CE-386
Concrete Structure Design Sessional I (1.5 Credit)

Lecture-3: Design of Stairs

Department of Environmental, Water Resources and Coastal Engineering
Military Institute of Science and Technology (MIST)

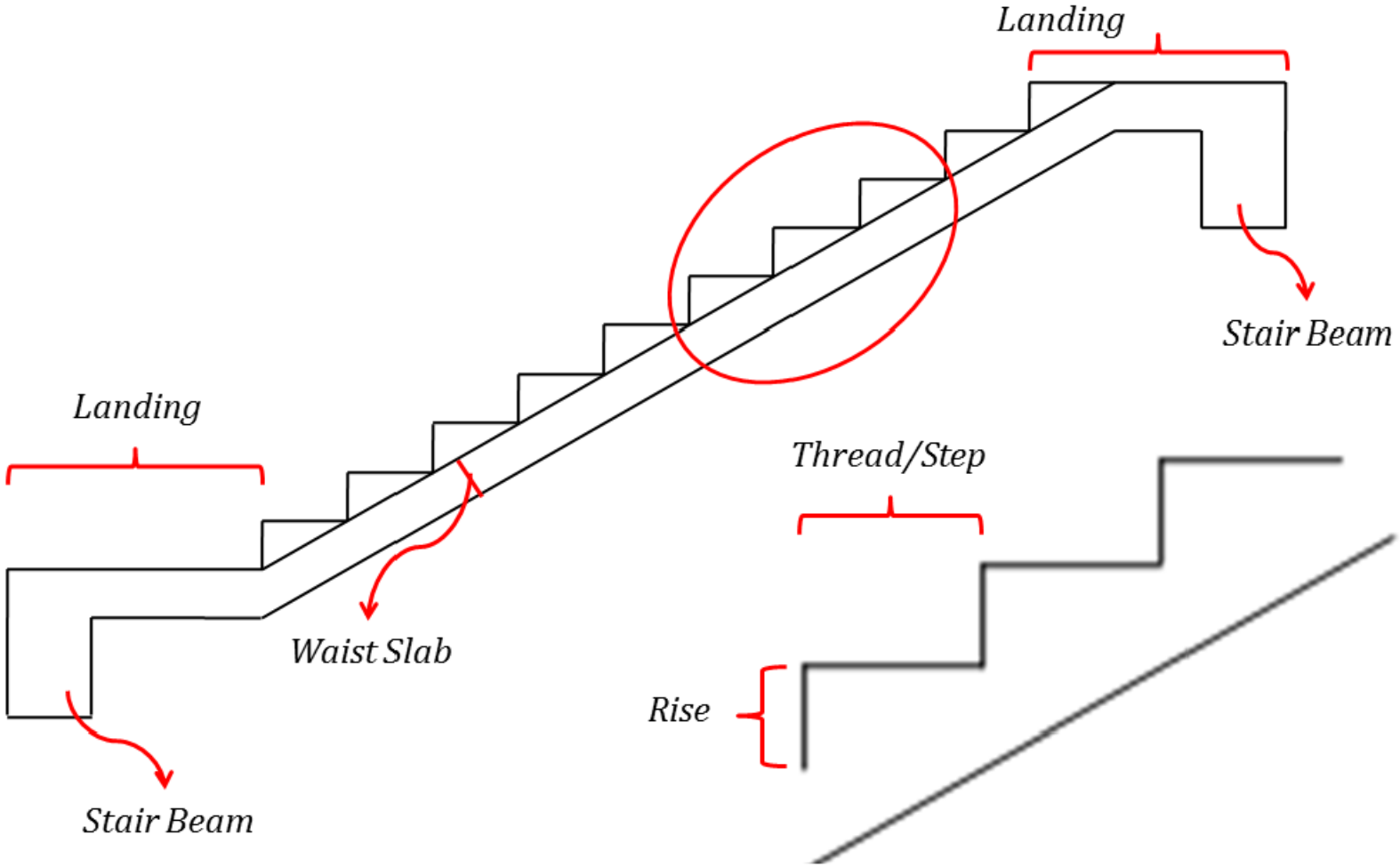
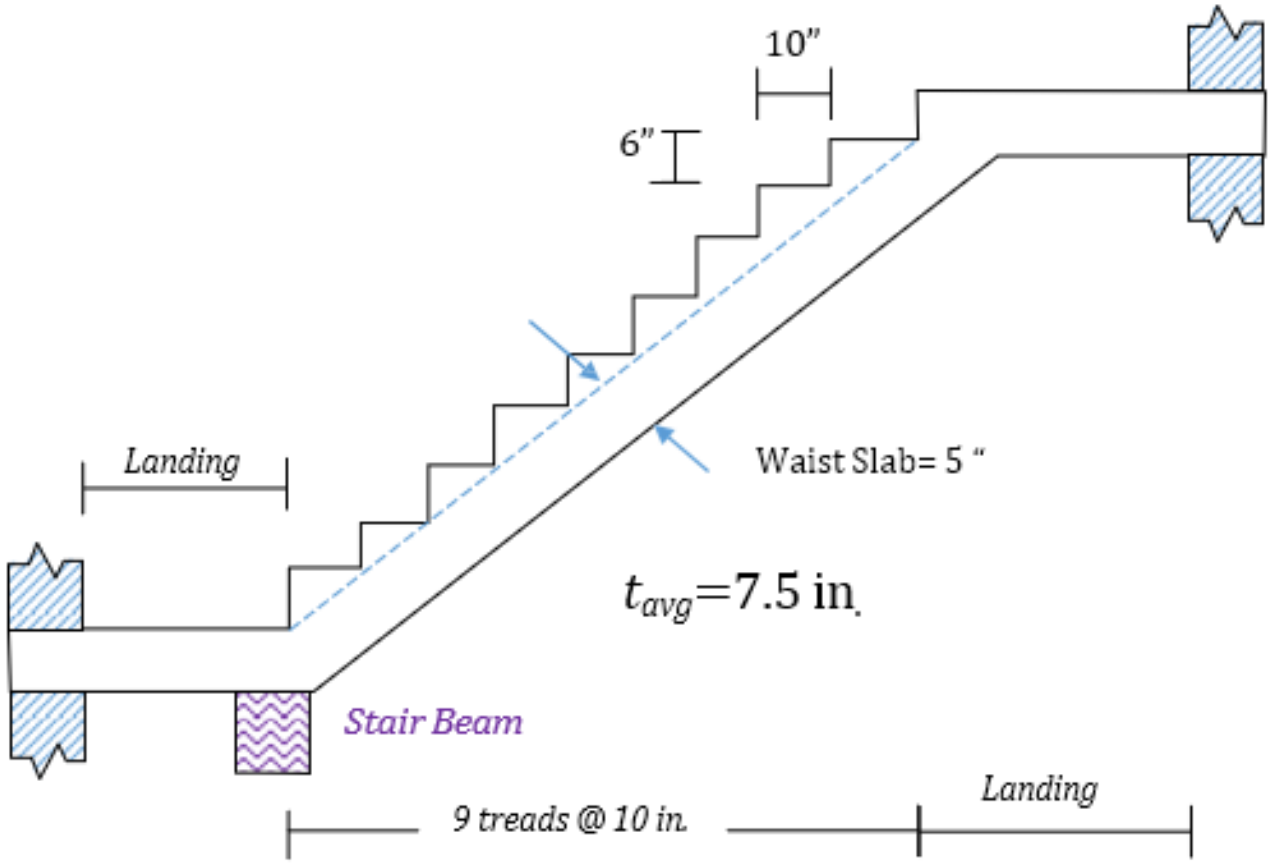
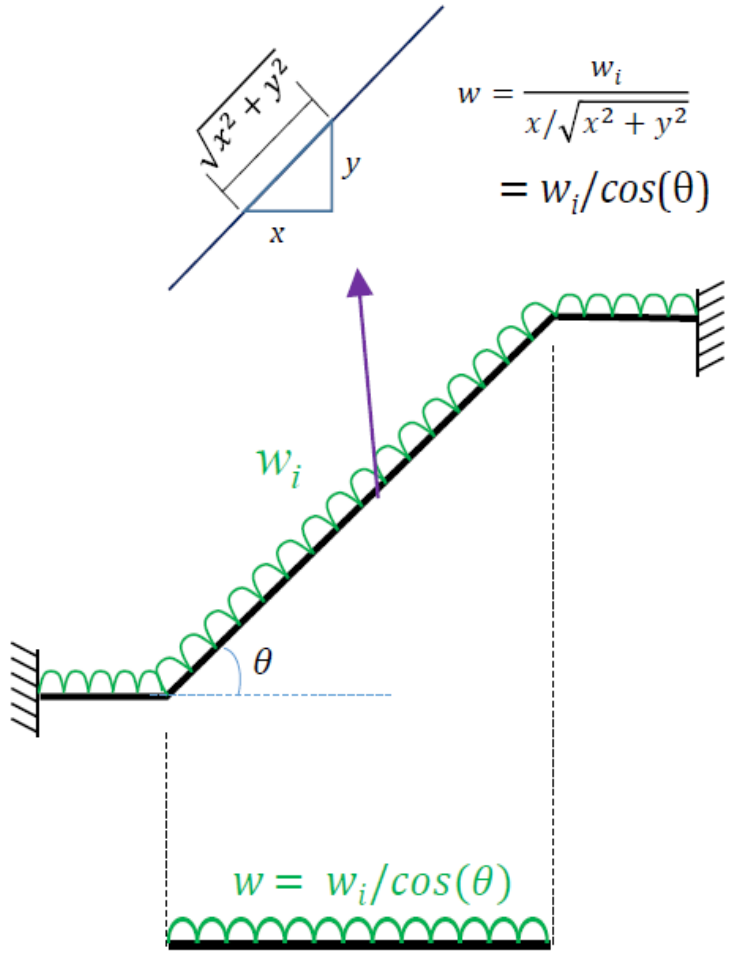


