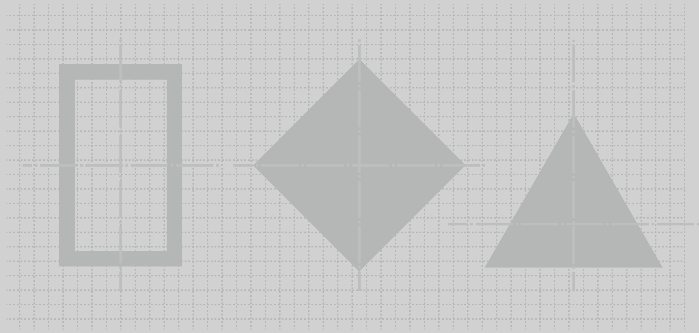
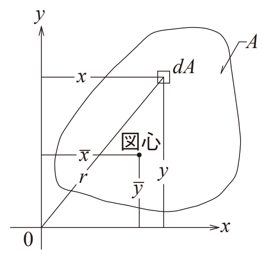
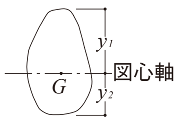
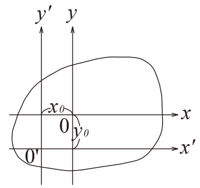
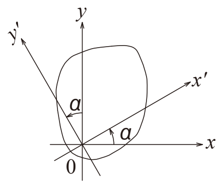
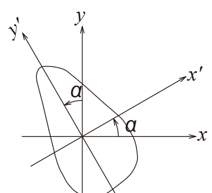
3. 力　学

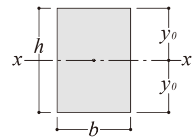
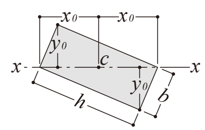
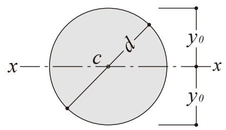
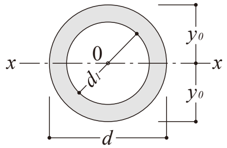
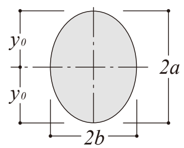
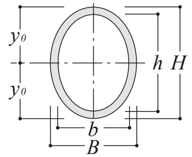
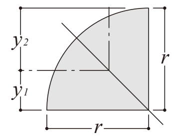
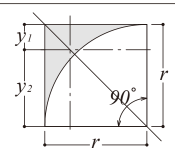


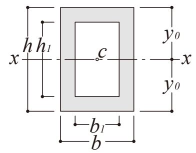
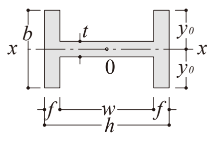
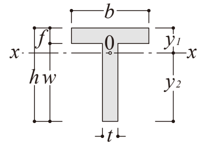
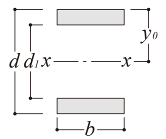
3-1. 平面図形

断面の諸係数の定義

断面積	$A=\int_A dA$	
断面1次モーメント	$S_x=\int_A y dA$, $S_y=\int_A x dA$	
図心	$\bar{y}=\dfrac{S_x}{A}$, $\bar{x}=\dfrac{S_y}{A}$	
断面2次モーメント	$I_x=\int_A y^2 dA$, $I_y=\int_A x^2 dA$	
断面相乗モーメント	$I_{xy}=\int_A xy dA$	
断面極2次モーメント	$I_p=\int_A r^2 dA$, $I_p=I_x+I_y$	
断面2次半径	$i_x=\sqrt{\dfrac{I_x}{A}}$, $i_y=\sqrt{\dfrac{I_y}{A}}$	
断面極2次半径	$i_p=\sqrt{\dfrac{I_p}{A}}$	
断面係数	$Z_1=\dfrac{I}{y_1}$, $Z_2=\dfrac{I}{y_2}$	
軸の平行移動	$S_{x'}=S_x+Ay_0$, $S_{y'}=S_y+Ax_0$ $I_{x'}=I_x+2y_0S_x+Ay_0^2$, $I_{y'}=I_y+2x_0S_y+Ax_0^2$ $I_{x'y'}=I_{xy}+x_0S_x+y_0S_y+Ax_0y_0$ 0を図心にとれば $I_{x'}=I_x+Ay_0^2$, $I_{y'}=I_y+Ax_0^2$ $I_{x'y'}=I_{xy}+Ax_0y_0$	
軸の回転移動	$S_{x'}=S_x\cos\alpha-S_y\sin\alpha$ $S_{y'}=S_x\sin\alpha+S_y\cos\alpha$ $I_{x'}=I_x\cos^2\alpha+I_y\sin^2\alpha-I_{xy}\sin2\alpha$ $I_{y'}=I_x\sin^2\alpha+I_y\cos^2\alpha+I_{xy}\sin2\alpha$ $I_{x'y'}=\dfrac{I_x-I_y}{2}\sin2\alpha+I_{xy}\cos2\alpha$	
主軸および主断面2次モーメント	$I_{x'y'}=0$となるとき、x' , y'を主軸という 主軸の傾き $\tan2\alpha=\dfrac{2I_{xy}}{I_y-I_x}$ $I_{x'}=\dfrac{1}{2}(I_x+I_y)+\dfrac{1}{2}\sqrt{(I_x-I_y)^2+4I_{xy}^2}$ $I_{y'}=\dfrac{1}{2}(I_x+I_y)-\dfrac{1}{2}\sqrt{(I_x-I_y)^2+4I_{xy}^2}$ $I_{x'}=I_x\cos^2\alpha+I_y\sin^2\alpha$ $I_{y'}=I_x\sin^2\alpha+I_y\cos^2\alpha$ $I_{x'y'}=\dfrac{I_x-I_y}{2}\sin2\alpha$	

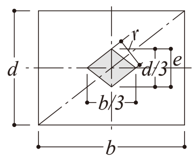
断面性能算出公式

断　面	面　積 A	図心より縁に至る距離 y_0	断面2次モーメント I_x	断面2次半径 i_x	断面係数 Z_x
	bh	$\dfrac{h}{2}$	$\dfrac{bh^3}{12}$	$\dfrac{h}{\sqrt{12}}$ $=0.289h$	$\dfrac{bh^2}{6}$
	bh	$y_0=\dfrac{bh}{\sqrt{b^2+h^2}}$ $x_0=\dfrac{1}{2}\sqrt{b^2+h^2}$	$\dfrac{b^3h^3}{6(b^2+h^2)}$	$\dfrac{bh}{\sqrt{6(b^2+h^2)}}$	$\dfrac{b^2h^2}{6\sqrt{b^2+h^2}}$
	$\dfrac{\pi}{4}d^2$ $=0.785d^2$	$\dfrac{d}{2}$	$\dfrac{\pi}{64}d^4$ $=0.0491d^4$	$\dfrac{d}{4}$	$\dfrac{\pi}{32}d^3$ $=0.0982d^3$
	$\dfrac{\pi}{4}(d^2-d_1^2)$ $=0.785$ $\cdot(d^2-d_1^2)$	$\dfrac{d}{2}$	$\dfrac{\pi}{64}(d^4-d_1^4)$ $=0.0491$ $\cdot(d^4-d_1^4)$	$\dfrac{\sqrt{d^2+d_1^2}}{4}$	$\dfrac{\pi}{32}\dfrac{d^4-d_1^4}{d}$ $=0.0982$ $\cdot\dfrac{d^4-d_1^4}{d}$
	πab	a	$\dfrac{\pi ba^3}{4}$	$\dfrac{a}{2}$	$\dfrac{\pi ba^2}{4}$
	$\dfrac{\pi(BH-bh)}{4}$	$\dfrac{H}{2}$	$\dfrac{\pi(BH^3-bh^3)}{64}$	$\sqrt{\dfrac{BH^3-bh^3}{16(BH-bh)}}$	$\dfrac{\pi}{32H}(BH^3-bh^3)$
	$\dfrac{\pi}{4}r^2$	$y_1=0.4244r$ $y_2=0.5756r$	$0.055r^4$	$0.2643r$	$Z_1=0.1296r^3$ $Z_2=0.0956r^3$
	$0.2146r^2$	$y_1=0.2234r$ $y_2=0.7766r$	$0.0075r^4$	$0.187r$	$Z_1=0.03357r^3$ $Z_2=0.00966r^3$

断　面	面　積 A	図心より縁に至る距離 y_0	断面2次モーメント I_x	断面2次半径 i_x	断面係数 Z_x
	$bh-b_1h_1$	$\frac{h}{2}$	$\frac{bh^3-b_1h_1^3}{12}$	$\sqrt{\frac{bh^3-b_1h_1^3}{12(bh-b_1h_1)}}$	$\frac{bh^3-b_1h_1^3}{6h}$
	$bh-w(b-t)$	$\frac{b}{2}$	$\frac{2fb^3+wt^3}{12}$	$\sqrt{\frac{2fb^3+wt^3}{12\{bh-w(b-t)\}}}$	$\frac{2fb^3+wt^3}{6b}$
	$bf+wt$	$y_1=\frac{th^2+f^2(b-t)}{2(bf+wt)}$ $y_2=h-y_1$	$\frac{th^3+(b-t)f^3}{3}-Ay_1^2$	$\sqrt{\frac{I_x}{A}}$	$Z_1=\frac{I_x}{y_1}$ $Z_2=\frac{I_x}{y_2}$
	$b(d-d_1)$	$\frac{d}{2}$	$\frac{b(d^3-d_1^3)}{12}$	$\sqrt{\frac{d^3-d_1^3}{12(d-d_1)}}$ $=0.289\sqrt{d^2-dd_1+d_1^2}$	$\frac{b(d^3-d_1^3)}{6d}$

断面の核

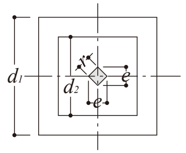
矩形



$e=d/3$

$r=\frac{bd}{3\sqrt{b^2+d^2}}$

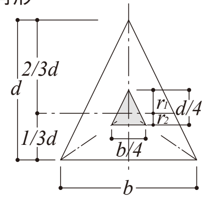
中空正方形



$e=\frac{11}{3}\left\{1+\left(\frac{d_2}{d_1}\right)^2\right\}$

$r=0.2358d_1\left\{1+\left(\frac{d_2}{d_1}\right)^2\right\}$

三角形

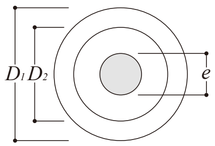


$e=d/4$

$r_1=d/6$

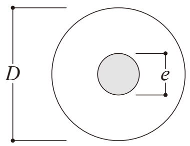
$r_2=d/12$

中空円



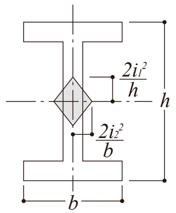
$e=\frac{D_1}{4}\left\{1+\left(\frac{D_2}{D_1}\right)^2\right\}$

円

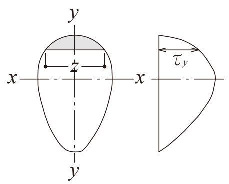


$e=D/4$

I 形



せん断応力



一般に　$\tau_y=\frac{QS_x}{bI_x}$

ここに

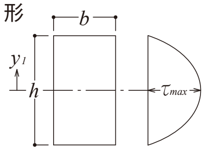
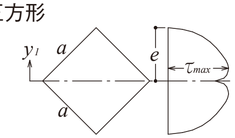
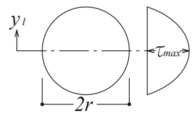
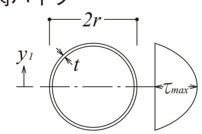
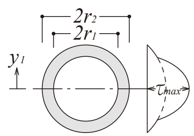
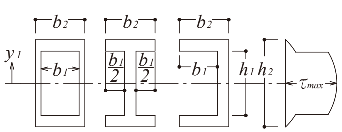
S_x:ハッチ部分の断面1次モーメント

