E. Ramy.

I. Rama trójkątna z przegubami stopowymi.

1.

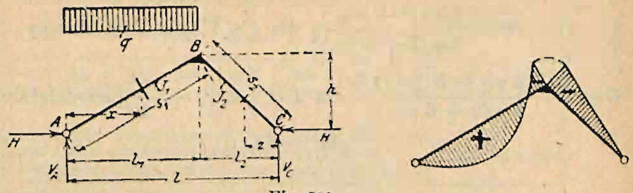


Fig. 513.

$$V_A = \frac{q l_1}{2 l}(l + l_2) \qquad V_C = \frac{q l_1^2}{2 l} \qquad k = \frac{J_2}{J_1} \cdot \frac{s_1}{s_2}$$

$$H = \frac{q l_1^2}{8 h l} \cdot \frac{4 l_2 + (l + 4 l_2) k}{k + 1}.$$

Dla AB: $M_x = + V_A x - H \cdot \frac{h x}{l_1} - \frac{q x^2}{2}$

$M_B = + V_C l_2 - H h.$

„ BC: $M_z = + V_C z - H \cdot \frac{h z}{l_2}$

„ AB: $N_x = + (V_A - q x) \frac{h}{s_1} + H \cdot \frac{l_1}{s_1}$

„ BC: $N = + V_C \cdot \frac{h}{s_2} + H \cdot \frac{l_2}{s_2}.$

2.

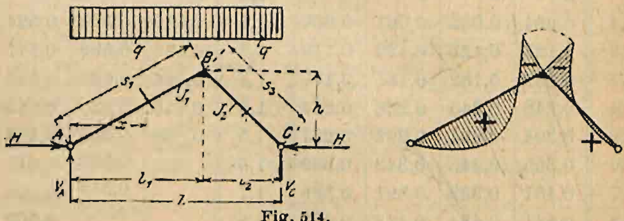


Fig. 514.

$$V = \frac{q l}{2} \qquad k = \frac{J_2}{J_1} \cdot \frac{s_1}{s_2}$$

$$H = \frac{q}{8 h} \cdot \frac{l_2 (4 l_1 + l_2) + (l_1 + 4 l_2) l_1 k}{k + 1}.$$

Dla AB: $M_x = + \frac{q x (l - x)}{2} - H \cdot \frac{h x}{l}$

$M_B = + \frac{q l_1 l_2}{2} - H h$

„ BC: $M_z = + \frac{q z (l - z)}{2} - H \cdot \frac{h z}{l_2}$

„ AB: $N_x = + (V - q x) \frac{h}{s_1} + H \cdot \frac{l_1}{s_1}.$

3.

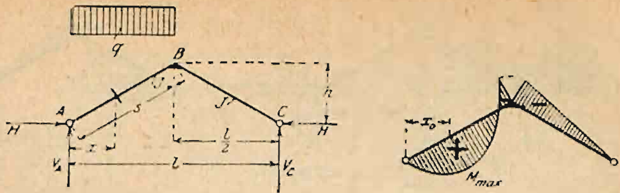


Fig. 515.

$$V_A = \frac{3}{8} q l \qquad V_C = \frac{q l}{8} \qquad H = \frac{5 q l^2}{64 h} \qquad k = 1.$$

Dla AB: $M_x = + \frac{7 q l x}{32} - \frac{q x^2}{2} \qquad M_B = - \frac{q l^2}{64}$

$+ M_{\max} = + \frac{49}{2048} q l^2 = \infty + \frac{q l^2}{42}$ $\left(\text{występuje dla } x_0 = \frac{7}{32} l\right)$.

Dla BC: $M_x = - \frac{q l x}{32}$ (x mierzone od c)

„ AB: $N_x = + (V_A - q x) \frac{h}{s} + H \cdot \frac{l}{2 s}$

„ BC: $N = + V c \cdot \frac{h}{s} + H \cdot \frac{l}{2 s}$.

4.

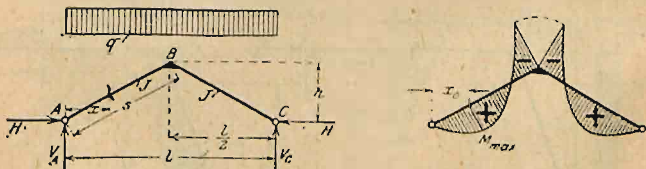


Fig. 516.

$$V = \frac{q l}{2} \quad H = \frac{5 q l^2}{32 h}. \qquad k = 1$$

Dla AB: $M_x = + \frac{3 q l x}{16} - \frac{q x^2}{2} \qquad M_B = - \frac{q l^2}{32}$

$+ M_{\max} = + \frac{9}{512} q l^2 = \infty + \frac{q l^2}{57}$; dla $x_0 = \frac{3}{16} l$.

Dla AB i BC: $N_x = + (V - q x) \frac{h}{s} + H \cdot \frac{l}{2 s}$

$\left(\begin{array}{c} x \text{ mierzone od } A, \\ \text{wzgl. } B \end{array}\right)$.

5.

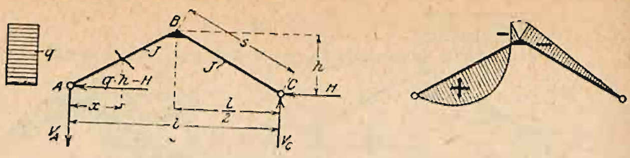


Fig. 517.

$$V = \frac{q h^2}{2 l} \qquad H = \frac{5}{16} \cdot q h. \qquad\qquad k = 1$$

Dla AB: $\qquad M_x = + \frac{q h^2 x}{8 l^2} (7 l - 16 x) \qquad M_B = - \frac{q h^2}{16}.$

Dla BC: $\qquad M_x = - \frac{q h^2 x}{8 l}$ (x mierzone od C)

„ AB: $\qquad N_x = - V \cdot \frac{h}{s} - \left(q h - H - \frac{2 q h x}{l}\right) \frac{l}{2 s}$

„ BC: $\qquad N = + V \cdot \frac{h}{s} + H \cdot \frac{l}{2 s}.$

II. Rama dwuprzegubowa ze słupem ukośnym i ryglem poziomym.

6.

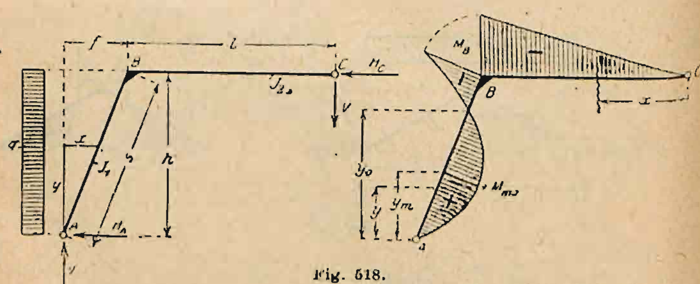


Fig. 518.

$$H_A = \frac{q h}{8} \left[4 - \frac{k \cdot s^2 (l + f)}{h^2 l (l + 1)} \right] \qquad\qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$H_C = q h - H_A$$

$$V = \frac{q s^2 k}{8 k (l + 1)} \qquad \begin{aligned} M_y &= + H_A \cdot y + V \cdot x - \tfrac{1}{2} q y^2 \\ M_B &= + H_A \cdot h - \tfrac{1}{2} q h^2 \end{aligned}$$

$$y_m = \frac{1}{q} \left(H_A + V \frac{f}{h} \right) \qquad M_x = - V \cdot x.$$

7.

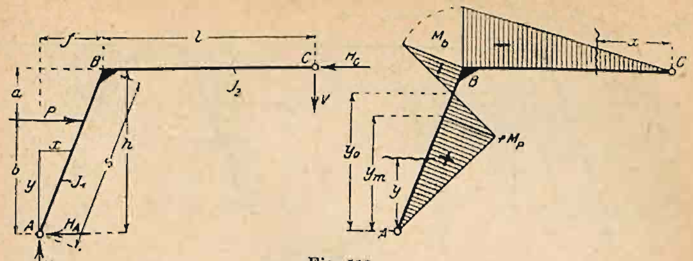


Fig. 519.

$$H_A = P.\frac{a}{h} - V\frac{l+f}{h} \qquad H_C = P.\frac{b}{h} + V\frac{l+f}{h} \qquad k = \frac{J_2}{J_1}.\frac{h}{l}$$

$$V = \frac{P.a\,b\,k\,s^2(h+b)}{2\,h^4 l\,(k+1)}.$$

Pole b: $M_y = +H_A.y + V.x \quad M_P + H_A.b + V.f.{}^1/_2\,b$

" a: $M_y = +H_A.y + V.x - P(y-b)$

$M_B = -V.l \qquad M_x = -V.x.$

8.

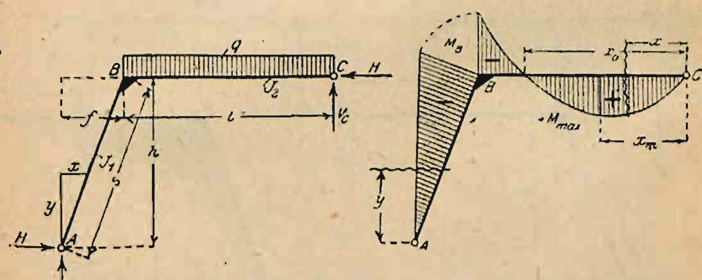


Fig. 520.

$$V_A = \frac{q\,l^2}{2\,(l+f)} + H\frac{h}{l+f} \qquad V_C = \frac{q\,l}{2}\cdot\frac{l+2f}{l+f} - H\frac{h}{l+f}$$

$$H = \frac{q\,l}{8\,h^2(k+1)}\left\{h\,(l+5f) + 4\,f\,s^2\,k\right\}.$$

$M_y = +V_A.x - H.y \qquad M_B = +V_A.f - H.h$

$M_x = +V_C.x - {}^1/_2\,q\,x^2.$

max M występuje w miejscu: $x_m = \dfrac{V_c}{q}.$

9.

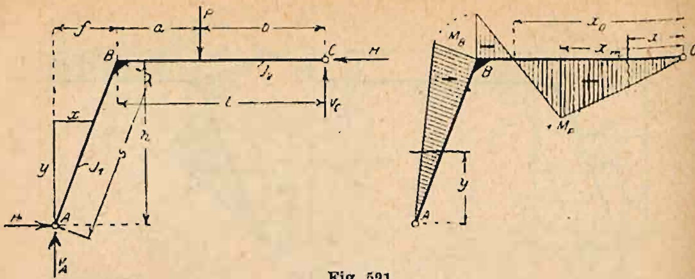


Fig. 521.

$$V_A = P.\frac{b}{l+f} + H\,\frac{h}{l+f} \qquad\qquad k = \frac{J_2}{J_2}\cdot\frac{h}{l}$$

$$V_C = P.\frac{a+f}{l+f} - H\frac{h}{l+f}$$

$$H = \frac{P.b}{2\,h^3 l^3 (k+1)}\left[h^2\left\{2\,b^2(a+f)+3\,a\,f\,(2b+a)+a^2\,(3\,b+a)\right\}+2l^2 f s^2 k\right]$$

$$M_y = +V_A . f . \frac{y}{h} - H . y \qquad M_B = +V_A . f - H . h$$

Pole b: $M_x = +V_C . x \quad M_P = +V_C . b$

„ a: $M_x = +V_C . x - P(x-b)$.

10.

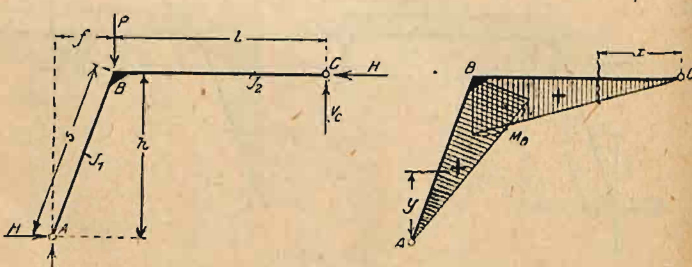


Fig. 522.

$$V_A = P . \frac{l}{l+f} + H . \frac{h}{l+f}$$

$$V_C = P . \frac{f}{l+f} - H . \frac{h}{l+f}$$

$$H = Pf . \frac{h^2 + s^2 k}{h^3 (k+1)} .$$

$$M_y = +V_A . f . \frac{y}{h} - H . y \qquad M_B = +V_C . l \qquad M_x = +V_C . x .$$

III. Rama prostokątna dwuprzegubowa.

11.

