CONEXIONES

CONECTORES A CORTANTE

DEFINICIÓN

- Elementos de acero
- Contrarrestan los esfuerzos de corte en la losa compuesta
- Reducen las deformaciones
- Impiden la separación vertical entre losa y viga
- Se asumen que todo el cortante considerado en la interfase entre el deck y el hormigón es transferido por los conectores a corte

GENERALIDADES

- El diámetro de los conectores de corte no debe ser mayor a 2,5 veces el espesor del metal base al cual es soldado, a menos que sea soldado a un ala directamente sobre el alma.

- La sección I8.2 aplica para los miembros compuestos en flexión donde los anclajes de acero son embebidos en una losa de concreto solido o en una losa formada sobre una plancha de acero colaborante.

- La sección I8.3 aplica para todos los otros casos.

- La distancia mínima entre el centro de un anclaje a un borde libre en la dirección de la fuerza de corte es de 8 in. (203 mm) si se emplea concreto de peso normal y 10 in (250 mm) si el empleado es concreto de peso liviano. Las se permite el uso de las disposiciones de ACI 318 Anexo D en vez de dichos valores.

GENERALIDADES

- La longitud del conector no debe ser menor a cuatro veces el diámetro medido desde la de la base del conector al extremo del perno después de la instalación

RESISTENCIA NOMINAL

- La resistencia nominal a cortante de un conector se determina por

$$Q_n = 0.5 A_{sa} \sqrt{f'_c E_c} \leq R_g R_p A_{sa} F_u \qquad \text{(I8-1)}$$

where

A_{sa} = cross-sectional area of steel headed stud anchor, in.^{2} (mm^2)

E_c = modulus of elasticity of concrete

$= w_c^{1.5} \sqrt{f'_c}$, ksi $\left(0.043 w_c^{1.5} \sqrt{f'_c}, \text{ MPa}\right)$

F_u = specified minimum tensile strength of a steel headed stud anchor, ksi (MPa)

RESISTENCIA NOMINAL

$$Q_n = 0.5 A_{sa} \sqrt{f'_c E_c} \leq R_g R_p A_{sa} F_u$$

- La resistencia nominal a cortante de un conector se determina por

R_g = 1.0 for:

(a) One steel headed stud anchor welded in a steel deck rib with the deck oriented perpendicular to the steel shape

(b) Any number of steel headed stud anchors welded in a row directly to the steel shape

(c) Any number of steel headed stud anchors welded in a row through steel deck with the deck oriented parallel to the steel shape and the ratio of the average rib width to rib depth ≥ 1.5

= 0.85 for:

(a) Two steel headed stud anchors welded in a steel deck rib with the deck oriented perpendicular to the steel shape

(b) One steel headed stud anchor welded through steel deck with the deck oriented parallel to the steel shape and the ratio of the average rib width to rib depth < 1.5

= 0.7 for three or more steel headed stud anchors welded in a steel deck rib with the deck oriented perpendicular to the steel shape

RESISTENCIA NOMINAL

$$Q_n = 0.5 A_{sa} \sqrt{f'_c E_c} \leq R_g R_p A_{sa} F_u$$

- La resistencia nominal a cortante de un conector se determina por

R_p = 0.75 for:
- (a) Steel headed stud anchors welded directly to the steel shape
- (b) Steel headed stud anchors welded in a composite slab with the deck oriented perpendicular to the beam and $e_{mid\text{-}ht} \geq 2$ in. (50 mm)
- (c) Steel headed stud anchors welded through steel deck, or steel sheet used as girder filler material, and embedded in a composite slab with the deck oriented parallel to the beam

= 0.6 for steel headed stud anchors welded in a composite slab with deck oriented perpendicular to the beam and $e_{mid\text{-}ht} < 2$ in. (50 mm)

$e_{mid\text{-}ht}$ = distance from the edge of steel headed stud anchor shank to the steel deck web, measured at mid-height of the deck rib, and in the load bearing direction of the steel headed stud anchor (in other words, in the direction of maximum moment for a simply supported beam), in. (mm)

User Note: The table below presents values for R_g and R_p for several cases. Available strengths for steel headed stud anchors can be found in the AISC *Steel Construction Manual*.

