October 12, 2011

Memorandum to: Members ACI/CRSI Committee 315 - Details of Concrete Reinforcement

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From: Anthony L. Felder
Secretary

Subject: Meeting Notice and Agenda
October 16, 2011
Duke Energy Convention Center
Cincinnati, Ohio

Our next meeting will be held on Sunday, October 16, 2011 from 2:00 p.m. to 5:00 p.m. in Room 202 of the Duke Energy Convention Center.

A proposed agenda is attached.

Copy to: David J. Bird, TAC Contact
Daniel W. Falconer, ACI Technical Director
AGENDA
ACI/CRSI COMMITTEE 315 - DETAILS OF CONCRETE REINFORCEMENT

October 16, 2011

1. 2:00 p.m. - call meeting to order

2. Approval of minutes of last meeting, April 3, 2011, distributed July 20, 2011

3. Committee membership changes since last meeting. See Exhibit 1, current roster.

4. ACI Detailing Manual (SP-66)
   a. Opening Remarks – Chairman Hunter
   b. BIM Overview
   c. Reformatting of the ACI 318 Code – Greg Zeisler, ACI Staff
   d. Discussion on development of “Details and Detailing of Concrete Reinforcement” - Zeisler. See Exhibit 2.
      - Lap Splices
      - Dimensions
        ○ Grid to Grid
        ○ Requirements of Architectural vs. Structural vs. Placing
      - Columns/Walls
   e. Walls and Coupling Beams – Paul Brienen
   f. Discussion of Example Drawings – Zeisler/Hunter


   Secretary's Note: Subcommittee B is scheduled to meet on Sunday, October 16, 2011 from 8:30 a.m. to 11:30 a.m. in Room 207 of the Duke Energy Convention Center.

6. Nuclear Verbatim Compliance – Robbie Hall

7. New Business
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CHAPTER 1—INTRODUCTION

1.1—Introduction

This guide is written assuming that the project, and subsequently, the drawings are a structural concrete building. This guide includes information required to be presented by ACI 318, Building Code Requirements for Structural Concrete, and the mandatory checklist of ACI 301, Specifications for Structural Concrete. ACI 301 also requires that applicable optional checklist items be presented as well. ACI SP-17, ACI Design Handbook: Design of Structural Reinforced Concrete Elements in Accordance with ACI 318, provides several design examples that are extended into ACI SP-66 Details and Detailing of Concrete Reinforcement in Part C. Many other ACI documents are available in addition to those specifically discussed above and may have more information available for the design engineer's use. Consider using these other documents to research and develop solutions to specific design requirements on a structural building project.

1.2—Scope

This guide indicates to the licensed design professional how reinforcement information should be shown in the structural drawings. It also shows the reinforcing bar detailer how reinforcement information should be shown in the reinforcement placing drawings. By providing this information, this guide is intended to aid both parties to communicate with each other. Improving this communication will aid all parties in the construction process and reduce or
prevent misinterpretation of either structural or placing drawings by the licensed design professional, reinforcing bar detailer, contractor, inspector, or building official.

CHAPTER 2—DEFINITIONS

ACI provides a comprehensive list of definitions through an online resource, “ACI Concrete Terminology,” http://terminology.concrete.org. Definitions provided here complement that resource.

TERMINOLOGY

licensed design professional—an engineer or architect who is licensed to practice structural design as defined by the statutory requirements of the professional licensing laws of a state or jurisdiction; or the architect or engineer, licensed as described, who is responsible for the structural design of a particular project.

CHAPTER 3— LAYOUT OF STRUCTURAL DRAWINGS

3.1—Scope

This chapter gives a basic layout of structural drawings. It shows a single way to order drawing sheets and describes what types of information might be found on each of those sheets. It is acknowledged that each design office usually has an “office standard” sheet order and naming
1 convention, so sheet order is flexible. The order here is taken from the United States National
2 CAD Standard – V5.
3 3.2—General
4 This document makes several assumptions with regards to drawing creation. It is assumed that
5 the drawings will be produced in a computer aided drafting (CAD) program. This could be a
6 simple two-dimensional piece of software or more sophisticated three-dimensional software. It
7 is also assumed that the drawings will be created by drafting the model in a 1:1 scale model
8 space and then scaled to fit on the typical sheet size for the project using a view of the model.
9 Each sheet is assumed to have the following basic parts included:
10 • Drawing area
11 • Production data area
12 • Title block area
13 The drawing area is the main portion of the sheet. This is the area where the plan, sections,
14 details, general notes, etc will be located.
15 The production data area is typically located in the left margin of the sheet and includes the CAD
16 filename and path to the file for this sheet. It may also include other information about the
17 printing of the sheet as well, such as default settings, pen assignments, printer/plotter commands,
18 overlay drafting control data, and reference files.
19 The title block area typically makes up the right edge of the sheet. It will usually include the
20 designers name, address, and logo; basic information about the project including location of the
21 worksite, owner, and project name; an information block regarding what issue (addendum,
22 design development, bidding, etc) of this sheet is; a sheet management block that indicates who
I was responsible for drawing and checking the drawings; a sheet title block; and a sheet identification block.

