ACI 439.4R-09

Report on Steel Reinforcement—Material Properties and U.S. Availability

Reported by ACI Committee 439

American Concrete Institute®

First Printing
October 2009

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ISBN 978-0-87031-348-6

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The material properties of the various types of steel reinforcement produced for use in the United States are described. Types of steel reinforcement defined in this report include deformed reinforcing bars, plain and deformed wire, welded wire reinforcement, bar mats, and prestressing reinforcement. The requirements, restrictions, and testing information of the pertinent ASTM specifications are reviewed. The availability of the various types and sizes of reinforcement in the U. S. is discussed.

Keywords: bend tests; bending (reinforcing steels); deformed reinforcement; deformed reinforcing bars; ductility; material properties; prestressing steels; reinforced concrete; reinforcing steels; specifications; spiral reinforcement; tensile strength; welded reinforcement grids; welded wire fabric; welded wire reinforcement; yield strength.

CONTENTS

ACI 439.4R-09 supersedes ACI 439.4R-89 and was adopted and published October 2009.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

The material properties of the various types of steel reinforcement produced for use in the U.S. are described. Types of steel reinforcement defined in this report include deformed reinforcing bars, plain and deformed wire, welded wire reinforcement, bar mats, and prestressing reinforcement. The requirements, restrictions, and testing information of pertinent ASTM specifications are reviewed. The availability of the various types and sizes of reinforcement in the U.S. is discussed.

1.2—Scope

Requirements for reinforcement are stated in Section 3.5.1 of ACI 318-08 as: "Reinforcement shall be deformed reinforcement, except that plain reinforcement shall be permitted for spirals or prestressing steel..." Deformed reinforcement is defined in Section 2.2 of ACI 318-08 as: "Deformed reinforcing bars, bar mats, deformed wire, welded wire reinforcement conforming to Section 3.5.3." This report excludes discussion of structural steel, steel pipe, steel tubing, steel fibers, expanded metal, and fiber-reinforced polymers (FRP) and other nonmetallic reinforcement.

This report describes these types of steel reinforcement in terms of availability and material properties, expressed in inch-pound units and metric units. The special requirements of ACI 349 and 359 are also discussed. American Association of State Highway and Transportation Officials (AASHTO) requirements (2002, 2004) are not discussed in this report because they generally follow ACI 318.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

There is no notation used in this document.

2.2—Definitions

compacted strand—prestressing strand that is drawn through a circular die deforming the wires to produce a strand with a smaller circular shape.

indented strand—prestressing strand in which the outer wires have small indentations to permit more rapid transfer of strand force to the concrete.

See ACI CT, 'Concrete Terminology,' for definitions at the ACI Web site, http://www.concrete.org/Technical/CCT/FlashHelp/ACI_Terminology.htm.

CHAPTER 3—REINFORCING BARS

3.1—Introduction

Reinforcing bars are the most popular type of nonprestressed reinforcing steel used in concrete construction. Approximately 10 million tons of reinforcing bars are used in the U.S. every year. Nearly all reinforced concrete construction, including precast and prestressed structures, requires some reinforcing bars.

Most of the reinforcing bars used in construction are deformed bars; that is, the bars have deformations to enhance the bond of the steel to the surrounding concrete. Limits on the deformation dimensions, such as the minimum deformation height and maximum deformation spacing, are prescribed in ASTM specifications. Plain reinforcing bars, which do not have deformations, are only permitted by ACI 318 for spiral reinforcement as used in reinforced concrete columns.

3.2—Material properties

The mechanical property requirements, chemical composition restrictions, and other requirements of the ASTM specifications for reinforcing bars are summarized in Tables 3.1 through 3.3. Reinforcing bars are primarily a hot-rolled product. The bars are manufactured by a steel mill using electric-arc furnaces to melt scrap steel to produce billets. These billets are then heated and passed through a series of rolls to make reinforcing bars. The deformations are formed on the bars during the final pass through the rolls.

Most of the properties of reinforcing bars of interest to the Architect/Engineer are defined by ASTM specifications. The significance of certain properties as defined by ASTM, however, is not readily apparent, and some special properties related to structural design are not defined by ASTM. Therefore, a brief review of the significance of various mechanical properties on structural design is appropriate. Plots of idealized stress-strain curves for ASTM A615 and ASTM A706 reinforcing bars are shown for two strain ranges in Fig. 3.1.

Of prime importance in structural design is the yield strength of nonprestressed reinforcement. ACI 318 requires determination of yield strengths over 60 ksi (420 MPa) at a