1 MÉTODO SIMPLIFICADO PARA EL CÁLCULO DE ESTRUCTURAS DE EDIFICIOS CON CARGAS VERTICALES

Para el cálculo simplificado de entramados de edificios sometidos a cargas verticales, pueden adoptarse los momentos indicados en las figuras 1 y 2, siempre que se cumplan simultáneamente las siguientes condiciones:

- La luz de cada tramo difiere, como máximo, un 20% de las correspondientes a los tramos adyacentes.
- La estructura está sometida exclusivamente a la acción de cargas verticales, uniformemente repartidas e iguales en todos los tramos.
- Los dinteles son de sección constante.
- La sobrecarga no es superior a la mitad de la carga permanente.

Por otra parte, para la utilización de este método deben tenerse en cuenta las siguientes observaciones:

- La luz l corresponde a distancia entre ejes de las piezas.
- Para el cálculo de los momentos negativos se tomará como luz l la semisuma de los valores correspondientes a los tramos adyacentes.
- Los números encerrados en círculos indican rigideces relativas.
- Los pilares interiores pueden calcularse con la excentricidad mínima, ea, siempre que se adopte un coeficiente de seguridad no menor que $\gamma_f = 1{,}6$.

Para los esfuerzos cortantes en los extremos de las vigas, se considerarán los siguientes valores:

- Sobre el primer soporte interior $1{,}15 \cdot q \cdot \frac{l}{2}$
- Sobre los restantes soportes $q \cdot \frac{l}{2}$

en donde q es la carga unitaria uniformemente repartida.

Cuando las luces, las cargas o las piezas no cumplan las condiciones anteriormente indicadas, puede emplearse el método de cálculo del apartado.2.

2 MÉTODO PRÁCTICO PARA EL CÁLCULO DE PÓRTICOS MÚLTIPLES

El presente método puede emplearse para el cálculo de pórticos múltiples, cualesquiera que sean las luces y sobrecargas, con forjados hormigonados a la vez que las vigas.

En este método se tiene en cuenta una redistribución de los momentos flectores de las vigas, como consecuencia del comportamiento del hormigón más allá de su fase elástica. No obstante, con objeto de prevenir una fisuración que pueda ser peligrosa, dicha redistribución se ha limitado a un 15% del máximo momento negativo.

Se ha tenido en cuenta también la variación del momento de inercia de las vigas, debida a la losa de compresión.

Este método no es válido cuando existan desplazamientos importantes o fuerzas horizontales.

2.1 MÉTODO DE CÁLCULO

a) En todos los cálculos se adoptarán como luces las distancias entre ejes de los distintos elementos de la estructura.
b) Se determinarán las rigideces relativas de las distintas piezas, disminuyendo en un 10% las correspondientes a los pilares de la última planta, así como las de las vigas extremas.
c) A continuación se calculan los coeficientes de reparto, en cada nudo (como en el método de Cross). Así, cuando en el nudo concurran cuatro barras, los coeficientes de reparto serán:

$$r_1 = \frac{k_1}{\Sigma k}\ ,\quad r_2 = \frac{k_2}{\Sigma k}\ ,\quad r_3 = \frac{k_3}{\Sigma k}\ ,\quad r_4 = \frac{k_{34}}{\Sigma k}$$

en donde las k son las rigideces relativas y

$$\Sigma k = k_1 + k_2 + k_3 + k_4$$

d) Los momentos de empotramiento perfecto se determinan por las fórmulas clásicas, disminuyéndolos en un 10%.
e) Los momentos de continuidad en los extremos de las barras de un nudo, se determinan dejándolas en libertad de girar y compensando el momento de desequilibrio proporcionalmente a los coefi cientes de reparto, como se hace en el método de Cross.
f) No se efectuarán transmisiones de momentos, excepto en las vigas extremas, en las que sólo se efectuará el traslado desde el nudo exterior al inmediato interior.

No obstante, también puede prescindirse de esta transmisión cuando la rigidez de la viga sea menor que la correspondiente a cualquiera de los dos pilares extremos del nudo considerado.

