

ICC-ES Evaluation Report**ESR-2948**

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Section: 03 16 00—Concrete Anchors**REPORT HOLDER:**fischerwerke GmbH & CO. KG
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ANCHOR FOR ANCHORING IN CRACKED AND
UNCRACKED CONCRETE****1.0 EVALUATION SCOPE****Compliance with the following codes:**

- 2009 *International Building Code*® (2009 IBC)
- 2009 *International Residential Code*® (2009 IRC)
- 2006 *International Building Code*® (2006 IBC)
- 2006 *International Residential Code*® (2006 IRC)
- 2003 *International Building Code*® (2003 IBC)
- 2003 *International Residential Code*® (2003 IRC)

Property evaluated:

Structural

2.0 USES

The fischer FAZ II metric wedge anchor is used to resist static, wind and seismic tension and shear loads in cracked and uncracked normal-weight and sand-lightweight concrete having a specified compressive strength, f'_c , of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The fischer FAZ II anchor complies with anchors installed in hardened concrete as described in Section 1912 of the 2009 and 2006 IBC and Section 1913 of the 2003 IBC. The anchor system is an alternative to cast-in-place anchors described in Section 1911 of the 2009 and 2006 IBC and Section 1912 of the 2003 IBC. The anchors may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the IRC.

3.0 DESCRIPTION**3.1 fischer FAZ II:**

3.1.1 General: The fischer FAZ II wedge anchor is a torque-controlled, mechanical expansion anchor as shown in Figure 1 of this report. The FAZ II consists of four components as shown in Figure 2. The anchor may be manufactured from carbon steel (FAZ II), and stainless steels (FAZ II A4 and FAZ II C).

All carbon steel parts have a minimum 5 μ m (0.0002 inch) zinc plating according to DIN EN ISO 4042. Dimensions and installation criteria are set forth in Tables 1 and 2 of this report.

Application of torque at the hexagon nut of the anchor causes the cone part to be drawn into the expansion clip. This in turn causes the clip to expand against the wall of the drilled hole. Application of the specified installation torque induces a tension force in the bolt that is equilibrated by a precompression force in the concrete acting through the component being fastened. Application of tension loads that exceed the precompression force in the bolt will cause the cone to displace further into the expansion clip (follow-up expansion), generating additional expansion force.

3.1.2 FAZ II: The anchor consists of a bolt with cone, steel washer, steel hexagon nut and steel expansion clip. The anchor FAZ II is available in diameters from M8 through M24. The material specifications are as follows:

- Cone bolt: Carbon steel complying with EN 10263.
- Washer: Carbon steel complying with EN 10139.
- Expansion clip: Carbon steel complying with EN 10139.
- Hexagon nut: Carbon steel, complying with EN 20898-2, Grade 8.8.

3.1.3 FAZ II A4: The anchor FAZ II A4 is available in diameters from M8 through M24. The FAZ II A4 has the same geometry and comparable functional coatings to the FAZ II; with the exception of the material specifications, which are as follows:

- Cone bolt: Stainless steel complying with EN 10088.
- Washer: Stainless steel complying with EN 10088.
- Expansion clip: Stainless steel complying with EN 10088.
- Hexagon nut: Stainless steel complying with EN 10088, ISO 2506-2, Grade 70.

3.1.4 FAZ II C: The anchor FAZ II C is available in diameters from M8 through M16. The FAZ II C has an improved corrosion resistance compared to the FAZ II A4

and the same geometry and comparable functional coatings to the FAZ II, with the exception of the material specifications, which are as follows:

- Cone bolt: Stainless steel complying with EN 10088.
- Washer: Stainless steel complying with EN 10088.
- Expansion clip: Stainless steel complying with EN 10088.
- Hexagon nut: Stainless steel complying with EN 10088, ISO 3506-2, Grade 70.

3.2 Concrete:

Normal-weight and sand-lightweight concrete must comply with Sections 1903 and 1905 of the IBC, as applicable.

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: Design strength of anchors under the 2009 and 2003 IBC, as well as Section R301.1.3 of the 2009 and 2003 IRC, must be determined in accordance with ACI 318-08 Appendix D and this report. Design strength of anchors under the 2006 IBC and Section R301.1.3 of the 2006 IRC must be determined in accordance with ACI 318-05 Appendix D and this report. Design parameters are based on the 2009 IBC (ACI 318-08) unless noted otherwise in Sections 4.1.1 through 4.1.12 of this report. The strength design of anchors must comply with ACI 318 D.4.1, except as required in ACI 318 D.3.3.

Strength reduction factors, ϕ , as given in ACI 318 D.4.4 must be used for load combinations calculated in accordance with Section 1605.2.1 of the IBC and Section 9.2 of ACI 318. Strength reduction factors, ϕ , as given in ACI 318 D.4.5 must be used for load combinations calculated in accordance with ACI 318 Appendix C.

The value of f'_c used in the calculations must be limited to 8,000 psi (55.2 MPa), maximum, in accordance with ACI 318 D.3.5. Strength reduction factors, ϕ , corresponding to ductile steel elements may be used except for the FAZ II M20 and M24 carbon steel anchors in tension and shear, which have a strength reduction factor corresponding to brittle steel elements. Example calculations in accordance with the 2009 IBC are provided in Figures 4 through 7 of this report.

4.1.2 Requirements for Static Steel Strength in Tension, N_{sa} : The nominal steel strength of a single anchor in tension in accordance with ACI 318 D.5.1.2, N_{sa} , is given in Table 3 of this report. Strength reduction factors, ϕ , corresponding to ductile elements may be used except for the FAZ II M20 and M24 carbon steel anchors, which have a strength reduction factor corresponding to brittle steel elements.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension, N_{cb} and N_{cbg} : The nominal concrete breakout strength of a single anchor or group of anchors in tension, N_{cb} and N_{cbg} , respectively, must be calculated in accordance with ACI 318 D.5.2, with modifications as described in this section. The basic concrete breakout strength of a single anchor in tension, N_b , must be calculated according to ACI 318 D.5.2.2, using the values of h_{ef} and k_{cr} as given in Table 3 of this report. The value of f'_c is limited to 8,000 psi (55.2 MPa), maximum, in accordance with ACI 318 D.3.5. The nominal concrete breakout strength in tension in regions where analysis indicates no cracking at service loads in accordance with ACI 318 D.5.2.6 must be calculated with $\Psi_{cp,N} = 1.0$ and using the value of k_{uncr} as given in Table 3 of this report.

4.1.4 Requirements for Critical Edge Distance: In applications where $c < c_{ac}$ and supplemental reinforcement to control splitting of the concrete is not present, the concrete breakout strength in tension for uncracked concrete, calculated according to ACI 318 D.5.2, must be further multiplied by the factor $\Psi_{cp,N}$ according to ACI 318 D.5.2.7 (Eq-1 of this report). In lieu of ACI 318 D.8.6, values of c_{ac} provided in Table 2 of this report must be used.

$$\Psi_{cp,N} = \frac{c}{c_{ac}} \quad (\text{Eq-1})$$

whereby the factor $\Psi_{cp,N}$ need not to be taken as less than $\frac{1.5h_{ef}}{c_{ac}}$. For all other cases $\Psi_{cp,N} = 1.0$.

