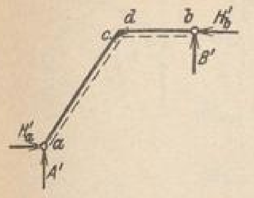
Die Statik im Stahlbetonbau

Beyer, Kurt

Berlin [u.a.], 1956

Dreifach statisch unbestimmte Rahmen

Tabelle 53. Halbrahmen mit waagerechtem Riegel.

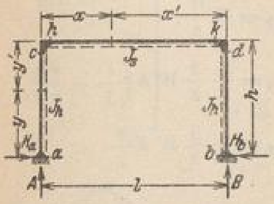


Mit den Werten A, B, $H_{a,b}$, M der Tabelle 52 für den mit seiner Belastung um 90° gedrehten Halbrahmen ergibt sich:

$$A' = H_b,$$
$$B' = -H_a,$$
$$H'_a = -B,$$
$$H'_b = A,$$
$$M_{c,k} = M_{d,e}.$$

Dreifach statisch unbestimmte Rahmen.

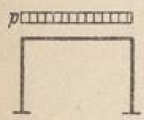
Tabelle 54. Symmetrischer Rahmen mit geradem Riegel.



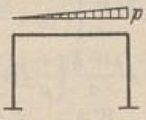
$$\xi = \frac{x}{l}, \qquad \eta = \frac{y}{h}, \qquad \omega \text{ Tabelle 22 S. 116}, \qquad \varkappa = \frac{h}{l}\frac{J_1}{J_h},$$

$$\xi' = \frac{x'}{l}, \qquad \eta' = \frac{y'}{h}, \qquad \mu = 2 + \varkappa, \qquad \nu = 1 + 6\varkappa,$$

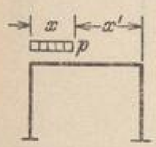
$M_{h,k} = M_{c,d}$, wenn nicht besonders angegeben.



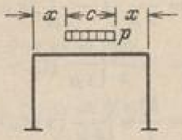
$$H_{a,b} = \frac{1}{4\mu}\frac{p l^2}{h},$$
$$M_{a,b} = \frac{p l^2}{12\mu},$$
$$M_{c,d} = -\frac{p l^2}{6\mu}.$$



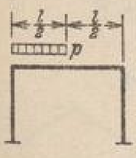
$$H_{a,b} = \frac{1}{8\mu}\frac{p l^2}{h},$$
$$M_{a,b} = \frac{p l^2}{120}\left(\frac{5}{\mu} \pm \frac{1}{\nu}\right),$$
$$M_{c,d} = -\frac{p l^2}{120}\left(\frac{10}{\mu} \mp \frac{1}{\nu}\right).$$



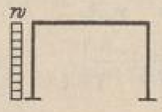
$$\Phi = \frac{1}{\mu}(3\xi^2 - 2\xi^3),$$
$$H_{a,b} = \frac{1}{4}\frac{p l^2}{h}\Phi,$$
$$M_{a,b} = \frac{p l^2}{12}\left(\Phi \mp \frac{3}{\nu}\omega_R^2\right),$$
$$M_{c,d} = -\frac{p l^2}{12}\left(2\Phi \pm \frac{3}{\nu}\omega_R^2\right).$$



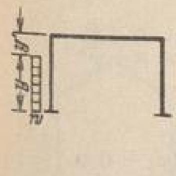
$$\Phi = \frac{1}{2\mu}(3\zeta - \zeta^3),$$
$$H_{a,b} = \frac{1}{4}\frac{p l^2}{h}\Phi,$$
$$M_{a,b} = \frac{p l^2}{12}\Phi,$$
$$\zeta = \frac{c}{l}. \qquad M_{c,d} = -\frac{p l^2}{6}\Phi.$$



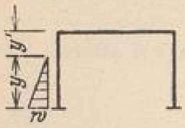
$$H_{a,b} = \frac{1}{8\mu}\frac{p l^2}{h},$$
$$M_{a,b} = \frac{p l^2}{24}\left(\frac{1}{\mu} \mp \frac{3}{8\nu}\right),$$
$$M_{c,d} = -\frac{p l^2}{24}\left(\frac{2}{\mu} \pm \frac{3}{8\nu}\right).$$



$$H_{a,b} = -\frac{w h}{4}\left(1 \pm 2 + \frac{1}{2\mu}\right),$$
$$M_{a,b} = -\frac{w h^2}{4}\left[\frac{3+\varkappa}{6\mu} \pm \left(1 - \frac{2\varkappa}{\nu}\right)\right],$$
$$M_{c,d} = -\frac{w h^2}{4}\varkappa\left(\frac{1}{6\mu} \mp \frac{2}{\nu}\right).$$



$$\Phi = \frac{1}{2} - \omega'_\varphi,$$
$$H_{a,b} = -\frac{w h}{4}\left\{2\eta \pm 2\eta - \eta^2 - \frac{1}{\mu}\left[\varkappa\,\omega_\varphi - (1+\varkappa)\Phi\right]\right\},$$
$$M_{a,b} = -\frac{w h^2}{4}\left\{\frac{1}{3\mu}\left[(3+2\varkappa)\Phi - \varkappa\,\omega_\varphi\right] \pm \eta^2\left(1 - 2\eta\frac{\varkappa}{\nu}\right)\right],$$
$$M_{c,d} = -\frac{w h^2}{4}\varkappa\left[\frac{1}{3\mu}(2\omega_\varphi - \Phi) \mp 2\frac{\eta^3}{\nu}\right].$$



$$H_{a,b} = -\frac{w\,h}{40}\,\eta\left\{10 \pm 10 - \frac{\eta^2}{\mu}\left[5\,(1+\varkappa) - \eta\,(1+2\,\varkappa)\right]\right\},$$

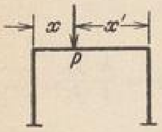
$$M_{a,b} = +\frac{w\,h^2}{40}\,\eta^2\left[\frac{\eta}{3\,\mu}\,(1+\varkappa)\,(5-3\,\eta) + \frac{5}{3}\,\eta - \frac{10}{3} \mp \left(\frac{10}{3} - \frac{5\,\varkappa}{\nu}\,\eta\right)\right],$$

$$M_{c,d} = -\frac{w\,h^2}{40}\,\varkappa\,\eta^3\left[\frac{1}{3\,\mu}\,(5-3\,\eta) \mp \frac{5}{\nu}\right].$$

$y = h$:

$$H_{a,b} = -\frac{w\,h}{40}\left[7 \pm 10 + \frac{2}{\mu}\right],$$

$$M_{a,b} = -\frac{w\,h^2}{40}\left[\frac{8+3\,\varkappa}{3\,\mu} \pm 5\left(\frac{2}{3} - \frac{\varkappa}{\nu}\right)\right], \qquad M_{c,d} = -\frac{w\,h^2}{40}\,\varkappa\left[\frac{2}{3\,\mu} \mp \frac{5}{\nu}\right].$$

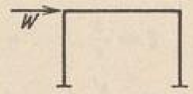


$$\Phi = \frac{1}{\nu}\,(1 - 2\,\xi),$$

$$H_{a,b} = \frac{3}{2}\,\frac{P\,l}{h}\,\frac{\omega_R}{\mu},$$

$$M_{a,b} = \frac{P\,l}{2}\,\omega_R\left(\frac{1}{\mu} \mp \Phi\right),$$

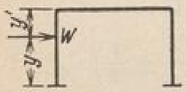
$$M_{c,d} = -\frac{P\,l}{2}\,\omega_R\left(\frac{2}{\mu} \pm \Phi\right).$$



$$H_{a,b} = \mp\frac{W}{2},$$

$$M_{a,b} = \mp\frac{3}{2}\,W\,h\left(\frac{1}{3} - \frac{\varkappa}{\nu}\right),$$

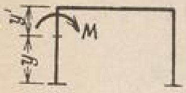
$$M_{c,d} = \pm\frac{3}{2}\,W\,h\,\frac{\varkappa}{\nu}.$$



$$H_{a,b} = -\frac{W}{2}\left\{1 \pm 1 - \eta - \frac{1}{\mu}\left[\varkappa\,\omega_D - (1+\varkappa)\,\omega_D'\right]\right\},$$

$$M_{a,b} = -\frac{W\,h}{2}\left\{\frac{1}{\mu}\left[(1+\varkappa)\,\omega_D' - \varkappa\,\omega_R\right] \pm \eta\left(1 - 3\,\eta\,\frac{\varkappa}{\nu}\right)\right\},$$

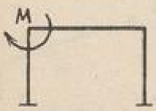
$$M_{c,d} = -\frac{W\,h}{2}\,\varkappa\,\eta^2\left[\frac{1}{\mu}\,(1-\eta) \mp \frac{3}{\nu}\right].$$



$$H_{a,b} = \frac{\mathsf{M}}{2\,h}\left\{1 - \frac{1}{\mu}\left[\varkappa\,\omega_M + (1+\varkappa)\,\omega_M'\right]\right\},$$

$$M_{a,b} = -\frac{\mathsf{M}}{2}\left\{\frac{1}{3\,\mu}\left[(3+2\,\varkappa)\,\omega_M' + \varkappa\,\omega_M\right] \pm \left(1 - 6\,\eta\,\frac{\varkappa}{\nu}\right)\right\}$$

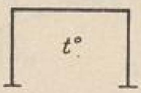
$$M_{h,k} = \frac{\mathsf{M}}{2}\,\varkappa\left\{\frac{1}{3\,\mu}\left[2\,\omega_M + \omega_M'\right] \pm \frac{6}{\nu}\,\eta\right\}.$$



$$H_{a,b} = \frac{3}{2\,\mu}\,\frac{\mathsf{M}}{h},$$

$$M_{a,b} = \frac{\mathsf{M}}{2}\left[\frac{1}{\mu} \mp \frac{1}{\nu}\right],$$

$$M_{h,k} = \frac{\mathsf{M}}{2}\,\varkappa\left[\frac{1}{\mu} \pm \frac{6}{\nu}\right].$$



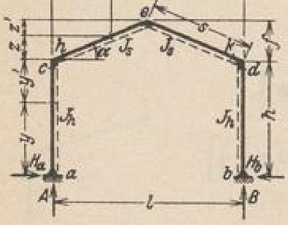
$$\Phi = \frac{3}{\mu}\,\frac{E\,J_s}{h}\,\alpha_t\,t,$$

$$H_{a,b} = \frac{2\,\varkappa+1}{\varkappa}\,\frac{\Phi}{h},$$

$$M_{a,b} = \frac{\varkappa+1}{\varkappa}\,\Phi,$$

$$M_{c,d} = -\Phi.$$

Tabelle 55. Symmetrischer Rahmen mit gebrochenem Riegel.



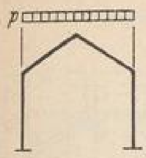
$$\xi = \frac{x}{l}, \quad \eta = \frac{y}{h}, \quad \zeta = \frac{z}{f}, \quad \lambda = \frac{l}{h}, \quad \varphi = \frac{f}{h},$$

$$\xi' = \frac{x'}{l}, \quad \eta' = \frac{y'}{h}, \quad \zeta' = \frac{z'}{f}, \quad \varkappa = \frac{h}{s}\,\frac{J_s}{J_h}, \quad \varrho = \frac{3}{2}\,\frac{\varkappa-\varphi}{\varkappa+\varphi^2},$$

$$\mu = 4\,(1+\varkappa) - 2\,\varrho\,(\varkappa-\varphi), \qquad \psi_1 = 2\,\frac{(1+\varkappa)}{\varkappa-\varphi},$$

$$\nu = 2 + 6\,\varkappa, \qquad \psi_2 = \frac{3}{2}\,\frac{2+\varkappa+\varphi}{\varkappa+\varphi^2} = (\psi_1 - 1)\,\varrho.$$

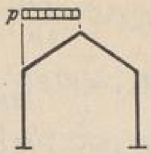
$M_{h,k} = M^*_{c,d}$, wenn nicht besonders angegeben.



$$H_{a,b}=\frac{p\,l}{24}\,\frac{\varrho\lambda}{\mu}\,(5\,\varphi\,\psi_1+8)\,,$$

$$M_{a,b}=\frac{p\,l^2}{24\,\mu}\,[5\,\varphi\,\psi_2+8\,(\varrho-1)]\,,$$

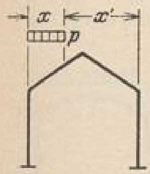
$$M_{c,d}=-\frac{p\,l^2}{24\,\mu}\,(5\,\varphi\,\varrho+8)\,.$$



$$H_{a,b}=\frac{p\,l}{48}\,\frac{\lambda\varrho}{\mu}\,(5\,\varphi\,\psi_1+8)\,,$$

$$M_{a,b}=\frac{p\,l^2}{96}\left\{\frac{2}{\mu}\,[5\,\varphi\,\psi_2+8\,(\varrho-1)]\mp\frac{3}{\nu}\right\}$$

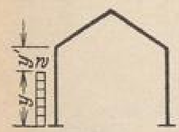
$$M_{c,d}=-\frac{p\,l^2}{96}\left[\frac{2}{\mu}\,(5\,\varphi\,\varrho+8)\pm\frac{3}{\nu}\right].$$



$$H_{a,b}=\frac{p\,l}{6}\,\frac{\varrho\lambda}{\mu}\,\xi^2\,[(\varphi\,\psi_1\,(3-2\,\xi^2)+2\,(3-2\,\xi)]\,,$$

$$M_{a,b}=\frac{p\,l^2}{6}\,\xi^2\left\{\frac{1}{\mu}\,[\varphi\,\psi_2\,(3-2\,\xi^2)+2\,(3-2\,\xi)\,(\varrho-1)]\mp\frac{3}{\nu}\,\xi'^2\right\};$$

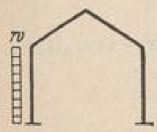
$$x\leqq\frac{l}{2}:\quad M_{c,d}=-\frac{p\,l^2}{6}\,\xi^2\left\{\frac{1}{\mu}\,[\varphi\,\varrho\,(3-2\,\xi^2)+2\,(3-2\,\xi)]\pm\frac{3}{\nu}\,\xi'^2\right\}.$$



$$H_{a,b}=-\frac{w\,h}{2}\,\eta\left\{\pm 1+1-\frac{\varkappa\varrho}{6\,\mu}\,\eta^2\,[\psi_1\,(4-\eta)-4]\right\},$$

$$M_{a,b}=\frac{w\,h^2}{12}\,\eta^2\left\{\frac{\varkappa}{\mu}\,\eta\,[\psi_2\,(4-\eta)-4\,(\varrho-1)]-3\mp\left(3-6\,\eta\,\frac{\varkappa}{\nu}\right)\right\},$$

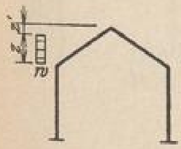
$$M_{c,d}=-\frac{w\,h^2}{12}\,\varkappa\,\eta^3\left\{\frac{1}{\mu}\,[\varrho\,(4-\eta)-4]\mp\frac{6}{\nu}\right\}.$$



$$H_{a,b}=-\frac{w\,h}{2}\left[\pm 1+1-\frac{\varkappa\varrho}{6\,\mu}\,(3\,\psi_1-4)\right],$$

$$M_{a,b}=\frac{w\,h^2}{12}\left\{\frac{\varkappa}{\mu}\,[3\,\psi_2-4\,(\varrho-1)]-3\mp\left(3-6\,\frac{\varkappa}{\nu}\right)\right\},$$

$$M_{c,d}=-\frac{w\,h^2}{12}\,\varkappa\left[\frac{1}{\mu}\,(3\,\varrho-4)\mp\frac{6}{\nu}\right].$$

