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ESR-2948

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Reissued 01/2018
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DIVISION: 03 00 00—CONCRETE
SECTION: 03 16 00—CONCRETE ANCHORS
DIVISION: 05 00 00—METALS
SECTION: 05 05 19—POST-INSTALLED CONCRETE ANCHORS

REPORT HOLDER:

FISCHERWERKE GMBH & CO. KG

WEINHALDE 14-18
72178 WALDACHTAL
GERMANY

EVALUATION SUBJECT:

fischer FAZ II, FAZ II A4 AND FAZ II C METRIC WEDGE ANCHOR FOR ANCHORING IN CRACKED AND UNCRACKED CONCRETE

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DIVISION: 03 00 00—CONCRETE
Section: 03 16 00—Concrete Anchors

DIVISION: 05 00 00—METALS
Section: 05 05 19—Post-Installed Concrete Anchors

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EVALUATION SUBJECT:

fischer FAZ II, FAZ II A4 AND FAZ II C METRIC WEDGE ANCHOR FOR ANCHORING IN CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2015, 2012, 2009 and 2006 *International Building Code®* (IBC)
- 2015, 2012, 2009 and 2006 *International Residential Code®* (IRC)
- 2013 *Abu Dhabi International building Code* (ADIBC)†

†The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.

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 lightweight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

The fischer FAZ II anchor complies with anchors installed in hardened concrete as described in Section 1901.3 of 2015 IBC, Section 1909 of the 2012 IBC, and Section 1912 of the 2009 and 2006 IBC. The anchor system is an alternative to cast-in-place anchors described in Section 1908 of the 2012 and Section 1911 of the 2009 and 2006 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 μm (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 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 complying with the 2015 IBC, as well as Section R301.1.3 of the 2015 IRC must be determined in accordance with ACI 318-14 Chapter 17 and this report.

Design strength of anchors complying with the 2012 IBC, as well as Section R301.1.3 of the 2012 IRC, must be in accordance with ACI 318-11 Appendix D and this report.

Design strength of anchors under the 2009 IBC, as well as Section R301.1.3 of the 2009 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 examples in accordance with the 2015 IBC and 2012 IBC are shown in Figures 4 through 7 of this report.

Design parameters are based on the 2015 IBC (ACI 318-14) and the 2012 IBC (ACI 318-11) unless noted otherwise in Sections 4.1.1 through 4.1.12 of this report. The strength design of anchors must comply with ACI 318-14 17.3.1 or ACI 318-11 D.4.1, as applicable, except as required in ACI 318-14 17.2.3 or ACI 318-11 D.3.3.

Strength reduction factors, ϕ, as given in ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC and Section 5.3 of ACI 318-14 or Section 9.2 of ACI 318-11, as applicable. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318-11 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 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable. 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.

4.1.2 Requirements for Static Steel Strength in Tension, N_{sa}: The nominal steel strength of a single anchor in tension must be calculated in accordance with ACI 318-14 17.4.1.2 or ACI 318-11 D.5.1.2, as applicable. The values for N_{sa} are 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 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, 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 318-14 17.4.2.2 or ACI 318-11 D.5.2.2, as applicable, using the values of $h_{ef,min}$ and k_{cr} as given in Table 3 of this report in lieu of h_{ef} and k_c, respectively. The nominal concrete breakout strength in tension in regions where analysis indicates no cracking in accordance with ACI 318-14 17.4.2.6 or ACI 318-11 D.5.2.6, as applicable, must be calculated with Ψ_{cN} = 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 318-14 17.4.2 or ACI 318-11 D.5.2, as applicable, must be further multiplied by the factor $\Psi_{cp,N}$ as given by the following equation:

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

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. In lieu of ACI 318-14 17.7.6 or ACI 318-11 D.8.6, as applicable, values for the critical edge distance c_{ac} provided in Table 2 of this report must be used.

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 318-14 17.4.3 or ACI 318-11 D.5.3, as applicable, 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.

$$N_{p,f'_c} = N_{p,cr}\sqrt{\frac{f'_c}{2,500}} \qquad \text{(lb, psi)} \qquad \text{(Eq-2)}$$

$$N_{p,f'_c} = N_{p,cr}\sqrt{\frac{f'_c}{17.2}} \qquad \text{(N, MPa)}$$

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 derived by calculation in ACI 318-14 17.5.1.2 (b) or ACI 318-11 D.6.1.2 (b), as applicable, 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 318-14 17.5.2 or ACI 318-11 D.6.2, as applicable, 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 318-14 17.5.2.2 or ACI 318-11 D.6.2.2, as applicable, using the value of l_e and d_o (d_a) given in Table 3. The value of l_e used in ACI 318-14 Eq. 17.5.2.2a or ACI 318-11 Eq. D-33 must be taken as no greater than the lesser of h_{ef} or $8d_a$.

