STATIS TAK TENTU
MOMENT DISTRIBUTION METHOD (FRAME)

ANALISIS STRUKTUR – TSI204 (3 sks)

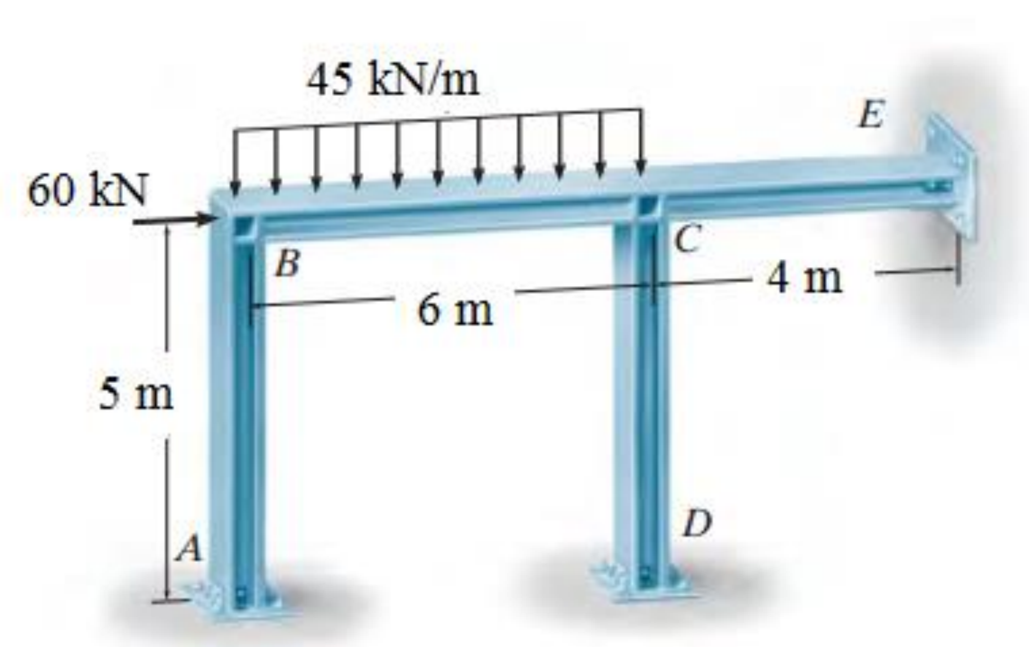
Pertemuan 15

Analisis Portal Tak Bergoyang Dengan Metode Distribusi Momen

- Metode distribusi momen dapat digunakan pada analisis struktur portal tanpa goyangan, dengan prosedur yang sama seperti pada analisis struktur balok
- Untuk meminimalkan kesalahan yang terjadi, maka sangat disarankan agar perhitungan dilakukan dalam bentuk tabel

Analisis Portal Tak Bergoyang Dengan Metode Distribusi Momen

Tentukan momen internal pada tiap titik tumpuan, apabila EI konstan. E dan D sendi, A tumpuan jepit



$$K_{AB} = \frac{4EI}{5} \quad K_{BC} = \frac{4EI}{6} \quad K_{CD} = \frac{3EI}{5} \quad K_{CE} = \frac{3EI}{4}$$

$$DF_{AB} = 0$$

$$DF_{BA} = \frac{4EI/5}{4EI/5 + 4EI/6} = 0{,}545 \qquad DF_{BC} = 1 - 0{,}545 = 0{,}455$$

$$DF_{CB} = \frac{4EI/6}{4EI/6 + 3EI/5 + 3EI/4} = 0{,}333$$

$$DF_{CD} = \frac{3EI/5}{4EI/6 + 3EI/5 + 3EI/4} = 0{,}298$$

$$DF_{CE} = 1 - 0{,}330 - 0{,}298 = 0{,}372$$

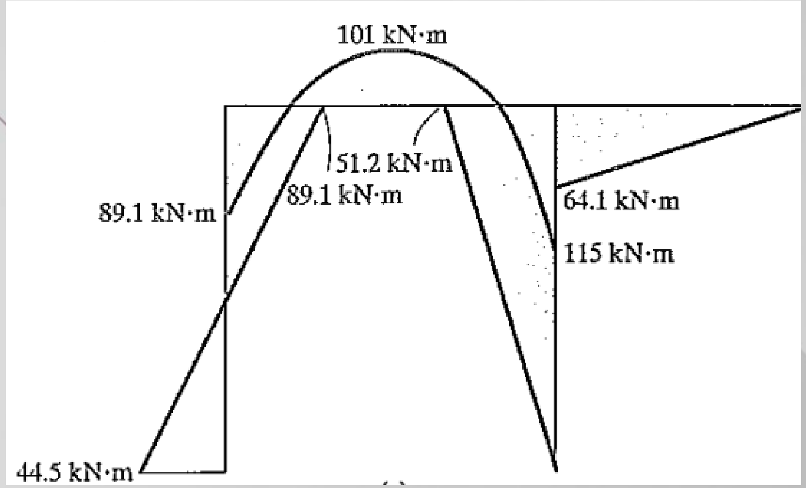
$$DF_{DC} = DF_{EC} = 1$$

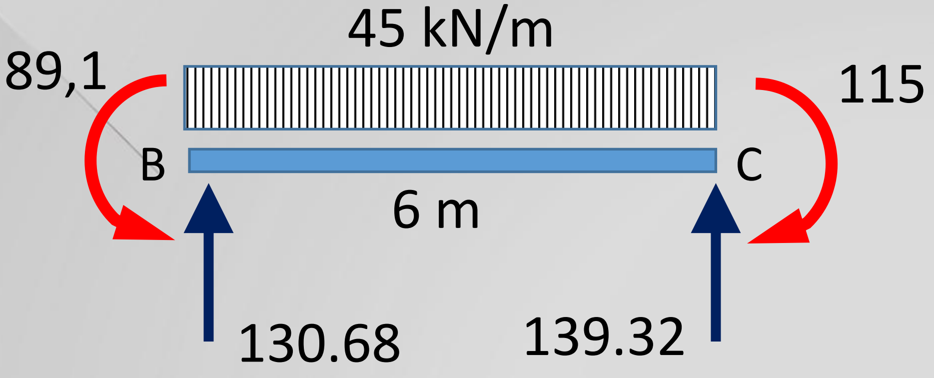
$$(FEM)_{BC} = -\frac{wL^2}{12} = -\frac{45(6)^2}{12} = -135\text{kN}\cdot\text{m}$$

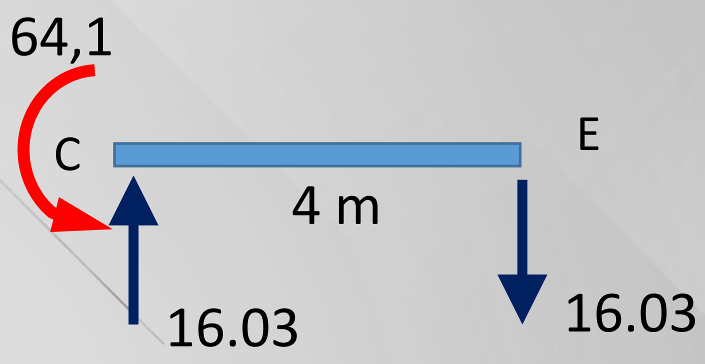
$$(FEM)_{CB} = \frac{wL^2}{12} = -\frac{45(6)^2}{12} = 135\text{kN}\cdot\text{m}$$

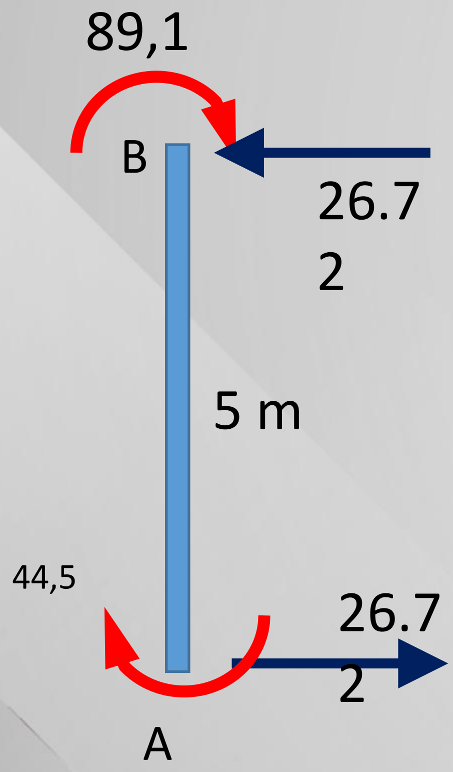
Analisis Portal Tak Bergoyang Dengan Metode Distribusi Momen

