October 16, 2012

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

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David A. Grundler  Amadeus L. Magpile  Richard D. Thomas
Robert W. Hall     Javed B. Malik       Peter Zdgiebloski

From: Anthony L. Felder
       Secretary

Subject: Meeting Notice and Agenda
          October 21, 2012
          Sheraton Centre
          Toronto, Ontario, Canada

Our next meeting will be held on Sunday, October 21, 2012 from 2:00 p.m. to 5:00 p.m. in the Pinnacle Room of the Sheraton Centre.

A proposed agenda is attached.

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

October 21, 2012

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

2. Approval of minutes of last meeting, March 18, 2012, distributed September 5, 2012

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

4. ACI Detailing Manual (SP-66)
   a. Opening Remarks – Chairman Hunter
   b. Status of the next ACI 318 Code – Greg Zeisler, ACI Staff
   c. Schedule for new Committee publication: “Guide for Details and Detailing of Concrete Reinforcement”. See Exhibit 2.
   d. Status of Text. See Exhibit 3, latest draft.
   e. Status of Example Structural Drawings and Placing Drawings

5. Bending of Reinforcing Bars
   b. Bend Diameters. See Exhibit 5.


   Secretary’s Note: Subcommittee B is scheduled to meet on Sunday, October 21, 2012 from 8:30 a.m. to 11:30 a.m. in the Windsor East Room of the Sheraton Centre.

7. Nuclear Verbatim Compliance – Robbie Hall

8. ACI Committee 131 and BIM Update – Pete Zdgiebloski

9. Other Business
ACI/CRSI COMMITTEE 315 ROSTER
October 2012

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CHAPTER 10—REFERENCES

10.1—Referenced standards
CHAPTER 1—INTRODUCTION

1.1—Introduction

SP-66, “Details and Detailing of Concrete Reinforcement,” was written to help engineers detail structural members of reinforced concrete buildings. The information presented in SP-66 complies with the requirements of ACI 318, Building Code Requirements for Structural Concrete, and ACI 301, Specifications for Structural Concrete including the mandatory checklist and applicable optional checklist items. SP-66 facilitates clear communication between designers, detailers, and reinforcing bar installers, by providing standardizing details and information presentation.

1.2—Scope

This guide provides general information for detailing reinforcing bars as well as specific information regarding detailing members, such as slabs, beams and columns. It provides sample structural drawings for various types of buildings.

CHAPTER 2—DEFINITIONS

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

CHAPTER 3—LAYOUT OF STRUCTURAL DRAWINGS

3.1—Scope
This chapter describes information that might be found on structural drawings. In engineering practice in the US, there isn’t a consensus sheet order, and each design office usually develops an “office standard” sheet order and naming convention. This guide, however, uses the project sheet order that follows the United States National CAD Standard – V5.

### 3.2—General

This guide assumes that the structural drawings are produced by a two-dimensional or three-dimensional computer aided drafting (CAD) program. It is also assumed that drawings are created in a 1:1 scale model space and then reduced to fit on the project drawings using a view of the model.

Each sheet should have a title block, production data, and a drawing area as shown in Fig. 3.2.

The drawing area is the largest portion of the sheet where technical information is presented. Examples of technical information are the overall framing plan, sections and details needed to illustrate information at specific areas, and general notes.

The production data area is located in the left margin of the sheet and includes information such as the CAD filename and path to the file, default settings, pen assignments, printer/plotter commands, date and time of plot, overlay drafting control data, and reference files.

The title block area is located at the right side of the sheet. It usually includes the designers name, address, and logo; basic information about the project including location of the worksite, owner, and project name; an information block regarding what issue (addendum,
design development, bidding, bulletin, etc.) of this sheet is; a sheet responsibility block that indicates who was the project manager, designer, drafter, and checker of the information on the drawing; a sheet title block; and a sheet numbering block.

3.3—Order of drawings

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

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If more than one sheet is required within the above order, then decimal sheet numbers are used, e.g., 5.1, 5.2, 5.3.

3.4—Content of drawings

3.4.1 General notes

A general notes sheet presents project design loads, the codes and standards that are the basis of design, material and product requirements, and construction directions. The notes can be the entire project structural specifications, act as an extension of the project structural specifications, or simply duplicate important aspects of the project structural specifications.

3.4.1.1 General building code – mandatory information

The general building code requires specific information be included on the construction documents and the general notes sheets of the structural drawings present this information. The 2012 IBC states: “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.”
1603.1.1 Floor live load
1603.1.2 Roof live load
1603.1.3 Roof snow load
1603.1.4 Wind design data
1603.1.5 Earthquake design data
1603.1.6 Geotechnical information
1603.1.7 Flood design data
1603.1.8 Special loads
1603.1.9 Systems and components requiring special inspections for seismic resistance

In addition to these items, ACI 318 requires that all applicable information from Chapter 23 related to construction be included in the construction documents.

3.4.1.2 Loads

Design loads are presented on the general notes sheet. Live loads, roof live loads, snow loads, and other simple gravity loads are commonly shown in a table. Basic wind load criteria assumptions and, when necessary, wind loading diagrams are included. Earthquake design data is usually presented as a list of the different criteria used to develop the design earthquake loads. Geotechnical design information shown is usually supplied to the structural designer in a geotechnical report. It can be presented as a note if the soil and water table on site is relatively consistent or in a table format if there is significant soil or water table variability. Flood design data and criteria used to determine the flood design loads are typically shown using notes.
Significant loads not included in the code-required live loads are also noted in the table that includes the live loads. Examples of such loads are architectural features, partition live loads, ceiling and hanging loads, and super-imposed dead loads. A diagram may be needed for heavy pieces of equipment, such as forklifts, with their assumed wheel spacing and axle loads.

Showing the self-weight of the structure is not a requirement of the code. However, it is often helpful to the formwork engineer hired by the contractor if the assumed design weight of the concrete is included in the loading section of the general notes. If the actual density of the concrete provided by the redi-mix concrete contractor is significantly different from the assumed design weight on the drawings, the redi-mix concrete provider should notify the LDP.

Felder noted that assigning responsibilities to the concrete provider may be outside of the scope of this document. Any suggestions? Perhaps we should just drop this discussion after "However, it is often helpful to the formwork engineer hired by the contractor if the assumed design weight of the concrete is included in the loading section of the general notes.".

3.4.1.3 Specifications

The first concrete general note is commonly a reference to require construction to be in accordance with ACI 301 “Specifications for Structural Concrete”. The LDP ensures that the construction documents meet Code provisions; therefore, requiring the contractor to conform to ACI 318 Code is not appropriate as the Code provides requirements to the LDP and not the contractor or materials supplier. By referencing ACI 301 into the construction documents and using the ACI 301 mandatory and optional checklists, the concrete materials and construction requirements will satisfy ACI 318.
ACI 301 contains the following three checklists: mandatory, optional requirements, and submittals. The LDP is often also the Specifier on a project and they must go through these checklists and make necessary changes to ACI 301 in the construction documents. The general notes sheet is a convenient way to communicate any necessary changes to ACI 301.

3.4.1.4 Concrete notes

Related to concrete, the mandatory requirements checklist indicates that the construction documents include the exposure classes and the specified compressive strength for different portions of the structure. Concrete general notes show this with a table with each member type along with its corresponding exposure and $f'_{c}$.

The construction documents should also indicate any exceptions to the default requirements of ACI 301. ACI 301 lists possible exceptions in the Optional Requirements Checklist. Concrete general notes often contain the following optional requirements checklist exceptions to ACI 301 default requirements:

- Air entrainment, % along with the tolerance
- Slump, in. along with the tolerance
- When high-range-water-reducing admixtures are allowed or required

When proprietary concrete products are required on a project, they can be specified in the general notes.

3.4.1.5 Reinforcement notes
The ACI 301 Mandatory Requirements Checklist items for reinforcement can be specified in the general reinforcement notes. The general notes almost always include the following:

- Type and grade of reinforcing bars
- Cover to the reinforcement
- Bar development and splice lengths

Type and grade of reinforcing bars are shown in a note. When there are many types, grades, or both of reinforcing bars used on a project, it may be easier to show this information in a table indicating what type and grade is used in what parts of the structure.

