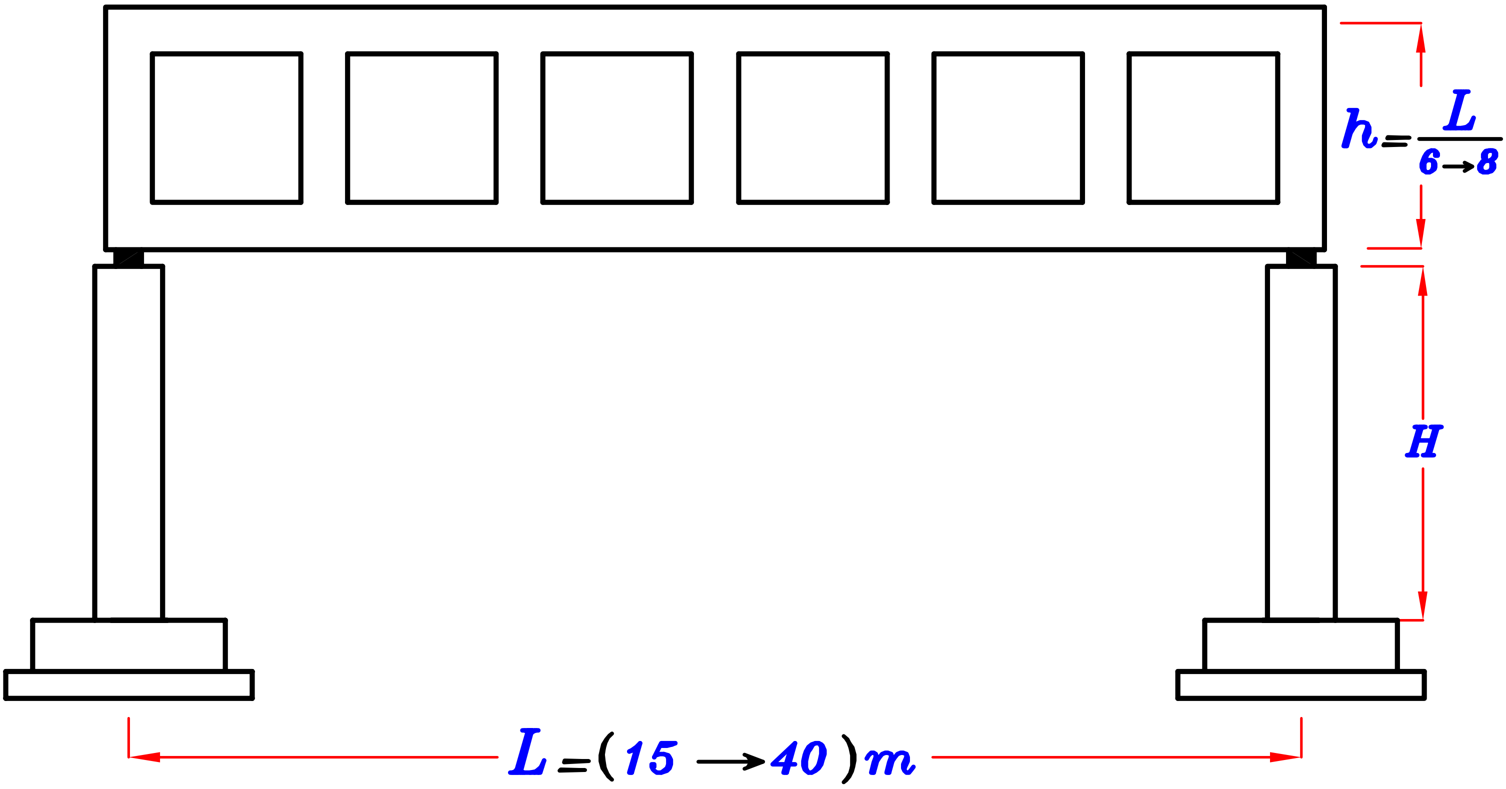
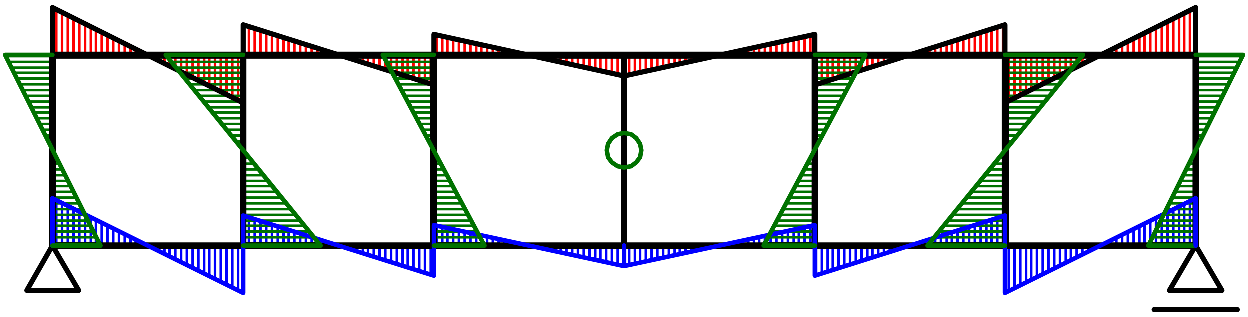
Vierendeel.

Vierendeel. Table of Contents.

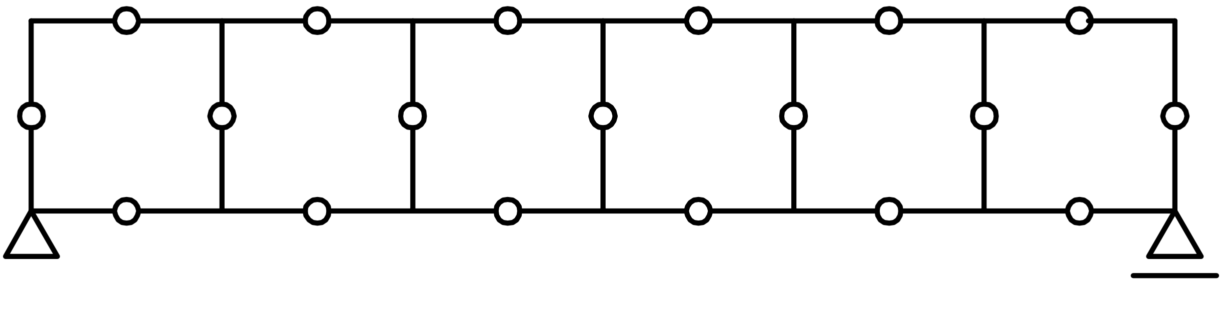
Introduction.



B.M.D.

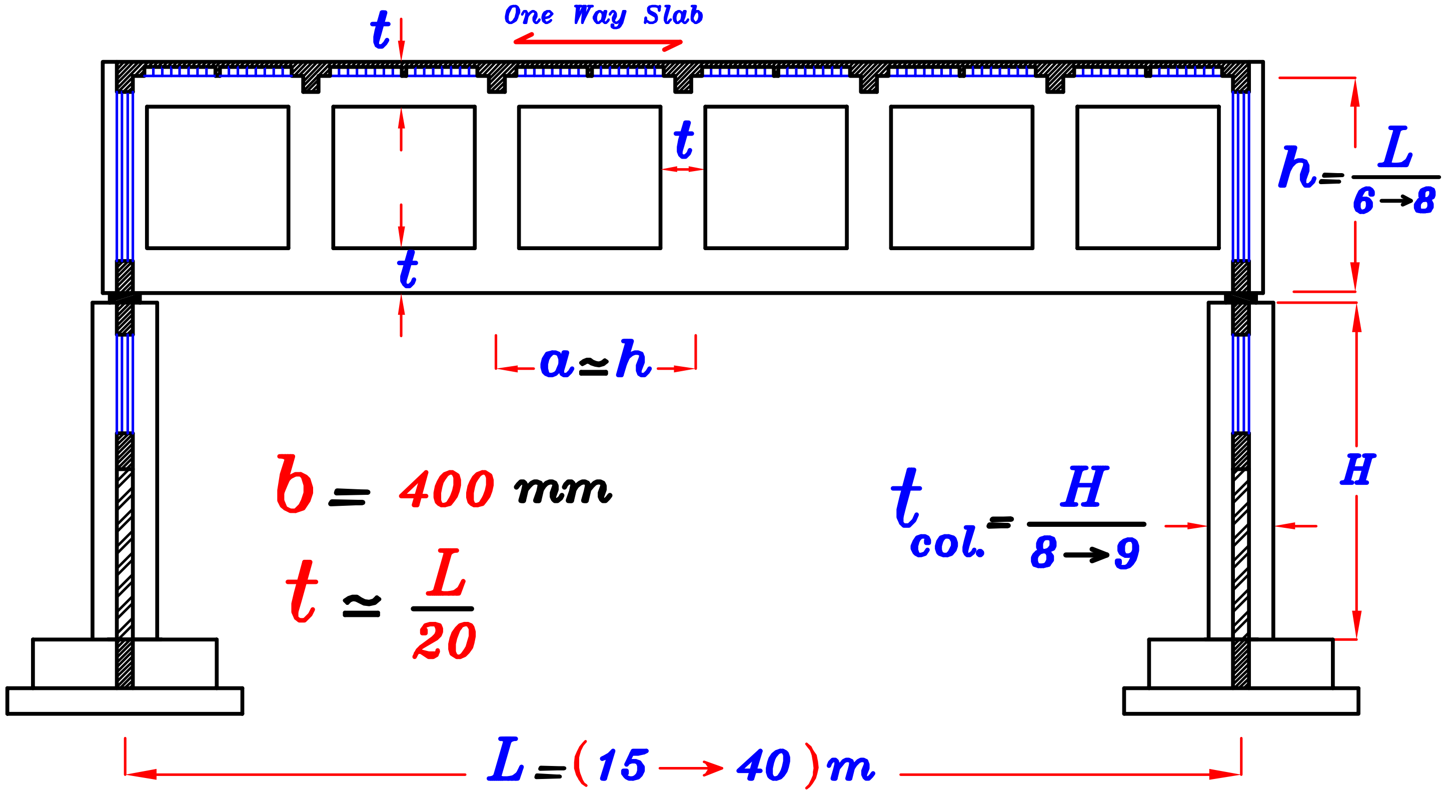


Statical System.



Concrete Dimensions.

يحمل سقف واحد

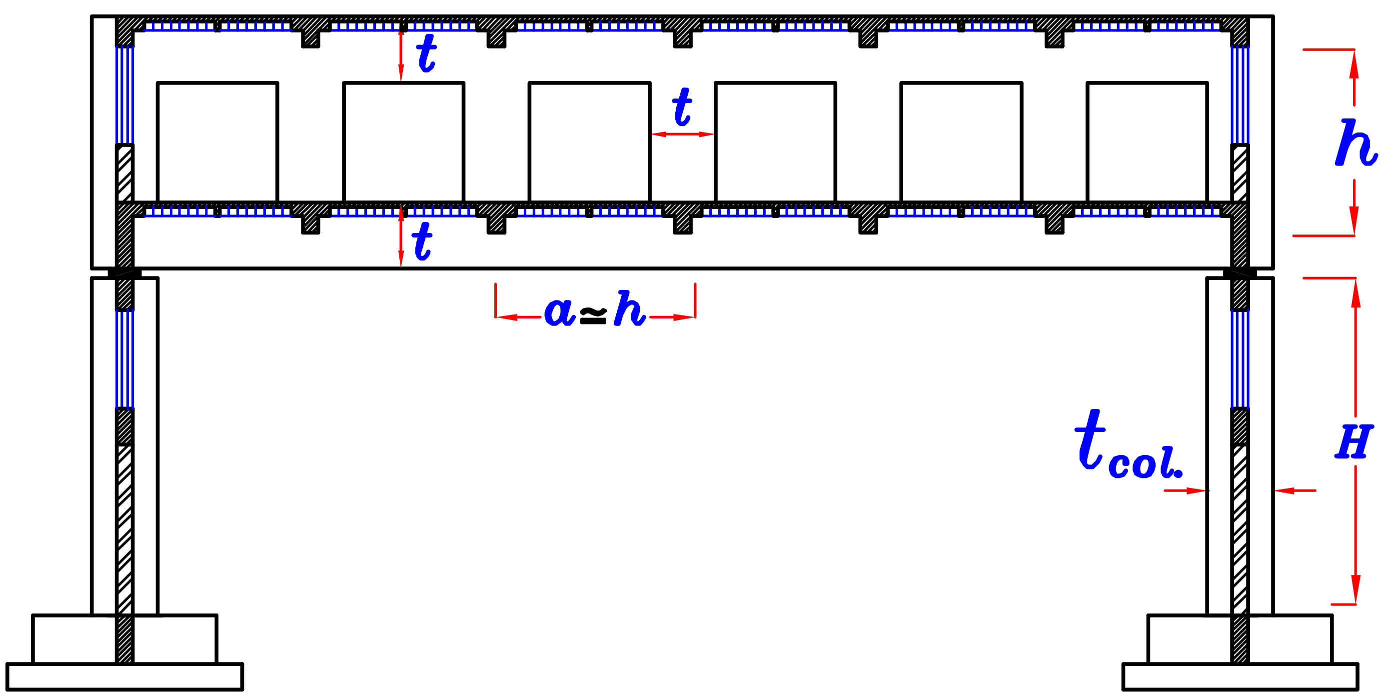


$b = 400\ mm$

$t \simeq \frac{L}{20}$

$t_{col.} = \frac{H}{8 \rightarrow 9}$

يحمل عده أدوار



$b = 600\ mm$

$t_{(Vierendeel)} \simeq \frac{L}{10 \rightarrow 12}$

$h =$ Floor Height

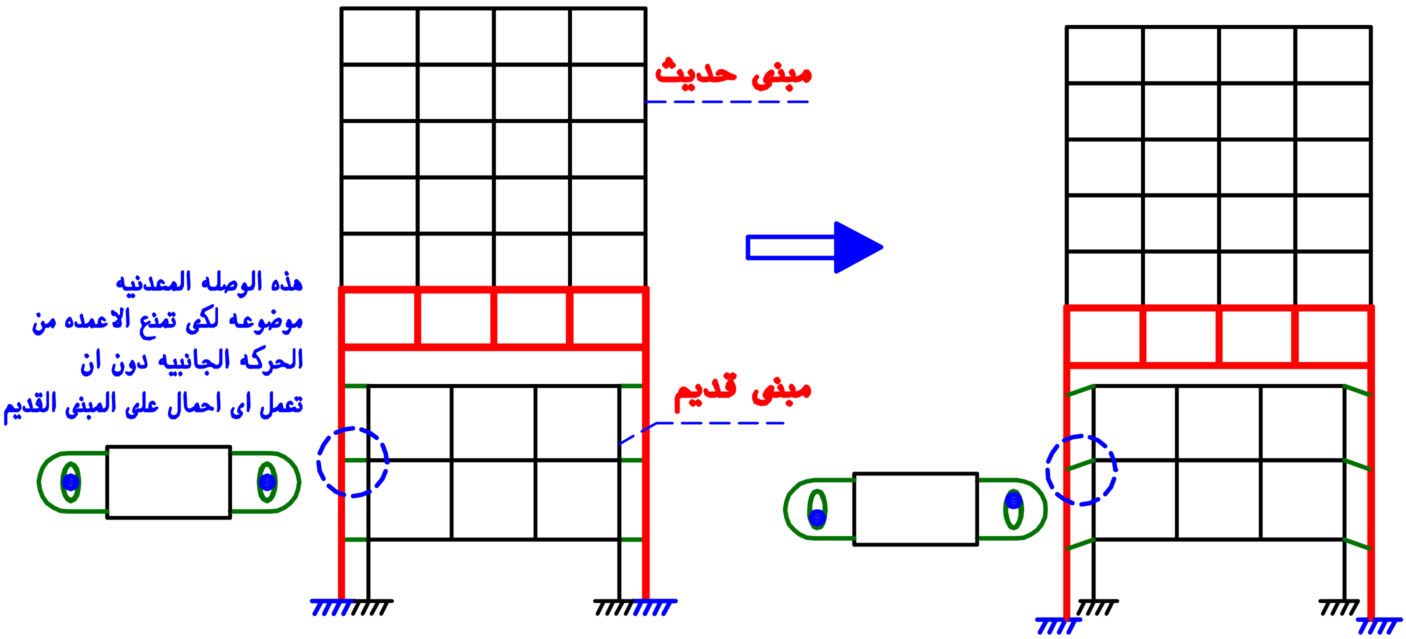
$t_{col.} \simeq t_{(Vierendeel)}$

Vierendeel Applications.

