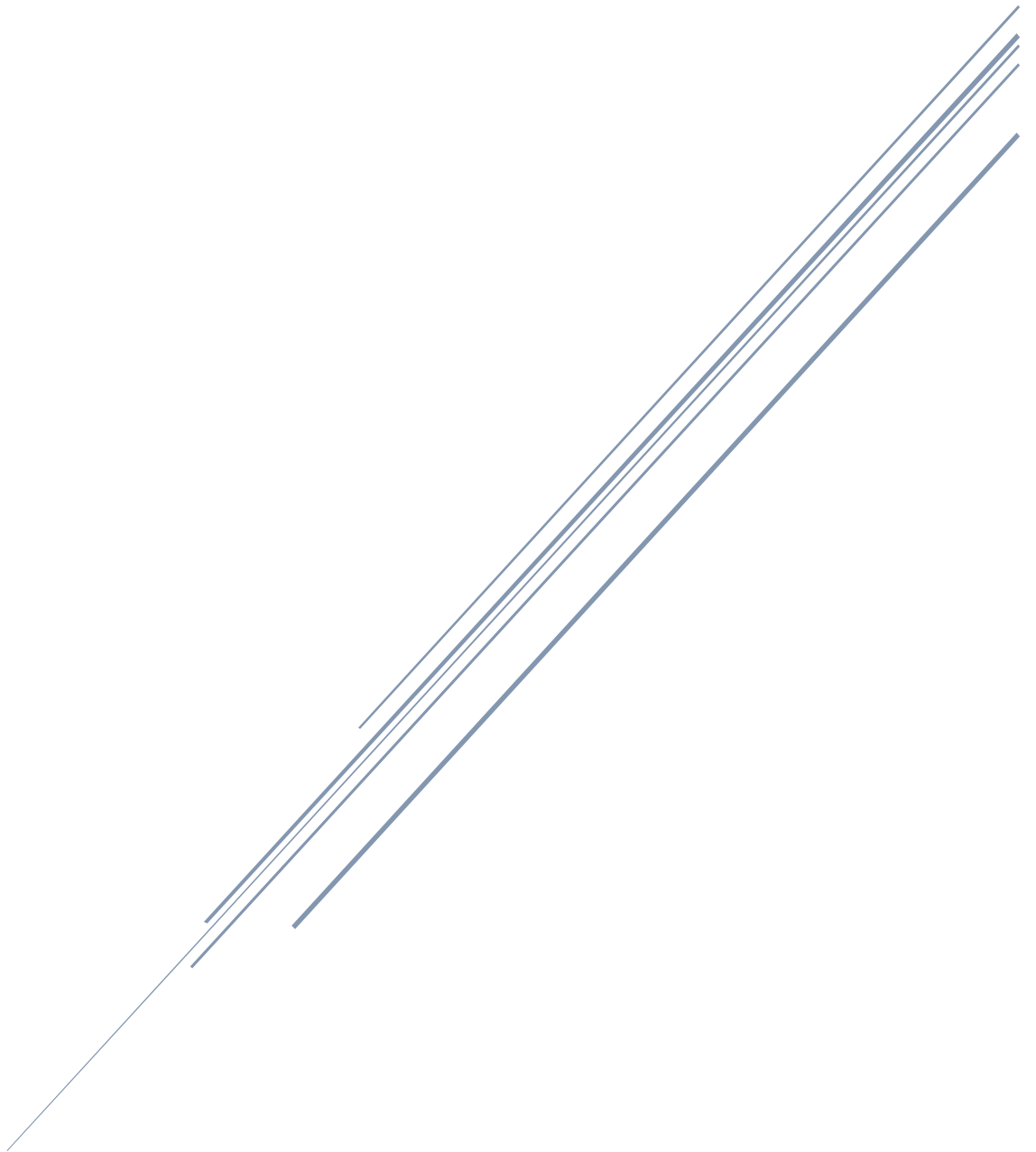


Portal Sederhana dan Portal Majemuk/Gerber

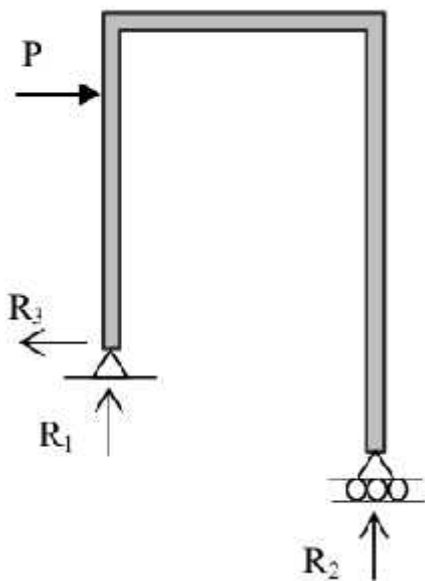
Oleh : Sarjono Puro, MT



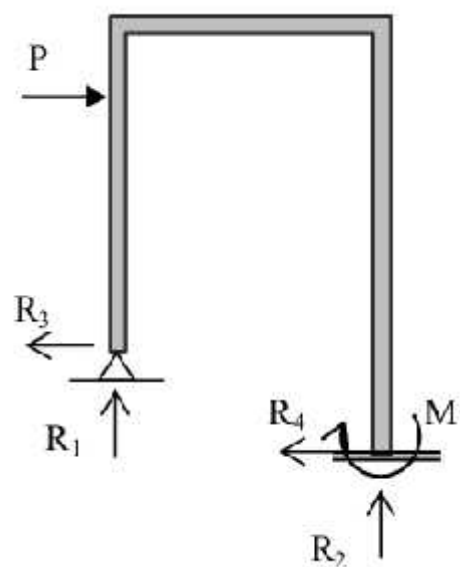
A. PENGERTIAN PORTAL

Portal adalah bagian struktur dengan elemen yang berupa balok dan kolom baik miring ataupun tegak. Portal merupakan suatu struktur yang tersusun dari batang-batang yang dihubungkan dengan sambungan yang kaku (rigid joint).

Struktur portal pada gambar a adalah struktur statis tertentu dimana diselesaikan dengan tiga persamaan keseimbangan. Bila tumpuan rol pada gambar a diganti jepit, seperti pada gambar b maka struktur menjadi statis tak tentu.



Gambar (a)



Gambar (b)

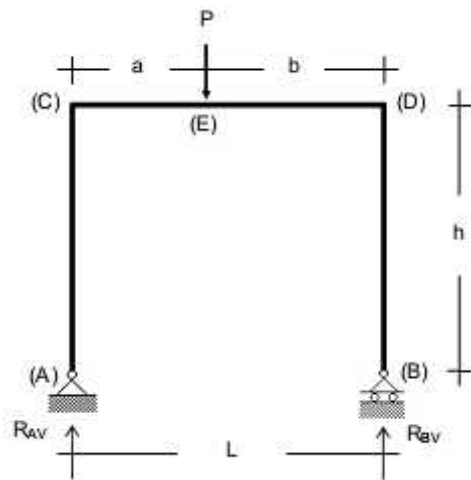
B. REAKSI PERLETAKAN BERBAGAI PORTAL SEDERHANA DENGAN BERBAGAI KOMBINASI BEBAN

Portal sederhana adalah struktur/bangunan sipil yang jumlah komponen perletakannya maksimum 3 buah dan terdiri atas satu buah portal, sehingga dengan menggunakan persyaratan persamaan keseimbangan, semua komponen yang ada dapat dihitung.

Pada portal sederhana ada 2 macam jenis portal yaitu : Portal simetris dan Portal tidak simetris/ asimetris. Struktur portal asimetris tidak mempunyai cerminan yang sama jika diberikan sumbu tengah yang membagi portal tersebut. Untuk menganalisis sebuah portal asimetris menggunakan ukuran model yang utuh sehingga membutuhkan ketelitian dan waktu yang agak lama penggunaan data yang lengkap pada tiap segmen portal dan proses analisis yang lebih panjang.

1. PORTAL SIMETRIS

1.a Memikul muatan/beban terpusat tunggal



Penyelesaian :

❖ Reaksi Perletakan :

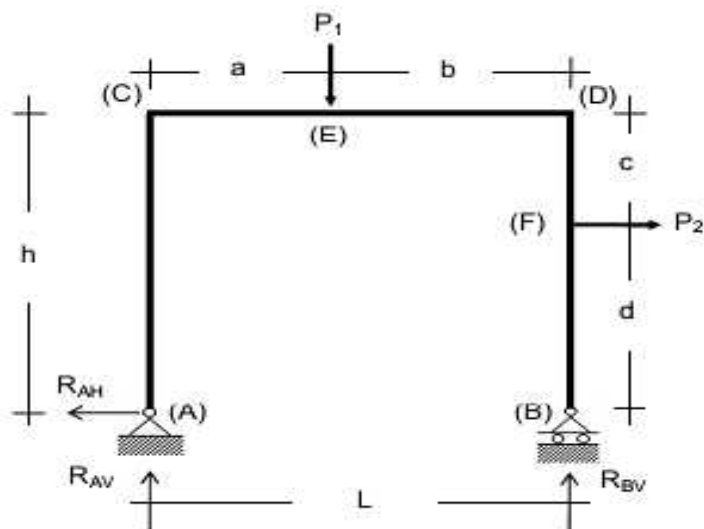
$$\begin{aligned} \bullet \sum M_B &= 0, \\ R_{AV} \cdot L - P \cdot b &= 0 \\ R_{AV} &= P \cdot b/L \text{ (ton)}. \end{aligned}$$

$$\begin{aligned} \bullet \sum M_A &= 0, \\ -R_{BV} \cdot L + P \cdot a &= 0 \\ R_{BV} &= P \cdot a/L \text{ (ton)}. \end{aligned}$$

❖ Kontrol (pengecekan hasil perhitungan) :

$$\begin{aligned} \sum V &= 0, \\ R_{AV} + R_{BV} - P &= 0 \end{aligned}$$

1.b Memikul muatan/beban terpusat vertikal dan horisontal.