Figure 21: Components of Stair

Stair (contd.)

Here, the stair is supported on '*Stair Beam*' and *wall* at two ends→ Hence, it will act as a One-way slab





Load Calculation:

Given:

Slab Thickness = 5 inch

Floor finish = 25 psf

Live load = 100 psf

Inclined Length = 104.96”

Triangle Area = (½* 6”*10”)*9= 270 in^2

Slab thickness considering only triangle = 270/104.96= 2.5

Total thickness, t_{avg} = 5”+2.57” = 7.57”

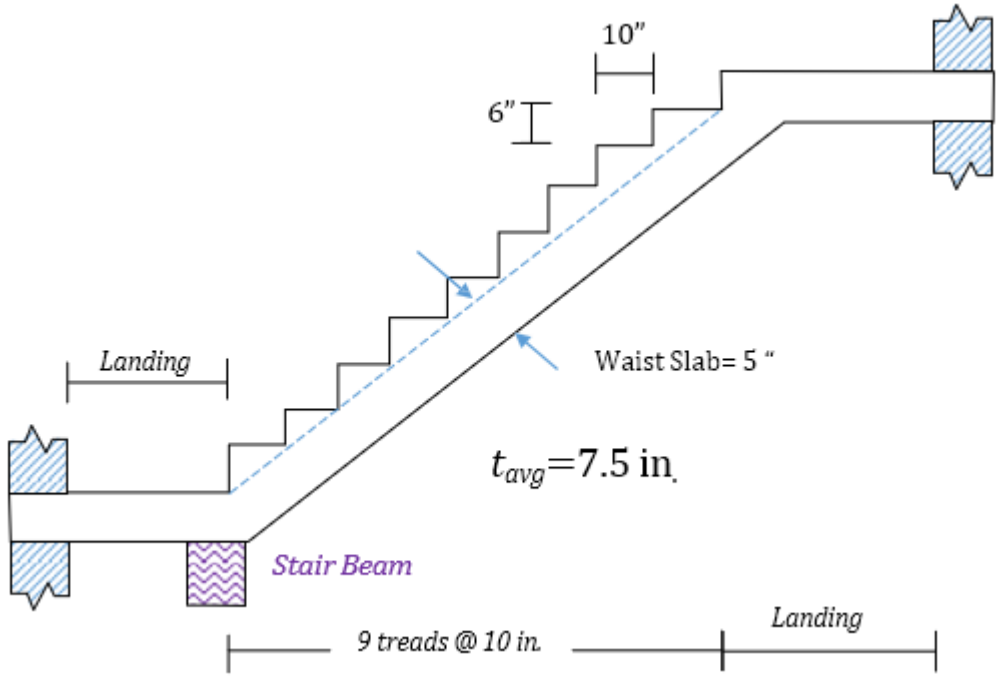
Self weight = (7.57/12)* 150 = 94.63 psf

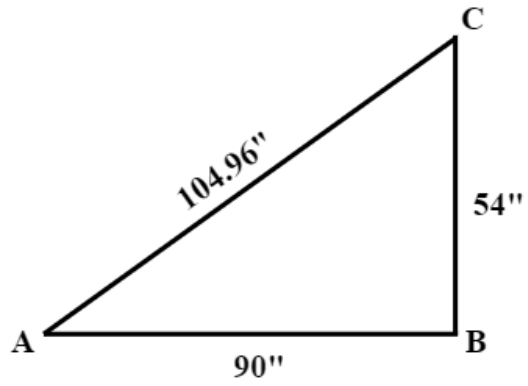
$W_{inclined}$ = 1.2 DL + 1.6 LL = 1.2 *(94.63+ 25) + 1.6*100

= 303.56 psf

$Cos\Theta = W_{inclined}/W_u$

Wu= 354.01 psf





Effective Span (BNBC 2017, Art. 6.7.1.1:)

(d) Where the landing slabs, running at right angle to the direction of the flight, supported by walls or beams on three sides (Figure 6.6.25c), the effective span shall be going of the stair measured horizontally. Both positive and negative moments along the direction of the flight shall be calculated as $wl^2/8$, where w is the intensity of the total dead and live load per unit area on a horizontal plane.