Condition	R_g	R_p
No decking	1.0	0.75
Decking oriented parallel to the steel shape		
$\frac{w_r}{h_r} \geq 1.5$	1.0	0.75
$\frac{w_r}{h_r} < 1.5$	0.85[a]	0.75
Decking oriented perpendicular to the steel shape		
Number of steel headed stud anchors occupying the same decking rib:		
1	1.0	0.6[b]
2	0.85	0.6[b]
3 or more	0.7	0.6[b]

h_r = nominal rib height, in. (mm)
w_r = average width of concrete rib or haunch (as defined in Section I3.2c), in. (mm)
[a] For a single steel headed stud anchor
[b] This value may be increased to 0.75 when $e_{mid\text{-}ht} \geq 2$ in. (50 mm).

Table 2-6

Applicable ASTM Specifications for Various Types of Structural Fasteners

ASTM Designation		F_y Min. Yield Stress (ksi)	F_u Tensile Stress[a] (ksi)	Diameter Range (in.)	High-Strength Bolts		Common Bolts	Nuts	Washers	Direct-Tension-Indicator Washers	Threaded Rods	Steel Headed Stud Anchors	Anchor Rods		
					Conventional	Twist-Off-Type Tension-Control							Hooked	Headed	Threaded & Nutted
A108		—	65	0.375 to 0.75, Incl.								■			
A325[d]		—	105	over 1 to 1.5, Incl.	■										
		—	120	0.5 to 1, Incl.	■										
A490[d]		—	150	0.5 to 1.5	■										
F1852[d]		—	105	1.125		■									
		—	120	0.5 to 1, Incl.		■									
F2280[d]		—	150	0.5 to 1.125, Incl.		■									
A194 Gr. 2H		—	—	0.25 to 4				▒							
A563		—	—	0.25 to 4				■							
F436[b]		—	—	0.25 to 4					■						
F959		—	—	0.5 to 1.5						■					
A36		36	58-80	to 10							■		▒		▒
A193 Gr. B7[e]		—	100	over 4 to 7							▒		▒		▒
		—	115	over 2.5 to 4							▒		▒		▒
		—	125	2.5 and under							▒		▒		▒
A307 Gr. A		—	60	0.25 to 4			■								
A354 Gr. BD		—	140	2.5 to 4, Incl.							▒		▒	▒	▒
		—	150	0.25 to 2.5, Incl.							▒		▒	▒	▒
A449		—	90	1.75 to 3, Incl.	[c]						▒		▒	▒	▒
		—	105	1.125 to 1.5, Incl.	[c]						▒		▒	▒	▒
		—	120	0.25 to 1, Incl.	[c]						▒		▒	▒	▒
A572	Gr. 42	42	60	to 6							▒		▒		▒
	Gr. 50	50	65	to 4							▒		▒		▒
	Gr. 55	55	70	to 2							▒		▒		▒
	Gr. 60	60	75	to 1.25							▒		▒		▒
	Gr. 65	65	80	to 1.25							▒		▒		▒
A588		42	63	Over 5 to 8, Incl.							▒		▒		▒
		46	67	Over 4 to 5, Incl.							▒		▒		▒
		50	70	4 and under							▒		▒		▒
A687		105	150 max.	0.625 to 3							▒		▒	▒	▒
F1554	Gr. 36	36	58-80	0.25 to 4									■	■	■
	Gr. 55	55	75-95	0.25 to 4									■	■	■
	Gr. 105	105	125-150	0.25 to 3									▒	▒	▒

■ – Preferred material specification

RESISTENCIA DE CONECTORES EN C

- La resistencia nominal de un canal se determina por

$$Q_n = 0.3(t_f + 0.5t_w)l_a\sqrt{f'_c E_c}$$

where

l_a = length of channel anchor, in. (mm)

t_f = thickness of flange of channel anchor, in. (mm)

t_w = thickness of channel anchor web, in. (mm)

- La resistencia del canal es desarrollada al soldar el canal a las alas de la viga para una fuerza igual a Qn, considerando la excentricidad

NÚMERO REQUERIDO DE CONECTORES

- El número de conectores entre la sección de momento flector positivo y negativo y la sección de momento cero debe ser igual a la cortante horizontal:
  - Positivo
  - El menor valor de

