

Fanalca



MANUAL DE DISEÑO

TUBOS ESTRUCTURALES



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1. INTRODUCCIÓN

FANALCA, una organización Colombiana diversificada, desde nuestra fundación en 1958, hemos trabajado para contribuir al desarrollo del país, atendiendo los sectores de transporte, servicio público, textil, financiero y metalmecánico.

Desde 1975 fabricamos tubos soldados con el mejor acero del mercado, construyendo un negocio basado en la calidad y el respaldo, convirtiéndonos en uno de los principales fabricantes de la industria.

Nuestros tubos son fabricados a partir de lámina cortada en flejes, la cual es sometida a un proceso de formado a través de una serie de rodillos y sus bordes se fusionan en un tratamiento especial de soldadura por inducción de alta frecuencia. El largo final se obtiene con un sistema de corte con sierra controlado por un PLC. Contamos con maquinaria de alta tecnología, que unida a un estricto control de procesos, nos permite ofrecer un producto de excelente calidad, con acabado perfecto en corte y soldadura, garantizando así la más alta confiabilidad.

Implementamos un sistema integrado de gestión de calidad que nos permite certificarnos en:

- ☒ **ISO 9001** (Sistema de gestión de calidad).
- ☒ **OHSAS 18001** (Sistema de gestión en seguridad y salud en el trabajo).
- ☒ **ISO 14001** (Sistema de gestión ambiental).

Nuestro gran interés es contribuir al crecimiento de nuestros clientes y por ende al del país, fortaleciéndonos con un amplio portafolio de productos, diversidad en referencias y calibres, para continuar atendiendo las necesidades de los sectores de construcción pesada, liviana y de transformación industrial. Buscamos siempre cumplir con las expectativas de nuestros clientes con disponibilidad, altos estándares de calidad y servicio.

Contamos con una fuerza de ventas experta y especializada con sede en las principales ciudades del país y cobertura en la mayoría de los territorios, por medio de la cual brindamos la mejor atención, asesoría y servicio a los canales mayorista, minorista e industrial.

Gracias a nuestros productos, nuestro talento humano, nuestra calidad, nuestros proyectos, nuestro servicio y nuestro compromiso, día a día nos posicionamos como una de las principales fábricas de tubos y perfiles en Colombia.

FANALCA consciente de la importancia de brindar herramientas que faciliten y ayuden al desarrollo, calidad, conocimiento, mejoramiento y buenas prácticas de la construcción en acero, presenta su manual técnico de diseño para tubería estructural, el cual servirá de apoyo a profesionales, ingenieros, calculistas, arquitectos, constructores, fabricantes de estructuras metálicas y estudiantes de ingeniería y arquitectura.

Las tablas, gráficas y valores consignados en el presente manual son válidos únicamente para los tubos estructurales **FANALCA**, cuyas propiedades físicas, geométricas y mecánicas son propias de su proceso productivo y del material utilizado en la fabricación.

Los resultados contenidos en este documento han sido realizados con base en el método de los Factores de Carga y Resistencia de las normas **AISI-LRFD 2007-Cold Formed Steel Design Manual y Reglamento Colombiano de Construcción Sismoresistente NSR-10**; y por tal motivo los cálculos realizados deben ser revisados y aprobados por un profesional idóneo en la materia.

Cali, Marzo de 2018.



NORMAS Y PROCEDIMIENTOS DE FABRICACIÓN

2. NORMAS Y PROCEDIMIENTOS DE FABRICACIÓN

Los Tubos Estructurales **FANALCA** son fabricados en lámina de acero HR Estructural (HR-E), para aplicaciones con alta exigencia mecánica y usos especiales con especificaciones definidas. Son utilizados en bodegas, cubiertas, cornisas, cerchas, columnas, escaleras, mezanines, edificios, estructuras para levantamiento de muros, fabricación de contenedores, estructuras de carrocerías, puentes peatonales y vehiculares, y estructuras metálicas en general.

Los tubos **FANALCA** se fabrican mediante un proceso comúnmente denominado "proceso de ERW" (*Electric Resistance Welding* o soldadura por resistencia eléctrica). Las bobinas de acero laminado en caliente se cortan en el ancho apropiado y se introducen en un laminador de tubos que prepara los bordes para su soldadura y luego utiliza una serie de rodillos para laminar en frío el acero plano y transformarlo en un tubo cilíndrico (circular). Una vez que el acero plano tomó la forma de un tubo cilíndrico, se sueldan entre sí los bordes. La soldadura es por resistencia eléctrica creada mediante la inducción de alta frecuencia y la resistencia eléctrica natural del acero para calentar los bordes de la tira de acero. Los rodillos utilizan presión para juntar los bordes de la placa de acero casi fundido y formar una unión metalúrgica. A medida que el acero se comprime y se crea la unión, el exceso de acero produce un cordón de soldadura tanto dentro como fuera del tubo. El cordón externo se elimina para que la terminación de la parte exterior quede lisa. Posteriormente el tubo se enfría y pasa por una serie de estaciones de compresión que le dan su forma definitiva, ya sea redonda, cuadrada o rectangular.

Finalmente, el tubo se corta en la longitud deseada. En este punto, el tubo se transporta a una mesa donde se agrupan los perfiles de similar tamaño y longitud, que luego se cargan en camiones para la entrega o se envían al sitio de almacenamiento.

Si bien existen varias normas ASTM para la producción de tubos, el proceso de fabricación denominado ERW, es el más utilizado para la producción de tubos bajo la norma A500 de ASTM, (Especificación para tubos estructurales de acero al carbono conformados en frío,

electrosoldados y con costura, de forma circular y no circular). Esta norma describe los procesos de fabricación, pedido de productos terminados y determinación de calidad del producto. La norma A500 de ASTM también describe los requisitos relativos a las propiedades químicas y mecánicas del producto terminado, así como las tolerancias permitidas en el producto y las pruebas de control de calidad requeridas. Adicionalmente, la norma A500 de ASTM exige la realización de dos pruebas destructivas: la prueba de resistencia a la tracción y la prueba de aplastamiento.

El **AISC** (American Institute of Steel Construction), en su 14a Edición del Steel Construction Manual del año 2010, en su última actualización presenta una nueva norma de **ASTM**, la **A1085**, Especificación para **HSS** (Hollow Structural Section) - Perfiles Estructurales Huecos, de acero al carbono conformados en frío, publicada en abril de 2013.

Esta nueva norma **A1085** de ASTM fue desarrollada para mejorar el nivel de rendimiento de los **HSS** utilizados en la construcción, en especial en aquellas estructuras que están sujetas a cargas dinámicas y sísmicas. Esto incluye puentes y edificios en zonas sísmicas. **FANALCA** apoya el desarrollo de esta nueva norma en nuestro país, porque considera que se trata de una mejora muy necesaria para la fabricación de los **HSS**, la cual debe quedar consignada en la próxima versión de la **NSR (18-19)**.



ESPECIFICACIONES TÉCNICAS

Norma de fabricación:
NTC 4526 – ASTM A500 Grado C.

Pruebas de producto:

Abocardado - Norma Técnica Colombiana NTC 103.

Aplastamiento - Norma Técnica Colombiana NTC 42.

Acero según norma:

ASTM A1011 SS Gr.50, ASTM A572 Gr.50, ASTM A1011 HSLAS Gr.50, ASTM A1018 Gr.50 Clase 1 u otras normas contempladas en la NTC 4526.

Tolerancias:

Longitud:

+13mm -6mm para tubos $\leq 6.7\text{m}$

+25mm -6mm para tubos $> 6.7\text{m}$.

Dimensión:

☒ Redondos: $\pm 0.0075\text{ De}$, si $\text{De} > 50\text{mm}$. $\pm 0.005\text{mm De}$, si $\text{De} \leq 50\text{mm}$.

☒ Cuadrados: $\pm 1.5\text{ mm}$.

☒ Rectangulares: $\pm 1.5\text{ mm}$ (medido sobre el lado mayor).

De = Diámetro exterior

Espesor:

$\pm 0.1t$, t = espesor especificado.

Longitud estándar:

6.0 metros / Para medidas especiales consulte a su coordinador de ventas.

PROPIEDADES

Composición Química

Elemento	% Máximo
Carbono (C)	0.27%
Manganeso (Mn)	1.40%
Fósforo (P)	0.045%
Azufre (S)	0.045%

Tipo de tubo	Esfuerzo de Fluencia F_y MPa - (psi)	Esfuerzo Último F_u MPa - (psi)	Elongación Mínima en 2" (%)
Redondos	317.2 - (46,000)	427.5 - (62,000)	21
Cuadrados y Rectangulares	345 - (50,000)	427.5 - (62,000)	21



REQUISITOS GENERALES DE DISEÑO Y CONSTRUCCIÓN SEGÚN NSR-10

3. REQUISITOS GENERALES DE DISEÑO Y CONSTRUCCIÓN SEGÚN NSR-10

PROPIEDADES DE LAS SECCIONES

Las propiedades de las secciones tubulares como son área transversal, momento de inercia, módulo de sección, radio de giro, etc., fueron obtenidas de acuerdo a las norma **AISI - LRFD 2007 (American Iron and Steel Institute- Cold Formed Steel Design Manual)**, y NSR-10 Título F, Capítulo F.4 "Estructuras de Acero con Perfiles de Lámina Formada en Frío".

RESISTENCIA MIEMBROS EN TENSIÓN

Para miembros en tensión cargados axialmente, la resistencia nominal a tensión $\phi_t T_n$, debe determinarse así:

a) Para Fluencia en la Sección Bruta

$$T_n = A_g F_y$$

$$\phi_t = 0.90$$

Donde:

T_n = resistencia nominal del miembro cuando se carga a tensión axial

ϕ_t = coeficiente de resistencia para tensión

A_g = área bruta o completa de la sección transversal

F_y = esfuerzo de fluencia de diseño (50 ksi, 35.15 kg/mm², 345 Mpa)

b) Para Rotura en la Sección Neta Lejos de la Conexión

$$T_n = A_n F_u$$

$$\phi_t = 0.75$$

Donde:

T_n = resistencia nominal del miembro cuando se carga a tensión axial

ϕ_t = coeficiente de resistencia para tensión

A_n = área neta de la sección transversal

F_u = resistencia a tensión (65 ksi, 45.69 kg/mm², 448 Mpa)

Nota: Para el caso de **FANALCA**, la resistencia a tensión de las tablas de diseño se obtuvieron para fluencia en la sección bruta y $\phi_t = 0.90$.

RESISTENCIA MIEMBROS A FLEXIÓN

La resistencia nominal a Flexión, M_n , se calculará, bien sea a partir de la base del punto de iniciación de la fluencia en la sección efectiva

(Procedimiento 1) o sobre la base de la capacidad de reserva inelástica (Procedimiento 2), según sea aplicable:

Para secciones con aletas a compresión rigidizadas o parcialmente rigidizadas, $\phi_b = 0.95$

Para secciones con aletas a compresión no rigidizadas, $\phi_b = 0.90$

Procedimiento I - Basado en la iniciación de fluencia – La resistencia nominal a flexión, M_n , para el momento de fluencia se calculará de acuerdo con la siguiente ecuación:

$$M_n = S_e F_y$$

Si la longitud no arriostrada lateralmente del miembro o elemento es menor o igual a L_u .

$$L_u = \frac{0.36 C_b \pi}{F_y S_f} \sqrt{E G J_y}$$

F_y = esfuerzo de fluencia de diseño (50 ksi, 35.15 kg/mm², 345 Mpa)

S_e = módulo elástico de la sección efectiva, calculado considerando la fibra extrema en compresión o tensión al alcanzar el esfuerzo F_y .

S_f = módulo elástico de la sección completa no reducida respecto a la fibra extrema en compresión

C_b = coeficiente de Flexión dependiente del Gradiente de Momento ($C_b = 1.0$)

J = constante Torsional de Saint-Venant de la Sección Tubular

G = módulo de Cortante del Acero

E = módulo de Elasticidad del Acero

I_y = momento de Inercia de la Sección Completa no Reducida Alrededor de su eje Centroidal paralelo al alma.



Procedimiento II - Basado en la capacidad de reserva inelástica – Se permite utilizar la capacidad de reserva inelástica a flexión cuando se cumplan las siguientes condiciones:

1. El miembro no está sujeto a torsión o a pandeo lateral o flexo-torsional.
2. El efecto del formado en frío no se tiene en cuenta para la determinación del punto de fluencia F_y .
3. La relación entre la altura de la zona a compresión y su espesor no excede λ_1 .
4. La fuerza de corte no excede $0.6F_y$ veces el área del alma, para elementos rigidizados ó wt para elementos no rigidizados.
5. El ángulo entre cualquier alma y la vertical no excede 30 Grados.

La resistencia nominal a flexión, M_n , no debe exceder $1.25F_y$ determinado de acuerdo con el procedimiento 1, ni el momento que causa la deformación unitaria máxima de compresión igual a $C_y e_y$. (No se limita la deformación unitaria máxima para la tensión).

Donde:

h = altura plana del alma

t = espesor del acero base del elemento

e_y = deformación unitaria en la fluencia $= F_y/E$

w = ancho plano del elemento

E = módulo de elasticidad del acero

$\lambda = w/t$

C_y = factor de determinación unitaria a compresión, determinado así:

a. Elementos en compresión rigidizados sin rigidizadores intermedios

$C_y = 3.0$ para $w/t \leq \lambda_1$

$C_y = 3-2 \left[\frac{(w/t) - \lambda_1}{\lambda_2 - \lambda_1} \right]$ para $\lambda_1 < w/t < \lambda_2$

$C_y = 1.0$ cuando $w/t \geq \lambda_2$

Donde:

$$\lambda_1 = \frac{1.11}{\sqrt{F_y/E}} \quad \lambda_2 = \frac{1.28}{\sqrt{F_y/E}}$$

Elementos en compresión no rigidizados

Para elementos en compresión no rigidizados, C_y , se calculará como sigue:

i. Elementos en compresión no rigidizados bajo gradiente de esfuerzo causando compresión en un borde longitudinal y tensión en el otro borde longitudinal:

$C_y = 3.0$ cuando $\lambda \leq \lambda_3$

$C_y = 3-2 \left[\frac{(\lambda - \lambda_3)}{(\lambda_4 - \lambda_3)} \right]$, Cuando $\lambda_3 < \lambda < \lambda_4$

$C_y = 1.0$ cuando $\lambda \geq \lambda_4$

Donde:

$\lambda_3 = 0.43$

$\lambda_4 = 0.673(1+\Psi)$

$\Psi = |f_1/f_2|$, f_1 y f_2 esfuerzos de compresión $f_1 \geq f_2$

ii. Elementos en compresión no rigidizados bajo gradiente de esfuerzo que cause compresión en ambos bordes longitudinales:

$C_y = 1.0$

iii. Elementos no rigidizados bajo compresión uniforme:

$C_y = 1.0$



RESISTENCIA AL PANDEO LATERAL TORSIONAL DE MIEMBROS DE SECCIÓN TUBULAR CERRADA (CUADRADA Y RECTANGULAR)

Para miembros en cajón cerrados o secciones tubulares cerradas la resistencia nominal a flexión, M_n , se determinará como sigue:

$$M_n = S_c F_c$$

Donde:

S_c = módulo elástico de la sección efectiva calculado con respecto a la fibra extrema en compresión sometida a un esfuerzo F_c .

F_c se determina así:

Para $F_e \geq 2.78F_y$

$$M_n = S_e F_y$$

Cuando el segmento del miembro o elemento no está sujeto a pandeo lateral torsional para momentos menores o iguales a M_y . La resistencia de diseño a flexión se determinará así:

$$\text{Para } 2.78F_y > F_e > 0.56 F_y ; F_c = \frac{10}{9} F_y \left(1 - \frac{10F_y}{36F_e} \right)$$

Para $F_e \leq 0.56F_y$; $F_c = F_e$

Donde:

F_y = esfuerzo de fluencia de diseño.

F_e = esfuerzo crítico elástico de pandeo lateral torsional

$$F_e = \frac{C_b \pi}{K_y L_y S_f} \sqrt{EGJ I_y}$$

K_y = coeficiente de longitud efectiva respecto al eje y.

L_y = longitud efectiva del elemento respecto al eje y.

RESISTENCIA A FLEXIÓN DE MIEMBROS DE SECCIÓN TUBULAR CILINDRICA CERRADA (REDONDOS)

Para miembros de sección tubular cilíndrica cerrada que tienen una relación diámetro exterior a espesor de pared, D/t , no mayor a $0.441E/F_y$, la resistencia nominal a flexión, M_n , se calculará como sigue:

$$M_n = F_c S_f$$

$$\phi_b = 0.95$$

Para $D/t \leq 0.0714E/F_y$

$$F_c = 1.25F_y$$

Para $0.0714E/F_y < D/t \leq 0.318E/F_y$

$$F_c = \left[0.970 + 0.020 \left(\frac{E/F_y}{D/t} \right) \right] F_y$$

Para $0.318E/F_y < D/t \leq 0.441E/F_y$

$$F_c = 0.328E/(D/t)$$

Donde:

D = diámetro externo del tubo cilíndrico

t = espesor

F_c = esfuerzo crítico de pandeo flector

S_f = módulo elástico de la sección transversal completa no reducida respecto a la fibra extrema en compresión



RESISTENCIA AL CORTE

La resistencia nominal a cortante, V_n , se calculará como sigue:

$$V_n = A_w F_v$$

$$\phi_v = 0.95$$

$$\text{Para } \frac{h}{t} \leq \sqrt{\frac{Ek_v}{F_y}}$$

$$F_v = 0.60F_y$$

$$\text{Para } \sqrt{\frac{Ek_v}{F_y}} < \frac{h}{t} \leq 1.51 \sqrt{\frac{Ek_v}{F_y}}$$

$$F_v = \frac{0.60 \sqrt{Ek_v F_y}}{(h/t)}$$

$$\text{Para } \frac{h}{t} > 1.51 \sqrt{\frac{Ek_v}{F_y}}$$

$$F_v = \frac{\pi^2 Ek_v}{12(1-\mu^2)(h/t)^2} = 0.904 Ek_v / (h/t)^2$$

Donde:

V_n = resistencia nominal al corte

A_w = área del elemento alma = ht

h = altura de la porción plana del alma medida a lo largo de su plano

t = espesor del alma

F_v = esfuerzo nominal de corte

E = módulo de elasticidad del acero

k_v = coeficiente de pandeo al corte igual a 5.34 para almas sin reforzar

μ = relación de poisson

RESISTENCIA MIEMBROS EN COMPRESIÓN

La resistencia de diseño a carga axial nominal de compresión, se calculará así:

$$P_n = A_e F_n$$

$$\phi_c = 0.85$$

Donde:

A_e = área efectiva calculada con el esfuerzo F_n .

F_n debe determinarse así:

$$\text{Para } \lambda_c \leq 1.5 ; F_n = (0.658^{\lambda_c^2}) F_y$$

$$\text{Para } \lambda_c > 1.5 ; F_n = \left[\frac{0.877}{\lambda_c^2} \right] F_y$$

Donde

$$\lambda_c = \sqrt{\frac{F_y}{F_e}}$$

F_e = es el valor mínimo del esfuerzo de pandeo flector elástico, de pandeo torsional y de pandeo flexo-torsional



ESFUERZOS COMBINADOS

FLEXIÓN Y CORTANTE COMBINADOS

$$\sqrt{\left(\frac{M_u}{\phi_b M_{nxo}}\right)^2 + \left(\frac{V_u}{\phi_v V_n}\right)^2} \leq 1.0 \quad \text{Para vigas con almas no reforzadas}$$

Donde:

M_n = resistencia nominal cuando solo se considera flexión

M_u = resistencia requerida a flexión

M_{nxo} = resistencia nominal a flexión alrededor del eje centroidal x

V_u = resistencia requerida a cortante

V_n = resistencia nominal cuando solo se considera cortante

CARGA AXIAL DE COMPRESIÓN Y FLEXIÓN COMBINADAS

$$\frac{P_u}{\phi_c P_n} + \frac{C_{mx} M_{ux}}{\phi_b M_{nx} \alpha_x} + \frac{C_{my} M_{uy}}{\phi_b M_{ny} \alpha_y} \leq 1.0$$

$$\frac{P_u}{\phi_c P_{no}} + \frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \leq 1.0$$

Cuando $P_u/\phi_c P_n \leq 0.15$, puede utilizarse la siguiente ecuación:

$$\frac{P_u}{\phi_c P_n} + \frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \leq 1.0$$

Donde:

P_u = resistencia requerida bajo compresión axial

M_{ux}, M_{uy} = resistencias requeridas a flexión con respecto a los ejes centroidales de la sección efectiva.

P_n = resistencia nominal axial

P_{no} = resistencia axial nominal determinada con $F_n = F_y$ (En las tablas es el valor para $KL=0$).

M_{nx}, M_{ny} = resistencias nominales a flexión con respecto a los ejes centroidales de la sección.

$1/\alpha_x, 1/\alpha_y$ = coeficientes de mayoración = $1/(1-(P_u/\phi_c P_e))$

$P_e = \pi^2 EI_b / (K_b L_b)^2$

I_b = momento de inercia de la sección transversal completa sin reducir respecto al eje de flexión

L_b = longitud real no arriostrada en el plano de flexión

K_b = coeficiente de longitud efectiva

C_{mx}, C_{my} = 0.85 para miembros en compresión de pórticos sometidos a desplazamientos laterales.

$C_m = 0.6-0.4(M_1/M_2)$, donde M_1/M_2 es la relación entre el momento menor y el momento mayor en los extremos de la porción no arriostrada del miembro en el plano de flexión.

COMBINACIONES DE CARGA

Las estructuras de acero, sus componentes y su cimentación deben diseñarse de tal manera que sus resistencias de diseño sean iguales o excedan los efectos producidos por las cargas mayoradas en las siguientes combinaciones de carga:

$$1.2D + 1.6L + 0.5(L_r \text{ ó } G \text{ ó } L_e)$$

$$1.2D + 1.6(L_r \text{ ó } G \text{ ó } L_e) + (L \text{ ó } 0.8W)$$

$$1.2D + 1.6W + 1.0L + 0.5(L_r \text{ ó } G \text{ ó } L_e)$$

$$1.2D + 1.0E + 1.0L$$

$$0.9D + 1.6W$$

$$0.9D + 1.0E$$

D = Carga Muerta

L = Carga Viva debida al uso y ocupación de la edificación

L_r = Carga Viva sobre cubierta

G = Carga debida a lluvia y granizo

W = Carga de viento

E = Fuerza debida al sismo.

L_e = Carga de empozamiento de agua.



TUBERÍA HSS HOLLOW STRUCTURAL SECTIONS SECCIONES ESTRUCTURALES HUECAS



4. TUBERÍA HSS HOLLOW STRUCTURAL SECTIONS (SECCIONES ESTRUCTURALES HUECAS)

En la industria del Acero, el término "HSS" significa perfiles estructurales huecos (por sus siglas en inglés Hollow Structural Sections). La mayoría de los HSS son de corte circular, cuadrado o rectangular. El uso de HSS ha aumentado considerablemente porque su flexibilidad se adapta muy bien a los diseños innovadores.

Usos

Los HSS se utilizan en la construcción de edificios, reforzamientos (riostros), puentes, señales de tránsito, barreras de seguridad, torres transmisión de energía eléctrica, puentes grúa y plataformas petroleras. También se utilizan para la fabricación de automóviles, equipos de construcción, maquinaria agrícola, muebles de oficina y estanterías de almacén.

Beneficios

- ✓ Resistencia: Los tubos HSS tienen una alta relación Resistencia/Peso generando rentabilidad, excelente resistencia a la compresión y torsión.
- ✓ Apariencia: Tienen un aspecto agradable y uniforme que se adapta muy bien al diseño de proyectos que requieren una función dual: estructural y estética. Facilita el mantenimiento y la limpieza.
- ✓ Uniformidad: Por ser formados en frío otorga una tolerancia dimensional precisa en tamaño y geometría, incluyendo caras planas, redondez en sus bordes, rectitud a todo lo largo del elemento y espesor uniforme que le permiten pintarse, soldarse y perforarse con facilidad.
- ✓ Facilidad de Fabricación: Los HSS pueden ser fácilmente doblados, curvados y perforados.
- ✓ Resistencia al Fuego: Las columnas rellenas de concreto aumentan su resistencia frente a la exposición al fuego.
- ✓ Eficiencia: Con tubos HSS ASTM A1085 se tienen estructuras más livianas y eficientes que las diseñadas con tubos fabricados bajo Norma ASTM A 500 Grado C, proporcionando una reducción significativa en peso, fabricación, montaje y fletes.

- ✓ La tubería cuadrada (HSS) requiere menor cantidad de acero en su estructura, lo que permitirá que sea fuerte, segura y a la vez más ligera que con cualquier otro componente. Resiste el fuego, la resequedad, la humedad, no se contrae, enrosca, cuarteo, hincha o deforma. Su interior puede ser llenado con concreto.

CONSIDERACIONES	ASTM A 500 GRADOS C		ASTM A 1085	
Alcance	Cold-Formed Welded & Seamless		Cold-Formed Welded	
Perímetro Máximo	88" (2235 mm)		88" (2235 mm)	
Rango Espesor	t<0.875" (22.22 mm)		0.148" <t<0.875"	
			3.76 mm<t<22.22 mm	
Esfuerzo de Fluencia	Redondo	46 ksi min	Todas las geometrías	50 ksi min
	Cuadrado y rectangular	50 ksi min		70 ksi min
Esfuerzo Último	Redondo	62 ksi min	Todas las geometrías	65 ksi min
	Cuadrado y rectangular	62 ksi min		
Tolerancia en Espesor	-10%		-5%	
Tolerancia en peso	N/A		-3.5%	
Radio Esquinas (Cuadrado y rectangular)	r<3t		t≤0.40" (10.16 mm)	1.6t a 3.0t
			t>0.40" (10.16 mm)	1.8t a 3.0t



Beneficios de las nuevas especificaciones ASTM A1085

- ✓ Se ajusta la tolerancia en espesor y se limita el valor del esfuerzo de fluencia a un mínimo de 50 ksi para todas las geometrías.
- ✓ Tolerancias de espesores de pared más ajustadas y se adiciona una tolerancia en peso, lo que significa que se puede utilizar el espesor total para diseño en secciones tipo HSS. Esto quiere decir que no es necesario reducir el espesor nominal por 0.93 como se prescribe en ASTM A500 Grado C, para diseño de elementos y conexiones.
- ✓ Mayor área admisible para diseño y un mínimo valor de esfuerzo de fluencia especificado, significa que los HSS son más eficientes y económicos.





COLUMNAS TUBULARES DE ACERO RELLENAS DE CONCRETO



5. COLUMNAS TUBULARES DE ACERO RELLENAS DE CONCRETO

INTRODUCCIÓN

Los perfiles tubulares de acero rellenos de concreto se utilizan principalmente en columnas. El uso de concreto como relleno al interior de la sección proporciona una mayor capacidad de soportar carga sin aumentar las dimensiones externas. La resistencia frente al fuego puede verse incrementada considerablemente con el concreto si se le incorpora la armadura o refuerzo adecuado.

Dado que la estructura de acero es visible, permite un diseño esbelto y arquitectónicamente atractivo. El perfil tubular no sólo actúa como encofrado o formaleta para el concreto, sino que también garantiza que el ensamble, montaje y proceso de construcción no sufra retrasos debido al tiempo de fraguado y endurecimiento del concreto.

Las columnas llamadas mixtas o compuestas las cuales están conformadas por acero y concreto, y en especial aquellas de secciones tubulares de acero rellenas de concreto presentan una serie de ventajas constructivas y económicas, las cuales son valoradas por arquitectos, ingenieros calculistas y constructores, ya que con este tipo de columnas se pueden definir proyectos de una manera más rápida, sencilla y eficiente.

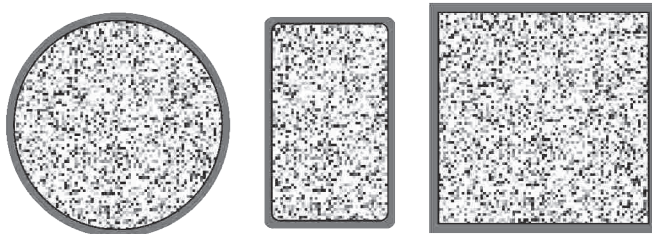
Aunque estas columnas han sido más utilizadas en países como Japón, Estado Unidos y España, ya es común en nuestro medio visualizar proyectos con este tipo de columnas, debido no solo a las exigencias de las Normas Colombianas de Construcción Sismoresistente, sino a sus mayores bondades, lo que hace que cobren mayor relevancia en la construcción de edificios para oficinas, vivienda, centro comerciales y en especial en las grandes superficies, donde debido a su alta resistencia permiten desarrollar cerchas de gran magnitud y longitud disminuyendo de esta manera la cantidad de columnas.





GEOMETRÍAS O SECCIONES TRANSVERSALES TIPO

Las secciones tubulares rellenas de concreto más utilizadas en la construcción de columnas compuestas son las redondas, rectangulares y cuadradas.

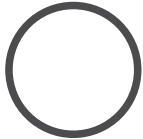


Columnas compuestas tubulares

*Los puntos representan concreto

En estas columnas se busca aprovechar al máximo la sumatoria de las ventajas de cada uno de los materiales que la conforman, logrando así una solución constructiva ideal para construcción, con las exigencias que actualmente nos demandan las normas de diseño y fabricación.

Las bondades de cada uno de los componentes se describen a continuación:

Perfil Tubular de Acero Estructural	Concreto	Columna Compuesta
Alta Resistencia Alta Ductilidad Buena Resistencia a Tensión Liviano	Alta Rigidez Resistente al Fuego Durable Buena Resistencia a la Compresión	"Sumatoria Sinergias de Materiales y Propiedades"
		

VENTAJAS

- ✓ Las columnas tubulares de acero rellenas de concreto tienen mayor ductilidad que las de solo concreto reforzado, debido al alto confinamiento del concreto y la alta resistencia al pandeo local. Se aprovechan al máximo las bondades de ambos materiales.
- ✓ Estructuralmente las columnas diseñadas con secciones tubulares de acero rellenas de concreto son más livianas, entre un 22% y 40%, dependiendo de la zona de amenaza sísmica y el tipo de sección tubular, que si se diseñaran con secciones tubulares de acero sin rellenar.
- ✓ Constructivamente las secciones tubulares de acero eliminan el uso de formaleta y del acero de refuerzo en algunos casos, lo cual aumenta la velocidad de ejecución, disminuyendo los costos de construcción.
- ✓ El concreto utilizado como relleno aumenta la resistencia frente al fuego y a la corrosión, lo que se ve reflejado económicamente debido a la disminución en el uso de la protección pasiva o activa al fuego (pinturas y aspersores de agua) y pintura anticorrosiva, la que se aplicaría solo al exterior de la columna.
- ✓ El concreto utilizado como relleno proporciona a los perfiles tubulares de acero mayor rigidez, disminuyendo de esta manera las derivas de la edificación. De igual manera este concreto aumenta la capacidad de carga frente a efectos sísmicos.
- ✓ Permite obtener columnas más esbeltas y estéticas sin disminución en la capacidad de carga, esto gracias a la reducción de la sección de la columna. Además generan mayor superficie o área útil en la planta del edificio, gracias a la disminución de las secciones, comparada con las columnas que se obtendrían si se utilizara concreto reforzado.

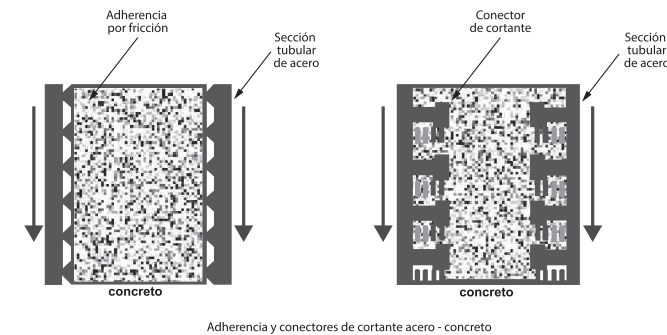


- ✓ Las conexiones, uniones o nudos de la estructura ya están resueltos, debido a las avanzadas técnicas de construcción en acero, lo que permite la posibilidad de prefabricación de elementos de conexión en taller con un ensamble rápido y sencillo en obra.
- ✓ No se requiere quitar formaleta o encofrado y tampoco es necesario esperar a que el concreto fragüe o endurezca para retirar la misma, lo cual impacta directamente el tiempo de ejecución del proyecto.

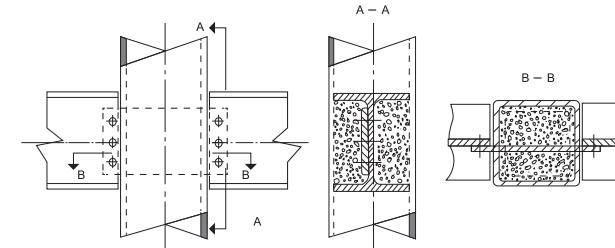
RECOMENDACIONES

- ✓ Se deben dejar pequeñas perforaciones de ventilación en las paredes de la sección tubular con el fin de disminuir las presiones internas durante la fundición del concreto y en caso de incendios evitar la presión de vapor generada por la presencia de fuego. Estas perforaciones casi siempre van en los extremos de la columna y en un punto intermedio de la misma. El diámetro de estas perforaciones debe ser menor a 20 mm.
- ✓ Antes de fundir el concreto, el interior de la sección tubular debe estar libre de agua y otros agentes o impurezas.
- ✓ La sección transversal del perfil tubular utilizado como columna no debe ser inferior a 200 mm bien sea de diámetro o ancho en el caso de sección cuadrada o rectangular, esto con el fin de facilitar la instalación del concreto y colocación del acero de refuerzo cuando exista.
- ✓ Se recomienda concreto con resistencia mayor o igual a 28 MPa (4,000 psi), con gravilla fina no mayor a 1/2" (12.7 mm). Se permite el uso de plastificantes o fluidificantes siempre que estos no genere corrosión al interior de sección tubular de acero.

- ✓ Se debe garantizar que el acero y concreto trabajen en conjunto, para lo cual se hace necesario la utilización de **"conectores de cortante"**.



DETALLES CONSTRUCTIVOS



Unión de una viga a columna con pieza de unión atravesando la columna

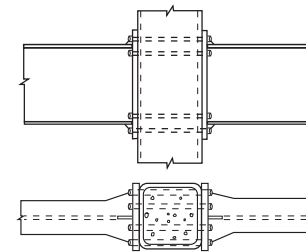


Figura 1



Figura 2

Figura1: Sistema de Conexión Viga-Columna propuesto en la investigación de Wu et ál (2.004)

Figura2: Detalle de Conexión emperrada viga-columna. Sistema PRM con columnas tubulares rellenas de concreto. Proyecto San Cayetano. Fuente Tecmo S.A.

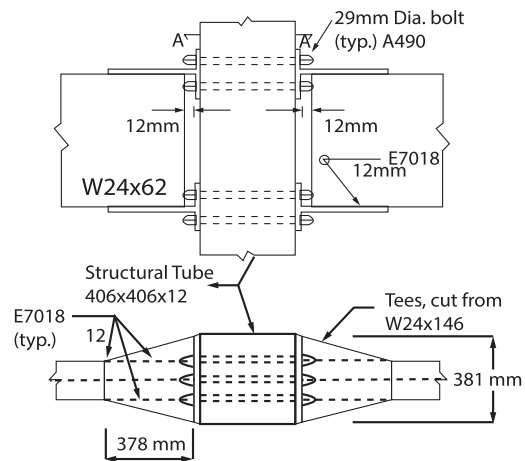


Figura3: Detalle de conexión Viga-Columna

APLICACIONES

- ✓ Grandes superficies
- ✓ Edificios o bodegas industriales con potencial importante de presentarse fuego
- ✓ Edificios para parqueaderos
- ✓ Edificios de gran altura para uso residencial, institucional, comercial, oficinas
- ✓ Edificios industriales tipo bodegas y centros de acopio
- ✓ Estructuras para ascensores
- ✓ Reforzamiento de estructuras
- ✓ Columnas hincadas para pilotes
- ✓ Estructuras de soporte para fachadas
- ✓ Mezzanines, cubiertas, hangares etc.
- ✓ Pilas o pilares de puentes vehiculares



Aplicaciones en grandes superficies
y mezzanines





CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO

Para compresión, las secciones tubulares rellenas de concreto se clasifican como compactas, no compactas y esbeltas, de acuerdo a la siguiente tabla:

Relaciones ancho/espesor límites para elementos de acero comprimidos en miembros compuestos sujetos a compresión axial.					
Descripción del elemento	Relación ancho / espesor	λ_p Compacto / No compacto	λ_r No Compacto / Esbelto	Máximo Permitido	Ejemplo
Paredes de secciones tubulares rectangulares de espesor uniforme	b/t	$2.26 \sqrt{\frac{E}{F_y}}$	$3.00 \sqrt{\frac{E}{F_y}}$	$5.00 \sqrt{\frac{E}{F_y}}$	
Secciones tubulares redondas	D/t	$\frac{0.15E}{F_y}$	$\frac{0.19E}{F_y}$	$\frac{0.31E}{F_y}$	

CONSIDERACIONES

- ✓ El área transversal de la sección de acero deberá ser por lo menos el 1% del área total de la sección compuesta.
- ✓ Los tubos compuestos rellenos deberán ser clasificados para pandeo local conforme a la tabla anteriormente expuesta.
- ✓ En la obtención de las tablas no se consideran barras de acero de refuerzo.

