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UCAN

SZ HEAVY LOAD EXPANSION ANCHOR

REQUEST FOR APPROVAL

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☐ FASTENER SUBSTITUTION ☐ FASTENER RECOMMENDATION ☐ ALTERNATIVE FASTENER

Please review the attached technical data and approve the **SZ HEAVY LOAD EXPANSION ANCHOR** (Part No. TYPE HERE) for the following application(S) below:

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PROJECT:

NAME: TYPE HERE

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SPECIFIED FASTENER: TYPE HERE

FASTENING APPLICATION: TYPE HERE

LOCATION: TYPE HERE DWG NO.: TYPE HERE

SPECIFICATION REF: SECTION: TYPE HERE PAGE: TYPE # PARAGRAPH: TYPE HERE

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DATE:

FOR USE BY THE ENGINEER OR/AND ARCHITECT

☐ APPROVED

☐ APPROVED AS NOTED

☐ ADDITIONAL INFORMATION REQUIRED

☐ REJECTED, REASON FOR REJECTION:

TYPE HERE

BY: TYPE HERE

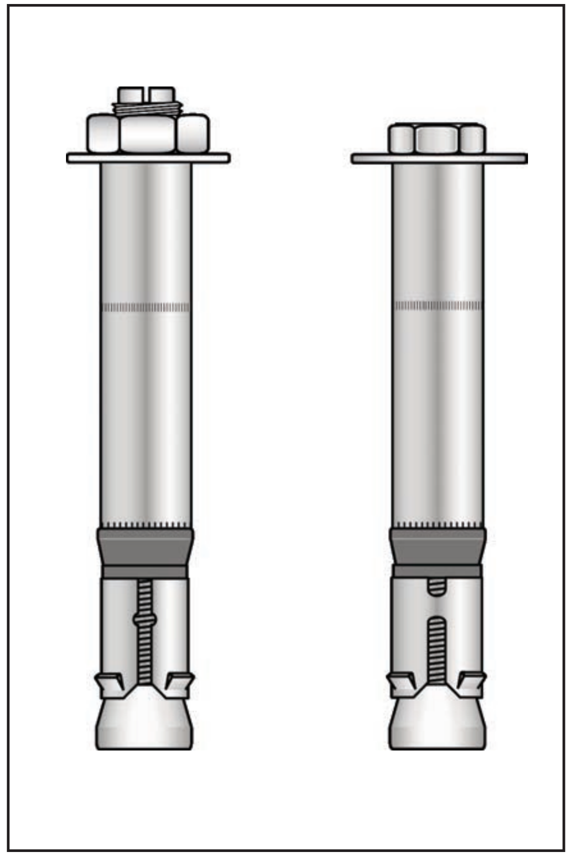
DATE:

PRINT SAVE

SZ HEAVY LOAD EXPANSION ANCHOR

DESCRIPTION

UCAN SZ Heavy Load Anchors are mechanical anchors with controlled expansion that deliver exceptionally high tension and shear loads. Available in both zinc plated Grade 8.8 carbon steel & Grade 316 stainless steel, heavy load anchors are ideal for applications requiring a high degree of security and reliability. UCAN SZ heavy load anchors are offered in a choice of 3 head styles, finished hex bolt, hex nut and countersunk. The size range is now expanded to include M24.



FEATURES

- ICC-ES® Listed ESR-3304
- ACI 318 category 1 anchor for cracked or uncracked concrete
- Superior fastening for dynamic and static loads
- Torque controlled expansion, High shear load, Through fastening
- Collapsible collar provides reliable pull-down force
- Expanded size range – now includes M24
- Available in Stainless Steel & Galvanized finish to order
- Offered in three different head styles - hex bolt, stud + hex nut & countersunk

TYPICAL APPLICATIONS

High load capacity, safety-relevant or dynamic applications including
- Road and bridge construction
- Medical equipment installation
- Heavy machinery and robotics installation
- Structural steel columns and frame
- Dynamic and seismic loading applications
- Parking structure rehabilitation
- Cantilevers, cranes, car hoists
- Heavy pipe supports, pumps

LIMITATIONS

- Not recommended for uncured concrete (less than 7 days old), lightweight concrete, masonry block or brick.
- Concrete compressive strength range:
  2,500 Psi (17.2 MPa) 8,500 Psi (58.6 MPa)

LISTING AND APPROVALS

ICC-ES® - ESR 3304

- ACI 318 category 1 anchor for cracked or uncracked concrete

COMPLIANCE WITH THE FOLLOWING CODES

- 2012, 2009, 2006 International Building Code® (IBC)
- 2012, 2009, 2006 International Residential Code® (IRC)

LEED® COMPLIANCE

MRc4 - 25% Recycled Materials

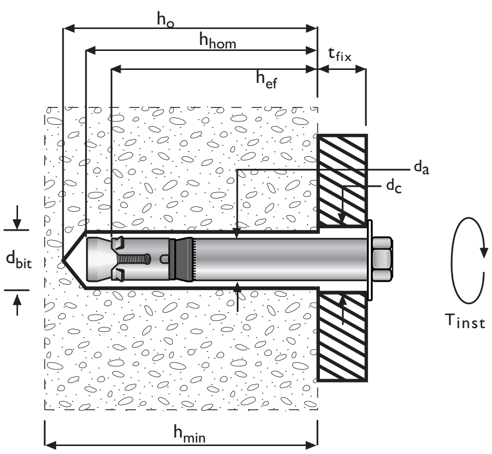
SZ HEAVY LOAD EXPANSION ANCHOR

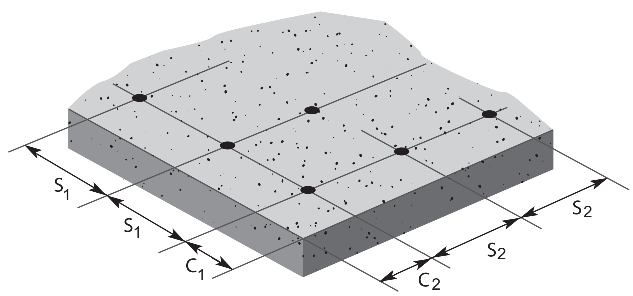
MATERIAL SPECIFICATIONS

Anchor Component	Material Standard	Mechanical Properties F_u	F_y
Carbon steel hex-head bolt	Class 8.8; EN ISO 891-1	800 MPa (116 ksi)	640 MPa (93 ksi)
Carbon steel threaded stud	Class 8.8; EN ISO 891-1	800 MPa (116 ksi)	640 MPa (93 ksi)
Collapsible collar	-	Polyethylene	
Corrosion protection	DIN ISO 4042	≤5μm, zinc plated	
Stainless steel (A4) hex bolt, distance and expansion sleeve cone, washer (EN 10088)	Class 70; EN10088 1.4401/ 1.4404 / 1.4571	700 MPa (101.5 ksi)	450 MPa (65.3 ksi)
Stainless steel hex nut (A4)	Class 70; ISO 3506		