Penyelesaian :

❖ Reaksi Perletakan :

$$\begin{aligned} \bullet \sum M_B &= 0, \\ R_{AV} \cdot L - R_{AH} \cdot 0 - P_1 \cdot b + P_2 \cdot d &= 0 \\ R_{AV} &= P_1 \cdot b/L - P_2 \cdot d/L \\ &\quad (\text{ton}) \end{aligned}$$

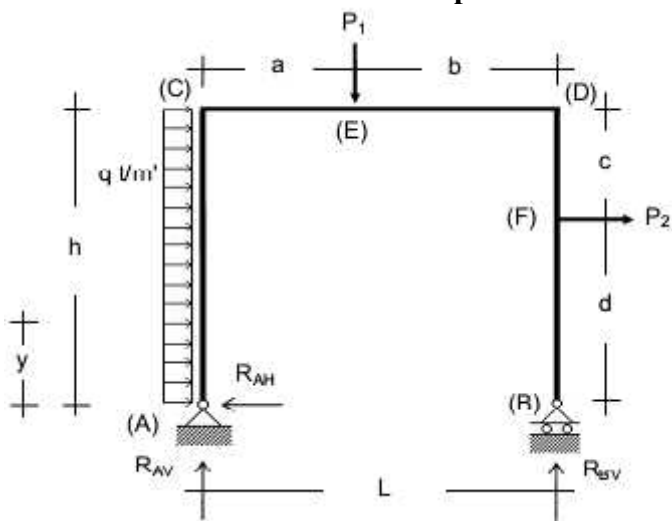
$$\begin{aligned} \bullet \sum M_A &= 0, \\ -R_{BV} \cdot L + P_1 \cdot a + P_2 \cdot d &= 0 \\ R_{BV} &= P_1 \cdot a/L + P_2 \cdot d/L \quad (\text{ton}) \end{aligned}$$

$$\begin{aligned} \bullet \sum H &= 0, \\ -R_{AH} + P_2 &= 0 \\ R_{AH} &= P_2 \quad (\text{ton, kekiri}). \end{aligned}$$

❖ Kontrol(pengecekan hasil perhitungan) :

$$\begin{aligned} \sum V &= 0, \\ R_{AV} + R_{BV} - P_1 &= 0 \end{aligned}$$

1.c Memikul muatan/beban campuran.



Penyelesaian :

❖ Reaksi Perletakan.

$$\begin{aligned} \bullet \sum M_B &= 0 \\ R_{AV} \cdot L - R_{AH} \cdot 0 + q \cdot h \cdot \frac{1}{2} h - P_1 \cdot b + P_2 \cdot d &= 0 \end{aligned}$$

$$\begin{aligned} \sum M_A &= 0 \\ -R_{BV} \cdot L + P_1 \cdot a + P_2 \cdot d + q \cdot h \cdot \frac{1}{2} h &= 0 \\ R_{BV} &= P_1 \cdot a/L + P_2 \cdot d/L + \frac{1}{2} q \cdot h/L \end{aligned}$$

$$\begin{aligned} \bullet \sum H &= 0 \\ -R_{AH} + q \cdot h + P_2 &= 0 \end{aligned}$$

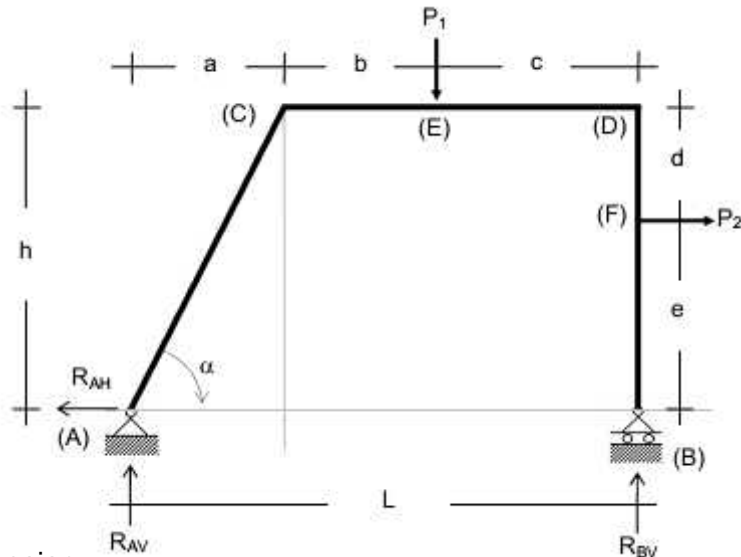
❖ Kontrol(pengecekan hasil perhitungan) :

$$\Sigma V = 0,$$

$$R_{AV} + R_{BV} - P_1 = 0$$

2. PORTAL ASIMETRIS

2.a Kolom miring sebelah, memikul muatan terpusat vertikal dan horisontal.



Penyelesaian :

❖ Reaksi Perletakan :

$$\Sigma M_B = 0$$

$$R_{AV} \cdot L - R_{AH} \cdot 0 - P_1 \cdot c + P_2 \cdot e = 0$$

$$R_{AV} = P_1 \cdot c/L - P_2 \cdot e/L$$

$$\Sigma M_A = 0$$

$$-R_{BV} \cdot L + P_1 \cdot (a+b) + P_2 \cdot e = 0$$

$$R_{BV} = P_1 \cdot (a+b)/L + P_2 \cdot e/L$$

$$\Sigma H = 0$$

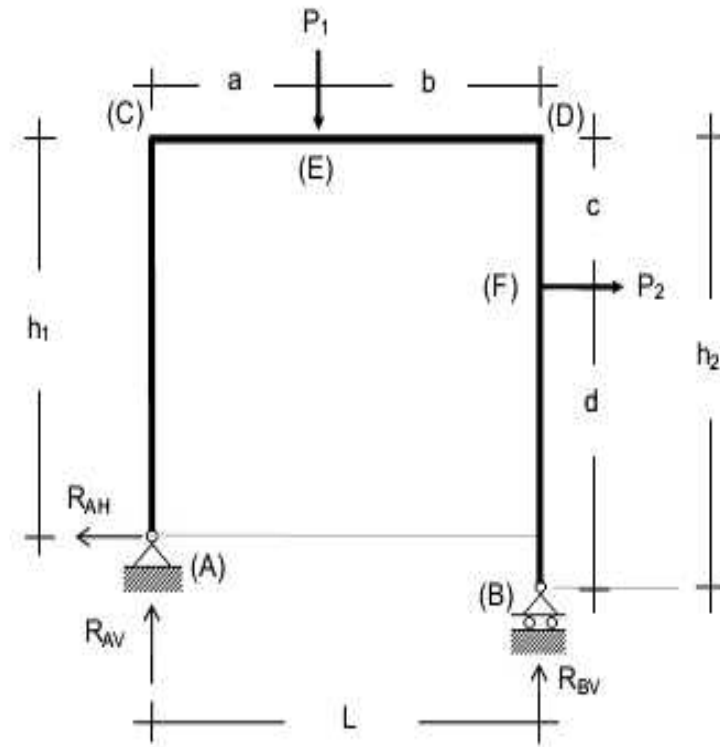
$$-R_{AH} + P_2 = 0$$

❖ Kontrol(pengecekan hasil perhitungan) :

$$\Sigma V = 0,$$

$$R_{AV} + R_{BV} - P_1 = 0$$

2.b Kolom tinggi sebelah, memikul muatan terpusat vertikal dan horisontal.



Penyelesaian :

❖ Reaksi Perletakan :

$$\Sigma M_B = 0,$$

$$R_{AV} \cdot L - R_{AH} \cdot (h_2 - h_1) - P_1 \cdot b + P_2 \cdot d = 0$$

$$R_{AV} = P_1 \cdot b/L + R_{AH} \cdot (h_2 - h_1)/L - P_2 \cdot d/L$$

$$\Sigma M_A = 0,$$

$$-R_{BV} \cdot L + P_1 \cdot a + P_2 \cdot (h_1 - c) = 0$$

$$R_{BV} = P_1 \cdot a/L + P_2 \cdot (h_1 - c)/L$$

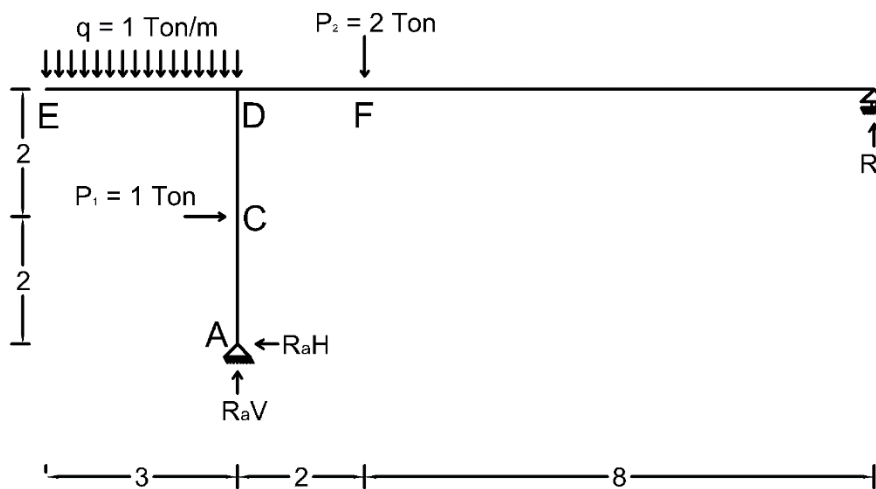
$$\Sigma H = 0,$$

$$-R_{AH} + P_2 = 0$$

$$R_{AH} = +P_2$$

❖ Kontrol(pengecekan hasil perhitungan) :

