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ICC-ES Evaluation Report

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DIVISION: 03 00 00—CONCRETE
SECTION: 03 21 00—REINFORCING STEEL

REPORT HOLDER:

SAS STRESSTEEL INC.

EVALUATION SUBJECT:

**SAS STRESSTEEL GRADE 97 THREAD BAR STEEL REINFORCING BARS AND
MECHANICAL SPLICE SYSTEMS**



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1.0 EVALUATION SCOPE

Compliance with the following code:

- 2015[†], 2012 and 2009 *International Building Code*® (IBC)
- 2013 *Abu Dhabi International Building Code* (ADIBC)^{††}

[†]The evaluation report references the appropriate sections of ACI 318 under the 2015 IBC. For applicable sections under other codes, see Table 3.

^{††}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 SAS Stressteel Grade 97 Thread Bars are deformed steel reinforcing bars used as reinforcement in concrete structural members, such as foundations, columns and walls. The bars are an alternative to deformed reinforcement complying with ACI 318. The SAS Stressteel mechanical splice systems are used as tension and compression mechanical splices of the Grade 97 Thread Bar reinforcing bars. Refer to Figure 1 for a typical installed assembly.

3.0 DESCRIPTION

3.1 SAS Stressteel Grade 97 Thread Bars:

SAS Stressteel Grade 97 Thread Bars are steel reinforcing bars with continuous protrusions in a threaded orientation to permit connections with the SAS Stressteel mechanical splice systems. The right-hand oriented protrusions also permit bar interlock with cast concrete. Available bar sizes and properties are provided in Table 1 of this report. Galvanizing, epoxy coatings, or other coatings are not permitted within the scope of application in this report.

3.2 SAS Stressteel TR 3003 Mechanical Splice Systems:

The SAS Stressteel mechanical splice systems are used as mechanical splices for the SAS Stressteel Grade

97 Thread Bars. The mechanical splice systems are formed from carbon steel and comply with the descriptions and product material specifications in the approved quality documentation. Produced in a hollow cylindrical configuration, the mechanical splice systems receive bars at each end through internal threads in a pattern matching the bars. As an option, each mechanical splice system may have two set screws, one near each end. Mechanical splice system dimensions and available bar sizes are described in Table 1 of this report. The mechanical splice systems comply as Type 1 mechanical splices in accordance with ACI 318.

4.0 DESIGN AND INSTALLATION

4.1 Design: SAS Stressteel Grade 97 Thread Bars:

The bars must be designed as reinforcement for normal-weight concrete in accordance with ACI 318, as amended in Chapter 19 of the IBC, using Table 1. The specified yield strength for design, f_y , used with ACI 318 calculations is 97,000 psi (670 MPa) in lieu of the limits set forth in ACI 318. The following limitations also apply:

1. The high-strength reinforcing bars and mechanical splice systems are limited for use as (a) longitudinal reinforcement for resisting flexure, axial force, and for shrinkage and temperature, in reinforced concrete structures that are not special seismic systems; (b) lateral support of longitudinal bars or for concrete confinement in reinforced concrete structures that are not special seismic systems; (c) shear reinforcement including shear friction in reinforced concrete structures that are not special seismic systems; and (d) torsional reinforcement including longitudinal and transverse reinforcement.
2. The high-strength reinforcing bars and mechanical splice systems shall not be used in beams or slabs.
3. The high-strength reinforcing bars and mechanical splice systems must be used in structures assigned to Seismic Design Category A or B only.
4. Welding of the high-strength reinforcing bars and mechanical splice systems is prohibited.
5. The bending of the high-strength reinforcing bars is limited to No's. 6, 7, 8, 9, 10, 11, and 14 only. Bending procedures must comply with ACI 318.
6. The specified concrete compressive strength shall range from either:
 - a. $6,000 \text{ psi (41.3 MPa)} \leq f'_c \leq 12,000 \text{ psi (82.7 MPa)}$ without limitation on A_{co}/A_g

or,

- b. 12,000 psi (82.7 Mpa) < $f'_c \leq 18,000$ psi (124.1 MPa) where $A_{cc}/A_g \geq 0.8$

Where,

A_{cc} = cross-sectional area of concrete column or wall center-to-center of transverse reinforcement.