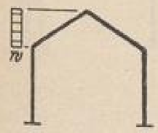


$$\Phi_1=1+\zeta'+\zeta'^2\,,\qquad \Phi_2=(1+\zeta')\,(1-\zeta'^2)\,,$$

$$H_{a,b}=-\frac{w\,f}{2}\,\zeta\left\{\pm 1+\frac{\varphi\,\varrho}{6\,\mu}\,[(3\,\varphi\,\psi_1+4)\,\Phi_1-\varphi\,\psi_1\,\zeta'^3]\right\},$$

$$M_{a,b}=-\frac{w\,f^2}{24}\left\{\frac{2}{\mu}\,[3\,\varphi\,\psi_2+4\,(\varrho-1)]\,\Phi_1+\varphi\,\varrho\left(1-\frac{2\,\psi_1}{\mu}\right)\zeta'^3\pm\left[\frac{12}{\varphi}-\frac{3}{\nu}\left(12\,\frac{\varkappa}{\varphi}-\Phi_2\right)\right]\right\}$$

$$M_{c,d}=\frac{w\,f^2}{24}\,\zeta\left[\frac{2}{\mu}\,(3\,\varphi\,\varrho+4)\,\Phi_1-\varphi\,\varrho\,\zeta'^3\pm\frac{3}{\nu}\left(12\,\frac{\varkappa}{\varphi}-\Phi_2\right)\right].$$



$$H_{a,b}=-\frac{w\,f}{2}\left[\pm 1+\frac{\varphi\,\varrho}{6\,\mu}\,(3\,\varphi\,\psi_1+4)\right],$$

$$M_{a,b}=-\frac{w\,f^2}{24}\left\{\frac{2}{\mu}\,[3\,\varphi\,\psi_2+4\,(\varrho-1)]\pm\left[\frac{12}{\varphi}-\frac{3}{\nu}\left(12\,\frac{\varkappa}{\varphi}-1\right)\right]\right\},$$

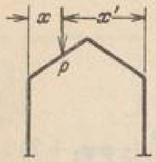
$$M_{c,d}=\frac{w\,f^2}{24}\left[\frac{2}{\mu}\,(3\,\varphi\,\varrho+4)\pm\frac{3}{\nu}\left(12\,\frac{\varkappa}{\varphi}-1\right)\right].$$

$y=h:\quad \eta=1$

$$H_{a,b}=-\frac{w\,h}{4}\,\eta\left\{\pm 1+1-\frac{\varkappa\varrho}{15\,\mu}\,\eta^2\,[\psi_1\,(5-\eta)-5]\right\},$$

$$M_{a,b}=\frac{w\,h^2}{120}\,\eta^2\left\{\frac{2\,\varkappa}{\mu}\,\eta\,[\psi_2\,(5-\eta)-5\,(\varrho-1)]-10\mp\left(10-15\,\frac{\varkappa}{\nu}\,\eta\right)\right\},$$

$$M_{c,d}=-\frac{w\,h^2}{120}\,\varkappa\,\eta^3\left\{\frac{2}{\mu}\,[\varrho\,(5-\eta)-5]\mp\frac{15}{\nu}\right\}.$$

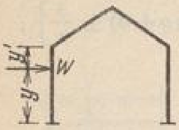


$x \leqq \frac{l}{2}$

$$H_{a,b} = P \frac{\varrho \lambda}{3\mu} \xi \left[\varphi \psi_1 (3 - 4\xi^2) + 6\xi'\right],$$

$$M_{a,b} = P l \xi \left\{\frac{1}{3\mu} \left[\varphi \psi_2 (3 - 4\xi^2) + 6(\varrho - 1)\xi'\right] \mp \frac{1}{\nu} \xi'(\xi' - \xi)\right\},$$

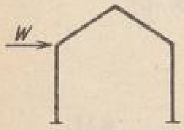
$$M_{c,d} = - P l \xi \left\{\frac{1}{3\mu} \left[\varphi \varrho (3 - 4\xi^2) + 6\xi'\right] \pm \frac{1}{\nu} \xi'(\xi' - \xi)\right\}.$$



$$H_{a,b} = -\frac{W}{2} \left\{\pm 1 + 1 - \frac{2\varkappa\varrho}{3\mu} \eta^2 \left[\psi_1 (3 - \eta) - 3\right]\right\},$$

$$M_{a,b} = \frac{W h}{2} \eta \left\{\frac{2\varkappa}{3\mu} \eta \left[\psi_2 (3 - \eta) - 3(\varrho - 1)\right] - 1 \pm \left(\frac{3}{\nu} \varkappa \eta - 1\right)\right\},$$

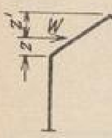
$$M_{c,d} = -\frac{W h}{6} \varkappa \eta^2 \left\{\frac{2}{\mu} \left[\varrho (3 - \eta) - 3\right] \mp \frac{9}{\nu}\right\}.$$



$$H_{a,b} = -\frac{W}{2} \left[\pm 1 + \frac{2\varphi\varrho}{3\mu} (2\varphi\psi_1 + 3)\right],$$

$$M_{a,b} = -\frac{W h}{2} \left\{\frac{2\varphi}{3\mu} \left[2\varphi\psi_2 + 3(\varrho - 1)\right] \mp \left(\frac{3\varkappa}{\nu} - 1\right)\right\},$$

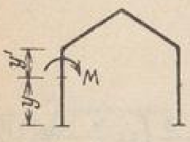
$$M_{c,d} = \frac{W h}{2} \left[\frac{2\varphi}{3\mu} (2\varphi\varrho + 3) \pm \frac{3\varkappa}{\nu}\right].$$



$$H_{a,b} = -\frac{W}{2} \left\{\pm 1 + \frac{2\varphi\varrho}{3\mu} \zeta'^2 \left[\varphi \psi_1 (3 - \zeta') + 3\right]\right\},$$

$$M_{a,b} = -\frac{W h}{2} \left\{\frac{2\varphi}{3\mu} \zeta'^2 \left[\varphi \psi_2 (3 - \zeta') + 3(\varrho - 1)\right] \pm \left[1 - \frac{1}{\nu} \left(3\varkappa - \varphi (2 - \zeta)\, \omega_R(\zeta)\right)\right]\right\},$$

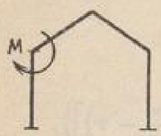
$$M_{c,d} = \frac{W h}{2} \left\{\frac{2\varphi}{3\mu} \zeta'^2 \left[\varphi \varrho (3 - \zeta') + 3\right] \pm \frac{1}{\nu} \left[3\varkappa - \varphi (2 - \zeta)\, \omega_R(\zeta)\right]\right\}.$$



$$H_{a,b} = \frac{\mathrm{M}}{h} \frac{\varkappa\varrho}{\mu} \eta \left[\psi_1 (2 - \eta) - 2\right],$$

$$M_{a,b} = \frac{\mathrm{M}}{2} \left\{\frac{2\varkappa\eta}{\mu} \left[\psi_2 (2 - \eta) - 2(\varrho - 1)\right] - 1 \mp \left(1 - 6\eta \frac{\varkappa}{\nu}\right)\right\},$$

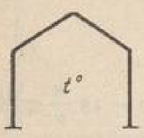
$$M_{h,k} = -\mathrm{M} \varkappa \eta \left\{\frac{1}{\mu} \left[\varrho (2 - \eta) - 2\right] \mp \frac{3}{\nu}\right\}.$$



$$H_{a,b} = \frac{\mathrm{M}}{h} \frac{\varkappa\varrho}{\mu} (\psi_1 - 2),$$

$$M_{a,b} = \frac{\mathrm{M}}{2} \left\{\frac{2\varkappa}{\mu} \left[\psi_2 - 2(\varrho - 1)\right] - 1 \mp \left[1 - \frac{6\varkappa}{\nu}\right]\right\},$$

$$M_{h,k} = -\mathrm{M} \varkappa \left[\frac{1}{\mu} (\varrho - 2) \mp \frac{3}{\nu}\right].$$

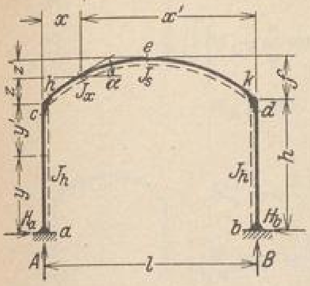


$$H_{a,b} = \varrho \left(2 \frac{\varrho}{\mu} + \frac{1}{\varkappa - \varphi}\right) \frac{l}{s} \frac{E J_s}{h^2} \alpha_t t,$$

$$M_{a,b} = \varrho \left[\frac{2}{\mu} (\varrho - 1) + \frac{1}{\varkappa - \varphi}\right] \frac{l}{s} \frac{E J_s}{h} \alpha_t t,$$

$$M_{c,d} = -\frac{2\varrho}{\mu} \frac{l}{s} \frac{E J_s}{h} \alpha_t t.$$

Tabelle 56. Symmetrischer Rahmen mit parabolisch gekrümmtem Riegel.



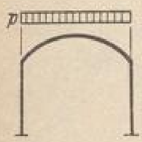
$$\xi = \frac{x}{l}, \quad \eta = \frac{y}{h}, \quad \zeta = \frac{z}{f}, \quad \varphi = \frac{f}{h}, \quad \frac{J_s}{J_x \cos\alpha} = 1,$$

$$\xi' = \frac{x'}{l}, \quad \eta' = \frac{y'}{h}, \quad \zeta' = \frac{z'}{f}, \quad \varkappa = \frac{h}{l}\,\frac{J_s}{J_h}, \quad \varrho = \frac{5}{2}\,\frac{3\varkappa - 2\varphi}{5\varkappa + 4\varphi^2},$$

$$\mu = 3(1 + 2\varkappa) - \varrho(3\varkappa - 2\varphi), \qquad \psi_1 = 3\,\frac{1 + 2\varkappa}{3\varkappa - 2\varphi},$$

$$\nu = 1 + 6\varkappa, \qquad \psi_2 = (\psi_1 - 1)\,\varrho,$$

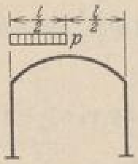
$M_{h,k} = M_{c,d}$, wenn nicht besonders angegeben.



$$H_{a,b} = \frac{p\,l^2}{20\,h}\,\frac{\varrho}{\mu}(4\varphi\psi_1 + 5),$$

$$M_{a,b} = +\frac{p\,l^2}{20\,\mu}[4\varphi\psi_2 + 5(\varrho - 1)],$$

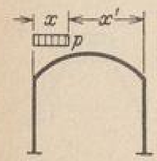
$$M_{c,d} = -\frac{p\,l^2}{20\,\mu}(4\varphi\varrho + 5).$$



$$H_{a,b} = \frac{p\,l^2}{40\,h}\,\frac{\varrho}{\mu}[4\varphi\psi_1 + 5],$$

$$M_{a,b} = +\frac{p\,l^2}{40}\left\{\frac{1}{\mu}[4\varphi\psi_2 + 5(\varrho - 1)] \mp \frac{5}{8\nu}\right\},$$

$$M_{c,d} = -\frac{p\,l^2}{40}\left[\frac{1}{\mu}(4\varphi\varrho + 5) \pm \frac{5}{8\nu}\right].$$

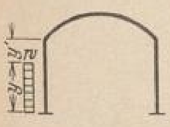


$$\Phi_1 = (5 - 5\xi^2 + 2\xi^3), \qquad \Phi_2 = (3 - 2\xi),$$

$$H_{a,b} = \frac{p\,l^2}{20\,h}\,\frac{\varrho}{\mu}\,\xi^2[2\varphi\psi_1\Phi_1 + 5\Phi_2],$$

$$M_{a,b} = +\frac{p\,l^2}{20}\,\xi^2\left\{\frac{1}{\mu}[2\varphi\psi_2\Phi_1 + 5(\varrho - 1)\Phi_2] \mp \frac{5}{\nu}\xi'^2\right\},$$

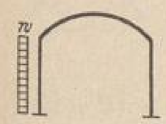
$$M_{c,d} = -\frac{p\,l^2}{20}\,\xi^2\left\{\frac{1}{\mu}[2\varphi\varrho\Phi_1 + 5\Phi_2] \pm \frac{5}{\nu}\xi'^2\right\}.$$



$$H_{a,b} = -\frac{w\,h}{2}\,\eta\left\{1 \pm 1 - \frac{\varkappa\varrho}{4\mu}\eta^2[\psi_1(4 - \eta) - 4]\right\},$$

$$M_{a,b} = +\frac{w\,h^2}{4}\,\eta^2\left\{\frac{\varkappa\eta}{2\mu}[\psi_2(4 - \eta) - 4(\varrho - 1)] - 1 \mp \left(1 - 2\eta\frac{\varkappa}{\nu}\right)\right\},$$

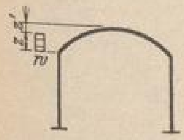
$$M_{c,d} = -\frac{w\,h^2}{4}\,\varkappa\,\eta^2\left\{\frac{1}{2\mu}[\varrho(4 - \eta) - 4] \mp \frac{2}{\nu}\right\}.$$



$$H_{a,b} = -\frac{w\,h}{2}\left[1 \pm 1 - \frac{\varkappa\varrho}{4\mu}(3\psi_1 - 4)\right],$$

$$M_{a,b} = +\frac{w\,h^2}{4}\left\{\frac{\varkappa}{2\mu}[3\psi_2 - 4(\varrho - 1)] - 1 \mp \left(1 - \frac{2\varkappa}{\nu}\right)\right\},$$

$$M_{c,d} = -\frac{w\,h^2}{4}\,\varkappa\left[\frac{1}{2\mu}(3\varrho - 4) \mp \frac{2}{\nu}\right].$$

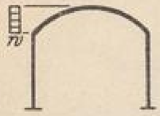


$$\Phi_1 = \left(1 - \zeta'^{\frac{5}{2}}\right), \qquad \Phi_2 = \left(1 - \zeta'^{\frac{7}{2}}\right),$$

$$H_{a,b} = -\frac{w\,f}{2}\left\{\pm\zeta + \frac{4}{5}\,\frac{\varphi\varrho}{\mu}\left[(\varphi\psi_1 + 1)\Phi_1 - \frac{1}{7}\varphi\psi_1\Phi_2\right]\right\},$$

$$M_{a,b} = -w\,f^2\left\{\frac{2}{5\mu}\left[(\varphi\psi_2 + \varrho - 1)\Phi_1 - \frac{\varphi\psi_2}{7}\Phi_2\right] \pm \zeta\left[\frac{1}{2\varphi} - \frac{1}{8\nu}\left(12\frac{\varkappa}{\varphi} - 1 + \zeta'^2\right)\right]\right\},$$

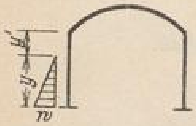
$$M_{c,d} = w\,f^2\left\{\frac{2}{5\mu}\left[(\varphi\varrho + 1)\Phi_1 - \frac{\varphi\varrho}{7}\Phi_2\right] \pm \frac{1}{8\nu}\,\zeta\left[12\frac{\varkappa}{\varphi} - 1 + \zeta'^2\right]\right\}.$$



$$H_{a,b} = -\frac{wf}{2}\left[\pm 1 + \frac{4}{5}\frac{\varphi\varrho}{\mu}\left(\frac{6}{7}\varphi\psi_1 + 1\right)\right],$$

$$M_{a,b} = -wf^2\left\{\frac{2}{5\mu}\left[\frac{6}{7}\varphi\psi_2 + (\varrho - 1)\right] \pm \left[\frac{1}{2\varphi} - \frac{1}{8\nu}\left(12\frac{\varkappa}{\varphi} - 1\right)\right]\right\},$$