$$\Sigma V = 0$$



Gambarkan bidang M D N

Jawab :

$$\sum H = 0$$

$$P_1 + R_a H = 0$$

$$R_a H = -1 \quad (\leftarrow)$$

$$\sum M_B = 0$$

$$10R_a + P_1 \cdot 2 + q \cdot 3 \cdot \left(\frac{3}{2} + 10\right) + P_2 \cdot 8 + R_a H \cdot 4 = 0$$

$$10R_a - 1 \cdot 2 - 1 \cdot 3 \cdot (11,5) + 2 \cdot 8 + 1 \cdot 4 = 0$$

$$R_a = \frac{48,5}{10} = 4,85 \text{ Ton}$$

$$\sum M_A = 0$$

$$10R_b + P_1 \cdot 2 + q \cdot 3 \cdot \left(\frac{3}{2}\right) + P_2 \cdot 2 - R_a H \cdot 0 = 0$$

$$10R_b + 1 \cdot 2 + 1 \cdot 3 \cdot (1,5) + 2 \cdot 2 - 0 = 0$$

$$R_b = \frac{1,5}{10} = 0,15 \text{ Ton}$$

$$\sum V = 0$$

$$R_a + R_b - q \cdot 3 - P_1 - P_2 = 0$$

$$0,15 + 4,85 - 1 \cdot 3 - 1 - 2 = 0 \quad (\text{OK})$$

Diagram Bidang Momen

$$M_A = 0 \text{ Ton Meter}$$

$$M_C = R_a H \cdot 2 = 1 \cdot 2 = 2 \text{ Ton Meter}$$

$$M_{DA} = R_a H \cdot 4 - P_1 \cdot 2 = 1 \cdot 4 - 1 \cdot 2 = 2 \text{ Ton Meter}$$

$$M_{DE} = -q \cdot 1 \cdot 3 \cdot \left(\frac{3}{2}\right) = 1 \cdot 3 \cdot \left(\frac{3}{2}\right) = -4,5$$

$$M_{DB} = M_{DA} + M_{DE} = 2 - 4,5 = -2,5$$

$$M_F = M_{DB} + R_{a2} \cdot 2 = -2,5 + 1,85 \cdot 2 = 1,2 \text{ Ton Meter}$$

$$M_B = 0 \text{ Ton Meter}$$

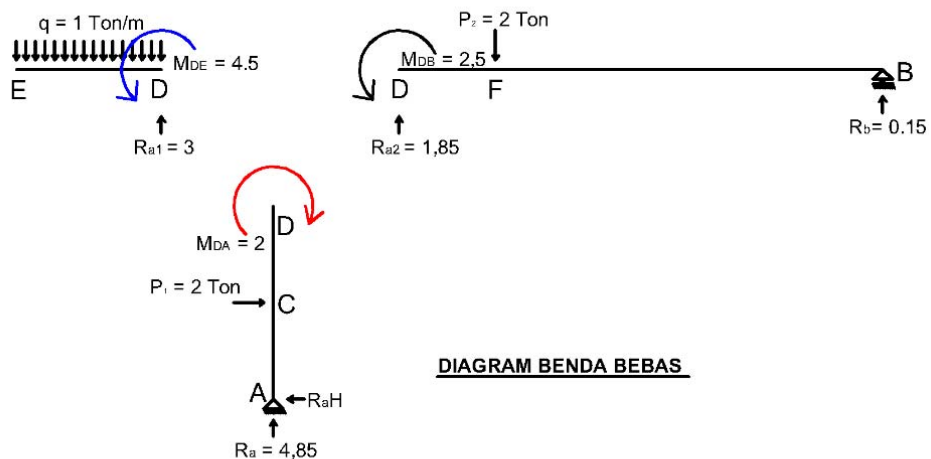


DIAGRAM BENDA BEBAS

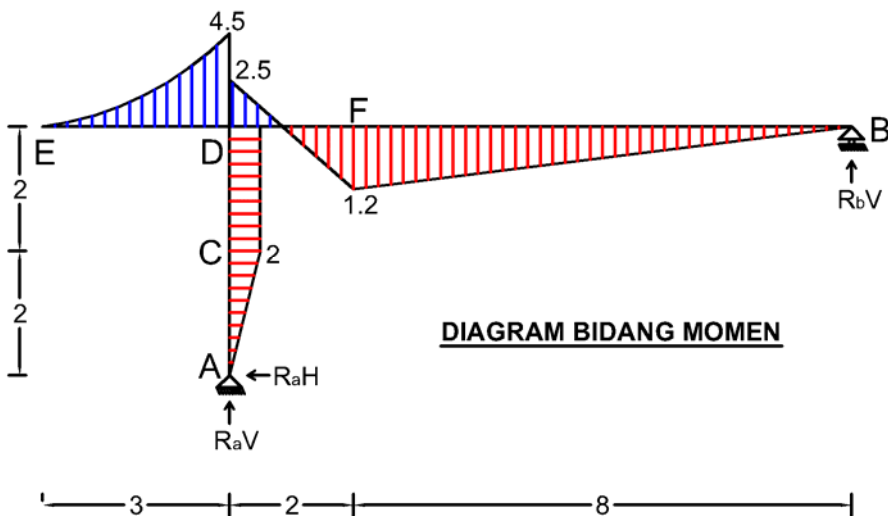


DIAGRAM BIDANG MOMEN

Diagram Bidang Lintang

$$D_A = R_a H = 1$$

$$D_C = R_a H - P_1 = 1 - 1 = 0$$

$$D_D = R_{a2} = R_a V - q \cdot 3 = 4,85 - 3 = 1,85$$

$$D_F = R_{a2} - P_2 = R_a V - q \cdot 3 - P_2 = 4,85 - 3 - 2 = -0,15$$

$$D_B = R_{a2} - P_2 + R_b = R_a V - q \cdot 3 - P_2 + R_b = 4,85 - 3 - 2 + 0,15 = 0$$

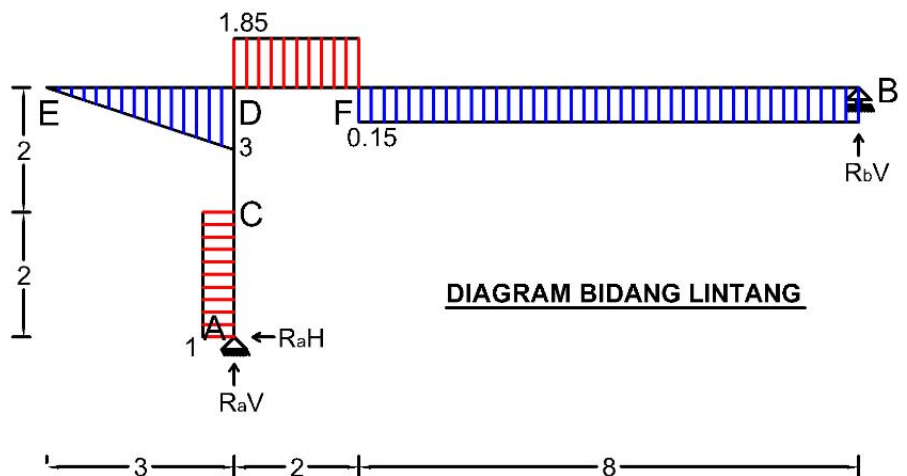
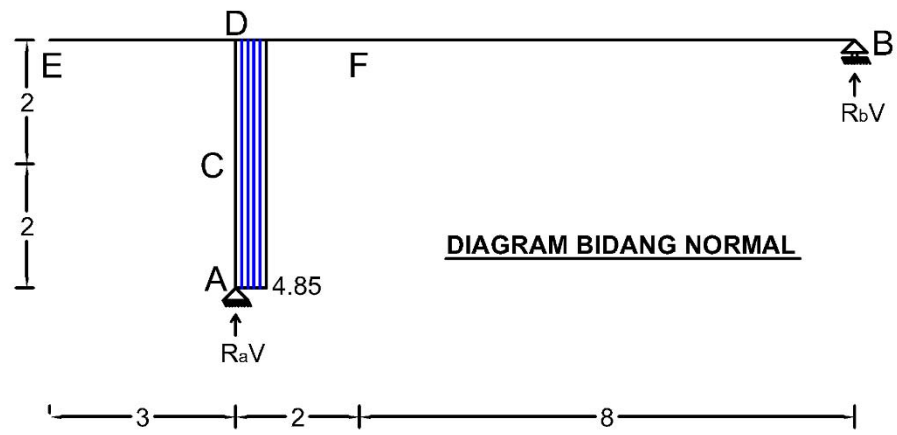
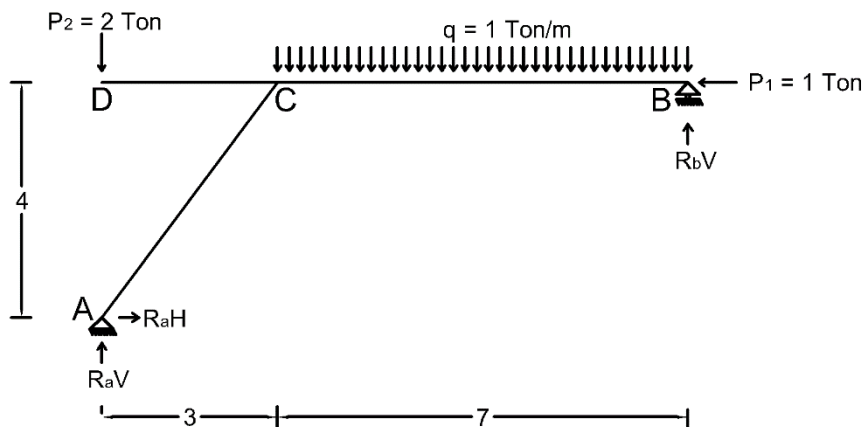


