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DIVISION: 03–CONCRETE
Section: 03151–Concrete Anchoring

REPORT HOLDER:

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EVALUATION SUBJECT:

FISCHER FIS EM 390 S ADHESIVE ANCHORS FOR UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2006 *International Building Code®* (2006 IBC)
- 2006 *International Residential Code®* (2006 IRC)
- 2003 *International Building Code®* (2003 IBC)
- 2003 *International Residential Code®* (2003 IRC)
- 2000 *International Building Code®* (2000 IBC)
- 2000 *International Residential Code®* (2000 IRC)
- 1997 *Uniform Building Code™* (UBC)

Property evaluated:

Structural

2.0 USES

Fischer FIS EM 390 S Adhesive Anchors are used to resist static wind or earthquake (as noted in Section 5.14 in this report) tension and shear loads in uncracked normal-weight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa). Uncracked concrete in the region of the anchors may be assumed, if analysis indicates no cracking at service load level. (See Section 5.5 in this report for additional details.) The anchor system is an alternative to cast-in-place anchors described in Sections 1911 and 1912 of the 2006 IBC, Sections 1912 and 1913 of the 2000 and 2003 IBC, and Section 1923 of the 1997 UBC. The anchor systems may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the 2006 IRC, Section R301.1.3 of the 2003 IRC, or Section R301.1.2 of the 2000 IRC.

3.0 DESCRIPTION

3.1 General:

The Fischer FIS EM 390 S Adhesive Anchor System is comprised of the following components:

- Fischer FIS EM 390 S and Fischer EM 1000 S adhesive packaged in cartridges
- Adhesive mixing and dispensing equipment
- Equipment for hole cleaning and adhesive injection

Fischer FIS EM 390 S adhesive may only be used with continuously threaded rods described in this report or deformed steel reinforcing bars. The primary components of the fischer adhesive anchor system, including the Fischer FIS EM 390 S Adhesive, mixer and 2 anchoring elements are shown in Figure 2 of this report.

Installation information and parameters, as included with each adhesive unit package, are replicated as Figure 4 of this report

3.2 Materials:

3.2.1 Fischer FIS EM 390 S Adhesive: Fischer FIS EM 390 S Adhesive is an injectable, epoxy adhesive. The two components are contained in a dual-chambered cartridge. The two components combine and react when dispensed through a static mixer attached to the manifold. The system is labeled Fischer FIS EM 390 S (13.2 oz. (390 ml)), or Fischer FIS EM 1100 S (37.2 oz. (1100 ml)). In this report, both systems are denoted as fischer FIS EM 390 S. The cartridge is stamped with the adhesive expiration date. The shelf life, as indicated by the expiration date, corresponds to an unopened pack stored in a dry, dark environment. Storage temperature of the adhesive is 41°F to 77°F (5°C to 30°C). Short-term (less than 48-hour) temperature variations during adhesive storage are permitted as long as the temperature remains between 41°F and 105°F (5°C and 40°C).

3.2.2 Hole cleaning equipment: Hole cleaning equipment must be in accordance with Figure 4 of this report.

3.2.3 Dispensers: Fischer FIS EM adhesive must be dispensed with manual dispensers or pneumatic dispensers provided by fischerwerke.

3.2.4 Anchor elements:

3.2.4.1 Threaded steel rods: Threaded steel rods must be clean, continuously threaded rods (all-thread) in diameters as described in Table 5 of this report. Specifications for permissible grades of threaded rod and associated nuts are provided in Table 2 and Table 3. Carbon steel threaded rods are furnished with a 5 µm thick zinc electroplate coating complying with ASTM B 633 SC 1. Threaded steel rods must be straight and free of indentations or other defects along their length. The end may be stamped with identifying marks and the embedded end may be flat cut or cut on the bias (chisel point).

3.2.4.2 Reinforcing bars: Steel reinforcing bars are deformed bars (rebar). Table 8 summarizes reinforcing bar size ranges. See Table 4 for specifications of permitted reinforcing bar types and grade. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust and other coatings that impair the bond with the adhesive. Reinforcing bars must not be bent after installation.

3.2.4.3 Ductility: In accordance with ACI 318-05 (ACI 318) Appendix D, in order for a steel element to be considered ductile, the tested elongation must be at least 14 percent and reduction of area must be at least 30 percent. Steel elements with a tested elongation less than 14 percent or a reduction of area less than 30 percent are considered brittle. Values for various common steel materials are provided in Table 2 and Table 3 of this report.

Due to the elongation valves, carbon steel threaded rods (steel class 5.8 and 8.8) must be considered as nonductile stainless steel threaded rods (steel class A4-70).

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: Design strengths are determined in accordance with ACI 318-05 Appendix D (ACI 318) and this report. Design examples are given in Figures 3 and 4 of this report. Table 1 provides an index to the design strengths. Design parameters including strength reduction factors, ϕ, corresponding to each limit state and anchor steel are provided in Tables 5 through 10 of this report. The anchor design must satisfy the requirements of ACI 318 Sections D.4.1.1 and D4.1.2. Strength reduction factors ϕ as described in ACI 318 D.4.4 must be used for load combinations calculated in accordance with Section 1612.2.1 of the UBC or Section 1605.2.1 of the IBC. Strength reduction factors, ϕ ,as described in ACI 318 D.4.5 must be used for load combinations calculated in accordance with Section 1909.2 of the UBC.

This section provides amendments to ACI 318, Appendix D, as required for the strength design of adhesive anchors. In conformance with ACI 318, all equations are expressed in inch-pound units.

Modify ACI 318 D.4.1.2 as follows:

D.4.1.2 – In Eq. (D-1) and (D-2), ϕN_n and ϕV_n are the lowest design strengths determined from all appropriate failure modes. ϕN_n is the lowest design strength in tension of an anchor or group of anchors as determined from consideration of: ϕN_{sa}, either ϕN_a or ϕN_{ag} and either ϕN_{cb} or ϕN_{cbg}. ϕV_n is the lowest design strength in shear of an anchor or a group of anchors as determined from consideration of ϕV_{sa}, either ϕV_{cb}, or ϕV_{cbg} and either ϕV_{cp} or ϕV_{cpg}.

Add ACI 318 D.4.1.4 as follows:

D.4.1.4 – For adhesive anchors subjected to tension resulting from sustained loading, a supplementary design analysis shall be performed using Eq. (D-1) whereby N_{ua} is determined from the sustained load alone, e.g., the dead load and that portion of the live load acting that may be considered as sustaining and ϕN_n is determined as follows:

D.4.1.4.1 – For single anchors, $\phi N_n = 0.75\phi N_{a0}$

D.4.1.4.2 – For anchor groups, Eq. (D-1) shall be satisfied by taking $\phi N_n = 0.75\phi N_{a0}$ for that anchor in an anchor group that resists the highest tension load.

D.4.1.4.3 – Where shear loads act concurrently with the sustained tension load, interation of tension and shear shall be analyzed in accordance with D.4.1.3

4.1.2 Static Steel Strength in Tension: The nominal strength of an anchor in tension as governed by the steel, N_{sa}, in accordance with ACI 318 D.5.1.2 is given in in Tables 5 and 8 for the corresponding anchor steel.

4.1.3 Static Concrete Breakout Strength in Tension: The nominal concrete breakout strength in tension, N_{cb} *or* N_{cbg}, must be calculated in accordance with ACI 318 D.5.2, with the following addition:

D.5.2.9 – The limiting concrete strength of adhesive anchors in tension shall be calculated in accordance with D.5.2.1 to D.5.2.8 where the value of k_c to be used in Eq. (D-7) shall be:

$k_{c,unc}$ = 24 (SI-units) or 10 (Imperial units) where analysis indicates no cracking ($f_t \le f_c$) at service load levels in the anchor vicinity (uncracked concrete)

The basic concrete breakout strength in tension, N_b, must be calculated in accordance with ACI 318 Section 5.2.2 using the values of h_{ef} and k_c as described in Table 6 and 9 of this report. The value of f'_c, for calculation purposes, must be limited to 8000 psi (55.1 MPa).

4.1.4 Static Pullout Strength in Tension: In lieu of determining the nominal pullout strength in accordance with ACI 318 D.5.3, nominal bond strength in tension must be calculated in accordance with the following sections added to ACI 318 using values described in Tables 7 and 10 of this report.

D.5.3.7 – The nominal bond strength of an adhesive anchor, N_a, or group of adhesive anchors, N_{ag}, in tension shall not exceed

(a) For a single anchor

$$N_a = \frac{A_{Na}}{A_{Na0}} \cdot \Psi_{p,Na} \cdot \Psi_{ed,Na} \cdot N_{a0} \qquad \text{(D-16a)}$$

(b) For a group of anchors

$$N_{ag} = \frac{A_{Na}}{A_{Na0}} \cdot \Psi_{ed,Na} \cdot \Psi_{g,Na} \cdot \Psi_{ec,Na} \cdot \Psi_{p,Na} \cdot N_{a0} \qquad \text{(D-16b)}$$

where

A_{Na} is the projected area of the failure surface for the anchor or group of anchors that shall be approximated as the base of the rectilinear geometrical figure that results from projecting the failure surface outward a distance from the centerlines of the anchor, or in the case of a group of anchors, from a line through a row of adjacent anchors. A_{Na} shall not exceed nA_{Na0} where n is the number of anchors in tension in the group. In ACI 318 Figures RD.5.2.1a and RD.5.2.1.b, the terms $1.5h_{ef}$ and $3.0h_{ef}$ shall be replaced with $c_{cr,Na}$ and $s_{cr,Na}$ respectively.