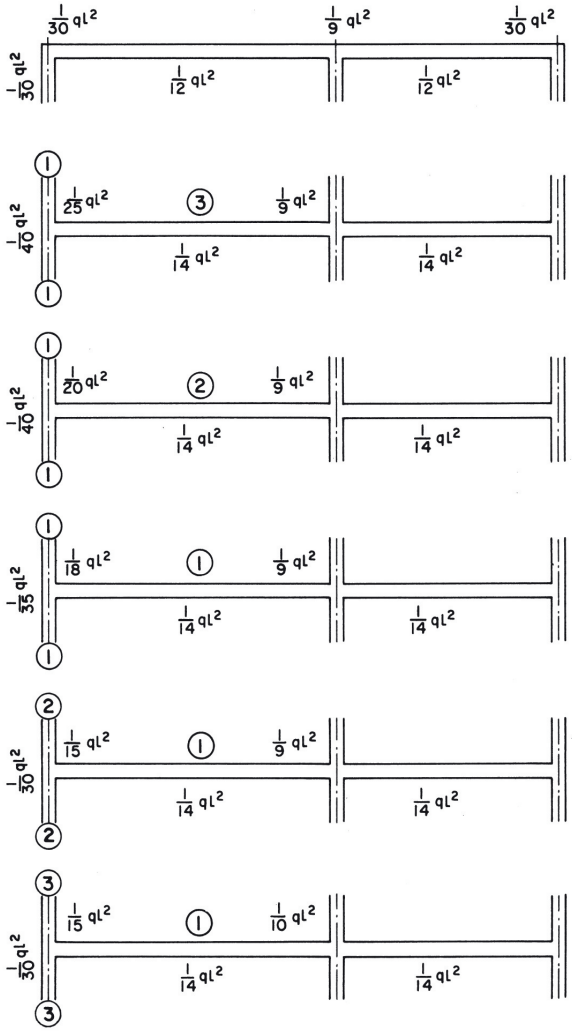


Figura 1. Pórtico de dos vanos

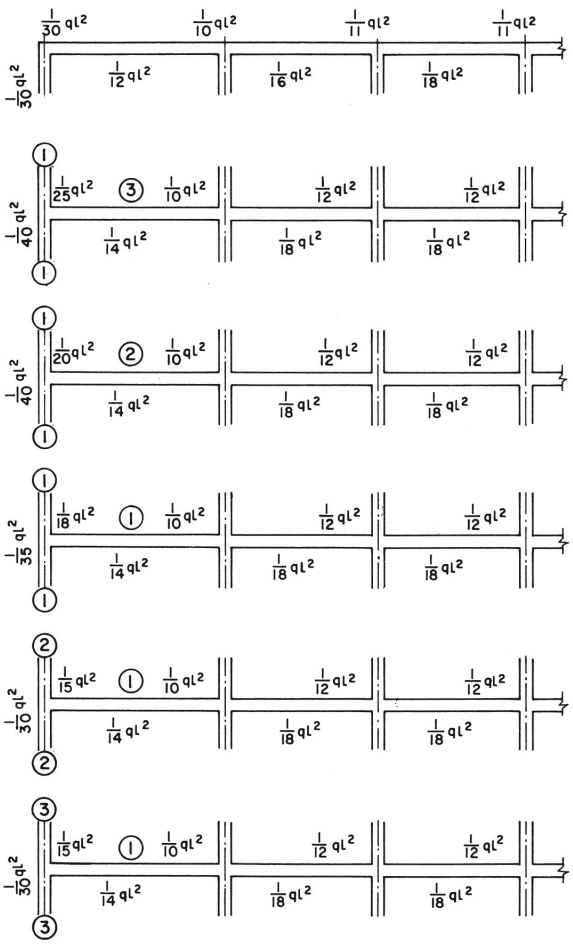


Figura 2. Pórtico de varios vanos

g) El método es válido cuando existan voladizos en los tramos extremos, en cuyo caso es necesario transmitir el momento que absorbe la viga al nudo inmediato al extremo.
h) Cuando las sobrecargas sean importantes, o en estructuras con luces muy desiguales, deben estudiarse separadamente los efectos de las cargas permanentes y los correspondientes a las sobrecargas, con objeto de obtener las leyes de momentos envolventes más desfavorables.
i) Si las cargas permanentes son más importantes que las sobrecargas, se aconseja reducir los momentos de apoyo correspondientes a dichas cargas en un 15%, con objeto de tener en cuenta la adaptación de la estructura por las deformaciones de fl uencia del hormigón. De esta forma se consideran mayorados, indirectamente, los momentos de vano. No obstante, si en algún caso puede ser peligrosa una eventual fi suración, la reducción del 15% de los momentos negativos sólo se aplicará para determinar los momentos positivos de vano.
j) Se recomienda no considerar momentos de vano inferiores a los siguientes valores:

- Cargas uniformes $\frac{1}{20} \cdot q \cdot l^2$
- Cargas concentradas $0,15 \cdot P \cdot l$

Por último, insertamos a continuación las fórmulas que proporcionan los momentos de empotramiento elástico, tanto en los nudos interiores de la estructura como en los nudos extremos e inmediatos a los extremos, calculados de acuerdo con las hipótesis enunciadas.

MOMENTOS DE NUDO

a) En los nudos de tramos intermedios (fig. 3):

$M_1 = -M'_1 + r_1 \cdot (M'_1 - M'_2)$
$M_2 = M'_2 + r_2 \cdot (M'_1 - M'_2)$
$M_3 = r_3 \cdot (M'_1 - M'_2)$
$M_4 = r_4 \cdot (M'_1 - M'_2)$

en donde M'i son los momentos de empotramiento perfecto, en valor absoluto, y ri los coefi cientes de reparto.

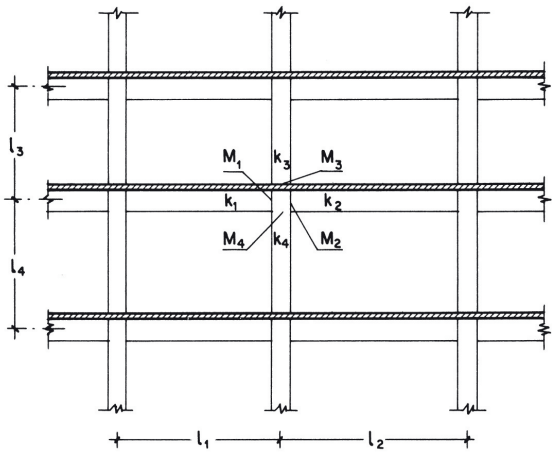


Figura 3. Momentos de nudo en los tramos intermedios

b) En los nudos de tramos extremos (fig. 4):

$M_5 = M'_5 - r_5 \cdot M'_5$
$M_6 = -r_6 \cdot M'_5$
$M_7 = -r_7 \cdot M'_5$

c) En los nudos de tramos inmediatos a los extremos (fig. 4):

$M_8 = -M'_8 + r_8 \cdot (M'_8 - M'_9)$ [1]
$M_9 = -M'_9 + r_9 \cdot (M'_8 - M'_9)$
$M_{10} = r_{10} \cdot (M'_8 - M'_9)$
$M_{11} = r_{11} \cdot (M'_8 - M'_9)$

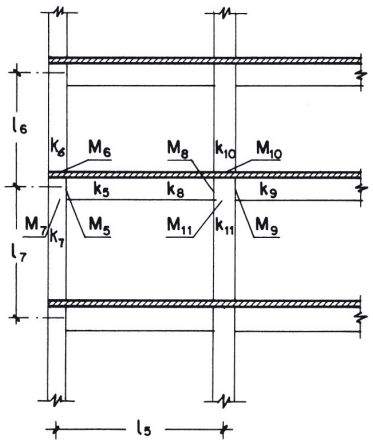


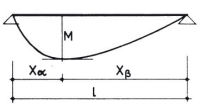
Figura 4. Momentos de nudo en los tramos extremos

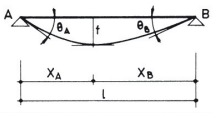
A continuación ofrecemos una serie de formularios para el cálculo de estructuras.

1) Si las vigas extremas son más rígidas que los pilares extremos correspondientes,se incrementará – M'P en el momento transmitido, – 0,5 · r5 · M'5.

TABLA 1
VIGA APOYADA. DISTINTAS HIPÓTESIS DE CARGA

F, q y segmentos en valor absoluto.





