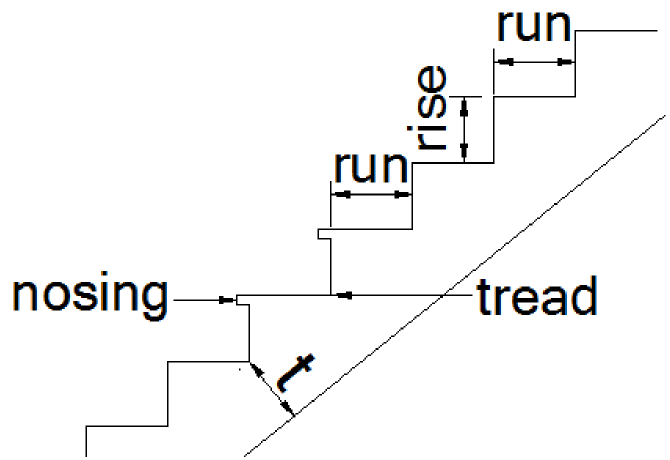
# Stair ways

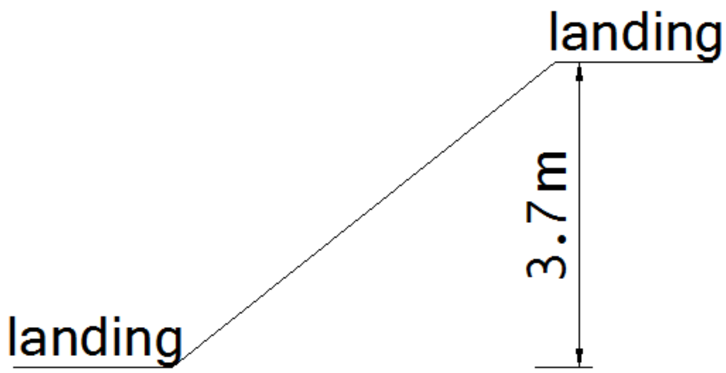
## Types:

1. Stair ways to acts as cantilever slab.
2. Stair ways to acts as simple slab:
   a) Stair with supports along the side.
   b) Stair with supports upon the ends.

# Limitations:




1. Minimum width of a stairway is 110cm.
2. Maximum rise of step is 200mm.
3. Minimum rise of step is 165mm.
4. Minimum run of step (exclusive nosing)=240mm
5. For step without nosing the sum of rise and run is at least 445mm.




6. Maximum height of straight flight between landings is 3.7m.
7. For stairways serving as exits from places of assembly, maximum height 2.5m.

8. Number of stairways in floor within a building is governed by:

a) Width of stairway.

b) The number of probable occupants.

c) Dimensions of floor area.

9. The distance from any point in open floor area to the nearest stairway shall not exceed 30m.

## Live load on stairway:

In stair each (55cm width* 1.5 tread) occupied one person (person weight 0.9-1.25kN)

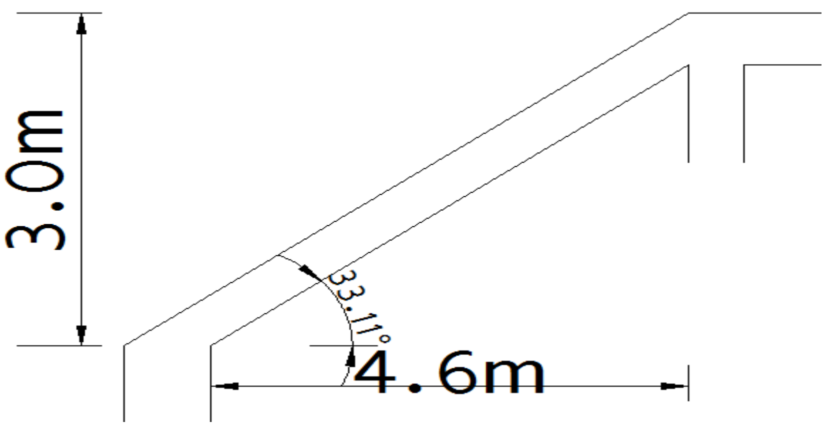
In landing each 0.325m$^2$ occupied one person

# Example:

Given:

Width=1.1m, height=3m, additional dead load=6 kN/m length, additional live load=6 kN/m length, $\gamma_{concrete}$ =24.5kN/m$^3$, fy=300 MPa, fc'=25MPa.

