

ACI 315R-18

Guide to Presenting Reinforcing Steel Design Details

Reported by Joint ACI-CRSI Committee 315



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Guide to Presenting Reinforcing Steel Design Details

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Guide to Presenting Reinforcing Steel Design Details

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This document guides designers of concrete structures how to determine information and design details that are required to prepare reinforcing steel fabrication details and placing drawings. The guide stresses the importance of this information to ensure that the reinforcing steel detailer effectively and accurately captures the intent of the designer, presenting it in a manner that is clear and unambiguous to the reinforcing steel fabricator and placer. Recommendations are also provided concerning the review of placing drawings.

Keywords: concrete structures; design details; detailing; engineering drawings; fabrication details; placing drawings; reinforcement; reinforcing steel; tolerances.

CONTENTS

CHAPTER 1—INTRODUCTION AND SCOPE, p. 2

- 1.1—Introduction, p. 2
- 1.2—Scope, p. 2

CHAPTER 2—NOTATION AND DEFINITIONS, p. 2

- 2.1—Notation, p. 2
- 2.2—Definitions, p. 2

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CHAPTER 3—GENERAL CONSIDERATIONS, p. 2

- 3.1—Building information modeling (BIM), p. 2
- 3.2—Tolerance considerations, p. 4
- 3.3—General cautions, p. 11
- 3.4—Drawing types and purposes, p. 12

CHAPTER 4—STRUCTURAL DRAWINGS, p. 12

- 4.1—Scope, p. 12
- 4.2—General, p. 12
- 4.3—Order of sheets, p. 13
- 4.4—General notes sheets, p. 13
- 4.5—Plan sheets, p. 20
- 4.6—Elevation sheets, p. 22
- 4.7—Section sheets, p. 23
- 4.8—Large-scale view sheets, p. 23
- 4.9—Detail sheets, p. 24
- 4.10—Schedule and diagram sheets, p. 26
- 4.11—Foundation sheets and schedules, p. 31
- 4.12—User-defined sheets, p. 32
- 4.13—Three-dimensional representations, p. 32

CHAPTER 5—DESIGNING FOR CONSTRUCTABILITY, p. 32

- 5.1—Defining requirements for concrete cover, clearance, development, and splices, p. 33
- 5.2—Defining bar placing configuration, p. 33
- 5.3—Foundations, p. 34
- 5.4—Walls, p. 36
- 5.5—Columns, p. 40
- 5.6—Beams, p. 42

ACI 315R-18 supersedes ACI 315-99 and was adopted and published January 2018.
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5.7—Slabs, p. 43

CHAPTER 6—REVIEW OF PLACING DRAWINGS, p. 46

6.1—Scope, p. 46

6.2—Definition, p. 46

6.3—Overview, p. 46

6.4—Procedure, p. 46

6.5—Review of placing drawings, p. 48

6.6—Levels of approval, p. 49

CHAPTER 7—REFERENCES, p. 49

Authored documents, p. 50

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

The purpose of this document is to guide the licensed design professional (LDP) in determining the information a reinforcing steel detailer requires to properly prepare reinforcing steel fabrication details and placing drawings. Guidance to the LDP is provided on how to present that information on their structural drawings so that the design intent is effectively and accurately conveyed.

The intent of this guide is to encourage clarity and consistency in reinforcing steel design details to help improve the quality and uniformity of steel reinforcement detailing, fabrication, and installation. It is intended to facilitate clear communication between LDPs, reinforcing steel detailers, fabricators, and placers by encouraging clear presentation of design details and information. Information presented is consistent with the requirements and recommendations of several ACI documents, including [ACI 318](#), [ACI 301](#), [ACI 117](#), [ACI 131.1R](#), and [ACI 132R](#).

