ACCEPTANCE CRITERIA FOR HIGH-STRENGTH STEEL REINFORCING BARS

AC429

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PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes. (Some reports may also reference older code families such as the BOCA National Codes, the Standard Codes, and the Uniform Codes.) Section 104.11 of the *International Building Code®* reads as follows:

> **The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.**

This acceptance criteria has been issued to provide interested parties with guidelines for demonstrating compliance with performance features of the codes referenced in the criteria. The criteria was developed through a transparent process involving public hearings of the ICC-ES Evaluation Committee, and/or on-line postings where public comment was solicited.

New acceptance criteria will only have an "approved" date, which is the date the document was approved by the Evaluation Committee. When existing acceptance criteria are revised, the Evaluation Committee will decide whether the revised document should carry only an "approved" date, or an "approved" date combined with a "compliance" date. The compliance date is the date by which relevant evaluation reports must comply with the requirements of the criteria. See the ICC-ES web site for more information on compliance dates.

If this criteria is a revised edition, a solid vertical line (|) in the margin within the criteria indicates a change from the previous edition. A deletion indicator (→) is provided in the margin where significant wording has been deleted.

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NOTE: The Preface for ICC-ES acceptance criteria was revised in July 2011 to reflect changes in policy.

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ACCEPTANCE CRITERIA FOR HIGH-STRENGTH STEEL REINFORCING BARS (AC429)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to establish procedures for high-strength steel reinforcing bars to be recognized in an ICC Evaluation Service, LLC (ICC-ES), evaluation report under the 2012 and 2009 *International Building Code*® (IBC). The basis of recognition is IBC Section 104.11.

1.2 Scope: This acceptance criteria applies to uncoated, deformed, high-strength, low-carbon, chromium-bearing steel reinforcing bars, complying with ASTM A1035 Grade 100, for use as longitudinal and transverse reinforcement in reinforced concrete as given in Table 1 of this criteria, subject to the following restrictions:

1.2.1 The ASTM A1035 Grade 100 reinforcing bars shall not be used as longitudinal reinforcement in special moment frame members, special structural wall boundary elements, and coupling beams.

1.2.2 The reinforcing bars shall not be welded.

1.2.3 The reinforcing bars shall not be used as headed deformed bars in tension.

1.2.4 The specified compressive strength for concrete shall range from 4,000 psi to 12,000 psi (27.6 MPa to 82.7 MPa).

1.2.5 This criteria is applicable to reinforcement under Sections 3.5.3.2, 3.5.3.3, 9.4, 11.4.2, 11.5.3.4 11.6.6, 18.9.3.2, and 19.3.2 of ACI 318, referenced in Section 1901.2 of the IBC.

1.2.6 Structural design using high-strength steel reinforcing bars shall be in accordance with ACI 318 and ACI ITG-6R, as summarized in Section 4.2 of this criteria.

1.2.7 For structures assigned to Seismic Design Categories D, E, or F, ASTM A1035 Grade 100 reinforcing bars are limited to placement in slab systems, foundations, and structural components not designated as part of the seismic force–resisting system but explicitly analyzed for induced effects of design displacements in accordance with ACI 318 Section 21.13.

1.3 Referenced Standards and Documents:

1.3.1 2012 and 2009 *International Building Code*® (IBC), International Code Council.

1.3.2 ACI 318-11, Building Code Requirements for Structural Concrete, American Concrete Institute.

1.3.3 ACI 318-08, Building Code Requirements for Structural Concrete, American Concrete Institute.

1.3.4 ASTM A1035-09, Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement, ASTM International.

1.3.5 ACI ITG-6R-10, Design Guide for the Use of ASTM A1035/A1035M Grade 100 (690) Steel Bars for Structural Concrete, American Concrete Institute.

1.4 Definitions:

High-strength Steel Reinforcing Bars: High-strength steel reinforcing bars are uncoated, deformed steel bars complying with ASTM A1035 Grade 100 for use as reinforcement in concrete construction. The bars shall have a minimum yield strength of 100,000 psi (690 MPa).

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted:

2.1.1 Product Description: A description of the reinforcing bars and splices shall be reported, including general specifications, dimensions, tolerances, deformation requirements and mechanical properties.

2.1.2 Installation Instructions: Complete installation instructions for the placement of bars and splices shall be provided.

