変断面剛構の解法

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§1．門形構の計算例

1．Wilson 型式に依る計算（第３図）

第三表の荷重項 C_{AB}, C_{BA} 欄中の式を再掲すれば、

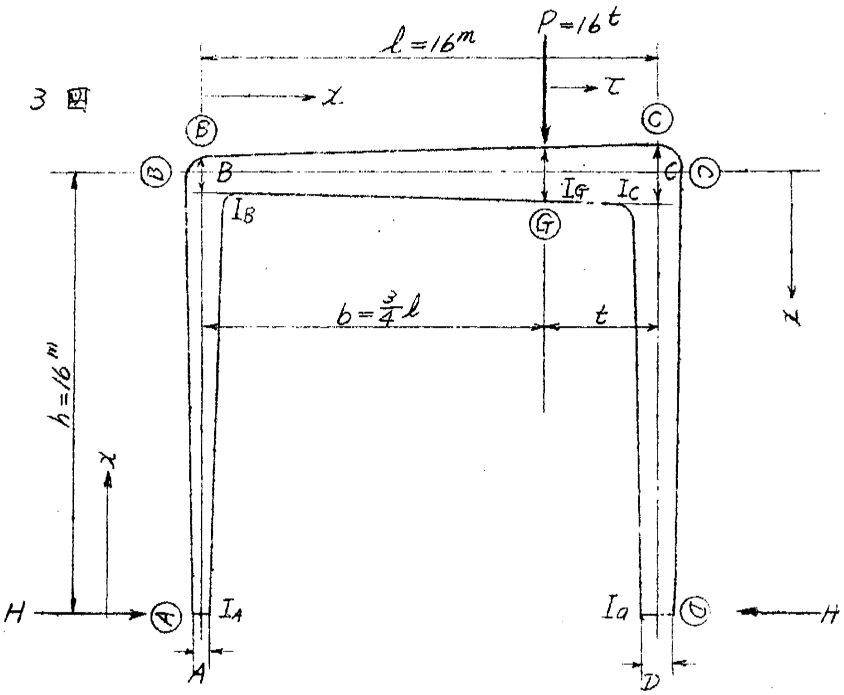
$$C_{BC}=\frac{P}{A_0}(\beta_{1B}\beta_{2G}-\beta_{2B}\beta_{1G})$$

$$C_{CB}=\frac{P}{A_0}\left\{A_0t-(\ell\alpha_{1B}-\beta_{1B})\beta_{2G}+(\ell\alpha_{2B}-\beta_{2B})\beta_{1G}\right\}$$

第一表 $\left(\frac{B}{A}\right)=\frac{C}{B}=2$ の段より○内番号欄を見れば

$$\begin{cases} ⑤⑤\ \alpha_{1B}=0.42076\ell \\ ⑤⑥\ \alpha_{2B}=0.2786\ \ell^2 \\ ⑤⑦\ \beta_{1B}=0.1422\ \ell^2 \end{cases} \qquad \begin{cases} ⑥⓪\ \beta_{2B}=0.06558\ \ell^2 \\ ⑥②_d\ A_0=+0.0121\ \ell^4 \end{cases}$$

第３図



$A:B:G:C:D=1:2:3.5:4:2$

$I_A:I_B:I_G:I_C:I_D=1:8:42.875:64:8$

$$\left[\frac{B}{A}\right] = \frac{C}{G} = \frac{4}{3.5} = 1.143$$

$$\left[\frac{I_G}{I_B}\right] = \frac{I_G}{I_B} = \left(\frac{3.5}{2}\right)^3 = 5.35$$

第4図及第5図より $\left[\frac{B}{A}\right] = \frac{C}{G} = 1.143$ の鉛直線上に於て

$$\begin{cases} 59,\ 62_b\ \beta_{1G} = (0.35 \sim 0.38)t^2 \fallingdotseq 0.35\left(\frac{l}{4}\right)^2 = 0.0219\,l^2 \\ 60,\ 62_b\ \beta_{2G} = 0.14\,t^3 = 0.14\left(\frac{l}{4}\right)^3 = 0.00219\,l^3 \end{cases}$$

従って

$$C_{AB} = \frac{P}{-0.0121\,l^4}\left(0.1422\,l^2 \times \frac{0.00219\,l^3}{5.35} - 0.06558\,l^3 \times \frac{0.0219\,l^2}{5.35}\right) = 0.0175\,Pl$$

$$C_{BA} = \frac{P}{-0.0121\,l^4}\left(-0.0121\,l^4 \times \frac{l}{4} - (0.42076\,l^2 - 0.1422\,l^2) \times \frac{0.00219\,l^3}{5.35} + (0.2786 - 0.06558)\,l^3 \times \frac{0.0219\,l^2}{5.35}\right) = 0.1865\,Pl$$

曲げモーメントの計算

附表の一般式を各部材に適用すれば

$$M_{BA} = EI_A\left(\frac{h^2}{h\beta_{1A} - \beta_{2A}}\theta_B - \frac{h}{h\beta_{1A} - \beta_{2A}}d\right)$$

$$M_{BC} = EI_B(A_1'\theta_B + A_2'\theta_2) - C_{BC}$$ （A_1' 及 A_2' の( )は部材の替る毎に附す）

$$M_{CB} = EI_B(B_1'\theta_B + B_2'\theta_C) - C_{CB}$$

$$M_{CD} = EI_C\left(\frac{h^2}{\beta_{2C} - h\alpha_{2C}} - \frac{h}{\beta_{2C} - h\alpha_{2C}}d\right)$$

第一表の $\left[\frac{B}{A}\right] = 2$ の段に於て

$$\begin{cases} 59\quad \beta_{1AB} = 0.142205\,h^2 \\ 60\quad \beta_{2AB} = 0.06558\,h^3 \end{cases}$$

第一表の $\left[\frac{B}{A}\right] = \frac{1}{2}$ の段に於て

$$\begin{cases} 56\quad \alpha_{2CD} = 1.13795\,h^2 \\ 60\quad \beta_{2CD} = 0.52437\,h^3 \end{cases}$$