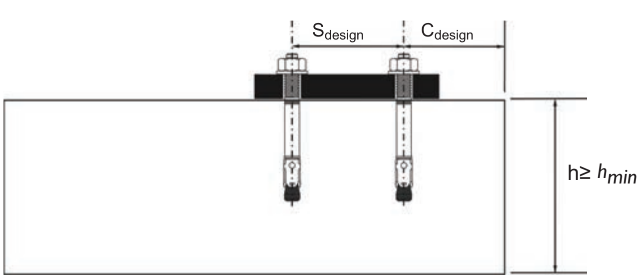
ANCHOR INSTALATION

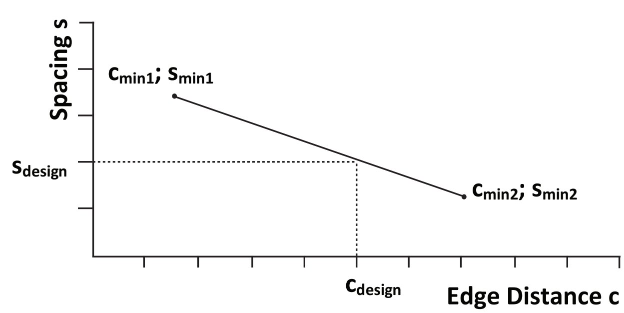
• INSTALLATION DETAILS



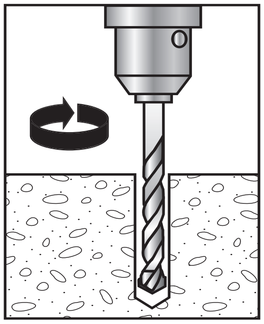


• EXAMPLE OF ALLOWABLE INTERPOLATION OF MINIMUM EDGE DISTANCE AND MINIMUM SPACING

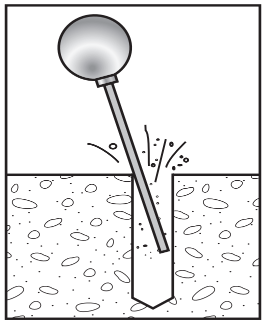




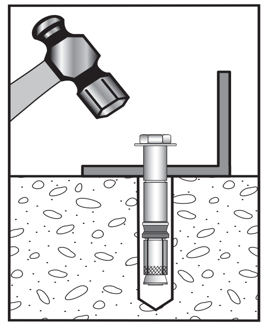
• INSTALLATION INSTRUCTION



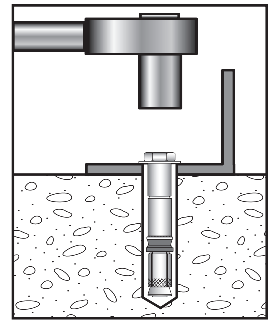
1) Select the correct diameter metric drill bit, drill hole to minimum required hole depth or deeper.



2) Remove drilling debris with a blowout bulb, compressed air or vacuum



3) Using a hammer, tap the anchor through the part being fastened into the drilled hole until the washer is in contact with the fastened part. Do not expand anchor by hand prior to installation.



4) Using a torque wrench, apply the specified installation to the anchor.

TABLE 1A - SZ CARBON STEEL INSTALLATION INFORMATION[1]

Setting Information	Symbol	Units	Nominal Anchor Diameter					
			M8	M10	M12	M16	M20	M24
Anchor Outside diameter	*da* (d_o)[5]	in. (mm)	0.45 (11.5)	0.57 (14.5)	0.69 (17.5)	0.93 (23.5)	1.08 (27.5)	1.26 (32)
Drill Bit Diameter	d_{bit}	mm	12	15	18	24	28	32
Minimum Hole Depth	h_0	in. (mm)	3.15 (80)	3.74 (95)	4.13 (105)	5.12 (130)	6.3 (160)	7.08 (180)
Minimum Base Plate Clearance Hole Dia.[2]	d_c	in. (mm)	0.55 (14)	0.67 (17)	0.79 (20)	1.20 (26)	1.22 (31)	1.38 (35)
Installation torque (Carbon Steel)	T_{inst}	ft-lbf (N-m)	22.1 (30)	36.8 (50)	59 (80)	118 (160)	207 (280)	207 (280)
Embedment Depth	h_{nom}	in. (mm)	2.72 (69)	3.25 (82.5)	3.72 (94.5)	4.65 (118)	5.83 (148)	6.65 (169)
Effective Embedment depth	h_{ef}	in. (mm)	2.4 (60)	2.8 (70)	3.1 (80)	3.94 (100)	4.92 (125)	5.92 (150)
Minimum Edge Distance	C_{min1}	in. (mm)	2.4 (60)	2.8 (70)	3.5 (90)	4.7 (120)	7.1 (180)	5.9 (150)
Minimum Spacing[3]	S_{min1}	in. (mm)	4.9 (125)	6.9 (175)	7.9 (200)	12.6 (320)	21.3 (540)	11.8 (300)
Minimum Edge Distance	C_{min2}	in. (mm)	3.9 (100)	5.1 (130)	6.3 (160)	7.1 (180)	11.8 (300)	11.8 (300)
Minimum Spacing[4]	S_{min2}	in. (mm)	2.4 (60)	2.8 (70)	3.1 (80)	3.9 (100)	4.9 (125)	5.9 (150)
Minimum Concrete Thickness	h_{min}	in. (mm)	4.7 (120)	5.5 (140)	6.3 (160)	7.9 (200)	9.8 (250)	11.8 (300)