Resistencia a Compresión

La resistencia a compresión $\phi_c P_n$ para tubos rellenos de concreto caragados axialmente deberá ser determinada para el estado límite de pandeo por flexión basado en la esbeltez de la columna como se describe a continuación:

$$\phi_c = 0.75$$

$$a) \text{ Cuando } \frac{P_{no}}{P_e} \leq 2.25$$

$$P_n = P_{no} \left[0.658^{\frac{P_{no}}{P_e}} \right]$$

$$b) \text{ Cuando } \frac{P_{no}}{P_e} > 2.25$$

$$P_n = 0.877 P_e$$

donde

$$P_{no} = F_y A_s + 0.85 f'_c A_c$$

$$P_e = \pi^2 (EI_{eff}) / (KL)^2$$

$$EI_{eff} = E_s I_s + C_3 E_c I_c$$

$$C_3 = 0.6 + 2 \left[\frac{A_s}{A_c + A_s} \right] \leq 0.9$$

A_c = área de concreto

A_s = área de la sección de acero

E_c = módulo de elasticidad del concreto

E_s = módulo de elasticidad del acero

F_y = límite fluencia del acero

f'_c = resistencia a la compresión del concreto

I_c = momento de inercia de la sección de concreto

I_s = momento de inercia de la sección de acero

K = factor de longitud efectiva

L = longitud no arriostrada del elemento

P_n = resistencia de diseño a compresión

P_e = carga crítica de pandeo elástico

I_{eff} = rigidez efectiva de la sección compuesta



i) para secciones compactas

$$P_{no} = P_p$$

Donde

$$P_{no} = F_y A_s + C_2 f'_c A_c$$

$C_2 = 0.85$ para secciones rectangulares y 0.95 para secciones redondas.

ii) para secciones no compactas

$$P_{no} = P_p - \frac{P_p - P_y}{(\lambda_r - \lambda_p)^2} (\lambda - \lambda_p)^2$$

Donde

$$P_y = F_y A_s + 0.7 f'_c A_c$$

iii) para secciones esbeltas

$$P_{no} = F_{cr} A_s + 0.7 f'_c A_c$$

donde

a) para secciones rectangulares rellenas de concreto

$$F_{cr} = \frac{9E_s}{\left(\frac{b}{t}\right)^2}$$

b) para secciones redondas rellenas de concreto

$$F_{cr} = \frac{0.72F_y}{\left(\left(\frac{D}{t}\right)\frac{F_y}{E_s}\right)^{0.2}}$$



TUBO REDONDO HR ESTRUCTURAL FANALCA
COLUMNAS RELLENAS DE CONCRETO
RESISTENCIA A COMPRESIÓN SECCIÓN COMPUESTA
 $\phi_c P_n$ (kg) donde $\phi_c=0.75$

$f'_c=3$ ksi (2.1 kgf/mm²)
 $F_y=50$ ksi (35.15 kgf/mm²)
 $F_u=65$ ksi (45.69 kgf/mm²)

Diametro Nominal / Diametro (mm)		4 / 114.3				5" / 127				6 / 168.3		8 / 219.1	10 / 273.1	12 / 323.9	
ESPESOR (mm)		3.00	4.00	5.00	6.00	3.00	4.00	4.50	5.00	6.00	4.00	6.00	5.00	9.00	10.00
PESO (kg/m)		8.23	10.88	13.48	16.03	9.17	12.13	13.59	15.04	17.90	16.21	24.02	26.4	58.62	77.41
Longitud Efectiva KL (mm) ↓	0	41,496	49,876	58,100	66,168	48,088	57,460	62,088	66,676	75,735	84,738	109,460	140,238	273,590	368,892
	100	41,473	49,850	58,069	66,132	48,067	57,435	62,061	66,647	75,703	84,716	109,434	140,216	273,564	368,867
	200	41,406	49,770	57,977	66,027	48,003	57,361	61,981	66,562	75,605	84,652	109,353	140,153	273,488	368,793
	300	41,293	49,638	57,824	65,851	47,896	57,236	61,848	66,420	75,443	84,545	109,219	140,048	273,360	368,670
	400	41,136	49,454	57,610	65,605	47,747	57,063	61,662	66,221	75,216	84,395	109,032	139,900	273,181	368,498
	500	40,935	49,218	57,335	65,291	47,555	56,841	61,424	65,966	74,925	84,202	108,792	139,711	272,951	368,277
	600	40,691	48,931	57,002	64,909	47,323	56,570	61,134	65,656	74,572	83,968	108,499	139,480	272,671	368,006
	700	40,405	48,594	56,611	64,460	47,049	56,252	60,793	65,292	74,156	83,691	108,155	139,208	272,340	367,687
	800	40,076	48,208	56,163	63,946	46,736	55,888	60,402	64,874	73,679	83,373	107,758	138,894	271,958	367,319
	900	39,707	47,775	55,659	63,369	46,383	55,478	59,962	64,403	73,142	83,014	107,310	138,539	271,526	366,902
	1,000	39,299	47,295	55,102	62,730	45,992	55,022	59,474	63,881	72,547	82,615	106,812	138,144	271,044	366,437
	1,100	38,853	46,770	54,492	62,031	45,563	54,524	58,939	63,310	71,894	82,176	106,264	137,708	270,513	365,924
	1,200	38,370	46,202	53,832	61,274	45,099	53,983	58,359	62,689	71,186	81,698	105,667	137,233	269,932	365,362
	1,300	37,851	45,592	53,124	60,463	44,599	53,401	57,734	62,022	70,425	81,182	105,022	136,718	269,302	364,753
	1,400	37,299	44,943	52,370	59,598	44,065	52,780	57,068	61,309	69,612	80,627	104,330	136,164	268,623	364,096
	1,500	36,716	44,255	51,571	58,683	43,500	52,120	56,360	60,552	68,748	80,036	103,592	135,571	267,896	363,391
	1,600	36,102	43,532	50,731	57,720	42,903	51,424	55,614	59,754	67,838	79,409	102,808	134,941	267,121	362,640
	1,700	35,459	42,775	49,852	56,713	42,276	50,694	54,830	58,916	66,882	78,747	101,980	134,272	266,298	361,842
	1,800	34,791	41,987	48,936	55,664	41,622	49,931	54,011	58,039	65,882	78,051	101,110	133,567	265,428	360,997
	1,900	34,097	41,170	47,986	54,576	40,941	49,136	53,158	57,127	64,842	77,322	100,198	132,826	264,512	360,106
	2,000	33,382	40,325	47,005	53,452	40,235	48,312	52,274	56,181	63,763	76,561	99,245	132,049	263,549	359,170
	2,100	32,645	39,456	45,995	52,295	39,507	47,461	51,360	55,204	62,648	75,768	98,254	131,238	262,541	358,188
	2,200	31,891	38,565	44,959	51,109	38,757	46,585	50,419	54,196	61,500	74,946	97,225	130,392	261,488	357,161
	2,300	31,119	37,653	43,900	49,897	37,987	45,685	49,452	53,162	60,321	74,096	96,159	129,512	260,390	356,089
	2,400	30,334	36,725	42,820	48,661	37,200	44,763	48,462	52,103	59,113	73,217	95,058	128,600	259,249	354,974
	2,500	29,536	35,781	41,723	47,406	36,396	43,822	47,452	51,021	57,880	72,313	93,924	127,655	258,064	353,814
	2,600	28,728	34,824	40,611	46,133	35,578	42,864	46,422	49,919	56,624	71,383	92,758	126,680	256,837	352,611
	2,700	27,911	33,857	39,486	44,847	34,747	41,891	45,376	48,799	55,348	70,430	91,562	125,674	255,567	351,366
	2,800	27,089	32,882	38,352	43,550	33,906	40,904	44,315	47,664	54,054	69,454	90,337	124,639	254,257	350,078
	2,900	26,262	31,901	37,211	42,246	33,055	39,905	43,242	46,514	52,745	68,457	89,085	123,575	252,906	348,748
	3,000	25,432	30,916	36,066	40,936	32,197	38,897	42,158	45,354	51,423	67,440	87,807	122,483	251,515	347,377
	3,100	24,602	29,930	34,919	39,626	31,334	37,882	41,066	44,185	50,091	66,404	86,505	121,365	250,085	345,965
3,200	23,773	28,944	33,773	38,316	30,466	36,862	39,968	43,009	48,751	65,351	85,180	120,220	248,616	344,512	
3,300	22,947	27,962	32,630	37,010	29,596	35,837	38,866	41,829	47,407	64,282	83,835	119,051	247,110	343,020	
3,400	22,126	26,984	31,492	35,710	28,725	34,811	37,762	40,646	46,060	63,199	82,470	117,857	245,567	341,489	
3,500	21,311	26,012	30,361	34,420	27,855	33,786	36,658	39,463	44,713	62,102	81,088	116,640	243,989	339,920	
3,600	20,503	25,049	29,241	33,140	26,988	32,762	35,555	38,281	43,368	60,993	79,691	115,401	242,375	338,312	
3,700	19,705	24,096	28,131	31,874	26,124	31,741	34,456	37,103	42,027	59,874	78,278	114,141	240,726	336,667	
3,800	18,917	23,154	27,035	30,624	25,265	30,726	33,363	35,930	40,693	58,746	76,854	112,861	239,045	334,985	
3,900	18,141	22,226	25,955	29,391	24,412	29,717	32,276	34,765	39,367	57,609	75,418	111,561	237,330	333,267	
4,000	17,378	21,312	24,891	28,178	23,568	28,716	31,197	33,609	38,052	56,466	73,973	110,243	235,584	331,514	

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO



TUBO REDONDO HR ESTRUCTURAL FANALCA
COLUMNAS RELLENAS DE CONCRETO
RESISTENCIA A COMPRESIÓN SECCIÓN COMPUESTA
 $\phi_c P_n$ (kg) donde $\phi_c=0.75$

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 $F_y=50$ ksi (35.15 kgf/mm²)
 $F_u=65$ ksi (45.69 kgf/mm²)

Diametro Nominal / Diametro (mm)		4 / 114.3				5" / 127				6 / 168.3		8 / 219.1	10 / 273.1	12 / 323.9	
ESPESOR (mm)		3.00	4.00	5.00	6.00	3.00	4.00	4.50	5.00	6.00	4.00	6.00	5.00	9.00	10.00
PESO (kg/m)		8.23	10.88	13.48	16.03	9.17	12.13	13.59	15.04	17.90	16.21	24.02	26.4	58.62	77.41
Longitud Efectiva KL (mm)	4,100	16,629	20,414	23,845	26,987	22,732	27,725	30,129	32,463	36,749	55,318	72,520	108,909	233,807	329,726
	4,200	15,873	19,533	22,820	25,818	21,906	26,746	29,072	31,330	35,460	54,165	71,060	107,557	232,000	327,904
	4,300	15,144	18,632	21,771	24,621	21,092	25,778	28,029	30,210	34,187	53,009	69,596	106,191	230,164	326,048
	4,400	14,463	17,795	20,793	23,514	20,290	24,824	26,999	29,106	32,931	51,852	68,129	104,811	228,300	324,159
	4,500	13,827	17,013	19,879	22,481	19,500	23,884	25,985	28,017	31,694	50,695	66,660	103,417	226,408	322,239
	4,600	13,233	16,281	19,024	21,514	18,715	22,960	24,988	26,947	30,477	49,538	65,191	102,011	224,491	320,287
	4,700	12,676	15,596	18,223	20,608	17,928	22,025	23,986	25,877	29,255	48,382	63,723	100,594	222,548	318,304
	4,800	12,153	14,953	17,472	19,759	17,188	21,117	22,997	24,810	28,048	47,230	62,257	99,167	220,580	316,291
	4,900	11,662	14,349	16,766	18,960	16,494	20,264	22,068	23,808	26,915	46,082	60,796	97,731	218,589	314,249
	5,000	11,200	13,781	16,102	18,210	15,841	19,461	21,194	22,865	25,849	44,939	59,339	96,286	216,576	312,179
	5,100	10,765	13,245	15,477	17,502	15,226	18,705	20,371	21,977	24,846	43,802	57,889	94,835	214,540	310,080
	5,200	10,355	12,741	14,887	16,836	14,646	17,993	19,595	21,140	23,899	42,673	56,447	93,377	212,485	307,955
	5,300	9,968	12,265	14,331	16,206	14,098	17,320	18,862	20,350	23,006	41,551	55,014	91,914	210,409	305,804
	5,400	9,602	11,815	13,805	15,612	13,581	16,685	18,170	19,603	22,162	40,438	53,591	90,447	208,315	303,627
	5,500	9,256	11,389	13,307	15,049	13,092	16,084	17,516	18,897	21,363	39,335	52,180	88,976	206,204	301,425
	5,600	8,929	10,986	12,836	14,517	12,628	15,514	16,896	18,228	20,607	38,243	50,780	87,503	204,075	299,199
	5,700	8,618	10,604	12,390	14,012	12,189	14,975	16,308	17,594	19,890	37,162	49,394	86,028	201,931	296,950
	5,800					11,772	14,463	15,750	16,992	19,210	36,093	48,022	84,553	199,772	294,679
	5,900					11,377	13,977	15,221	16,421	18,565	35,038	46,666	83,078	197,599	292,386
	6,000					11,001	13,515	14,718	15,879	17,951	33,996	45,325	81,604	195,413	290,071
	6,100					10,643	13,075	14,239	15,362	17,367	32,949	44,002	80,133	193,215	287,737
	6,200					10,302	12,657	13,784	14,871	16,811	31,895	42,696	78,664	191,006	285,384
	6,300					9,978	12,258	13,350	14,402	16,282	30,890	41,334	77,199	188,788	283,012
	6,400										29,932	40,052	75,738	186,560	280,622
	6,500										29,019	38,829	74,283	184,324	278,215
	6,600										28,146	37,662	72,834	182,080	275,792
	6,700										27,312	36,546	71,391	179,830	273,354
	6,800										26,515	35,479	69,956	177,575	270,901
	6,900										25,752	34,458	68,530	175,316	268,434
	7,000										25,021	33,480	67,112	173,053	265,954
	7,100										24,321	32,544	65,703	170,787	263,462
	7,200										23,650	31,646	64,305	168,519	260,959
	7,300										23,007	30,785	62,918	166,250	258,444
	7,400										22,389	29,959	61,542	163,981	255,920
	7,500										21,796	29,165	60,179	161,713	253,386
	7,600										21,226	28,403	58,827	159,447	250,844
7,700										20,679	27,670	57,489	157,183	248,295	
7,800										20,152	26,965	56,164	154,922	245,738	
7,900										19,645	26,287	54,854	152,665	243,176	
8,000										19,157	25,633	53,478	150,412	240,608	

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO



TUBO CUADRADO HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 3$ ksi (2.1 kgf/mm²)
 $F_y = 50$ ksi (35.15 kgf/mm²)
 $F_u = 65$ ksi (45.69 kgf/mm²)

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO

Dimensión Nominal (mm)		90x90				100x100			
ESPESOR (mm)		3.00	4.00	5.00	6.00	3.00	4.00	4.50	5.00
PESO (kg/m)		8.01	10.48	12.84	15.1	8.96	11.73	13.08	14.41
Longitud Efectiva KL (mm)	0	35,978	43,482	50,556	57,201	41,535	50,039	54,130	58,114
	100	35,955	43,454	50,523	57,162	41,513	50,013	54,102	58,083
	200	35,886	43,369	50,422	57,044	41,448	49,935	54,017	57,991
	300	35,771	43,229	50,255	56,849	41,341	49,806	53,875	57,837
	400	35,611	43,034	50,021	56,576	41,190	49,625	53,678	57,623
	500	35,406	42,784	49,723	56,227	40,998	49,394	53,425	57,348
	600	35,158	42,481	49,360	55,804	40,764	49,112	53,118	57,014
	700	34,866	42,125	48,935	55,308	40,489	48,782	52,757	56,622
	800	34,533	41,718	48,450	54,741	40,175	48,403	52,343	56,173
	900	34,159	41,262	47,905	54,105	39,821	47,978	51,879	55,668
	1,000	33,745	40,758	47,304	53,404	39,429	47,507	51,364	55,110
	1,100	33,295	40,208	46,648	52,639	39,001	46,991	50,801	54,499
	1,200	32,808	39,615	45,940	51,814	38,537	46,433	50,192	53,837
	1,300	32,286	38,979	45,182	50,931	38,039	45,834	49,538	53,128
	1,400	31,733	38,304	44,379	49,995	37,509	45,196	48,842	52,372
	1,500	31,149	37,593	43,531	49,009	36,947	44,520	48,104	51,572
	1,600	30,536	36,846	42,643	47,977	36,356	43,809	47,328	50,730
	1,700	29,897	36,068	41,717	46,901	35,738	43,065	46,516	49,849
	1,800	29,235	35,261	40,758	45,787	35,093	42,289	45,670	48,931
	1,900	28,550	34,427	39,767	44,638	34,424	41,484	44,792	47,979
	2,000	27,845	33,570	38,749	43,458	33,733	40,652	43,885	46,996
	2,100	27,124	32,691	37,707	42,251	33,021	39,796	42,951	45,985
	2,200	26,387	31,794	36,644	41,021	32,291	38,917	41,993	44,947
	2,300	25,637	30,882	35,564	39,772	31,544	38,018	41,013	43,886
	2,400	24,877	29,958	34,470	38,509	30,782	37,101	40,015	42,804
	2,500	24,108	29,023	33,365	37,234	30,007	36,169	38,999	41,705
	2,600	23,333	28,081	32,252	35,952	29,222	35,223	37,970	40,591
	2,700	22,554	27,135	31,135	34,667	28,427	34,267	36,929	39,465
	2,800	21,773	26,187	30,017	33,381	27,625	33,302	35,878	38,330
	2,900	20,993	25,239	28,901	32,099	26,818	32,330	34,822	37,187
	3,000	20,214	24,294	27,789	30,824	26,008	31,355	33,760	36,040
	3,100	19,439	23,354	26,684	29,559	25,196	30,377	32,697	34,892
	3,200	18,670	22,421	25,590	28,307	24,383	29,399	31,634	33,744
	3,300	17,909	21,498	24,507	27,071	23,573	28,423	30,574	32,600
	3,400	17,157	20,587	23,439	25,853	22,766	27,451	29,518	31,461
	3,500	16,415	19,688	22,388	24,657	21,963	26,485	28,469	30,329
	3,600	15,685	18,804	21,356	23,483	21,167	25,526	27,428	29,207
	3,700	14,968	17,937	20,344	22,334	20,378	24,576	26,397	28,097
	3,800	14,266	17,088	19,327	21,167	19,598	23,637	25,379	27,001
	3,900	13,554	16,224	18,349	20,095	18,829	22,711	24,374	25,919
	4,000	12,885	15,423	17,443	19,103	18,071	21,798	23,385	24,855
	4,100	12,264	14,680	16,602	18,182	17,325	20,900	22,412	23,809
	4,200	11,687	13,989	15,821	17,327	16,593	20,018	21,457	22,782
	4,300	11,150	13,346	15,094	16,530	15,853	19,127	20,486	21,733
	4,400	10,649	12,746	14,416	15,787	15,140	18,267	19,565	20,756
	4,500	10,181	12,186	13,782	15,094	14,475	17,464	18,705	19,844
	4,600	9,743	11,662	13,189	14,444	13,852	16,713	17,901	18,991
	4,700	9,333	11,171	12,634	13,836	13,269	16,010	17,147	18,191
	4,800	8,948	10,710	12,113	13,266	12,722	15,349	16,440	17,441
	4,900	8,586	10,278	11,624	12,730	12,208	14,729	15,776	16,736
	5,000	8,246	9,871	11,163	12,226	11,725	14,146	15,151	16,074
	5,100	7,926	9,487	10,730	11,751	11,269	13,597	14,563	15,449
	5,200	7,624	9,126	10,321	11,303	10,840	13,079	14,008	14,861
	5,300	7,339	8,785	9,935	10,881	10,435	12,590	13,485	14,305
	5,400	7,070	8,462	9,571	10,482	10,052	12,128	12,990	13,781
	5,500	6,815	8,158	9,226	10,104	9,690	11,691	12,522	13,284
	5,600	6,574	7,869	8,899	9,746	9,347	11,277	12,079	12,814
	5,700	6,345	7,595	8,590	9,407	9,022	10,885	11,658	12,368
	5,800	6,128	7,335	8,296	9,086	8,713	10,513	11,260	11,945
	5,900	5,922	7,089	8,017	8,780	8,420	10,160	10,881	11,544
	6,000	5,727	6,855	7,752	8,490	8,142	9,824	10,522	11,162

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez KL/r < 200.



TUBO CUADRADO HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

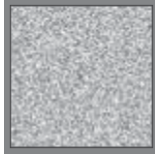
$f'_c = 3 \text{ ksi (2.1 kgf/mm}^2\text{)}$

$F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$

$F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

Dimensión Nominal (mm)	120x120	135x135		150x150		200x200		220x220		250x250			300x300	
ESPESOR (mm)	4.00	4.00	6.00	4.00	6.00	5.00	7.00	7.00	9.00	8.00	9.00	10.00	10.00	12.00
PESO (kg/m)	14.14	16.13	23.82	18.12	26.40	30.11	41.43	46.16	58.54	59.93	66.47	73.34	89.04	105.61
Longitud Efectiva KL (mm) ↓	0	63,961	75,108	97,834	86,860	112,588	148,485	183,362	208,666	245,828	270,436	291,805	312,744	399,754
	100	63,938	75,086	97,806	86,839	112,562	148,465	183,338	208,643	245,802	270,414	291,781	312,718	399,731
	200	63,868	75,022	97,721	86,779	112,484	148,407	183,267	208,576	245,723	270,346	291,708	312,640	399,661
	300	63,754	74,915	97,581	86,678	112,354	148,310	183,148	208,464	245,591	270,234	291,587	312,510	399,546
	400	63,593	74,765	97,385	86,537	112,173	148,174	182,982	208,308	245,406	270,077	291,418	312,329	399,385
	500	63,387	74,573	97,133	86,357	111,940	147,999	182,768	208,107	245,169	269,875	291,200	312,095	399,178
	600	63,136	74,340	96,827	86,136	111,656	147,785	182,508	207,861	244,879	269,628	290,934	311,810	398,925
	700	62,841	74,064	96,465	85,876	111,322	147,534	182,201	207,571	244,538	269,337	290,621	311,473	398,626
	800	62,502	73,748	96,050	85,578	110,937	147,244	181,847	207,238	244,144	269,002	290,259	311,085	398,281
	900	62,121	73,391	95,582	85,240	110,502	146,916	181,446	206,860	243,698	268,622	289,850	310,646	397,891
	1,000	61,697	72,993	95,061	84,865	110,019	146,550	181,000	206,439	243,202	268,199	289,393	310,156	397,456
	1,100	61,232	72,557	94,489	84,452	109,487	146,147	180,507	205,974	242,653	267,731	288,889	309,615	396,975
	1,200	60,726	72,082	93,867	84,002	108,907	145,707	179,970	205,466	242,055	267,220	288,339	309,024	396,449
	1,300	60,182	71,570	93,194	83,515	108,280	145,230	179,387	204,916	241,406	266,666	287,741	308,383	395,878
	1,400	59,599	71,020	92,474	82,993	107,608	144,716	178,761	204,323	240,706	266,068	287,097	307,692	395,262
	1,500	58,980	70,434	91,706	82,436	106,890	144,167	178,090	203,689	239,958	265,428	286,407	306,951	394,602
	1,600	58,325	69,814	90,893	81,844	106,128	143,582	177,375	203,012	239,160	264,745	285,671	306,161	393,897
	1,700	57,635	69,159	90,034	81,219	105,322	142,961	176,618	202,295	238,314	264,020	284,890	305,323	393,148
	1,800	56,913	68,471	89,133	80,561	104,475	142,307	175,818	201,536	237,419	263,254	284,064	304,436	392,356
	1,900	56,159	67,752	88,190	79,872	103,586	141,618	174,977	200,738	236,478	262,446	283,193	303,502	391,520
	2,000	55,375	67,001	87,207	79,151	102,658	140,895	174,094	199,900	235,489	261,597	282,278	302,520	390,640
	2,100	54,563	66,222	86,185	78,401	101,691	140,139	173,171	199,022	234,454	260,707	281,319	301,491	389,718
	2,200	53,724	65,414	85,126	77,621	100,686	139,351	172,208	198,106	233,374	259,778	280,317	300,415	388,753
	2,300	52,860	64,579	84,032	76,814	99,646	138,531	171,206	197,152	232,248	258,808	279,272	299,294	387,746
	2,400	51,973	63,718	82,905	75,980	98,571	137,679	170,166	196,160	231,079	257,800	278,185	298,127	386,697
	2,500	51,063	62,833	81,745	75,120	97,462	136,797	169,088	195,132	229,865	256,752	277,056	296,916	385,606
	2,600	50,133	61,924	80,555	74,235	96,321	135,885	167,974	194,067	228,609	255,667	275,886	295,660	384,474
	2,700	49,185	60,994	79,337	73,326	95,150	134,944	166,823	192,966	227,312	254,544	274,675	294,361	383,301
	2,800	48,220	60,044	78,093	72,395	93,950	133,974	165,638	191,831	225,973	253,383	273,425	293,018	382,087
	2,900	47,240	59,075	76,824	71,443	92,722	132,976	164,418	190,661	224,593	252,186	272,134	291,634	380,834
	3,000	46,246	58,088	75,532	70,470	91,468	131,951	163,165	189,458	223,174	250,953	270,805	290,207	379,540
	3,100	45,240	57,085	74,219	69,479	90,189	130,899	161,880	188,222	221,717	249,685	269,438	288,740	378,208
	3,200	44,225	56,067	72,887	68,469	88,887	129,822	160,563	186,954	220,221	248,381	268,033	287,232	376,837
	3,300	43,201	55,036	71,537	67,443	87,563	128,719	159,215	185,655	218,689	247,043	266,591	285,685	375,427
	3,400	42,171	53,994	70,173	66,401	86,219	127,593	157,838	184,325	217,121	245,672	265,113	284,099	373,980
	3,500	41,135	52,940	68,795	65,345	84,857	126,444	156,432	182,966	215,517	244,268	263,599	282,475	372,495
	3,600	40,096	51,878	67,405	64,276	83,477	125,271	154,999	181,577	213,880	242,831	262,051	280,813	370,974
	3,700	39,055	50,808	66,005	63,195	82,082	124,078	153,538	180,161	212,209	241,363	260,468	279,114	369,416
	3,800	38,014	49,731	64,597	62,103	80,674	122,863	152,052	178,717	210,506	239,864	258,852	277,380	367,822
	3,900	36,974	48,650	63,183	61,002	79,252	121,628	150,542	177,246	208,772	238,334	257,203	275,611	366,192
	4,000	35,936	47,565	61,764	59,893	77,820	120,374	149,008	175,750	207,008	236,775	255,523	273,808	364,528

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO



TUBO CUADRADO HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 3$ ksi (2.1 kgf/mm²)

$F_y = 50$ ksi (35.15 kgf/mm²)

$F_u = 65$ ksi (45.69 kgf/mm²)

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO

Dimensión Nominal (mm)		120x120		135x135		150x150		200x200		220x220		250x250		300x300	
ESPESOR (mm)		4.00	4.00	6.00	4.00	6.00	5.00	7.00	7.00	9.00	8.00	9.00	10.00	10.00	12.00
PESO (kg/m)		14.14	16.13	23.82	18.12	26.40	30.11	41.43	46.16	58.54	59.93	66.47	73.34	89.04	105.61
Longitud Efectiva KL (mm)	4,100	34,902	46,477	60,343	58,776	76,379	119,102	147,451	174,229	205,215	235,187	253,811	271,971	362,830	408,716
	4,200	33,874	45,389	58,920	57,654	74,929	117,812	145,872	172,685	203,393	233,571	252,069	270,101	361,098	406,763
	4,300	32,852	44,301	57,498	56,526	73,473	116,506	144,274	171,117	201,544	231,928	250,297	268,200	359,333	404,773
	4,400	31,838	43,214	56,078	55,395	72,013	115,184	142,655	169,527	199,670	230,257	248,497	266,268	357,535	402,746
	4,500	30,833	42,130	54,661	54,261	70,548	113,847	141,018	167,916	197,770	228,561	246,668	264,306	355,705	400,683
	4,600	29,839	41,049	53,250	53,126	69,082	112,496	139,364	166,285	195,846	226,840	244,812	262,315	353,844	398,584
	4,700	28,856	39,973	51,845	51,991	67,615	111,132	137,694	164,634	193,899	225,094	242,930	260,296	351,952	396,451
	4,800	27,884	38,904	50,448	50,856	66,148	109,756	136,008	162,964	191,930	223,324	241,023	258,249	350,029	394,283
	4,900	26,927	37,841	49,061	49,722	64,683	108,368	134,308	161,277	189,941	221,532	239,090	256,176	348,077	392,082
	5,000	25,983	36,786	47,685	48,592	63,222	106,970	132,595	159,573	187,932	219,717	237,134	254,077	346,096	389,849
	5,100	25,054	35,741	46,320	47,465	61,765	105,562	130,870	157,853	185,904	217,881	235,155	251,953	344,087	387,583
	5,200	24,097	34,705	44,969	46,342	60,314	104,146	129,134	156,118	183,858	216,025	233,154	249,806	342,050	385,286
	5,300	23,196	33,680	43,632	45,226	58,870	102,721	127,387	154,369	181,796	214,149	231,131	247,636	339,985	382,958
	5,400	22,345	32,667	42,310	44,115	57,433	101,289	125,632	152,607	179,718	212,253	229,088	245,443	337,894	380,601
	5,500	21,539	31,666	41,005	43,012	56,006	99,851	123,869	150,833	177,626	210,340	227,025	243,230	335,778	378,215
	5,600	20,777	30,678	39,717	41,917	54,590	98,408	122,099	149,047	175,521	208,409	224,943	240,997	333,636	375,800
	5,700	20,054	29,704	38,448	40,831	53,184	96,960	120,323	147,251	173,403	206,462	222,844	238,745	331,469	373,357
	5,800	19,369	28,704	37,136	39,754	51,791	95,508	118,542	145,445	171,274	204,499	220,727	236,474	329,279	370,887
	5,900	18,718	27,739	35,888	38,688	50,411	94,054	116,757	143,631	169,135	202,521	218,595	234,186	327,065	368,392
	6,000	18,099	26,822	34,701	37,633	49,045	92,597	114,970	141,808	166,987	200,528	216,447	231,881	324,829	365,870
	6,100	17,511	25,950	33,573	36,590	47,694	91,139	113,180	139,979	164,830	198,523	214,284	229,562	322,571	363,325
	6,200	16,950	25,120	32,499	35,559	46,359	89,680	111,389	138,144	162,667	196,504	212,108	227,227	320,292	360,755
	6,300	16,416	24,329	31,475	34,541	45,040	88,222	109,598	136,304	160,497	194,474	209,919	224,879	317,992	358,162
	6,400	15,907	23,574	30,499	33,503	43,710	86,764	107,808	134,459	158,322	192,433	207,719	222,518	315,672	355,546
	6,500	15,422	22,855	29,568	32,480	42,375	85,308	106,020	132,611	156,143	190,382	205,507	220,146	313,333	352,909
	6,600	14,958	22,167	28,679	31,504	41,101	83,855	104,234	130,760	153,961	188,321	203,285	217,762	310,975	350,252
	6,700	14,515	21,510	27,829	30,570	39,883	82,405	102,452	128,907	151,777	186,252	201,054	215,369	308,600	347,574
	6,800	14,091	20,882	27,017	29,678	38,719	80,958	100,674	127,054	149,592	184,175	198,814	212,966	306,208	344,876
	6,900	13,686	20,282	26,239	28,824	37,605	79,516	98,902	125,200	147,407	182,090	196,566	210,555	303,798	342,161
	7,000	13,297	19,706	25,495	28,006	36,538	78,080	97,135	123,346	145,222	180,000	194,312	208,137	301,374	339,427
	7,100	12,925	19,155	24,782	27,223	35,516	76,649	95,375	121,494	143,039	177,903	192,052	205,712	298,934	336,676
	7,200	12,569	18,627	24,098	26,472	34,536	75,225	93,623	119,645	140,859	175,802	189,786	203,282	296,479	333,909
	7,300	12,227	18,120	23,443	25,752	33,597	73,807	91,880	117,798	138,682	173,697	187,516	200,848	294,011	331,127
	7,400	11,899	17,633	22,813	25,060	32,695	72,398	90,145	115,954	136,509	171,589	185,243	198,409	291,530	328,330
	7,500	11,583	17,166	22,209	24,396	31,829	70,996	88,420	114,115	134,341	169,478	182,966	195,968	289,036	325,519
	7,600	11,281	16,718	21,628	23,759	30,997	69,604	86,706	112,281	132,180	167,365	180,688	193,524	286,531	322,695
	7,700	10,990	16,286	21,070	23,146	30,197	68,221	85,002	110,453	130,025	165,251	178,408	191,079	284,015	319,858
	7,800	10,710	15,871	20,533	22,556	29,427	66,848	83,311	108,631	127,878	163,137	176,128	188,634	281,488	317,010
	7,900	10,440	15,472	20,017	21,988	28,687	65,485	81,632	106,817	125,739	161,023	173,849	186,189	278,952	314,150
	8,000	10,181	15,088	19,520	21,442	27,974	64,134	79,966	105,010	123,610	158,910	171,570	183,745	276,406	311,281

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez KL/r< 200.