A_{Na0} is the projected area of the failure surface of a single anchor without the influence of proximate edges in accordance with Eq. (D-16c):

$$A_{Na0} = \left(s_{cr,Na}\right)^2 \quad \text{(D-16c)}$$

with $s_{cr,Na}$ = given by Eq. (D-14h) and Table 7 and Table 10 respectively

D.5.3.8 – The critical spacing and edge distance must be calculated as follows:

$$s_{cr,Na} = 20 \cdot d \cdot \sqrt{\frac{\tau_{k,uncr}}{1{,}450}} \leq 3 \cdot h_{ef} \quad \text{(D-16d)}$$

$$c_{cr,Na} = \frac{s_{cr,Na}}{2} \quad \text{(D-16e)}$$

D.5.3.9. - The basic strength of a single adhesive anchor in tension in uncracked concrete shall not exceed:

$$N_{a0} = \tau_{k,uncr} \cdot \pi \cdot d \cdot h_{ef} \quad \text{(D-16f)}$$

D.5.3.10 - The modification factor for the influence of the failure surface of a group of adhesive anchors is:

$$\psi_{g,Na} = \psi_{g,Na0} + \left[\left(\frac{s}{s_{cr,Na}}\right)^{0,5} \cdot \left(1 - \psi_{g,Na0}\right)\right] \quad \text{(D-16g)}$$

where

$$\psi_{g,Na0} = \sqrt{n} - \left[\left(\sqrt{n} - 1\right) \cdot \left(\frac{\tau_{k,uncr}}{\tau_{k,max,uncr}}\right)^{1,5}\right] \geq 1.0 \quad \text{(D-16h)}$$

n = the number of tension loaded adhesive anchors in a group

$$\tau_{k,max,uncr} = \frac{k_{c,uncr}}{\pi \cdot d}\sqrt{h_{ef} \cdot f_c'} \quad \text{(D-16i)}$$

D.5.3.11 - The modification factor for eccentrically loaded adhesive anchor groups is:

$$\psi_{ec,Na} = \frac{1}{1 + \frac{2e'_N}{s_{cr,Na}}} \leq 1.0 \quad \text{(D-16j)}$$

Eq. (D-16j) is valid for $e'_N \leq \frac{s}{2}$

If the loading on an anchor group is such that only certain anchors are in tension, only those anchors that are in tension shall be considered when determining the eccentricity, e'_N, for use in Eq. (D-14n)

In the case where eccentricity loading exists about two orthogonal axes, the modification factor $\psi_{ec,Na}$ must be computed for each axis individually and the product of these factors used as $\psi_{ec,Na}$ in Eq. (D-16b)

D.5.3.12 – The modification factor for the edge effects of single adhesive anchors or anchor groups loaded in tension is

for $c_{a,min} \geq c_{cr,Na}$

$$\psi_{ed,Na} = 1.0 \quad \text{(D-16l)}$$

or for $c_{a,min} < c_{cr,Na}$

$$\psi_{ed,Na} = \left(0.7 + 0.3 \cdot \frac{c_{a,min}}{c_{cr,Na}}\right) \leq 1.0 \quad \text{(D-16m)}$$

D.5.3.13 – When an adhesive anchor or a group of adhesive anchors is located in a region of a concrete member where analysis indicates no cracking at service load levels, the nominal strength N_a or N_{ag} of a single adhesive anchor or a group of adhesive anchors shall be calculated according to Eq. (D-16a) and Eq. (D-16b). $\tau_{k,uncr}$ shall be established based on tests in accordance with AC308. The factor $\psi_{g,Na0}$ shall be calculated in accordance with Eq. (D-16h) whereby the value of $\tau_{k,\max,uncr}$ shall be calculated in accordance with Eq. (D-16n) and substituted for $\tau_{k,\max,uncr}$ in Eq. (D-16h).

$$\tau_{k,\max,uncr} = \frac{k_{c,uncr}}{\pi \cdot d}\sqrt{h_{ef} \cdot f_c'} \quad \text{(D-16n)}$$

D.5.3.14 – The modification factor for the influence of splitting shall be taken as

$$\psi_{p,Na} = 1.0 \text{ when } c_{a,min} \geq c_{ac} \quad \text{(D-16o)}$$

$$\psi_{p,Na} = \frac{max\left|c_{a,min}; c_{cr,Na}\right|}{c_{ac}} \text{ when } c_{a,min} < c_{ac} \quad \text{(D-16p)}$$

The values of C_{ac} and $C_{a,min}$ must be as noted in Tables 6 and 9. The values of $C_{cr,na}$ are determined using equation D-16e.

Additional information for the determination of nominal bond strength in tension is given in Section 4.1.8

4.1.5 Static Steel Strength in Shear: The nominal static strength of an anchor in shear as governed by the steel, V_{sa}, in accordance with ACI 318 D.6.1.2 is given in the tables outlined in Table 1 for the corresponding anchor steel.

4.1.6 Static Concrete Breakout Strength in Shear: The nominal concrete breakout strength in shear, V_{cb}, or V_{cbg}, must be calculated in accordance with ACI 318 D.6.2 based on information given in the tables outlined in Table 1 of the corresponding anchor steel.

4.1.7 Static Concrete Pryout Strength in Shear: In lieu of determining the nominal pryout strength in accordance with ACI 318 D.6.3.1, the nominal pryout strength in shear must be calculated in accordance with the following sections added to ACI 318, Appendix D:

D.6.3.2 – The nominal pryout strength of an adhesive anchor or group of adhesive anchors must not exceed

(a) for a single adhesive anchor

$$V_{cp} = min\left|k_{cp} \cdot N_a; k_{cp} \cdot N_{cb}\right| \quad \text{(D-30a)}$$

(c) for a group of adhesive anchors

$$V_{cpg} = min\left|k_{cp} \cdot N_{ag}; k_{cp} \cdot N_{cbg}\right| \quad \text{(D-30b)}$$

where

k_{cp} = 1.0 for h_{ef} < 2.5 in. (64 mm)

k_{cp} = 2.0 for h_{ef} ≥ 2.5 in. (64mm)

N_a shall be calculated in accordance with Eq. (D-16a)

N_{ag} shall be calculated in accordance with Eq. (D-16b)

N_{cb}, N_{cbg} are determined in accordance with D.5.2.1

4.1.8 Bond Strength Determination: Bond strength values are a function of installation conditions (dry, water saturated). They are given in Table 7 (metric threaded rods) and Table 10 (reinforcement bars). The characteristic bond strength must be multiplied with the strength reduction factors ϕ_d (installation in dry concrete) or ϕ_{WS} (installation in water saturated concrete). The bond strength must be modified with the factor κ for cases where the holes are drilled in water saturated concrete as follows:

concrete	Hole drilling method	permissible installation conditions	bond strength	Associated strength reduction factor
uncracked	Hammer drilled	dry concrete	$\tau_{k,uncr}$	ϕ_d
		water-saturated	$\tau_{k,uncr} \cdot \kappa_{ws}$	ϕ_{ws}

4.1.9 Minimum Member Thickness, h_{min}, Anchor Spacing, s_{min}, and Edge Distance, c_{min}: In lieu of ACI 318 D.8.3, values of c_{min} and s_{min} described in this report (Tables 6 and 9) must be observed for anchor design and installation. In lieu of ACI 318 D.8.5, the minimum member thickness, h_{min}, described in this report (Table 6 and Table 9) must be observed for anchor design and installation. In determining minimum edge distances, c_{min}, the following section must be added to ACI 318, Appendix D:

D.8.8 – For adhesive anchors that will remain untorqued, the minimum edge distances shall be based on minimum cover requirements for reinforcement in 7.7. For adhesive anchors that will be torqued, the minimum edge distance and spacing shall be taken as described in this report.

4.1.10 Critical Edge Distance, c_{ac}: The critical edge distances, c_{ac}, is given in Table 6 (metric threaded rods and Table 9 (reinforcing bars).

4.1.11 Interaction of Tensile and Shear Forces: For the designs that include combined tension and shear, the interaction of tension and shear must be calculated in accordance with ACI 318 D.7

4.2 Allowable Stress Design:

Design values for use with allowable stress design load combinations (working stress design) calculated in accordance with Section 1612.3 of the UBC or Section 1605.3 of the 2006 IBC shall be established as follows:

$T_{allowable,ASD} = \phi N_n/\alpha$ *(Eq.5)*

and

$V_{allowable,ASD} = \phi V_n/\alpha$ *(Eq. 6)*

where:

$T_{allowable,ASD}$ = Allowable tension load (lbf or kn)

$V_{allowable,ASD}$ = Allowable shear load (lbf or kn)

ϕN_n = The lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 Appendix D as amended in Section 4.1 of this report and Section 1908.1.16 of the IBC.