3.3—Typical order of drawings

The typical order of drawings shown in the United States National CAD Standard – V5 is as follows:

<table>
<thead>
<tr>
<th></th>
<th>General (symbols legend, notes, etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Plans (horizontal views)</td>
</tr>
<tr>
<td>1</td>
<td>Elevations (vertical views)</td>
</tr>
<tr>
<td>2</td>
<td>Sections (sectional views, wall sections)</td>
</tr>
<tr>
<td>3</td>
<td>Large-Scale Views (plans, elevations, stair sections, or sections that are not details)</td>
</tr>
<tr>
<td>4</td>
<td>Details</td>
</tr>
<tr>
<td>5</td>
<td>Schedules and Diagrams</td>
</tr>
<tr>
<td>6</td>
<td>User Defined (for types that do not fall in other categories, including typical detail sheets)</td>
</tr>
<tr>
<td>7</td>
<td>User Defined (for types that do not fall in other categories)</td>
</tr>
<tr>
<td>8</td>
<td>3D Representations (isometrics, perspectives, photographs)</td>
</tr>
</tbody>
</table>

3.4—Typical content of drawings

3.4.1 General notes

A general notes sheet is typically an extension of the project specifications. They contain material, design, and construction information that impacts the entire project.

3.4.1.1 General building code – mandatory information

The general building code requires that certain information be included on the contract documents. Often, the General notes sheets of the structural drawings show this information.
The 2009 IBC requires: "Construction documents shall show the size, section, and relative locations of structural members with floor levels, column centers, and offsets dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.9 shall be indicated on the construction documents."

Sections 1603.1.1 through 1603.1.9 require the following to be shown on the contract documents:

- Floor live load
- Roof live load
- Roof snow load
- Wind design data
- Earthquake design data
- Geotechnical information
- Flood design data
- Special loads
- Systems and components requiring special inspections for seismic resistance.

All of these items are usually shown either in the general notes or the project specifications. In addition to these items, ACI 318 requires that all applicable information from Chapter 23 be included in the contract documents. This information may be included in the project specifications or the structural drawings.

Live loads, roof live loads, and snow loads and other simple gravity loads are typically shown in a table located in the general notes. The general notes list the basic wind load criteria assumptions and, when necessary, wind loading diagrams. Earthquake design data is usually shown through a list of the different criteria that are used to develop the estimated earthquake
loads. Geotechnical information shown is usually determined by the geotechnical engineer and supplied to the structural designer in the geotechnical report. The geotechnical report recommends to the structural engineer whether a shallow or deep foundation should be used. It also includes allowable soil pressures to be used for shallow foundations. What type of deep foundation is recommended as well, with end-bearing piles or caissons as one alternative or friction bearing piles are another. This information is shown via table or note. How the information is shown depends on the variability of soil conditions on the project site. A table may be necessary if there are several different foundation recommendations because of soil variability, but a note will usually suffice if there is little variability of soil conditions on the site.

Flood design data is typically shown using notes, showing the criteria used by the designer to determine the flood design loads.

Any special loads are typically included in the load table that shows the live loads. Some examples of these loads are especially heavy pieces of equipment, architectural features, partition live loads, ceiling and hanging loads, any super-imposed dead loads on the structure, etc.

Systems and components requiring special inspections for seismic resistance are usually shown using a general note. To avoid confusion, the engineer should reference structural drawings that contain the design information for the special inspection. The engineer should call out the grids for moment frames or shear walls that are used as part of the seismic resistance system.

3.4.1.2 Specifications

One of the first concrete general notes on the project is typically a reference to ACI 301. The licensed design professional should not refer to the ACI 318 Code in the general notes because the Code is written to the licensed design professional and not to the contractor or materials supplier. The licensed design professional is typically responsible for making sure that the
Contract Documents meet any and all Code provisions. Refer to the project specifications as applicable.

3.4.1.3 Concrete notes

ACI 301 Specifications for Structural Concrete (ACI 301) requires that the licensed design professional determine and show all information shown in the Mandatory Requirements Checklist in the Contract Documents. This means that the information can be shown either in the job specification or on the structural drawings. This is usually determined by the size of the project. A small project may not require a job specification and the general notes are often used to show all of the mandatory requirements information. Larger projects often require a full project specification. In this case, some of the mandatory information may be better shown in the project specification and some of it should be shown in the concrete general notes. Concrete general notes almost always include the following information:

- Exposure classes for different portions of the structure.
- Specified compressive strength of concrete (f′c) used on the project. This is often shown as a table with each member type shown with their corresponding f′c.

ACI 301 requires that the licensed design professional provide any changes from the default requirements of ACI 301 in the Contract Documents. The possible sections that contain default requirements and may be changed are listed in the Optional Requirements Checklist. In a similar fashion to the Mandatory Requirements Checklist, these items may be listed in the project specification or on the structural drawings. The size of the project will often determine where these requirements are shown. Concrete general notes often contain the following optional requirements information:

- Air entrainment, % along with the tolerance
• Slump, in. along with the tolerance

• When high-range-water-reducing admixtures are allowed or required

Proprietary products that are specified by the licensed design professional should be specified in the general notes or in the project specifications. Again, the location will often depend upon the size of the project and whether a project specification is developed.

3.4.1.4 Reinforcement notes

ACI 301 Specifications for Structural Concrete (ACI 301) requires that the licensed design professional determine and show all information shown in the Mandatory Requirements Checklist in the Contract Documents. This means that the information can be shown either in the job specification or on the structural drawings. This is usually determined by the size of the project. A small project may not require a job specification and the general notes are often used to show all of the mandatory requirements information. Larger projects often require a full project specification. In this case, some of the mandatory information may be better shown in the project specification and some of it should be shown in the concrete general notes.

Reinforcement general notes almost always include the following information:

• Specified type and grade of reinforcing bars

• Specified cover to the reinforcement

• Development and splice lengths

ACI 301 requires that the licensed design professional provide any changes from the default requirements of ACI 301 in the Contract Documents. The possible sections that contain default requirements and may be changed are listed in the Optional Requirements Checklist. In a similar fashion to the Mandatory Requirements Checklist, these items may be listed in the project specification or on the structural drawings. The size of the project will often determine where
these requirements are shown. Reinforcement general notes often contain the following optional requirements information:

• Whether bar mats are allowed to be used on the project
• Epoxy and zinc coatings and what standards they are required to adhere to
• If field cutting of reinforcement is allowed and what field cutting methods are allowed on the project

Proprietary reinforcement products that are specified by the licensed design professional should be specified in the general notes or in the project specifications. Again, the location will often depend upon the size of the project and whether a project specification is developed.

