Struktur Balok

- Balok (*Beam*) adalah suatu anggota struktur yang ditujukan untuk memikul beban transversal saja.

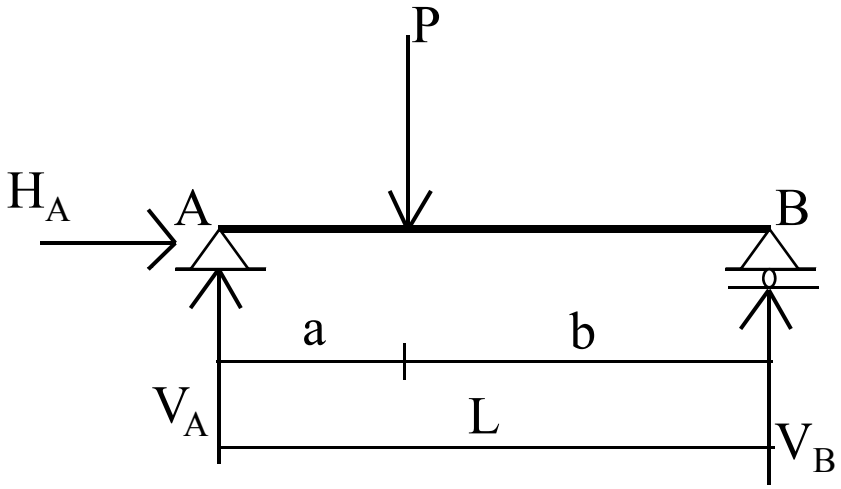
- Suatu balok akan teranalisa dengan secara lengkap apabila diagram gaya geser dan diagram momennya telah diperoleh.

- Diagram gaya geser dan momen suatu balok dapat digambarkan apabila semua reaksi luarnya telah diperoleh.

- Balok statis tertentu dapat berupa, balok sederhana yang terletak di atas dua tumpuan sendi rol, balok kantilever yang terletak di atas satu tumpuan jepit dan ujung lainnya lepas, dan balok gantung yang terletak di atas tumpuan sendi rol dengan salah satu atau kedua ujungnya ada perpanjangan.

Balok Sederhana

- Reaksi perletakan dan gaya dalam akibat beban terpusat



Balok AB akan seimbang, bila :

$$\Sigma H = 0 \rightarrow H_A = 0$$

$$\Sigma V = 0 \rightarrow V_A - V_B - P = 0$$

$$\Sigma M_B = 0 \rightarrow V_A.L - P.b = 0 \rightarrow V_A = \frac{P.b}{L}$$

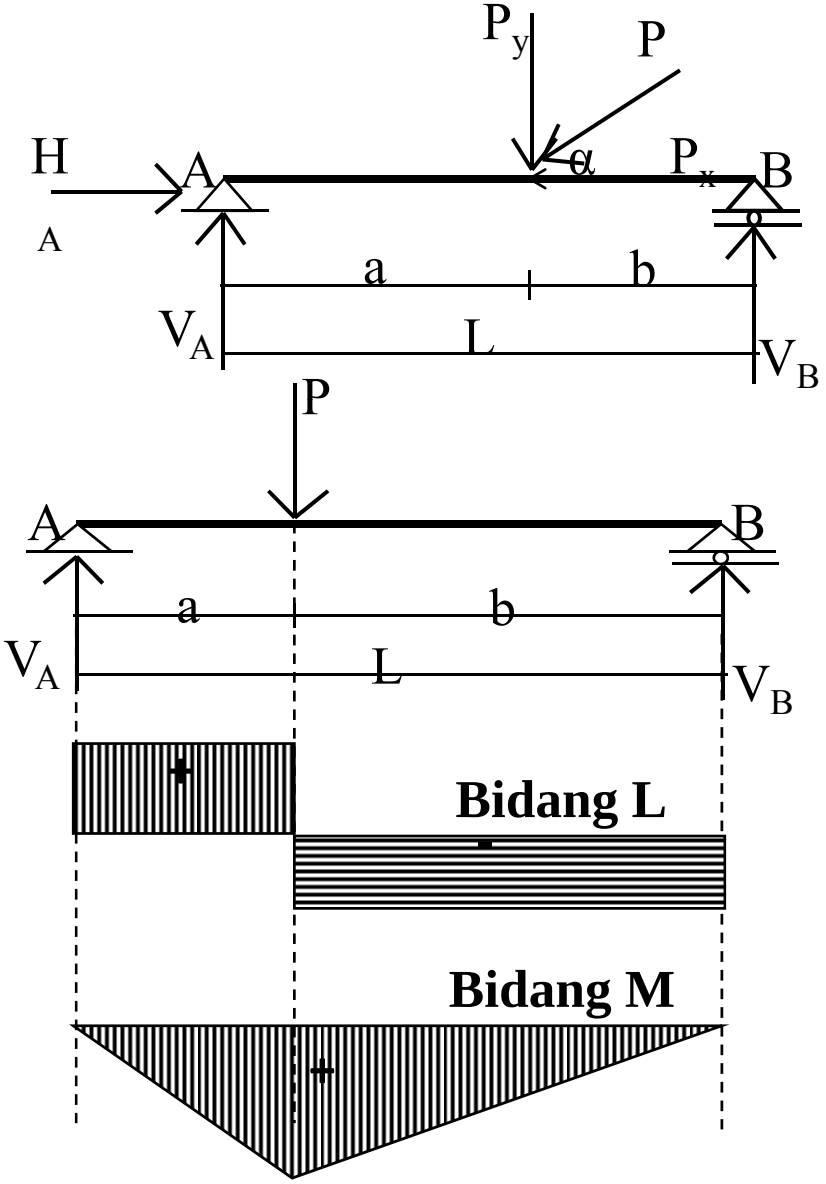
$$\Sigma M_A = 0 \rightarrow -V_B.L + P.a = 0 \rightarrow V_B = \frac{P.a}{L}$$

Penyelesaian reaksi perletakan balok :

- Semua gaya horizontal akan ditahan hanya oleh perletakan sendi saja.

- Reaksi-reaksi vertikl didapat dengan menggunakan persamaan momen terhadap salah satu titik perletakan.

Reaksi Perletakan dan Gaya-Gaya Dalam Pada Balok Sederhana Akibat Beban Terpusat



Keseimbangan gaya luar :

$$\Sigma H = 0 \rightarrow H_A - P_x = 0 \rightarrow H_A = P_x$$

$$\Sigma M_B = 0 \rightarrow V_A.L - P_y.b = 0 \rightarrow V_A = \frac{P_y.b}{L}$$

$$\Sigma M_A = 0 \rightarrow -V_B.L + P.a = 0 \rightarrow V_B = \frac{P_y.a}{L}$$

Keseimbangan gaya dalam :

$$0 \leq x \leq a$$

$$L_x = V_A$$

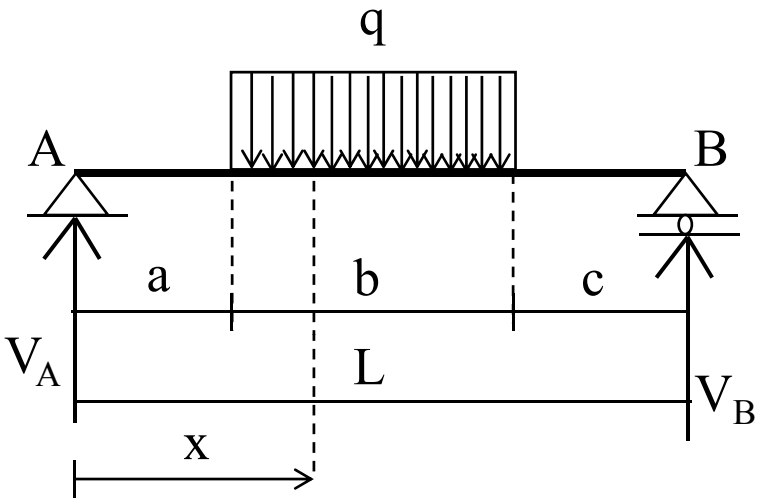
$$M_x = V_A.x$$

$$a \leq x \leq (a+b)/L$$

$$L_x = V_A - P$$

$$M_x = V_A.x - P(x-a)$$

Reaksi Perletakan Pada Balok Sederhana Akibat Beban Terbagi Rata



Keseimbangan gaya luar :

$$\Sigma M_B = 0 \rightarrow V_A.L - qb(1/2b + c) = 0$$

$$\rightarrow V_A = \frac{q.b(1/2b + c)}{L}$$

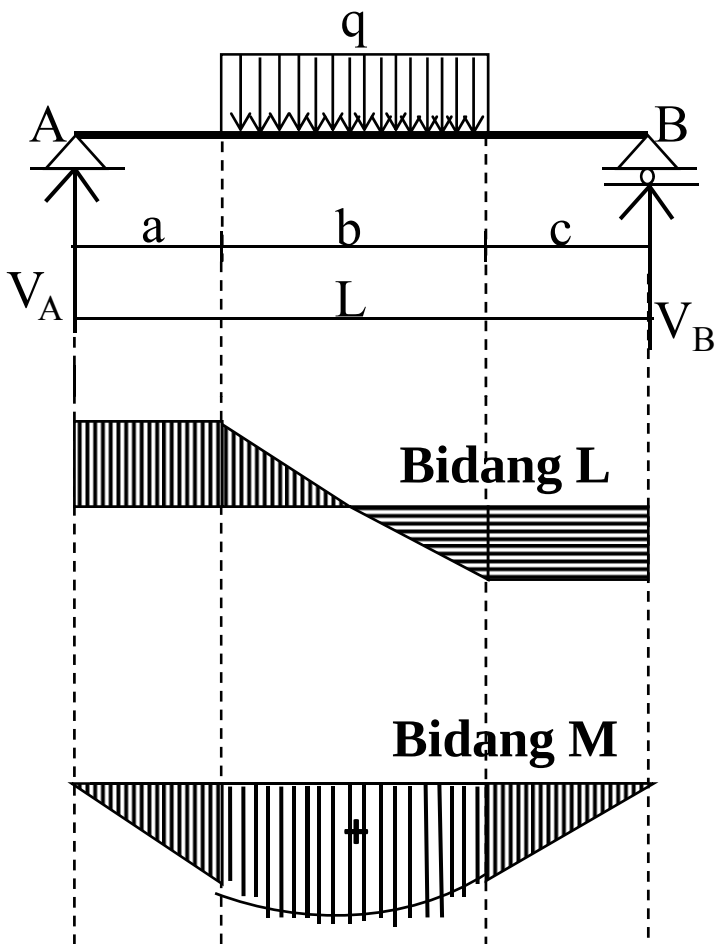
$$\Sigma M_A = 0 \rightarrow -V_B.L + q.b(1/2b + a) = 0$$

$$\rightarrow V_B = \frac{q.b(1/2b + a)}{L}$$

Bila a = 0, c = 0, dan b = L, maka balok dibebani muatan terbagi rata penuh, sehingga reaksinya adalah :

$$V_A = V_B = \frac{1}{2}q.L$$

Gaya-Gaya Dalam Pada Balok Sederhana Akibat Beban Terbagi Rata



Keseimbangan gaya dalam :