For SI: 1 inch = 25.4 mm, 1ft-lbf = 1.356 N-m.
[1]The information presented in this table must be used in conjunction with the design requirements of ACI 318 Appendix D, or CSA A23.3-19 Annex D
[2]The clearance must comply with applicable code requirements for the connected element.
[3]S_{min1} applies when C_{min1} is provided.
[4]S_{min2} applies when C_{min2} is provided.
[5]The notation in parenthesis is for 2006 IBC

SZ HEAVY LOAD EXPANSION ANCHOR

CARBON STEEL SELECTION

Part Number		Bolt/Stud	Drill Bit/ Anchor	Anchor Length		Maximum Fixture	Box
SHL	BHL	diameter	diameter	SHL/SHS	BHL/BHS	Thickness	Quantity
		mm	mm	mm	mm	mm	
SHL600	BHL600	6	10	65	67	0	100
SHL610	BHL610			75	77	10	50
SHL630	BHL630			95	97	30	50
SHL650	BHL650			115	117	50	25
_	BHL6100			_	167	100	25
SHL800	BHL800	8	12	77	80	0	50
SHL810	BHL810			87	90	10	50
SHL830	BHL830			107	110	30	50
SHL850	BHL850			127	130	50	25
_	BHL8100			_	180	100	25
SHL1000	BHL1000	10	15	93	96	0	25
SHL1015	BHL1015			108	111	15	25
SHL1025	BHL1025			118	121	25	25
SHL1045	BHL1045			138	141	45	25
SHL1095	BHL1095			188	191	95	25
SHL1200	BHL1200	12	18	107	112	0	20
SHL1210	BHL1210			117	122	10	20
SHL1220	BHL1220			127	132	20	20
SHL1240	BHL1240			147	152	40	20
SHL1270	BHL1270			177	182	70	20
_	BHL12100			_	212	100	10
SHL1600	BHL1600	16	24	132	137	0	10
SHL1620	BHL1620			152	157	20	10
SHL1650	BHL1650			182	187	50	10
_	BHL16100			_	237	100	5
SHL2010	BHL2010	20	28	152	161	0	10
SHL2030	BHL2030			192	201	30	10
SHL2060	BHL2060			222	231	60	5
SHL20100	BHL20100			262	271	100	5
SHL2410	BHL2410	24	32	212	217	10	5
SHL2430	BHL2430			232	237	10	5
SHL2460	BHL2460			262	267	10	5

TABLE 1B - SZ STAINLESS STEEL INSTALLATION INFORMATION[1]

Setting Information	Symbol		Units	Nominal Anchor Diameter			
				M8	M10	M12	M16
Anchor Outside diameter	da (d_o)		in. (mm)	0.45 (11.5)	0.57 (14.5)	0.69 (17.5)	0.93 (23.5)
Drill Bit Diameter	d_{bit}		(mm)	12	15	18	24
Minimum Hole Depth	h_0		in. (mm)	3.15 (80)	3.74 (95)	4.13 (105)	5.12 (130)
Minimum Base Plate Clearance Hole Diameter[2]	d_c		in. (mm)	0.55 (14)	0.67 (17)	0.79 (20)	1.20 (26)
Installation torque (Stainless Steel)	T_{inst}	SHS	ft-lbf (N-m)	22.1 (30)	36.8 (50)	59 (80)	125 (170)
		BHS		25.8 (35)	40.5 (55)	66.3 (90)	125 (170)
Embedment Depth	h_{nom}		in. (mm)	2.72 (69)	3.25 (82.5)	3.72 (94.5)	4.67 (118.5)
Effective Embedment depth	h_{ef}		in. (mm)	2.4 (60)	2.8 (70)	3.1 (80)	3.9 (100)
Minimum Edge Distance	C_{min1}		in. (mm)	2.9 (75)	3.3 (85)	3.9 (100)	7.1 (180)
Minimum Spacing[3]	S_{min1}		in. (mm)	5.3 (135)	7.2 (185)	8.3 (210)	7.1 (180)
Minimum Edge Distance	C_{min2}		in. (mm)	3.9 (100)	5.5 (140)	6.7 (170)	7.1 (180)
Minimum Spacing[4]	S_{min2}		in. (mm)	2.8 (70)	3.3 (85)	3.9 (100)	7.1 (180)
Minimum Concrete Thickness	h_{min}		in. (mm)	4.7 (120)	5.5 (140)	6.3 (160)	7.8 (200)

For SI: 1 inch = 25.4 mm, 1ft-lbf = 1.356 N-m.
[1]The information presented in this table must be used in conjunction with the design requirements of ACI 318 Appendix D, or CSA A23.3-19 Annex D
[2]The clearance must comply with applicable code requirements for the connected element.
[3]S_{min1} applies when C_{min1} is provided.
[4]S_{min2} applies when C_{min2} is provided.

STAINLESS STEEL SELECTION

Part Number		Bolt/Stud	Drill Bit/ Anchor	Anchor Length		Maximum Fixture	Box
SHS	BHS	diameter	diameter	SHL/SHS	BHL/BHS	Thickness	Quantity
		mm	mm	mm	mm	mm	
SHS830	BHS830	8	10	105	109	30	50
SHS850	BHS850			125	129	50	25
SHS1025	BHS1025	10	15	116	120	25	25
SHS1045	BHS1045			136	140	45	25
SHS1220	BHS1220	12	18	128	131	20	20
SHS1240	BHS1240			148	151	40	25
SHS1620	BHS1620	16	24	150	157	20	10
SHS1650	BHS1650			180	187	50	10

[1]Stainless steel sizes are in limited stock or special order
[2]Other lengths, sizes countersunk type anchors and custom assemblies are special order items.