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 3 \text{ ksi (2.1 kgf/mm}^2\text{)}$
 $F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$
 $F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

Dimensión Nominal (mm)		150x100		200x100		250x100	250x150	300x100		350x150	400x200
ESPESOR (mm)		4.00	6.00	4.00	6.00	5.00	5.00	5.00	7.00	7.00	9.00
PESO (kg/m)		14.87	21.69	18.01	26.40	26.35	30.11	30.11	41.10	52.42	80.60
Longitud Efectiva KL (mm) ↓	0	66,769	87,493	83,498	109,227	115,809	145,124	135,040	169,917	235,193	360,366
	100	66,736	87,450	83,459	109,176	115,756	145,093	134,980	169,841	235,146	360,324
	200	66,639	87,320	83,343	109,022	115,600	145,000	134,801	169,613	235,003	360,198
	300	66,478	87,105	83,149	108,767	115,339	144,844	134,504	169,234	234,765	359,989
	400	66,253	86,803	82,877	108,410	114,976	144,627	134,088	168,704	234,433	359,697
	500	65,964	86,417	82,530	107,954	114,510	144,349	133,555	168,026	234,006	359,321
	600	65,613	85,948	82,108	107,398	113,943	144,009	132,907	167,201	233,485	358,862
	700	65,201	85,397	81,611	106,746	113,276	143,609	132,145	166,230	232,872	358,320
	800	64,728	84,765	81,042	105,998	112,512	143,149	131,271	165,118	232,166	357,696
	900	64,197	84,055	80,402	105,156	111,652	142,629	130,287	163,866	231,368	356,990
	1,000	63,608	83,268	79,693	104,223	110,699	142,050	129,197	162,478	230,480	356,203
	1,100	62,964	82,407	78,916	103,202	109,655	141,412	128,003	160,958	229,502	355,335
	1,200	62,265	81,474	78,074	102,095	108,523	140,718	126,707	159,309	228,436	354,387
	1,300	61,515	80,472	77,169	100,905	107,306	139,967	125,314	157,536	227,283	353,359
	1,400	60,715	79,404	76,203	99,636	106,006	139,160	123,826	155,644	226,044	352,253
	1,500	59,867	78,272	75,179	98,290	104,628	138,299	122,248	153,636	224,720	351,068
	1,600	58,974	77,080	74,099	96,872	103,175	137,384	120,583	151,519	223,314	349,806
	1,700	58,038	75,832	72,968	95,384	101,650	136,416	118,835	149,297	221,828	348,467
	1,800	57,061	74,529	71,786	93,832	100,057	135,398	117,010	146,976	220,261	347,053
	1,900	56,046	73,177	70,558	92,218	98,400	134,330	115,110	144,562	218,618	345,564
	2,000	54,996	71,777	69,286	90,547	96,684	133,213	113,142	142,060	216,898	344,002
	2,100	53,914	70,335	67,973	88,822	94,912	132,048	111,108	139,476	215,105	342,367
	2,200	52,801	68,854	66,623	87,049	93,088	130,838	109,015	136,817	213,241	340,661
	2,300	51,661	67,338	65,239	85,232	91,217	129,584	106,867	134,089	211,307	338,885
	2,400	50,497	65,789	63,824	83,374	89,303	128,286	104,668	131,297	209,306	337,039
	2,500	49,311	64,213	62,382	81,480	87,350	126,948	102,424	128,448	207,240	335,126
	2,600	48,107	62,612	60,915	79,555	85,362	125,569	100,139	125,549	205,111	333,146
	2,700	46,886	60,991	59,428	77,602	83,345	124,152	97,819	122,605	202,922	331,101
	2,800	45,652	59,353	57,923	75,626	81,302	122,699	95,468	119,623	200,676	328,992
	2,900	44,408	57,702	56,403	73,632	79,238	121,211	93,091	116,610	198,373	326,821
	3,000	43,155	56,041	54,872	71,623	77,156	119,689	90,693	113,570	196,018	324,588
	3,100	41,897	54,374	53,332	69,603	75,061	118,136	88,279	110,511	193,612	322,296
	3,200	40,637	52,705	51,788	67,577	72,958	116,553	85,853	107,438	191,158	319,946
	3,300	39,376	51,036	50,241	65,548	70,849	114,943	83,419	104,357	188,659	317,539
	3,400	38,117	49,371	48,695	63,521	68,739	113,306	80,983	101,273	186,118	315,077
	3,500	36,863	47,713	47,153	61,499	66,632	111,644	78,549	98,193	183,536	312,561
	3,600	35,615	46,066	45,617	59,485	64,531	109,960	76,121	95,121	180,917	309,993
	3,700	34,376	44,431	44,089	57,483	62,440	108,255	73,702	92,063	178,263	307,375
	3,800	33,149	42,812	42,574	55,497	60,362	106,530	71,297	89,023	175,577	304,709
	3,900	31,934	41,211	41,071	53,529	58,301	104,788	68,910	86,007	172,861	301,995
	4,000	30,733	39,630	39,585	51,582	56,259	103,031	66,543	83,018	170,118	299,236



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 3 \text{ ksi (2.1 kgf/mm}^2\text{)}$
 $F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$
 $F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

Dimensión Nominal (mm)		150x100		200x100		250x100	250x150	300x100		350x150	400x200
ESPESOR (mm)		4.00	6.00	4.00	6.00	5.00	5.00	5.00	7.00	7.00	9.00
PESO (kg/m)		14.87	21.69	18.01	26.40	26.35	30.11	30.11	41.10	52.42	80.60
Longitud Efectiva KL (mm)	4,100	29,550	38,073	38,118	49,660	54,240	101,260	64,201	80,062	167,351	296,433
	4,200	28,384	36,540	36,670	47,764	52,246	99,476	61,887	77,142	164,563	293,588
	4,300	27,238	35,035	35,244	45,898	50,280	97,682	59,603	74,262	161,755	290,703
	4,400	26,113	33,514	33,843	44,063	48,345	95,879	57,353	71,425	158,931	287,780
	4,500	24,959	32,041	32,447	42,225	46,442	94,070	55,139	68,635	156,093	284,819
	4,600	23,885	30,663	31,051	40,409	44,522	92,255	52,964	65,845	153,244	281,824
	4,700	22,880	29,372	29,744	38,708	42,647	90,436	50,731	63,073	150,386	278,795
	4,800	21,936	28,161	28,517	37,112	40,889	88,615	48,639	60,473	147,521	275,735
	4,900	21,050	27,023	27,365	35,612	39,237	86,794	46,674	58,029	144,652	272,645
	5,000	20,216	25,953	26,282	34,202	37,683	84,974	44,826	55,731	141,782	269,527
	5,100	19,431	24,945	25,261	32,874	36,220	83,156	43,085	53,567	138,913	266,383
	5,200	18,691	23,995	24,299	31,622	34,840	81,342	41,444	51,527	136,046	263,214
	5,300	17,993	23,098	23,391	30,440	33,538	79,534	39,895	49,601	133,185	260,023
	5,400	17,332	22,251	22,532	29,323	32,307	77,733	38,431	47,781	130,331	256,811
	5,500	16,708	21,449	21,720	28,266	31,143	75,940	37,046	46,059	127,486	253,579
	5,600	16,116	20,690	20,952	27,266	30,041	74,156	35,735	44,429	124,653	250,330
	5,700	15,556	19,970	20,223	26,317	28,996	72,384	34,492	42,884	121,834	247,065
	5,800	15,024	19,288	19,532	25,418	28,005	70,623	33,313	41,418	119,030	243,786
	5,900	14,519	18,639	18,875	24,563	27,064	68,876	32,193	40,025	116,244	240,494
	6,000	14,039	18,023	18,251	23,751	26,169	67,143	31,129	38,702	113,477	237,192
	6,100	13,583	17,437	17,658	22,979	25,318	65,426	30,117	37,444	110,731	233,881
	6,200	13,148	16,879	17,093	22,244	24,508	63,726	29,153	36,246	108,008	230,563
	6,300	12,734	16,348	16,554	21,543	23,736	62,043	28,235	35,104	105,309	227,239
	6,400	12,339	15,841	16,041	20,875	23,000	60,379	27,360	34,016	102,636	223,911
	6,500	11,962	15,357	15,551	20,238	22,298	58,734	26,524	32,977	99,990	220,580
	6,600	11,603	14,895	15,084	19,629	21,627	57,110	25,727	31,985	97,373	217,248
	6,700	11,259	14,454	14,637	19,048	20,986	55,427	24,964	31,038	94,786	213,917
	6,800	10,930	14,032	14,209	18,492	20,374	53,809	24,235	30,132	92,231	210,588
	6,900	10,616	13,628	13,801	17,959	19,787	52,260	23,538	29,265	89,570	207,263
	7,000	10,315	13,241	13,409	17,450	19,226	50,778	22,870	28,434	87,030	203,942
	7,100	10,026	12,871	13,034	16,962	18,688	49,358	22,231	27,639	84,595	200,629
	7,200	9,749	12,516	12,674	16,494	18,173	47,996	21,617	26,877	82,262	197,323
	7,300	9,484	12,176	12,330	16,045	17,678	46,690	21,029	26,145	80,023	194,027
	7,400	9,230	11,849	11,999	15,615	17,204	45,437	20,465	25,444	77,875	190,741
	7,500	8,985	11,535	11,681	15,201	16,748	44,233	19,923	24,770	75,812	187,468
	7,600	8,750	11,233	11,375	14,804	16,310	43,077	19,402	24,122	73,830	184,208
	7,700	8,524	10,943	11,082	14,422	15,889	41,965	18,901	23,500	71,925	180,962
	7,800	8,307	10,665	10,800	14,054	15,485	40,896	18,420	22,901	70,093	177,733
	7,900	8,098	10,396	10,528	13,701	15,095	39,867	17,956	22,325	68,330	174,520
	8,000	7,897		10,266	13,360	14,720	38,877	17,510	21,770	66,632	171,326

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL = K_x L_x / (r_x / r_y)$.



TUBO REDONDO HR ESTRUCTURAL FANALCA
COLUMNAS RELLENAS DE CONCRETO
RESISTENCIA A COMPRESIÓN SECCIÓN COMPUESTA
 $\phi_c P_n$ (kg) donde $\phi_c=0.75$

$f'_c=4$ ksi (2.81 kgf/mm²)
 $F_y=50$ ksi (35.15 kgf/mm²)
 $F_u=65$ ksi (45.69 kgf/mm²)

Diámetro Nominal / Diámetro (mm)		4 / 114.3				5" / 127				6 / 168.3		8 / 219.1	10 / 273.1	12 / 323.9	
ESPESOR (mm)		3.00	4.00	5.00	6.00	3.00	4.00	4.50	5.00	6.00	4.00	6.00	5.00	9.00	10.00
PESO (kg/m)		8.23	10.88	13.48	16.03	9.17	12.13	13.59	15.04	17.90	16.21	24.02	26.4	58.62	77.41
Longitud Efectiva KL (mm)	0	46,110	54,321	62,379	70,285	53,848	63,031	67,565	72,061	80,938	94,844	119,068	157,434	299,181	357,046
	100	46,083	54,291	62,345	70,246	53,822	63,002	67,535	72,029	80,902	94,818	119,037	157,408	299,151	357,011
	200	46,003	54,199	62,241	70,129	53,745	62,915	67,442	71,931	80,793	94,740	118,945	157,332	299,062	356,907
	300	45,869	54,047	62,068	69,934	53,616	62,770	67,289	71,769	80,611	94,610	118,791	157,204	298,914	356,733
	400	45,682	53,835	61,828	69,662	53,435	62,568	67,075	71,543	80,358	94,429	118,575	157,025	298,706	356,490
	500	45,442	53,563	61,519	69,315	53,205	62,309	66,801	71,254	80,033	94,197	118,299	156,796	298,440	356,178
	600	45,151	53,233	61,144	68,892	52,924	61,994	66,468	70,901	79,638	93,914	117,963	156,516	298,114	355,797
	700	44,810	52,845	60,704	68,396	52,595	61,623	66,076	70,487	79,174	93,581	117,567	156,186	297,730	355,347
	800	44,420	52,401	60,201	67,828	52,217	61,198	65,626	70,012	78,641	93,198	117,111	155,805	297,287	354,828
	900	43,981	51,902	59,635	67,190	51,792	60,721	65,121	69,478	78,042	92,766	116,596	155,376	296,786	354,242
	1,000	43,496	51,351	59,009	66,485	51,321	60,191	64,560	68,885	77,378	92,285	116,024	154,897	296,228	353,587
	1,100	42,966	50,748	58,324	65,713	50,806	59,611	63,947	68,237	76,651	91,756	115,395	154,369	295,611	352,865
	1,200	42,393	50,096	57,584	64,878	50,247	58,982	63,281	67,533	75,862	91,181	114,710	153,794	294,937	352,076
	1,300	41,779	49,396	56,790	63,983	49,647	58,307	62,565	66,776	75,013	90,560	113,969	153,170	294,207	351,220
	1,400	41,126	48,652	55,944	63,030	49,007	57,585	61,802	65,968	74,108	89,893	113,175	152,500	293,420	350,298
	1,500	40,436	47,865	55,050	62,022	48,328	56,820	60,992	65,112	73,147	89,183	112,329	151,783	292,577	349,311
	1,600	39,711	47,038	54,110	60,963	47,614	56,014	60,137	64,208	72,134	88,430	111,430	151,021	291,679	348,259
	1,700	38,954	46,173	53,127	59,855	46,864	55,168	59,241	63,261	71,072	87,636	110,482	150,213	290,726	347,142
	1,800	38,166	45,273	52,104	58,701	46,083	54,285	58,306	62,270	69,961	86,801	109,485	149,361	289,718	345,961
	1,900	37,351	44,341	51,044	57,507	45,270	53,367	57,332	61,241	68,807	85,927	108,441	148,466	288,657	344,717
	2,000	36,510	43,379	49,951	56,273	44,430	52,416	56,324	60,174	67,610	85,015	107,352	147,529	287,542	343,411
	2,100	35,647	42,390	48,826	55,005	43,563	51,435	55,283	59,072	66,375	84,067	106,218	146,549	286,375	342,043
	2,200	34,764	41,377	47,673	53,706	42,672	50,425	54,212	57,938	65,103	83,085	105,042	145,529	285,156	340,615
	2,300	33,863	40,343	46,496	52,380	41,759	49,390	53,114	56,775	63,798	82,068	103,825	144,469	283,886	339,126
	2,400	32,946	39,291	45,298	51,029	40,826	48,331	51,990	55,585	62,464	81,020	102,569	143,370	282,565	337,578
	2,500	32,018	38,223	44,082	49,658	39,876	47,251	50,844	54,371	61,102	79,942	101,276	142,233	281,195	335,972
	2,600	31,079	37,142	42,850	48,270	38,910	46,153	49,678	53,135	59,716	78,834	99,947	141,060	279,776	334,308
	2,700	30,132	36,052	41,607	46,869	37,931	45,039	48,495	51,881	58,309	77,700	98,584	139,850	278,309	332,588
	2,800	29,180	34,954	40,355	45,458	36,942	43,912	47,296	50,611	56,885	76,540	97,190	138,606	276,795	330,812
	2,900	28,226	33,851	39,097	44,040	35,943	42,773	46,086	49,327	55,445	75,356	95,766	137,329	275,234	328,982
	3,000	27,270	32,746	37,837	42,619	34,938	41,625	44,865	48,033	53,992	74,150	94,314	136,019	273,628	327,098
	3,100	26,316	31,642	36,576	41,199	33,929	40,471	43,637	46,730	52,531	72,923	92,836	134,678	271,978	325,161
	3,200	25,366	30,541	35,318	39,781	32,917	39,312	42,404	45,422	51,063	71,677	91,334	133,306	270,283	323,174
	3,300	24,422	29,444	34,066	38,369	31,904	38,151	41,169	44,111	49,592	70,414	89,809	131,906	268,546	321,135
	3,400	23,486	28,356	32,821	36,967	30,893	36,991	39,933	42,798	48,120	69,136	88,265	130,478	266,767	319,048
	3,500	22,559	27,276	31,587	35,576	29,886	35,833	38,699	41,488	46,649	67,843	86,702	129,024	264,947	316,912
	3,600	21,643	26,209	30,365	34,199	28,883	34,679	37,469	40,181	45,183	66,539	85,122	127,544	263,088	314,730
	3,700	20,741	25,155	29,158	32,839	27,887	33,531	36,245	38,881	43,723	65,223	83,528	126,040	261,190	312,501
	3,800	19,852	24,116	27,969	31,498	26,900	32,392	35,029	37,588	42,273	63,899	81,921	124,514	259,254	310,228
	3,900	18,980	23,094	26,797	30,179	25,922	31,262	33,823	36,306	40,834	62,568	80,304	122,966	257,281	307,912
	4,000	18,125	22,090	25,647	28,882	24,957	30,144	32,629	35,036	39,408	61,230	78,678	121,398	255,273	305,553

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.



TUBO REDONDO HR ESTRUCTURAL FANALCA
COLUMNAS RELLENAS DE CONCRETO
RESISTENCIA A COMPRESIÓN SECCIÓN COMPUESTA
 $\phi_c P_n$ (kg) donde $\phi_c = 0.75$

$f'_c = 4 \text{ ksi (2.81 kgf/mm}^2\text{)}$
 $F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$
 $F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO

Diametro Nominal / Diametro (mm)		4 / 114.3				5" / 127				6 / 168.3		8 / 219.1	10 / 273.1	12 / 323.9	
ESPESOR (mm)		3.00	4.00	5.00	6.00	3.00	4.00	4.50	5.00	6.00	4.00	6.00	5.00	9.00	10.00
PESO (kg/m)		8.23	10.88	13.48	16.03	9.17	12.13	13.59	15.04	17.90	16.21	24.02	26.4	58.62	77.41
Longitud Efectiva KL (mm)	4,100	17,253	21,093	24,518	27,611	24,004	29,039	31,449	33,780	37,998	59,889	77,045	119,811	253,230	303,153
	4,200	16,441	20,100	23,367	26,313	23,065	27,949	30,284	32,540	36,605	58,545	75,407	118,206	251,154	300,714
	4,300	15,685	19,176	22,293	25,103	22,142	26,875	29,135	31,317	35,232	57,199	73,765	116,585	249,045	298,236
	4,400	14,980	18,315	21,291	23,975	21,235	25,818	28,004	30,113	33,880	55,855	72,122	114,949	246,905	295,721
	4,500	14,322	17,510	20,355	22,921	20,308	24,780	26,893	28,929	32,551	54,511	70,478	113,299	244,735	293,171
	4,600	13,706	16,757	19,480	21,936	19,435	23,717	25,764	27,736	31,214	53,171	68,837	111,636	242,535	290,585
	4,700	13,129	16,051	18,660	21,012	18,617	22,718	24,680	26,568	29,899	51,836	67,199	109,962	240,308	287,967
	4,800	12,588	15,389	17,890	20,146	17,849	21,782	23,662	25,473	28,667	50,507	65,566	108,278	238,054	285,316
	4,900	12,079	14,768	17,167	19,332	17,128	20,902	22,706	24,444	27,509	49,184	63,940	106,585	235,775	282,635
	5,000	11,601	14,183	16,488	18,566	16,450	20,074	21,807	23,476	26,419	47,871	62,321	104,885	233,470	279,924
	5,100	11,150	13,632	15,847	17,845	15,811	19,294	20,960	22,564	25,393	46,566	60,712	103,178	231,143	277,186
	5,200	10,726	13,113	15,244	17,166	15,209	18,559	20,162	21,705	24,426	45,273	59,114	101,466	228,793	274,421
	5,300	10,325	12,623	14,674	16,524	14,640	17,866	19,408	20,893	23,513	43,991	57,529	99,750	226,423	271,630
	5,400	9,946	12,159	14,135	15,918	14,103	17,210	18,696	20,127	22,650	42,723	55,957	98,031	224,032	268,816
	5,500	9,588	11,721	13,626	15,344	13,595	16,590	18,022	19,401	21,834	41,468	54,399	96,310	221,623	265,979
	5,600	9,248	11,306	13,144	14,801	13,113	16,003	17,384	18,715	21,061	40,228	52,858	94,589	219,196	263,120
	5,700	8,927	10,913	12,687	14,286	12,657	15,446	16,780	18,064	20,329	39,004	51,333	92,868	216,753	260,242
	5,800	8,621	10,540	12,253	13,798	12,225	14,918	16,206	17,446	19,634	37,796	49,827	91,149	214,294	257,345
	5,900	8,332	10,186	11,841	13,334	11,814	14,417	15,661	16,860	18,974	36,569	48,340	89,433	211,821	254,431
	6,000	8,056	9,849	11,450	12,893	11,423	13,940	15,144	16,303	18,347	35,360	46,873	87,721	209,336	251,501
	6,100	7,794	9,529	11,077	12,474	11,052	13,487	14,651	15,772	17,750	34,210	45,358	86,013	206,838	248,556
	6,200	7,545	9,224	10,723	12,075	10,698	13,055	14,182	15,268	17,182	33,115	43,907	84,312	204,330	245,598
	6,300	7,307	8,933	10,385	11,695	10,361	12,644	13,736	14,787	16,641	32,072	42,524	82,617	201,812	242,628
	6,400	7,081	8,656	10,063	11,332	10,040	12,252	13,310	14,328	16,125	31,078	41,205	80,930	199,285	239,647
	6,500	6,864	8,392	9,756	10,986	9,733	11,878	12,903	13,891	15,633	30,129	39,947	79,251	196,751	236,657
	6,600	6,658	8,140	9,463	10,656	9,441	11,521	12,515	13,473	15,163	29,223	38,746	77,582	194,211	233,658
	6,700	6,461	7,899	9,182	10,340	9,161	11,179	12,145	13,074	14,713	28,357	37,598	75,924	191,666	230,653
	6,800	6,272	7,668	8,914	10,038	8,894	10,853	11,790	12,692	14,284	27,529	36,500	74,277	189,116	227,642
	6,900	6,092	7,447	8,658	9,749	8,638	10,541	11,451	12,327	13,873	26,737	35,450	72,642	186,564	224,626
	7,000	5,919	7,236	8,412	9,473	8,393	10,242	11,126	11,977	13,479	25,979	34,444	71,020	184,009	221,608
	7,100	5,753	7,034	8,177	9,208	8,158	9,955	10,815	11,642	13,102	25,252	33,481	69,412	181,453	218,587
	7,200	5,595	6,840	7,951	8,954	7,933	9,681	10,516	11,321	12,741	24,555	32,557	67,818	178,897	215,565
	7,300	5,442	6,654	7,735	8,710	7,717	9,417	10,230	11,013	12,394	23,887	31,672	66,239	176,343	212,544
	7,400	5,296	6,475	7,527	8,476	7,510	9,164	9,956	10,717	12,061	23,246	30,821	64,676	173,790	209,525
	7,500	5,156	6,303	7,328	8,252	7,311	8,922	9,692	10,434	11,742	22,630	30,005	63,129	171,240	206,508
	7,600	5,021	6,139	7,136	8,036	7,120	8,688	9,439	10,161	11,435	22,039	29,220	61,599	168,694	203,495
7,700	4,892	5,980	6,952		6,936	8,464	9,195	9,899	11,140	21,470	28,466	59,996	166,153	200,487	
7,800	4,767	5,828			6,759	8,249	8,961	9,646	10,856	20,923	27,741	58,468	163,618	197,484	
7,900					6,589	8,041	8,735	9,404	10,583	20,397	27,043	56,997	161,090	194,489	
8,000					6,426	7,841	8,518	9,170	10,320	19,890	26,371	55,581	158,569	191,503	

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.



Fanalca



TUBO CUADRADO HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 4$ ksi (2.81 kgf/mm²)

$F_y = 50$ ksi (35.15 kgf/mm²)

$F_u = 65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		90x90				100x100				
ESPESOR (mm)		3.00	4.00	5.00	6.00	3.00	4.00	4.50	5.00	6.00
PESO (kg/m)		8.01	10.48	12.84	15.1	8.96	11.73	13.08	14.41	16.98
Longitud Efectiva KL (mm)	0	39,136	46,487	53,412	59,911	45,490	53,825	57,832	61,732	69,213
	100	39,109	46,456	53,376	59,868	45,465	53,795	57,800	61,698	69,174
	200	39,030	46,362	53,265	59,741	45,390	53,708	57,706	61,596	69,058
	300	38,899	46,206	53,082	59,530	45,265	53,562	57,548	61,427	68,863
	400	38,715	45,988	52,827	59,236	45,091	53,359	57,328	61,190	68,592
	500	38,480	45,710	52,501	58,860	44,868	53,098	57,047	60,887	68,245
	600	38,195	45,372	52,105	58,404	44,597	52,782	56,705	60,519	67,824
	700	37,862	44,976	51,640	57,869	44,278	52,410	56,303	60,087	67,329
	800	37,480	44,524	51,110	57,258	43,914	51,985	55,843	59,592	66,762
	900	37,052	44,016	50,515	56,573	43,504	51,506	55,327	59,036	66,126
	1,000	36,579	43,456	49,859	55,818	43,051	50,977	54,755	58,420	65,422
	1,100	36,064	42,844	49,143	54,994	42,556	50,399	54,130	57,748	64,652
	1,200	35,508	42,185	48,371	54,106	42,020	49,773	53,453	57,020	63,820
	1,300	34,914	41,480	47,545	53,158	41,445	49,101	52,728	56,239	62,927
	1,400	34,283	40,731	46,669	52,152	40,833	48,386	51,955	55,408	61,977
	1,500	33,617	39,942	45,747	51,092	40,186	47,629	51,138	54,529	60,972
	1,600	32,921	39,116	44,781	49,984	39,505	46,833	50,278	53,605	59,917
	1,700	32,195	38,255	43,775	48,830	38,793	46,001	49,379	52,638	58,813
	1,800	31,443	37,363	42,732	47,635	38,052	45,134	48,443	51,632	57,664
	1,900	30,667	36,442	41,657	46,404	37,284	44,235	47,473	50,589	56,475
	2,000	29,869	35,496	40,554	45,141	36,491	43,308	46,472	49,513	55,247
	2,100	29,053	34,528	39,425	43,850	35,676	42,353	45,441	48,406	53,986
	2,200	28,222	33,541	38,275	42,536	34,841	41,375	44,386	47,271	52,693
	2,300	27,377	32,538	37,107	41,203	33,988	40,375	43,307	46,113	51,374
	2,400	26,521	31,523	35,925	39,855	33,119	39,357	42,208	44,933	50,031
	2,500	25,658	30,498	34,734	38,497	32,236	38,323	41,092	43,735	48,669
	2,600	24,789	29,467	33,535	37,132	31,343	37,275	39,962	42,522	47,290
	2,700	23,917	28,432	32,333	35,765	30,441	36,216	38,821	41,297	45,899
	2,800	23,045	27,397	31,132	34,400	29,532	35,150	37,671	40,064	44,498
	2,900	22,174	26,364	29,934	33,040	28,619	34,078	36,515	38,824	43,092
	3,000	21,308	25,335	28,742	31,689	27,703	33,002	35,356	37,581	41,683
	3,100	20,448	24,314	27,560	30,350	26,788	31,926	34,196	36,338	40,275
	3,200	19,596	23,303	26,390	29,027	25,874	30,851	33,038	35,097	38,870
	3,300	18,754	22,303	25,235	27,722	24,963	29,780	31,885	33,861	37,472
	3,400	17,924	21,318	24,097	26,438	24,059	28,715	30,738	32,633	36,084
	3,500	17,108	20,349	22,979	25,178	23,161	27,658	29,600	31,415	34,708
	3,600	16,307	19,397	21,883	23,944	22,272	26,611	28,473	30,208	33,347
	3,700	15,522	18,465	20,800	22,700	21,394	25,576	27,359	29,017	32,003
	3,800	14,727	17,522	19,719	21,521	20,528	24,555	26,260	27,841	30,679
	3,900	13,982	16,635	18,721	20,432	19,675	23,548	25,177	26,683	29,376
	4,000	13,291	15,814	17,797	19,423	18,837	22,559	24,113	25,546	28,098
	4,100	12,651	15,052	16,939	18,487	18,015	21,587	23,068	24,430	26,824
	4,200	12,056	14,343	16,142	17,617	17,178	20,607	22,010	23,294	25,562
	4,300	11,501	13,684	15,400	16,807	16,389	19,660	20,999	22,224	24,386
	4,400	10,985	13,069	14,708	16,052	15,652	18,777	20,055	21,225	23,291
	4,500	10,502	12,495	14,062	15,346	14,964	17,951	19,174	20,292	22,267
	4,600	10,050	11,957	13,457	14,686	14,321	17,179	18,349	19,419	21,309
	4,700	9,627	11,454	12,890	14,068	13,718	16,456	17,577	18,602	20,412
	4,800	9,230	10,982	12,359	13,488	13,152	15,778	16,852	17,835	19,571
	4,900	8,857	10,538	11,860	12,943	12,621	15,140	16,171	17,114	18,780
	5,000	8,506	10,121	11,390	12,431	12,121	14,541	15,531	16,437	18,036
	5,100	8,176	9,728	10,948	11,948	11,650	13,976	14,928	15,798	17,336
	5,200	7,865	9,357	10,531	11,493	11,207	13,444	14,359	15,196	16,676
	5,300	7,571	9,007	10,137	11,063	10,788	12,941	13,822	14,628	16,052
	5,400	7,293	8,677	9,765	10,657	10,392	12,466	13,315	14,092	15,463
	5,500	7,030	8,364	9,413	10,273	10,017	12,017	12,835	13,584	14,906
	5,600	6,781	8,068	9,080	9,910	9,663	11,592	12,381	13,103	14,378
	5,700	6,545	7,788	8,764	9,565	9,327	11,188	11,950	12,647	13,878
	5,800	6,322	7,521	8,465	9,238	9,008	10,806	11,542	12,215	13,404
	5,900	6,109	7,269	8,180	8,927	8,705	10,443	11,154	11,804	12,953
	6,000	5,907	7,028	7,910	8,632	8,417	10,098	10,785	11,414	12,525

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez KL/r < 200.

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO



TUBO CUADRADO HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 4 \text{ ksi (2.81 kgf/mm}^2\text{)}$

$F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$

$F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO

Dimensión Nominal (mm)		120x120		135x135		150x150		200x200		220x220		250x250		300x300	
ESPESOR (mm)		4.00	4.00	6.00	4.00	6.00	5.00	7.00	7.00	9.00	8.00	9.00	10.00	10.00	12.00
PESO (kg/m)		14.14	16.13	23.82	18.12	26.40	30.11	41.43	46.16	58.54	59.93	66.47	73.34	89.04	105.61
Longitud Efectiva KL (mm)	0	69,548	82,303	104,565	95,865	121,076	164,629	198,816	227,634	264,046	294,919	315,888	336,404	434,842	484,422
	100	69,469	82,229	104,471	95,794	120,988	164,559	198,734	227,557	263,957	294,841	315,860	336,375	434,815	484,392
	200	69,337	82,104	104,315	95,675	120,842	164,444	198,599	227,428	263,809	294,712	315,778	336,287	434,736	484,305
	300	69,153	81,931	104,096	95,510	120,638	164,283	198,409	227,248	263,602	294,531	315,640	336,141	434,604	484,158
	400	68,917	81,708	103,816	95,297	120,376	164,076	198,166	227,016	263,336	294,298	315,447	335,936	434,419	483,954
	500	68,629	81,436	103,474	95,038	120,057	163,823	197,869	226,733	263,010	294,015	315,200	335,673	434,181	483,691
	600	68,291	81,116	103,072	94,733	119,680	163,525	197,518	226,399	262,627	293,679	314,897	335,352	433,891	483,370
	700	67,903	80,749	102,609	94,382	119,248	163,182	197,114	226,014	262,185	293,293	314,541	334,974	433,548	482,990
	800	67,466	80,335	102,088	93,986	118,759	162,793	196,657	225,579	261,684	292,856	314,129	334,537	433,153	482,553
	900	66,981	79,874	101,508	93,545	118,215	162,361	196,148	225,094	261,127	292,368	313,664	334,043	432,705	482,058
	1,000	66,448	79,368	100,871	93,060	117,617	161,884	195,587	224,559	260,511	291,829	313,145	333,491	432,206	481,505
	1,100	65,870	78,817	100,178	92,532	116,965	161,363	194,974	223,974	259,839	291,241	312,572	332,883	431,654	480,895
	1,200	65,247	78,223	99,430	91,961	116,261	160,798	194,310	223,340	259,111	290,603	311,945	332,218	431,051	480,227
	1,300	64,581	77,587	98,629	91,349	115,505	160,191	193,596	222,657	258,326	289,915	311,266	331,496	430,397	479,503
	1,400	63,874	76,909	97,775	90,696	114,699	159,542	192,831	221,926	257,486	289,178	310,534	330,719	429,691	478,722
	1,500	63,126	76,190	96,871	90,003	113,843	158,850	192,017	221,148	256,591	288,392	309,749	329,886	428,934	477,884
	1,600	62,339	75,433	95,917	89,271	112,939	158,117	191,154	220,322	255,642	287,558	308,913	328,998	428,126	476,990
	1,700	61,515	74,639	94,916	88,501	111,988	157,344	190,244	219,449	254,639	286,676	308,025	328,055	427,268	476,041
	1,800	60,657	73,807	93,869	87,694	110,992	156,530	189,286	218,531	253,583	285,747	307,086	327,058	426,360	475,035
	1,900	59,764	72,941	92,778	86,852	109,951	155,677	188,281	217,567	252,474	284,770	306,097	326,007	425,402	473,975
	2,000	58,841	72,042	91,645	85,975	108,868	154,785	187,231	216,558	251,314	283,748	305,057	324,903	424,394	472,860
	2,100	57,887	71,110	90,472	85,066	107,743	153,855	186,135	215,505	250,104	282,679	303,968	323,747	423,338	471,691
	2,200	56,906	70,148	89,260	84,124	106,578	152,888	184,996	214,408	248,843	281,565	302,830	322,539	422,233	470,468
	2,300	55,898	69,158	88,011	83,151	105,375	151,885	183,813	213,268	247,533	280,406	301,644	321,279	421,079	469,191
	2,400	54,867	68,140	86,728	82,149	104,135	150,846	182,588	212,087	246,174	279,202	300,410	319,969	419,878	467,861
	2,500	53,814	67,096	85,412	81,119	102,860	149,771	181,322	210,864	244,768	277,955	299,129	318,608	418,629	466,479
	2,600	52,741	66,028	84,066	80,062	101,551	148,663	180,016	209,601	243,315	276,665	297,801	317,198	417,333	465,044
	2,700	51,650	64,938	82,691	78,979	100,211	147,522	178,670	208,298	241,817	275,333	296,428	315,740	415,990	463,558
	2,800	50,544	63,828	81,290	77,873	98,841	146,349	177,286	206,956	240,273	273,959	295,009	314,233	414,601	462,021
	2,900	49,423	62,698	79,865	76,745	97,442	145,144	175,864	205,577	238,687	272,544	293,546	312,679	413,167	460,433
	3,000	48,291	61,551	78,418	75,595	96,017	143,908	174,406	204,160	237,057	271,089	292,039	311,079	411,688	458,796
	3,100	47,149	60,389	76,951	74,426	94,567	142,644	172,914	202,707	235,385	269,594	290,490	309,433	410,164	457,109
	3,200	45,998	59,212	75,467	73,238	93,093	141,350	171,387	201,218	233,673	268,061	288,898	307,743	408,596	455,373
	3,300	44,842	58,024	73,966	72,034	91,599	140,030	169,827	199,696	231,921	266,489	287,265	306,008	406,984	453,589
	3,400	43,682	56,825	72,452	70,814	90,085	138,682	168,236	198,140	230,131	264,880	285,591	304,230	405,330	451,757
	3,500	42,519	55,617	70,927	69,581	88,553	137,309	166,614	196,551	228,303	263,235	283,877	302,410	403,633	449,879
	3,600	41,356	54,401	69,391	68,335	87,005	135,912	164,962	194,931	226,439	261,554	282,125	300,549	401,895	447,954
	3,700	40,194	53,180	67,849	67,079	85,443	134,491	163,283	193,281	224,539	259,838	280,334	298,647	400,115	445,984
	3,800	39,035	51,955	66,301	65,813	83,868	133,048	161,576	191,601	222,606	258,088	278,506	296,706	398,295	443,968
	3,900	37,881	50,728	64,749	64,539	82,283	131,583	159,844	189,892	220,639	256,305	276,642	294,725	396,434	441,908
	4,000	36,732	49,499	63,196	63,258	80,689	130,098	158,087	188,157	218,641	254,489	274,742	292,708	394,535	439,805

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.