I_x:断面2次モーメント

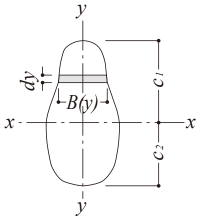
$\tau_{max}=\kappa\frac{Q}{A}$:最大せん断応力度

$\kappa=\frac{最大応力度}{平均応力度}$

y_1 = 中立軸からの距離

断 面 形	せん断力 τ	κ
1.矩　形 	$\tau=\frac{3}{2}\frac{Q}{bh}\left\{1-\left(\frac{2y_1}{h}\right)^2\right\}$ $\tau_{max}=\frac{3}{2}\frac{Q}{bh}=\frac{3}{2}\frac{Q}{A}$ $(y_1=0)$	$\frac{3}{2}$
2.正方形 	$\tau=\frac{Q}{a^2}\left\{1+\sqrt{2}\frac{y_1}{a}-4\left(\frac{y_1}{a}\right)^2\right\}$ $\tau_{max}=\frac{9}{8}\frac{Q}{a^2}=1.125\frac{Q}{A}$ $(y_1=\frac{1}{4}e=\frac{\sqrt{2}}{8}a)$	$\frac{9}{8}$
3.円 	$\tau=\frac{4}{3}\frac{Q}{\pi r^2}\left\{1-\left(\frac{y_1}{r}\right)^2\right\}$ $\tau_{max}=\frac{4}{3}\frac{Q}{\pi r^2}=\frac{4}{3}\frac{Q}{A}$ $(y_1=0)$	$\frac{4}{3}$
4.薄肉パイプ 	$\tau=\frac{Q}{\pi rt}\left\{1-\left(\frac{y_1}{r}\right)^2\right\}$ $\tau_{max}=\frac{Q}{\pi rt}=2\frac{Q}{A}$ $(y_1=0)$	2
6.パイプ 	$r_2≧y_1≧r_1$: $\tau=\frac{4}{3}\frac{Q}{\pi(r_2^4-r_1^4)}(r_2^2-y_1^2)$ $r_1≧y_1$: $\tau=\frac{4}{3}\frac{Q}{\pi(r_2^4-r_1^4)}\left\{r_2^2+r_1^2-2y_1^2+\sqrt{(r_2^2-y_1^2)(r_1^2-y_1^2)}\right\}$	$\kappa=\frac{4(r_2^2+r_2r_1+r_1^2)}{3(r_2^2+r_1^2)}$ $\tau_{max}=\frac{4}{3}\frac{Q(r_2^2+r_2r_1+r_1^2)}{\pi(r_2^4-r_1^4)}$ $=\frac{Q}{A}\frac{4(r_2^2+r_2r_1+r_1^2)}{3(r_2^2+r_1^2)}$
8.対称形断面 	$\frac{h_2}{2}≧y_1≧\frac{h_1}{2}$: $\tau=\frac{3Q}{2(b_2h_2^3-b_1h_1^3)}(h_2^2-4y_1^2)$ $\frac{h_1}{2}≧y_1$: $\tau=\frac{3Q}{2(b_2h_2^3-b_1h_1^3)}\left(\frac{b_2h_2^2-b_1h_1^2}{b_2-b_1}-4y_1^2\right)$	$\kappa=\frac{3(b_2h_2^2-b_1h_1^2)(b_2h_2-b_1h_1)}{2(b_2h_2^3-b_1h_1^3)(b_2-b_1)}$ $\tau_{max}=\frac{b_2h_2^2-b_1h_1^2}{(b_2h_2^3-b_1h_1^3)(b_2-b_1)}\frac{3Q}{2}$

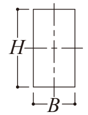
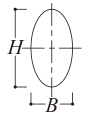
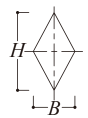
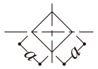
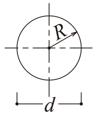
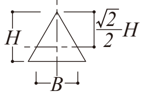
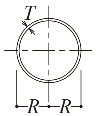
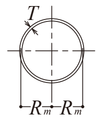
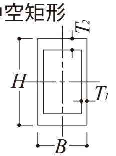
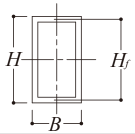
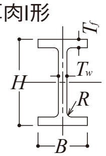
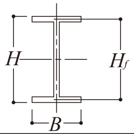
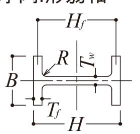
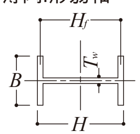
塑性断面係数



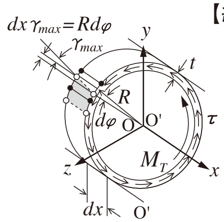
$$Z_p=\int_0^{c_1}B(y)y\,dy+\int_0^{c_2}B(y)y\,dy$$

$B(y)$:中立軸から距離 y だけ離れたところの断面幅

$c_1,\ c_2$:それぞれ中立軸から上下縁までの距離

断面形	塑性断面係数 Z_p	断面形	塑性断面係数 Z_p
矩形 	$B\cdot H^2/4$	楕円 	$B\cdot H^2/6$
菱形 	$B\cdot H^2/12$	斜正方形 	$\sqrt{2}\,a^3/6$
円 	$d^3/6,\ \frac{4}{3}R^3$	正三角形 	$\frac{2-\sqrt{2}}{6}B\cdot H^2$
中空円 	$\frac{4}{3}R^3\{1-(1-\frac{T}{R})^3\}$	薄肉中空円 	$4\cdot R_m{}^2\cdot T$
中空矩形 	$B\cdot T_2(H-T_2)+\frac{1}{2}(H-2T_2)^2T_1$	薄肉中空矩形 	$A_f\cdot H_f+\frac{1}{4}A_w\cdot H_f$ A_f：片側フランジプレートの断面積 A_w：ウェブプレートの全断面積
厚肉I形 	$B\cdot T_f(H-T_f)+\frac{1}{4}(H-2T_f)^2T_w+0.4292R^2(H-2T_f-0.4467R)$	薄肉I形 	$A_f\cdot H_f+\frac{1}{4}A_w\cdot H_f$ A_f：片側フランジの断面積 A_w：ウェブの全断面積
厚肉I形弱軸 	$\frac{1}{2}B^2\cdot T_f+\frac{1}{4}(H-2T_f)\cdot T_w{}^2+0.4292R^2(T_w+0.4467R)$	薄肉I形弱軸 	$\frac{1}{2}A_f\cdot B+\frac{1}{4}A_w\cdot T_w$ A_f：片側フランジの断面積 A_w：ウェブの全断面積

純ねじり・曲げねじりに関する断面の定数



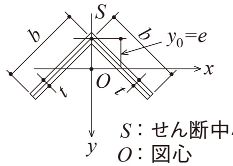
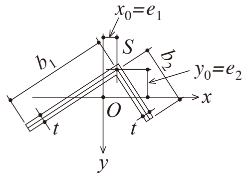
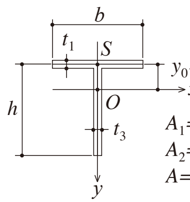
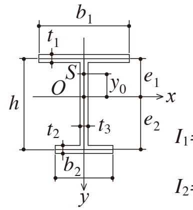
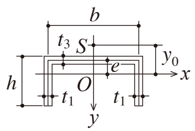
【純ねじり：反り拘束を無視した場合】

$$M_T=GJ\frac{d\varphi}{dx}\qquad \tau_{max}=M_T\frac{t}{J}$$

【曲げねじり：反り拘束を考慮した場合】

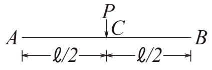
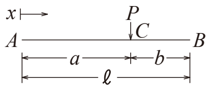
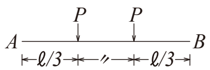
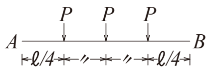
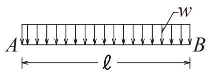
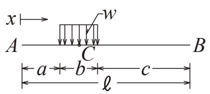
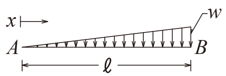
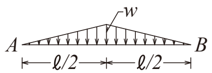
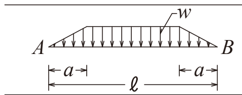
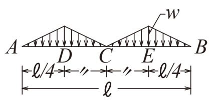
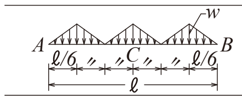
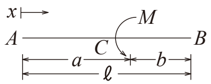
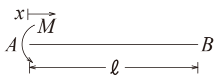
$$M_T=GJ\frac{d\varphi}{dx}-EI_W\frac{d^3\varphi}{dx^3}$$

O'：断面中心
t：板厚
M_T：ねじりモーメント
φ：ねじり角
τ_{max}：最大ねじりせん断応力度
GJ：ねじり剛性
J：サンブナンのねじり定数
G：せん断弾性係数
EI_W：曲げねじり剛性
I_W：曲げねじり定数
E：ヤング係数

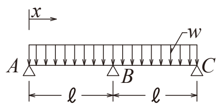
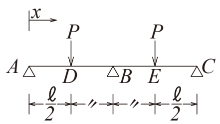
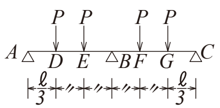
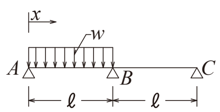
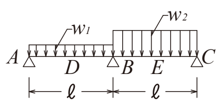
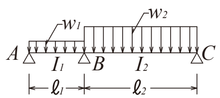
断面形	x_0	y_0	I_W	J
 S：せん断中心 O：図心	0	$-e=-\frac{\sqrt{2}}{4}b$	$\frac{(tb)^3}{18}$	$\frac{2}{3}bt^3$
	e_1	$-e_2$	$\frac{t^3}{36}(b_1{}^3+b_2{}^3)$	$\frac{t^3}{3}(b_1+b_2)$
 $A_1=t_1\cdot b$ $A_2=t_3\cdot h$ $A=A_1+A_2$	0	$-e=-\frac{t_3h^2}{2A}$	$\frac{(t_1b)^3}{144}+\frac{(t_3h)^3}{36}$	$\frac{1}{3}(bt_1{}^3+ht_3{}^3)$
 $I_1=\frac{t_1b_1{}^3}{12}$ $I_2=\frac{t_2b_2{}^3}{12}$	0	$-\frac{e_1I_1-e_2I_2}{I_1+I_2}$ $=-\left(e_1-\frac{t_2b_2{}^3}{t_1b_1{}^3+t_2b_2{}^3}h\right)$	$\frac{I_1I_2}{I_1+I_2}h^2$ $=\frac{h^2}{12}\cdot\frac{t_1b_1{}^3t_2b_2{}^3}{t_1b_1{}^3+t_2b_2{}^3}$	$\frac{b_1t_1{}^3+b_2t_2{}^3+ht_3{}^3}{3}$
 $I_1=t_1h\left(\frac{b}{2}\right)^2$ $I_3=\frac{t_3b^3}{12}$ $I_y=2I_1+I_3$	0	$-\left(e+\frac{I_1}{I_y}h\right)$ $=-\left(e+\frac{3t_1h^2}{6t_1h+t_3b}\right)$	$\frac{I_1{}^2+2I_1I_3}{I_1}\cdot\frac{h^2}{3}$ $=\frac{t_1h^3b^2}{12}\cdot\frac{3t_1h+2}{6t_1h+t_3b}$	$\frac{2ht_1{}^3+bt_3{}^3}{3}$

3-2. はりおよびラーメンの応力計算公式

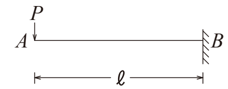
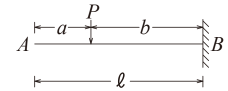
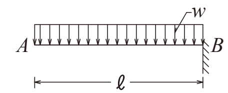
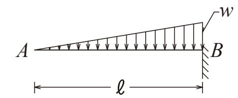
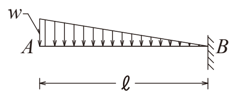
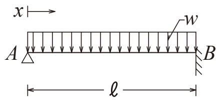
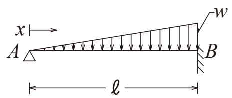
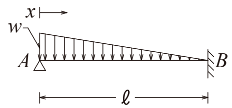
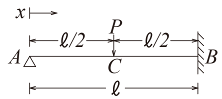
はりの応力計算公式