ϕV_n = The lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 Appendix D as amended in Section 4.1 of this report and Section 1908.1.16 of the IBC.

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination.

Limits on edge distance, anchor spacing and member thickness as given in Table 6 and Table 9 of this report must be applied. An example calculation for the derivation of Allowable Stress Design tension values is given in Tables 11 and 12 and in Figures 3 and 4.

4.2.1 Interaction: In lieu of ACI 318 D.7.1, D.7.2 and D.7.3, interaction must be calculated as follows:

For shear loads $V \le 0.2 \cdot V_{allow,ASD}$, the full allowable load in tension $T_{allow,ASD}$ may be taken.

For tension loads $T \le 0.2 \cdot T_{allow,ASD}$, the full allowable load in shear, $V_{allow,ASD}$, may be taken.

For all other cases:

$$\frac{T}{T_{allow,ASD}} + \frac{V}{V_{allow,ASD}} \le 1.2 \qquad (22)$$

4.3 Installation:

Installation parameters are illustrated in Figure 1. Overhead installations are limited to threaded rods less than or equal to M24. Installation of the Fischer FIS EM 390 S Adhesive Anchor System must conform to the manufacturer's published installation instructions included in each unit package as described in Figure 4 of this report.

4.4 Special Inspection:

Periodic special inspection must be performed where required in accordance with Sections 1704.4 and 1704.13 of the 2000, 2003 or 2006 IBC or Section 1701.5 of the UBC whereby periodic special inspection is defined in Section 1702.1 of the 2000, 2003 and 2006 IBC or Section 1701.6.2 of the UBC and this report. The special inspector must be on the jobsite initially during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, hole dimensions, hole cleaning procedures, anchor spacing, edge distances, concrete thickness, anchor embedment, and tightening torque. The special inspector must verify the initial installations of each type and size of adhesive anchor by construction personnel on site. Subsequent installations of the same anchor type and size by the same construction personnel are permitted to be performed in the absence of the special inspector. Any change in the anchor product being installed or the personnel performing the installation must require an initial inspection. For ongoing installations over an extended period the special inspector must make regular inspections to confirm correct handling and installation of the product. For all cases where overhead installations (vertical up) and designed to nearest sustained tension loads, continuous special inspection must be performed.

4.5 Jobsite Quality Assurance:

Where anchors are used for wind load resistance, jobsite quality assurance must conform to Sections 1705 or 1706 of the IBC.

5.0 CONDITIONS OF USE

The Fischer FIS EM 390 S Adhesive Anchor System described in this report complies with the codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 Fischer FIS EM 390 S adhesive anchors must be installed in accordance with this report and the manufacturer's published installation instructions included in the adhesive packaging and described in Figure 4 of this report.

5.2 The anchors must be installed in uncracked normal-weight concrete having a specified compressive strength f_c'= 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa) only.

5.3 The values of f_c' used for calculation purposes must not exceed 8,000 psi (55.1 MPa).

5.4 Anchors must be installed in concrete base materials in holes drilled with carbide-tipped drill bits complying with ANSI B212.15-1994.

5.5 The use of the anchors is limited to installation in concrete that is expected to be uncracked during service life of the anchors subject to the conditions in this report.

5.6 Fischer FIS EM 390 S adhesive anchors are recognized for use to resist short- and long-term loads, including wind, subject to the conditions of this report

5.7 Loads applied to the anchors shall be adjusted in accordance with Sections 1612.3 or 1909.2 of the UBC or Section 1605.2 of the 2000, 2003 or 2006 IBC for strength design and in accordance with Section 1612.3 of the UBC or Section 1605.3 of the 2000, 2003 or 2006 IBC for allowable stress design.

5.8 Strength design values are established in accordance with Section 4.1 of this report.

5.9 Allowable design values are established in accordance with Section 4.2 of this report.

5.10 Minimum anchor spacing and edge distance as well as minimum member thickness must comply with the values described in this report.

5.11 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.

5.12 Anchors are not permitted to support fire-resistive construction. Where not otherwise prohibited in the code, Fischer FIS EM 390 S adhesive 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 only.
- Anchors that support fire-resistance-rated construction or gravity load–bearing structural elements are within 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 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of adhesive 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.

5.14 Fischer FIS EM 390 S adhesive anchors are permitted for use in Seismic Zones 1 and 2A under the UBC and Seismic Design Categories A and B under the 2000 IBC, 2003 IBC and 2006 IBC.

5.15 Use of zinc-plated carbon steel anchors is limited to dry, interior locations.

5.16 Special inspections and jobsite quality assurance must be provided in accordance with Sections 4.4 and 4.5, respectively.

5.17 Fischer FIS EM 390 S adhesive is manufactured by fischerwerke GmbH & Co. KG, Denzlingen, Germany, with quality control inspections by Engineering Office Eligehausen and Asmus (AA-707).

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements AC308, dated October 2008.

7.0 IDENTIFICATION

7.1 Fischer FIS EM 390 S adhesive is identified by packaging labeled with the manufacturer's name (fischerwerke) and address, anchor name, evaluation report number (ICC-ES ESR-1990), and the name of the quality control agency, Ingenieurbro, Eligehausen and Asmus (AA-707).

7.2 Threaded rods, nuts, washers, bolts, cap screws, and deformed reinforcing bars are standard elements and must conform to applicable national or international specifications.

TABLE 1—DESIGN TABLE INDEX

Design strength[1]		Threaded rod	Deformed reinforcement
		metric	fractional
Steel	N_{sa}, V_{sa}	Table 5	Table 8
Concrete	N_{cb}, N_{cbg}, V_{cb}, V_{cbg}, V_{cp}, V_{cpg}	Table 6	Table 9
Bond[2]	N_a, N_{ag}	Table 7	Table 10

[1]Ref. ACI 318/08 D.4.1.2.
[2]See Section 4.1 of this evaluation report.

TABLE 2—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON CARBON STEEL THREADED ROD MATERIALS[1]

THREADED ROD SPECIFICATION		Minimum specified ultimate strength (f_{uta})	Minimum specified yield strength 0.2% offset (f_{ya})	f_{uta}/f_{ya}	Elongation, min.[3,5]	Reduction of Area, min.	Specification for nuts[4]
ASTM F568M[5] Class 5.8 (equivalent to ISO 898-1[2] Class 5.8)	MPa (psi)	500 (72,519)	400 (58,015)	1.25	10	35	DIN 934 (8-A2K) (Metric)
ISO 898-1[2] Class 8.8	MPa (psi)	800 (116,030)	640 (92,824)	1.25	12	52	DIN 934 (8-A2K)

[1]Fischer FIS EM 390 S must be used with continuously threaded carbon steel rod (all-thread) that have thread characteristics comparable with ANSI B1.1 UNC Coarse Thread Series or ANSI B1.13M M Profile Metric Thread Series. Values for threaded rod types and associated nuts supplied by fischer are provided here.
[2]Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs.
[3]Based on 2-in. (50 mm) gauge length which are based on the gauge length of 4d and ISO 898, which is based on 5d.
[4]Nuts of other grades and styles having specified proof load stresses greater than the specified grade and style are also suitable. Nuts must have specified proof load stresses equal or greater than the minimum tensile strength of the specific threaded rods.
[5]Standard specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners. These rods are brittle steel elements in accordance with Section 3.2.4.3 of this report.

TABLE 3—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON STAINLESS STEEL THREADED ROD MATERIALS[1]

THREADED ROD SPECIFICATION		Minimum specified ultimate strength (f_{uta})	Minimum specified yield strength 0.2% offset (f_{yal})	f_{uta}/f_{ya}	Elongation, min.[3]	Reduction of Area, min.	Specification for nuts[4]
ISO 3056-1[2] A4-70 M12 – M36	MPa (psi)	700 (101,780)	450 (65,430)	1.56	40	-	ISO 4032

[1] Fischer FIS EM 390 S must be used with continuously threaded stainless steel rod (all-thread) with thread characteristics comparable with ANSI B1.1 UNC Coarse Thread Series or ANSI B1.13M M Profile Metric Thread Series. Values for threaded rod types and associated nuts supplied by fischer are provided here.
[2] Mechanical properties of corrosion resistant stainless steel fasteners – Part 1: Bolts, screws and studs
[3] Based on 2-in. (50 mm) gauge length which are based on the gauge length of 4d and ISO 898, which is based on 5d
[4] Nuts of other grades and styles having specified proof load stresses greater than the specified grade and style are also suitable. Nuts must have specified proof load stresses equal or greater than the minimum tensile strength of the specific threaded rods.