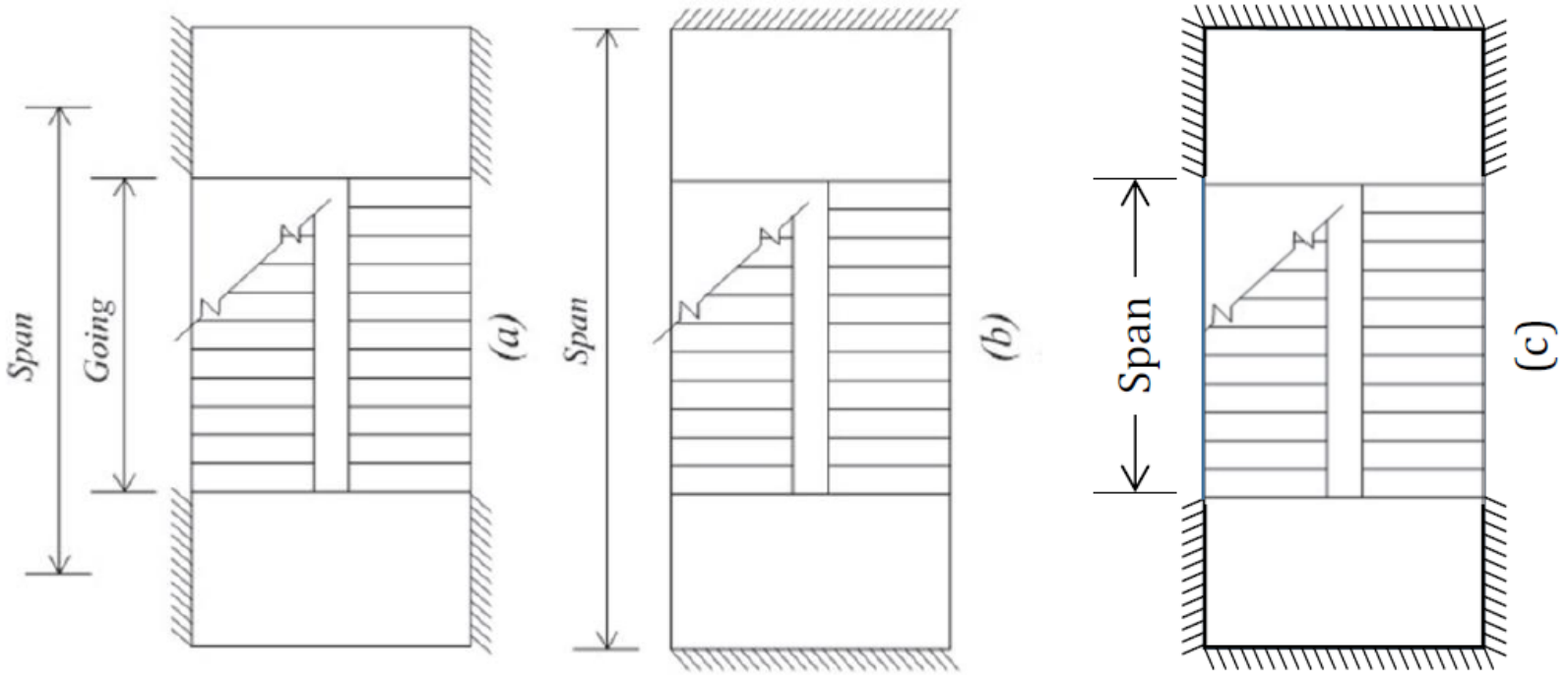
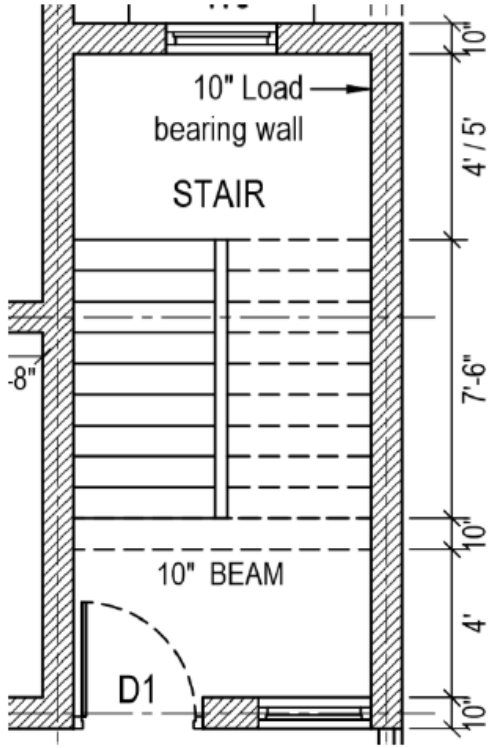


Figure: 6.6.25 (BNBC 2017)



Stair (Masonry Building: CE 316)

Moment Calculation:

L=90”

$M_u = W_u L^2/8 = (354.01*7.5^2)/8 = 2.489$ k-ft

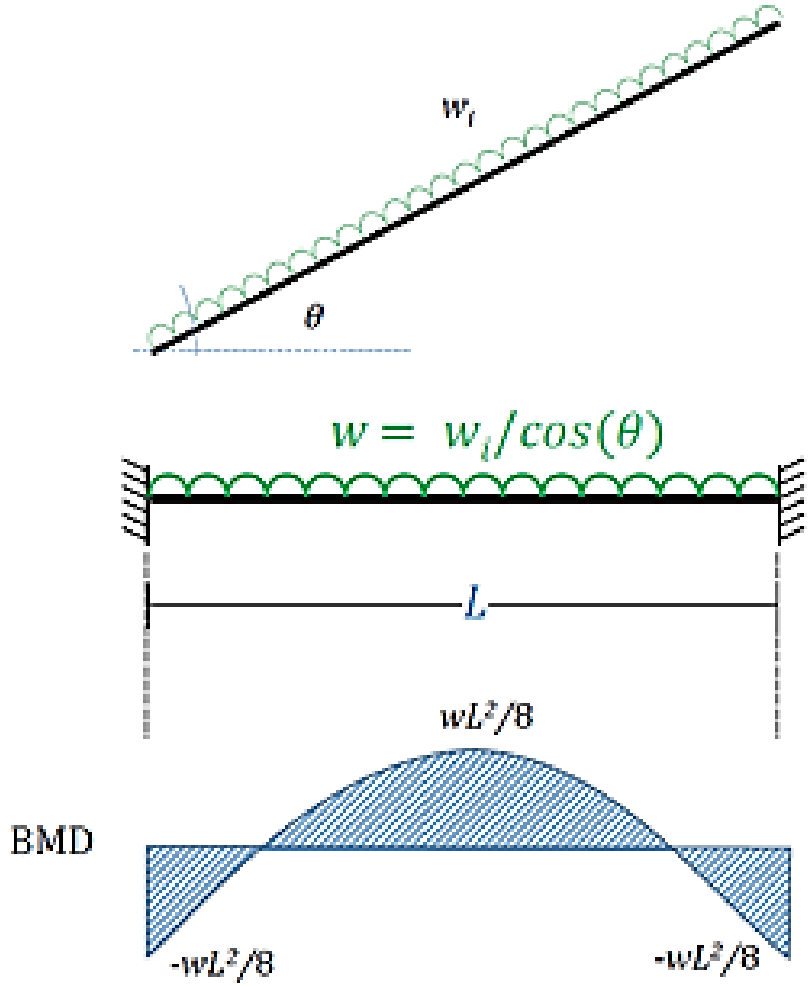
d Check:

$d_{prov} = t_{avg} - 1 = 7.5” - 1” = 6.5”$

$\rho_{0.005} = 0.85* \beta* fc’/fy* \varepsilon_u/(\varepsilon_u+0.005) = 0.0181$

$d_{req} = \sqrt{M_u/[\phi\rho f y b(1 - 0.59\rho fy/fc')]} = 1.74”$

$d_{prov} > d_{req}$ --okay



Reinforcement Calculation:

$$A_s = \frac{M_u}{\phi f_y (d - a/2)} \quad \& \quad a = \frac{A_s f_y}{0.85 f_c' b}$$

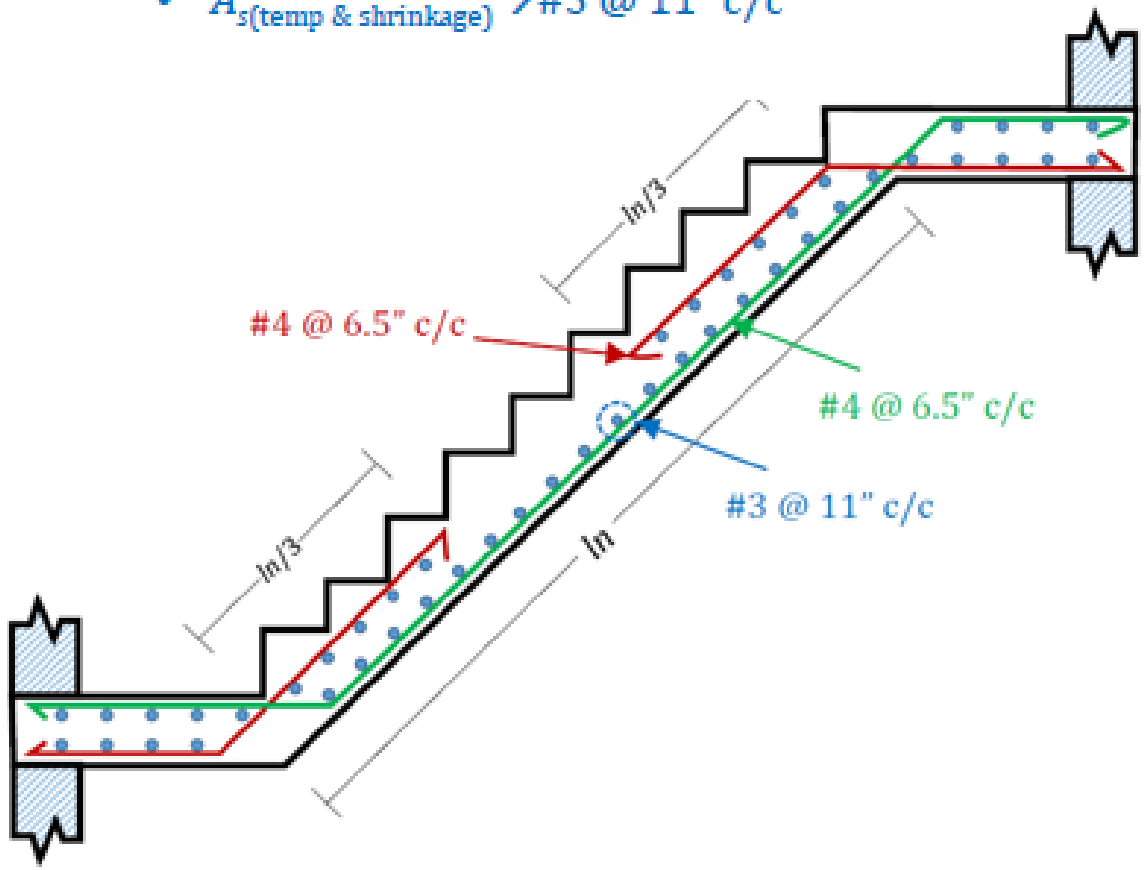
As_{min} = 0.0018bt = 0.0018*12*7.5 = 0.162 in^2
Spacing, s = 12*A_b/A_s = [#4 bar provided]
Smax = 3t = 3*7.5” = 22.5” or
= 18”
Smin = 1.5*t= 1.25”
If Smin< S< Smax –Okay
#bar c/c is provided

Shrinkage Reinforcement:

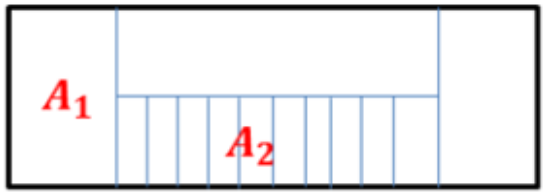
In longer direction, minimum reinforcement has to be provided for temperature and shrinkage.
Asmin = 0.0018bt
Spacing, s = 12* A_b/As_{min}
Smax = 5t
= 18”
Smin = 1.5t
If Smin < s < Smax– okay