SZ HEAVY LOAD EXPANSION ANCHOR

TECHNICAL DATA (LIMIT STATE DESIGN / STRENGTH DESIGN) IN CRACKED AND UNCRACKED CONCRETE

TABLE 2A - SZ CARBON STEEL CHARACTERISTIC TENSION STRENGTH DESIGN DATA[1]

Characteristic	Symbol	Units	Nominal anchor diameter					
			M8	M10	M12	M16	M20	M24
Anchor Category	1,2 or 3	-	3	1	1	1	1	1
Embedment Depth	h_{nom}	in. (mm)	2.76 (70)	3.31 (84)	3.74 (95)	4.65 (118)	5.83 (148)	6.65 (169)
Steel Strength in Tension								
Specified Yield Strength	f_{ya}	psi (N/mm^2)	92,888 640	92,888 640	92,888 640	92,888 640	92,888 640	92,888 640
Specified Tensile Strength	f_{uta}	psi (N/mm^2)	116,110 800	116,110 800	116,110 800	116,110 800	116,110 800	116,110 800
Effective Tensile Stress Area	A_{se}	in^2 (mm^2)	0.06 (36.6)	0.09 (58)	0.13 (84.3)	0.24 (156.7)	0.38 (244.8)	0.55 (352.8)
Tension Resistance of Steel	N_{sa}	lbf (kN)	6,580 29.3	10,427 46.4	15,155 67.4	28,171 125.4	44,009 195.8	63,486 282.4
Strength Reduction Factor-Steel Failure[2,9]	$Ø_{sa}$	-	0.65	0.65	0.65	0.65	0.65	0.65
Concrete Breakout Strength in Tension								
Effective Embedment Depth	h_{ef}	in. (mm)	2.4 (60)	2.8 (71)	3.1 (80)	3.94 (100)	4.92 (125)	5.92 (150)
Critical Edge Distance	C_{ac}	in. (mm)	5.2 (132)	7.0 (178)	6.3 (160)	9.1 (230)	11.3 (288)	12.2 (310)
Effectiveness Factor-Uncracked Concrete	k_{uncr}	-	24 (10)	24 (10)	24 (10)	27 (11.3)	27 (11.3)	27 (11.3)
Effectiveness Factor-Cracked Concrete	k_{cr}	-	17 (7.1)	17 (7.1)	21 (8.8)	21 (8.8)	21 (8.8)	24 (10)
Modification Factor[8,9]	$\Psi_{c,N}$	-	1.0	1.0	1.0	1.0	1.0	1.0
Strength Reduction Factor-Concrete Breakout Failure[3,9]	$Ø_{cb}$	-	0.65	0.65	0.65	0.65	0.65	0.65
Pull-Out Strength in Tension								
Pull-Out Resistance Cracked Concrete (f'_c=2,500 psi)[5]	$N_{pn,cr}$	lbf (kN)	2,911 (12.9)	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]
Pull-Out Resistance Uncracked Concrete (f'_c=2,500 psi)[5]	$N_{pn,uncr}$	lbf (kN)	3,887 (17.3)	4,734 (21.1)	6,149 (27.4)	N/A[4]	N/A[4]	N/A[4]
Strength Reduction Factor-Pullout Failure[6,9]	Φ_p	-	0.65	0.65	0.65	0.65	0.65	0.65
Tension Strength for Seismic Applications								
Tension Resistance of Single Anchor for Seismic Loads (f'_c=2,500 psi)[5]	$N_{np,eq}$	lbf (kN)	2,911 (12.9)	N/A[4]	N/A[4]	N/A[4]	N/A[4]	16,748 (74.5)
Strength Reduction Factor-Pullout Failure[6,8]	Φ_{eq}	-	0.65	0.65	0.65	0.65	0.65	0.65
Axial Stiffness in Service Load Range, Cracked Concrete[7]	$ß_{cr}$	lb/in. (kN/mm)	145,923 25.6	229,946 40.3	143,155 25.1	57,102 10	142,754 25	217,714 (38.1)
Axial Stiffness in Service Load Range, Uncracked Concrete[7]	$ß_{uncr}$	lb/in. (kN/mm)	386,670 67.7	455,987 80.0	483,412 84.7	114,203 20	485,364 85	1,056,000 184.8

For **SI:** 1 inch = 25.4mm, 1 lbf = 0.00445kN, 1 lb/in = 0.175 N/mm, 1 psi = 0.00689 N/mm^2, 1 in^2 = 645 mm^2

[1] The information presented in this table must be used in conjunction with the design requirements of ACI 318 Appendix D, or CSA A23.3 - 19 Annex D.

[2] The tabulated value of Φ_{sa} applies when the load combinations of Section 1605.2 of the IBC or ACI 318 9.2 are used. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ_{sa} must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 and -05 D.4.5). The M16 and M20 diameter anchors are brittle steel elements as defined in ACI 318 D.1.

[3] The tabulated value of Φ_{cb} applies when both the load combinations of Section 1605.2 of the IBC, or ACI 318 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c))for Condition B are satisfied. For installations where complying supplementary reinforcement can be verified, the Φ_{cb} factors described in ACI 318-11 D.4.3 (ACI 318-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ_{cb} must be determined in accordance with ACI 318 D.4.4.(ACI 318-11 D.4.4 (ACI 318-08 and -05 D.4.5

[4] As described in Section 4.1.3 of ESR-3304, N/A (Not Applicable) denotes that pullout resistance is not critical and does not need to be considered.

[5] For all design cases $\Psi_{c,N}$ = 1.0. The appropriate effectiveness factor for cracked concrete (K_{cr}) or uncracked concrete (K_{uncr}) must be used.

[6] The tabulated value of Φ_p or Φ_{eq} applies when both the load combinations of Section 1605.2 of the IBC, or ACI 318 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. Condition B applies where supplementary reinforcement is not provided or where pullout strength governs. For installations where complying supplementary reinforcement can be verified, the Φ factors described in ACI 318-11 D.4.3 (ACI 318-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 D.4.4 and -05 D.4.5).

[7] Minimum axial stiffness value. Actual stiffness may vary depending on the concrete strength, loading and geometry of the application.

[8] For all design cases $\Psi_{c,N}$ = 1.0. The appropriate effectiveness factor for cracked concrete (K_{cr}) or uncracked concrete (K_{uncr}) must be used.

[9] For limit State Design as per CSA A23.3-19 Annex D, material resistance factors (Φ) and resistance modification factor (R) listed in Table 4 shall be used.