# Solution:




Assume rise=175mm

run=270mm

No. of stairs=3000/175=17.143

Let rise=176mm, → No. of stairs=17 step

$$\theta = \tan^{-1}\frac{176}{270} = 33.11°$$

$t_{min}$=L/20=4.6/20=0.23m

Dead load of slab=0.23*1.1*(1/cos33.11)*24.5=7.4kN/m of horizontal projection

Dead load of step=$\frac{0.176*0.27}{2}*1.1*17*24.5*\frac{1}{4.6}=2.4\frac{kN}{m}$

Assume live load of each person=1.25kN

$$\left(\frac{110}{55}*\frac{17}{1.5}\right)*1.25*\frac{1}{4.6}=6.2kN/m\ of\ horizontal$$

$$\sum WD=7.4+2.4+6=15.8kN/m$$

$$\sum WL=6.2+6=12.2kN/m$$

$$Wu=1.2*15.8+1.6*12.2=38.48kN/m$$

$$M_{max} = \frac{Wl^2}{8} = \frac{38.48 * 4.6^2}{8} = 101.8 kN.m$$

d=t-25=230-25=205mm

## Check for shear:

$$V = \frac{38.48 * 4.6}{2} - 38.48 * 0.205 * \cos 33.11 = 81.9 kN$$

$$\frac{V_u}{\emptyset bd} = \frac{81.9 * 10^{-3}}{0.75 * 1.1 * \frac{0.205}{\cos 33.11}} = 0.405 MPa$$

$$V_c = \frac{1}{6}\sqrt{fc'} = \frac{1}{6}\sqrt{25} = 0.833 MPa$$

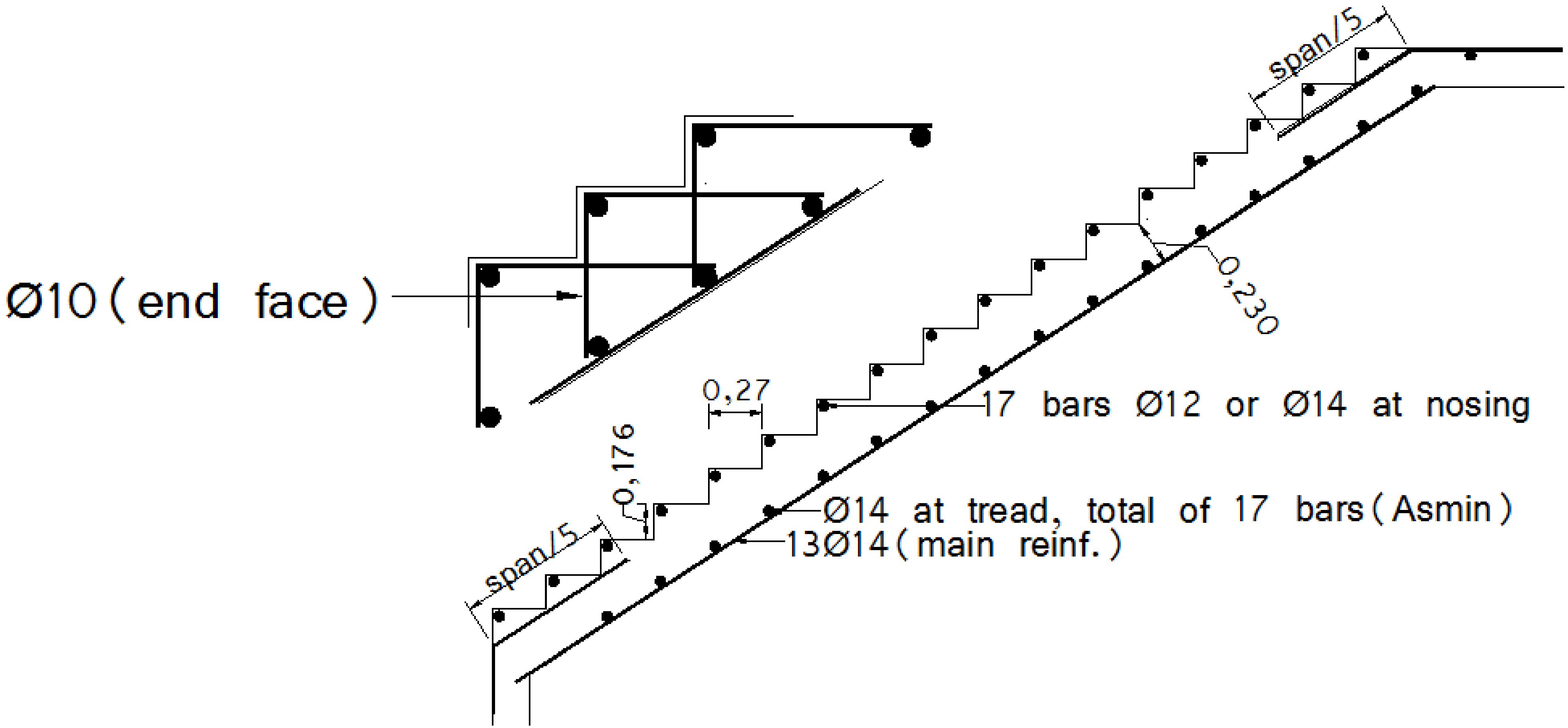
$$R = \frac{Mu}{\emptyset fc' bd^2} = \frac{101 * 10^{-3}}{0.9 * 25 * 1.1 * 0.205^2} = 0.0978$$