第二表の $\left[\frac{B}{A}\right] = 2$ の段に於て

$$\begin{cases} 65\quad A_1' = -6.3751/l \\ 66\quad A_2' = -5.4567/l \end{cases}$$

$$\begin{cases} 69\quad B_1' = 5.4563/l \\ 70\quad B_2' = 17.7200/l \end{cases}$$

従つて曲げモーメントは

$$M_{BA} = EI_A\left(\frac{h^2}{0.142205h^3-0.06558h^3}\theta_B - \frac{h}{0.142205h^3-0.06558h^3}d\right) \quad \left(\text{但し } EI_A \text{ は括弧内に入れる}\right)$$

$$= 13.0503\,\theta_B - 13.0503\,d$$

$$M_{BC} = 8(-6.3751\,\theta_B - 5.4567\,\theta_C) - 0.0175\,Pl \qquad (\;\;\text{〃}\;\;)$$

$$M_{CB} = 8(5.4563\,\theta_B + 17.7200\,\theta_C) - 0.1865\,Pl \qquad (\;\;\text{〃}\;\;)$$

$$M_{CD} = 64\left(\frac{h}{0.52437h^2-1.13791h^2}\theta_C - \frac{1}{0.52437h-1.13795h^2}d\right) \quad (\;\;\text{〃}\;\;)$$

$$= 64(-1.6297\,\theta_C + 1.6297\,d)$$

條件式

$$\begin{cases} M_{BA} = M_{BC} \\ M_{BC} = M_{CB} \\ M_{CB} = M_{CD} \end{cases}$$

従 つ て

$$\begin{cases} 13.0583\,\theta_B - 13.0503\,d = 8(-6.3751\,\theta_B - 5.4567\,\theta_C) - 0.0175\,Pl \\ 8(-6.3751\,\theta_B - 5.4567\,\theta_C) - 0.0175\,Pl = 8(5.4563\,\theta_B + 17.7200\,\theta_C) - 0.1865\,Pl \\ 8(5.4563\,\theta_B + 17.7200\,\theta_C) - 0.1865\,Pl = 64(-1.6297\,\theta_C + 1.6297\,d) \end{cases}$$

整理して

$$\begin{cases} 64.0511\,\theta_B + 43.6536\,\theta_C - 13.0503\,d + 0.0175\,Pl = 0 \\ 94.6512\,\theta_B + 185.4136\,\theta_C - 0.1690\,Pl = 0 \\ 43.6504\,\theta_B + 246.0608\,\theta_C - 104.3072\,d - 0.1865\,Pl = 0 \end{cases}$$

此の三つの方程式を解きて、

$$\begin{cases} \theta_B = -0.0010114\,Pl \\ \theta_C = 0.0014273\,Pl \\ d = 0.0011561\,Pl \end{cases}$$

従つて曲げモーメントは（Plを省略して）

$$M_{BA} = 13.0503(-0.0010114) - 13.0503(0.0011561) = -0.02821\,Pl$$

$$M_{BC} = 8\{-6.3751(1-0.0010114) - 5.45667(0.0014273)\} - 0.0175 = -0.02822\,Pl$$

$$M_{CB} = 8\{5.4563(-0.0010114) + 17.720(0.0014273)\} - 0.1865 = -0.02835\,Pl$$

$$M_{CD} = 64\{-1.6297(0.0014273) + 1.6297(0.0011561)\} = -0.02826\,Pl$$

従つて、

$$M_{BC} = -0.0282 \times 16^t \times 16^m = -7.2192\ t\cdot m.$$

2. 本文の計算 （図 3）

前文附表中の（a）.（b）.（c）.式の形式を直接に各部枝に適用すれは（接尾字に注意）

AB部枝に於ては曲げモーメントは．$M=-Hx$であるから．

$$\theta_A - H\beta_{1A} = \theta_B \text{ -------------- } (i)$$

$$h\theta_A - H\beta_{2A} = d \text{ -------------- } (ii)$$

BC部枝に於ては

$$M = -Hh + \frac{t}{\ell}Px - P\tau \quad \text{であるから}$$

$$\theta_B - Hh\alpha_{1B} + \frac{t}{\ell}P\beta_{1B} - P\beta_{1G} = \theta_C \text{ ------ } (iii)$$

$$\ell\theta_B - Hh\alpha_{2B} + \frac{t}{\ell}P\beta_{2B} - P\beta_{2G} = 0 \text{ ------ } (iv)$$

又CD部枝に対しては

$$M = -Hh + Hx \quad \text{であるから}$$

$$d + h\theta_C - Hh\alpha_{2C} + H\beta_{2C} = 0$$

以上5個の方程式を解きて．（未知数 θ_A．θ_B；θ_C.d 及びH）

$$H = \frac{Ph(\beta_{1G} - \frac{t}{\ell}\beta_{1B})}{\beta_{2A} - h\beta_{1A} + h^2\alpha_{1B} - h\alpha_{2C} + \beta_{2C}}$$

本式に前掲と全じ数値を代入すれは

$$H = \frac{Ph\left(\frac{0.0219\ell^2}{42.875} - \frac{1}{4}\cdot\frac{0.1422\ell^2}{8}\right)}{0.06558h^3 - h\times0.1422h^2 - h^2\frac{0.42072\ell}{8} - h\frac{1.138h^2}{64} + \frac{0.5244h^3}{64}} \fallingdotseq 0.0282P$$

3. Castigliano の最小働の原理に依る計算（図 3参照）

接尾字は各変数の原点を表はすものとすれば．

(1). A．B部枝に於ては曲げもーめんとは

$$M = -Hx \qquad \text{であるから}$$

$$\frac{\partial M}{\partial H} = -x$$

$$\therefore \frac{\partial W}{\partial H} = \int_0^h \frac{M}{EI_A}\cdot\frac{\partial M}{\partial H}dx = H\gamma_{1A} + d \text{ ------- } (i)$$