4.1.5 Requirements for Static Pullout Strength in Tension, N_{pn} : The nominal pullout strength of a single anchor in tension in accordance with ACI 318 D.5.3 in cracked concrete, $N_{p,cr}$ is given in Table 3 of this report. Where values for $N_{p,cr}$ are not provided in Table 3, the pullout strength does not need to be calculated. The static pullout strength in uncracked concrete $N_{p,uncr}$ does not govern and does not need to be calculated. For all design cases $\Psi_{c,P} = 1.0$. The nominal pullout strength may be adjusted for concrete strengths according to Eq-2.

$$N_{p,f'_c} = N_{p,cr} \sqrt{\frac{f'_c}{2,500}} \quad (\text{IMP units}) \quad (\text{Eq-2})$$

$$N_{p,f'_c} = N_{p,cr} \sqrt{\frac{f'_c}{17.2}} \quad (\text{SI units})$$

4.1.6 Requirements for Static Steel Strength in Shear, V_{sa} : The values of V_{sa} for a single anchor given in Table 3 of this report must be used in lieu of the values of V_{sa} as given in ACI 318 D.6.1.2 (c) in shear. Strength reduction factors, ϕ , corresponding to ductile elements must be used except for the FAZ II M20 and M24 carbon steel anchors, which have a strength reduction factor corresponding to brittle steel elements.

4.1.7 Requirements for Static Concrete Breakout Strength in Shear, V_{cb} or V_{cbg} : The nominal concrete breakout strength of a single anchor or group of anchors in shear, V_{cb} or V_{cbg} , respectively, must be calculated in accordance with ACI 318 D.6.2, with modifications as described in this section. The basic concrete breakout strength of a single anchor in shear, V_b , must be calculated in accordance with ACI 318 D.6.2.2 using the value of l_e and d_o (d_a) given in Table 3.

4.1.8 Requirements for Static Concrete Pryout Strength in Shear, V_{cp} or V_{cpg} : The nominal concrete pryout strength of a single anchor or group of anchors in shear, V_{cp} or V_{cpg} , must be calculated in accordance with ACI 318 D.6.3, modified by using the value of k_{cp} provided in Table 3 and the value of N_{cb} or N_{cbg} as calculated in accordance with Section 4.1.3 of this report.

4.1.9 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of ACI 318 D.8.5, minimum member thickness, $h_{a,min}$, must comply with Table 2 of this report. In lieu of ACI 318 D.8.1 and D.8.3, minimum edge distance and minimum spacing, $c_{a,min}$ and $s_{a,min}$, must comply with Table 2 of this report. Intermediate values between $s_{a,min}$ and $c_{a,min}$ may be calculated by linear interpolation.

4.1.10 Requirements for Seismic Design:

4.1.10.1 General: For load combinations including seismic, the design must be performed according to ACI 318 D.3.3, as modified by Section 1908.1.9 of the 2009 IBC or Section 1908.1.16 of the 2006 IBC, or the following:

CODE	ACI 318 D3.3 SEISMIC REGION	CODE EQUIVALENT DESIGNATION
2003 IBC and 2003 IRC	Moderate or high seismic risk	Seismic Design Categories C, D, E and F

The nominal steel strength and the nominal concrete breakout strength for anchors in tension, and the nominal concrete breakout strength and pryout strength for anchors in shear, must be calculated according to ACI 318 D.5 and D.6, respectively, taking into account the corresponding values in Table 2 and 3 of this report. The anchors comply with ACI 318 D.1 as ductile steel elements, and must be designed in accordance with ACI 318-08 D.3.3.4, D.3.3.5 or D.3.3.6; or ACI 318-05 D.3.3.4 or D.3.3.5, except for the FAZ II M20 and M24 carbon-steel anchors, which must be designed in accordance with ACI 318-08 Section D.3.3.5 or D.3.3.6 or ACI 318-05 D.3.3.5 as brittle steel elements.

4.1.10.2 Seismic Tension: The nominal steel strength and nominal concrete breakout strength for anchors in tension must be calculated according to ACI 318 D.5.1 and D.5.2, as described in Sections 4.1.2 and 4.1.3 of this report, and in accordance with ACI 318 D.5.3.2. The value for pullout strength in tension for seismic loads, N_{eq} , described in Table 3 of this report, must be used in lieu of N_p . The values of N_{eq} may be adjusted for concrete strength as follows:

$$N_{eq, f'_c} = N_{eq} \sqrt{\frac{f'_c}{2,500}} \quad (\text{IMP units}) \quad (\text{Eq-3})$$

$$N_{eq, f'_c} = N_{eq} \sqrt{\frac{f'_c}{17.2}} \quad (\text{SI units})$$

If no values of N_{eq} are given in Table 3, the static design strength values for pullout failure govern. (See Section 4.1.5 of this report.)

4.1.10.3 Seismic Shear: The nominal concrete breakout strength and pryout strength for anchors in shear must be calculated according to ACI 318 D.6.2 and D.6.3, as described in Sections 4.1.7 and 4.1.8 of this report. In accordance with ACI 318 D.6.1.2., the appropriate value for nominal steel strength in shear for seismic loads, V_{eq} , described in Table 3 of this report, must be used in lieu of V_{sa} . Strength reduction factors, ϕ , corresponding to ductile elements must be used except for the FAZ II M20 and M24 carbon steel anchors, which have a strength reduction factor corresponding to brittle steel elements.

4.1.11 Requirements for Interaction of Tensile and Shear Forces: For loadings that include combined tension and shear, the design must be performed in accordance with ACI 318 D.7.

4.1.12 Sand-lightweight Concrete: ACI 318-08: When anchors are used in sand-lightweight concrete, the modification factor λ in Appendix D must be taken as 0.6, in lieu of ACI 318-08 Section D.3.4. Additionally the pullout strength $N_{p, cr}$ and N_{eq} must be multiplied by λ .

ACI 318-05: When anchors are used in sand-lightweight concrete, N_b , $N_{p, cr}$, N_{eq} , and V_b determined in accordance with this report must be multiplied by 0.6, in lieu of ACI 318-05 D.3.4.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Design values for use with allowable stress design load combinations calculated in accordance with Section 1605.3 of the IBC shall be established using Eq-4 and Eq-5:

$$T_{allowable, ASD} = \frac{\phi N_n}{\alpha} \quad (\text{Eq-4})$$

and

$$V_{allowable, ASD} = \frac{\phi V_n}{\alpha} \quad (\text{Eq-5})$$

where:

$T_{allowable, ASD}$ = Allowable tension load [lbf or kN]

$V_{allowable, ASD}$ = Allowable shear load [lbf or kN]

ϕN_n = Lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 Appendix D and 2009 IBC Section 1908.1.9, or 2006 IBC Section 1908.1.16, as applicable (lbf or kN).

