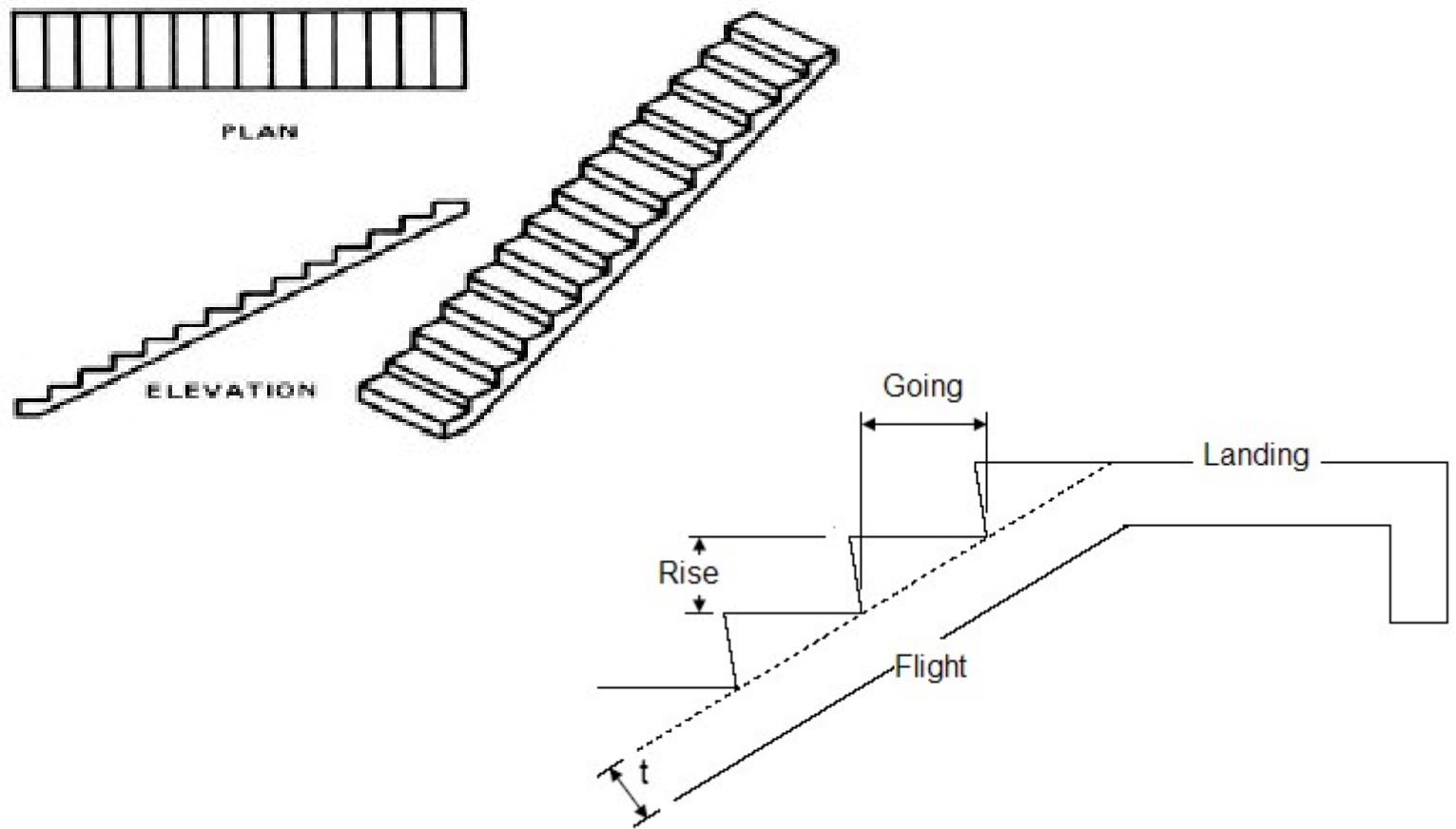


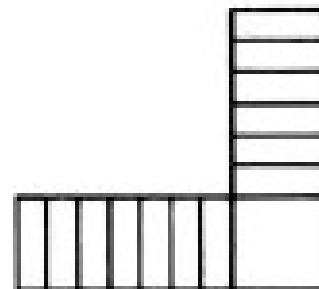
# Stair Types

Straight stairs

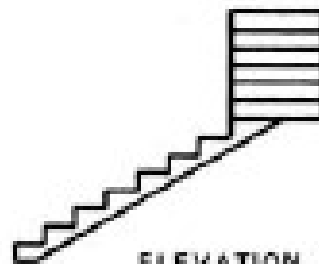


## L stairs

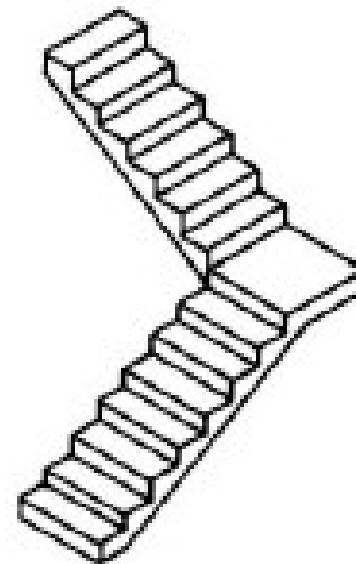
- One landing with a turn
- Used when little space is available



