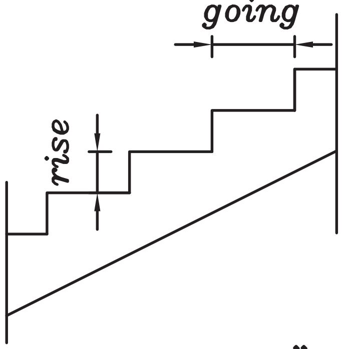
STAIRS

-هى بلاطات مائلة للتوصيل من منسوب الى منسوب اخر وتكون مزودة بدرج لامكانية الصعود عليها وعادة تكون بلاطة السلم اما

(one way or cantilever solid slab)



-وتتراوح ابعاد (rise) من (13-16 cm) وعادة تؤخذ (15cm) وتتراوح ابعاد (going) من (26-30 cm) وعادة تؤخذ (30cm) .

- أكبر عدد من الدرجات فـ اللبة الواحدة يساوى (١٤) درجة

$$No.\ of\ steps=\frac{difference\ between\ levels}{Rise\ height\ (0.15)}$$

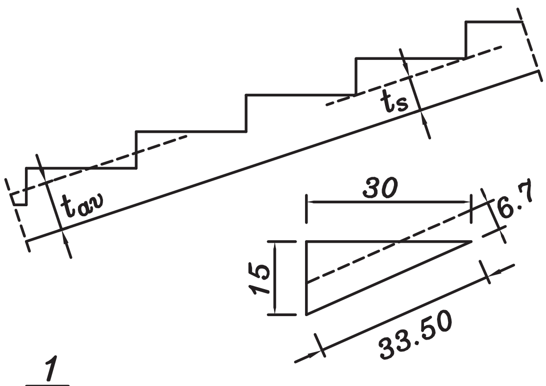
$$Length\ of\ stair=No.\ of\ steps\ *0.30$$

Concrete dimensions:

$$t_s=\frac{L_s}{25,30,36}\qquad (One\ way\ slab)$$

$$t_s=\frac{L_c}{10}\qquad (cantilever\ slab)$$

$$t_{av}=t_s+7\ cm$$

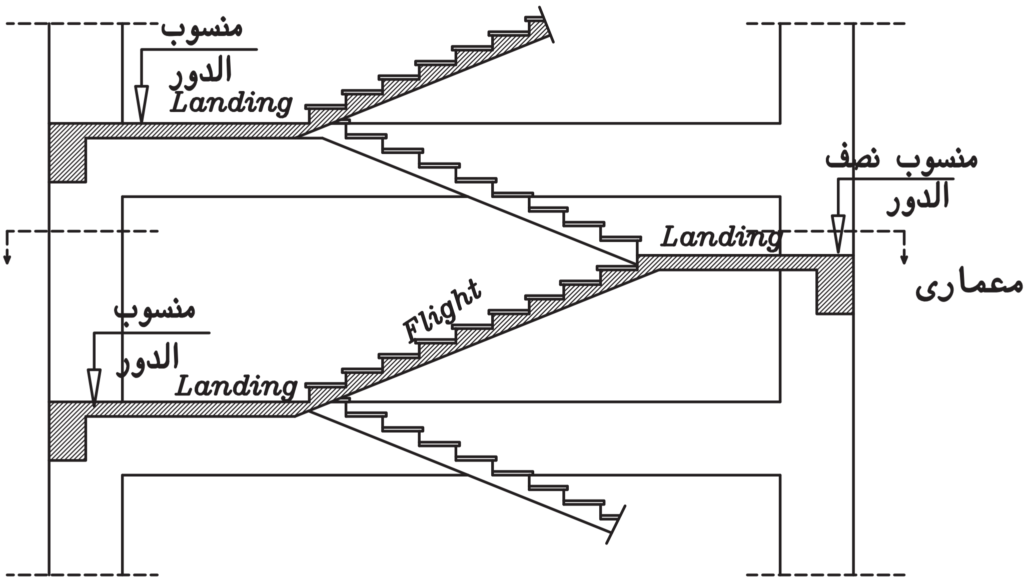


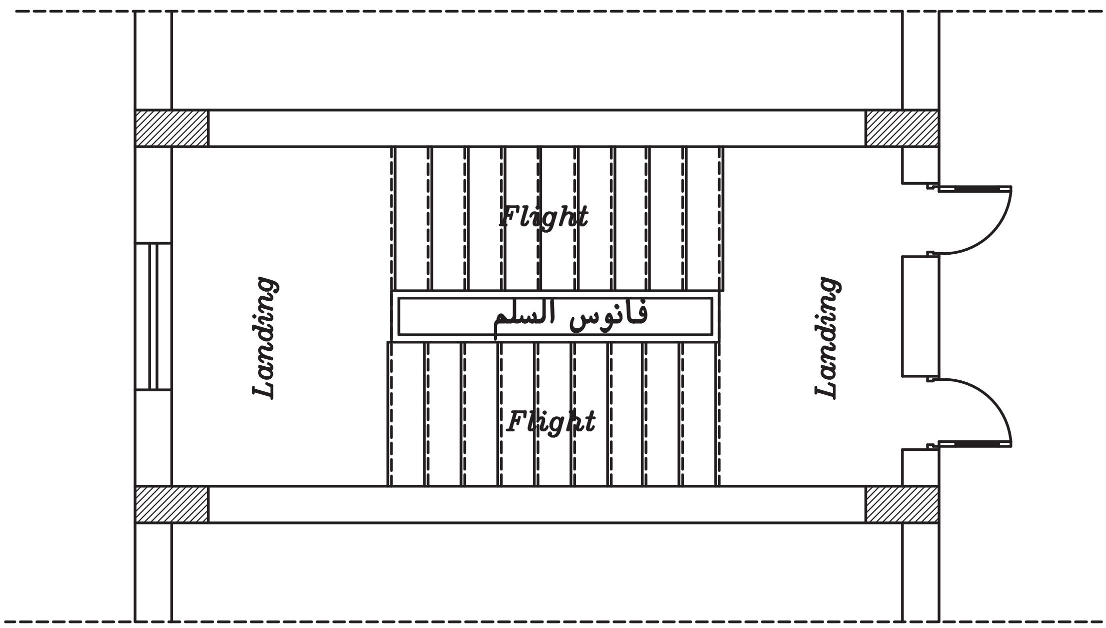
$$\frac{\frac{1}{2}*15*30}{33.5}=6.7\simeq 7.0cm$$

$$w_{su}=1.4(t_{av}\gamma_c+F.C.)+1.6L.L.\cos\theta\ \ kN/m^2$$

ـ ملحوظة

لاحظ ان (t_s) هى التى تستخدم فى التصميم بينما (t_{av}) تستخدم فى حساب الاحمال فقط.





Arc. Plan

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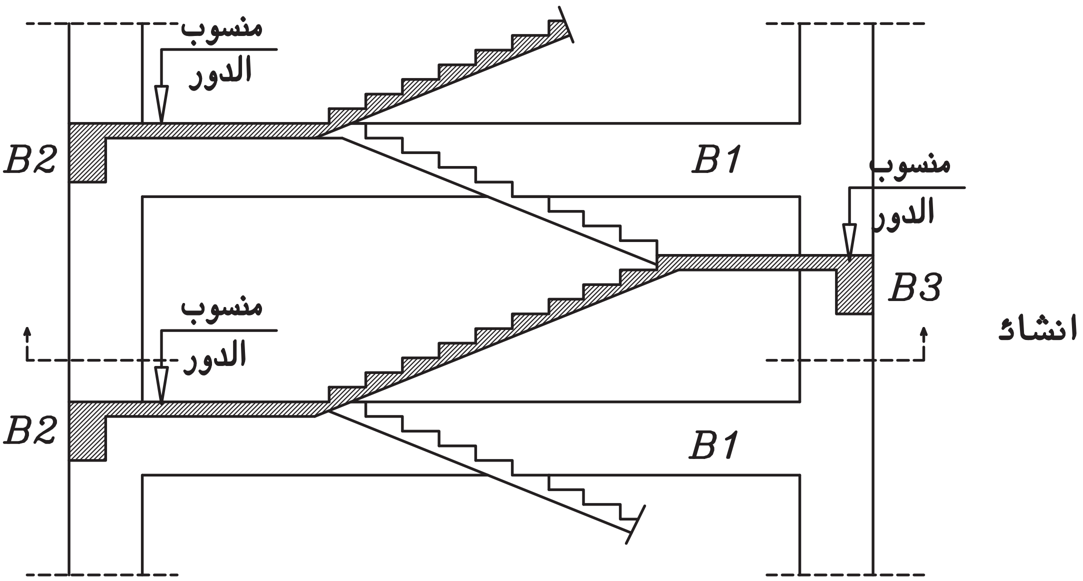
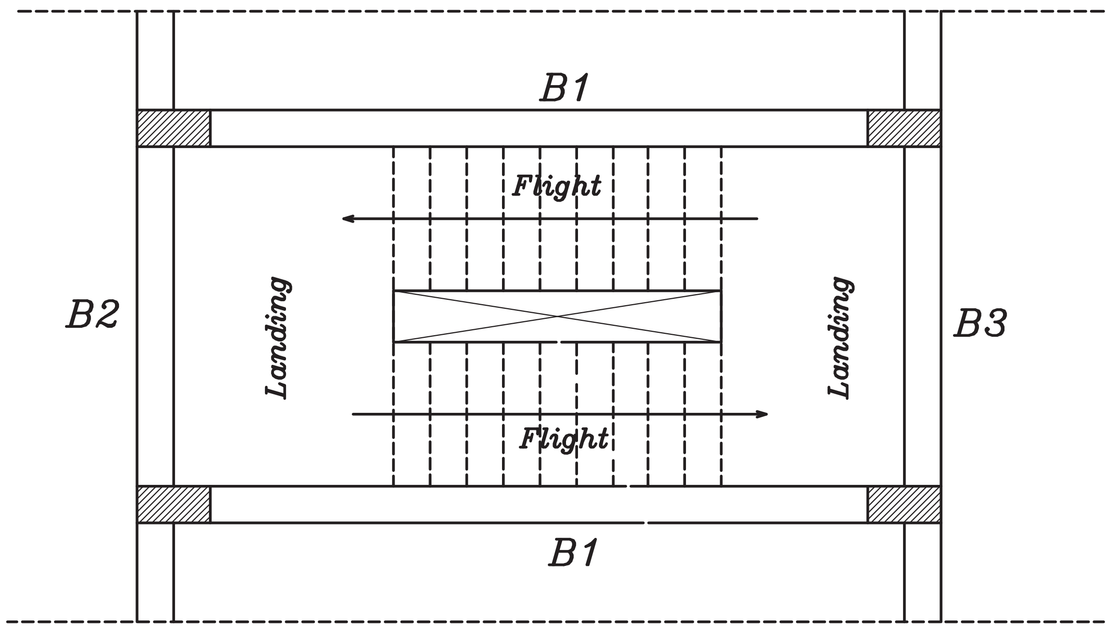
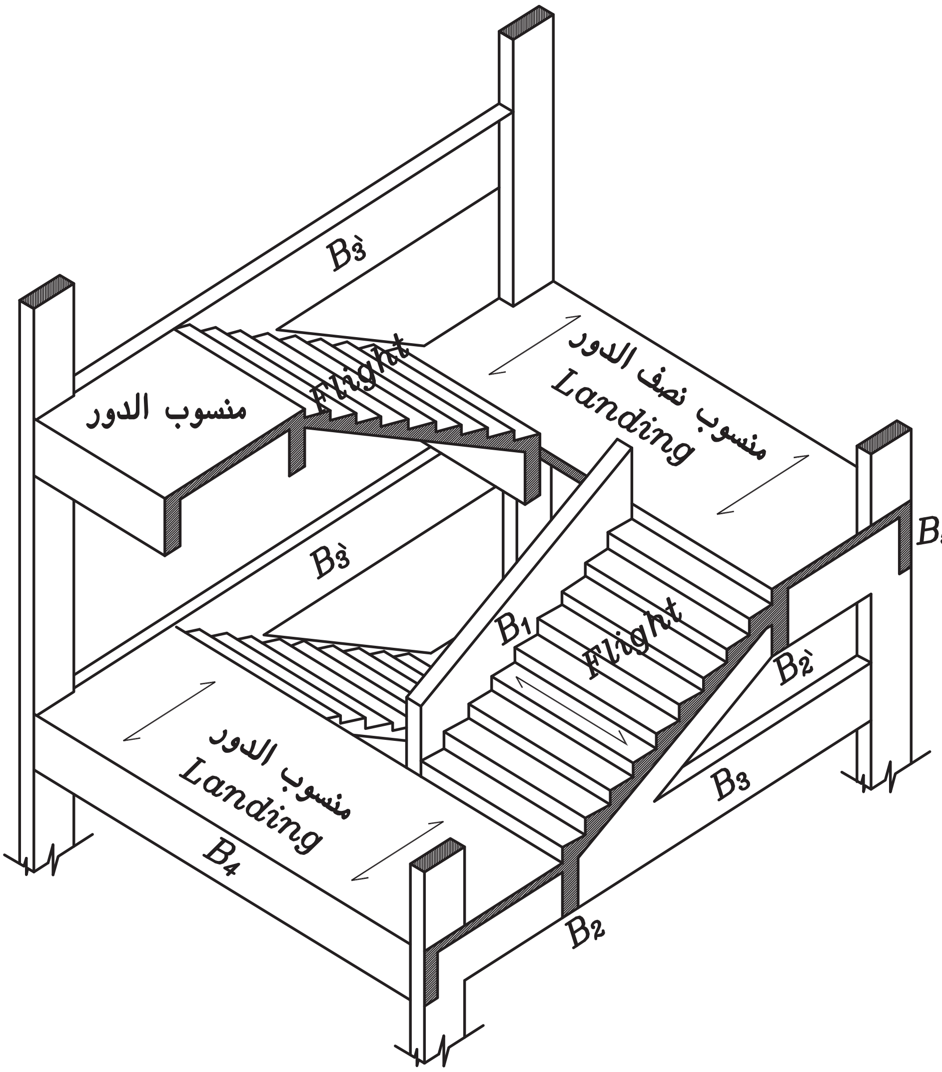


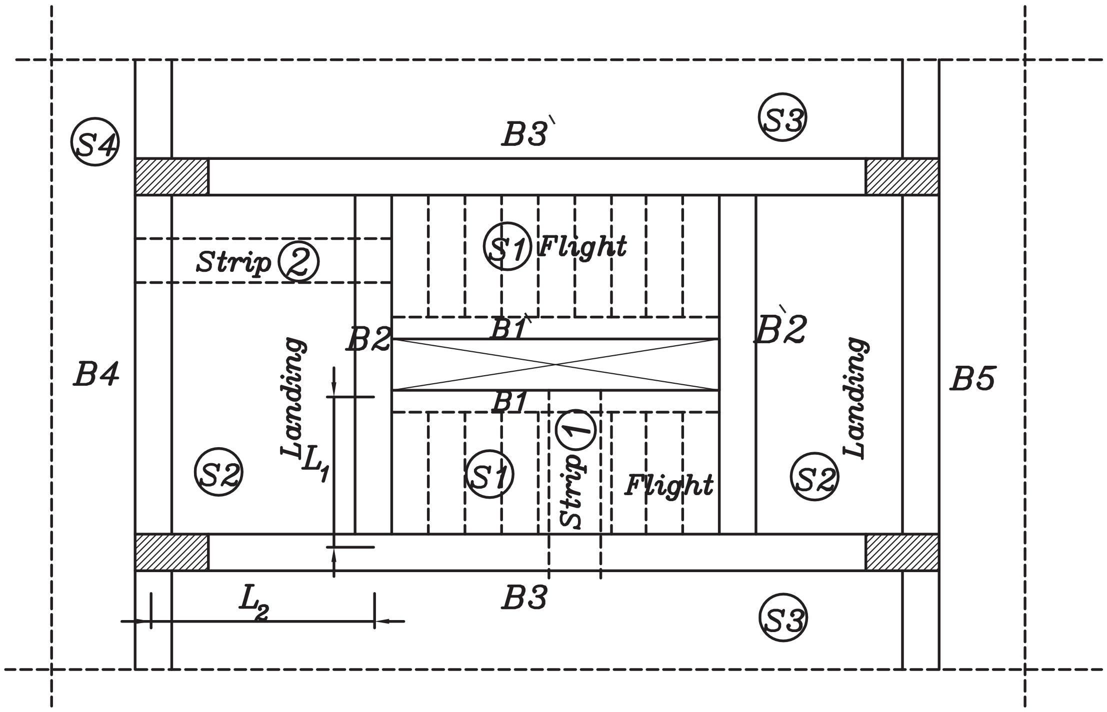


Structural Plan

Systems of Stairs used in ordinary buildings

Type(1)





$1-Slabs$

Calculate t_s

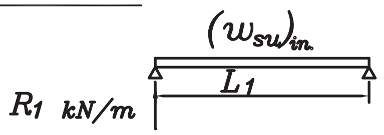
$t_{av}=t_s+7cm$

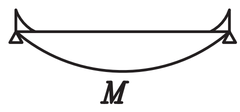
$w_{su_{Hl.}}=1.4[t_s\gamma_c+F.C.]+1.6L.L.$

$w_{su_{in.}}=1.4[t_{av}\gamma_c+F.C.]+1.6L.L.\cos\theta$

Strip (1)

شريحة افقية فى بلاطة مائلة

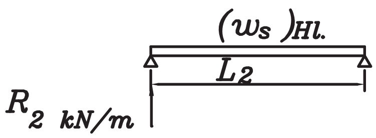


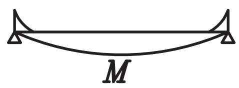


B.M.D.

$M_{des.}=M\ \cos\theta$
$d=t_s-20mm$

Strip (2)



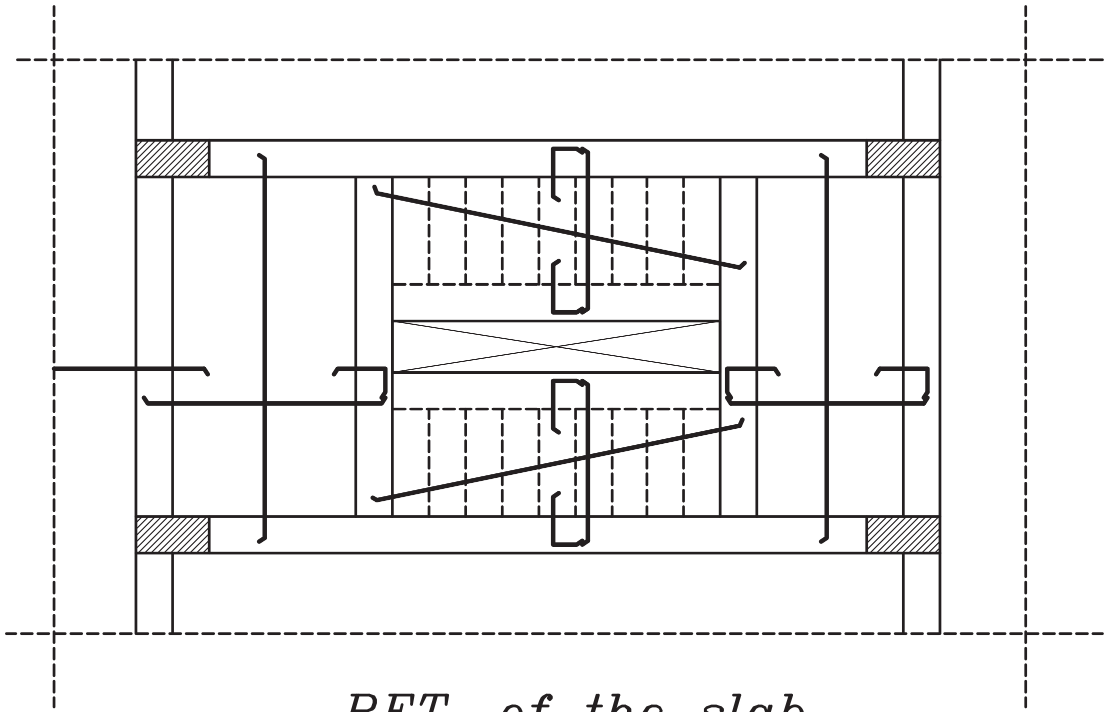


B.M.D.