ϕV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 Appendix D and 2009 IBC Section 1908.1.9, or 2006 IBC Section 1908.1.16, as applicable (lbf or kN).

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α must include all applicable factors to account for nonductile failure modes and required over-strength. An example of allowable stress design values for illustrative purposes is shown in Table 4.

4.2.2 Interaction of Tensile and Shear Forces: The interaction must be calculated in accordance and consistent with ACI 318 D.7, as follows:

For shear loads $V \leq 0.2 V_{allowable, ASD}$, the full allowable load in tension $T_{allowable, ASD}$ must be permitted.

For tension loads $T \leq 0.2 T_{allowable, ASD}$, the full allowable load in shear $V_{allowable, ASD}$ must be permitted.

For all other cases, Eq-6 applies:

$$\frac{T}{T_{allowable, ASD}} + \frac{V}{V_{allowable, ASD}} \leq 1.2 \quad (\text{Eq-6})$$

4.3 Installation:

Installation parameters are provided in Table 2 and in Figure 1 and 3 of this report. Anchor locations must be in accordance with this report and the plans and specifications approved by the code official. The FAZ II anchors must be installed according to the manufacturer’s published instructions and this report. Anchors must be installed in holes drilled into the concrete using carbide-tipped masonry drill bits complying with the requirements of Table 2 of this report. The minimum drilled hole depth, embedment, spacing and edge distances, and member thickness are given in Table 2. The predrilled hole must be cleaned free of dust and debris using a hand pump, compressed air or a vacuum. The anchor must be hammered into the predrilled hole until the proper nominal embedment depth is achieved. The nut must be tightened against the washer until the torque values T_{inst} specified in Table 2 of this report are achieved.

4.4 Special Inspection:

Special inspection is required, in accordance with Section 1704.15 of the 2009 IBC and Section 1704.13 of the 2006 or 2003 IBC. The special inspector must make periodic inspections during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, hole dimensions, hole cleaning procedures, anchor spacing(s), edge distance(s), concrete member thickness, anchor embedment depth, tightening torque and adherence to the manufacturer’s published installation instructions. The special inspector must be present as often as required in accordance with the “statement of special inspection.” Under the IBC, additional requirements as set forth in Sections 1705 and 1706 must be observed, where applicable.

5.0 CONDITIONS OF USE

The FAZ II anchors described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

- 5.1 Anchor sizes, dimensions and installation parameters are as set forth in this report.
- 5.2 The anchors must be installed in accordance with the manufacturer’s published installation instructions and this report. In case of a conflict, this report governs.
- 5.3 Anchors must be installed in cracked and uncracked normal-weight or sand-lightweight concrete having a specified compressive strength, f'_c of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).
- 5.4 The values of f'_c used for calculation purposes shall not exceed 8,000 psi (55.2 MPa).
- 5.5 Strength design values must be established in accordance with Section 4.1 of this report.
- 5.6 Allowable stress design values must be established in accordance with Section 4.2.
- 5.7 Anchor spacing(s) and edge distance(s) as well as minimum member thickness must comply with Table 2.
- 5.8 Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the code official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.
- 5.9 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of expansion anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under such conditions is beyond the scope of this report.
- 5.10 Anchors may be installed in regions of concrete where cracking has occurred or where analysis indicates cracking may occur ($f_t > f_r$), subject to the conditions of this report.

- 5.11 Anchors may be used to resist short-term loading due to wind or seismic forces, subject to the conditions of this report.
- 5.12 Where not otherwise prohibited in the code, FAZ II anchors are permitted for use with fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:
 - Anchors are used to resist wind or seismic forces only.
 - Anchors that support a fire-resistance-rated envelope or a fire-resistance-rated membrane are protected by approved fire-resistance-rated materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
 - Anchors are used to support nonstructural elements.
- 5.13 Use of zinc-coated carbon steel anchors is limited to dry, interior locations.
- 5.14 Special inspection must be provided in accordance with Section 4.4 of this report.
- 5.15 Anchors are manufactured by fischerwerke in Waldachtal, Germany, or in Ivanovice na Hane, Czech Republic, under an approved quality control program with inspections by IEA, Stuttgart (AA-707).

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated June 2012, for use in cracked and uncracked concrete; and quality control documentation.

7.0 IDENTIFICATION

The anchors can be identified on the packaging label with the manufacturer’s name (fischer) and address, anchor name, anchor size, evaluation report number (ICC-ES ESR-2948), and the name of the inspection agency (IEA). The “fish” symbol, the letters FAZ II, the material (blank, A4 or C), the anchor diameter and the maximum fixing thickness are stamped on each anchor.

TABLE 1—LENGTH LETTER-CODE ON THE DOG POINT OF THE CONE BOLT AND MAXIMUM THICKNESS OF FIXTURE t_{fix} : FAZ II M8-M24

marking		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(K)	(L)	(M)
max t_{fix}	[mm]	5	10	15	20	25	30	35	40	45	50	60	70
max t_{fix}	[in.]	0.20	0.39	0.59	0.79	0.98	1.18	1.38	1.57	1.77	1.97	2.36	2.76

marking		(N)	(O)	(P)	(R)	(S)	(T)	(U)	(V)	(W)	(X)	(Y)	(Z)
max t_{fix}	[mm]	80	90	100	120	140	160	180	200	250	300	350	400
max t_{fix}	[in.]	3.15	3.54	3.94	4.72	5.51	6.30	7.09	7.87	9.84	11.81	13.78	15.75