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 318-14 17.5.3 or ACI 318-14 D.6.3, as applicable, 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 318-14 17.7.5 or ACI 318-11 D.8.5, as applicable, minimum member thickness, $h_{a,min}$, must comply with Table 2 of this report. In lieu of ACI 318-14 17.7.1 and 17.7.3; or ACI 318 D.8.1 and D.8.3, respectively, as applicable, minimum spacing and minimum edge distance, s_{min} and c_{min}, must comply with Table 2 of this report. Intermediate values between s_{min} and c_{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 318-14 17.2.3 or ACI 318-11 D.3.3, as applicable. Modifications to ACI 318-14 17.2.3 shall be applied under Section 1905.1.8 of the 2015 IBC. For the 2012 IBC, Section 1905.1.9 shall be omitted. Modifications to ACI 318 (-08, -05) D.3.3 shall be applied under Section 1908.1.9 of the 2009 IBC, or Section 1908.1.16 of the 2006 IBC as applicable.

The anchors comply with ACI 318-14 2.3 or ACI 318-11 D.1, as applicable, as ductile steel elements, and must be designed in accordance with ACI 318-14 17.2.3.4, 17.2.3.5, 17.2.3.6 or 17.2.3.7; ACI 318-11 D.3.3.4, D.3.3.5, D.3.3.6 or D.3.3.7; 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, as applicable, except for the FAZ II M20 and M24 carbon-steel anchors, which must be designed in accordance with ACI 318-14 17.2.3.5 or 17.2.3.6; or ACI 318 (-11, -08) Section D.3.3.5 or D.3.3.6; or ACI 318-05 D.3.3.5, as applicable, as brittle steel elements. The anchors may be installed in Seismic Design Categories A through F or the IBC.

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 318-14 17.4.1 and 17.4.2 or ACI 318-11 D.5.1 and D.5.2, respectively, as described in Sections 4.1.2 and 4.1.3 of this report. In accordance with ACI 318-14 17.4.3.2 or ACI 318 D.5.3.2, as applicable, the value for pullout strength in tension for seismic loads, N_{eg}, 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:

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

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

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 318-14 17.5.2 and 17.5.3 or ACI 318-11 D.6.2 and D.6.3, respectively, as applicable, as described in Sections 4.1.7 and 4.1.8 of this report. In accordance with ACI 318-14 17.5.1.2 or ACI 318-11 D.6.1.2, as applicable, 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 und Shear Forces: For loadings that include combined tension and shear, the design must be performed in accordance with ACI 318-14 17.6 or ACI 318-11 D.7, as applicable.

4.1.12 Lightweight Concrete: For the use of anchors in lightweight concrete, the modification factor λ_a equal to 0.8λ is applied to all values of $\sqrt{f'_c}$ affecting N_n and V_n.

For ACI 318-14 (2015 IBC), ACI 318-11 (2012 IBC) and ACI 318-08 (2009 IBC), λ shall be determined in accordance with the corresponding version of ACI 318.

For ACI 318-05 (2006 IBC) λ shall be taken as 0.75 for all lightweight concrete and 0.85 for sand-lightweight concrete. Linear interpolation shall be permitted if partial sand replacement is used. In addition, the pullout strengths $N_{p,cr}$, and N_{eq} shall be multiplied by the modification factor, λ_a, as applicable.

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:

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

and

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

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 318-14 Chapter 17 and 2015 IBC Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D and 2009 IBC Section 1908.1.9, ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16, and Section 4.1 of this report, as applicable (lbf or kN).

ϕV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318-14 Chapter 17 and 2015 IBC Section 1905.1.8, ACI 318-11 Appendix D, ACI 318-08 Appendix D and 2009 IBC Section 1908.1.9, ACI 318-05 Appendix D and 2006 IBC Section 1908.1.16, and Section 4.1 of this report, 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 318-14 17.6 or ACI 318 (-11, -08, -05) D.7, as applicable, as follows:

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

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

For all other cases, Eq-6 applies:

$$\frac{T_{applied}}{T_{allowable,\ ASD}} + \frac{VV_{applied}}{V_{allowable,ASD}} \leq 1.2 \qquad \text{(Eq-6)}$$

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:

Periodic special inspection is required, in accordance with Section 1705.1.1 and Table 1705.3 of the 2015 IBC and 2012 IBC; Section 1704.15 and Table 1704.4 of the 2009 IBC; or Section 1704.13 of the 2006 IBC, as applicable. 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 printed 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, 1706 and 1707 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 the 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 printed 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 lightweight concrete having a specified compressive strength, f'_c of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa) [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

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 statues 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 in locations designated as Seismic Design Categories A through F of the IBC, 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 ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated October 2015, 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, and evaluation report number (ESR-2948). 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 INFORMATION[1]

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 ≥ 2,900 psi to 8,500 psi (20 MPa to 58.6 MPa)[3]	s_{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 ≥ 2,900 psi to 8,500 psi (20 MPa to 58.6 MPa)[3]	c_{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_{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_{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}	≥	mm in.	0	0	0	0	0	0
		≤	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.

