

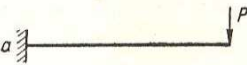
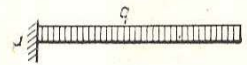
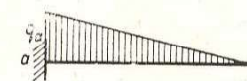
5. EHITUSMEHAANIKA

5.1. TALAD

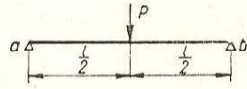
Tabel 5.1. Talade sisejõud ja läbipained

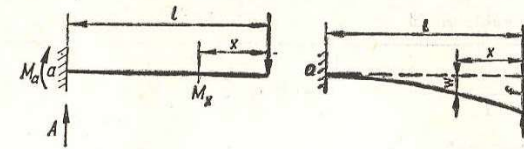
Joonistel on näidatud toereaktsioonide positiivne suund. Positiivne paindemoment põhjustab tala alumises servas tõmmet. Läbipaine allapoole loetakse positiivseks.

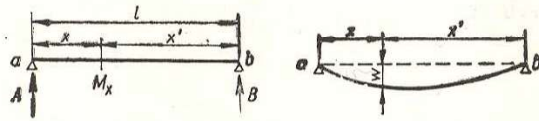
Konsool

Koormus	Toereaktsioonid	Paindemomendid
	$A = P$ $M_a = -Pl$	$M_x = -Px$ $\min M = M_a = -Pl$
	$A = ql$ $M_a = -\frac{ql^2}{2}$	$M_x = -\frac{qx^2}{2}$ $\min M = M_a = -\frac{ql^2}{2}$
	$A = \frac{qa l}{2}$ $M_a = -\frac{qa l^2}{6}$	$M_x = -\frac{qa x^3}{6l}$ $\min M = M_a = -\frac{qa l^2}{6}$

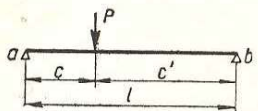
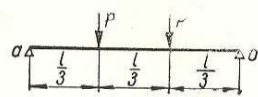
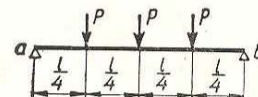
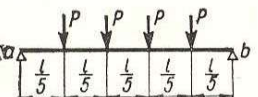
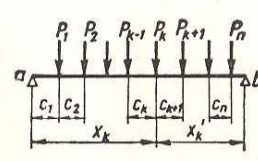
Lihttala (konsoolideta ja konsoolidega)

	$A = \frac{P}{2}$ $B = \frac{P}{2}$	$0 \leq x \leq \frac{l}{2} \quad M_x = \frac{Px}{2}$ $\frac{l}{2} \leq x \leq l \quad M_x = \frac{Px'}{2}$ $\max M = \frac{Pl}{4}$
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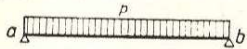
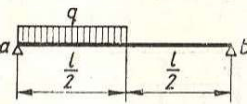

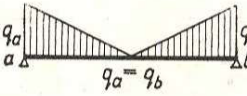
Ohtlik ristlõige	Elastse joone võrrand	Maksimaalne läbipaine
$x = l$	$w = \frac{Pl^3}{3EI} \left(1 - \frac{3}{2} \frac{x}{l} + \frac{1}{2} \frac{x^3}{l^3} \right)$	$f = \frac{Pl^3}{3EI}$ lõikes $x=0$
$x = l$	$w = \frac{ql^4}{8EI} \left(1 - \frac{4}{3} \frac{x}{l} + \frac{1}{3} \frac{x^4}{l^4} \right)$	$f = \frac{ql^4}{8EI}$ lõikes $x=0$
$x = l$	$w = \frac{qa l^4}{30EI} \left(1 - \frac{5}{4} \frac{x}{l} + \frac{1}{4} \frac{x^5}{l^5} \right)$	$f = \frac{qa l^4}{30EI}$ lõikes $x=0$
	$x = \frac{l}{2}$	$0 \leq x \leq \frac{l}{2}$ $w = \frac{Pl^3}{16EI} \left(\frac{x}{l} - \frac{4}{3} \frac{x^3}{l^3} \right)$ $\frac{l}{2} \leq x \leq l$ $w = \frac{Pl^3}{16EI} \left(\frac{x'}{l} - \frac{4}{3} \frac{x'^3}{l^3} \right)$
		$f = \frac{Pl^3}{48EI} = 0,02083 \frac{Pl^3}{EI}$ lõikes $x = \frac{l}{2}$