TABLE 2—INSTALLATION INFORMATION¹

Characteristic	Symbol	Unit	FAZ II, FAZ II A4, FAZ II C					
			M8	M10	M12	M16	M20	M24
Nominal drill bit diameter ²	d_{bit}	mm	8	10	12	16	20	24
Cutting diameter of drill bit	$d_{bit,min}$	mm	8.05	10.05	12.10	16.10	20.10	24.10
	$d_{bit,max}$	mm	8.45	10.45	12.50	16.50	20.55	24.55
Minimum drill hole depth	h_{hole}	mm	55	75	90	110	125	155
		in.	2.17	2.95	3.54	4.33	4.92	6.10
Minimum diameter of clearance hole in the fixture	d_f	mm	9	12	14	18	22	26
		in.	0.35	0.47	0.55	0.71	0.87	1.02
Required installation torque	T_{inst}	Nm	20	45	60	110	200	270
		ft-lbf	15	33	44	81	148	199
Minimum effective anchorage depth	$h_{ef} \geq$	mm	45	60	70	85	100	125
		in.	1.77	2.36	2.76	3.35	3.94	4.92
Minimum concrete member thickness	$h_{a,min}$	mm	80	100	120	140	160	200
		in.	3.15	3.94	4.72	5.51	6.30	7.87
Minimum nominal embedment depth ⁵	$h_{nom} \leq$	mm	55	75	90	110	125	155
		in.	2.17	2.95	3.54	4.33	4.92	6.10
Wrench socket size	-	mm	13	17	19	24	30	36
Washer diameter	$d_w \geq$	mm	15	19	23	29	36	43
		in.	0.59	0.75	0.91	1.14	1.42	1.69
Minimum spacing for concrete strength f'_c of $\geq 2,900$ psi to 8,500 psi (20 MPa to 58.6 MPa) ³	$s_{a,min}$	mm	35	40	50	80	125	150
		in.	1.38	1.57	1.97	3.15	4.92	5.91
	For $c_a \geq$	mm	70	100	90	130	220	230
		in.	2.76	3.94	3.54	5.12	8.66	9.06
Minimum edge distance for concrete strength f'_c of $\geq 2,900$ psi to 8,500 psi (20 MPa to 58.6 MPa) ³	$c_{a,min}$	mm	40	60	60	65	125	135
		in.	1.57	2.36	2.36	2.56	4.92	5.32
	For $s_a \geq$	mm	100	90	120	180	230	235
		in.	3.94	3.54	4.72	7.09	9.06	9.25
Minimum spacing for concrete strength f'_c of 2,500 psi to 2,900 psi (17 MPa to 20 MPa) ³	$s_{a,min}$	mm	39	44	55	88	138	165
		in.	1.52	1.73	2.17	3.47	5.41	6.50
	for $c_a \geq$	mm	77	110	90	143	242	253
		in.	3.04	4.33	3.89	5.63	9.53	9.67
Minimum edge distance for concrete strength f'_c of 2,500 psi to 2,900 psi (17 MPa to 20 MPa) ³	$c_{a,min}$	mm	44	66	66	72	138	149
		in.	1.73	2.60	2.60	2.82	5.41	5.85
	for $s_a \geq$	mm	110	99	132	198	253	259
		in.	4.33	3.90	5.20	7.80	9.96	10.20
Critical edge distance	c_{ac}	mm	120	160	165	180	220	260
		in.	4.72	6.30	6.50	7.09	8.66	10.24
Maximum thickness of fixture ⁴	t_{fix}	\geq	mm	0	0	0	0	0
		in.	0	0	0	0	0	0
	\leq	mm	200	250	300	400	500	600
		in.	7.87	9.84	11.81	15.75	19.69	23.62
Length of anchor ⁴	L_{min}	mm	67	85	100	125	140	174
		in.	2.64	3.35	3.94	4.92	5.51	6.85
	L_{max}	mm	267	335	400	525	640	774
		in.	10.51	13.19	15.75	20.67	25.20	30.47

For pound-inch units: 1 mm = 0.03937 inches, 1 Nm = 0.7376 ft-lbf.

¹All specifications excluding manufacturing tolerances.

²Use metric bits only.

³Intermediate values for $s_{a,min}$ and $c_{a,min}$ can be calculated by linear interpolation.

⁴Use of the two lines only in conjunction, intermediate values can be calculated $L = L_{min} + t_{fix}$

⁵ h_{nom} given is before anchor tightening.

TABLE 3—DESIGN INFORMATION

Design parameter	SYMBOL	Units	FAZ II, FAZ II A4, FAZ II C					
			M8	M10	M12	M16	M20	M24
Outside diameter of anchor	$d_a (d_a)^9$	mm	7.8	9.8	11.8	15.7	19.7	23.5
		in.	0.31	0.39	0.47	0.62	0.78	0.93
Effective min. embedment depth ¹	$h_{ef,min}$	mm	45	60	70	85	100	125
		in.	1.77	2.36	2.76	3.35	3.94	4.92
Anchor category ²	1,2 or 3	-	1					
Strength reduction factor for tension, steel failure modes	ϕ	-	0.75 ³				0.65 ⁴	
							0.75 ³	
Strength reduction factor for shear, steel failure modes	ϕ	-	0.65 ³				0.60 ⁴	
							0.65 ³	
Strength reduction factor for tension, concrete failure modes ^{5,6}	ϕ	Cond.A	0.75					
		Cond.B	0.65					
Strength reduction factor for shear, concrete failure modes ^{5,6}	ϕ	Cond.A	0.75					
		Cond.B	0.70					
Yield strength of anchor steel, neck and thread	f_{ya}	N/mm ²	560					544
		lbf/in. ²	80,287					77,993
Ultimate strength of anchor steel, neck and thread	f_{uta}^{10}	N/mm ²	700					680
		lbf/in. ²	100,358					97,491
Tensile stress area	$A_{se,N}$ ($A_{se,neck}$) ⁹	mm ²	19.6	34.2	52.8	85.0	147.4	219.0
		in. ²	0.030	0.053	0.082	0.132	0.228	0.340
Steel strength in tension ^{3,4}	N_{sa}^{10}	kN	13.7	23.9	37.0	59.5	103.2	148.9
		lbf	3,080	5,373	8,317	13,376	23,200	33,474
Effectiveness factor cracked concrete	k_{cr}	SI	7.1	7.1	7.1	10.0	8.8	8.8
		Imp	17	17	17	24	21	21
Effectiveness factor uncracked concrete	k_{unscr}	SI	10.0	10.0	11.3	11.3	11.3	11.3
		Imp	24	24	27	27	27	27
Modification factor for uncracked concrete ⁷	$\psi_{c,N}^{10}$	-	1.0	1.0	1.0	1.0	1.0	
Pullout strength uncracked concrete ⁸	$N_{p,unscr}$		not decisive					
Pullout strength cracked concrete ⁸	$N_{p,cr}$	kN	5.7	11.8	not decisive	23.7	30.2	not decisive
		lbf	1,281	2,653	not decisive	5,327	6,789	not decisive
Tension pullout strength seismic ⁸	N_{eq}^{10}	kN	6.6	11.0	not decisive			
		lbf	1,484	2,675	not decisive			
Shear stress area	$A_{se,V}$ ($A_{se,thread}$) ⁹	mm ²	36.6	58.0	84.3	156.7	244.8	352.5
		in. ²	0.057	0.090	0.131	0.243	0.379	0.546
Steel strength in shear, static	V_{sa}^{10}	kN	11	19	31	63	70	90
		lbf	2,473	4,271	6,969	14,163	15,737	20,233
Steel strength in shear, seismic	V_{eq}^{10}	kN	10	17	28	54	65	72
		lb	2,248	3,822	6,295	12,140	14,613	16,186
Coefficient for pryout strength	k_{cp}	[-]	1			2		
Effective length of anchor in shear loading	l_e^{10}	mm	45	60	70	85	100	125
		inch	1.77	2.36	2.76	3.35	3.94	4.92
Axial stiffness in service load range cracked concrete	$\beta_{m,cr}$	kN/mm	5	7	14	18	20	29
		10 ³ lbf/in	29	40	79	97	109	159
Axial stiffness in service load range uncracked concrete	$\beta_{m,unscr}$	kN/mm	15	21	29	42	45	46
		10 ³ lbf/in	80	113	159	228	242	248

¹Figure 2 illustrates the location of $h_{ef,min}$.

²See Section 4.1.1 of this report.