TUBO CUADRADO HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 4 \text{ ksi (2.81 kgf/mm}^2\text{)}$

$F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$

$F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

Dimensión Nominal (mm)		120x120		135x135		150x150		200x200		220x220		250x250		300x300	
ESPESOR (mm)		4.00	4.00	6.00	4.00	6.00	5.00	7.00	7.00	9.00	8.00	9.00	10.00	10.00	12.00
PESO (kg/m)		14.14	16.13	23.82	18.12	26.40	30.11	41.43	46.16	58.54	59.93	66.47	73.34	89.04	105.61
Longitud Efectiva KL (mm)	4,100	35,592	48,272	61,643	61,972	79,087	128,594	156,307	186,394	216,612	252,642	272,808	290,653	392,597	437,659
	4,200	34,461	47,046	60,093	60,682	77,480	127,072	154,504	184,607	214,554	250,764	270,840	288,563	390,621	435,471
	4,300	33,340	45,823	58,546	59,390	75,869	125,532	152,681	182,795	212,468	248,857	268,840	286,438	388,607	433,241
	4,400	32,232	44,605	57,005	58,096	74,255	123,976	150,838	180,960	210,354	246,921	266,808	284,279	386,557	430,971
	4,500	31,136	43,394	55,471	56,803	72,640	122,405	148,977	179,102	208,215	244,957	264,745	282,087	384,471	428,661
	4,600	30,055	42,189	53,946	55,510	71,027	120,821	147,098	177,224	206,052	242,965	262,652	279,864	382,350	426,312
	4,700	28,990	40,993	52,431	54,221	69,415	119,223	145,204	175,325	203,865	240,948	260,530	277,609	380,194	423,924
	4,800	27,941	39,807	50,929	52,935	67,808	117,614	143,295	173,408	201,656	238,906	258,380	275,325	378,005	421,499
	4,900	26,884	38,632	49,440	51,654	66,205	115,993	141,372	171,472	199,426	236,839	256,203	273,013	375,782	419,037
	5,000	25,841	37,469	47,965	50,379	64,610	114,363	139,437	169,520	197,176	234,749	254,000	270,672	373,527	416,539
	5,100	24,856	36,319	46,507	49,111	63,022	112,725	137,491	167,552	194,908	232,636	251,773	268,305	371,241	414,006
	5,200	23,927	35,183	45,066	47,851	61,444	111,078	135,535	165,569	192,623	230,502	249,521	265,913	368,923	411,439
	5,300	23,049	34,062	43,644	46,601	59,876	109,425	133,571	163,573	190,322	228,348	247,246	263,496	366,576	408,839
	5,400	22,219	32,957	42,241	45,361	58,320	107,767	131,599	161,564	188,006	226,174	244,949	261,056	364,199	406,205
	5,500	21,432	31,841	40,859	44,132	56,777	106,104	129,621	159,543	185,677	223,981	242,632	258,593	361,793	403,540
	5,600	20,687	30,733	39,425	42,915	55,248	104,437	127,638	157,513	183,335	221,771	240,294	256,109	359,360	400,844
	5,700	19,980	29,683	38,077	41,711	53,734	102,767	125,650	155,472	180,983	219,544	237,937	253,604	356,900	398,118
	5,800	19,308	28,685	36,797	40,521	52,237	101,096	123,660	153,424	178,620	217,301	235,563	251,081	354,413	395,363
	5,900	18,670	27,737	35,581	39,345	50,757	99,425	121,669	151,368	176,248	215,043	233,171	248,539	351,901	392,579
	6,000	18,063	26,835	34,424	38,184	49,295	97,753	119,676	149,305	173,869	212,772	230,763	245,980	349,364	389,768
	6,100	17,485	25,976	33,322	37,004	47,852	96,083	117,685	147,238	171,484	210,487	228,341	243,406	346,804	386,930
	6,200	16,934	25,158	32,273	35,838	46,367	94,415	115,694	145,166	169,093	208,191	225,904	240,816	344,220	384,067
	6,300	16,409	24,378	31,272	34,727	44,929	92,749	113,707	143,091	166,698	205,883	223,455	238,212	341,614	381,179
	6,400	15,908	23,634	30,317	33,667	43,557	91,088	111,723	141,013	164,300	203,565	220,993	235,596	338,987	378,266
	6,500	15,430	22,923	29,405	32,654	42,247	89,431	109,744	138,934	161,900	201,238	218,521	232,968	336,338	375,331
	6,600	14,972	22,244	28,534	31,687	40,996	87,780	107,770	136,855	159,500	198,903	216,038	230,329	333,670	372,373
	6,700	14,535	21,594	27,701	30,762	39,799	86,135	105,803	134,776	157,100	196,560	213,546	227,680	330,983	369,395
	6,800	14,117	20,973	26,904	29,876	38,653	84,497	103,843	132,699	154,701	194,211	211,047	225,023	328,278	366,395
	6,900	13,717	20,378	26,141	29,029	37,557	82,868	101,892	130,624	152,304	191,856	208,540	222,358	325,555	363,376
	7,000	13,333	19,808	25,410	28,217	36,506	81,246	99,951	128,553	149,911	189,497	206,027	219,686	322,815	360,339
	7,100	12,965	19,262	24,709	27,439	35,499	79,635	98,020	126,485	147,523	187,133	203,509	217,009	320,060	357,284
	7,200	12,612	18,738	24,036	26,692	34,534	78,033	96,099	124,423	145,140	184,767	200,986	214,327	317,289	354,212
	7,300	12,274	18,235	23,391	25,976	33,606	76,442	94,191	122,367	142,763	182,399	198,460	211,642	314,505	351,123
	7,400	11,949	17,751	22,772	25,287	32,716	74,863	92,295	120,317	140,394	180,029	195,932	208,953	311,706	348,020
	7,500	11,636	17,287	22,176	24,626	31,861	73,296	90,413	118,275	138,033	177,659	193,402	206,263	308,896	344,903
	7,600	11,336	16,841	21,604	23,991	31,039	71,741	88,545	116,241	135,681	175,289	190,872	203,573	306,073	341,772
	7,700	11,047	16,412	21,054	23,380	30,248	70,200	86,692	114,216	133,339	172,921	188,341	200,882	303,239	338,629
	7,800	10,769	15,999	20,524	22,792	29,487	68,672	84,855	112,201	131,009	170,555	185,812	198,193	300,395	335,474
	7,900	10,502	15,602	20,014	22,225	28,755	67,159	83,034	110,197	128,690	168,191	183,285	195,505	297,541	332,308
	8,000											180,761	192,820	294,679	329,133

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 4 \text{ ksi (2.81 kgf/mm}^2\text{)}$

$F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$

$F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

Dimensión Nominal (mm)		150x100		200x100		250x100	250x150	300x100		350x150	400x200
ESPESOR (mm)		4.00	6.00	4.00	6.00	5.00	5.00	5.00	7.00	7.00	9.00
PESO (kg/m)		14.87	21.69	18.01	26.40	26.35	30.11	30.11	41.10	52.42	80.60
Longitud Efectiva KL (mm)	0	72,616	92,919	91,407	116,624	125,477	160,170	146,725	180,916	255,649	391,485
	100	72,579	92,871	91,362	116,567	125,417	160,133	146,656	180,832	255,594	391,437
	200	72,467	92,727	91,226	116,395	125,238	160,023	146,450	180,578	255,430	391,292
	300	72,281	92,489	91,000	116,110	124,939	159,840	146,107	180,156	255,156	391,052
	400	72,023	92,156	90,684	115,712	124,523	159,585	145,628	179,566	254,773	390,716
	500	71,691	91,729	90,280	115,202	123,989	159,256	145,015	178,811	254,282	390,283
	600	71,288	91,211	89,788	114,583	123,340	158,856	144,269	177,893	253,682	389,756
	700	70,814	90,602	89,211	113,854	122,577	158,384	143,392	176,813	252,976	389,134
	800	70,272	89,904	88,549	113,020	121,703	157,841	142,387	175,576	252,163	388,417
	900	69,662	89,120	87,805	112,081	120,720	157,229	141,256	174,184	251,246	387,606
	1,000	68,986	88,251	86,981	111,041	119,631	156,547	140,003	172,641	250,224	386,701
	1,100	68,248	87,301	86,079	109,904	118,438	155,796	138,631	170,952	249,099	385,704
	1,200	67,447	86,273	85,102	108,671	117,145	154,978	137,143	169,121	247,874	384,615
	1,300	66,588	85,168	84,053	107,346	115,756	154,094	135,545	167,154	246,548	383,434
	1,400	65,673	83,992	82,934	105,934	114,275	153,145	133,839	165,054	245,124	382,164
	1,500	64,704	82,746	81,749	104,438	112,704	152,132	132,031	162,828	243,604	380,804
	1,600	63,683	81,434	80,501	102,862	111,050	151,057	130,125	160,482	241,990	379,355
	1,700	62,615	80,061	79,193	101,210	109,315	149,921	128,127	158,021	240,283	377,819
	1,800	61,501	78,630	77,830	99,488	107,504	148,725	126,041	155,453	238,486	376,197
	1,900	60,345	77,145	76,413	97,698	105,623	147,471	123,873	152,783	236,601	374,489
	2,000	59,151	75,610	74,949	95,847	103,676	146,161	121,628	150,019	234,630	372,698
	2,100	57,920	74,029	73,439	93,939	101,668	144,796	119,311	147,167	232,576	370,824
	2,200	56,657	72,407	71,888	91,978	99,603	143,378	116,929	144,234	230,441	368,869
	2,300	55,365	70,747	70,301	89,970	97,487	141,909	114,487	141,227	228,227	366,833
	2,400	54,047	69,054	68,680	87,920	95,325	140,391	111,991	138,153	225,938	364,720
	2,500	52,706	67,332	67,030	85,832	93,123	138,826	109,447	135,020	223,576	362,529
	2,600	51,345	65,585	65,354	83,712	90,884	137,215	106,860	131,834	221,144	360,263
	2,700	49,969	63,818	63,658	81,563	88,614	135,561	104,237	128,603	218,644	357,923
	2,800	48,579	62,035	61,944	79,392	86,319	133,866	101,583	125,334	216,080	355,511
	2,900	47,180	60,239	60,216	77,204	84,003	132,131	98,903	122,033	213,454	353,028
	3,000	45,774	58,435	58,478	75,001	81,672	130,359	96,204	118,709	210,770	350,477
	3,100	44,365	56,626	56,734	72,791	79,329	128,552	93,491	115,366	208,030	347,858
	3,200	42,954	54,817	54,988	70,576	76,980	126,712	90,769	112,013	205,238	345,174
	3,300	41,547	53,012	53,242	68,361	74,629	124,842	88,043	108,656	202,397	342,427
	3,400	40,143	51,212	51,501	66,151	72,281	122,942	85,320	105,300	199,509	339,617
	3,500	38,748	49,423	49,767	63,950	69,940	121,016	82,603	101,953	196,578	336,748
	3,600	37,363	47,648	48,044	61,761	67,610	119,066	79,898	98,620	193,607	333,822
	3,700	35,990	45,889	46,335	59,589	65,296	117,094	77,209	95,306	190,599	330,839
	3,800	34,632	44,149	44,642	57,436	63,001	115,101	74,540	92,018	187,558	327,802
	3,900	33,292	42,431	42,968	55,307	60,728	113,091	71,896	88,760	184,486	324,714
	4,000	31,970	40,738	41,316	53,205	58,482	111,065	69,281	85,537	181,386	321,575

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL = K_x L_x / (r_x / r_y)$.



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

COLUMNAS RELLENAS DE CONCRETO - RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) - $\phi_c = 0.75$

$f'_c = 4$ ksi (2.81 kgf/mm²)

$F_y = 50$ ksi (35.15 kgf/mm²)

$F_u = 65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		150x100		200x100		250x100	250x150	300x100		350x150	400x200
ESPESOR (mm)		4.00	6.00	4.00	6.00	5.00	5.00	5.00	7.00	7.00	9.00
PESO (kg/m)		14.87	21.69	18.01	26.40	26.35	30.11	30.11	41.10	52.42	80.60
Longitud Efectiva KL (mm)	4,100	30,670	39,073	39,688	51,133	56,265	109,026	66,699	82,354	178,262	318,388
	4,200	29,392	37,437	38,086	49,093	54,080	106,974	64,152	79,215	175,116	315,156
	4,300	28,116	35,794	36,513	47,088	51,931	104,914	61,645	76,124	171,953	311,880
	4,400	26,852	34,186	34,920	45,081	49,819	102,846	59,181	73,086	168,774	308,561
	4,500	25,672	32,683	33,385	43,100	47,671	100,773	56,710	70,046	165,583	305,203
	4,600	24,568	31,278	31,950	41,246	45,620	98,696	54,272	67,034	162,382	301,808
	4,700	23,534	29,961	30,605	39,510	43,700	96,618	51,987	64,212	159,175	298,376
	4,800	22,563	28,726	29,343	37,881	41,898	94,540	49,843	61,564	155,965	294,912
	4,900	21,652	27,565	28,157	36,350	40,205	92,465	47,829	59,077	152,753	291,416
	5,000	20,794	26,473	27,042	34,911	38,613	90,394	45,935	56,738	149,544	287,890
	5,100	19,987	25,445	25,992	33,555	37,114	88,329	44,152	54,534	146,339	284,337
	5,200	19,226	24,476	25,002	32,277	35,700	86,271	42,470	52,457	143,142	280,759
	5,300	18,507	23,561	24,067	31,070	34,366	84,223	40,882	50,496	139,954	277,158
	5,400	17,828	22,697	23,184	29,930	33,105	82,186	39,382	48,643	136,779	273,536
	5,500	17,185	21,879	22,349	28,852	31,912	80,161	37,963	46,891	133,618	269,894
	5,600	16,577	21,104	21,558	27,831	30,782	78,151	36,619	45,231	130,474	266,236
	5,700	16,001	20,370	20,808	26,863	29,712	76,156	35,346	43,658	127,350	262,563
	5,800	15,454	19,674	20,097	25,944	28,696	74,178	34,138	42,165	124,247	258,877
	5,900	14,934	19,013	19,421	25,072	27,731	72,219	32,990	40,748	121,168	255,179
	6,000	14,441	18,384	18,779	24,244	26,815	70,279	31,900	39,401	118,115	251,473
	6,100	13,971	17,787	18,169	23,455	25,943	68,360	30,862	38,120	115,089	247,760
	6,200	13,524	17,217	17,587	22,705	25,113	66,462	29,875	36,900	112,092	244,041
	6,300	13,098	16,675	17,033	21,990	24,322	64,588	28,934	35,738	109,127	240,319
	6,400	12,692	16,158	16,505	21,308	23,568	62,738	28,037	34,630	106,194	236,596
	6,500	12,304	15,665	16,001	20,657	22,848	60,814	27,181	33,573	103,296	232,873
	6,600	11,934	15,194	15,520	20,036	22,161	58,985	26,363	32,563	100,434	229,153
	6,700	11,581	14,744	15,060	19,442	21,504	57,237	25,582	31,598	97,464	225,436
	6,800	11,243	14,313	14,621	18,875	20,877	55,566	24,835	30,676	94,618	221,725
	6,900	10,919	13,901	14,200	18,332	20,276	53,967	24,121	29,793	91,895	218,022
	7,000	10,609	13,507	13,797	17,812	19,701	52,436	23,436	28,948	89,289	214,327
	7,100	10,313	13,129	13,411	17,313	19,150	50,969	22,781	28,138	86,791	210,644
	7,200	10,028	12,767	13,041	16,836	18,621	49,563	22,152	27,362	84,397	206,973
	7,300	9,755	12,420	12,686	16,378	18,115	48,215	21,550	26,617	82,101	203,316
	7,400	9,493	12,086	12,346	15,938	17,628	46,921	20,971	25,903	79,897	199,674
	7,500	9,242	11,766	12,019	15,516	17,161	45,678	20,416	25,217	77,780	196,050
	7,600	9,000	11,458	11,705	15,110	16,713	44,484	19,882	24,558	75,747	192,443
	7,700	8,768	11,163	11,403	14,720	16,281	43,336	19,369	23,924	73,792	188,857
	7,800	8,545	10,878	11,112	14,345	15,867	42,232	18,876	23,314	71,912	185,292
	7,900	8,330	10,605	10,832	13,984	15,468	41,169	18,401	22,728	70,103	181,750
	8,000	8,123		10,563	13,637	15,083	40,146	17,944	22,163	68,362	178,232

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

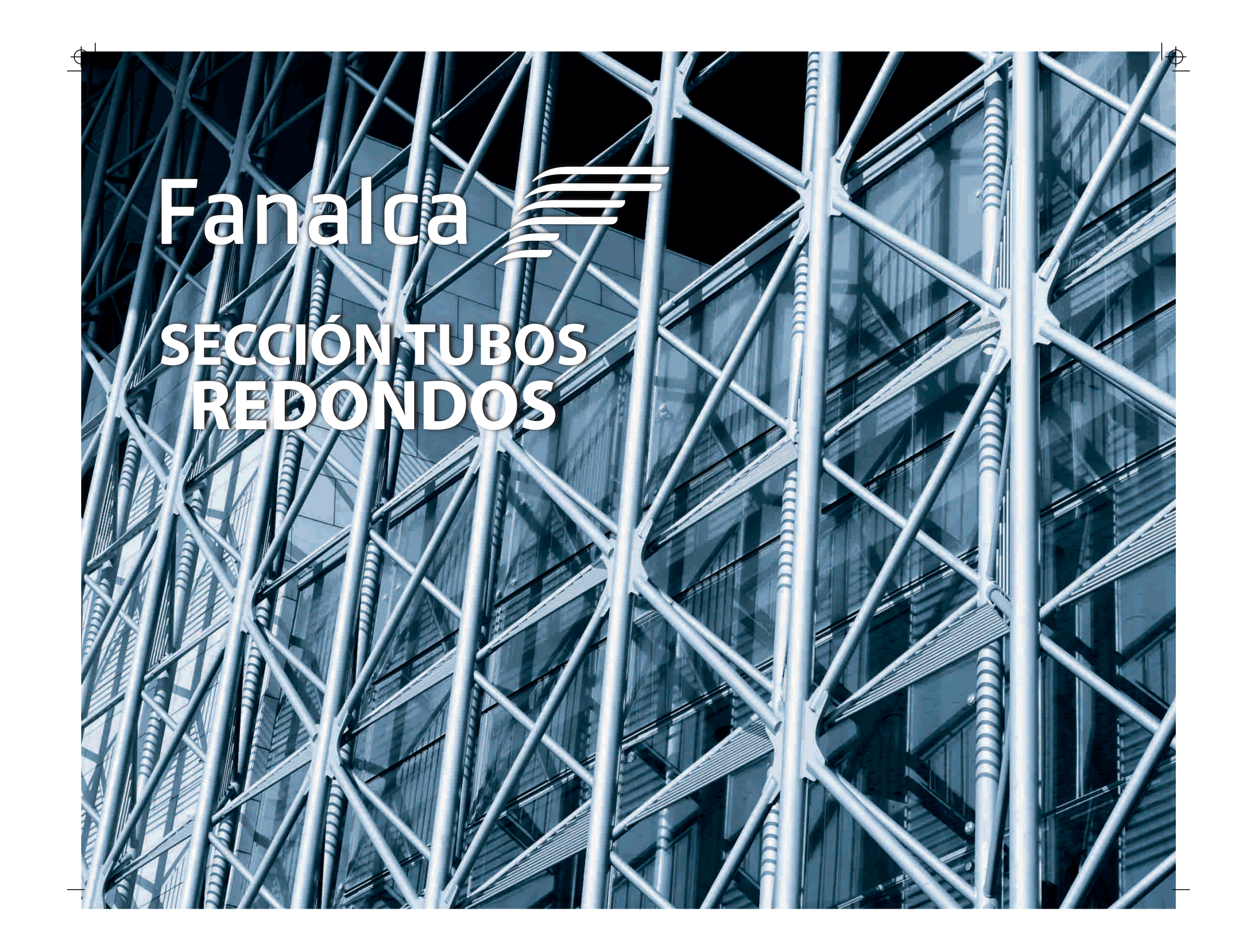
Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL = K_x L_x / (r_x / r_y)$.

CLASIFICACIÓN SECCIONES TUBULARES RELLENAS DE CONCRETO





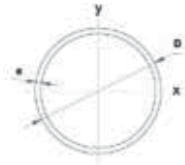
RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSION



Fanalca



SECCIÓN TUBOS
REDONDOS



TUBOS REDONDOS FANALCA

PROPIEDADES GEOMETRICAS

Tamaño Nominal	Diámetro Ext. D	Diámetro Ext. D (mm)	Espesor e (mm)	Peso Teórico (kg/m)	Área (cm ²)	I (cm ⁴)	S (cm ³)	Z (cm ³)	r (cm)	J (cm ⁴)
1/4	1.66"	42.24	1,50	1,51	1,92	3,99	1,89	2,49	1,44	7,98
			2,00	1,98	2,53	5,13	2,43	3,24	1,42	10,26
			2,50	2,45	3,12	6,19	2,93	3,95	1,41	12,37
			3,00	2,90	3,70	7,16	3,39	4,63	1,39	14,32
			4,00	3,77	4,81	8,88	4,20	5,87	1,36	17,76
1/2	1.9"	48.26	1,50	1,73	2,20	6,03	2,50	3,28	1,65	12,06
			2,00	2,28	2,91	7,79	3,23	4,28	1,64	15,58
			2,50	2,82	3,59	9,44	3,91	5,24	1,62	18,87
			3,00	3,35	4,27	10,97	4,55	6,15	1,60	21,94
			4,00	4,37	5,56	13,73	5,69	7,86	1,57	27,46
2	2.36"	59.9	1,50	2,16	2,75	11,74	3,92	5,12	2,07	23,48
			2,00	2,86	3,64	15,26	5,10	6,71	2,05	30,53
			2,50	3,54	4,51	18,60	6,21	8,24	2,03	37,20
			3,00	4,21	5,36	21,76	7,27	9,72	2,01	43,53
			4,00	5,51	7,02	27,58	9,21	12,52	1,98	55,16
2 1/2	2.875"	73.02	1,50	2,65	3,37	21,56	5,90	7,67	2,53	43,12
			2,00	3,50	4,46	28,16	7,71	10,09	2,51	56,31
			2,50	4,35	5,54	34,47	9,44	12,44	2,49	68,95
			3,00	5,18	6,60	40,52	11,10	14,72	2,48	81,04
			4,00	6,81	8,67	51,82	14,19	19,08	2,44	103,64
			5,00	8,39	10,68	62,13	17,02	23,18	2,41	124,25
			6,00	9,92	12,63	71,50	19,58	27,02	2,38	143,00
3	3.5"	88.9	2,00	4,29	5,46	51,57	11,60	15,11	3,07	103,14
			2,50	5,33	6,79	63,37	14,26	18,67	3,06	126,75
			3,00	6,36	8,10	74,76	16,82	22,15	3,04	149,53
			4,00	8,38	10,67	96,34	21,67	28,85	3,00	192,68
			5,00	10,35	13,18	116,37	26,18	35,24	2,97	232,75
			6,00	12,27	15,63	134,94	30,36	41,31	2,94	269,88
4	4.5"	114.3	2,00	4,29	5,46	51,57	11,60	15,11	3,07	103,14
			2,50	6,89	8,78	137,26	24,02	31,25	3,95	274,52
			3,00	8,23	10,49	162,55	28,44	37,17	3,94	325,10
			4,00	10,88	13,86	211,07	36,93	48,69	3,90	422,13
			5,00	13,48	17,17	256,92	44,96	59,77	3,87	513,84
			6,00	16,03	20,41	300,21	52,53	70,45	3,83	600,42
5	5"	127.00	2,50	7,68	9,78	189,53	29,85	38,76	4,40	379,06
			3,00	9,17	11,69	224,75	35,39	46,14	4,39	449,50
			3,50	10,66	13,58	259,11	40,80	53,40	4,37	518,21
			4,00	12,13	15,46	292,61	46,08	60,54	4,35	585,23
			4,50	13,59	17,32	325,29	51,23	67,56	4,33	650,57
			5,00	15,04	19,16	357,14	56,24	74,46	4,32	714,28
			6,00	17,90	22,81	418,44	65,90	87,92	4,28	836,88
6	6.625"	168.3	4,00	16,21	20,65	697,09	82,84	108,00	5,81	1394,18
			6,00	24,02	30,59	1008,69	119,87	158,12	5,74	2017,39
8	8.625"	219.1	5,00	26,40	33,63	1928,04	176,00	229,24	7,57	3856,09
10	10.75"	273.1	9,00	58,62	74,67	6517,96	477,33	627,98	9,34	13035,92
12	12.75"	323.9	10,00	77,41	98,61	12158,34	750,75	985,67	11,10	24316,68



TUBO REDONDO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSION

Diámetro Nominal/Diámetro (mm)		1 1/4 / 42.24					1 1/2 / 48.26					2 / 59.9				
ESPESOR (mm)		1.50	2.00	2.50	3.00	4.00	1.50	2.00	2.50	3.00	4.00	1.50	2.00	2.50	3.00	4.00
PESO (kg/m)		1.51	1.98	2.45	2.90	3.77	1.73	2.28	2.82	3.35	4.37	2.16	2.86	3.54	4.21	5.51
Longitud Efectiva KL (mm)	0	5,736	7,554	9,325	11,050	14,357	6,584	8,684	10,738	12,745	16,617	8,229	10,878	13,480	16,035	21,004
	100	5,736	7,554	9,325	11,050	14,357	6,584	8,684	10,738	12,745	16,617	8,229	10,878	13,480	16,035	21,004
	200	5,716	7,527	9,291	11,008	14,301	6,566	8,661	10,708	12,709	16,568	8,215	10,859	13,456	16,006	20,965
	300	5,656	7,446	9,189	10,884	14,132	6,514	8,590	10,619	12,601	16,422	8,172	10,802	13,385	15,920	20,849
	400	5,557	7,313	9,021	10,681	13,855	6,427	8,474	10,472	12,423	16,181	8,103	10,709	13,267	15,777	20,656
	500	5,422	7,131	8,791	10,402	13,477	6,308	8,313	10,270	12,178	15,849	8,006	10,579	13,104	15,580	20,389
	600	5,253	6,904	8,504	10,055	13,006	6,158	8,112	10,016	11,871	15,432	7,884	10,415	12,897	15,330	20,051
	700	5,054	6,636	8,166	9,646	12,452	5,980	7,872	9,714	11,506	14,938	7,737	10,217	12,648	15,030	19,645
	800	4,828	6,332	7,784	9,184	11,828	5,776	7,598	9,369	11,088	14,374	7,567	9,989	12,361	14,683	19,176
	900	4,580	5,999	7,365	8,678	11,147	5,549	7,294	8,986	10,626	13,750	7,375	9,732	12,037	14,292	18,649
	1,000	4,314	5,643	6,918	8,139	10,422	5,303	6,963	8,571	10,125	13,075	7,164	9,448	11,681	13,862	18,069
	1,100	4,035	5,270	6,450	7,576	9,668	5,040	6,612	8,129	9,593	12,360	6,935	9,141	11,295	13,396	17,442
	1,200	3,748	4,886	5,969	6,998	8,898	4,766	6,244	7,668	9,037	11,615	6,690	8,814	10,883	12,900	16,775
	1,300	3,457	4,497	5,484	6,417	8,124	4,482	5,864	7,192	8,465	10,851	6,432	8,468	10,450	12,378	16,073
	1,400	3,166	4,110	5,001	5,839	7,359	4,192	5,478	6,709	7,885	10,077	6,163	8,108	9,998	11,834	15,343
	1,500	2,879	3,729	4,527	5,273	6,614	3,900	5,089	6,223	7,303	9,303	5,885	7,736	9,532	11,273	14,592
	1,600	2,600	3,360	4,068	4,726	5,898	3,610	4,702	5,740	6,725	8,538	5,600	7,355	9,055	10,700	13,827
	1,700	2,331	3,005	3,627	4,198	5,206	3,323	4,321	5,266	6,158	7,789	5,311	6,969	8,572	10,120	13,053
	1,800	2,071	2,664	3,213	3,718	4,612	3,043	3,949	4,804	5,607	7,064	5,020	6,581	8,086	9,537	12,276
	1,900	1,848	2,377	2,866	3,317	4,113	2,771	3,590	4,358	5,076	6,360	4,728	6,192	7,601	8,956	11,503
	2,000	1,658	2,133	2,572	2,977	3,692	2,506	3,239	3,923	4,561	5,709	4,438	5,806	7,120	8,379	10,739
	2,100	1,497	1,925	2,321	2,687	3,332	2,262	2,923	3,540	4,116	5,152	4,152	5,425	6,645	7,812	9,988
	2,200	1,357	1,746	2,105	2,437	3,022	2,052	2,651	3,211	3,734	4,673	3,870	5,052	6,181	7,257	9,256
	2,300	1,237	1,591	1,918	2,220	2,754	1,869	2,416	2,926	3,402	4,258	3,596	4,688	5,728	6,717	8,545
	2,400	1,132	1,456	1,755	2,031	2,519	1,710	2,210	2,677	3,113	3,896	3,330	4,335	5,290	6,189	7,843
	2,500	1,039	1,337	1,612	1,866	2,314	1,571	2,030	2,459	2,859	3,578	3,066	3,986	4,858	5,684	7,203
	2,600	958	1,232	1,485	1,719	2,132	1,448	1,871	2,266	2,634	3,297	2,826	3,674	4,477	5,238	6,638
	2,700	886	1,139	1,373	1,590	1,972	1,339	1,729	2,095	2,436	3,049	2,613	3,397	4,140	4,843	6,138
	2,800	821	1,056	1,274	1,474	1,828	1,241	1,604	1,943	2,259	2,827	2,423	3,150	3,839	4,491	5,691
	2,900	764	982	1,184	1,371	1,700	1,154	1,491	1,806	2,100	2,629	2,253	2,929	3,569	4,176	5,292
	3,000						1,076	1,390	1,684	1,958	2,450	2,100	2,730	3,327	3,893	4,933
	3,100						1,005	1,299	1,573	1,830	2,290	1,962	2,551	3,109	3,638	4,610
	3,200						942	1,217	1,474	1,713	2,144	1,838	2,389	2,912	3,407	4,317
	3,300						884	1,142	1,383	1,608	2,012	1,725	2,242	2,733	3,197	4,052
	3,400						831	1,074	1,300	1,512		1,622	2,108	2,570	3,006	3,810
	3,500											1,528	1,986	2,421	2,832	3,589
	3,600											1,442	1,874	2,284	2,673	3,387
	3,700											1,363	1,772	2,159	2,526	3,201
	3,800											1,290	1,677	2,044	2,392	3,031
	3,900											1,223	1,590	1,938	2,267	2,873
	4,000											1,161	1,510	1,840	2,153	2,728
	4,100											1,104	1,435	1,749	2,046	2,593
	4,200											1,051	1,366	1,665	1,948	
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		79	101	122	142	175	104	135	163	190	238	164	213	260	304	385
RESISTENCIA A TENSION $\phi_u T_n$ (kg) - $\phi_u=0.90$		6,073	7,998	9,874	11,700	15,202	6,971	9,195	11,370	13,494	17,595	8,713	11,517	14,273	16,978	22,240

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)



TUBO REDONDO HR ESTRUCTURAL FANALCA
RESISTENCIA A COMPRESIÓN
 $\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)
 $F_u=65$ ksi (45.69 kgf/mm²)

Diámetro Nominal/Diámetro (mm)		2 1/2 / 73.02							3 / 88.9					
ESPEJOR (mm)		1.50	2.00	2.50	3.00	4.00	5.00	4.00	2.00	2.50	3.00	4.00	5.00	6.00
PESO (kg/m)		2.65	3.5	4.35	5.18	6.81	8.39	9.92	4.29	5.33	6.36	8.38	10.35	12.27
Longitud Efectiva KL (mm) ↓	0	10,070	13,333	16,549	19,718	25,916	31,925	37,747	16,313	20,274	24,188	31,876	39,376	46,687
	100	10,070	13,333	16,549	19,718	25,916	31,925	37,747	16,313	20,274	24,188	31,876	39,376	46,687
	200	10,059	13,318	16,530	19,695	25,884	31,885	37,698	16,301	20,259	24,169	31,850	39,343	46,648
	300	10,024	13,272	16,472	19,625	25,789	31,765	37,553	16,263	20,211	24,112	31,773	39,245	46,530
	400	9,967	13,195	16,375	19,508	25,632	31,566	37,311	16,200	20,132	24,017	31,645	39,083	46,333
	500	9,888	13,088	16,241	19,346	25,413	31,290	36,975	16,113	20,022	23,884	31,466	38,858	46,060
	600	9,787	12,953	16,071	19,140	25,135	30,938	36,548	16,001	19,882	23,715	31,237	38,569	45,710
	700	9,665	12,789	15,864	18,891	24,799	30,513	36,033	15,865	19,711	23,509	30,961	38,220	45,287
	800	9,522	12,598	15,624	18,601	24,408	30,019	35,433	15,707	19,512	23,269	30,637	37,811	44,791
	900	9,360	12,381	15,352	18,272	23,965	29,458	34,754	15,525	19,284	22,994	30,267	37,344	44,226
	1,000	9,180	12,140	15,048	17,906	23,472	28,836	33,999	15,322	19,029	22,687	29,854	36,823	43,595
	1,100	8,983	11,875	14,716	17,506	22,933	28,156	33,176	15,099	18,749	22,348	29,398	36,248	42,899
	1,200	8,770	11,590	14,358	17,074	22,351	27,422	32,288	14,855	18,443	21,980	28,903	35,624	42,144
	1,300	8,543	11,286	13,976	16,613	21,731	26,641	31,344	14,593	18,114	21,584	28,370	34,952	41,332
	1,400	8,303	10,964	13,571	16,126	21,077	25,817	30,348	14,314	17,763	21,161	27,802	34,237	40,466
	1,500	8,050	10,626	13,148	15,616	20,393	24,956	29,309	14,018	17,392	20,714	27,201	33,480	39,552
	1,600	7,788	10,275	12,708	15,087	19,682	24,063	28,232	13,707	17,002	20,244	26,570	32,686	38,594
	1,700	7,517	9,913	12,254	14,540	18,950	23,144	27,124	13,382	16,594	19,753	25,912	31,858	37,594
	1,800	7,239	9,541	11,788	13,980	18,200	22,204	25,993	13,045	16,171	19,244	25,229	31,000	36,559
	1,900	6,956	9,162	11,314	13,410	17,438	21,249	24,845	12,696	15,734	18,718	24,524	30,115	35,492
	2,000	6,668	8,778	10,833	12,832	16,667	20,283	23,686	12,338	15,285	18,178	23,801	29,207	34,398
	2,100	6,377	8,391	10,348	12,250	15,890	19,313	22,523	11,971	14,826	17,626	23,062	28,280	33,282
	2,200	6,085	8,002	9,862	11,667	15,113	18,344	21,362	11,598	14,358	17,063	22,309	27,336	32,147
	2,300	5,794	7,613	9,377	11,085	14,339	17,379	20,209	11,218	13,883	16,493	21,546	26,381	30,998
	2,400	5,504	7,226	8,894	10,507	13,571	16,424	19,068	10,834	13,403	15,916	20,776	25,416	29,840
	2,500	5,216	6,844	8,417	9,936	12,813	15,482	17,946	10,447	12,919	15,335	20,000	24,447	28,677
	2,600	4,932	6,466	7,946	9,373	12,068	14,557	16,846	10,059	12,433	14,751	19,223	23,475	27,512
	2,700	4,653	6,095	7,485	8,821	11,339	13,654	15,772	9,669	11,947	14,168	18,446	22,505	26,350
	2,800	4,380	5,733	7,033	8,282	10,627	12,774	14,729	9,281	11,461	13,586	17,671	21,540	25,194
	2,900	4,113	5,379	6,593	7,757	9,923	11,896	13,691	8,894	10,978	13,008	16,902	20,581	24,049
	3,000	3,848	5,026	6,154	7,233	9,250	11,090	12,763	8,511	10,500	12,434	16,140	19,633	22,916
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		238	322	394	463	593	710	818	477	595	702	905	1,093	1,267
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_t=0.90$		10,663	14,118	17,523	20,878	27,440	33,803	39,967	17,273	21,467	25,611	33,751	41,692	49,434

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)



TUBO REDONDO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSIÓN

Diámetro Nominal/Diámetro (mm)		2 1/2 / 73.02							3 / 88.9					
ESPESOR (mm)		1.50	2.00	2.50	3.00	4.00	5.00	4.00	2.00	2.50	3.00	4.00	5.00	6.00
PESO (kg/m)		2.65	3.5	4.35	5.18	6.81	8.39	9.92	4.29	5.33	6.36	8.38	10.35	12.27
Longitud Efectiva KL (mm)	3,100	3,596	4,696	5,750	6,758	8,644	10,363	11,926	8,131	10,026	11,867	15,388	18,698	21,800
	3,200	3,368	4,398	5,385	6,329	8,095	9,705	11,169	7,756	9,559	11,308	14,647	17,777	20,704
	3,300	3,161	4,128	5,054	5,940	7,597	9,108	10,482	7,387	9,099	10,758	13,919	16,874	19,629
	3,400	2,972	3,881	4,752	5,585	7,144	8,564	9,856	7,025	8,648	10,218	13,205	15,990	18,578
	3,500	2,800	3,656	4,477	5,262	6,730	8,068	9,285	6,670	8,206	9,691	12,509	15,109	17,520
	3,600	2,642	3,450	4,225	4,965	6,350	7,614	8,762	6,318	7,765	9,160	11,804	14,258	16,533
	3,700	2,497	3,261	3,993	4,693	6,003	7,196	8,282	5,972	7,339	8,658	11,157	13,477	15,627
	3,800	2,364	3,088	3,780	4,443	5,683	6,813	7,840	5,654	6,948	8,197	10,562	12,759	14,794
	3,900	2,241	2,927	3,584	4,212	5,387	6,459	7,433	5,360	6,587	7,771	10,014	12,096	14,026
	4,000	2,128	2,779	3,402	3,999	5,115	6,132	7,057	5,089	6,254	7,378	9,507	11,484	13,316
	4,100	2,023	2,642	3,234	3,802	4,862	5,829	6,708	4,837	5,945	7,013	9,037	10,917	12,658
	4,200	1,925	2,514	3,079	3,618	4,628	5,548	6,385	4,604	5,658	6,675	8,602	10,390	12,048
	4,300	1,835	2,396	2,934	3,448	4,410	5,287	6,085	4,388	5,392	6,361	8,197	9,902	11,481
	4,400	1,750	2,286	2,799	3,290	4,207	5,044	5,805	4,186	5,144	6,069	7,820	9,446	10,954
	4,500	1,672	2,183	2,673	3,142	4,018	4,817	5,544	3,998	4,913	5,796	7,469	9,022	10,461
	4,600	1,598	2,087	2,556	3,004	3,842	4,606	5,300	3,822	4,697	5,541	7,141	8,625	10,002
	4,700	1,529	1,998	2,446	2,875	3,676	4,408	5,072	3,658	4,495	5,303	6,833	8,254	9,571
	4,800	1,465	1,913	2,343	2,754	3,522	4,222	4,859	3,504	4,306	5,080	6,546	7,907	9,168
	4,900	1,405	1,835	2,246	2,640	3,376	4,048	4,659	3,359	4,128	4,870	6,276	7,581	8,790
	5,000	1,348	1,760	2,155	2,533	3,240	3,884		3,224	3,962	4,674	6,022	7,275	8,435
	5,100	1,295	1,691	2,070	2,433				3,096	3,805	4,488	5,784	6,987	8,101
	5,200	1,244	1,625						2,976	3,657	4,314	5,559	6,715	7,787
	5,300								2,862	3,518	4,150	5,347	6,459	7,490
	5,400								2,755	3,386	3,995	5,148	6,218	7,210
	5,500								2,654	3,262	3,848	4,959	5,990	6,946
	5,600								2,559	3,144	3,709	4,780	5,774	6,695
	5,700								2,468	3,033	3,578	4,611	5,570	6,458
	5,800								2,382	2,928	3,454	4,450	5,376	6,234
	5,900								2,301	2,827	3,336	4,298	5,192	6,021
	6,000								2,223	2,732	3,224	4,154	5,018	5,818
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		238	322	394	463	593	710	818	477	595	702	905	1,093	1,267
RESISTENCIA A TENSIÓN $\phi_b T_n$ (kg) - $\phi_b=0.90$		10,663	14,118	17,523	20,878	27,440	33,803	39,967	17,273	21,467	25,611	33,751	41,692	49,434

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez KL/r< 200.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n=F$