3.4.1.5 Construction notes

3.4.2 Plans

A plan drawing provides floor flatwork geometric, dimensional, concrete, and reinforcement information for each building level from a plan view.

Plan drawings are usually drawn in a scale near 1/8 inch, and include orientation information, such as column line numbers and a north arrow. If the information for one level is the same as another level, “typical level” sheets are frequently used.

The plan needs to provide floor flatwork slab and beam dimensions and also member reinforcement. This information can be directly given on the plan or indirectly provided through use of schedule marks, such as beam numbers.

Because plans only provide information in the X and Y directions, sectional views, also known as cuts, are needed to clarify geometric and reinforcement information in the Z dimension. A sectional view is indicated by a directional mark or cut drawn on the floor plan. A sectional view
will show the geometry and reinforcement details at the cut plane, and may be drawn on the plan
sheet or on a separate detail sheet. The cut identifies the section number and the sheet number
where the section is drawn. A plan drawing can also include a specific or general reference to an
elevation sheet or to a detail sheet.

3.4.3 Elevations

An elevation drawing shows the geometric, dimensional, concrete, and reinforcement
information for frames or shear walls from an elevation view.

There is no set scale for an elevation drawing. The structural detailer determines an appropriate
scale based on the height of the elevation being drawn and the level of detail needed.

The elevation needs to provide orientation information, such as column line numbers and floor
levels, and usually are referred tied to plan drawings by section references.

An elevation provides column and wall dimensions and can also provide member reinforcement.

This information can be directly given on the elevation or indirectly provided through use of
schedule marks.

3.4.4 Sections

Sections are usually drawn from a point of view $90^\circ$ from that of the drawing that calls out for
the section, and is oriented by pointers on the call out mark. Many smaller projects have a single
sheet that provides sections, details (3.4.6), and schedules (3.4.7). A separate section sheet is
used for projects with many sectional views.

Most sections are drawn at 1/2 inch scale, but some sections are drawn at a 3/4 inch scale, if
more detail is needed.

3.4.5 Large scale views
Sheets called large scale views is part of the United States National CAD Standard – V5, but are not used in every set of structural drawings. They are used if a dramatically increased scale of a section or detail is needed. They can be used to clarify reinforcement detailing in a stair case or elevator core. They are mainly used in a fashion similar to details and sections to show additional clarity in an area of a structure. These sheets are rarely entitled "large scale views". Rather, they are typically titled by what is being shown on the sheet. For example, "Stairs – Plans and Sections" could be an example title for a large scale view sheet for a stair tower.

3.4.6 Details

Details are usually drawn from the same point of view as the drawing that calls out for the detail. Many smaller projects have a single sheet that provides details, sections (3.4.4), and schedules (3.4.7). A separate detail sheet is used for projects with many details.

Most details are drawn at 1/2 inch scale, but some sections are drawn at a 3/4 inch scale, if needed for clarity.

Many design offices have details that have been found to apply to almost all projects, such as reinforcement around openings. Such details may be placed on a sheet called “typical details.” For example, the reinforcement around a slab or wall opening can be shown in a typical detail.

Some other examples might include conduit in a slab, detailing for a mechanical chase through a concrete slab, showing small openings through a reinforced concrete beam, and construction joints.

3.4.7 Schedules and Diagrams

Some design offices use schedules to provide size and reinforcement information for various members, such as beams and columns (see 3.3.2c). A member schedule usually requires a diagram to explain the notation used in the schedule.
Many smaller projects have a single sheet that provides sections (3.3.5), details (3.3.6), and schedules.

Member schedules should contain the following information:

- Member mark
- Member dimensions
- Member reinforcement
- Remarks or notes describing atypical reinforcement patterns, etc.

These sheets can be used to show information that is not discussed in other sections. They are rarely used by the structural engineering group on a building project.

These sheets are typically not used for structural drawings. When they are used, it is usually for an especially complicated connection or joint.

CHAPTER 4—PLACING DRAWINGS

CHAPTER 5—TOLERANCES

ACI 117 provides standard tolerances for concrete construction. Practical limitations of equipment and production efficiency have led to the establishment of certain fabrication tolerances that can be met with standard shop equipment. These standard tolerances are shown in ACI 117 for both straight and bent bars. Where more restrictive tolerances are required than those shown in the referenced figures, they shall be indicated in the contract documents. The effects of tolerances on cover, strength, constructability, and serviceability of the structure should be considered by the licensed design professional.
CHAPTER 6—REINFORCING BARS

6.1 ACI 318 bar requirements

The specifications for reinforcing bars published by the American Society for Testing and Materials (ASTM) are accepted for construction in the United States. ACI 318 (318M) requires deformed reinforcing bars to conform to the ASTM specifications listed in ACI 318 Chapter 3. Bar mats are also acceptable in ACI 318 and their ASTM specifications are listed in Chapter 3 as well.

Table 1 gives reinforcing bar nominal dimensions and weights for U.S. sizes (inch-pound). Table 2 summarizes the mechanical requirements for steel reinforcing bars. It also indicates the grades and bar sizes.

6.2 ACI 301 bar specifications

6.3 Welding of bars

The weldability of steel, which is established by its chemical composition, sets the minimum preheat and interpass temperatures and limits the applicable welding procedures. Chemical compositions are not ordinarily meaningful for rail-and axle-steel bars. Only reinforcing bars conforming to ASTM A706/A 706M should be used when wishing to weld reinforcing bars on a project. Because ASTM A706/A706M bars are not as typically used as bars conforming to other ASTM specifications, especially A615/A615M, local availability of A706/A706M bars should be investigated.

