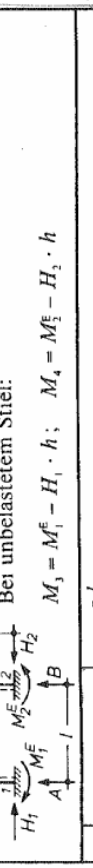
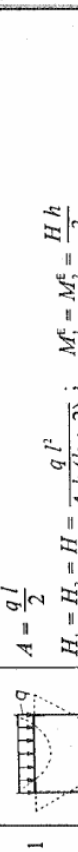
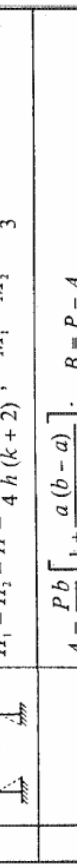
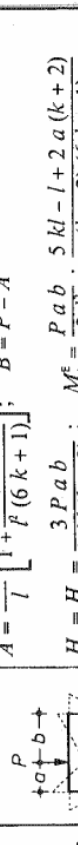
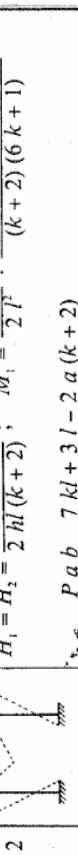
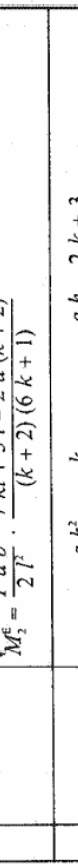
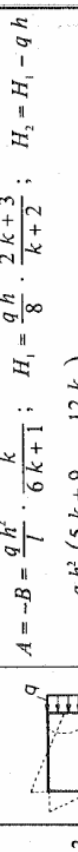
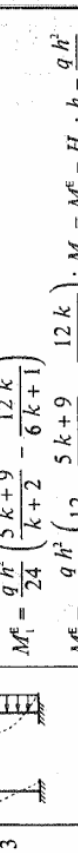
Eingespannter Rahmen