$M_{des.}=M$
$d=t_s-20mm$

ملحوظة

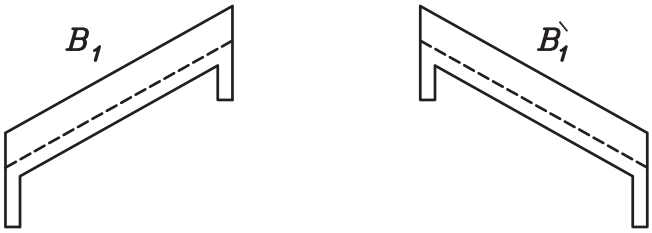
نصمم شريحة السلم على انها simple span وذلك لسهولة الحل والتنفيذ.



RFT. of the slab.

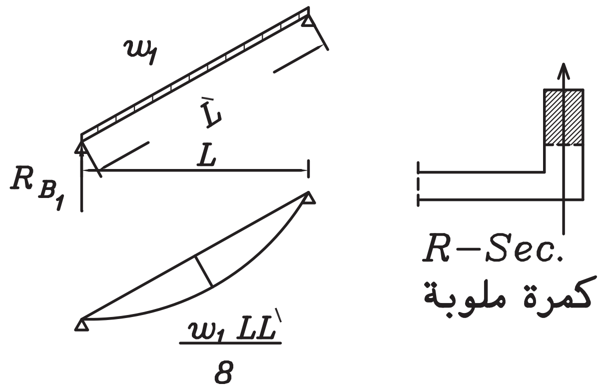
2-Beams

B_1 , B_1\`



$$w_1 = o.w. + R_1$$

$$w_1 = \gamma_c b(t - t_s) * 1.40 + R_1$$



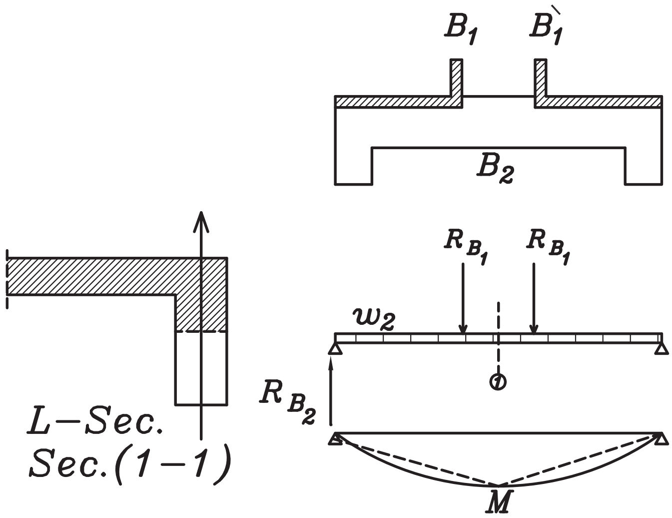
B_2 , B_2\`

$$w_2 = o.w. + R_2$$

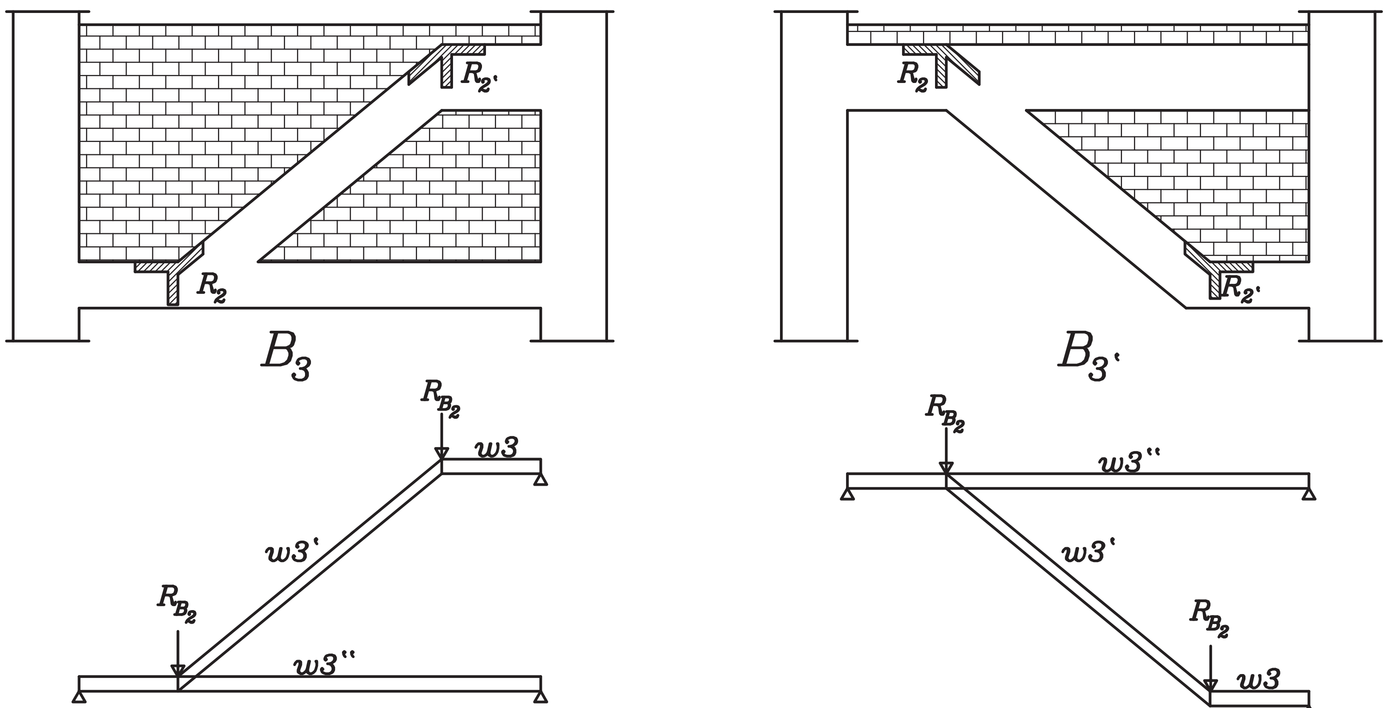
$$w_2 = \gamma_c b(t - t_s) * 1.40 + R_2$$

L-Sec.

$$B = \begin{cases} C.L. - C.L. \\ 6t_s + b \\ K\frac{L}{10} + b \end{cases}$$ الاقل



B_3 , B_3\`



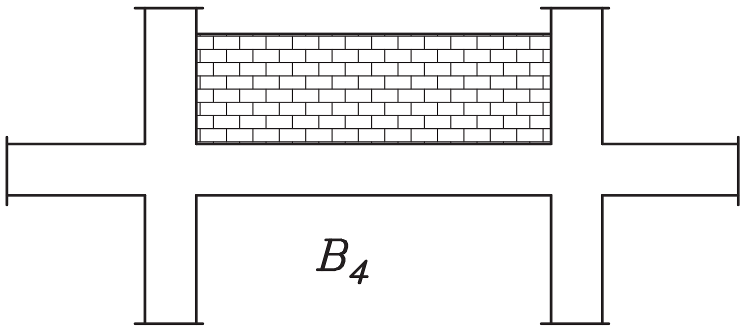
$w_3 = o.w. + walls$

$w_{3'} = o.w. + walls + R_1$

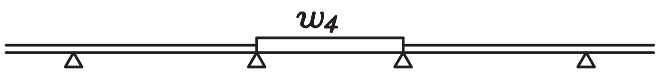
$w_{3''} = o.w. + walls + S_3$

B_4

$w_4 = o.w + walls + R_2 + S_4$

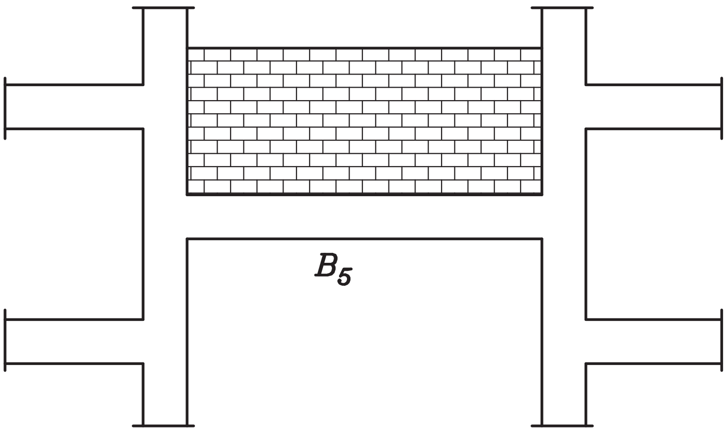


Continous Beam.

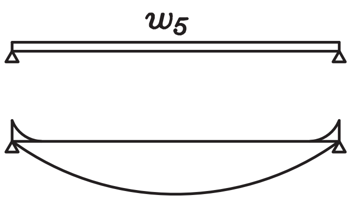


B_5

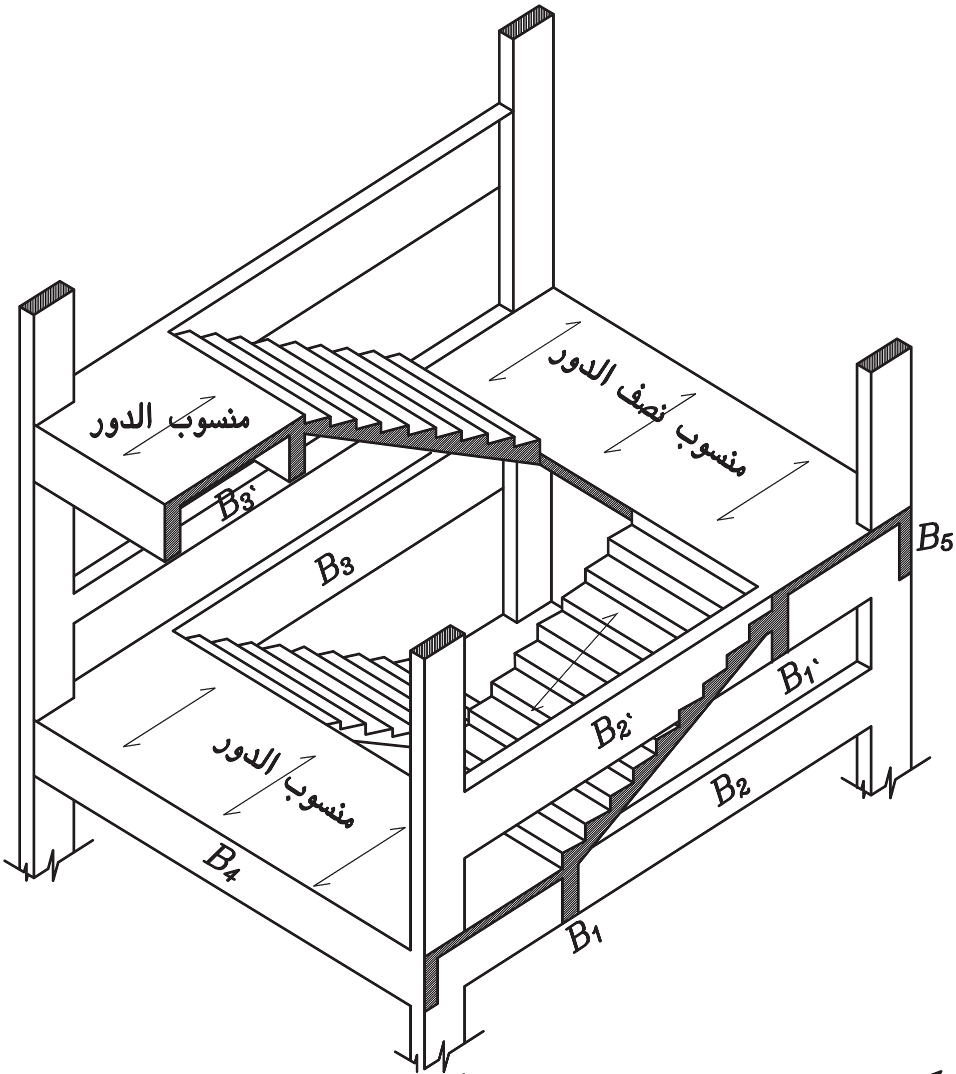
$w_5 = o.w. + walls + R_2$



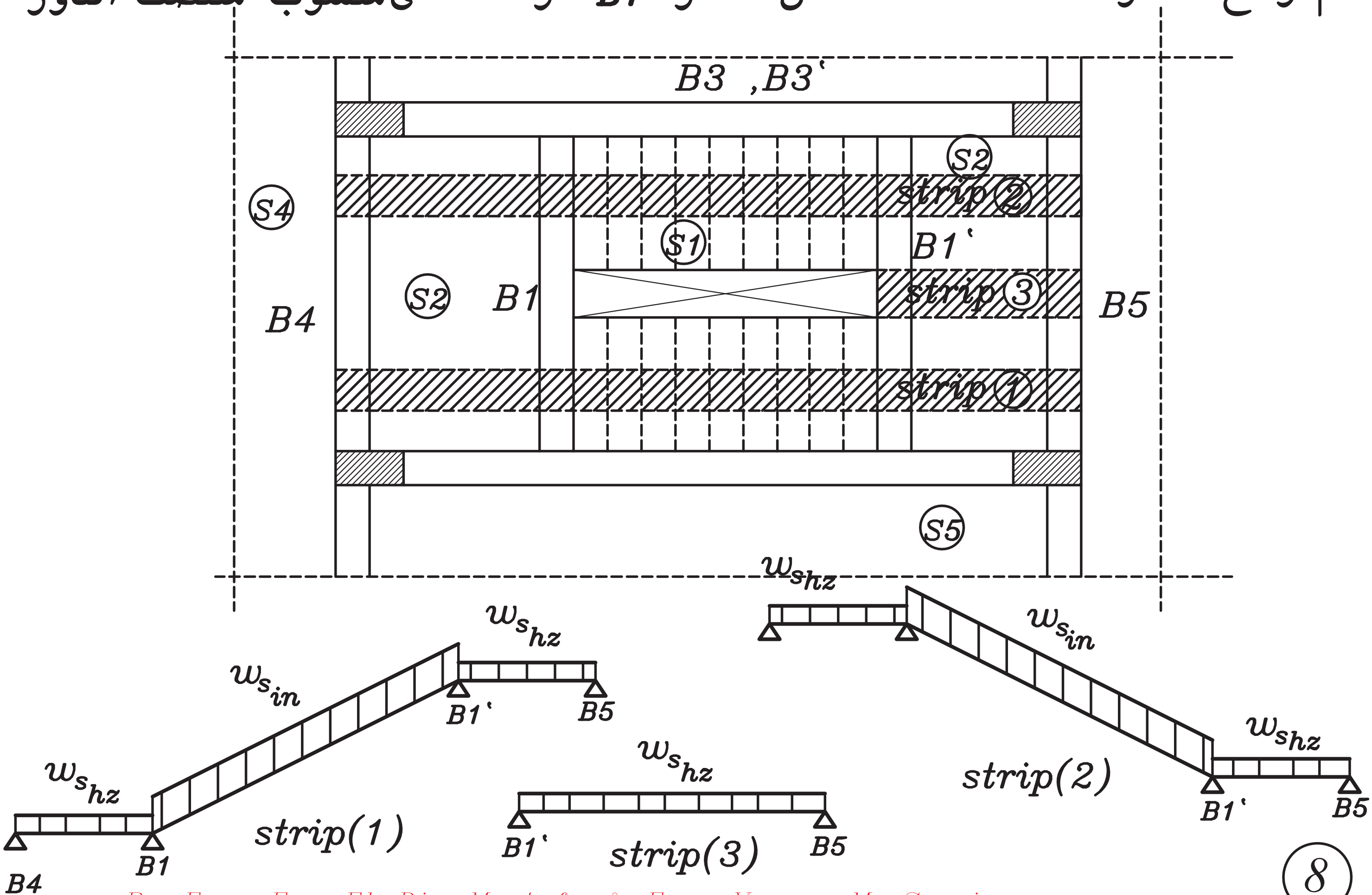
B_5 Simple Beam.



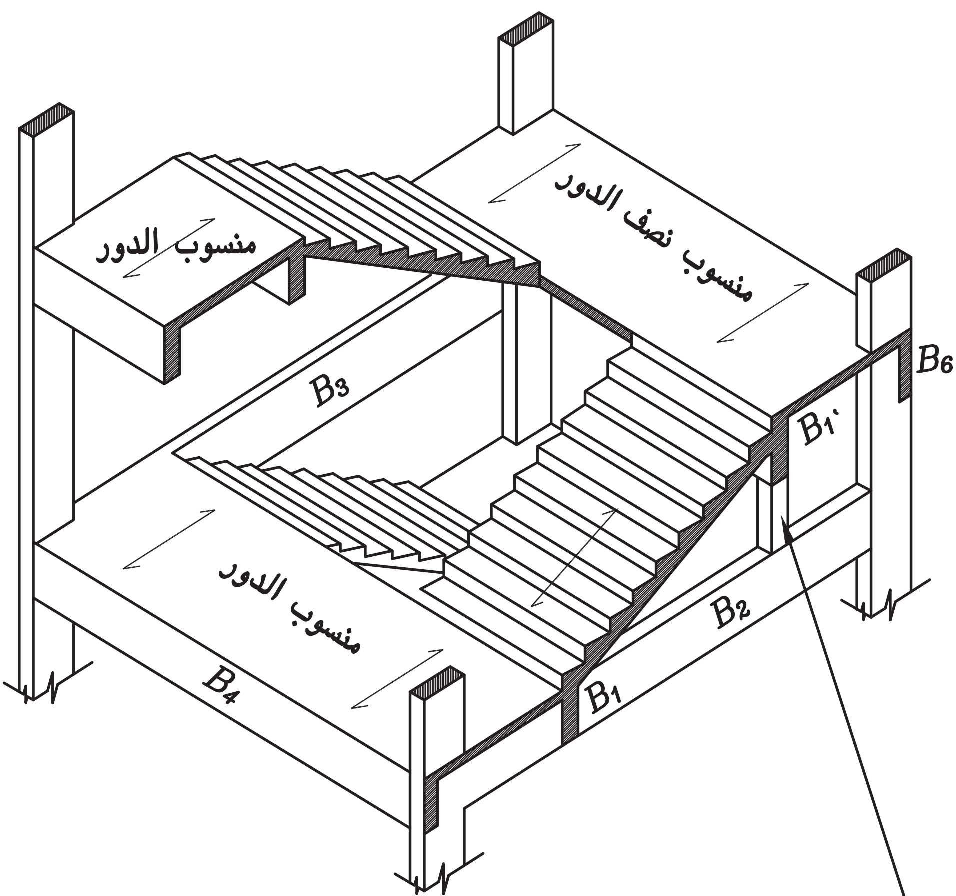
Type(2)