2.1.3 Identification:

2.1.3.1 Bundled reinforcing bars shall have an attached tag identifying the manufacturer's name, heat number and roll number. The tag shall also bear the ICC-ES evaluation report number. Individual reinforcing bars shall be identified by a distinguishing set of marks, rolled into the surface of one side of the bar, denoting point of origin, size designation and minimum yield strength designation in accordance with ASTM A1035. Illustrations of the bars highlighting the identifying marks shall be submitted for reproduction in the evaluation report.

2.1.3.2 Mechanical Splices: Mechanical connectors used for reinforcing bar splices shall comply with the ICC-ES Acceptance Criteria for Mechanical Connector Systems for Steel Reinforcing Bars (AC133), with the modifications described in Section 3.2.1 of this criteria.

2.2 Testing Laboratories: Testing laboratories shall comply with the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

2.3 Test Reports: Test reports shall comply with AC85. In addition, the test reports shall include sampling procedures, test specimen preparation, test procedures, and results of all tests. Where indicated, photographs shall be included in the report.

2.4 Product Sampling: Sampling of the reinforcing bars and mechanical connectors for splices for tests under this criteria shall comply with Sections 3.1, 3.3 and 3.4 of AC85.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 Reinforcing Bars:

3.1.1 General: High-strength steel reinforcing bars under this criteria shall comply with ASTM A1035 Grade 100.

3.1.2 Mechanical Properties:

3.1.2.1 Procedure: Testing for tensile and bending properties of reinforcing bars shall be in accordance with ASTM A1035. Each reinforcing bar size shall be tested.

3.1.2.2 Conditions of Acceptance: Conditions of acceptance are as set forth in ASTM A1035 for Grade 100.

3.1.3 Dimensions:

3.1.3.1 Procedure: The following dimensions shall be determined and reported by the testing laboratory for each reinforcing bar size: weight, lb/ft (kg/m); diameter, in. (mm); cross-sectional area, in^2 (mm^2); perimeter, in. (mm); deformation pattern, spacing and height, in. (mm); and finish. Deformations shall be determined based on procedures in Section 8 of ASTM A1035.

3.1.3.2 Conditions of Acceptance: Conditions of acceptance are as noted in ASTM A1035 for Grade 100.

3.1.4 Chemical Composition:

3.1.4.1 Procedure: The chemical analysis of a heat shall be determined in accordance with Section 6 of ASTM A1035.

3.1.4.2 Conditions of Acceptance: Conditions of Acceptance are as noted in Section 6 of ASTM A1035.

3.2 Splices:

3.2.1 Mechanical connectors shall comply with Section 12.14.3 of ACI 318 and shall be either Type 1 or Type 2 in compliance with the ICC-ES Acceptance Criteria for Mechanical Connector Systems for Steel Reinforcing Bars (AC133), except the testing shall demonstrate full tensile strength and full elongation of the actual tested reinforcing bars at failure. Verification of compliance, in the form of test results, shall be provided.

3.2.2 The clearance between a lap or mechanical splice and an adjacent reinforcing bar, or clearance between lap or mechanical splices, shall not be less than $^4/_3$ of the maximum size of coarse aggregates. In the event of making a splice after arrangement of reinforcing bars, clearances allowing insertion of equipment for construction of splices shall be provided.

3.2.3 The concrete cover for a splice shall comply with the requirements of Section 7.7 of ACI 318.

3.2.4 Splices of reinforcing bars of different diameters shall be in accordance with ACI 318 Sections 12.15.3, 12.16.2, and the following:

3.2.4.1 If $\sum A_{bs}/\sum A_{bt} \leq 0.5$, then $A_{b1}/A_{b2} \geq 0.5$

where:

A_{bs} = area of an individual bar at a member cross section that is spliced, in^2 (mm^2)

A_{bt} = area of an individual bar at a member cross section, in^2 (mm^2)

A_{b1} = area of the smaller individual bar in a splice, in^2 (mm^2)

A_{b2} = area of the larger individual bar in a splice, in^2 (mm^2)

3.2.4.2 If $\sum A_{bs}/\sum A_{bt} > 0.5$, then $A_{b1}/A_{b2} \geq 0.75$

3.2.5 The provisions in Section 4.2.16 of this criteria for development length of high-strength reinforcing bars in tension shall apply to ACI 318 Section 12.15, splices of deformed bars in tension.