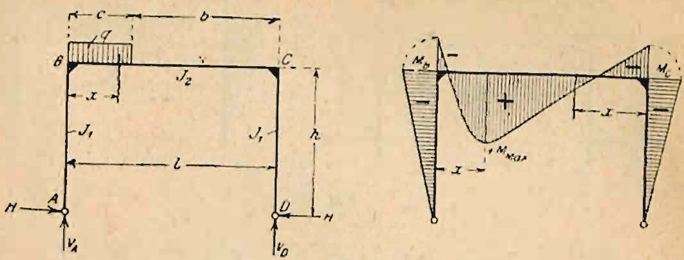


Fig. 523.

$$V_A = \frac{qc}{2l}(l+b) \qquad V_D = \frac{qc^2}{2l} \qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$H = \frac{qc^2}{4hl} \cdot \frac{l+2b}{2k+3} \qquad M_B = M_C = -Hh = -\frac{qc^2}{4l} \cdot \frac{l+2b}{2k+3}.$$

Pole c: $M_x = +V_A x - \frac{1}{2} q x^2 - M_B$ (x mierzone od B)

$+M_{\max} = +\frac{qc^2}{8l^2}(l+b)^2 - M_B$ w miejscu $x = \frac{c}{2l}(l+b) < c$.

Pole b: $M_x = +V_D x - M_C$ (x mierzone od C).

12.

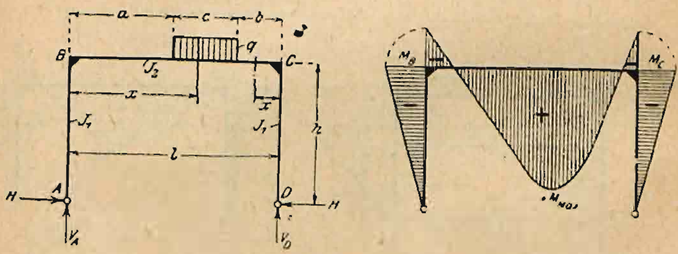


Fig. 524.

$$V_A = \frac{qc}{2l}(2b+c) \qquad V_D = \frac{qc}{2l}(2a+c)$$

$$H = \frac{qc}{4hl} \cdot \frac{(6bl + 3cl - 6bc - 6b^2 - 2c^2)}{2k+3} \qquad M_B = M_C = -H \,.\, h.$$

Pole a: $M_x = +V_A x - M_B$ (x mierzone od B)

„ c: $M_x = +V_A x - q \cdot \frac{1}{2}(x-a)^2 - M_B$ (x „ „ B)

„ b: $M_x = +V_D x - M_C$ (x „ „ C).

$M_{\max}$ występuje w miejscu $x_m = a + \frac{c}{2l}(2b+c)$.

W rozporze: $+M_{\max} = +\frac{qc(2b+c)}{2l}\left[a + \frac{c}{4l}(2b+c)\right] - M_B$.

Dla obciążenia symetr. $a = b$: $V_A = V_D = \frac{1}{2} qc \quad H = \frac{qc}{8hl} \cdot \frac{3l^2 - c^2}{2k+3}$.

13.

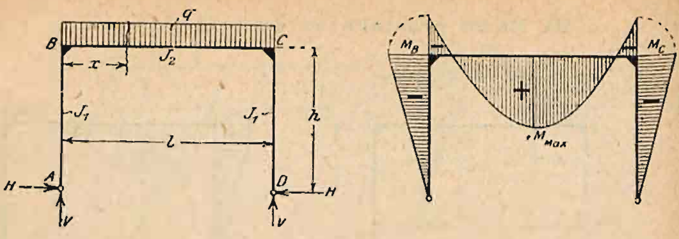


Fig. 525.

$$V = \frac{q l}{2} \qquad M_B = M_C = -H \,.\, h = -\frac{q l^2}{4(2k+3)} \qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$H = \frac{q l^2}{4 h (2k+3)}$$

$$M_x = M_0 - M_B = {}^1/_2\, q\, x\, (l - x) - M_B.$$

W rozporze $M_{\max} = + \dfrac{2k+1}{2k+3} \cdot \dfrac{q l^2}{8}$ (w środku rozpory).

14.

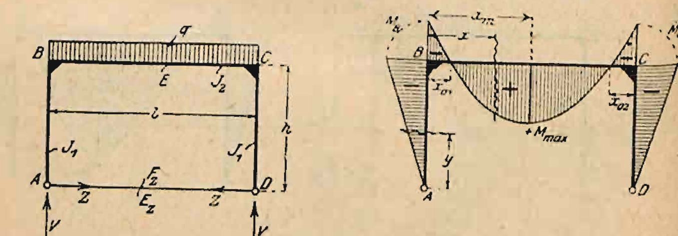


Fig. 526.

$$V = \frac{q l}{2} \qquad n = \frac{E J_2}{E_z F_z}$$

$$Z = \frac{1}{4} \, \frac{q h l^2}{h^2(2k+3) + 3n}.$$

$E\,(E_z)$ = spółczynnik sprężystości materjału ramy (cięgna):

F_z = przekrój cięgna.

$$M_B = M_c = -Zh = -\frac{1}{4} \, \frac{q h^2 l^2}{h^2(2k+3) + 3n}.$$

W rozporze: $+M_{\max} = + {}^1/_8\, q l^2 - M_B.$

15.

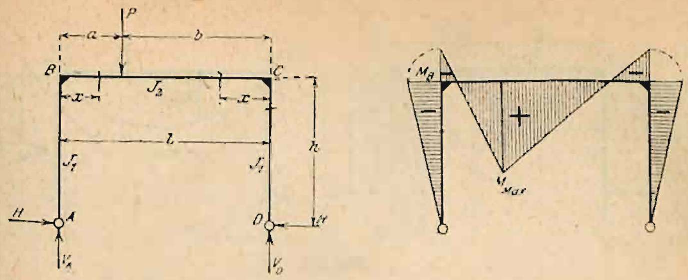


Fig. 527.

$$V_A = \frac{Pb}{l} \qquad V_D = \frac{Pa}{l} \qquad H = \frac{3\,P\,a\,b}{2\,h\,l\,(2\,k + 3)} \qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$M_B = M_C = -\,H \,.\, h = -\,\frac{3\,a\,b}{2\,l\,(2\,k+3)} \cdot P.$$

W polu a: $\quad M_x = +\,\frac{Pb}{l} \,.\, x - M_B \quad$ (x mierzone od B)

„ b: $\quad M_x = +\,\frac{Pa}{l} \,.\, x - M_C \quad$ (x „ „ C).

W rozporze: $M_{\max} = +\,\frac{4\,k+3}{2\,k+3} \cdot \frac{P\,a\,b}{2\,l}$ dla $x_m = a$.

16.

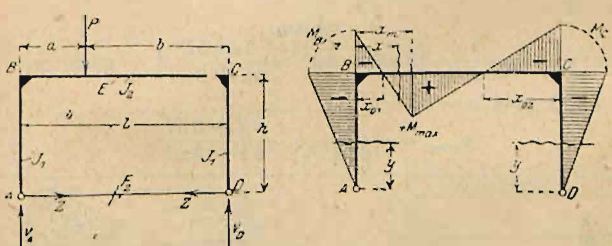


Fig. 528.

Dla $a = b = {}^1\!/_2\, l$, $\quad V_A = V_D = {}^1\!/_2\, P \quad H = \frac{3\,Pl}{8\,h\,(2\,k+3)}$.

$$V_A = P\,\frac{b}{l} \qquad V_D = P\,\frac{a}{l} \qquad m = \frac{E\,J_2}{E_Z\,F_Z} \cdot l.$$

$$Z = \frac{1{,}5\,a\,b\,h\,P}{h^2\,l\,(2\,k+3) + 3\,m}$$

$$M_B = M_C = -\,Z \,.\, h = -\,\frac{1{,}5\,a\,b\,h^2\,P}{h^2\,l\,(2\,k+3) + 3\,m}$$

$$+\,M_{\max} = +\,\frac{P\,a\,b}{l} - M_B.$$

17.

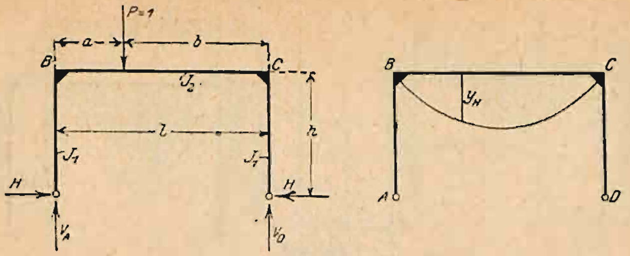


Fig. 529.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

Linja wpływowa rozporu poziomego H wskutek poruszającego się $P = 1$

$$y_H = \frac{1{,}5}{hl(2k+3)} \,.\, ab = m \,.\, ab, \qquad \text{gdzie: } m = \frac{1{,}5}{hl(2k+3)}.$$

$$\max y_H = \frac{3l}{8h(2k+3)}, \qquad \text{w miejscu } a = b = \frac{l}{2}.$$

18.

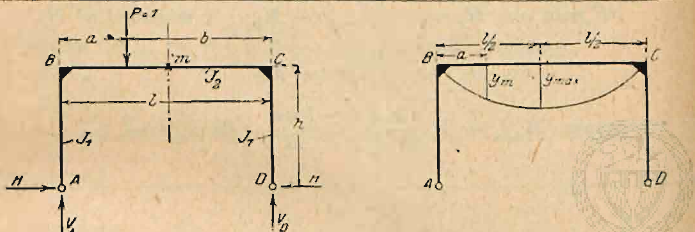


Fig. 530.

$$\text{Ugięcie: } y_m = \frac{1}{48EJ_2}\left\{3al^2 - 4a^3 - \frac{9nabl^2}{2h+3nl}\right\}, \qquad \text{gdzie: } n = \frac{J_1}{J_2}.$$

Dla $P = 1$ przy $a = b = \frac{1}{2}\,l$.

$$y_{\max} = \frac{l^3}{192EJ_2} \cdot \frac{8h+3nl}{2h+3nl}.$$

19.

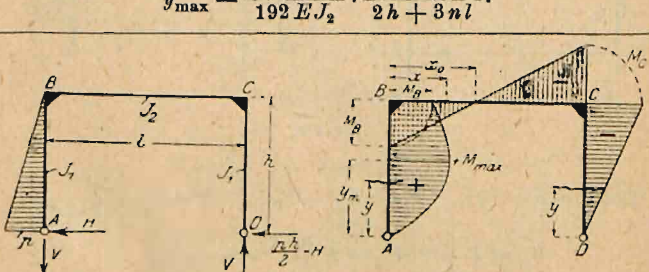


Fig. 531.

$$V = \frac{ph^2}{6l} \qquad H = \frac{ph}{40} \cdot \frac{31k+50}{2k+3}.$$

$$\text{Słup } AB\text{: } M_y = +Hy - \frac{py^2}{6h}(3h-y) \qquad M_B = +\frac{ph^2}{120} \cdot \frac{13k+30}{2k+3}$$

$$M_C = -\frac{ph^2}{40} \cdot \frac{9k+10}{2k+3} \qquad x_0 = \frac{l}{20} \cdot \frac{13k+30}{2k+3}.$$

20.

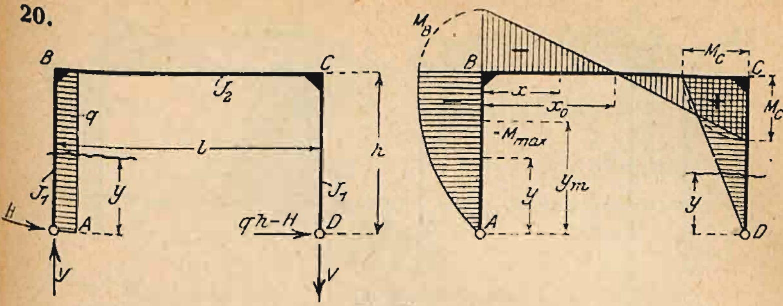


Fig. 532.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$V = \frac{q h^2}{2 l} \qquad H = \frac{q h}{8} \cdot \frac{11 k + 6}{2 k + 3} \qquad M_y = -H \cdot y + {}^1\!/_2\, q\, y^2.$$

Przekrój niebezpieczny w słupie AB występuje dla:

$$y_m = \frac{h}{8} \cdot \frac{11 k + 6}{2 k + 3}$$

$$-M_{\max} = \frac{q h^2}{128} \left(\frac{11 k + 6}{2 k + 3} \right)^2 \qquad M_B = -\frac{3}{8} q h^2 \frac{k - 2}{2 k + 3}$$

$$M_C = +\frac{q h^2}{8} \cdot \frac{5 k + 18}{2 k + 3}$$

$$x_0 = \frac{3}{4} l \frac{k - 2}{2 k + 3}.$$

21.

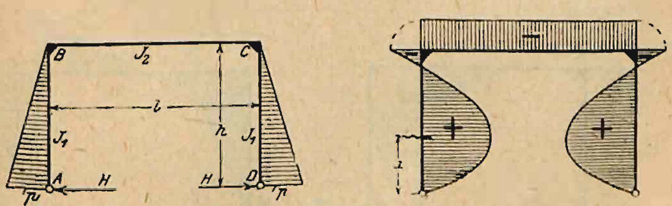


Fig. 533.

$$V = 0 \qquad H = \frac{p h}{20} \cdot \frac{11 k + 20}{2 k + 3}$$

$$M_x = +H x - \frac{p x^2}{6 h} (3 h - x) \qquad M_B = M_C = -\frac{p h^2}{60} \cdot \frac{7 k}{2 k + 3}$$

$$M_x = M_B = M_C = -\frac{p h^2}{60} \cdot \frac{7 k}{2 k + 3}.$$

22.