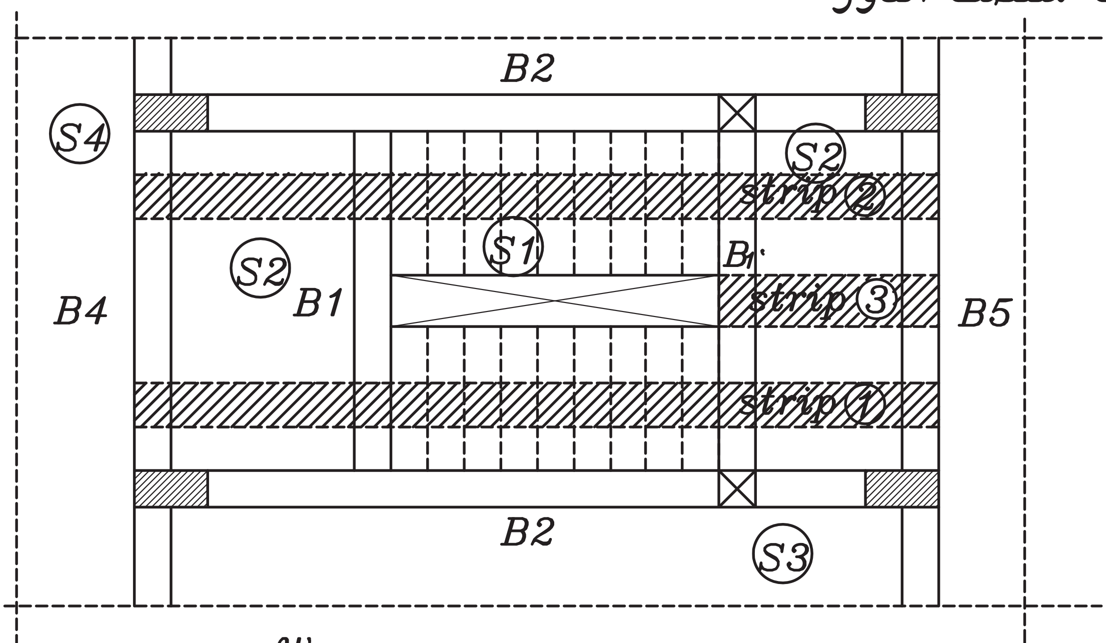
تم وضع الكمرات B2' & B3' لحمل الكمرة B1' الواقعة فى منسوب منتصف الدور

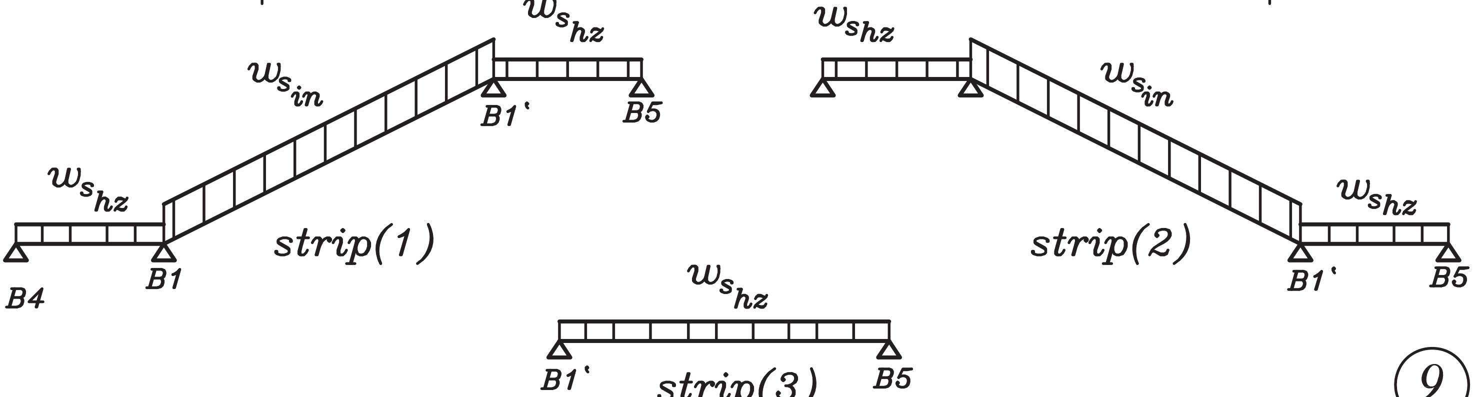


Type(3)

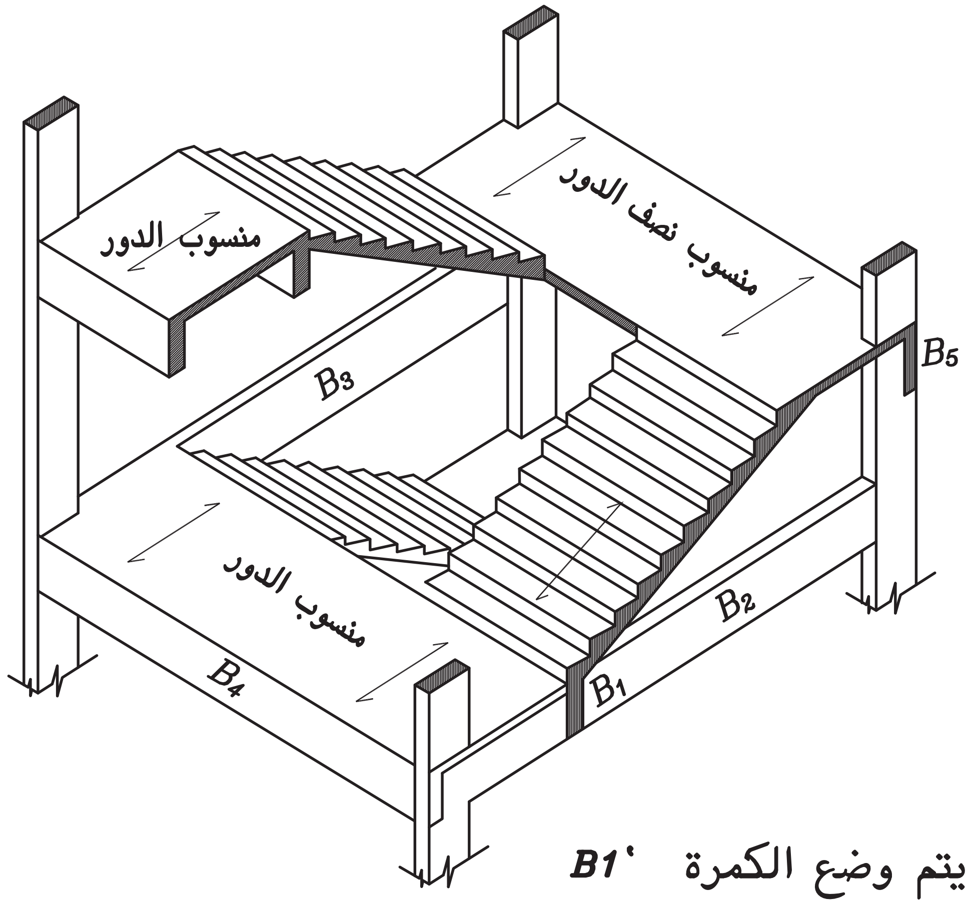


تم وضع **Post** بدلا من الكمرات **B2‘ & B3‘** وذلك لحمل الكمرة **B1‘** الواقعة فى منسوب منتصف الدور

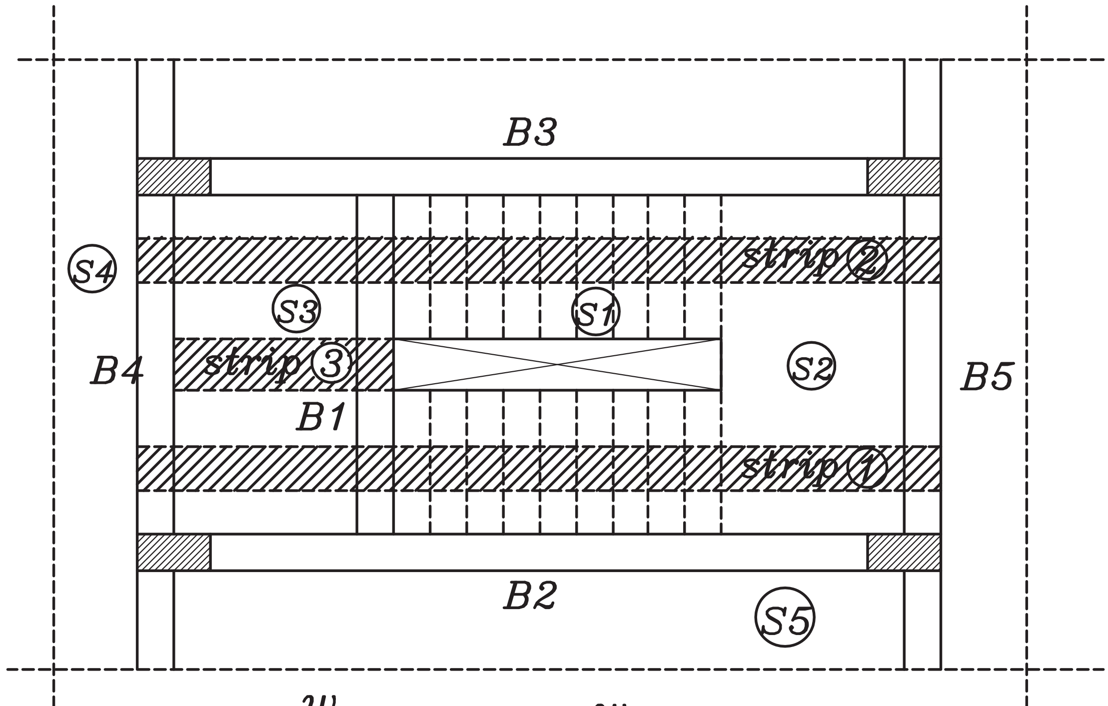


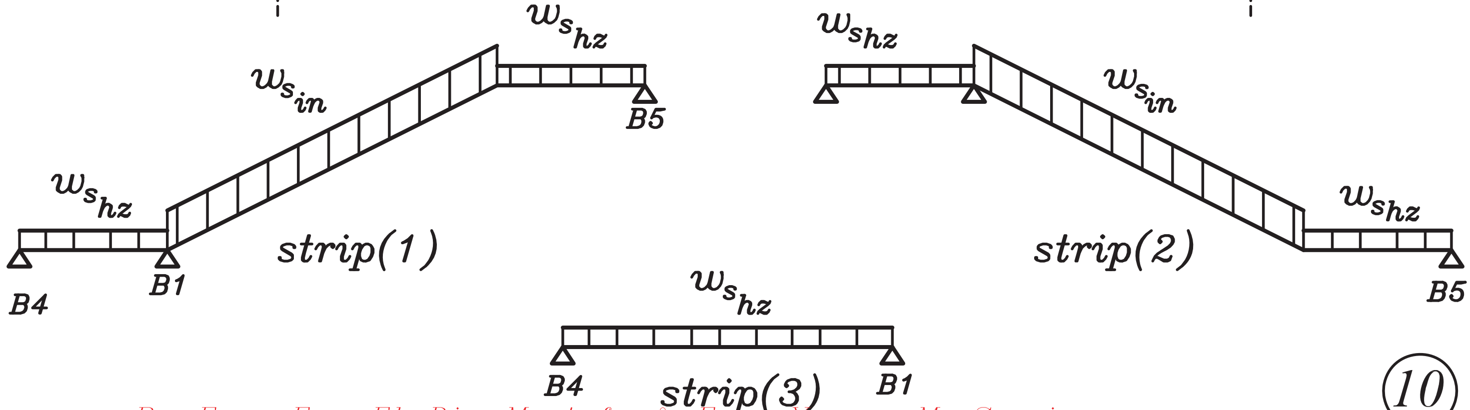


Type(4)



لم يتم وضع الكمرة **B1**`





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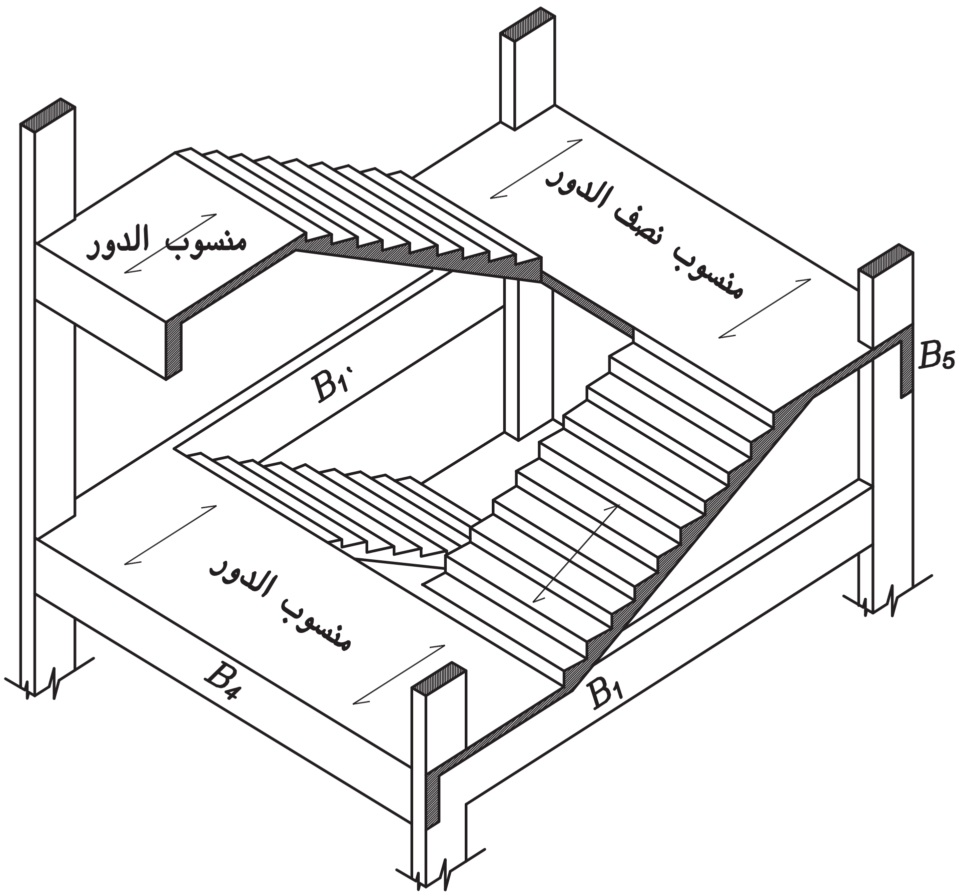