4.0 DESIGN METHODOLOGY

4.1 Structural design with high-strength reinforcing bars complying with this criteria shall be in accordance with ACI 318, except as outlined in ACI ITG-6R. Table 1 provides specified yield strengths of ASTM A1035 Grade 100 bars to be used in the design of structural members.

4.2 ACI ITG-6R provides further guidance for using high-strength steel reinforcing bars beyond current ACI 318 limitations. The evaluation report shall include the following modifications to ACI 318, taken from ACI ITG-6R, identified in Sections 4.2.1 through 4.2.20, and additional clarifications noted in Section 4.2.21 of this acceptance criteria :

4.2.1 Deformed Reinforcement: Modify ACI 318 Section 3.5.3.3 to read as follows:

> ***3.5.3.3****—Deformed Grade 100 reinforcing bars conforming to ASTM A1035 shall be permitted to be used subject to the specific modifications to ACI 318 given in this acceptance criteria. Tensile strain, ε_s, shall satisfy the following relationship:*
>
> $\varepsilon_s \leq 0.04$

4.2.2 Exposure Categories and Classes: Modify ACI 318 Section 4.2 by adding new Section 4.2.2:

> ***4.2.2****—ASTM A1035 Grade 100 bars shall be permitted to be in direct contact with other grades of steel except where the structure is in an aqueous environment. Aqueous environments include concrete exposure categories and classes where moisture or water contact is anticipated, as set forth in Section 4.2.1.*

4.2.3 Bending: Modify ACI 318 Section 7.3 by adding new Section 7.3.3:

> ***7.3.3—****Unbending of ASTM A1035 Grade 100 bars is prohibited.*

4.2.4 Redistribution of Moments: Modify ACI 318 Section 8.4 by adding the following:

> *Redistribution of moments shall not apply to members containing ASTM A1035 Grade 100 reinforcing bars.*

4.2.5 Strength Reduction Factor: Modify by ACI 318 Section 9.3.2.2 by replacing the second paragraph with the following:

> *For sections reinforced with ASTM A1035 Grade 100 bars in which the net tensile strain in the extreme tension steel at nominal strength, ε_t, is between the limits for compression-controlled and tension-controlled sections, φ shall be permitted to be linearly increased from that for compression-controlled sections to 0.90 as ε_t increases from the compression-controlled strain limit to 0.009 in accordance with Eq. 4-1:*
>
> $$\varphi = 0.45 + 50\varepsilon_t \qquad \text{(Eq. 4-1)}$$

4.2.6 Design Strength for Reinforcement: Modify ACI 318 Section 9.4 to read as follows:

> ***9.4****—The specified yield strengths of ASTM A1035 Grade 100 bars used in the design of structural members shall be as shown in Table 1.*

4.2.7 Control of Deflections: Modify ACI 318 Table 9.5(a) by adding the following note:

> *c) This table does not apply to members reinforced with ASTM A1035 Grade 100 bars. Deflections shall be computed in accordance with Section 9.5.2.3.*

Replace ACI 318 Eq. (9-8) with Eq. 4-2:

$$I_e = \frac{I_{cr}}{1-\left(1-\frac{I_{cr}}{I_g}\right)\left(\frac{M_{cr}}{M_a}\right)^2} \leq I_g \qquad \text{(Eq. 4-2)}$$

4.2.8 Tensile stress: Modify ACI 318 Section 10.2.4 to read as follows:

10.2.4—*Tensile stress in ASTM A1035 Grade 100 bars shall be computed in accordance with Eq. 4-3 or 4-4:*

f_s = 29,000ε_s (ksi) for $\varepsilon_s \leq 0.0034$ (Eq. 4-3)

100 ksi for $0.0034 < \varepsilon_s \leq 0.04$ (Eq. 4-4)

4.2.9 Compression-controlled Strain Limit: Modify ACI 318 Section 10.3.3 to read as follows:

10.3.3—*Sections are compression-controlled if the net tensile strain in the extreme tension steel, ε_t, is equal to or less than the compression-controlled strain limit when the concrete in compression reaches its assumed strain limit of 0.003. The compression-controlled strain limit is the net tensile strain in the reinforcement at balanced strain conditions. For ASTM A1035 Grade 100 reinforcement, it shall be permitted to set the compression-controlled strain limit equal to 0.004.*