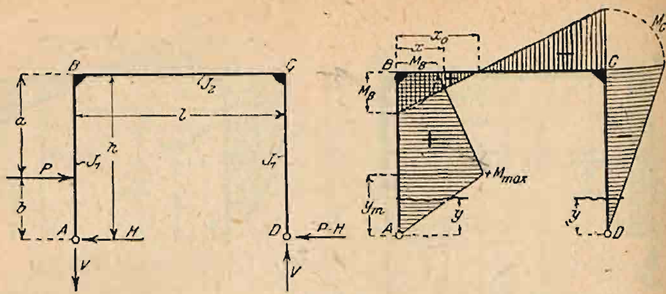


Fig. 534.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$V = \frac{P \,.\, b}{l} \qquad H = \frac{P}{2} \cdot \frac{k\,(4\,h^3 + b^3 - 3\,b\,.\,h^2) + 6\,h^3 - 3\,b\,.\,h^2}{h^3\,(2\,k + 3)} .$$

Słup AB w polu b: $M_y = + H \,.\, y$

„ a: $M_y = + H \,.\, y - P(y - a)$

$$M_B = + H \,.\, h - P \,.\, a = + P \,.\, b\,\frac{k\,(h^2 + b^2) + 3\,h^2}{2\,h^2\,(2\,k + 3)}$$

$$M_C = -(P - H)\,.\,h = - P \,.\, b\,\frac{k\,(b^2 - 3\,h^2) - 3\,h^2}{2\,h^2\,(2\,k + 3)}$$

$$x_o = \frac{k\,(h^2 + b^2) + 3\,h^2}{2\,h^2\,(2\,k + 3)} \,.\, l.$$

Dla: $a = b = {}^1\!/_2\, h$ mamy: $V = \dfrac{Ph}{2l} \qquad H = \dfrac{3}{16}\, P\, \dfrac{7\,k + 12}{2\,k + 3}$.

23.

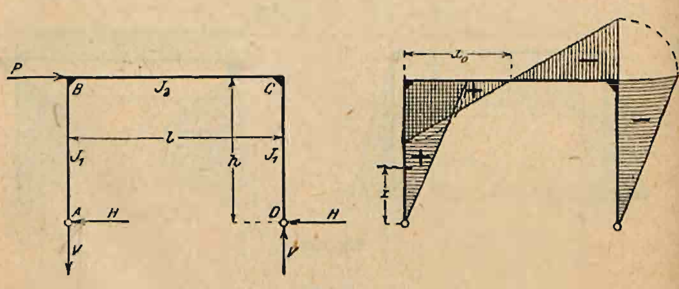


Fig. 535.

$$V = \frac{Ph}{l} \qquad H = \frac{P}{2} \qquad x_o = \frac{l}{2} .$$

Słup: $M_x = \pm H \,.\, x \qquad M_B = + {}^1\!/_2\, P \,.\, h = - M_C .$

Rozpora: $M_x = + H \,.\, h - V_A \,.\, x .$

24.

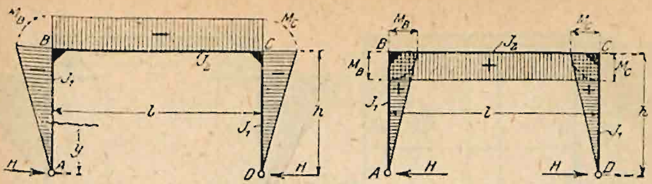


Fig. 536. Wpływ podniesienia temperatury. [ ] Wpływ obniżenia temperatury.

$$H = \frac{3\,\varepsilon E J_2 t}{h^2(3+2k)}. \qquad k = \frac{J_2}{J_1}\cdot\frac{h}{l}.$$

Słup: $M_y = \mp H \,.\, y.$ Rozpora: $M_B = M_C = \mp H \,.\, h.$

25.

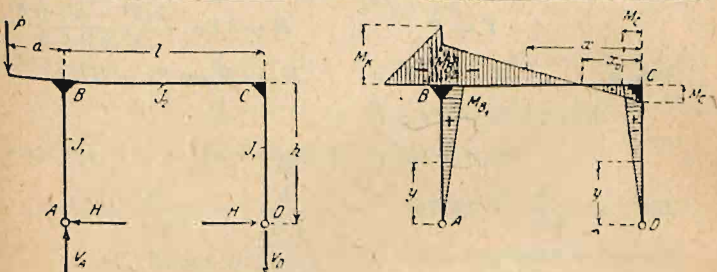


Fig. 537.

$$V_A = P\,.\,\frac{a+l}{l} \qquad V_D = P\,.\,\frac{a}{l} \qquad H = \frac{3Pa}{2h(2k+3)}.$$

Słup: $M_y = +H\,.\,y \qquad M_{B_1} = M_C = +H\,.\,h$

$$M_{B_2} = +Hh - P\,.\,a = -P\,.\,a\,\frac{4k+3}{2(2k+3)}$$

Rozpora: $M_x = +Hh - V_D\,.\,x \qquad x_0 = \frac{3l}{2(2k+3)}.$

26.

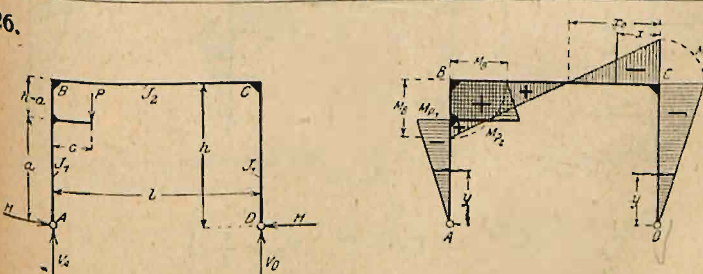


Fig. 538.

$$V_A = P\,.\,\frac{l-c}{l} \qquad V_D = \frac{Pc}{l} \qquad H = \frac{3}{2}\,Pc\,.\,\frac{k(h^2-a^2)+h^2}{h^3(2k+3)}.$$

Słup: pole a: $M_y = -Hy \qquad M_B = +Pc - Hh$

„ $(h-a)$: $M_y = +Pc - Hy$

Rozpora: $M_x = +\frac{Pc}{l}\,x - Hh \qquad M_C = -Hh.$

27.

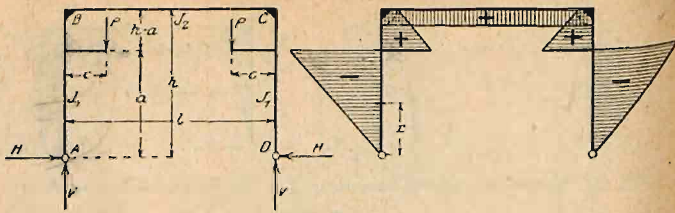


Fig. 539.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$V = P \qquad H = 3\,Pc \,.\, \frac{k(h^2 - a^2) + h^2}{h^3(2k + 3)}.$$

Pole a: $\quad M_x = -H \,.\, x \qquad M_B = M_C = Pc - Hh$

$(h - a)$: $\quad M_x = Pc - H \,.\, x$

$$M_{P_1} = -H \,.\, a \qquad M_{P_2} = -H \,.\, a + P \,.\, c.$$

Dla $\quad a > \frac{h}{\sqrt{3}}$ $(\sim 0{,}577\,h)$ $\qquad a = \frac{h}{\sqrt{3}} \qquad a < \frac{h}{\sqrt{3}}$.

Moment w rozporze
jest dodatni $\qquad = 0, \qquad$ **ujemny** [1]).

[1]) To samo dotyczy przypadku 29., tylko zamiast > będzie <.

28.

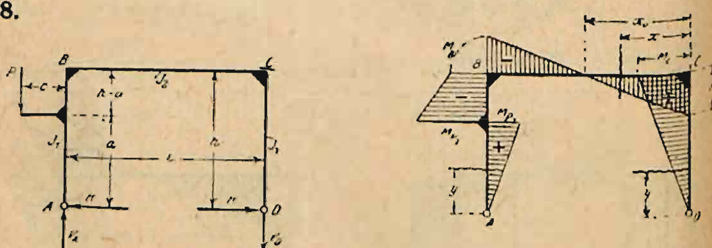


Fig. 540.

$$V_A = \frac{c + l}{l} \,.\, P = V_D + P \qquad V_D = \frac{c}{l} \,.\, P$$

$$H = \frac{3}{2}\, P \,.\, c \,.\, \frac{k(h^2 - a^2) + h^2}{k^3\,(2k + 3)}.$$

Słup AB, pole a: $\quad M_y = +H \,.\, y \qquad M_B = +H \,.\, h - P \,.\, c$

" $\quad (h - a)$: $M_y = +H \,.\, y - P \,.\, c.$

Rozpora: $\quad M_x = +H \,.\, h - P \,.\, \frac{c}{l} \,.\, x \qquad M_C = +H \,.\, h$

29.

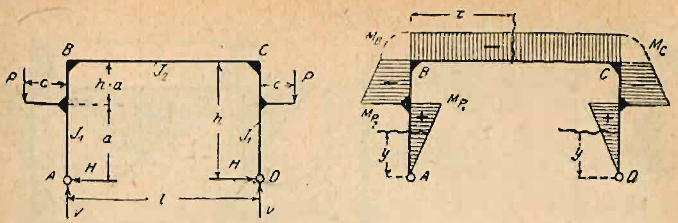


Fig. 541.

$$V = P \qquad H = 3\,P c \,.\, \frac{k(h^2 - a^2) + h^2}{h^3(2k+3)} \qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

Słupy pola a: $M_y = +H.y \quad M_{P_1} = +H.a \quad M_{P_2} = +H.a - P.c$

„ „ $(h-a)$: $M_y = +H.y - P.c \qquad M_B = M_C = +H.h - P.c.$

Rozpora: $M_x = M_B = M_C = +H.h - P.c.$

IV. Rama prostokątna bezprzegubowa.

30.

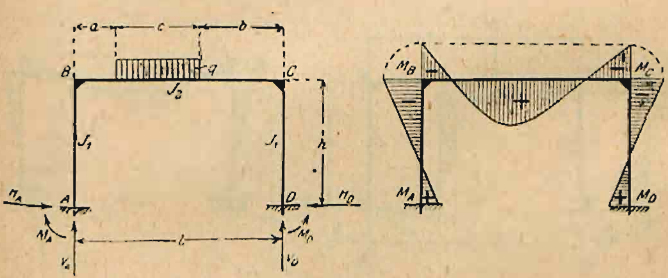


Fig. 542.

$$V_A = \frac{qc}{l^3(6k+1)}\left[3abc + b^2(3l-2b) + c^2\left(l + b - \frac{c}{2}\right) + 3l^2(2b+c)k\right]$$

$$V_D = qc - V_A \qquad H = \frac{qc}{4hl(k+2)}(6ab + 3cl - 2c^2)$$

$$M_A = \frac{q}{4l^2(k+2)(6k+1)}\left[6abcl + 4a^2c^2 + 8ab^2c + \frac{10}{3}\,.\,c^3l - \right.$$

$$\left. - c^2l^2 - 2c^4 + (14abcl + 2a^2c^2 - 4ab^2c - 2c^3l + 5c^2l^2 - c^4)k\right].$$

Przez zamianę a i b otrzymamy M_D:

$$M_B = M_A = Hh \qquad M_C = M_D - Hh.$$

31.

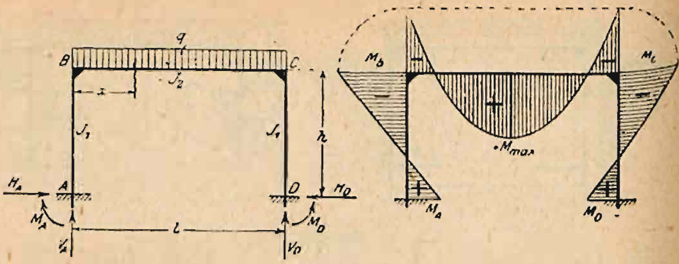


Fig. 543.

$$V = \tfrac{1}{2}\, q\, l \qquad H = \frac{q\, l^2}{4\, h\,(k+2)} \qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$M_A = M_D = + \frac{q\, l^2}{12\,(k+2)} \qquad M_B = M_C = - \frac{q\, l^2}{6\,(k+2)}.$$

Rozpora:
$$M_x = \frac{q\, x}{2}\,(l - x) - \frac{q\, l^2}{6\,(k+2)}$$

$$+ M_{\max} = \frac{q\, l^2}{8} - \frac{q\, l^2}{6\,(k+2)} = \frac{q\, l^2}{24} \cdot \frac{2 + 3\,k}{k+2}.$$

32.