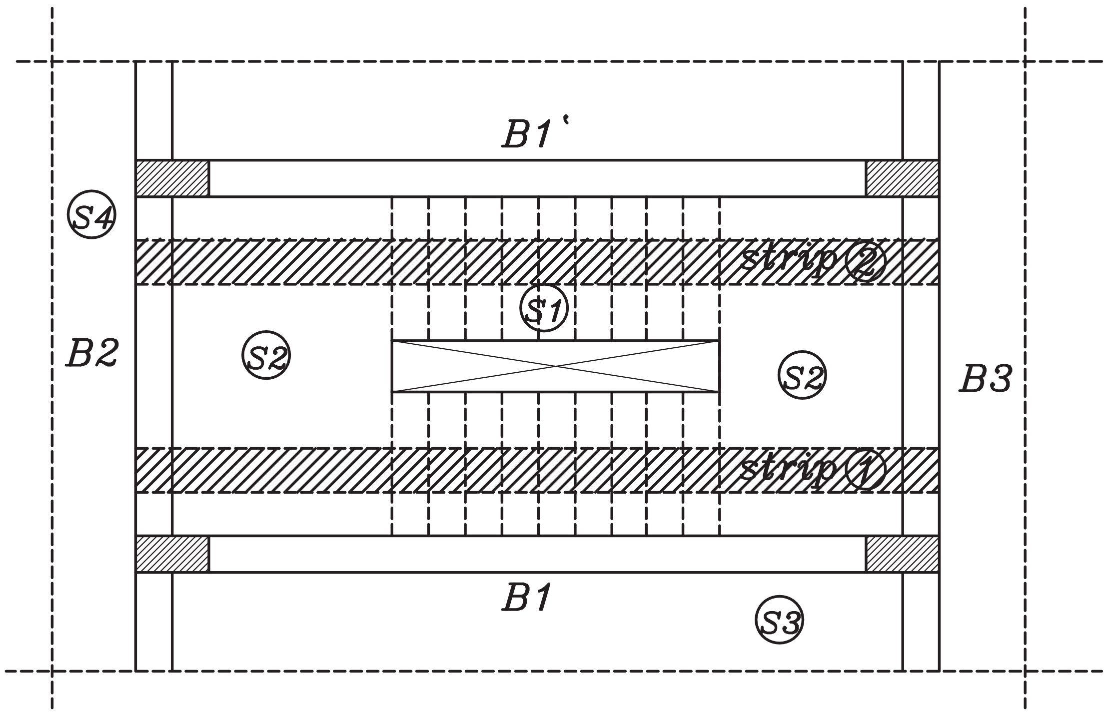

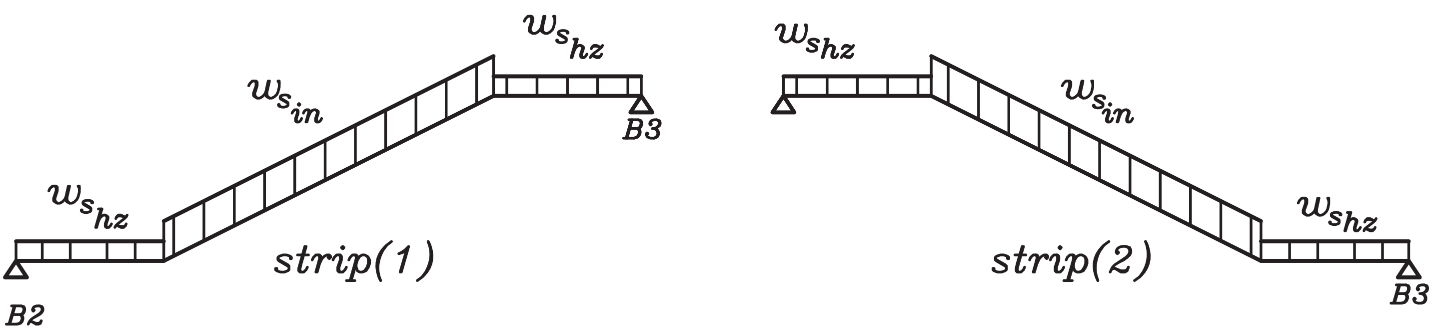

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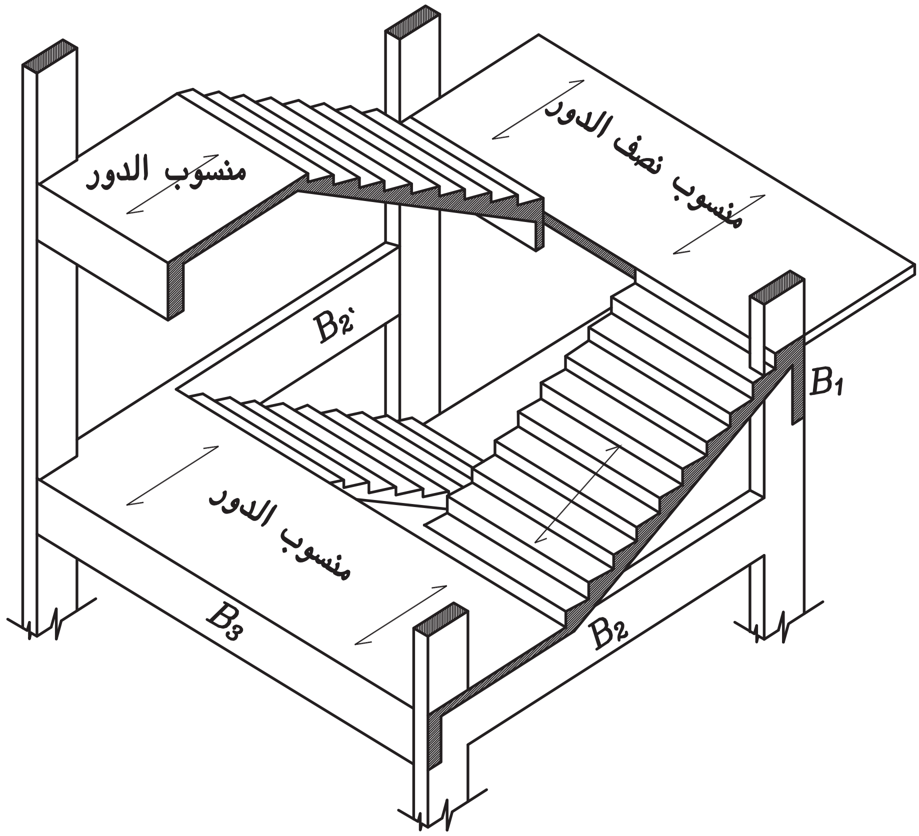
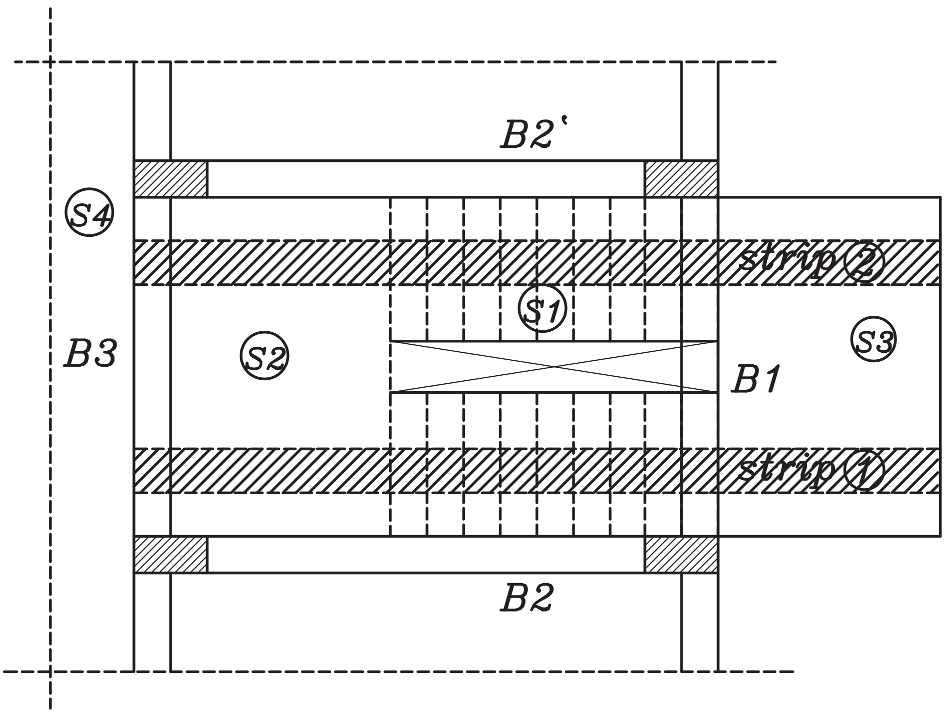
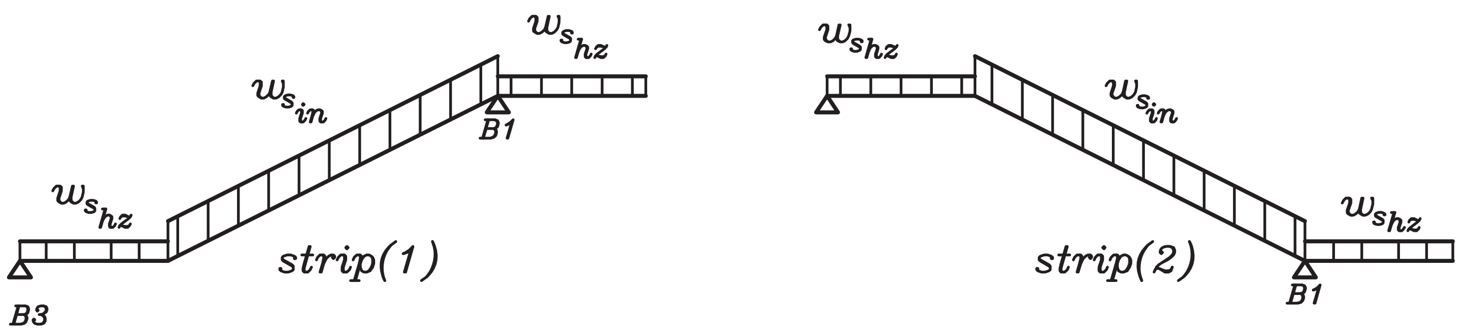
Type(6)



منسوب الدور
منسوب نصف الدور
B2'
B1
منسوب الدور
B3
B2

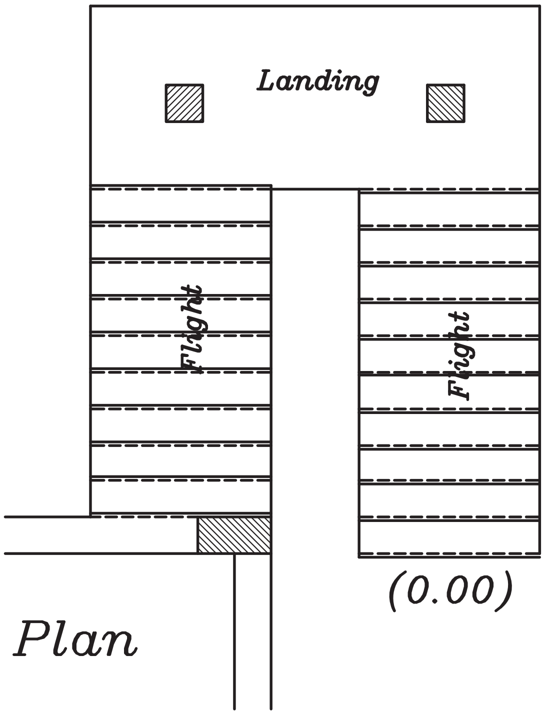


B2'
S4
strip 2
S1
B3
S2
S3
B1
strip 1
B2

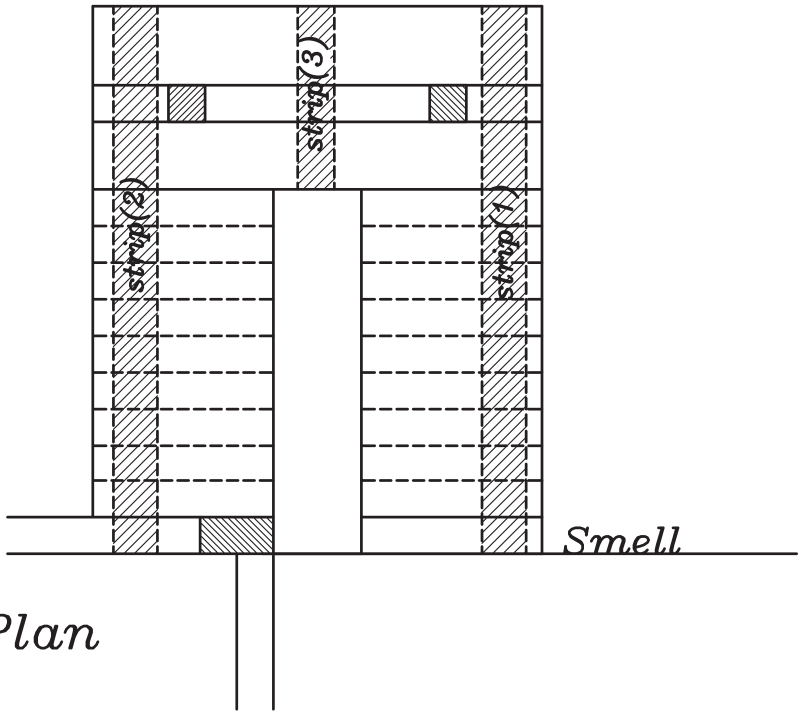


$w_{s_{hz}}$
$w_{s_{in}}$
B1
$w_{s_{hz}}$
strip(1)
B3
$w_{s_{hz}}$
$w_{s_{in}}$
$w_{s_{hz}}$
strip(2)
B1

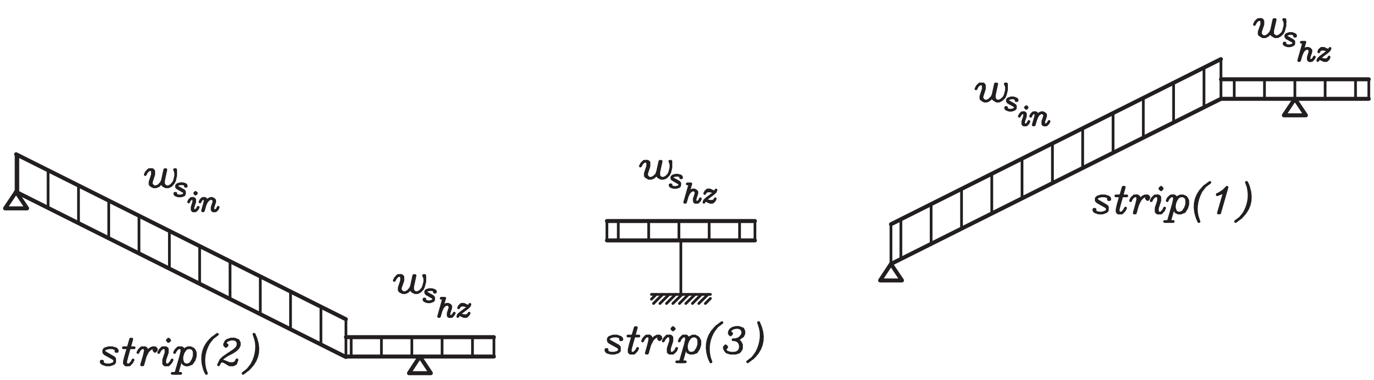
Example 1:- Show How to solve this stair



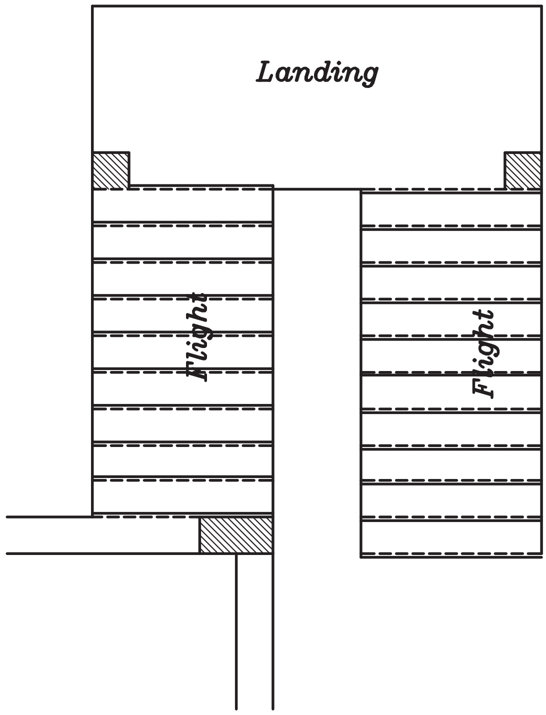
Arc. Plan



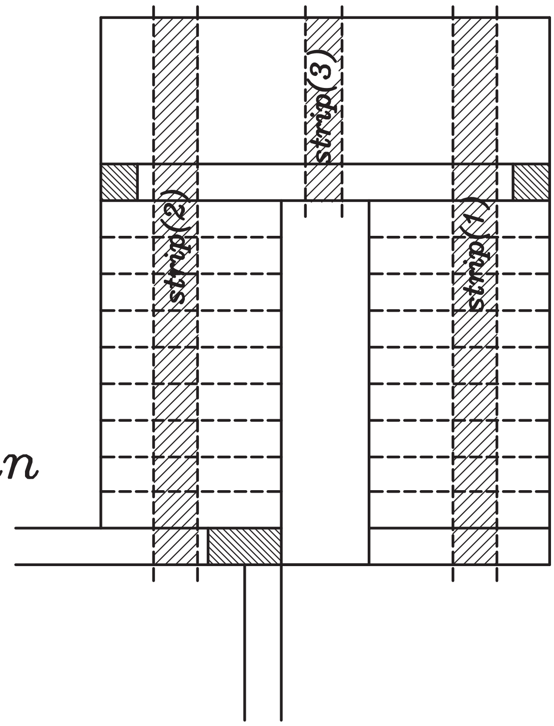
Structural Plan



Example 2:- Show How to solve this stair

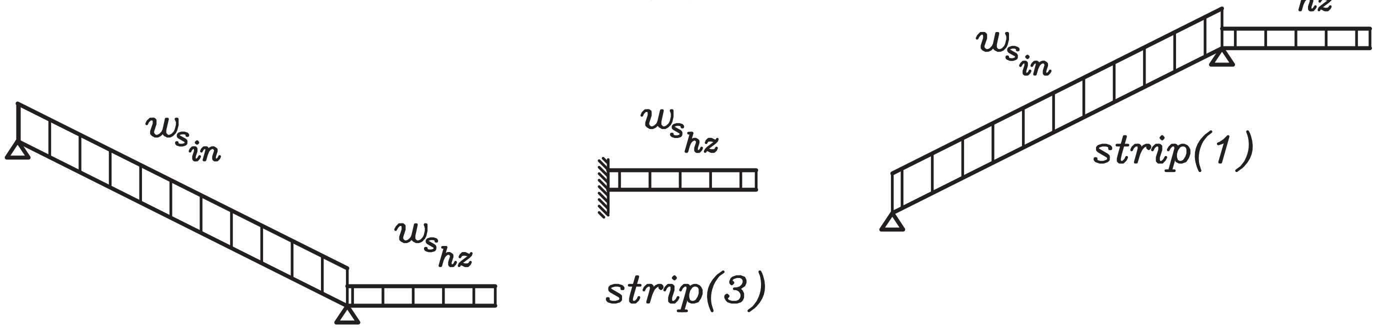


Arc. Plan



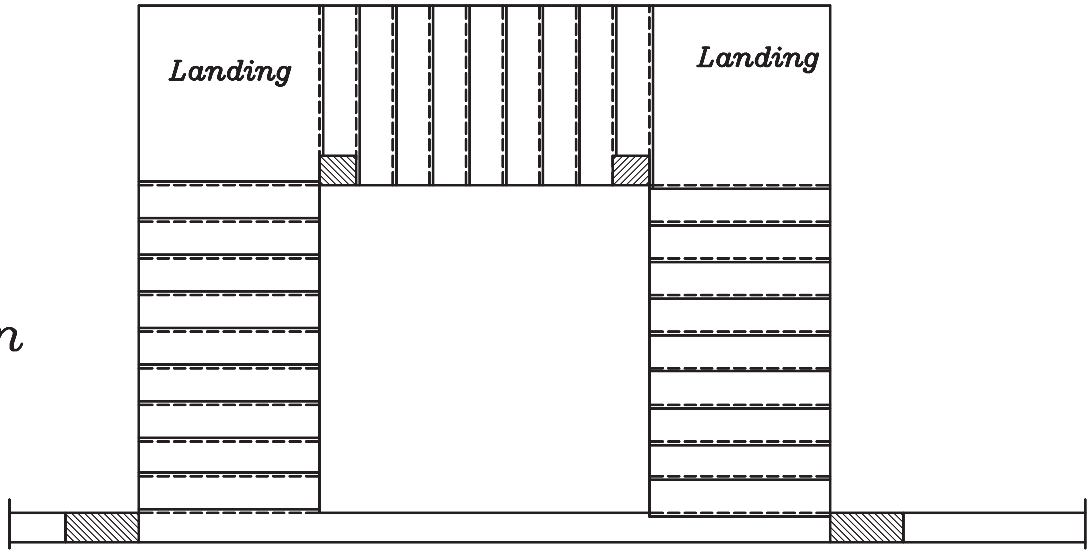
Structural Plan

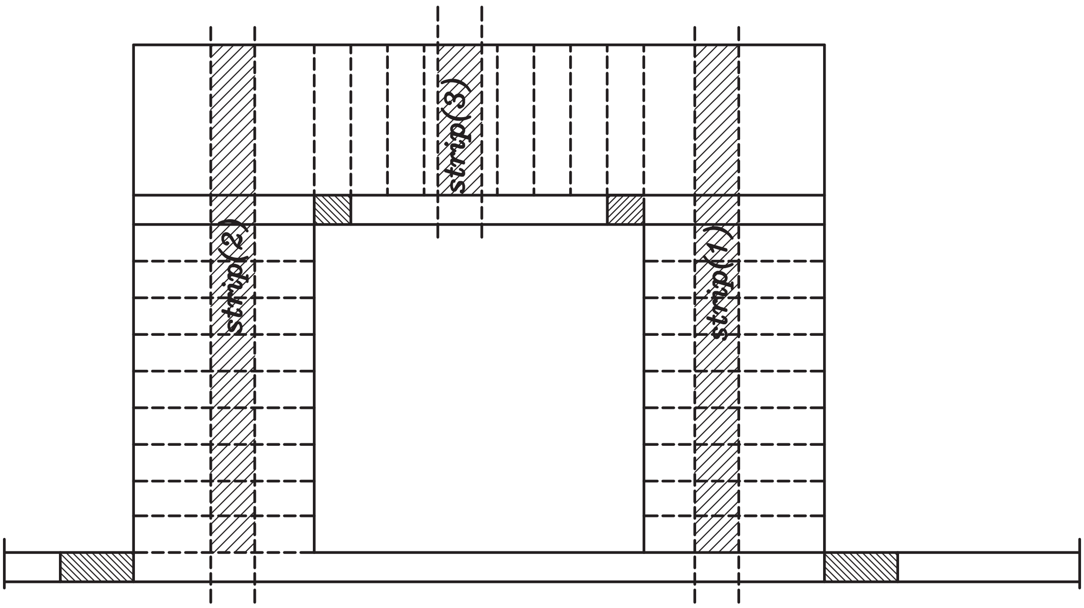
Smell



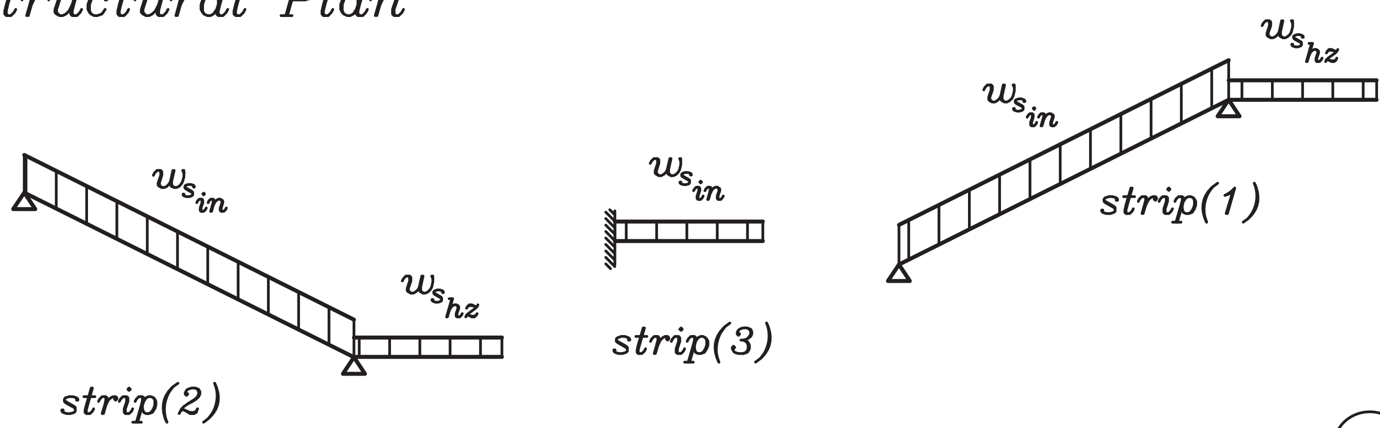
Example 3:– Show How to solve this stair