(a) Concrete crushing

$$V' = 0.85 f_c' A_c \qquad \text{(I3-1a)}$$

(b) Tensile yielding of the steel section

$$V' = F_y A_s \qquad \text{(I3-1b)}$$

(c) Shear strength of steel headed stud or steel channel anchors

$$V' = \Sigma Q_n \qquad \text{(I3-1c)}$$

where

A_c = area of concrete slab within effective width, in.^{2} (mm^2)
A_s = cross-sectional area of steel section, in.^{2} (mm^2)
ΣQ_n = sum of nominal shear strengths of steel headed stud or steel channel anchors between the point of maximum positive moment and the point of zero moment, kips (N)

NÚMERO REQUERIDO DE CONECTORES

- El número de conectores entre la sección de momento flector positivo y negativo y la sección de momento cero debe ser igual a la cortante horizontal dividido para la resistencia nominal de un conector
  - Negativo
  - El menor valor de

(a) For the limit state of tensile yielding of the slab reinforcement

$$V' = F_{ysr}A_{sr} \qquad \text{(I3-2a)}$$

where

A_{sr} = area of developed longitudinal reinforcing steel within the effective width of the concrete slab, in.^{2} (mm^2)

F_{ysr} = specified minimum yield stress of the reinforcing steel, ksi (MPa)

(b) For the limit state of shear strength of steel headed stud or steel channel anchors

$$V' = \Sigma Q_n \qquad \text{(I3-2b)}$$

DETALLES

- El espaciamiento mínimo de conectores (medido centro a centro) debe ser seis diámetros a lo largo del eje longitudinal de la viga compuesta soportante

- El espaciamiento mínimo de conectores (medido centro a centro) debe ser cuatro diámetros en la dirección transversal, **excepto dentro de los nervios de la plancha colaborante orientadas perpendicularmente a la viga de acero, donde el espaciamiento mínimo debe ser cuatro diámetros en cualquier dirección.**

- La distancia mínima del centro de un conector a un lado libre en dirección de la fuerza cortante debe ser de 200 mm (8 in) si se usa hormigón de peso normal

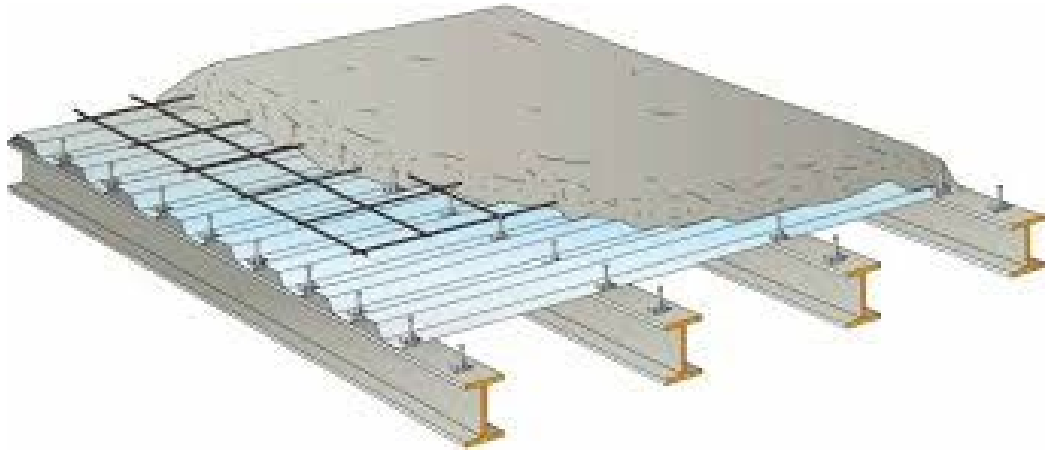
- Si se usa hormigón aligerado la distancia será de 250 mm (10 in)

- Máxima distancia entre centros no debe exceder 8 veces el total del espesor de losa o 36 in (900 mm)

- https://www.youtube.com/watch?v=zgqjZA9k_ms&t=1s
- https://www.youtube.com/watch?v=n8tVnzG-wkQ
- https://www.youtube.com/watch?v=j5NBk2BwG0c