$0 \le x \le a$

$L_x = V_A$

$M_x = V_A.x$

$a \le x \le (a+b)/L$

$L_x = V_A - q(x-a)$

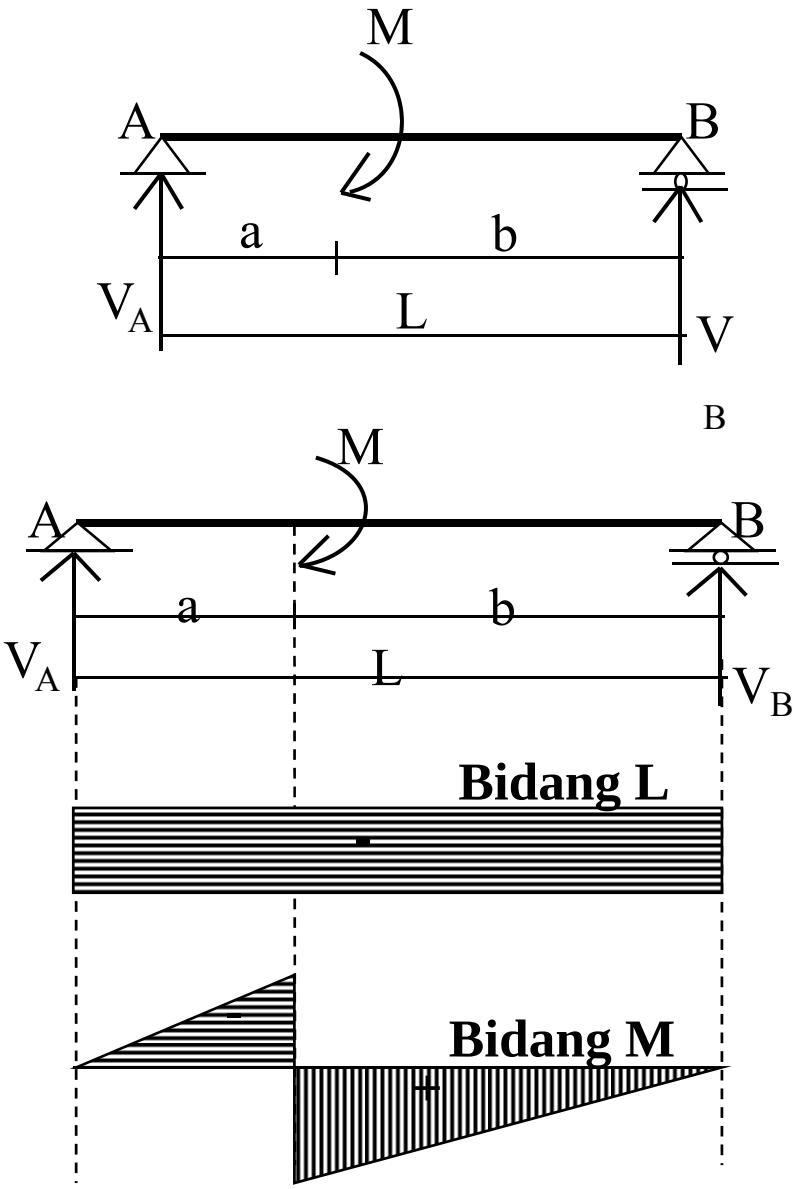
$M_x = V_A.x - 1/2q(x-a)^2$

$(a+b) \le x \le (a+b+c)/L$

$L_x = V_A - q.b$

$M_x = V_A.x - q.b(x - 1/2b)$

Reaksi Perletakan dan Gaya-Gaya Dalam Pada Balok Sederhana Akibat Beban Momen



Keseimbangan gaya luar :

$$\Sigma M_B = 0 \rightarrow V_A.L + M = 0 \rightarrow V_A = -\frac{M}{L}$$

$$\Sigma M_A = 0 \rightarrow -V_B.L + M = 0 \rightarrow V_B = \frac{M}{L}$$

Keseimbangan gaya dalam:

$$0 \le x \le a$$

$$L_x = -V_A$$

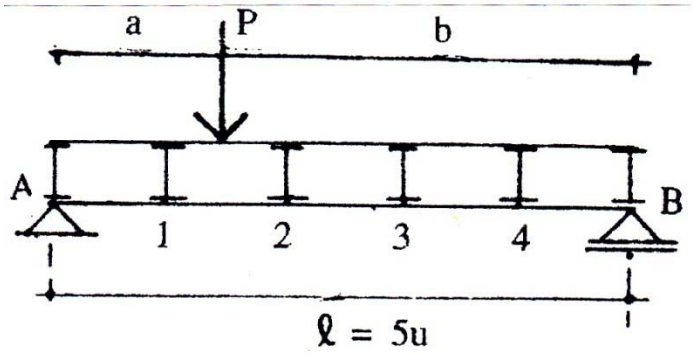
$$M_x = -V_A.x$$

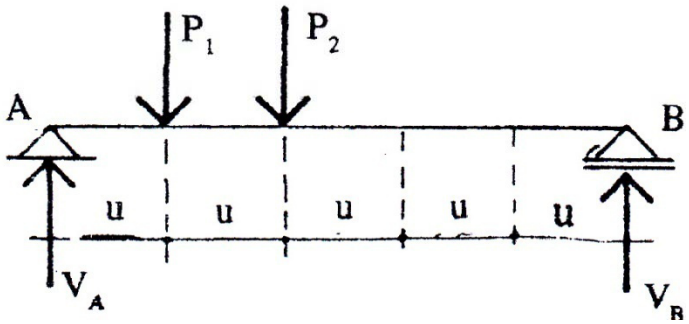
$$a \le x \le (a+b)/L$$

$$L_x = -V_B$$

$$M_x = V_B(L - x)$$

Reaksi Perletakan Pada Balok Sederhana Akibat Beban Tak Langsung





Uraian gaya P :

$$P_1 = \frac{2u - a}{u} P \qquad P_2 = \frac{a - u}{u} P$$

Keseimbangan gaya luar :

$$\Sigma M_B = 0 \rightarrow V_A.L - P_1.4u - P_2.3u = 0$$

$$\rightarrow V_A = \frac{P_1.4u + P_2.3u}{L}$$

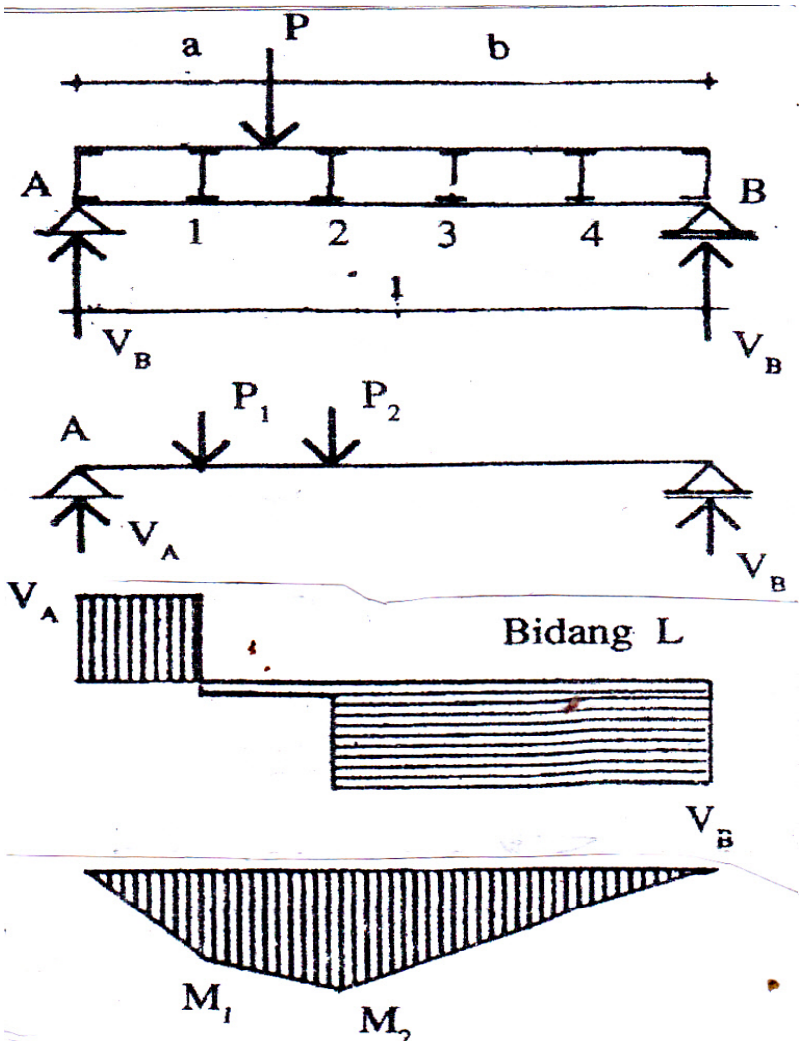
$$\Sigma M_A = 0 \rightarrow -V_B.L - P_1.u + P_2.2u = 0$$

$$\rightarrow V_B = \frac{P_1.u + P_2.2u}{L}$$

Dengan mensubstitusikan P_1 dan P_2 ke dalam persamaan V_A dan V_B, maka diperoleh :

$$V_A = \frac{P.b}{L} \qquad V_B = \frac{P.a}{L}$$

Gaya-Gaya Dalam Pada Balok Sederhana
Akibat Beban Tak Langsung



Keseimbangan gaya dalam :

$$0 \le x \le u$$

$$L_x = V_A$$

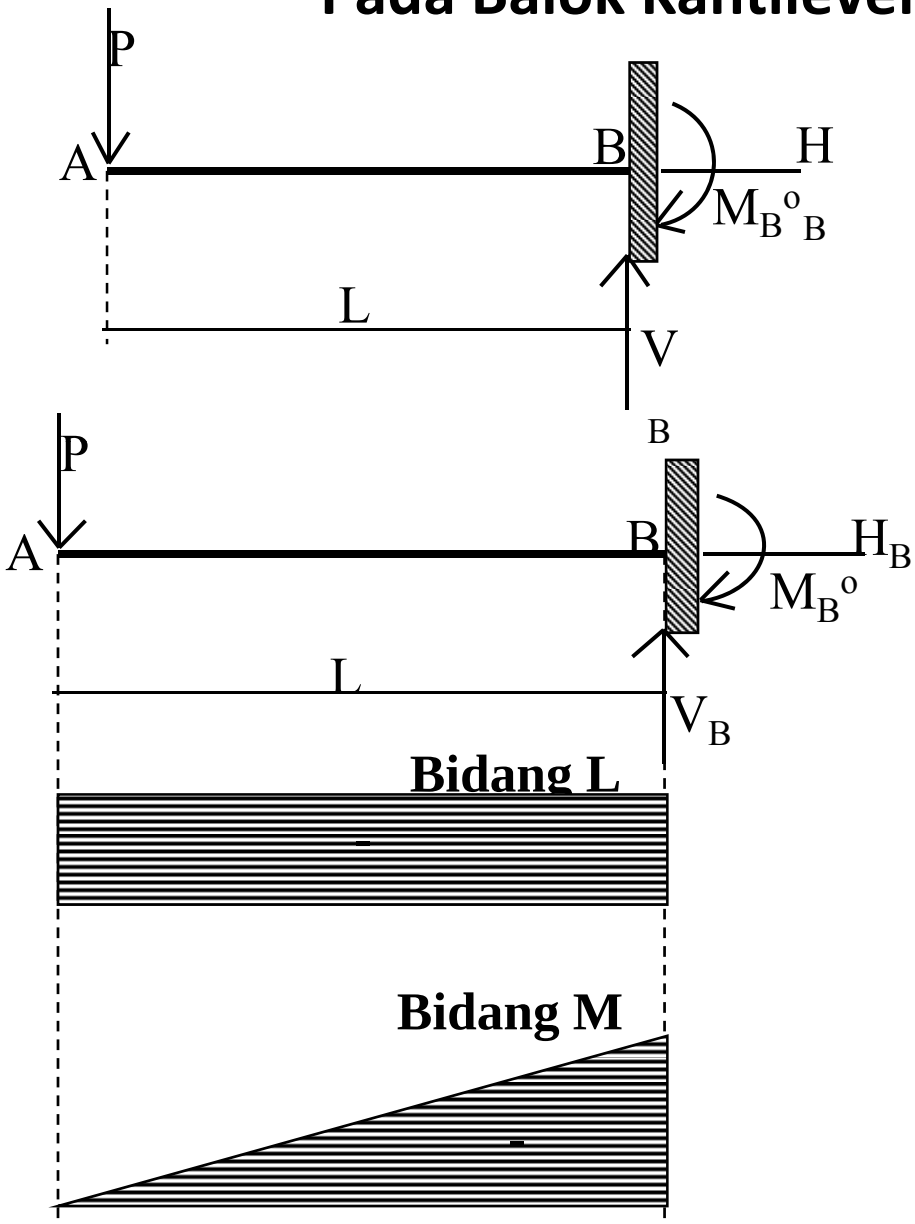
$$M_x = V_A . x$$

$$2u \le x \le L$$

$$L_x = -V_B$$

$$M_x = V_B (L - x)$$

Reaksi Perletakan dan Gaya-Gaya Dalam Pada Balok Kantilever Akibat Beban Terpusat



