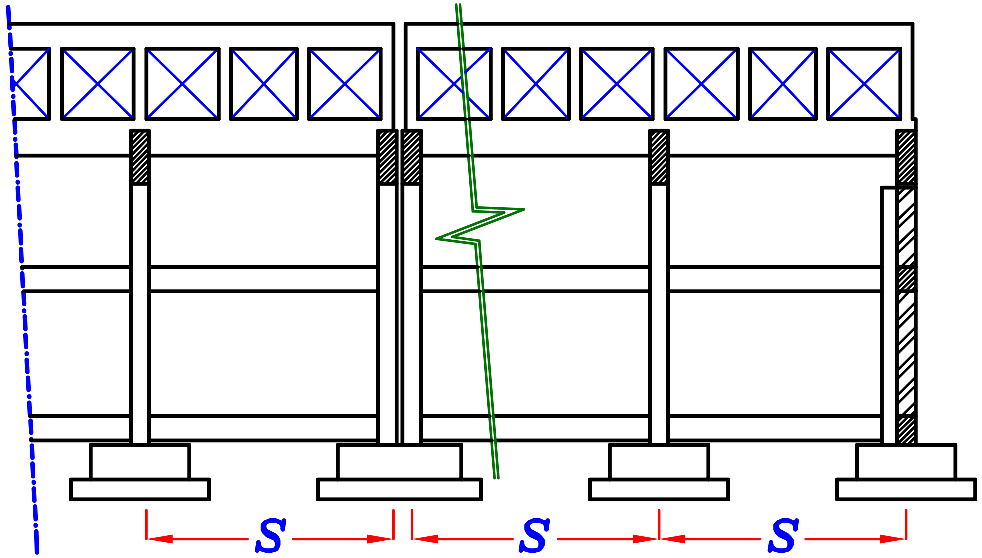
Saw Tooth Slab Type

Rested on Frame

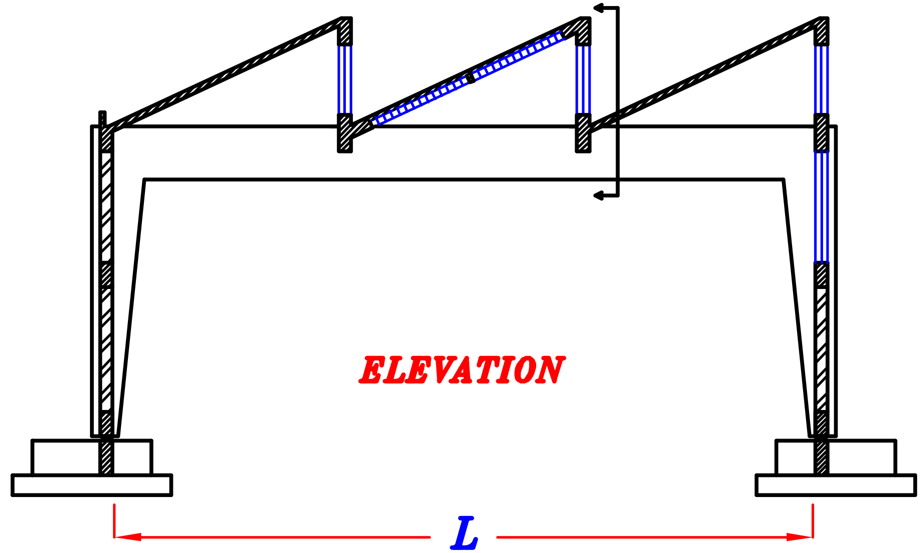
الشباك عمودى على ال **Frame**

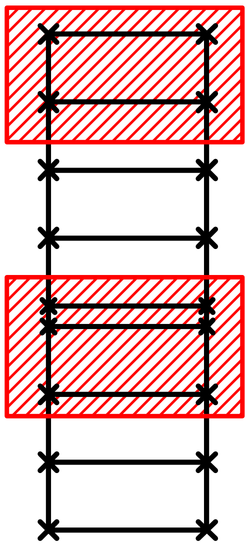
ممكن أن يكون الشباك رأسى





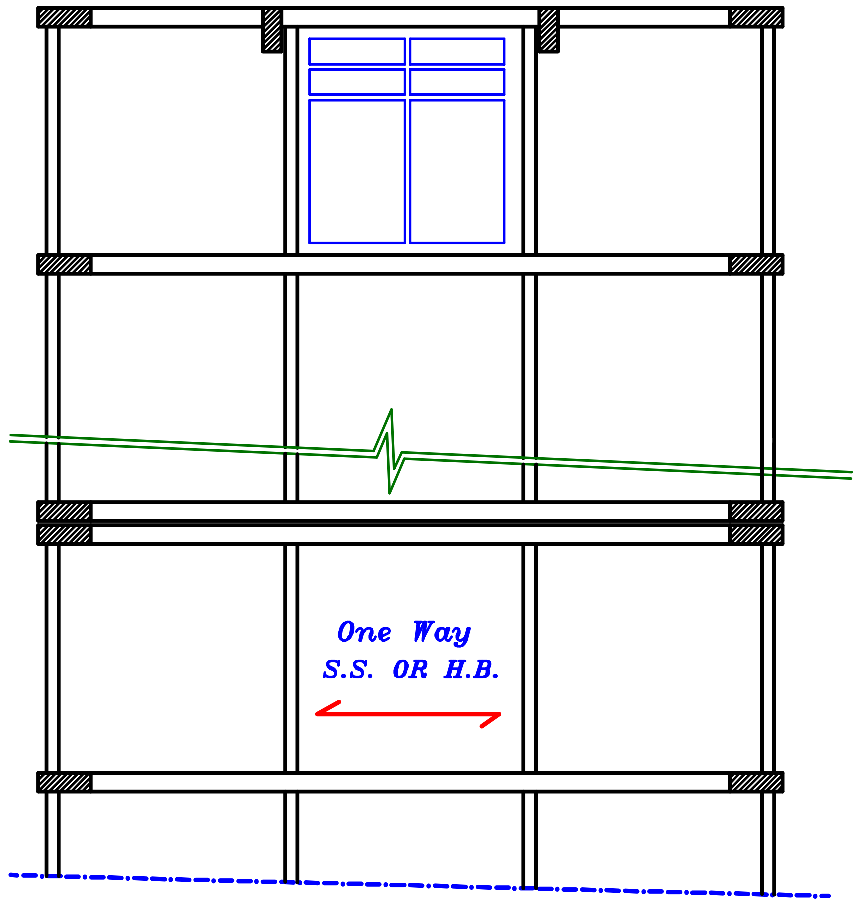
Side View



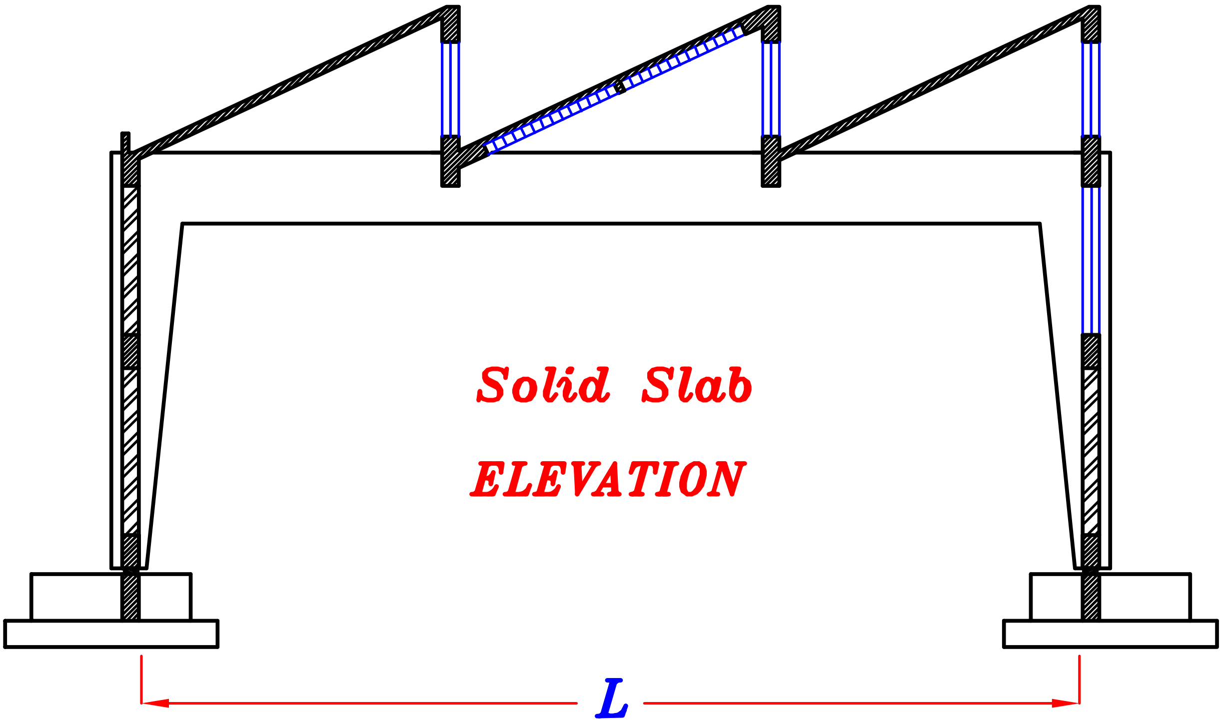


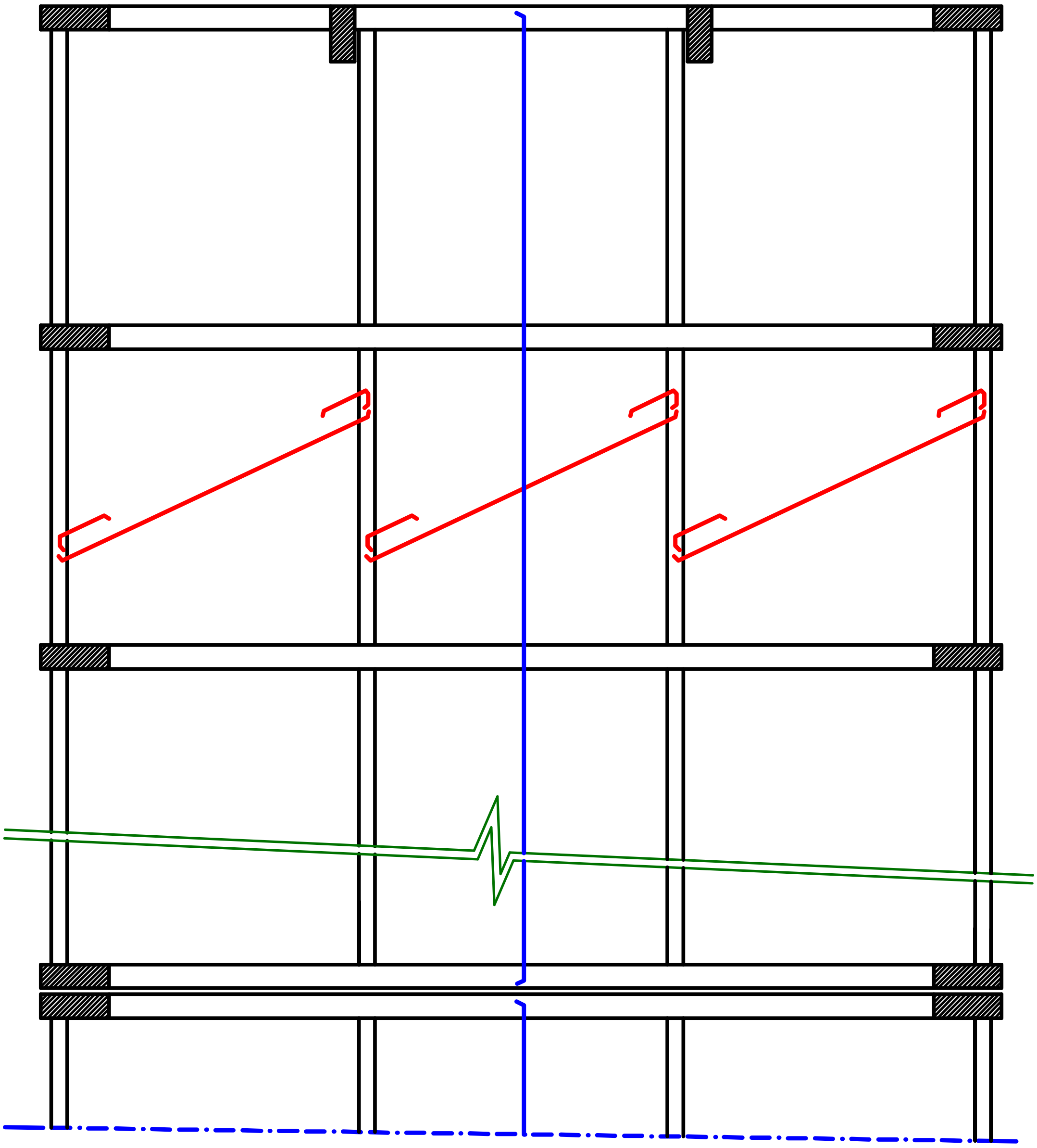
KEY PLAN

1:200 → 1:400

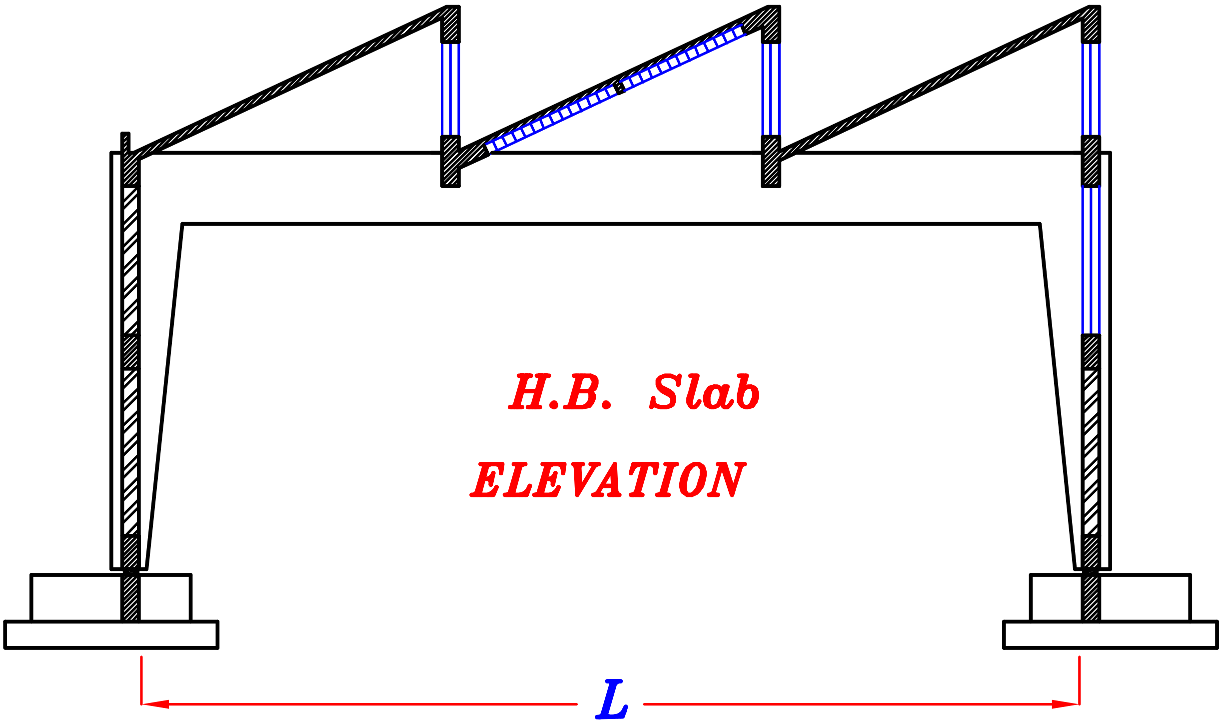


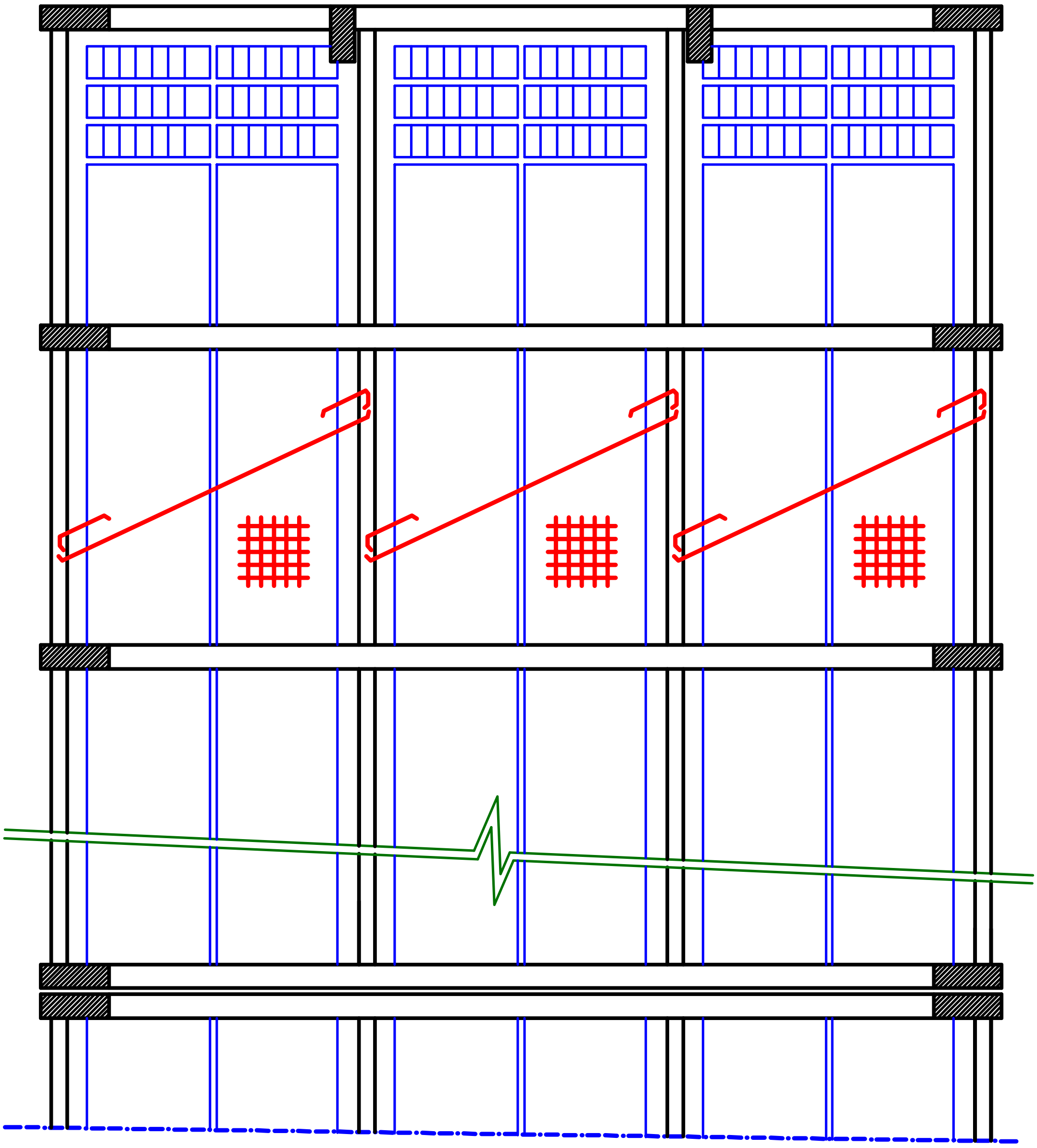
Plan





Plan

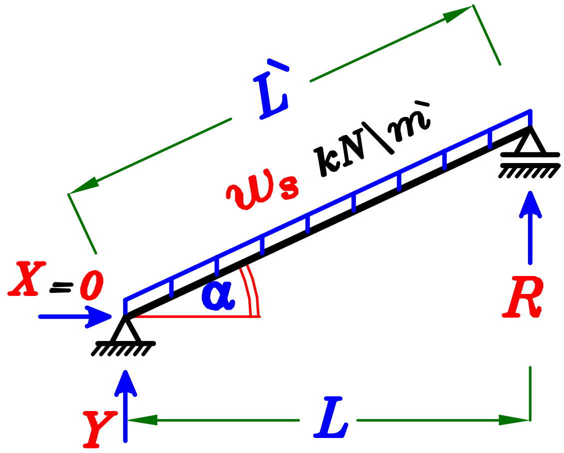




Plan

Steps of Design.