荷重形式	単純支持			両端固定		
	反力 R	曲げモーメント M_0	最大たわみ δ_{max}	反力 R	固定端モーメント C_A, C_B	最大たわみ δ_{max}
	$R_A=R_B=\frac{P}{2}$	$M_0=\frac{P\ell}{4}$	$\delta_{max}=\frac{P\ell^3}{48EI}$	$R_A=R_B=\frac{P}{2}$	$C_A=-C_B=-\frac{P\ell}{8}$	$\delta_{max}=\frac{P\ell^3}{192EI}$
	$R_A=\frac{Pb}{\ell}$ $R_B=\frac{Pa}{\ell}$	$M_C=\frac{Pab}{\ell}$	$\delta_{max}=\frac{Pb(\ell^2-b^2)^{3/2}}{9\sqrt{3}\,EI\ell}$ (a>b のとき $x=\sqrt{\frac{\ell^2-b^2}{3}}$) $\delta_c=\frac{Pa^2b^2}{3EI\ell}$	$R_A=\frac{Pb^2}{\ell^3}(3a+b)$ $R_B=\frac{Pa^2}{\ell^3}(3b+a)$	$C_A=-\frac{Pab^2}{\ell^2}$ $C_B=\frac{Pa^2b}{\ell^2}$	$\delta_{max}=\frac{2Pa^3b^2}{3EI(3a+b)^2}$ $(x=\frac{2a\ell}{3a+b})$
	$R_A=R_B=P$	$M_0=\frac{P\ell}{3}$	$\delta_{max}=\frac{23}{648}\frac{P\ell^3}{EI}$	$R_A=R_B=P$	$C_A=-C_B=-\frac{2P\ell}{9}$	$\delta_{max}=\frac{5}{648}\frac{P\ell^3}{EI}$
	$R_A=R_B=\frac{3P}{2}$	$M_0=\frac{P\ell}{2}$	$\delta_{max}=\frac{19}{384}\frac{P\ell^3}{EI}$	$R_A=R_B=\frac{3P}{2}$	$C_A=-C_B=-\frac{5P\ell}{16}$	$\delta_{max}=\frac{1}{96}\frac{P\ell^3}{EI}$
	$R_A=R_B=\frac{w\ell}{2}$	$M_0=\frac{w\ell^2}{8}$	$\delta_{max}=\frac{5}{384}\frac{w\ell^4}{EI}$	$R_A=R_B=\frac{w\ell}{2}$	$C_A=-C_B=-\frac{w\ell^2}{12}$	$\delta_{max}=\frac{1}{384}\frac{w\ell^4}{EI}$
	$R_A=wb\frac{2c+b}{2\ell}$ $R_B=wb\frac{2a+b}{2\ell}$	$M_{max}=R_A(a+\frac{R_A}{2w})$ $(x=a+R_A/w)$	$\delta_C=\frac{wb}{48EI\ell}\Big[\{(\ell+a-c)(\ell-a+c)$ $-\frac{b^2}{4}\}^2+\frac{b^3(2\ell-b)}{16}\Big]$	$R_A=\frac{wb}{2\ell^3}\{(b+2c)\ell^2$ $-(a-c)(2ac+bc+ab)\}$ $R_B=wb-R_A$	$C_A=-\frac{wb}{8\ell^2}\{(b+2c)^2(2a+b)$ $+\frac{1}{3}b^2(2\ell-6c-3b)\}$ $C_B=\frac{wb}{8\ell^2}\{(2a+b)^2(b+2c)$ $+\frac{1}{3}b^2(2\ell-6a-3b)\}$	$\delta_x=\frac{1}{6EI}\{3C_Ax^2-R_Ax^3+\frac{w}{4}(x-a)^4\}$
	$R_A=\frac{w\ell}{6}$ $R_B=\frac{w\ell}{3}$	$M_{max}=0.064\,w\ell^2$ $(x=0.577\ell)$	$\delta_{max}=0.00652\frac{w\ell^4}{EI}(x=0.519\ell)$	$R_A=\frac{3w\ell}{20}$ $R_B=\frac{7w\ell}{20}$	$C_A=-\frac{w\ell^2}{30}$, $C_B=\frac{w\ell^2}{20}$ $M_{max}=0.0215w\ell^2\ (x=0.548\ell)$	$\delta_{max}=0.00131\frac{w\ell^4}{EI}\ (x=0.525\ell)$
	$R_A=R_B=\frac{w\ell}{4}$	$M_0=\frac{w\ell^2}{12}$	$\delta_{max}=\frac{1}{120}\frac{w\ell^4}{EI}$	$R_A=R_B=\frac{w\ell}{4}$	$C_A=-C_B=-\frac{5w\ell^2}{96}$ $M_{max}=\frac{w\ell^2}{32}$	$\delta_{max}=\frac{7}{3840}\frac{w\ell^4}{EI}$
	$R_A=R_B=\frac{w(\ell-a)}{2}$	$M_0=\frac{w}{24}(3\ell^2-4a^2)$	$\delta_{max}=\frac{w}{1920EI}(5\ell^2-4a^2)^2$	$R_A=R_B=\frac{w(\ell-a)}{2}$	$C_A=-C_B=-\frac{w}{12}(\ell^2-2a^2+\frac{a^3}{\ell})$	$\delta_{max}=\frac{w}{1920EI}(5\ell^4-20\ell a^3+16a^4)$
	$R_A=R_B=\frac{w\ell}{4}$	$M_C=\frac{w\ell^2}{16}$ $M_{D,E}=\frac{5w\ell^2}{96}$	$\delta_{max}=\frac{7}{1024}\frac{w\ell^4}{EI}$	$R_A=R_B=\frac{w\ell}{4}$	$C_A=-C_B=-\frac{17}{384}w\ell^2$ $M_C=\frac{7}{384}w\ell^2$	$\delta_{max}=\frac{w\ell^4}{768EI}$
	$R_A=R_B=\frac{w\ell}{4}$	$M_C=\frac{7w\ell^2}{108}$	$\delta_{max}=\frac{259}{38880}\frac{w\ell^4}{EI}$	$R_A=R_B=\frac{w\ell}{4}$	$C_A=-C_B=-\frac{37}{864}w\ell^2$ $M_C=\frac{19}{864}w\ell^2$	$\delta_{max}=\frac{407}{311040}\frac{w\ell^4}{EI}$
	$R_A=-R_B=\frac{M}{\ell}$	a>bのとき $M_C=\frac{Ma}{\ell}$	a>bのとき $\delta_{max}=\frac{M(\ell^2-3b^2)^{3/2}}{9\sqrt{3}\,EI\ell}$ $(x=\sqrt{\frac{\ell^2-3b^2}{3}})$	$R_A=-R_B=\frac{6abM}{\ell^3}$	$C_A=-\frac{bM}{\ell^2}(2\ell-3b)$ $C_B=-\frac{aM}{\ell^2}(2\ell-3a)$	$\ell<3a$ のとき $\delta_{max}=\frac{b(2a-b)^3M}{54a^2EI}$ $x=\ell(2a-b)/3a$
	$R_A=-R_B=\frac{M}{\ell}$	$M_x=-M(1-\frac{x}{\ell})$	$\delta_{max}=\frac{M\ell^2}{9\sqrt{3}\,EI}$ $(x=(1-\frac{1}{\sqrt{3}})\ell)$	–	–	–

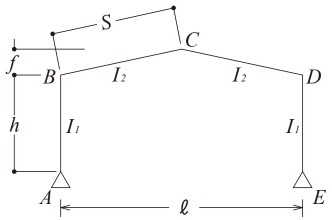
はりの応力計算公式

荷　重　形　式	反力 R	曲げモーメント M	最大たわみ δ_{max}
	$R_A=R_C=\frac{3}{8}w\ell$ $R_B=\frac{5}{4}w\ell$	$M_B=-\frac{1}{8}w\ell^2$ $M_D=\frac{9}{128}w\ell^2$ $(x=\frac{3}{8}\ell)$	$\delta_{max}=\frac{w\ell^4}{185EI}$ $(x=0.422\ell)$
	$R_A=\frac{5}{16}P$ $R_C=\frac{5}{16}P$ $R_B=\frac{11}{8}P$	$M_B=-\frac{3}{16}P\ell$ $M_D=M_E=\frac{5}{32}P\ell$	$\delta_{max}=\frac{P\ell^3}{48\sqrt{5}EI}$ $(x=\frac{1}{\sqrt{5}}\ell)$ $\delta_D=\delta_E=\frac{7P\ell^3}{768EI}$
	$R_A=R_C=\frac{2}{3}P$ $R_B=\frac{8}{3}P$	$M_B=-\frac{1}{3}P\ell$ $M_E=M_F=\frac{1}{9}P\ell$ $M_D=M_G=\frac{2}{9}P\ell$	$\delta_D=\delta_G=\frac{7P\ell^3}{486EI}$
	$R_A=\frac{7}{16}w\ell$ $R_C=-\frac{1}{16}w\ell$ $R_B=\frac{5}{8}w\ell$	$M_B=-\frac{1}{16}w\ell^2$ $M_D=\frac{49}{512}w\ell^2$ $(x=\frac{7}{16}\ell)$	$\delta_O=\frac{7w\ell^4}{768EI}$ $(x=\frac{1}{2}\ell)$
	$R_A=\frac{1}{16}(7w_1-w_2)\ell$ $R_C=\frac{1}{16}(7w_2-w_1)\ell$ $R_B=\frac{5}{8}(w_1+w_2)\ell$	$M_B=-\frac{1}{16}(w_1+w_2)\ell^2$	$\delta_D=\frac{1}{768EI}(7w_1-3w_2)\ell^4$ $\delta_E=\frac{1}{768EI}(7w_2-3w_1)\ell^4$
 $\alpha=\frac{I_2\ell_1}{I_1\ell_2}$	$W=w_1\ell_1+w_2\ell_2$ $R_B=W-R_A-R_C$ $R_A=\frac{w_1\ell_1}{2}-\frac{1}{8(1+\alpha)\ell_1}(\alpha w_1\ell_1^2+w_2\ell_2^2)$ $R_C=\frac{w_2\ell_2}{2}-\frac{1}{8(1+\alpha)\ell_2}(\alpha w_1\ell_1^2+w_2\ell_2^2)$	$M_B=-\frac{1}{8(1+\alpha)}(\alpha w_1\ell_1^2+w_2\ell_2^2)$	$\delta_O=\frac{5w_2\ell_2^4}{384EI_2}-\frac{M_B\ell_2^2}{16EI_2}$ (BCばり中央部)

片持ちはりの応力計算公式

荷　重　形　式	反力 R	曲げモーメント M	最大たわみ δ_{max}
	$R_B=P$	$M_B=-P\ell$	$\delta_A=\frac{1}{3}\frac{P\ell^3}{EI}$
	$R_B=P$	$M_B=-Pb$	$\delta_A=\frac{1}{6}\frac{P}{EI}(3b^2\ell-b^3)$
	$R_B=w\ell$	$M_B=-\frac{1}{2}w\ell^2$	$\delta_A=\frac{1}{8}\frac{w\ell^4}{EI}$
	$R_B=\frac{w\ell}{2}$	$M_B=-\frac{1}{6}w\ell^2$	$\delta_A=\frac{1}{30}\frac{w\ell^4}{EI}$
	$R_B=\frac{w\ell}{2}$	$M_B=-\frac{1}{3}w\ell^2$	$\delta_A=\frac{11}{120}\frac{w\ell^4}{EI}$
	$R_B=0$	$M_B=M$	$\delta_A=-\frac{1}{2}\frac{M\ell^2}{EI}$
	$R_A=\frac{3}{8}w\ell$ $R_B=\frac{5}{8}w\ell$	$M_{max}=\frac{9}{128}w\ell^2$ $(x=\frac{3}{8}\ell)$ $M_B=-\frac{1}{8}w\ell^2$	$\delta_{max}=0.00541\frac{w\ell^4}{EI}$ $(x=0.4215\ell)$
	$R_A=\frac{1}{10}w\ell$ $R_B=\frac{2}{5}w\ell$	$M_{max}=0.0298\ w\ell^2$ $(x=0.4474\ell)$ $M_B=-\frac{1}{15}w\ell^2$	$\delta_{max}=0.002385\frac{w\ell^4}{EI}$ $(x=0.4472\ell)$
	$R_A=\frac{11}{40}w\ell$ $R_B=\frac{9}{40}w\ell$	$M_{max}=0.0423\ w\ell^2$ $(x=0.329\ell)$ $M_B=-\frac{7}{120}w\ell^2$	$\delta_{max}=0.003045\frac{w\ell^4}{EI}$ $(x=0.402\ell)$
	$R_A=-R_B=\frac{3}{2}\frac{M}{\ell}$	$M_{max}=M$ $M_B=-\frac{1}{2}M$	$\delta_{max}=\frac{1}{27}\frac{M\ell^2}{EI}$ $(x=\frac{1}{3}\ell)$
	$R_A=\frac{5}{16}P$ $R_B=\frac{11}{16}P$	$M_C=\frac{5}{32}P\ell$ $M_B=-\frac{3}{16}P\ell$	$\delta_{max}=0.00932\frac{P\ell^3}{EI}$ $(x=0.4472\ell)$