³The FAZ II anchors M8-M16 carbon steel, M8-M24 stainless steel (A4) and M8-M16 stainless steel (C) are considered a ductile steel element as defined by ACI318 D.1.

⁴The FAZ II anchors M20-M24 carbon-steel are considered a brittle steel element as defined by ACI318 D.1.

⁵Condition A requires supplemental reinforcement, while Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI318 D.4.4. The tabulated value of ϕ applies when the load combinations of Section 1605.2.1 of the IBC, or ACI318 9.2 are used. If the load combinations of ACI318 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI318 D.4.5.

⁶Anchors are permitted to be used in sand-lightweight concrete provided that the provisions in accordance with Section 4.1.12 of this report are taken into account.

⁷The value $\psi_{c,N} = 1.0$ for all design cases.

⁸As described in Section 4.1.5 of this report, pullout resistance is only critical for the sizes M8, M10, M16 and M20 in cracked concrete.

⁹The notation in parenthesis is for the 2006 IBC.

¹⁰For 2003 IBC f_{uta} replaces f_{ut} ; N_{sa} replaces N_s ; $\psi_{c,N}$ replaces ψ_s ; N_{eq} replaces $N_{p,seis}$; V_{sa} replaces V_s ; l_e replaces l ; and V_{eq} replaces $V_{sa,seis}$.

TABLE 4—EXAMPLE ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES

Anchor type FAZ II, FAZ II A4, FAZ II C	Effective Embedment depth h_{ef} inch (mm)	Allowable Tension Load Lbf (kN)
M8	1.77	1,236
	(45)	(5.50)
M10	2.36	1,904
	(60)	(8.47)
M12	2.76	2,713
	(70)	(12.07)
M16	3.35	3,631
	(85)	(16.15)
M20	3.94	4,631
	(100)	(20.60)
M24	4.92	6,473
	(125)	(28.79)

For SI: 1 inch = 25.4 mm, 1 lbf = 4.45 N

Design Assumptions:

¹Single anchor with static tension load only

²Concrete determined to remain uncracked for the life of the anchorage

³Load combinations from ACI 318 9.2 (no seismic loading)

⁴30% dead load and 70% live load, controlling load combination 1.2 D + 1.6 L

⁵Calculation of weighted average for $\alpha = 0.3 \times 1.2 + 0.7 \times 1.6 = 1.48$

⁶ $f'_c = 2,500$ psi (17.2 MPa) (normal weight concrete)

⁷ $h \geq h_{min}$

⁸Condition B according to ACI 318 Appendix D, Section 4.4, no supplementary reinforcement is present