* Design the Slab.



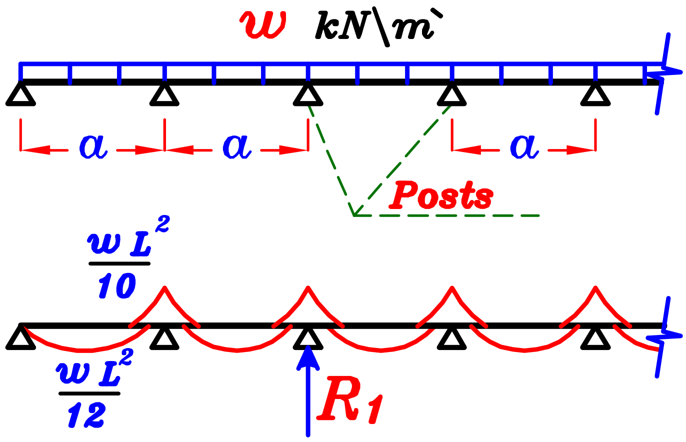
Get w_s

then take a strip 1.0 m in the slab.

$$w_s = 1.4\,(t_s\,\gamma_c + F.C.) + 1.6\ L.L.\ \cos\alpha$$

$$M = \frac{w_s\,L\,L`}{8} \quad , \quad R = Y = \frac{w_s\,L`}{2}$$

* Design the Ridge Beam.



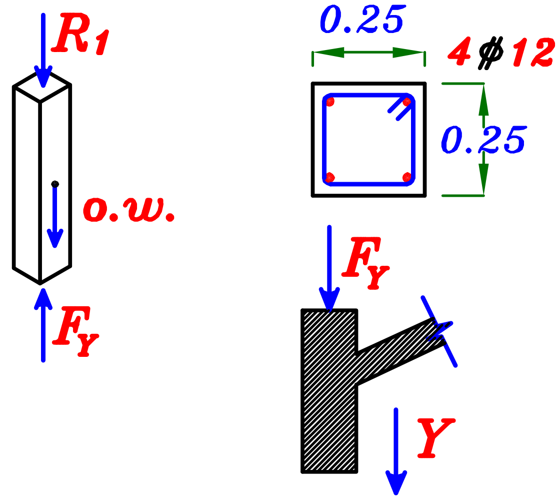
$w = O.W._{(beam)} + R$ kN\m`

a = Distance Between Posts

$= (2 \longrightarrow 3)$ m

$R_1 = w * a$

* Design the Post.

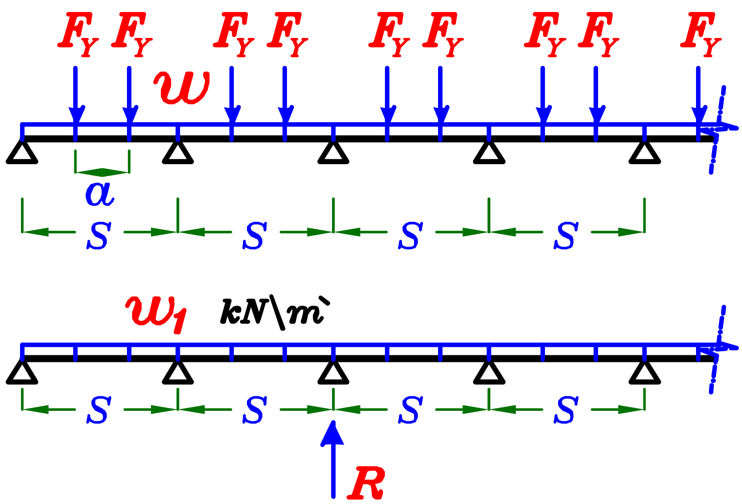


$F_Y = O.W._{(Post)} + R_1$

$O.W._{(Post)} \simeq 3.50$ kN (U.L.)

$P_{U.L.} = F_Y = 0.35\,A_c\,F_{cu} + 0.67\,A_s\,F_y$

* Design of the Y–Beam.



$w = O.W._{(beam)} + Y = \checkmark$ kN\m`

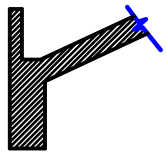
Solved by using Moment Dist.

or use Approximate Solution.

$$w_1 = w + \frac{\sum F_Y(\text{at one span})}{Span}$$

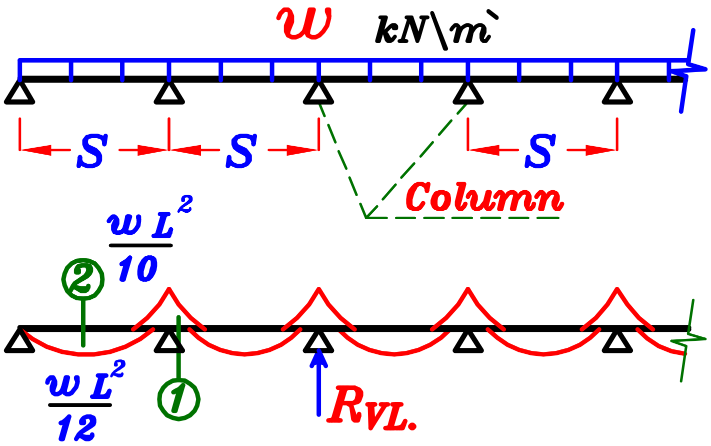
$$R = w_1 * S + F_Y$$

* Design of End Beam. B_1



$w = O.W._{(beam)} + Y$ kN\m`

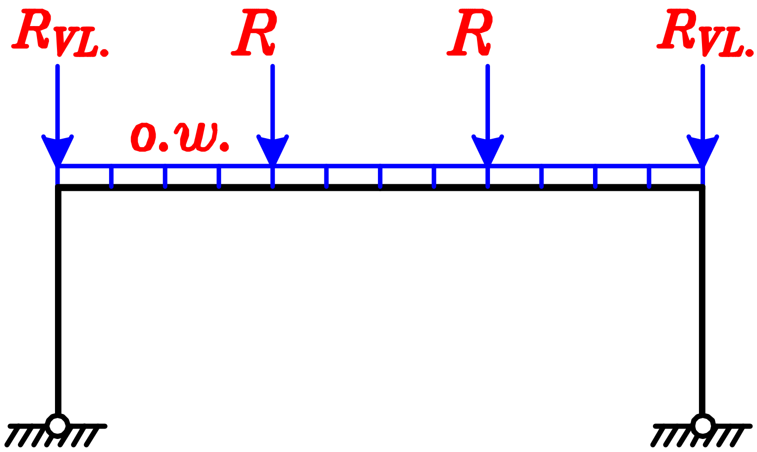
$O.W._{(beam)} \simeq 4.20$ kN (U.L.)

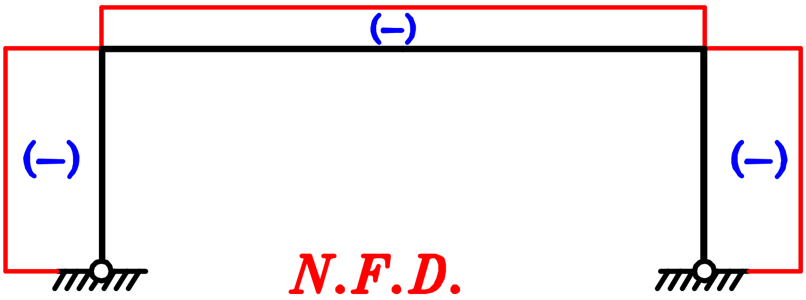


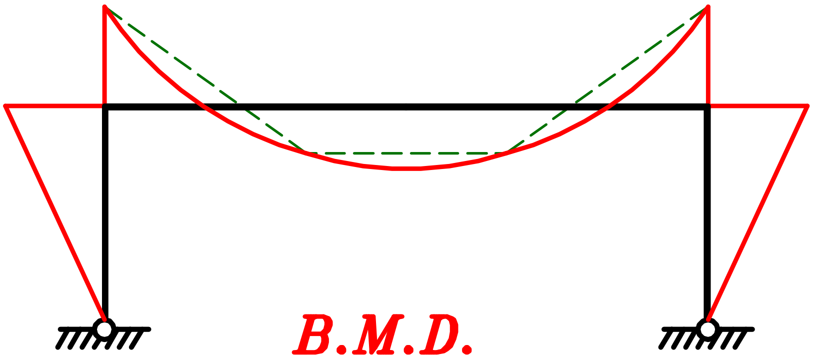
Designed as R−Sec.

$R_{VL.} = w_{VL.} * S$

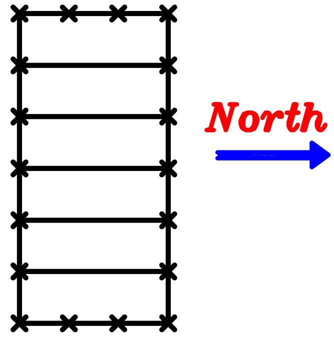
* Loads on The Frame.

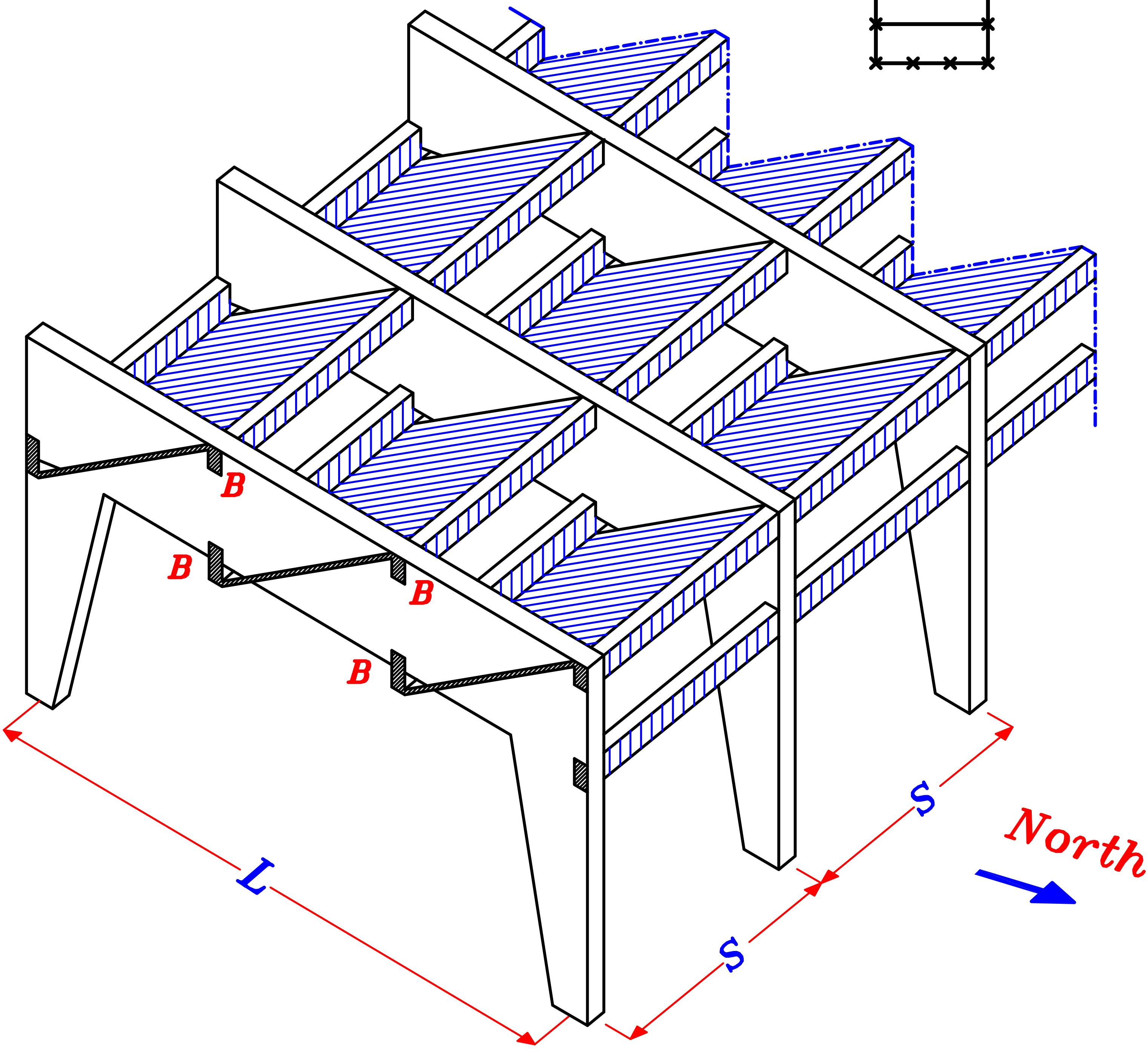


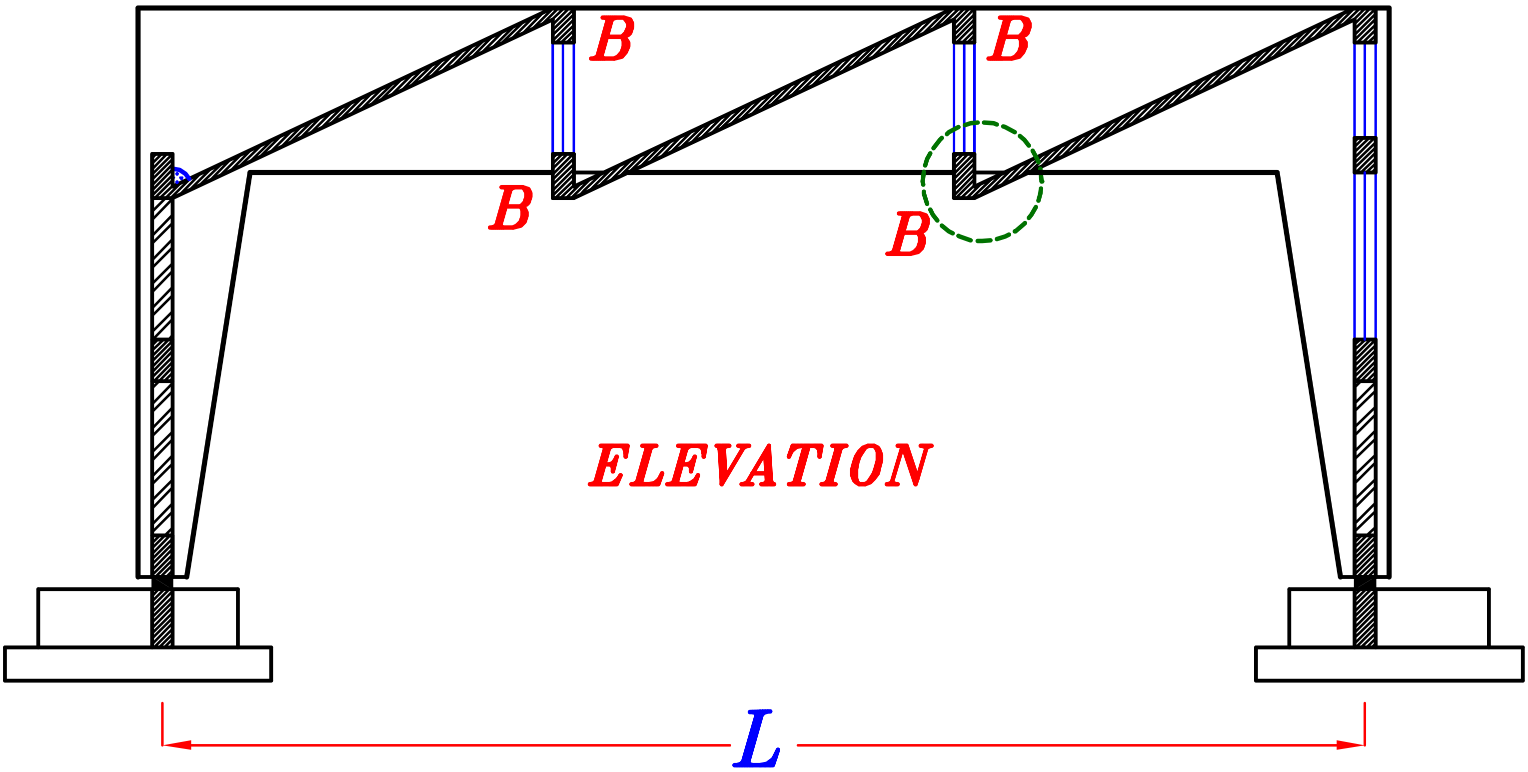




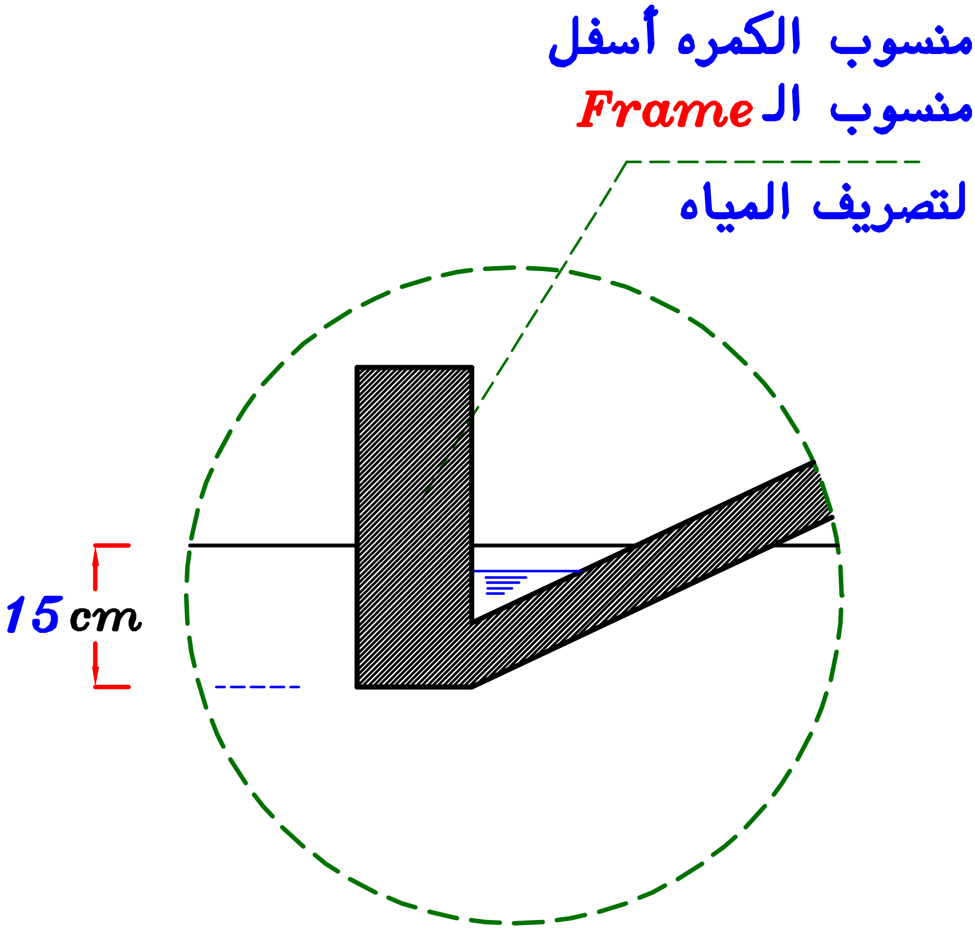
Saw Tooth Slab
Rested on Frame
منسوب الشباك داخل ال Frame
الشباك عمودى على ال Frame