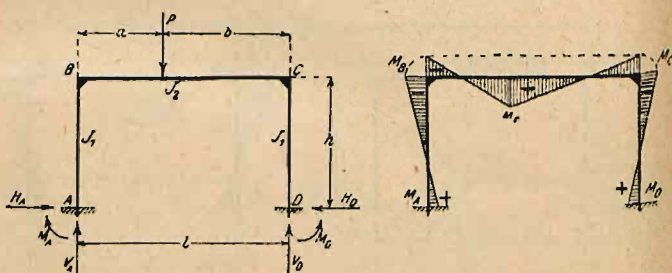


Fig. 544.

$$V_A = \frac{P\,b}{l} \cdot \frac{6\,k + 1 + \delta - 2\,\delta^2}{6\,k + 1} \qquad V_D = \frac{P\,a}{l} \cdot \frac{6\,k + 3\,\delta - 2\,\delta^2}{6\,k + 1}$$

$$H = \frac{3\,a\,b\,P}{2\,h\,l\,(k+2)} \qquad \delta = \frac{a}{l}$$

$$M_A = + \frac{a\,b\,P}{2\,l} \cdot \frac{5\,k - 1 + 2\,\delta\,(k+2)}{(k+2)\,(6\,k+1)}$$

$$M_D = + \frac{a\,b\,P}{2\,l} \cdot \frac{3 + 7\,k - 2\,\delta\,(k+2)}{(k+2)\,(6\,k+1)}$$

$$M_B = M_A - H\,h \qquad M_C = M_D - H\,h \qquad M_P = M_A - H\,h + V_A\,a.$$

Dla $a = b = \dfrac{l}{2}$ $\qquad V_A = V_D = \dfrac{P}{2} \qquad H = \dfrac{3\,P\,l}{8\,h\,(k+2)}.$

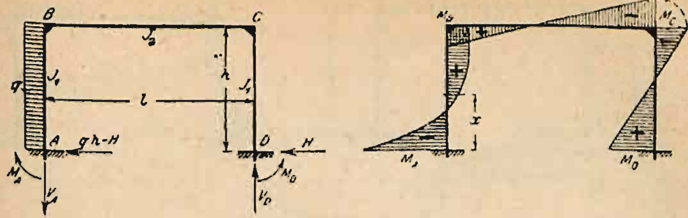
33. 

Fig. 545.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$V = \frac{q h^2 k}{l(6k+1)} \qquad H = \frac{qh}{8} \cdot \frac{2k+3}{2+k}$$

$$M_A = -\frac{q h^2}{24}\left(12 - \frac{5k+9}{k+2} - \frac{12k}{6k+1}\right)$$

$$M_D = +\frac{q h^2}{24}\left(+\frac{5k+9}{k+2} - \frac{12k}{6k+1}\right).$$

Słup AB: $\quad M_x = M_A + (qh - H)x - {}^1/_2\, q x^2$

$$M_B = M_A - Hh + {}^1/_2\, q h^2 \qquad M_C = M_D - Hh.$$

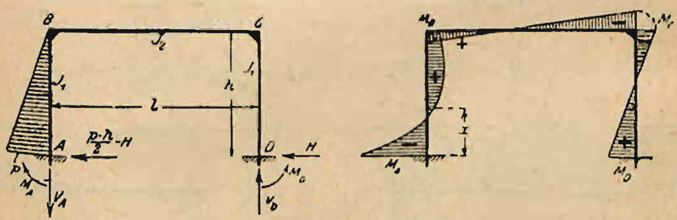
34. 

Fig. 546.

$$V = \frac{p k h^2}{4l(6k+1)} \qquad H = \frac{ph}{40} \cdot \frac{3k+4}{k+2}$$

$$M_A = -\frac{p h^2}{120}\left(20 - \frac{7k+12}{k+2} - \frac{15k}{6k+1}\right)$$

$$M_D = +\frac{p h^2}{120}\left(+\frac{7k+12}{k+2} - \frac{15k}{6k+1}\right).$$

Słup AB: $\quad M_x = M_A + \left(\frac{ph}{2} - H\right)x - \frac{p x^2}{6h}(3h - x)$

$$M_B = M_A - Hh + \frac{p h^2}{6} \qquad M_C = M_D - Hh.$$

35.

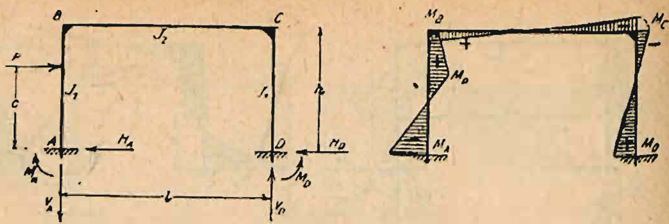


Fig. 547.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}; \qquad \delta = \frac{c}{h}$$

$$V = \frac{3 P c \delta k}{l(6k+1)} \qquad\qquad H_A = P - H_D$$

$$H_D = \frac{P\delta^2}{2(k+2)} \left[3(k+1) - \delta(2k+1)\right]$$

$$M_A = -\frac{Pc\delta}{2}\left[\frac{2}{\delta} - \frac{3+2k-\delta(k+1)}{k+2} - \frac{3k}{6k+1}\right]$$

$$M_D = +\frac{Pc\delta}{2}\left[\frac{3+2k-\delta(k+1)}{k+2} - \frac{3k}{6k+1}\right]$$

$$M_B = M - H_D h + Pc \qquad M_C = M_D - H_D h \qquad M_P = M_A + H_A c.$$

$$\text{Dla } c = \frac{h}{2} \qquad V = \frac{3P.h.k}{4l(6k+1)}$$

$$H_A = P - H_D \qquad H_D = \frac{P}{16} \cdot \frac{4k+5}{k+2}.$$

36.

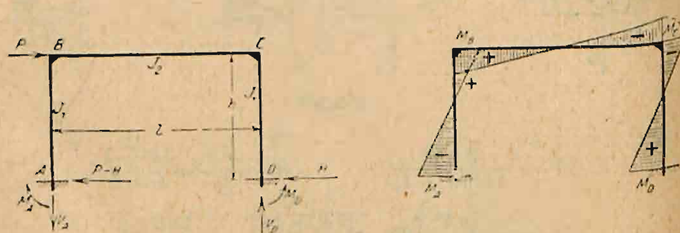


Fig. 548.

$$V = \frac{3Phk}{l(6k+1)} \qquad H = \frac{P}{2}$$

$$\left.\begin{matrix} M_A \\ M_D \end{matrix}\right\} = \mp \frac{Ph}{2} \cdot \frac{3k+1}{6k+1}$$

$$\left.\begin{matrix} M_B \\ M_C \end{matrix}\right\} = \pm \frac{Ph}{2} \cdot \frac{3k}{6k+1}.$$

V. Rama o rozporze łamanej symetrycznej i słupach pionowych dwuprzegubowa.

37.

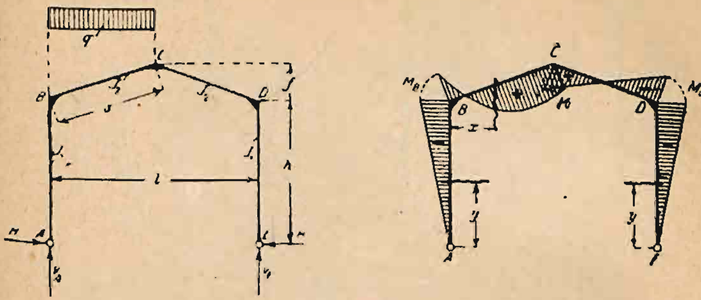


Fig. 549.

$$V_A = \frac{3ql}{8} \qquad V_E = \frac{ql}{8} \qquad\qquad k = \frac{J_2}{J_1} \cdot \frac{h}{s}$$

$$H = \frac{ql^2}{64} \cdot \frac{8h + 5f}{h^2(k+3) + f(3h+f)}.$$

Słupy: $\quad M_y = -Hy \qquad M_B = -Hh.$

Rozpora, część BC: $\quad M_x = +V_A x - H\left(h + \frac{2fx}{l}\right) - \frac{qx^2}{2}$

$$M_C = +V_E \cdot {}^1\!/_2\, l - H(h+f) \qquad M_D = -Hh.$$

38.

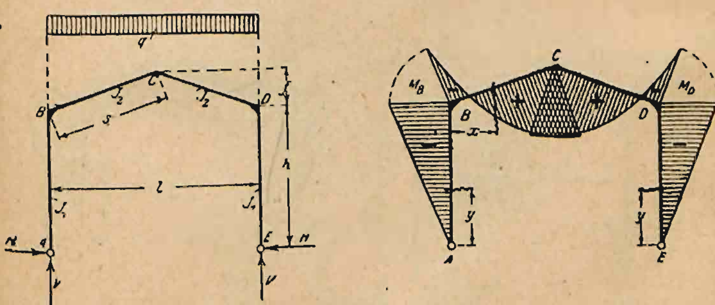


Fig. 550.

$$V = {}^1\!/_2\, ql \qquad H = \frac{ql^2}{32} \cdot \frac{8h + 5f}{h^2(k+3) + f(3h+f)}.$$

Słupy: $\quad M_y = -Hy \qquad M_B = -Hh.$

Rozpora: $\quad M_x = +\frac{qx}{2}(l - x) - H\left(h + \frac{2fx}{l}\right)$

$$M_C = +{}^1\!/_8\, ql^2 - H(h+f).$$

39.

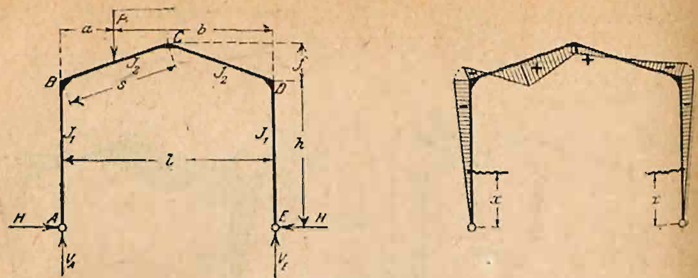


Fig. 551.

$$V_A = \frac{Pb}{l} \qquad V_E = \frac{Pa}{l} \qquad k = \frac{J_2}{J_1} \cdot \frac{h}{s}$$

$$H = \frac{Pa}{4\,l^2} \cdot \frac{6\,h\,b\,l + f\,(3\,l^2 - 4\,a^2)}{h^2\,(k+3) + f\,(3\,h + f)}\,.$$

Słupy: $M_x = -\,H\,x \qquad M_B = -\,H\,h.$

W miejscu działania siły P: $M_P = +\,V_A\,a - H\left(h + \frac{2\,f\,a}{l}\right)$

$$M_C = +\,{}^1\!/_2\,P\,a - H\,(h+f) \qquad M_D = -\,H\,h.$$

40.

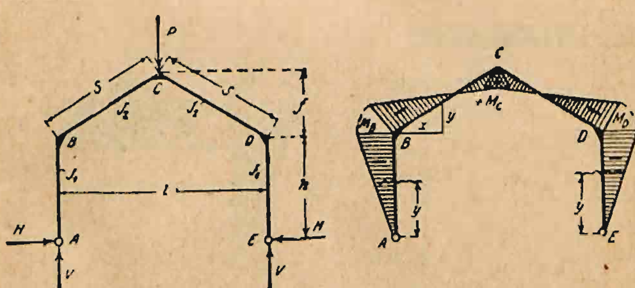


Fig. 552.

$$V = \frac{P}{2} \qquad H = \frac{P\,l}{8} \cdot \frac{3\,h + 2\,f}{h^2\,(k+3) + f\,(3\,h + f)}\,.$$

Słupy: $M_y = -\,H\,.\,y \qquad M_B = M_D = -\,H\,.\,h.$

Rozpora: $M_x = +\,\frac{P}{2}\,.\,x - H\left(h + \frac{2\,f\,x}{l}\right).$

$$M_C = +\,{}^1\!/_4\,P\,l - H\,(h+f).$$

41.

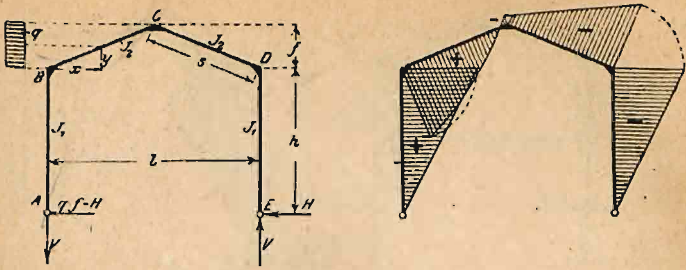


Fig. 553.

$$V = \frac{qf(2h+f)}{2l} \quad H = \frac{qf}{16} \cdot \frac{8h^2(k+3)+5f(4h+f)}{h^2(k+3)+f(3h+f)}.$$

$$M_B = +(qf - H)h.$$

Dla BC: $$M_x = +(qf - H)(h+y) - Vx - {}^1/_2\, q y^2$$

$$M_C = +{}^1/_2\, Vl - H(h+f)$$

$$M_D = -Hh. \qquad\qquad k = \frac{J_2}{J_1} \cdot \frac{h}{s}$$

42.