⁹ $c_{a1} = c_{a2} \geq c_{ac}$

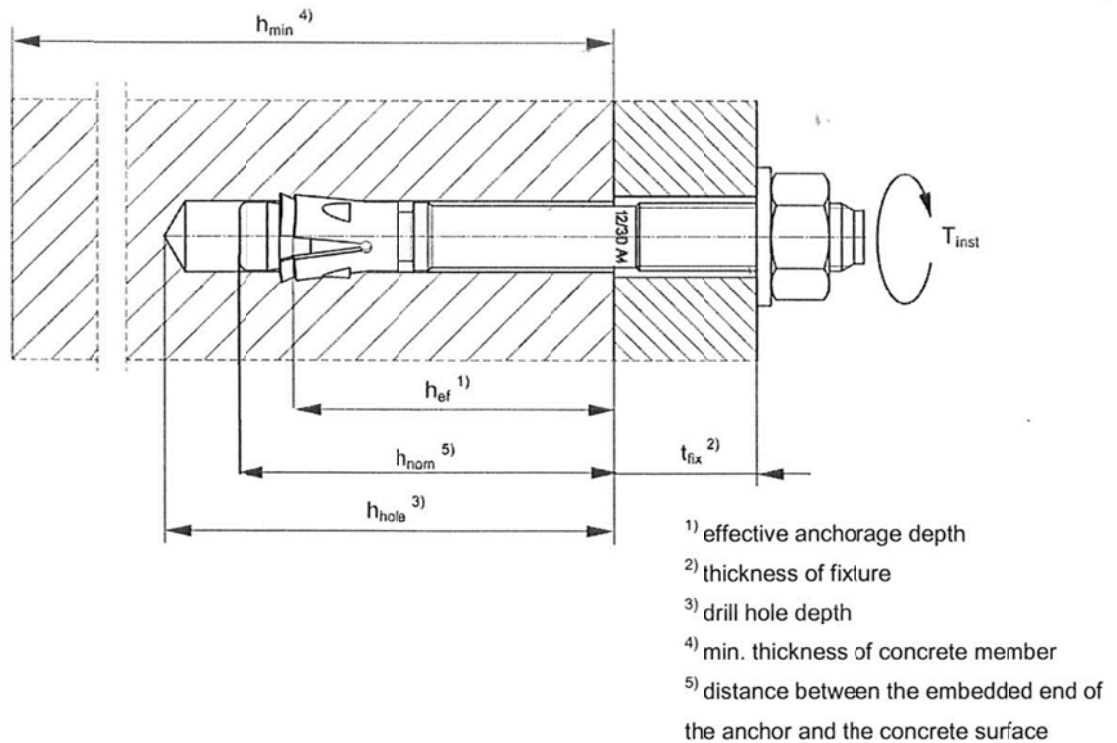


FIGURE 1—INSTALLED ANCHOR FAZ II

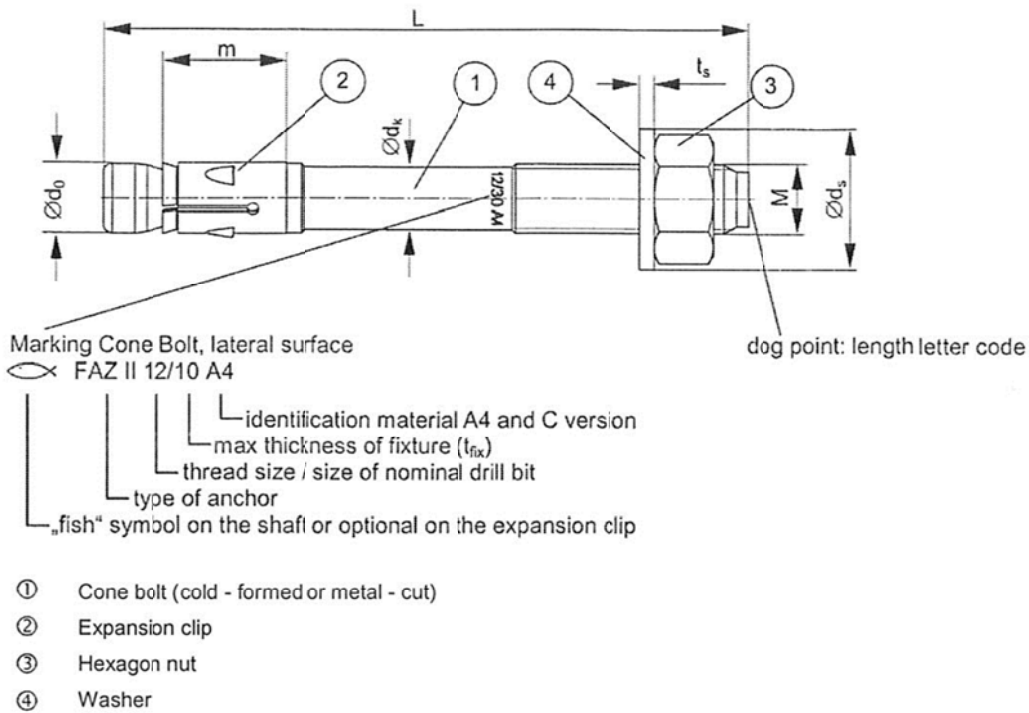


FIGURE 2—MARKING AND COMPONENTS OF THE FAZ II

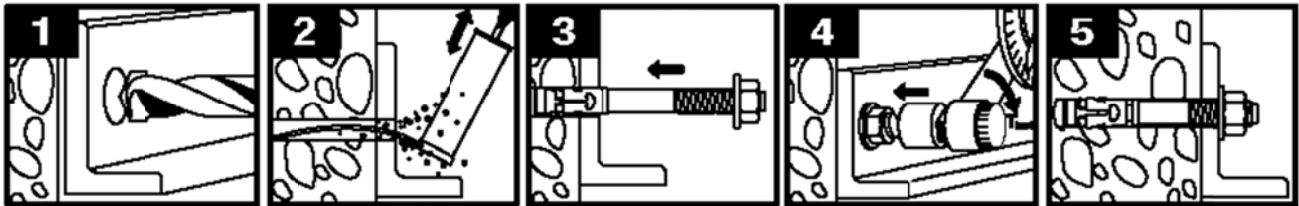


FIGURE 3—INSTALLATION OF THE FAZ II

Step 1: Drill the hole by using the correct metric bit diameter (see Table 2), drill hole to minimum required hole depth h_{hole} (see Table 2) or deeper

Step 2: Remove drilling debris with a blowout bulb or with compressed air.

Step 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. Make sure that the minimum required effective anchorage depth (h_{ef}) is kept and that the maximum thickness of fixture (t_{fix}) is not exceeded.

Step 4: Using a torque wrench, apply the specified installation torque T_{inst} (see Table 2)

Given:
 2 x FAZ II 12/30 A4
 Slab on concrete grade 5,076 psi
 No supplementary reinforcement. =>
 Condition B per ACI 318-08 D.4.4 c)
 Assume cracked concrete

$h_a = 4.72$ in.
 $h_{ef} = 2.76$ in.
 $s_a = 3.94$ in.
 $c_a = 3.15$ in.

Calculate the allowable static and seismic tension load for this configuration.

Calculation according to ACI 318-08 Appendix D and this report	Code Ref.	Report Ref.
<p>Step 1. Verify minimum member thickness, spacing and edge distance: Table 2: $h_a = 4.72$ in. $\geq h_{a,min} = 4.72$ in. => ok</p> <p>slope: $\frac{4.72 - 1.97}{2.36 - 3.54} = -2.3$</p> <p>For $c_a = 3.15$ in.</p> <p>$s_{min,calc} = [(3.15 - 3.94) \times (-2.3)] + 1.97 = 3.79$ in. $\leq s_a = 3.94$ in. => ok</p>	D.8	Table 2
<p>Step 2. Calculate steel strength of anchor in tension $N_{sg} = n N_{sa} = 16,636$ lbf Calculate steel capacity $\phi N_{sa} = 0.75 * 16,614 = 12,477$ lbf</p>	D.5.1.2 D.4.4 a)	Table 3
<p>Step 3. Calculate concrete breakout strength of anchor in tension</p> $N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \times \psi_{ec,N} \times \psi_{ed,N} \times \psi_{c,N} \times \psi_{cp,N} \times N_b$	D.5.2.1 b)	§ 4.1.3 § 4.1.4
<p>Step 3a. Check $1.5 h_{ef} = 1.5 \times 2.76 = 4.14$ in. $> c$ $3.0 h_{ef} = 3.0 \times 2.76 = 8.28$ in. $> s$</p>	D.5.2.1 b)	Table 2
<p>Step 3b. Calculate A_{Nc0} and A_{Nc} $A_{Nc0} = 9 \times h_{ef}^2 = 9 \times (2.76)^2 = 68.36$ in.² $A_{Nc} = (1.5 h_{ef} + c) \times (3 h_{ef} + s) = (1.5 \times 2.76 + 3.15) \times (3 \times 2.76 + 3.94) = 88.89$ in.² $< 2 \times A_{Nc0}$</p>	D.5.2.1 b)	Table 3
<p>Step 3c. Calculate $\psi_{ec,N} : e_N = 0 \Rightarrow \psi_{ec,N} = 1$</p>	D.5.2.4	-
<p>Step 3d. Calculate $N_b = \lambda k_{cr} \sqrt{f'_c} h_{ef}^{1.5} = 1.0 \times 17 \times \sqrt{5,076} \times 2.76^{1.5} = 5,452$ lbf</p>	D.5.2.2	Table 3
<p>Step 3e. Calculate modification factor for edge distance: $\psi_{ed,N} = 0.7 + 0.3 \frac{c_{a,min}}{1.5 \times h_{ef}} = 0.7 + 0.3 \times \frac{3.15}{1.5 \times 2.76} = 0.929 < 1$</p>	D.5.2.5	Table 2
<p>Step 3f. $\psi_{c,N} = 1.0$ (cracked concrete)</p>	D.5.2.6	Table 3
<p>Step 3g. $\psi_{cp,N} = 1.0$</p>	D.5.2.7	Table 3
<p>Step 3h. Calculate $N_{cbg} = (88.89/68.36) \times 1 \times 0.929 \times 1 \times 5,452 = 6,587$ lbf</p>	D.5.2.1 b)	§4.1.3 Table 3
<p>Step 4. Check: Seismic tension is not decisive. $N_{cbg} = N_{eg}$</p>	-	Table 3
<p>Step 5. Controlling strength: $\phi N_{cbg} = 0.75 \times 6,587 = 4,941$ lbf $< \phi N_s = 12,477$ lbf</p>	D.4.4.c)	Table 3
<p>Step 6. Calculate allowable stress design (30% dead load, 70% live load) $\alpha = 1.2 \times 0.3 + 1.6 \times 0.7 = 1.48 \rightarrow T_{allowable, ASD} = 4,941 / 1.48 = 3,338$ lbf</p>	ACI 318 Section 9.2	§4.2

FIGURE 4—EXAMPLE CALCULATION TENSION ACCORDING TO ACI 318-08 APPENDIX D AND THIS REPORT (IMP UNITS)

Given:
 2 x FAZ II 12/30 A4
 Slab on concrete grade 35 MPa
 No supplementary reinforcement. =>
 Condition B per ACI 318-08 D.4.4 c)
 Assume cracked concrete

$h_a = 120$ mm
 $h_{ef} = 70$ mm
 $s_a = 100$ mm
 $c_a = 80$ mm

Calculate the allowable static and seismic tension load for this configuration.