(2) B，C部枝も全様に．

$$M=-Hh+\frac{t}{l}Px-P\tau,\quad \frac{\partial M}{\partial H}=-h$$

$$\frac{\partial W}{\partial H}=\int\frac{M}{EI}\cdot\frac{\partial M}{\partial H}dx$$

$$=\int_0^l\left(\frac{Hh^2}{EI_B}-\frac{thPx}{lEI_B}\right)dx+\int_0^l\frac{hP\tau}{EI_G}d\tau$$

$$=Hh^2\alpha_{1B}-\frac{t}{l}hP\beta_{1B}+hP\beta_{1G}\text{ ---------- (ii)}$$

(3) C, D 部材に仝様に

$$M=-Hh+Hx$$

$$\frac{\partial M}{\partial H}=-h+x$$

$$\frac{\partial W}{\partial H}=\int\frac{M}{EI}\cdot\frac{\partial M}{\partial H}dx$$

$$=\int_0^h\frac{H}{EI_C}(h^2-2hx+x^2)dx$$

$$=H(h^2\alpha_{1C}-2h\beta_{1C}+\gamma_{1C})-d\text{ ---------- (iii)}$$

然るに各部材の全 $\frac{\partial W}{\partial H}=0$ なるに依り (i)+(ii)+(iii)=0,

$$H\gamma_{1A}+d+Hh^2\alpha_{1B}-\frac{t}{l}hP\beta_{1B}+hP\beta_{1G}+H(h^2\alpha_{1C}-2h\beta_{1C}+\gamma_{1C})-d=0$$

$$\therefore\ H=\frac{P\left(\frac{t}{l}\beta_{1B}-\beta_{1G}\right)}{\gamma_{1A}+h^2\alpha_{1B}+h^2\alpha_{1C}-2h\beta_{1C}+\gamma_{1C}}$$

$$=\frac{P\left(\frac{1}{4}\cdot\frac{0.1422}{8}-\frac{0.0219}{42.875}\right)}{0.07663+\frac{0.4207}{8}+\frac{1}{64}(3.3663-2\times2.2284+1.7040}=0.0283\,P$$

§2. 最小働の原理に依る変位と弾性式に依る変位との不同並びに其の連立不可性に就て.

最小働の原理に依る変位は附表2の通り.

$$\frac{\partial W}{\partial R}=d_A+\int\frac{M}{EI}\cdot\frac{\partial M}{\partial R}dx$$

であるがこれは Mohr の弾性変位と次の**太字**の通りの相異ありて同じからず、従って両者を連立方程式として解くことは出来ぬ. 換言すれば最小働の原理に依る変位曲線と Mohr の弾性曲線とは其の傾斜を異にする.

$$y=\theta_A x+d_A+\int\frac{M}{EI}\cdot\frac{\partial M}{\partial R}\cdot\frac{l-x}{x}dx$$

§ 3. $\int\frac{x^n}{(1\pm cx)^2}dx$，$\iint\frac{x^n}{(1\pm cx)^2}$，$\int\frac{x^n}{(1\pm cx)^3}dx$，$\iint\frac{x^n}{(1\pm cx)^3}dx$ ---- 等

標記計算冗長とならば $\int\frac{x^n}{(1\pm cx)^2}dx=\int\frac{x^n}{e^{mx}}dx\frac{\int e^{mx}dx}{\int(1\pm cx)^2dx}=\left(\int\frac{x^n}{e^{mx}}dx\right)K_1$

$$\iint\frac{x^n}{(1\pm cx)^2}dxdn=\iint\frac{x^n}{e^{mx}}dxdn\,\frac{\iint e^{mx}dxdn}{\iint(1\pm cx)^2dxdn}=\left(\iint\frac{x^n}{e^{mx}}dxdn\right)K_2$$

とすれば K_1, K_2 は割合に簡單に計算出來る.

變斷面剛構の解法　（附表二）前文圖 / 參照

Castiglians の最小働の原理に依る場合

1. 角變化

$$\begin{cases}M=M_A+Rx-\frac{1}{2}w\lambda^2-P\tau\\ \frac{\partial M}{\partial M_A}=1\\ \frac{\partial W}{\partial M_A}=\theta_A+\int\frac{M}{EI}\cdot\frac{\partial M}{\partial M_A}dx\\ \left[\frac{\partial W}{\partial M_A}\right]_{x=l}=\theta_A+\int_0^l\frac{1}{EI_A}(M_A+Rx)dx-\frac{w}{2}\int_0^s\frac{1}{EI_N}\lambda^2d\lambda-P\int_0^t\frac{1}{EI_G}\tau\,d\tau\\ \qquad=\theta_A+M_A\alpha_{1A}+R\beta_{1A}-\frac{w}{2}\gamma_{1N}-P\beta_{1G}=\theta_B\ \text{---}(M\text{ hr の角變化に全じ})\text{----}(a)\\ M_A+Rl-\frac{1}{2}ws^2-Pt=M_B\ \text{------------}(\text{靜力的條件})\text{------}(b)\\ \frac{l}{\beta_{1A}}\left(\theta_B-\theta_A-M_A\alpha_{1A}+\frac{w}{2}\gamma_{1N}+P\beta_{1G}\right)=M_B-M_A+\frac{1}{2}ws^2+Px\ \text{------}(a.b)\end{cases}$$

2. 變位

$$\begin{cases}M=M_A+Rx-\frac{1}{2}wx^2-P\tau\\ \frac{\partial M}{\partial R}=x=a+\lambda=b+\tau\\ \frac{\partial W}{\partial R}=d_A+\int\frac{M}{EI}\cdot\frac{\partial M}{\partial R}dx,\qquad(\text{Mohr の變位と同じからず})\\ \left[\frac{\partial W}{\partial R}\right]_{x=l}=d_A+\int_0^l\frac{1}{EI_A}(M_Ax+Rx^2)dx-\frac{w}{2}\int_0^s\frac{\lambda^2}{EI_N}(a+\lambda)d\lambda-P\int_0^t\frac{\tau}{EI_G}(b+\tau)d\tau\\ \qquad=d_A+M_A\beta_{1A}+R\gamma_{1A}-\frac{1}{2}w(a\gamma_{1N}+\delta_{1N})-P(b\beta_{1G}+\gamma_{1G})=d_B\ \text{------}(a')\\ M_A+Rl-\frac{1}{2}ws^2-Pt=M_B\ \text{-------------------}(b')\\ \frac{l}{\gamma_{1A}}\left\{d_B-d_A-M_A\beta_{1A}+\frac{w}{2}(a\gamma_{1N}+\delta_{1N})+P(b\beta_{1G}+\gamma_{1G})\right\}=M_B-M_A+\frac{w}{2}s^2+Pt\ \text{----}(a'.b')\end{cases}$$