4.2.10 Tension-controlled Strain Limit: Modify ACI 318 Section 10.3.4 to read as follows:

10.3.4—*Sections reinforced with ASTM A1035 Grade 100 bars are tension-controlled if the net tensile strain in the extreme tension steel, ε_t, is equal to or greater than 0.009 when the concrete in compression reaches its assumed strain limit of 0.003. Sections with ε_t between the compression-controlled strain limit and 0.009 constitute a transition region between compression-controlled and tension-controlled sections.*

4.2.11 Volumetric Spiral Reinforcement Ratio: Modify ACI 318 Section 10.9.3 to read as follows:

10.9.3—*Volumetric spiral reinforcement ratio, ρ_s, shall be not less than the value given by Eq. 4-5:*

$$\rho_s = 0.45\left(\frac{A_g}{A_{ch}} - 1\right)\frac{f_c'}{f_{yt}} \qquad \text{(Eq. 4-5)}$$

where the value of f_{yt} used in Eq. (4-5) shall not exceed 100,000 psi. For f_{yt} greater than 60,000 psi and ASTM A1035 Grade 100 reinforcement, lap splices according to 7.10.4.5(a) shall not be used.

4.2.12 Slenderness Effects: Modify ACI 318 Section 10.10.2 to read as follows:

10.10.2—*When slenderness effects are not neglected as permitted by 10.10.1, the design of compression members, restraining beams, and other supporting members reinforced with ASTM A1035 Grade 100 bars shall be based on the factored forces and moments from a second-order analysis satisfying 10.10.5. These members shall also satisfy 10.10.2.1 and 10.10.2.2. The dimensions of each member cross section used in the analysis shall be within 10 percent of the dimensions of the members shown on the contract documents or the analysis shall be repeated.*

4.2.13 Shear Strength Provided by Concrete for Nonprestressed Members: Modify ACI 318 Section 11.2.1.1 by adding the following:

For one-way slabs reinforced with ASTM A1035 Grade 100 bars where (1) ρ is less than one percent; (2) no significant axial load is present; and (3) no shear reinforcement is provided, V_c shall be computed in accordance with Eq. 4-5a or Eq. 4-5aM:

$$V_c = \frac{73}{39+2.1d}\sqrt{f'}\,b_w d \text{ (lb)} \qquad \text{(Eq. 4-5a)}$$

$$V_c = \frac{154}{1000+2.1d}\sqrt{f'}\,b_w d \text{ (N)} \qquad \text{(Eq. 4-5aM)}$$

4.2.14 Shear Reinforcement Design Strength: Modify ACI 318 Section 11.4.2 to read as follows:

11.4.2—*The values of f_y and f_{yt} used in design of shear reinforcement shall not exceed 60,000 psi (410 MPa), except the value may be increased to 80,000 psi (550 MPa) for beams and walls where appearance and serviceability due to shear cracking are not critical design considerations.*

4.2.15 Minimum Shear Reinforcement: Modify ACI Section 11.4.6.1 by replacing the first paragraph with the following:

A minimum area of shear reinforcement, $A_{v,min}$, shall be provided in all concrete flexural members reinforced with ASTM A1035 Grade 100 bars where V_u exceeds 0.5 φ V_c, except in members satisfying one or more of (a) through (f):

4.2.16 Development of Deformed Bars in Tension: Modify ACI 318 Section 12.2 by deleting Sections 12.2.2 and 12.2.3, renumbering Section 12.2.4 to become 12.2.3 and replacing Section 12.2.2 with the following:

12.2.2—*For ASTM A1035 Grade 100 deformed bars, l_d shall be in accordance with Eq. 4-6 or Eq. 4-6M:*

$$l_d = \frac{\left(\frac{f_y}{f_c'^{1/4}} - \phi 2400\omega\right)\alpha\beta_c\lambda}{\phi 76.3\left(\frac{c\,\omega + K_{tr}}{d_b}\right)} d_b \text{ (in.)} \qquad \text{(Eq. 4-6)}$$

where:

ϕ = 0.8

α = Ψ_t defined in ACI 318-11 and ACI 318-08,

= 1.3 for top cast bars

β_c = 1.0 for uncoated bars

λ = 1.0 for normal-weight concrete

c = spacing or cover dimension for reinforcing bar = $c_{min} + {}^{d_b}/_2$

c_b = bottom concrete cover for reinforcing bar being developed

c_{max} = maximum of $(c_b,\ c_s)$

c_{min} = smaller of minimum concrete cover or $^1/_2$ of the clear spacing between bars

C_{si} = $^1/_2$ of the bar spacing

C_{so} = side concrete cover for reinforcing bar

C_s = minimum of $[C_{so},\ C_{si} + 0.25\ in.\ (6.35\ mm)]$

d_b = diameter of bar

n = number of bars being developed

R_r = relative rib area of the reinforcement

$$= \frac{projected\ rib\ area\ normal\ to\ bar\ axis}{nominal\ bar\ diameter \times center\text{-}to\text{-}center\ rib\ spacing}$$

s = spacing of transverse reinforcement

$\omega = 0.1\left(\frac{c_{max}}{c_{min}}\right) + 0.9 \leq 1.25$

$K_{tr} = (0.52 t_r t_d A_{tr}/sn)\sqrt{f_c'}$ (in.) (Eq. 4-7)

$t_r = 9.6R_r + 0.28 \leq 1.72$ (Eq. 4-8)

$t_d = 0.78d_b + 0.22$ (in.) (Eq. 4-9)

$\left(\frac{c\,\omega + K_{tr}}{d_b}\right) \leq 4.0$ (Eq. 4-10)

In **SI** units

$$l_d = \frac{\left(\frac{f_y}{f_c'^{1/4}} - \emptyset 57.4\omega\right)\alpha\beta_c\lambda}{\emptyset 1.83\left(\frac{c\,\omega + K_{tr}}{d_b}\right)} d_b \text{ (mm)} \quad \text{(Eq.4-6M)}$$

$K_{tr} = (6.26 t_r t_d A_{tr}/sn)\sqrt{f_c'}$(mm) (Eq. 4-7M)

$t_r = 9.6R_r + 0.28 \leq 1.72$ (Eq. 4-8M)

$t_d = 0.03d_b + 0.22$ (mm) (Eq. 4-9M)

$\left(\frac{c\,\omega + K_{tr}}{d_b}\right) \leq 4.0$ (Eq. 4-10M)

4.2.17 Development of Deformed Bars in Compression: Modify ACI 318 Section 12.3 by adding the following:

The specified yield strength f_y in compression of ASTM A1035 Grade 100 bars is limited to 80,000 psi maximum (550 MPa).

4.2.18 Mechanical and Welded Splices: Modify ACI Section 12.14.3.1 to read as follows:

***12.14.3.1**—Mechanical splices shall be permitted when specifically recognized for use with ASTM A1035 Grade 100 reinforcing bars in an ICC-ES evaluation report. Welding of bars is prohibited.*

4.2.19 Modification of Moments for Two-way Slab Systems: Modify ACI 318 Section 13.6.7 to read as follows:

***13.6.7**—Modification of negative and positive factored moments using moment redistribution is prohibited in two-way slabs reinforced with ASTM A1035 Grade 100 bars.*

4.2.20 Use in Earthquake-resistant structures: Modify ACI Section 21.1.5 by adding new section 21.1.5.6 as follows:

***21.1.5.6**—Use of ASTM A1035 Grade 100 reinforcing bars as longitudinal reinforcement in a structural member that is part of the seismic-force-resisting system of a building assigned to SDC D, E or F is prohibited. The use of ASTM A1035 Grade 100 reinforcing bars as transverse reinforcement is permitted, provided f_{yt} is limited to 60,000 psi (410 MPa) maximum for computing shear strength.*

Modify ACI Section 21.3.2 to read as follows:

***21.3.2**—Where Grade 60 (420) reinforcing bars are used for column longitudinal reinforcement and ASTM A1035 Grade 100 reinforcing bars are used for beam longitudinal reinforcement in intermediate moment frames, the flexural strength requirements (strong-column-weak beam) in Section 21.6.2.2 shall be met using the actual strengths of the beams containing ASTM A1035 Grade 100 reinforcement. A nonlinear analysis shall be conducted to determine M_{nb}. The required shear strength of the beam shall be determined based on M_{nb} from such nonlinear analysis. Permitted methods of nonlinear analysis are given in ACI ITG-6R.*

4.2.21 Clarification with Respect to the Effect of Reinforcing Bar Tensile Strain: The design methodology for the ASTM A1035 Grade 100 reinforcing bars shall consider the effect of reinforcing bar tensile strain on the structural performance of the reinforced concrete structures containing ASTM A1035 Grade 100 reinforcement, including provisions noted in Sections 4.2, 4.8, 4.9 and Appendix B of ITG-6R.

