ICC-ES Evaluation Report

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DIVISION: 03 00 00—CONCRETE
Section: 03 21 00—Reinforcing Steel

REPORT HOLDER:

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EVALUATION SUBJECT:

ASTM A1035/A1035M GRADE 100 STEEL REINFORCING BARS

1.0 EVALUATION SCOPE

Compliance with the following codes:

2012 and 2009 *International Building* Code® (IBC)

Property evaluated:

Structural

2.0 USES

ASTM A1035/A1035M Grade 100 steel reinforcing bars are deformed steel reinforcing bars used as longitudinal and transverse reinforcement in reinforced concrete structural members, such as foundations, columns and walls.

3.0 DESCRIPTION

3.1 ASTM A1035/A1035M Grade 100 Bars:

ASTM A1035/A1035M Grade 100 Bars are deformed steel reinforcing bars available in Nos. 3 to 18 sizes. Examples of available bars are illustrated in Figure 1. Nominal weights, dimensions, and deformations comply with values given in Table 1 of ASTM A1035.

3.2 Materials:

The bars are rolled from identified heats of cast steel and comply with requirements in ASTM A1035/A1035M for Grade 100. The specified yield strength is 100,000 psi (690 MPa) and the specified tensile strength is 150,000 psi (1030 MPa).

4.0 DESIGN AND INSTALLATION

4.1 Design:

The bars must be designed in accordance with ACI 318 and ACI ITG-6R, as summarized in Annex 1 of this report, entitled, "Design Methodology, ASTM A1035/A1035M Grade 100 Bars."

The following limitations also apply:

1. The reinforcing bars must not be used as longitudinal reinforcement in special moment frame members, special structural wall boundary elements, or coupling beams.
2. The ASTM A1035 Grade 100 reinforcing bars must not be welded.
3. The ASTM A1035 Grade 100 reinforcing bars must not be used as headed deformed bars in tension.
4. The specified compressive strength for concrete must range from 4,000 psi to 12,000 psi (27.6 MPa to 82.7 MPa).
5. Use of the ASTM A1035 Grade 100 reinforcing bars 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, which is referenced in Section 1901.2 of the IBC.
6. For structures assigned to Seismic Design Category (SDC) 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. Additional requirements pertaining to structures assigned to SDC D, E, or F are described in Section A.2.20 of this report.

4.2 Installation:

4.2.1 ASTM A1035/A1035M Grade 100 Bars: The bars and splices must be located in the structure as set forth in the approved drawings and specifications. Reinforcement details, including surface conditions, bar placement, clear spacing, offsets, spirals and ties, must comply with the applicable provisions in Chapter 7 of ACI 318

4.2.2 Mechanical Splices: Mechanical splices are beyond the scope of this report. Mechanical connectors must be recognized in an ICC-ES evaluation report and specifically permitted for use with MMFX ASTM A1035/A1035M Grade 100 bars.

4.3 Special Inspection:

Special inspection is required in accordance with 2012 IBC Section 1705.3 or 2009 IBC Section 1704.4. The special inspector must verify the following:

1. That reinforcing steels are of the type, grade and size specified and are labeled in conformance with this report.

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2. That bending of reinforcing steel bars complies with ACI 318-11 Section 7.3 under the 2012 IBC, or with 2009 IBC Section 1907.3, and the modifications given in Annex 1 Section A2.1.
3. That reinforcing steel surface conditions comply with ACI 318-11 Section 7.4 under the 2012 IBC, or with 2009 IBC Section 1907.4.
4. That reinforcing steels are placed within tolerances set forth in ACI 318-11 Section 7.5 under the 2012 IBC, or with 2009 IBC Section 1907.5; and are adequately supported and secured to prevent displacement during concrete placement.
5. That minimum concrete protection is provided in accordance with ACI 318-11 Section 7.7 under the 2012 IBC, or with 2009 IBC Section 1907.7.
6. That placement of reinforcing steel complies with required spacing, profile and quantity requirements, as specified in the approved drawings and specifications.
7. That hooks, bends, ties, stirrups and supplemental reinforcement are fabricated and placed as specified in the approved drawings and specifications.
8. That lap lengths, stagger and offsets are provided in accordance with the approved drawings and specifications.

5.0 CONDITIONS OF USE

The ASTM A1035/A1035M Grade 100 Bars described in this report comply with applicable provisions of the codes indicated in Section 1.0 of this report, subject to the following conditions:

5.1 The bars 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 more restrictive governs.

5.2 Splice locations must comply with applicable code requirements and be noted on drawings approved by the building 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 Use in structures assigned to Seismic Design Categories D, E, or F and regulated by Chapter 21 of ACI 318 are beyond the scope of this report, except as noted in Section 4.1.6 of this report.

5.5 Special inspection must be provided in accordance with Section 4.3 of this report.

5.6 Limitations listed in Section 4.1 of this report must be observed.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for High-strength Reinforcing Bars (AC429), dated June 2012.

7.0 IDENTIFICATION

Each bar is identified in accordance with the provisions of ASTM A1035/A1035M and AC429 Section 2.1.3.1. Figure 2 provides an explanation of each bar mark. The bar bundles are identified by tags bearing the manufacturer's name, the report holder's name (MMFX Steel), the grade, the number of bars in the bundle, the nominal bar diameter, bar length, heat number, roll number, and the evaluation report number (ESR-2107).