PLAN

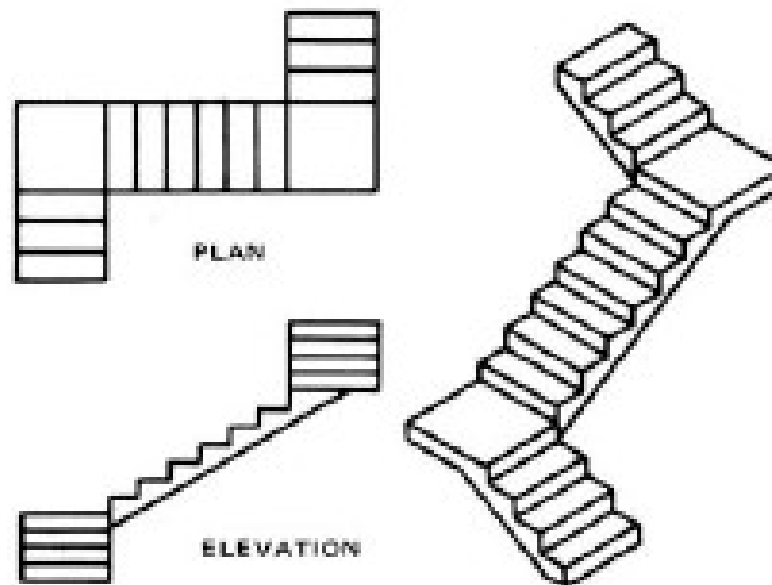


ELEVATION



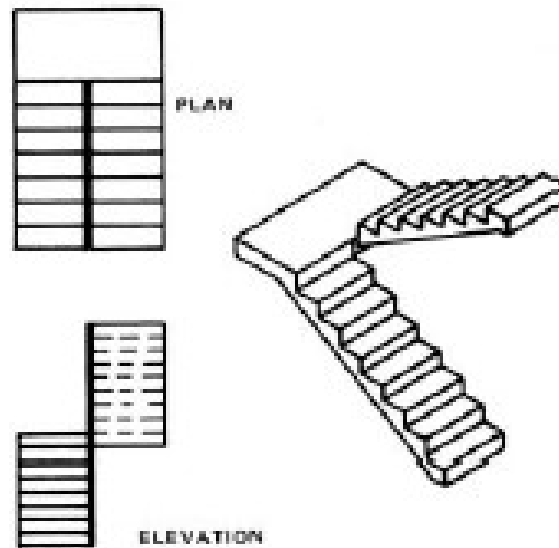
## Double-L stairs

- a. Two 90 degree turns, and two landings
- b. Not U shaped
- c. Often used in residential construction



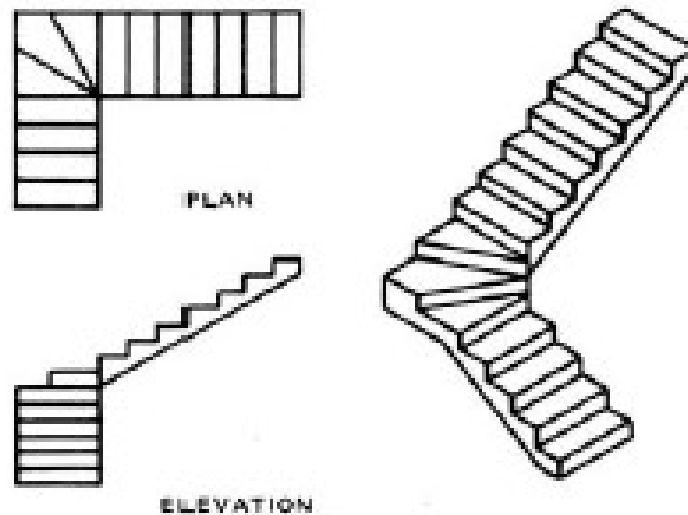
## U stairs

- a. Two flights of parallel stairs
- b. Introduces a landing midway the run
- c. May be open or closed
- d. Types
  1. Narrow U
  2. Wide U



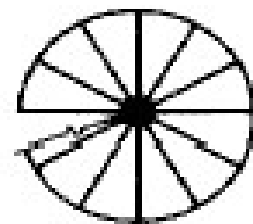
## Winder stairs

- Used in place of a landing
- Pie-shaped (triangular) steps
- Mid-point width should be equal to regular tread width.
- Not very safe

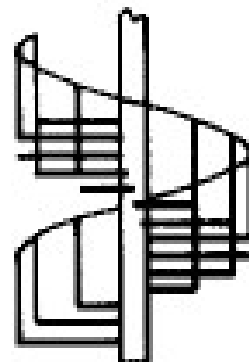


## Spiral Stairs

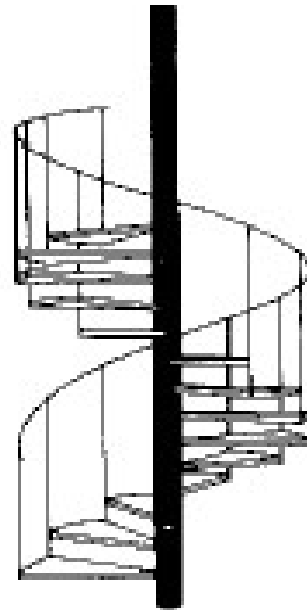
- a. Rise in a circle about a point
- b. Decorative styles can be used
- c. Used where little space is available



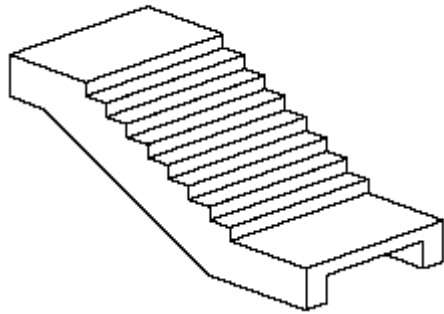
PLAN



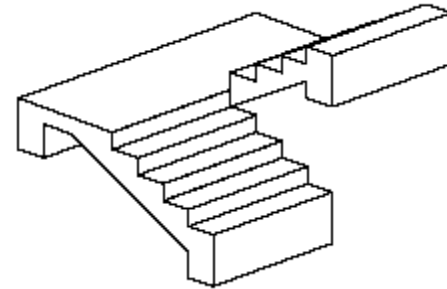
ELEVATION



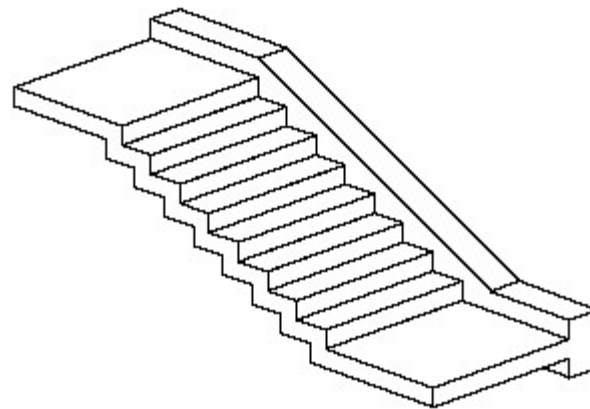
# Stair Type based on the structural loading type



Simply supported stair  
(transversely supported)



Longitudinally supported stair



Cantilever stair

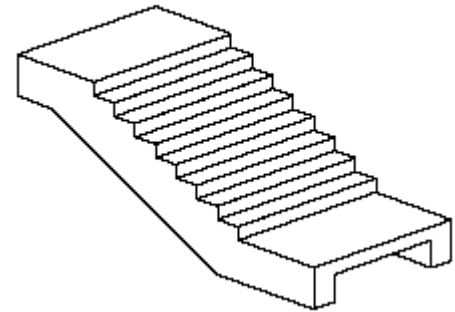
# Simply supported stair

*Design a straight flight stair in a residential building supported on reinforced concrete wall 1.5 m )(center to center)*