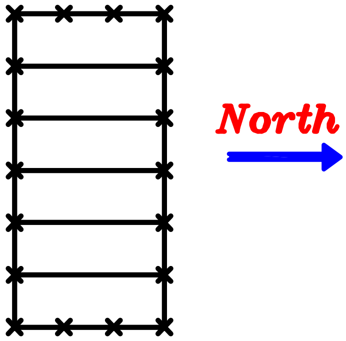


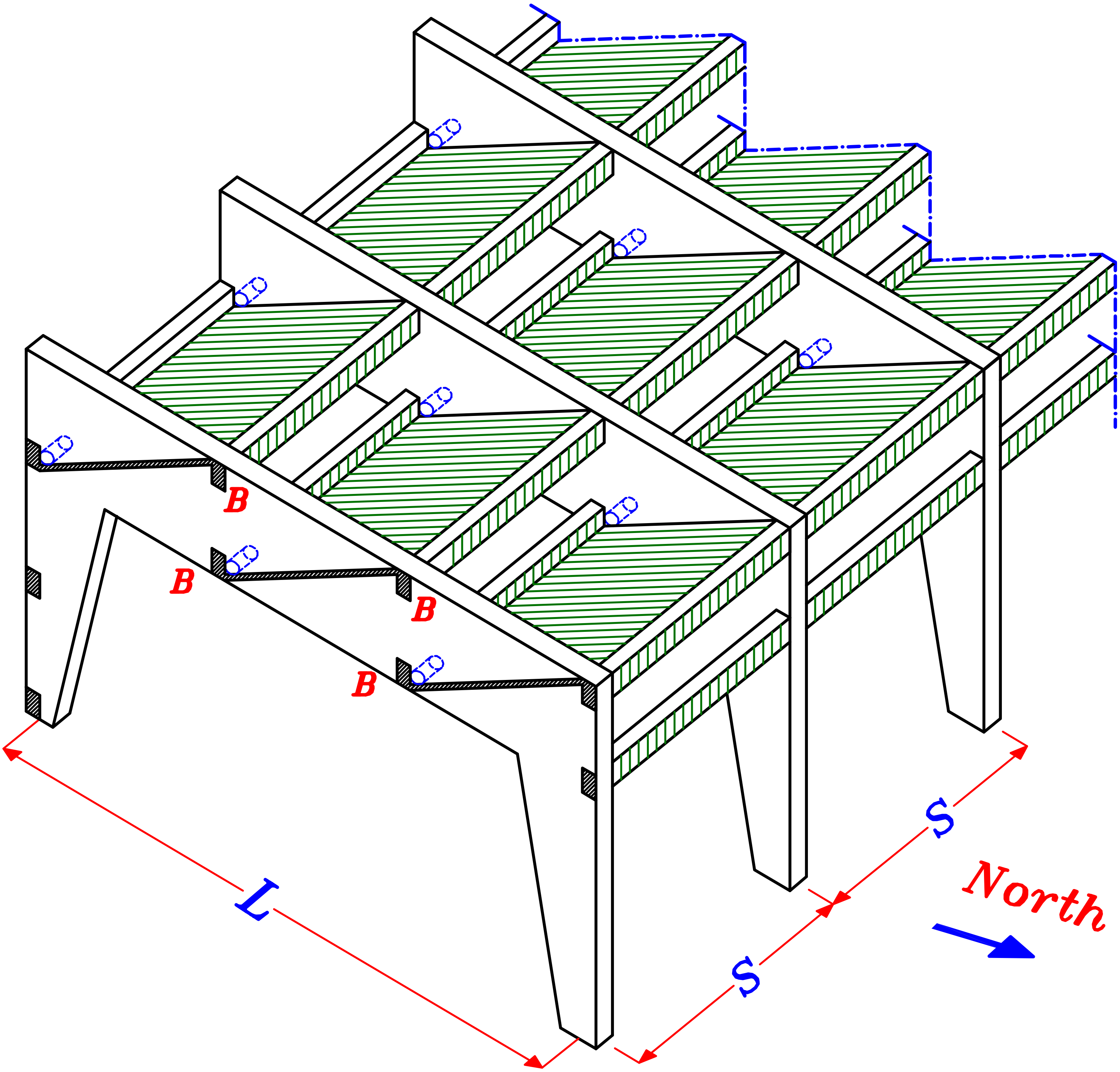
B
B
B
B
ELEVATION
L

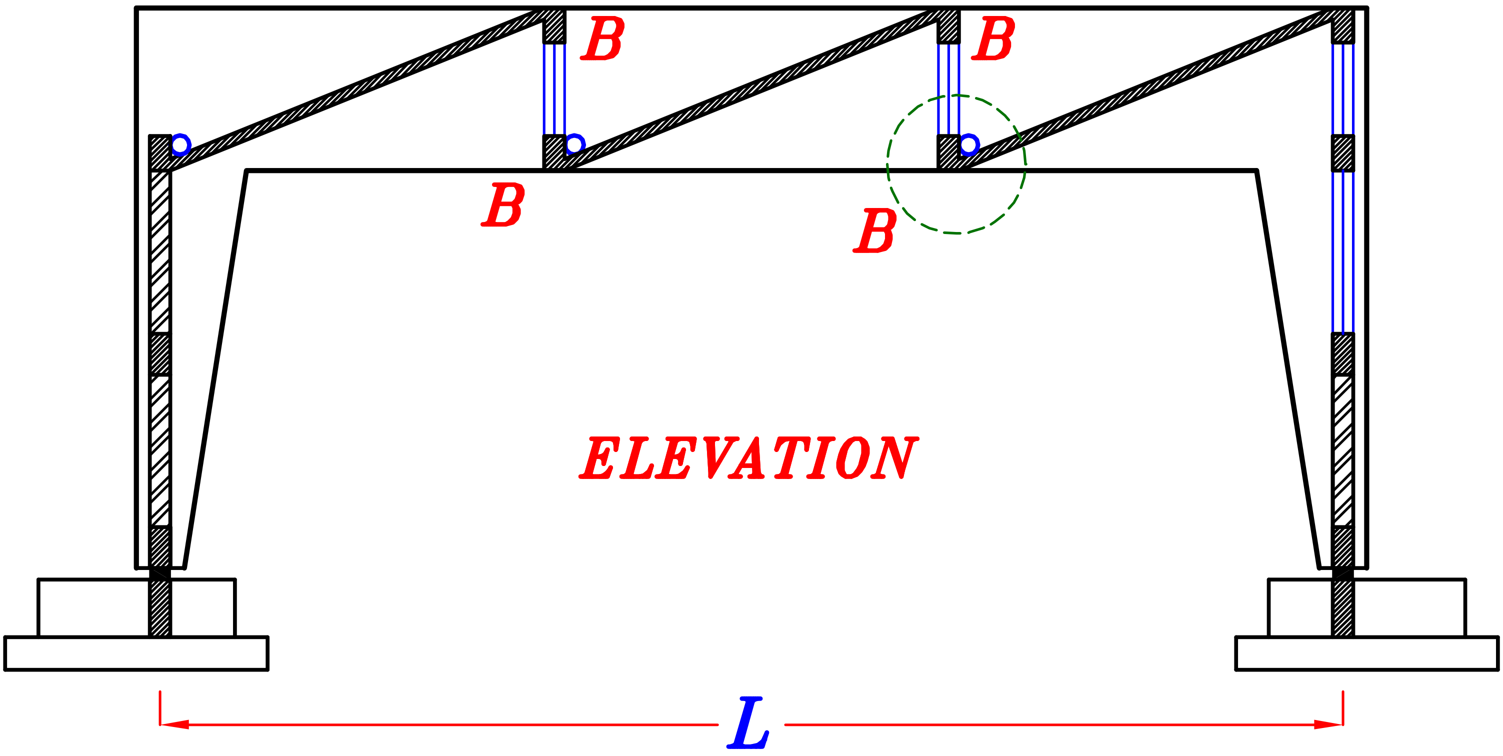


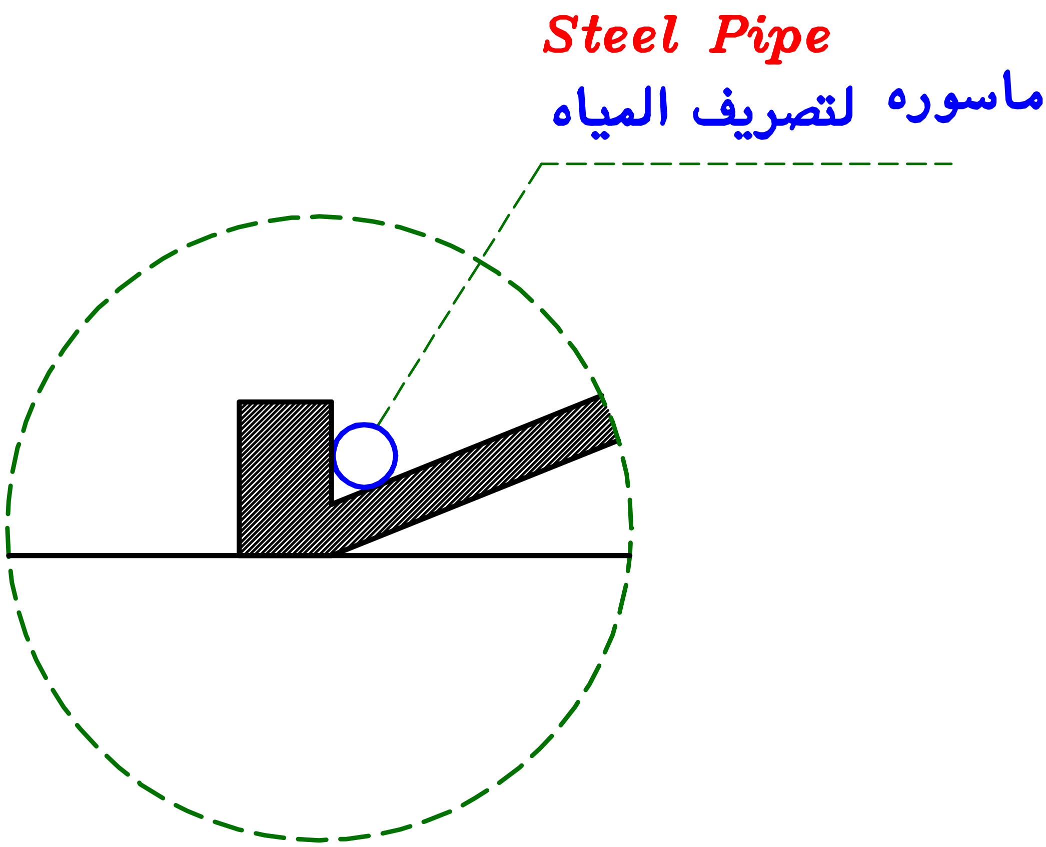
منسوب الكمره أسفل
منسوب الـ Frame
لتصريف المياه
15 cm

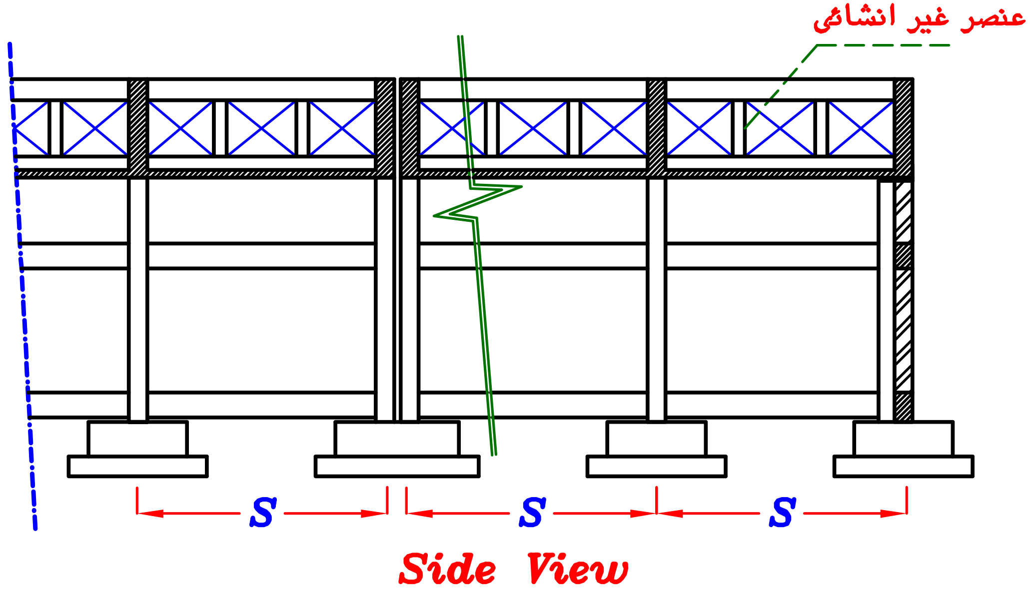
Saw Tooth Slab
Rested on Frame
منسوب الشباك داخل ال Frame
الشباك عمودى على ال Frame