Reinforcing bars require cover to protect the steel. ACI 318-14 shows concrete cover requirements for specific members in Chapter 6. The cover requirements for a project are shown in a table or list showing the type of member, the concrete exposure, the type of reinforcement and the cover requirements for each. If there are locations on a specific project that are questionable, the LDP should indicate which cover requirement control at each location.

Bar development and lap splice lengths can be shown using tables, but the preferred method for showing development and lap splice lengths and locations is graphically in elevation or plan views. This allows the fabrication detailer to more accurately pick this information from the drawings. Where lap splice location and length have structural safety implications, the lap splice lengths should be shown graphically. When engineering judgment indicates that lap splice location and length are less critical, a table can be used. Structural calculations should not be required of the fabrication detailer to determine the lap splice length or development lengths.

Please see Fig. XXXXXXX. The LDP should verify that all possible bar development and lap splice length situations that are on the project can be found on the drawings.
The construction documents should also indicate any exceptions to the default requirements of ACI 301. ACI 301 lists possible exceptions to the default requirements in the Optional Requirements Checklist. Reinforcement general notes often contain the following exceptions to ACI 301 default requirements:

- Permitting the use of bar mats
- Epoxy and zinc coating requirements
- Permitting field cutting of reinforcement and the cutting methods

When proprietary reinforcement products are required on a project, they can be specified in the general notes.

3.4.1.5.1 ACI 318 bar requirements

Reinforcing bars and bar mats in conformance with ASTM International specifications are accepted for construction in the United States and are required by ACI 318, “Building Code Requirements for Structural Concrete.”

Table 1 gives reinforcing bar nominal dimensions and weights for U.S. sizes (inch-pound). Table 2 summarizes the mechanical specifications for steel reinforcing bars, including grades and bar sizes.

Table 1:
Table 1—Designations, weights, dimensions, and deformation requirements of standard ASTM reinforcing bars

<table>
<thead>
<tr>
<th>Bar size, in. diameter (inch)</th>
<th>Nominal weight, lb/ft (nominal mass, kg/m)</th>
<th>Nominal dimensions</th>
<th>Deformation requirements, in. (mm)</th>
<th>Maximum average spacing</th>
<th>Minimum average height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diameter, in. (mm)</td>
<td>Cross-sectional area, in.² (mm²)</td>
<td>Perimeter, in. (mm)</td>
<td>Maximum gap (chord of 12.5% of nominal perimeter)</td>
<td></td>
</tr>
<tr>
<td>3 (10)</td>
<td>0.375 (9.5)</td>
<td>0.11 (71)</td>
<td>1.178 (29.9)</td>
<td>0.262 (6.7)</td>
<td>0.015 (0.38)</td>
</tr>
<tr>
<td>4 (13)</td>
<td>0.500 (12.7)</td>
<td>0.20 (129)</td>
<td>1.571 (39.9)</td>
<td>0.350 (8.9)</td>
<td>0.020 (0.51)</td>
</tr>
<tr>
<td>5 (16)</td>
<td>0.625 (15.9)</td>
<td>0.31 (199)</td>
<td>1.963 (49.9)</td>
<td>0.437 (11.1)</td>
<td>0.028 (0.71)</td>
</tr>
<tr>
<td>6 (19)</td>
<td>0.750 (19.1)</td>
<td>0.44 (284)</td>
<td>2.356 (59.8)</td>
<td>0.525 (13.3)</td>
<td>0.036 (0.97)</td>
</tr>
<tr>
<td>7 (22)</td>
<td>0.875 (22.2)</td>
<td>0.60 (387)</td>
<td>2.749 (68.8)</td>
<td>0.612 (15.5)</td>
<td>0.044 (1.12)</td>
</tr>
<tr>
<td>8 (25)</td>
<td>1.000 (25.4)</td>
<td>0.79 (510)</td>
<td>3.142 (79.8)</td>
<td>0.700 (17.8)</td>
<td>0.050 (1.27)</td>
</tr>
<tr>
<td>9 (29)</td>
<td>1.125 (28.7)</td>
<td>1.00 (645)</td>
<td>3.544 (90.0)</td>
<td>0.790 (20.1)</td>
<td>0.056 (1.42)</td>
</tr>
<tr>
<td>10 (32)</td>
<td>1.250 (32.3)</td>
<td>1.27 (819)</td>
<td>3.990 (101.3)</td>
<td>0.889 (22.0)</td>
<td>0.064 (1.65)</td>
</tr>
<tr>
<td>11 (36)</td>
<td>1.400 (35.8)</td>
<td>1.56 (1006)</td>
<td>4.430 (112.5)</td>
<td>0.987 (25.1)</td>
<td>0.071 (1.80)</td>
</tr>
<tr>
<td>12 (40)</td>
<td>1.550 (39.4)</td>
<td>1.85 (1220)</td>
<td>4.890 (125.8)</td>
<td>1.096 (27.5)</td>
<td>0.079 (1.97)</td>
</tr>
<tr>
<td>13 (43)</td>
<td>1.700 (43.0)</td>
<td>2.15 (1452)</td>
<td>5.35 (135.1)</td>
<td>1.208 (30.1)</td>
<td>0.085 (2.16)</td>
</tr>
<tr>
<td>14 (47)</td>
<td>1.850 (47.0)</td>
<td>2.45 (1680)</td>
<td>5.81 (145.2)</td>
<td>1.320 (32.1)</td>
<td>0.092 (2.39)</td>
</tr>
<tr>
<td>15 (50)</td>
<td>2.000 (50.0)</td>
<td>2.75 (1900)</td>
<td>6.27 (155.2)</td>
<td>1.432 (34.1)</td>
<td>0.100 (2.60)</td>
</tr>
</tbody>
</table>

*Bar sizes are based on number of eighths of an inch included in nominal diameter of the bar. (Bar numbers approximate number of millimeters of nominal diameter of bar.)

Table 2—ASTM specifications—bar sizes, grades, and requirements for strength in tension, elongation, and bending

<table>
<thead>
<tr>
<th>Type of steel and ASTM specification</th>
<th>Bar sizes, in.-lb (metric)</th>
<th>Grade, in.-lb (metric)</th>
<th>Minimum yield strength, psi (MPa)</th>
<th>Minimum tensile strength, psi (MPa)</th>
<th>Minimum percentage elongation in 8 in. (203.2 mm)</th>
<th>Cold bend test pin diameter (d = nominal diameter of specimen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billet-steel A 615/ A 615M</td>
<td>3 to 6 (10 to 19)</td>
<td>40 (300)</td>
<td>40,000 (280)</td>
<td>70,000 (500)</td>
<td>0.66 (14)</td>
<td>#3 (10)</td>
</tr>
<tr>
<td></td>
<td>3 to 18 (10 to 57)</td>
<td>60 (420)</td>
<td>60,000 (420)</td>
<td>90,000 (620)</td>
<td>0.66 (14)</td>
<td>#3, #4, #5 (10, 11, 12)</td>
</tr>
<tr>
<td></td>
<td>6 to 18 (19 to 57)</td>
<td>75 (520)</td>
<td>75,000 (520)</td>
<td>100,000 (690)</td>
<td>0.66 (14)</td>
<td>#3, #4, #5 (10, 11, 12)</td>
</tr>
<tr>
<td>Low-alloy steel A70A/A706M</td>
<td>3 to 18 (10 to 57)</td>
<td>60 (420)</td>
<td>60,000 (420)</td>
<td>80,000 (550)</td>
<td>0.66 (14)</td>
<td>#3, #4, #5 (10, 11, 12)</td>
</tr>
</tbody>
</table>

Notes: For low-alloy steel reinforcing bars, ASTM A 706/A 706M prescribes a maximum yield strength of 75,000 psi (515 MPa) and the tensile strength shall not be less than 1.25 times the actual yield strength; and bend tests are 180 degrees, except that ASTM A 615/A 615M permits 90 degrees for bar sizes #14 and #18 (434 and 575).
3.4.1.5.2 Welding of bars

The weldability of steel is established by its chemical composition. The American Welding Society AWS D1.4 sets the minimum preheat and interpass temperatures and provides the applicable welding procedures. Only reinforcing bars conforming to ASTM A706/A 706M are pre-approved for welding reinforcing bars. Because chemical compositions are not ordinarily meaningful for rail-and axle-steel bars, they are not recommended for welding.