3. 角変化式 a, b と変位式 a', b' との連立(不可)方程式の解

$$\begin{cases} M_{AB} = \dfrac{1}{\beta_{1A}^2 - \alpha_{1A}\gamma_{1A}}\left\{\gamma_{1A}(\theta_A - \theta_B) + \beta_{1A} d\right\} - C_{AB} & \text{但し } d = d_B - d_A \\ M_{BA} = \dfrac{1}{\beta_{1A}^2 - \alpha_{1A}\gamma_{1A}}\left\{\beta_{2A}(\theta_A - \theta_B) + \alpha_{2A} d\right\} + C_{BA} & 〃 \quad 〃 \end{cases}$$

但し

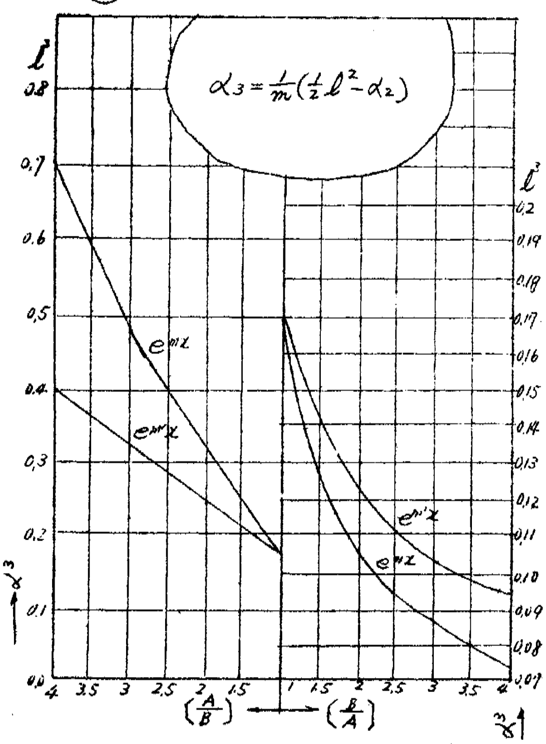
$$\begin{cases} C_{AB} = \dfrac{1}{\beta_{1A}^2 - \alpha_{1A}\gamma_{1A}}\left[\dfrac{w}{2}\left\{\gamma_{1A}\gamma_{1N} - \beta_{1A}(a\gamma_{1N} + \delta_{1N})\right\} + P\left\{\gamma_{1A}\beta_{1G} - \beta_{1A}(b\beta_{1G} + \gamma_{1G})\right\}\right] \\ C_{BA} = \dfrac{1}{\beta_{1A}^2 - \alpha_{1A}\gamma_{1A}}\left[\dfrac{w}{2}\left\{\beta_{2A}\gamma_{1N} - \alpha_{2A}(a\gamma_{1N} + \delta_{1N}) - (\beta_{1A}^2 - \alpha_{1A}\gamma_{1A})s^2\right\}\right. \\ \qquad \left. + P\left\{\beta_{2A}\beta_{1G} - \alpha_{2A}(b\beta_{1G} + \gamma_{1G}) - (\beta_{1A}^2 - \alpha_{1A}\gamma_{1A})t\right\}\right] \end{cases}$$

4. 一様断面の場合

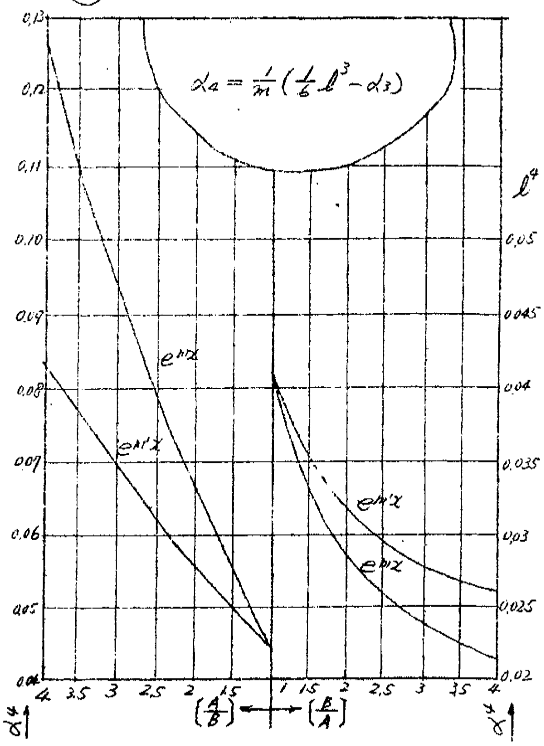
$$\begin{cases} M_{AB} = \dfrac{2EI}{l}(-2\theta_A + 2\theta_B - 3d) - \dfrac{1}{12}wl^2 - \dfrac{1}{8}Pl. & \text{但し } s = l,\ b = t = \dfrac{l}{2} \\ M_{BA} = \dfrac{2EI}{l}(\theta_A - \theta_B + 3d) - \dfrac{1}{12}wl^2 - \dfrac{1}{8}Pl. & 〃 \quad 〃 \quad 〃 \end{cases}$$