[1]All specifications excluding manufacturing tolerances.
[2]Use metric bits only.
[3]Intermediate values for s_{min} and c_{min} can be calculated by linear interpolation.
[4]Use 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_o)[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/mm²	560					544
		lbf/in.²	80,287					77,993
Ultimate strength of anchor steel, neck and thread	f_{uta}	N/mm²	700					680
		lbf/in.²	100,358					97,491
Tensile stress area	$A_{se,N}$ ($A_{se,neck}$)[9]	mm²	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}	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_{uncr}	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]	$\Psi_{c,N}$	-	1.0	1.0	1.0	1.0	1.0	1.0
Pullout strength uncracked concrete[8]	$N_{p,uncr}$	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		5,327	6,789	
Tension pullout strength seismic[8]	N_{eq}	kN	5.7	11.0	not decisive			
		lbf	1,281	2,675				
Shear stress area	$A_{se,V}$ ($A_{se,thread}$)[9]	mm²	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}	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}	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	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
		10³lbf/in	29	40	79	97	109	159
Axial stiffness in service load range uncracked concrete	$\beta_{m,uncr}$	kN/mm	15	21	29	42	45	46
		10³lbf/in	80	113	159	228	242	248

[1]Figure 2 illustrates the location of $h_{ef,min}$.
[2]See Section 4.1.1 of this report.
[3]The 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 ACI 318-14 2.3 or ACI 318-11 D.1, as applicable.
[4]The FAZ II anchors M20-M24 carbon-steel are considered a brittle steel element as defined by ACI 318-14 2.3 or ACI 318-11 D.1, as applicable.
[5]The tabulated value of ϕ applies when the load combinations of IBC Section 1605.2, ACI 318-14 Section 5.3 or ACI 318-11 9.2, as applicable, are used. Condition B applies where supplemental reinforcement is not provided or where pullout or pryout governs, as set forth in ACI 318-14 17.3.3 (c) or ACI 318-11 D.4.3 (c), as applicable. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318-11 D.4.4.
[6]Anchors are permitted to be used in lightweight concrete provided that the provisions in accordance with Section 4.1.12 of this report are taken into account.
[7]The value $\Psi_{c,N}$ = 1.0 for all design cases.
[8]As 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.
[9] The notation in parenthesis is for the 2006 IBC.

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:
[1]Single anchor with static tension load only
[2]Concrete determined to remain uncracked for the life of the anchorage
[3]Load combinations from ACI 318-14 5.3 or ACI 318-11 9.2, as applicable (no seismic loading)
[4]30% dead load and 70% live load, controlling load combination 1.2 D + 1.6 L
[5]Calculation of weighted average for α = 0.3 x 1.2 + 0.7 x 1.6 = 1.48
[6]f'_c = 2,500 psi (17.2 MPa) (normal weight concrete)
[7]$h \geq h_{min}$
[8]Condition B according to ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, where no supplementary reinforcement is present
[9]$c_{a1} = c_{a2} \geq c_{ac}$