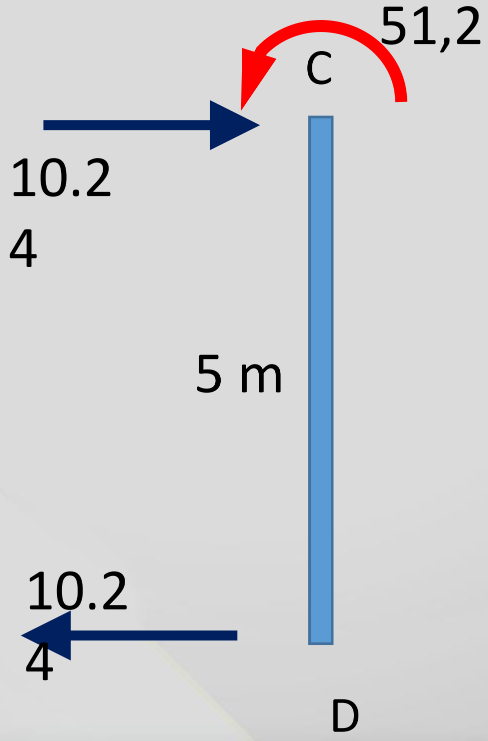
Joint	A	B		C			D	E
Member	*AB*	*BA*	*BC*	*CB*	*CD*	*CE*	*DC*	*EC*
DF	0	0.545	0.455	0.330	0.298	0.372	1	1
FEM			−135	135				
Dist.		73.6	61.4	−44.6	−40.2	−50.2		
CO	36.8		−22.3	30.7				
Dist.		12.2	10.1	−10.1	−9.1	−11.5		
CO	6.1		−5.1	5.1				
Dist.		2.8	2.3	−1.7	−1.5	−1.9		
CO	1.4		−0.8	1.2				
Dist.		0.4	0.4	−0.4	−0.4	−0.4		
CO	0.2		−0.2	0.2				
Dist.		0.1	0.1	−0.1	0.0	−0.1		
ΣM	44.5	89.1	−89.1	115	−51.2	−64.1		

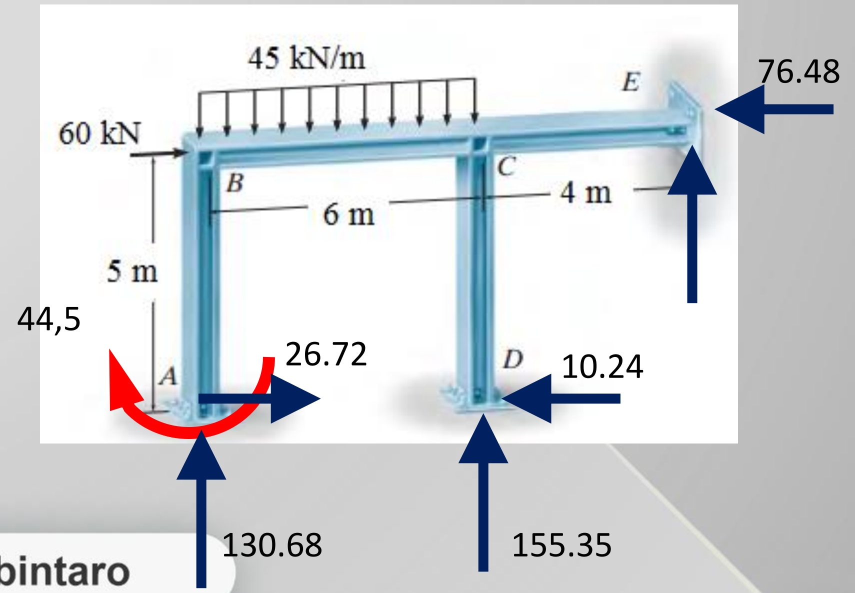



45 kN/m
89,1
115
B
C
6 m
130.68
139.32


64,1
C
E
4 m
16.03
16.03

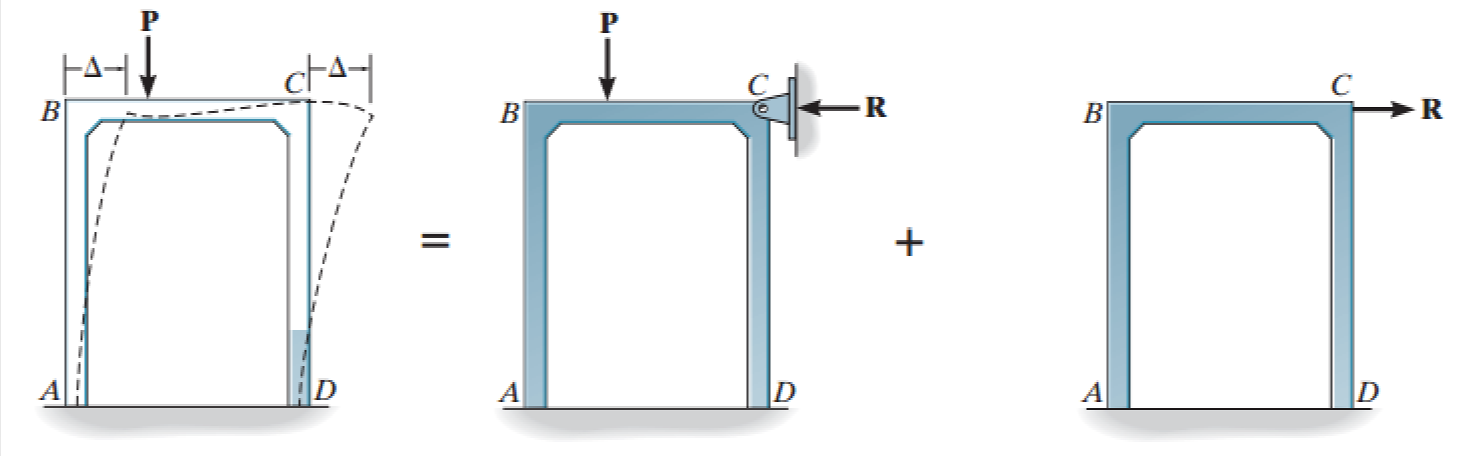

89,1
B
26.7
2
5 m
44,5
26.7
2
A


51,2
C
10.2
4
5 m
10.2
4
D


45 kN/m
E
76.48
60 kN
B
C
6 m
4 m
5 m
44,5
26.72
A
D
10.24
130.68
155.35

Analisis Portal Bergoyang Dengan Metode Distribusi Momen

- Dalam portal berikut, beban luar *P* akan menimbulkan momen internal di titik B dan C yang tidak sama besar, sehingga menimbulkan perpindahan horizontal sebesar Δ ke arah kanan.