TABLE 4—SPECIFICATIONS AND PHYSICAL PROPERTIES OF COMMON STEEL REINFORCING BARS[1,2]

REINFORCING BAR SPECIFICATION		Minimum specified ultimate strength (f_{uta})	Minimum specified yield strength (f_{ya})
ASTM A 615[1] Gr. 60	psi (MPa)	90,000 (620)	60,000 (420)

[1]Standard Specifications for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
[2]These bars are brittle steel elements in accordance with Section 3.2.4.3 of this report

TABLE 5—STEEL DESIGN INFORMATION FOR METRIC THREADED ROD[1]

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter (mm)						
				M12	**M16**	**M20**	**M24**	**M27**	**M30**	**M36**
ROD OUTSIDE DIAMETER		*d*	mm (in.)	12 (0.47)	16 (0.63)	20 (0.79)	24 (0.94)	27 (1.06)	30 (1.18)	36 (1.42)
ROD effective cross-sectional area		A_{se}	mm² (in².)	84.3 (0.131)	157 (0.243)	245 (0.380)	353 (0.547)	459 (0.711)	561 (0.870)	817 (1.266)
ISO 898-1 Class 5.8	Nominal strength as governed by steel strength	N_{sa}	kN (lb)	42.1 (9,441)	78.3 (17,602)	122.4 (27,516)	176.2 (39,611)	229.7 (51,638)	280.3 (63,013)	408.5 (91,722)
		V_{sa}	kN (lb)	25.3 (5,687)	47.0 (10,565)	73.4 (16,500)	105.8 (23,783)	137.8 (30,977)	168.2 (37,811)	245.1 (55,098)
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65						
	Strength reduction factor for ϕ for shear	ϕ	-	0.60						
ISO 898-1 Class 8.8	Nominal strength as governed by steel strength	N_{sa}	kN (lb)	67.4 (15,151)	125.3 (28,167)	195.8 (44,015)	282.0 (63,393)	367.5 (82,614)	448.5 (100,822)	653.6 (146,929)
		V_{sa}	kN (lb)	40.5 (9,104)	75.2 (16,904)	117.5 (26,414)	169.2 (38,103)	220.5 (49,568)	269.1 (60,493)	392.2 (88,166)
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.65						
	Strength reduction factor for ϕ for shear	ϕ	-	0.60						
ISO 3506-1 Class A4 Stainless	Nominal strength as governed by steel strength	N_{sa}	kN (lb)	59,0 (13,265)	109,7 (24,705)	171,4 (38,553)	246,7 (55,548)	321,5 (72,228)	392,4 (88,278)	571,9 (128,563)
		V_{sa}	kN (lb)	35.4 (7,957)	65.8 (14,791)	102.8 (23,109)	148.1 (33,292)	192.9 (43,363)	235.4 (52,828)	343.1 (77,128)
	Strength reduction factor ϕ for tension[2]	ϕ	-	0.75						
	Strength reduction factor for ϕ for shear	ϕ	-	0.65						

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 ps I = 0.006897 MPa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Values provided for common rod material types are based on specified strength and calculated in accordance with ACI 318-08 Eq. (D-3) and Eqn. (D-20). Nuts and washers must be appropriated for the rod.
[2]For use with load combinations of ACI 318-08 9.2 as set forth in ACI 318-08 D.4.4

TABLE 6—CONCRETE BREAKOUT DESIGN INFORMATION FOR METRIC THREADED ROD

DESIGN INFORMATION	Symbol	Units	Nominal rod diameter (mm)						
			12	**16**	**20**	**24**	**27**	**30**	**36**
EMBEDMENT DEPTH	h_{ef}	mm	110	125	170	210	250	280	330
		(in.)	(4.33)	(4.92)	(6.69)	(8.27)	(9.84)	(11.02)	(12.99)
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	SI	10						
		(in.lb)	(24)						
Min. anchor spacing	s_{min}	mm	55	62.5	85	105	125	140	165
		(in.)	(2.17)	(2.46)	(3.35)	(4.13)	(4.92)	(5.51)	(6.50)
Min. edge distance	c_{min}	mm	55	62.5	85	105	125	140	165
		(in.)	(2.17)	(2.46)	(3.35)	(4.13)	(4.92)	(5.51)	(6.50)
Minimum member thinckness	h_{min}	mm	140	160	210	260	310	340	410
		(in.)	(5.51)	(6.30)	(8.27)	(10.24)	(12.20)	(13.39)	(16.14)
Critical edge distance for splitting failure	c_{ac}	mm	290	320	340	470	530	580	650
		(in.)	(11.42)	(12.60)	(13.39)	(18.50)	(20.87)	(22.83)	(25.59)
Strength reduction factor for tension, concrete failure modes, Condition B[1]	ϕ	-	0.65						
Strength reduction factor for shear, concrete failure modes, Condition B[1]	ϕ	-	0.70						

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 MPa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Values provided for post-installed anchors installed under Condition B without supplementary reinforcement

TABLE 7—BOND STRENGTH DESIGN INFORMATION FOR METRIC THREADED ROD[1]

DESIGN INFORMATION		Symbol	Units	Nominal rod diameter (in.)						
				12	**16**	**20**	**24**	**27**	**30**	**36**
EMBEDMENT DEPTH		h_{ef}	mm	110	125	170	210	250	280	330
			(in.)	(4.33)	(4.92)	(6.69)	(8.27)	(9.84)	(11.02)	(12.99)
Temperature range A [3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	N/mm²	13.3	11.9	11.1	10.3	9.9	9.5	8.9
			(psi)	(1,929)	(1,726)	(1,610)	(1,494)	(1,436)	(1,378)	(1,291)
Temperature range B [3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	N/mm²	11.7	10.5	9.8	9.1	8.7	8.4	7.9
			(psi)	(1,697)	(1,523)	(1,421)	(1,320)	(1,262)	(1,218)	(1,146)
Strength reduction factor for permissible installation conditions	Dry concrete	ϕ_d	-	0.65	0.65	0.65	0.65	0.55	0.55	0.55
	Water saturated concrete	ϕ_{ws}	-	0.65	0.55	0.55	0.45	0.45	0.45	0.45
		κ_{ws}	-	1.0						

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 Mpa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Characteristic bond strength values correspond to concrete compressive strength in the range 2,500 psi≤f'_c≤4,500 psi. For the range 4,500 psi≤f'_c≤6,500 psi may be increased by 9% and range 6,500 psi≤f'_c≤8,000 psi tabulated characteristic bond strength may be increased by 15%.
[2]Characteristic bond strengths are for sustained loads including dead and live loads. For short-term loads including wind, bond strength may be increased 9 percent.
[3]Temperature range A: Maximum short term temperature = 110°F (43°C), Maximum long term Temperature = 80°F (26°C)
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term Temperature = 110°F (43°C)
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a results of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

TABLE 8—STEEL DESIGN INFORMATION FOR U.S: CUSTOMARY UNIT REINFORCING BARS[1]

DESIGN INFORAMTION		Symbol	Units	Bar size								
				#3	#4	#5	#6	#7	#8	#9	#10	#11
Nominal bar diameter		d	in.	$^3/_8$	$^1/_2$	$^5/_8$	$^3/_4$	$^7/_8$	1	1-$^1/_8$	1-$^1/_4$	1-$^3/_8$
			(mm)	(9.5)	(12.7)	(15.9)	(19.1)	(22.2)	(25.4)	(28.6)	(31.8)	(34.9)
Bar effective cross-sectional area		A_{se}	in².	0.11	0.2	0.31	0.44	0.6	0.78	1.0	1.27	1.48
			(mm²)	(71)	(129)	(200)	(284)	(387)	(510)	(645)	(819)	(956)
ASTM A 615 Gr. 60	Nominal strength as governed by steel strength	N_{sa}	lb	9.937	17.647	27.584	39.724	54.067	70.635	89.384	110.359	133.334
			(kN)	(44.2)	(78.5)	(122.7)	(176.7)	(240.5)	(314.2)	(397.6)	(490.9)	(593.1)
		V_{sa}	lb	5.957	10.588	16.545	23.828	32.438	42.374	53.637	66.203	79.983
			(kN)	(26.5)	(47.1)	(73.6)	(106.0)	(144.3)	(188.5)	(238.6)	(294.5)	(355.8)
	Strength reduction factor ϕ for tension[2)]	ϕ	0.75									
	Strength reduction factor ϕ for shear[2]	ϕ	0.65									

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 MPa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Values provided for common reinforcing bar based on specified strength and calculated in accordance with ACI 318-08 Eq. (D-3) and Eq. (D-20).
[2]For use with the load combination of ACI 318-08, as set forth in ACI 318-08 D.4.4

TABLE 9—CONCRETE BREAKOUT STRENGTH DESIGN INFORMATION FOR U.S: CUSTOMARY UNIT REINFORCING BARS[1]