Arc. Plan





Structural Plan



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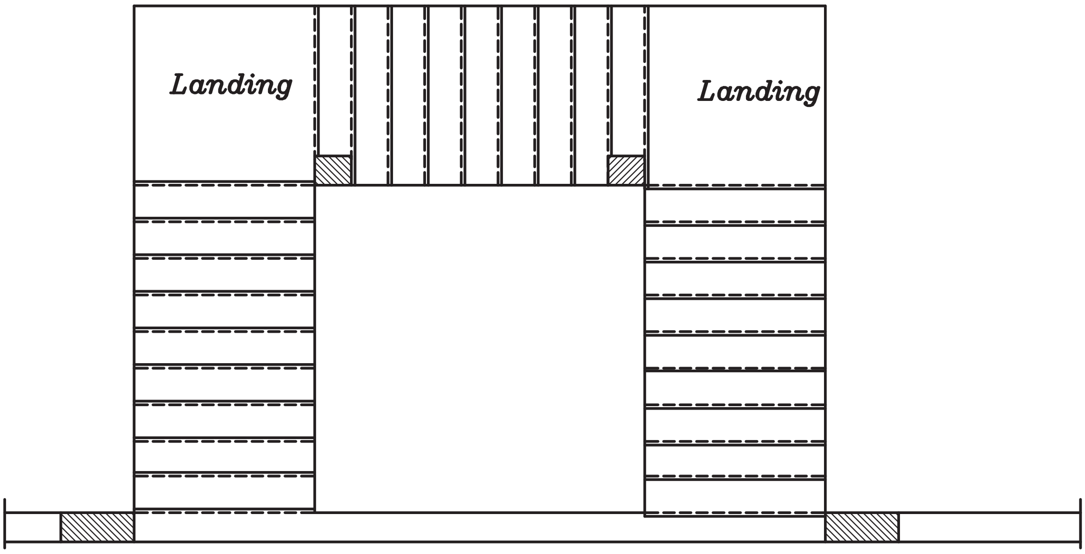
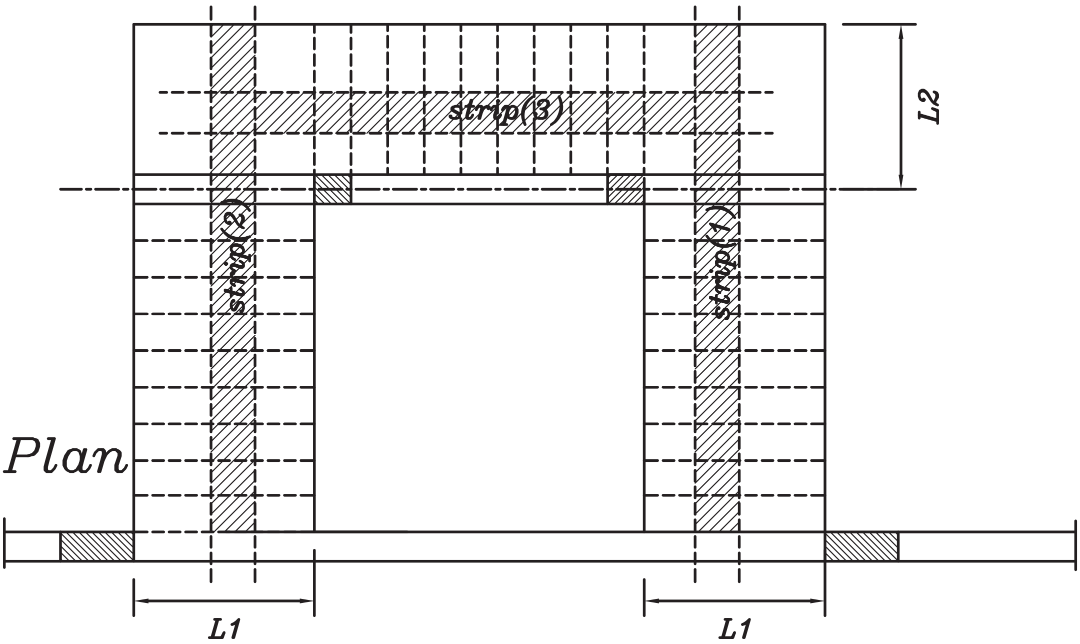
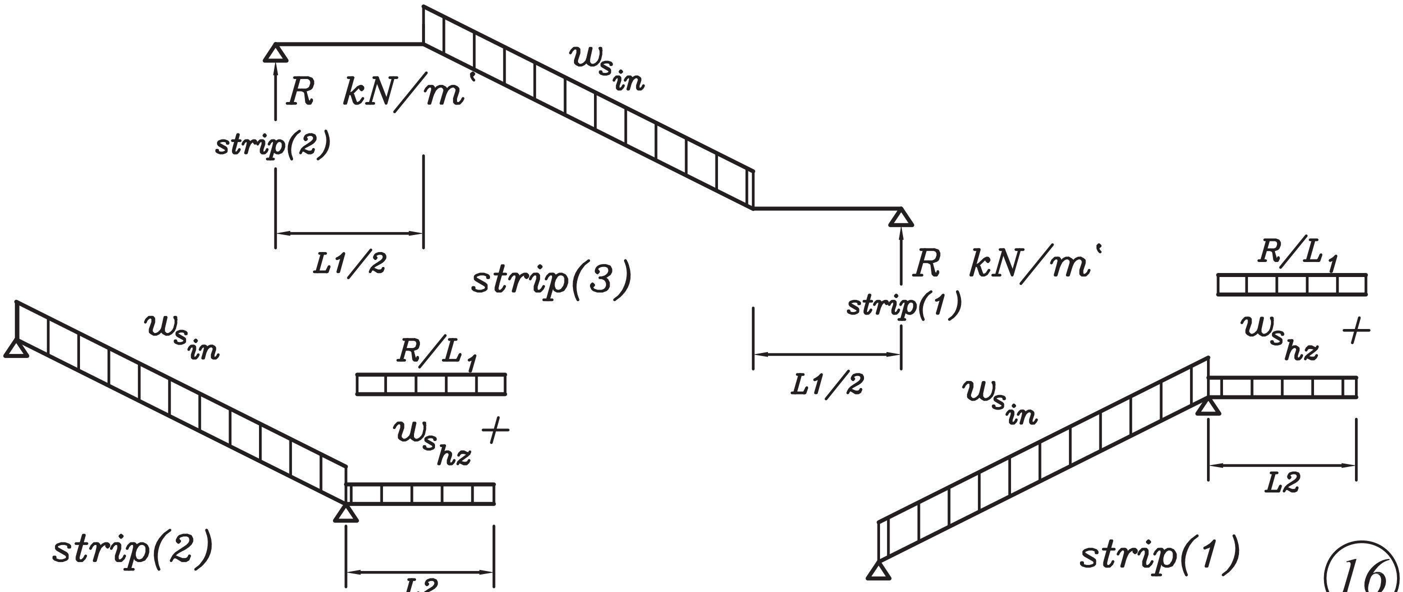
Another Solution



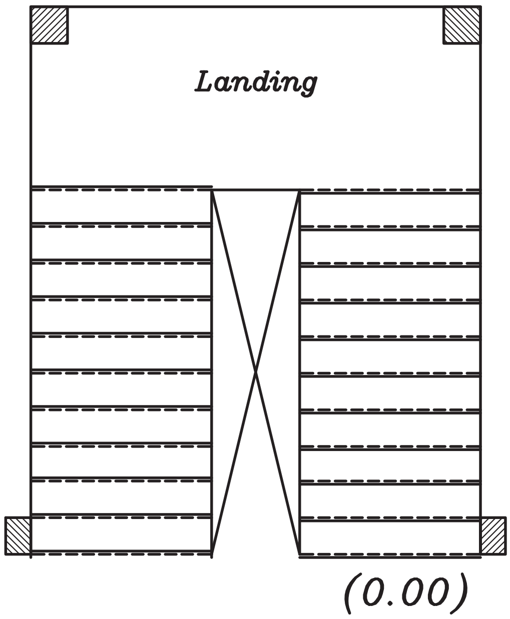
Arc. Plan

Structural Plan

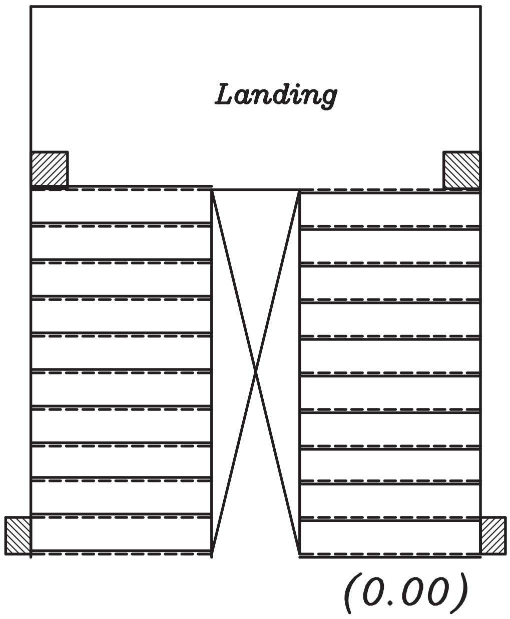




Example 4:- Show How to solve this stairs

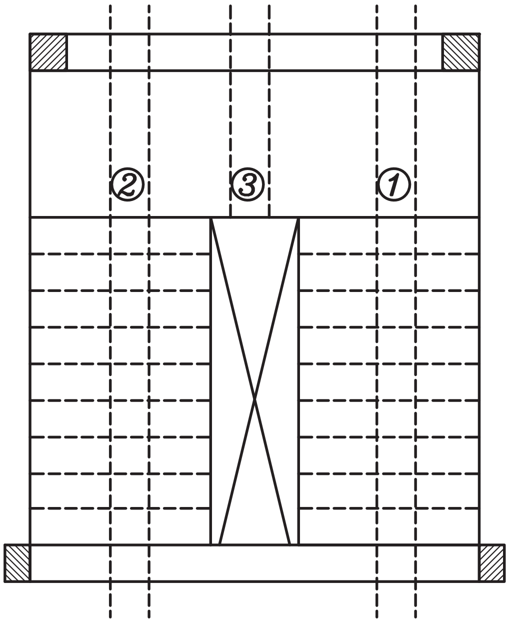


Case 1:-



Case 2:-

Case 1:-



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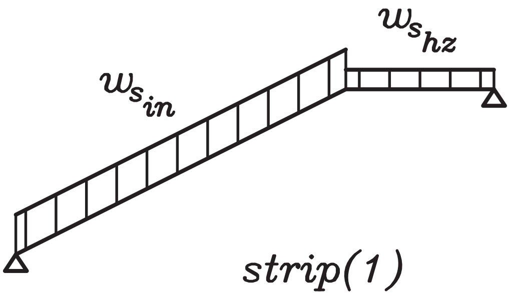
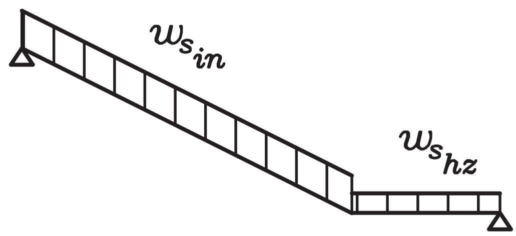
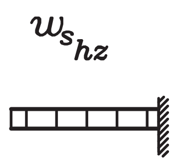


strip(1)

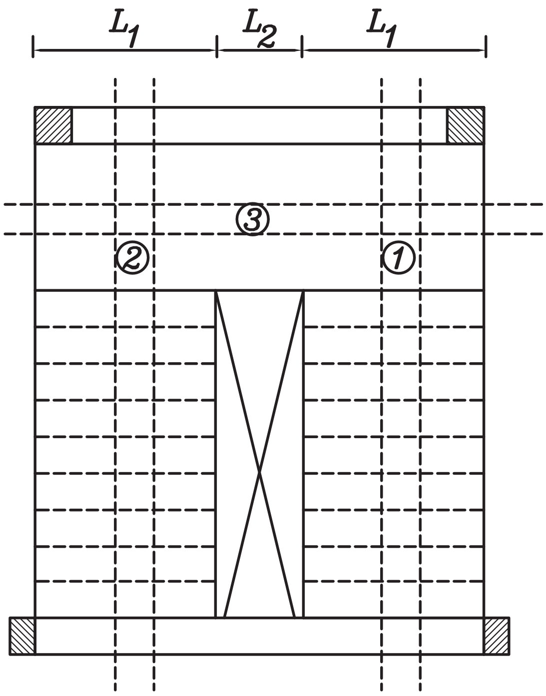


strip(2)



strip(3)

Alternative solution



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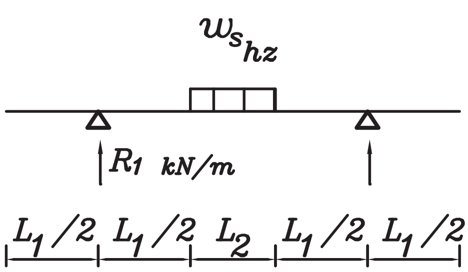
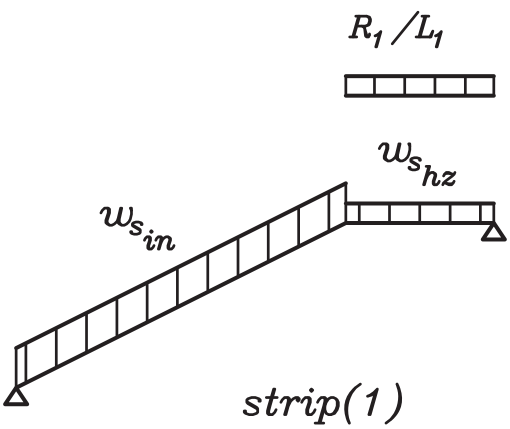
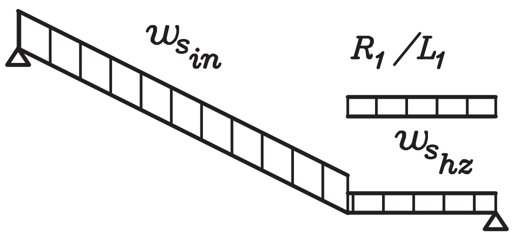


strip(3)

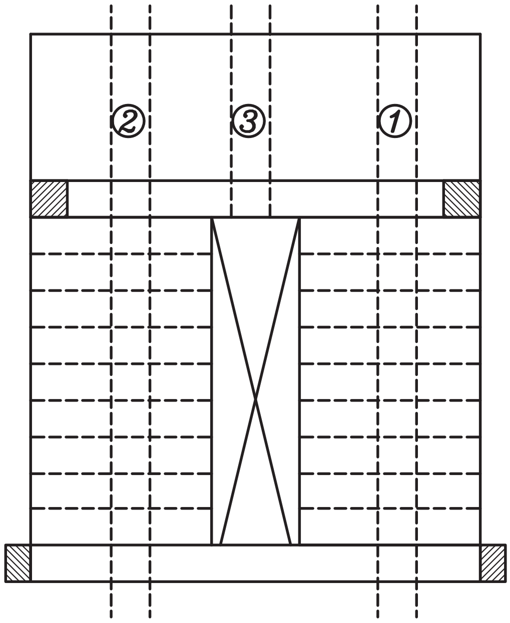


strip(1)



strip(2)

Case 2:-



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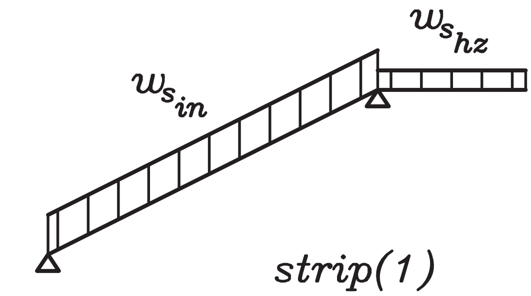
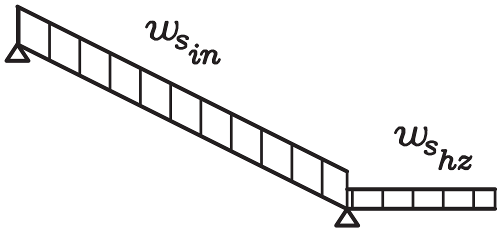
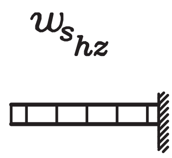


strip(1)

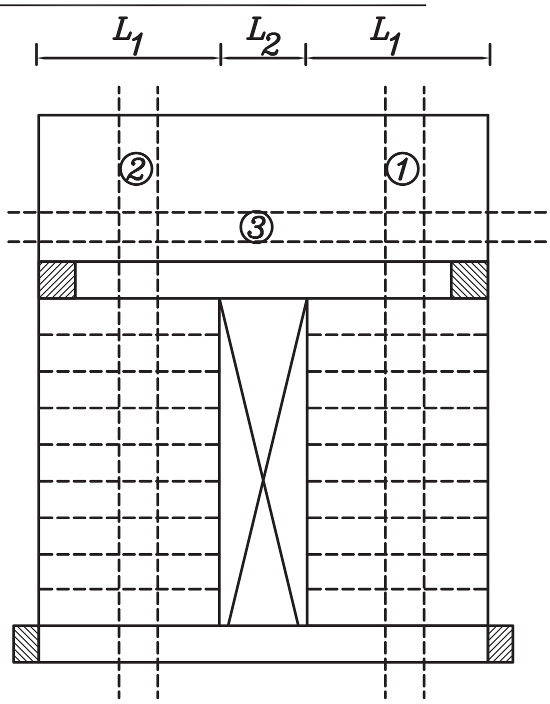


strip(2)



strip(3)

Alternative solution



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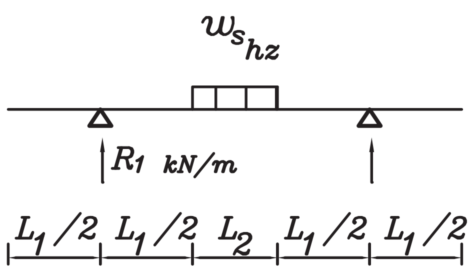
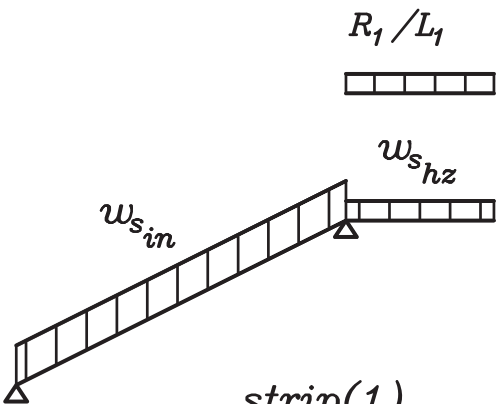
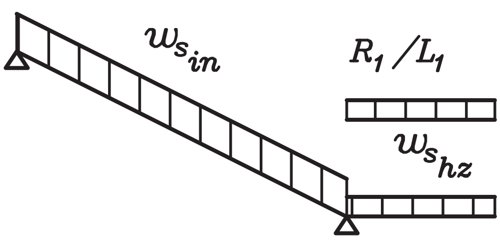


strip(3)



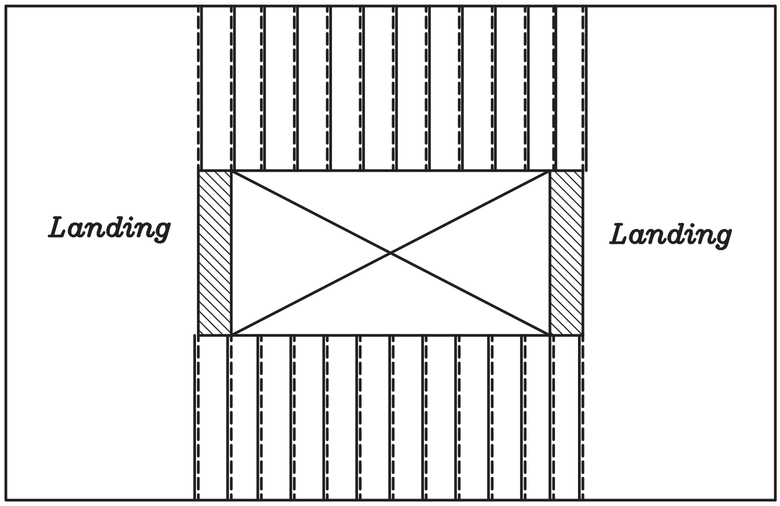
strip(1)



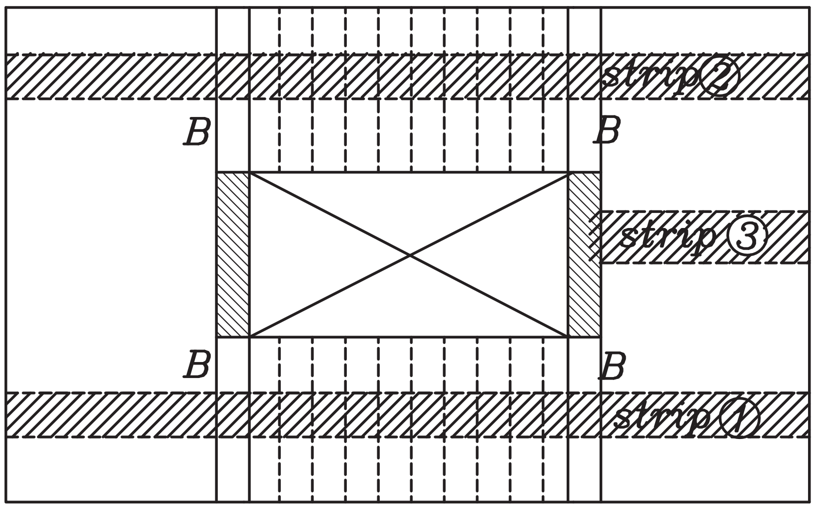
strip(2)