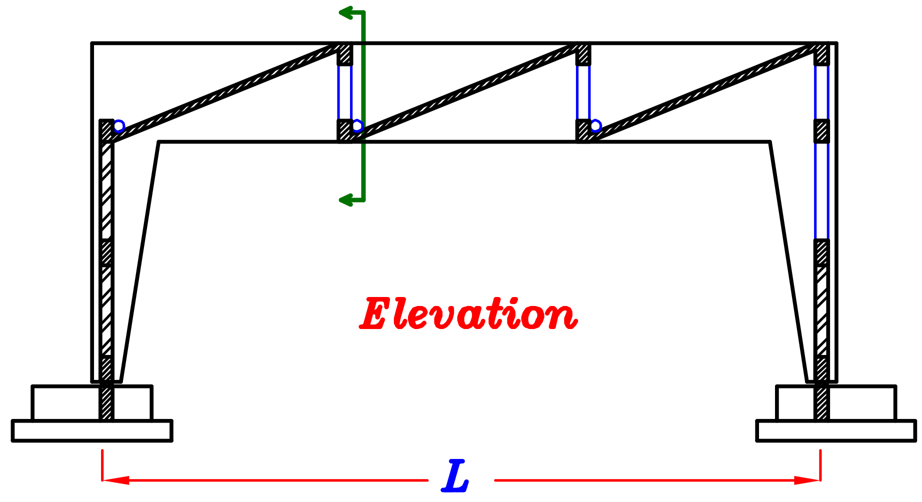



B
B
B
B
ELEVATION
L

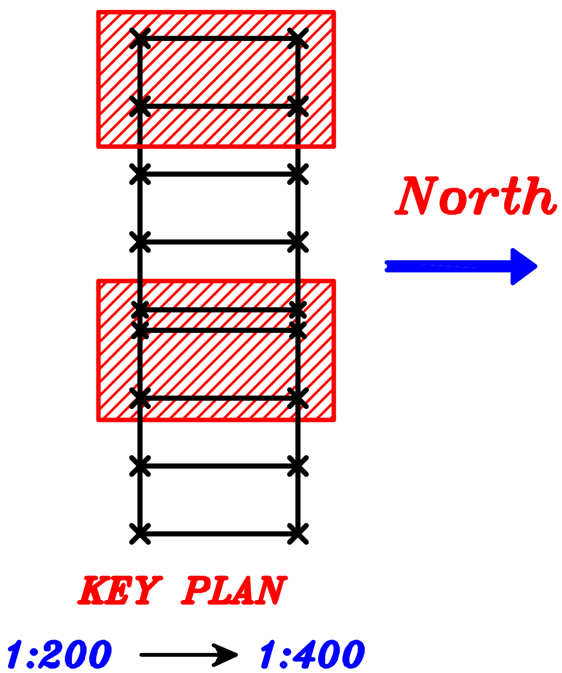

Steel Pipe
ماسوره لتصريف المياه



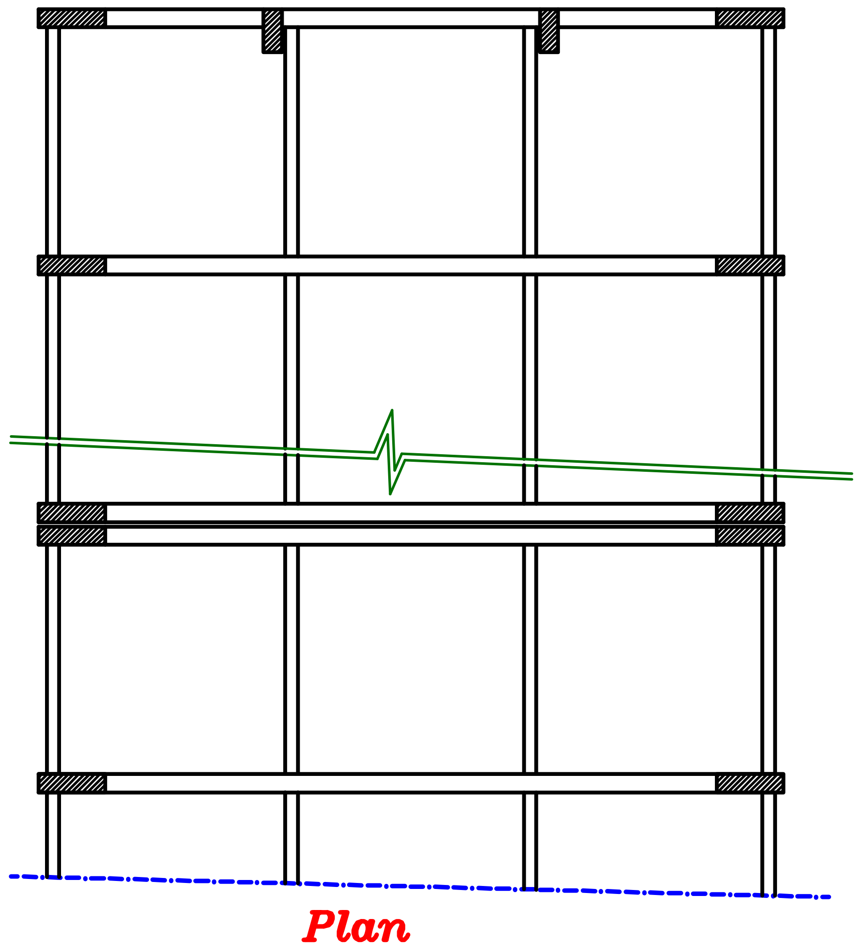
عنصر غير انشائى
S
S
S
Side View



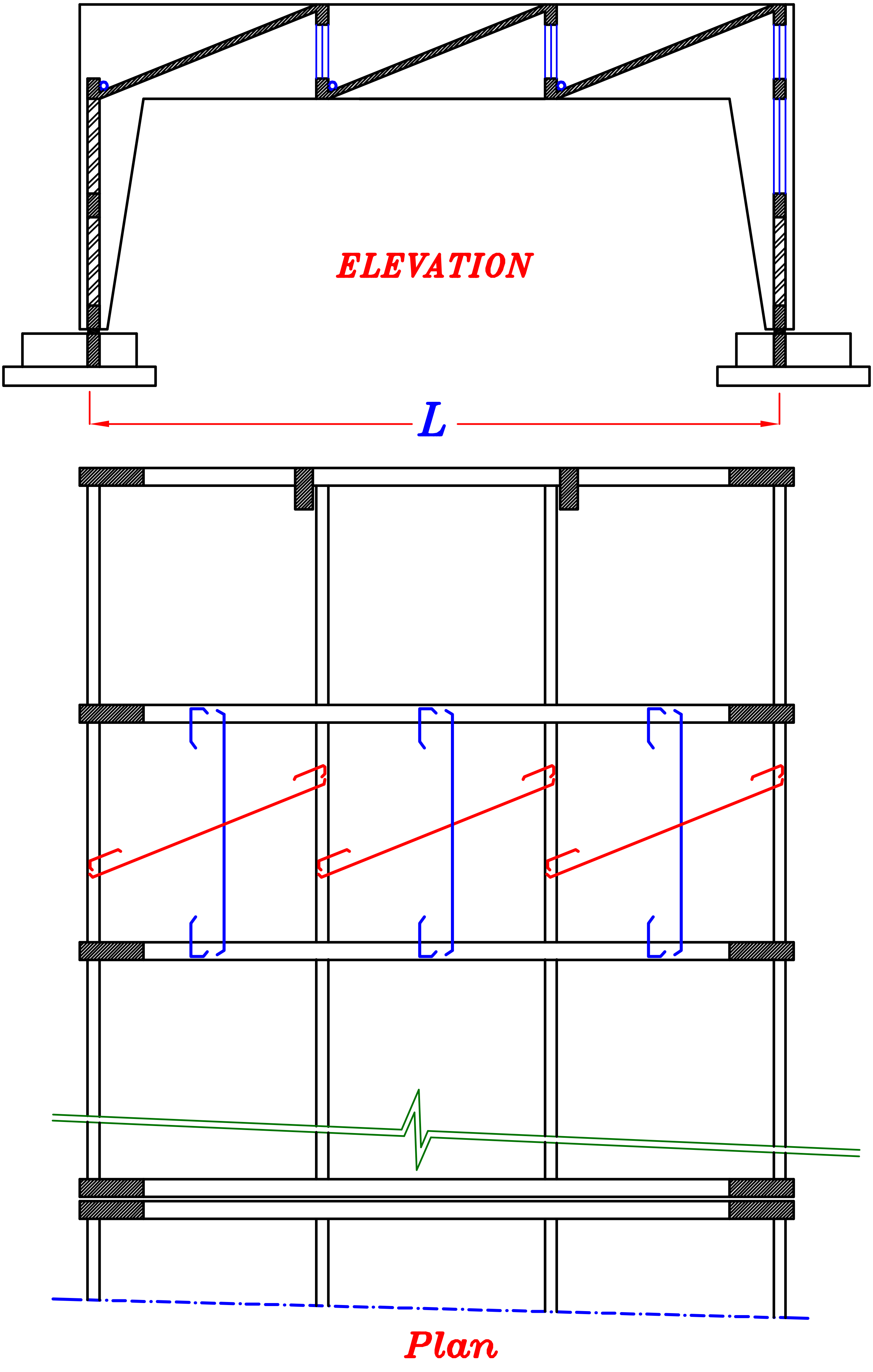
Elevation
L

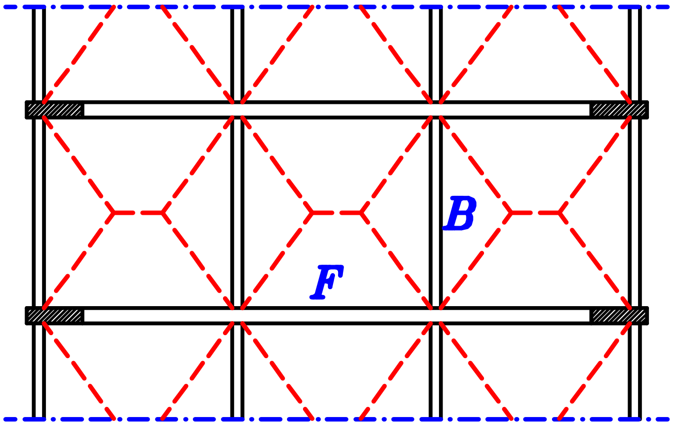


North
KEY PLAN
1:200 → 1:400

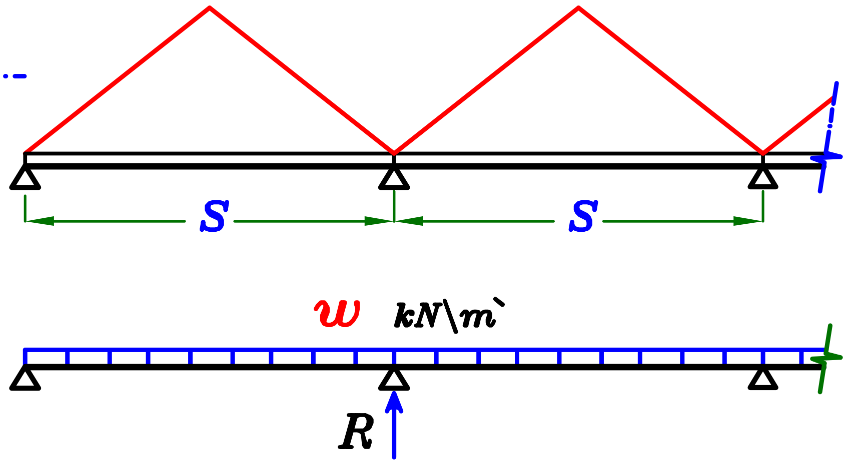


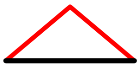
Plan


ELEVATION
L
Plan



* **Loads on Beam B**

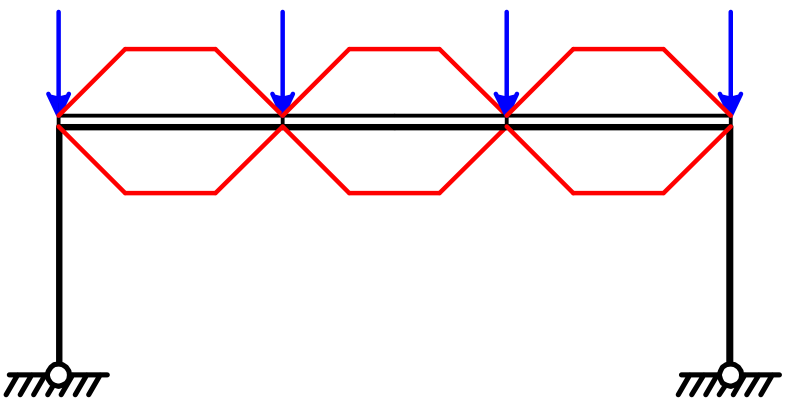




$$w = o.w. + C_a \, w_s \, \frac{L_s}{2} = \checkmark \; kN\backslash m`$$

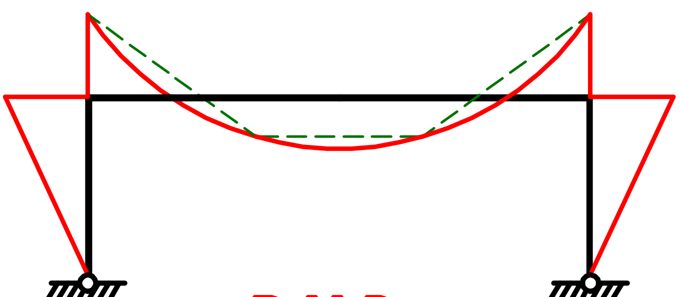
$$R = w * S$$

* **Loads on The Frame.**

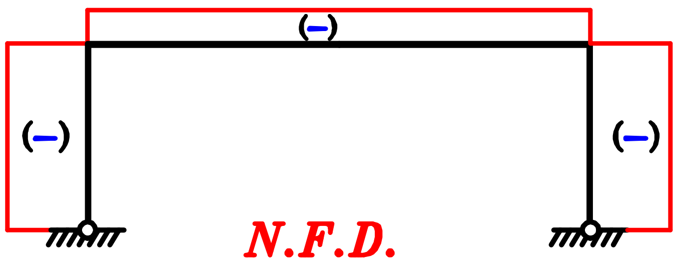


6 

$$w = o.w. + \frac{\sum area}{L} * w_s = \checkmark \; kN\backslash m`$$

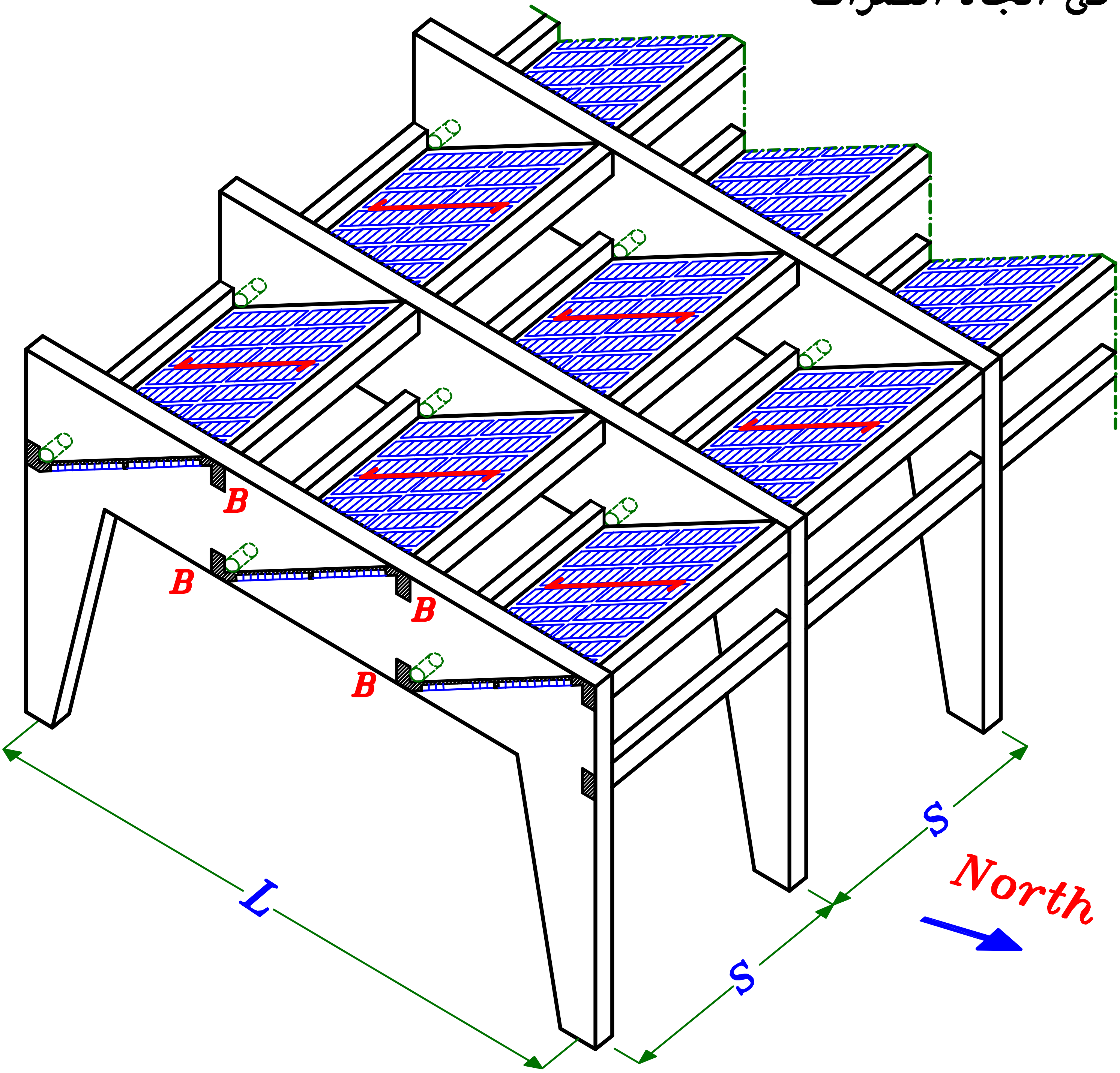


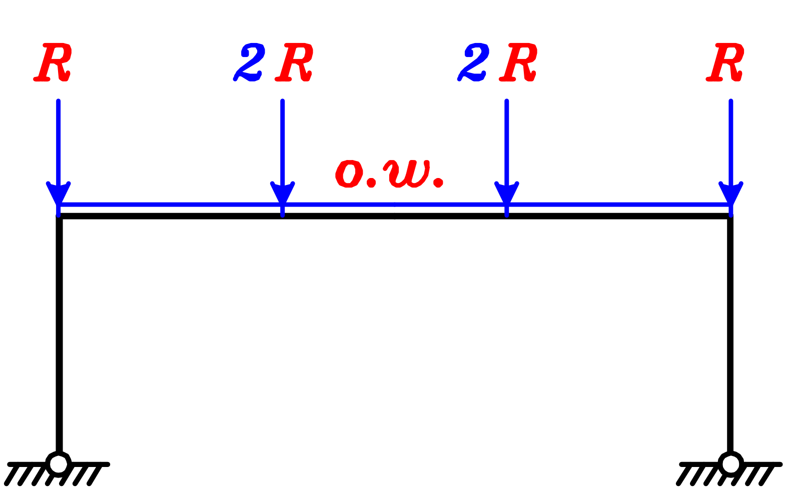
B.M.D.

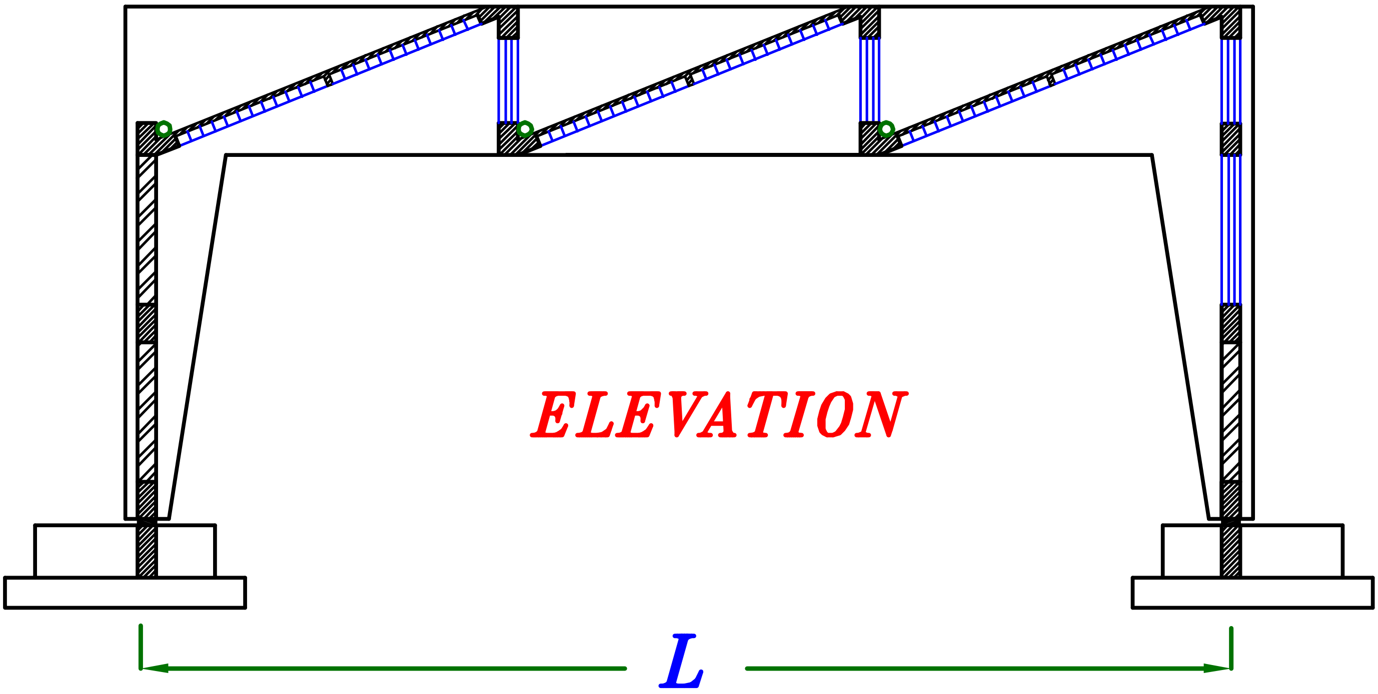


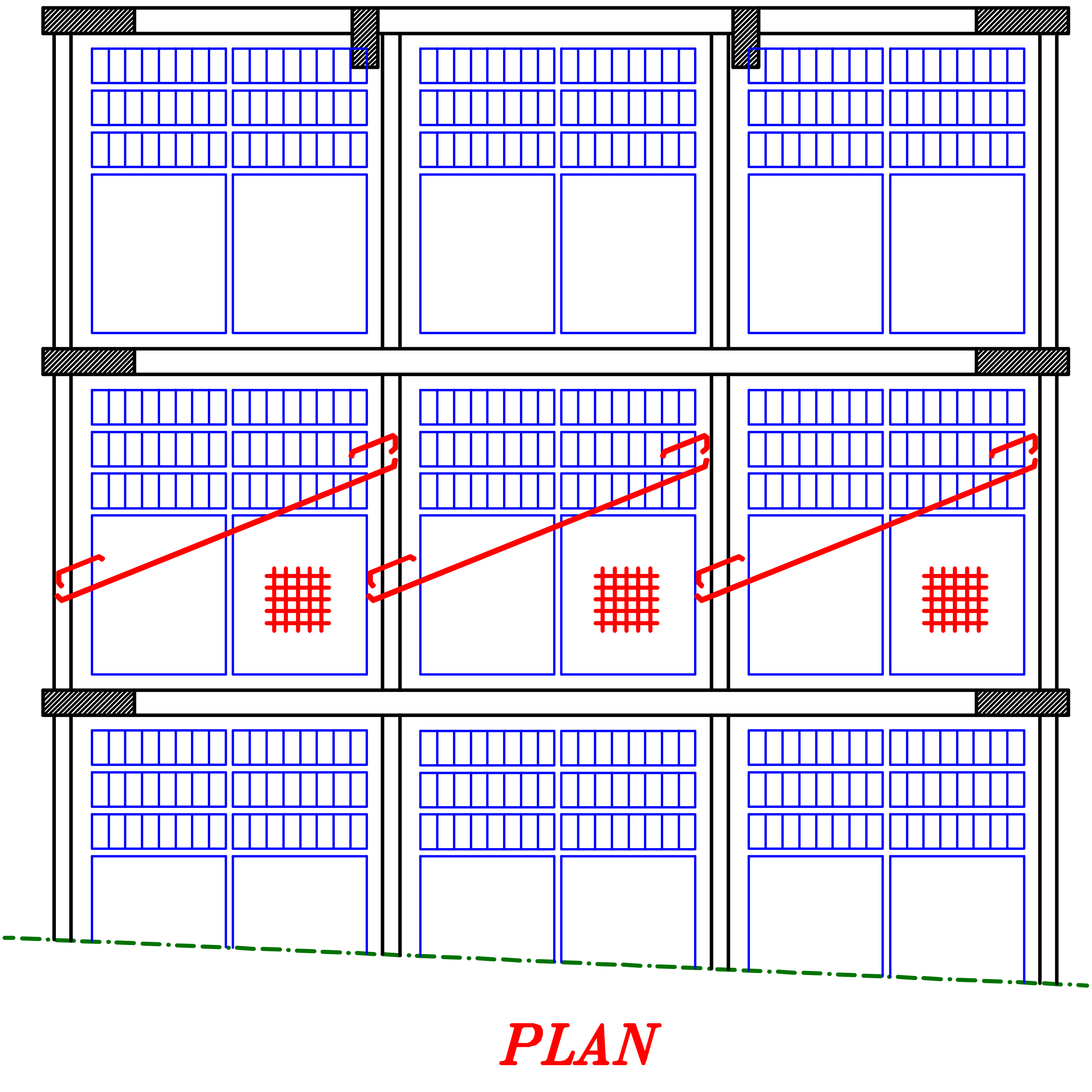
N.F.D.

One way H.B. الاسهل فى الحسابات ان نأخذ البلاطه فى اتجاه الكمرات .