Detailing fo reinforcements :

- Let, by calculation we get:
  - Main rebar → #4 @ 6.5" c/c
  - $A_{s(temp \& shrinkage)}$ → #3 @ 11" c/c



Step 05 : Stair Beam Design



$$Area = A_1 + A_2 = 7.5 \times 3.5 + 7.5 \times 3.5 = 52.5\ ft^2$$

Assume, Beam Size = 10"×12"

$$d_{eff} = (12 - 2.5)\ inch = 9.5\ inch$$

$$Self\ Weight = \frac{10}{12} \times \frac{12}{12} \times 0.150 = 0.125\ kip/ft (Unfactored)$$

$$Load\ on\ Stair\ beam\ from\ stair = \frac{Area \times UDL}{Length} =$$

$$Total\ Load\ on\ Beam, w = \quad + 0.125 \times 1.2 =$$

Positive Moment, $M(+ve)$ =

Negative Moment, $M(-ve)$ =

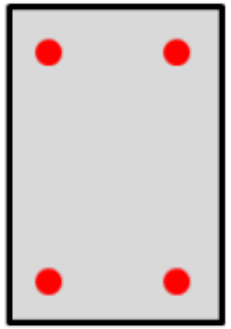
Maximum Moment, $M_{u,max}$ =

$$\rho = \rho_{0.005} = 0.85\beta_1 \frac{f_c'}{f_y} \frac{\epsilon_u}{\epsilon_u + 0.005} =$$

$$d_{req} = \sqrt{\frac{M_{u,max}}{\emptyset \rho f_y b \left(1 - 0.59\rho \frac{f_y}{f_c'}\right)}} = \sqrt{\frac{}{0.9 \times 0.0203 \times 40 \times 10 \left(1 - 0.59 \times 0.0203 \times \frac{40}{3}\right)}}$$

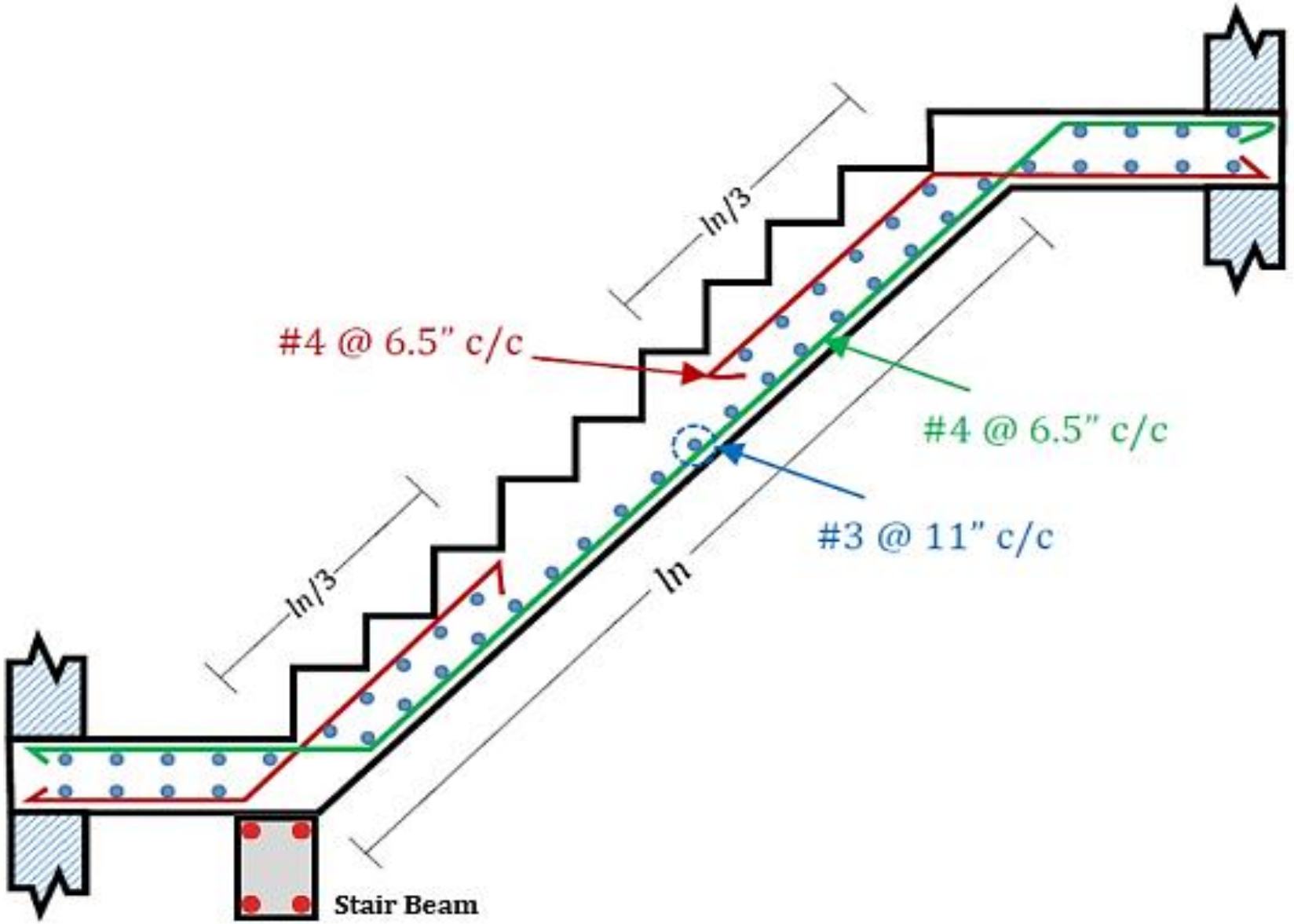
d_{req} = $d_{provided} = (12 - 2.5)\ in = 9.5"$ $d_{provided} > d_{required}$ → **ok**