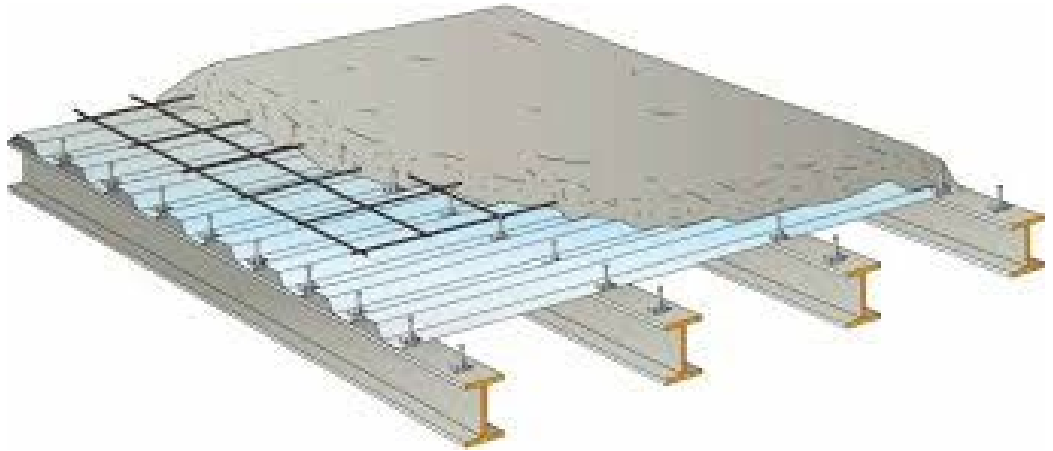
EJEMPLO

- Datos
  - Distancia entre viguetas
  - Longitud de viguetas
  - Altura total de losa
  - Área de viga de soporte (vigueta)



EJEMPLO

- Datos
  - Distancia entre viguetas = 1.15m
  - Longitud de viguetas = 4.5 m
  - Altura total de losa = 12 cm
  - Área de viga de soporte (vigueta) = IPE 200



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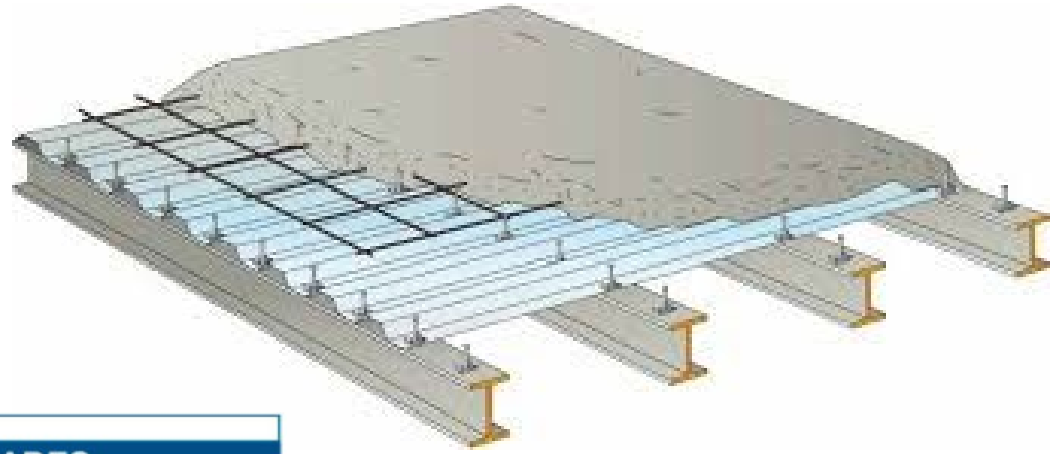
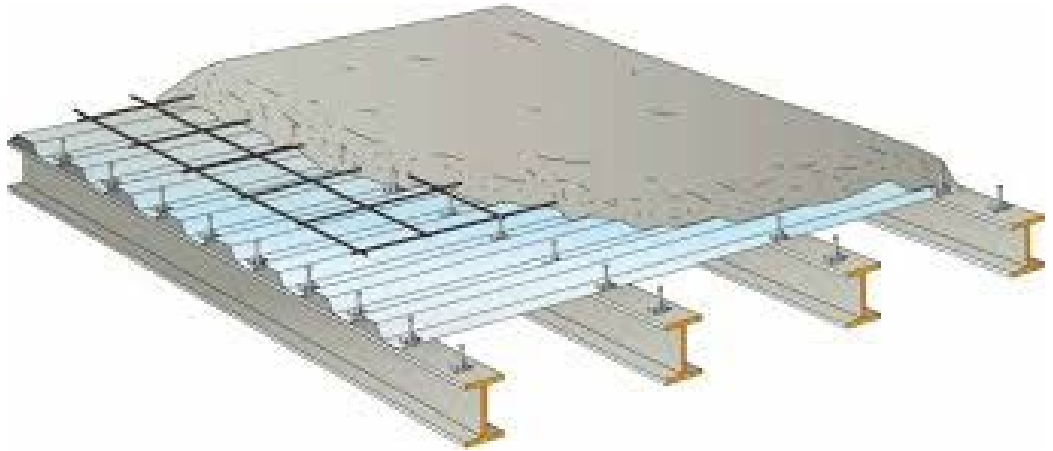