*L.L = 3kN/m<sup>2</sup>*

*Covering Material = 0.5kN/m*

*The riser are 16cm and goings are 30 cm*

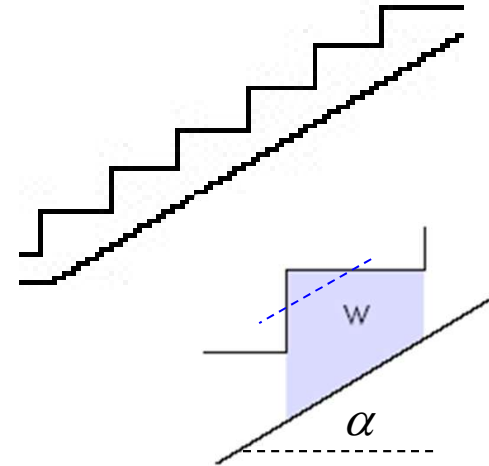




## ► Loads and Analysis

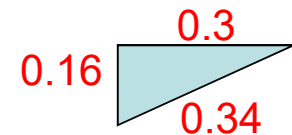
$$h_{\min} = \frac{l}{20} = \frac{150}{20} = 7.5 \text{ cm}$$

$$h_{\text{ave}} = 8 + \frac{7.5}{\cos \alpha} = 8 + \frac{7.5}{\frac{16}{\sqrt{30^2 + 16^2}}} = 16.5 \text{ cm}$$



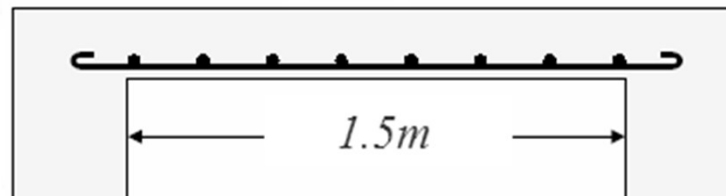
$$\text{D.L(O.W)} = 0.34 * 0.075 * 25 + 0.5 * 0.16 * 0.3 * 25 = 1.24 \text{ kN/m}$$

$$\text{D.L (covering material)} = 0.5 \text{ kN/m}$$



$$\text{D.L (total)} = 1.74 \text{ kN/m}$$

$$\text{L.L} = 3 * (0.3) = 0.9 \text{ kN/m}$$

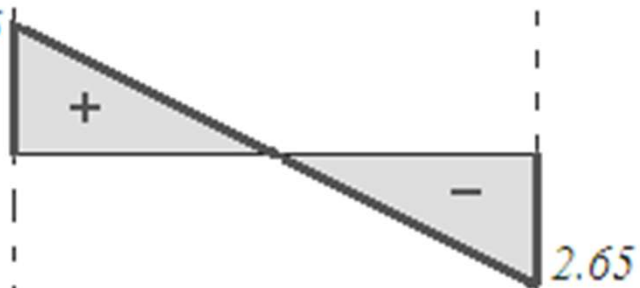


$$1.2(1.74) + 1.6(0.9) = 3.53 \text{ kN.m}$$



1.5 m

2.65



2.65



1.0

## Design for moment

$$M_u = 1kN.m$$

$$d = 16.5 - 2 - 0.6 = 13.9cm = 139mm$$

$$b_w = 30cm = 300mm$$

$$\text{assume} \Rightarrow \rho \leq \rho_{lim} \rightarrow \phi = 0.9$$

$$\rho = \frac{0.85(25)}{420} \left[ 1 - \sqrt{1 - \left( \frac{2 \times 10^6 \times 1}{0.85(0.9)(25)300 \times 139^2} \right)} \right] = 0.0005 < \rho_{min}$$

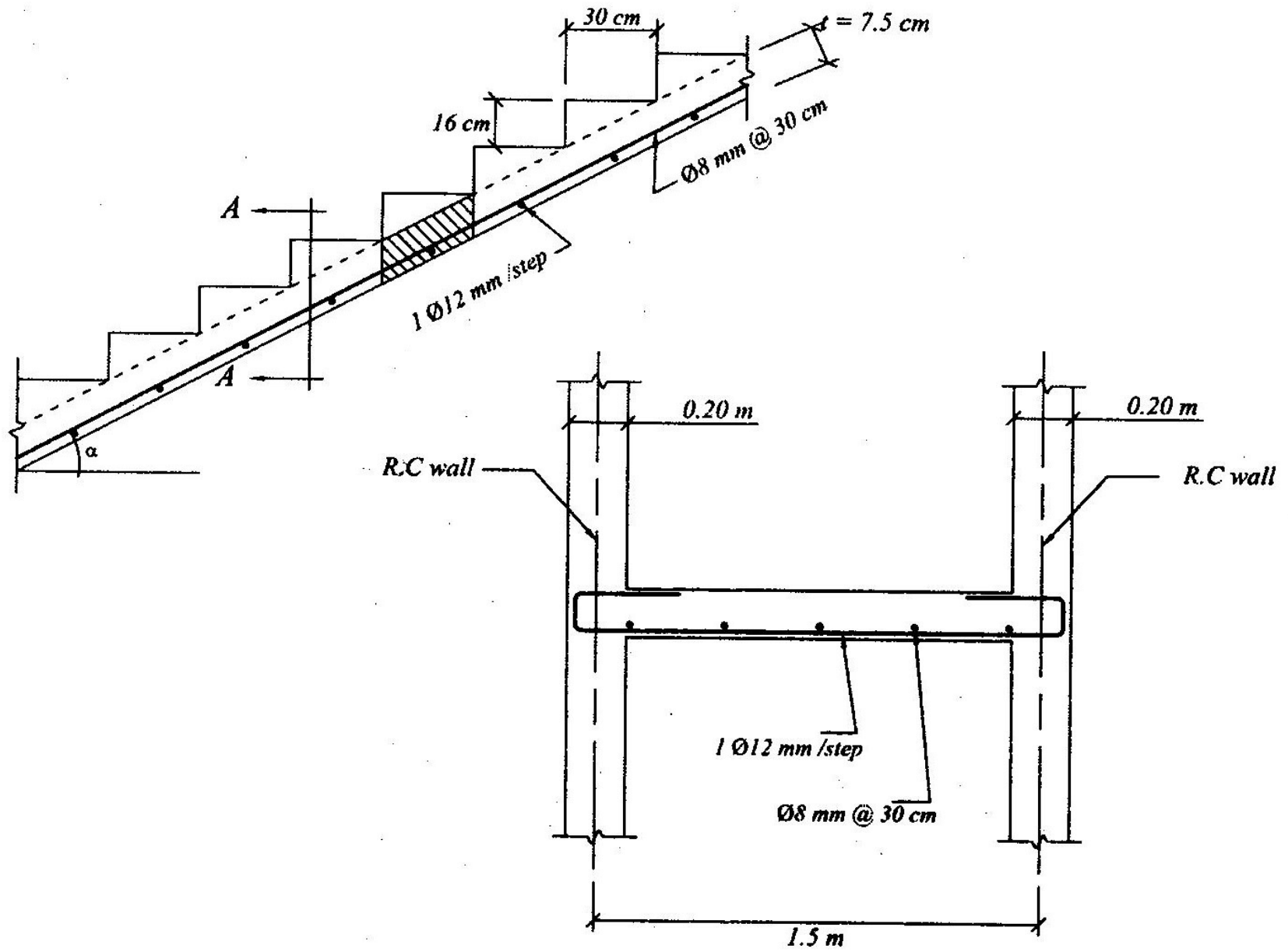
$$A_{s_{min}} = 0.0018 * 300 * 165 = 89.1mm^2 = 0.9cm^2$$

