

ACI 439.6R-19

Guide for the Use of ASTM A1035/A1035M Type CS Grade 100 (690) Steel Bars for Structural Concrete

Reported by ACI Committee 439



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Guide for the Use of ASTM A1035/A1035M Type CS Grade 100 (690) Steel Bars for Structural Concrete

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*This guide provides recommendations on design provisions for the use of **ASTM A1035/ASTM A1035M** Type CS Grade 100 (690) deformed steel bars for reinforced concrete members. The recommendations address only those requirements of **ACI 318-14** that limit efficient use of such steel bars. Other code requirements are not affected. Any other ACI 318 versions will be explicitly specified. Although there are limiting ACI 318 requirements, ACI 318-14 Section 1.10 would allow the use of high-strength reinforcement. “Sponsors...shall have the right to present the data on which their design is based to the building official or to a board of examiners appointed by the building official.”*

*The International Building Code (IBC 2012) would allow the same under Section 104.11, “Alternative materials, design and methods of construction and equipment”. To approve an alternative material under this section, a building department would typically require an ICC Evaluation Service (ICC-ES) Evaluation Report, which would be based on an ICC-ES Acceptance Criteria (AC) document. An AC document (**ICC-ES AC429**) and an Evalua-*

*tion Report (**ICC-ES ESR-2107**) exist, permitting the use of ASTM A1035/A1035M Grade 100 reinforcement.*

This guide includes a discussion of the material characteristics of Grade 100 (690) ASTM A1035/A1035M (CS) deformed steel bars and recommends design criteria for beams, columns, slab, systems, walls, and footings for Seismic Design Category (SDC) A, B, or C, and for structural components not designated as part of the seismic-force-resisting system for SDC D, E, or F.

A structure assigned to SDC A, B, or C is required to be designed for all applicable gravity and environmental loads. In the case of SDC A structures, seismic forces are notional structural integrity forces. This guide addresses all design required for SDC A, B, and C structures.

*Because the modulus of elasticity for ASTM A1035/A1035M (CS) is similar to that of carbon steel (**ASTM A615/A615M**) using higher specified minimum yield strength f_y , may result in higher steel stress at service load condition and potentially cause wider cracks and larger deflections, which may be objectionable if aesthetics and water-tightness are critical design requirements. Higher deflection can also contribute to serviceability issues. Also, with higher f_y , the required development length will be longer.*

Keywords: bar; design; guide; high-strength steel; structural.

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CHAPTER 1—INTRODUCTION

1.1—Objective

This guide is based on [ACI ITG-6R-10](#), “Design Guide for the Use of [ASTM A1035/A1035M](#) Grade 100 (690) Steel Bars for Structural Concrete,” reported by ACI Innovation Task Group 6. The ACI ITG-6R guide provides design provisions for the use of ASTM A1035/A1035M Type CS Grade 100 (690) deformed steel bars in reinforced structural members. This guide, which is based on ACI ITG-6R-10, is a stand-alone document, references and addresses only those requirements in ACI 318-14 that limit the use of such steel bars, and should not affect the application of other code requirements. Any other [ACI 318](#) version will be explicitly specified. This guide includes a discussion of the material characteristics of Grade 100 (690) ASTM A1035/A1035M Type CS (Chromium content 8.0 to 10.9 percent) deformed steel bars, and the design provisions are based on the specific material properties and stress-strain behavior of these bars.

Although there are limiting ACI 318 requirements, ACI 318-14 Section 1.10 would allow the use of high-strength reinforcement. “Sponsors...shall have the right to present the data on which their design is based to the building official or to a board of examiners appointed by the building official.”

The IBC International Building Code (IBC 2012) would allow the same under Section 104.11, “Alternative materials, design and methods of construction and equipment”. To approve an alternative material under this section, a building department would typically require an ICC Evaluation Service (ICC-ES) Evaluation Report that would be based on an ICC-ES Acceptance Criteria (AC) document. An AC document ([ICC-ES AC429](#)) and an Evaluation Report ([ICC-ES ESR-2107](#)) exist, permitting the use of ASTM A1035/A1035M Grade 100 reinforcement.

Since publication of ACI ITG-6R, additional Grade 100 (690) ASTM A1035/A1035M Types CM (Chromium content 4.0 percent to 7.9 percent) and CL (chromium content 2.0 percent to 3.9) were introduced to the market. The mechanical properties and stress-strain characteristics of these steels may affect the design criteria herein and limit the applicability of the guide. Additionally, ASTM A615/A615M Grade 100 (690) was introduced to the market. These bars will be addressed in future editions when research on concrete members reinforced with these bar types become available and the impact of the mechanical properties have been documented. Grade 120 (830) ASTM A1035/A1035M Type CS, CM and CL are available, but are not addressed under this guide.

1.2—Scope

This guide presents the material characteristics of ASTM A1035/A1035M (CS) steel bars and recommends design criteria for beams, columns, slab systems, walls, and footings for Seismic Design Category (SDC) A, B, or C. A structure assigned to SDC A, B or C is required to be designed for all applicable gravity and environmental loads. In the case of SDC A structures, seismic forces are notional structural integrity forces. This guide addresses all design required for SDC A, B, and C structures. Due to lack of adequate data,

the application of this guide for SDC D, E, or F is limited to slab systems, foundations, and structural components not designated as part of the seismic-force-resisting system, but explicitly checked for the induced effects of the design displacements. The only exception is the use of transverse reinforcement for concrete confinement with a specified minimum yield strength f_y up to 100,000 psi (690 MPa) in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers as permitted by ACI 318. Refer to 10.1 of this guide for more information on seismic design considerations. Shells, folded plate members, and prestressed concrete are beyond the scope of this guide. However, ASTM A1035/A1035M Type CS can be used as reinforcement in prestressed concrete but not as the prestressing strands. Design examples are included to illustrate design procedures and proper application of the design criteria. Modifications to these design criteria may be justified where the design adequacy within the scope of this guide is demonstrated by successful use, analysis, or test.

1.3—Historical perspective and background

For several decades prior to [ACI 318-71](#), the design of structural concrete was restricted to using specified minimum yield strength f_y of 60,000 psi (420 MPa) or less for reinforcing bars. Section A603(e) of ACI 318-56 specified that “Stress in tensile and compressive reinforcement at ultimate load shall not be assumed greater than the yield point or 60,000 psi, whichever is smaller.”

Section 1505 of [ACI 318-63](#), specified two requirements:

“(a) When reinforcement is used that has a yield strength, f_y , in excess of 60,000 psi (420 MPa), the yield strength to be used in design shall be reduced to $0.85f_y$ or 60,000 psi (420 MPa), whichever is greater, unless it is shown by tension tests that at a proof stress equal to the specified minimum yield strength, f_y , the strain does not exceed 0.003;

(b) Designs shall not be based on a yield strength, f_y , in excess of 75,000 psi (520 MPa). Design of tension reinforcement shall not be based on a yield strength, f_y , in excess of 60,000 psi (420 MPa) unless tests are made in compliance with Section 1508(b).”

The Commentary on Section 1505 of ACI 318-63 states that:

This section provides limitations on the use of high strength steels to assure safety and satisfactory performance. High strength steels frequently have a strain at yield strength or yield point in excess of the 0.003 assumed for the concrete at ultimate. The requirements of Section 1505(a) are to adjust to this condition.

The maximum stress in tension of 60,000 psi (420 MPa) without test is to control cracking. The absolute maximum is specified as 75,000 psi (520 MPa) to agree with present ASTM specifications and as a safeguard until there is adequate experience with the high stresses.