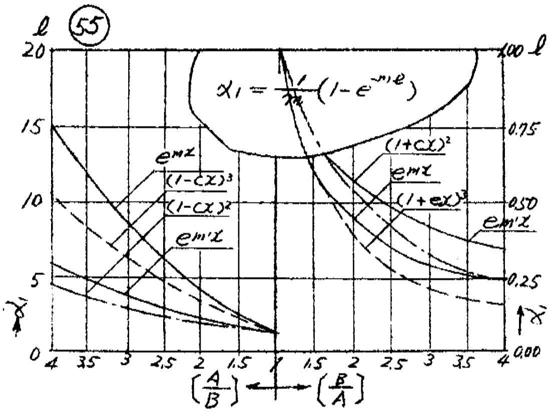
第四図及第五図

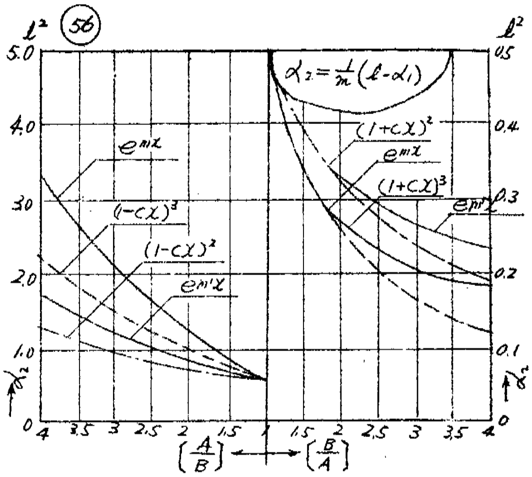
(57)

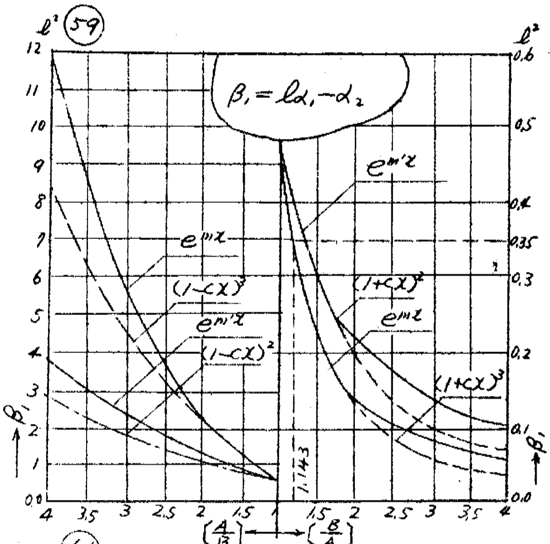


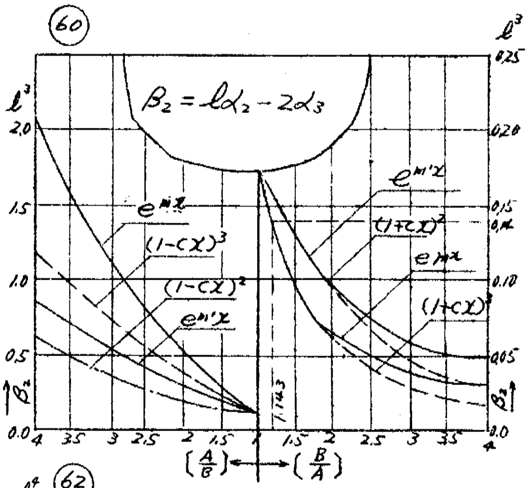
(58)

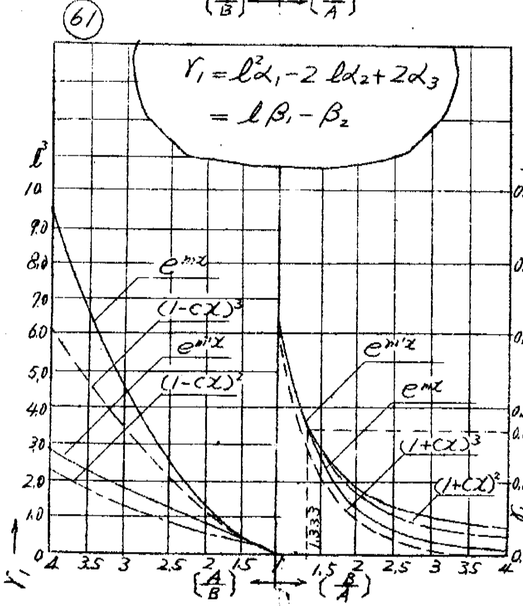



55
$\alpha_1 = \frac{1}{m}(1-e^{-m l})$
e^{mx}
$(1-cx)^3$
$(1-cx)^2$
$e^{m'x}$
$(1+cx)^2$
$(1+cx)^3$
$\left(\frac{A}{B}\right) \longleftrightarrow \left(\frac{B}{A}\right)$

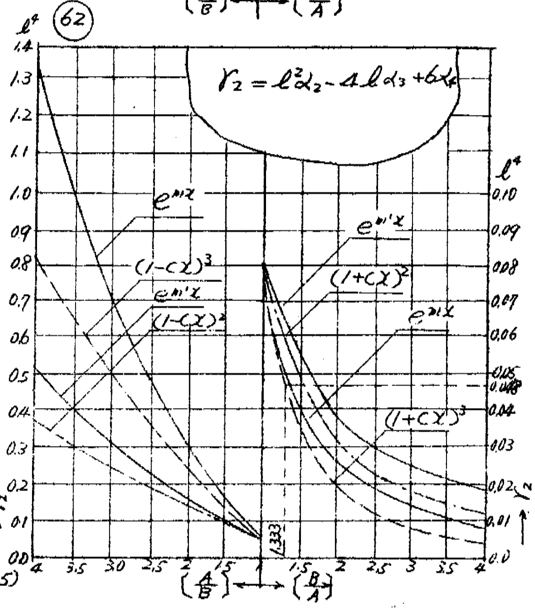

56
$\alpha_2 = \frac{1}{m}(l-\alpha_1)$
e^{mx}
$(1-cx)^3$
$(1-cx)^2$
$e^{m'x}$
$(1+cx)^2$
$(1+cx)^3$
$\left(\frac{A}{B}\right) \longleftrightarrow \left(\frac{B}{A}\right)$


59
$\beta_1 = l\alpha_1 - \alpha_2$
$e^{m'x}$
e^{mx}
$(1-cx)^3$
$(1-cx)^2$
$(1+cx)^2$
$(1+cx)^3$
1.143
$\left(\frac{A}{B}\right) \longleftrightarrow \left(\frac{B}{A}\right)$