$$\omega = 0.1042 < \omega_{max} = 0.364\beta1 = 0.364 * 0.85 = 0.309\ O.K$$

$$\rho = \omega \frac{fy}{fc'} = 0.1042 * \frac{300}{25} = 0.00868$$

As=0.00868*1100*205=1958 $mm^2$(main reinforcement)>$As_{min}$=0.002*230*1100=506 $mm^2$ O.K

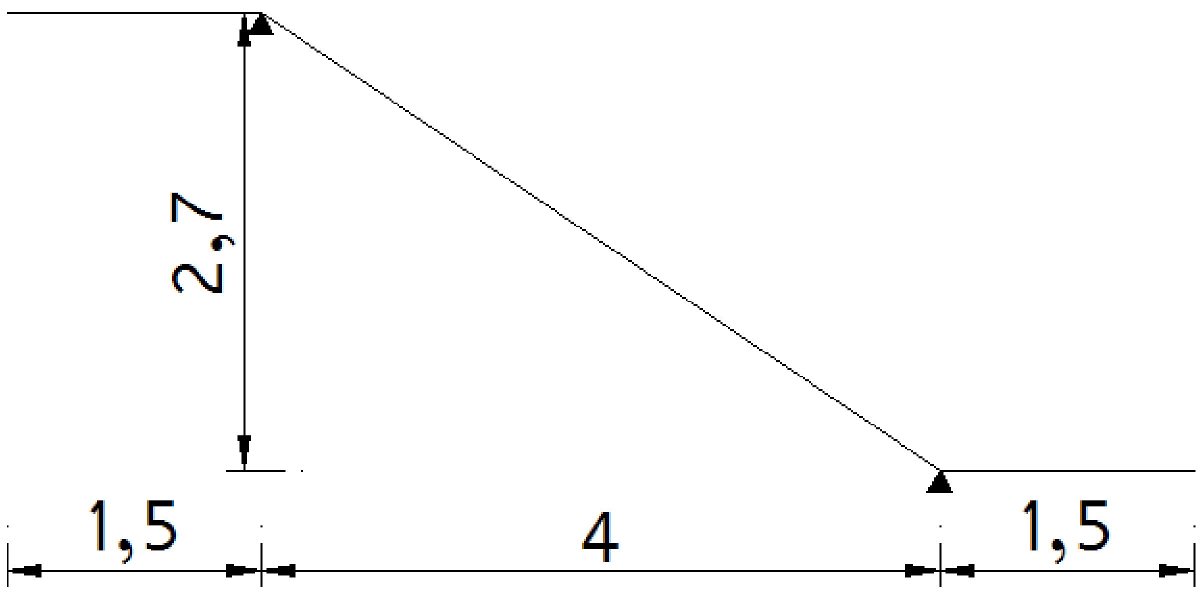
Shrinkage and temperature reinforcement=0.002*230*5492=2527 $mm^2$