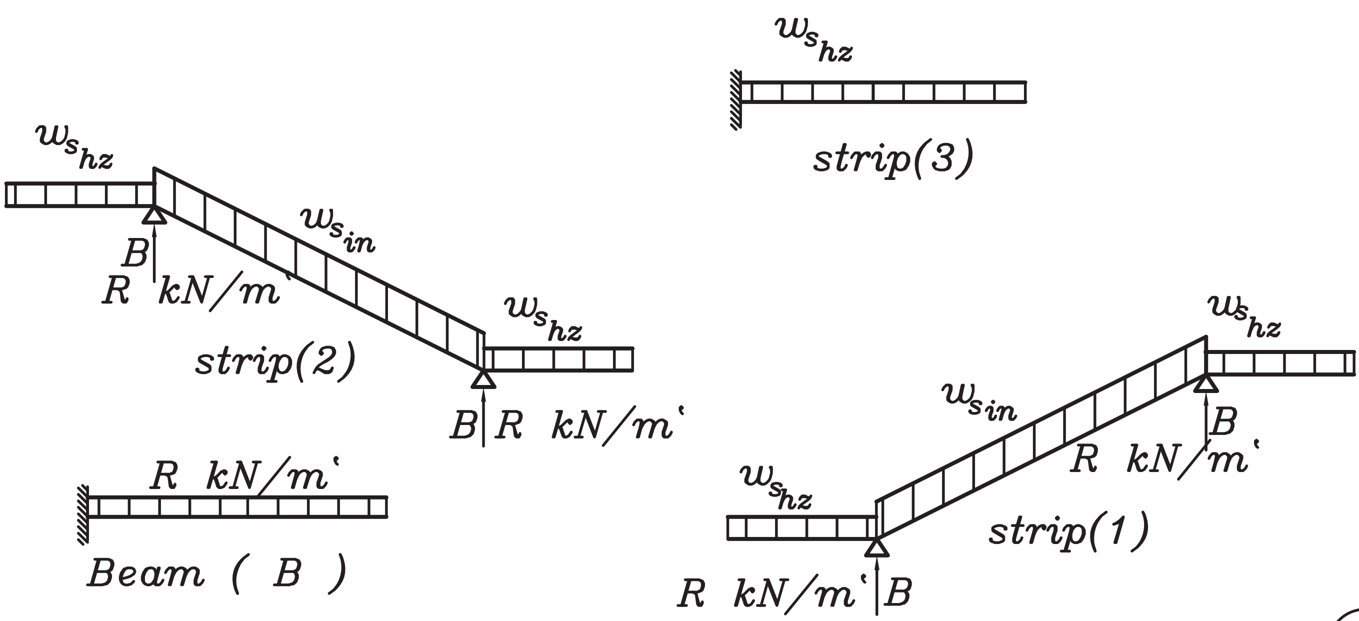
Example 5:– Show How to solve this stair

Arc. Plan



Structural Plan





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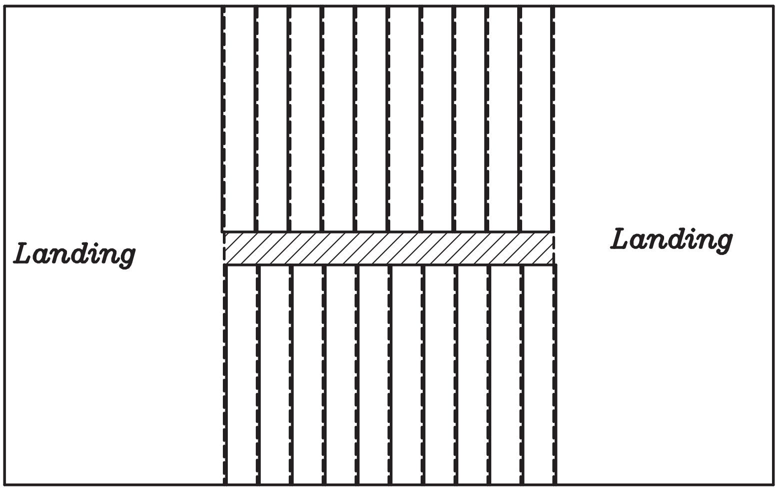
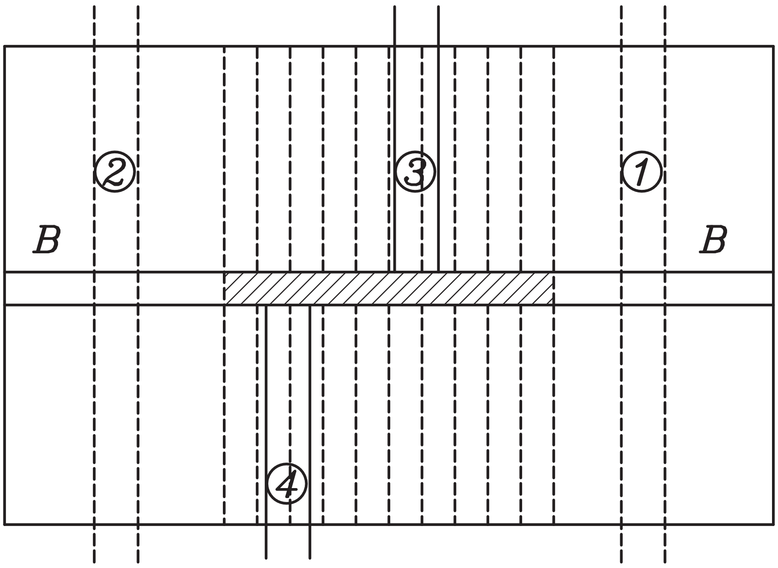
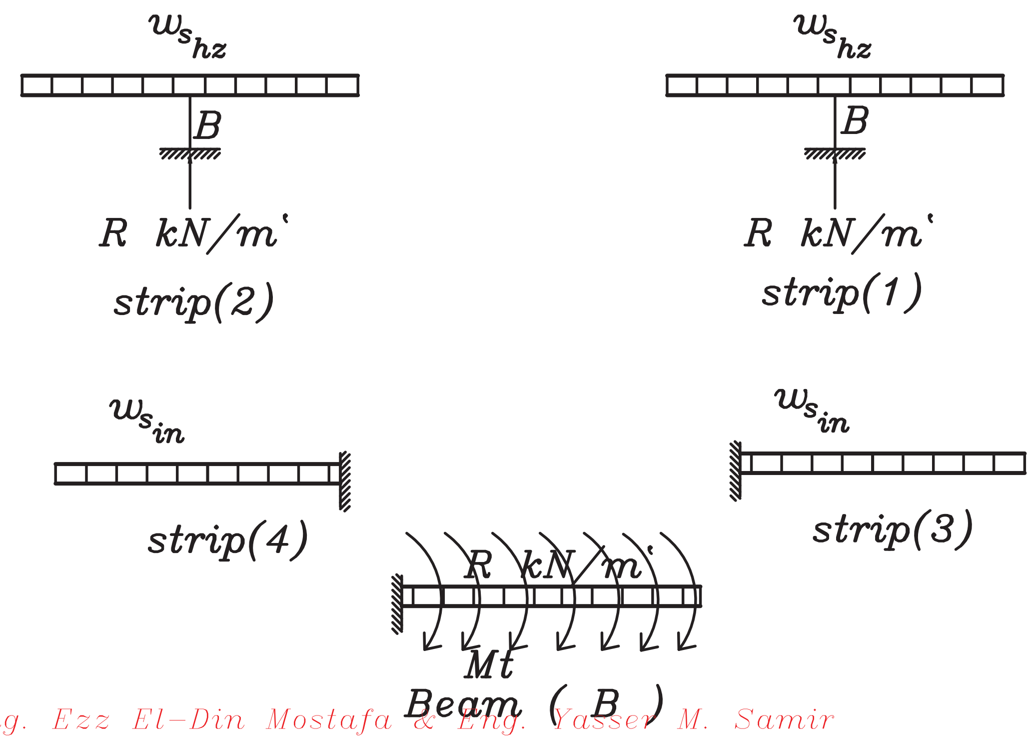
Example 6:– Show How to solve this stair

Arc. Plan



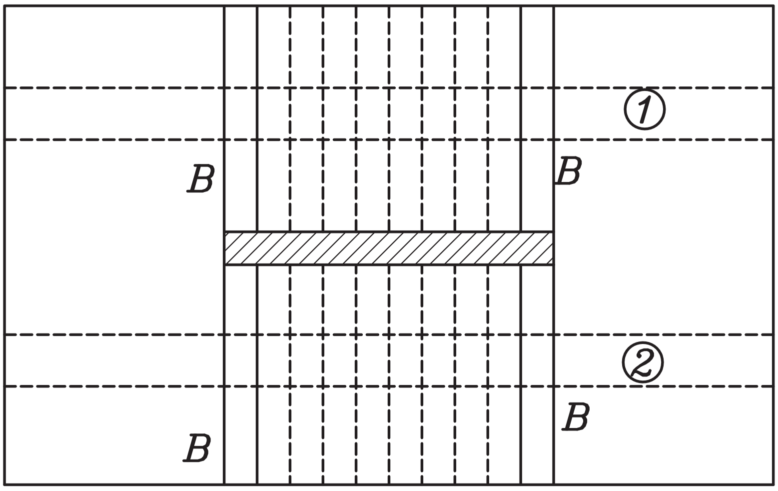
Structural Plan

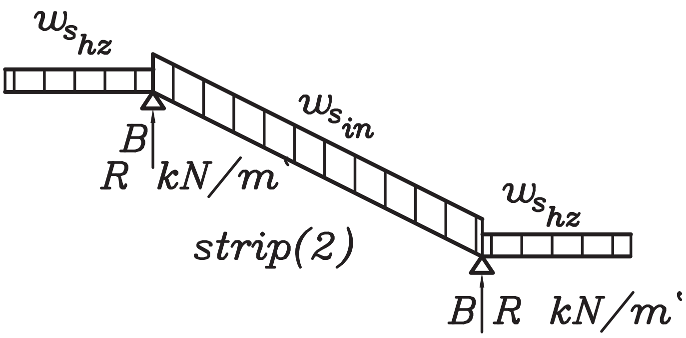


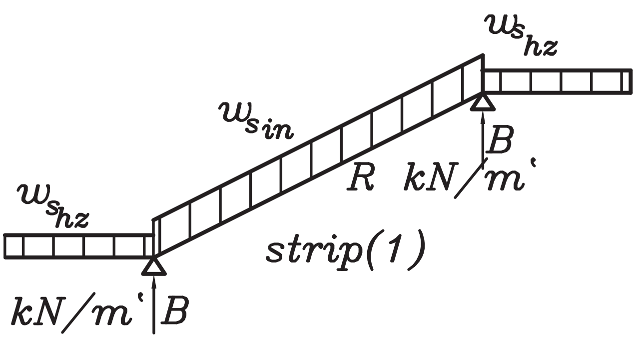


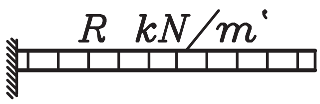
Another Solution

Structural Plan





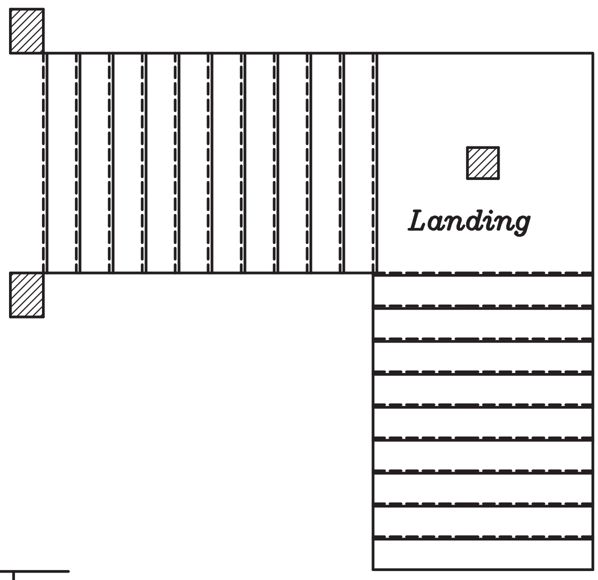




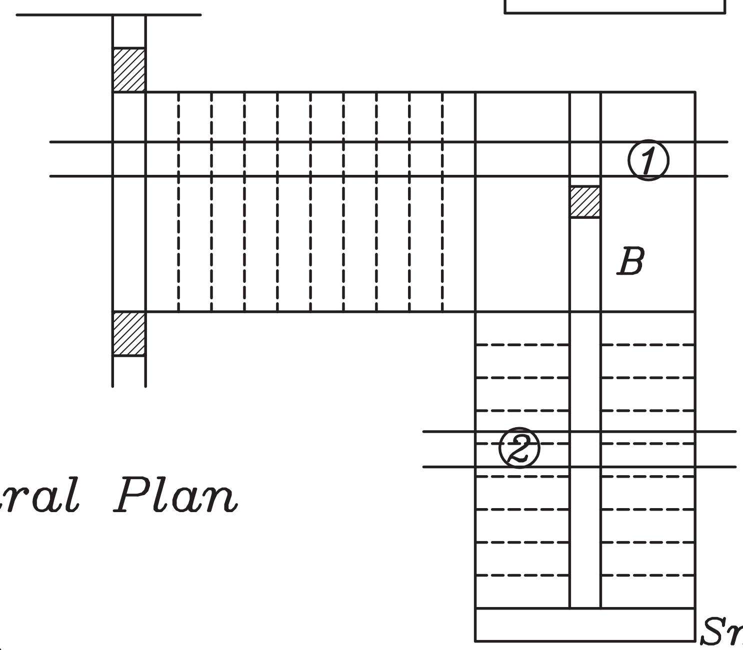
Beam (B)

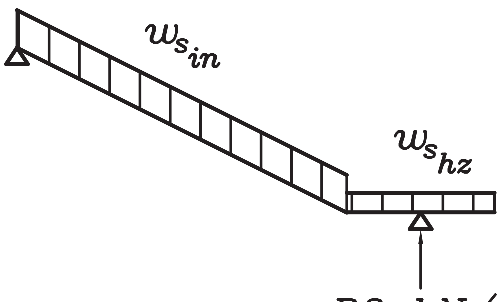
Example 7:– Show How to solve this stair

Arc. Plan

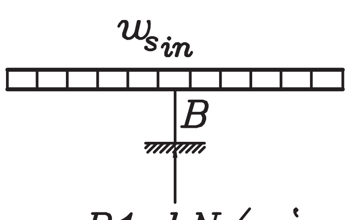


Structural Plan

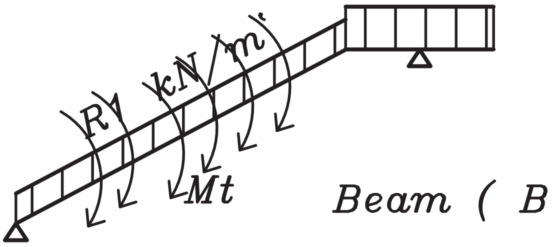




strip(1)



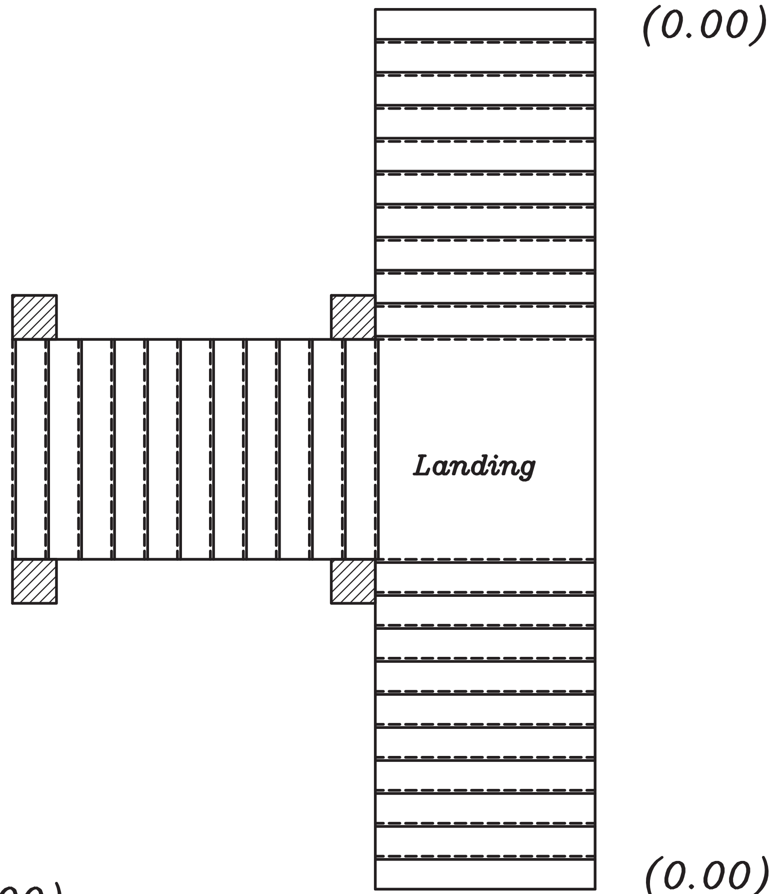
strip(2)

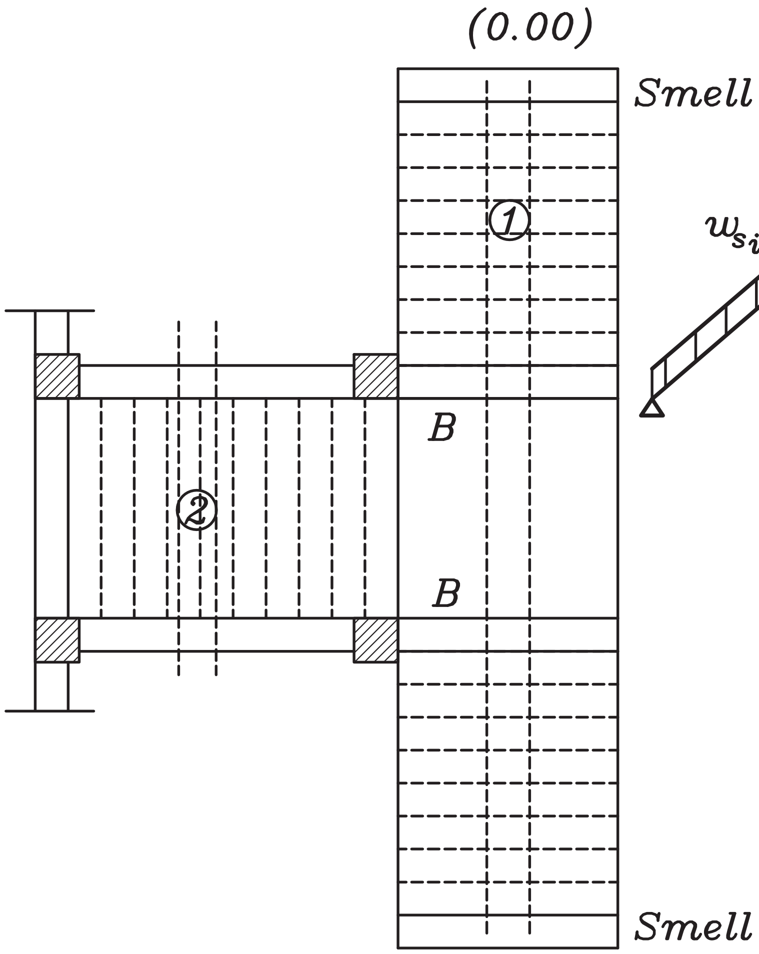


Beam (B)