Tabel 5.1 (järg)

Koormus	Toe-reaktsioonid	Paindemomendid
	$A = \frac{Pc'}{l}$ $B = \frac{Pc}{l}$	$0 \leq x \leq c \quad M_x = \frac{Pc'}{l} \cdot x$ $c \leq x \leq l \quad M_x = \frac{Pc}{l} \cdot x'$ $\max M = \frac{Pcc'}{l}$
	$A = B = P$	$\max M = \frac{Pl}{3}$
	$A = B = \frac{3}{2}P$	$\max M = \frac{Pl}{2}$
	$A = B = 2P$	$\max M = \frac{3}{5}Pl$
	$A = \frac{1}{l} \sum_{k=1}^{k=n} P_k x'_k$ $B = \frac{1}{l} \sum_{k=1}^{k=n} P_k x_k$	$Q_k = A - \sum_{i=1}^{i=k-1} P_i$ $M_k = M_{k-1} + Q_k c_k$

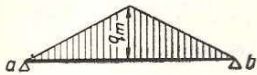
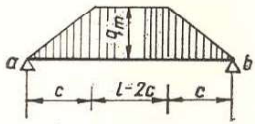
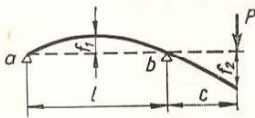
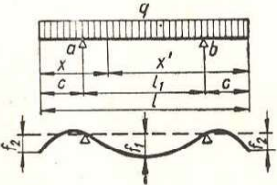
Ohtlik rist-lõige	Elastse joone võrrand	Maksimaalne läbipaine
$x = c$	$0 \leq x \leq c$ $w = \frac{Pl^3}{6EI} \left(\frac{c'x}{l^2} - \frac{c'^3x}{l^4} - \frac{c'x^3}{l^4} \right)$ $c \leq x \leq l$ $w = \frac{Pl^3}{6EI} \left(\frac{cx'}{l^2} - \frac{c^3x'}{l^4} - \frac{cx'^3}{l^4} \right)$	$f = \frac{Pl^3}{9EI} \cdot \frac{c'^2c^2}{l^4} \left(2 + \frac{c}{c'} \right) \sqrt{\frac{1}{3} + \frac{2}{3} \frac{c'}{c}}$ <p>lõikes $x = c \sqrt{\frac{1}{3} + \frac{2}{3} \frac{c'}{c}}$, kui $c > c'$;</p> $f = \frac{Pl^3}{9EI} \cdot \frac{c'^2c^2}{l^4} \left(2 + \frac{c'}{c} \right) \sqrt{\frac{1}{3} + \frac{2}{3} \frac{c}{c'}}$ <p>lõikes $x = c' \sqrt{\frac{1}{3} + \frac{2}{3} \frac{c}{c'}}$; kui $c > c'$</p>
$x = \frac{l}{2}$	Läbipainde arvutus vt. lk. 120...121	$f = \frac{23}{648} \frac{Pl^3}{EI} = 0,03549 \frac{Pl^3}{EI}$ <p>lõikes $x = \frac{l}{2}$</p>
$x = \frac{l}{2}$		$f = \frac{19}{384} \frac{Pl^3}{EI} = 0,04948 \frac{Pl^3}{EI}$ <p>lõikes $x = \frac{l}{2}$</p>
$x = \frac{l}{2}$		$f = \frac{63}{1000} \frac{Pl^3}{EI} = 0,063 \frac{Pl^3}{EI}$ <p>lõikes $x = \frac{l}{2}$</p>
$Q_k = 0$		

Tabel 5.1 (järg)

