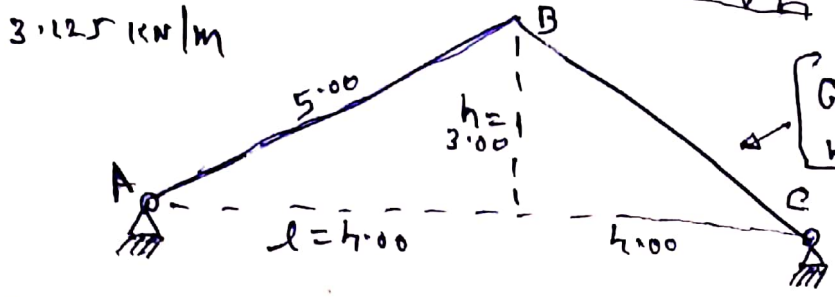
Gable frame with self weight only (Beam)

[Demonstration purpose]



Gable beam 0·40m x 0·25m with ends hinged

Total weight = 10·00 × 0·25 × 0·40 × 25 = 25 kN

Support reaction, V = $\frac{25}{2}$ = 12·5 kN

Load/m on horizontal span = $\frac{25.0 \text{ kN}}{8.00 \text{ m}}$ = 3·125 kN/m

The structure is analysed using Moment Distribution:

Distribution factors: 0·5 each at B, due to symmetry

Fixed end moments at A, B & C: $M_{FBA} = M_{FBC} = \frac{wl^2}{12} = \frac{3.125 \times 4.00^2}{12}$ = 4·17 kNm

Moment Distribution table

Joint	A	B		C
Members	AB	BA	BC	CB
DF	1	0·5	0·5	1
FEMs	−4·17	+4·17	−4·17	+4·17
Balance	+4·17			−4·17
CO		+2·09	−2·09	
Final M	0	6·26	−6·26	0

$M_{BA} = M_{BC} = 6.26$ kNm.

This is nothing, but $\frac{wl^2}{8}$ $\left(3.125 \times \frac{4^2}{8}\right)$

This is analogous to an equal double span continuous beam with pinned end supports.

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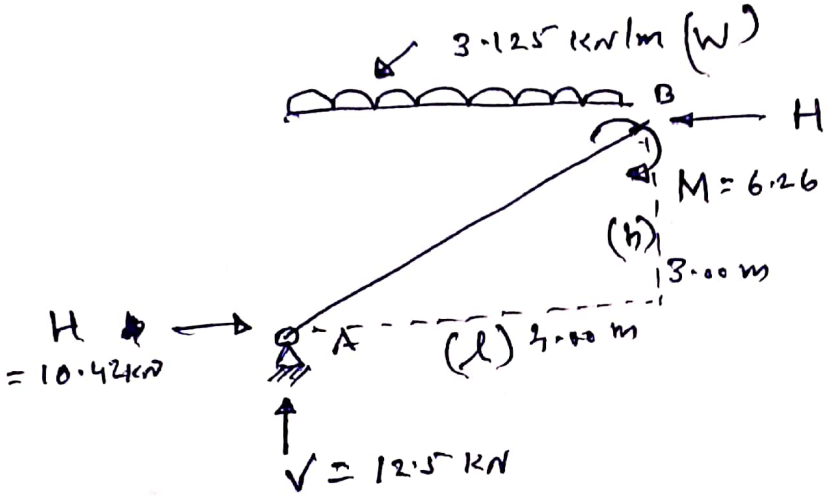
Free body diagram of half portion



Taking moments about A,

$$3.125 \times 4 \times \frac{4.0}{2} + 6.26 - 3.00\,H = 0$$

$$H = 10.42\ kN$$

Beam Axial force @ A $= H\cos\theta + V\sin\theta$

$$= 10.42 \times \frac{4}{5} + 12.5 \times \frac{3}{5} = 15.84\ kN$$

Generalising the case, we have, on taking moments about A,

$$Wl \times \frac{l}{2} + \frac{Wl^2}{8} - H \times h = 0 \Rightarrow \boxed{H = \frac{5}{8}\frac{wl^2}{h}}$$

Axial force at crown $= H\cos\theta$

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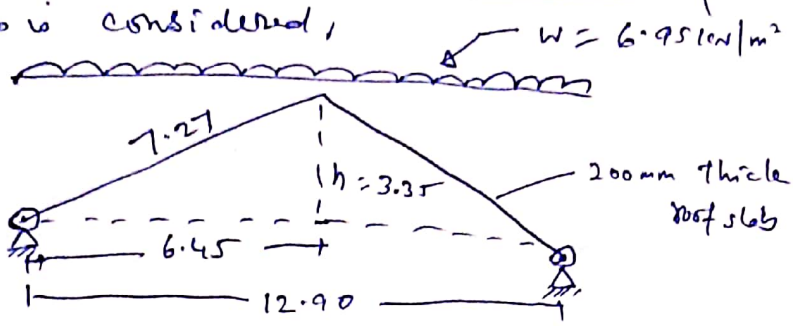
Design of one-way gable roof without transverse beam

1 m wide slab is considered,

Ends are assumed hinged



DL = 0.20×25 = 5.00 kN/m²

Roof finish = 0.50 "

5.50 "

Load on horizontal run = $\frac{5.50}{\cos\theta} = \frac{5.50}{(6.45/7.27)} = 6.20$ kN/m²

Add LL @ 0.75 kN/m² (inaccessible roof) 0.75

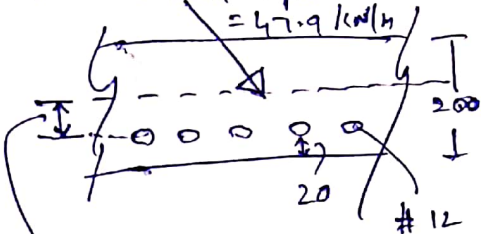
6.95 kN/m²

Max BM (-ve) is at crown = $\frac{Wl^2}{8} = 6.95 \times 6.45^2/8 = 36.14$ kNm/m

Axial force (compression) in slab at crown = $\frac{5}{8}\frac{Wl^2}{h}\cos\theta$

$= \frac{5}{8} \times 6.95 \times \frac{6.45^2}{3.35} \times \frac{6.45}{7.27} = 47.9$ kN/m

Axial compression = 47.9 kN/m



Additional moment in section due to the axial compression, which is assumed to act at centre

$= 47.9 \times 0.074 = 3.54$ kNm/m

$\frac{200}{2} - 20 - \frac{12}{2} = 74$ mm

$= 0.074$ m

Gross moment, M = 36.14 + 3.54 = 39.68 kNm

M_u = 59.52 kNm.

Provide #12 @ 100 mm c/c., for M_{20} & Fe 415

This is top reinforcement at crown, assuming unyielding hinged supports for one-way gable slab.

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