5.0 QUALITY CONTROL

5.1 The reinforcing bars shall be produced under a quality control program demonstrating compliance with ASTM A1035 Grade 100.

5.2 Mechanical splices shall be produced under a quality control program in accordance with AC133.

5.3 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted for each facility manufacturing or labeling products that are recognized in the ICC-ES evaluation report.

5.4 A qualifying inspection shall be conducted at each manufacturing facility in accordance with the requirements of the ICC-ES Acceptance Criteria for Inspections and Inspection Agencies (AC304).

5.5 An annual inspection shall be conducted at each manufacturing facility in accordance with AC304.

5.6 Special inspections for reinforcing bars and mechanical connectors shall comply with Section 1705.3 of the 2012 IBC (Section 1704.4 of the 2009 IBC). The evaluation report shall describe the special inspector's duties, as follows:

The special inspector shall verify that reinforcing bars are of the type, grade and size specified and are in conformance with this evaluation report; ensure that reinforcing bars are free of oil, dirt and rust; verify that reinforcing bars are located within acceptable tolerances and are adequately supported and secured to prevent displacement during concrete placement; verify that minimum concrete cover is provided; verify that placement of reinforcing bars complies with required spacing, profile and quantity requirements, as indicated by both the approved plans and installation drawings; verify that hooks, bends, ties, stirrups and supplemental reinforcement are fabricated and placed as specified; verify that required lap lengths, stagger and offsets are provided; and verify proper installation of approved mechanical connections in accordance with the evaluation report and approved plans and installation drawings.

6.0 EVALUATION REPORT RECOGNITION

6.1 Restrictions, limitations, and requirements summarized in Section 1.2 of this criteria.

6.2 Basic information required by Section 2.1 of this criteria, including product description, installation procedures, packaging and identification.

6.3 Permitted mechanical splices complying with Section 3.2 of this criteria. The mechanical splices shall be specifically recognized in an ICC-ES evaluation report for use with ASTM A1035 Grade 100 reinforcing bars.

6.4 Structural design methodology complying with Section 4.0 of this criteria.

6.5 Statements on special inspection complying with Section 5.7 of this criteria.

6.6 Table 1 of this criteria, summarizing specified yield strengths of ASTM A1035 Grade 100 bars to be used in the design of structural members.

6.7 Illustrations of the reinforcing bars showing deformation patterns and identification marks. ■

TABLE 1—SPECIFIED YIELD STRENGTHS FOR DESIGN OF MEMBERS USING ASTM A1035/A1035M GRADE 100 REINFORCEMENT[1]

TYPE OF MEMBER	LONGITUDINAL REINFORCEMENT		TRANSVERSE REINFORCEMENT		
	Tension, psi (MPa)	Compression, psi (MPa)	Shear, psi (MPa)	Torsion, psi (MPa)	Confinement, psi (MPa)
Beams and one-way slabs	100,000 (690)	80,000 (550)	80,000 (550)	60,000 (410)	N/A
Columns	100,000 (690)	80,000 (550)	80,000 (550)	60,000 (410)	100,000 (690)[2]
Tension ties	80,000 (550)	N/A	N/A	N/A	N/A
Compression struts	N/A	80,000 (550)	N/A	N/A	N/A
Two-way slabs	100,000 (690)	80,000 (550)	60,000 (410)	60,000 (410)	N/A
Walls	100,000 (690)	80,000 (550)	80,000 (550)	N/A	100,000 (690)[3]
Footings and pile caps	100,000 (690)	80,000 (550)	80,000 (550)	60,000 (410)	N/A
Mat foundations	100,000 (690)	80,000 (550)	80,000 (550)	N/A	N/A

[1]N/A = Not applicable
[2]Spirals and ties
[3]Ties