Keseimbangan gaya luar :

$\Sigma H = 0 \rightarrow H_B = 0$

$\Sigma V = 0 \rightarrow V_B - P = 0 \rightarrow V_B = P$

$\Sigma M_B = 0 \rightarrow P.L + M_B = 0 \rightarrow M_B{}^o = P.L$

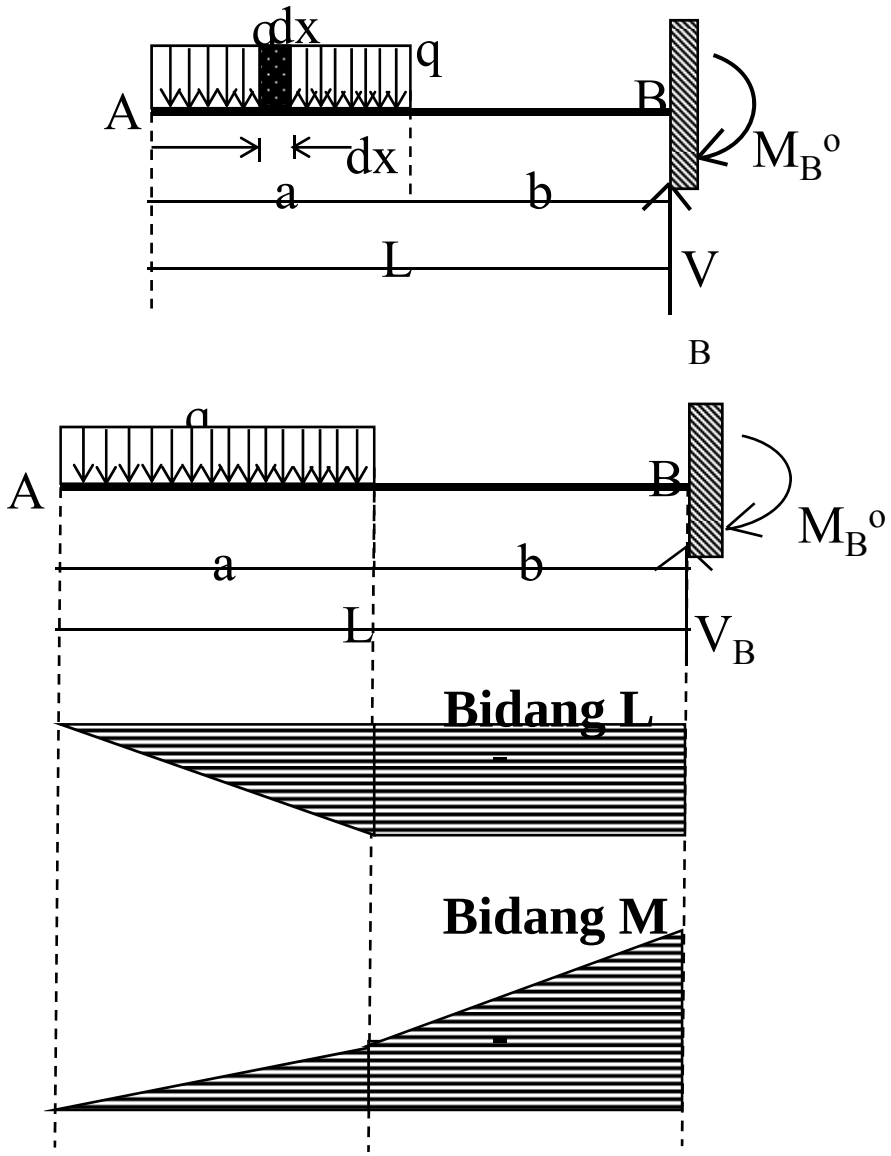
Keseimbangan gaya dalam :

$L \geq x \geq 0$

$L_x = -P$

$M_x = -P.x$

Reaksi Perletakan dan Gaya-Gaya Dalam Pada Balok Kantilever Akibat Beban Terbagi Rata



Keseimbangan gaya luar :

$$V_B = \int_0^a q.dx = q.dx = q.xI_0^a = q.a$$

$$M_B{}^o = \int_0^a q.dx(L-x) = q(L.x - 1/2x^2)I_0^a = q.a(L - 1/2a)$$

$$Bila \rightarrow a = L \rightarrow V_B = q.L \rightarrow M_B{}^o = 1/2.q.L^2$$

$$Bila \rightarrow a = 1/2.L \rightarrow V_B = 1/2.q.L \rightarrow M_B{}^o = 3/8.q.L$$

Keseimbangan gaya dalam :

$$0 \le x \le a$$

$$L_x = -q.x$$

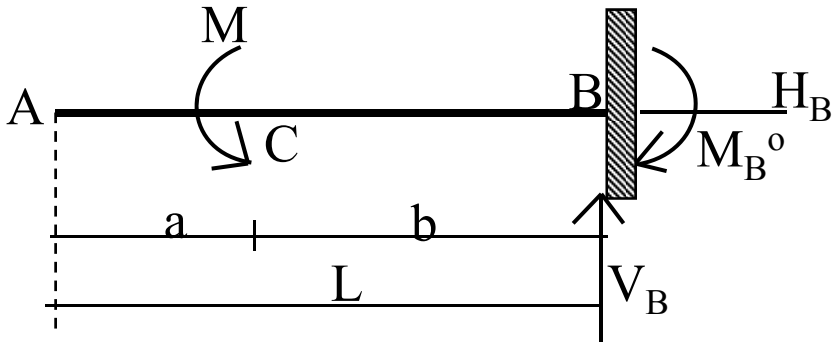
$$M_x = -1/2\, q.x^2$$

$$a \le x \le L$$

$$L_x = -q.a$$

$$M_x = -q.a(x - 1/2a)$$

Reaksi Perletakan dan Gaya-Gaya Dalam Pada Balok Kantilever Akibat Beban Momen

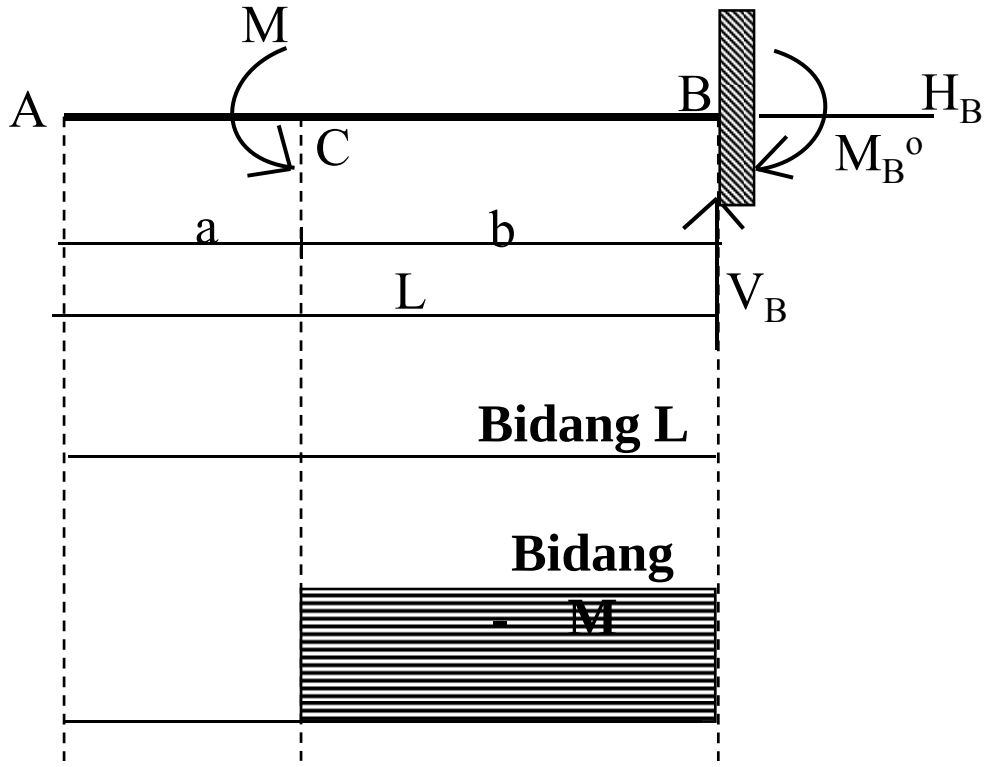


Keseimbangan gaya luar :

$\Sigma H = 0 \rightarrow H_B = 0$

$\Sigma V = 0 \rightarrow V_B = 0$

$\Sigma M_B{}^o = 0 \rightarrow M_B{}^o = M_1 + M_2$



Keseimbangan gaya dalam :

$0 \le x \le a$

$L_x = 0$

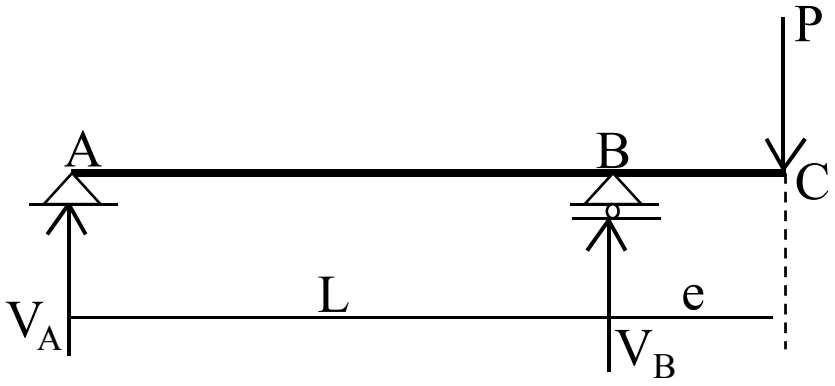
$M_x = 0$

$a \le x \le L$

$L_x = 0$

$M_x = M$

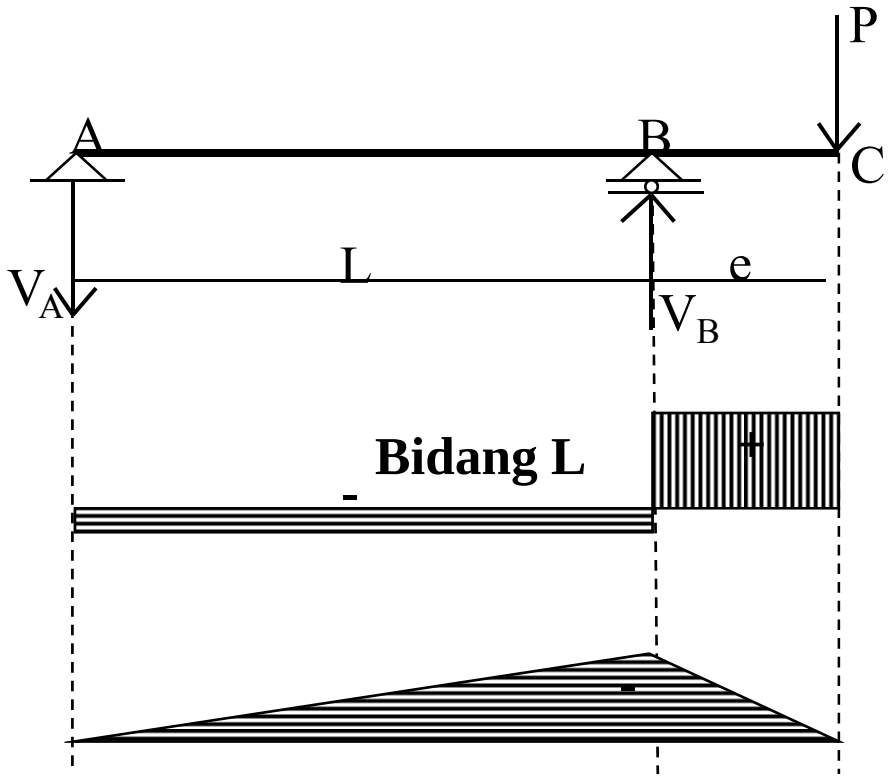
Reaksi Perletakan dan Gaya-Gaya Dalam Pada Balok Gantung Akibat Beban Terpusat