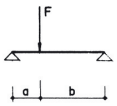
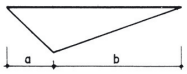
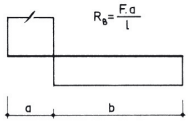
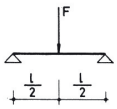
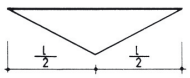
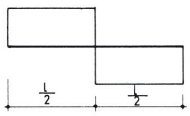
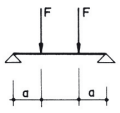
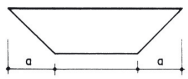
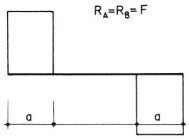
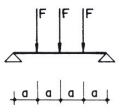
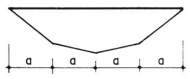
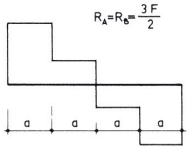
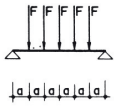
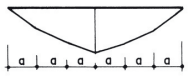
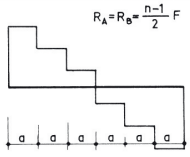
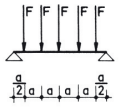
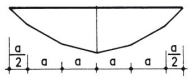
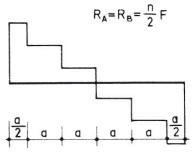
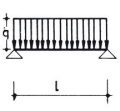
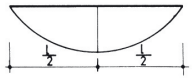
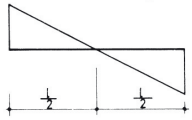
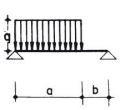
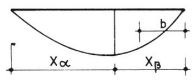
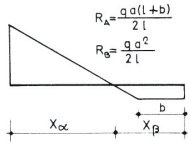
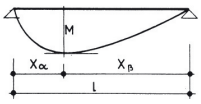
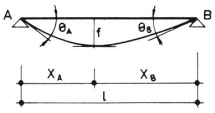
SOLICITACION	DIAGRAMA DE MOMENTOS FLECTORES MOMENTO MAXIMO	DIAGRAMA DE ESFUERZOS CORTANTES REACCIONES EN APOYOS	FLECHAS MAXIMAS ANGULOS DE GIRO EXTREMOS
	$M=\frac{F\,a\,b}{l}$ 	$R_A=\frac{F.b}{l}$ $R_B=\frac{F.a}{l}$ 	$a<b$ „ $x_B=\left[\frac{b(l+a)}{3}\right]^{\frac{1}{2}}$ „ $f=\frac{F\,a}{3l\,EI}\left[\frac{b(l+a)}{3}\right]^{\frac{3}{2}}$ $a>b$ „ $x_A=\left[\frac{a(l+b)}{3}\right]^{\frac{1}{2}}$ „ $f=\frac{F.b}{3l\,EI}\left[\frac{a(l+b)}{3}\right]^{\frac{3}{2}}$ $\theta_A=\frac{F\,a\,b(l+b)}{6l\,EI}$ „ $\theta_B=\frac{F\,a\,b(l+a)}{6l\,EI}$
	$M=\frac{F\,l}{4}$ 	$R_A=R_B=\frac{F}{2}$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{F\,l^3}{48\,EI}$ „ $\theta_A=\theta_B=\frac{F\,l^2}{16\,EI}$
	$M=F.a$ 	$R_A=R_B=F$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{F.a}{24EI}(3l^2-4a^2)$ $\theta_A=\theta_B=\frac{F.a(l-a)}{2EI}$
	$M=\frac{F\,l}{2}$ 	$R_A=R_B=\frac{3F}{2}$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{19}{384}\,\frac{F}{EI}\,l^3$ $\theta_A=\theta_B=\frac{5F\,l^2}{32\,EI}$
 $n=\frac{l}{a}$	$n=2k$ „ $M=\frac{n}{8}F\,l$ $n=2k+1$ „ $M=\frac{n^2-1}{8n}F\,l$ 	$R_A=R_B=\frac{n-1}{2}F$ 	$x_A=x_B=\frac{l}{2}\begin{cases} n=2k \text{ „ } f=\frac{5n^2-4}{384.n}\cdot\frac{F\,l^3}{EI} \\ n=2k+1 \text{ „ } f=\frac{(5n^2+1)(n^2-1)}{384\,n^3}\cdot\frac{F\,l^3}{EI}\end{cases}$ $\theta_A=\theta_B=\frac{n^2-1}{24\,n}\cdot\frac{F\,l^2}{EI}$
 $n=\frac{l}{a}$	$n=2k$ „ $M=\frac{n}{8}F\,l$ $n=2k+1$ „ $M=\frac{n^2+1}{8n}F\,l$ 	$R_A=R_B=\frac{n}{2}F$ 	$x_A=x_B=\frac{l}{2}\begin{cases} n=2k \text{ „ } f=\frac{-n^4+6n^3+2n^2+4n-4}{384\,n^2}\cdot\frac{F\,l^3}{EI} \\ n=2k+1 \text{ „ } f=\frac{5n^4+2n^2+1}{384\,n^3}\cdot\frac{F\,l^3}{EI}\end{cases}$ $\theta_A=\theta_B=\frac{2n^2+1}{48n}\cdot\frac{F\,l^2}{EI}$
	$M=\frac{1}{8}q\,l^2$ 	$R_A=R_B=\frac{q\,l}{2}$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{5}{384}\,\frac{q\,l^4}{EI}$ $\theta_A=\theta_B=\frac{q\,l^3}{24\,EI}$
	$x_\alpha=\frac{a(l+b)}{2l}$ „ $M=\frac{q\,a^2(l+b)^2}{8l^2}$ 	$R_A=\frac{q\,a(l+b)}{2l}$ $R_B=\frac{q\,a^2}{2l}$ 	$a<0'4531.l$ „ $x_B=\left[\frac{2l^2-a^2}{6}\right]^{\frac{1}{2}}$ „ $f=\frac{q\,a^2}{6}\left[\frac{2l^2-a^2}{6}\right]^{\frac{3}{2}}$ $a>0'4531.l$ „ $x_B=\frac{58'575\cdot l-8'575\,a}{100}$ „ $f=\frac{q\,l^4}{10^3\,EI}(13'5734\,\frac{a}{l}-0'5526)$ $\theta_A=\frac{q\,a^2 l}{24\,EI}(2-\frac{a}{l})^2$ „ $\theta_B=\frac{q\,a^2 l}{24\,EI}(2-\frac{a^2}{l^2})$