1.2—Scope

This guide provides general and specific information, as well as illustrative design details that are required for steel-reinforced concrete members such as slabs, beams, and columns. The importance of this information is emphasized to ensure that the reinforcing steel detailer effectively and accurately captures the intent of the LDP, and presents it in a manner that is clear and unambiguous to the reinforcing steel fabricator and placer. Recommendations are also provided concerning the review of placing drawings by the LDP.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

- A_g = gross area of concrete section, in.² (mm²) where for a hollow section, A_g is the area of the concrete only and does not include the area of the void(s)
- A_{st} = total area of nonprestressed longitudinal reinforcement, including bars or steel shapes and excluding prestressing reinforcement, in.² (mm²)
- b = width of member, in. (mm)
- d = distance from extreme compression fiber to centroid of tension reinforcement, in. (mm)

- d_{agg} = nominal maximum size of coarse aggregate, in. (mm)
- d_b = nominal diameter of bar or wire, in. (mm)
- f'_c = specified compressive strength of concrete, psi (MPa)
- f_y = specified yield strength for nonprestressed reinforcement, psi (MPa)
- h = overall thickness, height, or depth of member, in. (mm)
- ℓ_d = development length in tension of deformed bar, deformed wire, or plain and deformed welded wire reinforcement, in. (mm)
- ℓ_{dh} = development length in tension of deformed bar or deformed wire with a standard hook, measured from outside end of hook, point of tangency, toward critical section, in. (mm)
- ℓ_{ext} = straight extension at the end of a standard hook, in. (mm)
- V_u = factored shear force

2.2—Definitions

ACI provides a comprehensive list of definitions through an online resource, ACI Concrete Terminology. The definitions provided herein complement that resource.

design details—drawings or other information presented by the licensed design professional (LDP) defining steel reinforcement sizes, locations, clearances, splices, geometry, points of termination, relationships, and tolerances.

detailer—person, firm, or corporation producing the reinforcing steel fabrication details and placing drawings based on the design drawings and design details for the structure.

detailing—the process of determining fabrication details based on design details.

fabrication details—dimensions and geometry of steel reinforcement determined for fabrication.

fabricator—person, firm, or corporation producing the reinforcing steel cut and bent to needed dimensions and geometry.

federated model—a building information model (BIM) that electronically links, but does not merge, single-discipline models together for analysis or presentation; the model databases remain distinct and are not combined into a single database.

placing drawings—detailed drawings that give the quantity, size, dimensions, spacing, locations, and other information required for reinforcement fabrication and installation.

CHAPTER 3—GENERAL CONSIDERATIONS

3.1—Building information modeling (BIM)

3.1.1 Introduction to BIM—Building information modeling is a three-dimensional process used to generate and manage digital models of buildings and other structures. This process is used by those who plan, design, and build structures, as well as those who manage these facilities. The process involves creating and maintaining intelligent models with attributes that represent characteristics of a facility and contain parametric data about the elements within the model. Many software packages exist that fall within the definition

of BIM; each of these have distinct advantages to varying elements of the life cycle of a facility, from its design to construction through operation.

Although the focus of most BIM discussions center on the three-dimensional virtual model, the parametric data is of equal importance. The following is from the National BIM Standard-United States™ (NBIMS-US™ 2015):

Building Information Model: Is the DIGITAL REPRESENTATION of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onwards.

In general, what makes BIM different than simple three-dimensional modeling is more information; not only is it a virtual mockup of a structure, but also a relational database of information.

A building information model is applied to the details of concrete reinforcement in the design and construction phases of a structure. In the design phase, BIM is often used by the design team to define the physical characteristics of the concrete to be reinforced by defining concrete edges in physical space, and reinforcement information using either data within the concrete elements or physical representations of the reinforcement. During the construction phase, concrete geometry is often further developed to the level required for construction, and reinforcement is defined to a level from which it can be fabricated and installed. The definition of the level of modeling, which is known as the Level of Development (LOD), is a key concept described as follows.