Ø10 ( end face )
span/5
span/5
0,230
0,27
0,176
17 bars Ø12 or Ø14 at nosing
Ø14 at tread, total of 17 bars ( Asmin )
13Ø14 ( main reinf. )

# Example:

Given:

Width=2m , additional dead load=2 kN/m$^2$, additional live load=2 kN/m$^2$, $\gamma_{concrete}$ =25kN/m$^3$, fy=300 MPa, fc'=20MPa., weight of person=1kN, rise=180mm, run=270mm, No. of steps=15



**Solution:**

$t_{min}$=L/20=4000/20=200mm

**Loads on stair:**

Dead load of slab=0.2*2*(1/cos34)*25=12kN/m of horizontal projection

Dead load of step=$\frac{0.18*0.27}{2}*2*15*25*\frac{1}{4}=4.6kN/m$

$$\sum WD=12+4.6+2*2=20.6kN/m$$

$$WL=\left(\overbrace{\boxed{\frac{200}{55}}}^{=4}*\frac{15}{1.5}\right)*1.0*\frac{1}{4}=10kN/m\,of\,horizontal$$

$$\sum WL = 10 + 2 * 2 = 14kN/m$$

$$Wu = 1.2 * 20.6 + 1.6 * 14 = 47.12kN/m$$

## Loads on landing:

$$\mathrm{WD} = \frac{0.2 * 1.5 * 2 * 25}{1.5} = 10\ kN/m$$

$$\mathrm{WL} = \frac{1.5 * 2}{0.325} * 1.0 * \frac{1}{1.5} = 6.15\ kN/m$$

$$\sum WD = 10 + 2 * 2 = 14kN/m$$

$$\sum WL = 6.15 + 2 * 2 = 10.15kN/m$$

$$Wu_D = 1.2 * 14 = 16.8/m$$

$$Wu_L = 1.6 * 10.15 = 16.24kN/m$$

$$Wu = 16.8 + 16.24 = 33.04kN/m$$

## Case A: determine max. Positive moment

- Stair should be loaded by full(design)load
- Landings should be loaded by dead load