DIAGRAM BIDANG LINTANG

Diagram Bidang Normal

$$N_{AD} = - (R_a V) = - 4,85 \text{ Ton (TEKAN)}$$





$$\begin{aligned}\sum V &= 0 \\ R_a + R_b - q \cdot 3 - P_1 - P_1 &= 0 \\ 0,15 + 4,85 - 1 \cdot 3 - 2 &= 0 \quad (\text{OK})\end{aligned}$$

Diagram Bidang Momen

$$\begin{aligned}M_A &= 0 \text{ Ton Meter} \\ M_{CA} &= R_a V \cdot 3 - R_a H \cdot 4 = 4,85 \cdot 3 - 1 \cdot 4 = 10,55 \text{ Ton Meter} \\ M_{CD} &= -P_2 \cdot 3 = -2 \cdot 3 = -6 \text{ Ton Meter} \\ M_{CB} &= M_{CA} + M_{CD} = 10,55 - 6 = 4,55 \text{ Ton Meter}\end{aligned}$$

Pada bentang CB M_{Max} Terjadi di X_{max} , dimana X_{max} didapatkan dari turunan pertama fungsi dari momen max (M_{max})

$$\begin{aligned}0 &= \frac{dy}{dx} \left[-P_2 \cdot (3+x) + R_a V(3+x) + R_a H \cdot 4 - q \cdot x \cdot \left(\frac{x}{2}\right) \right] \\ 0 &= [-P_2 + R_a - q \cdot x] \\ X_{\text{max}} &= \frac{[-P_2 + R_a]}{q} = \frac{[-2 + 4,85]}{1} = 2,85 \\ &= 2,85 \text{ meter dari titik C}\end{aligned}$$

Sehingga M_{max} adalah

$$\begin{aligned}&= -P_2 \cdot (3+2,85) + R_a(3+2,85) + R_a H \cdot 4 - q \cdot 2,85 \cdot \left(\frac{2,85}{2}\right) \\ &= -2 \cdot (5,85) + 4,85 \cdot (5,85) + 1 \cdot 4 - 1 \cdot 2,85 \cdot \left(\frac{2,85}{2}\right) \\ &= 8,61125 \text{ Ton meter}\end{aligned}$$

Gambarkan bidang M D N

Jawab :

$$\begin{aligned}\sum H &= 0 \\ -P_1 + R_a H &= 0 \\ R_a H &= 1 \\ \sum M_B &= 0 \\ 10R_a - R_a H \cdot 4 - P_2 \cdot 10 - q \cdot 7 \cdot \left(\frac{7}{2}\right) + P_1 \cdot 0 &= 0 \\ 10R_a - 1 \cdot 4 - 2 \cdot 10 - 1 \cdot 7 \cdot \left(\frac{7}{2}\right) &= 0 \\ R_a &= \frac{48,5}{10} = 4,85 \text{ Ton}\end{aligned}$$

$$\begin{aligned}\sum M_A &= 0 \\ 10R_b - P_1 \cdot 4 - q \cdot 7 \cdot \left(\frac{7}{2} + 3\right) + P_2 \cdot 0 - R_a H \cdot 0 &= 0 \\ 10R_b - 1 \cdot 4 + 1 \cdot 7 \cdot (6,5) &= 0 \\ R_b &= \frac{41,5}{10} = 4,15 \text{ Ton}\end{aligned}$$

Cara lain untuk mencari M_{MAX} pada bentang CB adalah

$$\begin{aligned}0 &= \frac{dy}{dx} [M_{CB} + R_{a2} \cdot x - q \cdot x \cdot \left(\frac{x}{2}\right)] \\ 0 &= [R_{a2} - q \cdot x] \\ X_{\text{max}} &= \frac{[R_{a2}]}{q} = \frac{[2,85]}{1} = 2,85 \\ &= 2,85 \text{ meter dari titik C}\end{aligned}$$

Sehingga M_{max} adalah

$$\begin{aligned}&= M_{CB} + R_{a2} \cdot x - q \cdot x \cdot \left(\frac{x}{2}\right) \\ &= 4,55 + 2,85 \cdot 2,85 - 1 \cdot 2,85 \cdot \left(\frac{2,85}{2}\right) \\ &= 8,61125 \text{ Ton meter}\end{aligned}$$

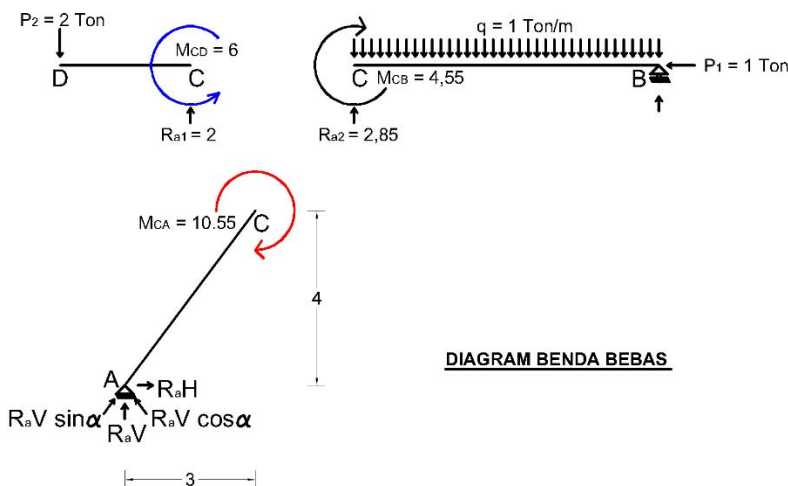


DIAGRAM BENDA BEBAS

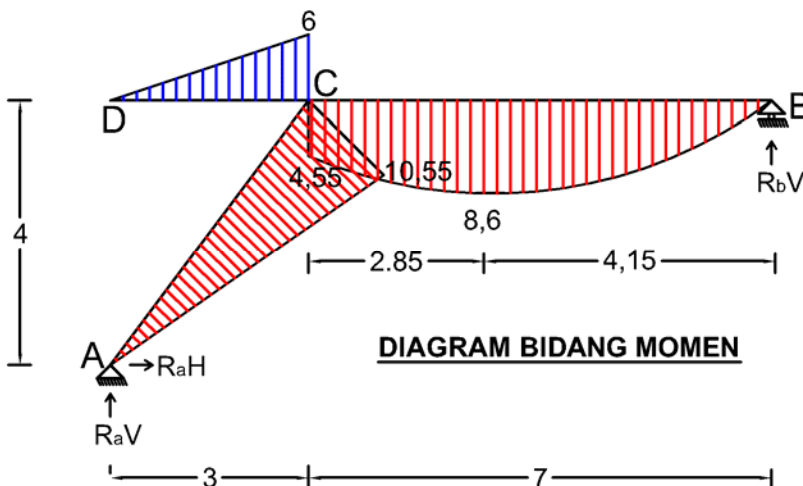


DIAGRAM BIDANG MOMEN

Diagram Bidang Lintang

$D_{AC} = D_{CA} = R_a V \cdot \cos \alpha - R_a H \cdot \sin \alpha$
 $= 4,85 \cdot \frac{3}{5} - 1 \cdot \frac{4}{5}$
 $= 2,11 \text{ Ton}$

$D_{DC} = -P_2 = -2 \text{ Ton}$

Gaya lintang pada batang CB :

$D_{CB (x=3)} = R_a V - P_2 = 4,85 - 2 = 2,85 \text{ Ton}$

$D_{x=4} = R_a V - P_2 - q \cdot 1 = 4,85 - 2 - 1 \cdot 1 = 1,85 \text{ Ton}$

$D_{x=5} = R_a V - P_2 - q \cdot 2 = 4,85 - 2 - 1 \cdot 2 = 0,85 \text{ Ton}$

$D_{x=5,85} = R_a V - P_2 - q \cdot 2,85 = 4,85 - 2 - 1 \cdot 2,85 = 0 \text{ Ton}$

$D_{x=6} = R_a V - P_2 - q \cdot 3 = 4,85 - 2 - 1 \cdot 3 = -0,15 \text{ Ton}$

$D_{x=7} = R_a V - P_2 - q \cdot 4 = 4,85 - 2 - 1 \cdot 4 = -1,15 \text{ Ton}$

$D_{x=8} = R_a V - P_2 - q \cdot 5 = 4,85 - 2 - 1 \cdot 5 = -2,15 \text{ Ton}$

$D_{x=9} = R_a V - P_2 - q \cdot 6 = 4,85 - 2 - 1 \cdot 6 = -3,15 \text{ Ton}$

$D_{x=10} = R_a V - P_2 - q \cdot 7 + R_b V$
 $= 4,85 - 2 - 1 \cdot 7 - 4,15 = 0 \text{ Ton}$