3.1.2 Level of Development—The content and reliability of a BIM is defined by an industry standard referred to as the Level of Development (LOD). The American Institute of Architects (AIA) and BIMForum have developed an **LOD specification (2016)** to standardize these definitions. The specification enables BIM stakeholders to specify and discuss with precision the content and reliability of models at different stages of the design and construction process. The LOD specification incorporates the AIA definition from the **AIA G202™-2013** form and is organized in The Construction Specifications Institute (CSI) **UniFormat™ (2010)**, which defines the important properties of model elements at various levels of development. This establishes a framework that allows model creators and users to establish reliable uses for the model. The intent of the specification is strictly to facilitate communication; it does not establish or prescribe what LOD is to be attained at any specific point in the project.

For example, in the construction phase, the concrete geometry is defined to a construction level of at least LOD 300 or 350, and the reinforcement is defined to LOD 350 to 400 to assure proper fabrication and placement (CSI UniFormat™ 2010). Many structural design models produced are not able to provide this level of detail for reinforcing steel.

3.1.3 Benefits and challenges of BIM—The technology of building construction and the preparation of documents for construction is rapidly evolving. All stakeholders should be

aware of the potential benefits and wary of potential challenges in using new or evolving technology.

Licensed design professionals who are using BIM will, in most cases, be focused on developing models for the primary purpose of design rather than construction. Consequently, downstream users of design models should be wary that the information found in them might not be developed to the level required for their purposes.

The benefits of BIM accrue at all stages of a project to all stakeholders, including the owner, owner's representative, construction manager, contractors, subcontractors, material and equipment suppliers, and designers. The manner of BIM implementation can be tailored to the nature of the project, nature of the owner, delivery method, and delivery time available. Potential benefits include:

3.1.3.1 Design and detailing—

- a) Better visualization, especially when dealing with complex structures
- b) Improved coordination between trades through information sharing, which is one goal of a BIM process
- c) Ability to rapidly compare alternatives
- d) Improved communications and efficiency and reduced errors through:

- 1) Detecting and addressing issues earlier in the design process, thereby reducing the number of requests for information (RFIs) and issues in the field
- 2) Clearer communication of structural geometry and design intent from the LDP to the reinforcement detailer than what would be possible using traditional two-dimensional documents
- 3) Reinforcing details presented in three dimensions at a construction LOD
- 4) Better communication of reinforcement fabrication and placement information with downstream entities

3.1.3.2 Construction—Enhanced project visualization made possible by having full building models and related information readily available

- a) More accurate material takeoffs, leading to less waste and reduced overall project costs
- b) Improved project coordination, clash detection, and resolution achieved by combining three-dimensional models from various subcontractors into a single federated model
- c) Validate the work sequence or progress with four-dimensional models created by the intelligent linking of individual three-dimensional components or assemblies with time- or schedule-related information
- d) Increased change management so stakeholders better understand the impacts associated with them

3.1.3.3 Operation

- a) Better 'as-built' documentation than conventional two-dimensional drawings, leading to easier remodels, rebuilds, and additions
- b) Improved management of a building's life cycle achieved by using the three-dimensional model as a central database of all the building's systems and components
- c) Enhanced tracking of building performance and maintenance needs

3.1.4 IFC files and BIM file transfers—Numerous BIM software packages exist that can define concrete geometry and data, detailing reinforcement, or both. Most BIM software is compatible with an open file format specification known as the Industry Foundation Classes (IFC) data models (ISO 16739:2013). This is an object-based file format that allows ease of interoperability between software platforms. Industry Foundation Classes files can be exported from, and imported into, most BIM software platforms, allowing model content and data created in different software to be viewed and used in other software.

In addition to IFC data file transfers, which can be brought directly into a building information model, there are many other electronic deliverable formats available for conveying model content to other stakeholders. Many programs share information-rich models securely, accurately, and in a relevant context that can be viewed on a variety of platforms—from desktop computers to hand-held tablets and smartphones. There are also various types of two- and three-dimensional PDF documents that can be used.