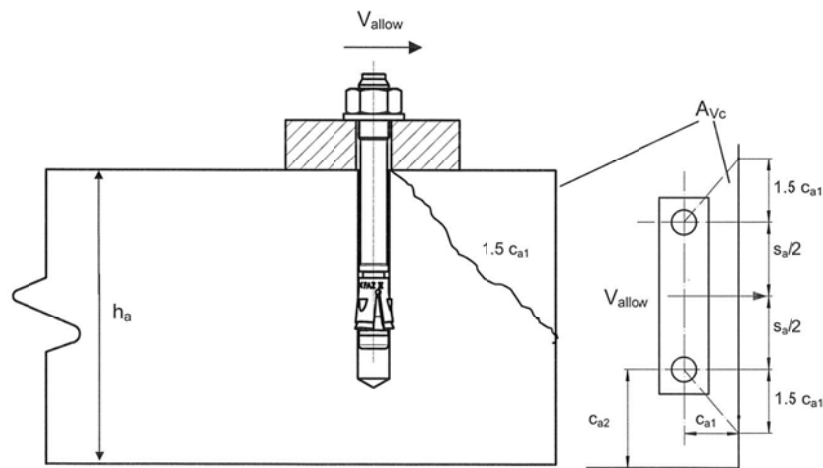
Calculation according to ACI 318-08 Appendix D and this report	Code Ref.	Report Ref.
<p>Step 1. Verify minimum spacing and edge distance: Table 2: $h_a = 120$ mm $\geq h_{a,min} = 120$ mm => ok slope: $\frac{120 - 50}{60 - 90} = -2.3$ For $c_a = 80$ mm $s_{min,calc} = [(80-100) \times (-2.3)] + 50 = 96$ mm. $\leq s_a = 100$ mm => ok</p>	D.8	Table 2
<p>Step 2. Calculate steel strength of anchor in tension $N_{sg} = n N_{sa} = 74$ kN Calculate steel capacity $\phi N_{sa} = 0.75 * 74 = 55.5$ kN</p>	D.5.1.2 D.4.4 a)	Table 3
<p>Step 3. Calculate concrete breakout strength of anchor in tension $N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \times \psi_{ec,N} \times \psi_{ed,N} \times \psi_{c,N} \times \psi_{cp,N} \times N_b$</p>	D.5.2.1 b)	§ 4.1.3 § 4.1.4
<p>Step 3a. Check $1.5 h_{ef} = 1.5 \times 70 = 105$ mm $> c$ $3.0 h_{ef} = 3.0 \times 70 = 210$ mm $> s$</p>	D.5.2.1 b)	Table 2
<p>Step 3b. Calculate A_{Nco} and A_{Nc} $A_{Nco} = 9 \times h_{ef}^2 = 9 \times (70)^2 = 44,100$ mm² $A_{Nc} = (1.5 h_{ef} + c) \times (3 h_{ef} + s) = (1.5 \times 70 + 80) \times (3 \times 70 + 100) = 57,350$ mm² $< 2 \times A_{Nco}$</p>	D.5.2.1 b)	Table 3
<p>Step 3c. Calculate $\psi_{ec,N} : e_N = 0 \Rightarrow \psi_{ec,N} = 1$</p>	D.5.2.4	-
<p>Step 3d. Calculate $N_b = \lambda k_c \sqrt{f'_c} h_{ef}^{1.5} = 1.0 \times 7.1 \times \sqrt{35} \times 70^{1.5} = 24,600$ N = 24.6 kN</p>	D.5.2.2	Table 3
<p>Step 3e. Calculate modification factor for edge distance: $\psi_{ed,N} = 0.7 + 0.3 \frac{c_{a,min}}{1.5 \times h_{ef}} = 0.7 + 0.3 \times \frac{80}{1.5 \times 70} = 0.929 < 1$</p>	D.5.2.5	Table 2
<p>Step 3f. $\psi_{c,N} = 1.0$ (cracked concrete)</p>	D.5.2.6	Table 3
<p>Step 3g. $\psi_{cp,N} = 1.0$</p>	D.5.2.7	Table 3
<p>Step 3h. Calculate $N_{cbg} = (57,350/44,100) \times 1 \times 0.929 \times 1 \times 24.6 = 29.72$ kN</p>	D.5.2.1 b)	§4.1.3 Table 3
<p>Step 4. Check: Seismic tension is not decisive. $N_{cbg} = N_{eq}$</p>		Table 3
<p>Step 5. Controlling strength: $\phi N_{cbg} = 0.75 \times 29.72 = 22.29$ kN $< \phi N_s = 55.5$ kN</p>	D.4.4.c)	Table 3
<p>Step 6. Calculate allowable stress design (30% dead load, 70% live load) $\alpha = 1.2 \times 0.3 + 1.6 \times 0.7 = 1.48 \rightarrow T_{allowable, ASD} = 22.29 / 1.48 = 15.06$ kN</p>	ACI 318 Section 9.2	§4.2

FIGURE 5—EXAMPLE CALCULATION TENSION ACCORDING TO ACI 318-08 APPENDIX D AND THIS REPORT (SI UNITS)

Given:

2 x FAZ II 12/30 A4
 Slab on grade = 5,076 psi
 No supplementary reinforcement. => Condition B per ACI 318-08 D.4.4 c)
 Assume cracked concrete
 $h_a = 4.72$ in.
 $h_{ef} = 2.76$ in.
 $s_a = 3.94$ in.
 $c_{a1} = 3.15$ in.

Calculate the allowable static shear load for this configuration.