6.4 Overall bar diameter

Bar diameters are nominal with the overall diameter measured to the outside of deformations being somewhat greater. Table 3 shows reinforcing bars outside dimensions and Figure 1 shows
a section cut of a reinforcing bar that indicates the difference between outside and nominal dimensions.

The outside diameter can be important when punching holes in structural steel member to accommodate bars or when allowing for the out-to-out width of a group of beam bars crossing and in contact with column longitudinal bars. Diameters tabulated are approximate sizes to the outside of the deformations so clearance should be added.

When the licensed design professional has designed any heavily reinforced section where there appears to be issues with spacing or clearance for bars, the licensed design professional should take the time to sketch the section to be certain that all of the reinforcement will fit. If it doesn't, the licensed design professional should consider redesigning the area with additional space to allow for all of the reinforcement. These out-to-out diameters should be used during this check as the nominal diameter might show a tight fit, while the actual out-to-out diameter will show interference.

6.5 Bar lengths

The licensed design professional should determine the length of all bars in the structure. While this is true, it is not necessary to show every bar on the structural drawings. Typically, the majority of the reinforcement is shown in a schedule in the structural drawings. The placing drawings that are produced by the reinforcing bar detailer will show every bar for the contractor to use.

6.6 Hooks and bends

Hooks and bends are usually shown on the structural drawings as a call out stating that the bar is required to have a standard hook on the end. When a licensed design professional wants to specify hooks and bends that are not standard, they should contact a minimum of one reinforcing bar supplier. This communication is to determine whether the non-standard hook or bend the licensed
design professional is proposing can be fabricated. Typically, the licensed design professional will want to use a standard hook or bend because that is how the development length equations for hooks in the ACI 318 Code were developed. Situations that require a non-standard hook should be looked at carefully and additional calculations be performed as needed.

6.7 Supports for reinforcing bars

The licensed design professional is responsible for specifying acceptable materials and corrosion protection required for reinforcing steel supports, or both, and if required, for side form spacers, as well as the particular structural elements or areas in which each is to be used. Specification for the use of reinforcing steel supports usually are based on established industry practice.

If the contract documents specify only that reinforcing steel needs to be accurately placed and adequately supported before the concrete is placed, and shall be secured against displacement within permitted tolerances, the contractor may select the type and class of wire bar supports, precast block, or other materials to use for each area. If the contract documents are more specific and specify the type, material, or both for bar supports in different areas, the reinforcing bar detailer should indicate these materials and areas in which they are to be used, number, size, type, arrangement, and quantities required.

6.7.1 Types of bar supports

There are three basic types of bar supports that are used extensively in the concrete industry in 2011: wire bar supports, precast concrete blocks, and all-plastic bar supports. More specific information regarding the types of bar supports may be found in the CRSI Manual of Reinforcing Bar Detailing (2000).

When specifying any type of support, make certain that the type of support chosen will not cause aesthetic issues. For example, when a precast block is used and the surface has a sand-blasted
finish, the different texture and color between the precast block and the cast-in-place concrete may
be objectionable.

6.7.2 Side form spacers and beam bolsters

All reinforcing steel is required to be firmly held in place before and during casting of concrete by
means of precast concrete blocks, metallic or plastic supports, spacer bars, wires, or other devices
adequate to ensure against displacement during construction and to keep the reinforcing steel at the
proper distance from the forms. Selection of the type of spacer traditionally has been the
responsibility of the contractor. Detailing of side from spacers is not a standard requirement and is
preformed only when specifically required by the contract documents. The reinforcing bar placing
drawings only need to show those side form spacers that are equal to the standard bar supports
referred to in 5.7.1. Beam bolsters are typically places transversely to the beam. Beam bolsters
placed longitudinally with the beam are supplied only upon special arrangements between the
contractor and the supplier, if approved by the licensed design professional.

6.7.3 Reinforcing steel supports for concrete cast on ground

Bar supports will be furnished by the reinforcing-steel supplier for bottom bars in grade beams or
slabs on ground and for the bars in singly reinforced slabs on ground only if specifically required
by the licensed design professional in the contract documents.

6.8 Anchorage and splices

In ACI 318, there are two methods to determine the development length of a reinforcing bar.
Because there are two methods that can be used, the choice, interpretation, and application of the
Code method are the licensed design professional's responsibility. Sufficient information shall be
presented in the contract documents to allow detailing of bars at splices and embedment locations
without referencing back to the code.
The CRSI Manual of Reinforcing Bar Detailing (2000) contains tables that give values of tension development lengths and tension lap splice lengths of straight bars. The CRSI document uses different terminology to differentiate between the type of structural element, concrete cover, and the center-to-center spacing of the bars. Separate tables for uncoated and epoxy-coated bars are included in the CRSI document.

ACI 318 requires that the anchorage length of reinforcement and location and length of lap splices be shown on the structural drawings. This information can be shown by dimensioning cut-off locations and including tables of applicable lap splice lengths.

The licensed design professional should show by details on structural drawings the location and length of all splices. In beams, girders, slabs, walls, or columns that require bars longer than can be carried in stock, splices shall be specified. The licensed design professional should show or specify by notes whether splicing is allowed to be done using lap, mechanical, or welded splices.

Splices are typically located at points of inflection to avoid high tensile stresses at the splice location.

6.8.1 Lap splices

It is important for the licensed design professional to show the lengths and locations of lap splices because the strength of the lap splice varies with the bar diameter, concrete strength, bar spacing, concrete cover, how much concrete is placed beneath the bar, distance from other bars and the type of stress induced in the bar (tensile or compressive).