TABLE 2B - SZ STAINLESS STEEL CHARACTERISTIC TENSION STRENGTH DESIGN DATA[1]

Characteristic	Symbol		Units	Nominal anchor diameter			
				M8	M10	M12	M16
Anchor Category	1,2 or 3		-	1	1	1	1
Embedment Depth	h_{nom}		in. (mm)	2.72 (69)	3.25 (82.5)	3.72 (94.5)	4.67 (118.5)
Steel Strength in Tension							
Specified Yield Strength	f_{ya}	SHS	psi (N/mm²)	65,312 (450)	65,312 (450)	65,312 (450)	65,312 (450)
		BHS		81,277 (560)	81,277 (560)	81,277 (560)	81,277 (560)
Specified Tensile Strength	f_{uta}		psi (N/mm²)	101,600 (700)	101,600 (700)	101,600 (700)	101,600 (700)
Effective Tensile Stress Area	A_{se}		in² (mm²)	0.06 (36.6)	0.09 (58)	0.13 (84.3)	0.24 (157)
Tension Resistance of Steel	N_{sa}		lbf (kN)	5,845 (26)	9,217 (41)	13,263 (59)	24,429 (110)
Strength Reduction Factor-Steel Failure[2,9]	$\varnothing_{sa}$		-	0.65	0.65	0.65	0.65
Concrete Breakout Strength in Tension							
Effective Embedment Depth	h_{ef}		in. (mm)	2.4 (60)	2.8 (71)	3.1 (80)	3.94 (100)
Critical Edge Distance	C_{ac}		in. (mm)	7.1 (180)	9.3 (235)	10.4 (265)	13.0 (330)
Effectiveness Factor-Uncracked Concrete	k_{uncr}		-	24 (10)	24 (10)	24 (10)	27 (11.3)
Effectiveness Factor-Cracked Concrete	k_{cr}		-	17 (7.1)	17 (7.1)	17 (7.1)	24 (10)
Modification Factor for uncracked Concrete[8,9]	$\Psi_{c,N}$		-	1.0	1.0	1.0	1.0
Strength Reduction Factor-Concrete Breakout Failure[3,9]	$\varnothing_{cb}$		-	0.65	0.65	0.65	0.65
Pull-Out Strength in Tension							
Pull-Out Resistance Cracked Concrete (f'_c=2,500 psi)[5]	$N_{pn,cr}$		lbf (kN)	2,700 (12)	3,600 (16)	N/A[4]	N/A[4]
Pull-Out Resistance Uncracked Concrete (f'_c=2,500 psi)[5]	$N_{pn,uncr}$		lbf (kN)	3,600 (16)	5,600 (25)	N/A[4]	N/A[4]
Strength Reduction Factor-Pullout Failure[6,9]	Φ_p		-	0.65	0.65	0.65	0.65
Tension Strength for Seismic Applications							
Tension Resistance of Single Anchor for Seismic Loads (f'_c=2,500 psi)[5]	$N_{np,eq}$		lbf (kN)	2,700 (12)	3,600 (16)	5,685 (25.3)	N/A[4]
Strength Reduction Factor-Pullout Failure[6,9]	Φ_{eq}		-	0.65	0.65	0.65	0.65
Axial Stiffness in Service Load Range, Cracked Concrete[7]	β_{cr}		lb/in. (kN/mm)	74,200 (13)	62,800 (11)	85,600 (15)	103,000 (18)
Axial Stiffness in Service Load Range, Uncracked Concrete[7]	β_{uncr}		lb/in. (kN/mm)	285,000 (50)	211,00 (37)	114,000 (20)	365,000 (64)

For **SI:** 1 inch = 25.4mm, 1 lbf = 4.45N, 1 lb/in = 0.175 N/mm, 1 psi = 6.89 Pa, 1 in² = 645 mm², 1 lb/in = 0.175 Nmm

1 The information presented in this table must be used in conjunction with the design requirements of ACI 318 Appendix D, or CSA A23.3 -19 Annex D.

2 The tabulated value of Φ_{sa} applies when the load combinations of Section 1605.2 of the IBC or ACI 318 Section 9.2 are used. If the load combination of ACI 318 Appendix C are used, the appropriate value of Φ_{sa} must be determined in accordance with ACI 318-11 D.4.3. (ACI 318-08 and -05 D.4.4). The M16 and M20 diameter anchors are brittle steel elements as defined in ACI 318 D.1.

3 The tabulated value of Φ_{cb} applies when both the load combinations of Section 1605.2 of the IBC, or ACI 318 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c))for Condition B are satisfied. For installations where complying supplementary reinforcement can be verified, the Φ_{cb} factors described in ACI 318-11 D.4.3 (ACI 318-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ_{cb} must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 and -05 D.4.5).

4 As described in Section 4.1.3 of ESR-3304, N/A (Not Applicable) denotes that pullout resistance is not critical and does not need to be considered.

5 The characteristic pull-out resistance for greater concrete compressive strengths may be increased by multiplying the tabular value by $(f'_c / 2,500)^{0.5}$ in accordance with Section 4.1.3 of this report.

6 The tabulated value of Φ_p or Φ_{eq} applies when both the load combinations of Section 1605.2 of the IBC, or ACI 318 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. Condition B applies where supplementary reinforcement is not provided or where pullout strength governs. For installations where complying supplementary reinforcement can be verified, the Φ factors described in ACI 318-11 D.4.3 (ACI 318-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 D.4.4 and -05 D.4.5).

7 Minimum axial stiffness value. Actual stiffness may vary depending on the concrete strength, loading and geometry of the application.

8 For all design cases $\psi_{c,N}$ = 1.0. The appropriate effectiveness factor for cracked concrete (K_{cr}) or uncracked concrete (K_{uncr}) must be used.

9 For limit State Design as per CSA A23.3-19Annex D, material resistance factors (Φ) and resistance modification factor (R) listed in Table 4 shall be used.