DENOMINACIÓN	DIMENSIONES					PROPIEDADES					
	h	b	t	e	R	ÁREA SECCIÓN	PESOS	INERCIA (cm^4)		MÓDULO RESISTENCIA (cm^3) SECCIÓN	
	mm	mm	mm	mm	mm	cm^2	kg/mts	Eje x-x	Eje y-y	Eje x-x	Eje y-y
IPE 80	80	46	3.80	5.20	5	7.64	6.00	80	8.49	20.00	3.69
IPE 100	100	55	4.10	5.70	5	10.30	8.10	171	15.90	34.20	5.79
IPE 120	120	64	4.40	6.30	5	13.20	10.40	318	27.70	53.00	8.65
IPE 160	160	82	5.00	7.40	7	20.10	15.80	869	68.30	109.00	16.70
IPE 200	200	100	5.60	8.50	9	28.50	22.40	1940	142.00	194.00	28.50
IPE 220	220	110	5.90	9.20	9	33.40	26.20	2770	205.00	252.00	37.30
IPE 240	240	120	6.20	9.80	12	39.10	30.70	3890	284.00	324.00	47.30
IPE 300	300	150	7.10	10.70	15	53.80	42.20	8360	604.00	557.00	80.50
IPE 400	400	180	8.60	13.50	118	84.50	63.30	23130	1320.00	1160.00	146.00
IPE 450	450	190	9.40	14.60	21	98.80	77.70	33740	1680.00	1500.00	176.00
IPE 500	500	200	10.20	16.00	21	116.00	90.70	48200	2140.00	1930.00	214.00

EJEMPLO

- Datos
  - Distancia entre viguetas = 1.15m
  - Longitud de viguetas = 4.5 m
  - Altura total de losa = 12 cm
  - Área de viga de soporte (vigueta) = IPE 200



Considerando que todas las viguetas se encuentran a la misma distancia el ancho cooperante es de 1.15 m

EJEMPLO

(a) Concrete crushing

$$V' = 0.85 f_c' A_c \qquad \text{(I3-1a)}$$

(b) Tensile yielding of the steel section

$$V' = F_y A_s \qquad \text{(I3-1b)}$$

(c) Shear strength of steel headed stud or steel channel anchors

$$V' = \Sigma Q_n \qquad \text{(I3-1c)}$$

where

A_c = area of concrete slab within effective width, in.^{2} (mm^2)
A_s = cross-sectional area of steel section, in.^{2} (mm^2)
ΣQ_n = sum of nominal shear strengths of steel headed stud or steel channel anchors between the point of maximum positive moment and the point of zero moment, kips (N)

- Aplastamiento del hormigón
  - $V = 0.85 \times 210 \times 115 \times 12 = 246330\ kg$
- Tensión máxima
  - $V = 2530 \times 28.5 = 72105$ kg
- Resistencia del conector
  - Asumimos un conector

EJEMPLO

(a) Concrete crushing

$$V' = 0.85 f_c' A_c$$

(b) Tensile yielding of the steel section

$$V' = F_y A_s$$

(c) Shear strength of steel headed stud or steel ch

$$V' = \Sigma Q_n$$

where

A_c = area of concrete slab within effective w
A_s = cross-sectional area of steel section, in.
ΣQ_n = sum of nominal shear strengths of stee anchors between the point of maximum of zero moment, kips (N)