A_g = gross area of column or wall concrete section.

If neither a. or b. is satisfied, sectional strength must be calculated in accordance with the additional mandatory modifications to ACI 318-14 following Section 4.2.

- 7. Concrete compressive strengths less than 6,000 psi (41.3 MPa) and greater than 18,000 psi (124.1 MPa) are not covered by this report.
- 8. For the purpose of providing lateral support of longitudinal steel reinforcing bars and for providing concrete confinement, the yield strength of high-strength steel bars used for design calculations must not exceed 97,000 psi (669 MPa) for spirals, and 80,000 psi (551 MPa) for non-spiral reinforcing bars (or lateral ties) in accordance with Section 20.2.2.4 and Table 20.2.2.4a of ACI 318.
- 9. For the purpose of providing shear and torsional resistance, the yield strength of high-strength steel bars used for design calculations shall not exceed 60,000 psi (413 MPa) in accordance with Section 20.2.2.4 and Table 20.2.2.4a of ACI 318.
- 10. The splice locations must comply with applicable code requirements and must be detailed in the approved construction documents.

4.2 Mandatory Modifications to ACI 318-14:

(Mandatory Modification to ACI 318-11 and -08 are provided in Section 4.3).

4.2.1 C1.1 Definitions: Modify Section 2.2 of ACI 318-14 to add the following notation:

α_1 = factor relating magnitude of uniform stress in the equivalent rectangular compressive stress block to specified compressive strength of concrete.

χ_1 = factor relating mean concrete compressive stress at axial load failure of concentrically loaded columns to specified compressive strength of concrete.

A_{cc} = cross-sectional area of concrete column or wall center-to-center of transverse reinforcement.

4.2.2 C1.2 Equivalent Rectangular Concrete Stress Distribution: Modify ACI 318-14 Section 22.2.4:

Section 22.2.2.4 The equivalent rectangular concrete stress distribution in accordance with Section 22.2.2.4.1 through Section 22.2.2.4.3 satisfies Section 22.2.2.3.

Section 22.2.2.4.1 Concrete stress of $\alpha_1 f'_c$ shall be assumed uniformly distributed over an equivalent compression zone bounded by edges of the cross-section and a line parallel to the neutral axis located a distance a from the fiber of maximum compressive strain, as calculated by:

$$a = \beta_1 c \quad (22.2.2.4.1)$$

Section 22.2.2.4.2 Distance from the fiber of maximum compressive strain to the neutral axis, c , shall be measured perpendicular to the neutral axis.

Section 22.2.2.4.3 Values of α_1 shall be in accordance with Table 22.2.2.4.3a and values of β_1 shall be in accordance with Table 22.2.2.4.3b.

Table 22.2.2.4.3a—Values of α_1 for Equivalent Rectangular Concrete Stress Distribution

f'_c (psi)	α_1	
$2,500 \leq f'_c \leq 4,000$	0.85	(a)
$4,000 < f'_c < 17,000$	$0.85 - \frac{0.010 (f'_c - 4000)}{1000}$	(b)
$f'_c \geq 17,000$	0.72	(c)

Table 22.2.2.4.3b—Values of β_1 for Equivalent Rectangular Concrete Stress Distribution

f'_c (psi)	β_1	
$2,500 \leq f'_c \leq 4,000$	0.85	(a)
$4,000 < f'_c < 18,000$	$0.85 - \frac{0.013 (f'_c - 4000)}{1000}$	(b)
$f'_c = 18,000$	0.668	(c)

Concrete compressive strengths less than 6,000 psi (41.3 MPa) and greater than 18,000 psi (124.1 MPa) are not by this report. Other values are shown above for completeness.