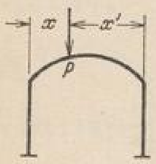
$$M_{c,d} = wf^2\left[\frac{2}{5\mu}\left(\frac{6}{7}\varphi\varrho + 1\right) \pm \frac{1}{8\nu}\left(12\frac{\varkappa}{\varphi} - 1\right)\right].$$



$$H_{a,b} = -\frac{wh}{4}\eta\left\{1 \pm 1 - \frac{\varkappa\varrho\eta^2}{10\mu}[\psi_1(5-\eta) - 5]\right\},$$

$$M_{a,b} = +\frac{wh^2}{40}\eta^2\left\{\frac{\varkappa\eta}{\mu}[\psi_2(5-\eta) - 5(\varrho - 1)] - \frac{10}{3} \mp \left(\frac{10}{3} - 5\eta\frac{\varkappa}{\nu}\right)\right\},$$

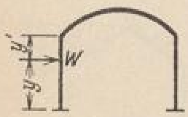
$$M_{c,d} = -\frac{wh^2}{40}\varkappa\eta^3\left\{\frac{1}{\mu}[\varrho(5-\eta) - 5] \mp \frac{5}{\nu}\right\}.$$



$$H_{a,b} = \frac{Pl}{2h}\frac{\varrho}{\mu}(2\varphi\psi_1\omega_P'' + 3\omega_R),$$

$$M_{a,b} = +\frac{Pl}{2}\left\{\frac{1}{\mu}[2\varphi\psi_2\omega_P'' + 3(\varrho - 1)\omega_R] \mp \frac{1}{\nu}(\xi' - \xi)\omega_R\right\},$$

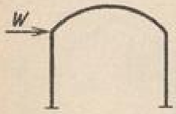
$$M_{c,d} = -\frac{Pl}{2}\left[\frac{1}{\mu}(2\varphi\varrho\omega_P'' + 3\omega_R) \pm \frac{1}{\nu}(\xi' - \xi)\omega_R\right].$$



$$H_{a,b} = -\frac{W}{2}\left\{1 \pm 1 - \frac{\varkappa\varrho}{\mu}\eta^2[\psi_1(3-\eta) - 3]\right\},$$

$$M_{a,b} = +\frac{Wh}{2}\eta\left\{\frac{\varkappa\eta}{\mu}[\psi_2(3-\eta) - 3(\varrho - 1)] - 1 \mp \left(1 - 3\eta\frac{\varkappa}{\nu}\right)\right\},$$

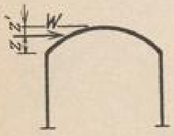
$$M_{c,d} = -\frac{Wh}{2}\varkappa\eta^2\left\{\frac{1}{\mu}[\varrho(3-\eta) - 3] \mp \frac{3}{\nu}\right\}.$$



$$H_{a,b} = -\frac{W}{2}\left[1 \pm 1 - \frac{\varkappa\varrho}{\mu}(2\psi_1 - 3)\right],$$

$$M_{a,b} = +\frac{Wh}{2}\left\{\frac{\varkappa}{\mu}[2\psi_2 - 3(\varrho - 1)] - 1 \mp \left(1 - 3\frac{\varkappa}{\nu}\right)\right\},$$

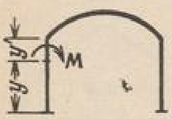
$$M_{c,d} = -\frac{Wh}{2}\varkappa\left[\frac{1}{\mu}(2\varrho - 3) \mp \frac{3}{\nu}\right].$$



$$H_{a,b} = -\frac{W}{2}\left\{\pm 1 + \frac{2}{5}\frac{\varphi\varrho}{\mu}\zeta'^{\frac{3}{2}}[\varphi\psi_1(5-\zeta') + 5]\right\},$$

$$M_{a,b} = -Wf\left\{\frac{\zeta'^{\frac{3}{2}}}{5\mu}[\varphi\psi_2(5-\zeta') + 5(\varrho - 1)] \pm \left[\frac{1}{2\varphi} - \frac{1}{8\nu}\left(12\frac{\varkappa}{\varphi} - 1 - 2\zeta' + 3\zeta'^2\right)\right]\right\},$$

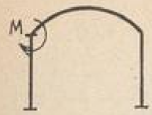
$$M_{c,d} = Wf\left\{\frac{\zeta'^{\frac{3}{2}}}{5\mu}[\varphi\varrho(5-\zeta') + 5] \pm \frac{1}{8\nu}\left[12\frac{\varkappa}{\varphi} - 1 - 2\zeta' + 3\zeta'^2\right]\right\}.$$



$$H_{a,b} = \frac{3}{2}\frac{\mathsf{M}}{h}\frac{\varkappa\varrho}{\mu}\eta[\psi_1(2-\eta) - 2],$$

$$M_{a,b} = +\frac{\mathsf{M}}{2}\left\{\frac{3\varkappa\eta}{\mu}[\psi_2(2-\eta) - 2(\varrho - 1)] - 1 \mp \left(1 - 6\eta\frac{\varkappa}{\nu}\right)\right\},$$

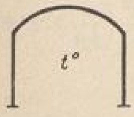
$$M_{c,d} = -\frac{3}{2}\mathsf{M}\varkappa\eta\left\{\frac{1}{\mu}[\varrho(2-\eta) - 2] \mp \frac{2}{\nu}\right\}.$$



$$H_{a,b} = \frac{3}{2}\,\frac{\mathsf{M}}{h}\,\frac{\varkappa\varrho}{\mu}\,(\psi_1 - 2),$$

$$M_{a,b} = +\frac{\mathsf{M}}{2}\left\{\frac{3\varkappa}{\mu}\,[\psi_2 - 2(\varrho - 1)] - 1 \mp \left(1 - 6\,\frac{\varkappa}{\nu}\right)\right\},$$

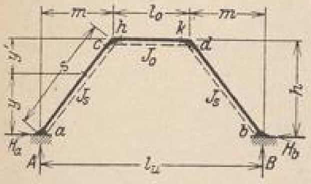
$$M_{h,k} = -\frac{3}{2}\,\mathsf{M}\varkappa\left[\frac{1}{\mu}(\varrho - 2) \mp \frac{2}{\nu}\right].$$



$$H_{a,b} = \frac{3\varrho\psi_1}{\mu}\,\frac{EJ_s}{h^2}\,\alpha_t t,$$

$$M_{a,b} = +\frac{3\psi_2}{\mu}\,\frac{EJ_s}{h}\,\alpha_t t, \qquad M_{c,d} = -\frac{3\varrho}{\mu}\,\frac{EJ_s}{h}\,\alpha_t t.$$

Tabelle 57. Symmetrischer Rahmen mit schrägen Pfosten.

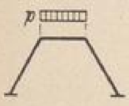


$$\eta = \frac{y}{h}, \qquad \lambda_1 = \frac{m}{l_u}, \qquad \lambda' = \frac{l_o}{l_u}, \qquad \varkappa = \frac{l_o}{s}\,\frac{J_s}{J_0},$$

$$\eta' = \frac{y'}{h}, \qquad \lambda_2 = \frac{m}{l_o}, \qquad \lambda'' = \frac{l_u}{l_o}, \qquad \mu = 1 + 2\varkappa,$$

$$\nu = \varkappa\lambda'^2 + 2(1 + \lambda' + \lambda'^2),$$ ω Tabelle 22, S. 116.

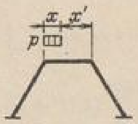
$M_{h,k} = M_{c,d}$, wenn nicht besonders angegeben.



$$H_{a,b} = \frac{p\,l_0^2}{4h}\left(\frac{\varkappa}{\mu} + 2\lambda_2\right),$$

$$M_{a,b} = \frac{p\,l_0^2}{12}\,\frac{\varkappa}{\mu},$$

$$M_{c,d} = -\frac{p\,l_0^2}{6}\,\frac{\varkappa}{\mu}.$$



$$\xi = \frac{x}{l_0}, \quad \xi' = \frac{x'}{l_0}$$

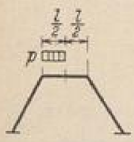
$$\Phi = \frac{\omega_R}{\nu}\,[\lambda'^2\varkappa\omega_R - 2\lambda_1(2 + \lambda')],$$

$$\psi = 3\xi^2 - 2\xi^3,$$

$$H_{a,b} = \frac{p\,l_0^2}{4h}\left(\frac{\varkappa}{\mu}\,\psi + 2\lambda_2\xi\right),$$

$$M_{c,d} = -\frac{p\,l_0^2}{4}\left(\frac{2\varkappa}{3\mu}\,\psi \pm \Phi\right),$$

$$M_{a,b} = \frac{p\,l_0^2}{4}\left[\frac{\varkappa}{3\mu}\,\psi \mp (2\lambda_2\omega_R + \lambda''\Phi)\right].$$

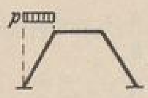


$$\Phi = \frac{1}{8\nu}\,[\lambda'^2\varkappa - 8\lambda_1(2 + \lambda')],$$

$$H_{a,b} = \frac{p\,l_0^2}{8h}\left(\frac{\varkappa}{\mu} + 2\lambda_2\right),$$

$$M_{a,b} = \frac{p\,l_0^2}{8}\left[\frac{\varkappa}{3\mu} \mp (\lambda_2 + \lambda''\Phi)\right],$$

$$M_{c,d} = -\frac{p\,l_0^2}{8}\left(\frac{2\varkappa}{3\mu} \pm \Phi\right).$$

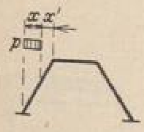


$$\Phi = \frac{2 - \lambda_1}{\nu},$$

$$H_{a,b} = \frac{p\,m^2}{4h}\left(1 - \frac{\varkappa}{2\mu}\right),$$

$$M_{a,b} = -\frac{p\,m^2}{4}\left[\frac{1 + 3\varkappa}{6\mu} \pm (1 - \Phi)\right],$$

$$M_{c,d} = -\frac{p\,m^2}{4}\left(\frac{1}{6\mu} \mp \lambda'\Phi\right).$$



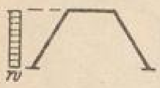
$$\xi = \frac{x}{m}, \quad \xi' = \frac{x'}{m}$$

$$\Phi = \frac{\xi^3}{\nu}(2 - \lambda_1\xi), \qquad \psi = \frac{1}{2} - \omega'_\varphi,$$

$$H_{a,b} = \frac{p\,m^2}{4h}\left\{\frac{1}{\mu}\,[\omega_\varphi - (1 + \varkappa)\psi] + \xi^2\right\},$$

$$M_{a,b} = -\frac{p\,m^2}{4}\left\{\frac{1}{3\mu}\,[(2 + 3\varkappa)\psi - \omega_\varphi] \pm (\xi^2 - \Phi)\right\},$$

$$M_{c,d} = -\frac{p\,m^2}{4}\left[\frac{1}{3\mu}(2\omega_\varphi - \psi) \mp \lambda'\Phi\right].$$

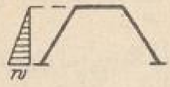


$$\Phi = \frac{2 - \lambda_1}{\nu},$$

$$H_{a,b} = -\frac{w\,h}{4}\left(1 \pm 2 + \frac{\varkappa}{2\,\mu}\right),$$

$$M_{a,b} = -\frac{w\,h^2}{4}\left[\frac{1 + 3\,\varkappa}{6\,\mu} \pm (1 - \Phi)\right],$$

$$M_{c,d} = -\frac{w\,h^2}{4}\left(\frac{1}{6\,\mu} \mp \lambda'\,\Phi\right).$$

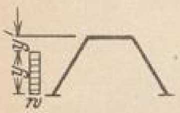


$$\Phi = \frac{1}{\nu}\,(5 - 2\,\lambda_1),$$

$$H_{a,b} = \frac{w\,h}{40}\left(\frac{1}{\mu} - 8 \mp 10\right),$$

$$M_{a,b} = -\frac{w\,h^2}{40}\left[\frac{2\,\varkappa}{3\,\mu} + 1 \pm \left(\frac{10}{3} - \Phi\right)\right]$$

$$M_{c,d} = -\frac{w\,h^2}{40}\left(\frac{2}{3\,\mu} \mp \lambda'\,\Phi\right).$$

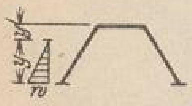


$$\Phi = \frac{\eta^3}{\nu}\,(2 - \lambda_1\,\eta), \qquad \omega''_\varphi = \frac{1}{2} - \omega'_\varphi,$$

$$H_{a,b} = \frac{w\,h}{4}\left\{\frac{1}{\mu}\left[\omega_\varphi - (1 + \varkappa)\,\omega''_\varphi\right] - 2\,\eta \mp 2\,\eta + \eta^2\right\},$$

$$M_{a,b} = -\frac{w\,h^2}{4}\left\{\frac{1}{3\,\mu}\left[(2 + 3\,\varkappa)\,\omega''_\varphi - \omega_\varphi\right] \pm (\eta^2 - \Phi)\right\},$$

$$M_{c,d} = -\frac{w\,h^2}{4}\left\{\frac{1}{3\,\mu}\left[2\,\omega_\varphi - \omega''_\varphi\right] \mp \lambda'\,\Phi\right\}.$$

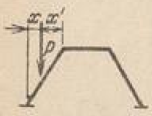


$$\Phi = \frac{\eta}{\nu}\,(5 - 2\,\lambda_1\,\eta),$$

$$H_{a,b} = \frac{w\,h}{40}\,\eta\left\{\frac{\eta^2}{\mu}\left[5\,(1 + \varkappa) - \eta\,(2 + \varkappa)\right] - 10 \mp 10\right\},$$

$$M_{a,b} = \frac{w\,h^2}{40}\,\eta^2\left[\frac{\eta}{3\,\mu}\,(1 + \varkappa)\,(5 - 3\,\eta) + \frac{5}{3}\,\eta - \frac{10}{3} \mp \left(\frac{10}{3} - \Phi\right)\right],$$

$$M_{c,d} = -\frac{w\,h^2}{40}\,\eta^2\left[\frac{\eta}{3\,\mu}\,(5 - 3\,\eta) \mp \lambda'\,\Phi\right].$$

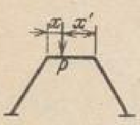


$$\Phi = \frac{\xi^2}{\nu}\,(3 - 2\,\lambda_1\,\xi),$$

$$H_{a,b} = \frac{P\,m}{2\,h}\left\{\frac{1}{\mu}\left[\omega_D - (1 + \varkappa)\,\omega'_D\right] + \xi\right\},$$

$\xi = \frac{x}{m}$ $$M_{a,b} = -\frac{P\,m}{2}\left\{\frac{1}{\mu}\left[(1 + \varkappa)\,\omega'_D - \omega_R\right] \pm (\xi - \Phi)\right\},$$

$\xi' = \frac{x'}{m}$ $$M_{c,d} = -\frac{P\,m}{2}\left[\frac{1}{\mu}\,(\omega_D - \omega_R) \mp \lambda'\,\Phi\right].$$

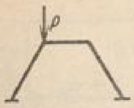


$$\Phi = \frac{1 - 2\,\xi}{\nu}\left[\lambda'^2\,\varkappa\,\omega_R - \lambda_1\,(2 + \lambda')\right],$$

$$H_{a,b} = \frac{P\,l_0}{2\,h}\left[\frac{3\,\varkappa}{\mu}\,\omega_R + \lambda_2\right],$$