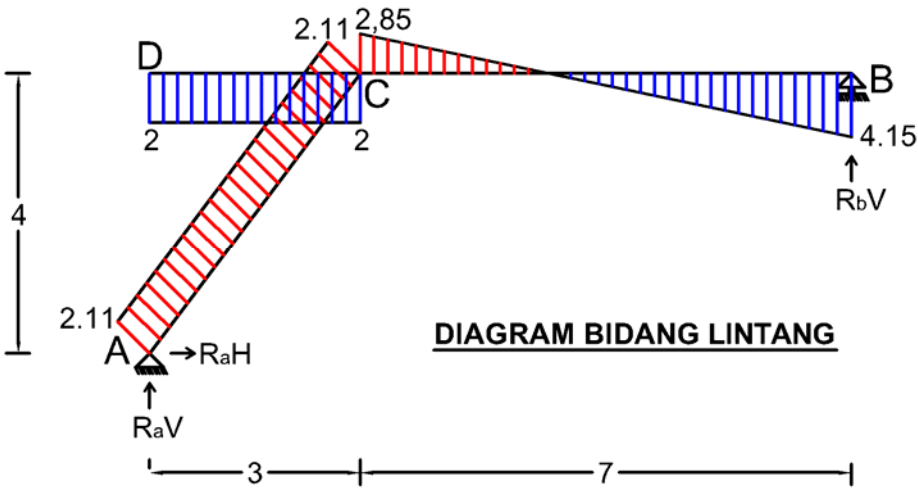
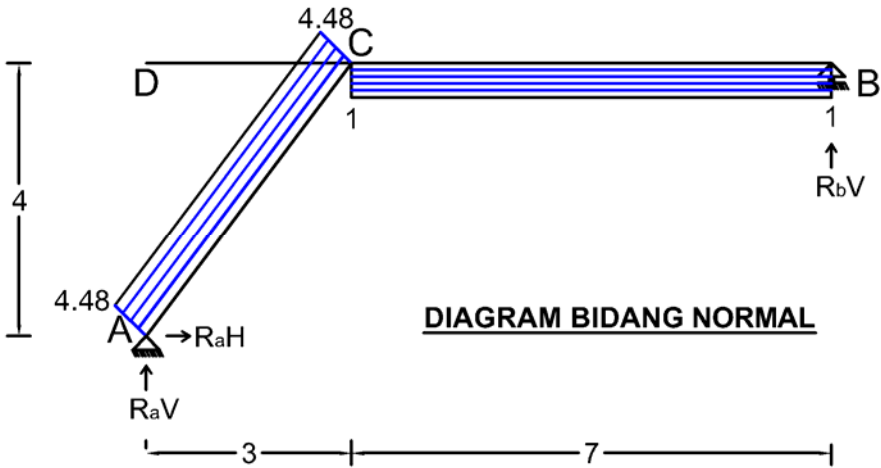
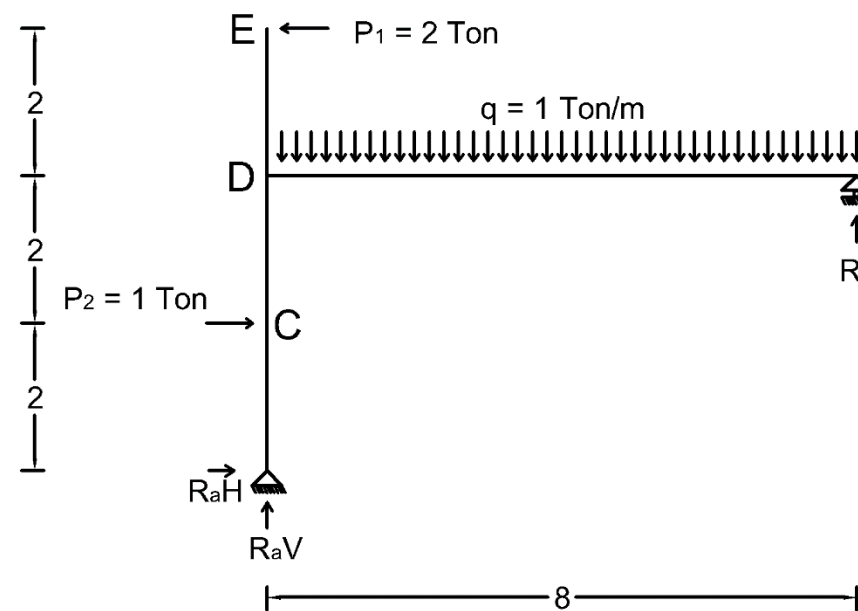


Diagram Bidang Normal

$N_{AC} = - (R_a V \cdot \sin \alpha - R_a H \cdot \cos \alpha)$
 $= - (4,85 \cdot \frac{4}{5} + 1 \cdot \frac{3}{5})$
 $= -4,48 \text{ Ton (TEKAN)}$

$N_{BC} = -P_1 = -1 \text{ Ton (TEKAN)}$





Gambarkan bidang M D N

Jawab :

$$\begin{aligned} \sum H &= 0 \\ -P_1 + P_2 + R_a H &= 0 \\ R_a H &= 1 \\ \sum M_B &= 0 \\ 8R_a - R_a H \cdot 4 - P_2 \cdot 2 - P_1 \cdot 2 - q \cdot 8 \cdot \left(\frac{8}{2}\right) &= 0 \\ 8R_a - 1 \cdot 4 - 1 \cdot 2 - 2 \cdot 2 - 1 \cdot 7 \cdot \left(\frac{7}{2}\right) &= 0 \\ R_a &= \frac{42}{8} = 5,25 \text{ Ton} \\ \sum M_A &= 0 \\ -8R_b + P_2 \cdot 2 - P_1 \cdot 6 + q \cdot 8 \cdot \left(\frac{8}{2}\right) - R_a H \cdot 0 &= 0 \\ -8R_b + 1 \cdot 2 - 2 \cdot 6 + 1 \cdot 8 \cdot (4) &= 0 \\ R_b &= \frac{22}{8} = 2,75 \text{ Ton} \end{aligned}$$

$$\begin{aligned} \sum V &= 0 \\ R_a + R_b - q \cdot 8 &= 0 \\ 5,25 + 2,75 - 1 \cdot 8 &= 0 \text{ (OK)} \end{aligned}$$

Diagram Bidang Momen

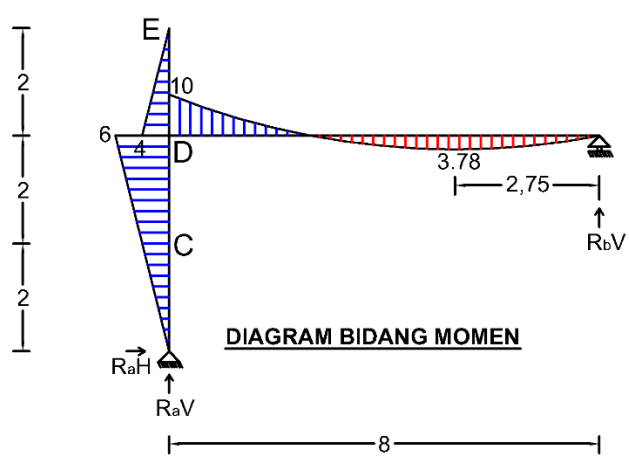
$$\begin{aligned} M_A &= 0 \text{ Ton Meter} \\ M_C &= -(R_a H \cdot 2) = -(1 \cdot 2) = -2 \text{ Ton Meter} \\ M_{DA} &= -(R_a H \cdot 4 + P_2 \cdot 2) = -(1 \cdot 4 + 1 \cdot 2) = -6 \text{ Ton Meter} \\ M_{ED} &= -(P_1 \cdot 2) = -(2 \cdot 2) = -4 \text{ Ton Meter} \\ M_{DB} &= M_{DA} + M_{ED} = -6 - 4 = -10 \text{ Ton Meter} \end{aligned}$$

Pada bentang DB M_{MAX} Terjadi di X_{max} , dimana X_{max} didapatkan dari turunan pertama fungsi dari momen max (M_{max})

$$\begin{aligned} 0 &= \frac{dy}{dx} [R_a V(x) - R_a H \cdot 4 - P_2 \cdot 2 - P_1 \cdot 2 - q \cdot x \cdot \left(\frac{x}{2}\right)] \\ 0 &= [R_a - q \cdot x] \\ X_{\text{max}} &= \frac{[R_a]}{q} = \frac{[5,25]}{1} = 5,25 \\ &= 5,25 \text{ meter dari titik D} \end{aligned}$$

Sehingga M_{max} adalah

$$\begin{aligned} &= R_a V(5,25) - R_a H \cdot 4 - P_2 \cdot 2 - P_1 \cdot 2 - q \cdot 5,25 \cdot \left(\frac{5,25}{2}\right) \\ &= 5,25(5,25) - 1 \cdot 4 - 1 \cdot 2 - 2 \cdot 2 - 1 \cdot 5,25 \cdot \left(\frac{5,25}{2}\right) \\ &= 3,78125 \text{ Ton meter} \end{aligned}$$



Cara lain untuk mencari M_{MAX} pada bentang DB adalah

$$\begin{aligned} 0 &= \frac{dy}{dx} [M_{DB} + R_a V \cdot x - q \cdot x \cdot \left(\frac{x}{2}\right)] \\ 0 &= [R_a V - q \cdot x] \\ X_{\text{max}} &= \frac{[R_a V]}{q} = \frac{[5,25]}{1} = 5,25 \\ &= 5,25 \text{ meter dari titik C} \end{aligned}$$

Sehingga M_{max} adalah

$$\begin{aligned} &= M_{DB} + R_a V \cdot 5,25 - q \cdot 5,25 \cdot \left(\frac{5,25}{2}\right) \\ &= -10 + 5,25(5,25) - 1 \cdot 5,25 \cdot \left(\frac{5,25}{2}\right) \\ &= 3,78125 \text{ Ton meter} \end{aligned}$$