4.2.3 C1.3 Maximum axial compressive strengths: Modify ACI 318-14 Section 22.4.2.2:

Section 22.4.2.2 For nonprestressed members and composite steel and concrete members, P_o shall be calculated by:

$$P_o = \chi_1 f'_c (A_g - A_{st}) + f_y A_{st} \quad (22.4.2.2a)$$

Where:

A_{st} = total area of nonprestressed longitudinal reinforcement

$$\chi_1 = 0.9 [\gamma + (1-\gamma)(A_{cc}/A_g)] \leq 0.85 \text{ and } \geq 0.65 \quad (22.4.2.2b)$$

And

$$\gamma = 1.1 - \frac{f'_c}{20,000} \leq 0.8 \text{ where } f'_c \text{ is in psi} \quad (22.4.2.2c)$$

4.3 C2.0 Modifications to ACI 318-11 and ACI 318-08

4.3.1 C2.1 Definitions: Modify Section 2.1 of ACI 318-11 and ACI 318-08 to add the following notation:

α_1 = factor relating magnitude of uniform stress in the equivalent rectangular compressive stress block to specified compressive strength of concrete.

χ_1 = factor relating mean concrete compressive stress at axial load failure of concentrically loaded columns to specified compressive strength of concrete.

A_{cc} = cross-sectional area of concrete column or wall center-to-center of transverse reinforcement.

4.3.2 C2.2 Equivalent Rectangular Concrete Stress Distribution: Modify ACI 318-11 and ACI 318-08 Section 10.2.7:

Section 10.2.7 Requirements of Section 10.2.6 are satisfied by an equivalent rectangular concrete stress distribution defined by the following:

Section 10.2.7.1 Concrete stress of $\alpha_1 f'_c$ shall be assumed uniformly distributed over an equivalent compression zone bounded by edges of the cross-section and a straight line located parallel to the neutral axis at a distance $a = \beta_1 c$ from the fiber of maximum compressive strain.

Section 10.2.7.2 Distance from the fiber of maximum strain to the neutral axis, c , shall be measured in a direction perpendicular to the neutral axis.

Section 10.2.7.3 For f'_c between 2,500 and 4,000 psi, β_1 shall be taken as 0.85. For f'_c above 4,000 psi, β_1 shall be reduced linearly at a rate of 0.013 for each 1,000 psi of strength in excess of 4,000 psi, but β_1 shall not be taken less than 0.668.

Section 10.2.7.4 For f'_c between 2,500 and 4,000 psi, α_1 shall be taken as 0.85. For f'_c above 4,000 psi, α_1 shall be reduced linearly at a rate of 0.010 for each 1,000 psi of strength in excess of 4,000 psi, but α_1 shall not be taken less than 0.72.

Concrete compressive strengths less than 6,000 psi (41.3 MPa) and greater than 18,000 psi (124.1 MPa) are not covered by this report. Other values for f'_c are shown for completeness.

4.3.3 C2.3 Maximum axial compressive strength: Modify ACI 318-11 and ACI 318-08 Section 10.3.6.1:

Section 10.3.6 Design axial strength ϕP_n of compression members shall not be taken greater than $\phi P_{n, max}$ computed by Eq. (10-1) or (10-2).

Section 10.3.6.1 For nonprestressed members with spiral reinforcement conforming to Section 7.10.4 or composite members conforming to Section 10.13:

$$\phi P_{n, max} = 0.85 \phi [\chi_1 f'_c (A_g - A_{st}) + f_y A_{st}] \quad (10-1)$$

where:

$$\chi_1 = 0.9 [\gamma + (1-\gamma)(A_{cd}/A_g)] \leq 0.85 \text{ and } \geq 0.65 \quad (10-1a)$$

and

$$\gamma = 1.1 - \frac{f'_c}{20,000} \leq 0.8 \text{ where } f'_c \text{ is in psi} \quad (10-1b)$$

Section 10.3.6.2 For nonprestressed members with tie reinforcement conforming to Section 7.10.5:

$$\phi P_{n, max} = 0.80 \phi [\chi_1 f'_c (A_g - A_{st}) + f_y A_{st}] \quad (10-2)$$

where:

χ_1 is computed by Eq. (10-1a) and Eq.(10-1b).