SZ HEAVY LOAD EXPANSION ANCHOR

TABLE 3A - SZ CARBON STEEL CHARACTERISTIC SHEAR DESIGN DATA

Characteristic	Symbol	Units	Nominal anchor diameter											
			M8		M10		M12		M16		M20		M24	
Anchor type			BHL	SHL	BHL	SHL	BHL	SHL	BHL	SHL	BHL	SHL	BHL	SHL
Anchor Category	1,2 or 3	-	3		1		1		1		1		1	
Embedment Depth	h_{nom}	in. (mm)	2.76 (70)		3.31 (84)		3.74 (95)		4.65 (118)		5.83 (148)		6.65 (169)	
Steel Strength in Shear														
Shear Resistance of Steel	V_{sa}	lb (kN)	5,475 (24.3)		8,793 (39.1)		13,037 (58.0)		19,100 (85)	21,600 (96)	22,400 (100)	27,600 (123)	44,984(200.1)	
Strength Reduction Factor-Steel Failure[2,5]	Φ_{sa}	-	0.6		0.6		0.6		0.6		0.6		06	
Concrete Breakout Strength is Shear														
Anchor Outside Diameter	d_a (d_{nom})	in. (mm)	0.45 (11,5)		0.57 (14.5)		0.69 (17.5)		0.93 (23.5)		1.08 (27.5)		1.26 (32)	
Load Bearing Length of Anchor in Shear	l_e	in. (mm)	0.91 (23)		1.14 (29)		1.38 (35)		1.85 (47)		2.17 (55)		2.52 (64)	
Strength Reduction Factor-Concrete Breakout Failure[3,5]	Φ_{cb}	-	0.7		0.7		0.7		0.7		0.7		0.7	
Concrete Pryout Strength in Shear														
Coefficient for Pryout Strength	k_{cp}	-	1		2		2		2		2		2	
Strength Reduction Factor-Concrete Pryout Failure[4,5]	Φ_{cp}	-	0.7		0.7		0.7		0.7		0.7		0.7	
Shear Strength for Seismic Applications														
Shear Resistance of Single Anchor for Seismic loads (f'_c=2,500 psi)	$V_{sa,eq}$	lb (kN)	3,934 (17.5)		6,627 (29.5)		8,977 (39.9)		9,217 (41)		22,256 (99)		35,992 (160.1)	
Strength Reduction Factor-Steel Failure[5]	Φ_{cq}	-	0.6		0.6		0.6		0.6		0.6		0.6	

For **SI:** 1inch = 25.4mm, 1lbf = 4.45N, 1 psi = 6.89 Pa, 1 in^2 = 645 mm^2.

[1]The information presented in Table 3A must be used in conjunction with the design criteria of ACI 318 Appendix D.

[2]The tabulated value of Φ_{sa} applies when the load combinations of Section 1605.2 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ_{sa} must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 and -05D.4.5(c)) The M16 and M20 diameter anchors are brittle steel elements as defined in ACI 318 D.1.1

[3]The tabulated value of Φ_{cb} applies when both the load combinations of Section 1605.2 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. Condition B applies where supplementary reinforcement is not provided or where pryout strength governs. For installations where complying supplementary reinforcement can be verified, the Φ factors described in ACI 318-11 D.4.3 (ACI3(ACI18-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 and -05 D.4.5).

[4]The tabulated value of Φ_{cp} applies when both the load combinations of Section 1605.2.1 of the IBC or ACI 318 9.2 are used and the requirements of ACI 318 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. Condition B applies where supplementary reinforcement is not provided or where Pryout governs. For installations where complying supplementary reinforcement can be verified, the Φ factors described in ACI 318 D.4.3 (ACI 318-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.4 (ACI 318-08 and -05 D.4.5).

[5]For limit State Design as per CSA A23.3-19Annex D, material resistance factors (*Φ)* and resistance modification factor (R) listed in Table 4 shall be used.

TABLE 3B - SZ STAINLESS STEEL CHARACTERISTIC SHEAR DESIGN DATA

Characteristic	Symbol	Units	Nominal anchor diameter			
			M8	M10	M12	M16
Anchor Category	1,2 or 3	-	1	1	1	1
Embedment Depth	h_{nom}	in. (mm)	2.72 (69)	3.25 (82.5)	3.72 (94.5)	4.67 (118.5)
Steel Strength in Shear						
Shear Resistance of Steel	V_{sa}	lb (kN)	5,463 (24.3)	8,273 (36.8)	13,668 (60.8)	19,963 (88.8)
Strength Reduction Factor-Steel Failure[2,5]	Φ_{sa}	-	0.60	0.60	0.60	0.60
Concrete Breakout Strength is Shear						
Anchor Outside Diameter	d_a (d_{nom})	in. (mm)	0.45 (11,5)	0.57 (14.5)	0.69 (17.5)	0.93 (23.5)
Load Bearing Length of Anchor in Shear	l_e	in. (mm)	0.91 (23)	1.14 (29)	1.38 (35)	1.85 (47)
Strength Reduction Factor-Concrete Breakout Failure[3,5]	Φ_{cb}	-	0.7	0.7	0.7	0.7
Concrete Pryout Strength in Shear						
Coefficient for Pryout Strength	k_{cp}	-	2	2	2	2
Strength Reduction Factor-Concrete Pryout Failure[4,5]	Φ_{cp}	-	0.7	0.7	0.7	0.7
Shear Strength for Seismic Applications						
Shear Resistance of Single Anchor for Seismic loads(f'_c=2,500 psi)	$V_{sa,eq}$	lb (kN)	2,158 (9.6)	3,012 (13.4)	5,485 (24.4)	15,983 (71.1)
Strength Reduction Factor-Steel Failure[5]	Φ_{cq}	-	0.60	0.60	0.60	0.60

For **SI:** 1inch = 25.4mm, 1lbf = 4.45N, 1 psi = 6.89 Pa, 1 in^2 = 645 mm^2.

[1]The information presented in Table 3A and 3B must be used in conjunction with the design criteria of ACI 318 Appendix D.

[2]The tabulated value of Φ_{sa} applies when both the load combinations of Section 1605.2 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ_{sa} must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 and -05 D.4.5) The M16 and M20 diameter anchors are brittle steel elements as defined in ACI 318 D.1.1

[3]The tabulated value of Φ_{cb} applies when both the load combinations of Section 1605.2 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. Condition B applies where supplementary reinforcement is not provided or where pryout strength governs. For installations where complying supplementary reinforcement can be verified, the Φ factors described in ACI 318-11 D.4.3 (ACI3(ACI18-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4. (ACI 318-08 and -05 D.4.5).