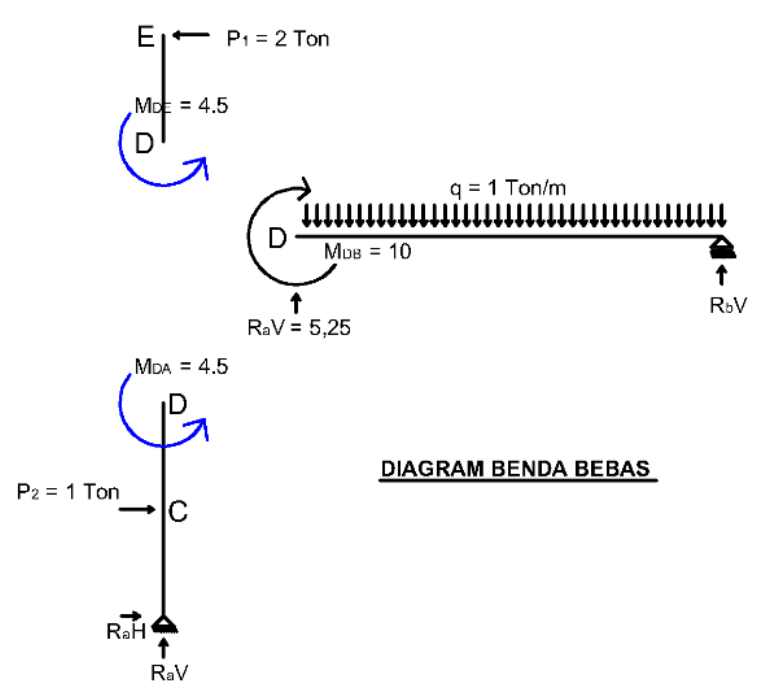


Diagram Bidang Lintang

$$\begin{aligned} D_{AC} &= R_a H = 1 \text{ Ton} \\ D_{CD} &= R_a H + P_2 = 1 + 1 = 2 \text{ Ton} \\ D_E &= R_a H + P_2 - P_1 = 1 + 1 - 2 = 0 \text{ Ton} \end{aligned}$$

Gaya lintang pada batang CB :

$$\begin{aligned} D_{x=0} &= R_a V = 5,25 \text{ Ton} \\ D_{x=1} &= R_a V - q \cdot 1 = 5,25 - 1 \cdot 1 = 4,25 \text{ Ton} \\ D_{x=2} &= R_a V - q \cdot 2 = 5,25 - 1 \cdot 2 = 3,25 \text{ Ton} \\ D_{x=3} &= R_a V - q \cdot 3 = 5,25 - 1 \cdot 3 = 2,25 \text{ Ton} \\ D_{x=4} &= R_a V - q \cdot 4 = 5,25 - 1 \cdot 4 = 1,25 \text{ Ton} \\ D_{x=5} &= R_a V - q \cdot 5 = 5,25 - 1 \cdot 5 = 0,25 \text{ Ton} \\ D_{x=5,25} &= R_a V - q \cdot 5,25 = 5,25 - 1 \cdot 5,25 = 0 \text{ Ton} \\ D_{x=6} &= R_a V - q \cdot 6 = 5,25 - 1 \cdot 6 = -0,75 \text{ Ton} \\ D_{x=7} &= R_a V - q \cdot 7 = 5,25 - 1 \cdot 7 = -1,75 \text{ Ton} \\ D_{x=8} &= R_a V - q \cdot 8 + R_b V = 5,25 - 1 \cdot 8 + 2,75 = 0 \text{ Ton} \end{aligned}$$

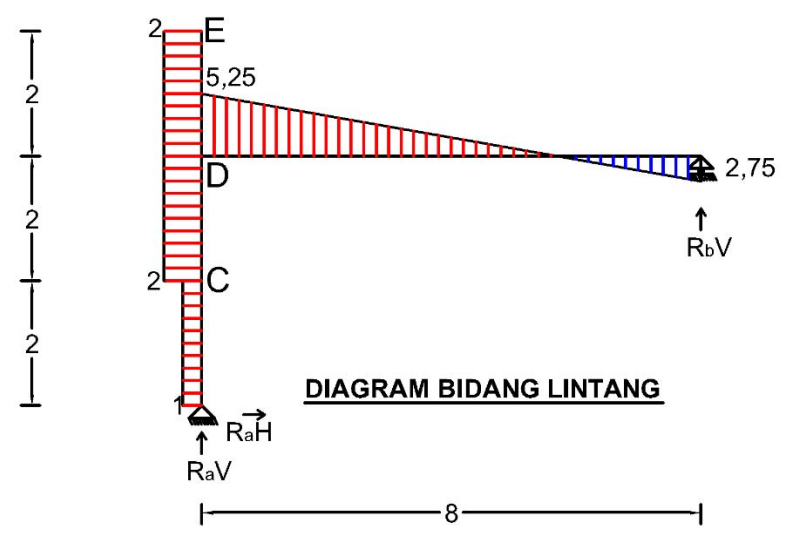
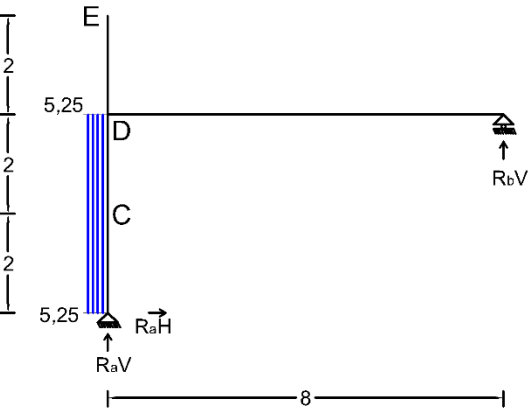
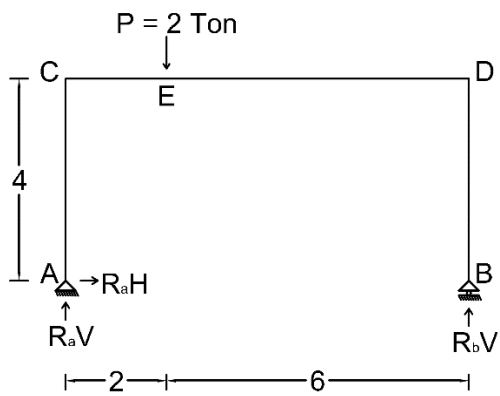


Diagram Bidang Normal

$N_{AD} = - (R_aV) = - 5,25 \text{ (TEKAN)}$





$$\begin{aligned}\sum V &= 0 \\ R_a + R_b - P &= 0 \\ 1,5 + 0,5 - 2 &= 0 \quad (\text{OK})\end{aligned}$$

Diagram Bidang Momen

$$\begin{aligned}M_A &= 0 \text{ Ton Meter} \\ M_C &= 0 \text{ Ton Meter} \\ M_E &= R_a V \cdot 2 = 1,5 \cdot 2 = 3 \text{ Ton Meter} \\ M_D &= R_a V \cdot 8 - P \cdot 6 = 1,5 \cdot 8 - 2 \cdot 6 = 0 \text{ Ton Meter} \\ M_B &= 0 \text{ Ton Meter}\end{aligned}$$

Gambarkan bidang M D N

Jawab :

$$\begin{aligned}\sum M_B &= 0 \\ 8R_a - P \cdot 6 &= 0 \\ 8R_a - 2 \cdot 6 &= 0 \\ R_a &= \frac{12}{8} = 1,5 \text{ Ton} \\ \sum M_A &= 0 \\ 8R_b - P \cdot 2 &= 0 \\ 8R_b - 2 \cdot 2 &= 0 \\ R_b &= \frac{4}{8} = 0,5 \text{ Ton}\end{aligned}$$

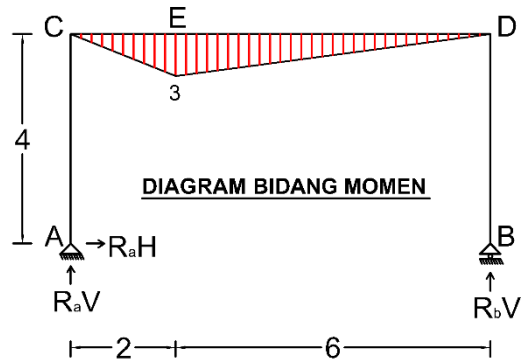


Diagram Bidang Lintang

$$\begin{aligned}D_A &= 0 \text{ Ton} \\ D_C &= R_a V = 1,5 \text{ Ton} \\ D_E &= R_a V - P = 1,5 - 2 = 0,5 \text{ Ton} \\ D_B &= R_a V - P + R_b V = 1,5 - 2 + 0,5 = 0 \text{ Ton}\end{aligned}$$

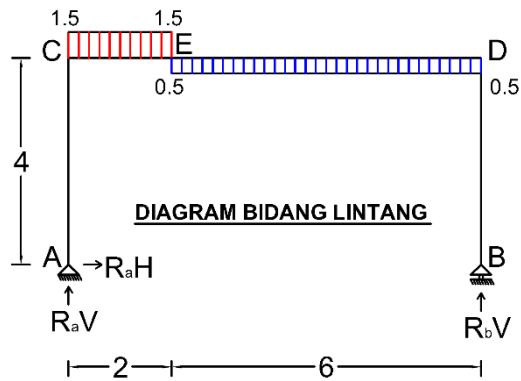
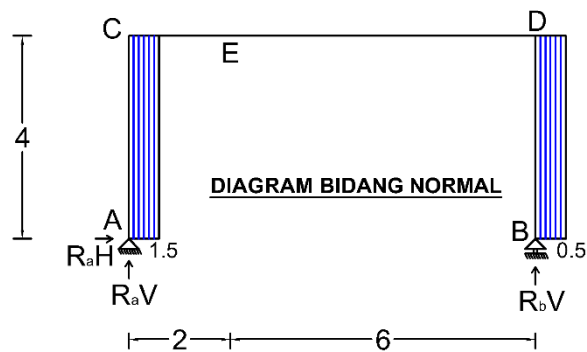
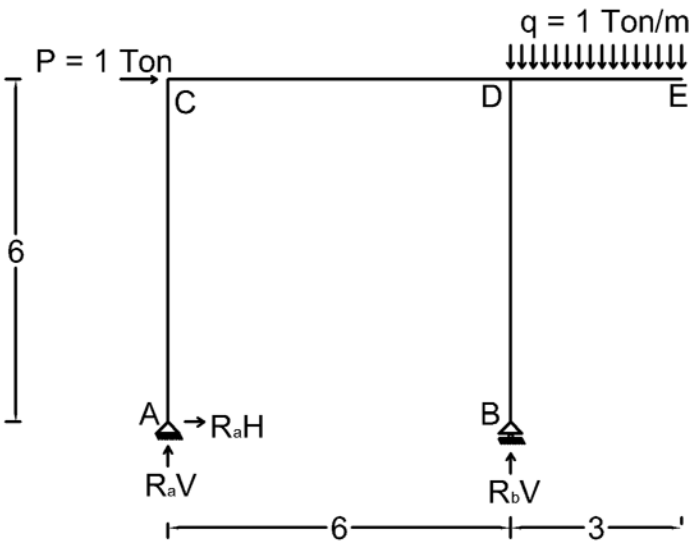