When bars of different diameters are lap spliced together, the licensed design professional should show what the appropriate lap splice length is. This is usually done using a general reinforcement note the ACI 318 Code requirement that when bars of different size are lap spliced in tension, splice length is required to be the larger of the development length of the larger bar and the tension
lap splice length of the smaller bar. This can also be indicated as a sheet note on the applicable
schedule sheets within the structural drawings.

Lap splices are often contact splices, but this is not required by ACI 318. ACI 318 allows a lap
splice to be offset by as much as the smaller of one-fifth the length of lap and 6 in. (150 mm).

6.9 Mechanical splices (couplers)
6.10 Welded wire reinforcement

CHAPTER 7—ONE-WAY SLABS

7.1 ACI 318 one-way slab reinforcing detailing requirements

ACI 318 has several reinforcing detailing requirements for the designer. Outside of the design of
the one-way slab reinforcement for strength, the following items also need to be considered and
included in the structural drawings:

• Concrete cover
• Development length
• Splice lengths
• Bundling of bars
• Minimum spacing of bars
• Maximum spacing of bars
• Termination of bars, where applicable
• Shear reinforcement, where applicable
• Shrinkage and temperature reinforcement

As discussed in section 3.4.1.4, concrete cover, development length, and splice lengths are
typically covered in the general notes sheets for all members.
While bundling of slab bars is fairly unlikely, when it is used, those details about how the bars are bundled, how development and splice lengths are affected, and where the licensed design professional determines the bundled bars should be spliced need to be shown in the structural drawings. Some of this information, especially the locations of where the splices occur, will be best shown as a typical detail on the slab schedule sheet because it will be slab specific. Typical details showing bundled bars that affect many different types of members, such as slabs, heavily reinforced beams, and columns, should be shown in the typical details later in the structural drawings.

The spacing of bars needs to be indicated on the structural drawings and is usually shown in the slab schedule.

Termination of bars is typically shown in a diagram that corresponds to the slab schedule, showing locations where reinforcement should be terminated. Normally, the geometry of a one-way slab does not allow for much termination of reinforcement.

Shear reinforcement in a one-way slab is rarely used, but if it is, the licensed design professional should show the location of the shear reinforcement on the plans by shading the area where it is needed or using a similar plan drawing presentation. A detail should be also used to indicate what spacing the shear reinforcement is at, what size bar is being used, and what shape that bar should be bent into. Stud rails may also be a viable option and a detail should be drawn if they are used by the licensed design professional.

Shrinkage and temperature reinforcement can be shown with a general note if the structural slabs on the project are all of the same thickness. If they are not, this reinforcement can be shown in a table in the general notes, with each thickness of slab being listed in one column and the corresponding shrinkage and temperature reinforcement being shown in another column.
7.2 Slab drawings

The following one-way slab information, dimensioned with respect to the overall plan grid, is shown on the structural drawings:

- Slab edges including openings in the slab
- Thickness of the slab
- Reinforcement of the slab
- Slab construction joints when applicable
- Structural expansion joints when applicable

7.2.1 Slab edges

The assumed viewpoint for a plan drawing is above the slab on each floor level of a structure. Therefore, slab edges are usually shown as solid lines on the plan drawings.

7.2.2 Slab thickness

Slab thickness is typically shown as a sheet note on the plan sheet or in the slab schedule. Occasionally, if the slab thickness is uniform throughout the project, a general note can indicate the slab thickness.

7.2.3 Slab reinforcement on plan views

Slab reinforcement is often shown using slab marks. The slab marks correspond to a schedule that is located on a separate sheet later in the structural drawings. Slab marks are usually only used for the reinforcement that is typical for a slab. Slab reinforcement that is not typical, such as reinforcement for a varied column layout or large slab openings, is often shown right on the plan drawings instead of using slab marks.

7.2.4 Slab reinforcement in slab schedules
One-way slab schedules usually contain the slab mark, thickness of slab, bottom reinforcing and top reinforcing, and any notes or remarks necessary for that portion of the slab. Sometimes the top and bottom reinforcement should be split into two or three parts to make the use of materials more efficient.

7.3 Typical details

See Chapter 15 to view typical examples of ways to show the information for a one-way slab.

CHAPTER 8—TWO-WAY SLABS

8.1 ACI 318 two-way slab reinforcing detailing requirements

ACI 318 has several reinforcing detailing requirements for the designer. Outside of the design of the two-way slab reinforcement for strength, the following items also need to be considered and included in the structural drawings:

- Concrete cover
- Development length
- Splice lengths
- Bundling of bars
- Minimum spacing of bars
- Maximum spacing of bars
- Corner restraint reinforcement
- Termination of reinforcement
- Structural integrity reinforcement
- Shear reinforcement
- Shrinkage and temperature reinforcement
As discussed in section 3.4.1.4, concrete cover, development length, and splice lengths are typically covered in the general notes sheets for all members. While bundling of slab bars is fairly unlikely, when it is used, those details about how the bars are bundled, how development and splice lengths are affected, and where the licensed design professional determines the bundled bars should be spliced need to be shown in the structural drawings. Some of this information, especially the locations of where the splices occur, will be best shown as a typical detail on the slab schedule sheet because it will be slab specific. Details with bundled bars that affect many different types of members should be shown in the typical details later in the structural drawings.

The spacing of bars needs to be indicated on the structural drawings and is usually shown in the slab schedule.

Two-way slabs where the corners of the slabs are supported by edge walls or in some cases where there are edge beams require reinforcement in the top and the bottom of the slab in the corner. This reinforcement is shown using a typical detail if it happens throughout the structure or the information is shown right on the plan drawings if it is not a prevalent detail.