Section 10.3.6.3 For prestressed members, design axial strength ϕP_n shall not be taken greater than 0.85 (for members with spiral reinforcement), or 0.80 (for members with tie reinforcement) of the design axial strength at zero eccentricity, ϕP_o , assuming concrete stress of $\chi_1 f'_c$ uniformly distributed across the entire depth of the concrete section.

4.4 Installation:

4.4.1 SAS Stressteel Grade 97 Thread Bars: The bars and mechanical splice systems must be located in the structure as set forth in the approved plans and specifications. Reinforcement details, including surface conditions, bar placement, clear spacing, offsets, spirals and ties, must comply with the applicable provisions in ACI 318. Bar development and mechanical splice systems must comply with ACI 318, except as modified by Section 4.4.2 of this report.

4.4.2 SAS Stressteel Mechanical Splice Systems: The thread bar ends must be machined flat to within 1.5 degrees of a right angle to the axis of the bars. Each bar end must be marked one-half the mechanical splice system length plus $\frac{1}{2}$ inch (12.7 mm) from the ends. The mechanical splice system must be threaded onto the end of one reinforcing bar. The second bar must be

positioned to full end bearing with the first bar, and the mechanical splice system is reverse-threaded until the marks on each bar are exposed. The resulting splice must be tightened with a calibrated torque wrench applied to the second reinforcing bar until the torque in Table 2 of this report is attained. After torquing, the optional screws in the mechanical splice system, when provided, must be set.

4.5 Special Inspection:

Special inspection is required in accordance with Section 1705 of the 2015 IBC and 2012 IBC (Section 1704 of the 2009 IBC). The special inspector must, at a minimum, verify the following:

1. The high-strength steel reinforcing bars are of the type, grade and size specified, and are labeled in accordance with this report.
2. The mechanical splice system identification is in accordance with this report.
3. The installation of high-strength steel reinforcing bars and mechanical splice systems, including field preparation and assembly of components, field preparation of reinforcing bar ends, bar surface conditions, bending, locations, spacing, protection (cover), embedment, and installation torque, must comply with the IBC, ACI 318, approved construction documents and this report.

5.0 CONDITIONS OF USE

The SAS Stressteel Grade 97 Thread Bars and Mechanical Splice Systems described in this report comply with, or are suitable alternatives to what is specified in, the code indicated in Section 1.0 of this report, subject to the following conditions:

- 5.1 The bars and mechanical splice systems must be installed in accordance with the applicable code, the manufacturer's instructions and this report. In case of conflict between the manufacturer's published instructions and this report, the most restrictive governs.
- 5.2 Mechanical splice system locations must comply with applicable code requirements and be noted on plans approved by the code official.
- 5.3 Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the building 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.
- 5.4 For mechanical splice systems, minimum concrete cover must be in accordance with the IBC, and must be measured to the outer surface of the coupler.
- 5.5 The SAS Stressteel Grade 97 Thread Bar Steel Reinforcing Bars and Mechanical Splice Systems are manufactured under a quality control program with inspections by ICC-ES

6.0 EVIDENCE SUBMITTED

- 6.1 Data in accordance with the ICC-ES Acceptance Criteria for Nonprestressed Deformed High-strength Steel Bars for Concrete Reinforcement (AC237), dated August 2018.
- 6.2 Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Splice Systems for Steel Reinforcing Bars (AC133), dated October 2015.