TABLA 1. Continuación
VIGA APOYADA. DISTINTAS HIPÓTESIS DE CARGA

q y segmentos en valor absoluto





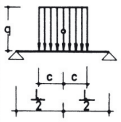
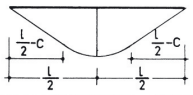
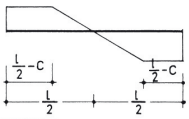
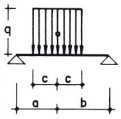
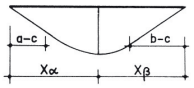
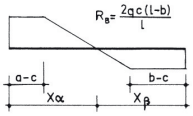
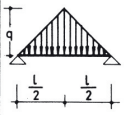
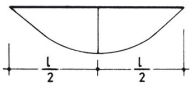
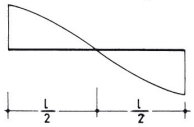
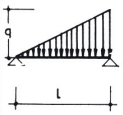
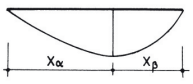
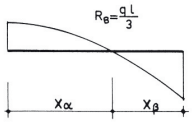
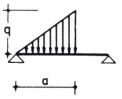
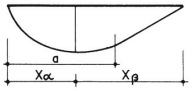
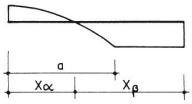
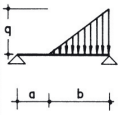
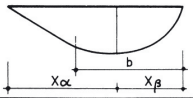
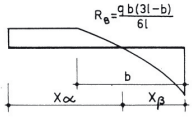
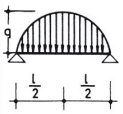
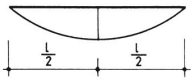
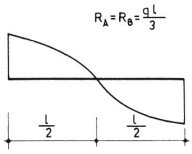
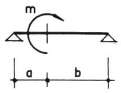
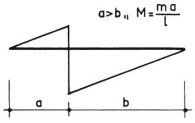
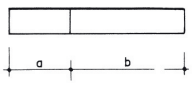
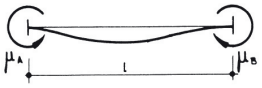
SOLICITACION	DIAGRAMA DE MOMENTOS FLECTORES MOMENTO MAXIMO	DIAGRAMA DE ESFUERZOS CORTANTES REACCIONES EN APOYOS	FLECHAS MAXIMAS ANGULOS DE GIRO EXTREMOS
	$M=\frac{qc(l-c)}{2}$ 	$R_A=R_B=qc$ 	$x_A=x_B=\frac{l}{2}$,, $f=\frac{qcl^3}{24EI}\left[1-\frac{c^2}{l^2}\left(2-\frac{c}{l}\right)\right]$ $\theta_A=\theta_B=\frac{qcl^2}{24EI}\left(3-4\frac{c^2}{l^2}\right)$
	$x_\alpha=a+c-\frac{2ac}{l}$,, $M=2qac\left(\frac{b-c}{l}+\frac{ac}{l^2}\right)$ 	$R_A=\frac{2qc(l-a)}{l}$ $R_B=\frac{2qc(l-b)}{l}$ 	$\theta_A=\frac{qbcl}{3EI}\left(1-\frac{b^2}{l^2}-\frac{c^2}{l^2}\right)$,, $\theta_B=\frac{qacl}{3EI}\left(1-\frac{a^2}{l^2}-\frac{c^2}{l^2}\right)$
	$M=\frac{ql^2}{12}$ 	$R_A=R_B=\frac{ql}{4}$ 	$x_A=x_B=\frac{l}{2}$,, $f=\frac{ql^4}{120EI}$ $\theta_A=\theta_B=\frac{5ql^3}{196\cdot EI}$
	$x_\alpha=\frac{l}{\sqrt{3}}$ $M=\frac{ql^2}{9\sqrt{3}}$ 	$R_A=\frac{ql}{6}$ $R_B=\frac{ql}{3}$ 	$x_A=0'5193\,l$,, $f=\frac{6'522}{10^3}\cdot\frac{ql^4}{EI}$ $\theta_A=\frac{7ql^3}{360\cdot EI}$,, $\theta_B=\frac{ql^3}{45\cdot EI}$
	$x_\alpha=a\left[\frac{3L-2a}{3L}\right]^{1/2}$,, $M=\frac{qa^2}{3}\left[\frac{3L-2a}{3L}\right]^{3/2}$ 	$R_A=\frac{qa(3L-2a)}{6l}$ $R_B=\frac{qa^2}{3l}$ 	$a<0'4607\cdot l$,, $x_B=\left[\frac{5l^2-3a^2}{15}\right]^{\frac{1}{2}}$,, $f=\frac{qa^2}{9EIl}\left[\frac{5l^2-3a^2}{15}\right]^{\frac{3}{2}}$ $a>0'4607\cdot l$,, $x_A=(1'593\frac{a}{l}-1'0737)\,l$,, $f=\frac{ql^4}{10^3EI}\left(4'117+2'405\frac{a}{l}\right)$ $\theta_A=\frac{(12a^2-45al+40l^2)qa^2}{360EIl}$,, $\theta_B=\frac{(5l^2-3a^2)qa^2}{90EIl}$,,
	$x_\beta=b\left(1-\sqrt{\frac{b}{3l}}\right)$,, $M=\frac{qb^2}{6}\left[\frac{a}{l}+2\left(\frac{b}{3l}\right)^{3/2}\right]$ 	$R_A=\frac{qb^2}{6l}$ $R_B=\frac{qb(3l-b)}{6l}$ 	$b<0'4396\cdot l$,, $x_A=\left[\frac{10l^2-3b^2}{30}\right]^{\frac{1}{2}}$,, $f=\frac{qb^2}{18EIl}\left[\frac{10l^2-3b^2}{30}\right]^{\frac{3}{2}}$ $b>0'4396\cdot l$,, $x_A=(1'2527-0'7334\frac{b}{l})\,l$,, $f=\frac{ql^4}{10^3EI}\left(8'267\frac{b}{l}-1'745\right)$ $\theta_A=\frac{(10l^2-3b^2)qb^2}{360EIl}$,, $\theta_B=\frac{(20l^2-15bl+3b^2)qb^2}{360\cdot EIl}$,,
c. parabólica 	$M=\frac{5}{48}ql^2$ 	$R_A=R_B=\frac{ql}{3}$ 	$x_A=x_B=\frac{l}{2}$,, $f=\frac{61\,ql^4}{5.760\cdot EI}$ $\theta_A=\theta_B=\frac{ql^3}{30\cdot EI}$
	$a<b$,, $M=\frac{mb}{l}$ $a>b$,, $M=\frac{ma}{l}$ 	$R_A=-R_B=\frac{m}{l}$ 	$a<b$,, $x_A=l-\left[\frac{l^2-3a^2}{3}\right]^{\frac{1}{2}}$,, $f=\frac{m}{3EIl}\left[\frac{l^2-3a^2}{3}\right]^{\frac{3}{2}}$ $b<a$,, $x_B=l-\left[\frac{l^2-3b^2}{3}\right]^{\frac{1}{2}}$,, $f=\frac{m}{3EIl}\left[\frac{l^2-3b^2}{3}\right]^{\frac{3}{2}}$ $\theta_A=\frac{m(l^2-3b^2)}{6EIl}$,, $\theta_B=\frac{m(l^2-3a^2)}{6EIl}$,,

TABLA 2
VIGA EMPOTRADA. DISTINTAS HIPÓTESIS DE CARGA

F,q y segmentos, en valor absoluto.