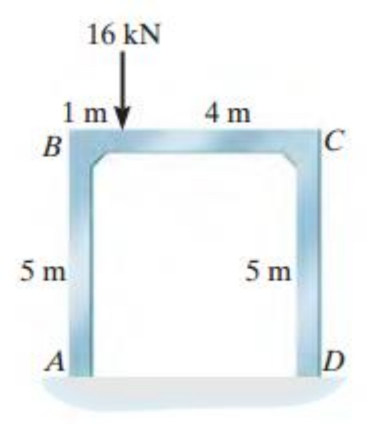


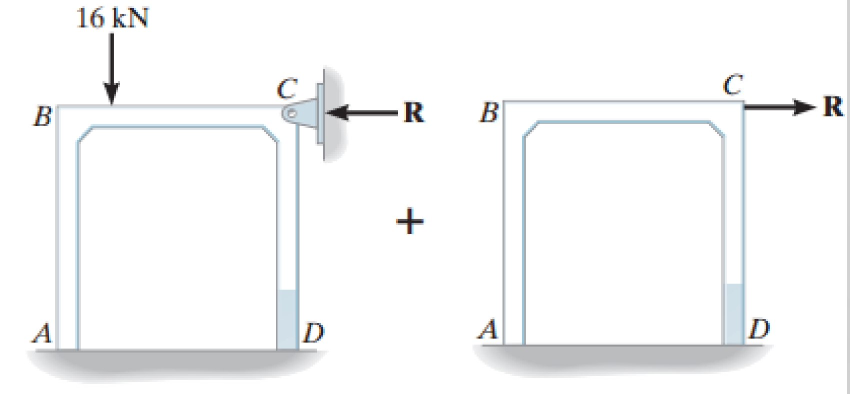
Analisis Portal Bergoyang Dengan Metode Distribusi Momen

- Untuk menentukan besarnya perpindahan horizontal, Δ, serta menghitung momen – momen internal yang terjadi pada portal tersebut dengan menggunakan metode momen distribusi, maka akan digunakan metode superposisi
- Awalnya portal ditahan terhadap goyangan dengan memberikan tumpuan di titik C,
- Kemudian lakukan analisis dengan menggunakan metode momen distribusi serta berdasarkan prinsip kesetimbangan statik, maka besar gaya *R* dapat ditentukan.
- Selanjutnya reaksi *R* yang sama besar namun berlawanan arah, diberikan pada portal tersebut
- Untuk melakukan analisis tersebut, maka mula – mula dapat diberikan momen internal $M_{BA}^{/}$ dengan besaran tertentu (semisal diambil sebesar 100 kN·m).
- Dengan menggunakan metode momen distribusi, maka besarnya $\Delta^{/}$ dan gaya eksternal $R^{/}$ akibat momen $M_{BA}^{/}$ dapat dihitung.
- Karena deformasi yang terjadi bersifat elastis linear, maka gaya $R^{/}$ menimbulkan momen pada portal yang besarnya proporsional terhadap momen yang ditimbulkan oleh *R*.
- Atau apabila $M_{BA}^{/}$ dan $R^{/}$ telah dapat dihitung, maka besarnya momen internal di titik B yang ditimbulkan oleh *R* adalah $M_{BA} = M_{BA}^{/}(R/R^{/})$.

Analisis Portal Bergoyang Dengan Metode Distribusi Momen

Tentukan momen internal pada tiap titik kumpul, apabila EI konstan.





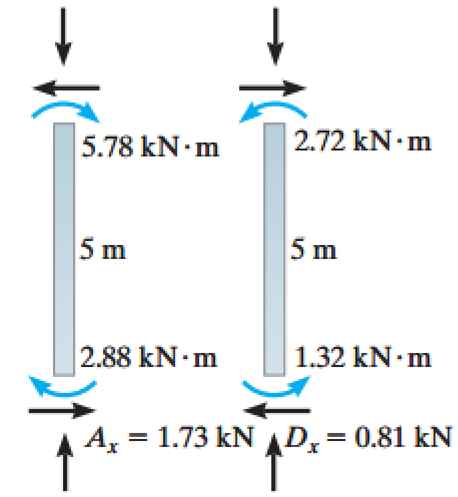
(b) (c)

$$(FEM)_{BC} = -\frac{16(4)^2(1)}{5^2} = -10{,}24\text{kN}\cdot\text{m}$$

$$(FEM)_{CB} = \frac{16(1)^2(4)}{5^2} = 2{,}56\text{kN}\cdot\text{m}$$

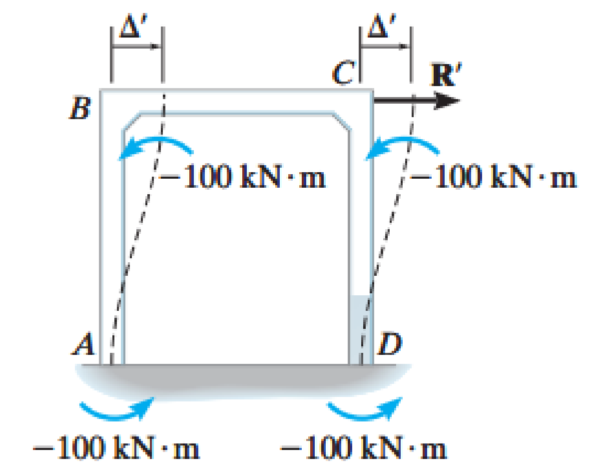
Analisis Portal Bergoyang Dengan Metode Distribusi Momen

Joint	A	B		C		D
Member	AB	BA	BC	CB	CD	DC
DF	0	0.5	0.5	0.5	0.5	0
FEM			−10.24	2.56		
Dist.		5.12	5.12	−1.28	−1.28	
CO	2.56		−0.64	2.56		−0.64
Dist.		0.32	0.32	−1.28	−1.28	
CO	0.16		−0.64	0.16		−0.64
Dist.		0.32	0.32	−0.08	−0.08	
CO	0.16		−0.04	0.16		−0.04
Dist.		0.02	0.02	−0.08	−0.08	
ΣM	2.88	5.78	−5.78	2.72	−2.72	−1.32

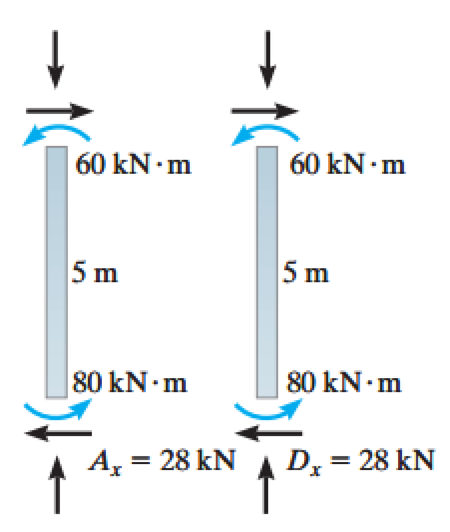


$$\Sigma F_x = 0; \qquad R = 1{,}73\text{kN} - 0{,}81\text{kN} = 0{,}92\text{kN}$$

Analisis Portal Bergoyang Dengan Metode Distribusi Momen



Joint	A	B		C		D
Member	*AB*	*BA*	*BC*	*CB*	*CD*	*DC*
DF	0	0.5	0.5	0.5	0.5	0
FEM	−100	−100			−100	−100
Dist.		50	50	50	50	
CO	25		25	25		25
Dist.		−12.5	−12.5	−12.5	−12.5	
CO	−6.25		−6.25	−6.25		−6.25
Dist.		3.125	3.125	3.125	3.125	
CO	1.56		1.56	1.56		1.56
Dist.		−0.78	−0.78	−0.78	−0.78	
CO	−0.39		−0.39	−0.39		−0.39
Dist.		0.195	0.195	0.195	0.195	
Σ*M*	−80.00	−60.00	60.00	60.00	−60.00	−80.00



$$\Sigma F_x = 0; \qquad R' = 28\text{kN} + 28\text{kN} = 56\text{kN}$$

Analisis Portal Bergoyang Dengan Metode Distribusi Momen

$$M_{AB} = 2{,}88 + \frac{0{,}92}{56{,}0}(-80) = 1{,}57 \text{kN}\cdot\text{m}$$

$$M_{BA} = 5{,}78 + \frac{0{,}92}{56{,}0}(-60) = 4{,}79 \text{kN}\cdot\text{m}$$

$$M_{BC} = -5{,}78 + \frac{0{,}92}{56{,}0}(60) = -4{,}79 \text{kN}\cdot\text{m}$$

$$M_{CB} = 2{,}72 + \frac{0{,}92}{56{,}0}(60) = 3{,}71 \text{kN}\cdot\text{m}$$

$$M_{CD} = -2{,}72 + \frac{0{,}92}{56{,}0}(-60) = -3{,}71 \text{kN}\cdot\text{m}$$