Koormus	Toe-reaktsioonid	Paindemomendid
	$A=B=\frac{ql}{2}$	$M_x = \frac{qx}{2}(l-x)$ $\max M = \frac{ql^2}{8} = 0,125ql^2$
	$A = \frac{3}{8}ql$ $B = \frac{1}{8}ql$	$0 \leq x \leq \frac{l}{2} \quad M_x = \frac{1}{8}qx(3l-4x)$ $\frac{l}{2} \leq x \leq l \quad M_x = \frac{1}{8}qlx'$ $\max M = \frac{9}{128}ql^2 = 0,07041ql^2$
	$A = \frac{qb l}{6}$ $B = \frac{qb l}{3}$	$M_x = \frac{qb l^2}{6} \left(\frac{x}{l} - \frac{x^3}{l^3} \right)$ $\max M = \frac{1}{9\sqrt{3}} qb l^2 = 0,0642 qb l^2$
	$A = \frac{qa l}{4}$ $B = \frac{qa l}{4}$	$0 \leq x \leq \frac{l}{2} \quad M_x = \frac{qa l^2}{2} \left(\frac{x}{2l} - \frac{x^2}{l^2} + \frac{2}{3} \frac{x^3}{l^3} \right)$ $\frac{l}{2} \leq x \leq l \quad M_x = \frac{qa l^2}{2} \left(\frac{x'}{2l} - \frac{x'^2}{l^2} + \frac{2}{3} \frac{x'^3}{l^3} \right)$ $\max M = \frac{qa l^2}{24} = 0,04167qa l^2$

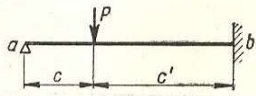

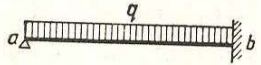
Ohtlik rist-lõige	Elastse joone võrrand	Maksimaalne läbipaine
$x = \frac{l}{2}$	$w = \frac{ql^4}{24EI} \left(\frac{x}{l} - 2 \frac{x^3}{l^3} + \frac{x^4}{l^4} \right)$	$f = \frac{5ql^4}{384EI} = 0,01302 \frac{ql^4}{EI}$ lõikes $x = \frac{l}{2}$
$x = \frac{3}{8}l$	$0 \leq x \leq \frac{l}{2} \quad w = \frac{ql^4}{24EI} \left(\frac{9}{16} \frac{x}{l} - \frac{3}{2} \frac{x^3}{l^3} + \frac{x^4}{l^4} \right)$ $\frac{l}{2} \leq x \leq l \quad w = \frac{ql^4}{384EI} \left(7 \frac{x'}{l} - 8 \frac{x'^3}{l^3} \right)$	$f = 0,00657 \frac{ql^4}{EI}$ lõikes $x = 0,460l$
$x = \frac{\sqrt{3}}{3}l$ $= 0,5774l$	$w = \frac{qb l^4}{360EI} \left(7 \frac{x}{l} - 10 \frac{x^3}{l^3} + 3 \frac{x^5}{l^5} \right)$	$f = 0,00652 \frac{qb l^4}{EI}$ lõikes $x = 0,5193l$
$x = \frac{l}{2}$	$0 \leq x \leq \frac{l}{2} \quad w = \frac{qa l^4}{24EI} \left(\frac{3}{8} \frac{x}{l} - \frac{x^3}{l^3} + \frac{x^4}{l^4} - \frac{2}{5} \frac{x^5}{l^5} \right)$ $\frac{l}{2} \leq x \leq l \quad w = \frac{qa l^4}{24EI} \left(\frac{3}{8} \frac{x'}{l} - \frac{x'^3}{l^3} + \frac{x'^4}{l^4} - \frac{2}{5} \frac{x'^5}{l^5} \right)$	$f = \frac{3}{640} \frac{qa l^4}{EI} = 0,004688 \frac{qa l^4}{EI}$ lõikes $x = \frac{l}{2}$

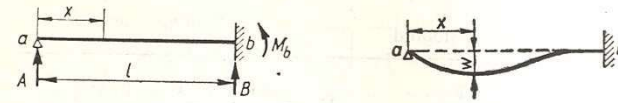
Tabel 5.1 (järg)