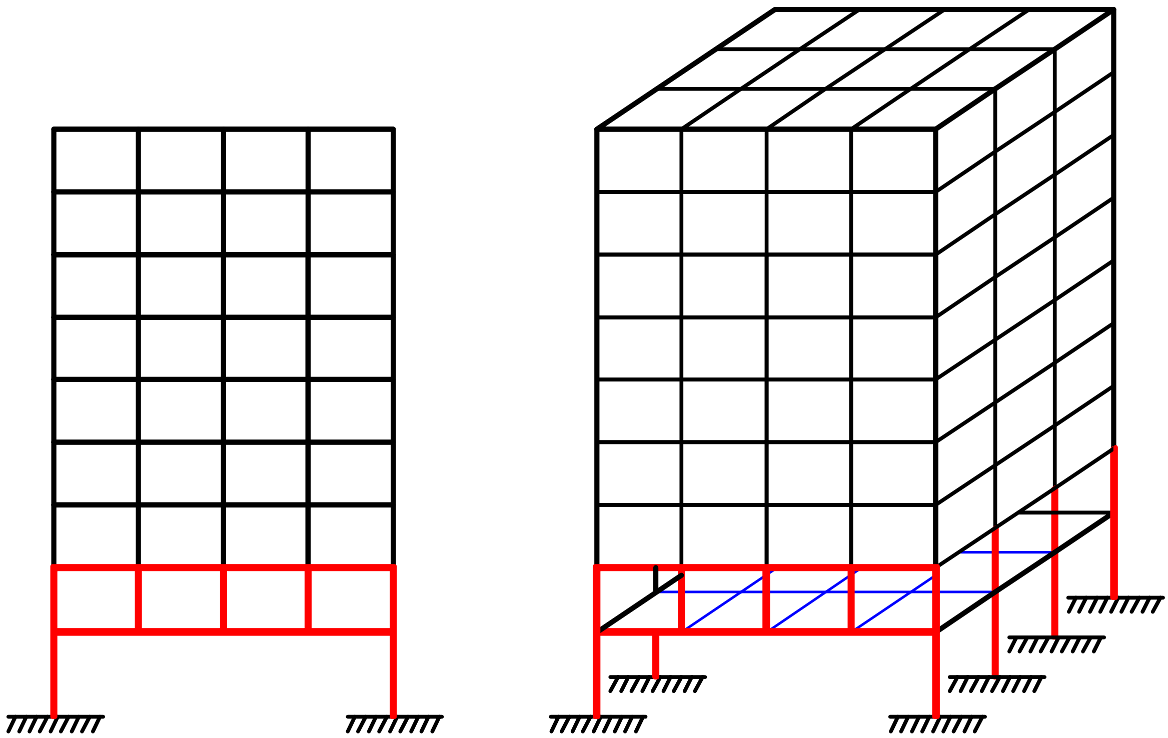
أهم إستخدامات ال Vierendeels

يتميز ال Vierendeels أنه يستطيع أن يحمل عدد من أدوار المبنى فوقه دون وضع أعمده فى المنتصف .

المبنى الحديث محمول على Vierendeels
و ال Vierendeels محموله على أعمده خارجيه دون أن يحمل على المبنى القديم

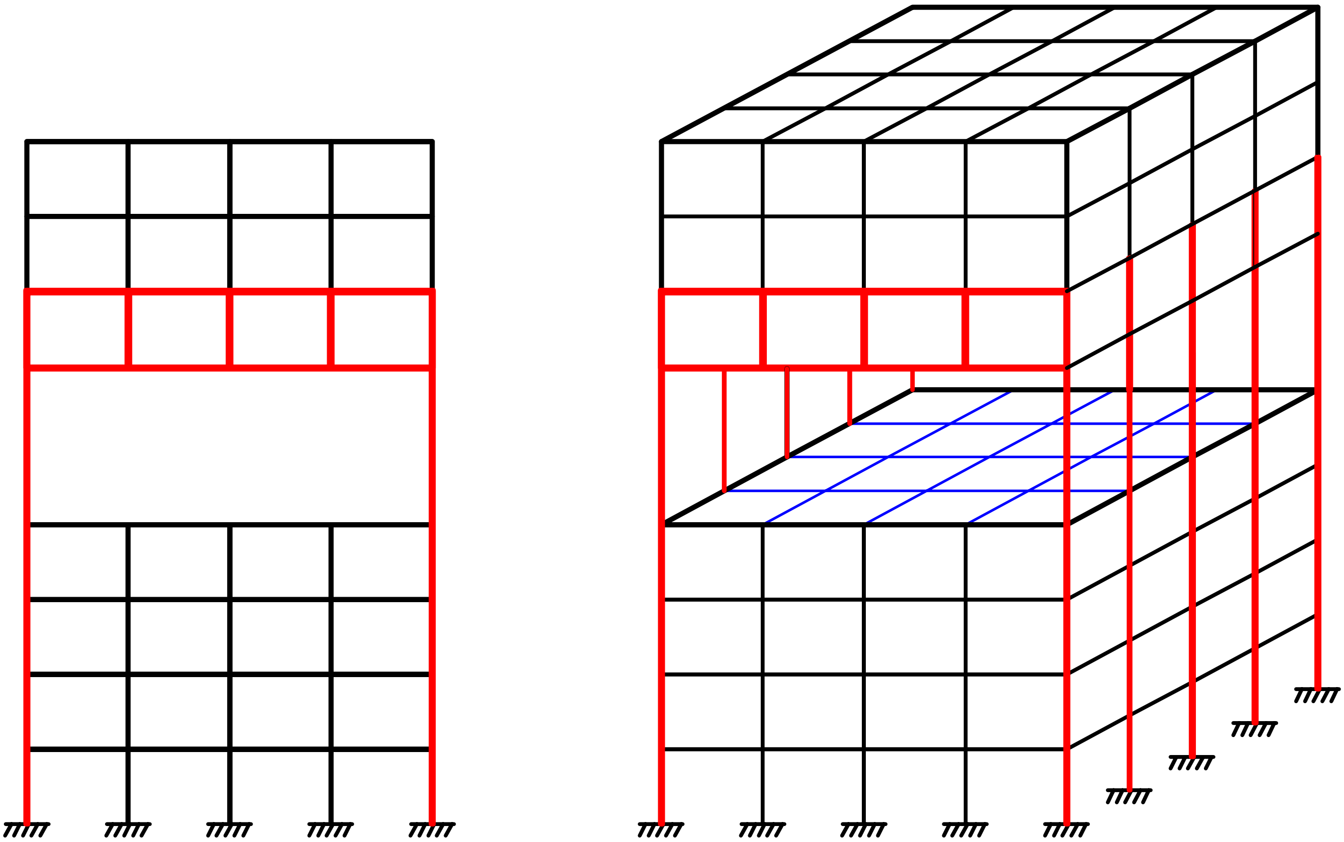


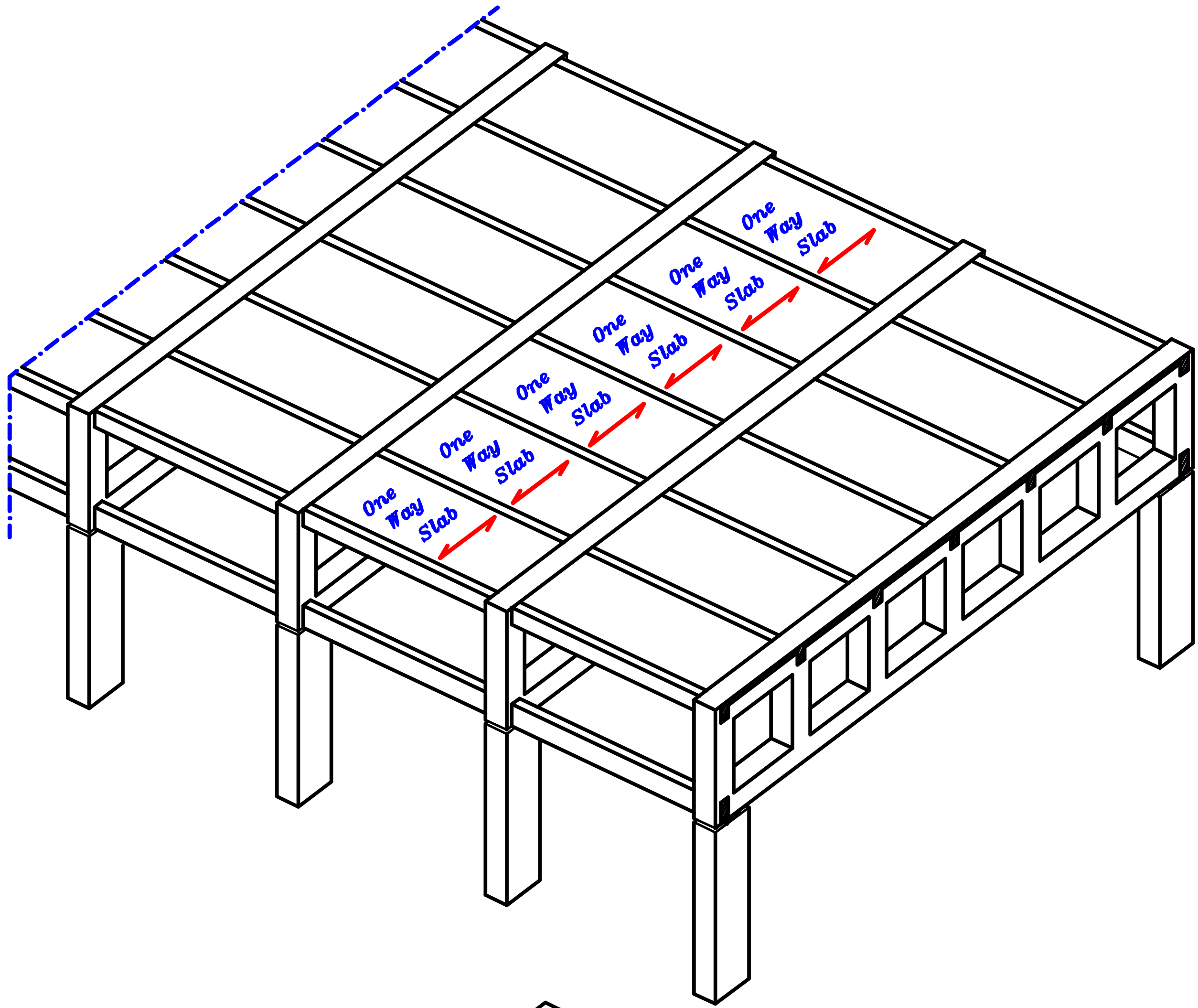
لا توجد أعمده فى الدور الارضى لان كل الادوارالعلويه محموله على Vierendeels
و ال Vierendeels محموله على أعمده خارجيه فقط.

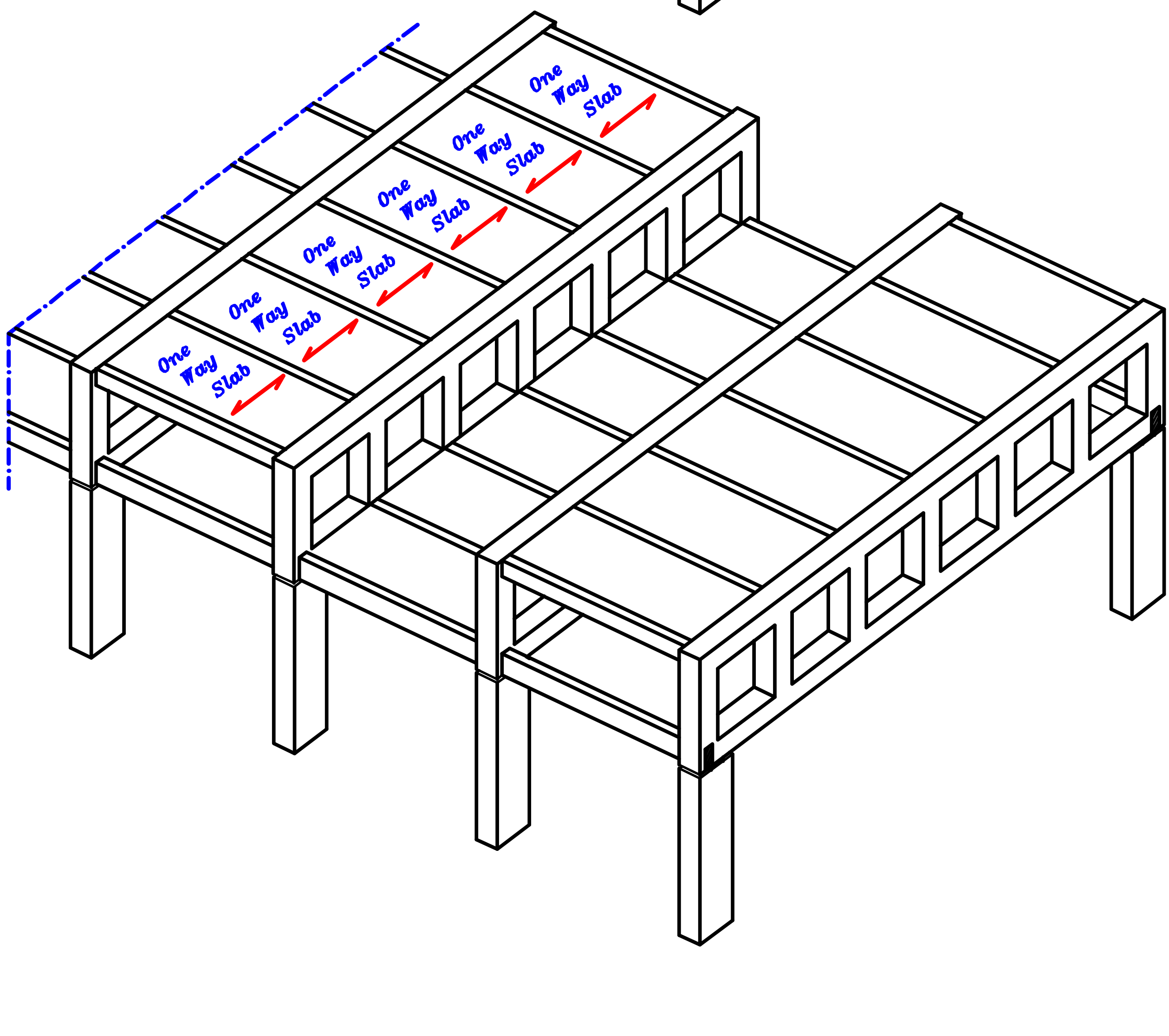


توجد قاعه بدون أعمده داخليه فى الدور الخامس

و الادوار العلويه محموله على *Vierendeels* فى الدور الخامس و ال *Vierendeels* محموله على أعمده خارجيه .




One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab


One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab

Analysis of Vierendeel.

We have Two methods to solve the Vierendeel.

① **Exact Method.** Using Computer

One way OR Two way في هذه الطريقه ممكن أخذ البلاطات

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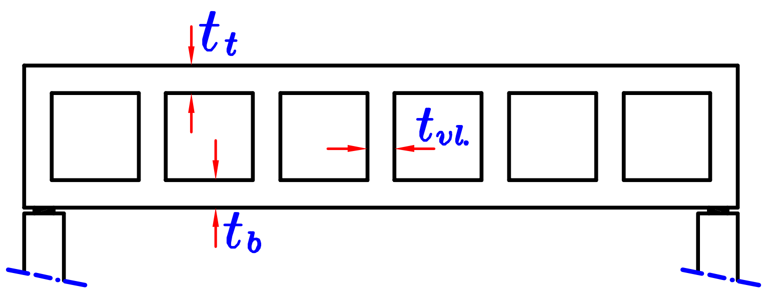
② **Approximate Method.**

To solve by this method we have to take

1_ Take the slabs one way (at beam direction)

2- $t_t = t_b$

3- $t_{vl.}$ is Constant.



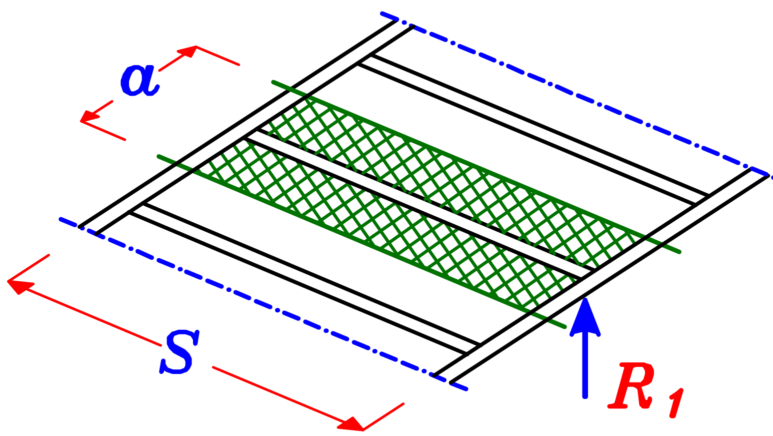
Calculation of Loads on Viernedeel.