3.1.5 State of the technology—Building information modeling began in the late 1990s. One characteristic that makes BIM superior to past technologies is the ability to change and evolve with newly developing technologies that are providing an ever-increasing level of detail and volume of information. Building information modeling use varies with companies, industry segments, and regions, and is continually expanding. The introduction and development of technology for mobile access to data and the documentation of field conditions is shaping the development of BIM methods and capabilities for the future. A major focus for the evolution of BIM is improving the ability of different users applying different tools to readily use the database information. Although most BIM software packages are compatible with opening IFC format databases, each interprets the data differently, which leads to differences and errors when applying this method. The goal of improved access is not only intended for designer-to-designer transfer; there has also been much effort in developing processes for transferring data for downstream fabrication uses. Structural steel, pipe and duct, and reinforcing steel fabricators benefit from the ability to seamlessly use information from the building information model directly on the fabrication line of these elements.

Reinforcement placement in the field is being enhanced through technology in similar ways to others in the reinforcing market. Using devices such as tablets and smartphones makes access to BIM, fabrication information, placing drawings, three-dimensional PDFs, and a host of other electronic data available on the job site at the point of reinforcement placement. This easy access to information, which in many cases is bidirectional, is providing a real-time exchange of information that ensures the most up-to-date details are installed correctly, a better visual understanding, and more efficient tracking of work. From hand-held scanners to smart devices, field placement crews can also record important information in real-time by scanning a variety of data from fabrication tags and other identification markers to track receipt, installation, location, heat and mill cert information and production rates.

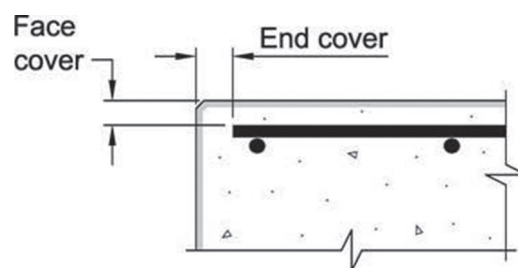


Fig. 3.2.2—Face cover and end cover for reinforcement.

as well as actual installation as-built conditions that can then be used for documentation, change management, coordination, and constructability reviews.

3.2—Tolerance considerations

3.2.1 Introduction and ACI 117—ACI 301 requires that construction tolerances comply with ACI 117. ACI 117 provides tolerances for concrete construction, including tolerances for concrete forming, reinforcing bar fabrication, and placement. These tolerances, which can have an effect on cover, strength, constructability, and serviceability, are required to make concrete construction physically possible and economically practical. If more restrictive tolerances are required than those shown in ACI 117, they should be clearly indicated in the construction documents.

Note that while welded wire reinforcement (WWR) is not explicitly referenced in ACI 117, the fabrication tolerance information therein is normally applicable to WWR produced for concrete construction, and is enforced at the plant level accordingly. Fabrication of WWR styles is carried out in accordance with ASTM A1064/A1064M with due consideration for tolerances set forth in ACI 117. Refer to the Wire Reinforcement Institute manuals WWR-500-R-16 and WWR-600 for additional specifics.

In areas of potential reinforcement congestion, the LDP should consider combinations of tolerances—namely, reinforcing bar fabrication; reinforcing bar placement; clearance and congestion resulting from items such as couplers, headed bars, and other reinforcing bar accessories; and formwork. Combinations of tolerances can result in placement conflicts that are not readily resolved in the field. As an example, bars fabricated to the maximum positive (+) tolerance could create a conflict with required cover in some circumstances, or with an embedded element. The design/construction team should be aware of tolerances and work to identify and remove conflicts prior to construction.

3.2.2 Concrete cover for reinforcement—ACI 301 and ACI 318 define concrete cover requirements for reinforcement. Concrete cover as protection of reinforcement against weather and other effects is measured from the concrete surface to the outermost surface of the steel to which the cover requirement applies. ACI 117 defines tolerances for concrete cover (measured perpendicular to the concrete surface). There are two measurements for concrete cover, as shown in Fig. 3.2.2:

- (1) Face cover – measured from the face or surface of a bar to the concrete surface