DESIGN INFORAMTION	Symbol	Units	Bar size								
			#3	#4	#5	#6	#7	#8	#9	#10	#11
EMBEDMENT DEPTH	h_{ef}	in.	4-$^1/_2$	6	7-$^7/_8$	9	10 $^5/_8$	12	13-$^1/_2$	15	16-$^1/_2$
		(mm)	(115)	(150)	(200)	(230)	(270)	(300)	(340)	(380)	(420)
Effectiveness factor	$k_{c,uncr}$	in.	10								
		(mm)	(24)								
Min anchor spacing	s_{min}	in.	1-$^6/_8$	2-$^2/_8$	2-$^6/_8$	3-$^2/_8$	5-$^2/_8$	5-$^7/_8$	6-$^2/_8$	6-$^7/_8$	7-$^1/_2$
		(mm)	(42.5)	(57.5)	(70)	(85)	(135)	(150)	(160)	(175)	(190)
Min edge distance	c_{min}	in.	1-$^6/_8$	2-$^2/_8$	2-$^6/_8$	3-$^2/_8$	5-$^2/_8$	5-$^7/_8$	6-$^2/_8$	6-$^7/_8$	7-$^1/_2$
		(mm)	(42.5)	(57.5)	(70)	(85)	(135)	(150)	(160)	(175)	(190)
Member thickness	h_{min}	in.	5-$^6/_8$	7-$^1/_8$	8-$^6/_8$	10-$^5/_8$	12-$^3/_8$	13-$^6/_8$	15-$^5/_8$	17-$^1/_2$	19-$^2/_8$
		(mm)	(145)	(180)	(220)	(270)	(315)	(355)	(400)	(450)	(490)
Critical edge distance – splitting (uncracked concrete)	c_{ac}	in.	11-$^6/_8$	14-$^5/_8$	18-$^1/_8$	20-$^1/_8$	22-$^3/_8$	24	26-$^3/_8$	28-$^6/_8$	30-$^6/_8$
		(mm)	(300)	(370)	(460)	(510)	(570)	(610)	(670)	(730)	(780)
Strength reduction factor for tension, concrete failure modes, Condition B[1]	ϕ	-	0.65								
Strength reduction factor for shear, concrete failure modes, Condition B[1]	ϕ	-	0.70								

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 MPa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Values provided for post-installed anchors installed under Condition B without supplementary reinforcement

TABLE 10—BOND STRENGTH DESIGN INFORMATION FOR U.S: CUSTOMARY UNIT REINFORCING BARS[1]

DESIGN INFORAMTION		***Symbol***	**Units**	**Bar size**								
				#3	**#4**	**#5**	**#6**	**#7**	**#8**	**#9**	**#10**	**#11**
EMBEDMENT DEPTH		h_{ef}	in.	4,5	5,9	7,9	9,0	10,6	11,8	13,4	15,0	16,5
			(mm)	(115)	(150)	(200)	(230)	(270)	(300)	(340)	(380)	(420)
Temperature range A[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	psi.	2,060	1,885	1,726	1,639	1,537	1,465	1,407	1,349	1,305
			(N/mm²)	(14.2)	(13.0)	(11.9)	(11.3)	(10.6)	(10.1)	(9.7)	(9.3)	(9.0)
Temperature range B[3]	Characteristic bond strength in uncracked concrete[2]	$\tau_{k,uncr}$	psi.	1,813	1,668	1,523	1,436	1,349	1,291	1,247	1,189	1,160
			(N/mm²)	(12.5)	(11.5)	(10.5)	(9.9)	(9.3)	(8.9)	(8.6)	(8.2)	(8.0)
Strength reduction factor for permissible installation conditions	Dry concrete	ϕ_d	-	0,65	0,65	0,65	0,65	0,65	0,65	0,55	0,55	0,55
	Water saturated concrete	ϕ_{ws}	-	0.65	0.55	0.55	0.55	0.45	0.45	0.45	0.45	0.45
		κ_{ws}	-	1.0								

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 Mpa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Characteristic bond strength values correspond to concrete compressive strength in the range 2,500 psi≤f'_c≤4,500 psi. For the range 4,500 psi≤f'_c≤6,500 psi may be increased by 9% and range 6,500 psi≤f'_c≤8,000 psi tabulated characteristic bond strength may be increased by 15%.

[2]Characteristic bond strengths are for sustained loads including dead and live loads. For short-term loads including wind, bond strength may be increased 9 percent.

[3]Temperature range A: Maximum short term temperature = 110°F (43°C), Maximum long term Temperature = 80°F (26°C)
Temperature range B: Maximum short term temperature = 162°F (72°C), Maximum long term Temperature = 110°F (43°C)
Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a results of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

TABLE 11—EXAMPLE OF FIS EM 390 S ADHESIVE ANCHOR ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES, THREADED RODS, TEMPERATUR RANGE A AND B[1,2,3,4,5,6,7,8,9,10,11,12,13,14]

DESIGN INFORMATION	Symbol	Units	Nominal rod diameter (in.)						
Diameter Threaded Rod	d	mm	12	16	20	24	27	30	36
		(in.)	(0.472)	(0.630)	(0.787)	(0.945)	(1.063)	(1.181)	(1.417)
Embedment Depth	h_{ef}	mm	110	125	170	210	250	280	330
		(in.)	(4.33)	(4.92)	(6.69)	(8.27)	(9.84)	(11.02)	(12.99)
Allowable Tension Load[15)]	$T_{allowable,ASD}$	kN	21.1	25.6	40.6	55.7	61.3	72.6	92.9
		(lbf)	(4749)	(5751)	(9120)	(12534)	(13765)	(16314)	(20878)

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 Mpa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Single anchor with static tension load only; ISO 898-1; Class 8.8 threaded rod.
[2]Vertical downward installation direction.
[3]Inspection regime = Periodic.
[4]Installation temperature = 50°F (10°C) to 104°F (40°C) for base material; 50°F (10°C) to 104°F (40°C) for cartridge adhesive.
[5]Long term temperature = 110°F (43°C).
[6]Short term temperature = 162°F (72°C).
[7]Dry hole condition; carbide drilled hole.
[8]Concrete determined to remain uncracked for the life of the anchorage.
[9]Load combinations from ACI 318 Section 9.2 (no seismic loading).
[10]30% dead load and 70% live load. Controlling load combination 1.2D + 1.6L.
[11]Calculation of weighted average for α = 1.2(O.3) + 1.6(0.7) = 1.48.
[12]$f_{c'}$ = 2,500 psi (normal weight concrete).
[13]$c_{a1} = c_{a2} \geq c_{ac}$
[14]$h \geq h_{min}$
[15]It is noted that concrete breakout is the decisive failure mode.

TABLE 12—EXAMPLE OF FIS EM 390 S ADHESIVE ANCHOR ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES, REINFORCING BAR, TEMPERATUR RANGE A AND B[1,2,3,4,5,6,7,8,9,10,11,12,13,14]

DESIGN INFORMATION	Symbol	Units	Bar size								
		-	#3	#4	#5	#6	#7	#8	#9	#10	#11
Diameter Threaded rod	d	mm	9.5	12.7	15.9	19.1	22.2	25.4	28.6	31.8	34.9
		(in.)	(0.375)	(0.500)	(0.625)	(0.750)	(0.875)	(1.000)	(1.125)	(1.250)	(1.375)
Embedment Depth	h_{ef}	mm	114	150	201	229	269	300	340	381	419
		(in.)	(4.5)	(5.9)	(7.9)	(9.0)	(10.6)	(11.8)	(13.4)	(15)	(16.5)
Allowable tension load Temperature Range A	$T_{allowable,ASD}$	kN	21.3	33.6	52.1	63.3	80.9	95.0	97.3	115.2	133.0
		(lbf)	(4796)	(7553)	(11702)	(14230)	(18188)	(21363)	(21875)	(25907)	(29889)
Allowable tension load Temperature Range B	$T_{allowable,ASD}$	kN	18.8	30.2	46.2	59.5	76.8	93.5	97.3	115.2	133.0
		(lbf)	(4221)	(6789)	(10375)	(13374)	(17263)	(21019)	(21875)	(25907)	(29889)

For **SI:** 1 inch = 25.4 mm, 1lbf = 4.448 N, 1 psi = 0.006897 Mpa.

For pound-inch-units: 1 mm = 0.03937 inches, 1 N = 0.2248 lbf, 1MPa = 150.0 psi.