3.4.1.5.3 Bar lengths

The LDP should review the length of all bars in a structure, but it is not necessary to show all bars on the structural drawings. The reviewed placing drawings produced by the reinforcing bar detailer show every bar that will be installed.

3.4.1.5.4 Hooks and bends

Bar hooks and bends are usually not shown on the plan drawings, but a note is placed stating that certain bars are required to end in a standard hook. Specifications that require a non-standard hook should be looked at carefully, because non-standard hooks may be difficult to obtain. If the LDP shows a hook but does not dimension the hook, the fabrication detailer will use a standard hook. In situations where a standard hook does not fit into the form, rotating the hook may be done for constructability purposes and the placement drawings should have this noted when submitted to the LDP. For this reason, it is prudent for the LDP to check standard 90 degree
and 180 degree hooks throughout the project during their constructability check suggested in chapter 8, especially if rotating the hooks causes issues with the design.

3.4.1.5.5 Supports for reinforcing bars

The LDP specifies acceptable materials and corrosion protection for reinforcing bar supports, side form spacers, and supports or spacers for structural members or areas. Specifications for reinforcing bar supports usually are consistent with established industry practice. If the construction documents only state that reinforcing bars need to be accurately placed, adequately supported, and secured against displacement within permitted tolerances, the contractor selects the type and class of wire bar supports, precast blocks, or other materials to use for each area. If the construction documents specify the type, material, or both for bar supports in different areas, however, the reinforcing bar detailer should indicate these materials and areas in which they are to be used, and the number, size, type, arrangement, and quantities required.

There are three common types of bar supports: wire bar supports, precast concrete block bar supports, and all-plastic bar supports. Information regarding bar supports may be found in the CRSI Manual of Reinforcing Bar Detailing.

Certain support types will cause aesthetic issues. For example, if precast blocks are used and the surface has a sand-blasted finish, the different texture and color between the precast blocks and the cast-in-place concrete may be objectionable.
Reinforcing bars should be firmly held in place before and during concrete casting at the proper distance from the forms. Side form spacer types are usually not specified and are thus selected by the contractor.

Beam bolsters are support beam reinforcement and are placed in the beam form, usually transverse to the axis of the beam.

Bar supports are furnished for bottom bars in grade beams or slabs-on-ground only if required by the LDP in the construction documents. When the element is a structural element, it is recommended that the LDP specify bar supports for the bottom bars in grade beams or slabs-on-ground.
grade. Aesthetics are not a concern in the bottom of a slab-on-ground or grade beam which allows
the use of precast blocks for bar supports.

3.1.4.5.6 Anchorage and splices

ACI 318 requires that the “anchorage length of reinforcement and location and length of
lap splices” be shown on the construction documents. Sufficient information must be provided in
the construction documents to allow detailing of bars at embedment and splice locations. This
information can be shown by dimensioning cut-off locations in sections and details, including
tables of applicable lap splice lengths. Splices are typically located to avoid high tensile stresses at
the splice location.

The CRSI Manual of Reinforcing Bar Detailing is a useful resource. It contains tables with
tension development lengths and tension lap splice lengths of straight bars, both uncoated and
epoxy-coated.

The LDP should provide the location and length of all lap splices on structural drawings.
This is important because the strength of a lap splice varies with the bar diameter, concrete
strength, bar spacing, concrete cover, depth of concrete placed beneath the bar, distance from other
bars and the type of stress (tensile or compressive) induced in the bar.
The construction documents should note that if bars of different size are lap spliced in tension, splice length is the larger of (a) the development length of the larger bar, and (b) the tension lap splice length of the smaller bar. This can be indicated on the general notes sheet or as a note on the applicable schedule sheet. Lap splices with bars in contact with each other are acceptable, but not necessary. Noncontact lap splices are also acceptable, with the offset distance between the bars limited in accordance with ACI 318.

If mechanical splices are permitted on a project, a note is needed on the general notes sheet or project specifications to permit them as well as the required ratio of bar strength to splice strength. The LDP should also include a typical detail or specific details on where mechanical splices are required or allowed.

3.4.1.5.7 Welded wire reinforcement

Welded wire reinforcement consists of a series of cold-drawn steel wire arranged at right angles to each other and electrically welded at all intersections. Welded wire reinforcement has many uses in reinforced concrete construction. It can be used in slabs-on-ground, joist and waffle slab construction, walls, pavements, box culverts and canal linings.

Welded wire reinforcement in conformance with ASTM International specifications are accepted for construction in the United States and are required by ACI 318, “Building Code Requirements for Structural Concrete.”

Table 1 gives common styles of welded wire reinforcement in the U.S. (inch-pound).
3.4.1.6 Shrinkage and temperature

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.

3.4.1.7 Construction notes

Construction notes are general notes that discuss many of the miscellaneous aspects of construction not covered by the other types of notes. Some examples of these notes include:

<table>
<thead>
<tr>
<th>Style Designation</th>
<th>Steel Area (in.(^2))</th>
<th>Approximate Weight (pounds per 100 sq ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Longitudinal</td>
<td>Transverse</td>
</tr>
<tr>
<td>4 x 4-W1.4 x W1.4</td>
<td>0.042</td>
<td>0.042</td>
</tr>
<tr>
<td>4 x 4-W2.0 x W2.0</td>
<td>0.060</td>
<td>0.060</td>
</tr>
<tr>
<td>4 x 4-W2.9 x W2.9</td>
<td>0.087</td>
<td>0.087</td>
</tr>
<tr>
<td>4 x 4-W/D4 x W/D4</td>
<td>0.120</td>
<td>0.120</td>
</tr>
<tr>
<td>5 x 5-W1.4 x W1.4</td>
<td>0.028</td>
<td>0.028</td>
</tr>
<tr>
<td>5 x 5-W2.0 x W2.0</td>
<td>0.040</td>
<td>0.040</td>
</tr>
<tr>
<td>5 x 5-W2.9 x W2.9</td>
<td>0.058</td>
<td>0.058</td>
</tr>
<tr>
<td>5 x 5-W/D4 x W/D4</td>
<td>0.080</td>
<td>0.080</td>
</tr>
<tr>
<td>6 x 6-W/D4.7 x W/D4.7</td>
<td>0.094</td>
<td>0.094</td>
</tr>
<tr>
<td>6 x 6-W/D7.4 x W/D7.4</td>
<td>0.148</td>
<td>0.148</td>
</tr>
<tr>
<td>6 x 6-W/D7.5 x W/D7.5</td>
<td>0.150</td>
<td>0.150</td>
</tr>
<tr>
<td>6 x 6-W/D7.8 x W/D7.8</td>
<td>0.155</td>
<td>0.155</td>
</tr>
<tr>
<td>5 x 5-W/D6 x W/D6</td>
<td>0.160</td>
<td>0.160</td>
</tr>
<tr>
<td>5 x 5-W/D8.1 x W/D8.1</td>
<td>0.162</td>
<td>0.162</td>
</tr>
<tr>
<td>5 x 5-W/D8.3 x W/D8.3</td>
<td>0.166</td>
<td>0.166</td>
</tr>
<tr>
<td>12 x 12-W/D8.3 x W/D8.3</td>
<td>0.083</td>
<td>0.083</td>
</tr>
<tr>
<td>12 x 12-W/D9.8 x W/D9.8</td>
<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>12 x 12-W/D9.1 x W/D9.1</td>
<td>0.091</td>
<td>0.091</td>
</tr>
<tr>
<td>12 x 12-W/D9.4 x W/D9.4</td>
<td>0.094</td>
<td>0.094</td>
</tr>
<tr>
<td>12 x 12-W/D16 x W/D16</td>
<td>0.160</td>
<td>0.160</td>
</tr>
<tr>
<td>12 x 12-W/D16.6 x W/D16.6</td>
<td>0.166</td>
<td>0.166</td>
</tr>
</tbody>
</table>

\*Many styles may be obtained in rolls.
information regarding what the contractor should do if there are discrepancies in field conditions to
what is shown on the construction drawings, shoring and bracing information, excavation rules,
information about relationships between other trades and the structural drawings, backfill
information, safety information, permits information, coordination information, general inspection
requirements, and final building characteristics information.