Termination of bars is typically shown in a diagram that corresponds to the slab schedule, showing locations where reinforcement may be terminated. ACI 318 has specific guidance regarding the extension of reinforcement in two-way slabs from one bay into another and from support to support.

Structural integrity reinforcement requirements should be shown in different ways. The splicing requirements for structural integrity can be shown on the slab schedule diagram. The requirement of two column strip bottom bars or wires that are required to go through the columns can be shown on the plan or in a typical detail. The typical detail option is probably used most often because
other information can be shown on the same detail if the designer wishes. When using shearheads, the two column strip bottom bars or wires should be shown in a typical detail.

Shear reinforcement in a two-way slab is mainly used for strengthening slab-column intersections from two-way shear punching failures. Stud rails are a typically used option and a detail should be drawn to show the layout of the studs and stud rails at a column. When several different layouts of stud rails are needed in a structure, it may make sense to use a series of stud rail diagrams to show the layouts of the stud rails as they vary throughout the structure. The plan sheets should be marked at each column to indicate which particular stud-rail diagram should be used at that location. While stirrups are not used as regularly as stud rails for two-way shear reinforcement, they are allowed to be used by the ACI 318 Code. When stirrups are used for two-way shear reinforcement, they should be shown using the methods described above for showing stud rails.

Shrinkage and temperature reinforcement can be shown with a general note if the structural slabs on the project are all of the same thickness. If they are not, this reinforcement can be shown in a table in the general notes, with each thickness of slab being listed in one column and the corresponding shrinkage and temperature reinforcement being shown in another column.

### 8.2 Slab drawings

The following two-way slab information, dimensioned with respect to the overall plan grid, is shown on the structural drawings:

- Slab edges including openings in the slab
- Thickness of the slab
- Reinforcement of the slab
- Slab construction joints when applicable
- Structural expansion joints when applicable
8.2.1 Slab edges

The assumed viewpoint for a plan drawing is above the slab on each floor level of a structure. Therefore, slab edges are usually shown as solid lines on the plan drawings.

8.2.2 Slab thickness

Slab thickness is typically shown as a sheet note on the plan sheet or in the slab schedule. Occasionally, if the slab thickness is uniform throughout the project, a general note can indicate the slab thickness.

8.2.3 Slab reinforcement on plan views

Slab reinforcement is often shown using slab marks. The slab marks correspond to a schedule that is located on a separate sheet later in the structural drawings. Slab marks are usually only used for the reinforcement that is typical for a slab. Slab reinforcement that is not typical, such as reinforcement for a varied column layout or large slab openings, is often shown right on the plan drawings instead of using slab marks.

8.2.4 Slab reinforcement in slab schedules

One-way slab schedules usually contain the slab mark, thickness of slab, bottom reinforcing and top reinforcing, and any notes or remarks necessary for that portion of the slab. Sometimes the top and bottom reinforcement should be split into two or three parts to make the use of materials more efficient.

8.3 Typical details

See Chapter 15 to view typical examples of ways to show the information for a two-way slab.

CHAPTER 9—BEAMS

9.1 ACI 318 beam reinforcing detailing requirements
ACI 318 has several reinforcing detailing requirements for the designer. Outside of the design of the beam reinforcement for strength, the following items also need to be considered and included in the structural drawings:

- Concrete cover
- Development length
- Splice lengths
- Bundling of bars
- Minimum spacing of bars
- Maximum spacing of bars
- Termination of bars
- Shear reinforcement
- Shrinkage and temperature reinforcement

As discussed in section 3.4.1.4, concrete cover, development length, and splice lengths are typically covered in the general notes sheets for all members. Details about how bars are bundled, how development and splice lengths are affected by bundling, and where the licensed design professional determines the bundled bars should be spliced need to be shown in the structural drawings. When bars are bundled, the majority of this information is best shown in a typical detail on the beam schedule sheet because the information is beam specific. Typical details showing bundled bars that affect many different types of members, such as slabs, heavily reinforced beams, and columns, should be shown in the typical details later in the structural drawings.

Maximum spacing of bars is not typically a controlling requirement in a beam design. However, especially in cases where high-strength steel is used, it can become an issue. Minimum spacing of
bars is not usually an issue in a typical nonprestressed beam with the exception being cases where the beam has an unusually high amount of reinforcement because of strength design. In such cases, it is often necessary to use two layers of reinforcement instead of one.

Termination of bars is typically shown in a diagram that corresponds to the beam schedule, showing locations where reinforcement should be terminated.

Shear reinforcement in a beam is typically shown using a diagram on the beam schedule sheet. Often, the spacing of the shear reinforcement at the ends of the beams is shown in a typical detail on the beam schedule sheet. Other typical details for shear reinforcement that are often necessary are shear reinforcement spacing near high loadings, such as in a transfer girder where a beam is supported.

Shrinkage and temperature reinforcement is rarely necessary to consider in a beam. Minimum flexural reinforcement required by the code is numerically equivalent to the amount necessary for shrinkage and temperature steel, therefore this requirement is met when the beam is designed for strength. The dimensions other than longitudinal are typically not large enough for a beam design to be controlled by shrinkage and temperature steel instead of shear reinforcement.

9.2 Beams on floor plans

Floor plan sheets typically show the following beam dimension information with respect to the project grid:

- Beam locations and beam marks
- Girder locations and girder marks
- Vertical transportation structural information
- Construction joints when applicable
- Structural expansion joints when applicable
9.2.1 Beams and girders on plans
Beam and girder locations are typically shown as hidden on the slab plan drawings because they are typically below the slab. Additional beam and girder reinforcement is rarely shown on the plan drawings because it can cause confusion. If additional reinforcement is required, it is typically shown in a note or remark in the beam schedule or a detail or section cut will be necessary to show the additional reinforcement.