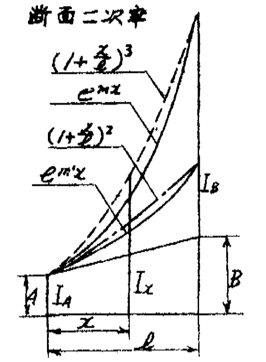

60
$\beta_2 = l\alpha_2 - 2\alpha_3$
$e^{m'x}$
e^{mx}
$(1-cx)^3$
$(1-cx)^2$
$(1+cx)^2$
$(1+cx)^3$
1.143
$\left(\frac{A}{B}\right) \longleftrightarrow \left(\frac{B}{A}\right)$


61
$\gamma_1 = l^2\alpha_1 - 2l\alpha_2 + 2\alpha_3 = l\beta_1 - \beta_2$
e^{mx}
$(1-cx)^3$
$e^{m'x}$
$(1-cx)^2$
$(1+cx)^3$
$(1+cx)^2$
1.333
$\left(\frac{A}{B}\right) \longleftrightarrow \left(\frac{B}{A}\right)$

(85)


62
$\gamma_2 = l^2\alpha_2 - 4l\alpha_3 + 6\alpha_4$
e^{mx}
$(1-cx)^3$
$e^{m'x}$
$(1-cx)^2$
$(1+cx)^2$
$(1+cx)^3$
1.333
$\left(\frac{A}{B}\right) \longleftrightarrow \left(\frac{B}{A}\right)$

第三表　各種断面二次率の α_1, α_2

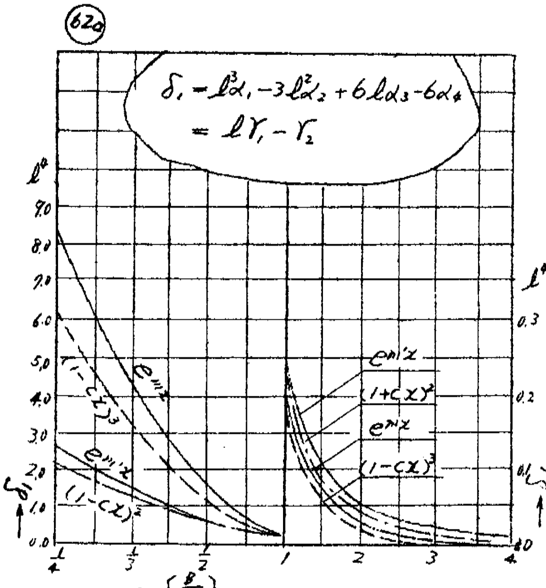
梁両端の梁高の比 $\left(\frac{B}{A}\right)$	梁両端の断面二次モーメントの比 $\left(\frac{I_B}{I_A}\right)$	断面二次率	$\alpha_1=\int_0^{\ell}\frac{1}{I_x}dx$ (55)	$\alpha_2=\int_0^{\ell}\int_0^{x}\frac{1}{I_x}dx\cdot dx$ (56)	$\beta_1=\int_0^{\ell}\frac{x}{I_x}dx=\ell\alpha_1-\alpha_2$ (59)	$\beta_2=\int_0^{\ell}\int_0^{x}\frac{x}{I_x}dx\cdot dx$ (60)	$\gamma_1=\int_0^{\ell}\frac{x^2}{I_x}dx=\ell\beta_1-\beta_2$ (61)	$\gamma_2=\int_0^{\ell}\int_0^{x}\frac{x^2}{I_x}dx\cdot dx$ (62)	
									
$\frac{1}{4}$	$\frac{1}{64}$	e^{mx}	15,148.270	$3.401920\ell^2$	11.746367ℓ	$2.006412\ell^3$	$9.739955\ell^3$	$1.377032\ell^4$	8.
		$\left(1-\frac{3}{4}\cdot\frac{x}{\ell}\right)^3$	10.223	2.000	8.250	$(1.152)^{小}$	7.04	0.811	6.
	$\frac{1}{16}$	$e^{m'x}$	5.410080	1.610586	3.79950	1.80947	2.990024	0.514502	2.
		$\left(1-\frac{3}{4}\cdot\frac{x}{\ell}\right)^2$	3.970	1.126	2.845	0.558	2.340	0.360	2.
$\frac{1}{3}$	$\frac{1}{27}$	e^{mx}	7.888740	2.090110	5.798630	1.124600	4.674030	0.733968	3
		$\left(1-\frac{2}{3}\cdot\frac{x}{\ell}\right)^3$	6.052	1.434	$(4.49)^{大}$	0.766	3.720	0.531	3
	$\frac{1}{9}$	$e^{m'x}$	3.640100	1.201200	2.438900	$(0.563)^{大}$	$(1.876)^{小}$	0.34114	1.
		$\left(1-\frac{2}{3}\cdot\frac{x}{\ell}\right)^2$	2.900	0.962	2.086	0.450	1.595	0.272	
$\frac{1}{2}$	$\frac{1}{8}$	e^{mx}	3.366300	1.137950	2.228390	0.524370	1704020	0.315380	1.
		$\left(1-\frac{1}{2}\cdot\frac{x}{\ell}\right)^3$	2.922	0.998	$(2.016)^{大}$	0.463	1.613	0.274	1.
	$\frac{1}{4}$	$e^{m'x}$	2.16405	0.84040	$(1.324)^{小}$	$(0.35)^{小}$	$(0.947)^{小}$	0.1996	0.
		$\left(1-\frac{1}{2}\cdot\frac{x}{\ell}\right)^2$	1.950	0.7719	$(1.3)^{大}$	$(0.313)^{小}$	$(0.909)^{大}$	$(0.192)^{大}$	0.
1	1	一　様　断　面	1.0000	0.5000	0.5000	0.166667	0.33333	0.08333	0.
2	8	e^{mx}	0.420760	0.278555	0.142205	0.065579	0.076626	0.026201	0.
		$\left(1+\frac{x}{\ell}\right)^3$	0.378	0.250	0.1248	0.0569	$(0.068)^{大}$	0.0218	0.
	4	$e^{m'x}$	0.54101	0.3311	$(0.21)^{大}$	$(0.087)^{大}$	0.12247	0.03682	0.
		$\left(1+\frac{x}{\ell}\right)^2$	0.494	0.3000	$(0.196)^{大}$	0.0828	0.1133	0.0326	0.
3	27	e^{mx}	0.292172	0.214762	0.077410	0.041672	0.035738	0.014442	0.
		$\left(1+2\frac{x}{\ell}\right)^3$	0.2307	0.1768	0.0540	$(0.0285)^{小}$	$(0.0265)^{大}$	0.010094	0.
	9	$e^{m'x}$	0.404455	0.270983	0.13347	0.06257	0.07090	0.02467	0.
		$\left(1+2\frac{x}{\ell}\right)^2$	0.336	0.232	0.1067	0.048	0.0587	0.0172	0.
4	64	e^{mx}	0.236692	0.183357	0.053335	0.031351	0.021984	0.009833	0.
		$\left(1+3\frac{x}{\ell}\right)^3$	0.1623	0.1323	0.03145	0.01853	0.01329	0.00520	0.
	16	$e^{m'x}$	0.33813	0.238717	$(0.0994)^{小}$	$(0.0402)^{小}$	0.049166	0.018518	0.
		$\left(1+3\frac{x}{\ell}\right)^2$	0.2436	0.174	0.0711	0.03501	0.03637	0.01253	0.