Keseimbangan gaya luar :

$$\Sigma M_B = 0 \rightarrow V_A.L + P.e = 0 \rightarrow V_A = \frac{-P.e}{L}$$

$$\Sigma M_A = 0 \rightarrow -V_B.L + P(e+L) = 0 \rightarrow V_B = \frac{P(e+L)}{L}$$



Keseimbangan gaya dalam :

$$0 \le x \le L$$

$$L_x = V_A$$

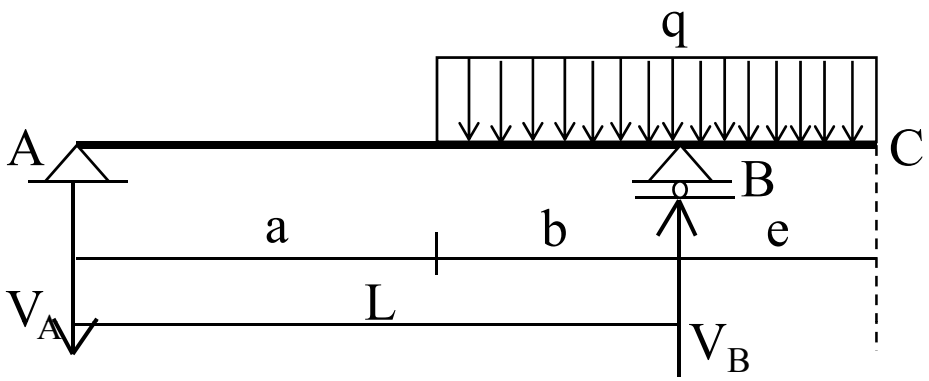
$$M_x = V_A.x$$

$$L \le x \le (L+e)$$

$$L_x = P$$

$$M_x = P(x-(L+e)$$

Reaksi Perletakan Pada Balok Gantung Akibat Beban Terbagi Rata



Keseimbangan gaya luar :

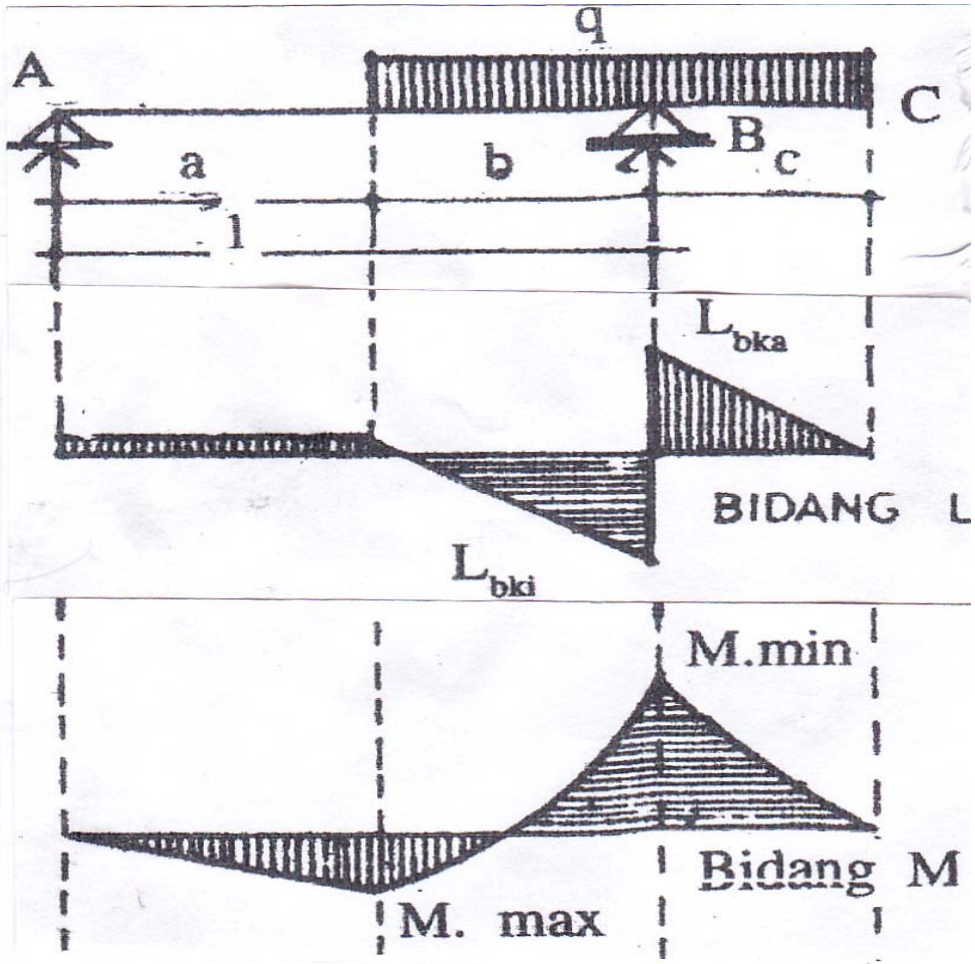
$$\Sigma M_B = 0 \rightarrow V_A.L - qb.1/2.b + q.e.1/2.e = 0$$

$$\rightarrow V_A = \frac{q.(b^2 - e^{2)}}{2L}$$

$$\Sigma M_A = 0 \rightarrow -V_B.L + q(L+e-a).((1/2(L+e-a)) + a) = 0$$

$$\rightarrow V_B = \frac{q.((L-e)^2 - a^2)}{2L}$$

Gaya-Gaya Dalam Pada Balok Gantung
Akibat Beban Terbagi Rata



Keseimbangan gaya dalam:

$$0 \le x \le a$$

$$L_x = V_A$$

$$M_x = V_A . x$$

$$a \le x \le L$$

$$L_x = V_A - q(x-a)$$

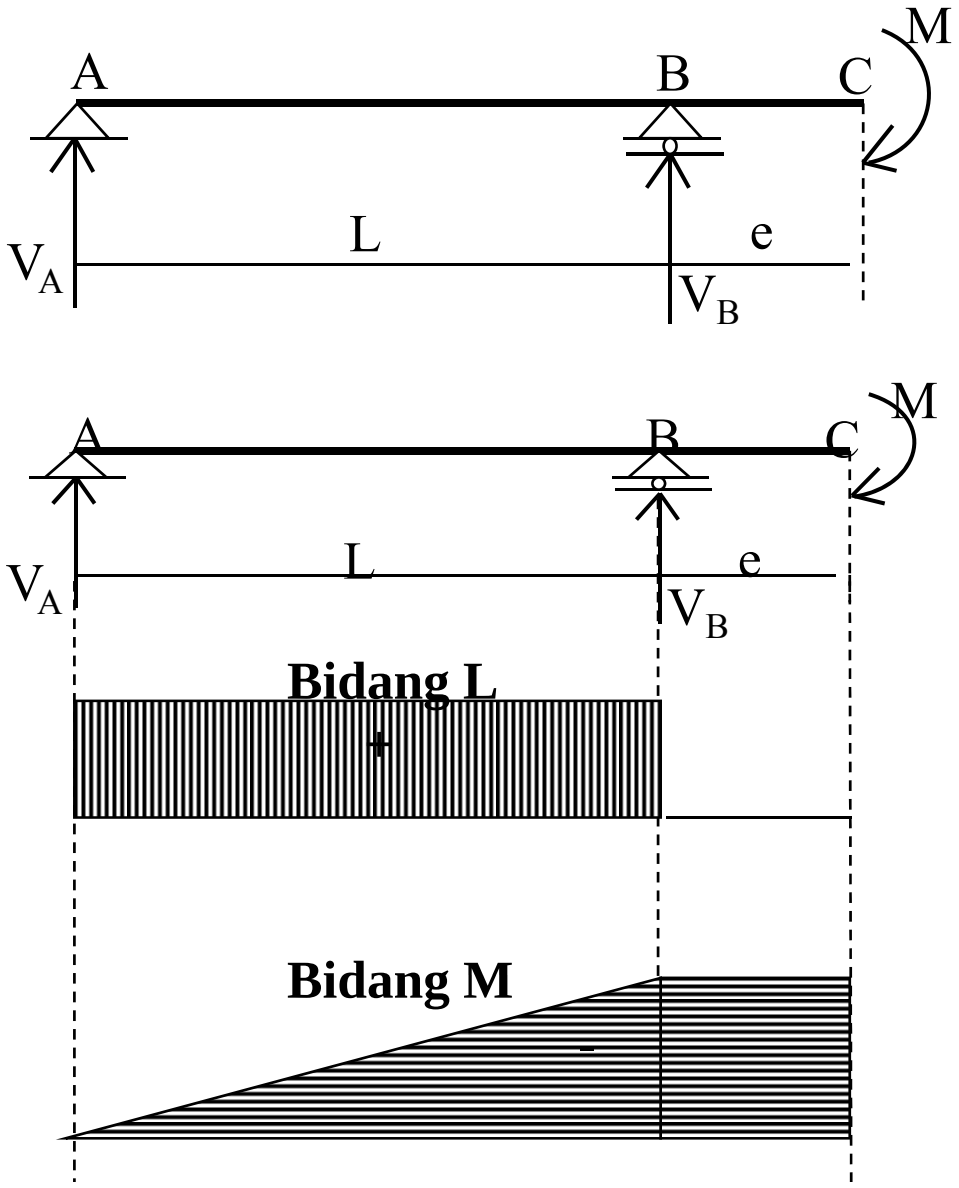
$$M_x = V_A . x - 1/2 q(x-a)^2$$

$$L \le x \le (L+e)$$

$$L_x = q(L+e-x)^2$$

$$M_x = -1/2 q(L+e-x)^2$$

Reaksi Perletakan dan Gaya-Gaya Dalam Pada Balok Gantung Akibat Beban Momen



Keseimbangan gaya luar :

$$\Sigma M_B = 0 \rightarrow -V_A.L + M = 0 \rightarrow V_A = \frac{M}{L}$$

$$\Sigma M_A = 0 \rightarrow -V_B.L + M = 0 \rightarrow V_B = \frac{M}{L}$$

Keseimbangan gaya dalam :