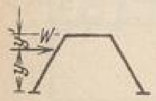
$\xi = \frac{x}{l_0}$ $$M_{a,b} = \frac{P\,l_0}{2\,h}\left\{\frac{\varkappa}{\mu}\,\omega_R \mp \left[\lambda_2\,(1 - 2\,\xi) + \lambda''\,\Phi\right]\right\},$$

$\xi' = \frac{x'}{l_0}$ $$M_{c,d} = -\frac{P\,l_0}{2}\left(\frac{2\,\varkappa}{\mu}\,\omega_R \pm \Phi\right).$$

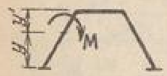


$$\Phi = \frac{2+\lambda'}{\nu},$$
$$H_{a,b} = \frac{P\,m}{2\,h},$$
$$M_{a,b} = \mp \frac{P\,m}{2}\,(1-\Phi),$$
$$M_{c,d} = \pm \frac{P\,m}{2}\,\lambda'\,\Phi.$$

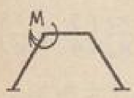
$$\Phi = \frac{2+\lambda'}{\nu},$$
$$H_{a,b} = \mp \frac{W}{2},$$
$$M_{a,b} = \mp \frac{W\,h}{2}\,(1-\Phi),$$
$$M_{c,d} = \pm \frac{W\,h}{2}\,\lambda'\,\Phi.$$



$$\Phi = \frac{\eta^2}{\nu}\,(3 - 2\,\lambda_1\,\eta), \qquad H_{a,b} = \frac{W}{2}\left\{\frac{1}{\mu}\,[\omega_D - (1+\varkappa)\,\omega_D'] - \eta' \mp 1\right\},$$
$$M_{a,b} = -\frac{W\,h}{2}\left\{\frac{1}{\mu}\,[(1+\varkappa)\,\omega_D' - \omega_R] \pm (\eta - \Phi)\right\},$$
$$M_{c,d} = -\frac{W\,h}{2}\left[\frac{1}{\mu}\,(\omega_D - \omega_R) \mp \lambda'\,\Phi\right].$$



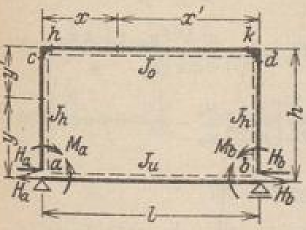
$$\Phi = \frac{6\,\eta}{\nu}\,(1 - \lambda_1\,\eta), \qquad H_{a,b} = -\frac{\mathsf{M}}{2\,h}\left\{\frac{1}{\mu}\,[(1+\varkappa)\,\omega_M' + \omega_M] - 1\right\},$$
$$M_{a,b} = -\frac{\mathsf{M}}{2}\left\{\frac{1}{3\,\mu}\,[(2+3\,\varkappa)\,\omega_M' + \omega_M] \pm (1-\Phi)\right\},$$
$$M_{h,k} = \frac{\mathsf{M}}{2}\left[\frac{1}{3\,\mu}\,(2\,\omega_M + \omega_M') \pm \lambda'\,\Phi\right].$$



$$\Phi = \frac{6}{\nu}\,(1 - \lambda_1),$$
$$H_{a,b} = \frac{3}{2}\,\frac{\mathsf{M}}{h}\,\frac{\varkappa}{\mu},$$
$$M_{a,b} = \frac{\mathsf{M}}{2}\left[\frac{\varkappa}{\mu} \mp (1-\Phi)\right],$$
$$M_{h,k} = \frac{\mathsf{M}}{2}\left(\frac{1}{\mu} \pm \lambda'\,\Phi\right).$$

$$\Phi = \frac{3}{\mu}\,\frac{l_u}{h}\,\frac{E\,J_s}{s}\,\alpha_t\,t,$$
$$H_{a,b} = \frac{2+\varkappa}{h}\,\Phi,$$
$$M_{a,b} = (1+\varkappa)\,\Phi,$$
$$M_{h,k} = -\Phi.$$

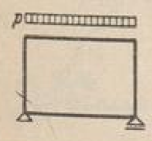
Tabelle 58. Geschlossener, symmetrischer Rechteckrahmen.



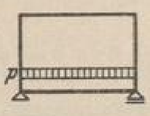
$$\xi = \frac{x}{l}, \qquad \eta = \frac{y}{h}, \qquad \varkappa_o = \frac{h}{l}\,\frac{J_o}{J_h}, \qquad \varkappa_u = \frac{h}{l}\,\frac{J_u}{J_h},$$
$$\xi' = \frac{x'}{l}, \qquad \eta' = \frac{y'}{h}, \qquad \mu = (2+\varkappa_o) + \frac{3+2\,\varkappa_o}{\varkappa_u}, \qquad \nu = 1 + 6\,\varkappa_o + \frac{\varkappa_o}{\varkappa_u}.$$

$M_{h,k} = M_{c,d}$, wenn nicht besonders angegeben. ω Tabelle 22 S. 116.

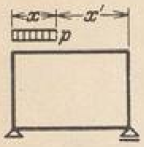
Gleichmäßige Temperaturänderung erzeugt keine Schnittkräfte.



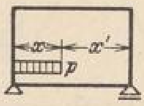
$$H_{a,b} = \frac{p\,l}{4}\,\frac{l}{h}\,\frac{1+\varkappa_u}{\mu\,\varkappa_u},$$
$$M_{a,b} = \frac{p\,l^2}{12\,\mu},$$
$$M_{c,d} = -\frac{p\,l^2}{12}\,\frac{3+2\,\varkappa_u}{\mu\,\varkappa_u}.$$



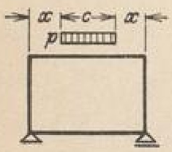
$$H_{a,b} = \frac{p\,l}{4}\,\frac{l}{h}\,\frac{1+\varkappa_o}{\mu\,\varkappa_u},$$
$$M_{a,b} = \frac{p\,l^2}{12}\,\frac{3+2\,\varkappa_o}{\mu\,\varkappa_u},$$
$$M_{c,d} = -\frac{p\,l^2}{12\,\mu}\,\frac{\varkappa_o}{\varkappa_u}.$$



$$\Phi = 3\xi^2 - 2\xi^3,$$
$$H_{a,b} = \frac{pl}{4}\frac{l}{h}\frac{1+\varkappa_u}{\mu\varkappa_u}\Phi,$$
$$M_{a,b} = \frac{pl^2}{4}\left(\frac{1}{3\mu}\Phi \mp \frac{1}{\nu}\omega_R^2\right),$$
$$M_{c,d} = -\frac{pl^2}{4}\left(\frac{3+2\varkappa_u}{3\mu\varkappa_u}\Phi \pm \frac{1}{\nu}\omega_R^2\right).$$
$$x = \frac{l}{2}: \qquad \Phi = \frac{1}{2}, \qquad \omega_R^2 = \frac{1}{16}.$$

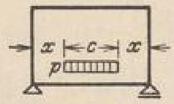


$$\Phi = 3\xi^2 - 2\xi^3,$$
$$H_{a,b} = \frac{pl}{4}\frac{l}{h}\frac{1+\varkappa_o}{\mu\varkappa_u}\Phi,$$
$$M_{a,b} = \frac{pl^2}{4}\left(\frac{3+2\varkappa_o}{3\mu\varkappa_u} \pm \frac{\varkappa_o}{\varkappa_u}\frac{1}{\nu}\omega_R^2\right),$$
$$M_{c,d} = -\frac{pl^2}{4}\frac{\varkappa_o}{\varkappa_u}\left(\frac{1}{3\mu}\Phi \mp \frac{1}{\nu}\omega_R^2\right).$$
$$x = \frac{l}{2}: \qquad \Phi = \frac{1}{2}, \qquad \omega_R^2 = \frac{1}{16}.$$



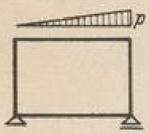
$$\zeta = \frac{c}{l}$$

$$\Phi = \frac{1}{2}(3\zeta - \zeta^3),$$
$$H_{a,b} = \frac{pl}{4}\frac{l}{h}\frac{1+\varkappa_u}{\mu\varkappa_u}\Phi,$$
$$M_{a,b} = \frac{pl^2}{12}\frac{1}{\mu}\Phi,$$
$$M_{c,d} = -\frac{pl^2}{12}\frac{3+2\varkappa_u}{\mu\varkappa_u}\Phi.$$

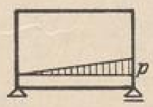


$$\zeta = \frac{c}{l}$$

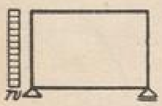
$$\Phi = \frac{1}{2}(3\zeta - \zeta^3),$$
$$H_{a,b} = \frac{pl}{4}\frac{l}{h}\frac{1+\varkappa_o}{\mu\varkappa_u}\Phi,$$
$$M_{a,b} = \frac{pl^2}{12}\frac{3+2\varkappa_o}{\mu\varkappa_u}\Phi,$$
$$M_{c,d} = -\frac{pl^2}{12}\frac{1}{\mu}\frac{\varkappa_o}{\varkappa_u}\Phi.$$



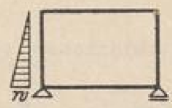
$$H_{a,b} = \frac{pl}{8}\frac{l}{h}\frac{1+\varkappa_u}{\mu\varkappa_u},$$
$$M_{a,b} = \frac{pl^2}{120}\left(\frac{5}{\mu} \pm \frac{1}{\nu}\right),$$
$$M_{c,d} = -\frac{pl^2}{120}\left(\frac{5}{\mu}\frac{3+2\varkappa_u}{\varkappa_u} \mp \frac{1}{\nu}\right).$$



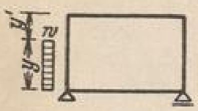
$$M_{a,b} = \frac{pl^2}{120}\left(\frac{5}{\mu}\frac{3+2\varkappa_o}{\varkappa_u} \mp \frac{\varkappa_o}{\varkappa_u}\frac{1}{\nu}\right),$$
$$M_{c,d} = -\frac{pl^2}{120}\frac{\varkappa_o}{\varkappa_u}\left(\frac{5}{\mu} \pm \frac{1}{\nu}\right),$$
$$H_{a,b} = \frac{pl}{8}\frac{l}{h}\frac{1+\varkappa_o}{\mu\varkappa_u}.$$



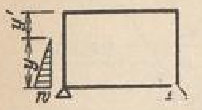
$$\Phi = \frac{\varkappa_o}{\varkappa_u}\frac{1+2\varkappa_u}{\nu},$$
$$H_{a,b} = \frac{wh}{4}\left[-1 + \frac{1}{2\mu}\frac{\varkappa_o - \varkappa_u}{\varkappa_u} \mp 2\right],$$
$$M_{a,b} = -\frac{wh^2}{4}\left[\frac{3+\varkappa_o}{6\mu} \pm (1-\Phi)\right],$$
$$M_{c,d} = -\frac{wh^2}{4}\left[\frac{\varkappa_o}{\varkappa_u}\frac{3+\varkappa_u}{6\mu} \mp \Phi\right].$$



$$\Phi = \frac{5}{\nu}\frac{\varkappa_o}{\varkappa_u}(2+3\varkappa_u),$$
$$M_{a,b} = -\frac{wh^2}{120}\left[\frac{8+3\varkappa_o}{\mu} \pm (10-\Phi)\right],$$
$$M_{c,d} = -\frac{wh^2}{120}\left[\frac{\varkappa_o}{\varkappa_u}\frac{7+2\varkappa_o}{\mu} \mp \Phi\right],$$
$$H_{a,b} = \frac{wh}{120}\left[\frac{1}{\mu}\left(7\frac{\varkappa_o}{\varkappa_u} - \varkappa_o - 8\right) - 20 \mp 30\right].$$



$$\Phi = \eta^2\frac{\varkappa_o}{\varkappa_u}\frac{1+2\eta\varkappa_u}{\nu}, \qquad \psi = \frac{1}{2} - \omega'_\varphi,$$
$$H_{a,b} = \frac{wh}{4}\left\{\frac{1}{\mu}\left[\frac{\varkappa_o}{\varkappa_u}(1+\varkappa_u)\omega_\varphi - (1+\varkappa_o)\psi + \eta^2\right] - 2\eta(1 \pm 1)\right\},$$
$$M_{a,b} = -\frac{wh^2}{4}\left\{\frac{1}{3\mu}\left[(3+2\varkappa_o)\psi - \varkappa_o\omega_\varphi\right] \pm (\eta^2 - \Phi)\right\},$$
$$M_{c,d} = -\frac{wh^2}{4}\left\{\frac{1}{3\mu}\left[\frac{\varkappa_o}{\varkappa_u}(3+2\varkappa_o)\omega_\varphi - \varkappa_o\psi\right] \mp \Phi\right\}.$$

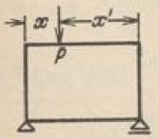


$$\Phi = \frac{5}{\nu}\,\frac{\varkappa_o}{\varkappa_u}(2 + 3\,\eta\,\varkappa_u),$$

$$H_{a,b} = \frac{w\,h}{120}\eta\left\{\frac{\eta}{\mu}\left[10\left(\frac{\varkappa_o}{\varkappa_u} - \varkappa_o - 2\right) + 15\eta(1+\varkappa_o) - 3\eta^2\left(1 + 2\varkappa_o + \frac{\varkappa_o}{\varkappa_u}\right)\right] + 10\eta - 30 \mp 30\right\},$$

$$M_{a,b} = -\frac{w\,h^2}{120}\eta^2\left\{\frac{1}{\mu}\left[10(2+\varkappa_o) - 5\,\eta(3 + 2\,\varkappa_o) + 3\,\eta^2(1+\varkappa_o)\right] \pm (10 - \Phi)\right\}.$$

$$M_{c,d} = -\frac{w\,h^2}{120}\eta^2\left\{\frac{\varkappa_o}{\mu\varkappa_u}\left[10 + 5\,\eta\,\varkappa_u - 3\,\eta^2(1+\varkappa_u)\right] \mp \Phi\right\}.$$

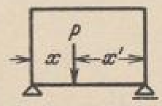


$$\Phi = \frac{1 - 2\,\xi}{\nu},$$

$$H_{a,b} = \frac{3}{2}\,\frac{P\,l}{h}\,\frac{1+\varkappa_u}{\mu\,\varkappa_u}\,\omega_R,$$

$$M_{a,b} = \frac{P\,l}{2}\,\omega_R\left[\frac{1}{\mu} \mp \Phi\right],$$

$$M_{c,d} = -\frac{P\,l}{2}\,\omega_R\left[\frac{3 + 2\varkappa_u}{\mu\varkappa_u} \pm \Phi\right].$$

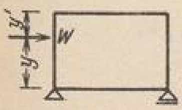


$$\Phi = \frac{1 - 2\,\xi}{\nu}\,\frac{\varkappa_o}{\varkappa_u},$$

$$H_{a,b} = \frac{3}{2}\,\frac{P\,l}{h}\,\frac{1+\varkappa_o}{\mu\,\varkappa_o}\,\omega_R,$$

$$M_{a,b} = \frac{P\,l}{2}\,\omega_R\left[\frac{3 + 2\,\varkappa_o}{\mu\,\varkappa_u} \pm \Phi\right],$$

$$M_{c,d} = -\frac{P\,l}{2}\,\omega_R\left[\frac{\varkappa_o}{\mu\varkappa_u} \mp \Phi\right].$$



$$\Phi = \frac{\eta}{\nu}\,\frac{\varkappa_o}{\varkappa_u}(1 + 3\,\eta\,\varkappa_u),$$

$$H_{a,b} = \frac{W}{2}\left\{\frac{1}{\mu}\left[(1+\varkappa_u)\frac{\varkappa_o}{\varkappa_u}\,\omega_D - (1+\varkappa_o)\,\omega_D'\right] + \eta - 1 \mp 1\right\},$$

$$M_{a,b} = -\frac{W\,h}{2}\left\{\frac{1}{\mu}\left[(1+\varkappa_o)\,\omega_D' - \varkappa_o\,\omega_R\right] \pm (\eta - \Phi)\right\}.$$