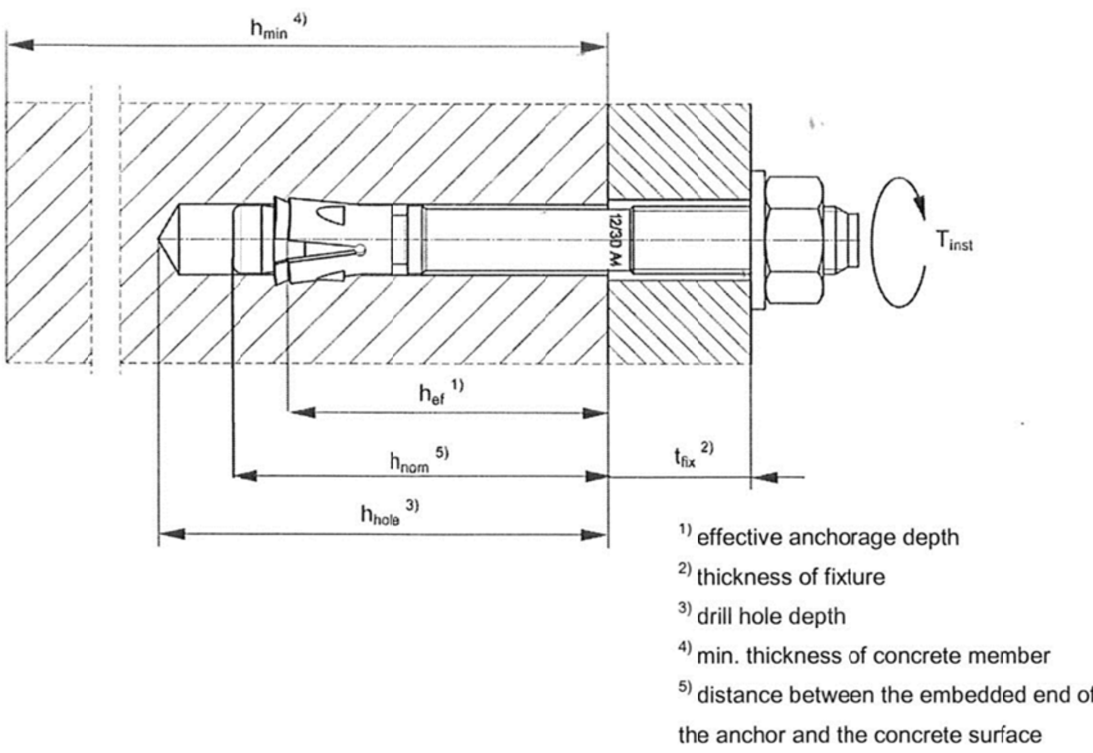


FIGURE 1—INSTALLED ANCHOR FAZ II

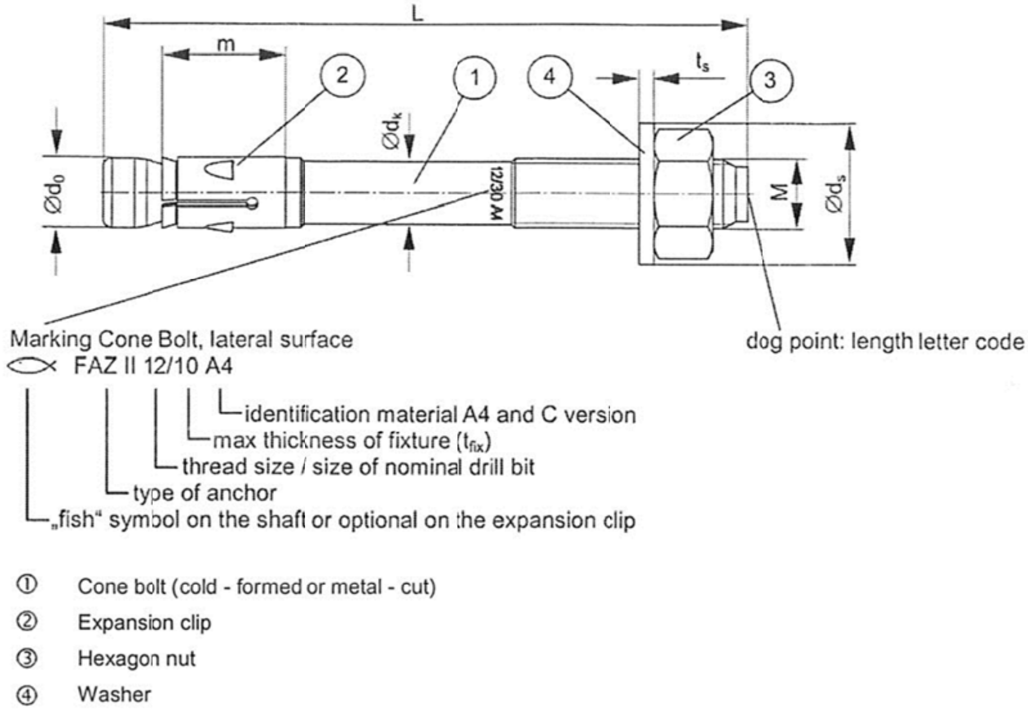


FIGURE 2—MARKING AND COMPONENTS OF THE FAZ II

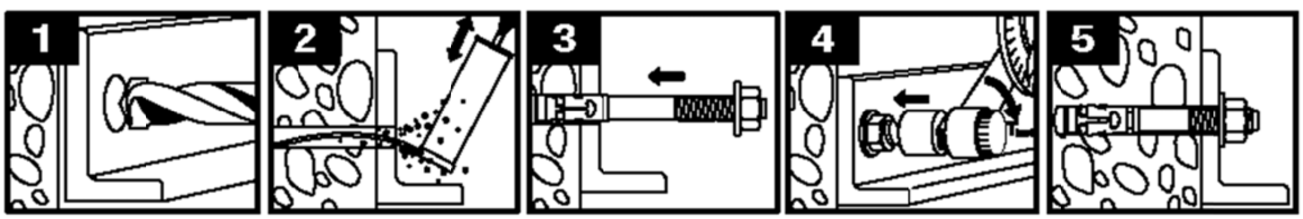


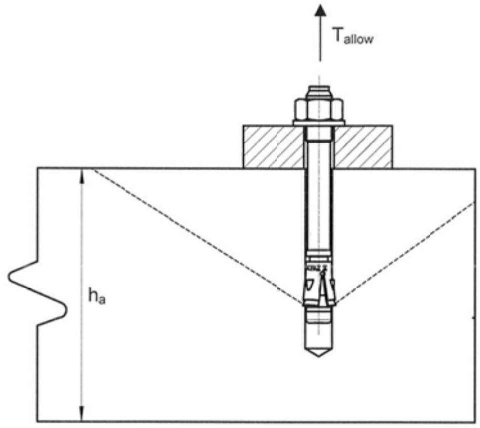
FIGURE 3—INSTALLATION OF THE FAZ II

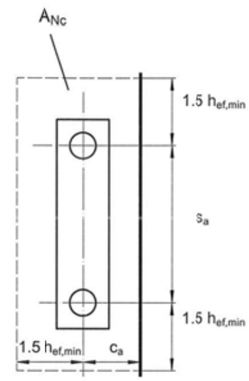
Step 1: Drill the hole by using the correct metric bit diameter **(see Table 2),** drill hole to minimum required hole depth h_{hole} **(see Table 2)** or deeper
Step 2: Remove drilling debris with a blowout bulb or with compressed air.
Step 3: Using a hammer, tap the anchor through the part being fastened 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 318-14 17.3.3 (c)
or ACI 318-11 D.4.3 (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.