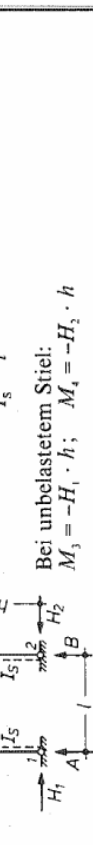


Abkürzung: $k = \frac{I_R}{I_S} \cdot \frac{h}{l}$ ---------- M-Linie

Bei unbelastetem Stiel:
$M_3 = M_1^E - H_1 \cdot h$; $M_4 = M_2^E - H_2 \cdot h$

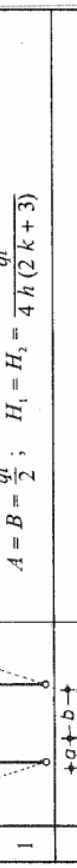
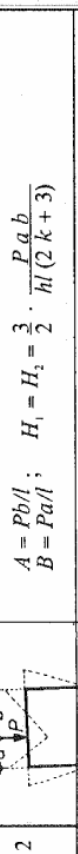
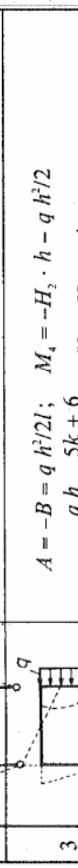
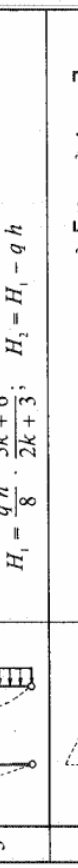
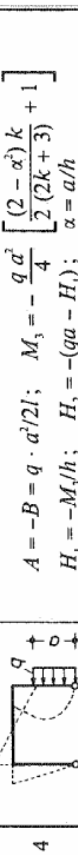
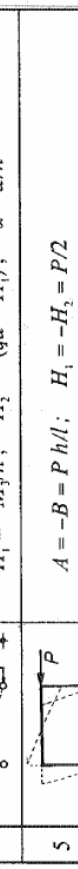
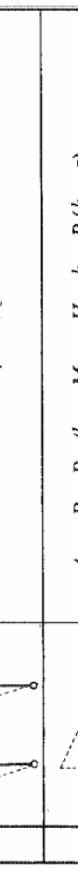
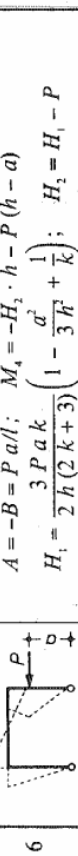
1		$A = \frac{q\,l}{2}$ $H_1 = H_2 = H = \frac{q\,l^2}{4\,h\,(k+2)}$; $M_1^E = M_2^E = \frac{H\,h}{3}$
2		$A = \frac{P\,b}{l}\left[1 + \frac{a\,(b-a)}{l^2\,(6\,k+1)}\right]$; $B = P - A$ $H_1 = H_2 = \frac{3\,P\,a\,b}{2\,h\,l\,(k+2)}$; $M_1^E = \frac{P\,a\,b}{2\,l^2} \cdot \frac{5\,kl - l + 2\,a\,(k+2)}{(k+2)\,(6\,k+1)}$ $M_2^E = \frac{P\,a\,b}{2\,l^2} \cdot \frac{7\,kl + 3\,l - 2\,a\,(k+2)}{(k+2)\,(6\,k+1)}$
3		$A = -B = \frac{q\,h^2}{l} \cdot \frac{k}{6\,k+1}$; $H_1 = \frac{q\,h}{8} \cdot \frac{2\,k+3}{k+2}$; $H_2 = H_1 - q\,h$ $M_1^E = \frac{q\,h^2}{24}\left(\frac{5\,k+9}{k+2} - \frac{12\,k}{6\,k+1}\right)$ $M_2^E = -\frac{q\,h^2}{24}\left(12 - \frac{5\,k+9}{k+2} - \frac{12\,k}{6\,k+1}\right)$; $M_4 = M_2^E - H_2 \cdot h - \frac{q\,h^2}{2}$
4		$A = -B = \frac{Ph}{l} \cdot \frac{3\,k}{6\,k+1}$; $H_1 = -H_2 = \frac{P}{2}$ $M_1^E = -M_2^E = \frac{Ph}{2} \cdot \frac{3\,k+1}{6\,k+1}$
5		$R_1 = \frac{Pab}{h} \cdot \frac{1+\beta+\beta k}{2\,(k+2)}$; $R_2 = \frac{Pab}{h} \cdot \frac{\alpha k}{2\,(k+2)}$; $R_3 = \frac{3\,Paak}{2\,(6\,k+1)}$ $A = -B = -\frac{2\,R_3}{l}$; $H_1 = \frac{Pa}{2\,h} - \frac{R_1 - R_2}{h}$; $H_2 = -(P - H_1)$ $M_1^E = -R_1 + (Pa/2 - R_3)$; $M_2^E = -R_1 - (Pa/2 - R_3)$ $\alpha = \frac{a}{h}$; $\beta = \frac{b}{h}$
6		gleichmäßige Erwärmung t $\quad M_1^E = M_2^E = H \cdot \frac{h\,(k+1)}{2\,k+1}$ $A = B = 0$; $H_1 = H_2 = H = 3\,\alpha_t \cdot t\,\frac{EI_R}{h^2} \cdot \frac{2\,k+1}{k\,(k+2)}$
7		$A = B = 0$; $H_1 = H_2 = \alpha_t\,\frac{EI_R}{h\,l}\left(\frac{\Delta t_R}{d_R}\,kl - \frac{\Delta t_S}{d_S}\,h\right)\frac{3}{k\,(k+2)}$ $M_1^E = M_2^E = \alpha_t\,\frac{EI_R}{l}\left[\frac{\Delta t_R}{d_R}\,kl - \frac{\Delta t_S}{d_S}\,h\,(k+3)\right]\frac{1}{k\,(k+2)}$