$$0 \le x \le L$$

$$L_x = V_A$$

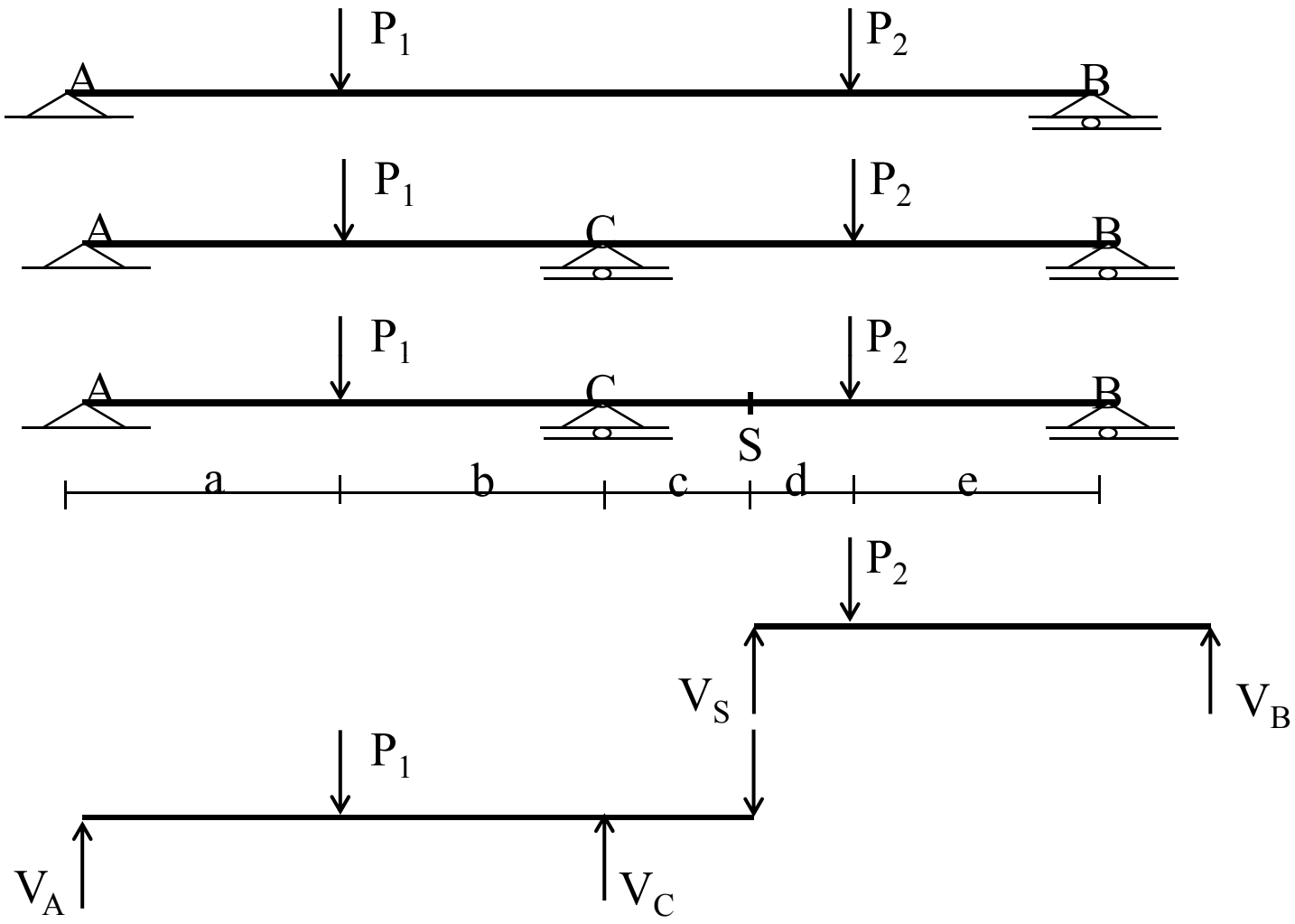
$$M_x = V_A.x$$

$$L \le x \le (L + e)$$

$$L_x = 0$$

$$M_x = -M$$

Konstruksi Balok Bersendi



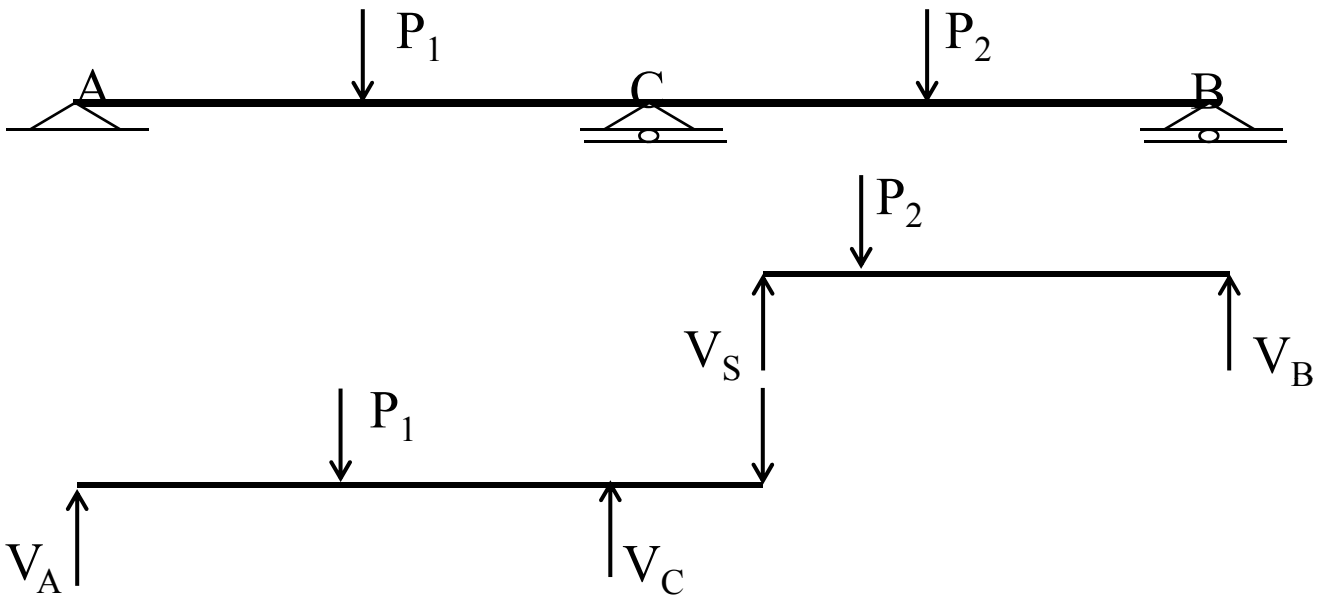
Konstruksi Balok Bersendi

- *Konstruksi Gerber* merupakan konstruksi balok di atas beberapa tumpuan, yang merupakan gabungan konstruksi balok gantung yang disambung dengan balok lain oleh sendi.

- Untuk menghindari timbulnya momen lentur yang besar pada konstruksi yang mempunyai bentang yang lebar, seringkali digunakan penunjang diantara dua perletakan,

- Konstruksi menjadi statis tak-tentu. Untuk mengembalikan sifat konstruksi itu menjadi konstruksi statis tertentu digunakan sambungan sendi.

Reaksi Perletakan Pada Konstruksi Balok Bersendi



Keseimbangan gaya luar :

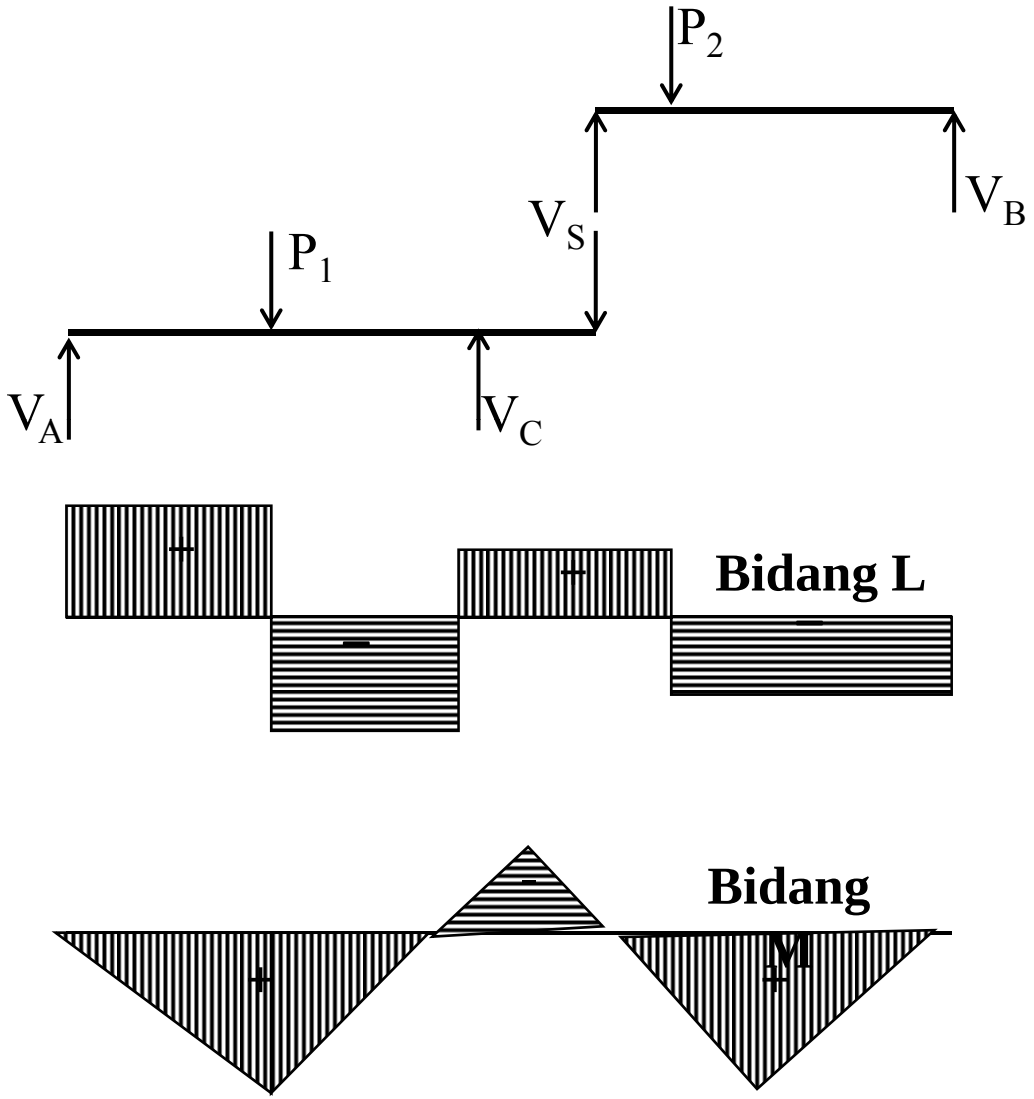
$$\Sigma H = 0 \rightarrow H_A = 0$$

$$\Sigma V = 0 \rightarrow V_A + V_B - P_1 - P_2 = 0$$

$$\Sigma M_A = 0 \rightarrow P_1.a - V_C.L_{AC} + P_2.(L_{AB} - e) = 0$$

$$\Sigma M_S = 0 \rightarrow -V_{B.}.L_{SB} + P_2.d = 0$$

Gaya-Gaya Dalam Pada Konstruksi Balok Bersendi



Keseimbangan gaya dalam :

$$\Sigma M_S = 0 \rightarrow V_B.L_{SB} - P_2.d = 0$$

$$\rightarrow V_B = \frac{P_2.d}{L_{SB}}$$

$$\Sigma M_B = 0 \rightarrow -V_S.L_{SB} + P_2.e = 0$$

$$\rightarrow V_S = \frac{P_2.e}{L_{SB}}$$

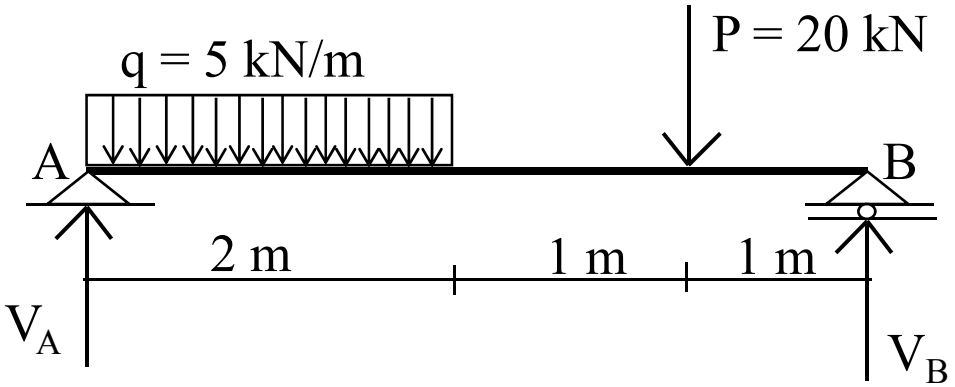
$$\Sigma M_C = 0 \rightarrow V_A.L_{AC} - P_1.b + V_S.c = 0$$

$$\rightarrow V_A = \frac{P_2.b - V_S.c}{L_{AC}}$$

$$\Sigma M_A = 0 \rightarrow -V_C.L_{AC} + P_1.a + V_S.(L_{AC} + c) = 0$$

$$\rightarrow V_C = \frac{P_1.a + V_S.(L_{AC} + c)}{L_{AC}}$$

Contoh Soal 1 dan Pembahasan



Keseimbangan gaya luar :