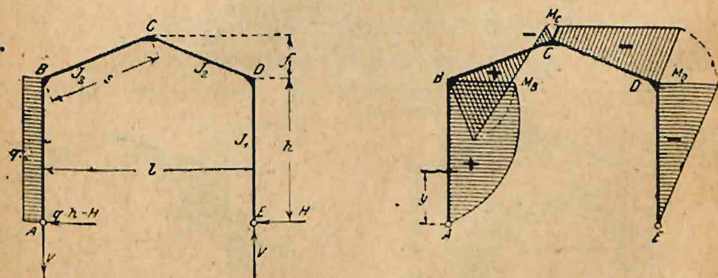


Fig. 554.

$$V = \frac{qh^2}{2l} \qquad H = \frac{qh^2}{16} \cdot \frac{5hk + 6(2h+f)}{h^2(k+3)+f(3h+f)}.$$

Dla AB: $$M_y = +(qh - H)y - {}^1/_2\, q y^2$$

$$M_B = +{}^1/_2\, q h^2 - Hh$$

$$M_C = +{}^1/_4\, q h^2 - H(h+f) \qquad M_D = -Hh.$$

43.

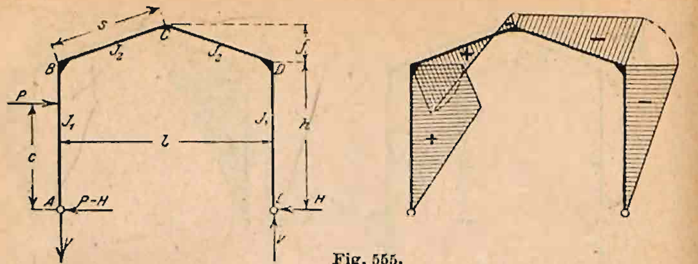


Fig. 555.

$$V = \frac{Pc}{l} \qquad H = \frac{P \cdot c}{4} \cdot \frac{k\left(3h - \frac{c^2}{h}\right) + 3(2h + f)}{h^2(k + 3) + f(3h + f)} \qquad k = \frac{J_2}{J_1} \cdot \frac{h}{s}$$

$$M_P = +(P - H)\,c \qquad M_B = +Pc - Hh$$

$$M_C = +\tfrac{1}{2}Pc - H(h + f) \qquad M_D = -Hh.$$

44.

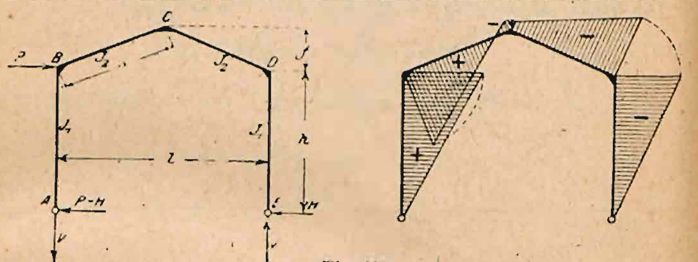


Fig. 556.

$$V = \frac{Ph}{l} \qquad H = \frac{Ph}{4} \cdot \frac{2hk + 3(2h + f)}{h^2(k + 3) + f(3h + f)}$$

$$M_B = +(P - H)\,h \qquad M_C = +\tfrac{1}{2}Ph - H(h + f) \qquad M_D = -Hh.$$

45.

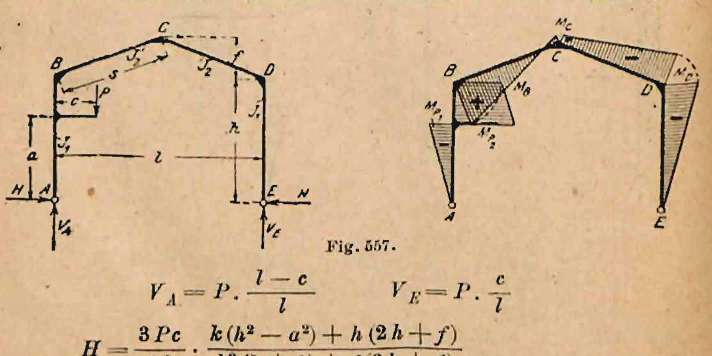


Fig. 557.

$$V_A = P \cdot \frac{l - c}{l} \qquad V_E = P \cdot \frac{c}{l}$$

$$H = \frac{3Pc}{4h} \cdot \frac{k(h^2 - a^2) + h(2h + f)}{h^2(k + 3) + f(3h + f)}$$

$$M_{P_1} = -Ha \qquad M_{P_2} = +Pc - Ha$$

$$M_B = +Pc - Hh \qquad M_C = +\tfrac{1}{2}Pc - H(h + f) \qquad M_D = -Hh.$$

46.

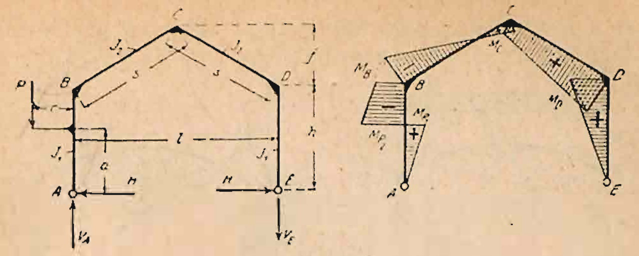


Fig. 558.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{s}$$

$$V_A = P \cdot \frac{l+c}{l} \qquad V_E = P \cdot \frac{c}{l} \qquad H = \frac{3}{4} \cdot \frac{P \cdot c}{h} \cdot \frac{k(h^2 - a^2) + h(2h+f)}{h^2(k+3) + f(3h+f)}$$

$M_{P_1} = + H \cdot a$ (tuż pod wspornikiem)

$M_{P_2} = + H \cdot a - P \cdot c$ (tuż nad wspornikiem)

$M_B = + Hh - P \cdot c \qquad M_C = + H(h+f) - {}^1\!/_2 Pc \qquad M_D = + Hh.$

47.

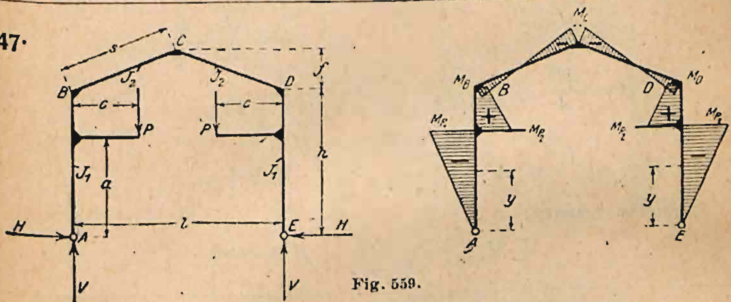


Fig. 559.

$$V = P \qquad H = \frac{3Pc}{2h} \cdot \frac{k(h^2 - a^2) + h(2h+f)}{h^2(k+3) + f(3h+f)}$$

$M_{P_1} = - Ha$ (tuż pod wspornikiem)

$M_{P_2} = + Pc - Ha$ (tuż nad wspornikiem)

$M_B = M_D = + Pc - Hh \qquad M_C = + Pc - H(h+f).$

48.

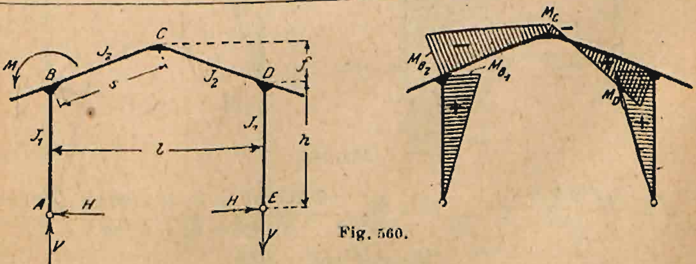


Fig. 560.

$$V = \frac{M}{l} \qquad H = \frac{3M}{4} \cdot \frac{2h+f}{h^2(k+3) + f(3h+f)} \qquad M_{B_1} = + Hh$$

$$M_{B_2} = + Hh - M \qquad M_C = + H(h+f) - {}^1\!/_2 M \qquad M_D = + Hh.$$

VI. Rama o rozporze parabolicznej i słupach pionowych dwuprzegubowa.

49.

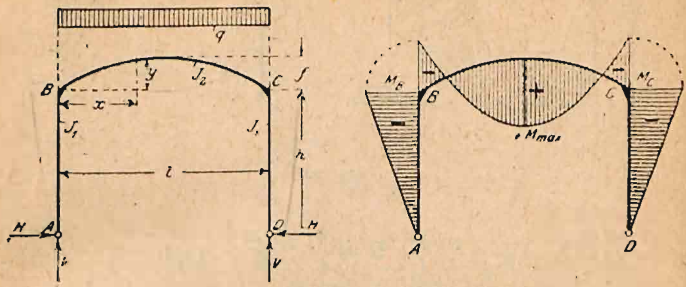


Fig. 561.

Równanie osi rozpory: $y = \frac{4f}{l^2}\, x\,(l - x)$

$$V = \frac{q\,l}{2} \qquad\qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$H = \frac{q\,l^2}{4} \cdot \frac{5\,h + 4\,f}{5\,h^2\,(2\,k + 3) + 4\,f\,(5\,h + 2\,f)}\,.$$

$$M_B = M_C = -\,H\,h.$$

Dla $B\,C$: $\quad M_x = +\,{}^1\!/\!_2\,q\,x\,(l - x) - H\,(h + y).$

W środku rozpory:

$$+\,M_{\max} = +\,\frac{q\,l^2}{8} - H\,(h + f).$$

50.

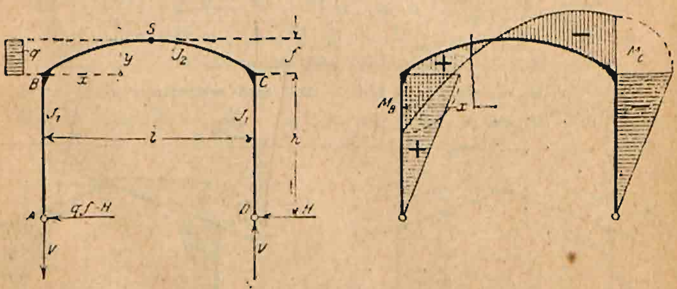


Fig. 562.

$$V = \frac{q\,f\,(2\,h + f)}{2\,l} \qquad H = \frac{q\,f}{28} \cdot \frac{70\,h^2\,(2\,k + 3) + f\,(224\,h + 64\,f)}{5\,h^2\,(2\,k + 3) + 4\,f\,(5\,h + 2\,f)}$$

$$M_B = +\,(q\,f - H)\,h.$$

Dla $B\,S$: $\quad M_x = +\,(q\,f - H)\,(h + y) - V\,x - \frac{q\,y^2}{2}$

„ $S\,C$: $\quad M_x = +\,V\,(l - x) - H\,(h + y) \qquad M_C = -\,H\,h.$

51.

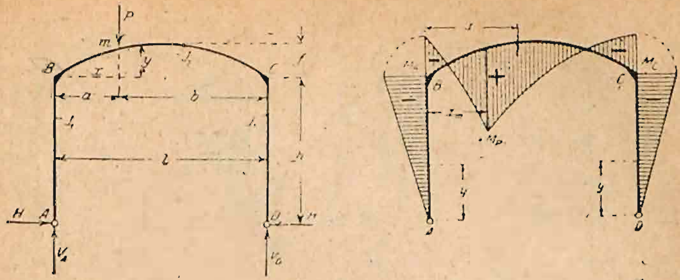


Fig. 563.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$V_A = \frac{Pb}{l} \qquad V_D = \frac{Pa}{l} \qquad H = \frac{5\,Pa}{2\,l^3} \cdot \frac{3\,b\,h\,l^2 + 2\,f\,l^3 - 4\,f\,a^2\,l + 2\,f\,a^3}{5\,h^2\,(2\,k + 3) + 4\,f\,(5\,h + 2\,f)}$$

$M_B = M_C = -Hh.$ Rozpora: $M_x = M_0 - H(h + y).$

(M_0 = moment belki wolno podpartej BC).

52.

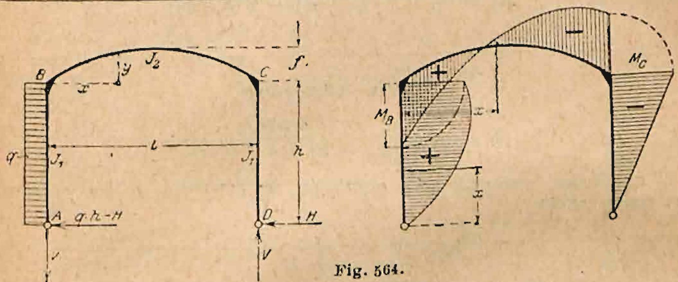


Fig. 564.

$$V = \frac{q\,h^2}{2\,l} \qquad H = \frac{5\,q\,h^2}{8} \cdot \frac{h\,(5\,k + 6) + 4\,f}{5\,h^2\,(2\,k + 3) + 4\,f\,(5\,h + 2\,f)}.$$

Dla AB: $M_x = +(q\,h - H)\,x - \frac{1}{2}\,q\,x^2 \qquad M_B = +\frac{1}{2}\,q\,h^2 - H\,h.$

Dla BC: $M_x = + V\,(l - x) - H(h + y) \qquad M_C = -H\,h.$

53.