Zweigelenkrahmen



Abkürzung: $k = \frac{I_R}{I_S} \cdot \frac{h}{l}$ ---------- M-Linie

Bei unbelastetem Stiel:
$M_3 = -H_1 \cdot h$; $M_4 = -H_2 \cdot h$

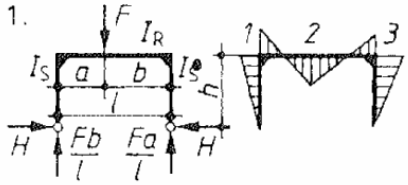
1		$A = B = \frac{ql}{2}$; $H_1 = H_2 = \frac{ql^2}{4\,h\,(2\,k+3)}$
2		$A = Pb/l$ $B = Pa/l$; $H_1 = H_2 = \frac{3}{2} \cdot \frac{P\,a\,b}{h\,l\,(2\,k+3)}$
3		$A = -B = q\,h^2/2l$; $M_4 = -H_2 \cdot h - q\,h^2/2$ $H_1 = \frac{q\,h}{8} \cdot \frac{5k+6}{2k+3}$; $H_2 = H_1 - q\,h$
4		$A = -B = q \cdot a^2/2l$; $M_3 = -\frac{q\,a^2}{4}\left[\frac{(2-\alpha^2)\,k}{2\,(2k+3)} + 1\right]$ $H_1 = -M_3/h$; $H_2 = -(qa - H_1)$; $\alpha = a/h$
5		$A = -B = P\,h/l$; $H_1 = -H_2 = P/2$
6		$A = -B = P\,a/l$; $M_4 = -H_2 \cdot h - P\,(h-a)$ $H_1 = \frac{3\,P\,a\,k}{2\,h\,(2\,k+3)}\left(1 - \frac{a^2}{3\,h^2} + \frac{1}{k}\right)$; $H_2 = H_1 - P$
7		$A = -B = -M^c/l$; $M_3 = M^c + H_1 \cdot h$ $H_1 = H_2 = \frac{3\,M^c}{2\,h}\left(1 - \frac{a^2}{h^2} + \frac{1}{k}\right)\frac{k}{2\,k+3}$
8		gleichmäßige Erwärmung t $A = B = 0$; $H_1 = H_2 = \alpha_t \cdot t\,\frac{EI_R}{h^2} \cdot \frac{3}{2\,k+3}$
9		ungleichmäßige Erwärmung $\Delta t = t_i - t_a$ $A = B = 0$ $H_1 = H_2 = \alpha_t\left(\frac{\Delta t_S}{d_S}\,h + \frac{\Delta t_R}{d_R}\,l\right)\frac{EI_R}{h\,l} \cdot \frac{3}{2\,k+3}$

Quelle: K.-J. Schneider (Hrsg.): Bautabellen für Ingenieure, 15. Auflage, 2002.

Hilfsgröße $c = \frac{I_R}{I_S} \cdot \frac{h}{l}$ $\quad I_R$ Trägheitsmoment des Riegelquerschnitts $\quad h$ Höhe

I_S Trägheitsmoment des Stielquerschnitts $\quad l$ Stützweite

1.



$H = \frac{3Fab}{2hl} \cdot \frac{1}{2c+3}$

$M_1 = M_3 = -Hh$

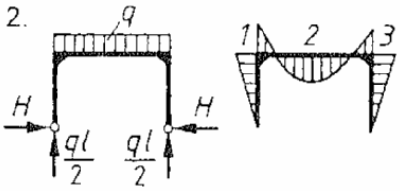
$M_2 = \frac{Fab}{l} - Hh$

Sonderfall $a = b = l/2$

$H = \frac{3Fl}{8h} \cdot \frac{1}{2c+3}$

$M_1 = M_3 = -Hh \quad M_2 = \frac{F \cdot l}{4} - Hh$

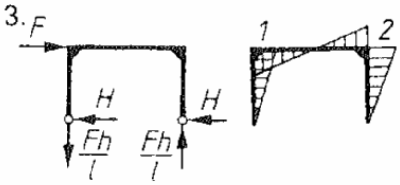
2.