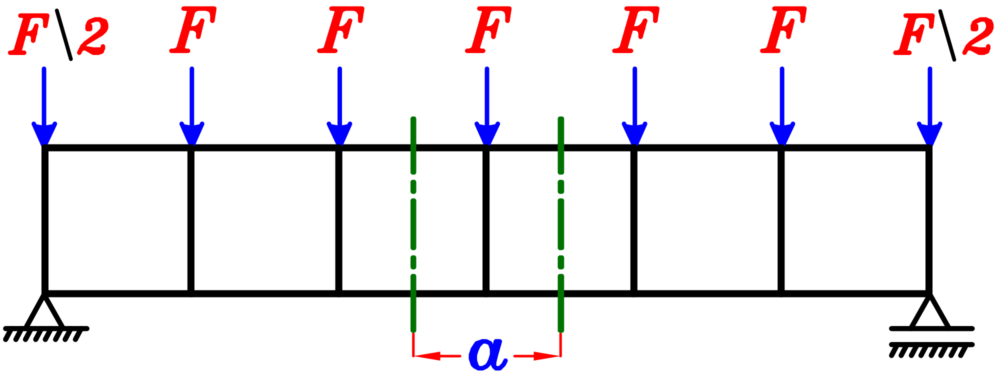
توجد طريقتان لحساب الاحمال على ال Vierendeel

١- assume O.W.(Vierendeel) ≃ 25.0 kN\m` (U.L.)

$w_1 = O.W._{(beam)} + w_S * a$

$R_1 = w_1 * S$





$$F = O.W.(\text{Vierendeel}) * a + R_1 * n$$

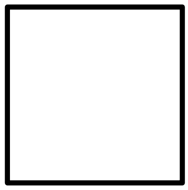
عدد الادوار

۲-

- Assume the total equivalant working loads is

$$w_{av\,(U.L.)} = (12.0 \rightarrow 15.0)\ kN/m^2$$

Floor area



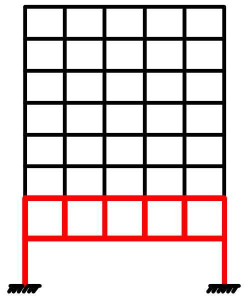
Plan

- Total Load For one Floor $= w_{av} *$ Floor area

- Total Load For the building

يتم زياده وزن سقف الدور الارضى .

$=$ Load of one Floor * No. of Floors.

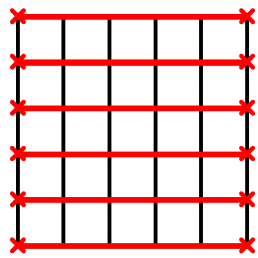


Elev.

- Total Load on One Vierendeel.

يتم توزيع الحمل الكلى على عدد ال Vierendeels

مع فرض أن أول و أخر system سيحمل نصف الحمل فقط.

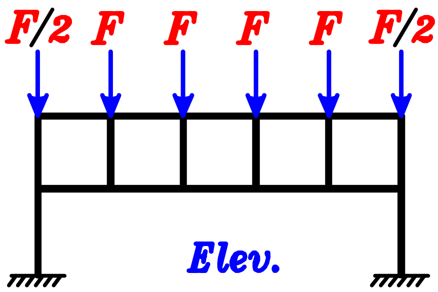


Plan

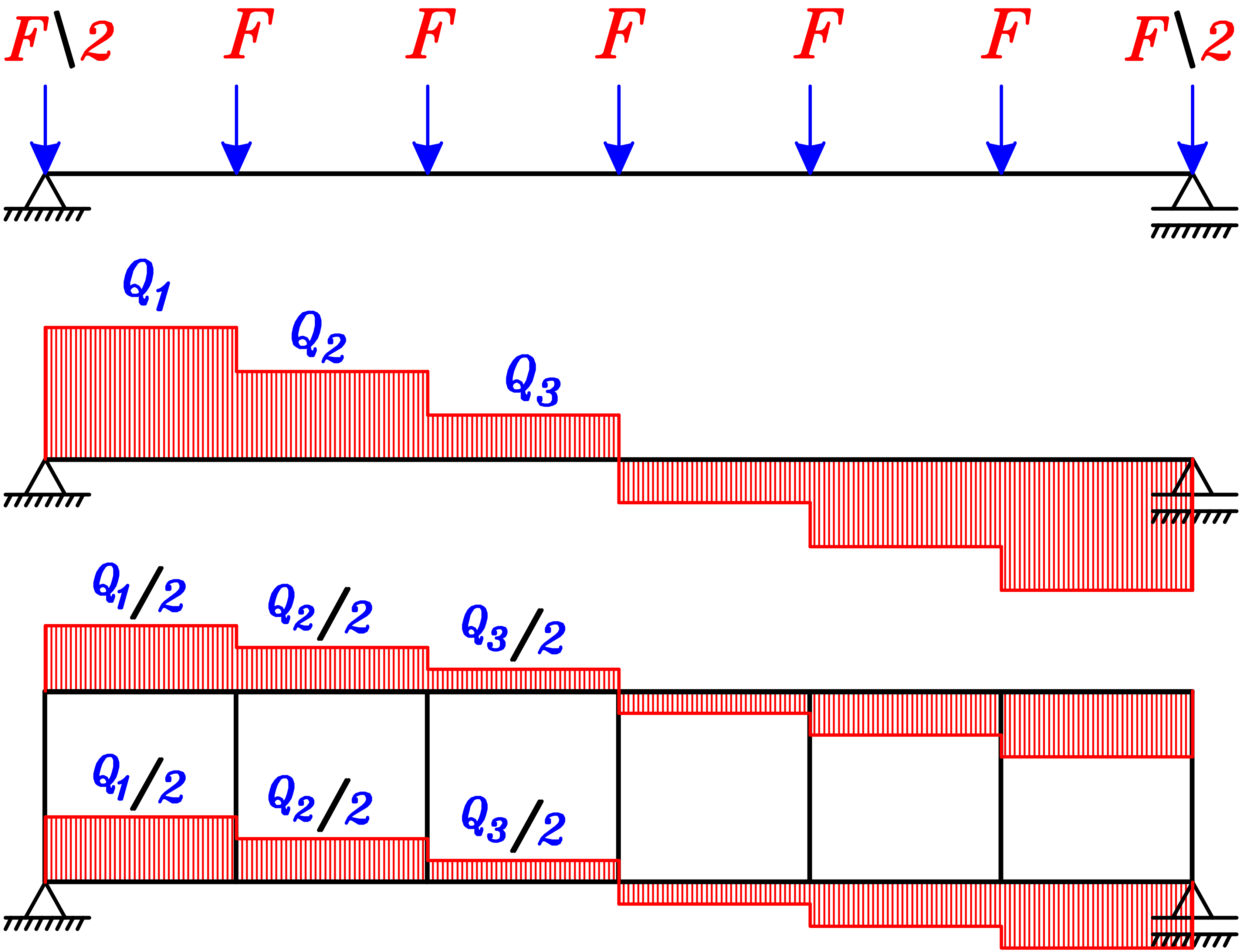
- Load on one joint of the Vierendeel.

يتم توزيع الحمل الكلى لل Vierendeels على عدد ال joints

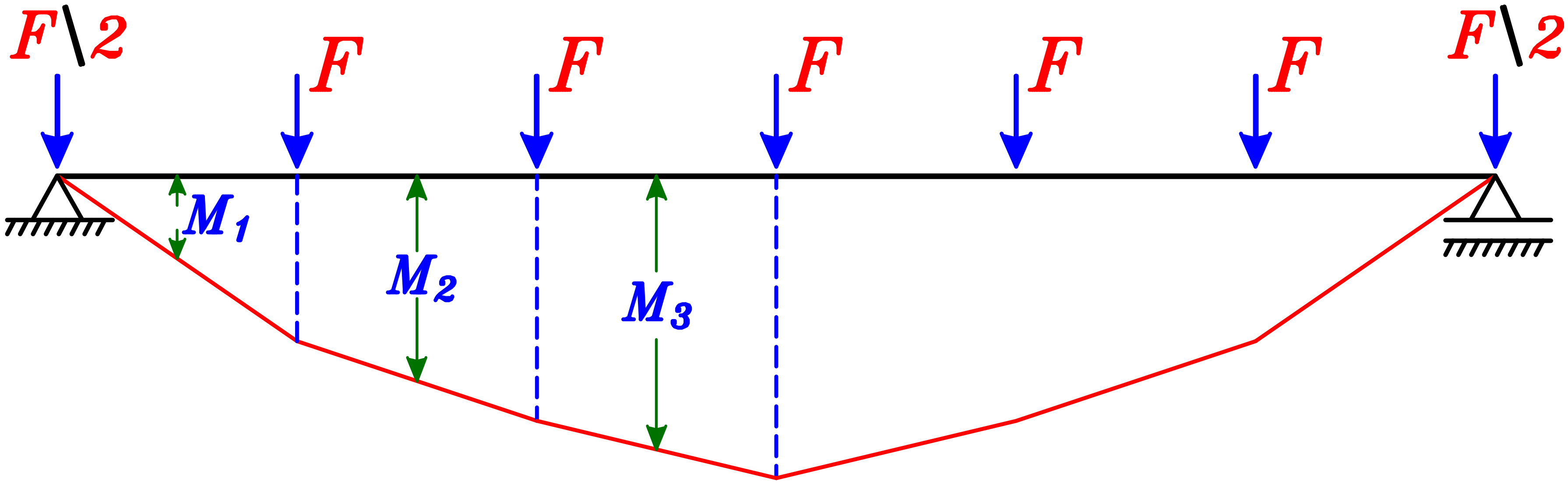
مع فرض أن أول و أخر joint ستحمل نصف الحمل فقط

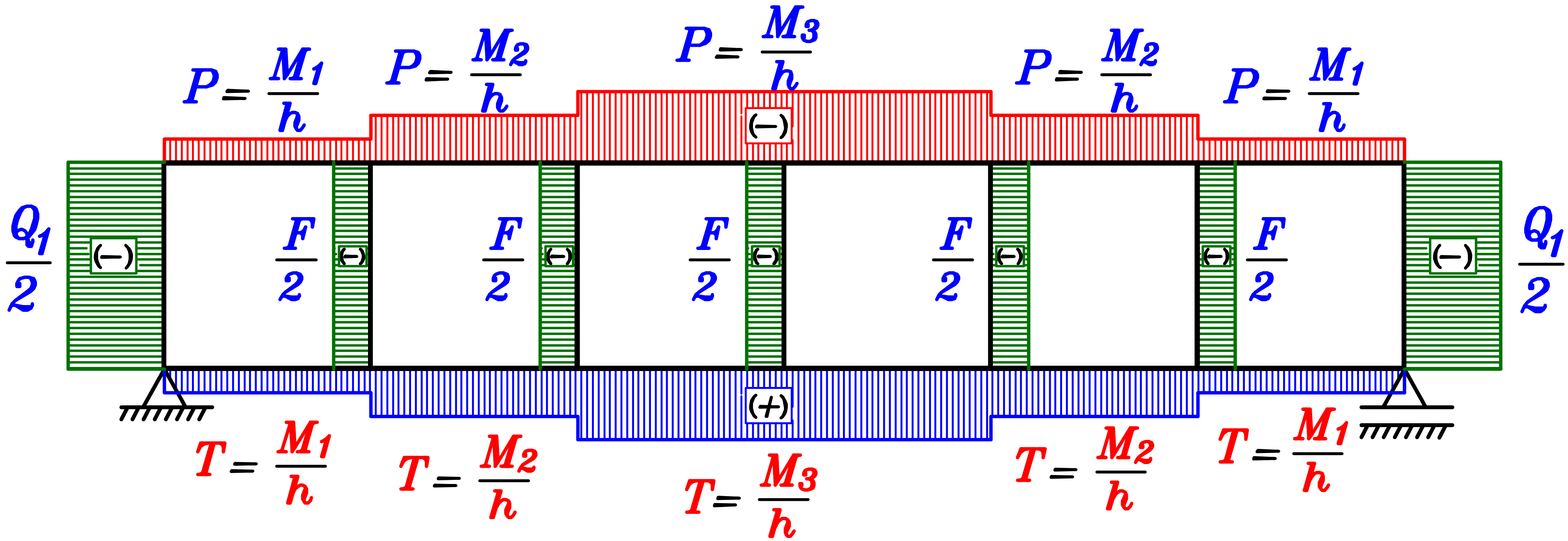


S.F.D. on Vierendeels.

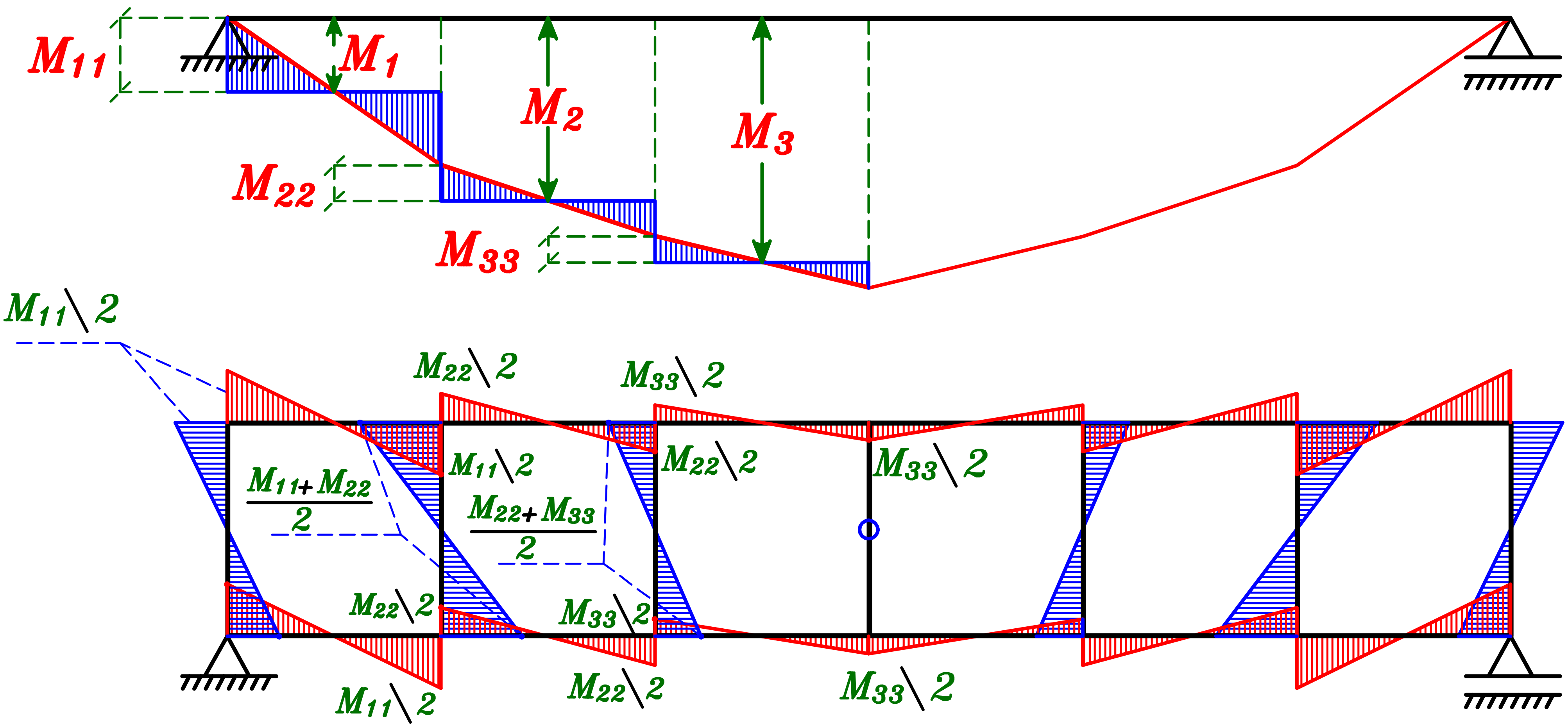


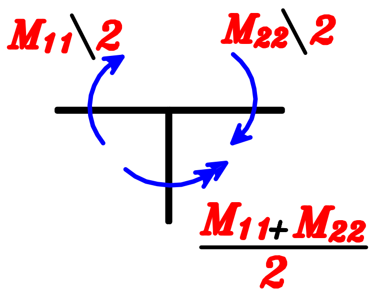
N.F.D. on Vierendeels.





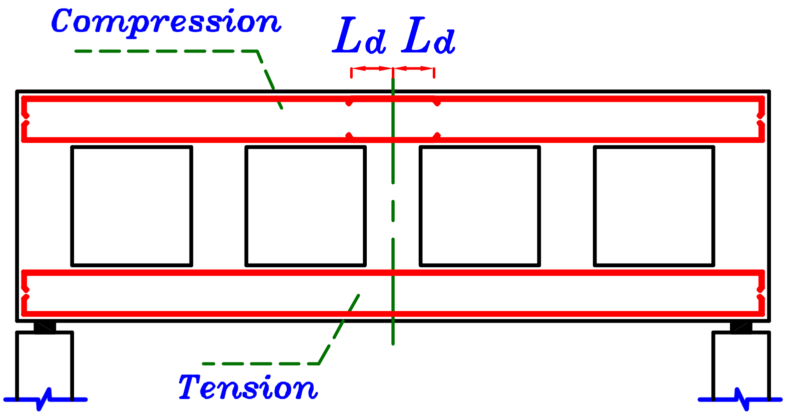
B.M.D. on Vierendeels.