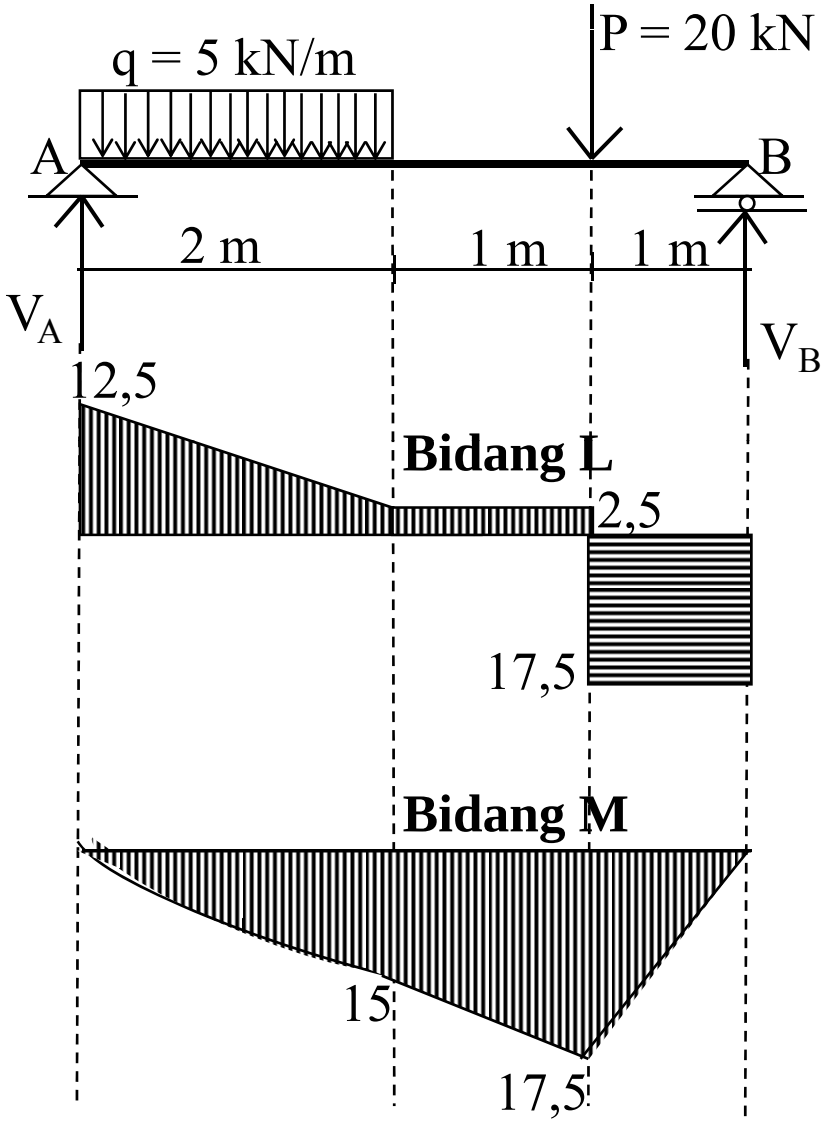
$$\Sigma M_B = 0 \rightarrow V_A.4 - 5.2.(1+2) - 20.1 = 0$$

$$\rightarrow V_A = \frac{30+20}{4} = 12{,}5kN.(\uparrow)$$

$$\Sigma M_A = 0 \rightarrow -V_B.4 + 5.2.1 + 20.3 = 0$$

$$\rightarrow V_B = \frac{10+60}{4} = 17{,}5kN.(\uparrow)$$

Contoh Soal 1 dan Pembahasan



Keseimbangan gaya dalam :

$0 \le x \le 2m$

$L_x = V_A - q.x$

$x = 0 \rightarrow L_0 = 12,5 - 5.0 = 12,5kN$

$x = 1m \rightarrow L_1 = 12,5 - 5.1 = 7,5kN$

$x = 2m \rightarrow L_2 = 12,5 - 5.2 = 2,5kN$

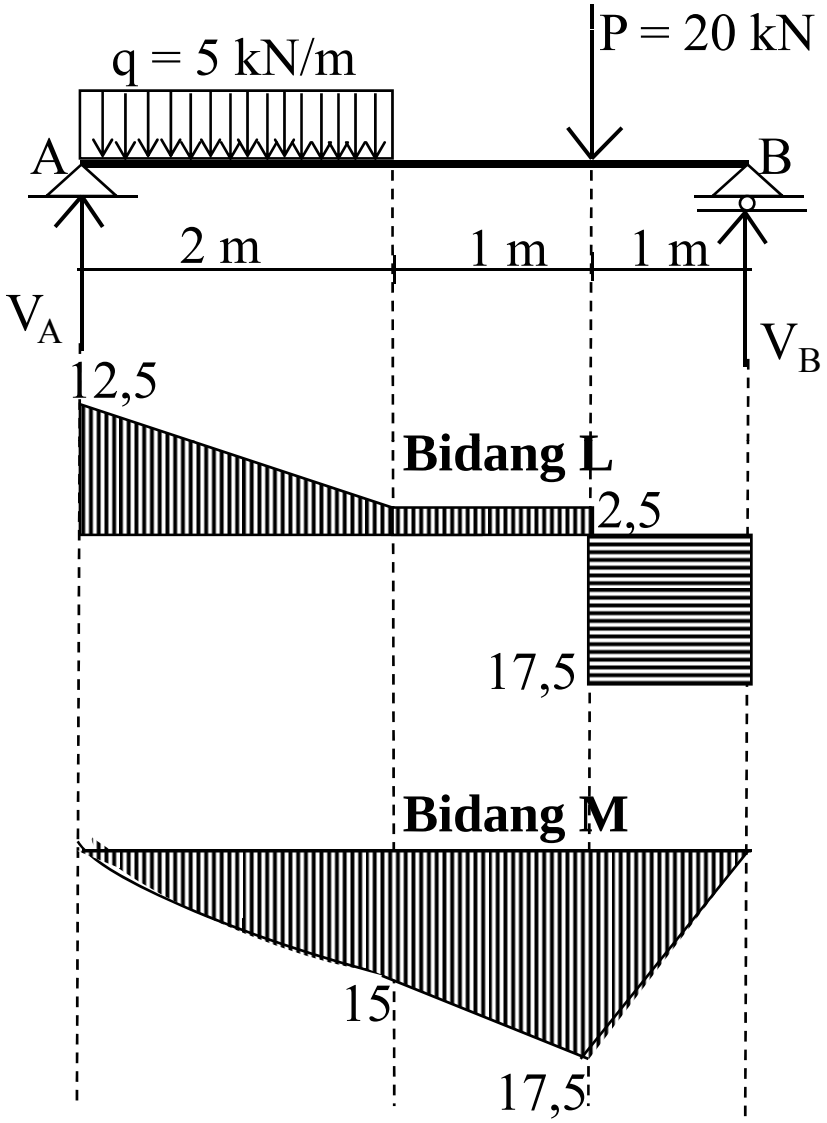
$M_x = V_A.x - 1/2qx^2$

$x = 0 \rightarrow M_0 = 12,5.0 - 1/2.5.0^2 = 0$

$x = 1m \rightarrow M_1 = 12,5.1 - 1/2.5.1^2 = 10kNm$

$x = 2m \rightarrow M_2 = 12,5.2 - 1/2.5.2^2 = 15kNm$

Contoh Soal 1 dan Pembahasan



Keseimbangan gaya dalam :

$2m \le x \le 3m$

$L_x = V_A - qb$

$x = 2m \rightarrow L_2 = 12{,}5 - 5.2 = 2{,}5kN$

$x = 3m \rightarrow L_3 = 12{,}5 - 5.2 = 2{,}5kN$

$M_x = V_A.x - q.b(x - 1/2.b)$

$x = 2m \rightarrow M_2 = 12{,}5.2 - 5.2(2 - 1/2.2) = 15kNm$

$x = 3m \rightarrow M_3 = 12{,}5.3 - 5.2(3 - 1/2.2) = 17{,}5kNm$

$3m \le x \le 4m$

$L_x = V_A - qb - P$

$x = 3m \rightarrow L_3 = 12{,}5 - 5.2 - 20 = -17{,}5kN$

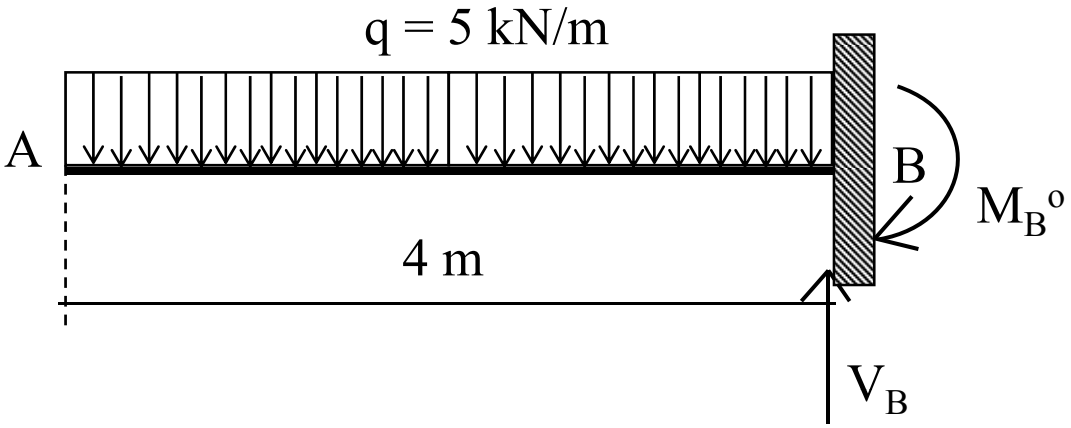
$x = 4m \rightarrow L_4 = 12{,}5 - 5.2 - 20 = -17{,}5kN$

$M_x = V_A.x - q.b(x - 1/2.b) - P(x - a)$

$x = 3m \rightarrow M_3 = 12{,}5.3 - 5.2(3 - 1/2.2) - 20(3 - 3) = 17{,}5kNm$

$x = 4m \rightarrow M_4 = 12{,}5.4 - 5.2(4 - 1/2.2) - 20(4 - 3) = 0kNm$

Contoh Soal 2 dan Pembahasan



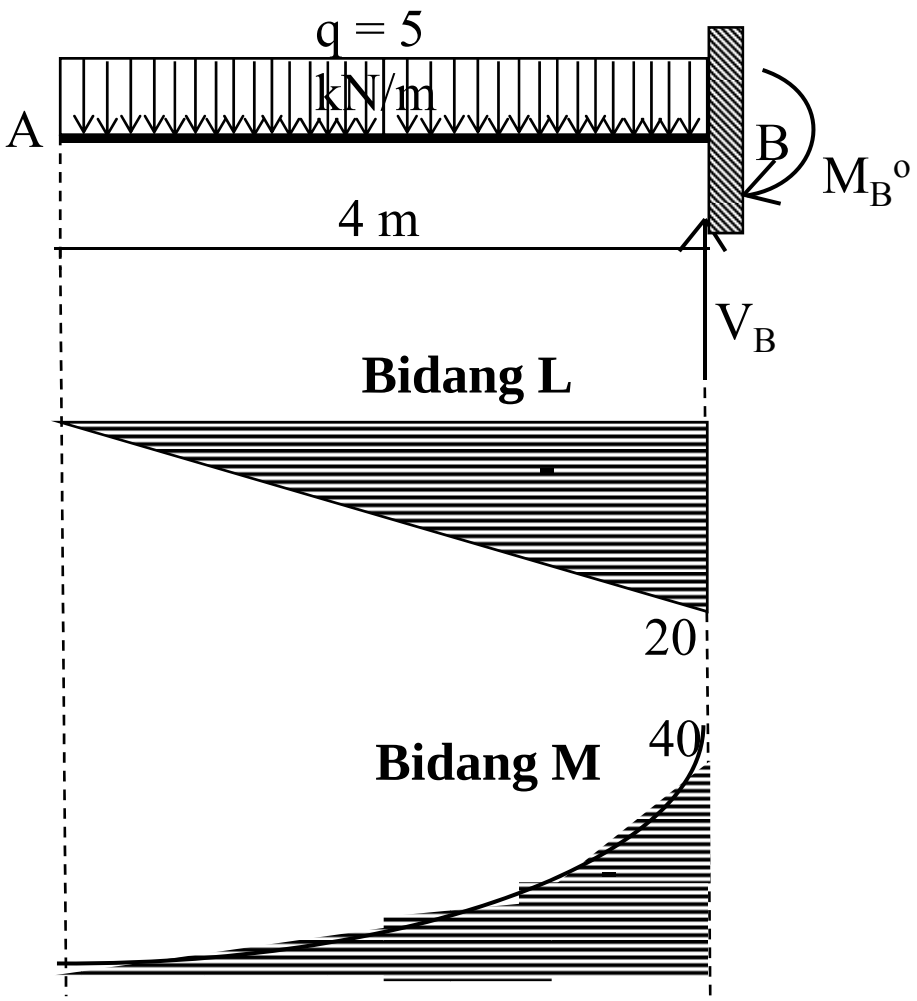
Keseimbangan gaya luar :

$$\Sigma H = 0 \rightarrow H_B = 0$$

$$\Sigma V = 0 \rightarrow V_B - 5.4 = 0 \rightarrow V_B = 20 kN$$

$$\Sigma M_B = 0 \rightarrow -1/2.5.4^2 + M_B = 0 \rightarrow M_B^{\ o} = 40 kNn$$