$H = \frac{ql^2}{4h} \cdot \frac{1}{2c+3}$

$M_1 = M_3 = -Hh \qquad \max M_2 = \frac{ql^2}{8} - Hh$

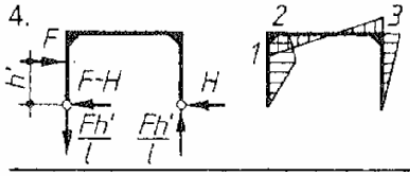
3.



$H = F/2$

$M_1 = -M_2 = \frac{Fh}{2}$

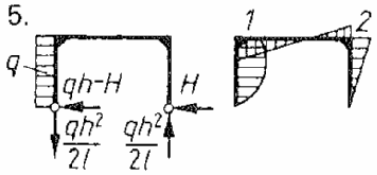
4.



$H = \frac{3Fh'}{2h}\left[1 - \frac{1}{3}\left(\frac{h'}{h}\right)^2 + \frac{1}{c}\right]\frac{c}{2c+3}$

$M_1 = (F-H)h' \qquad M_2 = Fh' - Hh \qquad M_3 = Hh$

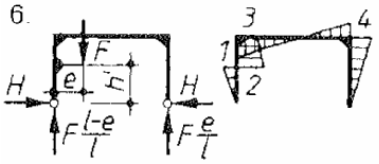
5.



$H = \frac{qh}{8}(5c+6)\frac{1}{2c+3}$

$M_1 = \frac{qh^2}{2} - Hh \qquad M_2 = -Hh$

6.

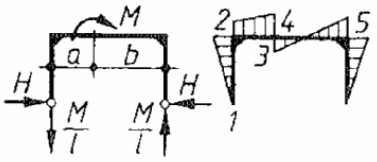


$H = \frac{3Fe}{2h}\left[1 - \left(\frac{h'}{h}\right)^2 + \frac{1}{c}\right]\frac{c}{2c+3}$

$M_1 = -Hh' \qquad M_2 = Fe - Hh'$

$M_3 = Fe - Hh \qquad M_4 = -Hh$

7. Belastung durch Moment am Riegel



$H = \frac{3M}{2h} \cdot \frac{b-a}{l} \cdot \frac{1}{2c+3} \qquad M_2 = M_5 = -H \cdot h$

$M_3 = -Hh - M\frac{a}{l} \qquad M_4 = -Hh + M\frac{b}{l}$

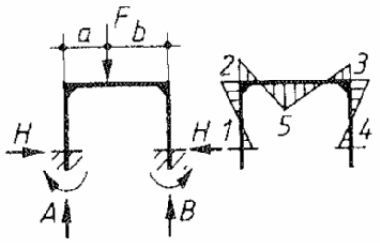
Ist $a > b$, so wird H negativ, d.h. ist von innen nach außen gerichtet, wenn M, wie eingezeichnet, rechtsdrehend.

8. gleichmäßige Erwärmung um t °C

$H = \frac{3EI_R\alpha_T t}{h^2} \cdot \frac{1}{2c+3} \qquad M_1 = M_2 = -Hh$

Quelle: Otto W. Wetzell (Hrsg.): Wendehorst Bautechnische Zahlentafeln, 31. Auflage, 2004.

9.



$$A=\frac{Fb}{l}\left[1+\frac{a(b-a)}{l^2(6c+1)}\right] \qquad B=F-A \qquad H=\frac{3Fab}{2hl}\cdot\frac{1}{c+2}$$

$$\left.\begin{matrix}M_1=\\M_4=\end{matrix}\right\rangle=\frac{Fab}{2l}\left[\frac{1}{c+2}\mp\frac{b-a}{l(6c+1)}\right]$$