柱脚ピン対称山形ラーメン

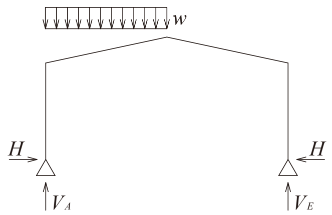
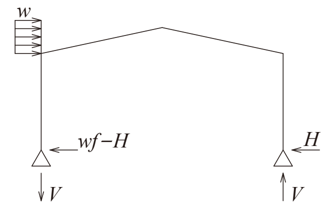
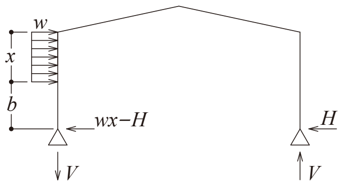
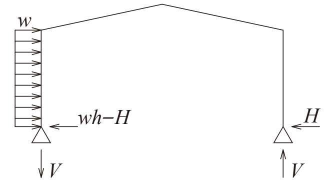


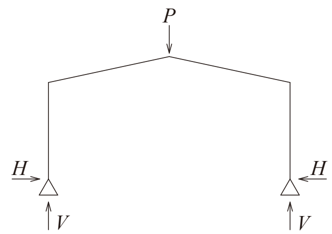
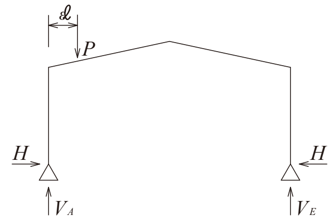
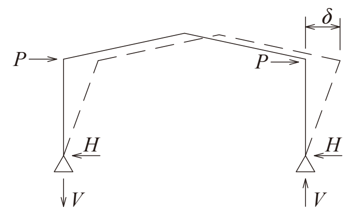
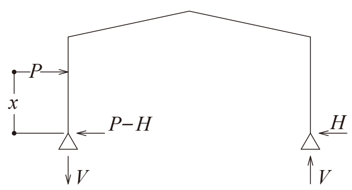
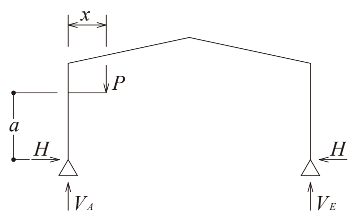
$K_1=\dfrac{I_1}{h}$

$K_2=\dfrac{I_2}{S}$

$k=\dfrac{K_2}{K_1}$

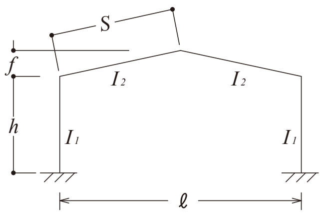
$\alpha=h^2(k+3)+f(3h+f)$

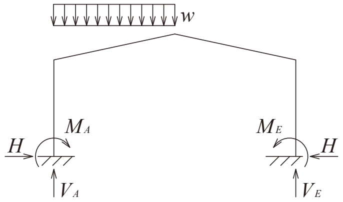
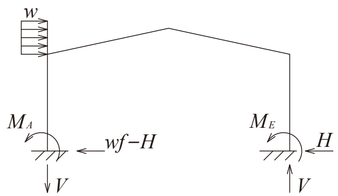
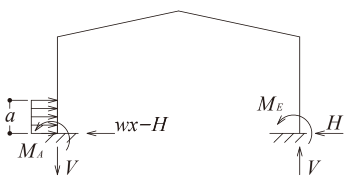
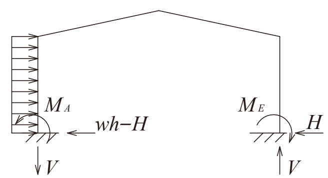
荷重状態	反力
	$V_A=\dfrac{3}{8}w\ell$ $V_E=\dfrac{1}{8}w\ell$ $H=\dfrac{w\ell^2}{64}\,\dfrac{8h+5f}{\alpha}$
	$V=\dfrac{wf}{\ell}\left(h+\dfrac{f}{2}\right)$ $H=\dfrac{wf}{16}\,\dfrac{8h^2(k+3)+5f(4h+f)}{\alpha}$
	$V=wx\dfrac{\left(h-\dfrac{x}{2}\right)}{\ell}$ $H=\dfrac{wx(h+b)}{16h}\,\dfrac{k(5h^2-b^2)+6h(2h+f)}{\alpha}$
	$V=\dfrac{wh^2}{2\ell}$ $H=\dfrac{wh^2}{16}\,\dfrac{5kh+6(2h+f)}{\alpha}$

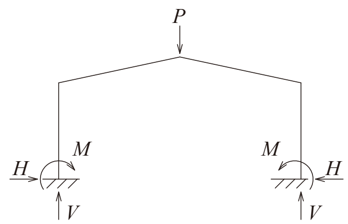
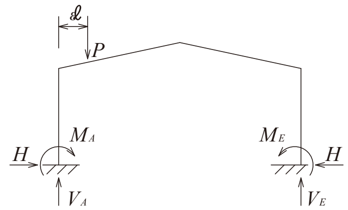
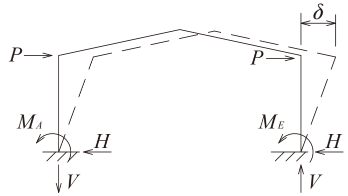
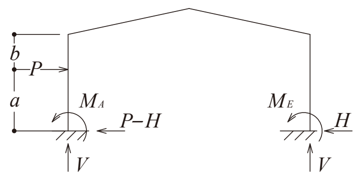
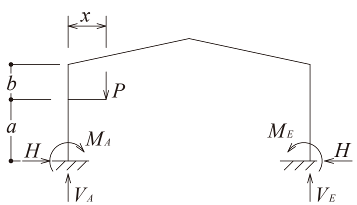
荷重状態	反力
	$V=\dfrac{P}{2}$ $H=\dfrac{P\ell}{8}\,\dfrac{3h+2f}{\alpha}$
	$V_A=(1-\varepsilon)P$ $V_E=\varepsilon P$ $H=\dfrac{P\ell}{4}\cdot\varepsilon\,\dfrac{6h(1-\varepsilon)+f(3-4\varepsilon^2)}{\alpha}$
	$V=\dfrac{2Ph}{\ell}$ $\delta=\dfrac{Ph^2}{12EK_1}\,\dfrac{4(k+1)}{k}$ $H=P$
	$V=\dfrac{Px}{\ell}$ $H=\dfrac{Px}{4}\,\dfrac{k\left(3h-\dfrac{x^2}{h}\right)+3(2h+f)}{\alpha}$
	$V_A=P\,\dfrac{\ell-x}{\ell}$ $V_E=\dfrac{Px}{\ell}$ $H=\dfrac{3Px}{4h}\,\dfrac{k(h^2-a^2)+h(2h+f)}{\alpha}$

3 力学

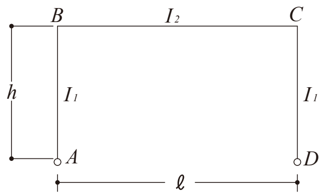
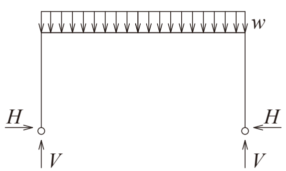
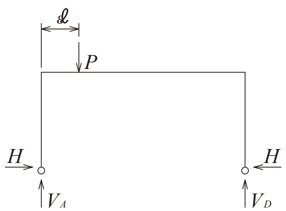
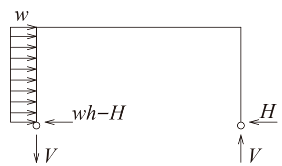
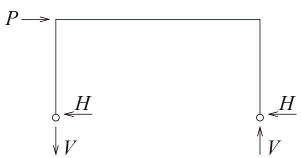
柱脚固定対称山形ラーメン

	$K_1=\frac{I_1}{h}$ $K_2=\frac{I_2}{S}$ $k=\frac{K_2}{K_1}$ $\beta=(kh+f)^2+4k(h^2+hf+f^2)$

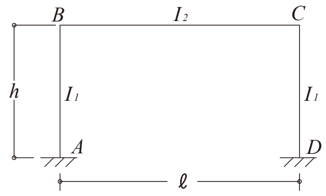
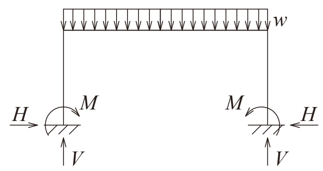
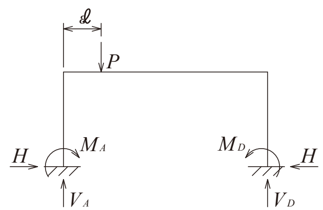
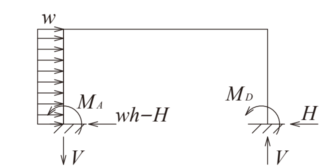
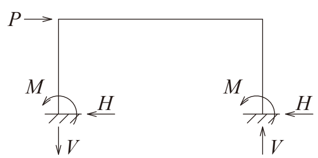
荷　重　状　態	反　　　力
	$V_E=\frac{w\ell}{32}\frac{3(4k+1)}{3k+1}$　　$V_A=\frac{w\ell}{2}-V_E$ $H=\frac{w\ell^2}{16}\frac{k(4h+5f)+f}{\beta}$ $M_A=\frac{w\ell^2}{96}\{\frac{kh(8h+15f)+f(6h-f)}{\beta}-\frac{3}{2(3k+1)}\}$ $M_E=\frac{w\ell^2}{96}\{\frac{kh(8h+15f)+f(6h-f)}{\beta}+\frac{3}{2(3k+1)}\}$
	$V=\frac{wf}{8}\frac{12k(h+f)+5f}{\ell(3k+1)}$ $H=\frac{wf}{4}\frac{2kh^2(k+4)+10khf+f^2(5k+1)}{\beta}$ $M_A=\frac{wf}{24}[\frac{12h(3k+2)+3f}{6k+2}+\frac{f\{kh(4h+9f)+f(6h+f)\}}{\beta}]$ $M_E=\frac{wf}{24}[\frac{12h(3k+2)+3f}{6k+2}-\frac{f\{kh(4h+9f)+f(6h+f)\}}{\beta}]$
	$V=\frac{wa^3}{2\ell h}\frac{k}{3k+1}$ $H=\frac{wa^3k}{4h}\frac{2h(k+2)+2f-a(k+1)}{\beta}$ $M_A=\frac{wa^2}{24h}\{-\frac{2h^2k(12h+3hk-4ak-12a+18f)}{\beta}$ $-\frac{3a^2k(kh+2h+f)+8fk(3hf-af-3ha)+6hf^2}{\beta}-\frac{6h+6k(3h-a)}{3k+1}\}$ $M_E=\frac{wa^2}{24h}\{-\frac{2h^2k(12h+3hk-4ak-12a+18f)}{\beta}$ $-\frac{3a^2k(kh+2h+f)+8fk(3hf-af-3ha)+6hf^2}{\beta}+\frac{6h+6k(3h-a)}{3k+1}\}$
	$V=\frac{wh^2}{2\ell}\frac{k}{3k+1}$ $H=\frac{wh^2}{4}\frac{k\{h(k+3)+2f\}}{\beta}$ $M_A=\frac{wh^2}{24}\{\frac{12k+6}{3k+1}+\frac{kh^2(k+6)+kf(15h+16f)+6f^2}{\beta}\}$ $M_E=\frac{wh^2}{24}\{\frac{12k+6}{3k+1}-\frac{kh^2(k+6)+kf(15h+16f)+6f^2}{\beta}\}$