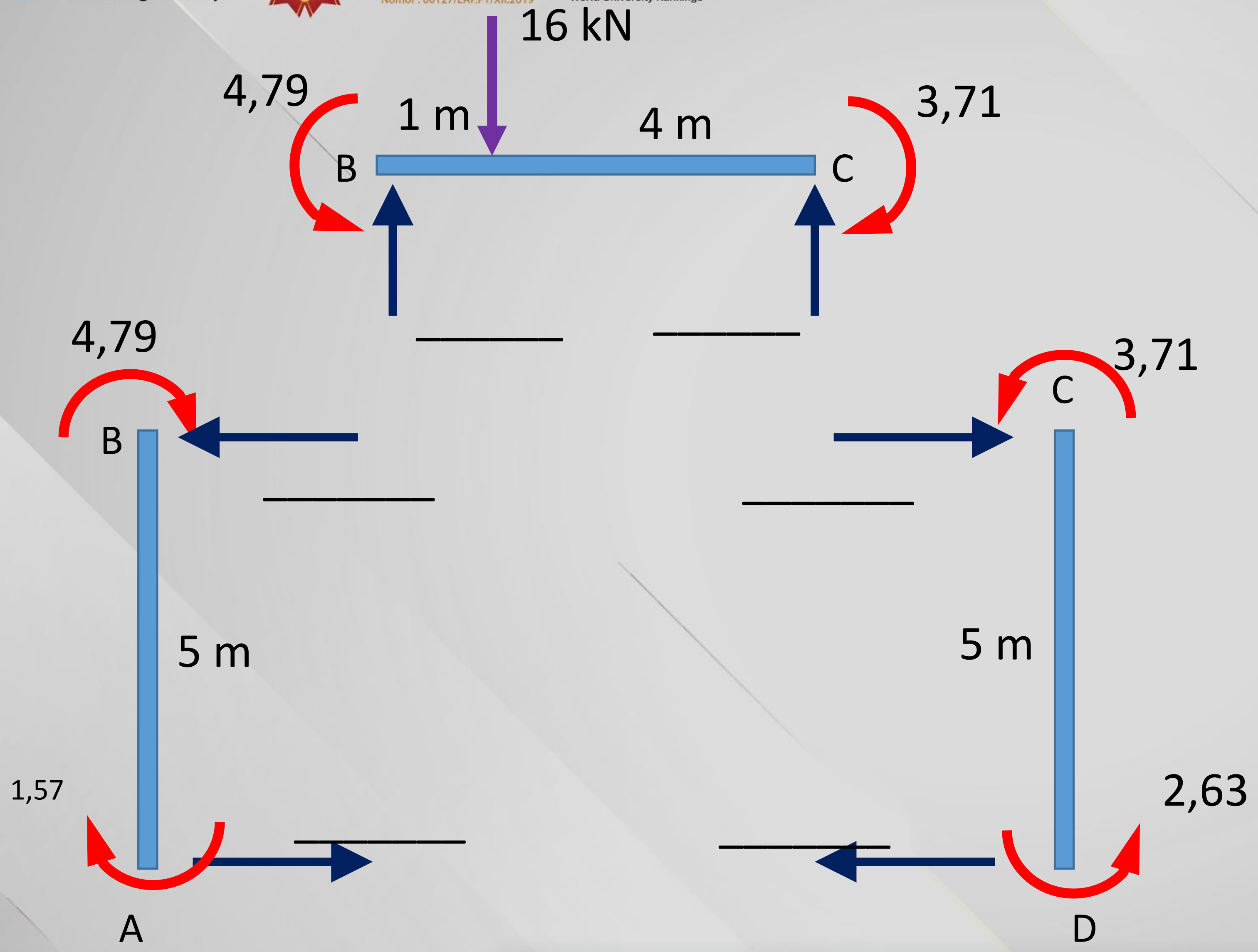
$$M_{DC} = -1{,}32 + \frac{0{,}92}{56{,}0}(-80) = -2{,}63 \text{kN}\cdot\text{m}$$

Momen tanpa goyangan

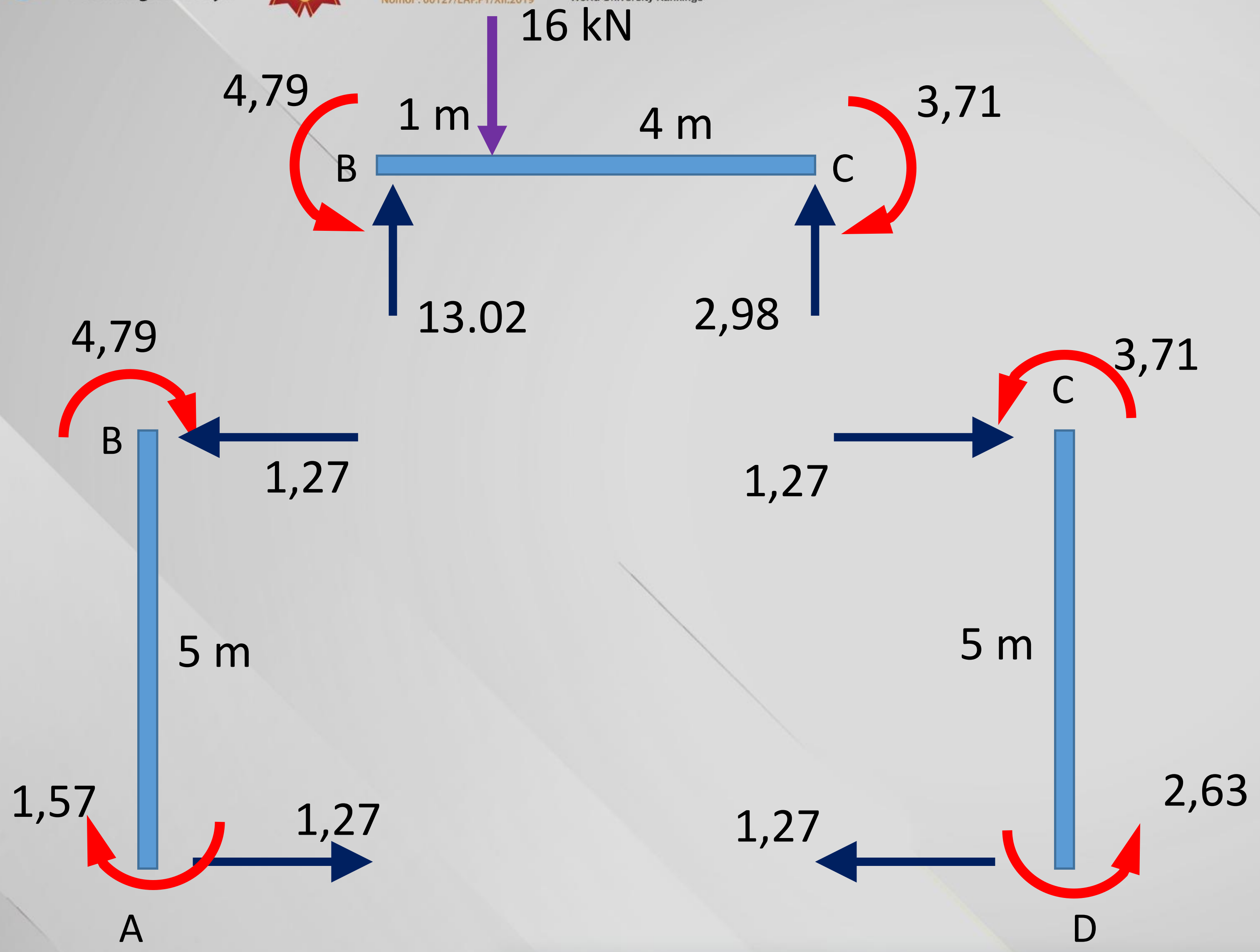
R/R'