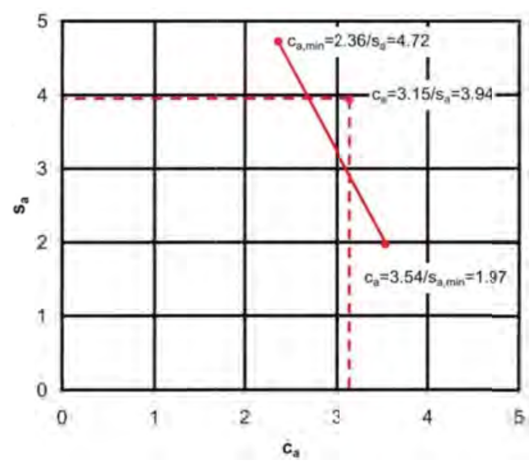
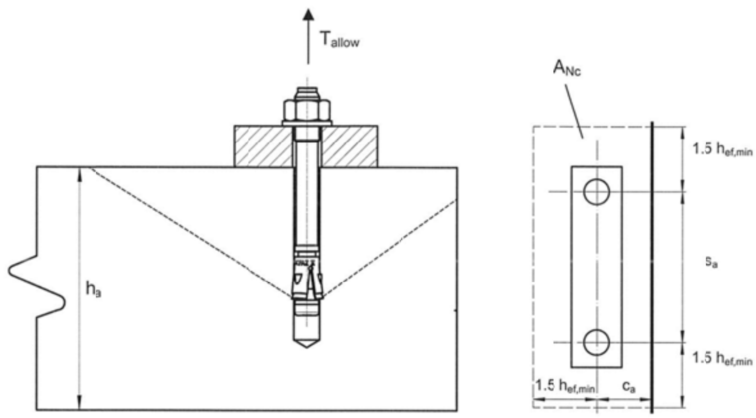
Calculation according to ACI 318-14, ACI 318-11 and this report:	ACI Ref. 318-14	ACI Ref. 318-11	Report Ref.
Step 1. Verify minimum member thickness, spacing and edge distance: Table 2: h_a = 4.72 in. $\geq h_{a,min}$= 4.72 in. => ok slope: $\frac{4.72-1.97}{2.36-3.54}=-2.3$ For c_a = 3.15 in. $s_{min,calc}$= [(3.15-3.94)x(-2.3)]+1.97 =3.79 in. $\leq$ s_a = 3.94 in. => ok 	17.7	D.8	Table 2
Step 2. Calculate steel strength of anchor in tension N_{sag} = n N_{sa} = 16,636 lbf Calculate steel capacity $\phi\ N_{sag}$ = 0.75 * 16,636 = 12,477 lbf	17.4.1.2 17.3.3(a)	D.5.1.2 D.4.3(a)	Table 3
Step 3. Calculate concrete breakout strength of anchor in tension $N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \times \psi_{ec,N} \times \psi_{ed,N} \times \psi_{c,N} \times \psi_{cp,N} \times N_b$	17.4.2.1 (b)	D.5.2.1 (b)	§ 4.1.3 § 4.1.4
Step 3a. Calculate A_{Nc0} and A_{Nc} A_{Nc0} = 9x h_{ef}^2 = 9x(2.76)^2 = 68.36 in.^{2} A_{Nc} = (1.5 h_{ef} + c) x (3 h_{ef} + s) A_{Nc} = (1.5x2.76+3.15) x (3x2.76 + 3.94)=88.89 in.^{2} < 2x A_{Nc0}	17.4.2.1 (b)	D.5.2.1 (b)	Table 3
Step 3b. Calculate $\psi_{ec,N}$: e'_N= 0 => $\psi_{ec,N}$ =1	17.4.2.4	D.5.2.4	-
Step 3c. Calculate $N_b = k_{cr}\ \lambda_a \sqrt{f'_c}\ h_{ef}^{1.5}$ = 17 x 1.0 x $\sqrt{5{,}076}$ x 2.76$^{1.5}$ = 5,452 lbf	17.4.2.2	D.5.2.2	Table 3
Step 3d. Calculate modification factor for edge distance: 1.5 h_{ef} = 1.5x2.76=4.14 in. > c $\therefore \psi_{ed,N}$ must be calculated $\psi_{ed,N} = 0.7 + 0.3\frac{c_{a,min}}{1.5 \times h_{ef}} = 0.7 + 0.3 \times \frac{3.15}{1.5 \times 2.76} = 0.929$ < 1	17.4.2.5	D.5.2.5	Table 2
Step 3e. $\psi_{c,N}$ = 1.0 (cracked concrete)	17.4.2.6	D.5.2.6	Table 3
Step 3f. $\psi_{cp,N}$ = 1.0	17.4.2.7	D.5.2.7	Table 3
Step 3g. Calculate N_{cbg} = (88.89/68.36)x1x0.929x1x5,452= 6,587 lbf	17.4.2.1 (b)	D.5.2.1 (b)	§4.1.3 Table 3
Step 4. Check: Seismic tension is not decisive. $N_{cbg} = N_{eq}$	-		Table 3
Step 5. Controlling strength: $\phi\ N_{cbg}$ = 0.75 x 6,587 = 4,941 lbf < $\phi\ N_{sag}$ = 12,477 lbf	17.3.3(c)	D.4.3(c)	Table 3
Step 6. Calculate allowable stress design (30% dead load, 70% live load) α=1.2x0.3+1.6x0.7=1.48 -> $T_{allowable,ASD}$ = 4,941 / 1.48 = 3,338 lbf	5.3	9.2	§4.2

FIGURE 4—EXAMPLE CALCULATION TENSION ACCORDING TO ACI 318-14, ACI 318-11 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 318-14 17.3.3 (c)
or ACI 318-11 D.4.3 (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.