7.0 IDENTIFICATION

7.1 Each bar is identified by the thread pattern and the mark “SAS 670.” The bar bundles are identified by tags bearing the manufacturer’s name (Stahlwerk Annahuette), the report holder’s name (SAS Stressteel, Inc.), the grade, the number of bars in the bundle, the nominal bar diameter, bar length, heat number and the evaluation report number (ESR-1163). The mechanical splice systems are identified by imprinted identification codes shown as “SAS TR XXXX-YY ZZZ” with the product name, report holder’s name (SAS Stressteel, Inc.), and the evaluation report number (ESR-1163) on packaging.

7.2 The report holder’s contact information is the following:

SAS STRESSTEEL, INC.
440 EAGLE ROCK AVENUE
ROSELAND, NEW JERSEY 07068
(973) 244-5995
www.stressteel.com
info@stressteel.com

TABLE 1—SAS STRESSTEEL GRADE 97 THREAD BAR DIMENSIONS AND PROPERTIES

BAR NUMBER	NOMINAL DIAMETER (in)	SPECIFIED YIELD STRENGTH (psi) ¹	SPECIFIED TENSILE STRENGTH (psi)	CROSS SECTIONAL AREA (in ²)	MINIMUM ELONGATION (percent) ²	WEIGHT (lb/ft)
6	3/4	97,000	116,000	0.39	7	1.34
7	7/8	97,000	116,000	0.59	7	2.00
8	1	97,000	116,000	0.76	7	2.59
9	1 1/8	97,000	116,000	0.95	6	3.25
10	1 1/4	97,000	116,000	1.10	6	3.73
11	1 3/8	97,000	116,000	1.49	6	5.07
14	1 3/4	97,000	116,000	2.25	6	7.66
18	2 1/4	97,000	116,000	4.03	6	13.7
20	2 1/2	97,000	116,000	4.91	6	16.7

For **SI**: 1 inch = 25.4 mm, 1 psi = 0.006894757 MPa, 1 lb/ft = 14.6 N/m.

¹Where it can be substantiated that the effects of creep in a reinforced concrete column or wall under sustained, in-situ, unfactored axial compression forces result in sufficient transfer of axial compressive stresses from concrete to longitudinal high-strength reinforcement at the section under consideration, it is permitted to use the specified yield strength for f_y in compression in calculations for flexural and axial compression sectional strength; specified yield strength in compression used in calculations shall be taken as the stress corresponding to strain at 0.35 percent. Otherwise, if sufficient internal stress transfer effects cannot be substantiated, f_y in compression used for high-strength reinforcing bars shall not exceed 80,000 psi (551 MPa) in the calculation of flexural and axial compression sectional strength.

²Elongation measured along an 8-inch length.

TABLE 2—SAS STRESSTEEL GRADE 97 TR 3003 MECHANICAL SPLICE SYSTEM DIMENSIONS AND TORQUE REQUIREMENTS

BAR NUMBER SIZE	OUTSIDE DIAMETER (in)	LENGTH (in)	TORQUE (ft-lb)
7	1.57	3.94	120
8	1.77	4.72	140
9	1.97	5.51	160
10	2.17	5.91	180
11	2.36	6.69	200
14	3.15	7.87	230
18	4.02	9.84	260
20	4.25	10.24	300

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

TABLE 3—APPLICABLE SECTIONS OF ACI 318 UNDER EACH EDITION OF THE IBC

ACI 318-14 (2015 IBC)	ACI 318-11 (2012 IBC)	ACI 318-08 (2009 IBC)
20.2.1.1 – 20.2.1.3	3.5.3.2	3.5.3.2
20.2.2.4 and Table 20.2.2.4a	9.4	9.4
	11.4.2	11.4.2
	11.5.3.4	11.5.3.4
	11.6.6	11.6.6
20.6	7.7	7.7
25.4.2	12.2	12.2
25.5.7	12.14.3	12.14.3
	12.15.4	12.15.4
	12.15.6	12.15.6
	12.16.3	12.16.3