TUBO REDONDO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

Diámetro Nominal/Diámetro (mm)		4 / 114.3						5" / 127.0						6 / 168.3		8 / 219.1	10 / 273.1	12 / 323.9
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	2.50	3.00	4.00	4.50	5.00	6.00	4.00	6.00	5.00	9.00	10.00
PESO (kg/m)		5.54	6.89	8.23	10.88	13.48	16.03	7.68	9.17	12.13	13.59	15.04	17.90	16.21	24.02	26.4	58.62	77.41
Longitud Efectiva KL (mm) ↓	0	21,082	26,235	31,341	41,412	51,296	60,992	29,215	34,917	46,181	51,742	57,256	68,144	61,677	91,390	100,469	223,061	294,589
	100	21,082	26,235	31,341	41,412	51,296	60,992	29,215	34,917	46,181	51,742	57,256	68,144	61,677	91,390	100,469	223,061	294,589
	200	21,072	26,222	31,326	41,392	51,271	60,962	29,204	34,904	46,163	51,722	57,234	68,117	61,664	91,369	100,456	223,042	294,571
	300	21,043	26,186	31,282	41,333	51,196	60,871	29,171	34,864	46,109	51,661	57,167	68,036	61,624	91,309	100,417	222,986	294,519
	400	20,994	26,125	31,208	41,234	51,071	60,720	29,116	34,798	46,020	51,561	57,055	67,901	61,557	91,207	100,353	222,893	294,432
	500	20,926	26,039	31,105	41,096	50,897	60,509	29,039	34,705	45,896	51,421	56,898	67,712	61,464	91,066	100,264	222,762	294,310
	600	20,839	25,930	30,974	40,918	50,674	60,239	28,941	34,587	45,737	51,241	56,698	67,469	61,344	90,885	100,149	222,594	294,153
	700	20,733	25,797	30,813	40,703	50,402	59,911	28,821	34,443	45,543	51,022	56,454	67,174	61,199	90,663	100,008	222,389	293,961
	800	20,608	25,641	30,625	40,450	50,083	59,525	28,680	34,273	45,315	50,765	56,167	66,827	61,027	90,402	99,843	222,147	293,734
	900	20,466	25,461	30,409	40,160	49,718	59,083	28,518	34,078	45,054	50,470	55,837	66,429	60,829	90,102	99,652	221,868	293,473
	1,000	20,305	25,260	30,166	39,834	49,307	58,586	28,336	33,859	44,759	50,137	55,467	65,981	60,605	89,763	99,436	221,553	293,178
	1,100	20,127	25,037	29,897	39,472	48,851	58,036	28,134	33,615	44,432	49,768	55,055	65,484	60,356	89,386	99,196	221,200	292,848
	1,200	19,932	24,792	29,603	39,076	48,353	57,433	27,912	33,348	44,073	49,363	54,603	64,938	60,083	88,971	98,931	220,812	292,483
	1,300	19,721	24,527	29,283	38,647	47,813	56,781	27,671	33,058	43,684	48,923	54,113	64,346	59,784	88,518	98,641	220,387	292,085
	1,400	19,494	24,242	28,940	38,187	47,233	56,080	27,412	32,745	43,264	48,450	53,585	63,709	59,462	88,029	98,327	219,926	291,652
	1,500	19,251	23,938	28,574	37,695	46,614	55,332	27,134	32,411	42,816	47,943	53,021	63,027	59,115	87,504	97,989	219,429	291,186
	1,600	18,994	23,616	28,186	37,174	45,959	54,541	26,839	32,056	42,339	47,406	52,422	62,303	58,745	86,943	97,628	218,897	290,685
	1,700	18,723	23,276	27,777	36,625	45,268	53,707	26,527	31,681	41,836	46,837	51,788	61,539	58,352	86,348	97,243	218,329	290,152
	1,800	18,439	22,920	27,348	36,050	44,545	52,834	26,199	31,286	41,306	46,240	51,123	60,735	57,937	85,718	96,834	217,727	289,584
	1,900	18,143	22,548	26,900	35,449	43,790	51,923	25,856	30,873	40,752	45,614	50,426	59,895	57,499	85,056	96,403	217,090	288,984
	2,000	17,834	22,161	26,435	34,826	43,006	50,977	25,498	30,442	40,174	44,963	49,700	59,018	57,041	84,361	95,949	216,418	288,351
	2,100	17,515	21,761	25,953	34,180	42,195	49,999	25,126	29,994	39,574	44,286	48,945	58,109	56,561	83,635	95,474	215,712	287,685
	2,200	17,185	21,348	25,456	33,514	41,358	48,990	24,740	29,530	38,952	43,585	48,165	57,168	56,061	82,878	94,976	214,973	286,987
	2,300	16,846	20,923	24,945	32,830	40,499	47,955	24,342	29,052	38,311	42,862	47,360	56,197	55,542	82,092	94,457	214,200	286,256
	2,400	16,499	20,487	24,422	32,128	39,619	46,894	23,933	28,559	37,652	42,118	46,531	55,199	55,003	81,277	93,916	213,394	285,493
	2,500	16,143	20,042	23,886	31,412	38,720	45,812	23,513	28,054	36,975	41,355	45,682	54,175	54,447	80,434	93,355	212,556	284,699
	2,600	15,781	19,588	23,341	30,682	37,805	44,710	23,082	27,536	36,282	40,574	44,812	53,128	53,872	79,565	92,774	211,686	283,873
	2,700	15,412	19,127	22,786	29,940	36,875	43,591	22,643	27,008	35,575	39,777	43,925	52,060	53,281	78,671	92,173	210,784	283,016
	2,800	15,038	18,659	22,224	29,188	35,933	42,458	22,195	26,469	34,854	38,965	43,022	50,972	52,673	77,752	91,552	209,850	282,128
	2,900	14,660	18,185	21,655	28,428	34,980	41,314	21,739	25,922	34,122	38,140	42,104	49,868	52,049	76,810	90,912	208,886	281,210
	3,000	14,278	17,707	21,081	27,661	34,020	40,160	21,277	25,367	33,380	37,304	41,173	48,748	51,411	75,845	90,254	207,891	280,261
	3,100	13,893	17,225	20,502	26,889	33,054	39,000	20,809	24,804	32,628	36,458	40,232	47,616	50,758	74,860	89,578	206,866	279,282
	3,200	13,505	16,741	19,921	26,113	32,084	37,836	20,336	24,236	31,869	35,603	39,281	46,473	50,093	73,854	88,884	205,812	278,274
	3,300	13,117	16,255	19,338	25,335	31,112	36,670	19,859	23,663	31,103	34,741	38,323	45,322	49,414	72,830	88,173	204,729	277,237
	3,400	12,728	15,769	18,754	24,557	30,140	35,504	19,378	23,085	30,333	33,873	37,358	44,163	48,724	71,788	87,445	203,618	276,171
	3,500	12,339	15,283	18,171	23,780	29,170	34,342	18,895	22,505	29,558	33,002	36,390	43,000	48,022	70,730	86,701	202,479	275,076
	3,600	11,950	14,798	17,589	23,006	28,204	33,184	18,410	21,923	28,782	32,128	35,418	41,835	47,310	69,656	85,942	201,312	273,953
	3,700	11,564	14,314	17,010	22,235	27,243	32,034	17,923	21,339	28,004	31,252	34,446	40,668	46,588	68,568	85,168	200,119	272,802
	3,800	11,179	13,834	16,434	21,470	26,289	30,893	17,437	20,756	27,225	30,377	33,474	39,503	45,858	67,467	84,379	198,899	271,624
	3,900	10,797	13,358	15,863	20,711	25,343	29,763	16,951	20,172	26,449	29,504	32,504	38,340	45,119	66,355	83,576	197,654	270,419
	4,000	10,419	12,885	15,298	19,960	24,408	28,646	16,466	19,591	25,674	28,633	31,537	37,182	44,373	65,232	82,759	196,383	269,187
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		763	982	1,187	1,542	1,876	2,193	1,195	1,470	1,923	2,138	2,348	2,751	3,445	5,002	7,256	19,916	31,327
RESISTENCIA A TENSIÓN $\phi_u T_n$ (kg) - $\phi_u=0.90$		22,322	27,778	33,184	43,848	54,314	64,580	30,933	36,971	48,897	54,786	60,624	72,153	65,305	96,766	106,378	236,182	311,918

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)



Fanalca



TUBO REDONDO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c = 0.85$

$F_y = 50$ ksi (35.15 kgf/mm²)

$F_u = 65$ ksi (45.69 kgf/mm²)

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSIÓN

Diámetro Nominal/Diámetro (mm)		4 / 114.3						5" / 127.0						6 / 168.3		8 / 219.1	10 / 273.1	12 / 323.9
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	2.50	3.00	4.00	4.50	5.00	6.00	4.00	6.00	5.00	9.00	10.00
PESO (kg/m)		5.54	6.89	8.23	10.88	13.48	16.03	7.68	9.17	12.13	13.59	15.04	17.90	16.21	24.02	26.4	58.62	77.41
Longitud Efectiva KL (mm)	4,100	10,044	12,418	14,738	19,217	23,484	27,543	15,983	19,011	24,903	27,767	30,575	36,031	43,621	64,099	81,930	195,088	267,929
	4,200	9,674	11,957	14,186	18,485	22,574	26,456	15,502	18,435	24,137	26,905	29,620	34,887	42,863	62,959	81,088	193,769	266,646
	4,300	9,309	11,502	13,641	17,763	21,677	25,388	15,025	17,863	23,376	26,050	28,671	33,752	42,099	61,811	80,235	192,427	265,337
	4,400	8,950	11,054	13,105	17,053	20,796	24,338	14,551	17,295	22,621	25,203	27,731	32,629	41,332	60,657	79,370	191,062	264,003
	4,500	8,596	10,613	12,579	16,356	19,918	23,274	14,081	16,733	21,874	24,364	26,801	31,518	40,561	59,498	78,495	189,675	262,645
	4,600	8,249	10,173	12,048	15,644	19,042	22,251	13,617	16,176	21,135	23,535	25,882	30,420	39,787	58,336	77,609	188,267	261,263
	4,700	7,892	9,736	11,530	14,971	18,223	21,294	13,157	15,627	20,406	22,717	24,975	29,337	39,010	57,171	76,714	186,838	259,857
	4,800	7,560	9,326	11,044	14,341	17,456	20,398	12,704	15,084	19,686	21,909	24,081	28,270	38,233	56,004	75,810	185,388	258,428
	4,900	7,248	8,941	10,589	13,749	16,736	19,557	12,257	14,549	18,978	21,114	23,200	27,221	37,455	54,837	74,897	183,919	256,977
	5,000	6,955	8,580	10,161	13,194	16,060	18,767	11,817	14,023	18,280	20,333	22,335	26,157	36,676	53,671	73,977	182,431	255,504
	5,100	6,680	8,240	9,759	12,671	15,424	18,023	11,379	13,493	17,567	19,529	21,441	25,121	35,899	52,506	73,049	180,925	254,008
	5,200	6,421	7,920	9,380	12,179	14,825	17,323	10,937	12,969	16,885	18,770	20,608	24,146	35,122	51,343	72,114	179,401	252,492
	5,300	6,176	7,619	9,022	11,715	14,261	16,664	10,520	12,475	16,242	18,055	19,823	23,226	34,348	50,184	71,174	177,860	250,955
	5,400	5,945	7,334	8,685	11,278	13,728	16,041	10,127	12,009	15,635	17,381	19,082	22,358	33,576	49,029	70,227	176,303	249,397
	5,500	5,727	7,065	8,366	10,864	13,224	15,452	9,755	11,568	15,061	16,743	18,382	21,537	32,807	47,880	69,276	174,730	247,820
	5,600	5,521	6,810	8,065	10,472	12,747	14,895	9,404	11,151	14,518	16,139	17,720	20,761	32,042	46,737	68,320	173,143	246,224
	5,700	5,325	6,569	7,780	10,102	12,296	14,368	9,071	10,757	14,004	15,568	17,093	20,027	31,281	45,601	67,360	171,541	244,609
	5,800	5,140	6,341	7,509	9,750	11,869	13,868	8,756	10,382	13,517	15,027	16,498	19,330	30,525	44,473	66,396	169,925	242,976
	5,900	4,964	6,124	7,252	9,417	11,463	13,394	8,456	10,028	13,055	14,513	15,934	18,669	29,775	43,353	65,430	168,296	241,325
	6,000	4,797	5,918	7,009	9,100	11,078	12,944	8,172	9,690	12,616	14,025	15,399	18,042	29,030	42,243	64,461	166,655	239,657
	6,100							7,902	9,370	12,199	13,562	14,890	17,445	28,292	41,143	63,491	165,003	237,972
	6,200							7,645	9,065	11,803	13,121	14,405	16,878	27,560	40,055	62,519	163,339	236,271
	6,300							7,400	8,775	11,425	12,701	13,945	16,338	26,836	38,977	61,546	161,665	234,554
	6,400							7,167	8,499	11,065	12,301	13,505	15,823	26,119	37,912	60,573	159,982	232,823
	6,500							6,945	8,235	10,722	11,919	13,087	15,333	25,411	36,859	59,600	158,290	231,076
	6,600							6,733	7,984	10,395	11,555	12,687	14,865	24,711	35,820	58,628	156,589	229,316
	6,700							6,530	7,744	10,082	11,208	12,305	14,418	24,008	34,739	57,657	154,880	227,542
	6,800							6,337	7,514	9,783	10,876	11,941	13,990	23,296	33,710	56,688	153,165	225,755
	6,900							6,152	7,295	9,498	10,558	11,592	13,582	22,616	32,726	55,720	151,443	223,955
	7,000							5,975	7,085	9,225	10,255	11,259	13,191	21,966	31,784	54,756	149,715	222,143
	7,100													21,342	30,882	53,794	147,983	220,320
	7,200													20,745	30,019	52,836	146,246	218,486
	7,300													20,173	29,191	51,881	144,505	216,642
	7,400													19,624	28,396	50,931	142,761	214,787
	7,500													19,098	27,634	49,985	141,014	212,924
	7,600													18,592	26,902	49,045	139,265	211,051
	7,700													18,106	26,199	48,110	137,515	209,170
	7,800													17,638	25,523	47,180	135,765	207,281
	7,900													17,189	24,872	46,257	134,014	205,385
	8,000													16,757	24,247	45,341	132,263	203,483
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b = 0.95$		763	982	1,187	1,542	1,876	2,193	1,195	1,470	1,923	2,138	2,348	2,751	3,445	5,002	7,256	19,916	31,327
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_t = 0.90$		22,322	27,778	33,184	43,848	54,314	64,580	30,933	36,971	48,897	54,786	60,624	72,153	65,305	96,766	106,378	236,182	311,918

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

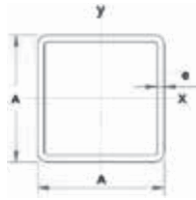
$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)



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PROPIEDADES GEOMETRICAS

Dimensión Ext. Ax A (pulg.)	Dimensión Ext. Ax A	Espesor e (mm)	Peso Teórico (kg/m)	Área (cm ²)	$I_x = I_y$ (cm ⁴)	$S_x = S_y$ (cm ³)	$Z_x = Z_y$ (cm ³)	$r_x = r_y$ (cm)	J (cm ⁴)
1 1/2" x 1 1/2"	38,1 x 38,1	1,50	1,68	2,14	4,71	2,47	2,91	1,48	7,52
		2,00	2,19	2,78	5,95	3,12	3,72	1,46	9,68
		2,50	2,67	3,40	7,04	3,69	4,46	1,44	11,66
		3,00	3,12	3,98	7,99	4,19	5,13	1,42	13,46
		4,00	3,96	5,04	9,56	5,02	6,25	1,38	16,53
	40 x 40	1,50	1,77	2,25	5,49	2,75	3,22	1,56	8,75
		2,00	2,31	2,94	6,95	3,48	4,13	1,54	11,28
		2,50	2,82	3,59	8,25	4,12	4,97	1,52	13,61
		3,00	3,30	4,21	9,39	4,70	5,72	1,49	15,75
		4,00	4,20	5,35	11,29	5,65	7,01	1,45	19,44
	50 x 50	5,00	4,99	6,36	12,79	6,39	8,02	1,42	22,31
		1,50	2,24	2,85	11,07	4,43	5,15	1,97	17,42
		2,00	2,93	3,74	14,16	5,66	6,66	1,95	22,63
		2,50	3,60	4,59	16,98	6,79	8,07	1,92	27,53
		3,00	4,25	5,41	19,54	7,81	9,39	1,90	32,13
	60 x 60	4,00	5,45	6,95	23,95	9,58	11,73	1,86	40,42
		5,00	6,56	8,36	27,57	11,03	13,70	1,82	47,46
		6,00	7,56	9,63	30,55	12,22	15,32	1,78	53,23
		1,50	2,71	3,45	19,53	6,51	7,53	2,38	30,48
		2,00	3,56	4,54	25,16	8,39	9,79	2,35	39,79
	70 x 70	2,50	4,39	5,59	30,38	10,13	11,93	2,33	48,66
		3,00	5,19	6,61	35,20	11,73	13,95	2,31	57,09
		4,00	6,71	8,55	43,77	14,59	17,64	2,26	72,64
		5,00	8,13	10,36	51,02	17,01	20,88	2,22	86,42
		2,00	4,19	5,34	40,74	11,64	13,52	2,76	63,96
	75 x 75	2,50	5,17	6,59	49,44	14,13	16,54	2,74	78,49
		3,00	6,13	7,81	57,60	16,46	19,42	2,72	92,42
		4,00	7,97	10,15	72,34	20,67	24,76	2,67	118,52
		5,00	9,70	12,36	85,16	24,33	29,56	2,63	142,21
		6,00	11,33	14,43	96,27	27,51	33,83	2,58	163,49
	90 x 90	2,00	4,50	5,74	50,50	13,47	15,61	2,97	79,05
		2,50	5,56	7,09	61,42	16,38	19,12	2,94	97,13
		3,00	6,60	8,41	71,69	19,12	22,49	2,92	114,54
		4,00	8,59	10,95	90,40	24,11	28,76	2,87	147,32
		5,00	10,48	13,36	106,86	28,50	34,46	2,83	177,35
	100 x 100	6,00	12,27	15,63	121,26	32,34	39,58	2,79	204,62
		2,50	6,74	8,59	108,59	24,13	28,00	3,56	170,26
		3,00	8,01	10,21	127,35	28,30	33,04	3,53	201,42
		4,00	10,48	13,35	162,14	36,03	42,58	3,49	260,80
		5,00	12,84	16,36	193,46	42,99	51,41	3,44	316,26
	120 x 120	6,00	15,10	19,23	221,58	49,24	59,54	3,39	367,76
		2,00	6,07	7,74	123,02	24,60	28,30	3,99	190,54
		2,50	7,53	9,59	150,66	30,13	34,86	3,96	235,21
		3,00	8,96	11,41	177,12	35,42	41,21	3,94	278,68
		4,00	11,73	14,95	226,57	45,31	53,30	3,89	362,01
	135 x 135	4,50	13,08	16,67	249,63	49,93	59,04	3,87	401,87
		5,00	14,41	18,36	271,63	54,33	64,59	3,85	440,52
		6,00	16,98	21,63	312,57	62,51	75,10	3,80	514,16
		4,00	14,25	18,15	402,49	67,08	78,33	4,71	636,57
		4,00	16,13	20,55	581,92	86,21	100,25	5,32	915,06
	150 x 150	6,00	23,58	30,03	820,82	121,60	143,72	5,23	1320,30
		4,00	18,01	22,95	808,03	107,74	124,87	5,93	1264,76
		6,00	26,40	33,63	1147,01	152,93	179,88	5,84	1832,69
		5,00	30,11	38,36	2410,62	241,06	278,87	7,93	3763,30
		7,00	41,43	52,78	3238,51	323,85	378,83	7,83	5135,13
	200 x 200	7,00	45,83	58,38	4367,59	397,05	462,83	8,65	6891,47
		9,00	57,99	73,87	5407,64	491,60	578,81	8,56	8652,22
		8,00	59,50	75,79	7319,13	585,53	682,67	9,83	11551,86
		9,00	66,47	84,67	8098,78	647,90	758,74	9,78	12861,53
		10,00	73,34	93,42	8850,35	708,03	832,79	9,73	14141,09
	220 x 220	10,00	89,04	113,42	15722,39	1048,16	1223,86	11,77	24866,11
		12,00	105,61	134,53	18352,09	1223,47	1439,07	11,68	29322,97



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TUBO CUADRADO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

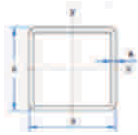
$F_u=65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		38.1x38.1					40x40						50x50						
ESPESOR (mm)		1.50	2.00	2.50	3.00	4.00	1.50	2.00	2.50	3.00	4.00	5.00	1.50	2.00	2.50	3.00	4.00	5.00	6.00
PESO (kg/m)		1.68	2.19	2.67	3.12	3.96	1.77	2.31	2.82	3.30	4.20	4.99	2.24	2.93	3.60	4.25	5.45	6.56	7.56
Longitud Efectiva KL (mm)	0	6,238	8,054	9,739	11,292	14,003	6,579	8,508	10,306	11,973	14,911	17,324	8,371	10,898	13,294	15,558	19,692	23,299	26,380
	100	6,217	8,026	9,703	11,247	13,940	6,559	8,481	10,272	11,931	14,852	17,242	8,355	10,877	13,267	15,525	19,647	23,240	26,304
	200	6,154	7,941	9,595	11,116	13,753	6,499	8,401	10,170	11,806	14,676	16,999	8,308	10,813	13,186	15,427	19,512	23,063	26,075
	300	6,051	7,802	9,418	10,899	13,446	6,400	8,268	10,002	11,601	14,387	16,603	8,229	10,707	13,053	15,265	19,289	22,772	25,699
	400	5,909	7,611	9,176	10,604	13,027	6,265	8,086	9,771	11,320	13,992	16,063	8,120	10,561	12,868	15,041	18,982	22,370	25,182
	500	5,732	7,372	8,875	10,235	12,509	6,095	7,858	9,483	10,968	13,501	15,394	7,981	10,375	12,634	14,758	18,594	21,863	24,532
	600	5,523	7,091	8,519	9,802	11,903	5,894	7,588	9,142	10,553	12,923	14,615	7,816	10,153	12,355	14,419	18,130	21,260	23,760
	700	5,285	6,772	8,117	9,314	11,224	5,665	7,280	8,754	10,083	12,272	13,744	7,624	9,896	12,032	14,029	17,597	20,568	22,880
	800	5,023	6,422	7,677	8,780	10,489	5,412	6,941	8,328	9,566	11,562	12,804	7,409	9,608	11,670	13,592	17,001	19,798	21,904
	900	4,743	6,048	7,207	8,213	9,714	5,138	6,576	7,869	9,012	10,806	11,816	7,173	9,292	11,273	13,112	16,351	18,960	20,848
	1,000	4,447	5,654	6,715	7,622	8,916	4,849	6,190	7,386	8,431	10,020	10,802	6,917	8,951	10,845	12,597	15,653	18,065	19,728
	1,100	4,142	5,250	6,211	7,018	8,109	4,548	5,790	6,887	7,833	9,217	9,782	6,646	8,589	10,391	12,050	14,916	17,125	18,561
	1,200	3,832	4,839	5,702	6,411	7,310	4,240	5,381	6,379	7,226	8,412	8,775	6,361	8,208	9,916	11,479	14,149	16,152	17,361
	1,300	3,522	4,430	5,196	5,811	6,529	3,928	4,970	5,870	6,619	7,616	7,797	6,064	7,814	9,424	10,889	13,360	15,156	16,145
	1,400	3,214	4,026	4,700	5,226	5,780	3,618	4,561	5,365	6,021	6,841	6,864	5,760	7,410	8,920	10,285	12,557	14,150	14,926
	1,500	2,914	3,634	4,220	4,663	5,060	3,311	4,159	4,871	5,439	6,096	5,983	5,450	6,999	8,408	9,674	11,749	13,143	13,720
	1,600	2,624	3,256	3,757	4,119	4,448	3,012	3,768	4,393	4,878	5,378	5,259	5,137	6,584	7,894	9,061	10,942	12,146	12,538
	1,700	2,342	2,892	3,328	3,649	3,940	2,724	3,393	3,930	4,336	4,764	4,658	4,824	6,170	7,381	8,451	10,143	11,168	11,392
	1,800	2,089	2,579	2,968	3,255	3,514	2,443	3,030	3,505	3,868	4,249	4,155	4,512	5,759	6,873	7,849	9,360	10,217	10,291
	1,900	1,875	2,315	2,664	2,921	3,154	2,192	2,719	3,146	3,471	3,814	3,729	4,205	5,355	6,375	7,259	8,598	9,299	9,232
	2,000	1,692	2,089	2,404	2,636	2,846	1,979	2,454	2,839	3,133	3,442	3,365	3,903	4,959	5,888	6,686	7,862	8,403	8,332
	2,100	1,535	1,895	2,181	2,391	2,582	1,795	2,226	2,575	2,842	3,122	3,053	3,610	4,575	5,417	6,131	7,140	7,622	7,557
	2,200	1,398	1,727	1,987	2,179	2,352	1,635	2,028	2,346	2,589	2,845	2,781	3,325	4,199	4,952	5,588	6,506	6,945	6,886
	2,300	1,279	1,580	1,818	1,993	2,152	1,496	1,856	2,147	2,369	2,603	2,545	3,045	3,842	4,531	5,113	5,953	6,354	6,300
	2,400	1,175	1,451	1,670	1,831	1,977	1,374	1,704	1,972	2,176	2,390	2,337	2,797	3,528	4,161	4,695	5,467	5,835	5,786
	2,500	1,083	1,337	1,539	1,687	1,822	1,266	1,571	1,817	2,005	2,203	2,154	2,577	3,252	3,835	4,327	5,038	5,378	5,332
	2,600	1,001	1,236	1,423	1,560	1,684	1,171	1,452	1,680	1,854	2,037		2,383	3,006	3,546	4,001	4,658	4,972	4,930
	2,700	928	1,146	1,319	1,447		1,086	1,347	1,558	1,719	1,889		2,210	2,788	3,288	3,710	4,320	4,611	4,572
	2,800	863	1,066	1,227			1,010	1,252	1,449	1,598			2,055	2,592	3,057	3,450	4,017	4,287	4,251
	2,900	805					941	1,167	1,350				1,915	2,417	2,850	3,216	3,744	3,997	3,963
	3,000						879	1,091					1,790	2,258	2,663	3,005	3,499	3,735	3,703
	3,100												1,676	2,115	2,494	2,814	3,277	3,498	3,468
	3,200												1,573	1,985	2,341	2,641	3,075	3,282	3,255
	3,300												1,479	1,866	2,201	2,484	2,892	3,087	
	3,400												1,394	1,758	2,073	2,340	2,724	2,908	
	3,500												1,315	1,659	1,957	2,208	2,571		
3,600												1,243	1,568	1,849	2,087	2,430			
3,700												1,177	1,485	1,751	1,976				
3,800												1,116	1,407						
3,900												1,059							
RESISTENCIA A FLEXIÓN ϕ _b M _{nx} =ϕ _b M _{ny} (kg-m) - ϕ _b =0.95		79	98	112	123	133	88	109	126	139	153	150	143	181	213	241	280	299	296
RESISTENCIA A CORTE ϕ _v V _n =ϕ _v V _{ny} (kg) - ϕ _v =0.95		1,502	1,923	2,304	2,645	3,206	1,623	2,083	2,505	2,885	3,527	3,008	2,224	2,885	3,507	4,088	5,130	6,011	6,252
RESISTENCIA A TENSIÓN ϕ _t T _n (kg) - ϕ _t =0.90		6,605	8,528	10,312	11,956	14,827	6,966	9,009	10,913	12,677	15,789	18,343	8,864	11,540	14,076	16,473	20,850	24,670	27,932
Lu (m)		1.94	1.95	1.96	1.98	2.00	2.03	2.05	2.06	2.07	2.10	2.12	2.53	2.55	2.56	2.57	2.60	2.62	2.65

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO CUADRADO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSIÓN

Dimensión Nominal (mm)		60x60						70x70						75x75					
ESPESOR (mm)		1.50	2.00	2.50	3.00	4.00	5.00	2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	5.00	6.00
PESO (kg/m)		2.71	3.56	4.39	5.19	6.71	8.13	4.19	5.17	6.13	7.97	9.70	11.33	4.50	5.56	6.60	8.59	10.48	12.27
Longitud Efectiva KL (mm)	0	9,783	13,289	16,282	19,144	24,472	29,275	15,679	19,270	22,729	29,253	35,250	40,721	16,857	20,764	24,522	31,643	38,238	44,307
	100	9,773	13,271	16,260	19,117	24,435	29,227	15,664	19,251	22,706	29,222	35,210	40,672	16,846	20,746	24,500	31,614	38,201	44,262
	200	9,745	13,218	16,193	19,036	24,325	29,086	15,618	19,193	22,637	29,128	35,092	40,526	16,814	20,693	24,436	31,527	38,091	44,126
	300	9,697	13,130	16,082	18,902	24,143	28,851	15,543	19,099	22,522	28,973	34,894	40,283	16,747	20,604	24,329	31,383	37,908	43,902
	400	9,631	13,007	15,928	18,715	23,890	28,526	15,438	18,967	22,363	28,758	34,620	39,945	16,649	20,481	24,181	31,183	37,653	43,589
	500	9,546	12,851	15,732	18,479	23,569	28,113	15,304	18,798	22,160	28,483	34,270	39,515	16,524	20,324	23,991	30,927	37,328	43,191
	600	9,443	12,664	15,496	18,194	23,181	27,617	15,141	18,595	21,914	28,151	33,848	38,995	16,372	20,133	23,761	30,617	36,935	42,709
	700	9,322	12,445	15,221	17,862	22,732	27,042	14,952	18,357	21,627	27,764	33,355	38,390	16,194	19,910	23,493	30,255	36,475	42,146
	800	9,184	12,198	14,911	17,487	22,225	26,393	14,736	18,086	21,301	27,324	32,796	37,703	15,991	19,656	23,186	29,842	35,952	41,506
	900	9,030	11,923	14,567	17,072	21,663	25,676	14,495	17,784	20,937	26,833	32,173	36,940	15,765	19,372	22,844	29,381	35,368	40,793
	1,000	8,860	11,624	14,191	16,620	21,053	24,899	14,231	17,452	20,538	26,295	31,491	36,105	15,516	19,059	22,467	28,874	34,726	40,009
	1,100	8,675	11,302	13,787	16,133	20,398	24,066	13,944	17,093	20,105	25,713	30,754	35,204	15,244	18,719	22,058	28,324	34,031	39,161
	1,200	8,423	10,959	13,358	15,617	19,703	23,186	13,637	16,708	19,642	25,090	29,966	34,243	14,953	18,354	21,619	27,734	33,285	38,253
	1,300	8,152	10,599	12,907	15,075	18,976	22,267	13,310	16,299	19,150	24,431	29,133	33,228	14,643	17,965	21,151	27,106	32,493	37,290
	1,400	7,870	10,223	12,437	14,510	18,220	21,314	12,967	15,869	18,633	23,738	28,259	32,166	14,314	17,555	20,658	26,444	31,659	36,277
	1,500	7,578	9,833	11,951	13,927	17,442	20,337	12,607	15,420	18,093	23,015	27,350	31,063	13,970	17,124	20,140	25,751	30,787	35,219
	1,600	7,277	9,434	11,452	13,330	16,647	19,341	12,234	14,953	17,533	22,267	26,410	29,925	13,611	16,675	19,601	25,031	29,881	34,123
	1,700	6,971	9,026	10,945	12,722	15,840	18,335	11,849	14,472	16,957	21,498	25,446	28,760	13,240	16,211	19,043	24,286	28,946	32,993
	1,800	6,659	8,613	10,430	12,108	15,027	17,325	11,454	13,979	16,365	20,710	24,461	27,574	12,856	15,732	18,469	23,520	27,986	31,836
	1,900	6,346	8,197	9,913	11,491	14,213	16,317	11,051	13,476	15,763	19,910	23,461	26,374	12,463	15,241	17,881	22,736	27,006	30,656
	2,000	6,031	7,780	9,396	10,874	13,403	15,319	10,641	12,965	15,152	19,099	22,452	25,164	12,062	14,740	17,281	21,939	26,011	29,461
	2,100	5,716	7,365	8,881	10,262	12,601	14,335	10,226	12,449	14,535	18,282	21,437	23,953	11,654	14,232	16,672	21,130	25,003	28,254
	2,200	5,405	6,953	8,371	9,657	11,811	13,371	9,809	11,930	13,915	17,463	20,422	22,745	11,241	13,717	16,057	20,315	23,989	27,041
	2,300	5,096	6,547	7,869	9,061	11,038	12,431	9,391	11,410	13,294	16,645	19,412	21,546	10,824	13,198	15,437	19,495	22,971	25,828
	2,400	4,793	6,147	7,377	8,479	10,284	11,520	8,972	10,891	12,676	15,832	18,410	20,362	10,405	12,678	14,815	18,673	21,954	24,619
	2,500	4,496	5,757	6,897	7,911	9,553	10,619	8,556	10,375	12,062	15,026	17,420	19,196	9,986	12,157	14,193	17,854	20,942	23,418
	2,600	4,207	5,377	6,430	7,352	8,829	9,818	8,144	9,864	11,454	14,231	16,446	18,053	9,568	11,637	13,574	17,040	19,938	22,231
	2,700	3,922	5,000	5,965	6,818	8,187	9,104	7,736	9,359	10,855	13,450	15,492	16,938	9,151	11,121	12,959	16,232	18,946	21,061
	2,800	3,647	4,649	5,546	6,339	7,612	8,465	7,335	8,863	10,266	12,684	14,560	15,845	8,739	10,609	12,350	15,435	17,968	19,912
	2,900	3,399	4,334	5,170	5,910	7,096	7,892	6,940	8,376	9,690	11,936	13,642	14,771	8,330	10,103	11,749	14,650	17,008	18,787
	3,000	3,177	4,050	4,831	5,522	6,631	7,374	6,555	7,901	9,127	11,194	12,748	13,802	7,928	9,605	11,158	13,880	16,068	17,689
RESISTENCIA A FLEXIÓN $\phi_b M_{nx} = \phi_b M_{ny}$ (kg-m) - $\phi_b=0.95$		207	270	322	368	442	492	377	454	523	640	729	789	437	528	610	752	864	945
RESISTENCIA A CORTE $\phi_v V_{nx} = \phi_v V_{ny}$ (kg) - $\phi_v=0.95$		2,825	3,687	4,508	5,290	6,733	8,015	4,488	5,510	6,492	8,336	10,019	11,061	4,729	5,811	6,853	8,816	10,620	12,263
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_t=0.90$		10,762	14,070	17,240	20,270	25,912	30,997	16,601	20,403	24,066	30,973	37,324	43,117	17,867	21,985	25,964	33,504	40,487	46,913
Lu (m)		3.03	3.04	3.06	3.07	3.09	3.12	3.54	3.56	3.57	3.59	3.62	3.64	3.79	3.81	3.82	3.84	3.87	3.89

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO CUADRADO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)	60x60						70x70						75x75					
ESPESOR (mm)	1.50	2.00	2.50	3.00	4.00	5.00	2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	5.00	6.00
PESO (kg/m)	2.71	3.56	4.39	5.19	6.71	8.13	4.19	5.17	6.13	7.97	9.70	11.33	4.50	5.56	6.60	8.59	10.48	12.27
Longitud Efectiva KL (mm)	3,100	2,975	3,793	4,525	5,172	6,210	6,906	6,179	7,430	8,564	10,483	11,939	12,926	7,532	9,116	10,578	13,126	15,151
	3,200	2,792	3,559	4,246	4,854	5,828	6,481	5,800	6,973	8,037	9,838	11,204	12,131	7,144	8,638	10,011	12,390	14,229
	3,300	2,625	3,347	3,993	4,564	5,480	6,094	5,454	6,557	7,557	9,251	10,536	11,407	6,765	8,170	9,448	11,648	13,639
	3,400	2,473	3,153	3,762	4,299	5,163	5,741	5,138	6,177	7,119	8,715	9,925	10,746	6,384	7,698	8,900	10,973	12,604
	3,500	2,334	2,975	3,550	4,057	4,872	5,418	4,848	5,829	6,718	8,224	9,366	10,141	6,024	7,264	8,399	10,355	11,894
	3,600	2,206	2,812	3,355	3,835	4,605	5,121	4,583	5,510	6,350	7,773	8,853	9,585	5,694	6,866	7,939	9,788	11,243
	3,700	2,088	2,662	3,176	3,630	4,359	4,848	4,338	5,216	6,011	7,359	8,381	9,074	5,391	6,500	7,515	9,266	10,643
	3,800	1,980	2,524	3,011	3,442	4,133	4,596	4,113	4,945	5,699	6,977	7,945	8,603	5,111	6,162	7,125	8,785	10,090
	3,900	1,880	2,396	2,859	3,268	3,924	4,363	3,905	4,694	5,411	6,623	7,543	8,167	4,852	5,850	6,764	8,340	9,580
	4,000	1,787	2,278	2,718	3,106	3,730	4,148	3,712	4,463	5,144	6,296	7,171	7,764	4,612	5,561	6,430	7,928	9,107
	4,100	1,701	2,168	2,587	2,957	3,550	3,948	3,533	4,248	4,896	5,993	6,825	7,390	4,390	5,294	6,120	7,546	8,668
	4,200	1,621	2,066	2,465	2,817	3,383	3,762	3,367	4,048	4,665	5,711	6,504	7,042	4,184	5,044	5,833	7,191	8,260
	4,300	1,546	1,971	2,352	2,688	3,228	3,589	3,212	3,862	4,451	5,449	6,205	6,718	3,991	4,813	5,564	6,861	7,880
	4,400	1,477	1,883	2,246	2,567	3,083		3,068	3,688	4,251	5,204	5,926	6,416	3,812	4,596	5,314	6,552	7,526
	4,500	1,412	1,800	2,147	2,454			2,933	3,526	4,064	4,975	5,666	6,134	3,644	4,394	5,081	6,264	7,195
	4,600	1,351	1,722	2,055				2,807	3,374	3,889	4,761	5,422	5,871	3,488	4,205	4,862	5,995	6,886
	4,700	1,294						2,689	3,232	3,726	4,561	5,194	5,623	3,341	4,028	4,658	5,742	6,596
	4,800							2,578	3,099	3,572	4,373	4,980	5,392	3,203	3,862	4,466	5,506	6,324
	4,900							2,474	2,974	3,428	4,196	4,779	5,174	3,074	3,706	4,285	5,283	6,069
	5,000							2,376	2,856	3,292	4,030	4,589	4,969	2,952	3,559	4,115	5,074	5,828
	5,100							2,283	2,745	3,164	3,873	4,411		2,837	3,421	3,956	4,877	5,602
	5,200							2,196	2,641	3,044	3,726			2,729	3,291	3,805	4,691	5,389
	5,300							2,114	2,542	2,930				2,627	3,168	3,663	4,516	5,187
	5,400							2,037	2,449					2,531	3,052	3,528	4,350	4,997
	5,500													2,440	2,942	3,401	4,193	4,817
	5,600													2,353	2,837	3,281	4,045	
	5,700													2,271	2,739	3,167		
	5,800													2,194	2,645			
	5,900													2,120				
	6,000																	
RESISTENCIA A FLEXIÓN $\phi_b M_{nx} = \phi_b M_{ny}$ (kg-m) - $\phi_b=0.95$																		
	207	270	322	368	442	492	377	454	523	640	729	789	437	528	610	752	864	945
RESISTENCIA A CORTE $\phi_v V_{nx} = \phi_v V_{ny}$ (kg) - $\phi_v=0.95$																		
	2,825	3,687	4,508	5,290	6,733	8,015	4,488	5,510	6,492	8,336	10,019	11,061	4,729	5,811	6,853	8,816	10,620	12,263
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_t=0.90$																		
	10,762	14,070	17,240	20,270	25,912	30,997	16,601	20,403	24,066	30,973	37,324	43,117	17,867	21,985	25,964	33,504	40,487	46,913
Lu (m)																		
	3.03	3.04	3.06	3.07	3.09	3.12	3.54	3.56	3.57	3.59	3.62	3.64	3.79	3.81	3.82	3.84	3.87	3.89