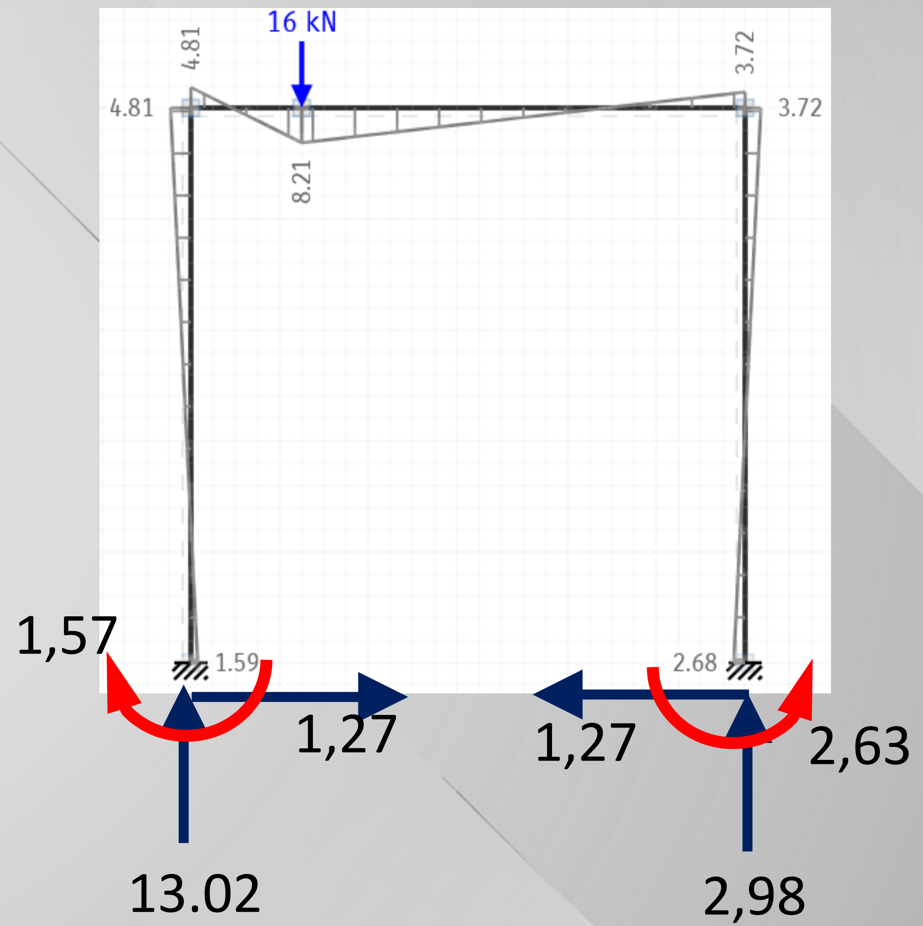
Momen akibat goyangan

FBD



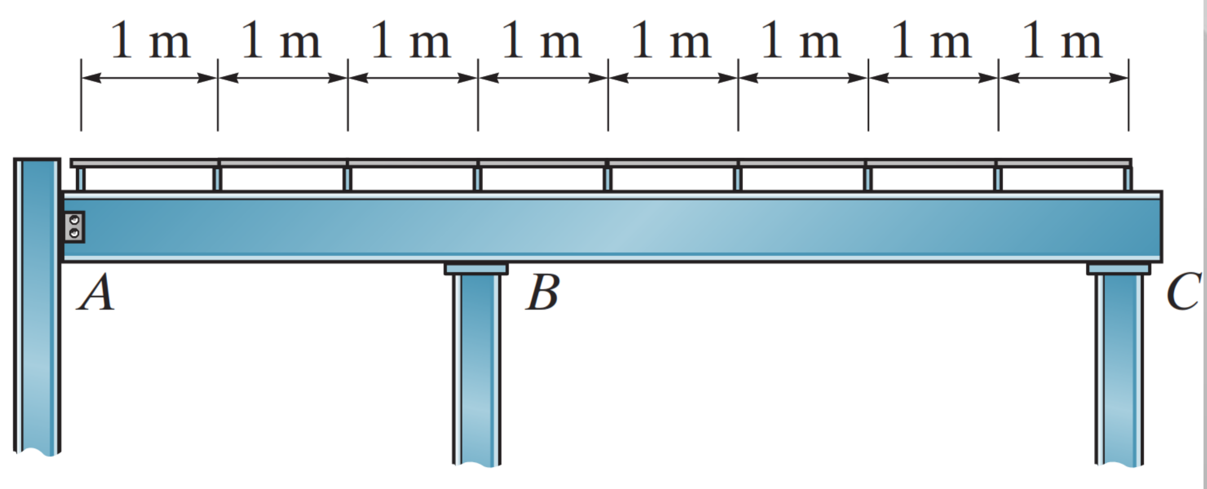
For each FBD
@ 5 poin


16 kN
4,79
1 m
4 m
3,71
B
C
13.02
2,98
4,79
B
1,27
5 m
1,57
1,27
A
3,71
C
1,27
5 m
2,63
1,27
D


16 kN
4.81
4.81
3.72
3.72
8.21
1.59
2.68
1,57
1,27
1,27
2,63
13.02
2,98

PROJECT PROBLEM

The roof is supported by joists that rest on two girders.
Each joist can be considered simply supported, and the front girder can be considered attached to the three columns by a pin at A and rollers at B and C.



PROJECT PROBLEM

Assume the roof will be made from 75 mm-thick cinder concrete, and each joist has a weight of 2.5 kN.

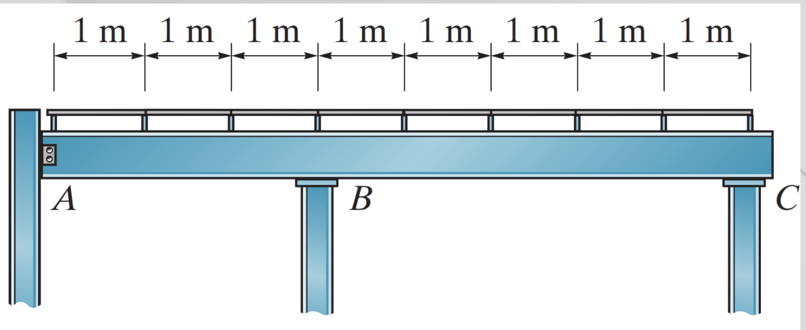
According to code the roof will be subjected to a snow loading of 1.2 kN/m^2.

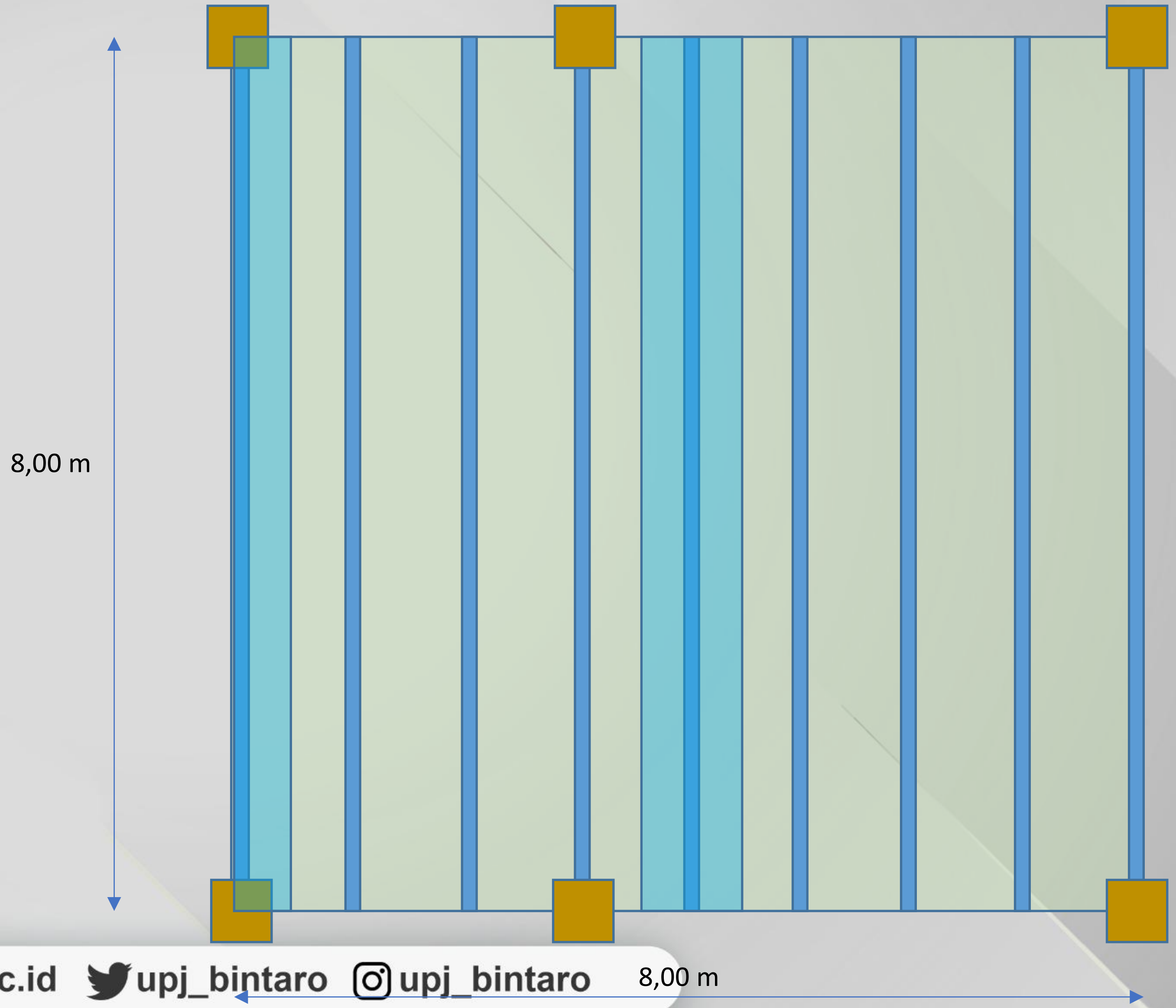
The joists have a length of 8 m. Draw the shear and moment diagrams for the girder. Assume the supporting columns are rigid.