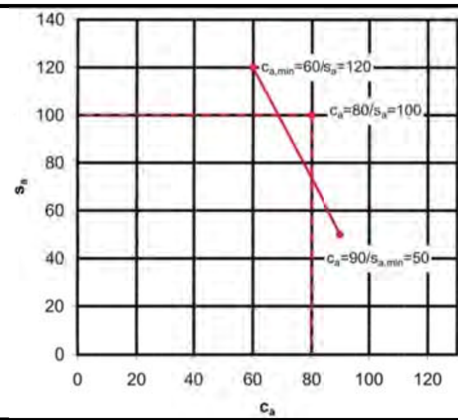
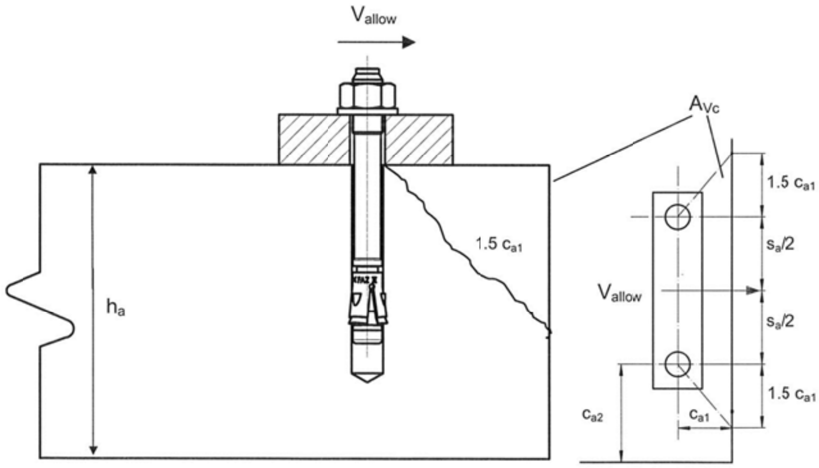
Calculation according to ACI 318-14, ACI 318-11 and this report:	ACI Ref. 318-14	ACI Ref. 318-11	Report Ref.
Step 1. Verify minimum spacing and edge distance: Table 2: h_a = 120 mm $\geq h_{a,min}$= 120 mm => ok slope: $\frac{120-50}{60-90} = -2.3$ For c_a = 80 mm $s_{min,calc}$= [(80-100)x(-2.3)]+50 =96mm. $\leq$ s_a = 100 mm => ok 	17.7	D.8	Table 2
Step 2. Calculate steel strength of anchor in tension N_{sag} = n N_{sa} = 74 kN Calculate steel capacity ϕ N_{sag} = 0.75 * 74 = 55.5 kN	17.4.1.2 17.3.3(a)	D.5.1.2 D.4.3(a)	Table 3
Step 3. Calculate concrete breakout strength of anchor in tension $N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \times \psi_{ec,N} \times \psi_{ed,N} \times \psi_{c,N} \times \psi_{cp,N} \times N_b$	17.4.2.1 (b)	D.5.2.1 (b)	§ 4.1.3 § 4.1.4
Step 3a. Calculate A_{Nc0} and A_{Nc} A_{Nc0} = 9x h_{ef}^2 = 9x$(70)^2$ = 44,100 mm² A_{Nc} = (1.5 h_{ef} + c) x (3 h_{ef} + s) A_{Nc} = (1.5x70+80) x (3x70 + 100)=57,350mm² < 2x A_{Nc0}	17.4.2.1 (b)	D.5.2.1(b)	Table 3
Step 3b. Calculate $\psi_{ec,N}$: e'_N= 0 => $\psi_{ec,N}$ =1	17.4.2.4	D.5.2.4	-
Step 3c. Calculate $N_b = k_c \lambda_a \sqrt{f'_c}\ h_{ef}^{1.5}$ = 7.1 x 1.0 x $\sqrt{35}$ x $70^{1.5}$ N_b = 24,600 N = 24.6 kN	17.4.2.2	D.5.2.2	Table 3
Step 3d. Calculate modification factor for edge distance: 1.5 h_{ef} = 1.5x70=105 mm > c $\therefore \psi_{ed,N}$ must be calculated $\psi_{ed,N} = 0.7 + 0.3\frac{c_{a,min}}{1.5 \times h_{ef}} = 0.7 + 0.3 \times \frac{80}{1.5 \times 70} = 0.929 < 1$	17.4.2.5	D.5.2.5	Table 2
Step 3e. $\psi_{c,N}$ = 1.0 (cracked concrete)	17.4.2.6	D.5.2.6	Table 3
Step 3f. $\psi_{cp,N}$ = 1.0	17.4.2.7	D.5.2.7	Table 3
Step 3g. Calculate N_{cbg} = (57,350/44,100)x1x0.929x1x24.6= 29.72 kN	17.4.2.1 (b)	D.5.2.1 (b)	§4.1.3 Table 3
Step 4. Check: Seismic tension is not decisive. $N_{cbg} = N_{eq}$	-		Table 3
Step 5. Controlling strength: ϕ N_{cbg} = 0.75 x 29.72 = 22.29 kN < ϕ N_{sag} = 55.5 kN	17.3.3(c)	D.4.3(c)	Table 3
Step 6. Calculate allowable stress design (30% dead load, 70% live load) α=1.2x0.3+1.6x0.7=1.48 -> $T_{allowable,ASD}$ = 22.29/ 1.48 = 15.06 kN	5.3	9.2	§4.2