Koormus	Toereakt-sioonid	Paindemomendid
	$A = \frac{q_m l}{4}$ $B = \frac{q_m l}{4}$	$0 \leq x \leq \frac{l}{2}$ $M_x = \frac{q_m l^2}{2} \left(\frac{x}{2l} - \frac{2}{3} \frac{x^3}{l^3} \right)$ $\frac{l}{2} \leq x \leq l$ $M_x = \frac{q_m l^2}{2} \left(\frac{x'}{2l} - \frac{2}{3} \frac{x'^3}{l^3} \right)$ $\max M = \frac{q_m l^2}{12} = 0,08333 q_m l^2$
	$A = B = \frac{q_m}{2}(l - c)$	$0 \leq x \leq c$ $M_x = \frac{q_m l^2}{2} \left[\left(1 - \frac{c}{l} \right) \frac{x}{l} - \frac{1}{3} \frac{x^3}{c l^2} \right]$ $c \leq x \leq l - c$ $M_x = \frac{q_m l^2}{2} \left(\frac{x}{l} - \frac{x^2}{l^2} - \frac{1}{3} \frac{c^2}{l^2} \right)$ $\max M = \frac{q_m l^2}{24} \left(3 - 4 \frac{c^2}{l^2} \right)$
	$A = -\frac{Pc}{l}$ $B = +\frac{P(l+c)}{l}$	$0 \leq x \leq l$ $M_x = -\frac{Pc}{l} \cdot x$ $l \leq x \leq l+c$ $M_x = -P(l+c-x)$ $\min M = -Pc$
	$A = q \left(\frac{l_1}{2} + c \right)$ $B = q \left(\frac{l_1}{2} + c \right)$	$0 \leq x \leq c$ $M_x = -\frac{qx^2}{2}$ $c \leq x \leq l_1 + c$ $M_x = -\frac{ql^2}{2} \left(\frac{x-c}{l} - \frac{x^2}{l^2} \right)$ $l_1 + c \leq x \leq l_1 + 2c$ $M_x = -\frac{qx'^2}{2}$ $\max M = \frac{ql^2}{8} \left(1 - 4 \frac{c}{l} \right) = \frac{q}{8} (l_1^2 - 4c^2)$ $\min M = -\frac{qc^2}{2}$

Ohtlik rist-lõige	Elastse joone võrrand	Maksimaalne läbipaine
$x = \frac{l}{2}$	$0 \leq x \leq \frac{l}{2}$ $w = \frac{q_m l^4}{24EI} \left(\frac{5}{8} \frac{x}{l} - \frac{x^3}{l^3} + \frac{2}{5} \frac{x^5}{l^5} \right)$ $\frac{l}{2} \leq x \leq l$ $w = \frac{q_m l^4}{24EI} \left(\frac{5}{8} \frac{x'}{l} - \frac{x'^3}{l^3} + \frac{2}{5} \frac{x'^5}{l^5} \right)$	$\bar{f} = \frac{q_m l^4}{120EI} = 0,008333 \frac{q_m l^4}{EI}$ lõikes $x = \frac{l}{2}$
$x = \frac{l}{2}$		$\bar{f} = \frac{q_m l^4}{1920EI} \left(25 - 40 \frac{c^2}{l^2} + 16 \frac{c^4}{l^4} \right)$ lõikes $x = \frac{l}{2}$
$x = l$	$0 \leq x \leq l$ $w = -\frac{Pl^2 c}{6EI} \left(\frac{x}{l} - \frac{x^3}{l^3} \right)$ $l \leq x \leq l+c$ $w = \frac{Plc^2}{6EI} \left(\frac{2l+3c}{l} \frac{x'}{c} - \frac{x'^3}{lc^2} - 2 \frac{l+c}{l} \right)$	$\bar{f}_1 = -\frac{Pl^2 c}{9EI \sqrt{3}} = -0,06415 \frac{Pl^2 c}{EI}$ lõikes $x = \frac{l}{\sqrt{3}} = 0,5774l$ $\bar{f}_2 = \frac{Pc^2}{3EI} (l+c)$ lõikes $x = l+c$
$x = \frac{l}{2}$ $x = c; x' = c$	$w = \frac{ql^4}{24EI} \left(\frac{x}{l} - 2 \frac{x^3}{l^3} + \frac{x^4}{l^4} + 6 \frac{cx^2}{l^3} - 6 \frac{cx}{l^2} - \frac{c}{l} + 6 \frac{c^2}{l^2} - 4 \frac{c^3}{l^3} - \frac{c^4}{l^4} \right)$	$\bar{f}_1 = \frac{5ql_1^4}{384EI} \left(1 - \frac{24}{5} \frac{c^2}{l_1^2} \right)$ lõikes $x = \frac{l}{2}$ $\bar{f}_2 = \frac{ql_1^4}{24EI} \left(3 \frac{c^4}{l_1^4} + 6 \frac{c^3}{l_1^3} - \frac{c}{l_1} \right)$ lõikes $x = 0; x' = 0$