Contoh Soal 2 dan Pembahasan



Keseimbangan gaya dalam :

$0 \le x \le 4m$

$L_x = -q.x$

$x = 0 \rightarrow L_0 = -5.0 = 0kN$

$x = 1m \rightarrow L_1 = -5.1 = -5kN$

$x = 2m \rightarrow L_2 = -5.2 = -10kN$

$x = 3m \rightarrow L_3 = -2.3 = -15kN$

$x = 4m \rightarrow L_4 = -5.4 = -20kN$

$M_x = -1/2.q.x^2$

$x = 0 \rightarrow M_0 = -1/2.5.0^2 = -0kNm$

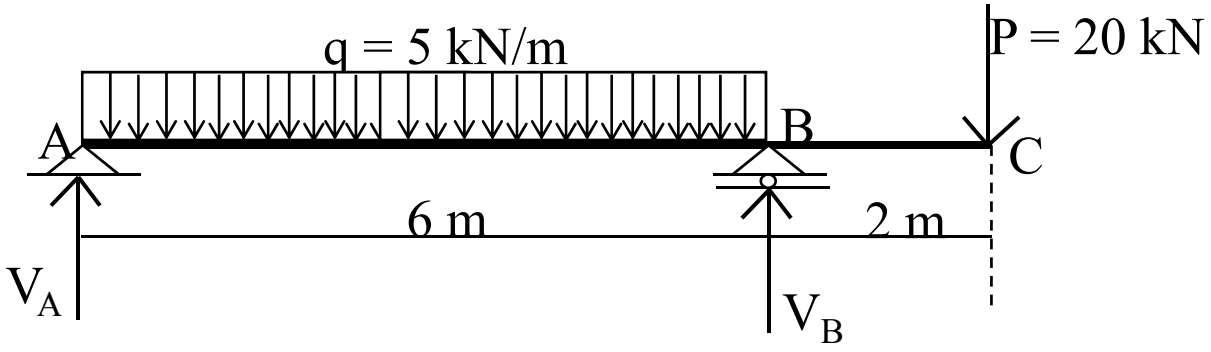
$x = 1m \rightarrow M_1 = -1/2.5.1^2 = -2,5kNm$

$x = 2m \rightarrow M_2 = -1/2.5.2^2 = -10kNm$

$x = 3m \rightarrow M_3 = -1/2.5.3^2 = -22,5kNm$

$x = 4m \rightarrow M_4 = -1/2.5.4^2 = 40kNm$

Contoh Soal 3 dan Pembahasan



Keseimbangan gaya luar :

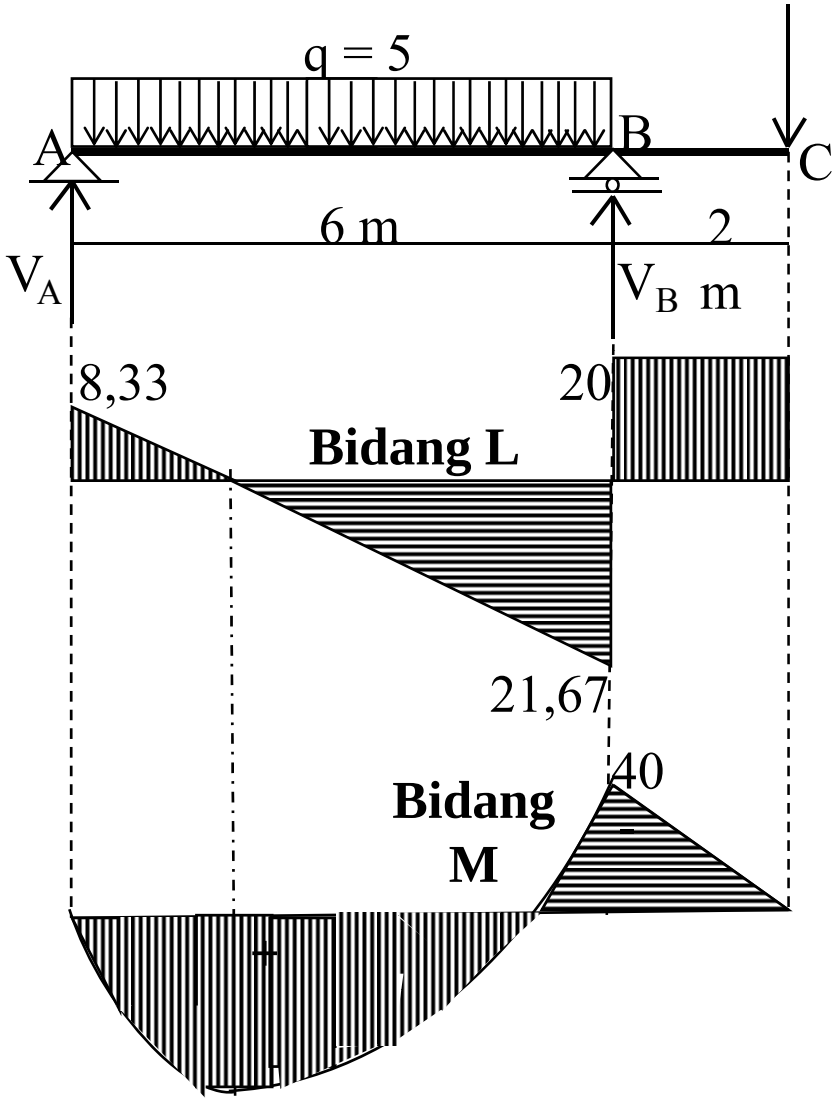
$$\Sigma M_B = 0 \rightarrow V_A.6 - 5.6.3 + 20.2 = 0$$

$$\rightarrow V_A = \frac{90 - 40}{6} = 8{,}33kN.(\uparrow)$$

$$\Sigma M_A = 0 \rightarrow -V_B.6 + 5.6.3 + 20.8 = 0$$

$$\rightarrow V_B = \frac{90 + 160}{6} = 41{,}67kN.(\uparrow)$$

Contoh Soal 3 dan Pembahasan



Keseimbangan gaya dalam :

$$0 \le x \le 6m$$

$$L_x = V_A - q.x$$

$$x = 0 \rightarrow L_0 = 8{,}33 - 5.0 = 8{,}33kN$$

$$x = 1m \rightarrow L_1 = 8{,}33 - 5.1 = 3{,}33kN$$

$$x = 2m \rightarrow L_2 = 8{,}33 - 5.2 = -1{,}67kN$$

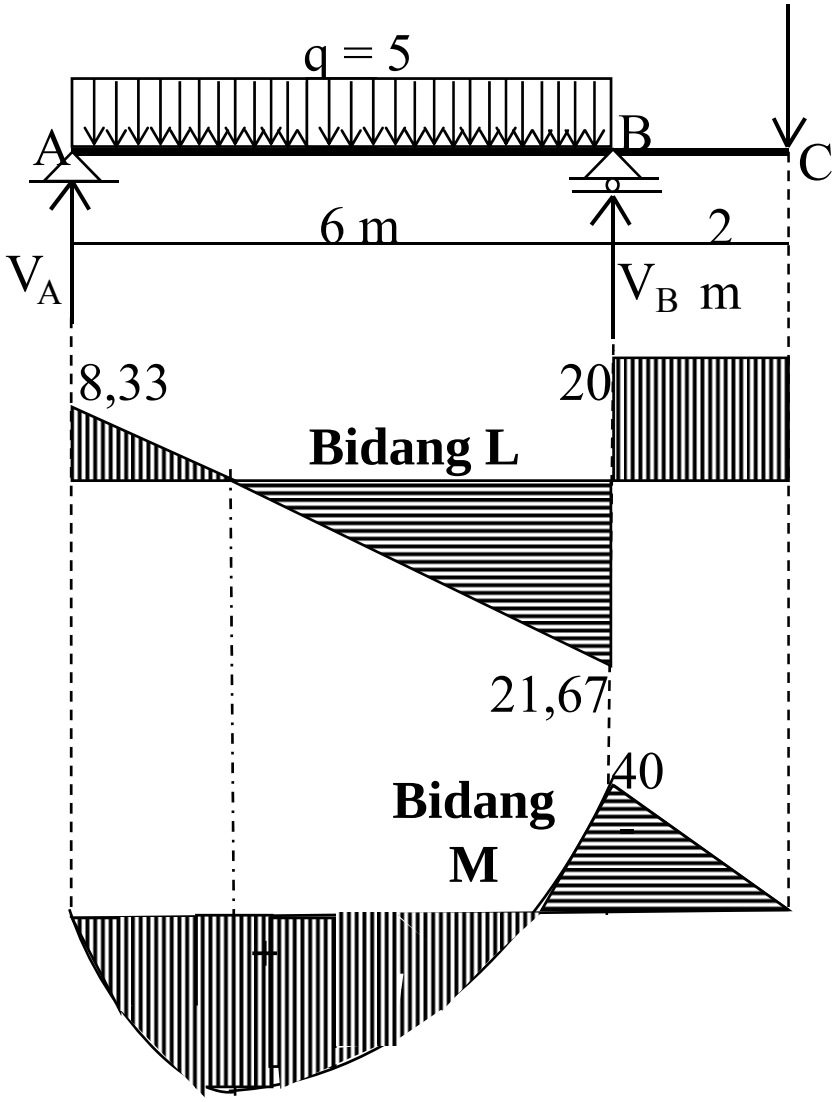
$$x = 3m \rightarrow L_3 = 8{,}33 - 5.3 = -6{,}67kN$$

$$x = 4m \rightarrow L_4 = 8{,}33 - 5.4 = -11{,}67kN$$

$$x = 5m \rightarrow L_5 = 8{,}33 - 5.5 = -16{,}67kN$$

$$x = 6m \rightarrow L_6 = 8{,}33 - 5.6 = -21{,}67kN$$

Contoh Soal 3 dan Pembahasan



Keseimbangan gaya dalam :