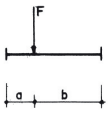
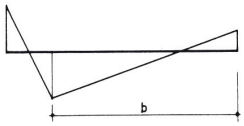
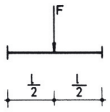
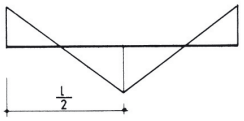
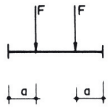
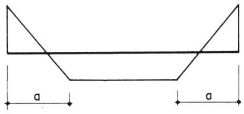
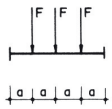
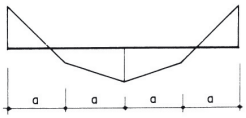
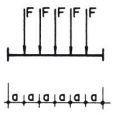
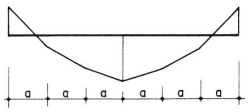
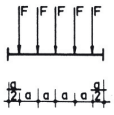
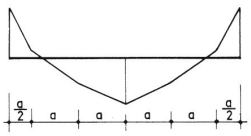
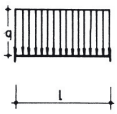
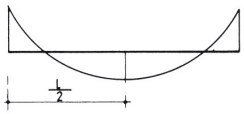
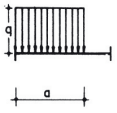
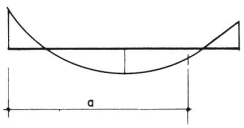
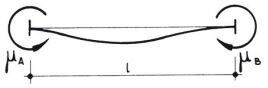
SOLICITACION	MOMENTOS DE EMPOTRAMIENTO PERFECTO	REACCIONES EN LOS APOYOS	DIAGRAMA DE MOMENTOS FLECTORES
	$\mu_A = \frac{Fab^2}{l^2}$ $\mu_B = -\frac{Fa^2b}{l^2}$	$R_A = F\frac{b^2}{l^2}(3-2\frac{b}{l})$ $R_B = F\frac{a^2}{l^2}(3-2\frac{a}{l})$	
	$\mu_A = \frac{Fl}{8}$ $\mu_B = -\frac{Fl}{8}$	$R_A = \frac{F}{2}$ $R_B = \frac{F}{2}$	
	$\mu_A = \frac{Fa(l-a)}{l}$ $\mu_B = -\frac{Fa(l-a)}{l}$	$R_A = F$ $R_B = F$	
	$\mu_A = \frac{5Fl}{16}$ $\mu_B = -\frac{5Fl}{16}$	$R_A = \frac{3}{2}F$ $R_B = \frac{3}{2}F$	
 nº de fuerzas=n−1	$\mu_A = \frac{Fl(n^2-1)}{12n}$ $\mu_B = -\frac{Fl(n^2-1)}{12n}$	$R_A = \frac{n-1}{2}F$ $R_B = \frac{n-1}{2}F$	
 nº de fuerzas = n	$\mu_A = \frac{Fl(2n^2+1)}{24n}$ $\mu_B = -\frac{Fl(2n^2+1)}{24n}$	$R_A = \frac{n}{2}F$ $R_B = \frac{n}{2}F$	
	$\mu_A = \frac{ql^2}{12}$ $\mu_B = -\frac{ql^2}{12}$	$R_A = \frac{ql}{2}$ $R_B = \frac{ql}{2}$	
	$\mu_A = \frac{qa^2}{12}\left[6-\frac{a}{l}(8-3\frac{a}{l})\right]$ $\mu_B = -\frac{qa^3}{12l}(4-3\frac{a}{l})$	$R_A = \frac{qa}{2}\left[2-\frac{a^2}{l^2}(2-\frac{a}{l})\right]$ $R_B = \frac{qa^3}{2l^2}(2-\frac{a}{l})$	

TABLA 2. Continuación
VIGA EMPOTRADA. DISTINTAS HIPÓTESIS DE CARGA

F, q y segmentos, en valor absoluto.