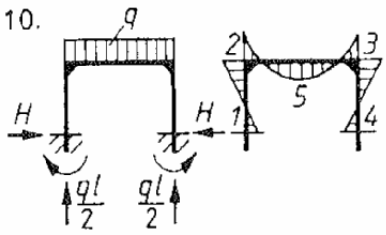
$$\left.\begin{matrix}M_2=\\M_3=\end{matrix}\right\rangle=-\frac{Fab}{l}\left[\frac{1}{c+2}\pm\frac{b-a}{2l(6c+1)}\right]$$

$$M_5=\frac{1}{l}(Fab+bM_2+aM_3)$$

Sonderfall $a=b=\frac{l}{2}$: $\quad A=B=\frac{F}{2} \qquad H=\frac{3Fl}{8h}\cdot\frac{1}{c+2}$

$$M_1=M_4=\frac{H\cdot h}{3} \qquad M_2=M_3=-2M_1 \qquad M_5=\frac{Fl}{4}+M_2$$

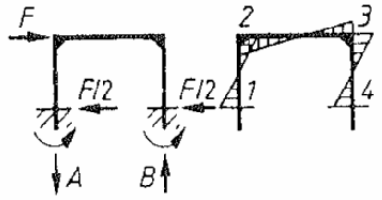
10.



$$H=\frac{ql^2}{4h}\cdot\frac{1}{c+2} \qquad M_1=M_4=\frac{ql^2}{12}\cdot\frac{1}{c+2}$$

$$M_2=M_3=-2M_1 \qquad M_5=\frac{ql^2}{8}+M_2$$

11.

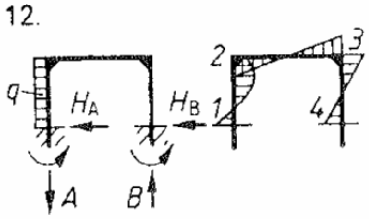


$$A=-B=\frac{Fh}{l}\cdot\frac{3c}{6c+1}$$

$$M_1=M_4=\frac{Fh}{2}\cdot\frac{3c+1}{6c+1}$$

$$M_2=-M_3=\frac{Fh}{2}\cdot\frac{3c}{6c+1}$$

12.

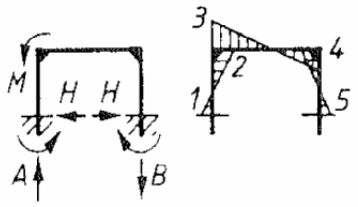


$$B=-A=\frac{q\cdot h^2}{l}\cdot\frac{c}{6c+1};\ H_A=-\frac{q\cdot h}{8}\cdot\frac{6c+13}{c+2};\ H_B=\frac{q\cdot h}{8}\cdot\frac{2c+3}{c+2}$$

$$\left.\begin{matrix}M_1=\\M_4=\end{matrix}\right\rangle=\frac{qh^2}{4}\left[-\frac{c+3}{6(c+2)}\mp\frac{4c+1}{6c+1}\right]$$

$$\left.\begin{matrix}M_2=\\M_3=\end{matrix}\right\rangle=\frac{qh^2}{4}\left[-\frac{c}{6(c+2)}\pm\frac{2c}{6c+1}\right]$$

13.



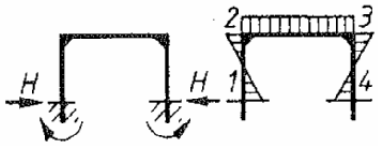
$$A=-B=\frac{6M}{l}\cdot\frac{c}{6c+1} \qquad H=-\frac{3M}{2h}\cdot\frac{1}{c+2}$$

$$\left.\begin{matrix}M_1=\\M_5=\end{matrix}\right\rangle=-\frac{M}{2}\left(\frac{1}{c+2}\mp\frac{1}{6c+1}\right) \qquad M_3=-(M-M_2)$$

$$\left.\begin{matrix}M_2=\\M_4=\end{matrix}\right\rangle=\frac{M}{2}\left(\frac{2}{c+2}\pm\frac{1}{6c+1}\right)$$

14. gleichmäßige Erwärmung um t°C

$$H=\frac{3EI_R\alpha_T t}{h^2}\cdot\frac{2c+1}{c(c+2)}$$



$$M_1=M_4=-\frac{3EI_R\alpha_T t}{h}\cdot\frac{c+1}{c(c+2)}$$

$$M_2=M_3=M_1-Hh \text{ (negativ)}$$

Quelle: Otto W. Wetzell (Hrsg.): Wendehorst Bautechnische Zahlentafeln, 31. Auflage, 2004.