[1]Single anchor with static tension load only; ASTM A 615 Grade 60 reinforcing bar.
[2]Vertical downward installation direction.
[3]Inspection regime = Periodic.
[4]Installation temperature = 50°F (10°C) to 104°F (40°C) for base material; 50°F (10°C) to 104°F (40°C) for cartridge adhesive.
[5]Long term temperature = 110°F (43°C).
[6]Short term temperature = 162°F (72°C).
[7]Dry hole condition; carbide drilled hole.
[8]Concrete determined to remain uncracked for the life of the anchorage.
[9]Load combinations from ACI 318 Section 9.2 (no seismic loading).
[10]30% dead load and 70% live load. Controlling load combination 1.2D + 1.6L.
[11]Calculation of weighted average for α = 1.2(O.3) + 1.6(0.7) = 1.48.
[12]$f_{c'}$ = 2,500 psi (normal weight concrete).
[13]$c_{a1} = c_{a2} \geq c_{ac}$
[14]$h \geq h_{min}$

FIGURE 1—FIS EM 390 S and FIS EM 1100 S ANCHORING SYSTEM & STEEL ELEMENTS

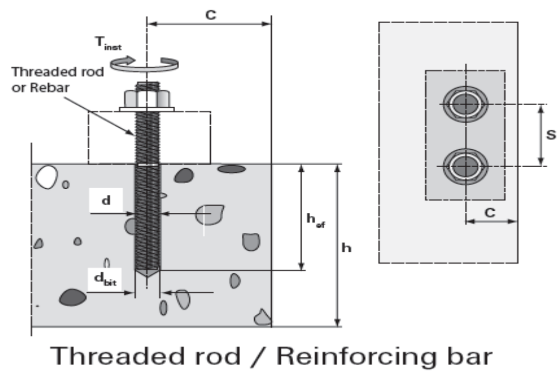
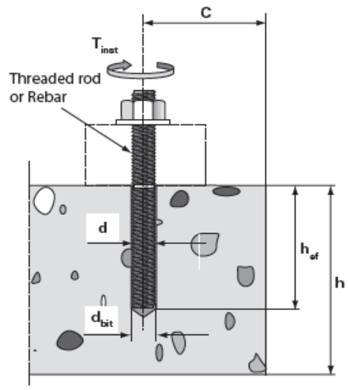


FIGURE 2—INSTALLATION PARAMETERS FOR THREADED ROADS AND REINFORCING BARS

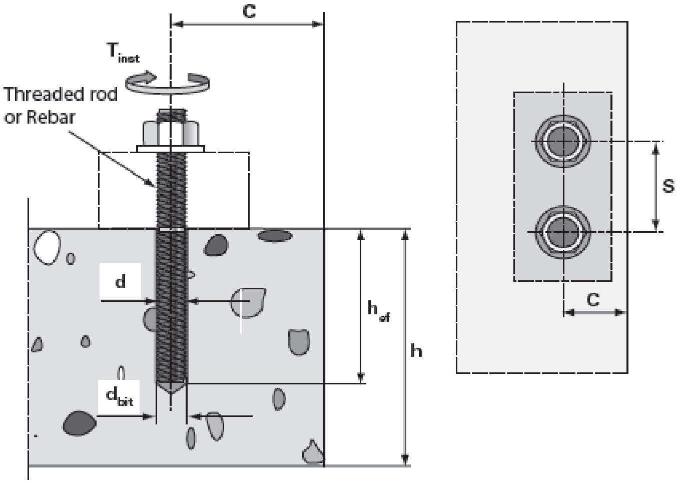
Given: Size M16 (0.63-in.) FIS EM 390 S adhesive anchors without edge effect subjected to a tension load as shown. **Design Objective:** Calculate the design tension resistance for this configuration	 Threaded rod
Dimensional Parameters: h_{ef} = 125 mm= 4.92 in. c = 350 mm= 13.8 in. h = 305 mm= 12.0 in. d = M16= 0.63 in.	Specifications/assumptions **Steel class:** ISO 898-1 Class 8.8, all threaded rod **Concrete class:** Normal weight concrete, f'_c= 2.500 psi No supplementary reinforcing in accordance with ACI 318-05 D.1 will be provided **Short term temperature:** Assume maximum short term temperature (diurnal) base material temperature ≤100°F **Long term temperature** Assume maximum long term base material temperature ≤ 80°F. **Condition of borehole:** Assume installation in dry concrete **<u>Concrete must be uncracked for service live of anchorage</u>**

Calculation in Accordance with ACI 318-08 Appendix D and this report		ACI 318 Code Ref.	Report Ref.
Step 1	Check minimum edge distance, anchor spacing and member thickness: c = 13.8 in. > $c_{a,min}$= 2.46 in. therefore ok.		Table 6
Step 2	Calculate steel strength: $N_{sa}= n \cdot A_{sa} \cdot f_{uta}$ ISO 898-1 Class 8.8 rods comply as brittle, ϕ= 0.65 $\phi N_{sa}= \phi \cdot n \cdot A_{se} \cdot f_{uta}$= 0.65·0.243·116,030= 18,3 lb= 18.3 k or, using Table 5. ϕN_{sa}= 0.65·28,167= 18.3 k	D.5.1 D.1 D.5.1.2	Table 2 Table 5
Step 3	Determine concrete breakout strength: $N_{cbg} = \frac{A_{Nc}}{A_{Nc0}} \cdot \psi_{ec,N} \cdot \psi_{ed,N} \cdot \psi_{c,N} \cdot \psi_{cp,N} \cdot N_b$ $A_{Nc}=(1{,}5h_{ef}+1{,}5h_{ef})(1.5 \cdot h_{ef}+1{,}5h_{ef})= 9h_{ef}^2$ = 218 in² $A_{Nc0}= (3 \cdot h_{ef})^2= 9 \cdot h_{ef}^2$ = 218 in² $\psi_{ec,N}$= 1.0 no eccentricity of tension load with respect to tension loaded anchors $\psi_{ed,N} = 1.0$ for $c \geq 1.5\ h_{ef}$ c = 13.8 > 1.5 · 4.92 <u>Concrete must be uncracked for service live of anchorage</u> $\psi_{c,N}$= 1.0 ($k_{,uncr}$= 24) Determine c_{ac}: c_{ac}= 12.60 in. For $c > c_{ac}$ $\psi_{cp,N}$= 1.0 $N_b = k_{c,uncr} \cdot \sqrt{f'_c} \cdot h_{ef}^{1{,}5} = N_b = 24 \cdot \sqrt{2500} \cdot (4.92)^{1{,}5}$	D.5.2.1 and Eqn. (D-4) D.5.2.1 and Eqn. (D-6) D.5.2.4 D.5.2.5 and Eqn. (D-10) D.5.2.6 D.5.2.7 and Eqn. (D-12) D.5.2.2 and	- - - - - Table 6 Table 6 - -

FIGURE 3—FIRST SAMPLE CLACULATION

	N_b=13,096 lb $N_{cbg} = \frac{218.0}{218.0} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 13{,}096$ = 13,096 lb ϕN_{cbg} = 0.65·13,096= 8,512 lb = <u>8.512 k</u>	Eq. (D-7) D.4.4c)	- -
Step 4	Determine bond strength: $N_{ag} = \frac{A_{Na}}{A_{Na0}} \cdot \psi_{ed,Na} \cdot \psi_{g,Na} \cdot \psi_{ec,Na} \cdot \psi_{p,Na} \cdot N_{a0}$	-	Section 4.1.4 Eqn. (D-16b)
	$s_{cr,Na} = 20 \cdot d \cdot \sqrt{\frac{\tau_{k,uncr}}{1{,}450}} \leq 3 \cdot h_{ef}$ $s_{cr,Na} = 20 \cdot 0.63 \cdot \sqrt{\frac{1.726}{1.450}} = 13.75 \leq 3 \cdot h_{ef}$ $3 \cdot h_{ef} = 14.76$ in. $s_{cr,Na} = 13.75$ in.	-	Section 4.1.4 Eqn. (D-16d)
	$c_{cr,Na} = \frac{s_{cr,Na}}{2}$ = 6.88 in.	-	Section 4.1.4 Eqn. (D-16e)
	A_{Na}=(2·$c_{cr,Na}$)(2·$c_{cr,Na}$)= (2·6.88)(2·6.88)= 189.1 in²	-	
	A_{Na0}= $(s_{cr,Na})^2$= (13.75)²= 189.1 in²		Section 4.1.4 (D-16c)
	$\psi_{ed,N} = 1{,}0$ for $c > c_{cr,Na}$	-	Section 4.1.4 Eqn. (D-16l)
	$\psi_{ec,Na}$= 1.0 no eccentricity of tension load with respect to tension loaded anchors	-	Section 4.1.4 Eqn. (D-16j)
	$\psi_{p,Na} = 1{,}0$ for $c > c_{ac}$	-	Section 4.1.4 Eqn. (D-16o)
	$\psi_{g,Na} = 1{,}0$ for single anchor	-	
	$N_{a0} = \tau_{k,uncr} \cdot \pi \cdot d \cdot h_{ef}$ =1,726·π·0.63·4.92=16,804 lb	-	Section 4.1.4 Eqn. (D-16f)
	$N_{ag} = \frac{A_{Na}}{A_{Na0}} \cdot \psi_{ed,Na} \cdot \psi_{g,Na} \cdot \psi_{ec,Na} \cdot \psi_{p,Na} \cdot N_{a0}$ $N_{ag} = \frac{189.1}{189.1} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 16{,}804 = 16{,}804$ lb	-	Section 4.1.4 Eqn. (D-16b)
	ϕ= 0.65 ϕN_{ag}= 0.65·16,804 lb= 10.923 k		Table 7
Step 5	Determine controlling resistance strength in tension: $\phi N_n = \min\lvert \phi N_{sa}, \phi N_{cbg}, \phi N_{ag} \rvert = \phi N_{cbg}$ = 8.512 k	D.4.1.2	
Step 6	Calculate allowable stress design conversion factor for loading condition: Controlling load combination: 1.2D + 1.6L α=1.2(30%) + 1.6(70%) = 1.48	9.2	Section 4.2
Step 7	Calculate allowable stress design value: $T_{allow,ASD} = \frac{\phi N_n}{\alpha} = \frac{8.512}{1.48} = 5.751$ k		