use

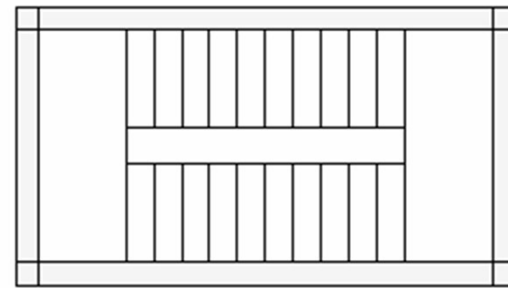
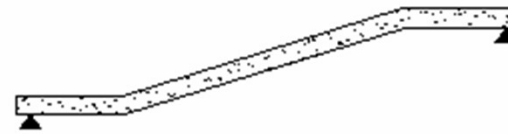
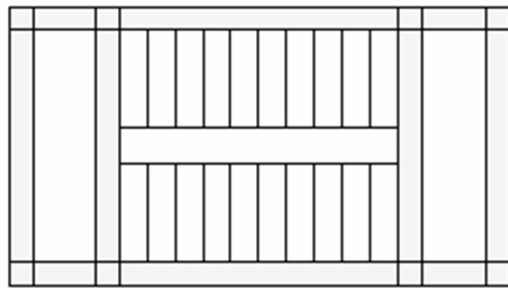
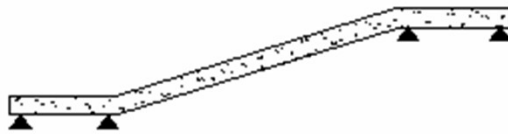
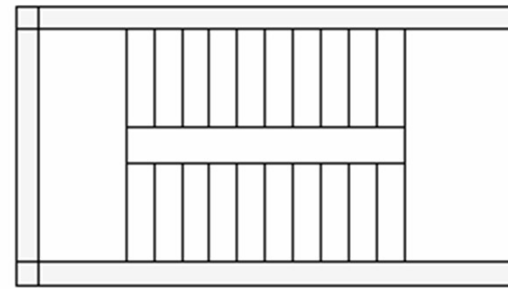
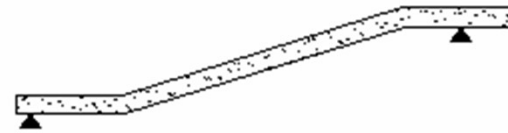
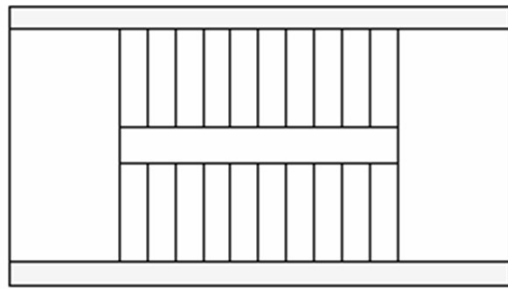
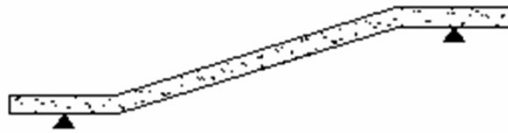
1 $\phi$ 12 for each step

## Design for shear

$$\phi V_c = 0.75 \times \frac{\sqrt{25}}{6} \times 139 \times 300 / 1000 = 26kN > V_u$$



# Longitudinal – Supported stairs

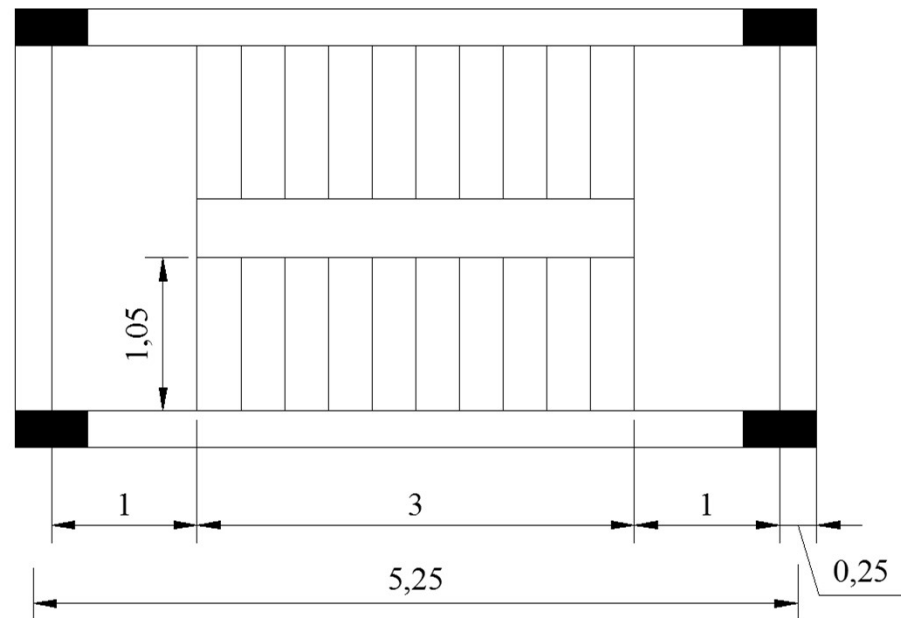


# Longitudinal – Supported stairs (Example)

*Design a U- stair in a residential building  $L.L = 3 \text{ kN/m}^2$*

*Covering Material =  $2 \text{ kN/m}^2$*

*The riser are 16 cm and goings are 30 cm*



## ► Loads and Analysis

$$h_{\min} = 0.85 \frac{l}{20} = \frac{525}{20} \approx 22 \text{ cm}$$

$$D.L \text{ (slab)} = 0.22 * 25 = 5 \text{ kN/m}^2$$

$$D.L \text{ (step)} = 0.5 * 0.16 * 25 = 2 \text{ kN/m}^2$$

$$D.L \text{ (covering material)} = 2 \text{ kN/m}^2$$

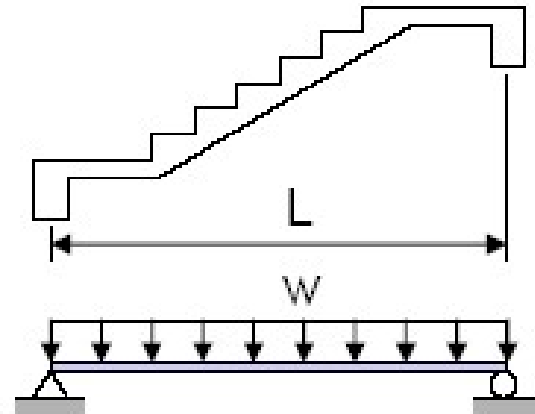
$$D.L \text{ (flight)} = 9 \text{ kN/m}^2$$