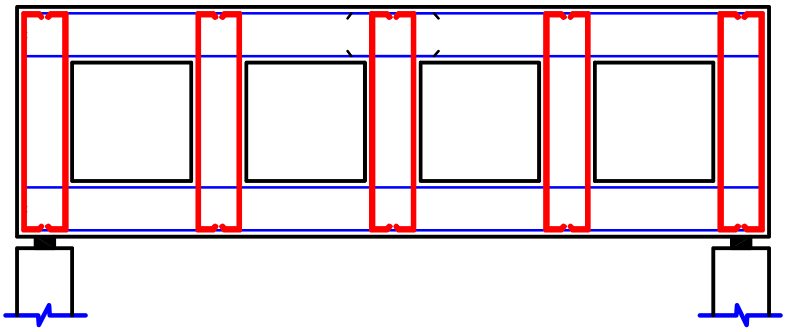




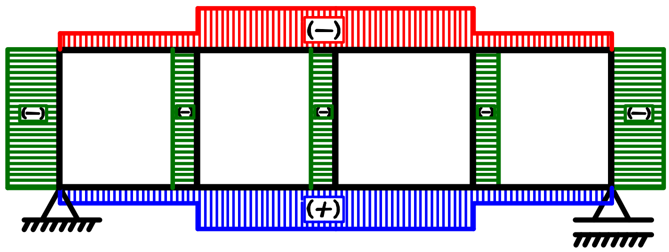
Drawing RFT. of Vierendeel.

١- نبداء برسم نصف التسليح مع مراعاه ان الحديد ناحيه الشد يكمل
و الحديد ناحيه الضغط يمتد كل باكيتين و بعدها يمتد L_d

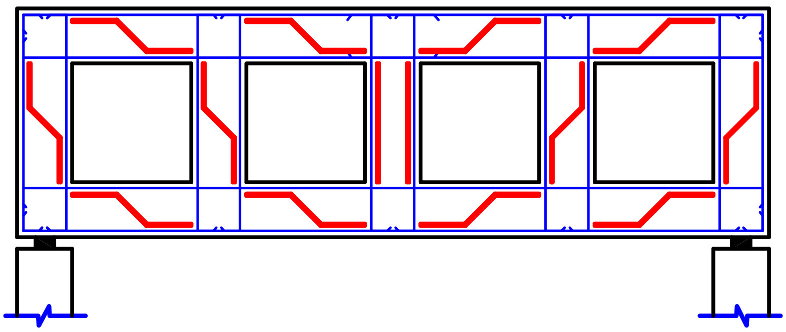


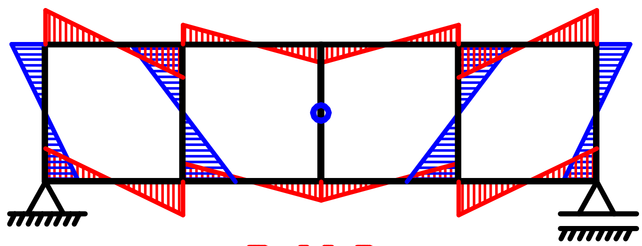


N.F.D.



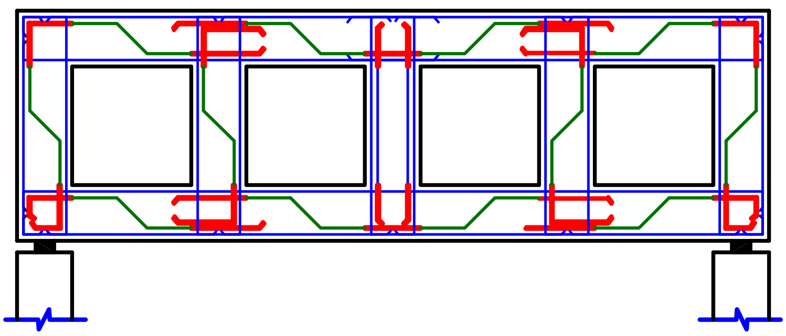
٢- نرسم النصف الاخر من التسليح ناحيه العزم و نكسحه عند منتصف الـ member

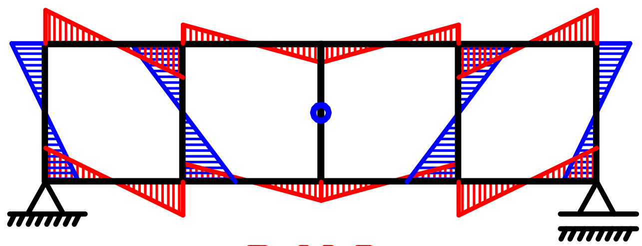




B.M.D.

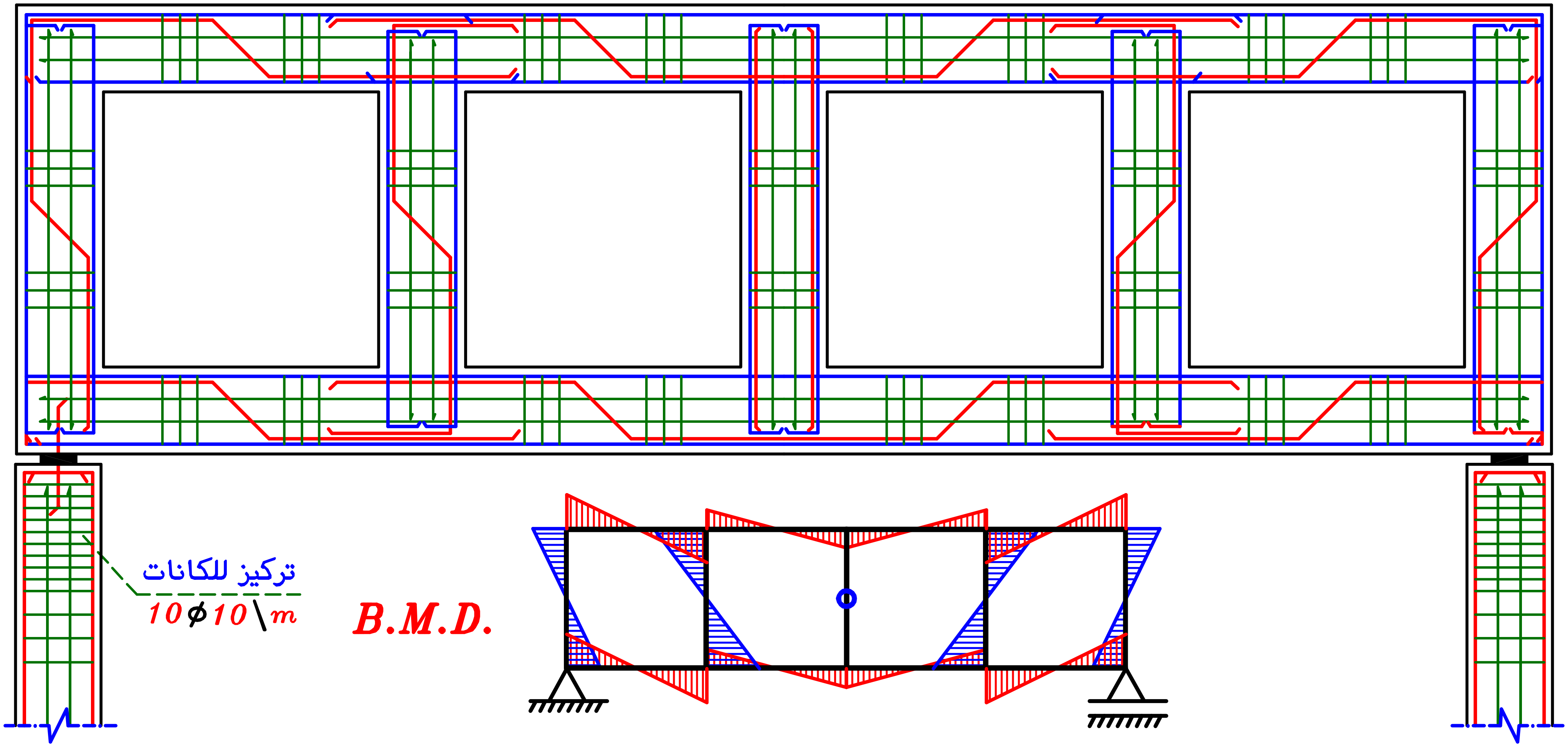
٣- نمد التسليح المكسح بعد نهايه كل member مسافه L_d





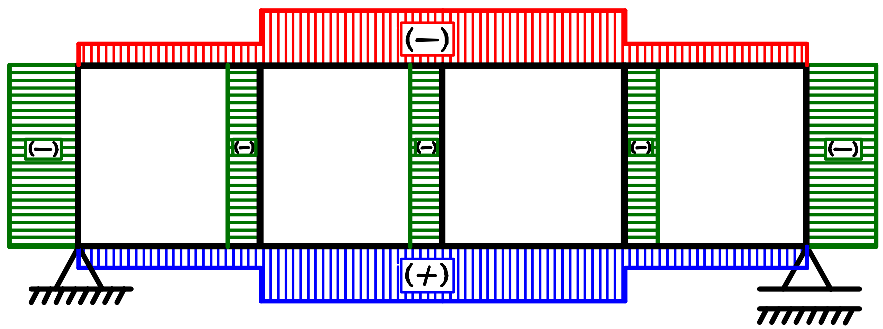
B.M.D.

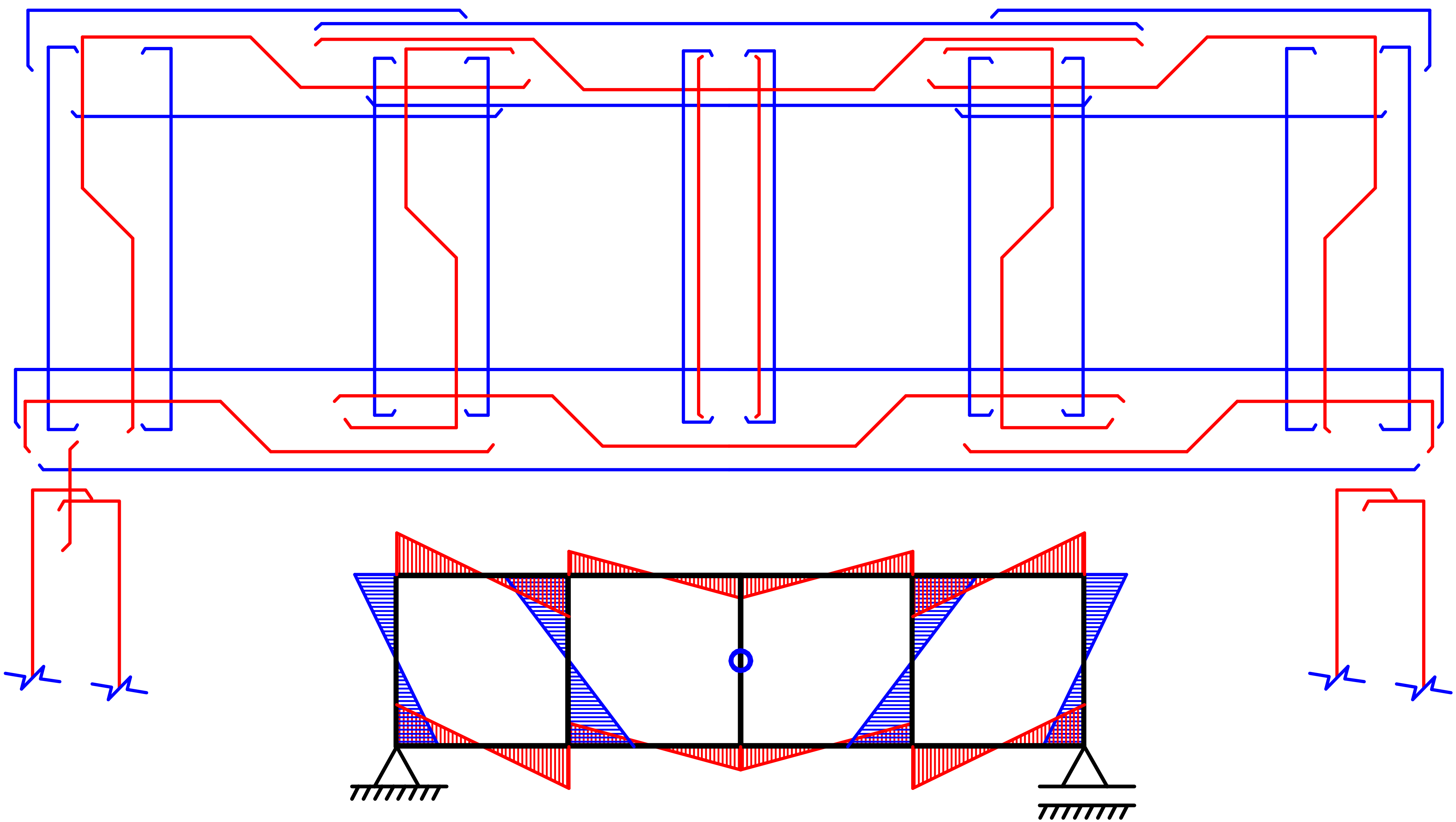
RFT. of the Vierendeel.



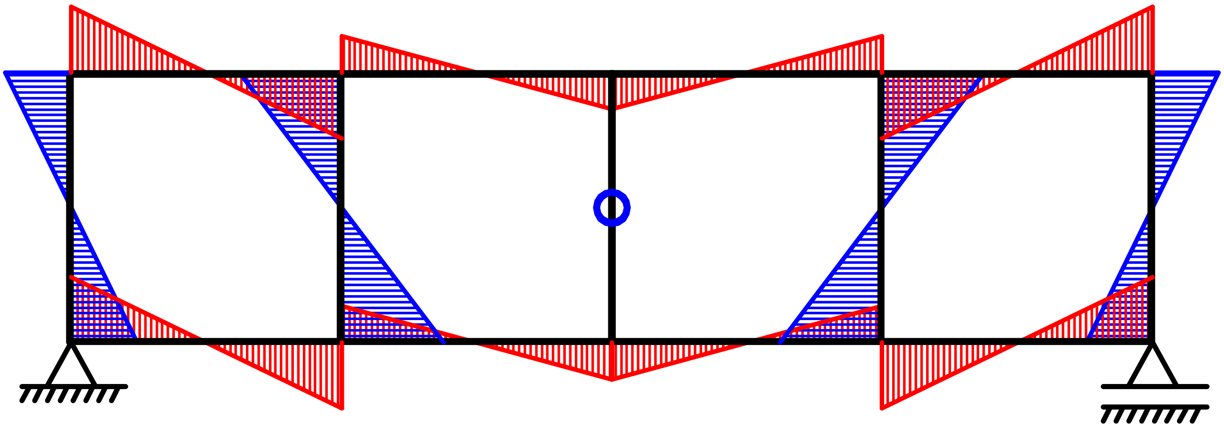
B.M.D.

N.F.D.