荷　重　状　態	反　　　力
	$V=\frac{P}{2}$ $H=\frac{P\ell}{4}\frac{k(3h+4f)+f}{\beta}$ $M=\frac{P\ell}{4}\frac{kh^2+hf(2k+1)}{\beta}$
	$V_A=P(1-\varepsilon)\frac{3k+(1-\varepsilon)(1+2\varepsilon)}{3k+1}$ $V_E=P\varepsilon\frac{3k+\varepsilon(3-2\varepsilon)}{3k+1}$ $H=P\frac{\varepsilon\ell}{\beta}\{3k(h+f)-4\varepsilon^2(k+1)f-3\varepsilon(kh-f)\}$ $M_A=\frac{P\varepsilon\ell}{2}[\frac{1}{\beta}\{2k(1-\varepsilon)h^2+3(2\varepsilon+k)hf-(1-4\varepsilon)f^2$ $-4\varepsilon^2(k+2)hf-4\varepsilon^2f^2\}-\frac{(1-\varepsilon)(1-2\varepsilon)}{3k+1}]$ $M_E=\frac{P\varepsilon\ell}{2}[\frac{1}{\beta}\{2k(1-\varepsilon)h^2+3(2\varepsilon+k)hf-(1-4\varepsilon)f^2$ $-4\varepsilon^2(k+2)hf-4\varepsilon^2f^2\}+\frac{(1-\varepsilon)(1-2\varepsilon)}{3k+1}]$
	$V=\frac{Ph}{\ell}\frac{3k}{3k+1}$,　$H=P$ $M_A(M_E)=\frac{Ph}{2}\frac{3k+2}{3k+1}$,　$M_B(M_D)=\frac{Ph}{2}\frac{3k}{3k+1}$ $\delta=\frac{Ph^2}{12EK_1}\frac{3k+4}{3k+1}$
	$V_E=\frac{3Pa^2}{2h\ell}\frac{k}{3k+1}$,　$H=\frac{Pa^2k}{2h}\frac{3h(k+2)+3f-2a(k+1)}{\beta}$ $M_A=\frac{Pa}{2h}\{-\frac{h^2k(4h+hk-2ak-6a+6f)+a^2k(hk+2h+f)}{\beta}$ $\frac{+2fk(2hf-af-3ah)+hf^2}{\beta}-\frac{2h+3k(2h-a)}{6k+2}\}$ $M_E=\frac{Pa}{2h}\{-\frac{h^2k(4h+hk-2ak-6a+6f)+a^2k(hk+2h+f)}{\beta}$ $\frac{+2fk(2hf-af-3ah)+hf^2}{\beta}+\frac{2h+3k(2h-a)}{6k+2}\}$
	$V_E=\frac{3Pxk}{h\ell}\frac{a}{3k+1}$,　$V_A=P-V_E$,　$H=\frac{3Pxk}{h}\frac{a\{h+f+b(k+1)\}}{\beta}$ $M_A=\frac{Px}{2h}\{\frac{h^2k(2bk+2h+3f)-bfk(6h+3b+4f)}{\beta}$ $\frac{-h(3b^2k^2+6b^2k+f^2)}{\beta}-\frac{3bk+h}{3k+1}\}$ $M_E=\frac{Px}{2h}\{\frac{h^2k(2bk+2h+3f)-bfk(6h+3b+4f)}{\beta}$ $\frac{-h(3b^2k^2+6b^2k+f^2)}{\beta}+\frac{3bk+h}{3k+1}\}$

柱脚ピン門形ラーメン

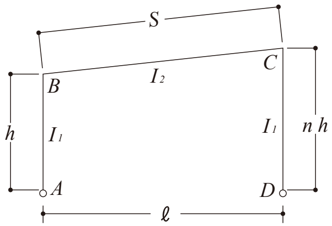
	$K_1=\dfrac{I_1}{h}$ $K_2=\dfrac{I_2}{\ell}$ $k=\dfrac{K_2}{K_1}$
荷　重　状　態	**反　　　　力**
	$V=\dfrac{w\ell}{2}$ $H=\dfrac{w\ell^2}{4h}\ \dfrac{1}{2k+3}$
	$V_A=(1-\varepsilon)P$ $V_D=\varepsilon P$ $H=\dfrac{3P\ell}{2h}\ \dfrac{\varepsilon(1-\varepsilon)}{2k+3}$ $\varepsilon=\dfrac{1}{2}$ のとき　$V_A=V_D=\dfrac{P}{2}$ $H=\dfrac{3P\ell}{8h}\ \dfrac{1}{2k+3}$
	$V=\dfrac{wh^2}{2\ell}$ $H=wh\ \dfrac{5k+6}{8(2k+3)}$
	$V=\dfrac{Ph}{\ell}$ $H=\dfrac{P}{2}$

柱脚固定門形ラーメン

	$K_1=\dfrac{I_1}{h}$ $K_2=\dfrac{I_2}{\ell}$ $k=\dfrac{K_2}{K_1}$
荷　重　状　態	**反　　　　力**
	$V=\dfrac{w\ell}{2}$ $H=\dfrac{w\ell^2}{4h}\ \dfrac{1}{k+2}$ $M=\dfrac{w\ell^2}{12}\ \dfrac{1}{k+2}$
	$V_A=P(1-\varepsilon)\ \dfrac{6k+1+\varepsilon(1-2\varepsilon)}{6k+1}$ $V_D=P-V_A$ $H=\dfrac{3P\ell}{2h}\ \dfrac{\varepsilon(1-\varepsilon)}{k+2}$ $M_A=\dfrac{P\ell}{2}\ \varepsilon(1-\varepsilon)\ \dfrac{5k-1+2\varepsilon(k+2)}{(k+2)(6k+1)}$ $M_D=\dfrac{P\ell}{2}\ \varepsilon(1-\varepsilon)\ \dfrac{7k+3-2\varepsilon(k+2)}{(k+2)(6k+1)}$
	$V=\dfrac{wh^2}{\ell}\ \dfrac{k}{6k+1}$ $H=\dfrac{wh}{8}\ \dfrac{2k+3}{k+2}$ $M_A=\dfrac{wh^2}{24}\left(12-\dfrac{5k+9}{k+2}-\dfrac{12k}{6k+1}\right)$ $M_D=\dfrac{wh^2}{24}\left(\dfrac{5k+9}{k+2}-\dfrac{12k}{6k+1}\right)$
	$V=\dfrac{Ph}{\ell}\ \dfrac{3k}{6k+1}$ $H=\dfrac{P}{2}$ $M_A=\dfrac{Ph}{2}\ \dfrac{3k+1}{6k+1}$

3 力学

柱脚ピン片流れ門形ラーメン

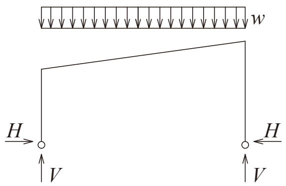
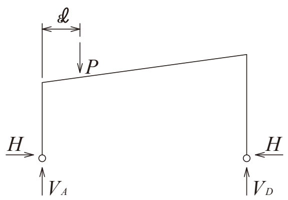
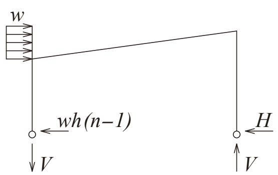
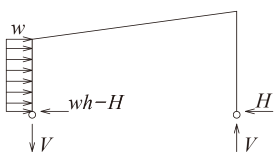
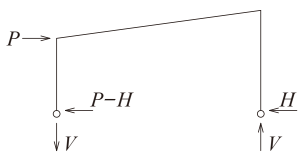


$K_1 = \frac{I_1}{h}$

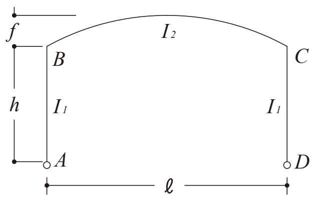
$K_2 = \frac{I_2}{S}$

$k = \frac{K_2}{K_1}$

$\gamma = 1+n+n^2+(1+n^3)k$

荷重状態	反力
	$V = \frac{w\ell}{2}$ $H = \frac{w\ell^2}{8h}\,\frac{1+n}{\gamma}$
	$V_A = (1-\varepsilon)P$ $V_D = \varepsilon P$ $H = \frac{P\ell\varepsilon(1-\varepsilon)}{2h}\,\frac{2+n+\varepsilon(n-1)}{\gamma}$ $\varepsilon = \frac{1}{2}$ のとき $V_A = V_D = \frac{P}{2}$ $H = \frac{3P\ell}{16h}\,\frac{n+1}{\gamma}$
	$V = \frac{wh^2}{2\ell}(n^2-1)$ $H = \frac{wh(n-1)}{8}\,\frac{8k+7+n(n+4)}{\gamma}$
	$V = \frac{wh^2}{2\ell}$ $H = \frac{wh}{8}\,\frac{5k+2(n+2)}{\gamma}$
	$V = \frac{Ph}{\ell}$ $H = \frac{P}{2}\,\frac{2k+n+2}{\gamma}$

柱脚ピンアーチ形ラーメン

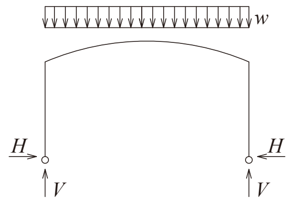
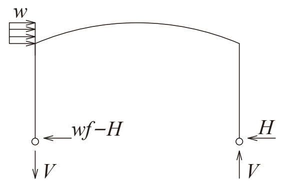
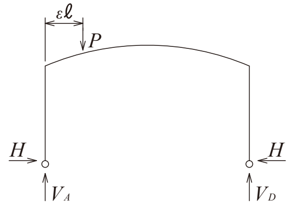
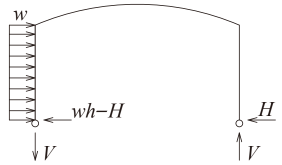
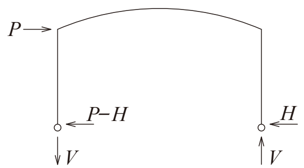


$K_1 = \frac{I_1}{h}$

$K_2 = \frac{I_2}{\ell}$

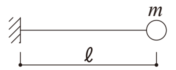
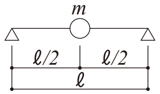
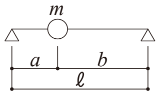
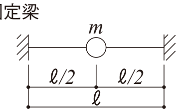
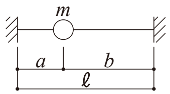
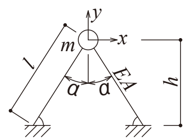
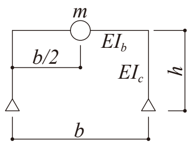
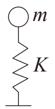
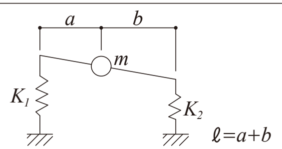
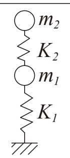
$k = \frac{K_2}{K_1}$

$\delta = 5h^2(2k+3)+4f(5h+2f)$

荷重状態	反力
	$V = \frac{w\ell}{2}$ $H = \frac{w\ell^2}{4}\,\frac{5h+4f}{\delta}$
	$V = \frac{wf}{2\ell}(2h+f)$ $H = \frac{wf}{14}\,\frac{35h^2(2k+3)+16f(7h+2f)}{\delta}$
	$V_A = (1-\varepsilon)P$ $V_D = \varepsilon P$ $H = \frac{5P\ell}{2}\,\frac{3h+2f\{\varepsilon(1-\varepsilon)+1\}}{\delta}\,\varepsilon(1-\varepsilon)$
	$V = \frac{wh^2}{2\ell}$ $H = \frac{5wh^2}{8}\,\frac{h(5k+6)+4f}{\delta}$
	$V = \frac{Ph}{\ell}$ $H = \frac{5Ph}{2}\,\frac{h(2k+3)+2f}{\delta}$