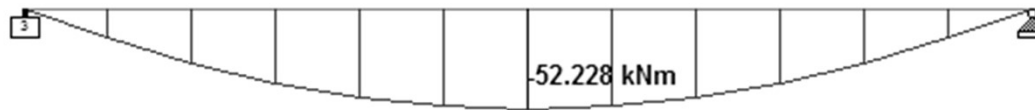
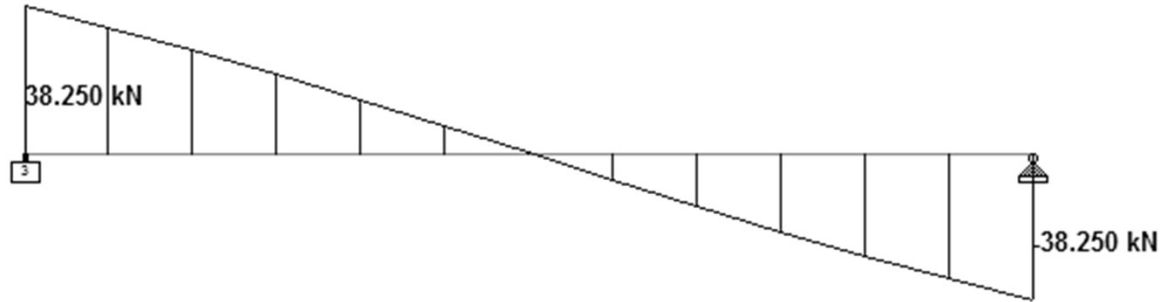
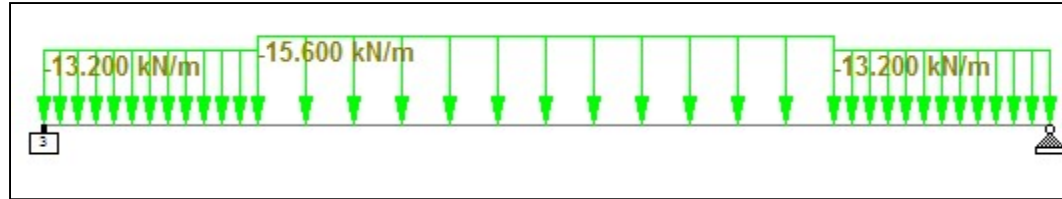
$$D.L \text{ (landing)} = 7 \text{ kN/m}^2$$

$$L.L = 3 \text{ kN/m}^2$$

$$W_u \text{ (flight)} = 1.2(9) + 1.6(3) = 15.6 \text{ kN/m}$$

$$W_u \text{ (landing)} = 1.2(7) + 1.6(3) = 13.2 \text{ kN/m}$$







## Design for moment

$$M_u = 52.2 \text{ kN.m}$$

$$d = 22 - 2 - 0.6 = 19.4 \text{ cm} = 194 \text{ mm}$$

$$b_w = 105 \text{ cm} = 1050 \text{ mm}$$

$$\text{assume} \Rightarrow \rho \leq \rho_{\text{lim}} \rightarrow \phi = 0.9$$

$$\rho = \frac{0.85(25)}{420} \left[ 1 - \sqrt{1 - \left( \frac{2 \times 10^6 \times 52.2}{0.85(0.9)(25)1050 \times 194^2} \right)} \right] = 0.0036$$

$$A_{s_{\text{min}}} = 0.0036 * 1050 * 194 = 733.32 \text{ mm}^2 = 7.33 \text{ cm}^2$$