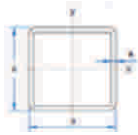
NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez KL/r< 200.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n=F_y$ (Valor con KL = 0)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



Fanalca



TUBO CUADRADO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

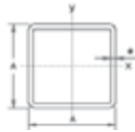
RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSIÓN

Dimensión Nominal (mm)		90x90						100x100						
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	4.50	5.00	6.00
PESO (kg/m)		5.45	6.74	8.01	10.48	12.84	15.1	6.07	7.53	8.96	11.73	13.08	14.41	16.98
Longitud Efectiva KL (mm) ↓	0	18,252	25,245	29,899	38,813	47,201	55,063	18,914	27,175	33,485	43,594	48,451	53,177	62,233
	100	18,244	25,230	29,882	38,790	47,171	55,026	18,908	27,165	33,469	43,572	48,427	53,150	62,200
	200	18,222	25,186	29,828	38,718	47,080	54,915	18,890	27,136	33,421	43,508	48,354	53,069	62,102
	300	18,184	25,113	29,740	38,599	46,930	54,732	18,859	27,089	33,341	43,401	48,233	52,934	61,938
	400	18,132	25,010	29,616	38,432	46,720	54,476	18,817	27,022	33,230	43,252	48,065	52,745	61,710
	500	18,065	24,879	29,458	38,220	46,451	54,149	18,763	26,936	33,088	43,061	47,849	52,504	61,417
	600	17,983	24,719	29,266	37,961	46,124	53,752	18,697	26,832	32,915	42,828	47,586	52,211	61,062
	700	17,887	24,532	29,041	37,658	45,742	53,287	18,620	26,708	32,711	42,555	47,278	51,867	60,644
	800	17,776	24,318	28,783	37,312	45,304	52,755	18,530	26,567	32,478	42,242	46,924	51,472	60,166
	900	17,652	24,077	28,493	36,923	44,813	52,158	18,430	26,407	32,216	41,890	46,527	51,029	59,628
	1,000	17,513	23,811	28,173	36,493	44,270	51,500	18,318	26,230	31,925	41,500	46,087	50,538	59,033
	1,100	17,362	23,521	27,823	36,023	43,678	50,781	18,194	26,035	31,607	41,074	45,605	50,000	58,382
	1,200	17,196	23,206	27,445	35,516	43,039	50,006	18,060	25,822	31,263	40,612	45,083	49,418	57,678
	1,300	17,018	22,869	27,040	34,973	42,355	49,176	17,915	25,593	30,892	40,115	44,523	48,794	56,922
	1,400	16,827	22,511	26,609	34,396	41,628	48,296	17,760	25,346	30,497	39,585	43,925	48,128	56,116
	1,500	16,624	22,133	26,154	33,786	40,862	47,368	17,594	25,084	30,078	39,025	43,293	47,422	55,263
	1,600	16,410	21,735	25,676	33,146	40,058	46,396	17,419	24,806	29,637	38,434	42,626	46,680	54,366
	1,700	16,183	21,320	25,177	32,479	39,219	45,383	17,234	24,512	29,174	37,815	41,928	45,903	53,427
	1,800	15,946	20,888	24,659	31,785	38,349	44,333	17,039	24,204	28,691	37,169	41,200	45,092	52,449
	1,900	15,698	20,441	24,122	31,069	37,450	43,249	16,835	23,829	28,189	36,498	40,445	44,251	51,435
	2,000	15,440	19,980	23,569	30,330	36,526	42,135	16,622	23,396	27,670	35,804	39,663	43,381	50,387
	2,100	15,172	19,506	23,001	29,573	35,578	40,995	16,400	22,950	27,134	35,089	38,858	42,485	49,308
	2,200	14,895	19,022	22,420	28,800	34,611	39,833	16,171	22,491	26,583	34,355	38,031	41,565	48,201
	2,300	14,610	18,528	21,828	28,012	33,627	38,652	15,933	22,020	26,019	33,602	37,184	40,624	47,070
	2,400	14,316	18,026	21,226	27,212	32,629	37,455	15,688	21,540	25,442	32,834	36,320	39,664	45,916
	2,500	14,014	17,516	20,616	26,402	31,620	36,247	15,436	21,049	24,855	32,052	35,440	38,687	44,744
	2,600	13,706	17,002	20,000	25,585	30,603	35,032	15,177	20,551	24,257	31,257	34,547	37,695	43,555
2,700	13,390	16,483	19,380	24,762	29,581	33,811	14,911	20,046	23,652	30,452	33,643	36,692	42,353	
2,800	13,032	15,961	18,756	23,937	28,556	32,590	14,640	19,534	23,040	29,639	32,730	35,679	41,141	
2,900	12,612	15,438	18,131	23,110	27,531	31,371	14,362	19,018	22,422	28,819	31,810	34,659	39,922	
3,000	12,191	14,914	17,506	22,284	26,510	30,157	14,079	18,498	21,800	27,995	30,885	33,634	38,698	
RESISTENCIA A FLEXIÓN ϕ _b M _{n_x} =ϕ _b M _{n_y} (kg-m) - ϕ _b =0.95		602	783	912	1,142	1,335	1,492	719	958	1,147	1,446	1,581	1,705	1,924
RESISTENCIA A CORTE ϕ _v V _{n_x} =ϕ _v V _{n_y} (kg) - ϕ _v =0.95		5,931	7,314	8,656	11,221	13,625	15,870	6,733	8,316	9,858	12,824	14,247	15,629	18,274
RESISTENCIA A TENSIÓN ϕ _t T _n (kg) - ϕ _b =0.90		21,663	26,730	31,658	41,097	49,978	58,302	24,194	29,894	35,454	46,158	51,301	56,305	65,894
Lu (m)		4.54	4.55	4.57	4.59	4.62	4.64	5.04	5.05	5.07	5.09	5.10	5.12	5.14

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO CUADRADO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		90x90						100x100						
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	4.50	5.00	6.00
PESO (kg/m)		5.45	6.74	8.01	10.48	12.84	15.1	6.07	7.53	8.96	11.73	13.08	14.41	16.98
Longitud Efectiva KL (mm)	3,100	11,770	14,392	16,882	21,462	25,493	28,951	13,792	17,976	21,175	27,167	29,956	32,605	37,471
	3,200	11,351	13,871	16,261	20,644	24,484	27,756	13,499	17,452	20,548	26,337	29,027	31,576	36,246
	3,300	10,935	13,354	15,644	19,833	23,485	26,575	13,202	16,927	19,921	25,508	28,098	30,549	35,023
	3,400	10,521	12,841	15,033	19,031	22,498	25,410	12,902	16,402	19,295	24,681	27,172	29,524	33,806
	3,500	10,112	12,333	14,429	18,238	21,524	24,264	12,597	15,879	18,670	23,857	26,250	28,506	32,597
	3,600	9,707	11,831	13,832	17,457	20,567	23,138	12,290	15,358	18,048	23,038	25,334	27,494	31,397
	3,700	9,308	11,337	13,244	16,689	19,626	22,036	11,980	14,840	17,431	22,225	24,425	26,491	30,211
	3,800	8,915	10,850	12,666	15,935	18,705	20,923	11,667	14,327	16,819	21,420	23,525	25,499	29,038
	3,900	8,529	10,373	12,099	15,196	17,771	19,864	11,299	13,818	16,212	20,623	22,636	24,519	27,881
	4,000	8,150	9,904	11,532	14,443	16,893	18,883	10,893	13,314	15,613	19,837	21,759	23,552	26,742
	4,100	7,766	9,427	10,977	13,747	16,079	17,974	10,492	12,817	15,021	19,062	20,895	22,601	25,623
	4,200	7,400	8,983	10,460	13,100	15,323	17,128	10,097	12,327	14,438	18,299	20,045	21,666	24,524
	4,300	7,060	8,570	9,979	12,498	14,618	16,340	9,707	11,844	13,865	17,549	19,210	20,749	23,403
	4,400	6,743	8,185	9,531	11,936	13,961	15,606	9,324	11,370	13,301	16,796	18,361	19,808	22,352
	4,500	6,447	7,825	9,112	11,412	13,348	14,920	8,947	10,894	12,728	16,058	17,554	18,938	21,369
	4,600	6,169	7,489	8,720	10,921	12,774	14,279	8,561	10,425	12,181	15,367	16,799	18,123	20,450
	4,700	5,910	7,173	8,353	10,461	12,236	13,677	8,201	9,986	11,668	14,720	16,092	17,360	19,589
	4,800	5,666	6,878	8,009	10,030	11,731	13,113	7,863	9,575	11,187	14,113	15,428	16,645	18,782
	4,900	5,437	6,600	7,685	9,625	11,257	12,584	7,545	9,188	10,735	13,543	14,805	15,972	18,023
	5,000	5,222	6,338	7,381	9,243	10,812	12,085	7,246	8,824	10,310	13,007	14,219	15,340	17,309
	5,100	5,019	6,092	7,094	8,884	10,392	11,616	6,965	8,481	9,909	12,502	13,666	14,744	16,637
	5,200	4,828	5,860	6,824	8,546	9,996	11,174	6,699	8,158	9,532	12,025	13,146	14,182	16,003
	5,300	4,647	5,641	6,569	8,227	9,622	10,756	6,449	7,853	9,176	11,576	12,654	13,652	15,405
	5,400	4,477	5,434	6,328	7,925	9,269	10,361	6,212	7,565	8,839	11,151	12,190	13,151	14,840
5,500	4,316	5,238	6,100	7,639	8,935	9,988	5,989	7,293	8,520	10,749	11,751	12,677	14,305	
5,600	4,163	5,053	5,884	7,369	8,619	9,634	5,777	7,034	8,219	10,369	11,335	12,229	13,799	
5,700	4,018	4,877	5,679	7,113	8,319	9,299	5,576	6,790	7,933	10,008	10,941	11,803	13,319	
5,800	3,881	4,710	5,485	6,869	8,035	8,981	5,385	6,558	7,662	9,666	10,567	11,400	12,864	
5,900	3,750	4,552	5,301	6,638	7,765	8,680	5,204	6,337	7,404	9,341	10,212	11,017	12,431	
6,000	3,626	4,402	5,125	6,419	7,508	8,393	5,032	6,128	7,160	9,032	9,874	10,653	12,020	
RESISTENCIA A FLEXIÓN $\phi_b M_{nx} = \phi_b M_{ny}$ (kg-m) - $\phi_b = 0.95$		602	783	912	1,142	1,335	1,492	719	958	1,147	1,446	1,581	1,705	1,924
RESISTENCIA A CORTE $\phi_v V_{nx} = \phi_v V_{ny}$ (kg) - $\phi_v = 0.95$		5,931	7,314	8,656	11,221	13,625	15,870	6,733	8,316	9,858	12,824	14,247	15,629	18,274
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_b = 0.90$		21,663	26,730	31,658	41,097	49,978	58,302	24,194	29,894	35,454	46,158	51,301	56,305	65,894
Lu (m)		4.54	4.55	4.57	4.59	4.62	4.64	5.04	5.05	5.07	5.09	5.10	5.12	5.14

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO CUADRADO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c = 0.85$

$F_y = 50 \text{ ksi (35.15 kgf/mm}^2\text{)}$
 $F_u = 65 \text{ ksi (45.69 kgf/mm}^2\text{)}$

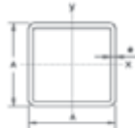
RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSIÓN

Dimensión Nominal (mm)	120x120	135x135	150x150	200x200	220x220	250x250	300x300
ESPESOR (mm)	4.00	4.00	6.00	4.00	6.00	5.00	7.00
PESO (kg/m)	14.14	16.13	23.82	18.12	26.40	30.11	41.43
Longitud Efectiva KL (mm)	0	52,580	59,751	86,038	66,921	96,794	110,178
	100	52,562	59,735	86,014	66,907	96,772	110,168
	200	52,509	59,688	85,942	66,865	96,708	110,138
	300	52,421	59,609	85,823	66,794	96,601	110,088
	400	52,297	59,500	85,656	66,696	96,451	110,018
	500	52,138	59,359	85,442	66,569	96,259	109,928
	600	51,945	59,187	85,181	66,415	96,025	109,818
	700	51,717	58,985	84,873	66,232	95,749	109,688
	800	51,456	58,752	84,520	66,023	95,432	109,538
	900	51,162	58,490	84,121	65,786	95,073	109,368
	1,000	50,835	58,198	83,678	65,523	94,674	109,179
	1,100	50,475	57,877	83,191	65,233	94,235	108,970
	1,200	50,085	57,527	82,660	64,917	93,756	108,742
	1,300	49,664	57,150	82,087	64,575	93,238	108,494
	1,400	49,213	56,745	81,473	64,208	92,683	108,227
	1,500	48,734	56,313	80,819	63,816	92,089	107,941
	1,600	48,226	55,855	80,125	63,400	91,460	107,635
	1,700	47,692	55,372	79,393	62,959	90,794	107,311
	1,800	47,132	54,864	78,624	62,496	90,093	106,967
	1,900	46,547	54,332	77,819	62,009	89,358	106,605
	2,000	45,938	53,777	76,980	61,501	88,589	106,225
	2,100	45,306	53,200	76,107	60,970	87,789	105,826
	2,200	44,653	52,601	75,202	60,419	86,957	105,409
	2,300	43,980	51,981	74,267	59,848	86,095	104,973
	2,400	43,288	51,341	73,302	59,257	85,203	104,520
	2,500	42,577	50,683	72,310	58,647	84,284	104,049
	2,600	41,851	50,007	71,292	58,019	83,338	103,435
	2,700	41,108	49,314	70,249	57,373	82,365	102,790
	2,800	40,352	48,605	69,182	56,710	81,368	102,124
	2,900	39,583	47,881	68,094	56,032	80,348	101,439
	3,000	38,802	47,143	66,986	55,338	79,305	100,734
	3,100	38,011	46,391	65,859	54,630	78,241	100,011
	3,200	37,211	45,628	64,715	53,908	77,157	99,269
	3,300	36,404	44,854	63,556	53,173	76,055	98,510
	3,400	35,589	44,069	62,383	52,426	74,935	97,733
	3,500	34,770	43,276	61,197	51,667	73,798	96,940
	3,600	33,946	42,474	60,000	50,898	72,647	96,130
	3,700	33,120	41,665	58,795	50,120	71,483	95,305
	3,800	32,292	40,851	57,581	49,332	70,305	94,464
	3,900	31,463	40,031	56,361	48,537	69,117	93,609
	4,000	30,635	39,206	55,136	47,734	67,918	92,739
RESISTENCIA A FLEXIÓN $\phi_b M_n = \phi_b M_{ny}$ (kg-m) - $\phi_b = 0.95$							
	2,119	2,745	3,741	3,450	4,758	7,663	10,194
RESISTENCIA A CORTE $\phi_v V_n = \phi_v V_{ny}$ (kg) - $\phi_v = 0.95$							
	14,748	17,152	24,766	19,557	28,373	34,064	46,567
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_t = 0.90$							
	55,673	63,266	91,099	70,858	102,487	118,624	161,641
Lu (m)							
	6.09	6.84	6.89	7.59	7.64	10.11	10.16

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO CUADRADO HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		120x120		135x135		150x150		200x200		220x220		250x250		300x300	
ESPESOR (mm)		4.00		4.00		6.00		5.00		7.00		8.00		10.00	
PESO (kg/m)		14.14		16.13		23.82		30.11		41.43		59.93		89.04	
Longitud Efectiva KL (mm)	4,100	29,809	38,379	53,908	46,924	66,711	91,856	124,298	143,203	178,551	193,048	214,415	235,153	300,099	352,772
	4,200	28,985	37,549	52,678	46,109	65,496	90,960	123,043	142,020	177,027	191,812	213,021	233,602	298,757	351,155
	4,300	28,165	36,718	51,447	45,288	64,275	90,051	121,771	140,819	175,480	190,554	211,604	232,025	297,388	349,507
	4,400	27,350	35,886	50,217	44,464	63,049	89,130	120,483	139,600	173,910	189,274	210,163	230,421	295,994	347,827
	4,500	26,540	35,055	48,990	43,636	61,818	88,198	119,179	138,364	172,318	187,975	208,699	228,792	294,574	346,118
	4,600	25,737	34,225	47,765	42,806	60,585	87,255	117,860	137,112	170,706	186,655	207,213	227,139	293,130	344,379
	4,700	24,942	33,397	46,546	41,973	59,350	86,302	116,527	135,844	169,074	185,316	205,705	225,461	291,661	342,611
	4,800	24,154	32,572	45,332	41,139	58,115	85,338	115,182	134,561	167,423	183,958	204,176	223,760	290,168	340,814
	4,900	23,376	31,750	44,126	40,305	56,880	84,366	113,824	133,263	165,754	182,581	202,627	222,037	288,651	338,989
	5,000	22,608	30,933	42,927	39,471	55,647	83,385	112,454	131,951	164,068	181,187	201,057	220,292	287,112	337,136
	5,100	21,850	30,121	41,738	38,638	54,416	82,396	111,074	130,626	162,365	179,776	199,469	218,525	285,550	335,256
	5,200	21,103	29,315	40,559	37,807	53,189	81,400	109,684	129,289	160,647	178,348	197,862	216,738	283,965	333,350
	5,300	20,351	28,516	39,392	36,978	51,967	80,396	108,285	127,940	158,914	176,904	196,237	214,932	282,359	331,418
	5,400	19,604	27,724	38,237	36,152	50,750	79,386	106,877	126,579	157,167	175,444	194,595	213,106	280,732	329,461
	5,500	18,898	26,939	37,096	35,329	49,540	78,371	105,462	125,208	155,408	173,970	192,936	211,263	279,084	327,479
	5,600	18,229	26,163	35,968	34,511	48,337	77,350	104,041	123,827	153,636	172,481	191,261	209,402	277,415	325,473
	5,700	17,595	25,396	34,855	33,697	47,143	76,324	102,613	122,437	151,853	170,979	189,571	207,524	275,727	323,444
	5,800	16,994	24,638	33,758	32,888	45,957	75,294	101,180	121,038	150,060	169,463	187,867	205,630	274,019	321,391
	5,900	16,422	23,891	32,622	32,086	44,782	74,261	99,743	119,631	148,258	167,935	186,149	203,722	272,293	319,316
	6,000	15,879	23,135	31,544	31,289	43,618	73,224	98,302	118,217	146,447	166,395	184,417	201,798	270,548	317,220
	6,100	15,363	22,383	30,518	30,500	42,464	72,185	96,859	116,797	144,628	164,844	182,673	199,861	268,786	315,102
	6,200	14,872	21,667	29,541	29,718	41,324	71,144	95,413	115,370	142,802	163,281	180,917	197,911	267,006	312,964
	6,300	14,403	20,984	28,611	28,944	40,196	70,101	93,966	113,938	140,970	161,709	179,149	195,949	265,209	310,806
	6,400	13,957	20,334	27,724	28,178	39,081	69,057	92,518	112,502	139,133	160,126	177,371	193,975	263,396	308,629
	6,500	13,530	19,713	26,878	27,421	37,980	68,013	91,070	111,061	137,291	158,535	175,583	191,991	261,566	306,433
	6,600	13,124	19,120	26,069	26,672	36,837	66,968	89,623	109,617	135,446	156,935	173,786	189,997	259,722	304,218
	6,700	12,735	18,553	25,297	25,913	35,746	65,924	88,177	108,170	133,598	155,328	171,980	187,993	257,863	301,987
	6,800	12,363	18,012	24,558	25,156	34,702	64,881	86,734	106,720	131,748	153,712	170,166	185,981	255,989	299,739
	6,900	12,007	17,494	23,852	24,432	33,703	63,840	85,293	105,270	129,897	152,091	168,345	183,961	254,102	297,474
	7,000	11,667	16,997	23,175	23,739	32,747	62,800	83,856	103,818	128,045	150,463	166,518	181,934	252,201	295,194
	7,100	11,340	16,522	22,527	23,075	31,831	61,762	82,422	102,365	126,194	148,829	164,684	179,900	250,287	292,899
	7,200	11,027	16,066	21,905	22,439	30,953	60,728	80,994	100,913	124,344	147,190	162,845	177,861	248,361	290,590
	7,300	10,727	15,629	21,309	21,828	30,111	59,696	79,570	99,462	122,495	145,547	161,001	175,817	246,423	288,266
	7,400	10,439	15,209	20,737	21,242	29,303	58,669	78,153	98,012	120,649	143,900	159,153	173,769	244,474	285,930
	7,500	10,163	14,806	20,188	20,680	28,527	57,645	76,742	96,563	118,807	142,250	157,301	171,718	242,514	283,582
	7,600	9,897	14,419	19,660	20,139	27,781	56,626	75,338	95,117	116,968	140,596	155,447	169,663	240,544	281,221
	7,700	9,642	14,047	19,153	19,619	27,064	55,612	73,942	93,674	115,134	138,941	153,590	167,607	238,564	278,849
	7,800	9,396	13,689	18,665	19,119	26,374	54,603	72,554	92,235	113,305	137,283	151,732	165,548	236,575	276,467
	7,900	9,160	13,345	18,195	18,638	25,711	53,599	71,174	90,799	111,483	135,625	149,872	163,490	234,577	274,075
	8,000	8,932	13,014	17,743	18,175	25,072	52,602	69,804	89,368	109,667	133,965	148,012	161,431	232,571	271,673
RESISTENCIA A FLEXIÓN $\phi_b M_n = \phi_b M_{ny}$ (kg-m) - $\phi_b=0.95$		2,119	2,745	3,741	3,450	4,758	7,663	10,194	12,584	15,262	18,551	20,348	22,030	33,113	38,067
RESISTENCIA A CORTE $\phi_v V_n = \phi_v V_{ny}$ (kg) - $\phi_v=0.95$		14,748	17,152	24,766	19,557	28,373	34,064	46,567	51,056	62,036	65,402	72,856	80,150	97,783	115,416
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_t=0.90$		55,673	63,266	91,099	70,858	102,487	118,624	161,641	179,357	224,902	232,816	259,068	284,687	347,957	409,949
Lu (m)		6.09	6.84	6.89	7.59	7.64	10.11	10.16	11.16	11.21	12.68	12.70	12.73	15.22	15.27

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez KL/r< 200.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n=F_y$ (Valor con KL = 0)

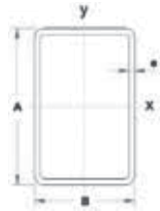
L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



Fanalca



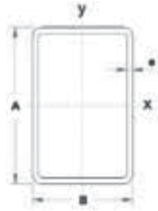
SECCIÓN TUBOS
RECTANGULARES



TUBOS RECTANGULARES FANALCA

PROPIEDADES GEOMETRICAS

Dimensión Ext. AxB	Espesor e (mm)	Peso Teórico(kg/m)	Área (cm ²)	I _x (cm ⁴)	I _y (cm ⁴)	S _x (cm ³)	S _y (cm ³)	Z _x (cm ³)	Z _y (cm ³)	r _x (cm)	r _y (cm)	J (cm ⁴)
50 x 30	1,50	1,77	2,25	7,54	3,42	3,02	2,28	3,70	2,60	1,83	1,23	7,60
	2,00	2,31	2,94	9,55	4,31	3,82	2,87	4,74	3,33	1,80	1,21	9,77
	2,50	2,82	3,59	11,33	5,08	4,53	3,39	5,70	3,98	1,78	1,19	11,74
	3,00	3,30	4,21	12,90	5,77	5,16	3,85	6,57	4,58	1,75	1,17	13,53
	4,00	4,20	5,35	15,47	6,91	6,19	4,61	8,05	5,58	1,70	1,14	16,53
	5,00	4,99	6,36	17,40	7,86	6,96	5,24	9,20	6,34	1,65	1,11	18,77
50 x 40	1,50	2,00	2,55	9,30	6,61	3,72	3,30	4,42	3,80	1,91	1,61	12,26
	2,00	2,62	3,34	11,86	8,40	4,74	4,20	5,70	4,89	1,88	1,59	15,86
	2,50	3,21	4,09	14,15	10,01	5,66	5,00	6,89	5,90	1,86	1,56	19,22
	3,00	3,77	4,81	16,22	11,45	6,49	5,73	7,98	6,83	1,84	1,54	22,34
	4,00	4,83	6,15	19,71	13,89	7,88	6,95	9,89	8,45	1,79	1,50	27,82
	5,00	5,77	7,36	22,48	15,87	8,99	7,94	11,45	9,77	1,75	1,47	32,30
60 x 40	1,50	2,24	2,85	14,39	7,72	4,80	3,86	5,77	4,38	2,25	1,65	15,97
	2,00	2,93	3,74	18,43	9,84	6,14	4,92	7,47	5,65	2,22	1,62	20,70
	2,50	3,60	4,59	22,10	11,77	7,37	5,88	9,06	6,84	2,19	1,60	25,14
	3,00	4,25	5,41	25,45	13,51	8,48	6,75	10,53	7,94	2,17	1,58	29,28
	4,00	5,45	6,95	31,20	16,50	10,40	8,25	13,16	9,89	2,12	1,54	36,67
	5,00	6,56	8,36	35,86	18,96	11,95	9,48	15,38	11,52	2,07	1,51	42,85
76 x 38	1,50	2,57	3,27	24,73	8,47	6,51	4,46	8,02	4,97	2,75	1,61	20,30
	2,00	3,37	4,30	31,81	10,83	8,37	5,70	10,42	6,44	2,72	1,59	26,33
	2,50	4,15	5,29	38,35	12,97	10,09	6,83	12,68	7,81	2,69	1,57	31,99
	3,00	4,90	6,25	44,36	14,92	11,67	7,85	14,80	9,09	2,66	1,55	37,29
	4,00	6,33	8,07	54,91	18,30	14,45	9,63	18,66	11,38	2,61	1,51	46,78
	5,00	7,66	9,76	63,63	21,12	16,74	11,12	21,99	13,34	2,55	1,47	54,79
80 x 40	6,00	8,88	11,31	70,74	23,55	18,62	12,39	24,83	14,96	2,50	1,44	61,32
	1,50	2,71	3,45	28,99	9,94	7,25	4,97	8,93	5,53	2,90	1,70	23,77
	2,00	3,56	4,54	37,37	12,74	9,34	6,37	11,61	7,17	2,87	1,68	30,88
	2,50	4,39	5,59	45,14	15,29	11,28	7,64	14,15	8,72	2,84	1,65	37,58
	3,00	5,19	6,61	52,32	17,62	13,08	8,81	16,54	10,16	2,81	1,63	43,88
	4,00	6,71	8,55	65,01	21,70	16,25	10,85	20,91	12,77	2,76	1,59	55,24
80 x 50	5,00	8,13	10,36	75,64	25,12	18,91	12,56	24,74	15,02	2,70	1,56	64,97
	6,00	9,45	12,03	84,42	28,06	21,11	14,03	28,03	16,92	2,65	1,53	73,07
	2,00	3,88	4,94	43,46	21,08	10,86	8,43	13,17	9,54	2,97	2,07	45,31
	2,50	4,78	6,09	52,65	25,45	13,16	10,18	16,08	11,64	2,94	2,04	55,40
	3,00	5,66	7,21	61,22	29,49	15,30	11,80	18,85	13,62	2,91	2,02	65,00
	4,00	7,34	9,35	76,57	36,68	19,14	14,67	23,95	17,25	2,86	1,98	82,70
90 x 50	5,00	8,91	11,36	89,72	42,82	22,43	17,13	28,49	20,45	2,81	1,94	98,40
	6,00	10,39	13,23	100,88	48,09	25,22	19,23	32,47	23,24	2,76	1,91	112,08
	1,50	3,18	4,05	44,68	18,13	9,93	7,25	12,06	8,06	3,32	2,12	40,87
	2,00	4,19	5,34	57,89	23,38	12,86	9,35	15,74	10,50	3,29	2,09	53,37
	2,50	5,17	6,59	70,30	28,27	15,62	11,31	19,25	12,82	3,27	2,07	65,30
	3,00	6,13	7,81	81,92	32,81	18,20	13,12	22,60	15,03	3,24	2,05	76,67
90 x 50	4,00	7,97	10,15	102,93	40,92	22,87	16,37	28,82	19,09	3,18	2,01	97,70
	5,00	9,70	12,36	121,13	47,90	26,92	19,16	34,41	22,70	3,13	1,97	116,47
	6,00	11,33	14,43	136,76	53,93	30,39	21,57	39,38	25,88	3,08	1,93	132,94



TUBOS RECTANGULARES FANALCA

PROPIEDADES GEOMETRICAS

Dimensión Ext. Ax B	Espesor e (mm)	Peso Teórico (kg/m)	Área (cm ²)	I _x (cm ⁴)	I _y (cm ⁴)	S _x (cm ³)	S _y (cm ³)	Z _x (cm ³)	Z _y (cm ³)	r _x (cm)	r _y (cm)	J (cm ⁴)
100 x 40	1,50	3,18	4,05	50,50	12,17	10,10	6,08	12,68	6,69	3,53	1,73	31,90
	2,00	4,19	5,34	65,39	15,63	13,08	7,81	16,54	8,69	3,50	1,71	41,47
	2,50	5,17	6,59	79,35	18,81	15,87	9,41	20,23	10,59	3,47	1,69	50,52
	3,00	6,13	7,81	92,41	21,74	18,48	10,87	23,75	12,38	3,44	1,67	59,05
	4,00	7,97	10,15	115,91	26,91	23,18	13,45	30,26	15,65	3,38	1,63	74,53
	5,00	9,70	12,36	136,13	31,29	27,23	15,64	36,09	18,52	3,32	1,59	87,92
100 x 50	6,00	11,33	14,43	153,31	35,06	30,66	17,53	41,26	21,00	3,26	1,56	99,26
	2,00	4,50	5,74	75,00	25,69	15,00	10,27	18,50	11,46	3,62	2,12	61,59
	2,50	5,56	7,09	91,24	31,09	18,25	12,44	22,67	14,01	3,59	2,09	75,39
	3,00	6,60	8,41	106,53	36,13	21,31	14,45	26,66	16,44	3,56	2,07	88,56
	4,00	8,59	10,95	134,36	45,17	26,87	18,07	34,10	20,93	3,50	2,03	112,99
	5,00	10,48	13,36	158,72	52,98	31,74	21,19	40,84	24,95	3,45	1,99	134,87
110 x 70	6,00	12,27	15,63	179,85	59,77	35,97	23,91	46,90	28,52	3,39	1,96	154,20
	2,50	6,74	8,59	144,62	72,23	26,29	20,64	31,72	23,29	4,10	2,90	152,93
	3,00	8,01	10,21	169,69	84,55	30,85	24,16	37,43	27,46	4,08	2,88	180,67
	4,00	10,48	13,35	216,22	107,23	39,31	30,64	48,25	35,32	4,02	2,83	233,32
	5,00	12,84	16,36	258,15	127,49	46,94	36,43	58,27	42,56	3,97	2,79	282,14
	6,00	15,10	19,23	295,73	145,57	53,77	41,59	67,50	49,19	3,92	2,75	327,11
120 x 60	2,00	5,45	6,94	131,93	45,35	21,99	15,12	27,00	16,75	4,36	2,56	107,88
	2,50	6,74	8,59	161,26	55,19	26,88	18,40	33,20	20,56	4,33	2,53	132,57
	3,00	8,01	10,21	189,19	64,47	31,53	21,49	39,18	24,21	4,30	2,51	156,34
	4,00	10,48	13,35	240,96	81,46	40,16	27,15	50,49	31,08	4,25	2,47	201,12
	5,00	12,84	16,36	287,51	96,52	47,92	32,17	60,95	37,38	4,19	2,43	242,23
	6,00	15,10	19,23	329,11	109,87	54,85	36,62	70,57	43,12	4,14	2,39	279,67
130 x 50	2,50	6,74	8,59	176,33	39,56	27,13	15,82	34,43	17,57	4,53	2,15	106,51
	3,00	8,01	10,21	206,77	46,08	31,81	18,43	40,62	20,67	4,50	2,12	125,22
	4,00	10,48	13,35	263,08	57,89	40,47	23,16	52,32	26,45	4,44	2,08	160,07
	5,00	12,84	16,36	313,54	68,23	48,24	27,29	63,13	31,70	4,38	2,04	191,50
	6,00	15,10	19,23	358,43	77,31	55,14	30,92	73,05	36,44	4,32	2,00	219,54
	2,00	6,07	7,74	207,54	37,21	27,67	14,89	35,35	16,26	5,18	2,19	104,24
150 x 50	2,50	7,53	9,59	254,11	45,21	33,88	18,08	43,52	19,95	5,15	2,17	127,74
	3,00	8,96	11,41	298,62	52,72	39,82	21,09	51,43	23,49	5,12	2,15	150,22
	4,00	11,73	14,95	381,61	66,38	50,88	26,55	66,47	30,13	5,05	2,11	192,14
	5,00	14,41	18,36	456,82	78,40	60,91	31,36	80,48	36,20	4,99	2,07	230,05
	6,00	16,98	21,63	524,57	88,99	69,94	35,60	93,48	41,72	4,92	2,03	263,99
	4,00	14,87	18,95	594,82	318,78	79,31	63,76	95,67	72,50	5,60	4,10	661,63
150x100	6,00	21,69	27,63	835,79	445,29	111,44	89,06	136,68	103,30	5,50	4,01	948,34
160x65	3,40	11,41	14,54	456,15	111,58	57,02	34,33	72,15	38,32	5,60	2,77	295,13
180x65	4,00	14,56	18,55	709,39	142,56	78,82	43,87	101,25	49,11	6,18	2,77	396,41
200x70	4,00	16,13	20,55	969,39	185,73	96,94	53,07	124,52	59,08	6,87	3,01	519,82
	6,00	23,58	30,03	1.365,58	256,49	136,56	73,28	178,35	83,75	6,74	2,92	734,49
200x100	4,00	18,01	22,95	1.199,92	411,00	119,99	82,20	148,04	91,70	7,23	4,23	985,38
	6,00	26,40	33,63	1.704,41	578,01	170,44	115,60	213,27	131,50	7,12	4,15	1.417,03
250x100	5,00	26,18	33,36	2.554,29	610,38	204,34	122,08	258,51	135,84	8,75	4,28	1.620,11
250x150	5,00	30,11	38,36	3.304,71	1.508,48	264,38	201,13	319,76	225,48	9,28	6,27	3.284,54
300x100	5,00	30,11	38,36	4.065,75	723,30	271,05	144,66	348,15	159,59	10,30	4,34	2.043,80
	7,00	41,43	52,78	5.457,68	956,25	363,85	191,25	472,62	215,04	10,17	4,26	2.746,92
350x150	7,00	52,42	66,78	10.224,39	2.734,06	584,25	364,54	733,37	405,79	12,37	6,40	7.044,94
400x200	9,00	80,60	102,67	21.308,57	7.279,85	1.065,43	727,99	1.319,09	816,15	14,41	8,42	17.553,73