FIGURE 3—FIRST SAMPLE CALCULATION (Continued)

Given: 2 x size M16 (0.63-in.) FIS EM 390 S adhesive anchors near to an edge subjected to a tension load as shown. **Design Objective:** Calculate the design tension resistance for this configuration	 Threaded rod / Reinforcing bar
Dimensional Parameters: h_{ef} = 125 mm= 4.92 in. s = 102 mm= 4.0 in. $c_{a,min}$ = 62.5 mm= 2.46 in. h = 305 mm= 12.0 in. d = M16= 0.63 in.	Specifications/assumptions **Steel class:** ISO 898-1 Class 8.8, all threaded rod **Concrete class:** Normal weight concrete, f'_c= 4,000 psi No supplementary reinforcing in accordance with ACI 318-05 D.1 will be provided **Short term temperature:** Assume maximum short term temperature (diurnal) base material temperature ≤100°F **Long tem temperature** Assume maximum long term base material temperature ≤ 80°F. **Condition of borehole:** Assume installation in dry concrete **<u>Concrete must be uncracked for service live of anchorage</u>**

Calculation in Accordance with ACI 318-08 Appendix D and this report		ACI 318 Code Ref.	Report Ref.
Step 1	**Check minimum edge distance, anchor spacing and member thickness:** c_{min}= 2.46 in. ≤$c_{a,min}$= 2.46 in. therefore ok. s_{min}= 2.46 in. ≤s = 4.0 in. therefore ok.		Table 6
Step 2	Calculate steel strength: $N_{sa}= n \cdot A_{sa} \cdot f_{uta}$	D.5.1.2	
	ISO 898-1 Class 8.8 rods comply as brittle, ϕ= 0.65 $\phi N_{sa}= \phi \cdot n \cdot A_{se} \cdot f_{uta}$= 0.65·2·0.243·116.030= 36.653 lb= 36.6 k or, using Table 5. ϕN_{sa}= 0.65·2·28.195= 36.6 k	D.1 D.5.1.2	Table 2 Table 5
Step 3	Determine concrete breakout strength:		
	$N_{cbg} = \frac{A_{Nc}}{A_{Nc0}} \cdot \psi_{ec,N} \cdot \psi_{ed,N} \cdot \psi_{c,N} \cdot \psi_{cp,N} \cdot N_b$	D.5.2.1 and Eqn. (D-5)	-
	$A_{Nc}=(3 \cdot h_{ef}+s)(1.5 \cdot h_{ef}+c_{a,min})$= (14.8+4)(7.4+2.5)= 186.1 in²		-
	$A_{Nc0}= (3 \cdot h_{ef})^2= 9 \cdot h_{ef}^2$ = 217.9 in²	D.5.2.1 and Eqn. (D-6)	-
	$\psi_{ec,N}$= 1.0 no eccentricity of tension load with respect to tension loaded anchors	D.5.2.4	-
	$\psi_{ed,N} = 0.7 + 0.3 \cdot \frac{c_{a,min}}{1.5 h_{ef}}$ for $c_{a,min} \leq 1.5\ h_{ef}$ $c_{a,min}$= 2.5< 1.5·4.92 $\psi_{ed,N} = 0.7 + 0.3 \cdot \frac{2.5}{7.4}$ = 0.80	D.5.2.5 and Eqn. (D-11)	-

FIGURE 4—SECOND SAMPLE CALCULATION

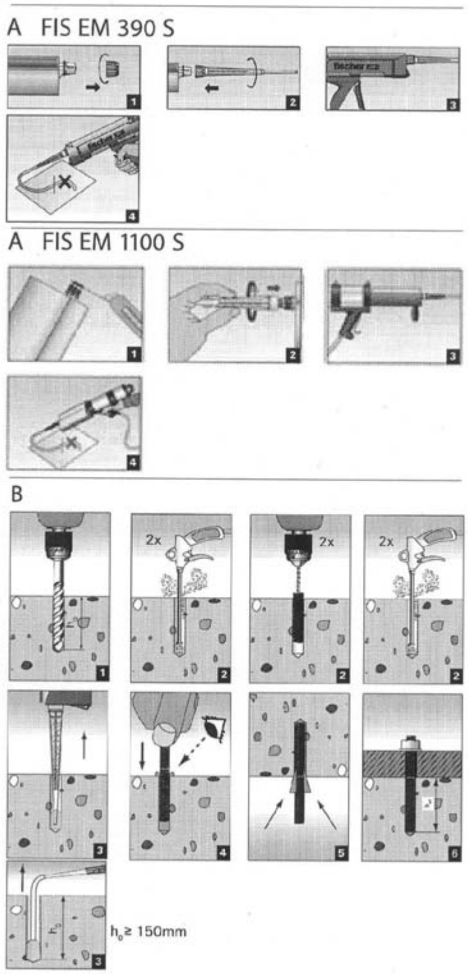
	Concrete must be uncracked for service live of anchorage $\psi_{c,N}$= 1.0 ($k_{,uncr}$= 24)	D.5.2.6	Table 6
	Determine c_{ac}: c_{ac}= 12.60 in.		Table 6
	For $c_{a,min}<c_{ac}$ $\psi_{cp,N}=\frac{max\vert c_{a,min};1.5\cdot h_{ef}\vert}{c_{ac}}=\psi_{cp,N}=\frac{max\vert 2.5;1.5\cdot 4.92\vert}{12.6}$ = 0.59	D.5.2.7 and Eqn. (D-13)	-
	$N_b=k_{c,uncr}\cdot\sqrt{f_c'}\cdot h_{ef}^{1,5}=N_b=24\cdot\sqrt{4000}\cdot(4.92)^{1,5}$ =16.565 lb	D.5.2.2 and Eq. (D-7)	-
	$N_{cbg}=\frac{186.1}{217.9}\cdot 1.0\cdot 0.80\cdot 1.0\cdot 0.59\cdot 16.565$ =6.678 lb		-
	ϕN_{cbg}= 0.65·6.678= 4.341 lb = 4.3 k	D.4.4c)	-
Step 4	Determine bond strength:	-	Section 4.1.4 Eqn. (D-16b)
	$N_{ag}=\frac{A_{Na}}{A_{Na0}}\cdot\psi_{ed,Na}\cdot\psi_{g,Na}\cdot\psi_{ec,Na}\cdot\psi_{p,Na}\cdot N_{a0}$ $s_{cr,Na}=20\cdot d\cdot\sqrt{\frac{\tau_{k,uncr}}{1,450}}\le 3\cdot h_{ef}$ $s_{cr,Na}=20\cdot 0.63\cdot\sqrt{\frac{1.726}{1.450}}=13.75$ $3\cdot h_{ef}=3\cdot 4.92=14.76$ $s_{cr,Na}$= 13.75 in.	-	Section 4.1.4 Eqn. (D-16d)
	$c_{cr,Na}=\frac{s_{cr,Na}}{2}=6.87\ in.$	-	Section 4.1.4 Eqn. (D-16e)
	$A_{Na}=(2\cdot c_{cr,Na}+s)(c_{cr,Na}+c_{a,min})$= (13.75+4)(6.87+2.5)= 166.3 in²	-	
	$A_{Na0}=(s_{cr,Na})^2$= (13.75)²= 189.1 in²		Section 4.1.4 (D-16c)
	$\psi_{ed,N}=0.7+0.3\cdot\frac{c_{a,min}}{c_{cr,Na}}$ for $c_{a,min}<c_{cr,Na}$ $\psi_{ed,N}=0.7+0.3\cdot\frac{2.5}{6.87}=0.81$	-	Section 4.1.4 Eqn. (D-16o)
	$\tau_{k,max,uncr}=\frac{k_{c,uncr}}{\pi\cdot d}\sqrt{h_{ef}\cdot f_c'}=\tau_{k,max,uncr}=\frac{24}{\pi\cdot 0.63}\sqrt{4.92\cdot 4000}$ =1701 psi	-	Section 4.1.4 Eqn. (D-16i)
	$\psi_{g,Na0}=\sqrt{n}-\left[(\sqrt{n}-1)\cdot\left(\frac{\tau_{k,uncr}}{\tau_{k,max,uncr}}\right)^{1,5}\right]\ge 1.0$ $\psi_{g,Na0}=\sqrt{2}-\left[(\sqrt{2}-1)\cdot\left(\frac{1.726}{1.701}\right)^{1,5}\right]=0.99$ $\psi_{g,Na}=\psi_{g,Na0}+\left[\left(\frac{s}{s_{cr,Na}}\right)^{0,5}\cdot(1-\psi_{g,Na0})\right]=$ $0.99+\left[\left(\frac{4.0}{13.75}\right)^{0,5}\cdot(1-0.99)\right]=1.00$	-	Section 4.1.4 Eqn. (D-16h) Section 4.1.4 Eqn. (D-16g)
	$\psi_{ec,Na}$= 1.0 no eccentricity of tension load with respect to tension loaded anchors		Section 4.1.4 Eqn. (D-16j)