3 力学

3-3. 各種構造物固有円振動数

片持梁 	$K=3EI/\ell^3$　　$\omega_n=\sqrt{\dfrac{3EI}{m\ell^3}}$ はりの質量 m_b を考えるとき　$\omega_n'=\sqrt{\dfrac{3EI}{(m+0.23m_b)\ell^3}}$
単純梁 	$K=48EI/\ell^3$　　$\omega_n=4\times\sqrt{\dfrac{3EI}{m\ell^3}}$ はりの質量 m_b を考えるとき　$\omega_n'=\sqrt{\dfrac{48EI}{(m+0.5m_b)\ell^3}}$
	$K=\dfrac{3EI\ell}{(ab)^2}$　　$\omega_n=\dfrac{1}{ab}\times\sqrt{\dfrac{3EI\ell}{m}}$
両端固定梁 	$K=\dfrac{192EI}{\ell^3}$　　$\omega_n=8\times\sqrt{\dfrac{3EI}{m\ell^3}}$ はりの質量 m_b を考えるとき　$\omega_n'=14\times\sqrt{\dfrac{EI}{(m+0.375m_b)\ell^3}}$
	$K=\dfrac{3EI\ell^3}{(ab)^3}$　　$\omega_n=\sqrt{\dfrac{3EI\ell^3}{a^3b^3m}}$
	$K_x=\dfrac{2EA}{\ell}\sin^2\alpha$　　$\omega_{nx}=\sqrt{\dfrac{K_x}{m}}$ $K_y=\dfrac{2EA}{\ell}\cos^2\alpha$　　$\omega_{ny}=\sqrt{\dfrac{K_y}{m}}$
	$K_x=\dfrac{bEI_c}{h^3}\times\dfrac{1}{1+\dfrac{I_cb}{2I_bh}}$　　$\omega_{nx}=\sqrt{\dfrac{K_x}{m}}$ $K_y=\dfrac{192EI_b}{h^3}\times\dfrac{1+\dfrac{2I_bb}{3I_cb}}{1+\dfrac{8I_bh}{3I_cb}}$　　$\omega_{ny}=\sqrt{\dfrac{K_y}{m}}$
	$\omega_n=\sqrt{\dfrac{K}{m}}$ ばねの質量 m' を考えるとき　$\omega_n'=\sqrt{\dfrac{K}{(m+m'/3)}}$
	$\omega_n=\sqrt{\dfrac{K_n}{m}}$　　$\dfrac{1}{K_n}=\dfrac{1}{K_1}\left(\dfrac{b}{\ell}\right)^2+\dfrac{1}{K_2}\left(\dfrac{b}{\ell}\right)^2$
	$\omega_n^2=\dfrac{1}{2}\left[\dfrac{K_1}{m_1}+\dfrac{K_2}{m_2}\left(1+\dfrac{m_2}{m_1}\right)\pm\sqrt{\left\{\dfrac{K_1}{m_1}+\dfrac{K_2}{m_2}\left(1+\dfrac{m_2}{m_1}\right)\right\}^2-\dfrac{4K_1K_2}{m_1m_2}}\right]$