Diagram Bidang Normal

$$\begin{aligned}N_{AC} &= - (R_a V) = - 1,5 \text{ Ton (TEKAN)} \\ N_{BD} &= - (R_b V) = - 0,5 \text{ Ton (TEKAN)}\end{aligned}$$





$$\begin{aligned} \sum V &= 0 \\ R_a + R_b - P &= 0 \\ 1,5 + 0,5 - 2 &= 0 \text{ (OK)} \end{aligned}$$

Diagram Bidang Momen

$$\begin{aligned} M_A &= 0 \text{ Ton Meter} \\ M_{CA} = M_{CD} &= R_a H \cdot 6 = 1 \cdot 6 = 6 \text{ Ton Meter} \\ M_{ED} &= q \cdot 3 \cdot \left(\frac{3}{2}\right) = 1 \cdot 3 \cdot 1,5 = 4,5 \text{ Ton Meter} \\ M_B &= 0 \text{ Ton Meter} \end{aligned}$$

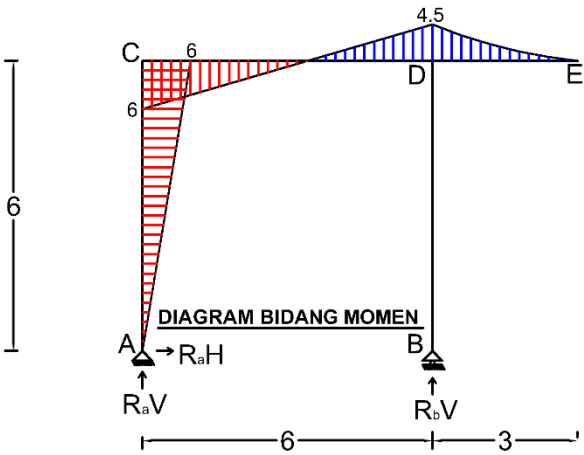


Diagram Bidang Lintang

$$\begin{aligned} D_A &= R_a H = 1 \text{ Ton} \\ D_{CA} &= R_a H - P = 0 \text{ Ton} \\ D_{CD} = D_{DC} &= R_a V = -1,75 \text{ Ton} \end{aligned}$$

Gaya lintang pada batang DE

$$\begin{aligned} D_{DE \ (x=6)} &= R_a V + R_b V = -1,75 + 4,75 = 3 \text{ Ton} \\ D_{(x=7)} &= R_a V + R_b V - q \cdot 1 = -1,75 + 4,75 - 1 \cdot 1 = 2 \text{ Ton} \\ D_{(x=8)} &= R_a V + R_b V - q \cdot 2 = -1,75 + 4,75 - 1 \cdot 2 = 1 \text{ Ton} \\ D_{(x=9)} &= R_a V + R_b V - q \cdot 3 = -1,75 + 4,75 - 1 \cdot 3 = 0 \text{ Ton} \end{aligned}$$

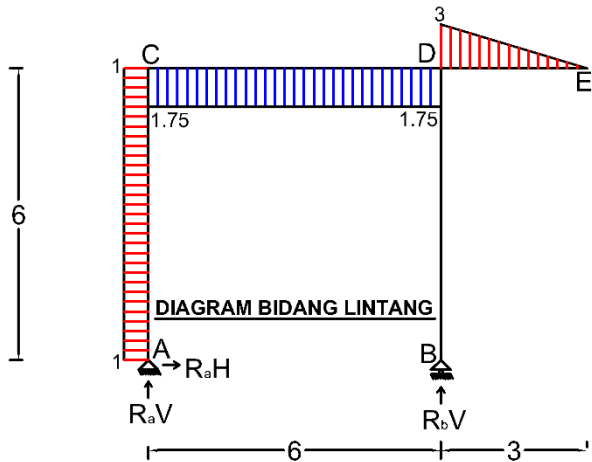
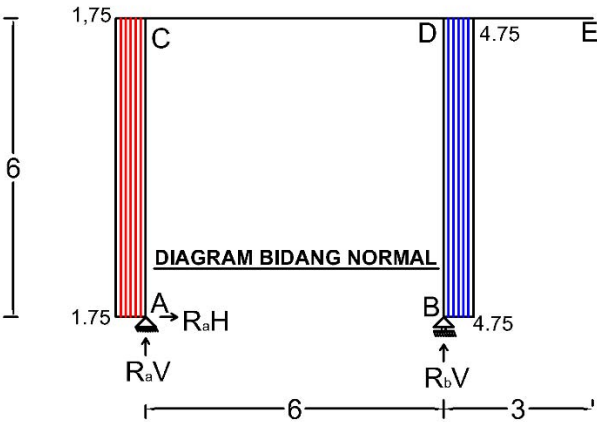


Diagram Bidang Normal

$$\begin{aligned} N_{AC} &= - (R_a V) = +1,75 \text{ Ton (TARIK)} \\ N_{CE} &= 0 \text{ Ton} \\ N_{BD} &= - (R_b V) = -4,75 \text{ Ton (TEKAN)} \end{aligned}$$



Gambarkan bidang M D N

Jawab :

$$\begin{aligned} \sum H &= 0 \\ P + R_a H &= 0 \\ R_a H &= -1 \text{ (} \leftarrow \text{)} \\ \sum M_B &= 0 \\ 6R_a + P \cdot 6 + q \cdot 3 \cdot \left(\frac{3}{2}\right) &= 0 \\ 6R_a + 1 \cdot 6 + 1 \cdot 3 \cdot \left(\frac{3}{2}\right) &= 0 \\ R_a &= -\frac{10,5}{6} = -1,75 \text{ Ton} \\ \sum M_A &= 0 \\ 6R_b - P \cdot 6 - q \cdot 3 \cdot \left(\frac{3}{2} + 6\right) &= 0 \\ 6R_b - 1 \cdot 6 - 1 \cdot 3 \cdot (7,5) &= 0 \\ R_b &= \frac{22,5}{6} = 4,75 \text{ Ton} \end{aligned}$$

Gambarkan bidang M D N

Jawab :