3.4.1.8 Inspection notes

The general note sheet should indicate the level of inspection required for the project. If
the building employs elements that require special inspection, such as a special seismic force
resisting system, they should be identified on the general note sheets.

3.4.2 Plans

Section 1603.1 in the 2012 IBC states: “Construction documents shall show the size,
section, and relative locations of structural members with floor levels, column centers, and
offsets dimensioned.” A plan drawing provides information about an identified building floor,
including overall geometry and dimensions, concrete member width and thicknesses (either
directly or by a designation keyed to a schedule), and reinforcement information for concrete
members (either directly or by a designation keyed to a schedule). A plan drawing can include a
general reference to other sheets, such as an elevation sheet or a detail sheet. A floor plan also
includes orientation information, such as column line numbers, a north arrow, top of slab relative
to a datum, and general notes specific to the floor plan.

Member reinforcement such as beams can be directly given on the plan or indirectly
provided through use of schedule marks, such as beam numbers. <a small figure may be helpful>

For clarity of reinforcement layouts, some offices provide two plans for the same floor level; one
provides top slab reinforcement information and the second provides bottom slab reinforcement
information. If the information for one level is the same (or very similar) as another level, “typical level” sheets can be used.

Plan drawings are usually drawn to 1/16 or 1/8 inch scale. For small floor plans larger scales may be used.

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 small figure may be helpful>

3.4.2.1 Plan graphics and member geometry

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.

Beam and girder locations are typically shown as hidden on the plan drawings because they are typically below the slab.

Columns and walls are shown as solid because they usually extend above the slab on the plan. These vertical members of the structure will be shown on all of the plans from their lowest elevation in the structure, usually the foundation but occasionally a transfer girder or plate, to their highest elevation in the structure, usually the top tier.

Foundations are drawn as hidden on the foundation plan drawings because the slab-on-ground is also shown on the foundation plan in many cases.

Slabs, beams, girders, columns, walls, and foundations are given schedule marks on the plan drawings to indicate the type of member, size, and reinforcement required.

3.4.2.3 Reinforcement on plan views
Reinforcement that is not typical, such as slab reinforcement required where a varied column layout or a large slab opening occurs, is often shown on the plan drawings instead of using slab marks.

When the amount of slab reinforcement being shown on a plan drawing becomes so large that the plan is difficult to read, it is acceptable to make two plans, one for the bottom reinforcement and one for the top reinforcement. When this occurs, it is critical to indicate that the two plan sheets are intended for one floor because it will cause some confusion until the detailer, inspector, and contractor all become used to the layout process on that specific project. Avoid this situation where possible because of this learning curve.

Additional beam and girder reinforcement is not shown on the plan drawings because it can cause confusion. If additional reinforcement is required for beams and girders, it is typically shown in a note or remark in the beam schedule and a corresponding detail or section cut will be necessary to show the additional reinforcement.

3.4.3 Elevations

An elevation sheet provides information about identified frames or shear walls from an elevation view.

Elevation drawings do not have a set scale, so an appropriate scale is chosen based on the height of the elevation being drawn and the level of detail needed.

The elevation sheet provides orientation information, such as column line numbers and floor levels, and is connected to the plan drawings by noted concrete elevations relative to a datum, section references, and orientation information.
An elevation drawing that provides column and wall dimensions can also provide member reinforcement. This information can be provided directly or by a designation keyed to a schedule.

3.4.3.1 *Seismic lateral load resisting systems*

When beams, columns, walls, or all are part of a seismic lateral load resisting system, elevations are often used to show all of the reinforcement in the members 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.

3.4.4 *Sections*

A section sheet is used for most projects. Sometimes, a single sheet combines sections, details (3.4.6), and schedules (3.4.7). Most sections are drawn at 1/2 inch scale, but larger scales may be used, if more detail is needed for clarity. 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. A sectional view will show the geometry and reinforcement details at the cut plane, and may be drawn on a plan sheet, a sections sheet, or on a details sheet. The cut identifies the section number and the sheet number where the section is drawn.

3.4.5 *Large scale views*

Large scale views are used if a dramatically increased scale of a section or detail is needed to show additional clarity in an area of a structure. They are used to clarify reinforcement detailing in an unusual element, such as a curved stair case, complex elevator core, or heavily reinforced link beam. These sheets are rarely entitled "large scale views but are
usually 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.

A separate detail sheet is usually used on a project. However, small projects may have a
single sheet that combines sections (3.4.4), details, and schedules (3.4.7).

Many details are drawn at 1/2 inch to 1 inch scales, but larger scales are used if needed for
clarity. In heavily congested areas, using full scale drawings is suggested to help with checking
constructability. <a couple of figures will be helpful to show this – both engineering and
fabrication detailing>

Details that are applicable to commonly encountered conditions are usually placed on
“typical details” Sheets.

For example, trim reinforcement around a slab or wall opening is often standard for a
certain range of opening sizes, and this arrangement is shown in a typical detail. This allows the
contractor to trim any opening within the stated range without asking the engineer for a specific
solution. Other typical details include reinforcement around an in-slab conduit, a mechanical chase
through a concrete slab, openings through a beam, reinforcement termination details at edges of
concrete, rebar lap slice orientations, contraction joints in slab-on-ground, and construction joints.

Bundling bar details should be shown in the structural drawings with the change in
development and splice lengths, and location of bundled bars splices. This information is best
shown in a typical detail on the respective member schedule sheet because the information is
member specific. Typical details showing bundled bars that affect many different types of
members, such as heavily reinforced slabs, beams, columns, and walls should be shown in the
typical details sheets. Bundling of bars is rare in a slab, but is occasionally necessary.

   Shear reinforcement in a one-way slab is rarely used, but if it is, the shear reinforcement
area is shaded or hatched on the plan drawing. A detail should be included on the slab schedule
sheet to indicate; bar size, spacing of shear reinforcement, and shape of bent bar. Stud rails may
also be a viable option and a detail should be drawn if chosen.

3.4.7 Schedules and Diagrams

Schedule sheets provide reinforcement information for various members, such as slabs,
beams, and columns. A diagram to explain the information in the schedule is usually provided.
Many smaller projects have a single sheet that provides sections (3.4.5), details (3.4.6), and
schedules.

Member schedules usually contain the following:

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

The spacing of bars needs to be indicated on the structural drawings and is shown using a
combination of the member schedule and their corresponding diagrams.

Termination of bars is shown in a diagram that corresponds to the member schedule, showing
locations where reinforcement should be terminated. Normally, the geometry of a one-way slab
does not allow for much termination of reinforcement. For two-way slabs, ACI 318 has specific
guidance regarding the extension of reinforcement from one bay into another and from support to
support. Beams and girders may require a few diagrams depending on the location and type of
beam. For example, a cantilever beam requires different termination of reinforcement than a
continuous beam. Because of their geometry, shallow foundations do not require termination of
reinforcement in most situations. Columns and walls show the termination of reinforcement in
their diagrams or schedules.

3.4.7.1 Member specific information

3.4.7.1.1 Slabs

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.

For one-way slabs, the LDP can use the termination rules to use material more efficiently.

Please see example XXX for details about this.

Two-way slabs supported by edge walls or by edge-beams require reinforcement in the top
and the bottom of the slab at the intersection of the two-way slab and edge members. This
reinforcement is shown using typical details if it happens throughout the structure or the
information is shown right on the plan drawings if it is not a prevalent detail.

Two-way slab structural integrity reinforcement requirements can 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 also 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.
Two-way slab shear reinforcement could be stud rails, typical stirrups, or steel structural members. Stud rails are used most often 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 or in a table. 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. Steel structural members are rarely used.