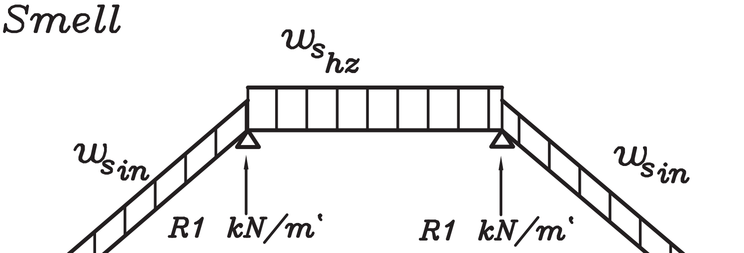
Example 8:– Show How to solve this stair

Arc. Plan



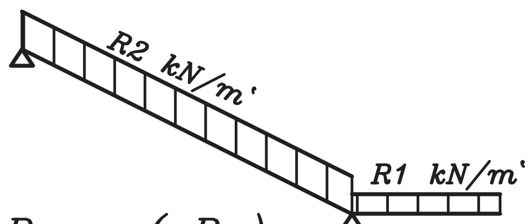


Structural Plan



strip(1)

strip(2)



Beam (B)

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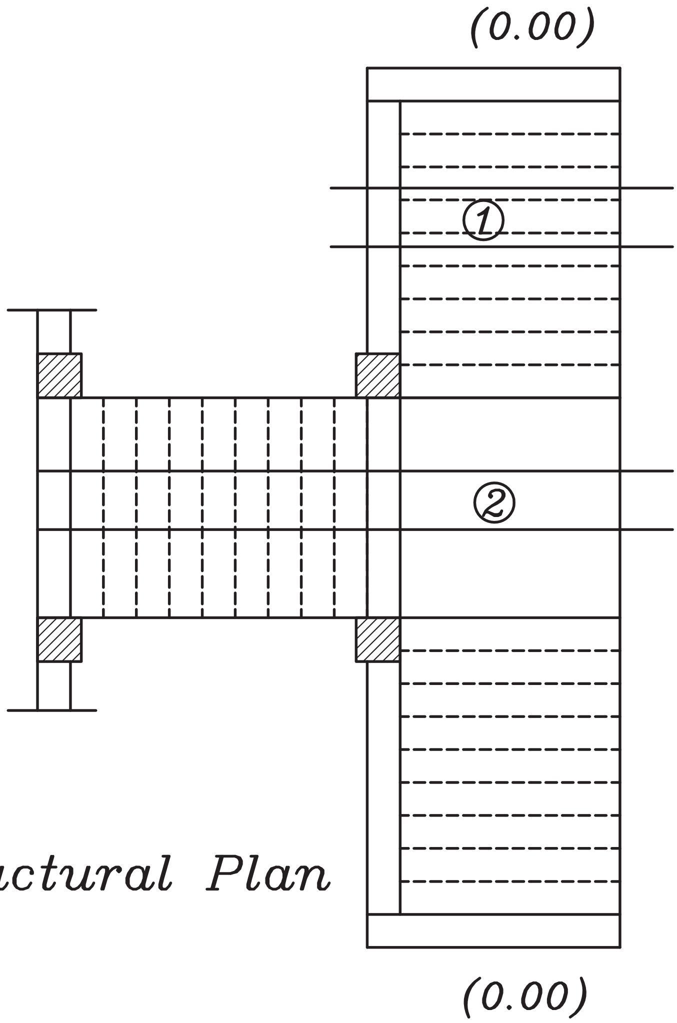
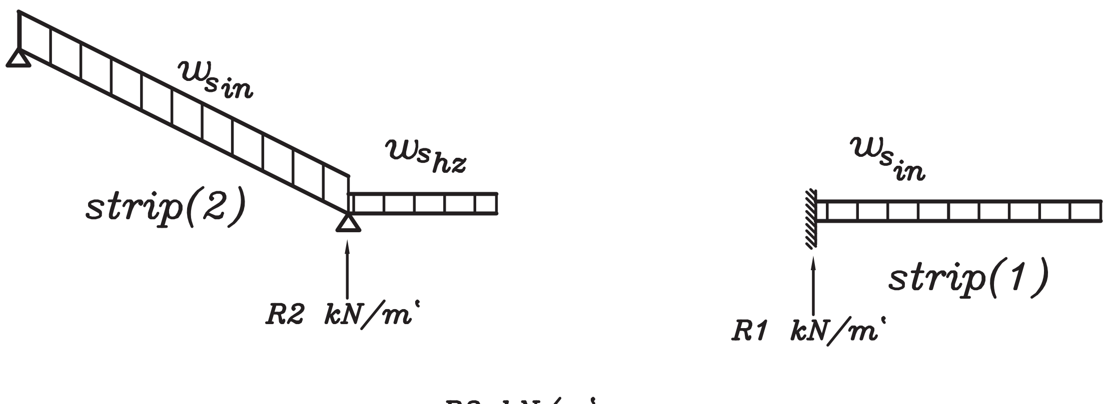
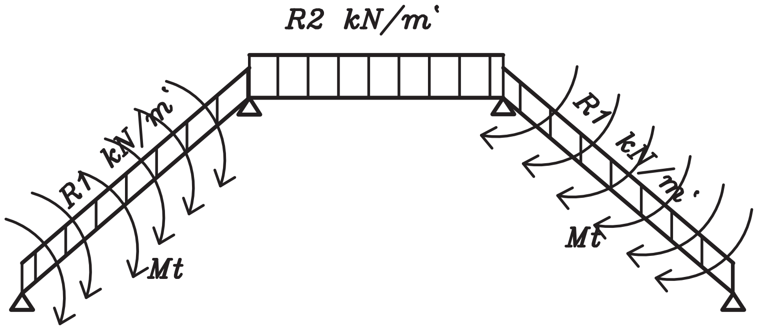
Another solution



Structural Plan





Example 9:-

The following figure show the general layout of stair cases (each step 300x150), proceed with the following :

1- *Complete design including all slabs and their supporting beams*

2- *Draw to a convenient scale the details of reinforcement of the stair and the supporting beams in plan & sections.*

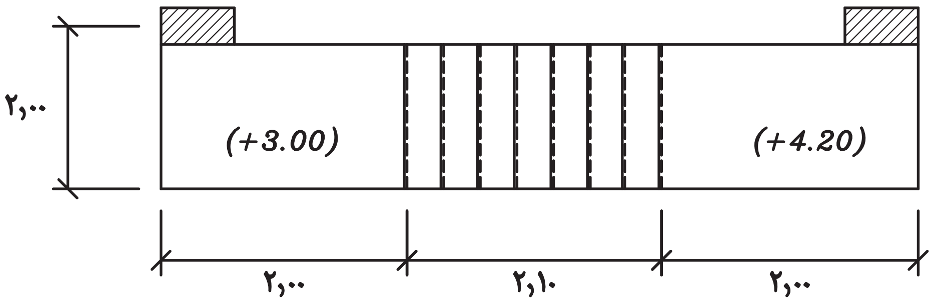
$F.C.=1.50 kN/m^2$

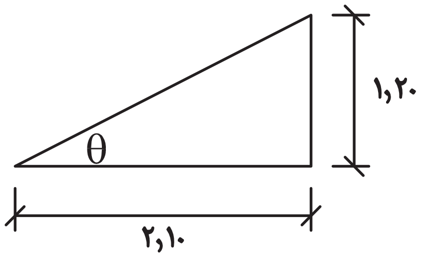
$L.L.=3.00 kN/m^2$

$f_{cu}=25\ N/mm^2$

Steel used 360/520

O.w of beam=4.0kN/m

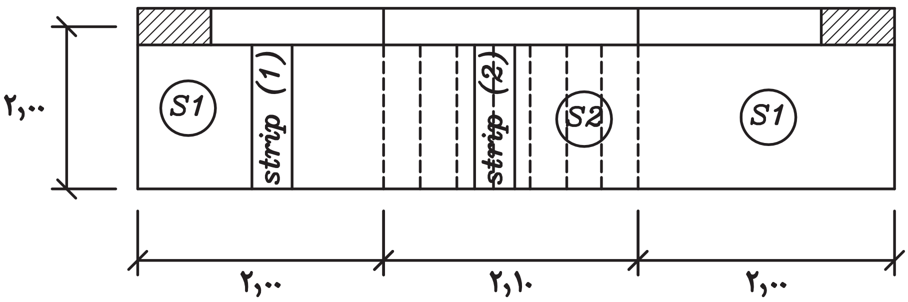




$\tan\theta = \frac{1.20}{2.10} = 0.571$

$\theta = 29.75$

Solution



1-slab thickness

for Cantilever slab S1

$$t_s = \frac{L_c}{15} + 20 = \frac{2000}{15} + 20 = 153.33mm$$

for Cantilever slab S2

$$t_s = \frac{L_c}{15} + 20 = \frac{2000}{15} + 20 = 153.33mm$$

$\Longrightarrow$ Take $t_s = 16\ cm$ (check deflection)

$$t_{av} = t_s + 7 = 23\ cm$$

2-Calculation of load

For Landing :-

$w_{shz} = 1.4[t_s \gamma_c + F.c.] + 1.6 L.L. \quad kN/m^2$

$w_{shz} = 1.4[0.16*25 + 1.50] + 1.6*3.00$

$w_{shz} = 12.50 \ kN \backslash m^2$

For Flight :-

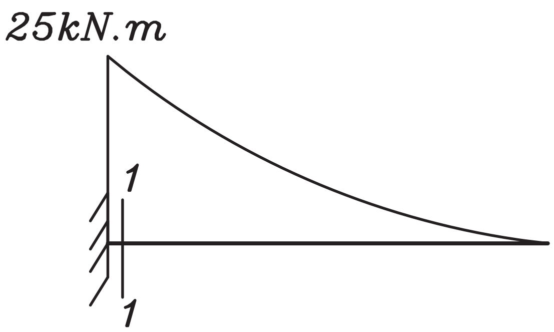
$w_{sin} = 1.4[t_{sav} \gamma_c + F.c.] + 1.6 L.L \cos\theta \quad kN/m^2$

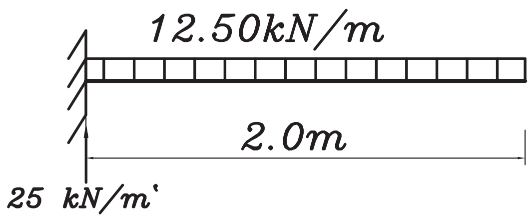
$w_{sin} = 1.4[0.23*25 + 1.50] + 1.6*3.00*\cos(29.75)$

$w_{sin} = 14.32 \ kN \backslash m^2$

-Design of sections

Strip (1) :-





Sec(1-1)

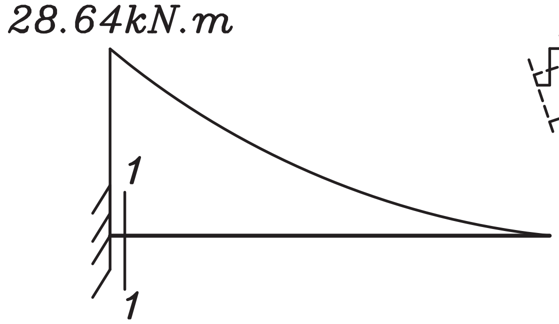
$M_{u.l.} = 25.00 kN.m \quad \& \quad B = 1000 mm \quad \& \quad d = 160 - 20 = 140 mm$

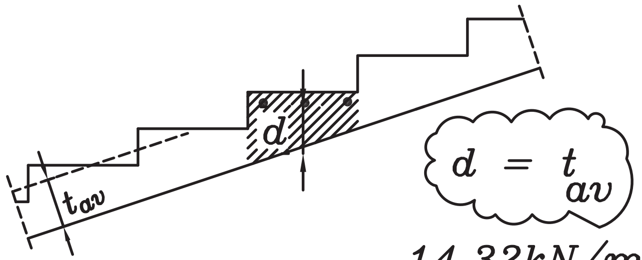
$140 = C_1 \sqrt{\frac{25.00*10^6}{1000*25}} \qquad C_1 = 4.43 \quad \& \quad J = 0.813$

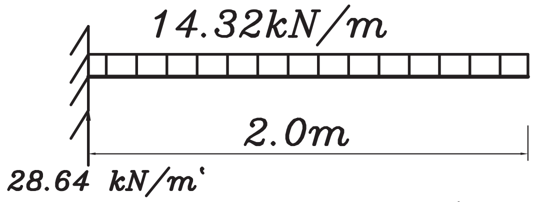
$A_s = \frac{25.00*10^6}{0.813*140*360} = 610.13 \ mm^2/m'$

$A_s = 5 \phi 13/m'$

Strip (2) :–



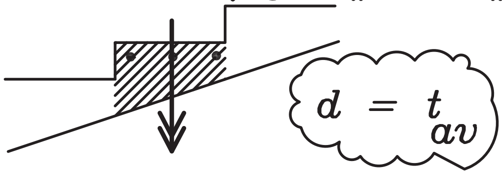




ـ ملحوظة

لاحظ أننا لا نعتبر هذة الشريحة شريحة أفقية فى بلاطة مائلة لأن العزم سالب وعمودى على أتجاة الحديد لذلك فهو لا يحتاج الى تحليل

Sec(1–1)



$M_{u.l.}=28.64kN.m$ & $B=1000mm$ & $d=230\ mm$

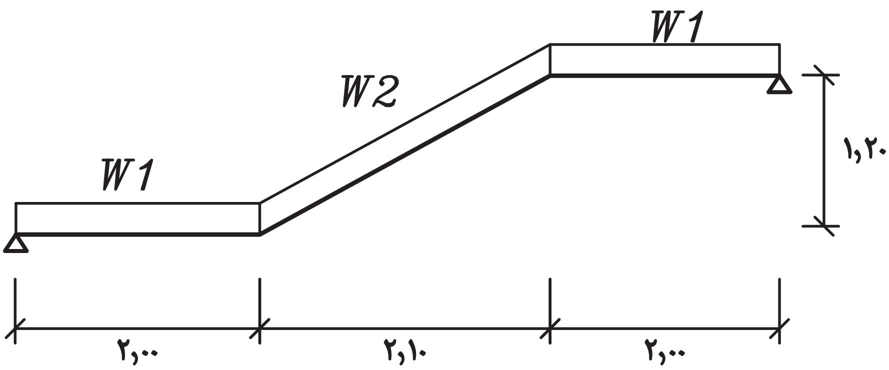
$$230=C_1\sqrt{\frac{28.64*10^6}{1000*25}} \qquad C_1=6.8 \ \& \ J=0.826$$

$$A_s=\frac{28.64*10^6}{0.826*230*360}=418.76\ mm^2/m'$$

$$A_s/step = 418.76*0.3 = 125.63\ mm^2/step.$$

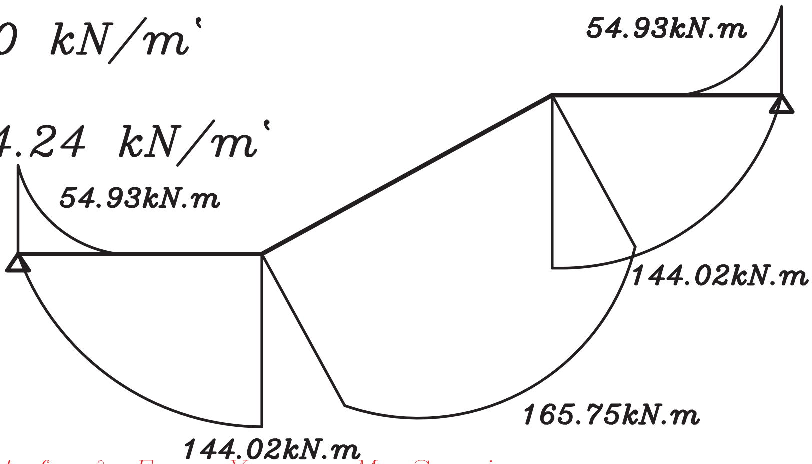
$$A_s=2\phi 10/step$$

–Design of Beam



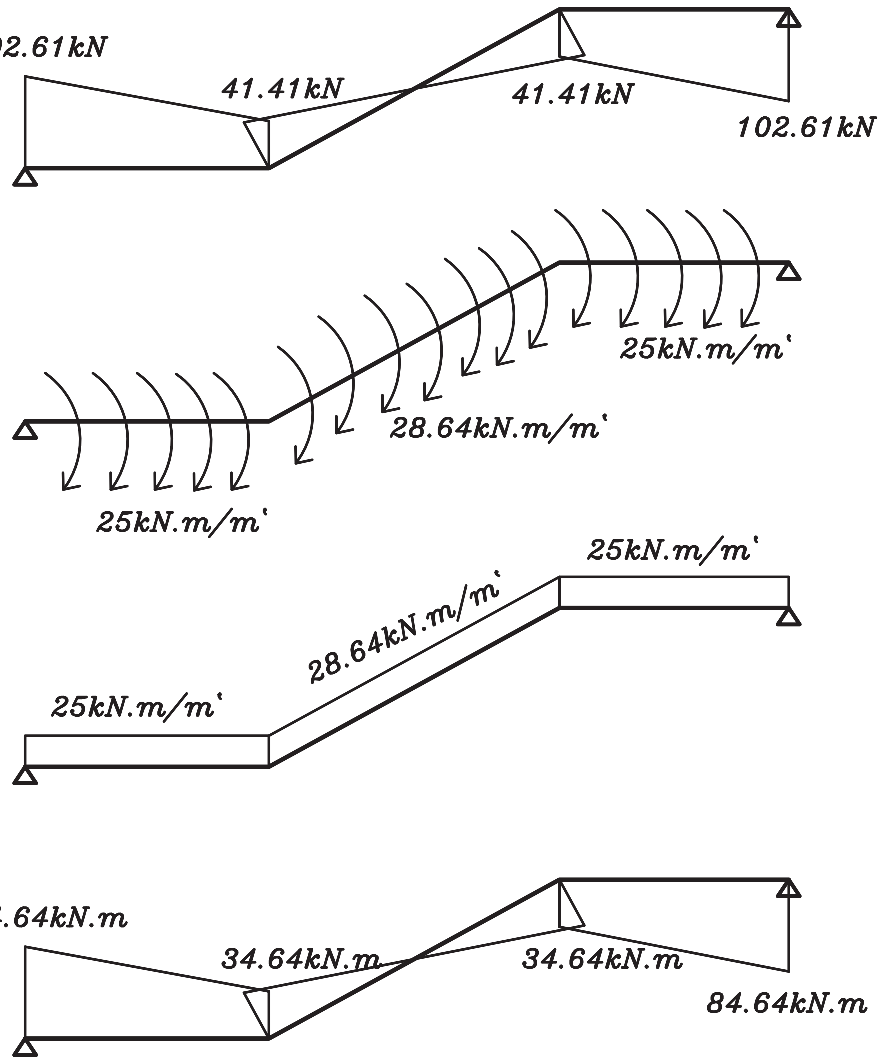
$W1 = 4*1.4+25=30.60\ kN/m'$

$W2 = 4*1.4+28.64=34.24\ kN/m'$



لاحظ

سبى



Take b = 400 mm

1-from bending $\Longrightarrow$ $d = 3.5\sqrt{\dfrac{165.75*10^6}{400*25}} = 451.00$ mm

d=500 mm $\qquad$ t = d+50mm = 550 mm

2-from Torsion $\Longrightarrow$ $\dfrac{3M_{tu}}{b^2\,t} = 2\ N/mm^2 \Longrightarrow \dfrac{3*84.64*10^6}{400^2 *\ t} = 2.00$

t = 793.5 mm $\Longrightarrow$ Take t = 800 mm

Take Beam = (400 x 800)

Design for shear+Torsion:

$$q_{su} = \frac{Q_u}{bd} = \frac{102.61*10^3}{400*750}$$

$$q_{su} = 0.342 \ N/mm^2$$

$$q_{tu} = \frac{M_{tu}}{1.7A_{oh} \ t_e}$$

$$A_{oh} = (400-50)(800-50)$$

$$A_{oh} = 262500mm^2$$

$$P_h = 2[350+750] = 2200mm$$

$$t_e = \frac{A_{oh}}{P_h} = 119.32mm$$

$$q_{tu} = \frac{84.64*10^6}{1.7*262500*119.32}$$

$$q_{tu} = 1.59 \ N/mm^2$$

$$q_{cu} = 0.24\sqrt{25/1.5} = 0.98N/mm^2$$

$$q_{tu_{min}} = 0.06\sqrt{25/1.5} = 0.24N/mm^2$$

$$q_{u_{max}} = 0.70\sqrt{25/1.5} = 2.86N/mm^2$$

$$\sqrt{q_{su}^2 + q_{tu}^2} = \sqrt{(0.34)^2 + (1.59)^2} = 1.63 \ N/mm^2 < q_{u_{max}} \quad (ok)$$

(Design for Torsion)

$$A_{str} = \frac{M_{tu} . S}{1.7 A_{oh} (\frac{f_{y_{st}}}{\gamma_s})}$$

$$\Longrightarrow \frac{A_{str}}{S} = \frac{84.64*10^6}{1.7*262500*360/1.15}$$

$$\frac{A_{str}}{S} = 0.606$$

assume $A_{str} = \phi 10 = 78.5 mm^2$

$$\frac{78.5}{S} = 0.606 \Longrightarrow S = 129.54 \text{ mm} > 100 \text{ mm}$$

$$No.of \ stirrups/m' = \frac{1000}{S} = 7.72$$

Take stirrups 8 ϕ 10/m' (2 branches)

$$A_{sL} = (\frac{A_{str}}{S})*(P_h)*(\frac{f_{y_{st}}}{f_{y_{l.b.}}})$$

$$A_{sL} = 0.606*2200*\frac{360}{360} = 1333.2 mm^2$$

$$\frac{A_{sL}}{4} = \frac{1333.2}{4} = 333.3 \ mm^2$$

Design for B.M.