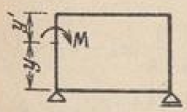
$$M_{c,d} = -\frac{W\,h}{2}\left\{\frac{\varkappa_o}{\mu\varkappa_u}\left[(1+\varkappa_u)\,\omega_D - \varkappa_u\,\omega_R\right] \mp \Phi\right\}.$$

$y = h$: $\Phi = \frac{\varkappa_o}{\varkappa_u}\,\frac{1 + 3\varkappa_u}{\nu}$,

$$H_{a,b} = \mp\frac{W}{2},$$

$$M_{a,b} = \mp\frac{W\,h}{2}(1 - \Phi),$$

$$M_{c,d} = \pm\frac{W\,h}{2}\Phi.$$



$y > 0$

$$\Phi = \frac{1}{\nu}\,\frac{\varkappa_o}{\varkappa_u}(1 + 6\,\eta\,\varkappa_u),$$

$$H_{a,b} = -\frac{\mathsf{M}}{2\,h}\left\{\frac{1}{\mu}\left[(1+\varkappa_o)\,\omega_M' + \varkappa_o\,\frac{1+\varkappa_u}{\varkappa_u}\,\omega_M\right] - 1\right\},$$

$$M_{a,b} = -\frac{\mathsf{M}}{2}\left\{\frac{1}{3\,\mu}\left[(3 + 2\,\varkappa_o)\,\omega_M + \varkappa_o\,\omega_M\right] \pm (1 - \Phi)\right\},$$

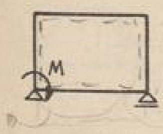
$$M_{hk} = \frac{\mathsf{M}}{2}\left\{\frac{\varkappa_o}{3\,\mu\,\varkappa_u}\left[(3 + 2\,\varkappa_u)\,\omega_M + \varkappa_u\,\omega_M'\right] \pm \Phi\right\}.$$

$y = h$:

$$H_{a,b} = \frac{3}{2}\,\frac{\mathsf{M}}{h}\,\frac{1+\varkappa_u}{\mu\,\varkappa_u},$$

$$M_{a,b} = \frac{\mathsf{M}}{2}\left(\frac{1}{\mu} \mp \frac{1}{\nu}\right),$$

$$M_{h,k} = \frac{\mathsf{M}}{2}\left[\frac{\varkappa_o}{\varkappa_u}\,\frac{2+\varkappa_u}{\mu} \mp \left(\frac{1}{\nu} - 1\right)\right],$$



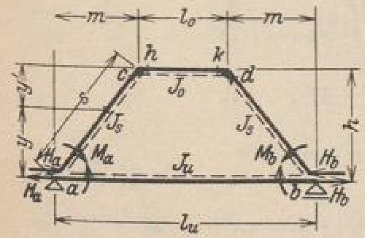
$$H_{a,b} = \frac{3}{2}\,\frac{\mathsf{M}}{h}\,\frac{1+\varkappa_o}{\mu\,\varkappa_u},$$

$$M_{a,b} = -\frac{\mathsf{M}}{2}\left[\frac{2+\varkappa_o}{\mu} \pm \left(1 - \frac{\varkappa_o}{\nu\varkappa_u}\right)\right],$$

$$M_{c,d} = -\frac{\mathsf{M}}{2}\,\frac{\varkappa_o}{\varkappa_u}\left[\frac{1}{\mu} \mp \frac{1}{\nu}\right],$$

M_a am Riegel.

Tabelle 59. Geschlossener, symmetrischer Trapezrahmen.



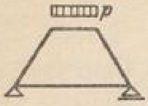
$\eta = \frac{y}{h}$, $\lambda_1 = \frac{m}{l_u}$, $\lambda' = \frac{l_o}{l_u}$, ω Tabelle 22 S. 116.

$\eta' = \frac{y'}{h}$, $\lambda_2 = \frac{m}{l_o}$, $\lambda'' = \frac{l_u}{l_o}$, $\varkappa_o = \frac{l_o}{s}\,\frac{J_s}{J_o}$, $\varkappa_u = \frac{l_u}{s}\,\frac{J_s}{J_u}$,

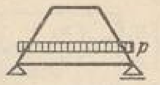
$\mu = (2 + 3\varkappa_o)(2 + 3\varkappa_u) - 1$, $\nu = \varkappa_o\,\lambda'^2 + \varkappa_u + 2(1 + \lambda' + \lambda'^2)$,

$M_{h,k} = M_{c,d}$, wenn nicht besonders angegeben.

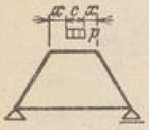
Gleichmäßige Temperaturänderung erzeugt keine Schnittkräfte.



$$H_{a,b}=\frac{p\,l_o^2}{2\,h}\left[\frac{3}{2}\frac{\varkappa_o}{\mu}\varkappa_o(1+\varkappa_u)+\lambda_2\right],$$
$$M_{a,b}=\frac{p\,l_o^2}{4}\frac{\varkappa_o}{\mu},$$
$$M_{c,d}=-\frac{p\,l_o^2}{4}\frac{\varkappa_o}{\mu}(2+3\,\varkappa_u).$$

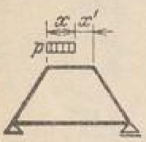


$$H_{a,b}=\frac{3}{4}\frac{p\,l_u^2}{h}\frac{\varkappa_u}{\mu}(1+\varkappa_o),$$
$$M_{a,b}=\frac{p\,l_u^2}{4}\frac{\varkappa_u}{\mu}(2+3\,\varkappa_o),$$
$$M_{c,d}=-\frac{p\,l_u^2}{4}\frac{\varkappa_u}{\mu}.$$



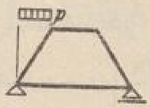
$$\Phi=\tfrac{1}{2}(3\,\zeta_o-\zeta_o^3),$$
$$H_{a,b}=\frac{p\,l_o^2}{2\,h}\left[\frac{3\varkappa_o}{2\,\mu}(1+\varkappa_u)\Phi+\lambda_2\zeta_o\right],$$
$$M_{a,b}=\frac{p\,l_o^2}{4}\frac{\varkappa_o}{\mu}\Phi,$$
$$\zeta_o=\frac{c}{l_o}.\qquad M_{c,d}=-\frac{p\,l_o^2}{4}\frac{\varkappa_o}{\mu}(2+3\,\varkappa_u)\Phi.$$

$$\Phi=\tfrac{1}{2}(3\,\zeta_u-\zeta_u^3),$$
$$H_{a,b}=\frac{3}{4}\frac{p\,l_u^2}{h}\frac{\varkappa_u}{\mu}(1+\varkappa_o)\Phi,$$
$$M_{a,b}=\frac{p\,l_u^2}{4}\frac{\varkappa_u}{\mu}(2+3\varkappa_o)\Phi,$$
$$\zeta_u=\frac{c}{l_u}.\qquad M_{c,d}=-\frac{p\,l_u^2}{4}\frac{\varkappa_u}{\mu}\Phi.$$

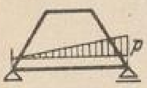


$$\Phi=\frac{\omega_R}{\nu}[\lambda'^2\varkappa_o\,\omega_R-2\,\lambda_1(2+\varkappa_u+\lambda')],\qquad \psi=3\,\xi^2-2\,\xi^3,$$
$$H_{a,b}=\frac{p\,l_o^2}{4\,h}\left[\frac{3\varkappa_o}{\mu}(1+\varkappa_u)\,\psi+2\,\lambda_2\,\xi\right],$$
$$\xi=\frac{x}{l_o},\quad \xi'=\frac{x'}{l_o}.\qquad M_{a,b}=\frac{p\,l_o^2}{4}\left[\frac{\varkappa_o}{\mu}\psi\mp(2\,\lambda_2\,\omega_R+\lambda''\Phi)\right],$$
$$M_{c,d}=-\frac{p\,l_o^2}{4}\left[\frac{\varkappa_o}{\mu}(2+3\varkappa_u)\,\psi\pm\Phi\right].$$

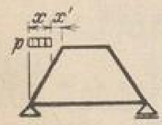
$$\Phi=3\,\xi^2-2\,\xi^3,$$
$$H_{a,b}=\frac{3}{4}\frac{p\,l_u^2}{h}\frac{\varkappa_u}{\mu}(1+\varkappa_o)\,\Phi,$$
$$\xi=\frac{x}{l_u},\quad \xi'=\frac{x'}{l_u}.\qquad M_{a,b}=\frac{p\,l_u^2}{4}\varkappa_u\left[\frac{2+3\varkappa_o}{\mu}\Phi\pm\frac{\omega_R^2}{\nu}\right],$$
$$M_{c,d}=-\frac{p\,l_u^2}{4}\varkappa_u\left[\frac{1}{\mu}\Phi\mp\frac{\lambda'}{\nu}\omega_R^2\right].$$



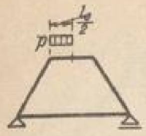
$$\Phi=\frac{1}{\nu}(2+\varkappa_u-\lambda_1),$$
$$H_{a,b}=\frac{p\,m^2}{4\,h}\left[\frac{3}{2\,\mu}(\varkappa_u-\varkappa_o)+1\right],$$
$$M_{a,b}=-\frac{p\,m^2}{4}\left[\frac{1+3\varkappa_o}{2\,\mu}\pm(1-\Phi)\right],$$
$$M_{c,d}=-\frac{p\,m^2}{4}\left[\frac{1+3\varkappa_u}{2\,\mu}\mp\lambda'\Phi\right].$$



$$H_{a,b}=\frac{3}{8}\frac{p\,l_u^2}{h}\frac{\varkappa_u}{\mu}(1+\varkappa_o),\qquad M_{a,b}=\frac{p\,l_u^2}{120}\varkappa_u\left[\frac{15}{\mu}(2+3\,\varkappa_o)\mp\frac{1}{\nu}\right],$$
$$M_{c,d}=-\frac{p\,l_u^2}{120}\varkappa_u\left[\frac{15}{\mu}\pm\frac{\lambda'}{\nu}\right].$$



$$\Phi=\frac{\xi^2}{\nu}[\varkappa_u+\xi(2-\lambda_1\xi)],\qquad \psi=\frac{1}{2}-\omega'_\varphi,$$
$$H_{a,b}=\frac{p\,m^2}{4\,h}\left\{\frac{3}{\mu}[(1+\varkappa_u)\,\omega_\varphi-(1+\varkappa_o)\,\psi]+\xi^2\right\},$$
$$\xi=\frac{x}{m},\quad \xi'=\frac{x'}{m}.\qquad M_{a,b}=-\frac{p\,m^2}{4}\left\{\frac{1}{\mu}[(2+3\,\varkappa_o)\,\psi-\omega_\varphi]\pm(\xi^2-\Phi)\right\},$$
$$M_{c,d}=-\frac{p\,m^2}{4}\left\{\frac{1}{\mu}[(2+3\,\varkappa_u)\,\omega_\varphi-\psi]\mp\lambda'\Phi\right\}.$$

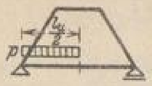


$$\Phi = \frac{1}{8\nu}\left[\lambda'^2 \varkappa_o - 8\lambda_1(2+\varkappa_u+\lambda')\right],$$

$$H_{a,b} = \frac{p\,l_o^2}{8\,h}\left[\frac{3\,\varkappa_o}{\mu}(1+\varkappa_u) + 2\,\lambda_2\right],$$

$$M_{a,b} = \frac{p\,l_o^2}{8}\left[\frac{\varkappa_o}{\mu} \mp (\lambda_2 + \lambda''\,\Phi\right],$$

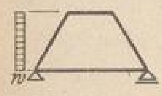
$$M_{c,d} = -\frac{p\,l_o^2}{8}\left[\frac{\varkappa_o}{\mu}(2+3\varkappa_u) \pm \Phi\right].$$



$$H_{a,b} = \frac{3}{8}\,\frac{p\,l_u^2}{h\,\mu}\,\varkappa_u(1+\varkappa_o),$$

$$M_{a,b} = \frac{p\,l_u^2}{8}\,\varkappa_u\left[\frac{2+3\,\varkappa_o}{\mu} \pm \frac{1}{8\,\nu}\right],$$

$$M_{c,d} = -\frac{p\,l_u^2}{8}\,\varkappa_u\left[\frac{1}{\mu} \mp \frac{\lambda'}{8\,\nu}\right].$$



$$\Phi = \frac{1}{\nu}(2+\varkappa_u-\lambda_1),$$

$$H_{a,b} = \frac{w\,h}{4}\left[\frac{3}{2\,\mu}(\varkappa_u-\varkappa_o) - 1 \mp 2\right],$$

$$M_{a,b} = -\frac{w\,h^2}{4}\left[\frac{1+3\,\varkappa_o}{2\,\mu} \pm (1-\Phi)\right],$$

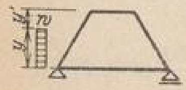
$$M_{c,d} = -\frac{w\,h^2}{4}\left[\frac{1+3\,\varkappa_u}{2\,\mu} \mp \lambda'\,\Phi\right].$$

$$\Phi = \frac{1}{3\,\nu}\left[5(3+2\,\varkappa_u) - 6\,\lambda_1\right],$$

$$H_{a,b} = \frac{w\,h}{120}\left[\frac{3}{\mu}(7\,\varkappa_u - 8\varkappa_o - 1) - 20 \mp 30\right],$$

$$M_{a,b} = -\frac{w\,h^2}{40}\left[\frac{3+8\,\varkappa_o}{\mu} \pm \left(\frac{10}{3} - \Phi\right)\right],$$

$$M_{c,d} = -\frac{w\,h^2}{40}\left[\frac{2+7\,\varkappa_u}{\mu} \mp \lambda'\,\Phi\right].$$

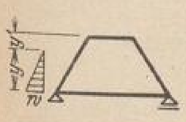


$$\Phi = \frac{\eta^2}{\nu}\left[\varkappa_u + \eta(2-\lambda_1\eta)\right], \qquad \psi = \frac{1}{2} - \omega'_\varphi,$$

$$H_{a,b} = \frac{w\,h}{4}\left\{\frac{3}{\mu}\left[(1+\varkappa_u)\,\omega_\varphi - (1+\varkappa_o)\,\psi\right] + \eta^2 - 2\,\eta \mp 2\,\eta\right\},$$

$$M_{a,b} = -\frac{w\,h^2}{4}\left\{\frac{1}{\mu}\left[(2+3\,\varkappa_o)\,\psi - \omega_\varphi\right] \pm (\eta^2 - \Phi)\right\},$$

$$M_{c,d} = -\frac{w\,h^2}{4}\left\{\frac{1}{\mu}\left[(2+3\,\varkappa_u)\,\omega_\varphi - \psi\right] \mp \lambda'\,\Phi\right\}.$$

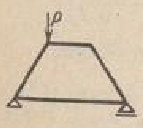


$$\Phi = \frac{1}{\nu}\left[10\,\varkappa_u + 3\,\eta(5 - 2\,\lambda_1\eta)\right],$$

$$H_{a,b} = \frac{w\,h}{120}\,\eta\left\{\frac{3\,\eta}{\mu}\left[10(\varkappa_u - 2\,\varkappa_o - 1) + 15\,\eta(1+\varkappa_o) - 3\,\eta^2(2+\varkappa_o+\varkappa_u)\right] + 10\,\eta - 30 \mp 30\right\},$$