$$A_{s,min} = max \begin{cases} \dfrac{3\sqrt{f_c(psi)}}{f_y(psi)} bd = \\ \dfrac{200}{f_y(psi)} bd = \end{cases}$$



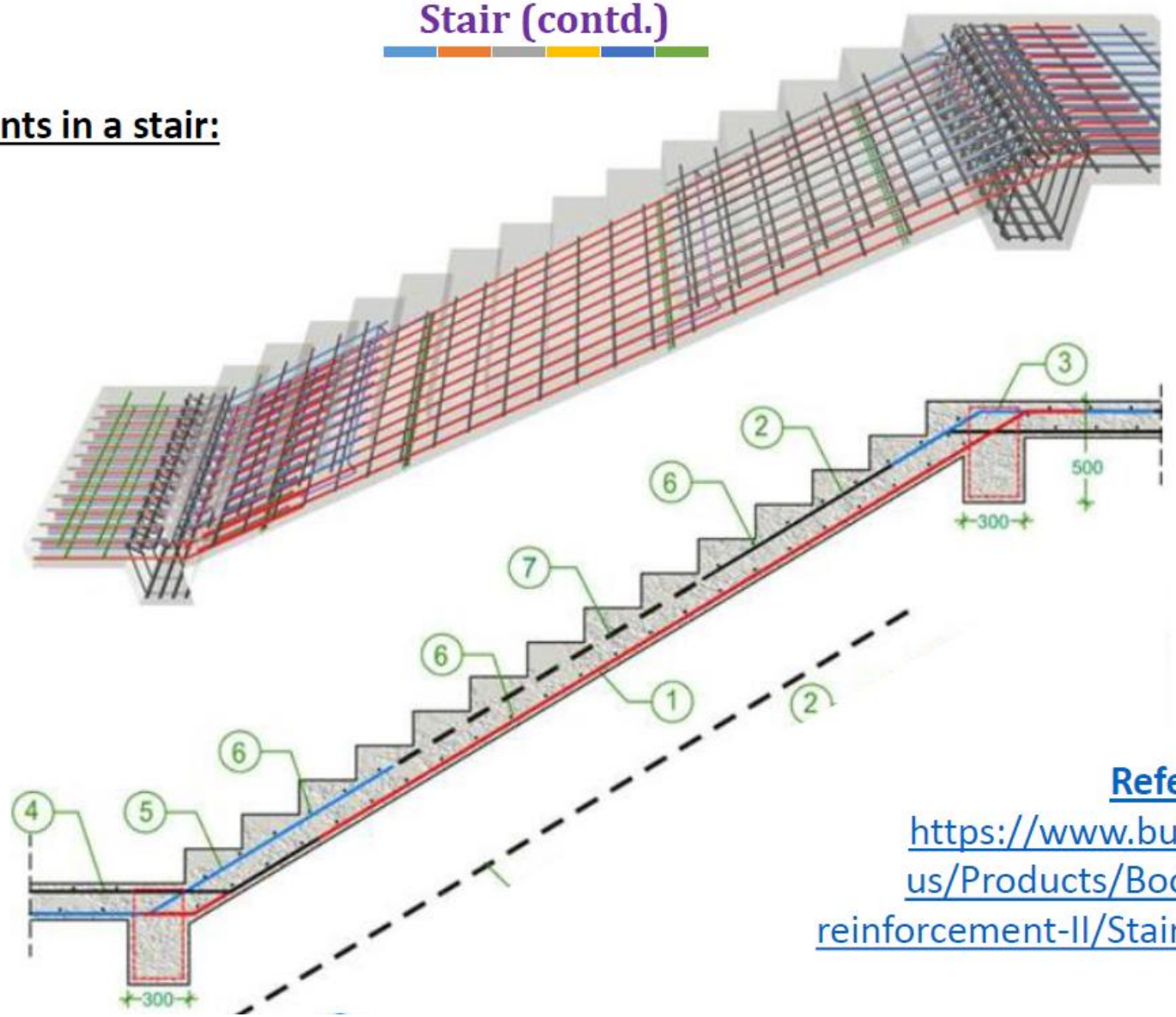
$$M(+ve) = \longrightarrow A_s(+ve) = < A_{s,min}$$

$$M(-ve) = \longrightarrow A_s(-ve) = < A_{s,min} \Big\} =$$


ln/3
#4 @ 6.5" c/c
#4 @ 6.5" c/c
#3 @ 11" c/c
ln/3
ln
Stair Beam

Stair (contd.)