FIGURE 5—EXAMPLE CALCULATION TENSION ACCORDING TO ACI 318-14, ACI 318-11 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 318-14 17.3.3 (c) or ACI 318-11 D.4.3 (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.



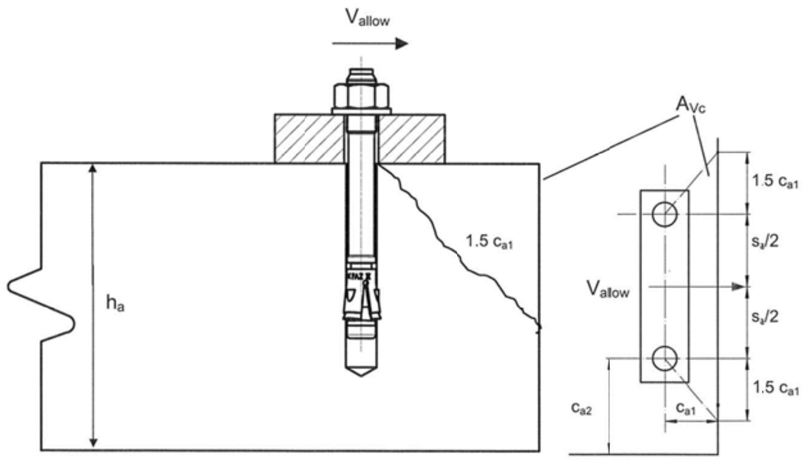
Calculation according to ACI 318-14, ACI 318-11 and this report:	ACI Ref. 318-14	ACI Ref. 318-11	Report Ref.
Step 1. Verify minimum spacing and edge distance according to Figure 4 – Tension (Step 1)	17.7	D.8	Table 2
Step 2. Calculate steel strength of anchor in shear V_{sag} = n V_{sa} = 13,938 lbf Calculate steel capacity ϕ V_{sag} = 0.65 * 13,938 = 9,060 lbf	17.5.1.2 17.3.3(b)	D.6.1.2 D.4.3(b)	Table 3
Step 3. Calculate concrete breakout strength of anchor in shear $V_{cbg} = \frac{A_{Vc}}{A_{Vc0}} \times \psi_{ec,V} \times \psi_{ed,V} \times \psi_{c,V} \times V_b$	17.5.2.1 (b)	D.6.2.1 (b)	§ 4.1.7
Step 3a. Check 3 c_{a1} = 3x3.15=9.45 in. > s = 3.94 in. s controls 1.5 c_{a1} = 1.5x3.15=4.73 in. < h_a c_{a1} controls 1.5 c_{a1} < c_{a2} c_{a1} controls	17.5.2.1	D.6.2.1	-
Step 3b. Calculate A_{Vc0} and A_{Vc} A_{vc} = h_a x (3c_{a1} + s_a) = 4.72 x (3x3.15 +3.91)=63.1 in.² A_{Vco} = 4.5 x c_{a1}^2 = 4.5x(3.15)^2 = 44.64 in.²	17.5.2.1	D.6.2.1	-
Step 3c. Calculate $\psi_{ec,v}$: e'_V= 0 => $\psi_{ec,v}$ =1	17.5.2.5	D.6.2.5	-
Step 3d. Calculate $V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2}\sqrt{d_a}\right)\lambda_a\sqrt{f'c}(c_{a1})^{1.5}$ $V_b = \left(7\left(\frac{2.76}{0.47}\right)^{0.2} \times \sqrt{0.47}\right) \times 1.0 \times \sqrt{5{,}076} \times (3.15)^{1.5} = 2{,}810\ lbf$	17.5.2.2	D.6.2.2	§ 4.1.7
Step 3e. Calculate modification factor for edge distance: $\Psi_{ed,V} = 1 \qquad c_{a2} \geq 1.5 \times c_{a1}$	17.5.2.6	D.6.2.6	-
Step 3f. $\psi_{c,V}$ = 1.0 (cracked concrete)	17.5.2.7	D.6.2.7	-
Step 3g. Calculate V_{cbg} = (63.1/44.64)x1x1x2,810 = 3,979 lbf	17.5.2.1 (b)	D.6.2.1 (b)	-
Step 3h. Calculate ϕ V_{cbg} = 3,979 lbf x 0.7= 2,788 lbf	17.3.3 (c)	D.4.3 (c)	Table 3
Step 4. Calculate Pryout: ϕ V_{cpg} = ϕ k_{cp} x N_{cbg} = 0.7 x 2 x 6,587 = 9,217 lbf (N_{cbg} According to Figure 4 (Step 3g) = 6,587 lbf; k_{cp} = 2 for h_{ef} > 2.5 in.)	17.5.3.1 (b)	D.6.3.1 (b)	§4.1.8
Step 5. Controlling strength: ϕ V_n = min | ϕ $\mathbf{V_{cpg}}$ ϕ V_{cbg} ϕ V_{sag} | = 2,788 lbf (static)	17.3.1.1	D.4.1.1	-
Step 6. Seismic shear steel capacity: ϕ $V_{s,eq}$ = 0.65 x 2 x 6,295 = 8,183 lbf > ϕ V_n static concrete strength controls	-		§4.1.10
Step 7. Calculate allowable stress design (30% dead load, 70% live load) α=1.2x0.3+1.6x0.7=1.48 -> $V_{allowable,ASD}$ = 2,788 / 1.48 = 1,884 lbf	5.3	9.2	§4.2