FIGURE 4—SECOND SAMPLE CALCULATION (Continued)

	$\psi_{p,Na} = \frac{\max\lvert c_{a,min}; c_{cr,Na}\rvert}{c_{ac}} = \psi_{cp,N} = \frac{\max\lvert 2.5; 6.87\rvert}{12.6} = 0.55$		Section 4.1.4 Eqn. (D-16p)
	$N_{a0} = \tau_{k,uncr} \cdot \pi \cdot d \cdot h_{ef}$ =1.726 · π · 0.63 · 4.92 = 16,804 lb		Section 4.1.4 Eqn. (D-16f)
	$N_{ag} = \frac{A_{Na}}{A_{Na0}} \cdot \psi_{ed,Na} \cdot \psi_{g,Na} \cdot \psi_{ec,Na} \cdot \psi_{p,Na} \cdot N_{a0}$ $N_{ag} = \frac{166.3}{189.1} \cdot 0.81 \cdot 1.00 \cdot 1.0 \cdot 0.55 \cdot 16.804$ = 6.584 lb		Section 4.1.4 Eqn. (D-16b)
	ϕ= 0.65		
	ϕN_{ag}= 0.65·6.584= 4.280 k		
Step 5	Determine controlling strength:	D.4.1.2	
	Steel strength		
	ϕN_{sa} = 36.6 k ϕN_{cbg} = 4.3 k ϕN_{ag} = *4.28* k Controls !		
Step 6	Calculate allowable stress design conversion factor for loading condition: Controlling load combination: 1.2D + 1.6L α=1.2(30%) + 1.6(70%) = 1.48	9.2	Section 4.2
Step 7	Convert strength to ASD using factor provided in Section 4.2 $N_{allow,ASD} = \frac{N_d}{\alpha} = \frac{\phi N_n}{\alpha} = \frac{4.280}{1.48} = 2.892\,k$		

FIGURE 4—SECOND SAMPLE CALCULATION (Continued)

FIGURE 5—FIS EM 390 S AND FIS EM 1100 S INSTALLATION INFORMATION (COVER SHEET)



ENGLISH

fischer Injection - Mortar FIS EM 390 S
fischer Injection - Mortar FIS EM 1100 S

A Preparing the cartridge

1. Remove the cap by turning it to left and pulling it off (FIS EM 390 S) or cut off cap (FIS EM 1100 S).
2. Insert the static mixer and lock it in place (turn to the right). **The spiral mixer in the static mixer must be clearly visible.** Never use without the static mixer!
3. Place the cartridge in the application gun.
4. Press approx 10 cm of material out **untill the resin mortar comes out evenly grey in colour.** Mortar which is not grey colour will not cure and must be disposed of.
5. After finishing work, leave the static mixer attached to the cartridge, or remove the static mixer and replace the cap (FIS EM 390 S).

Important: If the processing time is exceeded, use a new static mixer and if necessary remove encrusted material in the cartridge mouth.

B Installation

Important: Installation instructions - follow the pictograms 1 - 6 for the sequence of operating and refer to tables I - III for setting details. The construction drawings must be adhered. For any applications not covered by this document contact **fischer**.

1. Drill hole with a hammer drill set. Observe the correct hole diameter and depht according to **Table I**; **Table II** and **Table III.**
2. Standing water in bore holes must be completely removed by blowing out before cleaning the bore hole. The drill hole must blown out twice with compressed air (oil-free ≥ 6 bar), brushed two times (by hand) and then again blown out twice with compressed air (oil-free ≥ 6 bar). The drill hole are brushed twice starting from the bottom of the hole with special steel brushes by hand. The diameters of the brushes are given in **Table I.** Clean dirty brushes. Check brushes for wear with brush gauge (brush Ø ≥ drill hole Ø).
3. The temperature of the cartridge must be at least ϑ = 5°C. Fill approx.⅔ of the hole with mortar starting from the bottom of the hole. For drill hole depth > 150 mm use an extention tube.
4. Anchoring element must be straight and free of oil and other cotaminants. Press the anchoring element down to the bottom of the hole,turning it slightly while so doing. After insert the anchoring element,excess mortar must emerge from the mouth of the hole. If no mortar appears at the surface, remove the anchoring element immediately and inject more FIS EM mortar.
5. Overhead installations are limited to size ≤ M24 (use wedges; cartridge temperatur ≤ 25°C).
6. Do not apply load or installation torque moment to the anchor until the prescribed curing times are elapsed. The allowable working time and the minimum curing time are given in **Table IV.** The temperature of the concrete must be at least 10°C and at most 40°C (see **Table IV**)

Store mortar in a cool dry place.

Table IV
Processing and curing times

Temperature range	Working time/ processing time	Curing time
+ 10 °C – + 15 °C	45 min	48 h
+ 15 °C – + 20 °C	30 min	18 h
+ 20 °C – + 30°C	14 min	10h
+ 30 °C – + 40 °C	7 min	5 h

Storage temperature: + 5 °C – + 30 °C

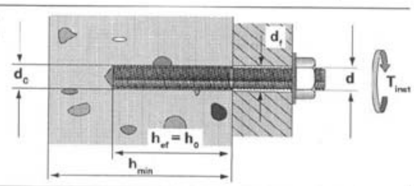
FIGURE 6—FIS EM 390 S AND FIS EM 1100 S INSTALLATION INFORMATION

Table I

Drill bit Ø [inch]	Drill bit Ø [mm]	Rods Ø [mm]	Rebar No.	Brush ≥ Ø [mm]	Brush length [mm]
5/16	10	M8 *	-	10.5	
7/16	12	M10 *	-	12.5	
9/16	14	M12	# 3	14.5	250
5/8	16	-	#4	16.5	-
11/16	18	M16	-	18.5	250
13/16	20	-	#5	20.5	-
15/16	24	M20	#6	25	300
1 1/8	28	M24	#7	29	350
1 3/16	30	M27	#8	31	350
1 3/8	33	M30	#9	36	400
1 9/16	40	M36	#10	42	450
1 3/4	45	-	#11	47	
-	55	-	-	58	

* not convered by ESR 1990

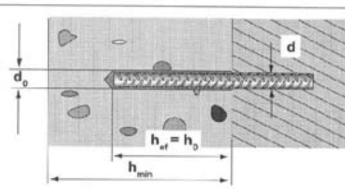
Table II Threaded rod



d	d_0 [mm]	d_0 [inch]	h_{ef} [mm]	h_{ef} [inch]	d_f [mm]	d_f [inch]	$T_{inst, max}$ [Nm]	$T_{inst, max}$ [ft - lb]	h_{min} [mm]	h_{min} [inch]
M8*	10	3/8	80	3 3/16	9	5/16	10	7.5	110	4 1/2
M10*	12	7/16	90	3 1/2	12	7/16	20	15	120	4 3/4
M12	14	9/16	110	4 1/2	14	9/16	40	30	140	5 1/2
M16	18	11/16	125	5	18	1 1/16	60	45	160	6 1/4
M20	24	15/16	170	6 5/8	22	7/8	120	90	210	6 3/4
M24	28	1 1/8	210	8 1/2	26	1 1/16	150	110	260	10 1/4
M27	30	1 3/16	250	10	30	1 3/16	200	150	310	12 1/4
M30	35	1 3/8	280	11 1/2	33	1 1/4	300	220	340	13 3/8
M36	40	1 9/16	330	13 1/2	40	1 9/16	500	370	410	16 1/8

* not convered by ESR 1990

Table III Rebars



d No.	d_0 [mm]	d_0 [inch]	h_{ef} [mm]	h_{ef} [inch]	h_{min} [mm]	h_{min} [inch]
#3	14	9/16	115	4 1/2	145	5 3/4
#4	16	5/8	150	6	180	7
#5	20	13/16	200	7 1/2	220	8 5/8
#6	24	15/16	230	8 1/2	270	10 5/8
#7	28	1 1/8	270	10 5/8	315	12 3/8
#8	30	1 3/16	300	12	355	14
#9	35	1 3/8	340	13 1/2	400	15 3/4
#10	40	1 9/16	380	15	450	17 3/4
#11	45	1 3/4	420	16 1/2	490	19 1/4

FIGURE 6—FIS EM 390 S AND FIS EM 1100 S INSTALLATION INFORMATION (Continued)