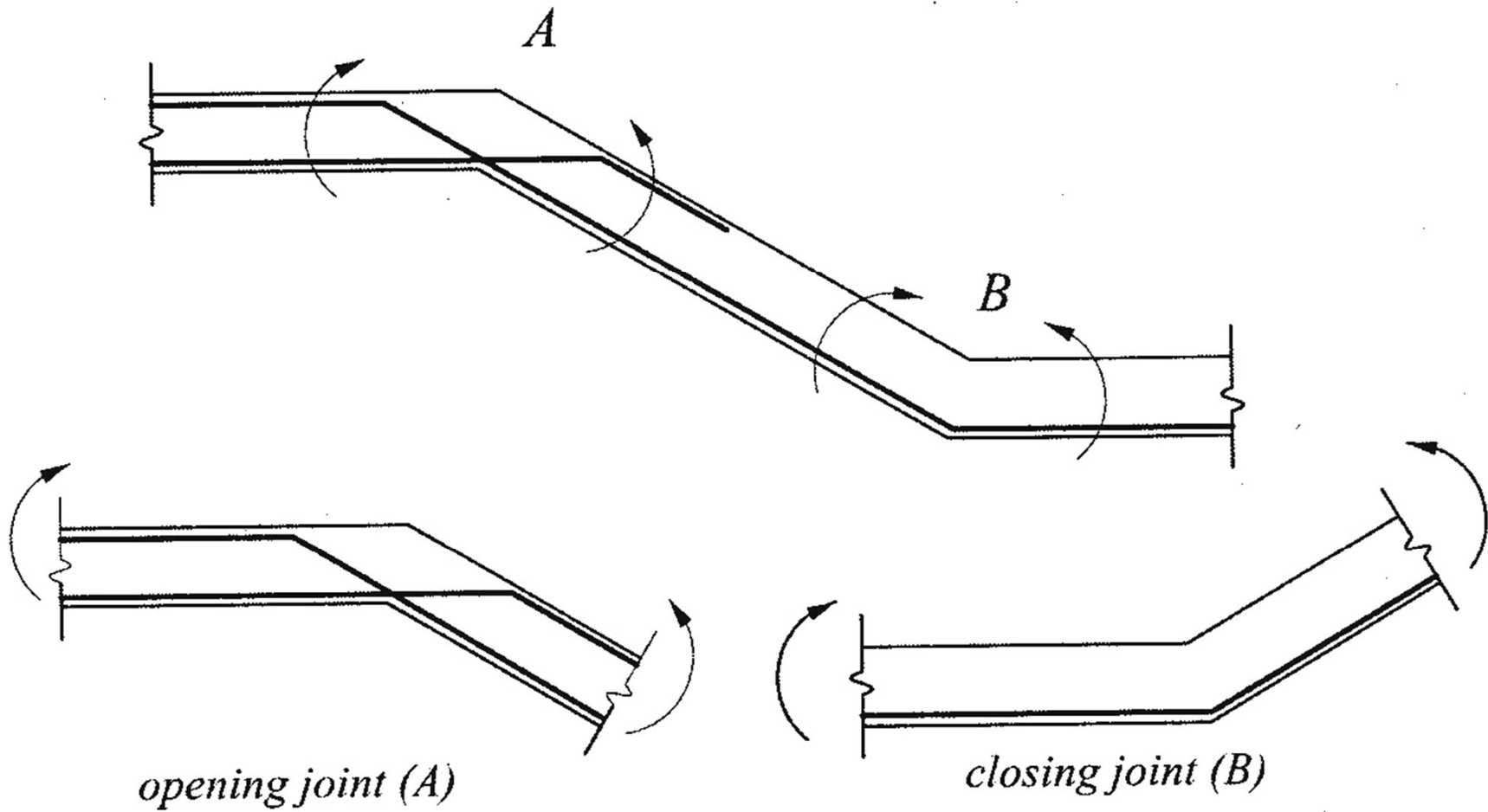
use

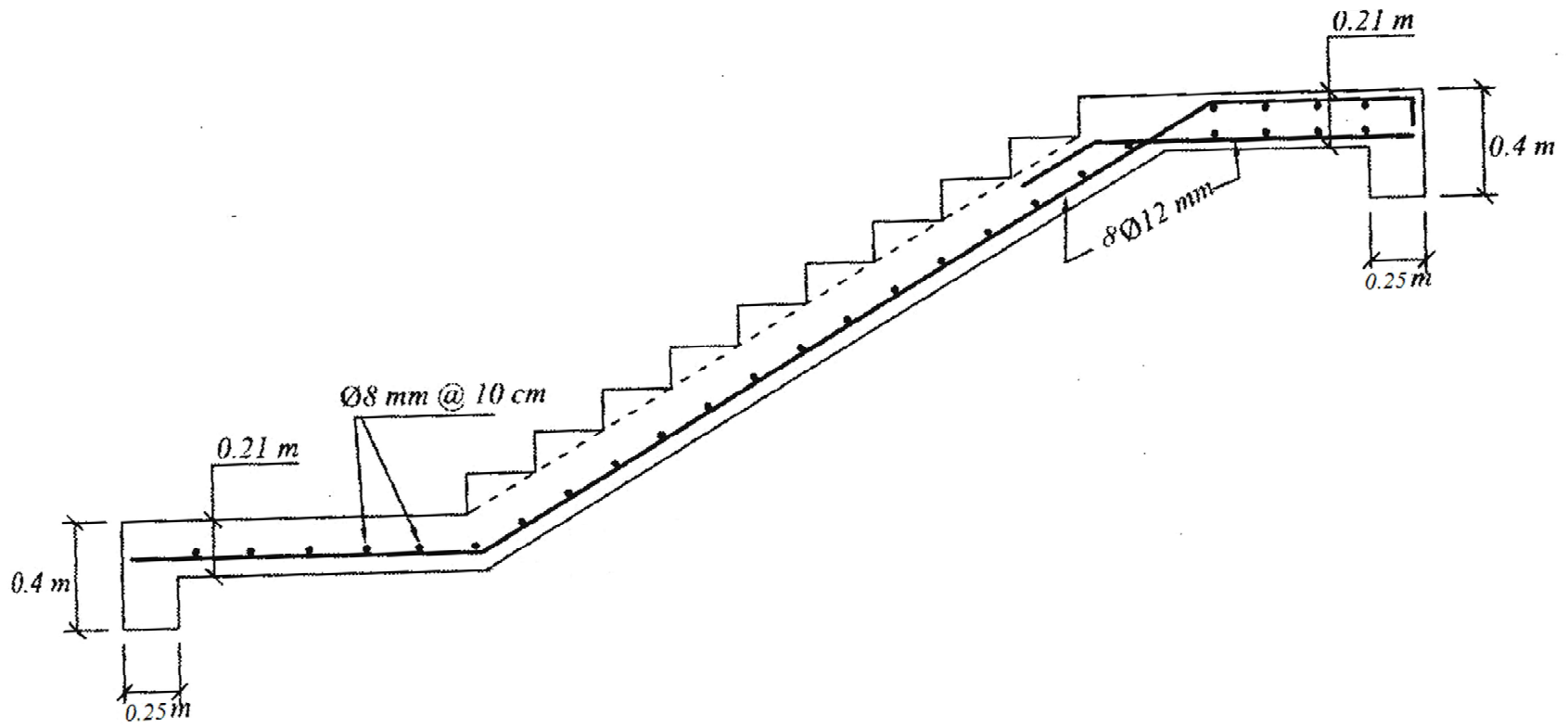
8 $\phi$ 12

## Design for shear

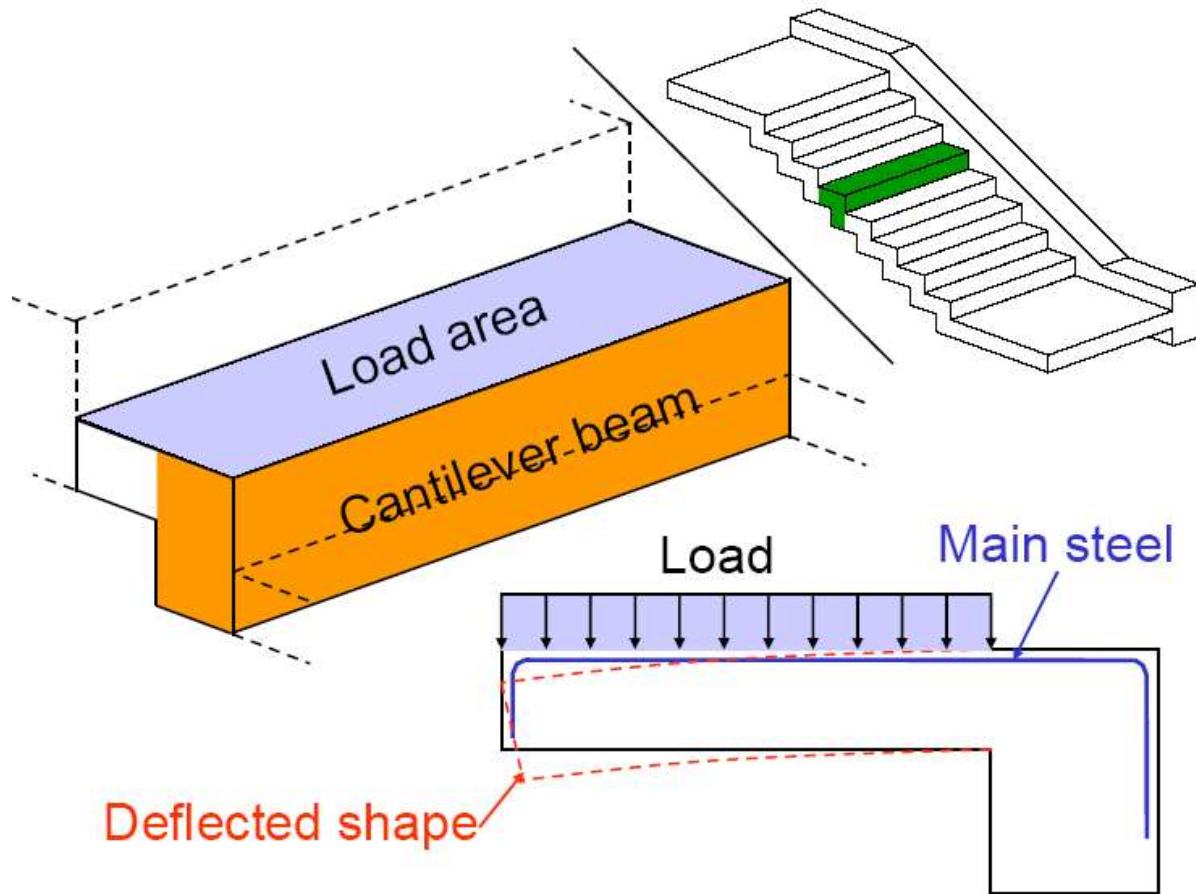
$$\phi V_c = 0.75 \times \frac{\sqrt{25}}{6} \times 194 \times 1050 / 1000 = 127.3 \text{ kN} > V_u$$