3.4.7.1.2 Beams and girders

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 assumed 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, number of 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. <add pointer to elevations section and sentence regarding elevating beams and girders>

Shear reinforcement in a beam is 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. The LDP should provide a detail of stirrups showing shape of stirrup and the length of the hooks.

3.4.7.1.3 Columns

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.

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.

3.4.7.1.4 Walls

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.
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.

3.4.7.1.5 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 piles, 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 elsewhere in this section. Pier cap
schedules are shown in 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 minimum 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.
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.

3.4.8 User defined

User defined sheets are used to show information that is not presented on other sheets,
and are rarely used in the structural drawings on a building project.

3.4.9 3D Representations

3D representation sheets are used to show an especially complicated connection or joint
or to coordinate among different disciplines to prevent clashes between different systems. 3D
representation sheets are not commonly used for structural drawings.

CHAPTER 4—PLACING DRAWINGS

<Placeholder for Robbie Hall text for placing drawings>

CHAPTER 5—TOLERANCES

5.1 ACI 117

ACI 301, “Specifications for Structural Concrete” requires construction tolerances
comply with ACI 117 “Specifications for Tolerances for Concrete Construction and Materials.”

ACI 117 provides tolerances that are standard for concrete construction, including tolerances for
rebar placement. Placing tolerances have an effect on cover, strength, constructability, and serviceability. If more restrictive tolerances are required than those shown in ACI 117, they need to be indicated in the construction documents.

CHAPTER 6—SYSTEMS CHECKLIST

6.1 General

This chapter is intended to give the user a checklist of sheets that are necessary for the basic design of a reinforced concrete structure. It is divided into building systems as described in ACI 318. During the design process, the LDP is required to choose both a vertical load resisting system and a lateral load resisting system. The vertical load resisting systems are either a one-way beam and slab system, a two-way slab system, or variants of either system, such as a joist or waffle slab system. The lateral load resisting system is either shearwall or moment frame, with the type being determined by the LDP based on the seismic loads that the structure will be designed for.

<Tony Felder makes a good comment regarding Chapter 6. This is written referencing drawings that "sort of" exist right now – the drawings that are included on the ACI website for the Case Studies (http://www.concrete.org/TKC/CaseStudies.asp). However, we will not be referencing those drawings in this document because we have to "adjust" them to make them fit the words and ideas that the committee wants to convey. These drawings can and will be adjusted and will be included in Chapter 9 (at this point). Chapter 9 still needs some adjustment at this moment in time.>

6.2 Ordinary shear wall with two-way slabs

<table>
<thead>
<tr>
<th>Sheet title</th>
<th>Information included</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>General notes</td>
</tr>
<tr>
<td>1</td>
<td>Plans</td>
</tr>
<tr>
<td>3</td>
<td>Sections</td>
</tr>
</tbody>
</table>
6.2.1 General notes

General notes for an ordinary shear wall system with two-way slabs should contain all of the information described in 3.4.1.

General building code information is shown in general note number 7, Design Criteria.

This project was designed under the International Building Code (IBC), 2006 edition. All of the live load information was included in the same general note. Note that the wind loadings change along the height of the structure in a step function according to the ASCE 7 procedures (referenced by IBC 2006), therefore the wind load information is shown by listing the wind speed assumed, exposure class and importance factor. Seismic loadings also change along the height of the structure and the ASCE 7 assumptions are listed in a similar fashion. Another reason this is done is because most software packages will calculate the wind and seismic loadings for the LDP.

ACI 301 is referenced in the concrete notes. Any changes needed were shown either in the plan notes or in the specifications for the project. Creating specific notes for the checklists included in ACI 301 is beyond the scope of this document.

Concrete strength is shown with concrete general note number 5. This structure needed several different concrete strengths and air contents depending upon where the concrete was used. A table was used to show the concrete information for the structure.

Type and grade of reinforcing bars is shown with concrete general note number 2. Grade 60 ASTM A615 reinforcement was used throughout the project.
Concrete cover to reinforcement was shown with concrete general note number 4. This structure was designed using nonprestressed reinforcement and the cover requirements are controlled by ACI 318 6.8.1.3.1.

Bar development and lap splice lengths are described in a table on Sheet S0.02. Note that the preferred method for this information from a fabricator’s standpoint is to show bar development and lap splice lengths and locations graphically in an elevation or plan view. To do this for any element with a schedule, lap splice length and bar development can be shown right in the diagram for the corresponding member. For example, a beam diagram that corresponds to a beam schedule can show the expected lap splice lengths and locations within the beam. Note that if a table is used to show the bar development and lap splice lengths, it should be simple enough to avoid many calculations being performed by the fabricator. The main reason for this is that the length of lap splices can be a safety issue if they are calculated to be too short by the fabricator and any issues of safety of the structural design are the responsibility of the LDP.

By referencing ACI 301 and not specifically allowing bar mats, epoxy and zinc coating, or field cutting provisions by using the general notes or specifications, these are not allowed to be done on this project. ACI 301 does not allow bar mats, epoxy and zinc coating, or field cutting in its default condition, but by using a general note or additional specifications, ACI 301 can be overruled by the construction documents.

General concrete note 17 shows that a requirement of plastic tipped accessories for reinforcement at all faces of exposed concrete is required. By only designating the plastic tips in these locations, the LDP is allowing the fabricator to supply all other supports as they see fit.

Welded wire reinforcement was allowed on this project and details were shown in concrete general note 3.
This project did not require any epoxy or zinc coated reinforcement; therefore, no information was provided on the drawings.

The general notes do not specifically allow field cutting of reinforcement; therefore, field cutting of reinforcement is not allowed on this project because the default condition of ACI 301 is that field cutting of reinforcement is not allowed.

Shrinkage and temperature reinforcement was checked on this project, but did not control the design. By showing all of the flexural reinforcement required, the shrinkage and temperature reinforcement requirements were met.

There are several notes in the general and concrete notes that are considered construction notes. These will not be discussed in detail, but a couple of examples of construction notes are concrete note 20 that indicates where electrical conduit can be installed in a slab-on-ground or supported slab and general note 15 indicating that no backfill shall be placed against any wall until the wall is supported. Both of these construction notes are included because of assumptions that were made during the design of the structure. If the electrical conduit is installed above the top reinforcement, it would reduce the concrete cover for the top layer of reinforcement and thereby likely reduce the overall durability of the structure. Walls are typically designed in their final layout and thus only have reinforcement in locations to resist the loads after they are completely constructed and supported. If backfill is placed against an unsupported wall, it is likely that some type of failure of the wall could be expected, whether that failure is more deflection than desired or the worst case scenario of a collapse of the wall during the backfilling process.

6.2.2 Plans

Plan sheets for an ordinary shear wall system with two-way slabs should contain all of the information described in 3.4.2.
In example 6.2, the thickness of the slab was defined using sheet note 1 where a symbol was used with a numerical thickness value in the center. Slab reinforcement was shown on the plan views instead of with slab marks which meant that a slab schedule was not needed for this example. To help show all of the slab reinforcement clearly, the slab main bottom reinforcement was shown as sheet note 6, while the top and additional bottom reinforcement were separated into two plan views. In the example, these were shown on one plan sheet, but it would be acceptable to split the top and bottom reinforcement plans and put them on two plan sheets if needed for clarity.

On this project, reinforcement hooks were shown on the plan. The beams in this example were shown using beam marks and a beam schedule. Columns were shown using a column schedule and location. Shearwalls were shown using shearwall marks and a schedule. The beam schedule, column schedule, and shearwall schedule were located separate sheets that will be discussed in more detail in 6.2.5.

The sheet notes also show a few other items that are code required. Sheet note 7 describes integrity reinforcement required by ACI 318 12.7.4.2.2.

Sheet note 8 indicates that the lap splices in the slab need to be Class B lap splices per ACI 318 12.7.4.2.1. Location of lap splices should be as shown in ACI 318 Figure 12.7.4.1.3.

Sheet note 9 tells the contractor that the north-south reinforcement should be placed at the lowest point and highest point in the slab.

Sheet note 10 tells the contractor that the design was based on the construction joint location marked on the plan. If the contractor wishes to change the locations of these construction joints, they will need to submit a request for information (RFI) to the LDP.