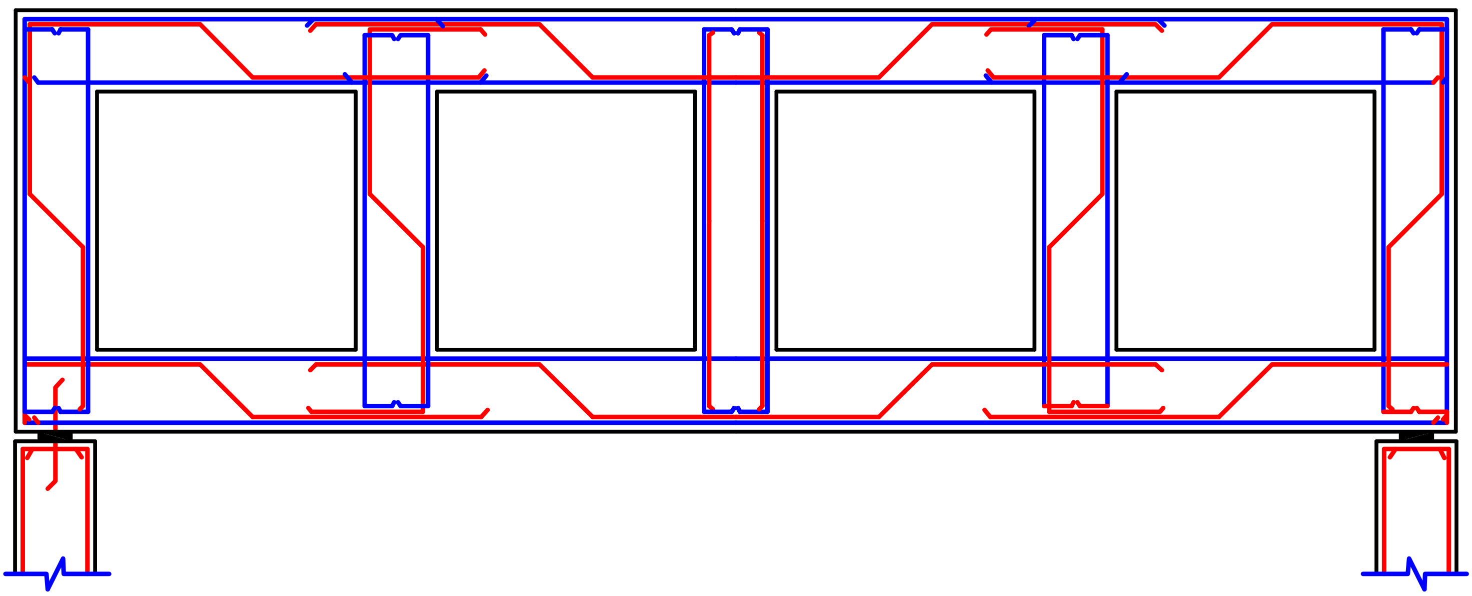


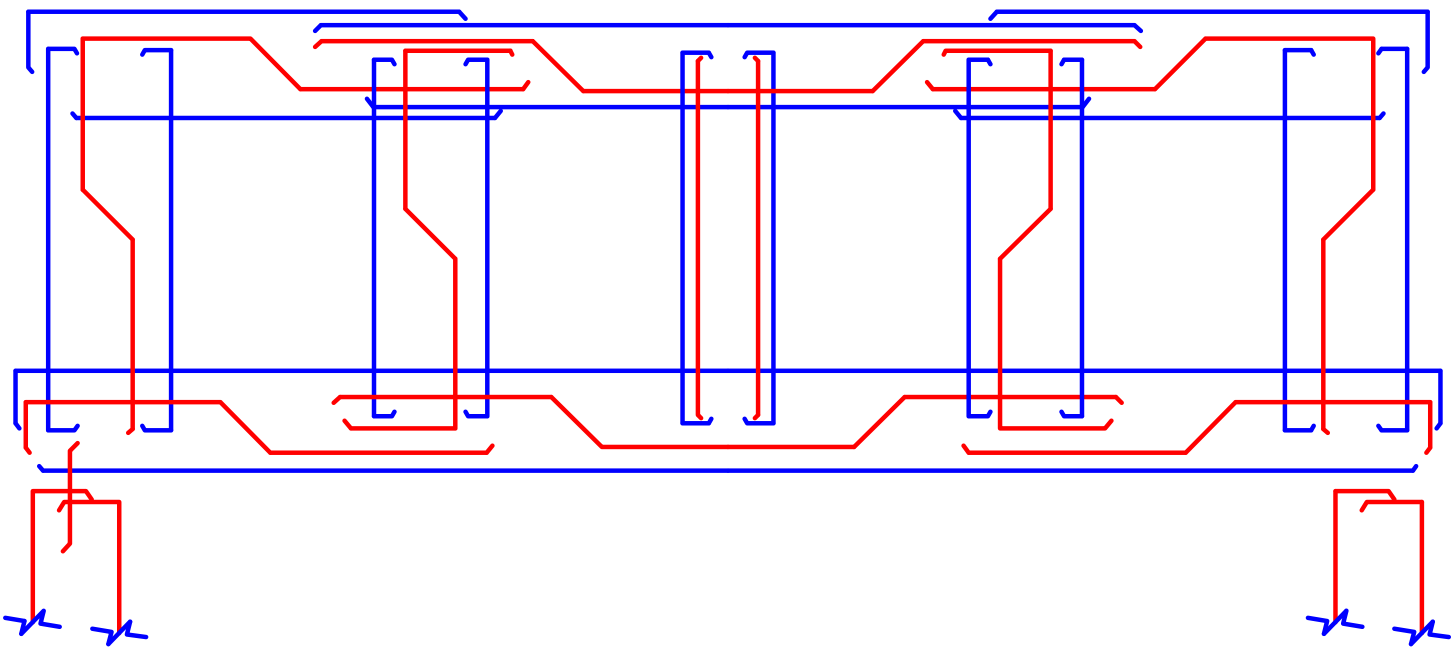

B.M.D.

4 Segments.

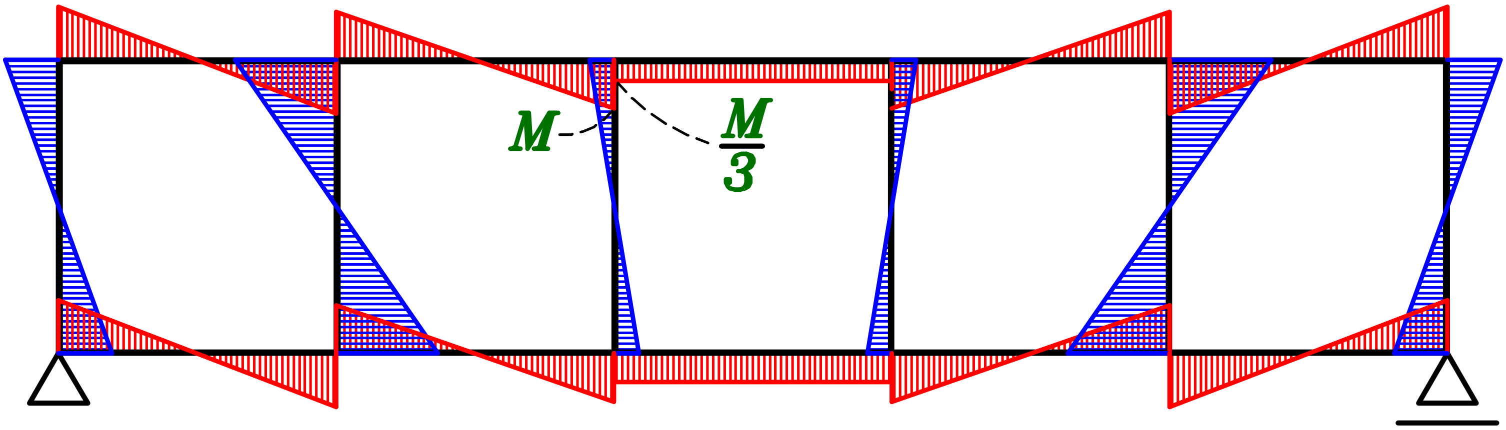


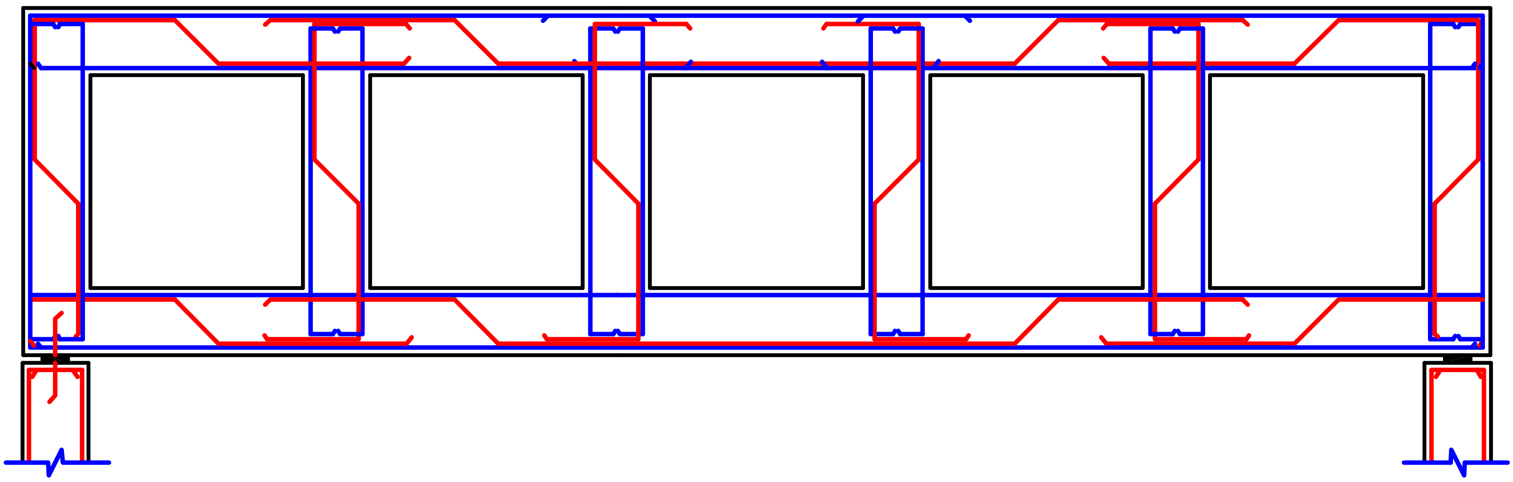
B.M.D.

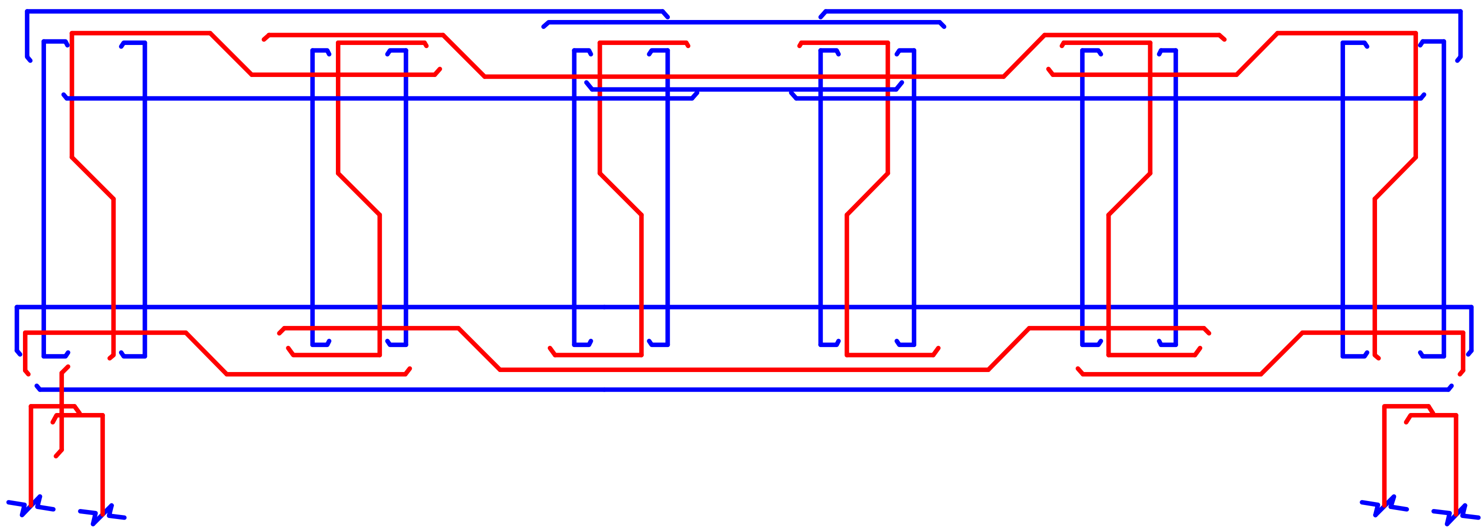




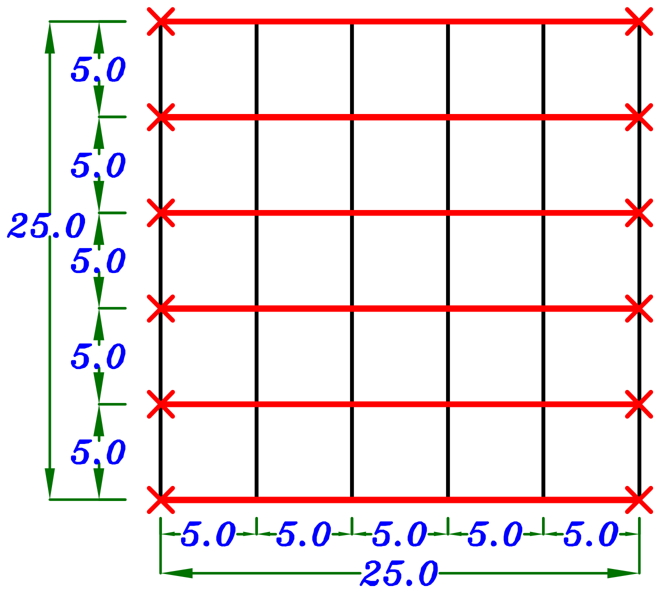
5 Segments.

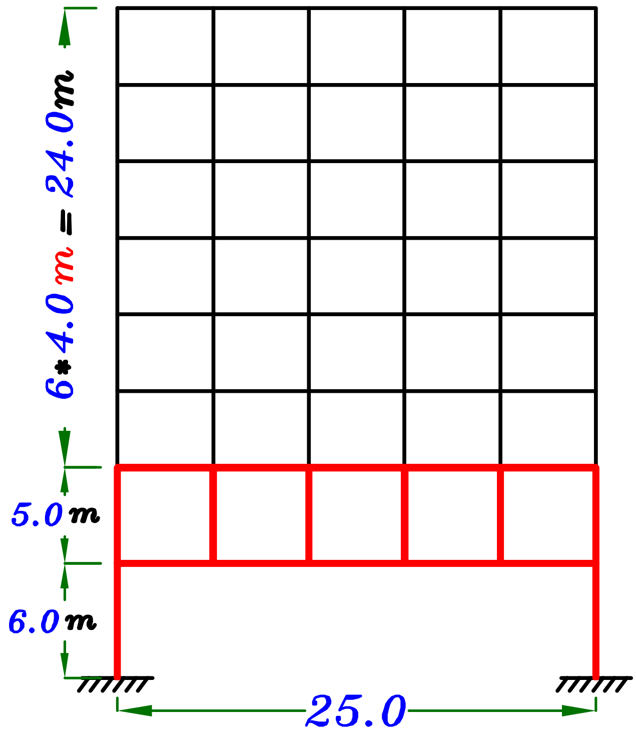






Example.





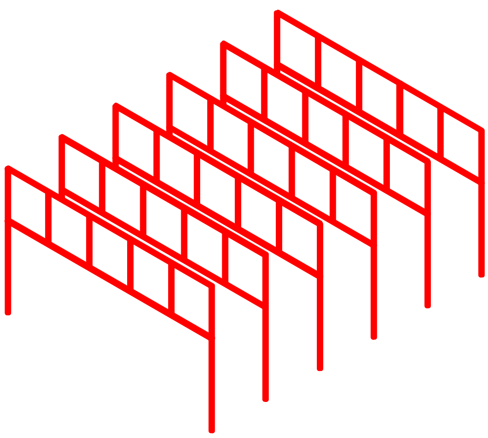
For the given Figure shows a layout of a building of an area **25.0 * 25.0** m^2
The building consists of ground Floor and Seven typical Floor.
The interior columns are removed at the ground Floor.
The total equivalent working loads is **10.0** kN/m^2

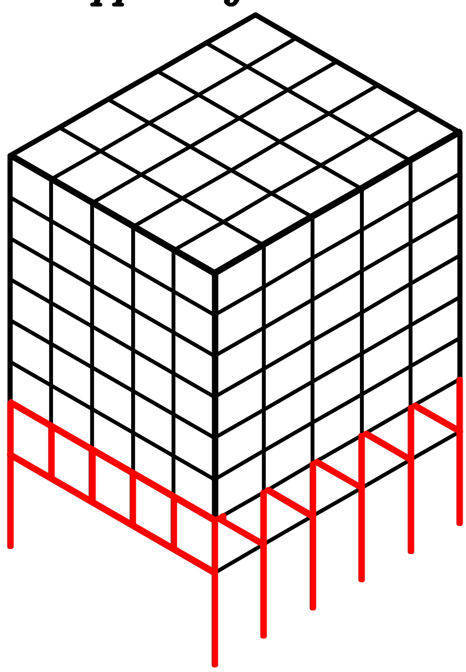
$F_{cu} = 30 \; N\backslash mm^2$, $F_y = 360 \; N\backslash mm^2$

It is required to:

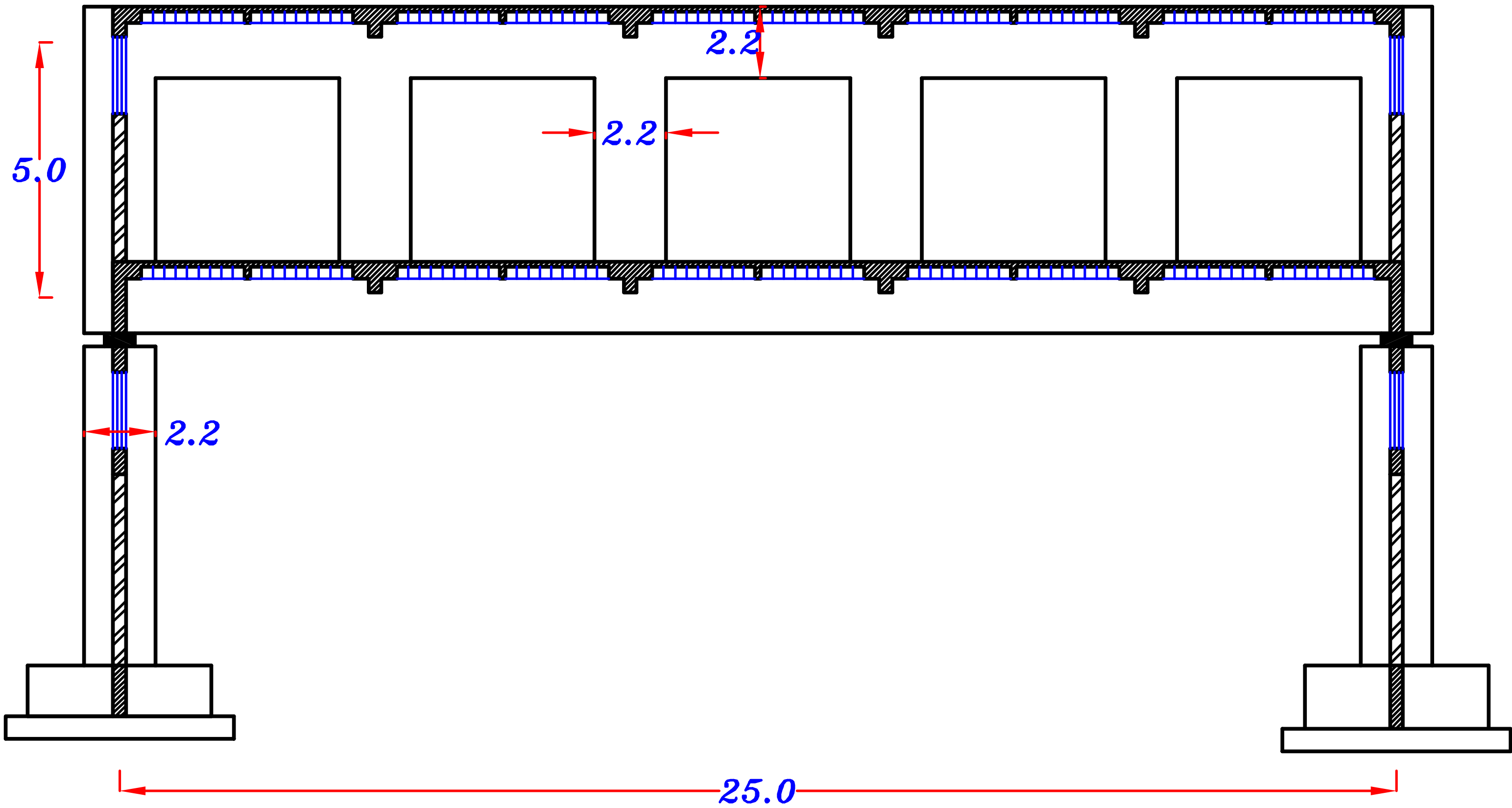
1- Choose a reasonable structural system For the ground Floor and draw its Concrete dimensions in plan and elevation to scale **1:50**
2- Calculate the Loads on the main supporting element.
3- Draw Internal Forces Diagrams For the main supporting element.
4- Design the main supporting element.
5- Draw details of RFT. of the main supporting element in elevation and cross sections to scale **1:25**

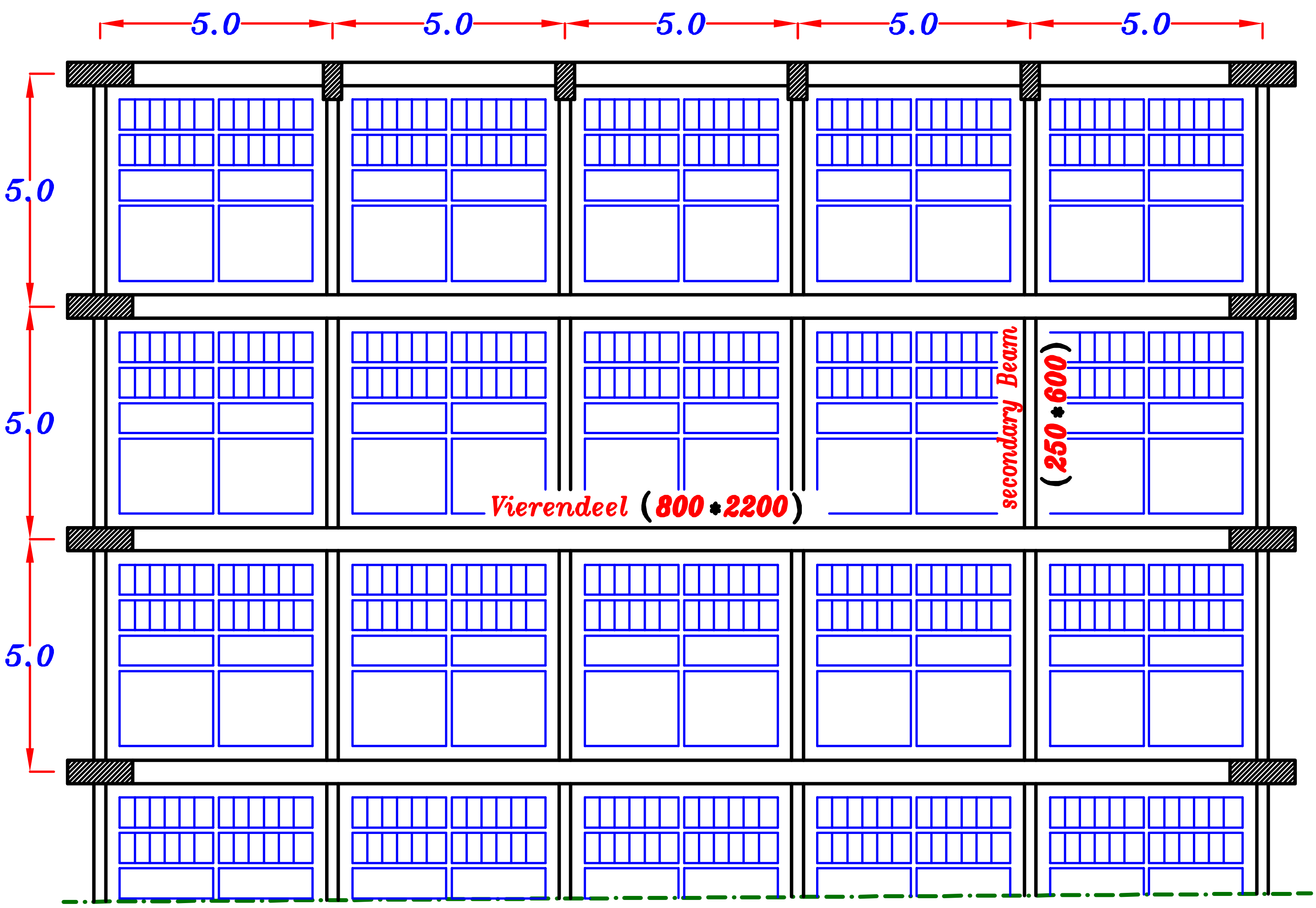
Vierendeel





1 – Take the main supporting element Vierendeel (800*2200)

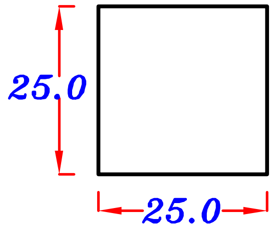




2 – Calculate the Loads on the main supporting element.

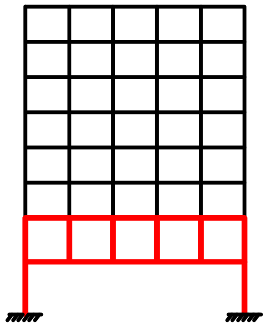
The total equivalent working loads is 10.0 kN/m^2

– $w_{av\,(U.L.)} = 10.0 * 1.5 = 15.0\ kN/m^2$



– Total Load For one Floor $= w_{av} *$ Floor area

$= 15.0 * 25.0 * 25.0 = 9375\ kN$

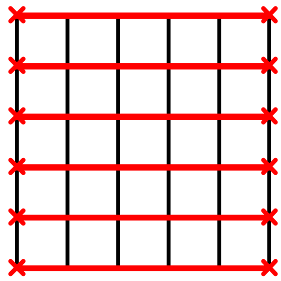


– Total Load For the building

يتم زياده وزن سقف الدور الارضى .

= Load of one Floor * No. of Floors.

$= 9375 * 8.0 = 75000\ kN$



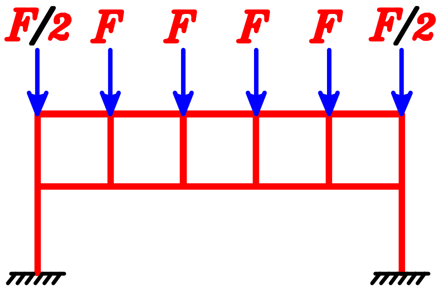
– Total Load on One Vierendeel.

يتم توزيع الحمل الكلى على عدد ال Vierendeels

مع فرض أن أول و أخر system سيحمل نصف الحمل فقط.

Total Load on One Vierendeel.

$$= \frac{75000}{5.0}\ kN = 15000\ kN$$



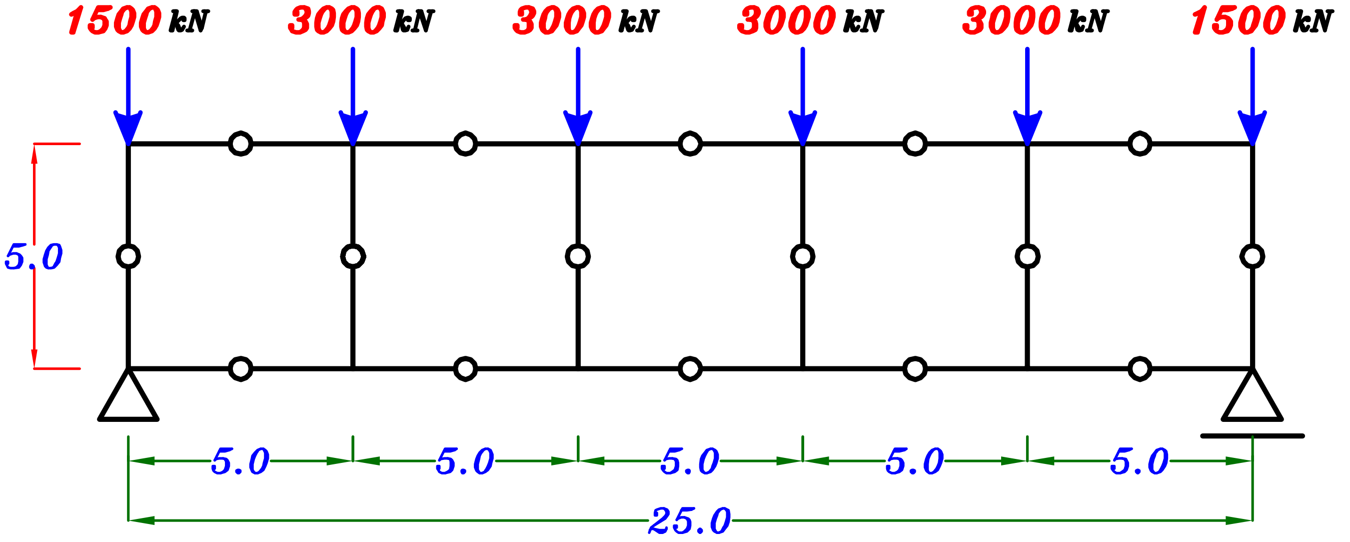
– Load on one joint of the Vierendeel.

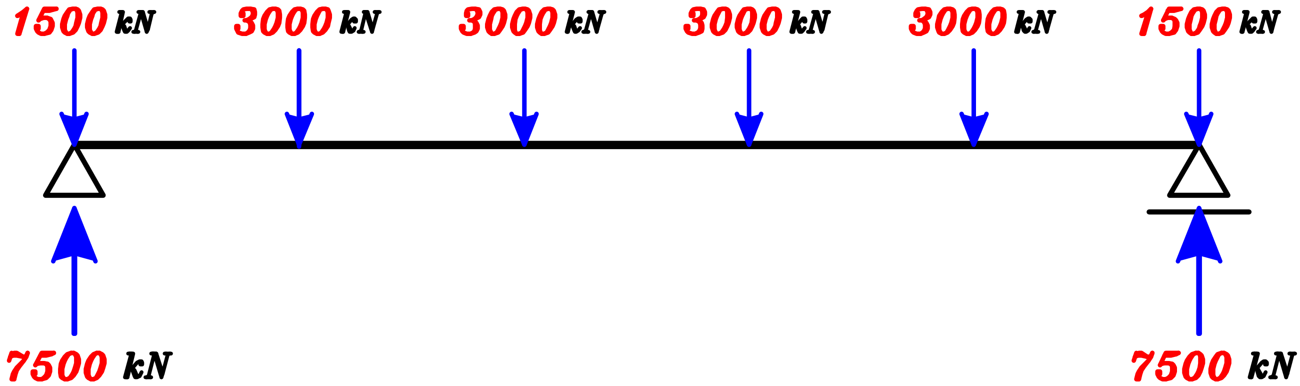
يتم توزيع الحمل الكلى لل Vierendeels على عدد ال joints

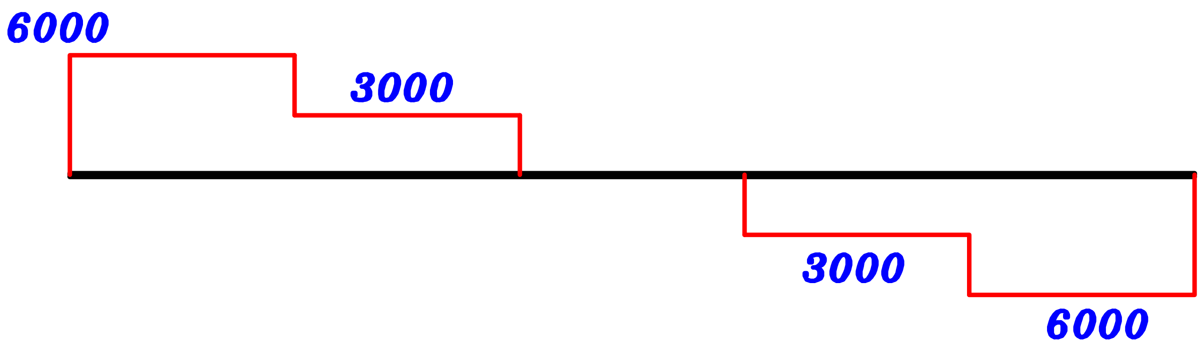
مع فرض أن أول و أخر joint ستحمل نصف الحمل فقط

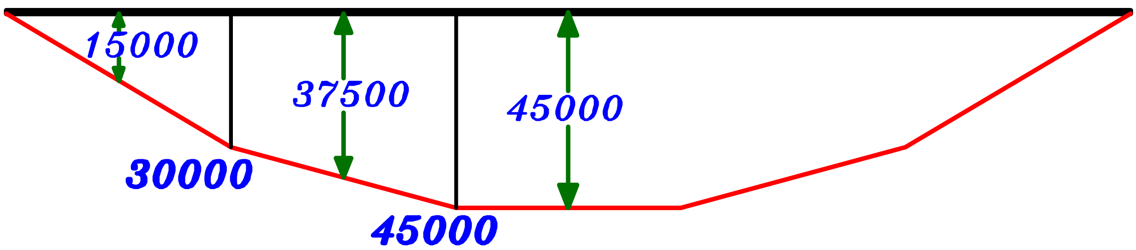
$$F = \frac{15000}{5.0}\ kN = 3000\ kN\ (U.L.)$$

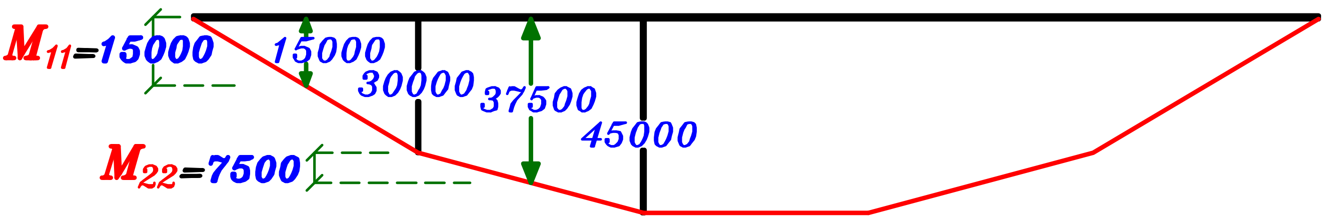
3 – Draw Internal Forces Diagrams For the main supporting element.