N.B. 表中(　)内数値は多少の大小あるにつき別紙曲

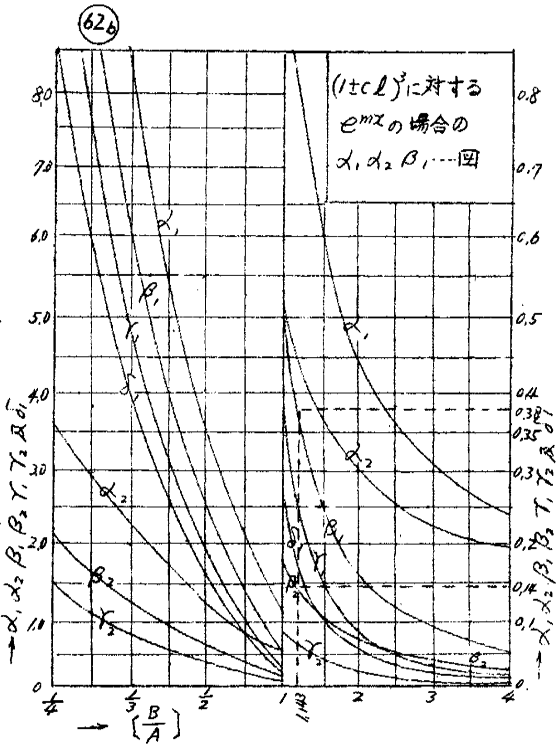
β_1, β_2 ----等の比較表

(62a)	$A_0=\alpha_1\beta_2-\alpha_2\beta_1$ (62d)	$A_1=\frac{1}{A_0}\left(\frac{\ell}{\beta_2}-\frac{1}{\beta_1}\right)=\frac{\ell\beta_1-\beta_2}{A_0}=\frac{\gamma_1}{A_0}$ (65)	$A_2=\frac{1}{A_0}\cdot\frac{1}{\beta_1}=\frac{\beta_2}{A_0}$ (66)	$A_3=\frac{1}{A_0}\cdot\frac{1}{\beta_2}=\frac{\beta_1}{A_0}=(A_1+A_2)\frac{1}{\ell}$ (67)	$B_1=\frac{1}{A_0}\left(\frac{\ell^2}{\ell\alpha_2-\beta_2}-\frac{\ell}{\ell\alpha_1-\beta_1}\right)=-\frac{\beta_2}{A_0}=-A_2$ (69)	$B_2=\frac{1}{A_0}\cdot\frac{\ell}{\ell\alpha_1-\beta_1}=-\frac{\ell\alpha_2-\beta_2}{A_0}$ (70)	$B_3=\frac{1}{A_0}\cdot\frac{\ell}{\ell\alpha_2-\beta_2}=\frac{\alpha_2}{A_0}=(B_1+B_2)\frac{1}{\ell}$ (71)	$C_{AB}=\frac{1}{A_0}\left(\frac{\gamma_{2N}}{\beta_2}-\frac{\gamma_{1N}}{\beta_1}\right)\frac{1}{2}W=\frac{1}{A_0}(\beta_1\gamma_{2N}-\beta_2\gamma_{1N})\frac{1}{2}W$ (68)	$C_{BA}=\frac{W}{2A_0}\left(\frac{\ell\beta_1(5/\ell)^2\gamma_{1N}}{\alpha_1-\beta_1/\ell}-\frac{\ell\beta_2(5/\ell)^2\gamma_{2N}}{\alpha_2-\beta_2/\ell}\right)=\frac{W}{2A_0}\left(A_0\ell^2(5/\ell)^2-(\ell\alpha_1-\beta_1)\gamma_{2N}+(\ell\alpha_2-\beta_2)\gamma_{1N}\right)$ (72)
ℓ^4	$-9.564\ell^4$	$-1.019\frac{1}{\ell}$	$-0.210\frac{1}{\ell}$	$-1.229\frac{1}{\ell^2}$	$0.210\frac{1}{\ell}$	$0.146\frac{1}{\ell}$	$0.356\frac{1}{\ell^2}$	$0.355\left(\frac{W\ell^2}{2}\right)$	$0.067\left(\frac{W\ell^2}{2}\right)$
7	-[illegible].725	-1.491	-0.300	-1.745	0.300	0.200	0.5000	0.331 〃	0.084 〃
522	-1.7408	-1.716	-0.465	-2.181	0.465	0.513	0.978	0.267 〃	0.0952 〃
20	-1.065	-2.170	-0.524	-2.694	0.524	0.600	1.058	0.255 〃	0.106 〃
0	-3.255	-1.541	-0.3462	-1.785	0.3463	0.297	0.643	0.315	0.076464
	-1.743	(-2.13)*	-0.450	(-2.58)*	0.450	0.375	0.825	0.285	0.0950
80	-0.880	-2.20	-0.640	-2.77	0.640	0.728	1.368	0.255	0.105
	-0.646	-2.535	-0.690	-3.229	0.690	0.801	1.491	0.233	0.118
	(-0.772)"	-2.211	-0.6865	-2.892	0.6805	0.0796	1.477	0.247553	0.108707
	-0.500	-2.40	-0.926	-3.33	0.800	0.800	1.600	0.232	0.121
8	-0.3565	-2.90	-1.04	-3.94	1.040	1.320	2.360	0.2105	0.130
	-0.286	-3.15	-1.111	-4.545	1.111	1.570	2.682	0.203	0.140
0	0.08333	-4.000	-2.000	-6.000	2.000	4.000	6.000	0.16667	0.16667
43	-0.0121	-6.375	-5.457	-11.832	5.456	17.7200	23.177	0.108009	0.2494
)*	-0.00976	-6.970	-5.840	-12.81	5.840	21.00	26.84	0.118	0.240
55	-0.02219	-5.518	-3.940	-9.00	3.600	11.30	14.90	0.132	0.220
5	(-0.021)*	-5.65	-4.00	-9.65	4.000	12.00	16.00	0.136	0.210
0	-0.00446	-8.038	-9.464	-17.100	9.300	39.00	49.00	0.084643	0.318998
8	-0.002166	-9.50	-10.7	-20.20	10.70	51.30	62.0	0.097	0.300
3	-0.01086	-6.526	-5.764	-12.290	5.764	19.196	24.96	0.107	0.257
5	-0.00862	-6.805	-6.50	-13.30	6.500	20.40	26.90	0.114	0.246
5	-0.00237	-9.432	-14.00	-22.70	13.510	66.10	79.60	0.0707	0.3518
0	-0.00166	-11.457	-16.00	-27.457	16.00	98.30	114.30	0.084	0.334
48	-0.006738	-7.30	-8.00	-15.3	8.500	28.50	37.00	0.0933	0.277
7	-0.00384	-7.8	-9.17	-16.97	9.170	36.07	45.24	0.1000	0.255