Note that reinforcement information regarding openings was not included on this plan sheet. This information is in the typical details because they are the same throughout the project.
Note that corner reinforcement per ACI 318 12.7.3.1 is not required because $\alpha_f$ is less than 1.0. If it had been required, the corner reinforcement would be best shown using a typical detail because all corner reinforcement would be identical.

The foundation for this project was a 48 inch thick mat footing. Please see 7.2 for further discussion of the plan view of the foundation.

6.2.3 Sections

Section sheets for an ordinary shear wall system with two-way slabs should contain all of the information described in 3.4.4.

In this example, the majority of the sections are cut to show details about the mat foundation used for this project. Those details are discussed in more detail in 7.2. <Tony Felder correctly comments that these details are not discussed in more detail in 7.2 – I accept this note as a placeholder to make certain that 7.2 will be filled with the correct information.>

There are two sections to discuss, the section that is cut on the plans through the beams on the exterior of the typical floor slab and the section cut through the concrete stairs. Both of these sections are typical sections for the whole project. They could have been located on a typical details sheet, but because there was room on the section sheet, they were included here.

6.2.4 Details

Details sheets for an ordinary shear wall system with two-way slabs should contain all of the information described in 3.4.6.

The example drawings reflect a common design. The LDP felt that the typical details sheet was the best place to show the table used for the reinforcement lap splice and embedment length table.
Required additional reinforcement around wall openings per ACI 318 15.7.5 is shown in a
detail on this page. Note that additional reinforcement around slab openings is not required by
ACI 318; however, it is good detailing practice as this reinforcement helps to control cracking
around the stress concentrations of openings. Construction joints are also shown on the typical
details sheet because the same detail can be used for both slabs and walls.

6.2.5 Schedules and diagrams

Schedules and diagram sheets for an ordinary shear wall system with two-way slabs should
contain all of the information described in 3.4.7.

The example drawings contain three schedule and diagram sheets: column, wall, and beam.

For the column schedule, the column grid locations are used to show what column is used where
rather than having a separate mark placed on the plan sheet. Because of the height of the structure,
the specified compressive strength of the column concrete changed with the floor level of the
column. 7000 psi concrete was used from the base to the top of the 5th floor and 5000 psi concrete
was used from the top of the 5th floor to the top of the structure. The other item of interest is the
change in section in the columns. Both column designs allowed for the section to become more
slender after the mezzanine was reached. Note that when the section for the T1 column was
allowed to become more slender, the architect wanted a feature included on the column. To
properly detail this, there needed to be vertical bars enclosed with ties to help control any cracking
that may occur in this architectural feature. Therefore, there were #5 bars placed in the corners and
tied back to the column. Overall, the number of vertical bars did not decrease, but the size of the
bars in the architectural feature was reduced because they were no longer needed for the strength of
the column, only crack control.

6.3 Ordinary moment frame with post-tensioned beams and one-way slabs

36
### 6.3.1 General notes

General notes for an ordinary moment frame with post-tensioned beams and one-way slabs should contain all of the information described in 3.4.1.

General building code information is shown in general note section A Codes and Standards, note 1. This project was designed under the International Building Code (IBC), 2006 edition. All of the live load information was included in general note, section B. Note that the wind loadings change along the height of the structure in a step function according to the ASCE 7 procedures (referenced by IBC 2006), therefore the wind load information is shown by listing the wind speed assumed, exposure class and importance factor. Seismic loadings also change along the height of the structure and the ASCE 7 assumptions are listed in a similar fashion. Another reason this is done is because most software packages will calculate the wind and seismic loadings for the LDP.

ACI 301 is referenced in the concrete notes, section G of the general notes. Any changes needed were shown either in the plan notes or in the specifications for the project. Creating specific notes for the checklists included in ACI 301 is beyond the scope of this document.

Concrete strength is shown in section D, note 5.b. This structure needed several different concrete strengths depending upon where the concrete was used and all are listed in 5.b. Note 5.a. specifies the air content for all of the concrete mixtures.
Type and grade of reinforcing bars is shown in section D, note 6.

Concrete cover to reinforcement was shown with general note G.1.b. This structure was designed as a prestressed structure and the cover requirements for nonprestressed reinforcement are controlled by ACI 318 6.8.1.3.2.

Bar development and splice lengths are described in table 1 on Sheet S2-2. Note that the preferred method for this information from a fabricator's standpoint is to show splice lengths and locations graphically in an elevation or plan view. To do this for any element with a schedule, splice length and development can be shown right in the diagram for the corresponding member. For example, a beam diagram that corresponds to a beam schedule can show the expected lap splice lengths and locations within the beam. Note that if a table is used to show the development and splice lengths, it should be simple enough to avoid many calculations being performed by the fabricator. The main reason for this is that splices can be a safety issue if they are calculated to be too short by the fabricator and any issues of safety of the structural design are the responsibility of the LDP.

By referencing ACI 301 and excluding any changes regarding bar mats, epoxy and zinc coating, or field cutting provisions, these are not allowed to be done on this project.

Section G note G1.k shows that a requirement of plastic tipped accessories for reinforcement at all faces of exposed concrete is required. By only designating the plastic tips in these locations, the LDP is allowing the fabricator to supply all other supports as they see fit.

Welded wire reinforcement was allowed on this project and details were shown in section D note 6.

Epoxy coated reinforcement requirements were provided in section D note 6.
The general notes do not specifically allow field cutting of reinforcement; therefore, field cutting of reinforcement is not allowed on this project.

Shrinkage and temperature reinforcement was shown on this project. The combination of the bottom mat of reinforcement steel shown on S1-3A and the three post-tensioning tendons in each bay parallel to the P series gridlines will compensate for the forces induced in the slab by shrinkage and temperature changes.

There are several notes in the general and concrete notes that are considered construction notes. These will not be discussed in detail.

6.3.2 Plans

Plan sheets for an ordinary moment frame with post-tensioned beams and one-way slabs should contain all of the information described in 3.4.2.

In example 6.3, the thickness of the slab was defined using plan note 2 on sheet S1-3B. Slab reinforcement was shown on the plan views instead of with slab marks which meant that a slab schedule was not needed for this example. This is typical in a post-tensioned structure because there is usually less need for nonprestressed reinforcement in the slab. The post-tensioning needed to be shown in the drawings as well. To help show all of the slab reinforcement clearly, the slab bottom reinforcement was shown using a clouded typical section of the slab. In this example, the designer also noted that the bottom slab reinforcement parallel to the beams could be used as support for the post-tensioning in the slab.

The beams in this example were shown using beam marks and a beam schedule. Columns were shown using a column schedule and location. The beam and column schedules were located on separate sheets that will be discussed in more detail in 6.3.5.
Note that reinforcement information regarding openings was not included on this plan sheet. This information is in the typical details because they are the same throughout the project. The foundation for this project was a caisson or drilled pier foundation using grade beams for wall support. Please see 7.3 for further discussion of the plan view of the foundation.

6.3.3 Sections

Section sheets for an ordinary moment frame with post-tensioned beams and one-way slabs should contain all of the information described in 3.4.4.

In this example, most of the sections that were cut were typical details and will be discussed in section 6.3.4.

6.3.4 Details

Details sheets for an ordinary moment frame with post-tensioned beams and one-way slabs should contain all of the information described in 3.4.6.

The example drawings are of a common post-tensioned parking deck design.

Construction joints are shown on the typical details sheet because the same detail can be used for both slabs and walls.

6.3.5 Schedules and diagrams

Schedules and diagrams sheets for an ordinary moment frame with post-tensioned beams and one-way slabs should contain all of the information described in 3.4.7.

The example drawings contain three schedule and diagram sheets: drilled pier/caisson, column, and beam.

For the drilled pier and column schedule, the foundation plan was used to show what drilled pier and column were used where
CHAPTER 7—FOUNDATION SYSTEMS CHECKLIST

7.1 General

This chapter is intended to give the user a checklist of sheets that are necessary for the basic design of a concrete foundation. The foundations are split from the remainder of the structural systems because almost any foundation system can be combined with any superstructure depending upon structure size, soil strength, seismic design, water table, and many other geotechnical design parameters. For example, an ordinary shearwall system with two-way slabs could be found sitting on shallow foundations, a mat foundation, a series of caissons/drilled piers, or a series of piles with pile caps.