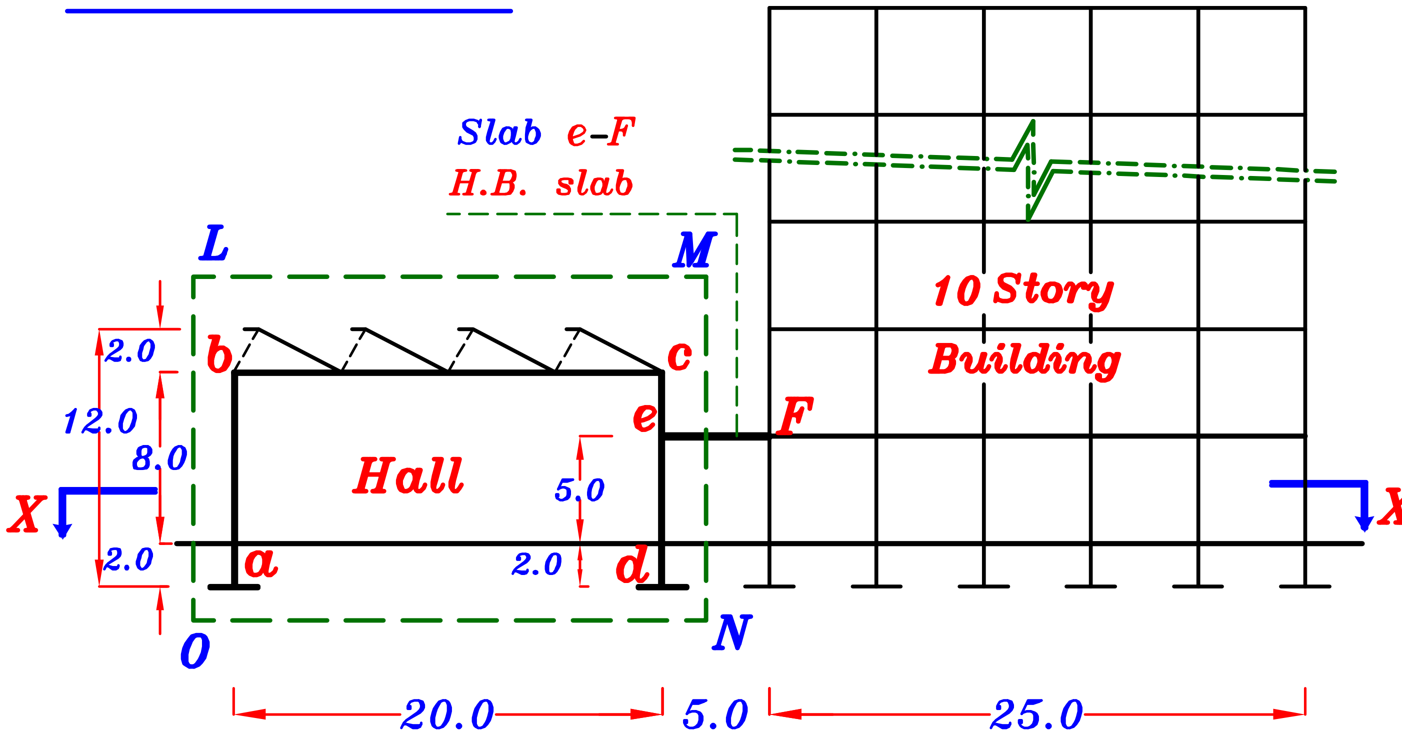



ELEVATION
L

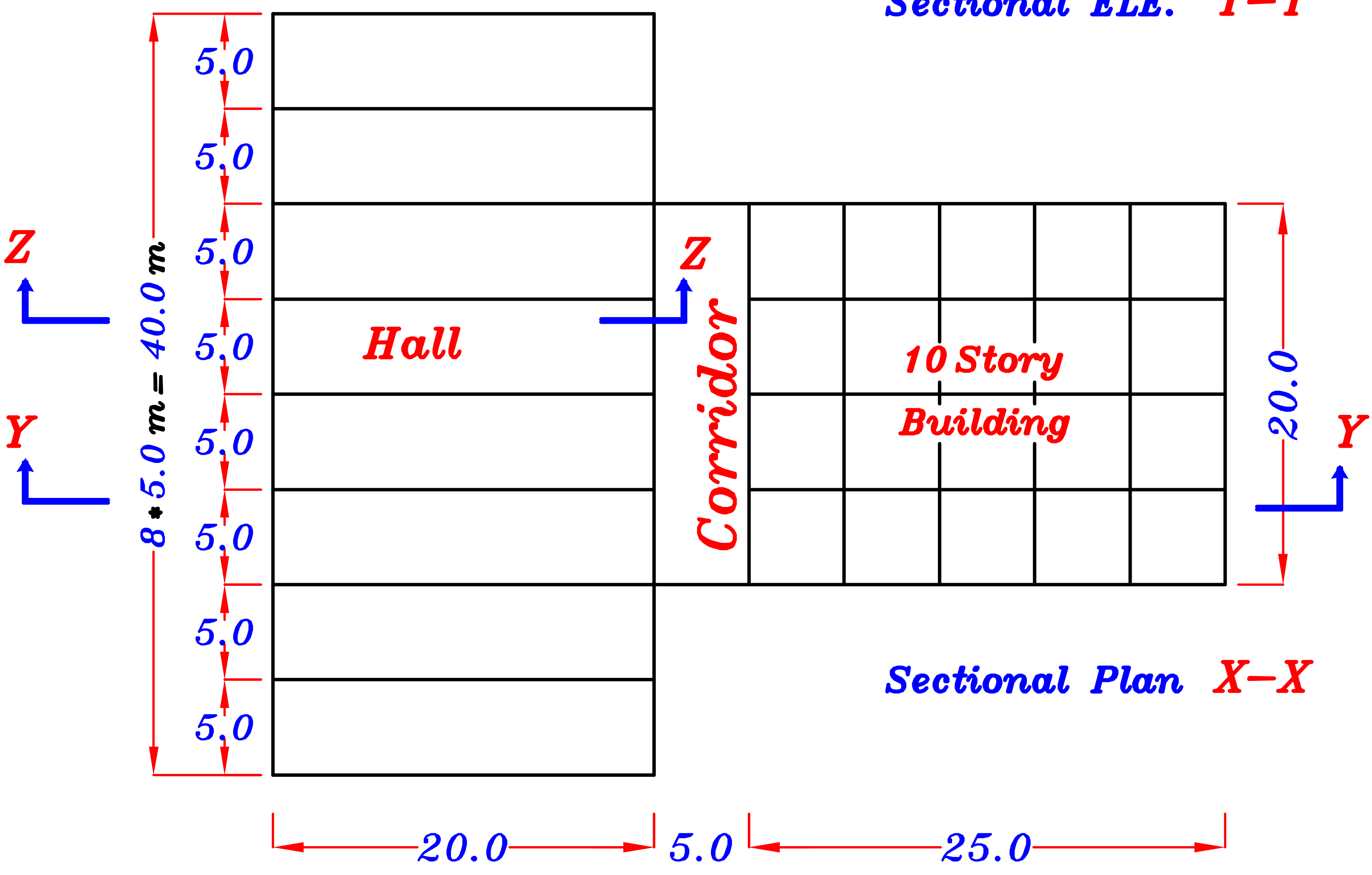

PLAN

Examples on Saw tooth Slab Type.

Example.



Sectional ELE. Y–Y



Sectional Plan X–X

The given sec. plan X–X & Elevation Y–Y show the General layout of ten story building (25*20 m)
which is attached to a hall (20*40 m) through a corridor.
The spacing between the main elements of the hall is 5.0 m
Columns and 25 cm brick walls are placed along the perimeter of the hall is of the Saw Tooth type.

Design Data :

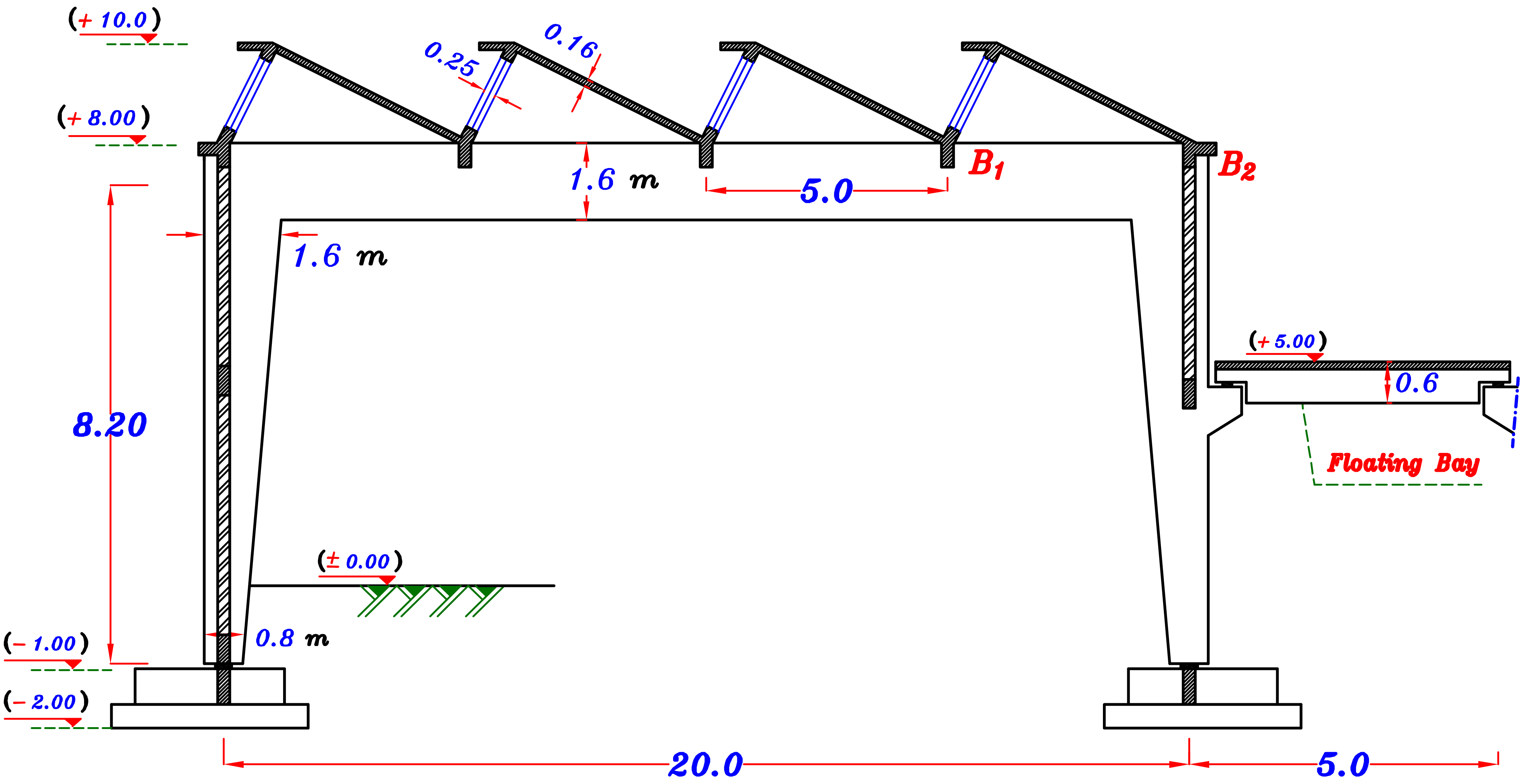
* Total loads (D.L.+L.L.) of the saw tooth roof are 5.0 kN\m^2 H.P.
* $F_{cu} = 25$ N\mm^2 $F_y = 360$ N\mm^2
* $t_s = 160$ mm

Required :

1- Without any calculations, but with reasonably assumed Concrete dimensions, Draw to scale 1:50 sectional elevation Z–Z (For the dotted area L,M,N,O) Showing all concrete elements including Foundations.

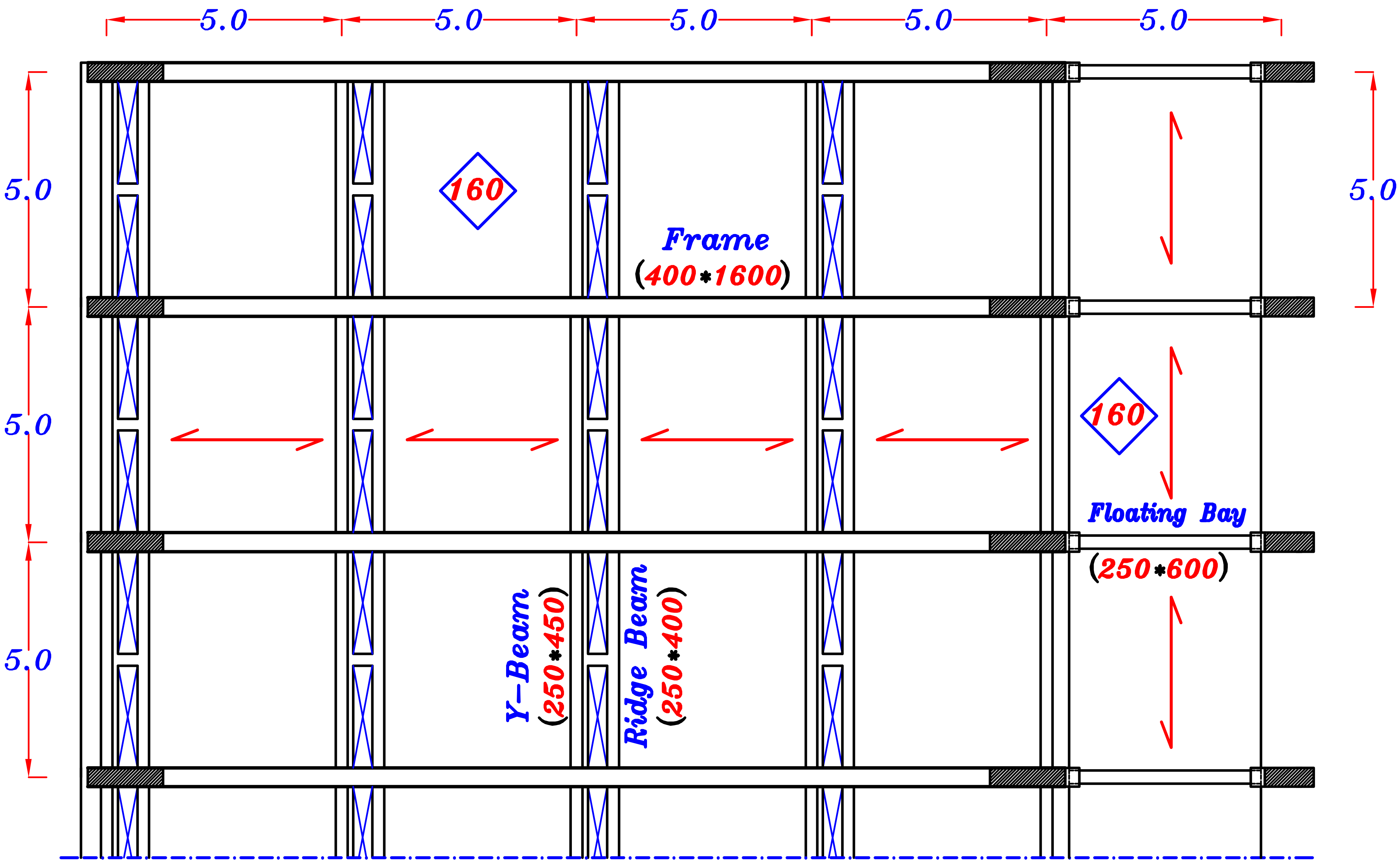
2- Design the saw tooth slab and it's elements.

3- Design one of the intermediate main elements a,b,c,d & e,F and show Details of Reinforcement on sectional elevation to scale 1:50



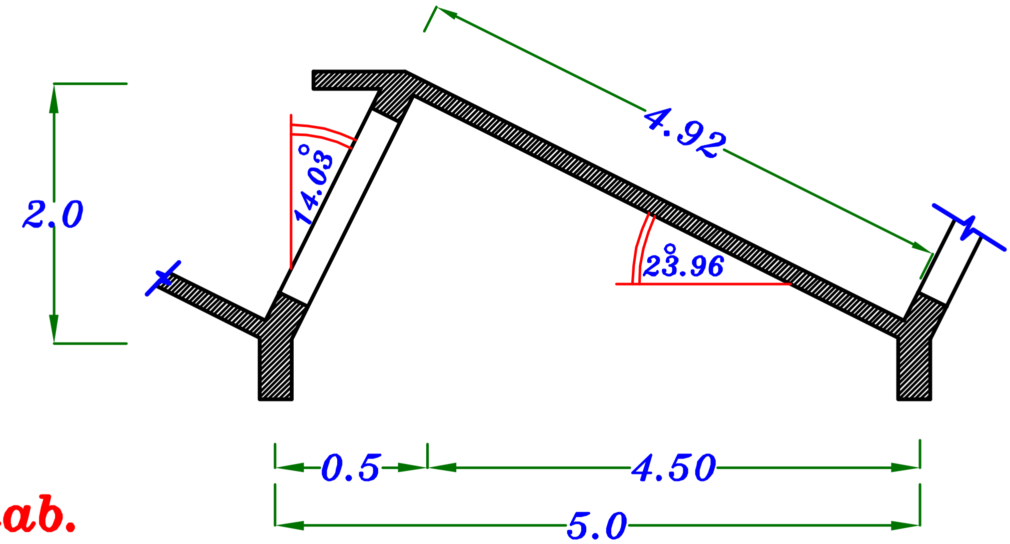
(+ 10.0)
(+ 8.00)
0.25
0.16
1.6 m
5.0
B1
B2
1.6 m
8.20
(+ 5.00)
0.6
Floating Bay
(± 0.00)
0.8 m
(− 1.00)
(− 2.00)
20.0
5.0

ELEVATION


5.0
5.0
5.0
5.0
5.0
5.0
5.0
5.0
5.0
160
Frame
(400*1600)
160
Floating Bay
(250*600)
Y-Beam
(250*450)
Ridge Beam
(250*400)

PLAN

2- Design the Saw Tooth Slab.

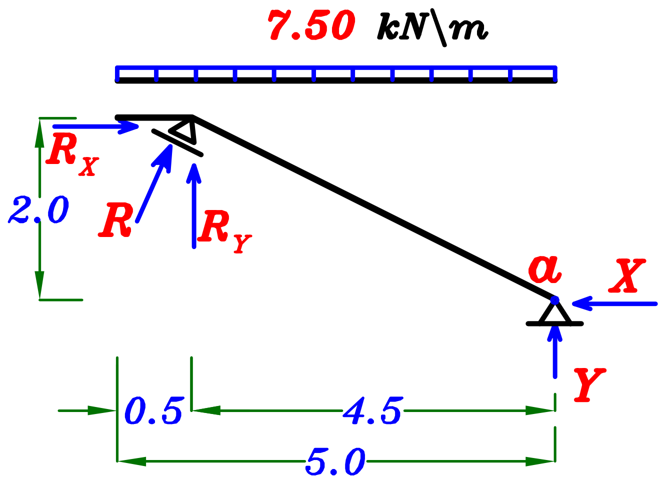


Strip in the Slab.

$(w_s)_{working} = 5.0 \ kN\backslash m^2$ H.P.

$(w_s)_{U.L.} = 1.5 * 5.0$

$= 7.50 \ kN\backslash m^2$ H.P.



$R_Y = R \ Cos \ 14.03^\circ$

$R_X = R \ Sin \ 14.03^\circ$

$\because \sum M_a = Zero$

$\therefore 7.50(5)(2.5) - R \ Cos \ 14.03^\circ (4.5) - R \ Sin \ 14.03^\circ (2.0) = Zero$

$\therefore R = 19.32 \ kN\backslash m`$

$\therefore R_Y = R \ Cos \ \beta = (19.32) \ Cos \ 14.03^\circ = 18.74 \ kN\backslash m`$

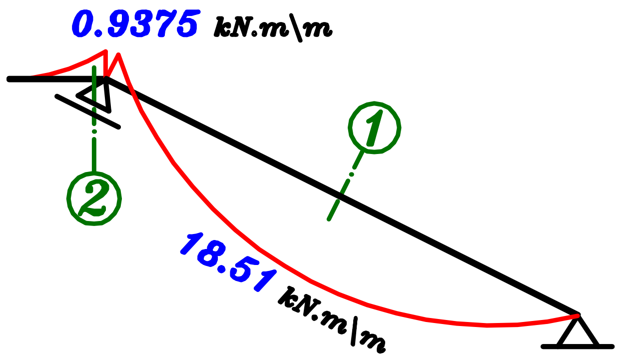
$R_X = R \ Sin \ \beta = (19.32) \ Sin \ 14.03^\circ = 4.68 \ kN\backslash m`$

$X = R_X = 4.68 \ kN\backslash m`$

$Y = 7.50(5) - 18.74 = 18.76 \ kN\backslash m`$

Design the Slab.