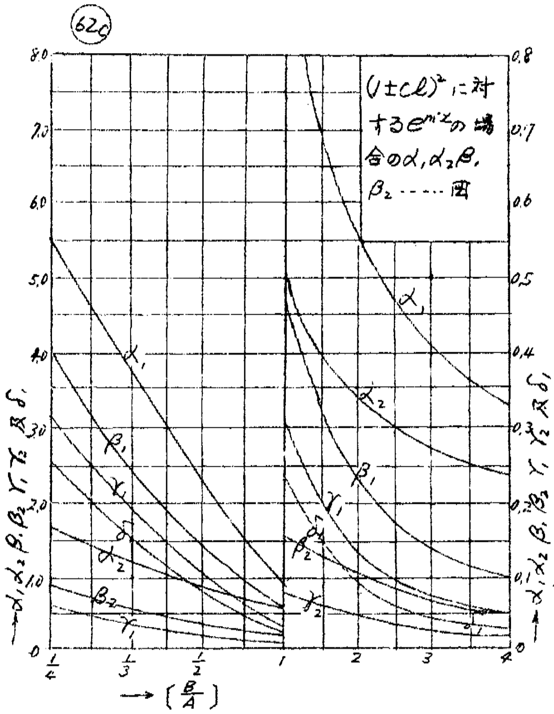
より採用するを可しとす.



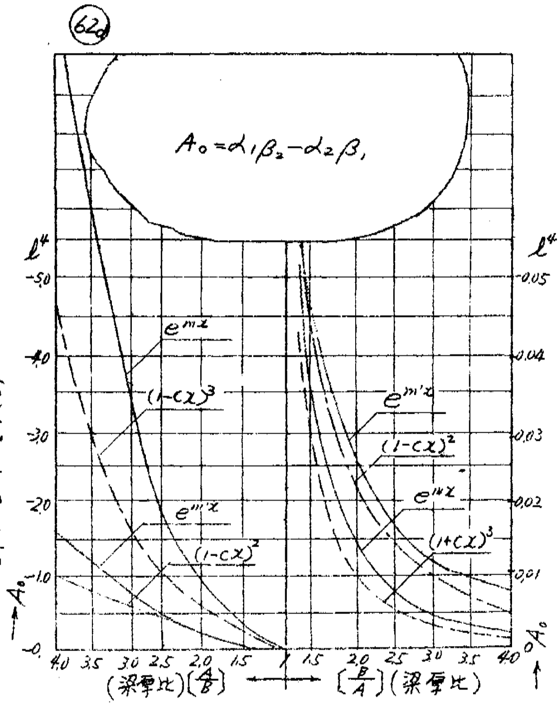
62a
δ₁ = l³α₁ − 3l²α₂ + 6lα₃ − 6α₄ = lγ₁ − γ₂
l⁴
δ₁
e^{m'x}
(1+cx)²
e^{mx}
(1−cx)³
(1−cx)²
[B/A]



62b
(1±cl)³に対するe^{mx}の場合のα₁ α₂ β₁ ……図
α₁
β₁
γ₁
δ₁
α₂
β₂
γ₂
α₁, α₂, β₁, β₂, γ₁, γ₂ 及 δ₁
[B/A]



62c
(1±cl)²に対するe^{m'x}の場合のα₁ α₂ β₁ β₂ ……図
α₁
β₁
γ₁
δ₁
α₂
β₂
γ₂
α₁, α₂, β₁, β₂, γ₁, γ₂ 及 δ₁
[B/A]



62d
A₀ = α₁β₂ − α₂β₁
l⁴
e^{mx}
(1−cx)³
e^{m'x}
(1−cx)²
e^{m'x}
(1−cx)²
e^{mx}
(1+cx)³
A₀
(梁厚比)[A/B]
[B/A](梁厚比)