7.2 Mat foundation

The mat foundation example that was used was for the ordinary shear wall with two-way slabs.

CHAPTER 8—FABRICATION AND CONSTRUCTION ISSUES(TIPS? HELP?)

8.1 General

This chapter is intended to aid the LDP with information regarding preferred reinforcement choices, common fabrication issues, and construction issues that can be avoided by the LDP using preferred detailing methods. Etc…<this needs more words???>

8.2 Overall bar diameter

The overall diameter of a reinforcing bar is equal to the nominal bar diameter plus twice the deformation height. Table 3 lists reinforcing bar overall diameters and Figure 1 shows a section cut of a reinforcing bar that indicates where the overall diameter is measured.
Table 3: Overall diameter of reinforcing bars

<table>
<thead>
<tr>
<th>Bar size, inch-pound (metric)</th>
<th>Approximate diameter to outside of deformations, in. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3 (#10)</td>
<td>7/16 (11)</td>
</tr>
<tr>
<td>#4 (#13)</td>
<td>9/16 (14)</td>
</tr>
<tr>
<td>#5 (#16)</td>
<td>11/16 (17)</td>
</tr>
<tr>
<td>#6 (#19)</td>
<td>7/8 (22)</td>
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<tr>
<td>#7 (#22)</td>
<td>1 (25)</td>
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<tr>
<td>#8 (#25)</td>
<td>1-1/8 (29)</td>
</tr>
<tr>
<td>#9 (#29)</td>
<td>1-1/4 (32)</td>
</tr>
<tr>
<td>#10 (#32)</td>
<td>1-7/16 (37)</td>
</tr>
<tr>
<td>#11 (#36)</td>
<td>1-5/8 (41)</td>
</tr>
<tr>
<td>#14 (#43)</td>
<td>1-7/8 (48)</td>
</tr>
<tr>
<td>#18 (#57)</td>
<td>2-1/2 (64)</td>
</tr>
</tbody>
</table>

Figure 1:
The overall diameter can be important if precise geometric information is needed, such as when punching holes in structural steel member to accommodate bars or when beam bars cross with column longitudinal bars. Diameters tabulated in Table 3 are approximate so some tolerance should be added. <We need a number from CRSI and the committee – Tony Felder commented that he is not aware of such a number. This is something that is fairly important – can we get a "throw together" number and for a future document do a small research project and get a better number? "Some tolerance" is a very poor piece of wording without some kind of number backing it up.>

These overall diameters should be used for a geometric check as the nominal diameter might show a tight fit, while the overall diameter will indicate interference.

CHAPTER 9—EXAMPLE DRAWINGS AND DETAILS

9.1 General
This chapter contains example drawings and details that can be used to aid the LDP produce a complete set of construction drawings. Each type of sheet discusses in detail how the LDP would determine the information that goes onto the drawing and then a basic description of how to show that information.

9.2 General notes

General notes are an extension of the specifications. In ACI 318-14, Chapter 23 contains information that is required to be included in the construction drawings. One way to develop a set of general notes is to use ACI 301. With this reference specification, there are mandatory and optional checklists included with the document that the LDP can go through and determine a set of notes from those checklists. ACI 301 also has an e-tool that aids the LDP with developing this list of notes. The e-tool is available for an annual fee in the Concrete Knowledge Center on the ACI website (http://www.concrete.org/Technical/CKC/Concrete_Spec_Center.htm).

9.3 Plan views

9.3.1 Two-way slab with shear walls

CHAPTER 10—REFERENCES

10.1—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.
Measuring Points

- Measuring point

**Vertical or Horizontal**

**Square**
180 Hook Measuring Points

Measuring point

Hook Min.

4db or 2½” Min.

A or G
Leg Name

Vertical or Horizontal
90 Hook Measuring Points

- Measuring point

**Extension(s):**
- 12 db Standard Bends
- 12 db Stirrup Bends #6 thru #8
- 6 db Stirrup Bends #3 thru #5

*Vertical or Horizontal*
135 Hook Measuring Points

Measuring point

Vertical / Horizontal

A or G

Leg Name

H

6db or 3” Min.

J Min.

Hook Min.
Measuring Points

Measuring point

Sloping

Leg Name

H Rise

K Run
Measuring Points

Measuring point

Obtuse Sloping

Acute Sloping
90 Hook Measuring Points

Measuring point

Extension(s):
12 db Standard Bends
12 db Stirrup Bends #6 thru #8
6 db Stirrup Bends #3 thru #5

Obtuse Sloping Hook Up
90 Hook Measuring Points

Measuring point

Extension(s):
12 db Standard Bends
12 db Stirrup Bends #6 thru #8
6 db Stirrup Bends #3 thru #5

Obtuse Sloping Hook Down

A or G
Extension

H Rise

Leg Name

K Run
180 Hook Measuring Points

Measuring point

4db or 2 1/2" Min.

Leg Name

A or G

H Rise

K Run

Obtuse Sloping Hook Up
180 Hook Measuring Points

Measuring point

Leg Name

A or G

H Rise

4db or 2 1/2" Min.

Hook Min.

J

K Run

Obtuse Sloping Hook Down
135 Hook Measuring Points

- Measuring point

Hook Min.
6db or 3" Min.

H

J Min.

Leg Name

A or G

H1 Rise

K Run

Obtuse Sloping Hook Up
135 Hook Measuring Points

Measuring point

Leg Name

A or G

J Min.

H

H1 Rise

6db or 3" Min.

Hook Min.

K Run

Obtuse Sloping Hook Down
Radial Measuring Points

+ Measuring point

O Diameter

Radius

Full Circle

K Chord

Leg name

H Chord Height

Radius

Partial Circle
Bend Diameters

ASTM A615/A615M-12

TABLE 3 Bend Test Requirements

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Pin Diameter for Bend Tests^</th>
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<th>Grade 60 [420]</th>
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<th>Grade 80 [550]</th>
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<td>3^1/2 ( d^a )</td>
<td>5d</td>
<td>5d</td>
<td>5d</td>
<td>5d</td>
</tr>
<tr>
<td>6 [19]</td>
<td>5d</td>
<td>5d</td>
<td>5d</td>
<td>5d</td>
<td>5d</td>
</tr>
<tr>
<td>7, 8 [22, 25]</td>
<td>...</td>
<td>5d</td>
<td>5d</td>
<td>5d</td>
<td>5d</td>
</tr>
<tr>
<td>9, 10, 11 [29, 32, 36]</td>
<td>...</td>
<td>7d</td>
<td>7d</td>
<td>7d</td>
<td>7d</td>
</tr>
<tr>
<td>14, 18 [43, 57] [90°]</td>
<td>...</td>
<td>9d</td>
<td>9d</td>
<td>9d</td>
<td>9d</td>
</tr>
</tbody>
</table>

^ Test bends 180° unless noted otherwise.

\( d^a \) = nominal diameter of specimen.

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7.2 — Minimum bend diameters

7.2.1 — Diameter of bend measured on the inside of the bar, other than for stirrups and ties in sizes No. 3 through No. 5, shall not be less than the values in Table 7.2.

7.2.2 — Inside diameter of bend for stirrups and ties shall not be less than \( 4d_b \) for No. 5 bar and smaller. For bars larger than No. 5, diameter of bend shall be in accordance with Table 7.2.

7.2.3 — Inside diameter of bend in welded wire reinforcement for stirrups and ties shall not be less than \( 4d_b \) for deformed wire larger than D6 and \( 2d_b \) for all other wires. Bends with inside diameter of less than \( 8d_b \) shall not be less than \( 4d_b \) from nearest welded intersection.

R7.2 — Minimum bend diameters

Standard bends in reinforcing bars are described in terms of the inside diameter of bend because this is easier to measure than the radius of bend. The primary factors affecting the minimum bend diameter are feasibility of bending without breakage and avoidance of crushing the concrete inside the bend.