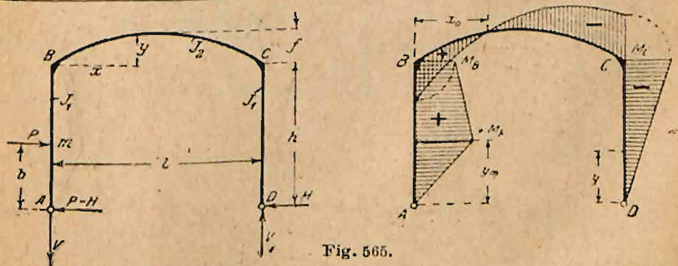


Fig. 565.

$$V = P \cdot \frac{b}{l} \qquad H = \frac{5\,Pb}{2\,h} \cdot \frac{3\,h^2\,(k + 1) + 2\,f\,h - b^2\,k}{5\,h^2\,(2\,k + 3) + 4\,f\,(5\,h + 2\,f)}.$$

Pod siłą P: $M_P = +(P - H)\,b \qquad M_B = + Pb - H\,h.$

Dla BC: $M_x = + P \cdot \frac{b}{l}\,(l - x) - H\,(h + y) \qquad M_C = -H\,h.$

54.

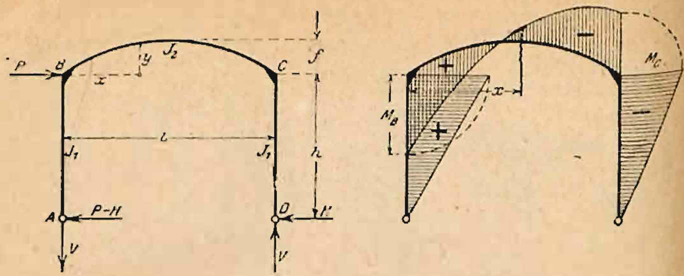


Fig. 566.

$$V = P\cdot\frac{h}{l} \qquad H = \frac{5P}{2}\cdot\frac{h^2(2k+3)+2fh}{5h^2(2k+3)+4f(5h+2f)}$$

$$M_B = +(P-H)h. \qquad k = \frac{J_2}{J_1}\cdot\frac{h}{l}.$$

Dla BC: $\quad M_x = +P\cdot\frac{h}{l}(l-x) - H(h+y) \qquad M_C = -Hh.$

---

55. **Wpływ temperatury.**

$$H = \frac{15\,\omega t E J_2}{5h^2(2k+3)+4f(5h+2f)}.$$

H działa ku środkowi, przy obniżeniu na zewnątrz, ω jest spółczynnikiem rozszerzalności.

56.

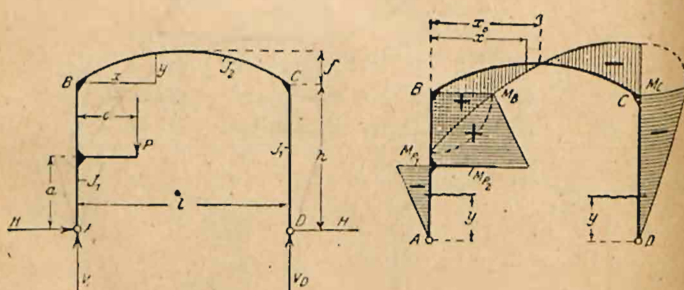


Fig. 567.

$$y = \frac{4f}{l^2}x(l-x)$$

$$V_A = P\cdot\frac{l-c}{l} \qquad V_D = P\cdot\frac{c}{l} \qquad H = \frac{5Pc}{2h}\cdot\frac{3k(h^2-a^2)+h(3h+2f)}{5h^2(2k+3)+4f(5h+2f)}$$

$$M_{P_1} = -Ha \qquad M_{P_2} = +Pc - Ha \qquad M_B = +Pc - Hh.$$

Rozpora: $\quad M_x = +P\cdot\frac{c}{l}(l-x) - H(h+y) \qquad M_C = -Hh.$

57.

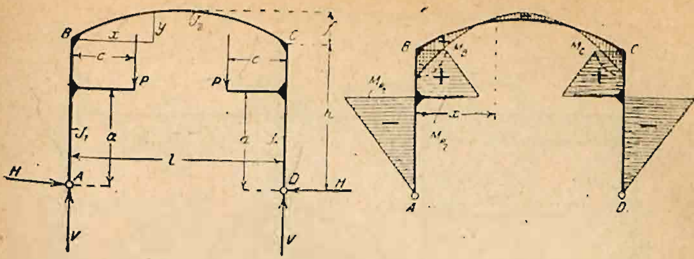


Fig. 568.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$V = P \qquad H = \frac{5\,P c}{h} \cdot \frac{3\,k\,(h^2 - a^2) + h\,(3\,h + 2\,f)}{5\,h^2\,(2\,k + 3) + 4\,f\,(5\,h + 2\,f)}$$

$$M_{P_1} = -\,H a \qquad M_{P_2} = +\,P c - H a$$

$$M_B = M_C = +\,P c - H h.$$

Rozpora: $$M_x = +\,P c - H\,(h + y).$$

58.

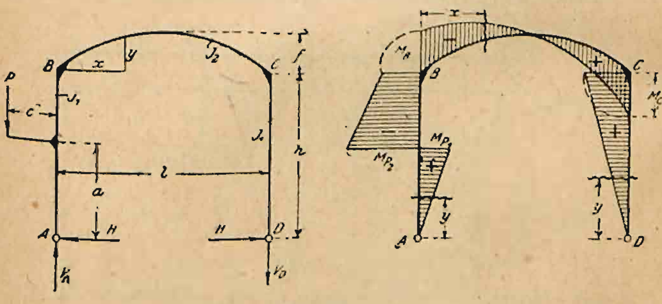


Fig. 569.

$$V_A = P \,.\, \frac{c + l}{l} \qquad V_D = P \,.\, \frac{c}{l} \qquad y = \frac{4\,f}{l^2}\,x\,(l - x)$$

$$H = \frac{5\,P c}{2\,h} \cdot \frac{3\,k\,(h^2 - a^2) + h\,(3\,h + 2\,f)}{5\,h^2\,(2\,k + 3) + 4\,f\,(5\,h + 2\,f)}$$

$$M_{P_1} = +\,H a \qquad M_{P_2} = +\,H a - P \,.\, c \qquad M_B = +\,H h - P \,.\, c.$$

Rozpora: $$M_x = -\,P \,.\, \frac{c}{l}\,(l - x) + H\,(h + y)$$

$$M_C = +\,H h.$$

VII. Rama prostokątna zamknięta.

59.

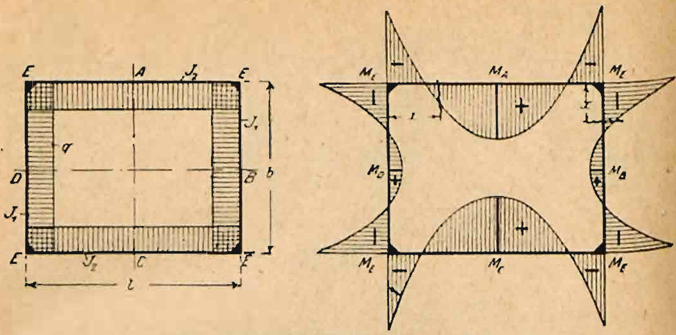


Fig. 570.

$$M_E = -\frac{q}{12} \cdot \frac{l^2 + b^2 k}{k+1} \qquad k = \frac{J_2}{J_1} \cdot \frac{b}{l}$$

$$M_A = B_C + \frac{q\,l^2}{8} - \frac{q}{12} \cdot \frac{b^2 + b^2 k}{k+1} \qquad M_B = M_D = + \frac{q\,b^2}{8} - M_E.$$

Dla AE (wzgl. CE) w odl. x od E: $M_x = + \frac{1}{2} q x (l - x) - M_E$.

Dla BE (wzgl. DE) w odl. x od E: $M_x = + \frac{1}{2} q x (b - x) - M_E$.

VIII. Rama trójprzęsłowa symetryczna o dwu słupach.

60.

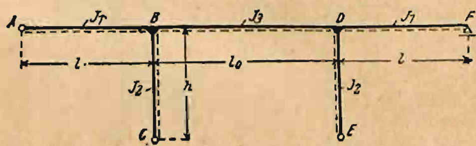


Fig. 571.

$$k = \frac{J_3}{J_2} \cdot \frac{h}{l_0} \qquad k_1 = \frac{J_1}{J_2} \cdot \frac{h}{l}$$

$$N = 3 + 2k + 3k_1 \qquad N_1 = 1 + 2k + k_1.$$

Uwaga. Momenty, wywołujące po stronie kreskowanej rozciąganie, są dodatnie (+).

61.

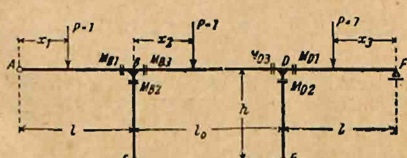


Fig. 572.

Równania linij wpływowych.

$$\delta_1 = \frac{x_1}{l} \qquad \delta_2 = \frac{x_2}{l_0} \qquad \delta_3 = \frac{x_3}{l}.$$

62.

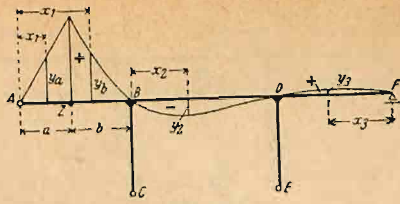


Fig. 573.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

Moment bieżący w punkcie Z przęsła AB

w polu AZ[1]): $y_a = + \delta_1 b - a \cdot \frac{\delta_1 (1 - \delta_1^2)}{4} \left[\frac{2k+1}{N_1} + \frac{2k+3}{N} \right]$

w polu ZB: $y_b = + a(1 - \delta_1) - a \cdot \frac{\delta_1 (1 - \delta_1^2)}{4} \left[\frac{2k+1}{N_1} + \frac{2k+3}{N} \right]$

w polu BD: $y_2 = - \frac{a}{l} \cdot \frac{x_2 (1 - \delta_2) k_1}{2} \left[\frac{3}{N} + \frac{1 - 2\delta_2}{N_1} \right]$

w polu DF: $y_3 = + a \cdot \frac{\delta_3 (1 - \delta_3^2)}{4} \left[\frac{2k+1}{N_1} - \frac{2k+3}{N} \right]$.

[1]) Z jest punktem działania ciężaru.

63.

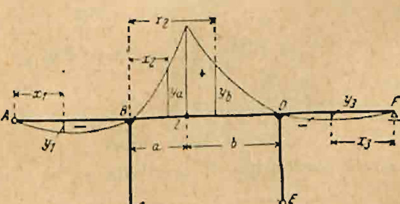


Fig. 574.

Moment bieżący przęsła BD

w polu AB: $y_1 = - \frac{x_1 (1 - \delta_1^2) k}{2} \left[\frac{1}{N} + \frac{1}{N_1} - \frac{a}{l_0} \cdot \frac{2}{N_1} \right]$

w polu BZ: $y_a = + \delta_2 b - \frac{\delta_2 (1 - \delta_2)(k_1 + 1)}{2} \left[\frac{3 l_0}{N} + (b - a) \cdot \frac{(1 - 2\delta_2)}{N_1} \right]$

w polu ZD:

$$y_b = + (1 - \delta_2) a - \frac{\delta_2 (1 - \delta_2)(k_1 + 1)}{2} \left[\frac{3 l_0}{N} + (b - a) \cdot \frac{(1 - 2\delta_2)}{N_1} \right]$$

w polu DF: $y_3 = - \frac{x_3 (1 - \delta_3^2) k}{2} \left[\frac{1}{N} - \frac{1}{N_1} + \frac{a}{l_0} \cdot \frac{2}{N_2} \right]$.

64.

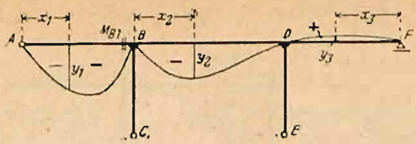


Fig. 575.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

Moment podporowy M_{B1}

w polu AB: $y_1 = -\frac{x_1(1-\delta_1^2)}{4}\left[\frac{2k+1}{N_1} + \frac{2k+3}{N}\right]$

w polu BD: $y_2 = -\frac{x_2(1-\delta_2)k_1}{2}\left[\frac{3}{N} + \frac{1-2\delta_2}{N_1}\right]$

w polu DF: $y_3 = +\frac{x_3(1-\delta_3^2)}{4}\left[\frac{2k+1}{N_1} - \frac{2k+3}{N}\right].$

65.

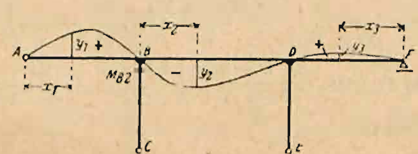


Fig. 576.

Dla M_{B2}

w polu AB: $y_1 = +\frac{x_1(1-\delta_1^2)}{4}\left[\frac{3}{N} + \frac{1}{N_1}\right]$

w polu BD: $y_2 = -\frac{x_2(1-\delta_2)}{2}\left[\frac{3}{N} + \frac{1-2\delta_2}{N_1}\right]$

w polu DF: $y_3 = +\frac{x_3(1-\delta_3^2)}{4}\left[\frac{3}{N} - \frac{1}{N_1}\right].$

Uwaga. Dla parcia poziomego H podzielić y_1, y_2 i y_3 przez h.