Calculation according to ACI 318-08 Appendix D and this report	Code Ref.	Report Ref.
Step 1. Verify minimum spacing and edge distance according to Figure 4 – Tension (Step 3a)	D.8	Table 2
Step 2. Calculate steel strength of anchor in shear $V_{sg} = n V_{sa} = 13,938$ lbf Calculate steel capacity $\phi V_{sg} = 0.65 * 13,938 = 9,060$ lbf	D.6.1 D.4.4 b)	Table 3
Step 3. Calculate concrete breakout strength of anchor in shear $V_{cbg} = \frac{A_{Vc}}{A_{Vc0}} \times \psi_{ec,V} \times \psi_{ed,V} \times \psi_{c,V} \times V_b$	D.6.2.1 b)	§ 4.1.7
Step 3a. Check $3 c_{a1} = 3 \times 3.15 = 9.45$ in. $> s = 3.94$ in. s controls $1.5 c_{a1} = 1.5 \times 3.15 = 4.73$ in. $< h_a$ c_{a1} controls $1.5 c_{a1} < c_{a2}$ c_{a1} controls	D.6.2.2	-
Step 3b. Calculate A_{Vc0} and A_{Vc} $A_{Vc} = 4.5 \times c_1^2 = 4.5 \times (3.15)^2 = 44.64$ in. ² $A_{Vc0} = (1.5 c_{a1}) \times (3 c_{a1} + s) = (1.5 \times 3.15) \times (3 \times 3.15 + 3.94) = 63.24$ in. ² $< 2 \times A_{Vc0}$	D.6.2.2	-
Step 3c. Calculate $\psi_{ec,V}$: $e_v = 0 \Rightarrow \psi_{ec,V} = 1$	D.6.2.5	-
Step 3d. Calculate $V_b = 7 \times \lambda \sqrt{f'_c} \times \sqrt{d_0} \times c_{a1}^{1.5} \times \left(\frac{l_e}{d_0}\right)^{0.2}$ $= 7 \times 1.0 \sqrt{5,076} \times \sqrt{0.47} \times 3.15^{1.5} \times \left(\frac{2.76}{0.47}\right)^{0.2} = 2,810$ lbf	D.6.2.2	§ 4.1.7
Step 3e. Calculate modification factor for edge distance: $\psi_{ed,V} = 1$ $c_{a2} \geq 1.5 \times c_{a1}$	D.6.2.6	-
Step 3f. $\psi_{c,V} = 1.0$ (cracked concrete)	D.6.2.7	-
Step 3g. Calculate $V_{cbg} = (63.24/44.64) \times 1 \times 1 \times 2,810 = 3,979$ lbf	D.6.2.1 b)	-
Step 3h. Calculate $\phi V_{cbg} = 3,979$ lbf $\times 0.7 = 2,788$ lbf	D.4.4 c)	Table 3
Step 4. Calculate Pryout: $\phi V_{cp} = \phi k_{cp} \times N_{cbg} = 0.7 \times 2 \times 6,585 = 9,217$ lbf (N_{cbg} According to Figure 4 (Step 3i)– Tension, $k_{cp} = 2$ for $h_{ef} > 2.5$ in.)	D.6.3.1 b)	§4.1.8
Step 5. Controlling strength: $\phi V_n = \min \phi V_{cp} \phi V_{cbg} \phi V_{sg} = 2,788$ lbf (static)	D.4.1.2	-
Step 6. Seismic shear steel capacity: $\phi V_{s,eq} = 0.65 \times 2 \times 6,295 = 8,183$ lbf $> \phi V_n$ static concrete strength capacity controls		§4.1.10
Step 7. Calculate allowable stress design (30% dead load, 70% live load) $\alpha = 1.2 \times 0.3 + 1.6 \times 0.7 = 1.48 \rightarrow V_{allowable, ASD} = 2,788 / 1.48 = 1,884$ lbf	ACI 318 Section 9.2	§4.2

FIGURE 6—EXAMPLE CALCULATION SHEAR ACCORDING TO ACI 318-08 APPENDIX D AND THIS REPORT (IMP UNITS)

Given:
 2 x FAZ II 12/30 A4
 Slab on grade 35 MPa
 No supplementary reinforcement. => Condition B per ACI 318-08 D.4.4 c)
 Assume cracked concrete
 $h_a = 120$ mm
 $h_{ef} = 70$ mm
 $s_a = 100$ mm
 $c_{a1} = 80$ mm

Calculate the allowable static and seismic shear load for this configuration.

Calculation according to ACI 318-08 Appendix D and this report	Code Ref.	Report Ref.
Step 3a. Verify minimum spacing and edge distance according to Figure 5 – Tension (Step 3a)	D.8	Table 2
Step 1. Calculate steel strength of anchor in shear $V_{sg} = n V_{sa} = 62$ kN Calculate steel capacity $\phi V_{sg} = 0.65 * 62 = 40.3$ kN	D.6.1 D.4.4 b)	Table 3
Step 3. Calculate concrete breakout strength of anchor in shear $V_{cbg} = \frac{A_{Vc}}{A_{Vc0}} \times \psi_{ec,V} \times \psi_{ed,V} \times \psi_{c,V} \times V_b$	D.6.2.1 b)	§ 4.1.7 § 4.1.8
Step 3a. Check $3 c_{a1} = 3 \times 80 = 240$ mm > $s = 100$ mm s controls $1.5 c_{a1} = 1.5 \times 80 = 120$ mm < h_a c_{a1} controls $1.5 c_{a1} < c_{a2}$ c_{a1} controls	D.6.2.2	-
Step 3b. Calculate A_{Vc0} and A_{Vc} $A_{Vc} = 4.5 \times c_1^2 = 4.5 \times (80)^2 = 28,800$ mm ² $A_{Vc0} = (1.5 c_{a1}) \times (3 c_{a1} + s) = (1.5 \times 80) \times (3 \times 80 + 100) = 40,800$ mm ² < $2 \times A_{Vc0}$	D.6.2.2	-
Step 3c. Calculate $\psi_{ec,V} : e_V = 0 \Rightarrow \psi_{ec,V} = 1$	D.6.2.5	-
Step 3d. Calculate $V_b = 0.6 \lambda \sqrt{f'_c} \times \sqrt{d_0} \times c_{a1}^{1.5} \times (\frac{le}{d_0})^{0.2} = 7 \times 1.0 \sqrt{35} \times \sqrt{12} \times 80^{1.5} \times (\frac{70}{12})^{0.2} = 12.5$ kN	-	§ 4.1.7
Step 3e. Calculate modification factor for edge distance: $\psi_{ed,V} = 1$ $c_{a2} \geq 1.5 \times c_{a1}$	D.6.2.6	-
Step 3f. $\psi_{c,V} = 1.0$ (cracked concrete)	D.6.2.7	-
Step 3g. Calculate $V_{cbg} = (40,800/28,800) \times 1 \times 1 \times 12.5 = 17.7$ kN	D.6.2.1 b)	-
Step 3h. Calculate $\phi V_{cbg} = 17.7$ kN $\times 0.7 = 12.4$ kN	D.4.4 c)	Table 3
Step 4. Calculate Pryout: $\phi V_{cp} = \phi \times k_{cp} \times N_{cbg} = 0.7 \times 2 \times 29.72 = 41.6$ kN (N_{cbg} According to Figure 5 (Step 3h) – Tension, $k_{cp} = 2$ for $h_{ef} > 63$ mm)	D.6.3.1 b)	§ 4.1.8
Step 5. Controlling strength: $\phi V_n = \min \phi V_{cp} \phi V_{cbg} \phi V_{sg} = 12.4$ kN (static)	D.4.1.2	-
Step 6. Seismic shear steel capacity: $\phi V_{s,eq} = 0.65 * 2 \times 28 = 36.4$ kN > ϕV_n static concrete strength capacity controls		§ 4.1.10
Step 7. Calculate allowable stress design (30% dead load, 70% live load) $\alpha = 1.2 \times 0.3 + 1.6 \times 0.7 = 1.48 \rightarrow V_{allowable, ASD} = 12.4 / 1.48 = 8.38$ kN	ACI 318 Section 9.2	§4.2

FIGURE 7—EXAMPLE CALCULATION SHEAR ACCORDING TO ACI 318-08 APPENDIX D AND THIS REPORT (SI UNITS)