R7.2.2 — The minimum \( 4d_b \) bend for the bar sizes commonly used for stirrups and ties is based on accepted industry practice in the United States. Use of a stirrup bar size not greater than No. 5 for either the 90-degree or 135-degree standard stirrup hook will permit multiple bending on standard stirrup bending equipment.

R7.2.3 — Welded wire reinforcement can be used for stirrups and ties. The wire at welded intersections does not have the same uniform ductility and bendability as in areas that were not heated. These effects of the welding temperature are usually dissipated in a distance of approximately four wire diameters. Minimum bend diameters permitted are in most cases the same as those required in the ASTM bend tests for wire material (ASTM A1064).

**TABLE 7.2 — MINIMUM DIAMETERS OF BEND**

<table>
<thead>
<tr>
<th>Bar size</th>
<th>Minimum Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 3 through No. 8</td>
<td>6( d_b )</td>
</tr>
<tr>
<td>No. 9, No. 10, and No. 11</td>
<td>8( d_b )</td>
</tr>
<tr>
<td>No. 14 and No. 18</td>
<td>10( d_b )</td>
</tr>
</tbody>
</table>

CRSI — Manual of Standard Practice

<table>
<thead>
<tr>
<th>Bar Size</th>
<th>Standard Bends</th>
<th>Stirrup/Tie Bends</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3</td>
<td>2.25 (6d)</td>
<td>1.5 (4d)</td>
</tr>
<tr>
<td>#4</td>
<td>3 (6d)</td>
<td>2 (4d)</td>
</tr>
<tr>
<td>#5</td>
<td>3.75 (6d)</td>
<td>2.5 (4d)</td>
</tr>
<tr>
<td>#6</td>
<td>4.5 (6d)</td>
<td>4.5 (6d)</td>
</tr>
<tr>
<td>#7</td>
<td>5.25 (6d)</td>
<td>5.25 (6d)</td>
</tr>
<tr>
<td>#8</td>
<td>6 (6d)</td>
<td>6 (6d)</td>
</tr>
<tr>
<td>#9</td>
<td>9.5 (8.4d)</td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>10.75 (8.5d)</td>
<td></td>
</tr>
<tr>
<td>#11</td>
<td>12 (8.5d)</td>
<td></td>
</tr>
<tr>
<td>#14</td>
<td>18.25 (10.8d)</td>
<td></td>
</tr>
<tr>
<td>#18</td>
<td>24 (10.6d)</td>
<td></td>
</tr>
</tbody>
</table>
## Standard Bending Tolerances

<table>
<thead>
<tr>
<th>Condition</th>
<th>Illustrations</th>
<th>#3 thru #11</th>
<th>#14</th>
<th>#18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight bar</td>
<td></td>
<td>+/- 1&quot;</td>
<td>+/- 2&quot;</td>
<td>+/- 2&quot;</td>
</tr>
<tr>
<td>90° Bent leg (Bounded or Unbounded)</td>
<td></td>
<td>+/- 1&quot;</td>
<td>+/- 2 1/2&quot;</td>
<td>+/- 3 1/2&quot;</td>
</tr>
<tr>
<td>90° Standard hook and Bends</td>
<td></td>
<td>+/- 2 1/2&quot; or +/- 1/2&quot; per foot</td>
<td>+/- 2 1/2&quot; or +/- 1/2&quot; per foot</td>
<td>+/- 2 1/2&quot; or +/- 1/2&quot; per foot</td>
</tr>
<tr>
<td>Rise/Run of a Bounded Sloping Leg</td>
<td></td>
<td>+0, -1/2&quot;</td>
<td>+/- 2 1/2&quot;</td>
<td>+/- 3 1/2&quot;</td>
</tr>
<tr>
<td>Rise/Run of an Unbounded Sloping Leg</td>
<td></td>
<td>+/- 1&quot;</td>
<td>+/- 2 1/2&quot;</td>
<td>+/- 3 1/2&quot;</td>
</tr>
<tr>
<td>Out to out of multiple legs and/or Rise/Runs</td>
<td></td>
<td>+/- 1&quot;</td>
<td>+/- 2 1/2&quot;</td>
<td>+/- 3 1/2&quot;</td>
</tr>
<tr>
<td>Bounded Radius</td>
<td></td>
<td>+/- 1&quot;</td>
<td>+/- 2 1/2&quot;</td>
<td>+/- 3 1/2&quot;</td>
</tr>
<tr>
<td>Unbounded Radius</td>
<td></td>
<td>+/- 1&quot;</td>
<td>+/- 2 1/2&quot;</td>
<td>+/- 3 1/2&quot;</td>
</tr>
<tr>
<td>Chord Height</td>
<td></td>
<td>+/- 1&quot; Min.</td>
<td>+/- 2 1/2&quot; Min.</td>
<td>+/- 3 1/2&quot; Min.</td>
</tr>
<tr>
<td>Chord Length</td>
<td></td>
<td>+/- 2&quot; min</td>
<td>+/- 2 1/2&quot; min</td>
<td>+/- 3 1/2&quot; min</td>
</tr>
<tr>
<td>Standard 180° Hook Depth J</td>
<td></td>
<td>+/- 1/2&quot;</td>
<td>+/- 1 1/2&quot;</td>
<td>+/- 2&quot;</td>
</tr>
<tr>
<td>Standard 90° Hook Length A or G</td>
<td></td>
<td>+/- 1&quot;</td>
<td>+/- 2 1/2&quot;</td>
<td>+/- 3 1/2&quot;</td>
</tr>
<tr>
<td>Standee Height</td>
<td></td>
<td>See Stirrup and Tie</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Truss Bar Overall Length</td>
<td></td>
<td>+/- 1&quot;</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Truss Bar Height</td>
<td></td>
<td>+/- 0, -1/2&quot;</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

### Proposed Tolerance

**ACI 117 - Tolerance for Concrete Construction - Section 2.1**
<table>
<thead>
<tr>
<th>Condition</th>
<th>Illustrations</th>
<th>#3 thru #5</th>
<th>#6 thru #8</th>
</tr>
</thead>
<tbody>
<tr>
<td>90° Bent leg</td>
<td>90° standard hook</td>
<td>+/- 1/2&quot;</td>
<td>+/- 1&quot;</td>
</tr>
<tr>
<td>(Bounded or Unbounded)</td>
<td>Bends</td>
<td></td>
<td>+/- 1&quot;</td>
</tr>
<tr>
<td></td>
<td>90° Standard hook</td>
<td>+/- 2 1/2° or</td>
<td>+/- 2 1/2° or</td>
</tr>
<tr>
<td></td>
<td>Rise/Run of a Sloping Leg</td>
<td>+/- 1/2&quot; or</td>
<td>+/- 1/2&quot; per foot</td>
</tr>
<tr>
<td></td>
<td>(Bounded or Unbounded)</td>
<td>+/- 2 1/2° or</td>
<td>+/- 1/2&quot; per foot</td>
</tr>
<tr>
<td></td>
<td>Hoop Diameter</td>
<td>+/- 1/2&quot;</td>
<td>+/- 1/2&quot;</td>
</tr>
<tr>
<td></td>
<td>Standard 135° Hook Width</td>
<td>+/- 1/2&quot;</td>
<td>+/- 1/2&quot;</td>
</tr>
<tr>
<td></td>
<td>Standard 90° Hook Length</td>
<td>+/- 1/2&quot;</td>
<td>+/- 1/2&quot;</td>
</tr>
<tr>
<td></td>
<td>Standee Height</td>
<td>+/- 1/2&quot;</td>
<td>+/- 1&quot;</td>
</tr>
<tr>
<td></td>
<td>Lap Length</td>
<td>-1&quot; or any</td>
<td>-1&quot; or any</td>
</tr>
<tr>
<td></td>
<td>Opposite parallel legs and/or</td>
<td>positive value</td>
<td>positive value</td>
</tr>
<tr>
<td></td>
<td>dimensions</td>
<td>+/- 1/2&quot;</td>
<td>+/- 1&quot;</td>
</tr>
</tbody>
</table>

Proposed Tolerance

ACI 117 _Tolerance for Concrete Construction_ - Section 2.1