TABLE 1.3 Minimum Design Dead Loads*

Walls	kN/m^2
102 mm clay brick	1.87
203 mm clay brick	3.78
305 mm clay brick	5.51
Frame Partitions and Walls	
Exterior stud walls with brick veneer	2.30
Windows, glass, frame and sash	0.38
Wood studs 51 × 102 mm, unplastered	0.19
Wood studs 51 × 102 mm, plastered one side	0.57
Wood studs 51 × 102 mm, plastered two sides	0.96
Floor Fill	
Cinder concrete, per mm	0.017
Lightweight concrete, plain, per mm	0.015
Stone concrete, per mm	0.023
Ceilings	
Acoustical fiberboard	0.05
Plaster on tile or concrete	0.24
Suspended metal lath and gypsum plaster	0.48
Asphalt shingles	0.10
Fiberboard, 13 mm	0.04

*Minimum Design Dead Loads. Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-16, American Society of Civil Engineers.


1 m
1 m
1 m
1 m
1 m
1 m
1 m
1 m
A
B
C


8,00 m
8,00 m

Beban dari joist interior : (lebar 1 m)

Beban Mati

Berat penutup atap cinder concrete, 75 mm = 75 × 0,017 × 1 = 1,275 kN/m

Beban Hidup

Beban salju (1,2 kN/m^2) = 1,2 × 1 = 1,2 kN/m

Total beban atap = (1,275 + 1,2) × 8 m = 19,8 kN

Berat sendiri 1 joist = 2,5 kN

Total beban 1 joist = 19,8 + 2,5 = 22,3 kN

Dibagi 2 portal → @ = 22,3/2 = 11,15 kN

Beban dari joist eksterior : (lebar 0,5 m)

Beban Mati

Berat penutup atap cinder concrete, 75 mm = $75 \times 0{,}017 \times 0{,}5$ = 0,6375 kN/m

Beban Hidup

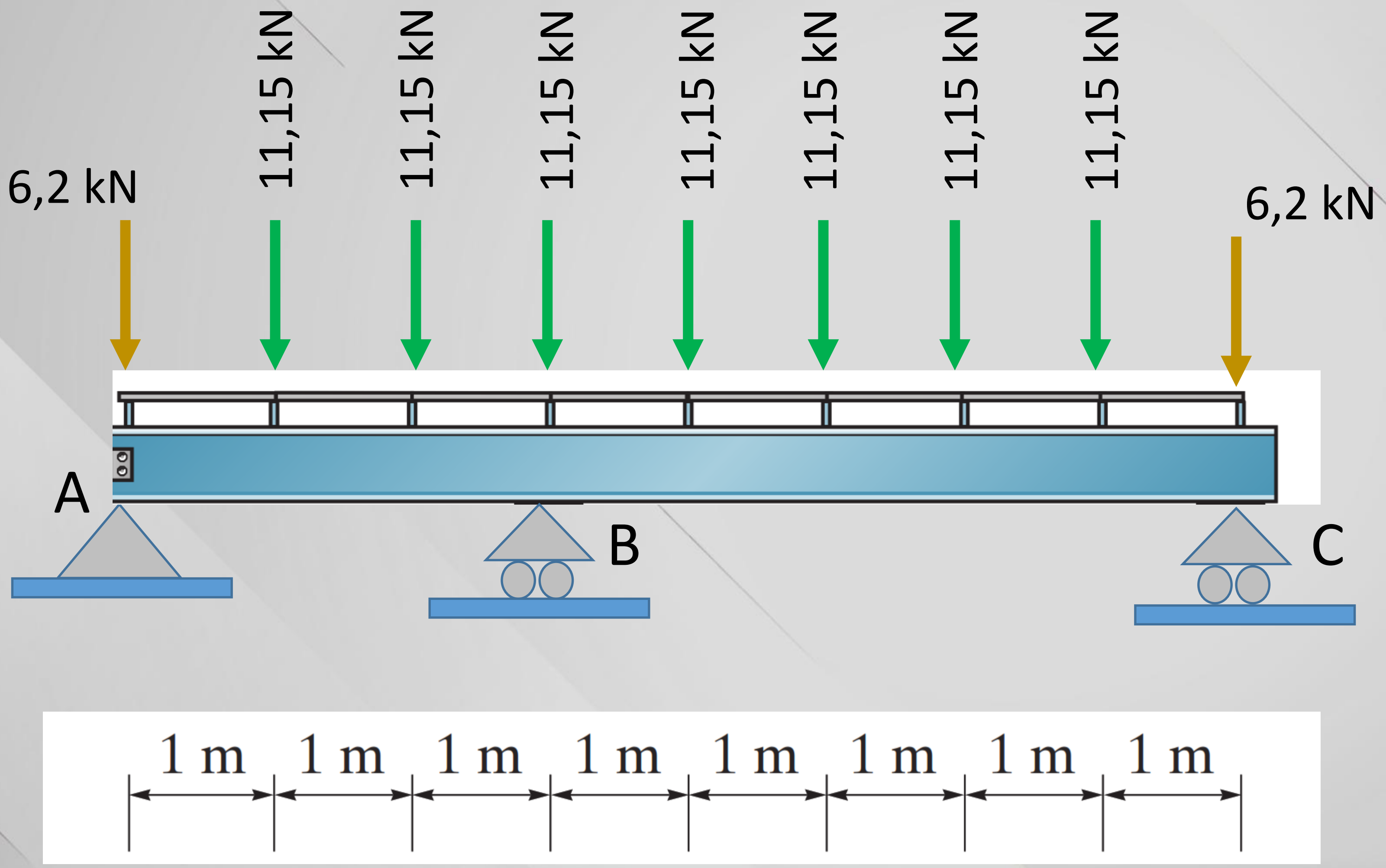
Beban salju (1,2 kN/m^2) = $1{,}2 \times 0{,}5$ = 0,6 kN/m