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		50x30						50x40						60x40					
ESPESOR (mm)		1.50	2.00	2.50	3.00	4.00	5.00	1.50	2.00	2.50	3.00	4.00	5.00	1.50	2.00	2.50	3.00	4.00	5.00
PESO (kg/m)		1.77	2.31	2.82	3.30	4.20	4.99	2.00	2.62	3.21	3.77	4.83	5.77	2.24	2.93	3.60	4.25	5.45	6.56
Longitud Efectiva KL (mm)	0	6,555	8,467	10,242	11,881	14,747	17,067	7,452	9,662	11,736	13,673	17,138	20,055	8,189	10,857	13,230	15,466	19,528	23,043
	100	6,523	8,424	10,187	11,812	14,646	16,917	7,430	9,634	11,700	13,629	17,075	19,969	8,170	10,827	13,191	15,419	19,461	22,954
	200	6,428	8,294	10,021	11,608	14,348	16,473	7,367	9,548	11,591	13,496	16,889	19,715	8,113	10,735	13,075	15,277	19,264	22,689
	300	6,272	8,083	9,752	11,275	13,863	15,759	7,262	9,406	11,412	13,278	16,582	19,299	8,018	10,584	12,884	15,044	18,940	22,254
	400	6,061	7,797	9,387	10,825	13,213	14,811	7,117	9,212	11,166	12,978	16,163	18,730	7,888	10,376	12,621	14,724	18,495	21,660
	500	5,799	7,444	8,937	10,273	12,421	13,676	6,936	8,968	10,858	12,602	15,640	18,024	7,723	10,115	12,291	14,322	17,938	20,918
	600	5,494	7,033	8,417	9,637	11,517	12,405	6,720	8,679	10,492	12,158	15,023	17,197	7,526	9,804	11,899	13,846	17,280	20,047
	700	5,155	6,577	7,841	8,935	10,533	11,055	6,474	8,349	10,076	11,653	14,325	16,268	7,299	9,449	11,452	13,304	16,533	19,064
	800	4,789	6,088	7,225	8,189	9,502	9,679	6,202	7,983	9,617	11,096	13,560	15,258	7,007	9,056	10,957	12,704	15,712	17,989
	900	4,406	5,577	6,586	7,418	8,455	8,326	5,906	7,589	9,121	10,497	12,742	14,190	6,689	8,630	10,421	12,057	14,830	16,844
	1,000	4,014	5,057	5,938	6,642	7,421	7,035	5,593	7,170	8,597	9,866	11,886	13,084	6,350	8,178	9,854	11,373	13,903	15,650
	1,100	3,621	4,538	5,296	5,879	6,424	5,842	5,266	6,735	8,053	9,213	11,007	11,961	5,996	7,705	9,263	10,662	12,946	14,429
	1,200	3,235	4,031	4,671	5,143	5,474	4,909	4,930	6,289	7,497	8,547	10,119	10,842	5,630	7,219	8,656	9,935	11,973	13,201
	1,300	2,862	3,543	4,076	4,438	4,664	4,183	4,588	5,837	6,936	7,877	9,234	9,744	5,258	6,725	8,041	9,200	10,998	11,984
	1,400	2,503	3,076	3,518	3,827	4,022	3,607	4,246	5,385	6,377	7,213	8,366	8,683	4,884	6,229	7,426	8,467	10,034	10,795
	1,500	2,181	2,680	3,065	3,333	3,503	3,142	3,907	4,939	5,826	6,562	7,524	7,660	4,511	5,738	6,818	7,745	9,093	9,649
	1,600	1,917	2,355	2,694	2,930	3,079	2,761	3,575	4,503	5,291	5,930	6,717	6,733	4,144	5,255	6,223	7,041	8,184	8,540
	1,700	1,698	2,086	2,386	2,595	2,727	2,446	3,252	4,081	4,774	5,322	5,949	5,964	3,787	4,786	5,647	6,362	7,301	7,565
	1,800	1,514	1,861	2,128	2,315	2,433	2,182	2,941	3,670	4,272	4,747	5,307	5,320	3,441	4,334	5,088	5,700	6,512	6,748
	1,900	1,359	1,670	1,910	2,078	2,184		2,641	3,294	3,834	4,261	4,763	4,774	3,103	3,895	4,566	5,116	5,845	6,056
	2,000	1,227	1,507	1,724	1,875	1,971		2,383	2,973	3,460	3,845	4,298	4,309	2,801	3,515	4,121	4,617	5,275	5,466
	2,100	1,113	1,367	1,564	1,701			2,162	2,696	3,139	3,488	3,899	3,908	2,540	3,188	3,738	4,188	4,785	4,958
	2,200	1,014	1,246	1,425	1,550			1,970	2,457	2,860	3,178	3,552	3,561	2,314	2,905	3,406	3,816	4,359	4,517
	2,300	927	1,140	1,304				1,802	2,248	2,617	2,907	3,250	3,258	2,118	2,658	3,116	3,491	3,989	4,133
	2,400	852						1,655	2,064	2,403	2,670	2,985	2,992	1,945	2,441	2,862	3,207	3,663	3,796
	2,500							1,525	1,903	2,215	2,461	2,751	2,758	1,792	2,250	2,637	2,955	3,376	3,498
	2,600							1,410	1,759	2,048	2,275	2,543	2,550	1,657	2,080	2,438	2,732	3,121	3,234
	2,700							1,308	1,631	1,899	2,110	2,358		1,537	1,929	2,261	2,534	2,894	2,999
	2,800							1,216	1,517	1,766	1,962	2,193		1,429	1,793	2,103	2,356	2,691	
	2,900							1,134	1,414	1,646	1,829			1,332	1,672	1,960	2,196	2,509	
	3,000							1,059	1,321	1,538				1,245	1,562	1,832	2,052		
	3,100							992	1,237					1,166	1,463	1,715			
	3,200							931						1,094	1,373				
RESISTENCIA A FLEXIÓN $\phi_b M_{nx}$ (kg-m) - $\phi_b=0.95$		96	118	136	149	185	210	119	149	173	193	241	278	154	194	228	256	320	373
RESISTENCIA A FLEXIÓN $\phi_b M_{ny}$ (kg-m) - $\phi_b=0.95$		66	67	99	115	137	154	98	126	151	173	212	242	116	149	179	206	253	291
RESISTENCIA A CORTE $\phi_v V_{nx}$ (kg) - $\phi_v=0.95$		1,142	1,442	1,302	1,683	1,924	2,004	1,623	2,084	2,505	2,885	3,527	4,007	1,623	2,084	2,505	2,885	3,527	4,007
RESISTENCIA A CORTE $\phi_v V_{ny}$ (kg) - $\phi_v=0.95$		2,344	3,045	3,306	4,088	5,130	6,011	2,224	2,885	3,507	4,088	5,130	6,011	2,825	3,687	4,508	5,290	6,733	8,015
RESISTENCIA A TENSIÓN $\phi_t T_n$ (kg) - $\phi_t=0.90$		6,941	8,965	10,845	12,580	15,615	18,071	7,890	10,231	12,427	14,478	18,146	21,235	8,839	11,496	14,008	16,376	20,676	24,398
Lu (m)		1.53	1.55	1.56	1.57	1.60	1.62	2.03	2.05	2.06	2.07	2.10	2.12	2.03	2.05	2.06	2.07	2.10	2.12

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL=K_x L_x / (r_x / r_y)$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSION

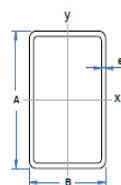
Dimensión Nominal (mm)		76x38							80x40							80x50						
ESPESOR (mm)		1.50	2.00	2.50	3.00	4.00	5.00	6.00	1.50	2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	5.00	6.00	
PESO (kg/m)		2.57	3.37	4.15	4.90	6.33	7.66	8.88	2.71	3.56	4.39	5.19	6.71	8.13	9.45	3.88	4.78	5.66	7.34	8.91	10.39	
Longitud Efectiva KL (mm)	0	8,469	12,510	15,321	17,976	22,874	27,226	31,030	8,730	12,965	16,218	19,051	24,308	29,018	33,181	14,145	17,776	20,936	26,862	32,262	37,136	
	100	8,450	12,479	15,275	17,919	22,794	27,119	30,889	8,712	12,936	16,174	18,997	24,233	28,919	33,052	14,124	17,744	20,898	26,810	32,195	37,051	
	200	8,392	12,384	15,135	17,748	22,557	26,803	30,469	8,659	12,850	16,041	18,836	24,010	28,624	32,666	14,062	17,650	20,784	26,654	31,993	36,798	
	300	8,296	12,202	14,905	17,468	22,167	26,283	29,782	8,570	12,709	15,824	18,571	23,642	28,138	32,034	13,960	17,493	20,594	26,395	31,660	36,380	
	400	8,164	11,953	14,590	17,083	21,632	25,573	28,847	8,448	12,514	15,523	18,206	23,137	27,472	31,169	13,817	17,277	20,332	26,038	31,198	35,803	
	500	7,997	11,640	14,194	16,601	20,964	24,687	27,687	8,294	12,266	15,146	17,747	22,503	26,638	30,090	13,635	17,003	20,000	25,585	30,615	35,074	
	600	7,797	11,268	13,724	16,030	20,175	23,647	26,332	8,108	11,970	14,697	17,201	21,752	25,654	28,823	13,416	16,673	19,601	25,042	29,918	34,203	
	700	7,567	10,845	13,189	15,380	19,280	22,473	24,816	7,895	11,627	14,184	16,578	20,897	24,537	27,394	13,162	16,292	19,140	24,416	29,113	33,202	
	800	7,310	10,375	12,597	14,663	18,297	21,192	23,176	7,655	11,186	13,614	15,888	19,951	23,309	25,833	12,873	15,863	18,622	23,712	28,212	32,083	
	900	7,028	9,868	11,959	13,891	17,244	19,827	21,447	7,391	10,695	12,995	15,140	18,932	21,992	24,171	12,553	15,390	18,051	22,940	27,225	30,860	
	1,000	6,725	9,330	11,284	13,076	16,138	18,406	19,667	7,107	10,171	12,337	14,345	17,853	20,607	22,440	12,181	14,879	17,434	22,106	26,162	29,548	
	1,100	6,405	8,770	10,582	12,230	14,998	16,954	17,871	6,805	9,622	11,649	13,515	16,733	19,178	20,671	11,746	14,333	16,777	21,219	25,035	28,164	
	1,200	6,070	8,195	9,863	11,367	13,842	15,494	16,091	6,488	9,054	10,939	12,661	15,587	17,726	18,892	11,287	13,759	16,085	20,289	23,857	26,721	
	1,300	5,724	7,612	9,137	10,498	12,686	14,049	14,357	6,159	8,475	10,216	11,794	14,429	16,272	17,132	10,809	13,160	15,366	19,324	22,639	25,237	
	1,400	5,371	7,030	8,413	9,633	11,545	12,640	12,694	5,821	7,892	9,489	10,925	13,276	14,836	15,415	10,315	12,543	14,625	18,334	21,393	23,727	
	1,500	5,013	6,454	7,698	8,784	10,435	11,284	11,101	5,477	7,309	8,765	10,062	12,139	13,434	13,762	9,810	11,912	13,869	17,326	20,132	22,205	
	1,600	4,629	5,890	7,002	7,959	9,365	9,972	9,757	5,129	6,734	8,053	9,215	11,032	12,081	12,164	9,297	11,273	13,104	16,310	18,865	20,686	
	1,700	4,213	5,344	6,330	7,165	8,329	8,833	8,642	4,781	6,172	7,358	8,391	9,963	10,768	10,775	8,781	10,630	12,336	15,294	17,605	19,184	
	1,800	3,813	4,814	5,675	6,399	7,429	7,879	7,709	4,424	5,627	6,686	7,598	8,924	9,605	9,611	8,265	9,989	11,570	14,286	16,359	17,709	
	1,900	3,426	4,320	5,093	5,743	6,668	7,072	6,919	4,025	5,097	6,030	6,827	8,009	8,620	8,626	7,752	9,352	10,813	13,292	15,139	16,273	
	2,000	3,092	3,899	4,597	5,183	6,017	6,382	6,244	3,635	4,600	5,442	6,162	7,228	7,780	7,785	7,246	8,726	10,068	12,319	13,950	14,885	
	2,100	2,804	3,537	4,169	4,701	5,458	5,789	5,664	3,297	4,172	4,936	5,589	6,556	7,056	7,061	6,749	8,112	9,340	11,373	12,802	13,524	
	2,200	2,555	3,222	3,799	4,284	4,973	5,275	5,160	3,004	3,801	4,498	5,092	5,974	6,430	6,434	6,265	7,514	8,633	10,453	11,674	12,323	
	2,300	2,338	2,948	3,476	3,919	4,550	4,826	4,721	2,749	3,478	4,115	4,659	5,465	5,883	5,886	5,795	6,936	7,937	9,564	10,681	11,274	
	2,400	2,147	2,708	3,192	3,599	4,179	4,432	4,336	2,524	3,194	3,779	4,279	5,020	5,403	5,406	5,330	6,368	7,289	8,783	9,809	10,354	
	2,500	1,979	2,495	2,942	3,317	3,851	4,085	3,996	2,327	2,944	3,483	3,944	4,626	4,979	4,982	4,913	5,869	6,718	8,095	9,040	9,543	
	2,600	1,829	2,307	2,720	3,067	3,561	3,776		2,151	2,722	3,220	3,646	4,277	4,603	4,606	4,542	5,426	6,211	7,484	8,358	8,823	
	2,700	1,696	2,139	2,522	2,844	3,302	3,502		1,995	2,524	2,986	3,381	3,966	4,269	4,272	4,212	5,031	5,759	6,940	7,750	8,181	
	2,800	1,577	1,989	2,345	2,644	3,070			1,855	2,347	2,777	3,144	3,688	3,969		3,916	4,678	5,355	6,453	7,207	7,607	
	2,900	1,470	1,855	2,186	2,465				1,729	2,188	2,588	2,931	3,438	3,700		3,651	4,361	4,992	6,016	6,718	7,092	
	3,000	1,374	1,733	2,043	2,304				1,616	2,044	2,419	2,739	3,212			3,411	4,075	4,665	5,621	6,278	6,627	
	3,100	1,287	1,623						1,513	1,915	2,265	2,565				3,195	3,817	4,369	5,265	5,879	6,206	
	3,200	1,208							1,420	1,797	2,126	2,407				2,998	3,582	4,100	4,941	5,518	5,824	
	3,300								1,335	1,690						2,819	3,368	3,855	4,646	5,188	5,477	
	3,400															2,656	3,173	3,632	4,377	4,888	5,159	
	3,500															2,506	2,994	3,427	4,130	4,612	4,869	
	3,600															2,369	2,830	3,240	3,904	4,360		
	3,700															2,243	2,679	3,067	3,696	4,127		
	3,800															2,126	2,540	2,908	3,504			
	3,900															2,019	2,411	2,760				
	4,000															1,919	2,292					
	4,100															1,826						
RESISTENCIA A FLEXIÓN ϕ _b M _n (kg-m) - ϕ _b =0.95		210	266	315	357	447	525	580	234	297	354	403	495	583	659	350	419	481	584	694	789	
RESISTENCIA A FLEXIÓN ϕ _b M _n (kg-m) - ϕ _b =0.95		121	174	209	241	297	343	374	132	192	231	268	331	384	426	254	309	360	450	528	595	
RESISTENCIA A CORTE ϕ _v V _n (kg) - ϕ _v =0.95		1,503	1,924	2,304	2,645	3,206	3,607	3,366	1,503	1,924	2,304	2,645	3,206	3,607	3,847	2,725	3,306	3,847	4,809	5,610	6,252	
RESISTENCIA A CORTE ϕ _v V _n (kg) - ϕ _v =0.95		3,787	4,969	6,111	7,214	9,297	11,221	12,503	3,907	5,130	6,312	7,454	9,618	11,622	13,465	5,130	6,312	7,454	9,618	11,622	13,465	
RESISTENCIA A TENSIÓN ϕ _t T _n (kg) - ϕ _t =0.90		10,168	13,268	16,223	19,033	24,220	28,827	32,856	10,737	14,027	17,172	20,172	25,738	30,725	35,133	15,336	18,821	22,168	28,443	34,160	39,321	
Lu (m)		1.93	1.95	1.96	1.97	2.00	2.02	2.05	2.03	2.05	2.06	2.07	2.10	2.12	2.15	2.55	2.56	2.57	2.60	2.62	2.65	

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL = K_x L_x / (r_x / r_y)$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c = 0.85$

$F_y = 50$ ksi (35.15 kgf/mm²)

$F_u = 65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		90x50							100x40							100x50						
ESPESOR (mm)		1,50	2,00	2,50	3,00	4,00	5,00	6,00	1,50	2,00	2,50	3,00	4,00	2,00	2,50	3,00	4,00	5,00	6,00			
PESO (kg/m)		3,18	4,19	5,17	6,13	7,97	9,70	11,33	3,18	4,19	5,17	6,13	7,97	4,50	5,56	6,60	8,59	10,48	12,27			
Longitud Efectiva KL (mm)	0	9,773	14,575	19,270	22,729	29,253	35,250	40,721	9,005	13,711	18,741	22,729	29,253	14,906	20,234	24,522	31,643	38,238	44,307			
	100	9,760	14,555	19,236	22,689	29,198	35,179	40,633	8,988	13,684	18,701	22,668	29,168	14,886	20,206	24,479	31,585	38,163	44,213			
	200	9,721	14,495	19,137	22,568	29,033	34,967	40,367	8,938	13,603	18,582	22,486	28,917	14,827	20,121	24,352	31,412	37,940	43,935			
	300	9,657	14,395	18,972	22,368	28,761	34,616	39,928	8,853	13,469	18,384	22,186	28,503	14,730	19,980	24,142	31,125	37,571	43,474			
	400	9,568	14,256	18,744	22,092	28,384	34,130	39,322	8,737	13,283	18,112	21,773	27,933	14,594	19,784	23,851	30,728	37,060	42,838			
	500	9,455	14,079	18,455	21,742	27,906	33,516	38,557	8,590	13,047	17,766	21,253	27,216	14,421	19,535	23,482	30,225	36,413	42,033			
	600	9,319	13,866	18,107	21,321	27,333	32,781	37,641	8,413	12,765	17,352	20,634	26,366	14,212	19,234	23,039	29,621	35,638	41,070			
	700	9,160	13,617	17,705	20,834	26,672	31,932	36,587	8,208	12,439	16,872	19,926	25,395	13,970	18,883	22,525	28,923	34,743	39,960			
	800	8,980	13,336	17,251	20,286	25,928	30,980	35,407	7,979	12,072	16,316	19,139	24,319	13,694	18,486	21,947	28,138	33,739	38,717			
	900	8,781	13,024	16,752	19,683	25,110	29,935	34,116	7,726	11,669	15,611	18,285	23,155	13,388	18,045	21,310	27,274	32,635	37,355			
	1.000	8,563	12,683	16,210	19,030	24,227	28,809	32,729	7,454	11,233	14,859	17,376	21,919	13,054	17,539	20,620	26,340	31,445	35,889			
	1.100	8,328	12,316	15,633	18,333	23,286	27,614	31,261	7,163	10,768	14,069	16,423	20,630	12,694	16,928	19,883	25,345	30,179	34,335			
	1.200	8,079	11,924	15,023	17,599	22,298	26,362	29,729	6,858	10,279	13,253	15,439	19,305	12,310	16,283	19,107	24,298	28,852	32,711			
	1.300	7,816	11,512	14,388	16,834	21,272	25,065	28,149	6,540	9,771	12,419	14,436	17,961	11,906	15,610	18,296	23,209	27,475	31,032			
	1.400	7,541	11,081	13,732	16,046	20,216	23,736	26,536	6,213	9,247	11,577	13,426	16,615	11,482	14,915	17,460	22,088	26,061	29,316			
	1.500	7,257	10,634	13,060	15,240	19,141	22,387	24,907	5,880	8,712	10,736	12,420	15,281	11,043	14,202	16,604	20,944	24,624	27,578			
	1.600	6,964	10,175	12,379	14,424	18,054	21,030	23,276	5,542	8,170	9,905	11,428	13,973	10,591	13,478	15,736	19,786	23,176	25,834			
	1.700	6,665	9,636	11,692	13,602	16,965	19,675	21,657	5,203	7,568	9,091	10,459	12,704	10,127	12,748	14,861	18,624	21,727	24,099			
	1.800	6,361	9,084	11,006	12,782	15,882	18,334	20,062	4,865	6,929	8,300	9,521	11,483	9,656	12,017	13,987	17,466	20,289	22,386			
	1.900	6,054	8,535	10,324	11,969	14,812	17,015	18,504	4,530	6,312	7,539	8,605	10,306	9,179	11,289	13,118	16,320	18,873	20,707			
	2.000	5,746	7,992	9,651	11,168	13,762	15,727	16,993	4,192	5,708	6,802	7,766	9,301	8,699	10,570	12,261	15,194	17,487	19,073			
	2.100	5,438	7,459	8,990	10,384	12,739	14,479	15,513	3,878	5,178	6,170	7,044	8,437	8,164	9,863	11,420	14,093	16,139	17,495			
	2.200	5,131	6,938	8,346	9,620	11,747	13,250	14,135	3,597	4,718	5,622	6,418	7,687	7,606	9,173	10,600	13,024	14,826	15,947			
	2.300	4,827	6,431	7,722	8,881	10,768	12,123	12,932	3,346	4,316	5,144	5,872	7,033	7,063	8,502	9,805	11,971	13,565	14,590			
	2.400	4,525	5,931	7,103	8,154	9,889	11,134	11,877	3,113	3,964	4,724	5,393	6,459	6,532	7,839	9,018	10,995	12,458	13,400			
	2.500	4,226	5,466	6,547	7,514	9,114	10,261	10,946	2,869	3,653	4,354	4,970	5,953	6,020	7,224	8,311	10,133	11,482	12,349			
	2.600	3,950	5,054	6,053	6,948	8,426	9,487	10,120	2,652	3,378	4,025	4,595	5,504	5,566	6,679	7,684	9,368	10,615	11,418			
	2.700	3,663	4,686	5,613	6,442	7,814	8,797	9,384	2,460	3,132	3,732	4,261	5,104	5,161	6,194	7,126	8,687	9,844	10,588			
	2.800	3,406	4,358	5,219	5,990	7,265	8,180	8,726	2,287	2,912	3,471	3,962	4,746	4,799	5,759	6,626	8,078	9,153	9,845			
	2.900	3,175	4,062	4,865	5,584	6,773	7,625	8,135	2,132	2,715	3,235	3,694	4,424	4,474	5,369	6,177	7,530	8,533	9,178			
	3.000	2,967	3,796	4,546	5,218	6,329	7,126	7,601	1,992	2,537	3,023	3,452	4,134	4,180	5,017	5,772	7,036	7,973	8,576			
	3.100	2,779	3,555	4,258	4,887	5,927	6,673	7,119	1,866	2,376	2,831	3,232	3,872	3,915	4,698	5,405	6,590	7,467	8,032			
	3.200	2,608	3,336	3,996	4,586	5,563	6,263	6,681	1,751	2,230	2,657	3,034		3,674	4,409	5,073	6,184	7,008	7,537			
	3.300	2,452	3,137	3,757	4,313	5,231	5,889	6,282	1,647	2,097	2,499			3,455	4,146	4,770	5,815	6,589	7,088			
	3.400	2,310	2,955	3,539	4,063	4,927	5,548	5,918	1,551	1,975				3,255	3,906	4,494	5,478	6,208	6,677			
	3.500	2,180	2,789	3,340	3,834	4,650	5,235	5,585						3,071	3,686	4,240	5,170	5,858	6,301			
	3.600	2,060	2,636	3,157	3,624	4,395	4,948	5,279						2,903	3,484	4,008	4,886	5,537	5,956			
	3.700	1,951	2,495	2,989	3,431	4,161	4,684							2,748	3,298	3,794	4,626	5,242	5,638			
	3.800	1,849	2,366	2,833	3,252	3,945	4,441							2,605	3,127	3,597	4,386	4,969				
	3.900	1,756	2,246	2,690	3,088	3,745								2,474	2,969	3,415	4,164					
	4.000	1,669	2,135	2,557	2,935									2,351	2,822	3,247						
	4.100	1,589	2,032	2,434										2,238	2,686	3,090						
	4.200	1,514												2,133								
RESISTENCIA A FLEXIÓN ϕ _b M _{nx} (kg-m) - ϕ _b =0.95		324	415	499	575	703	836	954	329	421	505	581	708	485	585	675	831	987	1.131			
RESISTENCIA A FLEXIÓN ϕ _b M _{ny} (kg-m) - ϕ _b =0.95		183	269	345	402	504	593	668	142	212	284	332	413	280	375	443	558	657	742			
RESISTENCIA A CORTE ϕ _v V _{nx} (kg) - ϕ _v =0.95		2.104	2.725	3.306	3.847	4.809	5.610	6.252	1.503	1.924	2.304	2.645	3.206	2.725	3.306	3.847	4.809	5.610	6.252			
RESISTENCIA A CORTE ϕ _v V _{ny} (kg) - ϕ _v =0.95		4.508	5.931	7.314	8.656	11.221	13.626	15.870	5.061	6.733	8.316	9.858	12.824	6.733	8.316	9.858	12.824	15.629	18.274			
RESISTENCIA A TENSION ϕ _t T _n (kg) - ϕ _b =0.90		12.660	16.601	20.403	24.066	30.973	37.324	43.117	12.660	16.601	20.403	24.066	30.973	17.867	21.985	25.964	33.504	40.487	46.913			
Lu (m)		2,53	2,55	2,56	2,57	2,60	2,62	2,65	2,03	2,05	2,06	2,07	2,10	2,55	2,56	2,57	2,60	2,62	2,65			



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSION

Dimensión Nominal (mm)		110x70						120x60						130x50					
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	5.00	6.00
PESO (kg/m)		5.45	6.74	8.01	10.48	12.84	15.10	5.45	6.74	8.01	10.48	12.84	15.10	5.45	6.74	8.01	10.48	12.84	15.10
Longitud Efectiva KL (mm)	0	17,559	23,774	29,899	38,813	47,201	55,063	16,577	22,725	29,138	38,813	47,201	55,063	15,559	21,598	28,019	38,813	47,201	55,063
	100	17,546	23,757	29,873	38,777	47,155	55,006	16,562	22,704	29,109	38,766	47,140	54,988	15,540	21,571	27,982	38,746	47,115	54,955
	200	17,509	23,705	29,793	38,669	47,018	54,838	16,518	22,641	29,024	38,624	46,959	54,764	15,484	21,491	27,872	38,546	46,857	54,634
	300	17,448	23,618	29,660	38,490	46,790	54,560	16,444	22,537	28,883	38,388	46,658	54,394	15,391	21,357	27,689	38,214	46,430	54,103
	400	17,362	23,497	29,475	38,240	46,473	54,172	16,342	22,391	28,686	38,060	46,239	53,879	15,262	21,171	27,435	37,755	45,839	53,369
	500	17,252	23,343	29,239	37,921	46,068	53,677	16,211	22,205	28,435	37,642	45,707	53,224	15,098	20,934	27,111	37,172	45,090	52,439
	600	17,119	23,155	28,952	37,535	45,578	53,078	16,052	21,980	28,130	37,138	45,065	52,435	14,899	20,648	26,720	36,472	44,191	51,324
	700	16,963	22,936	28,618	37,083	45,006	52,379	15,867	21,716	27,774	36,551	44,317	51,517	14,668	20,315	26,265	35,662	43,152	50,038
	800	16,784	22,685	28,237	36,569	44,355	51,584	15,655	21,415	27,368	35,886	43,470	50,478	14,405	19,936	25,748	34,749	41,983	48,593
	900	16,584	22,403	27,811	35,996	43,628	50,697	15,419	21,080	26,914	35,146	42,530	49,326	14,113	19,516	25,173	33,743	40,696	47,007
	1,000	16,363	22,093	27,342	35,365	42,830	49,725	15,159	20,710	26,415	34,337	41,502	48,069	13,794	19,055	24,544	32,653	39,305	45,294
	1,100	16,123	21,754	26,834	34,680	41,964	48,671	14,877	20,309	25,873	33,464	40,396	46,717	13,449	18,558	23,865	31,489	37,823	43,474
	1,200	15,863	21,388	26,287	33,946	41,037	47,543	14,574	19,878	25,256	32,534	39,218	45,280	13,081	18,028	23,140	30,262	36,264	41,565
	1,300	15,585	20,998	25,706	33,165	40,052	46,346	14,252	19,419	24,526	31,553	37,977	43,769	12,693	17,468	22,373	28,982	34,641	39,584
	1,400	15,291	20,583	25,093	32,343	39,014	45,088	13,911	18,934	23,762	30,526	36,680	42,192	12,286	16,881	21,570	27,661	32,971	37,551
	1,500	14,981	20,146	24,451	31,482	37,930	43,774	13,555	18,426	22,968	29,460	35,337	40,563	11,863	16,270	20,669	26,308	31,266	35,484
	1,600	14,656	19,688	23,782	30,586	36,804	42,412	13,183	17,897	22,148	28,362	33,955	38,890	11,427	15,640	19,644	24,936	29,541	33,399
	1,700	14,318	19,211	23,091	29,661	35,643	41,008	12,799	17,349	21,308	27,238	32,543	37,185	10,979	14,993	18,609	23,553	27,810	31,315
	1,800	13,967	18,717	22,380	28,711	34,450	39,570	12,403	16,784	20,451	26,094	31,110	35,459	10,523	14,334	17,570	22,171	26,084	29,246
	1,900	13,605	18,207	21,651	27,739	33,234	38,105	11,997	16,205	19,583	24,937	29,664	33,721	10,061	13,665	16,535	20,797	24,376	27,207
	2,000	13,234	17,683	20,909	26,751	31,998	36,620	11,583	15,614	18,708	23,774	28,212	31,981	9,594	12,989	15,510	19,442	22,696	25,212
	2,100	12,854	17,145	20,157	25,749	30,748	35,120	11,162	15,014	17,830	22,609	26,762	30,249	9,125	12,311	14,501	18,112	21,055	23,272
	2,200	12,467	16,510	19,396	24,739	29,489	33,613	10,737	14,406	16,954	21,448	25,322	28,533	8,657	11,629	13,513	16,814	19,461	21,384
	2,300	12,073	15,871	18,631	23,725	28,227	32,106	10,308	13,755	16,083	20,297	23,897	26,841	8,190	10,821	12,551	15,556	17,892	19,565
	2,400	11,675	15,229	17,865	22,710	26,967	30,603	9,877	13,032	15,221	19,161	22,495	25,181	7,727	10,036	11,612	14,311	16,432	17,968
	2,500	11,273	14,589	17,099	21,697	25,713	29,112	9,446	12,319	14,371	18,045	21,121	23,559	7,259	9,258	10,702	13,189	15,144	16,559
	2,600	10,868	13,950	16,337	20,692	24,469	27,637	9,016	11,619	13,537	16,951	19,779	21,983	6,817	8,560	9,894	12,194	14,001	15,310
	2,700	10,462	13,316	15,581	19,696	23,241	26,183	8,588	10,933	12,722	15,885	18,475	20,412	6,414	7,937	9,175	11,308	12,983	14,197
	2,800	10,055	12,689	14,833	18,713	22,031	24,755	8,163	10,264	11,927	14,829	17,176	18,980	6,045	7,381	8,531	10,514	12,072	13,201
	2,900	9,649	12,070	14,096	17,747	20,844	23,357	7,739	9,599	11,133	13,824	16,012	17,693	5,707	6,880	7,953	9,802	11,254	12,306
	3,000	9,244	11,461	13,372	16,799	19,682	21,993	7,316	8,969	10,403	12,918	14,962	16,533	5,334	6,429	7,432	9,159	10,516	11,500
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		701	851	991	1,241	1,451	1,694	716	868	1,010	1,263	1,497	1,730	721	874	1,016	1,268	1,506	1,739
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		445	599	746	952	1,138	1,306	375	511	649	844	1,004	1,147	305	418	535	719	850	964
RESISTENCIA A CORTE $\phi_v V_n$ (kg) - $\phi_v=0.95$		4,328	5,310	6,252	8,015	9,618	11,061	3,527	4,308	5,049	6,412	7,614	8,656	2,725	3,306	3,847	4,809	5,610	6,252
RESISTENCIA A CORTE $\phi_v V_n$ (kg) - $\phi_v=0.95$		7,534	9,317	11,061	14,427	17,633	20,679	8,336	10,319	12,263	16,030	19,637	23,083	8,998	11,321	13,465	17,633	21,640	25,488
RESISTENCIA A TENSION $\phi_t T_n$ (kg) - $\phi_t=0.90$		21,663	26,730	31,658	41,097	49,978	58,302	21,663	26,730	31,658	41,097	49,978	58,302	21,663	26,730	31,658	41,097	49,978	58,302
Lu (m)		3.54	3.56	3.57	3.59	3.62	3.64	3.04	3.06	3.07	3.09	3.12	3.14	2.55	2.56	2.57	2.60	2.62	2.65

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL = K_x L_x / (r_x / r_y)$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		110x70						120x60						130x50					
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	5.00	6.00	2.00	2.50	3.00	4.00	5.00	6.00
PESO (kg/m)		5.45	6.74	8.01	10.48	12.84	15.10	5.45	6.74	8.01	10.48	12.84	15.10	5.45	6.74	8.01	10.48	12.84	15.10
Longitud Efectiva KL (mm)	3,100	8,841	10,864	12,662	15,872	18,549	20,625	6,926	8,400	9,743	12,098	14,012	15,484	4,995	6,021	6,960	8,578	9,849	10,770
	3,200	8,443	10,279	11,968	14,952	17,409	19,356	6,519	7,883	9,143	11,353	13,150	14,531	4,688	5,651	6,532	8,050	9,243	10,107
	3,300	8,006	9,698	11,272	14,060	16,370	18,201	6,130	7,413	8,598	10,676	12,365	13,664	4,408	5,313	6,142	7,569	8,691	9,504
	3,400	7,540	9,136	10,618	13,245	15,421	17,146	5,775	6,983	8,099	10,057	11,649	12,872	4,153	5,005	5,786	7,131	8,188	8,953
	3,500	7,115	8,621	10,020	12,499	14,553	16,180	5,449	6,590	7,643	9,490	10,993	12,147	3,919	4,724	5,460	6,729	7,726	8,449
	3,600	6,725	8,149	9,471	11,814	13,755	15,294	5,151	6,229	7,224	8,971	10,390	11,482	3,704	4,465	5,161	6,360	7,303	7,986
	3,700	6,367	7,714	8,966	11,184	13,022	14,478	4,876	5,897	6,839	8,492	9,836	10,869	3,506	4,227	4,886	6,021	6,914	7,560
	3,800	6,036	7,314	8,501	10,603	12,346	13,726	4,623	5,590	6,484	8,051	9,325	10,305	3,324	4,007	4,632	5,709	6,555	7,167
	3,900	5,730	6,944	8,070	10,066	11,721	13,031	4,389	5,307	6,156	7,644	8,853	9,783	3,156	3,804	4,397	5,420	6,223	
	4,000	5,448	6,601	7,672	9,569	11,142	12,388	4,172	5,045	5,852	7,266	8,416	9,300	3,000	3,616	4,180	5,152		
	4,100	5,185	6,283	7,302	9,108	10,605	11,791	3,971	4,802	5,570	6,916	8,011	8,852	2,856	3,442	3,979	4,904		
	4,200	4,941	5,987	6,959	8,680	10,106	11,236	3,784	4,576	5,308	6,591	7,634	8,435	2,721	3,280	3,792			
	4,300	4,714	5,712	6,639	8,281	9,641	10,720	3,610	4,366	5,064	6,288	7,283	8,048	2,596					
	4,400	4,502	5,455	6,340	7,909	9,208	10,238	3,448	4,170	4,836	6,005	6,956	7,686						
	4,500	4,304	5,215	6,062	7,561	8,803	9,788	3,296	3,986	4,624	5,741	6,650	7,348						
	4,600	4,119	4,991	5,801	7,236	8,425	9,367	3,155	3,815	4,425	5,494	6,364	7,032						
	4,700	3,946	4,781	5,557	6,931	8,070	8,973	3,022	3,654	4,238	5,263	6,096							
	4,800	3,783	4,584	5,328	6,645	7,737	8,603	2,897	3,504	4,064	5,046								
	4,900	3,630	4,399	5,112	6,377	7,425	8,255	2,780	3,362	3,900									
	5,000	3,486	4,224	4,910	6,124	7,131	7,928	2,670	3,229										
	5,100	3,351	4,060	4,719	5,887	6,854	7,620												
	5,200	3,223	3,906	4,540	5,662	6,593	7,330												
	5,300	3,103	3,760	4,370	5,451	6,346	7,056												
	5,400	2,989	3,622	4,209	5,251	6,114													
	5,500	2,881	3,491	4,058	5,061														
	5,600	2,779	3,368	3,914	4,882														
	5,700	2,683	3,251	3,778															
	5,800	2,591																	
	5,900																		
	6,000																		
RESISTENCIA A FLEXIÓN $\phi_b M_{nx}$ (kg-m) - $\phi_b=0.95$		701	851	991	1,241	1,451	1,694	716	868	1,010	1,263	1,497	1,730	721	874	1,016	1,268	1,506	1,739
RESISTENCIA A FLEXIÓN $\phi_b M_{ny}$ (kg-m) - $\phi_b=0.95$		445	599	746	952	1,138	1,306	375	511	649	844	1,004	1,147	305	418	535	719	850	964
RESISTENCIA A CORTE $\phi_v V_{nx}$ (kg) - $\phi_v=0.95$		4,328	5,310	6,252	8,015	9,618	11,061	3,527	4,308	5,049	6,412	7,614	8,656	2,725	3,306	3,847	4,809	5,610	6,252
RESISTENCIA A CORTE $\phi_v V_{ny}$ (kg) - $\phi_v=0.95$		7,534	9,317	11,061	14,427	17,633	20,679	8,336	10,319	12,263	16,030	19,637	23,083	8,998	11,321	13,465	17,633	21,640	25,488
RESISTENCIA A TENSIÓN $\phi_t P_n$ (kg) - $\phi_t=0.90$		21,663	26,730	31,658	41,097	49,978	58,302	21,663	26,730	31,658	41,097	49,978	58,302	21,663	26,730	31,658	41,097	49,978	58,302
Lu (m)		3.54	3.56	3.57	3.59	3.62	3.64	3.04	3.06	3.07	3.09	3.12	3.14	2.55	2.56	2.57	2.60	2.62	2.65

NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.

Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL = K_x L_x / (r_x / r_y)$.