Table 3-21
Shear Stud Anchor
Nominal Horizontal Shear Strength for One Steel Headed Stud Anchor, Q_n, kips

F_u = 65 ksi

Q_n

Deck condition			Stud anchor diameter, in.	Normal weight concrete w_c = 145 pcf		Lightweight concrete w_c = 110 pcf	
				f_c' = 3 ksi	f_c' = 4 ksi	f_c' = 3 ksi	f_c' = 4 ksi
No deck			3/8	5.26	5.38	4.28	5.31
			1/2	9.35	9.57	7.60	9.43
			5/8	14.6	15.0	11.9	14.7
			3/4	21.0	21.5	17.1	21.2
Deck Parallel	$\frac{w_r}{h_r} \geq 1.5$		3/8	5.26	5.38	4.28	5.31
			1/2	9.35	9.57	7.60	9.43
			5/8	14.6	15.0	11.9	14.7
			3/4	21.0	21.5	17.1	21.2
	$\frac{w_r}{h_r} < 1.5$		3/8	4.58	4.58	4.28	4.58
			1/2	8.14	8.14	7.60	8.14
			5/8	12.7	12.7	11.9	12.7
			3/4	18.3	18.3	17.1	18.3
Deck Perpendicular	Weak studs per rib (R_p = 0.60)	1	3/8	4.31	4.31	4.28	4.31
			1/2	7.66	7.66	7.60	7.66
			5/8	12.0	12.0	11.9	12.0
			3/4	17.2	17.2	17.1	17.2
		2	3/8	3.66	3.66	3.66	3.66
			1/2	6.51	6.51	6.51	6.51
			5/8	10.2	10.2	10.2	10.2
			3/4	14.6	14.6	14.6	14.6
		3	3/8	3.02	3.02	3.02	3.02
			1/2	5.36	5.36	5.36	5.36
			5/8	8.38	8.38	8.38	8.38
			3/4	12.1	12.1	12.1	12.1
	Strong studs per rib (R_p = 0.75)	1	3/8	5.26	5.38	4.28	5.31
			1/2	9.35	9.57	7.60	9.43
			5/8	14.6	15.0	11.9	14.7
			3/4	21.0	21.5	17.1	21.2
		2	3/8	4.58	4.58	4.28	4.58
			1/2	8.14	8.14	7.60	8.14
			5/8	12.7	12.7	11.9	12.7
			3/4	18.3	18.3	17.1	18.3
		3	3/8	3.77	3.77	3.77	3.77
			1/2	6.70	6.70	6.70	6.70
			5/8	10.5	10.5	10.5	10.5
			3/4	15.1	15.1	15.1	15.1

Note:
Tabulated values are applicable only to concrete made with ASTM C33 aggregates for normal weight concrete and ASTM C330 aggregates for lightweight concrete.
After-weld steel headed stud anchor lengths assumed to be ≥ Deck height + 1.5 in.