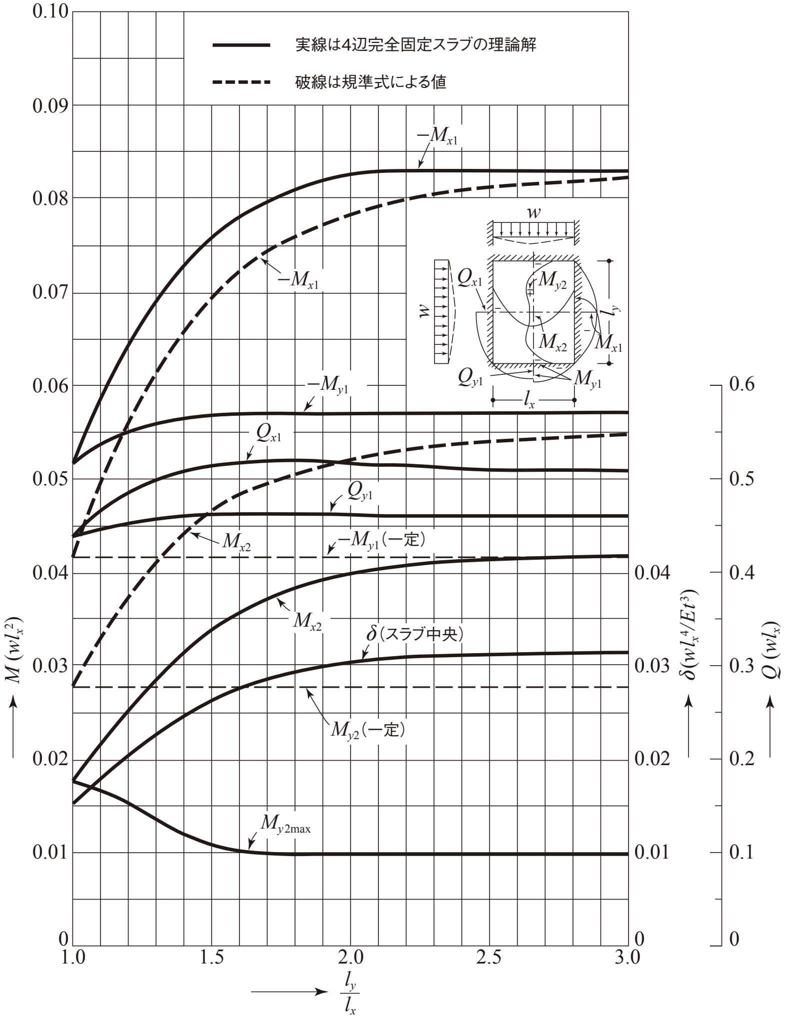
K：ばね定数　m：質量　ω_n：固有振動数　EI：曲げ剛性

3-4. 長方形スラブ算定図

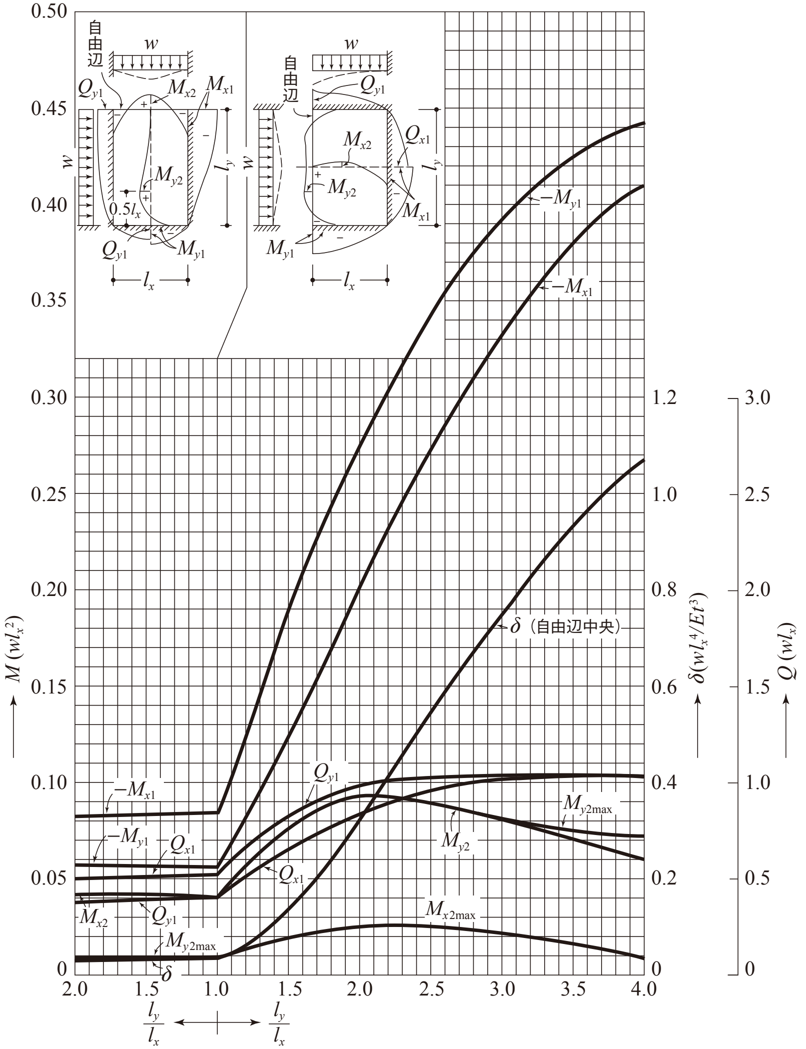
長方形スラブの応力とたわみ

等分布荷重時4辺固定スラブの応力図と中央点のたわみ（ν=0）

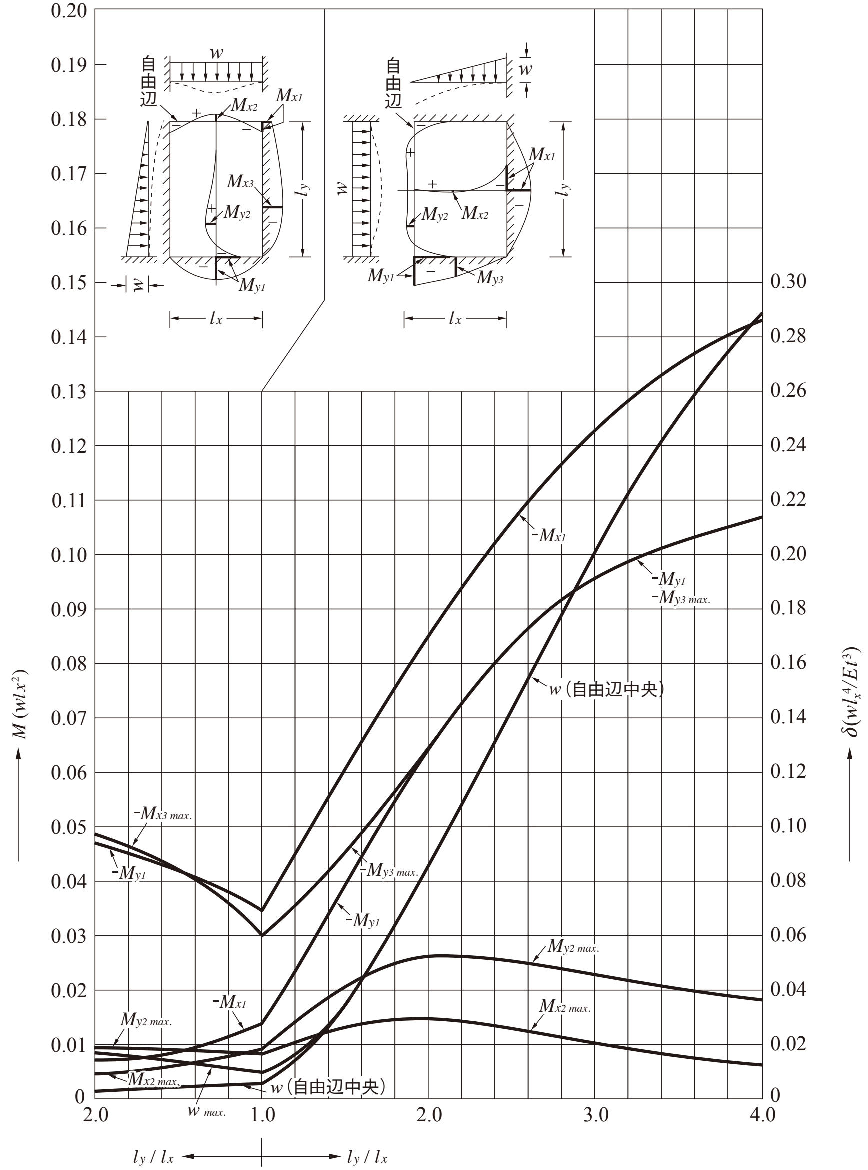
（E：コンクリートのヤング係数　t：スラブ厚）



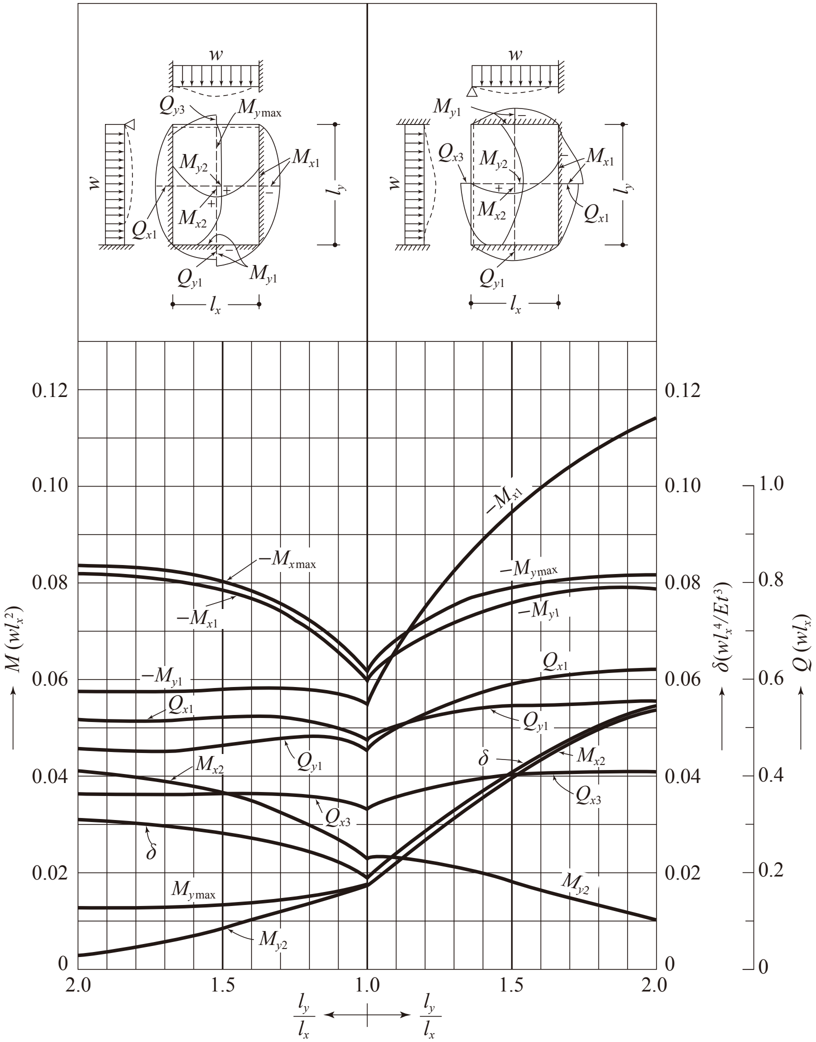
等分布荷重時3辺固定1辺自由スラブの応力図と自由辺中央点のたわみ（ν=0）



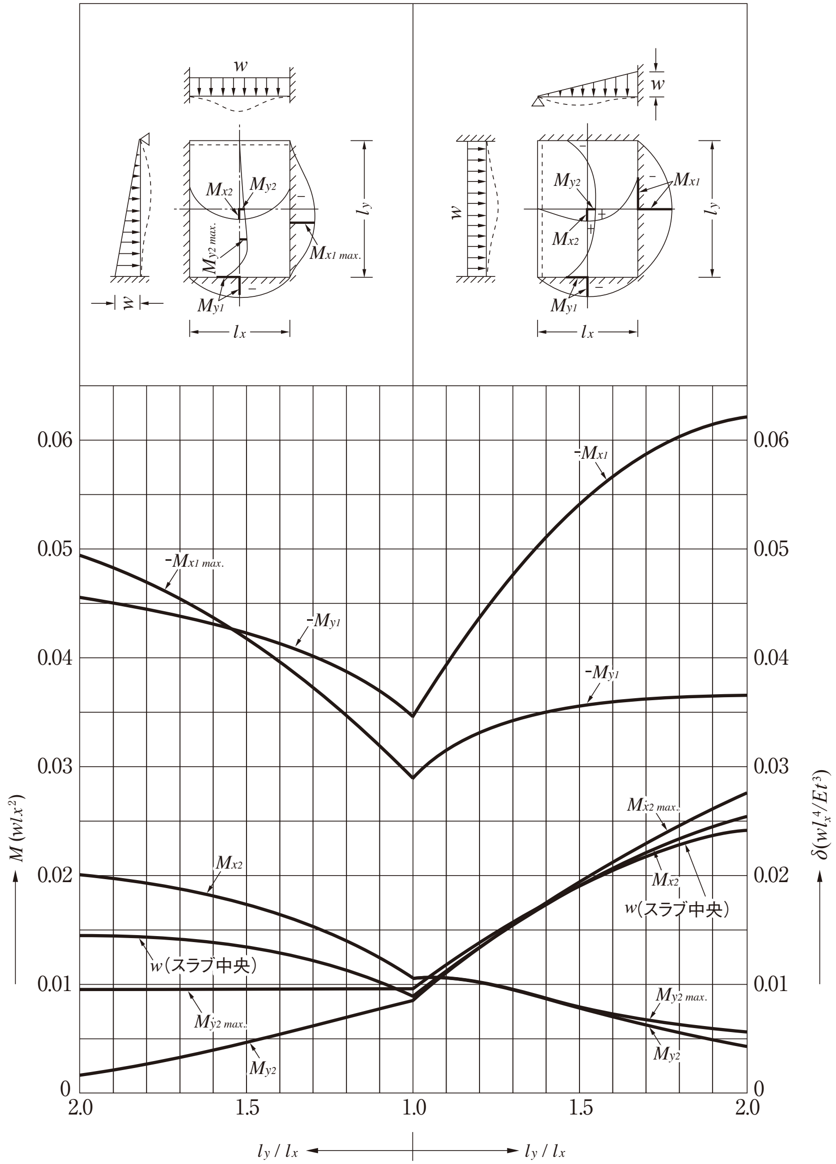
等変分布荷重時3辺固定、1辺自由スラブの応力図とたわみ（ν=0）



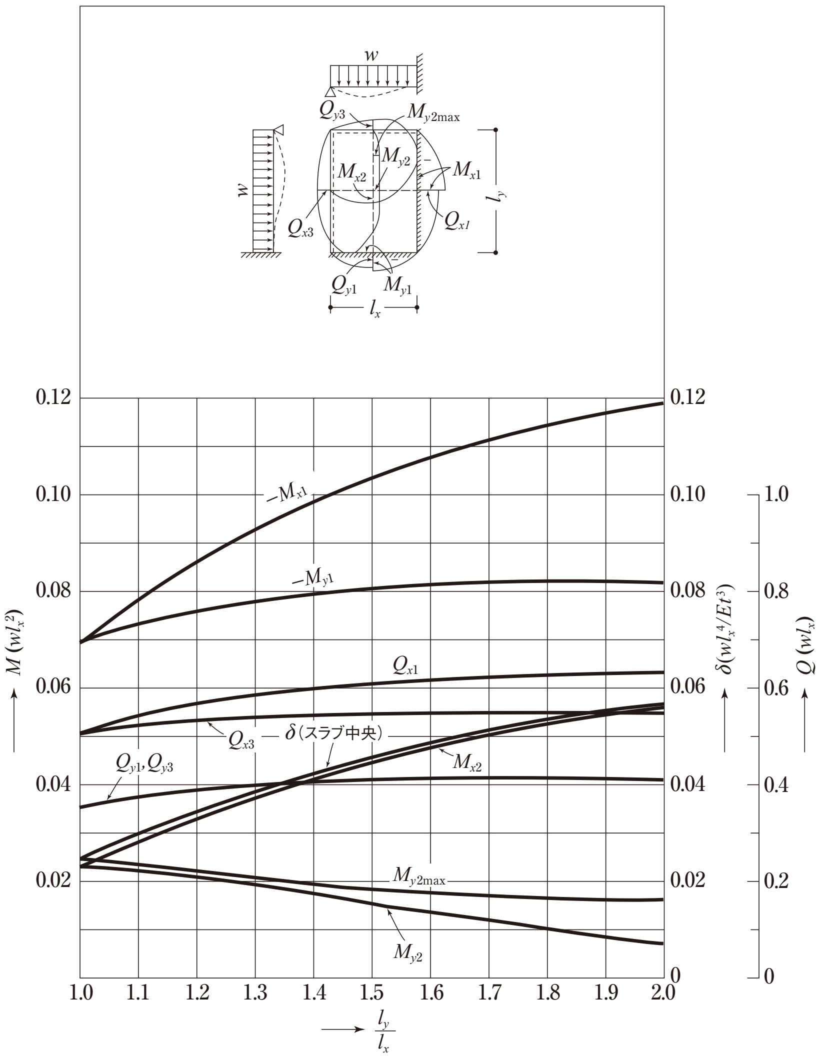
等分布荷重時3辺固定1辺単純支持スラブの応力図と中央点のたわみ（v=0）



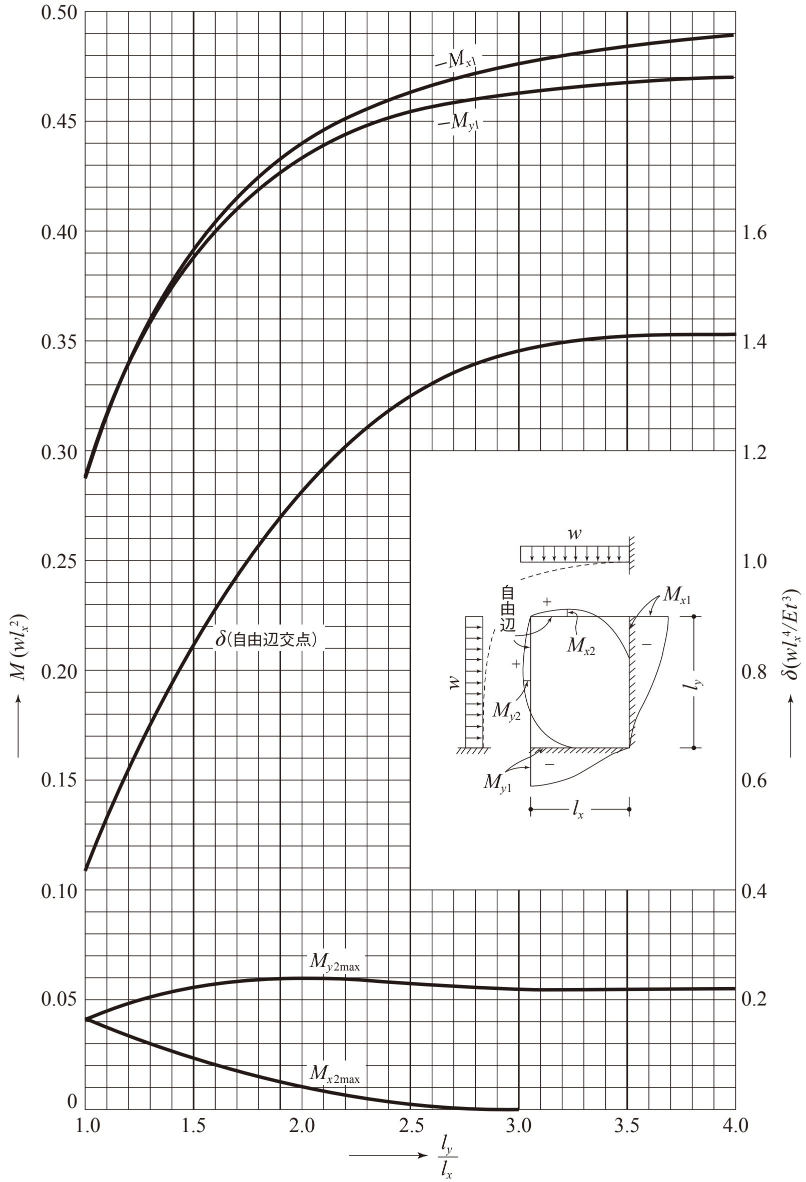
等変分布荷重時3辺固定、1辺単純支持スラブの応力図と中央点のたわみ（v=0）



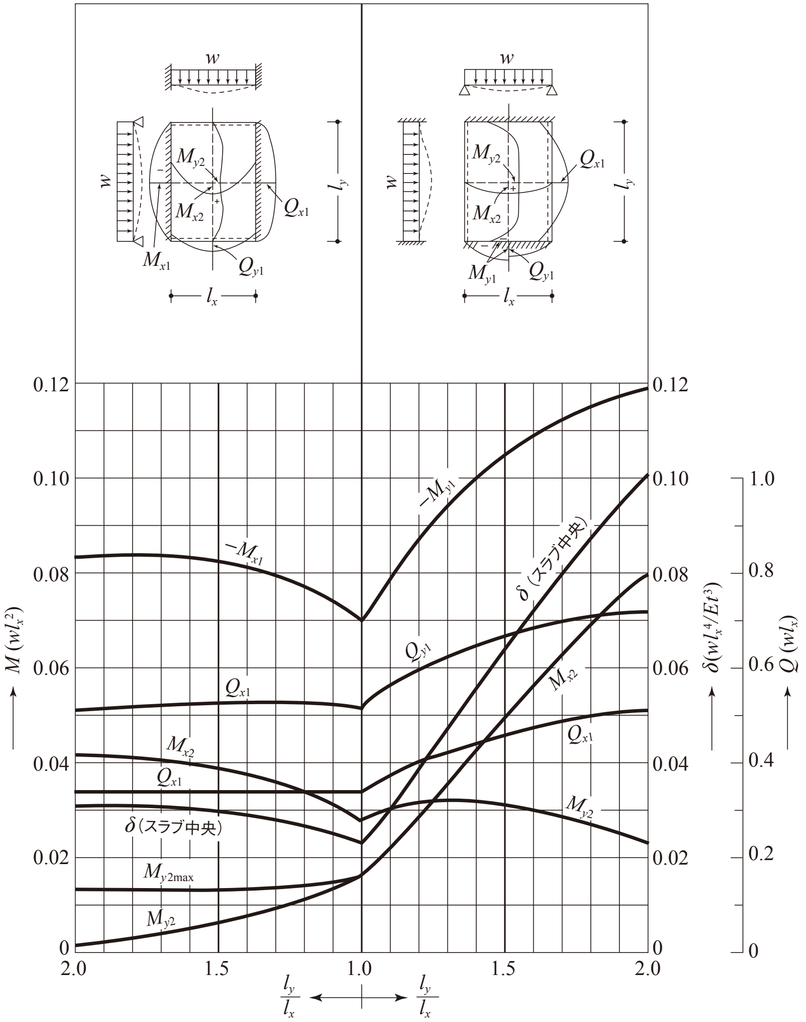
等分布荷重時2隣辺固定2辺単純支持スラブの応力図と中央点のたわみ（v=0）



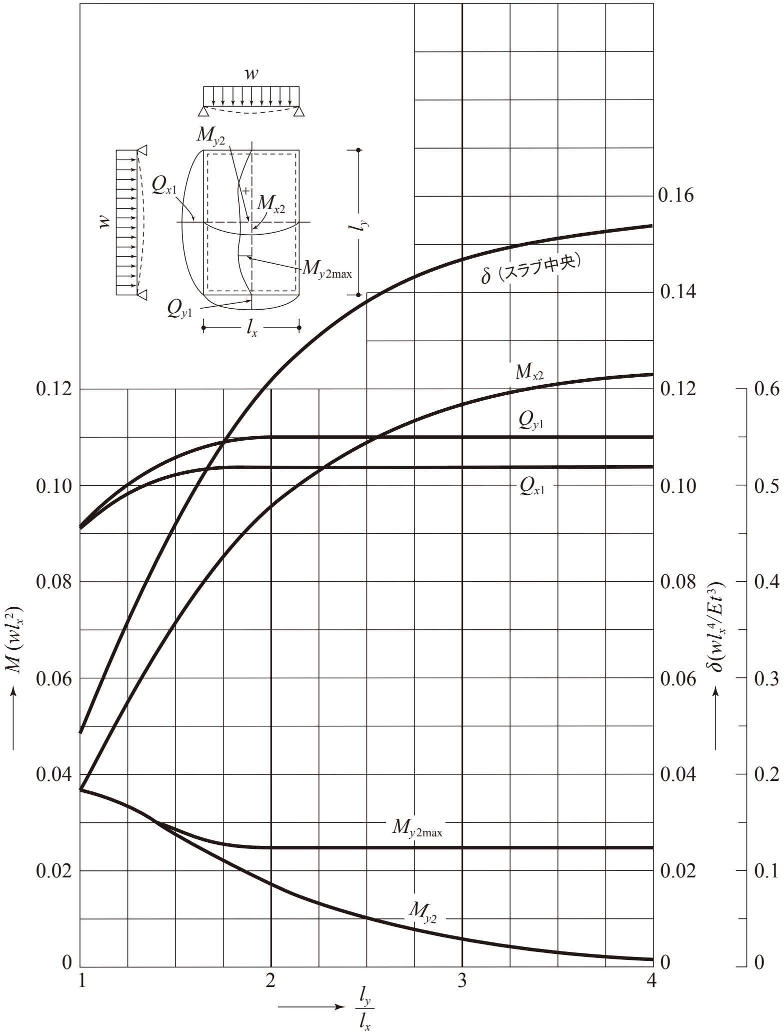
等分布荷重時2隣辺固定他辺自由スラブの応力図と自由辺交点のたわみ（v=0）



等分布荷重時2対辺固定他辺単純支持スラブの応力図と中央点のたわみ（ν=0）

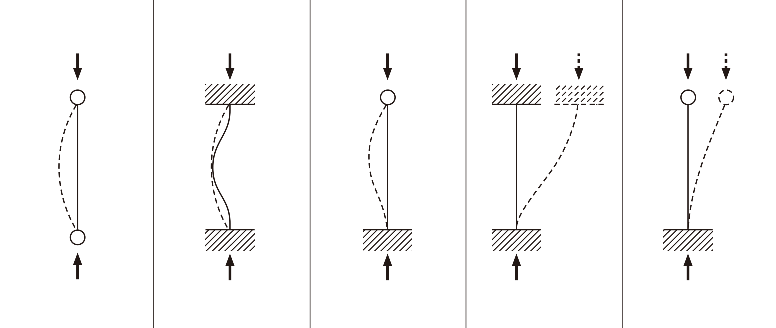


等分布荷重時4辺単純支持スラブの応力図と中央点のたわみ（ν=0）



3-5. 座屈長さ

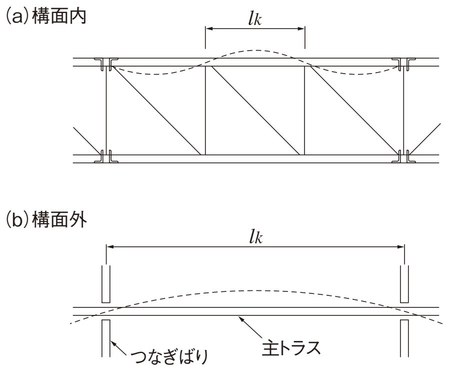
単純な支持条件をもつ材の座屈長さ(l_k)

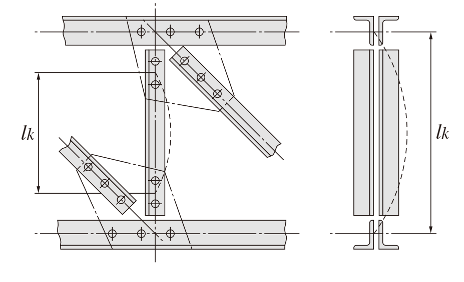
移動に対する条件		拘束			自由	
回転に対する条件		両端自由	両端拘束	1端自由 他端拘束	両端拘束	1端自由 他端拘束
座屈形						
l_k	理論値	l	$0.5l$	$0.7l$	l	$2l$
	推奨値	l	$0.65l$	$0.8l$	$1.2l$	$2.1l$

注) l:材長

トラス部材の座屈長さ(l_k)

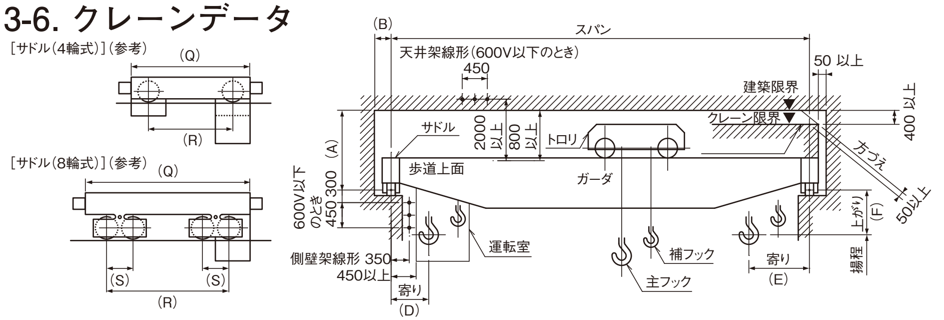
弦材の座屈長さ	ウェブ材の座屈長さ





(a)構面内　(b)構面外

3-6. クレーンデータ



建築限界および各種寸法(JIS B 8801-1974)

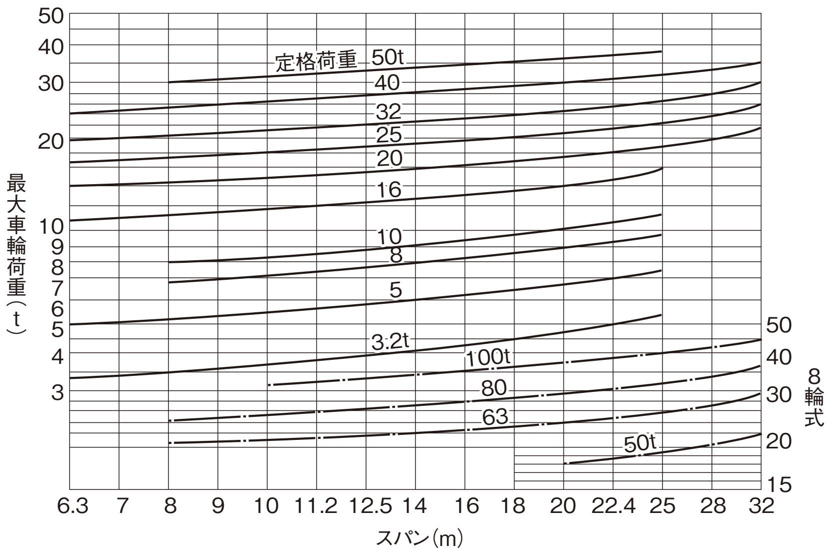
(単位:mm)

種類	定格荷重(t) 主巻	定格荷重(t) 補巻	スパン(m) を超え	スパン(m) 以下	揚程(m)	建築限界(mm) 軌上空間(A)	建築限界(mm) 側方空間(B)	主フック寄り、上がり(mm) 運転室側寄り(D)	主フック寄り、上がり(mm) 運転室反対側寄り(E)	主フック寄り、上がり(mm) 上がり(F)	サドル(参考)(mm) 長さ(Q)	サドル(参考)(mm) 軸間距離(R)	サドル(参考)(mm) 軸間距離(S)	車輪総数(参考)	走行レール(最小)(kg)
普通形	3.2	-	6.3	16	12.5	2200	260	700	700	200	3200	2300	-	4	15
			16	25		2300					4500	3600			
	5	-	6.3	16	12.5	2200	260	800	800	300	3600	2600	-	4	22
			16	25		2300					4600	3600			
	8	-	8	16	12.5	2200	280	900	900	400	3800	2700	-	4	22