$$M_x = V_A.x - 1/2.q.x^2$$

$$x = 0m \rightarrow M_0 = 8{,}33.0 - 1/2.5.0^2 = 0$$

$$x = 1m \rightarrow M_1 = 8{,}33.1 - 1/2.5.1^2 = 5{,}83kNm$$

$$x = 2m \rightarrow M_2 = 8{,}33.2 - 1/2.5.2^2 = 6{,}66kNm$$

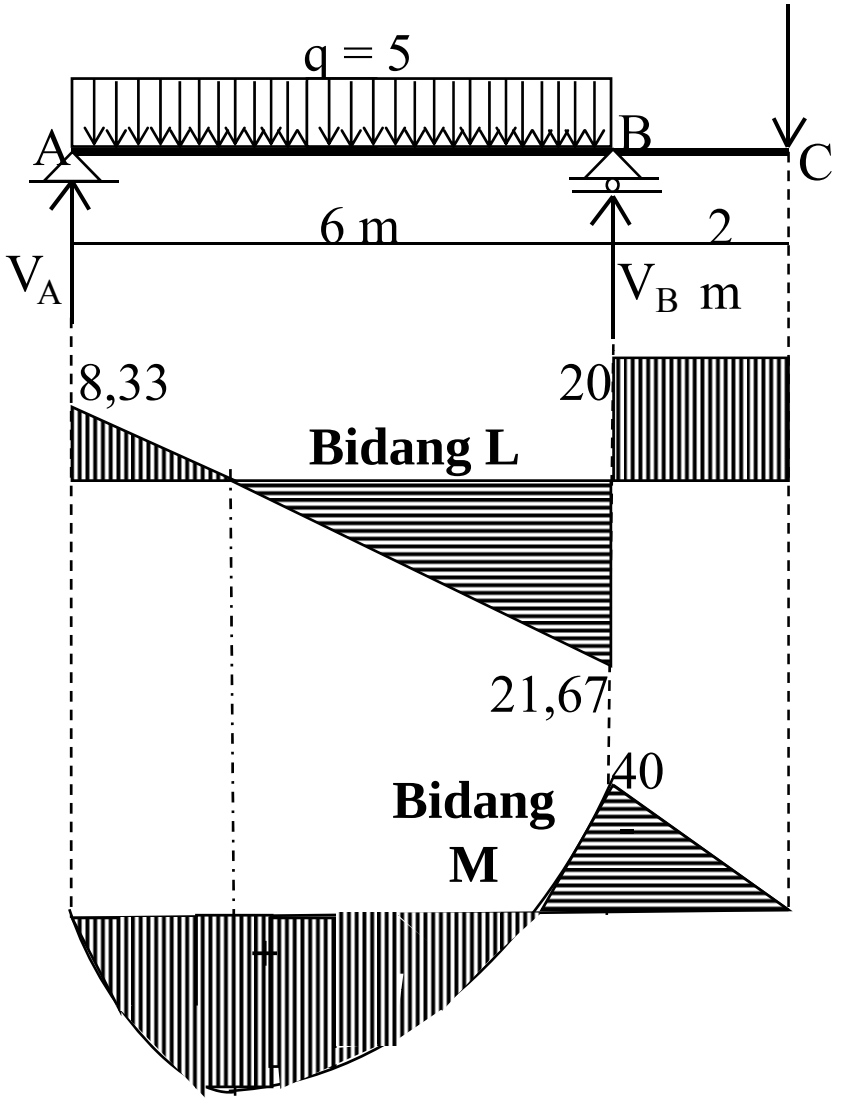
$$x = 3m \rightarrow M_3 = 8{,}33.3 - 1/2.5.3^2 = 2{,}49kNm$$

$$x = 4m \rightarrow M_4 = 8{,}33.4 - 1/2.5.4^2 = -6{,}68kNm$$

$$x = 5m \rightarrow M_5 = 8{,}33.5 - 1/2.5.5^2 = -20{,}85kNm$$

$$x = 6m \rightarrow M_6 = 8{,}33.6 - 1/2.5.6^2 = -40kNm$$

Contoh Soal 3 dan Pembahasan



Keseimbangan gaya dalam :

$6m \le x \le 8m$

$L_x = V_A - qb + V_B$

$x = 6m \rightarrow L_6 = 8{,}33 - 5.6 + 41{,}67 = 20kN$

$x = 7m \rightarrow L_7 = 8{,}33 - 5.6 + 41{,}67 = 20kN$

$x = 8m \rightarrow L_8 = 8{,}33 - 5.6 + 41{,}67 = 20kN$

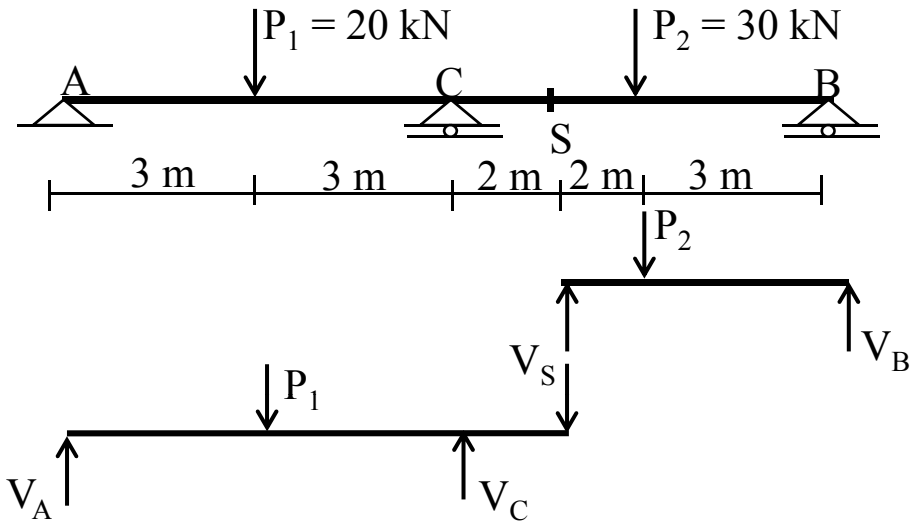
$M_x = V_A.x - q.b(x - 1/2L) + V_B(x - L)$

$x = 6m \rightarrow M_6 = 8{,}33.6 - 5.6(6-3) + 41{,}67(6-6) = 40kNm$

$x = 7m \rightarrow M_7 = 8{,}33.7 - 5.6(7-3) + 41{,}67(7-6) = 20kNm$

$x = 8m \rightarrow M_8 = 8{,}33.8 - 5.6(8-3) + 41{,}67(8-6) = 0$

Contoh Soal 4 dan Pembahasan



Keseimbangan gaya luar :

$$\Sigma M_S = 0 \rightarrow V_B .5 - 30 .2 = 0$$

$$\rightarrow V_B = \frac{30 .2}{5} = 12 .kN$$

$$\Sigma M_B = 0 \rightarrow -V_S .5 + 30 .3 = 0$$

$$\rightarrow V_S = \frac{30 .3}{5} = 18 .kN$$

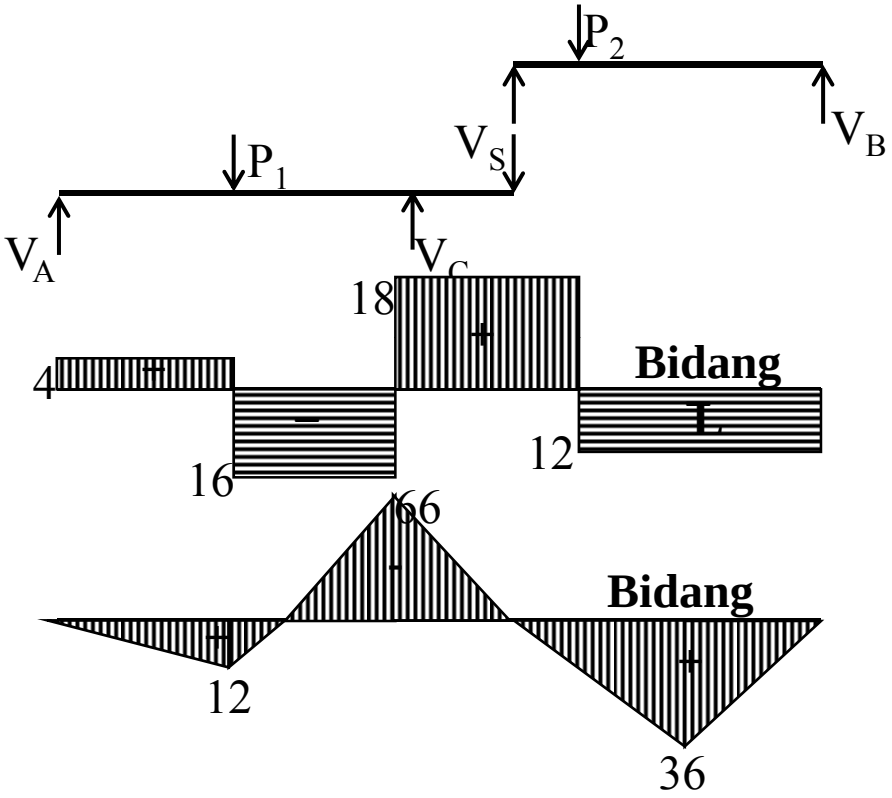
$$\Sigma M_C = 0 \rightarrow V_A .6 - 20 .3 + 18 .2 = 0$$

$$\rightarrow V_A = \frac{60 - 36}{6} = 4 .kN$$

$$\Sigma M_A = 0 \rightarrow -V_C .6 + 20 .3 + 18 .8 = 0$$

$$\rightarrow V_C = \frac{60 + 144}{6} = 34 .kN$$

Contoh Soal 4 dan Pembahasan



Keseimbangan gaya dalam :

$0 \le x \le 3m$

$L_X = V_A$

$x = 0 \rightarrow L_0 = 4.kN$

$x = 3m \rightarrow L_3 = 4.kN$

$M_x = V_A.x$

$x = 0 \rightarrow M_0 = 0$

$x = 3m \rightarrow M_3 = 4.3 = 12.kNm$

$3m \le x \le 6m$

$L_X = V_A - P_1$

$x = 3m \rightarrow L_3 = 4 - 20 = -16.kN$

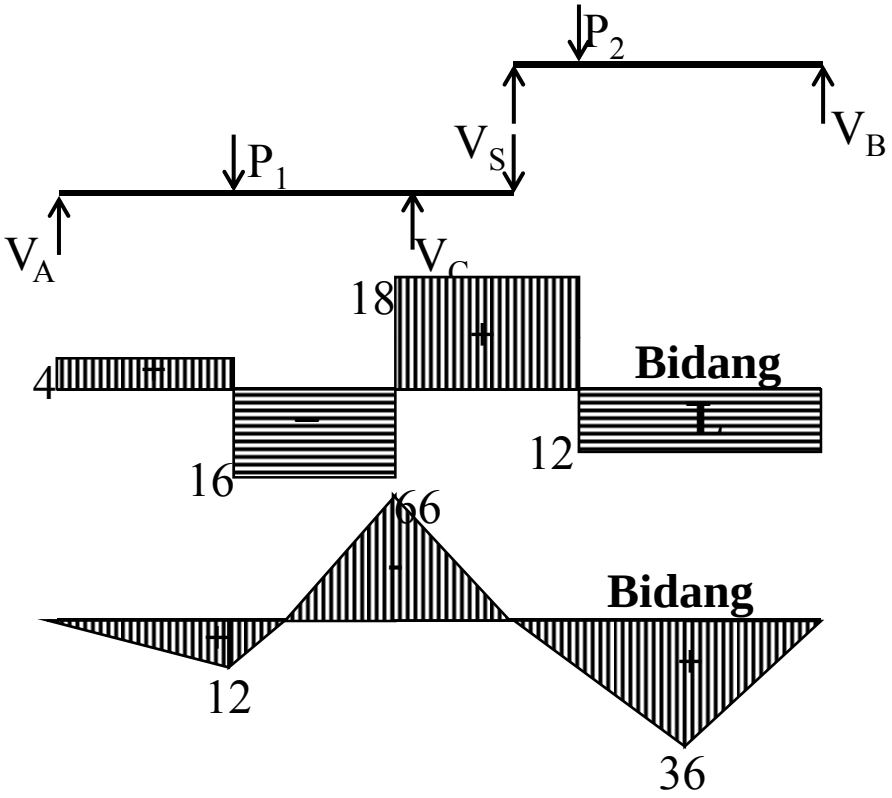
$x = 6m \rightarrow L_6 = 4 - 20 = -16.kN$

$M_x = V_A.x - P_1.(x - a)$

$x = 3m \rightarrow M_3 = 4.3 - 20.(3 - 3) = 12.kNm$

$x = 6m \rightarrow M_6 = 4.6 - 20.(6 - 3) = -66.kNm$

Contoh Soal 4 dan Pembahasan



Keseimbangan gaya dalam :

$6m \le x \le 8m$

$L_X = V_A - P_1 + V_C$

$x = 6m \rightarrow L_6 = 4 - 20 + 34 = 18.kN$

$x = 8m \rightarrow L_8 = 4 - 20 + 34 = 18.kN$

$M_x = V_A.x - P_1.(x-a) + V_C.(x - L_{AC})$

$x = 6m \rightarrow M_6 = 4.6 - 20.(6-3) + 34.(6-6) = -66.kNm$

$x = 8m \rightarrow M_8 = 4.8 - 20.(8-3) + 34.(8-6) = 0.kNm$

$0 \le x \le 3\,m$

$L_X = -V_B$

$x = 0\,m \rightarrow L_0 = -12\ .kN$

$x = 3\,m \rightarrow L_3 = -12\ .kN$

$M_x = V_B\ .x$

$x = 0\,m \rightarrow M_0 = 12\ .0 = 0\ .kNm$

$x = 3\,m \rightarrow M_3 = 12\ .3 = 36\ .kNm$