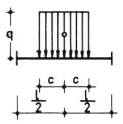
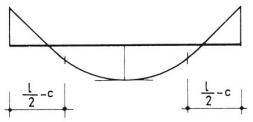
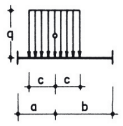
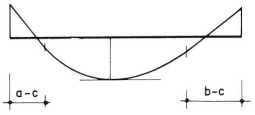
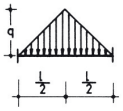
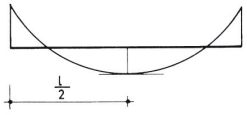
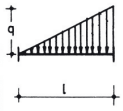
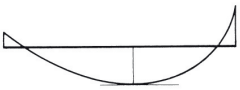
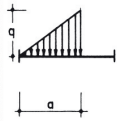
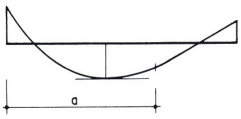
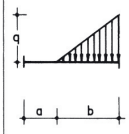
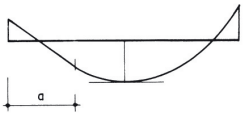
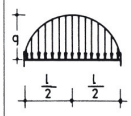
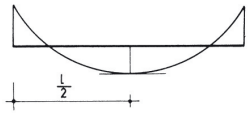
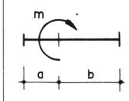
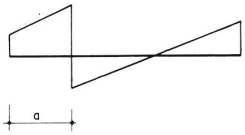
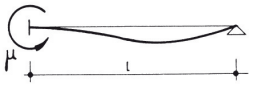
SOLICITACION	MOMENTOS DE EMPOTRAMIENTO PERFECTO	REACCIONES EN LOS APOYOS	DIAGRAMA DE MOMENTOS FLECTORES
	$\mu_A = \frac{qc}{12l}(3l^2-4c^2)$ $\mu_B = -\frac{qc}{12l}(3l^2-4c^2)$	$R_A = qc$ $R_B = qc$	
	$\mu_A = 2qc\left(a\frac{b^2}{l^2} - \frac{c^2}{l^2}\frac{3b-l}{3}\right)$ $\mu_B = -2qc\left(b\frac{a^2}{l^2} - \frac{c^2}{l^2}\frac{3a-l}{3}\right)$	$R_A = 2qc\left[1-3\frac{a^2}{l^2}\cdot\frac{c^2}{l^2}+2\frac{a}{l}\left(\frac{a^2}{l^2}+\frac{c^2}{l^2}\right)\right]$ $R_B = 2qc\left[3\frac{a^2}{l^2}+\frac{c^2}{l^2}-2\frac{a}{l}\left(\frac{a^2}{l^2}+\frac{c^2}{l^2}\right)\right]$	
	$\mu_A = \frac{5}{96}ql^2$ $\mu_B = -\frac{5}{96}ql^2$	$R_A = \frac{ql}{4}$ $R_B = \frac{ql}{4}$	
	$\mu_A = \frac{ql^2}{30}$ $\mu_B = -\frac{ql^2}{20}$	$R_A = \frac{3}{20}ql$ $R_B = \frac{7}{20}ql$	
	$\mu_A = \frac{qa^2}{30}\left[10-\frac{a}{l}\left(15-6\frac{a}{l}\right)\right]$ $\mu_B = -\frac{qa^3}{20l}\left(5-4\frac{a}{l}\right)$	$R_A = \frac{qa}{20}\left[10-\frac{a^2}{l^2}\left(15-8\frac{a}{l}\right)\right]$ $R_B = \frac{qa^3}{20l^2}\left(15-8\frac{a}{l}\right)$	
	$\mu_A = \frac{qb^3}{60l}\left(5-3\frac{b}{l}\right)$ $\mu_B = -\frac{qb^2}{60}\left[3\frac{b^2}{l^2}+10\frac{a}{l}\right]$	$R_A = \frac{qb^3}{20l^2}\left(5-\frac{2b}{l}\right)$ $R_B = \frac{qb}{20}\left[10-\frac{b^2}{l^2}\left(5-2\frac{b}{l}\right)\right]$	
carga parabólica 	$\mu_A = \frac{ql^2}{15}$ $\mu_B = -\frac{ql^2}{15}$	$R_A = \frac{ql}{3}$ $R_B = \frac{ql}{3}$	
	$\mu_A = m\frac{b}{l}\left(2-3\frac{b}{l}\right)$ $\mu_B = m\frac{a}{l}\left(2-3\frac{a}{l}\right)$	$R_A = m\frac{6ab}{l^3}$ $R_B = -m\frac{6ab}{l^3}$	

TABLA 3
VIGA APOYADA EMPOTRADA. DISTINTAS HIPÓTESIS DE CARGA

F,q y segmentos, en valor absoluto.



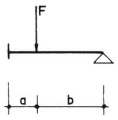
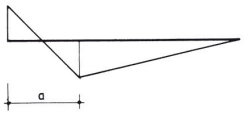
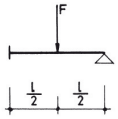
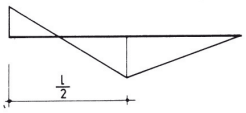
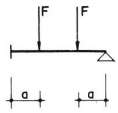
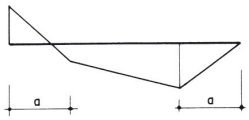
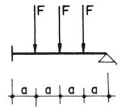
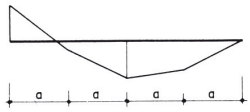
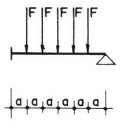
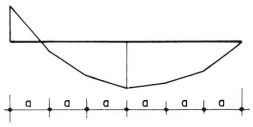
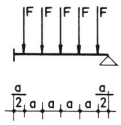
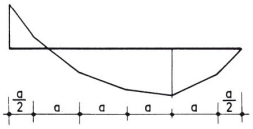
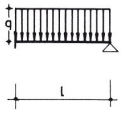
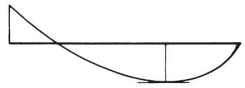
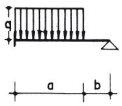
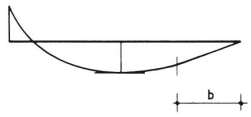
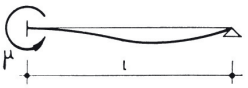
SOLICITACION	MOMENTOS DE EMPOTRAMIENTO PERFECTO	REACCIONES EN LOS APOYOS	DIAGRAMA DE MOMENTOS FLECTORES
	$\mu=\frac{Fab(l+b)}{2l^2}$	$R_A=\frac{Fb}{2l}(3-\frac{b^2}{l^2})$ $R_B=\frac{Fa^2}{2l^2}(3-\frac{a}{l})$	
	$\mu=\frac{3}{16}Fl$	$R_A=\frac{11}{16}F$ $R_B=\frac{5}{16}F$	
	$\mu=\frac{3Fa(l-a)}{2l}$	$R_A=\frac{F}{2}\left[2+3\frac{a}{l}(1-\frac{a}{l})\right]$ $R_B=\frac{F}{2}\left[2-3\frac{a}{l}(1-\frac{a}{l})\right]$	
	$\mu=\frac{15}{32}Fl$	$R_A=\frac{63}{32}F$ $R_B=\frac{33}{32}F$	
 nº de fuerzas = n−1	$\mu=\frac{n^2-1}{8n}Fl$	$R_A=\frac{(n-1)(5n+1)}{8n}F$ $R_B=\frac{(n-1)(3n-1)}{8n}F$	
 nº de fuerzas = n	$\mu=\frac{2n^2+1}{16n}Fl$	$R_A=\frac{10n^2+1}{16n}F$ $R_B=\frac{6n^2-1}{16n}F$	
	$\mu=\frac{1}{8}ql^2$	$R_A=\frac{5}{8}ql$ $R_B=\frac{3}{8}ql$	
	$\mu=\frac{qa^2(l+b)^2}{8l^2}$	$R_A=\frac{qa}{8}(5-\frac{b^2}{l^2})(1+\frac{b}{l})$ $R_B=\frac{qa^3}{8l^2}(4-\frac{a}{l})$	