FIGURE 6—EXAMPLE CALCULATION SHEAR ACCORDING TO ACI 318-14, ACI 318-11 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 318-14 17.3.3 (c) or ACI 318-11 D.4.3 (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 318-14, ACI 318-11 and this report:	ACI Ref. 318-14	ACI Ref. 318-11	Report Ref.
Step 1. Verify minimum spacing and edge distance according to Figure 5 – Tension (Step 1)	17.7	D.8	Table 2
Step 2. 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	17.5.1.2 17.3.3(b)	D.6.1.2 D.4.3(b)	Table 3
Step 3. Calculate concrete breakout strength of anchor in shear $V_{cbg} = \frac{A_{Vc}}{A_{Vc0}} \times \psi_{ec,V} \times \psi_{ed,V} \times \psi_{c,V} \times V_b$	17.5.2.1 (b)	D.6.2.1 (b)	§ 4.1.7 § 4.1.8
Step 3a. Check 3 c_{a1} = 3x80=240 mm > s = 100 mm s controls 1.5 c_{a1} = 1.5x80=120 mm < h_a c_{a1} controls 1.5 $c_{a1} < c_{a2}$ c_{a1} controls	17.5.2.1	D.6.2.1	-
Step 3b. Calculate A_{Vc0} and A_{Vc} $A_{vc} = h_a$ x $(3c_{a1} + s_a)$ = 120 x (3x80 + 100)=40,800mm² A_{Vco} = 4.5 x c_{a1}^2 = 4.5x$(80)^2$ = 28,800 mm²	17.5.2.1	D.6.2.1	-
Step 3c. Calculate $\psi_{ec,v}$: e'_V= 0 => $\psi_{ec,v}$ =1	17.5.2.5	D.6.2.5	-
Step 3d. Calculate $V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2}\sqrt{d_a}\right)\lambda_a\sqrt{f'c}(c_{a1})^{1.5}$ $V_b = \left(7\left(\frac{70}{12}\right)^{0.2} \times \sqrt{12}\right) \times 1.0 \times \sqrt{35} \times (80)^{1.5} = 12.5\ kN$	17.5.2.2	D.6.2.2	§ 4.1.7
Step 3e. Calculate modification factor for edge distance: $\Psi_{ed,V} = 1 \qquad c_{a2} \geq 1.5 \times c_{a1}$	17.5.2.6	D.6.2.6	-
Step 3f. $\psi_{c,V}$ = 1.0 (cracked concrete)	17.5.2.7	D.6.2.7	-
Step 3g. Calculate V_{cbg} = (40,800/28,800)x1x1x12.5 = 17.7 kN	17.5.2.1 (b)	D.6.2.1 (b)	-
Step 3h. Calculate $\phi\ V_{cbg}$ = 17.7 kN x 0.7 = 12.4 kN	17.3.3 (c)	D.4.3 (c)	Table 3
Step 4. Calculate Pryout: $\phi\ V_{cpg} = \phi$ x k_{cp} x N_{cbg} = 0.7 x 2 x 29.72 = 41.6 kN (N_{cbg} According to Figure 5 (Step 3g) = 29.72 kN; k_{cp} = 2 for h_{ef} > 63 mm)	17.5.3.1 (b)	D.6.3.1 (b)	§ 4.1.8
Step 5. Controlling strength: $\phi\ V_n = \min \mid \phi\ V_{cpg}\ \phi\ V_{cbg}\ \phi\ V_{sg} \mid$ = 12.4 kN (static)	17.3.1.1	D.4.1.1	-
Step 6. Seismic shear steel capacity: $\phi\ V_{s,eq}$ = 0.65 * 2 x 28 = 36.4 kN > $\phi\ V_n$ static concrete strength controls	-		§ 4.1.10
Step 7. Calculate allowable stress design (30% dead load, 70% live load) α=1.2x0.3+1.6x0.7=1.48 -> $V_{allowable,ASD}$ = 12.4 / 1.48 = 8.38 kN	5.3	9.2	§4.2

FIGURE 7—EXAMPLE CALCULATION SHEAR ACCORDING TO ACI 318-14, ACI 318-11 AND THIS REPORT (SI UNITS)