66.

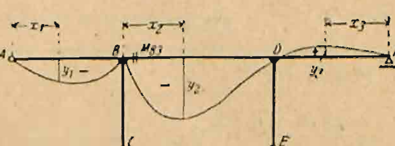


Fig. 577.

Dla M_{B3}

w polu AB: $y_1 = -\frac{x_1(1-\delta_1^2)k}{2}\left[\frac{1}{N_1} + \frac{1}{N}\right]$

w polu BD: $y_2 = -\frac{x_2(1-\delta_2)(k_1+1)}{2}\left[\frac{3}{N} + \frac{1-2\delta_2}{N_1}\right]$

w polu DF: $y_3 = +\frac{x_3(1-\delta_3^2)k}{2}\left[\frac{1}{N_1} - \frac{1}{N}\right].$

67.

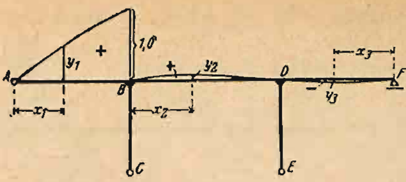


Fig. 578.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

Siła poprzeczna z lewej strony B

w polu AB: $$y_1 = + \delta_1 + \frac{\delta_1 (1 - \delta_1^2)}{4} \left[\frac{2k+1}{N_1} + \frac{2k+3}{N} \right]$$

w polu BD: $$y_2 = + \frac{x_2 (1 - \delta_2) k_1}{2l} \left[\frac{3}{N} + \frac{1 - 2\delta_2}{N_1} \right]$$

w polu DF: $$y_3 = - \frac{\delta_3 (1 - \delta_3^2)}{4} \cdot \left[\frac{2k+1}{N_1} - \frac{2k+3}{N} \right].$$

68.

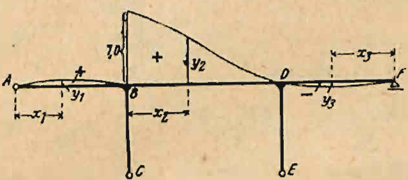


Fig. 579.

Siła poprzeczna z prawej strony B

w polu AB: $$y_1 = + \frac{x_1 (1 - \delta_1^2) k k_1}{l_0 N_1}$$

w polu BD: $$y_2 = + (1 - \delta_2) + \frac{\delta_2 (1 - \delta_2)(1 - 2\delta_2)(k_1 + 1)}{N_1}$$

w polu DF: $$y_3 = - \frac{x_3 (1 - \delta_3^2) k k_1}{l_0 N_1}.$$

69.

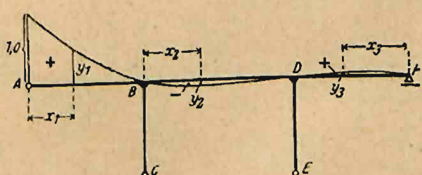


Fig. 580.

Siła poprzeczna i reakcja w A

w polu AB: $$y_1 = + (1 - \delta_1) - \frac{\delta_1 (1 - \delta_1^2)}{4} \left[\frac{2k+1}{N_1} + \frac{2k+3}{N} \right]$$

w polu BD: $$y_2 = - \frac{x_2 (1 - \delta_2) k_1}{2l} \left[\frac{3}{N} + \frac{1 - 2\delta}{N_1} \right]$$

w polu DF: $$y_3 = + \frac{\delta_3 (1 - \delta_3^2)}{4} \left[\frac{2k+1}{N_1} - \frac{2k+3}{N} \right].$$

70. Reakcja w B (siła osiowa w słupie BC).

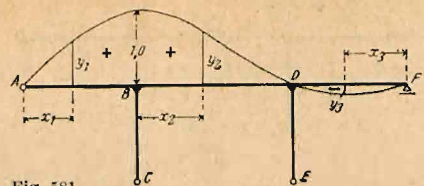


Fig. 581.

Linję wpływową reakcji B otrzymujemy, sumując rzędne „y“ z wzorów 67 i 68.

71.

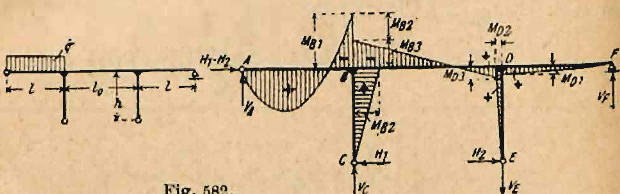


Fig. 582.

$$M_{B1} = -\frac{q l^2}{16}\left[\frac{2k+1}{N_1} + \frac{2k+3}{N}\right] \qquad M_{B2} = M_{B3} - M_{B1}$$

$$M_{D1} = +\frac{q l^2}{16}\left[\frac{2k+1}{N_1} - \frac{2k+3}{N}\right] \qquad M_{D2} = M_{D3} - M_{D1}$$

$$M_{B3} = -\frac{q l^2 k}{8}\left[\frac{1}{N_1} + \frac{1}{N}\right] \qquad V_A = \frac{q l}{2} + \frac{M_{B1}}{l}$$

$$M_{D3} = +\frac{q l^2 k}{8}\left[\frac{1}{N_1} - \frac{1}{N}\right] \qquad V_C = \frac{q l}{2} - \frac{M_{B1}}{l} + \frac{M_{D3} - M_{B3}}{l_0}$$

$$V_E = \frac{M_{D3} - M_{B3}}{l_0} + \frac{M_{D1}}{l} \qquad V_F = \frac{M_{D1}}{l} \qquad H_1 = \frac{M_{B2}}{h} \qquad H_2 = \frac{M_{D2}}{h}.$$

72.

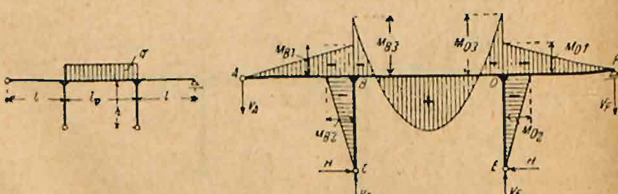


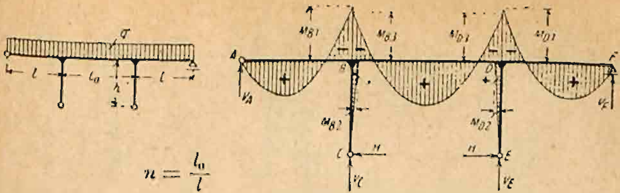
Fig. 583.

$$M_{B1} = M_{D1} = -\frac{q l_0^2 k_1}{4N}$$

$$M_{B2} = M_{D2} = -\frac{q l_0^2}{4N} \qquad V_A = V_F = -\frac{M_{B1}}{l} \qquad H = -\frac{M_{B2}}{h}$$

$$M_{B3} = M_{D3} = -\frac{q l_0^2 (k_1 + 1)}{4N} \qquad V_C = V_E = \frac{q l_0}{2} - \frac{M_{B1}}{l}.$$

73.



$$n = \frac{l_0}{l}$$

Fig. 584.

$$n = \frac{l_0}{l} \qquad\qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$M_{B1} = M_{D1} = -\frac{q\,l^2}{8} \cdot \frac{2\,k + 3 + 2\,n^2\,k_1}{N} \qquad V_A = V_F = \frac{q\,l}{2} + \frac{M_{B1}}{l}$$

$$M_{B2} = M_{D2} = +\frac{q\,l^2}{8} \cdot \frac{3 - 2\,n^2}{N} \qquad V_C = V_E = \frac{q\,(l + l_0)}{2} - \frac{M_{B1}}{l}$$

$$M_{B3} = M_{D3} = -\frac{q\,l^2}{4} \cdot \frac{k + n^2\,(k_1 + 1)}{N} \qquad H = \frac{M_{B2}}{h}.$$

74.

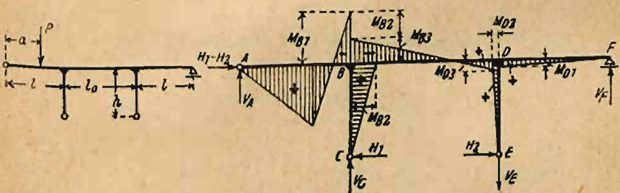


Fig. 585.

$$\delta = \frac{a}{l}$$

$$\left.\begin{matrix} M_{B1} \\ M_{D1} \end{matrix}\right\} = \mp \frac{P\,a\,(1 - \delta^2)}{4} \left[\frac{2\,k + 1}{N_1} \pm \frac{2\,k + 3}{N}\right] \qquad \begin{matrix} M_{B2} = M_{B3} - M_{B1} \\ M_{D2} = M_{D3} - M_{D1} \end{matrix}$$

$$M_{B3} = -\frac{P\,a\,(1 - \delta^2)\,k}{2} \left[\frac{1}{N_1} + \frac{1}{N}\right] \qquad V_A = P\,(1 - \delta) + \frac{M_{B1}}{l}$$

$$M_{D3} + \frac{P_a\,(1 - \delta^2)\,k}{2} \left[\frac{1}{N_1} - \frac{1}{N}\right] \qquad V_C = P\,\delta - \frac{M_{B1}}{l} + \frac{M_{D3} - M_{B3}}{l_0}$$

$$V_E = \frac{M_{D3} - M_{B3}}{l_0} + \frac{M_{D1}}{l} \qquad V_F = \frac{M_{D1}}{l} \qquad H_1 = \frac{M_{B2}}{h} \qquad H_2 = \frac{M_{D2}}{h}.$$

75.

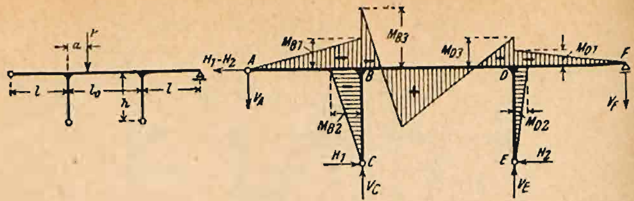


Fig. 586.

$$\delta = \frac{a}{l_0} \qquad\qquad k = \frac{J_2}{J_1} \cdot \frac{h}{l}$$

$$\left.\begin{matrix} M_{B1} \\ M_{D1} \end{matrix}\right\} = -\frac{P a (1-\delta) k_1}{2} \left[\frac{3}{N} \pm \frac{1-2\delta}{N_1}\right] \qquad V_A = -\frac{M_{B1}}{l}$$

$$V_F = -\frac{M_{D1}}{l}$$

$$\left.\begin{matrix} M_{B3} \\ M_{D3} \end{matrix}\right\} = -\frac{P a (1-\delta)(k_1+1)}{2} \left[\frac{3}{N} \mp \frac{1-2\delta}{N_1}\right] \qquad H_1 = -\frac{M_{B2}}{h}$$

$$H_2 = -\frac{M_{D2}}{h},$$

$$M_{B2} = M_{B3} - M_{B1} \qquad V_C = P(1-\delta) - \frac{M_{B1}}{l} + \frac{M_{D3} - M_{B3}}{l_0}$$

$$M_{D2} = M_{D3} - M_{D1} \qquad V_E = P\delta + \frac{M_{B3} - M_{B3}}{l_0} + \frac{M_{D1}}{l}.$$

IX. Rama jednopiętrowa.

76.

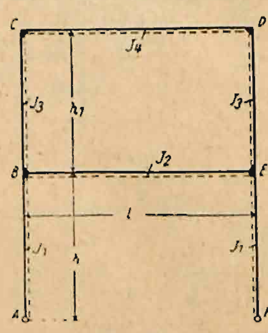


Fig. 587.

$$k = \frac{J_2}{J_1} \cdot \frac{h}{l}; \qquad k_1 = \frac{J_2}{J_3} \cdot \frac{h_1}{l}; \qquad k_2 = \frac{J_2}{J_4};$$

$$N = k_1^2 (2k+3) + 6 k_2 (k + k_1) + 4 k k_1 (k_2 + 1)$$

$$N_1 = 6 k_1 + k_2 + 1.$$

Uwaga. Momenty, wywołujące ciągnienie po stronie kreskowanej, dodatnie (+).

77.

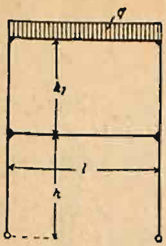
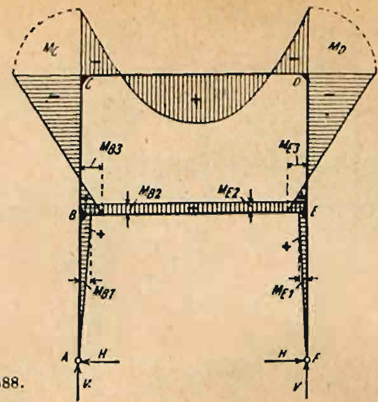


Fig. 588.



$$V = \frac{q\,l}{2} \qquad H = \frac{M_{B1}}{h} = \frac{M_{E1}}{h}$$

$$M_{B1} = M_{E1} = + \frac{q\,l^2}{4} \cdot \frac{k_1\,k_2}{h} \qquad M_{B2} = M_{E2} = - \frac{q\,l^2}{6} \cdot \frac{k\,k_1\,k_2}{N}$$

$$M_{B3} = M_{E3} = M_{B1} - M_{B2}$$

$$M_C = M_D = - \frac{q\,l^2}{6} \cdot \frac{k_2\,(2\,k\,k_1 + 3\,k + 3\,k_1)}{N}.$$

78.