Sample Image of Reinforcements in a stair:

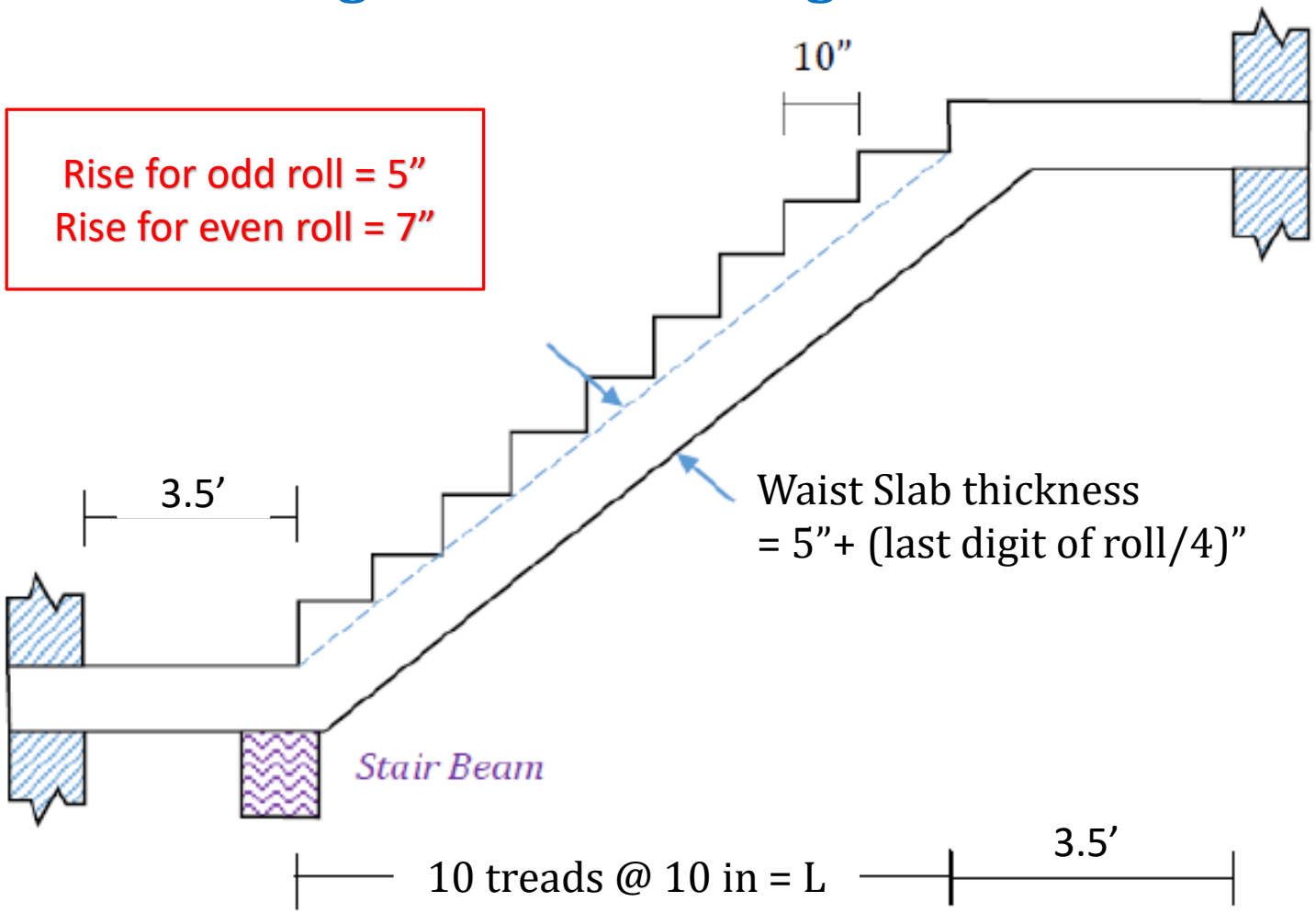


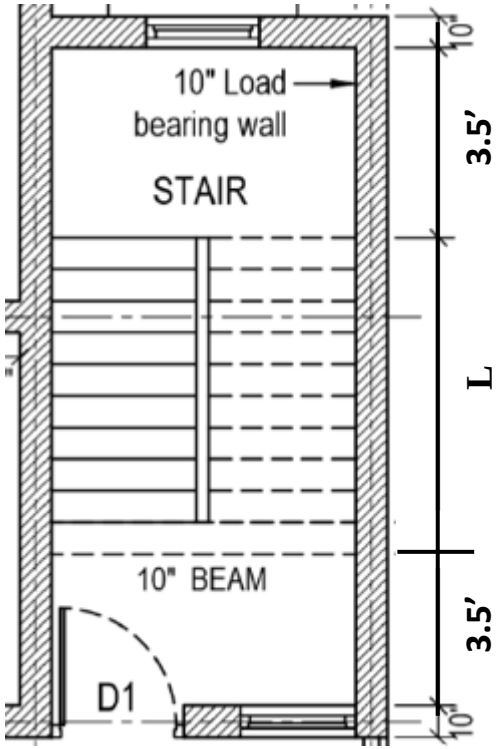
Reference:

https://www.buildinghow.com/en-us/Products/Books/Volume-A/The-reinforcement-II/Staircases/Simply-supported

❑ Do the design of the following stairs:

Rise for odd roll = 5”
Rise for even roll = 7”





Plan View