TABLA 3. Continuación
VIGA APOYADA EMPOTRADA. DISTINTAS HIPÓTESIS DE CARGA

F, q y segmentos, en valor absoluto



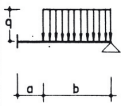
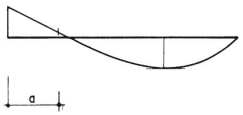
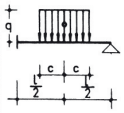
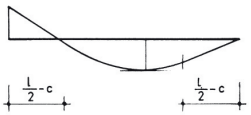
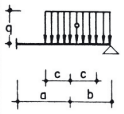
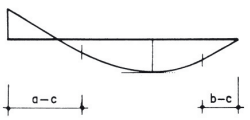
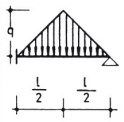
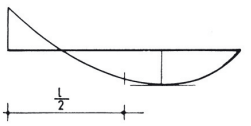
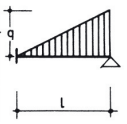
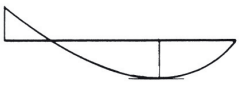
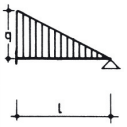
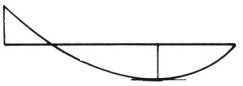
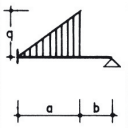
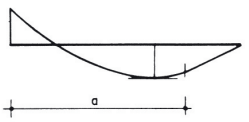
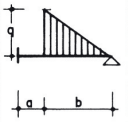
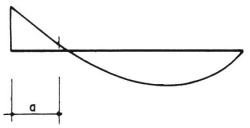
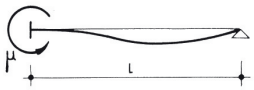
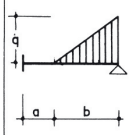
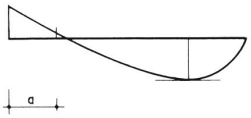
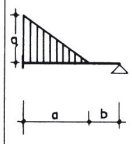
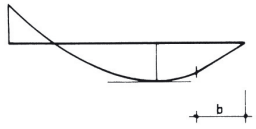
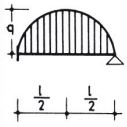
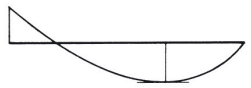
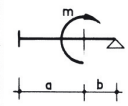
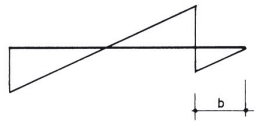
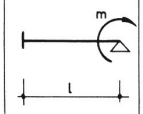
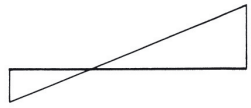
SOLICITACION	MOMENTOS DE EMPOTRAMIENTO PERFECTO	REACCIONES EN LOS APOYOS	DIAGRAMA DE MOMENTOS FLECTORES
	$\mu = \frac{q b^2}{8 l^2}(2l^2 - b^2)$	$R_A = \frac{q b^2}{8 l}\left(6 - \frac{b^2}{l^2}\right)$ $R_B = \frac{q b}{8}\left[8 - \frac{b}{l}\left(6 - \frac{b^2}{l^2}\right)\right]$	
	$\mu = \frac{q c}{8 l}(3l^2 - 4c^2)$	$R_A = \frac{q c}{8}\left(11 - 4\frac{c^2}{l^2}\right)$ $R_B = \frac{q c}{8}\left(5 + 4\frac{c^2}{l^2}\right)$	
	$\mu = \frac{q b c}{l^2}\left[a(l+b) - c^2\right]$	$R_A = qc\left[2 - 3\frac{a^2}{l^2} - \frac{c^2}{l^2} + \frac{a}{l}\left(\frac{a^2}{l^2} + \frac{c^2}{l^2}\right)\right]$ $R_B = qc\left[3\frac{a^2}{l^2} + \frac{c^2}{l^2} - \frac{a}{l}\left(\frac{a^2}{l^2} + \frac{c^2}{l^2}\right)\right]$	
	$\mu = \frac{5}{64} q\, l^2$	$R_A = \frac{21}{64} q\, l$ $R_B = \frac{11}{64} q\, l$	
	$\mu = \frac{7}{120} q\, l^2$	$R_A = \frac{9}{40} q\, l$ $R_B = \frac{11}{40} q\, l$	
	$\mu = \frac{q l^2}{15}$	$R_A = \frac{2}{5} q\, l$ $R_B = \frac{q l}{10}$	
	$\mu = \frac{q a^2}{120}\left[40 - 3\frac{a}{l}\left(15 - 4\frac{a}{l}\right)\right]$	$R_A = \frac{q a}{40}\left[20 - \frac{a^2}{l^2}\left(15 - 4\frac{a}{l}\right)\right]$ $R_B = \frac{q a^3}{40 l^2}\left(15 - 4\frac{a}{l}\right)$	
	$\mu = \frac{q b^2}{30}\left(5 - 3\frac{b^2}{l^2}\right)$	$R_A = \frac{q b^2}{10 l}\left(5 - \frac{b^2}{l^2}\right)$ $R_B = \frac{q b}{10}\left[5 - \frac{b}{l}\left(5 - \frac{b^2}{l^2}\right)\right]$	

TABLA 3. Continuación
VIGA APOYADA EMPOTRADA. DISTINTAS HIPÓTESIS DE CARGA

F, q y segmentos, en valor absoluto



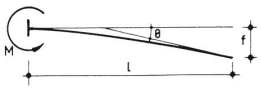
SOLICITACION	MOMENTOS DE EMPOTRAMIENTO PERFECTO	REACCIONES EN LOS APOYOS	DIAGRAMA DE MOMENTOS FLECTORES
	$\mu=\frac{q\,b^2}{120}(10-3\frac{b^2}{l^2})$	$R_A=\frac{q\,b^2}{40\cdot l}(10-\frac{b^2}{l^2})$ $R_B=\frac{q\,b}{40}\left[20-\frac{b}{l}(10-\frac{b^2}{l^2})\right]$	
	$\mu=\frac{q\,a^2}{120}\left[20-3\frac{a}{l}(5-\frac{a}{l})\right]$	$R_A=\frac{q\,a}{40}\left[20-\frac{a^2}{l^2}(5-\frac{a}{l})\right]$ $R_B=\frac{q\,a^3}{40\cdot l^2}(5-\frac{a}{l})$	
c. parabólica 	$\mu=\frac{q\,l^2}{10}$	$R_A=\frac{13}{30}q\,l$ $R_B=\frac{7}{30}q\,l$	
	$\mu=\frac{m}{2}(1-3\frac{b^2}{l^2})$	$R_A=\frac{3}{2}\frac{m\,a}{l^2}(2-\frac{a}{l})$ $R_B=-\frac{3}{2}\frac{m\,a}{l^2}(2-\frac{a}{l})$	
	$\mu=\frac{m}{2}$	$R_A=\frac{3}{2}\frac{m}{l}$ $R_B=-\frac{3}{2}\frac{m}{l}$	