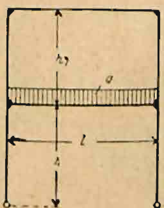
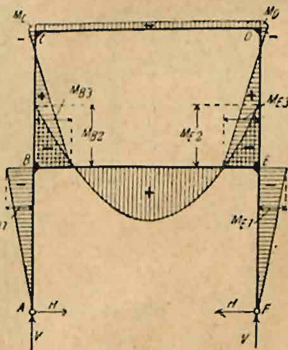


Fig. 589.



$$V = \frac{q\,l}{2} \qquad H = - \frac{M_{B1}}{h} = - \frac{M_{E1}}{h}$$

$$M_{B1} = M_{E1} = - \frac{q\,l^2}{4} \cdot \frac{k_1\,(k_1 + 2\,k_2)}{N}$$

$$M_{B2} = M_{E2} = M_{B1} - M_{B3}$$

$$M_{B3} = M_{E3} = + \frac{q\,l^2}{6} \cdot \frac{k\,(2\,k_1 + 3\,k_2)}{N} \qquad M_C = M_D = - \frac{q\,l^2}{6} \cdot \frac{k\,k_1}{N}.$$

79.

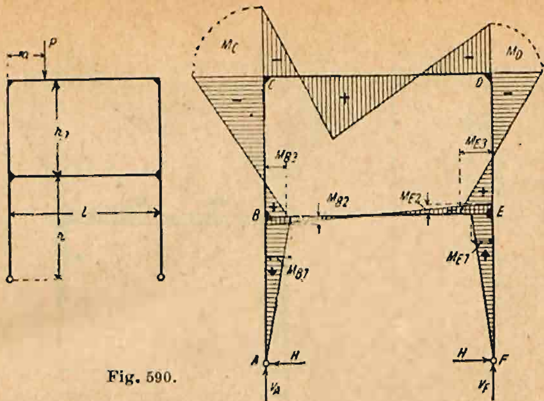


Fig. 590.

$$\delta = \frac{a}{l} \qquad V_A = P(1-\delta) \qquad V_F = P\delta \qquad H = \frac{M_{B1}}{h} = \frac{M_{E1}}{h}$$

$$M_{B1} = M_{E1} = + \frac{3\,P\,a\,(1-\delta)}{2} \cdot \frac{k_1\,k_2}{N}$$

$$\left.\begin{matrix} M_{B3} \\ M_{E3} \end{matrix}\right\} = + \frac{P\,a\,(1-\delta)\,k_2}{2}\left[\frac{k_1\,(2\,k+3)}{N} \mp \frac{1-2\,\delta}{N_1}\right]$$

$$\left.\begin{matrix} M_C \\ M_D \end{matrix}\right\} = - \frac{P\,a\,(1-\delta)\,k_2}{2}\left[\frac{2\,(2\,k\,k_1+3\,k+3\,k_1)}{N} \pm \frac{1-2\,\delta}{N_1}\right]$$

$$M_{B2} = M_{B1} - M_{B3} \qquad\qquad M_{E2} = M_{E1} - M_{E3}.$$

80.

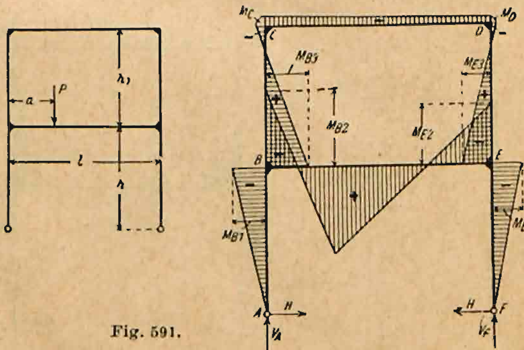


Fig. 591.

$$\delta = \frac{a}{l} \qquad V_A = P(1-\delta) \qquad V_F = P\delta \qquad H = -\frac{M_{B1}}{h} = -\frac{M_{E1}}{h}$$

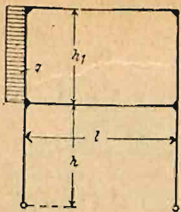
$$M_{B1} = M_{E1} = - \frac{3\,P\,a\,(1-\delta)}{2} \cdot \frac{k_1\,(k_1+2\,k_2)}{N}$$

$$\left.\begin{matrix} M_{B3} \\ M_{E3} \end{matrix}\right\} = + \frac{P\,a\,(1-\delta)}{2}\left[\frac{2\,k\,(2\,k_1+3\,k_2)}{N} \pm \frac{1-2\,\delta}{N_1}\right]$$

$$\left.\begin{matrix} M_C \\ M_D \end{matrix}\right\} = - \frac{P\,a\,(1-\delta)}{2}\left[\frac{2\,k\,k_1}{N} \mp \frac{1-2\,\delta}{N_1}\right]$$

$$M_{B2} = M_{B1} - M_{B3} \qquad\qquad M_{E2} = M_{E1} - M_{E3}.$$

81.



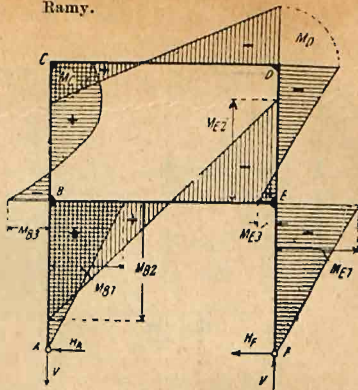


Fig. 592.

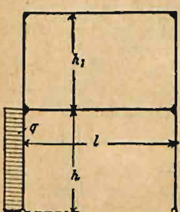
$$n = \frac{h}{h_1} \qquad V = \frac{q\,h_1^2\,(1+2\,n)}{2\,l} \qquad H_A = \frac{M_{B1}}{h} \qquad H_F = -\frac{M_{E1}}{h}$$

$$\left.\begin{matrix} M_{B1} \\ M_{E1} \end{matrix}\right\} = \pm\,\frac{q\,h_1^2}{8}\left[4\,n \mp \frac{k_1\,(k_1+3\,k_2)}{N}\right] \qquad \begin{matrix} M_{B2} = M_{B1} - M_{B3} \\ M_{E2} = M_{E1} - M_{E3} \end{matrix}$$

$$\left.\begin{matrix} M_{B3} \\ M_{E3} \end{matrix}\right\} = \pm\,\frac{q\,h_1^2}{4}\left[\frac{4\,k_1+k_2-2\,n}{N_1} \pm \frac{k_1\,(2\,k+3)\,(k_1+3\,k_2)}{6\,N}\right]$$

$$\left.\begin{matrix} M_C \\ M_D \end{matrix}\right\} = \pm\,\frac{q\,h_1^2}{4}\left[\frac{2\,k_1+1+2\,n}{N_1} \mp \frac{k_1\,(2\,k\,k_1+6\,k+3\,k_1)}{6\,N}\right]$$

82.



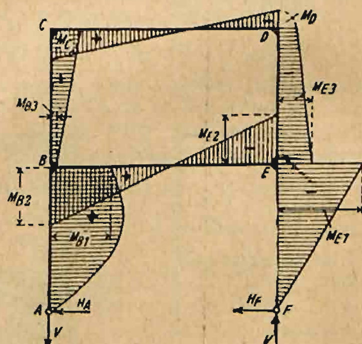


Fig. 593.

$$V = \frac{q\,h^2}{2\,l} \qquad H_A = \frac{M_{B1}}{h} + \frac{q\,h}{2\,h} \qquad H_F = -\frac{M_{E1}}{h}$$

$$M_{B1} = +\,\frac{q\,h^2}{8}\left[2 - \frac{k\,[k_1\,(k_1+2) + k_2\,(2\,k_1+3)]}{N}\right]$$

$$M_{E1} = -\,\frac{q\,h^2}{8}\left[2 + \frac{k\,[k_1\,(k_1+2) + k_2\,(2\,k_1+3)]}{N}\right]$$

$$M_{B3} = +\,\frac{q\,h^2}{8}\left[\frac{2}{N_1} - \frac{k\,(2\,k_1+3\,k_2)}{N}\right] \qquad M_{B2} = M_{B1} - M_{B3}$$

$$M_{E3} = -\,\frac{q\,h^2}{8}\left[\frac{2}{N_1} + \frac{k\,(2\,k_1+3\,k_2)}{N}\right] \qquad M_{E2} = M_{E1} - M_{E3}$$

$$\left.\begin{matrix} M_C \\ M_D \end{matrix}\right\} = \pm\,\frac{q\,h^2}{8}\left[\frac{2}{N_1} \pm \frac{k\,k_1}{N}\right].$$

83.

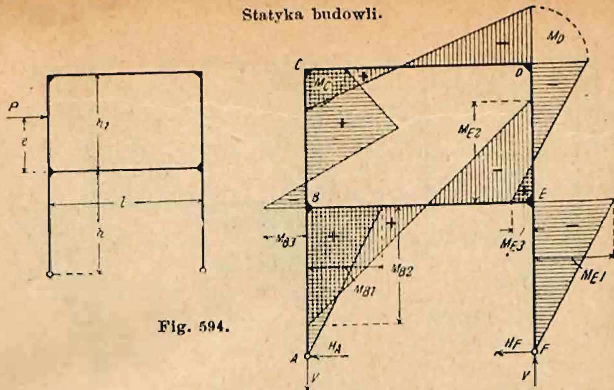


Fig. 594.

$$\delta = \frac{e}{h_1} \qquad V = \frac{P(h+e)}{l} \qquad H_A = \frac{M_{B1}}{h} \qquad H_F = -\frac{M_{E1}}{h}$$

$$\left.\begin{matrix} M_{B1} \\ M_{E1} \end{matrix}\right\} = \pm \frac{P}{2}\left[h \mp \frac{3\,e\,k_1(1-\delta)\,[k_1(1-\delta)+k_2(2-\delta)]}{N}\right]$$

$$\left.\begin{matrix} M_{B3} \\ M_{E3} \end{matrix}\right\} = \mp \frac{P}{2}\left[\frac{e\,[3\,k_1(2-\delta)+k_2]-h}{N_1} + \frac{e\,k_1(1-\delta)(2\,k+3)\,[k_1(1-\delta)+k_2(2-\delta)]}{N}\right]$$

$$\left.\begin{matrix} M_C \\ M_D \end{matrix}\right\} = \pm \frac{P}{2}\left[\frac{e\,(3\,k_1\,\delta+1)+h}{N_1} \mp \frac{e\,k_1(1-\delta)\,[\delta\,(2\,k\,k_1+2\,k+3\,k_1)+2\,k]}{N}\right]$$

$$M_{B2} = M_{B1} - M_{B3} \qquad M_{E2} = M_{E1} - M_{E3}.$$

84.

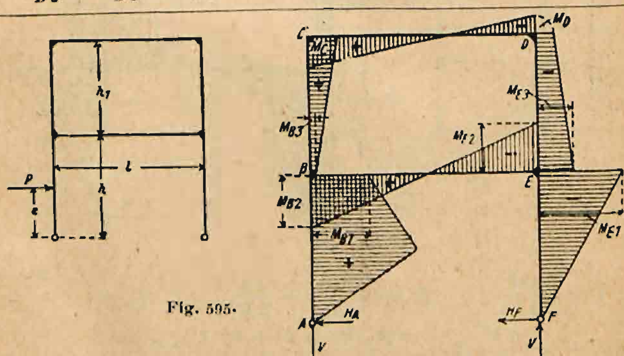


Fig. 595.

$$\delta = \frac{e}{h} \qquad V = \frac{P\,e}{l} \qquad H_A = \frac{M_{B1}}{h} + P(1-\delta) \qquad H_F = -\frac{M_{E1}}{h}$$

$$\left.\begin{matrix} M_{B1} \\ M_{E1} \end{matrix}\right\} = \pm \frac{P\,e}{2}\left[1 \mp \frac{(1-\delta^2)\,k\,[k_1(k_1+2)+k_2(2\,k_1+3)]}{N}\right]$$

$$\left.\begin{matrix} M_{B3} \\ M_{E3} \end{matrix}\right\} = + \frac{P\,e}{2}\left[\frac{1}{N_1} \mp \frac{(1-\delta^2)\,k\,(2\,k_1+3\,k_2)}{N}\right]$$

$$\left.\begin{matrix} M_C \\ M_D \end{matrix}\right\} = \pm \frac{P\,e}{2}\left[\frac{1}{N_1} \pm \frac{(1-\delta^2)\,k\,k_1}{N}\right] \qquad \begin{matrix} M_{B2} = M_{B1} - M_{B3} \\ M_{E2} = M_{E1} - M_{E3}. \end{matrix}$$