$t_s = 160$ mm as ginev in data



Sec. ①

$M_{U.L.} = 18.51$ kN.m\m , $t_s = 160$ mm , $d = 160 - 20 = 140$ mm

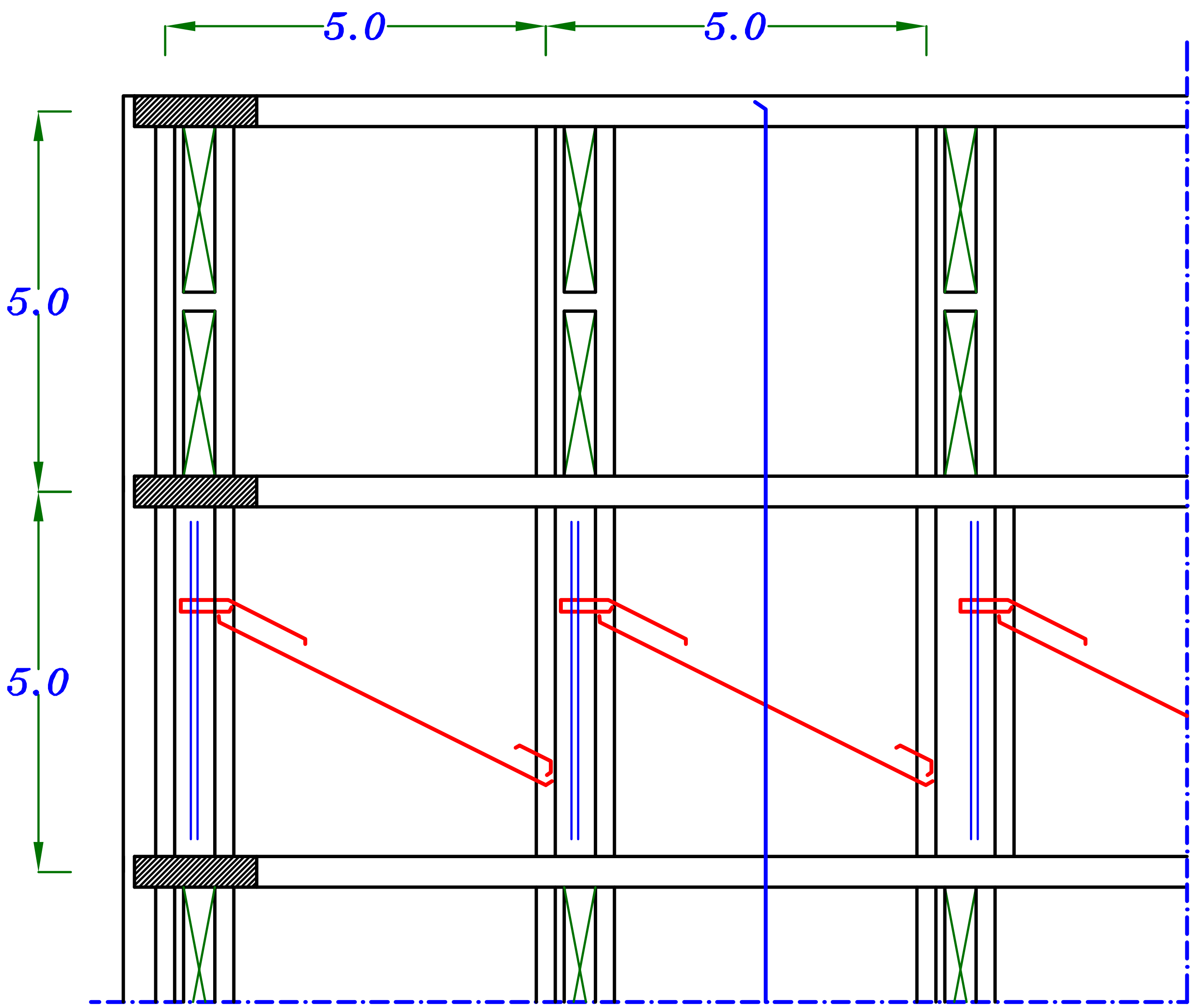
$$140 = C_1 \sqrt{\frac{18.51 * 10^6}{25 * 1000}} \longrightarrow C_1 = 5.14 \longrightarrow J = 0.826$$

$$A_s = \frac{18.51 * 10^6}{0.826 * 360 * 140} = 444 \ mm^2/m'$$

6 Ø 10 \ m'

Sec. ②

5 Ø 10 \ m'



Ridge Beam. (250 * 400)

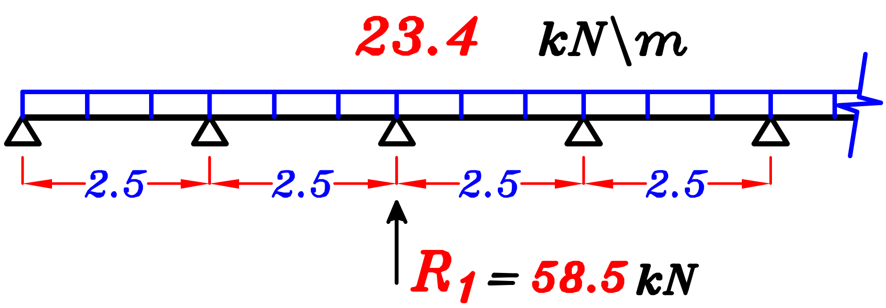
Take Distance between Posts. $a = 2.50$ m.

$$w = R + O.W. * \cos\beta$$

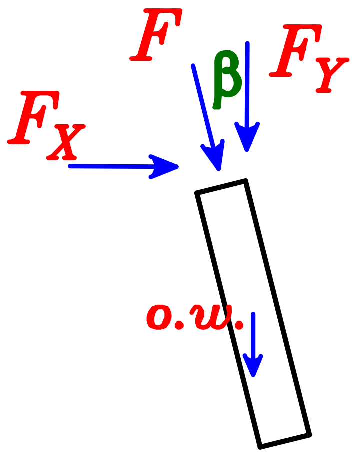
$w = 19.32 + 4.20 * \cos 14.03^\circ = 23.4$ kN\m

$$R_1 = w * a$$

$R_1 = 23.4 * 2.5 = 58.5$ kN



Post. (250*250) 4 ∅ 12



$$F = R_1 + O.W. (Post) * \cos\beta$$

$F = 58.5 + 3.50 * \cos 14.03^\circ = 61.9$ kN

$$F_Y = F * \cos\beta$$

$F_Y = 61.9 * \cos 14.03^\circ = 60.0$ kN

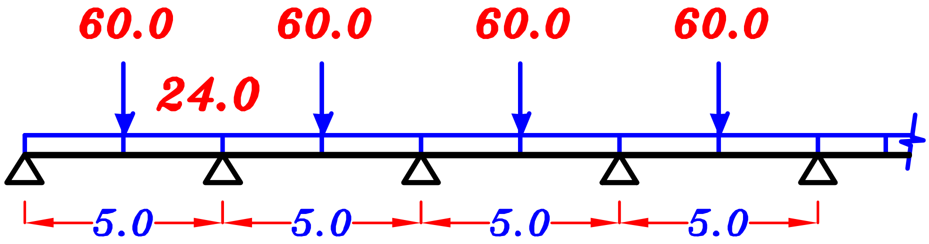
Y–Beam.

Take $t = \frac{Spacing}{12} = \frac{5.0}{12} = 0.41 = 0.45$ m

Take Y–Beam (250*600)

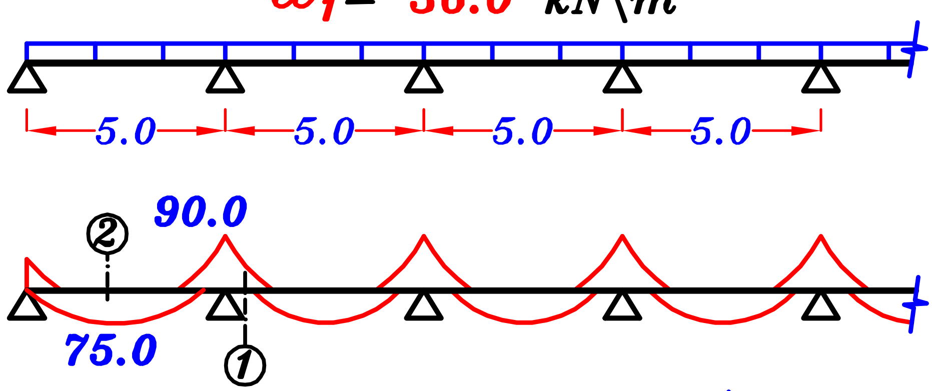
$o.w. = 1.4\, b\, t\, \gamma_c = 1.4 * 0.25 * 0.60 * 25 = 5.25$ kN\m`

$w = o.w.(beam) + Y = 5.25 + 18.76 = 24.0$ kN\m



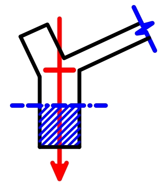
$$w_1 = w + \frac{\sum F_Y \text{ (at one span)}}{Span}$$

$$w_1 = 24.0 + \frac{60.0}{5.0} = 36.0 \text{ kN\\m}$$



Sec. ①

$M_{U.L.} = 90.0$ kN.m R–sec.



$$550 = C_1 \sqrt{\frac{90.0 * 10^6}{25 * 250}} \rightarrow C_1 = 4.58 \rightarrow J = 0.818$$

$$A_s = \frac{90.0 * 10^6}{0.818 * 360 * 550} = 555.6 \text{ mm}^2$$

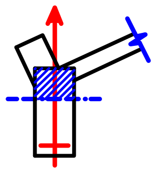
Check $A_{s\,min.}$ $A_{s_{req.}} = 555.6 \; mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 550 = 429.7 \; mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.} b\, d \quad \therefore$ Take $A_s = A_{s_{req.}} = 555.6 \; mm^2$ **3 ϕ16**

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{16 + 25} = 5.48 = 5.0 \text{ bars}$$

Sec. ②

$M_{U.L.} = 75.0 \; kN.m$ R−sec. 

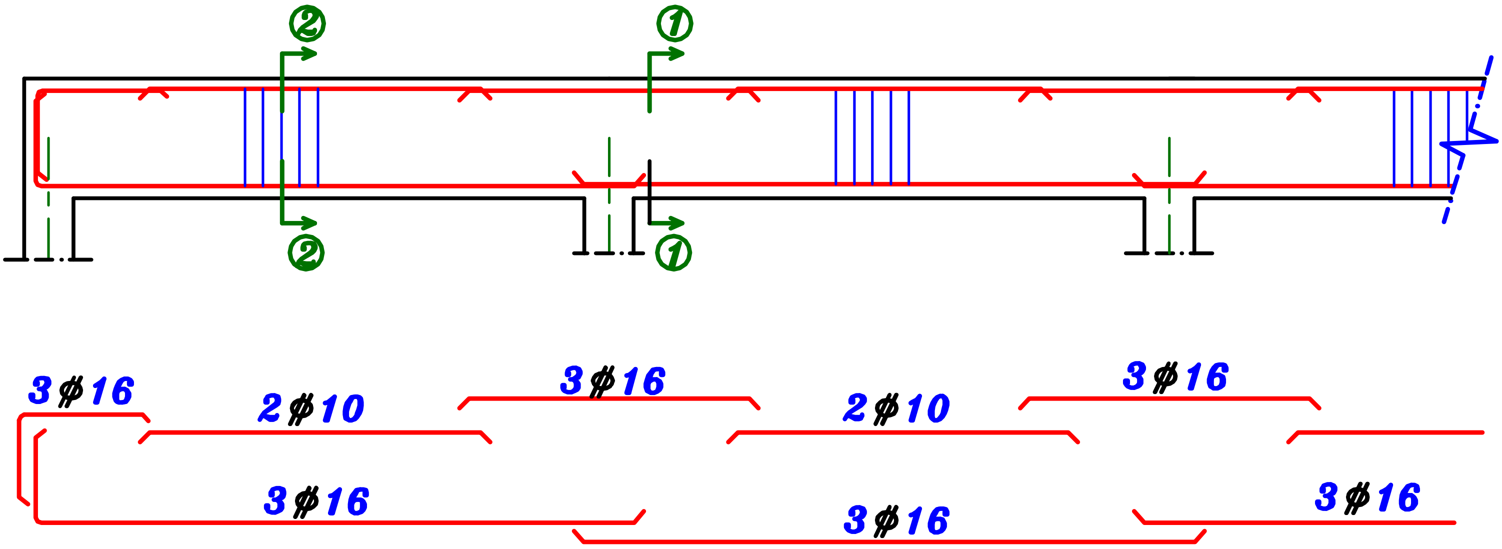
$$550 = C_1 \sqrt{\frac{75.0 * 10^6}{25 * 250}} \rightarrow C_1 = 5.02 \rightarrow J = 0.826$$

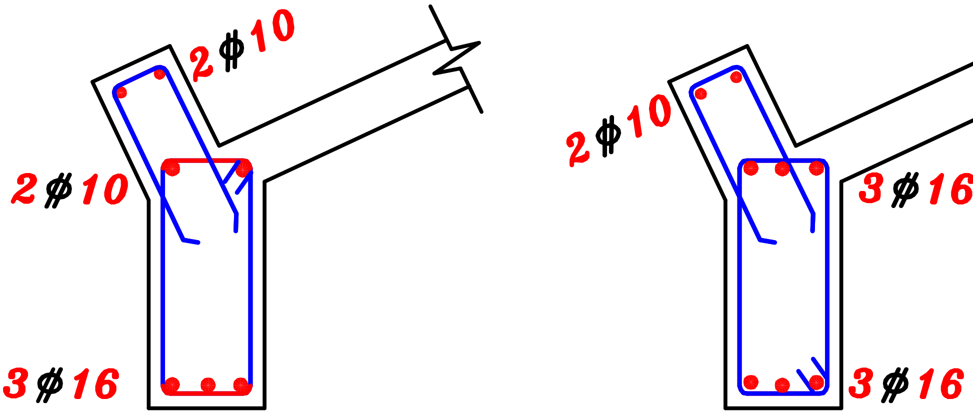
$$A_s = \frac{75.0 * 10^6}{0.826 * 360 * 550} = 458.5 \; mm^2$$

Check $A_{s\,min.}$ $A_{s_{req.}} = 458.5 \; mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 550 = 429.7 \; mm^2$$

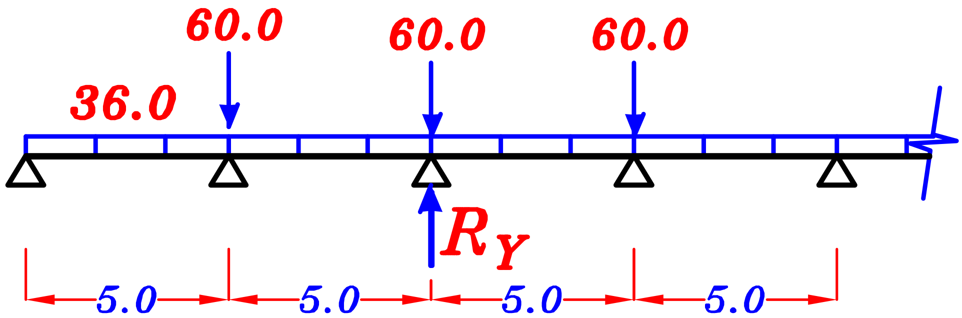
$\therefore A_{s_{req.}} > \mu_{min.} b\, d \quad \therefore$ Take $A_s = A_{s_{req.}} = 458.5 \; mm^2$ **3 ϕ16**





Sec. (2-2) Sec. (1-1)

Reaction of Y-Beam.



$$R_Y = w_1 * S + F_Y$$

$$R_Y = 36.0 * 5.0 + 60.0 = 240.0 \text{ kN}$$

End Beam

VL. Beam $w_{VL.} = O.W. + Y = 7.0 + 18.76 = 25.76$ kN\m

$R_{VL.} = w_{VL.} * S = 25.76 * 5.0 = 128.8$ kN

HL. Beam $w_{HL.} = X = 4.68$ kN\m

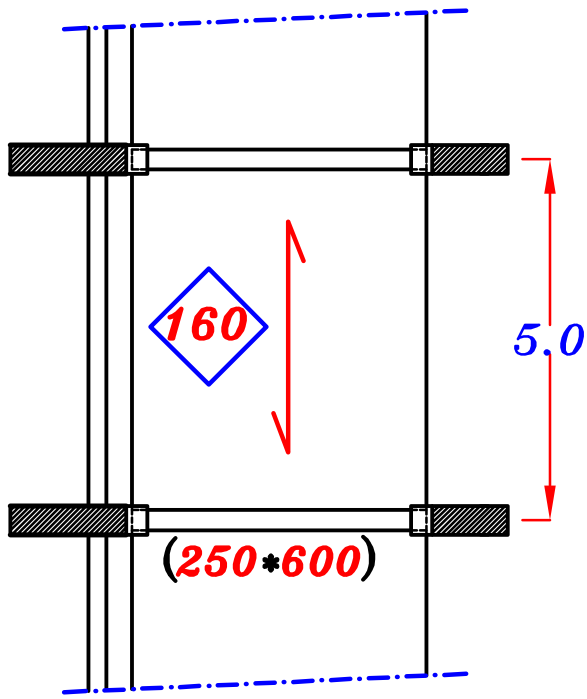
$R_{HL.} = X * S = 4.68 * 5.0 = 23.4$ kN

Floating Bay. (250*600)

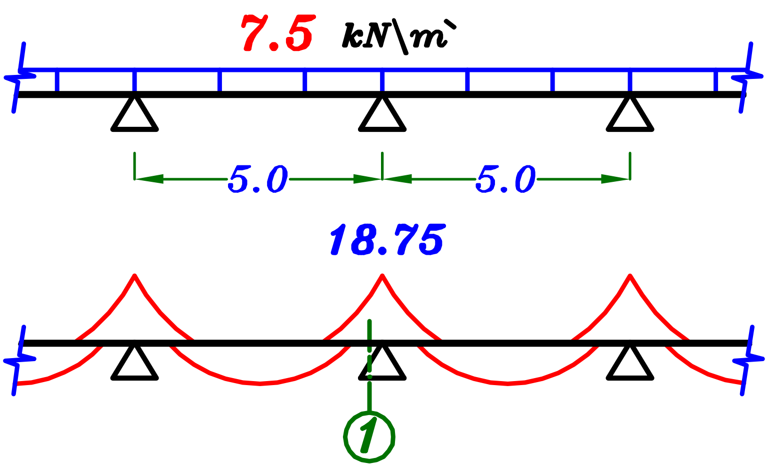
$$t_s = \frac{5000}{30} = 166 \text{ mm}$$

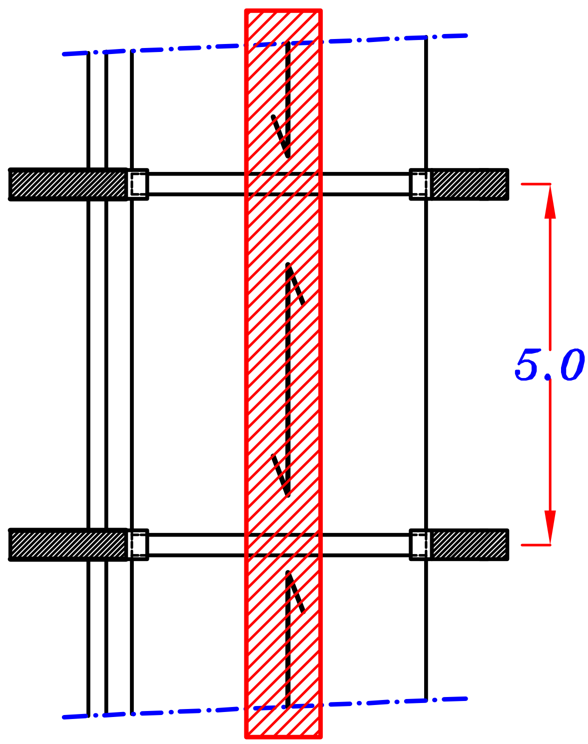
$$\boxed{t_s = 160 \text{ mm}}$$

$$(w_s)_{U.L.} = 1.5 * 5.0 = 7.50 \text{ kN}\backslash m^2$$



Design the slab.