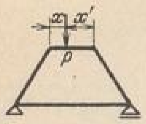
$$M_{a,b} = -\frac{w\,h^2}{120}\,\eta^2\left\{\frac{3}{\mu}\left[10(1+2\,\varkappa_o) - 5\,\eta(2+3\,\varkappa_o) + 3\,\eta^2(1+\varkappa_o)\right] \pm (10-\Phi)\right\},$$

$$M_{c,d} = -\frac{w\,h^2}{120}\,\eta^2\left\{\frac{3}{\mu}\left[10\varkappa_u + 5\,\eta - 3\,\eta^2(1+\varkappa_u)\right] \mp \lambda'\,\Phi\right\}.$$



$$\Phi = \frac{1}{\nu}(2+\varkappa_u+\lambda'), \qquad H_{a,b} = \frac{P\,m}{2\,h}(2\,\Phi - 1),$$

$$M_{a,b} = \mp\frac{P\,m}{2}\left[1-\Phi\right], \qquad M_{c,d} = \pm\frac{P\,m}{2}\,\lambda'\,\Phi.$$



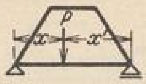
$$\xi = \frac{x}{l_o}, \quad \xi' = \frac{x'}{l_o}.$$

$$\Phi = \frac{1 - 2\xi}{\nu}\left[\lambda'^2 \varkappa_o \omega_R - \lambda_1 (2 + \varkappa_u + \lambda')\right],$$

$$H_{a,b} = \frac{P\,m}{2\,h}\left[\frac{9\,\varkappa_o}{\mu\,\lambda_2}(1 + \varkappa_u)\,\omega_R + 1\right],$$

$$M_{a,b} = \frac{P\,l_o}{2}\left\{\frac{3\,\varkappa_o}{\mu}\,\omega_R \mp [\lambda_2 (1 - 2\xi) + \lambda''\Phi]\right\},$$

$$M_{c,d} = -\frac{P\,l_o}{2}\left[\frac{3\,\varkappa_o}{\mu}(2 + 3\varkappa_u)\,\omega_R \pm \Phi\right].$$

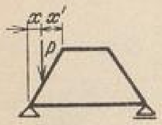


$$\Phi = \frac{1 - 2\xi}{\nu},$$

$$\xi = \frac{x}{l_u}, \quad \xi' = \frac{x'}{l_u}. \qquad H_{a,b} = \frac{9\,P\,l_u}{2\,h}\,\frac{\varkappa_u}{\mu}(1 + \varkappa_o)\,\omega_R,$$

$$M_{a,b} = \frac{P\,l_u}{2}\varkappa_u\,\omega_R\left[\frac{3}{\mu}(2 + 3\varkappa_o) \pm \Phi\right],$$

$$M_{c,d} = -\frac{P\,l_u}{2}\varkappa_u\,\omega_R\left[\frac{3}{\mu} \mp \lambda'\Phi\right].$$



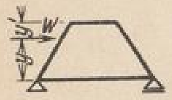
$$\xi = \frac{x}{m}, \quad \xi' = \frac{x'}{m}.$$

$$\Phi = \frac{\xi}{\nu}\left[\varkappa_u + \xi (3 - 2\lambda_1 \xi)\right],$$

$$H_{a,b} = \frac{P\,m}{2\,h}\left\{\xi + \frac{3}{\mu}\left[(1 + \varkappa_u)\,\omega_D - (1 + \varkappa_o)\,\omega_D'\right]\right\},$$

$$M_{a,b} = -\frac{P\,m}{2}\left\{\frac{3}{\mu}\left[(1 + \varkappa_o)\,\omega_D' - \omega_R\right] \pm (\xi - \Phi)\right\},$$

$$M_{c,d} = -\frac{P\,m}{2}\left\{\frac{3}{\mu}\left[(1 + \varkappa_u)\,\omega_D - \omega_R\right] \mp \lambda'\Phi\right\}.$$



$$\Phi = \frac{\eta}{\nu}\left[\varkappa_u + \eta (3 - 2\lambda_1 \eta)\right],$$

$$H_{a,b} = \frac{W}{2}\left\{\frac{3}{\mu}\left[(1 + \varkappa_u)\,\omega_D - (1 + \varkappa_o)\,\omega_D'\right] + \eta - 1 \mp 1\right\},$$

$$M_{a,b} = -\frac{W\,h}{2}\left\{\frac{3}{\mu}\left[(1 + \varkappa_o)\,\omega_D' - \omega_R\right] \pm (\eta - \Phi)\right\},$$

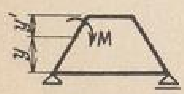
$$M_{c,d} = -\frac{W\,h}{2}\left\{\frac{3}{\mu}\left[(1 + \varkappa_u)\,\omega_D - \omega_R\right] \mp \lambda'\Phi\right\}.$$

$y = h$: $\Phi = \frac{1}{\nu}(2 + \varkappa_u + \lambda')$,

$$H_{a,b} = \mp \frac{W}{2},$$

$$M_{a,b} = \mp \frac{W\,h}{2}(1 - \Phi),$$

$$M_{c,d} = \pm \frac{W\,h}{2}\lambda'\Phi.$$



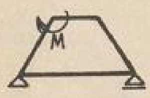
$y > 0.$

$$\Phi = \frac{1}{\nu}\left[\varkappa_u + 6\eta (1 - \lambda_1 \eta)\right],$$

$$H_{a,b} = \frac{M}{2\,h}\left\{1 - \frac{3}{\mu}\left[(1 + \varkappa_u)\,\omega_M + (1 + \varkappa_o)\,\omega_M'\right]\right\},$$

$$M_{a,b} = -\frac{M}{2}\left\{\frac{1}{\mu}\left[(2 + 3\varkappa_o)\,\omega_M' + \omega_M\right] \pm (1 - \Phi)\right\},$$

$$M_{h,k} = \frac{M}{2}\left\{\frac{1}{\mu}\left[(2 + 3\varkappa_u)\,\omega_M + \omega_M'\right] \pm \lambda'\Phi\right\}.$$

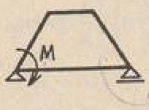


$$\Phi = \frac{1}{\nu}\left[\varkappa_u + 6(1 - \lambda_1)\right],$$

$$H_{a,b} = \frac{M}{2\,h}\left[1 - \frac{3}{\mu}(1 + 2\varkappa_u - \varkappa_o)\right],$$

$$M_{a,b} = \frac{M}{2}\left[\frac{3\,\varkappa_o}{\mu} \mp (1 - \Phi)\right],$$

$$M_{h,k} = \frac{M}{2}\left[\frac{3}{\mu}(1 + 2\varkappa_u) \pm \lambda'\Phi\right].$$



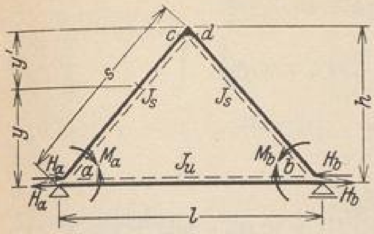
$$H_{a,b} = \frac{M}{2\,h}\left[1 - \frac{3}{\mu}(1 + 2\varkappa_o - \varkappa_u)\right],$$

$$M_{a,b} = -\frac{M}{2}\left[\frac{3}{\mu}(1 + 2\varkappa_o) \pm \left(1 - \frac{\varkappa_u}{\nu}\right)\right],$$

M_a am Riegel,

$$M_{c,d} = -\frac{M}{2}\left[\frac{3\,\varkappa_u}{\mu} \mp \lambda'\frac{\varkappa_u}{\nu}\right].$$

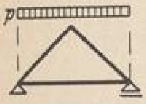
Tabelle 60. Geschlossener, symmetrischer Dreiecksrahmen.



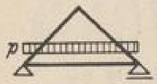
$$\eta = \frac{y}{h}, \qquad \eta' = \frac{y'}{h}, \qquad \varkappa = \frac{l}{s}\,\frac{J_s}{J_u},$$

$$\mu = 3\,(1 + 2\varkappa), \qquad \nu = 2 + \varkappa.$$

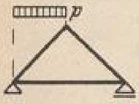
Gleichmäßige Temperaturänderung erzeugt keine Schnittkräfte.



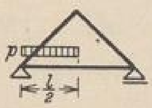
$$H_{a,b} = \frac{3}{16}\,\frac{p\,l^2}{h}\,\frac{1}{\mu}\,(2 + 5\varkappa),$$
$$M_{a,b} = -\frac{p\,l^2}{16\,\mu},$$
$$M_{c,d} = -\frac{p\,l^2}{16}\,\frac{1 + 3\varkappa}{\mu}.$$



$$H_{a,b} = \frac{3}{4}\,\frac{p\,l^2}{h}\,\frac{\varkappa}{\mu},$$
$$M_{a,b} = \frac{p\,l^2}{2}\,\frac{\varkappa}{\mu},$$
$$M_{c,d} = -\frac{p\,l^2}{4}\,\frac{\varkappa}{\mu}.$$

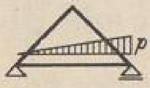


$$H_{a,b} = \frac{p\,l^2}{32\,h}\left(2 + \frac{3\varkappa}{\mu}\right)$$
$$M_{a,b} = -\frac{p\,l^2}{32}\left[\frac{1}{\mu} \pm \frac{1}{\nu}\right],$$
$$M_{c,d} = -\frac{p\,l^2}{32}\,\frac{1 + 3\varkappa}{\mu}.$$

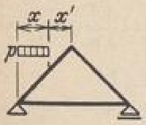


$$H_{a,b} = \frac{3}{8}\,\frac{p\,l^2}{h}\,\frac{\varkappa}{\mu},$$
$$M_{a,b} = \frac{p\,l^2}{8}\,\varkappa\left(\frac{2}{\mu} \pm \frac{1}{8\,\nu}\right),$$
$$M_{c,d} = -\frac{p\,l^2}{8}\,\frac{\varkappa}{\mu}.$$

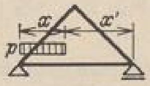
$$H_{a,b} = \frac{3}{8}\,\frac{p\,l^2}{h}\,\frac{\varkappa}{\mu}\,(3\,\zeta - \zeta^3),$$
$$M_{a,b} = \frac{p\,l^2}{4}\,\frac{\varkappa}{\mu}\,(3\,\zeta - \zeta^3),$$
$$\zeta = \frac{c}{l}. \qquad M_{c,d} = -\frac{p\,l^2}{8}\,\frac{\varkappa}{\mu}\,(3\,\zeta - \zeta^3).$$



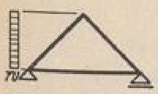
$$H_{a,b} = \frac{3}{8}\,\frac{p\,l^2}{h}\,\frac{\varkappa}{\mu},$$
$$M_{a,b} = \frac{p\,l^2}{120}\,\varkappa\left(\frac{30}{\mu} \mp \frac{1}{\nu}\right),$$
$$M_{c,d} = -\frac{p\,l^2}{8}\,\frac{\varkappa}{\mu}.$$



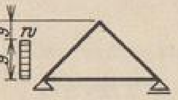
$$\Phi = \frac{1}{2} - \omega'_\varphi,$$
$$\xi = \frac{2\,x}{l}, \qquad \xi' = \frac{2\,x'}{l},$$
$$H_{a,b} = \frac{p\,l^2}{16\,h}\left\{\xi^2 + \frac{3}{\mu}\,[(1 + \varkappa)\,\omega_\varphi - \Phi)]\right\},$$
$$M_{a,b} = -\frac{p\,l^2}{16}\left[\frac{1}{\mu}\,(2\,\Phi - \omega_\varphi) \pm \frac{1}{\nu}\,\Phi\right],$$
$$M_{c,d} = -\frac{p\,l^2}{16}\,\frac{1}{\mu}\,[(2 + 3\varkappa)\,\omega_\varphi - \Phi].$$



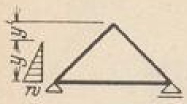
$$\Phi = 3\,\xi^2 - 2\,\xi^3,$$
$$H_{a,b} = \frac{3}{4}\,\frac{p\,l^2}{h}\,\frac{\varkappa}{\mu}\,\Phi,$$
$$M_{a,b} = \frac{p\,l^2}{4}\,\varkappa\left[\frac{2}{\mu}\,\Phi \pm \frac{1}{\nu}\,\omega_R^2\right],$$
$$\xi = \frac{x}{l}, \quad \xi' = \frac{x'}{l}. \qquad M_{c,d} = -\frac{p\,l^2}{4}\,\frac{\varkappa}{\mu}\,\Phi.$$



$$H_{a,b} = \frac{w\,h}{4}\left[\frac{3\varkappa}{2\,\mu} - 1 \mp 2\right],$$
$$M_{a,b} = -\frac{w\,h^2}{8}\left[\frac{1}{\mu} \pm \frac{1}{\nu}\right],$$
$$M_{c,d} = -\frac{w\,h^2}{8}\,\frac{1 + 3\varkappa}{\mu}.$$



$$\Phi = \frac{1}{2} - \omega'_\varphi,$$
$$H_{a,b} = \frac{w\,h}{4}\left\{\frac{3}{\mu}\,[(1 + \varkappa)\,\omega_\varphi - \Phi] + \eta^2 - 2\,\eta \mp 2\,\eta\right\},$$
$$M_{a,b} = -\frac{w\,h^2}{4}\left[\frac{1}{\mu}\,(2\,\Phi - \omega_\varphi) \pm \frac{1}{\nu}\,\Phi\right],$$
$$M_{c,d} = -\frac{w\,h^2}{4}\,\frac{1}{\mu}\,[(2 + 3\varkappa)\,\omega_\varphi - \Phi].$$



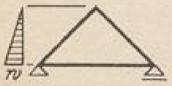
$$H_{a,b} = \frac{w\,h}{120}\,\eta\left\{\frac{3\,\eta}{\mu}\,[10\,(\varkappa - 1) + 15\,\eta - 3\,\eta^2\,\nu] + 10\,\eta - 30 \mp 30\right\},$$

$$M_{a,b} = -\frac{w\,h^2}{120}\,\eta^2\left\{\frac{3}{\mu}\,[10\,(1-\eta) + 3\,\eta^2] \pm \frac{1}{\nu}\,[20 - 15\,\eta + 3\,\eta^2]\right\},$$

$$M_{c,d} = -\frac{w\,h^2}{40}\,\frac{\eta^2}{\mu}\,[10\,\varkappa + 5\,\eta - 3\,(1+\varkappa)\,\eta^2].$$

$$H_{a,b} = \frac{w\,h}{120}\left[\frac{3}{\mu}\,(7\,\varkappa - 1) - 20 \mp 30\right],$$

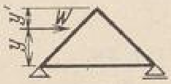
$$M_{a,b} = -\frac{w\,h^2}{40}\left(\frac{3}{\mu} \pm \frac{8}{3\,\nu}\right),$$



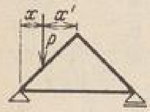
$$M_{c,d} = -\frac{w\,h^2}{40}\,\frac{2 + 7\,\varkappa}{\mu}.$$

$$H_{a,b} = \frac{W}{2}\left\{\frac{3}{\mu}\,[(1+\varkappa)\,\omega_D - \omega'_D] + \eta - 1 \mp 1\right\},$$

$$M_{a,b} = -\frac{w\,h}{2}\left[\frac{3}{\mu}\,(\omega'_D - \omega_R) \pm \frac{\omega'_D}{\nu}\right],$$



$$M_{c,d} = -\frac{w\,h}{2}\,\frac{3}{\mu}\,[(1+\varkappa)\,\omega_D - \omega_R].$$