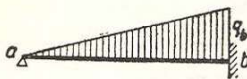
Tabel 5.1 (järg)
Ühest otsast jäigalt kinnitatud tala

Koormus	Toereakt-sioonid	Paidemomendid
	$A = \frac{P}{2} \left(2 - 3 \frac{c}{l} + \frac{c^3}{l^3} \right)$ $B = \frac{P}{2} \left(3 \frac{c}{l} - \frac{c^3}{l^3} \right)$ $M_b = -\frac{1}{2} Pl \left(\frac{c}{l} - \frac{c^3}{l^3} \right)$	$0 \leq x \leq c$ $M_x = \frac{Px}{2} \left(2 - 3 \frac{c}{l} + \frac{c^3}{l^3} \right)$ $c \leq x \leq l$ $M_x = -\frac{Pl}{2} \left[2 \frac{c}{l} - \left(3 \frac{c}{l} - \frac{c^3}{l^3} \right) \frac{x}{l} \right]$ $\max M = \frac{Pl}{2} \left[2 \frac{c}{l} - 3 \frac{c^2}{l^2} + \frac{c^4}{l^4} \right]$ $\min M = M_b = -\frac{Pl}{2} \left(\frac{c}{l} - \frac{c^3}{l^3} \right)$
	$A = \frac{5}{16} P$ $B = \frac{11}{16} P$ $M_b = -\frac{3}{16} Pl$	$0 \leq x \leq \frac{l}{2}$ $M_x = \frac{5}{16} Px$ $\frac{l}{2} \leq x \leq l$ $M_x = Pl \left(\frac{1}{2} - \frac{11}{16} \frac{x}{l} \right)$ $\max M = \frac{5}{32} Pl$ $\min M = -\frac{3}{16} Pl$
	$A = \frac{3}{8} ql$ $B = \frac{5}{8} ql$ $M_b = -\frac{ql^2}{8}$	$M_x = \frac{ql^2}{2} \left(\frac{3}{4} \frac{x}{l} - \frac{x^2}{l^2} \right)$ $\max M = \frac{9}{128} ql^2$ $\min M = -\frac{ql^2}{8}$

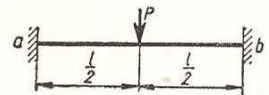
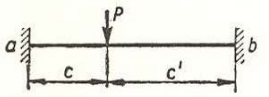


Ohtlik rist-lõige	Elastse joone võrrand	Maksimaalne läbipaine
$x = c$ $x = l$	$0 \leq x \leq c$ $w = \frac{Pc^2x}{12EI} \left[3 \frac{c}{l} - \frac{x^2}{l^2} \left(2 + \frac{c}{l} \right) \right]$ $c \leq x \leq l$ $w = \frac{Pl^3}{12EI} \left[\frac{x^3}{l^3} \left(3 \frac{c}{l} - \frac{c^3}{l^3} \right) - 6 \frac{x^2}{l^2} + 3 \frac{x}{l} \left(\frac{c^2}{l^2} + 1 \right) - 2 \frac{c^2}{l^2} \right]$	$c \leq 0,414l$ $f = \frac{Pc^2}{6EI} \sqrt{\frac{c}{c+2l}} \text{ lõikes } x=l \sqrt{\frac{c}{c+2l}}$ $c \geq 0,414l$ $f = \frac{Pc}{3EI} \frac{(l^2 - c^2)^3}{(3l^2 - c^2)^2}$ $\text{lõikes } x=l \cdot \frac{l^2 + c^2}{3l^2 - c^2}$
$x = \frac{l}{2}$ $x = l$	$0 \leq x \leq \frac{l}{2}$ $w = \frac{Pl^3}{32EI} \left(\frac{x}{l} - \frac{5}{3} \frac{x^3}{l^3} \right)$ $\frac{l}{2} \leq x \leq l$ $w = \frac{Pl^3}{32EI} \left(3 \frac{x^2}{l^2} - \frac{11}{3} \frac{x^3}{l^3} \right)$	$f = \frac{1}{48 \sqrt{5}} \frac{Pl^3}{EI} = 0,00932 \frac{Pl^3}{EI}$ $\text{lõikes } x = \frac{1}{\sqrt{5}} l = 0,4472l$
$x = \frac{3}{8} l$ $x = l$	$w = \frac{ql^4}{48EI} \left(\frac{x}{l} - 3 \frac{x^3}{l^3} + 2 \frac{x^4}{l^4} \right)$	$f = 0,0054 \frac{ql^4}{EI} \text{ lõikes } x = 0,4215l$