$\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)

L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSIÓN



TUBO RECTANGULAR HR ESTRUCTURAL FANALCA

RESISTENCIA A COMPRESIÓN

$\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)

$F_u=65$ ksi (45.69 kgf/mm²)

RESISTENCIA A LA COMPRESIÓN, FLEXIÓN, CORTE Y TENSIÓN

Dimensión Nominal (mm)		150x50					150x100			160x65	180x65	200x70		200x100		250x100	250x150	300x100		350x150	400x200
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	4.00	6.00	3.40	4.00	4.00	6.00	4.00	6.00	5.00	5.00	7.00	7.00	9.00	
PESO (kg/m)		6.07	7.53	8.96	11.73	14.41	16.98	14.87	21.69	11.34	14.45	16.13	23.58	18.01	26.40	26.35	30.11	30.11	41.10	52.42	80.60
Longitud Efectiva KL (mm) ↓	0	15,835	22,167	29,057	43,561	53,177	62,233	55,512	80,160	37,465	49,935	52,454	87,330	59,624	98,086	85,694	100,632	88,668	145,095	172,142	280,848
	100	15,817	22,141	29,021	43,500	53,082	62,116	55,491	80,122	37,432	49,897	52,420	87,254	59,605	98,044	85,666	100,617	88,642	145,047	172,118	280,824
	200	15,762	22,062	28,914	43,302	52,800	61,765	55,428	80,011	37,333	49,783	52,321	87,024	59,546	97,916	85,585	100,571	88,563	144,906	172,044	280,753
	300	15,671	21,932	28,735	42,939	52,333	61,185	55,322	79,824	37,168	49,593	52,155	86,642	59,447	97,705	85,449	100,494	88,432	144,670	171,922	280,633
	400	15,545	21,750	28,488	42,437	51,687	60,382	55,155	79,565	36,938	49,329	51,924	86,111	59,310	97,409	85,260	100,386	88,248	144,340	171,750	280,467
	500	15,385	21,519	28,172	41,799	50,867	59,365	54,937	79,232	36,644	48,991	51,628	85,432	59,133	97,030	85,017	100,248	88,013	143,918	171,530	280,252
	600	15,190	21,239	27,790	41,033	49,883	58,145	54,672	78,827	36,287	48,581	51,268	84,610	58,919	96,568	84,721	100,079	87,726	143,402	171,261	279,990
	700	14,964	20,914	27,346	40,146	48,745	56,736	54,361	78,352	35,870	48,100	50,846	83,649	58,666	96,026	84,372	99,880	87,388	142,796	170,944	279,681
	800	14,708	20,544	26,841	39,146	47,463	55,152	54,003	77,806	35,395	47,551	50,364	82,553	58,375	95,404	83,971	99,650	87,000	142,098	170,578	279,325
	900	14,422	20,133	26,279	38,043	46,052	53,411	53,601	77,193	34,863	46,935	49,822	81,329	58,048	94,704	83,520	99,391	86,562	141,312	170,165	278,922
	1,000	14,110	19,683	25,664	36,847	44,524	51,530	53,155	76,513	34,277	46,256	49,223	79,982	57,684	93,928	83,017	99,102	86,075	140,437	169,705	278,472
	1,100	13,772	19,197	25,000	35,568	42,894	49,527	52,666	75,768	33,640	45,515	48,568	78,519	57,284	93,077	82,465	98,783	85,540	139,476	169,197	277,975
	1,200	13,412	18,677	24,291	34,219	41,177	47,423	52,136	74,961	32,954	44,716	47,860	76,947	56,849	92,154	81,865	98,436	84,958	138,430	168,642	277,432
	1,300	13,031	18,128	23,540	32,811	39,389	45,238	51,566	74,094	32,223	43,862	47,102	75,275	56,381	91,162	81,217	98,059	84,329	137,302	168,042	276,843
	1,400	12,632	17,552	22,754	31,354	37,544	42,990	50,957	73,168	31,451	42,955	46,296	73,509	55,878	90,102	80,522	97,654	83,655	136,091	167,395	276,208
	1,500	12,217	16,953	21,935	29,862	35,660	40,701	50,311	72,187	30,639	42,000	45,444	71,659	55,343	88,977	79,782	97,221	82,938	134,802	166,703	275,527
	1,600	11,788	16,334	21,088	28,345	33,749	38,388	49,630	71,152	29,793	41,000	44,549	69,733	54,777	87,790	78,999	96,759	82,177	133,436	165,967	274,801
	1,700	11,348	15,699	20,219	26,815	31,828	36,070	48,915	70,067	28,915	39,959	43,614	67,739	54,180	86,544	78,172	96,271	81,375	131,995	165,186	274,031
	1,800	10,899	15,050	19,332	25,283	29,910	33,764	48,168	68,935	28,008	38,879	42,642	65,687	53,554	85,242	77,305	95,755	80,532	130,481	164,362	273,216
	1,900	10,443	14,391	18,430	23,758	28,008	31,487	47,390	67,757	27,077	37,765	41,636	63,585	52,899	83,886	76,398	95,213	79,651	128,898	163,495	272,356
	2,000	9,982	13,725	17,519	22,250	26,134	29,252	46,584	66,538	26,125	36,621	40,599	61,442	52,217	82,481	75,452	94,644	78,731	127,246	162,586	271,453
	2,100	9,520	13,055	16,539	20,768	24,298	27,074	45,752	65,280	25,155	35,450	39,534	59,267	51,509	81,029	74,469	94,050	77,776	125,530	161,636	270,507
	2,200	9,057	12,384	15,440	19,319	22,512	24,964	44,895	63,986	24,166	34,096	38,443	57,068	50,777	79,533	73,452	93,431	76,787	123,752	160,644	269,518
	2,300	8,595	11,715	14,367	17,911	20,783	22,881	44,015	62,659	22,973	32,649	37,331	54,855	50,020	77,998	72,401	92,787	75,764	121,915	159,613	268,486
	2,400	8,136	11,051	13,327	16,522	19,081	21,014	43,114	61,303	21,790	31,204	36,199	52,635	49,242	76,426	71,318	92,120	74,709	120,020	158,543	267,413
	2,500	7,676	10,377	12,295	15,227	17,585	19,366	42,195	59,920	20,622	29,765	35,052	50,416	48,442	74,821	70,204	91,428	73,625	118,072	157,434	266,298
	2,600	7,227	9,738	11,368	14,078	16,258	17,905	41,259	58,514	19,472	28,338	33,891	48,206	47,622	73,186	69,063	90,714	72,513	116,073	156,287	265,142
	2,700	6,817	9,100	10,541	13,054	15,076	16,603	40,308	57,087	18,345	26,927	32,719	46,012	46,784	71,525	67,894	89,977	71,374	114,026	155,104	263,945
	2,800	6,442	8,461	9,802	12,139	14,019	15,439	39,345	55,644	17,244	25,538	31,541	43,840	45,929	69,841	66,700	89,219	70,210	111,934	153,885	262,709
	2,900	6,098	7,888	9,137	11,316	13,069	14,392	38,371	54,186	16,162	24,173	30,338	41,698	45,058	68,137	65,484	88,439	69,023	109,405	152,632	261,433
	3,000	5,781	7,371	8,538	10,574	12,212	13,449	37,388	52,718	15,103	22,838	28,910	39,590	44,172	66,418	64,245	87,639	67,814	106,792	151,344	260,118
	3,100	5,488	6,903	7,996	9,903	11,437	12,595	36,398	51,242	14,144	21,534	27,504	37,523	43,273	64,686	62,987	86,819	66,585	104,155	150,024	258,766
	3,200	5,217	6,478	7,504	9,294	10,733	11,820	35,404	49,760	13,274	20,223	26,124	35,502	42,362	62,944	61,711	85,980	65,338	101,501	148,671	257,376
	3,300	4,965	6,092	7,056	8,739	10,092	11,115	34,406	48,277	12,481	19,016	24,772	33,488	41,440	61,197	60,419	85,122	64,074	98,833	147,287	255,948
	3,400	4,731	5,738	6,647	8,232	9,508	10,471	33,407	46,794	11,758	17,914	23,437	31,547	40,509	59,446	59,112	84,247	62,795	96,157	145,874	254,485
	3,500	4,484	5,415	6,273	7,769	8,972	9,881	32,408	45,315	11,096	16,905	22,117	29,770	39,570	57,695	57,792	83,354	61,503	93,476	144,431	252,985
	3,600	4,238	5,119	5,929	7,343	8,480	9,339	31,412	43,841	10,488	15,979	20,906	28,139	38,625	55,948	56,461	82,444	60,199	90,795	142,960	251,451
	3,700	4,012	4,846	5,613	6,952	8,028	8,841	30,419	42,376	9,929	15,127	19,791	26,639	37,673	54,206	55,121	81,519	58,886	88,120	141,462	249,882
	3,800	3,804	4,594	5,322	6,591	7,611	8,382	29,432	40,922	9,413	14,341	18,763	25,255	36,717	52,473	53,773	80,578	57,563	85,453	139,939	248,280
	3,900	3,611	4,361	5,052	6,257	7,226	7,958	28,452	39,480	8,936	13,615	17,813	23,976	35,758	50,752	52,419	79,623	56,234	82,798	138,390	246,645
	4,000	3,433	4,146	4,803	5,948	6,869		27,481	38,055	8,495	12,943	16,933	22,793	34,797	49,044	51,060	78,655	54,900	80,161	136,817	244,977
RESISTENCIA A FLEXIÓN ϕ _b M _{nx} (kg-m) - ϕ _b =0.95		901	1,095	1,277	1,604	1,904	2,208	2,553	3,497	1,682	2,519	3,113	4,316	3,882	5,403	6,581	8,585	8,762	11,573	18,843	34,308
RESISTENCIA A FLEXIÓN ϕ _b M _{ny} (kg-m) - ϕ _b =0.95		316	438	566	826	979	1,112	1,978	2,811	865	1,246	1,421	2,308	2,220	3,650	3,267	5,451	3,453	5,562	9,759	20,828
RESISTENCIA A CORTE ϕ _v V _{nx} (kg) - ϕ _v =0.95		2,725	3,306	3,847	4,809	5,610	6,252	12,824	18,274	5,614	7,213	8,015	11,061	12,824	18,274	15,629	25,648	15,629	20,198	34,224	59,151
RESISTENCIA A CORTE ϕ _v V _{ny} (kg) - ϕ _v =0.95		8,998	13,325	15,870	20,839	25,648	30,297	20,839	30,297	19,239	25,648	28,854	42,319	28,854	42,319	45,685	45,685	55,704	76,303	90,329	131,286
RESISTENCIA A TENSIÓN ϕ _t T _n (kg) - ϕ _t =0.90		24,194	29,894																		

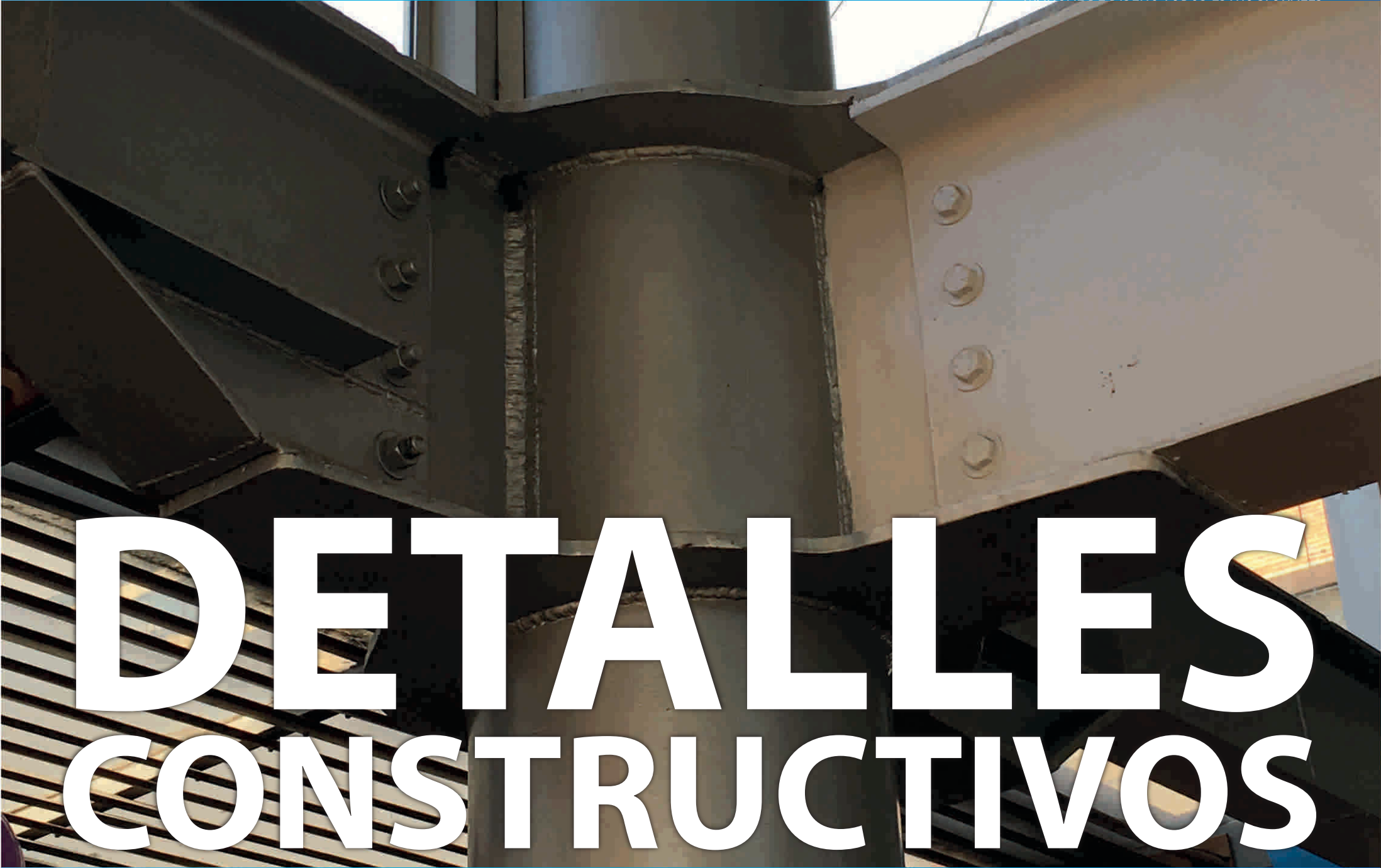


TUBO RECTANGULAR HR ESTRUCTURAL FANALCA
RESISTENCIA A COMPRESIÓN
 $\phi_c P_n$ (kg) donde $\phi_c=0.85$

$F_y=50$ ksi (35.15 kgf/mm²)
 $F_u=65$ ksi (45.69 kgf/mm²)

Dimensión Nominal (mm)		150x50					150x100		160x65	180x65	200x70		200x100		250x100	250x150	300x100		350x150	400x200
ESPESOR (mm)		2.00	2.50	3.00	4.00	5.00	6.00	4.00	6.00	3.40	4.00	4.00	6.00	4.00	6.00	5.00	5.00	7.00	7.00	9.00
PESO (kg/m)		6.07	7.53	8.96	11.73	14.41	16.98	14.87	21.69	11.34	14.45	16.13	23.58	18.01	26.40	26.35	30.11	30.11	41.10	52.42
Longitud Efectiva KL (mm)	4,100	3,267	3,946	4,571	5,661			26,519	36,646	8,086	12,319	16,118	21,694	33,792	47,353	49,698	77,673	53,562	77,544	135,222
	4,200	3,114	3,761	4,356				25,568	35,257	7,705	11,740	15,359	20,674	32,657	45,681	48,110	76,679	52,221	74,951	133,605
	4,300	2,970	3,588					24,630	33,889	7,351	11,200	14,653	19,723	31,534	44,029	46,489	75,673	50,879	72,385	131,967
	4,400							23,705	32,543	7,021	10,697	13,995	18,837	30,425	42,401	44,886	74,656	49,538	69,850	130,310
	4,500							22,795	31,206	6,712	10,227	13,380	18,009	29,331	40,797	43,303	73,629	48,198	67,349	128,634
	4,600							21,901	29,864	6,424	9,787	12,804	17,234	28,252	39,220	41,743	72,592	46,862	64,883	126,941
	4,700							20,986	28,607	6,153	9,375	12,265	16,509	27,191	37,625	40,206	71,546	45,529	62,457	125,231
	4,800							20,120	27,427	5,899	8,988	11,759	15,828	26,127	36,073	38,695	70,493	44,203	60,038	123,506
	4,900							19,307	26,319	5,661	8,625	11,284	15,189	25,072	34,616	37,148	69,432	42,883	57,612	121,767
	5,000							18,543	25,277	5,437	8,284	10,837	14,587	24,079	33,245	35,677	68,364	41,507	55,331	120,014
	5,100							17,823	24,296		7,962	10,417	14,021	23,144	31,954	34,291	67,290	40,200	53,182	118,250
	5,200							17,144	23,370		7,659	10,020	13,487	22,262	30,737	32,985	66,210	38,953	51,156	116,474
	5,300							16,503	22,497		7,372	9,645	12,983	21,430	29,588	31,752	65,126	37,761	49,244	114,688
	5,400							15,897	21,671		7,102	9,291	12,506	20,644	28,502	30,587	64,038	36,399	47,437	112,893
	5,500							15,325	20,890		6,846	8,957	12,056	19,900	27,475	29,485	62,946	35,087	45,728	111,090
	5,600							14,782	20,151			8,640	11,629	19,196	26,503	28,441	61,851	33,845	44,109	109,280
	5,700							14,268	19,450			8,339	11,224	18,528	25,581	27,452	60,754	32,668	42,575	107,463
	5,800							13,780	18,785			8,054		17,895	24,706	26,514	59,656	31,551	41,120	105,642
	5,900							13,317	18,154			7,783		17,293	23,876	25,622	58,556	30,491	39,738	103,816
	6,000							12,877	17,554					16,721	23,087	24,775	57,457	29,483	38,424	101,988
	6,100							12,458	16,983					16,178	22,336	23,970	56,247	28,524	37,175	100,157
	6,200							12,060	16,439					15,660	21,621	23,203	54,966	27,612	35,985	98,180
	6,300							11,680	15,922					15,167	20,940	22,472	53,694	26,742	34,852	95,994
	6,400							11,318	15,428					14,697	20,291	21,775	52,432	25,913	33,771	93,822
	6,500							10,972	14,957					14,248	19,672	21,110	51,180	25,122	32,740	91,667
	6,600													13,819	19,080	20,476	49,939	24,366	31,755	89,529
	6,700													13,410	18,515	19,869	48,710	23,644	30,815	87,409
	6,800													13,018	17,974	19,289	47,494	22,954	29,915	85,308
	6,900													12,644	17,457	18,734	46,291	22,293	29,054	83,228
	7,000													12,285	16,962	18,202	45,101	21,661	28,230	81,170
	7,100													11,942	16,487	17,693	43,899	21,055	27,440	79,134
	7,200													11,612	16,033	17,205	42,688	20,474	26,683	77,121
	7,300													11,296	15,596	16,737	41,527	19,917	25,957	75,028
	7,400													10,993	15,178	16,288	40,412	19,383	25,260	73,014
	7,500													10,702	14,776	15,856	39,342	18,869	24,591	71,080
	7,600													10,422	14,389	15,442	38,313	18,376	23,948	69,222
	7,700													10,153	14,018	15,043	37,324	17,902	23,330	67,435
	7,800													9,894	13,661	14,660	36,373	17,446	22,736	65,717
	7,900													9,645	13,317	14,291	35,458	17,007	22,164	64,064
	8,000													9,406	12,986	13,936	34,578	16,584	21,614	62,473
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		901	1,095	1,277	1,604	1,904	2,208	2,553	3,497	1,682	2,519	3,113	4,316	3,882	5,403	6,581	8,585	8,762	11,573	18,843
RESISTENCIA A FLEXIÓN $\phi_b M_n$ (kg-m) - $\phi_b=0.95$		316	438	566	826	979	1,112	1,978	2,811	865	1,246	1,421	2,308	2,220	3,650	3,267	5,451	3,453	5,562	9,759
RESISTENCIA A CORTE $\phi_v V_n$ (kg) - $\phi_v=0.95$		2,725	3,306	3,847	4,809	5,610	6,252	12,824	18,274	5,614	7,213	8,015	11,061	12,824	18,274	15,629	25,648	15,629	20,198	34,224
RESISTENCIA A CORTE $\phi_v V_n$ (kg) - $\phi_v=0.95$		8,998	13,325	15,870	20,839	25,648	30,297	20,839	30,297	19,239	25,648	28,854	42,319	28,854	42,319	45,685	45,685	55,704	76,303	90,329
RESISTENCIA A TENSION $\phi_t T_n$ (kg) - $\phi_t=0.90$		24,194	29,894	35,454	46,158	56,305	65,894	58,812	84,875	41,954	57,547	63,874	92,467	71,466	103,856	103,757	119,575	119,575	163,504	207,793
Lu (m)		2.55	2.56	2.57	2.60	2.62	2.65	5.09	5.14	3.08	3.34	3.59	3.64	5.09	5.14	5.12	7.61	5.12	5.17	7.66

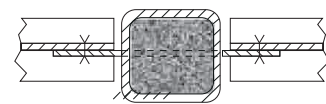
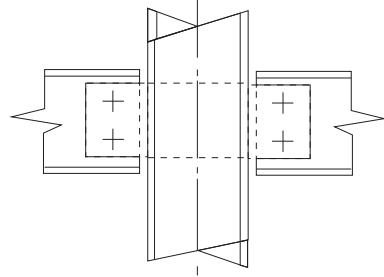
NOTA: Los anteriores valores contemplan cargas con relaciones de esbeltez $KL/r < 200$.
Para encontrar la carga axial con respecto al eje x, se encuentra un longitud equivalente $KL = K_x L_x / (r_x / r_y)$.
 $\phi_c P_{no}$ = Resistencia axial nominal determinada con $F_n = F_y$ (Valor con $KL = 0$)
 L_u = Máxima longitud sin soporte lateral para secciones cerradas tipo cajón, usadas como vigas sujetas a flexión alrededor del eje x-x.



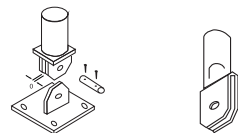
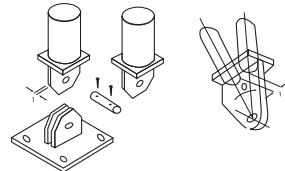
DETALLES CONSTRUCTIVOS



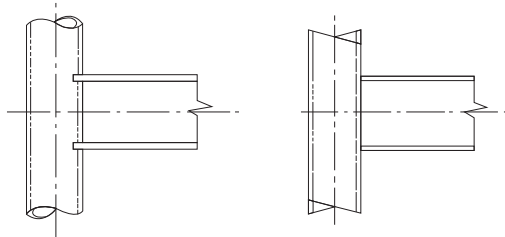
7. DETALLES CONSTRUCTIVOS



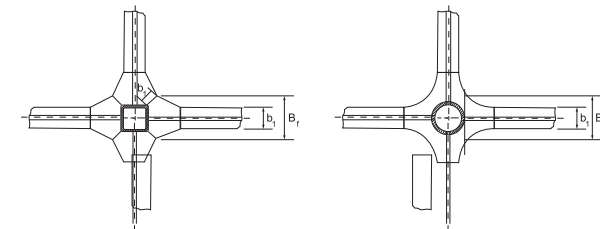
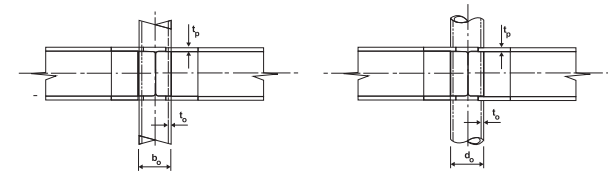
Introducción de carga en perfiles tubulares mediante placas insertadas



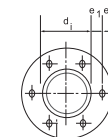
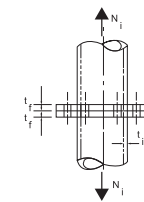
Nudos con piezas aplicadas en los extremos de las barras para uniones atornilladas



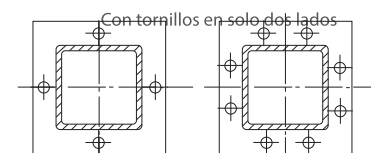
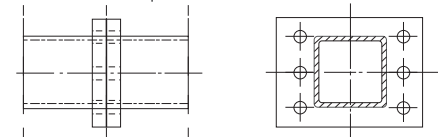
Unión sin rigidizar entre viga de sección en I y columna de perfil CHS o RHS



Diafragma de ala en unión entre columnas de perfiles CHS y RHS y viga con sección en I

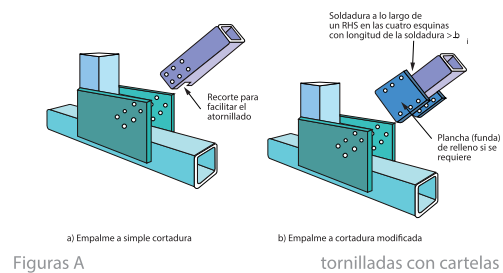


Unión de perfiles CHS con bridas atornilladas

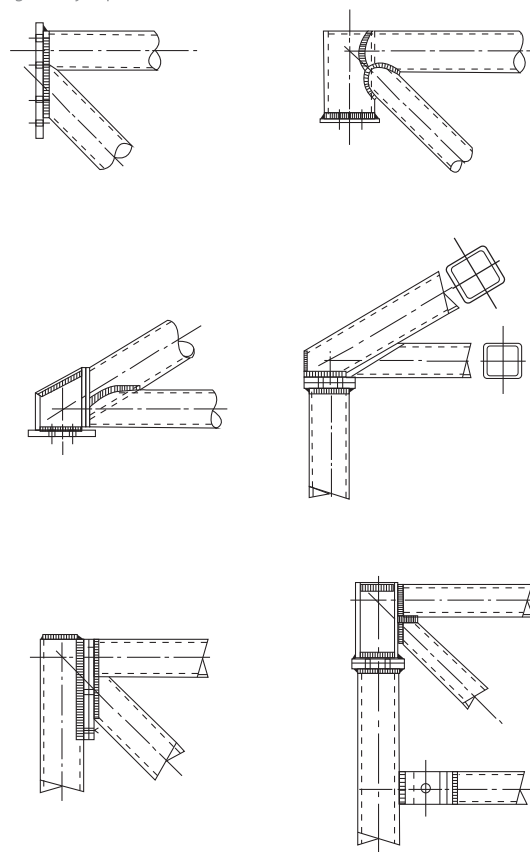


Configuraciones con cuatro y 8 tornillos

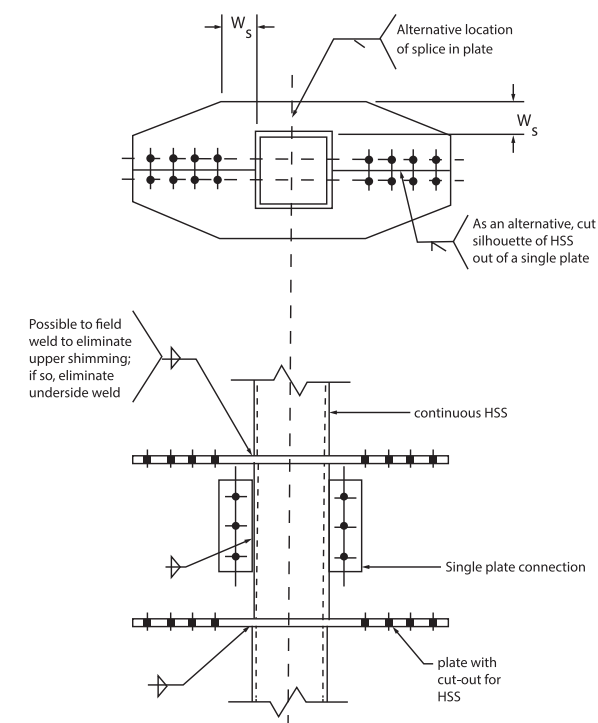
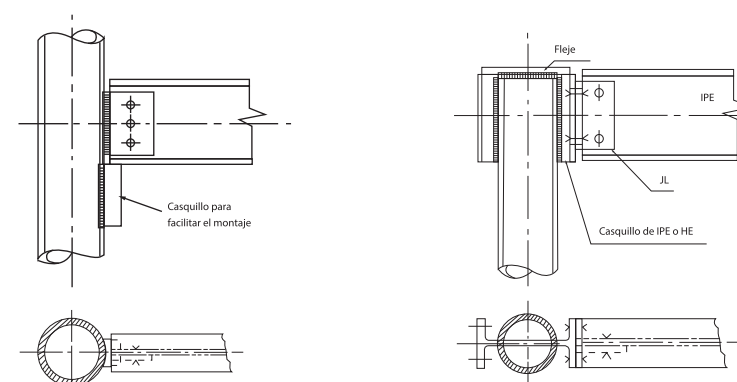
Uniones entre perfiles RHS con bridas atornilladas

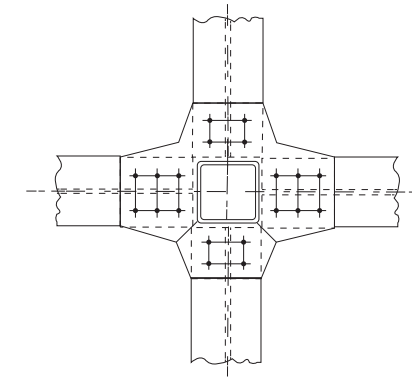
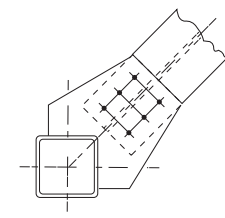
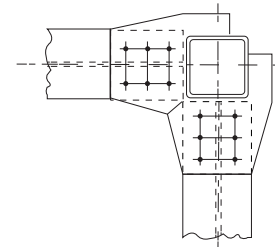
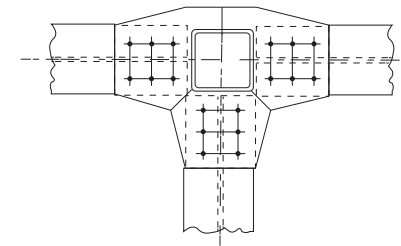
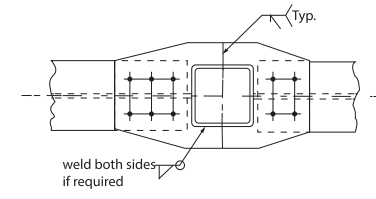
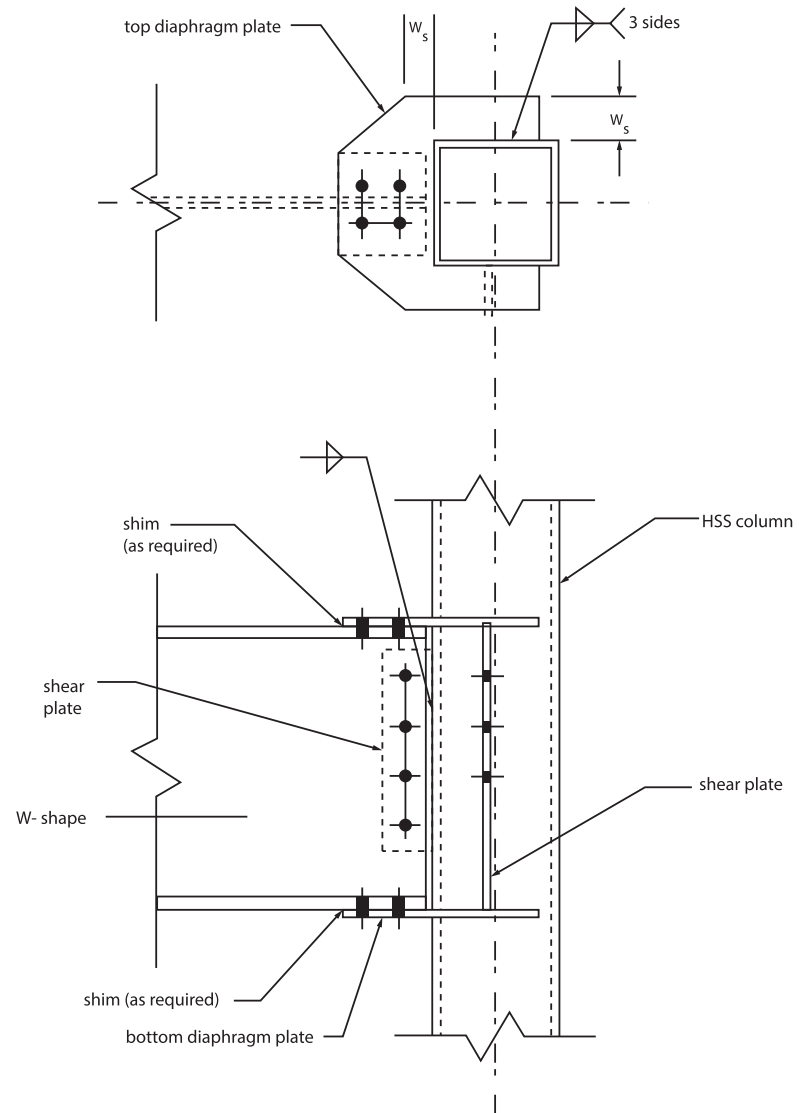


Algunos ejemplos del uniones a



Figuras Uniones atornilladas para apoyos de vigas celosía.







EJEMPLOS DE DISEÑO



8. EJEMPLOS DE DISEÑO

EJEMPLO 1

Diseñar la columna cuadrada más liviana, para soportar una carga P_u mayorada axial concéntrica de 50Ton. La longitud efectiva KL del elemento es de 3.50m.

R/ Revisando las tablas de diseño de resistencia a la compresión, para tubos cuadrados, con KL=3500 mm, se obtienen las siguientes alternativas:

- Tubo cuadrado de 135x135x6.00 mm $\phi_c P_n = 61.20 \text{ Ton} > P_u = 50 \text{ Ton}$ "Cumple"
- Tubo cuadrado de 150x150x4.00 mm $\phi_c P_n = 51.67 \text{ Ton} > P_u = 50 \text{ Ton}$ "Cumple"
- Tubo cuadrado de 150x150x6.00 mm $\phi_c P_n = 73.80 \text{ Ton} > P_u = 50 \text{ Ton}$ "Cumple"
- Tubo cuadrado de 200x200x5.00 mm $\phi_c P_n = 96.94 \text{ Ton} > P_u = 50 \text{ Ton}$ "Cumple"

Seleccionar el Tubo Cuadrado de 150x150x4.00mm (Peso=18.12kg/ml).

EJEMPLO 2

Diseñar una columna rectangular de 200x100 mm, para soportar una carga P_u mayorada axial concéntrica de 35 Ton, si la longitud efectiva, $K_y L_y$, del elemento respecto al eje y es de 4.10 m y la longitud efectiva, $K_x L_x$, respecto al eje x es de 6.50 m.

R/ Revisando las tablas de diseño de resistencia a la compresión, para el tubo rectangular de 200x100 mm se tienen las siguientes alternativas:

Con KL = $K_y L_y$ = 4100mm:

- Tubo rectangular de 200x100x4.00mm $\phi_c P_n = 33.79 \text{ Ton} < P_u = 35 \text{ Ton}$ "No Cumple"
- Tubo rectangular de 200x100x6.00mm $\phi_c P_n = 47.35 \text{ Ton} > P_u = 35 \text{ Ton}$ "Cumple"

Para el eje x se obtiene una longitud equivalente dividiendo KL por la relación entre radios de giro así:

Tubo rectangular 200x100x4.00 mm

$$\frac{r_x}{r_y} = \frac{7.23}{4.23} = 1.71$$

La longitud equivalente KL = $6500/1.71 = 3800 \text{ mm}$

Con KL = $K_x L_x$ = 3800 mm:

- Tubo rectangular de 200x100x4.00mm $\phi_c P_n = 36.71 \text{ Ton} > P_u = 35 \text{ Ton}$ "Cumple"
- Tubo rectangular de 200x100x6.00mm $\phi_c P_n = 52.47 \text{ Ton} > P_u = 35 \text{ Ton}$ "Cumple"

Aunque el Tubo de 200x100x4.00mm cumple respecto al eje x, no cumple respecto al eje y, por tal motivo **seleccionar el tubo rectangular de 200x100x6.00 mm.** (Peso=26.40 kg/m).

EJEMPLO 3

Diseñar una correa de sección rectangular, para soportar una carga viva de 50kg/m² y una carga muerta de 30 kg/m². La longitud de la correa es de 7.50 m y la separación de la misma es de 1.90m. Inicialmente se analizará como primera opción el tubo rectangular 200x100x4.00 mm. Suponer la correa simplemente apoyada.

$$\text{Carga Última } w_u = 1.2D + 1.6L_r$$

$$w_u = 1.2(30 \text{ kg/m}^2) + 1.6(50 \text{ kg/m}^2) = 116 \text{ kg/m}^2$$

$$\text{Carga Última sobre la correa } w_{uc} = w_u \times \text{Separación correa}$$

$$w_{uc} = 116 \frac{\text{kg}}{\text{m}^2} \times 1.90 \text{ m} = 220 \frac{\text{kg}}{\text{m}}$$

$$M_u = \frac{w_{uc} \times l^2}{8}$$

$$M_u = \frac{220 \text{ kg/m} \times (7.50 \text{ m})^2}{8} = 1,547 \text{ kg} \cdot \text{m} < \phi_b M_n = 3,882 \text{ kg} \cdot \text{m} \text{ "Cumple"}$$

$$V_u = \frac{w_{uc} \times l}{2}$$

$$V_u = \frac{220 \text{ kg/m} \times 7.50 \text{ m}}{2} = 825 \text{ kg} < \phi_v V_{ny} = 28,854 \text{ kg} \text{ "Cumple"}$$



REVISIÓN DE DEFLEXIONES

Maxima permitida $\delta \leq L/360 = 7500\text{mm}/360 = 20.8\text{mm}$

$$\delta = \frac{5}{384} \frac{w_{lr} L^4}{EI}$$

$$\delta = \frac{5}{3842.04 \cdot 10^{10} \text{ kg/m}^2 \cdot 1.199 \cdot 10^{-5} \text{ m}^4} \cdot 1.9\text{m} \cdot (7.5\text{m})^4 \cdot 1000 = 16\text{mm} < 20.8\text{mm} \text{ "cumple"}$$

Se puede observar, que aunque la correa está sobre especificada en cuanto a la Flexión y Cortante, no sucede lo mismo cuando se revisan las deflexiones. Si se hace el mismo ejercicio con el Tubo Rectangular de 200x70x4.00mm la deflexión que se obtiene es de 19.8mm, la cual cumple.

Para el Tubo Rectangular de 200x100x4.00mm el Lu es de 5.09m, por tal motivo se debe colocar una riostra intermedia a la correa. En el caso del Tubo Rectangular de 200x70x4.00mm se tiene un Lu de 3.59m, entonces colocar dos riostras intermedias.



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