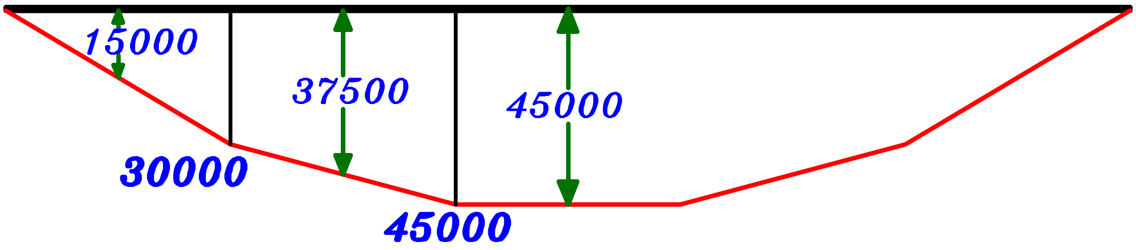


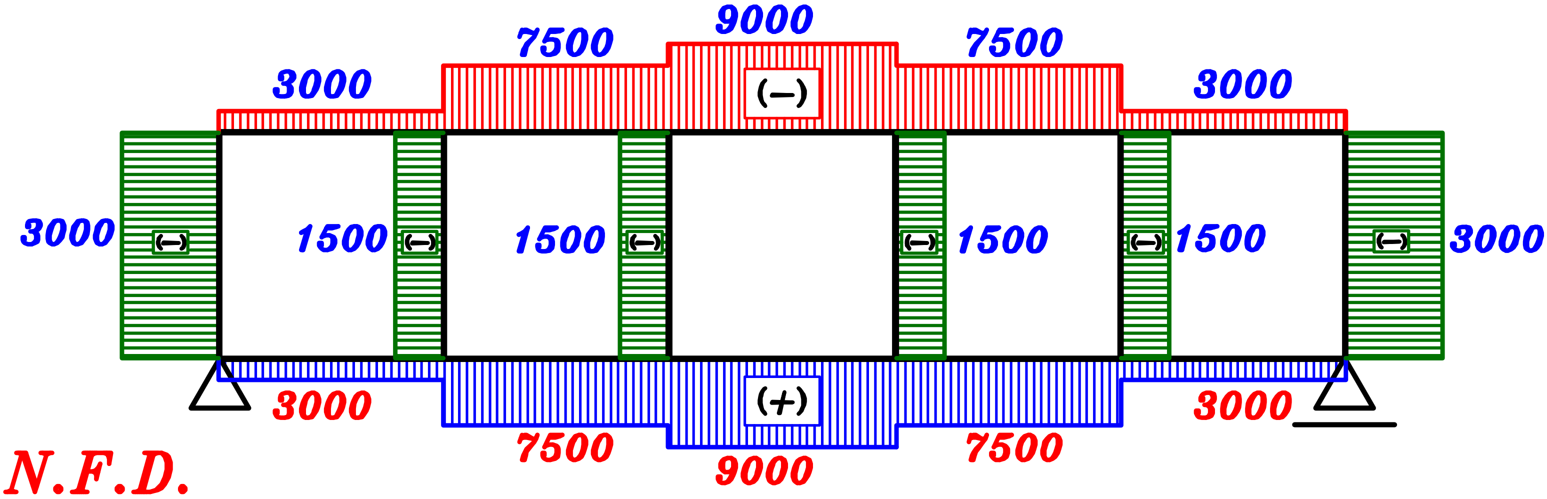






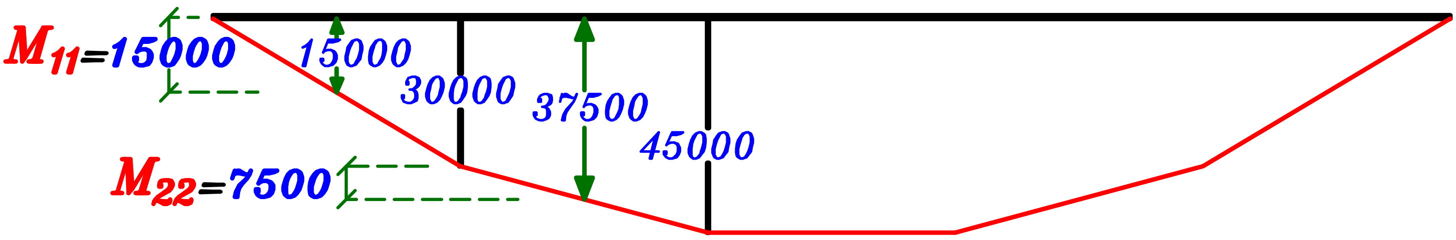
N.F.D. on Vierendeel.

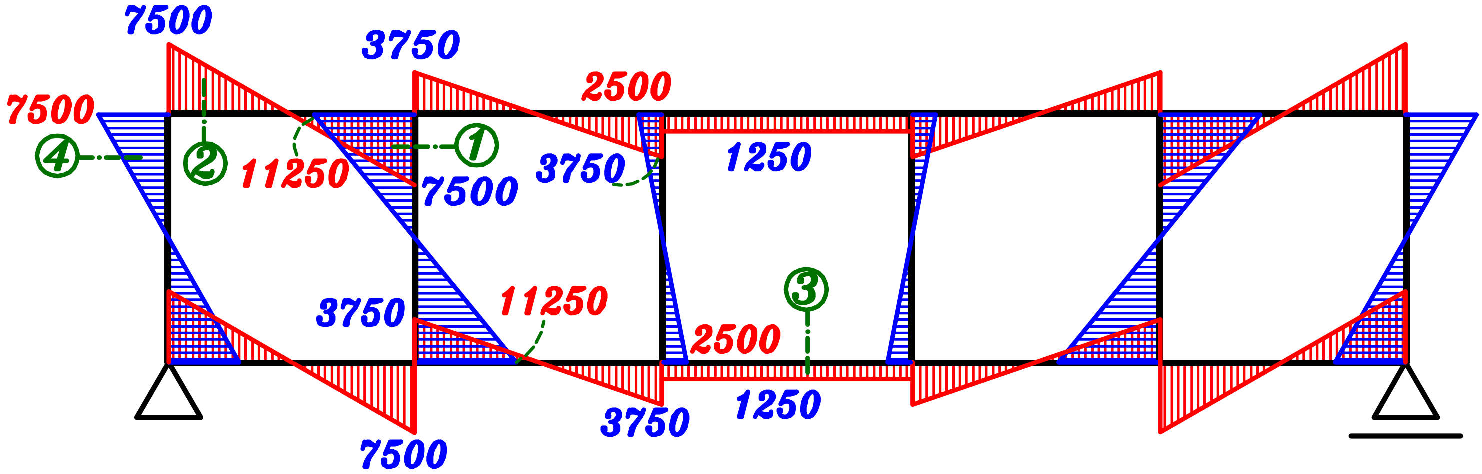




N.F.D.

B.M.D. on Vierendeel.





B.M.D.

Design of sections.

Sec. ① R–Sec.

$M = 11250$ kN.m , $P = 1500$ kN , $b = 800$ mm , $t = 2200$ mm

Check $\frac{P}{F_{cu}\, b t} = \frac{1500 * 10^3}{30 * 800 * 2200} = 0.028 < 0.04$ (Neglect P)

$$2100 = C_1 \sqrt{\frac{11250 * 10^6}{30 * 800}} \longrightarrow C_1 = 3.06 \longrightarrow J = 0.747$$

$$A_s = \frac{M_{U.L.}}{J F_y d} = \frac{11250 * 10^6}{0.747 * 360 * 2100} = 19920 \ mm^2$$

Check $A_{s\,min.}$ $\quad A_{s_{req.}} = 19920 \ mm^2$

$$\mu_{min.} b d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 800 * 2100 = 5751.1 \ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.} b d \quad \therefore$ Take $A_s = A_{s_{req.}} = 19920 \ mm^2$ **26 ϕ 32**

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{800 - 25}{32 + 25} = 13.6 = 13.0 \ \text{bars}$$

Sec. ② R–Sec.

$M = 7500$ kN.m , $P = 3000$ kN , $b = 800$ mm , $t = 2200$ mm

Check $\frac{P}{F_{cu}\, b t} = \frac{3000 * 10^3}{30 * 800 * 2200} = 0.056 > 0.04$ (Don't Neglect P)

$e = \frac{M}{P} = \frac{7500}{3000} = 2.50 \ m \quad \therefore \frac{e}{t} = \frac{2.50}{2.2} = 1.13 \ m > 0.5 \xrightarrow{use} e_s$

$$e_s = e + \frac{t}{2} - c = 2.50 + \frac{2.2}{2} - 0.1 = 3.50 \ m$$

$$M_s = P * e_s = 3000 * 3.50 = 10500 \ kN.m$$

$$2100 = C_1 \sqrt{\frac{10500 * 10^6}{30 * 800}} \longrightarrow C_1 = 3.17 \longrightarrow J = 0.757$$

$$A_s = \frac{M_s}{J F_y d} - \frac{P_{U.L.}}{(F_y \backslash \gamma_s)} = \frac{10500 * 10^6}{0.757 * 360 * 2100} - \frac{3000 * 10^3}{(360 \backslash 1.15)}$$

$$= 8764 \ mm^2$$

<u>Check $A_{s\,min.}$</u> $\quad A_{s_{req.}} = 8764 \ mm^2$

$$\mu_{min.} b d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 800 * 2100 = 5751.1 \ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.} b \ d \quad \therefore$ Take $A_s = A_{s_{req.}} = 8764 \ mm^2$ **12∅32**

Sec. ③ R–Sec.

$M = 7500 \ kN.m$, $P = 1500 \ kN$, $b = 800 \ mm$, $t = 2200 \ mm$

Check $\frac{P}{F_{cu} b t} = \frac{1500 * 10^3}{30 * 800 * 2200} = 0.028 < 0.04$ (Neglect P)

$$2100 = C_1 \sqrt{\frac{7500 * 10^6}{30 * 800}} \longrightarrow C_1 = 3.75 \longrightarrow J = 0.793$$

$$A_s = \frac{M_{U.L.}}{J F_y d} = \frac{7500 * 10^6}{0.793 * 360 * 2100} = 12510 \ mm^2$$

<u>Check $A_{s\,min.}$</u> $\quad A_{s_{req.}} = 12510 \ mm^2$

$$\mu_{min.} b d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 800 * 2100 = 5751.1 mm^2$$

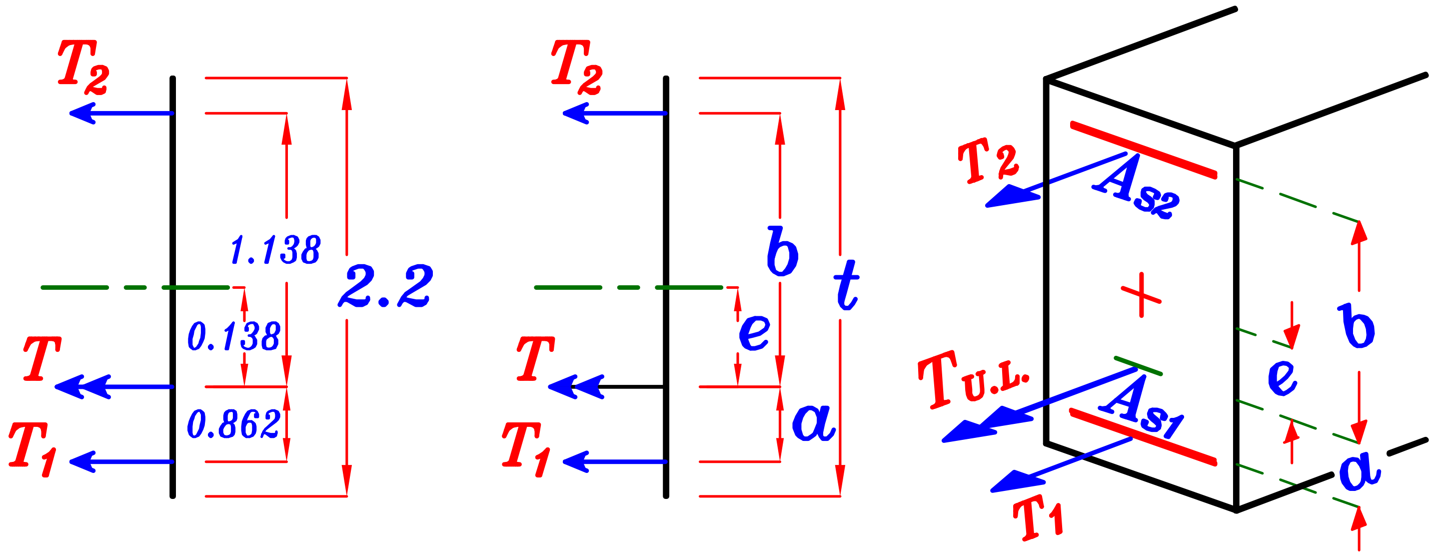
$\therefore A_{s_{req.}} > \mu_{min.} b \ d \quad \therefore$ Take $A_s = A_{s_{req.}} = 8764 \ mm^2$ **16∅32**

Sec. ④ R–Sec.

$M = 1250\ kN.m$, $T = 9000\ kN$, $b = 800\ mm$, $t = 2200\ mm$

$$e = \frac{M}{T} = \frac{1250}{9000} = 0.138\ m$$

$$\therefore \frac{e}{t} = \frac{0.138}{2.20} = 0.062 < 0.5 \longrightarrow$$ Small Eccentricity.



$$a = \frac{t}{2} - c - e = \frac{2.20}{2} - 0.10 - 0.138 = 0.862\ m$$

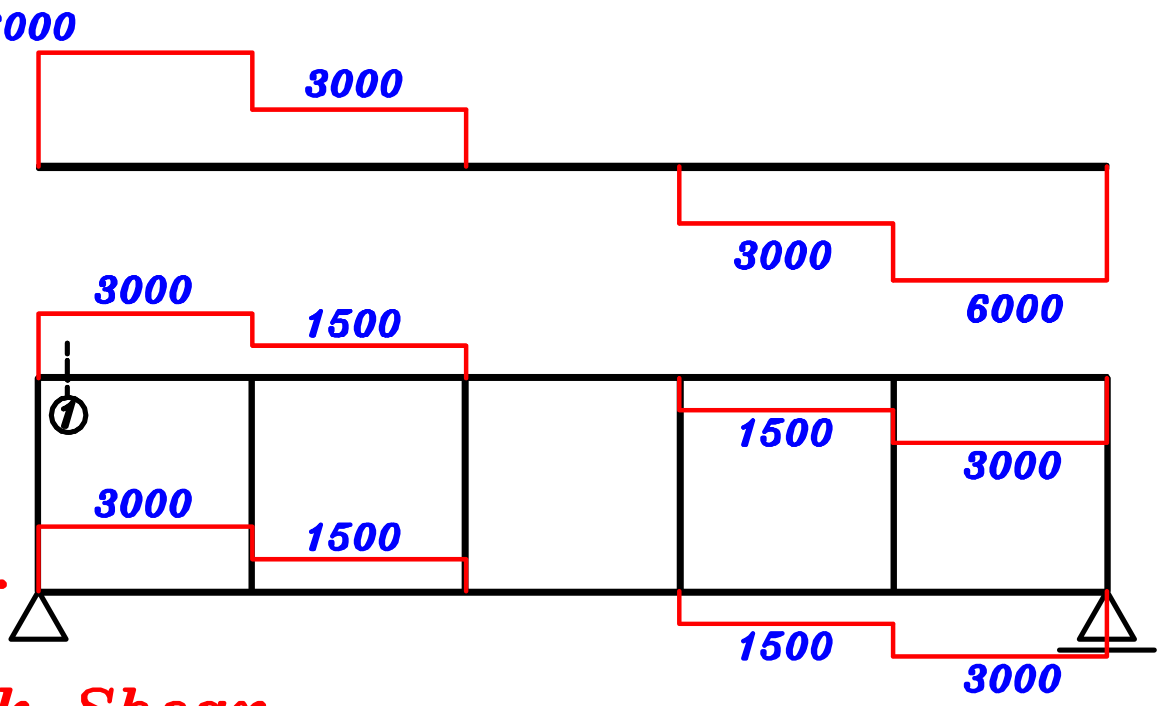
$$b = \frac{t}{2} - c + e = \frac{2.20}{2} - 0.10 + 0.138 = 1.138\ m$$

$$T_1 = T_{U.L.}\left(\frac{b}{a+b}\right) = 9000\left(\frac{1.138}{0.862 + 1.138}\right) = 5121\ kN$$

$$A_{s1} = \frac{T_1}{(F_y/\gamma_s)} = \frac{5121 * 10^3}{(360 \backslash 1.15)} = 16358\ mm^2$$

22 ϕ 32

S.F.D. on Vierendeels.



S.F.D.

Check Shear.