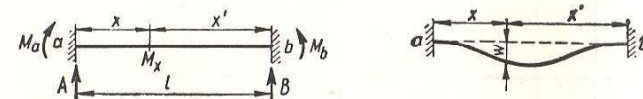
Tabel 5.1 (järg)

Koormus	Toe-reaktsioonid	Paindemomendid
	$A = \frac{q_b l}{10}$ $B = \frac{2q_b l}{5}$ $M_b = -\frac{q_b l^2}{15}$	$M_x = \frac{q_b l^2}{2} \left(\frac{1}{5} \frac{x}{l} - \frac{1}{3} \frac{x^3}{l^3} \right)$ $\max M = \frac{q_b l^2}{75} \cdot \sqrt{5} \approx 0,0298 q_b l^2$ $\min M = -\frac{q_b l^2}{15}$

Mõlemast otsast jäigalt kinnitatud tala

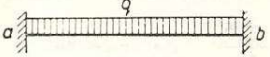
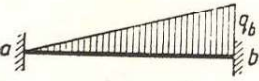
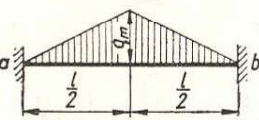
	$A = B = \frac{P}{2}$ $M_a = M_b = -\frac{Pl}{8}$	$0 \leq x \leq \frac{l}{2} \quad M_x = \frac{Pl}{2} \left(\frac{x}{l} - \frac{1}{4} \right)$ $\frac{l}{2} \leq x \leq l \quad M_x = \frac{Pl}{2} \left(\frac{x'}{l} - \frac{1}{4} \right)$ $\max M = \frac{Pl}{8}$ $\min M = M_a = M_b = -\frac{Pl}{8}$
	$A = P \frac{c'^2}{l^2} \left(1 + \frac{2c}{l} \right)$ $B = \frac{Pc^2}{l^2} \left(1 + \frac{2c'}{l} \right)$ $M_a = -P \frac{cc'^2}{l^2}$ $M_b = -P \frac{c^2c'}{l^2}$	$0 \leq x \leq c \quad M_x = P \frac{c'^2}{l} \left(\frac{x}{l} + \frac{2cx}{l^2} - \frac{c}{l} \right)$ $c \leq x \leq l \quad M_x = P \frac{c^2}{l} \left(\frac{x'}{l} + \frac{2c'x'}{l^2} - \frac{c'}{l} \right)$ $\max M = 2P \frac{c^2c'^2}{l^3}$ $c \leq c' \quad \min M = M_a = -P \frac{cc'^2}{l^2}$ $c \geq c' \quad \min M = M_b = -P \frac{c^2c'}{l^2}$

Ohtlik ristlõige	Elastse joone võrand	Maksimaalne läbipaine
$x = \frac{l}{\sqrt{5}} \quad l = 0,4472l$ $x = l$	$w = \frac{q_b l^4}{120EI} \left(\frac{x}{l} - 2 \frac{x^3}{l^3} + \frac{x^5}{l^5} \right)$	$f = 0,00238 \frac{q_b l^4}{EI}$ lõikes $x = 0,4472l$