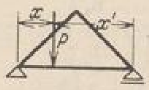


$$\xi = \frac{2\,x}{l}, \qquad \xi' = \frac{2\,x'}{l},$$

$$H_{a,b} = \frac{P\,l}{4\,h}\left\{\xi + \frac{3}{\mu}\,[(1+\varkappa)\,\omega_D - \omega'_D]\right\},$$

$$M_{a,b} = -\frac{P\,l}{4}\left[\frac{3}{\mu}\,(\omega'_D - \omega_R) \pm \frac{\omega'_D}{\nu}\right],$$

$$M_{c,d} = -\frac{P\,l}{4}\,\frac{3}{\mu}\,[(1+\varkappa)\,\omega_D - \omega_R].$$



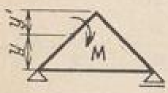
$$H_{a,b} = \frac{9}{2}\,\frac{P\,l}{h}\,\frac{\varkappa}{\mu}\,\omega_R,$$

$$M_{a,b} = \frac{P\,l}{2}\,\varkappa\,\omega_R\left(\frac{6}{\mu} \pm \frac{1 - 2\,\xi}{\nu}\right),$$

$$M_{c,d} = -\frac{P\,l}{2}\,\frac{3\,\varkappa}{\mu}\,\omega_R.$$

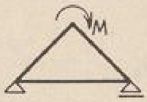
$$H_{a,b} = \frac{\mathsf{M}}{2\,h}\left\{1 - \frac{3}{\mu}\,[(1+\varkappa)\,\omega_M + \omega'_M]\right\},$$

$$M_{a,b} = -\frac{\mathsf{M}}{2}\left[\frac{1}{\mu}\,(2\,\omega'_M + \omega_M) \pm \frac{1}{\nu}\,\omega'_M\right],$$



$$M_d = \frac{\mathsf{M}}{2}\,\frac{1}{\mu}\,[(2+3\varkappa)\,\omega_M + \omega'_M].$$

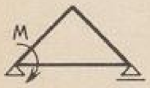
$y > 0$



$$H_{a,b} = 0,$$

$$M_{a,b} = \pm\frac{\mathsf{M}}{2\,\nu},$$

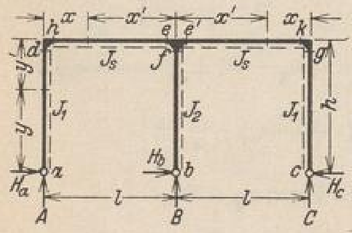
$$M_{c,d} = \mp\frac{\mathsf{M}}{2}.$$



$$H_{a,b} = \frac{9}{2}\,\frac{\mathsf{M}}{h}\,\frac{\varkappa}{\mu}, \qquad M_{c,d} = -\frac{3}{2}\,\mathsf{M}\,\frac{\varkappa}{\mu},$$

$$M_{a,b} = -\frac{\mathsf{M}}{2}\left[\frac{3}{\mu} \pm \frac{2}{\nu}\right], \qquad M_a \text{ am Riegel.}$$

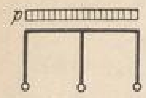
Tabelle 61. Symmetrischer, dreistieliger Rahmen mit geradem Riegel.



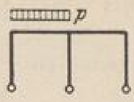
$$\xi = \frac{x}{l}, \quad \eta = \frac{y}{h}, \quad \varkappa_1 = \frac{h}{l}\,\frac{J_s}{J_1}, \quad \mu = 3 + 4\,\varkappa_1, \quad \alpha = 3 + 2\,\varkappa_1.$$

$$\xi' = \frac{x'}{l}, \quad \eta' = \frac{y'}{h}, \quad \varkappa_2 = \frac{h}{l}\,\frac{J_s}{J_2}, \quad \nu = 3 + \varkappa_1 + 2\,\varkappa_2,$$

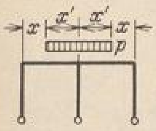
$M_{h,k} = M_{d,g}$, wenn nicht besonders angegeben.



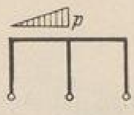
$$M_{d,g} = -\frac{p\,l^2}{4\,\mu}, \quad M_{e,e'} = -\frac{p\,l^2}{4\,\mu}(1 + 2\,\varkappa_1), \quad M_f = 0.$$



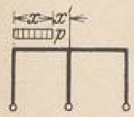
$$M_{d,g} = -\frac{p\,l^2}{8}\left[\frac{1}{\mu} \pm \frac{1}{\nu}\right], \quad M_{e,e'} = -\frac{p\,l^2}{8}\left[\frac{1+2\,\varkappa_1}{\mu} \pm \frac{1}{\nu}\right], \quad M_f = \frac{p\,l^2}{4\,\nu}.$$



$$M_{d,g} = -\frac{p\,x'^2}{4\,\mu}\,\xi'(4 - 3\,\xi'), \quad M_{e,e'} = -\frac{p\,x'^2}{4\,\mu}\left[2\,\mu - 8(1+\varkappa_1)\,\xi' + \alpha\,\xi'^2\right], \quad M_f = 0.$$

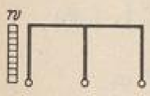


$$M_{d,g} = -\frac{p\,l^2}{40}\left[\frac{2}{\mu} \pm \frac{5}{2\,\nu}\right], \quad M_{e,e'} = \frac{p\,l^2}{120}\left[\frac{9+16\,\varkappa_1}{\mu} \pm \frac{15}{2\,\nu}\right], \quad M_f = \frac{p\,l^2}{8\,\nu}.$$

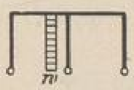


$$\Phi = \frac{1}{\nu}(3 - 2\,\xi), \qquad M_{e,e'} = -\frac{p\,x^2}{8}\left[\frac{1}{\mu}(4\,\varkappa_1 + 4\,\xi - \alpha\,\xi^2) \pm \Phi\right],$$

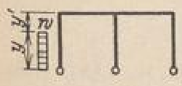
$$M_{d,g} = -\frac{p\,x^2}{8}\left[\frac{1}{\mu}(6 - 8\,\xi + 3\,\xi^2) \pm \Phi\right], \qquad M_f = \frac{p\,x^2}{4}\,\Phi.$$



$$\Phi = \frac{1}{2\,\nu}(2\,\alpha + \varkappa_1), \quad M_{d,g} = -\frac{w\,h^2}{4}\left[\frac{\varkappa_1}{\mu} \mp \left(1 - \frac{1}{2}\,\Phi\right)\right], \quad M_{e,e'} = \frac{w\,h^2}{8}\left[\frac{\varkappa_1}{\mu} \mp \Phi\right], \quad M_f = \frac{w\,h^2}{4}\,\Phi.$$

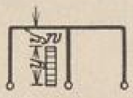


$$\Phi = \frac{1}{2\,\nu}(\alpha - \varkappa_2), \quad M_{d,g} = \pm\frac{w\,h^2}{4}[1 - \Phi], \quad M_{e,e'} = \mp\frac{w\,h^2}{4}\,\Phi, \quad M_f = \frac{w\,h^2}{2}\,\Phi.$$

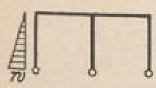


$$\Phi = \frac{1}{2\,\nu}[\varkappa_1(2 - \eta^2) + 2\,\alpha], \quad M_{d,g} = -\frac{w\,y^2}{8}\left[2\,\frac{\varkappa_1}{\mu}(2 - \eta^2) \mp (2 - \Phi)\right],$$

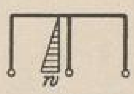
$$M_{e,e'} = \frac{w\,y^2}{8}\left[\frac{\varkappa_1}{\mu}(2 - \eta^2) \mp \Phi\right], \quad M_f = \frac{w\,y^2}{4}\,\Phi.$$



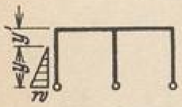
$$\Phi = \frac{1}{2\,\nu}[\alpha - \varkappa_2(2 - \eta^2)], \quad M_{d,g} = \pm\frac{w\,y^2}{4}[1 - \Phi], \quad M_{e,e'} = \mp\frac{w\,y^2}{4}\,\Phi, \quad M_f = \frac{w\,y^2}{2}\,\Phi.$$



$$\Phi = \frac{3}{2\,\nu}(10 + 9\,\varkappa_1), \quad M_{d,g} = -\frac{w\,h^2}{120}\left[14\,\frac{\varkappa_1}{\mu} \mp (10 - \Phi)\right], \quad M_{e,e'} = \frac{w\,h^2}{120}\left[7\,\frac{\varkappa_1}{\mu} \mp \Phi\right], \quad M_f = \frac{w\,h^2}{60}\,\Phi.$$



$$\Phi = \frac{1}{\nu}(7\,\varkappa_2 - 5\,\alpha), \quad M_{d,g} = \pm\frac{w\,h^2}{120}[10 + \Phi], \quad M_{e,e'} = \mp\frac{w\,h^2}{120}\,\Phi, \quad M_f = \frac{w\,h^2}{60}\,\Phi.$$

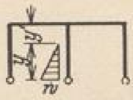


$$\Phi = \frac{3}{2\nu}\left[10(1+\varkappa_1) - \varkappa_1\eta^2\right],$$

$$M_{d,g} = -\frac{w\,y^2}{120}\left[2\frac{\varkappa_1}{\mu}(10-3\eta^2) \mp (10-\Phi)\right],$$

$$M_{e,e'} = \frac{w\,y^2}{120}\left[\frac{\varkappa_1}{\mu}(10-3\eta^2) \mp \Phi\right],$$

$$M_f = \frac{w\,y^2}{60}\,\Phi.$$

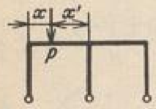


$$\Phi = \frac{1}{\nu}\left[5(\alpha - 2\varkappa_2) + 3\varkappa_2\eta^2\right],$$

$$M_{d,g} = \pm\frac{w\,y^2}{120}(10-\Phi),$$

$$M_{e,e'} = \mp\frac{w\,y^2}{120}\,\Phi,$$

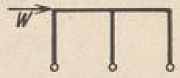
$$M_f = +\frac{w\,y^2}{60}\,\Phi.$$



$$M_{d,g} = -\frac{3}{2}P\,l\,\omega_R\left[\frac{1}{\mu}\xi' \pm \frac{1}{2\nu}\right],$$

$$M_{e,e'} = -\frac{P\,l}{2}\,\omega_R\left[\frac{1}{\mu}(2\varkappa_1 + \alpha\xi) \pm \frac{3}{2\nu}\right],$$

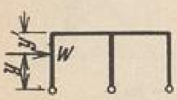
$$M_f = \frac{3}{2}\,\frac{P\,l}{\nu}\,\omega_R.$$



$$M_{d,g} = \pm\frac{W\,h}{2}\left(1 - \frac{\alpha}{2\nu}\right),$$

$$M_{e,e'} = \mp\frac{W\,h}{4}\,\frac{\alpha}{\nu},$$

$$M_f = \frac{W\,h}{2}\,\frac{\alpha}{\nu}.$$

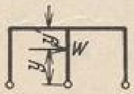


$$\Phi = \frac{1}{2\nu}\left[\varkappa_1(1-\eta^2) + \alpha\right],$$

$$M_{d,g} = -\frac{W\,y}{2}\left[2\frac{\varkappa_1}{\mu}(1-\eta^2) \mp (1-\Phi)\right],$$

$$M_{e,e'} = \frac{W\,y}{2}\left[\frac{\varkappa_1}{\mu}(1-\eta^2) \mp \Phi\right],$$

$$M_f = W\,y\,\Phi.$$

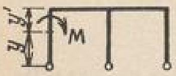


$$\Phi = \frac{1}{2\nu}\left[2\varkappa_2(1-\eta^2) - \alpha\right],$$

$$M_{d,g} = \pm\frac{W\,y}{2}\left[1+\Phi\right],$$

$$M_{e,e'} = \pm\frac{W\,y}{2}\,\Phi,$$

$$M_f = -W\,y\,\Phi.$$



$$\Phi = \frac{1}{2\nu}(\alpha - \varkappa_1\omega_M),$$

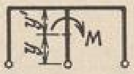
$$M_{hk} = +\frac{\mathsf{M}}{2}\left[2\frac{\varkappa_1}{\mu}\omega_M \pm (1-\Phi)\right],$$

$$M_{e,e'} = -\frac{\mathsf{M}}{2}\left[\frac{\varkappa_1}{\mu}\omega_M \pm \Phi\right],$$

$$M_f = \mathsf{M}\,\Phi.$$

$y = h$: $\Phi = \frac{3}{2\nu}$, $\omega_M = 2$,

$y = 0$: $\Phi = \frac{3}{2\nu}(1+\varkappa_1)$, $\omega_M = -1$.



$$\Phi = +\frac{1}{2\nu}(\alpha + 2\varkappa_2\omega_M),$$

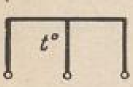
$$M_{d,g} = \pm\frac{\mathsf{M}}{2}(1-\Phi),$$

$$M_{e,e'} = \mp\frac{\mathsf{M}}{2}\,\Phi,$$

$y' > 0$: $M_f = \mathsf{M}\,\Phi$,

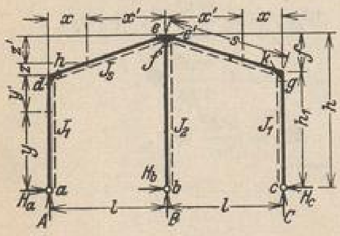
$y = h$: $\Phi = \frac{1}{2\nu}(2\nu - 3)$, $M_f = -\mathsf{M}(1-\Phi)$,

$y = 0$: $\Phi = \frac{1}{2\nu}(\alpha - 2\varkappa_2)$.



$$M_{d,g} = -\frac{12\,E\,J_s\,\alpha_t\,t}{\mu\,h}, \qquad M_{e,e'} = \frac{6\,E\,J_s\,\alpha_t\,t}{\mu\,h}, \qquad M_f = 0.$$

Tabelle 62. Symmetrischer, dreistieliger Rahmen mit gebrochenem Riegel.