CALCULO DEL MOMENTO DE EMPOTRAMIENTO DE UNA VIGA APOYADA-EMPOTRADA EN FUNCION DE LOS MOMENTOS DE EMPOTRAMIENTO PERFECTO.

$$\mu=\mu_A-\beta_B\cdot\mu_B$$

$$\mu=\mu_A-\frac{1}{2}\mu_B$$

TABLA 4
VIGA EN VOLADIZO. DISTINTAS HIPÓTESIS DE CARGA



F, q y segmentos en valor absoluto

SOLICITACION	DIAGRAMA DE MOMENTOS FLECTORES MOMENTO MAXIMO	DIAGRAMA DE ESFUERZOS CORTANTES REACCION EN APOYO	FLECHA MAXIMA ANGULO DE GIRO EXTREMO
F; a, b	b; $M = F.a$	b; $R = F$	$f = Fa^2 \frac{3L-a}{6EI}$; $\theta = \frac{Fa^2}{2EI}$
F; l	$M = Fl$	$R = F$	$f = \frac{Fl^3}{3EI}$; $\theta = \frac{Fl^2}{2EI}$
q; l	$M = \frac{1}{2} q l^2$	$R = q l$	$f = \frac{q l^4}{8EI}$; $\theta = \frac{q l^3}{6EI}$
q; a, b	b; $M = \frac{1}{2} q a^2$	b; $R = qa$	$f = q a^3 \frac{4l-a}{24EI}$; $\theta = \frac{q a^3}{6EI}$
q; c, c; a, b	$M = 2qca$; a-c, 2c, b-c	$R = 2qc$; a-c, 2c, b-c	$f = \frac{qca^2}{3EI}\left[l\left(3+\frac{c^2}{a^2}\right) - a\left(1+\frac{c^2}{a^2}\right)\right]$; $\theta = \frac{q}{6EI}\left[a^3 - 15c^3 + 3ac(a+c)\right]$
q; l	$M = \frac{1}{6} q l^2$	$R = \frac{1}{2} q l$	$f = \frac{q l^4}{30EI}$; $\theta = \frac{q l^3}{24EI}$
q; a, b	$M = \frac{1}{6} q l^2$; b	$R = \frac{1}{2} q l$; b	$f = \frac{q a^3}{120EI}(5l - a)$; $\theta = \frac{q a^3}{24EI}$
m; a, b	$M = m$; a, b	$R = 0$	$f = \frac{ma}{2EI}(2l - a)$; $\theta = \frac{ma}{EI}$

TABLA 5
TABLA DE CARACTERÍSTICAS GEOMÉTRICAS DE DIVERSAS FIGURAS

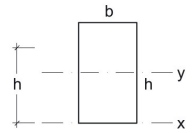
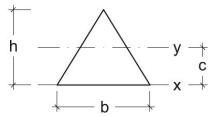
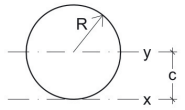
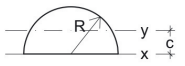
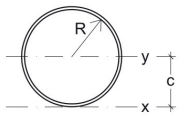
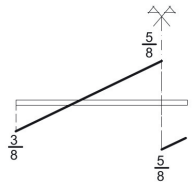
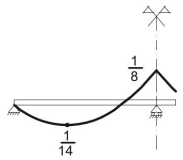
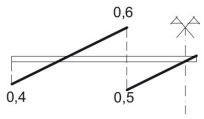
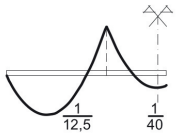
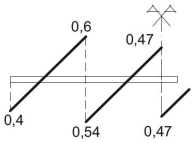
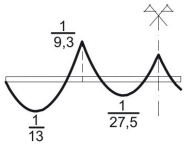
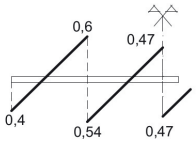
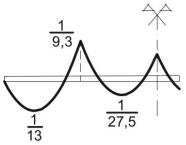
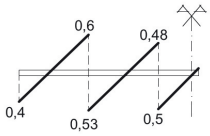
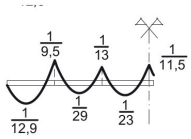
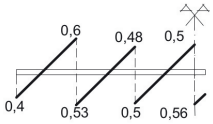
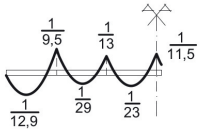
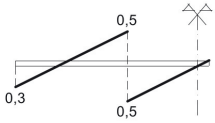
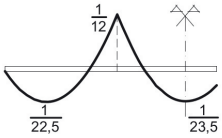
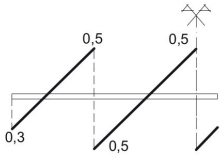
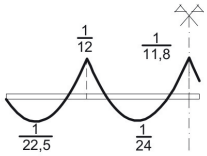
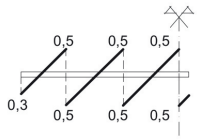
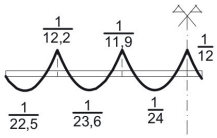
Figura	*c* (centro de gravedad)	*A*, área *L*, longitud	S_x momento estático	I_y momento de inercia
	$\frac{h}{2}$	$b \cdot h$	$\frac{b\,h^2}{2}$	$\frac{1}{12} b\,h^3$
	0	$\frac{1}{2} b\,h$	$\frac{b\,h^2}{6}$	$\frac{1}{36} b\,h^3$
	R	πR^2	πR^3	$\frac{1}{4} \pi R^4$
	$\frac{4}{3\pi} R$	$\frac{\pi}{2} R^2$	$\frac{2}{3} R^3$	$I_x = \frac{1}{8} \pi R^4$ $I_y = 0{,}1098\, R^4$
 (*e*<<*R*)	R	$2\,\pi R \cdot e$	$2\,\pi R^2 e$	$\pi R^3\, e$
(*e*<<*R*)	$\frac{2R}{\pi}$	$\pi R \cdot e$	$2 R^2 e$	$I_x = \frac{\pi}{2} R^3 e$ $I_y = \left(\frac{\pi}{2} - \frac{4}{\pi}\right) R^3 e$

TABLA 6
ESFUERZOS FLECTORES Y CORTANTES DE VIGAS CONTINUAS CON CARGA UNIFORME q

Luces	Esfuerzo cortante [$k \cdot q\ L$]	Momento flector [$k \cdot q\ l^2$]
Luces iguales		
		
		
		
		
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