$x = \frac{l}{2}$ $x = 0, x = l$	$0 \leq x \leq \frac{l}{2} \quad w = \frac{Pl^3}{16EI} \left(\frac{x^2}{l^2} - \frac{4}{3} \frac{x^3}{l^3} \right)$ $\frac{l}{2} \leq x \leq l \quad w = \frac{Pl^3}{16EI} \left(\frac{x'^2}{l^2} - \frac{4}{3} \frac{x'^3}{l^3} \right)$	$f = \frac{Pl^3}{192EI} = 0,005208 \frac{Pl^3}{EI}$ lõikes $x = \frac{l}{2}$
$x = c$ $x = 0$ $x = l$	$0 \leq x \leq c \quad w = \frac{Plc'^2}{2EI} \left[\frac{c}{l} \frac{x^2}{l^2} - \frac{x^3}{3l^3} \left(1 + \frac{2c}{l} \right) \right]$ $c \leq x \leq l \quad w = \frac{Plc^2}{2EI} \left[\frac{c'}{l} \frac{x'^2}{l^2} - \frac{x'^3}{3l^3} \left(1 + \frac{2c'}{l} \right) \right]$	$c > c' \quad f = \frac{2}{3} \frac{Pc^3}{EI} \cdot \frac{c'^2}{l^2} \left(\frac{l}{l+2c} \right)^2$ lõikes $x = l \frac{2c}{l+2c}$ $c < c' \quad f = \frac{2}{3} \frac{Pc'^3}{EI} \cdot \frac{c^2}{l^2} \left(\frac{l}{l+2c'} \right)^2$ lõikes $x' = l \frac{2c'}{l+2c'}$

Tabel 5.1 (järg)

Koormus	Toereaktsioonid	Paindemomendid
	$A = B = \frac{ql}{2}$ $M_a = M_b = -\frac{ql^2}{12}$	$M_x = -\frac{ql^2}{2} \left(\frac{1}{6} - \frac{x}{l} + \frac{x^2}{l^2} \right)$ $\max M = \frac{ql^2}{24}$ $\min M = M_a = M_b = -\frac{ql^2}{12}$
	$A = \frac{3}{20} q_b l$ $B = \frac{7}{20} q_b l$ $M_a = -\frac{q_b l^2}{30}$ $M_b = -\frac{q_b l^2}{20}$	$M_x = -\frac{q_b l^2}{60} \left(10 \frac{x^3}{l^3} - 9 \frac{x}{l} + 2 \right)$ $\max M = \frac{q_b l^2}{30} \cdot (3\sqrt[3]{0,3} - 1) \approx 0,02144 q_b l^2$ $\min M = M_b = -\frac{q_b l^2}{20}$
	$A = B = \frac{q_m l}{2}$ $M_a = M_b = -\frac{5}{96} q_m l^2$	$0 \leq x \leq \frac{l}{2}$ $M_x = -\frac{q_m l}{2} \left(\frac{5}{48} - \frac{x}{2l} + \frac{2}{3} \frac{x^3}{l^3} \right)$ $\frac{l}{2} \leq x \leq l$ $M_x = -\frac{q_m l}{2} \left(\frac{5}{48} - \frac{x'}{2l} + \frac{2}{3} \frac{x'^3}{l^3} \right)$ $\max M = \frac{q_m l^2}{16}$ $\min M = M_a = M_b = -\frac{5}{96} q_m l^2$

Ohtlik ristlõige	Elastse joone võrrand	Maksimaalne läbipaine
$x = \frac{l}{2}$ $x = 0, x = l$	$w = \frac{ql^4}{24EI} \left(\frac{x^2}{l^2} - 2 \frac{x^3}{l^3} + \frac{x^4}{l^4} \right)$	$f = \frac{ql^4}{384EI} = 0,002604 \frac{ql^4}{EI}$ lõikes $x = \frac{l}{2}$
$x = \sqrt[3]{0,3l} = 0,5477l$ $x = l$	$w = \frac{q_b l^4}{120EI} \left(2 \frac{x^2}{l^2} - 3 \frac{x^3}{l^3} + \frac{x^5}{l^5} \right)$	$f = \frac{q_b l^4}{764EI} = 0,001309 \frac{q_b l^4}{EI}$ lõikes $x = 0,525l$
$x = \frac{l}{2}$ $x = 0, x = l$	$0 \leq x \leq \frac{l}{2}$ $w = \frac{q_m l^4}{12EI} \left(\frac{5}{16} \frac{x^2}{l^2} - \frac{x^3}{2l^3} + \frac{x^5}{5l^5} \right)$ $\frac{l}{2} \leq x \leq l$ $w = \frac{q_m l^4}{12EI} \left(\frac{5}{16} \frac{x'^2}{l^2} - \frac{x'^3}{2l^3} + \frac{x'^5}{5l^5} \right)$	$f = \frac{7}{3840} \cdot \frac{q_m l^4}{EI} = 0,001823 \cdot \frac{q_m l^4}{EI}$ lõikes $x = \frac{l}{2}$