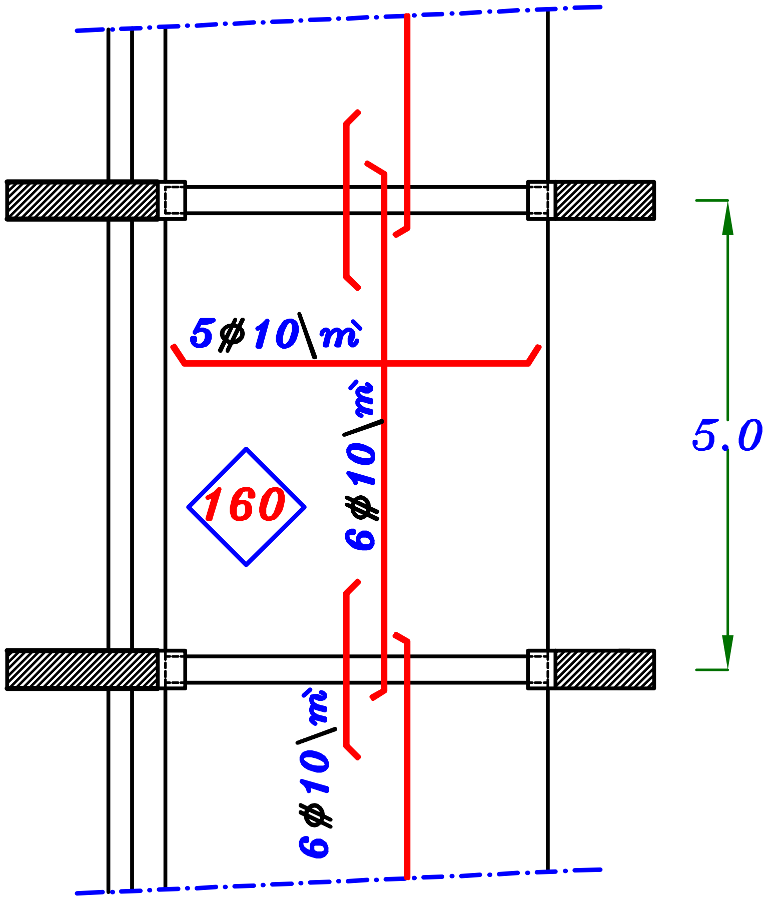
Sec. ① $M_{U.L.} = 18.75$ kN.m\m

$$140 = C_1 \sqrt{\frac{18.75 * 10^6}{25 * 1000}} \longrightarrow C_1 = 5.11$$

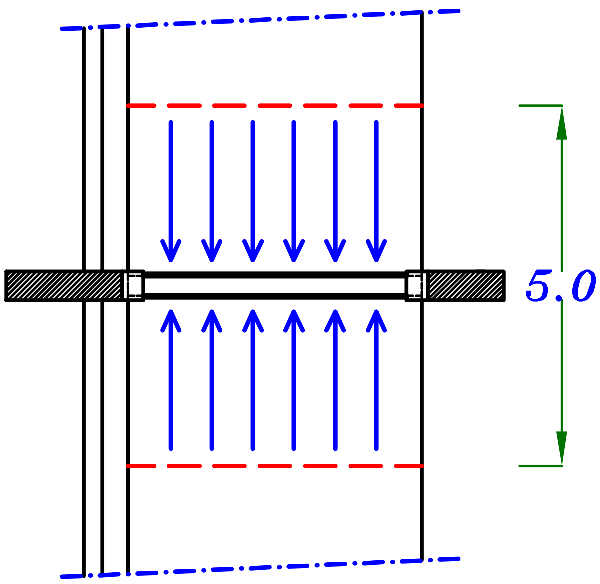
$$\longrightarrow J = 0.826$$

$$A_s = \frac{18.75 * 10^6}{0.826 * 360 * 140} = 450 \text{ mm}^2/\text{m}$$

6 Ø 10 \m`

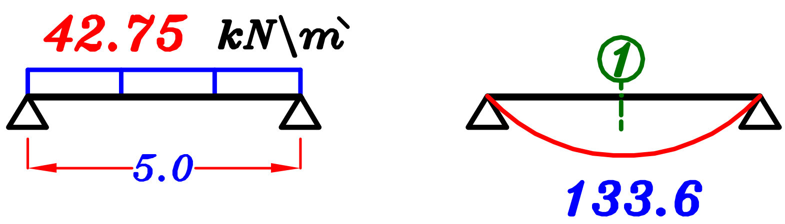


Design the Floating Bay.



$$o.w. = 1.4\, b\, t\, \gamma_c = 1.4 * 0.25 * 0.60 * 25 = 5.25 \ kN\backslash m`$$

$$w = o.w. + 2\, w_s \frac{L_s}{2} = 5.25 + 2\,(7.50)\left(\frac{5.0}{2}\right) = 42.75 \ kN\backslash m`$$



Sec. ① $M_{U.L.} = 133.6$ kN.m T-sec.

$$B = \begin{cases} C.L.-C.L. = 5.0\ m = 5000\ mm \\ 16\ t_s + b = 16*160+250 = 2810\ mm \\ K\ \frac{L}{5} + b = 1.0*\frac{5000}{5} + 250 = 1250\ mm \end{cases}$$

$B = 1250\ mm$

$$550 = C_1\sqrt{\frac{133.6*10^6}{25*1250}} \longrightarrow C_1 = 8.41 \longrightarrow J = 0.826$$

$$A_s = \frac{133.6*10^6}{0.826*360*550} = 816.9\ mm^2$$

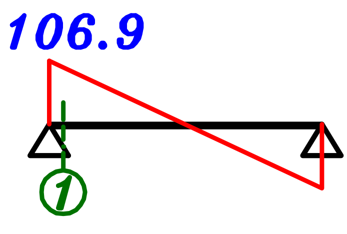
Check $A_{s\,min.}$ $A_{s_{req.}} = 816.9\ mm^2$

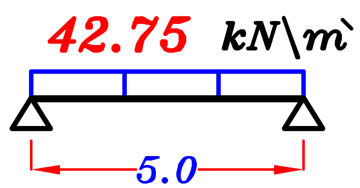
$$\mu_{min.}\ b\ d = \left(0.225*\frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225*\frac{\sqrt{25}}{360}\right) 250*550 = 429.7\ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\ b\ d$ $\therefore$ Take $A_s = A_{s_{req.}} = 816.9\ mm^2$ $5\phi16$

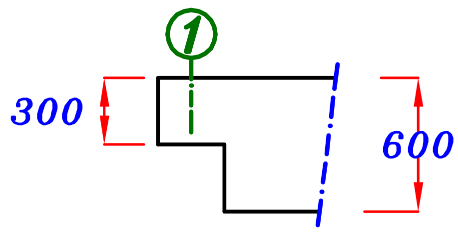
$$\therefore n = \frac{b-25}{\phi+25} = \frac{250-25}{16+25} = 5.48 = 5.0\ \text{bars}$$

Check Shear.





Sec. ①



$$q_{cu} = (0.24)\sqrt{\frac{25}{1.50}} = 0.98\ N\backslash mm^2$$

$$q_{u_{max}} = (0.70)\sqrt{\frac{25}{1.50}} = 2.85\ N\backslash mm^2$$

$$q_u = \frac{Q_{max}}{b\ d} = \frac{106.9*10^3}{250*250} = 1.71\ N\backslash mm^2$$

$\therefore\ q_{cu} < q_U < q_{max.}$ $\therefore$ We need Stirrups more Than $5\phi 8\backslash m'$

$\therefore$ Use $q_s = q_u - \frac{q_{cu}}{2} = \frac{n A_s (F_y \backslash \gamma_s)}{b \quad S}$

* Take $n = 2$, $\phi\ 8 \longrightarrow A_s = 50.3\ mm^2$

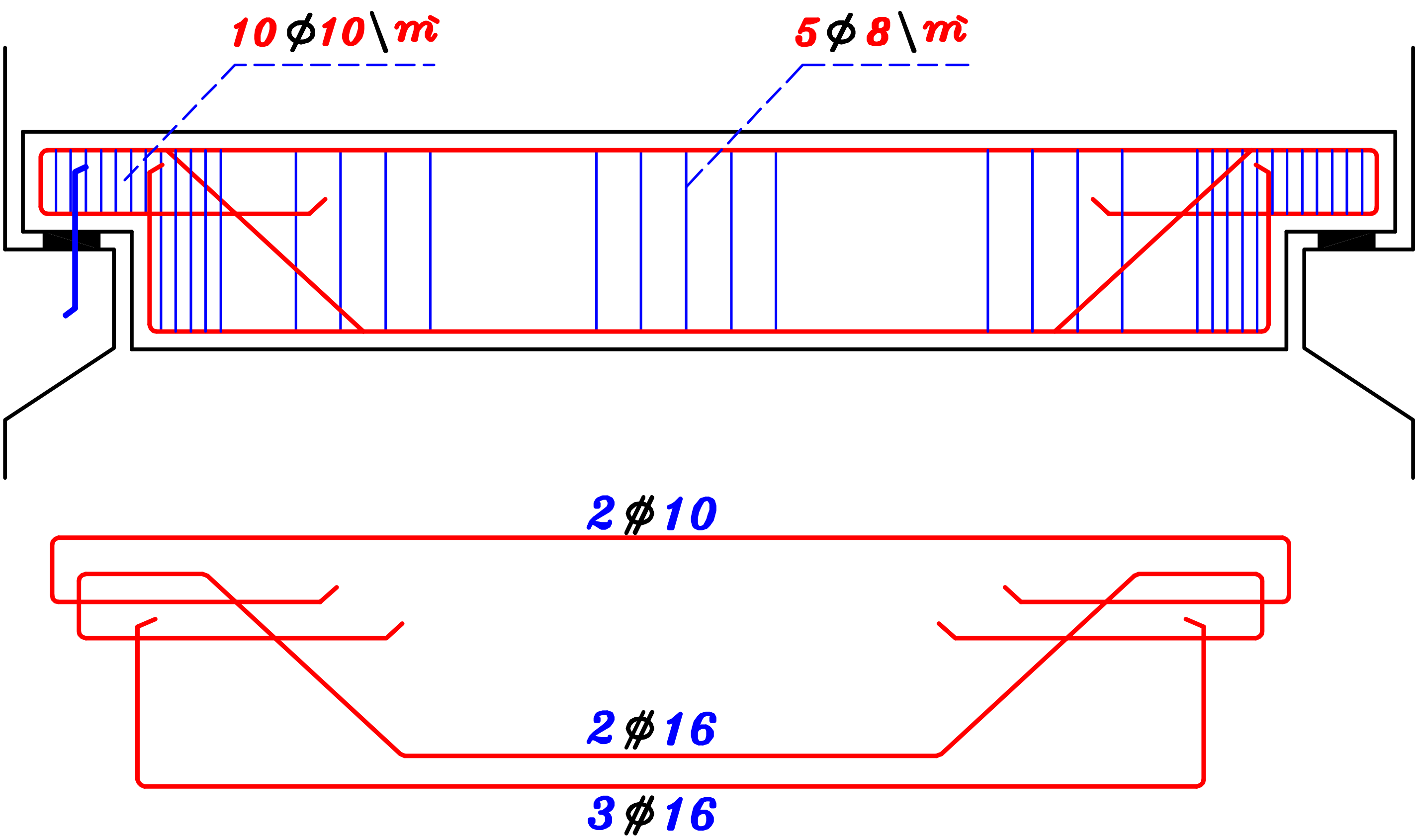
$$1.71 - \frac{0.98}{2} = \frac{2 * 50.3\ (240 \backslash 1.15)}{250 * S} \longrightarrow S = 68.8\ mm < 100\ mm$$

* Take $n = 2$, $\phi\ 10 \longrightarrow A_s = 78.5\ mm^2$

$$1.71 - \frac{0.98}{2} = \frac{2 * 78.5\ (240 \backslash 1.15)}{250 * S} \longrightarrow S = 107.4\ mm > 100\ mm \therefore o.k.$$

$\therefore$ No. of stirrups$\backslash m' = \frac{1000}{S} = \frac{1000}{107.4} = 9.30 = 10\backslash m'$

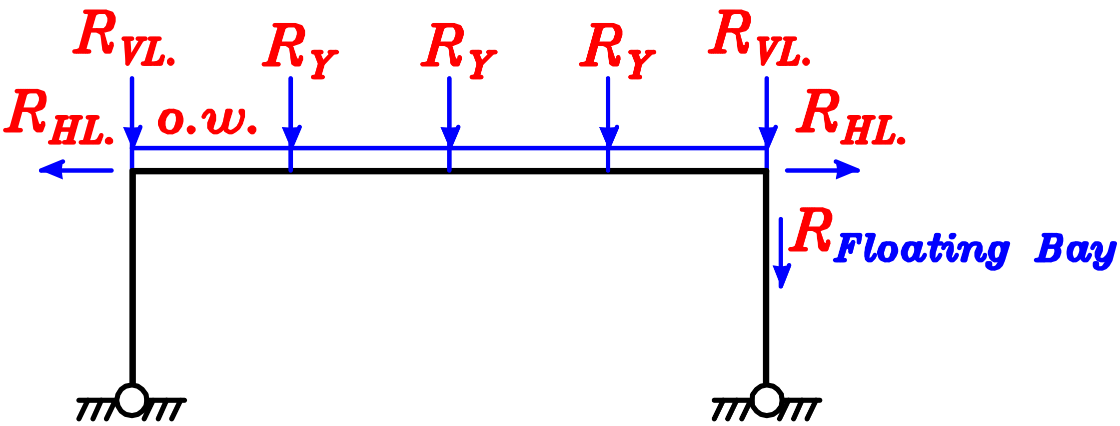
$\therefore$ Use Stirrups $\boxed{10\phi 10\backslash m'}$ 2 branches

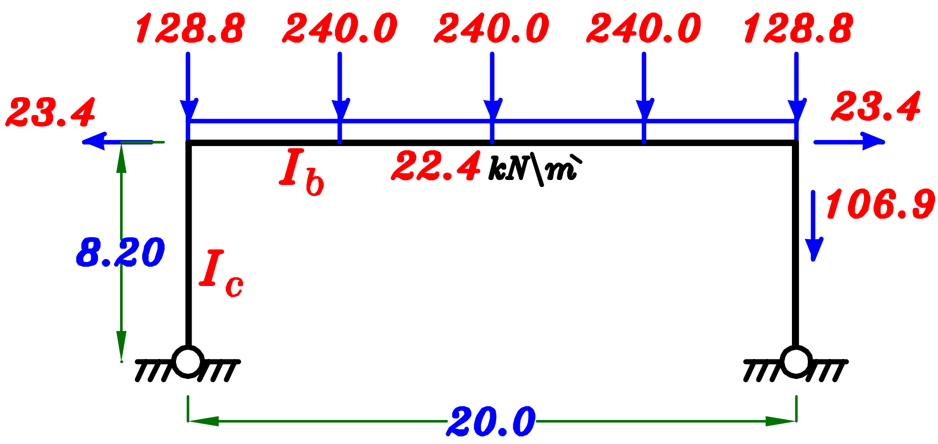


Design the Frame.

Loads on Frame.

$o.w. = 1.4\, b\, t\, \gamma_c = 1.4 * 0.40 * 1.60 * 25 = 22.4$ kN\m`

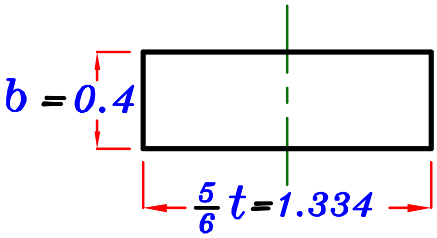




Solve the Frame using Moment Distribution.

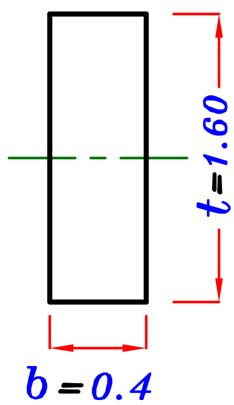
I_c

$$I_c = \frac{b\left(\frac{5}{6}t\right)^3}{12} = \frac{0.4\left(\frac{5}{6}*1.6\right)^3}{12} = 0.0790\ m^4$$



I_b

$$I_b = \frac{b*t^3}{12} = \frac{0.4(1.6)^3}{12} = 0.1365\ m^4$$



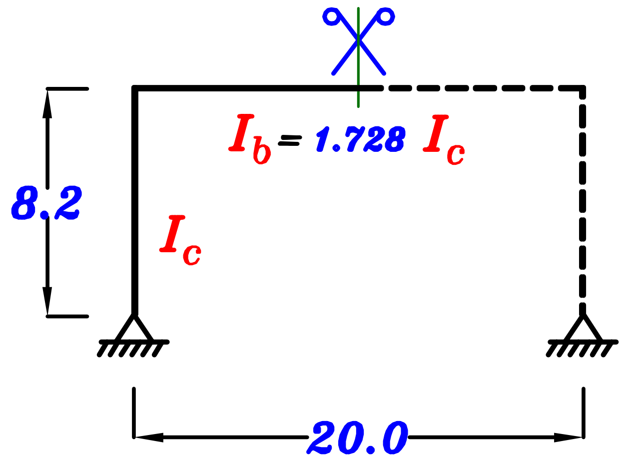
$$\therefore\ I_b = 1.728\ I_c$$

D.F.

$$K_c = \frac{3}{4} * \frac{I_c}{h} = \frac{3}{4} * \frac{I_c}{8.2} = 0.0915\ I_c$$

$$K_b = \frac{1}{2}\ \frac{I_b}{L} = \frac{1}{2} * \frac{1.728\ I_c}{20} = 0.0432\ I_c$$

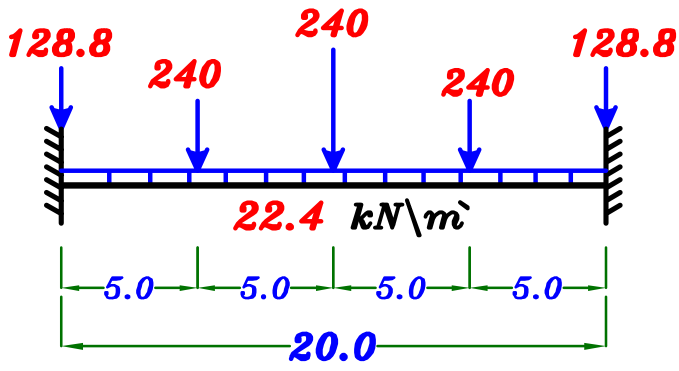
$$D.F._{(Col.)} = \frac{0.0915}{0.0915 + 0.0432} = 0.68$$

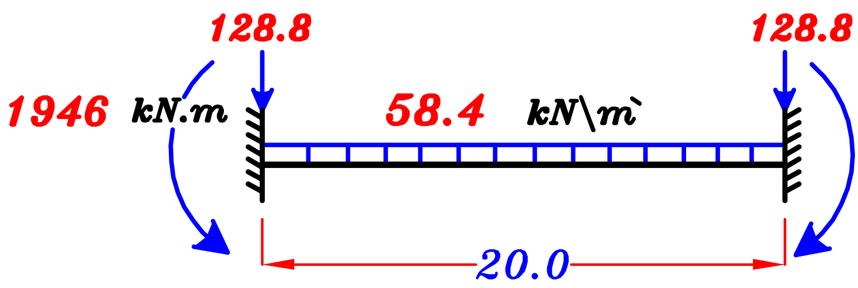


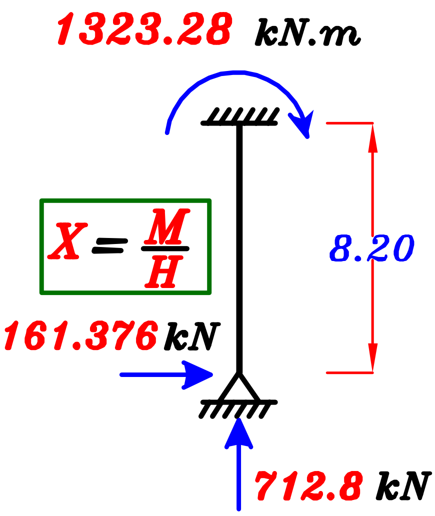
F.E.M.