# Reinforcement Notes





# Cantilever Stair



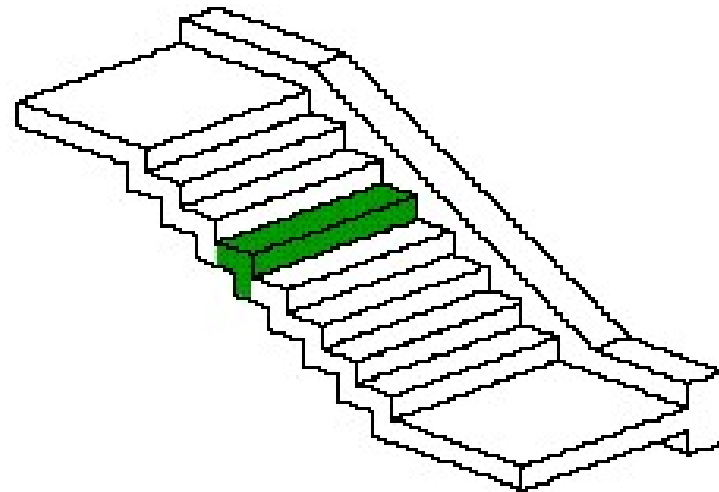
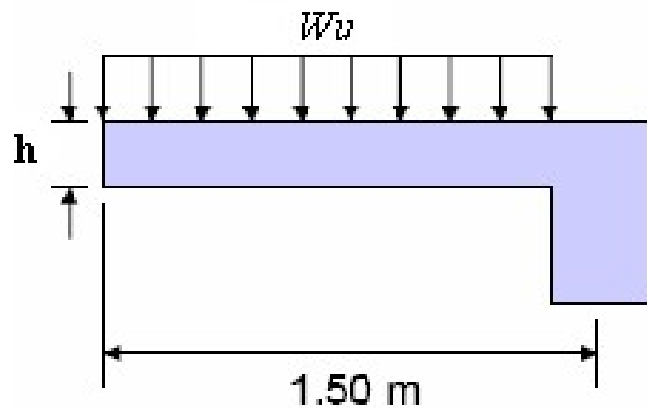
## Cantilever stairs (Example)

*Design a cantilever straight flight stair in a residential building*

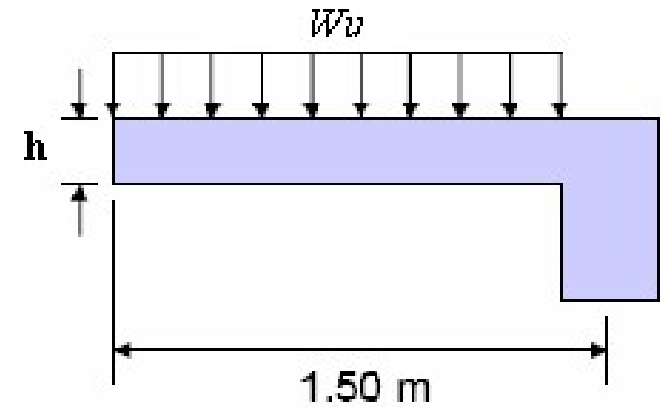
*L.L = 3 kN/m<sup>2</sup>*

*Covering Material = 0.5 kN/m*

*The riser are 16cm and goings are 30 cm*



$$h_{\min} = \frac{l}{10} = \frac{150}{10} = 15\text{cm}$$



$$D.L(O.W) = 0.15 * 0.075 * 25 + 0.15 * 0.075 * 25 = 0.6 \text{ kN/m}$$

$$D.L \text{ (covering material)} = 0.5 \text{ kN/m}$$

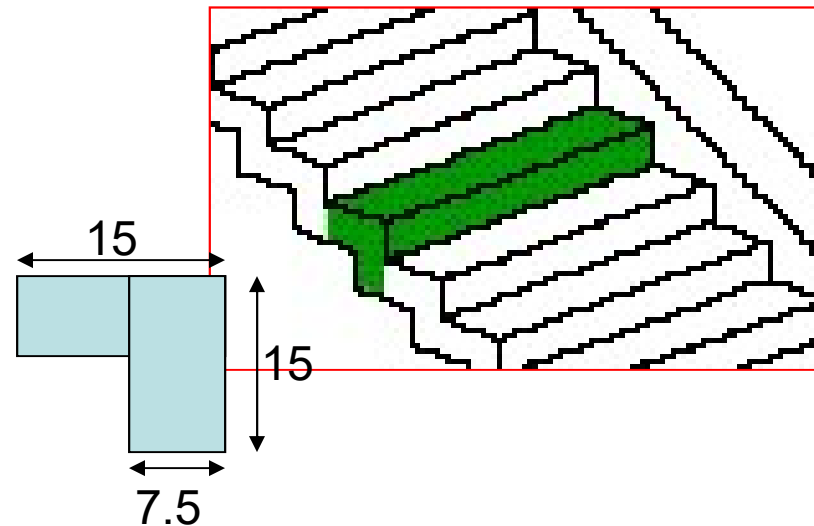
$$D.L \text{ (total)} = 1.1 \text{ kN/m}$$

$$L.L = 3 * (0.3) = 0.9 \text{ kN/m}$$

$$W_u = 1.2(1.1) + 1.6(0.9) = 2.76 \text{ kN/m}$$

$$V_u = 2.76(1.5) = 4.14 \text{ kN}$$

$$M_u = W_u L^2 / 2 = 3.1 \text{ kN.m}$$



## Design for moment

$$M_u = 3.1kN.m$$

$$d = 15 - 2 - 0.6 = 12.4cm = 124mm$$

$$b_w = 7.5cm = 75mm$$

$$\text{assume} \Rightarrow \rho \leq \rho_{lim} \rightarrow \phi = 0.9$$

$$\rho = \frac{0.85(25)}{420} \left[ 1 - \sqrt{1 - \left( \frac{2 \times 10^6 \times 3.1}{0.85(0.9)(25)75 \times 124^2} \right)} \right] = 0.0077$$