FIGURE 1—EXAMPLES OF AVAILABLE ASTM A1035 GRADE 100 BARS

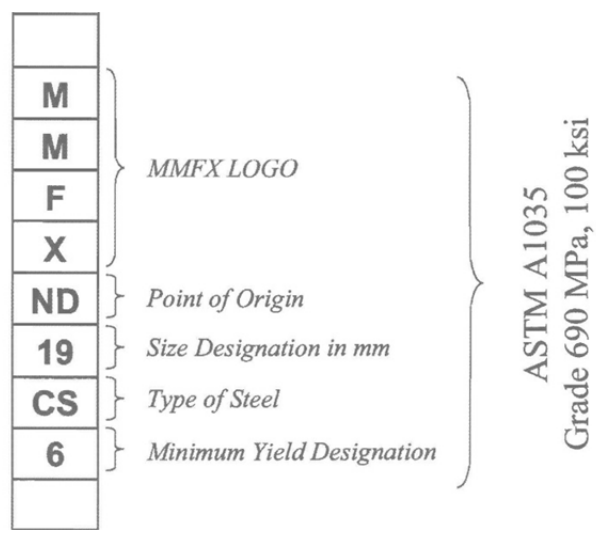

FIGURE 2—EXPLANATION OF BAR MARKINGS

ANNEX 1—DESIGN METHODOLOGY, ASTM A1035/A1035M GRADE 100 BARS

A1.0 Structural design with high-strength reinforcing bars must be in accordance with ACI 318, as modified by ACI ITG-6R. Table A1 provides the highest permissible values of the specified yield strengths for the ASTM A1035/A1035M Grade 100 bars to be used in the design of structural members.

A2.0 ACI ITG-6R provides further guidance for using high-strength steel reinforcing bars beyond current ACI 318 limitations. The design and installation of ASTM A1035/A1035M Grade 100 bars must observe the following modifications to ACI 318, taken from ACI ITG-6R:

A2.1 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 report. Tensile strain, ε_s, shall satisfy the following relationship:*

$$\varepsilon_s \leq 0.015.$$

A2.2 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.*

A2.3 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.*

A2.4 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.

A2.5 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. A2-1:

$$\varphi = 0.45 + 50\varepsilon_t \qquad \text{(Eq. A2-1)}$$

A2.6 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 no more than the values shown in Table A1.*

TABLE A1—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

A2.7 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. A2-2.

$$I_e = \frac{I_{cr}}{1-\left(1-\frac{I_{cr}}{I_g}\right)\left(\frac{M_{cr}}{M_a}\right)} \leq I_g \qquad \text{(Eq. A2-2)}$$

A2.8 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. A2-3 or A2-4:*

$f_s = 29{,}000\varepsilon_s$ (ksi) for $\varepsilon_s \leq 0.0034$ (Eq. A2-3)

100 ksi for $0.0034 < \varepsilon_s \leq 0.015$ (Eq. A2-4)

A2.9 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.*

A2.10 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.*

A2.11 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. A2-5:*

$$\rho_s = 0.45\left(\frac{A_g}{A_{ch}} - 1\right)\frac{f'_c}{f_{yt}} \quad \textit{(Eq. A2-5)}$$

where the value of f_{yt} used in Eq. (4-5) shall not exceed 100,000 psi (690 MPa). For f_{yt} greater than 60,000 psi (410 MPa) and ASTM A1035 Grade 100 reinforcement, lap splices according to 7.10.4.5(a) shall not be used.

A2.12 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.*

A2.13 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. A2-6 or Eq. A2-6M:

$$V_c = \frac{73}{39+2.1d}\sqrt{f'}\, b_w d \quad \textit{(Eq. A2-6)}$$

$$V_c = \frac{154}{1000+2.1d}\sqrt{f'}\, b_w d \quad \textit{(Eq. A2-6M)}$$

A2.14 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.*

A2.15 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):

A2.16 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. A2-7 or Eq. A2.7M:*

$$l_d = \frac{\left(\frac{f_y}{f'^{1/4}_c} - \emptyset\, 2400\, \omega\right)\alpha\, \beta_c \lambda}{\emptyset\, 73.6\left(\frac{c_b\, \omega + K_{tr}}{d_b}\right)}\, d_b \ \textit{(in.)} \quad \text{(Eq. A2-7)}$$

where:

ϕ = 0.8
α = 1.3 for top cast bars
β_c = 1.0 for uncoated bars
λ = 1.0 for normal-weight concrete

$K_{tr} = (0.52 t_r t_d A_{tr}/sn)\sqrt{f'_c}$ (in.) (Eq. A2-8)

$t_r = 9.6R_r + 0.28 \leq 1.72$ (Eq. A2-9)

$t_d = 0.78d_b + 0.22$ (in.) (Eq. A2-10)

$\left(\frac{c_b\,\omega + K_{tr}}{d_b}\right) \leq 4.0$ (Eq. A2-11)

In SI units

$l_d = \frac{\left(\frac{f_y}{f'^{1/2}_c} - \emptyset\, 57.4\,\omega\right)\alpha\,\beta_c\lambda}{\emptyset\, 1.83\left(\frac{c_b\,\omega + K_{tr}}{d_b}\right)}\, d_b$ (mm) (Eq. A2-7M)

$K_{tr} = (6.26 t_r t_d A_{tr}/sn)\sqrt{f'_c}$ (mm) (Eq. A2-8M)

$t_r = 9.6R_r + 0.28 \leq 1.72$ (Eq. A2-9M)

$t_d = 0.03d_b + 0.22$ (in.) (Eq. A2-10M)

$\left(\frac{c_b\,\omega + K_{tr}}{d_b}\right) \leq 4.0$ (Eq. A2-11M)

A2.17 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 (550 MPa) maximum.

A2.18 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.*

A2.19 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.*

A2.20 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 MPa) 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.*