Sec(1−1) (L−sec)

$$B = \begin{cases} 6*0.16+0.4=1.36 \text{ m} \\ C.L. \rightarrow C.L.=2.0+0.2=2.20m \\ \dfrac{1*6.42}{10}+0.40=1.04m \end{cases}$$

$B=1040mm$ & $d=800-50mm=750mm$ & $M_u=165.75$ kN.m

$$750=C_1\sqrt{\frac{165.75*10^6}{1040*25}} \quad C_1=9.4 \quad \& \quad J=0.826$$

$$A_s=\frac{165.75*10^6}{0.826*750*360}=743.21mm^2$$

$$A_{s_{min}}=\frac{1.1}{f_y}bd=\frac{1.1}{360}400*750 \quad =916.67mm^2 > A_s$$

$$A_{s_{min}}= \begin{cases} \dfrac{1.1}{f_y}bd=\dfrac{1.1}{360}400*750=916.67mm^2 \\ 1.3A_{s_{req}}=1.3*743.21=966.173mm^2 \\ \dfrac{0.15}{100}bd=\dfrac{0.15}{100}400*750=450.00mm^2 \end{cases}$$

$$A_{s_{min}}=916.67mm^2$$

$$A_{s_{total}}=A_{s_{(B.M.)}}+\frac{A_{sL}}{4}$$

$$=916.67+333.3=1250.0 \quad mm^2$$

$$A_{s_{total}}=5\phi 18$$

Sec(2-2) (R-sec)

$b=400mm$ & $d=800-50mm=750mm$ & $M_u=54.93$ kN.m

$$750=C_1\sqrt{\frac{54.93*10^6}{400*25}} \quad C_1=10.12 \quad \& \quad J=0.826$$

$$A_s=\frac{54.93*10^6}{0.826*750*360}=246.30mm^2$$

$$A_{s_{min}}=\frac{1.1}{f_y}bd=\frac{1.1}{360}400*750 \;=916.67mm^2 > A_s$$

$$A_{s_{min}}=\begin{cases}\frac{1.1}{f_y}bd=\frac{1.1}{360}400*750=916.67mm^2\\ 1.3A_{s_{req}}=1.3*246.30=320.20\ mm^2\\ \frac{0.15}{100}bd=\frac{0.15}{100}400*750=450.00mm^2\end{cases}$$

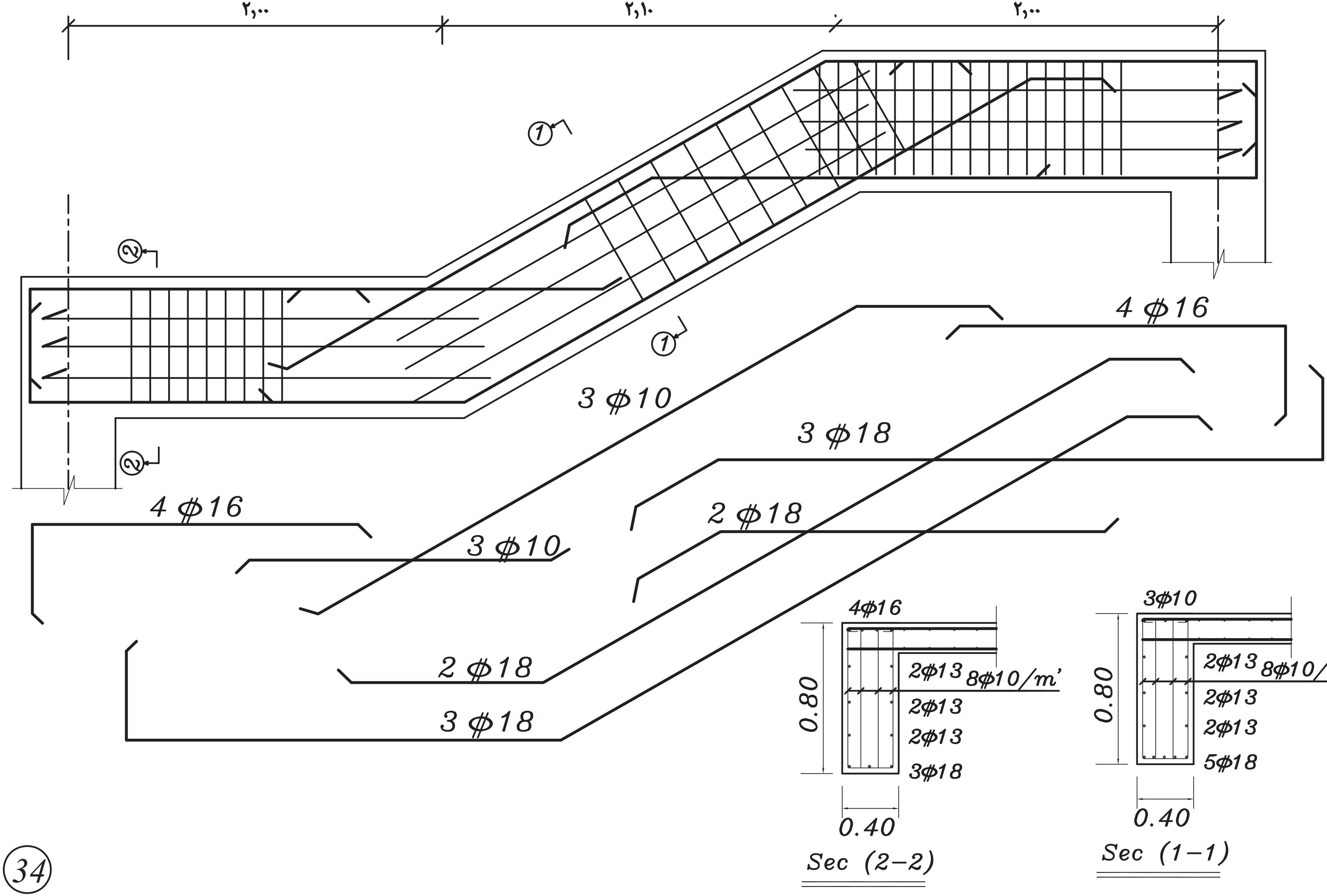
$$A_{s_{min}}=450.00mm^2$$

$$A_{s_{total}}=A_{s_{(B.M.)}}+\frac{A_{sL}}{4}$$

$$=450.00+333.3=783.30\quad mm^2$$

$$A_{s_{total}}=4\phi16$$

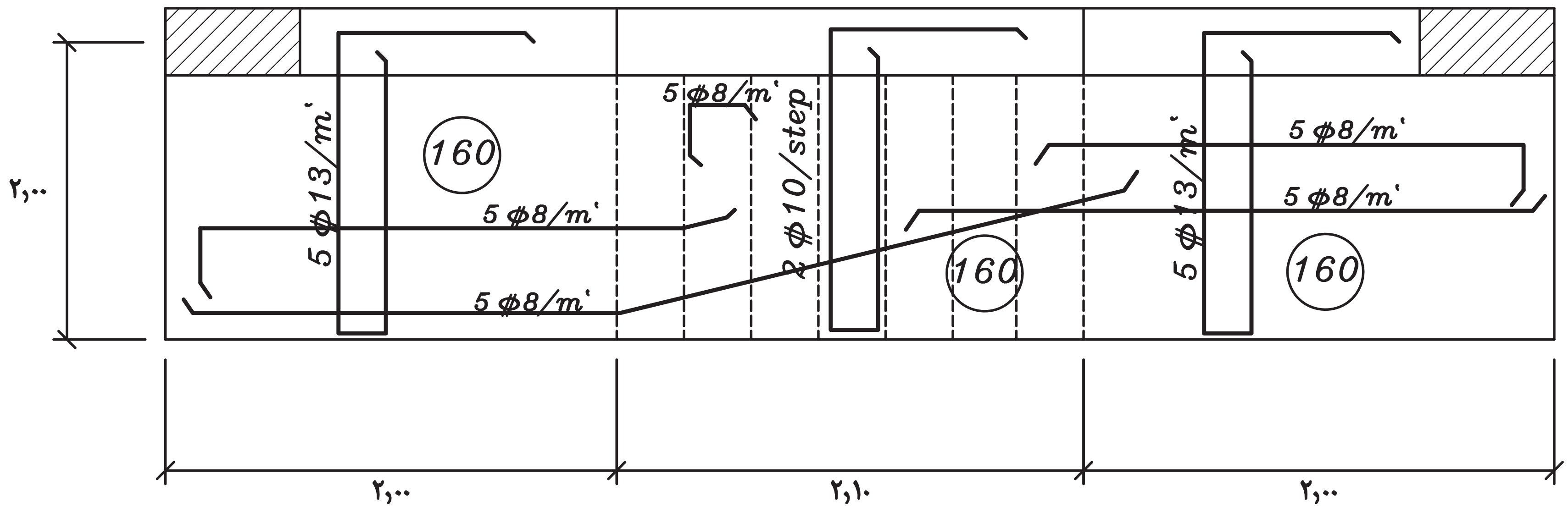
Details of R.F.T. for the beam

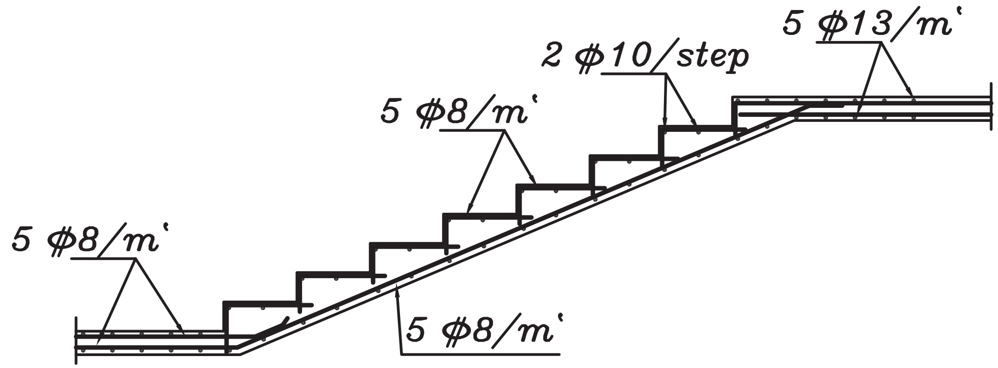


Sec (2–2)

Sec (1–1)

Details of R.F.T. for Stair





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Example 10:-

The following figure show the general layout of stair cases (each step 300x150), proceed with the following :

1- *Complete design including all slabs and their supporting beams*

2- *Draw to a convenient scale the details of reinforcement of the stair and the supporting beams in plan & sections.*

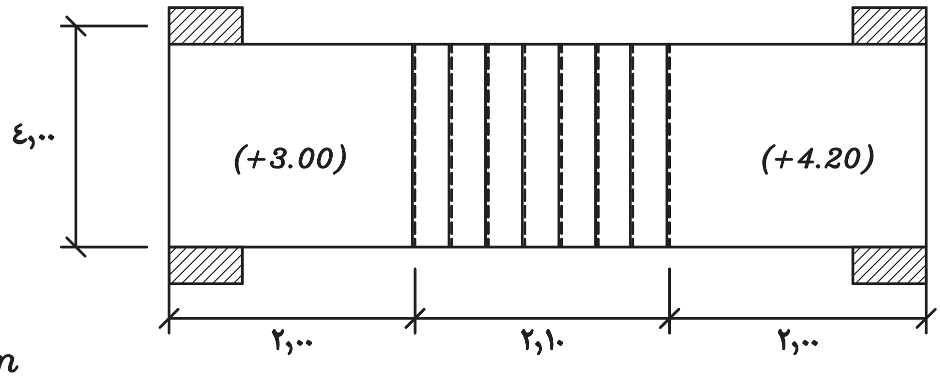
$F.C. = 1.50 kN/m^2$

$L.L. = 3.00 kN/m^2$

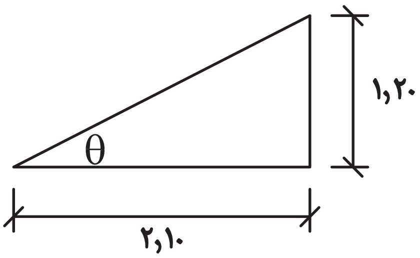
$f_{cu} = 25 \ N/mm^2$

Steel used 360/520

O.w of beam = 4.0 kN/m

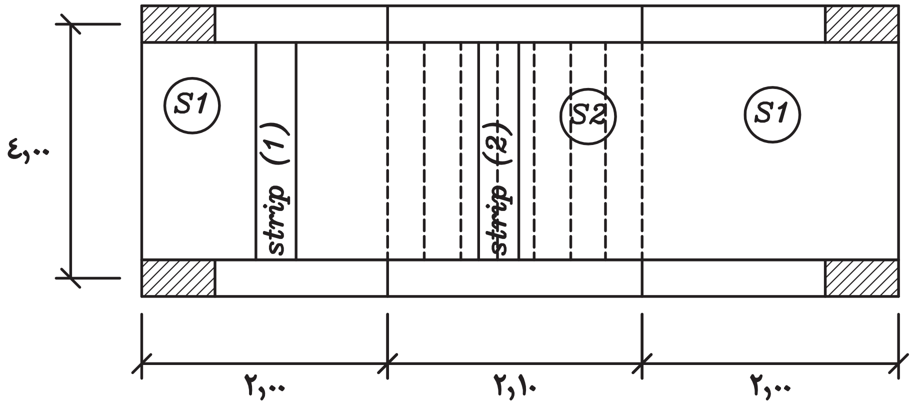


Solution



$$\tan\theta = \frac{1.20}{2.10} = 0.571$$

$$\theta = 29.75$$



1-slab thickness

for one way slab S1

$$t_s = \frac{L}{25} = \frac{400}{25} = 16 cm$$

for one way slab S2

$$t_s = \frac{L}{25} = \frac{400}{25} = 16 cm$$

$\Longrightarrow$ Take $t_s = 16 \ cm$

$$t_{av} = t_s + 7 = 23 \ cm$$

2-Calculation of load

For Landing :-

$$w_{shz} = 1.4[t_s \gamma_c + F.c.] + 1.6L.L. \quad kN/m^2$$

$$w_{shz} = 1.4[0.16*25+1.50]+1.6*3.00$$

$$w_{shz} = 12.50 \ kN\backslash m^2$$

For Flight :-

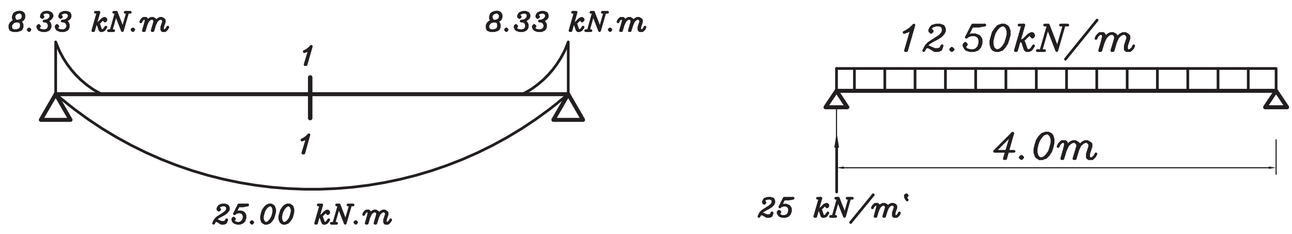
$$w_{sin} = 1.4[t_{sav} \gamma_c + F.c.] + 1.6L.L\cos\theta \quad kN/m^2$$

$$w_{sin} = 1.4[0.23*25+1.50]+1.6*3.00*\cos(29.75)$$

$$w_{sin} = 14.32 \ kN\backslash m^2$$

-Design of sections

Strip (1) :-



Sec(1-1)

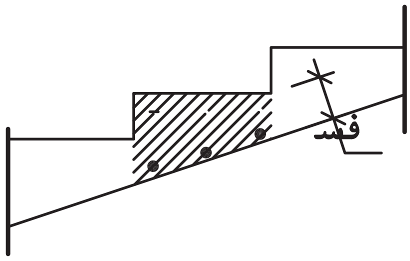
$M_{u.l.} = 25.00 kN.m$ & $B = 1000 mm$ & $d = 160-20 = 140 mm$

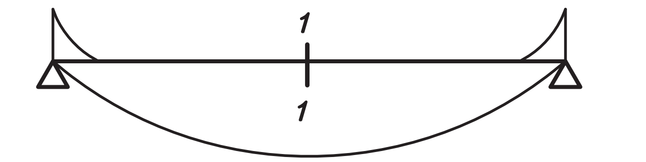
$$140 = C_1 \sqrt{\frac{25.00*10^6}{1000*25}} \quad C_1 = 4.43 \quad \& \quad J = 0.82$$

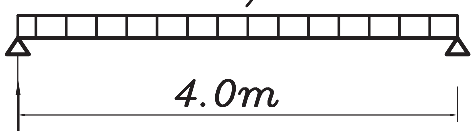
$$A_s = \frac{25.00*10^6}{0.82*140*360} = 607.58 \ mm^2/m'$$

$$A_s = 6\phi 12/m'$$

Strip (2) :-

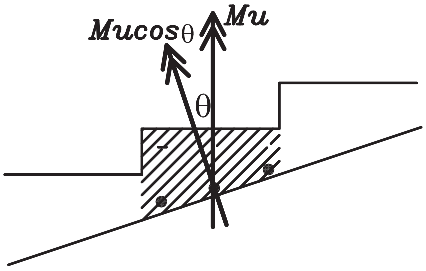






ـ ملحوظة

لاحظ أننا هنا نعتبر هذة الشريحة شريحة أفقية فى بلاطة مائلة لأن العزم موجب ومائل على أتجاة الحديد لذلك فهو يحتاج الى تحليل



Sec(1-1)

$M_{u.l.}=28.64kN.m$ & $B=1000mm$ & $d=160-20=140mm$

$Mdes=28.64\cos\theta=24.87\ kN.m$

$140=C_1\sqrt{\frac{24.87*10^6}{1000*25}}$ $C_1=4.44$ & $J=0.82$

$A_s=\frac{24.87*10^6}{0.82*140*360}=604.20\ mm^2/m'$

$A_s=6\phi 12/m'$

Details of R.F.T. for Stair