– **Allowable shear stress.**

$$q_{cu} = 0.24\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.24\sqrt{\frac{30}{1.5}} = 1.07 \ N\backslash mm^2$$

$$q_{max.} = 0.7\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.7\sqrt{\frac{30}{1.5}} = 3.13 \ N\backslash mm^2$$

Actual shear stress.

$$q_U = \frac{Q}{b\,d} = \frac{3000 * 10^3}{800 * 2100} = 1.78 \ N\backslash mm^2$$

$\therefore \ q_{cu} < q_U < q_{max.}$ $\therefore$ We need Stirrups more Than 5 ϕ8 \m`

Use Stirrups ϕ 12 steel 360/520

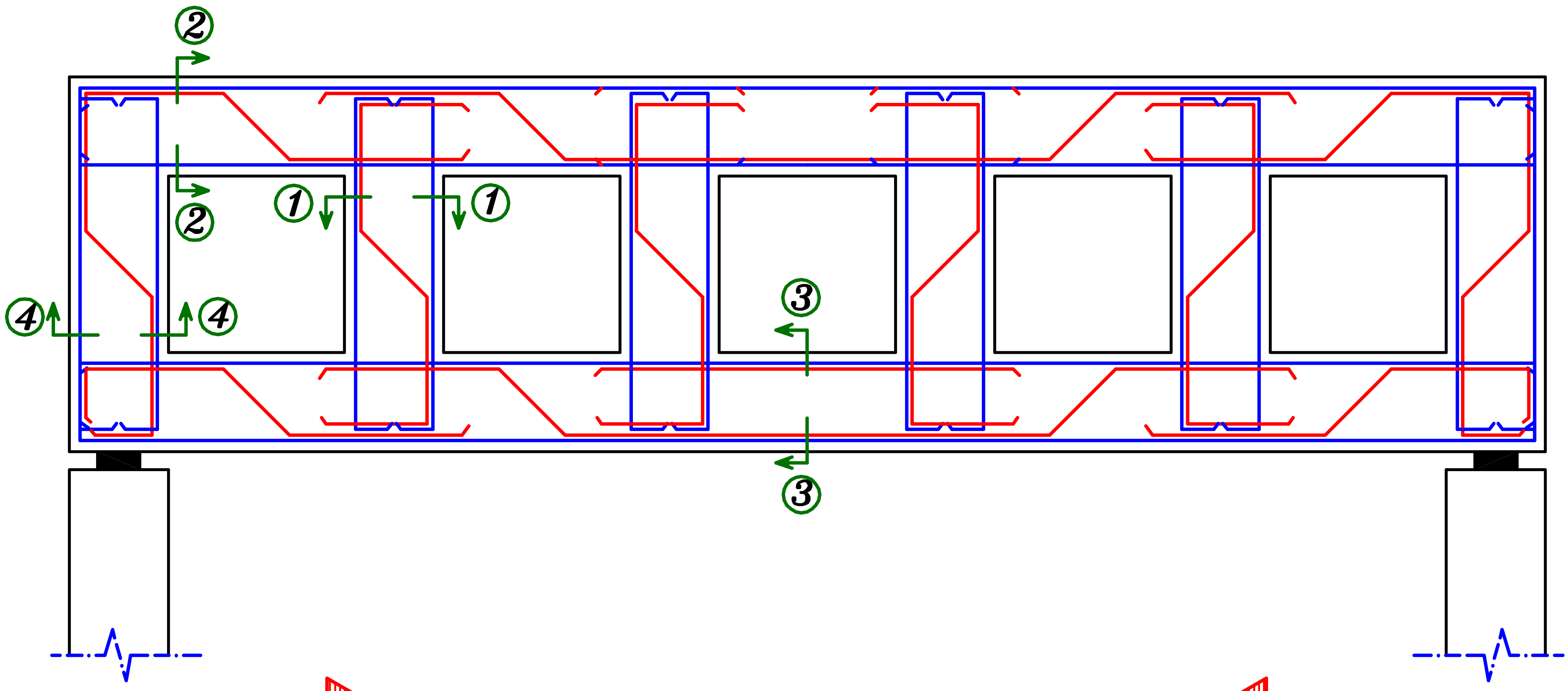
$$\therefore \text{ Use } \quad q_s = q_u - \frac{q_{cu}}{2} = \frac{n\,A_s\,(F_y\backslash\gamma_s)}{b \quad S}$$

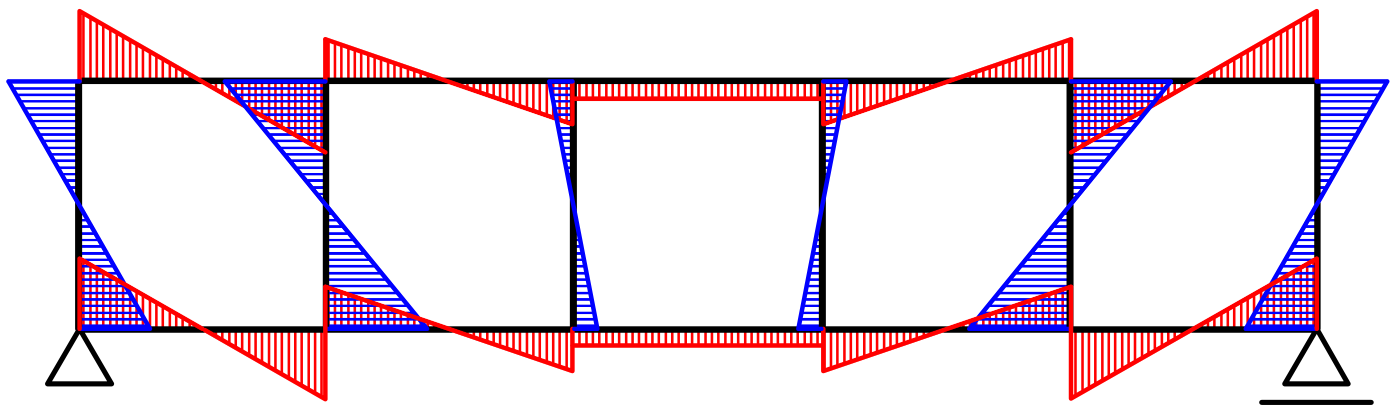
* Take $n = 4$, ϕ12 ⟶ $A_s = 113 \ mm^2$

$$1.78 - \frac{1.07}{2} = \frac{4 * 113 \ (360\backslash 1.15)}{800 * S} \longrightarrow S = 142.0 \ mm > 100 \ mm$$

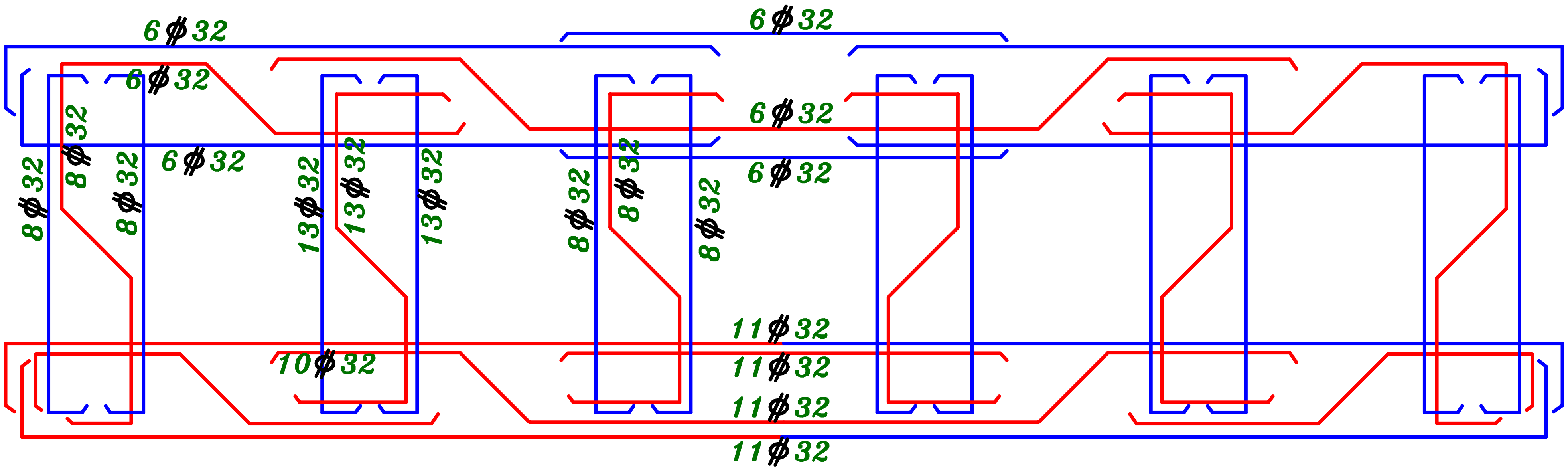
$$\therefore \text{ No. of stirrups}\backslash m` = \frac{1000}{S} = \frac{1000}{142.0} = 7.0 \backslash m`$$

Use Stirrups **7ϕ12\m`** 4 branches





B.M.D.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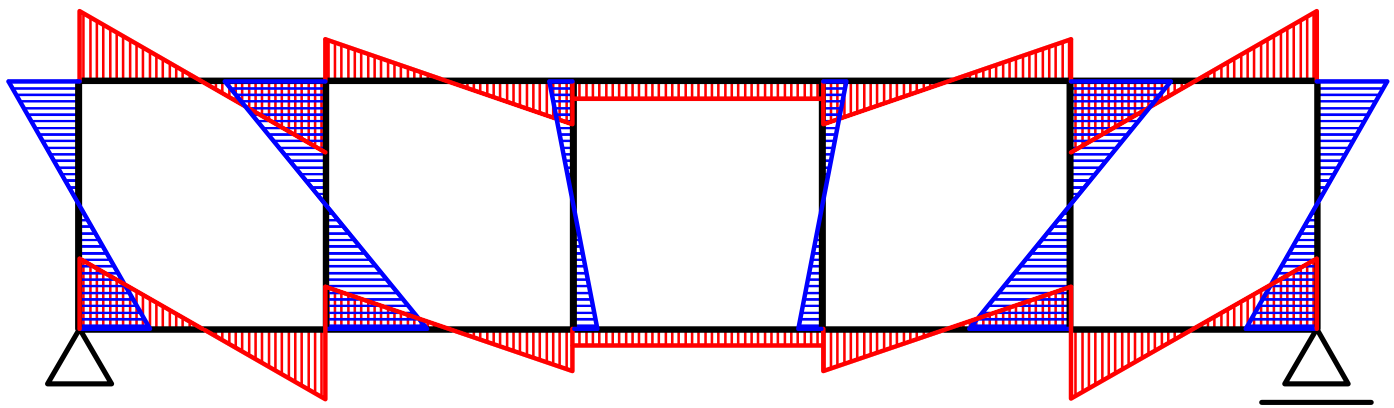
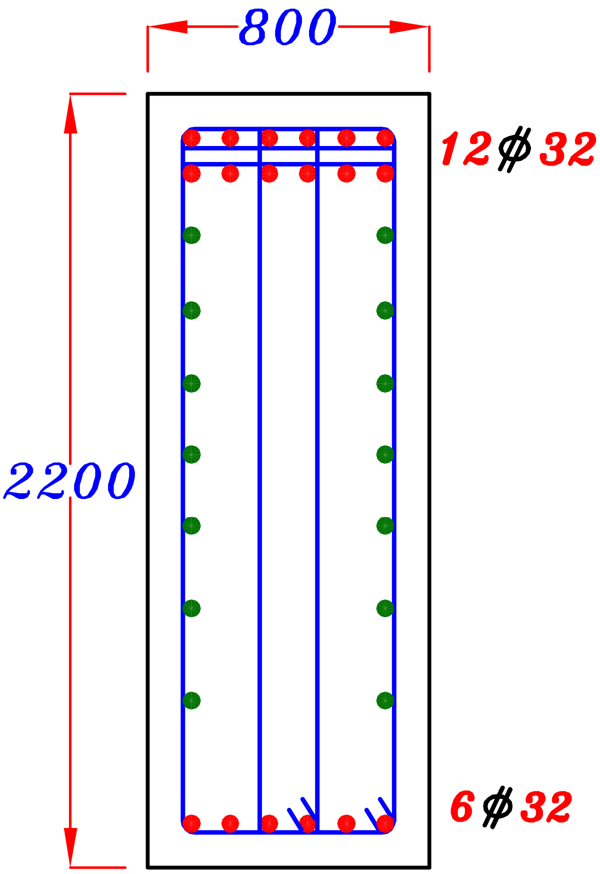
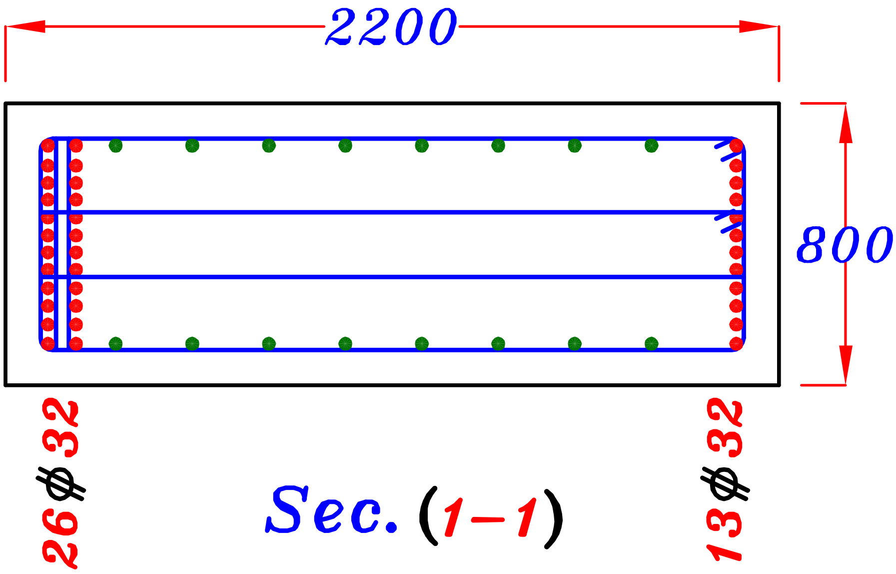


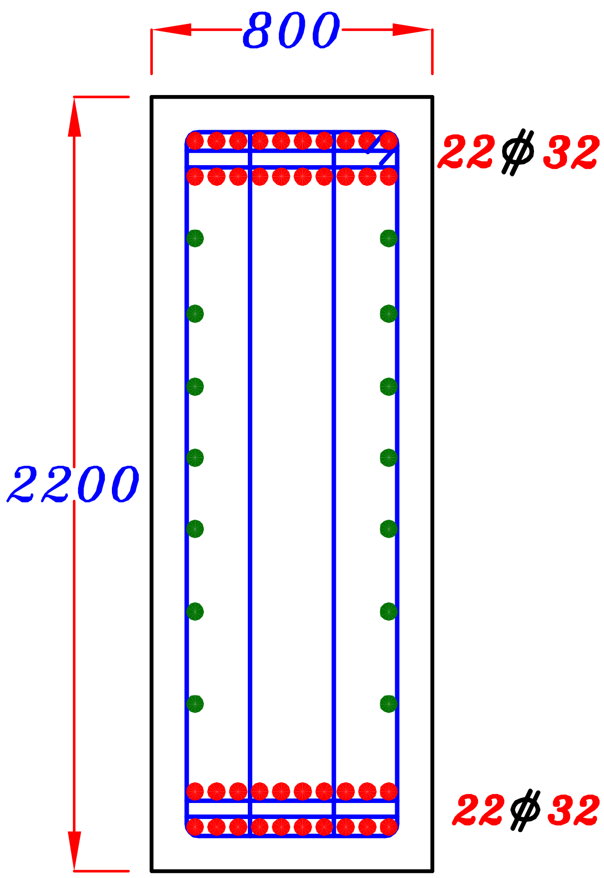
B.M.D.



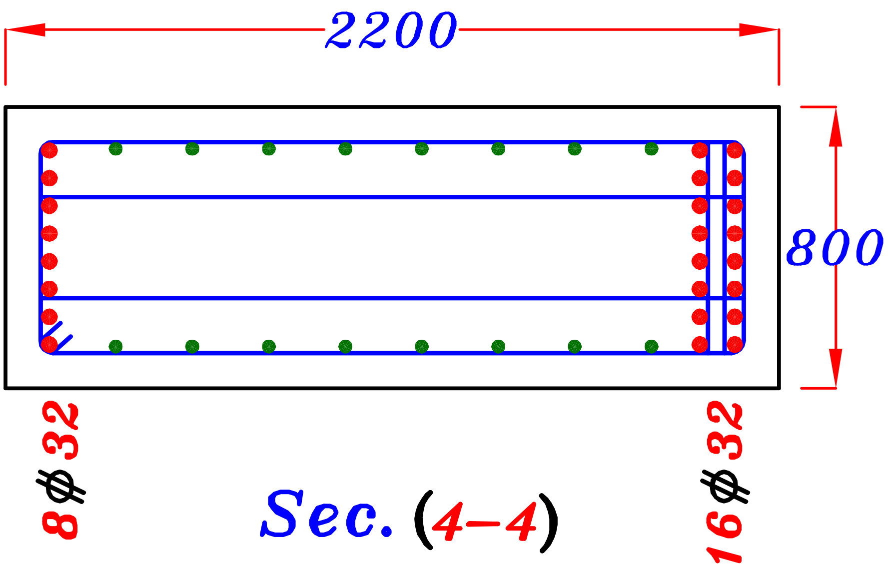
Sec. (2–2)



Sec. (1–1)



Sec. (3–3)



Sec. (4–4)