$$\sum H = 0$$

$$-P_2 + R_b H = 0$$

$$R_b H = 1$$

$$\sum M_B = 0$$

$$5R_a - P_1 \cdot 6 - P_2 \cdot 4 = 0$$

$$5R_a - 2.6 - 1.4 = 0$$

$$R_a = \frac{16}{5} = 3,2 \text{ Ton}$$

$$\sum M_A = 0$$

$$-5R_b - P_1 \cdot 1 - P_2 \cdot 4 = 0$$

$$-5R_b - 2.1 - 1.4 = 0$$

$$R_b = -\frac{6}{5} = -1,2 \text{ Ton (↓)}$$

$$\sum V = 0$$

$$R_a + R_b - P_1 = 0$$

$$3,2 - 1,2 - 2 = 0 \text{ (OK)}$$

Diagram Bidang Momen

$$M_A = 0 \text{ Ton Meter}$$

$$M_{CD} = -P_1 \cdot 2 = -2.1 = -2 \text{ Ton Meter}$$

$$M_{FD} = -P_2 \cdot 1 = -1.1 = -1 \text{ Ton Meter}$$

$$M_{DE} = M_{CD} + M_{FD} = -2 - 1 = -3$$

$$M_E = R_a V \cdot 5 - P_1 \cdot 6 - P_2 \cdot 1$$

$$= 3,2 \cdot 5 - 2.6 - 1.1$$

$$= 3$$

$$M_B = R_a V \cdot 5 - P_1 \cdot 6 - P_2 \cdot 4$$

$$= 3,2 \cdot 5 - 2.6 - 1.4$$

$$= 0$$

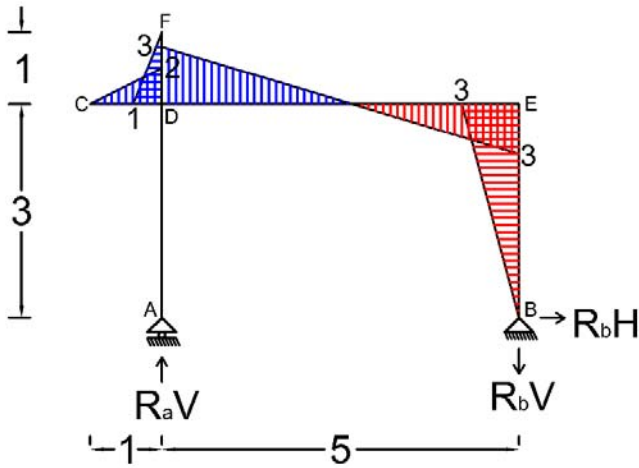


Diagram Bidang Lintang

$$D_{FD} = -P_2 = -1 \text{ Ton}$$

$$D_{CD} = -P_1 = -2 \text{ Ton}$$

$$D_{CD} = -P_1 + R_a V = -2 + 3,2 = 1,2 \text{ Ton}$$

$$D_{DB} = -P_2 = -1 \text{ Ton}$$

$$D_B = -P_2 + R_b H = -1 + 1 = 0 \text{ Ton}$$

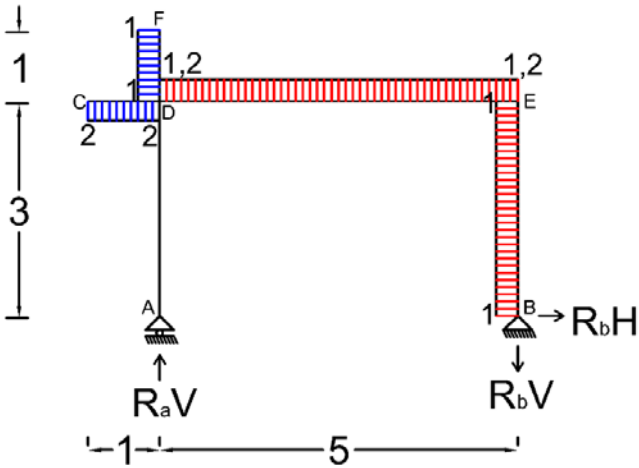
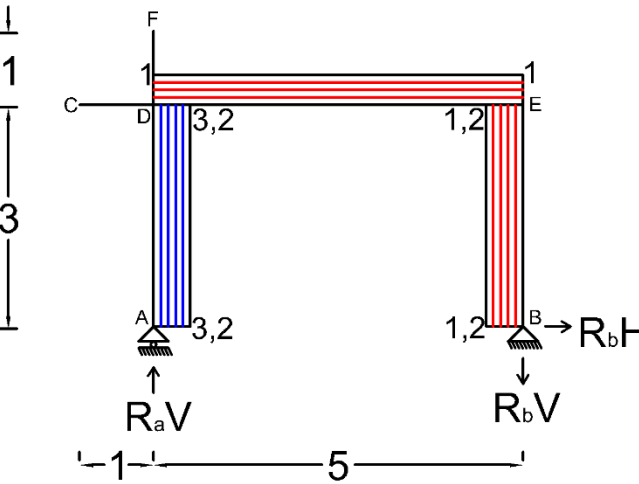


Diagram Bidang Normal

$$N_{AD} = -(R_a V) = -3,2 \text{ Ton (TEKAN)}$$

$$N_{DE} = R_b H = 1 \text{ Ton (TARIK)}$$

$$N_{BDE} = -(R_b V) = 1,2 \text{ Ton (TARIK)}$$



Gambarkan bidang M D N

Jawab :

$$\sum M_B = 0$$

$$10R_a - P.2 - q.3.\left(\frac{3}{2} + 7\right) = 0$$

$$10R_a - 4.2 - 1.3.8,5 = 0$$

$$R_a = \frac{33,5}{10} = 3,35 \text{ Ton}$$

$$\sum M_A = 0$$

$$10R_a - P.8 - q.3.\left(\frac{3}{2}\right) = 0$$

$$10R_a - 4.8 - 1.3.1,5 = 0$$

$$R_a = \frac{36,5}{10} = 3,65 \text{ Ton}$$

$$\sum V = 0$$

$$R_a + R_b - P - q.3 = 0$$

$$3,65 + 3,35 - 4 - 1.3 = 0 \text{ (OK)}$$

Diagram Bidang Momen

$$M_A = 0 \text{ Ton Meter}$$

$$M_{CA} = R_a V. 3 = 3,35.3 = 10,05 \text{ Ton Meter}$$

$$M_{CD} = -q.3.\left(\frac{3}{2}\right) = -1.3.\left(\frac{3}{2}\right) = -4,5 \text{ Ton Meter}$$

$$M_{CE} = M_{CA} + M_{CD} = 10,05 - 4,5 = 5,55 \text{ Ton Meter}$$

$$M_E = R_a V.8 - q.3.\left(\frac{3}{2} + 5\right)$$

$$= 3,35.8 - 1.3.(6,5)$$

$$= 7,3 \text{ Ton Meter}$$

$$M_B = R_a V.10 - q.3.\left(\frac{3}{2} + 7\right) - P.2$$

$$= 3,35.10 - 1.3.(8,5) - 4.2$$

$$= 0 \text{ Ton Meter}$$

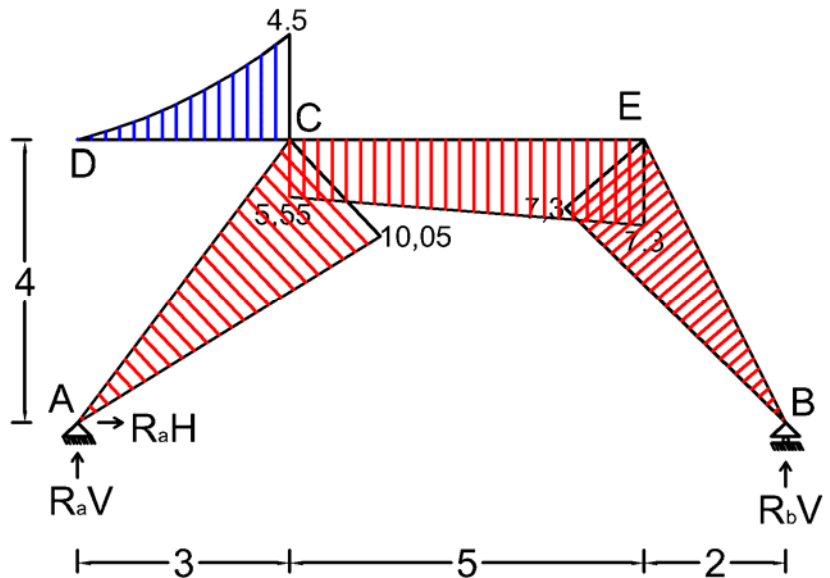


Diagram Bidang Lintang

$$D_{AC} = D_{CA} = R_a V. \cos \alpha - R_a H. \sin \alpha$$

$$= 3,35. \frac{3}{5} - 0. \frac{4}{5}$$

$$= 2,01 \text{ Ton}$$

Gaya lintang pada batang DC :

$$D_{x=0} = q.0 = 1.0 = 0 \text{ Ton}$$

$$D_{x=1} = q.1 = 1.1 = 1 \text{ Ton}$$

$$D_{x=2} = q.2 = 1.2 = 2 \text{ Ton}$$

$$D_{x=3} = q.3 = 1.3 = 3 \text{ Ton}$$

$$D_{CE} = (D_{AC} / \cos \alpha) - D_{CD} = 2,01. \frac{5}{3} - 3 = 0,35$$

$$D_{EB} = [(D_{AC} / \cos \alpha) - D_{CD} - P]. \cos \beta$$

$$= [2,01. \frac{5}{3} - 3 - 4] \frac{2}{4,47}$$

$$= -1,633$$

$$D_B = [(D_{AC} / \cos \alpha) - D_{CD} - P]. \cos \beta - R_b H. \cos \beta$$

$$= [2,01. \frac{5}{3} - 3 - 4] \frac{2}{4,47} - 3,65. \frac{2}{4,47}$$

$$= 0 \text{ Ton}$$

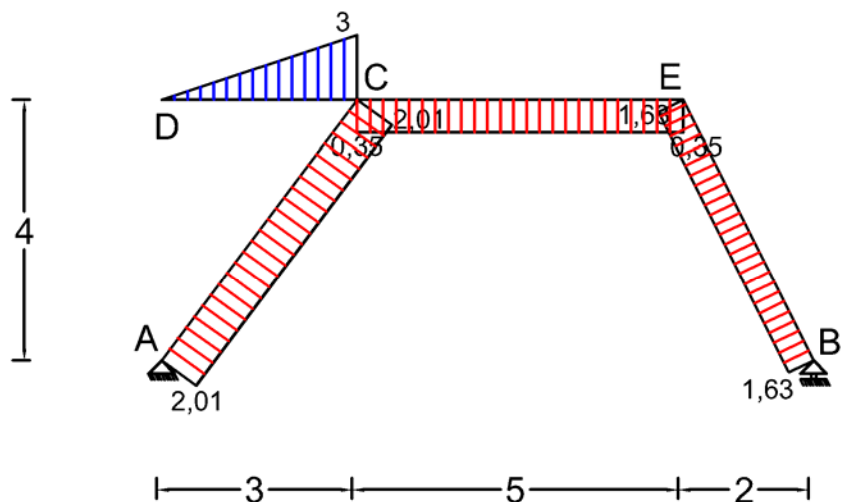
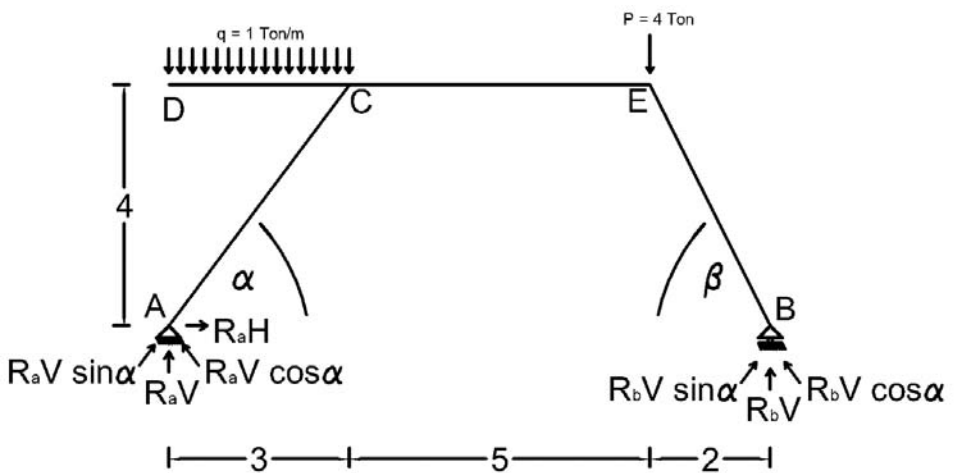


Diagram Bidang Normal

$N_{AC} = - (R_a V . \sin \alpha) = - (3,35 . \sin \alpha) = - 2,68 \text{ Ton (TEKAN)}$

$N_{BE} = - (R_b V . \sin \beta) = - (3,65 . \sin \beta) = - 3,26 \text{ Ton (TEKAN)}$