			16	25		2300					4700	3600			
	10	-	8	16	12.5	2250	300	1000	1000	500	4000	2800	-	4	30
			16	25		2350					4800	3600			
	16	なし又は3.2	8	16	10又は16	2400	320	1300	1400(1100)	700	4800	3600	-	4	30
			16	25		2500					4800	3600			
	20	なし又は5	10	20	10又は16	2500	320	1400	1500(1200)	800	5200	3900	-	4	30
			20	32		2600					5900	4600			
	25	5	10	20	10又は16	2600	320	1500	1600	900	5500	4200	-	4	37
			20	32		2700					5900	4600			
	32	8	10	20	10又は16	2700	320	1600	1700	1000	5700	4400	-	4	37
			20	32		2800					5900	4600			
	40	8	10	20	10又は16	2900	340	1800	1900	1100	5800	4400	-	4	37
			20	32		3000					6000	4600			
	50	10	12.5	20	10又は16	3300	400	1900	2000	1000	6400	5000	-	4	37
			20	32		3800	380			600	6400	5300	900	8	
	63	16	12.5	32	10又は16	4100	400	2000	2100	500	6600	5400	1000	8	37
	80	16	12.5	32	10又は16	4200	450	2200	2300	700	6900	5600	900	8	73
	100	20	12.5	32	10又は16	4400	450	2400	2500	800	7100	5800	1000	8	73
	125	25	12.5	32	10又は16	4600	450	-	-	-	-	-	-	8	73
	160	32	12.5	32	10又は16	5000	450	-	-	-	-	-	-	8	73
	200	40	12.5	32	10又は16	5400	450	-	-	-	-	-	-	8	73

注)E欄中の括弧内は補巻のない場合の寸法です。

クレーン自重（建築学会・建築物荷重指針より）　（単位：t）

定格荷重（t）		スパン（m）								
主巻	補巻	8	10	12	14	16	18	20	22	24
3	-	7.2	8.1	9.0	9.9	10.9	11.8	12.8	13.8	14.8
5	-	8.8	9.7	10.6	11.5	12.6	13.7	14.7	15.8	16.9
10	-	11.6	12.8	14.0	15.3	16.5	17.7	19.2	21.0	22.8
15	3		16.9	18.4	19.9	21.4	22.9	24.4	26.0	27.5
25	5			25.3	27.3	29.3	31.4	33.5	35.5	37.6
30	5			27.1	29.4	31.2	34.0	36.3	38.6	40.8
40	10			38.4	41.1	43.8	46.5	48.9	51.3	53.7
50	10			46.8	50.3	53.7	57.1	60.5	64.3	68.1
60	10			54.2	58.9	63.5	68.0	71.7	75.4	79.1
80	20			70.3	74.5	78.7	83.0	88.1	93.1	98.2
100	20			86.0	91.0	96.0	101.0	107.7	114.5	121.2



最大車輪荷重（JIS B8801-1974）

備考）一点鎖線は8輪式を示す。

MEMO

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