Total beban atap = $(0{,}6375 + 0{,}6) \times 8$ m = 9,9 kN

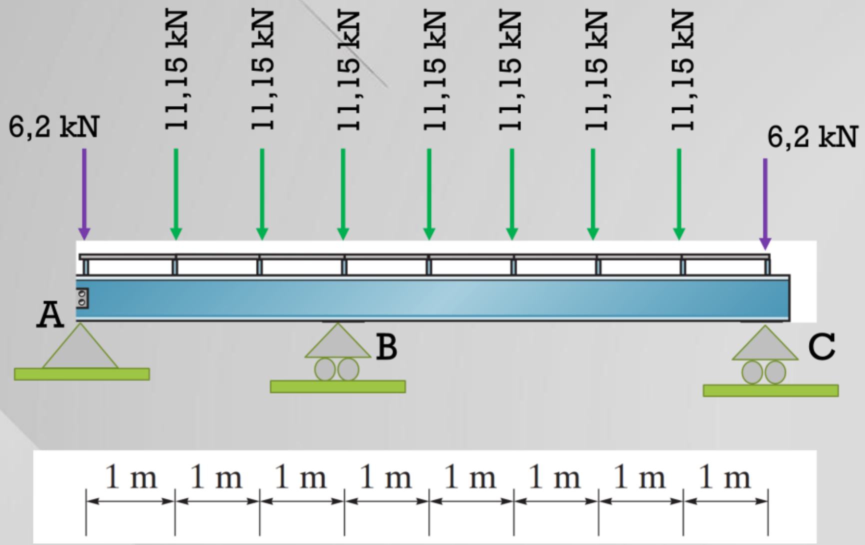
Berat sendiri 1 joist = 2,5 kN

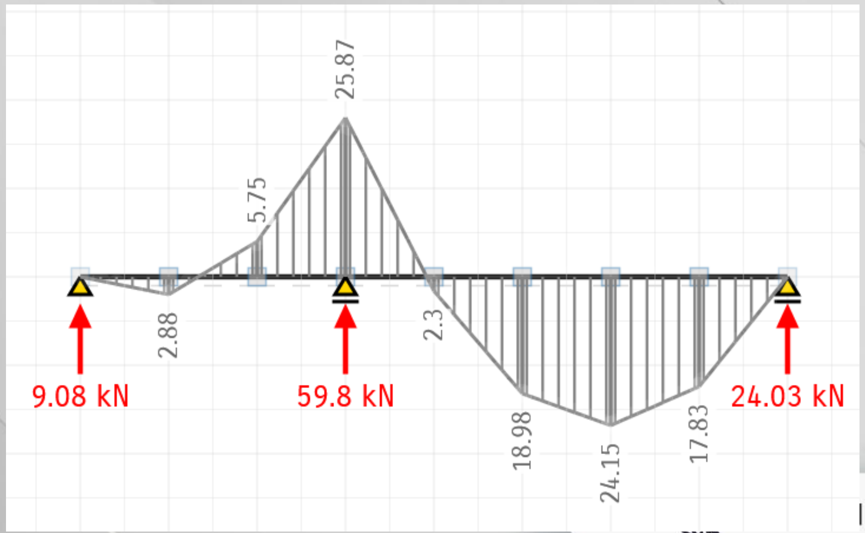
Total beban 1 joist = 9,9 + 2,5 = 12,4 kN

Dibagi 2 portal → @ = 12,4/2 = 6,2 kN

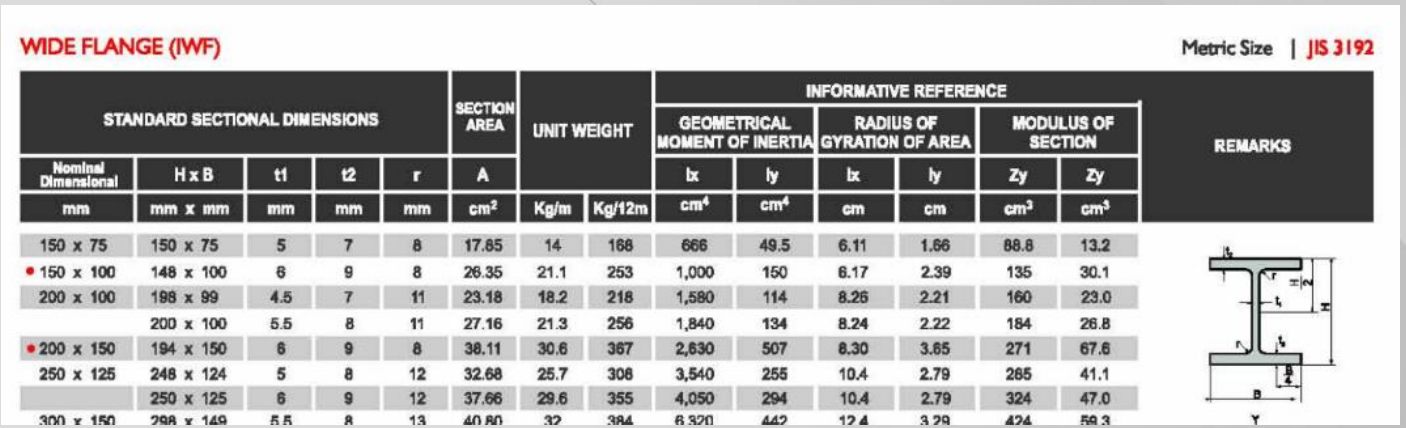

6,2 kN
11,15 kN
11,15 kN
11,15 kN
11,15 kN
11,15 kN
11,15 kN
11,15 kN
6,2 kN
A
B
C
1 m
1 m
1 m
1 m
1 m
1 m
1 m
1 m

BEAM DESIGN





$M_{max}+ = 24.15$ kN.m



WIDE FLANGE (IWF) — Metric Size | JIS 3192

STANDARD SECTIONAL DIMENSIONS					SECTION AREA	UNIT WEIGHT		INFORMATIVE REFERENCE: GEOMETRICAL MOMENT OF INERTIA		RADIUS OF GYRATION OF AREA		MODULUS OF SECTION		REMARKS
Nominal Dimensional	H x B	t1	t2	r	A			Ix	Iy	Ix	Iy	Zy	Zy	
mm	mm x mm	mm	mm	mm	cm²	Kg/m	Kg/12m	cm⁴	cm⁴	cm	cm	cm³	cm³	
150 x 75	150 x 75	5	7	8	17.85	14	168	666	49.5	6.11	1.66	88.8	13.2	
• 150 x 100	148 x 100	6	9	8	26.35	21.1	253	1,000	150	6.17	2.39	135	30.1	
200 x 100	198 x 99	4.5	7	11	23.18	18.2	218	1,580	114	8.26	2.21	160	23.0	
	200 x 100	5.5	8	11	27.16	21.3	256	1,840	134	8.24	2.22	184	26.8	
• 200 x 150	194 x 150	6	9	8	38.11	30.6	367	2,630	507	8.30	3.65	271	67.6	
250 x 125	248 x 124	5	8	12	32.68	25.7	308	3,540	255	10.4	2.79	265	41.1	
	250 x 125	6	9	12	37.66	29.6	355	4,050	294	10.4	2.79	324	47.0	
300 x 150	298 x 149	5.5	8	13	40.80	32	384	6,320	442	12.4	3.29	424	59.3	

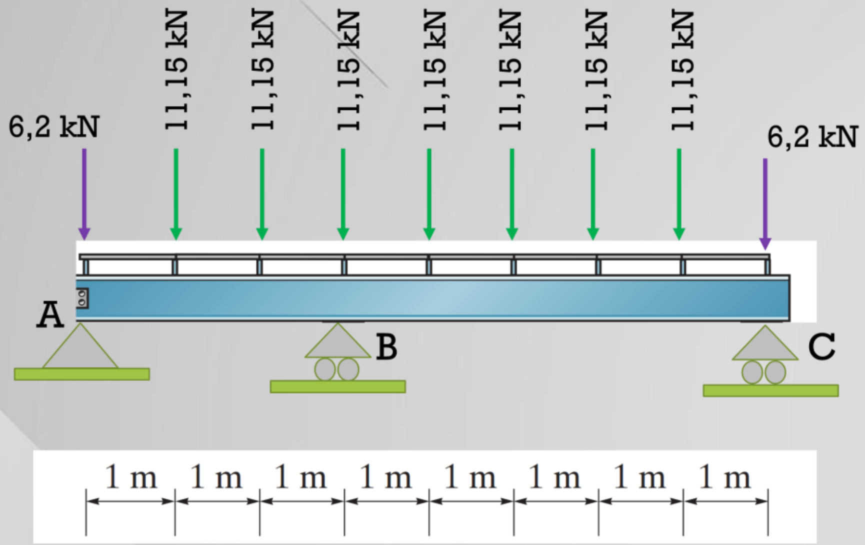
Try WF 200.100 ($W_x = 184.10^3$ mm³)

$$\bar{\sigma} = 160 MPa$$

$$\sigma = \frac{M}{w} = \frac{24,15 \cdot 10^6}{184.10^3} MP_a = 131,25 \text{ MPa} < \bar{\sigma}$$

OK!!