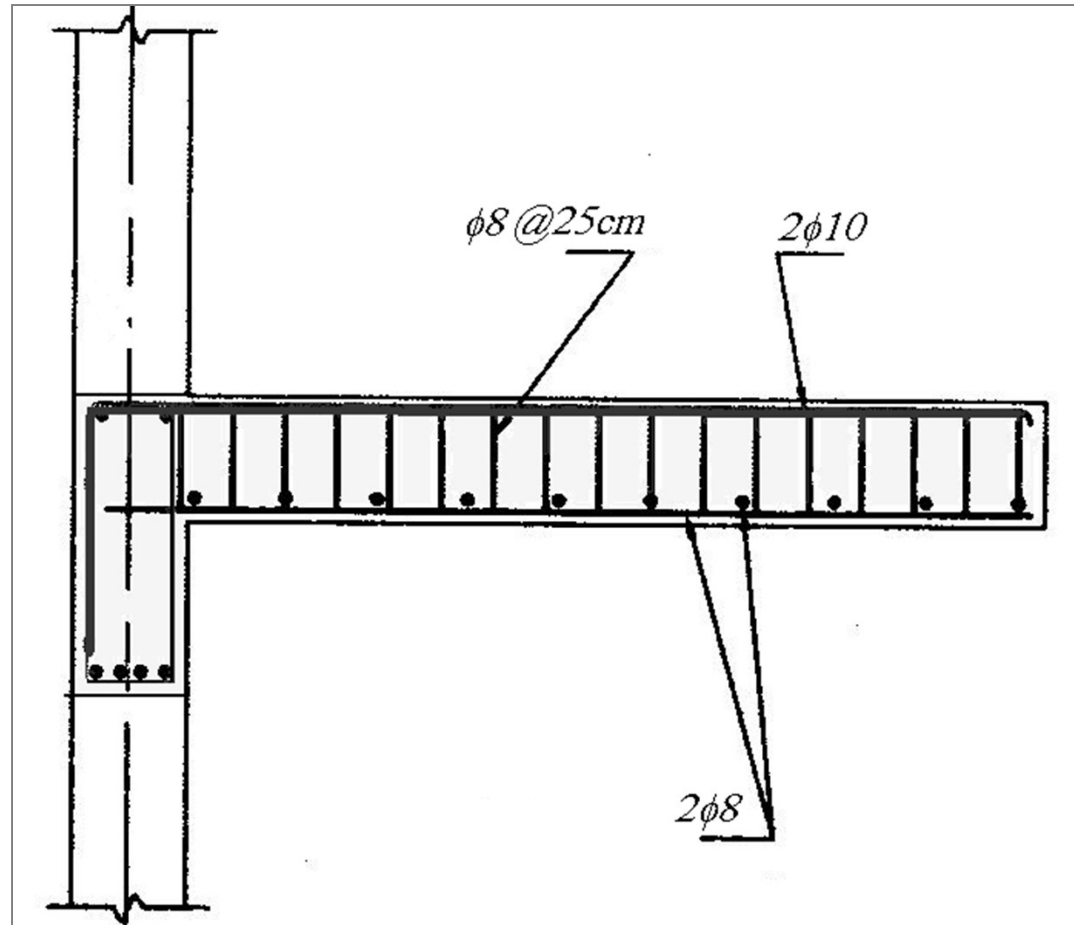
$$A_{s_{min}} = 0.0077 * 75 * 124 = 71.61mm^2 = 0.72cm^2$$

use

$$2\phi 10$$

## Design for shear

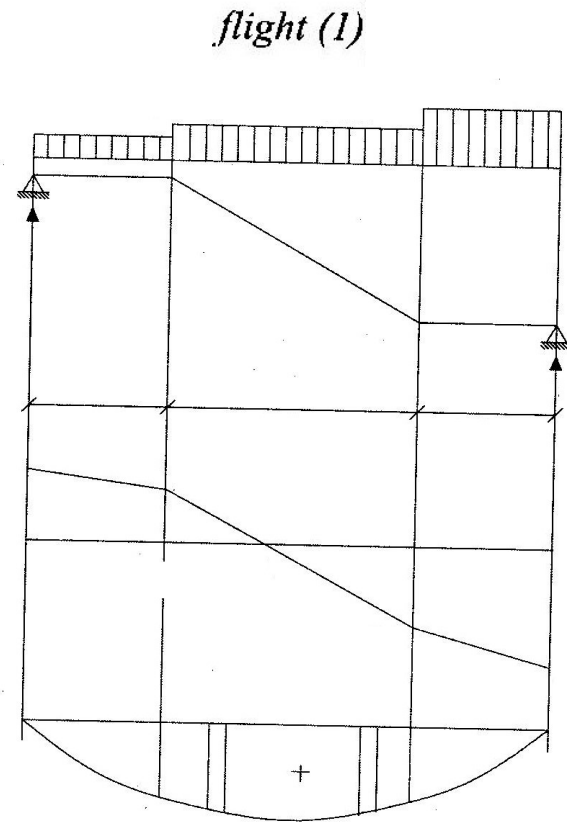
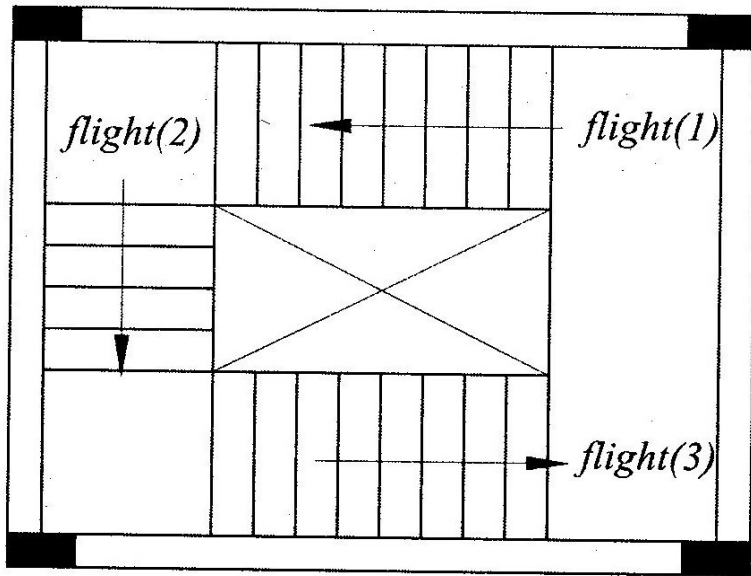
$$\phi V_c = 0.75 \times \frac{\sqrt{25}}{6} \times 124 \times 75 / 1000 = 5.8kN > V_u$$





# Longitudinal – Supported stairs

## Open-well stairs



# General Example