9.2.1 Beam and girder schedules
Beams and girders are often shown in the same schedule, therefore only beam schedules are addressed in this document. Beam schedules contain the beam mark, beam width and depth dimensions, top and bottom reinforcement, post-tensioning reinforcement when applicable, and stirrup size and spacing. When post-tensioning is used, the post-tensioning is typically called out using the effective force that is expected to be applied to the beam and the tendon profile is called out for each end and at mid-span. Non-prestressed deformed reinforcement is called out in both non-prestressed and post-tensioned beams in a similar manner, with the size of the bar used, how many bars, where they are located along the length of the beam (ends, midspan, or continuous), and whether they are top or bottom bars. Typical stirrup size and spacing are called out in the schedule by calling out each grouping of stirrups. For example, a beam or girder may need 6-#4 stirrups at 2"o.c. and 6-#4 stirrups at 6"o.c. at each end of the beam and the remainder along the length of the beam at 12" o.c.

9.2.2 Seismic lateral load resisting systems
When beams are part of a seismic lateral load resisting system, elevations are often used to show all of the reinforcement in the beams and columns that are part of that system. Ordinary moment frames, intermediate moment frames, and special moment frames and shearwalls all have seismic detailing requirements in ACI 318.
9.3 Typical details

See Chapter 15 to view typical examples of ways to show the information for beams and girders.

CHAPTER 10—COLUMNS

10.1 ACI 318 column reinforcing detailing requirements

ACI 318 has several reinforcing detailing requirements for the designer. Outside of the design of the column reinforcement for strength, the following items also need to be considered and included in the structural drawings:

- Concrete cover
- Development length
- Splice lengths
- Bundling of bars
- Minimum spacing of bars
- Maximum spacing of bars
- Termination of bars
- Shear reinforcement
- Shrinkage and temperature reinforcement

As discussed in section 3.4.1.4, concrete cover, development length, and splice lengths are typically covered in the general notes sheets for all members.

Details about how bars are bundled, how development and splice lengths are affected by bundling, and where the licensed design professional determines the bundled bars should be spliced need to be shown in the structural drawings. When bars are bundled, the majority of this information is best shown in a typical detail on the column schedule sheet because the information is column
specific. Typical details showing bundled bars that affect many different types of members, such
as slabs, heavily reinforced beams, and columns, should be shown in the typical details later in the
structural drawings.

Maximum spacing of bars is not typically a controlling requirement in a column design. Spacing
of longitudinal reinforcement does have an effect on column tie configuration. The further apart
the longitudinal reinforcement is placed from each other, the more likely that an additional tie will
have to be added to aid with prevention of buckling of the longitudinal reinforcing if the confining
concrete were to spall off. Minimum spacing of bars is not usually an issue in a typical
nonprestressed column because of the maximum allowed area of longitudinal reinforcement of 8%
of gross area of concrete.

Termination of bars is typically shown in a diagram that corresponds to the column schedule,
showing locations where reinforcement should be terminated.

Shear reinforcement in a column is typically shown using a diagram on the column schedule sheet.
Often, the spacing of the shear reinforcement at the tops and bottoms of columns is shown in a
typical detail on the column schedule sheet.

Shrinkage and temperature reinforcement is rarely necessary to consider in a column. Minimum
reinforcement required by the code is more than the amount necessary for shrinkage and
temperature steel, therefore this requirement is met when the column is designed for strength. The
dimensions other than longitudinal are typically not large enough for a column design to be
controlled by shrinkage and temperature steel instead of shear reinforcement.

10.2 Columns on floor plans Floor plan sheets typically show the following column dimension
information with respect to the project grid:

- Column locations marks
• Vertical transportation structural information
• Construction joints when applicable
• Structural expansion joints when applicable

10.2.1 Columns on floor plans
Column locations are shown on the plans above foundation for the extent of their height. The sizes of columns are usually carried in their respective schedule, along with the reinforcement required.

10.2.2 Column schedules
Column schedules usually contain the column mark, a sketch of the column from the bottom of one level to the bottom of the next or the top of the column, with the amount of longitudinal reinforcement called out at each level, and the spacing and size of ties. Typical layout information for the column reinforcement is often shown in section cuts or diagrams. These diagrams should show splice locations, including locations of staggered splices.

10.3 Seismic lateral load resisting systems
When columns are part of a seismic lateral load resisting system, elevations are often used to show all of the reinforcement in the beams and columns that are part of that system. Ordinary moment frames, intermediate moment frames, and special moment frames and shearwalls all have seismic detailing requirements in ACI 318.

CHAPTER 11—WALLS

11.1 ACI 318 wall reinforcing detailing requirements
ACI 318 has several reinforcing detailing requirements for the designer. Outside of the design of the wall reinforcement for strength, the following items also need to be considered and included in the structural drawings:
• Concrete cover
• Development length
• Splice lengths
• Bundling of bars
• Minimum spacing of bars
• Maximum spacing of bars
• Termination of bars
• Shrinkage and temperature reinforcement

As discussed in section 3.4.1.4, concrete cover, development length, and splice lengths are typically covered in the general notes sheets for all members.

Details about how bars are bundled, how development and splice lengths are affected by bundling, and where the licensed design professional determines the bundled bars should be spliced need to be shown in the structural drawings. When bars are bundled, the majority of this information is best shown in a typical detail on the wall schedule sheet because the information is wall specific. Typical details showing bundled bars that affect many different types of members, such as slabs, heavily reinforced beams, and columns, should be shown in the typical details later in the structural drawings.

Maximum spacing of bars is typically controlled by the minimum ratio of reinforcement to the gross area of a wall design. Minimum spacing of bars is typically controlled by the strength design of the wall and the size of bars chosen.