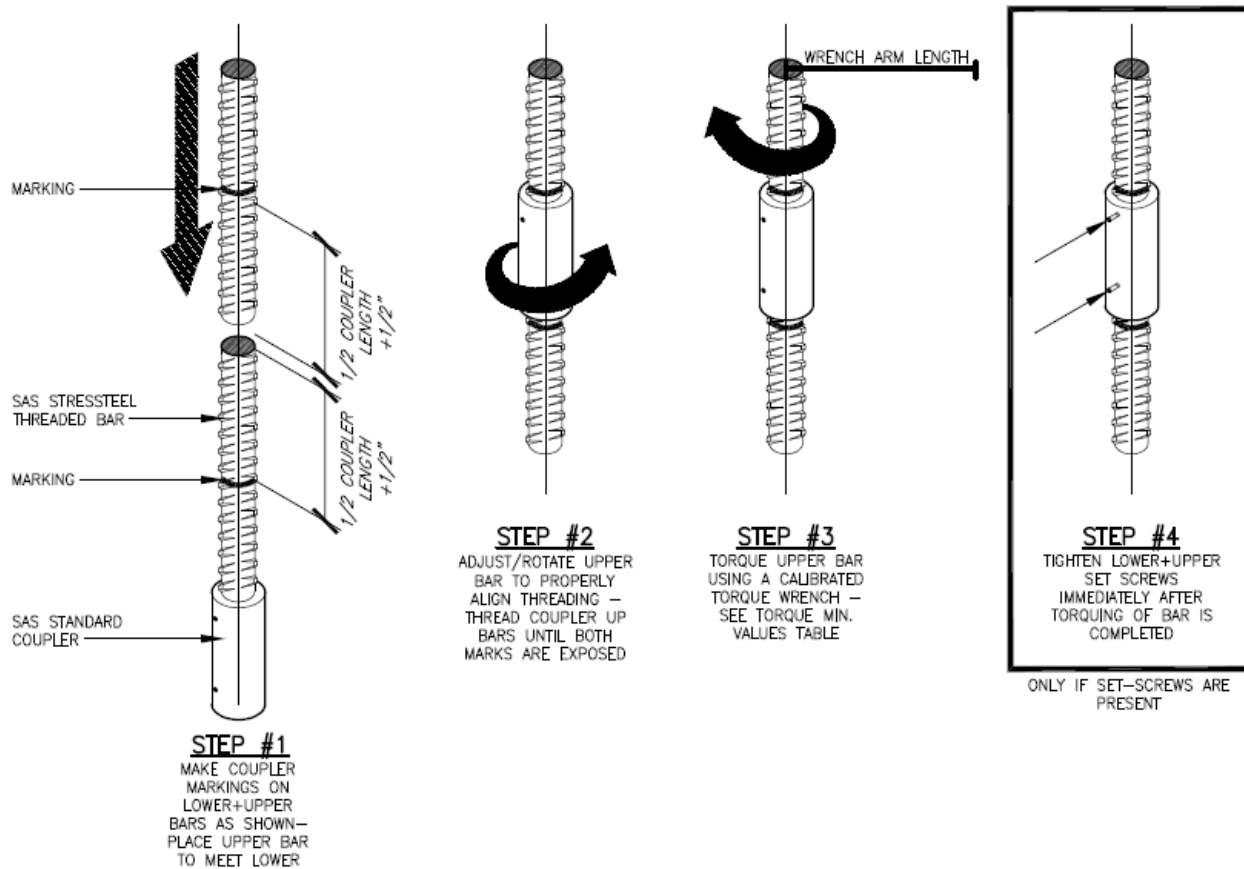


FIGURE 1—ASSEMBLED SAS STRESSTEEL GRADE 97 THREAD BAR AND MECHANICAL SPLICE SYSTEM