[4]The tabulated value of Φ_{cp} applies when both the load combinations of Section 1605.2.1 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.3(c) (ACI 318-08 and -05 D.4.4(c)) for Condition B are satisfied. Condition B applies where supplementary reinforcement is not provided or where Pryout governs. For installations where complying supplementary reinforcement can be verified, the Φ factors described in ACI 318-11 D.4.3 (ACI18-08 and -05 D.4.4) for Condition A are allowed. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4 (ACI 318-08 and -05 D.4.5).

[5]For limit State Design as per CSA A23.3-19Annex D, material resistance factors (Φ) and resistance modification factor (R) listed in Table 4 shall be used.

TABLE 4 - RESISTANCE FACTORS FOR LIMIT STATE DESIGN IN ACCORDANCE WITH CSA A23.3-14, ANNEX D[1]

Setting Information	Symbol	Units	Nominal Anchor Diameter				
			M8	M10	M12	M16	M20
Concrete material resistance factor	Φ_c	-	0.65				
Steel material resistance factor	Φ_s	-	0.85				
Strength reduction factor for tension, steel failure modes	R		0.80			0.70	
Strength reduction factor for shear, steel failure modes	R		0.75			0.65	
Strength reduction factor for tension, concrete failure modes	R	Cond. A	1.15				
		Cond. B	1.00				
Strength reduction factor for Shear, concrete failure modes	R	Cond. A	1.15				
		Cond. B	1.00				
Coefficient for factored concrete breakout in tension, cracked concrete	k	-	7				
Modification factor concrete resistance to account uncracked concrete	$\Psi_{c,N}$	-	1.4				

[1]The M16 and M20 diameter anchors are brittle steel elements as difined in ACI 318 D.1.1

ALLOWABLE STRESS DESIGN

TABLE 5A - SZ CARBON STEEL SAMPLE ALLOWABLE DESIGN VALUES FOR ILLUSTRATIVE PURPOSES[1,2,3,4,5,6,7]

Nominal Anchor Diameter	Embedment Depth, h_{nom} (in.)	Effective Embedment Depth, h_{ef} (in.)	Allowable Tension Load, ΦN_n / a (lbf)
M8	2.76	2.4	1,707
M10	3.31	2.8	2,079
M12	3.74	3.1	2,802
M16	4.65	3.94	4,117
M20	5.83	4.94	4,634
M24	6.65	5.92	8,540

For **SI:** 1 inch = 25.4 mm, 1ft-lbf = 1.356 N-m, 1 ibf = 4.45 N.

TABLE 5B - SZ STAINLESS STEEL SAMPLE ALLOWABLE DESIGN VALUES FOR ILLUSTRATIVE PURPOSES[1,2,3,4,5,6,7]

Nominal Anchor Diameter	Embedment Depth, h_{nom} (in.)	Effective Embedment Depth, h_{ef} (in.)	Allowable Tension Load, ΦN_n / a (lbf)
M8	2.72	2.4	1,581
M10	3.25	2.8	2,459
M12	3.72	3.1	2,877
M16	4.67	3.94	4,637

For **SI:** 1 inch = 25.4 mm, 1ft-lbf = 1.356 N-m, 1 ibf = 4.45 N.

[1]Single anchor with static tension load only

[2]Concrete determined to remain uncracked for the life of the anchorage.

[3]load combination from ACI 318 Section 9.2 (no seismic loading) with Φ_{sa} = 0.65, Φ_{cb} = 0.65, and Φ_p = 0.65

[4]30%dead load and 70% live load. Controlling load combination is 1.2D + 1.6L. calculation of a = 0.3*1.2 + 0.7*1.6 = 1.48

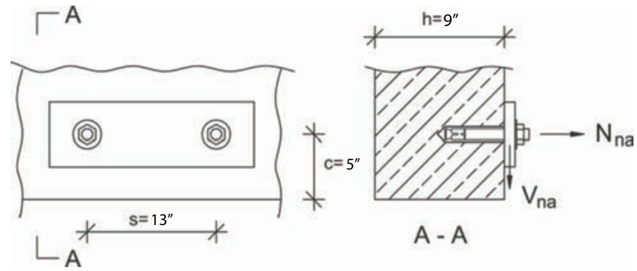
[5]f'_c = 2,500 psi (normal weight concrete)

[6]$C_{a1} = C_{a2} \geq C_{ac}$

[7]$h \geq h_{min}$

EXAMPLE CALCULATION - STRENGTH DESIGN

Determine if two M16 diameter SZ-B (Stud) carbon steel High Load anchors with an effective embedment depth h_{ef} = 3.94 inches installed 13 inches from center to center and 5 inches from the edge of a 9 inch deep slab is adequate for a service tension load of 4,000 lb. (live load) and a reversible service shear load of 2,000 lb. (live load) The anchor group will be in the tension zone, away from other anchors in f'_c = 3,000 psi normal – weight concrete.



	ACI318-08 (ACI 318-19) Code Ref.	Report Ref.

1. Verify minimum Member Thickness, Spacing and Edge Distance:

h = 9 in. ≥ h_{min} = 7.9 in.	o.k.	Table 1A
s = 13 in. ≥ S_{min} = 12.6 in.	o.k.	Table 1A
$c_{a,\,min}$ = 5 in. ≥ c_{min} = 4.7 in.	o.k.	Table 1A

2. Determine the Factored Tension and Shear Design Loads: 9.2.1

N_{ua} = 1.6 L = 1.6 x 4,000 = 6,400 lb.
V_{ua} = 1.6 L = 1.6 x 2,000 = 3,200 lb.

3. Steel Capacity under Tension Loading: D.5.1

N_{sa} = 28,171 — Table 2A
Φ = 0.65 — Table 2A
n = 2 (double anchor group)
Calculating for ΦN_{sa} :
ΦN_{sa} = 0.65 x 2 x 28,171 = 36,622 lb.