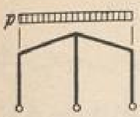


$$\xi = \frac{x}{l}, \quad \zeta = \frac{z}{f}, \quad \varphi = \frac{f}{h}, \quad \varphi' = \frac{h_1}{h}, \quad \varphi'' = \frac{h}{h_1},$$

$$\xi' = \frac{x'}{l}, \quad \zeta' = \frac{z'}{f}, \quad \varkappa_1 = \frac{h_1}{s}\,\frac{J_s}{J_1}, \quad \varkappa_2 = \frac{h}{s}\,\frac{J_s}{J_2}, \quad \mu = 3 + 4\varkappa_1,$$

$$\alpha = 2(1 + \varkappa_1) + \varphi'', \qquad \nu = 1 + 2\varkappa_2 + \varphi' + \varphi'^2(1+\varkappa_1),$$

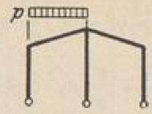
$M_{h,k} = M_{d,g}$, wenn nicht besonders angegeben.



$$M_{d,g} = -\frac{p\,l^2}{4\,\mu},$$

$$M_{e,e'} = -\frac{p\,l^2}{4\,\mu}\left[1 + 2\,\varkappa_1\right],$$

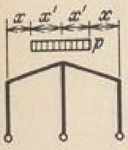
$$M_f = 0.$$



$$M_{d,g} = -\frac{p\,l^2}{8}\left[\frac{\varphi'(1+\varphi')}{2\,\nu}\right],$$

$$M_{e,e'} = -\frac{p\,l^2}{8}\left[\frac{1+2\,\varkappa_1}{\mu} \pm \frac{1+\varphi'}{2\,\nu}\right]$$

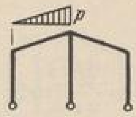
$$M_f = \frac{p\,l^2}{8}\,\frac{1+\varphi'}{\nu}.$$



$$M_{d,g} = -\frac{p\,x'^2}{4\,\mu}\,\xi'\left[4 - 3\,\xi'\right],$$

$$M_{e,e'} = -\frac{p\,x'^2}{4\,\mu}\left[2\,\mu - 8\,(1+\varkappa_1)\,\xi' + (3 + 2\,\varkappa_1)\,\xi'^2\right],$$

$$M_f = 0.$$

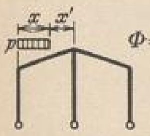


$$\Phi = \frac{8+7\,\varphi'}{\nu},$$

$$M_{d,g} = -\frac{p\,l^2}{120}\left[\frac{6}{\mu} \pm \frac{\varphi'}{2}\,\Phi\right],$$

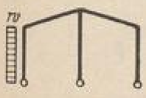
$$M_{e,e'} = -\frac{p\,l^2}{120}\left[\frac{9+16\,\varkappa_1}{\mu} \pm \frac{1}{2}\,\Phi\right],$$

$$M_f = \frac{p\,l^2}{120}\,\Phi.$$



$$\Phi = \frac{1}{\nu}\left[3 - 2\,\xi - \frac{\varphi}{2}\,(\xi^2 + 4\,\xi')\right], \quad M_{e,e'} = -\frac{p\,x^2}{8}\left\{\frac{1}{\mu}\left[4\,\varkappa_1 + 4\,\xi - (3 + 2\,\varkappa_1)\,\xi^2\right] \pm \Phi\right\},$$

$$M_{d,g} = -\frac{p\,x^2}{8}\left[\frac{1}{\mu}\,(6 - 8\,\xi + 3\,\xi^2) \pm \varphi'\,\Phi\right], \qquad M_f = \frac{p\,x^2}{4}\,\Phi.$$

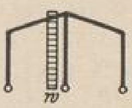


$$\Phi = \frac{\varphi'}{2\,\nu}\,(2\,\alpha + \varkappa_1),$$

$$M_{d,g} = -\frac{w\,h_1^2}{4}\left[\frac{\varkappa_1}{\mu} \mp \left(1 - \frac{\varphi'}{2}\,\Phi\right)\right],$$

$$M_{e,e'} = \frac{w\,h_1^2}{8}\left[\frac{\varkappa_1}{\mu} \mp \Phi\right],$$

$$M_f = \frac{w\,h_1^2}{4}\,\Phi.$$

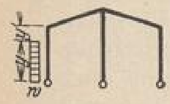


$$\Phi = \frac{1}{2\,\nu}\,(\varphi'^2\,\alpha - \varkappa_2),$$

$$M_{d,g} = \pm\frac{w\,h^2}{4}\,\varphi'\left[1 - \Phi\right],$$

$$M_{e,e'} = \mp\frac{w\,h^2}{4}\,\Phi,$$

$$M_f = \frac{w\,h^2}{2}\,\Phi.$$



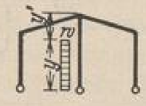
$$\eta = \frac{y}{h_1}, \quad \eta' = \frac{y'}{h_1}.$$

$$\Phi = \frac{\varphi'}{2\,\nu}\left[\varkappa_1\,(2 - \eta^2) + 2\,\alpha\right],$$

$$M_{d,g} = -\frac{w\,y^2}{8}\left[2\,\frac{\varkappa_1}{\mu}\,(2 - \eta^2) \mp (2 - \varphi'\,\Phi)\right],$$

$$M_{e,e'} = \frac{w\,y^2}{8}\left[\frac{\varkappa_1}{\mu}\,(2 - \eta^2) \mp \Phi\right],$$

$$M_f = \frac{w\,y^2}{4}\,\Phi.$$



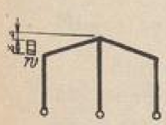
$$\eta = \frac{y}{h}, \quad \eta' = \frac{y'}{h}.$$

$$\Phi = \frac{1}{2\,\nu}\left[\varphi'^2\,\alpha - \varkappa_2\,(2 - \eta^2)\right],$$

$$M_{d,g} = \pm\frac{w\,y^2}{4}\,\varphi'\left[1 - \Phi\right],$$

$$M_{e,e'} = \mp\frac{w\,y^2}{4}\,\Phi,$$

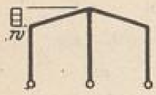
$$M_f = \frac{w\,y^2}{2}\,\Phi.$$



$$\psi = \frac{1}{2} - \omega'_\varphi, \qquad \Phi = \frac{1}{4\,\nu}\left(\omega_\varphi + \varphi'\,\psi + 2\,\frac{\varphi'^2}{\varphi}\,\alpha\,\zeta\right),$$

$$M_{d,g} = -\frac{w\,f^2}{2}\left[\frac{1}{2\,\mu}\,(2\,\psi - \omega_\varphi) \mp \frac{\varphi'}{\varphi}\,(\zeta - \varphi\,\Phi)\right],$$

$$M_{e,e'} = -\frac{w\,f^2}{2}\left[\frac{1}{2\,\mu}\left[2\,\omega_\varphi(1+\varkappa_1) - \psi\right] \pm \Phi\right], \qquad M_f = w f^2\,\Phi.$$



$$\Phi = \frac{1}{2\nu}\left(1 + \varphi' + 4\,\frac{\varphi'^2}{\varphi}\,\alpha\right),$$

$$M_{d,g} = -\frac{w f^2}{8}\left[\frac{1}{\mu} \mp \frac{\varphi'}{\varphi}\,(4 - \varphi\,\Phi)\right],$$

$$M_{e,e'} = -\frac{w f^2}{8}\left[\frac{1}{\mu} + \frac{2\varkappa_1}{\mu} \pm \Phi\right],$$

$$M_f = \frac{w f^2}{4}\,\Phi.$$

$$\Phi = \frac{1}{\nu}\left[5\,(\varphi'^2\alpha - 2\varkappa_2) + 3\varkappa_2\eta^2\right],$$

$$M_{d,g} = \pm\frac{w y^2}{120}\,\varphi'\,[10 - \Phi],$$

$$\eta = \frac{y}{h}, \quad \eta' = \frac{y'}{h} \qquad M_{e,e'} = \mp\frac{w y^2}{120}\,\Phi,$$

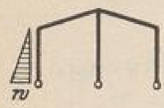
$$M_f = +\frac{w y^2}{60}\,\Phi.$$

$$\eta = \frac{y}{h_1}, \quad \eta' = \frac{y'}{h_1}.$$

$$\Phi = \frac{\varphi'}{2\nu}\left[10\,(\alpha + \varkappa_1) - 3\varkappa_1\eta^2\right],$$

$$M_{d,g} = -\frac{w y^2}{120}\left[\frac{2\varkappa_1}{\mu}\,(10 - 3\eta^2) \mp (10 - \varphi'\,\Phi)\right],$$

$$M_{e,e'} = \frac{w y^2}{120}\left[\frac{\varkappa_1}{\mu}\,(10 - 3\eta^2) \mp \Phi\right], \qquad M_f = \frac{w y^2}{60}\,\Phi.$$

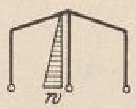


$$\Phi = \frac{\varphi'}{2\nu}\,(10\,\alpha + 7\varkappa_1),$$

$$M_{d,g} = -\frac{w h_1^2}{120}\left[14\,\frac{\varkappa_1}{\mu} \mp (10 - \varphi'\,\Phi)\right],$$

$$M_{e,e'} = \frac{w h_1^2}{120}\left[7\,\frac{\varkappa_1}{\mu} \mp \Phi\right],$$

$$M_f = \frac{w h_1^2}{60}\,\Phi.$$

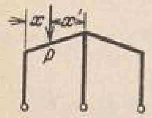


$$\Phi = \frac{1}{\nu}\,(7\varkappa_2 - 5\varphi'^2\alpha),$$

$$M_{d,g} = \pm\frac{w h^2}{120}\,\varphi'\,(10 + \Phi),$$

$$M_{e,e'} = \pm\frac{w h^2}{120}\,\Phi,$$

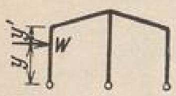
$$M_f = -\frac{w h^2}{60}\,\Phi.$$



$$M_{d,g} = -\frac{Pl}{2}\,\omega_R\left\{\frac{3}{\mu}\,\xi' \pm \frac{\varphi'}{2\nu}\left[3 - \varphi\,(1 + \xi')\right]\right\},$$

$$M_{e,e'} = -\frac{Pl}{2}\,\omega_R\left\{\frac{1}{\mu}\left[2\varkappa_1 + (3 + 2\varkappa_1)\,\xi\right] \pm \frac{1}{2\nu}\left[3 - \varphi\,(1 + \xi')\right]\right\},$$

$$M_f = \frac{Pl}{2}\,\frac{\omega_R}{\nu}\left[3 - \varphi\,(1 + \xi')\right].$$

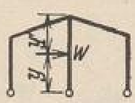


$$\Phi = \frac{\varphi'}{\nu}\left[\varkappa_1\,(1 - \eta^2) + \alpha\right],$$

$$M_{d,g} = -\frac{W y}{2}\left[2\,\frac{\varkappa_1}{\mu}\,(1 - \eta^2) \mp \left(1 - \frac{\varphi'}{2}\,\Phi\right)\right],$$

$$M_{e,e'} = \frac{W y}{2}\left[\frac{\varkappa_1}{\mu}\,(1 - \eta^2) \mp \frac{1}{2}\,\Phi\right],$$

$$M_f = \frac{W y}{2}\,\Phi.$$

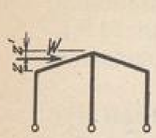


$$\Phi = \frac{1}{2\nu}\left[2\varkappa_2(1 - \eta^2) - \varphi'^2\alpha\right],$$

$$M_{d,g} = \pm\frac{W y}{2}\,\varphi'\,(1 + \Phi)$$

$$M_{e,e'} = \pm\frac{W y}{2}\,\Phi,$$

$$M_f = -W y \cdot \Phi.$$



$$\Phi = \frac{1}{2\nu}\left(\omega_D + \varphi'\omega'_D + \frac{\varphi'^2}{\varphi}\alpha\right),$$

$$M_{d,g} = -\frac{Wf}{2}\left[\frac{1}{\mu}(2\omega'_D - \omega_D) \mp \frac{\varphi'}{\varphi}(1 - \varphi\Phi)\right],$$

$$M_{e,e'} = -\frac{Wf}{4}\left[\omega_D + \frac{1}{\mu}(2\omega_D - \omega'_D) \pm 2\Phi\right],$$

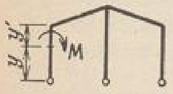
$$M_f = Wf\Phi.$$

$z = 0$:

$$M_{d,g} = \pm\frac{Wh_1}{2}\left(1 - \frac{\varphi'^2}{2\nu}\alpha\right),$$

$$M_{e,e'} = \mp\frac{Wh_1}{4}\frac{\varphi'}{\nu}\alpha,$$

$$M_f = \frac{Wh_1}{2}\frac{\varphi'}{\nu}\alpha.$$



$$\Phi = \frac{\varphi'}{2\nu}(\dot{\alpha} - \varkappa_1\omega_M),$$

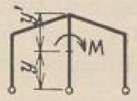
$$M_{h,k} = \frac{\mathrm{M}}{2}\left[2\frac{\varkappa_1}{\mu}\omega_M \pm (1 - \varphi'\Phi)\right],$$

$$\eta = \frac{y}{h_1}, \quad \eta' = \frac{y'}{h_1}. \quad M_{e,e'} = -\frac{\mathrm{M}}{2}\left[\frac{\varkappa_1}{\mu}\omega_M \pm \Phi\right],$$

$$M_f = \mathrm{M}\Phi.$$

$$y = h_1: \quad \Phi = \frac{\varphi'}{2\nu}(2 + \varphi''), \quad \omega_M = 2.$$

$$y = 0: \quad \Phi = \frac{\varphi'}{2\nu}(\alpha + \varkappa_1), \quad \omega_M = -1.$$



$$\Phi = \frac{1}{2\nu}(2\varkappa_2\omega_M + \varphi'^2\alpha),$$

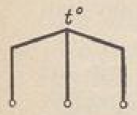
$$M_{d,g} = \pm\frac{\mathrm{M}}{2}\varphi'(1 - \Phi),$$

$$\eta = \frac{y}{h}, \quad \eta' = \frac{y'}{h}. \quad M_{e,e'} = \mp\frac{\mathrm{M}}{2}\Phi,$$

$$y' > 0: \quad M_f = \mathrm{M}\Phi.$$

$$y = h: \quad \Phi = \frac{1}{2\nu}(4\varkappa_2 + \varphi'^2\alpha), \quad M_f = -\mathrm{M}(1 - \Phi).$$

$$y = 0: \quad \Phi = \frac{1}{2\nu}(\varphi'^2\alpha - 2\varkappa_2).$$



$$M_{d,g} = -\frac{12 E J_s l \alpha_t t}{\mu s h_1},$$

$$M_{e,e'} = \frac{6 E J_s \alpha_t t l}{\mu s h_1}, \qquad M_f = 0.$$

62. Die räumliche Belastung des ebenen Tragwerks.

Während das ebene Tragwerk bei Belastung in der Symmetrieebene als Scheibe oder Scheibenverbindung angesehen und berechnet wird, ist bei allgemeinem Kraftangriff die räumliche Betrachtung von Träger, Stützung und Formänderung notwendig. Der Abschnitt eines Stabes besitzt in diesem Falle sechs Freiheitsgrade, so daß für die äußeren Kräfte sechs Gleichgewichtsbedingungen angeschrieben werden können. Die Verschiebung eines Querschnitts ist durch sechs geometrische Parameter, der Spannungszustand (σ_x, τ_{xy}, τ_{xz}) eines Querschnitts bei Annahme eines linearen Ansatzes für σ_x durch sechs Schnittkräfte (43) bestimmt.

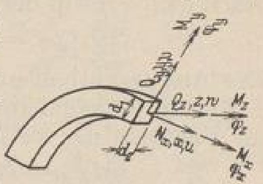


Abb. 581.

Die äußeren Kräfte werden in Komponenten zerlegt, die in der Trägerebene und senkrecht dazu angreifen. Der Beitrag jeder Gruppe zum Spannungs- und Verschiebungszustand darf nach dem Superpositionsgesetz getrennt angegeben werden. Die räumliche Belastung besteht daher nur aus Kräften winkelrecht zur Ebene des Tragwerks, für welche das Biegungsmoment M_z und die Querkraft Q_y Null sind, während die Verschiebungen u, v und die Verdrehung φ_z als klein gegen die Komponenten w, φ_x, φ_y vernachlässigt werden (Abb. 581).

Lösung A. Die ebenen Tragwerke des Bauwesens mit räumlichem Charakter sind, abgesehen von wenigen Ausnahmen, statisch unbestimmt. Der Spannungszustand kann daher ebenso wie in Abschn. 24 aus den Schnittkräften eines Hauptsystems entwickelt werden, an dem die statisch unbestimmten Schnittkräfte neben der