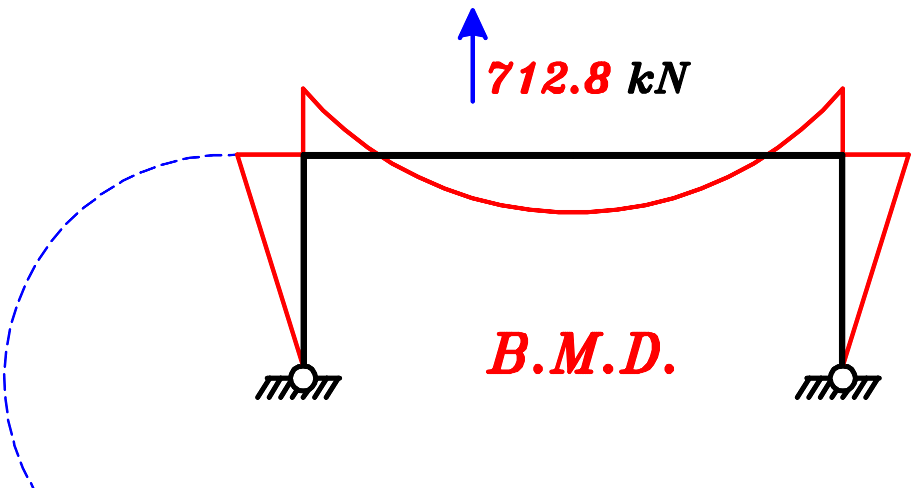
$$W = 22.4 + \frac{3\ (240)}{20} = 58.4\ kN\backslash m$$

$$F.E.M. = \frac{58.4 * 20^2}{12} = 1946\ kN.m$$

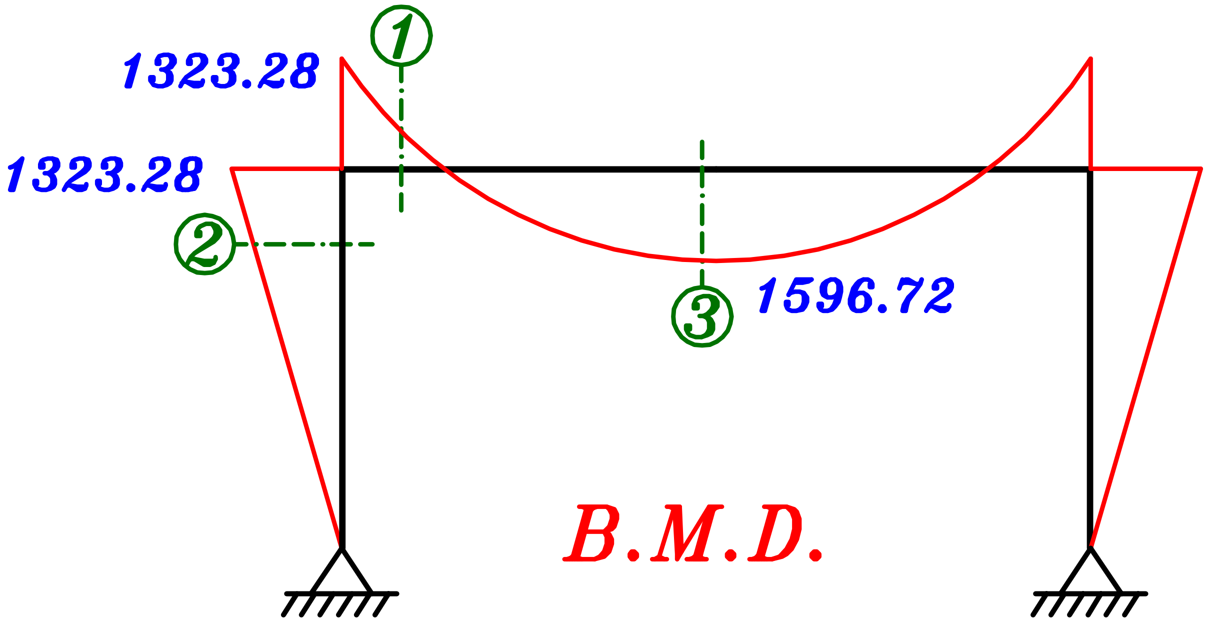




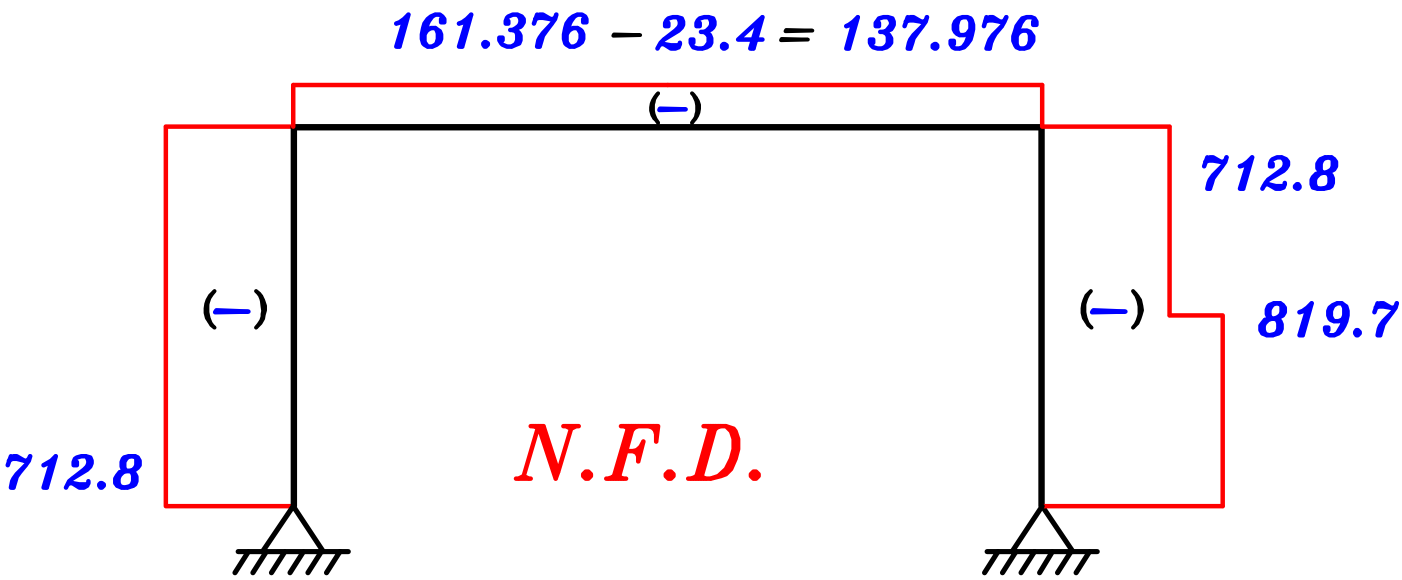




$$F.E.M._{(Beam)} * D.F._{(Col.)} = 1946 * 0.68 = 1323.28\ kN.m$$



1323.28
1323.28
1
2
3
1596.72
B.M.D.



161.376 − 23.4 = 137.976
(−)
712.8
(−)
(−)
819.7
712.8
N.F.D.

Design of Sections.

Sec. ① R–Sec.

$M = 1323.28$ kN.m , $P = 137.976$ kN , $b = 0.4$ m , $t = 1.60$ m

Check $\frac{P}{F_{cu}\, b t} = \frac{137.976 * 10^3}{25 * 400 * 1600} = 0.0086 < 0.04$ (neglect P)

$\therefore 1500 = C_1 \sqrt{\frac{1323.28 * 10^6}{25 * 400}} \longrightarrow C_1 = 4.12 \longrightarrow J = 0.808$

$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{1323.28 * 10^6}{0.808 * 360 * 1500} = 3033\ mm^2$

Check $A_{s\,min.}$ $\quad A_{s_{req.}} = 3033\ mm^2$

$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 400 * 1500 = 1875\ mm^2$

$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d \quad \therefore$ Take $A_s = A_{s_{req.}} = 3033\ mm^2$ $\quad$ **12ϕ18**

$\therefore n = \frac{b - 25}{\phi + 25} = \frac{400 - 25}{18 + 25} = 8.70 = 8.0$ bars

---

Sec. ② R–Sec.

Neglect effect of Buckling.

$M = 1323.28$ kN.m , $P = 712.8$ kN

Check $\frac{P}{F_{cu}\, b t} = \frac{712.8 * 10^3}{25 * 400 * 1600} = 0.0445 > 0.04$ (Don't neglect P)

$e = \frac{M}{P} = \frac{1323.28}{712.8} = 1.86\ m \quad \therefore \frac{e}{t} = \frac{1.86}{1.60} = 1.16 > 0.5 \xrightarrow{use} e_s$

$e_s = e + \frac{t}{2} - c = 1.86 + \frac{1.6}{2} - 0.1 = 2.56\ m$

$M_s = P * e_s = 712.8 * 2.56 = 1824.8$ kN.m

$$\therefore 1500 = C_1 \sqrt{\frac{1824.8 * 10^6}{25 * 400}} \longrightarrow C_1 = 3.51 \longrightarrow J = 0.782$$

$$\therefore A_s = \frac{M_s}{J\, F_y\, d} - \frac{P_{U.L.}}{(F_y \backslash \gamma_s)} = \frac{1824.8 * 10^6}{0.782 * 360 * 1500} - \frac{712.8 * 10^3}{(360 \backslash 1.15)}$$

$$= 2044.3 \ mm^2$$

Check $A_{s_{min.}}$ $\qquad A_{s\,req.} = 2044.3 \ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 400 * 1500 = 1875 \ mm^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d \quad \therefore \text{Take } A_s = A_{s_{req.}} = 2044.3 \ mm^2$$

$9 \phi 18$

Sec. ③ R–Sec.

$M = 1596.72\ kN.m$, $P = 137.976\ kN$, $b = 0.4\ m$, $t = 1.60\ m$

Check $\frac{P}{F_{cu}\, b\, t} = \frac{137.976 * 10^3}{25 * 400 * 1600} = 0.0086 < 0.04$ (neglect P)

$$\therefore 1500 = C_1 \sqrt{\frac{1596.72 * 10^6}{25 * 400}} \longrightarrow C_1 = 3.75 \longrightarrow J = 0.794$$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{1596.72 * 10^6}{0.794 * 360 * 1500} = 3724 \ mm^2$$

Check $A_{s_{min.}}$ $\qquad A_{s_{req.}} = 3724 \ mm^2$

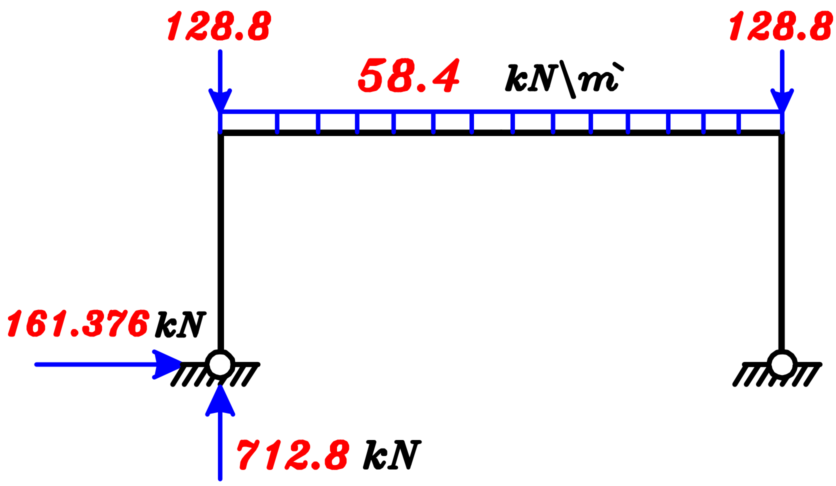
$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 400 * 1500 = 1875 \ mm^2$$

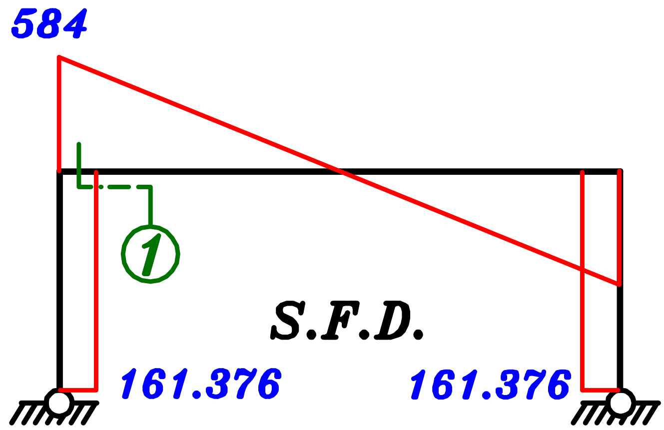
$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d \quad \therefore \text{Take } A_s = A_{s_{req.}} = 3724 \ mm^2$$

$10 \phi 22$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{400 - 25}{22 + 25} = 8.70 = 8.0 \text{ bars}$$

Check Shear.





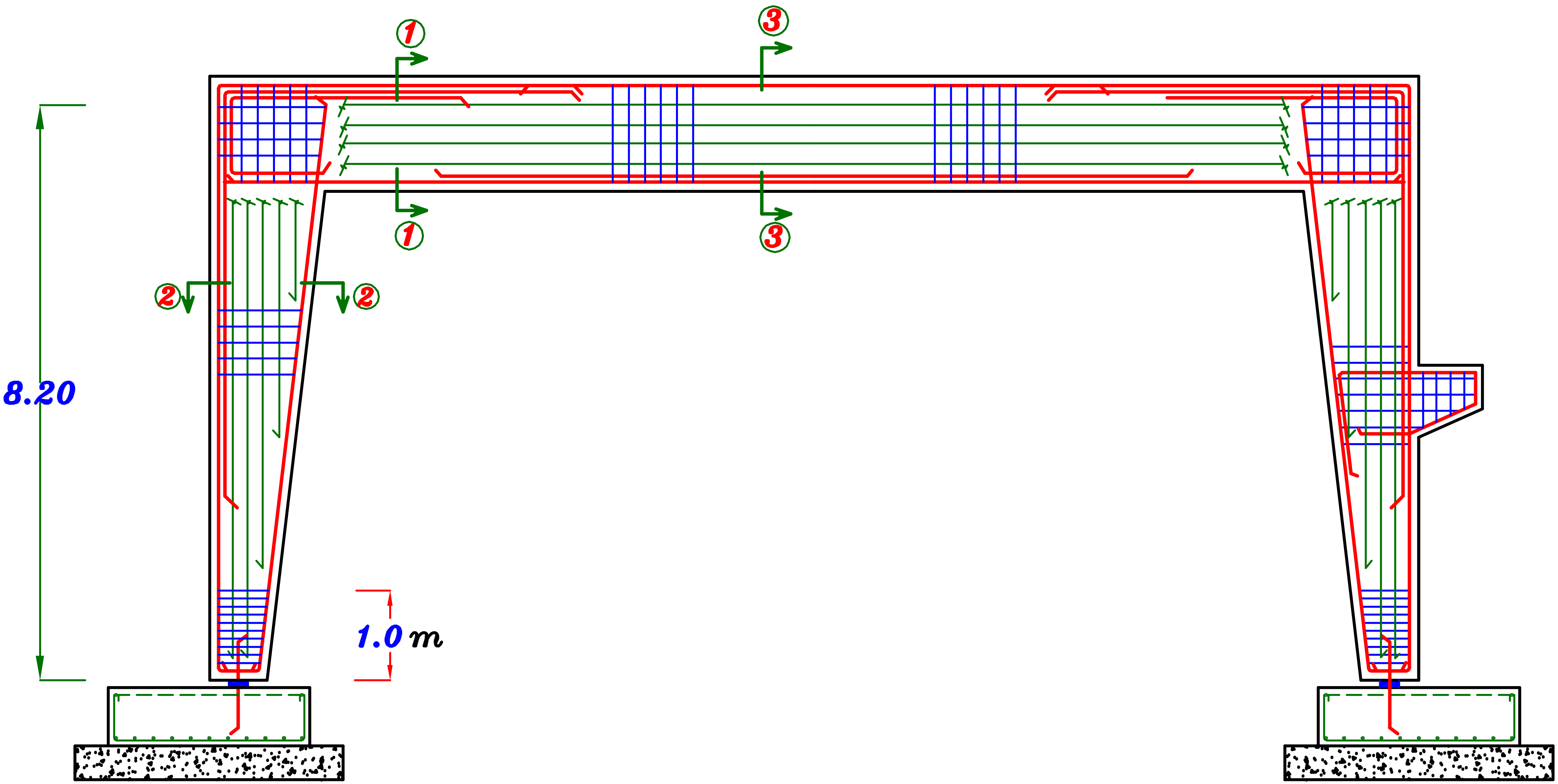
Sec. ①

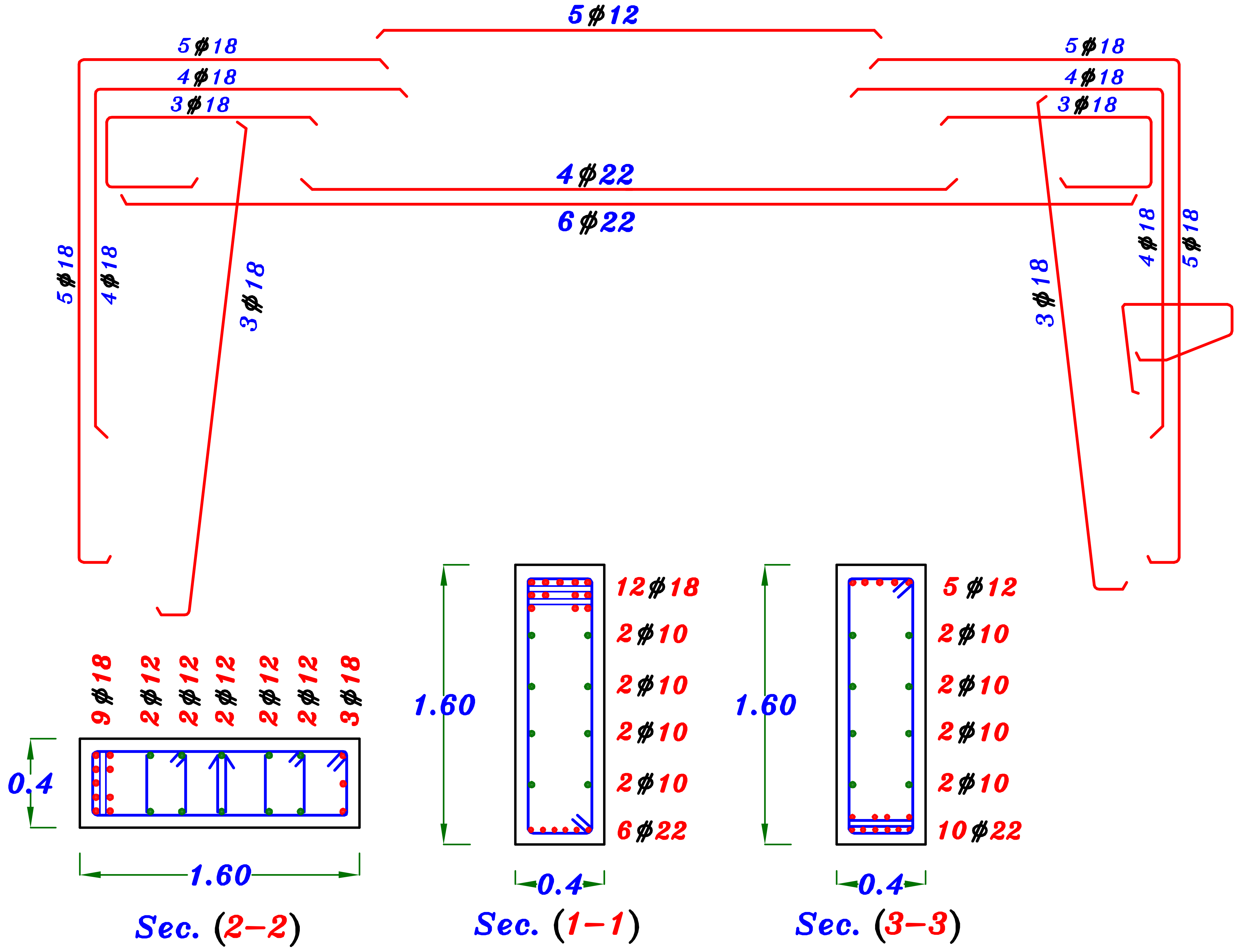
$$q_{cu} = (0.24)\sqrt{\frac{25}{1.50}} = 0.98 \quad N\backslash mm^2$$

$$q_{u_{max}} = (0.70)\sqrt{\frac{25}{1.50}} = 2.85 \quad N\backslash mm^2$$

$$q_u = \frac{Q_{max}}{b\,d} = \frac{584 * 10^3}{400 * 1500} = 0.97 \quad N\backslash mm^2 \qquad \because \; q_u < q_{cu}$$

$\therefore$ Use min. Shear RFT. $5\phi8\backslash m$`


1
1
3
3
2
2
8.20
1.0 m



5 ϕ 12
5 ϕ 18
4 ϕ 18
3 ϕ 18
4 ϕ 22
6 ϕ 22
5 ϕ 18
4 ϕ 18
3 ϕ 18
3 ϕ 18
3 ϕ 18
4 ϕ 18
5 ϕ 18
9 ϕ 18
2 ϕ 12
2 ϕ 12
2 ϕ 12
2 ϕ 12
2 ϕ 12
3 ϕ 18
0.4
1.60
Sec. (2-2)
1.60
12 ϕ 18
2 ϕ 10
2 ϕ 10
2 ϕ 10
2 ϕ 10
6 ϕ 22
0.4
Sec. (1-1)
1.60
5 ϕ 12
2 ϕ 10
2 ϕ 10
2 ϕ 10
2 ϕ 10
10 ϕ 22
0.4
Sec. (3-3)