hormigón
$15 \times 12 = 246330\ kg$

72105 kg

ector
ctor

EJEMPLO

(a) Concrete crushing

$$V' = 0.85 f_c' A_c$$

(b) Tensile yielding of the steel section

$$V' = F_y A_s$$

(c) Shear strength of steel headed stud or steel ch

$$V' = \Sigma Q_n$$

where

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				f_c' = 3 ksi	f_c' = 4 ksi	f_c' = 3 ksi	f_c' = 4 ksi
No deck			3/8	5.26	5.38	4.28	5.31
			1/2	9.35	9.57	7.60	9.43
			5/8	14.6	15.0	11.9	14.7
			3/4	21.0	21.5	17.1	21.2
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			1/2	9.35	9.57	7.60	9.43
			5/8	14.6	15.0	11.9	14.7
			3/4	21.0	21.5	17.1	21.2
	$\frac{w_r}{h_r} < 1.5$		3/8	4.58	4.58	4.28	4.58
			1/2	8.14	8.14	7.60	8.14
			5/8	12.7	12.7	11.9	12.7
			3/4	18.3	18.3	17.1	18.3
Deck Perpendicular	Weak studs per rib (R_p = 0.60)	1	3/8	4.31	4.31	4.28	4.31
			1/2	7.66	7.66	7.60	7.66
			5/8	12.0	12.0	11.9	12.0
			3/4	17.2	17.2	17.1	17.2
		2	3/8	3.66	3.66	3.66	3.66
			1/2	6.51	6.51	6.51	6.51
			5/8	10.2	10.2	10.2	10.2
			3/4	14.6	14.6	14.6	14.6
		3	3/8	3.02	3.02	3.02	3.02
			1/2	5.36	5.36	5.36	5.36
			5/8	8.38	8.38	8.38	8.38
			3/4	12.1	12.1	12.1	12.1
	Strong studs per rib (R_p = 0.75)	1	3/8	5.26	5.38	4.28	5.31
			1/2	9.35	9.57	7.60	9.43
			5/8	14.6	15.0	11.9	14.7
			3/4	21.0	21.5	17.1	21.2
		2	3/8	4.58	4.58	4.28	4.58
			1/2	8.14	8.14	7.60	8.14
			5/8	12.7	12.7	11.9	12.7
			3/4	18.3	18.3	17.1	18.3
		3	3/8	3.77	3.77	3.77	3.77
			1/2	6.70	6.70	6.70	6.70
			5/8	10.5	10.5	10.5	10.5
			3/4	15.1	15.1	15.1	15.1

Note:
Tabulated values are applicable only to concrete made with ASTM C33 aggregates for normal weight concrete and ASTM C330 aggregates for lightweight concrete.
After-weld steel headed stud anchor lengths assumed to be ≥ Deck height + 1.5 in.

hormigón
$15 \times 12 = 246330\ kg$

72105 kg

ector
ctor

EJEMPLO

(a) Concrete crushing

$$V' = 0.85 f_c' A_c \qquad \text{(I3-1a)}$$

(b) Tensile yielding of the steel section

$$V' = F_y A_s \qquad \text{(I3-1b)}$$

(c) Shear strength of steel headed stud or steel channel anchors

$$V' = \Sigma Q_n \qquad \text{(I3-1c)}$$

where

A_c = area of concrete slab within effective width, in.^{2} (mm^2)
A_s = cross-sectional area of steel section, in.^{2} (mm^2)
ΣQ_n = sum of nominal shear strengths of steel headed stud or steel channel anchors between the point of maximum positive moment and the point of zero moment, kips (N)

- Aplastamiento del hormigón
  - $V = 0.85 \times 210 \times 115 \times 12 = 246330\ kg$
- Tensión máxima
  - $V = 2530 \times 28.5 = 72105$ kg
- Resistencia del conector
  - Asumimos un conector
  - $Qn = 5.26\ kips = 2385.9\ kg$

EJEMPLO

(a) Concrete crushing

$$V' = 0.85 f_c' A_c \qquad \text{(I3-1a)}$$

(b) Tensile yielding of the steel section

$$V' = F_y A_s \qquad \text{(I3-1b)}$$

(c) Shear strength of steel headed stud or steel channel anchors

$$V' = \Sigma Q_n \qquad \text{(I3-1c)}$$

where

A_c = area of concrete slab within effective width, in.^{2} (mm^2)
A_s = cross-sectional area of steel section, in.^{2} (mm^2)
ΣQ_n = sum of nominal shear strengths of steel headed stud or steel channel anchors between the point of maximum positive moment and the point of zero moment, kips (N)

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  - $V = 0.85 \times 210 \times 115 \times 12 = 246330\ kg$
  - $\frac{246330}{2385.9} = 103.24$
- Tensión máxima
  - $V = 2530 \times 28.5 = 72105$ kg
  - $\frac{72105}{2385.9} = 30.22$
- Escogemos el menor valor

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- Se consideran 31 conectores
- Determinamos el espaciamiento
- $S = \frac{4.5}{31} = 0.14\ m = 14cm$
- Distancia máxima
- $8 \times t = 8 \times 12cm = 96cm = 960mm\ -$ $consideramos\ 900\ mm\ de\ acuerdo\ a\ la\ normativa$
- Distancia mínima
- $4 \times diámetro = 4 \times \frac{3}{8} \times 2.54cm = 3.81\ cm$
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  - Se coloca un conector en cada rib/valle