Termination of bars is typically shown in a diagram that corresponds to the wall schedule, showing locations where reinforcement should be terminated.
Both vertical and horizontal reinforcement in a wall is typically shown using a diagram on the wall schedule sheet.

Shrinkage and temperature reinforcement is not necessary to consider in a wall because minimum required reinforcement ratios required by ACI 318 have proven to be adequate.

11.2 Walls on floor plans Floor plan sheets typically show the following wall dimension information with respect to the project grid:

- Wall locations and marks
- Vertical transportation structural information
- Construction joints when applicable
- Structural expansion joints when applicable

11.2.1 Walls on floor plans Wall locations are shown on the plans above foundation for the extent of their height. The sizes of walls are usually carried in their respective schedule, along with the reinforcement required.

11.2.2 Wall schedules

Wall schedules usually contain the wall mark, a sketch of the wall from the bottom of the wall to the top of the wall with the amount of vertical and horizontal reinforcement called out, and if two layers of reinforcement are required. Typical layout information for the wall reinforcement is often shown in section cuts or diagrams. These diagrams should show splice locations, including locations of staggered splices as necessary.

11.3 Seismic lateral load resisting systems

When walls are part of a seismic lateral load resisting system, elevations are often used to show all of the reinforcement in the wall that are part of that system. Ordinary moment frames,
intermediate moment frames, and special moment frames and shearwalls all have seismic
detailing requirements in ACI 318.

CHAPTER 12—FOUNDATIONS

12.1 ACI 318 foundation reinforcing detailing requirements

ACI 318 has several reinforcing detailing requirements for the designer. Outside of the design of
the foundation reinforcement for strength, the following items also need to be considered and
included in the structural drawings:

• Concrete cover
• Development length
• Splice lengths
• Bundling of bars
• Minimum spacing of bars
• Maximum spacing of bars
• Corner restraint reinforcement
• Termination of reinforcement
• Structural integrity reinforcement
• Shear reinforcement
• Shrinkage and temperature reinforcement

As discussed in section 3.4.1.4, concrete cover, development length, and splice lengths are
typically covered in the general notes sheets for all members.

Details about how bars are bundled, how development and splice lengths are affected, and where
the licensed design professional determines the bundled bars should be spliced need to be shown in
the structural drawings. Some of this information, especially the locations of where the splices
coccur, will be best shown as a typical detail on the foundation schedule sheet because it will be
foundation specific. Details with bundled bars that affect many different types of members should
be shown in the typical details later in the structural drawings.
The spacing of bars needs to be indicated on the structural drawings and is usually shown in the
foundation schedule.
Termination of bars is typically shown in a diagram that corresponds to the foundation schedule,
showing locations where reinforcement may be terminated. Typically, because of the geometry of
shallow foundations, this is often unnecessary because the bars will often extend to the edges of the
foundation.
Shear reinforcement in a foundation is not frequently used, but when it is, it is typically detailed in
a manner similar to a beam. When stirrups are used for shear reinforcement, they should be shown
on the foundation schedule and a separate detail should be considered.
Shrinkage and temperature reinforcement limits occasionally control reinforcement design of a
foundation and can be shown in the foundation schedule. Because it is essentially replacing the
strength required reinforcement in this case, it does not need to be marked as shrinkage and
temperature steel.

12.2 Foundation drawings

The following foundation information, dimensioned with respect to the overall plan grid, is
shown on the structural drawings:

- Foundation location
- Size of the foundation
- Reinforcement of the foundation
12.2.1 Foundation plans

Foundation plans typically give the following information: location and size of each foundation element and of the base of each column or wall of the structure. Often, most of the information that is shown on this sheet is shown using foundation, column, or wall marks. These marks are detailed in their respective schedules later in the plan set and will be discussed in more detail there. The sheets containing the foundation, column, and wall schedules are typically shown in the foundation plan sheet notes to guide the user to the location of the schedules.

12.2.2 Foundation schedule

Foundation member marks usually use the first letter of the type of foundation element represented. For examples, P1 is usually related to a pier cap over one pile, while F1 is often used to describe a shallow footing and GB1 is often used to mark grade beams. Size is often determined by the type of foundation element as well. Grade beam schedules are similar to elevated beam schedules and advice regarding beam schedules is shown later in this section. Pier cap schedules are shown two different ways, on where the schedule is more like a diagram and each different kind of pier cap shows with the respective reinforcement required right in the diagram. They can also have a text table that shows the dimensions of the pier cap and the required reinforcement in either direction. Footing schedules are usually of this nature as well, with the schedule containing footing dimensions and the required reinforcement in either direction. Drilled caissons are often not scheduled by mark, but by shaft diameter. Then, each diameter caisson has a corresponding vertical reinforcement, tie reinforcement, and depth that the reinforcement has to extend into the top of the caisson.
Each different type of foundation element on the project should have a corresponding typical diagram. This typical diagram will show a typical layout of the member with typical locations of the reinforcement inside of it.

**12.3 Typical details**

See Chapter 15 to view typical examples of ways to show the information for a two-way slab.

**CHAPTER 13—JOINTS AND CONNECTIONS**

**CHAPTER 14—DISCONTINUITY REGIONS**

**CHAPTER 15—EXAMPLE DRAWINGS AND DETAILS**

**CHAPTER 16—REFERENCES**

**16.1—Reference standards and reports**

The standards and reports listed below were the latest editions at the time this document was prepared. Because these documents are revised frequently, the reader is advised to contact the proper sponsoring group if it is desired to refer to the latest version.

**APPENDIX A—RELATIONSHIP TO ACI 318**

**PART B—EXAMPLE PLAN SETS**

**PART C—EXAMPLES ACI 318 DETAILING REQUIREMENT CALCULATIONS**