Max. Positive moment=75.34kN.m

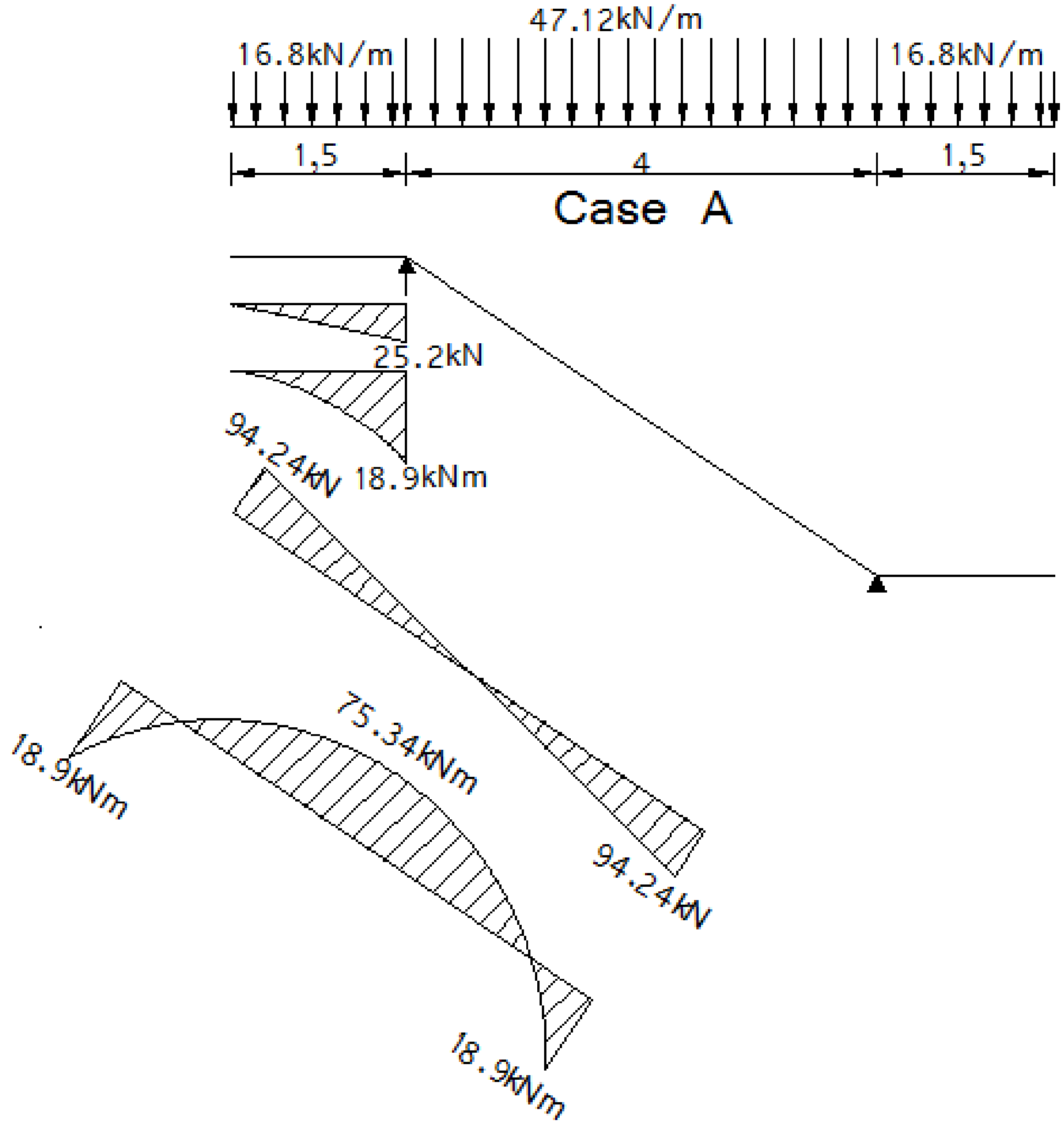
## **Check for shear:**

d=t-25=200-25=175mm

$$Vu_{max} = 94.24 - 47.12 * 0.175 = 86kN$$

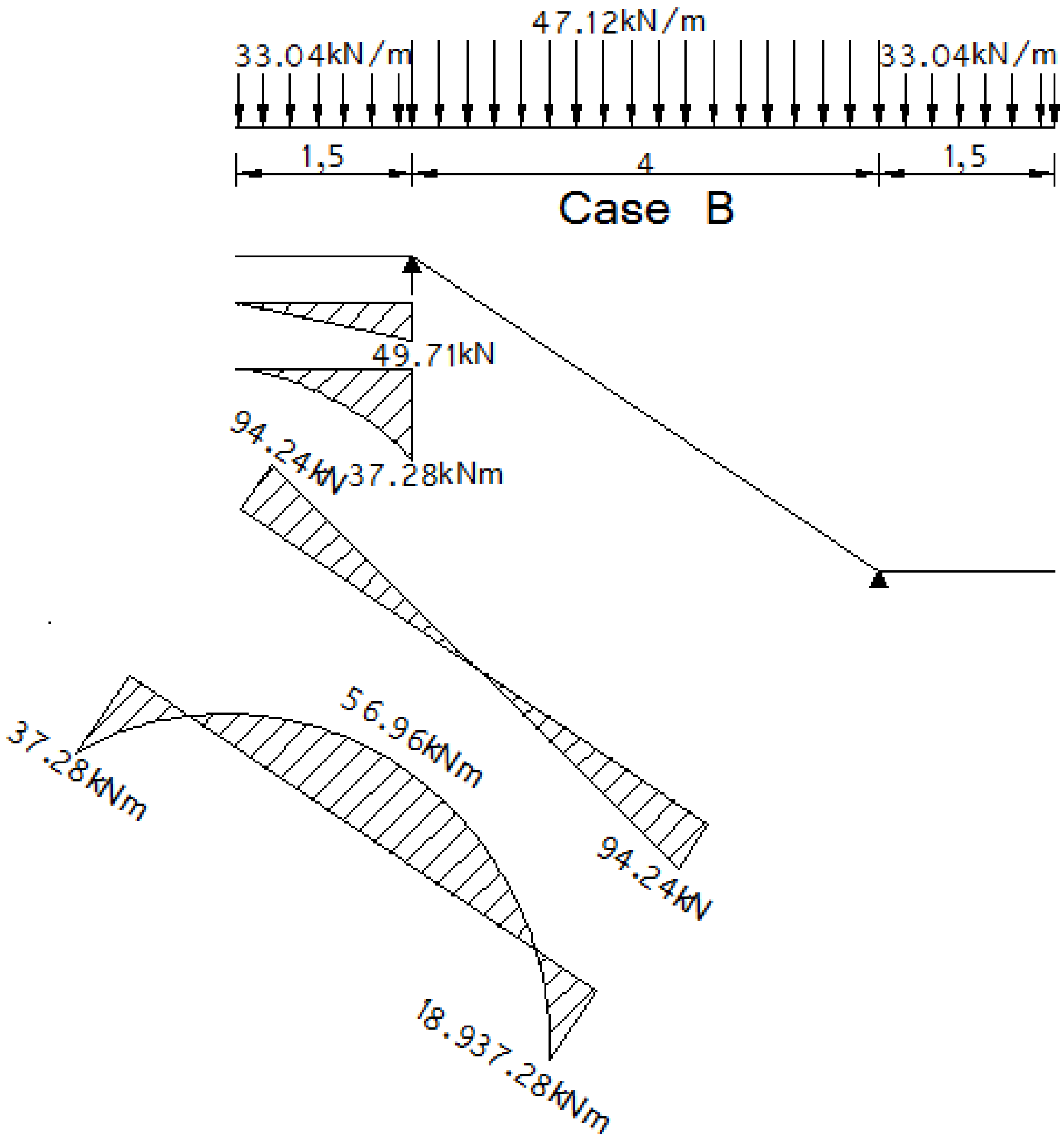
$$\frac{Vu_{max}}{\emptyset bd} = \frac{86 * 10^{-3}}{0.75 * 2 * 0.175} = 0.327MPa$$

$$V_c = \frac{1}{6}\sqrt{fc'} = \frac{1}{6}\sqrt{20} =$$
$$0.745MPa > \frac{Vu_{max}}{\emptyset bd} =$$
$$0.327MPa \;\; O.K$$



## Case B: determine max. Negative moment

Max. Negative moment=37.28kN.m



| M | R | ω | ρ | As= ρ bd |
|---|---|---|---|---|
| Positive=75.34 | 0.0682 | 0.0712 | 0.00474 | 1659 $mm^2$ |
| Negative=37.28 | 0.0338 | 0.0345 | 0.0023 | 805 $mm^2$ |
| | | $<\omega_{max}$ O.K | | $>As_{min}$= 0.002*2000*200 =800 $mm^2$ |

Main reinforcement:

- Positive: use 9Φ16mm
- Negative: use 4Φ16mm