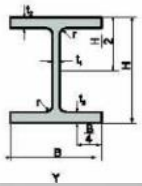
COLUMN DESIGN

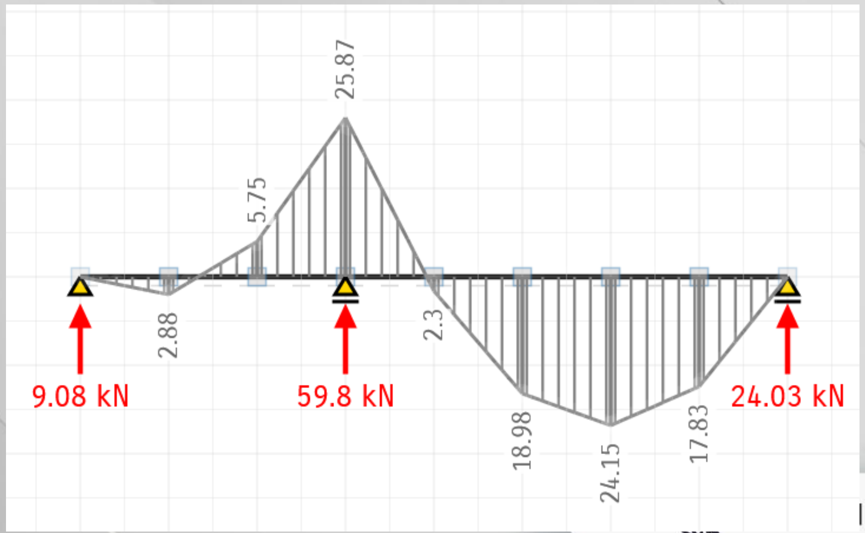


P_{max} = 59.8 kN

WIDE FLANGE (IWF) — Metric Size | JIS 3192

STANDARD SECTIONAL DIMENSIONS					SECTION AREA	UNIT WEIGHT		INFORMATIVE REFERENCE						REMARKS
								GEOMETRICAL MOMENT OF INERTIA		RADIUS OF GYRATION OF AREA		MODULUS OF SECTION		
Nominal Dimensional	H x B	t1	t2	r	A			Ix	Iy	Ix	Iy	Zy	Zy	
mm	mm x mm	mm	mm	mm	cm²	Kg/m	Kg/12m	cm⁴	cm⁴	cm	cm	cm³	cm³	
150 x 75	150 x 75	5	7	8	17.65	14	168	666	49.5	6.11	1.66	88.8	13.2	
• 150 x 100	148 x 100	6	9	8	26.35	21.1	253	1,000	150	6.17	2.39	135	30.1	
200 x 100	198 x 99	4.5	7	11	23.18	18.2	218	1,580	114	8.26	2.21	160	23.0	
	200 x 100	5.5	8	11	27.16	21.3	256	1,840	134	8.24	2.22	184	26.8	
• 200 x 150	194 x 150	6	9	8	38.11	30.6	367	2,630	507	8.30	3.65	271	67.6	
250 x 125	248 x 124	5	8	12	32.68	25.7	308	3,540	255	10.4	2.79	265	41.1	
	250 x 125	6	9	12	37.66	29.6	355	4,050	294	10.4	2.79	324	47.0	
300 x 150	298 x 149	5.5	8	13	40.80	32	384	6,320	442	12.4	3.29	424	59.3	



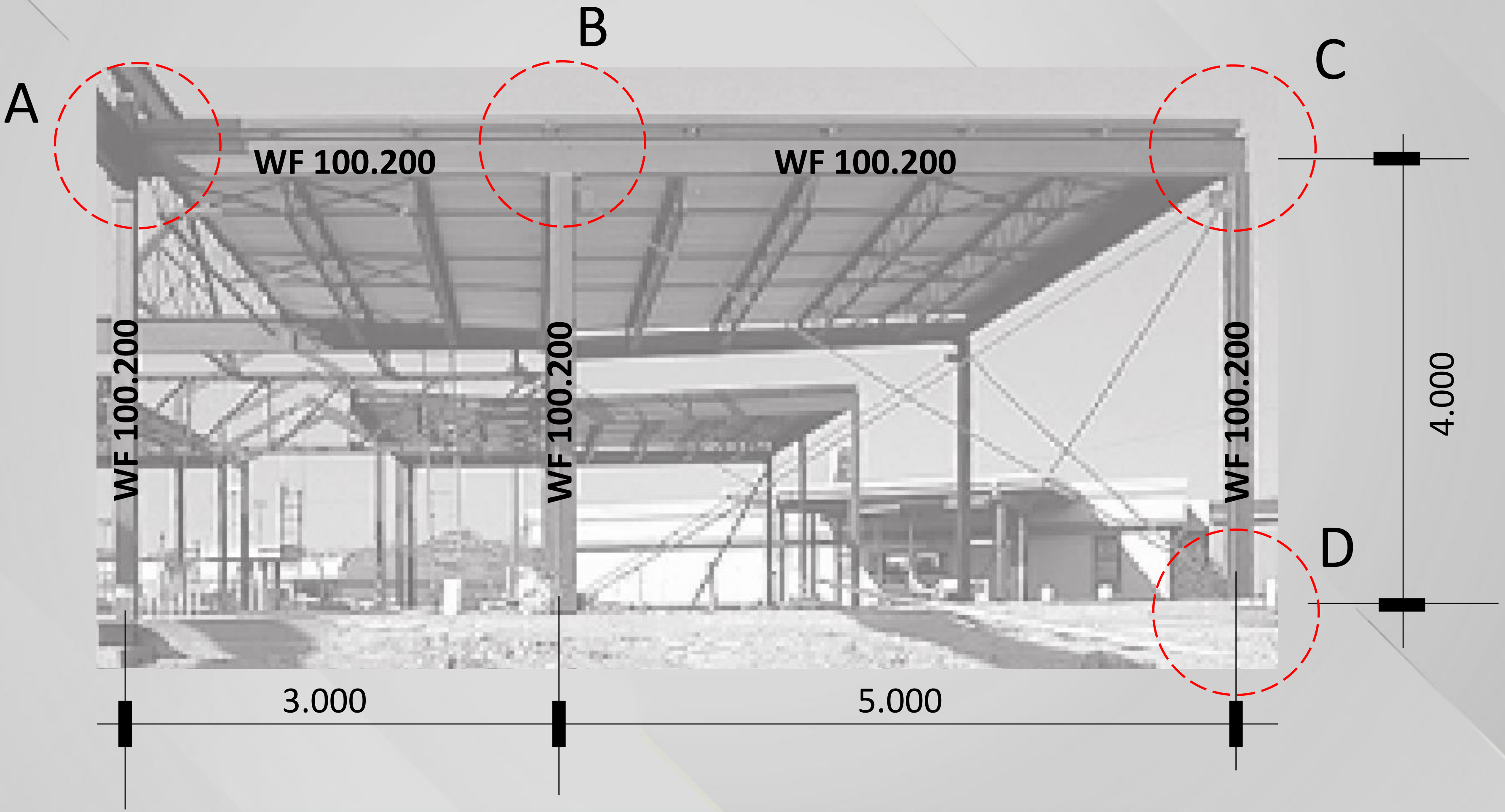


Try WF 200.100 (A = $27{,}16.10^2$ mm^2)

$$\bar{\sigma} = 160 MPa$$

$$\sigma = \frac{P}{A} = \frac{59{,}8 \cdot 10^3}{27{,}16.10^2} MP_a = 22{,}02 \text{ MPa} < \bar{\sigma}$$

OK!!


A
B
C
D
WF 100.200
WF 100.200
WF 100.200
WF 100.200
WF 100.200
4.000
3.000
5.000