4. Concrete Breakout Capacity under Tension Loading — D.5.2

$$N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \Psi_{ec,N}\Psi_{ed,N}\Psi_{c,N}\Psi_{cp,N}N_b \quad \text{Eq.(D-6)}$$

where:

$N_b = K_c \lambda \sqrt{f'_c} h_{ef}^{1.5}$ — Table 2A

with $K_c = K_{cr} = 21$

λ = 1.0 for normal-weight concrete

$\Psi_{ec,N}$ = 1.0 since eccentrically e_N= 0 — Eq.(D-8)

$\Psi_{ed,N} = 0.7+0.3 \frac{C_{a,min}}{1.5h_{ef}}$ when $C_{a,min} \le 1.5h_{ef}$ — Eq.(D-10)

by observation $C_{a,min}$ =3<$1.5h_{ef}$ = 5.91in.

$$\Psi_{ed,N} = 0.7 + 0.3\frac{(5)}{1.5(3.94)} = 0.95$$

$\Psi_{c,N}$ = 1.0 assuming cracking at service loads ($f_t > f_r$) — D.5.2.6

$\Psi_{cp,N}$= 1.0 designed for cracked concrete — D.5.2.7

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calculation for $\frac{A_{Nc}}{A_{Nco}}$

$A_{Nco} = 9h_{ef}^2 = 9(3.94)^2$ = 139.71 In^2 — Eq. (D-5)

$A_{Nc} = (c_{a1}+1.5h_{ef})\ (2 \times 1.5h_{er} + s_1)$
= (5 + 1.5 x 3.94) (2 x 1.5 x 3.94 + 13) — Fig. RD.5.2.1 b
= 270.8 in.^{2}

$$\frac{A_{Nc}}{A_{Nco}} = \frac{270.8}{139.71} = 1.94$$

Calculation for N_b and N_{cbg}:

$N_b = 21 \times 1.0 \times \sqrt{3{,}000} \times (3.94)^{1.5}$ = 8,995 lb.
N_{cbg} = 1.94 x 1.0 x 0.95 x 1.0 x 1.0 x 8,995 = 16,576 lb.
Φ = 0.65 for Condition B
(no supplementary reinforcement provided) — Table 2A

ΦN_{cb} = 0.65 x 16,576 = 10,776 lb.

5. Pullout Capacity — D.5.3

not decisive — Table 2A

6. Check all Failure Modes under Tension Loading: D.4.1.2

Summary:

Steel Capacity	= 36,622 lb.
Concrete Breakout Capacity	= 10,776 lb. ← **Controls**
Pullout Capacity	= not decisive

ΦN_n = 10,776 lb. as Concrete Breakout Capacity Controls > N_{ua} = 6,400 lb. - OK

7. Steel Capacity under Shear Loading: D.6.1

Calculating for ΦV_{sa}:
V_{sa} = 2 x 19,100 = 38,200 lb. — Table 3A
Φ = 0.65 — Table 3A
ΦV_{sa} = 0.65 x 38,200 = 24,830 lb.

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8. Concrete Breakout Capacity under Shear Loading: D.6.2

$V_{cbg} = \frac{A_{vc}}{A_{vco}} \Psi_{ec,V} \Psi_{ed,V} \Psi_{c,V} V_b$ Eq.(D-31)

where:

$V_b = 7\left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\, \lambda_a \sqrt{f'_c}\, c_{a1}^{1.5}$ Eq. (D-33)

$\Psi_{ec,V} = 1.0$ since eccentricity $e'_V = 0$ Eq.(D-36)

$\Psi_{ed,V} = 1.0$ since $c_{a2} > 1.5c_{a1}$ Eq.(D-37)

$\Psi_{c,V} = 1.0$ assuming cracking at service loads ($f_t > f_r$) D.6.2.7

calculating for $\frac{A_{Vc}}{A_{Vc0}}$

$h = 9 > 1.5\ c_{a1} = 1.5 \times 5 = 7.5$ in.

$A_{Vc} = (2(1.5c_{a1}) + s_1)\ 1.5c_{a1}$ Fig.

$= (2 \times 1.5 \times 5 + 13) \times 1.5 \times 5$ RD.6.2.1b

$= 210$ in.^{2}

$A_{Vc0} = 4.5\ (c_{a1})^2 = 4.5 \times 5^2 = 112.5$ in.^{2} Eq.(D-32)

$\frac{A_{Vc}}{A_{Vc0}} = \frac{210}{112.5} = 1.87$ D.6.2.1

calculating for V_b and $\Phi\ V_{cbg}$

$d_a = 0.93$ in. Table 3A

$l_e = 2_{da} = 1.86$ in. D.6.2.2

$c_{a1} = 5$ in.

$\Phi = 0.70$ for Condition B Table 3A

(no supplementary reinforcement provided)

$Vb = 7 \times \left(\frac{1.86}{0.93}\right)^{0.2} \times \sqrt{0.93} \times 1.0 \times \sqrt{3{,}000} \times (5)^{1.5} = 4{,}749$ lb.

$\Phi V_{cbg} = 0.70 \times 1.87 \times 1.0 \times 1.0 \times 1.0 \times 4{,}749 = 6{,}216$ lb.

9. Concrete Pryout Strength: D.6.3

$V_{cpg} = K_{cp} N_{cbg}$ Eq. (D-40)

Where:

$K_{cp} = 2.0$ for $h_{ef} \geq 2.5$

$V_{cpg} = 2.0 \times 16{,}579 = 33{,}158$ lb. $\Phi\ V_{cbg} = 0.70$

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10. Check all Failure Modes under Shear Loading: D.4.1.2

Summary:

Steel Capacity = 24,870 lb.
Concrete Breakout Capacity = 6,216 lb. ← **Controls**
Pryout Capacity = 23,211 lb

$\Phi\ V_n$ = 6,216 lb. as Concrete Breakout Capacity controls > V_{ua} = 3,000 lb. - OK

11. Check Interaction of Tension and Shear Forces D.7

If $0.2\ \Phi\ V_n \geq V_{ua}$ then the full tension design strength is permitted. D.7.1
By observation, this is not the case.

If $0.2\ \Phi\ N_n \geq N_{ua}$ then the full shear design strength is permitted. D.7.2
By observation, this is not the case.

Therefore:

$\frac{N_{ua}}{\Phi N_n} + \frac{V_{ua}}{\Phi V_n} \leq 1.2$

$\frac{6{,}400}{10{,}776} + \frac{3{,}200}{6{,}216} = 0.59 + 0.51 = 1.10 \leq 1.2$ - OK

12. Summary

Two M16 diameter SZ High Load anchor at 3.94 in. effective embedment depth are adequate to resist the applied service tension and shear loads of 4,000 lb. and 2,000 lb., respectively.